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INTEGRATED SERVICES DIGITAL NETWORK (ISDN)

MAINTENANCE PRINCIPLES

B-ISDN OPERATION AND MAINTENANCE PRINCIPLES AND FUNCTIONS

ITU-T Recommendation I.610

(Previously "CCITT Recommendation")

FOREWORD

The ITU Telecommunication Standardization Sector (ITU-T) is a permanent organ of the International Telecommunication Union. The ITU-T is responsible for studying technical, operating and tariff questions and issuing Recommendations on them with a view to standardizing telecommunications on a worldwide basis.

The World Telecommunication Standardization Conference (WTSC), which meets every four years, established the topics for study by the ITU-T Study Groups which, in their turn, produce Recommendations on these topics.

ITU-T Recommendation I.610 was revised by the ITU-T Study Group XVIII (1988-1993) and was approved by the WTSC (Helsinki, March 1-12, 1993).

NOTES

1 As a consequence of a reform process within the International Telecommunication Union (ITU), the CCITT ceased to exist as of 28 February 1993. In its place, the ITU Telecommunication Standardization Sector (ITU-T) was created as of 1 March 1993. Similarly, in this reform process, the CCIR and the IFRB have been replaced by the Radiocommunication Sector.

In order not to delay publication of this Recommendation, no change has been made in the text to references containing the acronyms "CCITT, CCIR or IFRB" or their associated entities such as Plenary Assembly, Secretariat, etc. Future editions of this Recommendation will contain the proper terminology related to the new ITU structure.

2 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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B-ISDN OPERATION AND MAINTENANCE PRINCIPLES AND FUNCTIONS

(Geneva, 1991; revised Helsinki, 1993)

1 Introduction

1.1 General

Considerations on Operations and Maintenance (OAM) functions take into account the following Recommendations:

- Rec. M.20 – Maintenance philosophy for telecommunications networks
- Rec. M.30 – Principles for a telecommunications management network
- Rec. M.36 – Principles for the maintenance of ISDNs
- Rec. I.113 – Vocabulary of terms for broadband aspects of ISDN
- Rec. I.150 – B-ISDN asynchronous-transfer mode functional characteristics
- Rec. I.311 – B-ISDN general network aspects
- Rec. I.321 – B-ISDN Protocol Reference Model and its application
- Rec. I.361 – B-ISDN ATM Layer Specification
- Rec. I.413 – B-ISDN user-network interface
- Rec. I.432 – B-ISDN user-network interface – Physical Layer specification
- Recommendations of I.600-Series

1.2 Scope

The scope of this Recommendation is to identify the minimum set of functions required to operate and maintain the Physical Layer and ATM Layer aspects of the B-ISDN user network interface (UNI) as well as the individual virtual path (VP) and virtual channel (VC) connections that may be routed through the Broadband ISDN. Whenever the term "customer access" is referred to in this Recommendation, it includes the UNI.

The functions of the layers above the ATM Layer are not considered but are for further study.

2 OAM principles

The following five phases have been considered in specifying the OAM functions of the B-ISDN.

a) *Performance monitoring*

Normal functioning of the managed entity is monitored by continuous or periodic checking of functions. As a result, maintenance event information will be produced.

b) *Defect and failure detection*

Malfunction or predicted malfunctions are detected by continuous or periodic checking. As a result, maintenance event information or various alarms will be produced.

c) *System protection*

Effect of failure of a managed entity is minimized by blocking or changeover to other entities. As a result the failed entity is excluded from operation.

d) *Failure or performance information*

Failure information is given to other management entities. As a result, alarm indications are given to other management planes. Response to a status report request will also be given.

e) *Fault localization*

Determination by internal or external test systems of a failed entity if failure information is insufficient.

NOTE – Some of these phases and others (as described in 5/M.20) are, at present, not subject to the description in this Recommendation.

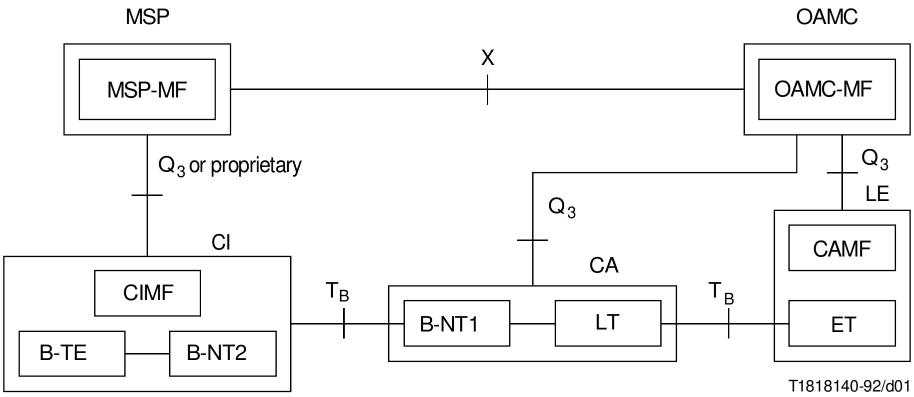
2.1 Network configuration for maintenance activities

The network configuration for maintenance activities is described in Recommendation M.36. This configuration is also applicable for the B-ISDN.

2.2 Relation with the Telecommunication Management Network (TMN)

An example of a customer access network architecture describing the relation with the TMN is given in Figure 1. The protocols used for maintenance are specified through Q-interfaces and may include the transmission section between B-NT2 and B-NT1.

Network element internal monitoring functions are not subject to standardization. The results of that monitoring will be delivered to the TMN via Q-interfaces.



CIMF	Customer installation management function
CAMF	Customer access management function
MSP	Management service provider
LE	Local exchange
MF	Management function
OAMC	Operation administration maintenance center
CI	Customer installation
CA	Customer access
X	Interface between two management systems
Q_3	TMN Interface

NOTE – Mediation/adaptation functions with Q_2 interfaces may be distributed in different equipment.

FIGURE 1/I.610

Example of TMN architecture for the customer access

The Figure 1 illustrates management related systems and their relationship for the B-ISDN customer access.

3 OAM Levels and Flows

3.1 OAM levels in the B-ISDN

OAM functions in the network are performed on five OAM hierarchical levels associated with the ATM and Physical Layer of the protocol reference model. The functions result in corresponding bidirectional information flows Fl, F2, F3, F4 and F5 referred to as OAM flows (see Figure 2). Not all of these need to be present. The OAM functions of a missing level are performed at the next higher level. The levels are as follows:

- *Virtual channel level*: Extends between network elements performing virtual channel connection termination functions and is shown extending through one or more path connections (see also 2.3.1/I.311).
- *Virtual path level:* Extends between network elements performing virtual path connection termination functions (see 2.3.2/I.311) and is shown extending through one or more transmission path.
- *Transmission path level:* Extends between network elements assembling/disassembling the payload of a transmission system and associating it with its OAM functions. Cell delineation and header error control (HEC) functions are required at the end points of each transmission path. The transmission path is connected through one or more digital sections.
- *Digital section level:* Extends between section end points and comprises a maintenance entity according to the definition of 3/M.20.
- *Regenerator section level:* A regenerator section is a portion of a digital section and as such is a maintenance sub-entity.

3.2 Relationship of OAM functions with the B-ISDN Protocol Reference Model

OAM functions are allocated to the Layer Management of the B-ISDN protocol reference model (see Recommendation I.321).

This layered concept and the requirements of independence of the layers from each other lead to the following principles:

1) OAM functions related to OAM levels are independent from the OAM functions of other layers and have to be provided at each layer;
2) Each layer, where OAM functions are required, is able to carry out its own processing to obtain quality and status information. OAM functions are performed by the Layer Management. These results may be provided to the Plane management or to the adjacent higher layer. Higher layer functions are not necessary to support the OAM of the lower layer.

The functions of the layers above the ATM Layer are not considered in this Recommendation.

4 Mechanisms to provide OAM flows

4.1 Physical Layer mechanisms

The physical layer contains the three lowest OAM levels as outlined in Figure 2. The allocation of the OAM flows is as follows:

- Fl: regenerator section level;
- F2: digital section level;
- F3: transmission path level.

The mechanisms to provide OAM functions and to generate OAM flows Fl, F2 and F3 will depend on the format of the transmission system as well as on the supervision functions contained in B-NT1 and B-NT2 for the section crossing the T_B reference point. Three types of transmission can be foreseen for the customer access.

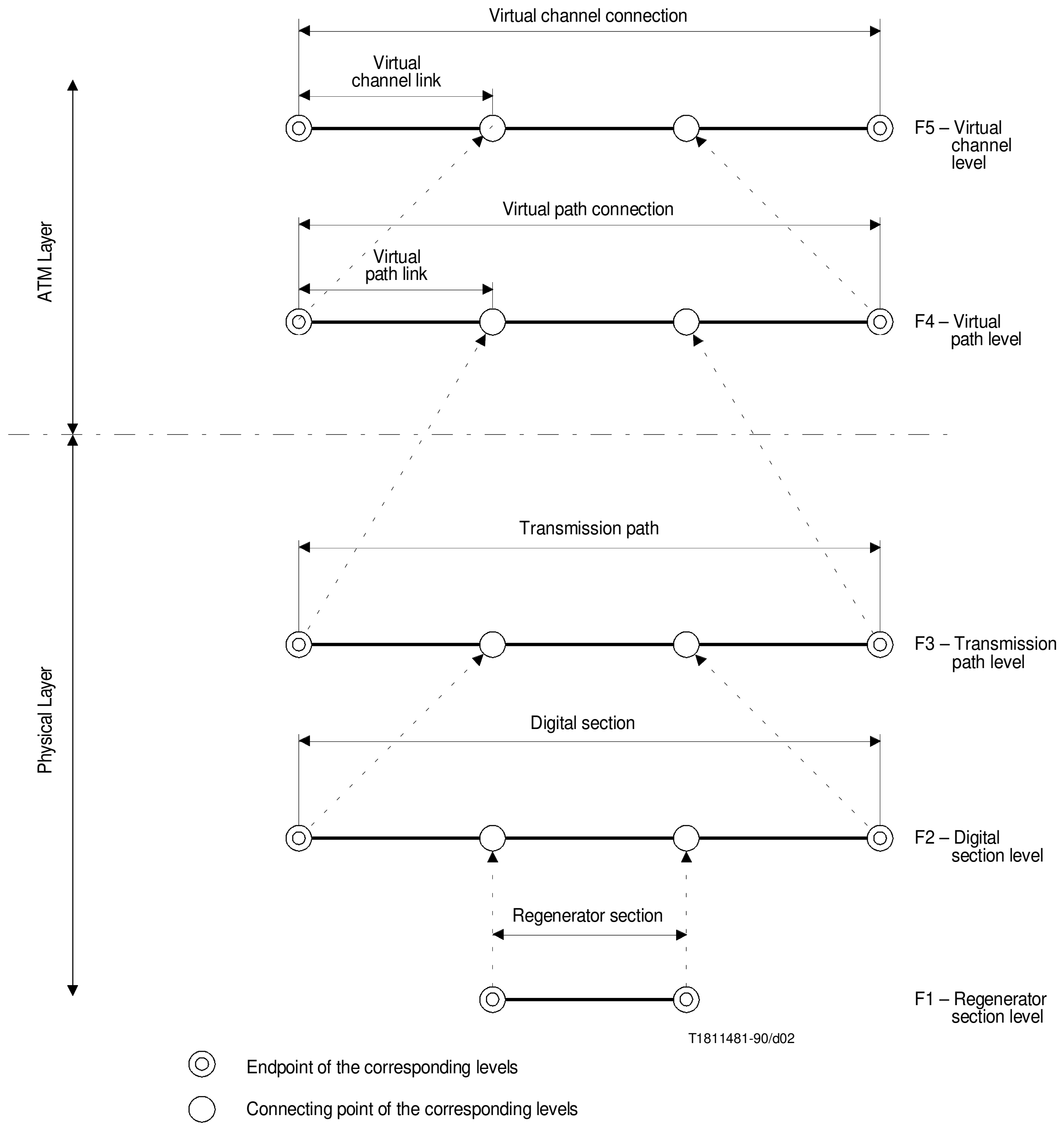


FIGURE 2/I.610

OAM hierarchical levels and their relationship with the ATM Layer and Physical Layer

4.1.1 SDH-based transmission systems (Recommendations G.707 to 709)

Flows Fl and F2 are carried on bytes in the section overhead (SOH), flow F3 is carried in the path overhead (POH) of the transmission frame.

4.1.2 Cell-based transmission systems

Such transmission systems may use an interface structure as specified in 4.2/I.432. OAM flows Fl and F3 are carried through maintenance cells for the Physical Layer using a specific pattern in the header for Fl and F3. F2 flows are not provided, but the associated functions are supported by F3 flows. These cells are not passed to the ATM layer. The occurrence of a PLOAM cell is determined by the requirements of the supported OAM functions. For each type (Fl and F3) of PL-OAM cell, maximum spacing is applied. If maximum spacing is exceeded, loss of OAM flow (LOM) will occur.

When TP-FERF is sent, the cause of this failure (LOC, LOM, AIS) is indicated in the layer management message.

4.1.3 PDH-based transmission systems (Recommendations G.702 and G.703)

These systems may only be used on the network side of the B-NT1. Specific means to monitor the section performance (e.g., violation code counting CRC, etc.) are specified for these systems. The capability to carry OAM information other than bit-oriented messages is very limited.

4.2 ATM layer mechanism

The ATM layer contains the two highest OAM levels as outlined in Figure 2. The allocation of the OAM flows is as follows:

- F4: virtual path level;
- F5: virtual channel level.

These OAM flows are provided by cells dedicated to ATM layer OAM functions for both virtual channel connections (VCC) and virtual path connections (VPC). In addition, such cells are usable for communication within the same layers of the management plane.

4.2.1 F4 flow mechanism

The F4 flow is bidirectional. OAM cells for the F4 flow have the same VPI value as the user cells of the VPC and are identified by one or more preassigned VCI values. The same pre-assigned VCI value shall be used for both directions of the F4 flow. The OAM cells for both directions of the F4 flow must follow the same physical route so that any connecting points supporting that connection can correlate the fault and performance information from both directions.

There are two kinds of F4 flows, which can simultaneously exist in a VPC. These are:

- *End-to-end F4 flow* – This flow, identified by a standardized VCI (see Recommendation I.361), is used for end-to-end VPC operations communications.
- *Segment F4 flow* – This flow, identified by a standardized VCI (see Recommendation I.361), is used for communicating operations information within the bounds of one VPC link or multiple inter-connected VPC links, where all of the links are under the control of one Administration or organisation. Such a concatenation of VPC links is called a VPC Segment. A VPC Segment can be extended beyond the control of one Administration by mutual agreement.

F4 flows must be terminated only at the end-points of a VPC or at the connecting points terminating a VPC Segment. Intermediate points (i.e. connecting points) along the VPC or along the VPC Segment may monitor OAM cells passing through them and insert new OAM cells, but they cannot terminate the OAM flow. The F4 flow will be initiated at or after connection set-up.

The Administration/ organisation that controls the insertion of OAM cells for operations and maintenance of a VPC Segment must ensure that such OAM cells are extracted before they leave the span of control of that Administration/organisation.

4.2.2 F5 flow mechanism

The F5 flow is bidirectional. OAM cells for the F5 flow have the same VCI/VPI values as the user cells of the VCC and are identified by the payload type identifier (PTI). The same PTI value shall be used for both directions of the F5 flow. The OAM cells for both directions of the F5 flow must follow the same physical route so that any connecting points supporting that connection can correlate the fault and performance information from both directions.

There are two kinds of F5 flows, which can simultaneously exist in a VCC. These are:

– *End-to-end F5 flow* – This flow, identified by a standardized PTI (see Recommendation I.361), is used for end-to-end VCC operations communications.

– *Segment F5 flow* – This flow, identified by a standardized PTI (see Recommendation I.361), is used for communicating operations information within the bounds of one VCC link or multiple inter-connected VCC links, where all of the links being are under the control of one Administration or organisation. Such a concatenation of VCC links is called a VCC Segment. A VCC Segment can be extended beyond the control of one Administration by mutual agreement.

F5 flows must be terminated only at the end-points of a VCC or at the connecting points terminating a VCC Segment. Intermediate points (i.e. connecting points) along the VCC or along the VCC Segment may monitor OAM cells passing through them and insert new OAM cells, but they cannot terminate the OAM flow. The F5 flow will be initiated at or after connection set-up.

The Administration/ organisation that controls the insertion of OAM cells for operations and maintenance of a VCC Segment must ensure that Such OAM cells are extracted before they leave the span of control of that Administration/organisation.

4.3 Association of the OAM mechanisms with the transport functions

Figure 3 gives an example of a virtual channel connection supported by all lower network levels according to the techniques described in 2/I.311. The associated OAM mechanisms for each level are also shown. The digital section and the regenerator section levels are shown combined under the term “section”.

5 OAM functions of the Physical Layer

5.1 OAM flows in some physical configurations

Figure 4 illustrates examples of the OAM flows in some physical configurations for B-ISDN customer access.

5.2 OAM Functions

Two types of OAM functions are distinguished:

1) OAM functions supported solely by the flows Fl, F2, and F3:

   – dedicated to detection and indication of unavailability state;

   – requiring “real time”, failure information transport towards the affected end points for system protection.

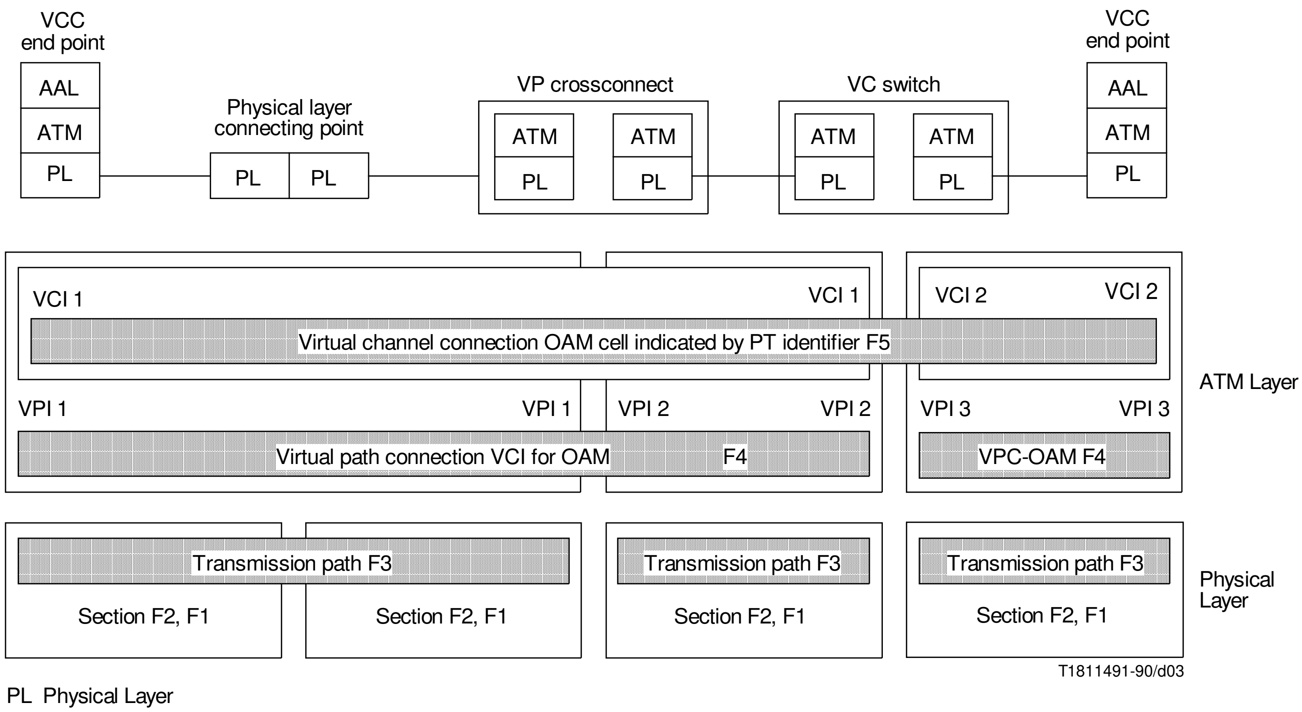


FIGURE 3/I.610

Example of mechanisms for OAM flows

2) OAM functions with regard to the system management:

– dedicated to performance monitoring and reporting, or for localization of failed equipment;

– may be supported by the flows Fl to F3 or by other means, e.g., TMN via the Q-interfaces.

5.2.1 OAM functions supported solely by the Flows Fl to F3

Table 1 gives an overview of the OAM functions and the related OAM flows. It also lists the different failures to be detected together with the failure indications for the SDH based Physical Layer, and Table 2 illustrates the same aspects for the cell based Physical Layer.

Tables 1 and 2 cover failures occurring on the B-NT2 <–> B-NT1 section and on the B-NT2 <–> transmission path termination. The B-NT1 <–> LT section has to provide some capability to report failures from the T reference point to the relevant Q-interface.

5.2.2 OAM Functions with regard to the System Management

For the SDH based option, examples of these functions are:

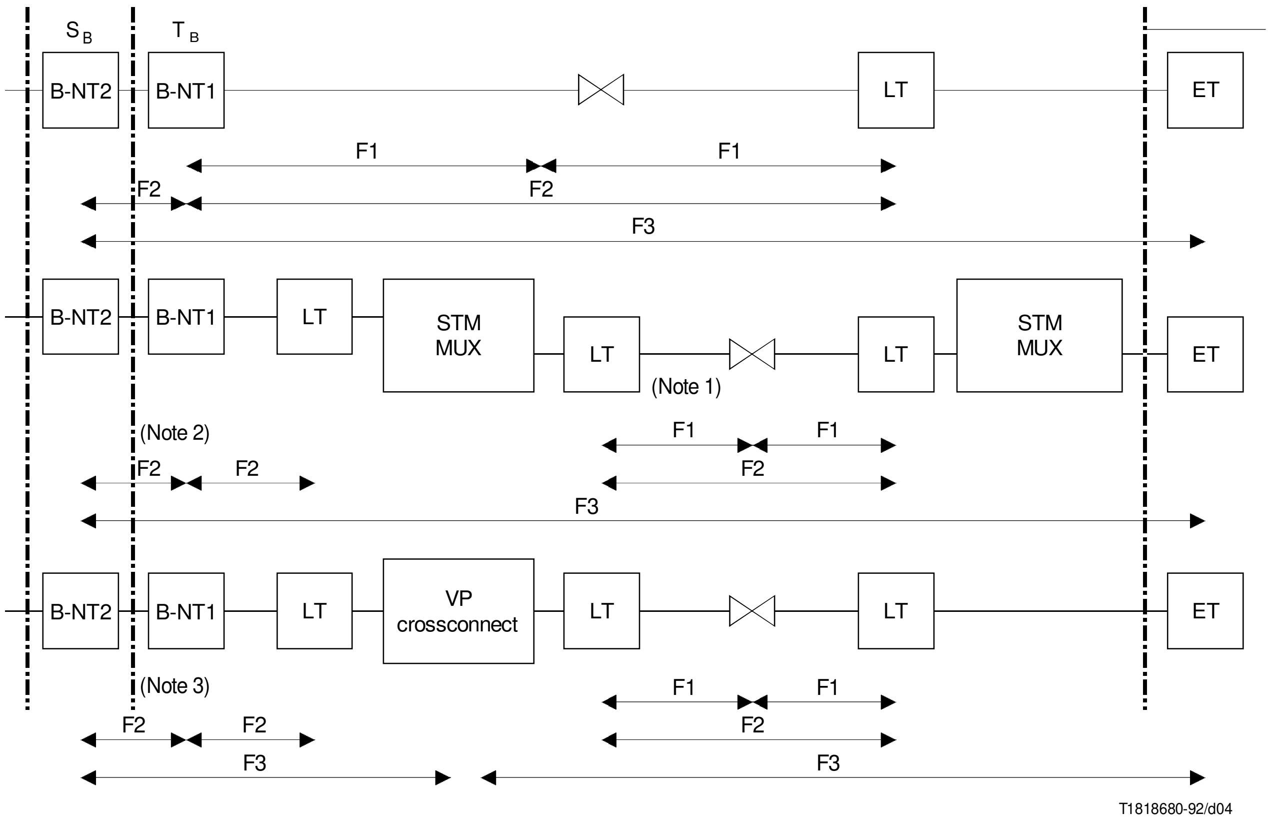
– section error monitoring at the regenerator section level, allowing the detection of a degraded error performance (optional);

– section error monitoring at the digital section level, allowing the detection of a degraded error performance;

– section error reporting at the digital section level, allowing the detection of a degraded error performance;

– path error monitoring at the transmission path level, allowing the detection of a degraded error performance;

– path error reporting at the transmission path level, allowing the detection of a degraded error performance.



ET Exchange termination
LT Line termination
STM Synchronous transfer mode

NOTES

1 Depending on the transmission system used (e.g. G.702, SDH, etc.) and its funcional implementation (e.g. LT integrated in STM MUX) the related OAM flows may be implemented but not shown.

2 In case of cell-based transmission systems, F2 functions are supported by F3 flow.

3 In case of cell-based transmission system a F1 flow is provided.

FIGURE 4/I.610

Examples of physical configurations and OAM flows at the Physical Layer

TABLE 1/I.610

OAM functions of the SDH-based Physical Layer
(Failures occurring on the B-NT2 <–> B-NT1 section)

Level	Function	Failure detection	System protection and failure information transmitted in the flow		
			F2 on the B-NT2 <–> B-NT1 section	B-NT1 <–> LT section (Note 2)	F3 on the B-NT2 <–> transmission path termination
Regenerator section	Signal detection frame alignment	Loss of Signal or Loss of Frame into B-NT1 (from B-NT2)	MS-FERF towards the B-NT2 (Note 3)	(Note 1)	Path-AIS towards the transmission path termination (generated by the B-NT1)
		Loss of Signal or Loss of Frame into B-NT2 (from B-NT1)	MS-FERF towards the B-NT1 (Note 3)		Path-FERF towards the transmission path termination (generated by the B-NT2)
Digital section	Section error monitoring (B2)	Unacceptable error performance into B-NT1	MS-FERF towards the B-NT2 (Notes 3,4)	(Note 1)	Path-AIS towards the transmission path termination (generated by the B-NT1) (Note 4)
		Unacceptable error performance into B-NT2	MS-FERF towards the B-NT1 (Notes 3,4)		–
Transmission path	Cell rate decoupling	Failure of insertion/ suppression of idle cells in B-NT2	–	(Note 1)	For further study
	Cell delineation	Loss of Cell Sync into B-NT2	–		Path-FERF
	CN status monitoring	CN not available	–		Path-AIS
	AU Pointer operation	Loss of AU pointer or Path-AIS into B-NT2	–		Path-FERF towards the transmission path termination

NOTES

1 Capabilities for reporting faults from the T_B reference point to the relevant Q-interface must be accommodated by the transmission equipment specification.

2 In accordance with the OAM Recommendation of the transmission system.

3 In conformance with the SDH Recommendations the term MS (Multiplex Section) is used.

4 Can be disabled (see Recommendation G.783).

TABLE 2/I.610

OAM functions of the cell-based Physical Layer
(Failures occurring on the B-NT2 <–> B-NT1 section)

Level	Function	Failure detection	System protection and failure information transmitted in the flow		
			F1 on the B-NT2 <–> B-NT1 section	B-NT1 <–> LT section (Note 2)	F3 on the B-NT2 <–> Transmission path termination
Regenerator section	Signal detection PL-OAM cell recognition	Loss of Signal or Loss of F1 PL-OAM cell recognition into B-NT1 (from B-NT2)	Section-FERF towards the B-NT2	(Note 1)	Path-AIS towards the transmission path termination (generated by the B-NT1) (Note 3)
		Loss of Signal or Loss of F1 PL-OAM cell recognition into B-NT1 (from B-NT2)	Section-FERF towards the B-NT1		Path-FERF towards the transmission path termination (generated by the B-NT2)
	Section error monitoring	Unacceptable error performance into B-NT1	Section-FERF towards the B-NT2		Path-AIS towards the transmission path termination (generated by the B-NT1)
		Unacceptable error performance into B-NT2	Section-FERF towards the B-NT1		–
Transmission path	Cell rate decoupling	Failure of insertion/ suppression of idle cells in B-NT2	–	(Note 1)	For further study
	PL-OAM cell recognition	Loss of F3 PL-OAM cell recognition into B-NT2	–		Path-FERF
	Cell delineation	Loss of Cell Sync into B-NT2	–		Path-FERF
	CN status monitoring	CN not available	–		Path-AIS

NOTES

1 Capabilities for reporting faults from the T_B reference point to the relevant Q-interface must be accommodated by the transmission equipment specification.

2 In accordance with the OAM Recommendation of the transmission system.

3 The B-NT1 as a connecting point can insert a Path-AIS at the F3 level.

For the cell based option, examples of these functions are:

- section error monitoring at the regenerator section level, allowing the detection of a degraded error performance;
- section error reporting at the regenerator section level, allowing the detection of a degraded error performance;
- path error monitoring at the transmission path level, allowing the detection of a degraded error performance;
- path error reporting at the transmission path level, allowing the detection of a degraded error performance.

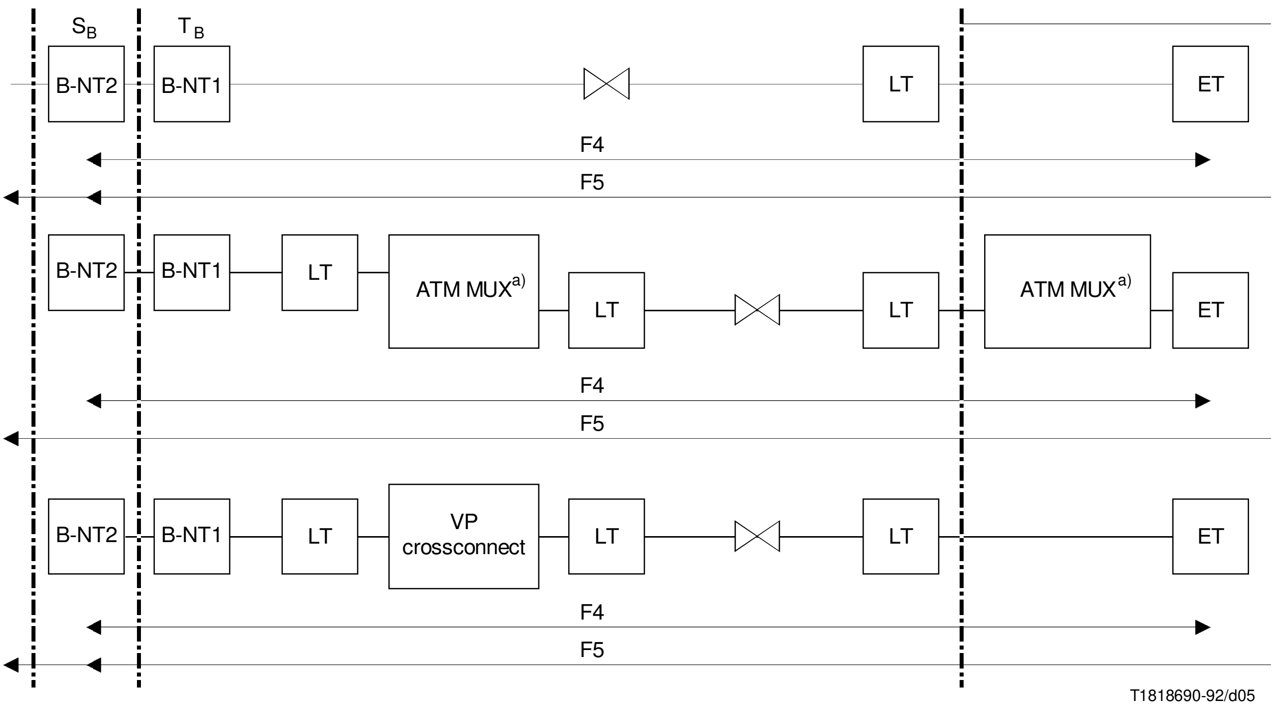
For both options, examples of these functions are:

- uncorrectable headers count;
- header error performance monitoring (degraded or not).

6 OAM functions of the ATM Layer

6.1 OAM flows in some physical configurations

Figure 5 illustrates the implementation of the above-mentioned OAM flows in some physical configurations for B-ISDN customer access. The arrow heads show possible flow termination points. Double arrow heads indicate the existence of alternatives.



a) ATM MUX without VP termination.

FIGURE 5/I.610

Examples of physical configurations and OAM flows at the ATM Layer

6.2 OAM functions

Table 3 gives an overview of the OAM functions and the related OAM flows. Additional functions for testing, fault localization and performance measurement are for further study. The ATM Layer loopback capability, described in the Appendix I, is an example of one such technique to provide those functions under consideration.

6.2.1 OAM functions for VPC (F4 flow)

This subclause addresses VP-level Fault Management and Performance Management functions.

6.2.1.1 Virtual Path Fault Management Functions

The following Fault Management functions shall be used:

TABLE 3/I.610

OAM functions of the ATM Layer

Level	Function	Flow	Defect/failure detection	System protection and failure information
Virtual path	Monitoring of path availability	F4	Path not available	For further study
	Performance monitoring		Degraded performance	
Virtual channel	Monitoring of channel availability	F5	Channel not available	For further study
	Performance monitoring		Degraded performance	

6.2.1.1.1 VP-AIS and VP-FERF Alarms

VP-AIS and VP-FERF alarms shall be used for identifying and reporting VPC failures.

6.2.1.1.1.1 VP-AIS

VP-AIS cells shall be generated and sent downstream to all affected active VPCs from the VPC connecting point (e.g. ATM cross-connect) which detects the VPC failure. VP-AIS will result from failure indications from the Physical Layer as shown in Table 1 and Table 2. Generation of VP-AIS due to failures detected at VP level are for further study as indicated in Table 3.

VP-AIS Cell Generation Condition – VP-AIS cells are generated and transmitted as soon as possible after failure indication, and transmitted periodically during the failure condition in order to indicate VPC unavailability. The Generation frequency of VP-AIS cells is nominally one cell per second and shall be the same for each VPC concerned.

VP-AIS cell generation shall be stopped as soon as the failure indications are removed.

VP-AIS Cell Detection condition – VP-AIS cells are detected at the VPC end-point and VP-AIS status is declared after the reception of one VP-AIS cell. VPC connecting points may monitor the VP-AIS cells.

VP-AIS Release condition – The VP-AIS state is removed under either of the following conditions:

- absence of VP-AIS cell for nominally 3 seconds;
- receipt of one valid cell (user cell or continuity check cell).

6.2.1.1.1.2 VP-FERF

VP-FERF is sent to the far-end from a VPC end-point as soon as it has declared a VP-AIS state or detected VPC failure.

VP-FERF Cell Generation Condition – VP-FERF cells are generated and transmitted periodically during the failure condition in order to indicate VPC unavailability. Generation frequency of VP-FERF cells is nominally one cell per second and shall be the same for all VPCs concerned.

VP-FERF cell generation shall be stopped as soon as the failure indications are removed.

VP-FERF Cell Detection Condition – VP-FERF cells are detected at the VPC end point and VP-FERF state is declared after the reception of one VP-FERF cell. VPC connecting points may monitor the VP-FERF cells.

VP-FERF Release condition – The VP-FERF state is removed when no VP-FERF cell is received during a nominally 3 second period.

6.2.1.1.2 VPC continuity check

The continuity check cell is sent downstream by a VPC end-point when no user cell has been sent for a period of t, where $Ts < t < 2Ts$ and no VPC failure is indicated. If the VPC end-point does not receive any cell within a time interval Tr ($Tr > 2Ts$), it will send VP-FERF to the far-end. Further details of this procedure (e.g. activation/deactivation, Ts, and Tr) are for further study.

This mechanism can also be applied to test continuity across a VPC Segment. The need for supporting this mechanism for all VPCs simultaneously is for further study.

6.2.1.2 VP Performance Management Functions

Performance monitoring of a VPC or VPC Segment is performed by inserting monitoring cells at the ends of the VPC or VPC Segment, respectively. In the procedure supporting this function, forward error detection information (e.g. the error detection code) is communicated by the end points using the forward (outgoing) F4 flow. The performance monitoring results, on the other hand, are received on the reverse (incoming) F4 flow. Note that when monitoring VPCs that are entirely within one span of control or when monitoring VPC Segments, the monitoring result may be reported using the reverse F4 flow or via some other means (e.g. TMN).

Performance monitoring shall be done by monitoring blocks of user cells.

A performance monitoring cell insertion request is initiated after every N user cells. The monitoring cell is inserted at the first free cell location after the request.

The block size N may have the values 128, 256, 512, and 1024. These are nominal block size values, and the actual size of the monitored cell block may vary. The cell block size may vary up to a maximum margin of 50% of the value of N for end-to-end performance monitoring. However, for end-to-end performance monitoring, the monitoring cell must be inserted into the user cell stream no more than N/2 user cells after an insertion request has been initiated. The actual monitoring block size averages out to approximately N cells.

To eliminate forced insertions when monitoring VPC Segment performance, the actual monitoring block size may be extended until a free cell is available after the insertion request. However, in this case, the actual monitoring block size may not average out to N cells. Forced insertion at the segment level remains as an option.

The monitoring cell will detect:

- errored blocks;
- loss/mis-insertion of cells within a monitored block of cells;
- other functions (e.g. cell transfer delay) are for further study.

Performance monitoring can be simultaneously carried out on a certain number of selected VPCs per interface (UNI, NNI). The value of this number requires further considerations.

Performance monitoring can be activated either during connection establishment or at any time after the connection has been established. Such activation (and associated deactivation) is initiated by the TMN or by the end user. After the TMN or the end user has requested activation/deactivation of VPC performance monitoring, a "handshaking" procedure is needed between the two end-points of the connection (or connection segment) to properly initialize the process. This "handshaking" procedure is performed using Performance management OAM cells and is illustrated in Figures 6 and 7 for activation and deactivation, respectively. However, activation and deactivation of VPC Segment Performance Monitoring may also be done entirely via TMN.

Note that the performance monitoring- activation/deactivation "handshaking" procedure serves the following purposes:

- To coordinate the beginning or end of the transmission and downstream reception of OAM cells used to monitor VPC performance;
- To establish agreement on the Block Size and the direction of transmission to start or stop monitoring.

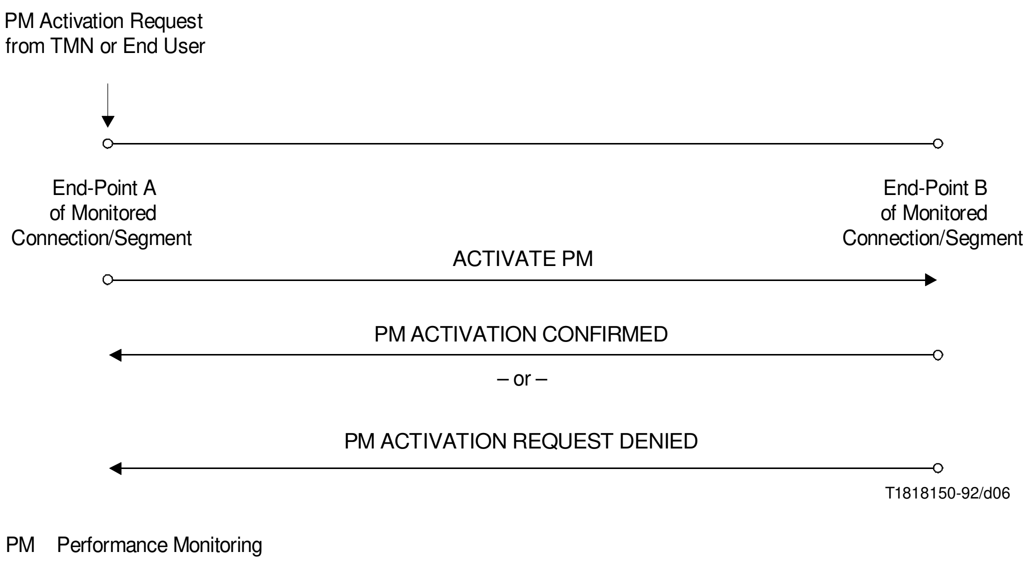


FIGURE 6/I.610

Handshaking Procedure for PM Activation

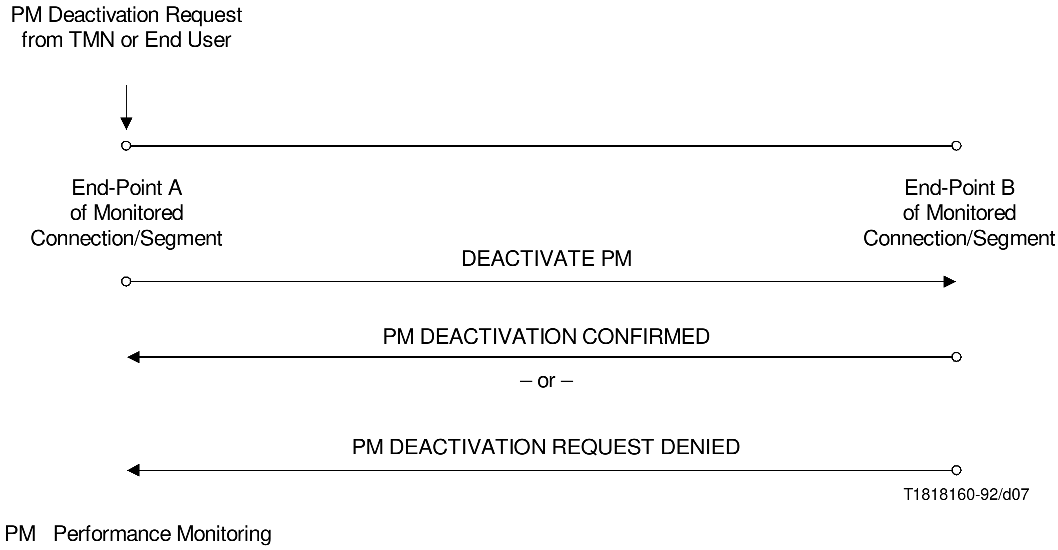


FIGURE 7/I.610

Handshaking Procedure for PM Deactivation

When allocating bandwidth to a connection, it is necessary to allocate sufficient bandwidth for the OAM cells in that connection. There may be potential interference between Performance Monitoring and UPC/NPC actions. This requires further study.

6.2.2 OAM functions for the VCC (F5 flow)

This subclause addresses VC-level Fault Management and Performance Management functions.

6.2.2.1 Virtual Channel Fault Management Functions

The following fault management functions shall be used.

6.2.2.1.1 VC-AIS and VC-FERF Alarms

VC-AIS and VC-FERF alarms shall be used for identifying and reporting VCC failures.

6.2.2.1.1.1 VC-AIS

VC-AIS cells shall be generated and sent downstream to selected (see Note) VCCs from the VCC connecting point (e.g. ATM switch) which detects the VCC failure. VC-AIS will result from failure indications from the VP Level or the Physical Layer. Generation of VC-AIS due to failures detected at VC level are FFS.

NOTE – To reduce implementation complexity, the number of VCCs per interface (UNI, NNI) that provide VCC alarm surveillance will be limited. The actual limit, however, is beyond the scope of standards.

VC-AIS Cell Generation Condition – VC-AIS cells are generated and transmitted as soon as possible after failure indication, and transmitted periodically during the failure condition in order to indicate VCC unavailability. The Generation frequency of VC-AIS cells is nominally one cell per second and shall be the same for each VCC concerned.

VC-AIS cell generation shall be stopped as soon as the failure indications are removed.

VC-AIS Cell Detection condition – VC-AIS cells are detected at the VCC end-point and VC-AIS status is declared after the reception of one VC-AIS cell. VCC connecting points may monitor the VC-AIS cells.

VC-AIS Release condition – The VC-AIS state is removed under either of the following conditions:

- absence of VC-AIS cell for nominally 3 seconds;
- receipt of one valid cell (user cell or Continuity Check cell).

6.2.2.1.1.2 VC-FERF

VC-FERF is sent to the far-end from a VCC end-point as soon as it has declared a VC-AIS state or detected VCC failure.

VC-FERF Cell Generation Condition – VC-FERF cells are generated and transmitted periodically during the failure condition in order to indicate VCC unavailability. Generation frequency of VC-FERF cells is nominally one cell per second and shall be the same for all VCCs concerned.

VC-FERF cell generation shall be stopped as soon as the failure indications are removed.

VC-FERF Cell Detection Condition – VC-FERF cells are detected at the VCC end-point and VC-FERF state is declared after the reception of one VC-FERF cell. VCC connecting points may monitor the VC-FERF cells.

VC-FERF Release condition – The VC-FERF state is removed when no VC-FERF cell is received during a nominally 3 second period.

6.2.2.1.2 VCC continuity check

The continuity check cell is sent downstream by a VCC end point when no user cell has been sent for a period of *t*, where Ts < *t* < 2Ts and no VCC failure is indicated. If the VCC end-point does not receive any cell within a time interval Tr (Tr > 2Ts), it will send VC-FERF to the far-end. Further details of this procedure (e.g. activation/deactivation, Ts, and Tr) are for further study.

This mechanism can also be applied to test continuity across a VCC Segment. The need for supporting this mechanism for all VCCs simultaneously is for further study.

6.2.2.2 VC Performance Management Functions

Performance monitoring of a VCC or VCC Segment is performed by inserting monitoring cells at the ends of the VCC or VCC Segment, respectively. In the procedure supporting this function, forward error detection information (e.g. the error detection code) is communicated by the end-points using the forward (outgoing) F5 flow. The performance monitoring results, on the other hand, are received on the reverse (incoming) F5 flow. Note that when monitoring VCCs that are entirely within one span of control or when monitoring VCC Segments, the monitoring result may be reported using the reverse F5 flow or via some other means (e.g. TMN).

Performance monitoring shall be done by monitoring blocks of user cells.

A performance monitoring cell insertion request is initiated after every N user cells. The monitoring cell is inserted at the first free cell location after the request.

The block size N may have the values 128, 256**,** 512, and 1024. These are nominal block size values, and the actual size of the monitored cell block may vary. The cell block size may vary up to a maximum margin of 50% of the value of N for end-to-end performance monitoring. However, for end-to-end performance monitoring, the monitoring cell must be inserted into the user cell stream no more than N/2 user cells after an insertion request has been initiated. The actual monitoring block size averages out the approximately N cells.

To eliminate forced insertions when monitoring VCC Segment performance, the actual monitoring block size may be extended until a free cell is available after the insertion request. However, in this case, the actual monitoring block size may not average out to N cells. Forced insertion at the segment level remains an option.

The monitoring cell will detect

- errored blocks;
- loss/mis-insertion of cells within a monitored block of cells;
- other functions (e.g. cell transfer delay) are for further study.

Performance monitoring can be simultaneously carried out on a certain number of selected VCCs per interface. The value of this number requires further study.

Performance monitoring can be activated either during connection establishment or at any time after the connection has been established. Such activation (and associated deactivation) is initiated by the TMN. After the TMN has requested activation/deactivation of VCC performance monitoring, a "handshaking" procedure is needed between the two end-points of the connection (or connection segment) to properly initialize the process. This "handshaking" procedure is performed using Performance management OAM cells and is illustrated in Figures 6 and 7 for activation and deactivation, respectively. However, activation and deactivation of VCC Segment Performance Monitoring may also be done entirely via TMN.

When allocating bandwidth to a connection, it is necessary to allocate sufficient bandwidth for the OAM cells in that connection. There may be potential interference between Performance Monitoring and UPC/NPC actions. This requires further study.

7 ATM Layer OAM Cell Format

The ATM Layer OAM cells contain fields common to all types of OAM cells (see Table 4) as well as specific fields for each type of OAM cell. The coding principles for unused common and specific fields are:

- Unused OAM cell information field octets are coded 0110 1010 (6AH)
- Unused OAM cell information field bits (incomplete octets) are coded all zero.

TABLE 4/I.610

OAM Type Identifiers

OAM Type	4bit	Function Type	4bit
Fault Management	0001	AIS	0000
	0001	FERF	0001
	0001	Continuity Check	0100
Performance Management	0010	Forward Monitoring	0000
	0010	Backward Reporting	0001
	0010	Monitoring/Reporting	0010
Activation/Deactivation	1000	Performance Monitoring	0000
		Continuity Check	0001

7.1 Common OAM Cell Fields

All ATM Layer OAM cells will have the following common fields (see Figure 8):

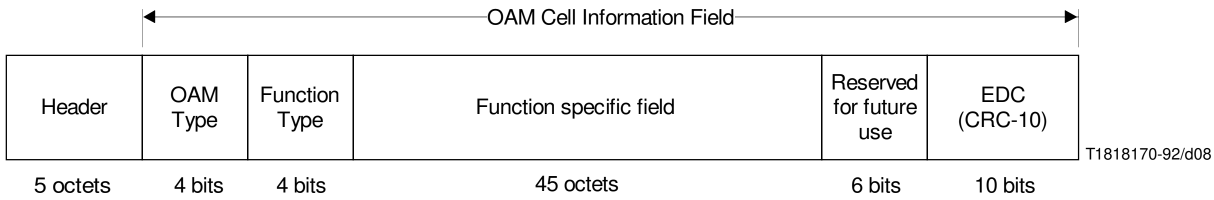


FIGURE 8/I.610

Commom OAM Cell Format

1) *Header* – Details of this field are in Recommendation I.361. For F4 flow identification, two pre-assigned VCIs are used to distinguish OAM cells for VPCs and VPC segments. These two values are defined in Recommendation I.361. For F5 flow identification, two PTI values are used to distinguish OAM cells for VCCs and VCC segments. These two values are defined in Recommendation I.361.

2) *OAM Cell Type (4 bits)* – This field indicates the type of management function performed by this cell, e.g. fault management, performance management, and activation/deactivation.

3) *Reserved field for future use (6 bits)* – Default value coded all zero.

4) *OAM Function Type (4 bits)* – This field indicates the actual function performed by this cell within the management type indicated by the OAM Cell Type field.

5) *Error Detection Code (10 bits)* – This field carries a CRC-10 error detection code computed over the information field of the OAM cell. The CRC-10 generating polynomial is:

$$G(x) = 1 + x + x^4 + x^5 + x^9 + x^{10}$$

7.2 Specific Fields for Fault Management Cell

The Function Type field for Fault Management applications will be used to identify the following possible functions: AIS, FERF, and continuity check. Further specifications of cells carrying these functions are provided in the subclauses that follow.

7.2.1 AIS Fault Management Cell

The AIS Fault management cell will have the following fields:

1) *Failure Type (8 bits)* – As an option, this field may be used to indicate the nature of the reported failure (e.g. a Physical Layer failure or an ATM Layer failure). The default value for this field shall be 6AH. Details are for further study.

2) *Failure Location (x bits)* – As an option, this field may be used to carry information about the failure location. The default value f or this field shall be 6AH. Details are for further study.

7.2.2 FERF Fault Management Cell

The FERF Fault Management cell (see Figure 9)will have the following fields:

1) *Failure Type (8 bits)* – As an option, this field may be used to indicate the nature of the reported failure. The default value for this field shall be 6AH. Details are for further study.

2) *Failure Location (x bits)* – As an option, this field may be used to carry information about the failure location. The default value for this field shall be 6AH. Details are for further study.

Failure type (Optional)	Failure location (Optional)	Unused octets (6AH)
1 octet	For further study (octets)	

FIGURE 9/I.610

Specific Fields for AIS/FERF Fault Management Cell

7.2.3 Continuity Check Fault Management Cell

There are currently no fields that are specific to the Continuity Check function, and hence it is coded 6AH.

7.3 Specific Fields for Performance Management Cell (see Figure 10)

The Function Type field for Performance Management applications will be used to identify the following possible functions: Forward Monitoring, Backward Reporting, and Monitoring/Reporting.

The Performance Management Cell will have the following specific fields:

MCSN	TUC	BIP-16	TS (Optional)	Unused (6AH) (Note)	Block error result	Los/Misinserted cell count
8 bits	16 bits	16 bits	32 bits		8 bits	16 bits

NOTE – Possible future use of this field includes

- Forward monitoring: cell count for CLP = 0 cells
- Backward report: CRC-10 violation, lost monitoring cell count.

FIGURE 10/I.610

Specific Fields for Performance Management Cell

1) *Monitoring Cell Sequence Number (MCSN) (8 bits)* – This field indicates the sequence number of the monitoring, reporting, and monitoring/reporting OAM cells modulo 256.

2) *Total User Cell Number (TUC) (16 bits)* – This field indicates the total number of transmitted user cells, modulo 65 536 before the monitoring cell is inserted.

3) *Block Error Detection Code (16 bits)* – This field carries the even parity BIP-16 (see Note) error detection code computed over the information field of the block of user cells transmitted after the last monitoring cell.

NOTE – Bit lnterleaved Parity-X (BIP-X) code is defined as a method of error monitoring. With even parity an X bit code is generated by the transmitting equipment over a specific portion of the signal in such a manner that the first bit of the code provides even parity over the first bit of all X-bit sequences in the covered portion of the signal, the second bit provides even parity over the second bit of all X-bit sequences within the specific portion, etc. Even parity is generated by setting the BIP-X bits so that there is an even number of ls in each of all monitored partitions of the signal including the BIP-X (a monitor partition of the signal is built by all bits which are in the same bit position within the X-bit sequences in the covered portion of the signal).

4) *Time Stamp (32 bits)* – As an option this field may be used to represent the time at which the OAM cell was inserted. Default value for this field shall be all ones.

5) *Block Error Result (8 bits)* – This field carries the number of errorred parity bits in the BIP-16 code of the incoming monitoring cell. This field will be used for backward reporting.

6) *Lost/Mis-inserted Cell Count (16 bits)* – This field carries the count of lost or mis-inserted cells computed over the incoming monitored block. This field will be used for backward reporting.

7.4 **Specific Fields for Activation/Deactivation Cell** (see Figure 11)

The Function Type field for Activation/Deactivation applications will be used to identify the following possible function:

– PM Activation/Deactivation; and

– Continuity Check Activation/Deactivation.

The Activation/Deactivation cell will have the following specific fields:

1) *Message ID (6 bits)* – This field indicates the message ID for activating or deactivating specific VPC/VCC OAM functions. Code values for this field are shown in Table 5.

TABLE 5/I.610

Message ID Values

Message	Value
Activate	000001
Activation Confirmed	000010
Activation Request Denied	000011
Deactivate	000101
Deactivation Confirmed	000110
Deactivation Request Denied	000111

2) *Correlation Tag (8 bits)* – A correlation tag is generated for each message so nodes can correlate commands with responses.

3) *Direction(s) of Action (2 bits)* – This field identifies the direction(s) of transmission to activate/deactivate OAM function. The A-B and B-A notation is used to differentiate between the direction of transmission away or towards the activator/deactivator, respectively. This field value is used as a parameter for the ACTIVATE and DEACTIVATE messages. This field shall be encoded as 01 for B-A, 10 for A-B, 11 for two-way action, and 00 (default value) when not applicable.

4) *PM Block Size(s) A-B (4 bits)* – This field specifies the A-B PM block size or block size choices supplied by the activator for Performance Monitoring function. Each of the four bit positions in this field, from the most significant bit to the least significant bit, if set, indicates block sizes of 128, 256, 512, or 1024, respectively. For example, a value of 1010 would mean that block size 128 or 512 may be used, but 256 and 1024 can not. This field value is used as a parameter for the ACTIVATE and ACTIVATION CONFIRMED messages. The default value for this field shall be 0000.

5) *PM Block Size(s) B-A (4 bits)* – This field specifies the B-A block size or block size choices supplied by the activator for Performance Monitoring function. It is encoded and used in the same manner as the Block Size(s) A-B field.

Message ID	Directions of Action	Correlation Tag	PM Block Sizes A-B	PM Block Sizes B-A	Unused octets (6AH)
6 bits	2 bits	8 bits	4 bits	4 bits	336 bits

FIGURE 11/I.610

Specific Fields for Activation/deactivation Cell

Appendix I

ATM layer loopback capability

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

I.1 Introduction

This Recommendation specifies a number of OAM functions of the ATM Layer. However, additional ATM Layer OAM functions are currently under study. The OAM cell loopback capability, described in this appendix, is one such technique. Specifically, this appendix:

1) provides a general description of the ATM Layer loopback capability;

2) highlights some of its potential uses; and

3) describes the potential information fields in the OAM cell.

I.2 General Description

The ATM Layer loopback capability allows for operations information to be inserted at one location along a virtual (path/channel) connection and returned (or looped back*)* at a different location, without having to take the virtual connection out-of-service. This capability is performed by non-intrusively inserting a loopback OAM cell at an accessible point along the virtual connection (i.e. at a local end-point or intermediate point) with instructions in the OAM cell payload for the cell to be looped back at one or two other identifiable points. For illustrative purposes, four example scenarios have been identified in Figure I-1:

In the first scenario, an OAM cell is inserted and looped back within a single network. The second shows an end-to-end ATM Layer loopback that extends across an intermediate network. In the third scenario, an OAM cell is inserted at the edge of one network and looped back at one end of the virtual connection. In the fourth and final scenario, Network #2 performs an end-to-end loopback by inserting an OAM cell at an intermediate point with instructions for it to be looped back at both end-point locations (in series). Note that other scenarios exist that have not been explicitly shown in Figure 1.

I.3 Potential Uses

An ATM Layer loopback capability may prove to be a useful tool in performing the following functions:

- *Pre-service Connectivity Verification* – The last step prior to putting a permanent virtual circuit (PVC) in-service could be to verify its end-to-end connectivity. This could be performed by inserting an OAM cell that is to be looped back over the entire virtual circuit (round-trip) and verifying its return.

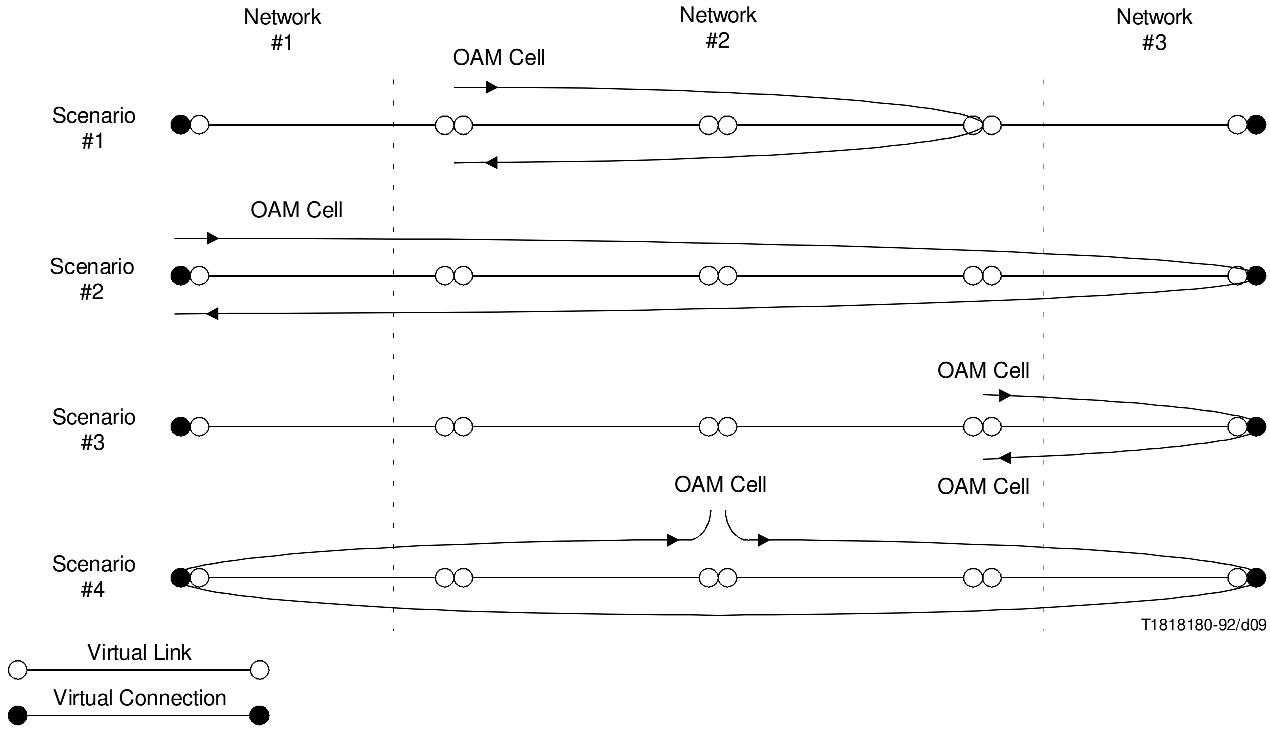


FIGURE I.1/I.610

Example Loopback Scenarios

- *VPC/VCC Fault Sectionalization* – Various levels of sectionalization may be performed using this ATM Layer loopback capability. First, by verifying end-to-end connectivity, reported troubles could be sectionalized between upper-layer troubles (e.g. at the service and adaptation levels) and lower layer troubles (e.g. at the connection and link levels). Second, a network may perform piecewise loopbacks to verify whether a reported trouble is their responsibility (i.e. within their jurisdiction) or the responsibility of another network provider. Third, a network provider can perform local piecewise loopbacks to isolate the faulty portion of a failed connection (i.e., down to an individual virtual link) routed through their network.

- *On-demand Delay Measurements* – A time-stamp or set of time-stamps may be encoded in such OAM cells to measure both round-trip and one-way (incoming or outgoing) cell transfer delay.

These are a few of the potential uses of the proposed ATM Layer loopback capability. Other uses for this tool will undoubtedly be defined in the future. The important advantage of the loopback approach is that it can be administered from a single node, while the connection is in-service.

I.4 Potential Information Fields

In general, ATM Layer loopbacks require

1) a means of identifying the desired loopback location;

2) a means by which a Network Element (NE) can correlate the transmitted OAM cell with the received OAM cell;

3) a way of identifying whether or not the OAM cell is to be looped back; and

4) a way of identifying the Administration which originated the loopback cell. These information fields are discussed below:

   – *Loopback Location ID Fields* – These fields identify one or two point(s) along the virtual connection where the loopback is to occur. In general, loopback locations include virtual link termination points as well as virtual connection termination points. Virtual connection end-points may use a default Loopback Location ID value (e.g. all ones).

   – *Correlation Tag Field* – At any given time, multiple loopback cells may be inserted in the same virtual connection. As a result, the ATM Layer loopback requires a means of correlating transmitted OAM cells with received OAM cells. This field provides this OAM cell correlation capability.

   – *Loopback Indication Field* – This field identifies, for the end-point receiving the OAM cell, whether the incoming OAM cell is to be looped back.

   – *Source Code Field* – This field identifies the network that inserted the loopback OAM cell.

   – *Time Stamp Fields* – These fields represent the times at which the OAM cell is transmitted from the loopback originating point, and the times at which the cell is received at, then transmitted from, the loopback point.

I.5 Example of a Simplified Loopback Capability

A simplified loopback capability can be defined to provide the following loopback functions:

– Loopback at connection end-points using end-to-end loopback OAM cells.

– Loopback across the UNI using connection segment OAM cells.

This simplified loopback capability may be used to verify connectivity across the UNI and the end-to-end connection. This simplified loopback capability needs only two specific fields, namely, the Loopback Indication and the Correlation Tag.