QWEST Communications International Inc. Technical Publication

Frame Relay Service

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CONTENTS

CONTENTS (Continued)

CONTENTS (Continued)

CONTENTS (Continued)

Exhibits **Page**

CONTENTS

Chapter and Section **Page**

1. Introduction

1.1 General

This document describes QWEST Frame Relay Service offered by QWEST to its customers. The information provided in this document includes service features, technical specifications, performance objectives, and defines the valid Network Interfaces (NIs).

1.2 Reason for Reissue

This publication is being revised to:

Remove the following services

- 2-Wire 128kbps Frame Relay Service
- Multicast Service
- Priority Permanent Virtual Circuit (PVC) Service

Update information regarding the following services

- Video PVC Service
- Fault Tolerant PVC Service

1.3 Purpose

The purpose of this document is to describe QWEST Frame Relay Service appropriate for the majority of applications. Sufficient technical detail is furnished to allow a customer, such as an Interexchange Carrier (IC), Frame Relay Service Provider, or an End-User (EU), to select a service that may be incorporated into an end-to-end communications channel. It is not the intent of this document to provide specific ordering information, but to describe the technical features of this service offering.

1.4 Applicability of Technical Specifications

The technical specifications presented in this document are applicable to QWEST Frame Relay Service only. It is not the intent of this document to describe the various types of transmission and switching equipment used to provide Frame Relay Service (FRS). The service as described in this document pertains to the presently deployed transport and frame relay switching technology. As further frame relay hardware and software enhancements become available for network deployment, additional QWEST Frame Relay Service features will be offered to the customer.

CONTENTS

Chapter and Section **Page**

CONTENTS (Continued)

Figures **Page**

Table

Exhibits

2. Description of Basic Frame Relay Service

2.1 General Frame Relay Service Description

QWEST Frame Relay Service employs "fast packet" technology with access speeds of 56 kbit/s, 64 kbit/s, 1.544 Mbit/s and 44.736 Mbit/s to provide a high-speed connection-oriented data transfer service. "Fast Packet" technology may be classified as having two types of packets: cells and frames. A cell is defined as a fixed-size packet (53 octets), whereas a frame may vary in packet size. Frame relay is a frame-oriented packet technology that supports variable frame sizes to cost effectively support bursty applications (e.g., Local Area Network [LAN] interconnection and file transfers), which contain both variable bandwidth requirements and low delay requirements. The frame relay protocol contains less overhead than the X.25 protocol, translating into reduced processing requirements by the frame relay network nodes, hence, less transit delay and increased throughput.

QWEST Frame Relay Service utilizes Permanent Virtual Circuits to establish logical connections between customer locations to provide higher access speeds and less delay than traditional packet-switch technologies. In lieu of multiple physical dedicated lines, multiple logical connections may be established on a single Frame Relay Service (FRS) Access Link to provide simultaneous logical connections between customer Network Interfaces. These multiple logical connections increase the customers' flexibility for data transfer applications. On pre-subscribed logical connections, variable length frames are relayed between the FRS customer's source and destination locations, utilizing the FRS Access Link's bandwidth as needed.

For Frame Relay service enhancements see Section 2.3 and 3.1.

2.2 Frame Relay Standards and Reference Documents

Frame Relay is an established standard described by the following standard documents:

- ITU-T I.122, "Framework for Providing Additional Packet Mode Bearer Service".
- ITU-T Q.922, "ISDN Data Link Layer Specification for Frame Mode Bearer Services".
- ITU-T Q.933, "DSS1 Signaling Specifications for Frame Mode Basic Call Control".
- ANSI T1.602-1989, "ISDN - Data-Link Layer Signaling Specification for Application at the User-Network Interface".
- ANSI T1.606-1990, "ISDN - Architectural Framework and Service Description for Frame-Relaying Bearer Service".
- ANSI T1.606a-1992, "ISDN - Architectural Framework and Service Description for Frame Relaying Bearer Service (Congestion Management and Frame Size)".
- ANSI T1.606b-1993, " Network to Network Interface Requirements - Frame Relaying Bearer Service - Architectural Framework and Service Description".

- ANSI T1.617-1991, "ISDN - Signaling Specification for Frame Relay Bearer Service for Digital Subscribers Signaling System Number 1 (DSS1)".
- ANSI T1.617a-1994 - "ISDN - Signaling Specification for Frame Relay Bearer Service for Digital Subscribers Signaling System Number 1 (Supplement to ANSI T1.617-1991, T1 default - T1S1/93 - 464)".
- ANSI T1.618-1991, "ISDN - Core Aspects of Frame Protocol for Use with Frame Relay Bearer Service".
- ANSI/T1A/EIA 612-1993 - "Electrical Characteristics For an Interface at Data Signaling Rates up to 52 Mbit/s".
- ANSI/T1A/EIA 613-1993 - "High Speed serial Interface for Data Terminal Equipment and Data Circuit Terminating Equipment".
- Frame Relay Forum Document FRF.1.1, January 1996, "User-to-Network Interface (UNI) Implementation Agreement".
- Frame Relay Forum Document FRF.2.1, July 1995, "Network-to-Network Interface (NNI) Implementation Agreement".
- Frame Relay Forum Document FRF.3.1, July 1995, "Multiprotocol Encapsulation Implementation Agreement".

As stated in International Telecommunications Union - Telecommunications Sector (ITU-T) Recommendation I.122 (see Reference Section), FRS is based on a portion of the Layer 2 procedures (i.e., Link Access Procedure D [LAPD]) of the ISDN protocol. The LAPD protocol is a variant of other widely available High-level Data Link Control (HDLC) type protocols (e.g., ITU-T Link Access Procedure B [LAPB] and System Network Architecture [SNA] Synchronous Data Link Control [SDLC]). Today, HDLC-type protocol functionality is typically implemented in the data communication hardware using Very Large Scale Integration (VLSI) technology, and the respective variants (e.g., LAPB and SDLC) are accomplished via software/firmware.

2.3 Frame Relay - Service Overview

QWEST Frame Relay Service is a connection-oriented service which is accomplished by establishing a logical connection between the following : (1) End-User (EU) customer Frame Relay devices, (2) Interexchange Carrier-Point of Presence (IC-POP) and an EU customer Frame Relay device, (3) Frame Relay Service Providers Network and an EU customer Frame Relay device. QWEST Frame Relay Service Customers may send data to any designated locations using pre-established Permanent Virtual Circuits (PVCs). A PVC(s) is established at service subscription time, and remains established until appropriate customer disconnect information is provided. Hence, both the data transfer call set-up and call termination phases are eliminated during each individual FRS data transfer.

2.3.1 Frame Relay Service Using Permanent Virtual Circuits (PVC)

Permanent Virtual Circuits (PVCs) are logical circuits that define a specific path between a Data Terminal Equipment (DTE) source device and a DTE destination device. A PVC, which could emulate a dedicated private line in today's circuit switched environment, is identified by Data Link Connection Identifiers (DLCIs) in a Frame Relay Network. Each DLCI(s) is located within the address field of the standard frame relay protocol structure, which is described in Chapter 4.

Multiple PVCs can be provisioned on a single customer's FRS Access Link. The PVCs can be backed up by the Fault Tolerant PVC (See Section 2.3.10). The customer's Frame Relay DTE device and the Frame Relay Node (described in Section 2.3) exchange data utilizing the pre-established PVCs within a customer's FRS Access Link(s). Therefore, depending upon the customer EU application(s) and bandwidth requirements, FRS offers each customer with the capability to replace multiple private access lines with a single FRS Access Link comprised of multiple PVCs. The FRS Access Link's bandwidth is dynamically allocated on a PVC basis to multiple applications as required. Allocation of the bandwidth within the customer's FRS Access Link in this manner allows multiple applications to share the entire bandwidth of the Frame Relay Access Link.

2.3.2 Customer's FRS Access Link Line Speed and Local In-channel Signaling Protocol Requirements

The access line speed and local in-channel signaling protocol must be specified by the FRS Customer at service subscription time. The frame relay access link(s) is provisioned on appropriate transmission facilities and frame relay ports while considering the QWEST Engineering and Network Congestion Control Procedures (see Chapter 6). Each customer's FRS Access Link(s) will be terminated on one of the following:

- A Frame Relay Port(s) of a QWEST Frame Relay Node.
- A Frame Relay Port(s) of another Frame Relay Service Providers Network in the case of the Stand-Alone Access Link. (Does not apply to the 44.736 Mbit/s UNI/NNI.)

PVCs are provisioned within the customer FRS Access Link(s) which operate at the following rates: 56 kbit/s, 64 kbit/s, 1.544 Mbit/s and 44.736 Mbit/s. For the Frame Relay Fractional Port Access Service Enhancement, the port speeds are provisioned on a (Nx56) kbit/s or (Nx64) kbit/s basis, where N equals 1,2,4,6, or 8, 12. The Committed Information Rate (CIR) options associated with the FRS Access Link are identified in Subsection 2.3.6.

2.3.3 "PVC with CIR" versus "PVC with 'Equivalent' CIR"

QWEST Frame Relay Service has been enhanced to support CIR on a PVC basis for FRS Access Links, which terminate on QWEST Frame Relay Nodes. With the QWEST Frame Relay Service CIR Feature, each customer's PVC within the FRS Access Link is assigned a specific CIR value which is predetermined based on the customer's traffic characteristics (e.g., burst size, burst length, frame size), communication protocols (e.g., TCP/IP, Novell, Appletalk™), routing protocols (e.g., RIP, IGRP), and response time requirements for given EU application(s).

Prior to the availability of CIR with QWEST Frame Relay Service, subscribers were requested to provide an "equivalent CIR" for each PVC at service subscription. The term "equivalent CIR" refers to the manner in which bandwidth is allocated amongst multiple PVCs prior to the availability of the CIR feature. Prior to the introduction of the CIR Feature with QWEST Frame Relay Service, the QWEST Pre-CIR Congestion Control Procedures (described in Chapter 6) were performed by QWEST Frame Relay Nodes during congestion in order to alleviate the network congestion. With the introduction of the QWEST Frame Relay Service CIR Feature, the QWEST CIR Congestion Control Procedures will be performed by QWEST Frame Relay Nodes in order to alleviate congestion if network congestion should occur.

2.3.4 CIR and Associated Parameters

The CIR Feature essentially provides the ability to define a minimum bandwidth for each PVC. CIR and its associated parameters (i.e., Committed Burst Size [Bc], Measurement Interval [Tc], Excess Burst Size [Be]) are defined in ANSI T1.606a-1992 *ISDN - Architectural Framework and Service Description to Frame-Relaying Bearer Service (Congestion Management and Frame Size).* The QWEST Frame Relay Service CIR Feature and its associated parameters are consistent with the definitions specified in the aforementioned ANSI standard. The four parameters which define CIR for QWEST Frame Relay Service are indicated below:

- Committed Information Rate (CIR)
- Measurement Interval (Tc)
- Committed Burst Size (Bc)
- Excess Burst Size (Be)

CIR is defined as the rate at which the U S WEST's Frame Relay Network agrees to transfer information under normal conditions. The CIR is measured over a *Tc*. *Tc* denotes the time interval for which the Customer Provided Equipment Frame Relay Access Device, Interexchange Carrier, or Carrier (including other Frame Relay Service Provider) Network offers data to the QWEST Frame Relay Network. The Tc for QWEST Frame Relay Service will always be a constant value equal to one (1) second. The CIR for each PVC is negotiated at service subscription time based upon the following factors:

- EU Application(s) Bandwidth Requirements
- EU Application(s) Response Time Requirements
- EU Traffic Characteristics (e.g., burst size, burst length, frame size)
- EU Communications Protocols (e.g., TCP/IP, IPX) and Routing Protocols

With QWEST Frame Relay Service CIR Feature, *Bc* is defined as the maximum amount of data that the QWEST Frame Network will transfer under normal conditions during a Tc. Per ANSI T1.606a-1992 (see Reference Section), the committed burst data does not necessarily have to be contiguous, but may reside in one or more frames.

CIR is proportional to the Bc over a Tc. The formula for determining the relationship of Bc and CIR is given below:

$$\text{CIR (bits/s)} = \frac{\text{Bc (bits)}}{\text{Tc (seconds)}}$$

Where Tc equals 1 second for QWEST Frame Relay Service

Due to fact that Tc=1 for QWEST Frame Relay Service, Bc and CIR will always be equal.

Be is defined as the maximum amount of uncommitted data (bits) that the QWEST Frame Relay Network will attempt to deliver during Tc. This parameter determines the number of bits beyond the Bc, which the QWEST Frame Relay Network is willing to accept for transport. As is the case for Bc, this data does not necessarily need to be contiguous. See Subsection 2.3.6 for further information on the manner in which Be is determined for QWEST Frame Relay Service.

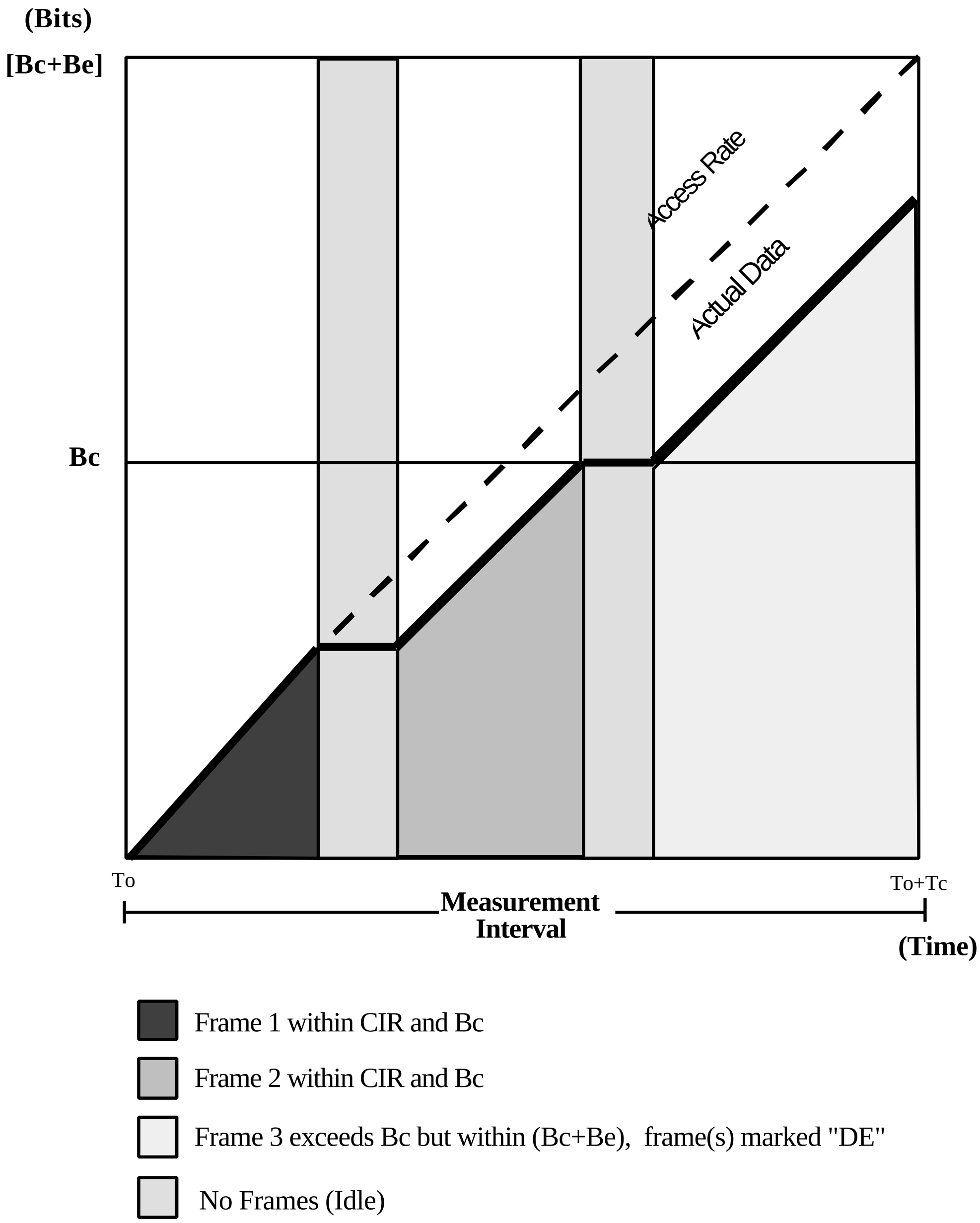
2.3.5 CIR Overview

In order for QWEST to support the CIR value specified by the customer at service subscription time, the QWEST Frame Relay Network must transmit, under normal conditions, the Bc bits offered to the network within a one (1) second measurement interval. All EU customer frames are transmitted at the operating line speed of the Frame Relay Access Link. Any frames offered to the QWEST Frame Relay Network beyond the Bc, but not exceeding (Bc+Be) will be marked as Discard Eligible (DE) by the QWEST Frame Relay Network. Since QWEST supports the capability to burst up to the frame relay port speed, all customer frames for any given measurement interval will be equal to or less than the summed information rate [(Bc + Be)]/Tc.

As shown in Figure 2-1, the frames marked as DE may be discarded during a period of congestion in order to meet the CIR of other PVCs. Since the customer's frames for any given measurement interval will be less than or equal to (Bc + Be), no data will be discarded at ingress for exceeding the Summed Information Rate ([Bc + Be] / Tc). The exception is the high speed Frame Relay 44.736 Mbit/s UNI/NNI port access speed. See section 2.3.6 for more information. See Chapter 6 for additional information on QWEST Congestion Control and Frame Discard Schemes in a CIR environment.

Figure 2-2 provides an example of the CIR feature applied to a FRS 64 kbit/s Access Link provisioned for a PVC with a CIR value of 32 kbit/s. Figure 2-2 depicts the manner in which continuous 8 kbit/s blocks of data are processed by the QWEST Frame Relay Network supporting CIR. Each 8 kbit/s block of data is contained within one or more ITU-T Q.922A frames.

Coordination of the CIR parameters for a PVC which traverses multiple Frame Relay Networks is necessary due to the variations in the CIR options offered by the interconnecting Frame Relay Network Providers. See Section 5.2 of this document for further information on multiple Frame Relay Network PVCs. It is recommended that Bc and CIR values of a multiple Frame Relay Network PVC should be equivalent for each Frame Relay Network. Specifically, ingress, egress, and intermediate Frame Relay Networks should have equivalent Bc and CIR parameters in order to avoid congestion. However, due to the various implementations of CIR in frame relay network switching equipment used by other Frame Relay Network Providers, some CIR parameters may not be selectable by the service subscriber in all cases. In cases where the same CIR and Bc values are not supported by other Frame Relay Service Providers, the effective CIR and Bc equivalents should be negotiated at service subscription time. Furthermore, the Be supported by each Frame Relay Network Provider should also be coordinated during the service subscription process of a multiple Frame Relay Network PVC.



LEGEND:

To + Tc	-	Measurement Interval
Bc	-	Committed Burst Size
Be	-	Excess Burst Size
CIR	-	Committed Information Rate

Figure 2-1 CIR and Associated Parameters

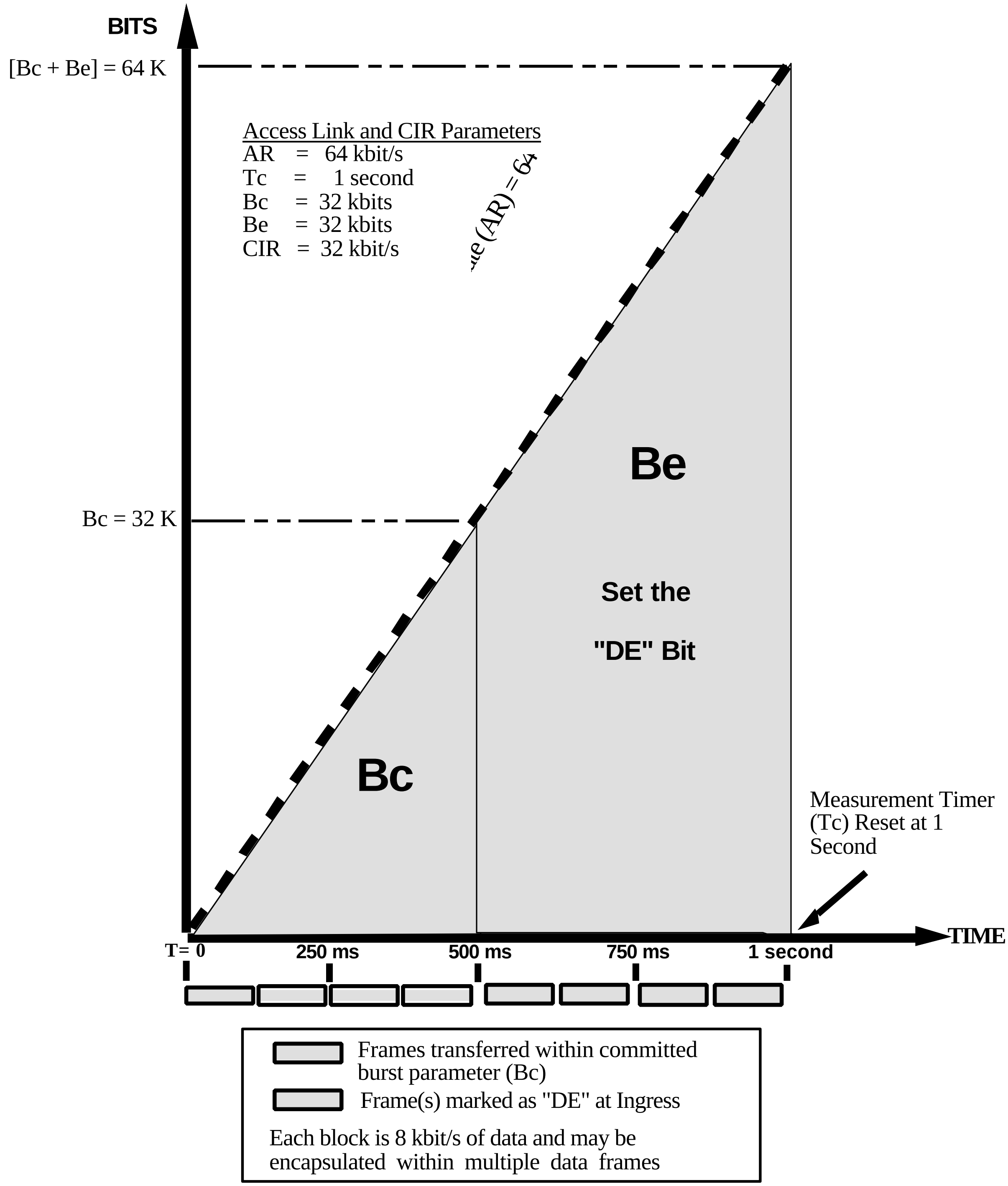
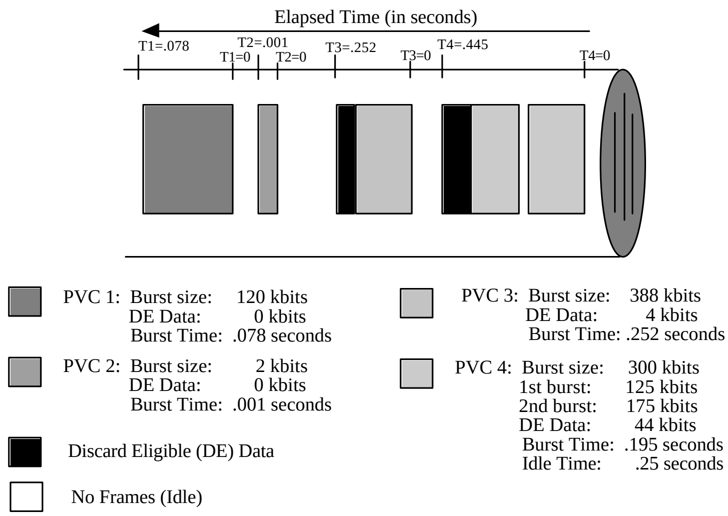


Figure 2-2 QWEST 64 kbit/s Access Link with 32 kbit/s CIR

Figure 2-3 depicts the manner in which the Tc operates as a sliding interval of fixed duration for each PVC. The Tc for each PVC (i.e., PVC 1 through PVC 4) is initiated upon the receipt of the first bits of an EU customer's frame by the QWEST Frame Relay Network. During the interval Tc, if data in excess of the Bc is received by the QWEST Frame Relay Network, the current frame and subsequent frames received during Tc will be marked DE by the QWEST Frame Relay Network.



PVC	FRS Access Link Operating Speed	CIR (N x 64)	Committed Burst Size (Bc)	Measurement Interval (Tc)
1	1.544 Mbit/s	256 kbit/s	256 kbits	1 second
2	1.544 Mbit/s	64 kbit/s	64 kbits	1 second
3	1.544 Mbit/s	384 kbit/s	384 kbits	1 second
4	1.544 Mbit/s	256 kbit/s	256 kbits	1 second

Figure 2-3 Measurement Interval (Tc) as a Sliding Interval

2.3.6 QWEST Frame Relay Service CIR Options

Table 2-1 provides the available CIR Options supported by the QWEST Frame Relay Service. For QWEST Frame Relay Service, the committed burst (Bc) parameter value will be equal to the CIR due to fact that Tc is a constant of one (1) second.

Table 2-1 CIR Options for Customer PVCs

FRS Access Link Usable Bandwidth	Recommended CIR Options (kbit/s)	Other Available CIR Options (kbit/s)
56 kbit/s	0, 2.4, 4.8, 9.6, 16, 24, 28	32, 48
64 kbit/s	0, 2.4, 4.8, 9.6, 16, 24, 32	48
112 kbit/s	0, 2.4, 4.8, 9.6, 16, 24, 32, 48, 56	70, 84
128 kbit/s	0, 2.4, 4.8, 9.6, 16, 24, 32, 48, 64	80, 96
224 kbit/s	0, 2.4, 4.8, 9.6, 16, 24, 32, 48, 64, 96, 112	140, 168
256 kbit/s	0, 2.4, 4.8, 9.6, 16, 24, 32, 48, 64, 96, 128	160, 192
336 kbit/s	0, 2.4, 4.8, 9.6, 16, 24, 32, 48, 64, 96, 128, 168	210, 252
384 kbit/s	0, 2.4, 4.8, 9.6, 16, 24, 32, 48, 64, 96, 128, 192	240, 288
448 kbit/s	0, 2.4, 4.8, 9.6, 16, 24, 32, 48, 64, 96, 128, 192, 224	274, 336
512 kbit/s	0, 2.4, 4.8, 9.6, 16, 24, 32, 48, 64, 96, 128, 192, 224, 256	320, 384
672 kbit/s	0, 2.4, 4.8, 9.6, 16, 24, 32, 48, 64, 96, 128, 192, 224, 256, 336	392, 448, 504
768 kbit/s	0, 2.4, 4.8, 9.6, 16, 24, 32, 48, 64, 96, 128, 192, 224, 256, 384	448, 512, 576
1.344 * Mbit/s (N x 56 kbit/s)	0, 2.4, 4.8, 9.6, 16, 24, 32, 48, 56, and multiples of 56 up to 672	728 and greater multiples of 56 up to 1008
1.536 Mbit/s (N x 64 kbit/s)	0, 2.4, 4.8, 9.6, 16, 24, 32, 48, 64, and multiples of 64 up to 768	832 and greater multiples of 64 up to 1024
44.736 Mbit/s	See note 1 below.	

* Indicates the channel data rate option pertinent for Channel Service Unit / Data Service Unit (CSU / DSU) terminating equipment. (See Section 3.8)

Note 1: The "recommended" CIR parameters and bursting capability for a 44 .736 Mbit / s UNI / NNI should be based on the access rates and the CIR parameters of the remote FRALs (i.e., 56 / 64 kbit / s, 1.544 Mbit / s).

All customer's CIR parameters will be provisioned to enable bursting up to the subscribed port speed. QWEST will provision the committed burst (Bc) parameter to support the CIR values shown in Table 2.1. Due to the nature of specific customer's traffic characteristics, tuning the CIR configuration parameters, namely Bc and Be, may be necessary for the following reasons:

- Prevent excessive DE frames from being generated, which could potentially result in frame(s) loss in the event of network congestion.
- Enabling the optimization of the frame relay network resources.
- QWEST Network integrity is based on the traffic load measurements performed via the QWEST Network Management and Administration Systems.

The customer's CIR parameters (i.e., Be, and Tc) can be configured such that the following conditions apply:

- Bc and Be have to be symmetrical at both ends of the PVC.
- In most cases, Maximum Committed (Bc) supported will not be less than one-half the frame relay port speed, with the exception of high speed FR UNI/NNI port access speed at the 44.736 Mbit/s rate. The maximum allowable Bc supported for the high speed FR UNI/NNI access port at the 44.736 Mbit/s rate is 1.024 Mbit/s.
- Bursting up to the port speed at any given time will be supported to avoid excessive frame discards at ingress**,** with the exception of high speed FR UNI port access speed at the 44.736 Mbit/s rate. This condition ensures that no frames greater than (Bc + Be) will occur within any given measurement interval as a result of the CIR parameter provisioning. Specifically, Be is calculated as follows:

Be (kbit/s) / Tc = (FRS Access Link Usable Bandwidth) - (Bc / Tc)

Or

Be (kbit/s) / Tc = (FRS Access Link Usable Bandwidth) - CIR

For example, given the following CIR, Bc, and Tc values for a particular PVC provisioned on a 1.544 Mbit/s FRS Access Link, Be will be configured as follows:

Given : CIR = 768 kbit/s , Bc = 768 kbit/s, Tc = 1 s
Then: Be = 1.536 Mbit/s - 768 kbit/s = 768 kbit/s

For the high speed FR UNI access port speed at the 44.736 rate, the sum of Be+Bc cannot exceed 1.544 Mbit/s.

For example, if Bc=1.024 Mbit/s, then Be=1.544 Mits-Bc=540 kbit/s.

Any packet bursting above Be+Bc will be discarded at the switch ingress.

2.3.7 PVC Subscription Quantities and Subscription Levels

At service subscription time, each QWEST Frame Relay Service Customer may request multiple PVCs per Frame Relay Access Link. The maximum throughput achievable for multiple PVCs provisioned on a given Frame Relay Port cannot exceed the payload capacity for any given FRS Access Link. Assuming traffic characteristics generated by EU applications operating over QWEST Frame Relay Service are bursty in nature, the aggregate of the subscribed PVC CIR values for a given FRS Access Link may exceed the payload capacity for any given FRS Access Link.

Congestion which may occur as a result of either bandwidth over subscription or high traffic volumes will be rectified by the following components:

- Customer Provided Equipment Frame Relay Access Device
- Customer Provided Equipment (CPE) congestion as a result of simultaneous bursts (CPE towards the QWEST Frame Relay Network) from multiple PVCs are serialized by the CPE Frame Relay Access Device (e.g., Router) for transmission over the QWEST Frame Relay Network. CPE congestion is typically controlled via buffering which may potentially cause delay or discarding of data in order to alleviate the CPE congestion condition. Frame Relay Customers should refer to the frame relay access device documentation or CPE equipment supplier for specific CPE congestion information pertinent to customer’s frame relay access device.
- QWEST Frame Relay Port(s)
- The Frame Relay Port may become congested with high traffic volumes that are non-bursty. In the event that the QWEST Frame Relay Service EU Customer’s network congestion procedures do not alleviate the congestion conditions of a particular Frame Relay Port(s), QWEST reserves the right to implement its own congestion control procedures on the congested Frame Relay Module located within a Frame Relay Node(s). These congestion control procedures are described in Chapter 6.

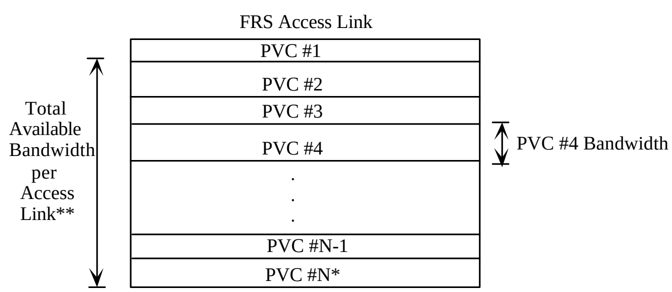
The degree of CIR over subscription for any individual FRS access link should be determined based on the following factors:

- Nature of traffic patterns: bursty, non-bursty
- QWEST recommends lower aggregate CIR subscription levels (i.e., from 100 to 150 percent of port speed) for less bursty traffic patterns. Higher subscription levels (i.e., greater than 150 percent of port speed) may be allowed for bursty traffic patterns.
- Total Offered traffic load or traffic volume

- For traffic loads which contain multiple large burst sizes, lower aggregate CIR subscription levels are recommended for delay sensitive applications. Due to the nature of packet switching technologies, large volumes of small data packets sent at a high rate may cause delay patterns to occur in the EU applications.
- Traffic Aggregation (e.g., Network-to-Network Interface Access Links)
- For service arrangements in which multiple EU traffic is aggregated into a single frame relay access link, lower subscription levels are recommended.

The aggregate CIR subscription level for an individual frame relay access link is determined by the following factors: (1) Quantity of PVCs per Frame Relay Access Link, (2) CIR values of each PVC provisioned on the Frame Relay Access Link, (3) UNI or NNI Service Arrangement. The recommended maximum number of PVCs per Frame Relay Access Link should be no greater than 30 for 56/64 kbit/s FRS Access Links, no greater than 125 for 1.544 Mbit/s FRS Access Link, and no greater than 500 for high speed FR UNI/NNI access link at 44.736 Mbit/s. In some cases it is possible to assign more PVCs per Frame Relay Access Link when there is high burst/low load traffic characteristics on that link. For Fractional Port Access, N x 20 PVCs is the recommended maximum number of PVCs, where N equals the number of contiguous 56/64 kbit/s channels which comprise the fractional port.

Figure 2-4 illustrates the manner in which multiple PVCs with various CIR values are provisioned on a QWEST Frame Relay Service Access Link. Essentially, each PVC is allocated, at any particular instance in time, a percentage (based on the CIR value) of the total port speed available. The line speed at which the FRS Access Link operates must be pre-determined at service subscription time. For Fractional Port Access, port speeds must also be specified at service subscription time. The determination of the line speed, port speed, and PVC CIRs of the access link must incorporate the FRS EU customer application's bandwidth requirements as well as response time requirements.



* N equals the total quantity of PVCs provisioned on a FRS Access Link

** Bandwidth available for subscription per FRS Access Link is listed in Table 2-1.

Figure 2-4 PVC Assignments within an Access Line

Due to the bursty nature of the traffic being transported over the QWEST Frame Relay Network, individual PVCs will be typically transporting data at different instances in time. However, should multiple PVCs burst at the same time, the CPE Frame Relay DTE device(s) and CPE CSU(s)/DSU(s) are responsible for interleaving the individual frames of the bursting PVCs onto the QWEST Frame Relay Access Link. Chapter 6 describes in detail the manner in which QWEST performs congestion control in the event of network congestion in a CIR environment.

2.3.8 Frame Relay Implicit and Explicit Congestion Notification

The standard frame relay protocol imposes the burden upon the higher-layer protocol functionalities of the End User (EU) applications to perform the functions of flow control and error correction that are not performed by the Frame Relay Network. The frame relay protocol standards do not specify notification of errored packets. However, the typical network protocols (e.g., Transmission Control Protocol/Internet Protocol [TCP/IP]) of the EU application(s) do provide implicit flow control via an acknowledgment process between EU application(s).

Should network congestion occur, each individual PVC will be notified via explicit protocol congestion notification (i.e., Forward Explicit Congestion Notification [FECN] and Backward Explicit Congestion Notification [BECN]) bits. Both EU customer and QWEST Frame Relay Service network congestion responsibilities are addressed in Chapter 6.

2.3.9 PVC Enhancement Features

QWEST Frame Relay Service offers the Fault Tolerant Permanent Virtual Circuit (PVC) enhancement feature to address customer’s application needs.

Fault Tolerant Permanent Virtual Circuit (PVC) feature addresses customer’s disaster recovery needs. This service feature reroutes all the customer’s PVCs from a failed frame relay connection to a standby UNIT upon customer notification. Failed connections can be due to a customer’s CPE malfunction, site failure, etc. The standby UNIT is specifically for protecting customer’s CPE malfunction and site failure. Protection against access loop failure requires the subscription of additional loop protection services (e.g., diversity routing, etc.).

A standby UNIT is a regular UNIT but without configured PVCs of its own. It serves as a backup for one or more of the customer’s primary connections (and the associated PVCs) for fault protection. The PVCs that are backed up by the standby UNIT are called Fault Tolerant PVCs. A standby UNIT can protect multiple connections, but only a single connection can be backed up at a time. That is, during multiple connections failure, only a single UNIT and its associated PVCs can be selected for switching to the standby UNIT.

The service will reroute all the PVCs on a failed connection to the standby UNIT. Rerouting a subset of the PVCs is not supported. QWEST only initiates PVC reroute to the standby UNIT upon notification by the customer's designated representative, and only restores service back to the primary connections when specifically requested by the customer's designated representative. U S WEST's time commitment for the service is specified in Chapter 8.

The service requires customers to subscribe to one or more standby UNITs and purchase some form of access to those UNITs (i.e., FRAL, Private Line Access and COCC, etc.). The number of standby UNITs required depends upon customer's backup requirements. The standby UNIT speed must be equal to the highest speed of the UNITs designated for backup. The service offering is currently limited to UNIT connections. Network interfaces as described in sections 3.1.1, 3.1.2, 3.1.3, 3.1.4, and 3.1.5 apply to this service offering. Exhibit 2-8 provides a service configuration example. This feature has limited availability, check the Qwest tariff to determine where it is offered.

2.3.10 Video Permanent Virtual Circuit (PVC)

The video PVC service offering allows packetized point-to-point videoconferencing applications (both 384 kbit/s and 512 kbit/s Committed Information Rate) to be transported over FRS. Multipoint videoconferencing applications at 384Kb/s are also available. The service also assigns a higher transit priority for the video PVC than the basic PVC to minimize delay and loss during intermittent network congestion.

The service currently has no quality of service guarantees, but performance for the video PVC can be expected to be equal to or better than the performance objectives specified in Chapter 7.

Service subscription is identical to the current basic FRS, requiring the subscription of both FRAL and User-To-Network Information Transfer (UNIT). The CIR value for the video PVC, however, will need to be specified at service subscription time. Excess burst (Be) will not be allowed and will be set to zero.

The video PVC service offering is based on special switch and trunk engineering and vendor proprietary schemes, therefore the service may not interoperate with other service provider's video PVC offering. The service offering is currently restricted to FR network only. Check your local tariff to determine availability.

Network interface as described in section 3.1.2 apply to this service offering.

2.4 General Architecture

The QWEST Frame Relay Service essentially establishes logical connectivity between the frame relay EU customer devices, using PVCs which can be multiplexed over a single access path. The QWEST Frame Relay Network Architecture which supports and administers the FRS Access Links and the virtual connections consists of the following elements:

- Fiber optic facility or 4-Wire twisted pair copper used for physical access into the QWEST Frame Relay Network or other service providers frame relay network. Each FRS Access Link can operate at different line speeds.

  QWEST Frame Relay Nodes located within a QWEST Central Offices.
- Digital Internodal Facilities between QWEST Frame Relay Nodes.
- QWEST Network Administration and Monitoring System.
- CPE - Access Interface Unit, CSU / DSU.

QWEST Frame Relay Service will incorporate Frame Relay Nodes and the necessary internodal trunk circuits within the defined geographical service areas.

2.4.1 End User CPE Data Terminal Equipment Requirements

The EU's CPE DTE device must accumulate customer traffic (e.g., host computers), and encapsulate the customer data into a standard frame relay format (i.e., Q.922 Annex A). The EU CPE DTE Device must also support the implementation of a frame relay local in-channel signaling protocol (i.e., ITU-T Q.933 Annex A, ANSI T1.617a--1994, LMI). The CPE CSU / DSU units must support the appropriate data communications interface(s) (e.g., V.35 for the CPE DTE device), and a 4-Wire physical interface to the network for transport. A 2 wire physical interface is required for the 2-Wire FRAL.

For Fractional Port Access within a FRS 1.544 Mbit / s Access Link, the CPE CSU / DSU functionality must support (Nx56) kbit / s or (Nx64) kbit / s channel rates. Recommended customer CSU / DSU options and the FRS physical NIs are addressed in Chapter 3.

For the high speed Frame Relay UNI, the CPE is required to provide a DS3 signal for T3 transmission. The service is standard compliant with UNI interface conforming to Frame Relay Forum (FRF) 1.1 specification. The network interface signals may be electrical, or optical, as selected by the customer and conforming to the following DS3 network interface and frame format applications. The network interface at the customer premise will be at a SJA44 connector with signal characteristics described in ANSI T1.404-1994. The physical electrical DS3 NI configurations are shown in Exhibit 3-6.

2.4.2 Frame Relay Node

The administration and coordination of each PVC, and its associated DLCI(s), is performed at QWEST Frame Relay Node Locations. A Frame Relay Node examines each DLCI to determine the frame's destination path based on the pre-subscribed PVC information.

Due to the fact that each DLCI has only local significance, each Frame Relay Node will associate each local DLCI with a pre-defined path. The destination DLCI may reside within a local or remote Frame Relay Node, or within another Frame Relay Network Provider's Serving Area. If the Frame Relay Node determines the frames destination is not local, the frame is transmitted over internodal facilities to the next appropriate Frame Relay Node, or to the interconnecting Frame Relay Network. This process is reiterated until the frame reaches its final destination (i.e., EU CPE DTE device).

2.5 QWEST Frame Relay Service Configuration

The purpose of the following paragraphs is to describe some of the typical service configurations associated with QWEST Frame Relay Service. The QWEST Frame Relay Service may utilize both interoffice and local loop facilities to support the transport of QWEST Frame Relay Service customer traffic. The FRS EU customers, ICs, and Carrier (including other Frame Relay Service Providers) can access the QWEST Frame Relay Network via a FRS Access Link(s) or an equivalent private line transport. Frame Relay Access Link(s) are established between the customer premise location, Carrier POT, or IC-POP and the nearest Service Point. A service point(s) is a geographic location(s), designated by, where the QWEST Frame Relay Network is to be accessed. The service configurations apply to the 56Kb/s, 64Kb/s, 1.544Mb/s signal rates only unless otherwise stated.

2.5.1 QWEST Frame Relay Network and Service Points

The QWEST Frame Relay Network is considered to consist of Service Points, Frame Relay Nodes, Frame Relay Ports, and internodal facilities. A Service Point is any Wire Center contained within the disclosed Frame Relay Serving Area. A Frame Relay Node is a Central Office that contains a Frame Relay Switch. A Frame Relay switch contains Frame Relay Ports that are used to access the switch. QWEST Interoffice Facilities will be utilized to transport QWEST Frame Relay internodal traffic within the same Local Access and Transport Area (LATA).

QWEST will establish Frame Relay Nodes in designated Serving Wire Centers (SWCs) to support the QWEST Frame Relay Service. Subsections 2.5.4 through 2.5.9 give examples of Wire Center Service Configurations.

2.5.2 QWEST Frame Relay Service EU Network Interface (NI)

The NIs offered to the EU customers will be at the following signal rates: 56 kbit/s, 64 kbit/s, and 1.544 Mbit/s and 44.736 Mbit/s. The UNI for frame relay signaling is specified in ANSI T1.617-1991, (see Reference Section). The data transfer protocol of this UNI applicable to QWEST Frame Relay Service, is described in ANSI T1.618-1991 (see Reference Section). Chapter 4 of this document describes the protocol structure of the data link layer protocol for frame relay. The EU customer's physical interfaces for Frame Relay Service are described in Chapter 3. The FRS Access Link(s) which terminates on the EU customer's NI may be provided over existing QWEST Fiber Optic Facilities.

2.5.3 QWEST Frame Relay IC and Carrier Network Interface

The NIs offered to a Carrier (including Independent Exchange Carriers and other Frame Relay Service Providers) are 56 kbit/s, 64 kbit/s, 1.544 Mbit/s and 44.736 Mbit/s signal rates as well as the fractional port signal rates. The Carrier's physical interfaces are described in Chapter 3. Both the UNI protocol and the NNI protocol are supported at the IC or Carrier NI. The FRS Access Link between an IC-POP and a QWEST Frame Relay Node may also be provisioned on existing QWEST Fiber Optic Facilities.

The NNI protocol specifies the manner in which the IC and/or Carrier (including other Frame Relay Service Provider) Frame Relay Networks are interconnected. The NNI protocol supported at the IC or Carrier NI by QWEST Frame Relay Network is based upon the Frame Relay Forum Document FRF.1.1, FRF.2.1, FRF.3.1 (see Reference Section).

2.5.4 Single Wire Center Service Configuration

A single wire center configuration, shown in Exhibit 2-1, will support multiple QWEST Frame Relay Service EUs whose nearest serving Frame Relay Node is located within the same SWCs.

A single wire center service configuration consists of the following:

- Single Frame Relay Node
- A single wire center, which contains each EU customer's nearest Service Point.

2.5.5 Multiple Wire Center Service Configuration

A multiple wire center service configuration, shown in Exhibit 2-2, will support multiple QWEST Frame Relay Service EUs whose nearest Frame Relay Nodes are located in different SWCs.

A multiple wire center service configuration consists of the following:

- Multiple Frame Relay Nodes
- Multiple wire centers, which contain each EU customer's Service Point.

2.5.6 Non-Local Service Point Service Configuration

A service configuration in which the nearest Service Point is not located within the FRS customer's QWEST or Alternate Carrier Serving Wire Center is shown in Exhibit 2-3. Private line tariffs (e.g., QWEST Digital Data Service and QWEST DS1 Service) will apply in this service configuration for the interoffice facility between the EU SWC and the nearest Service Point.

A Non-Local Service Point service configuration consists of the following:

- A customer's SWC which is neither a Frame Relay Node nor an Service Point.
- A FRS Access Link which consists of a loop facility, CO cross-connections, and an interoffice facility.
- Nearest Service Point(s).
- Frame Relay Node(s).

2.5.7 Alternate Carrier Access Service Configuration

The manner in which a Frame Relay Service EU Customer is provided access to an IC or Carrier (including other Frame Relay Service Provider) is shown in Exhibit 2-4. The DLCI values associated with the PVCs assigned to interLATA PVCs must be closely coordinated between the IC or Carrier (including other Frame Relay Service Provider) and U S WEST. Chapter 5 provides additional information on the administration of the PVCs.

2.5.8 Frame Relay Service 56/64 kbit/s Stand-Alone Access Link Service Configuration

The manner in which a Frame Relay Service (FRS) EU Customer is provided access to another service provider's frame relay network is shown in Exhibit 2-5. A FRS 56 kbit/s or 64 kbit/s (where available) Stand Alone Access Link is supported for the transport of frame relay traffic exclusively between the EU customer (or Carrier) and another service provider's frame relay network. In the application of the FRS 56/64 kbit/s Stand Alone Access Link, the Frame Relay switching functionality is provided by the frame relay switching component within the other Frame Relay Service provider's network.

As indicated in Exhibit 2-5, the FRS 56 kbit/s or 64 kbit/s Stand Alone Access Link is interconnected through a QWEST Central Office(s) to the Non QWEST Central Office via a Frame Relay Stand Alone Multiplexer. The interconnection of the FRS 56 kbit/s or 64 kbit/s (where available) Stand Alone Access Link may require interoffice facility transport systems within the QWEST serving territory.

Customer data transported within the FRS 56/64 kbit/s Stand Alone Access Link must be encapsulated within the frame structure defined in ITU-T Q.922 Annex A. In addition, frame relay local in-channel signaling must be implemented over the FRS 56/64 kbit/s (where available) Stand Alone Access Link. In the event that the non-frame relay traffic and/or improper local in-channel signaling occurs on the receive line of the 56/64 kbit/s Stand Alone Access Link, customer data will be substituted with an HDLC idle code (7E) in the direction from customer premise to the frame relay network. During normal frame relay data transfer and local in-channel signaling message exchange, the Frame Relay Stand Alone Multiplexer located in the QWEST Central Office will not modify, set, or alter the data or frame relay header information.

2.5.9 Frame Relay Service 1.544 Mbit/s Stand Alone Link Service Configuration

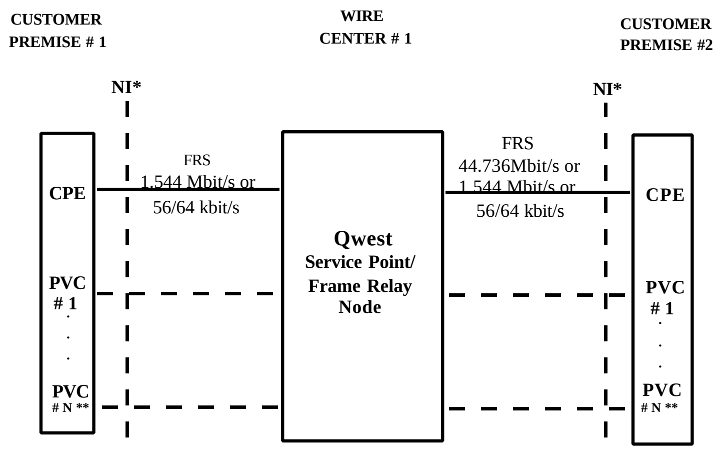
A FRS 1.544 Mbit/s (where available) Stand Alone Access Link is supported for the transport of frame relay traffic exclusively between the EU customer (or Carrier) and other service provider's frame relay network. In the application of the FRS 1.544 Mbit/s Stand Alone Access Link, the Frame Relay switching functionality is provided by the frame relay switching component within the other Frame Relay Service provider's network.

The FRS 1.544 Mbit/s Stand Alone Access Link is interconnected through a QWEST Central Office(s) to the Non QWEST Central Office via interoffice facilities.

Customer data transported within the FRS 1.544 Mbit/s Stand Alone Access Link must be encapsulated within the frame structure defined in ITU-T Q.922 Annex A. In addition, frame relay local in-channel signaling must be implemented over the FRS 1.544 Mbit/s Stand alone Access Link. In the event that the non-frame relay traffic and/or improper local in-channel signaling occurs on the receive line of the 1.544 Mbit/s Stand Alone Access Link, customer data will be substituted with an HDLC idle code (7E) in the direction from customer premise to the frame relay network. During normal frame relay data transfer and local in-channel signaling message exchange, the Frame Relay Stand Alone Multiplexer located in the QWEST Central Office will not modify, set, or alter data or frame relay header information.

2.5.10 Interconnection and Collocation

The Expanded Interconnection and Collocation Channel Terminations (EICT) used with Frame Relay Service are of four types operating at the 44.736 Mbit/s, 1.544 Mbit/s, 56 kbit/s and 64 kbit/s rates. Further information about the EICT may be found in Technical Publication 77386, *Expanded Interconnection and Collocation for Private Line Transport and Switched Access Services.*



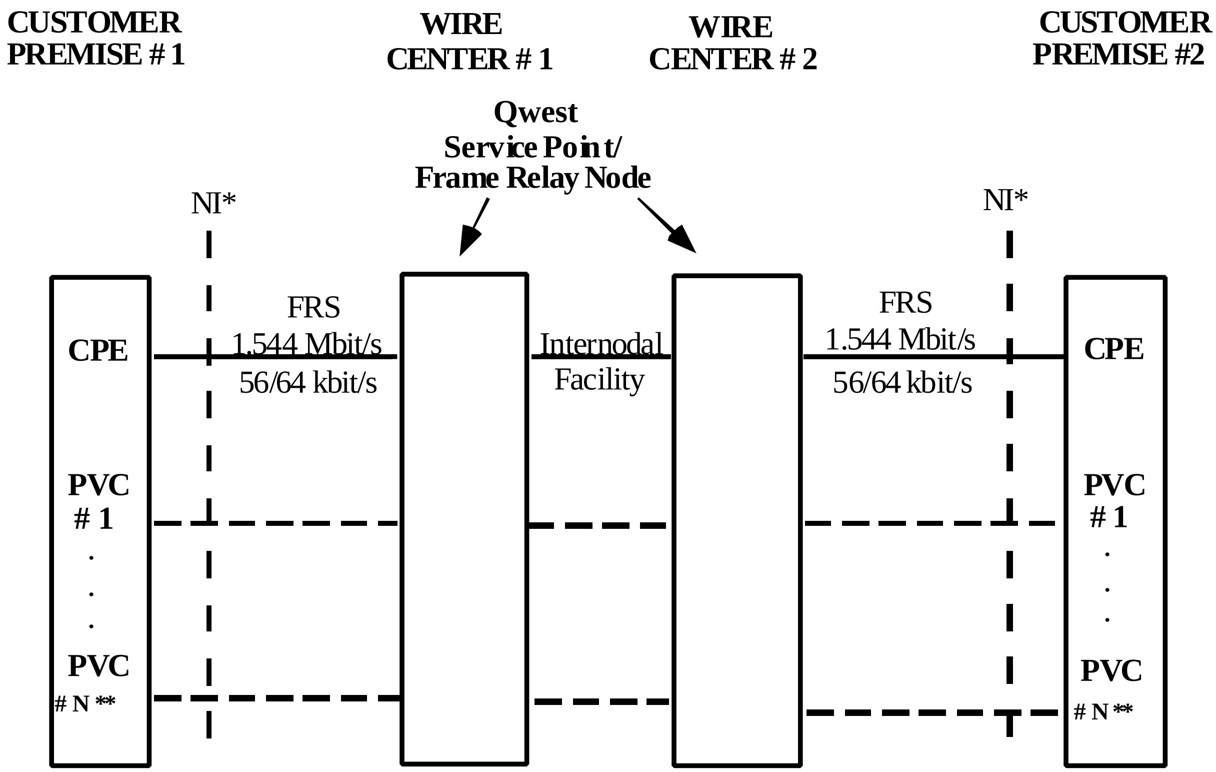
** N represents the quantity of PVCs provisioned within the Frame Relay Access Connection

* Qwest Frame Relay EU customer traffic will exchange information at the NI based on the local in-channel signalling protocols for UNI described in Section 5.2.

LEGEND:

CPE - Customer Provided Equipment
FRS - Frame Relay Service
NI - Network Interface
PVC - Permanent Virtual Connection

Exhibit 2-1 Single Wire Center Configuration

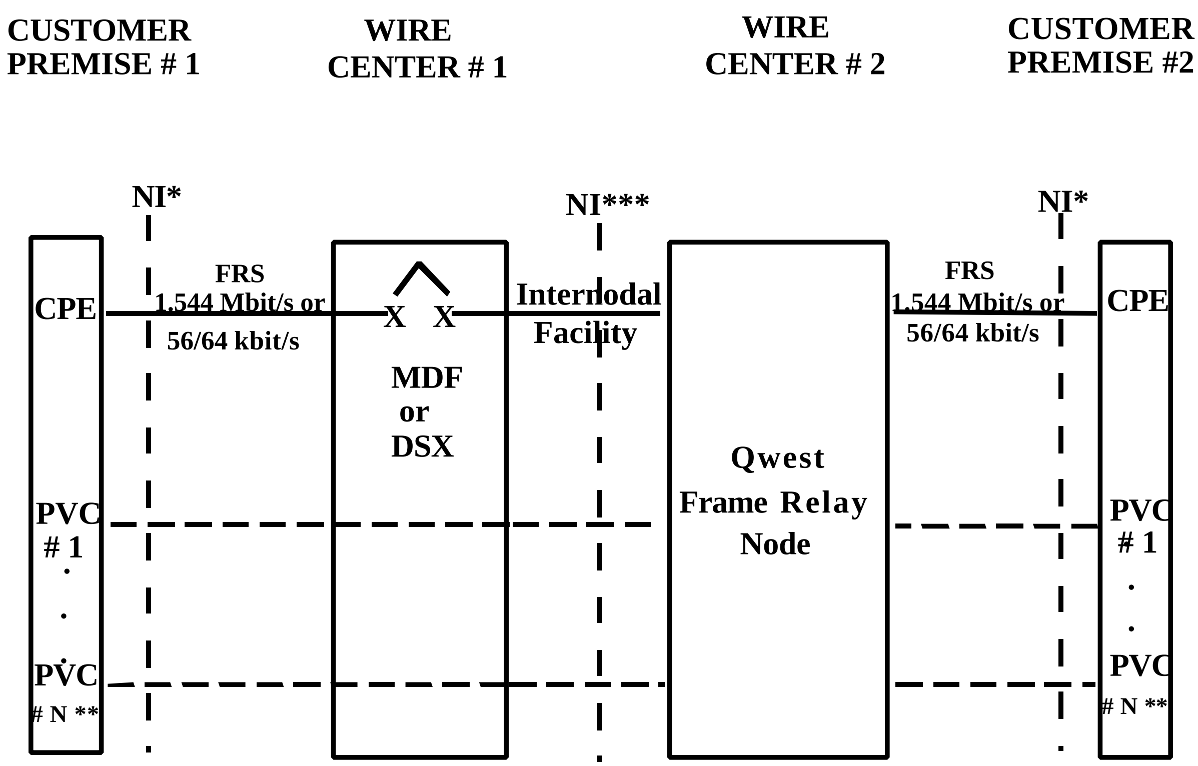


** N represents the quantity of PVCs provisioned within the Frame Relay Access Connection

* Qwest Frame Relay EU customer traffic will exchange information at the NI based on the local in-channel signalling protocols for UNI described in Section 5.2.

LEGEND:
CPE - Customer Provided Equipment
FRS - Frame Relay Service
NI - Network Interface
PVC - Permanent Virtual Connection

Exhibit 2-2 Multiple Wire Center Configuration



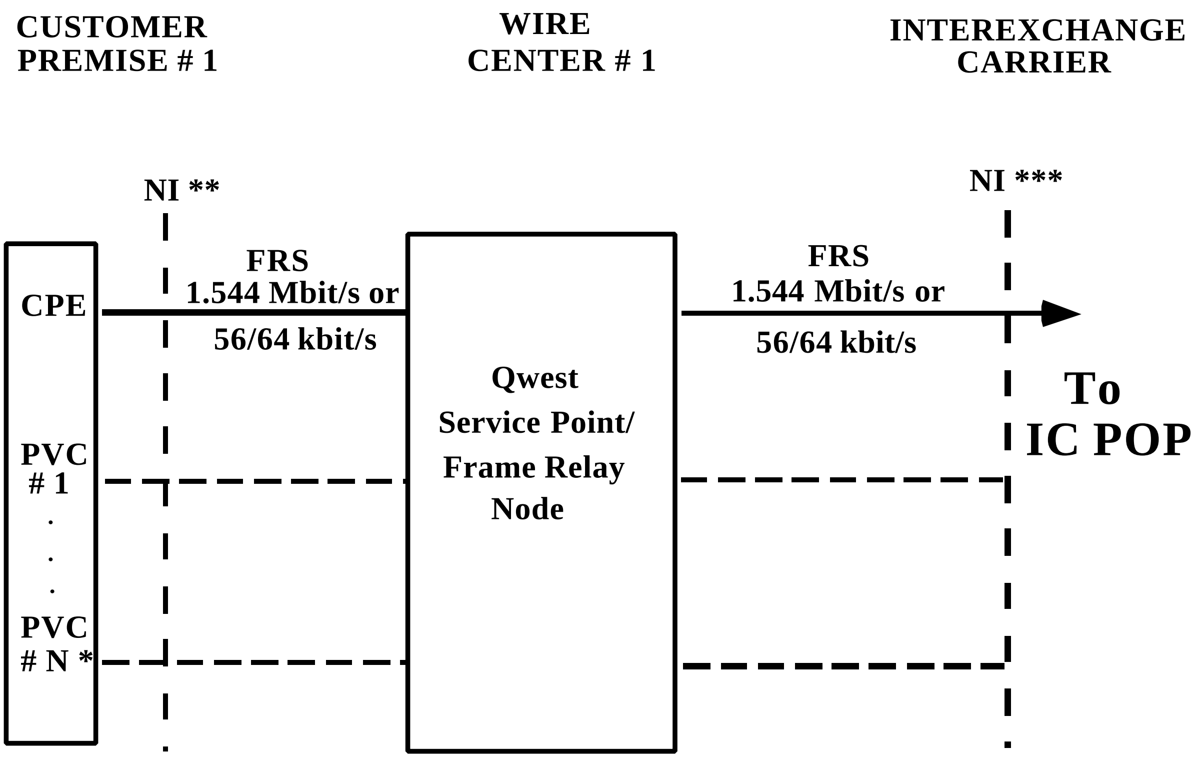
** N represents the quantity of PVCs provisioned within Frame Relay Access Connection

* Qwest Frame Relay EU customer traffic will exchange information at the NI based on the local in-channel signalling protocols for described in Section 5.2.

*** Alternate Service Provider Network Interface

LEGEND:
CPE - Customer Provided Equipment
FRS - Frame Relay Service
NI - Network Interface
PVC - Permanent Virtual Connection

Exhibit 2-3 Non-Local !NTERPRISE Networking Services Service Point



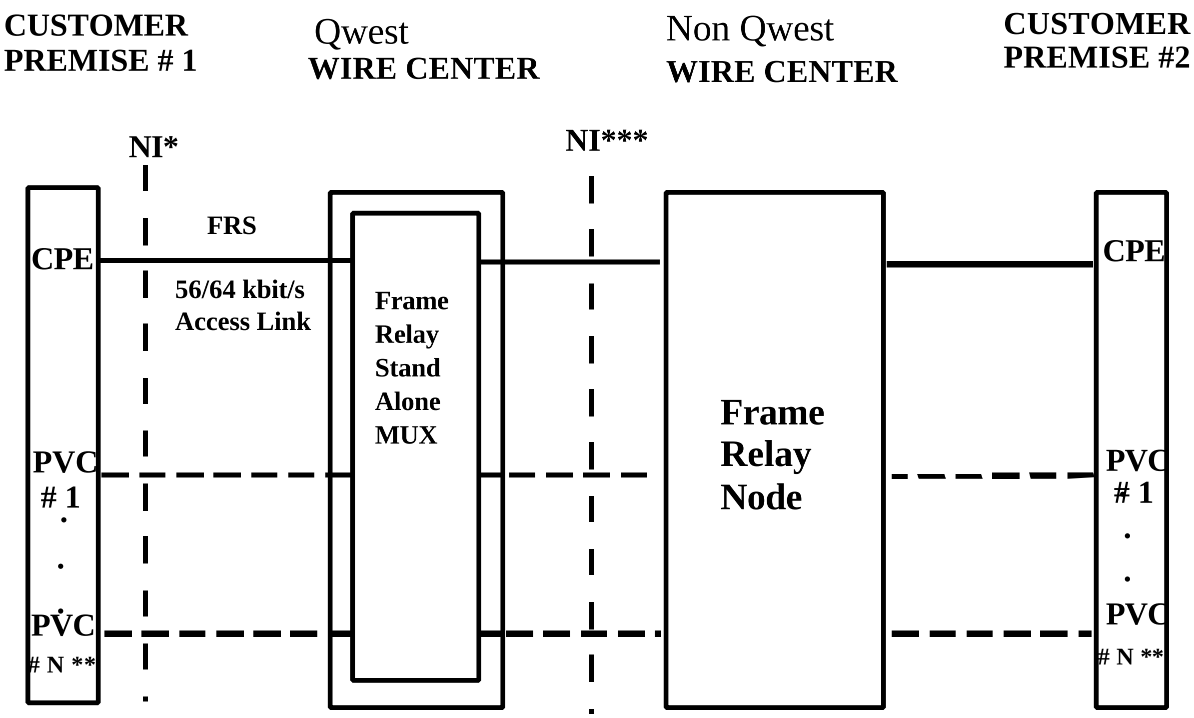
* N represents the quantity of PVCs provisioned within Frame Relay Access

** Qwest Frame Relay EU customer traffic will exchange information at the NI based on the local in-channel signalling protocols for described in Section

*** Qwest Frame Relay customer traffic will exchange information at the NI based local in-channel signalling protocols for NNI in Section 5.2 of this

LEGEND:
CPE - Customer Provided
FRS - Frame Relay
IC- Interexchange
NI - Network
POP - Point of
PVC - Permanent Virtual

Exhibit 2-4 FRS EU Customer Access to IC



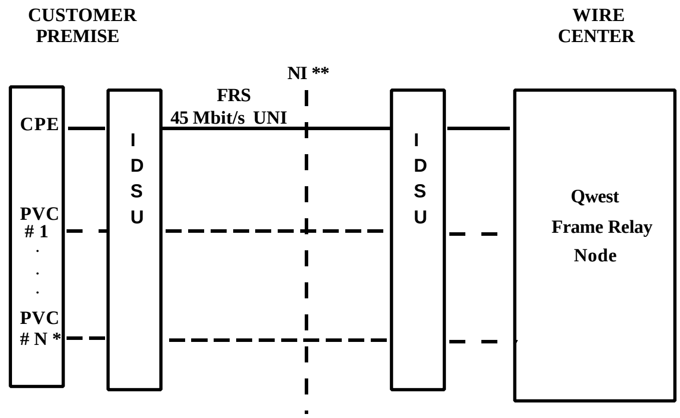
* Qwest Frame Relay EU customer traffic will exchange information at the NI based on the local in-channel signalling protocols for described in Section 5.2.

** N represents the quantity of PVCs provisioned within Frame Relay Access Connection

*** Qwest Frame Relay customer traffic will exchange information at the NI based local in-channel signalling protocols for NNI in Section 5.2 of this document.

LEGEND:
CPE - Customer Provided Equipment
FRS - Frame Relay Service
MDF - Main Distribution Frame
NI - Network Interface
PVC - Permanent Virtual Connection

Exhibit 2-5: 56/64 kbit/s Stand Alone Frame Relay Access Link Service Configuration



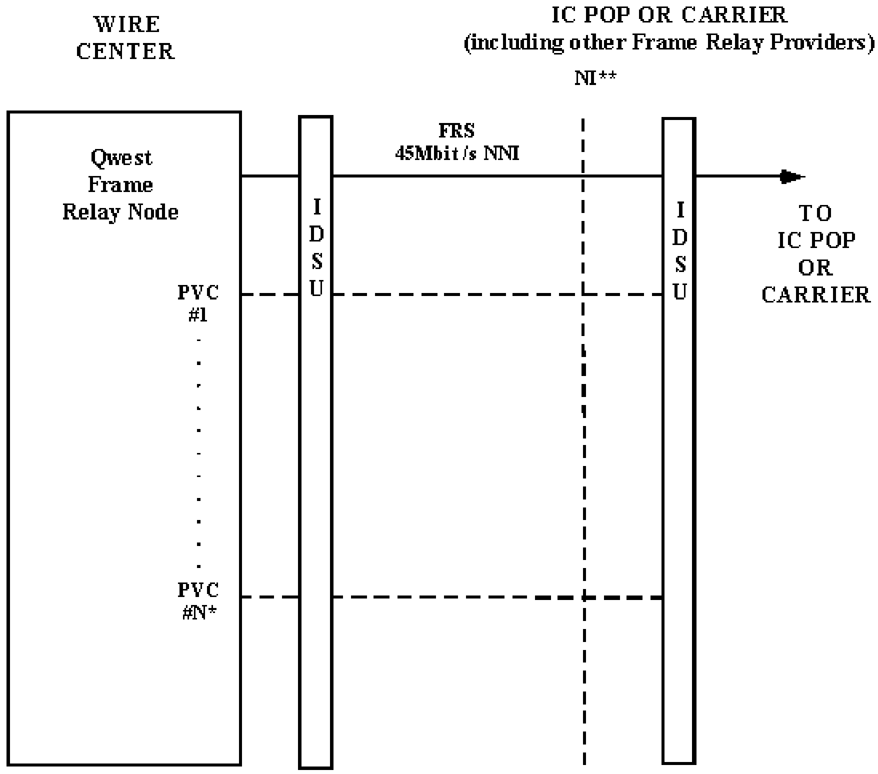
* N represents the quantity of PVCs provisioned within the Frame Relay Access Connection

** Qwest Frame Relay EU customer traffic will exchange information at the NI based on the local in-channel signalling protocols for UNI described in Section 5.2.

Access to the 44.736 UNI will be through a DS3 transport service and a COCC.

LEGEND:
CPE - Customer Provided Equipment
FRS - Frame Relay Service
NI - Network Interface
PVC - Permanent Virtual Connection

Exhibit 2-6 44.736 Mbit/s Frame Relay UNI Access Service Configuration



* N represents the quantity of PVCs provisioned within the Frame Relay Access Connection

** Qwest Frame Relay customer traffic will exchange information at the NI based on local in-channel signalling protocols for NNI described in Section 5.2 of this document.

LEGEND:

FRS - Frame Relay Service
IC - Interexchange Carrier
IDSU - Intelligent Data Service Unit
NI - Network Interface
POP - Point of Presence
PVC - Permanent Virtual Connection

Exhibit 2-7 44.736 Mbit/s Frame Relay NNI Access Service Configuration

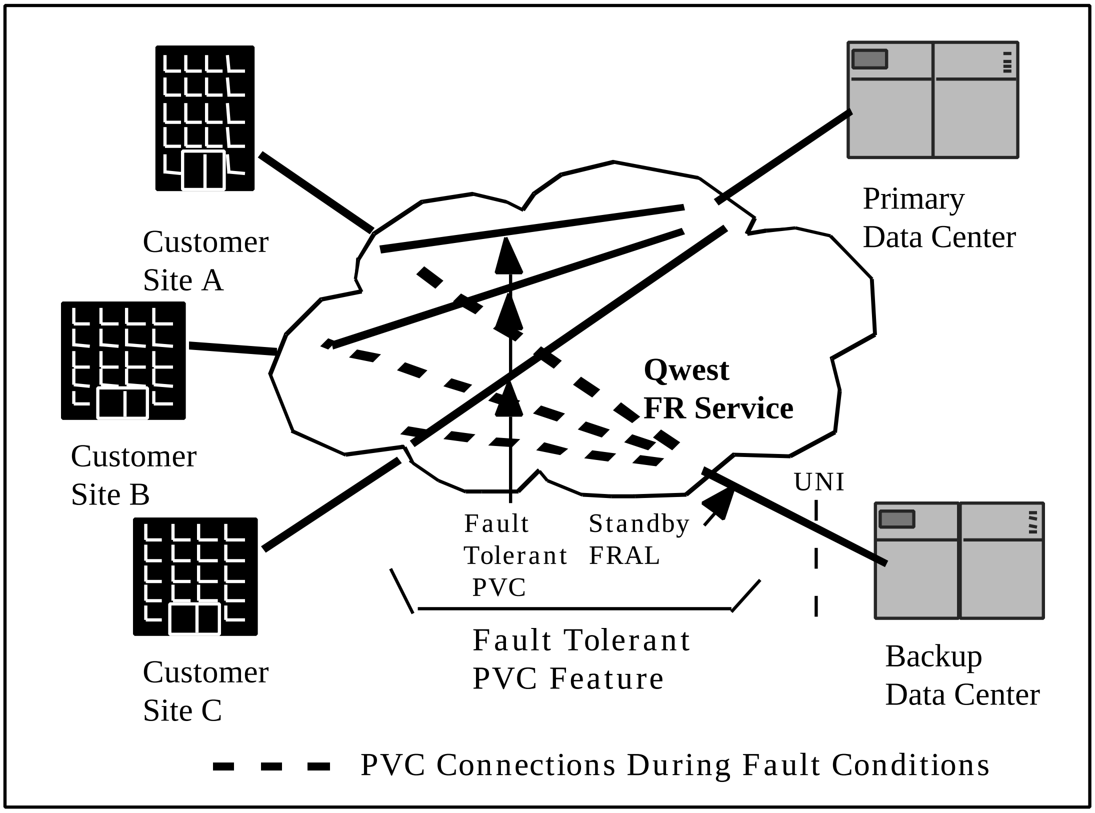


Exhibit 2-8 Fault Tolerant PVC Service Configuration

CONTENTS

Chapter and Section **Page**

CONTENTS

CONTENTS (Continued)

Tables **Page**

3. Physical Layer

3.1 Description of Network Interface for QWEST Frame Relay Service

3.1.1 44.736 Mbit/s High Speed Frame Relay UNI/NNI Network Interface

The QWEST high speed Frame Relay Service (FRS) offering is a high-speed access service. The service is for high-speed user-network-interface (UNI) or network to network interface (NNI) access to the Frame Relay network at the DS3 transmission speed. It is specifically targeted for low speed traffic aggregation (e.g., 56 kbit/s, 64 kbit/s, 1.544 Mbit/s and Fractional T1) onto a single high speed UNI/NNI. The signal characteristics and the physical NI described in QWEST Technical Publication 77324, "*QWEST DS3 Service, Technical Specifications For DS3 Electrical Network Interfaces...*" are also applicable for the 44.736 Mbit/s High Speed Frame Relay UNI/NNI. The application information is shown in Exhibit 3-6.

3.1.2 1.544 Mbit/s Network Interface

QWEST Frame Relay Service 1.544 Mbit/s Access Links are supported for both the customer End-Users (EUs) and the Carriers. The 1.544 Mbit/s Frame Relay Access Link is offered in state and FCC tariffs. The Network Interface (NI) to a Carrier customer will be at a DSX-1 jack with the signal characteristics described in ANSI T1.102-1993, *Digital Hierarchy- Electrical Interfaces*. The signal characteristics at the NI of an EU customer are described in QWEST Technical Publication 77375.

The physical NI to an EU customer will be a Registration Jack of type: RJ48C, RJ48H, RJ48M. Wiring and application information for these jacks is shown in Exhibits 3-1 through 3-3. The selection of one of the above physical connectors is a customer option.

3.1.3 1.544 Mbit/s Network Interface for Frame Relay Fractional Port Access

Enhancements to the QWEST Frame Relay Service include the support for fractional port access within a FRS 1.544 Mbit/s Access Link.

The signal characteristics and the physical NI described in QWEST Technical Publication 77375 are also applicable for the Frame Relay Fractional Port Access. The QWEST Fractional Port Access Feature provides the capability for the QWEST Frame Relay Service Subscriber(s) to access a QWEST Frame Relay Service Port via 56/64 kbit/s channels provisioned within a FRS 1.544 Mbit/s Access Link. The fractional port access speeds supported are (Nx56) kbit/s or (Nx64) kbit/s, where N equals 1,2,4,6, or 8, 12. Multiple fractional access circuits may be established on a single FRS 1.544 Mbit/s Access Link. Refer to Table 3-4 for the specific fractional access channels provisioned within a 1.544 Mbit/s FRS Access Link. Frame Relay Fractional Port Access is available only in Frame Relay Service Areas that have a Frame Relay Node collocated with 1:0 Digital Cross-connect System (DCS).

3.1.4 56 kbit/s Network Interface

QWEST Frame Relay Service 56 kbit/s Access Links are provided to both the customer EUs and Carriers. The digital signal levels at the NI must comply with PUB 77312, *QWEST Digital Data Service Technical Description* and ANSI T1.410-1992. The physical NI to an EU customer or IC (including other Frame Relay Service Provider) will be a Registration Jack of type: RJ48S or RJ48T. Wiring and application information for these jacks are shown in Exhibits 3-4 and 3-5. The selection of one of the above physical connectors is a customer option.

3.1.5 64 kbit/s Network Interface

QWEST Frame Relay Service 64 kbit/s Access Links are provided to both EU Customers and Carriers. The digital signal levels at the NI must comply with the ANSI T1.410-1992, (see Reference Section).

The physical NI to an EU customer or IC (including other Frame Relay Service Provider) will be a Registration Jack of type: SJA56 or SJA57. Wiring and application information for these jacks is shown in Exhibits 3-4 and 3-5. The selection of one of the above physical connectors is a customer option.

3.2 Network Channel Format Structure

Network Channel (NC) Code Format Structure. The NC code is a four-character code that consists of two (2) data elements (see Figure 3-1).

1	2	3	4
Channel Service Code		Optional Feature Code	
X	X	X or -	X or -

X= Alpha-numeric
-= Hyphen

Figure 3-1 Network Channel Code Format Structure

3.3 Data Element Descriptions

Figure 3-1 shows the format of the NC Code structure. The following paragraphs describe each data element.

3.3.1 Channel Service Code

The Channel Service Code (character positions 1 and 2) is a two character alpha-numeric code that describes the channel service in an encoded form. The Channel Service Code will typically be specified as the service code of the special service circuit or the transmission grade of the message trunk circuit. The NC channel service code field is always populated.

3.3.2 Optional Feature Code

The Optional Feature Code (positions 3 and 4) is a two-character alpha, alpha-numeric or hyphen that represents the option codes available for each Channel Service Code. A hyphen (-) is a special character that is used in positions 3 or 4 of the NC code to indicate the absence of features or options. Standard combinations of this code will allow the customer to enhance the technical performance of the requested channel, or to further identify the type of service. It is also used to specify options such as conditioning, effective 4-Wire, multiplexing, etc.

3.3.3 Network Channel Fill Requirements

The NC Optional Feature Code field is always populated. All four-character positions of a NC code must be populated.

3.4 Network Channel Codes

The NC Code is an encoded description of the channel that is provided by U S WEST. This channel is established between one (or combination) of the following:

- Carrier, Interexchange Carrier (IC), Frame Relay Service Provider, or QWEST Point of Termination (POT) and an End-User POT (EU-POT)
- Two EU-POTS
- Two Carrier POTs

The NC Code set contains customer options associated with individual channel services. The EU customer or Carrier must specify the NC codes for the desired service when ordering QWEST Frame Relay Service. This section describes the NC codes which apply specifically to QWEST Frame Relay Service. The Frame Relay Service (FRS) NC Code definitions emulate existing NC code definitions, only differing by a "fast packet" identifier which signifies the transport of packets over a communications channel provided by QWEST Frame Relay Service.

3.4.1 Compatible NC Codes for FRS 44.736 Mbit/s UNI/NNI Access Service

Table 3-1 lists the compatible DS3 NC codes for the 44.736 Mbit/s FRS UNI/NNI Access Service associated with the QWEST Frame Relay Service. See Technical Publication 77324 for additional information.

Table 3-1 44.736 Mbit/s Compatible Network Channel Codes

Network Channel Code	Description
HF--	HF-- For Individual DS3 Channels, customer premise-to-customer premise channel or customer premise to CO channel terminated on DSX-3 cross connect panel, ANSI T1.107-1995,GR-342
HFC-	HFC- For Individual DS3 Channels, same as above with C-Bit parity, ANSI T1.107-1995,GR-342
HF-E	HF-E For Individual DS3 Channels, Digital Packet Frame Relay NNI bi-directional polling, per ANSI T1.107-1995
HFCE	HFCE For Individual DS3 Channels with C-Bit parity, Digital packet NNI (e.g. Frame Relay), per ANSI T1.107 1995

3.4.2 Compatible NC Codes for FRS 1.544 Mbit/s Access Links

Table 3-2 lists the compatible DS1 NC codes for the 1.544 Mbit/s FRS Access Links associated with the QWEST Frame Relay Service. The NC Codes listed in Table 3-2 are applicable for "access" and "non-access" service applications of QWEST Frame Relay Service. An "access" service is offered in the interstate FCC #5 jurisdiction as well as various state access tariffs and price catalogs (applicable for deregulated jurisdictions). A "non-access" service is only offered in the intrastate jurisdiction.

Table 3-3 lists the compatible DS1 NC codes for the 1.544 Mbit/s FRS Access Links associated with QWEST Frame Relay Service, differentiating between Network-to-Network Interface (NNI) and User-to-Network Interface (UNI).

Table 3-2 1.544 Mbit/s Compatible Network Channel Codes

Network Channel Code	Description
HCER	Digital Packet, HC-1 Channel Service, **ANSI ESF, B8ZS
HCZR	Digital Packet, HC-1 Channel Service, SF, ***B8ZS
HCGR	Digital Packet, HC-1 Channel Service, *Non-ANSI ESF, B8ZS
HCDR	Digital Packet, HC-1 Channel Service, **ANSI ESF, AMI
HCFR	Digital Packet, HC-1 Channel Service, *Non-ANSI, AMI
HC-R	Digital Packet, HC-1 Channel Service, SF, AMI

* Non-ANSI refers to Extended Superframe (ESF) versions prior to ANSI T1.403-1995, "Carrier-to-Customer Installation - DS1 Metallic Interface" such as AT&T Technical Reference, PUB 54016, "Requirements for Interfacing Digital Terminal Equipment to Services Employing the Extended Superframe Format".

** ANSI ESF refers to the ESF format published in ANSI T1.403-1995 (see Reference Section).

*** SF/B8ZS is not recommended due to the potential replication of in-band alarm codes.

Table 3-3 UNI and NNI 1.544 Mbit/s Compatible Network Channel Codes

Network Channel Codes	Description
HC-O	NNI Digital Packet, HC-1 Channel Service, SF, AMI
HC-R	UNI Digital Packet, HC-1 Channel Service, SF, AMI
HCEO	NNI Digital Packet, HC-1 Channel Service, **ANSI ESF, B8ZS
HCER	UNI Digital Packet, HC-1 Channel Service, **ANSI ESF, B8ZS

** ANSI ESF refers to the ESF format published in ANSI T1.403-1995 (see Reference Section).

3.4.3 Compatible NC Codes for FRS 1.544 Mbit/s Access Links with Fractional Access Ports

Table 3-4 lists the compatible DS1 NC codes for the fractional access channels provisioned within a 1.544 Mbit/s FRS Access Link(s). The channel descriptor for each NC Code contains the quantity of channels, which derive the fractional speeds. Each channel within the 1.544 Mbit/s FRS Access Link is equivalent to a 56 kbit/s or 64 kbit/s increment. The 64 kbit/s increments are only applicable for 1.544 Mbit/s FRS Access Links with B8ZS line coding. For instance, if a 1.544 Mbit/s FRS Access Link with B8ZS contains 6 channels provisioned for fractional access, the appropriate NC Code is "HXFF".

Table 3-4 Fractional 1.544 Mbit/s Compatible Network Channel Codes

Network Channel Code	Description
HXFA	Fractional, Fast Packet, 1 Channel
HXFB	Fractional, Fast Packet, 2 Channels
HXFD	Fractional, Fast Packet, 4 Channels
HXFF	Fractional, Fast Packet, 6 Channels
HXFH	Fractional, Fast Packet, 8 Channels
HXFL	Fractional, Fast Packet, 12 Channels

3.4.4 Recommended Line Coding Format for FRS 1.544 Mbit/s Access Links

Bipolar with 8 Zero Substitution (B8ZS) is the recommended line coding format to be used for QWEST FRS. U S WEST's ones density requirements on the loop facility are as follows:

- No more than 15 consecutive zeros transmitted on the loop facility.

- Each and every time window of 8 (N+1) digit time slots (where N can equal 1 through 23), at least N "ones" shall be present.

3.4.5 Compatible NC Codes for FRS 56 kbit/s and 64 kbit/s Access Links

Table 3-7 lists the compatible NC codes for the 56 kbit/s and 64 kbit/s FRS Access Links associated with the QWEST Frame Relay Service.

Table 3-5 56/64 kbit/s Network Channel Codes

Network Channel Code	Description
XH-R	Digital Packet, Digital Access Channel Service 4 (56 kbit/s)
XD-R	Digital Packet, Digital Access Channel Service 6 (64 kbit/s)

3.5 Network Channel Interface Format Structure

The Network Channel Interface (NCI) code format is a maximum twelve-character code that consists of five (5) data elements (see Figure 3-2). The NCI code identifies NI characteristics at the customers Point of Termination (POT).

The interface to the QWEST Network is described by an interface code for each EU customer or carrier termination. The interface codes for the service desired must be specified by the customer when ordering US WEST FRS. The purpose of this section is to describe the interface codes which apply specifically to QWEST FRS.

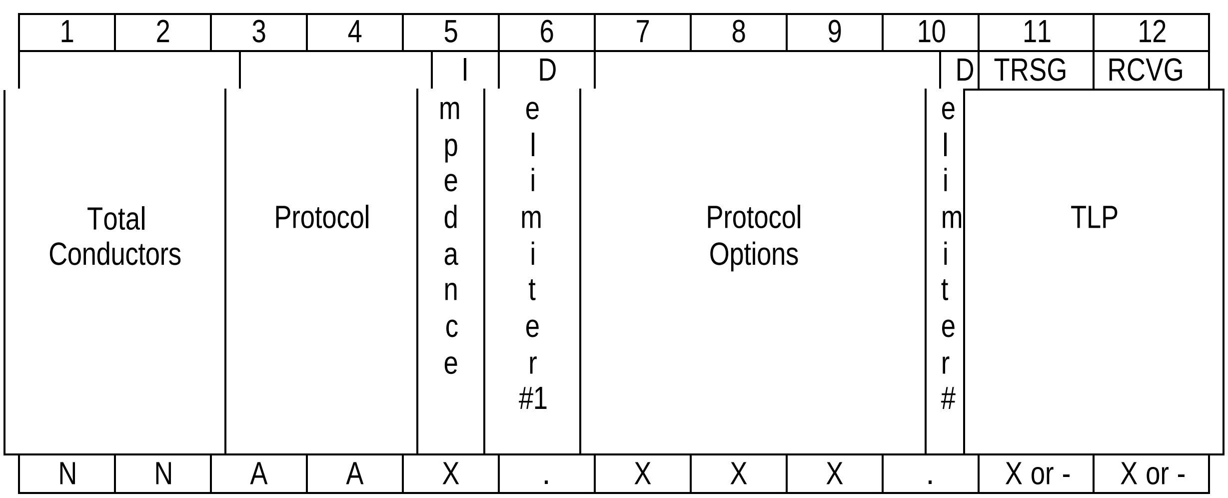


Figure 3-2 Network Channel Interface Code Format

Figure 3-2 shows the format of the NCI code. Each data element of the NCI code is described below:

3.5.1 Total Conductors

Total conductors (character positions 1 and 2) is a two-character numeric code that represents the total number of physical conductors (e.g., wires) required at the interface. This field is always populated.

3.5.2 Protocol

Protocol (character positions 3 and 4) is a two-character alpha code that defines requirements for the interface regarding signaling and transmission. This field is always populated.

3.5.3 Impedance

Impedance (character position 5) is a one-character alpha or numeric code representing the nominal reference impedance that will terminate the channel for the purpose of evaluating transmission performance. This field is always populated.

3.5.4 Protocol Options

Protocol Options (character positions 7, 8, and 9) is a one to three character alpha, numeric, or alpha-numeric code that describes additional features (e.g. bit rate, bandwidth, etc.) of the Protocol to be used. It is an optional field that is always left justified when less than three characters are specified.

3.5.5 Transmission Level Point(s)

The Transmission Level Points (TLPs) (character positions 11 and 12) are the Transmit (TRSG) and Receive (RCVG) characters that may appear anywhere between positions 8 and 12 due to left-justification rules. TLPs are not applicable for QWEST Frame Relay Service.

3.5.6 The NCI Delimiter Usage

Delimiters are required for overall code readability when using the NCI code format in a manual or mechanized mode. For purposes of this document, and to be consistent with most service order and mechanized systems, delimiters will be counted as characters of information. The actual character used as the delimiter may differ from system-to-system, but is generally either a period (.) or a virgule (\ , /). Delimiter representation for the NCI code may not be specified as alpha, numeric, or hyphen.

The NCI code delimiters will be labeled as Delimiter #1 and #2 to show the difference between the delimiters (see Figure 3-2).

- Delimiter #1 is used to indicate the start of the Protocol Option field if a Protocol Option code is assigned. When specified it will be in character position six (6).
- Delimiter #2 is used to indicate the start of the TLP field if a TLP level is assigned to TRSG or RCVG or both. Delimiter #2 will not be assigned if both the TRSG and RCVG TLP character positions are blank.

If the Protocol Option Field is not coded and the TLP is coded, a double Delimiter #1 and #2 will be placed after character position five (5). In this case Delimiter #1 will be in character position six (6), and Delimiter #2 will be in character position seven (7). The TLP will be left-justified into character positions eight (8) and nine (9) accordingly.

If the Protocol Option code is assigned, Delimiter #2 character position will be dependent on the length of the Protocol Option code. Delimiter #2 is used in character position ten (10) if a three-character Protocol Option code is assigned. Delimiter #2 will be in character position nine (9) if a two-character Protocol Option code is assigned. Delimiter #2 will be in character position eight (8) if a one-character Protocol Option code is assigned.

3.5.7 Applicable NCI Protocol Codes for FRS Access Links

All existing NCI Codes for the 56 kbit/s, 64 kbit/s, 1.544 Mbit/s and 44.736 Mbit/s NIs apply for QWEST Frame Relay Service. FRS uses all the existing NCI specifications to define the IC (including other Frame Relay Service Provider) and/or the EU Customer network access. The options for positions 3 and 4, which denote the protocol code of an NCI Code, are defined in Table 3-8.

Table 3-6 Network Channel Interface Protocol Code

Position 3 & 4	Definitions	Application Location
DS	Digital Hierarchy Interface	Carrier Interface or POT
CS	Digital Hierarchy Interface at a Digital Cross-connect System	Central Office Interface
DJ	Joint Designed (Access Only)	IC-POT
DU	Digital Access Interface	EU-POT

Further information on the "DS" Code is provided in the following documents:

- QWEST Technical Publication 77375, (see Reference Section).
- QWEST Technical Publication 77324, (see Reference Section).

See QWEST Technical Publication 77375 for additional information pertaining to the "DJ" protocol code. The "CS" code is typically used with the QWEST COMMAND A LINK^{SM} Service (Technical Publication 77371). The "CS" code is only available in limited locations within QWEST Serving Areas.

NCI Protocol Option Codes (positions 7 through 9) for the "DU", "DS", and "DJ" protocol codes (NCI Code positions 3 & 4) which are pertinent for QWEST Frame Relay Service are described in further detail in QWEST Technical Publication 77375.

3.5.8 FRS 44.736 Mbit/s UNI/NNI Access Service NCI Codes

The "DS" protocol code is used at any carrier interface. The NCI Codes with protocol codes of "DS" that are applicable to FRS 44.736 Mbit/s UNI/NNI Access Service are shown in Table 3-9 below.

Table 3-7 "DS" NCI Protocol Codes for 44.736 Mbit/s UNI/NNI Access Service

Network Channel Interface Code for FRS 44.736 Mbit/s UNI/NNI	Description
04DS6.44R	DS3 M-frame structured signal. It is an unchannelized signal application, supporting a user payload of 44.210 Mbits/s per ANSI T1.107-1995.
04DS6.44A	DS3 M-frame structured signal with C-bit Parity application. It is an unchannelized signal application, supporting a user payload of 44.210 Mbit/s per ANSI T1.107-1995.

3.5.9 FRS 1.544 Mbit/s Access Link NCI Codes at the Carrier Interface and IC-POP

The "DJ" protocol code is used to specify an IC-POP, while the "DS" protocol code is used at any carrier interface. The NCI Codes with protocol codes of "DS" and "DJ" that are applicable to FRS 1.544 Mbit/s Access Link, including FRS 1.544 Mbit/s Access Links used for Fractional Port Access are shown in Table 3-10 below.

Table 3-8 "DS" and "DJ" NCI Protocol Codes for 1.544 Mbit/s Access Links

IC-POP and Carrier Network Channel Interface Code for FRS 1.544 Mbit/s Access Links*	Description
04DS9.1S, 04DJ9.1S	B8ZS, ANSI ESF
04DS9.15K, 04DJ9.15K	AMI, Non-ANSI ESF
04DS9.15S, 04DJ9.15S	B8ZS, Non-ANSI ESF
04DS9.1K, 04DJ9.1K	AMI, ANSI ESF
04DS9.15, 04DJ9.15	AMI, SF
04DS9.15B, 04DJ9.15B	**B8ZS, SF

* Includes 1.544 Mbit/s Access Links used for Fractional Port Access

** SF/B8ZS is not recommended due to the potential replication of in-band alarm codes.

3.5.10 FRS 1.544 Mbit/s Access Link NCI Codes at the EU-POT

The "DU" protocol code is used to specify the interface at the EU-POT. The NCI Codes with the "DU" protocol code that are applicable to FRS 1.544 Mbit/s Access Link, including 1.544 Mbit/s Access Links used for Fractional Port Access, are shown in Table 3-11 below.

Table 3-9 "DU" NCI Protocol Codes for 1.544 Mbit/s Access Links

End User Network Channel Interface Code for FRS 1.544 Mbit/s Access Links*	Description
04DU9.1SN	B8ZS, ANSI ESF
04DU9.BN	AMI, SF
04DU9.DN	**B8ZS, SF
04DU9.CN	AMI, Non-ANSI ESF
04DU9.SN	B8ZS, Non-ANSI ESF
04DU9.1KN	AMI, ANSI ESF

* Includes 1.544 Mbit/s Access Links used for Fractional Port Access

** SF/B8ZS is not recommended due to the potential replication of in-band alarm codes.

3.5.11 FRS 56 kbit/s and 64 kbit/s Access Link NCI Codes

FRS supports 56 kbit/s and 64 kbit/s interfaces for EU-POTS. The QWEST Frame Relay Network Channel Interface Codes for 56 kbit/s and 64 kbit/s access rates may take the following forms:

- 04DU5.56 56 kbit/s, two point, Digital Access 4 (DA4)
- 04DU5.64 64 kbit/s, two point, Digital Access 6 (DA6)

Additional NCI code information pertaining to 56 kbit/s and 64 kbit/s circuits is available in QWEST Technical Publication 77312, "QWEST Digital Data Service, Technical Description."

3.5.12 Specifying NCI Codes for FRS Access Links

The NCI codes specified by the customer when subscribing to the QWEST Frame Relay Service must be compatible. Section 3.7 provides additional NCI compatibility information based upon the NC Codes defined for the QWEST Frame Relay Service access rates (e.g., 56 kbit/s, 64 kbit/s, 1.544 Mbit/s and 44.736 Mbit/s).

The following references are available for additional information on NCI codes:

- QWEST Technical Publication 77312, *QWEST Digital Data Service, Technical Description*.
- QWEST Technical Publication 77375, Chapter 4 (see Reference Section).
- QWEST Technical Publication 77324, Chapter 4 (see Reference Section).
- QWEST Technical Publication 77386, *Expanded Interconnection and Collocation for Private Line Transport and Switched Access Services.*
- Telcordia Technical Reference TR-NPL-000054 (see Section 10.2), "High Capacity Digital Service (1.544 Mbit/s) Interface Generic Requirements for End Users".

3.5.13 Compatible NC/NCI Combinations

Table 3-12 lists some of the possible NC/NCI compatible combinations for the QWEST Frame Relay Service. A complete list of all NC/NCI valid combinations is beyond the scope of this publication due to the various levels of multiplexing which may be encountered when interconnecting other services with QWEST Frame Relay Service.

Table 3-10 Frame Relay Service NC/NCI Compatible Combination

NC Code	Characteristics	Compatible NCI Codes
HC-R	SF and AMI	04DJ9.15, 04DS9.15, 04DU9.BN, 04DU9.1SX
HCZR	SF and B8ZS**	04DJ9.15B, 04DS9.15B, 04DU9.DN, 04DU9.1SX
HCFR	Non ANSI ESF and AMI	04DJ9.15K, 04DS9.15K, 04DU9.CN, 04DU9.1SX
HCGR	Non ANSI ESF and B8ZS	04DS9.15S, 04DJ9.15S, 04DU9.SN, 04DU9.1SX
HCDR	ANSI ESF and AMI	04DJ9.1K, 04DS9.1K, 04DU9.1KN, 04DU9.1SX
HCER	ANSI ESF and B8ZS *	04DJ9.1S, 04DS9.1S, 04DU9.1SN, 04DU9.1SX
HFC-	Unchannelized DS3 M-frame format with C-bit parity	04DS6.44A
HF- -	Unchannelized DS3 M-frame format	04DS6.44R
HF-E	Unchannelized DS3 M-frame format, Digital Packet frame relay NNI bi-directional polling	04DS6.44R
HFCE	Unchannelized DS3 M-frame format with C-bit parity, digital packet NNI (e.g. frame relay)	04DS6.44A

* Recommended Combination

** SF/B8ZS is not recommended due to the potential replication of in-band alarm codes.

3.6 Application of Frame Relay with other QWEST Services

Interconnection to Frame Relay Service with other QWEST Services (e.g., QWEST COMMAND A LINK[SM] , Self-Healing Alternate Route Protection [SHARP], Self-Healing Network Services [SHNS], Synchronous Service Transport [SST]) is supported via a Central Office Connecting Channel arrangement. These arrangements are discussed in Subsections 3.6.1 through 3.6.4.

3.6.1 QWEST COMMAND A LINKSM with QWEST Frame Relay Service

QWEST COMMAND A LINK[SM] Service is described in Technical Publication 77371, "COMMAND A LINK[SM] Technical Description and Interface Combinations". The publication should be consulted for a full description of the service.

COMMAND A LINK[SM] is an option available with the Frame Relay Service offered by QWEST which allows a customer to connect services together into a network and then rearrange the connections on a near-real-time basis at 56 kbit/s, 64 kbit/s, or 1.544 Mbit/s.

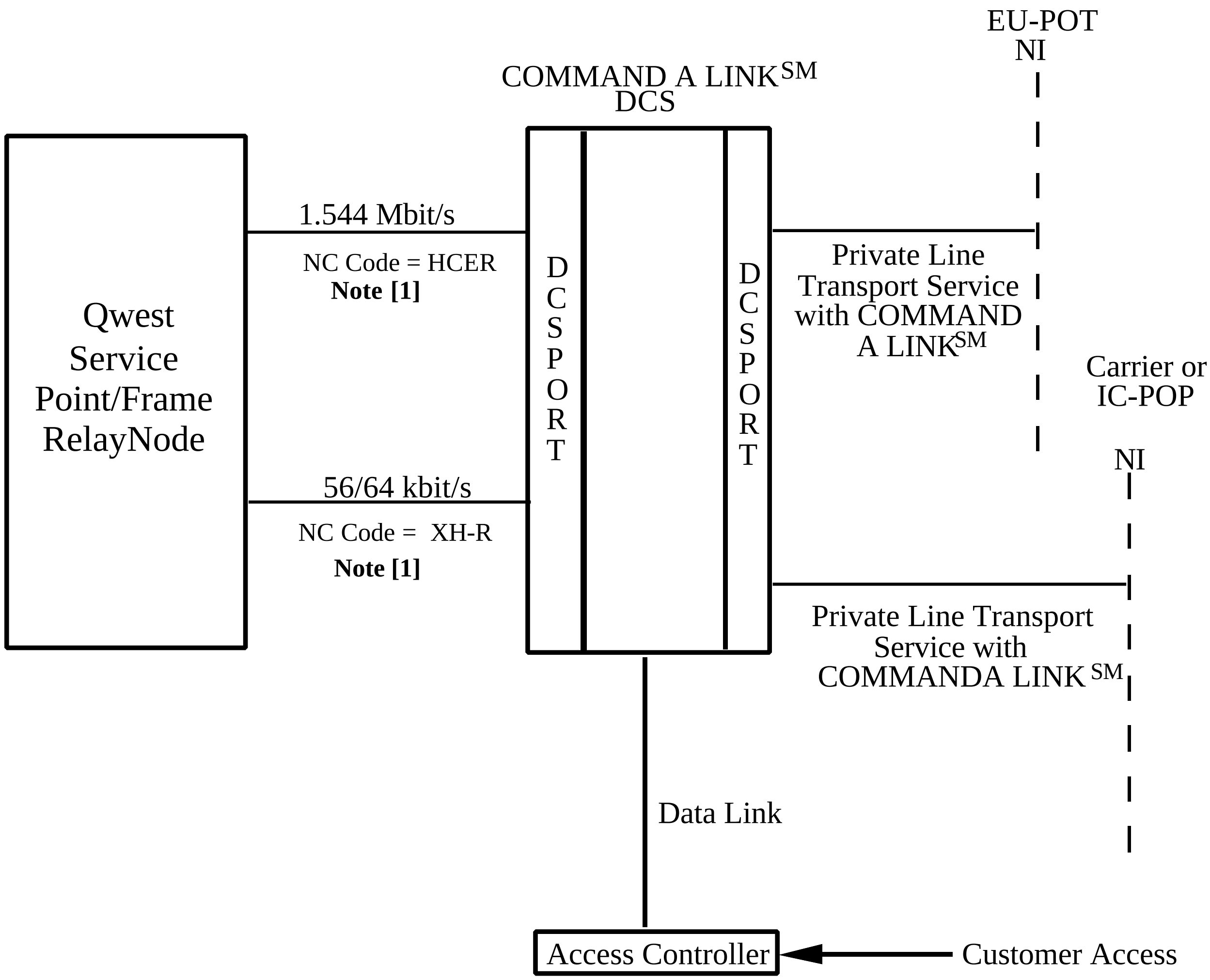
The services are connected and rearranged by an Intelligent Network Element, usually a Digital Cross-connect System (DCS). The customer controls the DCS by means of a Customer Controller.

Two types of channels will be required to use COMMAND A LINK[SM] with Frame Relay. The first is a channel connecting the COMMAND A LINK[SM] DCS to the customer, which is detailed in the COMMAND A LINK[SM] Technical Publication 77371. The second type of channel is used to connect the DCS to the Frame Relay Network via a Central Office Connecting Channel (COCC). Table 3-13 lists the appropriate NC/NCI code combinations for this connection.

Table 3-11 COMMAND A LINK[SM] with Frame Relay Compatible Code Combinations

NC Code	DCS NCI Code	Frame Relay Network NCI Code	Description
XH-R	04CS9.10R	04DS9.1S	56 kbit/s Channel
XD-R	04CS9.10R	04DS9.1S	64 kbit/s Channel
HCER	04CS9.10R 04CS9.11R	04DS9.1S	1.544 Mbit/s Channel

COMMAND A LINK[SM] is an option to Fractional Frame Relay Service. Also, a customer controller has to be connected to the DCS providing the customer's Fractional Frame Relay Service.



Note [1] - FRS Port and Switching Connection (Information transfer rate element is applicable for interstate applications)

LEGEND:
DCS - Digital Cross-connect System
EU - End-User
FR - Frame Relay
IC - Interexchange Carrier
NC - Network Channel
POT - Point of Termination
POP - Point of Presence
NI - Network Interface

Figure 3-3 COMMAND A LINK SM with Frame Relay Service

3.6.2 QWEST Self-Healing Alternate Route Protection with QWEST Frame Relay Service

QWEST Self-Healing Alternate Route Protection (SHARP) Service is described in Technical Publication 77340, *Self-Healing Alternate Route Protection (SHARP)*. The publication should be consulted for a full description of the service.

SHARP is an optional service that improves the reliability of DS-1 or DS-3 services that are transported over fiber optic facilities. This feature provides a separate facility path for the protection system between the Serving Wire Center (SWC) and the QWEST Point of Termination (POT) located in the same building as the customer designated premises.

Table 3-12 QWEST Self-Healing Alternate Route Protection with QWEST Frame Relay DS3 UNI / NNI Access Service

NC Code	Characteristics	Compatible NCI Codes
HFHT	Self Healing Protection and Disaster Recovery-Interoffice Protection Only	04DS6.44A 04DS6.44R
HFHA	Self Healing Protection and Disaster Recovery-One End Only	04DS6.44A 04DS6.44R
HFH-	Self Healing Protection and Disaster Recovery-One End Only including Interoffice Protection	04DS6.44A 04DS6.44R
HFHD	Self Healing Protection and Disaster Recovery-Both Ends	04DS6.44A 04DS6.44R
HFHE	Self Healing Protection and Disaster Recovery-Both Ends including Interoffice Protection	04DS6.44A 04DS6.44R

This information is being provided for the readers convenience, please consult Technical Publication 77340 for full description.

3.6.3 QWEST Self Healing Network Service with QWEST Frame Relay Service

QWEST Self Healing Network Service(SHNS) is described In Technical Publication 77332, *Self Healing Network Service (DS1, DS3, OC-3 & OC-12).* The publication should be consulted for a full description of the service.

QWEST Self Healing Network Services offers a premium service arrangement designed to provide survivability of premises or between customer designated premises and QWEST Wire Centers. The SHNS dedicates available bandwidth on the network exclusively to a single customer.

Table 3-13 QWEST Self Healing Network Service with QWEST Frame Relay DS3 UNI/NNI Access Service

NC Code	Characteristics	Compatible NCI Codes
HFPS	DS3 Channel, Premium Service, Self Healing Network	04DS6.44A 04DS6.44R

This information is being provided for the readers convenience, consult Technical Publication 77332 for full description.

3.6.4 QWEST Synchronous Service Transport with QWEST Frame Relay Service

QWEST Synchronous Service Transport (SST) Service is described in Technical Publication 77346, *Synchronous Service Transport*. The publication should be consulted for a full description of the service.

As shown in Figure 3-4, to implement a QWEST SST connection to the QWEST Frame Relay Service Network a COCC is required. If the SST node is not a Frame Relay Service Point, private line tariffs will apply. These charges apply to the interoffice facility between the EU SST Node and the nearest Service Point. In order to provide SST with FRS, SST must be available to the customer.

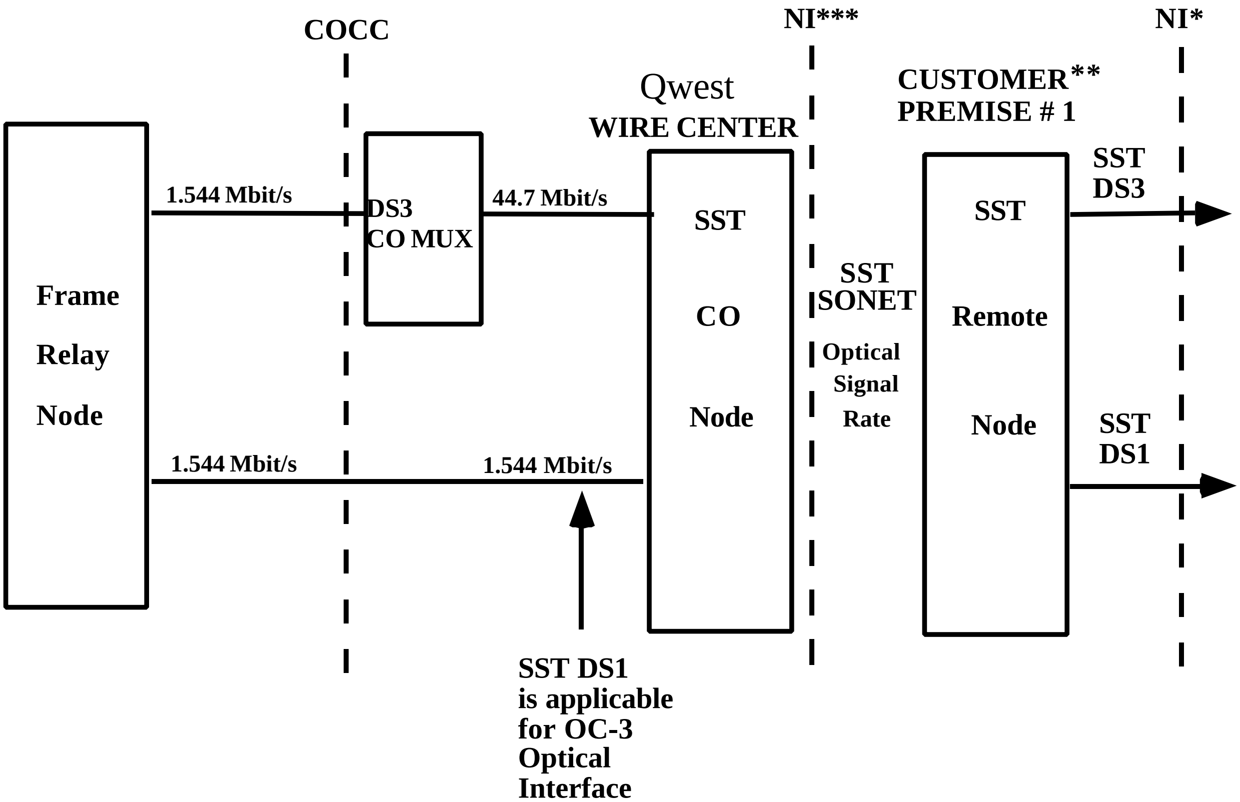
The Network Interface from the customer to the QWEST Network is at the optical rate of OC-3 (155 Mbit/s) or above. This optical channel will enter into the remote SST node and leave at an electrical signal rate of 45 Mbit/s or 1.544 Mbit/s. Either of these rates could be multiplexed down as needed to a rate appropriate for entrance into the Frame Relay network.

The NCI and NC codes for use in conjunction with the QWEST SST portion of this service are available in the SST Technical Publication 77346. Table 3-16 lists the codes necessary to connect from the QWEST SST network to the QWEST Frame Relay network.

Table 3-14 SST with Frame Relay Compatible Code Combinations

NC Code	SST Node NCI Code	Frame Relay Network NCI Code	Description
HCER	04DU9.1SX	04DS9.1S	ANSI ESF, B8ZS
HCZR	04DU9.DX	04DS9.15B	SF, B8ZS*
HCGR	04DU9.SX	04DS9.15S	Non-ANSI ESF, B8ZS
HCDR	04DU9.1KX	04DS.9.1K	ANSI ESF, AMI
HCFR	04DU9.CX	04DS9.15K	Non-ANSI ESF, AMI
HC-R	04DU9.BX	04DS9.15	SF, AMI

SF/B8ZS is not recommended due to the potential replication of in-band alarm codes. This information is being provided for the readers convenience, please consult Technical Publication 77346 for full description.



* This is the network interface from the customer to Qwest if the customer does NOT purchase the SST Remote Node

** It is an SST option for the customer to purchase the SST Remote Node

*** This is the network interface from the customer to Qwest if the customer does purchase the SST Remote Node

LEGEND: CO - Central Office COCC - Central Office Connecting Channel MUX - Multiplexer NI - Network Interface

Figure 3-4 Synchronous Service Transport with Frame Relay Service

3.7 CPE Channel Service Unit/Data Service Unit Information

Table 3-17 and 3-18 identify and recommend options for the customer provided Channel Service Unit / Date Service Unit (CSU / DSU). It should be noted that not all CSU / DSU equipment may have the following options and / or features. However, an attempt has been made to identify and select the most common options.

Table 3-15 1.544 Mbit / s CSU / DSU Options

BASIC FEATURES / OPTIONS FOR 1.544 Mbit/s CSU/DSU	SETTING
Network Frame Format	ESF
Auto Framing	on
Line Code	B8ZS* or AMI
In-Band DS1 Loopback Code Test Type	DS1 Test Loop
In-Banding DS1 Loopback Code Framing	Framed
Ones Density	15 zeros
In-Band DS1 Loopback Code Detection	Enabled
Network Line Build-Out	Automatic
Network Line Build-Out Amount	0 dB, 7.5 dB, 15 dB
Network Compatibility	ANSI mode
Common Ground	on
Loop Span Power	disabled
Internal Timing	disabled
Channel Timing	disabled
Network Timing	enabled
Channel Data Rate	1.344 Mbit/s, Nx56/64 kbit/s, 1.536 Mbit/s
Remote Digital Loop Pattern	ITU-T PN-127
Remote Digital Loop Enable	disabled
Digital Loop Enable	disabled
Local Loop Enable	disabled
DSR Operation	normal
CTS Operation	10 ms delay

* Recommended line coding format.

Table 3-16 56 kbit/s and 64 kbit/s CSU/DSU Options (Page 1 of 2)

BASIC FEATURES / OPTIONS FOR 56/64 kbit/s CSU/DSU	SETTING
Zero Code Suppression	off*
Common Ground	on
DTE Control or Primary Channel Remote Terminal Test	off
DTE Control of Primary Channel Self Test	off
DTE Control of Primary Channel Line Loopback Test	off
DTE Interface	V.35
DTE Control of Primary Channel Remote Digital Loopback Test	off
Auto Baud (56 or 64 kbit/s)	on
Anti Streaming Enable	off
Primary Channel Asynch	on
Word Size Selection	off
Extended Overspeed	off
System Status Option	off
Circuit Assurance Option	off
MR OFF During Analog Loopback	off
Analog Loopback Only	off
Remote Terminal Loop for Line Loopback	off
Test Pattern 2047	off
Remote Digital Loopback Inhibit	off
Remote Digital Loopback Methods	V.54
Remote Digital Loopback Timeout	10 min.
Bilateral Remote Terminal Loop	off
Standard DDS or DDS/SC	off
Timing	External
Permanent RTS	off
Primary Channel Zero Bit RTS/CTS	on
Invert Primary Data	off
DTE Control of Secondary Channel Remote Terminal Test	off
DTE Control of Secondary Channel Self Test	off
DTE Control of Secondary Channel Line Loopback Test	off
DTE Control of Secondary Channel Remote Digital Loopback Test	off

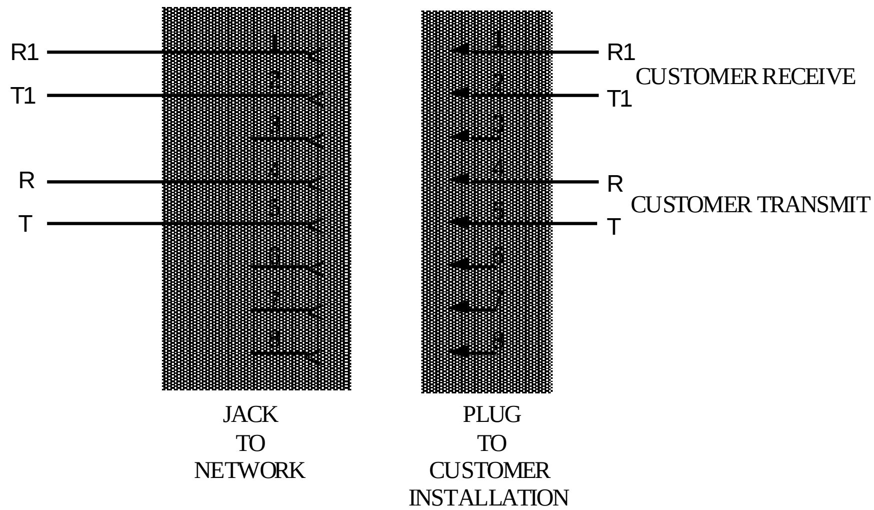
* Applicable for 64 kbit/s access rate

Table 3-16 56 kbit/s and 64 kbit/s CSU/DSU Options (Page 2 of 2)

BASIC FEATURES / OPTIONS FOR 56/64 kbit/s CSU/DSU	SETTING
DTE Control of Secondary Channel Test Mode Indicator	off
Secondary Channel Data Rate Select	no secondary
Secondary Permanent Request-To-Send	off
Seven Data Bits	off
Parity Enable	off
Odd Parity	off
Two Secondary Channel Stop Bits	off
Secondary Channel Anti-Streaming	disabled
Inhibit Secondary Channel RDL	off
Secondary Channel Permanent Loopback	off

JACK TYPE: 8 PIN MINI-MODULAR **NCI CODES**: 04DU9.- - -

WIRING DIAGRAM:



APPLICATION:

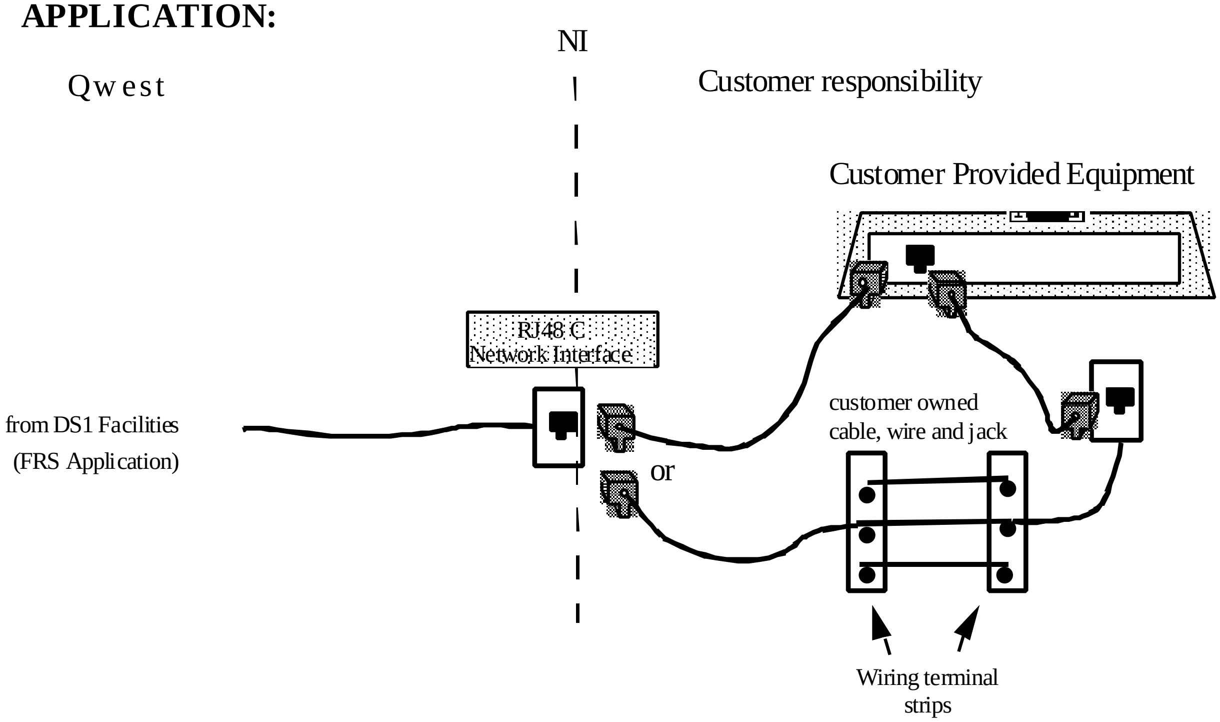
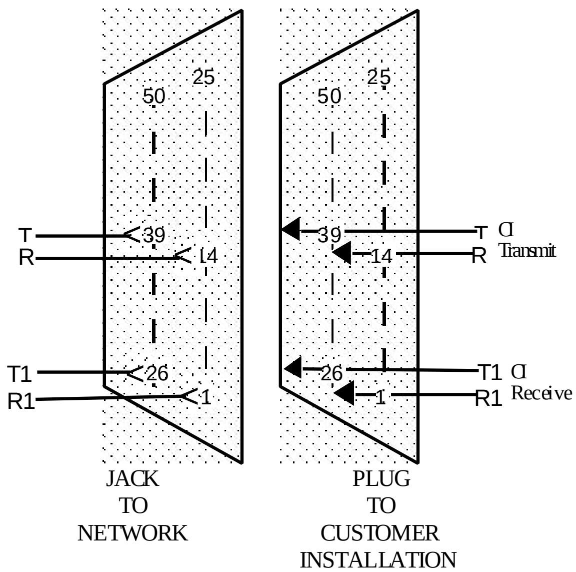


Exhibit 3-1 RJ48C Wiring and Application

JACK TYPE: 50 PIN = 12 CIRCUIT CONFIGURATION

NCI CODES: 04DU9.- - -

WIRING DIAGRAM:



Line	T1	R1	T	R
1	26	1	39	14
2	27	2	40	15
3	28	3	41	16
4	29	4	42	17
5	30	5	43	18
6	31	6	44	19
7	32	7	45	20
8	33	8	46	21
9	34	9	47	22
10	35	10	48	23
11	36	11	49	24
12	37	12	50	25

APPLICATION:

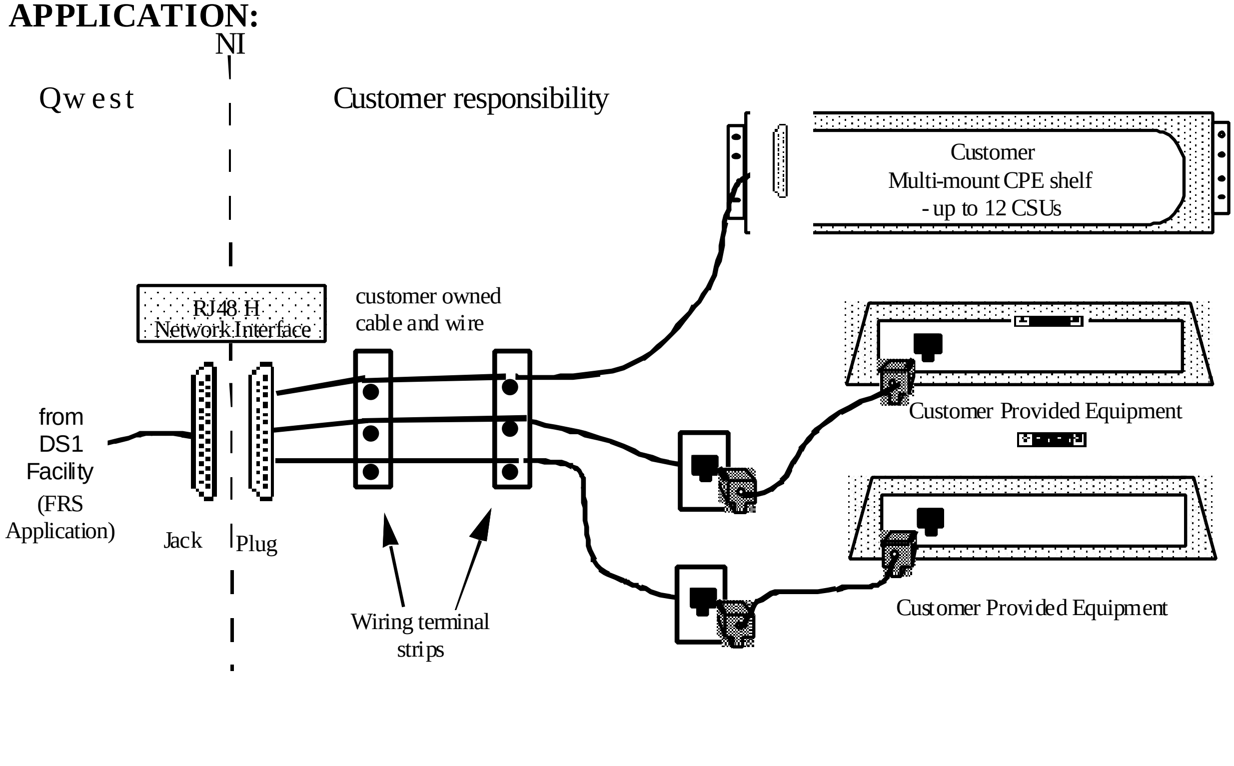
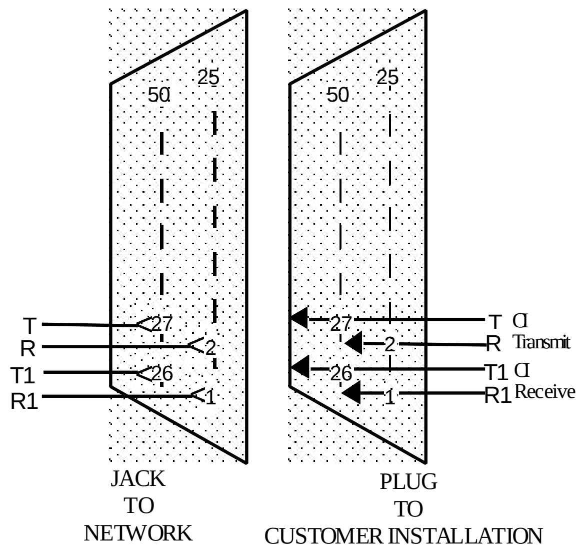


Exhibit 3-2 RJ48H Wiring and Application

JACK TYPE: 50 PIN - 8 CIRCUIT CONFIGURATION **NCI CODES:** 04DU9.- - -

WIRING DIAGRAM:



Line	T1	R1	T	R
1	26	1	27	2
2	29	4	30	5
3	32	7	33	8
4	35	10	36	11
5	38	13	39	14
6	41	16	42	17
7	44	19	45	20
8	47	22	48	23

APPLICATION:

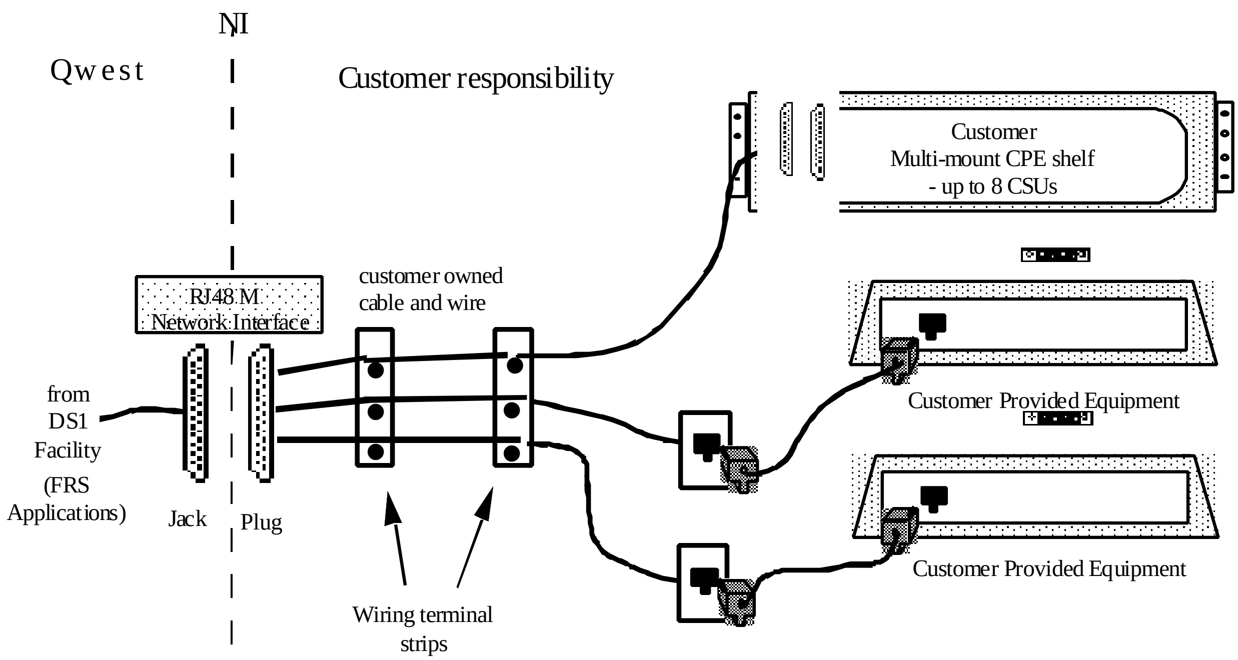
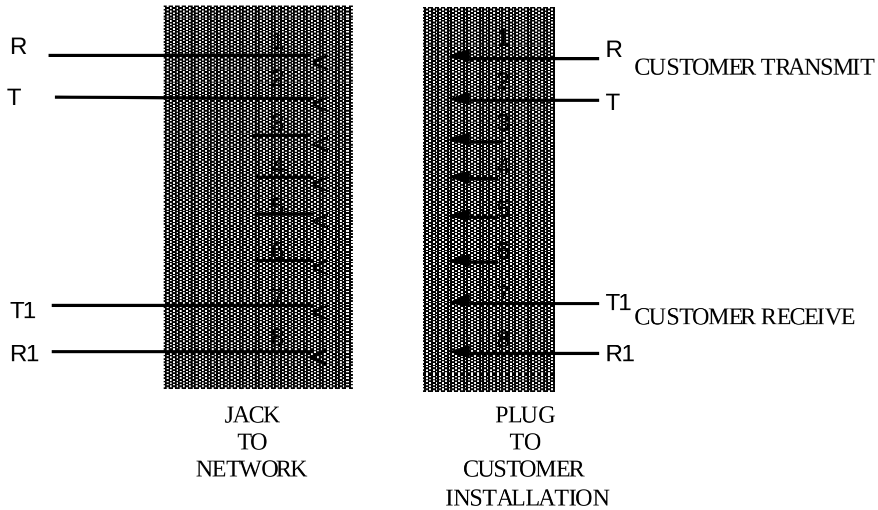


Exhibit 3-3 RJ48M Wiring and Application

JACK TYPE: 8 PIN MINI-MODULAR - KEYED NCI CODES: 04DU5.- - -

WIRING DIAGRAM:



APPLICATION:

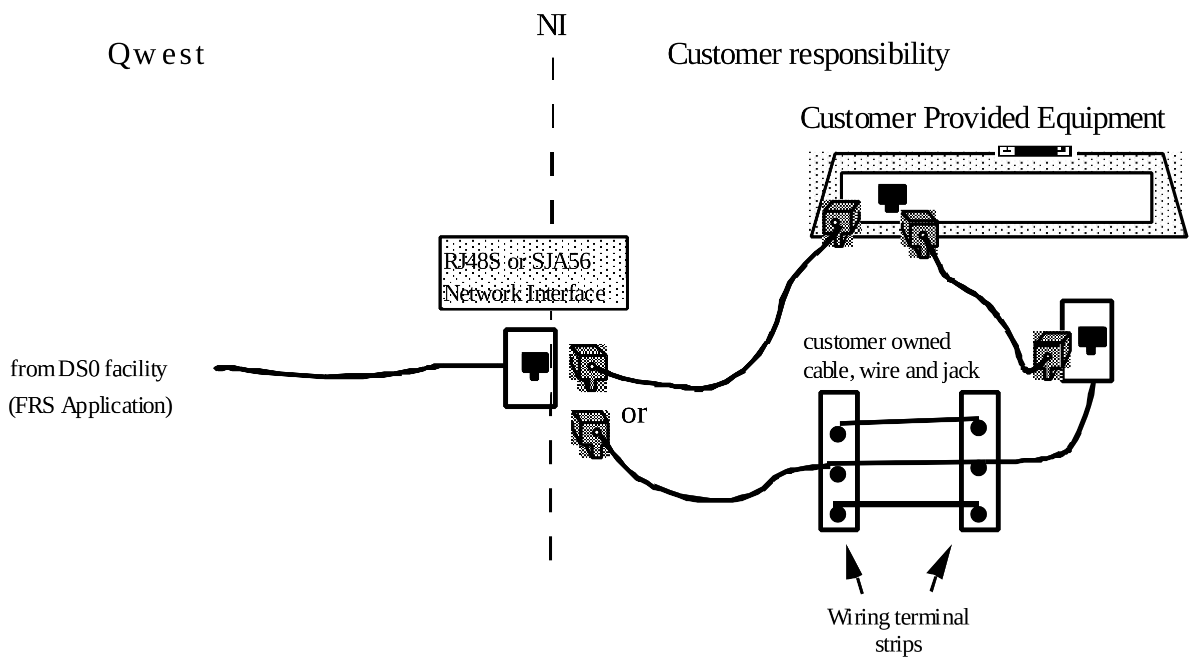
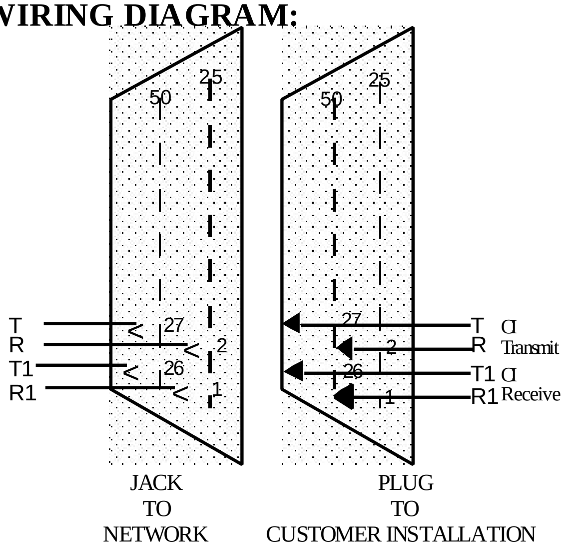


Exhibit 3-4 RJ48S and SJA56 Wiring and Application

JACK TYPE: 50 PIN - 12 CIRCUIT CONFIGURATION NCI CODES: 04DU5.- - -

WIRING DIAGRAM:



Line	T1	R1	T	R
1	26	1	27	2
2	28	3	29	4
3	30	5	31	6
4	32	7	33	8
5	34	9	35	10
6	36	11	37	12
7	38	13	39	14
8	40	15	41	16
9	42	17	43	18
10	44	19	45	20
11	46	21	47	22
12	48	23	49	24

APPLICATION:

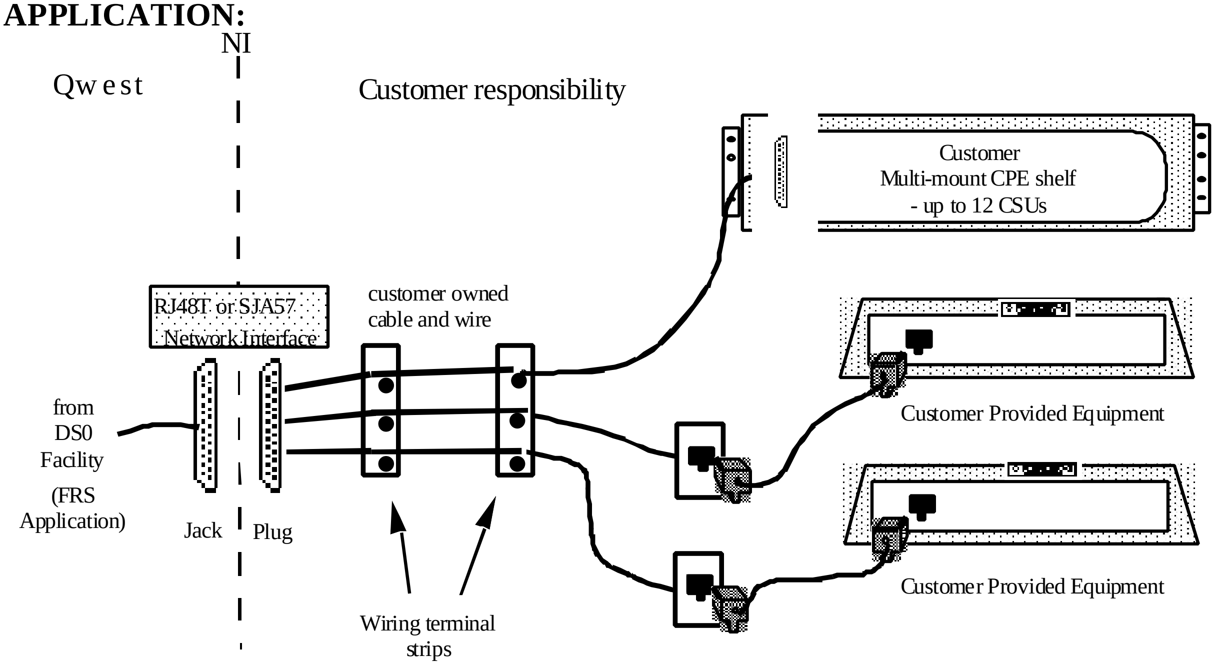
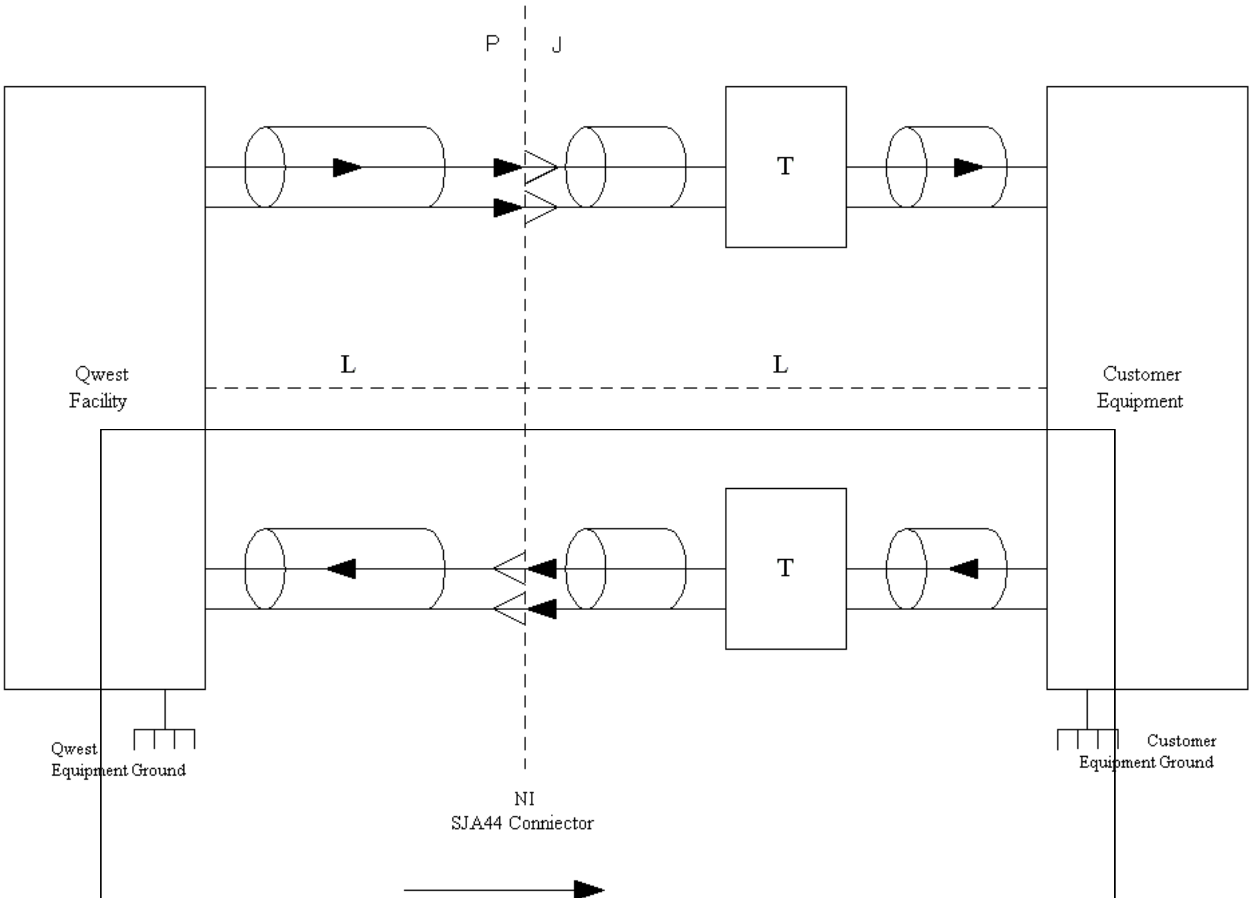


Exhibit 3-5 RJ48T and SJA57 Wiring and Application



denotes direction of transmission

Legend:

T -	Optional wide band tranforms to mitigate
P -	TNC connector plug
J -	TNC connector plug
L -	Maximum cable length to NI 450 feet of 75 ohm coaxial cable.
Note1:	This diagram indicates signal continity arrangements and maximum allowable cable lengths.
Note 2:	Equipment grounding shuld follow recommended Carrier /customer installation practices consistent with existing safety standards.
Note 3:	If the maximum distance between the DSx-# Cross-connect panel and the customer equipment exceeds 450 feet a DS3Regenerator will be required.

Exhibit 3-6 Customer Premises Network Interface - Electrical DS3 - SJA44 Network Interface Connector

CONTENTS

4. Data Link Layer Interface

4.1 General

The purpose of this chapter is to describe the frame structure and the embedded information of the frame relay data link layer protocol.

4.2 Protocol Structure

ANSI T1.618-1991, "ISDN - Core Aspects of Frame Protocol for Use with Frame Relay Bearer Service" and ITU-T Recommendation Q.922 (Annex A), "ISDN - User-Network Data Link Layer Specification" describe the data transfer protocol. The standards are based on a subset of the Core Aspects of Link Access Procedure D (LAPD) protocol.

4.3 Frame Structure

The data link layer interface for QWEST Frame Relay Service is defined in ANSI T1.618-1991 (see Reference Section). A summary of the frame relay format structure is provided in this section. The frame relay protocol structure is shown in Figure 4-1.

FLAG 0 1 1 1 1 1 1 0
ADDRESS FIELD (first octet) < High Order DLCI > C/R EA
ADDRESS FIELD (second octet) < Low Order DLCI > FECN BECN DE EA
FRAME RELAY INFORMATION FIELD (1 to 4096 octets [default value : 4096 octets])
FRAME CHECK SEQUENCE (first octet)
FRAME CHECK SEQUENCE (second octet)
FLAG 0 1 1 1 1 1 1 0

Figure 4-1 Frame Relay Structure

4.3.1 Flag Sequence

Each frame is delimited by a flag sequence. The opening flag marks the beginning of a frame and precedes the address field. The closing flag follows the frame check sequence field. The closing flag may also be used as the opening flag for the next frame.

4.3.2 Address Field Format

The address field supported by the QWEST Frame Relay Service consists of two octets as shown in Figure 4-2.

8	7	6	5	4	3	2	1
< (DLCI) HIGH ORDER >						C/R	EA (0)
< (DLCI) LOW ORDER >				FECN	BECN	DE	EA (1)

Figure 4-2 Address Field Format

4.3.3 Address Field Extension Bit

The Address Field Extension (EA) bit allows the address field range to be extended beyond the first octet. A zero in the first octet and a one in the second octet specifies an address field length of 2 octets.

4.3.4 Data Link Connection Identifier

The 10-bit (e.g., 6 High Order bits and 4 Low Order bits) Data Link Connection Identifier (DLCI) field identifies the logical connections between the Frame Relay Node (i.e., Frame Relay Port) and the Customer Provided Equipment (CPE) Data Terminal Equipment (DTE) device. All frames which contain the same DLCI value are associated with the same logical connection. The DLCI(s), which specifies a Permanent Virtual Circuit (PVC), is of local significance only. Thus, a logical connection consisting of multiple Frame Relay Nodes will be specified by multiple DLCIs.

In addition to providing the identification of logical connections, particular DLCI values are reserved to support other functionalities. These functions are listed in Table 4-1.

Table 4-1 Data Link Connection Identifier Function Definition

DLCI Values	Function
0	In-channel Signaling used for ANSI T1.617a-1994 PVC Management
1 - 15	Reserved
16 - 1007	QWEST Frame Relay PVC Assignments
1008 - 1022	Reserved
1023	Reserved for In-channel Layer Management / Local Management Interface

4.3.5 Command/Response Bit

The use of the Command / Response (C / R) bit is application specific. QWEST Frame Relay Service will not affect the Command / Response bit.

4.3.6 Forward Explicit Congestion Notification Bit

The Forward Explicit Congestion Notification (FECN) bit is set to "1" by the QWEST Frame Relay Network on the frames which have encountered congestion. The purpose of the FECN bit is to notify the End-User (EU) customer's CPE DTE device that congestion avoidance procedures should be initiated where applicable for traffic in the direction of the frame carrying the FECN indicator set to "1". See Chapter 6 for additional details on the setting of the FECN bit by the QWEST Frame Relay Service.

4.3.7 Backward Explicit Congestion Notification Bit

The Backward Explicit Congestion Notification (BECN) bit is set to "1" by the QWEST Frame Relay Network to notify the EU customer that the frames it transmits may encounter network congestion. The purpose of the BECN bit is to notify the EU customer's CPE DTE device that congestion avoidance procedures should be initiated where applicable for traffic in the opposite direction of the frame carrying the BECN indicator set to "1". See Chapter 6 for additional details on the setting of the BECN bit by the QWEST Frame Relay Service.

4.3.8 Discard Eligibility Bit

The Discard Eligible (DE) bit may be set to "1" by the CPE to indicate to the frame relay network(s) that the current frame may be discarded, in a congestion situation, in preference to frames whose DE bit is not set to "1". In addition, with the QWEST Frame Relay Service CIR Feature, the DE bit will be set to "1" by the QWEST Frame Relay Network for frames which have exceeded the pre-negotiated CIR during any committed rate measurement interval (Tc). The committed Tc for QWEST Frame Relay Service is one second.

An individual PVC's frame whose DE bit is set to "1" will be considered discard eligible during a state of congestion. See Chapter 6 for additional information on the setting of the DE bit by the QWEST Frame Relay Network, and discard schemes during congestion for frames whose DE bit is set "1".

4.3.9 Frame Relay Information Field

The information field follows the address field and precedes the Frame Check Sequence Field. The contents of the information field consists of an integral number of octets between 1 and 4096. Unless specified by the customer at service subscription time, the default maximum frame size will be configured to be 4096 octets upon service initiation. Any frames received that are larger than the configured maximum (i.e., 4096 octets) will be discarded at point of ingress by the QWEST Frame Relay Node. QWEST will migrate to the use of 4096 octets as the default maximum frame size.

4.3.10 Frame Check Sequence Field

The Frame Check Sequence (FCS) field is a 16-bit sequence that is based on the ITU-T error checking polynomial. The FCS is calculated for all bits within the frame between the last bit of the opening flag and the first bit of the FCS sequence, excluding bits inserted for transparency.

4.4 Transparency

Zero bit stuffing / de-stuffing is used to ensure the bit patterns within the frame content between the opening and closing flag sequences do not simulate an abort sequence and / or flags.

4.5 Invalid Frames

Validation of frames will be performed by each of the QWEST Frame Relay Service Nodes. The QWEST Frame Relay Network will discard invalid frames. The following types of frames will be considered invalid:

- Frame not contained within an opening and closing flag
- Frame which has fewer than three octets between the address field and the closing flag
- Frame which does not contain an integral number of octets after zero bit extraction
- Frame containing a FCS error
- Frame containing an address field length of only one octet
- A particular DLCI of a frame not assigned at service subscription time
- Frame relay information field which exceeds the configured maximum number of octets (default configured maximum number of octets is 4096 octets)

4.6 Frame Abort

A frame abort sequence of seven or more contiguous bits may be sent across the Network Interface to indicate the current frame should be aborted.

CONTENTS

Chapter and Section **Page**

Figures

Tables

5. Permanent Virtual Circuit Management

5.1 Permanent Virtual Circuit Management Procedures Via Local In-channel Signaling Protocols

Each QWEST Frame Relay Service Subscriber access connection is assigned a local in-channel signaling protocol at service subscription time. Frame Relay Permanent Virtual Circuit (PVC) Management Procedures enable Customer Provided Equipment (CPE) Frame Relay access devices (e.g., routers) and/or interconnecting Frame Relay Networks to administer and determine the status and configuration information of PVCs. The QWEST Frame Relay Service supports PVC Management Procedures based on the following standard local in-channel signaling protocols for both the User-to-Network Interface (UNI) and Network-to-Network Interface (NNI):

- ANSI T1.617a-1994 - "ISDN - Signaling Specification for Frame Relay Bearer Service for Digital Subscriber Signaling System Number 1 (DSS1)".
- Local Management Interface (LMI) - "Frame Relay Specification With Extensions Based on Proposed T1S1 Standards, Document No. 001-208966, Revision 1.0".
- ITU-T Q.933 Annex A - "DSS1 Signaling Specifications for Frame Mode Basic Call Control".
- The ITU-T Q. 933 Annex A is the preferred local in-channel signaling protocol for NNI per FRF.2. ANSI T1.617a-1994 can be used in the interim.

The QWEST Frame Relay Nodes implement the above local in-channel signaling protocols in order to exchange PVC and link information. Hence, the appropriate PVC Management Procedure type is specified at service subscription time based on the local in-channel signaling protocols supported in the customer's Frame Relay Data Terminal Equipment (DTE) device. The type of information contained within the messages exchanged between the QWEST Frame Relay Network and the customer is as follows:

- Notification of the addition of a PVC
- Detection of the deletion of a PVC
- Link integrity verification
- Notification of the status of the PVCs configured (i.e., active or inactive)

For FRS 56/64 kbit/s Stand Alone Access Links applications, the EU Frame Relay DTE Device and/or other Frame Relay Service Provider Frame Relay Switching Component must implement one of the aforementioned local in-channel signaling protocols. The Frame Relay Stand Alone Multiplexer will pass-through only proper local in-channel signaling protocol messages. The Frame Relay Stand Alone Multiplexer will not set, modify, or alter the PVC management frame header bits and/or information elements.

5.2 PVC Management for Single and Multiple Frame Relay Network PVCs

QWEST Frame Relay Service supports PVC Management Procedures for single and multiple frame relay network PVCs. As shown in Figure 5-1, a multiple frame relay provider network PVC is considered to consist of two or more PVC segments. A PVC segment is defined as the portion of the PVC which is provided by a particular Carrier's (e.g., Local Exchange Carrier [LEC], Interexchange Carrier [IC], Independent Carrier, or other Frame Relay Service Provider) Network. The PVC status information of a single frame relay network PVC (i.e., does not interconnect with another Carrier's Frame Relay Network) is provided using the User-to-Network Procedures at the User-to-Network Interface (UNI).

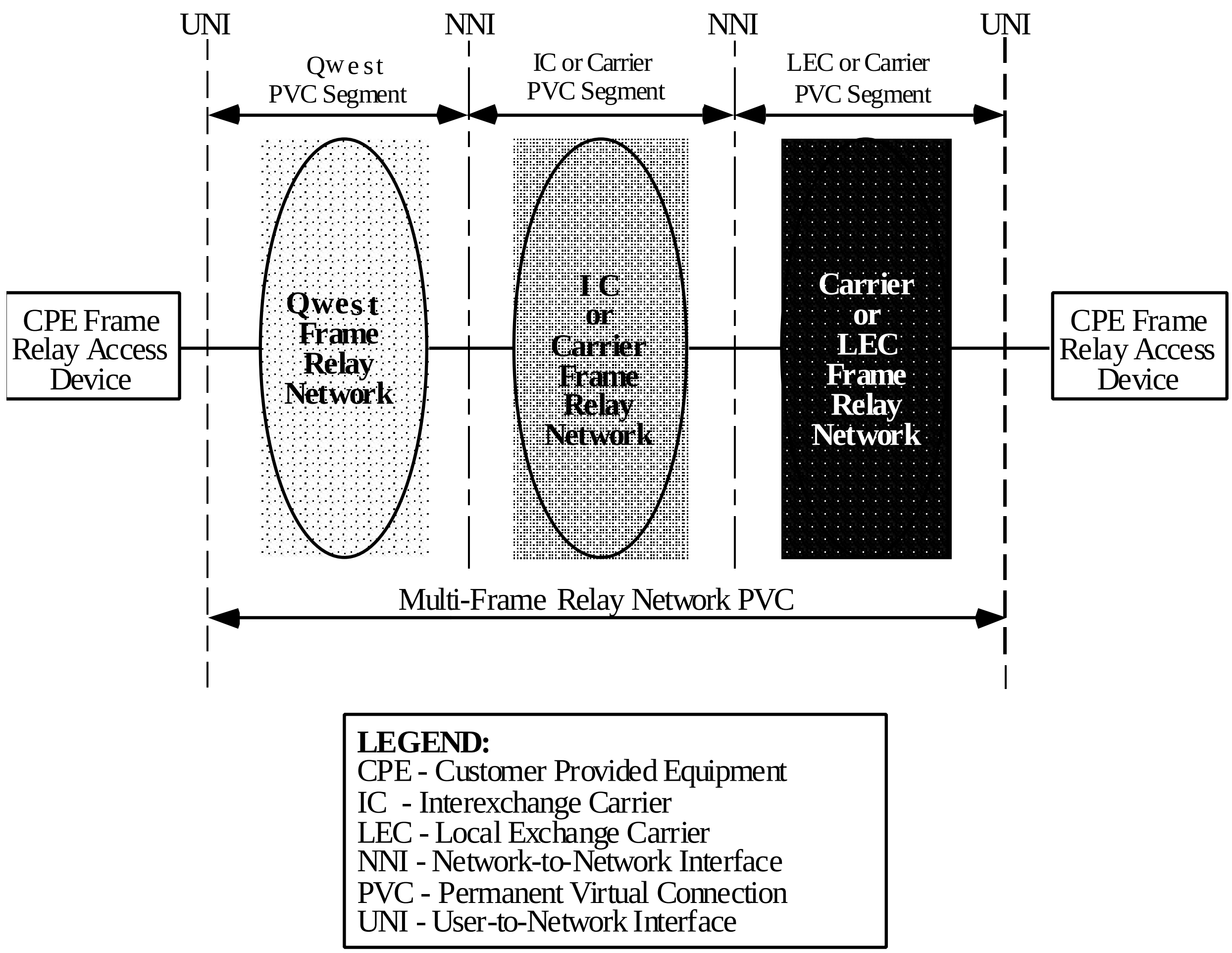


Figure 5-1 Multiple Frame Relay Provider Network PVC

5.2.1 PVC Management Procedures at the User-to-Network Interface

In order to exchange PVC status information of a multiple frame relay network PVC, Network-to-Network PVC Management Procedures are performed at the NNI, and the User-to-Network Procedures are performed at the UNI. As shown in Figure 5-2, the User-to-Network PVC Management Procedures assume that the QWEST Frame Relay Network is exchanging PVC status information with a CPE Frame Relay Access Device utilizing uni-directional polling. The User-to-Network PVC Management Procedures implemented by the QWEST Frame Relay Network at the UNI are based on the procedures specified in ANSI T1.617a-1994 and/or LMI (see Reference Section).

5.2.2 PVC Management Procedures at the Network-to-Network Interface (NNI)

Also shown in Figure 5-2, the Network-to-Network PVC Management Procedures assume that the QWEST Frame Relay Network is exchanging PVC status information with an IC or Carrier (including other Frame Relay Service Provider) Frame Relay Network Device. The Network-to-Network PVC Management Procedures implemented by the QWEST Frame Relay Network at the NNI are based on the Frame Relay Forum Document FRF.1.1, FRF.2.1. The NNI can be provisioned for public or private use. At the NNI, the QWEST Frame Relay Node which represents the ingress/egress point for other interconnecting Frame Relay Networks is optioned to support bi-directional polling. Bi-directional polling allows interconnected Frame Relay Networks to inquire the status of the link and the associated PVCs in both directions.

As shown in Figure 5-2, User-to-Network Procedures at the UNI utilize uni-directional polling in order to determine the status of DLCI x and DLCI z, and/or to verify link integrity. Bi-directional Procedures utilize bi-directional polling at the NNI in order to determine the status of DLCI y and/or verify link integrity.

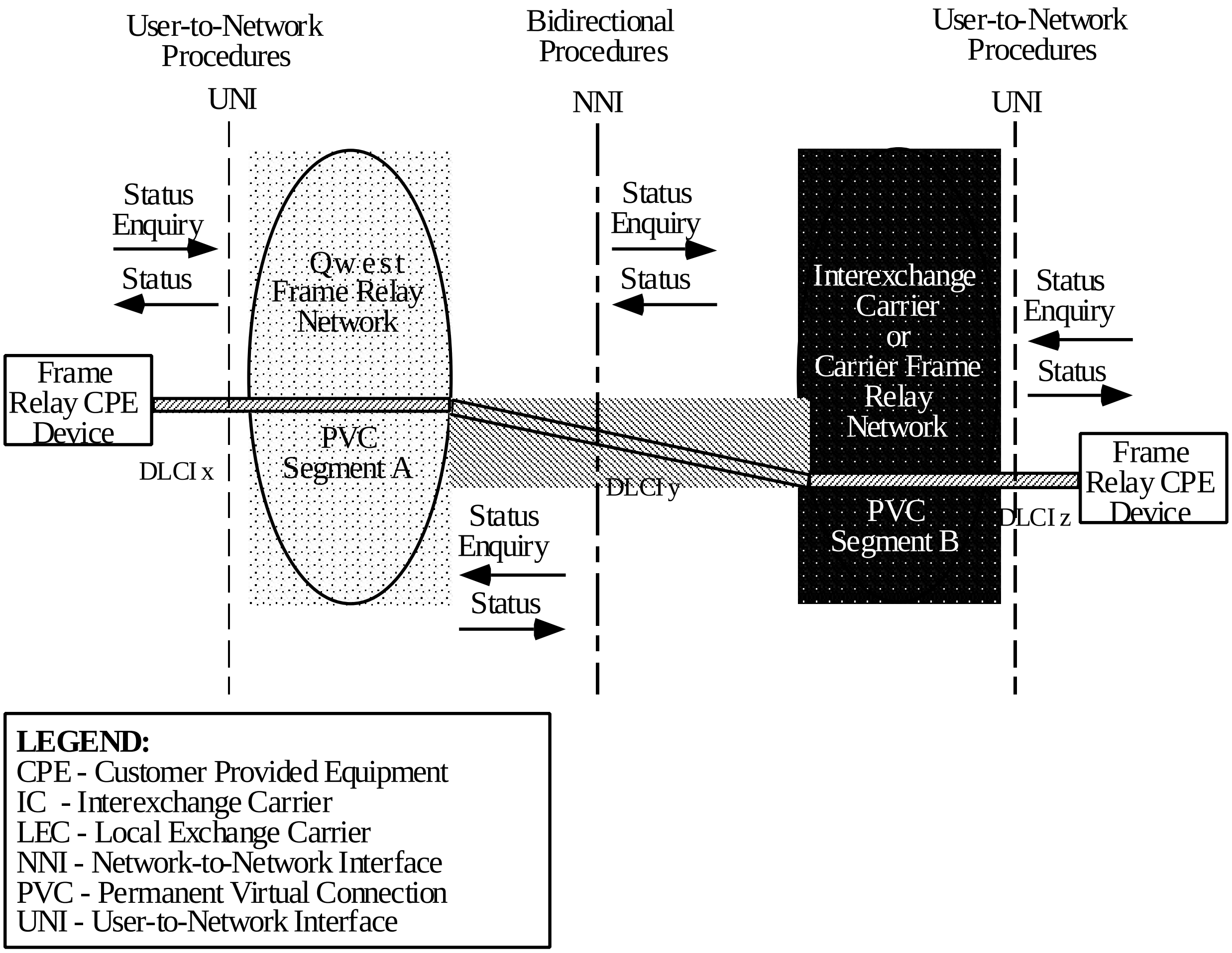


Figure 5-2 User-to-Network and Network-to-Network PVC Management

5.2.3 PVC Management Unnumbered Information Frame Structure

The frame structure for the PVC Management Procedures listed in the preceding subsection is based on an unnumbered information frame. ITU-T Q.933 Annex A and ANSI T1.617a-1994 (see Reference Section) specifies the use of an unnumbered frame with the Data Link Connection Identifier (DLCI) field set to "0", where as LMI specifies the use of an unnumbered frame with DLCI field set to 1023. See Figure 5-3 for the applicable DLCI assignments and the layer 2 unnumbered frame structure (defined in ITU-T Q.922) of the local in-channel signaling messages.

Although ANSI T1.617a-1994 and ITU-T Q.933 Annex A are similar local in-channel signaling protocols, the following identifier codes for the following information elements are different within the respective protocols: Locking Shift (ANSI T1.617a-1994 only), Report Type, Link Integrity Identifier Code, PVC Status.

Field							
Flag							
0	1	1	1	1	1	1	0
DLCI*							
0/1	0/1	0/1	0/1	0/1	0/1	0	0
DLCI*							
0/1	0/1	0/1	0/1	0	0	0	1
Unnumbered Information Field							
0	0	0	0	0	0	1	1
Protocol Discriminator							
0	0	0	0	1	0	0	0
Call Reference							
0	0	0	0	0	0	0	0
Message Type (STATUS / STATUS ENQUIRY)							
0	1	1	1	1/0	1	0	1
Information Elements							
Frame Check Sequence (first octet)							
Frame Check Sequence (second octet)							
Flag							
0	1	1	1	1	1	1	0

- * DLCI Field Bit Value : (ANSI T1.617a-1994 / Q.933 Annex A = 0, LMI = 1)

Figure 5-3 Unnumbered Information Frame Structure

5.3 Types of PVC Management Frames

The QWEST Frame Relay Service supports both User-to-Network and Network-to-Network local in-channel signaling protocols for the purpose of PVC management. These local in-channel signaling protocols are used to exchange the following types of messages : STATUS and STATUS ENQUIRY. As shown in Figure 5-2, STATUS messages are sent from the QWEST Frame Relay Network Nodes to the CPE Frame Relay Access Device for UNI arrangements, and to the interconnecting Frame Relay Network(s) for NNI arrangements. The STATUS ENQUIRY messages are received from EU customer's CPE in UNI arrangements, and from interconnecting Frame Relay Networks in a NNI arrangement. The purpose of this section is to describe the contents and functions performed by both of these message types.

5.3.1 STATUS Message Information Elements

The QWEST Frame Relay Network will send STATUS messages in response to STATUS ENQUIRY messages based upon the DLCI field values ("0" per ANSI T1.617a-1994 or 1023 per LMI [see Reference Section]) of the STATUS ENQUIRY. STATUS messages contain information elements as shown in Table 5-1. Each message is populated based on the information elements specified in ANSI T1.617a-1994, LMI, Q.933 Annex A (see Reference Section).

Table 5-1 Status Message Information Elements

Information Element	Described in T1.617 Reference	Described in LMI Reference	Described in Q.933 Annex A Reference	Type *	Length (Octets)
Protocol Discriminator	6.2	6.1.2	4.2	R	1
Call Reference	6.3	6.1.2	4.3	R	1
Message Type	6.4	6.1.3	4.4	R	1
Locking Shift	6.5.3	N/A	N/A	R	1
Report Type	D.3.1	6.1.4.3	A.3.1	R	3
Link Integrity	D.3.2	N/A	A.3.2	R	4
Keep Alive Sequence	N/A	6.1.4.1	N/A	R	4
PVC Status	D.3.3	6.1.4.2	A.3.3	O	5 for ANSI 8 for LMI

N/A - Not Applicable
* R = Required, O = Optional

Further information on the format and options associated with each PVC Management Information Element is provided in ANSI T1.617a-1994, LMI, and ITU-T Q.933 Annex A (see Reference Section).

5.3.2 STATUS ENQUIRY Message Information Elements

In an NNI service arrangement, the QWEST Frame Relay Network will send STATUS ENQUIRY messages to the interconnecting Frame Relay Network in order to request the status of a PVC or to verify link integrity. The STATUS ENQUIRY message content must contain the information elements as shown in Table 5-2. Each message is populated based on the information elements specified in ANSI T1.617a-1994, LMI, and Q.933 Annex A (see Reference Section).

Table 5-2 Status Enquiry Message Information Elements

Information Element	Described in T1.617 Reference	Described in LMI Reference	Described in Q.933 Annex A Reference	Type *	Length (Octets)
Protocol Discriminator	6.2	6.1.2	4.2	R	1
Call Reference	6.3	6.1.2	4.3	R	1
Message Type	6.4	6.1.3	4.4	R	1
Locking Shift	6.5.3	N/A	N/A	R	1
Report Type	D.3.1	6.1.4.3	A.3.1	R	3
Link Integrity	D.3.2	N/A	A.3.2	R	4
Keep Alive Sequence	N/A	6.1.4.1	N/A	R	4

N/A - Not Applicable
* R = Required

Further information on the format and options associated with each PVC Management Information Element is provided in ANSI T1.617a-1994, LMI, and Q.933 Annex A (see Reference Section).

5.4 PVC Management Parameters and Counters

For UNI and NNI service arrangements, the QWEST Frame Relay Network supports the PVC management parameters and counters associated with both ANSI T1.617a-1994and LMI. Table 5-3 indicates the default values (ANSI T1.617a-1994 and LMI [see Reference Section]) of the system parameters and counters implemented in the QWEST Frame Relay Nodes. The default values shown in Table 5-3 are consistent with the default values specified in the Frame Relay Forum Document FRF.2 (see Reference Section).

The default values at the NNI were established by the Frame Relay Forum in order to decrease the polling delay and allow faster propagation of status information between multiple interconnected Frame Relay Networks. The QWEST Frame Relay Customer may request, at service subscription time, the counter or parameter value to be configured for any value within the parameters specified range (see Table 5-3 for specific ranges).

Table 5-3 PVC Management Parameters and Counters

ANSI T1.617a Parameter	LMI Parameter	Description	Range	UNI & NNI Default Value
N391	nN1	Full Status Polling Counter	1-255	6
N392	nN2	Error Threshold	1-10	3
N393	nN3	Monitored Events Count	1-10*	4
T391	nT1	Link Integrity Verification Polling Timer	5-30 seconds	10
T392	nT2	Polling Verification Timer	5-30 seconds	15

* N393/nN3 = N392/nN2

5.5 Frame Relay PVC Administration

Each QWEST Frame Relay Node is responsible for the administration of the Frame Relay Network PVCs. Each PVC is assigned an associated DLCI pair at the time the customer subscribes to the QWEST Frame Relay Service. During the service subscription process, the assignment(s) of DLCI values to each of the QWEST Frame Relay Service subscriber's PVC(s) will require close coordination and cooperation to achieve conformity of DLCI assignments.

PVCs will remain in the QWEST Frame Relay Node(s) until each are individually removed, even in the case of a temporary unavailability of the virtual circuits due to a service failure.

It is the responsibility of each QWEST Frame Relay Service customer to populate and maintain its own CPE Data Terminal Equipment (DTE) DLCI routing tables. QWEST provides DLCI(s) information for each PVC at service subscription time.

CONTENTS

Chapter and Section **Page**

Tables

Exhibits

6. Network Congestion Responsibilities and Procedures

6.1 End-User Network Congestion Responsibilities

The QWEST Frame Relay Node(s) will monitor the traffic volume of each QWEST Frame Relay Service Access Link which terminate on QWEST Frame Relay Nodes, and compare the Permanent Virtual Circuits (PVCs) associated traffic volume with the negotiated data traffic parameters. In the event that a customer's PVC(s) causes a Frame Relay Module to become congested, the End-User (EU) customers which are assigned to the congested Frame Relay Module may experience network congestion conditions.

Network congestion conditions may cause the following conditions to be experienced by a Frame Relay Service (FRS) EU Customer:

- Receipt of explicit network congestion notifications.
- Receipt of implicit network congestion notifications.
- Discarding of frame(s).
- Excessive transit delay.

If network congestion should occur due to the traffic volume of any particular EU PVC, QWEST recommends the EU customer implements its own network congestion procedures for the following reasons:

- To reduce the impact of network congestion upon the EU customer's application.
- To avoid the possibilities of discarding the EU frames by the Frame Relay Node(s).
- EU implemented congestion procedures should be exercised until the network congestion situation no longer exists.

In regards to the setting of the network congestion notification bits (i.e., Forward Explicit Congestion Notification / Backward Explicit Congestion Notification [FECN / BECN]) supported by the QWEST Frame Relay Service, it would be advantageous, to both the service subscriber and the QWEST Frame Relay Network, for the EU Customer Provided Equipment (CPE) Data Terminal Equipment (DTE) (e.g., Frame Relay Access Device, router, etc.) device(s) to support congestion procedures based on the explicit network congestion notification bits. The congestion notification bits are the first indicators of the possible occurrence of congestion conditions on a Frame Relay Module(s) which contains the service subscribers FRS Access Link(s). The setting of the FECN and BECN bits by QWEST Frame Relay Service is described in the following paragraphs.

In addition to the explicit congestion control mechanisms associated with QWEST Frame Relay Service, EU customers can use the internal performance measurement capabilities of the CPE Applications in order to determine the impact of traffic loads on the Frame Relay Network, and adjust the traffic loads accordingly. Also, additional implicit congestion control is typically provided by the upper layer transport protocols (e.g., Transmission Control Protocol / Internet Protocol [TCP / IP]) which may limit the amount of outstanding data within a given time period.

QWEST recommends that port connections for Interexchange Carriers (ICs), other Frame Relay Service Providers, and local FRS Network User-to-Network Interface (UNI) be utilized to support multiple ports being shared for multiple EU networks. FRS will implement congestion management procedures at the network boundary per the Frame Relay Forum Document FRF.2, "Frame Relay Network-to-Network Interface Phase 1 Implementation Agreement" and ANSI T1.606b-1993, " ISDN - Supplement to Architectural Framework and Service Description to Frame-Relaying Bearer Service (Network-to-Network Interface Requirements)".

6.2 QWEST Frame Relay Service Congestion Control Procedures

The manner in which congestion control procedures are performed by QWEST Frame Relay Service is described in the following paragraphs. The purpose of the following information is to provide the QWEST Frame Relay Service Customers with a fundamental understanding of the congestion control procedures, which pertain to the QWEST Frame Relay Service. QWEST Frame Relay Service Congestion Control Procedures will be performed on the congested Frame Relay Port(s) by QWEST Frame Relay Node(s), in order to alleviate the Frame Relay Port(s) congestion.

QWEST Frame Relay Service will provide explicit network congestion notification (i.e., FECN and BECN) to alert the EU customer's CPE DTE device that congestion may have and / or will occur during the exchange of information. In the event that the EU customer's CPE DTE device does not react to alleviate the Frame Relay Port(s) congestion status, the Frame Relay Port may become congested if the traffic volume of the particular Frame Relay Port is not reduced.

In the event that the QWEST Frame Relay Service EU Customer's network congestion procedures do not alleviate the network congestion conditions of a particular Frame Relay Port(s), QWEST reserves the right to implement its own congestion control procedures on the congested Frame Relay Module located within a Frame Relay Node(s).

6.2.1 Purpose for QWEST Frame Relay Service Network Congestion Control Procedures

QWEST Frame Relay Service Network Congestion Control Procedures will be implemented with the following goals in mind:

- Provide fairness of service during congestion among the QWEST Frame Relay Service EU's associated Frame Relay Ports, FRS Access Links, and PVCs.
- Maximize throughput.
- Minimize loss of data.
- To cease the congestion condition of the Frame Relay Module in a fast and effective manner.

QWEST will also provision and monitor the frame relay internodal trunk thresholds in order to avoid excessive traffic congestion between Frame Relay Nodes. The EU customer's FRS Access Link(s) traffic will be distributed, when possible, over multiple FRS internodal trunks.

6.2.2 Types of Congestion Control Procedures Supported by QWEST Frame Relay Service

The following two types of congestion control procedures are supported by the QWEST Frame Relay Network:

- Congestion Control Procedures in a Pre-Committed Information Rate (CIR) environment.
- Congestion Control Procedures in a CIR environment.

Prior to the availability of the CIR feature with QWEST Frame Relay Service throughout the QWEST Frame Relay Network, the QWEST Congestion Control Procedures are implemented based on an "equivalent CIR". The term "equivalent CIR" refers to the manner in which bandwidth is allocated amongst multiple PVCs prior to the availability of the CIR feature. The congestion control procedures which are applicable prior to the introduction of QWEST Frame Relay Service CIR Feature are described in the next subsection. However, as the CIR feature is introduced into the QWEST Frame Relay Network, congestion control procedures based on CIR will be implemented throughout the QWEST Frame Relay Network.

Pre-CIR network congestion control procedures essentially focus upon the management of the buffer occupancy associated with each Frame Relay Module. A Frame Relay Module is a specific plug-in of a Frame Relay Node which terminates the FRS Access Link. In this environment, network congestion is determined based on the total buffer occupancy of a Frame Relay Module, and the number of active PVCs on a Frame Relay Module, at any given instant. Section 6.3 below describes these procedures in further detail.

Based upon the negotiated CIR parameters (i.e., CIR, excess burst size [Be], committed burst size [Bc], and committed rate measurement interval [Tc]) of each PVC, congestion control procedures in a CIR environment will accomplish congestion control by focusing on the management of each Frame Relay Module's total buffer occupancy. In this environment, the occurrence of network congestion is based on the pre-negotiated CIR parameters for each customer's EU PVC.

6.3 Network Congestion Control Procedures in a Pre-CIR Environment

Prior to the availability of CIR Features with QWEST Frame Relay Service, congestion control is supported on the basis of buffer occupancy per Frame Relay Module at any given instance. Specifically, each Frame Relay Module supports a fixed amount of buffer capacity. For any instant in time, if a Frame Relay Module's buffer fill capacity exceeds 75%, it's associated Frame Relay Port's status is considered to be in the state of congestion. If a Frame Relay Module's state of congestion continues and the fill capacity of the buffer exceeds 90% of the total buffer capacity, the Frame Relay Module will implement frame discard procedures until the congestion status is alleviated. The discarding of frames due to congestion will only occur while a Frame Relay Module is in the state of congestion.

While a Frame Relay Port Module is in the state of congestion, each customer's QWEST Frame Relay Service Access Link is allocated a fixed amount of buffer capacity. Allocation of buffer capacity is based on the following:

- Operating line speed (i.e., 56 kbit/s, 64 kbit/s, and 1.544 Mbit/s) of the FRS Access Link.
- Number of FRS Access Links provisioned on the congested Frame Relay Module.

6.3.1 Allocation of Frame Relay Module Port Buffer Capacities During Congestion

The minimum Frame Relay Port buffer capacities, based on the FRS Access Link's operating line speed and the number of FRS Access Links provisioned on the congested Frame Relay Port Module, are shown in Table 6-1.

Table 6-1 FRS Access Link Buffer Capacities During Congestion (Pre-CIR)

FRS Access Link Operating Line Speed	Minimum Allocated Buffer Capacity per Frame Relay Port During Congestion
56 kbit/s	25%
64 kbit/s	25%
1.544 Mbit/s	50%

The Frame Relay Port buffer capacities shown in Table 6-1 only apply for the Frame Relay Port(s) which are in the state of congestion. For example, if a Frame Relay Module containing four 56 kbit/s FRS Access Links becomes congested, each 56 kbit/s FRS Access Link is allocated a minimum of 25% of the Frame Relay Module's total buffer capacity. Further, if a Frame Relay Module containing two 1.544 Mbit/s FRS Access Links becomes congested, each 1.544 Mbit/s FRS Access Link will be allocated a minimum of 50% of the Frame Relay Module's buffer capacity. However, the EU customer whose FRS Access Links are provisioned on other non-congested Frame Relay Port(s) of the same Frame Relay Node will maintain the ability to utilize the maximum buffer capacities of their respective Frame Relay Module(s).

The process of Pre-CIR buffer allocation per FRS Access Link, as stated in the previous paragraph, only applies for Frame Relay Ports in the state of congestion. Under normal conditions in a Pre-CIR environment, no Frame Relay Port buffer occupancy restrictions are placed on the associated FRS Access Link(s). Thus, in a non-congested state, the active PVCs within a given FRS Access Link(s) may share the entire (100%) Frame Relay Module buffer capacity.

For example, a 1.544 Mbit/s FRS Access Link containing four (4) active PVCs may utilize the entire Frame Relay Module's buffer capacity, if no other access links provisioned on the same Frame Relay Module contain any active PVCs at the same instance. This process of sharing the entire Frame Relay Module's buffer capacity, amongst the active PVCs of a non-congested Frame Relay Module, supports the QWEST Frame Relay Service EU Customer's bandwidth on demand needs by providing additional burst capability.

6.3.2 Allocation of PVC Buffer Capacities During Congestion (Pre-CIR) and PVC Buffer Threshold Values

The amount of buffer occupancy per PVC within the congested Frame Relay Port is defined as the PVC Buffer Threshold Value (BTV) of that particular Frame Relay Port. The following formula can be used to calculate the BTV for any given PVC which is provisioned on a congested Frame Relay Port(s):

Buffer Threshold Value (BTV) = (1 / N) X (Frame Relay Port Buffer Capacity, see Table 6-1)

where N = number of active PVCs on a single Frame Relay Port.

6.3.3 Setting of FECN and BECN based on PVC BTV (Pre-CIR)

The preceding formula is used by each congested Frame Relay Module to allocate, in a fair manner, the overall Frame Relay Module's buffer capacity between multiple EU customer's active PVCs, whose respective FRS Access Links are provisioned on the same Frame Relay Module. Each PVC's BTV represents the threshold at which the Frame Relay Module will begin setting the FECN and BECN bits. For each PVC of a given congested Frame Relay Port whose BTV is exceeded during congestion, the FECN and BECN bits will be set to "1" by the Frame Relay Port(s). The BTV of a Frame Relay Port in congestion will vary based on the number of active PVCs on a given Frame Relay Port at any instant in time.

6.3.4 QWEST Frame Relay Service Pre-CIR Frame Discard Scheme

In the event that a Frame Relay Module reaches a severe congestion status (i.e., Frame Relay Module's total buffer occupancy exceeds 90%), the QWEST Frame Relay Network will begin frame discard procedures. The procedure of determining which PVC's frame(s) of a congested Frame Relay Port to discard is as follows:

- Step 1) Each congested Frame Relay Module will determine which of the FRS Access Link(s) has the highest buffer occupancy beyond its "fair share" (see Table 6-1).
- Step 2) The PVC whose associated FRS Access Link has the highest buffer occupancy (as determined in Step 1) has exceeded the BTV by the largest margin is identified by the congested Frame Relay Module(s). This specific EU customer's PVC may be regarded as the "worst offender".
- Step 3) The Frame Relay Module will begin discarding the "worst offenders" frames.
- Step 4) Once discarding is complete, the Frame Relay Module determines if congestion still exists by determining the buffer occupancy associated with each FRS Access Link. If congestion has ceased, normal operation is resumed. If not, this procedure is repeated from Step 1 until the congestion state of the Frame Relay Module is alleviated.

Note: A "worst offender" is determined each time the above procedure is performed based on the new buffer occupancy. This means that a new "worst offender" may be selected during each iteration of the above procedure.

6.3.5 Pre-CIR Frame Discard Based on Discard Eligible Bit

Prior to the QWEST CIR Feature becoming available as part of the QWEST Frame Relay Service offering, the Discard Eligible (DE) bit of the address field was only monitored by the Frame Relay Port(s). The Frame Relay Port(s) did not modify the status of the DE bit. If a congested Frame Relay Module identified a PVC as the "worst offender", the Frame Relay Module discarded, if necessary, the frames whose DE bits were set to "1" in preference to the other "worst offender's" frames whose PVCs were not set to "1". Should the congestion status remain after discarding the frames whose DE bits were set to "1", the Frame Relay Module will continue to discard the "worst offender's" frames until network congestion has ceased.

6.4 Network Congestion Control Procedures in a CIR Environment

With the introduction of the QWEST Frame Relay Service CIR Feature, the QWEST Frame Relay Network will have additional administrative control of congestion based on the software configurable CIR parameters (i.e., Bc, Tc, Be). The key difference of congestion control in a Pre-CIR (i.e., "CIR equivalent") environment versus a CIR environment is the ability to administer the burst capabilities on a PVC basis in a CIR environment. As previously described in Chapter 2 of this document, Bc and CIR must be selected by the customer at service subscription.

Although the concepts of CIR and congestion control are intrinsically related, a fundamental difference exists between the functionality provided by each. CIR and its associated parameters establish the foundation upon which congestion control mechanisms are administered during congestion. In other words, CIR is not the only factor which impacts the successful implementation of congestion control. Congestion control encompasses additional factors such as frame discard schemes, buffer management, and traffic management.

Due to the mix of switch types within the QWEST Frame Relay Service Network, there are several variations of congestion control procedures. Both procedures will be outlined in the following sections (6.4.1 & 6.4.2).

6.4.1 Variation One of Network Congestion Control Procedures in a CIR Environment

As was the case in the Pre-CIR environment, congestion control is implemented during congestion based on the buffer occupancy of each individual Frame Relay Module. The Frame Relay Module supports a fixed amount of buffer capacity. For any instant in time, the Frame Relay Module begins implementing congestion control if the buffer usage exceeds 76%.

The Frame Relay Module will continually monitor the usage of the total buffer capacity as it receives frames from the customer Frame Relay Access Device (i.e., ingress data) or the Frame Relay Node backplane (i.e., egress data). If the Frame Relay Module's buffer usage exceeds 76%, the process of allocating port buffer capacities is initiated.

Allocation of Port Buffer Capacities

In order to support the burst requirements of the QWEST Frame Relay Service Customers, fair allocation of minimum port buffer capacities is accomplished based on the following factors:

- FRS Access Links with higher operating line speeds are allocated a greater portion of the total available buffer capacity.
- Allocation is only implemented when a Frame Relay Module becomes congested in order to determine the "worst offenders".
- Partitioning of the Frame Relay Module buffer with respect to ingress and egress traffic in order to ensure that frames (egress data) traversing the QWEST Frame Relay Network are the <u>least</u> likely to be discarded. Essentially, the QWEST Frame Relay Network places an emphasis on ensuring the successful transport of egress data.

During congestion in a CIR environment, fair allocation of port buffer capacities is based on the following:

- FRS Access Link's operating line speed.
- Number of FRS Access Links provisioned on the congested Frame Relay Module.
- 75% of the Port Buffer Capacity is partitioned for ingress data, and 25% of the Port Buffer Capacity is partitioned for egress data.

The manner in which buffer capacities on a port basis are allocated during congestion is essentially the same as in Pre-CIR (described in Section 6.3). Specifically, the minimum port buffer capacity per FRS Access Link is based on the ratio of the operating line speed of a FRS Access Link to the aggregate operating line speed of all FRS Access Links provisioned on the congested Frame Relay Module (see formula below). The following buffer threshold values (water marks) are monitored by each Frame Relay Module in order to identify the "worst offenders" during congestion for possible frame discard:

$$\text{Port High Water Mark} = \frac{\text{Operating Line Speed of FRS Access Link}}{\text{? FRS Access Link Operating Line Speed}} \text{ X (Total Buffer Capacity)}$$

In addition to the allocation of buffer capacities to each FRS Access Link, the following buffer threshold values (water marks) are monitored by each Frame Relay Module in order to identify the "worst offenders" during congestion for possible frame discard:

Ingress Port High Water Mark = 75% of minimum Port Buffer Capacity

Egress Port High Water Mark = 25% of minimum Port Buffer Capacity

Allocation of PVC Buffer Capacities

During congestion, based upon the port buffer allocation process described in the previous subsection, the Frame Relay Module will determine which PVC most exceeds its Ingress High Water Mark. The allocation of the buffer capacities for each individual PVC is based on the CIR value requested at service subscription time. *The "Equivalent CIR" values of existing QWEST Frame Relay Customers will be converted to actual CIR values.* The following PVC buffer threshold values (water marks) are monitored by each Frame Relay Module in order to identify the "worst offenders" during congestion for possible frame discard:

$$\text{Ingress DLCI High Water Mark} = 1.5 \times \frac{\text{CIR} \times (\text{Ingress Port High Water Mark})}{\text{FRS Access Link Operating Line Speed}}$$

$$\text{Egress DLCI High Water Mark} = 1.5 \times \frac{\text{CIR} \times (\text{Egress Port High Water Mark})}{\text{FRS Access Link Operating Line Speed}}$$

$$\text{Ingress DLCI Low Water Mark} = 2/3 \times \text{Ingress DLCI High Water Mark}$$

$$\text{Egress DLCI Low Water Mark} = 2/3 \times \text{Egress DLCI High Water Mark}$$

If the calculated Ingress/Egress Data Link Connection Identifier (DLCI) High Water Mark value is less than 10% of the respective High Water Mark, the Ingress/Egress DLCI value automatically becomes the 10% of the respective High Water Mark.

Setting of FECN and BECN Bits by the QWEST Frame Relay Network

Explicit network notification bits (i.e., FECN and BECN) will be provided as a network congestion avoidance mechanism in a CIR environment. The FECN and BECN bits will be set to "1" by the QWEST Frame Relay Network when a particular DLCI exceeds the greater of the following two buffer threshold values:

- Ingress/Egress DLCI High Water Mark.
- 10% of the port's ingress/egress high water mark.

CIR Frame Discard based on DE Bit

In a CIR environment, the Frame Relay Port(s) will not modify the DE bit within a PVC's frame(s) whose value is set to "1". However, the DE bit of a given PVC's frame(s) may be set to "1" if excess burst frames exist. During the state of congestion, frames which have the DE bit set to "1" by the network may be discarded if the associated DLCI for the PVC is determined to be the "worst offender".

While determining the "worst offending" DLCI, each Frame Relay Module creates and maintains a list of DLCIs which are waiting to transmit frames with the DE bit set to "1". A list of frames whose DE bit is set to "1" is maintained by the Frame Relay Module. These frames will be discarded during congestion in preference to those frames which do not have the DE bit set to "1".

QWEST Frame Relay CIR Discard Scheme

The Frame Relay Module will enter into a state of congestion if the fill capacity of the buffer exceeds 76%. During normal operation, the Frame Relay Module will monitor the buffer fill capacity in order to determine if sufficient buffers are available to process frames received from the FRS Access Link or the Frame Relay Node backplane. In the event that the Frame Relay Module does not have sufficient buffer capacity to process the current frame, the Frame Relay Module determines the buffer capacity required in order to alleviate the congestion status.

Based on the buffer threshold values discussed in the preceding subsections, the Frame Relay Module proceeds to determine the cause for congestion. Only during congestion will the Frame Relay Module enforce the buffer threshold values (water marks) for that particular module. Exhibit 6-1 provides a description of how the Frame Relay Module determines the cause for congestion and identifies the "worst offender". As indicated in Exhibit 6-1, the Frame Relay Module will examine the ingress traffic before the egress traffic.

If during the examination of the port buffer threshold values (water marks), the Frame Relay Module identifies a port which has exceeded its port buffer threshold value (i.e., Ingress and Egress Port High Water Mark), the process of identifying the "worst offending" DLCI for that specific port is initiated. This process of identifying the "worst offending" DLCI for ingress and egress frames is described in Exhibit 6-2 and 6-3, respectively.

6.4.2 Second Variation of Network Congestion Control Procedures in a CIR Environment

Congestion Control consists of several components: Rate Enforcement, Congestion Avoidance and Congestion Recovery. These are used together to provide prevention of and recovery from congestion.

Rate Enforcement

Rate enforcement conforms to ANSI T1.606 Addendum #1 and is based on the "leaky bucket" algorithm. Rate enforcement is implemented on a per DLCI basis on user links in ingress switches. As data is received over time interval T, a determination is made as to whether the frame is under the committed burst size (Bc), over the committed burst size but under the excess burst size (Bc+Be), or over the excess burst size.

Frame Discard Eligible (DE) marking is handled in the following manner:

Table 6-2 Frame Marking for Congestion Control

Number of Bits Received During Current Time Interval (Including Current Frame)	Frame Handling
less than Bc	Never discard except under extreme circumstances (i.e., node or link failure)
greater than Bc, less than Bc+Be	Forwarded with DE bit set
greater then Bc+Be	Immediately discarded

As the marked frames travel through the network, congested nodes that must discard packets use the designations to determine which frames to discard.

Two counters are maintained for each DLCI on each user link. Bc_cnt is the number of committed bits allowed during the current time interval. Be_cnt is the number of uncommitted bits allowed during the current time interval. A time interval is 1 second and it measured by a continuously running 1 second timer started when the switch is initialized. Bc_cnt and Be_cnt are initialized to the Bc and Be, respectively, set for each user DLCI. In addition, two adjustment variables, Bc_adj and Be_adj, are defined for each user DLCI and set to Bc*(1/T) and Be*(1/T), respectively. These values represent the number of committed and uncommitted bits allowed during any one second interval and are used when readjusting Bc_cnt and Be_cnt during each timer expiration.

Each time a frame is received by an ingress node, the following algorithm is used to update the counters. Note that frames received with the DE bit already set are always counted against Be and frame marking for each step is handled as indicated in Table 6-2.

- If the DE bit isn't set and the number of bits received is less than Bc_cnt, decrement Bc_cnt by the number of bits in the frame.
- If step 1 doesn't apply, then if the number of bits received is less than Be_cnt, decrement Be_cnt by the number of bits in the frame.
- If steps 1 and 2 don't apply, the frame is over the excess burst size and the counters are unaffected.

For each timer expiration, the Bc_cnt and Be_cnt of each user DLCI is updated as follows:

- Bc_cnt = min(Bc, Bc_cnt+Bc_adj)
- Be_cnt = min(Be, Be_cnt+Be_adj)

Congestion Avoidance

As data travels through the network and is queued for transmit, the state of each transmit queue is checked for pending congestion. A time averaged average queue length (AQL) algorithm is executed each time a frame is queued for transmit and the AQL is calculated and compared against a pre-calculated threshold. The threshold is calculated such that when the AQL is less than or equal to the threshold, maximum throughput and minimum delay is achieved. If the AQL exceeds the threshold, the state of the link is considered mildly congested. In this state, congestion avoidance procedures are invoked to reduce the flow of data into the network so that the AQL can return to a value less than or equal to the threshold. The following steps are taken when mildly congested:

- All frames with DE bit set because they were over the excess burst size are discarded.
- All frames transmitted on the mildly congested link are marked with the FECN bit.
- All frames received on the mildly congested link are marked with the BECN bit before being forwarded out another link.

The average queue length (AQL) algorithm implemented is used to detect the point at which increasing the load on a link causes little if any increase in throughput but significant increases in delay. It's at this point that the user must decrease its offered load to alleviate the pending congestion. The AQL algorithm reflects a stable condition of the queue length by using time averaging, and hysteresis calculation.

Congestion Recovery

The actual depth of each transmit queue is monitored each time a frame is queued for transmit. If the actual queue size is greater than a second pre-determined threshold (greater than the AQL threshold), the state of the link is considered severely congested. When in this state, the following steps are taken:

- FECN and BECN bits are set as described in the previous section.
- All incoming packets with the DE bit set are discarded.

If the actual queue length reaches another pre-determined threshold (greater than the thresholds for mild and severe congestion), there's no room on the queue for any packets, regardless of the type. In this absolutely congested state, the following steps are taken:

- BECN bits are set.
- All incoming packets are removed from the transmit queue down to the level of the second threshold. Frames are removed starting from the lowest priority (priority 3) to the highest priority (priority 1).

In a network that is designed so that there is enough bandwidth to support the committed rates and bursts, this state should only be reached in the event of link or node failures.

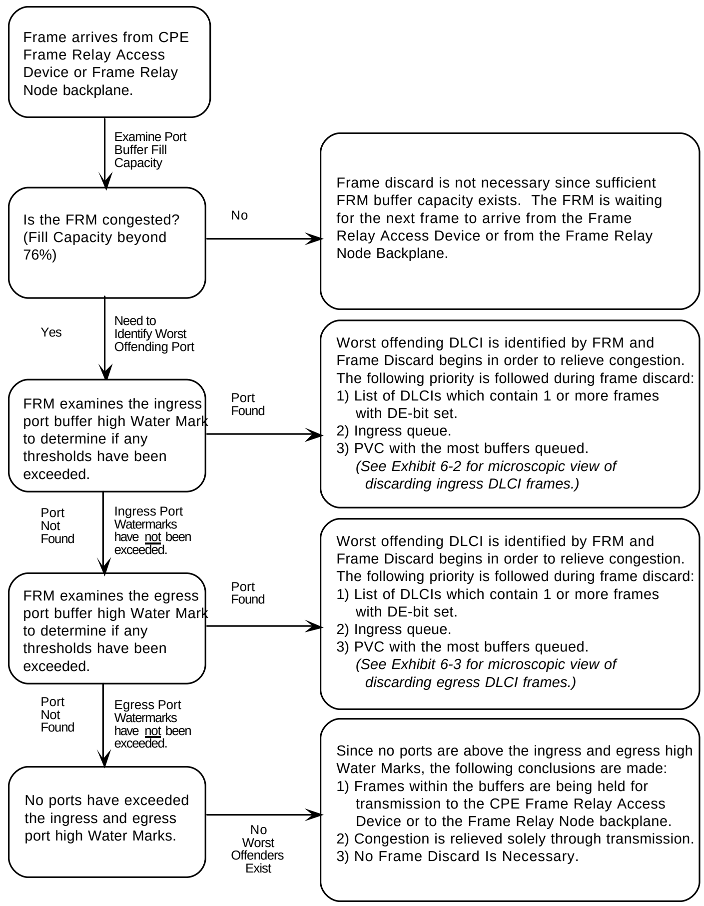


Exhibit 6-1 Process of Examining of Port Buffer Capacities (Variation 1)

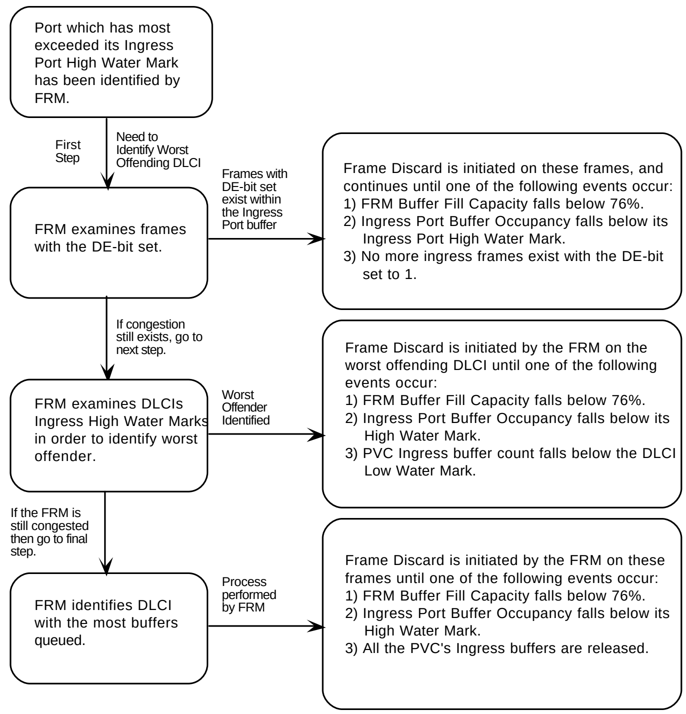


Exhibit 6-2 Process of Examining of Ingress Buffer Capacities (Variation 1)

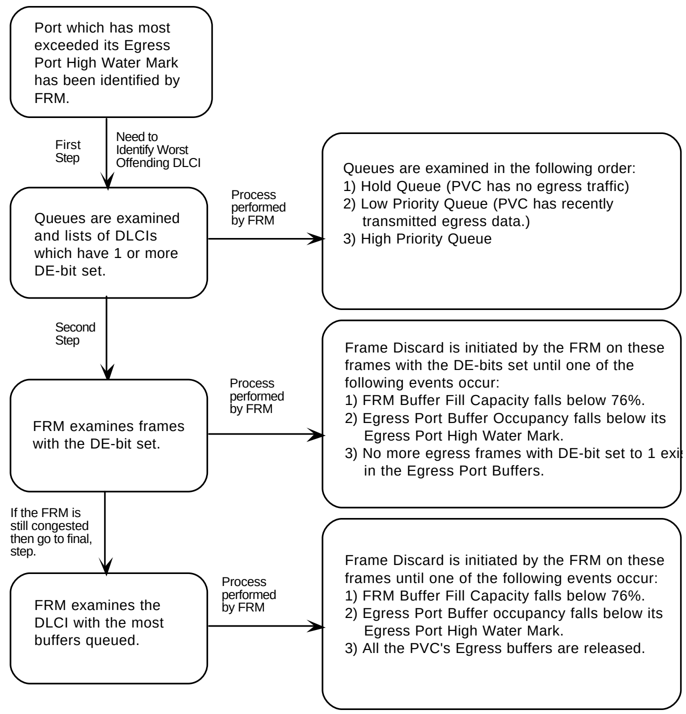


Exhibit 6-3 Process of Examining of Egress Buffer Capacities (Variation 1)

CONTENTS

Chapter and Section **Page**

Tables

7. Performance Specifications

7.1 General

This section describes the service objectives and transmission requirements for QWEST Frame Relay Service.

7.2 Objectives

7.2.1 Availability

The availability objective for QWEST Frame Relay Service is 99.9%. The availability of a service is a measure of the time the service is usable by a customer. The availability is expressed as a percentage the service is performing in accordance with the service performance objectives over an average 12-month period. This percentage may be expressed as:

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

The total time is 12 months and the outage time is expressed in similar units.

The service performance objectives for QWEST Frame Relay Service are shown in Table 7-1. The proceeding section describes the service performance parameters of Table 7-1.

7.3 Performance Parameters Definitions

The following definitions describe the applicable performance parameters:

- Frame Relay Protocol Data Units (PDUs) Not Delivered - Ratio of the number of lost PDUs to the total number of PDUs delivered across the Frame Relay User-to-Network Interface or the Frame Relay Network-to-Network Interface (FR_UNI/NNI).). Only PDUs submitted to the FR_UNI/NNI in compliance with the negotiated Committed Information Rate (CIR) are considered in this calculation. Lost PDUs include those PDUs that are discarded by the receiving Customer Provided Equipment (CPE) as a result of error detected in the PDU. PDUs that are not delivered as a result of conditions that are not the fault of the network, such as discards due to error detection in the PDUs by the network, or discards due to traffic enforcement are excluded from this error ratio.
- Errored Frame Relay PDUs - Ratio of errored PDUs delivered across the FR_UNI/NNI to the sum of errored and correct PDUs delivered across the FR_UNI/NNI. Only PDUs submitted to the FR_UNI/NNI in compliance with the negotiated Committed Information Rate (CIR) are considered in this calculation. An errored PDU is defined as a PDU with one or more bits in error, or one with one or more missing or extra bits. Errored PDUs do not include PDUs that are discarded by the network or the receiving CPE, as a result of error detection in the frame relay access protocol (ANSI T1.618-1991, "ISDN - Core Aspects of Frame Protocol for Use

with Frame Relay Bearer Service").

Note: Based on PDU size of 1600 octets.

- Mis-delivered Frame Relay PDUs - The ratio of mis-delivered PDUs to the total number of PDUs delivered across a FR_UNI/NNI. This objective establishes the maximum allowable inaccuracy, on a network end-to-end basis, of the routing elements in the network, originating from hardware and software malfunctions.
- Duplicated Frame Relay PDUs - Ratio of duplicated PDUs to the total number of PDUs delivered across the FR_UNI/NNI. Duplicated PDUs that are caused by user actions such as retransmission are excluded from this error rate.
- Mis-sequenced FR PDUs - Probability that a PDU received across the FR_UNI/NNI is mis-sequenced.
- PDU Delay - The time elapsed between emission of the first bit of a PDU at the originating FR_UNI/NNI to the receipt of the last bit of the same PDU at the destination FR_UNI/NNI. The delay objectives specified in Table 7-1 are based on the following assumptions:
  - # of Frame Relay Nodes : 2
  - Frame Relay Node delay : .65 ms
  - PDU size : 1000 octets
  - Internodal speed : 1.544 Mbit/s

Table 7-1 QWEST Frame Relay Service Performance Requirements

Performance Parameters	QWEST Service Objective
PDUs Not Delivered	< 10 exp -4
Errored PDUs	< 10 exp -6
Mis-Delivered PDUs	< 5x10 exp -8
Duplicated PDUs	< 1x10 exp -9
PDU Transmit Delay - 64 kbit/s	< 265.8 ms*
PDU Transmit Delay - 56 kbit/s	< 301.3 ms*
PDU Transmit Delay - 1.544 Mbit/s	< 25.8 ms*
PDU Transmit Delay - 45 Mbit/s	< 17.2 ms*
Availability	99.9% (12 months)

* This delay objective is specified in the form of an end-to-end transit PDU delay. These delays include both CPE ingress and egress delays which are discussed on the following page. The total delay attributed to the QWEST Frame Relay Network is (based on the delay objectives assumptions) = 28.5 ms.

CPE Ingress and Egress delays are calculated as follows:

$$\text{CPE Ingress/Egress Delay} = \frac{\text{PDU Size (kbit/s)}}{\text{Access Rate (i.e., 56 kbit/s, 64 kbit/s, 1.544 Mbit/s and 44.736 Mbit/s)}}$$

CPE ingress and egress delays are attributed to the CPE Frame Relay Access Device which serializes and interleaves the PDU into a FRS Access Link operating at the access rates supported by QWEST Frame Relay Service. The CPE egress and ingress delays encountered with the access rates supported by QWEST Frame Relay Service are shown in Table 7-2.

Table 7-2 CPE Ingress/Egress Delay with Access Rates

ACCESS RATE	CPE INGRESS DELAY	CPE EGRESS DELAY
56 kbit/s	143 ms	143 ms
64 kbit/s	125 ms	125 ms
1.544 Mbit/s	5 ms	5 ms
44.736 Mbit/s	.2 ms	.2 ms

CONTENTS

Chapter and Section **Page**

8. Maintenance

8.1 Customer Responsibilities

The customer is responsible for all equipment and cable beyond the Network Interface (NI) at their location. The physical connector at the NI will be one of the following jacks: RJ48S, RJ48T, RJ48C, RJ48H, RJ48M, or equivalent.

In the case of service trouble, the customer or their responsible agent is responsible for sectionalizing the trouble, and verifying that the trouble is not in the customer owned equipment or cable before calling the Customer Service Center.

In order for QWEST to provide a state of the art frame relay network, maintenance and upgrades for Frame Relay Service nodes will be required. The customer will be required to allow QWEST to perform necessary maintenance. QWEST will notify customer via a written notice or telephone contact to affected customers prior to a maintenance date.

If the service trouble is isolated to the customer owned equipment or cable, the customer or its responsible agent is responsible for clearing the trouble and restoring the service to normal operation.

In the case of degraded service (e.g., discarded frames, excessive frame transmission delay), the customer should contact the Customer Service Center at 1-800-227-2218.

Joint testing between the customer and/or its responsible agent, and QWEST personnel may sometimes be necessary to isolate the trouble.

For Frame Relay Fractional Port Access, QWEST will utilize 64 kbit/s maintenance signals per ANSI T1.107-1995 in order to test the individual 56/64 kbit/s channels that comprise the Fractional Port Access channel. The customer provided equipment that supports multiple Fractional Port Access Connections within a 1.544 Mbit/s access link should invoke a Latching Loopback (LLB) in response to the CSU/DSU LLB sequences. For customer provided equipment that supports only a single Frame Relay Fractional Port Connection, a 1.544 Mbit/s CSU loopback may be substituted.

Upon receipt of a LLB code sequence detected on any single 56/64 kbit/s channel within a contiguous 56/64 kbit/s channel, each 56/64 kbit/s channel which comprises the fractional channel should loopback. Hence, testing of the frame relay fractional access port can be accomplished without affecting any other channels within the 1.544 Mbit/s access link.

8.2 QWEST Responsibilities

QWEST is responsible for all equipment and cable on the QWEST side (i.e., network side) of the NI at the customer location, and also for maintaining the transmission facility between customer locations, and between the Central Office Hub and the customer location.

QWEST will furnish the customer a trouble reporting telephone number, and will commit to a two (2) hour maximum service restoral time in the event of a service interruption due to an electronic component failure. If the trouble is caused by a cable failure, the maximum service restoral time will be eight (8) hours. The maximum service restoral time in the event of a node failure is two and a half (2.5) hours.

Fault Tolerant PVC is committed to a 30-minute turn around upon customer notification unless the notification is due to trouble on the QWEST side of the NI. In this case the above-mentioned intervals apply.

CONTENTS

9. Definitions

9.1 Acronyms

AMI	Alternate Mark Inversion
ANSI	America National Standards Institute
AT&T	American Telephone and Telegraph
B8ZS	Bipolar with 8 Zero Substitution
Bc	Committed Burst Size
Be	Excess Burst Size
BECN	Backward Explicit Congestion Notification
Bellcore	Bell Communications Research, Inc.
BTV	Buffer Threshold Value
CCITT	Consultative Committee on International Telephone and Telegraph
CIR	Committed Information Rate
CNM	Customer Network Management
CO	Central Office
CPE	1) Customer Provided Equipment 2) Customer Premises Equipment
CSU	Channel Service Unit
CTS	Clear to Send
DCS	Digital Cross-Connect System
DDS	Digital Data Service
DE	Discard Eligible
DLCI	Data Link Correction Identifier
DS1	Digital Signal Level 1 (1.544 Mbit/s)
DS3	Digital Signal Level 3 (44.736 Mbit/s)
DS0	Digital Signal Level 0 (64 kbit/s) (1 voice channel)
DSU	Data Service Unit
DSX	Digital Signal Cross-connect
DTE	Data Terminal Equipment

EC	Exchange Carrier
ESF	Extended Super Frame
EU	End-User
EU-POT	End-User-Point of Termination
FCC	Federal Communications Commission
FCS	Frame Check Sequence
FECN	Forward Explicit Congestion Notification
FRS	Frame Relay Service
IC	Interexchange Carrier
IC-POP	Interexchange Carrier-Point of Presence
IGRP	Interior Gateway Routing Protocol
IPX	Internetwork Packet Exchange
ISDN	Integrated Services Digital Network
ITU	International Telecommunications Union
ITU-T	ITU Telecommunications Sector
LAN	Local Area Network
LAPB	Link Access Procedure- Balanced
LAPD	Link Access Procedure D
LATA	Local Access and Transport Area
LEC	Local Exchange Carrier
LMI	Local Management Interface
MDF	Main Distributing Frame
MUX	Multiplexer
NC	Network Channel
NCI	Network Channel Interface
NI	Network Interface
NMS	Network Management System
NNI	Network-to-Network Interface
OSI	Open Systems Interconnection

PDU	Protocol Data Unit
POP	Point Of Presence
POT	Point Of Termination
PVC	Permanent Virtual Circuit
RIP	Routing Information Protocol
RTS	Request-To-Send
SF	Superframe Format
SHARP	Self-Healing Alternate Route Protection
SHNS	Self-Healing Network Services
SNA	System Network Architecture
SST	Synchronous Service Transport
SWC	Serving Wire Center
Tc	Measurement Interval
TCP/IP	Transmission Control Protocol/Internet Protocol
TLP	Transmission Level Point
UNI	User-Network Interface
VLSI	Very Large Scale Integration
WAN	Wide Area Network

9.2 Glossary

Alternate Mark Inversion (AMI)

A one (mark) pulse which is the opposite polarity as its predecessor.

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.

Availability

The relative amount of time that a service is "usable" by a customer, represented as a percentage over a consecutive 12 month period.

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 system is designed to operate.

Bc - Committed Burst Size (bits)

The maximum amount of subscriber data that the network agrees to transfer, under normal conditions, during a time interval Tc.

Be - Excess Burst Size (bits)

The maximum amount of uncommitted data in excess of Bc that the network will attempt to transfer during a time interval Tc.

Bipolar With 8 Zero Substitution (B8ZS)

Bipolar 8 Zero Substitution is an application of BPRZ and is an exception to the Alternate Mark Inversion (AMI) line-code rule. It is one method of providing bit independence for digital transmission by providing a minimum 1s density of 1 in 8 bits.

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.

Bits/second (bit/s)

Bits per second, e.g., 1200 bit/s. In data transmission, it is the number of binary zero and one bits transmitted in 1 second. Modern terminology uses "bit/s" e.g., 1200 bit/s.

Bit Error Rate (BER)

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

Buffer Threshold Value (BTV)

This value represents the buffer capacity allocated, at any given instant in time, for each congested Frame Relay Port.

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.

Central Office (CO)

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

Central Office Connecting Channel (COCC)

A tariff rate category which provides for connections, within the same Hub wire center, between the Private Line Transport Channel and other services provided by U S WEST. See FCC #5 for more information.

Channel

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

Channel Service Unit (CSU)

This unit provides regeneration of the signal received from the network, controls the pulse shape and amplitude for transmission of the signal into the network, and possibly provides loop-back. the CSU function is frequently found within a Data Service Unit (DSU).

Committed Information Rate (CIR) bit/s

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

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 U S WEST 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.

Cyclic Redundancy Check (CRC)

A method of checking the integrity of received data, where the check uses a polynomial algorithm based on the content of the data.

Data Communications Equipment (DCE)

The equipment that provides the functions required to establish, maintain and terminate data transmission connections; e.g., a modem, as well as the signal conversion and coding required for communications between data terminal equipment and data circuit.

Data Link Connection Identifier (DLCI)

The DLCI is located within the address field of a frame relay packet, and is used to identify each PVC.

Data Service Unit (DSU)

Digital, customer premises equipment used to recover timing from a baseband BPRZ signal, and which converts from BPRZ line signals to a business machine interface signal such as V.35. At 64 kbit/s and below, DSU and Channel Service Unit (CSU) functions are, in modern equipment, combined in a single unit sometimes called a General Service Unit (GSU), Basic Service Unit (BSU) or Data Service Unit-A (DSU-A) so that it is part of the Data Communications Equipment (DCE). Above 64 kbit/s, DSU functions are frequently contained in the Data Terminal Equipment (DTE). the DSU usually contains circuitry to recognize, and respond to, loop-back commands from the serving test center.

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 (NTCE), e.g., a computer or a PBX.

Data Terminal Ready (DTR)

An EIA or CCITT defined control signal that indicates to the Data Terminal Equipment (DTE) that the Data Communications Equipment (DCE) is ready to transmit or receive data.

Destination Address

An 8-octet field contained within the Level 3 Protocol Data Unit which identifies a specific end point of the destination SNI.

Digital Cross-Connect System (DCS)

An intelligent (processor controlled) digital terminal that provides the capability to perform electronic cross-connects on digital channels operating at or below the bit rate of the transport systems terminated on the unit. This unit may also provide other features, e.g., bridging.

Digital Hierarchy Level

The level in the digital hierarchy. The levels and the respective bit rates are:

Level	Bit Rate	Level	Bit Rate
DS0	64.0 kbit/s	DS3	44.736 Mbit/s
DS1	1.544 Mbit/s	DS4NA	139.264 Mbit/s
DS1C	3.152 Mbit/s	DS4	274.176 Mbit/s
DS2	6.312 Mbit/s		

Discard Eligibility (DE) Indicator bit

A single bit located within the address field of a frame relay packet which is used to indicate that a frame should be discarded in preference to other frames during a frame discarding process.

Diversity

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

End-User (EU)

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.)

End-User POT (EU-POT)

The Network Interface at the end-user's premises at which U S WEST Communication, Inc.'s responsibility for the provision of service ends.

Extended Superframe (ESF) Format

An Extended Superframe consists of twenty-four consecutive DS1 frames. Bit one of each frame (the F-bit) is time shared during the 24 frames to describe a 6 bit frame pattern, a 6 bit Cyclic Redundancy Check (CRC) remainder, and a 12 bit data link. The transfer rate of each is 2 kbit/s, 2 kbit/s, and 4 kbit/s respectively.

Facilities

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

Flow Control

The function of managing the rate at which data is received / transmitted by a receiver / transmitter.

Frame Relay Access Link

A Frame Relay access channel used to access the designated geographical U S WEST Frame Relay Service Serving Area.

Frame Relay Module

A plug-in of a Frame Relay Node / Concentration Node which contains multiple Frame Relay Ports.

Frame Relay Port

A termination point on the Frame Relay Node for the FRS Access Link(s).

Frame Relay Fractional Port

A termination point for a fractional channel comprised of contiguous 56 / 64 kbit / s channels that are provisioned within a FRS 1.544 Mbit / s Access Link.

Integrated Services Digital Network (ISDN)

A network providing or supporting a range of telecommunications services that provides digital connections between end-users.

Interior Gateway Routing Protocol

An interior gateway protocol developed by Cisco Systems to exchange routing information within an autonomous system.

Interexchange Carrier (IC)/(IEC) or Interexchange Common Carrier

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.

Internetwork Packet Exchange (IPX)

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

Kilobit/Second (kbit/s)

One thousand (1000) bits / second

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)

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

Loopback

An out-of-service test procedure applied to a full duplex channel that causes a received signal to be returned to the source.

Megabit per Second (Mbit/s)

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

Multicast

When applies to the U S WEST Frame Relay Service, the functionality which supports the transport of multiple duplicate frames from a single location to multiple end-user locations within the U S WEST Frame Relay Serving Area.

Multiplexer (Mux)

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.

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 (5) interface elements located at a Point of Termination (POT) at a central office or at the Network Interface at a customer location. The Interface 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 point of demarcation on the customer's premises at which U S WEST's responsibility for the provision of service ends.

Octet

An eight (8) bit byte

Packet

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

Packet Switched Network

A switched network which provides connection for forwarding standard data packets between user parties.

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 U S WEST provides access service.

Point of Termination (POT)

The physical telecommunications interface that establishes the technical interface, the test point(s), and the point(s) of operational responsibility. (See Network Interface).

Point-To-Point

A circuit connecting two (and only two) points.

Port

A place at which energy or signals enter or leave a device, circuit, etc.

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.

Protocol Data Unit (PDU)

An International Standards Organization (ISO) term referring to a packet of information exchange between two entities via a protocol.

Redundant Route

Places the same customer services over two separate routes.

Request to Send (RTS)

An EIA or CCITT defined interface control signal that indicates the Data Terminal Equipment (DTE) has data to transmit and conditions the Data Communications Equipment (DCE) to transmit data to the network.

Route

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

Routing Information Protocol

An interior gateway protocol used to exchange routing information within an autonomous system.

Serving Area

Geographic Area which is normally provided telecommunications services via one Wire Center.

Serving Wire Center

The term "Serving Wire Center" denotes a U S WEST Central Office 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.

Signaling

The transmission of information to establish, monitor, or release connections and/or provide Network Control.

Stand Alone Access Link

An access link which is used to provide access to another service provider(s) frame relay network.

Superframe Format (SF)

A superframe consists of 12 consecutive DS1 frames. Bit one of each frame (the F-bit) is used to describe a 12-bit framing pattern during the 12 frames.

System Network Architecture (SNA)

IBM reference model.

Tc - Committed Rate Measurement Interval(s)

A time interval for which the subscriber's committed information rate is measured. The formula used to calculate Tc is: Tc=Bc/CIR.

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 Level 3, TCP to OSI Layer 4 and 5.

Transmission Level Point (TLP)

A point in a transmission system at which the ratio, usually expressed in decibels, of the power of a test signal at that point to the power of the test signal at a reference point, is specified. For example, a zero transmission level point (0TLP) is an arbitrarily established point in a communication circuit to which all relative levels at other points in the circuit are referred.

Trunk

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

X.25 Protocol

CCITT protocol recommendation, which specifies how user data terminal equipment should interface with data circuit-terminating equipment for packet-switched networks. Includes Open System Interconnection (OSI) layers 1-3 functionality.

CONTENTS

Chapter and Section **Page**

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