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Internet protocol aspects – Quality of service and network performance

Parameters for TCP connection performance in the presence of middleboxes

ITU-T Recommendation Y.1560

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GLOBAL INFORMATION INFRASTRUCTURE, INTERNET PROTOCOL ASPECTS AND NEXT GENERATION NETWORKS

GLOBAL INFORMATION INFRASTRUCTURE	
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Services, applications and middleware	Y.200–Y.299
Network aspects	Y.300–Y.399
Interfaces and protocols	Y.400–Y.499
Numbering, addressing and naming	Y.500–Y.599
Operation, administration and maintenance	Y.600–Y.699
Security	Y.700–Y.799
Performances	Y.800–Y.899
INTERNET PROTOCOL ASPECTS	
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Services and applications	Y.1100–Y.1199
Architecture, access, network capabilities and resource management	Y.1200–Y.1299
Transport	Y.1300–Y.1399
Interworking	Y.1400–Y.1499
Quality of service and network performance	**Y.1500–Y.1599**
Signalling	Y.1600–Y.1699
Operation, administration and maintenance	Y.1700–Y.1799
Charging	Y.1800–Y.1899
NEXT GENERATION NETWORKS	
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Quality of Service and performance	Y.2100–Y.2199
Service aspects: Service capabilities and service architecture	Y.2200–Y.2249
Service aspects: Interoperability of services and networks in NGN	Y.2250–Y.2299
Numbering, naming and addressing	Y.2300–Y.2399
Network management	Y.2400–Y.2499
Network control architectures and protocols	Y.2500–Y.2599
Security	Y.2700–Y.2799
Generalized mobility	Y.2800–Y.2899

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ITU-T Recommendation Y.1560

Parameters for TCP connection performance in the presence of middleboxes

Summary

This Recommendation defines the end-to-end Transmission Control Protocol (TCP) performance in terms of speed, accuracy, and dependability in an IP-based network with middleboxes, which are nodes terminating TCP connections.

Source

ITU-T Recommendation Y.1560 was approved by ITU-T Study Group 13 (2001-2004) under the ITU-T Recommendation A.8 procedure on 13 September 2003.

Keywords

Availability, Internet Protocol (IP), Transmission Control Protocol (TCP), TCP performance.

FOREWORD

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As of the date of approval of this Recommendation, ITU had not received notice of intellectual property, protected by patents, which may be required to implement this Recommendation. However, implementors are cautioned that this may not represent the latest information and are therefore strongly urged to consult the TSB patent database.

CONTENTS

		Page
1	Scope	1
2	References	1
3	Definitions	1
4	Abbreviations	1
5	Reference model	2
5.1	Layered model	2
5.2	Reference configuration	2
5.3	Reference events	3
6	Performance parameters	4
6.1	Speed parameters	4
6.2	Accuracy and dependability parameters	5
6.3	Availability parameters	6
Appendix I – Middlebox		6
I.1	Introduction	6
I.2	Factors that affect TCP performance	6
I.3	References	6
Appendix II – Effectiveness of middleboxes		8
Appendix III – Information on throughput		8
III.1	Issue to define TCP throughput	8
III.2	Data communication throughput	9
III.3	Overall communication throughput	9
Appendix IV – Bibliography		9

ITU-T Recommendation Y.1560

Parameters for TCP connection performance in the presence of middleboxes

1 Scope

This Recommendation defines the end-to-end, point-to-point Transmission Control Protocol (TCP) performance in terms of speed, accuracy, and dependability in an IP-based network with middleboxes, which are nodes terminating TCP connections. TCP performance is specified in an end-to-end timeline of TCP connections composed of three phases: connection establishment, data communication, and connection clearing. Availability performance is also one of TCP performance. The TCP connection performance that a user can experience through an application can be measured by monitoring the IP-based network. Performance interaction between the TCP and IP layers is for further study.

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.

[1] ITU-T Recommendation I.350 (1993), *General aspects of quality of service and network performance in digital networks, including ISDNs*.

[2] ITU-T Recommendation Y.1540 (2002) (formerly ITU-T Rec. I.380), *Internet protocol data communication service – IP packet transfer and availability performance parameters*.

[3] ITU-T Recommendation Y.1541 (2002), *Network performance objectives for IP-based services*.

[4] IETF RFC 793 (1981) – *Transmission Control Protocol (TCP)*.

3 Definitions

This Recommendation defines the following terms:

3.1 end-to-end TCP performance: Performance on TCP layer from SRC to DST.

3.2 ports: The portion of a socket that specifies which logical input or output channel of a process is associated with the data.

4 Abbreviations

This Recommendation uses the following abbreviations.

ACK Acknowledgment

DST Destination host

FIN Finish

FTP File Transfer Protocol

HTTP HyperText Transfer Protocol

IETF	Internet Engineering Task Force
IP	Internet Protocol
ISDN	Integrated Services Digital Network
ITU-T	International Telecommunication Union – Telecommunication Standardization Sector
LL	Lower Layers, protocols and technology supporting the IP layer
MP	Measurement Point
SMTP	Simple Mail Transfer Protocol
SRC	Source host
SYN	Initiation flag of TCP connection

5 Reference model

5.1 Layered model

Figure 1 illustrates the layered nature of the performance of a TCP connection with a middlebox, which terminates TCP connections. TCP connection is a logical communication path established between a pair of ports and initialized on each side. The performance provided to TCP service users depends on the performance of the IP layer and other layers.

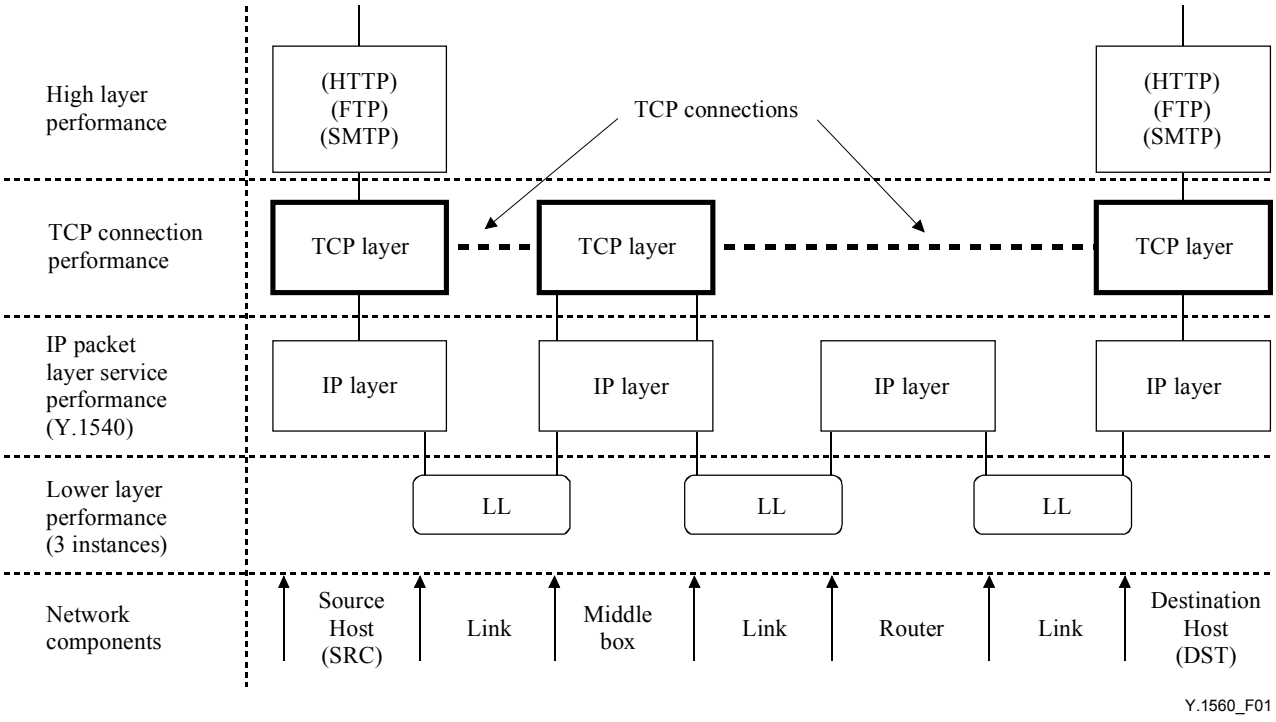

Figure 1/Y.1560 – Layered model of performance for TCP connection with a middlebox – example

5.2 Reference configuration

Figure 2 illustrates the relationship between reference events and measurement points for a TCP connection. When there is no middlebox, there are only two edge measurement points.

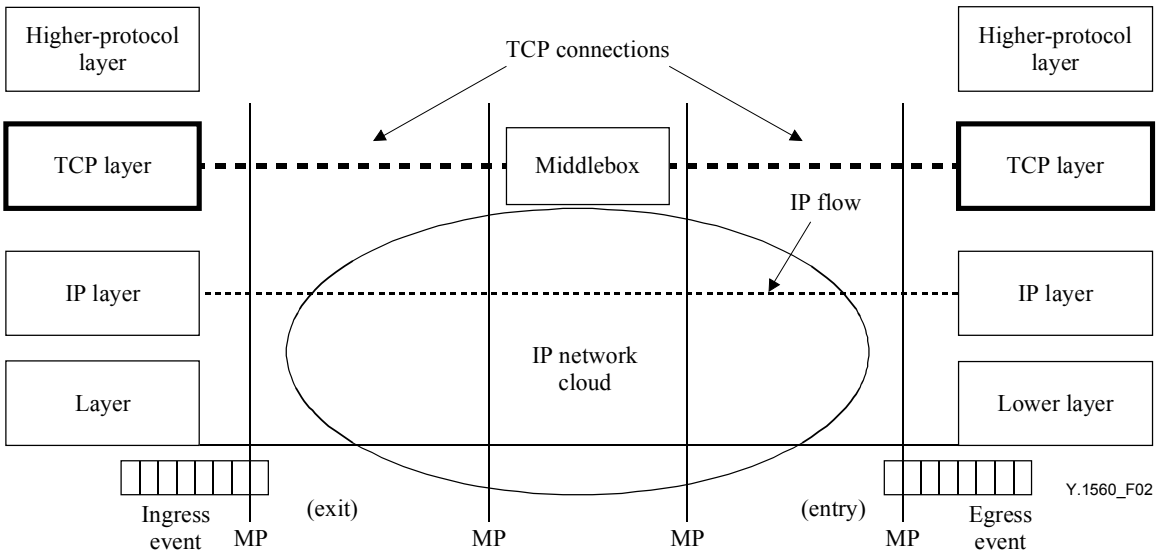

Figure 2/Y.1560 – Relationship between reference events and measurement points

5.3 Reference events

Figure 3 illustrates the end-to-end timelines of some TCP connections. Each end-to-end timeline has a connection establishment phase, data communication phase, and connection clearing phase.

The connection establishment phase is the duration between the time that the SYN packet is sent from Ingress MP to middlebox, and ACK packet from middlebox is received at Egress MP.

The data communication phase is the duration between the time that the first data request packet is sent from Ingress MP to middlebox, and ACK packet from Ingress MP for the last data transfer packet is received at middlebox.

The connection clearing phase is the duration between the time that the FIN packet is sent from Ingress MP to middlebox, and FIN+ACK packet from middlebox is received at Egress MP.

The overall communication phase is the duration between the time that the SYN packet is sent from Ingress MP to middlebox, and FIN+ACK packet from middlebox is received at Egress MP. Overall communication phase consists of communication establishment, data communication, and connection clearing phases.

TCP performance reference events and parameters are defined based on these phases and flows. The end-to-end timeline of TCP connections depends on the TCP version. To define the end-to-end timeline, one should specify the TCP version.

NOTE 1 – TCP version means IETF RFC 793, Reno, Tahoe, and so on.

NOTE 2 – Figure 3 is one sample. There are some ACK handling ways in middlebox. See Appendix I.

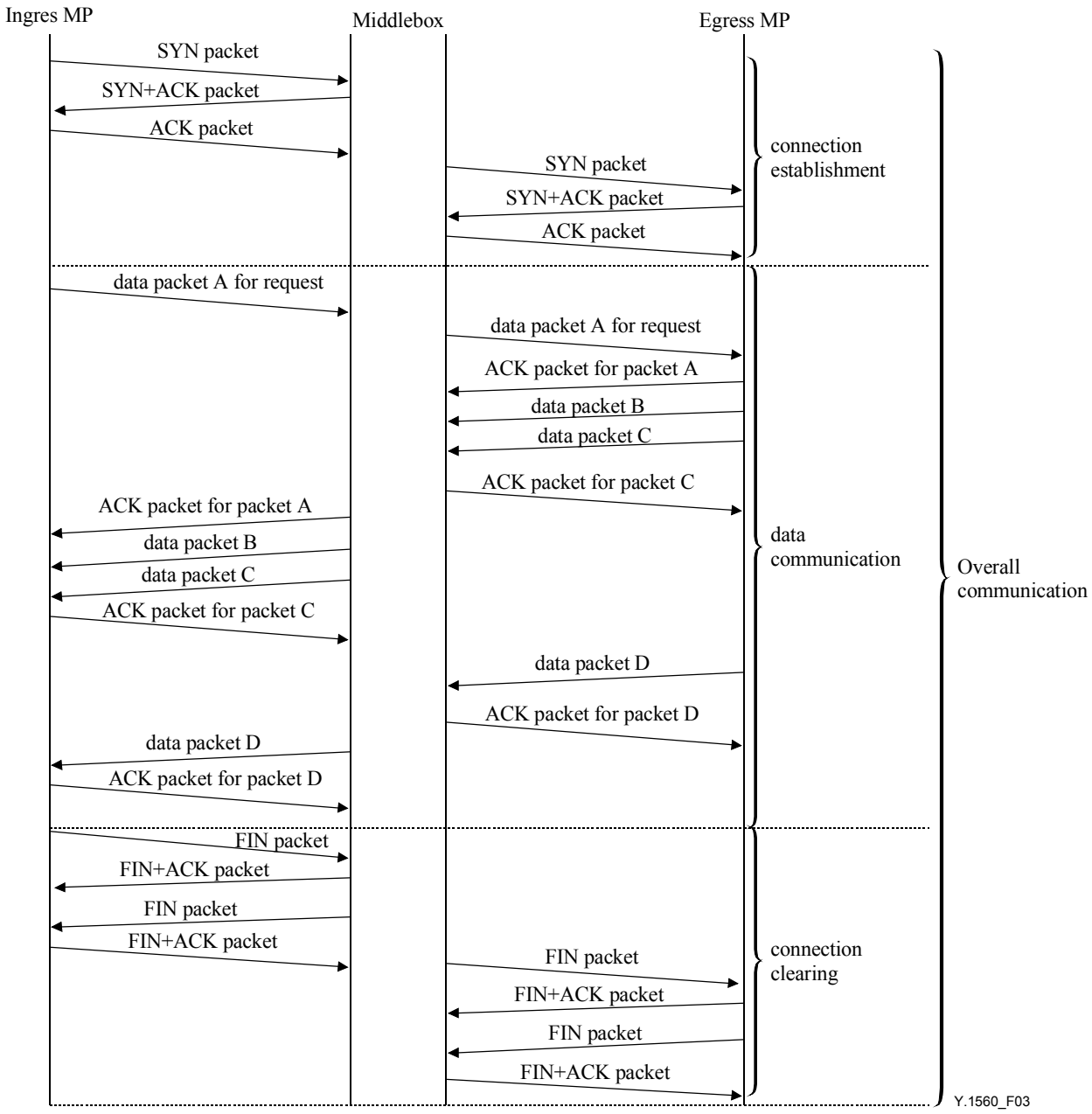

Figure 3/Y.1560 – End-to-end timelines of TCP connections

6 Performance parameters

Table 1 illustrates the application of the three generic performance criteria to each of the three TCP functions. Availability performance is also one of TCP performance derived from the three generic performance parameters.

6.1 Speed parameters

6.1.1 Connection establishment delay

The connection establishment delay is the duration between the time that the SYN packet is sent from Ingress MP to middlebox, and ACK packet from middlebox is received at Egress MP.

The connection establishment delay is the duration of the connection establishment phase in Figure 3.

6.1.2 Data communication throughput

The definition of throughput parameters for data communication is for further study.

NOTE – See Appendix III.2.

Table 1/Y.1560 – Generic performance criteria for TCP connection functions

		Speed		Accuracy	Dependability
TCP connection	Connection establishment	Connection establishment delay	Overall communication throughput	Connection establishment error probability	Connection establishment failure probability
	Data communication	Data communication throughput		–	–
	Connection clearing	Connection clearing delay		Premature disconnect probability	Connection clearing failure probability

6.1.3 Connection clearing delay

The connection clearing delay is the duration between the time that the FIN packet is sent from Ingress MP to middlebox, and FIN+ACK packet from middlebox is received at Egress MP.

The connection clearing delay is the duration of the connection clearing phase in Figure 3. The definition of clearing delay depends on the TCP version and is for further study.

6.1.4 Overall communication throughput

The definition of throughput parameters for overall communication is for further study.

NOTE – See Appendix III.3.

6.2 Accuracy and dependability parameters

6.2.1 Connection establishment error probability

The connection establishment error probability is the ratio of the number of connection establishment attempts that result in an error in connection establishment to the total number of connection establishment attempts in a measurement period.

6.2.2 Connection establishment failure probability

The connection establishment failure probability is the ratio of the number of connection establishment attempts that fail to establish a connection to the total number of connection establishment attempts in a measurement period.

6.2.3 Premature disconnect probability

The definition of premature disconnect probability is for further study.

6.2.4 Connection clearing failure probability

The connection release failure probability is the ratio of connection clearing failures to the total number of connection release attempts in a measurement period.

6.3 Availability parameters

Decisions on the appropriate primary performance parameters, outage threshold and algorithms for its definition require further detailed study. TCP service unavailability may be one of availability performance parameters.

Appendix I

Middlebox

I.1 Introduction

Middleboxes are being discussed by IETF [1]. The main ones are: i) packet filtering firewall, ii) application proxy and iii) Network Address Translation (NAT).

i) A packet filtering firewall drops packets that are not permitted to pass through. TCP connections are not terminated.

ii) An application proxy terminates a TCP connection, and acts for the connection to the outside. HTTP proxy, Wireless Application Protocol (WAP) proxy and performance enhancing proxy (PEP) are examples of application proxies.

iii) NATs translate private IP addresses to/from global IP addresses. TCP connections are not terminated.

I.2 Factors that affect TCP performance

The following factors affect TCP performance when there are middleboxes in the network:

a) An increase in delay caused by passing through a middlebox (Figure I.1);

b) an increase in throughput as a result of the middlebox (Figure I.2).

For the middleboxes introduced in I.1:

i) packet filtering firewalls involve factor a;

ii) application proxies involve factors a and b;

iii) NATs involve factor a.

Other middleboxes also involve these two factors.

I.3 References

[1] RFC 3234 (2002), *Middleboxes: Taxonomy and Issues*.

[2] RFC 3303 (2002), *Middlebox communication architecture and framework*.

[3] RFC 3135 (2001), *Performance Enhancing Proxies Intended to Mitigate Link-Related Degradations*.

[4] WAP, Home Pages, http://www.wapforum.org/

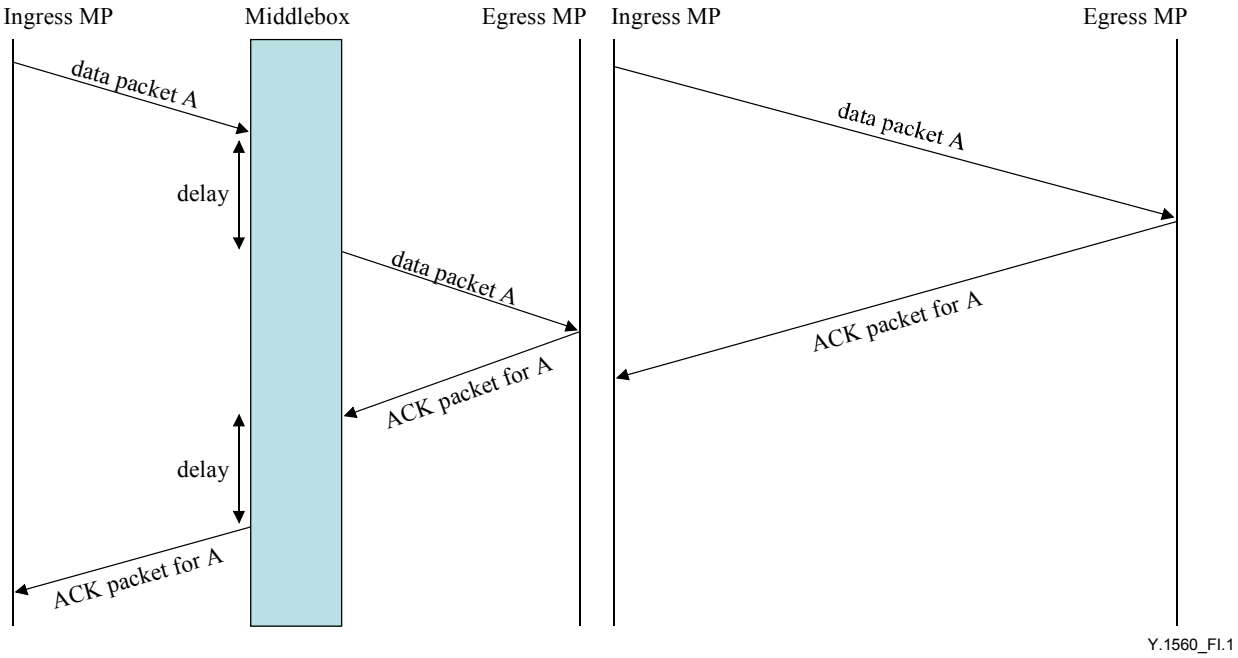

Figure I.1/Y.1560 – Increase in delay

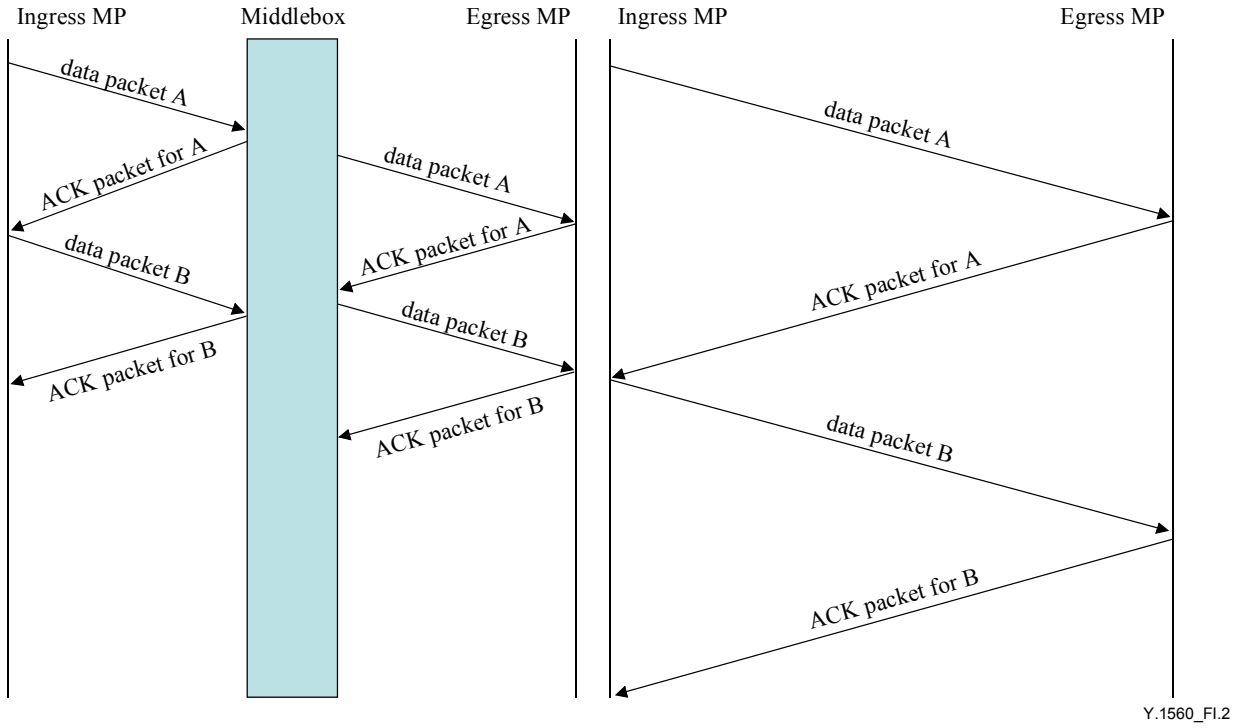

Figure I.2/Y.1560 – Effect of PEP

Appendix II

Effectiveness of middleboxes

The effectiveness of middleboxes is obtained by comparing the cases where middleboxes are and are not used in the network. Therefore, it is important to consider the case without middleboxes, which is shown in Figure II.1. The parameters described in clause 5 should be determined and evaluated when middleboxes are not in the network.

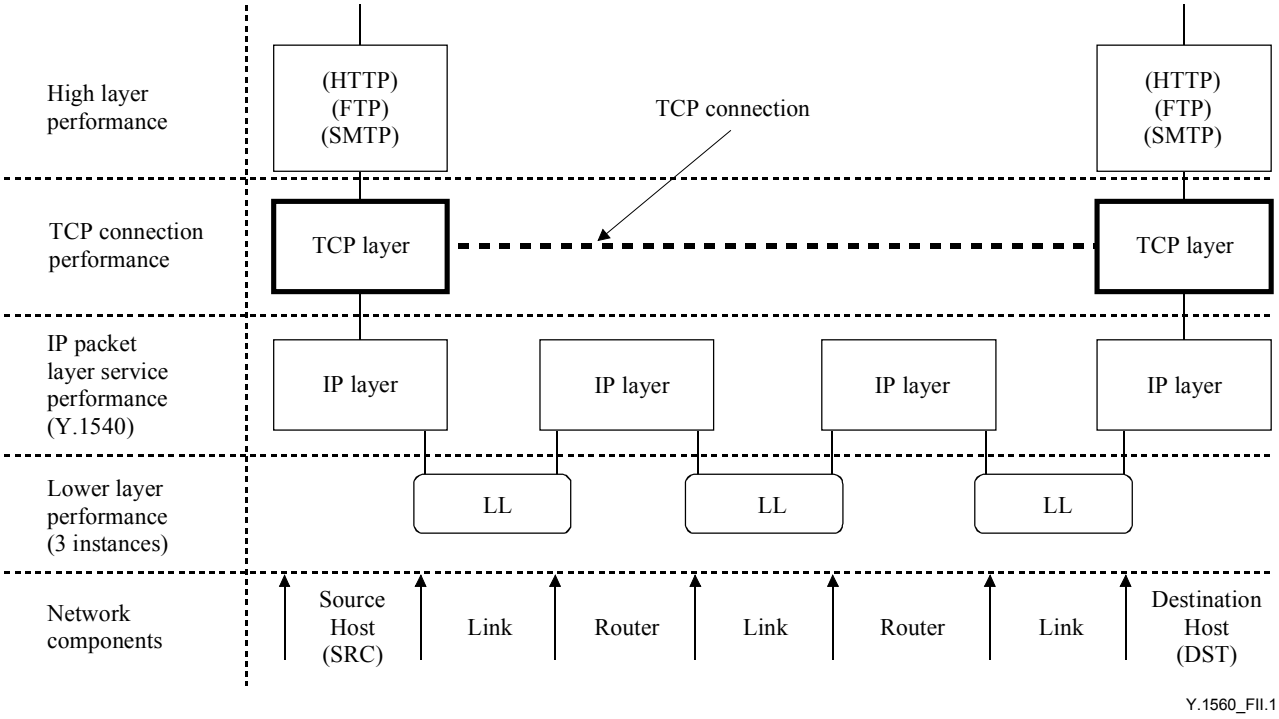

Figure II.1/Y.1560 – Layered model of performance for TCP connection without a middlebox – example

Appendix III

Information on throughput

III.1 Issue to define TCP throughput

Following aspects affect the definition of TCP throughput.

Version dependency

Various TCP versions exist, and each version acts differently on the data communication phase. Therefore, each TCP throughput version has to be defined individually. This is for further study.

Client aspects

TCP throughput depends on client's setting and performance. To define TCP throughput we have to consider client aspects and this is beyond the scope of this Recommendation.

III.2 Data communication throughput

Data communication throughput is expressed by dividing the total number of bytes sent in the data communication phase by the time taken between the first packet's departure and the last packet's arrival. Data communication throughputs of the upstream and downstream directions are specified. Performance parameters for evaluating the variation during data communication, like FTP bulk communication, are also necessary.

III.3 Overall communication throughput

Overall communication throughput is expressed by dividing the total number of bytes sent in overall communication by the time taken between the first packet's departure in connection establishment and the last packet's arrival in connection clearing. Connection throughputs of the upstream and downstream directions are specified. Overall communication throughput is a measure of the performance of the whole connection including connection establishment, data communication, and connection clearing.

Appendix IV

Bibliography

RFC 2330 (1998), *Framework for IP Performance Metrics*.

RFC 3148 (2001), *A Framework for Defining Empirical Bulk Transfer Capacity Metrics*.

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