EEE 432
Introduction to Data Communications

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SWITCHING

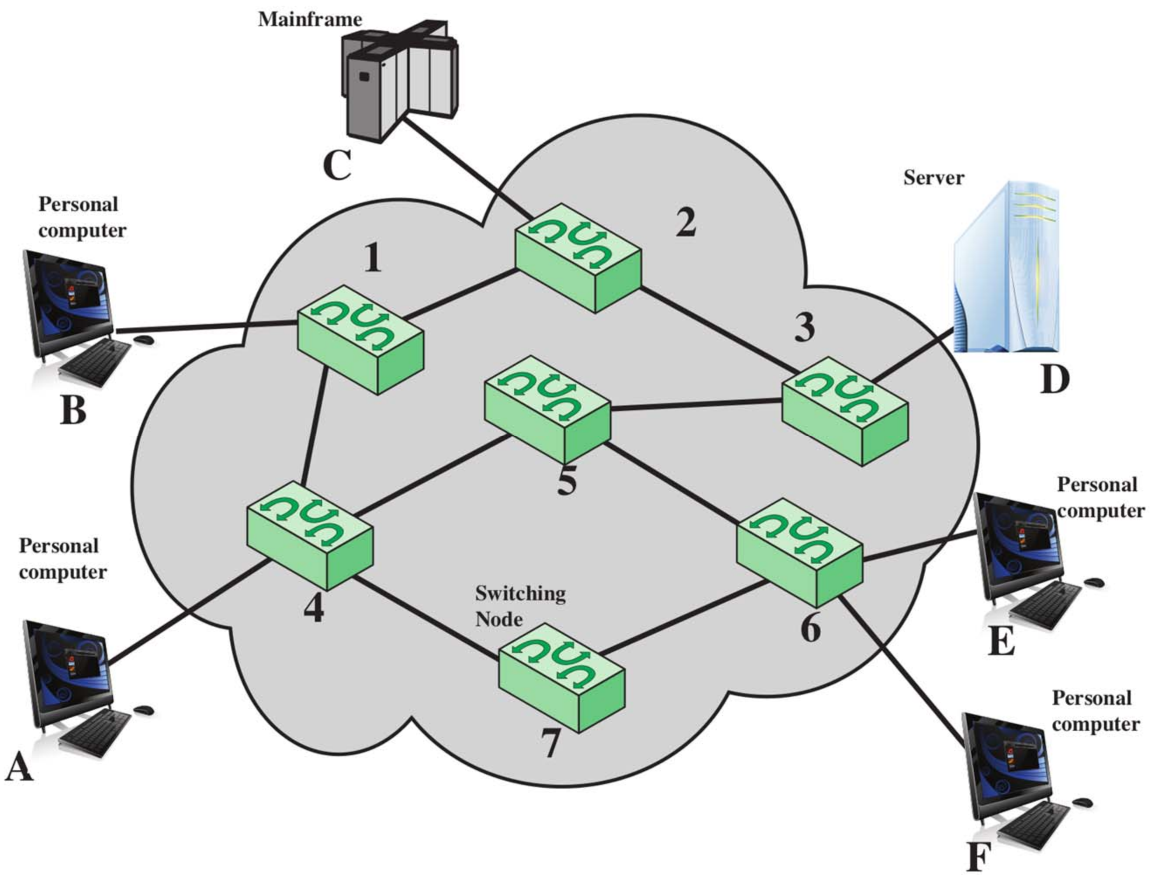
Course Information

1. Data Communications and Networks
2. Data Transmission
3. Transmission Media
4. Signal Encoding Techniques
5. Digital Data Communication Techniques
6. Multiplexing
7. Networking and Protocol Architectures
8. **Switching**
9. Routing in Switched Networks
10. LANs and WANs
11. Ethernet
12. The Internet

Switched Communications Networks

- So far focussed on encoding and transmitting information over a link
- Now how networks used to interconnect many devices
- Switched Communication Networks
  - Data transmitted from source to destination through network of **switching nodes**
  - Switching nodes are not concerned with content of data
  - Collection of nodes referred to as **communications network**
  - Devices attached to network are called **stations**
  - Node--station links often dedicated point-to-point links
  - Nod--node links often multiplexed
  - Network is often not fully connected; but desirable to have multiple paths for each pair of stations
- Two technologies used in wide area switched networks: **circuit switching** and **packet switching**

Simple Switching Network



In the figure, the devices from A to F, They are end-user devices. The devices that create data and receive data. In general they refer to **stations** or **hosts.**

Instead of making individual connections between the stations, we connect them via some intermediate devices that have role of forwarding data to the destination. These intermediate devices are called **switching nodes** or **switches.** Their role is not to create date, not to receive data but just to forward data on the behalf of the stations. When they need to forward the data they need to make decisions about where to send it to reach the destination.

Circuit Switching → Example of Old-Style Circuit Switch

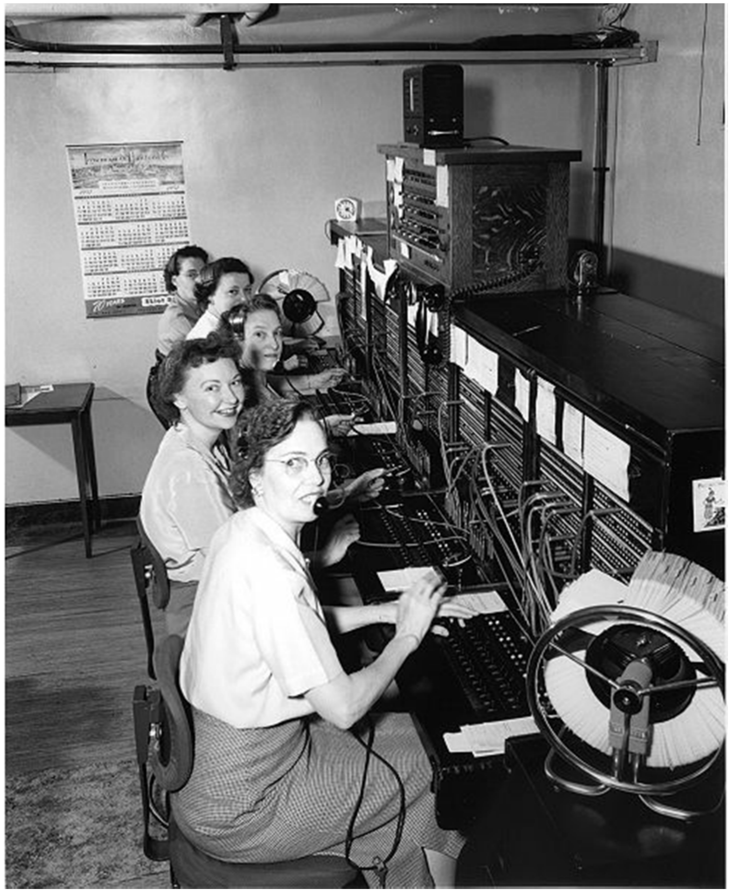


Fig. Seattle Municipal Archives from Seattle

Circuit switching is a communication method where a dedicated communication path, or circuit, is established between two devices before data transmission begins.

The circuit remains dedicated to the communication for the duration of the session, and no other devices can use it while the session is in progress. Circuit switching is commonly used in voice communication and some types of data communication.

Example of Current-Style Circuit Switch

Fig. 1 Nortel DMS100 public voice exchange

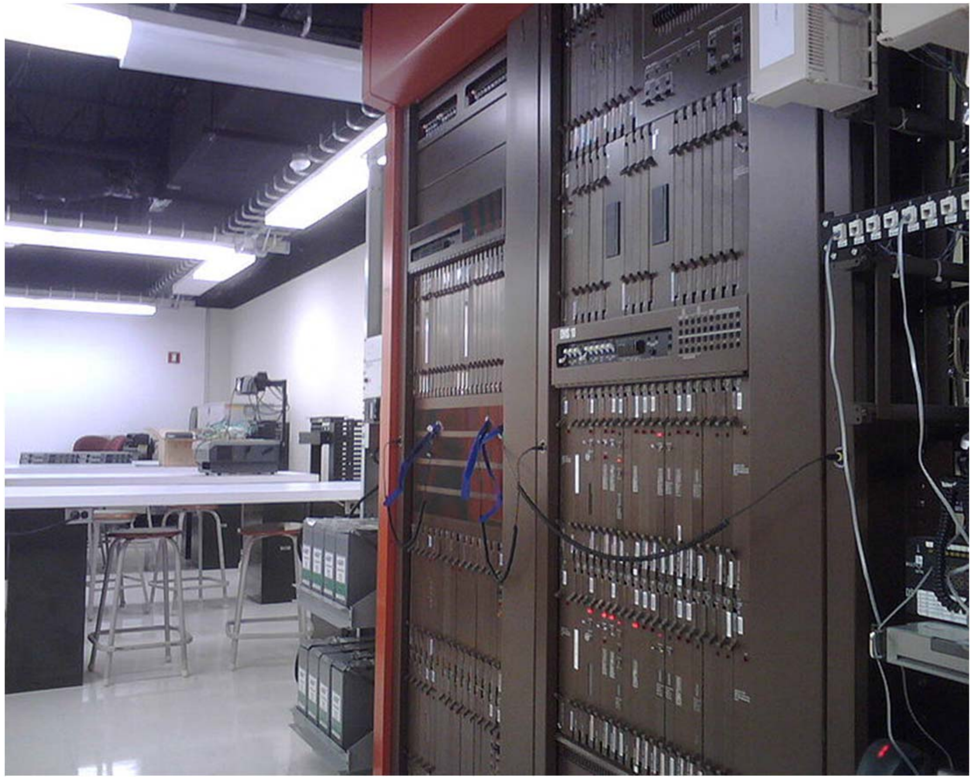


Fig. 2 Nortel DMS10 via Wikimedia Commons

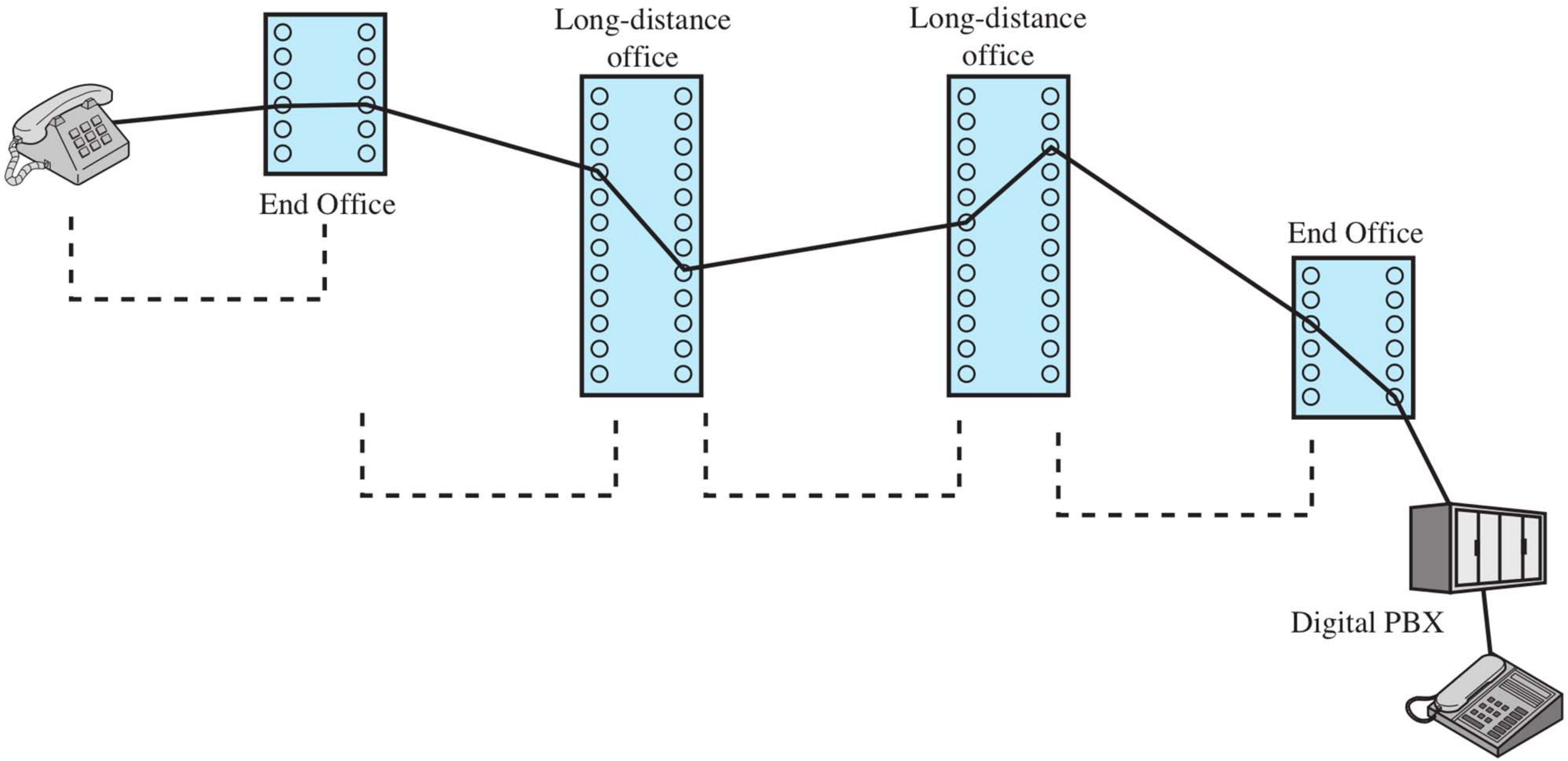
Circuit Switching Networks

- Dedicated communications path between two stations; path is sequence of links between nodes
- On each physical link, logical channel allocated to connection
- Three phases:
  - **1.** Circuit establishment: Create station-to-station circuit, allocating resources as needed
  - **2.** Data transfer: Analog or digital data transmitted from station to station
  - **3.** Circuit disconnect: Circuit is terminated, de-allocation of resources

Circuit Switching Networks

- Path established before data transfer begins; channel capacity must be reserved between each pair of nodes in path, and switching capacity allocated at each switching node
- Developed to handle voice traffic, but also used for data traffic
- **Examples:** public telephone network, private telephone networks, private data networks

Example Connection Over a Public Circuit-Switching Network

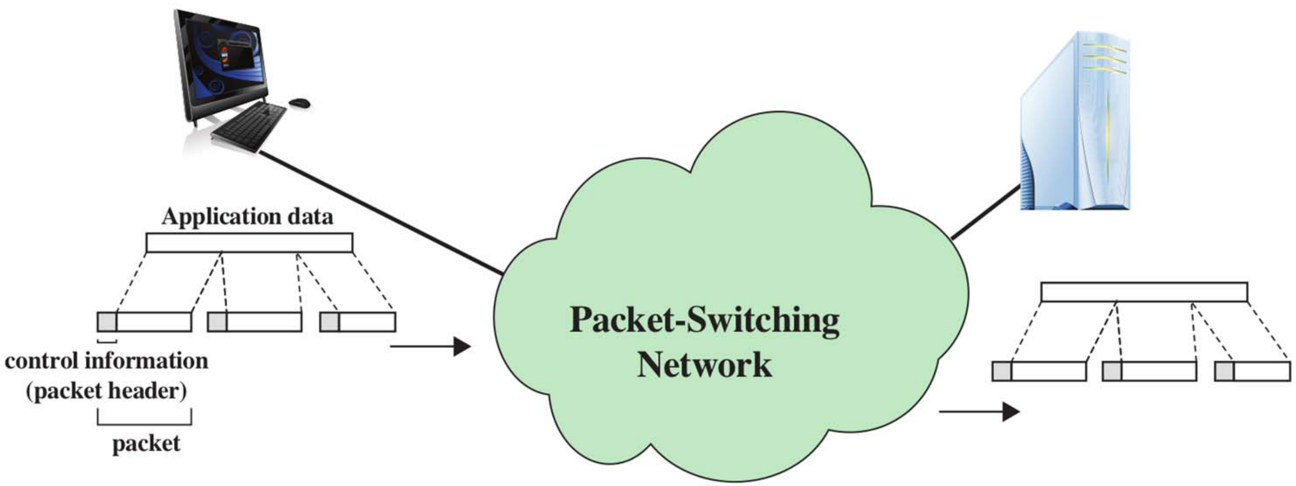


Issues in Circuit-Switching

- **Efficiency**
  - Resources reserved for duration of connection (capacity in all links, circuit in all switches)
  - Inefficient if applications do not use the capacity
- **Quality**
  - Data rate, delay guaranteed for duration of connection
- **Link Speeds**
  - End devices must be the same speed

Packet Switching

- For data connections, much of the time the line is idle; circuit-switching inefficient
- **Packet switching** is a communication method where data is divided into smaller units called packets and transmitted over the network. Each packet contains the source and destination addresses, as well as other information needed for routing. The packets may take different paths to reach their destination, and they may be transmitted out of order or delayed due to network congestion.



Circuit Switching Vs Packet Switching

Circuit Switching Vs Packet Switching

Circuit Switching	Packet Switching
Physical path between source and destination	No physical path
All packets use same path	Packets travel independently
Reserve the entire bandwidth in advance	Does not reserve
Bandwidth Wastage	No Bandwidth wastage
No store and forward transmission	Supports store and forward transmission

3

Types of Packet Switching

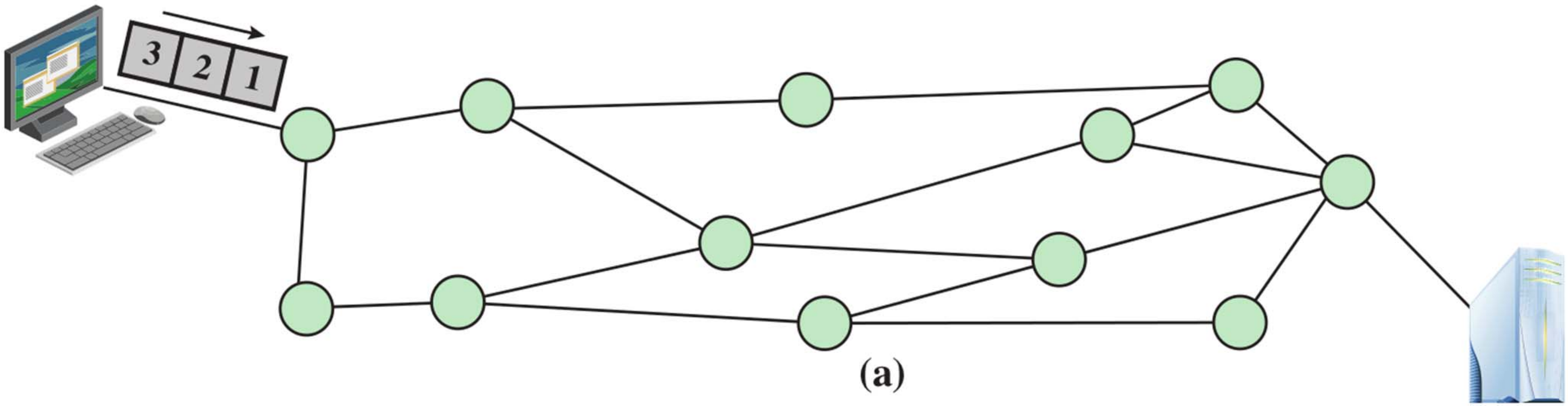
Datagram Packet Switching

- Each packet is treated independently of all others
- Packets belonging to the same message may:
  - Take different paths across the network
  - Arrive at destination out of order and may be lost
- Packets need headers so switches know where to send them

Virtual Circuit Packet Switching

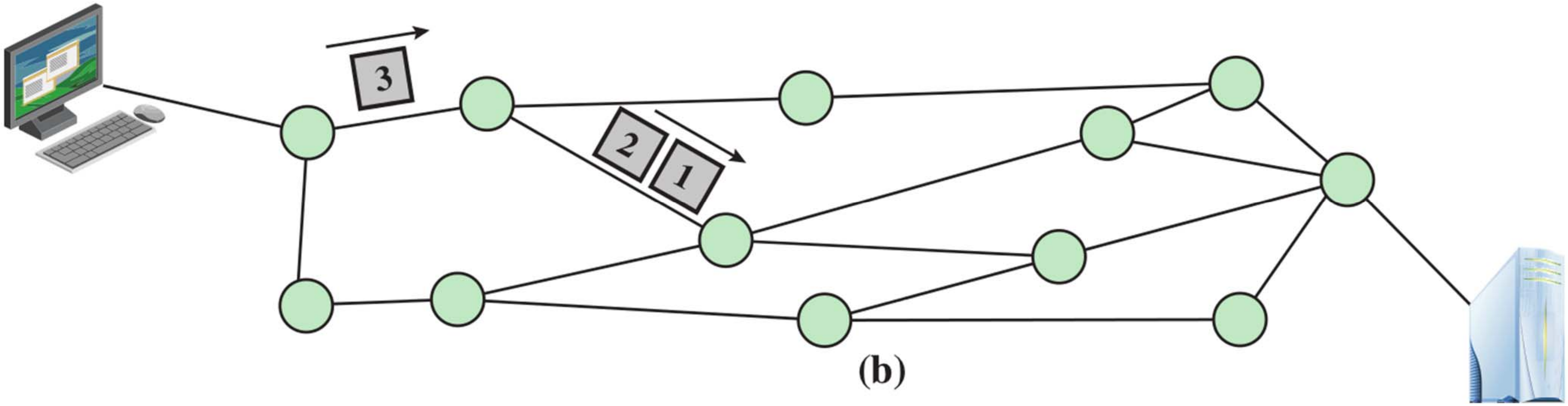
- Virtual circuit setup and teardown
- Once setup, data is transferred as individual packets
  - Take the same path across the network
  - Arrive in-order at the destination, but may be lost
- Packets need headers so switches know what is the next switch it must be sent to

Packet Switching: Datagram Approach: (a)



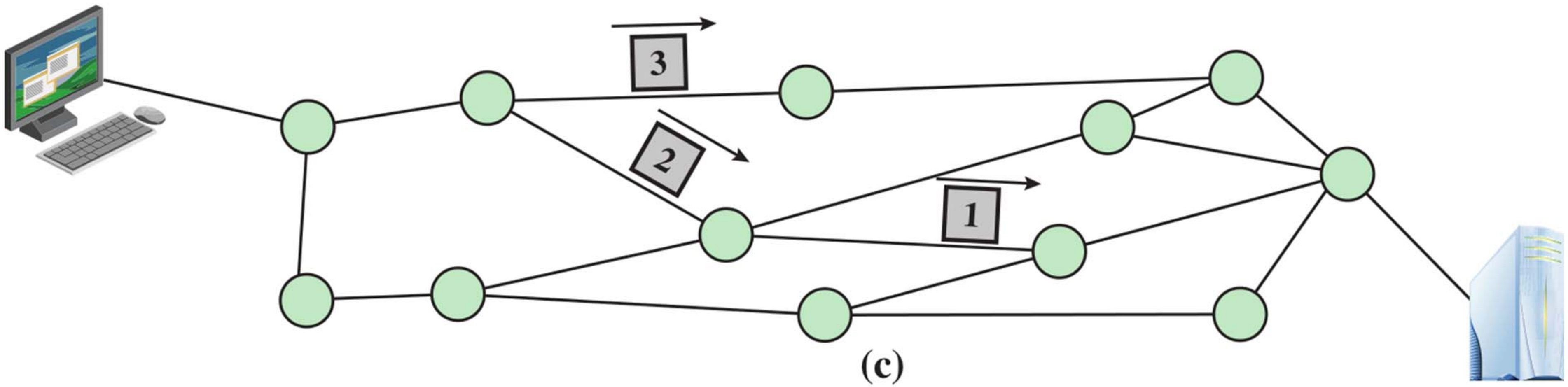
(a)

Packet Switching: Datagram Approach: (b)



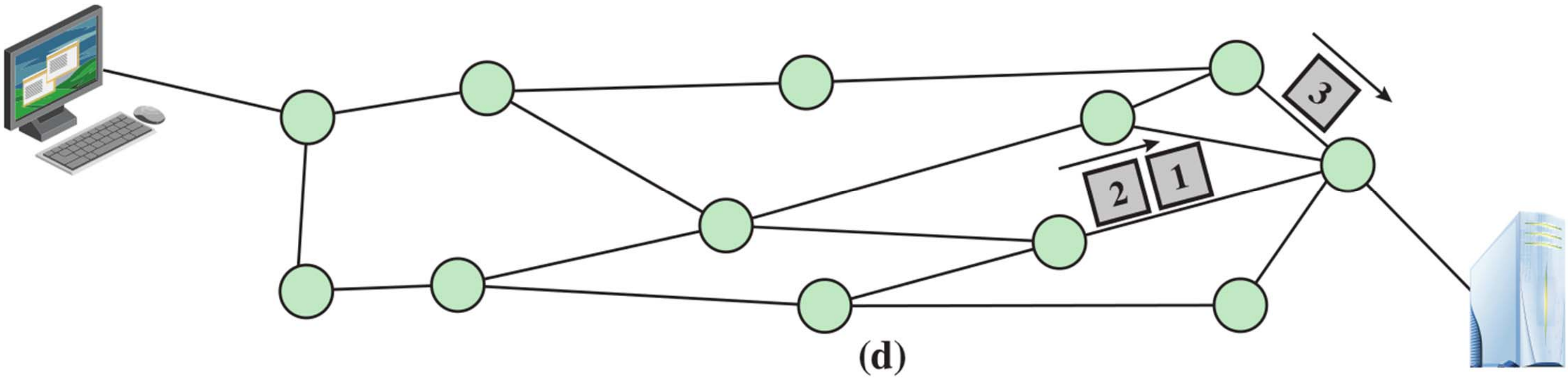
(b)

Packet Switching: Datagram Approach: (c)



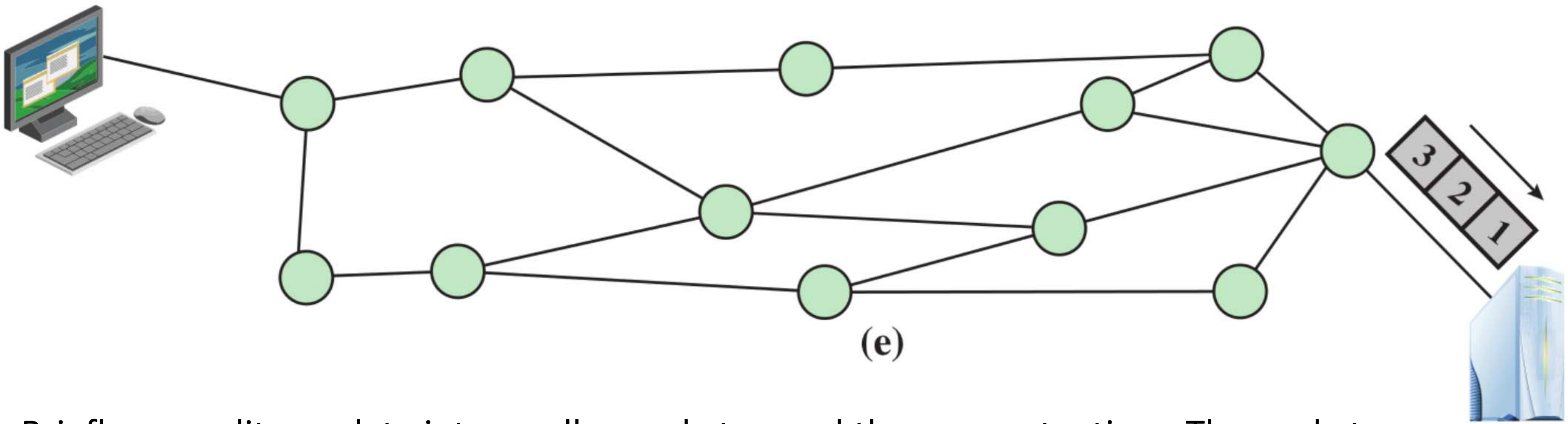
(c)

Packet Switching: Datagram Approach: (d)



(d)

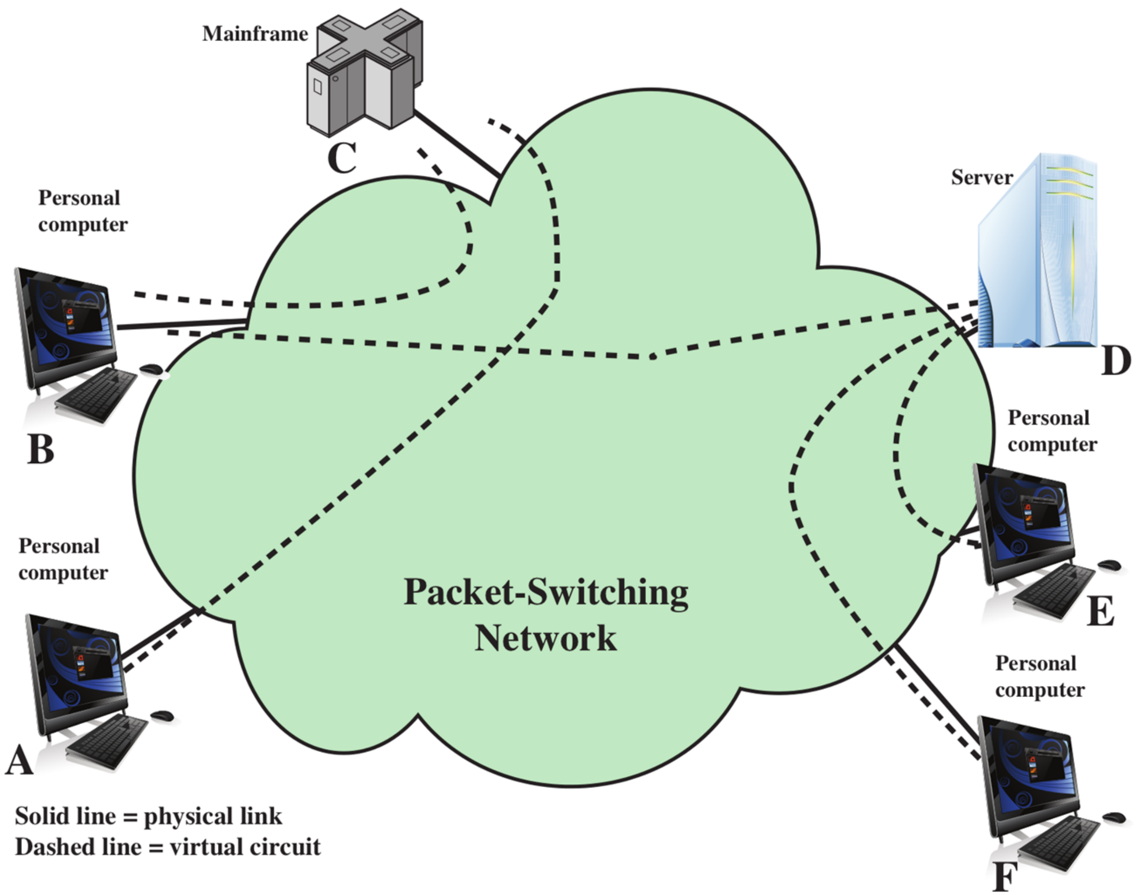
Packet Switching: Datagram Approach: (e)



(e)

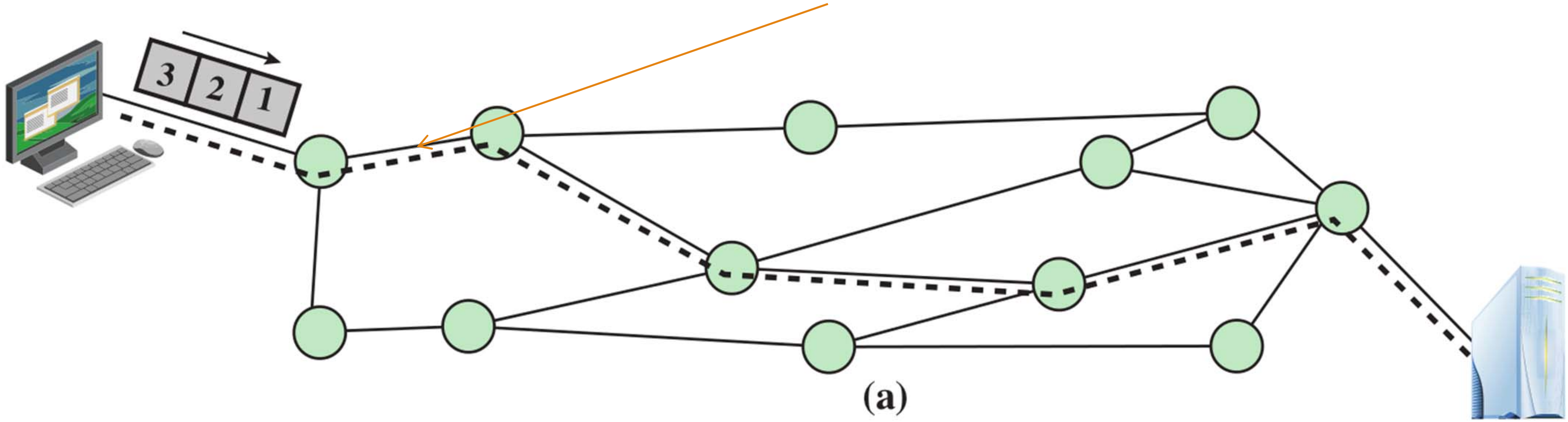
Briefly, we split our data into smaller packets, send them one at a time. The packets are treated independently by the switching nodes. When they receive a packet, look at its destination address and decide where to send it and they may arrive out of order. Last switching node puts them back together. Even though it received 3rd packet first, it delivers the data in correct order (1st, 2nd and 3rd)

The Use of Virtual Circuits



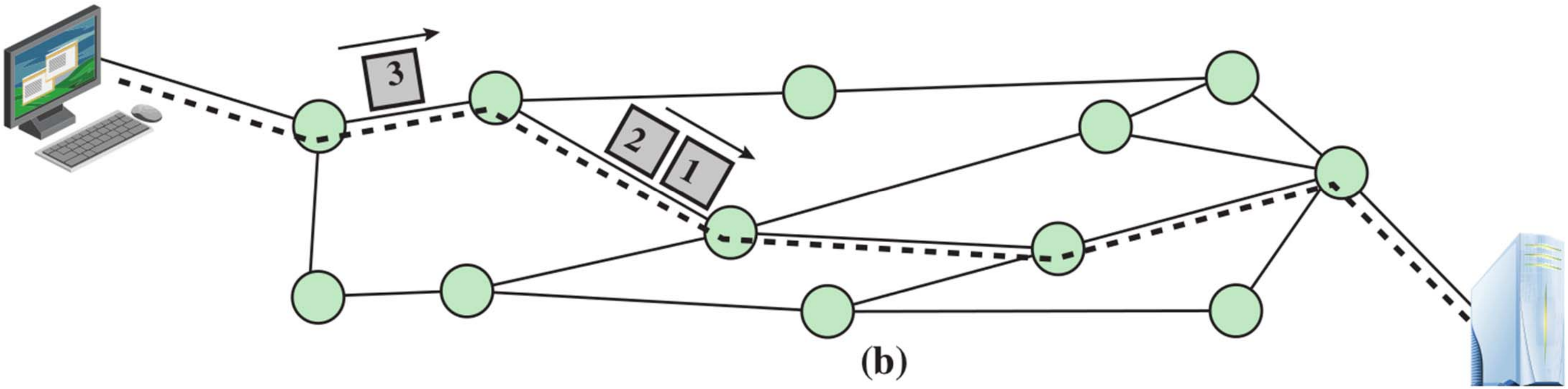
Packet Switching: Virtual-Circuit Approach: (a)

Virtual Circuit (dashed line). Once it is set up, all the packets follow the same path.

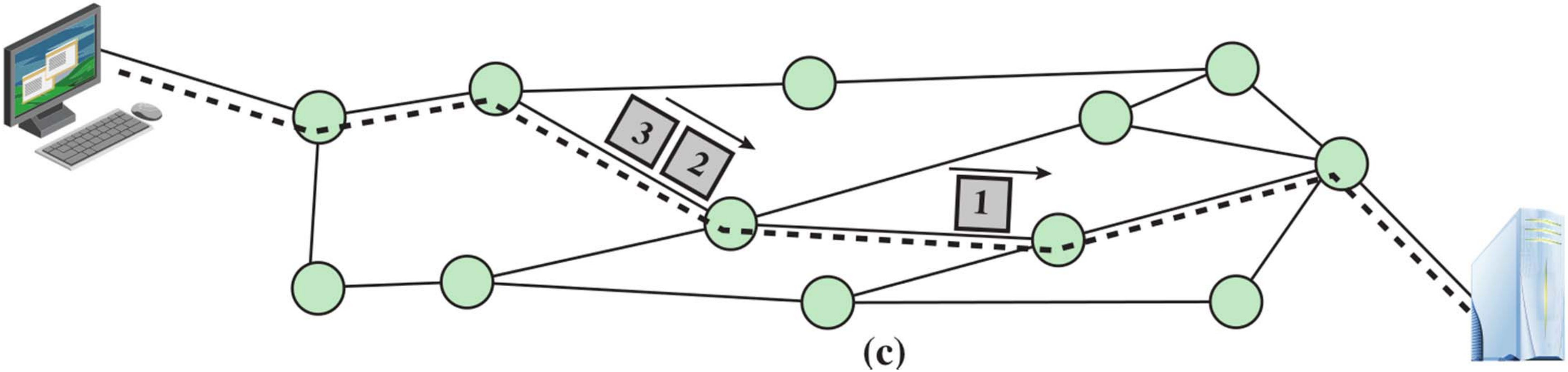


(a)

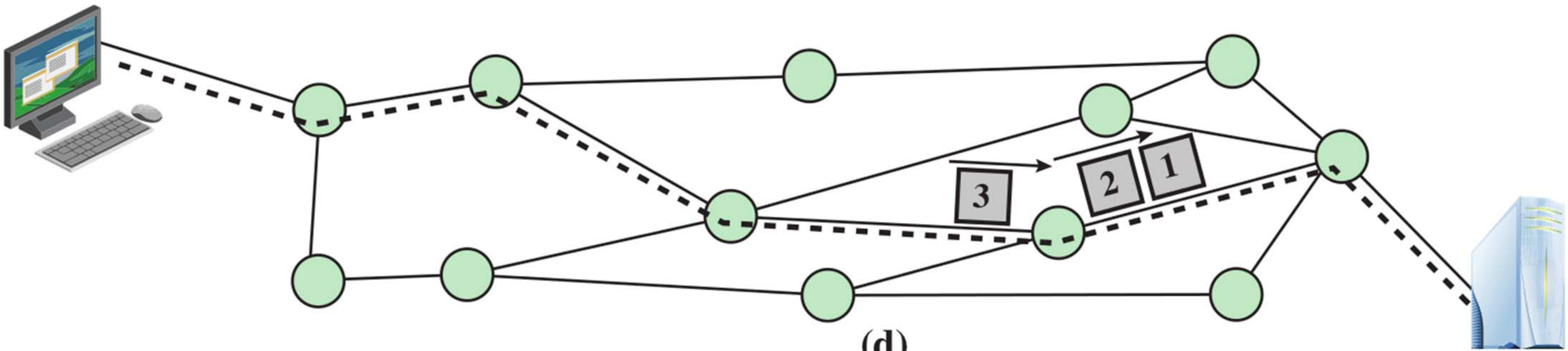
Packet Switching: Virtual-Circuit Approach: (b)



Packet Switching: Virtual-Circuit Approach: (c)

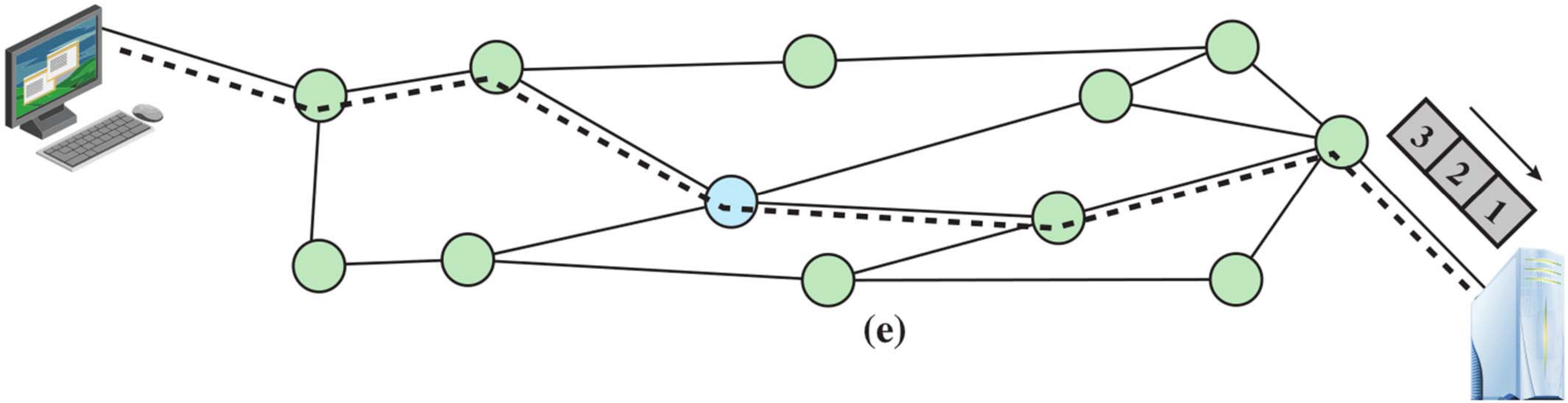


Packet Switching: Virtual-Circuit Approach: (d)



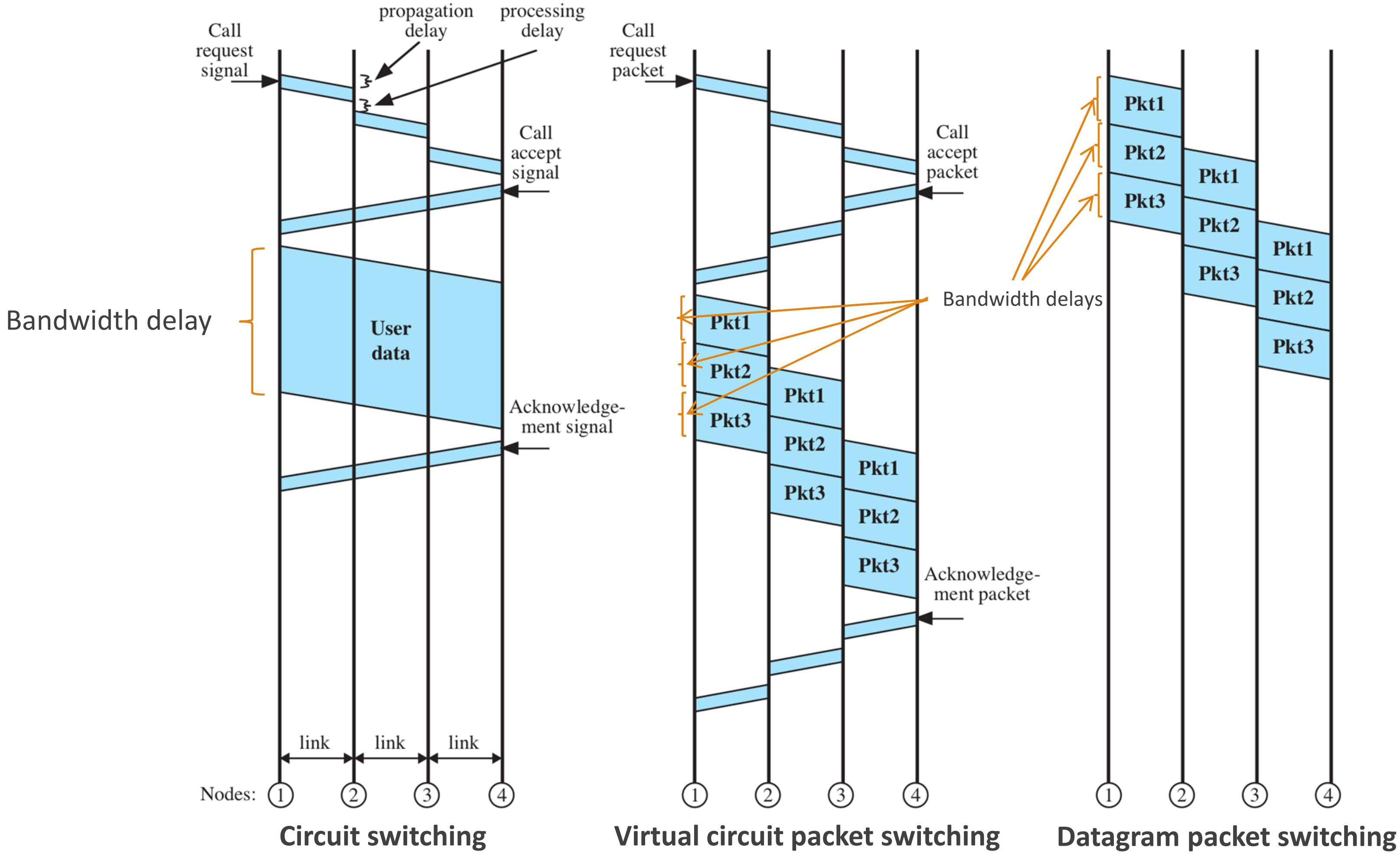
(d)

Packet Switching: Virtual-Circuit Approach: (e)



(e)

Event Timing for Circuit Switching and Packet Switching



Delay examples…

(Datagram Packet Switching with no processing delay)

Case 1: A---------->B

- Propagation delay is 40 µs
- Bandwidth is 1 byte/µs (1 MB/s, 8 Mbit/s)
- Packet size is 200 bytes (200 µs bandwidth delay)
- Then the total one-way transmit time is 240 µs = 200 µs + 40 µs

Case 2: A-------------------->B

- Like the previous example except that the propagation delay is increased to 4 ms
- The total transmit time is now 4200 µs = 200 µs + 4000 µs.

Delay examples…

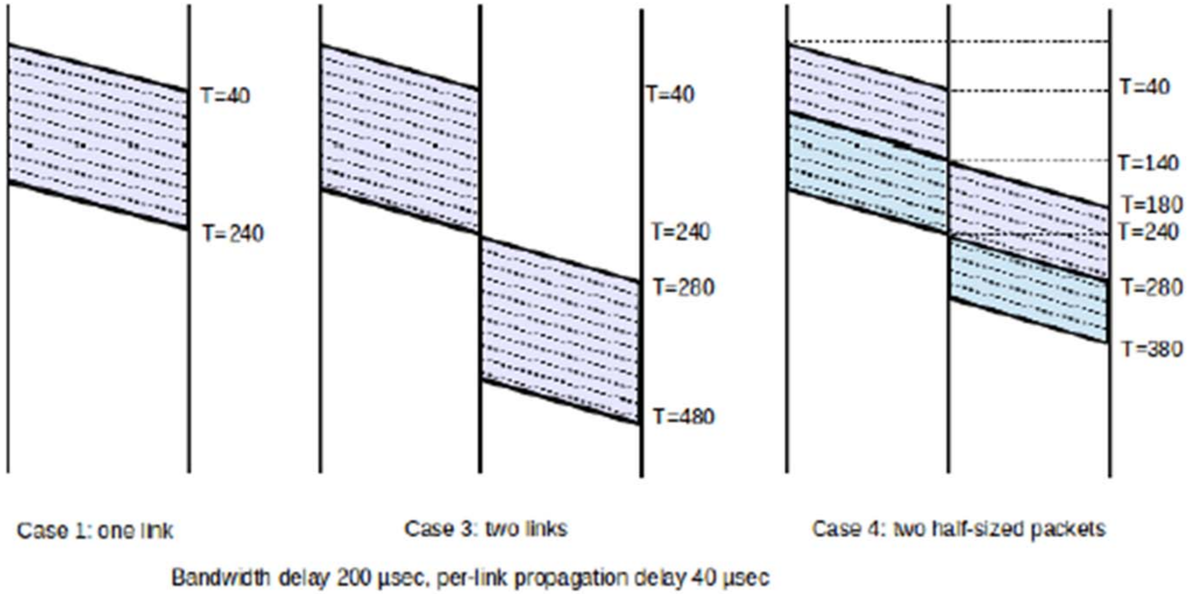
Case 3: A----------->R------------>B

- We now have two links, each with propagation delay 40 µs bandwidth and packet size as in Case 1
- The total transmit time for one 200-byte packet is now 480 µs = 240 + 240. There are two propagation delays of 40 µs each; A introduces a bandwidth delay of 200 µs and R introduces a store-and-forward delay (or second bandwidth delay) of 200 µs.

Case 4: A----------->R------------>B

- The same as 3, but with data sent as two 100-byte packets
- The total transmit time is now 380 µs = 3x100 + 2x40. There are still two propagation delays, but there is only 3/4 as much bandwidth delay because the transmission of the first 100 bytes on the second link overlaps with the transmission of the second 100 bytes on the first link.

Delay examples…



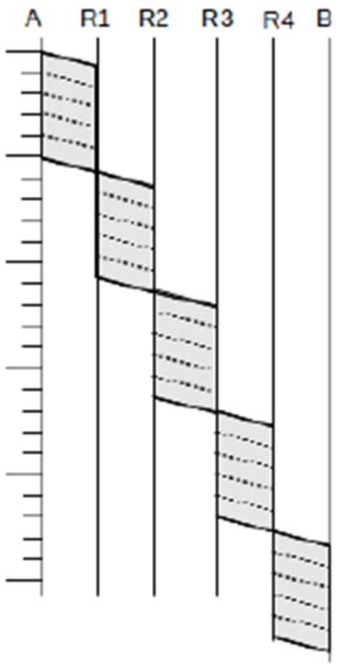
These ladder diagrams represent the full transmission; a snapshot state of the transmission at any one instant can be obtained by drawing a horizontal line. In the middle, case 3, diagram, for example, at no instant are both links active.

Packet Size

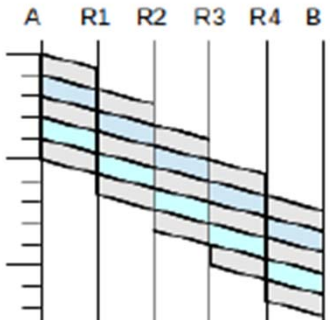
- As an example of this, consider a path from A to B with four switches and five links:

A-----R1-----R2-----R3-----R4-----**B**

- Suppose we send either one big packet or five smaller packets. The relative times from A to B are illustrated in the following figures:



One large packet over five links



Five smaller packets over five links

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Comparison of Communication Switching Techniques

Circuit Switching	Datagram Packet Switching	Virtual Circuit Packet Switching
Dedicated transmission path	No dedicated path	No dedicated path
Continuous transmission of data	Transmission of packets	Transmission of packets
Fast enough for interactive	Fast enough for interactive	Fast enough for interactive
Messages are not stored	Packets may be stored until delivered	Packets stored until delivered
The path is established for entire conversation	Route established for each packet	Route established for entire conversation
Call setup delay; negligible transmission delay	Packet transmission delay	Call setup delay; packet transmission delay
Busy signal if called party busy	Sender may be notified if packet not delivered	Sender notified of connection denial
Overload may block call setup; no delay for established calls	Overload increases packet delay	Overload may block call setup; increases packet delay
Electromechanical or computerized switching nodes	Small switching nodes	Small switching nodes
User responsible for message loss protection	Network may be responsible for individual packets	Network may be responsible for packet sequences
Usually no speed or code conversion	Speed and code conversion	Speed and code conversion
Fixed bandwidth	Dynamic use of bandwidth	Dynamic use of bandwidth
No overhead bits after call setup	Overhead bits in each packet	Overhead bits in each packet