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INTERCONNECT BETWEEN UK LICENSED OPERATORS BASED UPON PERMANENT ATM CONNECTIONS

TECHNICAL RECOMMENDATION

Issue 3

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0.1 Contents

0.2 History

Revision	Date of Issue	Updated By	Description
Issue 1.0	March 1997	Ian Jones (BT)	Agreed for release to the PNO-IG steering committee
Issue 2.0	July 1997	Ian Jones (BT)	Agreed for release to the PNO-IG steering committee
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0.3 Issue Control

SECTION	ISSUE	DATE
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0.4 References

[1] ATM-F Specification (04/96) Traffic Management v4.0

[2] ATM-F Specification (09/94) User Network Interface v3.1

[3] ITU-T Recommendation I.113 (06/97) Vocabulary of Terms for Broadband Aspects of ISDN

[4] ITU-T Recommendation I.150 (11/95) B-ISDN ATM Functional Characteristics

[5] ITU-T Recommendation I.356 (10/96) B-ISDN ATM Layer Cell Transfer Performance

[6] ITU-T Recommendation I.361 (11/95) B-ISDN ATM layer specification

[7] ITU-T Recommendation I.371 (06/97) Traffic Control & Congestion in B-ISDN

[8] ITU-T Recommendation I.432.1 (02/99) B-ISDN User Network interface (UNI) Physical layer specification: General characteristics

[9] ITU-T Rec. I.610 B-ISDN Operation And Maintenance Principles and Functions (02/99)

[10] ITU-T Recommendation G.704 (10/98) Synchronous frame structures used at 1544, 6312, 2048, 8488 & 44736 kbits/s hierarchical levels

[11] ITU-T Recommendation G.707 (03/96) NNI for the SDH

[12] ITU-T Recommendation G.804 (02/98) ATM Cell Mapping into PDH

[13] ITU-T G.826 Recommendation (08/96) Error Performance parameters & objectives for international, CBR digital paths at or above the primary rate.

[14] ITU-T G.832 Recommendation (10/98) Transport of SDH elements on PDH networks. Frame and Multiplexing structures

[15] ANSI (TI.646)

[16] PNO-IG/ATM/TG/ CP(98)12 (10/98) ATM Access and Interconnect between UK Licensed Operators - Overview Recommendation Issue 2.0

[17] (03/99) SDH Interconnect Between UK Licensed Operators - Technical Recommendation Issue 5

0.5 Glossary of terms

0.5.1 Abbreviations

ANSI	American National Standards Institute
ATM	Asynchronous Transfer Mode
ATM-F	ATM Forum
CAC	Connection Admission Control
CBR	Constant Bit Rate
CDV	Cell Delay Variation
CDVT	Cell Delay Variation Tolerance
CER	Cell Error Rate
CLP	Cell Loss Priority
CLR	Cell Loss Ratio
CMR	Cell Miss-insertion Rate
CTD	Cell Transfer Delay
EFCI	Explicit Forward Congestion Indicator
ETSI	European Telecommunications Standards Institute
GCRA	Generic Cell Rate Algorithm
GFC	Generic Flow Control
HEC	Header Error Control
HRX	Hypothetical Reference Connection
ITU-T	International Telecommunication Union-Telecommunications standardisation sector
OAM	Operations And Maintenance
PCR	Peak Cell Rate
PDH	Plesiosychronous Digital Hierarchy
PNO-IG	Public Network Operators- Interest Group
PTI	Payload Type Indicator
PVC	Permanent Virtual Channel
PVP	Permanent Virtual Path
QoS	Quality of Service
RM	Resource Management
SCR	Sustainable Cell Rate
SDH	Synchronous Digital Hierarchy
SECBR	Severely Errored Cell Block Ratio
STM	Synchronous Transfer Mode
UPC	Usage Parameter Control
VBR	Variable Bit Rate

nrt-VBR	non-real time VBR
VC	Virtual Channel
VCC	Virtual Channel Connection
VCI	Virtual Channel Identifier
VP	Virtual Path
VPC	Virtual Path Connection
VPI	Virtual Path Identifier

0.5.2 Definitions

asynchronous transfer mode (ATM)

A transfer mode in which the information is transferred within labelled cells; it is asynchronous in the sense that the recurrence of cells containing information from an individual user is not necessarily periodic.

ATM traffic descriptor

A generic list of traffic parameters that can be used to capture the intrinsic traffic characteristics of an ATM connection.

cell

A block of fixed length which is identified by a label at the asynchronous transfer mode layer of the B-ISDN protocol reference model.

cell delineation

The identification of cell boundaries in a cell stream.

cell header

The bits within a cell allocated for functions required to transfer the cell payload within the network.

congestion

A set of one or more network elements in which the network is not able to meet the negotiated QoS objective for the already established connections and for the new connection requests.

congestion control

The set of actions taken to relieve congestion by limiting the spread and duration of it.

connection admission control (CAC)

The set of actions taken by the network at the call set-up phase (or during call re-negotiation phase) in order to establish whether a virtual channel/virtual path connection can be accepted or rejected (or a request for re-allocation can be accommodated). Routing is part of connection admission control actions.

constant bit rate (CBR)

A type of telecommunication service characterized by a service bit rate specified by a constant value.

network node interface (NNI)

The interface at a network node which is used to interconnect with another network node.

network parameter control (NPC)

The set of actions taken by the network to monitor and control traffic at the inter network node interface, to protect network resources from malicious as well as unintentional misbehaviour by detecting violations of negotiated parameters and taking appropriate actions.

OAM cell

An ATM cell that carries OAM information for the performing of specific OAM functions. The term maintenance cell is often used as a synonym for OAM cell.

source traffic descriptor

A set of traffic parameters belonging to the ATM traffic descriptor, which is used during the connection set-up to capture the intrinsic traffic characteristics of the connection requested by the source.

synchronous transfer mode (STM)

A transfer mode which offers periodically to each connection a fixed-length word.

traffic contract

The requested QoS for any given ATM connection and the maximum cell delay variation tolerance allocated to the customer equipment.

traffic control

The set of actions taken by the network in all relevant network elements to avoid congestion conditions.

transmission path

The whole of the means of transmitting and receiving a digital signal of specified rate between two digital distribution frames (or equivalent) at which terminal equipment or switches will be connected. Terminal equipment are those at which the signal originates or terminates. A transmission path is connected through one or more digital sections.

usage parameter control (UPC)

The set of actions taken by the network to monitor and control traffic at the user network interface, to protect network resources from malicious as well as unintentional mis-behaviour by detecting violations of negotiated parameters and taking appropriate actions.

user network interface (UNI)

The interface between a network and a user's terminal equipment, identified by the ITU-T reference point (S/T).

variable bit rate (VBR)

A type of telecommunication service characterized by a service bit rate specified by statistically expressed parameters which allow the bit rate to vary within defined limits.

virtual channel (VC)

A concept used to describe the transport of ATM cells associated by a common unique identifier value called VCI.

virtual channel link

A means of transport of ATM cells between a point where a virtual channel identifier value is assigned and the point where that value is translated or removed.

virtual channel connection (VCC)

A concatenation of virtual channel links that extends between two points where the adaptation layer is accessed.

VC cross connect

A network element which connects virtual channel links, terminates virtual path connections, and is directed by management plane functions.

VC switch

A network element which connects virtual channel links, terminates virtual path connections, and is directed by control plane functions.

virtual path (VP)

A concept used to describe the transport of ATM cells belonging to virtual channels that are associated by a common identifier value called VPI.

virtual path link

The group of virtual channel links, identified by a common value of the virtual path identifier, between the point where the VPI value is assigned and the point where the VPI value is translated or removed.

virtual path connection (VPC)

A concatenation of virtual path links that extends between the point where the virtual channel identifier values are assigned and the point where those values are translated or removed.

VP cross connect

A network element that connects virtual path links, translates VPI values and is directed by management plane functions.

VP switch

A network element that connects virtual path links, translates VPI values and is directed by control plane functions.

VP-VC cross connect

A network element that may act as VC cross connect and/or VP cross connect.

VP-VC switch

A network element that may act as VP switch and/or VC switch.

0.6 Scope

This technical document represents Phase 1 of the deployment of ATM interconnects between UK licensed operators. There are a number of options covering the provision of ATM interconnect. Operators are not obliged to support every option listed within this technical recommendation. Phase 1 of the Interconnect will be based upon Permanent Virtual Channel (PVC) Link(s) and Permanent Virtual Path (PVP) Link(s). It is recognised by the UK licensed operators that when the deployment of ATM becomes more wide spread, this recommendation will be updated to reflect the increase in ATM switch capabilities. The applicability of this recommendation for transit scenario's involving three or more operators is for further study.

END OF PNO-IG/ATM/TG/CP(99)89/§0

1 Introduction

This document addresses interconnects between UK licensed operators' public ATM networks, based upon permanent ATM connections. It recommends an interface for interconnecting ATM networks based on ATM Forum specifications, ITU-T Recommendations, ANSI and ETSI standards as detailed in Section 0.4. It also recommends guidelines for the QoS performance that the interconnecting networks can expect from each other. Where details of ATM related interfaces are not covered in this recommendation, reference shall be made to the appropriate ITU-T recommendations and/or ETSI standards. The long-term objective is to migrate to ETSI standards when the individual standards become available and sufficiently mature. Information on Interconnect Topologies and Virtual Connection Configurations are described in Sections 7 and 8 of the Overview document, Ref [16]. Definitions of B-ISDN terms used within this document can be found in ITU-T Recommendation I.113, Ref [3].

END OF PNO-IG/ATM/TG/CP(99)89§1

2 Physical Layer Characteristics

2.1 Principles of Physical layer Interface characteristics

Physical layer interface shall be in accordance to one of the following listed below:

- The existing SDH Interconnect between UK Licensed Operators which can be found in the PNO-IG SDH Technical Recommendation [17].
- The existing PDH Interconnects between UK licensed operators, subject to bi-lateral agreement.

2.2 Framing

Framing procedures shall be in accordance to one of the following listed below:

- STM-1 ITU-T Recommendation G.707, Ref [11];
- STM-4 ITU-T Recommendation G.707, Ref [11];
- STM-16 ITU-T Recommendation G.707, Ref [11];
- E3 ITU-T Recommendation G.832 Ref [14];
- E1 ITU-T Recommendation G.704 Ref [10];
- DS3 ANSI (TI.646) Ref [15].

2.3 Mapping

Mapping procedures shall be in accordance to one of the following listed below:

- STM-1 ITU-T Recommendation G.707 Ref [11];
- STM-4 ITU-T Recommendation G.707, Ref [11];
- STM-16 ITU-T Recommendation G.707, Ref [11];
- E3 ITU-T Recommendation G.804 Ref [12];
- E1 ITU-T Recommendation G.804 Ref [12];
- DS3 ITU-T Recommendation G.804 Ref [12]. (Note)

NOTE : The procedures available in G.804 are for bi-lateral agreement between the interconnecting operators.

2.4 Header Error Control (HEC)

The ATM Header Error Check (HEC) shall be in accordance with the ITU-T Recommendation I.432.1, Ref [8]. Single bit error correction shall be enabled.

2.5 Payload Scrambling

ATM Cell Payload scrambling shall be in accordance with the ITU-T Recommendation I.432.1, Ref [8]. Scrambling shall be enabled. At the receiving side descrambling shall be enabled.

2.6 Cell Rate Decoupling

Idle or unassigned cells shall be used for Cell Rate Decoupling. The use of Idle or Unassigned cells is for bi-lateral agreement.

3 ATM Layer Characteristics

3.1 ATM Cell Structure

The structure of the ATM cell header shall be in accordance with ITU-T Recommendation I.361, Ref [6]. The use of a UNI or NNI cell structure is for bi-lateral agreement. The functionality that shall be supported within the cell header is listed below:

3.1.1 Generic Flow Control (GFC)

The GFC field is only relevant for a UNI cell structure. The procedures relating to GFC are not supported and the GFC field shall be encoded to all zeros (0000) as in accordance with ITU-T Recommendation I.361, Ref [6].

3.1.2 Routing Field (VPI/VCI)

The valid combinations of pre-assigned of VPI and VCI values shall be in accordance with ITU-T Recommendation I.361, Ref [6].

3.1.3 Payload Type Indicator (PTI)

The Payload Type Indicator (PTI) shall be coded in accordance with ITU-T Recommendation I.361, Ref [6]. The support of Operations And Maintenance (OAM) F4 and F5 segment and end-to-end cells, as defined in [9] are for bi-lateral agreement.

3.1.4 Cell Loss Priority (CLP)

The interconnect shall support both levels of CLP (i.e. CLP=0 and CLP=1).

3.1.5 Header Error Control (HEC)

See Section 2.4.

3.2 Service Categories

The following service categories specified at the interconnect are:

- Constant Bit Rate (CBR), as defined in ATM-F Traffic Management v4.0 Specification, Ref [1];
- Variable Bit Rate non real-time (VBR-nrt), as defined in ATM-F Traffic Management v4.0 Specification, Ref [1].

A VBR-nrt service category includes either VBR.1, VBR.2 or VBR.3 conformance definitions.

Other additional service categories, which have been defined by either the ATM-F or ITU-T, may be supported later subject to bi-lateral agreement.

3.3 ATM Connection Types

The types of permanent ATM connections supported are:

- Permanent Virtual Channel (PVC) Link(s).
- Permanent Virtual Path (PVP) Link(s).

The reserved VPI/VCI values for control and management plane information, shall be in accordance with the ITU-T Recommendation I.361, Ref [6]. The remaining VPI and VCI values for user plane information shall be bi-laterally agreed by the interconnecting operators.

The QoS performance values of a PVP Link shall meet the most demanding QoS performance values of a PVC Link carried within that PVP Link, as defined in ITU-T Recommendation I.150, Ref [4].

3.4 Quality of Service (QoS)/ATM Layer Network Performance

The QoS performance values at the ATM layer are dependent upon many different factors, such as the chosen service category, degree of overbooking within the switch, the effective bandwidth algorithm of the CAC and also the route length and complexity of a given connection. In this context, the term complexity refers to the impairments that increase with additional switching and queuing stages and/or increase as more international and jurisdictional boundaries are crossed.

Thus, for UK network operators wishing to interconnect, the QoS performance values will depend upon the length of the end-to-end connection and the number of ATM nodes traversed within this end-to-end connection. This end-to-end connection consists of the two interconnecting networks, plus the interconnect. With this in mind the values stated in this recommendation show the upper and lower boundaries of what end-to-end QoS performances values could be expected with regard to interconnecting ATM networks within the UK.

As the QoS values are dependent on many different factors, the actual value of these QoS parameters shall be bi-laterally agreed between the interconnecting operators in that the service level(s) that an operator offers at the interconnect shall be no less than those offered by the operator to its end customers.

3.4.1 Hypothetical Reference Connections (HRX)

This section describes two HRXs which can be used for determining the QoS values expected on an end-to-end connection. Before any QoS values can be calculated a HRX model shall be agreed between the interconnecting operators. It should be noted that the two HRX's shown within this section are only examples. It is recognised that each interconnect scenario will have its own unique properties, such as complexity and distance, thus the formula for calculating QoS performance values have been included in Appendix B, enabling any interconnecting scenario performance figures to be calculated, within the scope of two interconnecting operators.

3.4.1.1 HRX(1)

The first HRX, HRX(1) as shown in Figure 3.1, is for a 27 500 km loop, and is identical to the HRX shown in ITU-T I.356, Appendix II, Ref [5]. With the large number of ATM nodes involved and the overall length of the connection this HRX will represent the upper boundaries of QoS performance values, and is seen as the 'worst case scenario'.

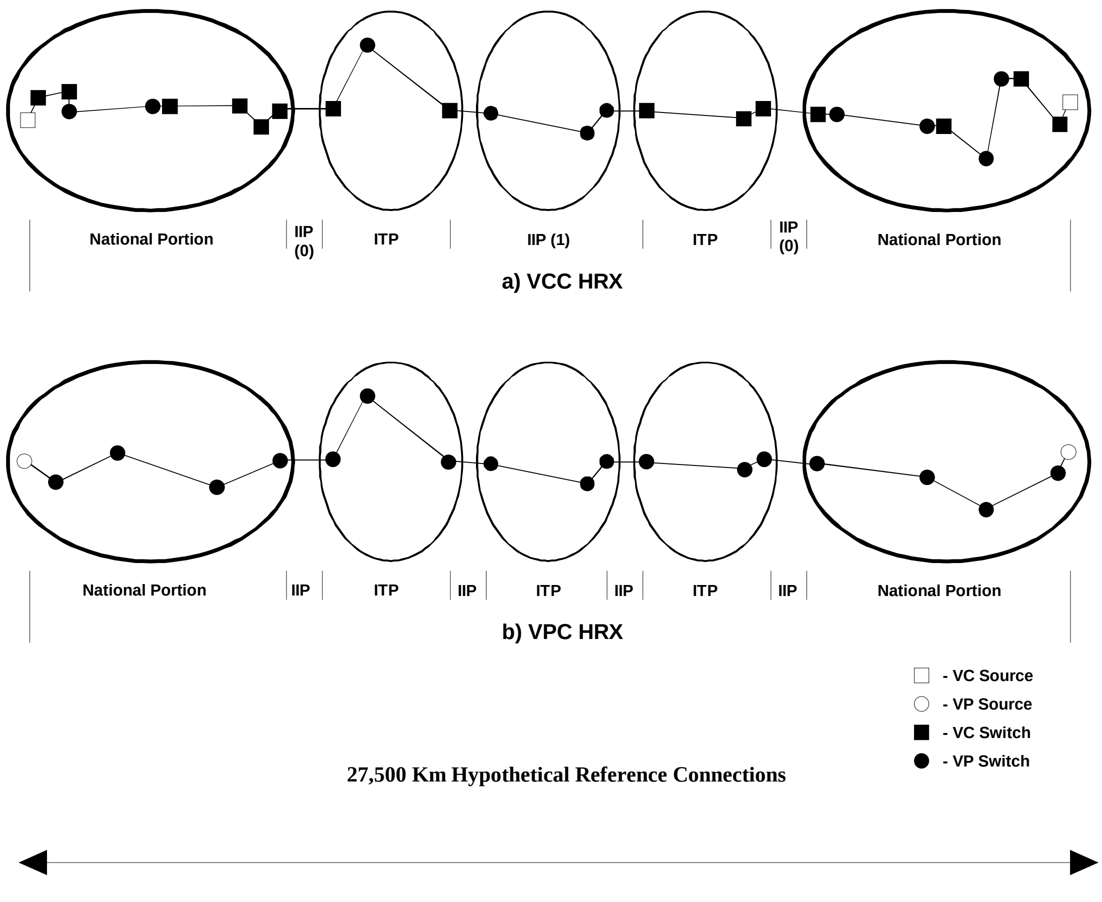

Figure 3.1 - HRX(1) Model

Both international HRXs (VCC and VPC) include two national portions and one International Portion (IP). The International portions each include ATM (VP and/or VC) switching or cross-connect functions in each of three transit countries. Both the VPC and the VCC HRX models are specified for a distance of 27 500 km, as defined in ITU-T Rec. G.826 Ref. [12].

Table 3.1 indicates the number of ATM (VP and VC) nodes that are crossed in the HRX(1) model.

	National Portion	IIP(0)	IIP(1)	IIP(2)	IIP(3)	ITP
a) VCC	8	0	3	6	9	3
b) VPC	4	0	not applicable	not applicable	not applicable	3

Table 3.1 - Number of ATM nodes (VP or VC nodes) in each portion of 2 HRX(1)s

- IIP International Inter-operator Portion.

- ITP International Transit Portion.

For detailed definitions of a National Portion, IIP(0), IIP(1), IIP(2), IIP(3) and ITP, refer to ITU-T Rec. I.356, Ref [6]. For more detailed information regarding HRX(1), concerning switching speeds, loading of transmission links, use of satellites and other aspects, refer to ITU-T Rec. I.356, Ref [6].

3.4.1.2 HRX(2)

The second HRX, HRX(2) as shown in Figure 3.2 shows only two ATM nodes with a user end-to-end distance of 1 km. This model, based upon a very simple scenario consisting of two ATM nodes, shall represent the lower boundaries of QoS performance values, and is seen as the 'best case scenario.'

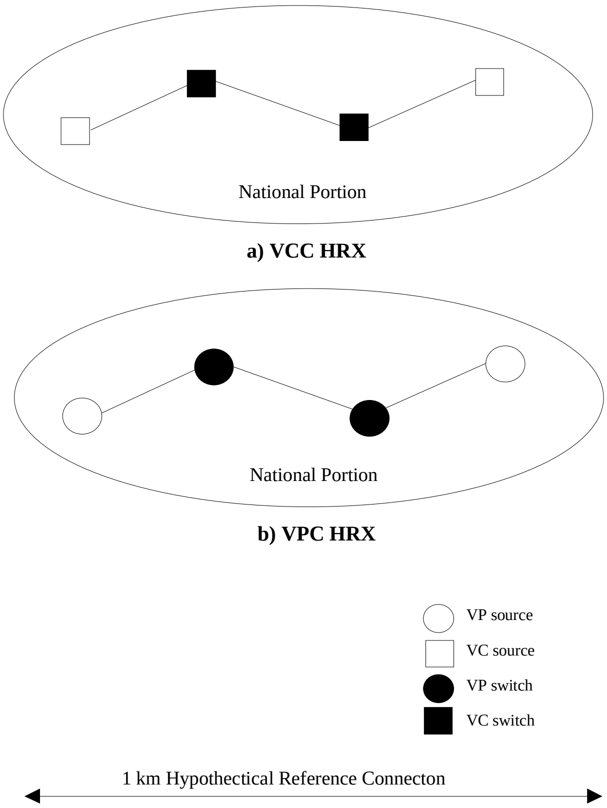

Figure 3.2 - HRX(2) Model

Table 3.2 indicates the number of ATM (VP and VC) nodes that are crossed in the HRX(2) model.

	National Portion
a) VCC	2
b) VPC	2

Table 3.2 - Number of ATM nodes (VP or VC nodes) in each portion of 2 HRX(2)s

For more detailed information regarding HRX(2), concerning switching speeds, loading of transmission links, use of satellites and other aspects, refer to ITU-T Rec. I.356, Ref [6].

3.4.2 QoS values

Each of the QoS tables below show the QoS values relating to each of the service categories supported within this recommendation, namely CBR and nrt-VBR. nrt-VBR service category is sub-divided into three separate conformance definitions VBR.1, VBR.2 and VBR.3. Due to the complexity of relating QoS values, with different service categories and QoS classes, Table 3.3, taken from ITU-T Rec. I.356, Ref [6] shows the relationship between QoS classes and service categories.

Service Category	Applicable QoS class
CBR.1, VBR.1	Class 1 (stringent class)
CBR.1, VBR.1	Class 2 (tolerant class)
VBR.2, VBR.3	Class 3 (bi-level class)
Any service category	U class

Table 3.3 - Relationship between Service Categories and QoS classes

The parameters which define the QoS for an ATM connection are shown below in Table 3.4, Table 3.5, Table 3.6 and Table 3.7 are taken from ITU-T Recommendation I.356 [6]. The QoS performance values expressed in the tables below represent the ATM layer performance and show the upper and lower values that could be expected for an end-to-end connection across the interconnecting operators networks. The QoS performance values shown below are based upon the two HRXs, HRX(1) and HRX(2) as described earlier in Section 3.4.1.

The formula for calculating the end-to-end QoS performance values for scenarios other than shown in section 3.4.1, (i.e. different route length and/or different number of nodes) are shown in Appendix B. If satellite hops are used within the UK or nodes are used to route traffic outside of the UK then reference shall be made to ITU-T I.356, Ref [6].

3.4.2.1 QoS values regarding CBR

The QoS values related to the CBR service category are shown below in, Table 3.4.

	CBR	
QoS parameters	**HRX(1)**	**HRX(2)**
CTD_{max}	400 msec	606 µsec
2-pt CDV	3 msec	Approx. 500µsec
CLR_{0+1}	$3*10^{-7}$ (Note 1)	$7*10^{-8}$ (Note 1)
CLR_0	Undefined	Undefined
CER	$4*10^{-6}$	$7*10^{-7}$
CMR	1 per 24 hours	1 per 72 hours
SECBR (Note 2)	10^{-4}	$2*10^{-5}$

Table 3.4 - CBR QoS values

3.4.2.2 QoS values regarding VBR.1

The QoS values related to the VBR.1 service category are shown below in, Table 3.5.

	VBR.1	
QoS parameters	**HRX(1)**	**HRX(2)**
CTD_{max}	Unbounded	Unbounded
2-pt CDV	Unbounded	Unbounded
CLR_{0+1}	$3*10^{-7}$ (Note 1)	$7*10^{-8}$ (Note 1)
CLR_0	Undefined	Undefined
CER	$4*10^{-6}$	$7*10^{-7}$
CMR	1 per 24 hours	1 per 72 hours
SECBR (Note 2)	10^{-4}	$2*10^{-5}$

Table 3.5 - VBR.1 QoS values

3.4.2.3 QoS values regarding VBR.2

The QoS values related to the VBR.2 service category are shown below in, Table 3.6.

	VBR.2	
QoS parameters	**HRX(1)**	**HRX(2)**
CTD_{max}	Unbounded	Unbounded
2-pt CDV	Unbounded	Unbounded
CLR_{0+1}	Undefined	Undefined
CLR_0	10^{-5}	$4*10^{-6}$
CER	$4*10^{-6}$	$7*10^{-7}$
CMR	1 per 24 hours	1 per 72 hours
SECBR (Note 2)	10^{-4}	$2*10^{-5}$

Table 3.6 - VBR.2 QoS values

3.4.2.4 QoS values regarding VBR.3

The QoS values related to the VBR.3 service category are shown below in, Table 3.7.

	VBR.3	
QoS parameters	**HRX(1)**	**HRX(2)**
CTD_{max}	Unbounded	Unbounded
2-pt CDV	Unbounded	Unbounded
CLR_{0+1}	Undefined	Undefined
CLR_0	10^{-5}	$4*10^{-6}$
CER	$4*10^{-6}$	$7*10^{-7}$
CMR	1 per 24 hours	1 per 72 hours
SECBR (Note 2)	10^{-4}	$2*10^{-5}$

Table 3.7 - VBR.3 QoS values

NOTE 1: CLR values are shown for Class 1. See Appendix B for more information regarding CLR values for Class 2.

NOTE 2: The Cell Block Size (N) used for the SECBR parameter will be related to the PCR of a PVC Link as described in ITU-T Rec. I.356 [6]. For practical measurement purposes, a cell block can be approximated by an OAM Cell Block. The size of the OAM Cell Blocks may vary from block to block but if the SECB ratio is to be approximated, the OAM block sizes should average to the specific value of N appropriate to the aggregate PCR [5].

The QoS values expressed in Table 3.4, Table 3.5, Table 3.6 and Table 3.7 above, act only as guidelines and could be revised in the future based upon practical experience. The QoS values apply to both the VP and VC level and assume ‘fault free operating conditions’. The QoS values expected between interconnecting operators under fault conditions is for bi-lateral agreement. It should be noted, that the QoS parameter values shall be specified for each direction of transmission in the case of a bi-directional PVC Link or PVP Link.

For more detailed information on these QoS parameters, see Appendix A, or refer to either the ITU-T Rec. I.356 Ref. [6] or the ATM Traffic Management Specification v4.0, Ref. [1]

3.5 Traffic Management

3.5.1 Traffic Contract

A traffic contract shall be agreed and policed for each of the PVC Link(s) and PVP Link(s) across the interconnect between the respective operator’s networks. It is recommended that the Traffic Contract shall possess a minimum of the following items as described by ITU-T Rec. I.371, Ref. [7] and ATM Traffic Management Specification v4.0, Ref [1]:

- Connection Traffic Descriptor;
- QoS Parameters and Values;
- Conformance Definition.

3.5.1.1 Connection Traffic Descriptor

The Connection Traffic Descriptor consists of:

- The Source Traffic Descriptor;
- The Cell Delay Variation Tolerance (CDVT);
- Compliance Definition.

3.5.1.1.1 Source Traffic Descriptor

The Source Traffic Descriptor describes the intrinsic characteristics of the user traffic passing through the PVC Link(s) or PVP Link(s). For CBR traffic, it comprises of just the Peak Cell Rate (PCR) parameter. For VBR traffic, two additional parameters are specified. These two additional parameters are known as the Sustainable Cell Rate (SCR) and the Maximum Burst Size (MBS). The values allocated to these parameters are for bi-lateral agreement and shall depend upon the ATM switches used and the total bandwidth available. The Source Traffic Descriptor values shall be specified for each direction of transmission.

3.5.1.1.2 Cell Delay Variation Tolerance

The CDVT specifies the maximum CDV that can be tolerated at the network ingress on each individual PVC Link or all PVC Links within a PVP Link. The CDVT allowed will depend upon the ATM Layer Service Category used and the buffering capabilities within the respective network operator's ATM switches. The actual value of CDVT allowed for cells transmitted at either the PCR or at the PCR and SCR are for bi-lateral agreement.

3.5.1.1.3 Compliance Definition

The compliance definition specifies the method which shall be used to ascertain whether or not each cell arriving at the interconnect interface is compliant or not with the traffic parameters agreed for the connection, taking into account the agreed CDVT. ITU-T Rec. I.371, Ref. [7] and ATM-F Traffic Management Specification v4.0, Ref [1] prescribes the use of the Generic Cell Rate Algorithm (GCRA) to assess cell compliance and shall be used as the default cell compliance method. Alternatively an operator can choose to use their own cell compliance algorithm, instead of their GCRA, providing it can be bi-laterally agreed and supported between the interconnecting operators.

3.5.1.2 Quality of Service Parameters and Values

See Section 3.4.

3.5.1.3 Conformance Definition

The conformance definition describes the method used to determine conformant cells, against the connection traffic descriptor, and how cells judged to be non-conformant are handled.

3.5.1.3.1 CBR Service Category

For PVC Links and PVP Links carrying a CBR service category, the conformance definition for CBR.1 shall be used as the default as defined in the ATM-F Traffic Management Specification v4.0, Ref [1]. Conformance definitions for CBR traffic assumes the use of the GCRA for assessing cell conformance. Cells judged to be non conformant shall be discarded under the ATM-F Traffic Management Specification v4.0, Ref [1] default conformance definition.

3.5.1.3.2 VBR Service Category

For PVC Links and PVP Links carrying a VBR service category, three conformance definition options are available. These three conformance definitions are known as VBR.1, VBR.2 and VBR.3. The support of each conformance definition, VBR.1, VBR.2 and VBR.3 shall be for bi-lateral agreement between the interconnecting operators. The conformance definitions for VBR.1, VBR.2 and VBR.3 as described in the ATM-F Traffic Management Specification v4.0, Ref. [1] shall be used as the default. Conformance definitions for VBR traffic assumes the use of the GCRA for assessing cell conformance.

NOTE: Tagging is only applicable to VBR.3.

3.5.2 Connection Admission Control and Overbooking

The Connection Admission Control (CAC) shall be supported to ensure that the ATM switches at either side of the interconnect shall have sufficient resources to support the traffic and QoS parameter values that have been agreed for the PVC Link(s) or PVP Link(s). The CAC algorithm is network specific but may require negotiation so that given the amount of free resources over the interconnect, both switches can accept the establishment of a new PVC Link or PVP Link request. Both operators shall bi-laterally agree a common booking policy for the interconnect which may be different from that used in their own networks.

3.5.3 Usage Parameter Control

Usage Parameter Control (UPC) shall be supported at the network ingress on both sides of the interconnect to ensure that the QoS objectives of compliant connections are not compromised.

3.5.4 Traffic Shaping

Traffic Shaping at the boundaries of the interconnect to stay within the agreed traffic contract for the PVC Link(s) or PVP Link(s) shall be for bi-lateral agreement. If Traffic Shaping is employed, details of the algorithm used shall be shared between the operators at each end of the interconnect. All Traffic Shaping algorithms used, must maintain the cell sequence integrity on the connection.

3.5.5 Tagging

Tagging functionality is only applicable if the VBR.3 Conformance Definition is supported. If the end-user(s) requests tagging, and if tagging is supported end-to-end (i.e. across the interconnecting networks and interconnect), then a CLP=0 cell that is not conforming to GCRA for SCR (CLP=0), but is conforming to GCRA for PCR (CLP=0+1), will have its CLP bit changed from 0 to 1 and will then be conforming to the connection traffic descriptor.

This conformance definition allows a connection to send CLP=1 cells at a PCR equal to the specified PCR of the CLP=0+1 cell stream. The CLR objective applies to the CLP=0 cell stream. The CLR of the CLP=1 cell-stream and the aggregate stream is undefined.

The support of tagging shall be for bi-lateral agreement between the interconnecting operators.

3.5.6 Selective Cell Discard

Selective Cell Discard can be used to discard cells which belong to a non-compliant ATM connection(s). In addition it can be used to discard cells with a CLP=1, in order to protect CLP=0 cells, under network congestion.

3.5.7 EFCI

The Explicit Forward Congestion Indicator (EFCI) set in one network shall be passed transparently over the interconnect into the other operators network, provided that congestion has not occurred at either of the interconnect interfaces. If congestion does occur at either of the interconnect interfaces, the EFCI shall be set in accordance with bi-laterally declared congestion threshold levels, established between the interconnecting operators.

3.5.8 Frame Discard

The support of frame discard shall be for bi-laterally agreement between the interconnecting operators.

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4 Appendix A

The following text gives a brief description of the various parameters which when combined form the QoS definition for an ATM connection. For a more detailed description of these QoS parameters, refer to ITU-T Rec. I.356, Ref [6].

4.1 CTD

Cell Transfer Delay (CTD) is generally composed of the propagation delay (generally fixed for each VCC/VPC) plus other variable delays caused by queuing, switching, the insertion of OAM/RM cells and effects of the physical layer framing overheads.

Maximum Cell Transfer Delay (CTDmax) is the time, $t_2 - t_1$, between the occurrence of two corresponding successful cell transfer events, CRE_1 at time t_1 and CRE_2 at time t_2. See Figure 4.1 below.

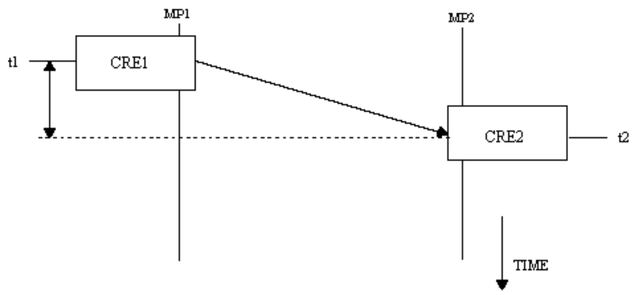

Figure 4.1 - CTD example

4.2 CDV

Cell Delay Variation (CDV) is mainly caused by the effects of queuing and switching cells within the overall connection. The effect of CDV can cause cells to arrive either 'late' compared to their expected arrival time which will in turn degrade the performance of the end-to-end application, especially CBR services. In addition to cells arriving late, cells can also arrive earlier than their expected arrival time, this causes 'bunching or clumping' of cells which causes the agreed PCR to be exceeded, thus causing network congestion and buffer overflow within the switches.

Two cell transfer performance parameters associated with Cell Delay Variation (CDV) have been defined. The first parameter, known as 1-point CDV, is defined on the basis of observing a sequence of consecutive cell arrivals at a single Measurement Point (MP). In general 1-pt CDV is of use only when the cells are transmitted at a known fixed rate as in AAL-1 type services, otherwise it does not offer any value in QoS measurements. The second parameter, known as 2-point CDV, is defined on the basis of observing cell arrivals times at two MPs that delimit a virtual connection. 2-point CDV is explained in more detail below.

4.3 2-pt CDV

The 2-point CDV parameter describes variability in the pattern of cell arrival events at the output of a connection portion (e.g. measurement point MP_2) with reference to the pattern of corresponding events at the input to the portion (e.g. measurement point MP_1); it includes only variability introduced within the connection portion. It provides a direct measure of portion performance and an indication of the maximum (aggregate) length of cell queues that may exist within the portion. It is the 2-point CDV parameter which is used to define the QoS values, within I.356.

The 2-point CDV (v_k) for cell k between MP_1 and MP_2 is the difference between the absolute cell transfer delay (x_k) of cell k between the two MPs and a defined reference cell transfer delay ($d_{1,2}$) between those MPs [see Figure 4.2]: $v_k = x_k – d_{1,2}$. The absolute cell transfer delay (x_k) of cell k between MP_1 and MP_2 is the difference between the cell's actual arrival time at MP_2 (a_{2k}) and the cell's actual arrival time at MP_1 (a_{1k}): $x_k = a_{2k} – a_{1k}$[1] . The reference cell transfer delay ($d_{1,2}$) between MP_1 and MP_2 is the absolute cell transfer delay experienced by cell 0 between the two MPs.

- Positive values of 2-point CDV correspond to cell transfer delays greater than that experienced by the reference cell.
- Negative values of 2-point CDV correspond to cell transfer delays less than that experienced by the reference cell.

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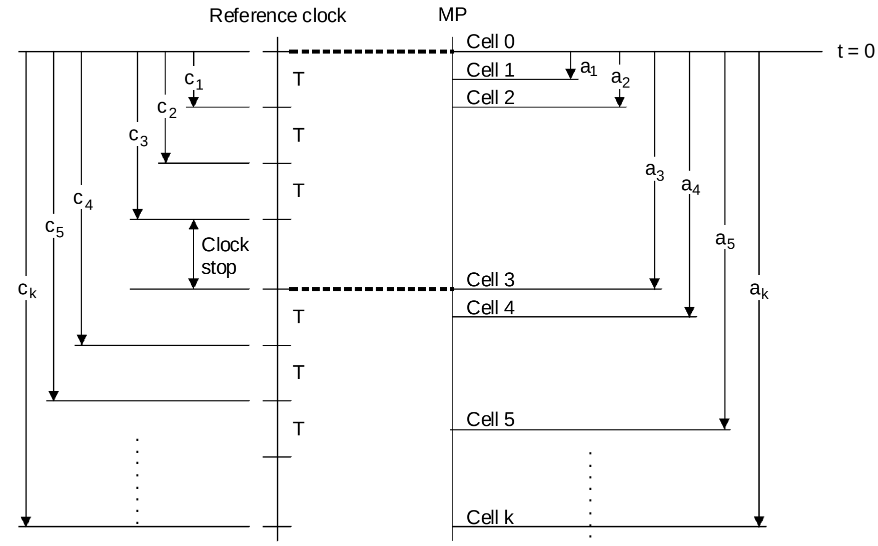
1 Variables a_{2k} and a_{1k} are measured with reference to the same reference clock.

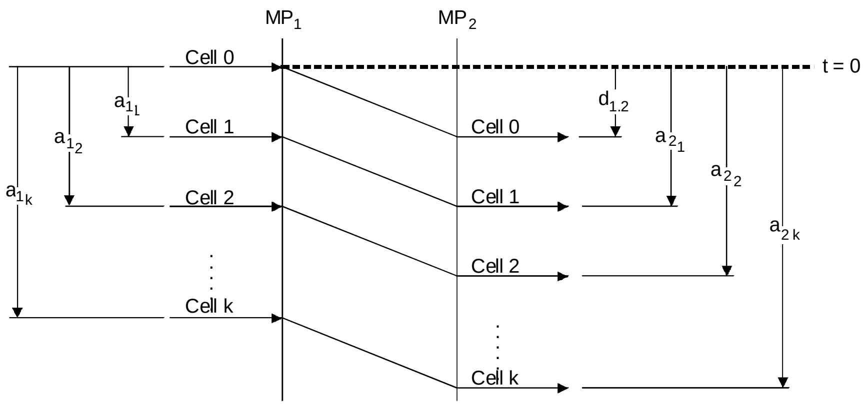


Variables:

a_k Cell k actual arrival time at MP
c_k Cell k reference arrival time at MP
y_k 1-point CDV

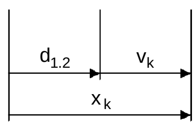
$$y_k = c_k - a_k$$

a) Call delay variation – 1-point definition



Variables:

a_{1k} Cell k actual arrival time at MP_1
a_{2k} Cell k actual arrival time at MP_2
$d_{1.2}$ Absolute cell O transfer delay between MP_1 and MP_2
x_k Absolute cell k transfer delay between MP_1 and MP_2
v_k 2-point CDV value between MP_1 and MP_2



$x_k = a_{2k} - a_{1k}$

$$v_k = x_k - d_{1.2}$$

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b) Cell delay variation – 2 point definition

Figure 4.2 – CDV Parameter Definitions

4.4 CLR

Cell Loss Ratio (CLR) is the ratio of total lost cells to total transmitted cells in a population of interest. ATM cells are lost due to congestion resulting in queue overflow, physical layer impairments corrupting the cell header (where the cell header error correction rules discard cells) and network equipment failure. In order that bursts of errors do not distort the true background CLR, cells lost during such bursts are not considered as part of the CLR, but are captured within the Severely Errored Cell Block Ratio (SECBR) parameter. The SECBR parameter is described later.

The CLR definition has been divided into a number of categories, namely CLR_{0+1} CLR_1 and CLR_0. These are explained below.

4.5 CLP_{0+1}

CLR 0+1 is the CLR for an aggregate cell stream, containing both CLP=0 and CLP=1 cells.

NOTE 1: Tagged cells are not considered lost from an aggregate cell stream.

NOTE 2: When all cells have a CLP=1 then CLR_{0+1} is equal to the $CLR_{1.}$

4.6 CLR_0

CLR_0 is the CLR for only high priority cells, (i.e. those cells with a CLP=0).

NOTE: Tagged cells, (i.e. Cells which have their CLP changed from a 0 to a 1) are considered lost from the high priority stream. Thus the CLR_0 calculation only applies to the conforming CLP=0 cells.

4.7 CLP_1

CLR_1 is the CLR for only low priority cells, (i.e. those cells with a CLP=1).

4.8 CER

Cell Error Ratio (CER) is the ratio of total errored cells to total successfully transferred cells, plus tagged cells and errored cells in a population of interest. The primary causes of errored cells are due to physical layer impairments and network failures. Successfully transferred cells and errored cells contained in cell blocks counted as severely errored cell blocks should be excluded from the population used in calculating the cell error ratio.

4.9 CMR

Cell Mis-insertion is defined as the arrival of a cell within a VCC or VCC which was NOT originally sent, by the sender in that particular VCC or VPC. The Cell Mis-insertion Rate (CMR) is the total number of mis-inserted cells observed during a specified time interval divided by the time interval duration (or equivalently, the number of mis-inserted cells per connection second[2)]**.** Cell mis-insertion can occur when the bit errors in the cells header cause corruption in the VPI/VCI fields such that the any errors still pass through the HEC procedures, or when network

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[2)] By definition, a mis-inserted cell is a received cell that has no corresponding transmitted cell. Cell mis-insertion on a particular connection is most often caused by an undetected error in the header of a cell being transmitted on a different connection. Since the mechanism that most often causes mis-inserted cells has nothing to do with the number of cells transmitted on the observed connection, this performance parameter cannot be expressed as a ratio, only as a rate.

equipment fails. Mis-inserted cells and time intervals associated with cell blocks counted as severely errored cell blocks should be excluded from the population used in calculating cell mis-insertion rate.

4.10 SECBR

A cell block is a sequence of N cells transmitted consecutively on a given connection. A severely errored cell block outcome occurs when more than M errored cell, lost cell, or mis-inserted cell outcomes are observed in a received cell block. These blocks of bursts of errors are usually caused due to physical layer impairments corrupting a group of cells.

NOTE: The severally errored cell block outcome and parameter provide a means of quantifying bursts of cell transfer failures and preventing those bursts from influencing the observed values for CER, CLR, CMR and the associated availability parameters.

Table 4.1 below summarises the main attributes which impair the QoS parameters.

Attribute	CTD	CDV	CLR	CER	CMR	SECBR
Propagation Delay	X					
Media Error Statistics			X	X	X	X
Switch Architecture	X	X	X			
Buffer Capacity	X	X	X			X
No. of Tandem Nodes	X	X	X	X	X	X
Traffic Load	X	X	X		X	
Failures			X	X		X
Resource Allocation	X	X	X			

Table 4.1 - Attributes effecting QoS Parameters

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5 Appendix B

The equations used to calculate the values of the QoS parameters are described below. The equations shown below were taken from ITU-T Rec. I.356, Ref [6]. It is recommended that network operators use these formula as a way of estimating the end-to-end QoS performance values which could be expected from one operator to another.

5.1 CTD

The Cell Transfer Delay (CTD) is expressed in microseconds.

CTD (microseconds) = (R_{km} * 6.25) + (N_{sw} * 300)

In this formula:

- R_{km} represents the route length assumption. This route length assumption shall be computed in accordance to ITU-T Rec. I.356, Ref [6], Clause 9.2
- (R_{km} * 6.25) is an allowance for ‘distance’ within a portion
- N_{sw} is the number of ATM switching and/or cross-connect stages within a HRX. The HRX shall be bi-laterally agreed between the interconnecting operators.
- (N_{sw} * 300) is an allowance for the complexity of a portion.

5.2 2-pt CDV

See ITU-T Rec. I.356, Ref [6], Section 6.5.2.2 for equation relating to 2-pt CDV.

CDV is approx. 250µs per switch traversed (See Telecordia TA-NWT-001110)

5.3 CLR_0

Two Cell Loss Ratio values are shown below. The CLR value will depend on which QoS class is supported.

Class 1 National portion: 23 % + 1% per 1000 km of end-to-end objective.

Class 2/3 National portion: 34.5 % of end-to-end objective.

NOTE: See ITU-T Rec. I.356, Ref [6], Table 2 for end-to-end objective values for $CLR_{0.}$

5.4 CLR_{0+1}

Two Cell Loss Ratio values are shown below. The CLR value will depend on which QoS class is supported.

Class 1 National portion: 23 % + 1% per 1000 km end-to-end objective**.**

Class 2/3 National portion: 34.5 % of end-to-end objective.

NOTE: See ITU-T Rec. I.356, Ref. [6], Table 2 for end-to-end objective values for $CLR_{0+1.}$

5.5 CER

The Cell Error Ratio (CER) is related to the distance of the connection over which the measurement is to be calculated. The equation is shown below.

CER = 17% + 1% per 500 km * $4*10^{-6}$

5.6 CMR

No equation is expressed for Cell Mis-insertion Rate, (CMR). It is stated in I.356 that for a National portion the value of 1 per 72 hours or 1 per 24 hours shall be supported.

5.7 SECBR

The Severely Errored Cell Block Ratio (SECBR) is related to the distance of the connection over which the measurement is to be calculated. The equation is shown below.

SECBR = 17% + 1% per 500 km * 10^{-4}

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