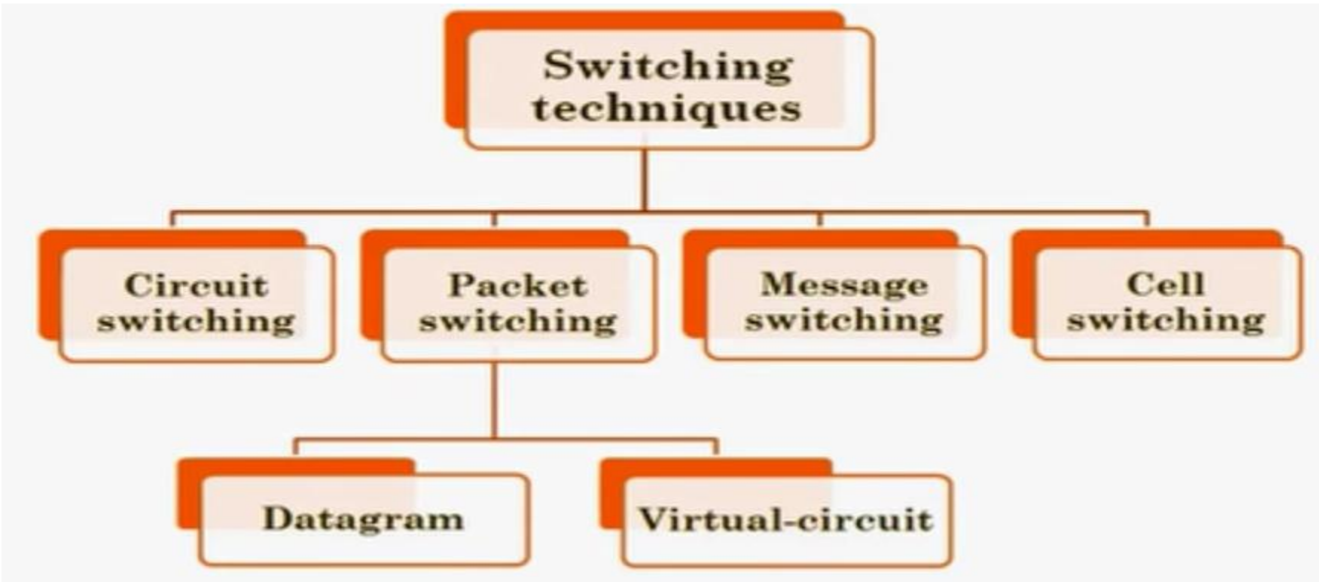
Switching

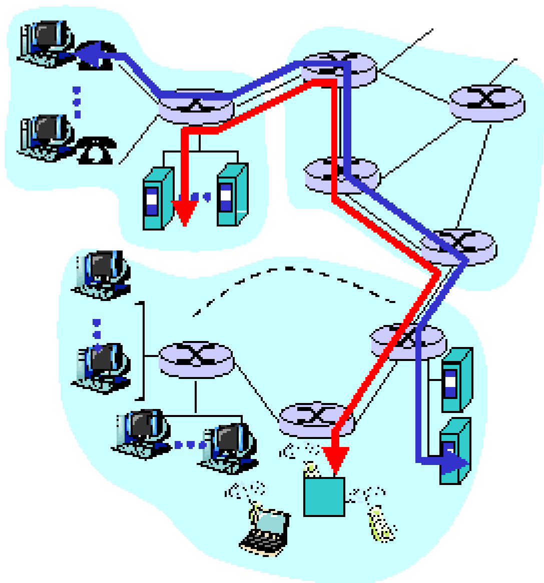
The Concept of switching is:

- Passage of massage from source to destination involves many decisions.
- When a message reaches a connecting device, a decision needs to be made to select one of the output ports through which the packet needs to be sent out.
- The connecting device acts as a switch that connects one port to another port.

Switching techniques are:



Circuit Switching



Circuit switching is a methodology of implementing a telecommunications network in which two network nodes establish a dedicated communications channel (circuit) through the network before the nodes may communicate. The circuit guarantees the full bandwidth of the channel and remains connected for the duration of the communication session. The circuit functions as if the nodes were physically connected as with an electrical circuit.

The defining example of a circuit-switched network is the early analog telephone network. When a call is made from one telephone to another, switches within the telephone exchanges create a continuous wire circuit between the two telephones, for as long as the call lasts.

Packet Switching

Packet switching features delivery of variable bit rate data streams (sequences of packets) over a computer network which allocates transmission resources as needed using statistical multiplexing or dynamic bandwidth allocation techniques. When traversing network adapters, switches, routers, and other network nodes, packets are buffered and queued, resulting in variable delay and throughput depending on the network's capacity and the traffic load on the network.

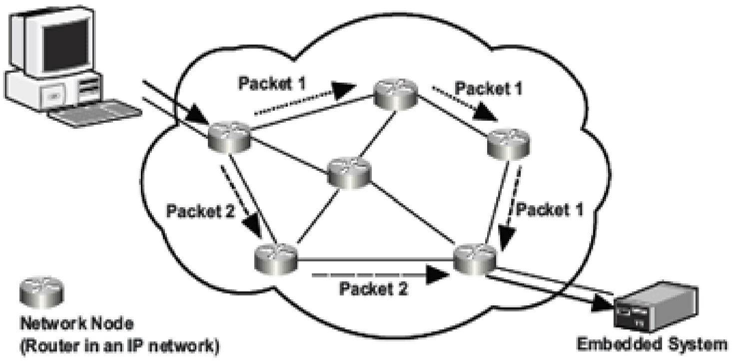


Figure 2-2 Packet Switched Network

Packet switching is used to optimize the use of the channel capacity available in digital telecommunication networks such as computer networks

Circuit Switching Vs. Packet Switching

Circuit switching contrasts with packet switching which divides the data to be transmitted into packets transmitted through the network independently. In packet switching, instead of being dedicated to one communication session at a time, network links are shared by packets from multiple competing communication sessions, resulting in the loss of the quality of service guarantees that are provided by circuit switching.

In circuit switching, the bit delay is constant during a connection, as opposed to packet switching, where packet queues may cause varying and potentially indefinitely long packet transfer delays. No circuit can be degraded by competing users because it is protected from use by other callers until the circuit is released and a new connection is set up. Even if no actual communication is taking place, the channel remains reserved and protected from competing users.

Virtual circuit switching is a packet switching technology that emulates circuit switching, in the sense that the connection is established before any packets are transferred, and packets are delivered in order.

	CIRCUIT SWITCHING	PACKET SWITCHING
Call Setup	Required	Optional
Overhead during call	Minimal	Per Packet
State	Stateful	No state
Resource Reservation	Easy	Difficult
QoS (Quality of Service)	Easy	Difficult
Sharing	By overbooking	Easy

Connectionless and connection-oriented packet switching

Two major packet switching modes exist:

1. connectionless packet switching, also known as datagram switching; and
2. connection-oriented packet switching, also known as virtual circuit switching.

In the first case, each packet includes complete addressing or routing information. The packets are routed individually, sometimes resulting in different paths and out-of-order delivery. In the second case, a connection is defined and pre-allocated in each involved node during a connection setup phase before any packet is transferred. The packets include a connection identifier rather than address information. Some connectionless protocols are Ethernet, IP, and UDP; connection oriented packet-switching protocols include X.25, Frame relay, Multiprotocol Label Switching (MPLS), and TCP.

In connection-oriented networks, each packet is labeled with a connection ID rather than an address. Address information is only transferred to each node during a connection set-up phase, when the route to the destination is discovered and an entry is added to the switching table in each network node through which the connection passes. The signaling protocols used allow the application to specify its requirements and the network to specify what capacity etc. is available, and acceptable values for service parameters to be negotiated. Routing a packet is very simple, as it just requires the node to look up the ID in the table. The packet header can be small, as it only needs to contain the ID and any information (such as length, timestamp, or sequence number) which is different for different packets.

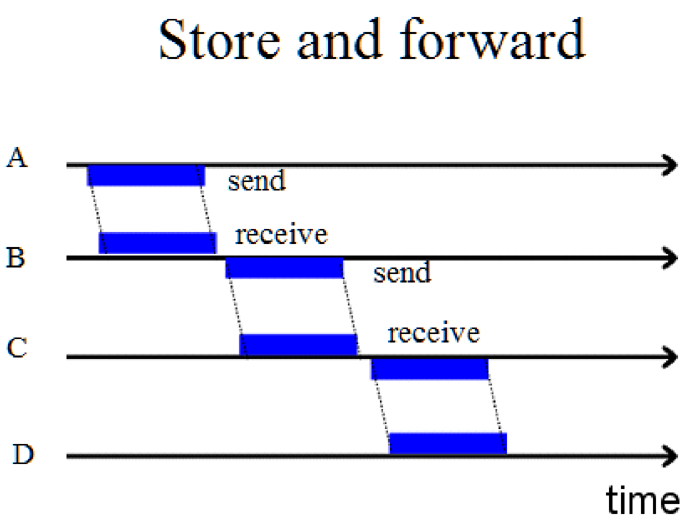
In connectionless networks, each packet is labeled with a destination address, source address, and port numbers; it may also be labeled with the sequence number of the packet. This precludes the need for a dedicated path to help the packet find its way to its destination, but means that much more information is needed in the packet header, which is therefore larger, and this information needs to be looked up in power-hungry content-addressable memory. Each packet is dispatched and may go via different routes; potentially, the system has to do as much work for every packet as the connection-oriented system has to do in connection set-up, but with less information as to the application's requirements. At the destination, the original message/data is reassembled in the correct order, based on the packet sequence number. Thus a virtual connection, also known as a virtual circuit or byte stream is provided to the end-user by a transport layer protocol, although intermediate network nodes only provides a connectionless network layer service.

Message Switching

Message switching was the precursor of packet switching, where messages were routed in their entirety, one hop at a time. It was first built by Collins Radio Company, Newport Beach, California during the period 1959-1963 for sale to large airlines, banks and railroads. Message switching systems are nowadays mostly implemented over packet-switched or circuit-switched data networks. Each message is treated as a separate entity. Each message contains addressing information, and at each switch this information is read and the transfer path to the next switch is decided. Depending on network conditions, a conversation of several messages may not be transferred over the same path. Each message is stored (usually on hard drive due to RAM limitations) before being transmitted to the next switch. Because of this it is also known as a 'store-and-forward' network. Email is a common application for Message Switching. A delay in delivering email is allowed unlike real time data transfer between two computers.

Store and forward delays

Since message switching stores each message at intermediate nodes in its entirety before forwarding, messages experience an end to end delay which is dependent on the message length, and the number of intermediate nodes. Each additional intermediate node introduces a delay which is at minimum the value of the minimum transmission delay into or out of the node. Note that nodes could have different transmission delays for incoming messages and outgoing messages due to different technology used on the links. The transmission delays are in addition to any propagation delays which will be experienced along the message path.



In a message-switching centre an incoming message is not lost when the required outgoing route is busy. It is stored in a queue with any other messages for the same route and retransmitted when the required circuit becomes free. Message switching is thus an example of a delay system or a queuing system. Message switching is still used for telegraph traffic and a modified form of it, known as packet switching, is used extensively for data communications.

Advantages

The advantages to Message Switching are:

- Data channels are shared among communication devices improving the use of bandwidth.

- Messages can be stored temporarily at message switches, when network congestion becomes a problem.
- Priorities may be used to manage network traffic.
- Broadcast addressing uses bandwidth more efficiently because messages are delivered to multiple destinations.

Virtual circuit

A virtual circuit (VC) is a means of transporting data over a packet switched computer network in such a way that it appears as though there is a dedicated physical layer link between the source and destination end systems of this data. The term virtual circuit is synonymous with virtual connection and virtual channel. Before a connection or virtual circuit may be used, it has to be established, between two or more nodes or software applications, by configuring the relevant parts of the interconnecting network. After which, a bit stream or byte stream may be delivered between the nodes; hence, a virtual circuit protocol allows higher level protocols to avoid dealing with the division of data into segments, packets, or frames.

Examples of Packet Switching Protocols that provide virtual circuits

Examples of network layer and data link layer virtual circuit protocols, where data always is delivered over the same path:

- X.25, where the VC is identified by a virtual channel identifier (VCI). X.25 provides reliable node-to-node communication and guaranteed Quality of Service QoS.
- Frame relay, where the VC is identified by data link connection identifier (DLCI). Frame relay is unreliable, but may provide guaranteed QoS.
- Asynchronous Transfer Mode (ATM), where the circuit is identified by a virtual path identifier (VPI) and virtual channel identifier (VCI) pair. The ATM layer provides unreliable virtual circuits.

Permanent and switched virtual circuits in ATM, frame relay, and X.25

Switched virtual circuits (**SVCs**) are generally set up on a per-call basis and are disconnected when the call is terminated; however, a **permanent virtual circuit** (**PVC**) can be established as an option to provide a dedicated circuit link between two facilities. PVC configuration is usually preconfigured by the service provider. Unlike SVCs, PVC are usually very seldom broken/disconnected.

A switched virtual circuit (SVC) is a virtual circuit that is dynamically established on demand and is torn down when transmission is complete, for example after a phone call or a file download. SVCs are used in situations where data transmission is sporadic and/or not always between the same data terminal equipment (DTE) endpoints.

A permanent virtual circuit (PVC) is a virtual circuit established for repeated/continuous use between the same DTE. In a PVC, the long-term association is identical to the data transfer phase of a virtual call. Permanent virtual circuits eliminate the need for repeated call set-up and clearing.

- Frame relay is typically used to provide PVCs.

- ATM provides both **switched virtual connections** and **permanent virtual connections**, as they are called in ATM terminology.
- X.25 provides both **virtual calls** and PVCs, although not all X.25 service providers or DTE implementations support PVCs as their use was much less common than SVCs

X.25 vs. Frame Relay packet switching

Both X.25 and Frame Relay provide connection-oriented operations. But X.25 does it at the network layer of the OSI Model. Frame Relay does it at data link layer. Another major difference between X.25 and Frame Relay is that X.25 requires a handshake between the communicating parties before any user packets are transmitted. Frame Relay does not define any such handshakes. The simplicity of Frame Relay makes it faster and more efficient than X.25. Because Frame relay is a data link layer protocol, like X.25 it does not define internal network routing operations. In X.25 the IDs , the virtual circuit and virtual channel numbers have to be correlated to network addresses. The same is true for Frame Relay. For a while, Frame Relay was used to interconnect LANs across wide area networks. However, X.25 and well as Frame Relay have been supplanted by the Internet Protocol (IP) at the network layer, and the Asynchronous Transfer Mode (ATM) and or versions of Multi-Protocol Label Switching (MPLS) at layer two. A typical configuration is to run IP over ATM or a version of MPLS.

Cell Switching

It is considered to be a high speed switching technology that attempted to overcome the speed problems faced by the shared media like Ethernet and FDDI. Cell switching uses a connection-oriented packet-switched network.

When a connection is established it is known as signaling. It is called cell switching because this methodology uses a fixed length of packets of **53 bytes** out of which **5 bytes** are reserved for header. Unlike cell technology, packet switching technology uses variable length packets. Even though cell switching closely resembles packet switching because cell switching also breaks the information into smaller packets of fixed length and thereby ensuring guaranteed delays.

Cell switching has many advantages. High performance, common LAN/WAN architecture multimedia support, dynamic bandwidth, and scalability. High performance is achieved because this technology uses hardware switches. Cell switching uses virtual circuit rather than physical circuit, therefore it is not necessary to reserve network resources for a particular connection. Also, once a virtual circuit is established switching time is minimized, which ensures higher network throughputs.

The cell has a fixed length of 53 bytes out of which 48 bytes are reserved for payloads and 5 bytes act as header. The header contains payload-type information, virtual-circuit identifiers, and header error check.

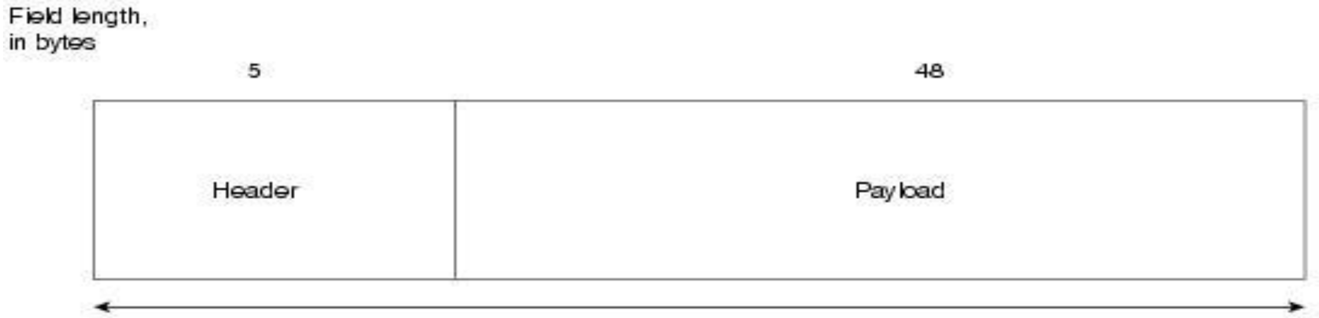
Cell switching has features of circuit switching, as .it is a connection-oriented service where each connection during its set up phase creates a virtual circuit. The connection, oriented virtual circuits for each phase allocates specified resources for different streams of traffic. This makes cell switching a cost effective service.

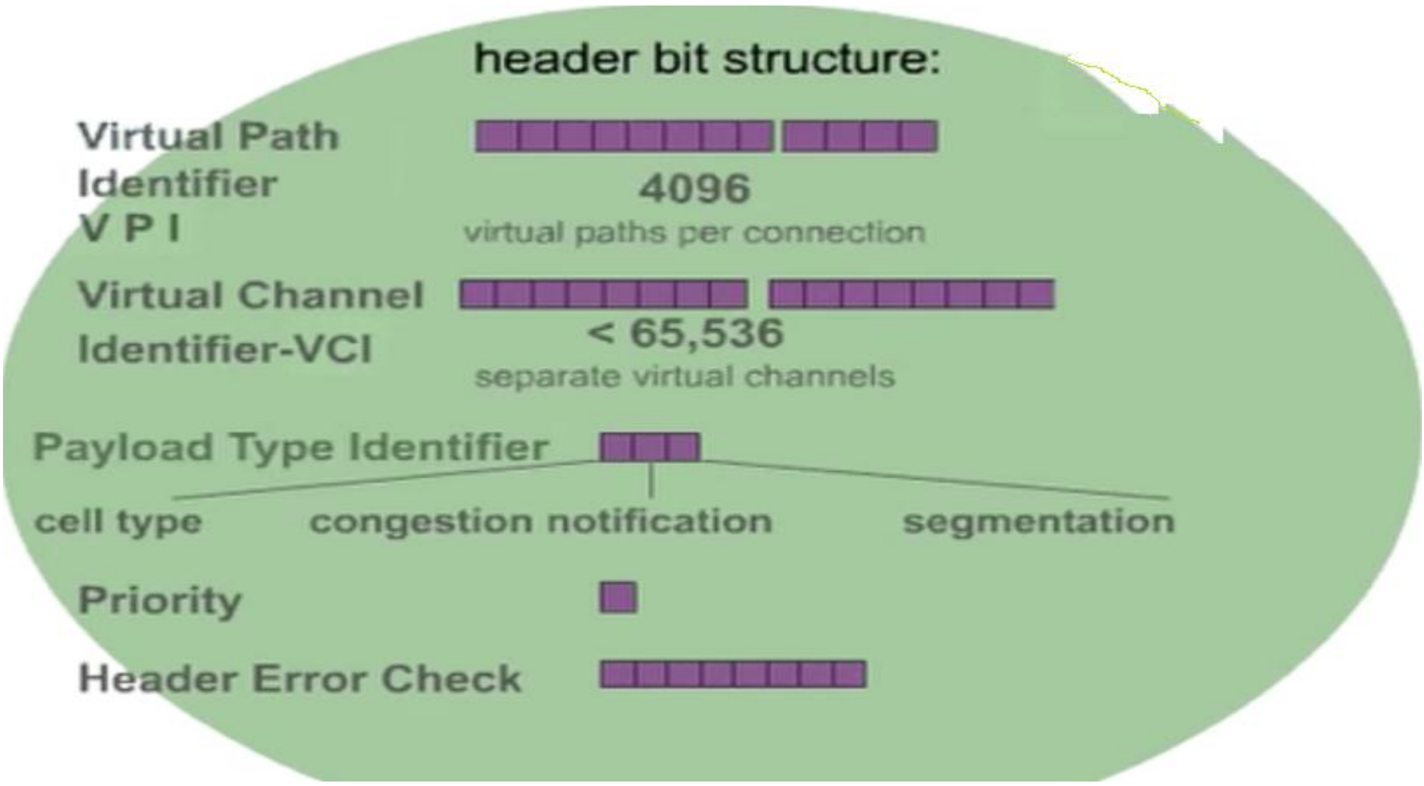
Asynchronous Transfer Mode Switching (ATM)

ATM is a cell-switching and multiplexing technology that combines the benefits of circuit switching (guaranteed capacity and constant transmission delay) with those of packet switching (flexibility and efficiency for intermittent traffic). It provides scalable bandwidth from a few megabits per second (Mbps) to many gigabits per second (Gbps).

ATM Cell Basic Format

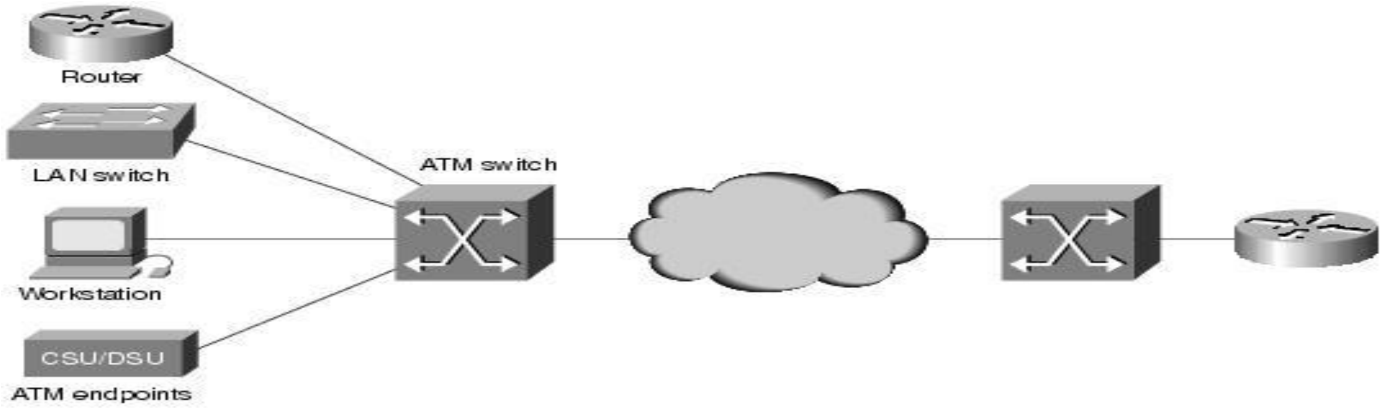
ATM transfers information in fixed-size units called cells. Each cell consists of 53 octets, or bytes. The first 5 bytes contain cell-header information, and the remaining 48 contain the payload (user information). Small, fixed-length cells are well suited to transferring voice and video traffic because such traffic is intolerant of delays that result from having to wait for a large data packet to download, among other things. Figure: An ATM Cell Consists of a Header and Payload Data illustrates the basic format of an ATM cell.





ATM Devices

An ATM network is made up of an ATM switch and ATM endpoints. An ATM switch is responsible for cell transit through an ATM network. The job of an ATM switch is well defined: It accepts the incoming cell from an ATM endpoint or another ATM switch. It then reads and updates the cell header information and quickly switches the cell to an output interface toward its destination. An ATM endpoint (or end system) contains an ATM network interface adapter. Examples of ATM endpoints are workstations, routers, digital service units (DSUs), LAN switches, and video coder-decoders (CODECs). Figure: An ATM Network Comprises ATM Switches and Endpoints illustrates an ATM network made up of ATM switches and ATM endpoints.



ATM Virtual Connections

ATM networks are fundamentally connection-oriented, which means that a virtual channel (VC) must be set up across the ATM network prior to any data transfer. (A virtual channel is roughly equivalent to a virtual circuit.)

Two types of ATM connections exist: virtual paths, which are identified by virtual path identifiers (VPI), and virtual channels, which are identified by the combination of a VPI and a virtual channel identifier (VCI).

A virtual path is a bundle of virtual channels, all of which are switched transparently across the ATM network based on the common VPI. A transmission path is the physical media that transports virtual channels and virtual paths.

Figure: VCs Concatenate to Create VPs, which, in turn, traverse the media or transmission path.

ATM Reference Model

The ATM architecture uses a logical model to describe the functionality that it supports. ATM functionality corresponds to the physical layer and part of the data link layer of the OSI reference model.

The ATM reference model is composed of the following planes, which span all layers:

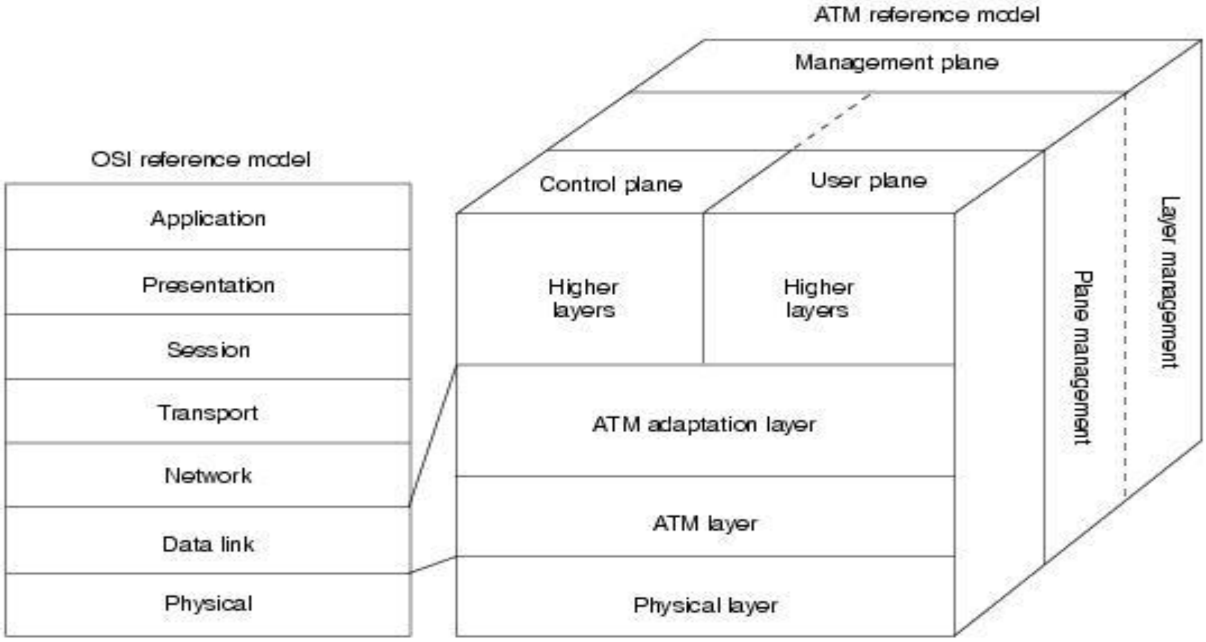
- **Control** - This plane is responsible for generating and managing signaling requests.
- **User** - This plane is responsible for managing the transfer of data.
- **Management** - This plane contains two components:
  - Layer management manages layer-specific functions, such as the detection of failures and protocol problems.
  - Plane management manages and coordinates functions related to the complete system.

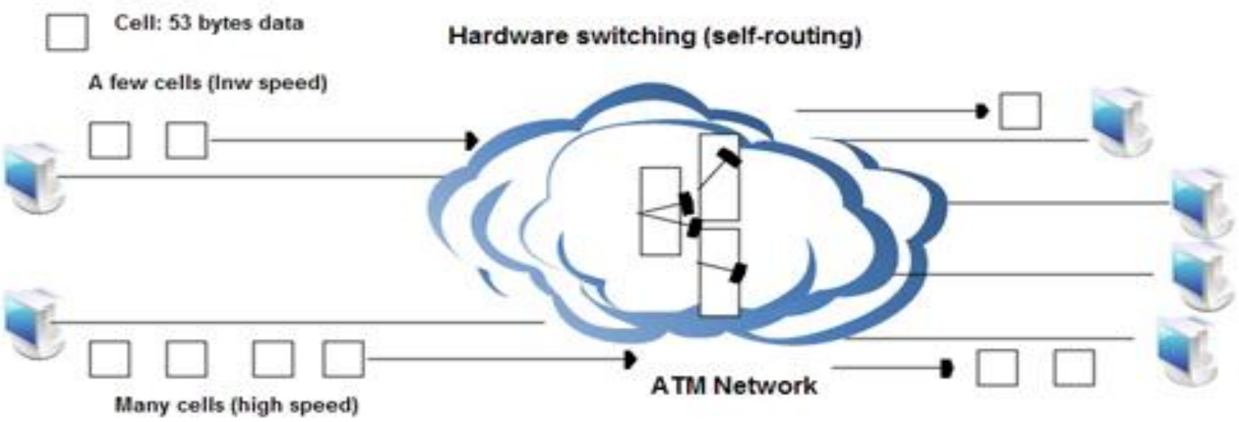
The ATM reference model is composed of the following ATM layers:

- **Physical layer** - Analogous to the physical layer of the OSI reference model, the ATM physical layer manages the medium-dependent transmission.
- **ATM layer** - Combined with the ATM adaptation layer, the ATM layer is roughly analogous to the data link layer of the OSI reference model. The ATM layer is responsible for the simultaneous sharing of virtual circuits over a physical link (cell multiplexing) and passing cells through the ATM network (cell relay). To do this, it uses the VPI and VCI information in the header of each ATM cell.
- **ATM adaptation layer (AAL)** - Combined with the ATM layer, the AAL is roughly analogous to the data link layer of the OSI model. The AAL is responsible for isolating higher-layer protocols from the details of the ATM processes. The adaptation layer prepares user data for conversion into cells and segments the data into 48-byte cell payloads.

Finally, the higher layers residing above the AAL accept user data, arrange it into packets, and hand it to the AAL.

Figure: The ATM Reference Model Relates to the Lowest Two Layers of the OSI Reference Model illustrates the ATM reference model:





ATM Structure

Characteristics of ATM

1- The transport speeds of most ATM applications are most often 155Mbps and 622 Mbps.

2- ATM is a flexible service made possible by the size of the packets (cells). The cell size for all applications is 53 bytes.

3- The small cell size allows a variety of applications to run on ATM networks including voice, video, and data. The appeal of the service has to do with the ability to pass voice and video information. These two services are time sensitive or otherwise known as isochronous data. This means that voice and video are susceptible to time delays. The small cell size of ATM and the service options such as Continuous Bit Rate Service allow such traffic to flow over the network where others such as Frame Relay and SMDS cannot guarantee this level of service.