

Introduction

Many times it is necessary to connect a local area network to another local area network or to a wide area network.

Local area network to local area network connections are often performed with a bridge.

Local area network to wide area network connections are usually performed with a router.

A third device, the switch, can be used to interconnect segments of a local area network.

Why Interconnect?

To separate / connect one corporate division with another.

To connect two LANs with different protocols.

To connect a LAN to the Internet.

To break a LAN into segments to relieve traffic congestion.

To provide a security wall between two different types of users.

To connect WLAN to LAN

Internetworking devices

Descending in increasing power and complexity

- Hubs
- Bridges
- Switches
- Routers

Hubs

As seen earlier, a hub interconnects two or more workstations into a local area network. A simple interconnecting device that requires no overhead to operate.

When a workstation transmits to a hub, the hub immediately resends the data frame out all connecting links.

A hub can be managed or unmanaged. A managed hub possesses enough processing power that it can be managed from a remote location.

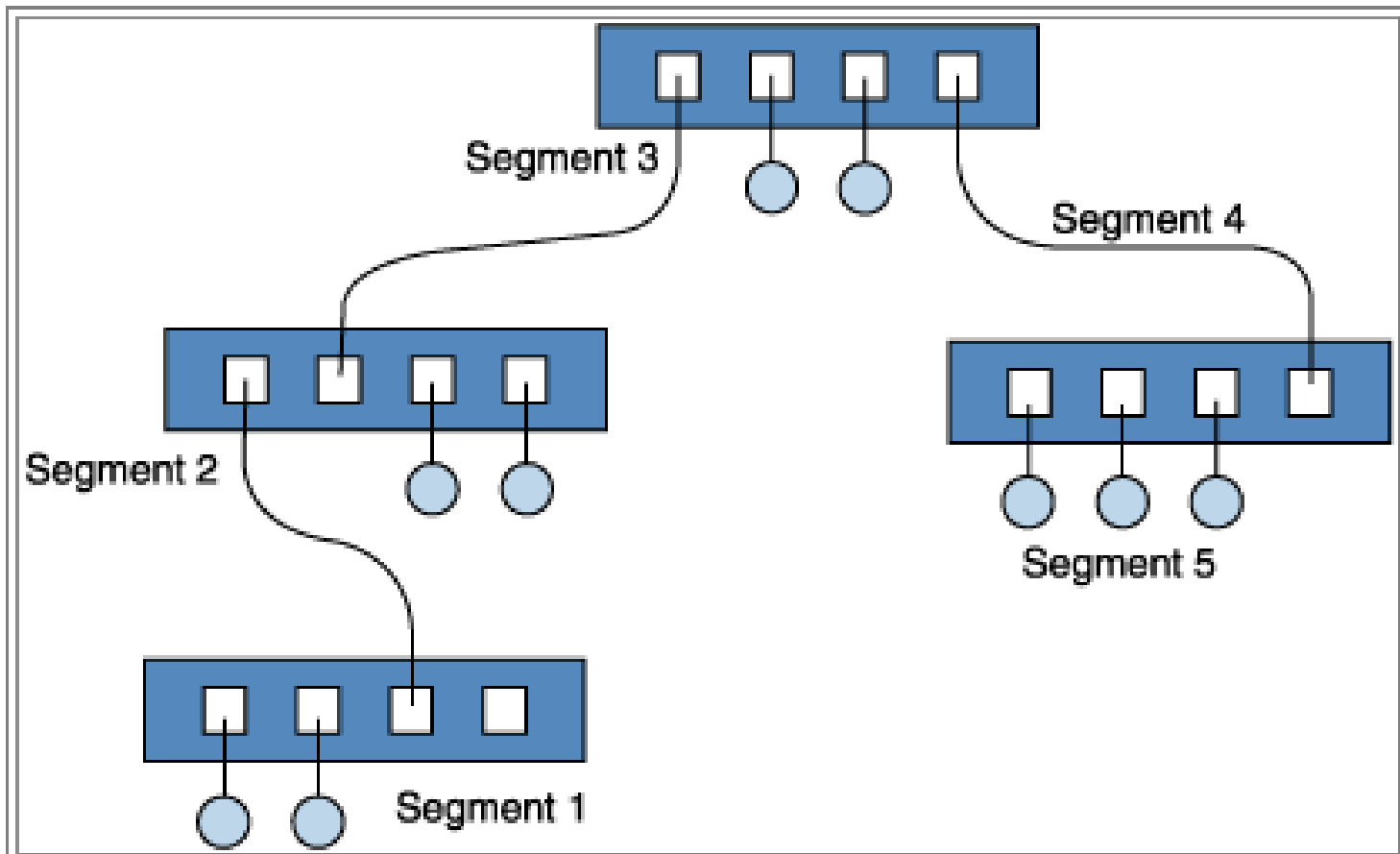
Hubs continue to become smarter.

Some call any interconnection device in a LAN a hub!

Hubs

- Hubs, also called concentrators, expand one Ethernet connection into many. For example, a four-port hub connects up to four machines (or other network devices) via UTP cables. The hub provides a star connection for the four ports. Many hubs contain a single BNC connector as well to connect the hub to existing 10Base-2 network wiring. The hub also can be connected via one of its ports. One port is designed to operate in either Straight-Through or Crossover mode, selected by a switch on the hub.
- A hub is similar to a repeater, except it broadcasts data received by any port to all other ports on the hub. Most hubs contain a small amount of intelligence as well, examining received packets and checking them for integrity. If a bad packet arrives or the hub determines that a port is unreliable, it will shut down the line until the error condition disappears. Because of its slight delay when processing a packet, the number of hubs that may be connected in series is also limited. Several hubs can be used to connect five Ethernet segments within the accepted limits. Because each UTP cable may be as long as 100 m, the maximum distance between nodes is 500 m (the network diameter).

Hubs connecting segments



Bridges

A bridge can be used to connect two similar LANs, such as two CSMA/CD LANs.

A bridge can also be used to connect two closely similar LANs, such as a CSMA/CD LAN and a token ring LAN.

The bridge examines the destination address in a frame and either forwards this frame onto the next LAN or does not.

The bridge examines the source address in a frame and places this address in a routing table, to be used for future routing decisions.

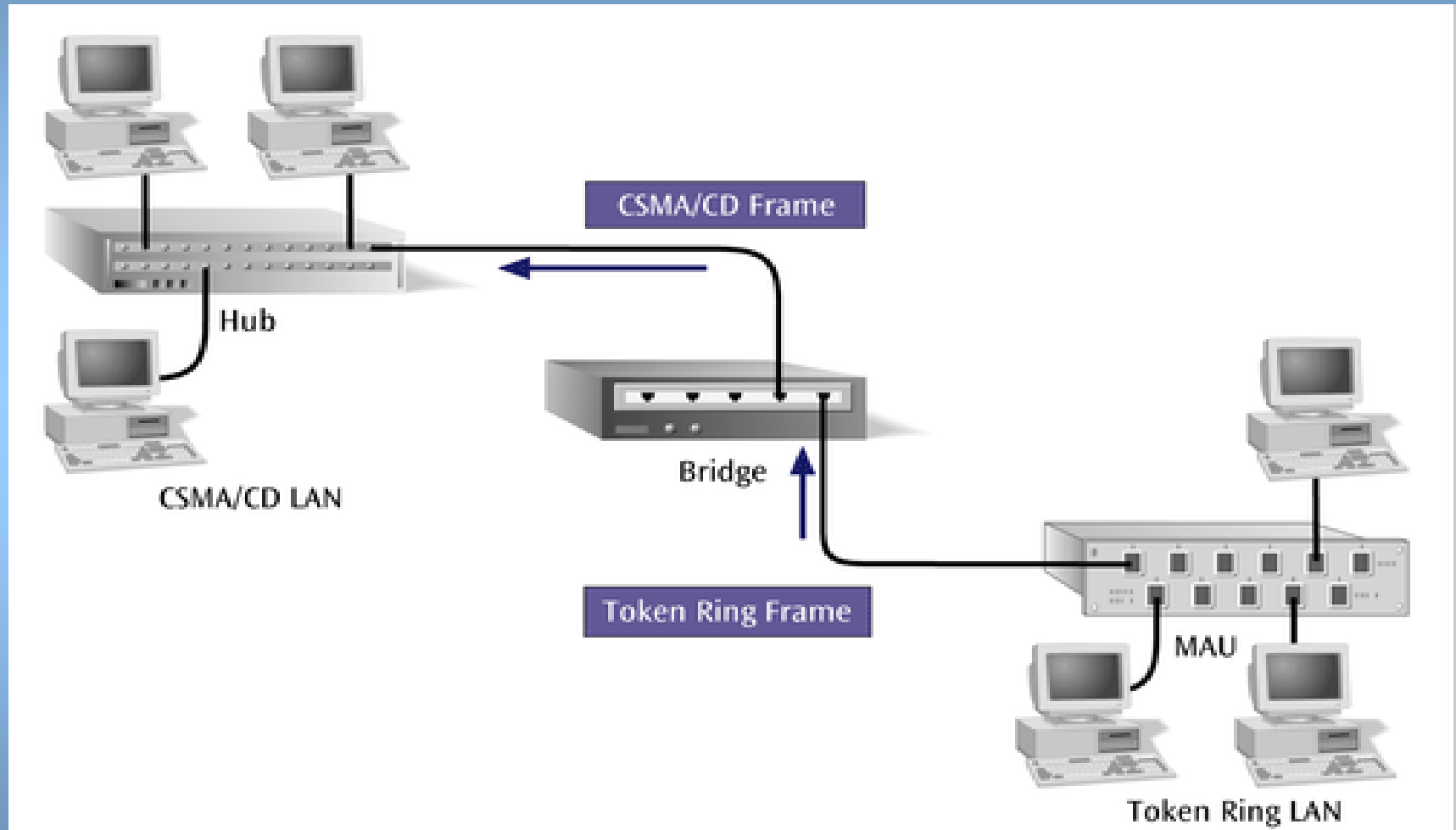
Bridges vs Routers

Bridge: A bridge is a device that connects two segments of the *same* network. The two networks being connected can be alike or dissimilar. Unlike routers, bridges are *protocol-independent*. They simply forward packets without analyzing and re-routing messages.

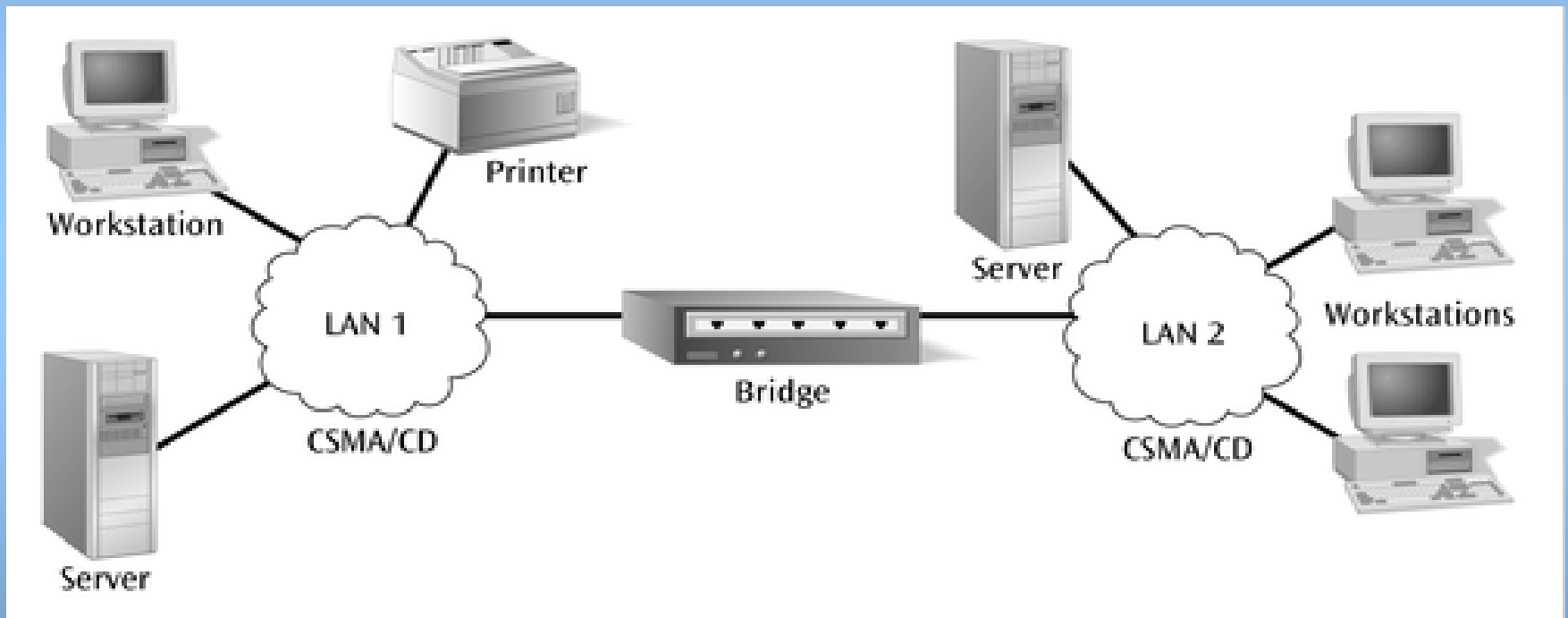
Router: A router is a device that connects two *distinct* networks. Routers are similar to bridges, but provide additional functionality, such as the ability to filter messages and forward them to different places based on various criteria. The Internet uses routers extensively to forward packets from one host to another.

- Based on these definitions we can see that key difference between a bridge and router is that a bridge does not look at protocols and a router does. A bridge does not look at traffic for the purpose of allowing or disallowing it, and it does not decide what to do with certain types of traffic; it simply moves data from one network to another. Whereas a router examines protocols and decides what to do with each packet based on defined criteria.

A bridge interconnecting two dissimilar LANs



Bridge interconnecting two identical LANs



Transparent Bridges

A transparent bridge does not need programming but observes all traffic and builds routing tables from this observation.

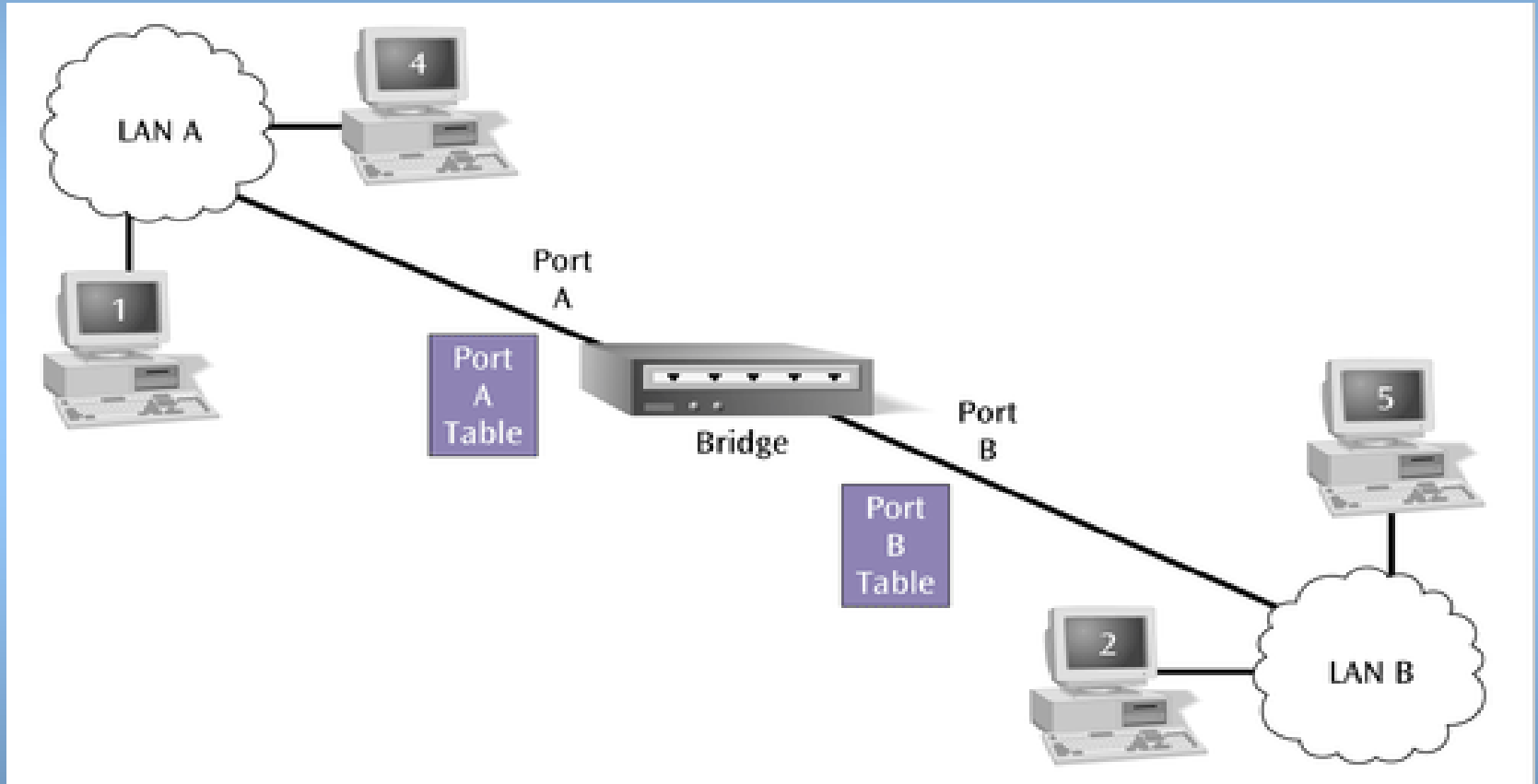
This observation is called backward learning.

Each bridge has two connections (ports) and there is a routing table associated with each port.

A bridge observes each frame that arrives at a port, extracts the source address from the frame, and places that address in the port's routing table.

A transparent bridge is found with CSMA/CD LANs.

A bridge interconnecting two CSMA/CD networks has two internal port tables



Two internal port tables and their entries



Port A
Table



Port B
Table

(a) Empty Tables



Port A
Table



Port B
Table

(b) Workstation 1 Transmits



Port A
Table



Port B
Table

(c) Workstation 4 Transmits

Transparent Bridges

A transparent bridge can also convert one frame format to another.

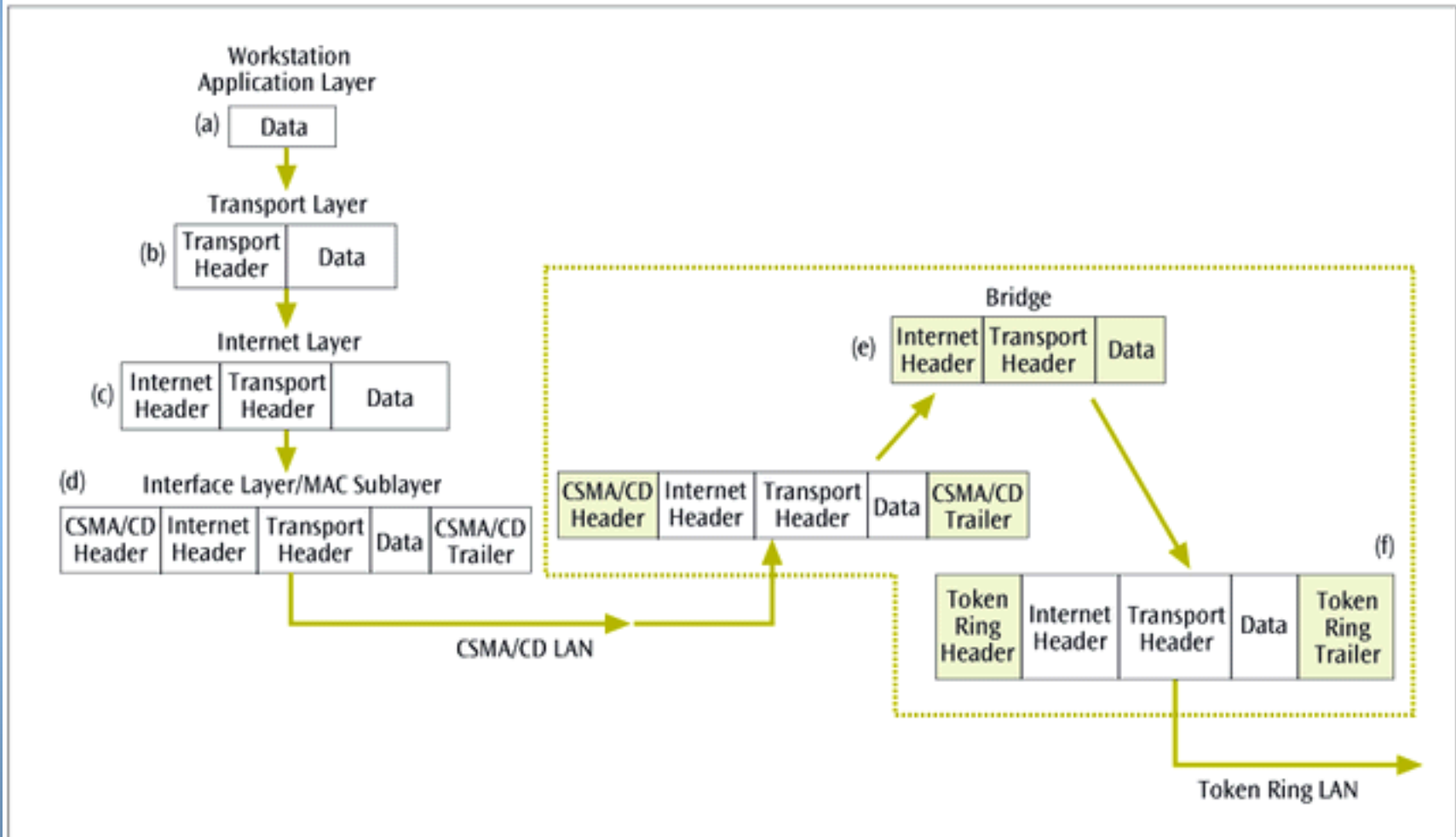
Note that some people / manufacturers call a bridge such as this a gateway or sometimes a router.

The bridge removes the headers and trailers from one frame format and inserts (encapsulates) the headers and trailers for the second frame format.

Figure 8-5

A data frame as it moves from a CSMA/CD LAN to a token ring LAN

Encapsulation



Source-routing Bridges

A source-routing bridge is found with token ring networks.

Source-routing bridges do not learn from watching tables.

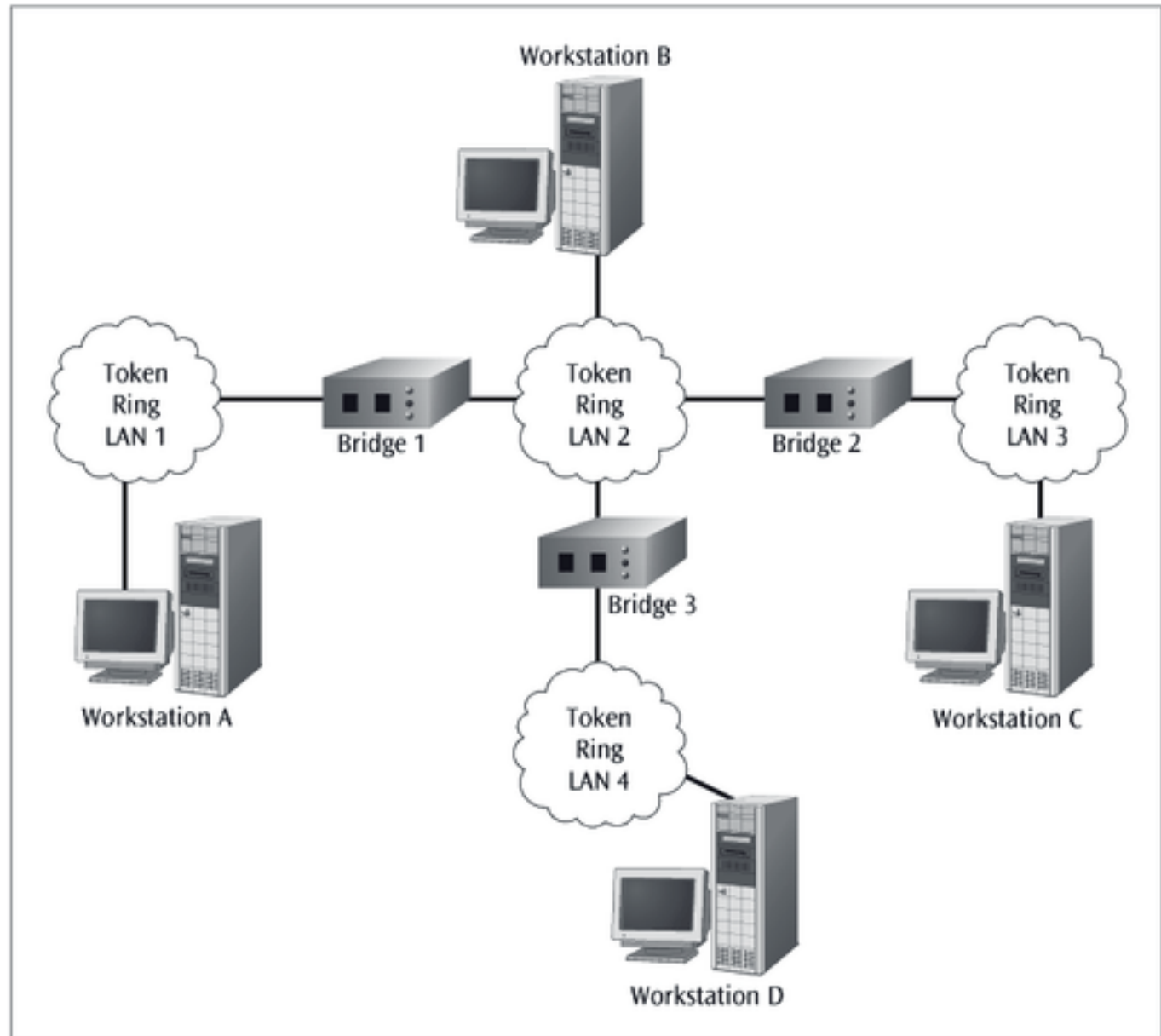
When a workstation wants to send a frame, it must know the exact path of network / bridge / network / bridge / network ...

If a workstation does not know the exact path, it sends out a discovery frame.

The discovery frame makes its way to the final destination, then as it returns, it records the path.

Figure 8-8

A token ring system composed of multiple token ring local area networks



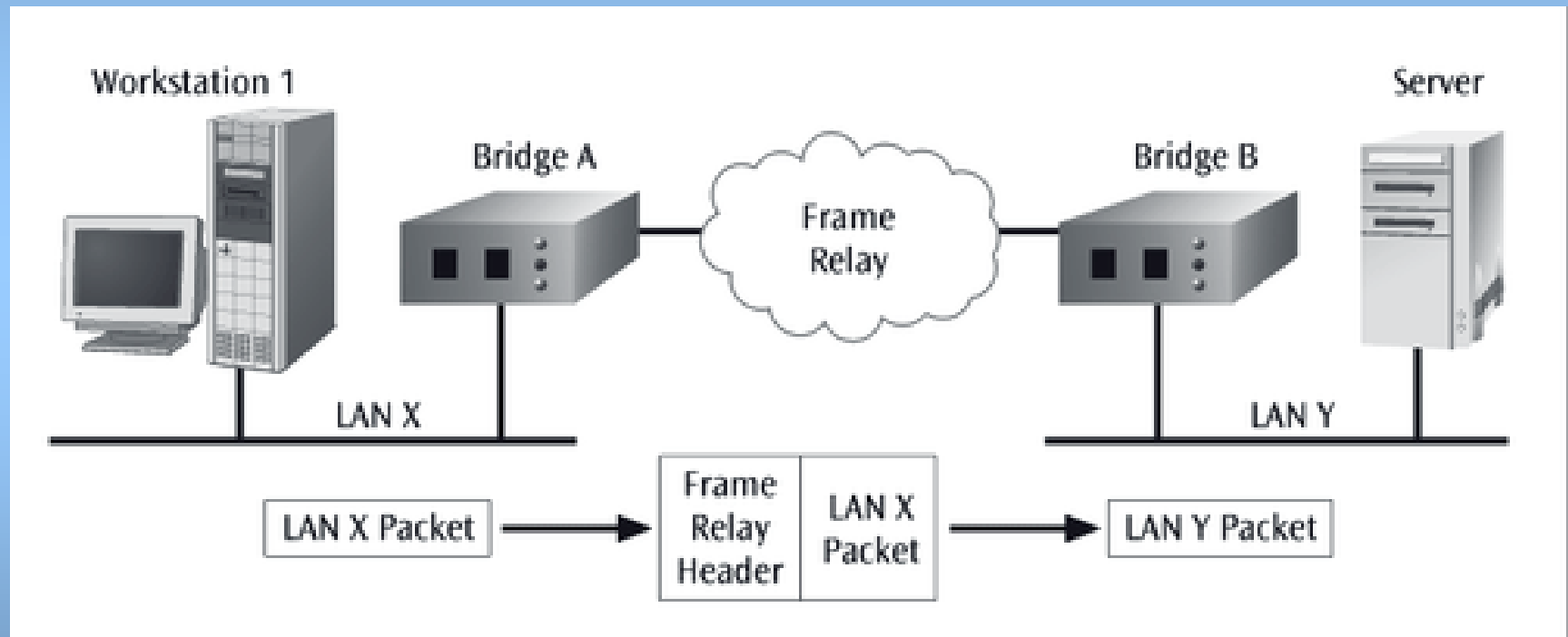
Remote Bridges

A remote bridge is capable of passing a data frame from one local area network to another when the two LANs are separated by a long distance and there is a wide area network connecting the two LANs.

A remote bridge takes the frame before it leaves the first LAN and encapsulates the WAN headers and trailers.

When the packet arrives at the destination remote bridge, that bridge removes the WAN headers and trailers leaving the original frame.

Two LANs with intervening frame relay network



Switches

A switch is a combination of a hub and a bridge.

It can interconnect two or more workstations, but like a bridge, it observes traffic flow and learns.

When a frame arrives at a switch, the switch examines the destination address and forwards the frame out the one necessary connection.

- Workstations that connect to a hub are on a *shared segment*.
- Workstations that connect to a switch are on a *switched segment*.

Switches

The backplane of a switch is fast enough to support multiple data transfers at one time.

A switch that employs a *cut-through architecture* is one that passes on the frame before the entire frame has arrived at the switch.

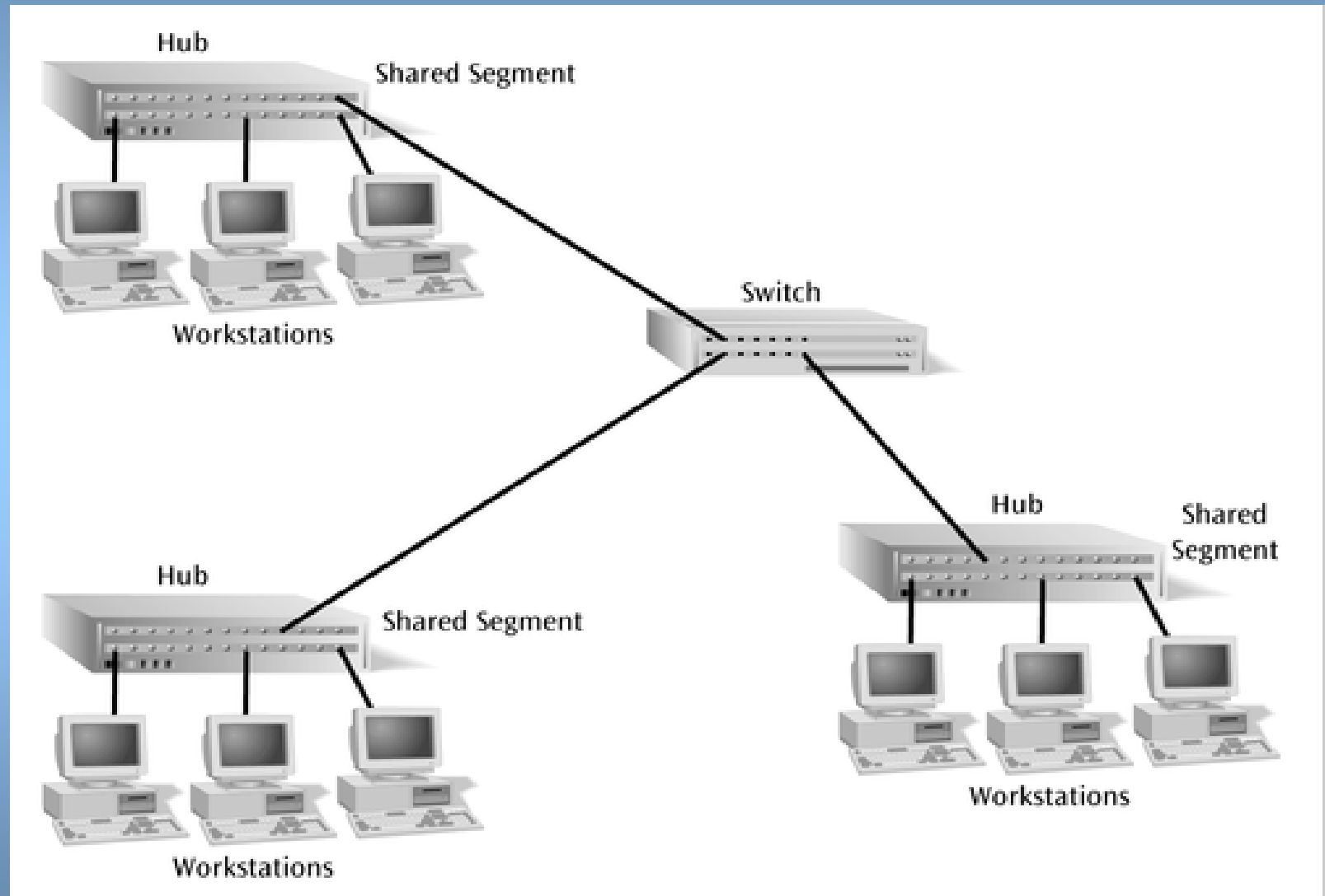
Multiple workstations connected to a switch use dedicated segments. This is a very efficient way to isolate heavy users from the network.

A switch can allow simultaneous access to multiple servers, or multiple simultaneous connections to a single server.

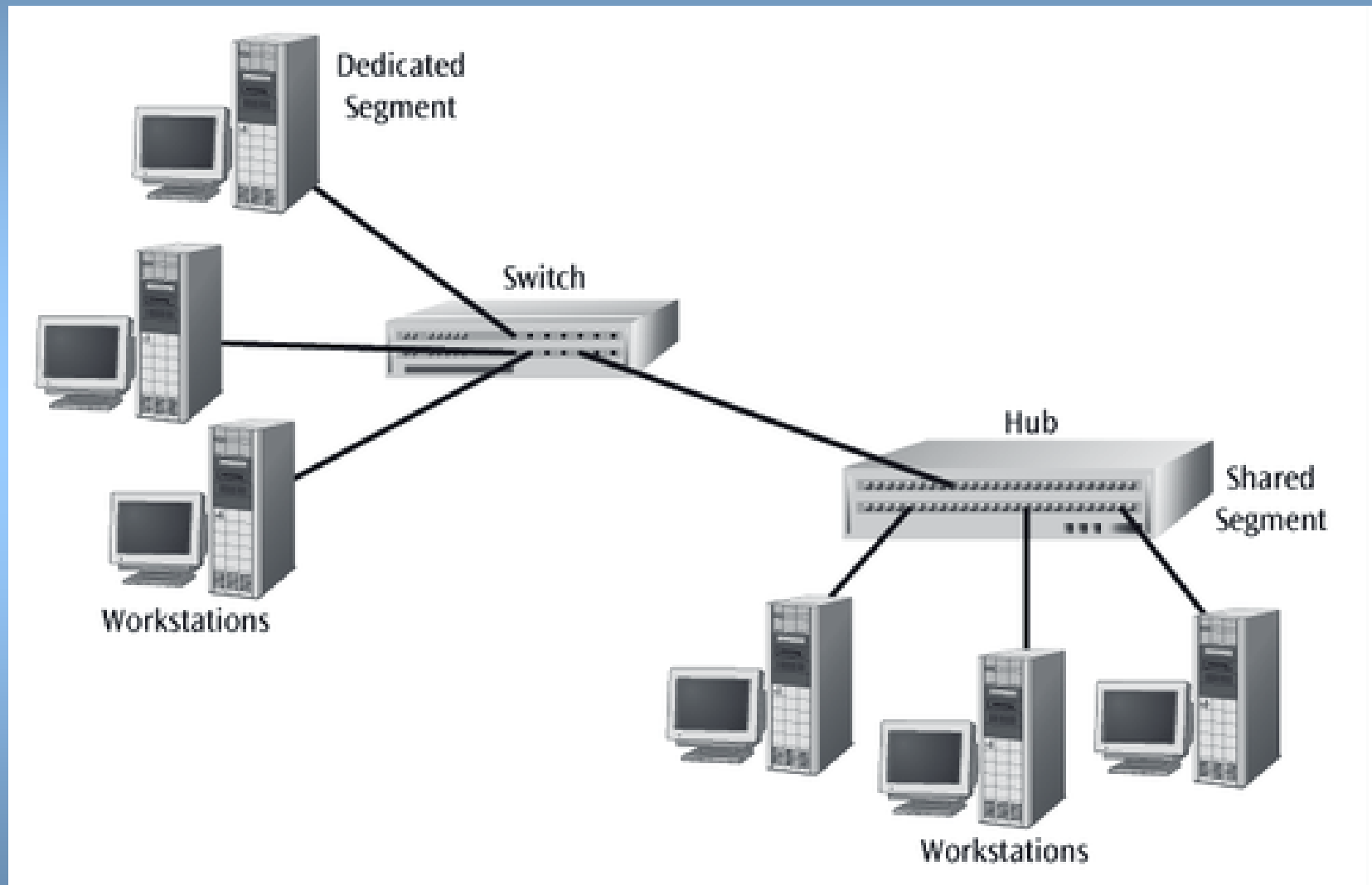
Switches vs routers

- Switches are considered layer-two devices, using MAC addresses to forward frames to their proper destination. Routers, layer-three devices, are much more complex, using microprocessor-based circuitry to route packets between networks based on their IP address. Routers provide the following services: route discovery; selection of the best route to a destination; adaptation to changes in the network; translation from one technology to another, such as Ethernet to token ring; packet filtering based on IP address, protocol, or UDP/TCP port number; and connection to a WAN.
- Because of the additional processing required for each packet, a router has a higher latency than a switch. In addition, a router requires an initial set-up sequence, in which the ports are programmed and certain protocols and characteristics are enabled or disabled. A switch may be simply plugged into the network, automatically learning how to forward frames as the network is used. Note that some protocols (e.g., NetBEUI) can't be routed; instead, they will pass through a switch. Finally, switches are used within networks to forward local traffic intelligently. Routers are used between networks to route packets between networks in the most efficient manner.

Workstations connected to a shared segment of a LAN



Workstations connected to a dedicated segment of a LAN

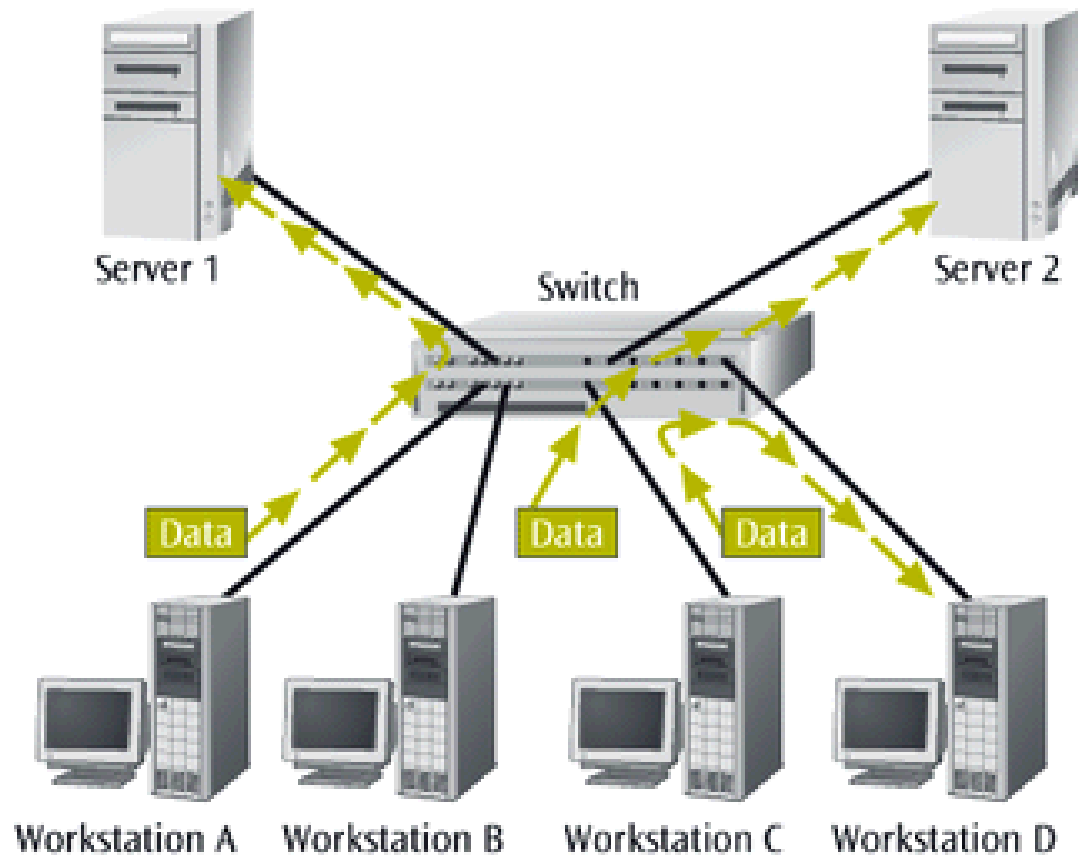


Switches

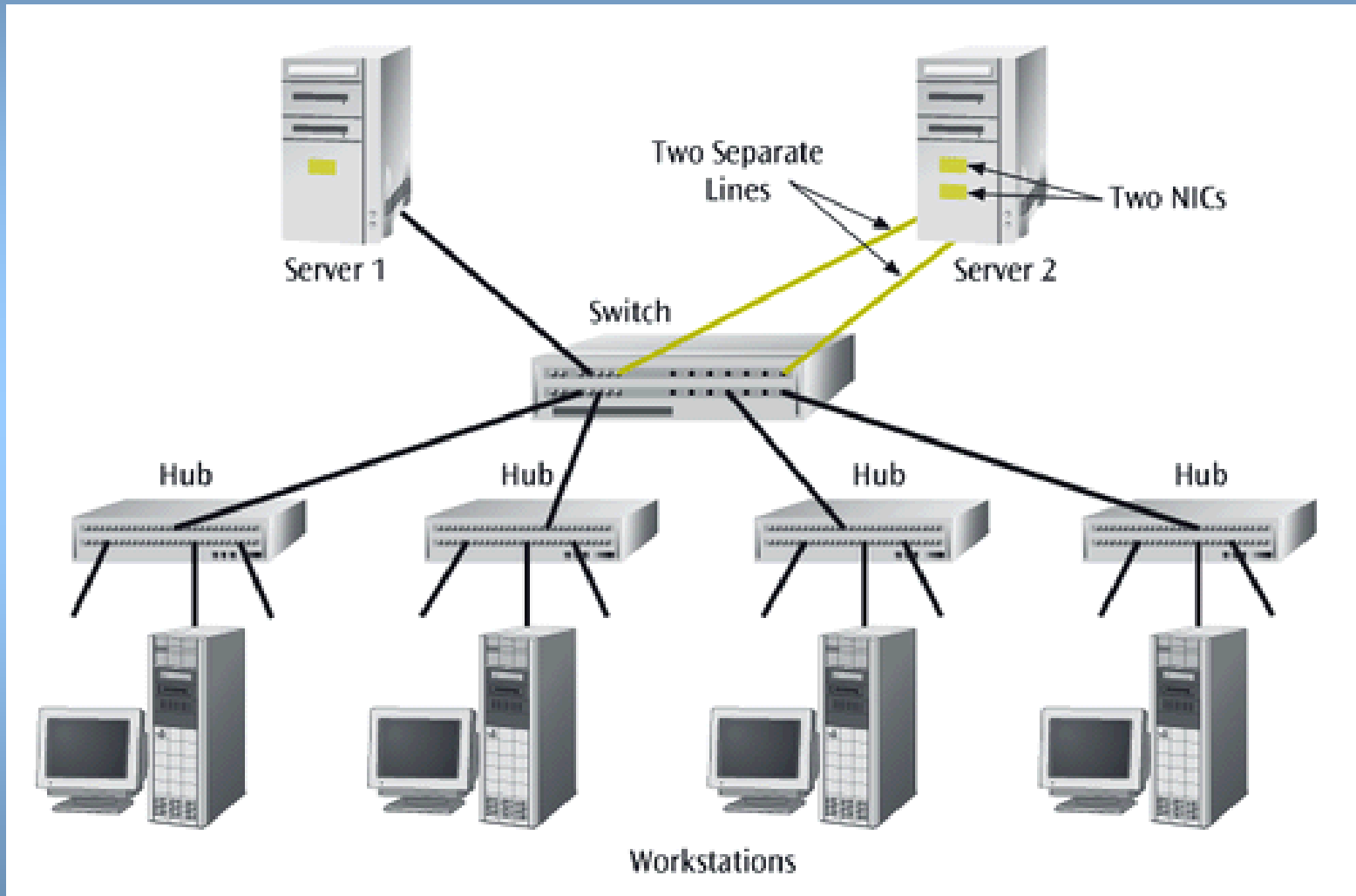
Major role: isolating traffic patterns and providing multiple access. This design is usually done by the network manager.

Switches are easy to install and have components that are hot-swappable.

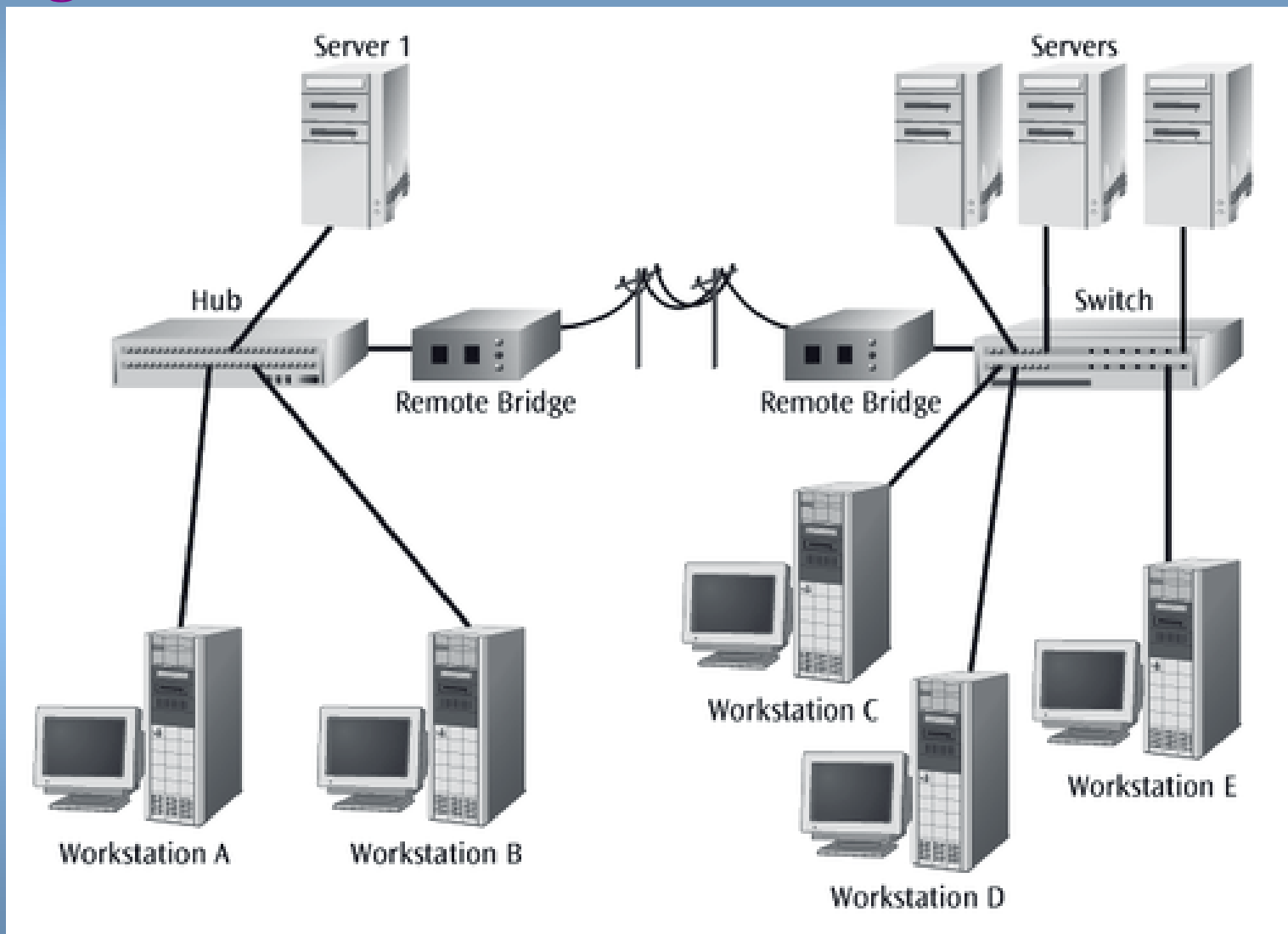
A Switch with Two Servers Allowing Simultaneous Access to Each Server



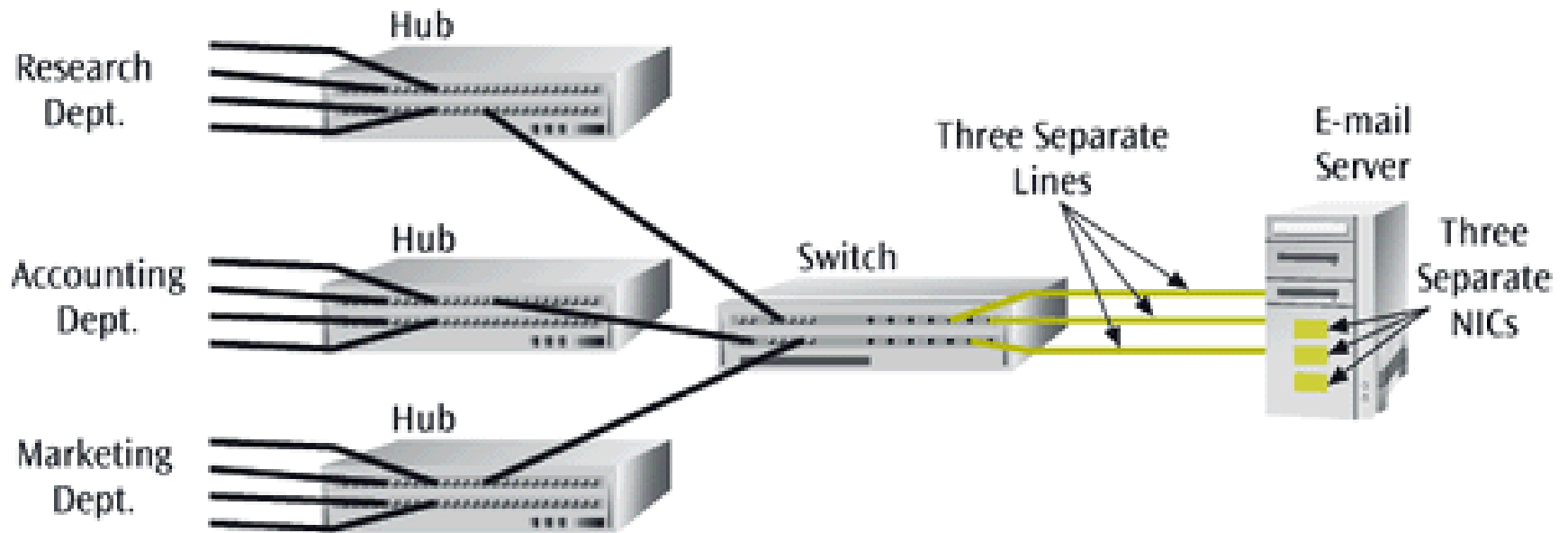
A server with two NICs and two connections to a switch



A pair of remote bridges and switch combination designed to isolate network traffic



Switch providing multiple access to an e-mail server



Full Duplex Switches

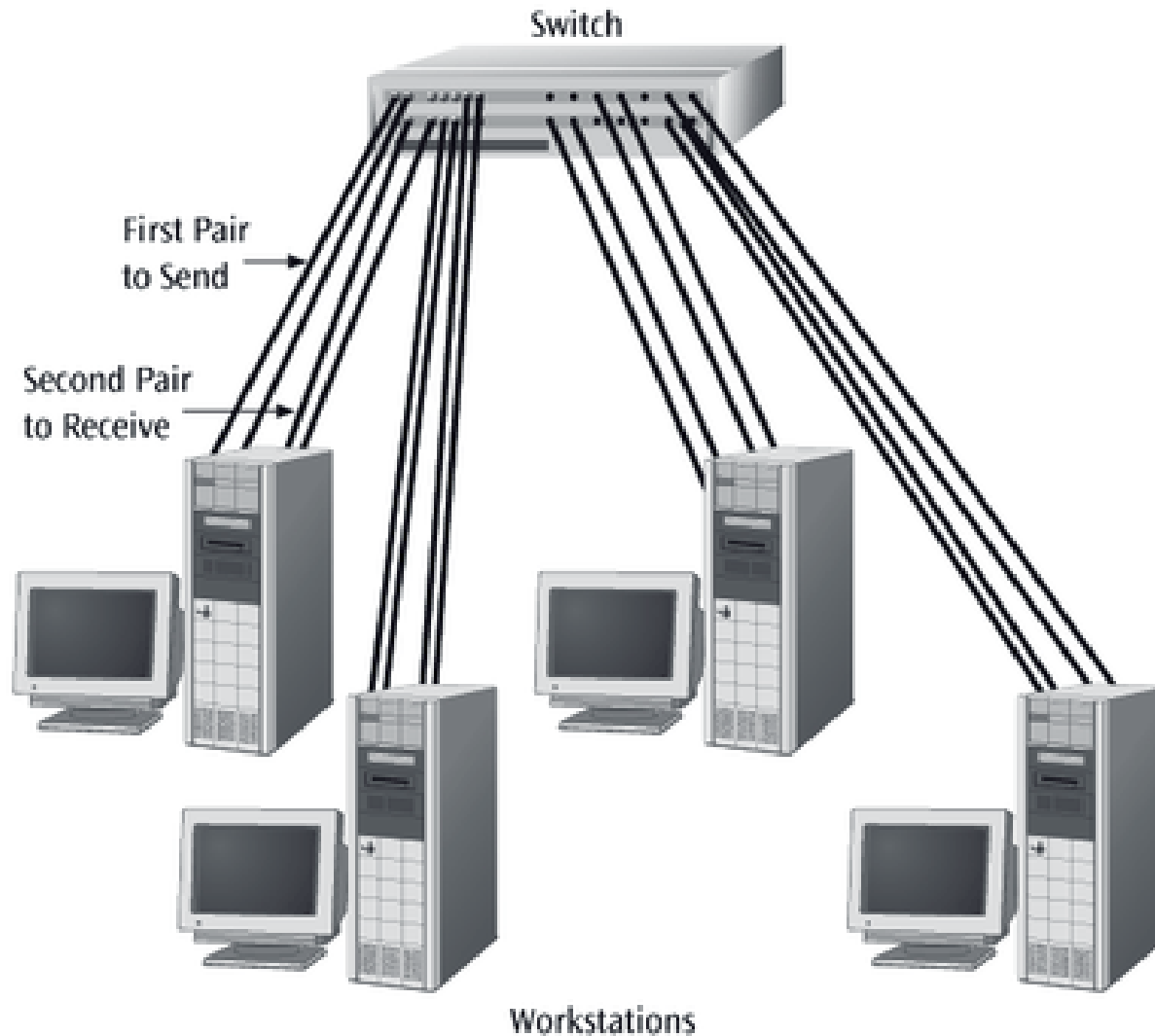
A full duplex switch allows for simultaneous transmission and reception of data to and from a workstation.

Problem with ethernet – half duplex.

This full duplex connection helps to eliminate collisions.

To support a full duplex connection to a switch, two sets of wires are necessary - one for the receive operation and one for the transmit operation.

Full duplex connection of workstations to a LAN switch



Network Servers

Network servers provide the storage necessary for LAN software.

They are usually the focal point for the network operating system.

Increasingly, network servers are functioning as bridges, switches, and routers. By adding the appropriate card, a server can assume multiple functions.

Routers (really specialized computers)

The device that connects a LAN to a WAN or a WAN to a WAN (the INTERNET! – uses IP addresses).

A router accepts an outgoing packet, removes any LAN headers and trailers, and encapsulates the necessary WAN headers and trailers.

Because a router has to make wide area network routing decisions, the router has to dig down into the network layer of the packet to retrieve the network destination address.

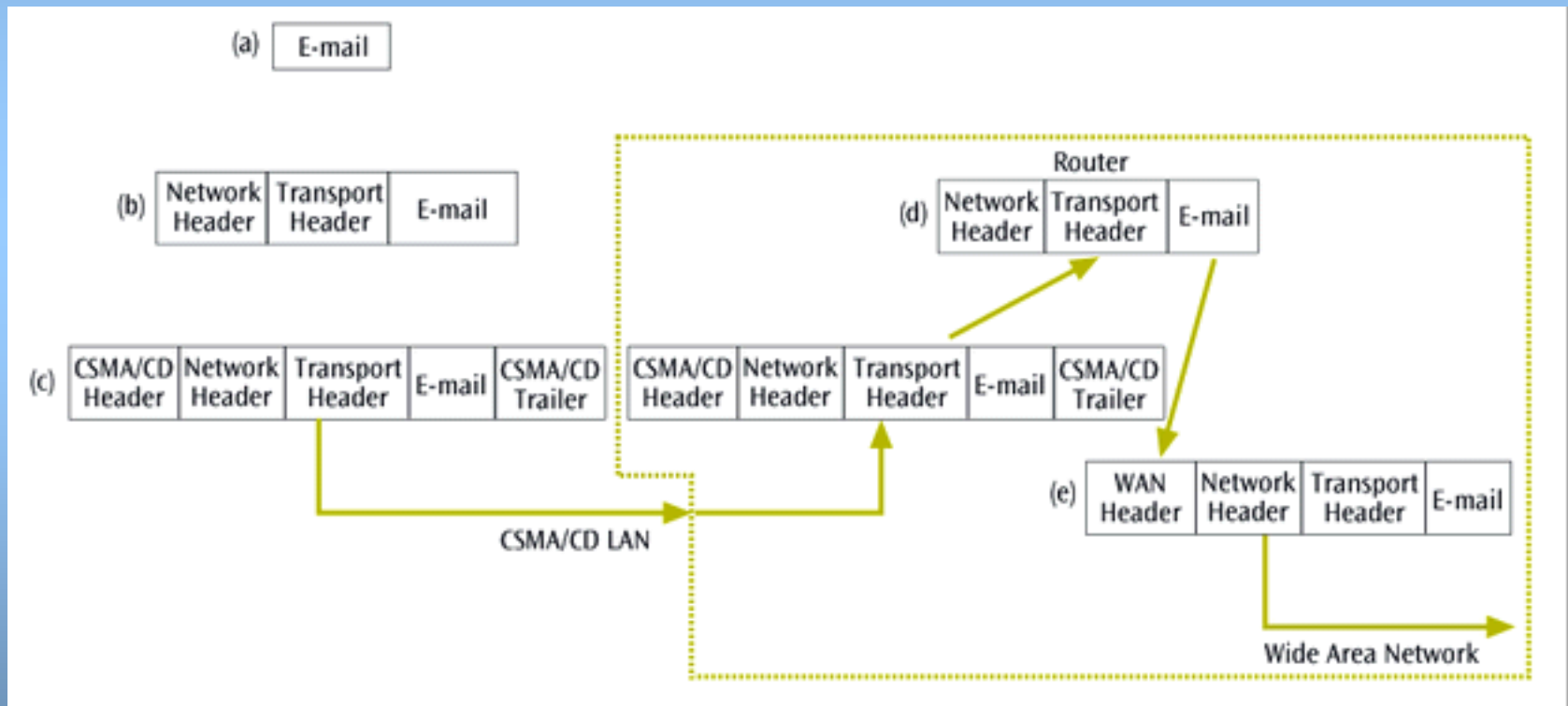
Routers

Thus, routers are often called “layer 3 devices”. They operate at the third layer, or OSI network layer, of the packet.

Routers often incorporate firewall functions.

An example of a router’s operation is shown on the next slide.

Router conversion of CSMA/CD data frame to an internet frame as it passes from a LAN to the internet



Wireless connections: Access Point as a Bridge

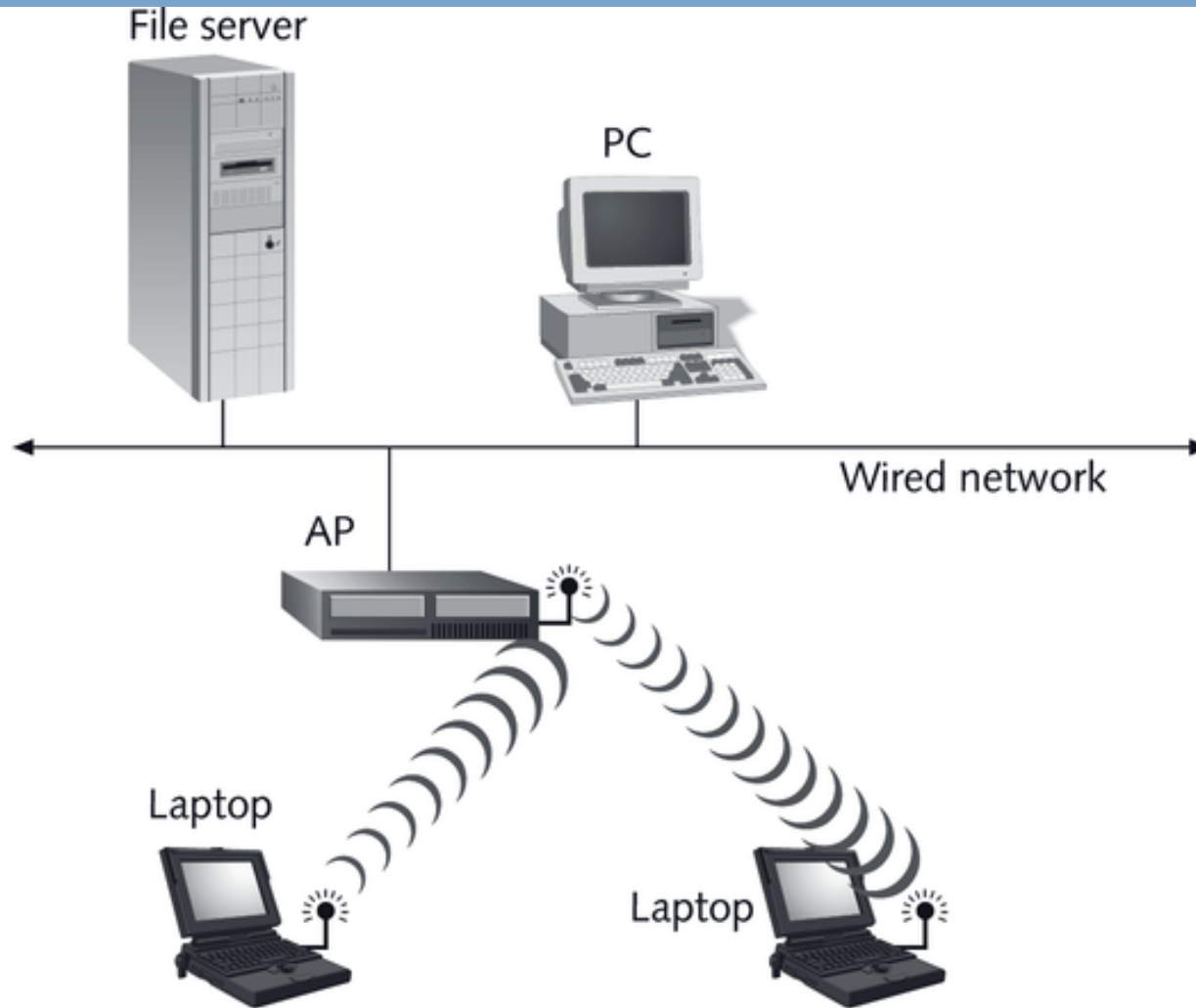


Figure 6-7 Access point as a bridge

Connections (in general)

Bridges for LANs and hubs.

Switches for LANs and workstations.

Routers for LANs and WANs (the Internet).

Linksys Router for Home Network

Linksys 4-Port Cable/DSL Router

Brand/Model: LKS BEFSR41




\$79.99

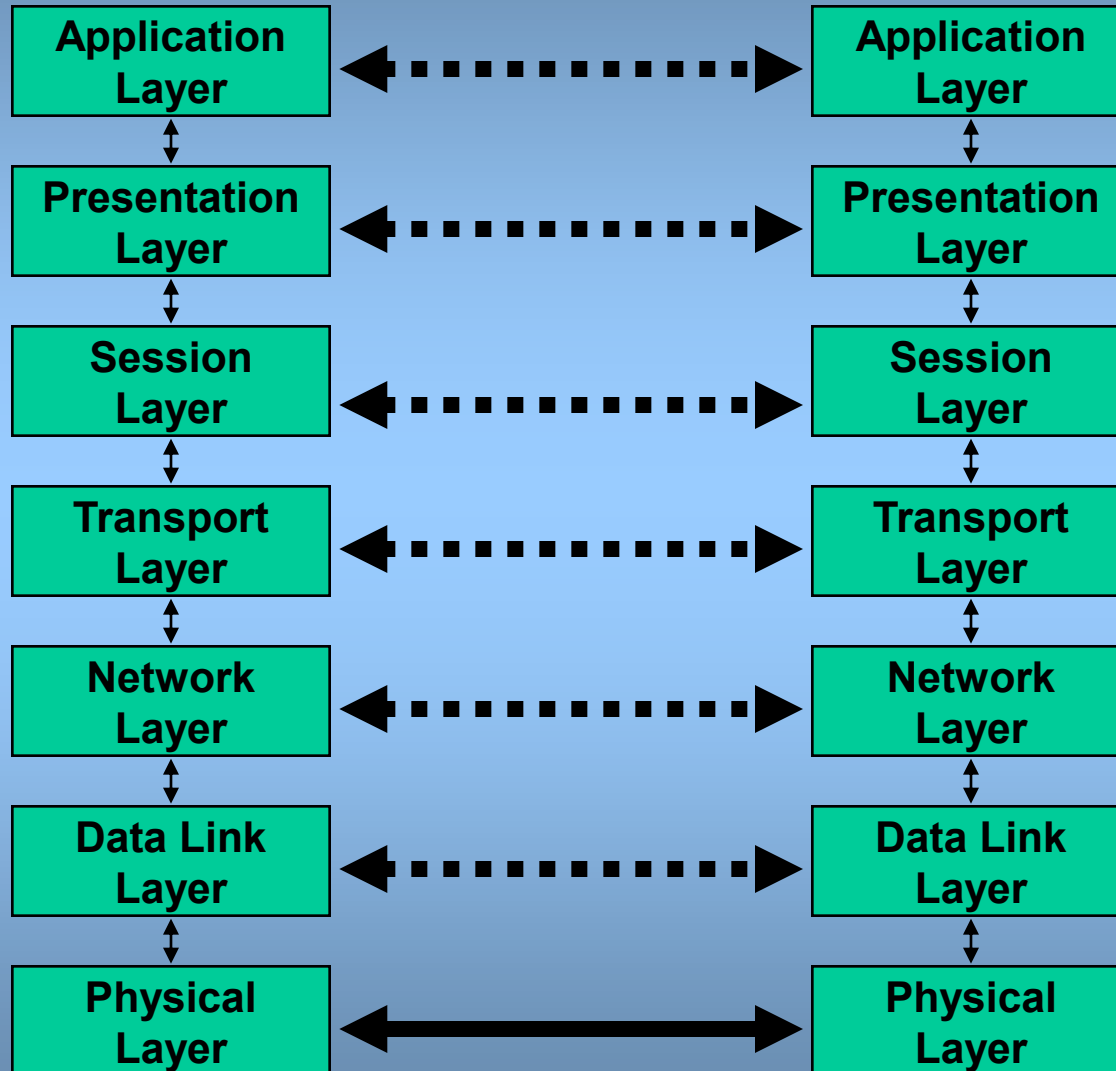


Linksys Router for Home Network

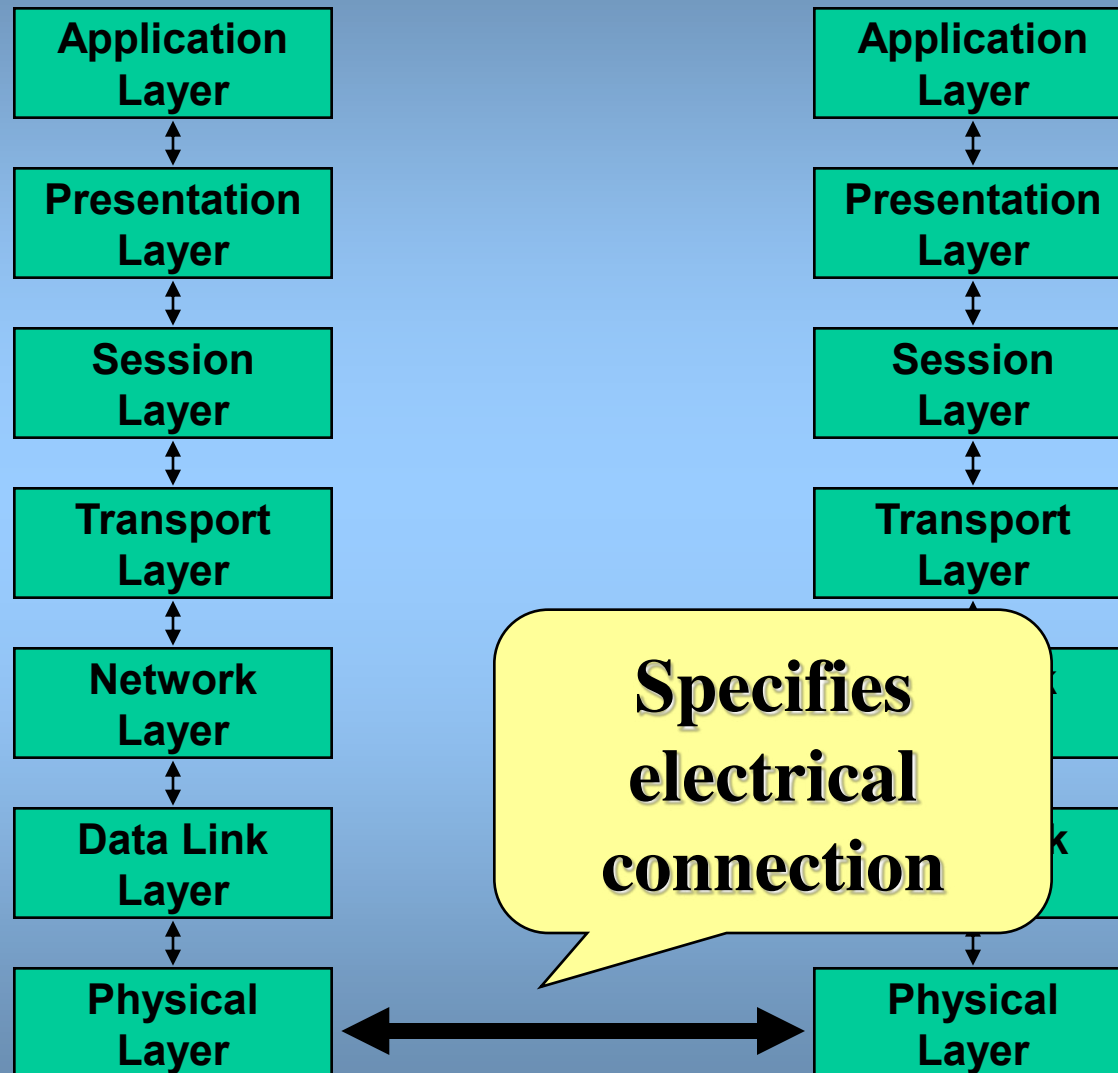
Product Specs

Specification	Linksys 4-Port Cable/DSL Router
Warranty: Months Labor/Parts	12/12
Product Description	Linksys EtherFast 4-Port Cable/DSL Router
Type of Device	Routers/Hubs
>	Connects to a Broadband Modem & a 10/100 Ethernet backbone
>>	Equipped with a 4-port 10/100 switch
>>>	Administrators can block specific internal users' Internet access with filtering & it can serve as an Internet firewall against unwanted outside intruders
>>>>	Dramatically speeds up your gaming and multimedia connections
System Requirements	This unit requires an external cable or DSL modem with an Ethernet RJ-45 interface
Other Features	Supports up to 253 users; Connects all of your PCs to the Internet with only one purchased IP address; Configurable through any networked PC's Web Browser; Can act as either a DHCP server or client; Compatible with all standard Internet applications.
<p>All prices, specifications & items are subject to change without notice. Be sure to check our rebates section to see if there are any current rebates on these products. Prices in your local Circuit City store may vary due to local sales and competitive adjustments.</p> <p>See our On-line Low Price Guarantee!</p>	
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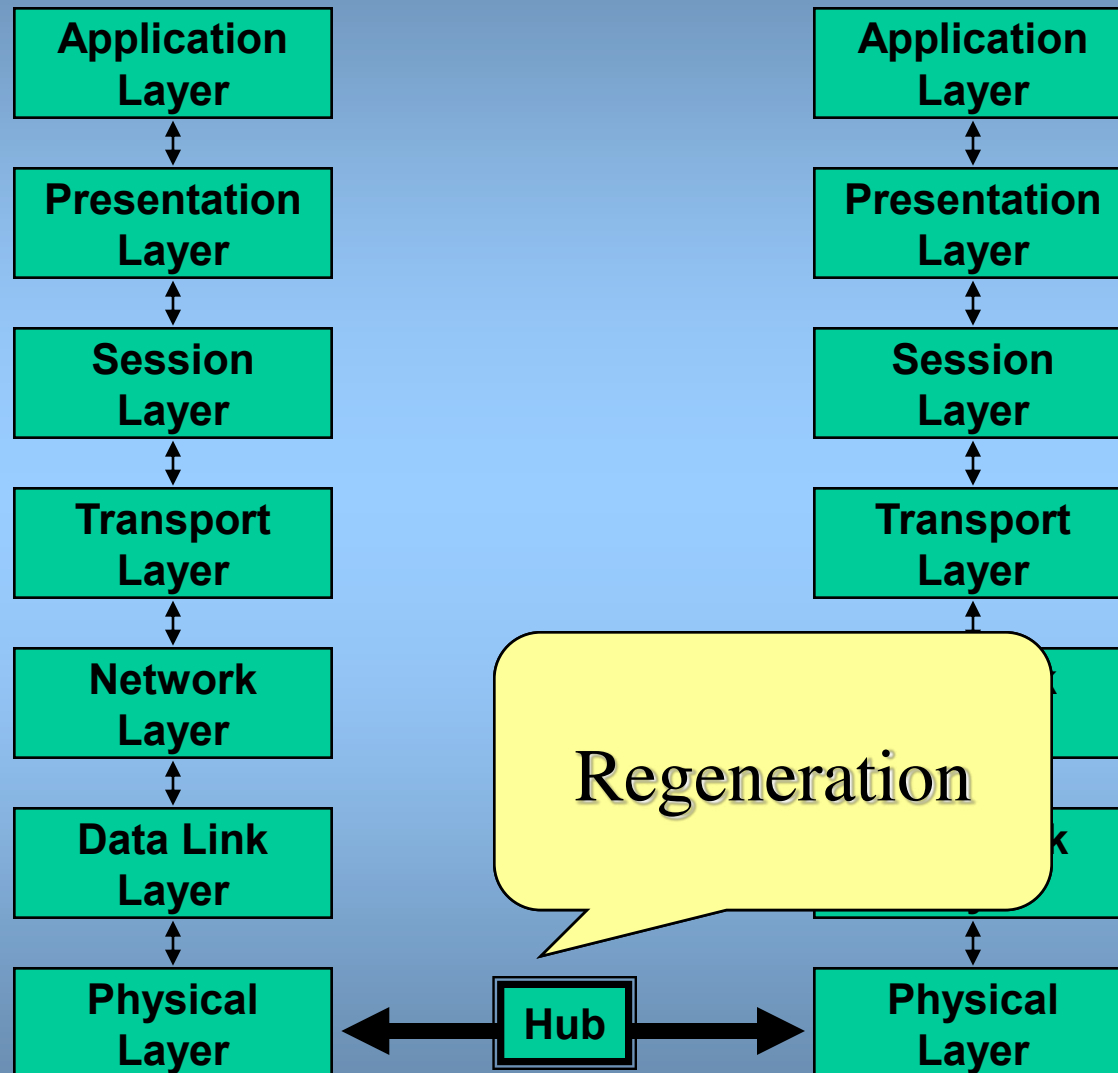
The OSI Reference Model



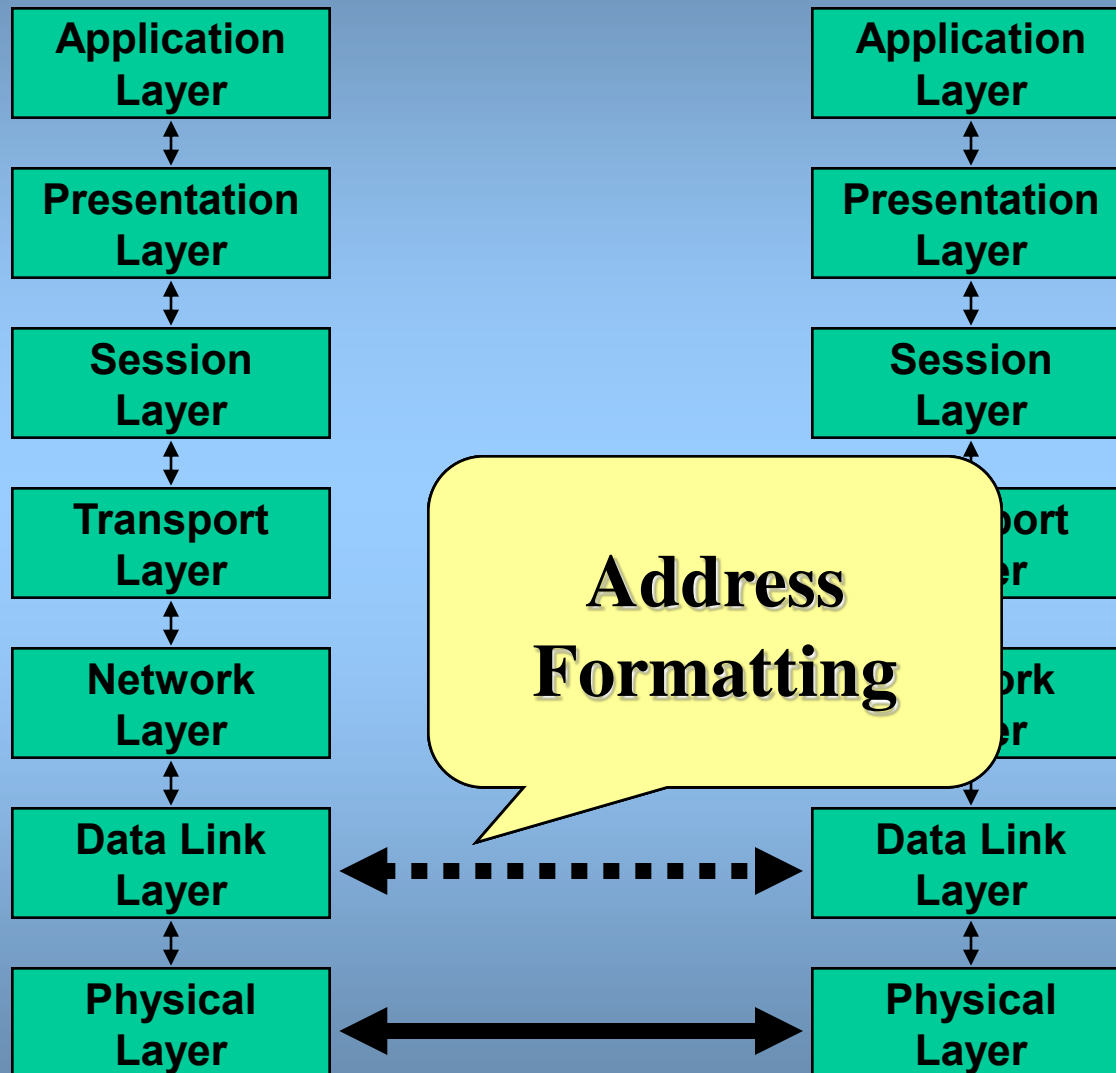
The Physical Layer Connection



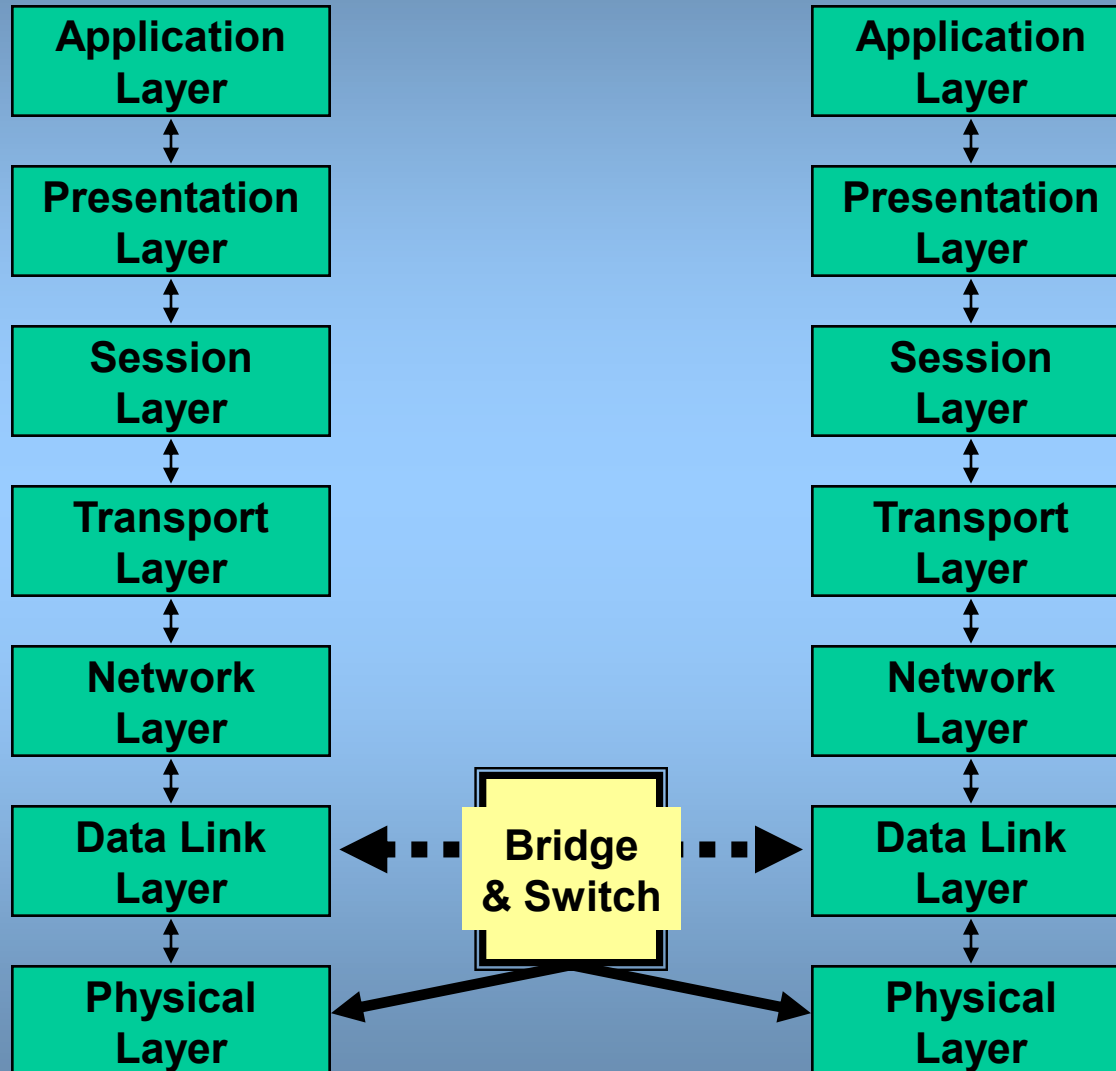
The Physical Layer Connection



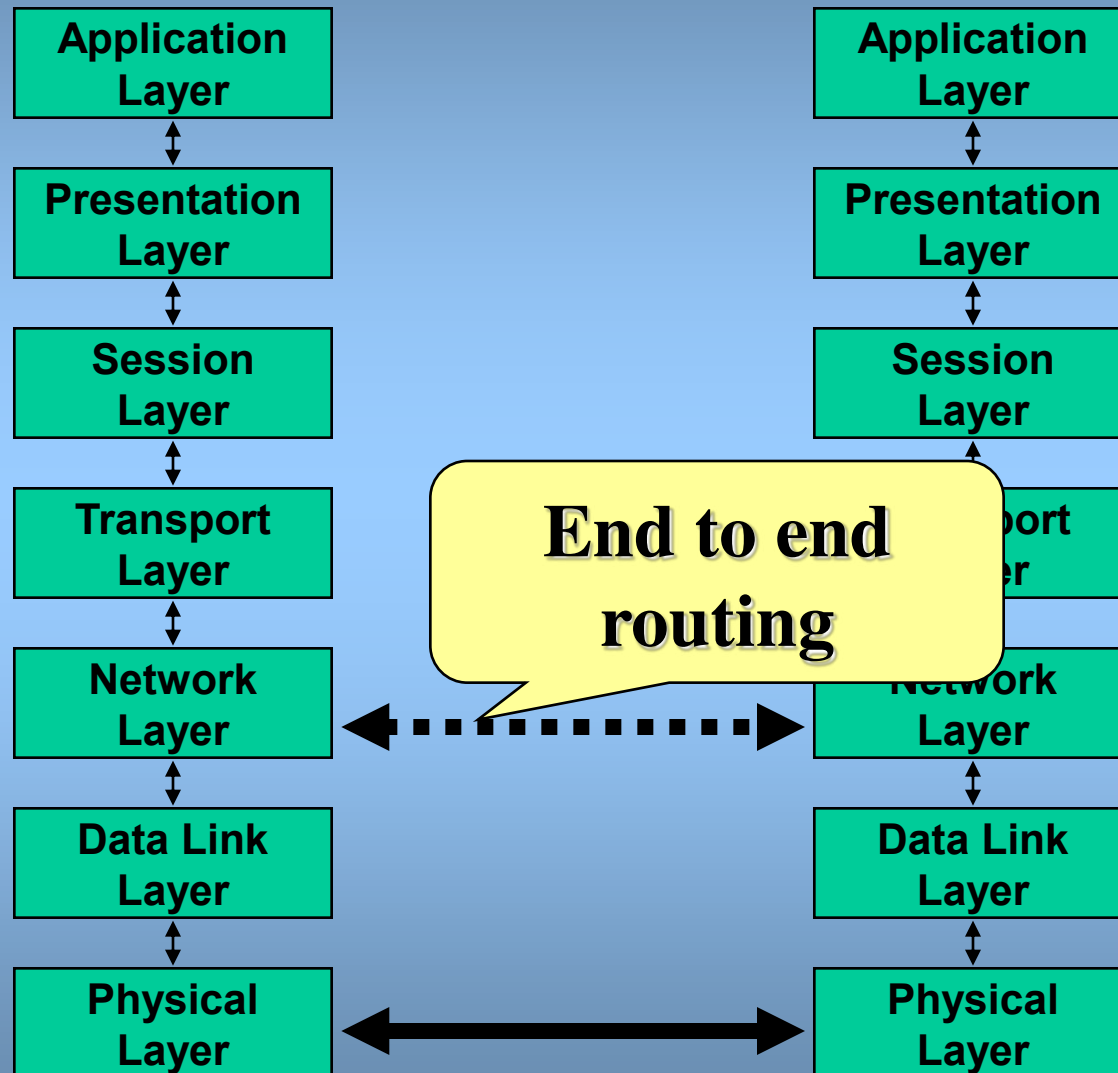
The Data Link Connection



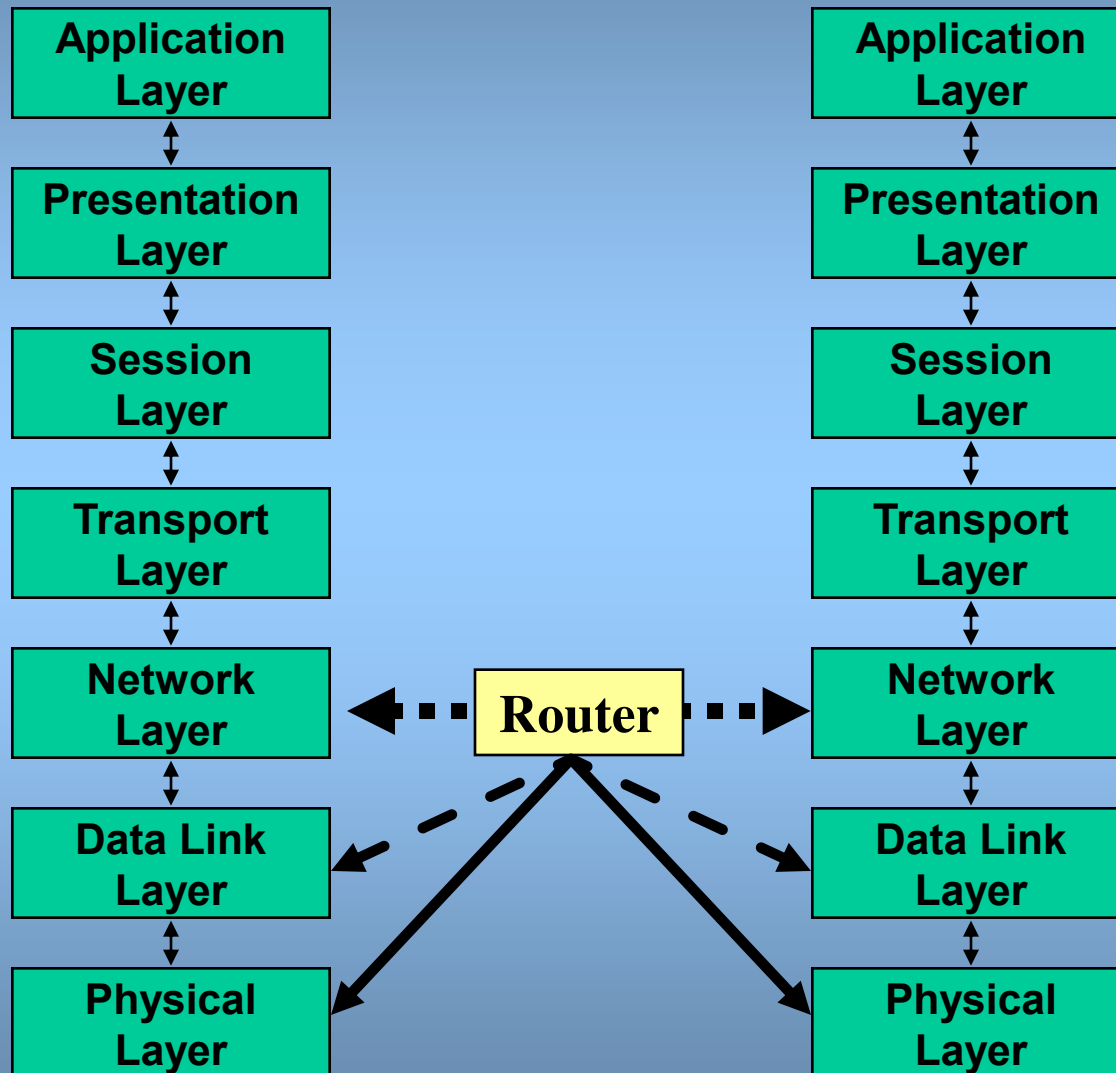
The Data Link Connection



The Network Layer Connection



The Network Layer Connection



Data Communications and Computer Networks

Chapter 8

QoS (Quality of Service):

Concept that data transmission rates, error rates, and other network characteristics can be measured, improved and guaranteed in advance. Routers play an important role in this business and engineering concept.

Data Communications and Computer Networks

Chapter 8

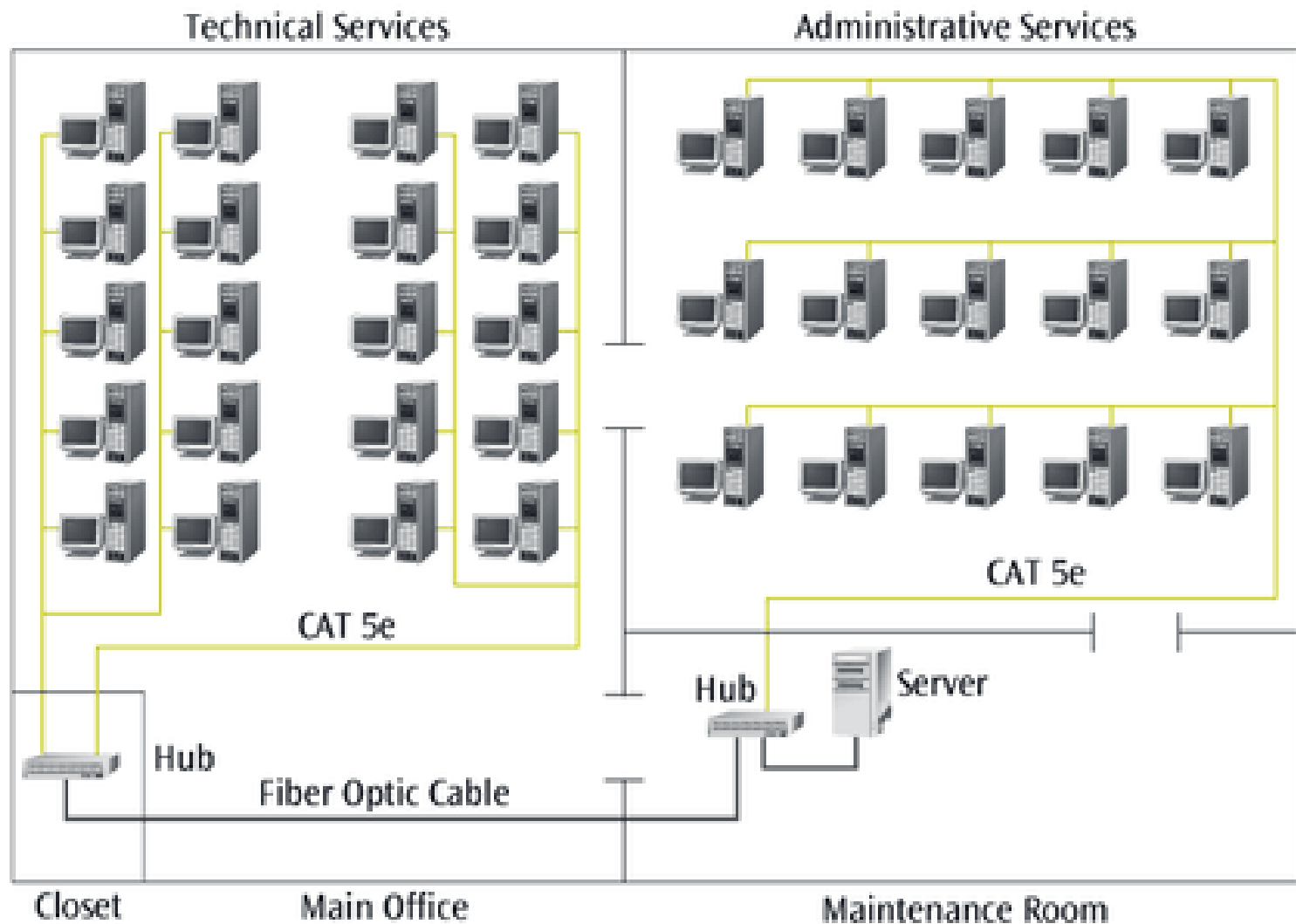
LAN Internetworking In Action: A Small Office Revisited

Recall the In Action example from Chapter Seven.

A small office with 20 workstations in one room and 15 workstations in another room were connected to a server via 100BaseTX.

One hub was kept in a closet near the 20 workstations while a second hub was near the server.

Hannah's earlier small business solution



Data Communications and Computer Networks

Chapter 8

LAN Internetworking In Action: A Small Office Revisited

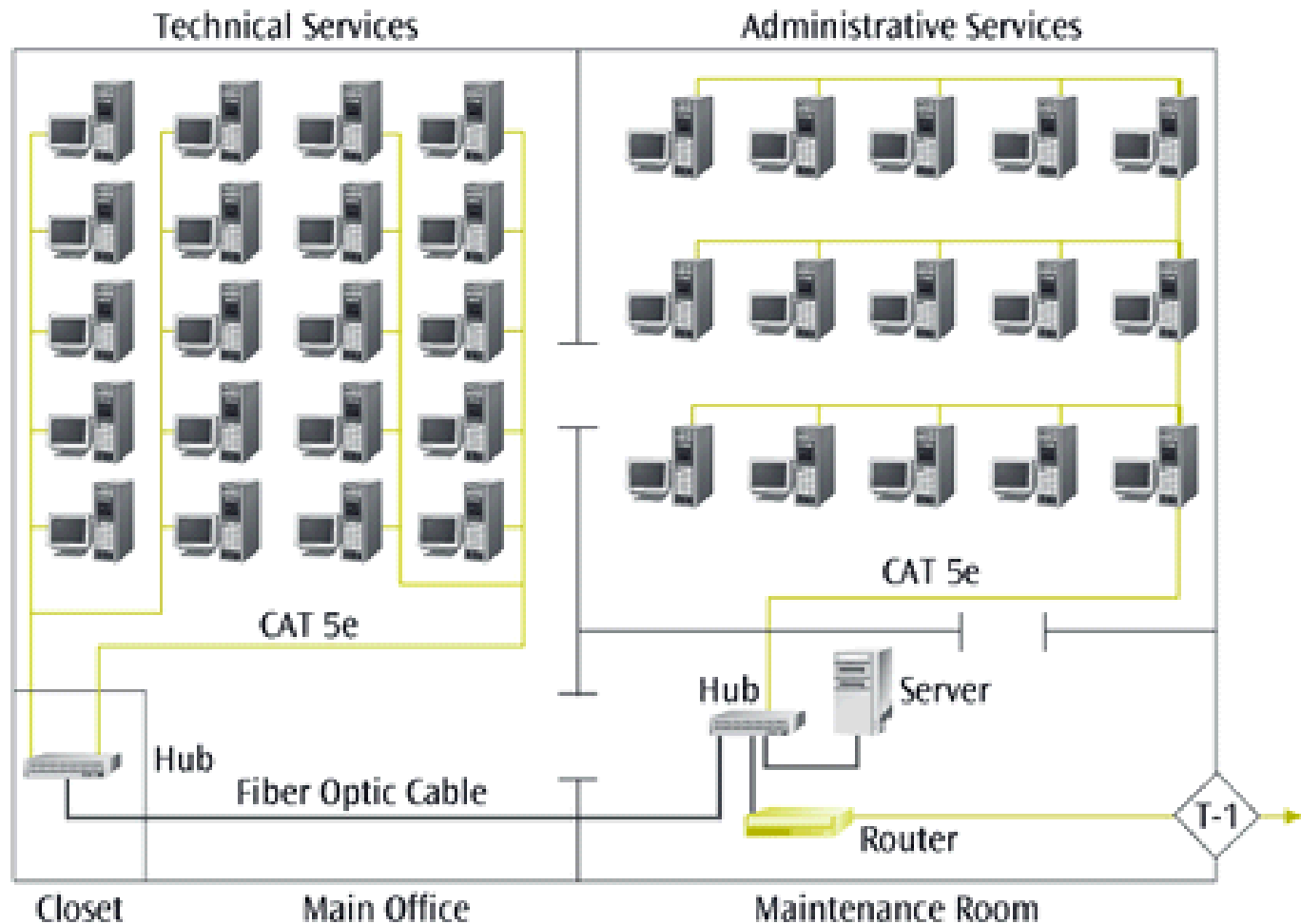
Now Hannah wants to connect the LAN to the Internet.

She adds a router next to the server and connects it to the hub.

She connects the router to a high-speed telephone line such as a T-1 service.

She will also have to program the router to perform IP addressing and firewall functions.

The modified network with a router and high-speed phone line



Data Communications and Computer Networks

Chapter 8

LAN Internetworking In Action: A Small Office Revisited

Now network usage is so high that Hannah must consider segmenting the network.

She decides to install a database server near the original server and replace both hubs with switches.

Upgraded network with additional server and switches in the place of hubs

