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# **Chapter 6**

# **Wired and Wireless Local Area Networks**

# **Chapter 6: Outline**

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**6.2 - LAN Components**

**6.3 - Wired Ethernet**

**6.4 - Wireless Ethernet**

**6.5 - Best Practice LAN design**

**6.6 - LAN Performance**

# **Dedicated Servers vs. Peer-to-Peer**

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- **Dedicated server network**
  - **Server permanently assigned specific task**
    - **Majority of all LANs**
- **Peer-to-peer network**
  - **Computers act as both clients and servers**
    - **No dedicated servers**
    - **Cheaper than dedicated with less capability**

```
Nslookup -type=any
```

```
> yahoo.com
```

# Dedicated Server Types

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- **Common server types:**
  - Web
  - e-mail
  - DNS (name server)
  - SQL
  - DHCP
  - AAA (authentication, authorization, and accounting)
- **Other Server Types**
  - File servers
  - Print servers

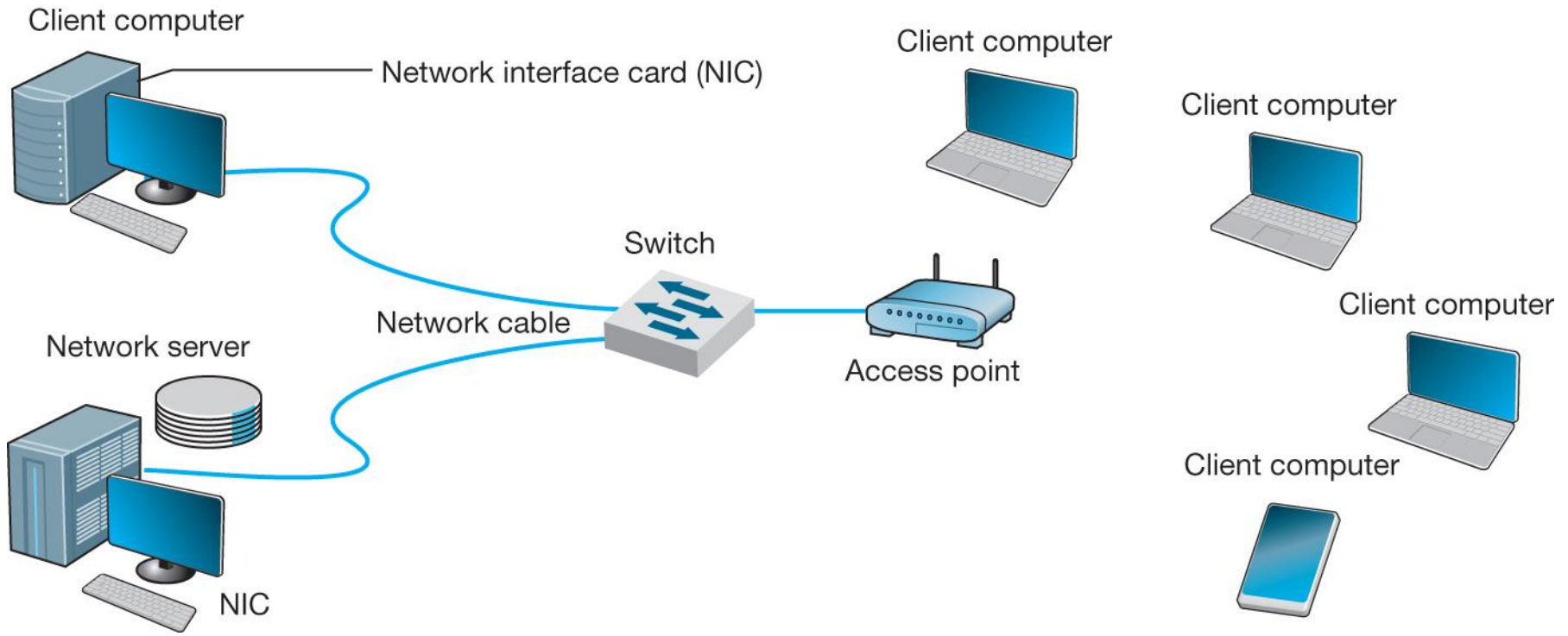
# Peer-to-Peer Networks

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- **Historically, more appropriate for small networks**
- **Advantage: Lower cost**
  - **No dedicated server**
- **Disadvantage: Slower than dedicated server networks**
  - **Each computer may be in use as a client and/or a server at the same time**
    - **Potentially, difficult to manage**
- **Which type of network is bit torrent?**
- **With IoT peer to peer utilization likely to increase...**

# 6.2 LAN Components

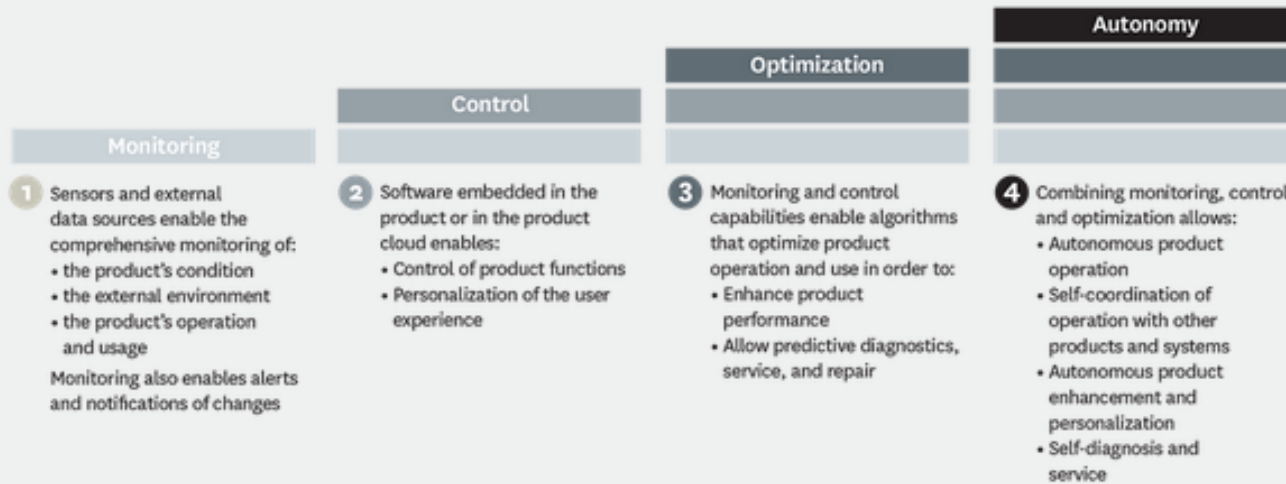
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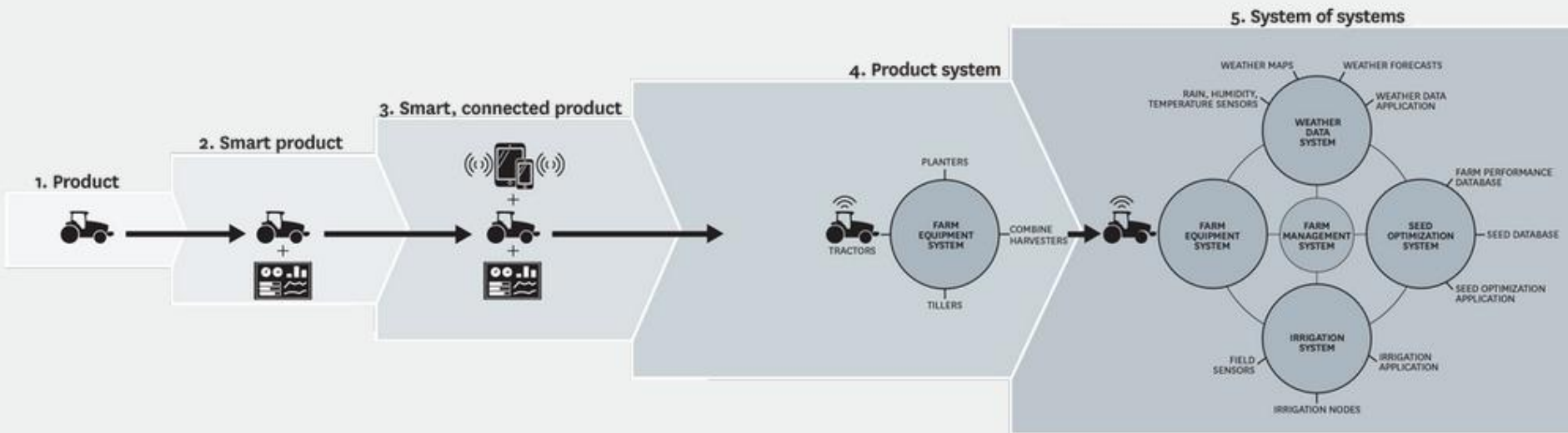
***Now, you can also see storage components like Network Attached Storage (NAS) or Storage Area Networks (SAN)...***

# Capabilities of Smart, Connected Products

The capabilities of smart, connected products can be grouped into four areas: monitoring, control, optimization, and autonomy. Each builds on the preceding one; to have control capability, for example, a product must have monitoring capability.



# Pervasive Communication and the Internet of Everything



# **Network Interface Cards (NICs)**

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- **AKA network cards or adapters**
- **Physical and data link layer functions**
  - Includes a unique data link layer address (called a MAC address), from manufacturer (& IEEE)
  - Organizes data into frames, sends them on to the network
- **Now, usually built into motherboard**
  - Makes it network interface chip rather than network interface card...
  - Also, external wireless NICs available with USB interface



# Network Circuits

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- **Physically connect computers**
- **Cable types**
  - **Untwisted wire pairs (UTP)**
  - **Shielded twisted pair (STP)**
  - **Optical fiber**
- **Air...**
  - **Microwave**
  - **Radio**
  - **Laser**
  - **802.11**

# Hubs & Switches

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## Functions:

1) Link cables from several networked computers

1) 4,8,16,24, or more ports



2) May allow connection of more than one media type, such as UTP and coax.

2) Repeats (reconstructs and strengthens) incoming signals

– Extends the maximum LAN segment distance




3. Hubs: level 1 devices

4. Switches: level 2 devices

# Wireless Access Points

Improve Wireless Performance Everywhere

Gigabit Wi-Fi for Any Size Organization / Any Business Model

On-Premise			Cloud-Managed		
<b>Indoor</b> <b>WAP371</b> 802.11ac  2x3:2 – 2.4 GHz 3x3:3 – 5 GHz MDR: 1.3Gbps	<b>Indoor</b> <b>1700</b> 802.11ac <b>NEW</b>  3x3:2   MDR: 867	<b>Indoor</b> <b>2700</b> 802.11ac   HDX  4x3:3   MDR: 1.3Gbps	<b>Indoor</b> <b>3700</b> 802.11ac   HDX   Modular  4x4:3   MDR: 1.3Gbps <b>3600</b> 802.11n w/ 802.11ac Module 	<b>Outdoor</b> <b>1570</b> 802.11ac   HDX <b>NEW</b>  4x4:3   MDR: 1.3Gbps	<b>Indoor</b> <b>MR34</b> 802.11ac  3x3:3   MDR: 1.75Gbps

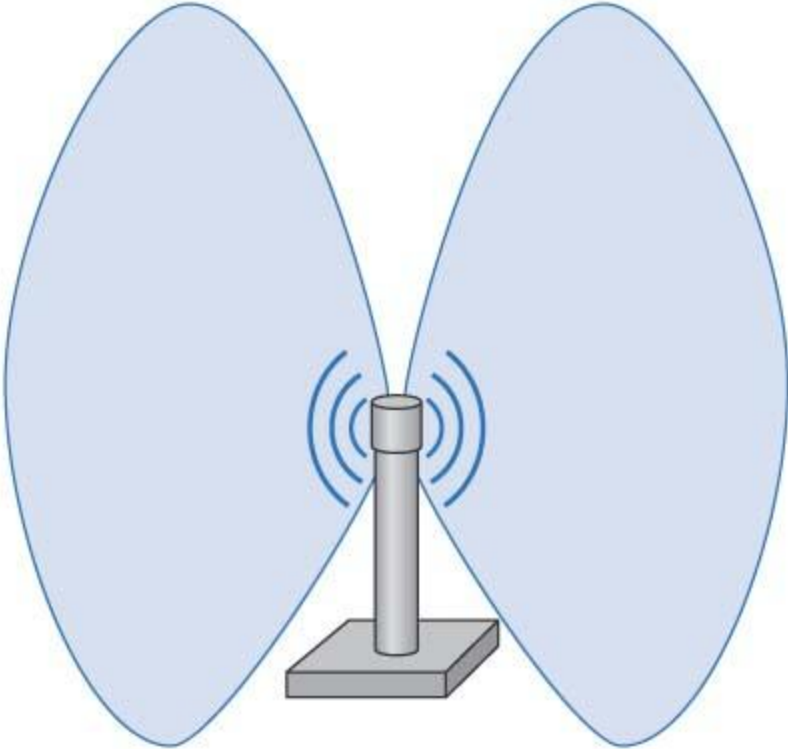
- **Act as repeaters (hubs)**
  - **Must be able to hear all computers on a WLAN**
  - **Level one devices...**

# Three WLAN Antenna Types

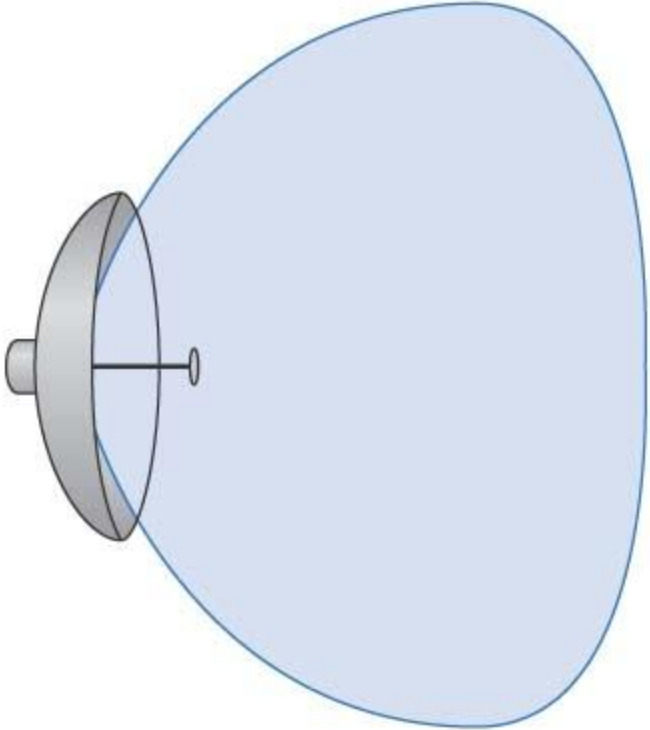
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- **Omni directional**
  - Most common...
    - Dipole antenna
      - Transmits in all direction
- **Directional antennas**
  - Project signal primarily in one direction
    - Focused; stronger signal; farther ranges
  - Most often used on inside of an exterior wall
    - May reduce security vulnerabilities
- **Yagi Antennas**
  - Can also be made from Pringles, etc. cans
  - Called “Cantennas” ([www.cantenna.com](http://www.cantenna.com))
  - Older outdoor TV antennas were also Yagis....

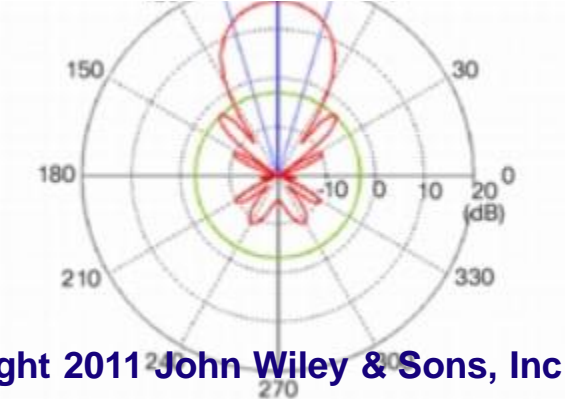
# Antenna Types



(a) Omnidirectional antenna

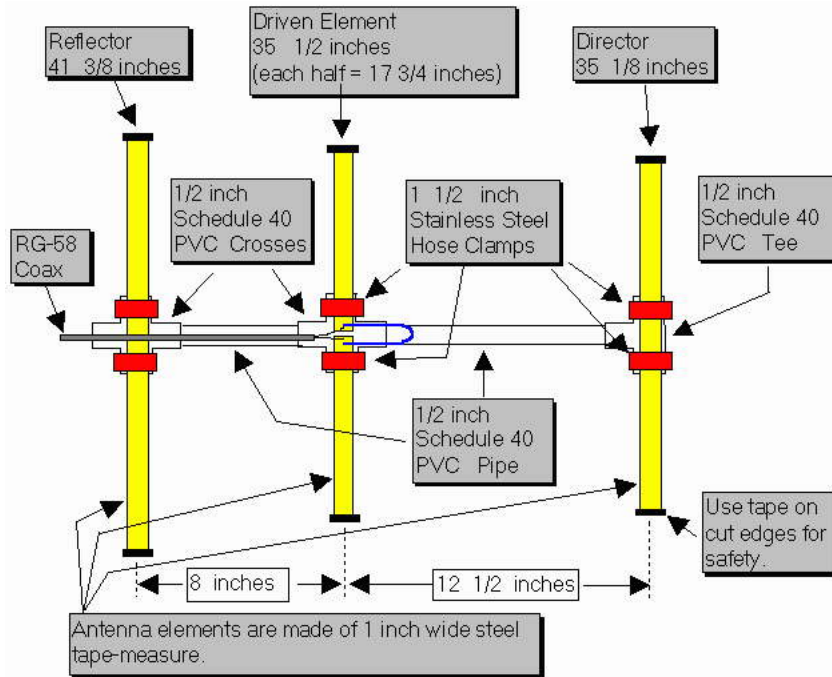


(b) Directional antenna



(c) Yagi Antenna Azimuth Plane Pattern

# Yagi Antenna



*Special purpose...*

# **Network Operating Systems (NOS)**

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- **NOS Components**
  - Server software
  - Client software
- **Directory Services**
  - Provides information about LAN resources
- **Network Profiles**
  - Specifies what resources are available for use by other computers and which devices or people are allowed what access.

# **NOS Directory Service**

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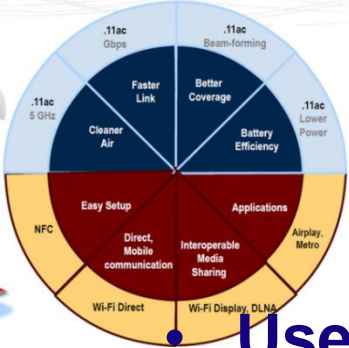
- **Provides LAN resource information**
  - Yellow Pages
- **Example: Microsoft's Active Directory (AD)**
  - AD servers, or domain servers, act as Domain Name Server (DNS)
    - Organizes resources into a tree, each branch contains a domain (a group of resources)
      - A domain has a server (domain controller)
        - » Responsible for resolving address information (textual name of resource → network address)
        - » Responsible for managing authorization
    - Uses Lightweight Directory Service Protocol (LDAP) to interact with client computers



# Profiles

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- **Network Profiles**
  - Reside on servers
  - Specify resources available for use by other computers
    - Include data files, printers, etc.
  - Configured when LAN is established, and updated
- **User profiles**
  - One profile for each user
  - Describe what each user on a LAN can access
  - Includes access codes assigned to devices and users
    - Only user with a correct code can use a specific device



# Wireless Ethernet

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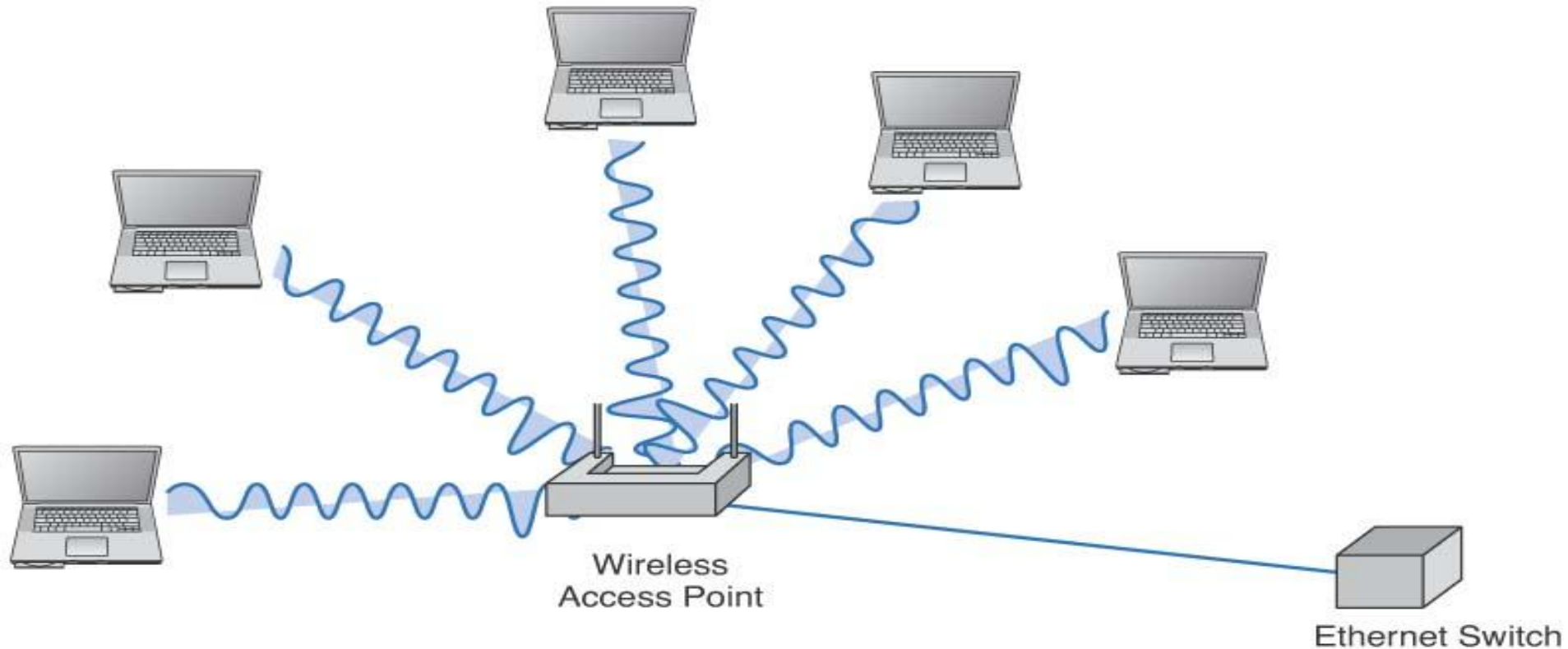
## • Uses radio frequencies

- **Transmits through air**
  - 802.1x Standard Family (aka, Wi-Fi)
- **Wi-Fi popularity**
  - Eliminates cabling
  - Facilitates network access from multiple locations
  - Facilitates mobile workers
  - Used in 90 percent of companies
  - Enables user to communicate when and where they want...

# WLAN Topology

Same as Ethernet

- Physical star
- Logical bus



# **WLAN Media Access Control**

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- **CSMA/CA Media Access methodology**
  - CA → collision avoidance
  - Before sending anything, a station waits until another station is finished transmitting plus an additional random period of time

# Association with an AP

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- **Scanning- searching for available APs**
- **May be active or passive**
  - **Active**
    - **NIC transmits probe frame on all active channels**
    - **AP responds with association info**
  - **Passive**
    - **NIC listens on all channels for beacon frame**
    - **NIC can use info in beacon frame to associate with AP**

# WLAN Characteristics

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- Two frequency ranges
  - 2.4 GHz
  - 5 GHz
- Distance 100-150 meters
- Channels used to reduce interference

## 2.4 GHz channels (U.S.)



## 5 GHz channels (U.S.)



# Popular Wireless Ethernet Standards

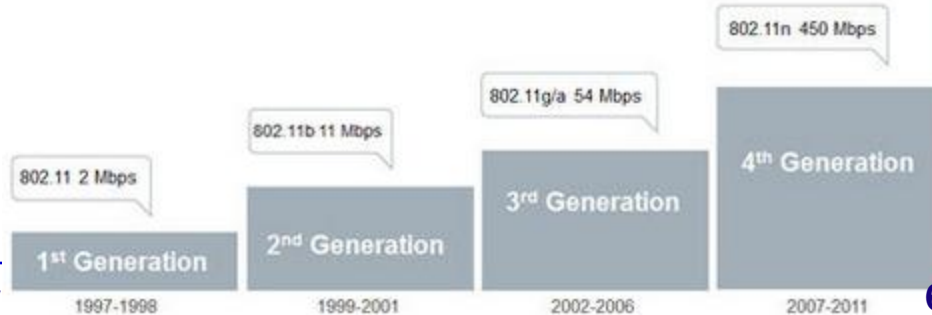
**TABLE I**  
**THE EVOLUTION OF THE 802.11 STANDARDS**

<i>Protocol</i>	<i>Year Introduced</i>	<i>Maximum Data Transfer Speed</i>	<i>Frequency</i>	<i>Highest Order Modulation</i>	<i>Channel Bandwidth</i>	<i>Antenna Configurations</i>
802.11a	1999	54 Mbps	5 GHz	64 QAM	20 MHz	1×1 SISO
802.11b	1999	11 Mbps	2.4 GHz	11 CCK	20 MHz	1×1 SISO
802.11g	2003	54 Mbps	2.4 GHz	64 QAM	20 MHz	1×1 SISO
802.11n	2009	65 to 600 Mbps	2.4 or 5 GHz	64 QAM	20 and 40 MHz	Up to 4×4 MIMO
802.11ac	2012	78 Mbps to 3.2 Gbps	5 GHz	256 QAM	20, 40, 80 and 160 MHz	Up to 8×8 MIMO; MU-MIMO

802.11ac Gigabit Speeds



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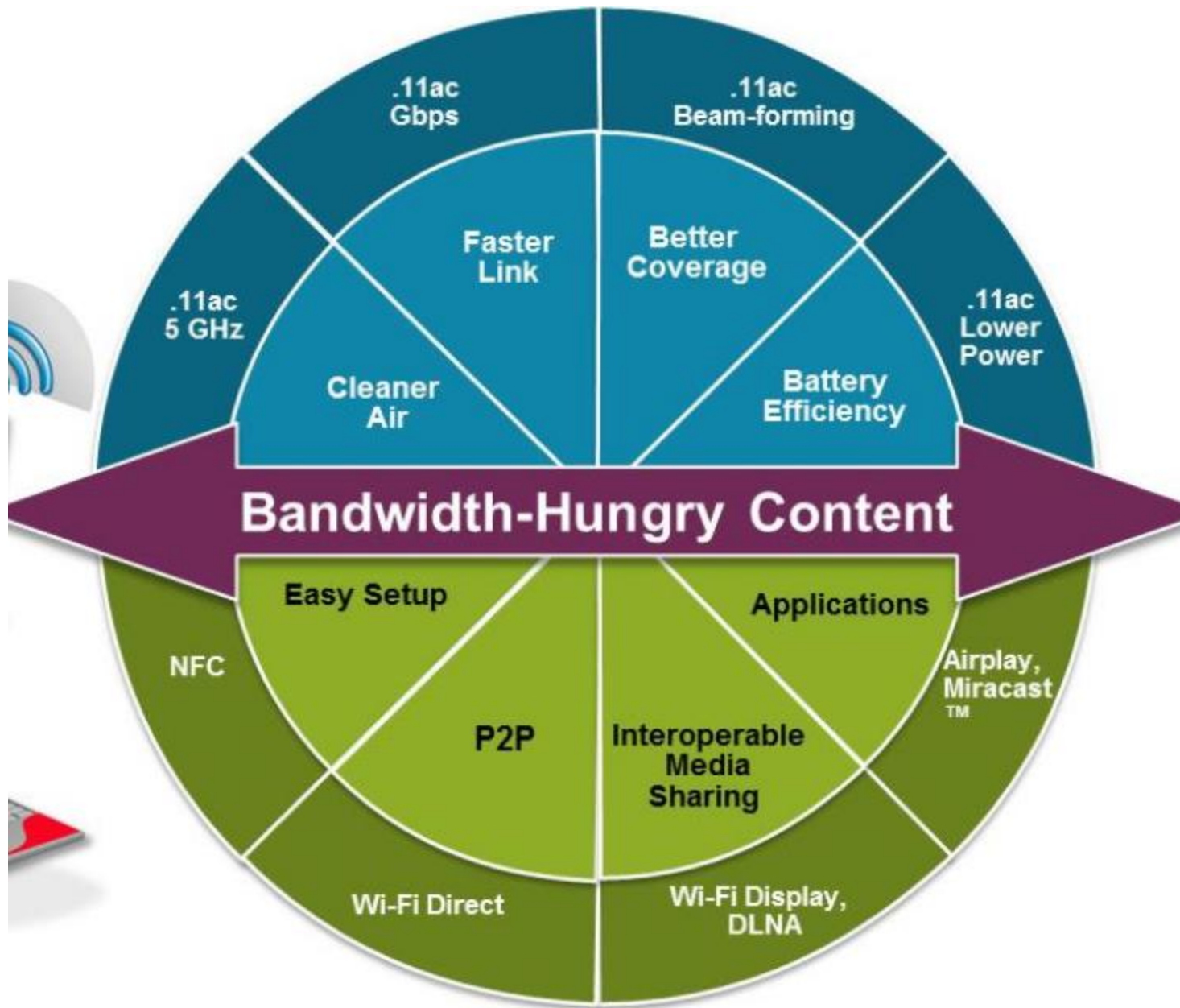
6 - 23 Today!

# IEEE 802.11n

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- **Backward compatible with a, b, and g**
- **Disadvantage: one laptop using a, b, or g slows down access by all other laptops (even when they are using n)**





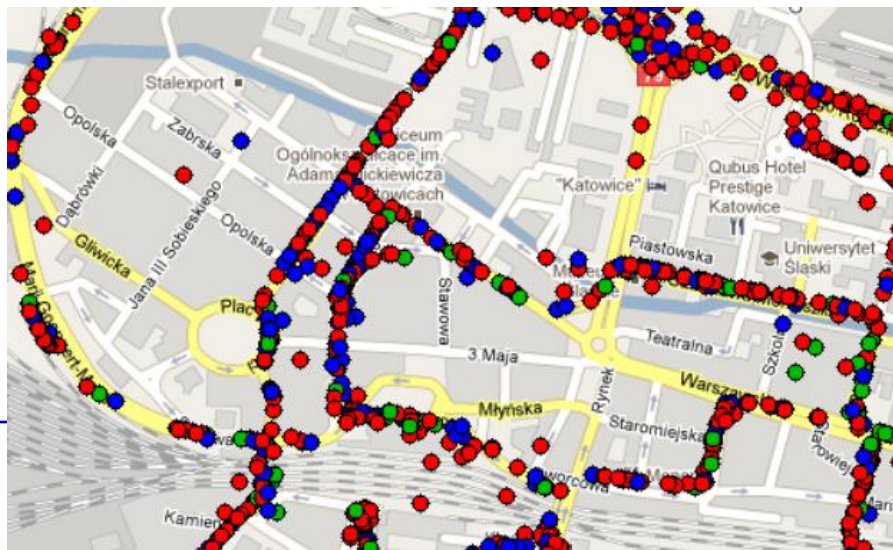
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**802.11ac delivers bandwidth required for streaming high-quality media.**

# WLAN Security

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- Anyone within range can use unsecure WLAN
- Finding a WLAN
  - Use special purpose software tools to learn about WLAN you discovered
  - Wardriving – reconnaissance



# **Types of WLAN Security**

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- **Service Set Identifier (SSID)**
  - Required by all clients in every packet
  - Included as plain text
- **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
- **Extensible Authentication Protocol (EAP)**
  - One time WEP keys created dynamically after login
  - Requires a login (with password) to a server

# **Types of WLAN Security, cont'd**

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- **Wi-Fi Protected Access (WPA)**
  - new standard
  - longer key, changed for every packet
- **802.11i (WPA2)**
  - EAP login used to get session key
  - uses AES
- **MAC address filtering**
  - Allows computers to connect to AP only if their MAC address is entered in the “accepted” list

# Wireless Recommendations:

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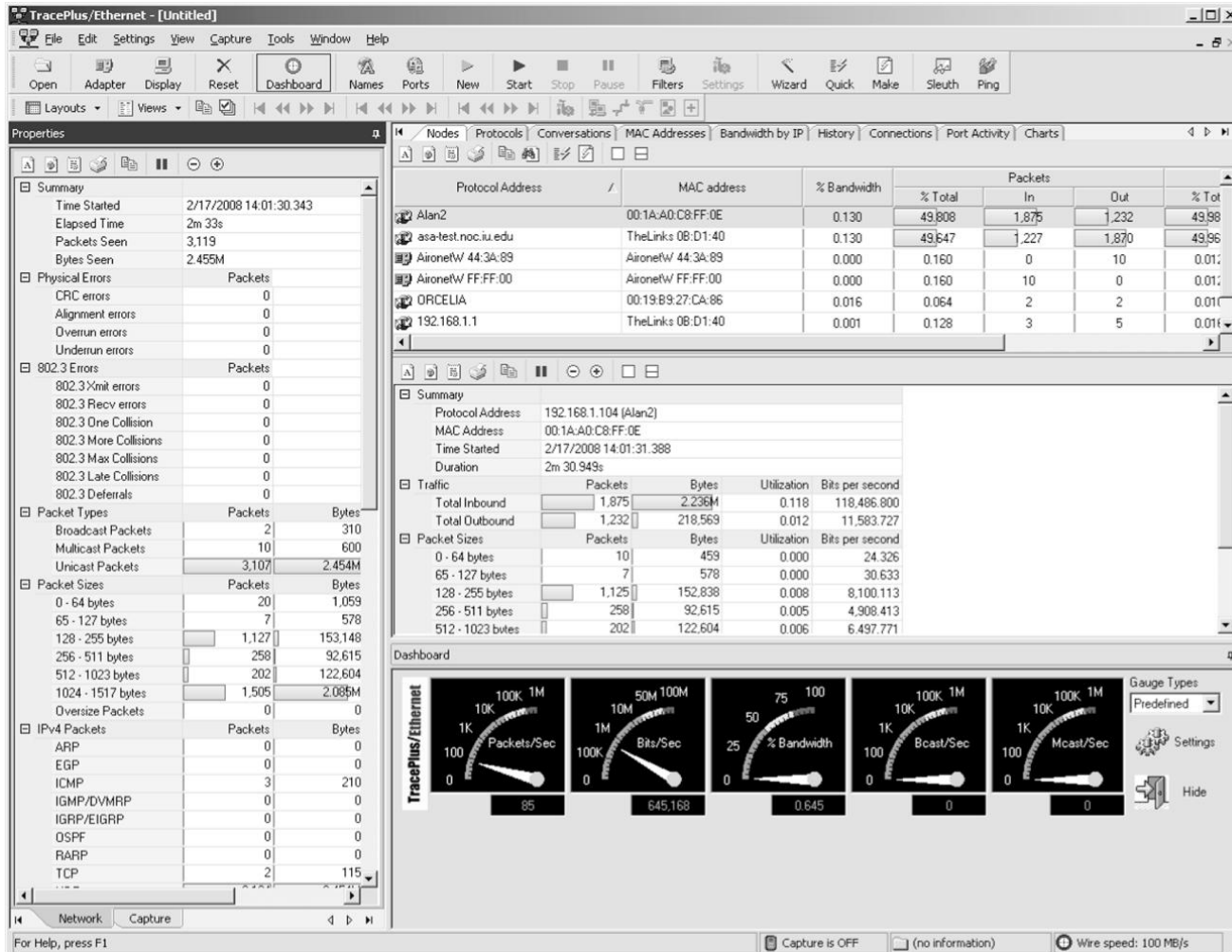
- **Pick newest one that cost permits**
  - 802-11ac
- **Placement of APs a design consideration**
  - So is likelihood of furniture moving

# Physical WLAN Design

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- **Design begins with a site survey that determines:**
  - **Feasibility of desired coverage**
    - **Measuring the signal strength from temporary APs**
  - **Potential interference sources**
    - **Most common source: Number and type of walls**
  - **Locations of wired LAN and power sources**
  - **Estimate of number of APs required**

# Wireless Auditing



# Identifying Network Bottlenecks

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- **server vs. circuit**
  - Network server
  - Network circuit (especially LAN-BN connection)
  - Client computer
- **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 Disk Drive Performance**

- **Consider Redundant Array of Inexpensive Disks (RAID)**
  - Replacing one large drive with multiple drives
  - Can improve performance and increase reliability
  - Can increase redundancy so a single drive failure does not result in data loss
- **Also consider NAS or SAN**

# Questions?

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