# Service Level Definitions Implementation Agreement

# FRF.13

Frame Relay Forum Technical Committee
August 4, 1998

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**Editor:**

**Kenneth Rehbehn**
**Visual Networks**

**For more information contact:**

**The Frame Relay Forum**
Suite 307
39355 California Street
Fremont, CA 94538 USA

Phone:  +1 (510) 608-5920
FAX:     +1 (510) 608-5917
E-Mail:  frf@frforum.com
WWW:  http://www.frforum.com

# Table of Contents

# List of Tables

# List of Figures

## Revision History

| Version | Change | Date |
|---------|--------|------|
| FRF.13 | Document Approved | August 4, 1998 |

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# 1   Introduction

## 1.1   Purpose

Frame relay service offerings are available from a wide variety of network service providers.  Each provider describes the offering by specifying user information transfer parameters.  End-users of frame relay services utilize these parameters to:

- Compare different frame relay network service providers,

- Measure the quality of specific frame relay service offerings, and

- Enforce contractual commitments.

Network service providers and equipment vendors also utilize these parameters to plan, describe, and evaluate frame relay products and service offerings.

This document establishes a Frame Relay Forum Implementation Agreement on the definitions of transfer parameters that describe frame relay service performance.  These parameters are suitable for reference by network Service Level Agreement (SLA) documents established between the network service provider and the customer.  They also are suitable for reference by SLA documents established between network service providers.  These parameters may be applied to the information transfer phase of PVC or SVC implementations and services.

The definitions of these parameters reflect common industry practice. Where appropriate, the principles documented in ITU Recommendation X.144, <u>User Information Transfer Performance Parameters for Data Networks Providing International Frame Relay PVC Service</u>, are applied.  The frame relay service is described in [2], [3], [4], [5], [6], [7], [8] and [9].

The parameters address the following characteristics of frame relay service:

- Frame transfer delay,

- Frame delivery ratio,

- Data delivery ratio, and

- Service availability.

The focus of this agreement is the definition of these parameters. An implementation or service may claim compliance to this agreement when the following conditions are met:

 a) Whenever any of the parameters identified in Section 1.3 are referenced, they are used as defined within this agreement, and

 b) Whenever any of the parameters identified in Section 1.3 are referenced, all applicable requirements of the appropriate section of this agreement are met.

This IA is organized as follows:

- Section 2 defines a reference model that provides a basis for performance parameter definition.

- Section 3 defines VC frame-based delay parameters,

- Section 4 defines VC frame-based delivery ratio parameters,

- Section 5 defines VC data delivery ratio parameters,

- Section 6 defines VC service availability parameters, and

- Appendix A and Appendix B to provide additional information.

## 1.2   Definitions

**Must**, **Shall**, or **Mandatory** — the item is an absolute requirement of the implementation agreement.

**Should** — the item is highly desirable.

**May** or **Optional** — the item is not compulsory and may be followed or ignored according to the needs of the implementor.

## 1.3   Terminology

**Frame Transfer Delay (FTD)** — Refer to Section 3 for definition.

**Frame Delivery Ratio (FDR, FDR$_c$, FDR$_e$)** — Refer to Section 4 for definition.

**Data Delivery Ratio (DDR, DDR$_c$, DDR$_e$)** — Refer to Section 5 for definition.

**Service Availability (FRVCA, FRMTTR, FRMTBSO)** — Refer to Section 6 for definition.

## 1.4   Acronym List

| | |
|---|---|
| ACS | Access Circuit Section |
| ANS | Access Network Section |
| B$_e$ | Excess Burst |
| CIR | Committed Information Rate |
| CPE | Customer Premises Equipment |
| DDR | Data Delivery Ratio |
| DesRP | Destination Reference Point |
| DLCI | Data Link Connection Identifier |
| DTE | Data Terminal Equipment |
| EqiRP | Egress Queue Input Reference Point |
| EqoRP | Egress Queue Output Reference Point |
| FCS | Frame Check Sequence |
| FDR | Frame Delivery Ratio |
| FO | Fault Outage |
| FRMTBSO | Frame Relay Mean Time Between Service Outages |
| FRMTTR | Frame Relay Mean Time to Repair |
| FRVCA | Frame Relay Virtual Connection Availability |
| FTD | Frame Transfer Delay |
| IA | Implementation Agreement |
| ICS | Internetwork Circuit Section |
| IngRP | Ingress Reference Point |
| L1 | Layer 1 – Physical Layer of OSI Reference Model |

| L2 | Layer 2 – Link Layer of OSI Reference Model |
|----|----|
| kbps | kilobits per second |
| Mbps | Megabits per second |
| OA&M | Operations, Administration, and Maintenance |
| PVC | Permanent Virtual Connection |
| SLA | Service Level Agreement |
| SrcRP | Source Reference Point |
| SVC | Switched Virtual Connection |
| TNS | Transit Network Section |
| TpRP | Traffic Policing Reference Point |
| UNI | User Network Interface |
| VC | Virtual Connection |

## 1.5    Relevant Standards

The following is a list of standards on which these implementation agreements are based:

[1] X.144 ITU-T. *Recommendation X.144 (1995), User information transfer performance parameters for data networks providing international frame relay PVC service.*

[2] I.122 ITU-T. *Recommendation I.122 (1988), Framework for providing additional packet mode bearer services.*

[3] I.233 ITU-T. *Recommendation I.233 (1991), Frame mode bearer services.*

[4] I.233.1 ITU-T. *Recommendation I.233.1 (1991), ISDN frame relaying bearer service.*

[5] I.370 ITU-T. *Recommendation I.370 (1991), Congestion management for the ISDN frame relaying bearer service.*

[6] X.36 ITU-T. *Recommendation X.36 (1994), Interface between Data Terminal Equipment (DTE) and Data circuit-terminating Equipment for public data networks providing frame relay data transmission service by dedicated circuit.*

[7] X.76 ITU-T. *Recommendation X.76 (1995), Network-to-network interface between public data networks providing the frame relay data transmission service.*

[8] Q.922 ITU-T. *Recommendation Q.922, ISDN Data Link Layer Specification for Frame Mode Bearer Services.*

[9] Q.933 ITU-T. *Recommendation Q.933, ISDN Signaling Specification for Frame Mode Bearer Services.*

[10] NMF 701 Network Management Forum. *Performance Reporting Definitions Document*, Issue 1.0, April 1997.

## 2   Reference Model

This agreement addresses user information transfer performance parameters that apply to a point-to-point frame relay connection (i.e., a VC – either a PVC or the data transfer part of a SVC) section or a concatenated set of connection sections.

### 2.1   Connection Components

Section 4 of X.144 defines the basic component types of an end-to-end connection.  These connection section types are:

- The Access Circuit Section (ACS),

- The Internetwork Circuit Section (ICS),

- The Access Network Section (ANS), and

- The Transit Network Section (TNS).

These sections provide building blocks for representing the structure of any end-to-end connection.  This agreement applies to the uni-directional transfer of user information on either a single section or a series of concatenated sections.

Figure 1 illustrates the sections of a VC established over a single public network.
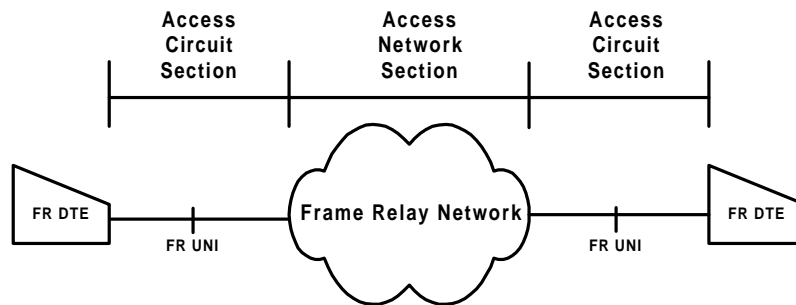


**Figure 1**
**Single public network**

Two public frame relay networks may support service to frame DTEs located in the different networks.  This connection is supported over the frame relay network-to-network interface (NNI) on an internetwork circuit section.  Figure 2 illustrates the sections of a VC established over two public networks.
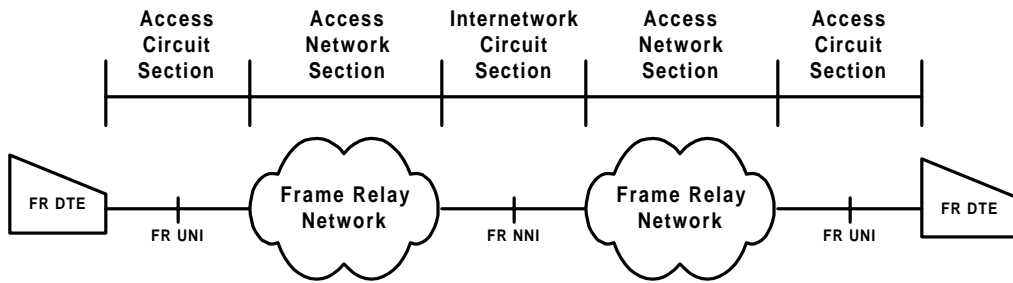
**Figure 2**
**Connection over two public networks**

A connection that is routed via an intermediate transit network is illustrated in Figure 3.
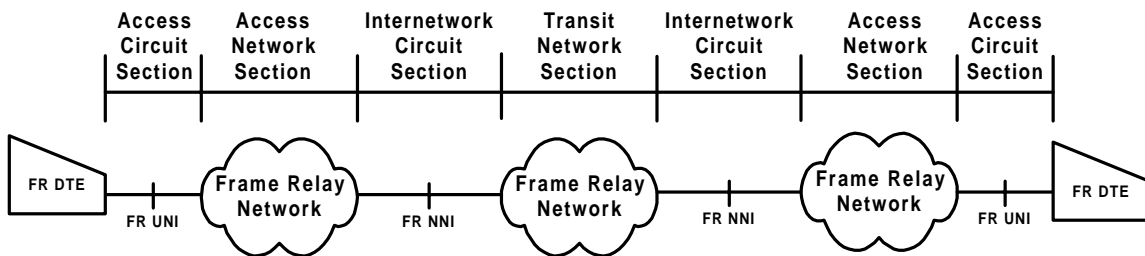


**Figure 3**
**Connection via intermediate transit network**

## 2.2    Frame Transfer Reference Events

In addition to the connection section types, Section 4 of X.144 defines a set of frame transfer reference events. Reference events provide formal definitions of frame exit and entrance.

| | |
|---|---|
| **Frame Entry Event** | Frame enters a network section or end system. The event occurs when the last bit of the closing flag of the frame crosses the boundary. |
| **Frame Exit Event** | Frame exits a network section or end system.  The event occurs when the first bit of the address field of the frame crosses the boundary. |

## 2.3    Connection Path Reference Points

The parameters defined in this document apply between two reference points within the connection path. Figure 4 shows the key components of a connection path for the purposes of this agreement.  Specific reference points used in the calculation of service level definitions are identified in Figure 4.  The connection path reference points identify points to which measurements on a frame are referenced as the frame transits between source and destination.
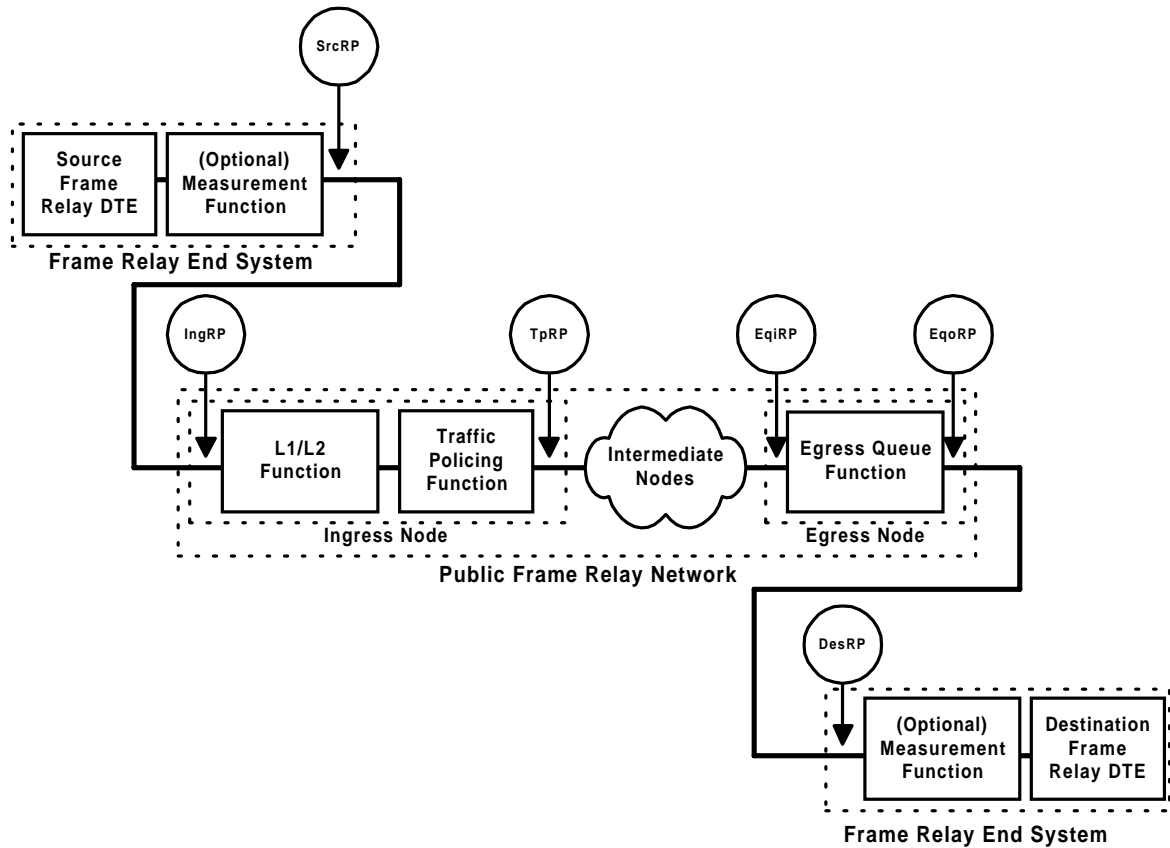
**Figure 4**
**Reference points for calculation of service level definitions**

The functional elements of the connection path are defined as follows:

**Source Frame Relay DTE**                 The DTE originating frame relay traffic.

**Measurement Function**                   A measurement mechanism.  This capability is located in
                                           either external devices (e.g., a probe) or integrated within the
                                           frame relay DTE.  When located in an external device, the
                                           device may be active or passive at the physical and frame
                                           relay layers.

**Public Frame Relay Network**             An abstraction of a public network service offering.  The
                                           offering may be implemented with one, two, or more networks
                                           concatenated using network-to-network interfaces.

**Ingress Node**                           An abstraction of the first public network equipment in the
                                           path of the frame.

**Egress Node**                            An abstraction of the last public network equipment in the
                                           path of the frame.

**L1/L2 Function**                         An abstraction of L1 and L2 processing applied to an
                                           incoming frame.  As an example, frames are discarded at this
                                           point due to FCS errors and invalid addresses.

| | |
|---|---|
| **Traffic Policing Function** | An abstraction of traffic policing functions applied to an incoming frame.  As an example, some network equipment discards frames at this point when traffic exceeds burst excess limitations of the connection. |
| **Egress Queue Function** | An abstraction of a physical interface transmission queue.  All frames for all connections are queued here.  Some implementations support an aggregation of connection CIR commitments in excess of the bandwidth available on an interface (refer to Annex A for additional information).  In such implementations, frames may be discarded by the egress queue function when queue growth exceeds the system's resources. |
| **Destination Frame Relay DTE** | The DTE receiving frames. |

The reference points of the connection path are defined as follows:

| | |
|---|---|
| **Source Reference Point (*SrcRP*)** | Measurement point at source end system. |
| **Ingress Reference Point (*IngRP*)** | Measurement point at the ingress to the ingress node |
| **Destination Reference Point (*DesRP*)** | Measurement point at destination end system. |
| **Traffic Policing Reference Point (*TpRP*)** | Measurement point after L1/L2 and traffic policing functions have processed a frame. |
| **Egress Queue Input Reference Point (*EqiRP*)** | Measurement point prior to interface transmission queue. |
| **Egress Queue Output Reference Point (*EqoRP*)** | Measurement point after interface transmission queue. |

## 2.4   Service Level Definition Measurement Domain

Service level definitions apply to connection sections as described in the applicable service level agreement.  The scope of coverage can include the following measurement domains:

- Edge-to-Edge Interface
- Edge-to-Edge Egress Queue
- End-to-End

The characteristics of measurement domain are described in the following sections.

## 2.4.1   Edge-to-Edge Interface

A service offering may restrict measurement to connection sections for which the carrier has direct control.  Thus, the parameter applies from one edge of a frame relay network cloud to the other edge as shown in Figure 5.  A parameter applied in this fashion is referred to as an "edge-to-edge" interface parameter and is measured between *IngRP* and *EqoRP* reference points.
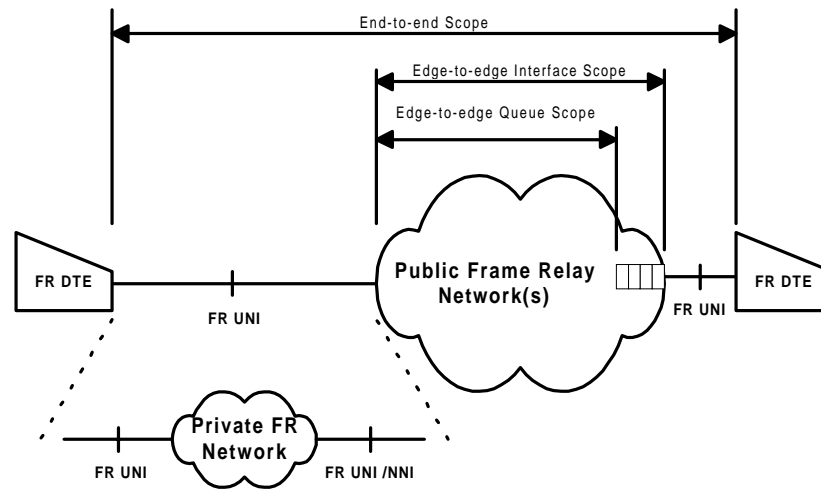
**Figure 5**
**Service level definition reference model**

## 2.4.2   Edge-to-Edge Egress Queue

A service offering may restrict the scope of service level agreements to exclude delay and loss experienced at the destination egress queue.  The destination egress queue experience is excluded to eliminate inclusion of poor service delivery that is beyond the control of the network service provider.  A parameter applied in this fashion is referred to as an "edge-to-edge egress queue" parameter and is measured between *IngRP* and *EqiRP* reference points.

## 2.4.3   End-to-End

A service offering may support measurement of end-to-end connection performance, including the performance of all circuit sections in the path from source frame relay endpoint (*SrcRP*) to destination frame relay endpoint (*DesRP*). A parameter applied in this fashion is referred to as an "end-to-end" parameter. Note that the circuit section between the public frame relay network and the ultimate destination may, for some implementations, transit through one or more intermediate private frame relay networks.

# 3 Delay

## 3.1 Parameter Definition

Frame Transfer Delay parameters report the time required to transport frame relay data through the network. The frame transfer delay service level parameter is the difference in milliseconds between the time a frame exits a source and the time the same frame enters the destination. The formal definition of frame transfer delay is as follows:

$$FTD = t_2 - t_1$$

Where:

$t_1$    is the time in milliseconds when a frame left the source (i.e., frame exit event), and

$t_2$    is the time in milliseconds when a frame arrived at the destination (i.e., frame entry event.

The source and destination locations where delay measurements are made must be specified as part of a service level agreement. Delay measurements may be structured to produce end-to-end, edge-to-edge interface, or edge-to-edge egress queue parameters. For the edge-to-edge egress queue measurement domain the destination arrival time is recorded when the frame arrives at the egress queue function servicing the destination interface.

Table 1 identifies the applicable reference points of Figure 4 for each type of delay measurement.

| Measurement Domain | Source | Destination |
|---|---|---|
| End-to-end | *SrcRP* | *DesRP* |
| Edge-to-edge Interface | *IngRP* | *EqoRP* |
| Edge-to-edge Egress Queue | *IngRP* | *EqiRP* |

**Table 1**
**Locations for delay measurement**

Delay jitter parameters are not addressed in this agreement. Support for delay jitter service level parameters including the associated measurement and aggregation methodologies are for further study.

## 3.2 Measurement Methodology

The mechanism used to perform the measurement of delay is not specified in this agreement. Definition of a frame relay OA&M mechanism that tracks delay is for further study. Mechanisms that depend on a round-trip delay measurement may derive the one-way measurement by dividing a round-trip delay measurement by two.

Delay must be measured using consistent frame sizes. Delay measurements are made using a default 128 octet reference frame (payload without address field or FCS), unless otherwise specified in the service level agreement.

Service level agreements must describe the following:

- measurement domain,
- applicable reference points,
- delay measurement mechanism,
- identification of connections subject to measurement,
- measurement frequency, and
- frame size.

Specification of the delay measurement mechanism may address issues such as:

- the use of specially generated delay measurement frames or the use of customer originated frames and

- the use of special connections dedicated to service level monitoring.

## 3.3    Measurement Aggregation

Service level agreements may aggregate delay measurements. Aggregation may include components such as frequency of delay measurement, the number of connections aggregated, and the time period reported.  Section B.1 provides example delay aggregation mechanisms.

The methodology applied by a service level agreement to aggregate delay measurements is outside the scope of this agreement.

Service level agreements using aggregation must describe the measurement aggregation methodology.  These descriptions must specify how aggregation is processed over the following:

- the object dimension (e.g., on a per VC basis, on an interface basis, on a per customer network basis, etc.), and

- the time dimension (e.g., day, week, month, 24-hour day versus business day, 7-day weeks versus business day weeks, etc.).

# 4   Frame Delivery Ratio

## 4.1   Parameter Definition

The Frame Delivery Ratio (FDR) service level parameter reports the network's effectiveness in transporting an offered frame relay load in one direction of a single virtual connection. The FDR is a ratio of successful frame receptions to attempted frame transmissions.  Attempted frame transmissions are referred to as Frames Offered. Successfully delivered frames are referred to as Frames Delivered.  These loads may be further differentiated as being within the committed information rate or as burst excess.

Three frame relay ratios may be reported:

**FDR**   Frame Delivery Ratio:

$$FDR = \frac{(FramesDelivered_c + FramesDelivered_e)}{(FramesOffered_c + FramesOffered_e)} = \frac{FramesDelivered_{c+e}}{FramesOffered_{c+e}}$$

**FDR$_c$**   Frame Delivery Ratio for load consisting of frames within the committed information rate:

$$FDR_c = \frac{FramesDelivered_c}{FramesOffered_c}$$

**FDR$_e$**   Frame Delivery Ratio for load in excess of the committed information rate:

$$FDR_e = \frac{FramesDelivered_e}{FramesOffered_e}$$

Where,

| | |
|---|---|
| *FramesDelivered$_c$* | Successfully delivered frames within committed information rate, |
| *FramesDelivered$_e$* | Successfully delivered frames in excess of CIR, |
| *FramesDelivered$_{c+e}$* | Successfully delivered total frames, including those within committed information rate and those in excess of CIR, |
| *FramesOffered$_c$* | Attempted frame transmissions within committed information rate, |
| *FramesOffered$_e$* | Attempted frame transmissions in excess of CIR, and |
| *FramesOffered$_{c+e}$* | Attempted total frame transmissions, including those within committed information rate and those in excess of CIR. |

An independent set of frame delivery ratios exists for each direction of a full duplex connection.

## 4.2   Measurement Methodology

The mechanism used to perform the measurement of frame delivery ratio is not specified in this agreement. However, the quantities **FramesDelivered** and **FramesOffered** identified in Section 4.1 are associated with a specified measurement interval and should correspond the same set of frames.  Thus, the received frames counted by **FramesDelivered** correspond to the sent frames counted by **FramesOffered**.  The Frame Relay Forum is studying the definition of a frame relay delivery measurement mechanism using Operations, Administration, and Maintenance (OA&M) frames.

Network implementations may adjust the Frames Offered parameter to eliminate frames from a delivery ratio calculation.  Adjustments may be applied depending on the type of service level agreement: end-to-end or edge-to-

edge.  Figure 6 illustrates a representative sample of adjustments that may apply to the calculation of offered and delivered load.  The specification of internal network mechanisms that perform these adjustments is beyond the scope of this agreement.

Service Level Agreements must describe the following:

- FDR measurement mechanism,

- identification of connections subject to measurement,

- applicable reference points, and

- specific adjustments applied by a network implementation.

Frames dropped due to preemptive congestion alleviation techniques at ingress to network (Note 1)

Frames dropped due to congestion induced transit queue overflow

Frames lost due to unknown causes within (other) transit network(s) (Note 2)

Lost or dropped frames due to network outage

**Total Frames Offered**

**Frames Delivered**

Frames lost due to bad frame length or bad FCS (Note 3)

Frames lost due to CPE induced outage

Frames lost due to congestion at egress queue due to oversubscription (Note 4)

Frames in Excess of $B_c + B_E$

Edge-to-edge:
Frames optionally not counted in Frames Offered
(Note 5)
End-to-end:
Frames counted in Frames Offered

**Figure 6**
**Frame delivery adjustments**

Note 1:  Some network implementations attempt to prevent congestion by discarding traffic as close to the source as possible.  Frames lost as a result of attempts to prevent congestion must be counted as part of the Frames Offered.  These mechanisms are implementation specific and beyond the scope of this agreement.

Note 2:  An example of an unknown cause is when a frame is corrupted and subsequently discarded during transport through a network implementation.

Note 3:  This adjustment is applied to invalid frames received from the customer equipment at *IngRP*. Invalid frames cannot be attributed to the Frames Offered for a specific DLCI.  Implementations must track this loss by incrementing loss counters associated with the interface rather than a virtual connection.

Note 4:  Some network implementations may have the ability to track frame loss due to customer over-subscription[1] of the egress interface. For example, if an egress interface is over-subscribed and queue growth occurs at the egress queue, frames might be discarded at *EqiRP* or some earlier reference point. These mechanisms are implementation specific and beyond the scope of this agreement.

Note 5:  Edge-to-edge service level agreements may include these statistics.

## 4.3   Measurement Aggregation

Service level agreements aggregate frame delivery ratio measurements.  Aggregation may have components that include the number of connections aggregated and the time period reported.  Section B.2 provides example frame delivery ratio aggregation mechanisms.

The methodology applied by a service level agreement to aggregate frame delivery ratios is outside the scope of this agreement.

Service level agreements using aggregation must define the measurement aggregation methodology.  These descriptions must specify how aggregation is processed over the following:

- the object dimension (e.g., on a per VC basis, on an interface basis, on a per customer network basis, etc.), and

- the time dimension (e.g., day, week, month, 24-hour day versus business day, 7-day weeks versus business day weeks, etc.).

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[1] See Section A

# 5    Data Delivery Ratio

## 5.1    Parameter Definition

The Data Delivery Ratio (DDR) service level parameter reports the network's effectiveness in transporting offered data (payload without address field or FCS) in one direction of a single virtual connection. The DDR is a ratio of successful payload octets received to attempted payload octets transmitted.  Attempted payload octets transmitted are referred to as *DataOffered*.  Successfully delivered payload octets are referred to as *DataDelivered*.  These loads are further differentiated as being within the committed information rate or as burst excess.

Three data relay ratios may be reported:

**DDR**    Data Delivery Ratio:

$$DDR = \frac{(DataDelivered_c + DataDelivered_e)}{(DataOffered_c + DataOffered_e)} = \frac{DataDelivered_{c+e}}{DataOffered_{c+e}}$$

**DDR$_c$**    Data Delivery Ratio for load consisting of frames within the committed information rate:

$$DDR_c = \frac{DataDelivered_c}{DataOffered_c}$$

**DDR$_e$**    Data Delivery Ratio for load in excess of the committed information rate:

$$DDR_e = \frac{DataDelivered_e}{DataOffered_e}$$

Where,

| | |
|---|---|
| *DataDelivered$_c$* | Successfully delivered data payload octets within committed information rate, |
| *DataDelivered$_e$* | Successfully delivered data payload octets in excess of CIR, |
| *DataDelivered$_{c+e}$* | Successfully delivered total data payload octets, including those within committed information rate and those in excess of CIR, |
| *DataOffered$_c$* | Attempted data payload octet transmissions within committed information rate, |
| *DataOffered$_e$* | Attempted data payload octet transmissions in excess of CIR, and |
| *DataOffered$_{c+e}$* | Attempted total data payload octet transmissions, including those within committed information rate and those in excess of CIR, |

Each direction of a full duplex connection has a discrete set of data delivery ratios.

Data delivery ratio measurements may not be representative of data delivery effectiveness for a given application. For example, the discarding of a small frame containing an acknowledgement message may result in the retransmission of a large number of data frames.  In such an event, a good data delivery ratio would be reported while the user experienced poor performance.

## 5.2    Measurement Methodology

The mechanism used to perform the measurement of data delivery ratio is not specified in this agreement. However, the quantities *DataDelivered* and *DataOffered* identified in Section 5.1 are associated with a specified measurement interval and should correspond to the same set of frames.  Thus, the received frames included in the count of *DataDelivered* octets correspond to the sent frames included in the count of *DataOffered* octets.  The Frame Relay

Forum is studying the definition of a frame relay data delivery measurement mechanism using Operations, Administration, and Maintenance (OA&M) frames.

Network implementations may adjust the *DataOffered* parameter to eliminate octets from a delivery ratio calculation. Adjustments may be applied depending on the type of service level agreement: end-to-end or edge-to-edge. Refer to Section 4.2 for a representative sample of adjustments that may apply to the calculation of offered and delivered load.

Service Level Agreements must describe the following:

- DDR measurement mechanism,

- identification of connections subject to measurement,

- applicable reference points, and

- specific adjustments applied by a network implementation.

## 5.3   Measurement Aggregation

Service level agreements aggregate data delivery ratio measurements. Aggregation may have components that include the number of connections aggregated and the time period reported. Section B.3 provides example data delivery ratio aggregation mechanisms.

The methodology applied by a service level agreement to aggregate data delivery ratios is outside the scope of this agreement.

Service level agreements using aggregation must define the measurement aggregation methodology. These descriptions must specify how aggregation is processed over the following:

- the object dimension (e.g., on a per VC basis, on an interface basis, on a per customer network basis, etc.), and

- the time dimension (e.g., day, week, month, 24-hour day versus business day, 7-day weeks versus business day weeks, etc.).

# 6   Service Availability

Service availability can be defined on a per-VC basis and/or on a per-port basis.  Frame relay port-based service availability parameters are not addressed in this agreement.  The addition to this agreement of port-based service availability parameters and associated measurement and aggregation methodologies is for further study.

## 6.1   Parameter Definition

The service availability parameters report the operational readiness of individual frame relay virtual connections. Service availability is affected by outages that interrupt the transport of frame relay traffic.  Two types of outages are differentiated:

| | |
|---|---|
| **Fault outages** | Outages resulting from faults in the network and thus tracked by the service availability parameters, and |
| **Excluded outages** | Outages resulting from faults beyond the control of the network as well as scheduled maintenance.  Refer to Table 2 for some possible classifications of failures. |

Service availability may be described using three parameters:

**FRVCA**                    Frame relay virtual connection availability:

$$FRVCA = \frac{IntervalTime - ExcludedOutageTime - OutageTime}{IntervalTime - ExcludedOutageTime} * 100$$

**FRMTTR**                Frame relay mean time to repair for virtual connection when OutageCount > 0:

$$FRMTTR = \frac{OutageTime}{OutageCount}$$

Frame relay mean time to repair for virtual connection when  OutageCount = 0:

$$FRMTTR = 0$$

**FRMTBSO**            Frame relay mean time between service outages for virtual connection when Outage Count > 0:

$$FRMTBSO = \frac{IntervalTime - ExcludedOutageTime - OutageTime}{OutageCount}$$

Frame relay mean time between service outages for virtual connection when OutageCount = 0:

$$FRMTBSO = 0$$

Where,

| | |
|---|---|
| **IntervalTime** | Time in minutes of period that availability is measured |
| **OutageTime** | Aggregate time of all fault outages that occur during the period availability is measured |
| **ExcludedOutageTime** | Aggregate time of all excluded outages that occur during the period availability is measured |

**OutageCount**          Count of all fault outages that occur during the period availability is measured[2]

## 6.2    Measurement Methodology

The mechanisms to determine connection availability are outside the scope of this agreement.  Some examples of how outages may be indicated include:

- VC status change indicated by the status procedures of Q.933 Annex A[9].  The indication may be inferred from one of the following:

    - A failure of the link verification procedure,

    - The lack of a PVC status information element for a connection,

    - The state of the Delete bit in the connection's PVC status information element, or

    - The state of the Active bit in the connection's PVC status information element.

- Correlating reports of physical layer (L1) alarms with virtual connections

- Customer fault reports from a management database

Network implementations may distinguish between fault and excluded outages.  The classification of specific types of faults (e.g., customer equipment failure) as fault or excluded is network specific and outside the scope of this agreement.

Possible classifications of failures as fault outages (FO) or excluded outages are presented in Table 2.

### Indication of Failure

<table>
<tr><td rowspan="2"></td><td rowspan="2"></td><td>VC Status Change</td><td>L1 Alarm System</td><td>Fault Reports (Trouble Tickets)</td><td>Scheduled Maintenance</td></tr>
<tr><td colspan="4"></td></tr>
<tr><td rowspan="5">Location of Failure</td><td>Customer Premises Equipment</td><td>Should Exclude (Edge-to-edge) May Exclude (End-to-end)</td><td>Should Exclude (Edge-to-edge) May Exclude (End-to-end)</td><td>Should Exclude (Edge-to-edge) May Exclude (End-to-end)</td><td>Must Exclude</td></tr>
<tr><td>Local Loop</td><td>Must Include as FO</td><td>May Include as FO (Edge-to-edge) Should Include as FO (End-to-end)</td><td>May Include as FO (Edge-to-edge) Should Include as FO (End-to-end)</td><td>Must Exclude</td></tr>
<tr><td>Frame Node & Backbone</td><td>Must Include as FO</td><td>Should Include as FO (Edge-to-edge) Should Include as FO (End-to-end)</td><td>Should Include as FO</td><td>Must Exclude</td></tr>
<tr><td>Other Network (Note 1)</td><td>Should Exclude (Edge-to-edge) Should Include as FO (End-to-end)</td><td>Should Exclude</td><td>Should Exclude</td><td>Must Exclude</td></tr>
<tr><td>Unknown</td><td>Must Include as FO</td><td>Should Include as FO</td><td>May Include as FO</td><td>Must Exclude</td></tr>
</table>

**Table 2**
**Classification of failures**

Note 1    An edge-to-edge service level agreement may apply to one network segment in a series of network segments.  An example of this is the transit network section illustrated in Figure 3.  The network service provider may restrict the service level agreement to the access circuit section under the control of the

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[2] This definition of Outage Count is not aligned with X.144.

provider.  In that case, failures in the adjacent transit network section and distant access network section may be excluded from consideration as outages.

Transient service outages may be excluded from the computation of FRMTTR and FRMTBSO.  In such cases, the computation of FRMTTR and FRMTBSO is restricted to fault outages that exceed a minimum duration threshold.

Service Level Agreements must describe the following:

- mechanisms used to determine connection availability,

- policies for classification of faults as qualified or excluded,

- minimum fault outage threshold for FRMTTR/FRMTBSO computation, and

- identification of connections subject to measurement.


## 6.3   Measurement Aggregation

Service level agreements aggregate frame relay connection availability measurements. Aggregation may have components that include the number of connections aggregated and the time period reported.  Section B.4 provides example availability aggregation mechanisms.

The methodology applied by a service level agreement to aggregate frame relay connection availability is outside the scope of this agreement.

Service level agreements must describe the availability aggregation methodology.  These descriptions must specify how aggregation is processed over the following:

- the object dimension (e.g., on a per VC basis, on an interface basis, on a per customer network basis, etc.), and

- the time dimension (e.g., day, week, month, 24-hour day versus business day, 7-day weeks versus business day weeks, etc.).

# A   Informative Annex - Sources of Egress Queue Congestion

Frame relay interfaces, UNI and NNI, may develop egress queue congestion due to factors beyond the control of a network service provider.  In extreme situations, egress queue congestion will degrade service delivery performance. The sources of egress queue congestion are described in the following sections.

## A.1   Committed Traffic Oversubscription

Frame relay interfaces, UNI and NNI, may be provisioned with one or more connections which have combined committed information rate (CIR) requirements in excess of the physical capability of the link.  This practice is referred to as committed traffic oversubscription.  Figure 7 illustrates an example of oversubscription created when the sum of many connection CIRs exceed the physical capability of an egress interface.
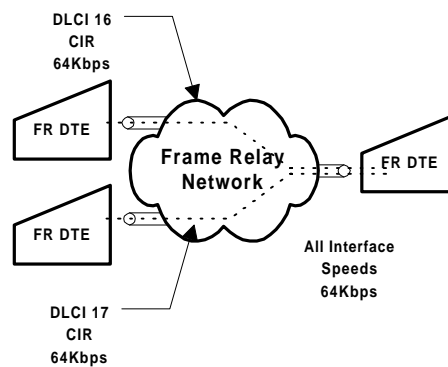


**Figure 7**
**Oversubscription with multiple connections**

The CIR reflects the network service provider's commitment for transport of frames through the network. In the case of oversubscription, the network operator provides the network transport to support this commitment.  However, the network user and the network service provider jointly agree to risk frame delay and loss at the network user's egress interface (Figure 4,  *EqoRP*).  Oversubscription provides users and network service providers with flexibility needed to take advantage of distributed network applications that do not contend for the bandwidth.  An example is an application that is distributed across a number of time zones such that simultaneous access by all remote locations is unlikely.
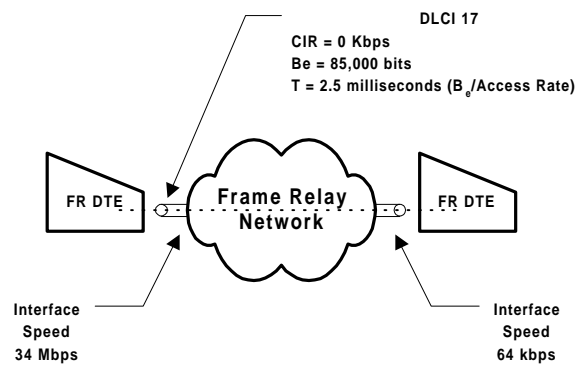
When an interface is oversubscribed, frame queue growth at the egress interface occurs as frames arrive faster than the interface can transmit.  This queue growth may eventually degrade service level delivery quality as frames successfully transferred by the network encounter delay and potential frame loss as a result of the network user's offered frame load.

This agreement addresses the impact of oversubscription on Frame Transfer Delay in Section 3, on Frame Delivery Ratio in Section 4, and on Data Delivery Ratio in Section 5.

## A.2   Excess Traffic Oversubscription

An egress interface also is subject to congestion due to excess burst traffic when the connection involves interfaces at different speeds. Such traffic is the result of one or more ingress connections that have burst excess capability ($B_e$) in excess of the physical capability of the egress link. An example of this case is a connection that links a high-speed interface with a low-speed interface. A burst of excess traffic on the high-speed interface will cause substantial egress queue growth on the low-speed interface.

Figure 8 illustrates an example of oversubscription resulting from ingress and egress interface speed mismatch. In this example, a PVC with a committed information rate of 0 kbps and burst excess size of 85,000 bits is defined between the interfaces. The ingress interface speed is 34Mbps while the egress interface speed is a much lower 64kbps. A sustained burst of traffic from the ingress interface can result in significant queue growth at the egress port.

DLCI 17
CIR = 0 Kbps
Be = 85,000 bits
T = 2.5 milliseconds ($B_e$/Access Rate)

FR DTE

**Frame Relay Network**

FR DTE

Interface Speed 34 Mbps

Interface Speed 64 kbps

**Figure 8**
**Mismatched interface speeds**

Another example of excess traffic oversubscription is a variation of the case presented in Section A.1. The transport of excess traffic on multiple connections that terminate at a single egress interface can cause frame queue growth at the egress interface.

# B   Informative Annex - Examples of Service Level Parameter Aggregation

Service level agreements report aggregations of data collected for given service level parameters. Aggregations vary among network service providers. This agreement does not specify how aggregation of data is conducted. This Annex provides a number of examples to illustrate some of the aggregation techniques.

## B.1   Delay

| | |
|---|---|
| Delay Example 1 | Delay is reported as an average of all delay measurements performed on all connections serving the customer during a 30 day period. Each connection is measured once every 15 minutes, 24 hours a day. |
| Delay Example 2 | Delay is reported on a per site basis as an average of all delay measurements during the hours between 09:00 and 19:00. |
| Delay Example 3 | Delay is reported as a percentile of delay measurements above a predetermined delay value over the measurement period. |

## B.2   Frame Delivery Ratio

| | |
|---|---|
| Delivery Example 1 | Frame delivery ratio is reported as an average of FDR measurements performed on all connections serving the customer during a 30 day period. |
| Delivery Example 2 | Sum of all frames delivered (for all connections) divided by the total number of all offered frames (for all connections). |

## B.3   Data Delivery Ratio

| | |
|---|---|
| Delivery Example 1 | Data delivery ratio is reported as an average of DDR measurements performed on all connections serving the customer during a 30 day period. |
| Delivery Example 2 | Sum of all octets delivered (for all connections) divided by the total number of all offered octets (for all connections). |

## B.4   Service Availability

| | |
|---|---|
| Availability Example 1 | Availability is reported as an average of all connection availability measures in a customer's network over a 30-day period. |
| Availability Example 2 | Sum of availability intervals (interval times less excluded outage times less outage times - for all virtual connections) divided by the total activity time (interval times less excluded outage times - for all virtual connections). Refer to Section 5.2.1 of [10] for more information. |