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**SERIES Y: GLOBAL INFORMATION
INFRASTRUCTURE, INTERNET PROTOCOL ASPECTS
AND NEXT-GENERATION NETWORKS**

Internet protocol aspects – Architecture, access, network
capabilities and resource management

Traffic control and congestion control in IP-based networks

Recommendation ITU-T Y.1221



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Recommendation ITU-T Y.1221

Traffic control and congestion control in IP-based networks

Summary

Recommendation ITU-T Y.1221 provides a general description as well as objectives and procedures for traffic control and congestion control for IP-based networks. In particular, it describes the concepts of the traffic contract between a user and the network. It specifies the IP transfer capabilities (IPTCs) including, for each IPTC, the service model, the associated traffic patterns and conformance definition.

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FOREWORD

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The World Telecommunication Standardization Assembly (WTSA), which meets every four years, establishes the topics for study by the ITU-T study groups which, in turn, produce Recommendations on these topics.

The approval of ITU-T Recommendations is covered by the procedure laid down in WTSA Resolution 1.

In some areas of information technology which fall within ITU-T's purview, the necessary standards are prepared on a collaborative basis with ISO and IEC.

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As of the date of approval of this Recommendation, ITU had received notice of intellectual property, protected by patents, which may be required to implement this Recommendation. However, implementers are cautioned that this may not represent the latest information and are therefore strongly urged to consult the TSB patent database at <http://www.itu.int/ITU-T/ipr/>.

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Recommendation ITU-T Y.1221

Traffic control and congestion control in IP-based networks

1 Scope

This Recommendation describes traffic control and congestion control procedures for IP-based networks. Such control procedures are necessary in order to support services with quality of service (QoS), where the QoS is negotiated between a user and the network.

Traffic control refers to all network actions aiming to meet the negotiated performance objectives in an IP-based network and to allow the avoidance of congested conditions.

Congestion control refers to all network actions to minimize the intensity, spread and duration of congestion.

This Recommendation provides a general description, as well as objectives and procedures, for traffic control and congestion control. In particular, it describes the concepts of the traffic contract between a user and the network. It specifies the IP transfer capabilities (IPTCs) including, for each IPTC, the service model, the associated traffic patterns and conformance definition.

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.

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|----------------|--|
| [ITU-T I.371] | Recommendation ITU-T I.371 (2000), <i>Traffic control and congestion control in B-ISDN</i> . |
| [ITU-T Y.1241] | Recommendation ITU-T Y.1241 (2001), <i>Support of IP-based services using IP transfer capabilities</i> . |
| [ITU-T Y.1540] | Recommendation ITU-T Y.1540 (1999), <i>Internet protocol data communication service – IP packet transfer and availability performance parameters</i> . |
| [ITU-T Y.1541] | Recommendation ITU-T Y.1541 (2002), <i>Network performance objectives for IP-based services</i> . |

3 Definitions

3.1 Terms defined elsewhere

None.

3.2 Terms defined in this Recommendation

This Recommendation defines the following terms:

3.2.1 conformance: Conformance is the application of one or more criteria, at a given standardized interface, to a flow.

3.2.2 congestion: Congestion is defined as a state of network elements (e.g., router, switches) in which the network is not able to meet the network performance objectives and the negotiated QoS commitments for the already established flows.

3.2.3 IP congestion control: Refers to all network actions to minimize the intensity, spread and duration of congestion.

3.2.4 IP flow: An IP flow at a given interface is defined as the occurrence at that interface of the set of IP packets which match a given classification (see clause 7.1.2).

3.2.5 IP traffic control: Refers to network actions aiming to meet the network performance objectives and negotiated QoS commitments.

3.2.6 IP transfer capability: An IP transfer capability is a set of network capabilities provided by an IP-based network to transfer IP flows.

3.2.7 overload: Overload is defined as a state of a network element in which buffer overflow results in packet discard for flows with no QoS commitments.

3.2.8 packet classification: The process of distinguishing IP packets for the purpose of applying appropriate traffic control and congestion control mechanisms (see clause 7.1.1).

3.2.9 traffic contract: For a given IP flow, the selected IP transfer capability (see clause 8), the traffic descriptor at a given interface and the QoS class [ITU-T Y.1541] define the traffic contract at that interface (see clause 7.1.5).

3.2.10 traffic descriptor: A traffic descriptor is the set of traffic parameters that is used to capture the traffic characteristics of an IP flow at a given standardized interface as part of the traffic contract (see clause 7.1.4).

3.2.11 traffic parameter: A traffic parameter describes one aspect of a flow (see clause 7.1.3).

4 Abbreviations and acronyms

This Recommendation uses the following abbreviations and acronyms:

BE	Best Effort
Bp	Bucket size of peak token bucket
Bs	Bucket size of sustainable token bucket
CBR	Constant Bit Rate
CDBW	Conditionally Dedicated Bandwidth (IP transfer capability)
CDV	Cell Delay Variation
CSPF	Constrained Shortest Path First
DBW	Dedicated Bandwidth (IP transfer capability)
DS	Differentiated Services (IP header field)
DSBW	Delay-sensitive Statistical Bandwidth (IP transfer capability)
FRR	Fast Reroute
GBRA	Generic Byte Rate Algorithm
GCRA	Generic Cell Rate Algorithm
IP	Internet Protocol
IPDV	IP Delay Variation
IPLR	IP Loss Ratio

IPTC	IP Transfer Capability
IPTD	IP Transfer Delay
LR	Line Rate
LSP	Label Switched Path
MPLS	Multiprotocol Label Switching
OSPF	Open Shortest Path First
PC	Parameter Control
PCR	Peak Cell Rate
QoS	Quality of Service
Rp	Rate of peak token bucket
Rs	Rate of sustainable token bucket
SBW	Statistical Bandwidth (IP transfer capability)
SDP	Session Description Protocol
SIP	Session Initiation Protocol
TAT	Theoretical Arrival Time
TB	Token Bucket
TC	Transfer Capability
ToS	Type of Service (IP header field, see DS)

5 Conventions

This Recommendation uses the following conventions:

- *B*: Bucket size of a token bucket;
- *M*: Maximum allowed packet size;
- *N*: Size (in bytes) of an IP packet;
- *R*: Rate of a token bucket.

6 General

The primary role of traffic control and congestion control procedures is to protect the IP network and the traffic entering the network in order to achieve the IP network performance objectives and QoS commitments. Traffic and congestion control allows the use of IP network resources to be optimized.

In IP-based networks, congestion is defined as a state of network elements (e.g., routers, switches) in which the network is not able to meet the network performance objectives and the negotiated QoS commitments for the established flow. Congestion is to be distinguished from the state where buffer overflow causes IP packet loss, but the negotiated quality of service is still met. For services with no QoS commitments, such as best effort services, the term overload is used rather than congestion.

This Recommendation defines a set of traffic control and congestion control capabilities. It may be appropriate to consider additional sets of such capabilities, for which additional traffic control mechanisms will be used to achieve increased network efficiency.

It should be noted that traffic control procedures apply to IP packet flows. For some IP flows, the network commits to meet QoS objectives, assuming the user-generated IP packet flow conforms to a traffic contract. For IP flows without a traffic contract between the user and the network, the network may provide a best effort service.

7 Traffic parameters and descriptors

7.1 Definitions

7.1.1 IP packet classification

Typically, IP packets from many different sources may cross a given interface to many different destinations. For the purpose of IP traffic control and congestion control, it is essential that not all IP packets are treated the same way but differently, depending on the objectives and on the commitments made. Therefore, it is useful to distinguish IP packets into relevant categories. The process of distinguishing IP packets for the purpose of applying appropriate traffic control and congestion control mechanisms is called IP packet classification. IP packet classification is based on information in the following IP header fields: source address, destination address [b-IETF RFC 791] and TOS/DS field [b-IETF RFC 791]/[b-IETF RFC 2474]. The level of detail in the classification may differ, depending on its intended use. The following examples illustrate this:

- Example 1 – In order to recognize IP packets which flow from a given source address to a given destination address, the entire length of the source and destination address fields is used in the classification.
- Example 2 – In order to recognize IP packets which flow from a given source address to a given destination address with a given service level, the entire length of the source and destination address fields and the DS field is used in the classification.
- Example 3 – In order to recognize IP packets which flow from a source in one given subnet to a destination in another given subnet, the respective subnet masks are applied to the source and destination address fields.

NOTE – In this version of this Recommendation, only the packet classification for IP version 4 has been addressed. Classification for IPv6 and MPLS is for further study.

7.1.2 IP flow and IP subflow

An IP flow at a given interface is defined as the occurrence at that interface of the set of IP packets that match a given classification (see clause 7.1.1). An IP flow may consist of packets from a single application session, or it may be an aggregation comprising the combined traffic from a number of application sessions. When a classification may be subdivided into different sub-classifications (separate or overlapping), different IP subflows may be recognized in the corresponding IP flow.

7.1.3 Traffic parameter

A traffic parameter describes one aspect of a flow. It may be qualitative or quantitative. A traffic parameter may for example describe the peak bit rate, the peak packet rate, the average bit rate, the average or maximum packet size, the (average or maximum) burst length of a flow, etc.

7.1.4 Traffic descriptor

A traffic descriptor is the set of traffic parameters that is used to capture the traffic characteristics of an IP flow at a given standardized interface as part of the traffic contract (see clause 7.1.5).

7.1.5 Traffic contract

For a given IP flow, the selected IP transfer capability (see clause 8), the traffic descriptor at a given interface (see clause 7.1.4) and the QoS class (see [ITU-T Y.1541]) define the traffic contract at that interface.

7.2 Requirements on traffic parameters and traffic descriptors

Any traffic parameter to be involved in a traffic descriptor should:

- have the same interpretation on both sides of an interface;
- be meaningful in resource allocation schemes to meet network performance requirements;
- be enforceable by the parameter control (PC), see clause 9.1.3.

7.3 Traffic parameter specifications

7.3.1 Reference configuration

For further study.

7.3.2 Traffic parameter description

The following traffic parameters are defined, which may be used in traffic descriptors.

7.3.2.1 Maximum allowed packet size

The maximum allowed packet size, M , is expressed in bytes. It is a mandatory traffic parameter for each IP transfer capability (IPTC).

7.3.2.2 GBRA or token bucket

The generic byte rate algorithm (GBRA) or token bucket (TB), as described in Annex A, is used to characterize a rate and the associated burstiness. Both concepts are equivalent and use the following set of two parameters:

- the rate, R , expressed in bytes/s;
- the bucket size, B , expressed in bytes.

The traffic descriptor may contain zero or more token buckets (with the respective values of R and B).

The current set of IP transfer capabilities (see clause 8) recognizes a peak token bucket (TB) (with parameters peak rate, R_p , and peak bucket size, B_p) and a sustainable TB (with parameters sustainable rate, R_s , and sustainable bucket size, B_s).

8 IP transfer capabilities

An IP transfer capability is a set of network capabilities provided by IP-based networks to transfer IP packets. For each IP transfer capability, the service model, traffic descriptor, conformance definition and any QoS commitments are defined. An IP transfer capability is supported by a set of traffic control and congestion control functions.

In order to offer multiple classes of QoS to multiple applications and to optimize the usage of network resources, IP-based networks should be capable of providing multiple transfer capabilities.

Five IP transfer capabilities are defined:

- dedicated bandwidth (DBW) IP transfer capability;
- statistical bandwidth (SBW) IP transfer capability;
- best-effort (BE) IP transfer capability;
- delay-sensitive statistical bandwidth (DSBW) transfer capability;
- conditionally dedicated bandwidth (CDBW) transfer capability.

This set of IP transfer capabilities are based on current IP service models and it may be extended in the future.

8.1 Dedicated bandwidth transfer capability

8.1.1 Description

The dedicated bandwidth (DBW) transfer capability is intended to support applications with stringent delay requirements. It aims to support the guaranteed and timely delivery of IP packets along the end-to-end path of the network.

The DBW transfer capability strives for compatibility with the guaranteed service [b-IETF RFC 2212] and the end-to-end services based on the expedited forwarding per-hop behaviour [b-IETF RFC 2598].

8.1.2 Service model

The DBW IPTC can be used by applications that characterize the traffic with a single token bucket.

The commitment made by the network is that the negotiated IP QoS is assured to all IP packets when all packets are conforming to the conformance tests. The DBW user should expect that (possibly all) non-conforming packets be discarded by the network.

The DBW capability can be associated with specified loss commitments (IP loss ratio (IPLR)) and specified delay commitments (IP transfer delay (IPTD) and IP delay variation (IPDV)), (see [ITU-T Y.1541]).

The network does not fragment packets. In addition, the network commits to attempt, as long as possible (e.g., until there is a need to reroute the flow), to maintain packet sequence integrity.

8.1.3 Traffic descriptor

The traffic descriptor consists of the following parameters:

- The peak rate, R_p , and peak bucket size, B_p , as specified in clause 7.3.2.2.
- The maximum allowed packet size, M , as specified in clause 7.3.2.1.

8.1.4 Conformance definition

An IP packet is conforming if the arrival conforms to the following two parts:

- the arrival is conforming to the GBRA(R_p, B_p);
- the actual packet length does not exceed the maximum allowed packet size, M .

The GBRA is updated for conforming packets only.

8.1.5 QoS commitments

The DBW capability may be associated with specified loss commitments and specified delay commitments.

If all packets are conforming, the QoS commitments apply to all IP packets. The DBW user should expect that (possibly all) non-conforming packets be discarded by the network. If not all packets are conforming, the network may choose to commit QoS to some of the packets, for example to a volume of packets that is conforming.

8.2 Statistical bandwidth transfer capability

8.2.1 Description

The statistical bandwidth (SBW) transfer capability is intended to support applications that do not have stringent delay requirements. It aims to support the guaranteed delivery of IP packets along the end-to-end path of the network.