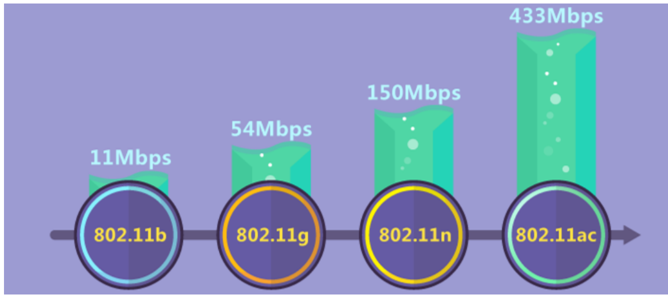
IEEE 802.11g

- ➢Designed to combine advantages of 802.11a and 802.11b
  - – Offers higher data rates (up to 54 Mbps) in 2.4 GHz band (as in .11b) with longer ranges
  - – Backward compatible with 802.11b
    - .11b devices can interoperate with .11g APs
    - **Price to pay:** when an .11g AP detects an .11b device, it prohibits .11g devices from operating at higher speeds
- ➢Uses the same topology as .11b
  - – Provides 3-6 channels (depending on configuration)
  - – 54 Mbps rate obtained within 50 meter range

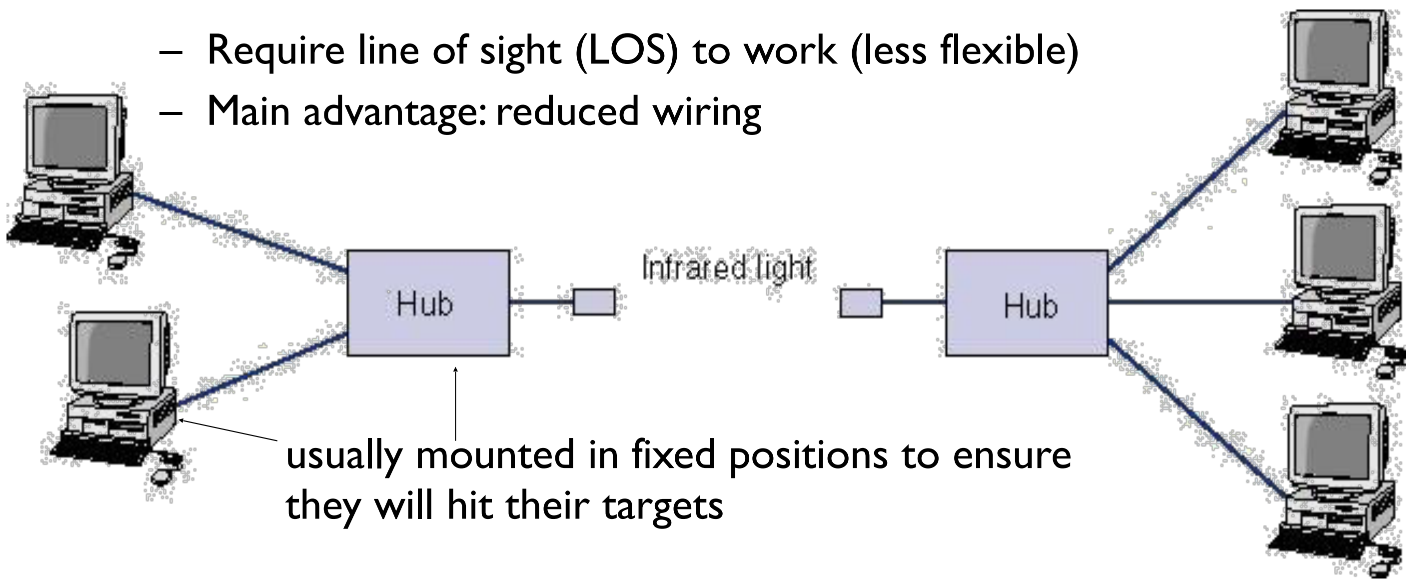
IEEE 802.11n

- Under perfect conditions, it **provides three channels of about 150~200 Mbps** each with a maximum range of 150 meters or 450 feet
- Although in practice both the speed and range are lower.
- It is also possible to configure APs to use different frequency ranges to provide fewer channels that run at higher speeds up to 600 Mbps each.
- 802.11n is **backward compatible** with 802.11b and 802.11g, so that laptops that use these older versions can use an 802.11n access point.
- **Price to Pay:** These old laptops become confused when 802.11n devices operate at high speeds near them, so when an 802.11n AP detects the presence of an 802.11b or 802.11g device, it prohibits newer laptops that use 802.11n devices from operating at high speeds. Thus one old laptop will slow down all the other laptops around it.



Infrared Wireless LAN

- Require line of sight (LOS) to work (less flexible)
- Main advantage: reduced wiring



- New version: diffuse infrared,
  - Operates without a direct LOS by bouncing the infrared signal off of walls
  - Only able to operate within a single room and at distances of only about 50-75 feet

Effective Data Rates in WLANs

- Maximum speed in bits the hardware layers can provide
  - Depends on Nominal data rate, Error rate, Efficiency of data link layer protocol, and Efficiency of MAC protocol
- Error plays a greater role in WLANs
  - Significant impact of interference on performance
    - Causes frequent retransmissions, thus lower data rates

Data Link Protocol Efficiency

- **Factors involved:**
  - Typical WLAN overhead:
    - *51-bytes* (with a short preamble)
  - Packet size:
    - Data packets: assume a *1500-byte* for full length
    - Control packets: ACK packets
  - Transmission rates:
    - Overhead bits transmission speeds
    - Payload transmission speeds
- Assuming a mix of short and full length packets
  - 85% average efficiency for 802.11b
  - 75% average efficiency for 802.11a and 802.11g

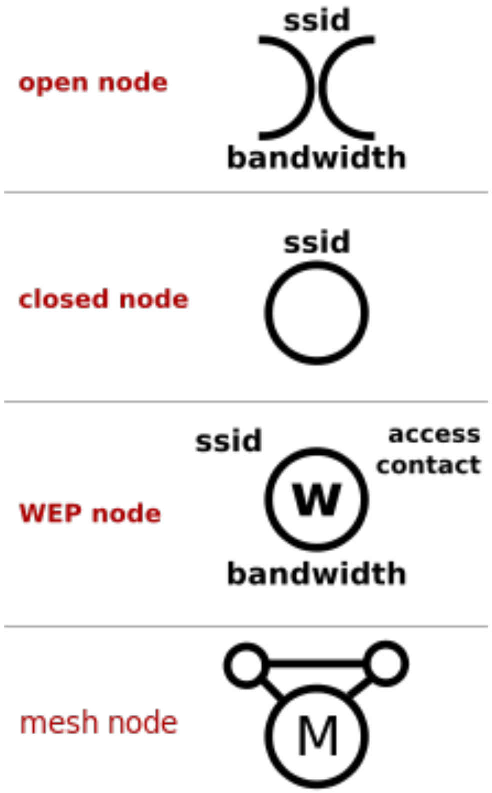
Effective Rate Estimates

Technology	Effective Data Rate per User: Low Traffic	Moderate Traffic	High Traffic
802.11b under perfect conditions (11 Mbps)	4.8 Mbps	1.9 Mbps	960 Kbps
802.11b under normal conditions (5.5 Mbps)	2.4 Mbps	1 Mbps	480 Kbps
802.11a under perfect conditions (54 Mbps)	17.2 Mbps	6.9 Mbps	3.4 Mbps
802.11a under normal conditions (12 Mbps)	3.8 Mbps	1.5 Mbps	760 Kbps
802.11a under perfect conditions with four APs (54 Mbps)	34.4 Mbps	27.5 Mbps	13.7 Mbps
802.11g under perfect conditions (54 Mbps)	17.2 Mbps	6.9 Mbps	3.4 Mbps
802.11g under normal conditions (36 Mbps)	11.4 Mbps	4.5 Mbps	2.3 Mbps

Assumptions:
1. Most packets are 1,500 bytes or larger.
2. No transmission errors occur.
3. Low traffic means 2 active users, moderate traffic means 5 active users, high traffic means 10 active users.

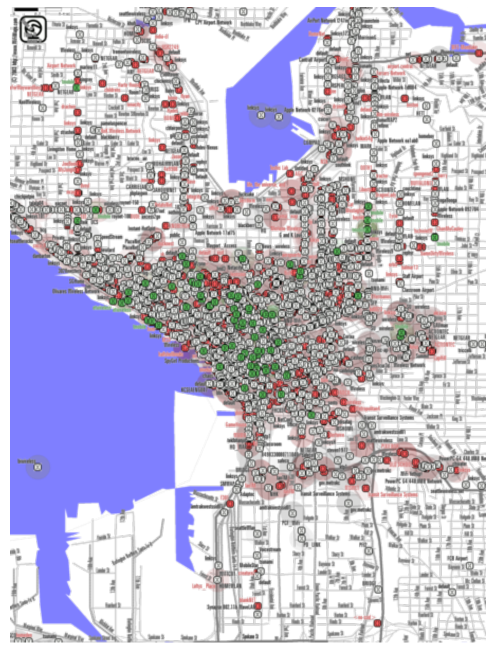
WLAN Security

- Especially important for wireless network
  - Anyone within the range can use the WLAN
- Finding a WLAN
  - Move around with WLAN equipped device and try to pick up the signal
  - Use special purpose software tools to learn about WLAN you discovered
    - *Wardriving* – Type reconnaissance
    - *Warchalking* – Writing symbols on walls to indicate presence of an unsecure WLAN


ssid
open node
bandwidth
ssid
closed node
ssid
access contact
WEP node
W
bandwidth
mesh node
M


FREE INTERNET
seattle
Wi Fi
hotspot

inSSIDer 3



MANAGEMENT FOCUS 6.4 Mooching Wi-Fi

If you connect into someone else's Wi-Fi network and start using their Internet connection are you:

- **a.** Guilty of stealing from the owner because you haven't paid them
- **b.** Guilty of stealing from the ISP because you haven't paid them
- **c.** Committing an unethical but not illegal act
- **d.** Really frugal, and not unethical
- **e.** All of the above

According to the St Petersburg, Florida, police department, the answer is a. They arrested a man named Benjamin Smith for ''willfully, knowingly, and without authorization'' accessing the network of a homeowner while sitting in a car parked on the street.

According to Verizon and most ISPs, which explicitly prohibit sharing, the answer is b. ''It's obviously not good for Verizon to have its services given away for free, just as a cable company won't want someone funneling their cable connection next door,'' said a Verizon spokeswoman.

According to Miss Manners, the answer is c. It's not nice to use other people's stuff without asking their permission.

According to Jennifer Granick, executive director of the Center for Internet and Society at Stanford Law School, the answer is d. ''Such use [i.e., sharing] might be allowed or even encouraged [by the owner].'' Unless the owner states you can't enter their network, how do you know you're not invited?

As Lee Tien, a senior staff attorney at the Electronic Frontier Foundation says ''Right now, we don't have a way of saying 'Even though my wireless signal is open, I'm saying you can't use it.''' Until we do, the answer is e. So, tread carefully. Don't leave your WLAN unsecured or you may be legally inviting others to use it as well as your Internet connection. Likewise, don't intentionally enter someone else's WLAN and use their Internet connection or you might end up like Benjamin Smith—spending the night in jail.

SOURCE: John Cox, ''Mooching Wi-Fi,'' Network World, August 8, 2005, pp. 1, 49.

Types of WLAN Security

- **Service Set Identifier (SSID)**
  - Required by all clients to include this in every packet
  - Included as plain text ==> Easy to break
- **Wired Equivalent Privacy (WEP)**
  - Requires that user enter a key manually (to NIC and AP)
  - Communications encrypted using this key
  - Short key (40-128 bits) ==> Easy to break by "brute force"
- **Extensible Authentication Protocol (EAP)**
  - WEP keys created dynamically after correct login
    - Requires a login (with password) to a server
  - After logout, WEP keys discarded by the server
- **Wi-Fi Protected Access (WPA)** – new standard
  - A longer key, changed for every packet

Outline

6.1 Introduction

6.2 LAN Components

6.3 Wired Ethernet

6.4 Wireless Ethernet

6.5 The Best Practice LAN Design

6.6. Improving LAN Performance

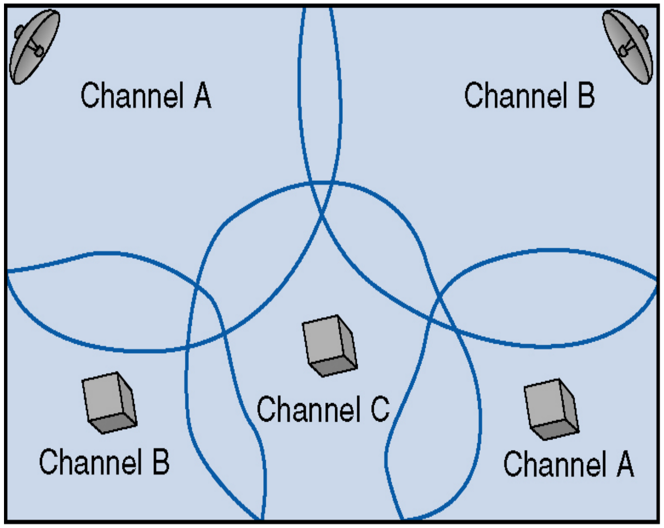
Physical WLAN Design

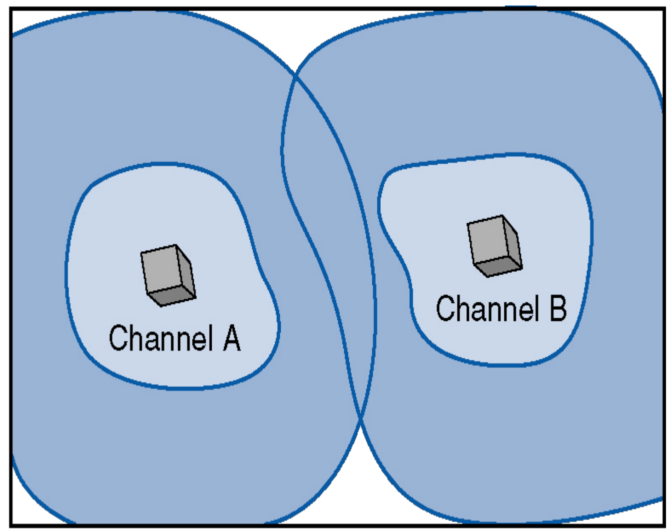
- **More challenging than designing a traditional LAN**
  - **Placement of APs**, Locations chosen to:
    - Provide coverage
    - Minimize potential interference
- **Begins with a site survey to determine**
  - Feasibility of desired coverage
    - Measuring the signal strength from temporary APs
  - Potential sources of interference
    - Most common source: Number and type of walls
  - Locations of wired LAN and power sources
  - Estimate of number of APs required

Physical WLAN Design

- ➢ **Begin locating APs**
  - – Place an AP in one corner
  - – Move around measuring the signal strength
  - – Place another AP to the farthest point of coverage
    - • AP may be moved around to find best possible spot
    - • Also depends on environment and type of antenna
  - – Repeat these steps several times until the corners are covered
  - – Then begin the empty coverage areas in the middle
- ➢ Allow about 15% overlap in coverage between APs
  - – To provide smooth and transparent roaming
- ➢ Set each AP to transmit on a different channel

WLAN Designs for the Same Area





More expensive
- **3 omni and**
- **2 directional antennas**

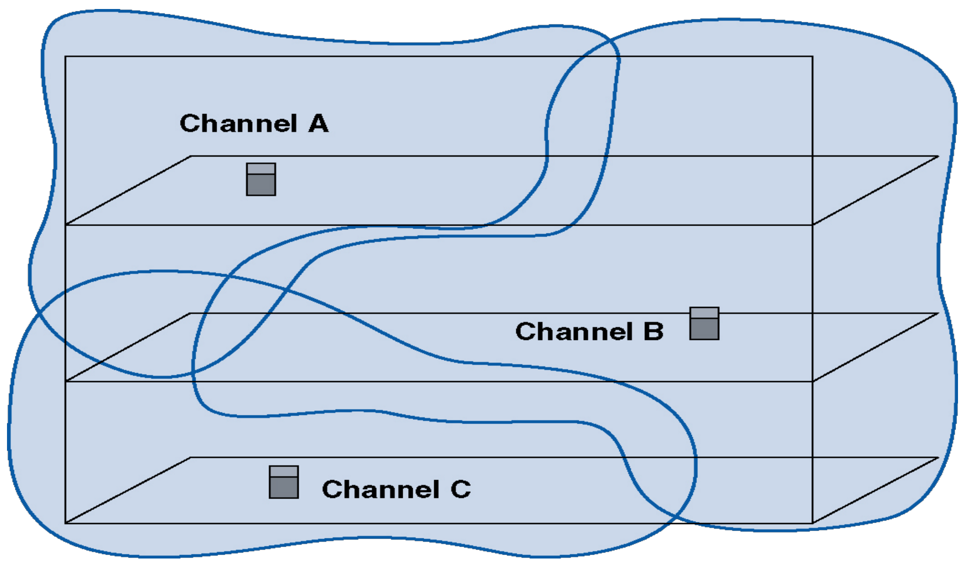
Evenly distributed

Less expensive
- **2 omnidirectional antennas**

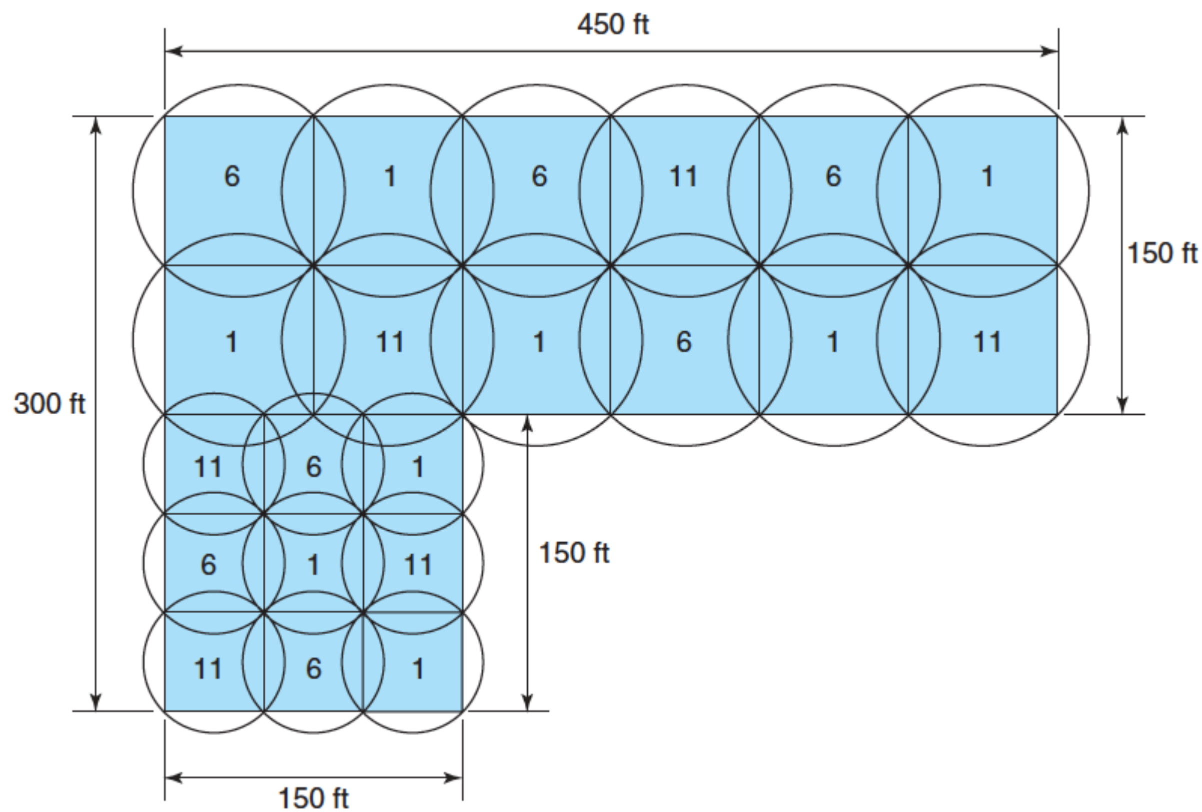
Not evenly distributed
(High speed: Areas closer to AP
Lower speed: Areas farther to AP
A few dead spots too)

Multistory WLAN Design

- **Must include**
  - Usual horizontal mapping, and
  - Vertical mapping to minimize interference from APs on different floors



A WiFi Design: 802.11b



Factors in LAN Design

- Effective Data Rates
  - Data Link Protocol Efficiency
  - MAC Protocol Efficiency
- Costs

Effective Rate Estimates

Technology	Effective Data Rate per User: Low Traffic	Moderate Traffic	High Traffic
Shared 10Base-T	2.5 Mbps	1 Mbps	500 Kbps
Shared 100Base-T	37.5 Mbps	15 Mbps	7.5 Mbps
Switched 10Base-T	9 Mbps	9 Mbps	9 Mbps
Switched 100Base-T	90 Mbps	90 Mbps	90 Mbps
Full Duplex 1 GbE	1.8 Gbps	1.8 Gbps	1.8 Gbps
Full Duplex 10 GbE	18 Gbps	18 Gbps	18 Gbps

Assumptions:

1. Most packets are 1,500 bytes or larger
2. No transmission errors occur
3. Low traffic means 2 active users, moderate traffic means 5 active users, high traffic means 10 active users

Costs

- Very cheap
  - Shared 10Base-T (old technology)
- Relatively inexpensive
  - Shared 100Base-T (old technology)
  - Switched Ethernet
- Very expensive
  - 1 GbE
  - 10 GbE

Best Practice Recommendations

- Switched 10Base-T
  - Less susceptible to response time delays
  - More robust as traffic increases
  - Provides the best cost-performance tradeoff
  - Costs almost the same as Shared 10Base-T
- Category 5 or 5e cables
  - Costs almost the same as cat3
  - Provides room for upgrades to 100Base-T or 100Base-T
- Fiber
  - LAN with very high traffic needs
  - Used with switched 100Base-T or 1 GbE
  - Currently expensive

Best Practice Recommendations

Most networks	Switched 10Base-T Ethernet over Category 5e cables
Very small networks (e.g., home networks)	Traditional shared 10Base-T Ethernet over Category 5 or Category 5e cables
Networks with high demands (e.g., multimedia networks)	Switched 100Base-T Ethernet over Category 5 cables or full duplex 1 GbE over fiber

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6.6. Improving LAN Performance

Improving LAN Performance

- **Throughput:**
  - Used often as a measure of LAN performance
  - Total amount of user data transmitted in a given period of time
- To improve throughput (thus LAN performance)
  - Identify and eliminate bottlenecks
- **Bottlenecks**
  - Points in the network where congestion is occurring
- **Congestion**
  - Network or device can’t handle all of the demand it is experiencing

Identifying Network Bottlenecks

- **Potential Places**
  - Network server
  - Network circuit (especially LAN-BN connection)
  - Client's computer (highly unlikely, unless too old)
- **How to find it**
  - Check the server utilization (during poor performance)
    - If high (>60%),
      - Then the server is the bottleneck
    - If low (<40%),
      - Then the network circuit is the bottleneck
    - If between (40% - 60%)
      - Both the server and circuits are the bottlenecks

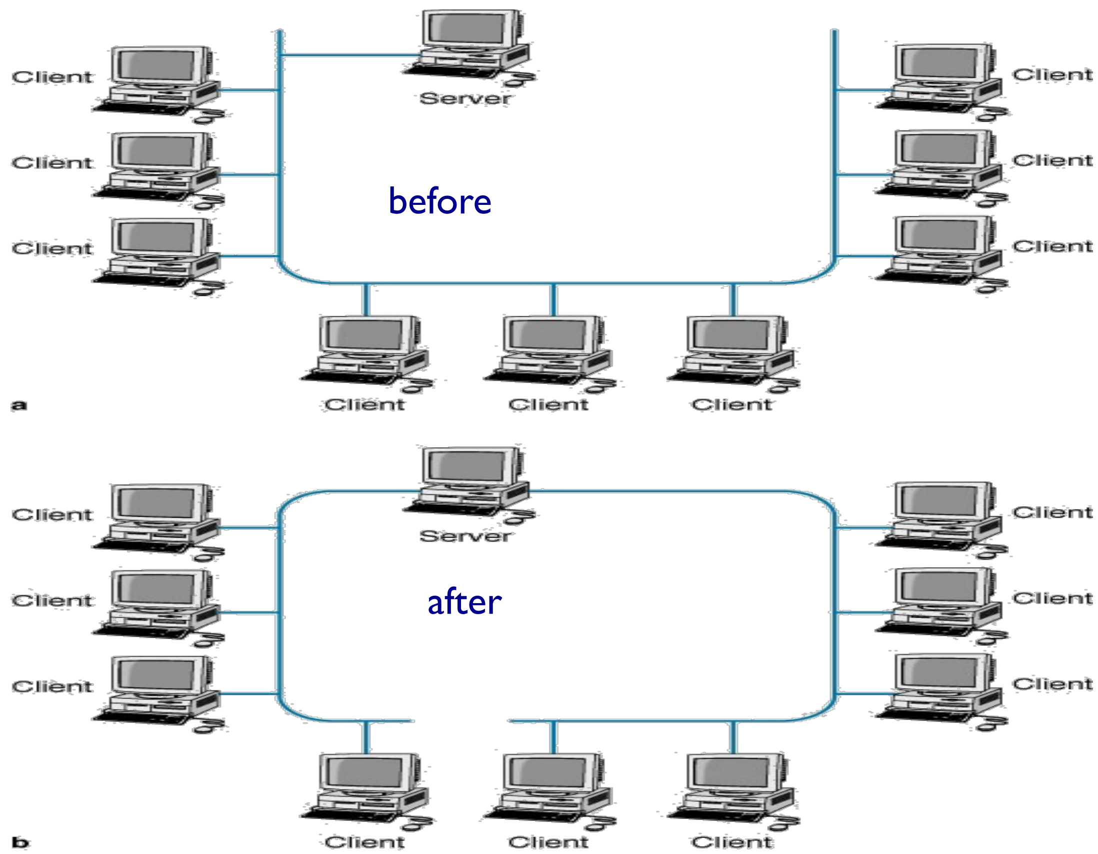
Improving Server Performance

- **Software improvements**
  - Choose a faster NOS
  - Fine tune network and NOS parameters such as
    - Amount of memory used for disk cache
    - Number of simultaneously open files
    - Amount of buffer space
- **Hardware improvements**
  - Add a second server
  - Upgrade the server's CPU
  - Increase its memory space
  - Add more hard disks
  - Add a second NIC to the server

Improving Disk Drive Performance

- Especially important, since disk reads are the slowest task the server needs to do
- Redundant Array of Inexpensive Disks (RAID)
  - Replacing one large drive with many small ones
  - Can be used to both improve performance and increase reliability
    - Building redundancy into the hard drives
      - A hard drive failure does not result in any loss of data

Network Segmentation



Reducing Network Demand

- Move files to client computers
  - Such as heavily used software packages
- Install disk caching software on client machines
  - Reduces the need to access files stored on the server
- Move user demands to off peak times
  - Tell network users about peak usage times
    - Typically: Early morning and after lunch
  - Encourage users to **not use the network as heavily** during these times
  - Delay some network intensive jobs to off-peak times
    - Run heavy printing jobs at night

Improving LAN Performance Summary

- **Increase Server Performance**
  - Software: Fine-tune the NOS settings
  - Hardware:
    - Add more servers and spread the network applications across the servers to balance the load
    - Upgrade to a faster computer
    - Increase the server's memory
    - Increase the number and speed of the server's hard disk(s)
    - Upgrade to a faster NIC
- **Increase Circuit Capacity**
  - Upgrade to a faster circuit
  - Segment the network
- **Reduce Network Demand**
  - Move files from the server to the client computers
  - Increase the use of disk caching on client computers
  - Change user behavior

Implications for Management

- Cost of LAN equipment dropping quickly
  - Commodity market
    - Flood of vendors into the market
    - Varying quality of products
  - Difficult to justify the purchase of high quality LAN equipment
- Became more common everywhere
  - Look for applications to take advantage of this
- More network enabled devices to deal with
  - Networked printers, scanners, vending machines, etc.,

Improving WLAN Performance

- Similar to improving wired LANs
  - Improving device performance
  - Improving wireless circuit capacity
  - Reducing network demand

Improving WLAN Performance

- **Similar to improving wired LANs**
  - Improving device performance
    - If 802.11g and 11ac widely deployed
    - By high-quality cards and APs
  - Improving wireless circuit capacity
    - Upgrade to 802.11ac
    - Reexamine placement of APs
    - Check sources of interference (other wireless devices operating in the same frequencies))
    - Use different type of antennas
  - Reducing network demand

Improving Wireless Circuit Capacity

- **Upgrade to 802.11g and 11ac**
- **Re-place APs**
  - Fewest walls between AP and devices
  - Ceiling or high mounted to minimize obstacles
  - On halls, not in closets
- **Remove sources of interference**
  - Other wireless devices operating in the same frequencies
    - Bluetooth devices, cordless phones, etc.
- **Use different type of antennas**
  - Directional antennas in smaller range to get stronger signals (faster throughput)

Reducing WLAN Demand

- **Never place a serve in a WLAN**
  - Doubles the traffic between clients and server
    - Since all communications go through the AP
  - Locate the server in the wired part of the network (ideally with a switched LAN)
- **Place wired LAN jacks in commonly used locations**
  - If WLAN becomes a problem, users can switch to wired LAN easily

Implications for Management

- **WLANs becoming common place**
  - Access to internal data, any time, any place
    - Better protection of corporate networks
  - Public access through WLAN hotspots
    - Competition with cell phone technologies
      - New cell phone technologies (faster, longer ranges)
  - Drastic price drops of WLAN devices
    - Widespread Internet access via multiplicity of devices
  - Development of new Internet applications
    - New companies created; some old ones out of business
  - Drastic increase in the amount of data flowing around