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International transport network

Performance objectives, allocations and limits for bringing-into-service and maintenance of international ATM virtual path and virtual channel connections

ITU-T Recommendation M.2201

(Formerly CCITT Recommendation)

ITU-T M-SERIES RECOMMENDATIONS

TMN AND NETWORK MAINTENANCE: INTERNATIONAL TRANSMISSION SYSTEMS, TELEPHONE CIRCUITS, TELEGRAPHY, FACSIMILE AND LEASED CIRCUITS

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ITU-T Recommendation M.2201

Performance objectives, allocations and limits for bringing-into-service and maintenance of international ATM virtual path and virtual channel connections

Summary

This Recommendation provides performance objectives, allocations and limits, and measurement procedures for bringing-into-service and maintenance of international end-to-end permanent and semi-permanent ATM Virtual Path Connections (VPCs), Virtual Channel Connections (VCCs), and connection portions that form part of an international ATM VPC or VCC. Error, delay and availability performance aspects are addressed. Some of the performance objectives depend on the user's selection of Quality of Service (QoS) class, definitions of which are given in ITU-T I.356 and ITU-T I.371.

Source

ITU-T Recommendation M.2201 was prepared by ITU-T Study Group 4 (2001-2004) and approved under the WTSA Resolution 1 procedure on 15 March 2001.

Keywords

Availability, bringing-into-service, degraded performance limit, errored second, in-service monitoring, performance allocation, performance limits, severely errored second, unacceptable performance limit.

FOREWORD

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NOTE

In this Recommendation, the expression "Administration" is used for conciseness to indicate both a telecommunication administration and a recognized operating agency.

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CONTENTS

Introduction

This Recommendation describes the operational procedures and performance of ATM VPCs that are designed and engineered according to the relevant I-series Recommendations, and are used to support ATM VCCs. It relies heavily on the use of in-service monitoring facilities built into ATM equipment, and focuses on the F4 and F5 Operation, Administration and Maintenance (OAM) information flows specified in ITU-T I.610. However, these OAM facilities are not present in all types of ATM equipment. Therefore, Out-Of-Service (OOS) tests will also be required to ensure operational performance limits are met during Bringing-Into-Service (BIS) and maintenance activities.

The long-term (one month) cell transfer and availability performance objectives for ATM networks are defined in ITU-T I.356 and ITU-T I.357 respectively. Short-term cell transfer and availability performance requirements from an operation and maintenance perspective are covered in this Recommendation.

ITU-T I.356 and ITU-T M.2201 apply end-to-end from terminal measuring point MPT to MPT. This Recommendation enables the derivation of the performance objectives for real connections according to ITU-T I.356 (which has a country-based model); the performance allocation to a single operator is not specifically addressed. In cases where multiple operators operate one or more connections/portions, the subdivision of the objectives between them is subject to further study.

This Recommendation is part of the M.22xx series that address the operation and maintenance of the ATM layer (i.e. above the physical layer). It does not address the ATM Adaptation Layer (AAL) services or consider provisioning and commissioning of ATM equipment into the network. Recommendations in the M.21xx series provide performance objectives, allocations and limits for the physical layer network supporting the ATM layer. The built-in monitoring used by these Recommendations is the OAM information flows defined in ITU-T I.610 as F1, F2 and F3.

ITU-T Recommendation M.2201

Performance objectives, allocations and limits for bringing-into-service and maintenance of international ATM virtual path and virtual channel connections

1 Scope

This Recommendation provides performance objectives, allocations and limits, and measurement procedures for bringing-into-service and maintenance of international, permanent or semi-permanent end-to-end ATM Virtual Path Connections (VPCs), Virtual Channel Connections (VCCs), and connection portions that form part of an international ATM VPC or VCC. Error, delay and availability performance aspects are addressed.

This Recommendation provides performance objectives, allocations and limits for Bringing-Into-Service (BIS) and maintaining international ATM permanent and semi-permanent VPCs that are transported over PDH, SDH or optical fibre networks, referring to the Operations, Administration and Maintenance (OAM) information flows F1-F5 (see Figure 3/I.610 [7]). This Recommendation is part of the M.22xx series, which address flows F4 and F5 (i.e. above the physical level); the M.21xx series address flows F1-F3. This Recommendation does not address the ATM Adaptation Layer (AAL) services or consider provisioning and commissioning of ATM equipment into the network.

Because BIS and maintenance requirements differ according to cell priority level, different limits are provided based on Cell Loss Priorities CLP = 0, and CLP = 0 + 1. Performance parameters and limits are also given for triggering maintenance activity (e.g. fault localization, repair, etc.). Automatic re-routing of cells in the case of a fault is assumed in the determination of limits. The limits are designed to support the long-term performance objectives in ITU-T I.356 [4].

This Recommendation assumes the ATM cell format and structure described in ITU-T I.150 [1] and the use of ITU-T I.610 [7] B-ISDN OAM principles and functions. Methods of deriving performance information from OAM cells and other path information are given.

This Recommendation enables the derivation of the performance objectives for real connections according to ITU-T I.356 [4] (which has a country-based model); the performance allocation to a single operator is not specifically addressed. In cases where multiple operators operate one or more connections/portions, the subdivision of the objectives between them is subject to further study.

2 References

The following ITU-T Recommendations and other references contain provisions which, through reference in this text, constitute provisions of this Recommendation. At the time of publication, the editions indicated were valid. All Recommendations and other references are subject to revision; all users of this Recommendation are therefore encouraged to investigate the possibility of applying the most recent edition of the Recommendations and other references listed below. A list of the currently valid ITU-T Recommendations is published regularly.

[1] ITU-T I.150 (1999), *B-ISDN asynchronous transfer mode functional characteristics*.

[2] ITU-T I.326 (1995), *Functional architecture of transport networks based on ATM*.

[3] ITU-T I.353 (1996), *Reference events for defining ISDN and B-ISDN performance parameters*.

[4] ITU-T I.356 (2000), *B-ISDN ATM layer cell transfer performance*.

[5] ITU-T I.357 (2000), *B-ISDN semi-permanent connection availability*.

[6] ITU-T I.371 (2000), *Traffic control and congestion control in B-ISDN*.

[7] ITU-T I.610 (1999), *B-ISDN operation and maintenance principles and functions*.

[8] ITU-T M.20 (1992), *Maintenance philosophy for telecommunication networks*.

[9] ITU-T M.34 (1988), *Performance monitoring on international transmission systems and equipment*.

[10] ITU-T M.60 (1993), *Maintenance terminology and definitions*.

[11] ITU-T M.2100 (1995), *Performance limits for bringing-into-service and maintenance of international PDH paths, sections and transmission systems*.

[12] ITU-T M.2101 (2000), *Performance limits and objectives for bringing-into-service and maintenance of international SDH paths and multiplex sections*.

[13] ITU-T M.2140 (2000), *Transport network event correlation*.

[14] ITU-T M.3010 (2000), *Principles for a telecommunications management network*.

[15] ITU-T M.3200 (1997), *TMN management services and telecommunications managed areas: overview*.

[16] ITU-T M.3207.1 (1996), *TMN management service: maintenance aspects of B-ISDN management*.

[17] ITU-T M.3400 (2000), *TMN Management Functions*.

[18] ITU-T M.3600 (1992), *Principles for the management of ISDNs*.

[19] ITU-T M.3610 (1996), *Principles for applying the TMN concept to the management of B-ISDN*.

[20] ITU-T M.3611 (1997), *Test management of the B-ISDN ATM layer using the TMN*.

[21] ITU-T O.191 (2000), *Equipment to measure the cell transfer performance of ATM connections*.

3 Terms and definitions

General terms and definitions relating to this Recommendation are provided in ITU-T Recommendations I.326 [2], I.353 [3], I.356 [4], I.357 [5], I.371 [6], I.610 [7], M.20 [8], M.34 [9], M.60 [10], M.2100 [11] and M.2101 [12]. For the purpose of this Recommendation, the following definitions also apply:

3.1 Allocated Performance Objective (APO): An APO is the PO for a real connection calculated according to the allocation rules defined in this Recommendation.

3.2 Bringing-Into-Service Performance Objective (BISPO): A BISPO is the PO for a real connection or connection portion calculated from its APO and used for BIS testing.

3.3 Connection Point (CP): A CP is a reference point where the output of a trail termination source or a connection is bound to the input of another connection, or where the output of a connection is bound to the input of a trail termination sink or another connection.

3.4 End-to-end VPC or VCC: An end-to-end VPC or VCC is the VPC or VCC existing between two MPTs and may traverse a number of ATM switching/cross-connect nodes.

3.5 Measurement Point (MP): A MP is located at an interface that separates either Customer Equipment (CEQ)/customer network or a Switching/Signalling Node (SSN) from an attached transmission system at which ITU-recommended protocols can be observed.

NOTE 1 – The term SSN collectively denotes any equipment that accesses the ATM layer in the transport network under consideration.

NOTE 2 – As defined, MPs exist at many physical interfaces in a connection. It is not the intention in this Recommendation to specify performance between arbitrary pairs of MPs.

NOTE 3 – For B-ISDN, the MPs are located at interfaces where the ATM is accessible. The exact location within the protocol stack depends on whether the connection is a VPC or a VCC.

3.6 Measurement Point O (MPO): A MPO is located at an interface that terminates a transmission system, for example, at an operator's boundary (Point Of Presence (POP)) or an International Switching Centre (ISC). MPTs and individual associated MPOs delimit portions of an end-to-end connection for which performance objectives are specified.

3.7 Measurement Point T (MPT): A MPT is located at an interface associated with a T reference point. This interface separates CEQ from an attached digital section. The T (or T_B in the case of B-ISDN) may be different from the ideal location and difficult to access. Two practical methods for measuring at the B-ISDN MPT are:

– locating a physical test set at the MPT and replicating the ATM protocol functions outside of the CEQ, or

– approximating the performance at the MPT by observations made within the network at the first point where the ATM layer is observable.

3.8 OAM Flow: Information flow transferred through the network by the means of a dedicated channel supported by specific bytes or bits of the transmission systems for the physical layer and by specific ATM cells referred to as OAM cells for the ATM layer.

3.9 Performance Objective (PO): A PO is the target performance to be achieved over the end-to-end reference connection specified in this Recommendation (see Figure 1 for example), assuming a maximum length of 27 500 km.

3.10 Permanent Virtual Path Connection (VPC) or Virtual Channel Connection (VCC): A permanent VPC or VCC is the ATM layer connection which exists between two MPTs or two ATM switches/cross-connect nodes that is permanently set up and configured for transporting ATM information between those two points. Each VPC is considered to be a unidirectional transport entity and may contain one or more VCCs. For a bidirectional VPC or VCC, all performance objectives, limits, etc. shall be applied to each direction independently of the other direction. However, note that use of ITU-T I.610 [7] OAM functionality requires the provision of a reverse channel to carry OAM information.

3.11 segment: Portion of a VPC or a VCC delimited by two CPs referred to respectively as the segment source CP and segment sink CP.

3.12 semi-permanent VPC or VCC: A semi-permanent VPC or VCC is the ATM layer connection which exists between two MPTs or two ATM switches/cross-connect nodes that is set up and configured for a limited time to transport ATM information between those two points. Each VPC is considered to be a unidirectional transport entity and may contain one or more VCCs. For a bidirectional VPC or VCC, all performance objectives, limits etc. shall be applied to each direction independently of the other direction.

3.13 sink: Term used to indicate that OAM information is removed (e.g. at the sink trail termination function) from the incoming signal for further processing.

3.14 Source: Term used to indicate that OAM information is added (e.g. at the source trail termination function) to the outgoing signal for further processing downstream (e.g. at the sink trail termination function).

3.15 Termination Connection Point (TCP): A TCP is a special case of a CP where a trail termination function is bound to an adaptation function or a connection function. In the information model, the termination connection point is called Trail Termination Point (TTP).

3.16 VPC/VCC End-to-end Maintenance Entity (ME): Maintenance entity delimited by the connection end points, which are:

i) the source TCP; and

ii) the sink TCP.

This ME is a bidirectional entity in the sense that the source TCP for a given direction and the sink TCP for the opposite direction are paired at each end of the ME (the VP/VC trail termination functions are located at those TCPs). This ME is created (or deleted) when the VPC/VCC is set up (or released).

3.17 VPC/VCC Segment Maintenance Entity (ME): Maintenance entity delimited by the segment end points, which are:

i) the segment source CP; and

ii) the segment sink CP.

This ME is a bidirectional entity in the sense that the segment source CP for a given direction and the segment sink CP for the opposite direction are paired at each end of the ME (the VP/VC sub-layer trail termination functions are located at those CPs). This ME is a flexible ME which can be created or deleted following a TMN action. It should be noted that the segment source/sink CP may be adjacent to the source/sink TCP and that segment MEs can be nested inside end-to-end MEs. Thus there can be end-to-end OAM flows and segment OAM flows on the same connection.

4 Abbreviations

This Recommendation uses the following abbreviations:

AAL ATM Adaptation Layer

AIS Alarm Indication Signal

APO Allocated Performance Objective

APS ATM Protection Switching

ATC ATM Transfer Capability

ATM Asynchronous Transfer Mode

BIS Bringing-Into-Service

B-ISDN Broadband ISDN

BISPO BIS Performance Objective

BR Backward Reporting

CBR Constant Bit Rate

CC Continuity Check

CDV Cell Delay Variation

CDVT Cell Delay Variation Tolerance

CEQ Customer Equipment/Customer network

CER Cell Error Ratio

CL Cell Loss

CLP Cell Loss Priority

CLR Cell Loss Ratio

CM Cell Misinsertion

CMR Cell Misinsertion Rate

CP Connection Point

CRC Cyclic Redundancy Checksum

CTD Cell Transfer Delay

DPL Degraded Performance Limit

ECB Errored Cell Block

ES Errored Second

FPM Forward Performance Monitoring

FS Frontier Station

IIP International Inter-operator Portion

IoP Inter-operator Portion

IS In-Service

ISDN Integrated Services Digital Network

ISM In-Service Monitoring

ITP International Transit Portion

LB LoopBack

LCD Loss of Cell Delineation

LOC Loss Of Continuity

LOS Loss Of Signal

MBS Maximum Burst Size

MCTD Mean Cell Transfer Delay

ME Maintenance Entity

MP Measurement Point

MPI Measurement Point International boundary

MPO Measurement Point Operator boundary

MPT Measurement Point at T_B

NE Network Element

NP Network Performance

NPC Network Parameter Control

NPP Network Performance Parameter

OAM Operation, Administration and Maintenance

OOS Out-Of-Service

OS Operations System

PCR Peak Cell Rate

PDH	Plesiochronous Digital Hierarchy
PM	Performance Monitoring
PO	Performance Objective
POH	Path OverHead
PTI	Payload Type Indicator
QoS	Quality of Service
RDI	Remote Defect Indication
SCR	Sustainable Cell Rate
SDH	Synchronous Digital Hierarchy
SECB	Severely Errored Cell Block
SECBR	Severely Errored Cell Block Ratio
SES	Severely Errored Second
SSN	Switching/Signalling Node
TCP	Termination Connection Point
TMN	Telecommunication Management Network
UAS	UnAvailable Second
UNI	User-Network Interface
UPC	Usage Parameter Control
UPL	Unacceptable Performance Limit
VC	Virtual Container
VCC	Virtual Channel Connection
VCI	Virtual Channel Identifier
VP	Virtual Path
VPC	Virtual Path Connection
VPI	Virtual Path Identifier

5 Hypothetical reference model

5.1 General model

5.1.1 Country-based model

ATM cell transfer performance is measured by observing the reference events created as ATM cells cross MPs. ITU-T I.353 [3] defines the MPs and the associated reference events that provide the basis for ISDN and B-ISDN performance description.

According to ITU-T I.353 [3], the only cells that create reference events are those with a payload type field indicating a user information cell. Thus, the performance recommendations of ITU-T I.356 [4], and consequently this Recommendation, only apply to the transfer of user information cells.

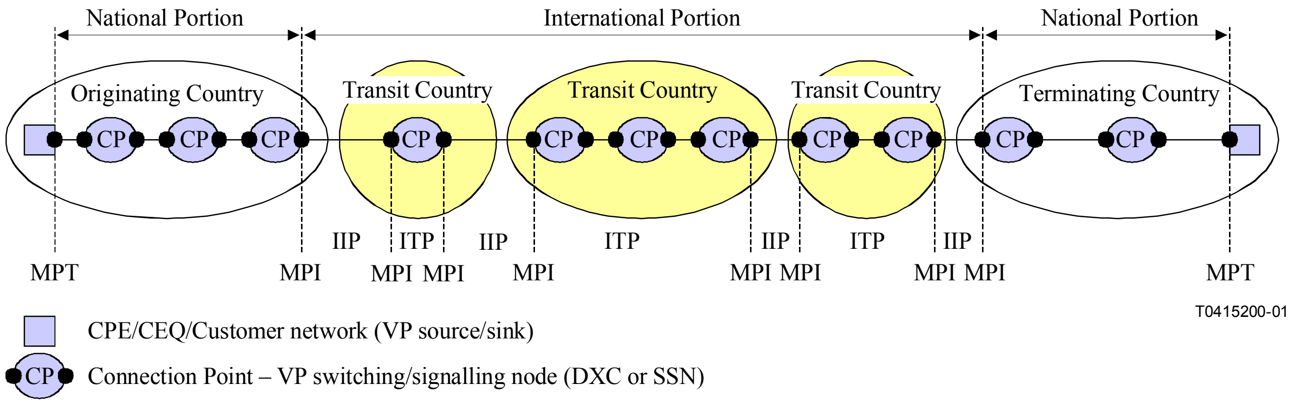


Figure 1a/M.2201 – Example of a VPC and its connection portions

Figure 1a shows an example of a VPC crossing three transit countries. In general, the international portion of such a connection can be partitioned into several International Transit Portions (ITPs) and International Inter-operator Portions (IIPs). An ITP is a connection portion between two MPIs in a single transit country. An IIP is a connection portion between two MPIs in different countries.

The convention IIP(n) is used to indicate the number "n" of intervening transit countries in each IIP.

It should be noted that, in the case of a VPC:

– the number of IIPs is equal to one more than the number of transit countries;

– all IIPs are of the type IIP(0);

– all transit countries have at least one MPI.

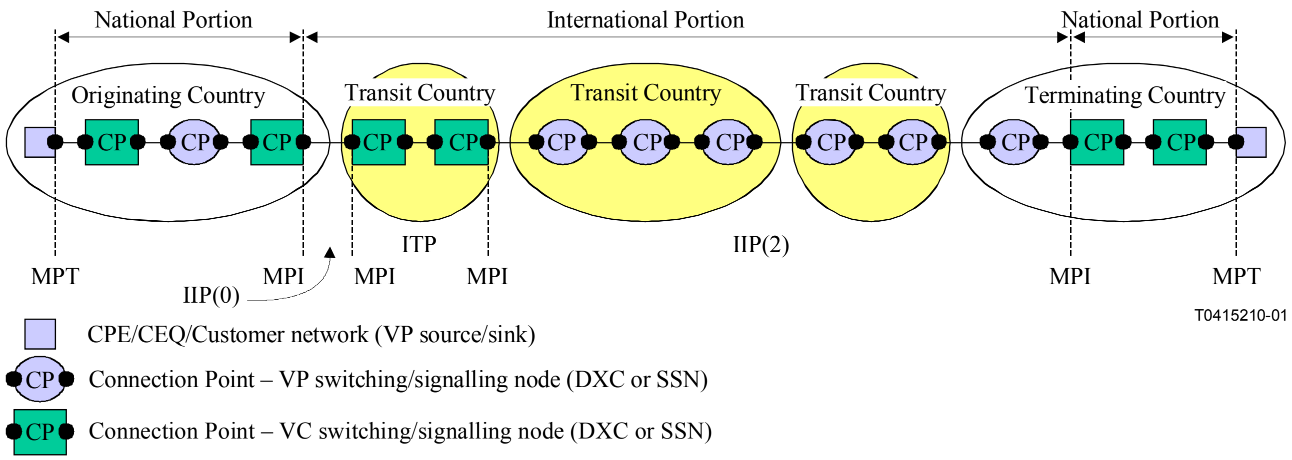


Figure 1b/M.2201 – Example of a VCC and its connection portions

Figure 1b shows an example of a VCC crossing three transit countries. As stated in ITU-T I.353 [3], MPTs are measurement points at or near T_B reference points and thus are at or near customer equipment (CEQ)/customer networks.

It should be noted that, in the case of a VPC:

– the number of IIPs depends on the position of VCC SSNs;

– several kinds of IIP can be present in a connection;

– not all transit countries have a MPI.

5.1.2 Operator-based model

The model used in 5.1.1 does not take into account a multi-operator environment. This case can be better described by means of the model shown in Figure 1c, applied to a VPC.

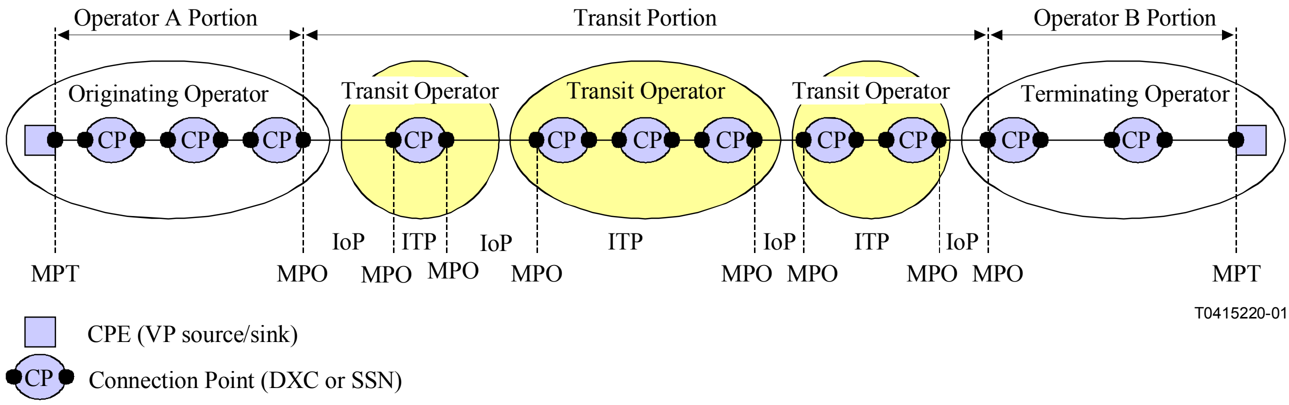


Figure 1c/M.2201 – Example of VPC and its connection portions in a multi-operator environment

In this clause, MPOs are measurement points established at the switching/signalling nodes (SSN) before and after the connection crosses the operator's boundary.

For the purpose of performance management in this environment, ATM connections are divided into the following types of connection portions:

– Connection portions between the MPT and the MPO both within the originating or terminating operator.

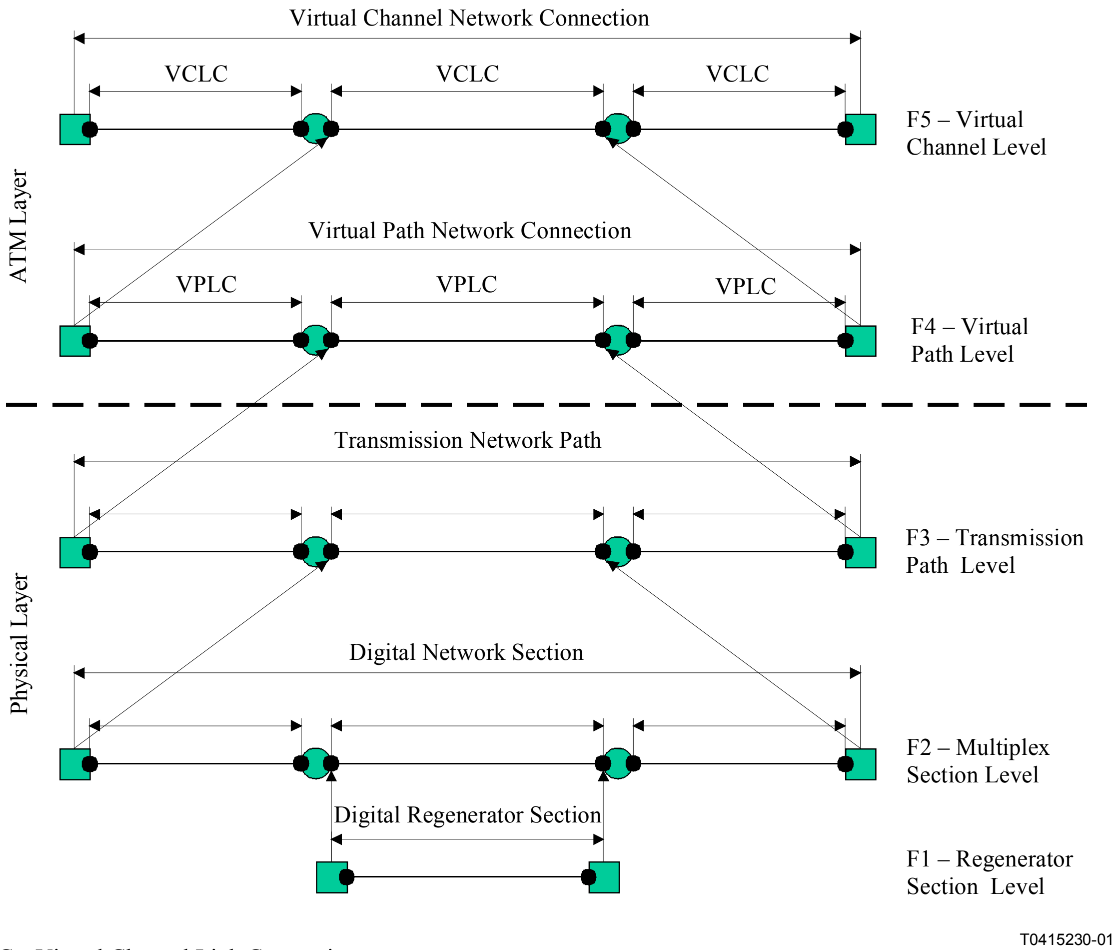
– Intra-operator Transit Portions (ITPs) between two MPOs in a single transit operator's domain. For VPs, the ITP will consist of at least one VP SSN.

– Inter-operator Portions (IoPs): connection portions between two MPOs in different operator domains. For VPs there are no ATM switching or cross-connect elements between these two MPOs.

– Private ATM networks may connect the end users to this public network model at one or both MPTs. The quantitative impact of such networks on the end-to-end QoS is an issue for further study and is not currently addressed in this Recommendation.

5.2 Relationship of ATM virtual paths to physical paths

Virtual paths originate and terminate in ATM switches or cross-connects that need not be coincident with the physical layer paths or other VPs, as shown in Figure 2.



VCLC Virtual Channel Link Connection
VPLC Virtual Path Link Connection

Figure 2/M.2201 – OAM hierarchical levels and relationship to network layers

5.3 Testing arrangement

Since performance is specified from MPT to MPT, BIS testing will use an OOS information flow transported between measuring instruments conforming to ITU-T O.191 [21] applied at the MPTs (or MPIs, MPOs for a connection portion). ISM OAM flow can be used between the connection portions as shown in Figure 3.

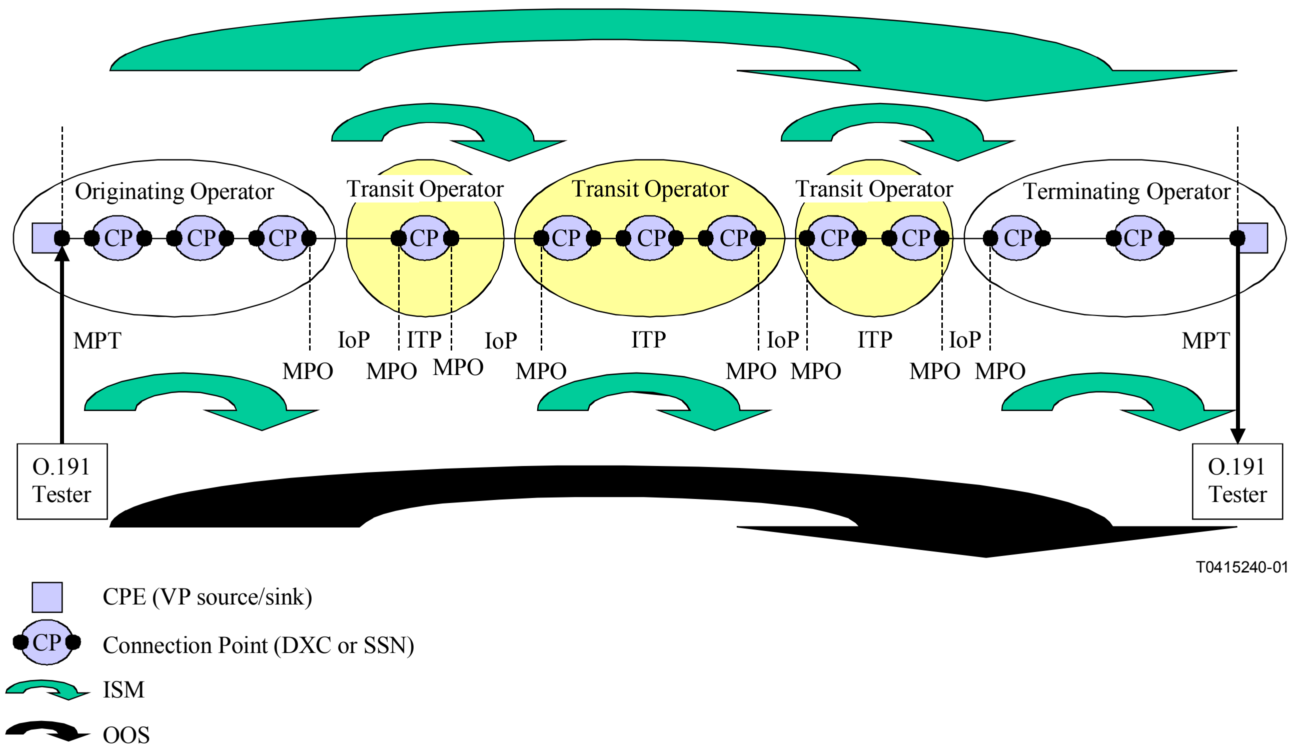


Figure 3/M.2201 – Test arrangement for ATM connection portions

6 Performance objectives

6.1 Reference performance events, performance parameters and performance objectives

ITU-T I.353 [3] and ITU-T I.356 [4] define ATM cell reference events and ATM cell transfer outcomes between two MPs. These are used to determine ATM Network Performance Parameters (NPPs) and resulting Quality of Service (QoS) provided by the VPC or VCC. The NPPs are related to both connection distance and connection complexity, and include:

– Cell Error Ratio (CER);
– Cell Loss Ratio (CLR) for all three CLP flows;
– Cell Misinsertion Rate (CMR)[1];
– Severely Errored Cell Block Ratio (SECBR);
– Cell Transfer Delay (CTD);
– Mean Cell Transfer Delay (MCTD);
– Cell Delay Variation (CDV), both 1-pt CDV and 2-pt CDV;
– Availability.

Table 1 shows the typical reference performance objectives in terms of NPPs for different QoS classes. These practical operational performance objectives apply to each direction over 24 hours, as opposed to the long-term (one month) objectives specified in ITU-T I.356 [4] and ITU-T I.357 [5].

[1] CMR performance objective may not be relevant or practical to measure during BIS (e.g. < 1 misinserted cell per day), but monitoring for misinserted cells should still be done during maintenance.

Table 1/M.2201 – ATM VPC/VCC reference performance objectives

QoS Class	CER	CLR_{0+1}	CLR_0	CMR	SECBR	UAT	CTD (ms) *Terrestrial*	CTD (ms) *Satellite*	2-pt CDV (ms)
1	2×10^{-6}	1.5×10^{-7}	X	0	5×10^{-5}	0	400	700	1.5
2	2×10^{-6}	5×10^{-6}	X	1/day	5×10^{-5}	0	X	X	X
3	2×10^{-6}	X	5×10^{-6}	1/day	5×10^{-5}	0	X	X	X
5	2×10^{-6}	X	1.5×10^{-7}	1/day	5×10^{-5}	0	400	700	3
U	X	X	X	X	X	X	X	X	X
NOTE – The need for different tests to assess QoS is under study. X = no commitment									

The methods for detecting the unavailable state are specified in ITU-T I.357 [5]. One method uses a 10-second consecutive SES_{ATM} event counter with hysteresis. However, no SES_{ATM} event count limit or PO for availability is currently specified. Further information on availability performance is given in 7.3.

6.2 Allocation principles for end-to-end VPCs/VCCs

This clause specifies the allocation principles of performance objectives for the end-to-end ATM VPCs or VCCs, in terms of the connection portions as shown in Figures 1a and 1b.

It is the responsibility of each operator to design its network in a way that is consistent with its connection portion allocation for the VPC or VCC. The allocation of each portion of the VPC or VCC, as a percentage of the overall end-to-end PO, can be determined from the values given in Table 2 and Table 3 respectively. These allocation figures are based on I.356 [4].

Table 2/M.2201 – Maximum allocation of PO to terrestrial VPC portions

	Parameter	Units	Block Allowance		Distance allocation	Complexity
			International portion	National portion (Note 2)		
Error Perf.	CER/SECBR	Ratio	$1\% + (N_{TC} \times 3)\%$	17.5%	1% per 500 km	–
	CLR class 1 & 5	Ratio	$1\% + (N_{TC} \times 8)\%$	23.0%	1% per 1000 km	–
	CLR class 2 & 3	Ratio	$1\% + (N_{TC} \times 10)\%$	34.5%	–	–
Delay Perf.	CTD class 1 & 5	µs	–	–	$\leq (R_{km} \times 6.25)$	$N_{sw} \times 300$
	CDV class 1	ms	$N_{TC} \times 0.7$	1.5	–	–
	CDV class 5	ms	$N_{TC} \times 1.5$	3.0	–	–
NOTE 1 – N_{TC} = number of transit countries, R = route length (in km), N_{SW} = number of SSNs. NOTE 2 – For each end-to-end connection, there will be an originating country national portion and a terminating country national portion.						

Table 3/M.2201 – Maximum allocation of PO to terrestrial VCC portions

	Parameter	Units	Block Allowance			Distance allocation	Complexity
			International portion IIP(n)	International portion ITP	National portion (Note 2)		
Error Perf.	CER/SECBR	Ratio	1% + (n × 3)%	2%	17.5%	1% per 500 km	–
	CLR class 1 & 5	Ratio	1% + (n × 8)%	7%	23.0%	1% per 1000 km	–
	CLR class 2 & 3	Ratio	1% + (n × 10)%	9%	34.5%	–	–
Delay Performance	CTD class 1 & 5	µs	–		–	≤ (R_{km} × 6.25)	N_{sw} × 300
	CDV class 1 (Note 3)	ms	0.7 + 0.2 × (n–1)	0.7	1.5	–	–
	CDV class 5 (Note 3)	ms	1.5 + 0.5 × (n–1)	1.5	3.0	–	–

NOTE 1 – R = route length (in km), NSW = number of SSNs.

NOTE 2 – For each end-to-end connection, there will be an originating country national portion and a terminating country national portion.

NOTE 3 – For CDV, the block allowance in the IIP is calculated only for the case n > 0; for the case n = 0, there is no IIP block allowance.

CER and SECBR are mainly distance related. Practical measurements show that CLR is distance and complexity related for QoS class 1, and complexity dominated for QoS class 2 and QoS class 3. However, the complexity is taken into account in the block allowance shown in Table 2 and Table 3 and there is no distance allowance for CLR in QoS classes 2 & 3.

CTD and mean CTD are mainly distance related, but also depend on the connection complexity or number of SSNs. CDV is independent of distance and depends on the number of SSNs. However, the block allowance takes complexity into account in this case.

Distances referred to in Table 2 and Table 3 are actual distances or, in the case where the actual distance is not known, calculated according to Table 5. If any connection portion is carried over satellite, the following allocations should be used:

Table 4/M.2201 – Maximum allocation of PO to satellite VPC portions

	Parameter	Units	National portion	International portion	
				IIP(n)	ITP
Error Perf.	CER/SECBR	Ratio	42%	35 + (4 × n)%	36%
	CLR class 1 & 5	Ratio	35%	25 + (5 × n)%	30%
	CLR class 2 & 3	Ratio	–	–	–
Delay Perf.	CTD class 1 & 5	ms	320	320	320

Table 5/M.2201 – Calculated terrestrial connection distance

Air route distance d	Calculated Distance
d < 1000 km	d × 1.5
1000 ≤ d < 1200 km	1500 km
d ≥ 1200 km	d × 1.25

It is possible that access to the bit stream for a given VPC or VCC may not coincide with the end of a connection portion. In this case, or if a transit operator has other access points within its network, it may be necessary to make a sub-allocation for maintenance purposes, e.g. fault localization. Such sub-allocations will be the responsibility of the Network Operator(s) involved, with the following constraints:

– the sum of sub-allocations may not exceed the allocation of Tables 2 or 3 for the connection portion in question;

– the values of the sub-allocations must be communicated to all maintenance centres involved before bringing the path into service and after any rearrangement, which changes the values.

Two examples follow of how to calculate the performance allocations.

Example 1: Calculation of SECBR and CER for VPC in Figure 1a

The connection consists of:

- one NP with air-route distance between its MPT and MPI equal to 1000 km; the calculated route length is 1500 km;
- four IIP(0)s with air-route distance between its MPIs equal to 500 km; the calculated route length is 750 km;
- three ITPs with air-route distance between its MPIs equal to 500 km; the calculated route length is 750 km;
- one NP with air-route distance between its MPI and MPT equal to 1000 km; the calculated route length is 1500 km.

SECBR and CER allocation:

NP = 2 × (17.5 + 3) = 41%;

IIP + ITP (block allowance) = 1 + (3 × 3) = 10%;

IIP + ITP distance = (4 × 750) + (3 × 750) = 5250 km (rounded up to 5500) ⇒ 11%;

Global allocation = 41 + 10 + 11 = 62%.

Example 2: Calculation of SECBR, CER and CDV class 1 for VCC in Figure 1b

The connection consists of:

- one NP with air-route distance between its MPT and MPI equal to 1000 km; the calculated route length is 1500 km;
- one IIP(0) with air-route distance between its MPIs equal to 500 km; the calculated route length is 750 km;
- one IIP(2) with actual distance between its MPIs equal to 3000 km;
- one ITP with air-route distance between its MPIs equal to 500 km; the calculated route length is 750 km;
- one NP with air-route distance between its MPI and MPT equal to 1000 km; the calculated route length is 1500 km.

SECBR and CER allocation:

NP = 2 × (17.5 + 3) = 41%;

IIP(0) (block allowance) = 1%;

IIP(2) (block allowance) = 1 + (2 × 3) = 7%;

ITP (block allowance) = 2%;

IIP + ITP distance = 750 + 750 + 3000 = 4500 km ⇒ 9%;

Global allocation = 41 + 1 + 7 + 2 + 9 = 60%.

CDV class 1 calculation:

NP = 2 × (1.5) = 3 ms;

IIP(0) (block allowance) = 0;

IIP(2) (block allowance) = 0.7 + 0.2 = 0.9 ms;

ITP (block allowance) = 0.7 ms;

Global allocation = 3 + 0.9 + 0.7 = 4.6 ms.

7 Performance measurements

BIS measurements are to be made in an OOS state, and the performance parameters to be measured are described in 7.1. However, it should be noted that the results will be dependent on the traffic loading of the network, which is a shared resource, unlike the circuit-switched connection-oriented SDH network. Maintenance measurements are to be made in-service (if possible), and the technique and performance parameters to be measured are described in 7.2.

7.1 BIS performance measurements

BIS performance is normally measured OOS using test equipment conforming to ITU-T O.191 [21]. For new VPCs, a 24-hour test duration is recommended. For VCCs being added to an existing VPC, a shorter test duration e.g. 2 hours is acceptable. However, if during this shorter test, the BIS test limit is exceeded, a longer test should be carried out.

However, not all NPPs may be specified or required for a given ATM VPC or VCC, and will depend on what OAM facilities are available and activated in network equipment. Not all of these NPPs may be practical to measure during BIS. For example, CMR performance may not be relevant or practical to measure during BIS, but monitoring for misinserted cells should still be done during maintenance.

In addition, it should be noted that accurate CTD measurements require the two test sets to be synchronized in frequency and phase, and accurate 2-point CDV measurements require them at least to be synchronized in frequency. Synchronization methods are under study. A method of estimating

2-point CDV from 1-point CDV measurements is suggested in Annex C/I.356 [4], although this method has some accuracy constraints. Further details are given in ITU-T O.191 [21].

ITU-T I.371 [6] defines traffic profile parameters used to specify traffic contracts for VPCs and VCCs, whether switched or non-switched. These traffic parameters are related to the ATM Transfer Capabilities (ATCs) offered by the VPCs or VCCs and are controlled via the Usage Parameter Control (UPC) or Network Parameter Control (NPC) function in ATM network equipment. These traffic profile parameters include:

– Cell Delay Variation Tolerance (CDVT);
– Maximum Burst Size (MBS);
– Peak Cell Rate (PCR);
– Peak Emission Interval (PEI);
– Sustainable Cell Rate (SCR).

For details on classes of service and QoS commitments, refer to ITU-T I.371 [6].

BIS performance measurements may include checks of UPC/NPC operation in order to determine the correct functioning of the UPC/NPC mechanism and/or the ability of the VPC or VCC to support its contracted traffic parameters (see also ITU-T I.356 [4] and ITU-T I.371 [6]). Test equipment conforming to ITU-T O.191 [21] may be used for this purpose and can provide user-programmable settings of UPC/NPC traffic profiles in terms of CDVT, MBS, PCR, PEI, SCR etc. BIS tests must include busy hour traffic periods because of the effect of traffic congestion on the result, especially delay parameters.

7.2 Maintenance performance measurements

ATM network equipment with built-in OAM facilities defined in ITU-T I.610 [7] can provide ISM of performance and fault events, and control of various other functions such as activation/deactivation of Performance Monitoring (PM) and/or Continuity Check (CC), protection switching, system management, etc. These can be used in conjunction with TMN facilities (see ITU-T Recommendations M.3010 [14], M.3200 [15], M.3207.1 [16], M.3400 [17], M.3600 [18], M.3610 [19] and M.3611 [20]) to provide integrated performance and fault management of ATM VPCs and VCCs.

OAM functions in the network are performed on five OAM hierarchical levels associated with the ATM and physical layers of the protocol reference model (see Figure 1). The functions result in corresponding bidirectional information flows F1, F2, F3, F4 and F5 referred to as OAM flows. The physical layer contains the three lowest OAM flows as follows:

– F1: regenerator section level;
– F2: multiplex section level;
– F3: transmission path level.

The ATM layer contains the two higher OAM levels, F4 at the virtual path level and F5 at the virtual channel level. These OAM flows are related to bidirectional Maintenance Entities (MEs) corresponding to either the entire end-to-end ATM VPC/VCC, referred to as the VPC/VCC ME, or to a portion of this connection referred to as a VPC/VCC segment ME.

For maintenance purposes, F4 and F5 OAM flows are defined at the ATM layer covering the VPC and VCC levels respectively. Both flows are bidirectional and follow the same physical route as the user-data cells, thus constituting an in-band maintenance flow. OAM cells of the F4 flow have the same VPI value in the ATM header as the user cells of the VPC. Both end-to-end F4 flow and segment F4 flow can exist simultaneously in a VPC. When allocating bandwidth to a VPC/VCC, it is necessary to allocate sufficient bandwidth for the OAM cells in that connection as described in ITU-T I.371 [6]. The ISM maintenance method is illustrated in Figure 4 below.

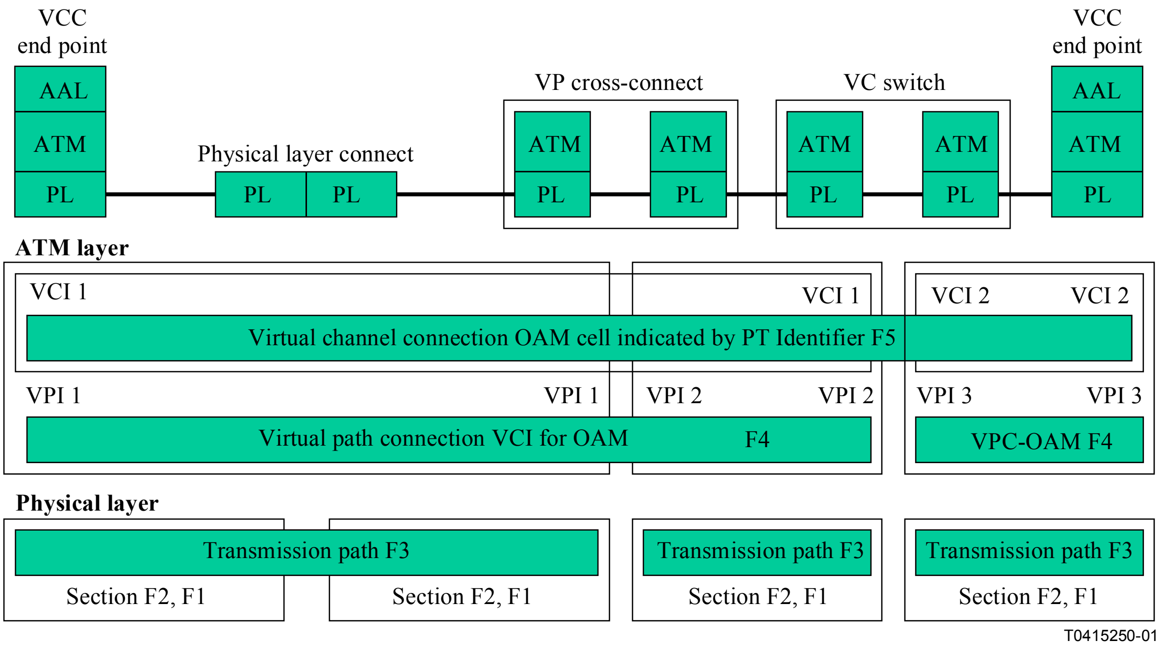


Figure 4/M.2201 – Maintenance in-service monitoring OAM flows

In-service performance monitoring is provided by the ATM network operator applying a flow of Performance Monitoring (PM) OAM cells that are inserted into the traffic stream to divide the user cell flow into cell blocks of a nominal size N. This procedure is described in ITU-T I.610 [7]. Only user cells are monitored by PM flows: if no user cells are inserted for a period of time (e.g. in the case of VBR connections), then no PM cells are inserted. The added OAM cells can be used to monitor path segments (segment flow) or the entire virtual connection (end-to-end flow). Dedicated OAM cells with pre-assigned VCI and PTI values are used to implement F4 and F5 flows respectively at segment or end-to-end levels. Further details are given in ITU-T I.610 [7]. The different OAM cell types can be summarized under the following categories:

– Fault management using AIS, RDI, CC and LB cells;
– Performance management using FPM and BR cells;
– Activation/deactivation of PM and/or CC using activation/deactivation cells;
– Protection switching at the ATM layer using APS cells;
– System management cells for use by end-systems only.

Anomalies and defects are detected via the OAM cells by the ATM network equipment and can be used in a similar way as that for the physical layer to determine performance parameters. Anomalies include Errored Cell Block (ECB), Cell Loss (CL) and Cell Misinsertion. Defects include Alarm Indication Signal (AIS), Remote Defect Indication (RDI), Loss Of Signal (LOS), Loss Of Continuity (LOC), and Loss of Cell Delineation (LCD). Persisting defects result in a failure state. Methods of detecting OAM procedure failures are for further study.

ECBs and CLs can be counted and processed into performance parameters such as ES_{ATM}, SES_{ATM} and UAS_{ATM}. These can provide a means to correlate VPC performance degradations with physical layer degradations. Detailed definitions, measurement and accumulation methods are for further study.

7.3 Availability

Two methods of detecting and declaring the unavailable state at the ATM layer are specified in ITU-T I.357 [5]. The main part of ITU-T I.357 [5] defines the availability criteria for ATM connections based on the SES_{ATM} event. This method uses a 10-second consecutive SES_{ATM} counter with hysteresis analogous to the 10-second consecutive SES counter approach used at the SDH and PDH layers. The means by which this SES_{ATM} event is estimated in-service and its accuracy depends on which OAM flows are activated on the connection. Only option 2 of the CC cell (i.e. one CC cell sent nominally every second independently of user cells) is used for in-service estimation of availability. However, there is a potential problem in the declaration of unavailability at the ATM layer using this method. If there is an error in the time at which unavailability is declared, e.g. 1 second late, there could be a large number of cells erroneously declared as lost. This could result in the declared cell loss exceeding the ITU-T I.356 [4] limit for one year.

An alternative bidirectional method for estimating availability is specified in Annex A.1.2/I.357 [5] based on declaring unavailable state on the detection of AIS or RDI. This estimation is based on the fault management defined in ITU-T I.610 [7] for detecting an outage of a connection. The method is not tied to the 10-second entry and exit criteria for unavailability and does not capture all periods of unavailability, but may result in declaring unavailable state faster than the conventional method. Further information is given in ITU-T I.357 [5] and ITU-T I.610 [7].

It should be noted that ATM equipment using different methods of availability estimation on the same connection could lead to inter-operability problems and uncertainty in the performance results obtained. Therefore, it is advisable that the interconnected ATM equipments should use the same method. Furthermore, use of the alternative estimation method in Annex A.1.2/I.357 [5] may result in problems reaching the long-term availability performance objective of ITU-T I.356 [4] since the declaration of unavailable state may occur faster. However, this may be counter-balanced by some improvement in the CER and CLR results taken over available time. In general, the results may favour the connection user at the expense of the Service Provider and care should be taken when estimating availability this way against an SLA.

7.4 Evaluation of performance objectives

Practical operational measurements will be carried out in as short a time as possible. In all cases, the aim should be to meet the long-term end-to-end ATM cell transfer performance objectives specified in ITU-T I.356 [4] and ITU-T I.357 [5].

Any BIS test duration should be 24 hours because:

- CMR is specified over 24 hours in ITU-T I.356 [4] (unless it is deemed acceptable to only detect cell misinsertions).
- CER and CLR will be dependent on server layer performance, which varies over long-term periods.
- Traffic busy hours vary by location/destination.
- Server layer BIS tests may have taken place several months or years prior to the ATM BIS process.

8 Role within the TMN

The network configuration for maintenance activities is described in ITU-T M.3600 [18]. This configuration is also applicable to the B-ISDN carrying ATM traffic. The B-ISDN OAM principles described in ITU-T I.610 [7] and used in this Recommendation are intended to be consistent with the TMN principles described in ITU-T M.3010 [14]. OAM information is processed by the management function within the ATM Network Elements (NEs) and passed to the TMN Operations Systems (OSs) at NE management level, network management level and service management level. This includes correlation of events occurring simultaneously at multiple layers of the network so as to avoid a large number of events being recorded when a "parent" event causes multiple performance impairment indications at different layers. Further details are given in ITU-T I.610 [7], ITU-T M.2140 [13] and in the other TMN Recommendations.

9 Performance limits

9.1 Relationship between performance limits and objectives

The limits in this Recommendation are to be used to indicate the need for actions during maintenance and bringing-into-service. A network maintained to these limits should meet the performance objectives specified in ITU-T I.356 [4].

The particular parameters measured, the measurement duration, and the limits used for the procedure need not be identical to those used for specifying the performance objectives as long as they result in network performance which meets these objectives. For example, the long-term performance objectives refer to long periods, such as one month. However, practical considerations demand that maintenance and BIS limits be based on shorter measurement intervals.

Statistical fluctuations in the occurrence of anomalies and defects mean that one cannot be certain that the long-term objectives are met. The limits on the numbers of events and the duration of measurements attempt to ensure that connections exhibiting unacceptable or degraded performance can be detected. The only way to ensure that a connection meets network performance objectives is to evaluate continuous measurement over a long period (i.e. months).

9.2 Types of limits

Limits are needed for several maintenance functions as defined in ITU-T M.20 [8]. This Recommendation provides connection limits for three of these functions:

– Bringing-Into-Service (BIS);
– keeping the network operational (maintenance);
– restoration.

The limits for BIS and restoration are the same. Limits for commissioning (installation and acceptance) of ATM equipment are not provided in ITU-T Recommendations.

Once entities have been placed into service, supervision of the network requires additional limits, as described in ITU-T M.20 [8]. This supervision is done by in-service performance monitoring. The supervision process involves analysing anomalies and defects detected by maintenance entities to determine if the performance level is normal, degraded or unacceptable. Thus, Degraded Performance Limit (DPL) thresholds and Unacceptable Performance Limit (UPL) thresholds are required. In addition, a limit on performance after intervention (repair) is also required.

9.3 Process for calculation of ATM connection performance objectives and limits

The following steps shall be followed to obtain ATM connection performance limits:

– Calculate the APO from APO = PO × Allocation × Test duration.
– Calculate the BISPO from BISPO = APO/2.
– Set the BIS limit = BISPO.
– Set the Maintenance UPL ≥ APO × 10 when measured over 15 minutes.
– Set the Maintenance DPL = APO × 0.75 when measured over 24 hours.

The UPL and DPL are used as maintenance thresholds that, when exceeded, trigger threshold exception reports to TMN management systems (see ITU-T M.34 [9]).

9.4 Long-term quality monitoring/measurement

Performance monitoring history should be kept for at least one year (suggested) by the management system.

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