ATM Fundamental detail….

Note: Calculations & Related Numerical details are attached on separate sheets

11.7. ASYNCHRONOUS TANSFER MODE (ATM)

ATM is a high Performance, cell oriented switching and multiplexing technology that utilizes fixed length packets to carry different types of traffic. ATM is the next generation of networking technology to be used on the information superhighway. ATM is well suited for bursty traffic and allows communications between devices that operate at different speeds.

ATM is a technology that has its history in the development of broadband ISDN in the 1970s and 1980s. ATM is a telecommunications concept defined by ANSI and ITU committees for the transport of a broad range of user information. The ATM Forum has played a vital role in the ATM Market since its formulation in 1991. The forum writes specifications and definitions for ATM technology. ITU approves this specification. ITU-T and ATM forum are works closely.

11.7.1. Advantages of ATM

The most important advantages or benefits of the ATM are:

1. A much wider array of information can be transmitted using ATM technology, for example, voice, data, images, CATV scans, MRI images and video conferencing.
2. ATM delivers bandwidth on demand, is not dependent on applications and works at a data rate from 1.5 Mbps to 2 Gbps.
3. All types of networking, from LANs to WANs and from backbone to desktop can be integrated by ATM technology.
4. The service is connection oriented, with data transferred over a virtual circuit.
5. ATM switches are statistical multiplexing.
6. Higher quality of service.
7. Wider array of information can be handled.
8. Accepts variety of transmission media such as optical fiber or twisted pair cable.
9. Works with current LAN and WAN technologies and supports current protocols such as TCP/IP.

11.7.2. Concepts of ATM

Connection oriented service. In connected oriented service, over a virtual circuit, the data stream from origin to destination follows the same path. Virtual circuit (a type of packet switching) operate on the same concept as packet switching, but the routing of packet is specified before transmission. Data from different connections is distinguished by means of virtual path identifier (VPI) and virtual channel identifier (VCI). By virtual circuit, cells in the same connection reach the destination in the order they are sent. It eliminates the need for sequencing numbers and buffering packets. Also, each cell incurs an overhead corresponding to the length of VPI/VCI which is less than the length source/destination address nedded. VPI and VCI are called connection identifiers.

ATM Services. ATM forum specifies five types of services. They are:

1. **Constant bit rate (CBR).** This is used for emulating circuit switching. The cell rate is constant with time. Telephone traffic, videoconferencing and television are the examples that use CBR.

2. **Variable bit rate–non real time (VBR–NRT).** This service allows users to send traffic at a rate that varies with time depending on the availability of user information. Multimedia email is an example of VBR–NRT.

3. **Variable bit rate–real time (VBR–RT).** This service is similar to VBR–NRT, but it is designed for applications that are sensitive to cell delay variation. Examples for real time VBR are voice with speech activity detection (SAD) and interactive compressed video.

4. **Available bit rate (ABR).** This service provides rate based flow control and is aimed at data traffic such as file transfer and e-mail.

5. **Unspecified bit rate (UBR).** This class is widely used today for TCP/IP.

Traffic parameters:

1. **Peak Cell Rate (PCR).** PCR is the reciprocal of the minimum time between two cells.
2. **Sustained Cell Rate (SCR).** Long term average cell rate.
3. **Initial Cell Rate (ICR).** Rate at which a should send after an idle period.
4. **Cell Delay Variation Tolerance (CDUT).** Measures permissible departure from periodicity of the traffic.
5. **Burst tolerance.** Maximum number of cells in a burst of back-to-back cells.
6. **Minimum Cell Rate (MCR).** Reciprocal of the maximum time between two cells.

Quality of Service Parameters:

1. Cell loss ratio (CCR)
2. Cell delay variation (CDV)
3. Peak-to-peak cell delay variation (peak-to-peak CDV)
4. Maximum cell transfer delay (Max CTD)
5. Mean cell transfer delay (Mean CTD).

Two types of connection:

1. **Permanent virtual connection (PVC).** PVC is a connection that is setup and taken down manually by a network manager. A set of network switches between the ATM source and destination are programmed with predefined values for VCI/VPI.

2. **Switched virtual circuit (SVC).** SVC is a connection that is setup automatically by a signalling protocol. SVC is more widely used because it does not require manual setup, but it is not reliable.

ATM switch operation : ATM switch process cells at an extremly high rate or speed. Fig. 11.27 illustrates the basic operation of ATM switch.

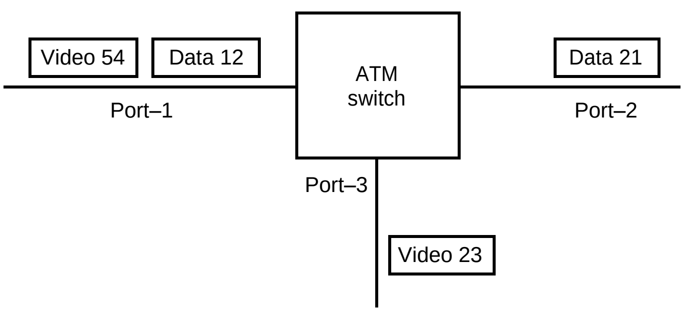


Fig. 11.27. ATM switch.

Fig. 11.27 shows the ATM switch with 3 ports. The cells enter the switch from port 1 and go out from the switch to ports 2 and 3 according to the routing table. The routing table is shown in table 11.4.

Table 11.4. Routing table for Fig. 11.27

Input		**Output**	
Port	VPI/VCI	Port	VPI/VCI
1	1/12	2	2/21
1	1/54	3	3/23

The ATM switch should have enough capacity to store incoming calls and the routing table. It should have 16 to 32 input and output ports and supports all AAL (ATM Adaptation layer). It should acts as support for congestion control. The switch should support cell switching at a rate of atleast 1 million cells per sec. The ATM switch operation is given below by step by step procedure.

1. The switch examines the VPI/VCI of the incoming cell to determine the output port to which the cell should be forwarded.
2. The ATM switch modifies the VPI/VCI fields to new value for the output port.
3. The Header error control (HEC) is used for error detection and correction in the header field of each cell. If the HEC can not correct the error, the ATM switch will discard the cell.
4. The ATM switch can modify the routable table using its control unit.

Traffic congestion : An ATM switch involved with two types of blocking of traffic congestion. They are

1. **Fabric blocking.** It occurs when the fabric capacity of a switch is less than the sum of its input data rate. In this case the switch must drop some of the cells. Some ATM switches are limited to 16 or 32 OC-3 input ports.
2. **Head of the line blocking.** It occurs when an output port is congested and a cell is waiting in the input port. The switch must drop some of the cells in the output port. Some switches randomly discard the cells, and all stations must retransmitt all the cells.

ATM Switch Architecture. Fig. 11.28 shows the general architecture of an ATM switch. The ATM switch uses statistical packet multiplexing. SDM dynamically allocates bandwidth

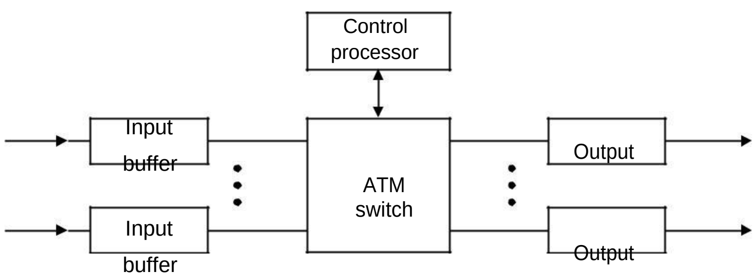


Fig. 11.28. ATM switch architecture.

to the active input channels, resulting in very efficient bandwidth utilization. In SDM, an idle channel does not receive any time allocation. SDM uses a store and forward mechanism in order to detect and correct error from incoming packets. SDM will not allocate a time slot to any idle input.

The control processor is used to control the input/output buffers and update the routing table of the switch. The switch must be capable of processing atleast one billion cells per second and supports atleast one million cells per second. The buffers are used to store the incoming data cell and the routing table.

ATM cell format. ATM uses VLSI technology to segment data to the cell at high speeds. Each cell consists of 53 bytes, in which there are a 5 byte header and a 48 byte payload. ATM cell format is shown in Fig. 11.29.

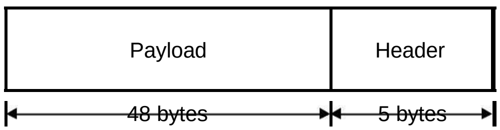


Fig. 11.29. ATM cell format.

The ATM protocol is not influenced by the actual configuration of the payload. The data is segmented into 48 bytes sizes and packaged into ATM cells. These cells can be multiplexed with other payload cells and transported through ATM routers and delivered to an end point network, where there are demultiplexed and reassembled into the original payload format and placed on to the end point network to be eventually routed to the user terminal or node. The fixed cell size ensures that time critical information such as voice or video is not adversely affected by long data frames or packets.

ATM Network Interface. Fig. 11.30 illustrates a typical ATM network. It consists of switches and end users with necessary interfaces.

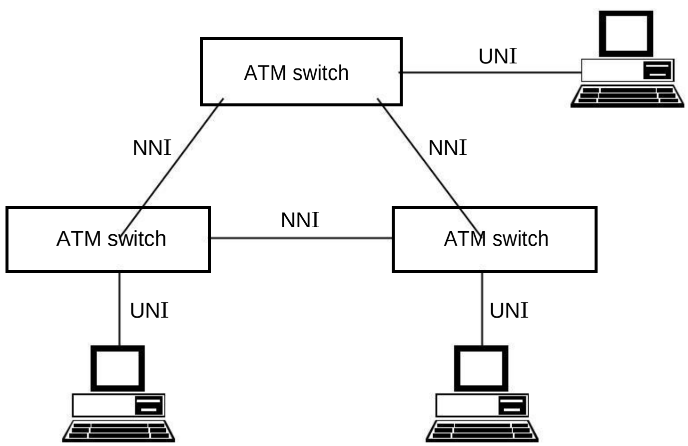


Fig. 11.30. ATM network interfaces.

ATM switches offer two types of interfaces. They are:

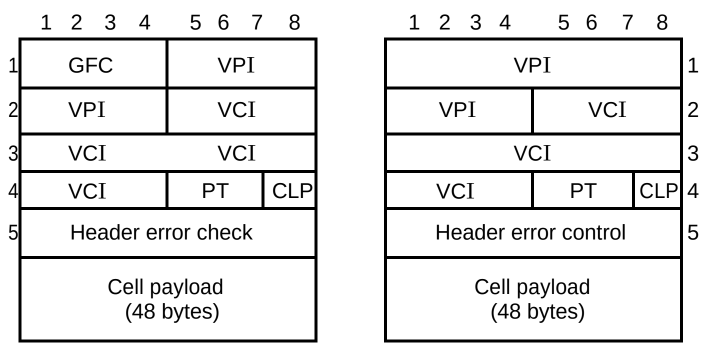
1. **Switch to Switch Interface or Network to Network Interface (NNI).** It is an interface between nodes within the network or between different sub network.

2. **Switch to User Interface or User to Network Interface (UNI).** UNI is the standard technical specification allowing ATM customer equipment (CEQ) from various manufacturers to communicate over a network provided by yet another manufacturer. It is the interface employed between ATM customer equipment and either ATM switch.

Another interface called ATM inter network interface (INI) used for intercommunication. It is also used for operational and administrative boundaries between interconnected networks. It is based upon NNI but include more features for ensuring security, control and proper administration of inter-carrier connections.

11.7.3. ATM Header Structure

As mentioned, all informations are formatted into fixed length cells consisting of 48 bytes of payload and 5 bytes of cell header. The header is organised for efficient switching in high speed hardware implementation and carries payload type information, virtual circuit identifiers and header error check. Fig. 11.31 shows the ATM header structure. It shows the header structure for both UNI and NNI interfaces.



(a) UNI header (b) NNI header

Fig. 11.31. ATM header structure.

Various fields of the ATM header are explained below:

Generic Flow Control (GFC). GFC is 4 bit field. It can be used to provide local functions such as identifying multiple stations sharing a single ATM interface. This is currently not used.

Virtual Path Identifier (VPI). It is a 8 bit field used with VCI to identify the next destination of a cell as it passes through a series of ATM switches.

Virtual Channel Identifier (VCI). It is a 16 bit field. With VPI, it is used to identify the next destination of a cell as it passes through a series of ATM switches.

Payload type (PT). It is a 3 bit field. The first bit indicates whether the payload is data or control data. The second bit indicates congestion, and third bit indicates whether the cell is the last cell in the series.

Congestion loss priority (CLP). It is just a one bit field. It indicates whether a cell should be discarded if it encounters extreme congestion. This bit is used for QOS.

Header Error Control (HEC). It is an 8 bit field. This 8 bit CRC detect all single errors and certain multiple bit errors.

The only difference between UNI header and NNI header is that UNI has a GFC field of 4 bit and VPI of 8 bit and NNI has no GFC field but VPI is 12 bit field. The 4 bit GFC field in UNI as used to signal to the user the need for flow control. The NNI uses these bits to expand the VPI field.

11.7.4. ATM Layers

Fig. 11.32 shows an ATM end point operational model and an ATM switch operational model.

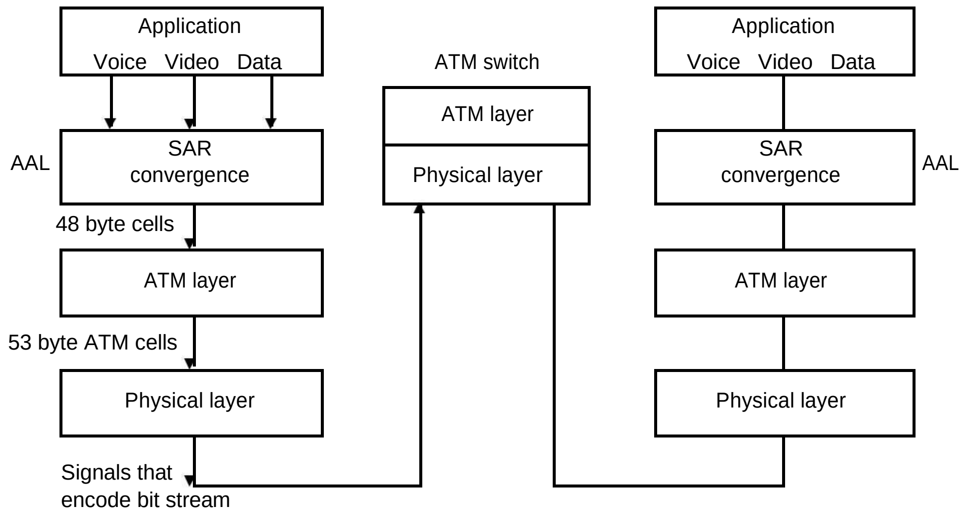


Fig. 11.32. Headers of ATM cell.

ATM end point operational model:

The ATM end point operational model consists of three layers

1. ATM adaptation layer (AAL)
2. ATM layer and
3. Physical layer

The ATM adaptation layer (AAL) is described in the section 11.7.5. Remaining two layers are explained below.

Physical layer. The physical layers are divided into two sublayers. They are Physical Medium Dependent (PMD) layer and the transmission convergence (TC) layer.

The DMP sublayer provides bit transmission, coding, electrical and optical conversion and bit timing. The functions of the TC sublayer are as follows:

1. Extracting the cell from physical layer
2. Scrambling the cell before transmission and descrambling the cell after transmission.

3. After receiving a cell from physical layer, TC calculate the HEC header and compares with the cell's HEC header. The results of the comparison are used for error correction in the cell header. If the error can not be corrected, the cell will be discarded.

ATM layer. There is no sublayers. It performs the following function.

1. It adds cell header and remove cell header.
2. The VPI/VCI values of incoming cell is translated to a new VPI/VCI value for the outgoing cell.
3. Generic flow control—to determine the destination of the receiving cell.
4. Multiplexes and demultiplexes cell.

11.7.5. ATM Adaptation Layer (AAL)

The AAL converts the large Service Data Unit (SDU) data packet of the upper layer to 48 bytes for the ATM cell pay load. The AAL is divided into two sublayers. They are convergence sublayer (CS) and the segmentation and Reassembly sublayer (SAR) as shown in Fig. 11.33.

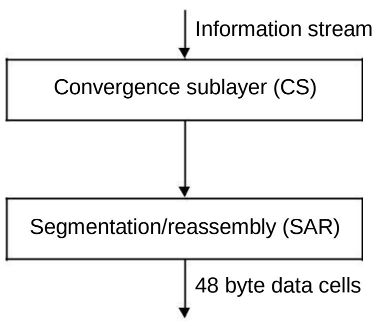


Fig. 11.33. ATM adaptation layer.

ATM can be used for various applications. Therefore different types of AALs are needed to provide service to upper layer applications. The AALs are divided into four classes of traffic (class A, class B, class C and class D). Also AAL is divided into four types of AAL protocol (Type 1, Type 2, Type 3/4 and Type 5). Table 11.5 shows the service classification of ATM AAL.

Table 11.5. Service classification of ATM

Application type	Class A	Class B	Class C	Class D
AAL type	AAL 1	AAL 2	AAL 3/4 AAL 5	AAL 3/4 AAL 5
Timing relation between source and destination	Required	Required	Not required	Not required
Bit rate	constant	variable	variable	variable
Connection type	connection oriented	connection oriented	connection oriented	connection-less
Applications	voice communications	compressed audio or video	data	data

The CS converts the information stream into four types of packet streams called AAL Type 1, Type 2, Type 3/4 and Type 5. The packet formats should match the five types of ATM services already described. CS tasks are likely to be application dependent. Hence CS is further subdivided into the upper, service specific CS (SSCS) and the lower common part SS (CPCS).

SAR tasks are quite standard, depending only on traffic type. The SAR segments the SDU received from CS and add necessary overhead and convert them into 48 byte cells or protocol data units (PDU).

Types of Adaptation Layers

The types of ATM adaptation layers are AAL type 1 or AAL 1, AAL type 2 or AAL 2, AAL type 3/4 or AAL 3/4 and AAL type 5 or AAL 5. Fig. 11.34 shows the cell format of all these types.

AAL 1. It is designed to carry class A traffic. The field SN (4 bits) is used as cell sequence number to detect any missing cell or disordered cell. The sequence number protection field (SNP) is 4 bit and used for error detection on an SN field using a CRC polynomial $X^3 + X^2 + 1$.

The SAR sublayer takes the (periodic) packet stream generated by the CS sublayer, segments it into 47 byte SDU, and prepends to each SDU, a 4 bit sequence number (SN) protected by a 4 bit SNP field.

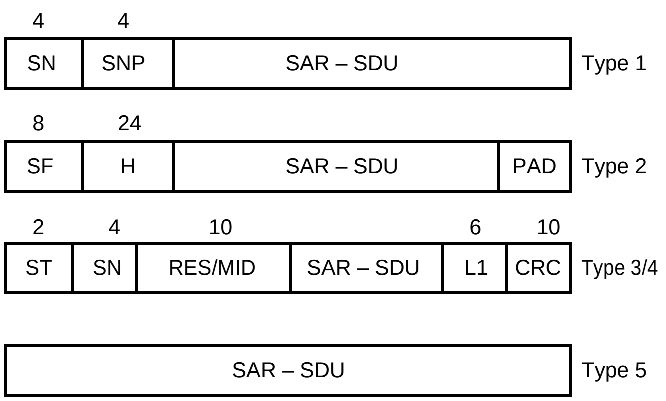


Fig. 11.34. Types of ATM adaptation layer.

AAL 2. It is designed to carry class B traffic. The 8 bit start field (SF) includes a 6 bit offset field (OSF), which indicates the number of bytes between the start field and the payload or between the start field. The 24 bit Header (H) includes the Length indicator (LI) for variable length payload.

AAL 3/4. It is started as two separate adaptation layers (AAL 3 and AAL 4). The specification of two AAL's merged and the newly formed type is called AAL 3/4. AAL 3/4 is designed to take variable length frames up to 64 kbytes and segment them into cells. The 2-bit ST or segment type is set as follows. ST = 10 for BOM, ST = 00 for COM, ST = 01 for EOM and ST = 11, if the packet fits in side a single cell. The 10 bit multiplexing identifier (MID) is used to distinguish among the cells originating from different data grams.

AAL 5. It is an efficient way to transfer information in ATM. The IP packet upto 64 k bytes is packaged into a CS packet that contains a length indicator and a 32 bit CRC calculated over the complete CS packet with the generator. AAL 5 provides services similar to those AAL 3/4, but uses fewer control fields.