Module Name

Basics of Communication Network

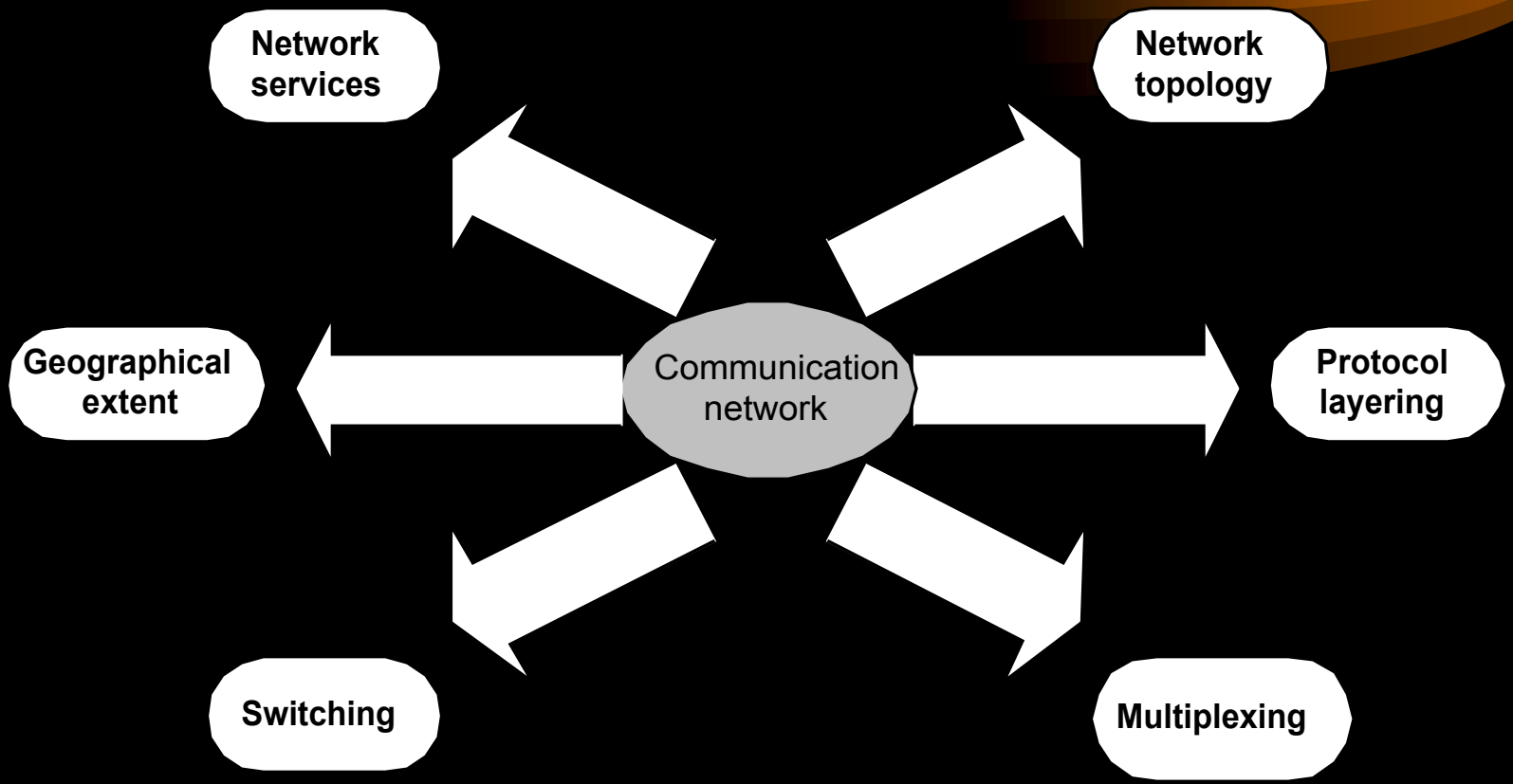
Sub-Modules:

- Network Services
- Network Topology
- Protocol Layering
- Multiplexing
- Switching
- Geographical classification

Defn. of Communication Network

- An interconnection of communicating entities. Personal computers, laptops, telephone, pagers and mobile phones are all examples of communicating entities.
- Not synonymous with computer network.
  - Computer network is merely one of the forms of communication network.
- When the world is heading towards integrated networks, there is a drastic change in the way one perceives a computer network.

Elements of Communication Network



Module Name

Basics of Communication Network

Sub-Modules:

- Network Services
- Network Topology
- Protocol Layering
- Multiplexing
- Switching
- Geographical classification

Network Services

- Network provide means to transfer user information from one network entity to other.
- Network services are classified into two distinct categories, namely *connection-oriented service* and *connectionless service*.
- Type of network service significantly effects
  - the bandwidth provided to users,
  - the range of applications supported,
  - the extent of resource utilization

Connection-oriented service

- General Characteristics:
  - A connection is established before data. exchange and is usually accompanied by some form of resource reservation.
  - Provides reliable services (i.e., lost packets are retransmitted).
  - Uses switching for data transfer.
  - Provides sequential delivery of data packets (packets for a connection follow the same path).

Connection-oriented service (2)

- General Characteristics (contd..):
  - Data packets do not carry the full address of the destination.
  - Due to small header size, per packet overhead is minimal.
  - Suitable for long and steady transmissions.
  - Generally faster than connectionless services.

Connectionless service

- General Characteristics:
  - A connection is not established before data exchange. Thus, there is hardly any prior resource reservation.
  - Provides unreliable or best-effort services (lost or dropped packets are not retransmitted).
  - Use routing for data transfer
  - Data packets may or may not arrive sequentially (i.e., data packets may or may not follow the same path).

Connectionless service (2)

- General Characteristics (contd..):
  - Data packets carry the full address of the destination.
  - Due to large header size, per packet overhead can be significant.
  - Suitable for bursty transmissions.
  - Usually slower than connection-oriented service.

Connection-oriented versus Connectionless service

- Resource utilization
- Service guarantees
- State information
- Call-setup latency

Module Name

Basics of Communication Network

Sub-Modules:

- Network Services
- Network Topology
- Protocol Layering
- Multiplexing
- Switching
- Geographical classification

Network topology

- Defines the physical interconnection of its constituent elements.
- Interconnection are *real* or *logical*.
  - Real interconnection refers to the way the elements are physically connected.
  - Logical interconnection refers to the way data is exchanged between the constituent elements.

Network topology (2)

- Most common topologies are *bus, ring, mesh (partially connected* and *fully connected), star* and *tree*.
- Network topology affects
  - Number of hops required for data transmission
  - Vulnerability to single point failures
  - Cost (e.g., fully meshed topology is costlier to build).

Module Name

Basics of Communication Network

Sub-Modules:

- Network Services
- Network Topology
- Protocol Layering
- Multiplexing
- Switching
- Geographical classification

Protocols and Protocol layering

- A *protocol* is a set of rules and frame formats that govern how two entities communicate.
- A protocol consists of two parts
  - *syntax:* provides means to interpret an incomprehensible data stream consisting of 0s and 1s
  - *semantics:* defines the actions to be taken based on the received information.

Protocol layering

- Software are not monolithic piece.
- Rather, they are organized as a set of layers, where each layer has a well-defined function.
- This design approach, where modules are distributed into layers, results in a *layered architecture*.
- For a layered architecture, there must be a consensus on functional distribution.

Essentials of Protocol Layering

- Concept of Services
- Concept of Interfaces, Primitives and Service access points (SAPs)
- Concept of Peers and peer-to-peer protocols
- Concept of Interface data units (IDUs), Service data units (SDUs) and Protocol data units (PDUs)

Concept of Services

- Each layer has a well-defined task to perform.
- Each layer takes help of the *services* of the layer below it (*service user*).
- In turn, the layer provides services to the layer above it (*service provider*).
- The services provided by a layer forms the *service definition* of that layer as per the protocol defining it.

Concept of Interface and Primitives

- The service definition does not tell as to how the services are used or provided. This is provided by interfaces and primitives.
  - An *interface* is the boundary between two adjacent layers.
  - The interface definition states how a layer accesses the services of the layer below it. This definition is in the form of *primitives*. For e.g. SEND_DATA(data) and REC_DATA (data) are

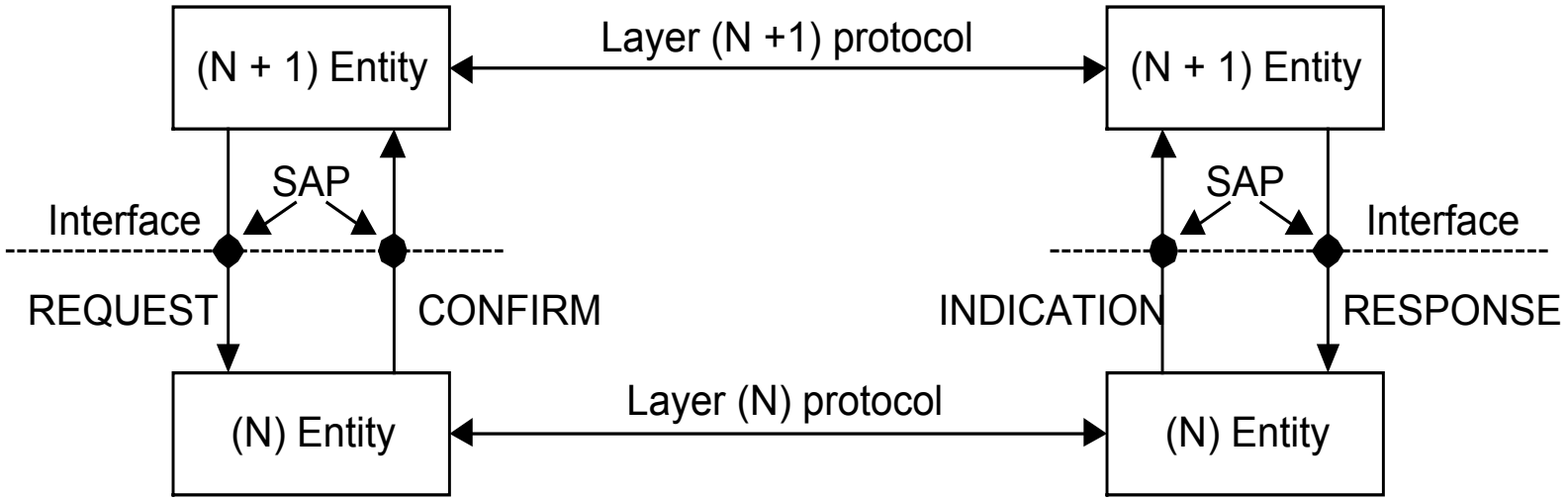
Concept of SAPs

- Layer (N+1) entity communicates with the layer (N) entity via *service access points* or SAPs.
- SAPs are the connection entities that adjacent layers use to communicate.
- Each SAP has its unique address. For a layer (N+1) entity to communicate with another layer (N+1) entity, the former must have the layer ‘N’ SAP address of the latter.

Concept of Peers and Peer-to-peer protocols

- Two layer (N+1) entity residing on different machines are called *peers.*
- The layer (N+1) protocol between two layer (N+1) entities is referred to as *peer-to-peer protocol*.
- “Peering” is important to understand the way data is carried from one entity to another.
  - In simple terms, peers can be viewed as entities talking in the same language.

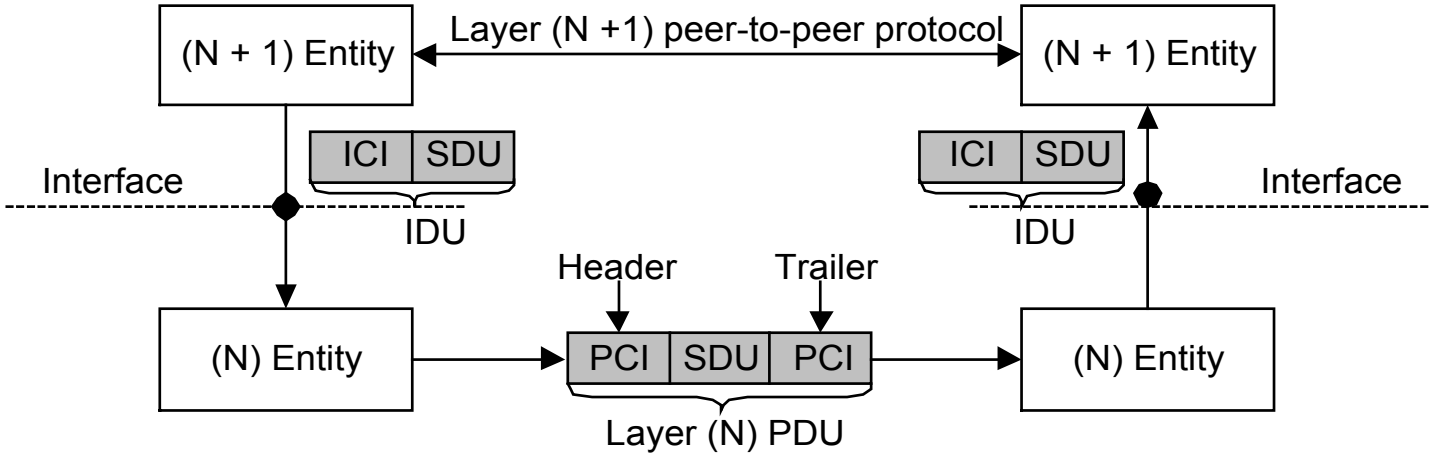
Concept of Peers and peer-to-peer protocols



Concept of IDUs, SDUs and PDUs

ICI: Interface Control Information
IDU: Interface Data Unit
SDU: Service Data Unit

PCI: Protocol Control Information
PDU: Protocol Data Unit



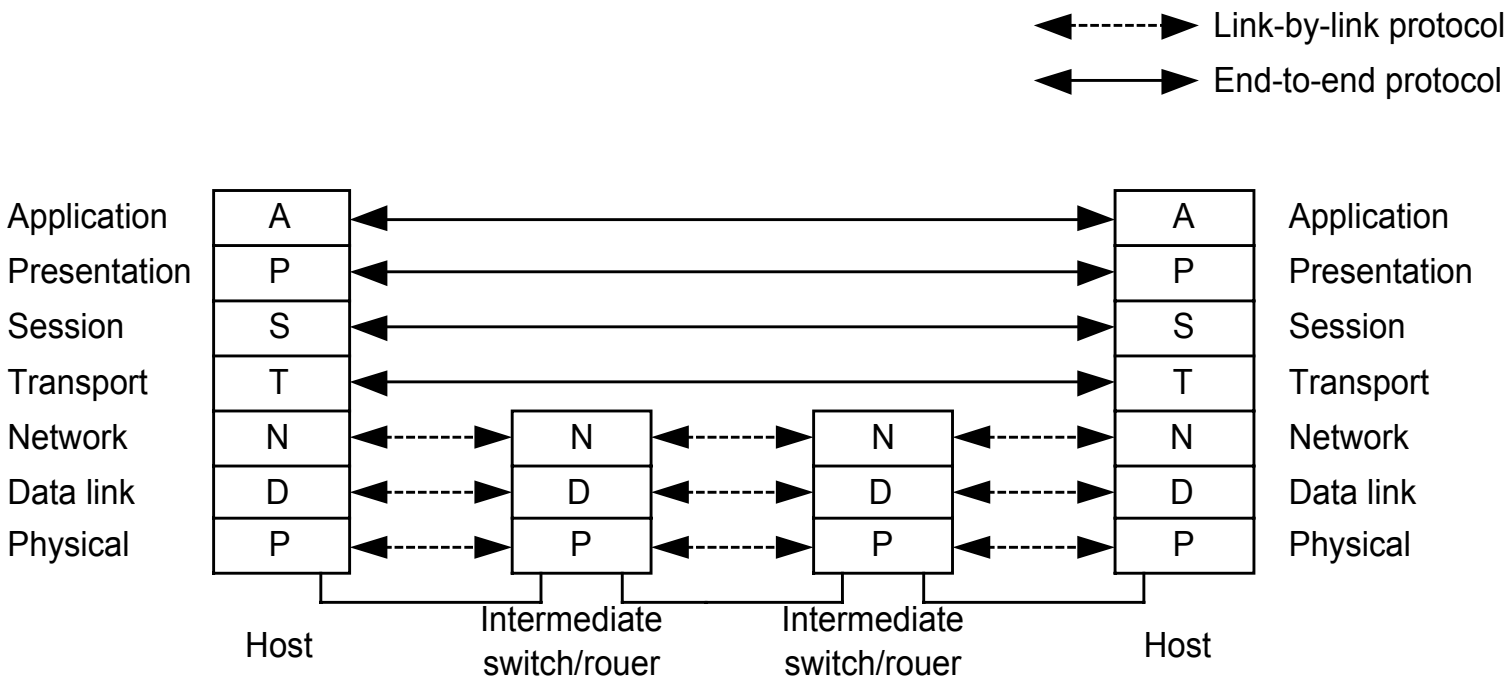
Open Systems Interconnection-Reference Model (OSI-RM)

- Defined for Open Systems:
  - Standards/Recommendations are fully published.
  - Systems are open for communication with other systems.
  - Communication takes place using internationally accepted protocols.
  - Multi-vendor solutions are interoperabl
  - Standards are developed by independent and neutral bodies.

OSI-RM (2)

- Uses layered abstraction concepts :
  - Each layer has a well defined function
  - Layering violation not entertained
  - Each layer provides services to its upper layer and uses the service provided to it by the lower layer
- Reference model has seven distinct layers
- Lower three layers are hop-by-hop

OSI-RM (3)



Module Name

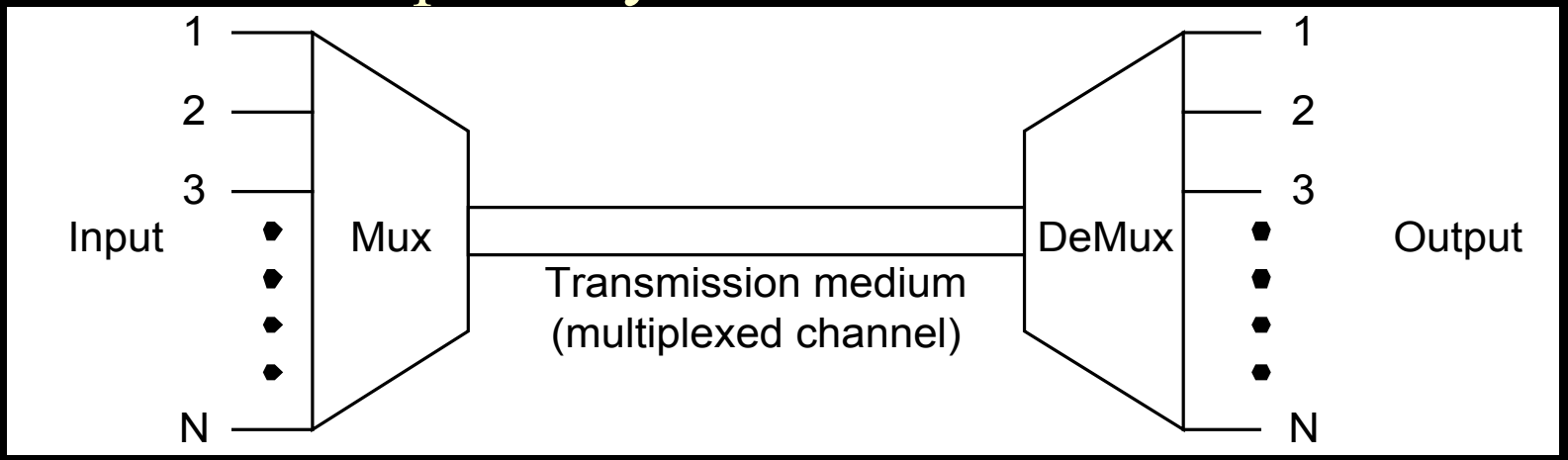
Basics of Communication Network

Sub-Modules:

- *Network Services*
- *Network Topology*
- *Protocol Layering*
- *Multiplexing*
- *Switching*
- *Geographical classification*

Multiplexing

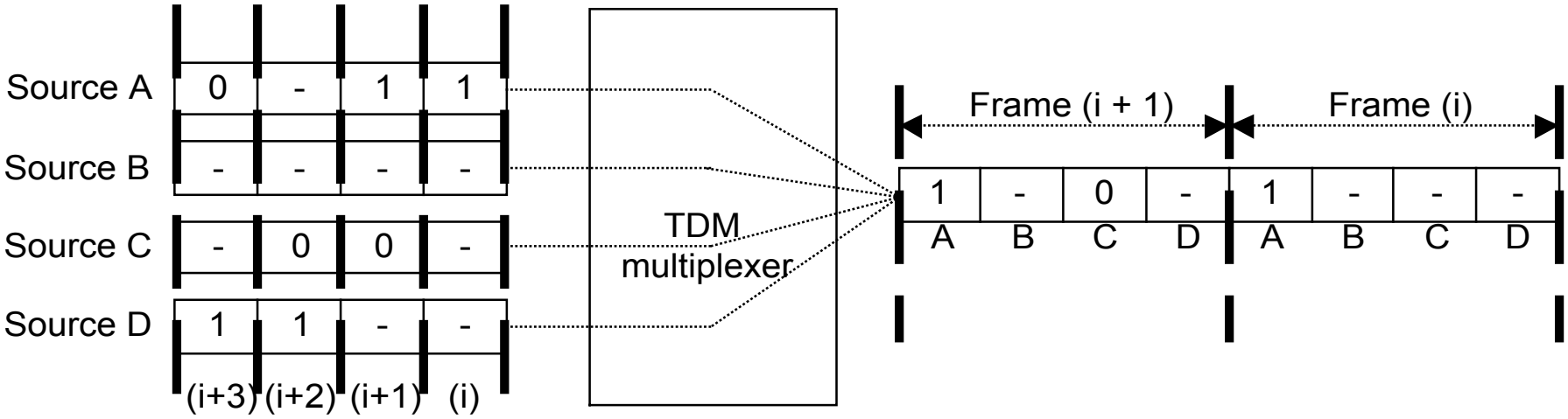
- Multiplexing the means by which multiple streams of information share the same medium.
  - In general, multiplexing is used to share a resource optimally.



Time Division Multiplexing (TDM)

- TDM is a technique in which individual input channels are multiplexed onto a single channel.
- The multiplexed channel is divided into frames and each frame further sub-divided into slots, with each input channel getting a fixed slot.
- Since input channels equally share the time slots, fairness is ensured.
- However, this means that the slot goes wasted if the input channel has nothing to send for that slot

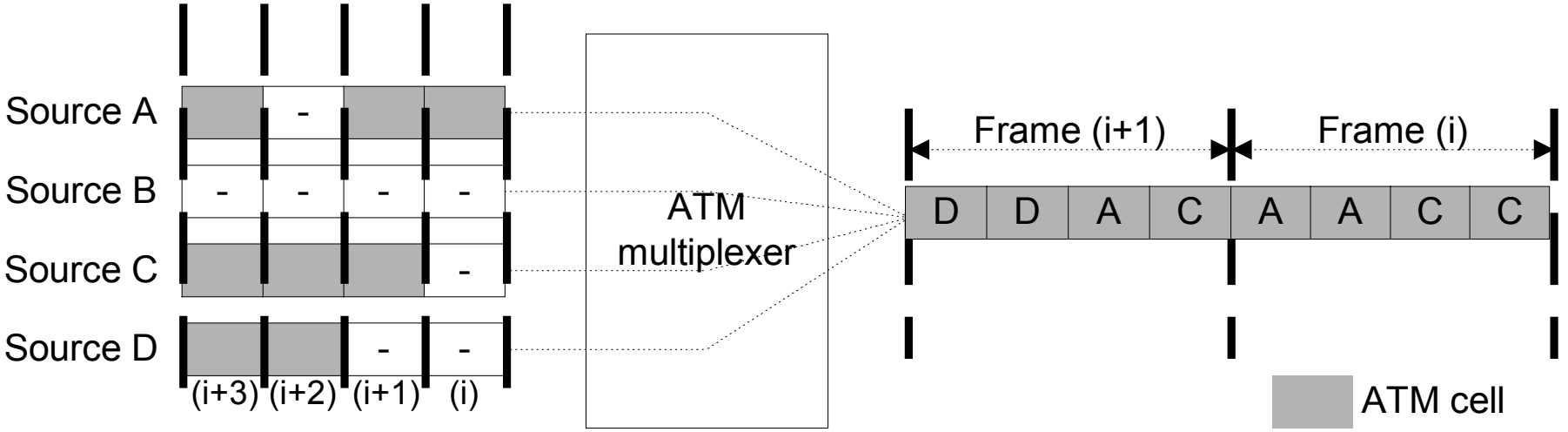
TDM(2)



Statistical Time Division Multiplexing (STDM)

- In STDM no slot is reserved for an incoming channel (i.e. allocation is made dynamically).
- Resources are allocated using statistical methods.
- Request for new connection is accepted only if there are ample resources throughout the path of the connection.

STDM(2)



Frequency Division Multiplexing (FDM)

- FDM is a broadband analog technique in which multiple input streams are transmitted simultaneously by using different frequency bands.
- In this technique, input signal modulates the carrier frequency such that input is carried on a different frequency band.
- FDM is successfully used in radio broadcasts to transmit multiple channels.

Wavelength Division Multiplexing (WDM)

- WDM is a multiplexing technique employed for fiber-optic cables.
- The basic idea behind WDM is to partition the bandwidth of a fiber into multiple channels, with each channel carrying a light signal of different wavelength.
- Thus, WDM for fiber is analogous to FDM used in microwave systems.

Module Name

Basics of Communication Network

Sub-Modules:

- Network Services
- Network Topology
- Protocol Layering
- Multiplexing
- Switching
- Geographical classification

Switching

- Switches switch user information from an input link to an output link.
- Switching, along with multiplexing together define the way data is transmitted from the source to a destination.
- Switching is broadly classified into two categories, namely *circuit switching* and *packet switching*.

Circuit Switching

- Used in telecos networks to carry voice.
- A dedicated non-sharable connection is established between two end-systems.
  - using copper cables,
  - or a wireless satellite link.
- Circuit Switching is a three step process:
  - call-setup
  - data transfer,
  - and call clearing.

Circuit Switching (2)

- Merits:
  - Low switching delay (Switching in Hardware), low propagation delay and low delay variance
  - No overheads of Packetization
  - No routing and link level error control
- Demerits
  - Highly Inflexible (fixed bandwidth allocation in multiple of 64 Kbps)
  - Inefficient for variable bit-rate traffic (bandwidth is allocated at the peak rate)

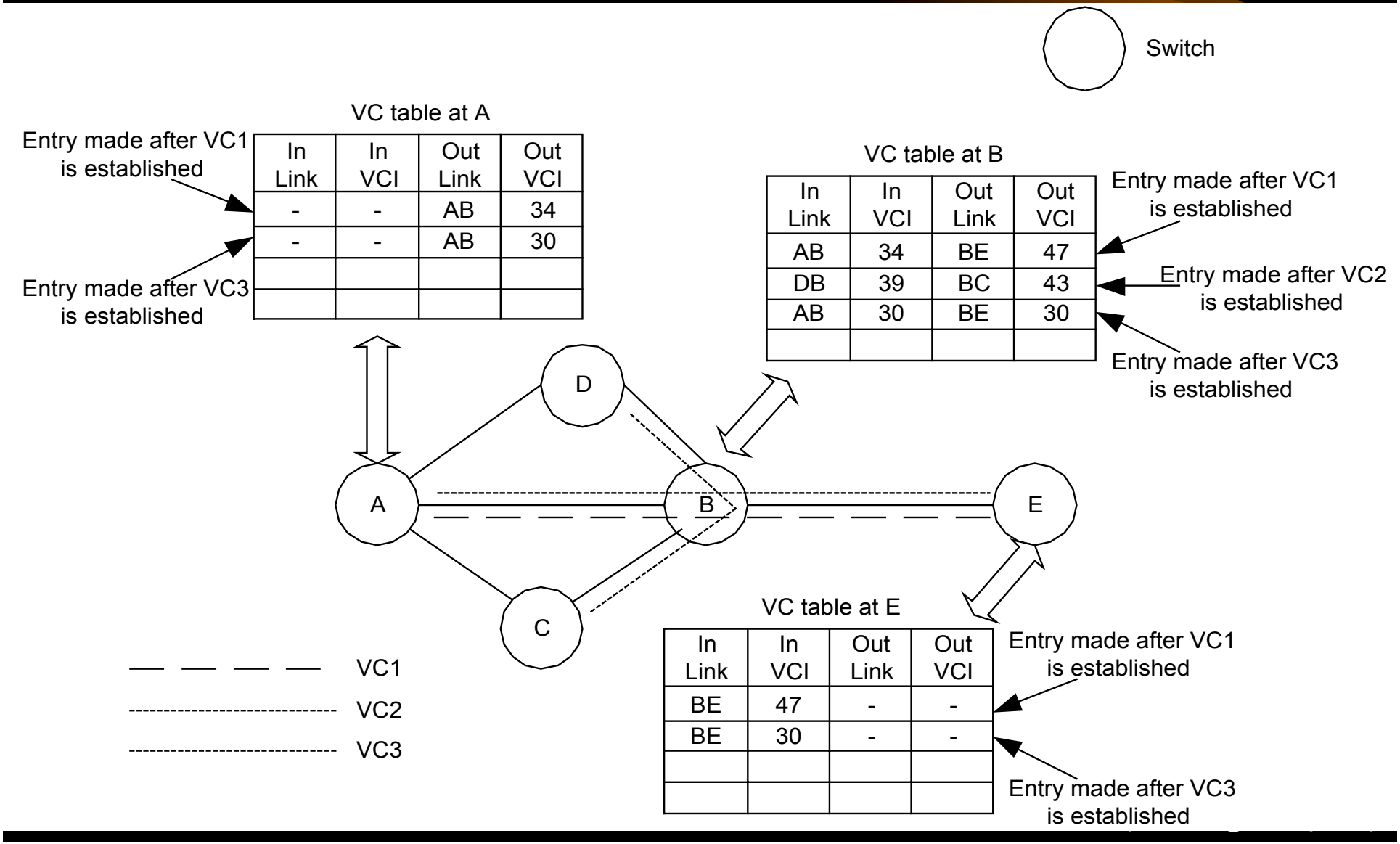
Packet Switching

- Used in datacomm. networks to carry data.
- User information is carried in variable-sized or fixed-sized packets (called packets, cells, or datagrams).
- Each packet has a *header* and a *payload*.
  - Header carries address information and is used to make switching decisions.
  - Payload carries the actual user information.
- Classified into *virtual circuit switching* and *datagram switching*

Virtual Circuit Switching

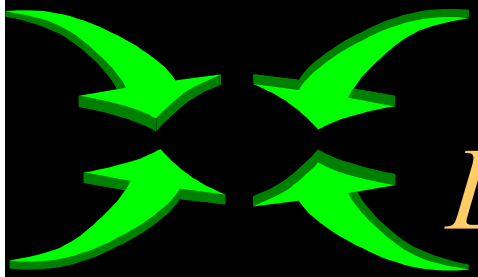
- Logical Connection, established using signalling protocol
  - Route from the source to the destination is chosen
  - The same route is used for all packets of the connection
  - Unlike ckt. Switching, no dedicated path is established.
- Simple switching decision is made at intermediate nodes.
- VC switching in ATM is called *cell switching*.

Virtual Circuit Switching (2)



Virtual Circuit Switching (3)

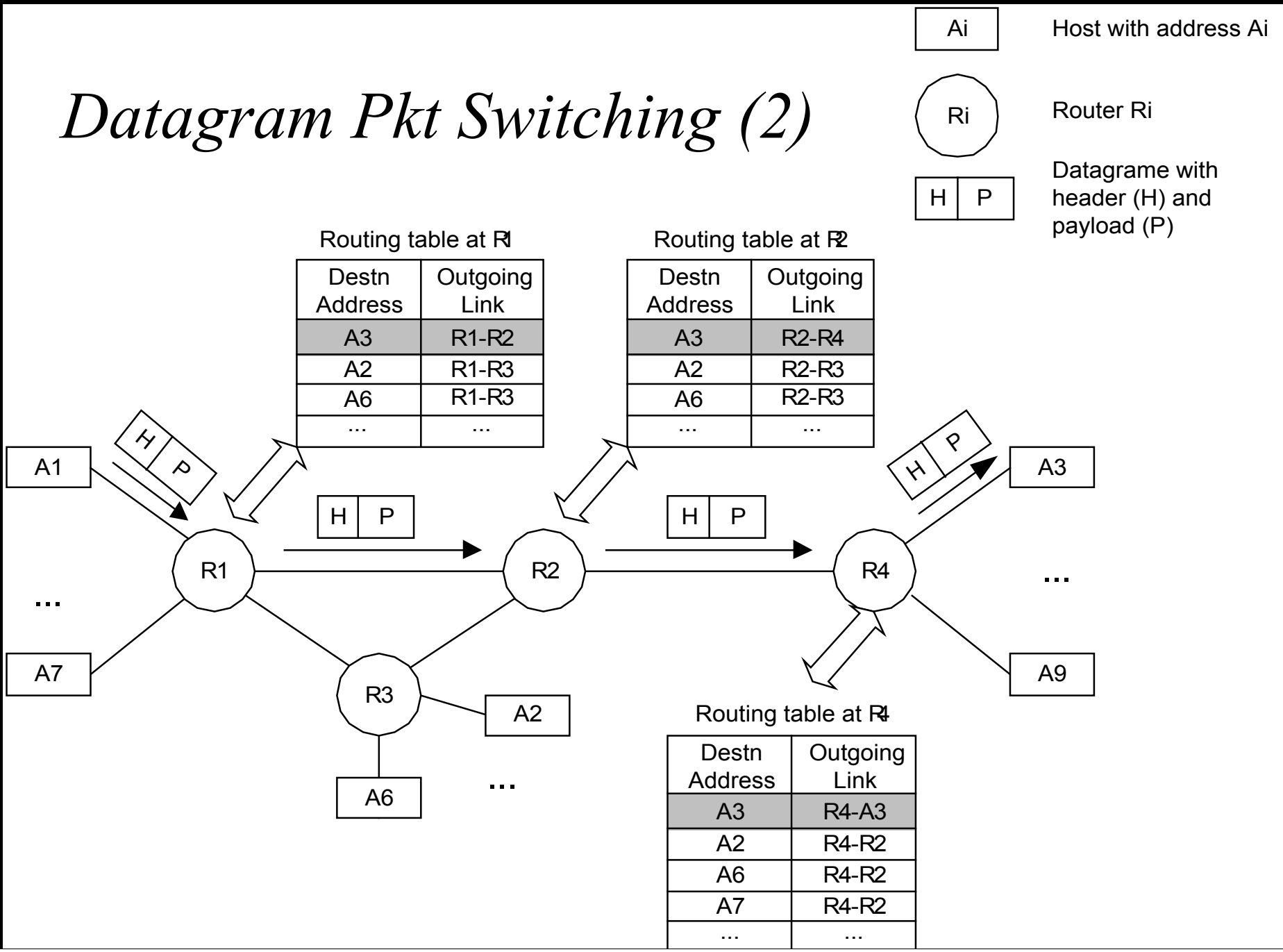
- Merits:
  - In order delivery of packets or cells
  - Faster Switching Decision Less Header Overhead
  - Better Resource Utilization
- Demerits
  - Complicated call-setup procedures may be required
  - Link failures are not easy to handle. Connections have to be re-established.
  - Resource wastage can take place.



Datagram Packet Switching

- Full addresses are used
- Connectionless Service
- For each packet/datagram, routing decision takes place.
- Routing takes place using routing tables
- Example: TCP/IP

Datagram Pkt Switching (2)



Datagram Packet Switching (3)

- Merits:
  - No call-setup required
  - Link failures is easy to manage
  - Resource wastage is minimised
- Demerits
  - Routing decision for each packet.
  - Variable processing and switching delays
  - Best Effort transfer (packet loss might occur)
    - No class based resources reservation.
  - Low efficiency for small size packets
    - Due to high header overheads

Datagram Packet Switching (3)

- Merits:
  - No call-setup required
  - Link failures is easy to manage
  - Resource wastage is minimised
- Demerits
  - Routing decision for each packet.
  - Variable processing and switching delays
  - Best Effort transfer (packet loss might occur)
    - No class based resources reservation.
  - Low efficiency for small size packets
    - Due to high header overheads

Comparison of Switching Techniques

Circuit Switching	**Virtual Circuit Switching**	**Cell Switching**	**Datagram Switching (or routing)**
Connection-oriented (call setup required)	Connection-oriented (call setup required)	Connection-oriented (call setup required)	Connectionless (call setup not required)
Before data transfer, a dedicated connection established	Before data transfer, a virtual circuit established	Before data transfer, a virtual circuit established	No connection is established
Fixed resource allocation	Statistical resource allocation	Statistical resource allocation	No resource reservation
Stream oriented	Packets or frames oriented; variable size packets or frames	Cell oriented; small fixed size cells	Packet (datagrams) oriented; variable size packets

Comparison of Switching Techniques (contd..)

Circuit Switching	**Virtual Circuit Switching**	**Cell Switching**	**Datagram Switching (or routing)**
Hardware based switching	Hardware or software based switching	High-speed hardware based switching	Mainly software based switching; hardware based solutions coming up
Mainly for voice traffic	Mainly for data traffic	For all kinds of traffic	Mainly for data traffic
Very fast, but inefficient resource utilization	Relatively slow, but better resource utilization	Fast and optimal resource utilization	Slowest of all, but robust and flexible
Ex: Plain old telephone systems (POTS)	Ex: X.25 and Frame relay networks	Ex: ATM networks	Ex: TCP/IP networks (i.e., Internet)

Module Name

Basics of Communication Network

Sub-Modules:

- Network Services
- Network Topology
- Protocol Layering
- Multiplexing
- Switching
- Geographical classification

Geographical extent

- Geographical extent influences various aspects of a network like
  - maximum bandwidth,
  - error rates, and
  - ease of management are related to geographical extent.
- Depending upon the geographical extent, networks are classified as:
  - *local area network* (LAN) and
  - *wide area network* (WAN)

LANs

- LANs are shared communication systems to which various nodes are attached.
- General Characteristics of LANs:
  - Have a diameter in the order of few kilometers.
  - Are privately owned by an organization.
  - Bandwidth is considered to be free
  - Low error rates
  - High bandwidth (4-16 to 100-1000Mbps)
  - For e.g., Ethernet, Token Ring, FDDI and ATM

WANs

- WANs cover large geographical distances spanning multiple states/countries and are used primarily to connect dispersed sites.
- General Characteristics of LANs:
  - Have a diameter in the order of few 1000Km
  - Are seldom owned by one organization.
  - Bandwidth is very costly.
  - Bandwidth is in the order of 1-45 Mbps.
  - Error-rates are high
  - For e.g., X.25, Frame Relay and ATM

The following module

Basics of Communication Network

ends here