ATM

August 5, 2004

Trademarks and Copyrights

Adobe Acrobat and Reader are registered trademarks of Adobe Systems, Inc.

UNIX is a registered trademark of The Open Group

All other products or services mentioned in this document are identified by the trademarks, service marks, or product names as designated by the companies that market those products or services or own those marks. Inquiries concerning such products, services, or marks should be made directly to those companies

This document and its contents are provided by Fujitsu Network Communications Inc. (FNC) for guidance purposes only. This document is provided “as is” with no warranties or representations whatsoever, either express or implied, including without limitation the implied warranties of merchantability and fitness for purpose. FNC does not warrant or represent that the contents of this document are error free.

Furthermore, the contents of this document are subject to update and change at any time without notice by FNC, since FNC reserves the right, without notice, to make changes in equipment design or components as progress in engineering methods may warrant. No part of the contents of this document may be copied, modified, or otherwise reproduced without the express written consent of FNC.

Introduction

This self-study tutorial satisfies the prerequisite for Asynchronous Transfer Mode (ATM) that is required for attendance at Fujitsu Network Communications Inc. (FNC) Educational Services training classes.

Objectives

After completing this lesson, the student should be able to describe ATM cells, discuss ATM protocol and transmission (including ATM service classes, categories, and quality), and define ATM terminology.

Standards

The student should complete the tutorial and take the Self Evaluation at the end of the tutorial. If the student passes the evaluation by missing no more than three questions, the ATM prerequisite is satisfied. If more than three questions are answered incorrectly, the student should review the tutorial again and make sure the information relating to the missed questions is understood. Each student should be familiar with concepts and terms of the tutorial prior to attending class.

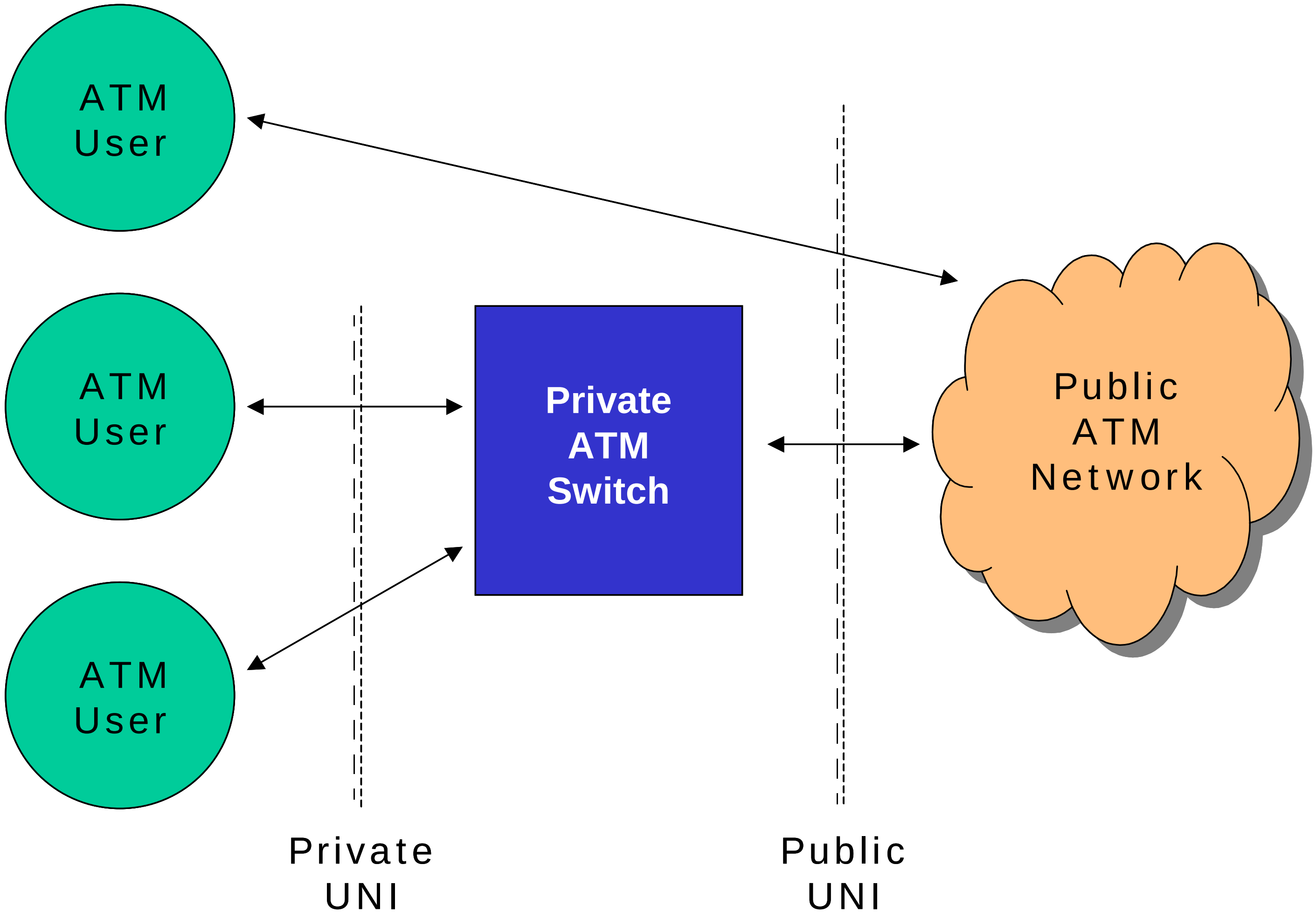
Distribution Method

The ATM tutorial is available at the following Internet address:

http://us.fujitsu.com/img_assets/FNC/pdfServices/atm-guide.pdf

The tutorial can be viewed using Adobe® Acrobat® Reader®.

Figure 1: ATM Network



ATM

Asynchronous Transfer Mode (ATM) is a switching and multiplexing technology that employs small, fixed-length cells to very quickly and efficiently move all types of traffic. ATM is fast and efficient because its cells fit into spaces too small for larger packets or frames, traffic routes are preplanned, switching is done without the need for time-consuming software, and payload error checking and correction is performed only at the destination node, not at every hop along the way.

ATM was designed to be the protocol of choice for future Broadband-Integrated Services Digital Network (B-ISDN) services. Because ATM is asynchronous, it provides true bandwidth-on-demand. Additionally, its small cell size makes ATM adaptable to any form of information—data, voice, video, audio, e-mail, faxes—and capable of moving this information amazingly fast across a network that can provide millions of virtual paths and channels between end user equipment.

Characteristically, ATM has two dimensions: transport and switching. In the transport dimension, ATM can move no faster or slower than any other digital communication technology. It is in the switching dimension that ATM shines. Packets and frames of various sizes need smart switches controlled by slow-moving software to move them through a network. Small, uniformly sized cells on an ATM network move through switches without needing software assistance. The cells already know the route to take and do not need to slow down to look for road signs or stop to get directions.

ATM allows the user to select the level of service it needs, provides guaranteed service quality, and makes reservations and preplans routes so those signals needing the most attention are given the best service. Whether the signal travels first class or standby, ATM can accommodate the user.

The ATM Forum, ITU and ANSI

The ATM Forum was started in 1991 by four computer and telecom vendors. Today nearly 1000 members of the ATM Forum work for equipment and service providers, manufacturers, carriers, and end users interested in accelerating the definition, development, and deployment of ATM technology. While the forum is not a standards body, the International Telecommunication Union (ITU), the most important telecommunications standards body in the world, considers the ATM Forum a very credible working group.

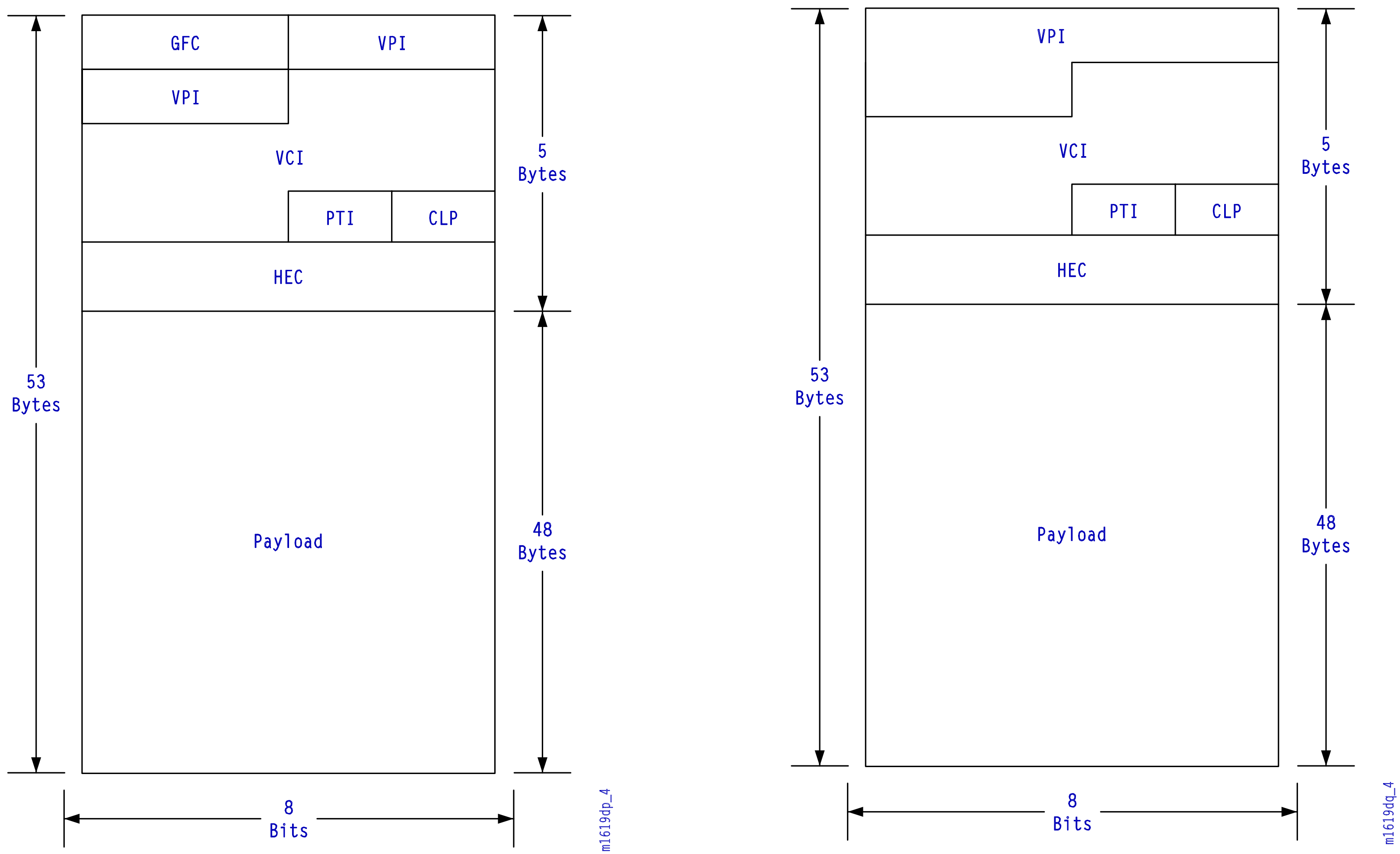
The ITU is rooted in the International Telegraphy Union, founded in Paris in 1865. Its name changed in 1934, and in 1947 the ITU became an agency of the United Nations. The ITU works with public and private organizations to develop earth-linked and satellite communications, while developing standards for all types of telecommunication technology.

The ITU-Telecommunication Standardization Sector (ITU-T) is the leader in defining Integrated Services Digital Network (ISDN), B-ISDN, and ATM specifications. The American National Standards Institute (ANSI) is the formal standards body guiding the development of ATM in the US.

Besides the ATM Forum, Telecom and the Internet Engineering Task Force (IETF) are interested in ATM standards. Telecom focuses on network products and services affecting local exchange service, and IETF is concerned with how ATM is used with the Internet

Figure 2: ATM Cells

UNI Cell **NNI Cell**



ATM Cells

An ATM cell is a 53-octet packet of information consisting of two main parts (see Figure 2):

- **Header**—5 octets reserved for:
  - Routing (GFC)
  - Addressing (VPI, VCI, PTI)
  - Flow control (CLP, HEC)
- **Payload**—48 octets reserved for voice, video, audio, and data (user or service)

The cell size is a compromise between what Europe and the United States wanted. Europe liked a 32-octet payload to reduce delay (smaller cells get through switches more quickly). The US preferred a 64-octet payload to increase bandwidth efficiency (because of a better header-to-payload ratio). The ITU settled the issue with a 48-octet compromise, giving both sides a portion of what they wanted. After adding five header octets, the ATM cell size is 53 octets (this gives an approximate 1:10 ratio between header and payload cells).

Header Cell Structure

There are 40 bits in each ATM header. These bits are subdivided into various-sized groupings designed to move payload through the ATM network to its destination. These subgroups are:

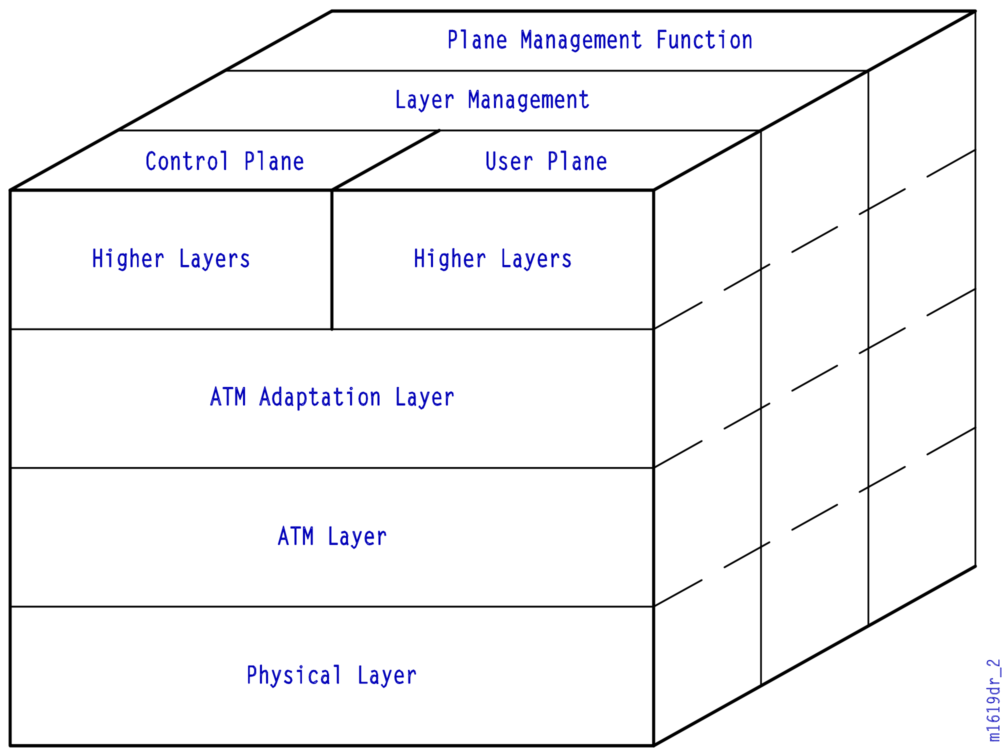
- **Generic Flow Control (GFC)**—Four bits that control traffic flow between the ATM network and terminal equipment. These are gatekeeper bits that do not travel with the cells across the ATM network but are used to establish connections with end user equipment.

Additionally, GFC bits:

- Manage access conflicts, giving each user fair access to the ATM network
- Ensure that proper quality of service is allotted to each user (see *ATM Traffic Contract* on page 19)
- Support up to 100 users on each UNI

- **Virtual Path Identifier (VPI)**—The address for up to 256 UNI virtual paths (VPs) (8 VPI bits) or up to 4096 NNI VPs (12 VPI bits). The path is fixed at connection but is shared with multiple other calls. Because NNI VPIs overwrite UNI GFC bits, more than 4000 virtual paths can be used within the ATM network.
- **Virtual Channel Identifier (VCI)**—The rest of the VPI address that identifies virtual channels within each virtual path. Sixteen bits make possible 65,536 virtual channels. The combination of VPI and VCI fields allow for 16,777,216 simultaneous UNI calls and up to 268,435,456 simultaneous NNI calls.
- **Payload Type Identifier (PTI)**—Three bits that identify the cell as carrying information for the user or as carrying service information.
- **Cell Loss Priority (CLP)**—One bit that determines if a cell can be discarded if the network becomes too congested (0 = keep, 1 = discard).
- **Header Error Control (HEC)**—Eight bits that do cyclical redundancy checks on the first four header octets. The HEC ensures multiple bit error detection and single bit error correction.

Figure 3: ATM Protocol



ATM Protocol

The ATM protocol layer model consists of four layers and three planes (see Figure 3). The layers are closely interrelated, but each layer addresses a specific set of functions. The physical layer and ATM layer can be compared with the physical layer of the OSI reference model. As with the OSI model, the various layers function independently, but continuous interaction among the layers is highly coordinated.

Physical Layer

The physical layer has four functions:

- Converts cells to a bit stream
- Controls transmission and receipt of bits on the physical medium
- Tracks ATM cell boundaries
- Packages cells into frame types that fit the physical medium (SONET cells are packaged differently than cells going to or coming from a DS3 line)

The physical layer is divided into two sublayers that perform these four functions:

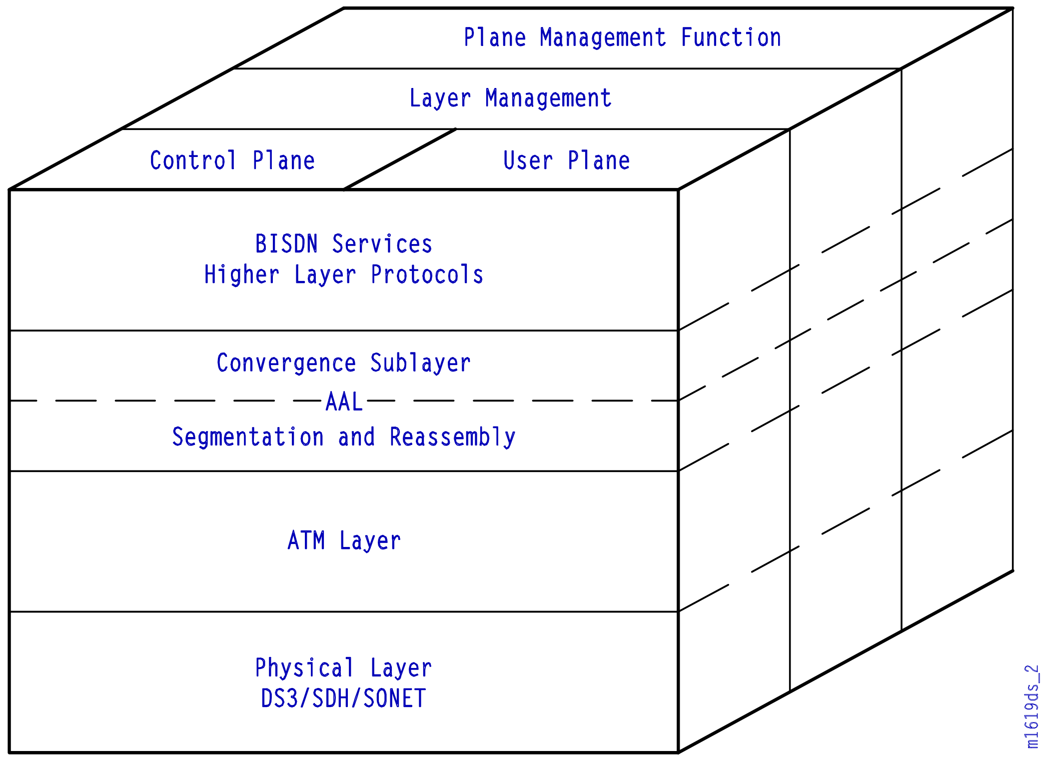
- **Physical Medium-Dependent (PMD)**—Syncs the bits and gets them to or from the correct medium, down to the correct cable and connector types
- **Transmission Convergence (TC)**—Performs error checking, maintains cell boundaries and synchronization, and packages the cells for the particular physical medium

ATM Layer

The ATM layer performs many very critical functions essential to the exchange of end-to-end communications:

- First the ATM layer takes the 48-byte payload from the ATM adaptation layer and adds the 5-byte addressing header.
- Then it multiplexes all the cells from various connections, prepares a single-cell stream for the physical layer, and puts in idle cells, if needed, as fillers for synchronous transmission systems (for example, SDH or SONET).
- Next the ATM layer provides translation (directional coding) for every cell to get the cells switched through multiple virtual connections. The ATM layer can do this because it knows the capabilities of virtual connections carrying the cells. These capabilities vary according to:
  - Bandwidth
  - Delay
  - Delay variation
  - Cell loss

Figure 4: BISDN Protocol



ATM Adaptation Layer

The ATM adaptation layer (AAL) is the top ATM layer in the protocol stack. This layer interacts with higher layers to get such customer information as voice, video, and data into and out of the payload portion of a 53-byte ATM cell.

AAL functions are divided within two sublayers (see Figure 4):

- **Segmentation and Reassembly (SAR)**
- **Convergence Sublayer (CS)**

The SAR sublayer takes a continuous bit stream of customer data, slices it up, and puts it into small ATM cells. At the other end of the network, the SAR sublayer unwraps the ATM cells and exactly reconstructs the bit stream.

The CS provides difference classes of service (A, B, C, D, or X) and performs a variety of tasks that are dependent on the AAL type in which the CS resides. AALS types are described in the following paragraphs.

AAL Type 1 (AAL1)

AAL Type 1 is class A service that is connection-oriented and capable of handling constant bit rate (CBR) traffic such as voice and videoconferencing. AAL1 requires exact timing between source and destination, so it needs to travel over a synchronous network (for example, SONET or SDH).

Synchronization samples are inserted into the payload field, and one payload byte is used for sequencing (4 bits each for a sequence number [SN] and sequence number protection [SNP]).

AAL Type 2 (AAL2)

AAL2 supports class B traffic. This too is connection-oriented; however, AAL2 can have a variable bit rate in real time and does not require end-to-end timing. AAL2 is great for compressed audio and video and travels at a high priority through the ATM network. Forty-four bytes make up the AAL2 payload. Four bytes are reserved to support AAL2 processes.

AAL Type 3/4 (AAL3/4)

After AAL types 3 and 4 were developed, it was determined they so closely resembled each other that they were combined to form AAL3/4. This combined type supports class C or class D non-real time, variable bit rate traffic that requires no timing.

Class C traffic (such as Frame Relay and X.25 data packets) require connections. Connectionless traffic (such as LAN and SMDS data) is considered Class D. Both classes are sensitive to loss but not especially sensitive to delay.

AAL3/4 provides two types of mode services: message and streaming. Message mode has one interface data unit (IDU), a single framed cell of up to 65,535 octets. Streaming mode contains multiple IDUs that are transported asynchronously. Both modes are tagged with 10-bit SAR CRC trailers for error checking and a CS protocol data unit (PDU) that is prepended with begin/end tags and a length field.

AAL Type 5 (AAL5)

AAL5 is the primary AAL for data, both connection-oriented and connectionless. AAL5 is known as the simple and efficient layer (SEAL) because nothing extra is appended to the CS-PDU that goes into the 48-octet payload.

AAL5 supports class C and class X traffic, including LAN Emulation (LANE) and IP, with unspecified or available bit rates (UBR or ABR). As no header or trailer is added, AAL5 traffic cannot be interleaved.

Table 1: ATM Service Classes

Service Class	Class A	Class B	Class C	Class D	Class X
AAL Type	1	2	3/4; 5 in Message Mode	3/4	5
ATM Forum	CBR	rt-VBR	nrt-VBR	UBR	ABR
Bit Rate	CBR	VBR	UBR	ABR	
Timing	Required	Required			
Connection Mode	Connection oriented	Connectionless	Connection or con-nectionless		
Traffic Contract Parameters	PCR, CDVT	PCR, CDVT, SCR, MBS, BT	PCR, CDVT	PCR, CDVT, MCR	
QoS Parameters	CDV, CTD, CLR	CLR	Not specified		
Some Applications	Uncompressed voice, video and audio	Compressed voice, video and audio	X.25, Frame Relay, Transaction Processing	SMDS, LAN, nrt buffered video	Network management, E-mail, FTP, WAN, LAN, IP

ATM Service Categories

ATM offers five classes of service. Each class is designed to accommodate data bursts according to customer needs and provide the appropriate quality of service (QoS) for each service class. The five service categories are:

- **Constant Bit Rate (CBR)**
  - Provides a continuous rate of flow
  - Supports traffic sensitive to delay and loss
  - Emulates circuit switching
  - Carries uncompressed voice and video
- **Real-time Variable Bit Rate (rt-VBR)**
  - Supports traffic dependent on timing and control information
  - Carries compressed voice, video, and audio
- **Non-real-time Variable Bit Rate (nrt-VBR)**
  - Supports traffic at rates that vary with time
  - Unaffected by loss or delay because of time to recover
  - Carries data and buffered voice and video
- **Unspecified Bit Rate (UBR)**
  - Provides no assurance the data will be delivered (best effort only)
  - Carries file transfers and E-mail
- **Available Bit Rate (ABR)**
  - Provides no assurance the data will be delivered (best effort only)
  - Supports nrt-VBR traffic with flow control

QoS standards have been established for each service category. Table 1 lists ATM service classes, and Table 2 lists QoS parameters for each service category.

Table 2: QoS Parameters

Service Category	Quality of Service
CBR	CDV, CTD, CLR
rt-VBR	CLR
nrt-VBR	CLR
UBR	none
ABR	none

Table 3: ATM Connections

Interface(s)	Connections (VP & VC)
Digital signal (DS)1	254
Japan level 2 (J2)	254
DS3 (single-line card)	1022
Synchronous transport mode (STM)-1 (single-line card)	1022
Optical carrier-3 concatenated (OC-3c) (single-line card)	1022
OC-12c (single-line card)	4094
DS3 (multiline card)	8190
STM-1 (multiline card)	8190
OC-3c (multiline card)	8190
OC-12c (multiline card)	8190
STM-4 (multiline card)	8190
ATM E3 (AE-3) (multiline card)	8190

ATM Access

A rate of DS1 or greater is needed to access an ATM backbone. The access can be made through customer premises equipment (CPE) or by way of a switched multibit data service (SMDS), Frame Relay, or X.25 network switch (or more commonly, a DS3 or SONET/SDH connection) through a User Network Interface (UNI).

A UNI is where the access network stops and the ATM network begins. The UNI is the point between the user and the public network service provider, and it is here that specifications for procedures and protocols between these two networks are established. Also, the ATM network takes responsibility for converting user protocol data units (PDUs) to ATM PDUs and cells.

A private UNI that allows end user access to an ATM network is a data exchange interface (DXI). DXI access is through a router, bridge, or ATM data service unit. DXI allows protocol sharing between the user and network provider and reduces ATM protocol responsibility, such as breaking out and reconstructing ATM cells.

Network-to-network interface (NNI) is a public UNI. The NNI provides access to the public network along permanent virtual circuits established at the UNI.

UNIs and NNIs can be connected in the following arrangements:

- UNI to UNI (subscriber-to-subscriber)
- UNI to NNI (subscriber-to-network)
- NNI to UNI (network-to-subscriber)
- NNI to NNI (network-to-network)

ATM Interface Connections

Each interface permits a maximum number of virtual path (VP) and virtual channel (VC) connections for user data. These are the physical limits due to hardware, not software. Table 3 lists the total number of VPs and VCs available at each interface connection.

ATM Connections

A permanent virtual circuit (PVC) is a logical connection between two end users established by administrative procedures. A PVC is usually created long before it is used and remains in place until the connection is deprovisioned. PVCs can be virtual path or virtual channel connections (VPC or VCC). Bandwidth is allocated for a PVC whether it is used or not.

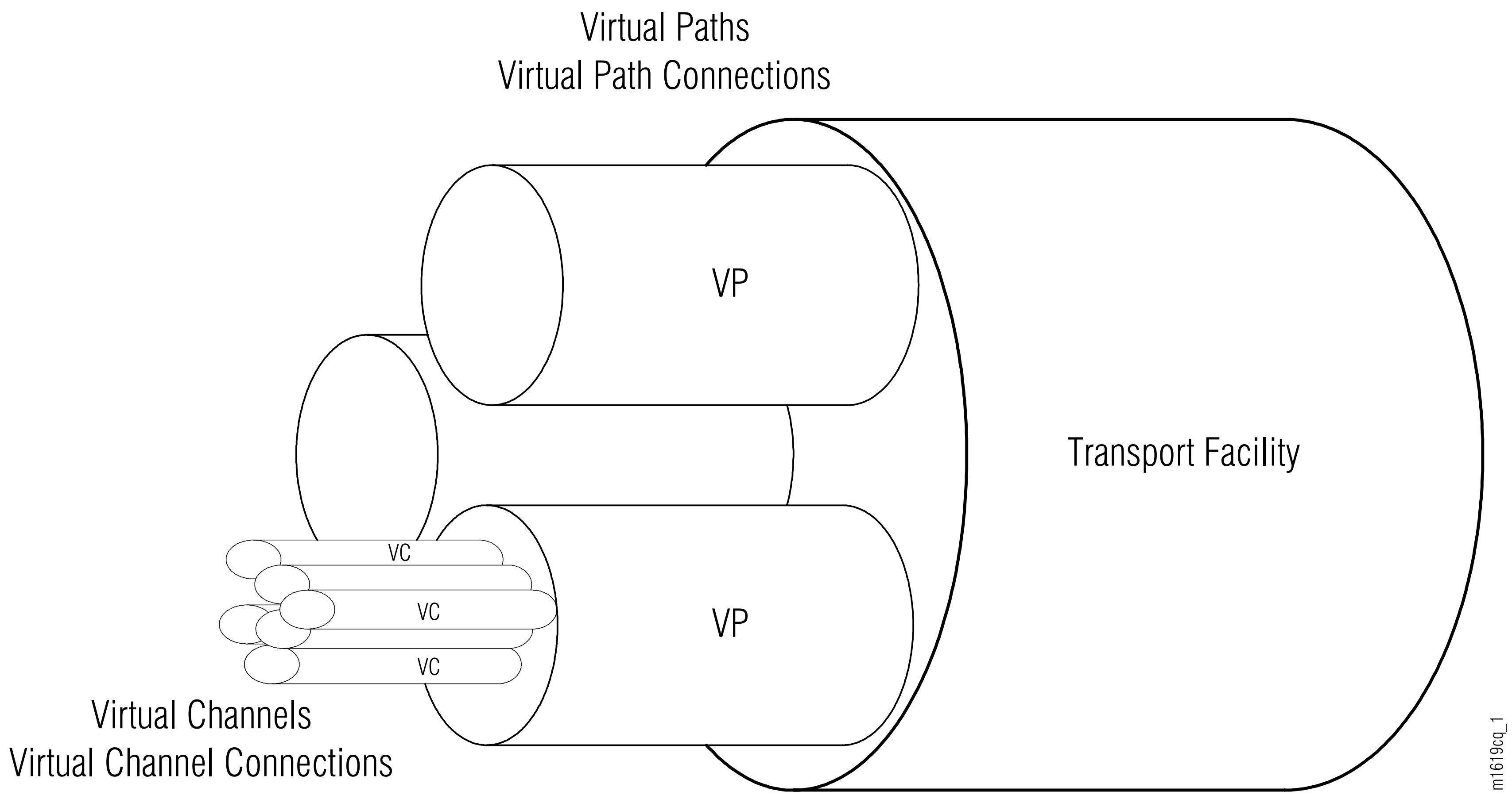
A switched virtual circuit (SVC) is a logical connection between two subscribers that is established and deconstructed with access and network signaling procedures. Cell transfer instructions for user traffic are established as each SVC is created. Bandwidth is allocated dynamically as it is needed.

ATM Connection Topologies

ATM topologies can be point-to-point, point-to-multipoint, unidirectional, and bidirectional. In a point-to-multipoint configuration, the primary source is only from a UNI, while the multiple end points can be UNI or NNI. This configuration also makes use of multicasting to replicate and distribute data to multiple subscribers. Multicasting types are logical and spatial.

In logical multicasting, the multiple endpoints are on the same physical interface. In spatial multicasting, the endpoints are on separate physical interfaces.

Figure 5: Paths and Channels



Virtual Paths and Virtual Channels

In ATM, cells move on the transmission protocol using known end-to-end routes called virtual connections. These virtual connections link one communicating entity with another through what is sometimes a very complex system of physical medium links. Every transmission link can support thousands of virtual connections, depending on when and how much traffic needs to be sent. The pathways between virtual connections are virtual paths and virtual channels.

Traffic from various sources is bundled in a pipe and directed as a whole until it reaches its destination. While the path in the network can be redirected, all bundled channels arrive at their destination. The ATM pipe is a virtual path (VP) and is a concatenation of circuits in a link (see Figure 5). The action of redirecting the pipe is called VP switching (VPS).

Various sources or channels request connection to specific destinations. These channels are not fixed throughout the network and can jump from one VP to another to reach their destination. These are called virtual channels (VCs), and the redirecting of VCs is called VC switching (VCS).

ATM cells contain header VPI and VCI that keep track of where the cells are from one node or switch to another. These identifiers do not remain constant from endpoint to endpoint but change from hop to hop.

Virtual Path and Channel Switches

Switches join transmission resources together and make sure a cell gets from one transmission link to another. If needed, switches use buffers that hold cells until time for them to move onto the next link.

The switch checks the incoming cell's VPI and VCI, determines the next outgoing VP and VC, and switches accordingly. The switch has the intelligence to move the cells to the appropriate next node by using switching tables that provide information for permanent or switched virtual connections.

Switched virtual connections are the preferred mode of operation as they are dynamically established. They are much like the connections established each time a phone call is made. The destination of the call is determined by dialing the number, and the network determines the links to that destination and establishes the connection. The connection is permanent until the call is finished and all call traffic is delivered in the same order it was sent.

Table 4: ATM Quality of Service

Service Category	Network Priority	Cell Delay and Delay Variation[a]	Cell Loss	Burst Tolerance[b]
CBR	1	Low	Low	None
rt-VBR	2	Low	Medium	Some
nrt-VBR	3	High	Medium	Some
ABR	4	High	Medium	High
UBR	5	High	High	High

[a]Cell delay variation is the change in arrival time for each cell.

[b]Burst tolerance is how long a peak cell rate can be maintained.

ATM Quality of Service

Quality of Service (QoS) performance parameters are concerned with accuracy, dependability, and speed. QoS guarantees for the five service categories (refer to Table 4) are:

- **Cell Transfer Delay (CTD)**—The average data transfer time across a UNI network. This time includes delays for all processes the data experiences:
  - Coding and decoding
  - Segmentation and reassembly
  - Propagation delay
  - Queuing
  - Loss and recovery
- **Cell Delay Variation (CDV)**—A form of CTD that addresses jitter. The cells should not arrive too early (they bunch up, can't get through quickly, and could be discarded) or too late (they can be considered lost and the whole packet could be jettisoned and reordered).
- **Cell Loss Ratio (CLR)**—The number of cells lost to the number of cells transmitted. CLR is determined by interaction between end stations and the ATM network and is in effect for the life of the connection.

As illustrated in Table 2 on page 13, QoS parameters apply most specifically to traffic requiring a constant bit rate. Uncompressed voice, audio, and video require quality service guarantees that assure that the signal transmitted at the highest, mots consistent bit rate is the signal received with the least amount of loss.

Only ATM can segregate traffic and provide specific delivery guarantees. This is part of an agreement between the ATM network and the source endpoint before traffic is accepted.

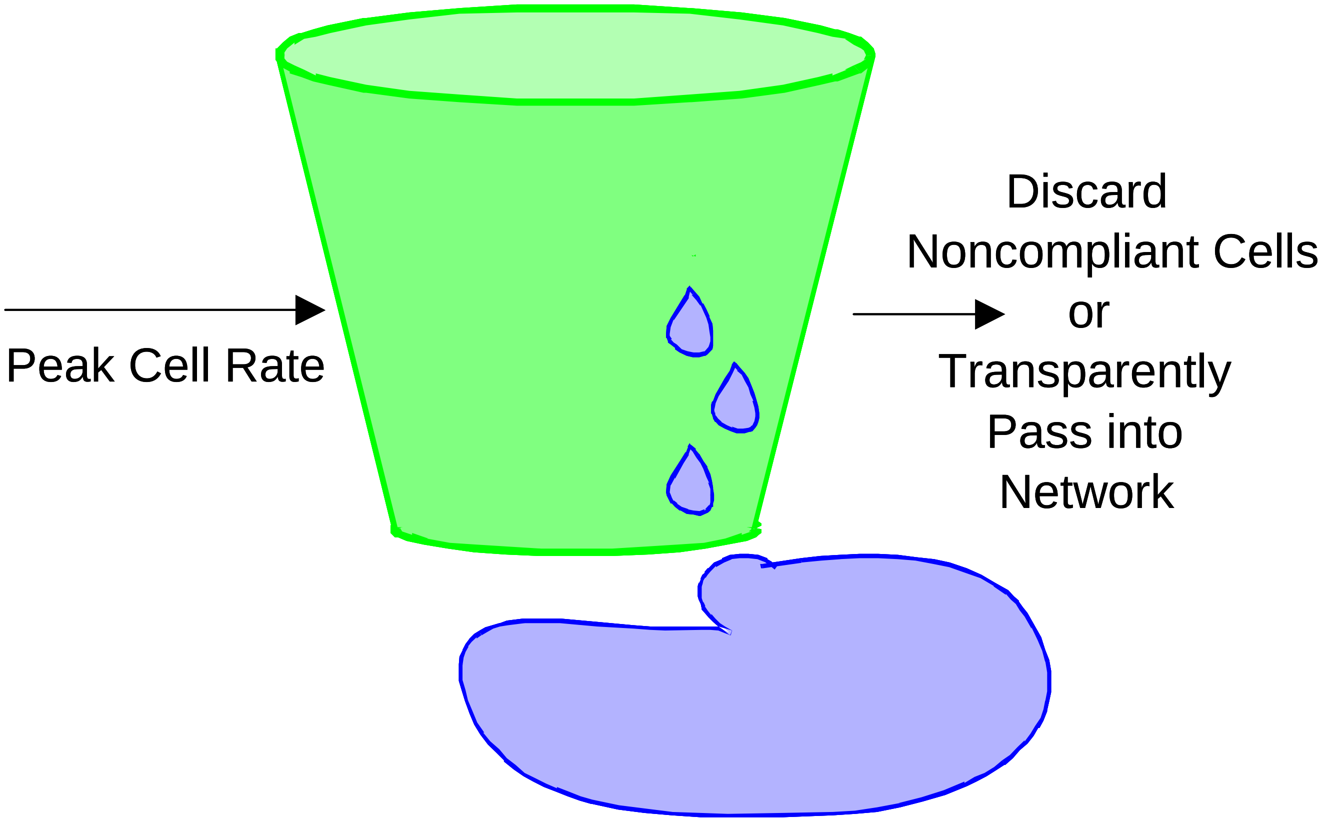
ATM Traffic Contract

The ATM network checks with the source to determine the specific signal requirements according to traffic characteristics. As each connection is made, traffic parameters are determined, and an agreement is reached. The ATM network provides service that falls within agreed to parameters. There parameters are:

- **Peak Cell Rate (PCR)** —The most cells per second the ATM network can accept and transfer for a given UNI:
  - Excess cells can be discarded.
  - PCR can apply to all service categories.
  - PCR is the rate of the virtual circuit (for CBR service).
- **Sustained Cell Rate (SCR)**—The average throughput (applies to VBR services)
- **Maximum Burst Size (MBS)**—The largest burst of traffic the network can transmit during PCR
- **Minimum Cell Rate (MCR)**—The fewest number of cells per second the network agrees to transfer across a UNI (for ABR service, the rate the originating endpoint always transmits during a connection)

Note: *QoS and ATM traffic contract rates are expressed as cells per second, not bits per second. 8 x 53 or 424 bits are in an ATM cell.*

Figure 6: Leaky Bucket



ATM Traffic Control

Connection Admission Control

There are many traffic control functions that take place within an ATM network. The first function, connection admission control (CAC), occurs before customer source information is admitted to the ATM network. A call is made to see if resources are available to establish an end-to-end connection that can provide the quality of service the customer requires without jeopardizing the quality of service needed for data already allowed on the network. The CAC looks at the source information to determine its peak and average cells, burstiness, and peak duration and to ascertain the quality of service the source information will require, such as cell transfer delay, cell loss ratio, and burst cell loss. If everything checks out, a connection is made, and customer information is admitted to the ATM network.

Parameter Controls

Additional traffic control measures are usage and network parameter controls (UPC and NPC). These controls are used in UNIs and NNIs, respectively, and monitor cell traffic volume and cell routing validity. These connection controls ensure compliance of every ATM connection to its negotiated traffic contract. The leaky bucket analogy is used for cells that exceed the contract rate and are discarded (leaked out) through a hole in the bucket that is only as big as the contract required (see Figure 6).

Priority Control

The cell loss priority (CLP) bit in the ATM cell header is used to control traffic by designating cells that are discard candidates if traffic gets backed up and priority cells must go through. Priority is determined by the quality of service the source information requested before being admitted to the ATM network.

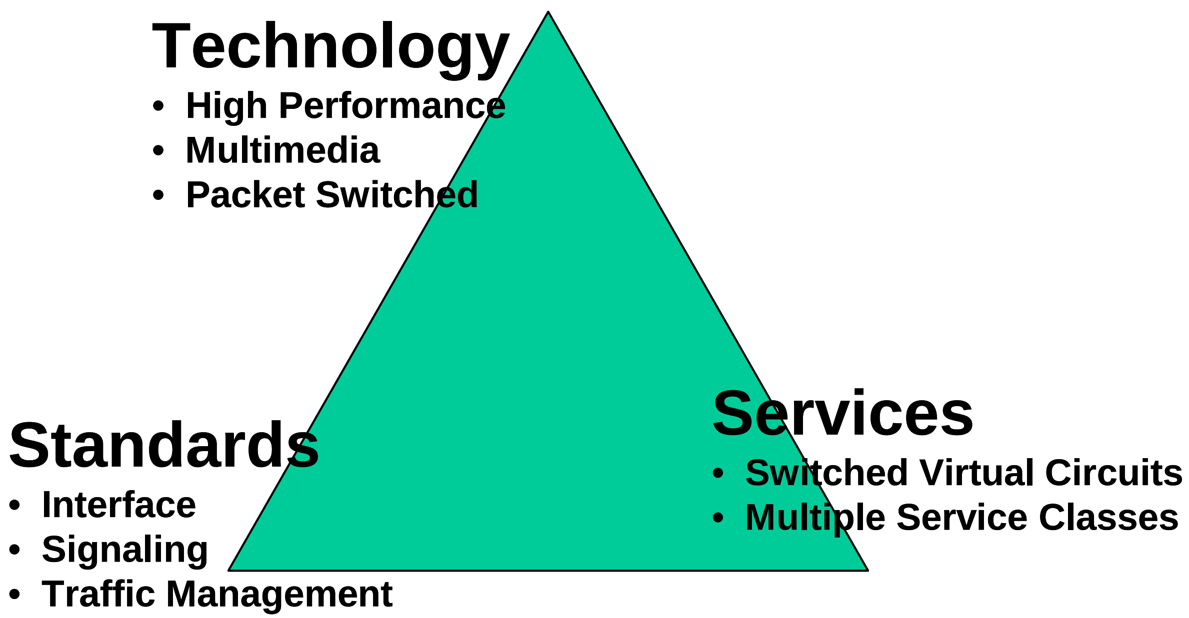
Network Resource Management

Virtual paths (VPs) are used as an important traffic control and network resource management tool. The paths are used for traffic aggregation and segregation, allowing cells requiring the same services to travel together, while segregating those cells that have greater or lesser priority. VPs also distribute congestion notifications that are alerts to reroute and establish connections away from congested areas.

Traffic Shaping

The ATM switch can be used to alter traffic characteristics of a cell stream to reduce peak cell rate, limit burst lengths, and minimize cell delay variation. This is done by respacing the cells in time so that congestion is reduced at subsequent switches. This is very important at times when long bursts of high priority traffic could otherwise bring lower priority traffic to a standstill.

Figure 7: ATM Advantages



ATM Advantages

ATM provides several advantages (see Figure 7):

- ATM fixed-length cells require lower processing overhead and produce higher transmission speeds than traditional packet switching methods.
- ATM transmits asynchronous data in a synchronous network while prioritizing time-sensitive traffic ahead of delay-tolerance traffic to ensure that quality of service is maintained.
- ATM delivers true bandwidth-on-demand (a big plus for high-speed voice, data, and video service) and uses statistical multiplexing techniques to efficiently use resources.
- ATM is application-independent, meaning it can be used as a common infrastructure for many network types, including public, private, LAN, and campus backbones.
- ATM is designed for high-performance, multimedia networking on a broad range of devices:
  - PC, workstation, server network interface cards
  - Switched Ethernet and token ring workgroup hubs
  - Workgroup and campus ATM switches
  - Enterprise network switches, multiplexers, edge and backbone switches
- International standards compliance in central office and customer premises environments allow multi-vendor operation and interoperability.

ATM Disadvantages

While ATM has several advantages, ATM disadvantages can be seen in three areas:

- Cost
- Complexity
- Availability

Compared with voice switches, ATM switches are still much more expensive per line. ATM was implemented before the designers intended, and ATM standards are still trying to catch up, which should help to bring down the cost of ATM equipment.

ATM equipment is very complex and intelligent. It takes a very intelligent management team and system to operate ATM successfully (that is, efficiently and cost-effectively).

ATM is not as widely available as SONET and SDH. These are older protocols that are widely accepted and very well standardized. Additionally, with the proliferation of Fast Ethernet and Gigabit Ethernet, ATM may not be necessary. This is especially true for those who transport Ethernet over already ubiquitous SONET/SDH networks.

ATM Acronyms

AAL	ATM adaptation layer
ABR	Available bit rate
ANSI	American National Standards Institute
ATM	Asynchronous Transfer Mode
BT	Burst tolerance
CAC	Connection admission control
CBR	Constant bit rate
CDV	Cell delay variation
CDVT	CDV tolerance
CER	Cell error ratio
CLP	Cell loss priority
CLR	Cell loss ratio
CPE	Customer premises equipment
CRC	Cyclic redundancy check
CS	Convergence sublayer
CTD	Cell transfer delay
DXI	Data exchange interface
GFC	Generic flow control
HEC	Header error control
IDU	Interface data unit
IETF	Internet Engineering Task Force
IP	Internet Protocol
ISDN	Integrated Services Digital Network
ITU	International Telecommunication Union
LAN	Local area network
LANE	LAN emulation
MBS	Maximum burst size
MCR	Minimum cell rate
NNI	Network-to-network interface
NPC	Network parameter control
nrt-VBR	Non-real time Variable Bit Rate
OAM	Operation, administration, and maintenance
PCR	Peak cell rate
PDU	Protocol data unit
PM	Physical medium
PMD	PM dependent
PTI	Payload type identifier
PVC	Permanent virtual circuit
QoS	Quality of service
rt-VBR	Real-time Variable Bit Rate
SAR	Segmentation and reassembly
SCR	Sustained cell rate
SEAL	Simple and efficient layer
SMDS	Switched multimegabit data service
SN	Sequence number
SNP	SN protection
SVC	Switched virtual circuit
TC	Transmission convergence
UBR	Unspecified bit rate
UNI	User network interface
UPC	Usage parameter control
VBR	Variable bit rate
VC	Virtual channel
VCC	VC connection
VCI	VC identifier
VCS	VC switching
VP	Virtual path
VPC	VP connection
VPI	VP identifier
WAN	Wide area network

Tutorial Review

Instructions

Please read the questions below and circle the correct answer.

1. ATM has ____ service categories.
   a. 10
   b. 3
   c. 7
   d. 5

2. An ATM cell consists of _________.
   a. 48 bits
   b. 53 bits
   c. 53 bytes
   d. 48 bytes

3. There are no Quality of Service guarantees for ___ and ___ service categories.
   a. ABR, UBR
   b. rt-VBR, nrt-VBR
   c. ABR, rt-VBR
   d. UBR, CBR

4. The ATM Protocol Layer Model consists of ___ layers and ___ planes.
   a. 4,3
   b. 3,3
   c. 3,4
   d. 4,4

5. All but one are ATM advantages.
   a. Rate and medium independent
   b. Flexibility
   c. Availability
   d. Low latency

6. The two ATM Adaption Layer sublayers are ___ and ___.
   a. SAR, CS
   b. CRT, CPU
   c. SC, SAR
   d. PMD, TC

7. The ATM Adaptation Layer puts data into the _____.
   a. virtual paths
   b. cells
   c. virtual channels
   d. ATM switches

8. ATM offers true bandwidth on demand because it is ___________.
   a. fixed-length
   b. asynchronous
   c. packet switched
   d. all of the above

9. The four bits field not used in a NNI network header is ____; four additional ____ bits used in the header.
   a. GFC, VPI
   b. VCI, GFC
   c. GFC, CRT
   d. HEC, GFC

10. The ATM QoS categories that addresses jitter is:
   a. CMR
   b. CTD
   c. CLP
   d. CDV

11. The ATM transmission link is comprised of _______ ________ within _________________.
   a. virtual paths, virtual channel
   b. virtual tributaries, virtual tributary groups
   c. virtual channels, virtual paths
   d. none of the above

12. The maximum average rate at which ATM networks agree to accept calls is the _____ cell rate.
   a. peak
   b. sustainable
   c. median
   d. mean

13. The header bits that plan all the trips but never get to go anywhere are ______.
   a. VPI
   b. GFC
   c. VCI
   d. HEC

14. An acronym for a public user network interface is:
   a. UNI
   b. PUNI
   c. PPNI
   d. NNI

Answers

Note: *Click on the answer to go to the tutorial reference page.*

1. d
2. c
3. a
4. a
5. c
6. a
7. b
8. b
9. a
10. d
11. a
12. a
13. b
14. d