# **Chapter 6**

# Wired and Wireless Local Area Networks

#### **Chapter 6: Outline**

- 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**

- 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

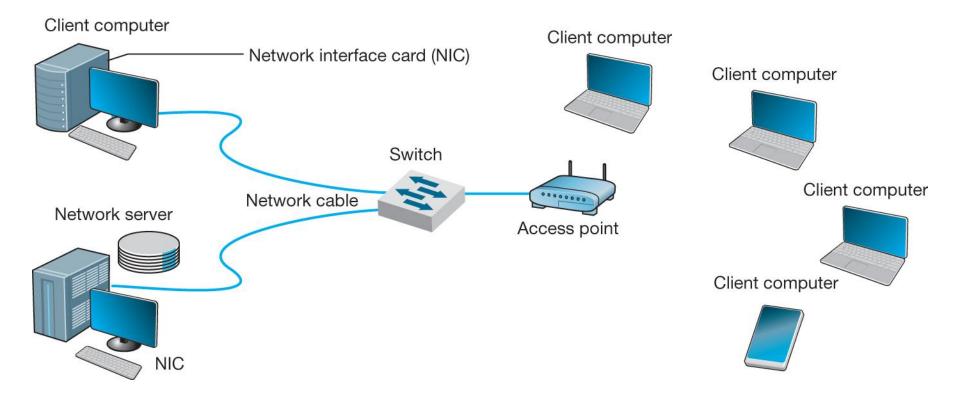
#### **Dedicated Server Types**

- 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**

- 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...

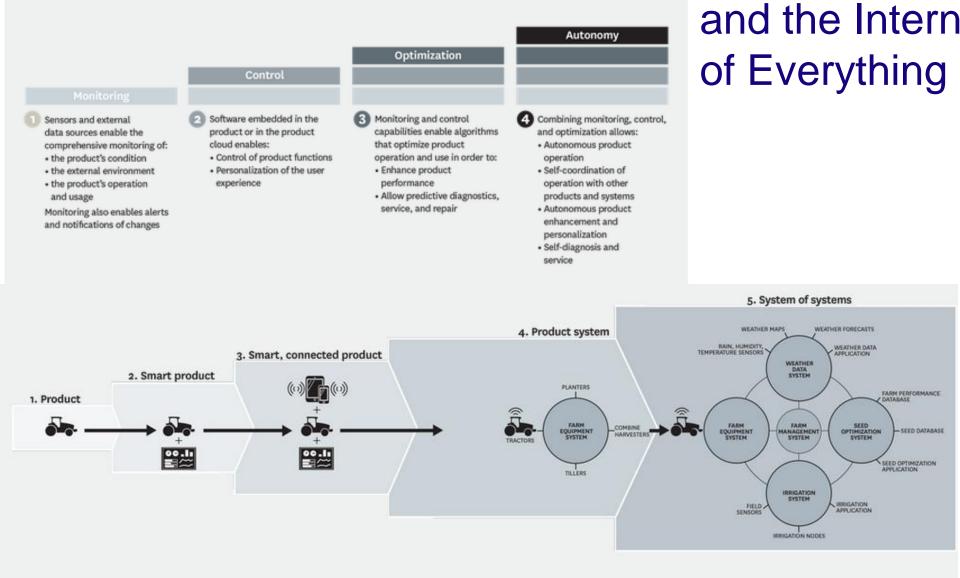
## **6.2 LAN Components**



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

<u>Communication</u>

#### **Network Interface Cards (NICs)**

- 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**

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

#### **Hubs & Switches**

#### **Functions:**

#### 1) Link cables from several networked computers

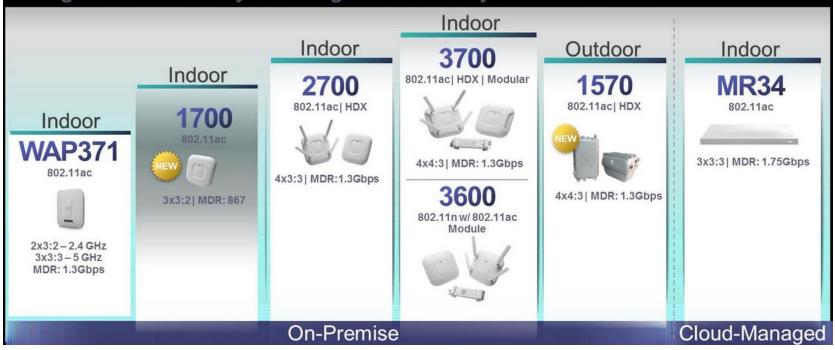
1) 4,8,16,24, or more ports



- 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

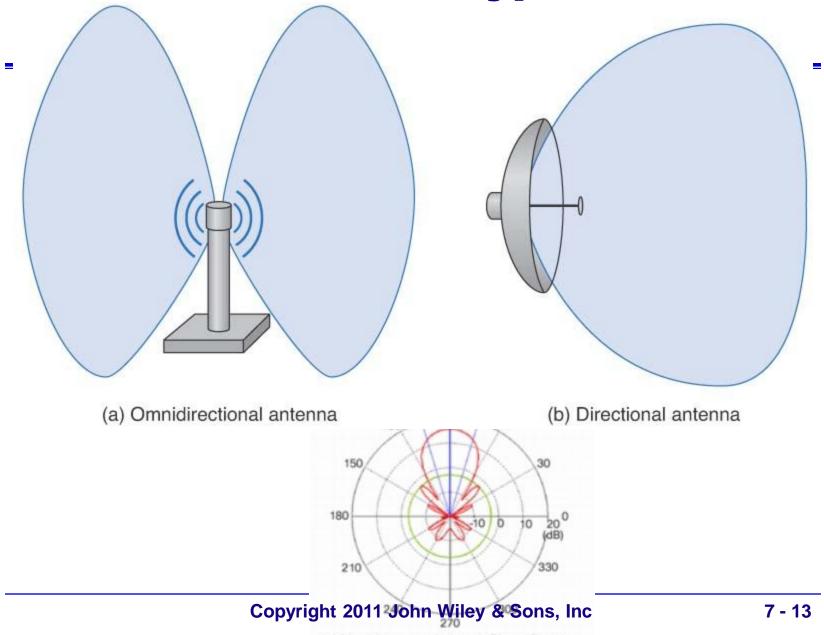


- Act as repeaters (hubs)
  - Must be able to hear all computers on a WLAN
  - Level one devices...

#### **Three WLAN Antenna Types**

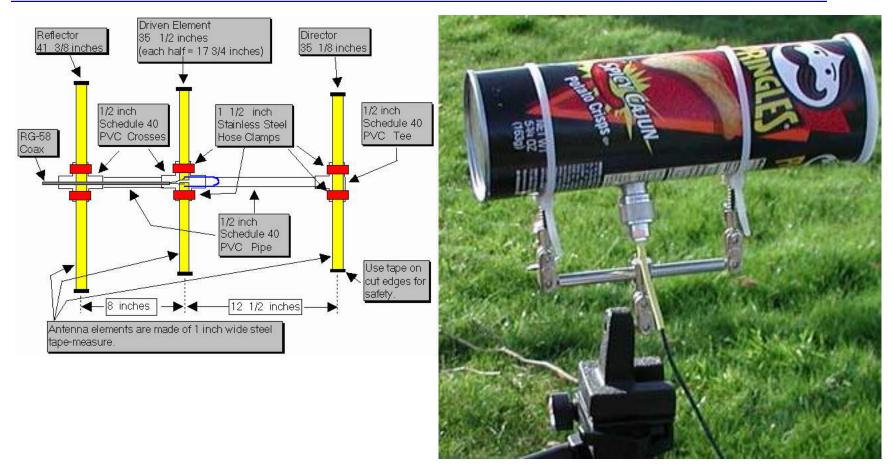
- Omni directional
  - Most common...
    - Dipole antenna
      - Transmits in all direction
- Directional antennas
  - Project signal primarily in one direction
    - Focused; stronger signal; farther ranges
  - Most often used on inside of an exterior wall
    - May reduce security vulnerabilities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

#### **Antenna Types**



<sup>(</sup>c) Yagi Antenna Azimuth Plane Pattern

#### Yagi Antenna



Special purpose...

### **Network Operating Systems (NOS)**

- 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**

- 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**

- 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**

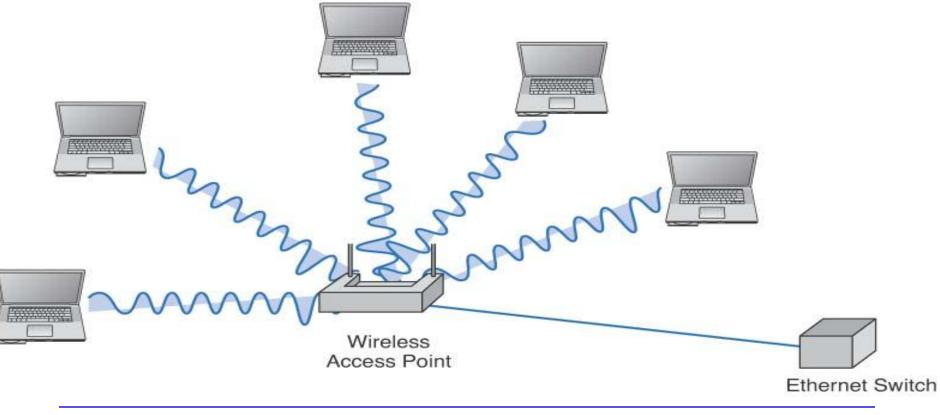
Uses radio frequencies

- 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**

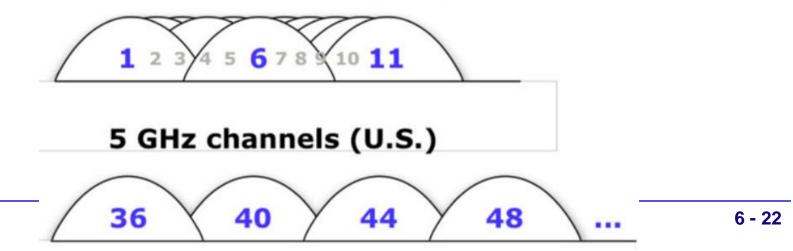
- CSMA/CA Media Access methodology
  - CA  $\rightarrow$  collision avoidance
  - Before sending anything, a station waits until another station is finished transmitting plus an additional random period of time

#### **Association with an AP**

- 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**

- Two frequency ranges
  - 2.4 GHz
  - 5 GHz
- Distance 100-150 meters
- Channels used to reduce interference 2.4 GHz channels (U.S.)

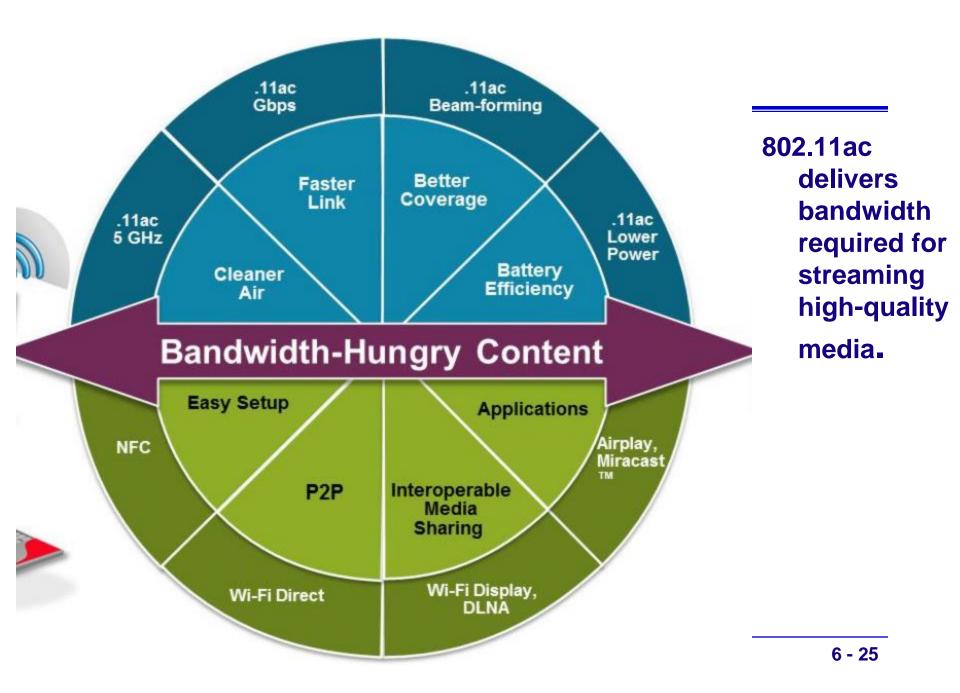


#### **Popular Wireless Ethernet Standards**

		THE EVOLUT	TABL	E I 802.11 STAN	DARDS		
Protocol	Year Introduced	Maximum Data Transfer Speed	Frequency	Highest Order Modulation	Channel Bandwidth	Antenna Configurations	
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 Gigabit Spee
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	<b>5</b> 9
						802.11n 450 Mbps	CWIFICI
				802 11b 11 Mbps	802.11g/a 54 Mbps		
			11 2 Mbps	2 <sup>nd</sup> Generation	3 <sup>rd</sup> Generatio	4 <sup>th</sup> Generation	
		Copyr	<sup>1</sup> Generation 1997-1998	1999-2001	2002-2006	2007-2011	6 - 23 Today!

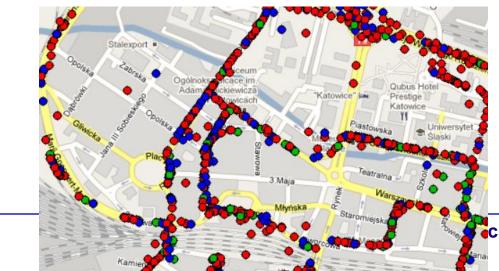
#### IEEE 802.11n

- 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)



#### **WLAN Security**

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



### **Types of WLAN Security**

- 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)  $\rightarrow$  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**

- 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:**

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

## **Physical WLAN Design**

- 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**

the second second	iew <u>C</u> apture <u>T</u> ools					i an			* 0		- 8>
	× C	0.0		Stop Pause	Filters Setting	~	Eź ☑ I Quick Make		8		
Open Adapter Display			s Ports New Start		Filters Setting:	s Wizard	l Quick Make	Sleuth P	Ping		
pperties						dwidth hy IP	History Coope	ections Port Ar	tivity) Charte		4 D H
A @ 5 🥩 📴 🖬	0.0						1		and I ana a		
	00								Packets		
3 Summary		<u> </u>	Protocol Address	Δ.	MAC addres	is .	% Bandwidth	% Total	In	Out	% Tot
Time Started	2/17/2008 14:01:30.3	43	2 Alan2	00	1A:A0:C8:FF:0E		0.130	49,808	1,875	1,232	49.98
Elapsed Time	2m 33s		asa-test.noc.iu.edu	TE	eLinks 0B:D1:40		0.130	49,647	1,227	1,870	49.96
Packets Seen	3,119		AironetW 44:3A:89		onetW 44:3A:89					-	
Bytes Seen	2.455M						0.000	0.160	0	10	0.012
3 Physical Errors	Packets		AironetW FF:FF:00	Ai	onetW FF:FF:00		0.000	0.160	10	0	0.012
CRC errors	0		CRCELIA	00	:19:B9:27:CA:86		0.016	0.064	2	2	0.01
Alignment errors	0		192.168.1.1	Tł	eLinks 0B:D1:40		0.001	0.128	3	5	0.016
Overrun errors	0							0.160			)
Underrun errors	0										-
E 802.3 Errors	Packets			⊙ ⊕ □							
802.3 Xmit errors	0										
802.3 Recv errors	0			192.168.1.104 (Ak	m2)						-
802.3 One Collision	0			00:1A:A0:C8:FF:08							
802.3 More Collisions	0			2/17/2008 14:01:1							
802.3 Max Collisions	0			2/17/2008 14:01: 2m 30.949s	51.300						
802.3 Late Collisions	0		E Traffic	2m 30.949s Packets	Bytes	Utilization	0)				
002.3 Late Collisions							Bits per second				
802.3 Deferrals	0						110 100 000				
802.3 Deferrals	0 Packets	Bytes	Total Inbound	1,875	2.236M	0.118					
802.3 Deferrals	-	Bytes 310	Total Inbound [ Total Outbound [	1,875	2.236M 218,569	0.118	11,583.727				
802.3 Deferrals El Packet Types	Packets		Total Inbound [ Total Outbound [ Packet Sizes	1,875 1,232 Packets	2.236M 218,569 Bytes	0.118 0.012 Utilization	2 11,583.727 Bits per second				
802.3 Deferrals Packet Types Broadcast Packets	Packets 2	310	Total Inbound [ Total Outbound [ □ Packet Sizes 0 · 64 bytes	1,875 1,232 Packets 10	2.236M 218,569 Bytes 459	0.118 0.012 Utilization 0.000	2 11,583.727 Bits per second 24.326				
802.3 Deferrals Packet Types Broadcast Packets Multicast Packets Unicast Packets	Packets 2 10 3,107	310 600 2.454M	Total Inbound Total Outbound [ □ Packet Sizes 0 · 64 bytes 65 · 127 bytes	1,875 1,232 Packets 10 7	2.236M 218,569 Bytes 459 578	0.118 0.012 Utilization 0.000 0.000	2 11,583.727 Bits per second 2 24.326 3 30.633				
802.3 Deferrals Packet Types Broadcast Packets Multicast Packets Unicast Packets Packet Sizes	Packets 2 10	310 600	Total Inbound Total Outbound □ Packet Sizes 0 · 64 bytes 65 · 127 bytes 128 · 255 bytes	1,875 1,232 Packets 10 7 1,125	2.236M 218,569 Bytes 459 578 152,838	0.118 0.012 Utilization 0.000 0.000	2 11,583,727 bits per second 0 24,326 0 30,633 8 8,100,113				
802.3 Deferrals Packet Types Broadcast Packets Multicast Packets Unicast Packets Packet Sizes 0 - 64 bytes	Packets 2 10 3,107 Packets	310 600 2.454M Bytes 1.059	Total Inbound Total Outbound □ Packet Sizes 0 · 64 bytes 65 · 127 bytes 128 · 255 bytes 256 · 511 bytes	1,875 1,232 Packets 10 7 1,125 258	2.236M 218,569 Bytes 459 578 152,838 92,615	0.118 0.012 Utilization 0.000 0.000 0.000	2 11,583,727 Bits per second 0 24,326 0 30,633 8 8,100,113 5 4,908,413				
802.3 Deferrals Packet Types Broadcast Packets Multicast Packets Unicast Packets Packet Sizes 0.64 bytes 65.127 bytes	Packets 2 10 3,107 Packets 20 7	310 600 2.454M Bytes 1,059 578	Total Inbound Total Outbound □ Packet Sizes 0 · 64 bytes 65 · 127 bytes 128 · 255 bytes	1,875 1,232 Packets 10 7 1,125	2.236M 218,569 Bytes 459 578 152,838	0.118 0.012 Utilization 0.000 0.000	2 11,583,727 Bits per second 0 24,326 0 30,633 8 8,100,113 5 4,908,413				
802.3 Deferrals Packet Types Broadcast Packets Multicast Packets Unicast Packets Packet Sizes 0.64 bytes 65.127 bytes 128.255 bytes	Packets 2 10 3,107 Packets 20 7 1,127	310 600 2.454M Bytes 1,059 578 153,148	Total Inbound           Total Outbound           □ Packet Sizes           0 · 64 bytes           65 · 127 bytes           128 · 255 bytes           256 · 511 bytes           512 · 1023 bytes	1,875 1,232 Packets 10 7 1,125 258	2.236M 218,569 Bytes 459 578 152,838 92,615	0.118 0.012 Utilization 0.000 0.000 0.000	2 11,583,727 Bits per second 0 24,326 0 30,633 8 8,100,113 5 4,908,413				
802.3 Defemals Packet Types Broadcast Packets Multicast Packets Unicast Packets Packet Sizes 0 - 64 bytes 65 - 127 bytes 128 - 255 bytes 256 - 511 bytes	Packets 2 10 3,107 Packets 20 7 1,127 258	310 600 2.454M Bytes 1,059 578 153,148 92,615	Total Inbound Total Outbound □ Packet Sizes 0 - 64 bytes 65 - 127 bytes 128 - 255 bytes 256 - 511 bytes 512 - 1023 bytes Dashboard	1,875 1,232 Packets 10 7 1,125 258 202	2.236M 218,569 Bytes 459 578 152,838 92,615	0.118 0.012 Utilization 0.000 0.000 0.000	2 11,583,727 Bits per second 0 24,326 0 30,633 8 8,100,113 5 4,908,413				-
802.3 Defemals Packet Types Broadcast Packets Multicast Packets Unicast Packets = Packet Sizes 0 - 64 bytes 65 - 127 bytes 128 - 255 bytes 256 - 511 bytes 512 - 1023 bytes	Packets 2 10 3,107 Packets 20 7 1,127 258 202 202	310 600 2.454M Bytes 1,059 578 153,148 92,615 122,604	Total Inbound Total Outbound □ Packet Sizes 0 - 64 bytes 128 - 255 bytes 256 - 511 bytes 512 - 1023 bytes Dashboard	1,875 1,232 Packets 10 7 1,125 258 202	2.236M 218,569 Bytes 459 578 152,838 92,615 122,604	0.118 0.012 Utilization 0.000 0.000 0.000 0.000	2 11,583,727 Bits per second 0 24,326 0 30,633 8 8,100,113 5 4,908,413 5 6,497,771		1	w 1M Gauge	Types
802.3 Deferrals Packet Types Broadcast Packets Multicast Packets Unicast Packets Packet Sizes 0 · 64 bytes 65 · 127 bytes 128 · 255 bytes 256 · 511 bytes 512 · 1023 bytes 1024 · 1517 bytes	Packets 2 10 3.107 Packets 20 7 1,127 258 202 1,505	310 600 2.454M Bytes 1.059 578 153,148 92,615 122,604 2.085M	Total Inbound Total Outbound □ Packet Sizes 0 - 64 bytes 128 - 255 bytes 256 - 511 bytes 512 - 1023 bytes Dashboard	1,875 1,232 Packets 10 7 1,125 258 202	2.236M 218,569 Bytes 459 578 152,838 92,615	0.118 0.012 Utilization 0.000 0.000 0.000 0.000	2 11,583,727 Bits per second 0 24,326 0 30,633 8,100,113 5 4,908,413 5 6,497,771	100K <sup>1M</sup>	100	K 1M Gauge Prede	
802.3 Deferrals Packet Types Broadcast Packets Multicast Packets Unicast Packets Packet Sizes 0 - 64 bytes 65.127 bytes 128 - 255 bytes 256 - 511 bytes 512 - 1023 bytes 1024 - 1517 bytes Oversize Packets	Packets 2 10 Packets 20 7 1,127 258 202 202 1,505 0	310 600 2.454M Bytes 1.059 578 153,148 92,615 122,604 2.085M 0	Total Inbound Total Outbound □ Packet Sizes 0 - 64 bytes 128 - 255 bytes 256 - 511 bytes 512 - 1023 bytes Dashboard	1,875 1,232 Packets 10 7 1,125 258 202	2.236M 218,569 Bytes 459 578 152,838 92,615 122,604	0.118 0.012 Utilization 0.000 0.000 0.000 0.000	2 11,583,727 Bits per second 0 24,326 0 30,633 8 8,100,113 5 4,908,413 5 6,497,771 100 1		100 10K		Types fined 💌
802.3 Defends Packet Types Broadcast Packets Multicast Packets Unicast Packets 0.64 bytes 65.127 bytes 128.255 bytes 226.611 bytes 512.1023 bytes 1024.1517 bytes Oversize Packets I P44 Packets	Packets 2 10 3.107 Packets 20 7 1,127 228 202 1,505 0 Packets	310 600 2.454M Bytes 1.059 578 153,148 92,615 122,604 2.085M 0 Bytes	Total Inbound Total Outbound □ Packet Sizes 0 - 64 bytes 128 - 255 bytes 256 - 511 bytes 512 - 1023 bytes Dashboard	1,975 1,232 Packets 10 7 1,125 255 202 10M	2.236M 218,569 Bytes 459 578 152,838 92,515 122,604	0.118 0.012 Utilization 0.000 0.000 0.000 0.000 0.000	2 11,583,727 Bits per second 0 24,326 0 30,633 8,100,113 5 4,908,413 5 6,497,771 100 1 1 1 K	100K 1M 0K	1K MC		Types fined 💌
802.3 Defends Packet Types Broadcast Packets Multicast Packets Unicast Packets 0 - 64 bytes 65 - 127 bytes 128 - 255 bytes 256 - 511 bytes 512 - 1023 bytes 1024 - 1517 bytes Oversize Packets 2   IPv4 Packets ARP	Packets 2 10 3.107 Packets 20 7 1,127 258 202 1,505 0 Packets 0	310 600 2.454M Bytes 1.059 578 153,148 92,615 122,604 2.085M 0 Bytes 0	Total Inbound Total Outbound □ Packet Sizes 0 - 64 bytes 128 - 255 bytes 256 - 511 bytes 512 - 1023 bytes Dashboard	1,875 1,232 Packets 10 7 1,125 258 202	2.236M 218,569 Bytes 459 578 152,838 92,615 122,604	0.118 0.012 Utilization 0.000 0.000 0.000 0.000 0.000	2 11,583,727 Bits per second 0 24,326 0 30,633 8,100,113 5 4,908,413 5 6,497,771	100K <sup>1M</sup>	1K 🖉		Types
802.3 Defensis Packet Types Broadcast Packets Multicast Packets Unicast Packets 9 Packet Sizes 0 - 64 bytes 65 - 127 bytes 128 - 255 bytes 256 - 511 bytes 512 - 1023 bytes 1024 - 1517 bytes Oversize Packets B IPA4 Packets ARP EGP	Packets 2 10 3,107 Packets 20 7 1,127 258 202 1,505 0 Packets 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0	310 600 2.454M Bytes 1.053 578 153,148 92,615 122,604 2.085M 0 Bytes 0 0	Total Inbound Total Outbound □ Packet Sizes 0 - 64 bytes 128 - 255 bytes 256 - 511 bytes 512 - 1023 bytes Dashboard	1,975 1,232 Packets 10 7 1,125 255 202 10M	2.236M 218,569 Bytes 459 578 152,838 92,515 122,604	0.118 0.012 Utilization 0.000 0.000 0.000 0.000 0.000	2 11,583,727 Bits per second 0 24,326 0 30,633 8,100,113 5 4,908,413 5 6,497,771 100 1 1 1 K	100K 1M 0K	1K MC		Types fined 💌
802.3 Defenals 9 Packet Types Broadcast Packets Multicast Packets Unicast Packets 9 Packet Sizes 0 - 64 bytes 65 - 127 bytes 128 - 255 bytes 256 - 511 bytes 512 - 1023 bytes 1024 - 1517 bytes Oversize Packets ARP EGP ICMP	Packets 2 10 3107 Packets 20 7 1.127 2258 2022 1,505 0 Packets 0 0 0 3	310 600 2.454M Bytes 1.059 578 153,148 92,615 122,604 2.085M 0 Bytes 0 0 0 210	Total Inbound Total Outbound □ Packet Sizes 0 · 64 bytes 65 · 127 bytes 128 · 255 bytes 256 · 511 bytes 512 · 1023 bytes Dashboard 100 · 1100 · 110 100 · 100 · 110 100 · 100 · 110 0 · 0 · 0 · 0 · 0 · 0 · 0 · 0 · 0 · 0 ·	1,975 1,232 Packets 10 7 1,125 255 202 10M	2.236M 218.569 Bytes 459 578 92.515 122.604 50M 100M Bla/Sec 25 0	0.116 0.012 Utilizatior 0.000 0.000 0.000 0.000 0.000 0.000 0.000	2 11.583.727 Bits per second 2 4326 0 30.633 8 4.100.113 5 6.497.771	0K 1M 0K Bcast/Sec	1K MC		Types fined 💌
802.3 Defenals Packet Types Broadcast Packets Multicast Packets Unicast Packets 0.64 bytes 65.127 bytes 128.255 bytes 128.255 bytes 126.511 bytes 512.1023 bytes 1024.1517 bytes Oversize Packets ARP EGP IGMP/DVMRP	Packets 2 10 3,107 Packets 20 7 1,127 258 202 1,505 0 Packets 0 0 3 0 0 3 0 0 0 0 0 0 0 0 0 0 0 0 0	310 600 2.454M Bytes 1.059 578 153,148 92,615 122,604 2.085M 0 Bytes 0 0 210 0 0	Total Inbound Total Outbound □ Packet Sizes 0 · 64 bytes 65 · 127 bytes 128 · 255 bytes 256 · 511 bytes 512 · 1023 bytes Dashboard 100K 1M 1K Raketz Si	1,975 1,232 Packets 10 7 1,125 255 202 10M	2.236M 218,569 Bytes 459 578 152,838 92,515 122,604	0.116 0.012 Utilizatior 0.000 0.000 0.000 0.000 0.000 0.000 0.000	2 11,583,727 Bits per second 0 24,326 0 30,633 8,100,113 5 4,908,413 5 6,497,771 100 1 1 1 K	100K 1M 0K	1K MC		Types fined 💌 Settings
802.3 Defenals Broadcast Packets Multicast Packets Unicast Packets 9 Packet Sizes 0 - 64 bytes 65 - 127 bytes 128 - 255 bytes 128 - 255 bytes 512 - 1023 bytes 1024 - 1517 bytes Oversize Packets 3 IPv4 Packets ARP EGP ICMP IGMP/DVMRP IGRP/EIGRP	Packets 2 10 3.107 Packets 20 7 1,127 258 202 1,505 0 Packets 0 0 0 3 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0	310 600 2.454M Bytes 1.059 578 153,148 92,615 122,604 2.085M 0 Bytes 0 0 210 0 0 0 0 0	Total Inbound Total Outbound □ Packet Sizes 0 · 64 bytes 65 · 127 bytes 128 · 255 bytes 256 · 511 bytes 512 · 1023 bytes Dashboard 100 · 1100 · 110 100 · 100 · 110 100 · 100 · 110 0 · 0 · 0 · 0 · 0 · 0 · 0 · 0 · 0 · 0 ·	1,975 1,232 Packets 10 7 1,125 255 202 10M	2.236M 218.569 Bytes 459 578 92.515 122.604 50M 100M Bla/Sec 25 0	0.116 0.012 Utilizatior 0.000 0.000 0.000 0.000 0.000 0.000 0.000	2 11.583.727 Bits per second 2 4326 0 30.633 8 4.100.113 5 6.497.771	0K 1M 0K Bcast/Sec	1K MC		Types fined 💌 Settings
802.3 Defends 9 Packet Types Broadcast Packets Multicast Packets Unicast Packets 0 - 64 bytes 65 - 127 bytes 128 - 255 bytes 512 - 1023 bytes 124 - 1517 bytes Oversize Packets ARP EGP ICMP IGMP/DV/MRP IGRP/EIGRP OSFF	Packets 2 10 300 Packets 20 7 1,127 258 202 1,505 0 Packets 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0	310 600 2.454M Bytes 1.059 578 93,615 153,148 93,615 122,604 2.085M 0 0 0 8ytes 0 0 0 0 210 0 0 0 0 0 0 0 0 0 0 0	Total Inbound Total Outbound □ Packet Sizes 0 · 64 bytes 65 · 127 bytes 128 · 255 bytes 256 · 511 bytes 512 · 1023 bytes Dashboard 100 · 1100 · 110 100 · 100 · 110 100 · 100 · 110 0 · 0 · 0 · 0 · 0 · 0 · 0 · 0 · 0 · 0 ·	1,975 1,232 Packets 10 7 1,125 2258 202	2.236M 218.569 Bytes 459 578 92.515 122.604 50M 100M Bla/Sec 25 0	0.116 0.012 Utilizatior 0.000 0.000 0.000 0.000 0.000 0.000 0.000	2 11.583.727 Bits per second 2 4326 0 30.633 8 4.100.113 5 6.497.771	0K 1M 0K Bcast/Sec	1K MC		Types fined 💌 Settings
802.3 Defends Packet Types Broadcast Packets Multicast Packets Unicast Packets 0.64 bytes 65.127 bytes 128.255 bytes 128.255 bytes 1224.1517 bytes Oversize Packets IV44 Packets ARP EGP ICMP IGMP//DVMRP IGMP//EIGRP OSPF RARP	Packets 2 10 3,107 Packets 20 7 1,127 258 202 1,505 0 Packets 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0	310 600 2.454M Bytes 1.059 578 153,148 92,615 122,604 0 0 8,ytes 0 0 0 0 0 210 0 0 0 0 0 0 0 0 0 0 0 0 0	Total Inbound Total Outbound □ Packet Sizes 0 - 64 bytes 65 - 127 bytes 128 - 256 bytes 512 - 1023 bytes Dashboard 0 10K 10K 10K 20K 0 85	1,975 1,232 Packets 10 7 1,125 2258 202	2.236M 218.569 Bytes 459 578 92.515 122.604 50M 100M Bla/Sec 25 0	0.116 0.012 Utilizatior 0.000 0.000 0.000 0.000 0.000 0.000 0.000	2 11.583.727 Bits per second 2 4326 0 30.633 8 4.100.113 5 6.497.771	0K 1M 0K Bcast/Sec	1K MC		Types fined 💌 Settings
802.3 Defensis Packet Types Broadcast Packets Multicast Packets Unicast Packets 0 - 64 bytes 65 - 127 bytes 128 - 255 bytes 128 - 255 bytes 512 - 1023 bytes 1024 - 1517 bytes Oversize Packets 266 - 511 bytes Oversize Packets 1024 - 1517 bytes Oversize Packets ARP EGP IGMP/DVMRP IGMP/DVMRP IGMP/EIGRP OSPF RARP TCP	Packets 2 10 3.107 Packets 20 7 1,127 258 202 1,505 0 Packets 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0	310 600 2.454M Bytes 1.059 578 153,148 9.2,615 122,604 0 8,ytes 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0	Total Inbound Total Outbound □ Packet Sizes 0 - 64 bytes 65 - 127 bytes 128 - 256 bytes 512 - 1023 bytes Dashboard 0 10K 10K 10K 20K 0 85	1,975 1,232 Packets 10 7 1,125 2258 202	2.236M 218.569 Bytes 459 578 92.515 122.604 50M 100M Bla/Sec 25 0	0.116 0.012 Utilizatior 0.000 0.000 0.000 0.000 0.000 0.000 0.000	2 11.583.727 Bits per second 2 4326 0 30.633 8 4.100.113 5 6.497.771	0K 1M 0K Bcast/Sec	1K MC		Types fined 💌 Settings
802.3 Defends Packet Types Broadcast Packets Multicast Packets Unicast Packets 0.64 bytes 65.127 bytes 128.255 bytes 128.255 bytes 122.1023 bytes 1024.1517 bytes Oversize Packets ARP EGP ICMP IGMP//DVMRP IGSP/EIGRP OSPF RARP	Packets 2 10 3,107 Packets 20 7 1,127 258 202 1,505 0 Packets 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0	310 600 2.454M Bytes 1.059 578 153,148 92,615 122,604 0 0 89,tes 0 0 0 0 0 210 0 0 0 0 0 0 0 0 0 0 0 0 0	Total Inbound Total Outbound □ Packet Sizes 0 - 64 bytes 65 - 127 bytes 128 - 256 bytes 512 - 1023 bytes Dashboard 0 10K 10K 10K 20K 0 85	1,975 1,232 Packets 10 7 1,125 2258 202	2.236M 218.569 Bytes 459 578 92.515 122.604 50M 100M Bla/Sec 25 0	0.116 0.012 Utilizatior 0.000 0.000 0.000 0.000 0.000 0.000 0.000	2 11.583.727 Bits per second 2 4326 0 30.633 8 4.100.113 5 6.497.771	0K 1M 0K Bcast/Sec	1K MC		Types fined 💌 Settings
802.3 Defends Packet Types Broadcast Packets Multicast Packets Unicast Packets 0.64 bytes 65.127 bytes 128.255 bytes 256.511 bytes 512.1023 bytes 1024.1517 bytes Oversize Packets ARP EGP ICMP IGMP//EGRP OSPF RARP TCP	Packets 2 10 3.107 Packets 20 7 1,127 258 202 1,505 0 Packets 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0	310 600 2.454M Bytes 1.059 578 153,148 92,615 122,604 122,604 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0	Total Inbound Total Outbound □ Packet Sizes 0 - 64 bytes 65 - 127 bytes 128 - 256 bytes 512 - 1023 bytes Dashboard 0 10K 10K 10K 20K 0 85	1,975 1,232 Packets 10 7 1,125 2258 202	2.236M 218.569 Bytes 459 578 92.515 122.604 50M 100M Bla/Sec 25 0	0.116 0.012 Utilizatior 0.000 0.000 0.000 0.000 0.000 0.000 0.000	2 11.583.727 Bits per second 2 4326 0 30.633 8 4.100.113 5 6.497.771	0K 1M 0K Bcast/Sec	1K MC		Types fined 💌 Settings

Copyright 2011 John Wiley & Sons, Inc

#### **Identifying Network Bottlenecks**

- 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

