Chapter 3
Network Media

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Network Adapter

- The network adapters, commonly known as network interface cards (NICs) or simply network cards, are responsible for moving data from the computer to the transmission media.
- Network adapters basically convert computer data into a signal that can be transmitted over media.

Network Adapter (Continued)

- When a network adapter transmits data, it first receives the data from the computer. It attaches its own header containing a checksum and the network card’s address. The data is then converted to signals that are passed over the network media.
- The circuitry on the card that does the conversion of the signal is known as a transceiver.

Adapter Settings

- Like most adapter cards installed in a computer, such as sound and video cards, they are configured by setting some parameters.
- Set some combination of the following parameters:
  - IRQ
  - I/O address
  - Shared memory address
  - DMA

IRQ

- An IRQ, or interrupt request, value is an assigned value that a device sends to the computer’s processor to interrupt its processing when it needs to send information.
- Each device in the computer must have a unique one.
  - IRQ7: LPT1
  - IRQ12: PS/2
I/O address

- After a network card has interrupted the CPU with an IRQ, it needs a way to communicate with the main board. Most cards use an input/output, or I/O, address to do this.
- I/O addresses are given as hexadecimal numbers. You will see them written as starting with “0x” or with a trailing “h”.

DMA

- Direct memory access (DMA) enables your adapter cards to work directly with the computer’s memory.
- If your network card supports DMA transfers, you should enable it, as this could bring about a significant performance increase.

Shared memory address

- Using this method, the network card and software driver use a shared RAM address in the high memory to communicate.
- Shared memory ranges will normally appear as D8000, C8000, CFFFF, and so on.

Hardware Configuration

- Jumpers
  - Jumpers are small metal pairs of pins that stick out of the card. You change their configuration by putting small plastic covers with metal internal connectors over them.
- DIP switches
  - Dual In-line Package (DIP) switches are small banks of switches on the adapter card.

Jumpers

DIP switches

DIP: Dual In-line Package
Software configuration

• Network adapters using the Extended Industry Standard Architecture (EISA), PCI (Peripheral Component Interface) and MicroChannel Architecture (MCA) bus type are almost always configured via software.
• Today’s network cards are almost always software configurable.

Adapter Drivers

• The two standards of drivers that you are most likely to see on the exam are:
  – Network Device Interface Specification (NDIS)
  – Open Datalink Interface (ODI).

Bus Architecture

• Bus refers to the connection [that your adapter cards have] to the rest of your computer.
• Any adapter card you have, such as a modem, sound card, or a printer port cards connect, to the rest of your computer over this bus.

ISA

• The Industry Standard Architecture, or ISA, bus was designed by IBM and used in the IBM PC.
• This bus was originally designed to transfer 8 megabits per second (Mbps).
• ISA is still a popular system for devices that don’t require higher than 16-bit transmissions.
• Use ISA bus:
  – Printers
  – sound cards
  – modems

MCA

• IBM introduced MicroChannel Architecture
• MCA operates at 16Mbps or 32Mbps and uses software to configure the resource settings.
• MicroChannel cards require what is known as a “Reference Disk” to be configured.

EISA

• While processing power was growing, their I/O speed was not. The answer to this problem was the Extended Industry Standard Architecture (EISA) bus.
• EISA slot on a computer’s main board can also be used by an ISA card.
• Another important feature: Bus Mastering
  – allows a card in a computer to operate without the main CPU being involved.
VES

- Why use VESA?
  - ISA bus was not fast enough for the graphics it needed, and EISA was too expensive.
- Originally designed for video cards, it was later used for hard drive controllers and network cards.
- A limiting factor of VLB (VESA Local Bus) was that it had a limit of three slots on the mother-board.

PCI

- PCI (Peripheral Component Interface) is a relatively new bus type.
- PCI was originally developed to help speed up graphics on newer computers.
- PCI slots are not backward compatible with any other type.
- PCI is that it is not tied to any one type of computer.

PCMCIA

- PCMCIA is a new type of bus mainly for notebook and laptop computers.
- All PCMCIA card types use the same 68-pin connector.
- Another great feature is
  - with the PCMCIA software you can insert and remove cards on-the-fly without rebooting the computer.

USB

- USB provides an expandable, hot-pluggable Plug and Play serial interface that ensures a standard, low-cost connection for peripheral devices.
- Devices suitable for USB range from simple input devices such as keyboards, mice, and joysticks, to advanced devices such as printers, scanners, storage devices, modems, and video conferencing cameras.

USB (Continued)

- Migration to USB is recommended for all peripheral devices that use legacy ports such as the PS/2, serial, and parallel ports.
- USB 1.0 and 1.1 support data transfer rate up to 1.5 Mbps for low-speed devices and up to 12 Mbps for full-speed devices.
- USB 2.0 will support up to 480 Mbps for high-speed devices.
  - high-quality video conferencing cameras,
  - high-resolution scanners,
  - high-density storage devices.

IEEE 1394

- The IEEE 1394 high-speed serial bus provides enhanced PC connectivity
  - consumer electronics audio/video (A/V) appliances, storage peripherals
  - other PCs
  - portable devices.
- IEEE 1394 provides a Plug and Play-compatible expansion interface for the PC.
- The 100-Mbps, 200-Mbps, and 400-Mbps transfer rates currently specified in IEEE 1394.a
- The enhancements in IEEE 1394.b are well suited to multi-streaming I/O requirements.
Network Adapter Ports

- **BNC Connector:**
  - Used in Attached Resource Computer Network (ARCNET) and in thin Ethernet (10Base-2).
  - The right is a T connector showing three BNC connectors.

Network Adapter Ports (Continued)

- **RJ-45 Connector**
  - Uses twisted-pair cabling with four pairs of wires
- **DIX Connector**
  - These connectors are not used often anymore but were widely used when thick Ethernet was popular.
- **AUI Connector**
  - The main use today of AUI connectors today is for external transceivers.

Bounded Media

- Bounded media are made up of a central conductor (usually copper) surrounded by a jacket material.
- Bounded media are great for LANs because they offer:
  - high speed
  - good security
  - low cost
- Sometimes they cannot be used due to distance limitations.

Bounded Media (Continued)

- Some of the characteristics you will look at for each cable type:
  - Cost
  - Installation
  - Capacity
  - Attenuation (Maximum Distance)
  - Immunity to Interference
    - EMI could be an important factor to choose cables.

Bounded Media (Continued)

- Three common types of bounded media are in use out in the world:
  - Coaxial
  - Twisted pair
  - Fiber optic

Electrical Properties

- **Resistance** (電阻)
  - Resistance only affects the transmission of direct current (DC), and it is measured in ohms.
  - The resistance causes the energy to be converted to heat.
  - Cables with small diameters have more resistance than cables with large diameters.

- **Impedance** (阻抗)
  - The loss of energy from an alternating current (AC) is impedance.
Electrical Properties (Continued)

- **Noise**
  - Noise can be easy to avoid if route new cable away from lights and other EMI sources.
  - Try to use shielded cabling if you can, and ground all equipment.
- **Attenuation**
  - Attenuation is the fading of the electrical signal over a distance.
- **Cross Talk**
  - The signal from one cable is leaked to another by an electrical field.

Coaxial Cable

- Coaxial cable gets its name because it contains two conductors that are parallel to each other, or on the same axis.
  - The center conductor in the cable is usually copper. The copper can be either a solid wire or a stranded material.
  - EMI interference is caught by the outer copper mesh.
  - The best coaxial cable will use a stranded central conductor with a tight mesh outer conductor.

Coaxial Cable

- **Which Coaxial Cable would you buy?**
  - **Gauge**
    - Gauge is the measure of the cables thickness.
    - Gauge is measured by the Radio-Grade measurement (RG) number.
    - The higher the RG number, the thinner the central conductor core; the lower the number, the thicker the core.
  - **Impedance (the common coaxial standards)**
    - 50-ohm RG-7 or RG-11: Used with thick Ethernet
    - 50-ohm RG-58: Used with thin Ethernet
    - 75-ohm RG-59: Used with cable television
    - 93-ohm RG-62: Used with ARCNET

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Coaxial Cable (Continued)

- Advantages:
  - Inexpensive
  - Easy to wire
  - Easy to expand
  - Moderate level of EMI immunity
- Disadvantage:
  - Single cable failure can take down an entire network

Coaxial Cable (Continued)

- Coaxial Cable characteristics:
  - Low cost
  - Easy to install
  - Up to 10Mbps capacity
  - Medium attenuation
  - Medium immunity from EMI

Twisted-Pair Cabling

- Twisted-pair cabling is made up of pairs of solid or stranded copper twisted around each other.
- The twists are done to reduce the vulnerability to EMI and cross talk.
- Two varieties of twisted-pair cabling:
  - Unshielded twisted pair (UTP)
  - Shielded twisted pair (STP)

Unshielded twisted pair

- UTP is the more common.
- It can be either voice grade or data grade, depending on the application.
- Five levels of data grade cabling:
  - Category 1: This category is intended for use in telephone lines and low-speed data cable.
  - Category 2: Category 2 includes cabling for lower-speed networks. These can support up to 4Mbps implementations.
  - Category 3: This is a popular category for standard Ethernet networks. These cables support up to 16Mbps but are most often used in 10Mbps Ethernet situations.
  - Category 4: Category 4 cable is used for longer distance and higher speeds than Category 3 cable. It can support up to 20Mbps.
  - Category 5: This cable is intended for high-performance data communications. This is the highest rating for UTP cable and can support up to 100Mbps.

Unshielded twisted pair (Continued)

- UTP data cable consists of two or four pairs of twisted cables. Cable with four-pairs use RJ-45 connectors.
- UTP cable known as a patch cable is used to connect the user’s workstation to an RJ-45 network jack in their office.
- The cable from the wall jack runs to a punchdown block in a wiring closet.
- From the punch-down block the cables run to a patch panel. (A patch panel is a set of jacks that allow the administrator to connect the individual wall jack cables to a network device such as a hub or router.)
Unshielded twisted pair (Continued)

- Characteristics:
  - Low cost (but slightly higher than coaxial).
  - Easy to install
  - High speed capacity
  - High attenuation
  - Susceptible to EMI
  - 100 meter limit

Unshielded twisted pair (Continued)

- Advantages:
  - Easy installation
  - Capable of high speeds for LANs
  - Low cost

- Disadvantages:
  - Short distances due to attenuation

Shielded twisted pair

- STP is mainly used in Token Ring.
- STP similar to UTP but has a mesh shielding that protects it from EMI, which allows for higher transmission rates and longer distances without errors.

Shielded twisted pair (Continued)

- IBM has defined different levels for STP cable:
  - Type 1: Type I STP features two pairs of 22-AWG, with each pair foil wrapped inside another foil sheath that has a wire braid ground.
  - Type 2: This type includes Type 1 with four telephone pairs sheathed to the outside to allow one cable to an office for both voice and data.

Shielded twisted pair (Continued)

- Type 6: This type features two pairs of stranded, shielded 26-AWG to be used for patch cables.
- Type 7: This type of STP consists of one pair of stranded, 26-AWG wire.
- Type 9: Two pairs of shielded 26-AWG, used for data, comprise this type of cable.

Shielded twisted pair (Continued)

- Characteristics:
  - Medium cost
  - Ease of installation is medium due to grounding and connectors.
  - Higher capacity than UTP
  - High attenuation, but the same as UTP
  - Medium immunity from EMI 100 meter limit
**Shielded twisted pair (Continued)**

- **Advantages:**
  - Shielded
  - Faster speed than UTP and coaxial
- **Disadvantages:**
  - More expensive than UTP and coaxial
  - More difficult installation
  - High attenuation rate

**Fiber-Optic Cable**

- Instead of using electrical signals to transmit data, it uses light.
- In a fiber cable, light only moves in one direction. For a two-way communication to take place, fiber cable is actually two strands of cable.
- In the center of the fiber cable is a glass strand, or core. Around the internal core is a reflective material known as cladding.

**Fiber vs Copper**

Not only does optical fiber offer enormous bandwidth, but it takes a lot less room. Any one of these copper bundles can be replaced with one fiber strand (center). (Image courtesy of Corning Incorporated.)
Embedding thousands of miles of fiber in the ground has been a herculean feat undertaken by many companies. In time, all copper wires are expected to give way to fiber. (Image courtesy of Metromedia Fiber Network.)

Fiber-optic Cable (Continued)

- Fiber-optic cable comes in two flavors:
  - Single mode
    - Only allows for one light path through the cable
  - Multimode
    - Has many paths through the cable

Fiber-Optic Cable (Continued)

- Characteristics:
  - Expensive
  - Very hard to install
  - Capable of extremely high speed
  - Extremely low attenuation
  - No EMI problems

Fiber-Optic Cable (Continued)

- Advantages:
  - Fast
  - Low attenuation
  - No EMI interference problems
- Disadvantages:
  - Hard to install
  - Expensive

Unbounded Media

- Unbounded (wireless) media does not use any physical connectors between the two devices communicating.
- Wireless media is used when a physical obstruction or distance blocks the use of normal cable media.
- Three main types of wireless media:
  - Radio wave
  - Microwave
  - Infrared
Radio Waves

• Radio waves have frequencies between 10KHz and 30GHz.

• 7 segments for Radio spectrum
  – Very Low Frequency: 10KHz - 30KHz
  – Low Frequency (Long Wave): 30KHz - 300KHz
  – Medium Frequency (Medium Wave): 300KHz - 3000KHz
  – AM radio
  – High Frequency (Short Wave): 3MHz - 30MHz
  – Very High Frequency (Super Short Wave): 30MHz - 300MHz
  – 88MHz-108MHz: use for FM radio
  – Ultra High Frequency: 300MHz - 3000MHz
  – Super High Frequency: 3GHz – 30GHz

Radio Waves (Continued)

• Some frequencies that are not regulated and anyone can use. These bands are:
  – 902-928 MHz
  – 2.4GHz (internationally unregulated)
    • IEEE 802.11b, IEEE 802.11g
  – 5.72-5.85 GHz
• Radio wave transmissions can be divided into these three categories:
  – Low power, single frequency
  – High power, single frequency
  – Spread spectrum

Low power, single frequency

• The normal operating range on these type of devices is 20-25 meters.
• The speed of these units can vary from 1Mbps to 10Mbps, which is about perfect for a small LAN.
• Problems:
  – Attenuation
  – EMI
• Benefits--In an office where everyone has a notebook or portable computer. There would be no need for cables or other net-working devices.

Low power, single frequency (Continued)

• Characteristics of low power, single frequency:
  – Low cost for wireless media
  – Simple installation with preconfigured equipment
  – 1Mbps to 10Mbps capacity
  – Low attenuation which can limit range to 25 meters
  – Low immunity to EMI

High power, single frequency

• Characteristics of high power, single frequency:
  – Moderate cost
  – Easier to Install than low-power solutions
  – 1Mbps to 10Mbps capacity
  – Low attenuation for long distances
  – Low immunity to EMI

Spread spectrum

• Use several frequencies at once to provide reliable data transmissions that are resistant to interference.
• Using multiple frequencies secure transmissions
  – Direct-sequence modulation
  – Frequency-hopping
Spread spectrum (Continued)

- Direct-sequence modulation
  - breaks data into chips and transmits the chips across several frequencies.
- Frequency-hopping
  - uses strict timing to switch frequencies. Both the sender and the receiver are set to change frequencies at a specific time.

Spread spectrum (Continued)

- Characteristics of spread spectrum:
  - Moderate cost
  - Simple to moderate installation
  - 2–6Mbps capacity
  - High attenuation
  - Moderate immunity to EMI

Microwaves

- Microwaves travel at higher frequencies than radio waves and provide better throughput as a wireless network media.
- Microwave transmissions require the sender to be within sight of the receiver.
- Two types of communication systems:
  - Terrestrial
  - Satellite

Terrestrial microwave

- Transmit wireless signals across a few miles.
- Require that direct parabolic antennas be pointed at each other.
- Characteristics of terrestrial microwave:
  - Moderate to high cost
  - Moderately difficult installation
  - 1–10Mbps capacity
  - Variable attenuation
  - Low immunity to EMI

Satellite microwave

- Transmit signals throughout the world.
- Satellite microwave characteristics:
  - High cost
  - Extremely difficult and complex installation
  - 1–10Mbps capacity
  - Variable attenuation
  - Low immunity to EMI

Infrared

- These high frequencies allow high-speed data transmissions.
- Can be affected by objects obstructing the sender or receiver and by interference from light sources.
- Immune to electromagnetic interference
- Two categories:
  - Point-to-point
  - Broadcast
Point-to-point

- Utilize highly focused beams to transfer signals directly between two systems.
- Point-to-point systems require direct alignment between devices.
- Point-to-point infrared characteristics:
  - Wide range of costs
  - Moderately easy installation
  - 100Kbps–16Mbps capacity
  - Variable attenuation
  - High immunity to EMI

Broadcast

- Use a spread signal, one broadcast in all directions, instead of a direct beam.
- Allows multiple receivers of a signal.
- Broadcast infrared characteristics:
  - Inexpensive
  - Simple installation
  - 1Mbps capacity (decrease in-speed)
  - Variable attenuation
  - Moderate immunity to EMI

Data Transmission

- Data transmissions across the network can occur in two forms:
  - Analog: Analog signals exist in an infinite number of values.
  - Digital: Digital signals exist in a finite number of values.

Analog and Digital Signal

Analog Signalizing

- Analog signal takes the form of a wave, which smoothly curves from one value to the next.
- Characteristics of an analog signal include amplitude, frequency, and phase.
- Different characteristics of the signal can be changed to show different data bits
  - Amplitude Shift Keying (ASK)
  - Frequency Shift Keying (FSK)
  - Phase Shift Keying (PSK)
Analog Signaling (Continued)

- Advantages of analog signaling:
  - Allows multiple transmissions across the cable
  - Suffers less from attenuation

- Disadvantages of analog signaling:
  - Suffers from EMI and noise
  - Can only be transmitted in one direction without sophisticated equipment

Digital Signaling

- Digital signals jump directly to the next value. (0,1)
- The jump from one value to another is known as a transition.
- Data rate is measured in bits per second (bps), (hertz, baud or baud rate).

Digital Signal Encoding

- State-transition encoding uses a change (or lack of a change) in a signal to represent a data value:
  - Manchester
  - Ethernet utilizes Manchester encoding
  - Use a low-to-high or high-to-low mid-bit transition to represent data values.
  - Differential Manchester
  - Used for clocking.
  - Token Ring LANs utilize Differential Manchester.
  - Non-Return-Zero (NRZ-S)
  - A transition signifies one value while the lack of a transition signifies another value—does not use a mid-bit transition for clocking.
Digital Signal Encoding (Continued)

- Current-state encoding is done by examining the current condition of the signal. (A specific voltage can represent a specific value.)
- The following encoding schemes use this method:
  - Return-to-Zero
    - Translates a high voltage to one value while a low voltage represents another
    - Includes a mid-bit transition to 0 for clocking purposes.

- Unipolar
  - Uses a 0 level to represent one value, while either a positive or a negative level represents the other value.

- Polar
  - The levels don’t have to be 0.
  - This scheme allows for a positive and a negative level to each represent a value.

Other Encodings

Data Transmission Considerations

- Bit synchronization
  - The receiving device must know when a signal begins and ends, and how to differentiate it from other signals on the cable.
- Multiplexing
  - Uses a single high-bandwidth channel to transmit lower-bandwidth channels.

Bit Synchronization

- Timing is essential if the encoding schemes are going to work.
- The signal must be examined at the appropriate time to determine what changes have occurred and to interpret the signal correctly.
- Coordinating timing between the sending device and the receiving device is known as bit synchronization.
- Bit synchronization can be either
  - Asynchronous
  - Synchronous.

Asynchronous Bit Synchronization

- Requires a start signal at the beginning of the message and a stop bit at the end of the message.
- Asynchronous systems also use parity for error checking in transmissions.
- The parity options available for asynchronous communications are
  - Even: The sum of the bits be an even number.
  - Odd: The sum be an odd number.
  - None: No parity error checking be used.
Synchronous Bit Synchronization

- Synchronous communications require the sending and receiving systems to agree upon clocking systems that are continuously synchronizing the clocks.
- Several methods can be used to synchronize the clocks on the sender and receiver:
  - Guaranteed state change
  - Separate clock signals
  - Oversampling:

(Continued)

- Guaranteed state change:
  - Used often with digital signals
  - Guaranteed state change uses regular changes in the voltage to clock the signal
- Separate clock signals:
  - Sends data over one wire and the clocking signal over a separate wire, and inefficient in the use of available bandwidth.
  - Most often use in short-distance transmissions

Synchronous Bit Synchronization (Continued)

- Oversampling:
  - The samplings provides data information and the others verify that the clocks are synchronized.
  - Receiver to work harder to maintain the clocking system.

Different Methods of Utilizing the Cable

- A transmission of data across network cable has limited bandwidth, or capacity.
- Two ways of utilizing bandwidth:
  - Baseband transmissions
  - Broadband transmissions

Baseband transmissions

- Use the entire bandwidth to transmit one signal at a time.
- Signals can be bidirectional
- Frequently used in LANs
- Repeaters are often used to extend the distance.
- A repeater is a device that removes any distortion in the signal and retransmits it.

Broadband transmissions

- Utilize bandwidth by dividing it into channels.
- Allows for multiple transmissions at once.
- Broadband is less susceptible to attenuation.
- Transmit further than baseband transmissions.
- Transmissions can occur only in one direction.
- Broadband transmissions are used only by analog signals.
Multiplexing

- Using a single high-bandwidth channel to transmit many lower-bandwidth channels.
- A Multiplexer/Demultiplexer (MUX) is the hardware device that allows the channels to be joined and separated.

Two Types of Multiplexing

- Frequency-Division Multiplexing (FDM):
  - Used in broadband transmissions to transmit analog signals.
- Time-Division Multiplexing (TDM):
  - TDM uses time slots to separate channels.
  - Each device is given a time slot to transmit using the entire available bandwidth.
  - The only technique that can be used to provide multiple channels on a baseband line.

Two Types of TDM

- Synchronous Time-Division Multiplexing:
  - All the time slots are the same length.
- Statistical Time-Division Multiplexing:
  - Utilizes time slots more efficiently by allotting time based on how busy a channel is.
  - This method requires expensive equipment.