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SERIES Y: GLOBAL INFORMATION INFRASTRUCTURE, INTERNET PROTOCOL ASPECTS AND NEXT-GENERATION NETWORKS, INTERNET OF THINGS AND SMART CITIES

Next Generation Networks – Packet-based Networks

Quality of service guaranteed mechanisms and performance model for public packet telecommunication data networks

Recommendation ITU-T Y.2617

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Recommendation ITU-T Y.2617

Quality of service guaranteed mechanisms and performance model for public packet telecommunication data networks

Summary

Recommendation ITU-T Y.2617 defines performance parameters including delay, jitter, and packet loss ratio, specifies end-to-end performance allocation when a public packet telecommunication data network (PTDN) interworks with other PTDNs or packet data networks (PDNs), describes service classification in terms of constant bit rate services and variable bit rate services and defines quality of service (QoS) guaranteed mechanisms in a PTDN.

History

Edition	Recommendation	Approval	Study Group	Unique ID*
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Keywords

Delay, jitter, packet loss, performance allocation, performance parameter, PTDN, QoS, QoS guaranteed mechanism, VPN.

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Quality of service guaranteed mechanisms and performance model for public packet telecommunication data networks

1 Scope

This Recommendation defines performance parameters, an end-to-end performance allocation approach, service classifications and quality of service (QoS) guaranteed mechanisms in a public packet telecommunication data network (PTDN) (defined in [ITU-T Y.2613]).

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 Y.1541] Recommendation ITU-T Y.1541 (2011), *Network performance objectives for IP-based services*.

[ITU-T Y.2613] Recommendation ITU-T Y.2613 (2010), *General technical architecture for public packet telecommunication data network (PTDN)*.

3 Definitions

3.1 Terms defined elsewhere

This Recommendation uses the following terms defined elsewhere:

3.1.1 constant bit rate service [b-ITU-T I.113]: A type of telecommunication service characterized by a service bit rate specified by a constant value.

3.1.2 control plane [b-ITU-T Y.2011]: The set of functions that controls the operation of entities in stratum or layer under consideration, plus the functions required to support this control.

3.1.3 data plane [b-ITU-T Y.2011]: The set of functions used to transfer data in stratum or layer under consideration.

3.1.4 management plane [b-ITU-T Y.2011]: The set of functions used to manage entities in the stratum or layer under consideration, plus the functions required to support this management.

3.1.5 packet loss [b-ITU-T G.1050]: The failure of a packet to traverse the network to its destination. Typically, packet loss is caused by packet discards due to buffer overflow. This model does not take into account packet loss due to discards in the terminal jitter buffer.

3.1.6 packet loss ratio (PLR) [b-ITU-R BT.1720]: The ratio between the number of the packets lost in the network and the total number of transmitted packets.[1]

3.1.7 queuing delay [b-ITU-T E.600]: In delay mode of operation, the time interval between the bid for a resource and its seizure.

3.1.8 variable bit rate service [b-ITU-T I.113]: A type of telecommunication service characterized by a service bit rate specified by statistically expressed parameters which allow the bit rate to vary within defined limits.

3.2 Terms defined in this Recommendation

This Recommendation defines the following term:

3.2.1 quality of service (QoS) domain: A collection of connected public packet telecommunication data network (PTDN) resources that are organized under common QoS policies and are under the control of the same network administration.

4 Abbreviations and acronyms

This Recommendation uses the following abbreviations and acronyms:

ADT Address Translator

ED Edge Device

IP Internet Protocol

IPER IP packet Error Ratio

IPLR IP packet Loss Ratio

NNI Network/Network Interface

PD Propagation Delay

PDN Packet Data Network

PLR Packet Loss Ratio

PTDN Public packet Telecommunication Data Network

QoS Quality of Service

RTP Real Time Protocol

SLA Service Level Agreement

TD Transmission Delay

UDP User Datagram Protocol

UNI User Network Interface

VPN Virtual Private Network

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[1] According to the measurement scheme and the methodology proposed in [b-ITU-R BT.1720], the total number of lost packets in the PLR parameter is the sum of IP packet loss ratio (IPLR) and IP packet error ratio (IPER) as defined in [ITU-T Y.1541]. A more complete definition of this parameter is given in clause 7.7.1 of [b-ITU-T G.1020], which defines "Overall (frame/packet) loss ratio" for frames or packets. Being the measurement header on top of the transport layer, if, for an IP packet, the IP or user datagram protocol (UDP) checksum fails, this packet will not be presented to the measurement (or real time protocol (RTP)) layer.

5 Conventions

None.

6 Performance parameters

In a PTDN, three performance parameters are specified as given in clauses 6.1 to 6.3.

6.1 Delay

Delay is the time between the first bit entering the network and the first bit arriving at the user across the network. It includes three factors: transmission delay, propagation delay and node processing delay (including queuing delay).

Transmission delay (TD), in seconds, is the delay caused by the data rate of the link. When the link rate is given, the transmission delay is proportional to the packet length, it can be calculated as follows:

$$TD = N/R$$

where:

N is the number of bits in the packet;

R is the rate of transmission (in bits per second).

Propagation delay (PD), in seconds, is the amount of time spent for the traffic to travel from the sender to the receiver. It relates to the link distance and propagation speed. It can be calculated as follows:

$$PD = L/S$$

where:

L is the length of the physical link (in kilometres);

S is the propagation speed in link (in kilometres per second).

Node processing delay is the time spent for in-node processing, such as output link selection, bit errors check and queuing delay. More processes, such as address resolution, en/de-capsulation, examining the packet for security, are only done on a PTDN edge device (ED). Therefore, the processing delay on an ED is larger than that on an intermediate PTDN node. In addition, the time spent for processing different packets may not be constant. For example, it will take a much longer time for address resolution by an address translator (ADT) than by a local address cache.

Queuing delay is the time spent between a packet arriving at a queue and it being transmitted out of the queue. If the number of incoming packets is bigger than that of outgoing packets, it causes queuing delay. Burst, load of a queue and packet length variance make queuing delay unstable; different queuing mechanisms (e.g., priority queue) and different schedule principles (e.g., weighted round robin) can affect queuing delay.

Transmission and propagation delays are relatively stable, while node-processing and queuing delays may vary from packet to packet.

6.2 Jitter

Jitter is the variation between the maximum delay and minimum delay within a specific time window. The node processing delay (including queuing delay) is the main factor of jitter.

6.3 Packet loss ratio

Packet loss ratio (PLR) is the total number of packets failing to deliver through the network divided by the total number of transmitted packets within a specific time window.

Packet loss can be caused by a number of factors including noise or signal degradation over the transmission link, packet drop because of congestion and hardware faults. Intentional packet dropping also causes packet loss. In a PTDN, this intentional packet dropping happens when virtual private network (VPN) traffic or multicast traffic are above the preset threshold.

7 Performance allocation

In a PTDN, an end-to-end network service may pass through concatenating QoS domains. End-to-end performance objectives are allocated to these QoS domains and interworking links between domains.

7.1 End-to-end QoS in PTDN

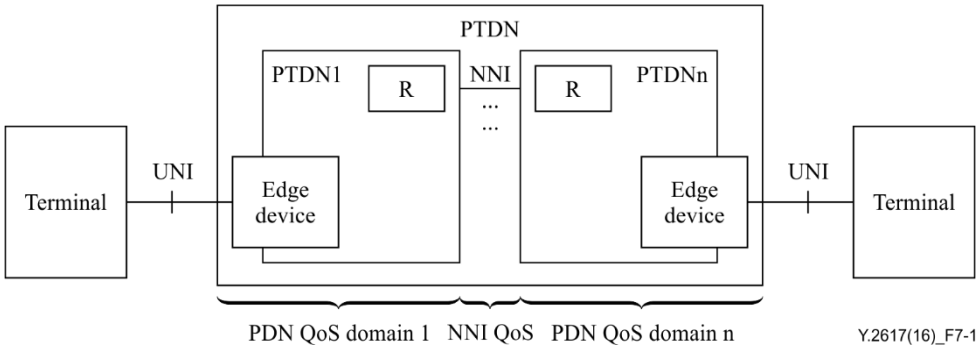

Figure 7-1 – End-to-end QoS model (without other types of PDNs)

As shown in Figure 7-1, end-to-end QoS in PTDN is decided by (1~*n*) PTDN QoS domains and (0~(*n*−1)) network/network interface(s) (NNI(s)) between these QoS domains.

In this case, the relationship between end-to-end performance parameters and those of QoS domains is as in clauses 7.1.1 to 7.1.3.

7.1.1 Delay

The end-to-end PTDN packet delay is the sum of the delays experienced along the concatenating QoS domains from source user network interface (UNI) to destination UNI (not included), as follows:

$$D_t = \sum_{i=1}^{n} Ddi + \sum_{i=1}^{n-1} D_{NNIi}$$

where:

D_t is the packet delay of end-to-end QoS;

Dd_i is the packet delay of the PTDN QoS domain *i*;

D_{NNIi} is the packet delay of the PTDN NNI between PTDN domain *i* and PTDN domain *i*+1.

7.1.2 Jitter

Although it is difficult to estimate accurately, an end-to-end delay variation occurs across a set of concatenated QoS domains along the path. For the relationship for estimating the UNI–UNI delay variation, see clause 8.2.4 of [ITU-T Y.1541].

7.1.3 Packet loss ratio

When packet loss can be expressed as a probability and the assumption of independence between QoS domains holds, UNI–UNI performance may be estimated by inverting the probability of successful packet transfer across QoS domains, as follows:

$$PLR_t = 1 - \prod_{i=1}^{n}(1 - PLR_{di}) \times \prod_{i=1}^{n-1}(1 - PLR_{NNIi})$$

where:

PLR_{di} is the packet loss rate of PTDN QoS domain *i*;

PLR_{NNIi} is the packet loss rate of PTDN NNI*i* between PTDN QoS domain *i* and PTDN OoS domain *i* + 1.

7.2 End-to-end QoS with other PDNs

As shown in Figure 7-2, end-to-end QoS in a mixed network that includes multiple PTDN QoS domains and two public data network (PDN) QoS domains, is decided by PTDN QoS domain(s), PDN QoS domain(s), NNI(s) and UNI(s) among PTDN QoS domains and PDN QoS domains.

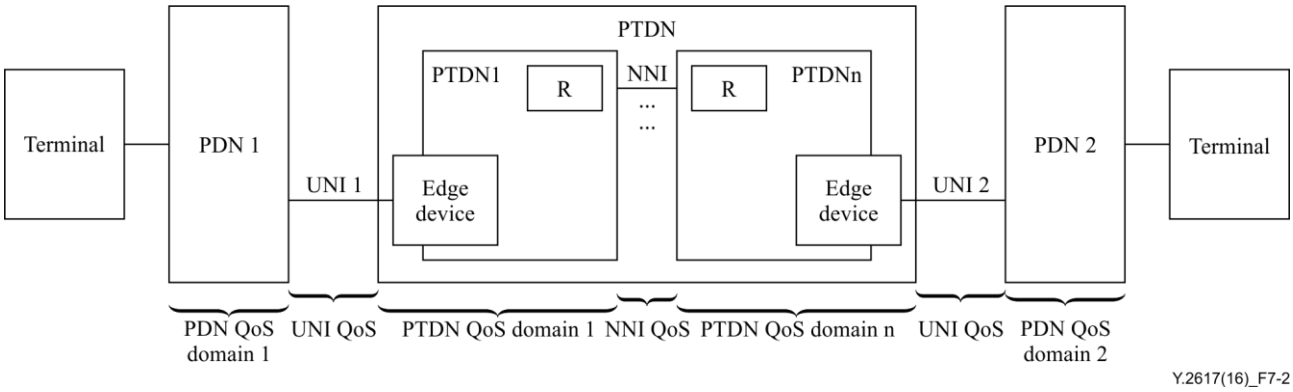

Figure 7-2 – End-to-end QoS domain (with PDN)

In this case, the relationship between end-to-end performance parameters and those of QoS domains is as given in clauses 7.2.1 to 7.2.3.

7.2.1 Delay

The end-to-end PTDN packet delay is the sum of the delays experienced along the concatenating QoS domains and interface between them as follows:

$$D_t = \sum_{i=1}^{n} Ddi + \sum_{i=1}^{n-1} D_{NNIi} + \sum_{j=1}^{2} D_{PDNj} + \sum_{j=1}^{2} D_{UNIj}$$

where:

D_t is the packet delay of end-to-end QoS;

Dd_i is the packet delay of PTDN QoS domain *i*;

D_{NNIi} is the packet delay of the PTDN NNI between PTDN domain *i* and PTDN domain *i*+1;

D_{PDNj} is the packet delay of PDN QoS domain *j*;

D_{UNIj} is the packet delay of UNI *j* between PDN domain *j* and its adjacent PTDN domain (e.g., PTDN domain 1 or PTDN domain *n*)

7.2.2 Jitter

For the relationship for estimating the delay variation, see clause 8.2.4 of [ITU-T Y.1541].

7.2.3 Packet loss ratio

When packet loss can be expressed as a probability and the assumption of independence between QoS domains holds, the end-to-end performance may be estimated by inverting the probability of successful packet transfer across QoS domains and interfaces, as follows:

$$PLR_t = 1 - \prod_{i=1}^{n}(1 - PLR_{di}) \times \prod_{i=1}^{n-1}(1 - PLR_{NNIi}) \times \prod_{j=1}^{2}(1 - PLR_{UNIj}) \times \prod_{j=1}^{2}(1 - PLR_{PDNj})$$

where:

PLR_{di} is the packet loss rate of PTDN QoS domain *i*;

PLR_{NNIi} is the packet loss rate of PTDN NNI*i* between PTDN QoS domain *i* and PTDN QoS domain *i* + 1;

PLR_{PDNj} is the packet loss rate of PDN QoS domain *j*;

PLR_{UNIj} is the packet loss rate of UNI*j* between PDN QoS domain *i* and PTDN QoS domain 1 or *n*.

8 Service classification

PTDN services can be divided generally into two types, which are constant bit rate services and variable bit rate services.

Constant bit rate services, such as telephone, video conference and other interactive real-time services, are sensitive to network QoS, especially to the packet delay and packet jitter of network. While variable bit rate services, such as text message, e-mail, file download, non-real-time audio and applications, may not be sensitive to packet delay, but may be sensitive to packet loss. So there should be different network QoS guaranteed mechanisms for constant bit rate services and variable bit rate services.

In order to guarantee network QoS, two types of network services should not be mixed: transmitted. PTDN VPN can provide independent network resources to two types of network services to guarantee QoS with high network bandwidth utilization.

9 QoS guaranteed mechanisms

9.1 Generic QoS guaranteed mechanisms

This Recommendation describes the following mechanisms used to meet PTDN QoS requirements.

- *Resource reservation*

  PTDN reserves network resources on demand.

  In connection-oriented mode, resources are reserved for end-to-end virtual circuits. Resource reservation involves means of setting up, maintenance and disconnection of virtual circuits.

  In connectionless mode, resources are reserved for a virtual network. The resources are reserved, controlled, maintained and monitored through controlling signalling in the control plane or directly managed through the management plane.

- *Queue (or buffer) management*

  Different mechanisms are deployed at different stages in the PTDN node. At ingress stage, some queue management mechanisms combined with admission control attempt to reduce the probability of congestion, to offer good burst absorption at the same time. At the egress stage, combined with different scheduling, such as strict priority, weighted round robin, and dropping polices, queue management can implement QoS guarantee.

- *Congestion avoidance*

  Congestion in PTDNs occurs when the traffic exceeds what the part of network or the whole network can handle.

  In the first situation, PTDN can select a new path to bypass these busy nodes. By choosing a new route satisfying the QoS parameters, PTDN can maintain end-to-end QoS guarantee.

  In the second situation, a feedback mechanism is used to notify ingress EDs cooperating with the admission control mechanism to reject new packets on UNI.

- *Admission control*

  This mechanism controls the traffic to be admitted into EDs and R nodes based on a service level agreement (SLA). Admission control has two control approaches: a parameter-based approach and a policy-based approach.

  The parameter-based approach usually specifies allowed gauge for delay, jitter and loss ratio and is appropriate for use to meet the guarantee of real-time service in the PTDN network.

  The policy-based approach depends on certain preset policies to decide whether to admit the traffic; relevant factors of policies include user profiles, service types, traffic characteristic and network status.

9.2 VPN QoS guaranteed mechanisms

Each VPN can provide its own QoS guaranteed mechanism, because each VPN works independently. The policies and mechanisms described in clause 9.1 can be used for VPN.

10 Security considerations

In a PTDN, QoS guaranteed mechanisms and performance model do not raise any new security issues.

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