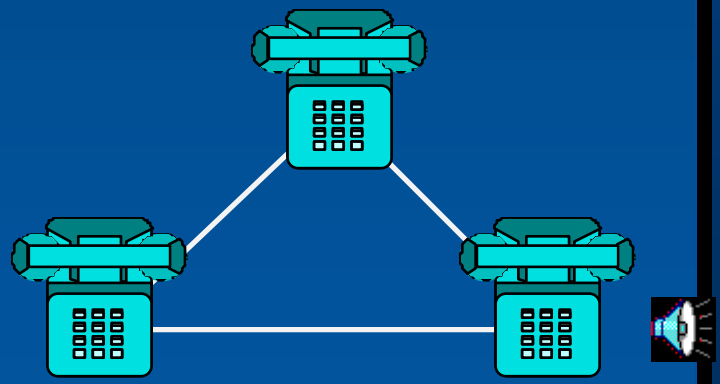
Communication Networks

Introduction

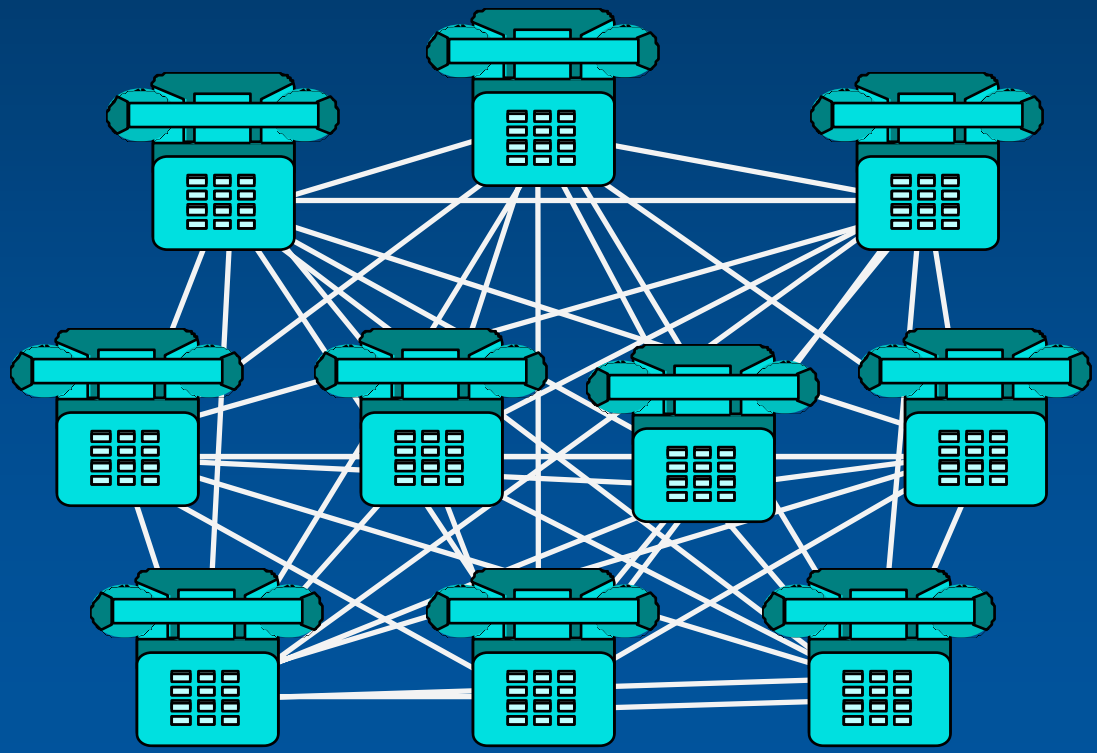
Communication Networks

- **Problem:** Given a set of devices that want to exchange information.
  (Device = telephone, computer, terminals, etc.)
- **Simple Solution:**
  Connect each pair of devices by a dedicated point-to-point link
- The simple solution is sufficient if the number of devices is small.



Communication Networks

- With a large number of devices it is not practical to connect each pair of devices

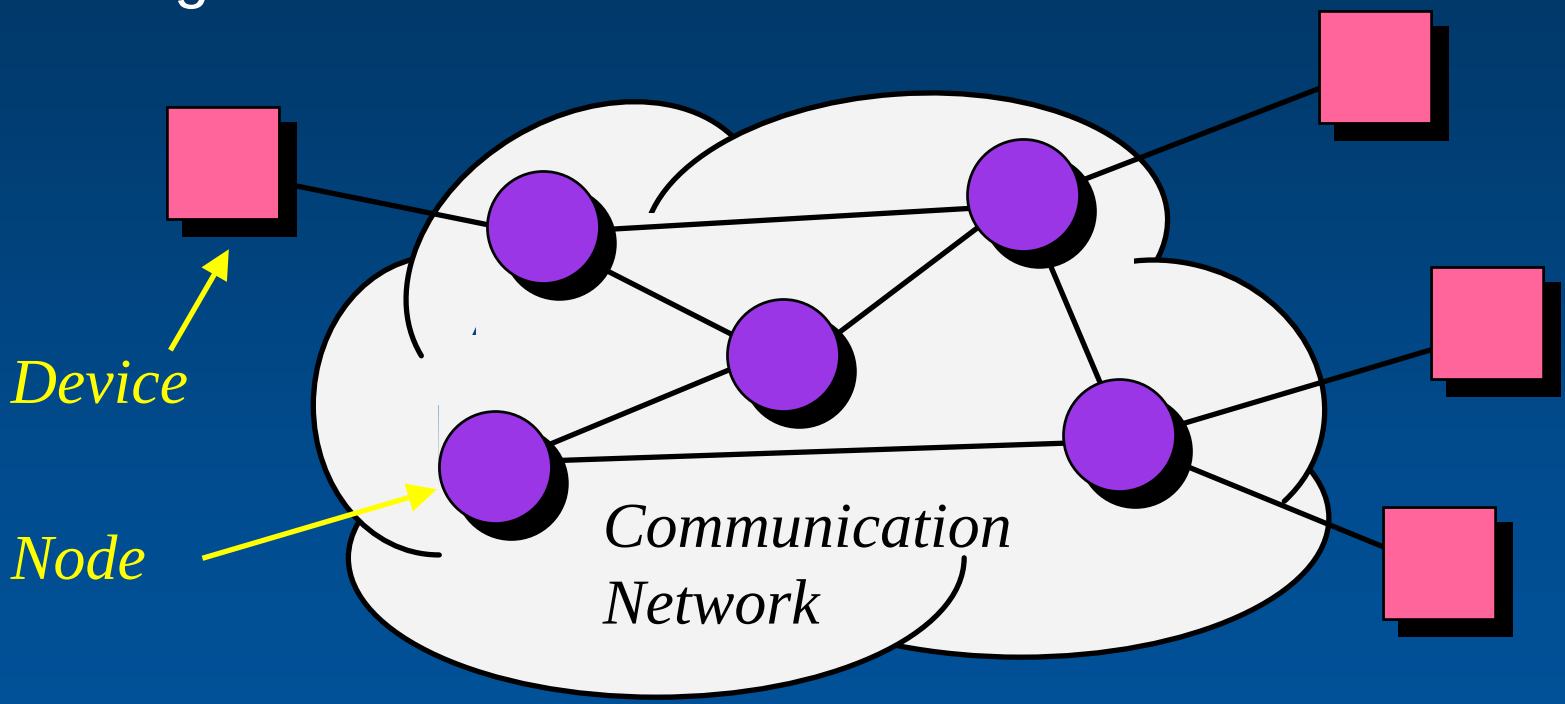


Communication Networks

- A **communication network** provides a general solution to the problem of connecting many devices:
  - Connect each device to a network node
  - Network nodes exchange information and carry the information from a source device to a destination device
  - Note: Network nodes do not generate information

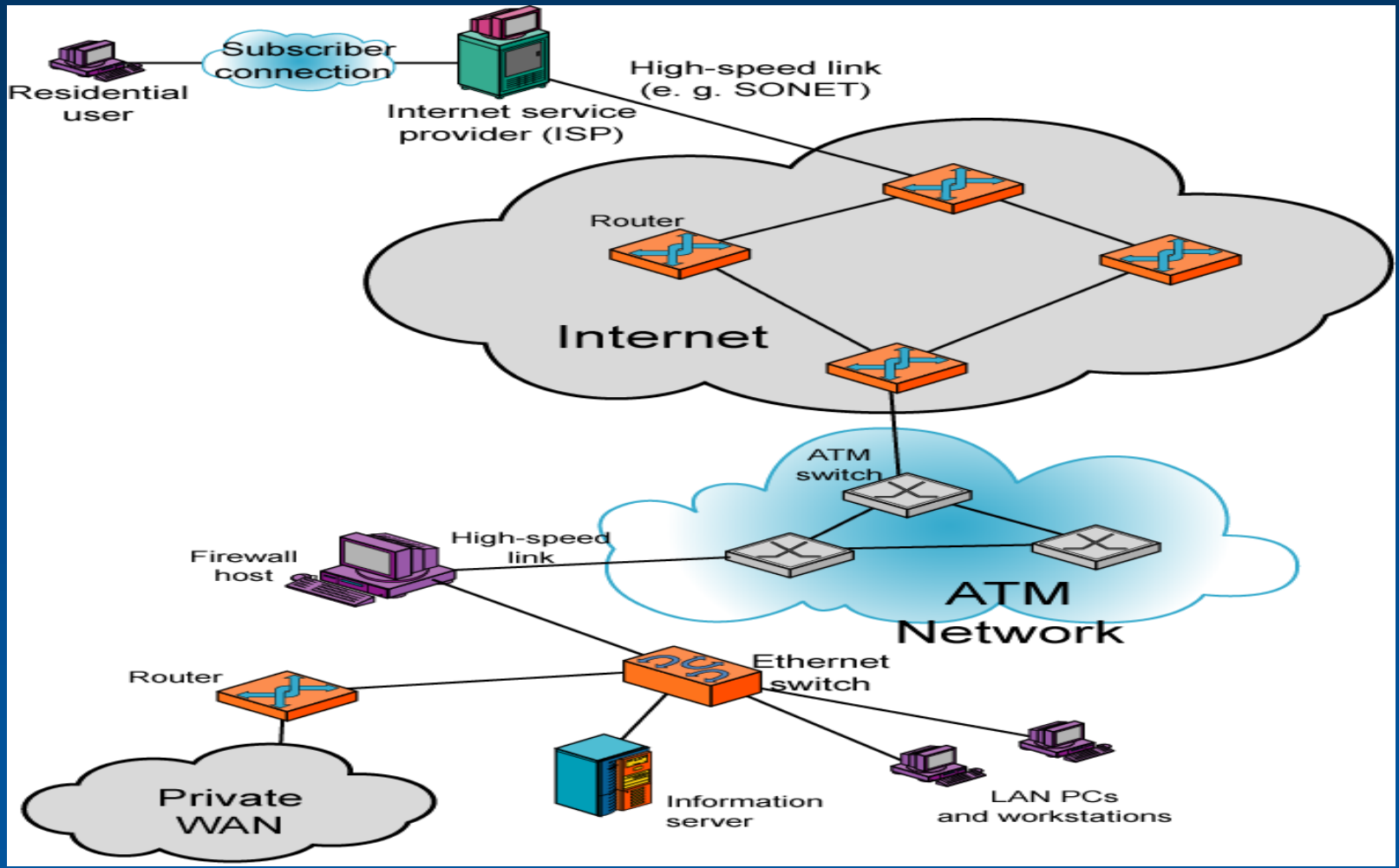
Communication Networks

- A generic communication network:

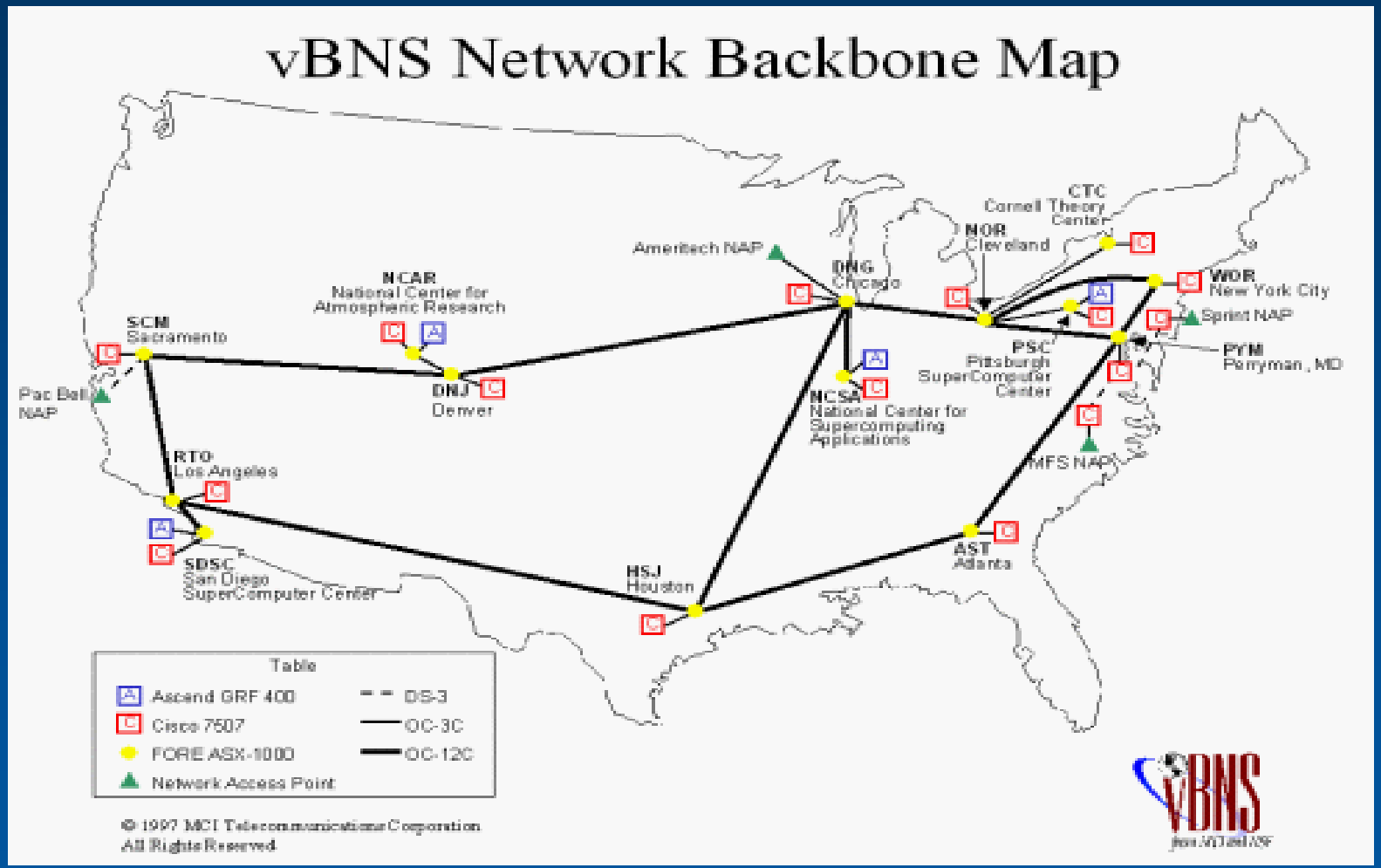


Other names for “device”: station, **host,** terminal
Other names for “node”: switch, **router**, gateway

Network Configuration

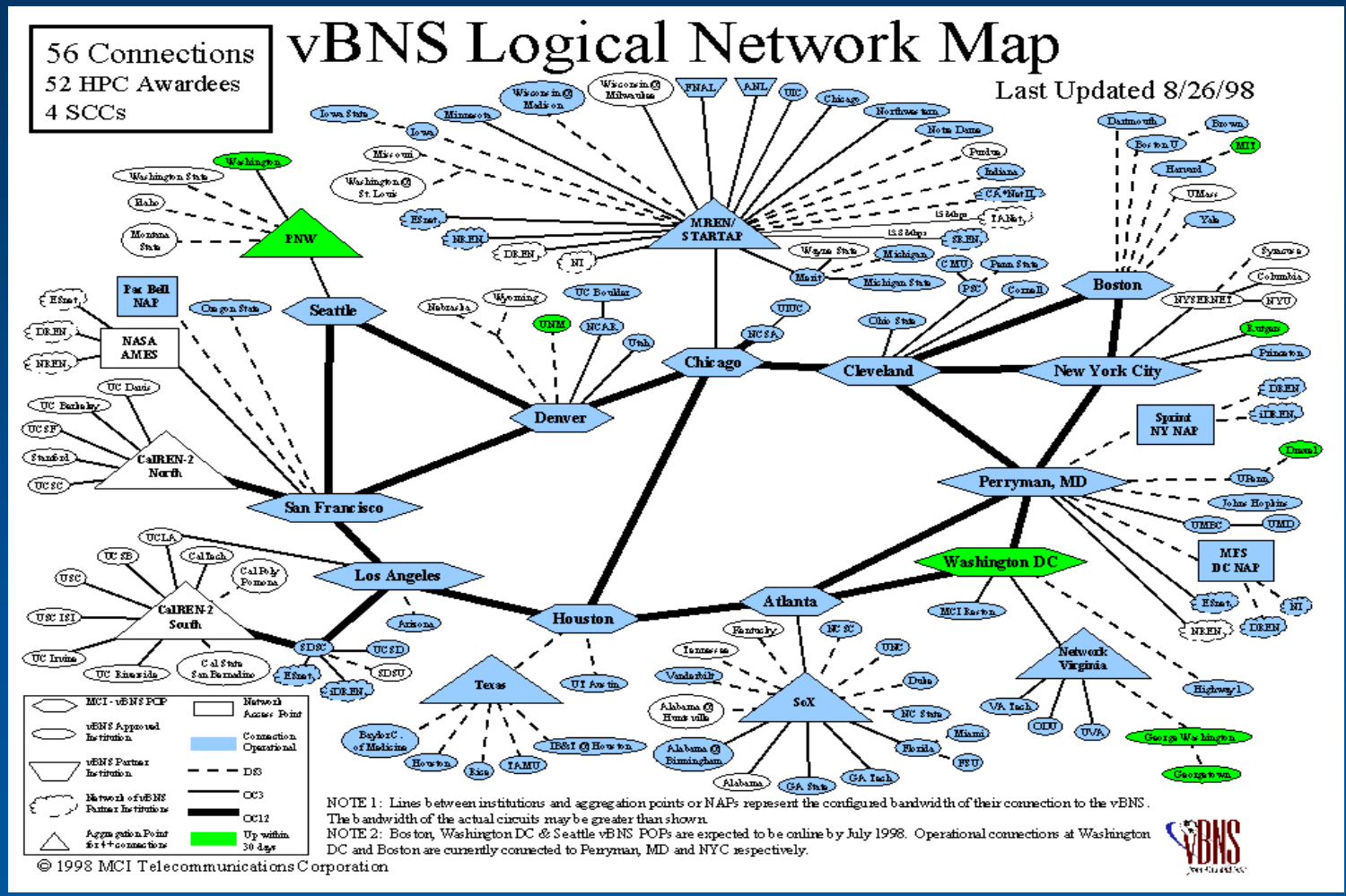


Example: vBNS Network



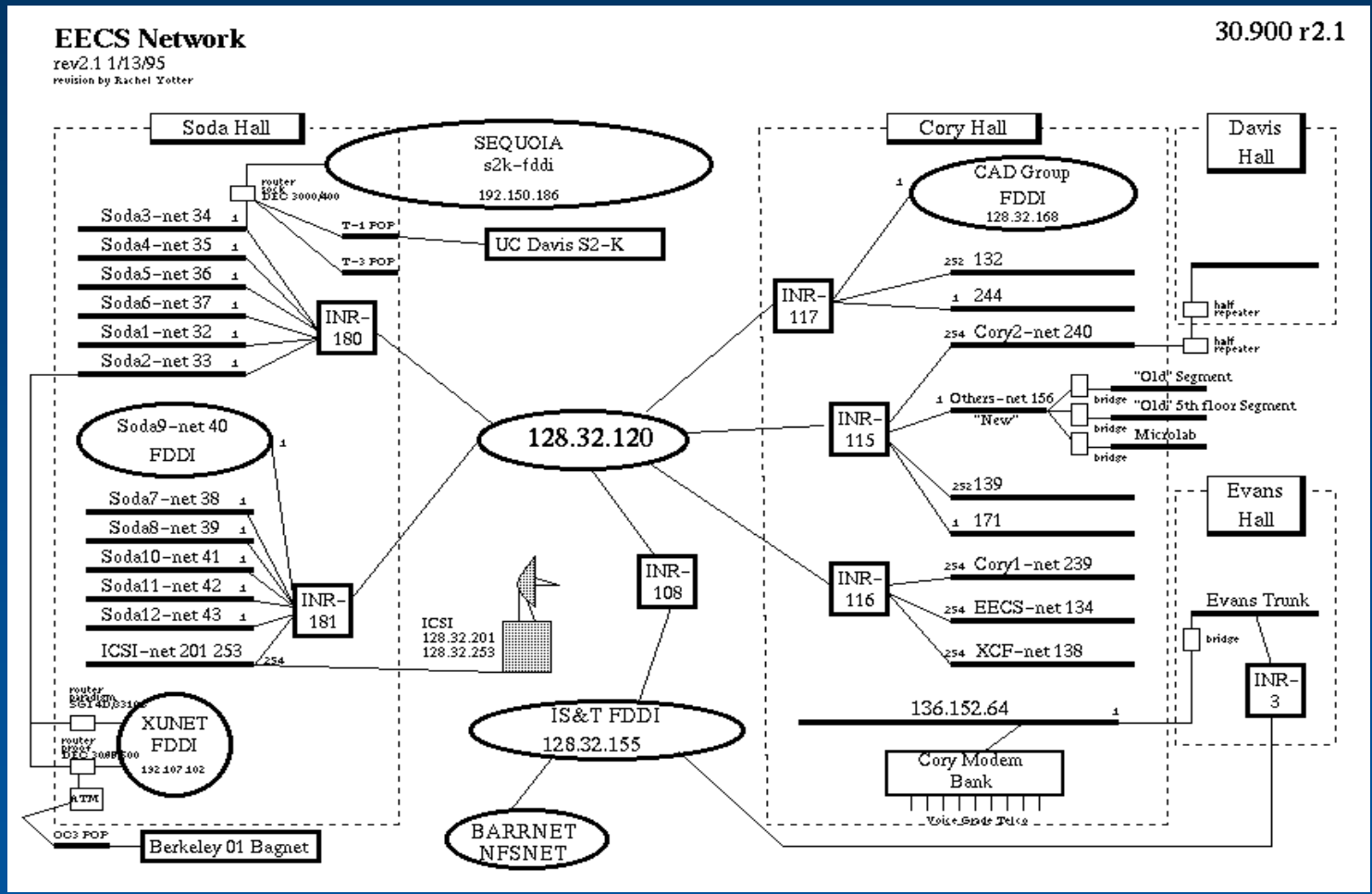
Source: National Science Foundation

Example: vBNS more Detailed



Source: National Science Foundation

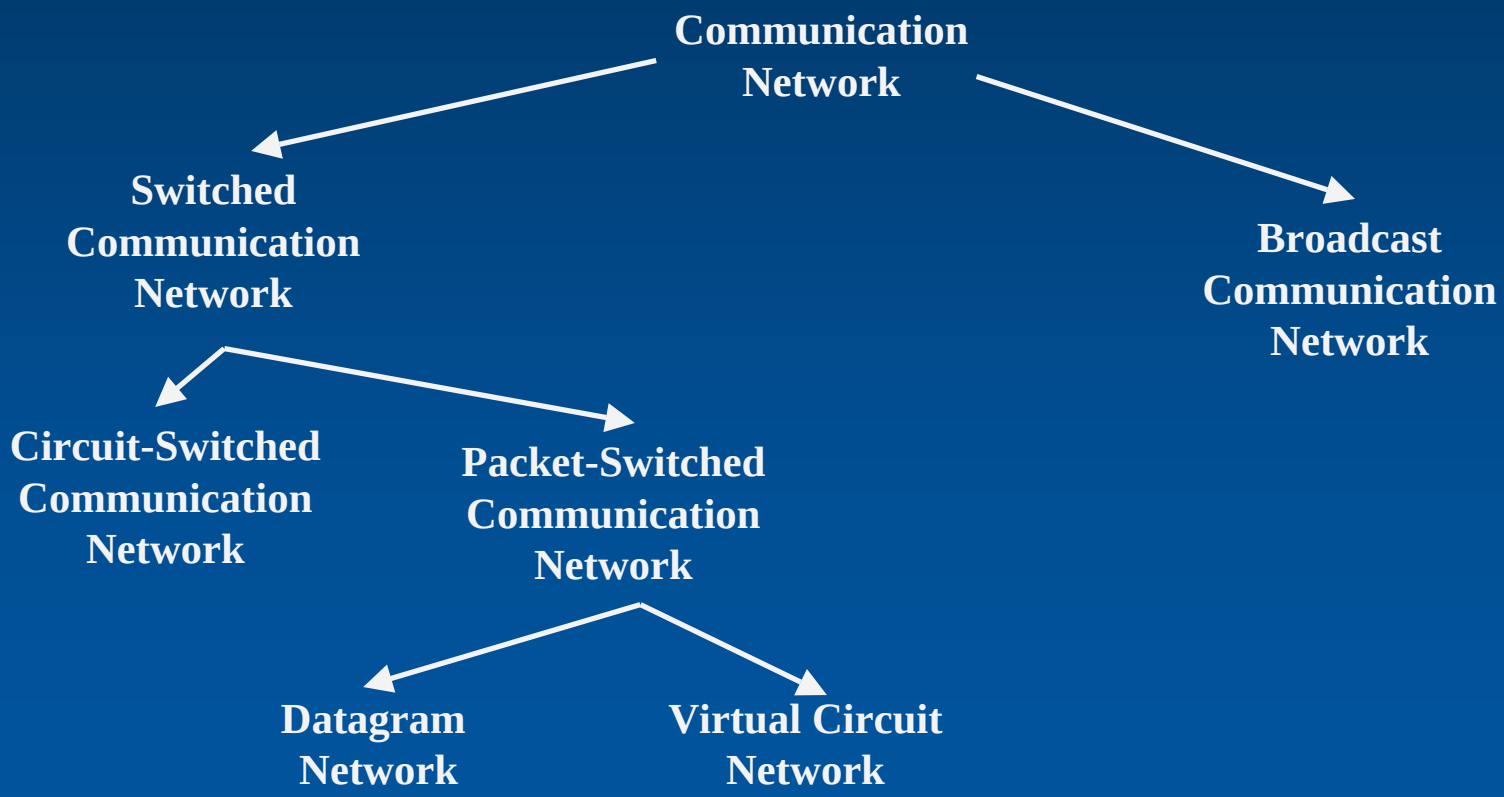
Example: Campus Network of UC Berkeley (1995)



Source: University of California

Classification of Communication

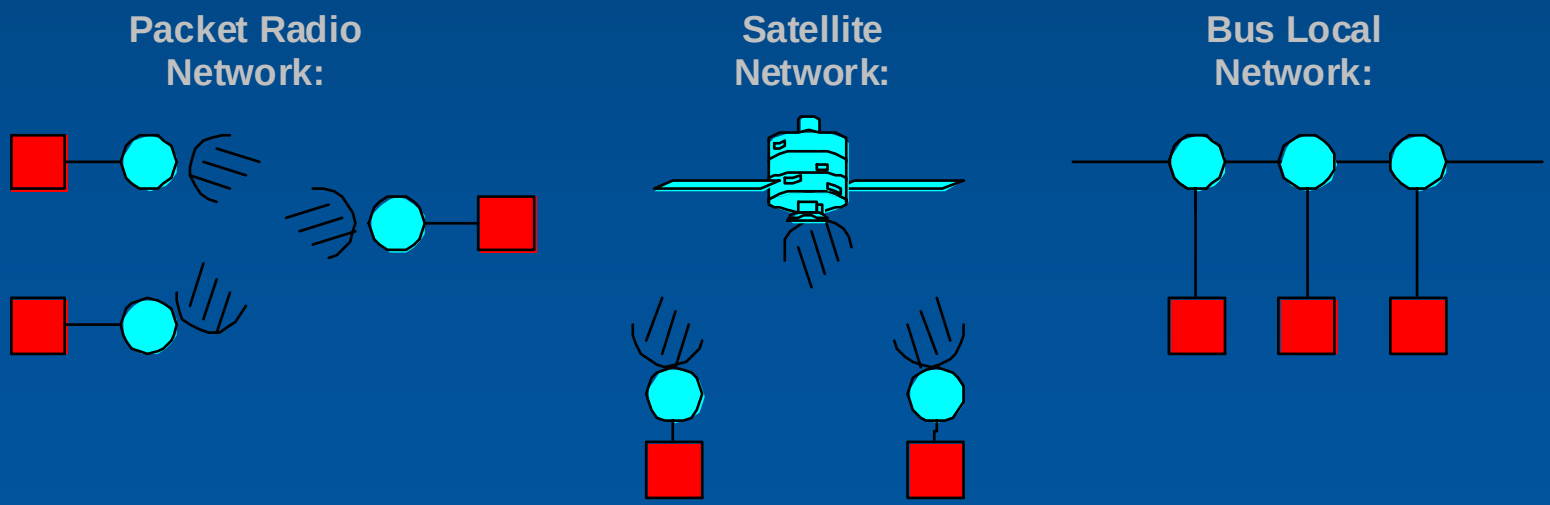
- Communication networks can be classified based on the way in which the nodes exchange information:



Broadcast Communication Networks

Broadcast Communication Network do not have intermediate switching nodes:

- Each station has a transmitter/receiver that communicates over a medium shared by other stations
- Transmission from any station is received by all other stations



Switched Communication Networks

- A switched **communication network** consists of an interconnected collection of nodes. Data are transmitted from source to destination by being routed through the nodes
- The switching method describes how data are processed and routed in the network
- The basic switching methods are:
  - **Circuit Switching**
  - **Packet Switching**
    - Datagram Packet Switching
    - Virtual-Circuit Packet Switching

Circuit Switching

- In a circuit-switched network, a dedicated communication path is established between two stations through the nodes of the network
- The dedicated path is called a circuit-switched connection or circuit
- A circuit occupies a fixed capacity of each link for the entire lifetime of the connection. Capacity unused by the circuit cannot be used by other circuits
- Data is not delayed at the switches

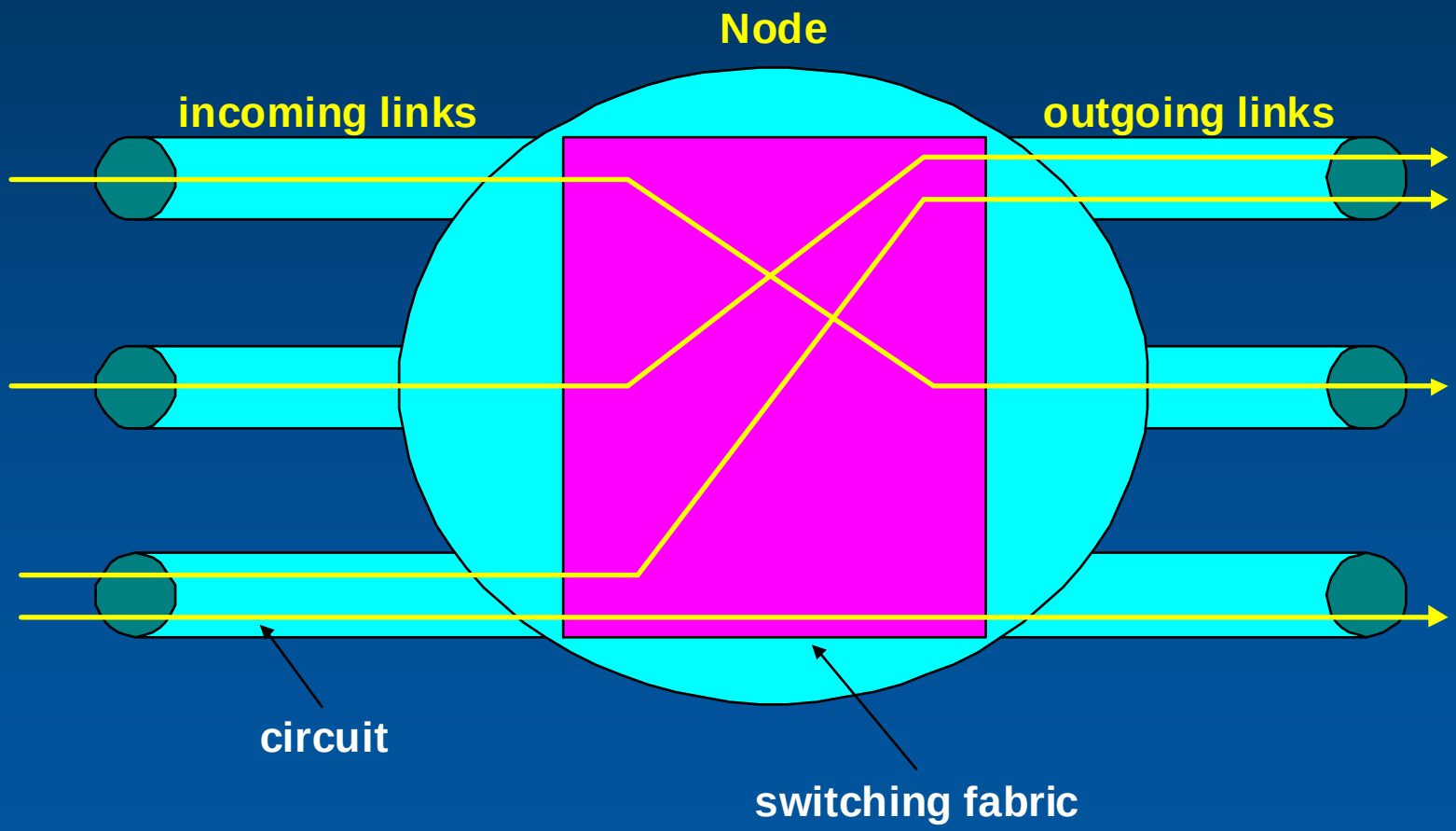
Circuit Switching

- Circuit-switched communication involves three phases:
  1. **Circuit Establishment**
  2. **Data Transfer**
  3. **Circuit Termination**
- "Busy Signal" if capacity for a circuit not available.

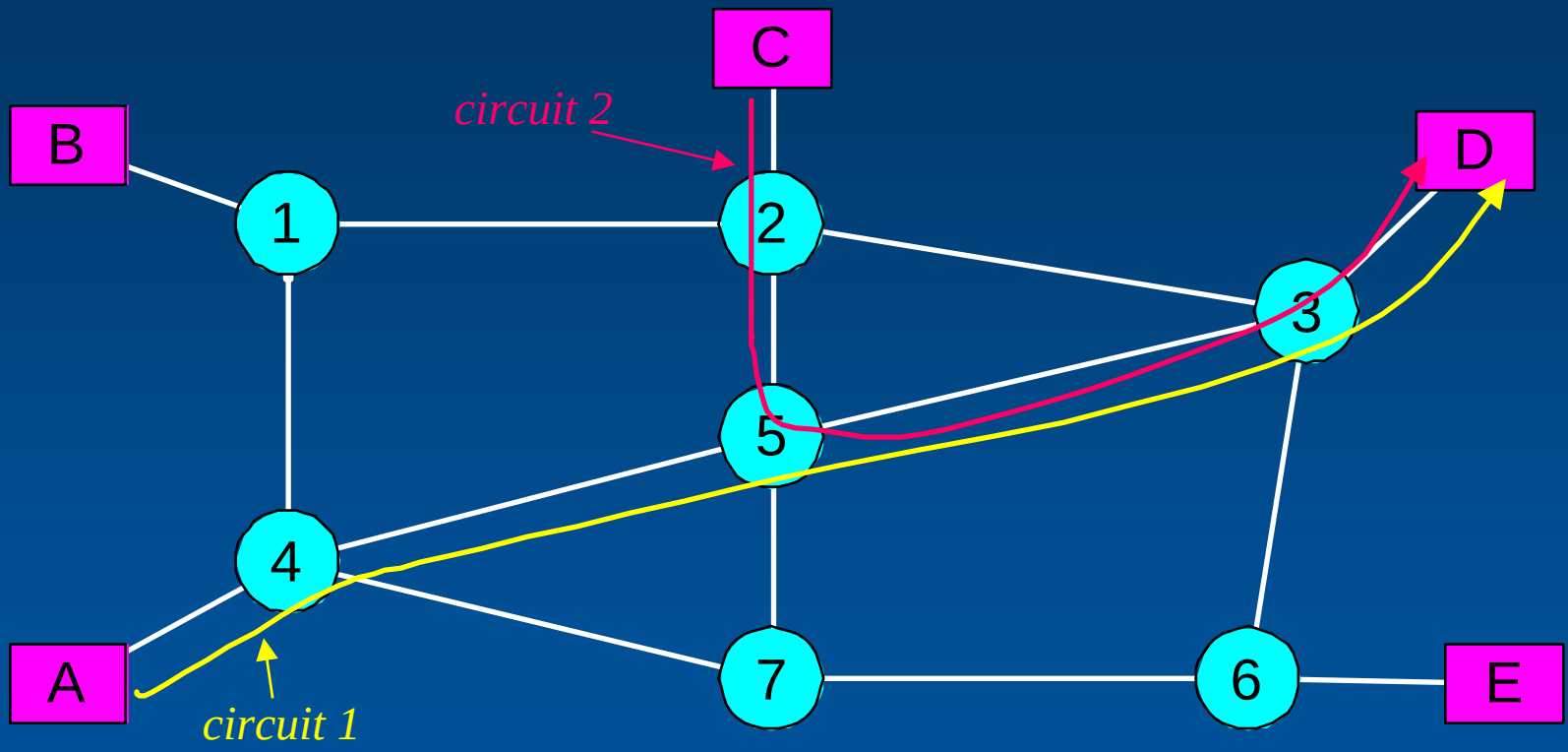
- Most important circuit-switching networks:
  - Telephone networks
  - ISDN (Integrated Services Digital Networks)

Circuit Switching

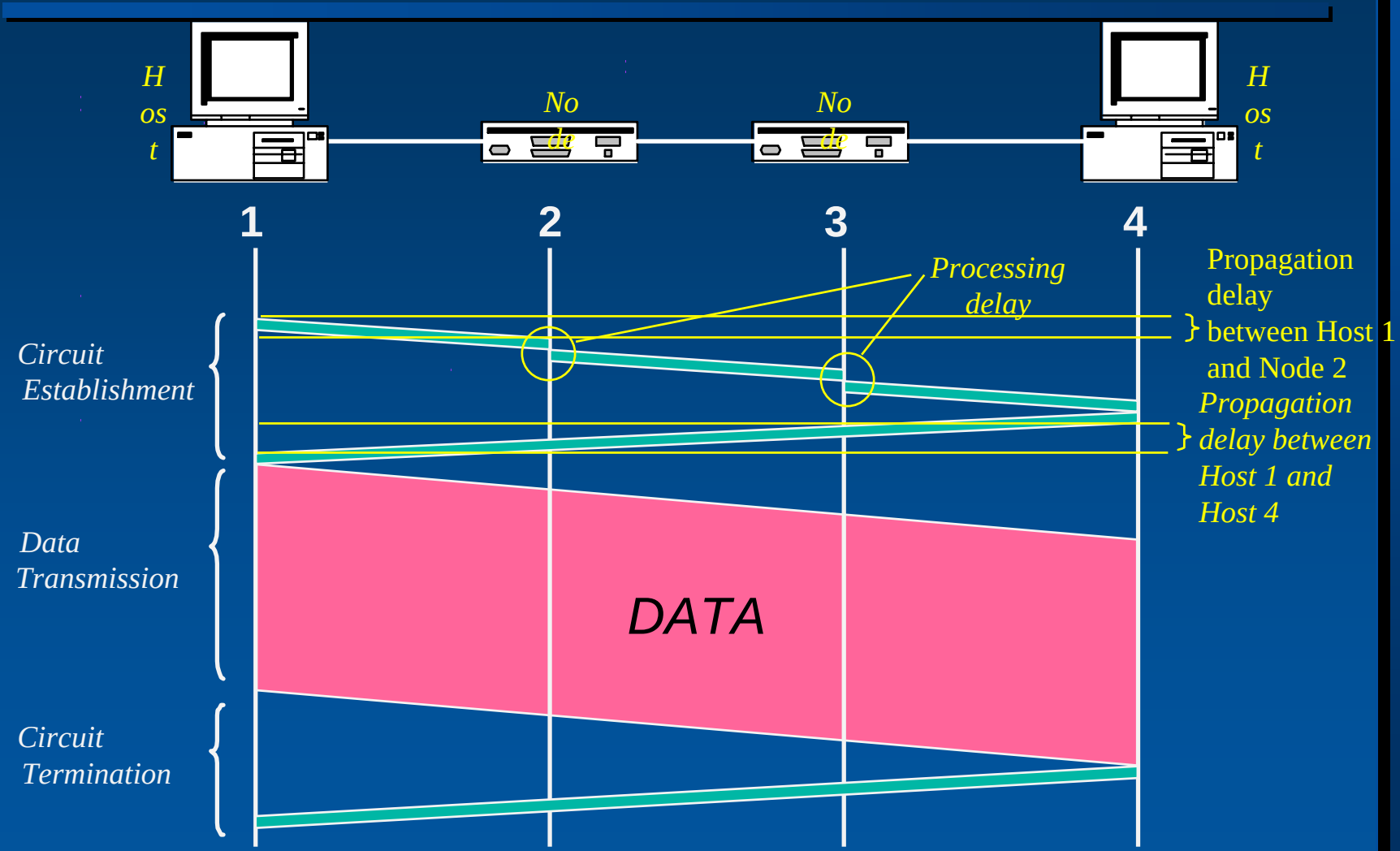
- A node in a circuit-switching network:



Circuit Switching

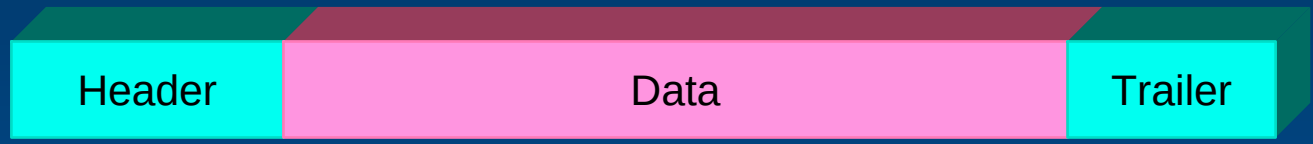


Timing in Circuit Switching



Packet Switching

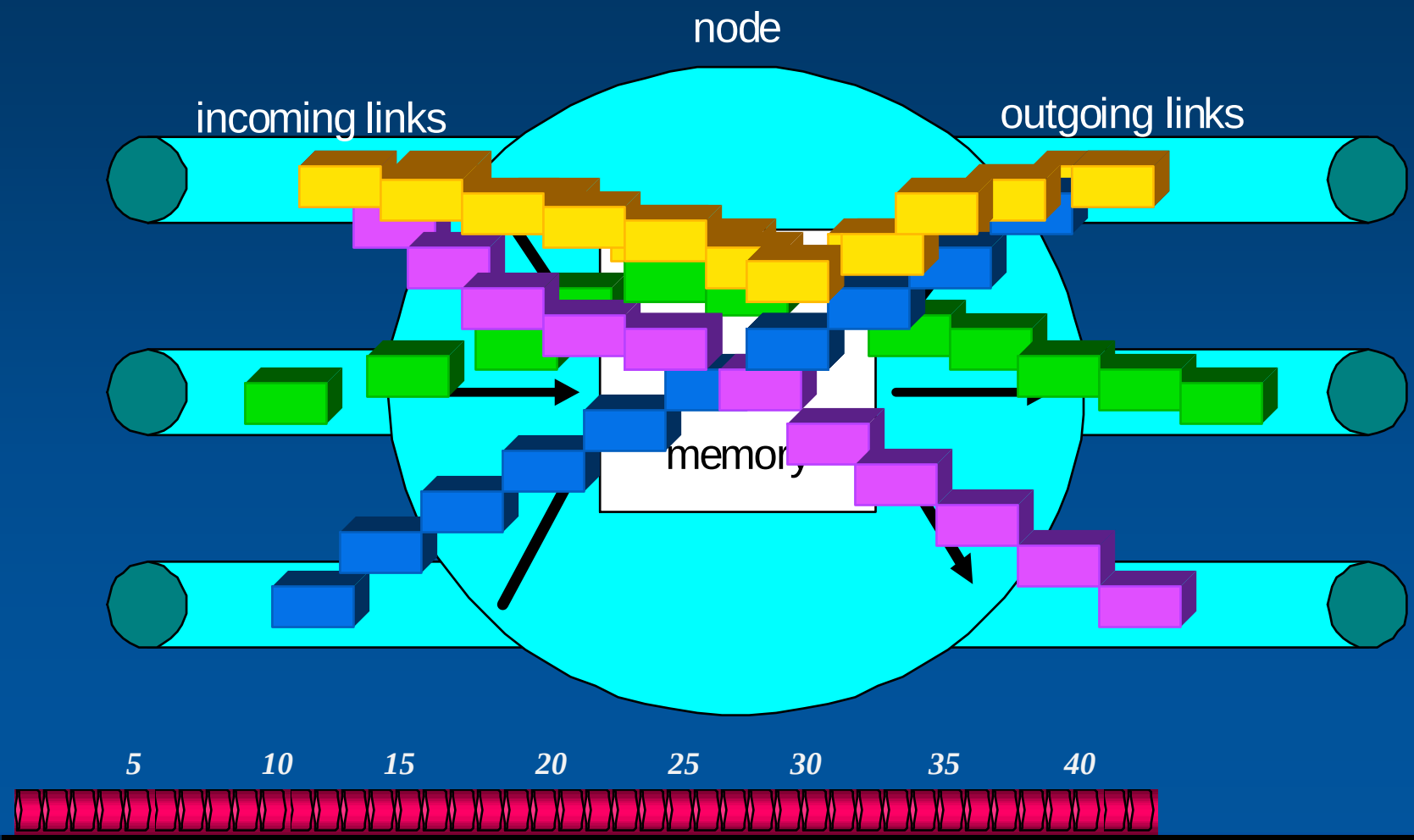
- Data are sent as formatted bit-sequences, so-called packets.
- Packets have the following structure:



  - Header and Trailer carry control information

- Each packet is passed through the network from node to node along some path (**Routing**)
- At each node the entire packet is received, stored briefly, and then forwarded to the next node (**Store-and-Forward Networks**)
- No capacity is allocated for packets

Packet Switching



Datagram Packet Switching

- Packets are called datagrams
- The network nodes process each packet independently

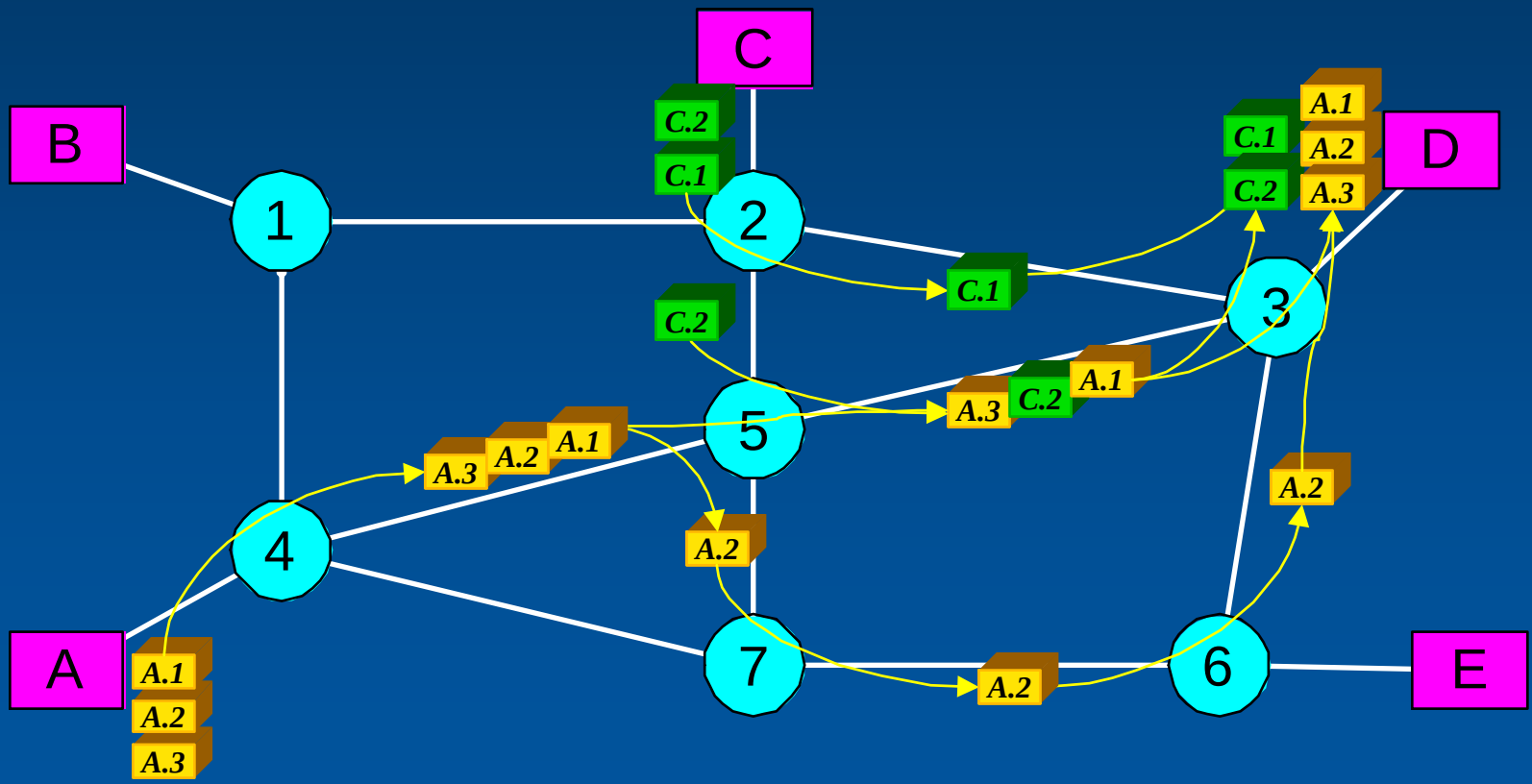
  If Host A sends two packets back-to-back to Host B over a datagram packet network, the network cannot tell that the packets belong together.

  In fact, the two packets can take different routes.
- Implications of processing packets independently:
  - A sequence of packets can be received in a different order than it was sent
  - Each packet header must contain the full address of the destination

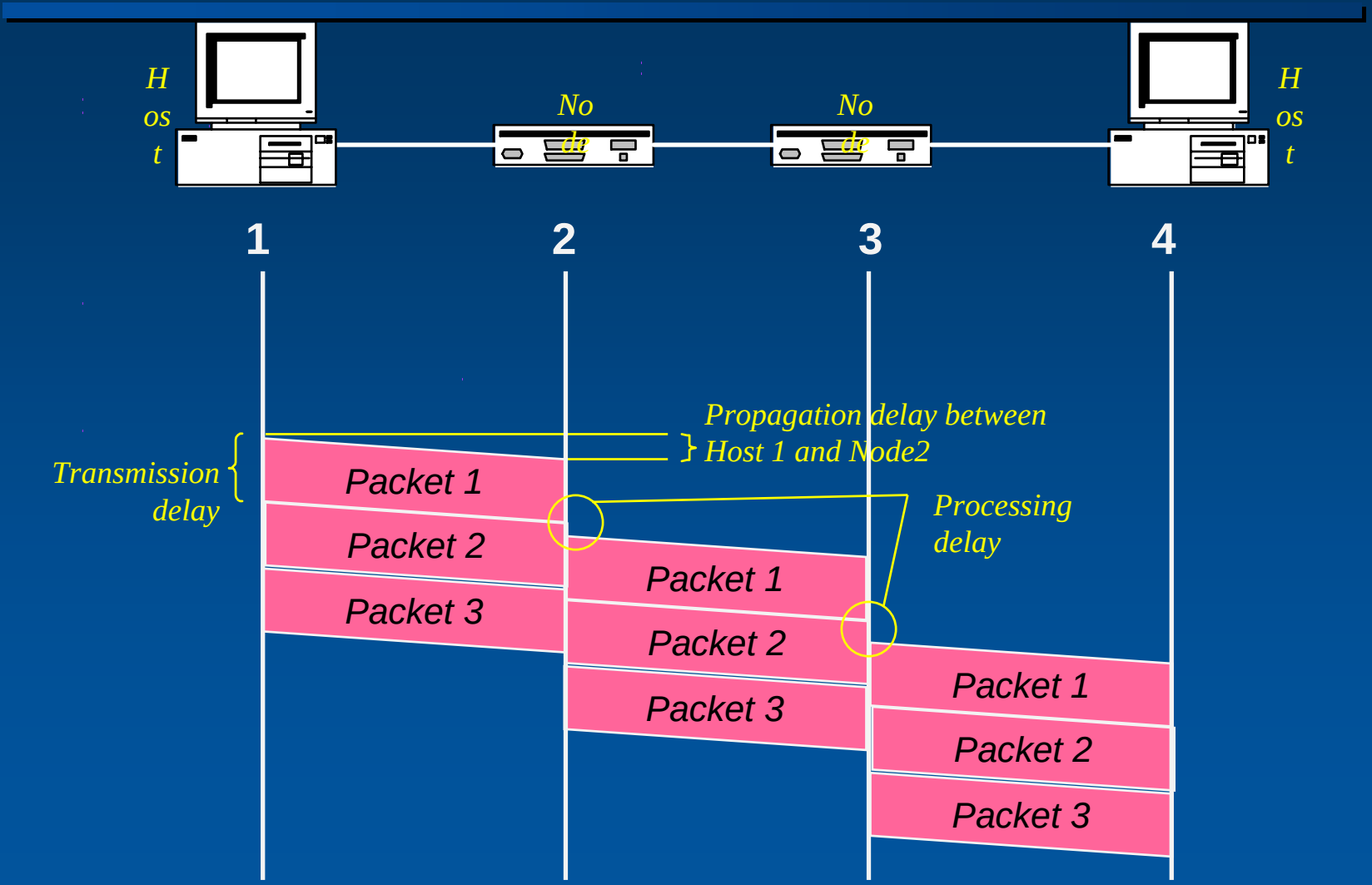
Exercise: Datagram Packet

- Exercise: Most network applications (think of email and file transfer) require that data is received in sequence. For such applications a datagram network appears to be inappropriate, since packets may need to get reordered.
- Question: What are advantages of datagram networks?
- The main example of a datagram packet-switching network is the Internet

Datagram Packet Switching



Timing of Datagram Packet Switching



Virtual-Circuit Packet Switching

- As the name suggests:
  Virtual-circuit packet switching is a hybrid of circuit switching and packet switching

- All data is transmitted as packets
- All packets from one packet stream are sent along a pre-established path (=virtual circuit)

- Guarantees in-sequence delivery of packets
- **However**: Packets from different virtual circuits may be interleaved

Examples

X.25

- X.25 networks have been around since the 1970s
- It is used in many public packet switching networks

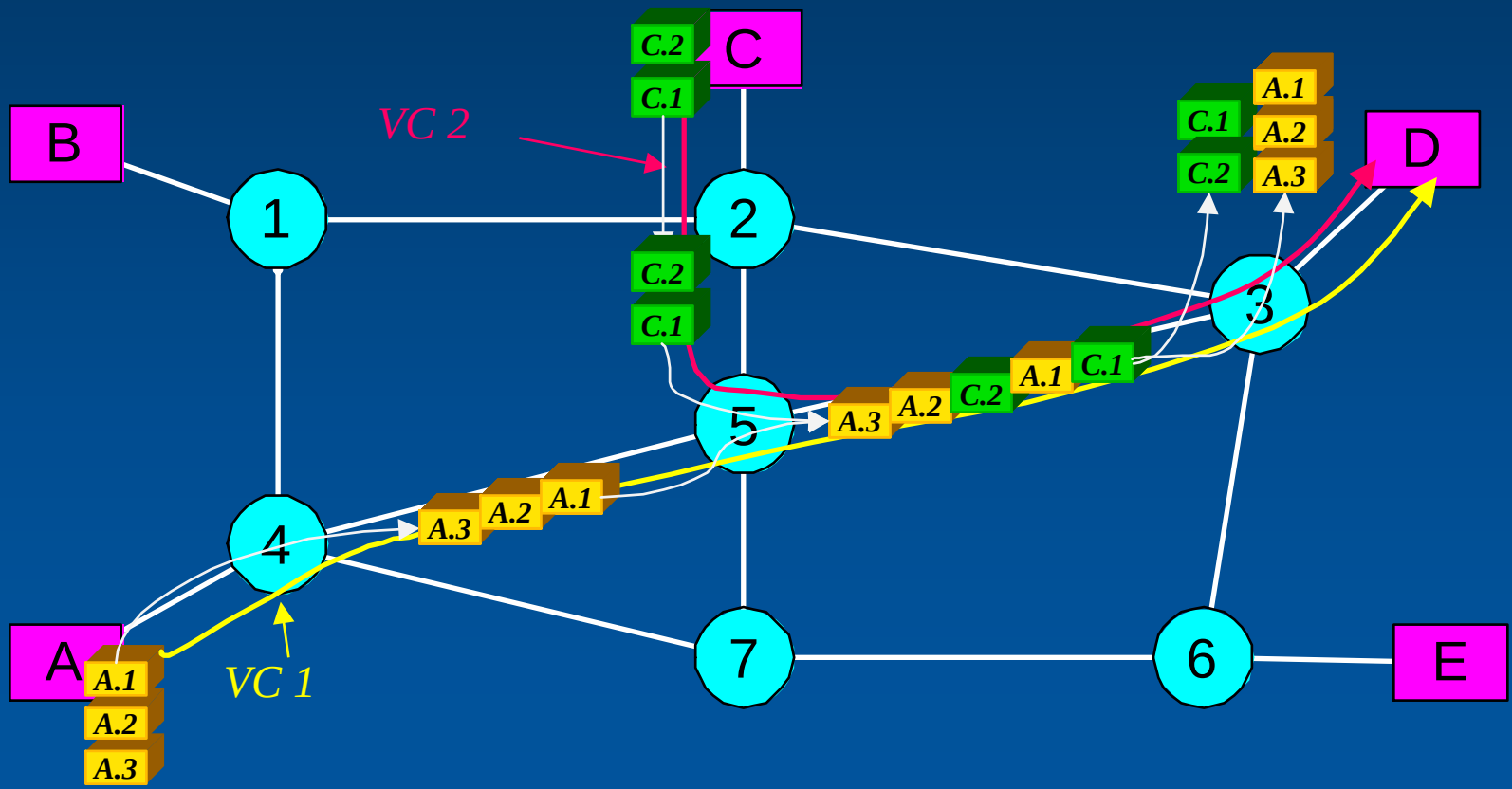
ATM (Asynchronous Transfer Mode)

- Developed in the 1980s
- For transmission of voice, video, and data in a single network

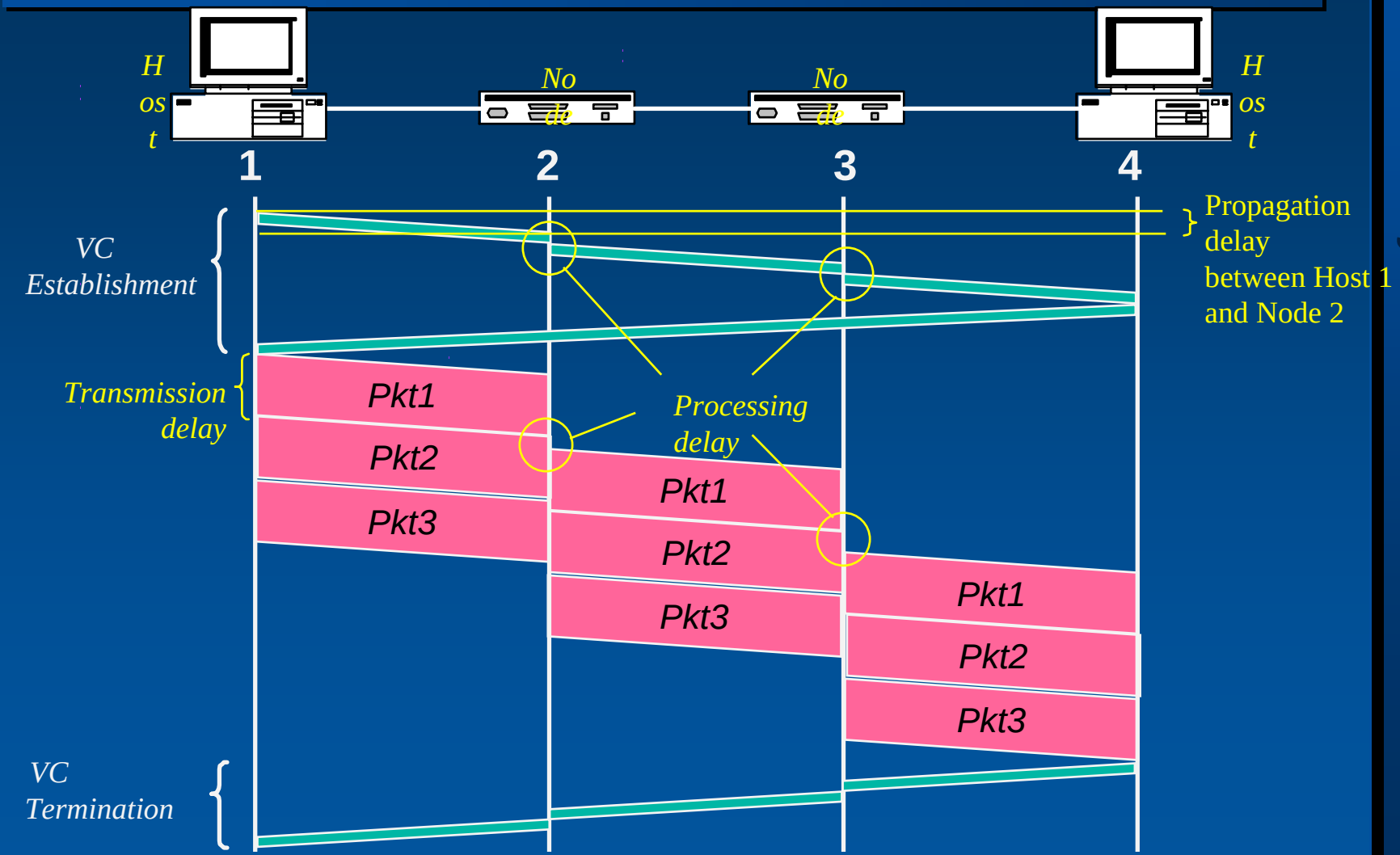
Others

- SNA (Systems Network Architecture) by IBM

Virtual-Circuit Packet Switching



Timing of Virt. Circ. Packet Switching



Comparison

Circuit Switching

- Dedicated transmission path
- Continuous transmission
- Path stays fixed for entire connection
- Call setup delay
- Negligible transmission delay
- No queueing delay
- Busy signal overloaded network
- Fixed bandwidth for each circuit
- No overhead after call setup

Datagram Packet Switching

- No dedicated transmission path
- Transmission of packets
- Route of each packet is independent
- No setup delay
- Transmission delay for each packet
- Queueing delays at switches
- Delays increase in overloaded networks
- Bandwidth is shared by all packets
- Overhead in each packet

VC Packet Switching

- No dedicated transmission path
- Transmission of packets
- Path stays fixed for entire connection
- Call setup delay
- Transmission delay for each packet
- Queueing delays at switches
- Delays increase in overloaded networks
- Bandwidth is shared by all packets
- Overhead in each packet