Interoperability Considerations Between ATM Equipment Based on the B-ISDN COMPASS/Mercuri Trial

M. T. Midani
Broadband and Photonic Switching Department
AT&T Bell Laboratories
Naperville, IL 60566

A. Guha
Systems and Software Technologies
Honeywell Technology Center
Minneapolis, MN 55417

J. D. Cavanaugh
Communications Department
Minnesota Supercomputer Center, Inc.*
Minneapolis, MN 55415

J. T. Pugaczewski
Communications Department
US WEST
Minneapolis, MN 55402

Abstract

The B-ISDN COMPASS Project 5 Mercuri Trial involved the interconnection of ATM equipment from three different vendors, which the authors found to be surprisingly difficult. This paper explains the technical challenges and difficulties we encountered and suggests a set of recommendations, which, if observed, should make the process of interconnecting ATM equipment from different vendors more likely to succeed. At the physical (SONET) layer, we discuss optical signal level, connector type, ATM cell delineation (which turned out to be one of the most troublesome problems in the trial), SONET payload type indication, and test Equipment. At the ATM layer, we discuss idle cell format (which also proved quite troublesome), VPI/VCI fields, ATM OA&M functions, and ATM signaling. At the application layer, we briefly describe the protocol stack.

Keywords: ATM, cell delineation, idle cells, COMPASS/Mercuri, path overhead, payload type.

1. Introduction

The B-ISDN COMPASS/Mercuri [1] (Communications Programs for Advanced Switched Services / Multimedia Environment for Real-time Control Using Remote Imagery) Trial involves the interconnection of ATM equipment from three different vendors. The interface between the various pieces of equipment is SONET OC-3c, via single mode fiber.

This paper explains the technical challenges and difficulties we encountered, their resolutions, and recommendations based on our experience in the trial. It concentrates mainly on the physical and data link layers of the OSI model.

2. Physical Layer (SONET Layer) Interoperability Issues

With respect to the physical layer, many issues ranging from optical signal strength to the SONET frame overhead fields are addressed.

2.1 Optical Signal Level

Many SONET devices currently on the market have different optical transmitter strength and receiver sensitivity. Fiber length contributes to optic signal loss, and the addition of intermediate connectors (e.g. in a fiber distribution panel) adds to the dB loss.

---

* Work supported by ARPA under Contract Number F19628-92-C-0072.

It is important to observe the minimum and maximum optical component specifications on both ends, so the optical signal is strong enough to be detected, and not so strong it saturates the receiver. Optical attenuators or regenerators might need to be added at some connections.

2.2 Connector Type

There are several kinds of connector types which can be used to terminate the fiber. Each connector type has its own loss characteristics. The table below gives the single mode fiber connector loss that can be expected. Note that the second number is the value of loss which is recommended when calculating the fiber loss budget.

Single Mode Fiber Connector Loss	
Connector Type	Loss(dB)
ST PC Compatible	0.3(0.8)
Biconic	0.7(1.3)
FC PC	0.3(0.5)
D4 PC	0.3(0.5)

Different equipment has different types of connectors (FC and ST being the most popular). It may be necessary to have special patch cords to interconnect equipment with different connector types.

2.3 ATM Cell Delineation

Cell delineation turned out to be one of the most troublesome problems in our trial. In the past five years, the standard for ATM cell delineation function within a SONET frame has changed. The original SONET standard specified the Virtual Tributary Multi Frame Indicator (the H4 byte) in the Path Overhead (POH) area as the pointer to the first ATM cell in the SONET Synchronous Payload Envelope (SPE). Many vendors, especially those who provided early equipment with SONET interfaces, base their ATM cell delineation on the H4 approach.

The standard, however, was changed about two years ago. The new ATM cell delineation method is based on the Header Error Control (HEC) field in the header of the ATM cells. The HEC approach uses a flywheel algorithm, where a detection circuit continuously hunts for cell boundaries. The cell boundary detector is based on the the property that a valid cell header will have a valid HEC byte. Two threshold counters (delta and alpha) are used on the process of changing the link state (in-sync or out-of-sync) in order to avoid oscillation in case of a spurious cell detection. Most equipment today uses the HEC-based approach for cell delineation.

In order to make interoperability possible between equipment from different vendors, the authors recommend the following:

i. All newly-designed equipment should base its ATM cell delineation on the HEC approach.

ii. Newly-designed equipment should populate the H4 field on transmission, even though the HEC approach is being used on the receiving end. This will allow new equipment to interface with existing outdated equipment in the field without retrofit.

2.4 SONET Pay Load Type Indication

Difficulties were encountered with the Synchronous Transport Signal Path Signal Label field (the C2 byte) in the POH. The standard specifies that the C2 byte indicates the payload type carried by the SPE. A value of 0x13 is specified to indicate an ATM payload, and a value of 0x01 is specified for non-specific payloads which need no further differentiation, or that achieve differentiation by other means.

One type of equipment in our trial populated the C2 field with 0x00, which is specified in the standard as the unequipped case. The consequences were severe, and confusing at the receiving end. The receiving equipment complained, in an ambiguous fashion, that there was a cell delineation problem, which masked the real cause of the problem.

Only after board-level debugging were the developers able to determine that cell delineation was not the source of the problem, but that it was a consequence of the invalid payload type indicator.

The authors recommend the following:

i. The C2 field should be populated based on the values defined in the standard.
ii. If, for some reason, the payload type cannot be specified, then the value 0x01 should be used, not the value 0x00.
iii. Equipment on the receiving end should make a distinction between cell delineation problems due to H4 or HEC incompatibility and an invalid or unexpected payload type.
iv. Equipment on the receiving end should report any invalid C2 value to the management software.
v. All the mandatory fields in the POH should be checked using a link analyzer.

2.5 Test Equipment

Test equipment is vital when performing interoperability studies. During system integration, the following pieces of test equipment were used:

- SONET/ATM Protocol Analyzer
- Fiber Optic Power Meter
- Fiber Optic Light Source

The SONET/ATM protocol analyzer was used in a "terminal mode" as well as a "through mode". The analyzer must be capable of decoding the SONET overhead (section, line and path) as well as the ATM cells (header and payload).

The fiber optic power meter and light source are required to measure the power loss on optical fiber and verify that the fiber meets the power loss budget. In addition, it is recommended that an OTDR (Optical Time Domain Reflectometer) be used to test the fiber splices and connectors. Measurements should be made at wavelengths of both 1330nm and 1550nm in both directions.

3. Data Link Layer (ATM Layer) Interoperability Issues

With respect to the data link layer, many issues ranging from idle cells to ATM OA&M functions are addressed.

3.1 Idle Cell Format

The standard is ambiguous regarding the format of *idle cells*. In The ATM Forum [2], two types of cells were defined, unassigned cell indication and invalid pattern, either of which could be thought of as the correct *idle cell*. In addition, there are different interpretations of idle cells between the UNI and NNI interfaces, and between the SONET and SDH standards.

With respect to the ATM Forum, the first format is referred to as the *unassigned cell indication* format, and is defined as:

The unassigned cell indicator format				
Byte 1	Byte 2	Byte 3	Byte 4	Byte 5
00000000	00000000	00000000	0000xxx0	HEC

The second format is referred to as the *invalid pattern* format, and is defined as:

The invalid pattern cell format				
Byte 1	Byte 2	Byte 3	Byte 4	Byte 5
00000000	00000000	00000000	0000xxx1	HEC

where: "x" indicates a don’t care bit in both tables.

The difference between the two cell formats is the value of the Cell Loss Priority (CLP) field. The failure of equipment to recognize idle cells can be devastating, as the receiving link module tries to process every cell it sees, and most likely overflows its buffers and/or crashes the system.

One piece of equipment in the trial translated between SONET and TAXI transmission media. ATM cells received on the SONET link were forwarded via the TAXI interface, and vice versa. This equipment dropped unassigned cells received on the SONET interface, but forwarded invalid cells. This resulted in a large number of cells being forwarded to a host ATM interface, swamping it as described above. The problem was fixed by changing the adaptor to discard both unassigned and invalid cells.

Until the standard becomes more specific about which of the above cells are to be used as the idle cell, the authors recommend the following:

i. Equipment should be capable of dropping both types of cells at the receiving end.

ii. Equipment should support the transmission of both types, and selection be based on a configuration parameter that could be set at provisioning time.

3.2 VPI/VCI Fields

Some ATM equipment is VC-based, some is VP-based, and others handle both. It is important for equipment that is only VC-based to carry the VPI field transparently, and for equipment that is only VP-based to carry the VCI field transparently.

Another consideration is the VCI/VPI ranges. It is reasonable for equipment (especially end systems) to support a limited number of concurrent virtual channels. It is not, however reasonable for equipment to support only a subset of the legal VCI values, as some equipment in the trial did. This led to some tight situations with VCI allocation. Fortunately, it did not prevent connections from being established.

3.3 ATM OA&M Functions

The ATM standard defines a set of ATM OA&M functions (F4 and F5 functions) for exchanging alarms and revealing status information between different equipment. Not all equipment on the market supports those functions, however. This led to difficulties during the trial, in fact, OA&M functions had to be disabled on some equipment so that it would not cause alarms on other equipment. The authors recommend that all equipment provide the capability of enabling/disabling the ATM OA&M function on a per-link basis to allow for the maximum interoperability between equipment.

3.4 ATM Signaling

A common signaling protocol is required for successful Switched Virtual Channel (SVC) applications. The ATM Forum calls for the use of Q.2931 as the signaling protocol to accomplish SVC. However, SVCs were not used during our experiments because while one switch used a Q.931 based protocol, the other used a proprietary signaling protocol.

is shown in Figure 1.

Figure 1: Protocol Architecture

While the use of PVCs avoids dynamic connection setup difficulties, it creates a host of other problems such as: requiring the establishment of a fully connected virtual network of PVCs; difficulties with bandwidth provisioning; and restrictions on the use of PVCs at the host ATM interfaces. Clearly, the specification and adoption of a common signaling standard between local and public ATM switches will resolve many of these difficulties, besides providing the OA&M functionality that we also had to forgo.

5. Conclusion

The authors found that the process of interconnecting ATM equipment from different vendors is full of traps and surprises. Considerable preparation needs to be performed before an attempt is made to interconnect ATM equipment and develop distributed applications.

It is the authors' hope that standards bodies will address some of the ambiguous standard issues mentioned in this paper in a timely fashion to maximize the possibility of successfully interconnecting ATM equipment. This paper suggests a set of recommendations, which, if observed, should make the process of interconnecting ATM equipment from different vendors more likely to succeed.

6. References

[1] M. T. Midani, J. L. Shepherd, COMPASS 5 BISDN/ATM Trial MERCURI/Honeywell Application Requirements and Design Specifications. *Technical Memorandum from AT&T Bell Laboratories*, Sept 1993.

[2] ATM User-Network Interface Spec., V 3.0, The ATM Forum, Sep. 10, 1993.

AUTHORS' BIOGRAPHIES

Mowaffak T. Midani is a Member of Technical Staff in the Broadband and Photonic Switching Department at AT&T Bell Laboratories, where he led the development of the AT&T ATM switch for the COMPASS trial. He received a B.S. degree in Electrical Engineering from Wayne State University, and a M.S. degree in Electrical Engineering from Arizona State University. Mr. Midani joined AT&T Bell Labs in 1986. Email: midani@iexist.att.com

John David Cavanaugh is a Communications Software Engineer at the Minnesota Supercomputer Center, Inc., which he joined in 1990. He has been involved with the MAGIC Gigabit Testbed since its inception. He holds a Bachelor of Computer Science degree from the University of Minnesota. Email: johnc@msc.edu

Aloke Guha is a Senior Principal Research Engineer at Honeywell Technology Center. He received a Bachelor of Technology degree from the Indian Institute of Technology, Kanpur, and the MS and Ph.D. degrees from the University of Minnesota, all in Electrical Engineering. His research interests are in high-speed and optical networking for real-time and distributed processing. He leads the development of ATM and multimedia networking at Honeywell. Email: guha_aloke@htc.honeywell.com

Jack T. Pugaczewski is a Member of Technical Staff at U S WEST Communications, He holds a Bachelor's Degree in Electrical Engineering and a Master's Degree in Software Engineering. Email: jtpugac@nwnt14.mnet.uswest.com

REFERENCES

1. M. T. Midani, J. L. Shepherd, COMPASS 5 BISDN/ATM Trial MERCURI/Honeywell Application Requirements and Design Specifications. *Technical Memorandum from AT&T Bell Laboratories*, Sept 1993.
2. *ATM User-Network Interface Spec., V 3.0*, The ATM Forum, Sep. 10, 1993.

CONTENTS