T1A1 T1A1/2003-070r1
Performance, Reliability, and Security Standards Committee
Jacksonville FL, USA, January 22, 2004

Title: **Liaison Statement on Mapping between ITU-T and 3GPP QoS Classes and Traffic Descriptors**

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As previously noted (see references) differences exist between the IP QoS classes, parameters, and parameter values specified in wireless (3GPP) and wireline (ITU-T) specifications. Alignment or interworking will be needed to provide adequate end-to-end Quality of Service for IP based multimedia services across networks.

T1A1 (Performance, Reliability, and Security Standards Committee) has studied the matter and developed a draft proposal for interworking as a possible way forward. The proposal is attached for your consideration.

T1A1 kindly requests your views on the matter, the degree to which the proposal meets interworking requirements, and if the proposed interworking can be adopted in the current or under development relevant specifications of your organization.

Please let us know if 3GPP SA2 subject matter experts are supportive of the described approach and if so, provide recommendations regarding needed Change Requests.

Best Regards,
Randolph Wohlert
Chairman, T1A1

Note: The contribution is also being submitted to ITU-T SG 13.

References:

[1] 3GPP TSG-SA WG2 meeting 35, Tdoc No. S2-033532, "IP QoS Interoperability Issues," October 2003. Available at http://www.3gpp.org/ftp/tsg_sa/WG2_Arch/TSGS2_35_Bangkok/tdocs/.

[2] Committee T1 Contribution to ITU-T Workshop on QoS, "IP QoS Interoperability Issues," October 2003. Available at http://www.itu.int/ITU-T/worksem/qos/program.html.

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ABSTRACT

As today's wireless and wireline networks converge in an IP-based multi-service next generation network (NGN), QoS interworking between the wireless and wireline technologies supporting end-to-end IP applications will become essential. Prior contributions to T1A1, ITU-T, 3GPP, and T1P1 have warned that incompatibilities between the end-to-end IP network QoS classes standardized in ITU-T and a set of QoS classes being standardized in 3GPP may confound that goal. This contribution assesses one possible means of overcoming this incompatibility, by mapping between the ITU-T defined QoS classes (and associated traffic descriptors) and a corresponding set of values for 3GPP defined "bearer service attributes." Limitations and suggested improvements in the mapping approach are discussed.

Mapping between ITU-T (Y.1541/Y.1221) and 3GPP (TS 23-107)
QoS Classes and Traffic Descriptors

1. Introduction

This contribution addresses the situation in which 3GPP wireless and non-3GPP wireline networks interwork in providing assured-quality end-to-end IP flows. The IP user applications of interest include real-time business quality VoIP and video teleconferencing in addition to all of the non-real-time applications supported by traditional "best effort" Internet services. As noted in previous contributions to T1A1, ITU-T, 3GPP, and T1P1 [1-4], incompatibilities between the QoS classes standardized in ITU-T and those being standardized in 3GPP could make such QoS interworking difficult.[1] ITU-T Recommendation Y.1541 [5] specifies six IP network QoS classes, each of which creates a specific combination of numerical bounds on a subset of the QoS parameters defined in a companion Recommendation, Y.1540 [6]. 3GPP TS 23-107 [7] specifies four universal mobile telecommunications system (UMTS) QoS classes (also called "traffic classes"), distinguished primarily by their delay sensitivity. The two sets of QoS classes have similarities but there is no unique mapping between them, and the 3GPP QoS classes alone do not convey enough information to enable quantitative end-to-end IP QoS requirements to be met. This contribution considers one possible means of achieving QoS interoperability between 3GPP based wireless networks and ITU-T based wireline IP networks, by mapping between the Y.1541 QoS classes (and associated traffic descriptors) and a corresponding set of values for 3GPP-defined "bearer service attributes." Limitations and possible improvements in the mapping approach are discussed.

2. Comparison of the Y.1541 and TS 23-107 QoS Classes

Table 1 illustrates the Y.1541 QoS classes and associated network performance objectives. These specifications apply between user-network interfaces that delimit end-to-end IP flows. The objectives are designed to be achievable on common IP network implementations. Classes 0 and 1 place upper bounds on packet transfer delay and packet loss. They also limit packet delay variation. Classes 2 and 3 place upper bounds on packet transfer delay and packet loss, but do not limit packet delay variation. Classes 0 and 2 differ from Classes 1 and 3 in their packet transfer delay objectives. Class 4 limits packet loss and provides a very loose upper bound on delay. A single packet error ratio objective is specified for classes 0-4; this value is chosen to ensure that packet loss is the dominant cause of defects presented to upper layers. Y.1541 also defines a "best effort" QoS class (Class 5) with no specific performance guarantees.

Y.1541 assumes that the user and network provider have agreed on a traffic profile that applies to one or more packet flows in a QoS class. At present, the agreeing parties may use whatever capacity specifications they consider appropriate so long as they allow both enforcement and

[1] As an example of the concerns expressed, [4] states in part: "The QoS Parameters, Parameter Values and QoS Classes defined in 3GPP specifications are different from, and may be incompatible with those in ITU-T specifications. This may result in interoperability problems between 3GPP based wireless networks, and ITU-T based wireline networks. Adversely impacted services may include Voice over IP, Video Streaming and multimedia services such as Telecommunications for Disaster Relief. Either alignment of specifications or the definition of standardized interworking that will not adversely impact service delivery between networks based on 3GPP and ITU-T specifications is therefore required."

verification. For example, peak bit rate (including lower layer overhead) may be sufficient. When protocols and systems supporting dynamic requests are available, users may negotiate a *traffic contract* that specifies one or several traffic parameters. ITU-T Recommendation Y.1221 [8] defines the traffic parameters in the context of three fundamental types of flows IP-based networks can support (dedicated bandwidth, statistical bandwidth, and best effort). The Y.1221 traffic parameters and corresponding UMTS service attributes are discussed in Section 4 *infra*.

Table 1 – IP QoS class definitions and network performance objectives (footnotes omitted)

		QoS Classes					
Network Performance Parameter	**Nature of Network Performance Objective**	**Class 0**	**Class 1**	**Class 2**	**Class 3**	**Class 4**	**Class 5 (Un-specified)**
IPTD	Upper bound on the mean IPTD	100 ms	400 ms	100 ms	400 ms	1 s	U
IPDV	Upper bound on the $1\text{-}10^{-3}$ quantile of IPTD minus the minimum IPTD	50 ms	50 ms	U	U	U	U
IPLR	Upper bound on the packet loss probability	$1*10^{-3}$	$1*10^{-3}$	$1*10^{-3}$	$1*10^{-3}$	$1*10^{-3}$	U
IPER	Upper bound	$1*10^{-4}$					U

Table 2 identifies some typical applications for each Y.1541 QoS class, and some typical node mechanisms and network techniques that could be used to implement them. For example, the node mechanisms could involve separate queues with preferential servicing and different drop priorities, or traffic grooming; the network techniques could involve constrains on routing and distance.[2] Y.1541 emphasizes that these guidelines are discretionary; network providers using the standard may employ whatever node mechanisms, routing constraints, provisioning strategies, or other QoS control techniques they choose.

[2] Recommendation Y.1541 notes that there will be very long paths that cannot support Classes 0 and 2; nevertheless it was considered important to specify (and offer) low delay services where feasible.

Table 2 – Guidance for IP QoS classes

QoS Class	Applications (Examples)	Node Mechanisms	Network Techniques
0	Real-Time, Jitter sensitive, high interaction(VoIP, VTC)	Separate Queue with preferential servicing, Traffic grooming	Constrained Routing and Distance
1	Real-Time, Jitter sensitive, interactive (VoIP, VTC).		Less constrained Routing and Distances
2	Transaction Data, Highly Interactive, (Signaling)	Separate Queue, Drop priority	Constrained Routing and Distance
3	Transaction Data, Interactive		Less constrained Routing and Distances
4	Low Loss Only (Short Transactions, Bulk Data, Video Streaming)	Long Queue, Drop priority	Any route/path
5	Traditional Applications of Default IP Networks	Separate Queue (lowest priority)	Any route/path

Table 3 illustrates the QoS (also called traffic) classes defined for the 3GPP defined universal mobile telecommunications system (UMTS). Four QoS classes are defined in 3GPP Technical Specification 23-107 [7]: conversational, streaming, interactive, and background. The main distinguishing factor among these classes is the delay sensitivity of the traffic. The conversational and streaming classes are intended to be used primarily in carrying real-time traffic flows. The conversational class supports real-time services like video telephony that are particularly delay sensitive. The streaming class supports one-way flows, and therefore is somewhat less delay sensitive. The interactive and background classes are primarily meant to be used by traditional Internet applications like WWW, e-mail, telnet, FTP and news. Because they have looser delay requirements than the conversational and streaming classes, they can provide better error rates using channel coding and retransmission. The main difference between the interactive and background classes is that the interactive class is mainly used by interactive applications, e.g. interactive e-mail or interactive Web browsing, while the background class is meant for background traffic, e.g. background download of e-mail or other files. Responsiveness of the interactive applications is ensured by separating the interactive and background applications. Interactive traffic is intended to have a higher priority in scheduling than background traffic, so that background applications use transmission resources only when interactive applications do not need them. TS 23-107 notes that such prioritization is particularly important in a wireless environment, where the bandwidth is low compared to fixed networks.

Table 3 – 3GPP UMTS QoS classes

Traffic class	Conversational class conversational RT	Streaming class streaming RT	Interactive class Interactive best effort	Background Background best effort
Fundamental characteristics	- Preserve time relation (variation) between information entities of the stream - Conversational pattern (stringent and low delay)	- Preserve time relation (variation) between information entities of the stream	- Request response pattern - Preserve payload content	- Destination is not expecting the data within a certain time - Preserve payload content
Example of the application	- Voice	- Streaming video	- Web browsing	- Background download of emails

Comparing Tables 1-3, it appears that Y.1541 classes 0 and 1 correspond generally with the 3GPP conversational and streaming classes, respectively. In each specification regime, the two classes are intended to support real time services and the first class has a more stringent delay requirement than the second. In both regimes delay variation is intended to be limited.[3]

Similarly, it appears that Y.1541 classes 2-4 correspond generally with the 3GPP interactive class. In both specification regimes, a key application of interest is interactive data. Y.1541 supports this application category with three classes, distinguished by different quantitative delay limits. TS 23-107 states (para. 6.4.3.2):

> "There is a definite need to differentiate between quality for bearers within the interactive class. One alternative would be to set absolute guarantees on delay, bitrate etc, which however at present seems complex to implement … Instead, **traffic handling priority** is used. SDUs of a UMTS bearer with higher traffic handling priority [are] given priority over SDUs of other bearers within the interactive class, through UMTS-internal scheduling."

Thus TS 23-107 envisions a QoS distinction for interactive traffic similar to that defined in Y.1541, but specifies a *relative* QoS mechanism for implementing it.[4]

Y.1541 class 5 corresponds closely with the 3GPP background class.

The most fundamental difference between the Y.1541 and TS 23-107 classes is that the former classes specify quantitative performance limits while the latter classes, in themselves, do not.

[3] The limit is implicit in the requirement to "preserve time relation (variation) between info entities of the stream" in the 3GPP case.

[4] Another 3GPP specification (TS 29-207) defines six QoS classes by expanding the interactive class into three classes, distinguished by three traffic handling priorities. This specification would align the UMTS and Y.1541 classes more closely, since a UMTS class would be associated with each of Y.1541 classes 2-4 (see Table 6).

Clearly, such limits would need to be specified in wireless/wireline interworking situations to assure particular QoS levels end-to-end.

3. Mapping between Y.1541 QoS Classes and 3GPP/UMTS Service Attributes

Although the 3GPP QoS classes do not in themselves provide a basis for QoS interworking with external IP networks, TS 23-107 specifies a related set of "bearer service attributes" that may. TS 23-107 in fact states that QoS will be defined by specifying such attributes. Any particular set of attributes that can be requested by the user is defined as a "QoS profile." The QoS profile is communicated among UMTS entities to activate QoS mechanisms ensuring provision of the negotiated UMTS service QoS. TS 23-107 further states:

> "The end-to-end service is provided by translation/mapping with UMTS external services. A Translation Function converts between the internal service primitives for UMTS bearer service control and the various protocols for service control of interfacing external networks. *The translation includes converting between UMTS bearer service attributes and QoS attributes of the external network's service control protocol.*[5]

Thus, the QoS mapping envisioned in TS 23-107 is a translation of *bearer service attributes*. The attributes specify values for particular performance (and traffic) parameters. If the set of bearer service attributes translated between 3GPP and external systems were comprehensive enough (including, for example, attributes related to error, delay, etc.) it could be possible to map between the 3GPP bearer service attributes and the Y.1541 QoS classes.

TS 23-107 discusses the attributes that can be specified (and mapped between 3GPP and external systems) for each of the four 3GPP QoS (or traffic) classes.[6] Table 4 summarizes the defined UMTS bearer attributes and their relevance for each traffic class. The bearer service attributes are listed in the column on the left. Three of these attributes describe bearer service *performance* (as opposed to traffic or functionality): transfer delay, SDU error ratio, and residual bit error ratio. The latter parameter cannot be easily related to the Y.1541 parameters because it is bit-based. Transfer delay and SDU error ratio are relatable to the Y.1541 parameters IPTD and IPLR/IPER respectively if the UMTS SDU corresponds to an IP packet. In that case the delay parameter definitions are similar enough that their values could be related. However, the specifications for the two delay parameters represent different distribution statistics: the IPTD specifications are means, while the SDU transfer delay specifications are maxima.

TS 23-107 defines SDU error ratio as "the fraction of SDUs lost or detected as erroneous." The Y.1540/Y.1541 lost packet and errored packet outcomes are thus, in effect, combined in the SDU error outcome, as illustrated in Figure 1.[7]

Although the definitions for the 3GPP conversational and streaming classes imply that IPDV must be limited to "preserve time relation (variation) between information entities of the stream," TS 23-107 does not define or specify a value for delay variation. It will not be possible to assure an end-to-end limit on IPDV in the absence of a quantitative limit on delay variation for the

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[5] Emphasis added. TS 23-107 also notes that the QoS (or traffic) classes are "attributes" in themselves.
[6] Para. 6.4.3.2, "Attributes discussed per traffic class."
[7] Delivery order is not addressed in the taxonomy of Figure 1.

3GPP portion. A QoS mapping between 3GPP and external IP networks could take IPDV into account qualitatively by mapping Y.1541 classes 0 and 1 to the conversational or streaming classes.

Table 4 – UMTS bearer attributes defined for each bearer traffic class

Traffic class	Conversational class	Streaming class	Interactive class	Background class
Maximum bitrate	X	X	X	X
Delivery order	X	X	X	X
Maximum SDU size	X	X	X	X
SDU format information	X	X		
SDU error ratio	X	X	X	X
Residual bit error ratio	X	X	X	X
Delivery of erroneous SDUs	X	X	X	X
Transfer delay	X	X		
Guaranteed bit rate	X	X		
Traffic handling priority			X	
Allocation/Retention priority	X	X	X	X
Source statistics descriptor	X	X		
Signalling indication			X	

Figure 1 – Taxonomy of packet (or SDU) transfer outcomes.

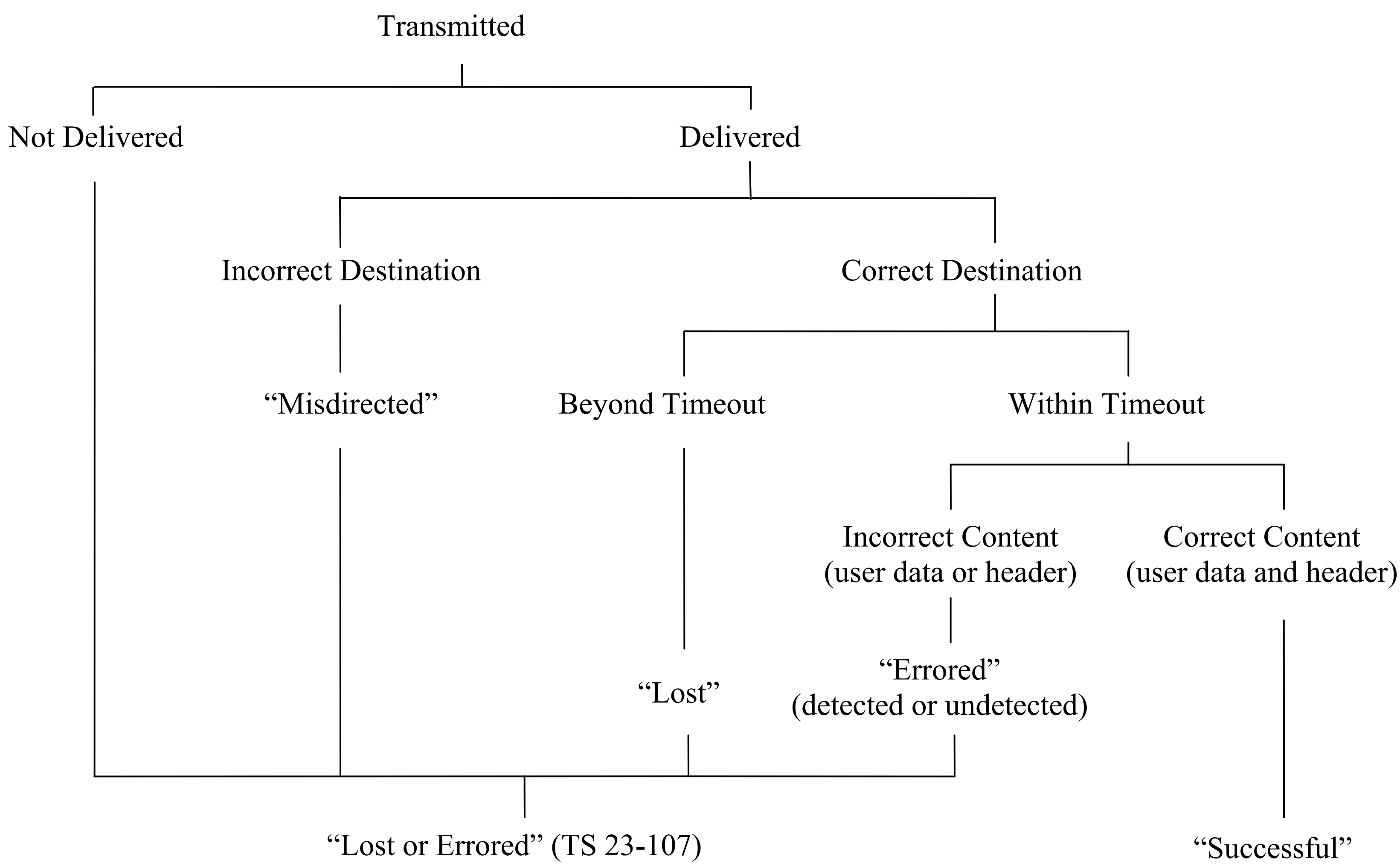

Table 5 lists a set of distinct attribute values or identifies the allowed range of values for each attribute as they apply to 3GPP UMTS networks. As noted earlier, the attributes that describe bearer service *performance* (of particular interest here) are transfer delay and SDU error ratio. The value list/value range defines the values that are *possible* to be used for an attribute, considering *every possible* service condition. When a service is defined as a combination of attributes, further limitations may apply; for example, the shortest possible delay may not be possible to use together with the lowest possible SDU error ratio.

Table 5 – Value ranges for UMTS Bearer Service Attributes (footnotes omitted)

Traffic class	Conversational class	Streaming class	Interactive class	Background class
Maximum bitrate (kbps)	<= 16 000	<= 16 000	<= 16 000 - overhead	<= 16 000 - overhead
Delivery order	Yes/No	Yes/No	Yes/No	Yes/No
Maximum SDU size (octets)	<=1 500 or 1 502	<=1 500 or 1 502	<=1 500 or 1 502	<=1 500 or 1 502
SDU format information	(RAN WG3)	(RAN WG3)		
Delivery of erroneous SDUs	Yes/No	Yes/No	Yes/No	Yes/No
Residual BER	$5*10^{-2}$, 10^{-2}, $5*10^{-3}$, 10^{-3}, 10^{-4}, 10^{-5}, 10^{-6}	$5*10^{-2}$, 10^{-2}, $5*10^{-3}$, 10^{-3}, 10^{-4}, 10^{-5}, 10^{-6}	$4*10^{-3}$, 10^{-5}, $6*10^{-8}$	$4*10^{-3}$, 10^{-5}, $6*10^{-8}$
SDU error ratio	10^{-2}, $7*10^{-3}$, 10^{-3}, 10^{-4}, 10^{-5}	10^{-1}, 10^{-2}, $7*10^{-3}$, 10^{-3}, 10^{-4}, 10^{-5}	10^{-3}, 10^{-4}, 10^{-6}	10^{-3}, 10^{-4}, 10^{-6}
Transfer delay (ms)	100 – maximum value	280 – maximum value		
Guaranteed bit rate (kbps)	<= 16 000	<= 16 000		
Traffic handling priority			1,2,3	
Allocation/Retention priority	1,2,3	1,2,3	1,2,3	1,2,3
Source statistic descriptor	Speech/unknown	Speech/unknown		
Signalling Indication			Yes/No	

Table 6 lists the Y.1541 QoS classes and the 3GPP UMTS QoS classes and associated bearer service attributes and values in the rows and columns of a matrix and indicates, at selected intersections, the most closely related classes and how they differ. This matrix provides a basis for assessing the opportunities and difficulties in mapping performance values between the Y.1541 QoS classes and the 3GPP service attributes as they are currently defined.

Table 6 – Relationships among ITU-T (Y.1541) and 3GPP (TS 23-107) UMTS QoS classes, parameters, and bearer attributes

<table>
<tr><th colspan="2" rowspan="3">3GPP UMTS QoS Class (and Relevant Attribute Values) / Y.1541 QoS Class (and Relevant Parameter Values)</th><th colspan="2">Real Time</th><th colspan="2">Best Effort</th></tr>
<tr><td><u>Conversational</u>
- Preserve time relation (variation) between info entities of the stream
- Conversational pattern (stringent and low delay)</td><td><u>Streaming</u>
- Preserve time relation (variation) between info entities of the stream</td><td><u>Interactive</u>
- Request/response pattern
- Preserve payload content</td><td><u>Background</u>
- Destination is not expecting data within a certain time
- Preserve payload content</td></tr>
<tr><td>- Transfer delay: 100 ms (maximum value)
- SDU error ratio (ER): 10^{-2}, $7*10^{-3}$, 10^{-3}, 10^{-4}, 10^{-5}</td><td>- Transfer delay: 280 ms (maximum value)
- SDU error ratio (ER): 10^{-1}, 10^{-2}, $7*10^{-3}$, 10^{-3}, 10^{-4}, 10^{-5}</td><td>- Transfer delay: ‘traffic handling priority’
- SDU error ratio (ER): 10^{-3}, 10^{-4}, 10^{-6}</td><td>- SDU error ratio (ER): 10^{-3}, 10^{-4}, 10^{-6}</td></tr>
<tr><td><u>Class 0</u></td><td>IPTD ≤ 100 ms
IPDV ≤ 50 ms
IPLR ≤ 10^{-3}
IPER ≤ 10^{-4}</td><td>- IPTD is a mean value; transfer delay is a maximum
-Y.1541 specifies IPDV limit
- Y.1541 specifies IPLR/IPER; TS 23-107 specifies SDU ER</td><td></td><td></td><td></td></tr>
<tr><td><u>Class 1</u></td><td>IPTD < 400 ms
IPDV < 50 ms
IPLR < 10^{-3}
IPER < 10^{-4}</td><td></td><td>- IPTD is a mean value; transfer delay is a maximum
- Y.1541 specifies IPDV limit
- Y.1541 specifies IPLR/IPER; TS 23-107 specifies SDU ER</td><td></td><td></td></tr>
<tr><td><u>Class 2</u></td><td>IPTD < 100 ms
IPLR < 10^{-3}
IPER < 10^{-4}</td><td></td><td></td><td rowspan="3">- Y.1541 specifies IPTD limits; TS 23-107 specifies ‘traffic handling priority’
- Y.1541 specifies IPLR/IPER; TS 23-107 specifies SDU ER ‘target’</td><td></td></tr>
<tr><td><u>Class 3</u></td><td>IPTD ≤ 400 ms
IPLR ≤ 10^{-3}
IPER < 10^{-4}</td><td></td><td></td><td></td></tr>
<tr><td><u>Class 4</u></td><td>IPTD ≤ 1 second
IPLR < 10^{-3}
IPER < 10^{-4}</td><td></td><td></td><td></td></tr>
<tr><td><u>Class 5</u></td><td>Best Effort</td><td></td><td></td><td></td><td>- TS 23-107 specifies SDU ER ‘target’</td></tr>
</table>

4. Mapping between Y.1221 Traffic Classes and 3GPP/UMTS Service Attributes

The other key requirement for QoS interworking between 3GPP wireless and non-3GPP wireline networks is compatibility in the capacity made available (and the traffic control applied) to particular end-to-end IP flows. In general, such compatibility will require a mapping of traffic descriptors among the two specification domains, analogous to the QoS mapping posited in the previous section. As noted earlier, ITU-T has defined a set of IP network traffic parameters in Recommendation Y.1221 [8]. The corresponding UMTS traffic descriptors are service attributes defined in TS 23-107 (see Tables 4 and 5 *supra*).

Although the units of measure differ, there appears to be good general correspondence between the Y.1221 traffic parameters and the traffic related subset of the TS 23-107 service attributes. Y.1221 defines five traffic parameters for which quantitative values may be specified: peak rate, peak token bucket size, sustainable rate, sustainable token bucket size, and maximum packet size. The related TS 23-107 service attributes listed in Tables 4 and 5 are maximum bit rate, guaranteed bit rate, and maximum SDU size. TS-23-107 also defines maximum and guaranteed bit rate token bucket sizes, both of which are equated to the maximum SDU size.[8]

5. A Hypothetical Mapping Example

This section describes a hypothetical QoS mapping (in each direction) between two concatenated networks: a 3GPP network providing UMTS service in accordance with the TS 23-107 QoS classes and bearer service attributes, and an "external" (non-3GPP) IP network supporting assured-quality IP flows in accordance with Recommendation Y.1541. See Figure 2. For simplicity, the UMTS SDU is assumed to correspond to an IP packet. The end-to-end (NI-NI) IP packet transfer service provided by the concatenated networks is intended to meet the end-to-end QoS objectives of Y.1541.[9] The objective in mapping QoS classes (and bearer attribute values) between the UMTS network and the IP network is to divide the end-to end "impairment budget" for each Y.1541 performance parameter (delay, delay variation, packet loss, packet error) appropriately between them. For illustration an equal division is assumed in this example, e.g., each network would get 50 ms of a 100 ms end-to-end IPTD objective.[10] A QoS translator in the interworking function between the UMTS network and the IP network would map QoS classes and attribute values between the two networks so as to ensure, where possible, that the end-to-end QoS objectives are met. The purpose of this example is not to suggest a specific mapping for implementation, but to explore the utility and limitations of the mapping approach to interworking, given the ITU-T and 3GPP UMTS QoS specifications as they exist today.

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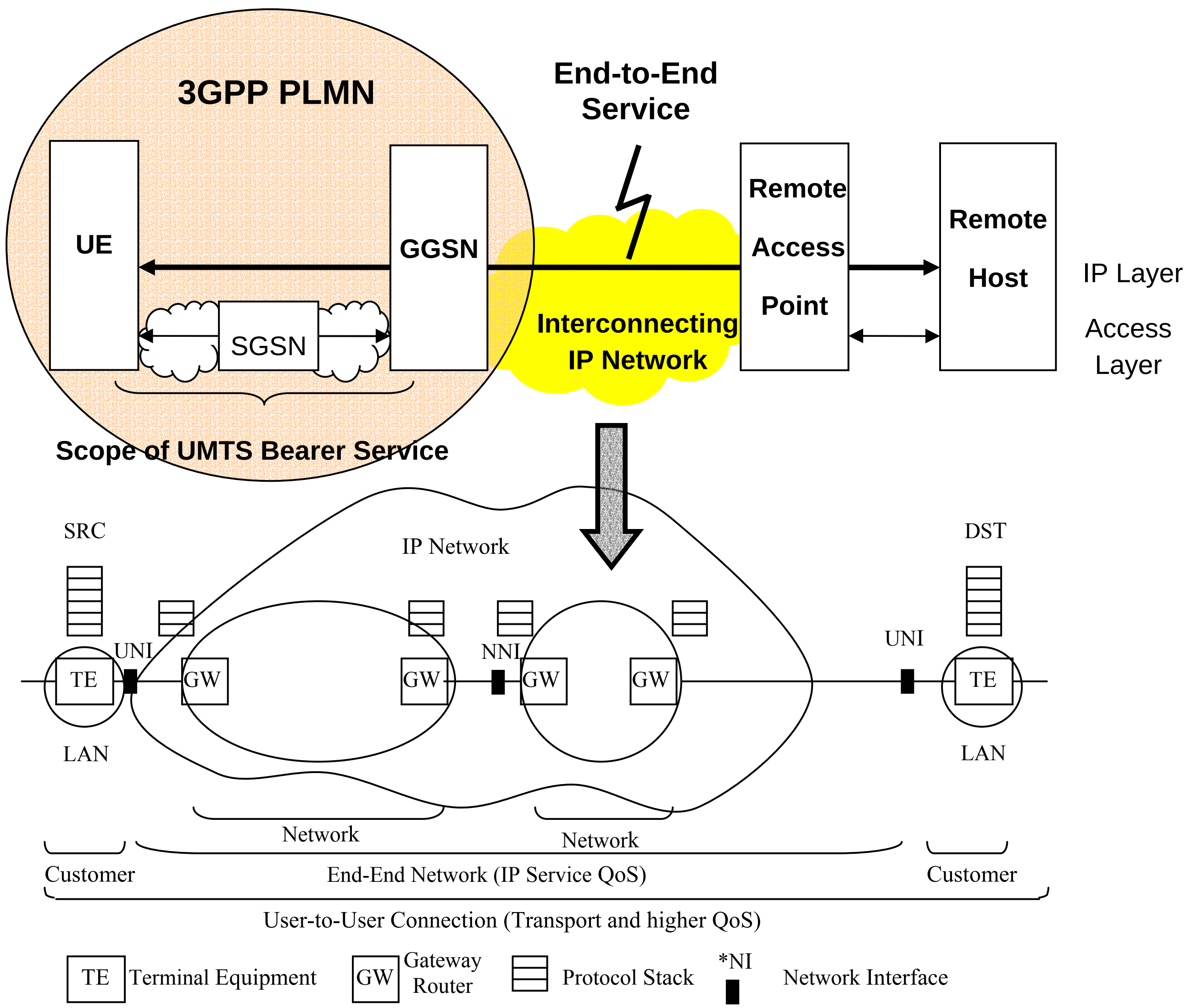
[8] Both Y.1221 and TS 23-107 frame the traffic conformance definitions in terms of a token bucket reference algorithm. TS 23-107 states (Annex B) that the token bucket algorithm "may be used for traffic contract between UMTS bearers and external network/user equipment."

[9] TS 23-107 notes that the UMTS attribute values and ranges apply to the UMTS network, not the end-to-end service.

[10] Y.1541 limits IPDV by specifying the numerical distance between the upper quantile and the minimum value of the IP packet delay distribution. Because IPDV is a distribution statistic, its value cannot be apportioned in a simple additive fashion. If independence is assumed, the distribution of the end-to-end delay introduced by two (or more) concatenated networks can be calculated by convolving the individual network delay distributions. However, closed-form solutions for the reverse ("de-convolution") problem exit only in special cases. Reference [9] provides examples of the use of convolution in calculating end-to-end delay distributions for concatenated networks.

Figure 2 – Correspondence between UE and GGSN of UMTS and TE, UNI, and NNI of ITU-T.



5.1 Y.1541 to UMTS

For the example and assumptions outlined above, the QoS translator would map Y.1541 class 0 to the UMTS conversational class, selecting the 10^{-4} value for the SDU error ratio attribute.[11] The UMTS SDU transfer delay value (100 ms maximum) might or might not meet the example objective for the UMTS network portion (50 ms mean), depending on the SDU transfer delay distribution. The UMTS SDU error ratio value (10^{-4}) would meet the Y.1541 IPLR and IPER objectives assumed for the UMTS network portion ($5x10^{-4}$, $5x10^{-5}$), since the former parameter definition combines the Y.1541 packet loss and packet error outcomes. The UMTS conversational class requirement to "preserve time relation (variation) between information entities of the stream" would relate qualitatively to the Y.1541 IPDV objective, but the end-to-end objective would not be assured since the UMTS specification does not currently limit IPDV.

Y.1541 class 1 would be mapped to the UMTS streaming class, again selecting the 10^{-4} SDU error ratio value. The UMTS SDU transfer delay value (280 ms maximum) might or might not meet the example objective for the UMTS network portion (200 ms mean), depending on the delay distribution. The UMTS SDU error ratio value would meet the example Y.1541 IPLR and IPER objectives as described for class 0 above. The Y.1541 IPDV objective would be addressed qualitatively but without end-to-end assurance as noted above.

Y.1541 classes 2-4 could be mapped to the UMTS interactive class with a 10^{-4} SDU error ratio. The three Y.1541 classes could be mapped to different UMTS interactive class priority levels to reflect their different IPTD objectives; but as noted in TS 23-107, these relative priorities would not provide assured quality levels. If more assured IPTD values were required, Y.1541 classes 2-4 could be mapped to the UMTS conversational or streaming class. The SDU transfer delay limit of the UMTS conversational class (100 ms maximum) might or might not meet the example IPTD objective of class 2 (50 ms mean); it would definitely meet the assumed IPTD objectives of classes 3 and 4 (200 ms and 500 ms mean, respectively). Similarly, the SDU transfer delay limit of the UMTS streaming class (280 ms maximum) might or might not meet the assumed IPTD objectives of classes 2 and 3 (50 ms and 200 ms mean respectively), but would definitely meet the assumed IPTD objective of class 4 (500 ms mean).

Y.1541 class 5 would be mapped to the UMTS background class.

The mappings suggested above are probably the most reasonable ones for the stated example, and they could meet the postulated IPLR and IPER requirements for all of theY.1541 classes. The suggested mappings would not meet the end-to-end delay requirements for some classes, and as noted, would place no quantitative bounds on end-to-end IPDV.

[11] See Table 7 for additional information on these and other mappings.

5.2 UMTS to Y.1541

Assuming the hypothetical conditions and mapping principles outlined above, the mapping from UMTS QoS classes to Y.1541 QoS classes would essentially reverse that described in 5.1 above. The UMTS conversational class would be mapped to Y.1541 class 0. The UMTS streaming class would be mapped to Y.1541 class 1.[12] The UMTS interactive class could be mapped to Y.1541 class 2, 3, or 4 depending on the specified traffic handling priority; the Y.1541 classes would provide quantitative limits supporting up to three priority levels. The UMTS background class would be mapped to Y.1541 class 5.

These mappings are (again) probably the most reasonable ones for the stated example, but as noted they would not meet the end-to-end delay requirements for some classes and would place no quantitative bounds on end-to-end IPDV.

Although they do not themselves apply to end-to-end services, the more stringent SDU error ratio specifications presented in Tables 5 and 6 (10^{-5}, 10^{-6}) suggest that there may be a need for end-to end IPLR and IPER objectives lower than those currently specified in Recommendation Y.1541 (10^{-3}, 10^{-4}). That possible need should be further investigated, and should be addressed in a future revision to Recommendation Y.1541 if it is validated for important user applications.

5.3 Summary Observations from the Mapping Example

A mapping between the currently defined ITU-T and 3GPP UMTS QoS specifications would improve interworking between wireless and IP-based wireline networks to some extent, but the result would be far from ideal. On the positive side, such a mapping could enable concatenated UMTS and IP networks to support quantitative end-to-end IP packet loss and packet error ratios (and associated values for UMTS SDU error ratio); to support assured end-to-end delay limits in some cases; and to relate end-to-end IPDV requirements with UMTS transfer capabilities in a qualitative way. Relatively good existing correspondence between the Y.1221 traffic parameters and TS 23-107 traffic attributes would make it possible to coordinate capacity assignment and traffic control between the two specification domains.

On the negative side, a mapping between the existing QoS classes and attribute values would not support end-to-end QoS limits that will be required to provide real-time telephony and other important applications in wireline/wireless interworking situations. Transfer delay specifications are not relatable between the two domains because Y.1541 specifies IPTD as a mean value, while TS 23-107 specifies SDU transfer delay as a maximum. IPDV cannot currently be limited end to end because the UMTS specification does not define or quantitatively limit delay variation.[13] TS 23-107's relative priorities

[12] When UMTS and wireline IP networks are concatenated, the end-to-end delay performance of the conversational class may fall in Class 1.

[13] TS 23-107 states: "It is assumed that the application's requirement on delay variation is expressed through the transfer delay attribute, which implies that there is no need for an explicit delay variation

would not support assured end-to-end QoS levels for interactive data applications. Combining the SDU loss and error outcomes in the TS 23-107 parameter SDU error ratio sacrifices some specificity that could be useful in UMTS network design and operation, although interoperation with IP-based networks is still possible as noted above.

All of the translations described in this paper will be more complicated in situations where the SDU and IP packet sizes substantially differ. IP QoS translation between 3GPP wireless and non-3GPP wireline networks would be greatly simplified if the SDU were defined to correspond to an IP packet in the relevant 3GPP specifications. It would be useful to make the observation intervals and payload sizes used in defining parameters and objectives in the two specification regimes equivalent as well.

6. Conclusions and Recommendations

QoS interworking between 3GPP wireless and non-3GPP wireline networks will be essential if future IP-based NGNs are to provide assured-quality IP flows. As shown above, a mapping between the QoS classes currently defined in ITU-T Recommendation Y.1541 and those currently defined in 3GPP would enable limited QoS interworking but would leave important end-to-end QoS requirements unfulfilled. TS 23-107 observes that "the discussion of UMTS bearer service attributes as well as radio access bearer attributes is still going on" and notes that "the translation function in the Gateway is FFS regarding packet oriented services." Taking advantage of this flexibility, and the fact that ITU-T Recommendations can also be changed when valid new requirements are identified, ITU-T and 3GPP should collaborate in revising the relevant specifications to ensure that all important QoS requirements can be met end-to-end when the two types of networks interwork.

Wireless/wireline interworking would be most effective if it were based on the same QoS classes and parameters. Earlier contributions [2, 3] have proposed that the Y.1541 QoS classes should be globally supported. As noted in [4], an alternative is to define a mapping between the two QoS specification regimes. In the event that the latter approach is pursued, the relevant specifications should be revised along the following lines.

1. The 3GPP requirements for SDU transfer delay should be expressed as means rather than as maxima. This will facilitate performance apportionment or concatenation, since means can generally be added while maxima cannot. If specifications for maxima must be retained, the means should be specified as well.
2. The 3GPP specifications should define and establish at least one numerical objective for SDU transfer delay variation. Delay variation must be limited to support interworking and the operation of jitter buffers in customer equipment, and it cannot be limited adequately by specifying only a transfer delay maximum.

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attribute." In general, a maximum transfer delay specification only limits delay variation to be less than the maximum. A different 3GPP specification [10] indicates that delay variation may be defined and limited in Release 6.

The delay variation should be expressed using the same statistic defined in Y.1541, i.e., upper 10^{-3} quantile minus minimum.

3. The 3GPP specifications should define numerical target values for the various "priority levels" in the interactive QoS class, to enable quantitative support for Y.1541 classes 2-4. As TS 23-107 notes, there is a definite need to differentiate between quality levels for bearers within the interactive class. Users envision substantially different applications for services in this category and will expect them to be supported with numerical objectives.
4. ITU-T Recommendation Y.1541 should be reviewed in light of emerging applications to determine whether it is necessary and practical to specify more stringent objectives for IPLR and IPER, consistent with the relatively stringent UMTS SDU error ratio requirements specified in TS 23-107.[14]
5. For comparability, the SDU should be defined to correspond to an IP packet in 3GPP specifications of QoS requirements for IP-based services. An evaluation interval of 1 minute should be used in assessing both mean delay and delay variation. Payload sizes of 160 and 1500 octets should be used in specifying and evaluating performance values.

[14] Conversely the 3GPP specifications could be reviewed to assess whether the many distinct levels identified for SDU error ratio actually need to be independently selectable.

7. References

[1] Contribution No. T1A1/2003-017, "QoS Interoperability Considerations" May 2003. Available at http://www.t1.org.

[2] Committee T1 Contribution to ITU-T Workshop on QoS, "IP QoS Interoperability Issues," October 2003. Available at http://www.itu.int/ITU-T/worksem/qos/program.html.

[3] 3GPP TSG-SA WG2 meeting 35, Tdoc No. S2-033532, "IP QoS Interoperability Issues," October 2003. Available at http://www.3gpp.org/ftp/tsg_sa/WG2_Arch/TSGS2_35_Bangkok/tdocs/.

[4] "QoS Interoperability Issue with Proposed T1 Specifications," Contribution T1P1/2003-049 (T1A1/2003-036), August 2003. Available at http://www.t1.org.

[5] ITU-T Recommendation Y.1541, "Network Performance Objectives for IP-Based Services," May 2002. Available at http://www.itu.int/ITU-T/publications/recs.html.

[6] ITU-T Recommendation Y.1540, "IP packet transfer and availability performance parameters," May 2002. Available at http://www.itu.int/ITU-T/publications/recs.html.

[7] 3GPP Technical Specification 23-107, "Quality of Service (QoS) concept and architecture," V5.10.0, September 2003. Available at http://www.3gpp.org/ftp/Specs/html-info/23107.htm.

[8] ITU-T Recommendation Y.1221, "Traffic control and congestion control in IP based networks," March 2002. Available at http://www.itu.int/ITU-T/publications/recs.html.

[9] Osterbo, Olav, "An approximate method to calculate the distribution of end-to-end delay in packet networks," Telnor Scientific Report R&D R 3/2002, IBSN 82-423-0527-7, January 28, 2002. Available at http://www.telenor.no/fou/publisering/rapporter/R_3_2002.pdf .

[10] 3GPP Technical Specification 22.105, "Services and service capabilities," V6.2.0, June 2003. Available at http://www.3gpp.org/ftp/Specs/html-info/22105.htm.

[11] 3GPP Technical Specification 29.207, "Policy control over the Go interface," V.5.5.1, October 2003. Available at http://www.3gpp.org/ftp/Specs/html-info/29207.htm.