Networking and Internet – Introduction to Computer (計算機概論)

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Some of the slides from [Mike Pangburn]

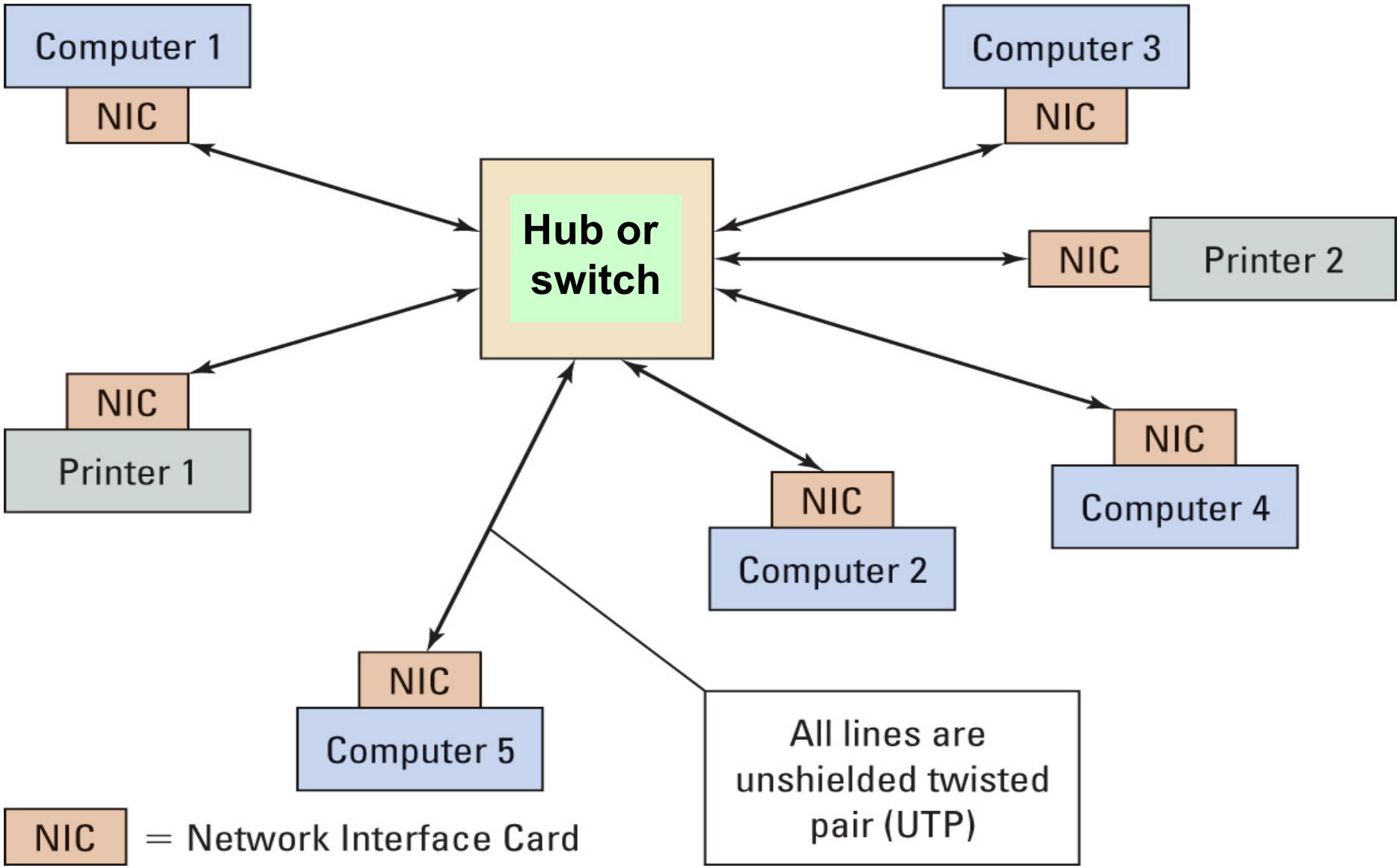
Networking: Computers on the Internet

- 1969 – 4
- 1971 – 15
- 1984 – 1000
- 1987 – 10,000
- 1989 – 100,000
- 1992 – 1,000,000
- 1996 – 10,000,000
- 2001 – 100,000,000
- …

Evolution of the Internet

- 1988 - businesses begin to connect to system for research purposes
- 1989 ARPANET - 100,000 nodes
- 1989 link email between CompuServe and ARPANET
- 1990 ARPANET becomes the Internet

Typical LAN "Local Area Network"



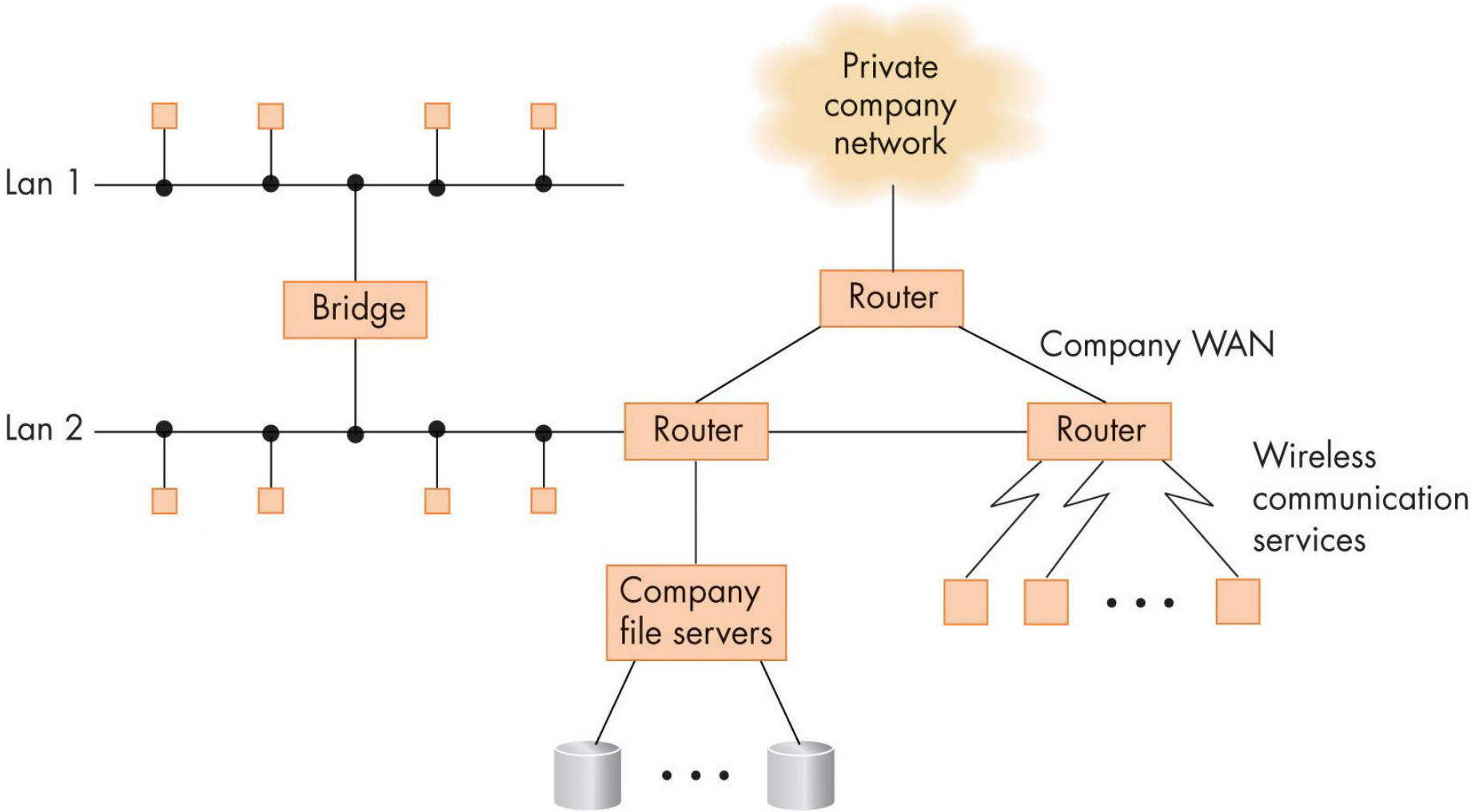


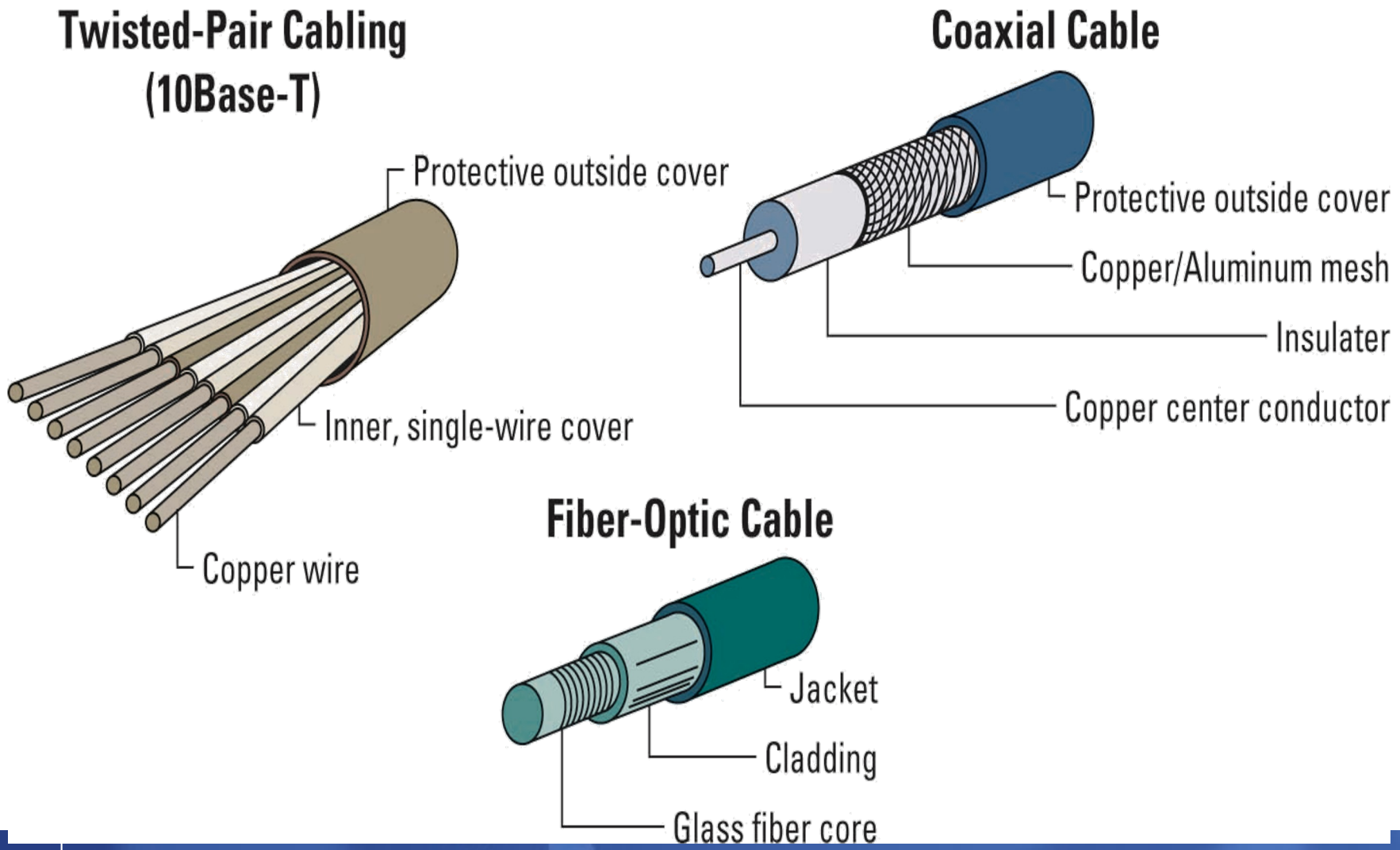
Figure 7.8(a)

Structure of a Typical Company Network

Network Hardware

- The most essential networking hardware devices for us to learn about are:
  - Cables
  - NICs
  - Hubs
  - Switches
  - Routers

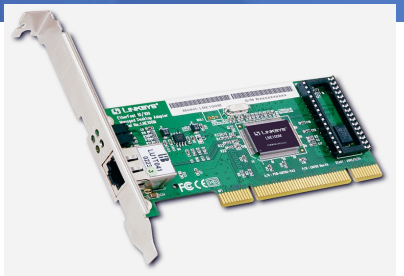
Wire Media


Twisted-Pair Cabling
(10Base-T)
Protective outside cover
Inner, single-wire cover
Copper wire
Coaxial Cable
Protective outside cover
Copper/Aluminum mesh
Insulater
Copper center conductor
Fiber-Optic Cable
Jacket
Cladding
Glass fiber core

Media Bandwidth

Line Type	Use	Maximum Speed
Telephone line (twisted pair copper lines)	Dial-up modem	56 Kbps
	DSL modem	1.544 Mbps
	WAN—T1—using a pair of telephone lines	1.544 Mbps
Coaxial cable	Cable modem	Upstream to 256 Kbps Downstream to 10 Mbps (usually much less, however)
Unshielded twisted pair (UTP)	LAN	100 Mbps **Now up to 1000Mbps = 1Gbps**
Optical fiber cable	LAN and WAN—T3, OC-768, etc.	40 Gbps or more
Satellite	WAN—OC-768, etc.	40 Gbps or more

NIC – a "Network Interface Card"



- Every networked device must have a NIC
  - Most laptops today have both a wired NIC and a wireless NIC
- Each NIC has an IP address (it's "logical address") and a physical address called a MAC address.
  - Each NIC is given an address at the factory that is the device's physical address or MAC address.
  - No two NIC devices will ever have the same MAC address.
- MAC Addresses are used within a LAN
  - IP addresses allow routers to route a message across different networks
  - when a message reaches the correct destination network, the correct NIC is identified via its MAC address.

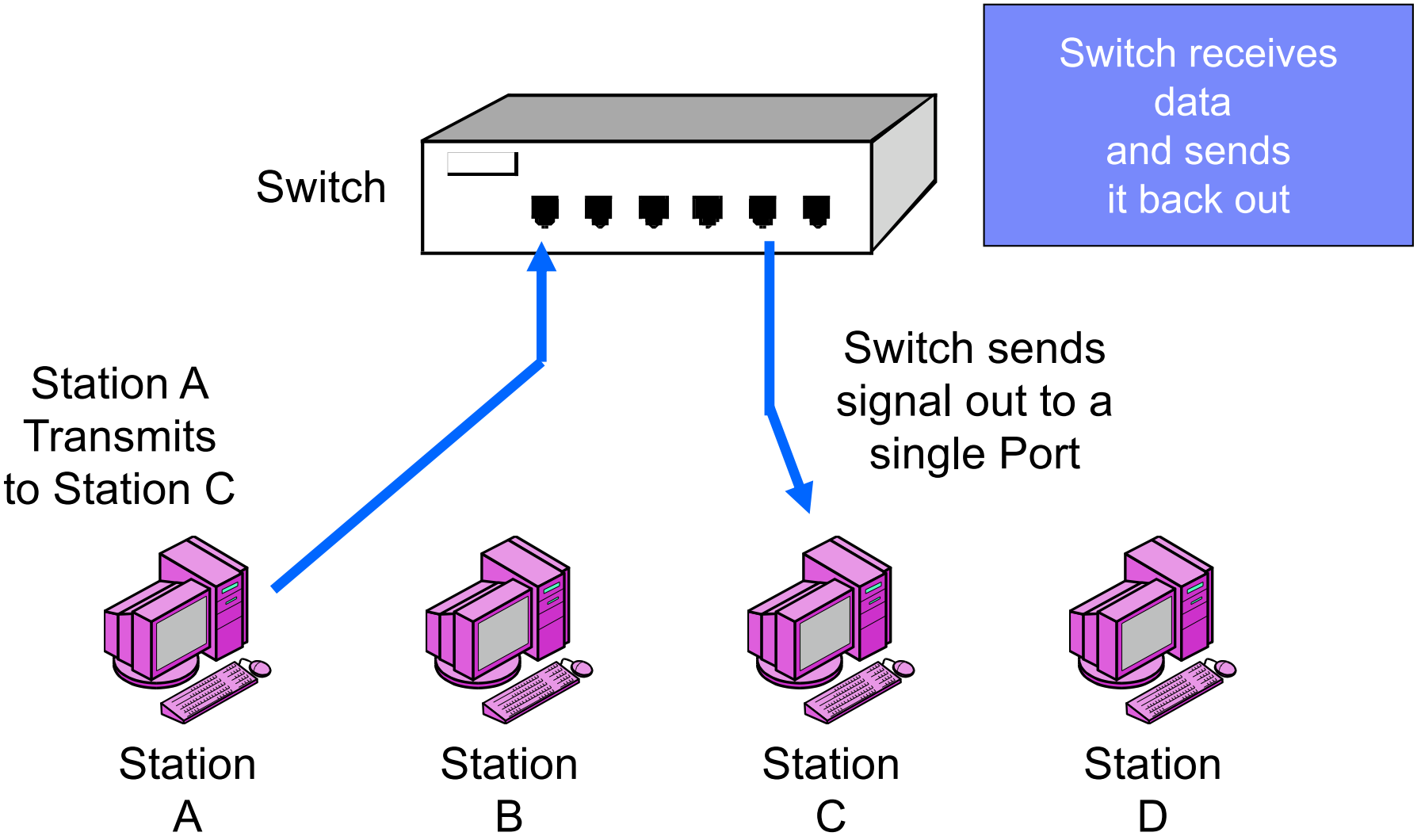
Hubs

- A “hub” is a networking component into which you can plug in multiple network devices
  - Connect computers, printers, scanners, etc.
- Anytime a connected device sends a network message, the hub forwards the message to all other connected devices (not just the intended recipient!)
  - Unintended recipients should ignore bogus network traffic (akin to “screening” telephone calls)
  - Creates opportunities for deviant “packet sniffers”
- Hub can only deal with one message at a time, since it is broadcast over all connections

Switches

- A **switch** is a network device which directs traffic only to its intended destination(s) rather than to all devices on the network.
  - sometimes referred to as an “intelligent hub”
- Provide a dedicated connection between individual devices
  - multiple devices can send data at once

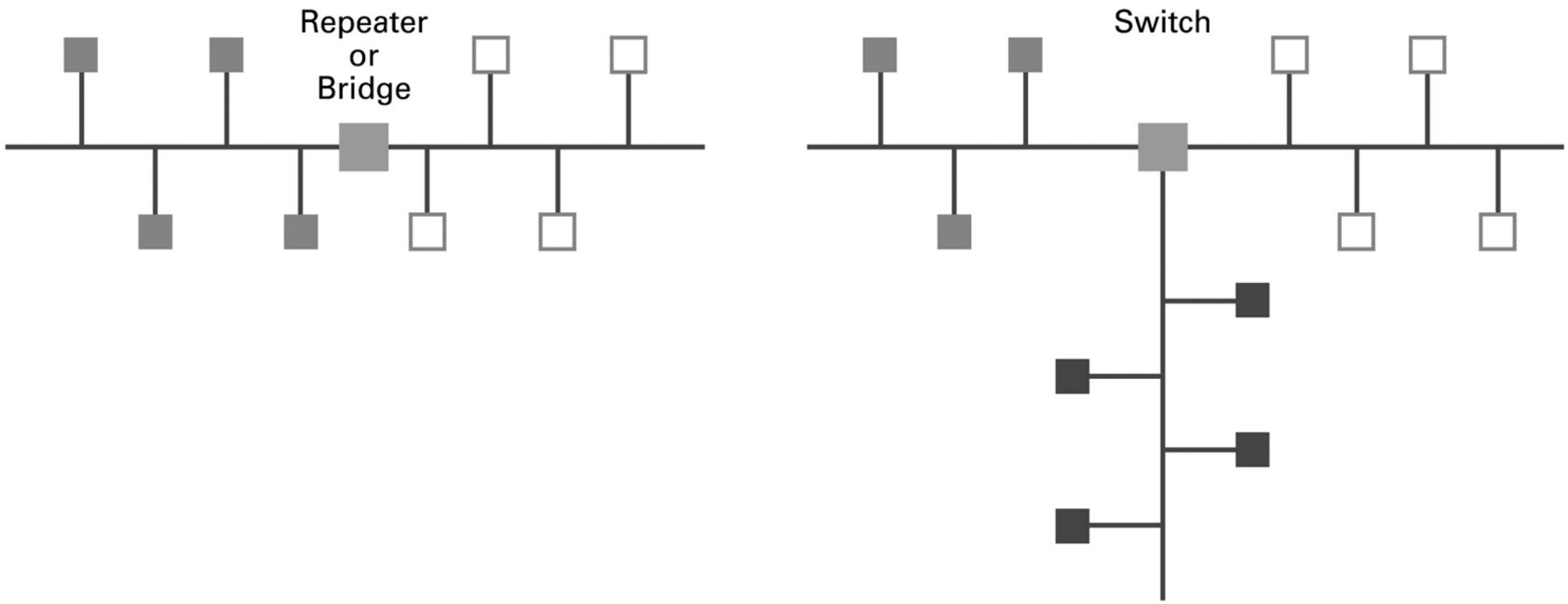
A Network Switch



Switches

- Consider **packing sniffing** software threat for people who share a **hub** and have not activated network encryption
  - Data sent "**in the clear**" means it has not been encrypted, and therefore is vulnerable to eavesdropping via a hub
- As the prices for switches have dropped tremendously over time, most companies have **replaced hubs with switches**
  - Switch protects from eavesdropping by sending data on the LAN only to the intended recipient

Building a large bus network from smaller ones

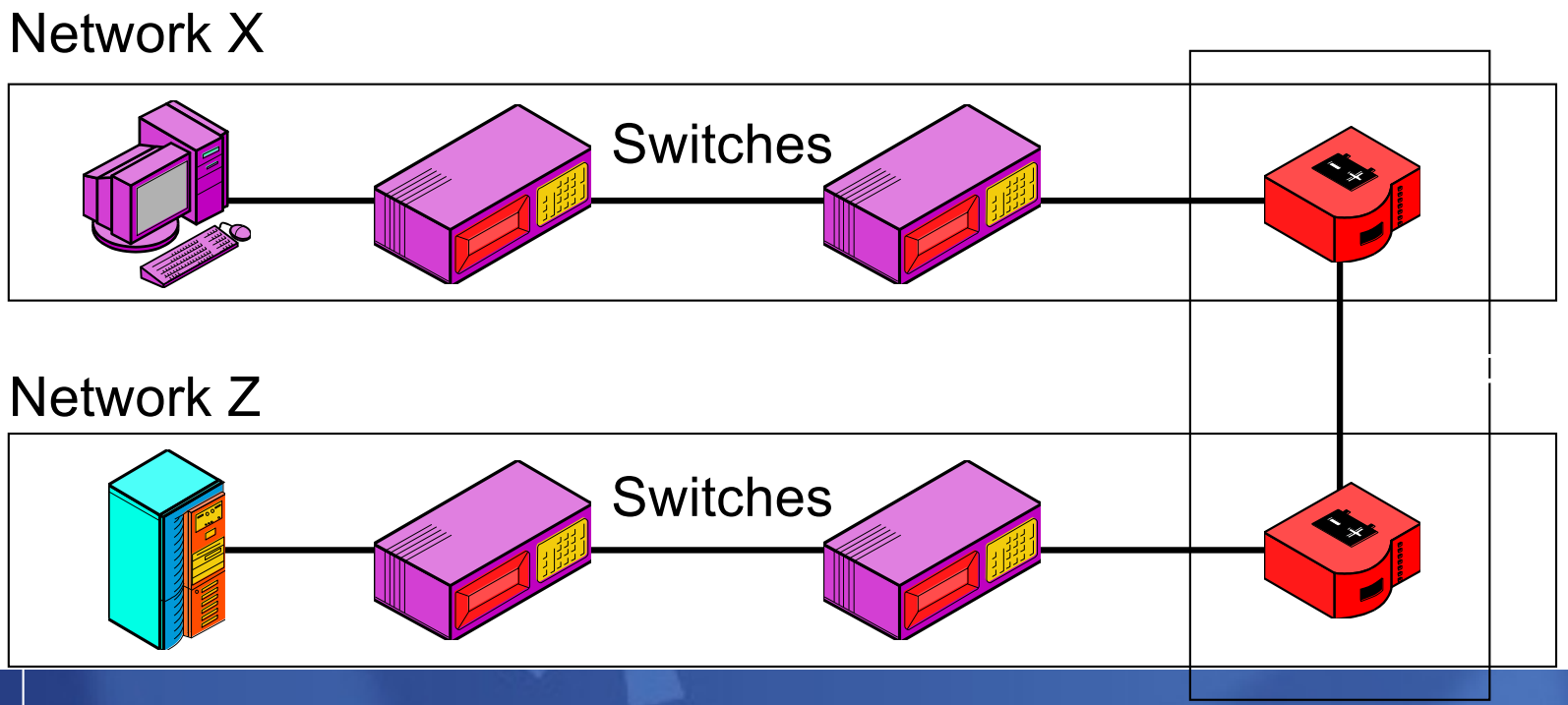


a. A repeater or bridge connecting two buses

b. A switch connecting multiple buses

Routers

- **Different networks** connect via **routers** (not switches or hubs)
- Routers even connect networks based on different protocols, which is important since not *all* networks use the same protocol.



Gateway Router

- When your computer needs to contact a computer that is not within the immediate network (i.e., your LAN), then your computer's networking software is configured to send the request to a particular router called a:
  - **Default Gateway**, or
  - **Gateway router**
- For each of us, the most noteworthy role of the **gateway** router is to connect your computer's LAN to your ISP's larger network so that your computer accesses the **Internet**
- Therefore, a **gateway router** is your computer's **onramp to the Internet**.

Standard networking protocols (communications standards)

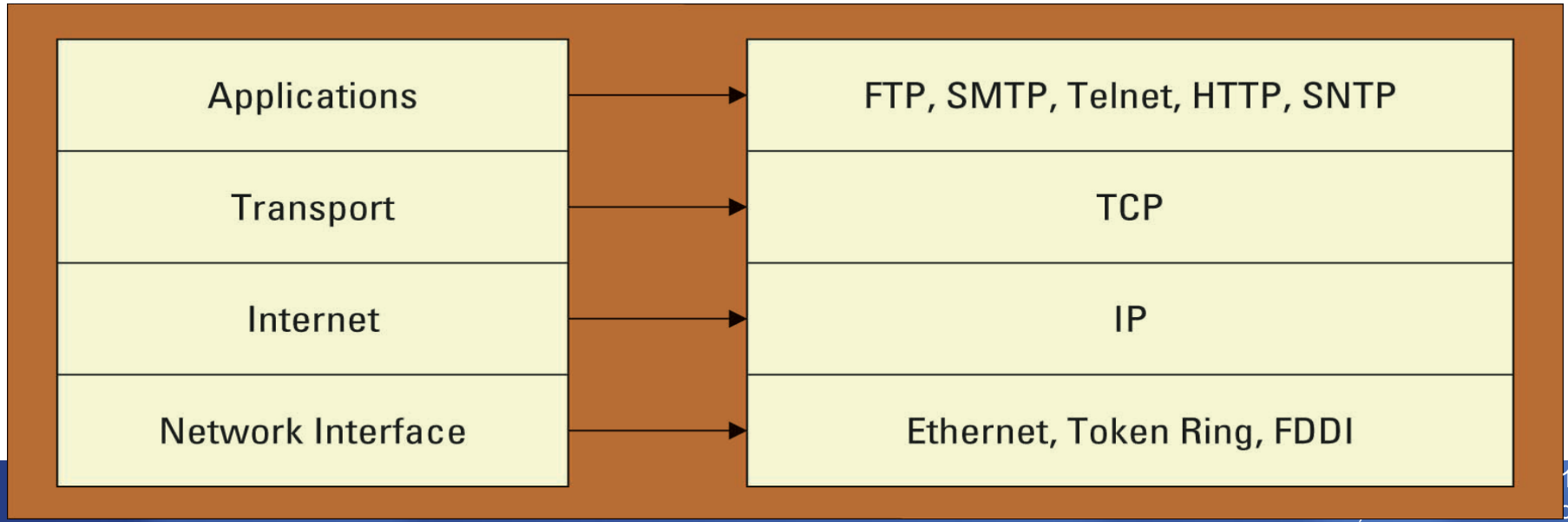
- The committee that addresses LAN standards is called the IEEE 802 Committee.
  - Thus, IEEE LAN protocols always start with the number 802.
- “Ethernet” is a particular protocol published by this committee as their “802.3” protocol.
  - Ethernet (802.3) is the world’s #1 standard wired-LAN protocol
  - There are other protocols besides Ethernet, but it is dominant
- Most PCs’ NICs support 10/100/1000 Mbps Ethernet.
- Wi-Fi: 802.11 (802.11a, b…)

Packet Switching

- The Ethernet (IEEE 802.3) standard transmits data in little chunks called **packets**
- Break long messages into short “packets”
  - Keeps one user from hogging a line
  - Each packet is tagged with where it’s going
- Route each packet separately
  - Each packet often takes a different route
  - Packets often arrive out of order
  - Receiver must reconstruct original message

TCP/IP

- Transmission Control Protocol/Internet Protocol (TCP/IP) provides the technical foundation for the public Internet as well as for large numbers of private network. It is defined in terms of layers.
- Do you use TCP/IP?
  - If you are on the Internet, yes, you are using TCP/IP.
- TCP/IP layers (at left, with particular implementations at right)

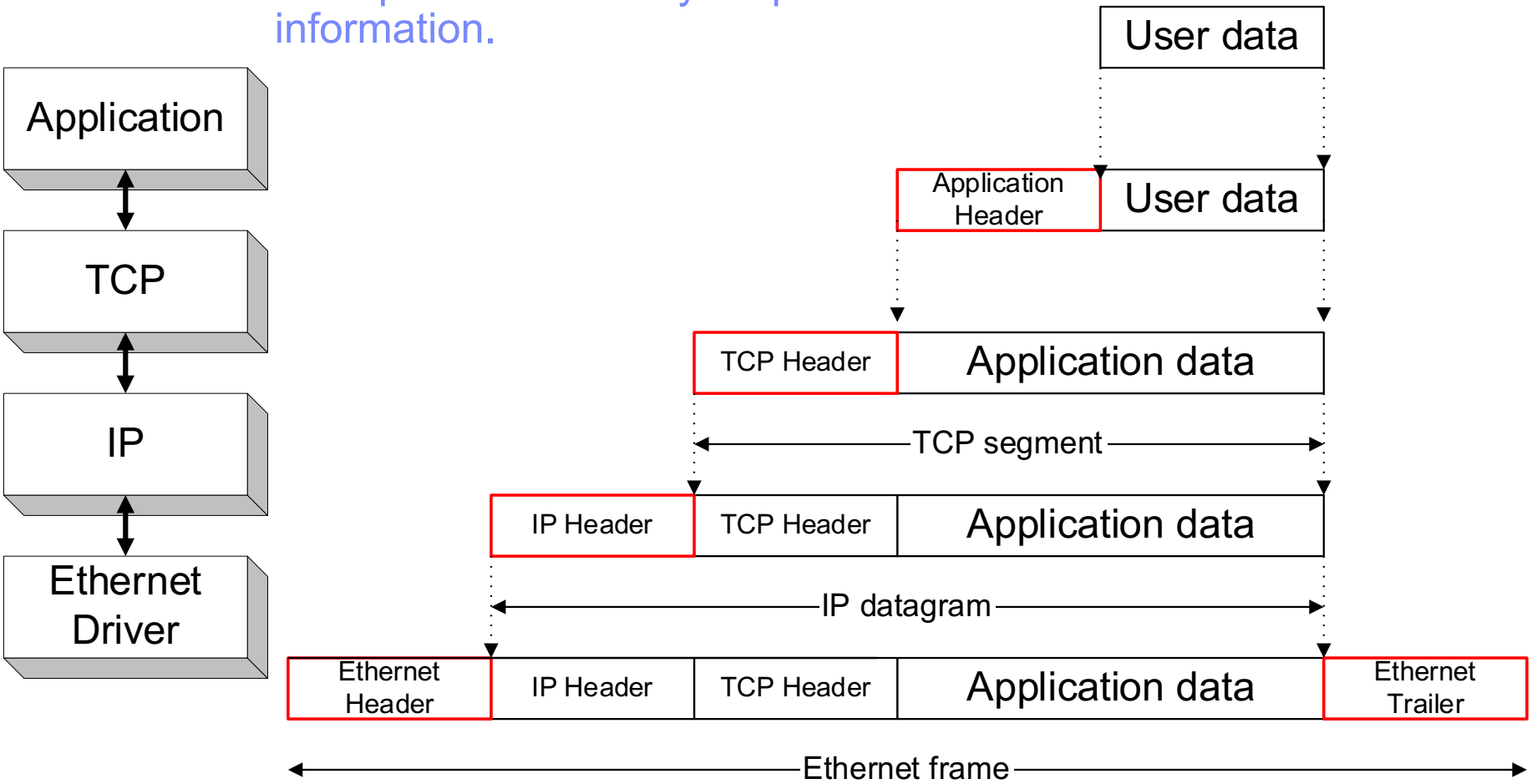


The Five-Layer TCP/IP Internet Protocol Hierarchy

Layer	Name	Examples	
5	Application	HTTP, SMTP, FTP	
4	Transport	TCP, UDP	
3	Network	IP	
2b	Logical Link Control	PPP, Ethernet	Data Link Layer
2a	Medium Access Control	Ethernet	
1	Physical	Modem, DSL, Cable Modem	

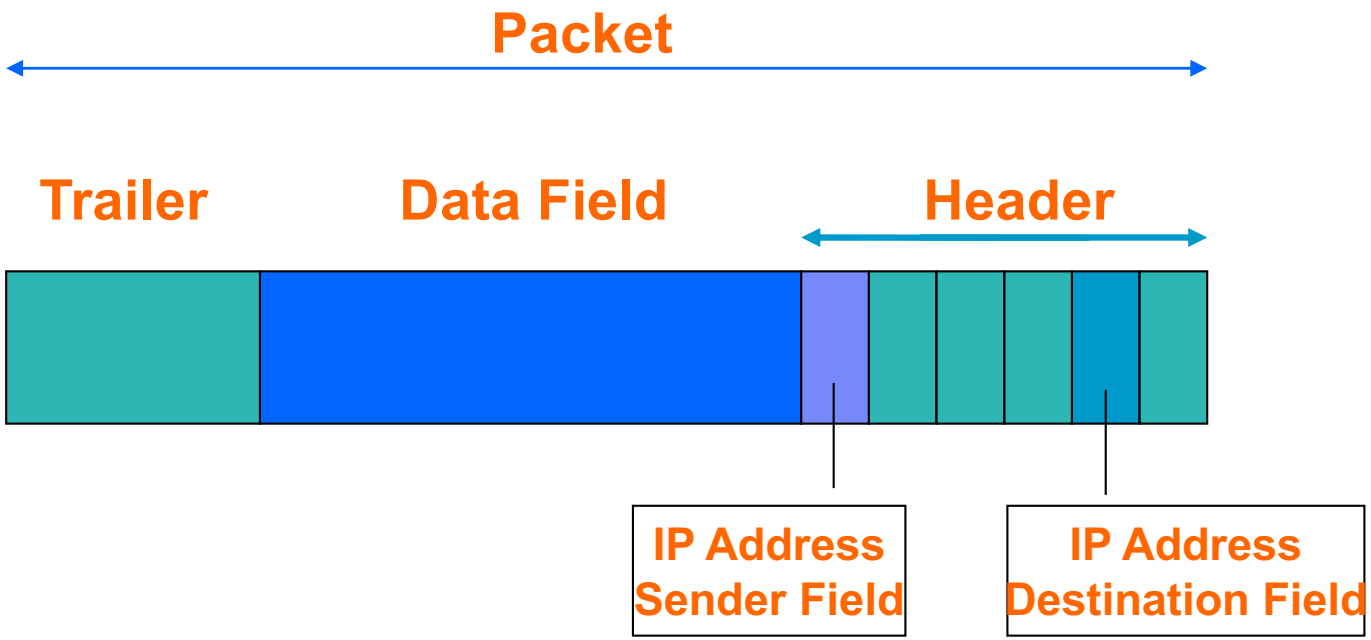
User-plane interworking -Encapsulation

As data moves down the protocol stack, each protocol adds layer-specific control information.

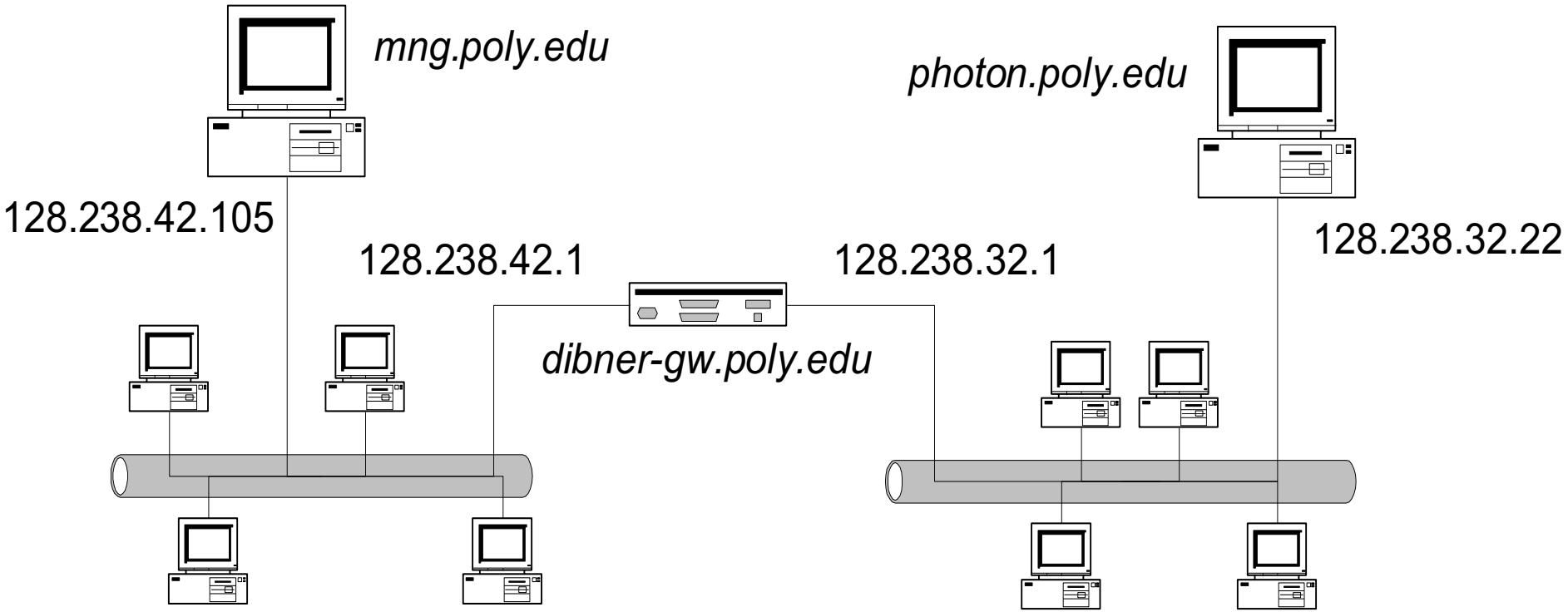


A TCP/IP Network Packet

- Here is the basic structure of any one of trillions of packets traversing the Internet at this moment

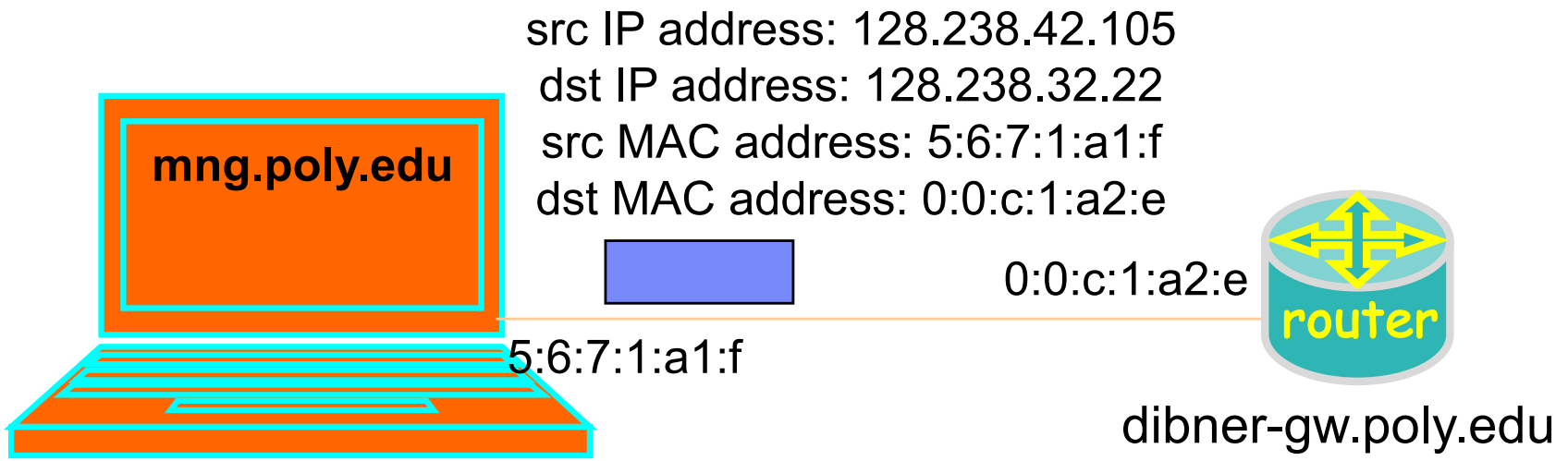


Packet sent from mng to photon



Note that IP router *dibner-gw* has more than one IP address

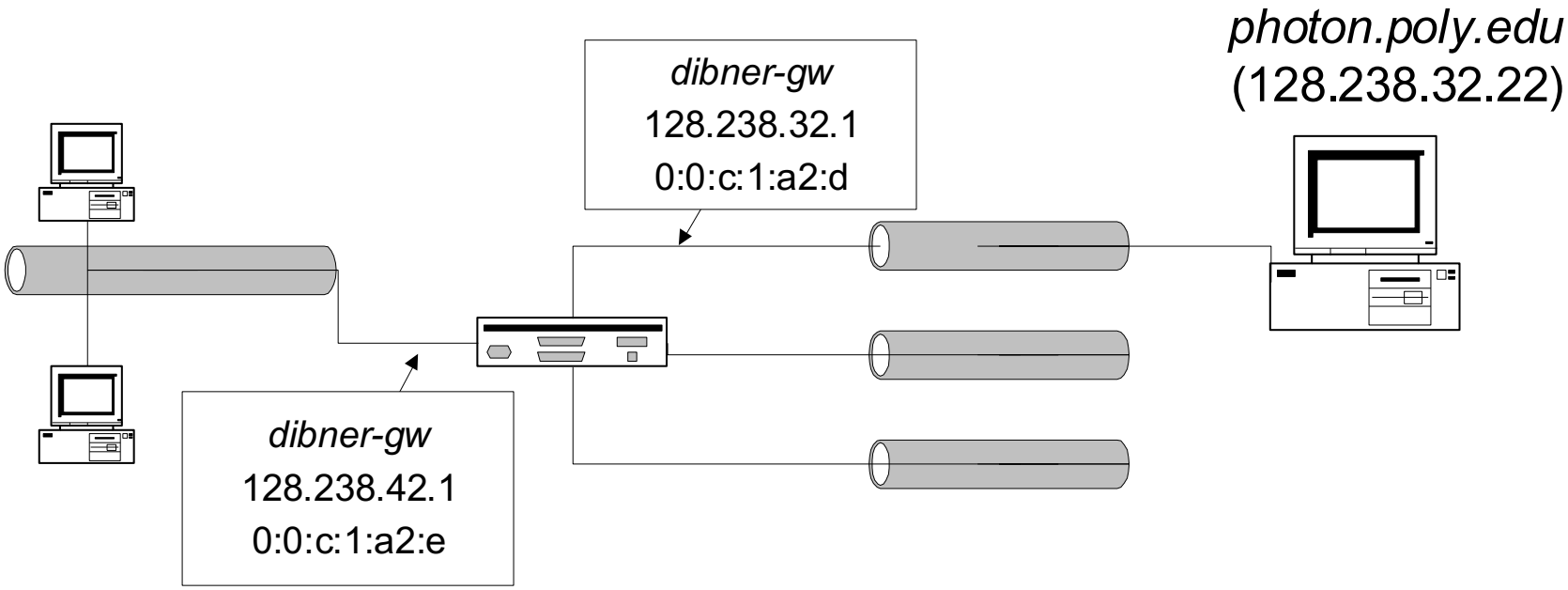
Packet sent from mng to IP router dibner-gw



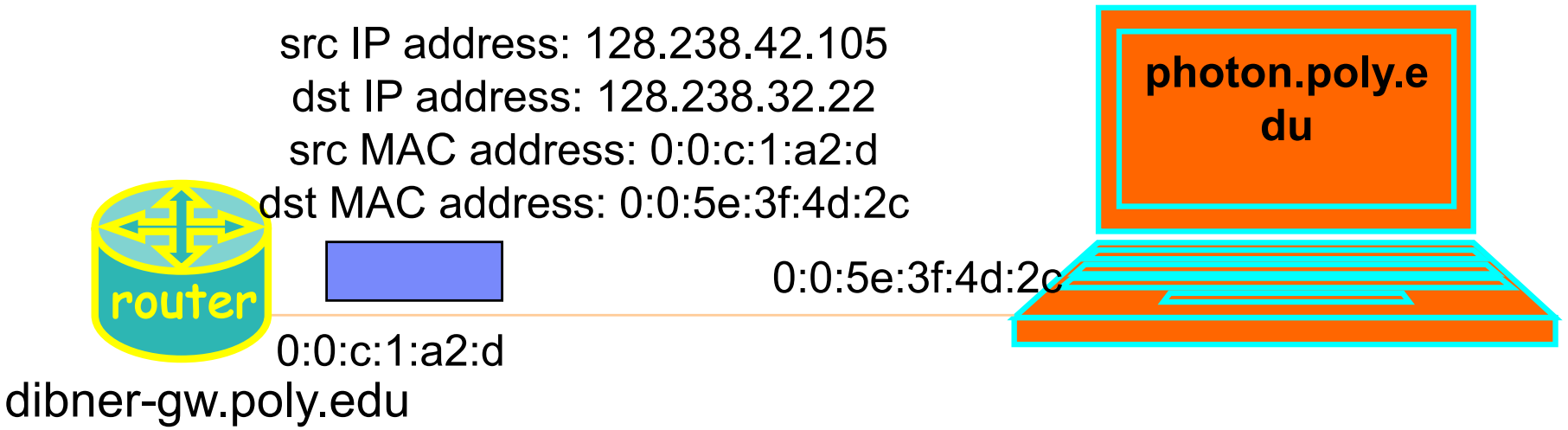
- Host mng consults its IP routing table. This says that to reach destination IP address 128.238.32.22, it needs to send the packet to the IP router because this destination is on a different network
- Hence it sends the packet within its Ethernet network to destination Ethernet (MAC) address 0:0:c:1:a2:e because this is the Ethernet address of the router interface that is connected to mng's Ethernet network. This destination MAC address allows the Ethernet packet (called frame) to be routed through the first Ethernet network – Ethernet switches determine how to route based on destination MAC address

At the IP router, dibner-gw

- When the packet arrives at the IP router, dibner-gw, it looks up its routing table
  - For destination IP address 128.238.32.22, the routing table shows which output port to use.



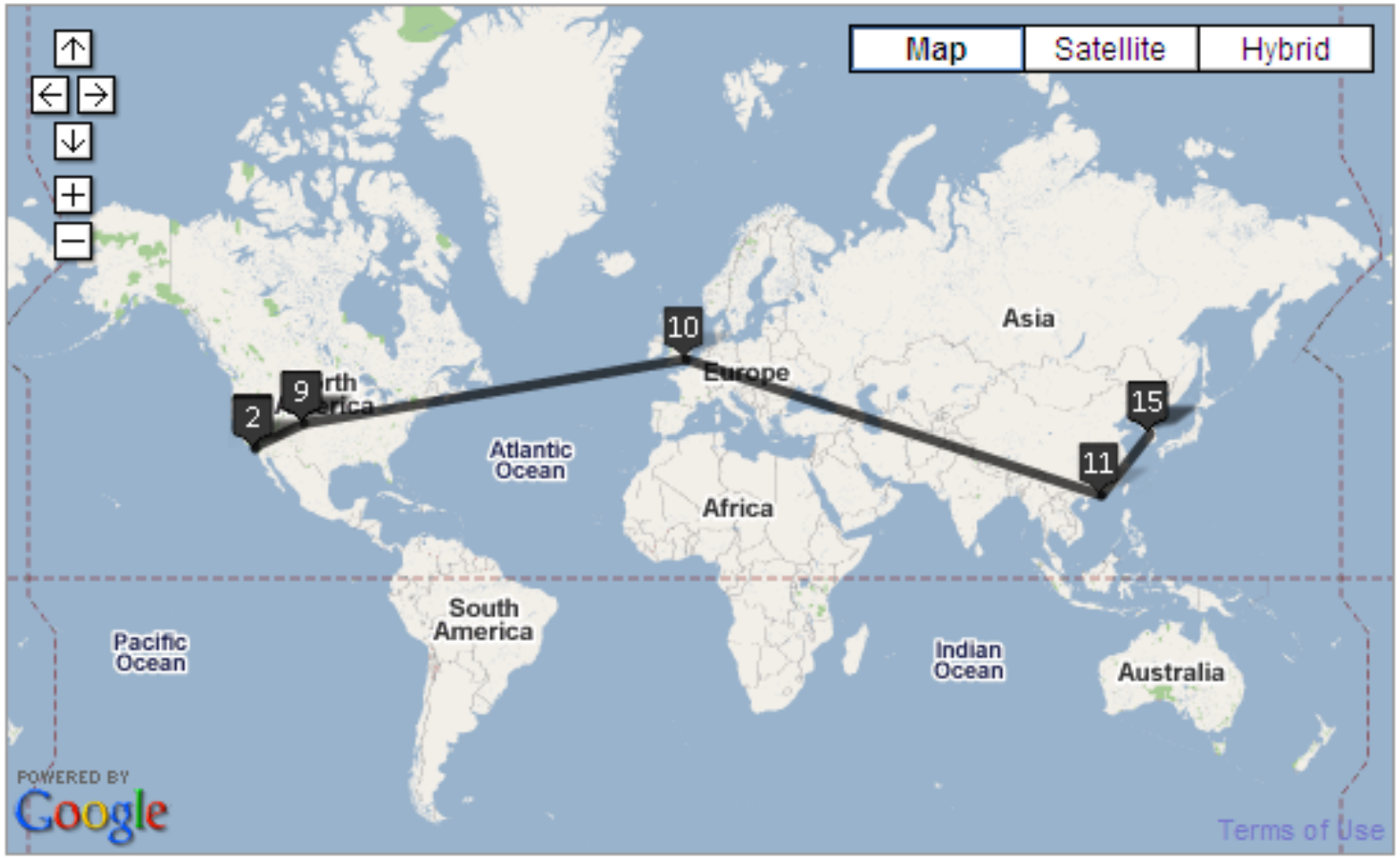
Packet sent from mng to IP router dibner-gw



- IP router, dibner-gw, finds MAC address of photon and adds the IP header and Ethernet header to the packet with the four addresses as shown and sends it.
- The destination MAC address allows for routing through the second Ethernet network; each Ethernet switch that the frame encounters will forward packets based on destination MAC address and its routing table.

Visual Trace Route Tool

approximate geophysical trace



trace information

Host trace to samsung.com
15 hops / 34.8 seconds

1. dreamhost.com
2. dreamhost.com
3. pnap.net
4. pnap.net
5. ntt.net
6. ntt.net
7. ntt.net
8. ntt.net
9. ntt.net
10. flagtel.com
11. 80.77.1.178
12. 157.197.66.5
13. samsung.co.kr
14. unitel.co.kr
15. 211.45.27.198

~12,838 miles traveled

Redraw Trace

trace the path to a network

Remote Address samsung.com Host Trace Proxy Trace

Use Current IP

Tying this back to Switches and Routers

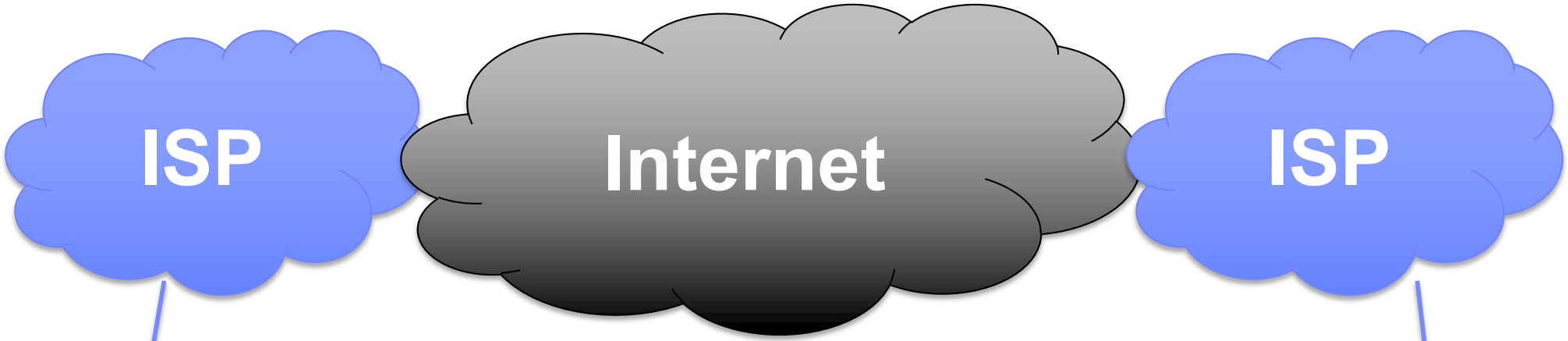
- ***Routers*** operate between networks (at the "**inter**net" layer of TCP/IP) and use IP addresses to direct network traffic

- ***Switches*** work within a single network (at the "network interface" layer of TCP/IP) and use hardware MAC addresses we discussed earlier

Wireless networking

- Wireless fidelity (wi-fi) – a means of linking computers into a wireless local area network (WLAN)
- Also referred to as 802.11
- Wi-Fi has evolved through various standards, the most common of which have been:
  - 802.11b, with 11 Mbps bandwidth
  - 802.11g, with 54 Mbps bandwidth
  - 802.11n, with 100 - 200 Mbps bandwidth

Basic web networking scenario



Not secure. You and your BFF are exposed and relying on your ISPs to provide all security (from hacker attacks, viruses, worms).

•IP's are public accessible.

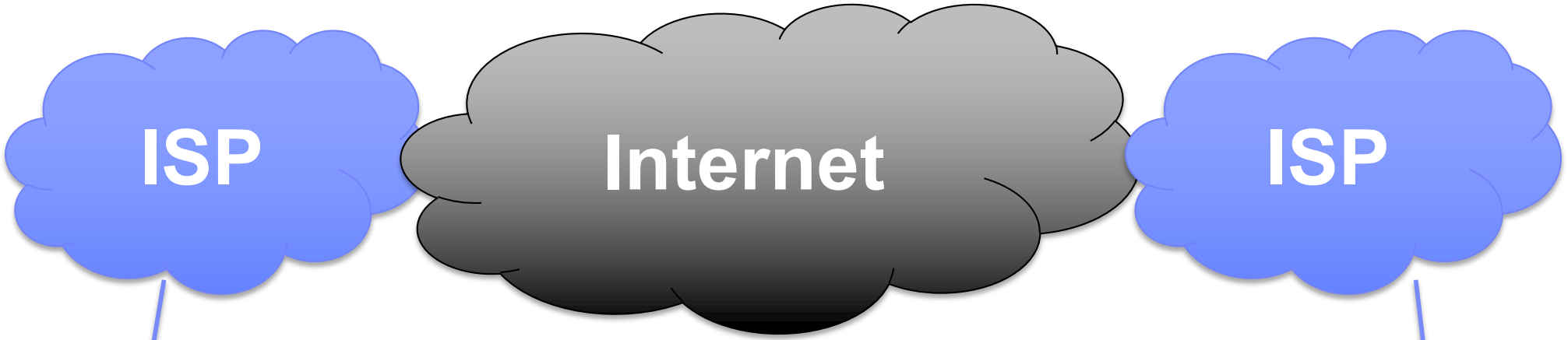
You

24.48.0.1

Your BFF

12.6.1.3

Better: add router (a “firewall”)



24.48.0.1

Better. You buy a router that connects to your ISP. The router assigns your PC a private IP address.

You

192.168.0.1

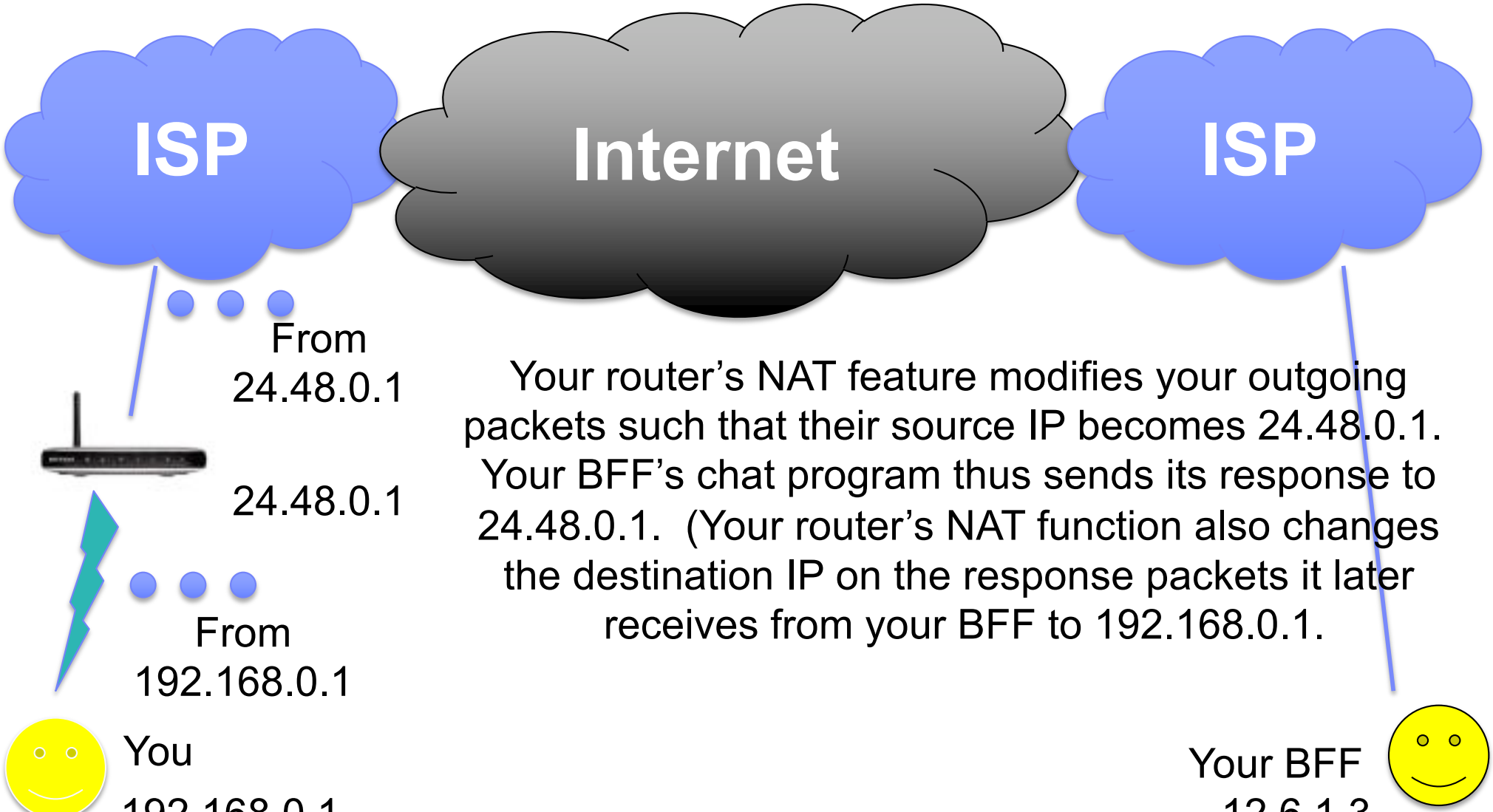
denotes wireless connection to hub/router

Your BFF

12.6.1.3

Recall Private IP addresses

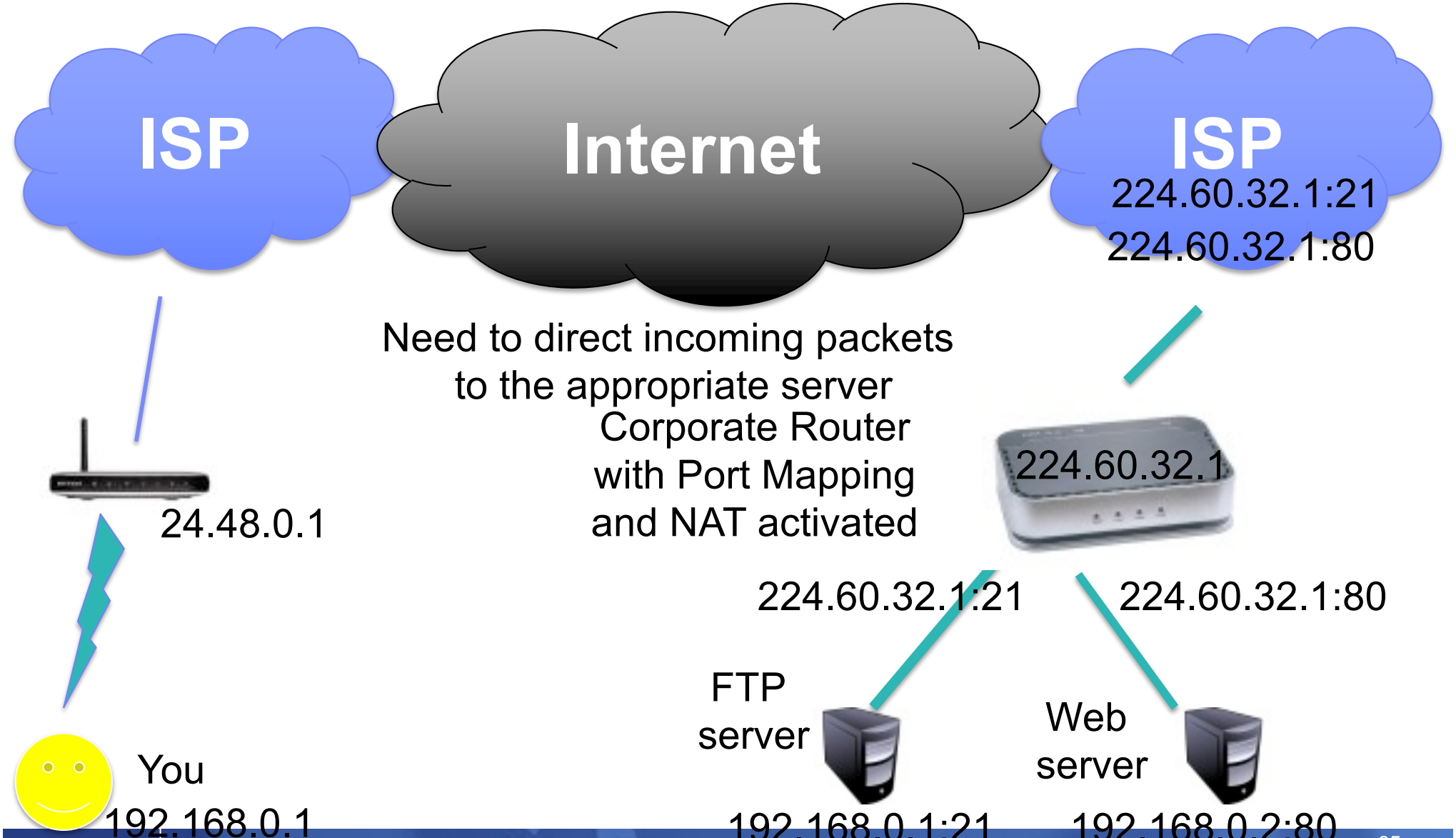
- Is anyone here using this IP address at home?
  - 192.168.0.1
- How can many people use the same IP address?
  - “I thought each computer on the internet required a different IP address?”
- Recall: the IT industry decided that the following ranges of IP addresses would be **non-routable** (i.e., a router will not pass along packets with such destinations to another network)
  - 10.0.0.0 – 10.255.255.255
  - 172.16.0.0 – 172.31.255.255
  - 192.168.0.0 – 192.168.255.255



Your router's NAT feature modifies your outgoing packets such that their source IP becomes 24.48.0.1. Your BFF's chat program thus sends its response to 24.48.0.1. (Your router's NAT function also changes the destination IP on the response packets it later receives from your BFF to 192.168.0.1.

Hiding multiple servers behind one IP address: Port Mapping

- Port mapping is what allows companies to have multiple servers accessible via one IP and corresponding DNS address
- Common example: company wish to run both an FTP and Web server from its domain name, **asite.com**
  - ftp://www.asite.com
    - Note: this is equivalent to typing **ftp://www.asite.com:21** because **port 21 is the default for ftp**
    - The firm's router with Port Mapping will send port 21 traffic to the FTP server
  - http://www.asite.com
    - Note: this is equivalent to typing **http://www.asite.com:80** because **port 80 is the default for http**
    - The firm's router with Port Mapping will send port 80 traffic to the web server


ISP
Internet
ISP
224.60.32.1:21
224.60.32.1:80
Need to direct incoming packets
to the appropriate server
Corporate Router
with Port Mapping
and NAT activated
24.48.0.1
224.60.32.1
224.60.32.1:21
224.60.32.1:80
FTP
server
Web
server
You
192.168.0.1
192.168.0.1:21
192.168.0.2:80

Network Addresses

- An **IP address** can be split into
  - **network address**, which specifies a specific network
  - **host number**, which specifies a particular machine in that network

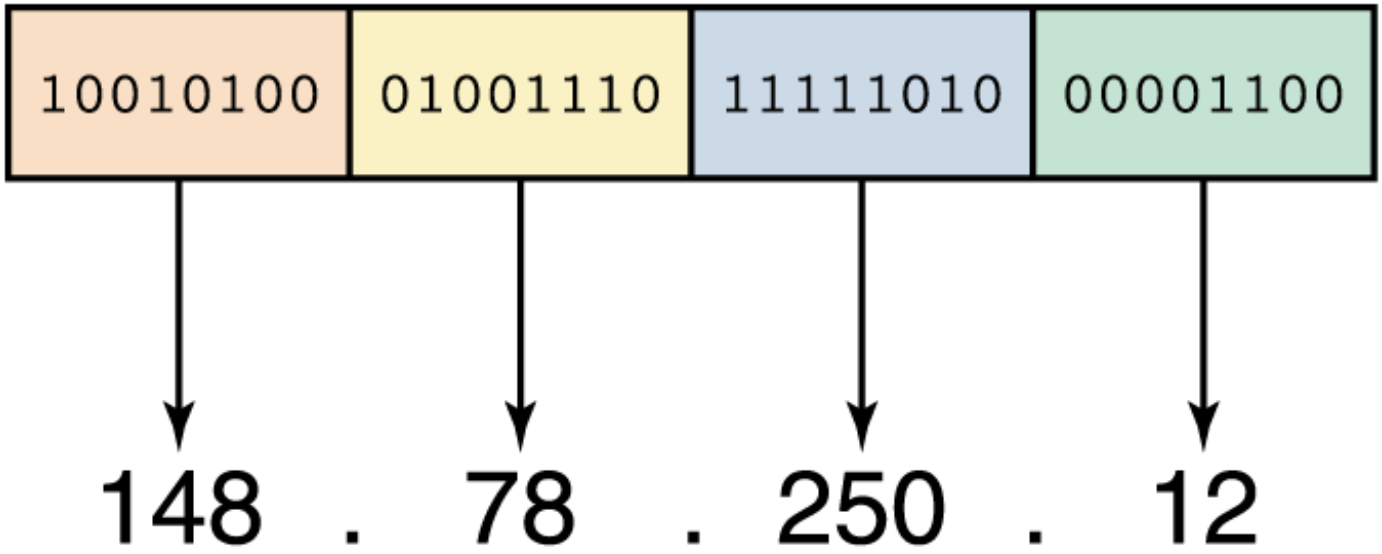


Figure 15.9
An IP address is stored in four bytes

Domain Name System

- A hostname consists of the computer name followed by **the domain name**
- csc.villanova.edu is the domain name
  - A domain name is separated into two or more sections that specify the organization, and possibly a subset of an organization, of which the computer is a part
  - Two organizations can have a computer named the same thing because the domain name makes it clear which one is being referred to

Domain Name System

- The very last section of the domain is called its **top-level domain (TLD)** name

Top-Level Domain	General Purpose	New TLDs	General Purpose
.com	U.S. Commercial	.biz	Business
.net	Network	.info	Information
.org	Nonprofit organization	.pro	Professional
.edu	U.S. Educational	.museum	Museums
.int	International	.aero	Aerospace industry
.mil	U.S. Military	.coop	Cooperative
.gov	U.S. Government		

Figure 15.10 **Top-level domains, including some relatively new ones**

Domain Name System

- Organizations based in countries other than the United States use a top-level domain that corresponds to their two-letter country codes

Country Code TLD	Country
.au	Australia
.br	Brazil
.ca	Canada
.gr	Greece
.in	India
.ru	Russian Federation
.uk	United Kingdom

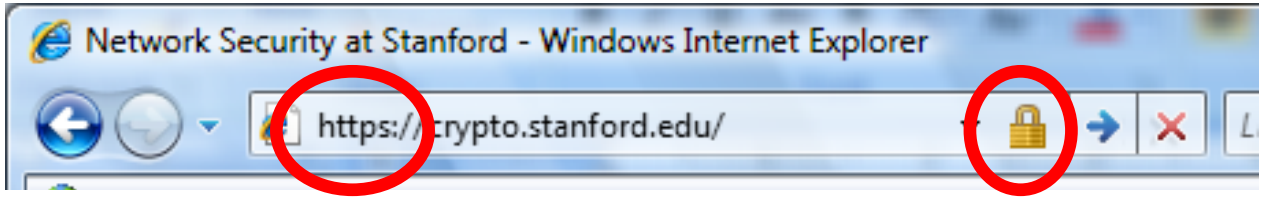
Figure 15.11
Some of the top-level domain names based on country codes

Domain Name System

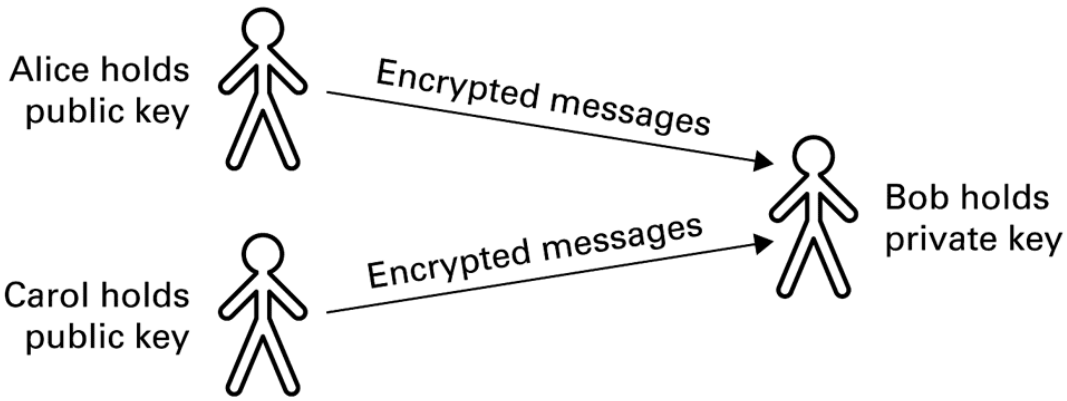
- The **domain name system** (DNS) is chiefly used to translate hostnames into numeric IP addresses
  - DNS is an example of a distributed database
  - If that server can resolve the hostname, it does so
  - If not, that server asks another domain name server

Encryption

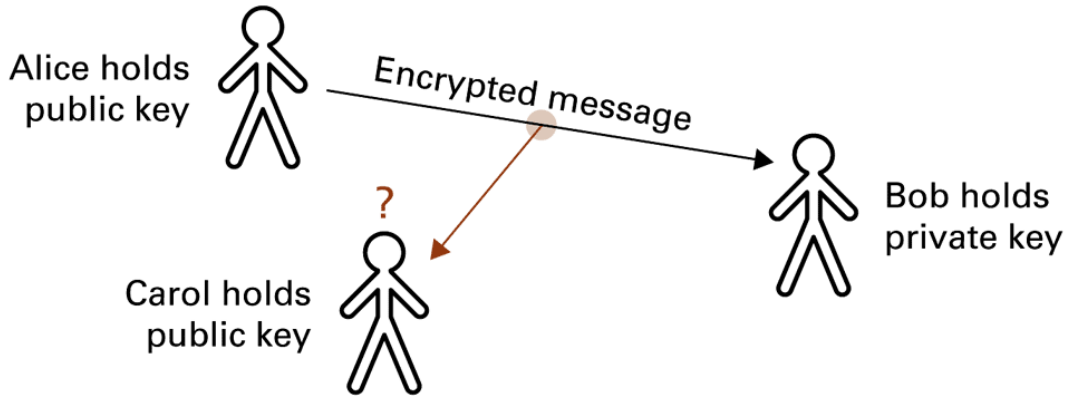
- HTTPS and SSL
- Public-key Encryption
  - Public key: Used to encrypt messages
  - Private key: Used to decrypt messages
- Certificates and Digital Signatures
  - Certificate authorities



Public-key Encryption



Both Alice and Carol can send encrypted messages to Bob.



Carol cannot decrypt Alice's message even though she knows how Alice encrypted it.

Internet 1990s

- 1991 - Tim Berners-Lee releases World Wide Web!
  - TBL is computer programmer at CERN, a physics lab in Europe (book *Weaving the Web* by TBL)
- 1993 - Mosaic (becomes Netscape) designed by graduate students at University of Illinois
  - first point-and-click browser
  - later developed into Netscape Navigator
- These are the two most significant events in the formation of the WWW

World Wide Web

- Via Internet, computers can contact each other
- Public files on computers can be read by remote user
  - usually HyperText Markup Language (.html)
- URL - Universal Resource Locator - is name of file on a remote computer
    - http://www.msu.edu/~urquhar5/tour/active.html

Universal Resource Locator

http://www.msu.edu/~urquhar5/tour/active.html

http://
identifies type
of transfer

www.msu.edu
Domain Name -
name of remote computer

/~urquhar5/tour/active.html
File Location on Remote Computer