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<Y.QoSmap>

QoS mapping and inter-connection between Ethernet, IP and MPLS networks

Summary

Existing QoS class standardisation for packet based layer 2 and layer 3 services is largely non binding or missing. This document intends to simplify technical Ethernet, MPLS and IP QoS interconnection negotiations. Four ordinary classes and four auxiliary classes have been defined. This set of classes covers a wide range of transport service offerings.

The Recommendation gives guidance how to deal with issues resulting from differences in QoS deployments of interconnecting service providers, aiming on preservation of the original intent of the service.

Keywords

QoS, mapping, matching, interworking, interconnection

1 Scope

This Recommendation defines a limited set of classes that provide a basis for inter-working between the different traffic class aggregates of different service providers, while preserving the original intent of the service (although packet markings might change).

The scope includes inter-working between layers and between networks using similar technologies.

Each QoS Class is defined by its qualitative performance characteristics and the suggested groups of applications whose performance requirements match the characteristics of one or more classes.

The limit on the number of classes is imposed by the space available in the widely-used three-bit code-point space.

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End to end QoS requires a common understanding of the QoS class properties in all involved domains. While many similarities are expected between the deployed or planned QoS architectures of different providers, these are often not obvious when starting interconnection negotiations. This specification aims on enabling end to end QoS (by preserving the intended service properties) across different packet networks and on simplification of the technical QoS interconnection negotiations between providers.

Informational examples in the Appendices provide:

- Code-point to class association, with an inter-working example
- Y.1541 QoS Class mapping to inter-working classes

The allocation of numerical performance budgets among inter-working networks in UNI-UNI path is out of scope.

The issue of matching 3GPP TS 23.203 standardized QCI characteristics to inter-working classes 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.371 (2000), *Traffic control and congestion control in B-ISDN.*

[2] ITU-T recommendation Y.1221 (2002), *Traffic control and congestion control in IP-based networks*.

[3] ITU-T recommendation Y.1541 (2006), *Network performance objectives for IP-based services*.

3 Definitions

3.2 Terms defined in this Recommendation

This Recommendation defines the following terms:

3.2.1 Matching: An operation performed to associate existing service classes with the Ordinary class set (or Auxiliary class set), and ultimately associate the classes of two different service providers.

3.2.2 Re-marking: An operation performed to replace the codepoint of an existing service class with the codepoint of the matching class used by another service provider on the interconnecting link.

3.2.3 Mapping Table: A table with entries for each class exchanged at an interconnecting point between service providers, with a row indicating the codepoint of each service class, the matching

Ordinary class (or Auxiliary class), and the codepoint of the class used by the other service provider on the interconnecting link.

4 Abbreviations and acronyms

This Recommendation uses the following abbreviations and acronyms:

3GPP	3rd Generation Partnership Project
AF	Assured Forwarding
CPE	Customer Premises Equipment
CS	Class Selector
DSCP	Differentiated Services Codepoint
EF	Expedited Forwarding
GSMA	Global System for Mobile Communications Alliance
IEEE	Institute of Electrical and Electronics Engineers
IETF	Internet Engineering Task Force
IP	Internet Protocol
MEF	Metro Ethernet Forum
MPLS	Multi Protocol Label Switching
QCI	QoS Class Identifier
QoS	Quality of Service
RFC	Request For Comments
TCP	Transmission Control Protocol
UNI	User Network Interface

5 The Ordinary Class proposal

Prior to development of this Recommendation, there was no single standard which provided:

1. qualitative QoS class definitions,
2. example classification of widely-deployed applications and services, and
3. coverage of interconnection and inter-working of the most popular packet based communication layers (IP, MPLS and Ethernet) and enabling transport technologies.

The last aspect is twofold: first, class properties need to match across interconnection boundaries and second, codepoint mapping should be deterministic and non-ambiguous (identical codepoints are not required).

The aim of this Recommendation is to simplify the production and negotiation of end to end QoS over a chain of retail, wholesale and inter-provider transport products. The Recommendation accomplishes this goal by defining a set of “ordinary” classes with the capability to support groups of commonplace user applications and/or services (with similar performance needs). This section briefly introduces existing standards and then proceeds to a proposal of classes, their properties and example uses. Codepoint and mapping proposals may be found in several appendices.

On IP and MPLS, IETF’s Differentiated Services (Diffserv) architecture RFC2475 [9]~~[9]~~ resulted in first commercial deployments of QoS differentiating IP services. Diffserv tries to respect prior standardisation of IP precedence RFC791 [7]~~[7]~~. Some informative work has been produced suggesting mappings of services to QoS classes and aggregation of IP classes to MPLS classes [15]~~[15]~~, [16]~~[16]~~.

ITU's Y.1541 standardises several generic QoS classes and specifies UNI to UNI performance objectives **Error! Reference source not found.**~~[16]~~.

IEEE standardised quality differentiating LAN services with strict priority scheduling, which was picked as a simple solution viable in local networks. While a QoS class concept similar to that of Diffserv wasn't mandatory within IEEE, an optional specification was provided (see Annex G of IEE802.1Q [18]~~[18]~~). MEF 23 proposes three service oriented classes including an IP to Ethernet mapping [20]~~[20]~~.

GSM alliance IR.34 proposes four service oriented interconnection IP QoS classes [6]~~[6]~~. 3GPP TS23.203 defines 9 classes with different properties and example usages **Error! Reference source not found.**~~[6]~~.

All of these standards have commonalities. But attempting to produce end to end QoS by simply combining the available standards is a challenge. QoS schemes independently developed by separate providers usually aren't identical (although most have many commonalities).

The inter layer QoS mappings to be covered are IP over Ethernet, IP over MPLS, Ethernet over MPLS and Ethernet over IP. These mappings cover the most widespread layer 2 and layer 3 service deployments.

In general, codepoints of an interconnecting party whose QoS markings are trusted (i.e. the receiving network providers is sure to that a given codepoint identifies a specific class) may only be remarked, if the class interpretation remains absolutely identical after remarking. This is required, to allow non ambiguous reversion of the remarking at other points in a communication path. If this can't be done, end to end QoS with pre defined performance properties can't be guaranteed. No suggestions are made here how to remark codepoints of parties to which a provider has no trust relation.

In some cases, the number of classes may differ at an interconnection point. It is then up to the interconnecting parties to agree class mappings and non revertible remarking of traffic, if it can't be avoided. Note that remarking IP precedence within a DSCP offers limited chances for class transparency, if only a single precedence codepoint is remarked and an AF class like DSCP differentiation is applied.

Any mapping of a QoS traffic to a class with different properties should be revertible by conserving the original codepoint. Tunnelling (and may be header stacking) may be appropriate mechanisms.

To simplify mapping of QoS classes, while being aware that neither classes nor codepoints are widely standardised, two tables below introduce lists of class definitions with properties of these classes and some usage examples.

Table 5.1 starts with well defined QoS classes and their properties. It is expected, that support of classes with the properties and usage examples shown in Table 5.1 are a commodity to a majority of carriers and service providers.

Table 5.1 - Ordinary Packet Service QoS Classes, their properties and matching suggestions

Class Properties	Class Name (Usage Example)	Recommended matching to connecting provider class (if per class mapping applies)
Extremely low loss. Very low bandwidth per flow or session.	Critical (Network Management) See [7]~~[7]~~, [8]~~[8]~~, [15]~~[15]~~, [16]~~[16]~~, [18]~~[18]~~. (Note 2 and 4)	This may be a provider internal class (see [7]~~[7]~~). Match to Assured class.
Low loss, very low delay, very low jitter, Short packets. Strict resource control (Note 5)	Priority beta (Voice) See **Error! Reference source not found.**~~[7]~~, [5]~~[5]~~, [6]~~[6]~~, [12]~~[12]~~, [15]~~[15]~~, [16]~~[16]~~, [18]~~[18]~~, [20]~~[20]~~. (Note 1)	Match to Priority class. If not possible, match to Bulk inelastic Class.
Very low loss, High bandwidth.	Assured alfa, (Interactive data) See [6]~~[6]~~, [10]~~[10]~~, [15]~~[15]~~, [16]~~[16]~~, [18]~~[18]~~, [20]~~[20]~~. (Note 1, 2 and 4)	Match to Assured class. If not possible, may be matched to Bulk inelastic class.
Unspecified performance.	Default beta (Best Effort) See **Error! Reference source not found.**~~[20]~~, [5]~~[5]~~, [6]~~[6]~~, [8]~~[8]~~, [15]~~[15]~~, [16]~~[16]~~, [18]~~[18]~~, [20]~~[20]~~. (Note 1, 3 and 4)	Match to Default class.

Note that statements related to bandwidth in table column "class properties" refer to provider internal interfaces. Class specific bandwidth requirements on customer or interconnection interfaces may differ significantly.

Note 1 - Alfa and beta may be interpreted as separate classes with similar properties. They may also be interpreted as priorities of sub-classes (alfa with lower loss probability and beta with higher loss probability).

Note 2 - IETF recommends a rate queue for these services [15]~~[15]~~. Queue configuration alone either allows optimisation for low delay and low jitter or low loss.

Note 3 - The class description is either “Better than best effort” [20]~~[20]~~ for the more valuable class or “Low Priority Data/Background” for the one with higher loss probability [15]~~[15]~~, [16]~~[16]~~ and [18]~~[18]~~. MEF, IEEE , IETF and ITU agree, that no performance targets are specified for “Best Effort or Standard” traffic. This definition is also applied here, Default alfa and Default beta are expected offer “Class of Service” only, meaning they have different but unspecified packet loss probabilities if both are present (contrary to that, MEF [20]~~[20]~~ specifies performance targets for the higher quality in a shared “Low” class). IEEE and IETF agree, that the “Low Priority Data/Background” class has a higher packet drop probability than the Best Effort class.

Note 4 - This class may be optimised to transport traffic without bandwidth requirements. Retransmissions after losses characterise the class and influence the buffer design. Active queue management with probabilistic dropping may be deployed.

Note 5 Traffic load in this class must be strictly controlled, e.g. by application servers. One example could be flow admission control, another one would be codec renegotiation. Congestion in this class may result in bursty packet loss.

Each individual class name (like Assured) identifies a single class. Each class may be produced via a single queue. An alfa and a beta sub class may either be produced on separate queues or on the same queue (and may have different packet loss probability in the latter case).

Class Critical has the same properties as the Assured class, but is listed here separately to emphasise its extra role (it is the only class reserved for provider internal use).

Table 5.2 lists additional QoS classes, which are known to be supported by some service providers and carriers, but not necessarily by a majority of those offering QoS differentiation. Some of these services may be transferred to table 5.1 over time. Table 5.2 indicates widespread temporal trends, while table 5.1 shows stable state.

Table 5.2 - Proposed auxiliary Packet Service QoS Classes, their properties and mapping suggestions

Class Properties	Usage Example	Recommended matching to connecting provider class (if per class mapping applies)
Very low loss, low delay.	Priority alfa (Emergency) (Note 1)	Match to Priority class. If not possible, match to Bulk inelastic Class.
Low loss, low delay, low jitter. High bandwidth.	Bulk inelastic alfa, (Streaming) See [6]~~[6]~~, [10]~~[10]~~, [15]~~[15]~~, [16]~~[16]~~, [18]~~[18]~~. (Note 1, 2 and 5)	Match to Bulk inelastic class. If not possible, match to Assured class.
Very low loss, High bandwidth.	Assured beta, (Interactive data) See [6]~~[6]~~, [10]~~[10]~~, [15]~~[15]~~, [16]~~[16]~~,	Match to Assured class. If not possible, may be matched to Bulk inelastic class.

	[18]~~[18]~~, [20]~~[20]~~. (Note 1, 2 and 4)	
Unspecified performance.	Default alfa (Better Than Best Effort) See [15]~~[15]~~, [16]~~[16]~~, [18]~~[18]~~, [20]~~[20]~~. (Note 1, 3 and 4)	Match to Default class.

Note that statements related to bandwidth in table column “class properties” refer to provider internal interfaces. Class specific bandwidth requirements on customer or interconnection interfaces may differ significantly.

Note 1 - Alfa and beta may be interpreted as separate classes with similar properties. They may also be interpreted as priorities of sub-classes (alfa with lower loss probability and beta with higher loss probability).

Note 2 - IETF recommends a rate queue for these services [15]~~[15]~~. Queue configuration alone either allows optimisation for low delay and low jitter or low loss.

Note 3 - The class description is either “Better than best effort” [20]~~[20]~~ for the more valuable class or “Low Priority Data/Background” for the one with higher loss probability [15]~~[15]~~, [16]~~[16]~~ and [18]~~[18]~~. MEF, IEEE, IETF and ITU agree, that no performance targets are specified for “Best Effort or Standard” traffic. MEF [20]~~[20]~~ specifies performance targets for the higher quality in a shared “Low” class. IEEE and IETF agree that the “Low Priority Data/Background” class has a higher packet drop probability than the Best Effort class. Please also be aware, that MEF, IETF and IEEE may expect the classes Best Effort and Less / Better Than Best Effort to share the same queue.

Note 4 - This class may be optimised to transport traffic without bandwidth requirements. Retransmissions after losses characterise the class and influence the buffer design. Active queue management with probabilistic dropping may be deployed.

Note 5 - Traffic load in this class must be controlled, e.g. by application servers. One example could be flow admission control. There may be infrequent retransmissions requested by the application layer to mitigate low levels of packet losses. Discard of packets through active queue management should be avoided in this class.. Congestion in this class may result in bursty packet loss. If used to carry multimedia traffic, it is recommended to carry audio and video traffic in a single class. All of these properties influence the buffer design.

Proposals on class mappings are made along the class properties. The codepoints to be applied are of secondary importance and may be mapped.

Three to four QoS classes are widely deployed by carriers. The tables 6.1 and 6.2 describe 4 classes (some of which have sub-classes identified as alfa and beta). Not all of the four classes and their sub-classes may be deployed by a single carrier or offered for interconnection. It is reasonable to assume that some sub-classes may share a queue with other sub-classes of a class or may be ordered by priority queuing (also if Ordered Aggregates are not supported for interconnection). The sub-classes indicated in the table should help to identify possibly grouped QoS classes.

The class Priority is expected to carry traffic being subjected to some kind of admission control. This may influence also Interconnection negotiations.

The Priority class may be engineered for a rather limited bandwidth share on an interconnection link carrying multiple QoS classes. As an exception to this, links interconnecting service nodes exchanging mainly Priority class traffic may allow for large bandwidth share of Priority traffic.

A description of methods to engineer the class properties indicated in Tables 5.1 and 5.2 is out of scope. Relevant IP performance class properties are defined in ITU-T Y.1541. See appendix II for more information.

6 Simplifying QoS mapping by a standard interconnection class and codepoint scheme

Due to the lack of a standardized class and codepoint scheme, interconnecting carriers or wholesale customers and carriers must negotiate individual service and codepoint mappings. This consumes time and resources, if such negotiations are repeatedly required on a bilateral basis. The task can be simplified by standardizing an interconnection class and codepoint scheme. Again, the aim is to preserve the original intent of the service at interconnection points.

Standardized interconnection classes and codepoints result in a single QoS class and codepoint mapping scheme per carrier or service provider instead of one per interconnection partner. This holds for the receiving as well as the sending party. Having done the QoS mapping once is sufficient for all other negotiations to come. The idea is simple:

- The sending party maps its own QoS classes and codepoints to the standard QoS interconnection class and codepoint scheme. The traffic is re-marked to the interconnection code point scheme at the egress gateway.
- The receiving party maps the standard QoS interconnection class and codepoint scheme to its own QoS class and codepoint scheme. The traffic is re-marked to the provider internal code point scheme at the ingress gateway.

The properties of the standardized QoS interconnection classes should be standardized to a degree reducing bilateral negotiations on fixing performance budget assignment.

The following are the provisional standardized interconnection classes (usage examples and class properties refer to Table 5.1 and 5.2):

- Priority (Conversational) beta Service (codepoint 5 is recommended on interconnection links, as it is expected to minimise remarking due to widespread deployment see e.g. [5]~~[5]~~, [6]~~[6]~~, [12]~~[12]~~, [20]~~[20]~~).
- Bulk inelastic (Streaming) alfa as single class without sub-classes, see Appendix I for a codepoint proposal.
- Assured (Interactive) beta as single class without sub-classes, see Appendix I for a codepoint proposal.
- Default (Background) class with codepoint 0.

The provisional interconnection classes should be reviewed and may be revised based on further study and experience.

The service class names of GSMA IR.34 [6]~~[6]~~ have been listed in brackets. While the “Interactive” class definition of IR.34 may be controversial in its application of the AF classes, the generic 4 class proposal given there seems to reflect the state of art QoS deployment fairly well.

If the above interconnection classes are not applied by negotiating parties, it is recommended to decide on QoS class mappings based on the qualities of configuration based queue properties. Class names, codepoints and performance guarantees are less useful when looking for a good match for a class.

The interconnection classes reflect commodity QoS deployments present in many networks. In combination with the codepoints suggested by Appendix I, aggregation of ordered aggregates (IP AF traffic classes, and MEF classes) is relatively simple.

Some examples for such a class and codepoint mapping scheme are shown in Figure 7.1. The interconnection classes apply the codepoints suggested by Appendix I.

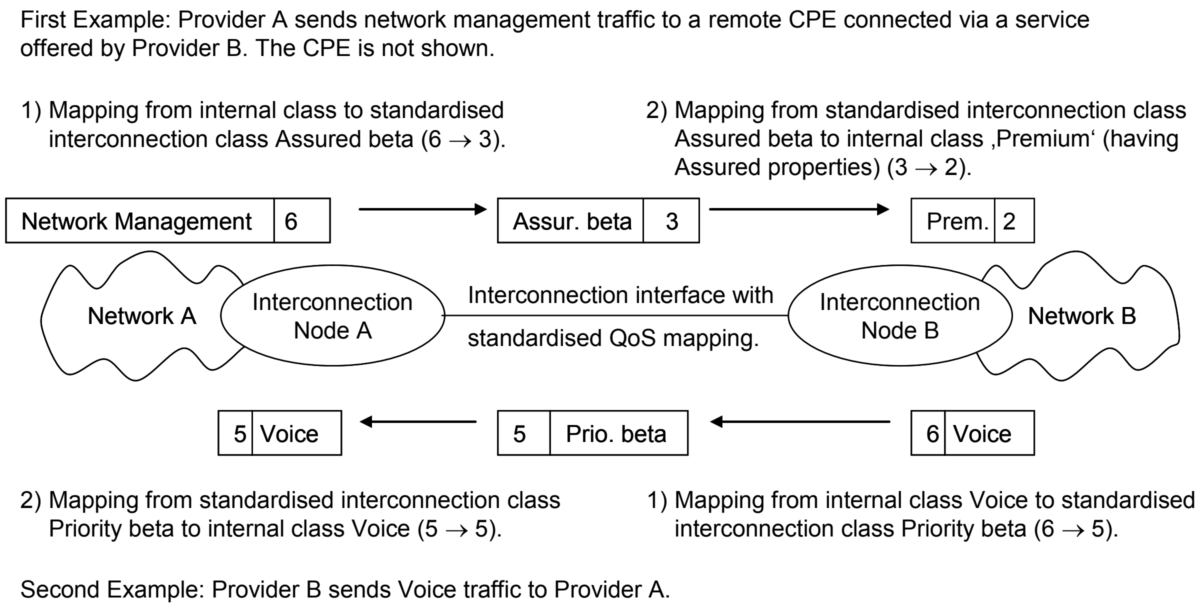

Figure 7.1 - Example usage of standardized QoS interconnection classes and codepoints

Appendix I

Example Codepoint Mapping for 3 bit codepoint classes

(This appendix does not form an integral part of this Recommendation)

This section proposes codepoints and mappings for them on interconnection interfaces for all of the classes shown in table 5.1 as well as table 5.2. A design criterion is a conservative consumption of 3 bit codepoints (hence the Assured Service carries only one codepoint), leaving space for carrier internal classes or future extensions like Explicit or Pre-Congestion Notification in 3 Bit QoS schemes

Table I.1 - Suggested Codepoints for the generic QoS Classes

Received class name (usage example)	**Received codepoint**	**Mapped to Codepoint / Class at Interconnection points**
Priority alfa (Emergency)	7	Priority 7 (or 5)
Critical (Network Management) (Note 1)	6	Assured 3
Priority beta (VoIP)	5	Priority 5
Bulk inelastic alfa	4	Bulk inelastic 4
Assured alfa	3	Assured 3
Assured beta	2	Assured 2 or 3
Default beta	0	Default 0
Default alfa (Note 2)	1	Default 1 or 0
Note 1) This class is regarded an “internal” in this table. A carrier may use different codepoints, especially for Multimedia traffic. Note 2) The author is not aware of the demand for this kind of service at interconnection points. Input is welcome.		

Ordered Aggregates in a QoS class should be mapped onto a single class, if Ordered Aggregates aren’t supported. Assured class with codepoint 3 (or 2) is suggested.

On IP level, the three bit codepoint identifies the IP precedence. The IP precedence codepoint of e.g. DSCP AF41 or CS 4 is 4, the IP precedence of the EF class (Voice) is 5. See RFC 4594 for a brief explanation the relation of IP precedence and DSCP [15]~~[15]~~.

Appendix II

Example Class Mapping for Y.1541 to Y.QoSmap

(This appendix does not form an integral part of this Recommendation)

This section proposes codepoints and mappings for the Y.1541 classes. The assessment is based on table 2/Y.1541 **Error! Reference source not found.**~~[15]~~. Please note that the node mechanisms and the mapping of application examples to classes as proposed by table 2/Y.1541 isn't explained in more detail in Y.1541. Appendix IX of Y.1541 mentions a discussion on a future separate QoS class to carry IP TV traffic.

Table II.1 - Suggested class mapping for Y.1541

<table>
<tr><th>Y.1541 QoS class</th><th>Y.1541 App. (examples)</th><th>Y.1541 Node mechanisms</th><th>Y.QoSmap</th></tr>
<tr><td>0</td><td>VoIP, VTC</td><td rowspan="2">Separate queue with preferential servicing, traffic grooming</td><td>Priority beta</td></tr>
<tr><td>1</td><td>VoIP, VTC</td><td>Priority beta</td></tr>
<tr><td>2</td><td>Transaction data, highly interactive (Signaling)</td><td rowspan="2">Separate queue, drop priority</td><td>Assured alfa
(Note 1 and 2)</td></tr>
<tr><td>3</td><td>Transaction data, interactive</td><td>Assured beta
(Note 2)</td></tr>
<tr><td>4</td><td>Low loss only (short transactions, bulk data, video streaming)</td><td>Long queue, drop priority</td><td>Assured beta
(Note 2)</td></tr>
<tr><td>5</td><td>Traditional applications of default IP networks</td><td>Separate queue (lowest priority)</td><td>Default beta</td></tr>
<tr><td colspan="4">Note 1 - Signaling or Network Management traffic may be prioritized within an Assured Service class. Here signaling is assigned to a Network Management class. This should be taken as an example, rather than a suggestion.
Note 2 - Y.1541 classes 3-5 don't offer delay variation bounds and are characterized by different delay bounds. While it is optimistically unclear from table 2/Y.1541 whether class 4 is produced with another queue as classes 2 and 3, above it is assumed that classes 2, 3 and 4 are produced with the same queue and share the same properties.</td></tr>
</table>

Mapping of classes Y.1541 classes 2-4 to an Assured service is based mainly on the given usage examples and the queue description. These seem to indicate data transfer as the applications suggested for these classes. Here, the bounds for IP packet loss have been ignored. Y.1541 suggests two provisional QoS classes (class 6 and class 7). Both define an upper bound IP Loss Rate of 10^{-5} and are identical to class 0 and 1 definitions on mean IP Transfer Delay and IP Delay Variation otherwise. Two appendices of Y.1541 refer to these classes, on about digital television transmission, the other about TCP based data transmission. Y.1541 does not point out example applications for these classes, nor does it offer node mechanisms. As digital television transmission may be expected to carry traffic benefitting from admission control and will not benefit from probabilistic dropping during congestion, TCP applications don't require admission control but

benefit from probabilistic dropping.
If Y.1541 classes 6 and 7 were used to carry digital television transmission traffic, the Y. QoS mapping class Bulk inealstic is a proposed match.

It is out of scope of this document to discuss the values proposed by Y.1541 or to suggest different ones.

Appendix III

Single class transport of multi class traffic

(This appendix does not form an integral part of this Recommendation)

A single class QoS transport of multi class traffic is to some extent similar to a leased line. Single class transport protects all traffic against congestion. Should drops or queuing delay occur, any multi class QoS properties will not be applicable. If realised by a tunnel, the inner header (e.g. IP) may carry different QoS marks, while the outer or tunnel header respectively (e.g. Ethernet or MPLS) only carries a single QoS mark.

Matching the highest QoS requirement of a customer packet is a possible but not a recommended strategy to decide on the single class transport (tunnel) service QoS. In some cases a combination of multi class requirements like lowest loss, jitter and delay will result in multiple optimum single class tunnel matches. Hence a more pragmatic approach consists of negotiating tunnel service QoS to match the dominating QoS class requested by the customer.

Most often arbitrary traffic mixes apply and data or streaming traffic dominates. It is generally recommended to realise a single class transport service by using the classes Bulk inealstic or Assured class for the single tunnel QoS.

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