

Objectives

- Identify the functions of LAN connectivity hardware
- Install and configure a NIC (network interface card)
- Identify problems associated with connectivity hardware

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Objectives (continued)

- Describe the factors involved in choosing a NIC, hub, switch, or router
- Discuss the functions of repeaters, hubs, bridges, switches, routers, and gateways, and the OSI Model layers at which they operate
- Describe the use and types of routing protocols

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NICs (Network Interface Cards)

- Connectivity devices that enable workstations, servers, printers, or other nodes to receive and transmit data over network media
 - Usually contain data transceiver
 - Belong to Physical and Data Link layers
 - Apply data signals to wire
 - Assemble and disassemble data frames
 - Interpret physical addressing information
 - Determine which node has right to transmit data at any given instant

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Types of NICs

- NICs come in variety of types depending on:
 - Access method
 - Network transmission speed
 - Connector interfaces
 - Type of compatible motherboard or device
 - Manufacturer

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Internal Bus Standards

- Bus: circuit used by motherboard to transmit data to computer's components
 - Including memory, processor, hard disk, and NIC
 - Capacity defined principally by:
 - Width of data path (number of bits that can be transmitted in parallel)
 - Clock speed
- Expansion slots allow devices to connect to computer's expanded bus
 - Devices found on circuit board called an expansion card

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Internal Bus Standards (continued)

- Peripheral Component Interconnect (PCI): 32- or 64-bit bus with 33- or 66-MHz clock speed
 - Maximum data transfer rate is 264 MBps
- Industry Standard Architecture (ISA): original PC bus type
- PCI Express specifies 64-bit bus with 133-MHz clock speed
 - Capable of up to 500 MBps per data path
 - Efficient data transfer, support for quality of service distinctions, error reporting and handling, and compatibility with current PCI software

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Internal Bus Standards (continued)

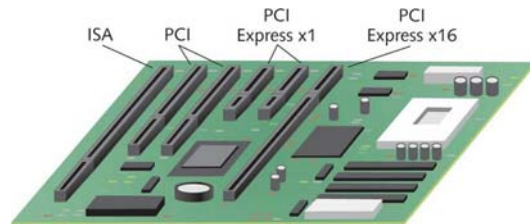


Figure 5-3: A motherboard with multiple expansion slots
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Peripheral Bus Standards

- Personal Computer Memory Card International Association (PCMCIA) adapter: connect external devices to most laptop computers
 - PC Card: First PCMCIA adapter
 - Specified 16-bit interface running at 8 MHz
 - CardBus: 32-bit interface running at 33 MHz
 - ExpressCard: 26-pin interface, offering data transfer rates of 250 MBps in each direction

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Peripheral Bus Standards (continued)



Figure 5-4: A CardBus NIC
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Peripheral Bus Standards (continued)

- USB: standard interface used to connect multiple types of peripherals
 - USB 1.1 and USB 2.0
- FireWire: codified by IEEE as IEEE 1394
 - Can be used to connect many types of peripherals
 - Can connect computers on a small network
 - 4-pin and 6-pin connectors
- CompactFlash: most likely found connecting devices too small to handle PCMCIA slots

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Peripheral Bus Standards (continued)



Figure 5-6: A USB NIC
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On-board NICs

- Some peripheral devices connect directly to motherboard using on-board ports
 - e.g., a mouse
- Many new computers use on-board NICs
 - Integrated into motherboard

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Wireless NICs



Figure 5-9: Wireless NICs

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Installing NICs

- First install hardware, then software
 - May have to configure firmware
 - Set of data or instructions saved to a ROM [electrically erasable programmable read-only memory (EEPROM)]
- Always read manufacturer's documentation and follow proper safety procedures
- Multiple NICs may be installed
- Jumper: plastic piece with metal receptacle
- Dual inline package (DIP) switch indicates parameter setting

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Installing and Configuring NIC Hardware



Figure 5-10: A properly inserted NIC

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Installing and Configuring NIC Hardware (continued)



Figure 5-11: Installing a PCMCIA-standard NIC

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Installing and Configuring NIC Software

- Device driver: software enabling attached device to communicate with computer's OS
 - Must ensure that correct device driver installed and configured properly for the NIC
- To install from Windows XP interface, need Windows XP software and NIC's device drivers
 - Can usually download NIC software from manufacturer's Web site
- Installing NIC drivers on UNIX or Linux depends somewhat on OS version

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Installing and Configuring NIC Software (continued)

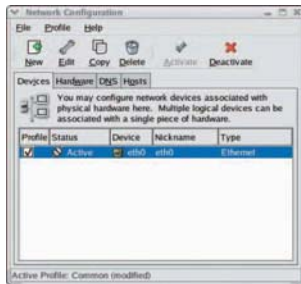


Figure 5-13: Fedora Core Linux Network Configuration window
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Interpreting LED Indicators

- NICs may have one or more of following lights:
 - ACT: if blinking, indicates that NIC is either transmitting or receiving data
 - If solid, heavy network traffic volume
 - LNK: if lit, NIC is functional
 - In some models, if blinking, NIC detects network but cannot communicate with it
 - TX: if blinking, NIC is functional and transmitting frames
 - RX: if blinking, NIC is functional and receiving frames

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IRQ (Interrupt Request)

- Message to computer instructing it to stop what it is doing and pay attention to something else
- Interrupt: circuit board wire over which device issues voltage to signal IRQ
- IRQ number: means by which bus understands which device to acknowledge
 - Range from 0 to 15

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IRQ (continued)

- Symptoms possibly indicating two devices attempting to use same IRQ:
 - Computer locks up either upon starting or when OS is loading
 - Computer runs much more slowly than usual
 - Devices such as USB or parallel ports stop working
 - Video or sound card problems
 - Computer fails to connect to network
 - Intermittent data errors during transmission

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IRQ (continued)

- If IRQ conflicts occur, must reassign device's IRQ
 - Through OS
 - Through adapter's EEPROM configuration utility or computer's CMOS configuration utility
- Complementary metal oxide semiconductor (CMOS): microchip that stores settings pertaining to computer's devices
- Basic input/output system (BIOS): instructions enabling computer to initially recognize hardware

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Memory Range

- Indicates area of memory that NIC and CPU use for exchanging (buffering) data
 - Hexadecimal notation
- Some memory ranges reserved for specific devices
- NICs typically use memory range in high memory area
 - A0000–FFFFFF
 - Some manufacturers prefer certain ranges

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Base I/O Port

- Specifies area of memory that will act as channel for moving data between NIC and CPU
 - Hexadecimal notation
 - Device's base I/O port cannot be used by any other device
- Most NICs use two memory ranges for this channel
 - Base I/O port settings identify beginning of each range

Firmware Settings

- Modify NIC's transmission characteristics
- When changing firmware settings, actually writing to NIC's EEPROM chip
 - Need bootable disk containing configuration or install utility shipped with NIC
- NIC configuration utilities:
 - View IRQ, I/O port, base memory, node address
 - Perform diagnostics
 - To perform entire group of diagnostic tests on utility disk, must have loopback plug

Choosing the Right NIC

NIC Feature	Function	Benefit
Automatic speed selection	Enables NICs to sense and adapt to a network's speed and mode (half- or full-duplex) automatically	Aids configuration and performance
One or more on-board CPUs	Allows the card to perform some data processing independently of the PC's CPU	Improves performance
Direct memory access (DMA)	Enables the card to transfer data to the computer's memory directly	Improves performance
Diagnostic LEDs (lights on the NIC)	Indicates traffic, connectivity, and, sometimes, speed	Aids in troubleshooting
Dual channels	Effectively creates two NICs in one slot	Improves performance; suited to servers
Load balancing	Allows the NIC's processor to determine when to switch traffic between internal cards	Improves performance for heavily-trafficked networks; suited to servers
"Look Ahead" transmit and receive	Allows the NIC's processor to begin processing data before it has received the entire packet	Improves performance
Management capabilities (SNMP)	Allows the NIC to perform its own monitoring and troubleshooting, usually through installed application software	Aids in troubleshooting; can find a problem before it becomes dire

Table 5-2: NIC characteristics

Choosing the Right NIC (continued)

NIC Feature	Function	Benefit
Power management capabilities	Allows a NIC to participate in the computer's power-saving measures; found on PCMCIA-based adapters	Increases the life of the battery for laptop computers
RAM buffering	Provides additional memory on the NIC, which, in turn, provides more space for data buffering	Improves performance
Upgradable (flash) ROM	Allows on-board chip memory to be upgraded	Improves ease of use and performance

Table 5-2 (continued): NIC characteristics

Repeaters and Hubs

- Repeaters: simplest type of connectivity devices that regenerate a digital signal
 - Operate in Physical layer
 - Cannot improve or correct bad or erroneous signal
 - Regenerate signal over entire segment
 - One input port and one output port
 - Suited only to bus topology networks

Repeaters and Hubs (continued)

- Hub: repeater with more than one output port
 - Multiple data ports
 - Operate at Physical layer
 - Uplink port: allows connection to another hub or other connectivity device
 - On Ethernet networks, can serve as central connection point of star or star-based hybrid topology
 - On Token Ring networks, hubs are called Multistation Access Units (MAUs)

Repeaters and Hubs (continued)

- Hubs (continued):
 - Connected devices share same amount of bandwidth and same collision domain
 - Logically or physically distinct Ethernet network segment on which all participating devices must detect and accommodate data collisions
- Types of hubs:
 - Passive
 - Intelligent
 - Standalone
 - Stackable

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Bridges

- Connect two network segments
 - Analyze incoming frames
 - Make decisions about where to direct them based on each frame's MAC address
 - Operate at Data Link layer
 - Protocol independent
 - Can move data more rapidly than traditional routers
 - Extend Ethernet network without extending collision domain or segment
 - Can be programmed to filter out certain types of frames

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Switches

- Subdivide network into smaller logical pieces (segments)
 - Can operate at levels 2, 3, or 4 of OSI model
 - Multiport bridges
 - Most have internal processor, OS, memory, and several ports
- Each port on switch acts like bridge
- Each connected device effectively receives own dedicated channel

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Installing a Switch

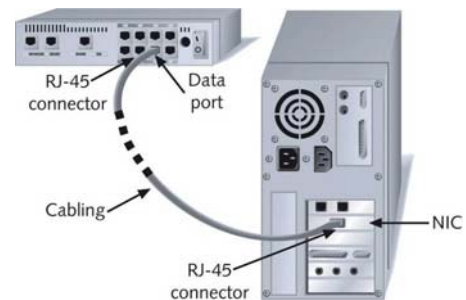


Figure 5-20: Connecting a workstation to a switch

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Installing a Switch (continued)

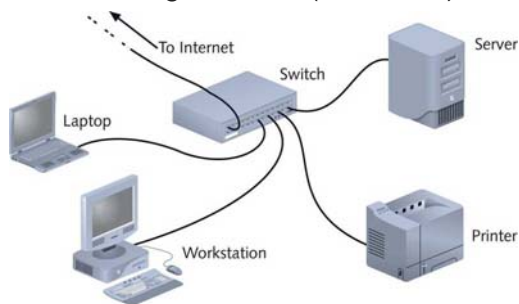


Figure 5-21: A switch on a small network

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Cut-Through Mode

- Switch running in cut-through mode reads frame's header and decides where to forward the data before receiving the entire packet
 - Cannot read FCS before transmission
 - Cannot detect corrupt packets
 - Can detect runts
 - Erroneously shortened packets
 - Biggest advantage is speed

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Store and Forward Mode

- Switch reads entire data frame into memory and checks for accuracy before transmitting
 - Transmits data more accurately
 - Slower than cut-through mode
 - Can transfer data between segments running different transmission speeds

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Using Switches to Create VLANs

- Virtual LANs (VLANs) logically separate networks within networks
- Use switches to group a number of ports into a broadcast domain
 - Combination of ports making up a Layer 2 segment
 - In TCP/IP, referred to as a subnet
- VLANs created by properly configuring switch's software
- VLAN configuration requires careful planning

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Higher-Layer Switches

- Layer 3 switches (routing switch) and Layer 4 switches
- Ability to interpret higher-layer data enables switches to perform advanced filtering, statistics keeping, and security functions

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Routers

- Multiport connectivity devices that direct data between nodes on a network
 - Can integrate LANs and WANs
 - Running at different transmission speeds
 - Using variety of protocols
 - Reads incoming packet's logical addressing information
 - Determines where to deliver packet
 - Determines shortest path to that network
 - Operate at Network layer
 - Protocol-dependent

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Router Features and Functions

- Typical router has internal processor, OS, memory, various input and output jacks, and management console interface
- Modular router: multiple slots to hold different interface cards or other devices
- All routers can:
 - Connect dissimilar networks
 - Interpret Layer 3 addressing and other information
 - Determine the best path for data to follow
 - Reroute traffic

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Router Features and Functions (continued)

- Other router functions:
 - Filter out broadcast transmissions
 - Prevent certain types of traffic from getting to a network
 - Support simultaneous local and remote connectivity
 - Provide high network fault tolerance through redundant components
 - Monitor network traffic and report statistics
 - Diagnose internal or other connectivity problems

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Router Features and Functions (continued)

- Interior router directs data between nodes on autonomous LANs
- Exterior router directs data between nodes external to given autonomous LAN
- Border routers connect autonomous LAN with a WAN
- Static routing: network administrator programs router to use specific paths between nodes
- Dynamic routing automatically calculates best path between two nodes
 - Accumulates information in routing table

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Router Features and Functions (continued)

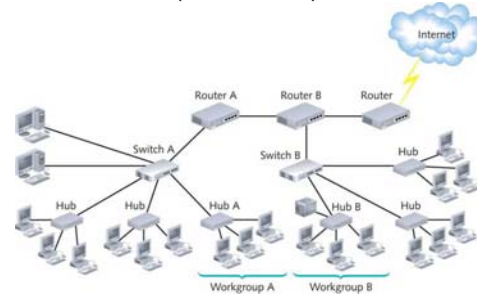


Figure 5-24: The placement of routers on a LAN

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Routing Protocols: RIP, OSPF, EIGRP and BGP

- Best path: most efficient route between nodes
- Routers communicate via routing protocols
 - Characterized according to convergence time
 - Time taken to recognize best path
 - Routing Information Protocol (RIP) for IP and IPX
 - Open Shortest Path First (OSPF) for IP
 - Enhanced Interior Gateway Routing Protocol (EIGRP) for IP, IPX, and AppleTalk
 - Border Gateway Protocol (BGP) for IP

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Brouters

- Bridge routers
- Routers that take on some characteristics of bridges
 - Can forward nonroutable protocols
 - Connect multiple network types through one device

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Gateways

- Connect two systems using different formatting, communications protocols, or architecture
 - Repackage information to be read by another system
 - Operates at multiple OSI Model layers
 - E-mail gateway
 - Internet gateway
 - LAN gateway
 - Voice/data gateway
 - Firewall

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Summary

- Network adapters come in a variety of types depending on access method, network transmission speed, connector interfaces, type of compatible motherboard, and manufacturer
- Desktops or tower PCs may use an expansion card NIC, which must match the system's bus
- NICs are designed to be used with either wire-bound or wireless connections
- Firmware combines hardware and software
- Repeaters are the connectivity devices that perform the regeneration of a digital signal

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Summary (continued)

- A hub contains multiple data ports into which the patch cables for network nodes are connected
- Bridges resemble repeaters in that they have a single input and a single output port, but they can interpret the data they retransmit
- As nodes transmit data through a bridge, the bridge establishes a filtering database
- Switches subdivide a network into smaller, logical pieces

Summary (continued)

- A router is a multiport device that can connect dissimilar LANs and WANs running at different transmission speeds, using a variety of protocols
- Routers are protocol-dependent
- Routing protocols provide rules for communication between routers and help them determine the best path between two nodes
- Gateways are combinations of networking hardware and software that connect two dissimilar kinds of networks