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# Terminology for Frame Relay Benchmarking

## Status of this Memo

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## Abstract

This memo discusses and defines terms associated with performance benchmarking tests and the results of these tests in the context of frame relay switching devices.

## I. Background

### 1. Introduction

This document provides terminology for Frame Relay switching devices. It extends terminology already defined for benchmarking network interconnect devices in RFCs 1242, 1944 and 2285. Although some of the definitions in this memo may be applicable to a broader group of network interconnect devices, the primary focus of the terminology in this memo is on Frame Relay Signaling.

This memo contains two major sections: Background and Definitions. The background section provides the reader with an overview of the technology and IETF formalisms. The definitions section is split into two sub-sections. The formal definitions sub-section is provided as a courtesy to the reader. The measurement definitions sub-section contains performance metrics with inherent units.

The BMWG produces two major classes of documents: Benchmarking Terminology documents and Benchmarking Methodology documents. The Terminology documents present the benchmarks and other related terms. The Methodology documents define the procedures required to collect the benchmarks cited in the corresponding Terminology documents.

For the purposes of computing several of the metrics, certain textual conventions are required. Specifically:

1) The notation sum {i=1 to N} A_i denotes: the summation of N instances of the observable A. For example, the set of observations {1,2,3,4,5} would yield the result 15.

2) The notation max {I=1 to N} A_i and min {I=1 to N} A_i denotes: the maximum or minimum of the observable A over N instances. For example, given the set of observations {1,2,3,4,5}, max {i=1 to 5} = 5 and min {I=1 to 5} = 1.

The terms defined in this memo will be used in addition to terms defined in RFCs 1242, 1944 and 2285. This memo is a product of the Benchmarking Methodology Working Group (BMWG) of the Internet Engineering Task Force(IETF).

## 2. Existing Definitions

RFC 1242, "Benchmarking Terminology for Network Interconnect Devices", should be consulted before attempting to make use of this document. RFC 1944, "Benchmarking Methodology for Network Interconnect Devices", contains discussions of a number of terms relevant to the benchmarking of switching devices and should also be consulted. RFC 2285, "Benchmarking Terminology for LAN Switching Devices", contains a number of terms pertaining to traffic distributions and datagram interarrival. For the sake of clarity and continuity this RFC adopts the template for definitions set out in Section 2 of RFC 1242.

# II. Definitions

The definitions presented in this section have been divided into two groups. The first group is formal definitions, which are required in the definitions of the performance metrics but are not themselves strictly metrics. These definitions are subsumed from other work done in other working groups both inside and outside the IETF. They are provided as a courtesy to the reader.

# 1. Formal Definitions

## 1.1. Definition Format (from RFC1242)

Term to be defined.

Definition: The specific definition for the term.

Discussion: A brief discussion of the term, its application and any restrictions on measurement procedures.

Specification: The working group and document in which the term is specified. Listed in the references.

## 1.2. Frame Relay Related Definitions

### 1.2.1. Access Channel

Definition: Access channel refers to the user access channel across which frame relay data travels. Within a given DS-3, T1 or E1 physical line, a channel can be one of the following, depending of how the line is configured. Possible line configurations are:

A. Unchannelized: The entire DS-3/T1/E1 line is considered a channel, where:

The DS-3 line operates at speeds of 45 Mbps and is a single channel. The T1 line operates at speeds of 1.536 Mbps and is a single channel consisting of 24 T1 time slots. The E1 line operates at speeds of 1.984 Mbps and is a single channel consisting of 30 DS0 time slots.

B. Channelized: The channel is any one of N time slots within a given line, where:

The T1 line consists of any one or more channels. Each channel is any one of 24 time slots. The T1 line operates at speeds in multiples of 56/64 Kbps to 1.536 Mbps, with aggregate speed not exceeding 1.536 Mbps. The E1 line consists of one or more channels. Each channel is any one of 31 time slots. The E1 line operates at speeds in multiples of 64 Kbps to 1.984 Mbps, with aggregate speed not exceeding 1.984 Mbps.

C. Fractional: The T1/E1 channel is one of the following groupings of consecutively or non-consecutively assigned time slots:

N DS0 time slots (NX56/64Kbps where N = 1 to 24 DS0 time slots per FT1 channel).

N E1 time slots (NX64Kbps, where N = 1 to 30 DS0 time slots per E1 channel).

Discussion: Access channels specify the physical layer interface speed of a DTE or DCE. In the case of a DTE, this may not correspond to either the CIR or EIR. Specifically, based on the service level agreement in place, the user may not be able to access the entire bandwidth of the access channel.

Specification: FRF

### 1.2.2. Access Rate (AR)

Definition: The data rate of the user access channel. The speed of the access channel determines how rapidly (maximum rate) the end user can inject data into a frame relay network.

Discussion: See Access Channel.

Specification: FRF

### 1.2.3. Backward Explicit Congestion Notification (BECN)

Definition: BECN is a bit in the frame relay header. The bit is set by a congested network node in any frame that is traveling in the reverse direction of the congestion.

Discussion: When a DTE receives frames with the BECN bit asserted, it should begin congestion avoidance procedures. Since the BECN frames are traveling in the opposite direction as the congested traffic, the DTE will be the sender. The frame relay layer may communicate the possibility of congestion to higher layers, which have inherent congestion avoidance procedures, such as TCP. See Frame Relay Frame.

Specification: FRF

### 1.2.4. Burst Excess(Be)

Definition: The maximum amount of uncommitted data (in bits) in excess of Committed Burst Size (Bc) that a frame relay network can attempt to deliver during a Committed Rate Measurement Interval (Tc). This data (Be) generally is delivered with a lower probability than Bc. The network treats Be data as discard eligible.

Discussion: See also Committed burst Size (Bc), Committed Rate Measurement Interval (Tc) and Discard Eligible (De).

Specification: FRF

### 1.2.5. Committed Burst Size (Bc)

Definition: The maximum amount of data (in bits) that the network agrees to transfer, under normal conditions, during a time interval Tc.

Discussion: See also Excess Burst Size (Be) and Committed Rate Measurement Interval (Tc).

Specification: FRF

### 1.2.6. Committed Information Rate (CIR)

Definition: CIR is the transport speed the frame relay network will maintain between service locations when data is presented.

Discussion: CIR specifies the guaranteed data rate between two frame relay terminal connected by a frame relay network.  Data presented to the network in excess of this data rate and below the Excess Information Rate (EIR) will be marked as Discard Eligible and may be dropped.

Specification: FRF

### 1.2.7. Committed Rate Measurement Interval (Tc)

Definition: The time interval during which the user can send only Bc-committed amount of data and Be excess amount of data.  In general, the duration of Tc is proportional to the "burstiness" of the traffic.  Tc is computed (from the subscription parameters of CIR and Bc) as Tc = Bc/CIR.  Tc is not a periodic time interval. Instead, it is used only to measure incoming data, during which it acts like a sliding window.  Incoming data triggers the Tc interval, which continues until it completes its computed duration.

Discussion: See also Committed Information Rate (CIR) and committed Burst Size (Bc).

Specification: FRF

### 1.2.8. Cyclic Redundancy Check (CRC)

Definition: A computational means to ensure the accuracy of frames transmitted between devices in a frame relay network.  The mathematical function is computed, before the frame is transmitted, at the originating device. Its numerical value is computed based on the content of the frame. This value is compared with a recomputed value of the function at the destination device. See also Frame Check Sequence (FCS).

Discussion: CRC is not a measurement, but it is possible to measure the amount of time to perform a CRC on a string of bits. This measurement will not be addressed in this document.

Specification: FRF

### 1.2.9. Data Communications Equipment (DCE)

Definition: Term defined by both frame relay and X.25 committees, that applies to switching equipment and is distinguished from the devices that attach to the network (DTE).

Discussion: Also see DTE.

Specification: FRF

### 1.2.10. Data Link Connection Identifier (DLCI)

Definition: A unique number assigned to a PVC end point in a frame relay network. Identifies a particular PVC endpoint within a user's access channel in a frame relay network and has local significance only to that channel.

Discussion: None.

Specification: FRF

### 1.2.11. Data Terminal Equipment (DTE)

Definition: Any network equipment terminating a network connection and is attached to the network. This is distinguished from Data Communications Equipment (DCE), which provides switching and connectivity within the network.

Discussion: See also DCE.

Specification: FRF

### 1.2.12. Discard Eligible (DE)

Definition: This is a bit in the frame relay header that provides a two level priority indicator, used to bias discard frames in the event of congestion toward lower priority frames. Similar to the CLP bit in ATM.

Discussion: See Frame Relay Frame.

Specification: FRF

### 1.2.13. Discardable frames

Definition: Frames identified as being eligible to be dropped in the event of congestion.

Discussion: The discard eligible field in the frame relay header is the correct -- and by far the most common -- means of indicating which frames may be dropped in the event of congestion. However, DE is not the only means of identifying which frames may be dropped. There are at least three other cases that apply.

In the first case, network devices may prioritize frame relay traffic by non-DE means. For example, many service providers prioritize traffic on a per-PVC basis. In this instance, any traffic from a given DLCI (data link channel identifier) may be dropped during congestion, regardless of whether DE is set.

In the second case, some implementations use upper-layer criteria, such as IP addresses or TCP or UDP port numbers, to prioritize traffic within a single PVC. In this instance, the network device may evaluate discard eligibility based on upper-layer criteria rather than the presence or absence of a DE bit.

In the third case, the frame is discarded because of an error in the frame. Specifically, frames that are too long or too short, frames that are not a multiple of 8 bits in length, frames with an invalid or unrecognized DLCI, frames with an abort sequence, frames with improper flag delimitation, and frames that fail FCS.

Specification: FRMIB

### 1.2.14. Discarded frames

Definition: Those frames dropped by a network device.

Discussion: Discardable and discarded frames are not synonymous. Some implementations may ignore DE bits or other criteria, even though they supposedly use such criteria to determine which frames to drop in the event of congestion.

In other cases, a frame with its DE bit set may not be dropped. One example of this is in cases where congestion clears before the frame can be evaluated.

Specification: DN

### 1.2.15. Forward Explicit Congestion Notification (FECN)

Definition: FECN is a bit in the frame relay header. The bit is set by a congested network node in any frame that is traveling in the same direction of the congestion.

Discussion: When a DTE receives frames with the FECN bit asserted, it should begin congestion avoidance procedures. Since the FECN frames are traveling in the same direction as the congested traffic, the DTE will be the receiver. The frame relay layer may communicate the possibility of congestion to higher layers, which have inherent congestion avoidance procedures, such as TCP. See Frame Relay Frame.

Specification: FRF

### 1.2.16. Frame Check Sequence (FCS)

Definition: The standard 16-bit cyclic redundancy check used for HDLC and frame relay frames. The FCS detects bit errors occurring in the bits of the frame between the opening flag and the FCS, and is only effective in detecting errors in frames no larger than 4096 octets. See also Cyclic Redundancy Check (CRC).

Discussion: FCS is not a measurement, but it is possible to measure the amount of time to perform a FCS on a string of bits. This measurement will not be addressed in this document.

Specification: FRF

### 1.2.17. Frame Entry Event

Definition: 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.

Discussion: None.

Specification: FRF.13

### 1.2.18. Frame Exit Event

Definition: 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.

Discussion: None.

Specification: FRF.13

### 1.2.19. Frame Relay

Definition: A high-performance interface for packet-switching networks; considered more efficient that X.25. Frame relay technology can handle "bursty" communications that have rapidly changing bandwidth requirements.

Discussion: None.

Specification: FRF

### 1.2.20. Frame Relay Frame

Definition: A logical grouping of information sent as a link-layer unit over a transmission medium. Frame relay frames consist of a pair of flags, a header, a user data payload and a Frame Check Sequence (FCS). Bit stuffing differentiates user data bytes from flags. By default, the header is two octets, of which 10 bits are the Data Link Connection Identifier (DLCI), 1 bit in each octet is used for address extension (AE), and 1 bit each for Forward Explicit Congestion Notification (FECN), Backward Explicit Congestion Notification (BECN) Command/Response (C/R) and Discard Eligible (DE). The EA bit is set to one in the final octet containing the DLCI. A header may span 2, 3 or 4 octets.

```
   Bit  7   6   5   4   3   2   1   0
       |---|---|---|---|---|---|---|---|
       |              FLAG             |
       |-------------------------------|
       | Upper 6 bits of DLCI  |C/R|AE |
       |-------------------------------|
       |   DLCI        |FE |BE |DE |AE |
       |               |CN |CN |   |   |
       |-------------------------------|
       |        User Data up to        |
       |          1600 Octets          |
       |-------------------------------|
       |      First Octet of FCS       |
       |-------------------------------|
       |      Second Octet of FCS      |
       |-------------------------------|
       |              FLAG             |
       |-------------------------------|
```

Discussion: Frame Relay headers spanning 3 or 4 octets will not be discussed in this document. Note, the measurements described later in this document are based on 2 octet headers. If longer headers are used, the metric values must take into account the associated overhead. See BECN, DE, DLCI and FECN.

Specification: FRF

1.2.21. Excess Information Rate (EIR)

Definition: See Burst Excess.

Discussion: None.

Specification: FRF

1.2.22. Network Interworking (FRF.5)

Definition: FRF.5 defines a protocol mapping called Network Interworking between

Frame Relay and Asynchronous Transfer Mode (ATM). Protocol mapping occurs when the network performs conversions in such a way that within a common layer service, the protocol information of one protocol is extracted and mapped on protocol information of another protocol. This means that each communication terminal supports different protocols. The common layer service provided in this interworking scenario is defined by the functions, which are common to the two protocols. Specifically, the ATM terminal must be configured to interoperate with the Frame Relay network and vice versa.

Discussion: None.

Specification: FRF.5

1.2.23. Port speed

Definition: See Access Rate

Discussion: None.

Specification: FRF

1.2.24. Service Interworking (FRF.8)

Definition: FRF.8 defines a protocol encapsulation called Service Interworking. Protocol encapsulation occurs when the conversions in the network or in the terminals are such that the protocols used to provide one service make use of the layer service provided by another protocol. This means that at the interworking point, the two protocols are stacked. When encapsulation is performed by the terminal, this scenario is also called interworking by port access. Specifically, the ATM service user performs no Frame Relaying specific functions, and Frame Relaying service user performs no ATM service specific functions.

Discussion: None.

Specification: FRF.8

1.2.25. Service Availability Parameters

Definition: The service availability parameters report the operational readiness of individual frame relay virtual connections. Service availability is affected by service outages.

Discussion: Service availability parameters provide metrics for assessment of frame relay network health and are used to monitor compliance with service level agreements. See Services Outages.

Specification: FRF.13

#### 1.2.26. Service Outages

Definition: Any event that interrupts the transport of frame relay traffic. Two types of outages are differentiated:

1) Fault outages: Outages resulting from faults in the network and thus tracked by the service availability parameters, and

2) Excluded outages: Outages resulting from faults beyond the control of the network as well as scheduled maintenance.

Discussion: 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 document. See Service Availability Parameters.

Specification: FRF.13

## 2. Performance Metrics

### 2.1. Definition Format (from RFC1242)

Metric to be defined.

Definition: The specific definition for the metric.

Discussion: A brief discussion of the metric, its application and any restrictions on measurement procedures.

Measurement units: Intrinsic units used to quantify this metric. This includes subsidiary units, e.g., microseconds are acceptable if the intrinsic unit is seconds.

### 2.2. Definitions

#### 2.2.1. Physical Layer-Plesiochronous Data Hierarchy (PDH)

##### 2.2.1.1. Alarm Indication Signal (AIS)

Definition: An all 1's frame transmitted after the DTE or DCE detects a defect for 2.5 s +/- 0.5 s.

Discussion: An AIS will cause loss of information in the PDH frame, which contains a frame relay frame which may contain IP datagrams.

Measurement units: Dimensionless.

#### 2.2.1.2. Loss of Frame (LOF)

Definition: An NE transmits an LOF when an OOF condition persists.

Discussion: A LOF will cause loss of information in the PDH frame, which contains a frame relay frame which may contain IP datagrams.

Measurement units: Dimensionless.

#### 2.2.1.3. Loss of Signal (LOS)

Definition: Indicates that there are no transitions occurring in the received signal.

Discussion: A LOS will cause loss of information in the PDH frame which contains a frame relay frame which may contain IP datagrams.

Measurement units: Dimensionless.

#### 2.2.1.4. Out of Frame (OOF)

Definition: An NE transmits an OOF downstream when it receives framing errors in a specified number of consecutive frame bit positions.

Discussion: An OOF will cause loss of information in the PDH frame which contains a frame relay frame which may contain IP datagrams.

Measurement units: Dimensionless.

#### 2.2.1.5. Remote Alarm Indication (RAI)

Definition: Previously called Yellow Alarm. Transmitted upstream by an NE to indicate that it detected an LOS, LOF, or AIS.

Discussion: An RAI will cause loss of information in the transmitted PDH frame, which may contain a frame relay frame, which, in turn, may contain IP datagrams.

Measurement units: Dimensionless.

### 2.2.2. Frame Relay Layer

#### 2.2.2.1. Data Delivery Ratio (DDR)

Definition: The DDR service level parameter reports the networks 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:

Data Delivery Ratio (DDR):

```
      (DataDelivered_c + DataDelivered_e   DataDelivered_e+c
DDR = -------------------------------- = -----------------
      (DataOffered_c + DataOffered_e)    DataOffered_e+c
```

Data Delivery Ratio (DDR_c) for load consisting of frames within the committed information rate:

```
        DataDelivered_c
DDR_c = -------------
        DataOffered_c
```

Data Delivery Ratio (DDR_e) for load in excess of the committed information rate:

```
        DataDelivered_e
DDR_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_e+c: 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_e+c: 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.

Discussion: 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.

Measurement units: dimensionless.

2.2.2.2. Frame Delivery Ratio (FDR)

Definition: The FDR service level parameter reports the networks 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.

Frame Delivery Ratio (FDR):

Frame Delivery Ratio (FDR):

```
      (FramesDelivered_c + FramesDelivered_e)  FramesDelivered_e+c
FDR = ------------------------------------- = -------------------
      (FramesOffered_c + FramesOffered_e)   FramesOffered_e+c
```

Frame Delivery Ratio (FDR_c) for load consisting of frames within the committed information rate:

```
        FramesDelivered_c
FDR_c = -----------------
        FramesOffered_c
```

Frame Delivery Ratio (FDR_c) for load in excess of the committed information rate:

```
        FramesDelivered_e
FDR_e = -----------------
        FramesOffered_e
```

where

FramesDelivered_c: Successfully delivered frames within committed information rate,

FramesDelivered_e: Successfully delivered frames in excess of CIR,

FramesDelivered_e+c: 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_e+c: 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.

Discussion: Frame delivery ratio measurements may not be representative of frame 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

Measurement units: dimensionless.

2.2.2.3. Frame Discard Ratio (FDR)

Definition: The number of received frames that are discarded because of a frame error divided by the total number of transmitted frames in one direction of a single virtual connection. Frame errors are defined as follows:

1) frames that are too long or too short,
2) frames that are not a multiple of 8 bits in length,
3) frames with an invalid or unrecognized DLCI,
4) frames with an abort sequence,
5) frames with improper flag delimitation,
6) frames that fail FCS.

The formal definition of frame discard ratio is as follows:

```
        sum {i=1 to N} fr_i
  FDR = -------------------
        sum {i=1 to N} ft_i,
```

where

fr_i is the number of successfully delivered frames for a particular DLCI at second i

and

ft_i is the total number of attempted frame transmissions within the committed plus extended information rate for a particular DLCI at second i.

Discussion: Frame discards can adversely effect applications running on IP over FR. In general, frame discards will negatively impact TCP throughput; however, in the case of frame discard due to frame error, frame discard will improve performance by dropping errored frames. As a result, these frames will not adversely effect the forwarding of retransmitted frames

Measurement units: dimensionless.

2.2.2.4. Frame Error Ratio (FER)

Definition: The number of received frames that contain an error in the frame payload divided by the total number of transmitted frames in one direction of a single virtual connection.

The formal definition of frame error ratio is as follows:

```
        sum {i=1 to N} fe_i
  FER = -------------------
        sum {i=1 to N} ft_i,
```

where

fe_i is the number of frames containing a payload error for a particular DLCI at second i

and

ft_i is the total number of attempted frame transmissions within the committed plus the extended information rate for a particular DLCI at second i. This statistic includes those frames which have an error in the Frame Check Sequence (FCS). Frame errors in the absence of FCS errors can be detected by sending frames containing a known pattern; however, this indicates an equipment defect.

Discussion: The delivery of frames containing errors will adversely effect applications running on IP over FR. Typically, these errors are caused by transmission errors and flagged as failed FCS frames; however, when Frame Relay to ATM Network interworking is used, an error may be injected in the frame payload which, in turn, is encapsulated into an AAL5 PDU (see RFC 2761 for a discussion of AAL5 related metrics).

Measurement units: dimensionless.

2.2.2.5. Frame Excess Ratio (FXR)

Definition: The number of frames received by the network and treated as excess traffic divided by the total number of transmitted frames in one direction of a single virtual connection. Frames which are sent to the network with DE set to zero are treated as excess when more than Bc bits are submitted to the network during the Committed Information Rate Measurement Interval (Tc). Excess traffic may or may not be discarded at the ingress if more than Bc + Be bits are submitted to the network during Tc. Traffic discarded at the ingress is not recorded in this measurement. Frames which are sent to the network with DE set to one are also treated as excess traffic.

The formal definition of frame excess ratio is as follows:

$$FXR = 1 - \frac{\sum_{i=1}^{N} fc_i}{\sum_{i=1}^{N} ft_i},$$

where

$fc_i$ is the total number of frames which were submitted within the traffic contract for a particular DLCI at second i

and

$ft_i$ is the total number of attempted frame transmissions for a particular DLCI at second i.

Discussion: Frame discards can adversely effect applications running on IP over FR. Specifically, frame discards will negatively impact TCP throughput.

Measurement units: dimensionless.

### 2.2.2.6. Frame Loss Ratio (FLR)

Definition: The FLR is a ratio of successful frame receptions to attempted frame transmissions at the committed information rate, in one direction of a single virtual connection. Attempted frame transmissions are referred to as Frames Offered. Successfully delivered frames are referred to as Frames Delivered.

The formal definition of frame loss ratio is as follows:

```
            FramesDelivered_c
 FLR = 1- -----------------
            FramesOffered_c,
```

where

FramesDelivered_c is the successfully delivered frames within committed information rate for a given DLCI

and

FramesOffered_c is the attempted frame transmissions within committed information rate for a given DLCI

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

Discussion: Frame delivery loss measurements may not be representative of frame delivery effectiveness for a given application. For example, the loss 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

Measurement units: dimensionless.

### 2.2.2.7. Frame Policing Ratio (FPR)

Definition: The number of frames received by the network and treated as excess traffic and dropped divided by the total number of received frames, in one direction of a single virtual connection. Frames which are sent to the network with DE set to zero are treated as excess when more than Bc bits are submitted to the network during the Committed Information Rate Measurement Interval (Tc). Excess traffic may or may not be discarded at the ingress if more than Bc + Be bits are submitted to the network during Tc. Traffic discarded at the ingress is recorded in this measurement. Frames which are sent to the network with DE set to one are also treated as excess traffic.

The formal definition of frame excess ratio is as follows:

```
            sum {i=1 to N} fr_i
  FPR = 1- -------------------
            sum {i=1 to N} ft_i,
```

where

fr_i is the successfully delivered frames for a particular DLCI at second i

and

ft_i is the total number of attempted frame transmissions for a particular DLCI

at second i.

Discussion: Frame discards can adversely effect applications running on IP over FR. Specifically, frame discards will negatively impact TCP throughput.

2.2.2.8. Frame Transfer Delay (FTD)

Definition: The time required to transport frame relay data from measurement point 1 to measurement point 2. The frame transfer delay is the difference in seconds between the time a frame exits measurement point 1 and the time the same frame enters measurement point 2, in one direction of a single virtual connection. The formal definition of frame transfer delay is as follows:

```
   FTD = 1/N * sum {i=1 to N} t2_i - t1_i,
```

where

t1_i is the time in seconds when the ith frame leaves measurement point 1 (i.e., frame exit event),

t2 is the time in seconds when the ith frame arrives at measurement point 2 (i.e., frame entry event)

and

N is the number of frames received during a measurement interval T.

FTD is computed for a specific DLCI and a specified integration period of T seconds. The computation does not include frames which are transmitted during the measurement period but not received.

Discussion: While frame transfer delay is usually computed as an average and, thus, can effect neither IP nor TCP performance, applications such as voice over IP may be adversely effected by excessive FTD.

Measurement units: seconds.

2.2.2.9. Frame Transfer Delay Variation (FTDV)

Definition: The variation in the time required to transport frame relay data from measurement point 1 to measurement point 2. The frame transfer delay variation is the difference in seconds between maximum frame transfer delay and the minimum frame transfer delay, in one direction of a single virtual connection. The formal definition of frame transfer delay is as follows:

$$FTDV = \max_{i=1 \text{ to } N} FTD_i - \min_{i=1 \text{ to } N} FTD_i.$$

where

FTD and N are defined as above.

Discussion: Large values of FTDV can adversely effect TCP round trip time calculation and, thus, TCP throughput.

Measurement units: seconds.

## 3. Security Considerations

As this document is solely for providing terminology and describes neither a protocol nor an implementation, there are no security considerations associated with this document.

## 4. Notices

Internet Engineering Task Force

Frame Relay Forum

## 5. References

[DN] Private communication from David Newman, Network Test, Inc.

[FRF] Frame Relay Forum Glossary, http://www.frforum.com, 1999.

[FRF.5] Frame Relay Forum, Frame Relay/ATM PVC Network Interworking Implementation Agreement, December 1994.

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