ECE230X Lectures 19-20

Data and Computer Communications Eighth Edition
By William Stallings
Chapter 10 – "Circuit Switching and Packet Switching"

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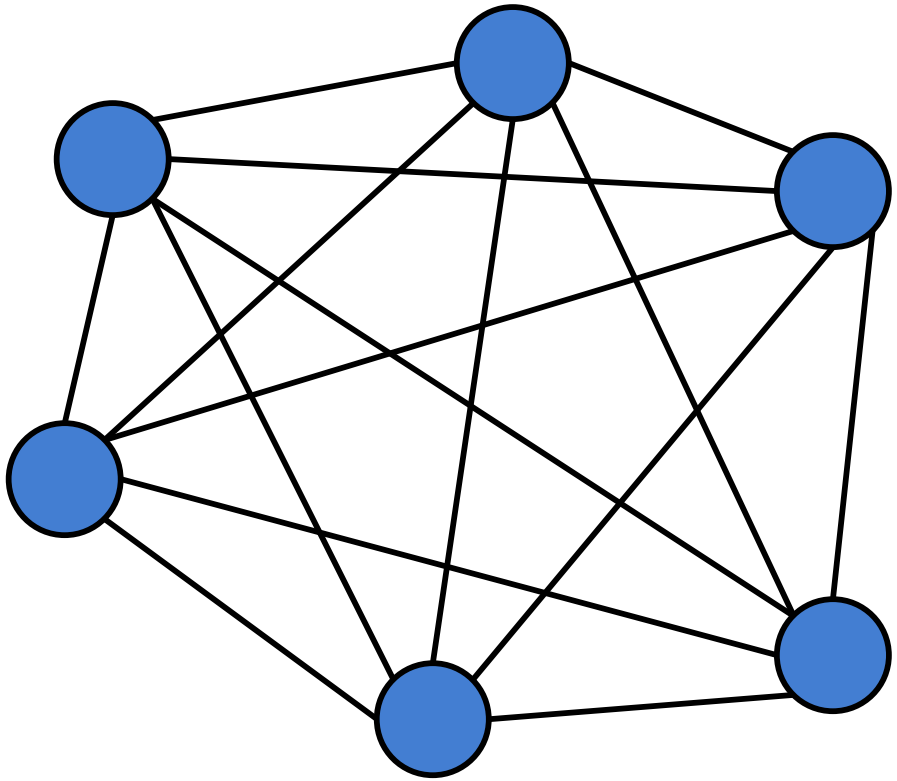
Adapted from Prentice Hall instructor resources

Overview

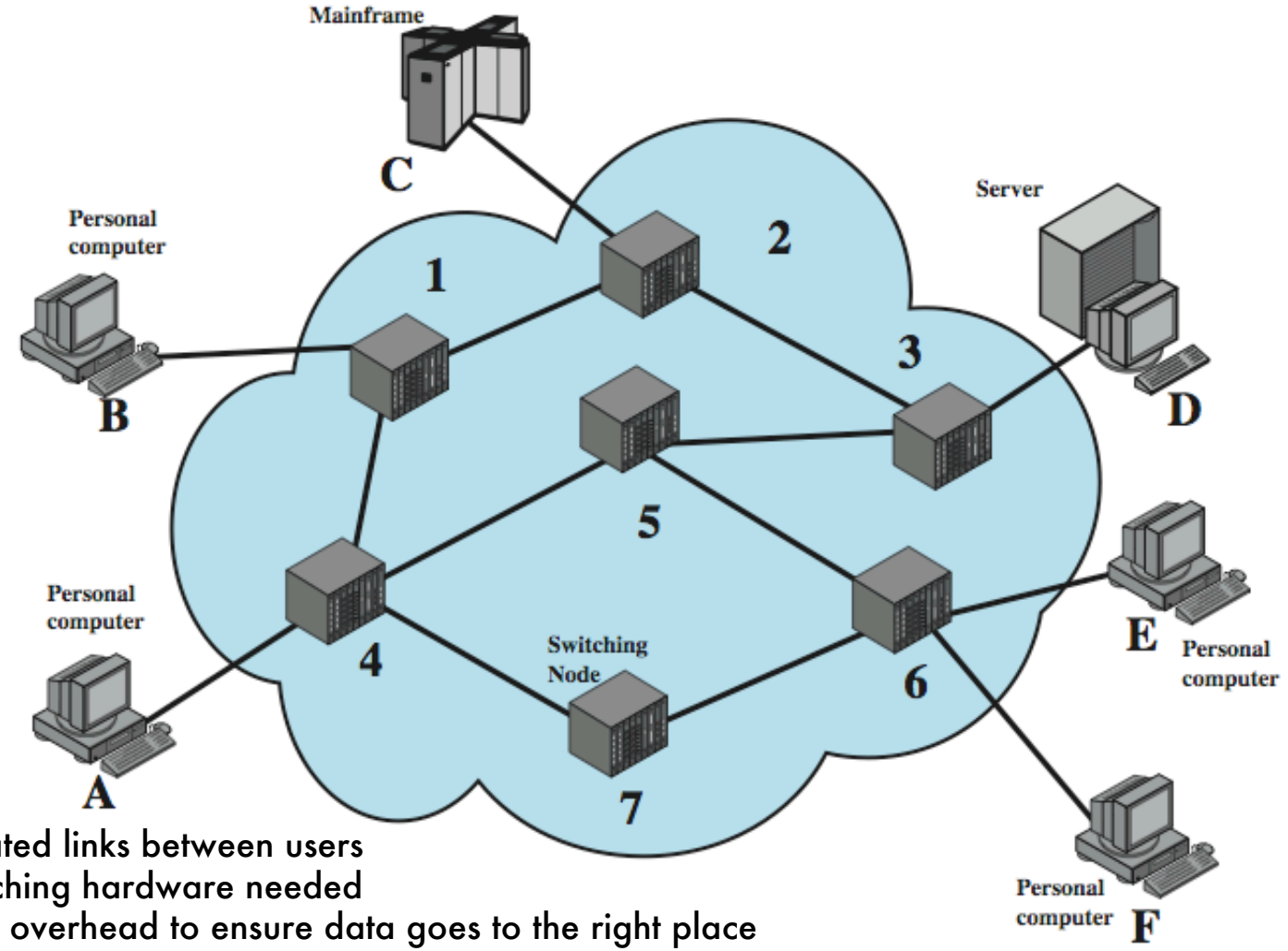
- Switched network basics
- Circuit switching
- Packet switching
- Performance comparison

Unswitched/Unmultiplexed Network



- Dedicated link between each user
- Lots of wires
- Lots of network ports
- Difficult to add more users

Switched Network

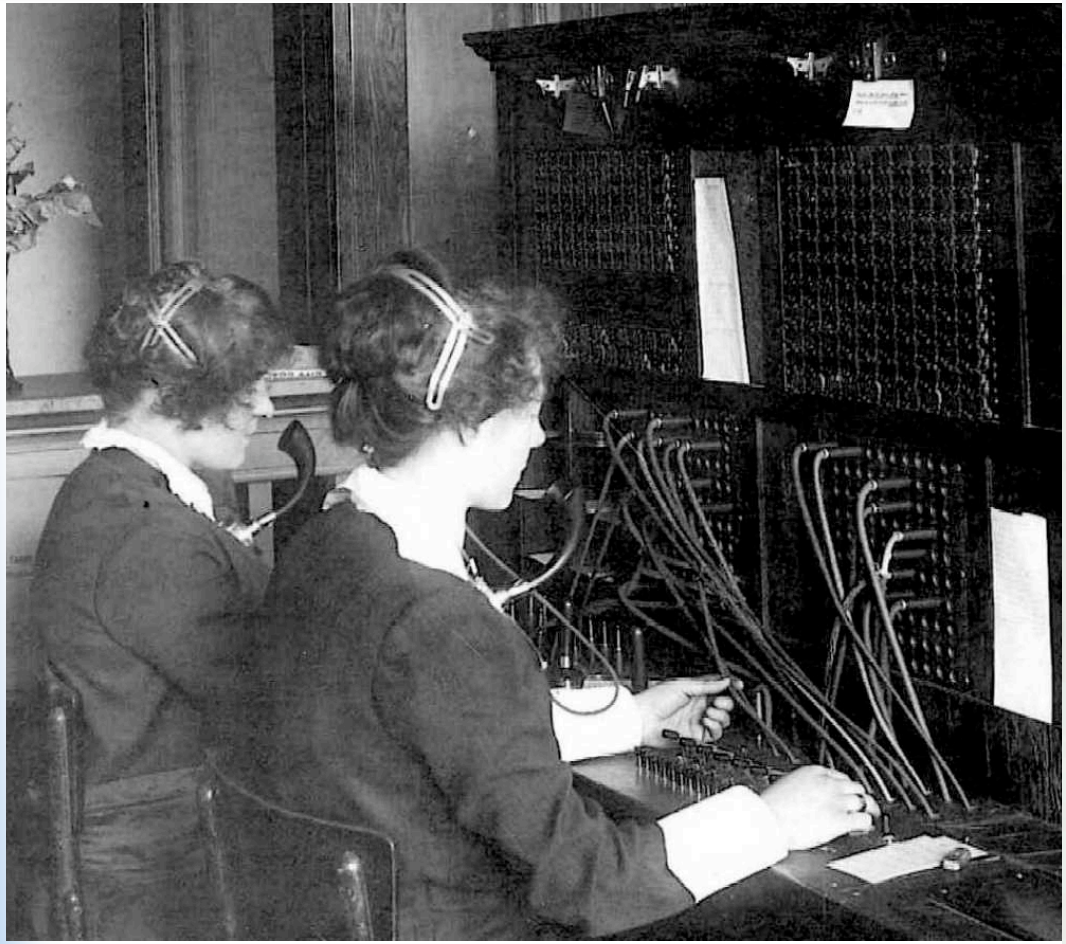


- No dedicated links between users
- Extra switching hardware needed
- Additional overhead to ensure data goes to the right place

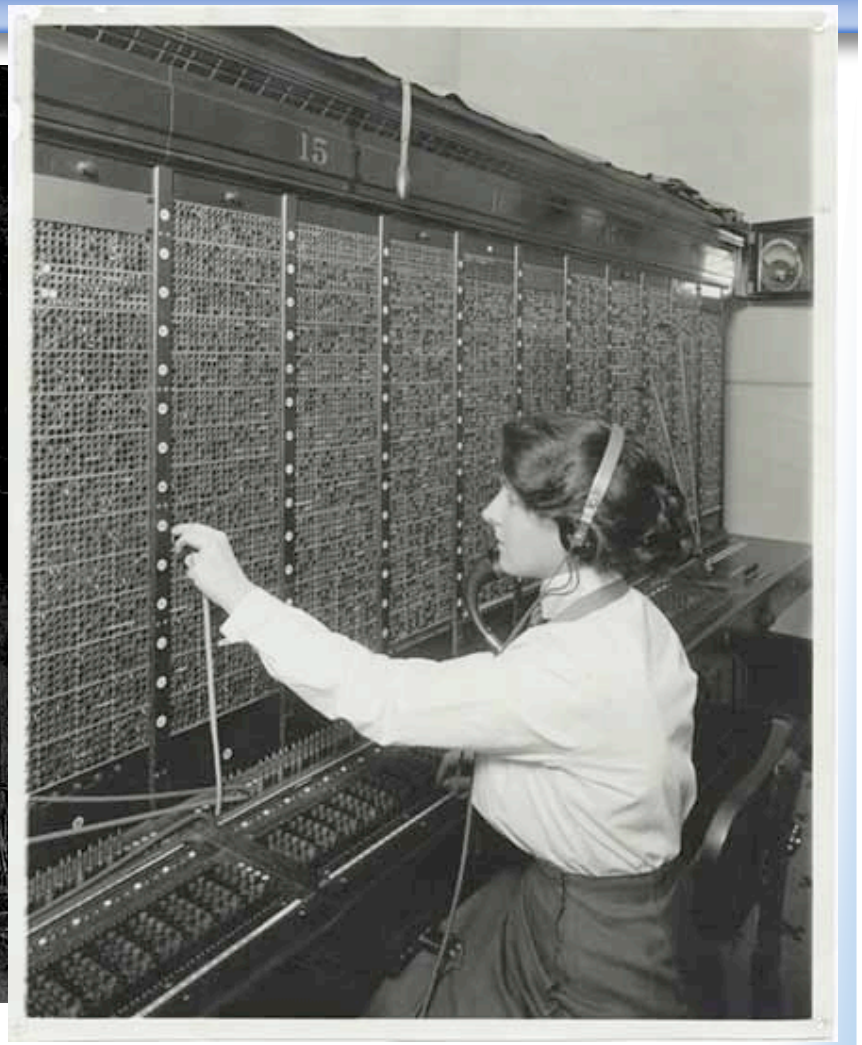
Circuit Switching

- Three phases:
  1. Circuit establishment
  2. Data transfer
  3. Circuit disconnect
- Once connected, the data transfer is transparent
  - Dedicated circuit between sender and receiver
  - Very low delay (almost entirely propagation delay)
- Note that the “circuit” might be virtual
  - Example: a timeslot in a synchronous TDM link
- Can be inefficient
  - Channel capacity dedicated for duration of connection
  - Like structured multiplexing techniques, channel is reserved even if not used (until disconnect)

Classic Circuit Switching

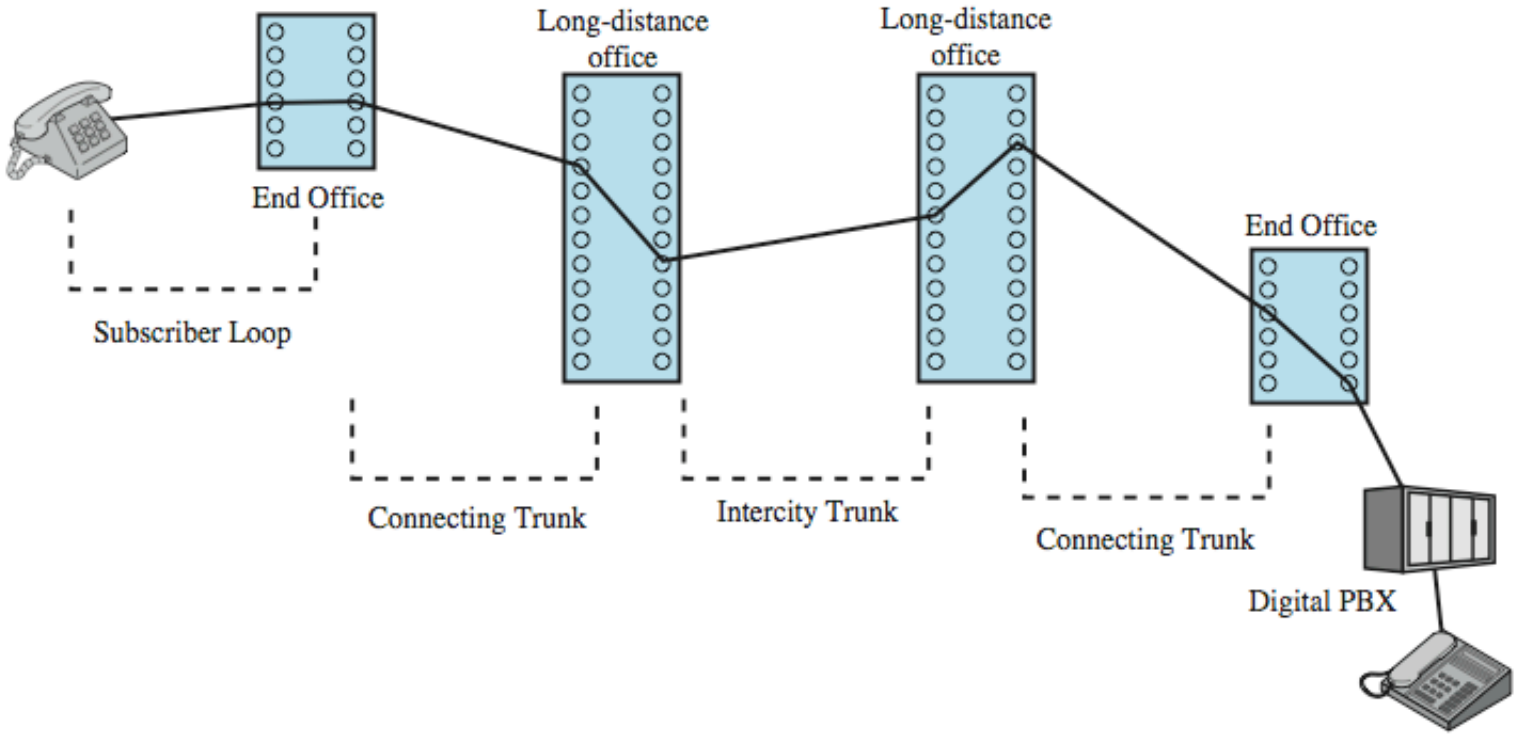


http://www.forensicgenealogy.info/contest_28_results.html



http://rhetoricaldevice.com/RingRingRing.html

Public Circuit Switched Network

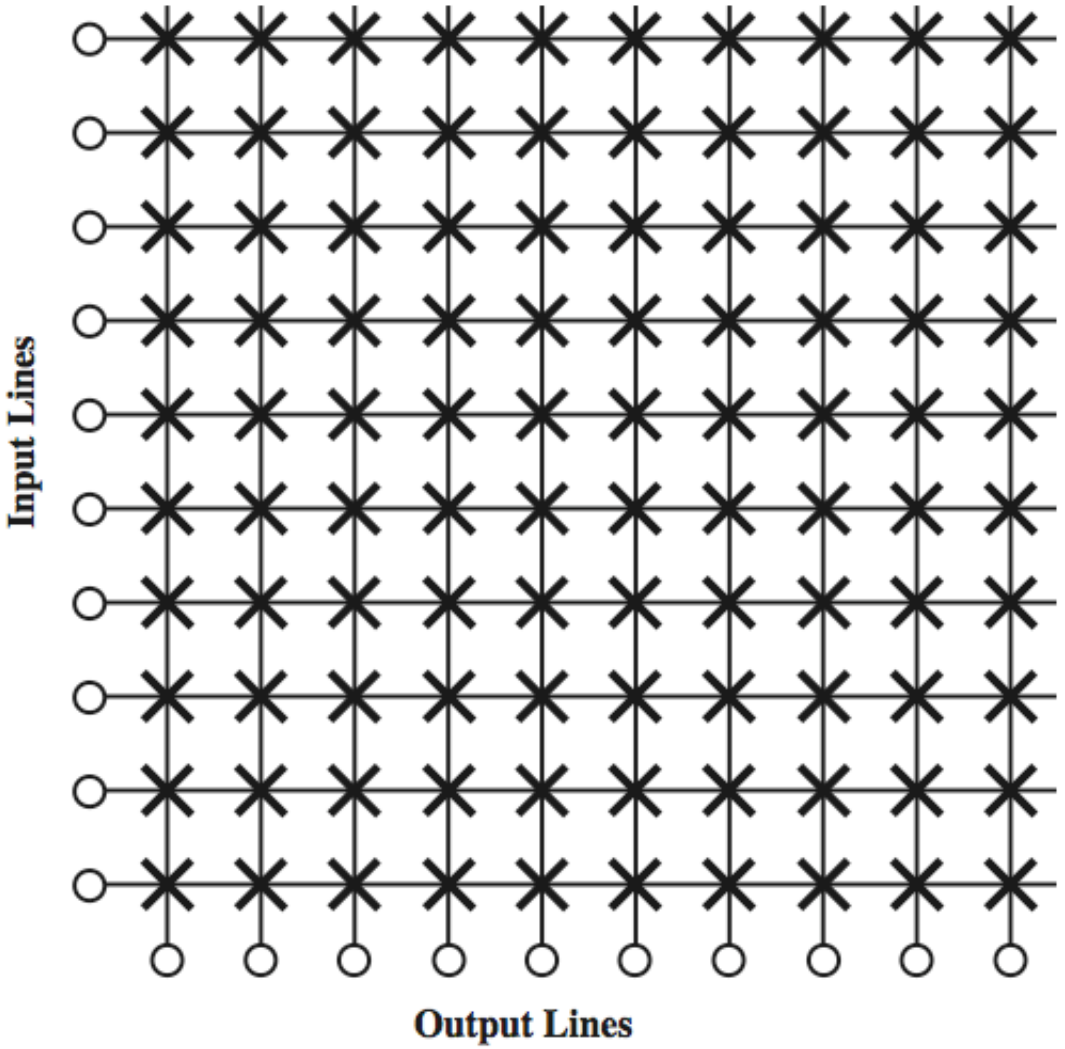


Note that trunks might be synchronous TDM lines, e.g. DS-1 or SONET
The main idea here is that, from the point of view of the users, there is a dedicated "circuit" between them.

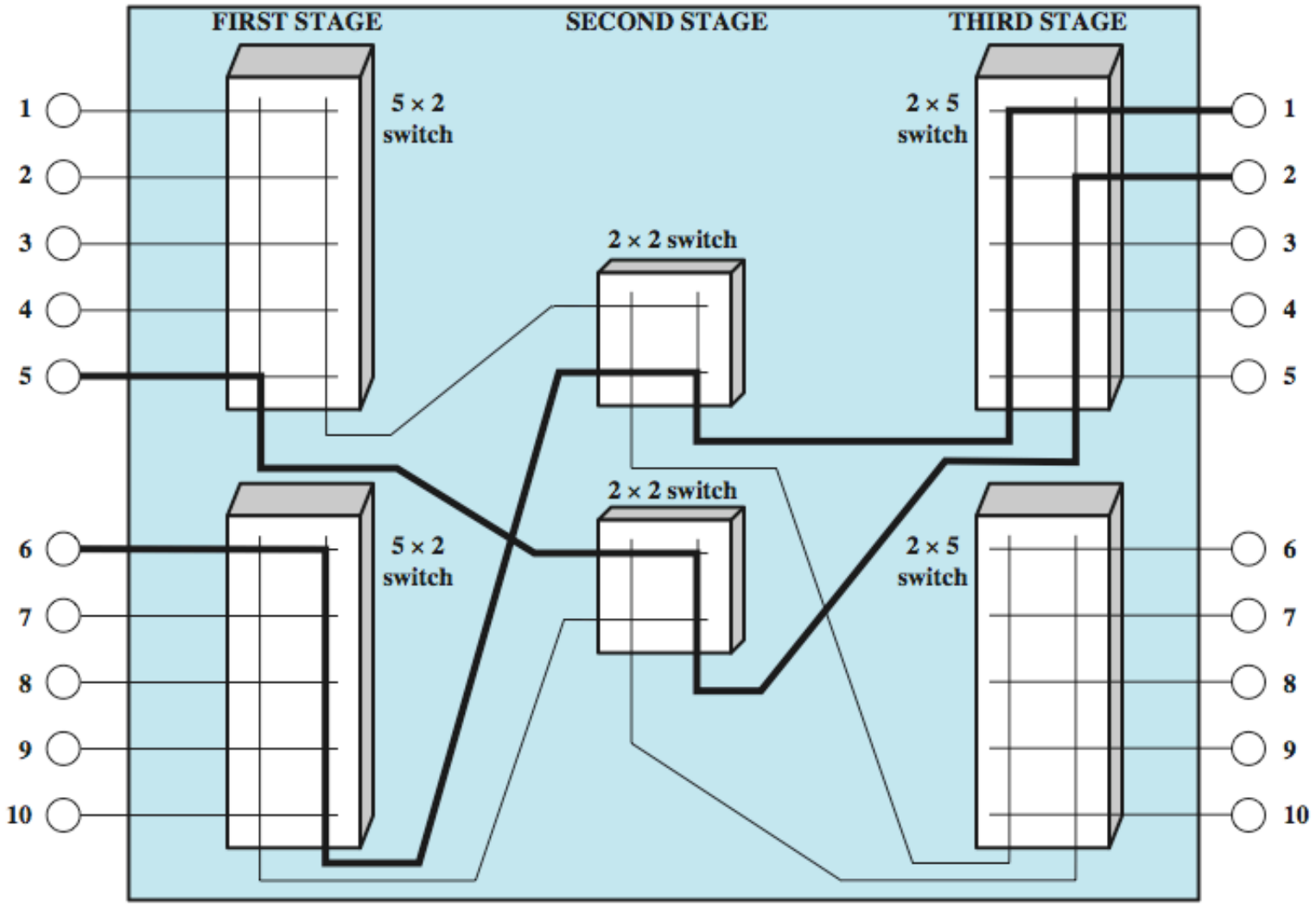
Blocking vs Non-Blocking Circuit Switched Networks

- Blocking network
  - More users than actual circuits available in network
  - May be unable to connect users in periods of high use because all circuits are busy
- Non-blocking network
  - Enough circuits available to permit all users to connect (in pairs) simultaneously
- Is telephone service blocking or non-blocking?

Space Division Switch



3 Stage Space Division Switch



Modern Circuit Switching

- Most analog signals are now digitized before transmission through a network
- Low cost of digital hardware
  - Telephone operators replaced by smart digital switches that automatically establish and release circuits
- Synchronous TDM multiplexing usually used to provide virtual “circuits”
  - Multiplex low rate data streams into dedicated timeslots in a high rate data stream
  - Guaranteed data rate through circuit
  - Low delay
  - Transparent to end users

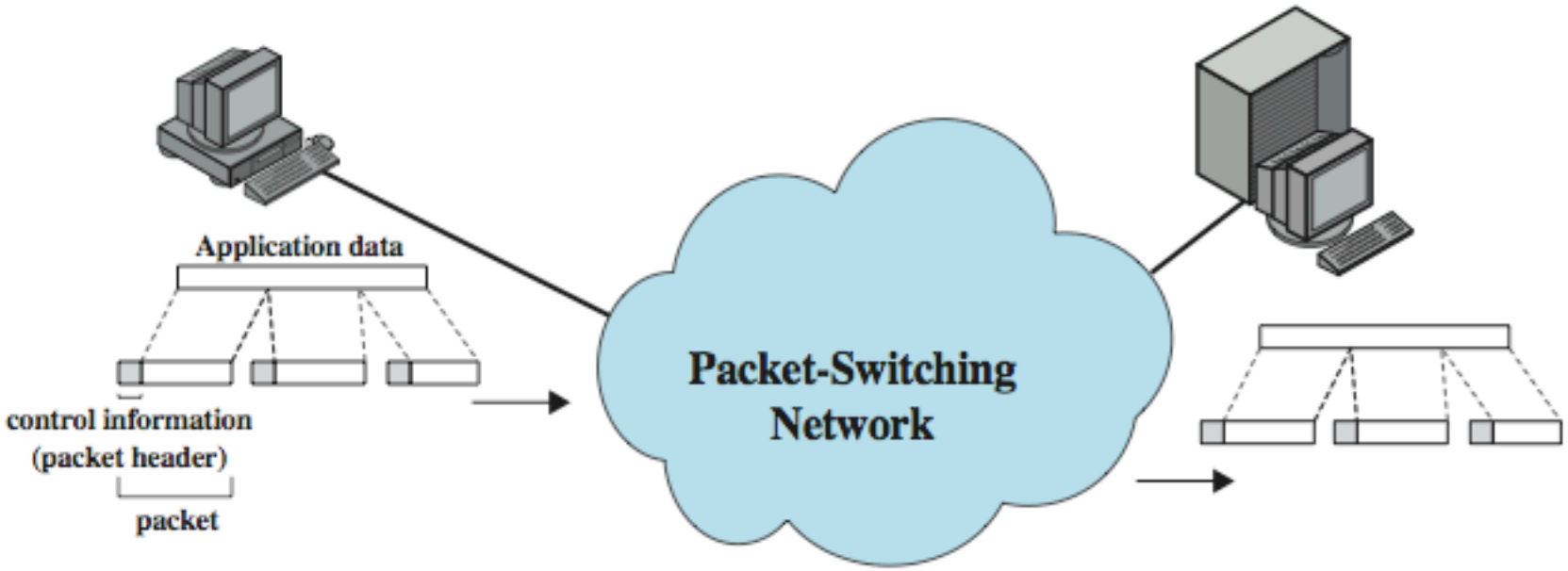
From Circuit to Packet Switching

- Fundamental conflict in communication systems
  - Pre-allocation of dedicated channel capacity (FDM, synchronous TDM, circuit switching)
  - Dynamic allocation of on-demand channel capacity (statistical TDM, packet switching)
- 1968
  - Almost all voice/data networks were circuit switched
  - Real-time dynamic allocation of channel capacity was unrealistic given current computer hardware
- 1969: ARPANET
  - First demonstrations of packet switched computer network
- **If lines are cheap**: use circuit switching
- **If computing is cheap**: use packet switching

Motivation for Packet Switching

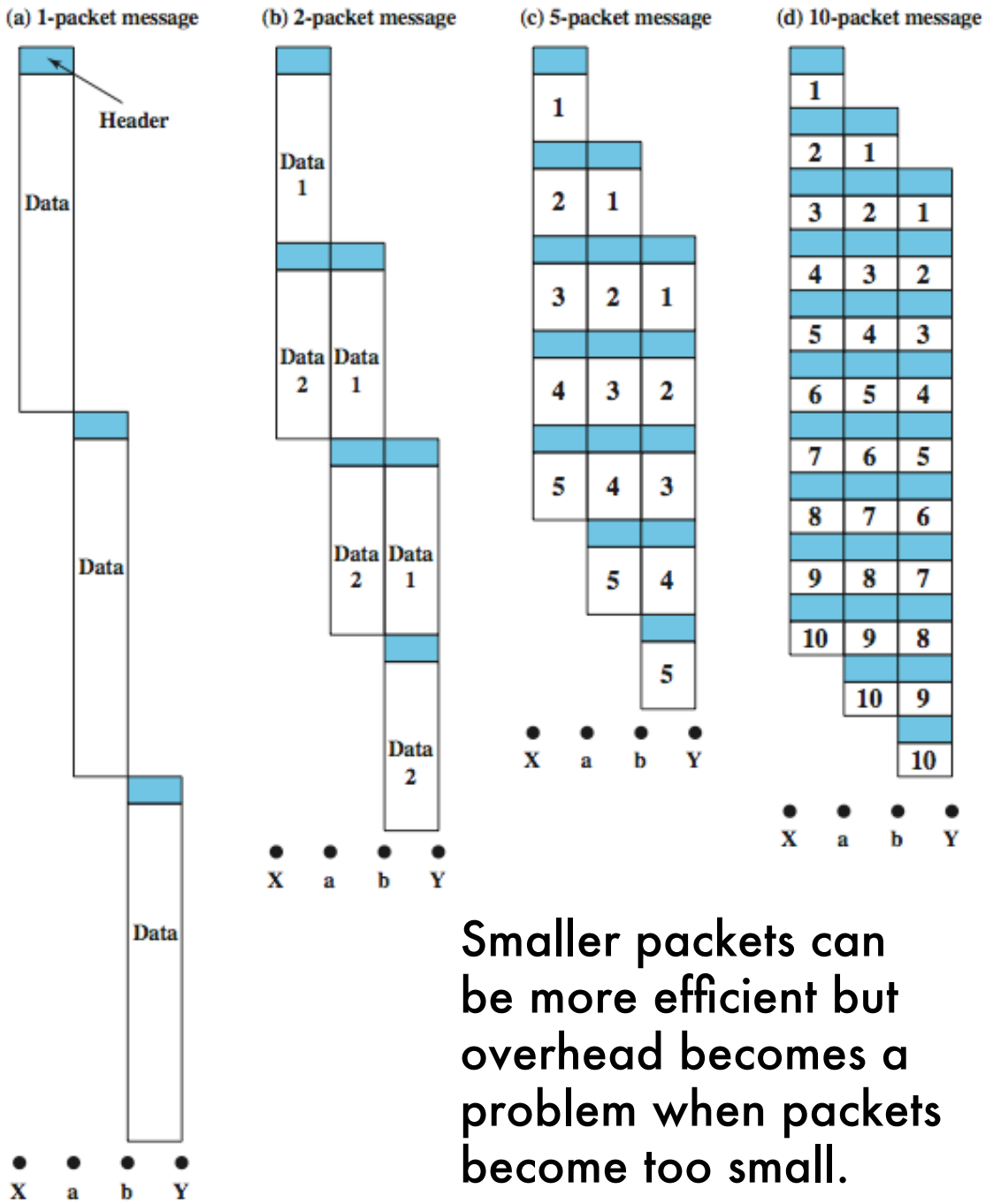
- Circuit switched networks for telephone
  - Efficient (one or both parties usually talking)
  - Low delay
- Circuit switched networks for data
  - Usually not very efficient (idle time)
  - Unable to connect devices with different data rates to a circuit without additional hardware
- Packet switching addresses both of these issues
  - Potential for increased delay, however.

Packet Switching



- Station breaks long message into packets
- Packets sent one at a time to the network
- Network dynamically allocates capacity and delivers packets to receiver without establishing a dedicated link

Effect of Packet Size



Smaller packets can be more efficient but overhead becomes a problem when packets become too small.

Datagram Packet-Switching

- Each packet is treated independently
- Packets may take different routes
- Packets may arrive out of order
- Robust to network problems
- Usually more efficient for short messages

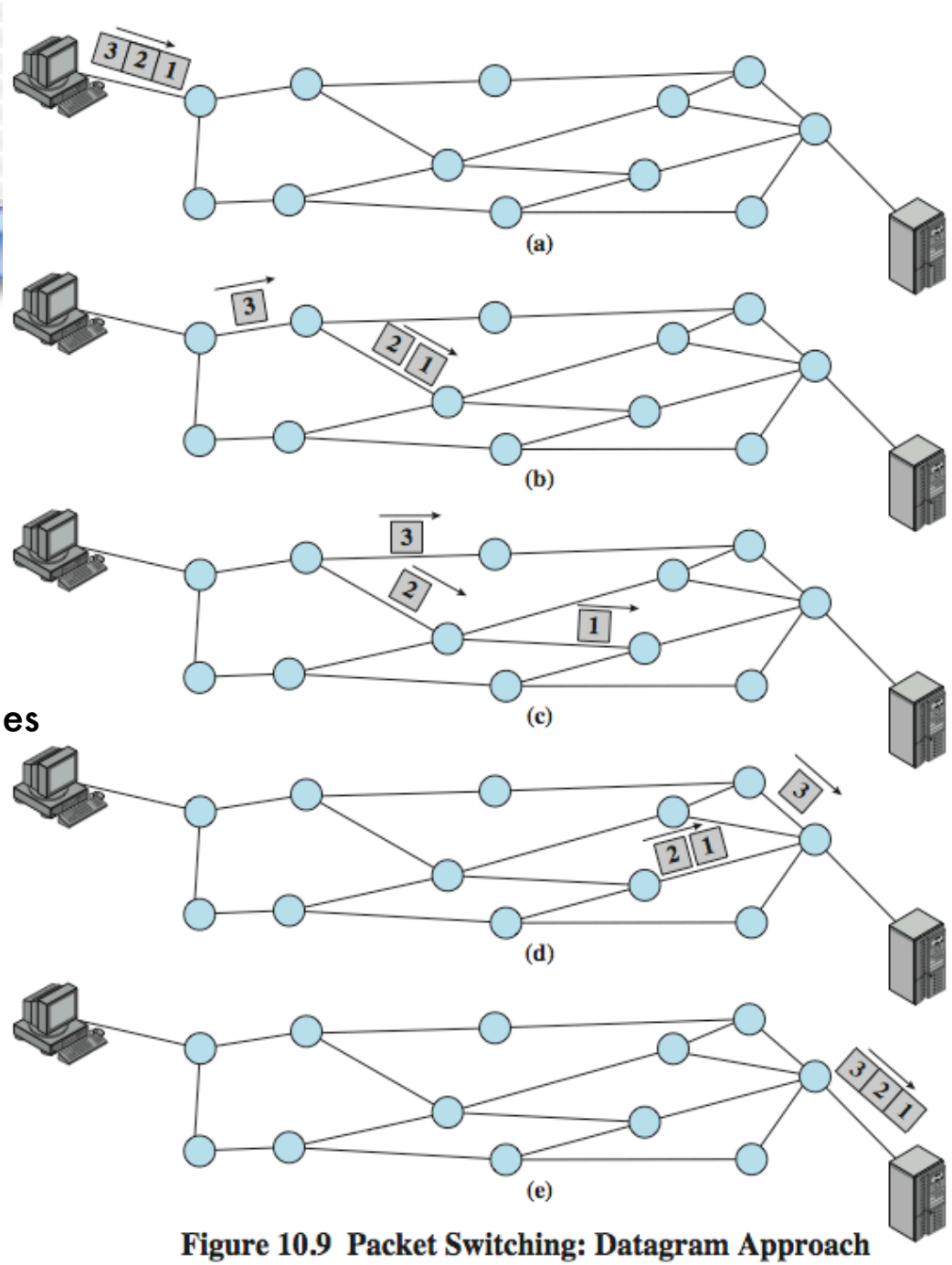


Figure 10.9 Packet Switching: Datagram Approach

Virtual Circuit Packet Switching

- Route is pre-planned
- Not a dedicated link (portions may be shared)
- All packets follow the same route
- Packets will arrive in order
- No routing decisions need to be made
- Less robust
- May be more efficient for long messages

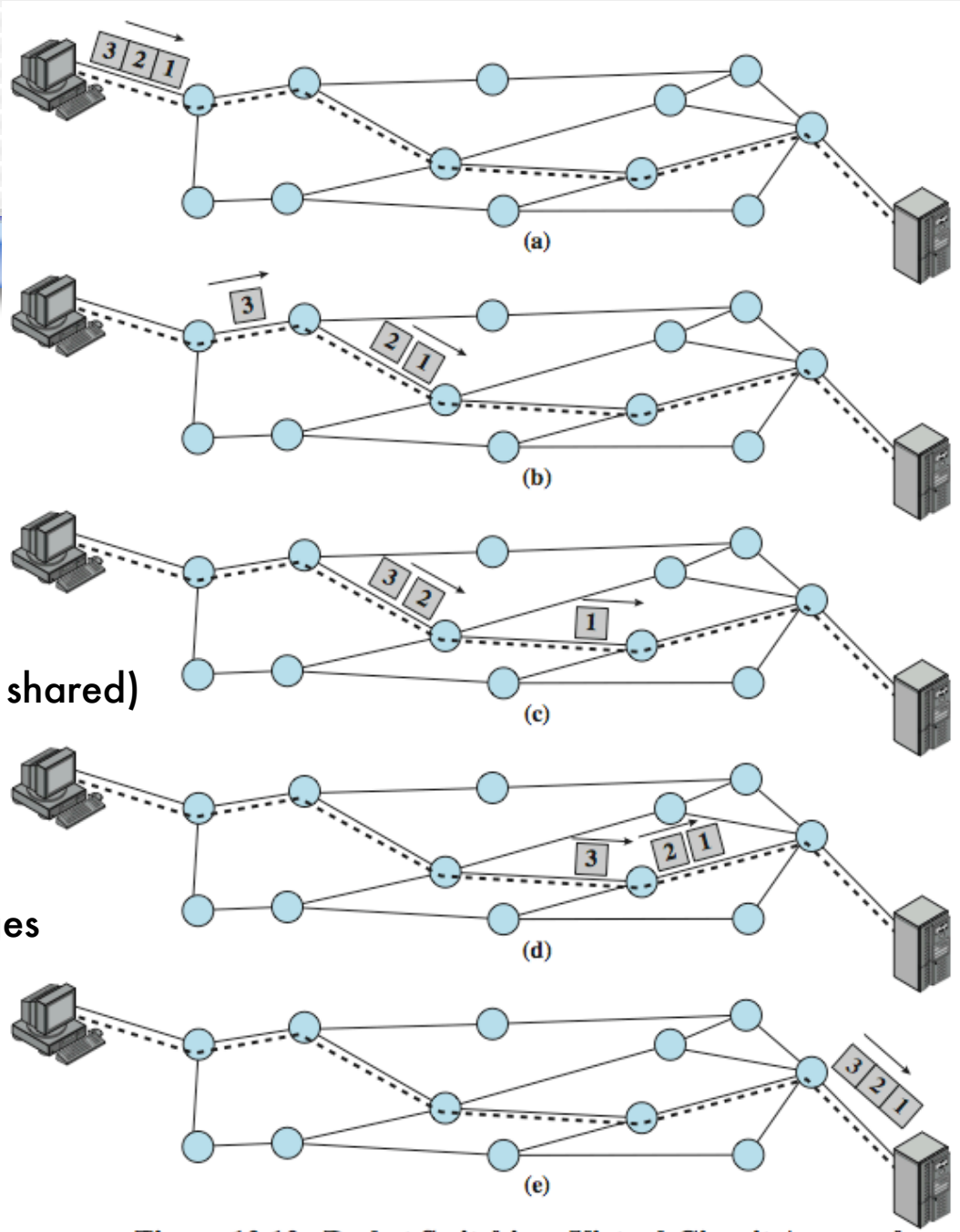


Figure 10.10 Packet Switching: Virtual-Circuit Approach

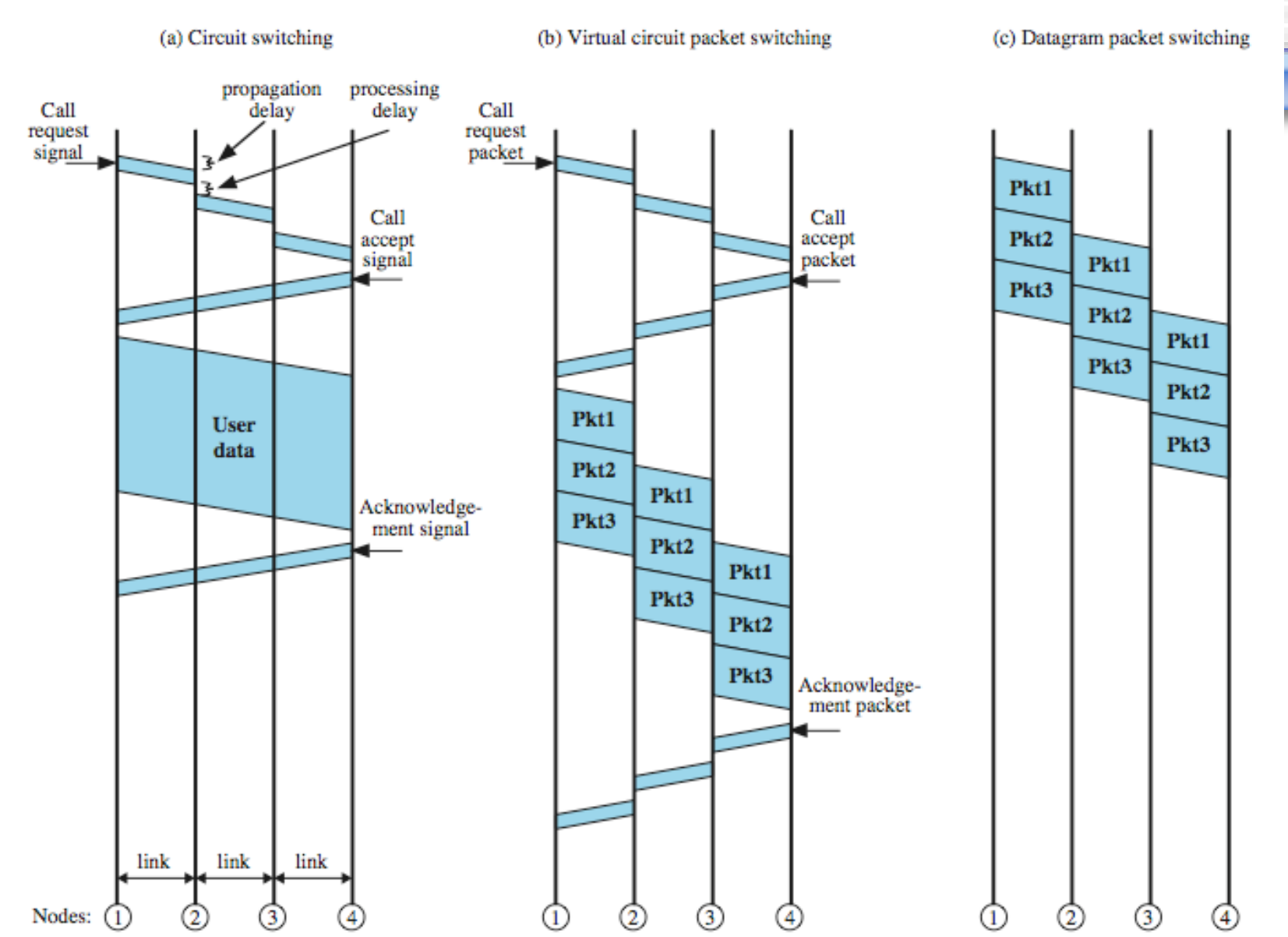
Virtual Circuits vs Datagram

- Datagram
  - Less fixed overhead but more per-packet overhead
    - No link setup phase
    - Routing decisions have to be made for each packet
  - More flexible and resilient to network problems
- Virtual circuits
  - More fixed overhead but less per-packet overhead
    - Link setup phase
    - No routing decisions have to be made for each packet
    - Per packet overhead savings may be small
  - Network can provide sequencing and error control
  - Susceptible to single point of failure

Circuit vs Packet Switching

- Performance depends on several factors
  - Propagation delays
  - Length of message that will be transmitted
  - Application (continuous data or intermittent?)
  - Size of packets
  - Switching/routing delays
- Bottom line:
  - Tradeoff between fixed overhead and per-packet overhead
  - Datagram packet switching preferred in most modern applications (flexibility)

Circuit vs Packet Switching



Summary of Packet Switching

- Line efficiency
  - Individual links shared by many users
  - Capacity is allocated on-demand
- Data rate conversion
  - Network allows connection of different data rate users
  - Flow control and buffering needed
- Packets accepted and buffered even when links are busy (non-blocking)
  - May increase delay with respect to circuit switched networks
  - Priorities can be used for delay-critical applications
- Datagram versus virtual circuit