Chapter 5
Network Operating Systems

Nassau Community College
CMP 110: Data Communications & the Internet
Prof. Christopher R. Merlo
cmerlo@ncc.edu

1

An Introduction to the Network OS

- What is a **Network Operating System?**

  - Software that interfaces between the server hardware and the network

  - Provides users with *controlled access* to *shared services* on a network

2

An Introduction to the Network OS

- Common features
  - File system, printing, and application services
  - **Directory services**
  - Web folder services
  - Web-based management, desktop management
  - Server *clustering*

Recent History

- Why did the Network OS become popular?
  - Most likely due to the economic principle of *substitution:* When resources are scarce, people will find and use substitutes

Recent History

- Why did the Network OS become popular?
  - As personal computers became less scarce in the 1980s, hard drives didn't
    - Early hard drives cost $2,000 - $3,000 each

Recent History

- Why did the Network OS become popular?
  - The need for storage space grew over time
    - Some files were too big to fit on one 360Kb floppy
  - Many files were transferred over the "sneaker net"

Recent History

- Why did the Network OS become popular?

  - The Network OS solved all these problems

    - The shared server(s) could contain expensive hard drives, to be shared by client machines

    - The shared server(s) could contain a network interface card, allowing appropriately-configured client machines to share the drives

Novell NetWare

- Novell started as a hardware company

  - Beaten to the market by IBM in the early 1980s

  - Venture capitalist, called in to liquidate Novell's assets, found the three founders playing a networked video game

  - First version of NetWare published in 1981; went public in 1983

  - Enjoyed **70%** market share in the late 1980s

Novell NetWare

- Novell NetWare 3
  - First widely-implemented network operating system
  - Released as version 3.10 in the early 1990s; soon updated to 3.11
  - Updated to 3.2 in 1999
  - Most commonly-used services were file sharing and printer sharing

Novell NetWare

- Novell NetWare 3
  - Ideal platform for multiuser applications
  - Network services were *server-specific*:
    - A user who needed the services of two different servers had to *authenticate* to each server individually
    - User and group accounts were stored in a linked file system called the **Bindery**; these accounts were not **replicated** to other servers, and had to be transferred by hand

Novell NetWare

- Novell NetWare 3
  - Innovative in terms of memory usage
    - RAM was still expensive in the late 1980s and early 1990s
    - NetWare servers with 8 MB or 16 MB of RAM were common

Novell NetWare

- Novell NetWare 3
  - Innovative in terms of memory usage
    - NetWare 3 was broken into **NetWare Loadable Modules (NLMs)**
      - Modularization of the operating system allowed portions of its code to remain off-line, thereby using only as much RAM as needed

Novell NetWare

- Novell NetWare 3
  - **IPX/SPX**
    - NetWare 3 was released long before the standardization of modern networking technologies
    - **IPX** (Internetwork Packet Exchange) was used for regular Layer 3 transmissions
    - **SPX** (Sequenced Packet Exchange), a connection-oriented Layer 4 protocol, was used where reliability between devices was required

Novell NetWare

- Novell NetWare 4
  - Introduced **NetWare Directory Services (NDS)**
    - Replaced the Bindery
    - Contains information about all network resources
    - Based on the X.500 standard, supported by ISO and ITU

Novell NetWare

- Novell NetWare 4
  - **NDS**
    - Simulates the structure of a typical organization
    - Each object (user, group, printer, etc.) has a related set of properties that identify it
    - NDS maintains a **hierarchical database** of network objects

Novell NetWare

- Novell NetWare 4
  - **NDS**
    - Objects on one server are **replicated** to other servers
      - Provides backups
      - Provides global user access

Novell NetWare

- Novell NetWare 5
    - NDS renamed to **eDirectory**
    - Support for third-party databases such as Oracle and MS SQL Server is added
    - More options for web server engines are made available

Novell NetWare

- Novell NetWare 5
    - Java-based graphical interface for network management called **ConsoleOne**
    - **Novell Storage Services (NSS)** can maintain files up to 8 TB in size
    - Browser-based network management utility to allow network administrators to manage the network from anywhere

Novell NetWare

- Novell NetWare 6

  - Includes **Native File Access Services**, which allows non-Windows client machines to access data stored on NetWare servers without having to run Novell client software

    - NetWare client software was still needed to gain access to complete set of NetWare services

  - Includes **iFolder** which maintains continuity of documents on multiple clients and servers

Novell NetWare

- Novell NetWare 6

  - Includes **iPrint** to ease client printing

  - Includes **Apache Tomcat** web server to allow developers to launch web-based Java applications

Novell NetWare

- Novell NetWare 6

  - NetWare 6.5 implemented *open standards* for web application development

  - In 2004, Novell acquired **SuSE Linux**

    - Novell now provides a Linux desktop environment that provides fill access to NetWare networks

Microsoft Windows

- Windows NT 3.1

  - Released in 1993 in workstation version and server version

  - Initially designed to deliver client/server-based applications to network users

  - Versions 3.5 and 3.51 provided incremental improvements, and better integration with NetWare networks

Microsoft Windows

- Windows NT 4.0

  - Released in 1996

  - First Microsoft product accepted by the market as a full-featured NOS

  - Provided full file services and print services along with application services

  - Provided ability to manage multiple servers within the same network

Microsoft Windows

- Windows NT 4.0

  - Provided built-in web server called **Internet Information Server (IIS)**

  - Introduced the concept of a Windows **Domain**

    - Group of objects that share common resource needs

    - Did not provide the ability for nested organizational units like Novell NDS did

    - Multiple domains could be configured on one network

Microsoft Windows

- Windows 2000 Server
  - Introduced **Active Directory**
    - Microsoft's version of *Directory Service*
    - Based on industry standards such as **Domain Name System (DNS)** and **Lightweight Directory Access Protocol (LDAP)**
    - Provides the same benefits as NDS

Microsoft Windows

- Windows Server 2003
  - Faster performance
  - Enhanced security
  - .NET application framework

Unix

- In November 1971, **Ken Thompson** and **Dennis Ritchie** develop the first version of Unix at Bell Labs

  - Ritchie also developed the C programming language at the same time, so that they could develop Unix in it

Unix

- In late 1973, Thompson and Ritchie presented a paper about Unix that drew lots of attention

- UC Berkeley CS professor **Bob Fabry** requested a copy of the software, and Bell Labs *gave it away for free.*

Unix

- Fabry's grad students **Bill Joy** and **Chuck Haley** made modifications, and in 1977, Joy released the first **Berkeley System Distribution (BSD)** version of Unix

  - BSD included the first version of Joy's vi text editor

  - Joy went on to found *Sun Microsystems*, creators of the Solaris OS and the Java language

29

Unix

- The release of BSD marked the first **fork** of Unix

  - Now two "versions" of Unix existed: the Bell Labs version (later called AT&T Unix)

30

Unix

- Many versions of Unix were forked and released; some for free and others commercially:
  - SCO Unix
  - Solaris (Sun Microsystems)
  - HP-UX (Hewlett Packard)
  - Mac OS X (Apple)

Unix

- Unix became popular due to its **portability**, or ability to run on diverse hardware platforms
- The author of your textbook considers the lack of an industry-standard directory-services package such as NDS or Active Directory to be a drawback

Linux

- **Linus Torvalds** was a sophomore Computer Science major at the University of Helsinki in Finland in 1991

- Linus used Unix in the campus computer labs, but had to use Windows at home

- He decided to develop a new Unix-like operating system for PCs

Linux

- In September 1991, Linus released Linux Version 0.01 over the Internet *for free*

- Since Linux was free, other programmers were able to help fix bugs and add features

- Version 0.96 was released in 1992 with a GUI and 40,000 lines of code, mostly donated by volunteers over the Internet

Linux

- Version 0.99 was released in 1993 with contributions by more than 100 programmers, containing more than 100,000 lines of code

- Version 1.0 was released in 1994 with built-in networking capability

Linux

- Many *distributions* of Linux exist, each containing the **kernel** and specialized applications

- Novell bought SuSE in 2004 and now releases its own distribution of Linux

Linux

- The Linux kernel is licensed according to the GNU Public License (GPL)

  - This spawned many important projects to be released as "open source" or "free software"

  - Most notable among these is the **Apache Web Server** which currently powers more than half of all web sites

- Heavy corporate mistrust still exists

NOS Management Utilities

- **Novell NetWare utilities**

  - **NetWare Administrator** (NetWare 4.10)

    - GUI utility for adding, deleting, and managing users and groups

  - **ConsoleOne** (NetWare 5.0)

    - New version of NetWare Administrator

    - The first of many admin tools written in Java to allow wider deployment

NOS Management Utilities

- **Novell NetWare utilities**

  - **NetWare Remote Manager** (NetWare 6)

    - Browser-based tool to allow network administrators to monitor and configure servers from anywhere

  - **iManager** (NetWare 6)

    - Browser-based tool to allow for remote management of eDirectory (users, groups, etc.)

NOS Management Utilities

- **Novell NetWare utilities**

  - **ZENWorks** (NetWare 5)

    - Network management application that provides workstation management, server management, and handheld-device management

NOS Management Utilities

- **Novell NetWare utilities**
  - **ZENWorks** (NetWare 5)
    - Provides for **policy-based administration**
      - Allows the admin to grant access on a user basis or a workstation basis
      - Allows admin to specify which icons appear, and which functions are allowed
      - Allows admin to allow/disallow changing of desktop settings such as colors, fonts, etc.

NOS Management Utilities

- **Novell NetWare utilities**
  - **ZENWorks** (NetWare 5)
    - Allows administrator to install and manage applications through eDirectory
    - Allows administrators to manage hardware and software inventory

NOS Management Utilities

- **Microsoft Windows utilities**
  - **Microsoft Management Console (MMC)**
    - Allows administrators to
      - Add users, groups, workstations, and printers
      - Manage domains and trusts
      - Manage system performance of individual servers and workstations

NOS Management Utilities

- **Microsoft Windows utilities**
  - **Microsoft Management Console (MMC)**
    - Allows administrators to
      - Manage shared folders
      - Manage disk drives on servers and workstations
      - Perform policy-based administration

NOS Management Utilities

- **Unix and Linux**

  - User and group management, and network service management, are built-in to the OS

  - There is little need for extra software

  - Most admins choose to perform these tasks at the command line (often through SSH)

  - Many desktop environments (Gnome, KDE, etc.) provide third-party administration tools

NOS Management Utilities

- Other Management Services and Products

  - **Dynamic Host Configuration Protocol (DHCP)**

    - Remember that each host on a TCP/IP network must have a unique IP address

    - Manually assigning IP addresses can be time-consuming and lead to errors

    - DHCP server software can automatically assign and manage IP addresses on a local network

NOS Management Utilities

- Other Management Services and Products
  - **Domain Name Service (DNS)**
    - Humans have a hard time remembering IP addresses, but computers must know them to communicate with each other
    - DNS allows us to assign **host names** to addresses

NOS Management Utilities

- Other Management Services and Products
  - **Domain Name Service (DNS)**
    - DNS servers perform the translation between host names and IP addresses
      - Upon a DNS request, the server either finds the host name in its table and sends it back, or sends the request on to another DNS server
      - Often, many DNS servers act together to satisfy a request, especially for a multi-level hostname lookup, such as www.matcmp.ncc.edu