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ATM Signalling Support for IP over ATM - UNI Signalling 4.0 Update

Status of this Memo

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Abstract

This memo describes how to efficiently use the ATM call control signalling procedures defined in UNI Signalling 4.0 [SIG40] to support IP over ATM environments as described in RFC 2225 [LAUB98] and in RFC 2332 [LUC98]. Among the new features found in UNI Signalling 4.0 are Available Bit Rate signalling and traffic parameter negotiation. This memo highlights the features of UNI Signalling 4.0 that provide IP entities capabilities for requesting ATM service in sites with SVC support, whether it is private ATM or publicly provisioned ATM, in which case the SVC support is probably configured inside PVPs.

This document is only relevant to IP when used as the well known "best effort" connectionless service. In particular, this means that this document does not pertain to IP in the presence of implemented IP Integrated Services. The topic of IP with Integrated Services over ATM will be handled by a different specification or set of specifications being worked on in the ISSLL WG.

This specification is a follow-on to RFC 1755, "ATM Signaling Support for IP over ATM", which is based on UNI 3.1 signalling [UNI95]. Readers are assumed to be familiar with RFC 1755.

Table of Contents

1. Conventions

The key words "MUST", "MUST NOT", "REQUIRED", "SHALL", "SHALL NOT", "SHOULD", "SHOULD NOT", "RECOMMENDED", "MAY", and "OPTIONAL" in this document are to be interpreted as described in RFC 2119 [BRA97].

2. Overview

UNI Signalling version 4.0 (SIG 4.0) is the ATM Forum follow-on specification to UNI 3.1 signalling (UNI 3.1). Among the new features in SIG 4.0, those of particular interest to IP over ATM environments are:

- o Available Bit Rate (ABR) Signalling for Point-to-Point Calls
- o Traffic Parameter Negotiation
- o Frame Discard Support
- o Leaf Initiated Join (LIJ) Capability
- o ATM Anycast Capability
- o Switched Virtual Path (VP) Service

This memo highlights the first three capabilities listed above. The last three capabilities are not discussed because models for their use in IP over ATM environments have not yet been defined. The ION WG is considering the applicability of LIJ and Group Addressing to the RFC2022 problem space. Furthermore, Anycast addressing is being explored as a technique for supporting server discovery in ATM networks.

3. Use of Protocol Procedures

Section 3 in RFC 1755 introduces requirements of virtual circuit (VC) management intended to prevent VC thrashing, excessive VC consumption, and other related problems. This section updates RFC 1755's requirements related to VC teardown.

3.1. VC Teardown

In environments running layer 3 (L3) signalling protocols, such as RSVP [RSVP], over ATM, data VCs might correspond to L3 reserved flows (even if the VC is a 'best effort' VC). In such environments it is beneficial for VCs to be torn down only when the L3 reservation has expired. In other words, it is more efficient for the sender of a L3 reserved flow to initiate VC tear-down when the receiver(s) has ceased refreshing the reservation. To support such L3 behavior, systems implementing a Public ATM UNI interface and serving as the _called_ party of a VCC MUST NOT use an inactivity timer on such a VCC by default. A system MAY use an inactivity timer on such a VCC if configured to do so.

4. Overview of Call Establishment Message Content

Signalling messages are structured to contain mandatory and optional variable length information elements (IEs). A SETUP message which establishes an ATM connection to be used for IP and multiprotocol interconnection calls MUST contain the following IEs:

AAL Parameters
ATM Traffic Descriptor
Broadband Bearer Capability
Broadband Low Layer Information
QoS Parameter
Called Party Number
Calling Party Number

and MAY, under certain circumstance contain the following IEs:

Calling Party Subaddress
Called Party Subaddress
Transit Network Selection

(New in SIG 4.0:)
Minimum Acceptable ATM Traffic Descriptor
Alternative ATM Traffic Descriptor
ABR Setup Parameters
ABR Additional Parameters
Connection Scope Selection
Extended QoS Parameters
End-to-End Transit Delay

In SIG 4.0, like UNI 3.1, the AAL Parameters and the Broadband Low Layer Information IEs are optional in a SETUP message. However, in support of IP over ATM these two IEs MUST be included. Appendix A shows a sample setup message.

5. Description of Information Elements

This section describes the coding of, and procedures surrounding, information elements in SETUP and CONNECT messages. The first two IEs described, ATM Adaptation Layer Parameters and Broadband Low Layer Information, are categorized as having significance only to the end-points of an ATM call supporting IP. That is, the network does not process these IEs.

5.1. ATM Adaptation Layer (AAL) Parameters

The AAL Parameters IE carries information about the ATM adaptation layer to be used on the connection. The parameters specified in this IE are the same as specified in [PER95].

Format and field values of AAL Parameters IE

aal_parameters		
aal_type	5	(AAL 5)
fwd_max_sdu_size_identifier	140	
fwd_max_sdu_size	65,535	(desired IP MTU)
bkw_max_sdu_size_identifier	129	
bkw_max_sdu_size	65,535	(desired IP MTU)
sscs_type identifier	132	
sscs_type	0	(null SSCS)

This shows maximum size MTUs. In practice, most sites have used 9180 IP MTUs for ATM [RFC1626].

5.2. Broadband Low Layer Information

Selection of an encapsulation to support IP over an ATM VCC is done using the Broadband Low Layer Information (B-LLI) IE, along with the AAL Parameters IE, and the B-LLI negotiation procedure. B-LLI negotiation is described in [PER95] in Appendix D. The procedures remain the same for this SIG 4.0 based specification.

Format of B-LLI IE indicating LLC/SNAP encapsulation

bb_low_layer_information		
layer_2_id	2	
user_information_layer	12	(lan_llc - ISO 8802/2)

5.3. Traffic Management Issues and Related IEs

The ATM Forum Traffic Management Sub-working group has completed version 4.0 of their specification [TMGT40]. This latest version focuses primarily on the definition of the ABR service category. As opposed to the Unspecified Bit Rate (UBR) traffic class, ABR uses a rate-based flow control mechanism to assure certain traffic guarantees (bandwidth and delay). There has been much debate on whether IP benefits from ABR, and if so, how IP should use ABR. The IP Integrated Services (IIS) and RSVP models in IP add complexity to this issue because mapping IIS traffic classes to ATM traffic classes is not straightforward.

This document attempts only to present the required IP to ATM signaling interface for IP over ATM systems that do not support IIS as yet. It is an attempt to cause IP over ATM vendors to support enough options for signalling the traffic characteristics of VCs serving non-IIS IP datagrams. This specification also aims to give guidance to ATM system administrators so that they can configure their IP over ATM entities to conform to the varied services that their ATM provider may have sold to them. By definition, IP without IIS cannot be expected to provide a signalling interface that is flexible and allows application specific traffic descriptors. The topic of IP over ATM signalling for IP _with_ IIS is to be presented in other specifications being produced by the ISSLL WG of the IETF.

An IP over ATM interface may be configured to support all the defined ATM Service Categories (ASC). They are:

- CBR
- CBR with CLR specified (loss-permitting CBR)
- ABR
- UBR
- real time VBR
- non-real time VBR

The ATM Traffic Descriptor IE, Broadband Bearer Capability IE, and the QoS Parameter IE together define the signalling view of ATM traffic management. Additionally, the Extended QoS parameters IE and the End-to-end Transit Delay IE may be used to provide more specifics about traffic requirements, however this note does not provide explicit recommendations on their use. Annex 9 of [SIG40] describes a set of allowable combinations of traffic and QoS related paramenters defined for SIG 4.0. This set includes all forms of non-IIS IP signaling configurations that MUST be implemented in ATM endsystems to accommodate varied sites' needs. The principle is that IP over ATM service may be available in different sites by different types of procured ATM service; for one site, a CBR PVP might be cost-effective and then the SVCs that IP over ATM without IIS must establish must be CBR. Similarly, VBR or ABR PVPs could be provisioned. The intent of this document is to specify the use of the most sensible parameters within this non-IIS configuration. For instance, for non-IIS VBR, the SCR value may need to be hand-configured for IP users, or for ABR, the PCR value may be link-rate with a 0 MCR.

For the reader's convenience, we have replicated the tables found in Annex 9 of [SIG40] in Appendix C of this document. Ideally this document could recommend specific values for the various table parameters that would offer the most sensible IP over ATM service. Nevertheless, it is not possible to mandate specific values given the varied scenarios of procured ATM service.

5.3.1. ATM Traffic Descriptor

Even with the newly defined ABR ASC, the most convenient model for supporting IP still corresponds to the best effort capability, the UBR ASC. The rationale for this assertion stems from the fact that a non-IIS IP service has no notion of the performance requirements of the higher layers it supports. Therefore, if a site's configuration allows use of UBR, users SHOULD signal for it using the IE's and parameters pertaining to the UBR ATC. See Appendix C for the list of those IE's and parameters.

Although we consider the UBR ASC the most natural ASC for best-effort IP, ATM vendors that implement VBR and ABR services could possibly create hooks for convenient use of these services. If this is the case, IP routers may perhaps have the most to gain from use of VBR or ABR services because of the large aggregated traffic volume they are required to forward. See Appendix B for detailed suggestions on VBR and ABR signalling for IP routers. We simply note here that, in support of ABR service, two new subfields have been added in SIG 4.0 to the Traffic Descriptor IE. These fields are the forward and backward 'Minimum Cell Rate' fields.

5.3.1.1. Tagging vs. Dropping

The Traffic Descriptor IE contains a 'tagging' subfield used for indicating whether the network is allowed to tag the source's data cells. Tagging in the network may occur during periods of congestion or when the source's traffic has violated the traffic contract for the connection. See Section 4 of [TMGT40] for an explanation of ATM connection conformance and the Usage Parameter Control (UPC) function.

SIG 4.0 and TMGT 4.0 define two modes of UBR, UBR.1 which disables tagging and UBR.2 which enables tagging (see Appendix C). In some network environments there is no potential for UBR traffic sources to violate the connection traffic contract because, either the user's terminal equipment supports traffic shaping, or the network does not enforce PCR. In such environments, the user SHOULD specify 'no tagging' in the SETUP message (UBR.1). Specifying 'no tagging' indicates to the network that cells should be dropped during periods of congestion instead of being randomly marked/tagged as low priority. Cells of packets that the source itself has marked as low priority are dropped first, thereby preserving the source's characterization of the traffic.

On the other hand, when the network applies PCR to the UPC function, meaning it enforces PCR, and traffic shaping is not enabled at the source, the source has the potential to violate the traffic contract and SHOULD therefore signal for tagging (UBR.2). Tagging allows the source's non-conforming cells to be tagged and forwarded instead of dropped.

5.3.2. Traffic Parameter Negotiation

SIG 4.0 allows certain traffic parameters to be negotiated during the call establishment phase Traffic parameters cannot be 'renegotiated' after the call is active. Two new IEs make negotiation possible:

- the Minimum Acceptable ATM Traffic Descriptor IE allows negotiation of PCR parameters

- the Alternative ATM Traffic Descriptor IE allows negotiation of other traffic parameters

A SETUP or CONNECT message may include ONLY one of the above IEs. That is, the calling party may only offer an 'alternative' or 'minimum' to the requested traffic parameters. (See Section 8 of [SIG40].) IP over ATM entities SHOULD take advantage of this capability whenever possible. In order to do so, IP over ATM entities SHOULD specify PCR _equal_ to the link rate in the ATM Traffic Descriptor IE of the SETUP message and a minimum of zero PCR in the Minimum Acceptable ATM Traffic Descriptor IE.

5.3.3. Broadband Bearer Capability

A new field in UNI signalling 4.0 called, 'ATM Transfer Capability' (ATC), has been defined in the Broadband Bearer Capability IE for the purpose of explicitly specifying the desired ATM traffic category. The figure below shows the allowable ATC values.

Format and field values of Broadband Bearer Capability IE

bb_bearer_capability	
spare	0
bearer_class	bcob-x,c,a or VP
transfer_capability	cbr, rt-vbr, nrt-vbr, abr
susceptibility_to_clipping	0 (not suscept)
spare	0
user_plane_configuration	pt-to-pt, pt-to-mpt

5.3.4. QoS Parameter

Inclusion of the QoS Parameter IE is not mandatory in SIG 4.0. It may be omitted from a SETUP message _if and only if_ the Extended QoS Parameters IE is included (see next section). This specification makes no explicit recommendation on the use of the QoS related IEs.

5.3.4.1. Two IEs for Signalling of Individual QoS Parameters

SIG 4.0 allows for signalling of individual QoS parameters for the purpose of giving the the network and called party a more exact description of the desired delay and cell loss characteristics. The two individual QoS related IEs, Extended QoS Parameters IE and End-to-End Transit Delay IE, can be used in the SETUP and CONNECT signaling messages in place of the 'generic' QoS Parameter IE. Note that inclusion of these two IEs depends on the type of ATM service category requested (see Annex 9 in [SIG40]).

5.4. ATM Addressing Information

ATM addressing information is carried in the Called Party Number, Calling Party Number, and, under certain circumstance, Called Party Subaddress, and Calling Party Subaddress IE. The ATM Forum ILMI Specification 4.0 [ILMI40] provides the procedure for an ATM endsystem to learn its own ATM address from the ATM network, for use in populating the Calling Party Number IE.

Format and field values of Called Party Number IE

```
----------------------------------------------------------
| called_party_number                                     |
----------------------------------------------------------
|  type_of_number      (international number / unknown)  |
|  addr_plan_ident     (ISDN / ATM Endsystem Address)    |
|  addr_number         (E.164 / ATM Endsystem Address)   |
----------------------------------------------------------
```

6. ABR Signaling In More Detail

The IEs and procedures pertaining to ABR signalling are briefly described in this section. Nevertheless, this document makes no specific recommendation on when to use the ABR service category for IP VCCs or give suggestions on appropriate values for the various parameters in the ABR related IEs.

Two new IEs have been defined for ABR signaling:

o ABR Setup Parameters
o ABR Additional Parameters

These IEs may be optionally included in a SETUP or CONNECT message. The ABR Setup Parameters IE contains the following subfields:

- Forward/Backward ABR Initial Cell Rate
- Forward/Backward ABR Transient Buffer Exposure
- Cumulative RM Fixed Round Trip Time
- Forward/Backward Rate Increment Factor
- Forward/Backward Rate Decrease Factor

The ABR Additional Parameters IE contains one subfield:

- Forward/Backward Additional Parameters Record

The Additional Parameters Record value is a compressed encoding of a set of ABR parameters (see [SIG40] and [ABRS]).

7. Frame Discard Capability

The frame discard capability in SIG 4.0 is primarily based on the 'Partial and Early Packet Discard' strategy [ROM94]. Its use is defined for any of the ATM services, except for loss-less CBR. Frame discard signaling MUST be supported by all IP over ATM entities and it is RECOMMENDED that frame discard be signaled for all IP SVCs because it has been proven to increase throughput under network congestion. Signaling for frame discard is done by setting the frame discard bit in the 'Traffic Management Options' subfield in the Traffic Descriptor IE. It is possible that not all network entities in the SVC path support frame discard, but it is required that they all forward the signaling.

8. Security Considerations

The ATM Forum Security sub-working group is currently defining security mechanisms in ATM. The group has yet to produce a specification, therefore it is premature to begin defining IP over ATM signalling's use of ATM security. The ATM Forum is working on authentication mechanisms for signalling and on mechanisms for providing data integrity and confidentiality (e.g encryption). Lack of these ATM security mechanisms prevents the authentication of the originator of signalling messages, such as, connection setup request or connection teardown request. IP Security (RFC1825) can be applied to IP datagrams over ATM VCs to overcome the lack of security at the ATM layer.

9. Acknowledgements

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Appendix A. A Sample SIG 4.0 SETUP Message

```
+---------------------------------------------------------------------+
                             SETUP

 Information Elements/
   Fields                          Value/(Meaning)
 --------------------              ---------------

aal_parameters
   aal_type                          5        (AAL 5)
   fwd_max_sdu_size_ident          140
   fwd_max_sdu_size                (xmit IP MTU value)
   bkw_max_sdu_size_ident          129
   bkw_max_sdu_size      (recv IP MTU, 0 for disallowing return traffic)
   sscs_type identifier            132
   sscs_type                         0        (null SSCS)

traffic_descriptor
   fwd_peak_cell_rate_0_1_ident   132
   fwd_peak_cell_rate_0_1         (link rate)
   bkw_peak_cell_rate_0_1_ident   133
   bkw_peak_cell_rate_0_1         (link rate)
   traff_mngt_options_ident       191
   fwd_frame_discard                1   (on)
   bkw_frame_discard                1   (on if return traffic indicated)
   spare                            0
   tagging_bkw                      1   (on)
   tagging_fwd                      1   (on if return traffic indicated)
   best_effort_indication         190   (on)

minimum_acceptable_traffic_descriptor
   fwd_peak_cell_rate_0_1_ident   132
   fwd_peak_cell_rate_0_1           0
   bkw_peak_cell_rate_0_1_ident   133
   bkw_peak_cell_rate_0_1           0

bb_bearer_capability     /* a coding for specifying UBR like service */
   spare                            0
   bearer_class                    16      (BCOC-X)
   spare                            0
   atm_transfer_capability         10      (nrt-vbr)
   susceptibility_to_clipping       0      (not susceptible to clipping)
   spare                            0
   user_plane_configuration         0      (point_to_point)
```

```
bb_low_layer_information
   layer_2_id                      2
   user_information_layer         12       (lan_llc - ISO 8802/2)

qos_parameter
   qos_class_fwd                   0        (class 0)
   qos_class_bkw                   0        (class 0)

called_party_number
   type_of_number                  (international number / unknown)
   addr_plan_ident                 (ISDN / ATM Endsystem Address)
   number                          (E.164 / ATM Endsystem Address)

calling_party_number
   type_of_number                  (international number / unknown)
   addr_plan_ident                 (ISDN / ATM Endsystem Address)
   presentation_indic              (presentation allowed)
   spare                           0
   screening_indic                 (user_provided verified and passed)
   number                          (E.164 / ATM Endsystem Address)

+---------------------------------------------------------------------+
```

Figure 1.
Sample contents of SETUP message

Appendix B. ABR and VBR Signaling Guidelines for IP Routers

When ATM is used to interconnect routers that are supporting a best effort service, the ATM connection typically carries an aggregation of IP flows, e.g., all best effort IP traffic between a pair of routers. With the efforts undertaken by ATM to be more "packet friendly" (e.g., frame discard), it is useful to examine ways that a VC can provide service comparable to or better than that of a dedicated or leased "link" in terms of performance and packet loss.

For ATM connections used to interconnect routers, a non-zero bandwidth reservation may be required to achieve consistently adequate performance for the aggregate set of flows. The support of bandwidth commitments for an ATM connection carrying IP traffic helps to assure that a certain fraction of each link's capacity is reserved for the total IP traffic between the routers. Reserving bandwidth for the aggregation of best-effort traffic between a pair of routers is analogous to provisioning a particular link bandwidth between the routers. There are at least 3 service classes defined in the ATM Traffic Management specification that provide varying degrees of capability that are suitable for interconnecting IP routers: UBR, ABR and VBR non-real-time. Although the use of best-effort service (UBR) at the ATM layer is the most straightforward and uncomplicated, it lacks the capability to enforce bandwidth commitments.

Note that we are talking of providing a "virtual link" between routers, for the aggregate traffic. The provisioning is for the aggregate. It is therefore distinct from the per-flow bandwidth reservations that might be appropriate for Integrated Services.

Even best-effort IP flows, when supported on an aggregate basis, have some broad service goals. The primary one is that of keeping packet loss rate reasonably small. A service class that strives to achieve this, keeping in mind the tradeoff between complexity and adequate service, is desirable. It has been recommended in this memo that UBR be the default service for this. UBR with (some form of) packet discard has the desirable goal of being simple in function, and it appears that vendors will be supporting it. However, when available, it may be quite worthwhile to consider ABR and VBR non-real-time service classes.

Because AAL5 frames with missing cells are discarded by the receiver, ATM bandwidth commitments are most useful if supported in the form of a committed rate of cell delivery in complete, non-errored AAL5 frames delivered to the receiver. In addition, it is desirable for the ATM connection to deliver additional complete frames, beyond this commitment, on a best-effort basis.

These characteristics can be achieved through the ABR service category through the use of a Minimum Cell Rate, if the ABR service is supported by the ATM endpoints and if efficient frame discard is supported at the ABR source. The mechanisms put in place for the ABR service strive to keep loss quite low within the ATM network.

The parameters that should be specified by the end system are (i) the Peak Cell Rate (likely the link rate), (ii) the Minimum Cell Rate (the committed rate), and (iii) the Cumulative RM Fixed Round-Trip Time. The remaining parameter values, if left unspecified by the calling party, are selected by the network or are chosen from the default values specified in the ATM Forum Traffic Management specification.

Parameters (i) and (ii) are contained in the mandatory Traffic Descriptor IE, whereas parameter (iii) is contained in the mandatory ABR Setup Parameters IE. Other paramenters in the ABR Setup Parameters IE may be omitted. (Note that the third IE which pertains to ABR signalling, the ABR Additional Parameters IE, is an optional IE and therefore need not be included.) Parameter (iii) is dependent on the hardware of the end system, so that the default value specified for that hardware should be used. In the absense of such a default, a value of zero MAY be specified by the end system. Entities using ABR connections for IP over ATM SHOULD take advantage of parameter negotiation by specifying Peak Cell Rate equal to the link rate in the ATM Traffic Descriptor IE of the SETUP message. The value selected for the Minimum Cell Rate is implementation specific. Note that the MCR also MAY be negotiated if an MCR parameter is included by the end system in the Minimum Acceptable ATM Traffic Descriptor IE. The use of MCR negotiation by the end system is implementation specific. Also, note that Frame Discard MAY be requested for ABR connections as well as for UBR connections. Although the ABR service attempts to minimize cell loss, the use of Frame Discard may improve throughput when cell loss is not eliminated.

ATM recognizes in addition to the service class (UBR, ABR, etc.), a notion of a QoS class. The QoS class specifies the type of guarantee requested of the network when the call is setup. This is distinct from the service class requested for the connection, and the specification of the traffic parameters (which specify what the source’s traffic will look like). QoS class 0 is the "simplest", and is called the Unspecified QoS class. In the context of ABR (and VBR non-realtime below), we are only concerned with the QoS class providing an assurance of acceptable loss behavior for the connection.

The Unspecified QoS Class (QoS Class 0) MUST be requested for ABR connections. In this context, QoS Class 0 corresponds to a network-specific objective for the cell loss ratio. Networks in general are expected to support a low Cell Loss Ratio for ABR sources that adjust cell flow in response to control information.

The VBR-nrt service category provides an alternate means of achieving these characteristics. These characteristics may be obtained with VBR-nrt connections for which (i) the VBR.3 conformance definition is used, (ii) a Sustainable Cell Rate (SCR) and Maximum Burst Size (MBS), and Peak Cell Rate (PCR) are specified, and (iii) both tagging and frame discard are requested. A request for tagging indicates that best-effort delivery is desired for traffic offered in excess of the SCR and MBS. A request for frame discard indicates to the network that the user desires allocations of committed and excess bandwidth to translate into corresponding throughputs at the frame level.

As with UBR connections, entities using VBR-nrt connections for IP over ATM should take advantage of parameter negotiation by specifying PCR equal to the link rate in the ATM Traffic Descriptor IE of the SETUP message and PCR equal to SCR in the Minimum Acceptable Traffic descriptor. The selection of SCR, MBS, and CLR (cell loss ratio) should be implementation specific. However, for IP over ATM, an MBS value of N*(Maximum MTU) is RECOMMENDED, where N>=1 with a default of 2 and where Maximum MTU is equal to 192 cells (consistent with an IP MTU size of 9180 bytes [RFC1626]).

Appendix C. Combinations of Traffic Related Parameters

This appendix contains a copy of the five tables found in Annex 9 of [SIG40] which show the allowable combinations of traffic and QoS related parameters in a SIG 4.0 SETUP message.

ATM Service Category	CBR								
Conformance	CBR.1 (note 10)			(note 4)			(note 4)		
Bearer Capability									
BB Bearer Class	A	X	VP	A	X	VP^	A	X	VP^
ATM Transfer Capability (note 1)	7			abs	4,5, or 6	5	abs	4,5, or 6	5
Traffic Descriptor for a given dir.									
PCR (CLP=0)							S		
PCR (CLP=0+1)	S			S			S		
SCR, MBS (CLP=0)									
SCR, MBS (CLP=0+1)									
Best Effort									
Tagging	N			N			Y/N		
Frame Discard	Y/N			Y/N			Y/N		
QoS Classes	*			*			*		
Transit Delay	O			O			O		
Peak-to-Peak CDV	O			O			O		
CLR (CLP=0)~				O			O		
CLR (CLP=0+1)~	O								

ATM Service Category	Real Time VBR								
Conformance	VBR.1 (note 10)			VBR.2			VBR.3		
Bearer Capability									
BB Bearer Class	C	X	VP	C	X	VP	C	X	VP
ATM Transfer Capability	19			9	1 or 9	9	9	1 or 9	9
Traffic Descriptor for a given dir.									
PCR (CLP=0)									
PCR (CLP=0+1)	S			S			S		
SCR, MBS (CLP=0)				S			S		
SCR, MBS (CLP=0+1)	S								
Best Effort									
Tagging	N			N			Y/N		
Frame Discard	Y/N			Y/N			Y/N		
QoS Classes	*			*			*		
Transit Delay(nt.2)	O			O			O		
Peak-to-Peak CDV	O			O			O		
CLR (CLP=0)~				O			O		
CLR (CLP=0+1)~	O								

ATM Service Category	Real Time VBR			
Conformance	(note 4,7)	(note 4,8)	(note 4)	
Bearer Capability				
BB Bearer Class	X	X	X	C or VP^
ATM Transfer Capability	1 or 9	1 or 9	1or9	9
Traffic Descriptor for a given dir.				
PCR (CLP=0)	S			
PCR (CLP=0+1)	S	S	S	
SCR, MBS (CLP=0)				
SCR, MBS (CLP=0+1)			S	
Best Effort				
Tagging	Y/N	N	N	
Frame Discard	Y/N	Y/N	Y/N	
QoS Classes	*	*	*	
Transit Delay(nt.2)	O	O	O	
Peak-to-Peak CDV	O	O	O	
CLR (CLP=0)~	O	O	O	
CLR (CLP=0+1)~				

ATM Service Category	Non-Real Time VBR								
Conformance	VBR.1 (note 10)			VBR.2			VBR.3		
Bearer Capability									
BB Bearer Class	C	X	VP	C	X	VP	C	X	VP
ATM Transfer Capability	11			ab	abs,0,2, 8,10	abs 10	ab	abs,0,2, 8,10	abs 10
Traffic Descriptor for a given dir.									
PCR (CLP=0)									
PCR (CLP=0+1)	S			S			S		
SCR, MBS (CLP=0)				S			S		
SCR, MBS (CLP=0+1)	S								
Best Effort									
Tagging	N			N			Y		
Frame Discard	Y/N			Y/N			Y/N		
QoS Classes	*			*			*		
Transit Delay(nt.2)	(note 3)			(note 3)			(note 3)		
Peak-to-Peak CDV									
CLR (CLP=0)˜				O			O		
CLR (CLP=0+1)˜	O								

ATM Service Category	Non-Real Time VBR						
Conformance	(note 4,7)		(note 4,8)		(note 4)		
Bearer Capability							
BB Bearer Class	C	X	C	X	C	X	VP^
ATM Transfer Capability	abs	abs,0,2 8 or 10		abs,0,2 8 or 10	ab	abs,0,2, 8 or10	abs 10
Traffic Descriptor for a given dir.							
PCR (CLP=0)	S						
PCR (CLP=0+1)	S		S		S		
SCR, MBS (CLP=0)							
SCR, MBS (CLP=0+1)					S		
Best Effort							
Tagging	Y/N		N		N		
Frame Discard	Y/N		Y/N		Y/N		
QoS Classes	*		*		*		
Transit Delay(nt.2)	(note 3)		(note 3)		(note 3)		
Peak-to-Peak CDV							
CLR (CLP=0)~	O		O		O		
CLR (CLP=0+1)~							

ATM Service Category	ABR			UBR					
Conformance	ABR			UBR.1			UBR.2		
Bearer Capability									
BB Bearer Class	C	X	VP	C	X	VP	C	X	VP
ATM Transfer Capability	12			ab	abs,0,2, 8,10	abs 10	ab	abs,0,2, 8,10	abs 10
Traffic Descriptor for a given dir.									
PCR (CLP=0)									
PCR (CLP=0+1)	S			S			S		
SCR, MBS (CLP=0)				S			S		
SCR, MBS (CLP=0+1)	S								
ABR MCR	(note 6)								
Best Effort				S (note 9)			S (note 9)		
Tagging	N			N			N		
Frame Discard	Y/N			Y/N			Y/N		
QoS Classes	0			0			0		
Transit Delay(nt.2)									
Peak-to-Peak CDV									
CLR (CLP=0)~									
CLR (CLP=0+1)~									

ab, abs = absent.

Y/N = either "Yes" or "No" is allowed.

O = Optional. May be specified using:

- an additional QoS parameter encoded i the Extended QoS parameters information element or the end-to-end transit information element; or,

- objectives implied from the QoS class If an Extended QoS Parameters IE is not present in the message, then any value of this parameter is acceptable. If neither the parameter nor the Extended QoS Parameters IE is present, then the objective for this parameter is determined from the QoS class in the QoS Parameter IE.

S = Specified.

(blank) = Unspecified.

* = allowed QoS class values are a network option. Class 0 is always for alignment with ITU-T.

^ = (note 5).

˜ = (note 11).

Note 1 - Values 0,1,2,4,6, and 8 are not used on transmission but shall be understood on reception.

Note 2 - Maximum end-2-end transit delay objectives may only be specified for the forward direction.

Note 3 - Maximum end-2-end transit delay objectives may be specified for the ATM Service Category of Non-real Time VBR for reasons of backward compatibility with ITU-T Recommendations.

Note 4 - Included for reasons of backward compatibility with UNI 3.1and ITU-T Recommendations. With these conformance definitions, the CLR commitment is only for the CLP=0 traffic stream.

Note 5 - Included to allow switched virtual paths to use the UNI 3.1 conformance definitions.

Note 6 - Optional in the user-to-network direction. Specified in the network-to-user direction.

Note 7 - This combination should be treated as if the received PCR (CLP=0) parameter were a SCR (CLP=0) parameter and a MBS (CLP=0) parameter with a value of 1.

Note 8 - This combination should be treated as if an additional SCR (CLP=0) parameter were received with the same value as a PCR (CLP=0+1) parameter and a MBS (CLP=0) parameter with a value of 1.

Note 9 - The best effort parameter applies to both the forward and backward directions.

Note 10 - This combination should only be used when the CLR commitment on CLP=0+1 is required versus CLR commitment on CLP=0 traffic, since these combinations are not supported by UNI 3.0/3.1 nor ITU-T Q.2931.

Note 11 - In this table the CLR commitment is shown as two entries to indicated explicitly whether the CLR commitment is for the CLP=0 or the CLP=0+1 cells.

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