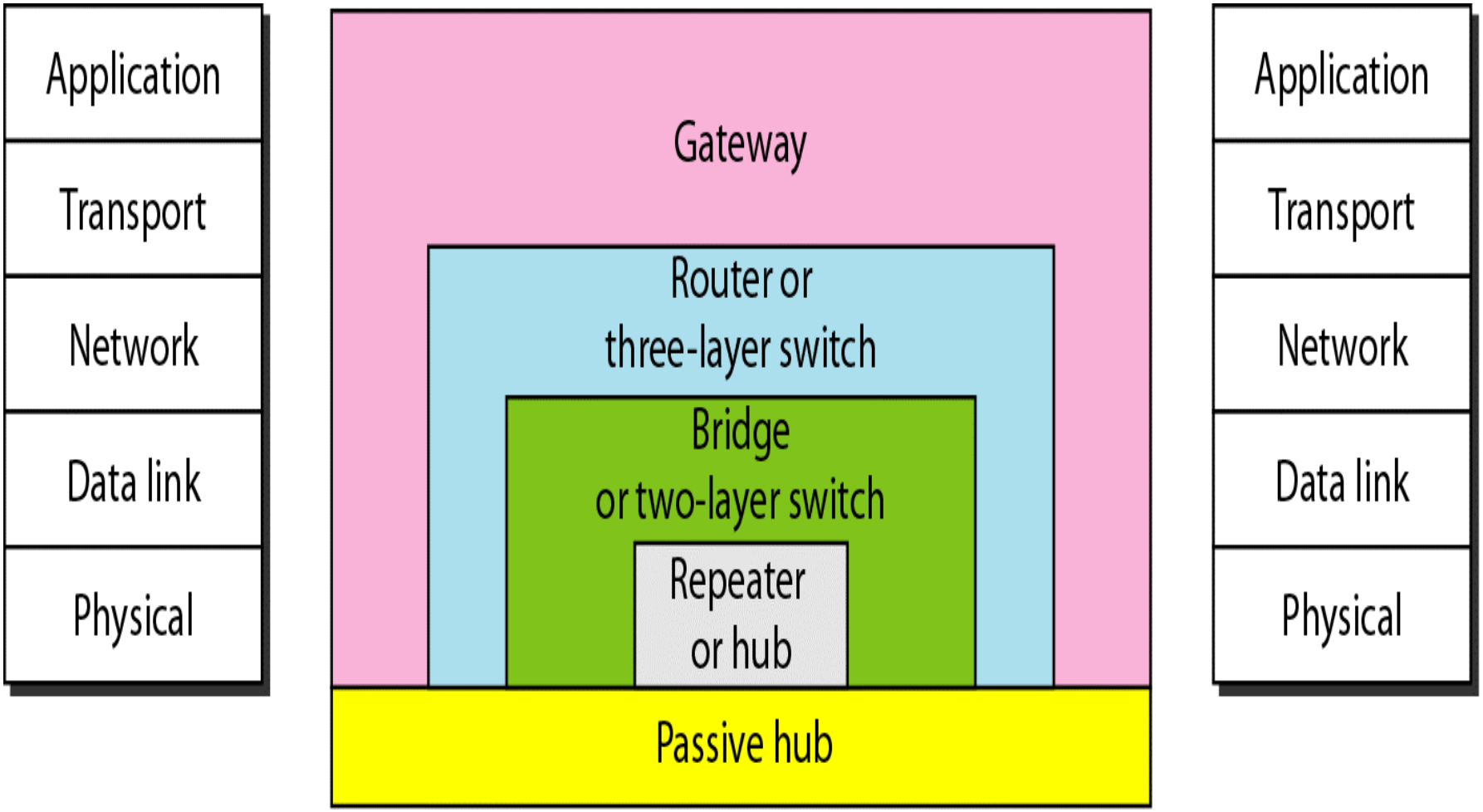
Internetworking Devices

EE450: Introduction to Computer Networks

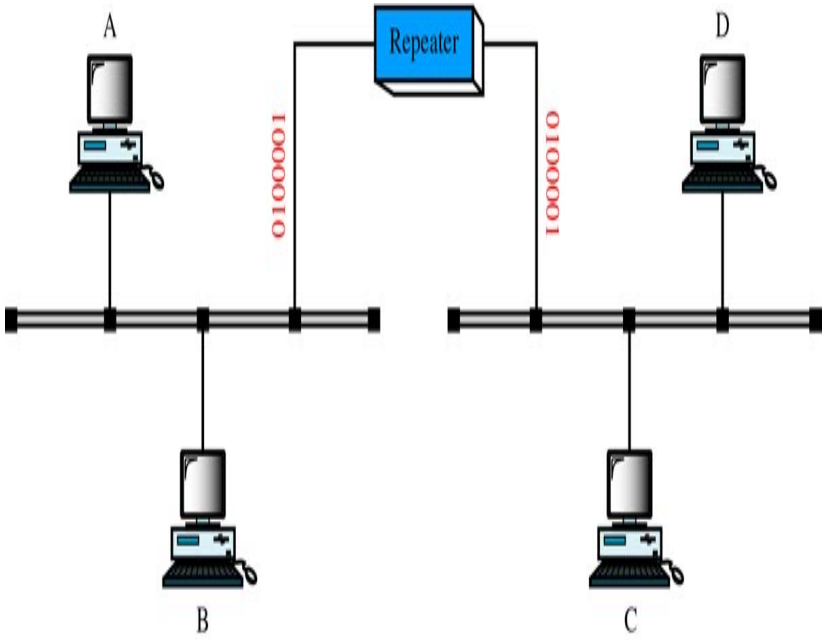
Professor A. Zahid

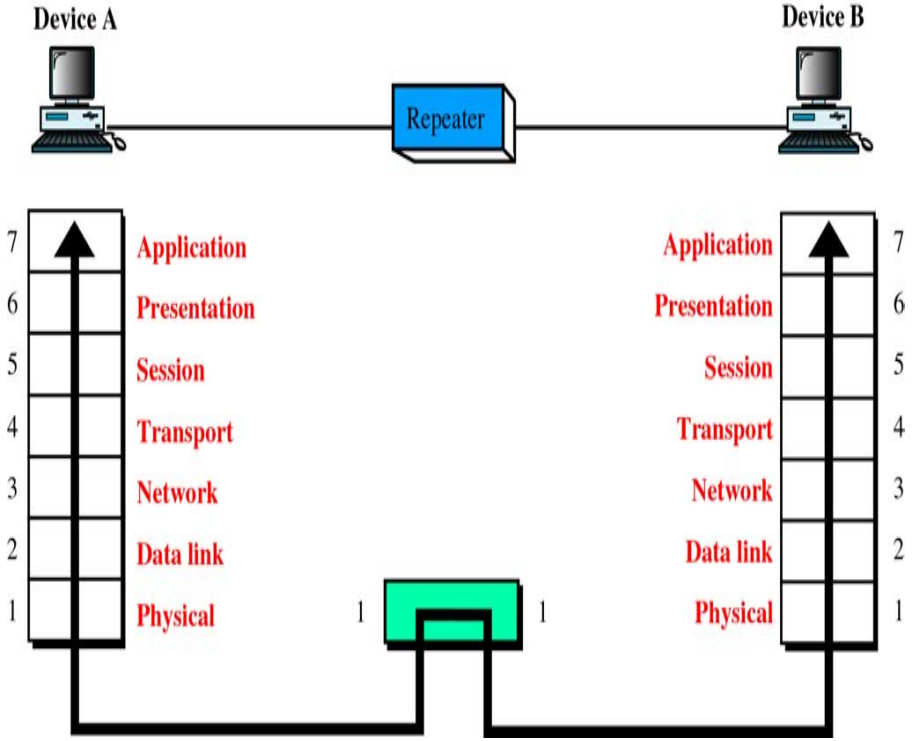
Classifications of Internetworking Devices



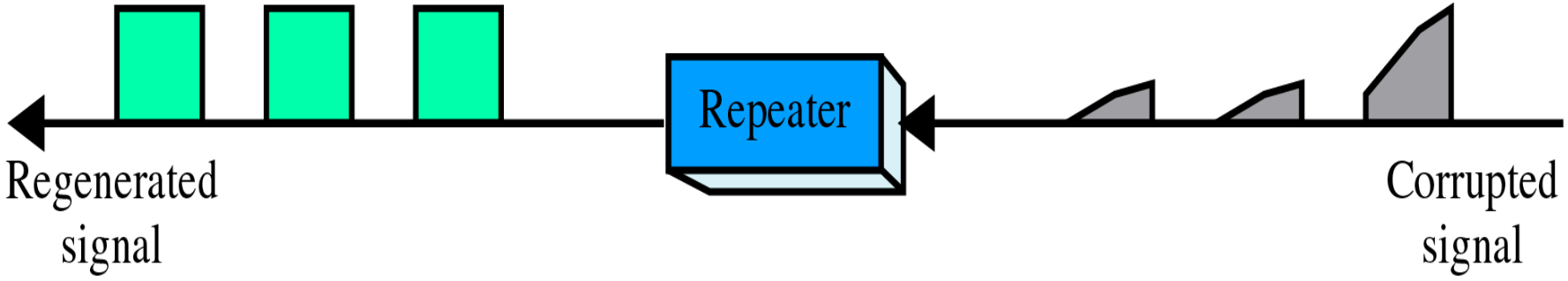
Repeaters

- Repeaters are physical layer devices
- Single collision and broadcast domain

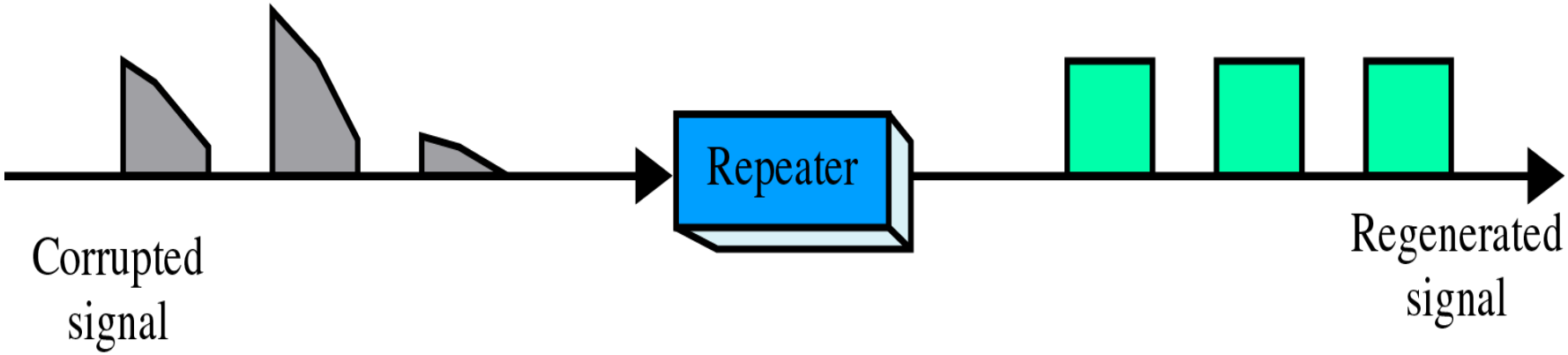




Functions of a Repeater



(a) Right-to-left transmission.

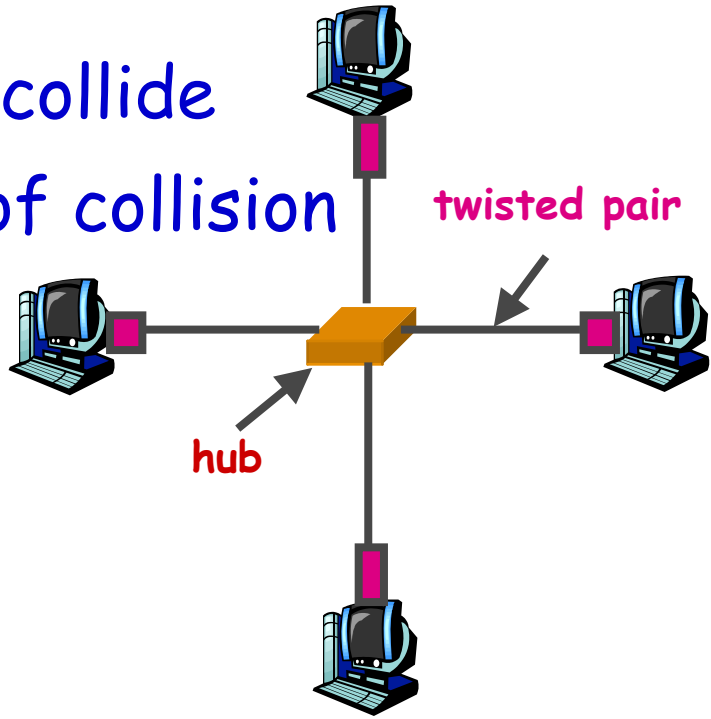


(b) Left-to-right transmission.

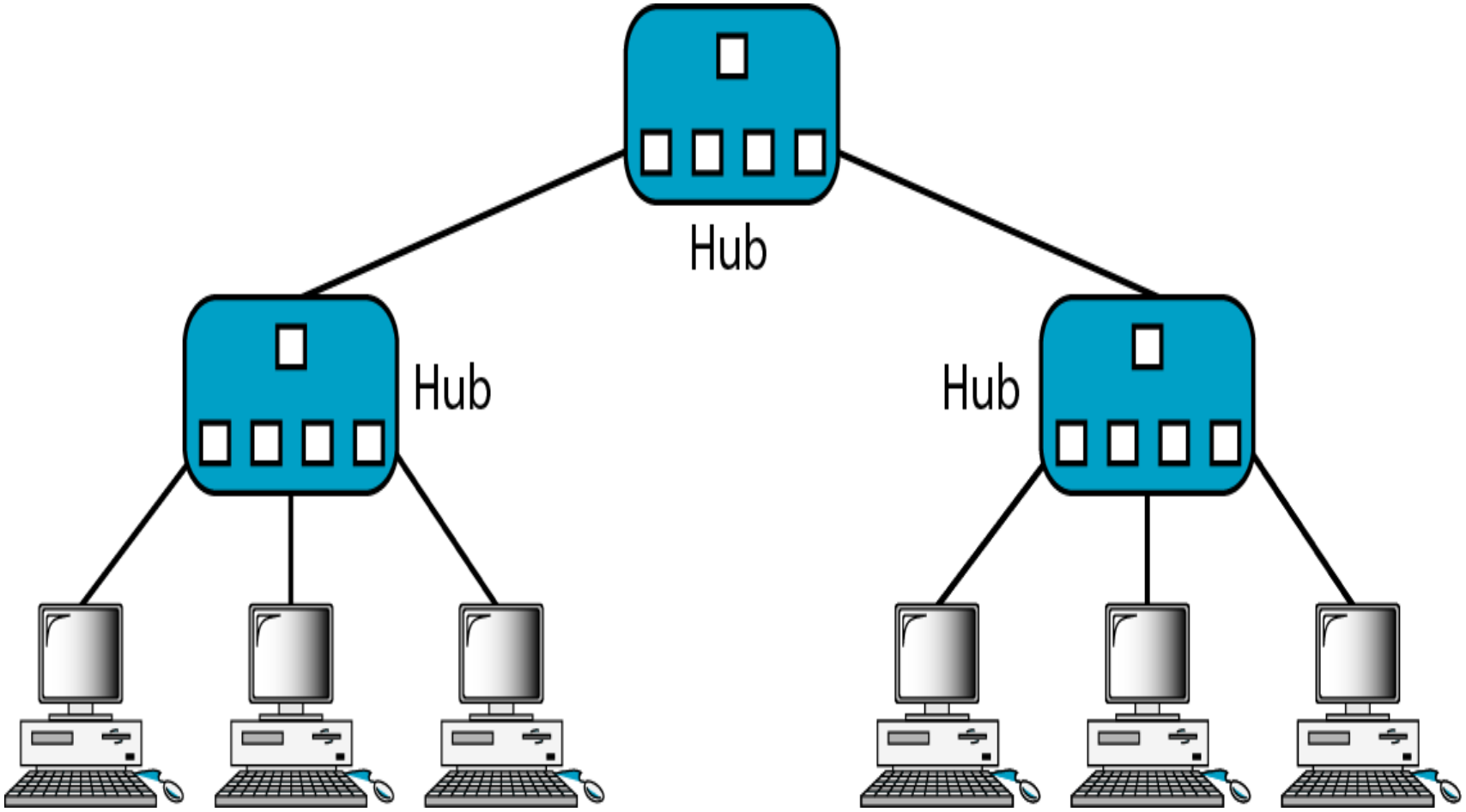
Hubs

Physical-layer ("dumb") repeaters:

- Bits coming in one link go out **all** other links at same rate
- All nodes connected to hub can collide with another one. No isolation of collision domains
- No frame buffering
- No CSMA/CD at hub
- Host NICs detect collisions
- No isolation of broadcast domain



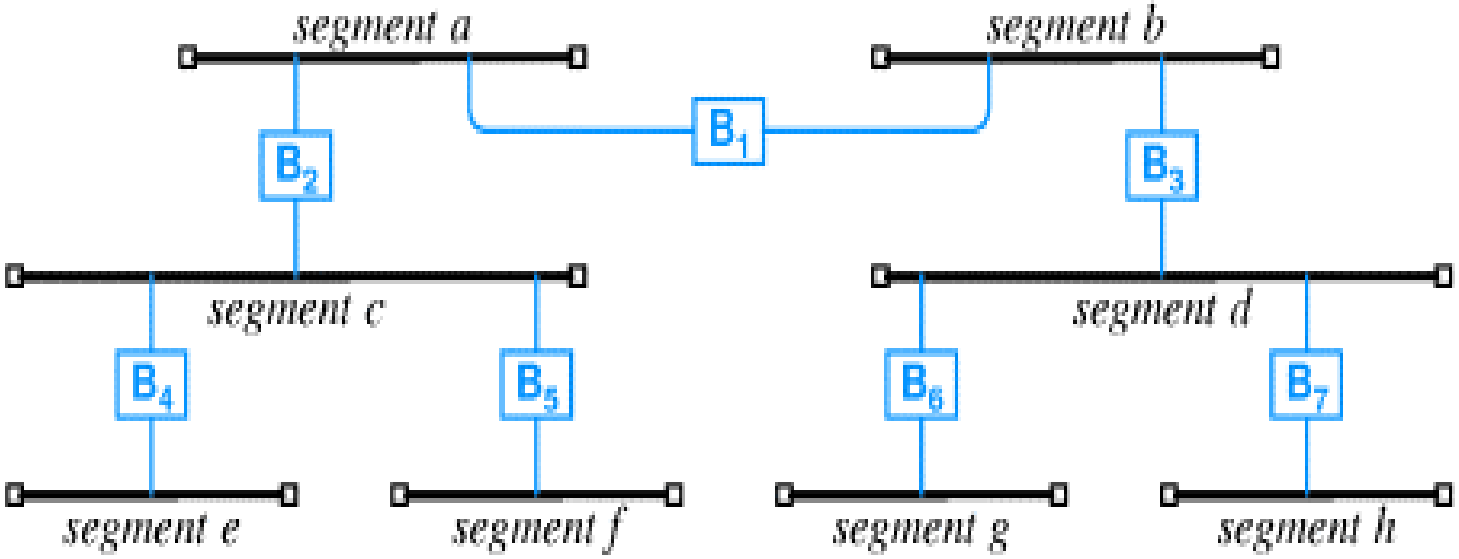
Hub Hierarchy



Bridges

- Bridges are MAC/Link layer devices operating on Ethernet frames, examining frame header and selectively forwarding frame based on its destination
- Bridge isolates collision domains since it buffers frames
- When frame is to be forwarded on segment, bridge uses CSMA/CD to access segment and transmit

Bridges LAN w/Multiple Segments



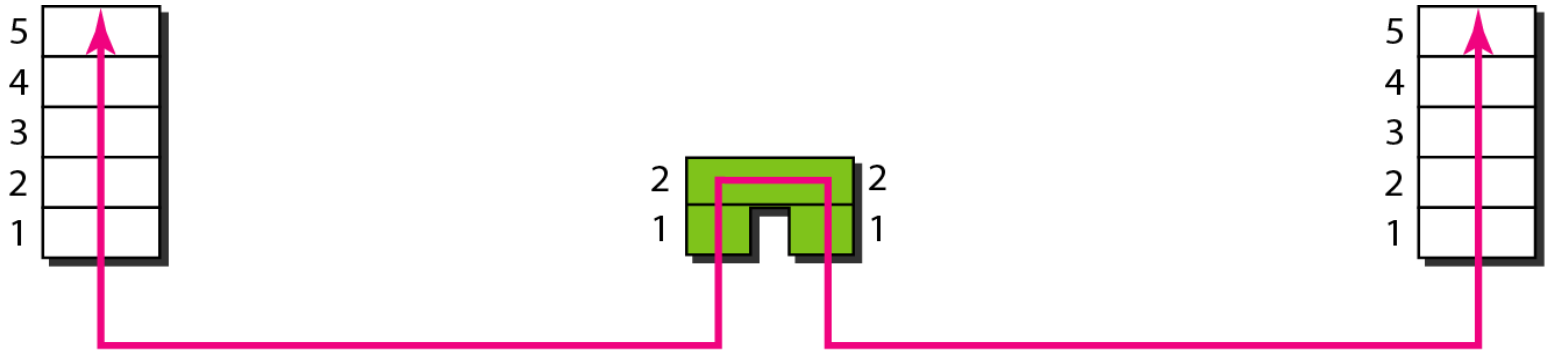
Pros and Cons of Bridges

- Bridge advantages:
  - Isolates collision domains resulting in higher total maximum throughput, and does not limit the number of nodes nor geographical coverage
  - Can connect different type Ethernet since it is a store and forward device
  - Transparent: no need for any change to hosts LAN adapters. Hosts do not communicate with bridges
- Disadvantage: Single broadcast domain!

Bridges Modes of Operation

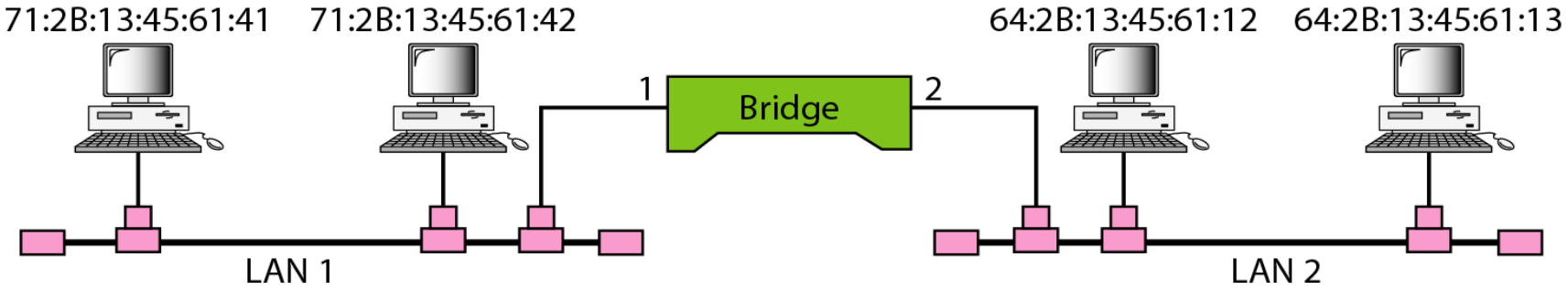
- **Filtering**: Bridges filter frames if source and destination hosts are on the same segment! Other segments will not get such frames
- **Forwarding**: Bridges forward frames if source and destination hosts are on different segments and the bridge knows on which segment is the destination host connected to
- **Flooding**: Bridges flood frames to all interfaces (except the one it received the frame from) if it doesn't know where the destination host is

Bridges



Address	Port
71:2B:13:45:61:41	1
71:2B:13:45:61:42	1
64:2B:13:45:61:12	2
64:2B:13:45:61:13	2

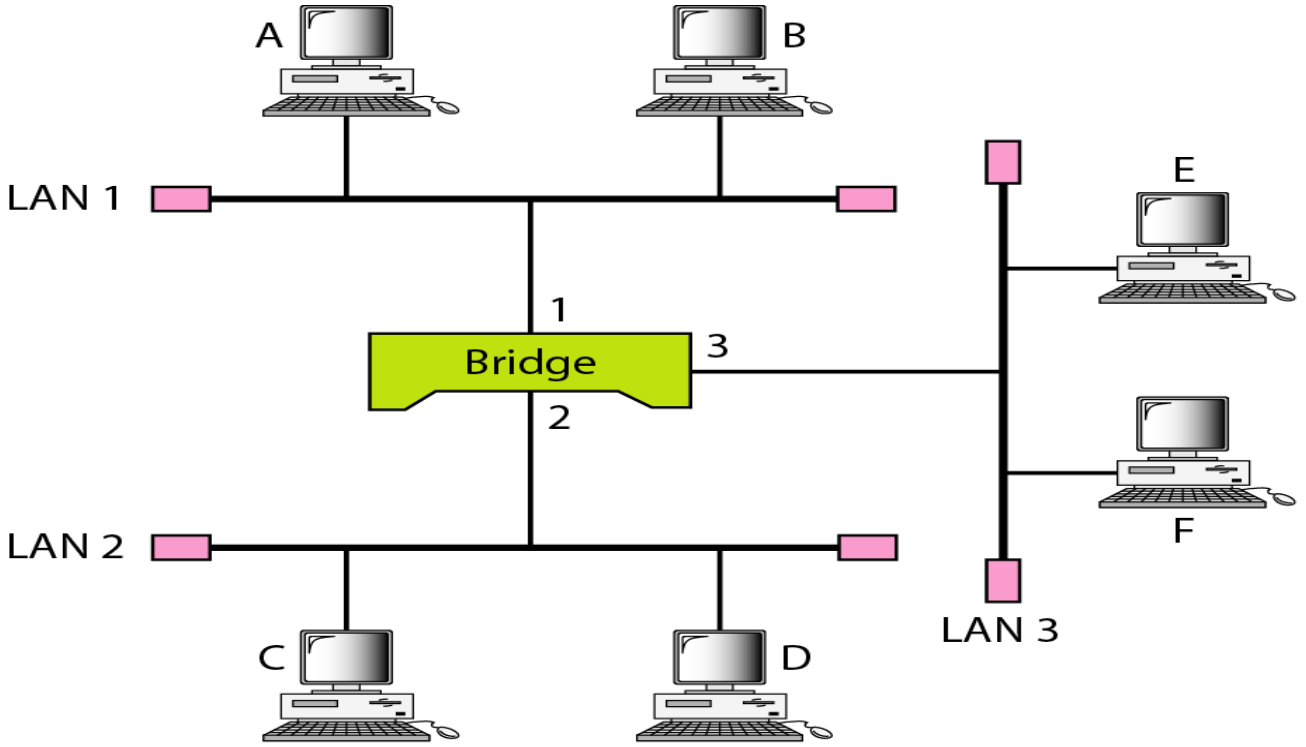
Bridge Table



Learning Bridges

- Bridges learn which hosts can be reached through which interfaces by maintain filtering tables
  - When a frame received, bridge "learns" location of sender: incoming LAN segment
  - Records sender location in filtering table
- Filtering table entries
  - Host MAC address, Bridge interface, Time stamp
  - Stale entries in filtering table dropped. Time stamp is configurable (may be ~ 60 minutes)

Learning Bridges



Address	Port

a. Original

Address	Port
A	1

b. After A sends a frame to D

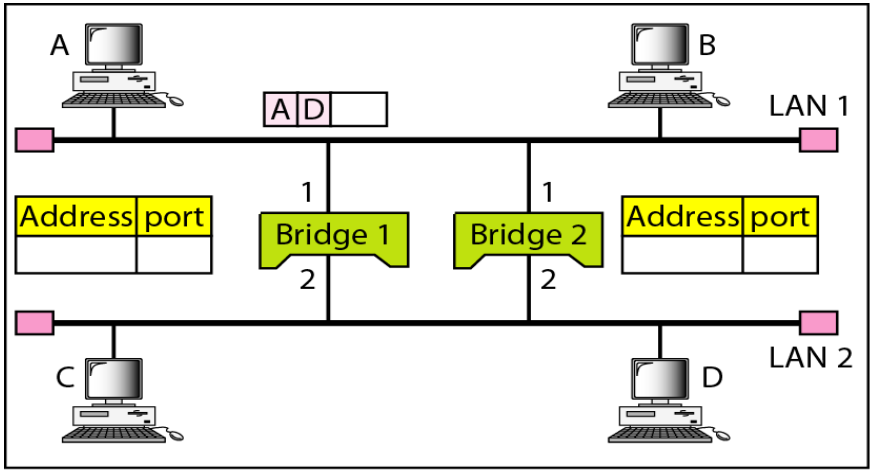
Address	Port
A	1
E	3

c. After E sends a frame to A

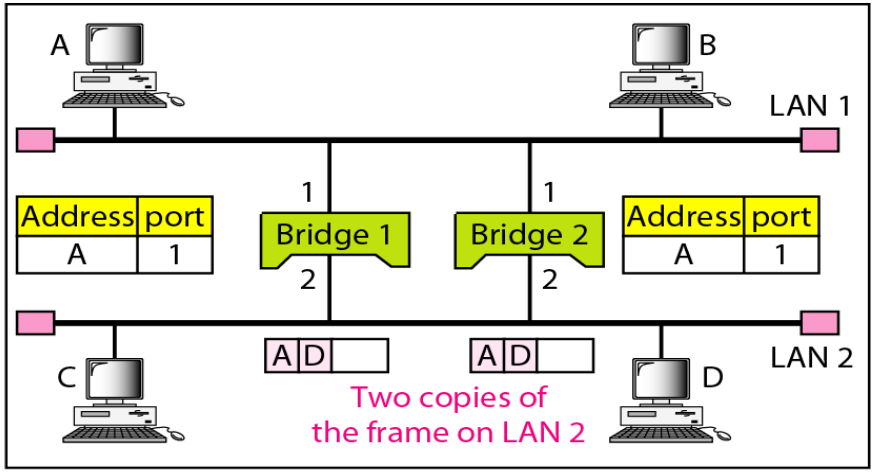
Address	Port
A	1
E	3
B	1

d. After B sends a frame to C

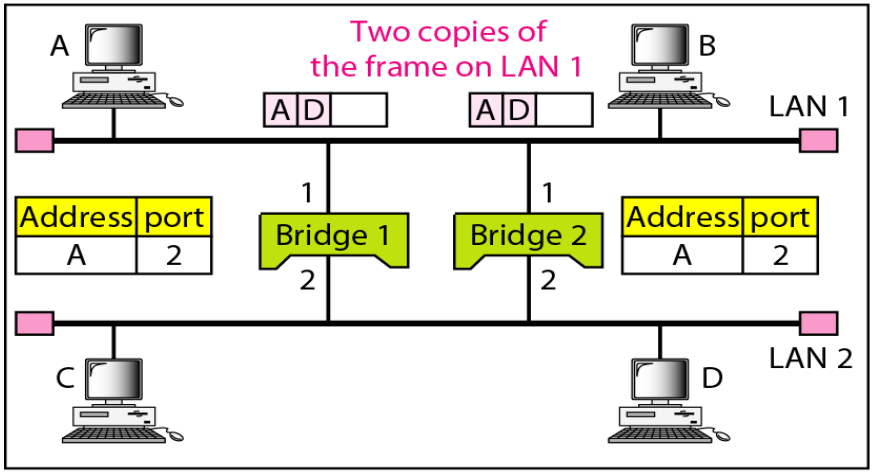
Loop Problem in Learning Bridges



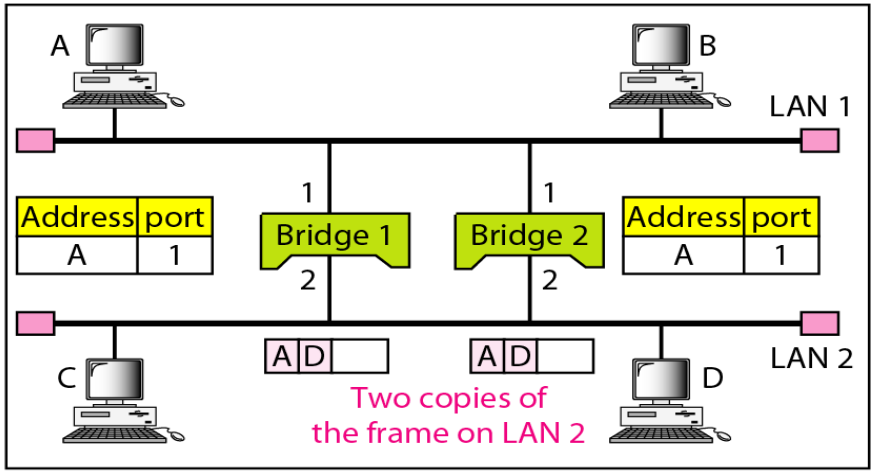
a. Station A sends a frame to station D



b. Both bridges forward the frame



c. Both bridges forward the frame

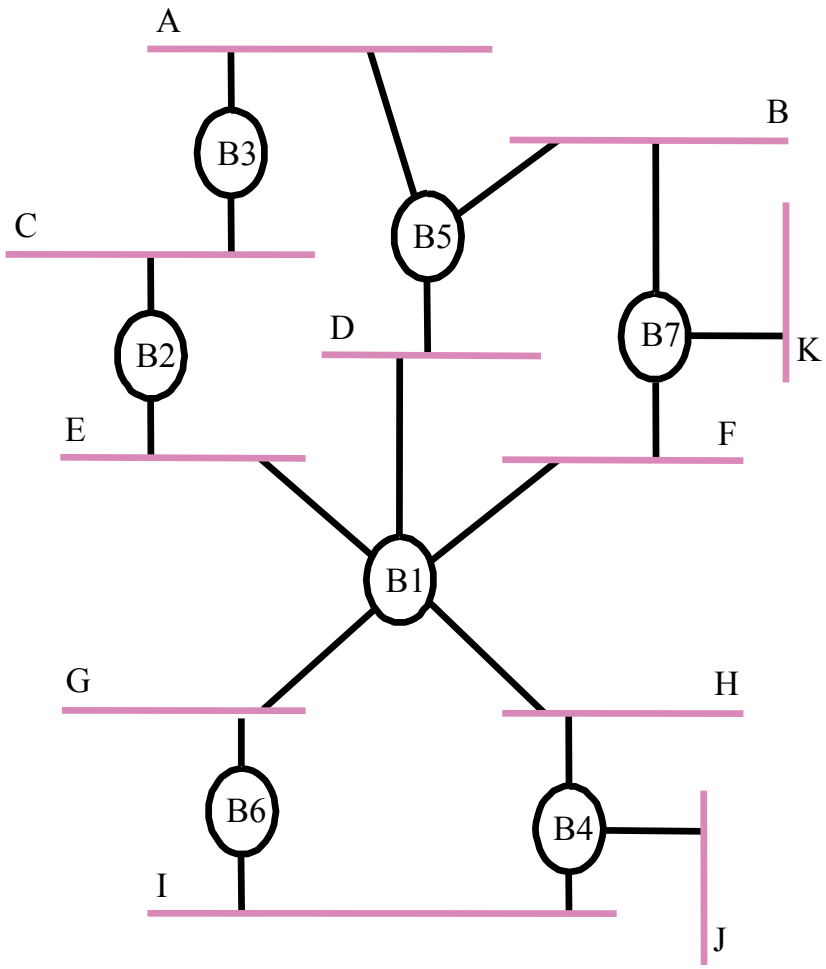


d. Both bridges forward the frame

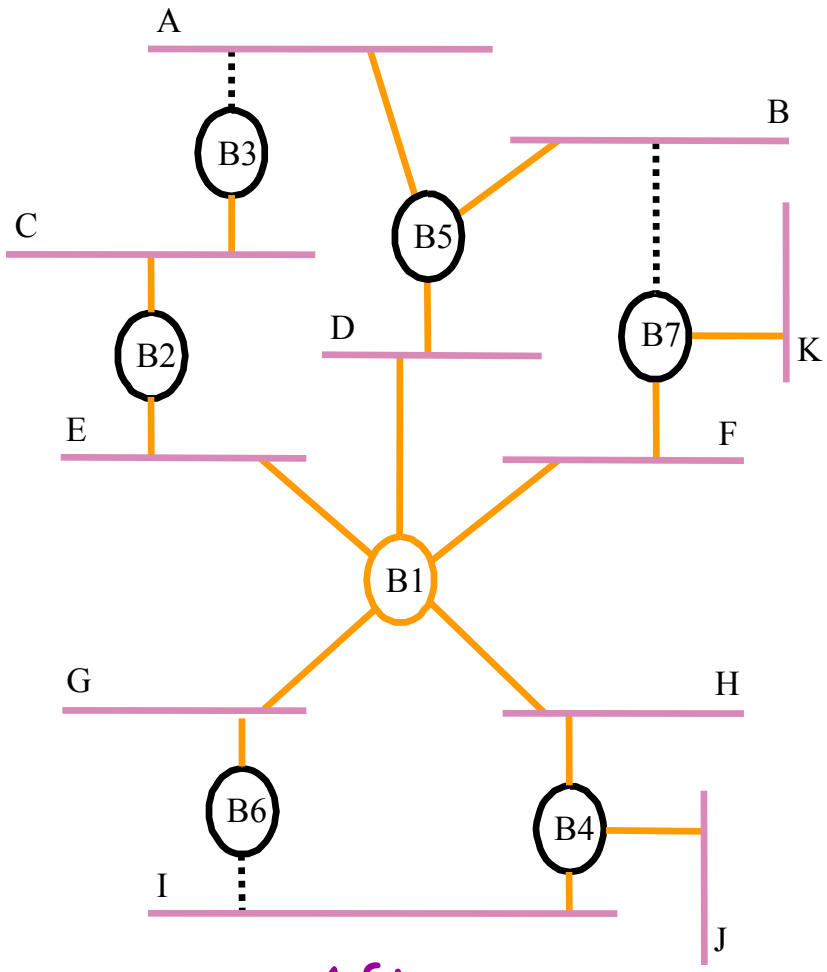
Solution: Spanning Tree Algorithm

- A distributed algorithm running in Bridges. Basic idea is to insure that there would be only one path between any two hosts
- Each bridge is assigned an ID
- Each port is assigned a cost
- Bridges choose a bridge to be the root of the tree – Done by assigning an ID to the bridge then finding the the bridge with smallest ID
- Each bridge determines it's root port – Port that has the least root path cost to the root
- One designated bridge is chosen for each segment

Example of SPT Algorithm

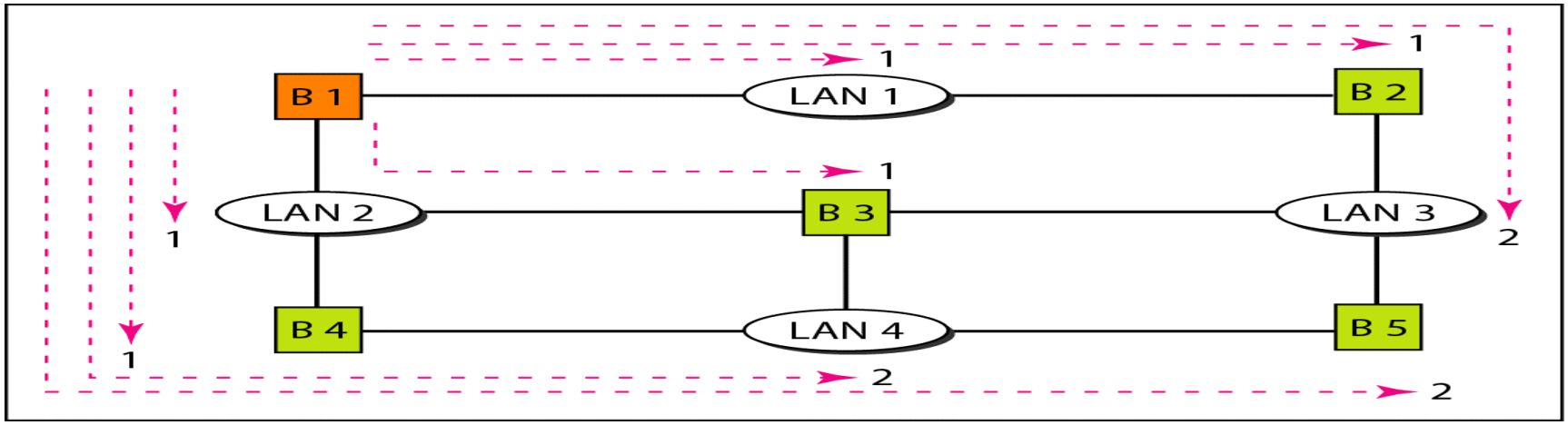


Before

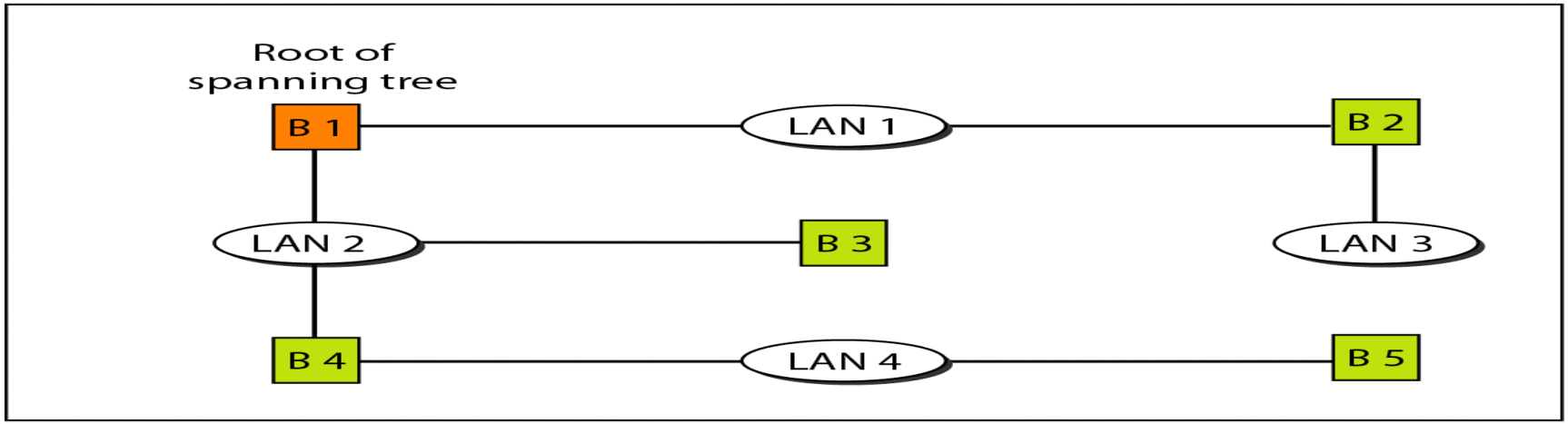


After

Shortest Path in SPT



a. Shortest paths



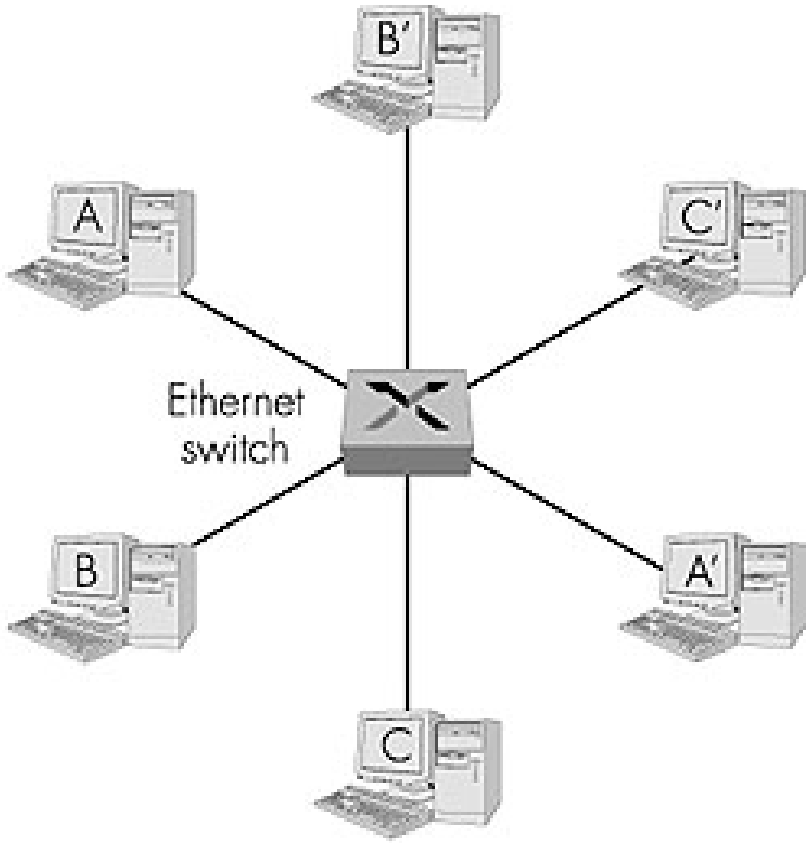
b. Spanning tree

Switching Hubs

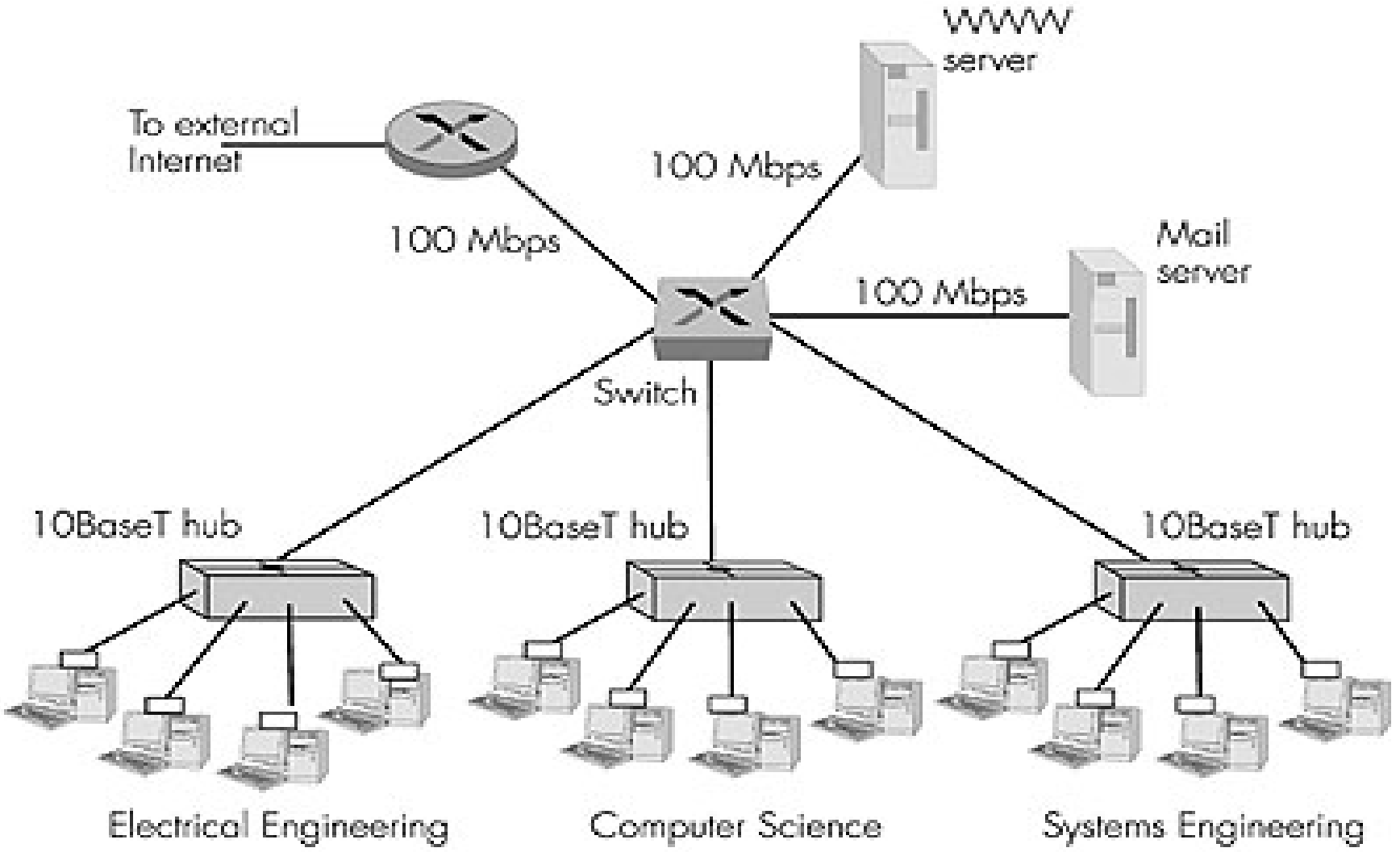
- Link-layer device: smarter than hubs, take active role
  - Store, forward Ethernet frames
  - Examine incoming frame's MAC address, selectively forward frame to one-or-more outgoing links when frame is to be forwarded on segment, uses CSMA/CD to access segment
- Transparent
  - Hosts are unaware of presence of switches
- Plug-and-play, self-learning
  - Switches do not need to be configured

Ethernet (Layer 2) Switches

- Layer 2 (frame) forwarding/ filtering/flooding based on MAC addresses
- Switching: A-to-B and A'-to-B' simultaneously, no collisions
- Ethernet but no collisions
- Store & Forward v.s Cut-through Switching
- Shared/Dedicated 10/100/1000 Mbps interfaces

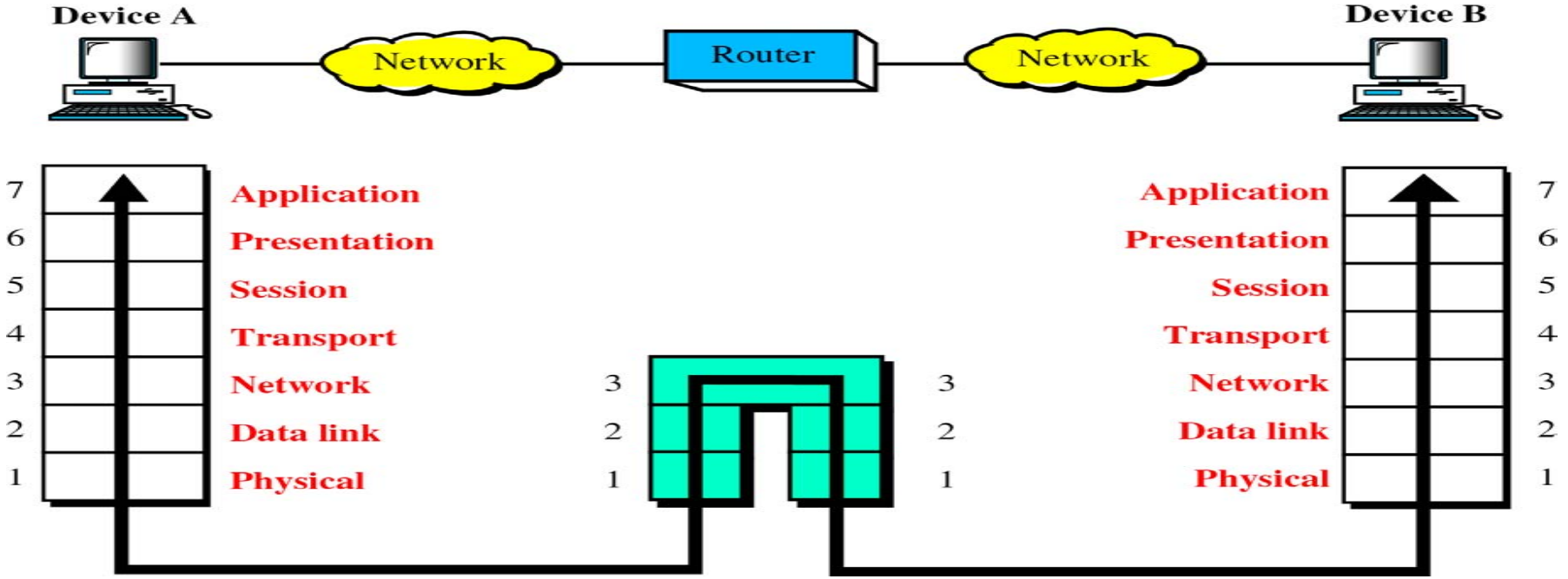


Ethernet Switches with dedicated/shared ports

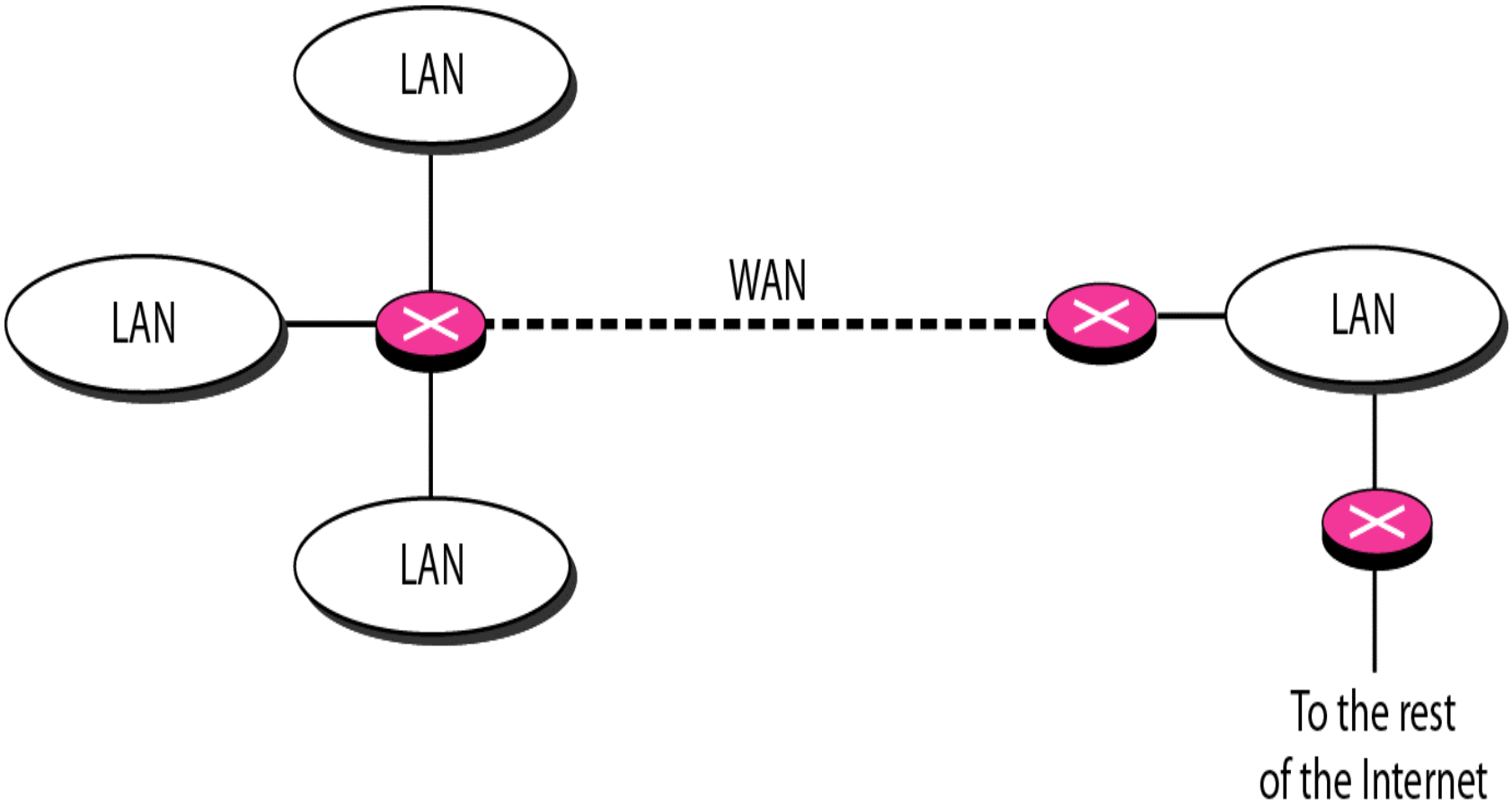


Routers

- Routers are network-layer devices
- Routers implement routing algorithms and maintain routing tables



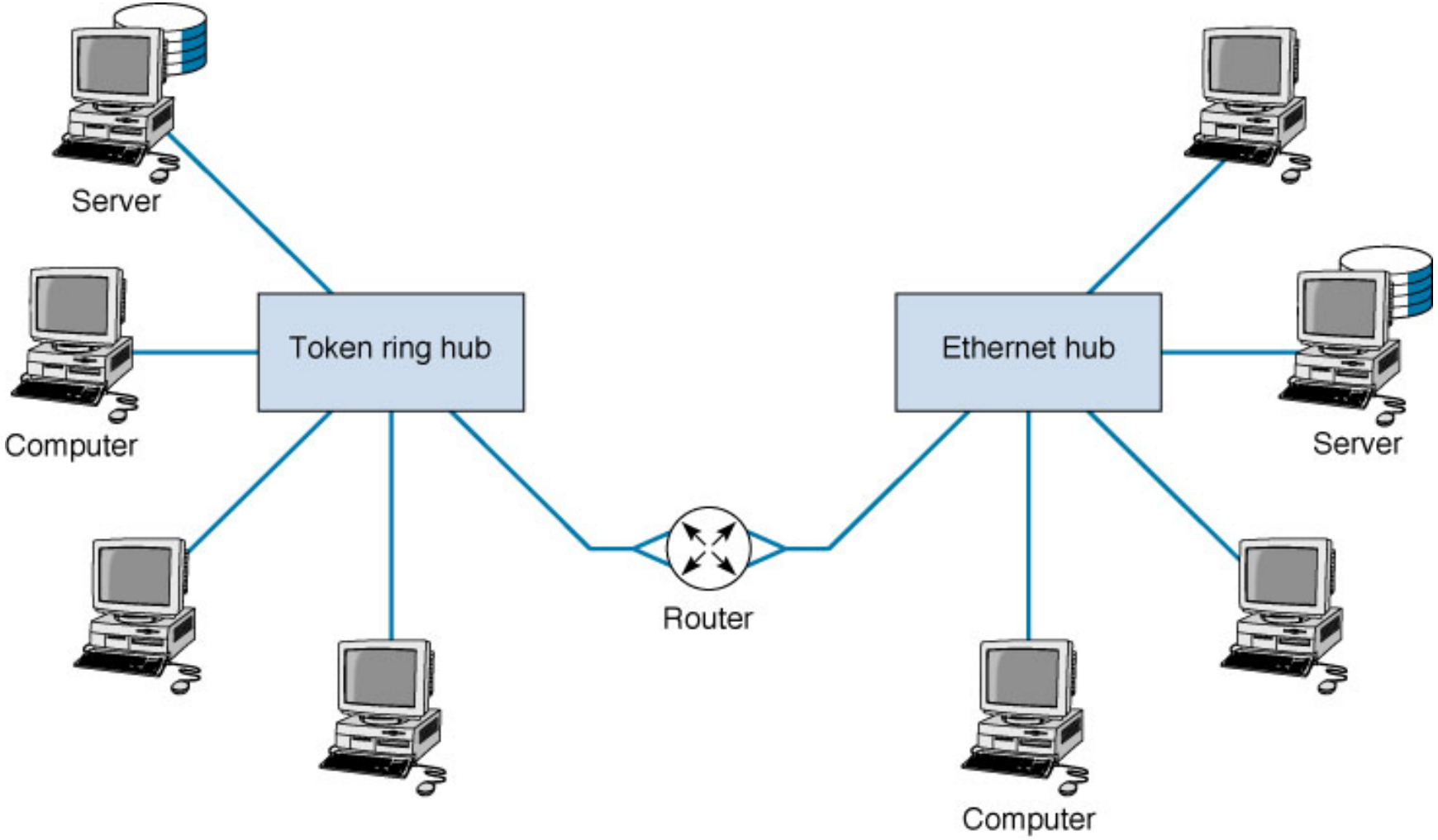
Routers: Connecting LANs/WANs



Router Principles

- Routers operate at the network layer, connecting two or more network segments that may be using different MAC link layer protocols, but the same network layer protocol. They can also connect different types of cabling.
- Router operations involve stripping off the header and trailer of the incoming data link layer frame and then examining the destination address of the network layer packet. The router then builds a new frame around the packet and sends it out onto another network segment.
- Another important router feature is that they choose the "best" route for a packet to follow, hence the name 'router'.
- Unlike a bridge, a router only processes frames that are specifically addressed to it.

Connecting Two Networks



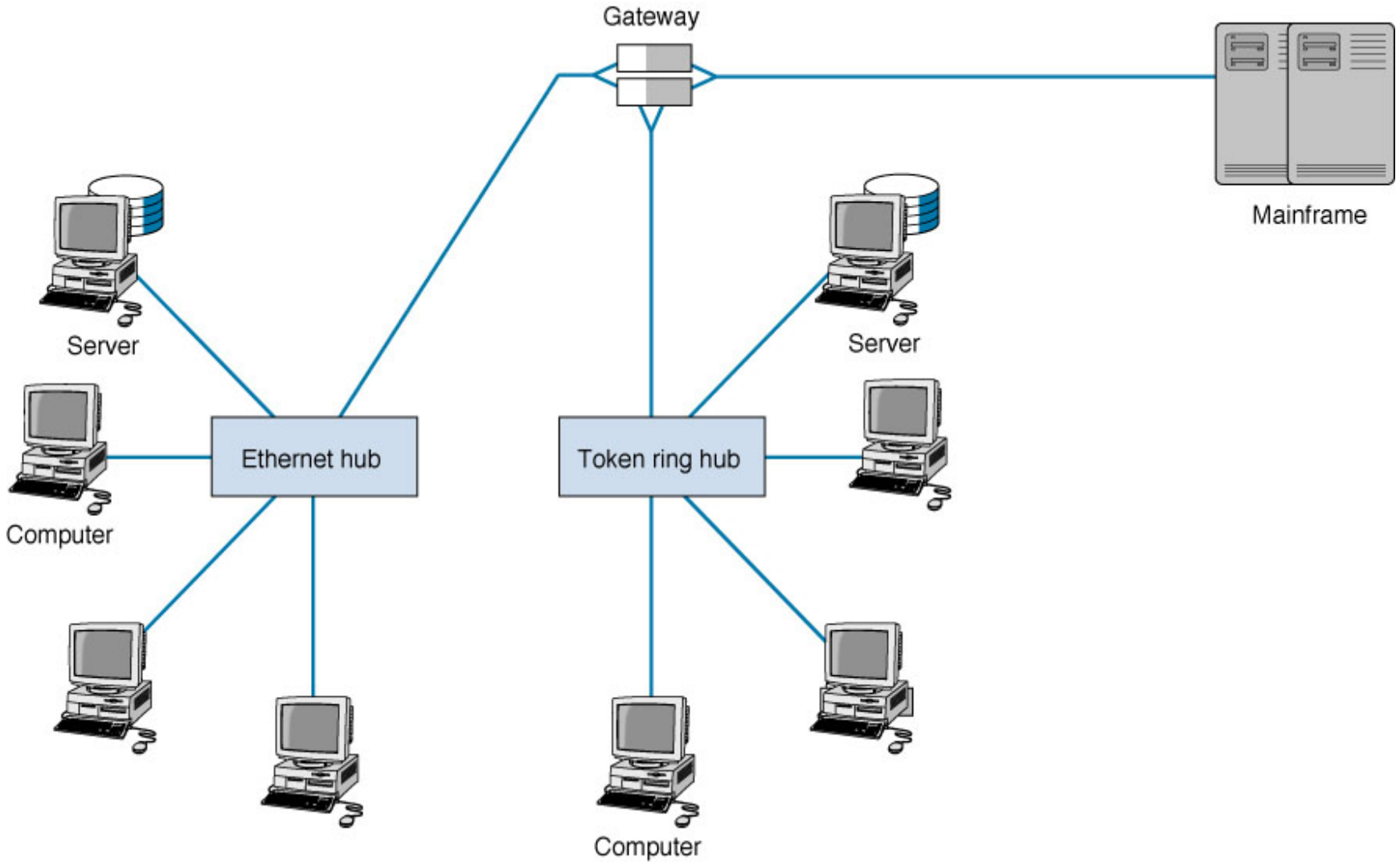
Switches vs.Routers

- Both store-and-forward devices
  - Routers: Network layer devices (examine network layer headers)
  - Switches are link layer devices
- Routers maintain routing tables, implement routing algorithms
- Switches maintain switching tables, implement filtering, learning algorithms

Gateways

- Gateways may also operate at the network layer, but they are more complex than routers because they provide an interface between more dissimilar networks.
- Like routers, gateways only process messages that are specifically addressed to them.
- Some gateways operate at the application layer as well.

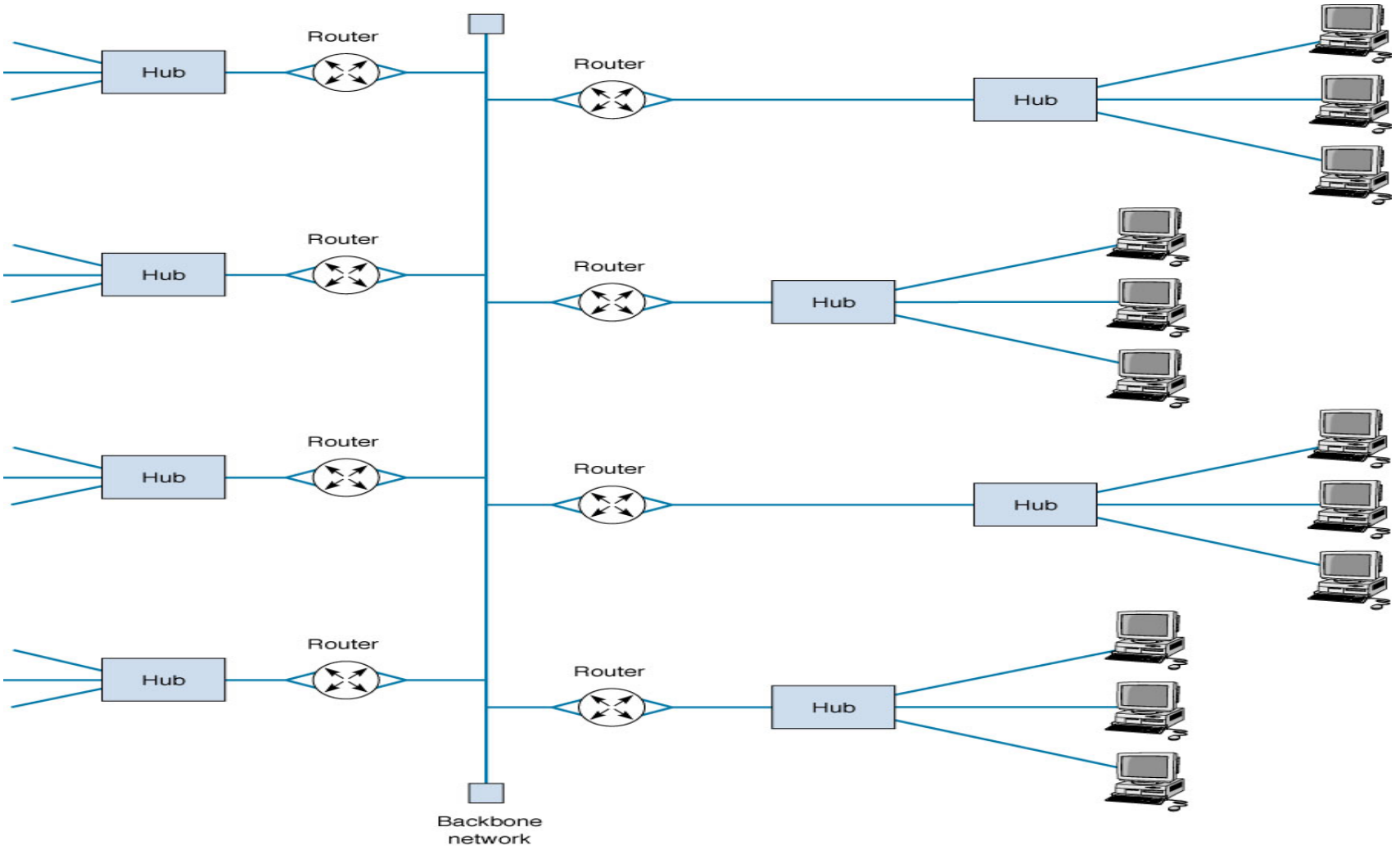
Example of a Gateway



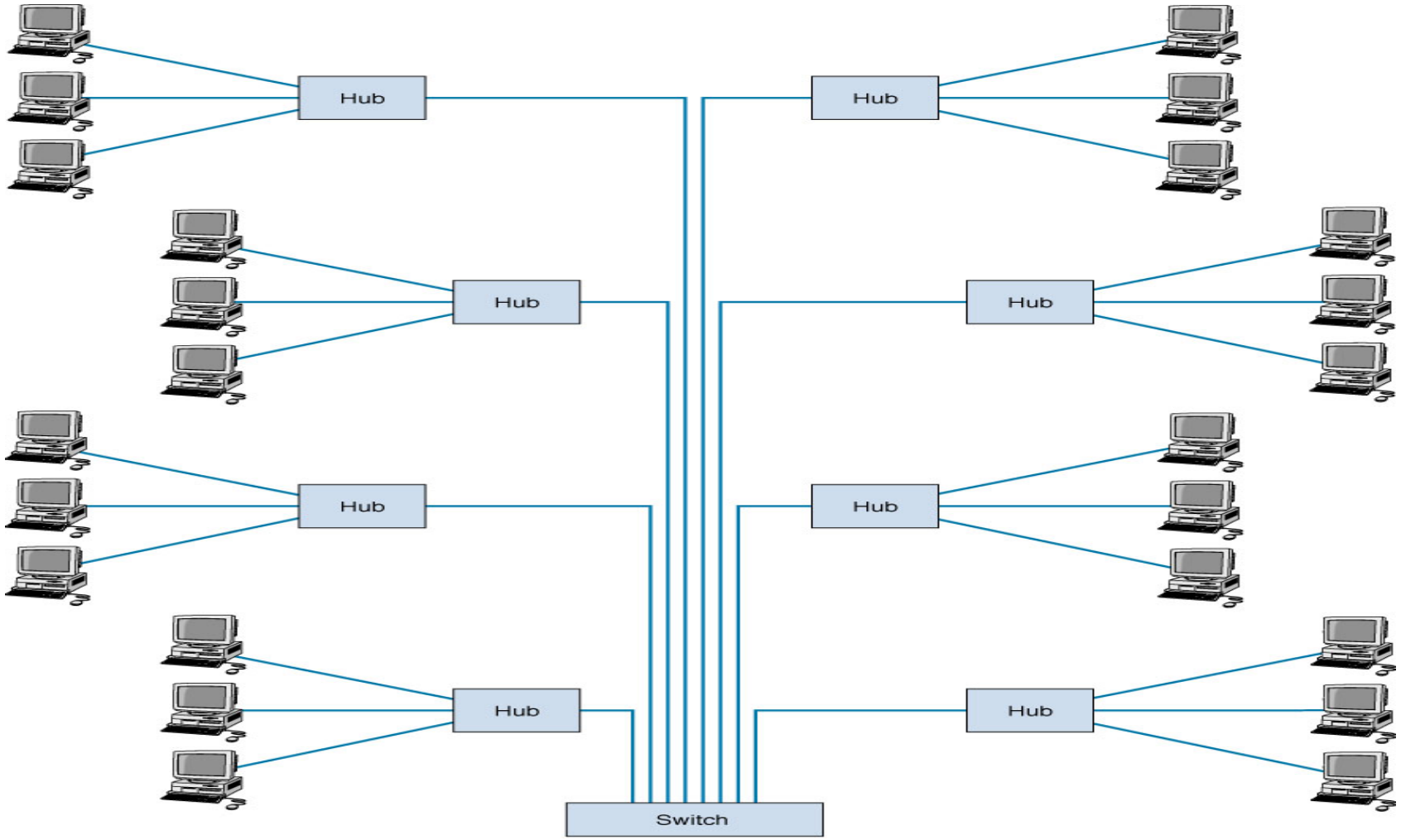
Backbone Network Architectures

- There are many types of backbone networks among them
  - Routed or Bridges Backbones
  - Collapsed Backbones
- EE555 Material (again depends on who offers it)

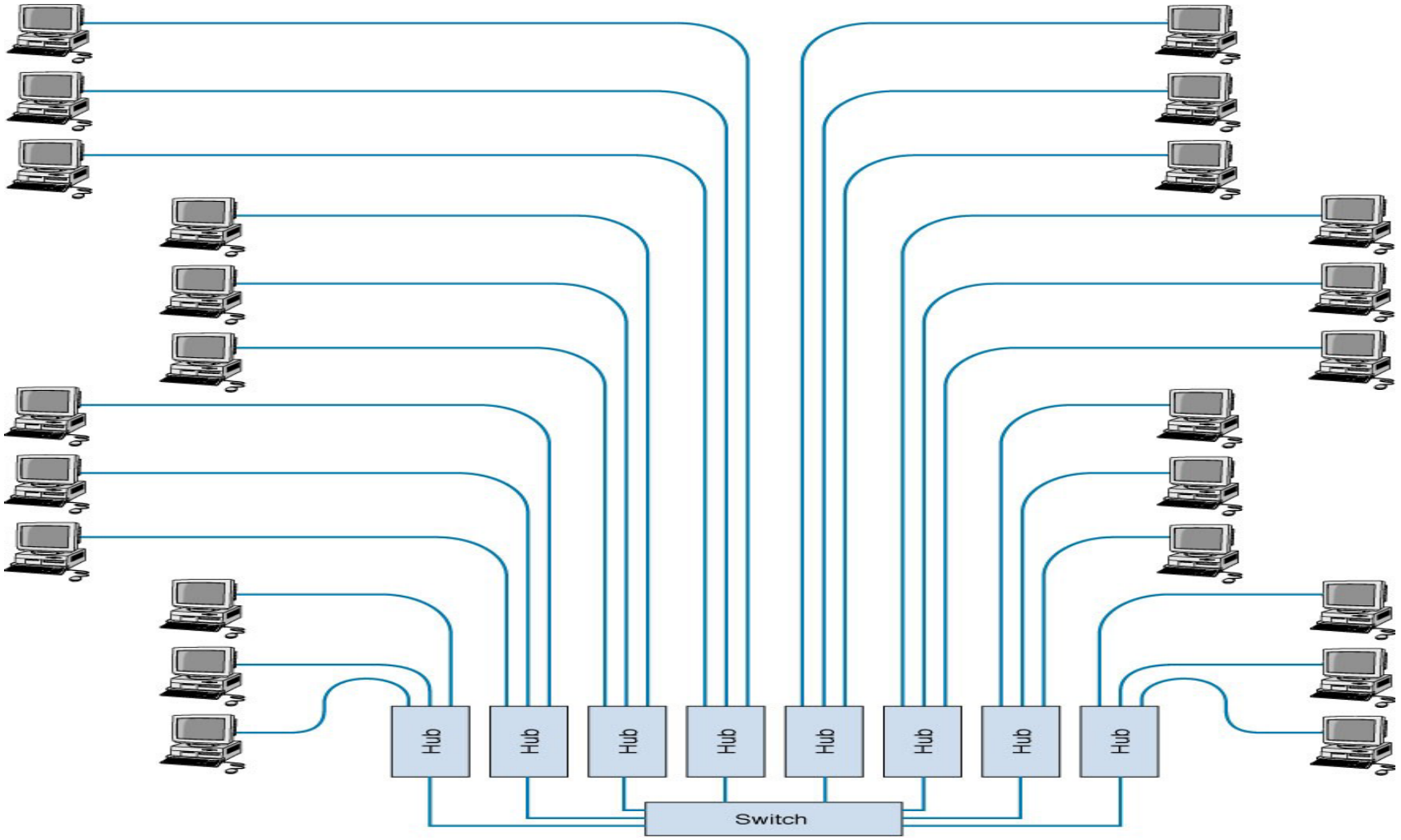
Routed Backbones



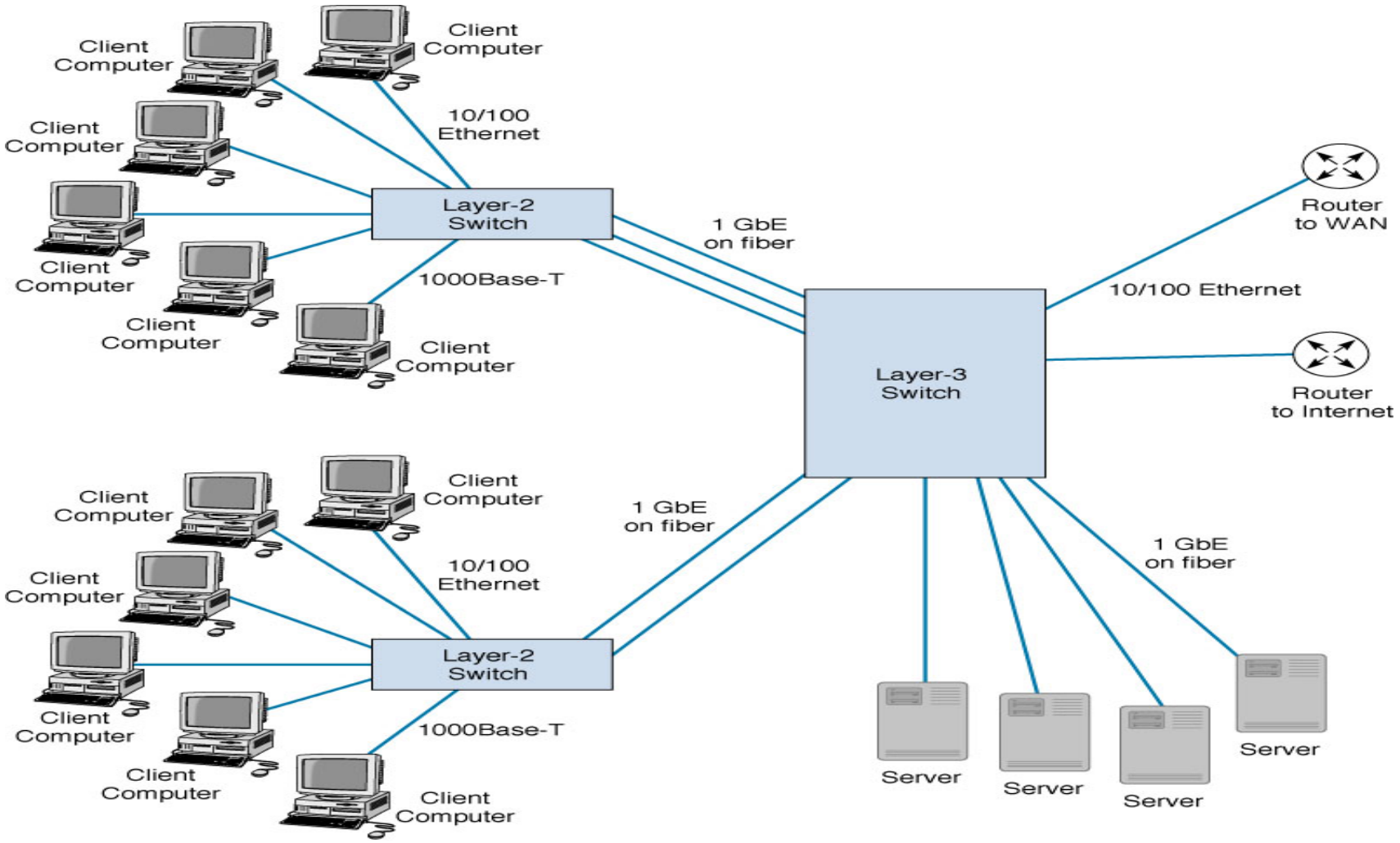
Collapsed Backbones



Racked-based Collapsed Backbone



Central Parking Collapsed Backbones



Hierarchical Network Design