FAULT MANAGEMENT AND MEASURING METHODS IN ATM-NETWORKS

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Abstract – The most important of Network Management Architectures in ATM can brief definition of each element of Operations, Administration, Maintenance, and Provisioning (OAM&P)

OAM CELL FORMATS

Figure 4 shows the ATM OAM cell format : There are Virtual Path (VP) flows (F4) and Virtual Channel (VC) flows (F5) between connection endpoints that are defined as end – to – end OAM flows. There are also F4 and F5 OAM flows that occur across one or more interconnected VC or VP links that are called segment OAM Flows. VP flows (F4) utilize different VCI to identify whether the flow in either end – to end (VCI = 3) or segment (VCI = 4). Recall that the first 16 VCIs are reserved for future tandardization. For a VC flow (F5), a specific VCI cannot be used because all VCIs are available to users in the service. Therefore, the Payload Type (PT) differentiates between the end – to – end (PT=100) and Segment (PT=101) flows in a VCC.

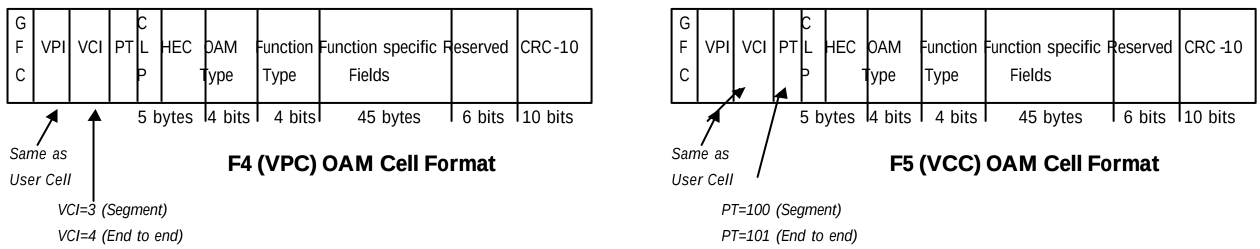


Figure 4 : ATM OAM Cell Types and Format

Table 1 summarizes the OAM type and function type fields in the OAM cells from Figure 4. The three OAM types are fault management, performance management, and activation / deactivation. Each OAM type has further function types with codepoints as identified in Table 1. For the fault management OAM type there are Alarm Indication Signal (AIS), Remote Defect Indication (RDI) (also called Far End Reporting Failure (FERF), and continuity check function types. For the performance management OAM type there are forward monitoring and backward reporting types, or a third type that is a combination of these two, called monitoring and reporting. The third OAM type defines activation and deactivation of the other OAM types. Currently, there are activation and deactivation function types for performance management and the continuity check.

OAM Type		**Function Type**	
Fault Management	0001	AIS	0000
	0001	RDI/FERF	0001
	0001	Continuity Check	0100
	0001	Loopback	1000
Performance management	0010	Forward Monitoring	0000
	0010	Backward Reporting	0001
	0010	Monitoring& Reporting	0010
Activation/Deactivation	1000	Performance Monitoring	0000
	1000	Continuity Check	0001

Table 1: OAM Types & OAM Function Types

Note that there are a significant number of unassigned codepoints in the OAM and function types. The definition of OAM cellformats, functions, and protocols is ongoing and evolving in standards and specification development . For this reason , the ATM Forum UNI specification recommends that these OAM functions be implemented in software.

FAULT MANAGEMENT

+ AIS and RDI/FERF Theory and Operation

Figure 5 illustrates the ATM OAM cell AIS and RDI/FERF function – specific fields. The meaning of each field is described below.

- **Failure Type** is an indication of what type of failure has occurred. Currently no specific values are standardized.

- **Failure Location** is an indication of where the failure occurred. Currently no specific values are standardized.

Failure Type *	Failure Location*	Unused
1 byte	9 bytes	35 bytes

* Default Coding = '6A' Hex for all octets

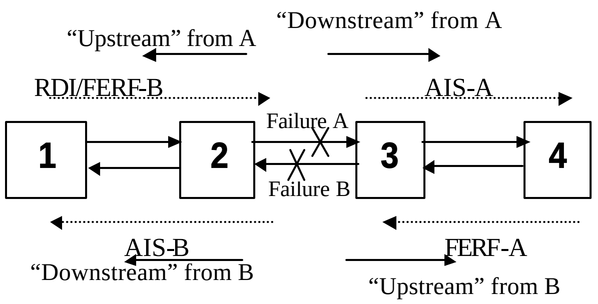
Figure 5 : Function – Specific Fields for AIS and RDI/FERF

Figure 6 illustrates the operation and theory of the Alarm indication Signal (AIS) and Far End Reporting Failure (FERF) {for equivalently Remote Defect Indication (RDI)} ATM OAM cell function types. We cover two examples, (a) where a failure occurs in both directions simultaneously, and (b) where a failure occurs in only one direction. In both examples there is a VP (or VC) connection between node 1 and node 4.

Part (a) illustrates the typical failure of both directions of the physical layer between nodes 2 and 3 that causes the underlying VPs and VCs to simultaneously fail. The failures in each direction are indicated as "Failure – A" and "Failure – B" in the figure so that the resulting AIS and RDI/FERF cells can be traced to the failure location. A node adjacent to the failure generates an AIS signal in the downstream direction to indicate that an upstream failure has occurred, as indicated in the figure. As can be seen from example (a), both ends of the connection (nodes 1 and 4) are aware of the failure because of AIS alarm that they receive. However, by convention, each generates a RDI/FERF signal.

Example (b) illustrates the purpose of the FERF (or RDI) signal. In most communications applications the connection should be considered failed, even if it fails in only one direction. This is especially true in data communication. Example (b) illustrates the case of a failure that affects only one direction of a full duplex connection between nodes 2 and 3. Node 3, which is downstream from the failure, generates an AIS alarm, which propagates to the connection end (node 4), which in turn generates the RDI/FERF signal. The RDI/FERF signal propagates to the other connection end (node 1), which is now aware that the connection has failed. Without the RDI/FERF signal, node 1 would not be aware that there was a failure in the connection between nodes 2 and 3. This method will also detect any combination of single – direction failures. Note that the node(s) that generate the AIS signals know exactly where the failure is, and could report this to a centralized network management system, or take a distributed rerouting response.

a) Failure in Both Directions



b) Failure in One Direction

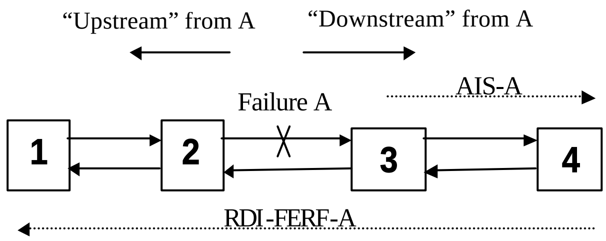


Figure 6: Illustration of AIS and RDI/FERF theory and Operation

+ Loopback Operation and Diagnostic Usage

Figure 7 illustrates the ATM OAM cell Loopback function-specific fields.

A summary of the ATM OAM cell Loopback function-specific fields is:

➯ **Loopback Indication** is a field that contains "01" when originated, and is decremented by the receiver. It should be extracted by the sender when it is received with a value of "00". This prevents the cell from looping around the network indefinitely.

➯ **Correlation Tag** is a field defined for use by the OAM cell originator since there may be multiple OAM cells in transit on a particular VPC/VCC, and this allows the sender to identify which one of these has been received.

➯ **Loopback Location ID** is a field provided to the sender and receiver for use in segment loopbacks to identify where the loopback should occur. The default value of all 1s indicates that the loopback should occur at the end point.

➯ **Source ID** is a field provided so that theloopback source can be identified in the cell. This can be used by nodes to extract OAM cells that they have inserted for extraction after they have loopback to the source.

Loopback Indication	Correlation Tag	Loopback Location ID	Source ID	Unused
1 byte	9 bytes	12 bytes	12 bytes	16 bytes

Unused 0000000	0/1
7 bit	1 bit

Figure 7 ATM OAM Loopback Function- Specific Fields.

As seen in the preceding section, AIS and RDI/FERF are most useful in detecting and identifying to the connection endpoints that a failure has occurred.

Figure 8 illustrates how these loopback primitives can be used to diagnose a failure that would not be detected by AIS and RDI/FERF at any node. An example of such a failure would be a misconfigured VP or VC cross-connect. The example shows two endpoints and two intervening networks, each with three nodes. Part (a) shows the verification of end–to-end continuity via an end-to-end loopback to endpoint 1. If this were to fail, then network 2 could diagnose the problem as follows. Part (b) shows verification of connectivity between a node in network 2 to endpoint 2 via an end-to-end loopback. If this fails, then the problem is between network 2 and endpoint 2. Part (c) shows verification of connectivity to endpoint 1 via an end-to-end loopback. If this fails, there is a problem in the link between endpoint 1 and network 1 , a problem in network 1 , or a problem in the link between network 1 and 2. Par (d) shows verification of connectivity across networks 1 and 2 via a segment loopback. If this succeeds, then the problem is the access line from endpoint1 to network 1. Part (e) shows verification of connectivity from entry to exit in network 1. If this succeeds, then the problem is in network 1. Verification within any of the networks could also be done using the segment loopback.

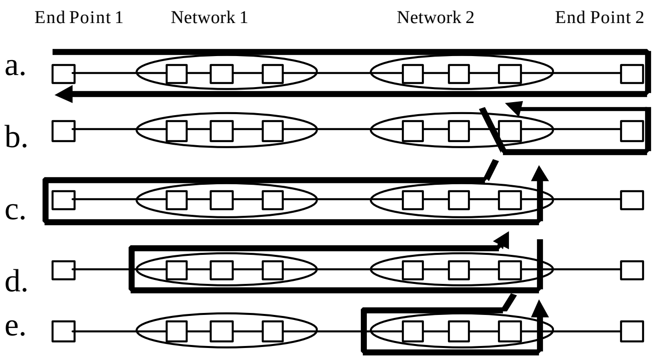
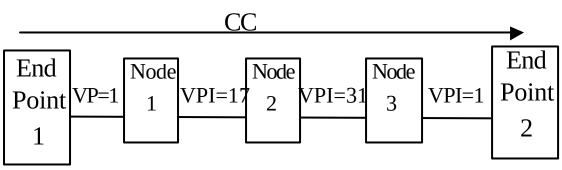


Figure 8 : Usage of Loopback in Verification/Problem Diagnostic

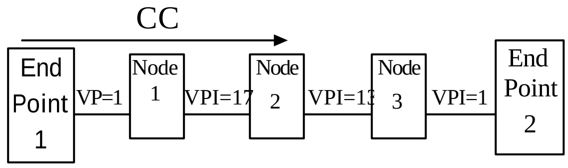
+ Continuity Check

The continuity check can detect failures that AIS cannot, such as an erroneous VP aross-connect change, as illustrated in Figure 9 .Part (a) shows an VP connection traversing three VP cross-connect nodes with VPI mappings shown in the figure carrying only Continuity Check (CC) cell traffic. In part (b) an erroneous cross-connect is made at node 2, interrupting the flow of CC cells. In part (c) node 3 detects this continuity failure and generates a VP-RDI/FERF OAM cell in the opposite (upstream) direction.

a) Intial Virtual Path Connection



b) Erroneous Change



c) Fault Notification

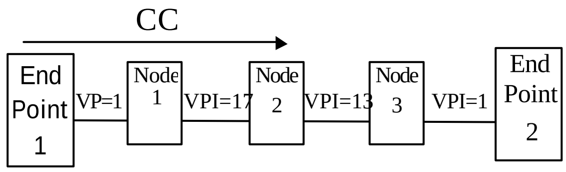


Figure 9: Illustration of Continuity Check (CC) OAM Cell Usage

+ RESTORATION

The standard currently do not specify what can be done in response to a fault at the ATM layer. There are SONET and SDH standards, however, that define physical layer protection switching on a point-to-point, 1:N redundant basis or a ring configuration. There are also restoration strategies for partial mesh networks. These same concepts could also be applied to restore ATM connections. Resoring Virtual Paths (VPs) that carry a large number of Virtual Channels (VCs) would be an efficient way to perform ATM-level restoration. We briefly discuss these three restoration methods with reference to Figure 10.

The term 1:N (read as “one for N”) redundancy means that there is one bidirectional protection channel for up to N working bidirectional channels, as illustrated in Figure 10 (a). If a working channel fails, its endpoints are switched to the protection channel. If a failure occurs and the protection channel is already in use or unavailable, then the failed working channel cannot be restored.

Figure 10 (b) illustrates a bidirectional ring. Traffic from node 1 to node 3 is sent in both directions around the ring. At each node signals may be added as shown by the plus sign inside the circle, or dropped as shown by the minus sign inside the circle. At the receiver (node3) only one of the signals is selected for output. Upon detection of a failure the receiver will switch to the other, redundant signal, as shown in the example for a failure between nodes 2 and 3.

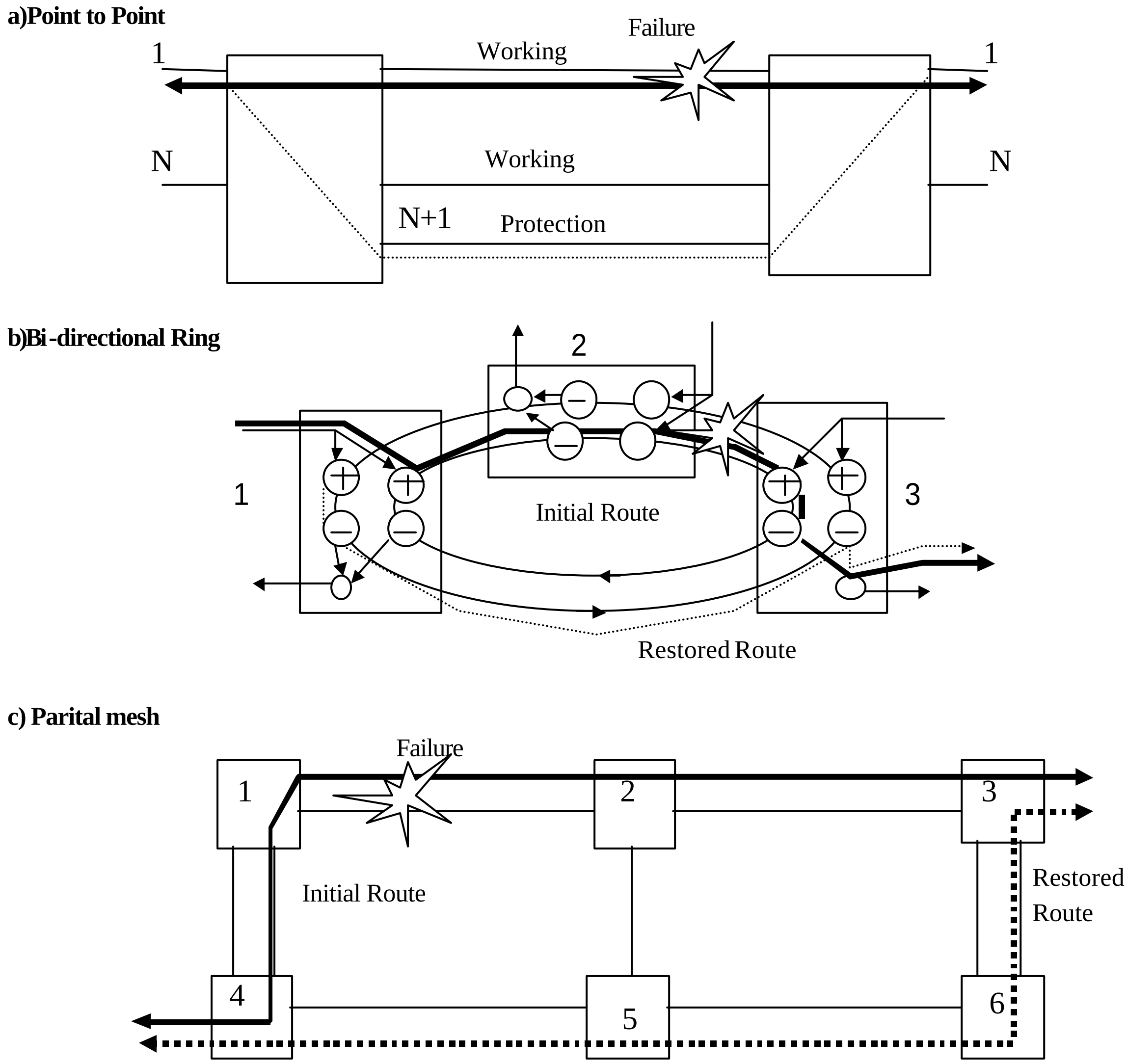
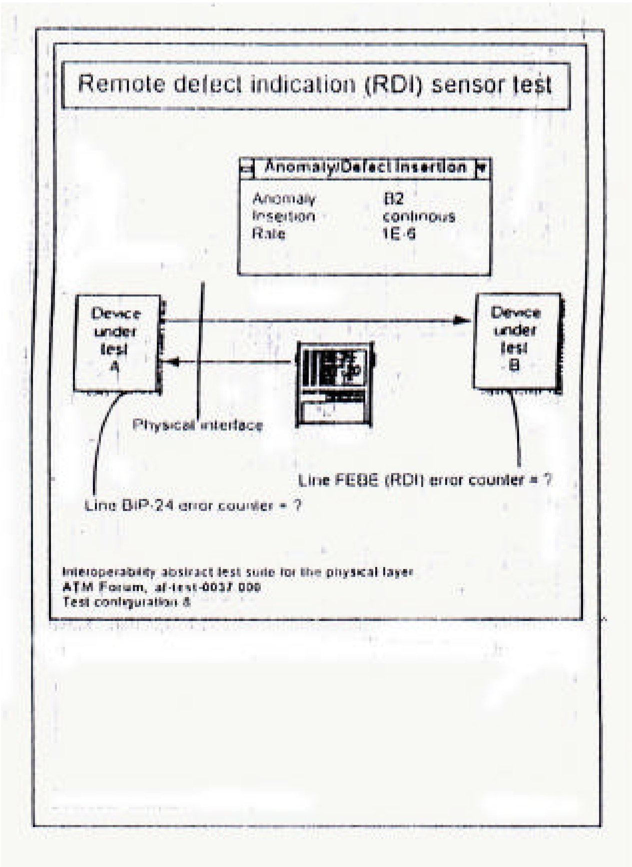


Figure 10 : Basic Restoration Method Examples

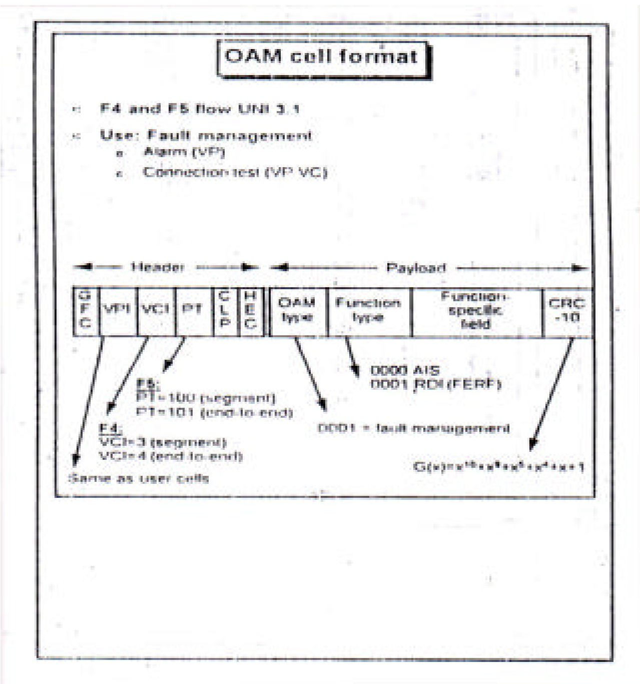
Figure 10 (C) illustrates a partial mesh network. In the example, traffic between nodes 3 and 4 initially follows the route shown by the solid line. A failure between nodes 1 and 2 impacts the node 3 to 4 traffic on its current route. This can be detected in a centralized, distributed, or hybrid network management system to find a new route shown by he dashed line in the example. Longer distance networks tend to have the type of lattice structure shown in the example and tend to use this type of restoration . In the example of Figure 10(c), 1:2 redundancy is provided for some routes.

The mirror image of this capability is in place for traffic between nodes 3 and 1. Note that the ring architecture achieves 1:1 redundancy, or in other words, only half of the transmission bandwidth is available to traffic. These types of ring architectures are economically attractive for metropolitan areas and can be further optimized for ATM using Virtual Path level Add Drop Multiplexing (ADM) to improve multiplexing efficiency

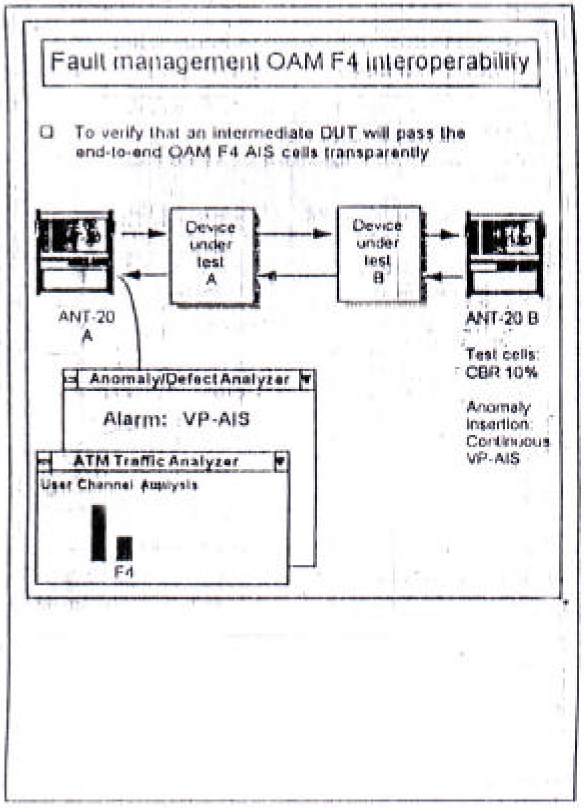
SENSOR TESTS



Remote Defect indication Sensor Test



This is a classic interoperability test for the physical connection.



Incorrect generation of the alarms as a result of anomalies leads to network errors and even to expensive network downtime.

The ANT generates B2 errors at a given rate for the RDI test.

The switch detects the parity errors (BIP-24) and returns the error count (RDI).

The error counters of both DUTs are read out.

Common OAM cell format

AIS/RDI fault management cell and function type identifiers.

OAM fault management flow F4/F5

These additional OAM cell flows for ATM paths (F4) and channels (F5) are generated when anomalies or defects occur .

The flows must be passed on transparently to their end points by the ATM switches.

The ANT allows you to simply switch in the flows for the test channel:

Anomaly/Defect Insertion : VP-AIS (or VP-RDI ,VC-AIS, VC-RDI), continuous insertion.

The ANT verifies the OAM cell flow with two virtual instruments:

-ATM traffic Analyzer: User channel analysis (logarithmic display) shows the F4 cell flow and verifies its bandwidth (CSR). Expected value: 1 cell/s

Anomaly/Defect Analyzer: VP-AIS defect display

Verifies that the cells contain the correct coding for VP-AIS.

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