Asynchronous Transfer Mode (ATM) in Computer Network

- **Why ATM networks?**

1. Driven by the integration of services and performance requirements of both telephony and data networking: “broadband integrated service vision” (B-ISON).

2. Telephone networks support a single quality of service and are expensive to boot.

3. Internet supports no quality of service but is flexible and cheap.

4. **ATM networks were meant to support a range of service qualities at a reasonable cost- intended to subsume both the telephone network and the Internet.**
   BSNL has set up ATM network with nodes at Delhi, Mumbai, Chennai, Kolkota and Bangalore.

Asynchronous Transfer Mode (ATM):

It is an International Telecommunication Union- Telecommunications Standards Section (ITU-T) **efficient for call relay and it transmits all information including multiple service types such as data, video, or voice which is conveyed in small fixed-size packets called cells. Cells are transmitted asynchronously and the network is connection-oriented.**

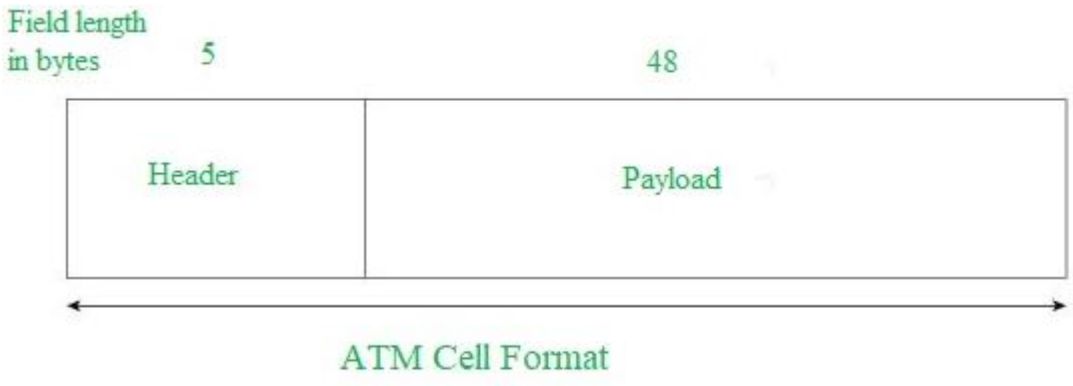
- Asynchronous transfer mode (ATM) is a technology that was developed in the year between 1970 and 1980.
- This was considered the revolution in packet switching.
- Each cell consists of 53 bytes longs.
- Further, the 53 bytes long can be divided into 5 bytes header and 48 bytes payload.
- Before making an ATM call, we need to send a message to set up the connection.

All the cells follow the same path connected to the destination. The cell can also handle both variable and constant rate traffic. Thus it has multiple types of traffic with end-to-end encryption.
Asynchronous transfer mode (ATM) does not depend on the transmission medium. Asynchronous transfer mode (ATM) uses cell or packet switching and virtual circuits to switch the transmission medium. The main purpose of

designing the Asynchronous transfer mode (ATM) is to help implement high-performance multimedia networking.

ATM Cell Format –

As information is transmitted in ATM in the form of fixed-size units called **cells**. As known already each cell is 53 bytes long which consists of a 5 bytes header and 48 bytes payload.

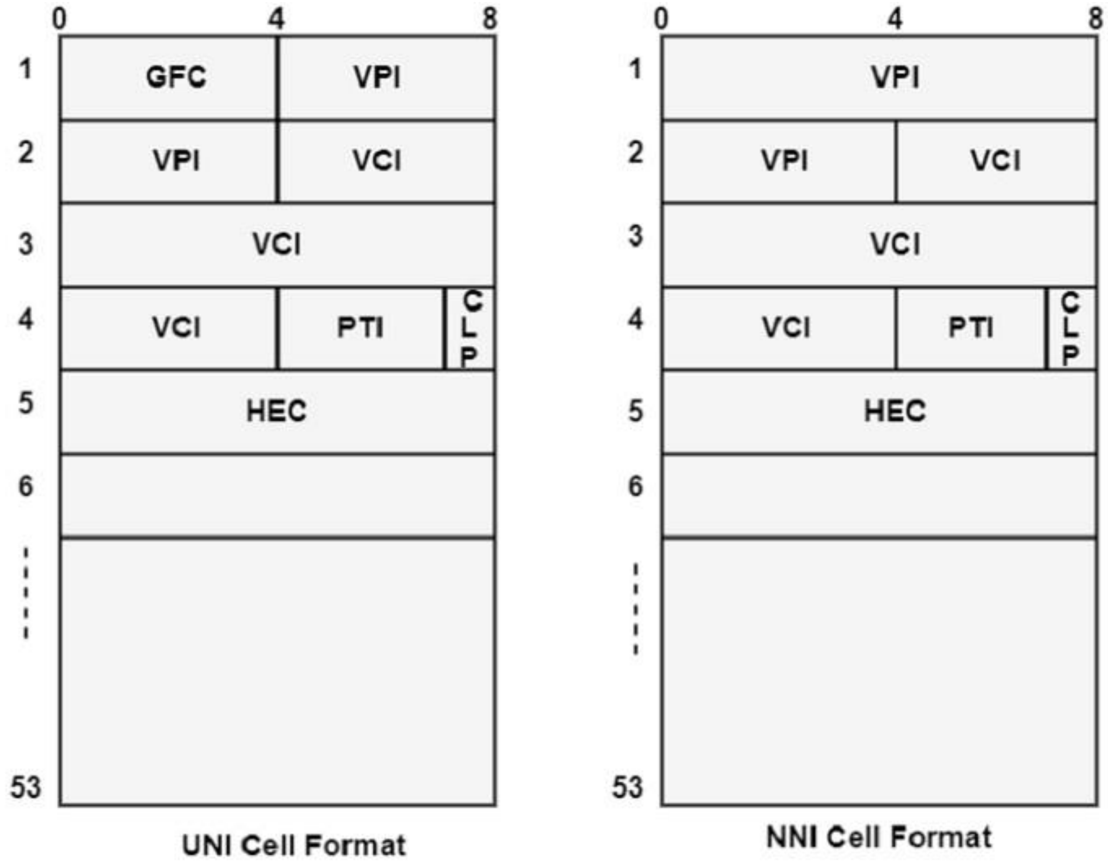


An ATM cell header can be two formats, such as User Network Interface (UNI) or Network to Network Interface (NNI).

The UNI header can be used for communication between ATM endpoints and ATM switches in private ATM networks.

The NNI header can be used for communication between ATM switches.

The figure shows the ATM UNI cell header format and the ATM NNI cell header format. Unlike the UNI, the NNI header does not contain the **Generic Flow Control (GFC) fi**eld. The NNI header has a **Virtual Path Identifier (VPI) field** that appears in the first 12 bits. It is allowing for high trunks between public ATM switches.



ATM Cell Formats

ATM Cell Header Fields

The following definitions summarise the ATM cell header fields as shown in the figure above −

- **Generic Flow Control (GFC)** − It supports local functions, such as recognizing multiple stations that send a single ATM interface. This field is generally not used and is set to its default value of 0 (binary 0000).
- **Virtual Path Identifier (VPI)** − In conjunction with the Virtual Channel Identifier (VCI), it recognises the next destination of a cell as it transfers through a series of ATM switches on the way to its destination.
- **Virtual Channel Identifier (VCI)** − In conjunction with the VPI, it recognizes the next destination of a cell as it transfers through a series of ATM switches on the way to its destination.
- **Payload Type (PT)** − It denotes in the first bit whether the cell includes user data or control data. If the cell includes user data, the bit is set to 0. If it includes control data, it is set to 1. The second bit denotes congestion (0 = no congestion, 1 = congestion), and the third bit denotes whether the cell is the last in a sequence of cells that define a single AAL5 frame (1 = last cell for the frame).

- **Cell Loss Priority (CLP)** − It denotes whether the cell should be removed if it encounters extreme congestion as it transfers through the network. Suppose the CLP bit similar is to 1, and the cell should be discarded in preference to cells with the CLP bit equal to 0.
- **Header Error Control (HEC)** − It evaluates checksum only on the first 4 bytes of the header. It can be valid a single bit error in these bytes, thereby preserving the cell instead of discarding it.

Working of ATM:

ATM standard uses two types of connections. i.e., **Virtual path connections** (VPCs) which consist of Virtual channel connections (VCCs) bundled together which is a basic unit carrying a single stream of cells from user to user. **A virtual path can be created end-to-end across an ATM network, as it does not rout the cells to a particular virtual circuit.** In case of major failure, all cells belonging to a particular virtual path are routed the same way through the ATM network, thus helping in faster recovery.

Switches connected to subscribers use both VPIs and VCIs to switch the cells which are Virtual Path and Virtual Connection switches that can have different virtual channel connections between them, serving the purpose of creating a *virtual trunk* between the switches which can be handled as a single entity. **Its basic operation is straightforward by looking up the connection value in the local translation table determining the outgoing port of the connection and the new VPI/VCI value of connection on that link.**

ATM vs DATA Networks (Internet) –

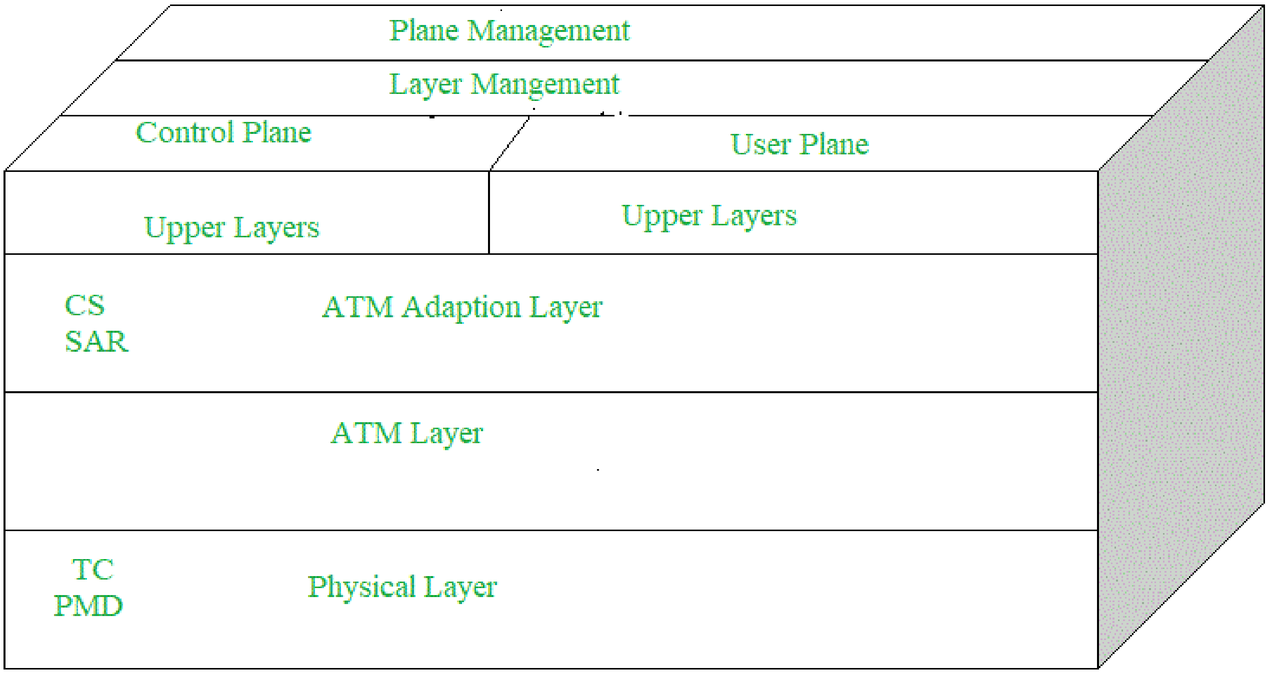
- **ATM is a "virtual circuit" based: the path is reserved before transmission. While Internet Protocol (IP) is connectionless and end-to-end resource reservations are not possible. RSVP is a new signaling protocol on the internet.**
  - **Resource Reservation Protocol (RSVP) is a network protocol that allows applications to request a specific quality of service (QoS) for their data flows.**

- **ATM Cells: Fixed or small size and Tradeoff is between voice or data. While IP packets are of variable size.**

- Addressing: ATM uses 20-byte global NSAP addresses for signaling and 32-bit locally assigned labels in cells. While IP uses 32-bit global addresses in all packets.

A **network service access point address** (**NSAP address**)

ATM Layers:



1. **ATM Adaption Layer (AAL) –**
   It is meant for isolating higher-layer protocols from details of ATM processes and prepares for conversion of user data into cells and segments it into 48-byte cell payloads. **AAL protocol excepts transmission from upper-layer services and helps them in mapping applications, e.g., voice, data to ATM cells.**

2. **Physical Layer –**
   It manages the medium-dependent transmission and is divided into two parts physical medium-dependent sublayer and transmission convergence sublayer. The main functions are as follows:
   - It converts cells into a bitstream.
   - It controls the transmission and receipt of bits in the physical medium.
   - It can track the ATM cell boundaries.
   - Look for the packaging of cells into the appropriate type of frames.

3. **ATM Layer –**
   It handles transmission, switching, congestion control, cell header processing, sequential delivery, etc., and is responsible for simultaneously sharing the virtual circuits over the physical link known as cell multiplexing and passing cells through an ATM network known as cell relay making use of the VPI and VCI information in the cell header.

ATM Applications:

1. **ATM WANs –**
   It can be used as a WAN to send cells over long distances, a router serving as an end-point between ATM network and other networks, which has two stacks of the protocol.

2. **Multimedia virtual private networks and managed services –**
   It helps in managing ATM, LAN, voice, and video services and is capable of full-service virtual private networking, which includes integrated access to multimedia.

3. **Frame relay backbone –**
   Frame relay services are used as a networking infrastructure for a range of data services and enabling frame-relay ATM service to Internetworking services.

4. **Residential broadband networks –**
   ATM is by choice provides the networking infrastructure for the establishment of residential broadband services in the search of highly scalable solutions.

5. **Carrier infrastructure for telephone and private line networks –**
   To make more effective use of SONET/SDH fiber infrastructures by building the ATM infrastructure for carrying the telephonic and private-line traffic.

Systems Network Architecture (SNA)

Systems Network Architecture (SNA) is a data communication architecture established by IBM to specify common conventions for communication among the wide array of IBM hardware and software data communication products and other platforms.

Among the platforms that implement SNA in addition to mainframes are IBM's Communications Server on Windows, AIX, and Linux, Microsoft's Host Integration Server (HIS) for Windows, and many more.

The way in which products internally implement these common conventions can differ from one product to another, but because the external interface of each implementation is compatible, different products can communicate without the need to distinguish among the many possible product implementations.

SNA products recognize and recover from loss of data during transmission, use flow control procedures to prevent data overrun and avoid network congestion, identify failures quickly, and recover from many errors with minimal involvement of network users.

SNA products also increase network availability through options such as the extended recovery facility, backup host, alternative routing capability, and maintenance and recovery procedures integrated into workstations, modems, and controllers.

History of SNA

In 1974, IBM introduced its Systems Network Architecture (SNA), which is a set of protocols and services enabling communication between host computers (IBM mainframes) and peripheral nodes, such as IBM's dedicated hardware boxes, the 3174 controller for 3270 type displays and printers, controllers for the retail and finance industry, and more. The mainframe subsystem that implements SNA was named Virtual Telecommunication Access Method (VTAM).

The robustness of the SNA protocol, the IBM hardware, and the transaction management infrastructure software supplied by IBM (CICS and IMS) made SNA the dominant protocol in the Fortune 1000 companies.

In order to understand the rationale of the many functions and services in SNA, you must understand the computing environment at that time. Prior to 1974, data processing was batch-based. Batch means that data was recorded on paper, usually on predefined templates, and was keyed into media (like punched cards) readable by the computer system. The computer department executed various programs on the data. The final result was a printed report.

Around 1974, transaction processing was introduced. People used terminals to key in the data directly and receive the output for their inquiry instantaneously. To implement transaction processing, networking infrastructure was put in place. The carriers at that time were geared to supply voice services rather than data service, so communication lines were slow and unreliable (in the range of 9600 bits per second).

The human ear can tolerate small errors in telephone lines, but computers cannot. Even a missing bit, or an extra bit, in a data communication line can be catastrophic. Try to imagine what might happen to your bank account if the ATM you use receives a garbled message.

In the early 1970s, computer memory was a scarce and expensive resource. Devices with 16 KB of memory were common in the computer industry. These devices were slow compared to the CPU speeds we see today.
IBM had to address the limitation imposed by the communication lines and networking hardware, and developed a robust protocol that would guarantee the integrity of the messages.

What you need to know about SNA today

During the 20-year period when SNA was the primary networking method, many CICS and IMS application programs were developed and put in place. The application programming interface (API) of these application programs is heavily dependent on the underlying protocol, SNA.

It is apparent that TCP/IP is the dominant networking protocol now and for the foreseeable future. Today, new applications use state-of-the-art programming techniques, like Java and HTTP, but it will take many years until all SNA applications disappear. Why is that so?

A networking application is dependent on the communication protocol it uses. Every protocol provides an application programming interface (API). TCP/IP's API is called socket programming and SNA has its own API. Migrating a networking application from one protocol to another (that is, from SNA to TCP/IP) requires replacing the calls to the API. Business mangers are reluctant to invest in protocol conversion only for the sake of changing the underlying protocol without introducing new functions and improvements.

More importantly, in the past 30 years businesses have invested a tremendous amount of labor and money in developing SNA applications. It is estimated that the investment made in CICS and IMS applications is in the range of 20 trillion US dollars. Considering the investments in SNA applications, these programs will be used for many years. To recode these applications as TCP socket applications is often impractical and cost-prohibitive. Besides, alternatives exist. IBM introduced new technologies to help businesses preserve the investment in SNA and use IP as the protocol for connecting SNA computers. The technology is known as SNA/IP ("SNA over IP"). The two endpoints, the SNA application in the mainframe and the SNA application in the remote location (branch, store), remain unchanged, thereby preserving the investment in SNA.

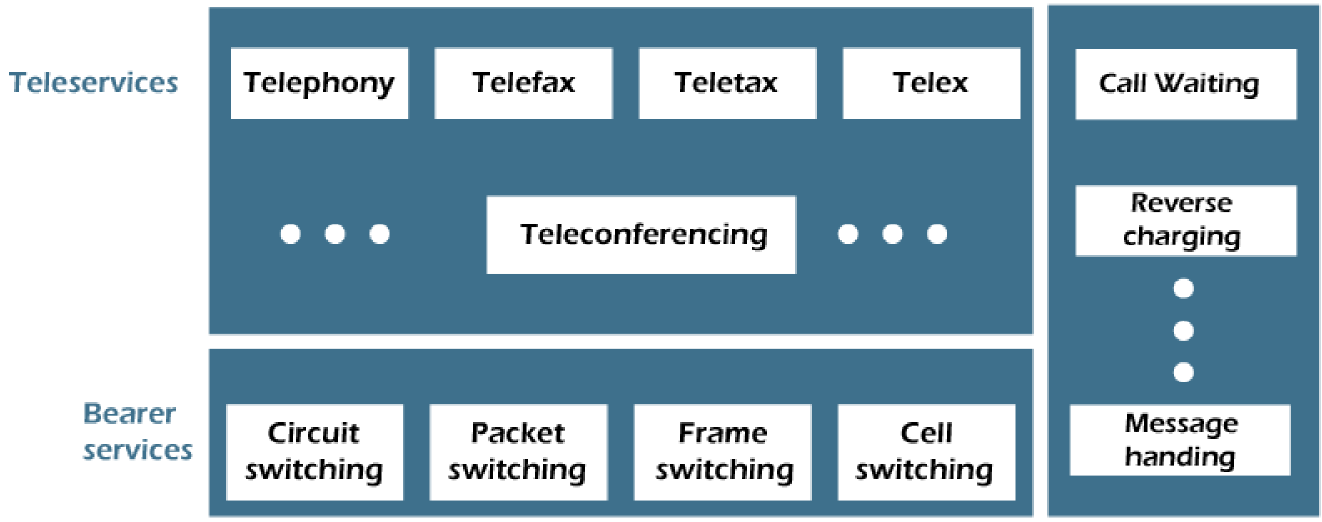
Because SNA applications will exist for years to come, someone has to care for SNA definitions, problem determination, recovery, business continuity procedures, and many other tasks. These tasks are the responsibility of the mainframe networking systems programmer who needs to know in depth the architecture and how to implement SNA on various hardware and software platforms.

Integrated Services Digital Network

Introduction:

ISDN is a set of protocols that is based on high-speed fully digitized telephone service. **The main aim of ISDN is to provide a fully integrated digital service to the users.**

In ISDN there are following three types of ISDN services:



Bearer Services:

This type of services is used to transfer information such as voice, data, and video between the users without manipulating the content of the network information. It belongs to the first 3 layers of the OSI reference model.

Tele Services:

In these types of services, the network may change the contents of the data. It belongs to the last 4 layers of the OSI reference model. It includes telephony, tele box, fax, and teleconferencing etc.

Supplementary Services:

It provides additional functionality to the bearer services and teleservices. Some of the examples of supplementary services are **reverse charging, call waiting, and message handling.**

Principles of ISDN:

Following are the principles of ISDN are:

- It supports both circuit switching & packet switching with the connections at 64 kbps.
- In ISDN layered protocol architecture is used for specification.
- ISDN services provides maintenance.
- ISDN services includes some network management functions.
- In ISDN network several configurations are possible for implementing.

ISDN SERVICES:

Following are the two types of services associated with ISDN:

Basic Rate Interface:

In the Basic Rate Interface digital pipe consists of 2 B channels and a 1 D channel. Therefore it is denoted as "2B + 1 D". These two B channels have a data rate of 64 kbps each, and the D channel have a data rate of 16 kbps. It has also a usable bandwidth of 144 kbps.

In the Integrated Services Digital Network (ISDN), the B channel (bearer channel) and D channel (delta channel) are two types of channels that carry different information:

- **B channel**

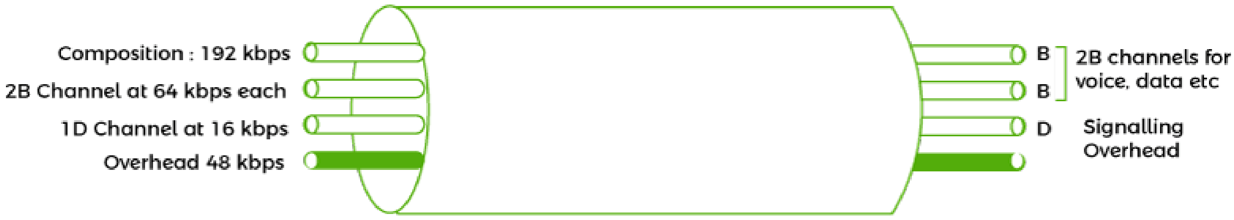
  Carries data, such as voice or computer data, for a call or session. The B channel has a capacity of 64 kilobits per second (Kb/s).

- **D channel**

  Carries signaling and control information for layers 1, 2, and 3 of the Open Systems Interconnection (OSI) model. The D channel also has a capacity of 64 Kb/s, but can be used for data as well.

Basic Rate Interface allows the concurrent use of voice and various data applications such as packet-switched access, a link to a central alarm service, video, tax, etc. The signaling information for the two channels is sent onto the D channel. The two B channels can be used for one 128 kbps connection or two independent connections on the two channels.

The following figure shows the basic structure of the frame in the Basic Rate Interface is:



Basic Rate Interface (BRI)

This service is used to meet the needs of most individual users, including residential and small offices. In this case, the two B channels and the D channel are multiplexed with overhead bits in the form of the frame structure. The overhead bits include framing, DC balancing, and other bits.

The 48 bit frame consists of

- 16 bits of B1 Channel
- 16 bits of B2 Channel
- 4 bits of D channel
- 12 overhead bits

The frame is transmitted in 250 μsec, which results in the following bit rates:

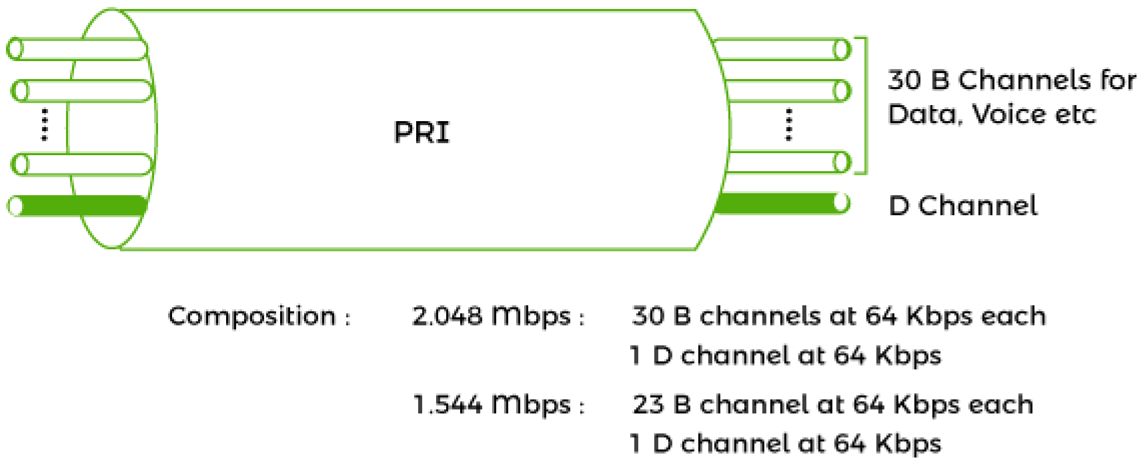
- In frame each B channel = 16 / 250 μsec = 64 kbps
- In frame D channel = 4 / 250 μsec = 16 kbps
- In frame Overhead Bits = 12 / 250 μsec = 48 kbps
- In frame Overall Bit rate = 48 / 250 μsec = 192 kbps

Primary Rate Interface:

Primary Rate Interface consists of either 23 B channels or 30 B channels and a one 64 Kbps D channel.

In North America and the Japan, 23 B channels and one D channel are used. It is also denoted by '23 B + 1 D'. In addition, the Primary Rate Interface service itself uses 8 kbps of overhead. Therefore 23D + 1D requires a data rate of 1.544 Mbps. In the case of 30 B channels and one D channel, the total bit rate is 2.048 Mbps.

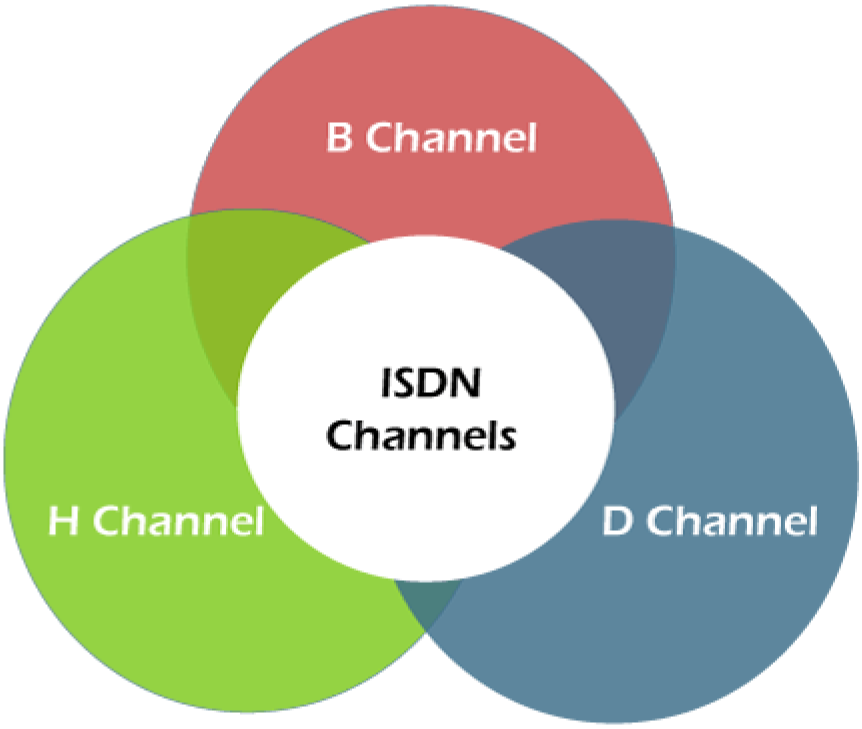
The following figure shows the basic structure of the frame in the Primary Rate Interface is:



ISDN CHANNELS:

ISDN structure have a central ISDN office in which all the users are linked to this through a digital pipe. This digital pipe have different capacities and have a different data transfer rates and these are organized into multiple channels of different sizes.

ISDN standard have the following three types of channels:



B Channel:

It stands for Bearer channel. It has a 64 kbps standard data rate. It is a basic user channel and can carry any digital information in full-duplex mode. In this transmission rate does not exceed 64 kbps. It can carry digital voice, digital data, and any other low data rate information.

D Channel:

It stands for Data Channel. This channel carry control signal for bearer services. This channel is required for signaling or packet-switched data and all-controlling signals such as establishing calls, ringing, call interrupt, etc.

H Channel:

It stands for Hybrid Channel. It provides user information at higher bit rates.

There are 3 types of Hybrid Channel depending on the data rates. Following are the hybrid channels types:

- Hybrid Channel 0 with 384 kbps data rate.
- Hybrid Channel 11 with 1536 kbps data rate.
- Hybrid Channel 12 with 1920 kbps data rate.

ISDN Devices:

Following are the types of ISDN devices:

TE1: Terminal equipment type (TE1) are specialized ISDN terminals. It includes digital telephone instruments such as FAX, or data terminal equipment. All these devices have an S-bus ISDN interface.

TE2: Terminal equipment type (TE2) is Non-ISDN compatible is connected through a Terminal Adapter. It includes analog phones and 3270 terminal Fax.

TA: It stands for Terminal Adapter. This device acts as an intermediary device for non-ISDN terminal devices. It converts the non-ISDN interface of these devices to the ISDN interface. The ISDN terminal Adapter can be either a standalone device or a board inside the Terminal equipment type 2. Some of the examples of Terminal adapter are EIA/TIA-232-C, V.24 etc.

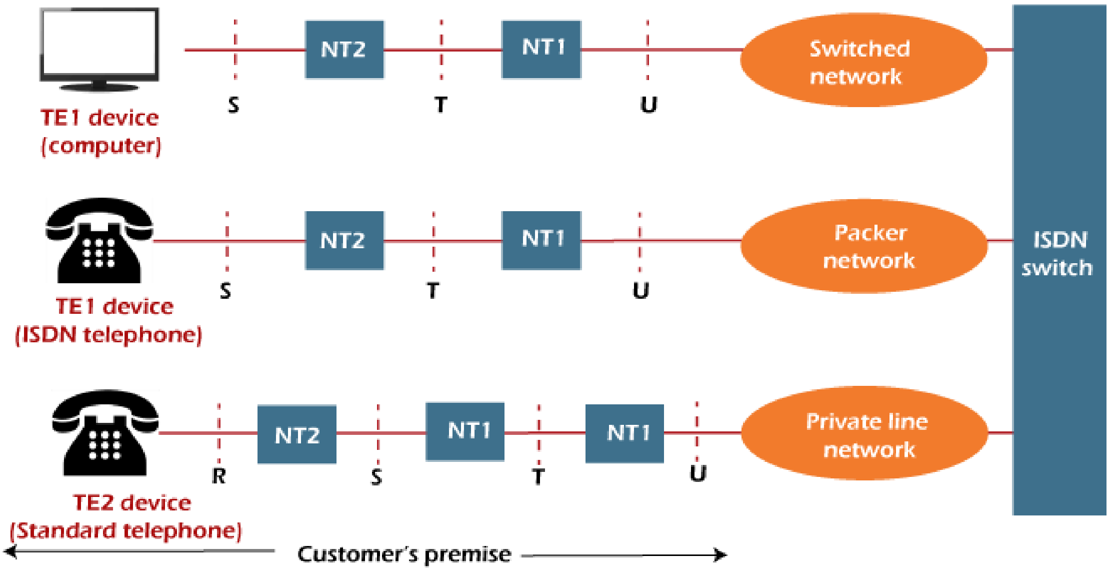
NT1: It stands for Network termination type 1. It provides a line termination at the customer's premise. They can also provide line monitoring, power feeding, error statistics, and proper timing.

NT2: It stands for Network termination type 2. It provides a switching, multiplexing, concentrating, or distributing information for the customer's premises. Some examples of Network termination type 2 are this could be a LAN server or Private Branch Exchange etc.

ISDN Reference Points:

It specifies the number of reference points that provide interfaces between the adjacent devices.

Following Figure displays the working of ISDN reference points:



In the above figure it shows an ISDN configuration in which 3 devices attached to an ISDN switch at the central office. In which 2 devices are ISDN compatible and they are attached through the S reference point to Network termination type 2 devices. Out of these third device is a standard non-ISDN telephone and is attached to a Terminal Adapter through an R reference point.

These reference points are R, S, T, and U.

- **R: It stands for Rate transfer point. It is an interface for non-ISDN devices and therefore is the reference point between non-ISDN equipment and a Terminal Adapter.** It can be RS-232-C, V, or X series of ITU-T standard or ordinary telephone interface with two wires.
- **S: It stands for System transfer point. The interface between the user terminal and NT2.** It is a four-wire balanced to which upto eight ISDN terminals can be connected. The physical connector for S - interface on terminals and NT1 is an 8-pin RJ-45 connector.
- **T: It stands for Terminal transfer point. It is the interface between Network termination type 1 and Network termination type 2**
- **U: It is the interface between Network termination type 1 device and the line termination equipment in the carrier network**. The U interface is the local copper pair of the access network. The same pair is used for full-duplex transmission of digital signals.

Asynchronous Transfer Mode (ATM) and Integrated Services Digital Network (ISDN) are both network architectures that can support different types of data and services:

- ATM

  A packet-switching technology that uses a three-dimensional architecture with a user plane, control plane, and management plane.

  ATM can support data rates from 155 Mbps to several Gbps, and is suitable for applications that require large amounts of bandwidth, such as video conferencing and multimedia streaming.

  ATM networks can also create and remove switched virtual circuits (SVCs) on demand, which can be used to carry individual telephone calls.

- ISDN

  A network that uses B and D channels to transfer data, and can offer speeds of up to 1 Gbps. ISDN is capable of connecting multiple devices, making it ideal for businesses and large groups.
  ISDN is also a secure and efficient technology for implementing Virtual Private Networks (VPNs), which allow organizations to establish encrypted and private communication networks over the public internet.

Broadband ISDN (B-ISDN) is a network architecture that uses ATM to deliver high-speed data, voice, and video services.

Why did ATM lose to IP?

Scalability Limitations: In the end, ATM was not as scalable as IP-based networks, which could more easily accommodate the rapid growth in network size and traffic volume.

What is ATM network disadvantages?

Disadvantages

- There is an overhead of the cell header (5 bytes/cell)
- Achieving QoS has a complex mechanism.
- There may be a condition of cell loss due to congestion.
- Compared to LAN hardware, ATM switches are very expensive.

ISDN Alternatives

https://www.fuse2.net/isdn-alternatives/