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Public data networks – Network aspects

Performance of IP networks when supported by public Frame Relay data networks

ITU-T Recommendation X.149

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ITU-T Recommendation X.149

Performance of IP networks when supported by public Frame Relay data networks

Summary

The key objective of this Recommendation is to provide an estimate of the IP layer performance obtained in the case where Frame Relay network infrastructure is used to provide the lower layer connectivity to transport the IP packets between the routers.

Mappings between Frame Relay and IP performance parameters are presented. Numerical values of IP performance parameters are estimated based on the objective values specified for the Frame Relay performance parameters specified in ITU-T Rec. X.146.

A general model for the calculation of transfer delay is presented. This model can be used to assist in the planning of networks. The analysis presented provides an upper bound on the performance that could be achieved by an IP network when carried over a Frame Relay network.

The performance mappings between FR and IP networks specified are seen as complementary to ITU-T Rec. Y.1541, since ITU-T Rec. Y.1541 is technology independent with regard to the provision of the physical and link layers. Accordingly, this Recommendation does not specify end-to-end performance objectives, but illustrates the way in which the Y.1541 objectives could be supported.

Source

ITU-T Recommendation X.149 was approved by ITU-T Study Group 17 (2001-2004) under the ITU-T Recommendation A.8 procedure on 29 October 2003.

Keywords

Frame Relay networks, IP networks, Performance.

FOREWORD

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ITU-T Recommendation X.149

Performance of IP networks when supported by public Frame Relay data networks

1 Scope

The key objective of this Recommendation is to specify the end-to-end performance that could be achieved by an IP network when the backbone network providing the connectivity between the IP routers is provided by Frame Relay infrastructure. This Recommendation does not specify end-to-end performance objectives for IP networks. The Recommendation provides an estimate of the IP layer performance obtained when Public Frame Relay Data Networks are used to transport the IP packets and indicates how the IP QoS classes defined in ITU-T Rec. Y.1541 could be supported.

The Recommendation provides an analysis of the mappings between the Frame Relay and IP performance parameters. Numerical values of the expected IP performance parameters are derived from the objective values specified for the Frame Relay Performance parameters as specified in ITU-T Rec. X.146.

Using a general model an analysis of the expected performance for various IP packet sizes (corresponding to various IP applications) and the influence of the Frame Relay network infrastructure (e.g., inter-node transmission trunks) is provided. This analysis provides an upper bound on the performance that could be achieved by an IP network when carried over a Frame Relay network, since the IP network infrastructure could increase both the achieved IP packet transit delay and IP packet loss rate.

This Recommendation, and in particular the performance parameter mappings between Frame Relay and IP networks, is seen as complementary to ITU-T Rec. Y.1541, since ITU-T Rec. Y.1541 is technology independent with regard to the provision of the physical and link layers.

The scope of the Recommendation is limited to IP networks where the link infrastructure is provided by or supported by Public Frame Relay Data Networks.

2 References

The following ITU-T Recommendations and other references contain provisions which, through reference in this text, constitute provisions of this Recommendation. At the time of publication, the editions indicated were valid. All Recommendations and other references are subject to revision; users of this Recommendation are therefore encouraged to investigate the possibility of applying the most recent edition of the Recommendations and other references listed below. A list of the currently valid ITU-T Recommendations is regularly published. The reference to a document within this Recommendation does not give it, as a stand-alone document, the status of a Recommendation.

- ITU-T Recommendation E.651 (2000), *Reference connections for traffic engineering of IP access networks*.
- ITU-T Recommendation G.114 (2003), *One-way transmission time*.
- ITU-T Recommendation G.1000 (2001), *Communications Quality of Service: A framework and definitions*.
- ITU-T Recommendation G.1010 (2001), *End-user multimedia QoS categories*.
- ITU-T Recommendation X.36 (2003), *Interface between Data Terminal Equipment (DTE) and Data Circuit-terminating Equipment (DCE) for public data networks providing frame relay data transmission service by dedicated circuit*.

- ITU-T Recommendation X.76 (2003), *Network-to-network interface between public networks providing PVC and/or SVC frame relay data transmission service.*
- ITU-T Recommendation X.140 (1992), *General quality of service parameters for communication via public data networks.*
- ITU-T Recommendation X.144 (2003), *User information transfer performance parameters for public frame relay data networks.*
- ITU-T Recommendation X.145 (2003), *Connection establishment and disengagement performance parameters for public Frame Relay data networks providing SVC services.*
- ITU-T Recommendation X.146 (2000), *Performance objectives and quality of service classes applicable to frame relay.*
- ITU-T Recommendation Y.1221 (2002), *Traffic control and congestion control in IP-based networks.*
- ITU-T Recommendation Y.1231 (2000), *IP Access Network Architecture.*
- ITU-T Recommendation Y.1540 (2002), *Internet protocol data communication service – IP packet transfer and availability performance parameters.*
- ITU-T Recommendation Y.1541 (2002), *Network performance objectives for IP-based services.*
- IETF RFC 791 (1981), *Internet Protocol, DARPA Internet Program Protocol Specification.*

3 Definitions

The terms and their definitions used in this Recommendation are consistent with those defined in ITU-T Recs X.36, X.76, X.144, X.145, X.146, Y.1231, Y.1540, and Y.1541. Appendix III provides the general network architecture for an IP network as per ITU-T Rec. Y.1231. Appendix IV provides a description (based on ITU-T Rec. Y.1540) of the network components together with the circuit and network sections that provide the building blocks with which any end-to-end IP service may be represented.

3.1 Definition of IP and Frame Relay performance parameters

The definitions (as per ITU-T Rec. Y.1540) of IP Loss Ratio and Frame Loss Ratio are presented here for clarity.

3.1.1 IP Packet performance parameters

3.1.1.1 IP packet loss ratio (IPLR): IP Packet Loss Ratio is the ratio of the total lost IP packet outcomes to total transmitted IP packets in a population of interest. "Lost IP packet outcomes" and "Populations of Interest" are defined in ITU-T Rec. Y.1540.

3.1.1.2 IP packet transfer delay (IPTD): IP packet transfer delay is defined for all successful and errored packet outcomes across a basic section or an NSE. IPTD is the time $(t_2 - t_1)$ between the occurrence of two corresponding IP packet reference events, ingress event IPRE₁ at time t_1 and egress event IPRE₂ at time t_2 , where $(t_2 > t_1)$ and $(t_2 - t_1) < T_{max}$. Network Section Ensemble (NSE) and IP Reference Events (IPRE) are defined in ITU-T Rec. Y.1540.

3.1.2 Frame Relay performance parameters

The definition of Frame Loss Ratio and Frame Transfer Delay (as per packet transfer X.144) are presented here for clarity.

3.1.2.1 frame loss ratio: The user information Frame Loss Ratio (FLR) is defined as:

$$FLR = \frac{F_L}{F_L + F_S + F_E}$$

where, in a specified population:

- F_S is the total number of successively transferred frame outcomes;
- F_L is the total number of lost frame outcomes; and
- F_E is the total number of residually errored frame outcomes.

The objective values for frame loss ratio specified in the Frame Relay QoS classes in ITU-T Rec. X.146, correspond to a special case of the above ratio. This is the FLR_C . The FLR for frames marked with the discard eligibility bit set to zero $DE = 0$ should remain relatively constant as long as the total $DE = 0$ traffic does not exceed the Committed Information Rate (CIR). If the network accepts all conforming frames, FLR_C is the probability that a $DE = 0$ frame accepted as conforming will subsequently be lost. $DE = 0$ frames relayed with the DE bit changed to $DE = 1$ are included in the calculation of FLR_C .

3.1.2.2 user information frame transfer delay: The user information frame transfer delay (FTD) is defined as:

$$FTD = t_2 - t_1$$

where, in a specified population:

- t_1 is the time of occurrence for the first FE (Frame Layer Reference Event);
- t_2 is the time of occurrence for the second FE;
- $t_2 - t_1 \leq T_{max}$.

and T_{max} is the value used in defining a successfully transferred frame outcome.

4 Abbreviations

This Recommendation uses the following abbreviations:

CPE	Customer Premises Equipment
CPN	Customer Premises Network
DBDJ	Data Block Delay Jitter
DBDR	Data Block Delivered Ratio
DBLR	Data Block Loss Ratio
DBTD	Data Block Transfer Delay
DST	Destination
FCS	Frame Check Sequence
FLR	Frame Loss Ratio
FR	Frame Relay
FTD	Frame Transfer Delay
IP	Internet Protocol
IPDV	IP Delay Variation
IPLR	IP Packet Loss Ratio
IPRE	IP packet transfer Reference Event

IPTD	IP Packet Transfer Delay
PFRDN	Public Frame Relay Data Network
PVC	Permanent Virtual Connection or Permanent Virtual Circuit
SRC	Source
SVC	Switched Virtual Connection or Switched Virtual Circuit
TE	Terminal Equipment
UNI	User-Network Interface
VC	Virtual Connection

5 Conventions

Within this Recommendation the term "Public Frame Relay Data Network" can be used interchangeably with the term "Public Data Network" providing the "Frame Relay Data Transmission Service".

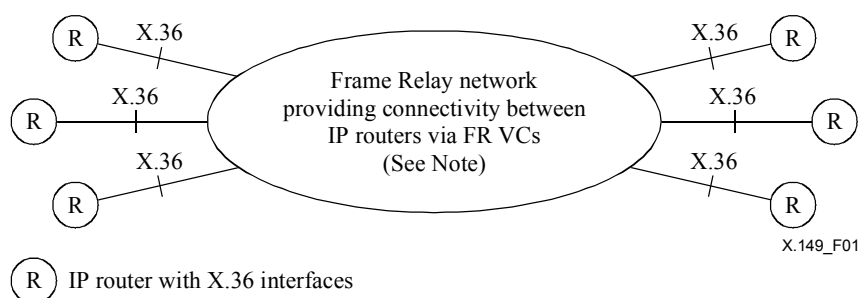
6 General model for interconnecting IP routers via Frame Relay

Figure 1 provides a general model for the interconnection of IP routers via Frame Relay virtual connections. This model applies in both the cases where the IP routers are either CPE Terminal Equipment or Gateway and Intermediate Routers belonging to IP service providers. The model assumes that the IP routers are interfaced to the Frame Relay network using the frame format and protocols defined in ITU-T Rec. X.36. The model applies to both the SVC and PVC cases. This model is a specific case of the general network architecture model for an IP network as defined in ITU-T Rec. Y.1231 (see Appendix III).

Figure 1 is a generalized reference model for an IP environment in which the basic infrastructure elements of an IP network (i.e., IP routing equipment) are interconnected using virtual circuits provided by Public Frame Relay Data Networks. The reference configuration also covers the case where the Frame Relay virtual connection is provided across multiple PFRDNs; i.e., the Frame Relay virtual connections may span more than one national or international transit network. In such cases, it is assumed that Public Frame Relay Data Networks will be interconnected utilizing the network-to-network interface defined in ITU-T Rec. X.76.

Within the context of this Recommendation, the Frame Relay virtual connections are only used to establish connectivity between a pair of IP routers. Accordingly, in establishing an IP network, the required connectivity may be provisioned by a multiplicity of Frame Relay networks. Each router may have multiple FR UNIs in order to connect to various Frame Relay networks.

NOTE – In establishing an IP network it is likely that the interconnecting links will be provided by a variety of lower-layer technologies of which Frame Relay is but one example.



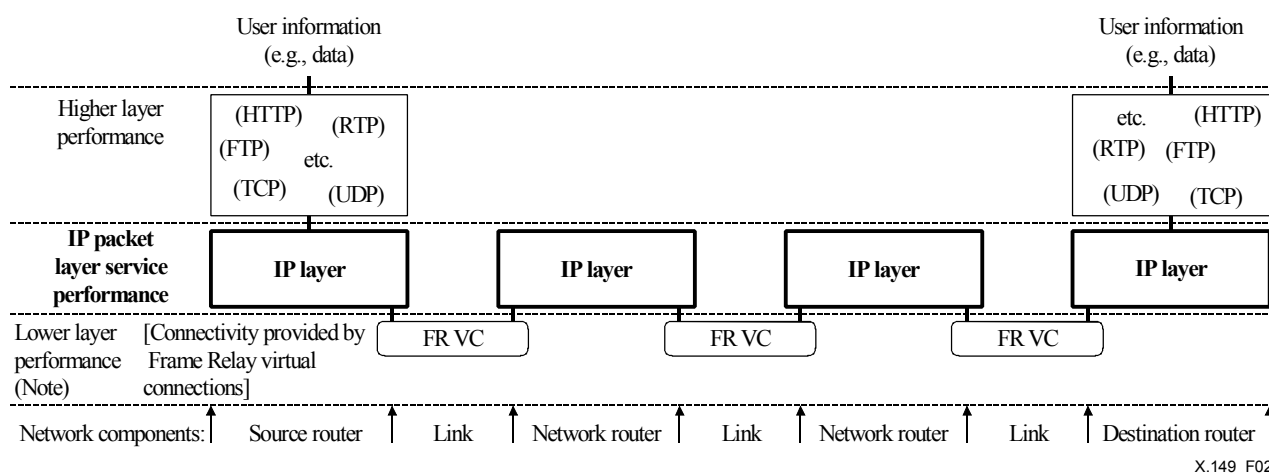
NOTE – The Frame Relay VCs may span more than one national or international FR network

Figure 1/X.149 – Use of Frame Relay VCs for the interconnection of IP routers

7 Layered model of performance for IP services

Figure 2 (an adaptation of the layered performance model defined in ITU-T Rec. Y.1540) illustrates the layered nature of the performance of IP service. (Within the scope of this Recommendation it is assumed that the lower layer connectivity is provided by Frame Relay infrastructure.) The performance provided to IP service users depends on the performance of other layers:

- Lower layers that provide (via "frame relay links") connection-oriented transport supporting the IP layer. Links are terminated at points where IP packets are forwarded (i.e., network routers, source routers and destination routers) and thus, have no end-to-end significance.
- The IP layer that provides connectionless transport of IP datagrams (i.e., IP packets). The IP layer has end-to-end significance for a given pair of source and destination IP addresses. Certain elements in the IP packet headers may be modified by IP network routers, but the IP user data may not be modified at or below the IP layer.
- Higher layers, supported by IP, that further enable end-to-end communications. Upper layers may include, for example, TCP, UDP, FTP, RTP and HTTP. The higher layers will modify and may enhance the end-to-end performance provided at the IP layer.



NOTE – For illustrative purposes only; 3 instances of FR VCs provide lower layer connectivity.

Figure 2/X.149 – Layered model of performance for IP service – Example only