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TECHNICAL INFORMATION BULLETIN 98-6

ASYNCHRONOUS TRANSFER MODE STANDARDIZATION

JUNE 1998

OFFICE OF THE MANAGER
NATIONAL COMMUNICATIONS SYSTEM
701 SOUTH COURT HOUSE ROAD
ARLINGTON, VA 22204-2198

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FOREWORD

Among the responsibilities assigned to the Office of the Manager, National Communications System, is the management of the Federal Telecommunications Standards Program. Under this program, the NCS, with the assistance of the Federal Telecommunications Standards Committee identifies, develops, and coordinates proposed Federal Standards which either contribute to the interoperability of functionally similar Federal telecommunications systems or to the achievement of a compatible and efficient interface between computer and telecommunications systems. In developing and coordinating these standards, a considerable amount of effort is expended in initiating and pursuing joint standards development efforts with appropriate technical committees of the International Organization for Standardization, the International Telecommunication Union-Telecommunications Standardization Sector, and the American National Standards Institute. This Technical Information Bulletin presents an overview of an effort which is contributing to the development of compatible Federal and national standards in the area of Asynchronous Transfer Mode Standardization. It has been prepared to inform interested Federal and industry activities. Any comments, inputs or statements of requirements which could assist in the advancement of this work are welcome and should be addressed to:

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SECTION 1

INTRODUCTION

The National Communications System (NCS) was established to ensure that a survivable telecommunication infrastructure exists to support the National Security and Emergency Preparedness (NS/EP) requirements of the Federal Government; and to serve as the focal point for joint Industry-Government NS/EP telecommunications planning. As part of this mission, the Office of the Manager, National Communications System (OMNCS) has been charged with management responsibility for the Federal Telecommunication Standards Program (FTSP), and directed to ensure that, whenever feasible, industry standards are used as the basis for developing Federal Telecommunication Standards.

Recognizing that industry standards development is a market driven process dominated by equipment vendors and service providers whose primary interests are guided by profit potential, the OMNCS has elected to play an active role in this process to ensure that NS/EP needs are fully met. To this end, personnel from the OMNCS Technology and Standards Division participate in a number of national and international standards bodies and other knowledgeable NCS members are encouraged to do the same.

In recent years, the development and use of international standards has been spurred by the growth of the global economy and its increasing dependence on telecommunications. This has had the effect of drastically increasing both the number and complexity of telecommunication standards. In order to promote the understanding and use of these standards, NCS members require concise reference resources that highlight those having a particular NS/EP implication. In response to this need, the OMNCS Office of Standards and Technology is developing a series of Standards Reference Resources addressing key areas of emerging standardization. These reports provide:

- An overview of the importance of the focus area for NS/EP interests;
- A brief tutorial of the relevant technologies;
- An introduction to the principal standards bodies involved;
- A summary of the pertinent standards, organized for easy reference;
- An assessment of standards activity impacting NS/EP standardization objectives with respect to the focus area.

The purpose of this Technical Report is to provide a technical overview of Asynchronous Transfer Mode (ATM) technology and summarize the associated standardization activity as it relates to NCS interests.

SECTION 2

OVERVIEW OF ATM TECHNOLOGY

2.1 WHAT IS ATM?

Asynchronous Transfer Mode (ATM) technology is a networking technique which provides seamless high-speed, low-delay, multiplexing and switching networks for the transport of all types of user traffic (such as voice, data, and video) either locally or over a wide (global) area. To accomplish this, ATM segments and multiplexes the user's traffic into small, fixed-length units called "cells" which are then rapidly relayed through the ATM network via high-speed switches operating on information contained in the cell header. Because of its networking flexibility and open-ended nature, ATM is paving the way for the rapid integration of voice, data and video into a wide variety of multimedia communication services and access techniques. Thus, ATM offers a number of major benefits for NS/EP users, of which the following are the more significant:

- **Bandwidth efficiency:** ATM provides the means for fulfilling the perennial desire of users for bandwidth on demand. The need to pay for idle circuit time on a circuit switched voice call or unused time slots in a TDM data channel will be largely eliminated. Just as the telephone and telegraph eliminated distance as a barrier to doing business, ATM will now remove bandwidth (speed) as a significant issue.

- **Scalability:** By utilizing a short, fixed cell format, ATM is adaptable to a variety of data rates, frame sizes, and physical transmission techniques. This allows an ATM cell to easily transition between significantly different transport systems such as LANs, SONET, and mobile radio. By offering scaleable data rates from 1.5 Mb/s to 155 Mb/s or higher, ATM provides the unifying mechanism for bridging the barrier between local and wide area networks.

- **Transparency:** ATM is application transparent since its short, fixed cell size is adaptable to either long frames generated by data communications applications or the short repetitive needs of voice; and will effectively support a mix of data, voice, and video (commonly referred to as Multimedia) in the same application.

- **Granularity:** ATM allows the network to be tailored to the user's application, rather than forcing the application to fit the network. Current TDM-based network services are generally offered at a limited number of data rates arranged in a hierarchical relationship (e.g. T-1, DS0, DS1, etc.). If an application needs a data rate other than

that offered by this fixed set, it is up to the user to make things fit, either by paying for additional unneeded capacity or finding ways to bundle other applications into the remaining spare capacity provided.

- **Network Flexibility:** ATM can solve network problems with which the current TDM network has difficulty coping. Unlike these networks, ATM provides the full mesh interconnectivity necessary to support dynamically changing user needs, such as traffic re-direction to meet changing time-of-day requirements or disruptive network outages. Additionally, ATM will readily accommodate NCS needs to transition from fixed plant to mobile operations in times of local or national emergencies.

This tutorial provides a brief overview of ATM technology and how this technology is able to provide the benefits cited above. For a more in-depth treatment, there are a number of good textbooks available on ATM[1]. However, unlike most text presentations that usually begin with a macro-level discussion of network topologies and comparisons with more familiar networking technologies; this tutorial starts with a discussion of the ATM cell structure which lies at the heart of ATM technology, before proceeding to a discussion of the macro-level network processes. In taking this approach, it is believed that the reader will be better able to appreciate the subtleties with which the simple ATM cell concept can be applied to solve the most complex of telecommunications issues. This approach should also help the reader to better understand the scope and applicability of the large body of ATM standards and specifications which is the main topic of this report.

[1] The following were found helpful in preparing this Report: "Asynchronous Transfer Mode: Bandwidth for the Future" by Teleco Systems; "Emerging Communications Technologies" by Uyless Black; and "ATM Solutions for Enterprise Internetworking" by David Ginsburg.

2.2 THE ATM PROTOCOL STACK

The ATM communications process is essentially a 3-stage process which involves the segmentation of the user's information into a fixed 53-byte cell format; the transfer of these cells through the telecommunications network; and the reconstruction of the original information at the receiving end. This concept was developed as part of the overall Broadband ISDN (B-ISDN) effort and is defined by the bottom three layers of the B-ISDN reference model, a simplified version of which is shown in Figure 2.1.

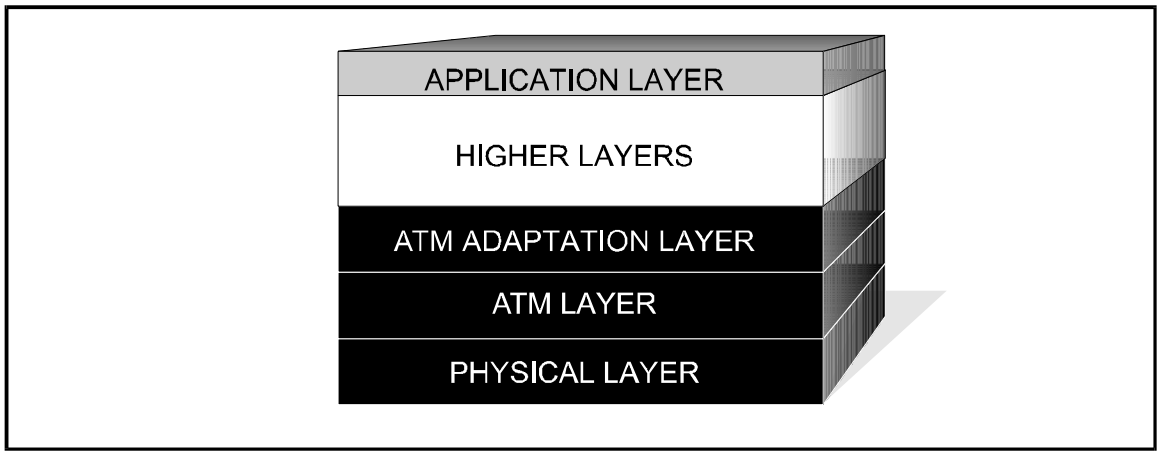

Figure 2.1 Simplified Version of the B-ISDN Reference Model

The B-ISDN model is based on a layered architecture concept similar to that used in the seven-layer OSI model developed by ISO. Using such a model, any communications process can be divided into sub-processes (referred to as layers) arranged vertically in a stack. Each layer provides services to the layers above and below that, when taken collectively, provide the desired communication between top layer user applications residing at each end of the connection. The principal benefit of such an arrangement is that each layer can be modified or changed without impacting the layers above or below. For example, the ATM physical layer may be changed from SONET to DS3 with no impact on the ATM layer above, or the services provided to higher layers. Although the ATM portion of the B-ISDN stack is roughly equivalent to Layer 1 (Physical Layer) and part of Layer 2 (Data Link Layer) of the OSI model, it also performs functions that are found at OSI layers 3, 4 and 5 (Network, Transport, and Session layers respectively). The B-ISDN model can also be divided vertically into a User Plane, a Control Plane, and a Management Plane, to denote the coordination required across layers to fully implement the ATM process. For the sake of brevity, this is not depicted in Figure 2.1.

The ATM Adaptation layer (AAL) divides higher level data streams into segments which are more compatible with the requirements of the ATM Layer. AAL operation is an end-to-end process which is considered to be external to the connecting networks. How this process is carried out will depend on the type of traffic being transmitted. Currently, five classes of traffic have been defined:

- **Class A** Constant Bit Rate (CBR), connection-oriented, with a required timing relationship between source and destination [constant bit-rate video];
- **Class B** Variable Bit Rate (VBR), connection-oriented, with a required timing relationship between source and destination [packet-video, voice];
- **Class C** Variable Bit Rate (VBR), connection-oriented, no timing relationship required between source and destination [bursty data traffic];
- **Class D** Variable Bit Rate (VBR), connectionless, no timing relationship required between source and destination [bursty datagram traffic];
- **Class X** Unrestricted (traffic type and timing requirements defined by the user)

The ATM layer is concerned with packaging the data received from the AAL into a single unit having a fixed length and format for easy transport through the connecting communication networks. The ATM layer operates between adjacent network nodes, and is the heart of the ATM communications process.

The B-ISDN physical layer defines the various transmission medium being used to transmit the ATM cell over the link connecting adjacent nodes of the network. This layer is primarily concerned with media dependent physical characteristics, such as waveform, data rates, transmission levels, framing, etc., which are essential to the transmission of information at the bit-level. The strength of ATM is that it can be accommodated by practically any form of transmission medium, although fiber optics, utilizing SONET, is the preferred choice due to the high data transfer rates that are possible.

2.2.1 The ATM Protocol Data Unit (Cell)

The basic unit of ATM information transfer is the 53-byte ATM protocol data unit, referred to as the ATM "cell". This unit consists of a 5-byte header and a 48-byte information field containing the information payload generated by the AAL. The 53-byte cell size is a compromise between transmission efficiency, implementation complexity, and compatibility with existing equipment. The basic configuration of the ATM cell is shown in Figure 2.2. Two different coding schemes have been adopted for the first byte depending on whether flow control is required or not (see GFC below). In addition, a small set of pre-assigned values for the cell header are reserved for use by the Physical Layer (e.g. Idle Cell Identification) and are not passed to the ATM layer (see Section 2.2.3). From a network operation point-of-view, only the ATM cell header is of significance.

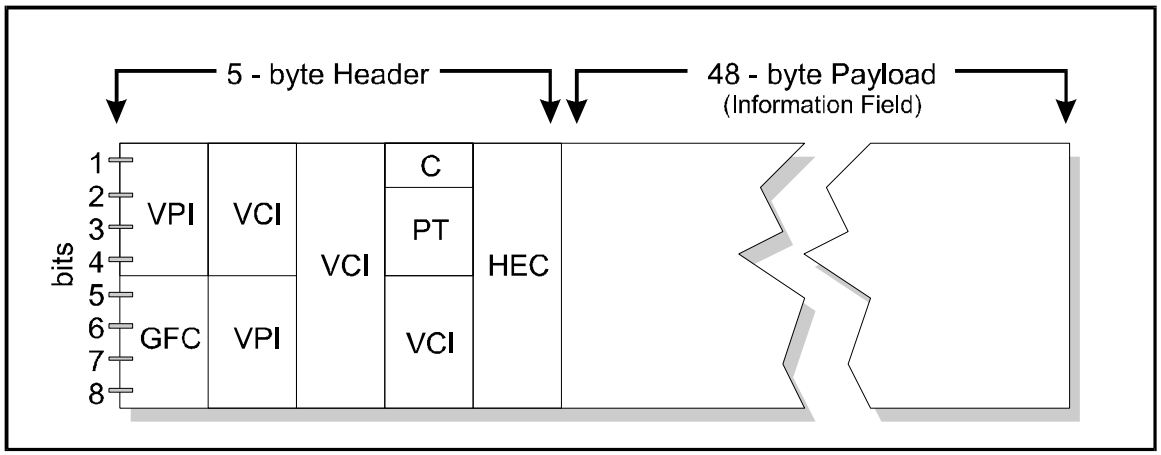

Figure 2.2 The ATM Cell Structure

GFC: The last four bits of byte-1[1] contain the generic flow control (GFC) information used to control the flow of traffic across the User-Network Interface (UNI). Since the GFC has meaning only at the UNI, these four bits can be used at a Network-Network Interface (NNI) to provide additional network addressing capability. In addition to simple flow control operations, the GFC can be used for a variety of other operations, administration, and maintenance (OAM) functions, including the establishment and releasing of virtual channel connections.

VPI/VCI: The first four bits of byte-1, all of bytes 2 and 3, and the last four bits of byte-4 (24 bits in all) make up the ATM address. This three-byte field is divided into two parts: the first eight bits contain the virtual path identifier (VPI) and the next 16 bits contain the virtual channel identifier (VCI). Collectively this field is commonly referred to as the VPCI field. As discussed above, under GFC, the VPI field will contain 12 bits (rather than eight) when used internally to the network. The role of virtual paths and virtual channels in establishing an ATM connection is discussed in Section 2.4. For the time being, the entire field can be considered as providing a single AAL address.

PT: Bits 2 through 4 of byte-4 identify the payload type (PT) or type of traffic carried by the cell. This field is used to indicate whether the cell contains user data or is being used to transfer management or control messages across the network. In addition, it is used to indicate whether or not a cell has experienced congestion, and may be used for resource management and other OAM purposes as well.

[1] By convention, bits within an octet are sent in decreasing order, starting with bit 8

CLP: The first bit of byte-4 indicates the cell loss priority (CLP). The value of this bit is designated by the user to indicate whether the cell may be discarded during periods of network congestion. Depending on network conditions, cells with a CLP set to "1" are subject to discard prior to cells for which the CLP is "0". The actual decision to discard a cell during a given level of network congestion may vary from network to network depending on the policy of the network administrator.

HEC: The final byte of the ATM cell header is the header error control (HEC) field used for detecting errors in the cell header (but not the Payload). While the principal purpose of this field is to provide protection against miss-routing of ATM cells due to addressing errors, it may also be used to synchronize the receiver to an incoming cell stream. The HEC utilizes an adaptive multiple error detection mechanism that can also correct a single-bit error.

PAYLOAD (Information Field): The remaining 48 bytes of the ATM Cell are reserved for the data inserted by the AAL. Depending on the type of AAL process, up to four bytes of this payload may be reserved for the adaptation process itself (see Section 2.2.2).

2.2.2 The ATM Adaptation Layer (AAL)

The AAL process acts on the user's side of the user-network interface, thus allowing the network to ignore the type of traffic being transmitted and concentrate only on the routing of cells from one point to another. This traffic will exhibit a variety of different characteristics - from those typical of continuous processes, such as voice, to those typical of bursty messages generated between a personal computer and the Internet. Also, regardless of traffic type, most of these transactions contain more then 48 bytes of information and require segmentation in order to fit into the fixed length of the ATM cell.

In order to accommodate these concerns, the AAL process has been divided into two sub-layers: the convergence sublayer (CS) and the segmentation and reassembly sublayer (SAR). In general, higher layer user data is passed to the CS, whose function it is to divide the application data stream into rational, fixed length protocol data units (PDUs) whose length depends on the nature of the traffic being passed (such as 64 Kbytes for Class D traffic). A header and trailer, containing information about the type and size of the CS- PDU, together with information required to check PDU integrity at the receiving end, is appended to the CS payload and then passed to the SAR. At the receiving end, the CS process checks the integrity of the received CS-PDU and then reassembles the application data stream based on the type of traffic indicated in the CS-PDU header.

The SAR accepts the CS-PDUs and divides them into small segments ranging from 44 to 48 bytes in length depending on the type of traffic being transmitted. If the CS-PDU is less than 44 bytes, it is padded with zeros to the desired length. Header and trailer information is added to the basic payload segment to form the SAR-PDU which is then passed to the ATM Layer for encapsulation into the ATM cell. At the receiving end, this process is reversed by each layer reassembling the received data in accordance with the instructions provided in the header and trailer of the associated PDU. After removing

these instructions, the remaining payload segment is passed to the next higher layer where a similar process is repeated. The overall process is illustrated in Figure 2.3.

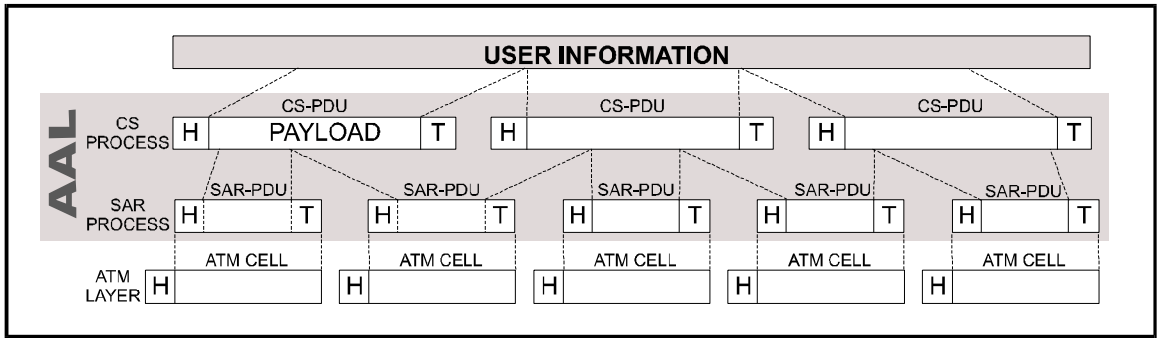

Figure 2.3 AAL Process

The specific manner in which the AAL process is carried out will depend on the type of user traffic being transmitted. For each traffic type, the length of the CS-PDU and the structure of the CS and SAR header and trailer may differ. In order to accommodate this variation, five types of AAL process have been developed. For simplicity, only the structure of the SAR-PDU, which is the final result of the AAL process, will be discussed. A more detailed description of the CS process can be found in Ginsburg[1] .

Type 1 - Constant Bit Rate (CBR) Services: This type of AAL supports user applications requiring a constant bit rate transfer typical of Class A traffic. In addition to user information segmentation and re-assembly, functions performed include handling the variable cell delay, detecting lost and miss-sequenced cells, and providing source clock frequency recovery at the receiver. In order to accomplish this, up to two octets of the cell payload are reserved for the AAL process, thus leaving either 46 or 47 octets for user information. The structure of the Type 1 SAR-PDU is shown in Figure 2.4.

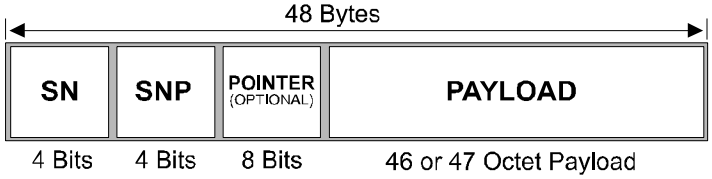

Figure 2.4 AAL Type 1 SAR-PDU

The AAL Type 1 header is divided into two 4-bit fields with an optional 8-bit pointer to the beginning of useable data should the user's application require a partially filled cell. The first field contains a sequence number (SN) which is used to detect lost cells or a mistakenly inserted cell. One bit of the SN, called the Convergence Sublayer Indication (CSI), indicates whether an 8-bit pointer is being used. The other three bits provide the sequence count and are coded in such a way as to designate whether unstructured data transfer (UDT) or structured data transfer (SDT) is in effect. UDT is a bit stream

[1] D. Ginsburg, "ATM solutions for enterprise interworking", Addison-Wesley, 1996

operation with an associated bit clock, while SDT is a byte stream operation (usually supporting a *n* x 64kbit/s channel) with a fixed block length and associated clock. The second field provides the sequence number protection (SNP) used for error detection and correction of the SN field. Due to the delays involved, a lost traffic indication does not result in a request for re-transmission by the AAL. Instead, the nature of the traffic loss is signaled to the user's application for appropriate action under user control.

Type 2 - Variable Bit Rate (VBR) Timing Sensitive Services: This type of AAL supports user applications having a variable bit rate and requiring a specific timing relationship between source and destination, a characteristic typical of Class B traffic. An example of this type of traffic is compressed video where the compression algorithms tend to generate bursty traffic of varying lengths. The Type 2 AAL process makes it possible to connect such applications directly into the ATM service without the need for complex buffers or other rate smoothing circuits typical of pre-ATM transmission schemes. In order to make this possible, the AAL provides for the handling of variable cell delay, the detection and handling of lost or miss-sequenced cells, and maintaining a mapping of how user information is distributed in the payload. The structure of the Type 2 SAR-PDU is shown in Figure 2.5.

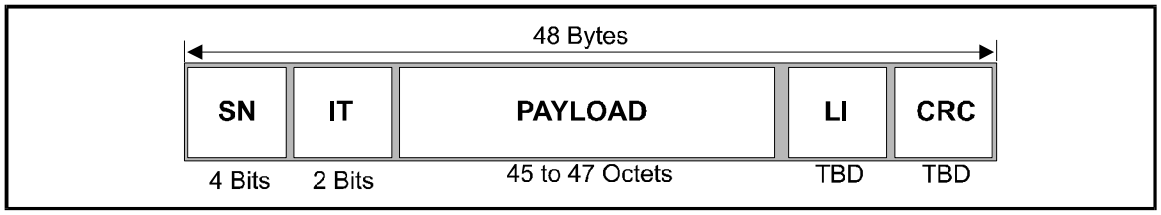

Figure 2.5 AAL Type 2 SAR-PDU

The AAL Type 2 protocol data unit consists of both a header and a trailer. The header consists of a sequence number (SN) and a information type (IT) field for which the length and exact functions have not yet been fully determined. However, the SN is used for the detection of lost and mistakenly inserted cells, the same as for AAL Type 1. As a minimum, the IT field will contain the indication for beginning of message (BOM), continuation of message (COM), or end of message (EOM), depending on where the cell fits in the overall user data stream. When timing information is required external to the payload, it will also reside in this field. The trailer consists of a length indicator (LI) which indicates the number of bytes of information in the payload; and a cyclic redundancy check (CRC) for error detection and correction of the payload information.

Type 3/4 - Variable Bit Rate (VBR) Common 3/4 Format Services: Initial ATM development work provided two separate AAL processes to support Class C traffic (Connection-Oriented VBR Data Transfer) and Class D traffic (Connectionless VBD Data Transfer). AAL Type 3 was intended for large, long period data transfer, such as file transfer; while AAL Type 4 was most efficient in short message situations where call set-up time could be longer than the message transfer time. However, as work progressed, it was found that both classes of traffic could be handled more effectively by a common AAL format and AAL Types 3 and 4 have now been merged. This common format consists of a two byte header, a two byte trailer and 44 bytes of user payload. The structure of the Type 3/4 SAR-PDU is shown in Figure 2.6.

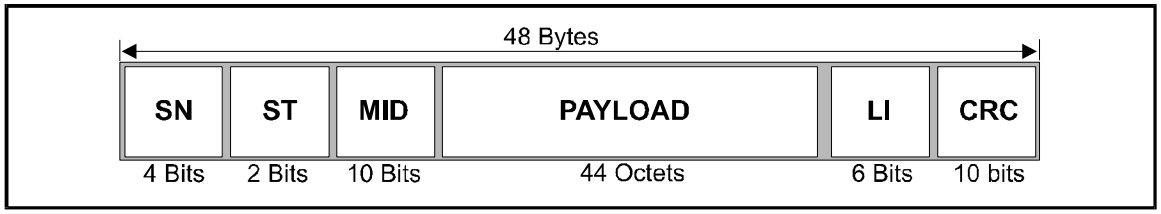

Figure 2.6 AAL Type 3/4 SAR-PDU

The header is divided into three fields. The 2-bit segment type (ST) field is used to indicate whether the cell is the beginning of message (BOM), end of message (EOM), continuation of message (COM), or a single segment message (SSM) requiring only one ATM cell for transmission. The 4-bit sequence number (SN) is used for sequencing the traffic and is incremented by one for each SAR-PDU sent. A SAR-PDU arriving at the receiver with an unexpected sequence number will be discarded. The 10-bit message identifier (MID) is used to reassemble traffic segments during a connection-oriented session, and allows for multiple messages to share one channel. In the trailer, the 6-bit length indicator (LI) defines the size of the payload, while the 10-bit CRC field is used to determine whether an error has occurred in any part of the SAR-PDU.

Type 5 - Simple and Efficient Adaptation Layer (SEAL): This type of AAL offers improved efficiency over AAL Type 3 by assuming that existing higher layer services will provide error detection and recovery. Instead of adding the 2-byte header and trailer of AAL type 3/4, SEAL fills all 48 bytes of the SAR-PDU with the data received from the CS. This translates into almost a 10% increase in network throughput at the SAR level, and even more efficiency at the higher layers where data transfer between the n x 8-byte data bus, used by the typical PC or Desktop Workstation, is optimized by using a 48, rather than a 44 byte information field. However, the loss of SAR header and trailer information means that the interleaving of messages is prohibited, and that CRC checking must be done at the CS level. SEAL also requires a specific pattern in the PT bits of the ATM cell header to indicate start, continuation, or end of message. In effect, SEAL acts like high-speed frame relay.

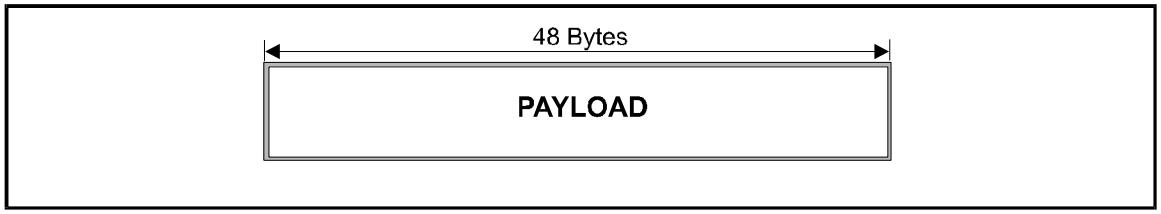

Figure 2.7 AAL Type 5 SAR-PDU

2.2.3 The Physical Layer

ATM resides on top of the physical layer of a conventional layered model, but does not require the use of a specific physical layer protocol and can be implemented with a variety of transmission schemes (such as SONET/SDH, DS3, FDDI, etc.). However, for large public networks, SONET/SDH is the preferred transport medium. As is the case with the AAL, the Physical layer is also divided into two parts: 1) the Transmission Convergence (TC) sublayer, and 2) the Physical Medium Dependent (PMD) Sublayer.

The PMD sublayer is directly associated with a given media type and transmission speed. It deals with the actual transfer of information bits between adjacent nodes of the transmission network and, as such, is concerned with waveforms, line coding, timing recovery, electro-optic conversion (in the case of fiber links), and other matters relating to the specific characteristics of a particular transmission technology. These topics are independent of the ATM process and are not addressed in this tutorial.

The TC sublayer is independent of the underlying physical media, and provides the necessary framing and convergence operations required to fit the ATM cells into the physical transport media. The TC sublayer process calculates and inserts the header error control information into the HEC field of the ATM cell header; and, before passing a recovered cell to the ATM layer at the receiving end, checks the received HEC field and discards the cell if an error is indicated. The TC sublayer also performs other specialized functions required to adapt the ATM cell to a particular transmission scheme. The more important of these schemes are summarized below.

- **SONET/SDH:** The Synchronous Optical Network (SONET) and Synchronous Digital Hierarchy (SDH) are optical-based transport schemes utilizing synchronous operations between network components. Both are deployed in wide area networks at data rates from 155 Mbps to 9.6 Gbps and use a similar framing structure (STM-1 for SDH and STS-3c for SONET). SDH is used in Europe and is an outgrowth of the North American SONET standard developed by Bellcore. While similar, SDH and SONET are not exactly alike and require variations in the multiplexer and switching equipment used in each of the two regions. The basic mapping of ATM cells into STM/STS repeats for the higher data rates and provides bit scrambling of the 48 byte ATM payload to prevent the occurrence of a pattern identical to the SONET/SDH framing pattern.

- **DS3/E3:** The existing (or pre-SONET) digital backbone technology is known as the Plesiosynchronous Digital Hierarchy (PDH), of which Digital Signal Level-3 (DS3), operating at 44.736 Mbit/s, is the preferred data rate for ATM application. The European counterpart to DS3 is E3 which operates at 34.368 Mbit/s. Unlike SONET/SDH, DS3 utilizes a distributed frame format which is not immediately compatible with the ATM cell. Since the ATM frame has no direct relationship to a DS3 frame, a Physical Layer Convergence Protocol (PLCP) has been defined which maps 53-byte ATM cells into a 125 micro-second frame running within the DS3 payload. The PLCP frame consists of 12 rows of ATM cells with each cell preceded by four bytes of overhead. This overhead is used to provide a framing pattern to identify the start of an ATM cell, error checking, bit stuffing, and other operational parameters for DS3 transport. Unlike SONET, bit-scrambling is not required for ATM over DS3.

- **DS1/E1**: Similar to DS3, DS1 operates in North America at 1.544 Mbit/s, while E1 operates in Europe at 2.048 Mbit/s. These rates are finding wide use in branch locations where higher data rates are not cost effective. The mapping of ATM cells into the DS1 frame is accomplished by using a 24-frame Extended Super-frame Format (ESF) which provides for PDH type operational overhead. As with other physical layer techniques, the ESF adapts the 53-byte ATM cell to the DS1 payload by inserting idle cells as required to fill out the DS1 frame structure, while the beginning of an ATM cell is identified by the HEC field in the ATM cell header. This process supports an ATM data rate of 1.536 Mbit/s over DS1 at an expense of only 8 Kbit/s for the DS1 overhead.

- **Other schemes** have been developed for ATM use over more restricted transport media or to support other specialized needs. These include:

FUNI: Frame User-to-Network Interface for Nx64 Kbit/s below DS1/E1;
AIMUX: ATM Inverse Multiplexing for data rates between DS1/E1 and DS3/E3;
4B/5B (TAXI), 8B/10B, UTP-3/5, and ATM25: For application in LANs;
FTTH: Fiber to the Home;
FTTC: Fiber to the Curb;
HFC: Hybrid Fiber Coax
VDSL: Very High-Speed Digital Subscriber Line;
ADSL: Asymmetric Digital Subscriber Line
Clear Channel: for media/data rates requiring no higher-layer processing;
UTOPIA and WIRE: Internal board or chip level interfaces allowing standardization between vendors.

A detailed description of each of these schemes can be found in Ginsburg[1]

[1] D. Ginsburg, "ATM solutions for enterprise interworking", Addison-Wesley, 1996

2.3 AN ATM TOPOLOGY

As with any networking technology, a physical topology can be specified which defines how the various network components and user terminal devices are interconnected. Such a topology for a typical ATM configuration is shown in Figure 2.8. The term "typical" is used since ATM's versatility allows for a variety of configurations of which this is just an example.

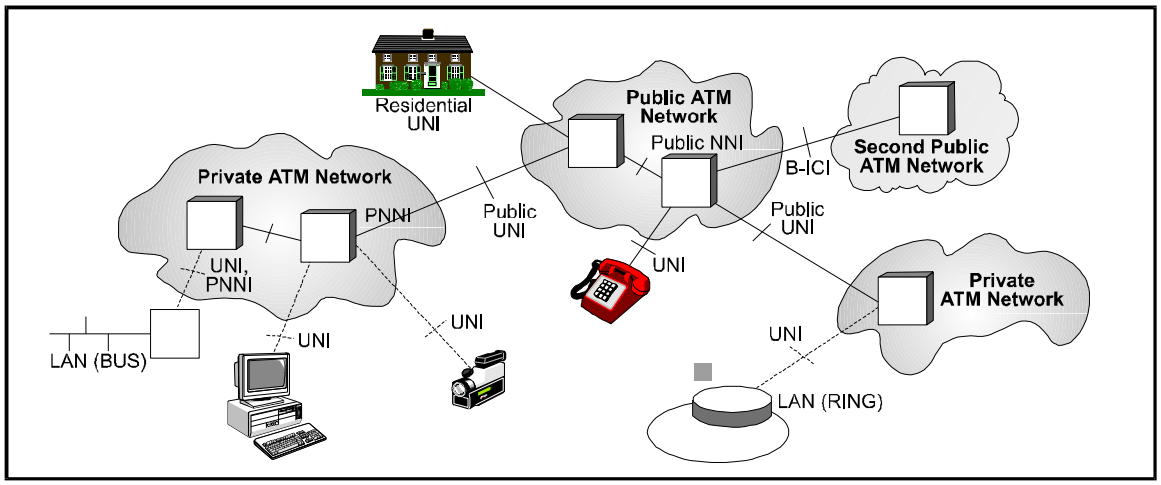

Figure 2.8 A Typical ATM Topology

The ATM topology is organized around the ISDN model which specifies number of standardized interfaces in order to support multiple vendor implementations. These interfaces are divided into two groups depending on whether they represent a user-to-network interface (UNI) or a network-to-network or node interface (NNI). For the UNI, there are three variations which are likely to use different physical media and addressing schemes, and span different geographical distances:

- A public UNI to connect ATM end-systems to a public ATM network;
- A private UNI to connect ATM end-systems to a private ATM network;
- A residential UNI which is a variant of the public UNI for residences or small businesses.

There are also three versions of the NNI, depending on whether the interconnected switches are in the same network or in different networks, either public or private:

- A public NNI interconnecting ATM switches in the same public network;
- A private NNI (PNNI) interconnecting ATM switches in a private network;
- A broadband inter-carrier interface (B-ICI) interconnecting two public networks supported by different service providers.

A conceptual model of the expanded ISDN user-access area has been developed by the standards bodies to facilitate the standards development process and to delineate where operational responsibility is transferred from the network operator to the user for a particular service implementation. The B-ISDN version of this model is shown in Figure 2.9, and depicts the arrangement of functional groupings and reference points required to implement the various B-ISDN user options.

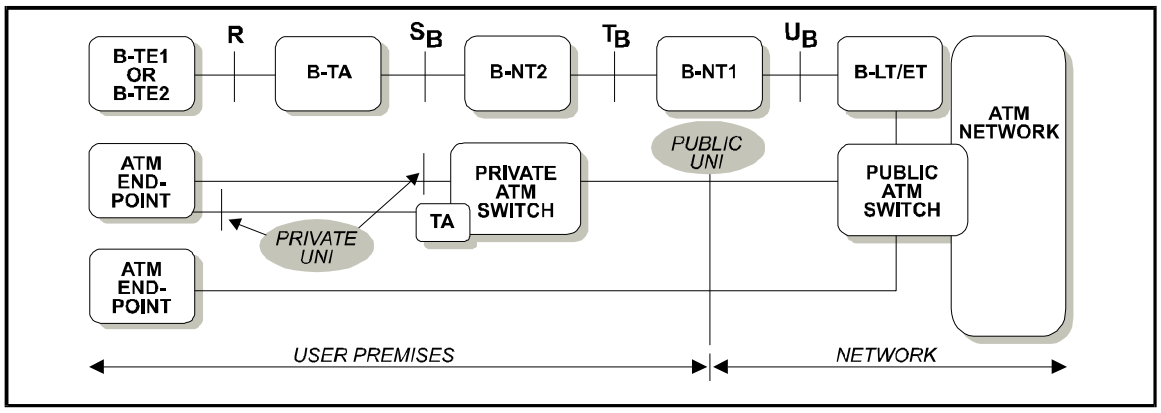

Figure 2.9 The ATM User-Access Interface

Functional Groupings represent the sets of related functional capabilities needed for a particular B-ISDN user-access interface. The following groupings have been designated:

- **B-TE1** a B-ISDN terminal;
- **B-TE2** a non-B-ISDN terminal;
- **B-TA** a terminal adapter (allows non-ISDN terminals to operate in a B-ISDN);
- **B-NT1** a device for connecting 4-wire subscribers to the conventional 2-wire loop (performs physical layer functions);
- **B-NT2** a more intelligent device typically found in a digital PBX (performs OSI layer 2 and 3 link and network functions);
- **B-LT** B-ISDN line termination equipment.

Reference points are the logical interfaces between functional groupings, and usually correspond to a physical interface between pieces of equipment. The following reference points have been designated:

- **R** a non-ISDN interface (typically, physical layer interfaces such as EIA-232-E, V.35, etc.);
- **S_B/T_B** ISDN interfaces (these interfaces are international standards);
- **U_B** the 2-wire side of the NT1 (this interface is a national standard which may vary from country to country).

2.4 THE ATM COMMUNICATIONS PROCESS

ATM is a communications process based on a simple and fast transport relay mechanism. This process relies on the accomplishment of the more complex communications functions, such as call connection, termination, addressing, sequencing, and payload error control, to be handled external to the "network" at the transmitting and receiving ends. Within the network, an ATM switch receives a cell from the transmission media, performs a quick check that the information in the cell header is valid, reads the address contained in the header, and then routes the cell to an output port for transmission to the next destination. The switch then moves to the next cell, which is most likely part of an entirely different message, and repeats the process. At no time is it necessary to gather more information than that contained in the cell header, nor refer to information provided by a previous cell. The network is not concerned with the relationship between groups of cells, nor with the processing of the data contained in the information field. A schematic of this process is shown in Figure 2.10.

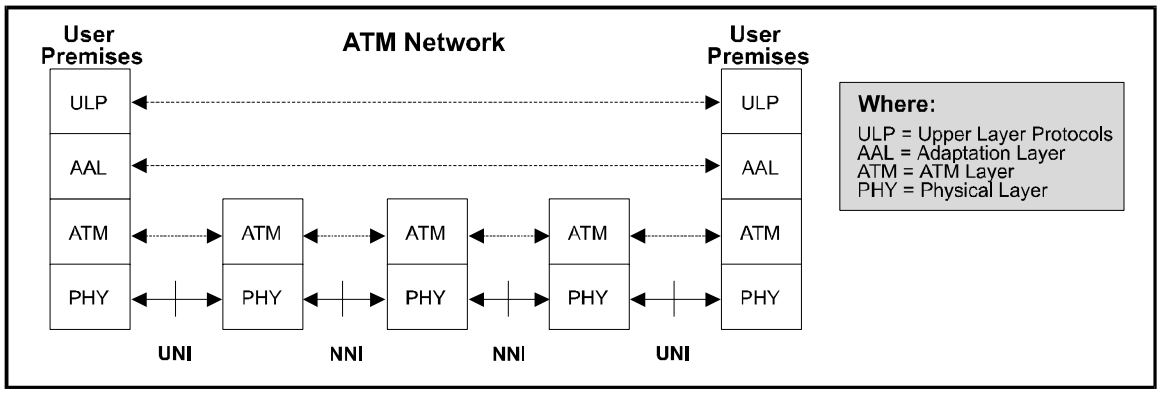

Figure 2.10 Association between User and Network Functions

2.4.1 ATM Networking

ATM networking depends on the establishment of connections between adjacent Layer 2 ATM entities. This means that ATM is a connection-oriented service since no information is transferred until these connections are established. However, as stated earlier, a principal benefit of ATM is that it does not require the pre-establishment of a physical path through the network before information transfer can begin. This apparent contradiction is resolved through the use of virtual channels and virtual paths to establish end-to-end virtual circuit connections which are identified by the VPI/VCI address in the ATM cell header. These virtual connections may be established either on demand, as in any circuit switched service, or pre-provisioned as is typical in a private network. Thus the user-to-user ATM connection is a series of physical ATM layer links established on-the-fly as the cell moves through the network.

- A **Virtual Channel (VC)** is a connection between two communicating ATM entities and may consist of a concatenation of several ATM links. All communications proceed along this same VC which preserves cell sequence and provides a certain quality of service. A VC is identified by a **Virtual Channel Identifier (VCI)**.

- A **Virtual Path (VP)** is a grouping of Virtual Channels between ATM switches used to facilitate network management. A VP may be established between two adjacent nodes in the network or involve many ATM links; and provides a grade of service consistent with the most demanding of the constituent VCs. A VP is identified by **a Virtual Path Identifier (VPI)**.

- A **Virtual Circuit Connection (VCC**) is an end-to-end connection consisting of a concatenation of two or more Virtual Channels between two user locations. VCCs may be bundled into a Virtual Path.

VPs provide an effective way for handling traffic heading for the same destination. Intermediate switches need only check the VPI portion of the ATM cell header, rather than the complete three byte VPI/VCI address, in order to relay traffic to the next destination. VPs can be established by the network for trunking purposes or by users to define the structure of their private networks. This concept is illustrated in Figure 2.11. In actual practice, the ATM cells pass one-at-a-time through the channel at the prescribed data rate. The illusion of bundling ATM cells into VCs and VPs is accomplished through the use of information contained in the VPI/VCI fields of the ATM cell header.

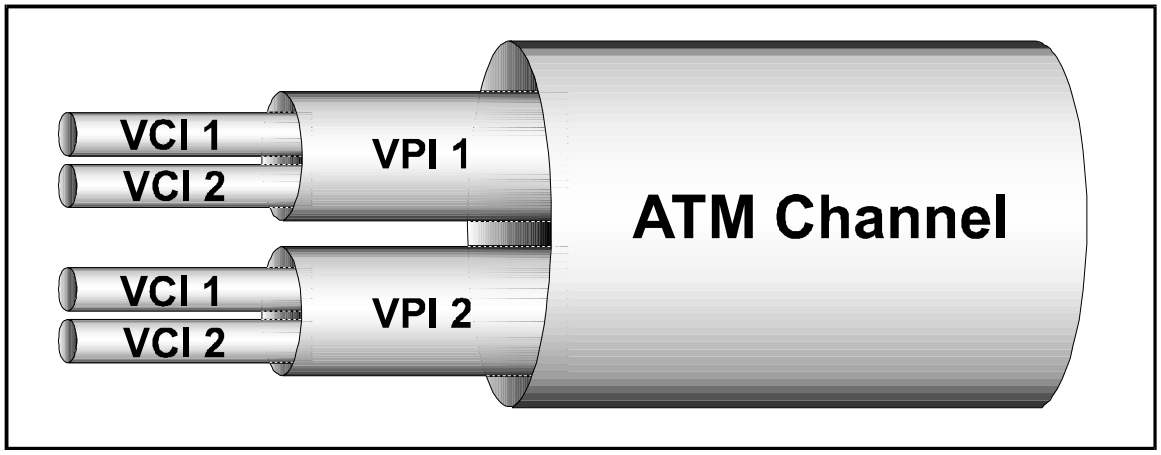

Figure 2.11 Cross Section of a Typical ATM Link

Traffic at the UNI is identified by the VCI/VPI address. Users are assigned these values when (a) the user enters into a session with a network as a connection on demand, or (b) when provisioned to the network with a permanent service connection. However, unlike telephone numbers, VCIs and VPIs have only local significance within the ATM network and do not apply end-to-end. How an end-to-end circuit connection is established from a collection of VCI/VPI addresses is treated in the next Section.

2.4.2 ATM Switching

ATM switches operate very differently from today's analog or digital switches which depend on the pre-establishment of a physical path through a cross-point or time-slot switching fabric based on information received from the source. This process is adequate for switching calls lasting seconds or minutes, but can not cope with switching ATM cells that last only microseconds when passing through the switch at 155 Mbit/s. For this reason, ATM switches use self-routing procedures wherein the ATM cell finds its own path through the switch fabric based on the addressing information contained in the cell header, rather than relying on an external process for establishing and tearing down a fixed path.

A self-routing switch relies on information contained in the VPI/VCI fields of the cell header to identify the proper output port to which the cell should be routed. This is accomplished through the use of routing tables which are set up in advance based on the network topology, but dynamically adjusted to reflect current traffic conditions. Based on the information in the routing tables, the switch adds a temporary routing header or "tag" to the cell and, at the same time, overwrites the VPI/VCI fields in the ATM cell header with new values for use in the next ATM network link. The ATM cell and its attached routing tag are then passed through the switching fabric by a series of switching elements that make routing decisions based on the contents of the tag. At the output port, the tag is removed and the ATM cell is passed on to the next switch or network termination point. A simplified illustration of this process is shown in Figure 2.9. It is important to note that the next cell passing through the switch may take an entirely different path.

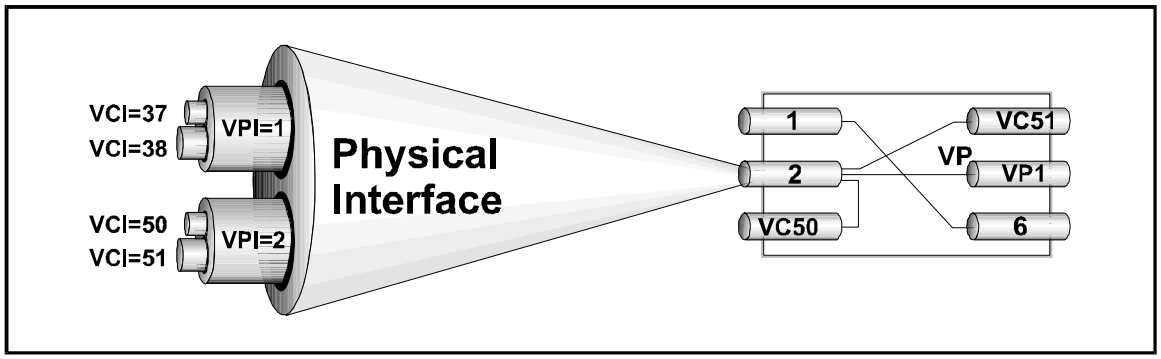

Figure 2.12 A Simplified ATM Switch

2.4.3 ATM Signaling

ATM end-users require the capability to establish connections across the network. This can be accomplished either on a fixed basis by the network provider provisioning a Permanent Virtual Circuit (PVC) between the two end-points desired; or on a dynamic basis by using some signaling mechanism to establish a temporary Switched Virtual Circuit (SVC). The signaling mechanism used for ATM is based on ISDN Signaling System Number 7 (SS7) or a modification of SS7 for application in the B-ISDN known as the B-ISDN Digital Subscriber Signaling System No.2 (DSS2 or ITU-T Recommendation Q.2931). The use of these signaling protocols can be viewed as a higher layer application running on top of the AAL as shown in Figure 2.13.

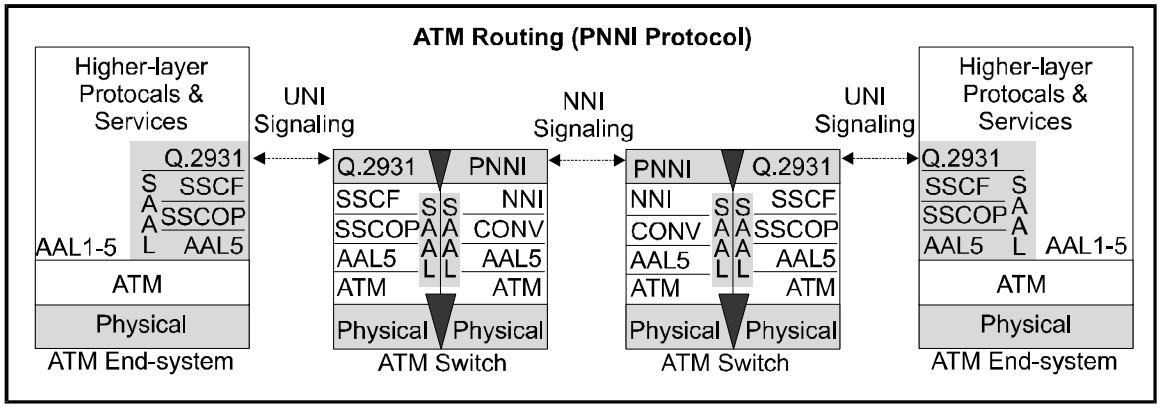

Figure 2.13 ATM Signaling

The Q.2931 signaling protocol is adapted for ATM use by adding a **Signaling ATM Adaptation Layer (SAAL)** between Q.2931 and the top of the ATM protocol stack. The SAAL provides for the reliable transport of signaling messages between two ATM systems, to include the recovery of multiple gaps in the data stream. Like the AAL, the SAAL is composed of two sublayers: the common part and a service-specific part. The service-specific part is again subdivided into the **Service-Specific Coordination Function (SSCF)** and a **Service-Specific Connection Oriented Protocol (SSCOP)**. The SSCF maps Q.2931 signaling requirements into the SSCOP, while the SSCOP includes mechanisms for establishing, releasing, and monitoring signaling information exchange between signaling entities. Signaling between the end-system and the ATM switch takes place through a process called **Meta-Signaling** wherein the VPI/VCI address and other parts of the ATM cell header are coded in a variety of formats that uniquely identify a signaling or other non-user payload message. In addition, the network administrator may set QoS parameters for each VC, that include: Peak Cell Rate (PCR), a Sustainable Cell Rate (SCR), a Burst Length (BL), and a Cell Loss Priority (CLP). For a more detailed treatment of ISDN SS7, see the companion NCS Technical Information Bulletin on this subject. An appreciation of the following concepts will help in acquiring a better understanding of the mechanism whereby ATM calls are established:

Connection Types: An ATM Virtual Circuit Connection (VCC) is actually composed of either one or two unidirectional connections, one for each direction traversed. The type of connection is based on the topology of senders and receivers participating in a given application, and is classified as being one of the following four types:

- **Type 1 - point-to-point (pt-pt):** The most basic configuration is a bi-directional point-to-point VCC connecting two single end-users. Bandwidth may be specified separately for each direction, but is generally symmetrical. This type of VCC must traverse the same physical path in both directions;

- **Type 2 - point-to-multipoint (pt-mpt):** A more complex configuration is the unidirectional point-to-multipoint VCC which supports multicast services. The controlling party (the point) is considered the ***root*** and the destinations (mpts) are termed the ***leaves***. In this type of VCC, the signaling mechanism must provide for adding and deleting these individual leaves on demand, either at the initiation of the ***root*** or a particular ***leave***;

- **Type 3 - Multipoint-to-point (mpt-pt):** A Unidirectional multipoint-to-point configuration is the opposite of a Type 2 configuration and requires the re-sequencing of each ATM cell at the root terminal since they arrive from different leaves with the same VPI/VCI address. This type of VCC finds use where data from different servers is merged at a central distribution point that would otherwise require multiple Type 1 connections for the same purpose;

- **Type 4 - multipoint-to-multipoint (mpt-mpt):** A multipoint-to-multipoint configuration supports full multipoint conferencing. This type of VCC requires some type of multipoint conferencing or control unit (MCU) to resolve the re-sequencing problems associated with the multipoint-to-point VCCs.

Relationship between VCCs and ATM Calls: An ATM call may consist of multiple VCCs, each optimized for a particular mode of information transfer, such as the case with a Multimedia (integrated voice/video/data) call. Although this could be accomplished separately for each VCC, it is preferable to group all related VCCs into a single connection request. This concept can be extended to also require that all VCCs associated with a particular ATM call be routed over the same physical path to eliminate the possibility of differential path delay. This can be accomplished by combining associated VCCs into a **Common Routing Group (CRG)** which is then transmitted over the same physical path. At the other extreme, a call consisting of no active VCCs can be used for identifying the available resources at each end of a proposed connection preparatory to completing the connection request. This reduces the chance of a call-initiation failure as a result of incompatible terminal characteristics.

2.4.4 ATM Addressing format

ATM-connected devices use an ATM layer end-system address (AES) in addition to a possible network layer address. The form of this address may differ depending on whether the end-system is connected to a private or public ATM network. The ATM addressing format is patterned after the OSI Network Service Access Point (NSAP)[1] extended to include the addressing structure of the global ISDN numbering plan specified in ITU-T Recommendation E.164. The hierarchical structure of the AES address is shown in Figure 2.14 and is divided into two parts.

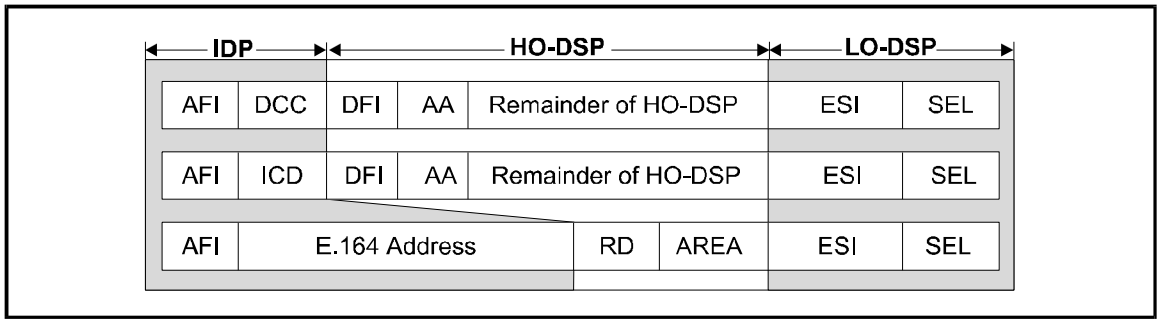

Figure 2.14 The ATM End-System (AES) Addressing Format

Initial Domain Part (IDP): This part contains an **Address Format Identifier (AFI)** which indicates the format being used; and an **Initial Domain Identifier (IDI)** that identifies the international organization responsible of the address space. The IDI can vary in length depending on whether the designated domain is represented by an ISO specified **Data Country Code (DCC)**, an **International Code Designator (ICD)** issued by an authorized international organization, or a public ISDN number in accordance with ITU-T Recommendation E.164. The E.164 address consists of 16 digits formed from the 8 octet E-164 address field. The highest order digit indicates whether the address is ***unicast*** or ***multicast***, while the next one-to-three digits identify the country code. The remainder of the E.164 address is nationally assigned and generally contains a city or area code, an exchange code, and an end-system identifier for a user of the public ATM network or the associated UNI for extension to a private network.

Domain Specific Part (DSP): This part contains the address of the destination user, as designated by the responsible addressing authority, and is further divided into a variable **high-order part (HO-DSP)** and a fixed length **lower-order part (LO-DSP)**. Within the HO-DSP, the **Domain Format Identifier (DFI)** identifies the address format used by the body responsible for assigning the **Address Authority (AA)** field. Assignment of the remainder of the HO-DSP depends on the particular addressing authority and may be based on divisions relating to organizational entities, buildings, switches, or other desired distinctions. The **Routing Domain (RD)** and associated **Area** serve a similar function in the E.164 domain. Within the LO-DSP, the **End-System Identifier (ESI)** identifies an actual end-system and is unique within a particular domain. The **Selector (SEL)** field is

[1] defined in ISO 8348 and Annex A of ITU-T Recommendation X.213

not used in routing and may be used by ATM end-systems for identifying upper layer protocol entities in the user device. Regardless of format, the combined length of the IDP and DSP is 20 octets.

ATM public networks must support the E.164 address and private networks must support all three formats. Provision is also made in the ATM addressing scheme for **Broadcast**, **Multicast**, and **Anycast** modes of data delivery. ***Broadcasting*** involves sending data to all end-systems connected to a particular network; ***Multicasting*** involves the sending of data to only a subset of the end-systems in a single network; while ***Anycasting*** is a new ATM service based on group addressing which may include end-systems on more than one network.

2.4.5 ATM Network Management

ATM network management addresses the five functional areas of configuration, performance, fault isolation, accounting, and security management; and is based on the ITU-T **Telecommunications Management Network (TMN)** model. The TMN defines a separate management network (parallel to the physical network being managed) which consists of five layers: the **Element Layer (EL)**, **Element Management Layer (EML)**, **Network Management Layer (NML)**, **Service Management Layer (SML)**, and **Business Management Layer (BML)**. The last two layers relate to the "business" side of network management and are not treated in this tutorial. The NML provides the network manager with a unified view of the network within a single management domain; and operates through the EML which provides for the grouping of similar **Network Elements (NEs)**. EL is the lowest management layer and performs basic management functions for specific ATM equipment. . These three layers are applicable to the management of a physical network and are mapped into the ATM Forum's management framework as shown in Figure 2.15.

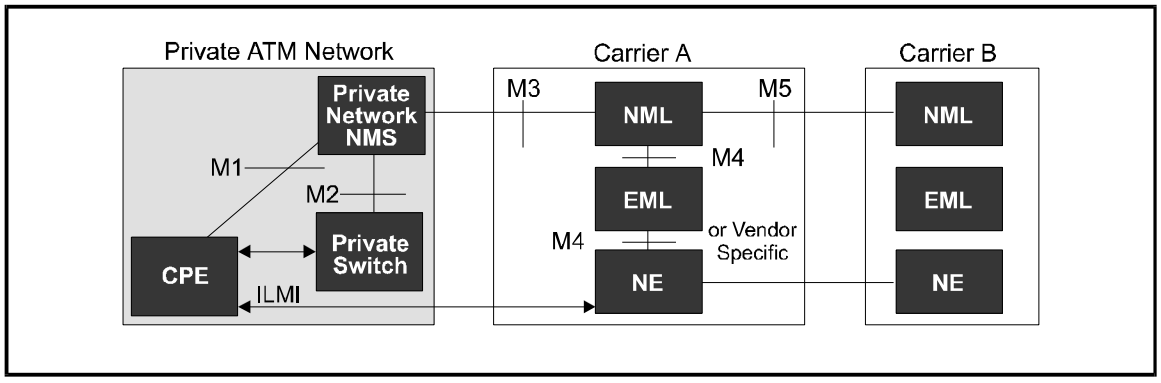

Figure 2.15 ATM Forum Network Management Framework

Management Interfaces: The interfaces between each component of the framework model have particular characteristics and provide for different management capabilities depending on where they are located within the management framework.

- **M1/M2:** These interfaces are between a private network management system (NMS) and it's constituent customer premise equipment (CPE) or private ATM switches. These interfaces are functional only within a single management domain.

- **M3:** Interfaces between private and public networks are required for service activation, troubleshooting, and accounting purposes. The most basic form of this interaction is through the **Interim Local Management Interface (ILMI)** which allows interconnected devices to share basic configuration information. Where more functionality is needed, a **Customer Network Management (CNM)** system based on the M3 interface is utilized. This private network to public carrier interface provides the added functionality required for full inter-management domain system communications, and is divided into three capability classes. Each class provides

increasing user control and are based on the **Simple Network Management Protocol (SNMP)** originally designed for TCP/IP devices but now extended to other devices and functions as well. The third class, which is not yet completely defined, also uses the **Electronic Data Interchange (EDI)** protocol in addition to SNMP.

- **M4:** This interface defines a SNMP or ISO **Common Management Information Protocol (CMIP)** connection within a public switching network. M4 is divided into two sub-interfaces - one connecting the NE and the EML, and the other connecting the EML with the NML.

- **M5:** This interface connects one TMN to another TMN for carrier-to-carrier management information exchange. These capabilities include circuit ordering and provisioning, configuration data verification, trouble administration, performance specification, and accounting.

Management Information Bases (MIBs): MIBs are one of the most important parts of a network management system, and represent various databases of device configuration and performance information needed by management protocols, such as SNMP or CMIP. A MIB is a tree-like data structure, wherein branches represent related functions and end-points contain information related to a specific network element or **object**. Objects are defined in a special language known as **ASN.1 (Abstract Syntax Notation 1)** which is a machine-readable language designed to facilitate location and retrieval of object-oriented information required for the proper functioning of the network management protocol.

A single device will generally include more than one MIB in order to support different networking functions. A special MIB (the **ATM MIB**) has been specified to support the configuration of ATM networks, and is used to define both Virtual Path Connections (VPCs) and Virtual Channel Connections (VCCs) consisting of Virtual Path Links (VPLs) and Virtual Channel Links (VCLs) respectively. A number of other MIBs are also needed in the ATM network to serve functions such as LAN emulation, power management, service management, the interface between a router and Data Service Unit (DSU), the M5 interface connection between two carrier networks, etc. The specific functioning of these MIBs is beyond the scope of this tutorial. However, the main point to remember is that the MIB defines: (a) the objects to be managed, (b) how information relating to these objections can be accessed, and (c) the form in which this information is to be reported.

SECTION 3

ATM STANDARDIZATION

3.0 OVERVIEW

This Technical Information Bulletin (TIB focuses on those standards organizations and associated standards development activities that treat topics directly relating to ATM. The relationship between these organizations and their principal contributions to the growing body of ATM "Standards"[1] is discussed in Section 3.1. The insights and guidelines necessary for identifying which standards organization has jurisdiction over a particular aspect of NS/EP interest is provided in Section 4.

There are a number of ways in which the lists of ATM Standards can be organized to provide a better understanding of how they relate to each other and are combined to provide useful services for the end-user. The more useful of these approaches are by:

- Network Topology (T);
- Protocol Reference Model (P);
- Network Management Architecture (M);
- Service Capabilities (C).

Each approach is briefly described beginning in Section 3.2, with tables provided that list those Standards which relate to each of the functional entities identified. A brief summary of the scope of each Standard is provided in Annex A.

3.1 PRINCIPAL ATM STANDARDS ORGANIZATIONS

The telecommunications industry depends on voluntary adherence to open Standards in order to assure both nationwide and internationally interoperable communication networks. Conformance to established Standards is facilitated by utilizing a formal consensus process in their development that is open to anyone caring to participate. On the U.S. national level, this process is administered by the American National Standards Institute (ANSI) which accredits selected organizations to develop American National Standards. These organizations are referred to as Accredited Standards Committees (ASCs), and include Committee T1 - Telecommunications (or just T1), the Institute of Electrical and Electronic Engineers (IEEE), and the Telecommunications Industry Association (TIA), to name a few. The ASC primarily responsible for ATM standards is Committee T1, with extensions into the LAN environment treated by the project 802 Committee of the IEEE.

[1] The term "Standard" as used in this TIB may refer to either a standard, a Recommendation, or a specification, depending on the custom of the particular group issuing the document (ANSI, ITU, etc.)

At the international level, "accredited" standards bodies are established by formal treaty between nations, such as the International Telecommunications Union (ITU), or by voluntary agreement between the organizations that officially represent a national standardization interest, such as the International Standards Organization (ISO). For the U.S., the interaction between national and international bodies is coordinated through the Department of State for treaty-based organizations and through ANSI for the volunteer groups. The international body having primary responsibility for ATM standardization is the Telecommunications Standardization Sector of the ITU (ITU-T).

In addition to formally accredited standards bodies, there are a number of independent fora and consortia which have been established to address the needs of a particular special-interest group. While these groups are not accredited to write formal standards, many of them have established close ties with the accredited standards bodies having jurisdiction over their specific areas of interest. The fora/consortia tend to focus their activity on developing technical specifications and implementation agreements which have considerable influence in the market place and, thereby, either directly or indirectly affect the formal standards development process. The principal fora/consortia for ATM is the ATM Forum, with the ADSL Forum, DAVIC, Frame Relay Forum, IETF, and SMDS Interest Group each addressing ATM applications within their spheres of interest.

Each of the principal ATM standardization bodies and special interest groups is briefly described below, together with a list of their principal contributions to the body of ATM Standardization[1] . Each entry is cross-referenced to the technical reference model with which it is most closely associated. Where entries may apply to more than one model, only those associations which are most significant are identified.

3.1.1 ADSL Forum:

The Asymmetric Digital Subscriber Line (ADSL) Forum is an association of competing companies established in late 1994 to solve the bandwidth bottleneck between the telecommunications network and the home or offices that still uses existing, twisted-pair copper "telephone" lines. ADSL techniques allow for the transmission of megabits over these twisted-pair lines and are a critical component in the extension of ATM to the home or office not yet directly connected to a high capacity ISDN. In carrying out it's technical work, the Forum advises the various standards body of perceived requirements for standardization in the hope they will take suitable action. The ADSL Forum works closely with Committee T1, the ATM Forum, and DAVIC.

Table 3.1.1 ADSL Documents Relating to ATM

Number	TITLE	P	T	M	C
TR-001	ADSL Forum System Reference Model				**X**
TR-002	ATM over ADSL Recommendations				**X**

[1] The list of ATM related Standards is continually changing with new entries being added and older versions being deleted. The lists of documents provided in this TIB are based on the most reliable information available at the time of writing (Feb 98).

3.1.2 ATM Forum: The ATM Forum is an international non-profit organization formed in 1991 to accelerate the use of ATM products and services through a rapid convergence of interoperability specifications. There are presently over 700 members organized into a Technical Committee, three regional marketing committees, and an end user's Enterprise Network Roundtable. The Technical Committee was created as one worldwide entity in order to promote a single set of global ATM specifications, thereby ensuring interoperability between all vendors of ATM products and services. In carrying out it's basic objectives, the ATM Forum maintains a close working relationship with the accredited standards community, particularly with Committee T1 and ITU-T.

Table 3.1.2 ATM Forum Specifications[1]

Number	TITLE	P	T	M	C
af-uni-0010.002	ATM User-Network Interface (UNI) Specification v3.1		X		
af-bici-0013.003	ATM B-ISDN Inter Carrier Interface (B-ICI) Spec. v2.0		X		X
af-dxi-0014.000	ATM Data Exchange Interface (DXI) Specification		X	X	
af-phy-0015.000	ATM PMD Interface Spec. for 155 Mb/s over TPC	X			
af-phy-0016.000	DS1 Physical Layer Specification	X			
af-phy-0017.000	UTOPIA Specification Level 1 v2.01	X			
af-phy-0018.000	Mid-Range Physical Layer Spec. for Category 3 UTP	X			
af-nm-0019.000	CNM for ATM Public Network Service (M3 Specification)			X	
af-nm-0020.000	M4 Interface Requirements and Logical MIB [ATM Network Element View]			X	
af-lane-0021.000	LAN Emulation Over ATM v1.0		X		
af-test-0022.000	Introduction to ATM Forum Test Specifications				X
af-test-0023.000	PICS Proforma for the DS3 Physical Layer Interface				X
af-test-0024.000	PICS Proforma for the SONET STS-3c PHY Layer Interface				X
af-test-0025.000	PICS Proforma for the 100 Mb/s Multimode Fiber Physical Layer Interface				X
af-pnni-0026.000	Interim Inter-Switch Signaling Protocol (IISP) Spec. v1.0		X		
af-nm-0027.000	CMIP Specification for the M4 Interface v2.0			X	
af-pics-0028.000	PICS Proforma for the UNI 3.0 ATM Layer	X	X		
af-phy-0029.000	6,312 kb/s User-Network Interface Specification v1.0	X	X		
af-test-0030.000	CATS for the UNI 3.0 ATM Layer of Intermediate Systems				X
af-saa-0031.000	Frame Based User-to-Network Interface (FUNI) Specs.		X	X	X
af-phy-0034.000	E3 Public User-Network Interface (UNI) Specification		X		
af-test-0035.000	Interoperability Abstract Test Suite for the ATM Layer				X
af-test-0036.000	Interoperability Abstract Test Suites for the Physical Layer				X
af-test-0037.000	PICS Proforma for the DS1 Physical Layer Interface				X
af-lane-0038.000	LAN Emulation Client Management Specification, v1.0		X	X	
af-phy-0039.000	UTOPIA Level 2 Specification v1.0	X			
af-phy-0040.000	Physical Interface Spec. for 25.6 Mb/s over TPC	X			
af-test-0041.000	Conformance Abstract Test Suite for the UNI 3.0 ATM Layer of End Systems				X
af-test-0042.000	PICS Proforma for AAL5				X

[1] Titles have been abbreviated to fit the available space and to correct for minor editorial inconsistencies which occur in the titles of several ATM Forum Specifications.

Table 3.1.2 (Cont.)

Number	TITLE	P	T	M	C
af-phy-0043.000	A Cell-Based TC Sublayer for Clear Channel Interfaces	X			
af-test-0044.000	PICS Proforma for the 51.84 Mb/s Mid-Range PHY Interface				X
af-test-0045.000	CATS for the UNI 3.1 ATM Layer of Intermediate Systems				X
af-phy-0046.000	622.08 Mb/s Physical Layer Specification	X			
af-phy-0047.000	155.52 Mb/s Physical Layer Spec. for Cat-3 UTP	X			
af-saa-0048.000	Native ATM Services: Semantic Description v1.0		X		X
af-saa-0049.001	Audiovisual Multimedia Services: Video on Demand v1.1		X		X
af-lane-0050.000	LAN Emulation over ATM v1.0 Addendum		X		
af-test-0051.000	PICS Proforma for the 25.6 Mb/s over TPC PHY Interface				X
af-test-0052.000	CATS for the ATM AAL5 Common Part (Part 1)				X
af-phy-0053.000	Addn. to ATM PMD Interface Spec. for 155 Mb/s Over TPC	X			
af-phy-0054.000	DS3 Physical Layer Interface Specification	X			
af-pnni-0055.000	Private Network-Network Interface Specification v1.0		X	X	
af-tm-0056.000	Traffic Management Specification v4.0				X
af-lane-0057.000	LAN Emulation Servers Management Specification v1.0		X	X	
af-nm-0058.000	M4 Network-View Interface Requirements and Logical MIB			X	
af-test-0059.000	PICS Proforma for the UNI 3.1 ATM Layer				X
af-test-0060.000	CATSuite for the UNI 3.1 ATM Layer of End Systems				X
af-sig-0061.000	ATM UNI Signaling Specification v4.0	X	X		
af-phy-0062.000	155.52 Mb/s Physical Layer Interface Specification for Short Wavelength Lasers	X			
af-phy-0063.000	Workable Interface Requirements Example (WIRE)	X	X		
af-phy-0064.000	E1 Physical Layer Interface Specification	X			
af-ilmi-0065.000	Integrated Local Management Interface (ILMI) Spec. v4.0			X	
af-pnni-0066.000	PNNI Spec. v1.0 Addendum (Soft PVC MIB)		X		
af-test-0067.000	Conformance Abstract Test Suite for the SSCOP for UNI 3.1				X
af-bici-0068.000	Addendum to B-ICI Specification v2.0		X		
af-saa-0069.000	ATM Name System Specification v1.0				X
af-test-0070.000	PICS Proforma for the 155 Mb/s Over TPC PMD Interface				X
af-nm-0071.000	AAL Management for the M4 "NE View" Interface			X	
af-nm-0072.000	CES Interworking M4 Interface "NE View" Requirements, Logical and CMIP MIB			X	
af-nm-0073.000	M4 Network View CMIP MIB Specification v1.0			X	
af-nm-0074.000	M4 Network-View Requirements & Logical MIB Addendum			X	
af-pnni-0075.000	Addendum to PNNI v1.0 for ABR Parameter Negotiation		X		X
af-sig-0076.000	Addn. to UNI Signaling v4.0 [ABR Parameter Negotiation]	X			X
af-tm-0077.000	Addn. to Traffic Mgmt. v4.0 [ABR Parameter Negotiation]				X
af-vtoa-0078.000	Circuit Emulation Service (CES) Interoperability Spec. v2.0		X		X
af-phy-0079.000	155 Mb/s Plastic Optical Fiber (POF) and Hard Polymer Clad Fiber (HPCF) PMD Specification	X			
af-test-0082.000	PICS Proforma for DS3 Direct Mapped				X
af-lane-0084.000	LAN Emulation Over ATM L-UNI Specification, v2.0		X		
af-vtoa-0089.000	Voice and Telephony over ATM-ATM Trunking using AAL1 for Narrowband Services		X		
af-lane-0093.000	LAN emulation client Management specification, v2.0		X		

3.1.3 Committee T1: Accredited Standards Committee T1-Telecommunications (Committee T1) is accredited by ANSI to develop American National Standards regarding the interconnection and interoperability of telecommunication networks at the interface with end-user systems, other carriers, information and enhanced service providers, and customer premises equipment. Work is carried out by six Technical Subcommittees (TSCs) which work closely at the international level with their counterparts in ITU-T. This close working relationship often leads to the issue of American National Standards which are an adaptations of their counterpart ITU-T Recommendation and, conversely, to ITU-T Recommendations which are based largely on Committee T1 contributions. Technical Subcommittees T1S1 (Services, Architectures and Signaling) and T1A1 (Performance and Signal Processing) are the TSCs primarily interested in matters pertaining to ATM. However, T1M1 (Internetwork Operations, Administration, Maintenance and Provisioning) and T1X1 (Digital Hierarchy and Synchronization) play a supporting role with respect to the telecommunications management network (TMN) and the SONET physical layer interface.

Table 3.1.3 Committee T1 Standards Relating to ATM[1]

Number	TITLE	P	T	M	C
T1.247-95	OAM&P - Perf. Mgnt. Functional Area Service & Info. Model for Interfaces between Operations Systems and Network Elements			X	
T1.511-94	B-ISDN ATM Layer Cell Transfer-Performance Parameter	X			
T1.627-93	B-ISDN ATM Layer Functionality and Specification	X			
T1.629-93	B-ISDN ATM AAL 3/4 Common Part Functions and Spec.	X			
T1.630-93	B-ISDN ATM Adaptation Layer CBR Service Functionality	X			X
T1.635-94	B-ISDN ATM AAL5 Common Part Functions and Specification	X			
T1.636-94	B-ISDN Signaling ATM Adaptation Layer Overview Description	X			
T1.637-94	B-ISDN ATM AAL - Service Specific Connection Oriented Protocol (SSCOP)	X			
T1.638-94	B-ISDN Signaling ATM Adaptation Layer - Service Specific Coordination Function for Support of Signaling at the UNI	X			
T1.645-95	B-ISDN Signaling ATM Adaptation Layer - Service Specific Coordination Function for Support of Signaling at the NNI	X			
T1.646-95	B-ISDN Physical Layer Specification for User-Network Interfaces Including DS1/ATM	X	X		
T1.652-96	B-ISDN Signaling ATM Adaptation Layer - Layer Management for the SAAL at the NNI	X	X		
T1.662-96	B-ISDN ATM End System Address for Calling and Called Party	X			
TR 46	Transmission Performance Standards Issues on ATM Voice Based Telecommunications Networks			X	
TR 53	Transmission Perf. Guidelines for ATM Technology Intended for Integration into Networks Supporting Voiceband Services			X	

[1] This list does not include the basic SONET and B-ISDN Standards which provide the underlying foundation for ATM operation.

3.1.4 DAVIC: The Digital Audio-Visual Council (DAVIC) is a non-profit Association established in 1994 to promote the success of emerging digital audio-visual applications and services. This is accomplished through the timely development of internationally agreed specifications for open system interfaces and protocols that maximize interoperability between countries, and between the various applications and services. The technical work is carried out by six technical committees whose aim it is to produce a single Technical Specification that is issued in a series of versions, each expanding on the previous work in order to add additional applications and functionality. One of the principal goals of DAVIC is to obtain endorsement of this work by the formal standards bodies through open collaboration with "all players in the field". DAVIC has a particular interest in assuring that it's defined functionalities are supported over ATM.

Table 3.1.4 DAVIC Specifications Relating to ATM

Number	TITLE	P	T	M	C
DAVIC 1.3	DAVIC Specification Part 1: Description of DAVIC Functionalities v1.3]				**X**

3.1.5 Frame Relay Forum: The Frame Relay Forum is an association of vendors, carriers, users, and consultants committed to the implementation of Frame Relay in accordance with national and international standards. The Forum's technical committees take existing ANSI, ITU-T, or other relevant Standards that are necessary but not sufficient for full interoperability, and create Implementation Agreements (IAs) which specify permitted options from the optional parts of the published Standard. In doing this, great care is taken to maintain complete alignment with the relevant standards bodies. Where interoperability considerations require original work by the Forum, the Technical Committee marshals the collective influence of its constituent members to lobby for acceptance of this work within the relevant standards bodies. The Forum has a particular interest in the interworking between Frame Relay and ATM.

Table 3.1.5 Frame Relay Forum Documents Relating to ATM

Number	TITLE	P	T	M	C
FRF.5	Frame Relay/ATM Network Internetworking Implementation Agreement				**X**
FRF.8	Frame Relay/ATM PVC Service Interworking Implementation Agreement				**X**

3.1.6 IEEE: The Institute of Electrical and Electronic Engineers (IEEE) was founded in 1884 to promote the advancement of the theory and practice of electrical engineering, and is the world's largest professional engineering society. The IEEE is an amalgamation of 37 distinct "Societies", each representing a specific technical discipline or industry. ANSI has accredited several of the IEEE societies to develop American National Standards in their areas of expertise. Draft standards are developed in Standards Committees (SCs) established within the various Societies, but carried out under the direction of the IEEE Standards Board. The SC of primary interest to ATM is the Communications Society's 802 Committee on Local Area Networks which is currently addressing the extension of ATM over LANs. The principal interface for the 802 Committee at the international level is the ISO/IEC Joint Technical Committee 1 for Information Technology (ISO/IEC JTC1).

Table 3.1.6 IEEE Standards Relating to ATM

Number	TITLE	P	T	M	C
802.9	Integrated Service (IS) LAN Interface at the Medium Access Control (MAC) and Physical Layers, 1994 (ISO 8802-9)	**X**	**X**		
802.9e	Supplement to IS LAN Interface at the MAC and PHY Layers: ATM Cell Bearer Mode [transport of ATM cells to the desktop in the isochronous information stream of an IEEE 802.9 interface]	**X**	**X**		
802.11	Standard for Wireless LAN Medium Access Control (MAC) and Physical Layer Specification	**X**	**X**		
802.12	Demand Priority Access Method, Physical Layer and Repeater Specification for 100 Mb/s Operation, 1995	**X**			
802.12a	Supplement to 802.12: Operation at Greater than 100 MB/s	**X**			
802.14	Standard Protocol for Cable-TV Based Broadband Communication Network [specifies compatibility with ATM]	**X**			**X**

3.1.7 IETF: The Internet Engineering Task Force (IETF) is the protocol engineering and development arm of the Internet Society (ISOC). From a beginning in 1986 as a forum for technical coordination between contractors working on the ARPANET, it has grown into a large open international community of network designers, operators, vendors, and researchers concerned with the smooth operation of the Internet and evolution of the Internet architecture. The technical work of the IETF is done by working groups organized into nine technical areas whose Directors make up the Internet Engineering Steering Group (IESG). This Group manages the Internet standards process under the auspices of the Internet Society's Internet Architecture Board (IAB) who in turn publish Internet Drafts and Request for Comments (RFCs). Many of these RFCs are regarded by the Internet community as "Standards". The IAB arranges formal liaisons with other standards bodies addressing technical areas of common interest, in particular with ITU-T, ISO/IEC-JTC1, and the ATM Forum.

Table 3.1.7 IETF Standards Relating to ATM

Number	TITLE	P	T	M	C
RFC 1483	Multiprotocol Encapsulation over AAL5	**X**			**X**
RFC 1577	Classical IP and ARP over ATM				**X**
RFC 1626	Default IP Message Transfer Unit for use over ATM AAL5	**X**			**X**
RFC 1695	Definitions of Managed Objects for ATM Management Version 8.0 using SMIv2			**X**	**X**
RFC 1755	ATM Signaling Support for IP over ATM	**X**			**X**
RFC 1821	Integration of Real-time Services in an IP-ATM Network Arch.				**X**
RFC 1932	IP Over ATM: A Framework Document				**X**
RFC 1946	Native ATM Support for Internet Streams Protocol v2+ (ST-II+)	**X**			**X**
RFC 2022	Support for Multicast over UNI 3.0/3.1 based ATM Networks				**X**
RFC 2149	Multicast Server Architecture for MARS-based ATM multicasting				**X**
RFC 2170	Application REQuested IP over ATM (AREQUIPA)				**X**
RFC 2225	Classical IP and ARP over ATM				**X**
RFC 2226	IP Broadcast over ATM Networks				**X**
RFC 2320	Definitions of Managed Objects for Classical IP and ARP over ATM using SMIv2 (IPOA-MIB)			**X**	**X**

3.1.8 ITU-T: The International Telecommunication Union (ITU) is a formal treaty organization, operated under the auspices of the United Nations, consisting of over 160 member nations. The objectives of the ITU are to maintain and extend international cooperation in the use of telecommunications of all types; promote development of technical facilities and their efficient operation; and coordinate member's actions in the attainment of these goals. The ITU is organized into three major Sectors: The Telecommunications Standardization Sector (ITU-T, formerly CCITT), the Radiocommunications Sector (ITU-R, formerly CCIR), and the Development Sector (ITU-D). The U.S. is officially represented in the ITU by the Department of State. The principal aim of the ITU-T is to study technical, operating and tariff questions regarding the international use of telecommunications; and to issue Recommendations (voluntary standards) resulting from these studies with a view toward developing telecommunication standards for use on a worldwide basis.

Table 3.1.8 ITU-T Recommendations Relating to ATM[1]

Number	TITLE	P	T	M	C
G.176	Planning Guidelines for the integration of ATM technology into the PSTN				X
G.702	Digital Hierarchical Bit Rates	X			
G-703	Physical/electrical characteristics of hierarchical digital interfaces	X			
G.774-series	SDH Management information model			X	
G.804	ATM Cell mapping into plesiochronous digital hierarchy (PDH)	X			
G-852.01	Management of the transport network - Enterprise viewpoint for simple subnetwork connection management			X	
G-853.01	Common elements of the information viewpoint for the management of a transport network model			X	
G-854.01	Management of the information viewpoint for the management of a transport network			X	
H.222.1	Multimedia Multiplex and synchronization for Audiovisual communications in ATM environment		X		
H.245	Control protocol for multimedia communication		X		
H.310	Broadband and AV communication systems and terminals		X		
H.321	Adaptation of H.320 visual telephone terminals to B-ISDN environments		X		
I.150	B-ISDN ATM functional characteristics	X			
I.326	Functional architecture of transport networks on ATM		X		
I.356	B-ISDN ATM layer cell transfer performance	X			
I.361	B-ISDN ATM layer specification	X			
I.362	B-ISDN ATM adaptation layer (AAL) functional description	X			
I.363 series	B-ISDN AAL specifications	X			
I.365 series	Frame relaying service specific convergence sublayer (FR-SSCS) and coordination functions	X			X

[1] This list does not include the ITU-T Recommendations which define the basic B-ISDN architecture. Additionally, B-ISDN Digital Subscriber Signaling System No. 2, which provides the underlying foundation for ATM signaling in the B-ISDN, is treated in a separate NCS-TIB.

Number	TITLE	P	T	M	C
I.432 series	B-ISDN UNI: physical layer specifications	X	X		
I.731	Types and general characteristics of ATM equipment		X		
I.732	Functional characteristics of ATM equipment		X		
I.751	ATM management of the network element view			X	
M.3010	Principles of Telecommunications Management Network (TMN)			X	
M.3611	Test management of the B-ISDN ATM layer using TMN			X	X
Q.2100	B-ISDN SAAL overview description	X			
Q.2110	B-ISDN AAL Service specific connection oriented protocol	X			
Q.2119	B-ISDN AAL protocols - Convergence function for SSCOP above the frame relay core service	X			
Q.2130	B-ISDN SAAL - Service specific coordination function for support of signaling at the user-network interface (SSCF at UNI)	X			
Q.2140	B-ISDN AAL - Service specific coordination function for signaling at the network node interface (SSCF at NNI)	X			
Q.2144	B-ISDN Layer management for the SAAL at the NNI	X	X		

3.1.9 SMDS Interest Group: The Switched Multi-megabit Data Service (SMDS) Interest Group was formed to provide an open forum where users can discuss and focus attention on both technical and business application issues related to SMDS. The Group relies on ITU-T standards, developing their own specifications only when needed to address specific implementation issues. The SMDS Interest Group's technical objectives have now been successfully achieved and the technical working groups dissolved.

Table 3.1.9 SMDS Interest Group Standards Relating to ATM

Number	TITLE	P	T	M	C
SIG-TS-008/ 1994	Protocol Interface Specification for Implementation of SMDS over an ATM-based Public UNI [AAL 3/4]				X
SIG-TS- 008/ 1996	Protocol Interface Specification for Implementation of SMDS over an ATM-based Public UNI [AAL 5]				X

3.2. ATM STANDARDS - PROTOCOL MODEL

The ATM portion of the B-ISDN protocol reference model was introduced in Section 2.2 (The ATM Protocol Stack). Specifications for each layer and sub-layer of this stack have been standardized in accordance with the model given in Figure 3.1. A list of Standards relating to each individual layer is given in the following sections.

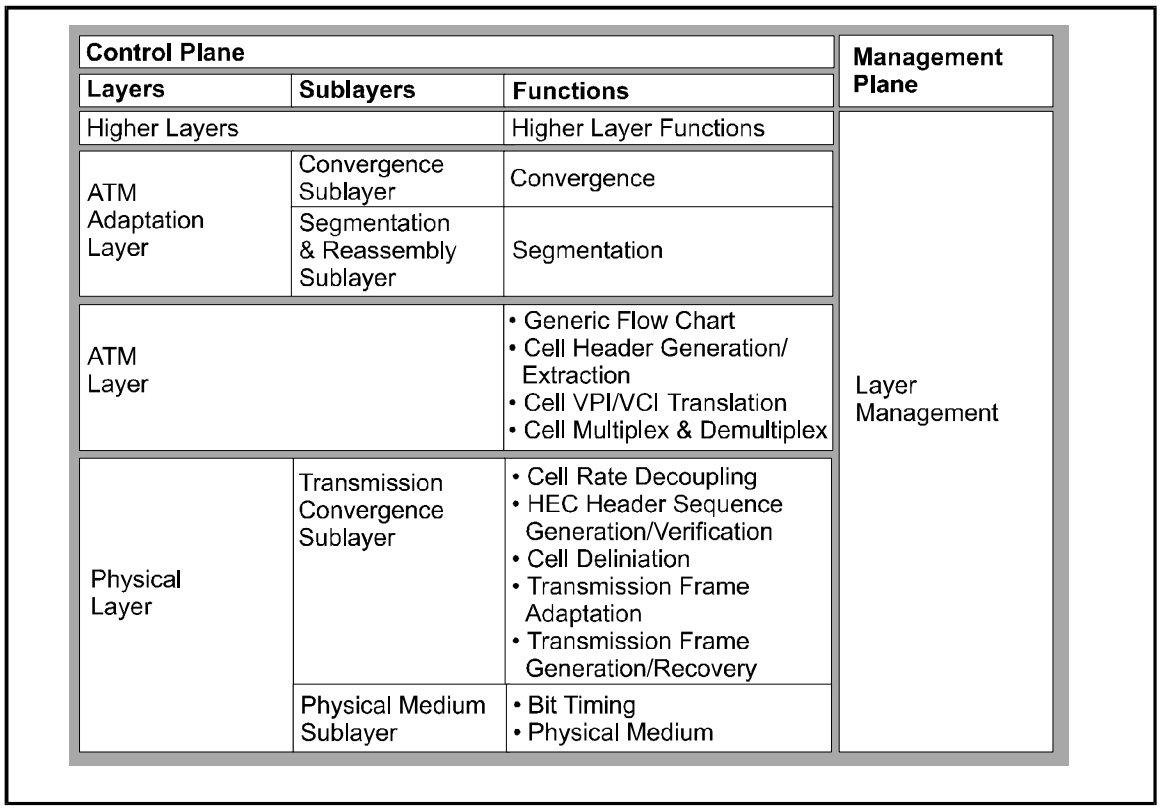

Figure 3.1: ATM Portion of the B-ISDN Protocol Reference Model

3.2.1 ATM Adaptation Layer (AAL)

Standards developed for the AAL provide for the segmentation of higher-layer traffic into a form more suitable for transmission over the ATM network infrastructure; and re-assembly of the segmented traffic into the original form at the receiving location. These processes can be divided into those that relate to the AAL as a whole or specifically to each of the two sublayers. The principal Standards addressing these processes are:

AAL General

- I.150 B-ISDN ATM functional characteristics
- I.356 B-ISDN ATM layer cell transfer performance
- I.362 B-ISDN AAL functional description
- I.363.1 B-ISDN AAL, type 1 (AAL1)specification
- I.363.2 B-ISDN AAL, type 2 (AAL2)specification
- I.363.3 B-ISDN AAL, type 3/4 (AAL3/4)specification
- I.363.5 B-ISDN AAL, type 5 (AAL5) specification
- Q.2100 B-ISDN SAAL overview description
- T1.630-93 B-ISDN AAL CBR Service Functionality
- T1.635-94 B-ISDN AAL Type 5 Common Part Functions and Specification
- T1.636-94 B-ISDN Signaling AAL Overview Description
- T1.662-96 B-ISDN ATM End System Address for Calling and Called Party
- RFC 1483 Multiprotocol Encapsulation over AAL5
- RFC 1626 Default IP Message Transfer Unit for use over ATM AAL5
- RFC 1755 ATM Signaling Support for IP over ATM
- RFC 1946 Native ATM Support for Internet Streams Protocol v2+ (ST-II+)

AAL Convergence Sublayer (AAL-CS)

Common Part

- af-pics-0028 PICS Proforma for the UNI 3.0 ATM Layer
- I.362 B-ISDN ATM adaptation layer (AAL) functional description
- I.365.1 Frame relaying service specific convergence sublayer
- T1.629-93 B-ISDN AAL 3/4 Common Part Functions and Specifications

SSCS/SSCOP

- Q.2110 B-ISDN AAL - Service specific connection oriented protocol (SSCOP)
- Q.2119 B-ISDN AAL protocols - Convergence function for SSCOP above the frame relay core service
- T1.637-94 B-ISDN AAL - SSCOP

SSCS/SSCF

- I.365.2 SSCF to provide CONS
- I.365.3 SSCF to provide COTS
- I.365.4 SSCF for HDLC applications
- Q.2130 B-ISDN SAAL - SSCF at the UNI
- Q.2140 B-ISDN SAAL - SSCF at the NNI
- T1.638-94 B-ISDN SAAL - Service Specific Coordination Function (SSCF) for Signaling
- T1.645-95 B-ISDN SAAL- SSCF at the NNI

AAL Segmentation and Reassembly Sublayer

- I.362 B-ISDN AAL functional description

3.2.2 ATM Layer

Standards developed for the ATM Layer define the structure of the 53-byte ATM Protocol Data Unit (cell) used to transport information between adjacent nodes; the performance parameters which govern cell transfer; and the manipulation of the cell structure for transfer across the User-to-Network Interface (UNI). The principal Standards addressing these topics are:

- I.150 B-ISDN ATM functional characteristics
- I.361 B-ISDN ATM layer specification
- I.361 B-ISDN ATM layer specification
- T1.511-94 B-ISDN ATM Layer Cell Transfer-Performance Parameter
- T1.627-93 B-ISDN ATM Layer Functionality and Specification

3.2.3 The Physical Layer

The B-ISDN physical layer defines the medium used for transmission and is divide into two sublayers: a **physical medium dependent sublayer (PMDS)** which deals with the transfer of bits of data between adjacent network nodes without regard for the higher layer traffic format; and a **transmission convergence sublayer (TCS)** which adapts the higher layer format to the specific characteristics of the medium to be used. Only those Standards required for an understanding of how ATM cells are processed at the Physical Layer are listed below.

- af-phy-0015.000 ATM PMD Interface Spec. for 155 Mb/s over TPC
- af-phy-0016.000 DS1 Physical Layer Specification
- af-phy-0017.000 UTOPIA Specification Level 1 v2.01
- af-phy-0018.000 Mid-Range Physical Layer Spec. for Cat. 3 UTP
- af-phy-0029.000 6,312 kb/s User-Network Interface Specification v1.0
- af-phy-0039.000 UTOPIA Level 2 Specification v1.0
- af-phy-0040.000 Physical Interface Spec. for 25.6 Mb/s over TPC
- af-phy-0043.000 Cell-based TCS for Clear Channel Interfaces
- af-phy-0046.000 622.08 Mbit/s Physical Layer Specification
- af-phy-0047.000 155.52 Mbit/s Physical Layer Spec. for Cat. 3 UPTC
- af-phy-0053.000 Addn. To ATM PMD Interface Spec. for 155 Mb/s over TPC
- af-phy-0054.000 DS3 Physical Layer Interface Specification
- af-sig-0061.000 ATM UNI Signaling Specification v4.0
- af-phy-0062.000 155.52 Mbit/s Physical Layer Interface Spec. for SW Lasers
- af-phy-0063.000 Workable Interface Reqirements Example (WIRE)
- af-phy-0064.000 E1 Physical Interface Specification
- af-sig-0076.000 Addn. To UNI Signaling v4.0 (ABR Parameter Negotiation)
- af-phy-0079.000 155 Mb/s POF and HPCF PMD Specification
- IEEE 802.9&9e Integrated Service LAN Interface at the Medium Access Control (MAC) and Physical Layer, (ISO 8802-9)
- IEEE 802.11 Standard for Wireless LAN MAC and Physical Layer Spec.

- IEEE 802.12 Demand Priority Access Method, Physical Layer and Repeater Spec. for 100 Mb/s Operation
- IEEE 802.14 Standard Protocol for Cable-TV Based Broadband Communication Network [specifies compatibility with ATM]
- G.702 Digital Hierarchial Bit Rate
- G.703 Physical/electrical characteristics of hierarchical digital interfaces
- G.804 ATM Cell mapping into plesiochronous hierarchy (PDH)
- I.150 B-ISDN ATM functional characteristics
- I.432 series B-ISDN UNI: physical layer specifications
- T1.646-95 B-ISDN PHY Layer Spec. for UNIs Including DS1/ATM

3.2.4 Layer Management

Layer management is concerned with the coordination of processes between layers at the various network interfaces. The principal Standards addressing this topic are:

- Q.2144 B-ISDN SAAL - Layer Management for the SAAL at the NNI
- T1.652-96 B-ISDN SAAL - Layer Management for the SAAL at the NNI

3.3 ATM STANDARDS - NETWORK TOPOLOGY

A typical ATM network topology was introduced in Section 2.3. The network interfaces associated with this topology have been standardized in accordance with the model given in Figure 3.2. A list of Standards relating to each interface and end-user capability is given in the following sections.

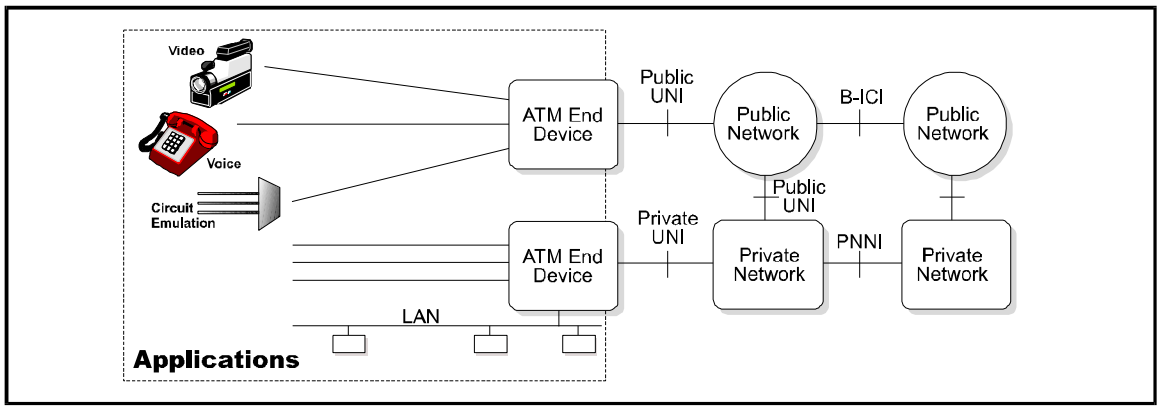

Figure 3.2 ATM Network Architecture

3.3.1 Public User-to-Network Interface (Public UNI): The interface between a public ATM switch and any ATM-capable end-system or user device. The following Standards are of particular interest regarding the Public UNI:

- af-uni-0010.002 ATM User-Network Interface (UNI), v3.1
- af-phy-0034.000 E3 Public UNI
- af-pics-0028.000 PICS Proforma for the UNI 3.0 ATM Layer
- af-sig-0061.000 ATM UNI Signaling Specification v4.0
- I.432.2 B-ISDN UNI: physical layer for 155.520/622.080 Mbit/s
- I.432.3 B-ISDN UNI: physical layer for 1.544/2.048 Mbit/s
- I.432.4 B-ISDN UNI: physical layer for 51.840 Mbit/s
- I.432.5 B-ISDN UNI: physical layer for 25. 6 Mbit/s
- T1.646-95 B-ISDN Physical Layer Spec. for UNIs Including DS1/ATM

3.3.2 Private User-to-Network Interface (Private UNI): The interface between a private ATM switch and any ATM-capable end-system or user device. The following Standards are of particular interest regarding the Private UNI:

- af-phy-0029.000 6.312 Mbit/s User-Network Interface Specification
- af-saa-0031.000 Frame Based User-to-Network Interface (FUNI)

3.3.3 Network-to-Network Interface (NNI): The NNI is better characterized as a switch-to-switch interface. The term NNI, by itself, generally refers to the interface between switches within a public ATM network operated by a single network provider. The following Standards are of particular interest regarding the NNI:

- Q.2144 B-ISDN SAAL- layer management for the SAAL at the NNI
- T1.652-96 B-ISDN SAAL- layer management for the SAAL at the NNI

3.3.4 Broadband Inter-Carrier Interface (B-ICI): The B-ICI is the ATM trunking interface between two different service providers, and can be considered to be a class of the NNI. The following Standards are of particular interest regarding the B-ICI:

- af-bici-0013.003 B-ISDN B-ICI Specification, v2.0 (integrated)
- af-bici-0068.000 B-ISDN B-ICI Specification, Addendum to v2.0
- I.326 Functional Architecture of transport networks on ATM

3.3.5 Private Network-to-Network (Node) Interface (PNNI): The inter-switch interface within a private ATM domain. The PNNI trucking protocol provides for hierarchical ATM-layer routing and quality of service (QoS) support. The following Standards are of particular interest regarding the PNNI:

- af-pnni-0026.000 Interim Inter-switch Signaling Protocol (IISP) Spec.
- af-pnni-0055.000 PNNI Specification v1.0
- af-pnni-0066.000 PNNI Specification v1.0 addum (Soft PVC MIB)
- af.pnni-0075.000 PNNI Specification v1.0 addum (ABR parameter negotiation)

3.3.6 End System/Device Emulation: The following standards pertain to the interface between ATM compatible end-user systems and devices:

LAN Emulation

- af-lane-0021.000 LAN Emulation over ATM Specification
- af-lane-0050.000 LAN Emulation over ATM Specification - addum
- af-lane-0038.000 LAN Emulation - Client Management Specification
- af-lane-0057.000 LAN Emulation - Server Management Specification
- af-lane-0084.000 LAN Emulation over ATM - LUNI Specification
- af-lane-0093.000 LAN Emulation Client Management Specification v2.0
- IEEE 802.9 Integrated Service LAN Interface at the MAC and PHY Layers
- IEEE 802.9e Supplement to 802.9: ATM Cell Bearer Mode
- IEEE 802.11 Standard for Wireless LAN MAC and PHY Layer Specification

Circuit Emulation

- af-vtoa-0078.000 Circuit Emulation Service (CES) Interoperability Specification v2

Video over ATM

- af-saa-0049.000 Audiovisual Multimedia Services: Video on Demand
- H.222.1 Multimedia multiplex and synchronization for audiovisual communications in an ATM environment
- H.245 Control protocol for multimedia communications
- H.310 Broadband and AV communication systems and terminals
- H.321 Adaptation of H.320 visual telephone terminals to B-ISDN

Audio over ATM

- af-vtoa-0089.000 Voice/Telephony over ATM using AAL1 N-band Services
- (T1) TR 46 Transmission Performance Standards Issues on ATM Voice Based Telecommunications Networks
- (T1) TR 53 Transmission Performance Guidelines for ATM Technology Intended for Integration into Networks Supporting Voiceband Services

End Devices

- af-test-0041.000 Conformance Abstract Test Suite for the UNI 3.0 ATM Layer End Systems
- af-saa-0048.000 Native ATM Services: Semantic Description
- af-test-0060.000 Conformance Abstract Test Suite for the UNI 3.1 ATM Layer End Systems
- af-dxi-0014.000 ATM Data Exchange Interface (DXI) Specification
- af-phy-0063.000 Workable Interface Requirements (WIRE)
- I.731 Types and general characteristics of ATM equipment
- I.732 Functional characteristics of ATM equipment

3.4 ATM STANDARDS - NETWORK MANAGEMENT ARCHITECTURE

The ATM network management framework was introduced in Section 2.4.4. The five management interfaces associated with this framework have been standardized in accordance with the model given in Figure 3.3. A list of Standards relating to each interface is given in the following sections.

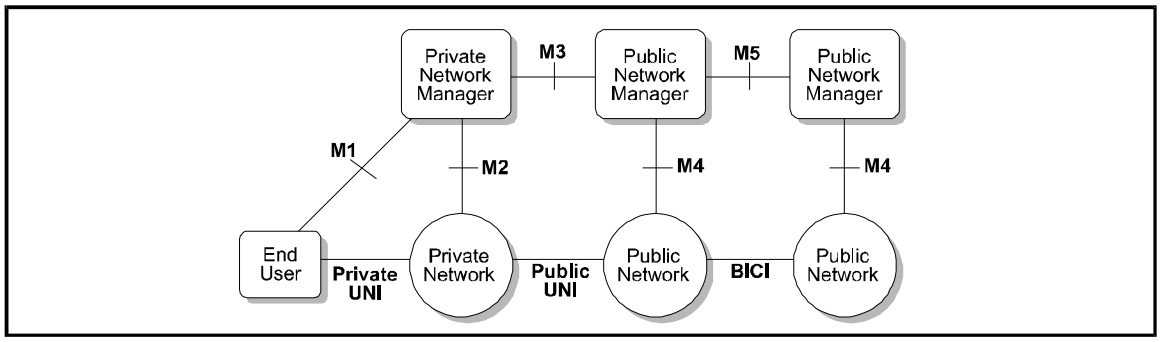

Figure 3.3 ATM Network Management Interface Reference Model

3.4.1 M1 Interface

- af-dxi-0014.000 ATM Data Exchange Interface (DXI) Specification
- af-lane-0038.000 LAN Emulation-Client Management Specification
- af-lane-0057.000 LAN Emulation-Server Management Specification
- IETF RFC 1695 Definitions of Managed Objects for ATM Management v8.0 using SMIv2
- G.774 series SDH Management Information Model
- T1.247-95 OAM&P-Performance Mgmt. Func. Area Services & Information Model for Interfaces between Operations Systems & Network Elements

3.4.2 M2 Interface

- af-saa-0031.000 Frame Based User-to-Network Interface (FUNI)
- af-lane-0038.000 LAN Emulation-Client Management Specification
- af-pnni-0055.000 Private Network Node Interface Specification v1.0
- af-lane-0057.000 LAN Emulation-Server Management Specification
- IETF RFC 1695 Definitions of Managed Objects for ATM Management v8.0 using SMIv2
- G.774 series SDH Management Information Model
- T1.247-1995 OAM&P-Performance Mgmt. Func. Area Services & Information Model for Interfaces between Operations Systems and Network Elements

3.4.3 M3 Interface

- af-nm-0019.000 Customer Network Management (CNM) for ATM Public Network Services
  (M3 Specification)

3.4.4 M4 Interface

- af-nm-0020.000 M4 Interface Reqs. and Logical MIB: ATM Network Element (NE) view
- af-nm-0027.001 CMIP Specification for M4 "NE" view Interface v2.0
- af-nm-0058.000 M4 Public Network View Specification
- af-nm-0071.000 AAL Management for the M4 "NE" view Interface
- af-nm-0072.000 CES Interworking M4 Interface "NE View" Requirements
- af-nm-0073.000 M4 Network View CMIP MIB Specification v1.0
- af-nm-0074.000 M4 Network-View Requirements and Logical MIB Addendum
- IETF RFC 1695 Definitions of Managed Objects for ATM Management v8.0 using SMIv2
- G.774x SDH Management Information Model
- G.852.01 Management of the transport network-Enterprise viewpoint for simple subnetwork connection management
- G.853.01 Common elements of the information viewpoint for the management of a transport network
- G. 854.01 Management of the transport network-Computational interfaces for basic transport network model
- I.751 ATM management of the network element
- T1.247-1995 OAM&P-Performance Mgmt. Func. Area Services & Information Model for Interfaces between Operations Systems and Network Elements

3.4.5 M5 Interface

The M5 Interface is currently under development in Committee T1

3.4.6 Other

- af-ilmi-0065.000 Integrated Local Management Interface (ILMI) Spec. v4.0
- M3611 Test Management of B-ISDN ATM layer using TMN
- RFC 2320 Definitions of Managed Objects for Classical IP and ARP over ATM using SMIv2 (IPOA-MIB)
- M.3010 Principles of Telecommunication Management Network (TMN)

3.5 ATM STANDARDS - SERVICE CAPABILITY

The documents specified in Sections 3.2 through 3.4 provide the foundation for all ATM services and capabilities. In addition to these foundation documents, the following references add additional clarification or capabilities.

3.5.1 Connection Types:

Permanent Virtual Circuits (PVC)

- af-bici-0013.001 B-ISDN Inter-Carrier Interface (B-ICI) Spec. v1
- af-saa-0048.000 Native ATM Services: Semantic Description

Switched Virtual Circuits (SVC)

- af-bici-0013.002 B-ISDN Inter-Carrier Interface (B-ICI) Spec. v2
- af-saa-0048.000 Native ATM Services: Semantic Description

3.5.2 Service Categories:

Constant Bit Rate (CBR)

- af-vtoa-0078.000 Circuit Emulation Service Interoperability Spec.
- T1.630-1993 B-ISDN AAL CBR Service Functionality and Spec.

Available Bit Rate (ABR)

- af-tm-0056.000 Traffic Management Specification
- af-pnni-0075.000 Addendum to PNNI v1.0 (ABR parameter negotiation)
- af-sig-0076.000 UNI Signaling Addendum (ABR parameter negotiation)
- af-tm-0077.000 Traffic Management Adm for ABR parameter negotiation

3.5.3 User Functionality

- af-saa-0049.001 Audiovisual Multimedia Services: Video on Demand v1.1
- af-saa-0069.000 ATM Name System Specification v1.0
- DAVIC 1.3 DAVIC Specification Part 1: Description of DAVIC Functionalities, v1.3

3.5.4 Interworking with other Services/Networks

Frame Relay

- af-saa-0031.000 Frame Based User-Network Interface (FUNI) Specifications
- I.365 series Frame relaying service specific convergence sublayer (FR-SSCS) and coordination functions
- FRF.5 Frame Relay/ATM Network Internetworking IA
- FRF.8 Frame Relay/ATM PVC Service Internetworking IA

ADSL

- TR-001 ADSL Forum System Reference Model
- TR-002 ATM over ADSL Recommendations

SMDS

- SIG-TS-008/94 Protocol Interface Specification for Implementation of SMDS over an ATM-based Public UNI [for AAL 3 /4]
- SIG-TS-008/94 Protocol Interface Specification for Implementation of SMDS over an ATM-based Public UNI [for AAL 3 /4]

INTERNET

- RFC 1483 Multiprotocol Encapsulation over AAL5
- RFC 1577 Classical IP and ARP over ATM
- RFC 1626 Default IP Message Transfer Unit for use over ATM AAL5
- RFC 1695 Definitions of Managed Objects for ATM Mgmt v8.0 using SMIv2
- RFC 1755 ATM Signaling Support for IP over ATM
- RFC 1821 Integration of Real-time Services in an IP-ATM Network Arch.
- RFC 1932 IP Over ATM: A Framework Document
- RFC 1946 Native ATM Support for Internet Streams Protocol v2+ (ST-II+)
- RFC 2022 Support for Multicast over UNI 3.0/3.1 based ATM Networks
- RFC 2149 Multicast Server Architecture for MARS-based ATM multicasting
- RFC 2170 Application REQuested IP over ATM (AREQUIPA)
- RFC 2225 Classical IP and ARP over ATM
- RFC 2226 IP Broadcast over ATM Networks
- RFC 2320 Definitions of Managed Objects for Classical IP and ARP over ATM using SMIv2 (IPOA-MIB)

Other Services/Networks

- G.176 Planning Guidelines for integration of ATM technology into PSTN
- IEEE 802.14 Standard Protocol for Cable-TV Based Broadband Communication Network [specifies compatibility with ATM]

3.5.5 Testing

- af-test-0022.000 Introduction to ATM Forum Test Specifications
- af-test-0023.000 PICS Proforma for the DS3 Physical Layer Interface
- af-test-0024.000 PICS Proforma for the SONET STS-3c PHY Layer Interface
- af-test-0025.000 PICS Proforma for the 100 Mb/s Multimode Fiber Physical Layer Interface
- af-test-0030.000 CATS for the UNI 3.0 ATM Layer of Intermediate Systems
- af-test-0035.000 Interoperability Abstract Test Suite for the ATM Layer
- af-test-0036.000 Interoperability Abstract Test Suites for the Physical Layer
- af-test-0037.000 PICS Proforma for the DS1 Physical Layer Interface
- af-test-0041.000 CATS for the UNI 3.0 ATM Layer of End Systems
- af-test-0042.000 PICS Proforma for AAL5
- af-test-0044.000 PICS Proforma for the 51.84 Mb/s Mid-Range PHY Interface
- af-test-0045.000 CATS for the UNI 3.1 ATM Layer of Intermediate Systems
- af-test-0051.000 PICS Proforma for the 25.6 Mb/s over TPC PHY Interface
- af-test-0052.000 CATS for the ATM AAL5 Common Part (Part 1)
- af-test-0059.000 PICS Proforma for the UNI 3.1 ATM Layer
- af-test-0060.000 CATS for the UNI 3.1 ATM Layer of End Systems
- af-test-0067.000 Conformance Abstract Test Suite for the SSCOP for UNI 3.1
- af-test-0070.000 PICS Proforma for the 155 Mb/s Over TPC PMD Interface
- af-test-0082.000 PICS Proforma for DS3 Direct Mapped
- M.3611 Test management of the B-ISDN ATM layer using TMN

SECTION 4

ATM STANDARDS ASSESSMENT

4.1 NCS Standardization Objectives

NS/EP telecommunications are required to maintain Government services through all types of conditions and hazards. In performing these critical services, NCS users place more stringent requirements on the telecommunication networks that serve them than do other users. NCS programs supporting these special NS/EP needs exhibit the following functional requirements:

- Priority information exchange;
- Priority service provisioning and restoration procedures;
- Emergency broadcast capability;
- Sustainable coordinating mechanisms;
- Interoperable services;
- Protected information support;
- Assured and reliable service;
- Network security.

In providing NS/EP telecommunication support, the NCS utilizes commercial networks and services whenever possible. To insure that commercial telecommunications are up to the task of supporting critical NS/EP needs, the OMNCS actively participates in the commercial standards development process that drives the evolution of commercial network capabilities. This participation focuses on achieving the following standardization objectives:

- **Interoperability (I) -** the ability of heterogeneous devices to effectively communicate and process information. Devices are taken to refer both to customer devices and network devices such as switches. In network terms, this translates into the ability of networks to provide access to a range of devices and services between differing networks in a seamless manner.

- **Network Management (M) -** the ability of the network operator to manage internal network operations, such as monitoring, control, reliability, restoration, and support for evolving capabilities. By supporting a Telecommunications Management Network (TMN) concept, this goal also supports the ability of network operators to manage inter-networked services (network to network interfaces) and address end-user concerns (user-to-network interfaces).

- **Applications/Services (A) -** the description and development of functionalities for network services such as wireless (digital cellular, land mobile radio, and PCS), facsimile, HF radio, High Speed (ISDN, B-ISDN, ATM, and SONET), multimedia (video teleconferencing and imagery), and Emergency Broadcast Services. Most of these services may be interactive.

- **Performance (P)** - the provision of service availability and quality of service over a broad range of network operating conditions, especially connectivity under periods of stress and congestion.

- **Security (S) -** the development of telecommunications networks and services which provide for both information security as a service and the physical security of the underlying network infrastructure.

4.2 NCS STANDARDIZATION NEEDS

ATM is a key enabling technology for achieving NCS standardization objectives. Behind ATM is the emerging recognition of the need for a new communications and networking paradigm to meet changing user requirements for seamless, end-to-end global telecommunications. This has resulted in ATM development being driven primarily by end-users (from the bottom up) rather than by service-providers (from the top down) as has been the case for past telecommunications innovations such as SONET and ISDN. However, commercial standards development is still a market driven, consensus process that exhibits a number of characteristics which may not be fully responsive to NS/EP needs:

Development priority - Service providers and equipment manufacturers are the principal source of participants and financial support for commercial standards development projects. As such, they tend to dominate the setting of agendas and priorities for commercial standards development. The initiation of projects to support requirements that do not appear to offer an acceptable profit potential can not be expected without strong user sponsorship and active participation in the process;

Service functionality - Since service providers and equipment manufacturers tend to dominate the standards process, it is their perception of user needs (strongly biased by market considerations) which generally drives the service features to be developed. The establishment of the ATM Form, with increased user participation, has mitigated this problem somewhat, but still requires NCS involvement to insure that specialized NS/EP needs are adequately expressed;

Network extension - ATM is primarily a broadband technology developed to support B-ISDN, but also has great promise for extension out to the home/office or mobile user as well. While the entertainment market is driving ATM the "last mile" to the home, there is much less emphasis on overcoming the spectrum limitations necessary to do the same for the mobile phone. Since NS/EP crisis management depends heavily on increasingly sophisticated mobile communications, the NCS has a strong interest in seeing that ATM is developed for implementation in the mobile environment as well;

Implementation options - In order for the consensus process to work, there is a need for considerable comprise in arriving at a final product. This comprise often leads to the establishment of several standardized options for implementing certain features of a given standard. This can pose a serious problem for heterogeneous groups, such as the NCS, unless specific implementation guidelines are developed specifying which options are needed for achieving the desired functionality and end-to-end interoperability;

End-user interface - Development of standards for the national segment of many international telecommunications services, such as ISDN, is generally left to the discretion of national or regional standards bodies. For the most part, these bodies following a similar path. However, when equipment manufacturers have a more regional focus, these standards may result in terminal equipment and end-systems which will not work in other regions. An example is the development of the mobile air interface to the public ATM network which is being approached differently in Europe, North America, and Japan. This requires NCS members (such as DoD and DoS) who have operational commitments in more than one "standardization" region to either maintain separate equipment inventories or to develop expensive "black box" interface devices for connecting U.S. equipment into foreign commercial networks. In many cases, such problems can be either reduced or entirely eliminated by a strong NCS presence during the initial standards development process.

Performance - In the past, bandwidth limitations in the transmission network has conditioned users to expect limitations in the quality of service provided . With the emergence of broadband ATM-based networks, these limitations are being drastically reduced, if not eliminated entirely. However, in many cases, the approach taken for specifying the performance to be provide by these new services is still based on the old "network-limited" paradigm and requires active user participation in the development of performance standards if their expectations for these new services are to be fully realized.

4.3 Assessment of ATM Standards Activity

There are a number of commercial standards bodies addressing matters relating to ATM. These bodies can be divided into three groups based on their potential for impacting NCS standardization objectives. The first group (ATM Forum, T1S1, and ITU-T Study Groups 11 and 13) are the key ATM standards setting bodies and, as such, are the most important from an NCS point-of-view. The second group (the IETF, T1A1, T1M1, and ITU-T Study Groups 2, 4, 12 and 16) play a major supporting role in the area of ATM standardization and are also important for achieving NCS objectives. The third group contains the remaining standards bodies that deal with ATM issues (such as the ADSL Forum, DAVIC, Frame Relay Forum, the IEEE Project 802 committee, and the SMDS Interest Group). This latter group, although important to the standardization process, deal with ATM related issues which either do not impact NS/EP requirements, or whose outcome is predictable and supportive of NCS interests. The relationship between the activities of the first two groups and the associated NCS Standardization Objectives which they support is shown in Table 4.1. The particular activities of each group relating to these standardization objectives are summarized in the following paragraphs.

Table 4.1. Important ATM Standards Bodies for NS/EP Objectives

Organization	I	M	A	P	S
ATM Forum	**X**	**X**	**X**	**X**	**X**
IETF	**X**				**X**
ITU-T SG2			**X**		
ITU-T SG4		**X**			
ITU-T SG 11	**X**				**X**
ITU-T SG 12				**X**	
ITU-T SG 13	**X**	**X**		**X**	
ITU-T SG 15	**X**				
ITU-T SG 16	**X**		**X**		
T1A1				**X**	**X**
T1M1		**X**			
T1S1	**X**				

4.3.1 Key Standardization Activities - These standards bodies represent the main driving force behind the development of ATM, and are the principal source of new innovations in service development and implementation. The activity of these groups is dynamic and may change focus over time, thus requiring a continuing NCS presents to ensure that overall work objectives and project priorities are fully responsive to NS/EP standardization needs.

ATM Forum: In addition to its marketing activities, the ATM Forum has established a Worldwide Technical Committee to provide a global frame of reference for promoting a single set of implementation specifications, thereby maximizing the opportunity for interoperable ATM products and services. The Technical Committee currently has 12 technical working groups, all of which treat matters directly relating to ATM. The following working groups address issues of particular interest for the NCS:

- WG for Network Management
- WG for Security
- WG for Service Aspects and Applications
- WG for Voice and Telephony over ATM
- WG for Wireless ATM

T1S1 (Services, Architectures and Signaling): T1S1 is the Committee T1 Technical Subcommittee responsible for developing standards and technical reports relating to new telecommunications services and their supporting architectures and enabling signaling protocols, of which ISDN, B-ISDN, SS7, and Intelligent Networks (INs) are the most prominent. T1S1 is the principal North American focal point for work to be submitted to ITU-T Study Groups 11 and 13, and maintains a close working relationship with the ATM Forum. The following working groups are most concerned with matters pertaining to ATM:

- T1S1.1 Architecture and Services
- T1S1.5 Broadband ISDN

ITU-T SG11 (Signaling Requirements and Protocols): SG11 is responsible for studies relating to signaling requirements and protocols for telephone, N-ISDN, B-ISDN, Universal Personal Telecommunications (UPT), mobile, and Multimedia communications. SG11 is the Lead ITU-T Study Group for Intelligent Network (IN) and Future Public Land Mobile Telecommunications Networks (FPLMTS). With regard to ATM, SG11 is the principal focal point for developing enhancements to Signaling System-7 (SS7) to support B-ISDN. Although much of the work of SG11 affects ATM developments, the following efforts are of particular importance:

- Q1/11 - Signaling and Protocol Framework for an Evolving Environment
- Q3/11 - Access and Network Security Requirements
- Q15/11 - Asynchronous Transfer Mode Adaptation Layer for Signaling

ITU-T SG13 (General Network Aspects): SG13 is responsible for studies relating to general network aspects and the initial studies of the impact of new system concepts and innovative technologies on telecommunication networks with far-reaching consequences. SG13 is the Lead ITU-T Study Group for GII, B-ISDN, and General Network Aspects. Within its general area of responsibility, SG13 addresses matters such as architectures, capabilities and interfaces, network performance and interworking; and is the principal architect for ATM. Most of SG13 work, either directly or indirectly, affects ATM developments. The following study questions are considered to be the basic core group:

- Q4/13 - ATM Layer
- Q5/13 - ATM Adaptation Layer
- Q6/13 - OAM and Network Management in B-ISDN [ATM layer management]
- Q7/13 - B-ISDN Resource Management [ATM layer transfer capabilities]
- Q8/13 - B-ISDN Interworking [B-ISDN to private ATM networks]
- Q14/13 - B-ISDN/ATM Cell Transfer Performance

4.3.2 Major Supporting Activities: These standards bodies, while addressing issues relating to ATM, have a principal focus on matters of which ATM is but a part. With the exception of the IETF, which is being encouraged to accept a more proactive role as a "key player" in the ATM game, the focus for each member of this group is generally directed at a single NCS standardization objective. The activity of these groups is also dynamic in nature, but may, or may not, be focused on ATM issues at any given point in time. A brief summary of the scope of each of these standards bodies as they relate to ATM is given below.

Internet Engineering Task Force (IETF): The IETF has a large number of working groups organized into eight major technical areas. Much of the ongoing standards work in these areas is still based on the past view that the Internet is a research laboratory rather than a fully operational system with all the associated responsibilities which this would imply. With the recent explosion in the use of the Internet as a fundamental communications tool, efforts have been initiated to accommodate ATM as an Internet transport technology. The following technical areas are most concerned with ATM and Internet survivability:

- Internet Area
- Operations and Management Area
- Security Area
- Transport Area

T1A1 (Performance and Signal Processing): T1A1 is the Committee T1 Technical Subcommittee responsible for developing standards and technical reports relating to the processing, transmission and performance of speech, audio, data, image and video signals within telecommunications networks, to include the multimedia integration of these signals. T1A1 is the principal North American focal point for work to be submitted to ITU-T Study Group 12 and for the signal processing work submitted to SG 16. The following T1A1 working groups are concerned with ATM network performance and survivability:

- T1A1.2 Network Survivability
- T1A1.3 Digital Network and Service Performance
- T1A1.5 Multimedia Communications Coding and Performance

T1M1 (Internetwork Operations, Administration, Maintenance and Provisioning (OAM&P)): T1M1 is the Committee T1 Technical Subcommittee responsible for developing standards and technical reports relating to all aspects of internetwork operations and management to include circuit and facility installation, restoration, routine maintenance, fault location and repair, and service evaluation. T1M1 is the principal North American focal point for work to be submitted to ITU-T Study Group 4. The following T1M1 working group is concerned with ATM network management and security:

- T1M1.5 OAM&P Architectures, Interfaces and Protocols

ITU-T SG 2 (Network and Service Operation): SG2 is responsible for studies relating to the general aspects of service definitions related to telecommunication services; principles for the interworking and relevant user quality of service (QoS) for PSTN, ISDN, mobile, and UPT based services; network operations including routing, numbering, network management and service quality of networks; human factors; and service and operational aspects of fraud prevention. SG2 is the Lead ITU-T Study Group on Service Definition, Numbering, Routing, and Global Mobility. Service definitions for B-ISDN, including ATM are addressed in:

- Q12/2 New Services for Broadband ISDN and B-ISDN

ITU-T SG 4 (TMN and Network Maintenance): SG4 is responsible for telecommunication management network (TMN) studies; and for studies relating to maintenance of networks, including their constituent parts, identifying needed maintenance mechanisms and for applications of specific maintenance mechanisms provided by other ITU-T Study Groups. SG 4 is the Lead ITU-T Study Group for TMN. ATM implications for TMN development are primarily considered in:

- Q13/4 TMN principles, architecture, and methodology
- Q15/4 Requirements integration and management information/models for TMN interfaces

ITU-T SG 12 (End-to-End Transmission Performance of Networks and Terminals): SG12 is responsible for studies concerning the end-to-end transmission performance of networks and terminals in relation with the perceived quality and the acceptance of text, speech and image signals by the user; and for the related transmission implications. ATM performance issues are primarily addressed in:

- Q19/12 Transmission performance considerations for networks which are implemented using ATM technology

ITU-T SG 15 (Transport Networks, Systems and Equipment): SG15 is responsible for studies relating to transport networks, switching and transmission systems/equipment to include the relevant signal processing aspects; and is the Lead ITU-T Study Group on Access Network Transport with a particular emphasis on optical systems. SG15 addresses the following study questions directly relating to ATM:

- Q8/15 - Speech, Voiceband and Audio Transmission in ATM/B-ISDN Systems
- Q10/15 - ATM Equipment

ITU-T SG 16 (Multimedia Services and Systems): SG16 is responsible for studies relating to multimedia service definition and multimedia systems to include the associated terminals, modems, protocols and signal processing; and is the ITU-T Lead Study Group on Multimedia services and systems. SG16 addresses the following study questions directly relating to ATM:

- Q12/16 - B-ISDM Multimedia Systems and Terminals
- GII/F.4 - GII End-to-end Interoperability

ADSL FORUM

TR-001 ADSL Forum System Reference Model: This document presents an ADSL-based System Reference Model and defines all relevant interfaces present in an ADSL Access Network.

TR-002 ATM over ADSL Recommendations: This document describes interfaces and system configurations for ATM transported over Access Networks based on Asymmetric Digital Subscriber Line (ADSL) technology**.**

ATM FORUM

af-uni-0010.002 ATM User-Network Interface (UNI) Specification v3.1: This document describes interfaces used between: ATM user devices and private/public ATM network equipment: and private ATM network equipment and public ATM network equipment. It includes specifications for the following layer 1 interfaces: SONET STS-3c (155.52 Mb/s) public and private, DS3 (44.736 Mb/s) [Replaced by af-phy-0054.000], 100 Mb/s, Multimode Fiber (2km), private using 4B/5B encoding, 155.52 Mb/s, fiber (2km) and shielded twisted pair (100m), and private using 8B/10B encoding.

af-bici-0013.003 ATM B-ISDN Inter-carrier Interface (B-ICI) Specification: This document describes the interface between two Public network switches or inter-exchange carriers, and is based on SS7. This version replaces the previous versions (v0, v1, and v2) and supports: Switched Virtual Connection (SVC) services, Permanent Virtual Connection (PVC) services, PVC based cell relay, PVC based CES, PVC based Frame Relay, and the Switched Multi-megabit Data Service (SMDS). The B-ICI is based on a physical layer at 155.520 Mb/s (STS-3c) and 622.080 Mb/s (STS-12c); and addresses both the user and management plane (U-plane and M-plane).

af-dxi-0014.000 ATM Data Exchange Interface (DXI) Specification: This document defines the interface used between a DTE and a DCE to provide a UNI for ATM networks. It treats the Physical and data link layers and the Local Management Interface (LMI); and specifies the Management Information Base (MIB) for the interface. Although all modes of operation at the interface are capable of transparently supporting Service Specific Convergence Sublayers and other higher layers, this document addresses only the Common Part Convergence Sublayer. This interface does not allow for the CPCS-user-to-CPSC-user field of the AAL5 CPCS-PDU.

af-phy-0015.000 ATM Physical Medium Dependent Interface Specification for 155 Mb/s over Twisted Pair Cable: This document defines the ATM Physical Medium Dependent (PMD) interface for 155 Mb/s operation over twisted pair cable (TPC) and is intended for use on a private UNI.

af-phy-0016.000 DS1 Physical Layer Specification: This document defines the DS1 physical layer (PMD and TC sublayers) for a 1.544 Mb/s interface rate based on ANSI

T1.408-1990 and ITU-T Recommendation G.804. It applies only to the public UNI and is intended to operate over clear-channel DS1 facilities.

af-phy-0017.000 UTOPIA Specification Level 1, v2.01: This document describes the Universal Test & Operations Physical Interface for an ATM (UTOPIA) level 1 data path interface. It defines the interface between the Physical Layer (PHY) and the upper layer (e.g., ATM) at rates from sub-100 Mb/s to 155 Mb/s, with guidance given for 622 Mb/s. It specifies an 8-bit wide data path using octet-level handshake at 25 MHz, an 8-bit wide data path using cell-level handshake at 25 MHz, and the cell format and extra signals required for a 16-bit wide data path for future use.

af-phy-0018.000 Mid-Range Physical Layer Specification for Category 3 Unshielded Twisted-Pair: This document defines the mid-range physical layer (PMD and TC sublayers) for category 3 unshielded twisted-pair cabling to a private UNI. It is based on a rate of 51.84 Mb/s for use on up to 100 m of cable consisting of two pairs. It also includes support for sub-rates of 25.92 and 12.96 Mb/s for use on longer links or links that do not meet the requirements of category 3 cable.

af-nm-0019.000 Customer Network Management (CNM) for ATM Public Network Service (M3 Specification): This document describes the requirements, interface, and objects that a public network provider could provide to a user of the public ATM network. This specification is intended to be used for an ATM PVC service to allow customers to manage performance, fault and configuration information about their ATM service.

af-nm-0020.000 M4 Interface Requirements and Logical MIB [ATM Network Element View]: This document describes the functional requirements and the Management Information Base to be used between the public network manager and the ATM devices in the public network; and addresses configuration, fault, and performance management.

af-lane-0021.000 LAN Emulation Over ATM Specification v1.0: This document describes the architectural framework, service interfaces, service components, service functions, frame formats, client/server protocols, and procedures for the LAN Emulation Service. Specific LAN services to be emulated are the Connectionless and Multicast services, and Interconnection with existing LANs. It also addresses the Management Information Base (MIB).

af-test-0022.000 Introduction to ATM Forum Test Specifications: This document provides a general overview of the different testing areas and their relationship to each other. The testing areas addressed are conformance, performance, and interoperability testing.

af-test-0023.000 PICS Proforma for the DS3 Physical Layer Interface: This document provides the Protocol Implementation Conformance Statement (PICS) for the DS3 Physical Layer Interface as specified in version 3.0 of the ATM User-Network Interface Specification. It consists of a form, which can be freely reproduced, which the

supplier of a protocol implementation is required to complete in order to claim conformance.

af-test-0024.000 PICS Proforma for the SONET STS-3c Physical Layer Interface: This document contains the Protocol Implementation Conformance Statement for the SONET STS-3c physical layer as specified in version 3.0 of the ATM User-Network Interface Specification. It consists of a form, which can be freely reproduced, which the supplier of a protocol implementation is required to complete in order to claim conformance.

af-test-0025.000 PICS Proforma for the 100 Mbit/s Multimode Fiber Physical Layer Interface: This document contains the Protocol Implementation Conformance Statement for the 100 Mbit/s Multimode Fiber physical layer interface as specified in version 3.0 of the ATM User-Network Interface Specification. It consists of a form, which can be freely reproduced, which the supplier of a protocol implementation is required to complete in order to claim conformance.

af -pnni-0026.000 Interim Inter-switch Signaling Protocol (IISP) Specification v1.0: This document describes signaling procedures based on UNI 3.1 to be used for private network-node interfaces; and was an interim solution pending completion of PNNI 1.0 [af-pnni-0055.000].

af-nm-0027.000 CMIP Specification for the M4 Interface v2.0: This document specifies an ATM information model which provides a formal representation of the information exchanged between a managed system and a managing system. It uses templates based on the Guidelines for the Definition of Managed Objects (GDMO), Abstract Syntax Notation One (ASN.1), and Common Management Information Service Element (CMISE) services and protocols. The focus is on the Management Information Base (MIB).

af-test-0028.000 PICS Proforma for the UNI 3.0 ATM Layer: This document contains the Protocol Implementation Conformance Statement for the ATM layer as specified in version 3.0 of the ATM User-Network Interface Specification. It consists of a form, which can be freely reproduced, which the supplier of a protocol implementation is required to complete in order to claim conformance.

af-phy-0029.000 6,312 kb/s User-Network Interface Specification v1.0: This document describes a physical layer at 6,312 kb/s for application at the public UNI. Although it utilizes the DS-2 rate, this specification is not based on the North American DS-2 interface. It is intended for use between the terminal equipment and the NT1 using coax cable in a point-to-point configuration.

af-test-0030.000 Conformance Abstract Test Suite for the UNI 3.0 ATM Layer of Intermediate Systems: This document is the initial part of a suite of specifications for the ATM layer as described in version 3.0 of the ATM User-Network Interface Specification. This test suite is designed for point-to-point configurations only, and does not address point-to-multipoint configurations. It includes cell switching for OAM F4 and F5 cells

af-saa-0031.000 Frame Based User-to-Network Interface (FUNI): This document fully defines the FUNI at speeds up to 2.048 Mb/s. It is based on the ATM Data Exchange Interface (DXI) specified in af-dxi-0014.000 and supports AAL 3/4 and AAL 5. It is intended to support only the VBR and UBR service classes. This specification defines the data link and physical layers, and management interface.

af-phy-0034.000 E3 Public User-Network Interface (UNI) Specification: This document defines the ATM physical layer interface for a bit rate of 34,368 kb/s, and is based on ITU-T Recommendations and European Telecommunications Standardization Institute (ETSI) specifications. It applies only to the public UNI.

af-test-0035.000 Interoperability Abstract Test Suite for the ATM Layer: This document provides an interoperability abstract test suite for the ATM Layer, and is based on version 3.0 of the ATM User-Network Interface Specification.

af-test-0036.000 Interoperability Abstract Test Suite for the Physical Layer: This document provides an interoperability abstract test suite for the Physical Layer. Included in this test suite are cases that address the DS3, STS-3c, and 100Mb/s multimode fibre physical layers. Interoperability is tested for both Basic Connectivity and for the support of Optional Features/Functions.

af-test-0037.000 PICS Proforma for the DS1 Physical Layer Interface: This document contains the Protocol Implementation Conformance Statement (PICS) for the DS1 Physical Layer Interface Specification [af-phy-0016.000]. It consists of a form, which can be freely reproduced, which the supplier of a protocol implementation is required to complete in order to claim conformance.

af-lane-0038.000 LAN Emulation Client Management Specification: This document describes network management for LAN Emulation Clients; and provides for the capability to remotely monitor and control networks and networked devices. This includes the functions of configuration, security, performance, fault, and accounting management.

af-phy-0039.000 UTOPIA Level 2 Specification v1.0: This document provides an Addendum to af-phy-0017.000 that describes enhancements to the Universal Test & Operations Physical Interface for the UTOPIA level 1 data path interface. A 16-bit wide data path is described for 33 and 50 MHz.

af-phy-0040.000 Physical Interface Specification for 25.6 Mb/s over Twisted Pair Cable: This document describes the physical layer for the 25.6 Mb/s private UNI over both shielded and unshielded twisted pair. It includes the Physical Media Dependent sublayer (bit timing, physical media, and connectors) and the Transmission Convergence sublayer (HEC generation/verification, cell scrambling/descrambling, line coding/decoding using 4B5B, and cell delineation).

af-test-0041.000 Conformance Abstract Test Suite for the UNI 3.0 ATM Layer of End Systems: This document contains the conformance Abstract Test Suite for the ATM

layer of end systems as specified in version 3.0 of the ATM User-Network Interface Specification. It is specified in the standardized test script language TTCN (Tree and Tabular Combined Notation) as described in ISO/IEC 9646-3. This version of the Abstract Test Suite covers only point-to-point.

af-test-0042.000 PICS Proforma for AAL Type 5: This document contains the Protocol Implementation Conformance Statement (PICS) for the ATM Adaptation Layer (AAL) Type 5 as specified in Section 6 of ITU-T Recommendation I.363 for the SSCS sublayer set to Null. It consists of a form which the supplier of a protocol implementation is required to complete in order to claim conformance.

af-phy-0043.000 A Cell-Based Transmission Convergence Sublayer for Clear Channel Interfaces: This document is derived from the ITU-T recommendation I.432 for 155.52 and 622.08 Mb/s optical interfaces. It makes optional the cell scrambling and the physical layer OAM features. It is intended to be used over clear channel facilities which do not impose bit stream coding restrictions.

af-test-0044.000 PICS Proforma for the 51.84 Mb/s Mid-range Physical Layer Interface: This document contains the Protocol Implementation Conformance Statement (PICS) for the Mid-range Physical Layer Specification for Category 3 Unshielded Twisted Pair Cable. It consists of a form which the supplier of a protocol implementation is required to complete in order to claim conformance.

af-test-0045.000 Conformance Abstract Test Suite for the UNI 3.1 ATM Layer of Intermediate Systems: This document is the initial part of a suite of specifications for the ATM layer as described in version 3.1 of the ATM User-Network Interface Specification. This test suite is designed for point-to-point configurations only, and does not address point-to-multipoint configurations. It includes cell switching for OAM F4 and F5 cells

af-phy-0046.000 622.08 Mb/s Physical Layer Specification: This document specifies the 622.08 Mb/s physical layer based on the SONET and SDH standards. It provides the payload envelope necessary for the transport of ATM cells, as well as overhead bytes for the carriage of OAM information. This specification applies to 622.08 Mbit/s interfaces at the public UNI, the private UNI, and the private NNI; and covers the Physical Media Dependent sublayer and the Transmission Convergence sublayer. The specification provides requirements for such parameters as: transmitter and receiver characteristics, jitter, error rate, and synchronization.

af-phy-0047.000 155.52 Mb/s Physical Layer Specification for Category 3 Unshielded Twisted Pair: This specification describes an extension to the Mid-range Physical Layer Specification for Category 3 Unshielded Twisted-Pair [af-phy-0018.000] for a private UNI over category-3 UTP cabling to support a higher bit rate of 155.52 Mb/s. It describes the Physical Media Dependent sublayer and refers to ITU-T Recommendation I.432 and ATM Forum UNI Specification Version 3.1 for the Transmission Convergence sublayer.

af-saa-0048.000 Native ATM Services: Semantic Description: This document specifies the semantic definition of ATM-specific services on the user side of the ATM User-Network Interface that are available to applications implemented in software or hardware. It addresses such matters as: requests to the underlying service to perform an action, notification that some event has occurred, parameters of the requests/notifications, responses to the requests/notifications. This specification provides support for data transfer (reliable and unreliable); provisions for setting up SVCs and PVCs; AAL1, AAL5, and user defined AAL; message mode of AAL 5; Virtual Channel (but not Virtual Paths); traffic management and distribution of connections/associated data to the correct applications; and provisions for local participation in network management (ILMI and OAM).

af-saa-0049.001 Audiovisual Multimedia Services: Video on Demand Specification v1.1: This document addresses the requirements of Video on Demand using Constant Packet Rate (CPR) MPEG-2 Single Program Transport Streams [ISO/ IEC 13818-1]. It addresses the AAL requirements; the encapsulation of MPEG-2 Transport Streams into AAL-5 PDUs; the ATM signaling and ATM connection control requirements; and the traffic and Quality of Service characteristics. This specification also provides informational material on Service Profiles. Later versions may include other retrieval services, conversational services, and high-quality broadcast.

af-lane-0050.000 LAN Emulation Over ATM Specification: This document is an addendum to af-lane-0021.000 to provide a delta list to the LAN Emulation Over ATM Specification - Version 1.0. It also addresses several points of clarification.

af-test-0051.000 PICS Proforma for the 25.6 Mb/s over Twisted Pair Cable Physical Layer Interface: This document contains the Protocol Implementation Conformance Statement (PICS) for the Mid-range Physical Layer Interface as specified in the Physical Interface Specification for 25.6 Mb/s over Twisted Pair Cable [af-phy-0040.000]. It consists of a form which the supplier of a protocol implementation is required to complete in order to claim conformance.

af-test-0052.000 Conformance Abstract Test Suite for the ATM Adaptation Layer (AAL) Type 5 Common Part (Part 1): This document is the initial part of a suite of specifications for the ATM AAL5 Common Part; and addresses cases which can br tested using the Remote Single Layer Test Method. Part 2 will address additional test methodologies for the remaining cases identified for testing.

af-phy-0053.000 Addendum to ATM Physical Medium Dependent Interface Specification for 155 Mb/s over Twisted Pair Cable: This document contains additions and changes to the ATM Physical Medium Dependent Interface Specification for 155 Mb/s over Twisted Pair Cable [af-phy-0015.000] to add a specification for a 120 Ohm Link Segment, update the reference section, and make minor editorial changes to the text.

af-phy-0054.000 DS3 Physical Layer Interface Specification: This document describes the physical layer specifications for DS3 transmission systems used for ATM. It supersedes Section 2.2 of versions 3.0 and 3.1 of the ATM User-Network Interface Specifications,.

af-pnni-0055.000 Private Network-Network (Node) Interface Specification v1.0: This document describes the protocol used between private ATM switches. It contains two major portions of the protocol: One for distribution of topology information between private network switches used to determine routes through the network; and a second for the signaling used to establish point-to-point and point-to-multipoint connections. The latter is based on the UNI Signaling Specification and Q.2931, with additional provisions added to support source routing, crankback, and alternate routing in case of a failure in the connection setup.

af-tm-0056.000 Traffic Management Specification v4.0: This document describes procedures and parameters related to traffic management and quality of service. Definitions and modifications have been added in this version for the ABR service category; ATM service architecture, and conformance testing. This specification addresses five service categories: Constant bit-rate (CBR), Real-time Variable bit rate (rt-VBR), Non-real-time Variable bit rate (nrt-VBR), Unspecified bit rate (UBR), and available bit rate (ABR). Each category is defined in terms of the following Quality of Service parameters: Peak-to-peak Cell Delay Variation, Maximum Cell Transfer Delay, and Cell Loss Ratio. This specification is based on ITU-T I.371, I.356, and I.150. It contains a number of differences from I.371 as detailed in the specification.

af-lane-0057.000 LAN Emulation Servers Management Specification v1.0: This document describes how to manage the following components of the LAN emulation: the LAN Emulation Client (LEC), the LAN Emulation Server (LES), the Broadcast and Unknown Server (BUS), and the LAN Emulation Configuration Server (LECS). LES, BUS, and LECS provide various services to enable communications between LECs, and are referred to collectively as “LAN Emulation Servers”. This specification includes the MIB modules for these three servers.

af-nm-0058.000 M4 Network-View Interface Requirements and Logical MIB Specification: This document defines the network view of the M4 interface used to support management of the ATM network. It relates this view to the Network Element view defined in the Network Element View specification [af-nm-0020.000]. This version contains the initial functionality in a protocol independent fashion and covers management of the following network functions: configuration provisioning, connection set-up, reservation, modification, fault correlation, localization, notification, performance, accounting, and security. Future versions will enhance the protocol-independent managed objects and profiles/ensembles.

af-test-0059.000 PICS Proforma for the UNI 3.1 ATM Layer: This document contains the Protocol Implementation Conformance Statement for the UNI ATM layer as specified in version 3.1 of the ATM User-Network Interface Specification. It consists of a

form which the supplier of a protocol implementation is required to complete in order to claim conformance.

af-test-0060.000 Conformance Abstract Test Suite for the UNI 3.1ATM Layer of End Systems: This document contains the conformance abstract test suite for the UNI ATM layer of end systems as specified in versions 3.0 and 3.1 of the ATM User-Network Interface Specification. This version of the test suite is specified in the standardized test script language TTCN (Tree and Tabular Combined Notation) and covers only point-to-point application.

af-sig-0061.000 ATM User-Network Interface (UNI) Signaling Specification v4.0: This document describes the signaling procedures for both a Public or Private UNI and is based on ITU-T Recommendations Q.2931 and Q.2961.1. The capabilities addressed describe only the changes from these references needed for ATM operation at the interface between a terminal or endpoint equipment and a public or private network the UNI; and address Layer 3 only.

af-phy-0062.000 155.52 Mb/s Physical Layer Interface Specification for Short Wavelength Laser: This specification describes the physical layer for 155.52 Mb/s private UNI for the short wavelength laser based on a multi-mode fiber interface. It contains the Physical Media Dependent (PMD) specification and refers to ANSI T1.646-1995 for the Convergence sublayer.

af-phy-0063.000 Workable Interface Requirements Example (WIRE): This document describes an interface between the Transmission Convergence Layer (TC) Device and the Physical Media Dependent (PMD) Devise. This is the point of change from digital technology supporting moderate clock rates on the TC side to high speed, mixed mode technology on the PMD side. Three groups of signals are addressed: a Data Group which includes data and clock; a Framing Group used to coordinate byte and frame synchronization; and a Signal Loss Group used by the PMD to indicate loss of media signal.

af-phy-0064.00 E1 Physical Layer Interface Specification: This document specifies the E1 Physical Layer interface requirements for 2048 kb/s operation at the public UNI, the private UNI and the private NNI.

af-ilmi-0065.000 Integrated Local Management Interface (ILMI) Specification v4.0: This document describes how the Simple Network Management Protocol (SNMP) and an ATM Interface Management Information Base (MIB) are used to provide configuration information to any ATM device. This configuration information may include information concerning Virtual Path and Virtual Channel Connections, Registered ATM network prefixes and addresses, Services, and other capabilities available to the ATM interface. This version describes the following MIB modules: the Textual Conventions MIB, the Link Management MIB, the Address Registration MIB, and the Service Registry MIB. Additional MIB modules will be added in future versions of this specification

af-pnni-0066.000 Private Network-Network Interface (PNNI) Specification v1.0 Addendum (Soft PVC MIB): This document is an addendum to the Private NNI Specification, Version 1.0 [af-pnni-0055.000] to add clarification for implementors of soft PVC and PVP Connections and to provide a Management Information Base (MIB) definition.

af-test-0067.000 Conformance Abstract Test Suite for SSCOP for UNI 3.1: This document contains the abstract test suite for the UNI Service Specific Connection Oriented Protocol (SSCOP) as specified in version 3.1 of the ATM User-Network Interface Specification and ITU-T Recommendation Q.2110; and is specified in the standardized test script language TTCN (Tree and Tabular Combined Notation) in accordance with ISO 9646.

af-bici-0068.000 Addendum to B-ISDN Inter Carrier Interface (B-ICI) Specification v2.0: This document adds support for BISUP signaling procedures for Variable Bit Rate connections,
Network Call Correlation ID, and Data Country Code (DCC) and International Code Designator (ICD) for the ATM End System Address (AESA) Formats.

af-saa-0069.000 ATM Name System Specification v1.0: This document defines the ATM Name System (ANS) directory service and is an extension to the Internet Engineering Task Force's (IETF) Domain Name System (DNS).

af-test-0070.000 PICS Proforma for the 155 Mb/s over Twisted Pair PMD Layer Interface: This document contains the Protocol Implementation Conformance Statement for the Physical Medium Dependent Interface Specification for 155 Mb/s over Twisted Pair Cable (af-phy-0015.000) and its addendum [af-phy-0053.000]. It consists of a form which the supplier of a protocol implementation is required to complete in order to claim conformance.

af-nm-0071.000 AAL Management for the M4 "NE View" Interface: This document proposes a set of requirements, logical information model and CMIP specification to support AAL management through the M4 management interface taken from a Network Element point-of-view. The requirements and the logical information model supplement to af-nm-0020.000 and the CMIP specification supplements to af-nm-0027.001.

af-nm-0072.000 Circuit Emulation Service (CES) Interworking M4 Interface "NE View" Requirements, Logical and CMIP MIB: This document specifies the requirements for Circuit Emulation Service Interworking to be supported by the M4 Network Element View Interface.

af-nm-0073.000 M4 Network View CMIP MIB Specification v1.0: This document provides the information model and GDMO template to support the requirements contained in the Network Element Logical MIB [af-nm-0058.000].

af-nm-0074.000 Addendum to M4 Network View Requirements and Logical MIB: This document provides the proposed improvements to the M4 network-level protocol-independent MIB [af-nm-0058.000] following the creation of a full M4 network-level Common Management Information Protocol (CMIP) Management Information Base (MIB).

af-pnmi-0075.000 Addendum to PNNI Specification v1.0 for ABR parameter negotiation: This document adds support for Available Bit Rate (ABR) negotiation to the Specification for the Private Network-Network Interface (PNNI) [af-pnni-0055.000].

af-sig-0076.000 Addendum to UNI Signaling Specification v4.0 for ABR Parameter Negotiation: This document adds support for Available Bit Rate (ABR) negotiation to version 4 of the Signaling Specification for the User-Network Interface (UNI) [af-sig-0061.000].

af-tm-0077.000 Addendum to Traffic Management Specification v4.0 for ABR Parameter Negotiation: This document adds support for Available Bit Rate (ABR) negotiation to version 1.0 of the Traffic Management Specification [af-tm-0056.000].

af-vtoa-0078.000 Circuit Emulation Service (CES) Interoperability Specification v2.0: This interoperability agreement describes the support for Constant Bit Rate (CBR) traffic over networks complying with the ATM Forum's other specifications. It specifically covers the following CBR services: Structured DS1/E1 Nx64 kb/s (Fractional DS1/E1), Unstructured DS1/E1 (1.544 / 2.048 Mb/s), Unstructured DS3/E3 (44.735 / 34.368 Mb/s), Structured J2 Nx64 kb/s (Fractional J2), and Unstructured J2 (6.312 Mb/s)

af-phy-0079.000 155 Mb/s Plastic Optical Fiber (POF) and Hard Polymer Clad Fiber (HPCF) PMD Specification: This document describes a 155 Mb/s interface using Light Emitting Diodes (LEDs) on Plastic Optical fiber (POF) for distances up to 50 meters and Hard Polymer Clad Fiber (HPCF) for distances up to 100 meters. It includes requirements for the cable plant, media interface connector (MIC), and the active input/output interfaces.

af-test-0082.000 PICS Proforma for DS3 Direct Mapped: This document contains the Protocol Implementation Conformance Statement for the DS3 Direct Mapped Physical Layer as defined in af-phy-0054.000 and ANSI T1.646-1995. It consists of a form which the supplier of a protocol implementation is required to complete in order to claim conformance.

af-lane-0084.000 LAN Emulation Over ATM L-UNI Specification v2.0: This document describes the architectural framework, service interfaces, service components, service functions, frame formats, client/server protocols, and procedures for the LAN Emulation Service at the UNI.

af-vtoa-0089.000 Voice and Telephony over ATM-ATM Trunking using AAL1 for Narrowband Services: This document describes a means for the interconnection of two

narrowband networks through an ATM network to provide transport of 64 kbit/s circuits using DSS1, PSS1, or CAS with E&M signaling and DTMF. The VTOA Trunking Management Information Base (MIB) is to be added by addendum at a later date.

af-lane-0093.000 LAN emulation client Management specification v2.0: This document contains the Management Information Base for LANE Version 1.0 [af-lane-0021.000] and Version 2.0 [af-lane-0084.000] to support the network management functions for configuration, performance, and fault management through remotely monitored and controled networks and networked devices..

COMMITTEE T1

ANSI T1.247-1995 OAM&P - Performance Management Functional Area Service and Information Model for Interfaces between Operations Systems and Network Elements: This document is part of a series of standards that specifies interface requirements between Operations Systems (OSs) and Network Elements (NEs). It describes a set of Performance Management functional area services and associated information models for Operations, Administration, Maintenance, and Provisioning (OAM&P) applications for DS1 and DS3 signals.

ANSI T1.511-1994 B-ISDN ATM Layer Cell Transfer-Performance Parameter: This document defines speed, accuracy, and dependability performance parameters for cell transfer in the ATM layer of a Broadband Integrated Services Digital Network (B-ISDN).

ANSI T1.627-1993 B-ISDN-ATM Layer Functionality and Specification: This document describes the protocol of the ATM Layer by specifying the service to be provided by the ATM Layer; the service required from the Physical Layer (PHY); the interrelation with Layer Management; the encoding of the protocol data units; and the protocol procedures to be followed. In specifying the service, the following are defined: the primitives and the resulting actions and events; the parameters and format associated with each primitive; interrelationship between the primitives; and the valid sequence of primitives.

ANSI T1.629-1993 B-ISDN - ATM Adaptation Layer 3/4 Common Part Functions and Specification: This document describes a protocol of the Common Part of the ATM Adaptation Layer type 3/4 to support Variable Bit Rate (VBR) Services. The protocol relies on the use of the ATM Layer described in ANSI T1.627 and specifies the service provided by the AAL3/4-CP; the service required from the ATM Layer; the interrelation with VBR AAL Service Specific Convergence Sublayer (SSCS); the interrelation with ATM Adaptation Layer Management (AALM); the encoding of the protocol data units; and the protocol procedures.

ANSI T1.630-1993 B-ISDN - ATM Adaptation Layer Constant Bit Rate Service Functionality and Specification: This document describes the protocol of the ATM Adaptation Layer for Constant Bit Rate Services (CBR AAL) based on the use of the ATM Layer as descried in ANSI T1.627. In particular, the following are specified: the service provided by the CBR AAL; the service required from the ATM Layer; the interrelation with the AAL Management (AALM); the encoding of the protocol data units; and the protocol procedures. The primitives and their associated parameters describe, in an abstract manner, the logical exchange of information between the CBR AAL and the AALM, and between sublayers of the AAL. They do not specify nor constrain the implementation of entities or interfaces.

ANSI T1.635-1994 B-ISDN - ATM Adaptation Layer Type 5 Common Part Functions and Specification: This document describes a protocol of the Common Part of the ATM Adaptation Layer type 5 to support Variable Bit Rate (VBR) services; and references the complete text on AAL Type 5 contained in section 6 of ITU-T Recommendation I.363.

ANSI T1.636-1994 B-ISDN Signaling ATM Adaptation Layer Overview Description: This document briefly describes the various components which make up the AAL functions necessary to support signaling (SAAL). It is intended to serve as a guide to all other standards required by a user who intends to construct an AAL for the purpose of signaling.

ANSI T1.637-1994 B-ISDN ATM Adaptation Layer - Service Specific Connection Oriented Protocol (SSCOP): This document provides a new protocol specification to be used in the B-ISDN ATM Adaptation Layer (AAL). The SSCOP provides assured data delivery between AAL connection endpoints.

ANSI T1. 638-1994 B-ISDN Signaling ATM Adaptation Layer - Service Specific Coordination Function (SSCF) for Support of Signaling at the User-To-Network Interface (UNI): This document provides a function which is part of the ATM Adaptation Layer for the support of signaling (SAAL) at the UNI of the B-ISDN. This function is used to map the service of the Service Specific Connection Oriented Protocol (SSCOP) of the AAL to the needs of layer 3 protocols for access signaling across the UNI (e.g., ITU-T Q.2931).

ANSI T1.645-1995 B-ISDN Signaling ATM Adaptation Layer - Service Specific Coordination Function for Support of Signaling at the Network Node Interface (NNI): This document provides a function which is part of the ATM Adaptation Layer for the support of signaling (SAAL) at the Network Node Interface (NNI) of the B-ISDN. This function is used to map the service of the Service Specific Connection Oriented Protocol (SSCOP) of the AAL to the requirements of an SAAL user at the NNI. It addresses the SSCF of the complete AAL structure for signaling applications at the NNI as defined in ANSI T1.636, and describes the interaction with the level 3 protocol entity for network node signaling defined in ANSI T1.111, layer management defined in ITU-T Recommendation Q.2144, and the Service Specific Connection Oriented Protocol defined in ANSI T1.637.

ANSI T1.646-1995 Broadband ISDN - Physical Layer Specification for User-Network Interfaces Including DS1/ATM: This document provides physical layer specifications for optical and electrical signals appearing at customer installation interfaces and the network interface (NI) for broadband rates above DS1 and wideband (DS1) access to a broadband integrated services digital network (B-ISDN). This standard provides interface compatibility information and is not intended to be an equipment specification. This standard supersedes ANSI T1.624-1993.

ANSI T1.652-1996 B-ISDN Signaling ATM Adaptation Layer - Layer Management for the SAAL at the NNI: This document specifies the Layer Management functions for

the Signaling ATM Adaptation Layer (SAAL) at the Network Node Interface (NNI). These include the interfaces to the Service Specific Connection Oriented Protocol (SSCOP) [ANSI T1.637], to the Service Specific Coordination Function (SSCF) at the NNI [ANSI T1.645], and to systems management.

ANSI T1.662-1996 Broadband ISDN - ATM End System Address for Calling and Called Party: This document contains formats and procedures for carrying ATM End System Address (AESA) of calling and called party in B-ISDN User Part. It also contains the mapping tables for the associated messages and information elements.

ANSI T1 TR 46 [April 1996] Transmission Performance Standards Issues Regarding the Introduction of ATM Technology into Networks Supporting Voiceband Services: This Technical Report assesses whether industry transmission standards are adequate to support the introduction of ATM technology into networks supporting voiceband services. In those instances where it was identified that industry standards are inadequate, this document identifies the areas where standards work is required to allow for an orderly integration of ATM technology, e.g. multiplexers and switches, into the PSTN and other networks.

ANSI TR 53 [June 1997] Transmission Performance Guidelines for ATM Technology Intended for Integration Into Networks Supporting Voiceband Services: This Technical Report addresses performance parameters to be considered for ATM Technology intended for integration into networks which support voiceband services. The document provides discussion on ATM technology that performs one or more of the following functions: echo cancellation; interworking between the ATM and the non-ATM domain; multiplexing; switching; and transport. Guidelines for acceptable transmission performance operating limits for these ATM functional network elements are provided.

DAVIC

DAVIC 1.3 Specification Part 1: Description of DAVIC Functionalities v2.0: This document describes the Digital Audio-Visual Council's list of target applications and services, and identifies their requirements. A core set of functionalities required to support these applications and services is defined and a description of their associated parameters and behavior provided. The use of Profiles as a method of classifying functional features and performance levels into meaningful groups is also described, together with a set of generic “tools” to be used in their construction.

FRAME RELAY FORUM

FRF.5 Frame Relay/ATM Network Internetworking Implementation Agreement: This Implementation Agreement describes the interworking necessary to allow the interconnection of two frame relay end nodes, such as Frame Relay Access Devises or routers, via an ATM backbone network. The end devices are unaware of the use of the ATM backbone, since network equipment, such as the ATM WAN switches, provide the interworking functions.

FRF.8 Frame Relay /ATM PVC Service Internetworking Implementation Agreement: This Implementation Agreement describes the interworking necessary to allow frame relay devises to communicate with ATM devises. This interworking allows coexistence or migration of a portion of an existing frame relay network to ATM without special functionality being required in the end-user devices. It also provides bidirectional PVC management and protocol conversion.

IEEE

802.9-1996 [ISO/IEC 8802-9 Local and metropolitan area networks - Specific requirements - Part 9] Integrated Services (IS) LAN Interface at the Medium Access Control (MAC) and Physical (PHY) Layers: This document provides a unified access method which offers integrated services (IS) to the desktop for a variety of publicly and privately administered backbone networks (e.g., ANSI FDDI, IEEE 802.x and ISDN) is defined. In addition, the interface at the MAC sublayer and the PHY Layer is specified.

802.9e-[draft] Supplement to IEEE 802.9 Integrated Services (IS) LAN Interface at the Medium Access Control (MAC) and Physical (PHY) Layers: Asynchronous Transfer Mode (ATM) Cell Bearer Mode: This document, when approved, will provide a standard which allows for a operational mode supporting the transport of ATM cells in the isochronous information stream of an IEEE 802.9 interface. This standard will facilitate the use of the IEEE 802.9 ISLAN as a medium for the delivery of ATM structured information to the desktop.

802.11-1997 IEEE Standard for Wireless LAN Medium Access Control (MAC) and Physical Layer (PHY) specifications: This document specifies the medium access control and physical characteristics for wireless LANs as part of a series of standards for local and metropolitan area networks. The medium access control unit specified is designed to support physical layer units as they may be adopted dependent on the availability of spectrum. Three physical layer units are addressed: two for radio, both operating in the 2400-2500 MHz band, and one for baseband infrared. One radio unit employs a frequency-hopping spread spectrum technique, while the other a direct sequence spread spectrum technique.

802.12-1995 IEEE Std 802.12-1990, IEEE Standards for Local and Metropolitan Networks: Demand Priority Access Method, Physical Layer and Repeater Specification: This document specifies the media access control characteristics for the Demand Priority access method. The layer management, physical layers, and media that

support this access method are also specified. Layer and sublayer interface specifications are aligned to the ISO Open Systems Interconnection Basic Reference Model and ISO/IEC 8802 models. Specifications for 100 Mb/s operation over balanced cable and fiber optic media are included.

802.12a-[draft] Demand-Priority Access Method, Physical Layer and Repeater Specifications: Supplement for Operation at Greater than 100 Mb/s: This document, when approved, will provide a standard that specifies the physical layers for operation at speeds higher than 100 Mb/s, and defines MAC and RMAC parameter values for such operation. It will also define an optional burst mode capability which allows an end node to send multiple packets per grant up to a defined time limit; and specify any needed network management extensions required for higher speed and burst mode operation. The speeds to be addressed will not exceed 4 Gb/s.

802.14-[draft] Standard for Cable-TV Based Broadband Communication: This document, when approved, will provide a standard for digital communication services over a branching bus system constructed from fiber and/or coaxial cable, as used in cable TV distribution networks. Compatibility with emerging technologies such as video compression and ATM is to be maintained insofar as consistent with efficiency and good economics.

IETF

RFC 1483 Multiprotocol Encapsulation over AAL 5: This document describes two encapsulation methods for carrying network interconnect traffic over ATM AAL5. The first method allows multiplexing of multiple protocols over a single ATM virtual circuit whereas the second method assumes that each protocol is carried over a separate ATM virtual circuit.

RFC 1577 Classical IP and ARP over ATM: This document defines an initial application of classical IP and ARP in an Asynchronous Transfer Mode (ATM) network environment configured as a Logical IP Subnetwork (LIS). This RFC considers only the application of ATM as a direct replacement for the "wires" and local LAN segments connecting IP end-stations ("members") and routers operating in the "classical" LAN-based paradigm.

RFC 1626 Default IP MTU for use over ATM AAL5: This document defines the default IP MTU size to be consistent with that defined for SMDS in order to reduce the occurrence of fragmentation. It also specifies the required negotiation for SVC implementations when default IP MTU is to be used.

RFC 1695 Definitions of Managed Objects for ATM Management Version 8.0 using SMIv2: This document defines a portion of the MIB for use with network management protocols in the Internet community. In particular, it describes objects used for managing ATM-based interfaces, devices, networks and services. The MIB module is specified in a manner that is both compliant with the SNMPv2 SMI, and semantically identical to the peer SNMPv1 definitions.

RFC 1755 ATM Signaling Support for IP over ATM: This document describes the ATM call control signaling exchanges needed to support Classical IP over ATM as described in RFC 1577. It is intended to be used for defining the support required by IP over ATM implementations using their local ATM signaling entities.

RFC 1821 Integration of Real-time Services in an IP-ATM Network Architecture: This document provides a statement of what issues need to be addressed for interfacing the IP integrated services environment with an ATM service environment so as to create a seamless interface between the two for supporting end users desiring real-time networking services.

RFC 1932 IP over ATM: A Framework Document: This document provides a discussion of the various proposals for IP over ATM that have been advanced over the period prior to April 1996. The intent of this framework is to help clarify the differences between proposals and identify common features in order to promote convergence to a smaller and more mutually compatible set of standards.

RFC 1946 Native ATM Support for ST2+: This document describes a working implementation which enables applications to directly invoke ATM services in the following environments: ATM to Internet; Internet to ATM; and Internet to Internet across ATM.

RFC 2022 Support for Multicast over UNI 3.0/3.1 based ATM Networks: This document describes a mechanism to support the multicast needs of Layer 3 protocols and the application to IP multicasting. The mapping of the connectionless IP multicast service over the connection oriented ATM services provided by UNI 3.0/3.1 is also described.
RFC 2149 Multicast Server Architectures for MARS-based ATM Multicasting: This document provides details on the design and implementation of a Multicast Server (MCS), building on the core mechanisms defined in RFC 2022. It also provides a mechanism for using multiple MCSs per group for providing fault tolerance. This approach can be used with RFC 2022 based MARS server and clients, without needing any change in functionality.

RFC 2170 Application REQuested IP over ATM (AREQUIPA): This document specifies a method for allowing ATM-attached hosts, that have direct ATM connectivity, to set up end-to-end IP connections over ATM within the reachable ATM cloud for the exclusive use of the requesting application. This capability allows the requesting applications to benefit in a straightforward way from ATM's inherent ability to guarantee the quality of service (QoS).
RFC 2225 Classical IP and ARP over ATM: This document defines an initial application of classical IP and ARP in an ATM network environment configured as a Logical IP Subnetwork (LIS).

RFC 2226 IP Broadcast over ATM Networks: This document describes how the IP multicast service being developed by the IP over ATM Working Group may be used to support IP broadcast transmission. The solution presented revolves around treating the broadcast problem as a special case of multicast, where every host in the subnet or cluster is a member of the group.

RFC 2320 Definitions of Managed Objects for Classical IP and ARP Over ATM Using SMIv2 (IPOA-MIB): This document defines the Management Information Base (MIB) for supporting Classical IP and ARP over ATM as specified in RFC 2225 (Classical IP and ARP over ATM).

ITU-T

G.176 Planning guidelines for the integration of ATM technology into the PSTN: This Recommendation provides transmission performance planning guidance to network and service planners who are responsible for the integration of ATM technology into the PSTN. This document addresses the interconnection of other networks, e.g. Private

Networks and Digital Cellular Networks, with the PSTN; and the continued need to support existing voiceband services.

G.702 Digital Hierarchical Bit Rates: This Recommendation specifies the bit rates to be used for networks based on a first level of 1544 kb/s and for networks based on a first level of 2048 kb/s.

G.703 Pysical/elcetrical characteristics of hierarchial digital interfaces: This Recommendation defines the physical and electrical characteristics for each of the transmission bit rates specified in G.702 and for a 2048 kbit/s synchronization interface.

G.774 SDH Management information model: This Recommendation introduces a series of sub-Recommendations which collectively present the various components of the SDH Management Information Model. Each Recommendation provides an information model for the component being addressed, and a description of the managed object classes, together with their associated properties. The following components of the SDH Management Information Model have been defined:

Performance monitoring for the network element view [G.774.01];
Configuration of the payload structure for the network element view [G.774.02];
Management of multiplex-section protection for the network element view [G.774.03];
Management of the subnetwork connection protection for the network element view [G.774.04]; Management of connection supervision functionality for the network element view [G.774.05]; Unidirectional performance monitoring for the network element view [G.774.06];
Management of lower order path trace and interface labeling for the network element view
[G.774.07]; Management of radio-relay systems for the network element view [G.774.08];
Configuration of multiplex section protection for the network element view [G.774.09].

G.804 ATM Cell mapping into plesiochronous digital hierarchy (PDH): This Recommendation defines the procedures for transporting ATM cells over PDH networks at different hierarchical bit rates. It specifically deals with 1544 and 2044 kb/s hierarchies and defines mapping of cells in terms of frame format; cell rate adaptation; header error control; cell delineation; cell header verification and extraction; and physical layer operation, administration, and maintenance.

G.852.01 Management of the transport network - Enterprise viewpoint for simple subnetwork connection management: This recommendation contains the enterprise viewpoint specification for managing a transport network from a Network viewpoint. In particular this Recommendation details the enterprise viewpoint for Subnetwork Connection Management.

G.853.01 Common elements of the information viewpoint for the management of a transport network: This recommendation provides the common information viewpoint specification to be used for developing management application specific information

viewpoints to support the management of transport networks. The common information viewpoint contains the definition of the information objects and relationships that represent the resources independent of any particular management service. Common information attributes and states are also specified.

G.854.01 Management of the transport network - Computational interfaces for basic transport network model: This recommendation contains the enterprise viewpoint specification for managing a transport network from a network viewpoint. In particular this Recommendation details the enterprise viewpoint for Subnetwork Connection Management.

H.222.1 Multimedia Multiplex and synchronization for AV communications in ATM environment: This recommendation defines a frame structure for audiovisual teleservices utilizing single or multiple B or H0 channels, or a single H11 or H12 channel. This structure allows for the synchronization of multiple 64 kb/s or 384 kb/s connections; and the control of the multiplexing of audio, video, data and other signals within the synchronized multiconnection structure of multimedia services such as video teleconferencing.

H.245 Control protocol for multimedia communication: This recommendation specifies syntax and semantics of terminal information messages and procedures to use them for in-band negotiation at the start or during communication. The messages cover receiving and transmitting capabilities as well as mode preference from the receiver, logical channel signaling, and Control/Indication. Signaling procedures for Acknowledgment are specified to ensure reliable audiovisual and data communication.

H.310 Broadband and audiovisual communication systems and terminals: This recommendation covers the technical requirements for systems and terminals of broadband audiovisual communication services defined in the H.200-Series Recommendations. Both unidirectional and bi-directional broadband terminals are defined. The classification of H.310 terminals into different terminal types is based on a set of audiovisual, network adaptation, and signaling capabilities. With these capabilities, H.310 terminals support a wide range of conversational and distributive applications and services.

H.321 Adaptation of H.320 visual telephone terminals to B-ISDN environments: This Recommendation describes technical specifications for adapting narrow-band visual telephone terminals to broadband ISDN environments. It is based on AAL1 over Constant Bit Rate connections. A terminal conforming to this Recommendation will interwork with any other terminal of the same type which is accommodated in B-ISDN as well as H.320 terminals accommodated in N-ISDN.

I.150 B-ISDN asynchronous transfer mode functional characteristics: This Recommendation defines the functions of the asynchronous transfer mode (ATM) layer. It explains the concepts of packet orientation, asynchronous time division multiplexing, blocks, cells, connection orientation, connection identifiers, and virtual channel connections. It also defines the nature of the header and information fields, and the nature of the UNI and NNI.

I.326 Functional architecture of transport networks based on ATM: This Recommendation describes the functional architecture of the ATM transport assembly using the generic functional architecture for transport networks defined in G.805. The ATM transport assembly consists of the VC layer network, the VC to VP adaptation, the VP layer network, and the VP to transmission path adaptation. The features described in the ITU-T "I-series" Recommendations relevant to ATM transport networks are described in this Recommendation.

I.356 B-ISDN ATM layer cell transfer performance: This recommendation defines speed, accuracy, and dependability performance parameters for cell transfer in the ATM layer of a broadband ISDN. The defined parameters apply to end-to-end ATM connections and to specified portions of such connections. The parameters are defined on the basis of ATM cell transfer reference events which may be observed at physical interfaces between ATM networks and associated customer equipment, and at physical interfaces between ATM networks.

I.361 B-ISDN ATM layer specification: This recommendation describes the cell structure, ATM cell coding, and ATM protocol procedures. Two different cell structure coding formats are included, one for the UNI and one for the NNI. It defines the contents of the following fields of the headers for each format: Generic flow control (GFC) field, Routing field (VPI/VCI), Payload type (PT) field, Cell loss priority (CLP) field, Header error control (HEC) field. The procedures are described in an abstract manner in terms of the service primitives exchanged with the upper and lower layers.

I.362 B-ISDN ATM adaptation layer (AAL) functional description: This recommendation describes the ATM adaptation layer (AAL) and its sublayers: the segmentation and reassembly sublayer (SAR), and the convergence sublayer (CS). Four classes of service are established which differ in terms of timing relation between source and destination, bit rate (constant or variable), and connection mode. The four classes of service are: circuit emulation constant bit ratio, variable bit rate video and audio, connection-oriented data transfer, and connectionless data transfer.

I.363.2 B-ISDN ATM Adaptation Layer (AAL), type 2 specification: This recommendation describes the interactions between the AAL and the next higher layer, interactions between the AAL and the ATM layer, and AAL peer-to-peer operations; and is based on the classification and AAL functional organization described in Recommendation I.362. It covers AAL type 2 which is intended for bandwidth-efficient transmission of low-rate, short, and variable length packets. Each AAL2 connection can carry multiple AAL 2 type information (eg, voice, dialed digit information, packet data, etc.) and it is envisioned that there will be multiple SSCSs defined for the different applications.

I.363.3 B-ISDN ATM Adaptation Layer (AAL), types 3/4 specification: This recommendation describes the interactions between the AAL type 3/4 and the next higher layer, interactions between the AAL type 3/4 and the ATM layer, and AAL type 3/4 peer-to-peer operations. This recommendation is applicable to equipment to be attached to a B-ISDN UNI or NNI when the services of the AAL type 3/4 are to be supported.

I.363.5 B-ISDN Adaptation Layer (AAL), type 5 specification: This recommendation describes the interactions between AAL type 5 and the next higher layer, interactions between AAL type 5 and the ATM layer, and AAL type 5 peer-to-peer operations. This recommendation is applicable to equipment to be attached to a B-ISDN UNI or NNI when the services of the AAL type 5 are to be supported.

I.365.1 Frame relaying service specific convergence sublayer (FR-SSCS): This recommendation specifies the Frame Relaying Service Specific Convergence Sublayer (FR-SSCS). The FR-SSCS is used at the B-ISDN TE to emulate the Frame Relaying Bearer Service (FRBS) in B-ISDN. It is also used for interworking between a B-ISDN and a Frame Relaying Network. This recommendation describes the services provided by the FR-SSCS (in terms of primitives), the functions, structure and coding of the FR-SSCS, and the procedures for the FR-SSCS sublayer.

I.365.2 Service specific coordination function to provide Connection Oriented Network Service (SSCF-CONS): This Recommendation specifies the Service Specific Coordination Function (SSCF) required to provide a Connection Oriented Network Service (CONS). It describes the mapping of primitives from the Synchronization and Coordination Function (SCF) to signals of the Service Specific Connection Oriented Protocol (SSCOP) and vice versa. It also describes the exchange of signals between Layer Management and the SSCF-CONS

I.365.3 Service specific coordination function to provide Connection Oriented Transport Service (SSCF-COTS): This Recommendation specifies the Service Specific Coordination Function (SSCF) required to provide a Connection Oriented Transport Service (COTS). It describes the mapping of primitives from the Synchronization and Coordination Function (SCF) to signals of the Service Specific Connection Oriented Protocol (SSCOP) and vice versa. It also describes the exchange of signals between Layer Management and the SSCF-COTS.

I.365.4 Service specific coordination function (SSCF) for HDLC applications: This recommendation specifies a mapping function that allows narrow-band data communication applications utilizing protocol stacks that include one of the Higher Level Data Link Control (HDLC) protocols. This recommendation is applicable to equipment to be attached to an ATM network when protocol stacks developed for a narrow-band environment are deployed in a B-ISDN environment.

I.432.2 B-ISDN User-Network Interface: physical layer specification for 155,520 and 622,080 kb/s: This recommendation covers Physical Layer characteristics for transporting ATM cells at nominal bit rates of 155,520 and 622,080 kb/s over coaxial cable and optical fiber interfaces at the TB and SB reference points of the B-ISDN User-Network Interface (UNI). The maximum distance specified is approximately 2 km for optical fiber and 200 m for coaxial cable.

I.432.3 B-ISDN User-Network Interface: physical layer specification for 1,544 and 2,048 kb/s: This recommendation covers Physical Layer characteristics for transporting ATM cells using existing Primary Rate ISDN systems. It includes both 1,544 and 2,048 kb/s interfaces at the TB and SB reference points of the B-ISDN User Network Interface (UNI). These Physical Layer characteristics may also be used to take advantage of existing transmission equipment and building wiring

I.432.4 B-ISDN User-Network Interface: physical layer specification for 51,840 kb/s: This recommendation covers Physical Layer characteristics for transporting Asynchronous Transfer Mode (ATM) cells at a nominal bit rate of 51,840 kb/s over category 3 Unshielded Twisted Pair (UTP) cabling at the SB reference point of the B-ISDN User Network Interface (UNI) for distances up to approximately 100 m. This specification may be used to take advantage of existing building wiring. Functionality is presented in terms of Physical Media Dependent (PMD) and Transmission Convergence (TC) sublayers, and both Synchronous Digital Hierarchy (SDH) based and cell based formats are included.

I.432.5 B-ISDN user network interface - Physical layer for 25,600 kb/s: This Recommendation covers physical layer characteristics for transporting asynchronous transfer mode (ATM) cells at a nominal bit rate of 25,600 kb/s over 100 ohm UTP, 120 ohm, and 150 ohm STP twisted pair cables at the SB reference point of the B-ISDN user network interface (UNI) for distances up to approximately 100 m. Functionality is presented in terms of physical media dependent (PMD) and transmission convergence (TC) sublayers, using a cell-based format.

I.731 Types and general characteristics of ATM equipment: This recommendation describes the general functional architecture and characteristics of ATM Network Elements (NE) in terms of specific functional blocks derived from the B-ISDN Protocol Reference Model (PRM) described in Recommendation I.321 and the modeling methodology in Recommendation G.805 and G.806. The intent of this recombination is to enable interoperability between ATM equipment based on the specific requirements described for the functional blocks. The more detailed description of the individual functional elements is given in Recommendation I.732.

I.732 Functional characteristics of ATM equipment: This recommendation describes the detailed functional requirements of ATM Network Elements (NEs) based on the general functional architecture described in the companion Recommendation I.731.

I.751 ATM management of the network element: This recommendation provides management functions and information which pertain to plane management. The information model describes the managed object classes and their properties that are useful to describe information exchanged across interfaces defined in the M.3010 Telecommunications Management Network (TMN) architecture. This recommendation specializes the generic object classes of Recommendations M.3100, Q.821 and Q.822 to provide management information specifically for the ATM network element.

M.3010 Principles of Telecommunications Management Network (TMN): This Recommendation describes the characteristics of the interfaces necessary to support a TMN and identifies the functionality, in terms of function blocks, which the interfaces delineate. Functional components are introduced to aid understanding of how function blocks support the interfaces. It also describes and names the physical devices which comprise a TMN and identifies the interfaces which each device could potentially support. A functional reference model for TMN is specified

M.3611 Test management of the B-ISDN ATM layer using TMN: This Recommendation describes how the test of the B-ISDN ATM layer is managed through Telecommunications Management Network (TMN). It identifies two types of ATM layer tests: one being a non-intrusive loop back test and the other a ATM layer performance test. For these test types, the required management functions and associated architecture are clarified.

Q.2100 B-ISDN signaling ATM adaptation layer (SAAL) overview description: This Recommendation briefly describes the various components which make up the AAL functions necessary to support signaling. It is intended to serve as a guide to all other recommendations required by the user for the implementation of an AAL for the purpose of signaling.

Q.2110 B-ISDN ATM adaptation layer - Service specific connection oriented protocol (SSCOP): This recommendation describes the Service Specific Connection Oriented Protocol (SSCOP) required to provide the service specific signaling functions required in the SAAL. The SSCOP is a peer-to-peer protocol which provides for the transfer of user data with sequence integrity, error correction by retransmission, flow control, connection control, error reporting to layer management, connection maintenance in the prolonged absence of data transfer, local data retrieval by the user, error detection of protocol control information, and status reporting.

Q.2119 B-ISDN ATM Adaptation Layer (AAL) protocols - Convergence function for SSCOP above the frame relay core service: This recommendation specifies a mapping function that allows B-ISDN data communications applications utilizing protocol

stacks which include SSCOP (Q.2110) also to be deployed in an HDLC-based environment.

Q.2130 B-ISDN signaling ATM adaptation layer - Service specific coordination function for support for signaling at the user-network interface (SSCF at UNI): This recommendation describes the SSCF at the User-Network Interface (UNI). The SSCF at the UNI performs a coordination function between the service required by the signaling layer 3 (Q.704) user and the service provided by SSCOP.

Q.2140 B-ISDN ATM adaptation layer - Service specific coordination function for signalling at the network node interface (SSCF at NNI): This Recommendation specifies the SSCF for signalling at the Network Node Interface (NNI). The SSCF at the NNI performs a coordination function between the service required by the signaling layer 3 (Q.704) user and the service provided by SSCOP.

Q.2144 B-ISDN Signaling ATM adaptation layer (SAAL) - Layer management for the SAAL at the network node interface (NNI): This Recommendation specifies the layer management functions for the SAAL at the Network Node Interface (NNI). The layer management functions at the NNI perform a coordination function and error monitoring between the systems management function and the SAAL. The common part protocol is defined in Recommendation I.363 and is used as the underlying protocol for the service specific part of this Recommendation.

SMDS INTEREST GROUP

SIG-TS-008/1994 Protocol Interface Specification for Implementation of SMDS over an ATM-based Public UNI: This specification provides a protocol interface to covers AAL 3/4 for encapsulation of SMDS Level 3 packets across a UNI.

SIG-TS-008/1996 Protocol Interface Specification for Implementation of SMDS over an ATM-based Public UNI: This specification incorporates support for AAL 5 as an alternative for AAL 3/4. It specifies access using PVCs only, and includes T1/E1 ATM access interfaces.

LIST OF ACRONYMS

4B/5B	see TAXI
8B/10B	a Fiber Channel standard based on 8B/10B Coding
AA	Address Authority
AAL	ATM Adaptation Layer
AALM	ATM Adaptation Layer Management
ABR	Available Bit Rate
ADSL	Asymmetric Digital Subscriber Line
AESA	ATM Layer End-System Address
AFI	Address Format Identifier
AIMUX	ATM Inverse Multiplexing
ANS	ATM Name System
ANSI	American National Standards Institute
AREQUIPA	Application REQested IP over ATM
ARP	Address Resolution Protocol
ARPANET	Advanced Research Project Agency Network
ASC	Accredited Standards Committee
ASN.1	Abstract Syntax Notation 1
ATM	Asynchronous Transfer Mode
ATM25	25(25.6)Mb/s ATM
AV	Audiovisual (Audio-Visual)
B-ICI	Broadband Inter-carrier Interface
B-ISDN	Broadband ISDN
BISUP	B-ISDN User Part
BL	Burst Length
B-LT	Broadband Line Termination Equipment
BML	Business Management Layer
B-NT	Broadband Network Termination
BOM	Beginning of Message
B-TA	Broadband Terminal Adaptor
B-TE	Broadband Terminal Equipment
BUS	Broadcast and Unknown Server
CAS	Channel Associated Signaling
CATS	Conformance Abstract Test Suite
CBR	Constant Bit Rate
CES	Circuit Emulation Service
CLP	Cell Loss Priority
CMIP	Common Management Information Protocol
CMISE	Common Management Information Service Element
CNM	Customer Network Management
COM	Continuation of Message
CONS	Connection Oriented Network Service
COTS	Connection Oriented Transport Service

CPCS	Common Part Convergence Sublayer
CPE	Customer Premise Equipment
CPR	Constant Packet Rate
CRC	Cyclic Redundancy Check
CRG	Common Routing Group
CS	Convergence Sublayer (of the AAL)
CS-PDU	CS Protocol Data Unit
CSI	Convergence Sublayer Identification
DAVIC	Digital Audio-Visual Council
DCC	Data Country Code
DFI	Domain Format Identifier
DNS	Domain Name System
DOD (DoD)	Department of Defense
DOS (DoS)	Department of State
DS0	(North American) Digital Signal Level-0 [64 Kb/s]
DS1	(North American) Digital Signal Level-1 [1.544Mb/s]
DS3	(North American) Digital Signal Level-3 [44.736Mb/s]
DSP	Domain Specific Part
DSS1	B-ISDN Digital Subscriber Signaling System No.1
DSS2	B-ISDN Digital Subscriber Signaling System No.2
DSU	Data Service Unit
DTMF	Dual Tone Multi-frequency (signaling)
DXI	Data Exchange Interface
E1	(European) Digital Signal Level-1 [2.048Mb/s]
E3	(European) Digital Signal Level-3 [34.368Mb/s]
EDI	Electronic Data Interchange
EIA	Electronic Industries Association (see TIA)
EL	Element Layer
EML	Element Management Layer
EOM	End of Message
ESF	Extended Super-frame Format
ESI	End-System Identifier
ETSI	European Telecommunications Standardization Institute
FDDI	Fiber Distributed Data Interface
FPLMTS	Future Public Land Mobile Telecommunications Networks
FR	Frame Relay
FRBS	Frame Relay Bearer Service
FTSP	Federal Telecommunications Standards Program
FTTC	Fiber to the Curb
FTTH	Fiber to the Home
FUNI	Frame User-to-Network Interface
GDMO	Guidelines for the Definition of Managed Objects
GFC	Generic Flow Control
GII	Global Information Infrastructure
H	Header
HDLC	High Level Data Link Control
HEC	Header Error Control

HF	High Frequency
HFC	Hybrid Fiber Coax
HO-DSP	High-order Domain Specific Part
HPCF	Hard Polymer Clad Fiber
IA	Implementation Agreement
IAB	Internet Architecture Board
ICD	International Code Designator
IDI	Initial Domain Identifier
IDP	Initial Domain Part
IEC	International Electrotechnical Commission
IEEE	Institute of Electrical and Electronic Engineers
IESG	Internet Engineering Steering Group
IETF	Internet Engineering Task Force
IISP	Interim Inter-Switch Signaling Protocol
ILMI	Interim Local Management Interface
IN	Intelligent Networks
IP	Internet Protocol
IPOA	IP Over ATM
IS	Integrated Service
ISDN	Integrated Services Digital Network
ISO	International Standards Organization
ISOC	Internet Society
IT	Information Type
ITU	International Telecommunications Union
ITU-D	Development Sector of the ITU
ITU-R	Radiocommunications Sector of the ITU
ITU-T	Telecommunications Standardization Sector of the ITU
JTC1	Joint Technical Committee 1 (of the IEC and ISO)
LAN	Local Area Network
LANE	LAN Emulation
LEC	LAN Emulation Client
LECS	LAN Emulation Configuration Server
LED	Light Emitting Diode
LES	LAN Emulation Server
LI	Length Indicator
LIS	Logical IP Subnetwork
LO-DSP	Lower-order Domain Specific Part
LMI	Local Management Interface
L-NNI	LAN Emulation Network-to-Network Interface
L-UNI	LAN Emulation User-to-Network Interface
MAC	Medium Access Control
MARS	Multicast Address Resolution Server
MCS	Multicast Server
MCU	Multipoint Conferencing/Control Unit
MIB	Management Information Base
MIC	Media Interface Connector
MID	Message Identifier

MPEG	Motion Picture (coding) Experts Group
mpt-mpt	multipoint-to-multipoint
mpt-pt	multipoint-to-point
MTU	Message Transfer Unit
NCS	National Communications System
NE	Network Element
N-ISDN	Narrow band ISDN
NML	Network Management Layer
NMS	Network Management System
NNI	Network-to-Network/Node Interface
NSAP	Network Service Access Point
NS/EP	National Security/Emergency Preparedness
OAM	Operations, Administration, and Maintenance
OAM&P	Operations, Administration, Maintenance and Provisioning
OMNCS	Office of the Manager, National Communications System
OS	Operating System
OSI	Open Systems Interconnection
PC	Personal Computer
PCR	Peak Cell Rate
PCS	Personal Communications Service
PDH	Plesiosynchronous Digital Hierarchy
PDU	Protocol Data Unit
PHY	Physical (Layer)
PICS	Protocol Implementation Conformance Statement
PLCP	Physical Layer Convergence Protocol
PMD	Physical Media Dependent
PMDS	Physical Media Dependent Sublayer
PNNI	Private Network-to-Network/Node Interface
POF	Plastic Optical Fiber
PSTN	Public Switched Transmission Network
PT	Payload Type
pt-mpt	point-to-multipoint
pt-pt	point-to-point
PVC	Permanent Virtual Circuit
PVP	Permanent Virtual Path
Q(#)	Question (#)
QOS(QoS)	Quality of Service
R	“R” Interface Reference Point
RD	Routing Domain
RFC	Request for Comment
SAAL	Signaling ATM Adaptation Layer
SAR	Segmentation and Reassembly Sublayer (of the AAL)
SAR-PDU	SAR Protocol Data Unit
S_B	Broadband “S” Interface Reference Point
SC	Standards Committee
SCF	Synchronization and Coordination Function
SCR	Sustainable Cell Rate

SDH	Synchronous Digital Hierarchy
SDT	Structured Data Transfer
SEAL	Simple and Efficient Adaptation Layer
SEL	Selector
SG	Study Group
SML	Service Management Layer
SMDS	Switched Multi-megabit Data Service
SN	Sequence Number
SNMP	Simple Network Management Protocol
SNP	Sequence Number Protection
SONET	Synchronous Optical Network
SS7	Signaling System Number 7
SSCF	Service-Specific Coordination Function
SSCOP	Service-Specific Connection Oriented Protocol
SSCS	Service-Specific Convergence Sublayer
SSM	Single Segment Message
ST	Segment Type
ST2	Internet Stream Protocol Version 2
ST-II	same as “ST-2”
STM-1	Synchronous Transfer Mode-1 (European) [155.52Mb/s]
STS-3c	Synchronous Transfer Signal-3c (North American) [equals STM-1]
SVC	Switched Virtual Circuit
SW	Short Wavelength
T	Trailer
T1	Accredited Standards Committee T1 - Telecommunications
T-1	Transmission Carrier System-1 [1.544Mb/s]
T1A1	Technical Subcommittee on Performance and Signal Processing
T1M1	Technical Subcommittee on Internetwork OAM&P
T1S1	Technical Subcommittee on Services, Architectures and Signaling
T1X1	Technical Subcommittee on Digital Hierarchy and Synchronization
TAXI	Transparent Asynchronous Transmitter/Receiver
T_B	Broadband “T” Interface Reference Point
TC	Transmission Convergence (sublayer)
TCS	Transmission Convergence Sublayer
TDM	Time Division Multiplex
TIA	Telecommunications Industries Association (EIA/TIA)
TIB	Technical Information Bulletin
TMN	Telecommunications Management Network
TPC	Twisted Pair Cable
TSC	Technical Subcommittee
TTCN	Tree and Tabular Combined Notation
U_B	Broadband “U” Interface Point
UBR	Unspecified Bit Rate
UDT	Unstructured Data Transfer
ULP	Upper Layer Protocols
UNI	User-to-Network Interface
UPT	Universal Personal Telecommunications

UTP	Unshielded Twisted Pair
UTOPIA	Universal Test and Operation Physical Interface for ATM
VBR	Variable Bit Rate
VC	Virtual Channel
VCC	Virtual Circuit Connection
VCI	Virtual Channel Identifier
VCL	Virtual Channel Link
VDSL	Very High-Speed Digital Subscriber Line
VPCI	a collective reference for the combined VCI and VPI data field
VP	Virtual Path
VPC	Virtual Path Connection
VPI	Virtual Path Identifier
VPL	Virtual Path Link
VTOA	Voice and Telephony Over ATM
WIRE	Workable Interface Example