

# Chapter Eight

## Local Area Networks: Part II

Data Communications and Computer  
Networks: A Business User's Approach  
Seventh Edition

After reading this chapter,  
you should be able to:

- Compare and contrast wireless LANs to wired LANs
- Identify the main functions of network operating systems
- Identify the basic features and contributions of one of the first network operating systems: Novell NetWare
- Compare and contrast the Windows Server family, Unix, Linux, and Mac OS X Server network operating systems

After reading this chapter,  
you should be able to (continued):

- Recognize the importance of the network server and the different types of network servers available
- Identify the different levels of RAID
- Identify common examples of network utility software and Internet software
- Enumerate the various components of software licenses
- Identify the different types of support devices commonly found on local area networks

# Wireless Ethernet

- Not really a specific topology
  - Workstation in a wireless LAN can be anywhere as long as it is within transmitting distance to an access point
- Several versions of IEEE 802.11 standard define various forms of wireless LAN connections (we'll take a look at these versions in a little bit)

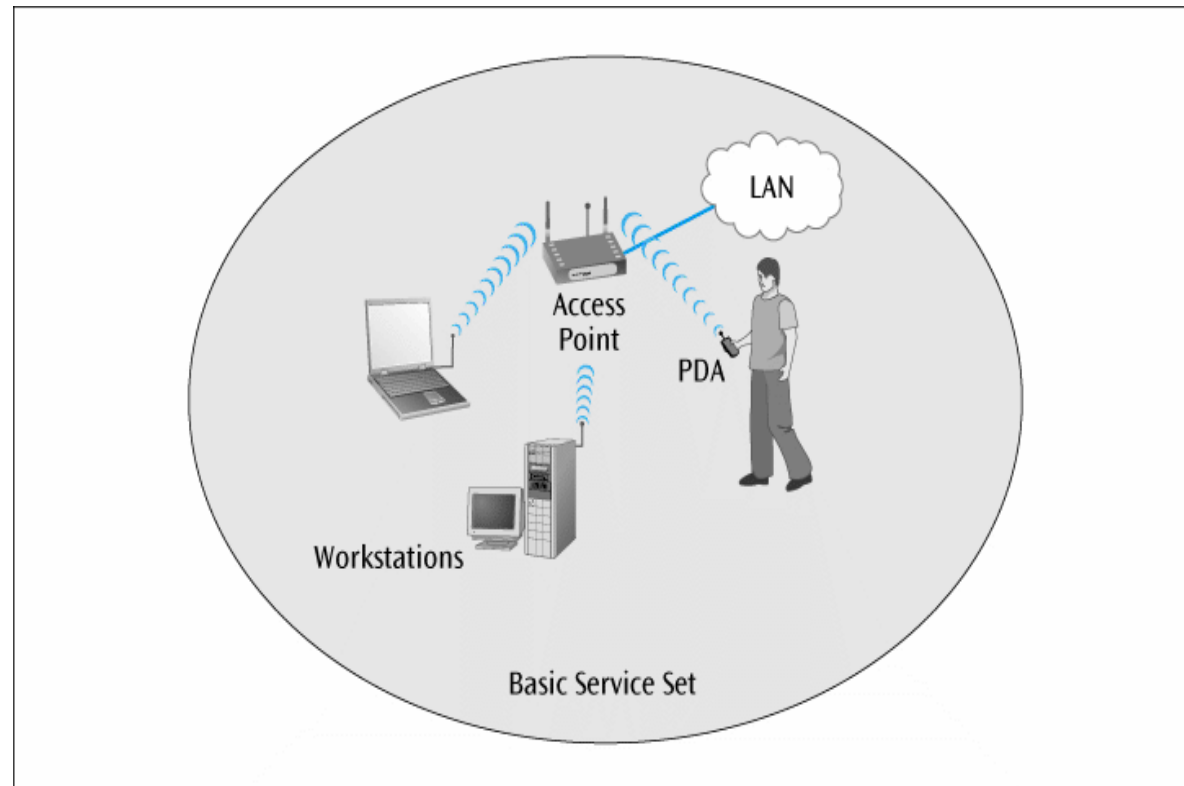
# Wireless Ethernet (continued)

- Two basic components necessary:
  - Client radio
    - Usually a PC card with an integrated antenna installed in a laptop or workstation
  - Access point (AP)
    - An Ethernet port plus a transceiver
- Access point acts as a bridge between the wired and wireless networks and can perform basic routing functions
- Workstations with client radio cards reside within Basic Service Set, while multiple basic service sets create an Extended Service Set

# Wireless Ethernet (continued)

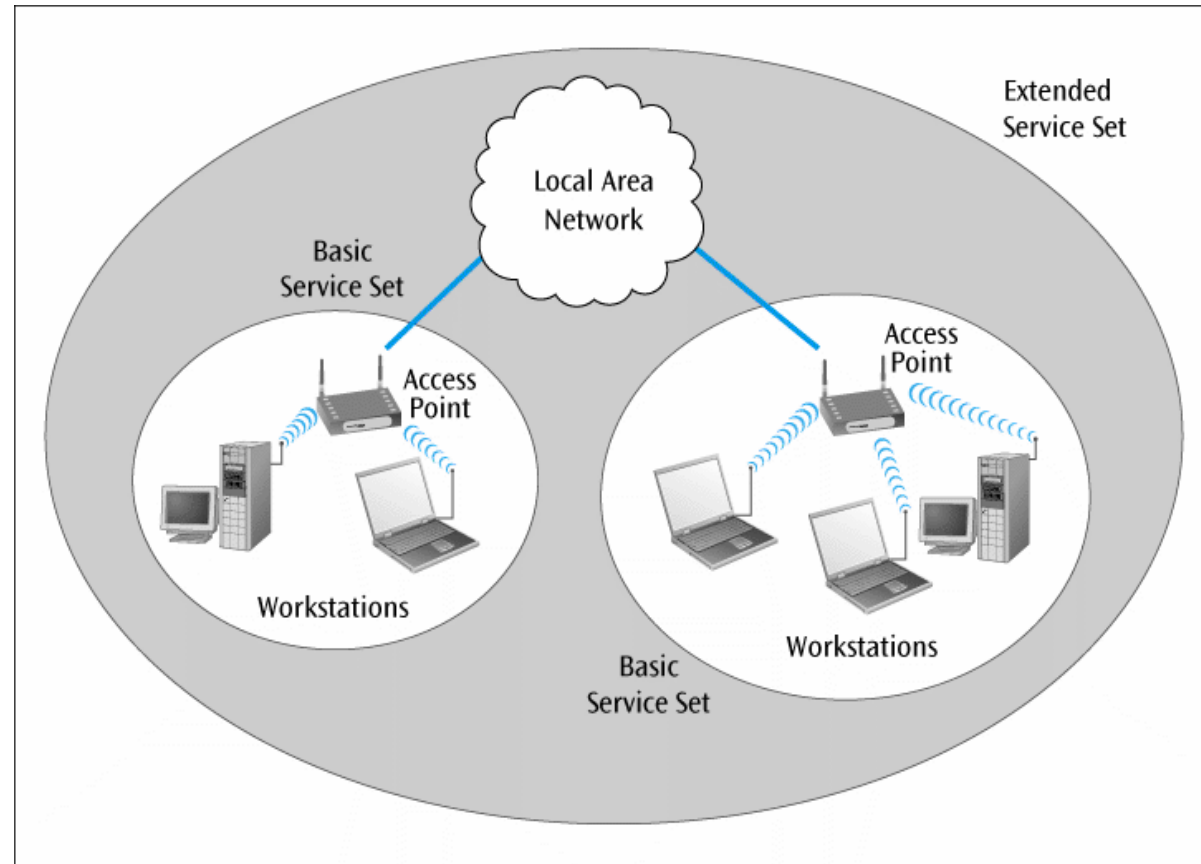
**Figure 8-1**

***A single-cell  
wireless LAN  
configuration***



# Wireless Ethernet (continued)

**Figure 8-2**  
***A multiple-cell***  
***wireless LAN***  
***configuration***



## Wireless Ethernet (continued)

- IEEE 802.11
  - Original wireless standard, capable of transmitting data at 2 Mbps
- IEEE 802.11b
  - Second wireless standard, capable of transmitting data at 11 Mbps
  - In actual tests, 11 Mbps 802.11b devices managed 5.5 Mbps (from a July 2000 test by *Network Computing*)



## Wireless Ethernet (continued)

- With directional antennae designed for point-to-point transmission (rare), 802.11b can transmit for more than 10 miles
- With an omni-directional antenna on typical AP, range may drop to as little as 100 feet

## Wireless Ethernet (continued)

- IEEE 802.11a
  - An improvement on the 802.11b standard
  - Capable of transmitting data at 54 Mbps (theoretical) using the 5-GHz frequency range
- IEEE 802.11g
  - An additional improvement on 802.11b
  - Also capable of transmitting data at 54 Mbps (theoretical) but using the same frequencies as 802.11b (2.4-GHz)
  - Is backwards compatible with 802.11b

## Wireless Ethernet (continued)

- IEEE 802.11n (100 Mbps theoretical) is the latest standard to be approved
- 802.11n uses MIMO technology (multiple input multiple output)
  - Sender and receiver have multiple antennas for optimum reception

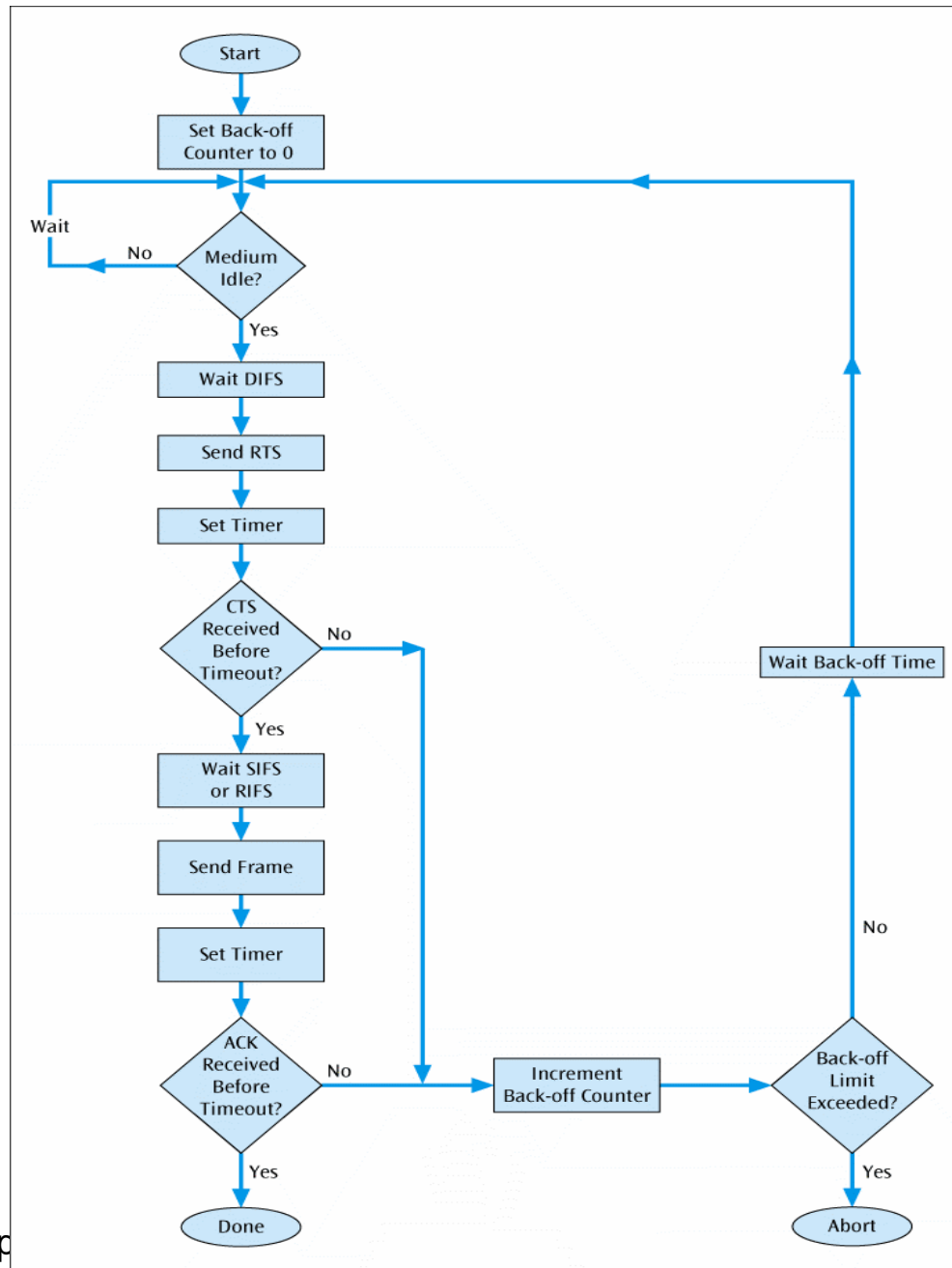
## Wireless Ethernet (continued)

- To provide security, most systems use either:
  - Wired Equivalent Privacy (WEP) – provides either 40- or 128-bit key protection (dated)
  - WPA or WPA 2 (Wi-Fi Protected Access)
  - WPA 2 uses the most advanced encryption techniques
- Wireless LANs may also be configured without an access point
  - These configurations are called “ad-hoc”

# Wireless CSMA/CA

- CA (Collision avoidance)
  - Protocol does not listen and detect collisions like CSMA/CD
  - Instead, tries to avoid collisions before they happen
- How does CSMA/CA do this?
  - All devices, before they transmit, must wait an amount of time called an interframe space (IFS)
  - Some applications have a short IFS, while others have a long IFS
    - If two applications want to transmit at same time, the application with shorter IFS will go first

**Figure 8-3**  
Flowchart showing the  
algorithm for CSMA/CA

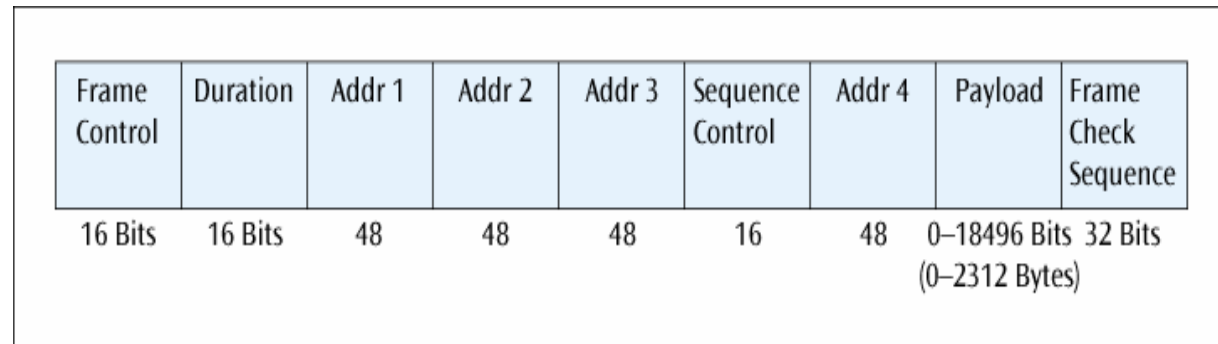


# Wireless CSMA/CA

- Note that the frame format for wireless Ethernet(CSMA/CA) has four address fields:

**Figure 8-4**

*The various fields of the CSMA/CA frame*



# LAN Support

- Proper support of a local area network requires hardware, software, and miscellaneous support devices
- Network OS is the most important software component
- Numerous network support programs are also required to support users on a LAN
  - Support devices such as hubs, switches, routers, servers, modems, power supplies, and more are also necessary



# Network Operating Systems

- An OS manages all applications and resources in a computer
- Multitasking OS supports execution of multiple processes at one time
- Network OS is large, complex program that manages the resources common on most local area networks; client OS such as Windows 7 can perform *some* networking functions
- Besides performing standard OS functions, a network OS is called upon for additional functions, such as:

# Network Operating Systems (continued)

**Table 8-1**

*Summary of network operating system functions*

<b>Network Operating System Functions</b>
Manage one or more network servers Maintain a file system of data sets, applications, user profiles, network peripherals Coordinate all resources and services available Process requests from users Prompt users for network login, validate accounts, apply restrictions, perform accounting functions
Manage one or more network printers
Manage the interconnection between local area networks
Manage locally connected users
Manage remotely connected users
Support system security
Support client/server functions
Support Web page development and Web server operations

# Current Network Operating Systems

- Several popular network OSs currently exist:
  - Windows Server family
  - Unix
  - Linux
  - NetWare derivatives
- Even though NetWare installations are now much fewer than any of the first three, NetWare is introduced first since it was the first to introduce the modern directory structure

# Novell NetWare

- At one time NetWare was the leading local area network OS
- Has since fallen way down the list on number of installations and may even pass into oblivion some day
- Nonetheless, it was NetWare that introduced a number of very powerful concepts, including the hierarchical directory structure

## Novell NetWare (continued)

- Version 3 – popular but older version of Novell NetWare
  - No longer supported by Novell (end of 2000)
  - User logs onto a particular server
  - Bindery maintains directory system
- Version 4
  - Unlike version 3 this version allows single network login
  - Bindery replaced by powerful NDS database
  - No longer supported by Novell (beginning of 2004)

## Novell NetWare (continued)

- Version 5
  - Allows administrator to use IP protocol instead of Novell's proprietary IPX/SPX protocols

# Novell NetWare (continued)

- Version 6
  - Any client anywhere on the Internet can print and use storage services from NetWare 6 server without loading a single byte of Novell's Client32 software
  - Powerful Internet printing services (iPrint) make printing nearly idiot-proof
    - User clicks on graphical image of floor plan showing printers; if user does not have printer driver, it is loaded automatically in background

# Novell NetWare (continued)

- Version 6 (continued)
  - iFolder
    - Very effective background application powered by Apache Web Server to “equalize” the documents in each system’s My Documents folder with an identical set on the server
  - Volumes can hold 8 terabytes of data in up to 8 trillion files and can keep 1 million files open concurrently



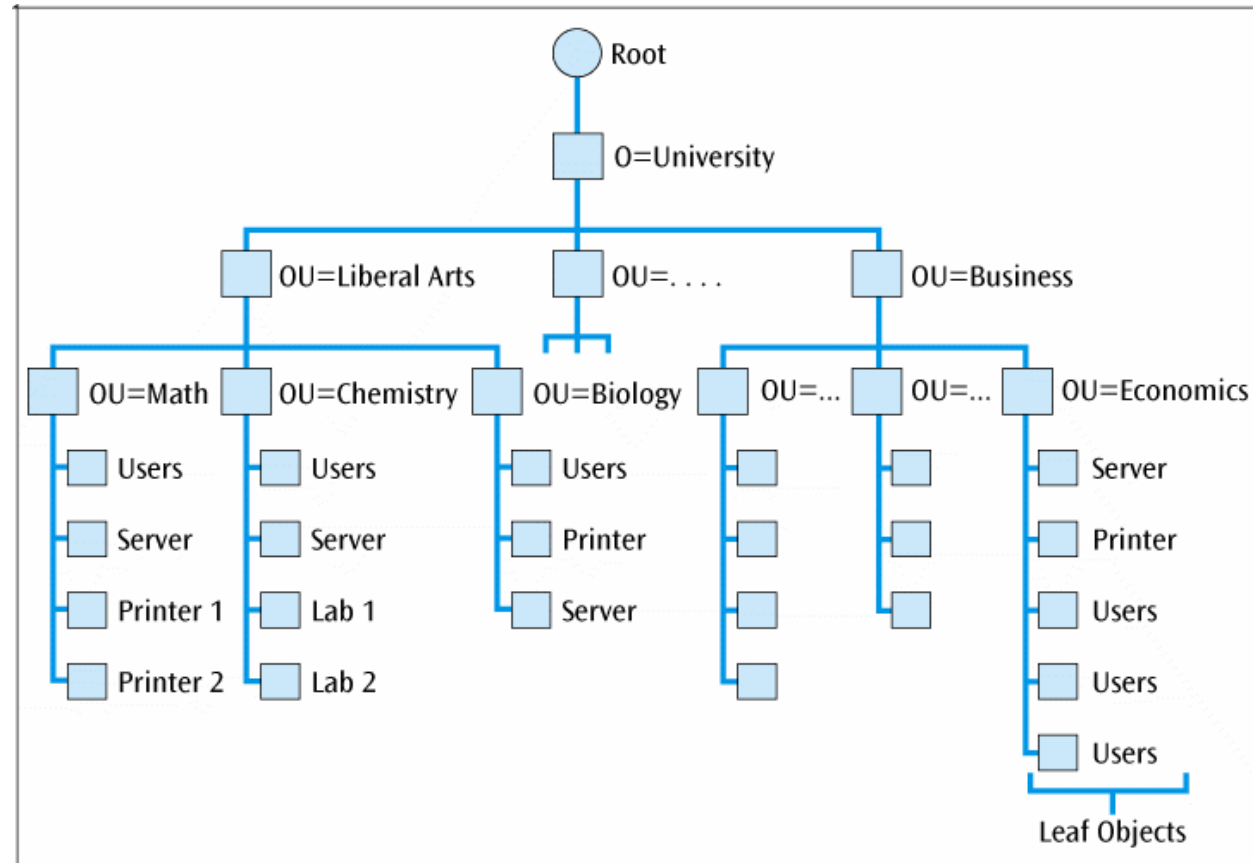
## Novell NetWare (continued)

- Novell NDS (NetWare Directory Services)
  - A database that maintains information on, and access to, every resource on the network, including users, groups of users, printers, data sets and servers
  - Network administrator creates a hierarchical tree structure that represents the layout of the organization
  - Tree structure is composed of organizational units which are composed of further objects, and *leaf objects* which are not composed of further objects

# Novell NetWare (continued)

**Figure 8-5**

*Possible design for a network operating system tree*

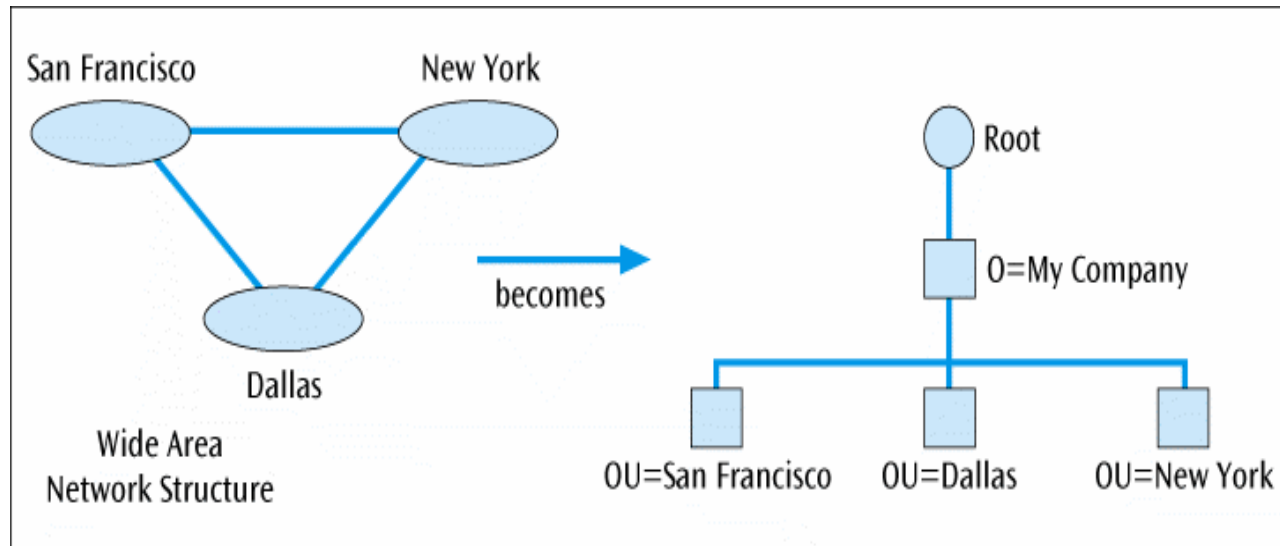


# Additional Suggestions for Designing a Network Tree

- Hierarchical directory design
  - Whether the NOS is NDS or Windows 2008, there are basic elements to designing a solid tree structure
  - Some designers like to base the root of the tree on the company's wide area network layout
  - For example, the next slide breaks the root over three wide area locations

# Additional Suggestions for Designing a Network Tree (continued)

**Figure 8-6**  
*Top level design  
based upon the  
corporate wide  
area network  
structure*

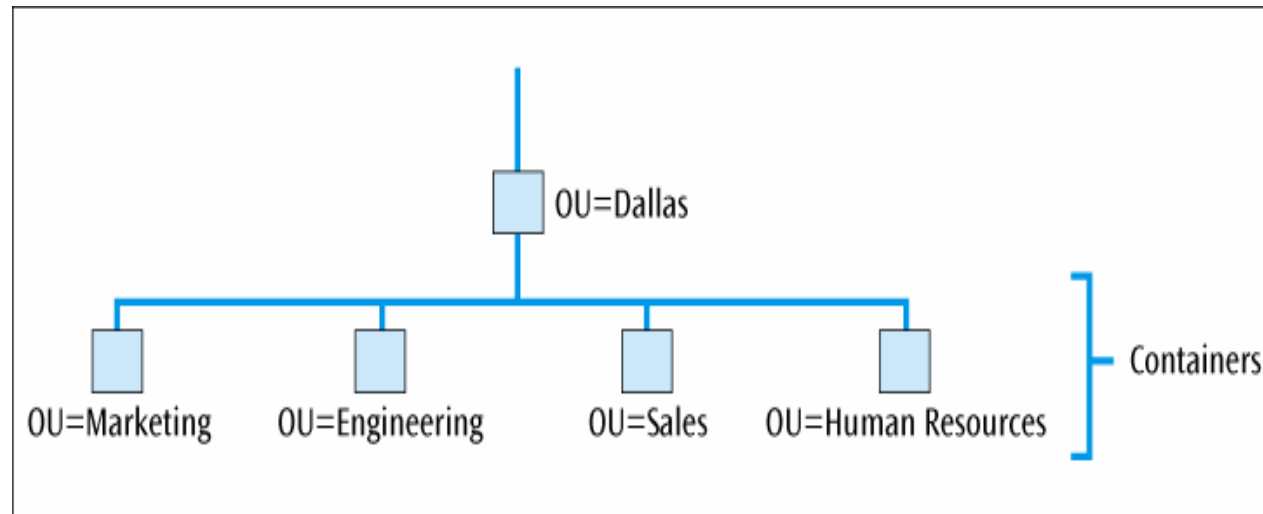


## Additional Suggestions for Designing a Network Tree (continued)

- Hierarchical directory design (continued)
  - Once the wide area has been designed, you can break each city into the various departments
  - Some designers like to break departments by their logical location, while others break departments by their physical location

# Additional Suggestions for Designing a Network Tree (continued)

**Figure 8-7**  
*Lower-level tree containers under the Dallas upper-level container*



## Windows NT Version 4

- User interface based on popular Windows OS
  - Is NOT same as Windows 98
- Full service multitasking OS capable of supporting multiple servers
- NT systems worked very well with other Microsoft products
- Questionable if NT can support large systems
- Blue screen of death (BSOD) plagued NT systems

# Windows NT Version 4 (continued)

- Domain
  - Group of users, servers, and other resources that share account and security information
  - May have from 1 to several hundred domains depending on size of system
- Every domain has one and only one primary domain controller (PDC) (a server)
  - Centrally manages account information and security
- Each domain should have at least one backup domain controller (BDC) (a server)



## Windows NT Version 4 (continued)

- Single domain model (Figure 8-4(a))
  - Simplest Window NT model
  - All users and resources are in one domain
- Multiple domain model (Figure 8-4(b))
  - Multiple domains, but no hierarchy
  - Each domain is equal to all other domains
  - To allow data to transfer between domains required the creation of trusts

## Windows NT Version 4 (continued)

- Master domain model
  - There is one domain model which provides a hierarchy, but the domains at the lower hierarchy cannot contain users, only resources
  - Users in the main domain exert control over user accounts

# Windows 2000

- Updated version of Windows NT network OS
- Specific versions of 2000 designed to support wide variety of system types:
  - Windows 2000 Professional
    - Replaces NT Workstation
  - Windows 2000 Server
    - Replaces Windows NT Server
  - Windows 2000 Advanced Server
    - Supports up to 8 procs / 8GB
  - Windows 2000 Datacenter Server
    - Supports up to 32 processors and 64GB RAM

## Windows 2000 (continued)

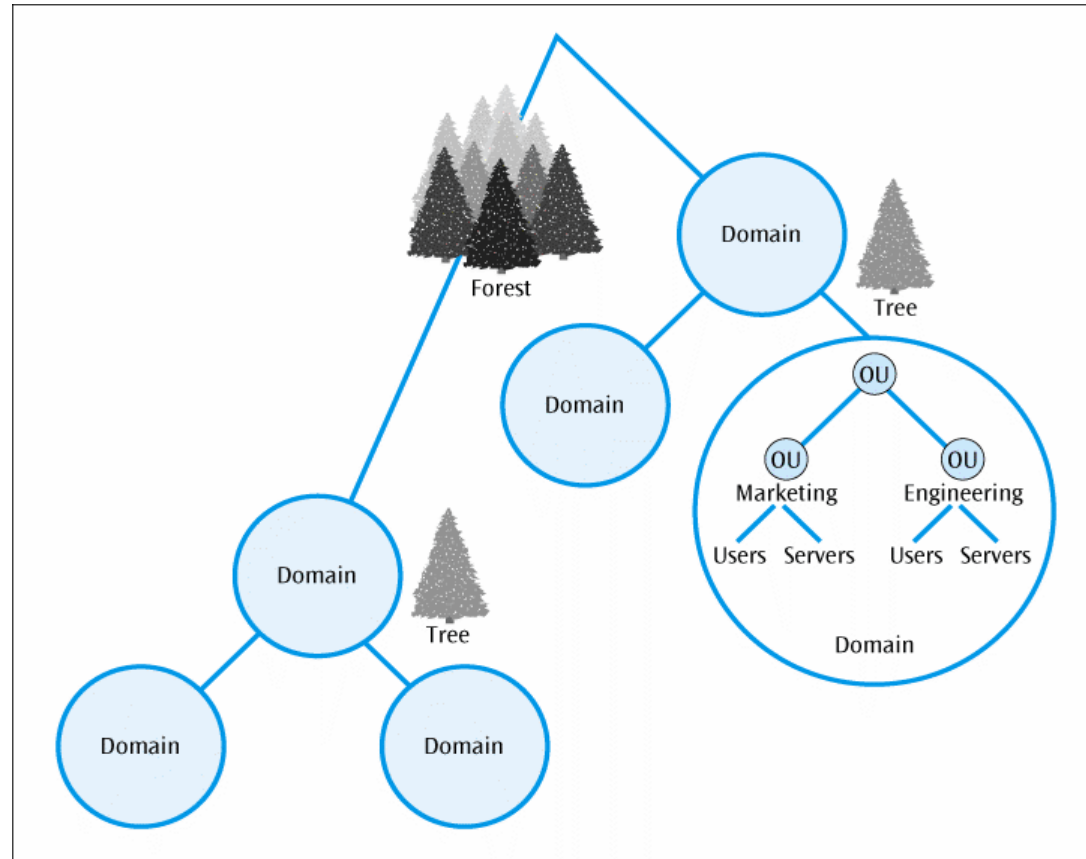
- Biggest change from NT is Active Directory (AD)
  - AD is central repository for all objects that make up the enterprise: domains, organizational units, users, groups, computers, printers, etc.
  - Roughly based on X.500 spec, creates a hierarchical tree

## Windows 2000 (continued)

- At the top of hierarchical model is single forest of one or more trees, which must contain at least one (root) domain, which must contain at least one organizational unit (OU), and several other containers (See next slide)
- Recommended size limitation of 1 million objects per domain, but lab tests have hit 10 million objects without failure

# Windows 2000 (continued)

**Figure 8-8**  
*Example of a tree design of Windows Active Directory*



## Windows 2000 (continued)

- The domain has basically remained the same, but now you can have parent and child domains
  - The parent and all its child domains are defined as a single domain tree, with multiple trees in the same AD a forest

## Windows 2000 (continued)

- Domains are named in accordance with the Internet's DNS standard RFCs 1034 and 1035
  - For example, the root domain in a tree could be called *bigcompany.com*
  - The marketing child domain could be *mktg.bigcompany.com*
  - The production child domain could be *prod.bigcompany.com*
- As in NT, you can create trusts between parent and child domains
  - Only with 2000 the trust can be transitive



# Windows 2003

- Improvements to Active Directory, including new management tools
- Capability to interconnect up to 8 Windows servers
- New and improved file and print support services
- Support for IPv6
- Security improvements

# Windows 2008

- The latest version of Windows network OS
- Continued improvements to Active Directory, including new management tools
- New server core (including a virtual server)
- Self-healing server that can fix corrupted files and/or folders
- Increased processing speed
- Advancements in network security

# Unix

- Well established and very popular multitasking OS capable of supporting network operations
- First OS written in the language C
- Very stable system capable of supporting very large operations
- Numerous versions available from different vendors

# Linux

- OS based on the principles of Unix.
- Many versions available for free (Free Software Foundation's GNU toolset) or very small price
- Very stable multitasking OS
- When incorporated with other free software products, such as the Apache Web server and Atipa's BlueBird network management software, this system becomes extremely cost effective and powerful

# Novell Linux

- Novell, seeing that its market share of NetWare was eroding, moved into the Linux market in the early 21st century
  - Novell currently offers a number of versions of Linux, including high-power servers and desktop OSs

# Mac OS X Server

- Apple Computer finally joined the NOS market with its Mac OS Server
- Version X is based on Linux code
  - Very stable and quite powerful
- While installed primarily in Apple networks, Mac OS X Server is also capable of supporting non-Apple networks

# Network Servers

- In order to support a network OS, you need one or more network servers
  - Network servers are high-power workstations often with multiple processors, RAID, SCSI, and lots of memory and disk space
  - Various forms of servers include server appliances, and server blades
- Server virtualization allows you to create multiple servers in software all running on a single physical server

## Network Servers (continued)

- To protect the server from catastrophic disk failure, disk drives on most network servers support one of the redundant array of independent disks (RAID) techniques
  - RAID is a collection of techniques for interfacing multiple hard disk drives to a computer



# Network Servers (continued)

- Some of the more common RAID techniques include:
  - RAID-0
    - Data is broken into pieces, and each piece is stored on different disk drives
      - This technique is known as striping.
  - RAID-1
    - Data is stored on at least two disk drives, in duplicate, to provide a level of redundancy (or fault tolerance), should one disk become corrupted
      - This technique is known also as disk mirroring

# Network Servers (continued)

- Some of the more common RAID techniques include (continued):
  - RAID-3
    - Data is redundantly stored across multiple disk drives (striping), and error-checking information concerning the stored data is kept on a separate disk
  - RAID-5
    - Data is broken into pieces (stripes) and stored across three or more disks
    - Parity information (error-checking code) is stored along with the striped data, not on a separate disk
    - RAID-5 is the most popular of the RAID techniques

# Client/Server Networks vs. Peer-to-Peer Networks

- A clear majority of LANs are client/server networks
- A client/server network has one or more network servers supporting the operations of one or more clients, or user workstations
- Peer-to-peer networks also exist
  - May have servers, but the network relies less on the servers and more on the communications between workstations

# Network Support Software

- In order to support a network OS, may also need:
  - Utilities
  - Internet software

# Utilities

- Eight of the more common groups of network utility software include:
  - Antivirus software
  - Anti-spam software
  - Anti-spyware software
  - Backup software
  - Network-monitoring software
  - Crash protection software
  - Security assessment software
  - Remote access software
  - Uninstall software

# Internet Software

- Software necessary to support server side of Internet connections
- Retrieves Web pages and other documents when asked to by a client workstation
- Can interface with database program allowing users to store and retrieve data via Internet
- Necessary with commercial Internet applications

# Software Licensing Agreements

- Virtually every commercial software program comes with a specific licensing agreement
- Most licensing agreements specify the following conditions:
  - Software installation and use
  - Network installation
  - Backup copies
  - Decompilation
  - Rental statement
  - Upgrade availabilities
  - Copyright restrictions
  - Maintenance agreements

# Software Licensing Agreements (continued)

- Most licensing agreements come in one of the following forms:
  - Single-user-single-station license
  - Single-user-multiple-station license
  - Interactive user license
  - Network server license
  - Site license
  - Corporate license



# LAN Support Devices

- Other devices necessary for the proper support of a LAN:
  - Uninterruptible power supplies (UPS)
  - Tape drives
  - Printers
  - Media converters
  - Workstations (including thin client workstations)

# LAN Software In Action: A Small Company Makes a Choice

- Hannah asks the following questions:
  - What are the primary uses (applications) of the current system?
    - Some applications work better (or only) with a specific NOS
  - How would the choice of a particular NOS affect maintenance and support?

# LAN Software In Action: A Small Company Makes a Choice (continued)

- Hannah asks the following questions (continued):
  - Are finances an issue in the selection of a NOS?
    - Linux offers an extremely attractive cost
  - Does the existing system have any unusual hardware or software that might influence the NOS choice?
  - Will the network be located in a single location or in multiple locations?
    - NDS is easier to maintain from remote locations
  - Are there any political pressures to select a particular NOS?

# LANs In Action: A Home Office Solution

- Sam has three computers at home and wants all three to share a printer and a connection to the Internet
- What are some of the questions that Sam has to answer before he can start purchasing and/or installing something?

# Wireless Networking In Action: Creating a Wireless LAN for Home

- Many decisions to make when installing a wireless LAN
  - Which IEEE 802.11 format?
    - 802.11a?
      - Fast (54 Mbps), uses higher frequencies
    - 802.11g?
      - Fast (54 Mbps), compatible with 802.11b
    - 802.11n?
      - Latest standard (100+Mbps)

# Wireless Networking In Action: Creating a Wireless LAN for Home (continued)

- Many decisions to make when installing a wireless LAN (continued)
  - What type of wireless access point do you need?
    - If you already have a wired network (with router and modem), all you need is a basic wireless access point
    - If you don't have a home network but have a high-speed Internet connection, you will need a wireless router
    - If you don't even have a high-speed Internet connection yet, you might want to consider a wireless gateway.

# Wireless Networking In Action: Creating a Wireless LAN for Home (continued)

- Many decisions to make when installing a wireless LAN (continued)
  - What type of network OS do you need?
    - Do you need something as powerful as Windows 2008 Server?
      - No, you only need a client OS such as Windows Vista or 7, Apple Mac OS, or Linux

# Summary

- Wireless Ethernet (or CSMA/CA) is a very popular LAN layout and continues growing every day
- There are a number of popular technologies for Wireless Ethernet, including IEEE 802.11a and IEEE 802.11g (54 Mbps theoretical) and IEEE 802.11n (100 Mbps theoretical)
- The CSMA/CA access protocol no longer detects collisions but has a number of operations which try to avoid collisions before they can happen



# Summary

- A network OS has several additional functions not normally found in an OS
- Novell NetWare was a network operating system with a powerful directory service (NDS)
  - Very good at performing file and print serving
- Windows NT was an older network OS
  - Very good at supporting client/server applications
  - Based on the domain
- Windows Server family represents significant advancement over NT
  - Includes powerful directory service, Active Directory

## Summary (continued)

- Unix is a mature operating system that is stable, fast, and capable of running on a variety of platforms
- Linux is a derivative of Unix
- Mac OS X Server is another derivative of Unix
- A network server is computer that stores software resources and either allows or denies workstations connected to network access to these resources
- Many network servers can perform one or more levels of RAID

## Summary (continued)

- Many types of software programs support a LAN
  - These include utility programs and Internet software tools
- Software licensing agreements are an important part of LAN software installation
- Many types of hardware devices are necessary to support a LAN