Computer Networks

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Delay in Switching Networks

- Set up Time
  - Connection Oriented Networks
- Transmission Time
- Propagation Delay
- Nodal Delay
  - Processing time at node
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Delay in Circuit Switched Networks

- **Delay in Circuit Switched Networks**
  - **Setup Time--connection oriented networks.**
  - **Transmission Time**
  - **Propagation Delay**
  - **Nodal Delay--processing time at nodes.**

•**<u>Total Delay → Delay of setup and teardown + delay of data transfer</u>**

Timing in Circuit Switching

Assume:

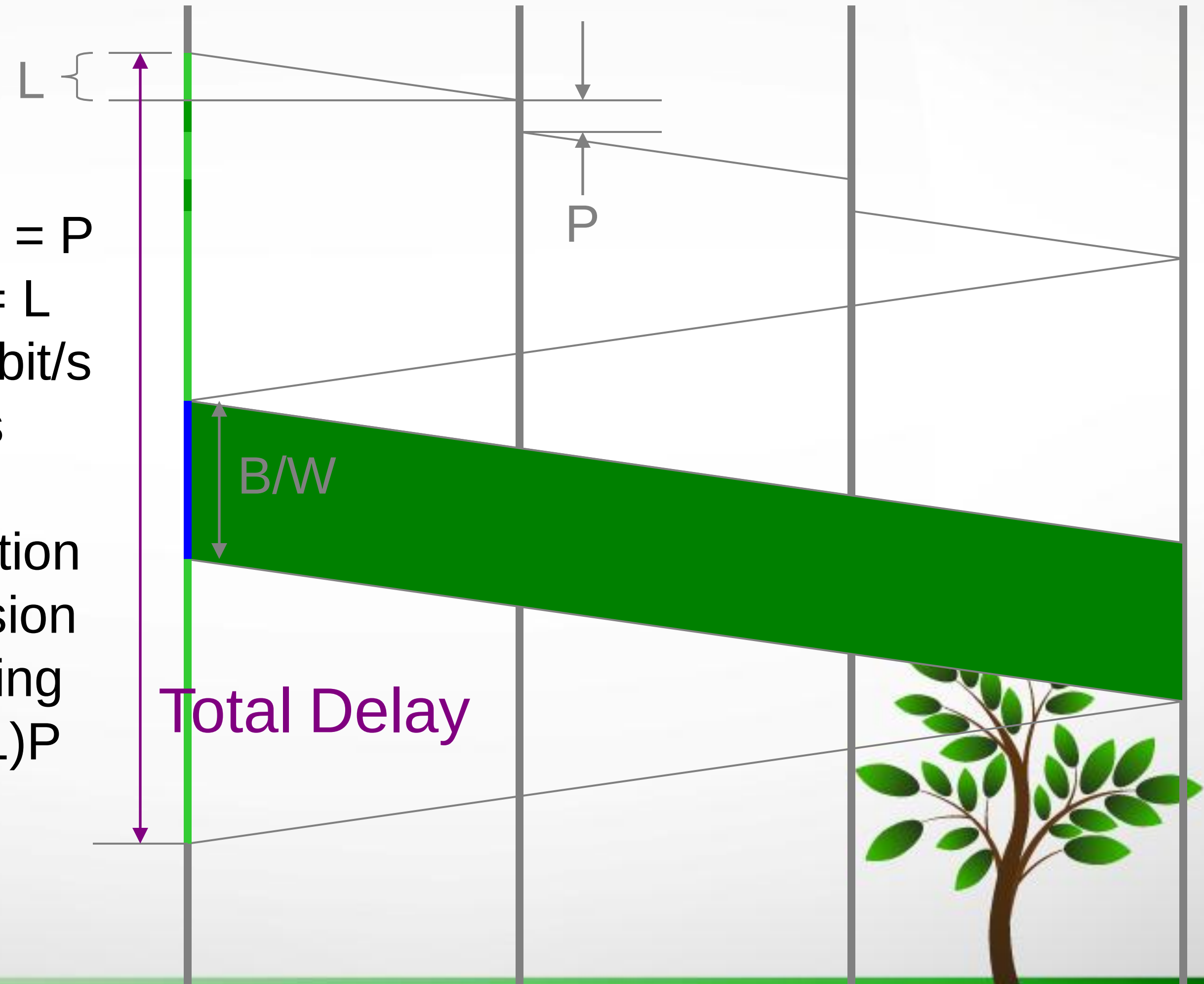
Number of hops = M

Per-hop processing delay = P

Link propagation delay = L

Transmission speed = W bit/s

Message size = B bits



Total Delay = total propagation
+ total transmission
+ total processing
= 3ML + B/W + (M-1)P

Delay in Packet Switched Networks

- **Delay in Packet Switching**
  - **Connection Setup Time**
    - **Required for virtual circuit.**
    - **None for datagram.**
  - **Packet transmission time and propagation delay occurs on each link.**
  - **Processing delay occurs at every node.**
    - **Datagram networks may require more than virtual circuit networks.**

Timing in Datagram Packet Switching

Assume:

Number of hops = M

Per-hop processing delay = P

Link propagation delay = L

Packet transmission delay = T

Message size = N packets

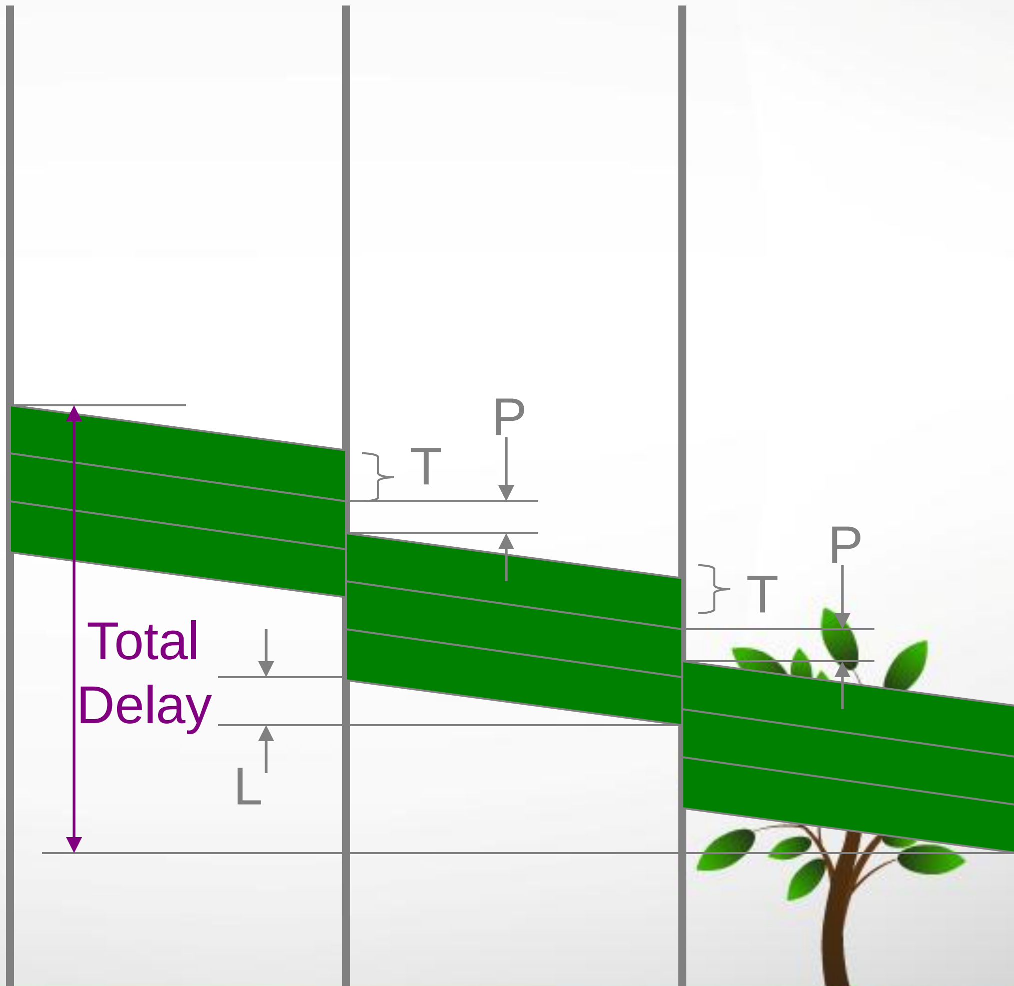
Total Delay = total propagation

+ total transmission

+ total store&forward

+ total processing

= ML + NT + (M-1)T + (M-1)P



Timing in Virtual Circuit Packet Switching

Assume:

Number of hops = M

Per-hop processing delay = P

Link propagation delay = L

Packet transmission delay = T

Message size = N packets

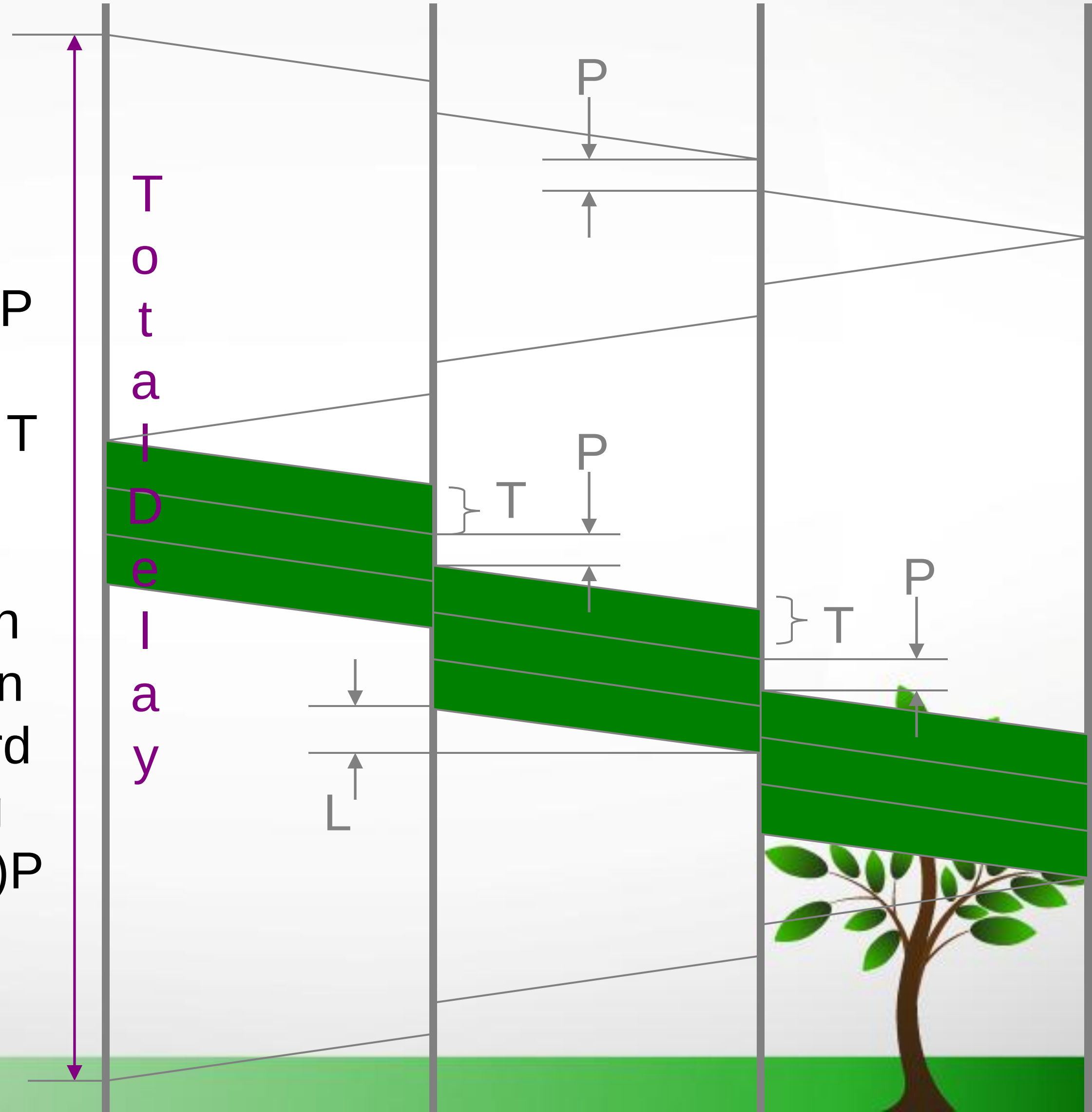
Total Delay = total propagation

+ total transmission

+ total store&forward

+ total processing

= 3ML + NT + (M-1)T + 3(M-1)P



Frame Relay

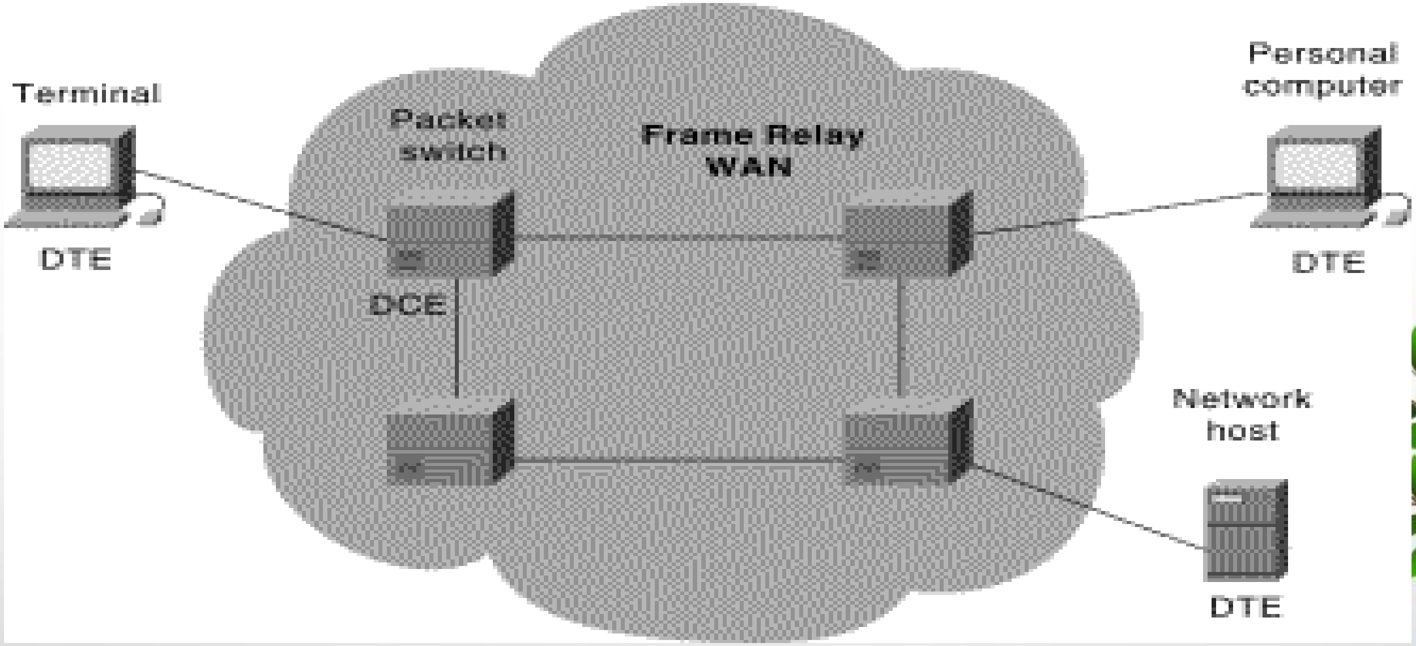
- **Frame Relay is based on packet-switched connection oriented technology.**
- **Frame Relay is a high-performance WAN protocol**
  - **operates at the physical and data link layers**
- **Uses high level data link protocols HDLC (high level data link control),**
  - **LAPF(Link Access Procedure for Frame Relay)**
- **It provides high speed than x.25 (1.544Mbps)**
- **It is invented to reduce the complexities of x.25.**
- **It provides high speed and error free transmissions.**
- **It provides standard organizations for interface b/w user and network only. → transport of frames is up to Provider**

Problems in X.25

- It also uses virtual circuit switching.
- It has low data rate (64kbps)
- It uses flow and error control at data and network layers.
- It used its own network layer encapsulation. If we use it in our network, more overhead will takes place.
- Fixed rate data at all time. We have to pay more than usage. → it is not supporting <u>bursty data</u>
- Bursty data requires different bandwidth at different interval of time. → <u>bandwidth on demand.</u>
-

Frame Relay

- It is used as a back bone network.
- It uses two different types of devices.
  - Data terminal equipment (DTE) (terminals, PC,)
  - Data circuit-terminating equipment (DCE)
- DCEs are <u>carrier-owned internetworking devices</u>.
  - to provide clocking and switching services in a network.



Frame Relay Virtual Circuits

- Frame Relay provides connection-oriented data link layer communication.
- This service is implemented by using a Frame Relay virtual circuit, which is a logical connection created between two data terminal equipment (DTE) devices across a Frame Relay packet-switched network (PSN).

- Virtual circuits provide a bidirectional communication path.
- The VCI's are named as data-link connection identifier (DLCI).

- Multiplexing is used for many virtual circuits in a single physical circuit .
- A virtual circuit can pass through any number of intermediate DCE devices (switches) located within the Frame Relay PSN.

- Frame Relay virtual circuits having two categories: switched virtual circuits (SVCs) and permanent virtual circuits (PVCs).

Permanent Virtual Circuits

- **A source and Destination have to choose PVC's**
- **In this, connection set up is simple. Most probably it doesnot require setup and teardown process.**
- **It establishes permanent connections , used for frequent and consistent data transfer.**
- **It uses existing and already established infrastructure for frame transmissions.**
- **Communication across PVC'**
  - **Data Transfer:** **Data is transmitted between the DTE devices over the virtual circuit.**
  - **Idle :** **The connection between DTE devices is active, but no data is transferred. Even in idle state, they have to pay. No automatic termination.**
- **An Outgoing Data Link Connection Identifier (DLCI) is given to source**
- **An incoming DLCI is given to the destination.**
- **<u>Problems:</u>**
  - **<u>Costly → </u>two parties pay for the connection even not use**
  - **Connection is created source to single destination only**

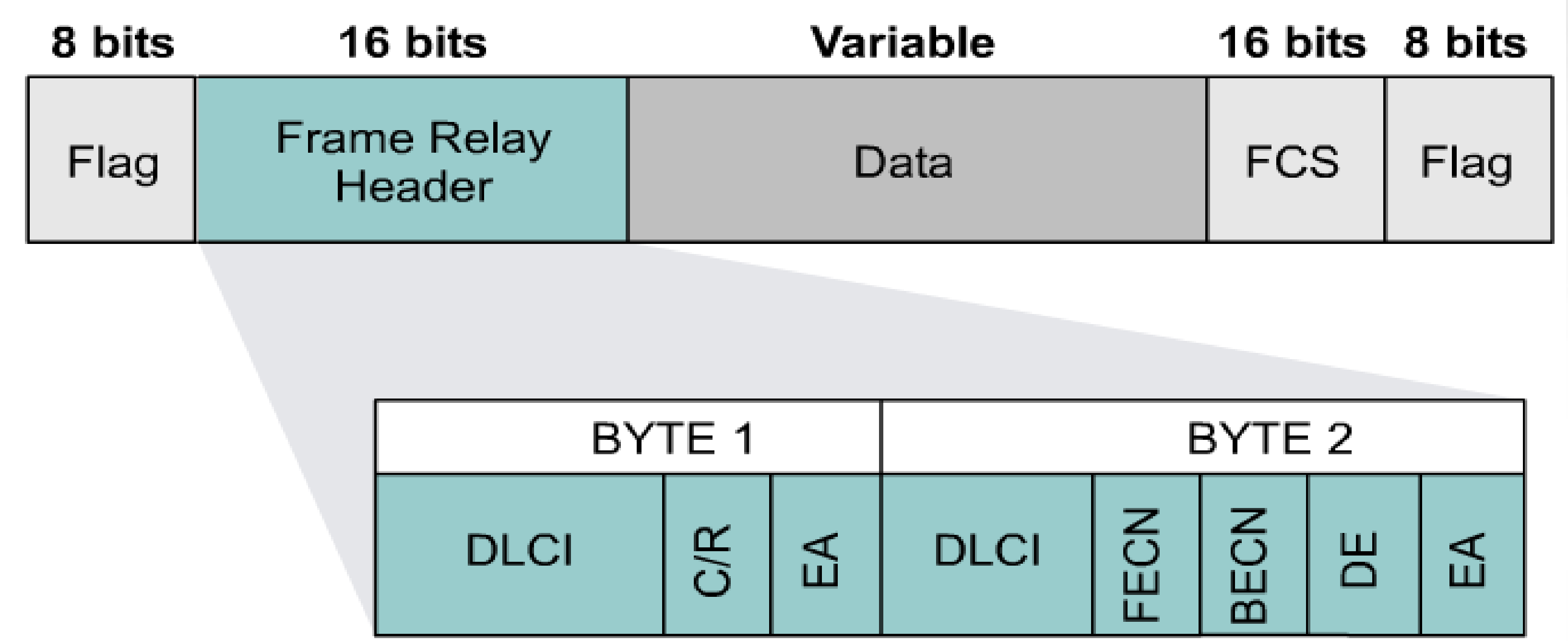
Switched Virtual Circuits

- Switched Virtual Circuits SVC's uses temporary connection establishments whenever the data need to transfer between DTE's.
- It uses setup phase and tear down phase like in circuit switching.
  - Call setup: The virtual circuit between two Frame Relay DTE devices is established.
  - Data Transfer: Data is transmitted between the DTE devices over the virtual circuit.
  - Idle : The connection between DTE devices is still active, but no data is transferred. If an SVC remains in an idle state for a defined period of time, the call can be terminated.
  - Call Termination: The virtual circuit between DTE devices is terminated.
- This technique is very rarely used even through it has more advantages.
- Very few manufactures of Frame Relay DCE are support this technique.

Data Link Connection Identifier

- Frame Relay virtual circuits are identified by data-link connection identifiers (DLCIs).
- DLCI values typically are assigned by the Frame Relay service provider (ex: telephone company).
- Frame Relay DLCIs have local significance, which means that their values are unique in the LAN,.
- But May not unique in the Frame Relay WAN.
- A Single Frame Relay Virtual Circuit Can be assigned Different DLCIs on each end of a VC.

Frame Relay Frame Format



- **3 main Component**
  - **Header and Address Part**
  - **User Data part**
  - **Frame Check Sequence**

Frame Relay Frame Format

- **Flags :**
  - **Delimits the beginning and end of the frame. The value of this field is always the same and is represented either as the hexadecimal number 7E or as the binary number 01111110.**
- **Address / Header Filed: it contains**
  - **DLCI**
  - **EA**
  - **C/R**
  - **FECN**
  - **BECN**
  - **DE**

Frame Relay Frame Format

- **Address filed is 2 bytes**
- **Possibility of different sized address field → 3 bytes, 4 bytes**

8	7	6	5	4	3	2	1
Upper DLCI						C/R	EA 0
Lower DLCI				FECN	BECN	DE	EA 1

(a) Address field - 2 octets (default)

8	7	6	5	4	3	2	1
Upper DLCI						C/R	EA 0
DLCI				FECN	BECN	DE	EA 0
Lower DLCI or DL-CORE control						D/C	EA 1

(b) Address field - 3 octets

8	7	6	5	4	3	2	1
Upper DLCI						C/R	EA 0
DLCI				FECN	BECN	DE	EA 0
DLCI							EA 0
Lower DLCI or DL-CORE control						D/C	EA 1

(c) Address field - 4 octets

EA Address field extention bit
C/R Command/response bit
FECN Forward explicit congestion notification
BECN Backward explict congestion notification
DLCI Data link connection identifier
D/C DLCI or DL-CORE control indicator
DE Dsicard eligibility

Frame Relay Frame Format

- **DLCI**
  - **Its 10-bit DLCI of the Frame Relay header.**
  - **This value represents the virtual connection between the DTE device and the switch.**
  - **Each virtual connection that is multiplexed onto the physical channel will be represented by a unique DLCI.**
  - **The DLCI values have local significance only,.**
  - **Therefore, devices at opposite ends of a connection can use different DLCI values to refer to the same virtual connection.**
- **DLCIs 1 to 15 and 1008 to 1023 are reserved for special purposes**
- **DLCI number – 0 as In-channel signal**
- **Service providers assign DLCIs in the range of 16 to 1007 to connections.**
  - DLCI 1019, 1020: Multicasts
  - DLCI 1023: Cisco LMI / In-Channel Layer Management
  - DLCI 0: ANSI LMI

Frame Relay Frame Format

- **Extended Address (EA)**
  - **If the value is 1, then the current byte is determined to be the last DLCI octet.**
  - **If the value is 0, then there should be another octet follows.**
  - **The eighth bit of each byte of the Address field is used to indicate the EA.**
- **Communication/Response(C/R):**
  - **The C/R is the bit that follows the most significant DLCI byte in the Address field.**
  - **Allows upper layers to identify the frame as either command or response.**
- **Congestion Control—**
  - **Frame Relay congestion-notification mechanisms. These are the FECN, BECN, and DE bits,**

Frame Relay Frame Format

- **Data Field**
  - Contains encapsulated upper-layer data.
  - this variable-length field includes a user data or payload field
  - vary in length up to 16,000 octets.
  - This field serves to transport the higher-layer protocol packet (PDU) through a Frame Relay network.
- **Frame Check Sequence**
  - Ensures the integrity of transmitted data.
  - This value is computed by the source device and verified by the receiver to ensure integrity of transmission.

Frame Relay Frame Format

- **FRADs → Frame Relay Assembler / Disassembler**
- **VOFR → Voice over Frame Relay**
- **LMI → Local Management Information**
  - **Controlling and managing the information**

Asynchronous Transmission Mode

- **Synchronous Transmission Mode:**
  - **used in Telecommunications**
  - **Time division Multiplexed STM – Example**
  - **Transmitter and Receiver agreed on time --> determines transmitter**
  - **Synchronous on time between sender and receiver**
- **Problems :**
  - **Unused time slots must be waste**
  - **Fixed cyclical schedule → equally long**

  → restricted BW

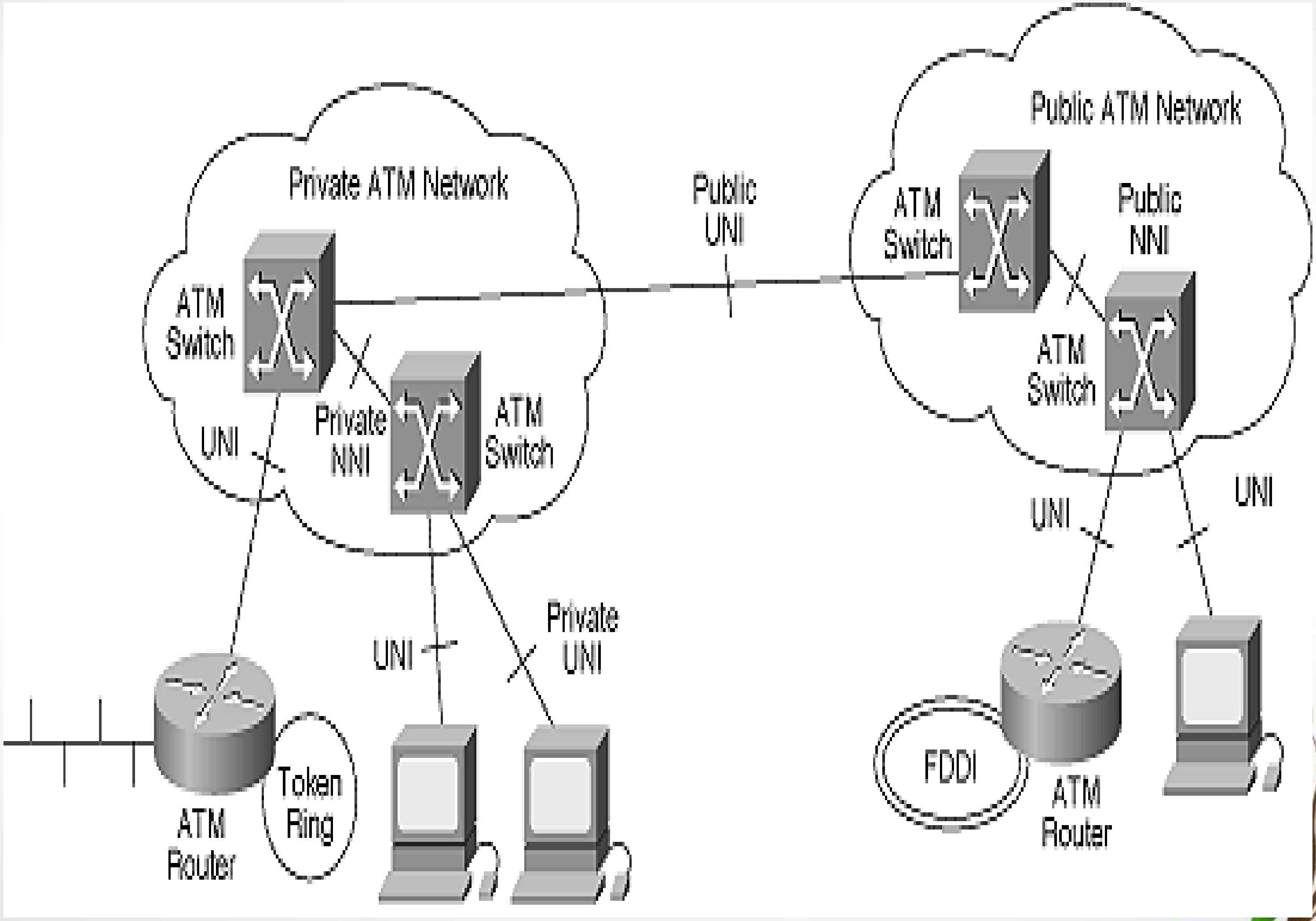
ATM

- **Design Goals**
  - **Take the advantage of Technology (Bandwidth and Transmission media) → high data rate**
  - **With out lowering the effectiveness of existing WAN system and lowering the replacement.**
  - **Must be available at low cost**
  - **Support existing telecommunication to better**
  - **To support low error rate and high predictable delivery with connection oriented services.**
  - **Eliminate software use and emphasis on hardware use for fastness.**

ATM

- The ATM supports variety of services and applications such as voice, video, and data with guarantee of QoS to each one.
- “ATM is a cell-switching technology based on a fixed-length cell. It combines the high throughput, low delay and transparency of circuit-switching and the bandwidth efficiency of packet-switching.”
- It can be used in LAN and WAN
- ATM standard (defined by CCITT) is widely accepted by common carriers as mode of operation for communication – particularly BISDN.
- ATM Forum

ATM Network



Private ATM Network
ATM Switch
Private NNI
ATM Switch
UNI
Public UNI
Public ATM Network
ATM Switch
Public NNI
ATM Switch
UNI
UNI
UNI
Private UNI
ATM Router
Token Ring
FDDI
ATM Router

ATM Network

- Two Types of Interfaces that interconnect ATM devices over point to point links
  - User-Network Interface (UNI)
  - Network-Network Interface (NNI)
- UNI link connects an ATM end-system (client side) with an ATM switch (network site).
- ATM UNI standards specify how a user connects to the ATM network to access these services.
- Also called Network Node interface (NNI).
- NNI link connect two ATM switches; in this case; both sides are network.
- NNI supports class of service-sensitive routing and bandwidth reservation.
- Parameters used as part of the path computation process include the destination ATM address, traffic class, traffic contract, QoS requirements and link constraints.

ATM Connections

- two levels of ATM connections:

  virtual path connections

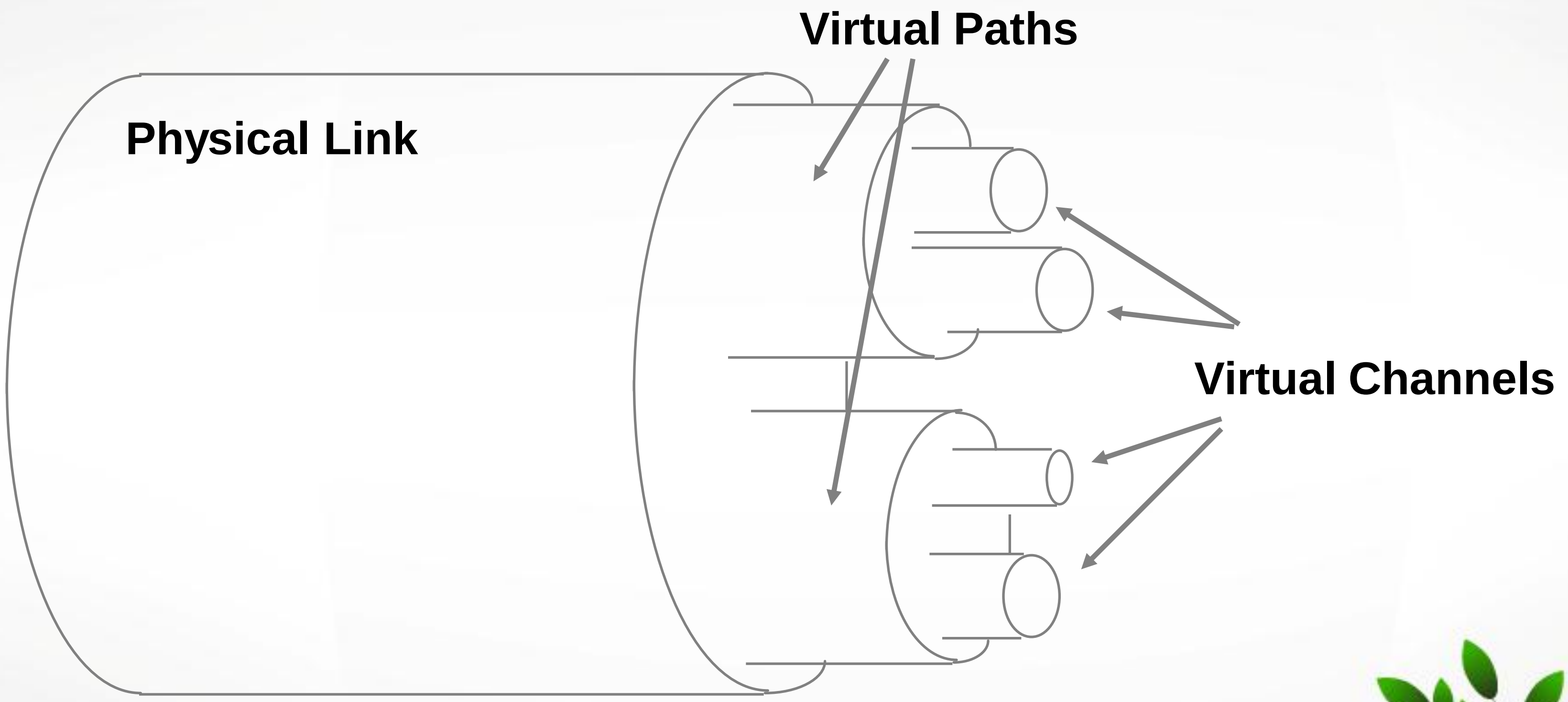
  virtual channel connections

- indicated by two fields in the cell header:

virtual path identifier VPI

virtual channel identifier VCI

ATM Connections



ATM Cell Switching

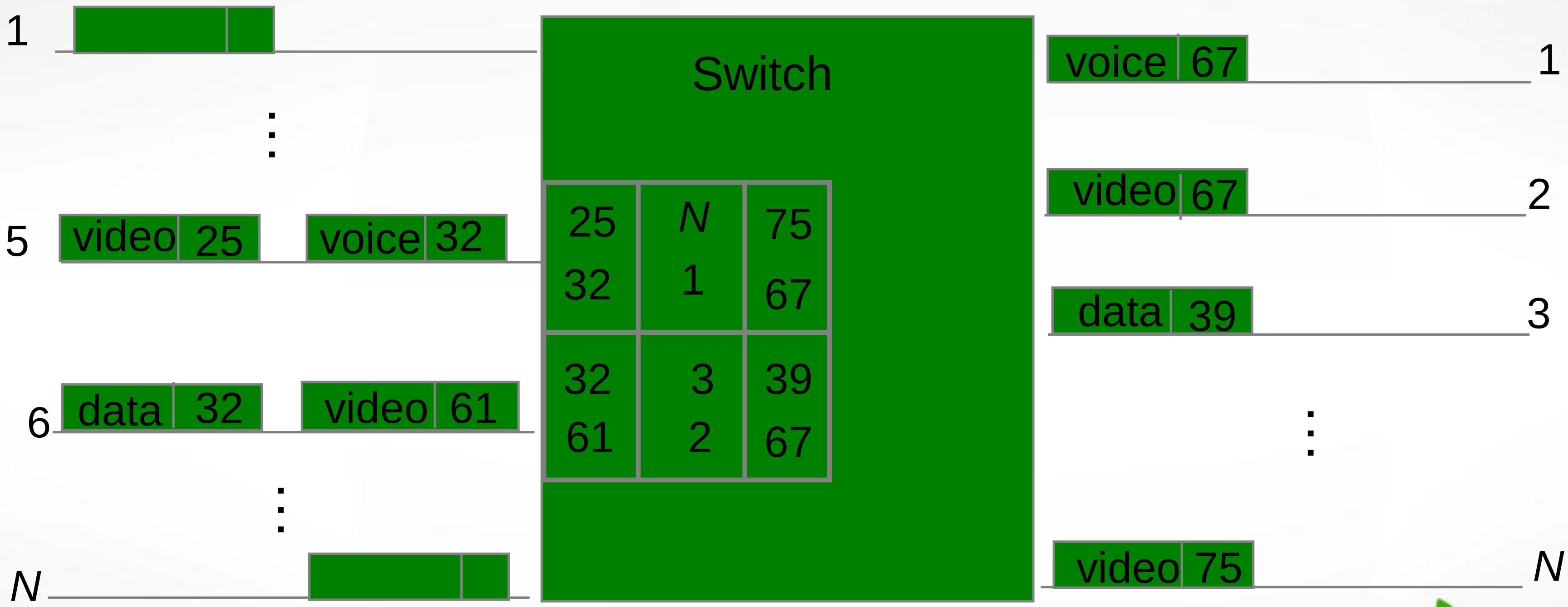
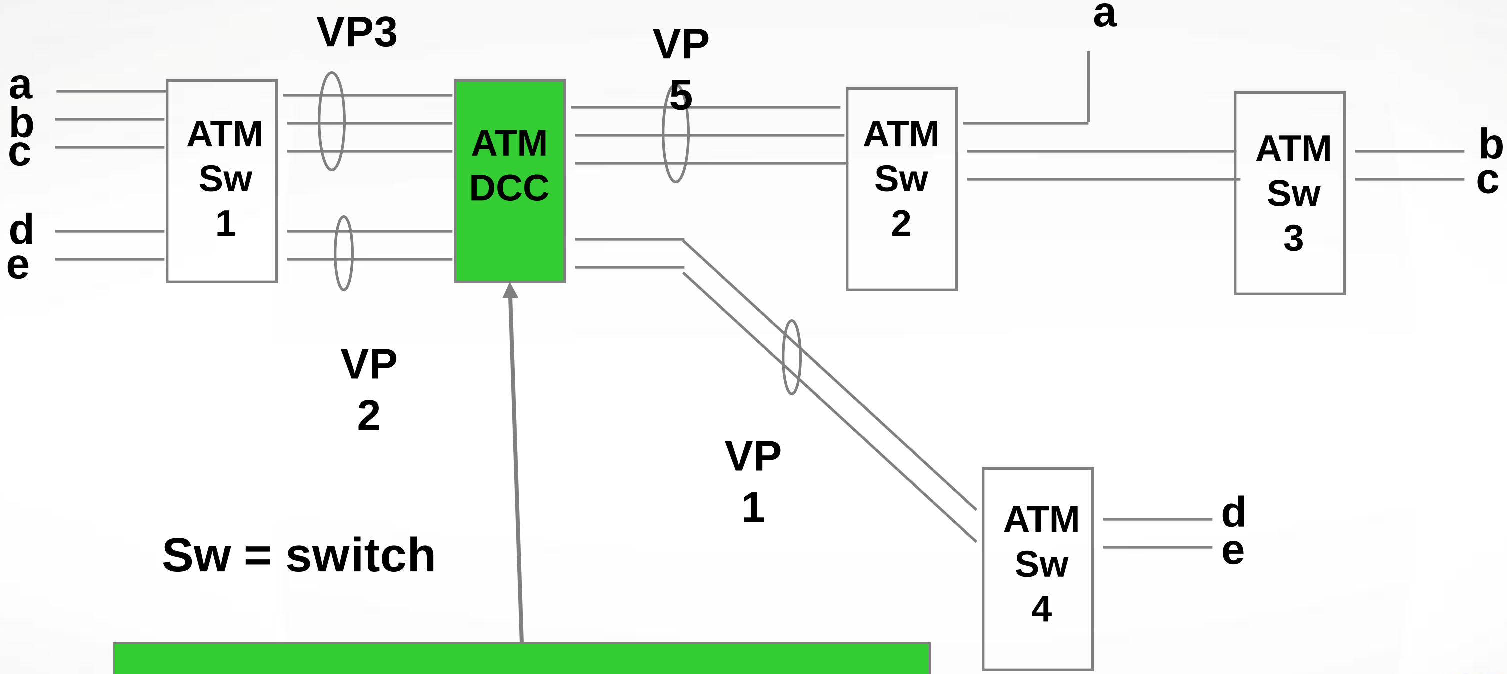


Figure 7.38

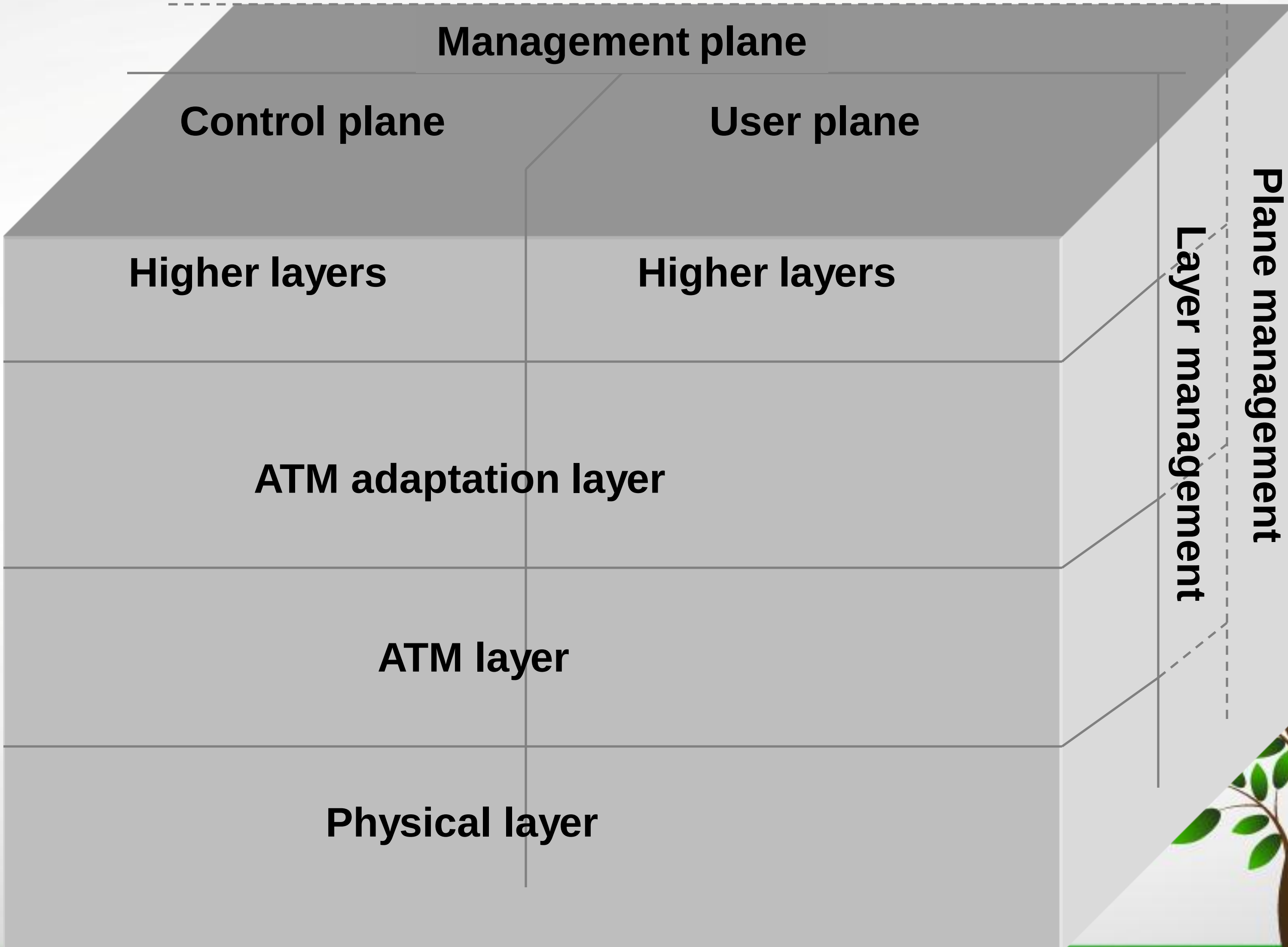
ATM



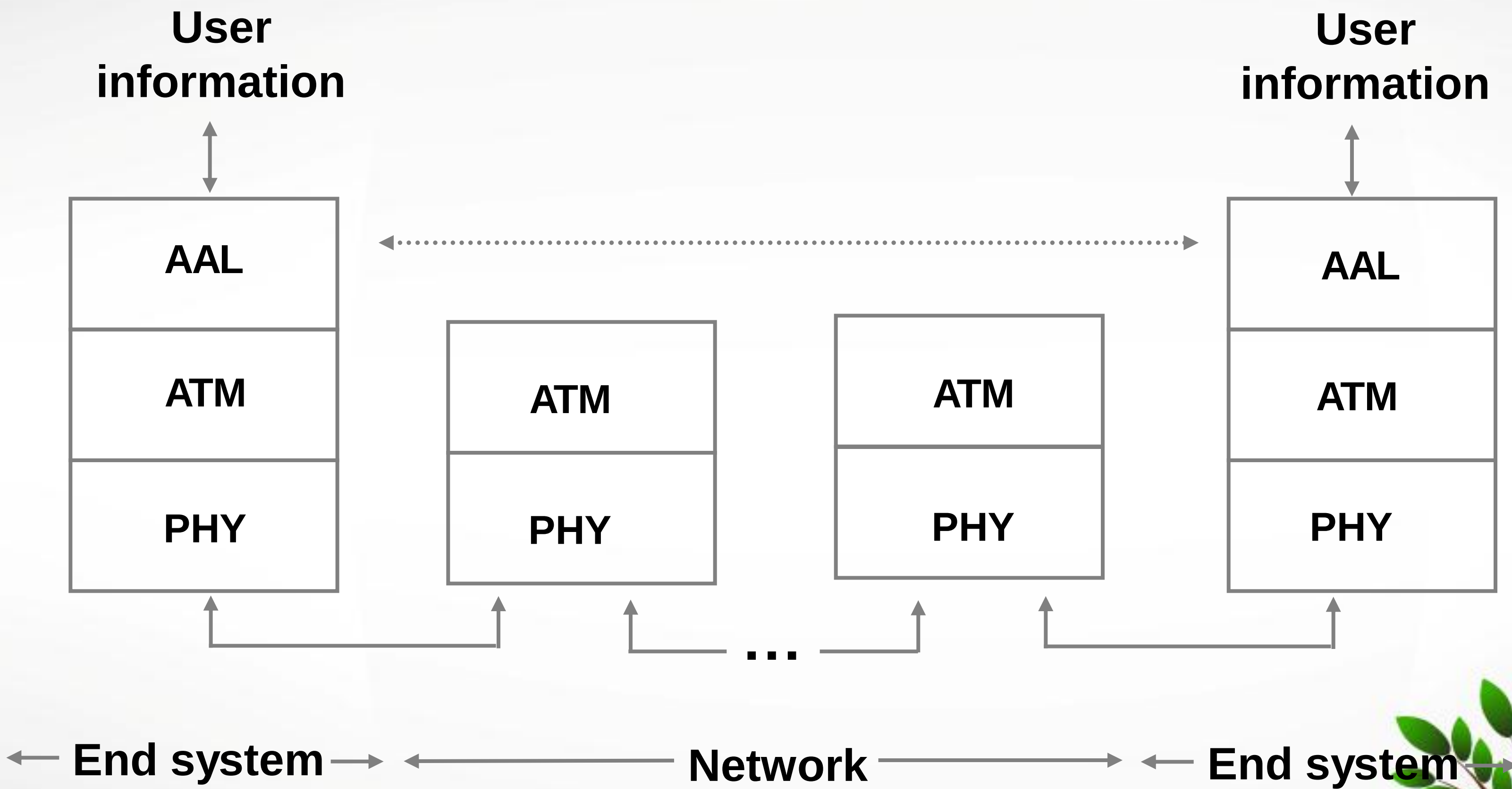
Digital Cross Connect

Only switches virtual paths

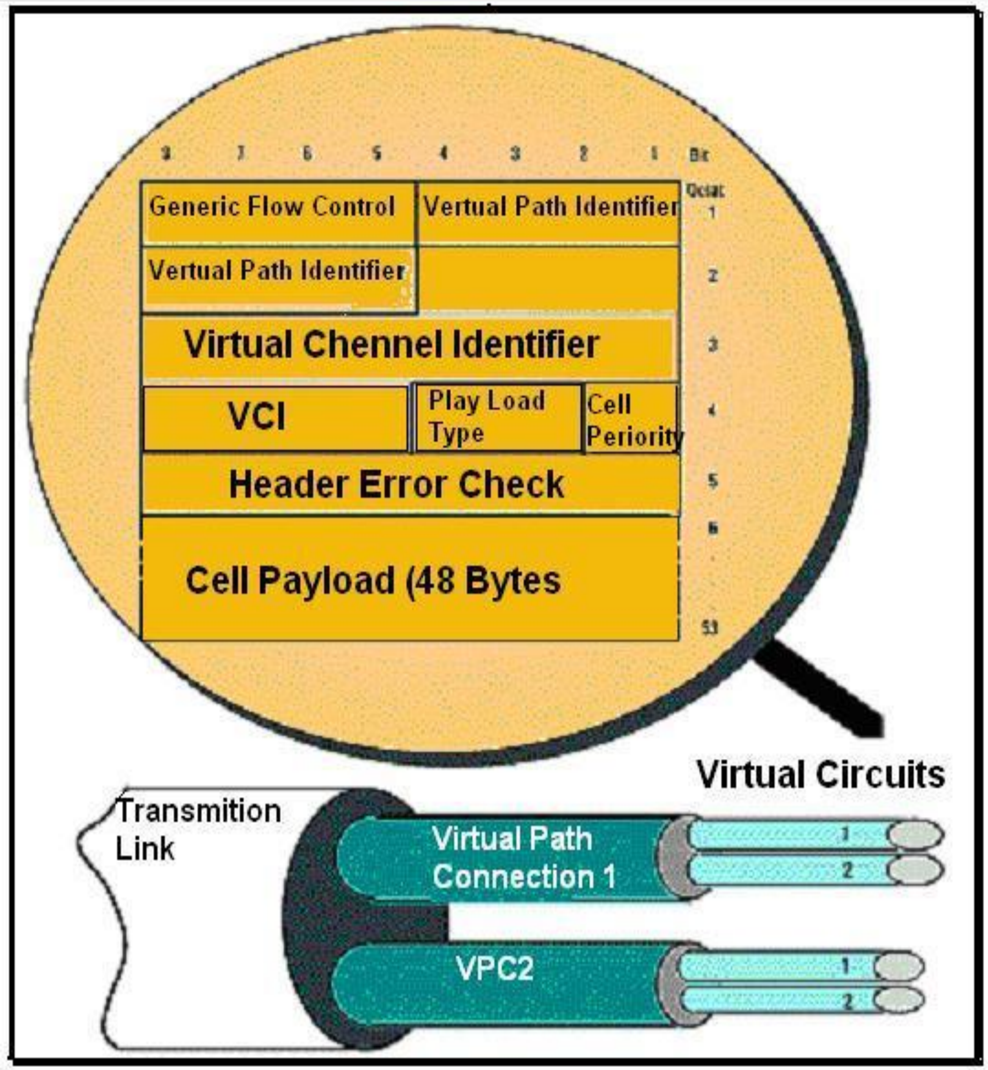
ATM Protocol Architecture



ATM Layers at end points



ATM Cell

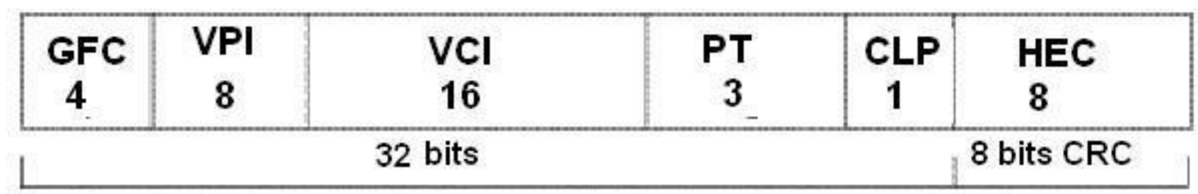


Name of Part	Length	Description
Flow Control	4 bits	Information Related to Flow Control
VPI	8 bits	Whole connection is identified by VPI
VCI	16 bits	When ATM creates physical connection, connection is identified by VCI.
Payload Type 3	3 bits	Data Type: Video, Sound
HEC/CRC	8 bits	Error Control when needed
Priority	1 bit	Priority of that cell

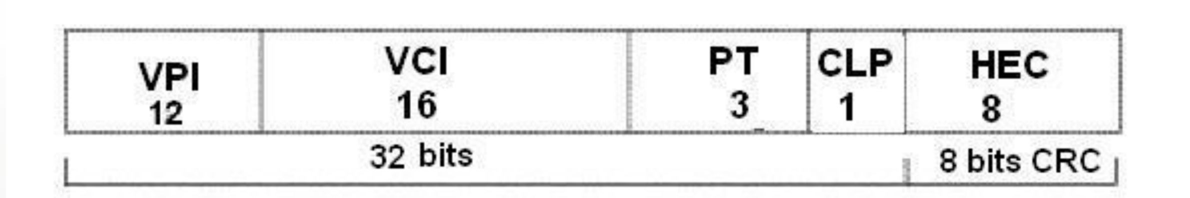
ATM Cell

The ATM Cell includes 5 Bytes Header; the header can be in either UNI or NNI format depending on the Interface.

ATM Cell Header—UNI Format



ATM Cell Header—NNI Format



ATM Cell

- General Flaw Control: Provides local functions, such as flow control from end point equipment to the ATM switch.

- Payload Type: Indicates in the first cell whether the cell contains user data or control data.

  - If the cell contains user data, the second bit indicates whether congestion is experienced or not, and the third bit indicates whether the cell is the last in a series of cells that represent a single AAL5 (ATM adoption layer 5) frame.

  - If the cell contains control data, the second and third bits indicates maintenance or management flow information.

ATM Cell

- **Cell Loss Priority: Indicates whether the cell should be removed if it encounters errors as it moves through the network.**

- **Header Error Control: Contains Cyclic Redundancy Check (CRC) on the cell header.**

- **Virtual Path Identifier (VPI): Identifies semi-permanent connections between ATM end points.**

- **Virtual Channel Identifier (VCI): Have only local significance on the link between ATM nodes.**