Lecture 4: Media

CS 5516
Computer Architecture
Networks

VA Tech

Prof. Roy M. Wnek
Electronic Industry Association (EIA)

• EIA is an umbrella organization of industry groups and related activities

• History
  – 1924: 50 radio manufacturers in the Chicago area formed the Associated Radio Manufacturers (ARM)
    • Develop radio standards, lobby, and agree on "terms of sale" (a now-illegal "price fixing")
    • Renamed Radio Manufacturers Association (RMA)
  – 1928: RMA formed a Television Committee
    • Recommended that upcoming TV technology be soft-pedaled because it would hurt radio sales
    • Recommended that TV programs be restricted to the period of 1:00 a.m. to 7 a.m.
  – 1950: RMA includes TV manufacturers and renamed Radio Television Manufacturers Association (RTMA)
  – 1953: RTMA renamed the Radio Electronics Television Manufacturers Association RETMA, included solid-state electronics companies
  – 1957: RETMA renamed Electronic Industries Association (EIA), to emphasize an all-inclusive scope
Joint Electron Device Engineering Council

- Trade association for companies involved in designing and manufacturing primary electronic components

- History reflects microelectronics technology development
  - 1926- National Association of Electrical Manufacturers (NEMA) formed
  - 1944- NEMA and RMA jointly formed the Joint Electron Tube Engineering Council (JETEC)
    - Devoted solely to electron tubes
    - Accomplished extensive standardization
    - Set up the type registration system for tubes
  - 1958- JETEC split into two Councils, renamed Joint Electron Devices Engineering Councils (JEDEC)
    - JEDEC Tube Council
    - JEDEC Semiconductor Council.
  - 1965-1977- Series of name reorganizations and name changes
    - De-emphasis, then cessation of electron tube activities
    - Increased activities for solid state components
    - Separate activities devoted to discrete devices
  - 1985- NEMA withdraws financial support, JEDEC became solely sponsored by EIA
EIA Standards and Technology Engineering Departments

- EIA group that is directly involved in standards work
  - Draft standards not released to the general public unless it is to be an ANSI-sponsored American National Standard (ANS)
  - Any interested party may cast votes via a purchased ballot
  - Draft document obtains industry consensus
  - Forwarded with all balloting info for review by
    - the TIA Telecommunications Standards Subcommittee (TSSC)
    - or the EIA Engineering Department Executive Committee (EDEC)
  - If it is to be an ANS the same info is forwarded to the ANSI Board of Standards Review (BSR)
  - After review & approval of the BSR, the document is published as an EIA or TIA Standard
  - A EIA or TIA standard which is an ANS is reviewed every 5 years
    - May be reaffirmed, modified, or rescinded
  - Component Information Management System (CIMS)
    - Standards & part numbers
    - Links to other data bases
    - Component attributes based on EIA universal data
    - Supplier profiles
EIA Government Division

- EIA Government Division
  - Advances the interests of the U. S. electronics, communications and information technology industries with Congress, and the Executive Branch
  - Government markets, requirements, and standards
    - U.S. national and international security interests
    - Federal space initiatives
    - National science and technology priorities
    - Efficient government operations.
  - Activities encompass all business disciplines
    - Market planning, forecasting, manufacturing, procurement, exports, support services, public relations, standards, and government specifications

- Consumer Electronics Manufacturers Association (CEMA)
  - A trade association whose primary members are US consumer electronic manufacturers
  - Sponsors of the International Winter Consumer Electronics Show and other trade shows
  - Promotes and distributes consumer electronics-related information, e.g. home-theater design and equipment
  - Provides information for technicians and educators including workshops, educational programs
Consumer Electronics Manufacturers Association (CEMA)

- Product-oriented divisions
  - **Accessories** Division (audio, video, computer, or telephone accessories; batteries; jewel cases)
  - **Audio** Division (loudspeakers, CD players, amplifiers, receivers)
  - **Home Theater** Subdivision (equipment and furniture designed for home theaters)
  - **Specialty Audio** Subdivision (high-end CD transports, amplifiers, speakers, cables)
  - **Communication and Information Products** Division
  - **Hand-Held Reference Products** Subdivision (calculators, personal digital assistants)
  - **Integrated Home Systems Subdivision** (products with home automation capabilities, control equipment for interconnecting home products)
  - **Small Office/Home Office Products** Subdivision (computers, printers, faxmachines, copiers)
  - **Telecommunications Subdivision** (cordless, corded and cellular phones, answering machines)
  - **Mobile Electronics Division** (car audio equipment, radar, vehicle security, navigation devices)
  - **Multimedia Division** (computer, audio, video, and telecommunications hardware and software)
  - **Video Division** (televisions, videotapes, VCRs, video cameras)
EIA Components Group

- EIA Components Group
  - Product-specific Divisions
    - Capacitor; Resistor; Inductive Products; Interconnective Devices and Enclosure Systems; Switch and Protective Devices; Electronic Display; Wire & Cable; Solid State Products
    - General Components including other electromechanical, recording systems, and service test equipment, and materials
      - Provides forums on distribution, sales and marketing and small business support
      - Annual trade shows

- The Electronic Industries Quality Registry
  - Internationally Recognized Audit and Certification for:
    - ISO-9000
    - QS-9000
    - ISO-14000 (Draft)
  - Third Party Quality / Technology Audits in a Variety of Manufacturing Industries.

- Electronic Information Group
  - Represents EIA's in Electronic Data Interchange and Design Automation
    - EIG divisions
      - Electronic Industry Data Exchange (EIDX)
      - Computer Aided Software Engineering Data interchange Format (CDIF)
      - Electronic Data Interchange Format (EDIF)
      - Design Automation Division (DA)
      - Industrial Automation Division (IAD)

- Electronic Industries Foundation
  - Philanthropic sector of the EIA
**Telecommunication Industry Association (TIA)**

- Full-service trade organization
  - 600 member companies in the United States and world-wide
  - Communications and information technology industry
    - communications materials, products, systems, distribution services and professional services
  - Affiliation with the EIA

- Numerous services
  - Forum for members
  - Government relations and industry advocate
    - National & International
  - Market support activities such as trade shows and trade missions
  - Standards setting activities
  - Educational programs
  - Accredited ANSI standards tester

- History
  - In 1924, group of suppliers to the independent telephone industry organized an industry trade show & became a committee of the US Telephone Association (USTA)
Telecommunication Industry Association (TIA)

- In 1979, the group split off as a separate affiliated association, US Telecommunications Suppliers Association (USTSA)
- TIA formed in 1988 after a merger of the USTSA and the Information and the EIA Telecommunications Technologies Group (EIA/ITG)

- Six issue-oriented standing committees chaired by a Board member
  - Membership Scope and Development;
  - International
  - Marketing and Trade Shows;
  - Public Policy and Government Relations
  - Small Company
  - Technical

- Product oriented divisions
  - Address the legislative and regulatory concerns of manufacturers
  - Prepare performance testing and compatibility standards
    - User Premises Equipment
    - Network Equipment
    - Mobile and Personal Communications Equipment
    - Fiber Optics
    - Satellite Communications
Two general configurations or topologies of media

- "bus" or common media
  - Multiple nodes communicate over a single medium
  - Requires link protocol which share the medium

- "point to point"
  - A single medium connects only two nodes
  - Link protocol need only coordinate two end nodes

Topologies define:

- Physical connectivity required between nodes
- Which protocols can be used most effectively
- The size of the network that can be supported
Communications Media

- Communications media provides the path along which all data signal is transmitted nodes
  - Message information and protocol overhead
  - One or more type of media may be used in a network

- Selection of the appropriate communications medium is an important part of network design
  - Each media has its strong and weak points
  - Avoids recabling costs as the network grows

- Major types of media
  - Thick Wire
  - Thin Coax
  - Twisted Pair Cable
    - Unshielded Twisted Pair (UTP)
    - Shielded Twisted Pair (STP)
  - Fiber Optic Cable
  - Wireless
    - Radio-frequency (RF)
    - Infra-red (IR)
Coaxial Cable

• Single copper conductor at its center

• Plastic layer provides insulation between the center conductor and a braided metal shield

• Metal shield helps to block outside interference
  – Fluorescent lights, motors, and other computers

• Support greater cable lengths between network devices than twisted pair cable

• More difficult to install than twisted pair cable

• Two types of coaxial cable
  – Thick Wire and Thin Coax
Coaxial Cable Connectors

• Most common type of connector used with coax cables is the Bayone-Neil-Councelman (BNC) connector

![BNC Connector]

Different types of adapters are available for BNC connectors, including
– T-connector
– Barrel connector
– Terminator

• Connectors on the cable are the weakest points in any network

• Always use the BNC connectors that crimp, rather than screw, onto the cable
<table>
<thead>
<tr>
<th>Jack Plug</th>
<th>Type</th>
<th>Typical Cable</th>
<th>Application</th>
</tr>
</thead>
<tbody>
<tr>
<td>BNC</td>
<td>RG-58</td>
<td>10Base2 Ethernet</td>
<td></td>
</tr>
<tr>
<td>TNC</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>SMA</td>
<td></td>
<td>Audio/Video</td>
<td></td>
</tr>
<tr>
<td>RCA</td>
<td></td>
<td></td>
<td>Broadband Cable TV</td>
</tr>
<tr>
<td>&quot;F&quot;</td>
<td>RG-59</td>
<td></td>
<td>Radio Antenna Leads</td>
</tr>
<tr>
<td>&quot;N&quot;</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Thick Wire - 10Base5

- ThickWire coaxial cable has an extra protective plastic cover that helps keep moisture away from the center conductor
  - Thick, hefty cable which does not bend easily
  - Used because of its immunity to common levels of electrical noise
  - Helps to ensure the integrity of network signals
  - Can be expensive and difficult to install

- 10Base5 refers to the specifications for thick coaxial cable carrying Ethernet
  - 10 refers to a maximum Ethernet datarate of 10 Mbps
  - 5 refers to the maximum segment length being 500 meters

- Used to create large "network backbones"
  - Joins many smaller network segments into one large LAN
  - A ThickWire segment can be up to 500m long with as many as 100 nodes attached in a bus topology
Thick Wire

- To install new nodes
  - Thick Wire must not be cut
  - Nodes are connected by drilling into the cable with a "vampire tap"

- Nodes must be spaced in 2.5m increments
  - Cable is often pre-marked at intervals
  - Prevents signals from interfering with one another

10Base5 Network
Thin Coax - 10Base2

- RJ-58 Cable is considerably thinner and more flexible than ThickWire
  - Lower cost and easier installation

- Supports 30 nodes (at least 0.5m apart)

- Each segment not longer than 185m

- 10Base2 refers to the specifications for thick coaxial cable carrying Ethernet signals
  - The 10 refers to a maximum Ethernet datarate of 10 Mbps
  - The 2 refers to the maximum segment length of approximately 200 meters (actually 185 meters)

- Attractive medium for small networks
  - Multiple node in one room (e.g. a computer lab)
  - Several adjacent rooms
    - Easy to reconfigure
    - Connecting small networks to larger backbones

- Thin coax can be used to create backbones, but with fewer nodes
Thin Coax Connections

- A thin coax segment is actually composed of many lengths of cables
  - Each with a BNC type connector on both ends

- Each cable length is connected to the next with a "T" connector at the nodes
  - 50 ohm resistors terminate each end
  - One end terminator must be grounded

- Nodes can be connected or disconnected at the "T" connectors as needed
  - No ill effects on the rest of the network
Twisted Pair

- Coaxial cables are relatively expensive and require some care during installation

- Two basic types of Twisted Pair cable
  - Unshielded Twisted Pair (UTP)
  - Shield Twisted Pair (STP)

- Twisted Pair Applications
  - Token ring (4 or 16MB/s)
  - 10BaseT Ethernet (10MB/s)

- Twisted Pair Advantages
  - Cheap
  - Easy to terminate
  - Easier to pull cable in existing buildings
  - Lend itself to star topologies
  - May already be installed as telephone lines

- Twisted Pair Advantages
  - Low to medium capacity
  - Medium to high loss
Unshielded Twisted Pair

- **Unshielded twisted pair (UTP)** is the most popular and is often the best option for existing buildings and new construction.

![Unshielded twisted pair](image)

- The quality of UTP may vary from telephone-grade wire to high-speed cable.
  - EIA/TIA standards specify five categories of UTP.

- The cable has four pairs of wires inside the jacket.
  - Each pair is twisted with a different number of twists per inch.
    - Help eliminate interference from adjacent pairs and other electrical devices.
Unshielded Twisted Pair (UTP)

- UTP often run in conjunction with telephone cabling

- Central location can be a telephone closet
  - or other area where it is convenient to connect the UTP segment to a backbone

- UTP segments are limited to 100 meters

- In 10BaseT Ethernet, each PC is wired back to a central hub using UTP
  - This topology allows the rest of the network to function if a break occurs in a particular segment

10BaseT Network
Categories of Unshielded Twisted Pair

• UTP cables come in a variety of grades, with each higher grade offering better performance

<table>
<thead>
<tr>
<th>Type</th>
<th>Use</th>
</tr>
</thead>
<tbody>
<tr>
<td>Category 1</td>
<td>voice only (telephone wire)</td>
</tr>
<tr>
<td>Category 2</td>
<td>data to 4 Mbps (LocalTalk)</td>
</tr>
<tr>
<td>Category 3</td>
<td>data to 10 Mbps (Ethernet)</td>
</tr>
<tr>
<td>Category 4</td>
<td>data to 20 Mbps (16 Mbps Token Ring)</td>
</tr>
<tr>
<td>Category 5</td>
<td>data to 100 Mbps (Fast Ethernet)</td>
</tr>
</tbody>
</table>

• Categories differ by the tightness of the twisting of the copper pairs
  – Tighter twisting => higher transmission rate & greater the cost per foot

• The length of exposed wires is very critical
  – The standard limits this to less than 1/2"

• Level 5 is the highest, most expensive grade
  – Unnecessary for ordinary 10BaseT applications
  – Uses 8 wires
  – Maximum segment length of 100 meters
UTP Connectors

• Level 4 and Level 3 cables are far more popular for current 10BaseT configurations
  – Minimum of Category 3 is recommended

• Level 2 and Level 1 cables are the lowest grades and least expensive wire
  – Designed primarily for voice use
  – Maybe used for low speed transmissions (less than 5Mbps)
  – Should not be used in 10BaseT networks

• RJ-45 is standard connector for Unshielded Twisted Pair
  – Registered Jack (RJ) standard designates which wire goes with each pin inside the connector

• Ethernet 10BaseT wiring specifies an 8 position jack, but uses only two pairs
UTP Patch Cables

- **Patch cables varieties**
  - Straight through
  - Reversed

- **Applications of patch cables**
  - Patching between modular patch panels in system centers
    - Straight through variety used
  - Connect workstation equipment to the wall jack
    - Either straight through or reversed depending upon the manufacturer
  - Voice systems
    - Reversed cables normally used

- **How to determine the type of patch cable**
  - Align the ends of the cable side by side
    - With contacts are facing you
  - Then compare the colors from left to right
  - If the colors are in the same order on both plugs
    - The cable is straight through.
  - If the colors appear in the reverse order
    - The cable is reversed

<table>
<thead>
<tr>
<th>Pair</th>
<th>Pin ID</th>
<th>Pin #</th>
</tr>
</thead>
<tbody>
<tr>
<td>T1</td>
<td>1</td>
<td></td>
</tr>
<tr>
<td>R1</td>
<td>2</td>
<td>2</td>
</tr>
<tr>
<td>T2</td>
<td>3</td>
<td>6</td>
</tr>
<tr>
<td>R2</td>
<td>6</td>
<td>6</td>
</tr>
</tbody>
</table>

**Pair Pin ID #**

**Pair 1**

1  2  3  4  5  6  7  8

**Pair 2**

1 White/orange  Tx data +
2 Orange/white  Tx data -
3 White/green   Rx data +
4 Blue/white    --
5 White/Blue    --
6 Green/white   Rx data -
7 White/brown   --
8 Brown/white   --
Wire Types

- **Solid Wire Cable**
  - For runs between two wiring closets
  - From the wiring closet
  - Designed for horizontal and backbone cable runs
  - Should not be bent or flexed or twisted repeatedly
  - More expensive

- **Stranded Wire Cable**
  - For connecting workstation NICs to the wallplate
  - Connections with patch panels and with other equipment such as
  - Made from multiple thinner conductors
  - Excellent for applications involving repeated flexing
  - Higher attenuation that solid conductor cable => shorter runs
Cable Types

- National Electrical Code (NEC)
  - Specifies minimum standards for new construction
  - Technical handbook published by National Fire Protection Association
  - Adopted by virtually all local jurisdictions
  - Based on tests by Underwriters Laboratories (UL)

- Class 2 cable (CL2)
  - Low power, digital transmission
  - Used in LAN backbones (4-16Mbps)
  - T1 Circuits

- Communications (CM)
  - Analog television - “Telephone Twisted Pair”
  - Standard Cable
  - Also can be used for 10Mbps Ethernet

- Riser - vertical chase way between building floors

- Air Plenum - space above drop ceiling used for return of breathing air
Cable Types 2

- **General Use Cable**
  - Least expensive cable type
  - Uses a PVC insulation and cable jacket
  - Not fire retardant
  - Must be encased in conduit or non-combustible wireway

- **Limited Use Cable**
  - Similar to General Use Cable
  - Can be used in open work spaces up to 10 ft

- **Riser Cable**
  - Replaces PVC jacket with fire-retardant sheath
  - Prevent spread of fire between floors
  - Does give off noxious fumes when burning

- **Plenum Cable**
  - Replaces PVC jacket with low-flame, low fume-producing sheath
  - Most expensive cable type
  - “Teflon Cable”
  - No need for protective cable

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1987 National Electrical Code

<table>
<thead>
<tr>
<th>CABLE TYPE</th>
<th>UL Cable Marking</th>
</tr>
</thead>
<tbody>
<tr>
<td>Class 2 Data Cable</td>
<td></td>
</tr>
<tr>
<td>General use</td>
<td>CL2</td>
</tr>
<tr>
<td>Limited use</td>
<td>CL2X</td>
</tr>
<tr>
<td>Riser cable</td>
<td>CL2R</td>
</tr>
<tr>
<td>Plenum cable</td>
<td>CL2P</td>
</tr>
<tr>
<td>Communications Cable</td>
<td></td>
</tr>
<tr>
<td>General use</td>
<td>CM</td>
</tr>
<tr>
<td>Limited use</td>
<td>CMX</td>
</tr>
<tr>
<td>Riser cable</td>
<td>CMR</td>
</tr>
<tr>
<td>Plenum cable</td>
<td>CMP</td>
</tr>
</tbody>
</table>
Shielded Twisted Pair

- UTP is susceptible to radio and electrical frequency interference.

- Shielded twisted pair (STP) is suitable for environments with electrical interference

- Extra shielding can make the cables quite bulky

- Shielded twisted pair is often used on networks using token ring topology.
Fiber Optic Cable

- An optical fiber is a thin strand of glass or plastic (Higher performance with glass)

- Fiber optic cable is more expensive, but is invaluable for situations where electromagnetic interference exist
  - Outdoor & industrial installations
  - Installation near power distribution
  - Lightening strikes and current loops due to ground potential differences
  - Potential damage to networking equipment
  - Noise on the communications lines

Multi-fiber Cable

- Fiber optic cables effectively prevent these conditions since they cannot conduct electricity
  - Data is transmitted as encoded pulses of light
  - Pulse of light is generated by either a laser or light emitting diode (LED)
  - Received by a light detector
Construction of a Optical Fiber Cable

- Core of the fiber conducts the light signal
- Core is surrounded by a cladding with an smaller index of refraction
  - To ensure total internal reflection of light

![Diagram of Fiber Optic Cable]

- The Coating is a layer of plastic that reinforces the core/cladding, helps absorb shocks and provide extra protection against bending
- Reinforcement sheath provides tensile strength which relieves the fibers of stress resulting from pulling the cable during installation
  - Kevlar sheath or
  - Either steel or composite stress members

Surrounding Jacket of Teflon or PVC
### Physical Parameters of an Optical Fiber Cable

- **Bending of the fiber**
  - Attenuates light signals by causing light to escape from the fiber
  - Breaks the transmission path by actually fracturing the fiber

- **Limited bending radius**
  - Typical minimum radii vary between 2 to 10 cm
  - 10 times the cable diameter

- **Cable Strength**
  - Amount of tension that can be exerted without stretching the fiber
  - Amount of compression that can be exerted without deforming the fiber
  - Amount of impact that can be exerted without deforming the fiber
  - Typical strength values:
    - 400lbs of tension @ 20o
    - 377 lb/in flat plan compression
    - 160 lb/in maximum impact
## Applications of Fiber Optic Cable

- The features of Fiber-optic cable systems are
  - expensive
  - capacity for high bandwidth data transmission
  - immune to electro magnetic interference
  - low signal attenuation or degradation
  - difficult for unauthorized penetration
  - connectors are expensive & require careful installation
  - longer transmission distance than copper wire

- Typical Uses
  - Join two hubs together (overcome distance limitations)
  - Backbones & FDDI rings (100MB/s)
  - Secure communications
  - Video transmission

- Kinds of fiber optic cables
  - Multimode step index fiber
  - Multimode graded index fiber
  - Single-mode step index fiber
Fiber Optic Connectors

- ST connector is the most common connector used with fiber optic cable
  - similar to a BNC connector

- SC is a newer connector
  - Has a molded body and a squared face; its push-pull locking system is easier to connect in a confined space

<table>
<thead>
<tr>
<th>Type</th>
<th>Features</th>
</tr>
</thead>
<tbody>
<tr>
<td>SMA906</td>
<td>threaded bayonet nut</td>
</tr>
<tr>
<td>SMA905</td>
<td>locking theaded nut</td>
</tr>
<tr>
<td>ST</td>
<td>bayonet locking nut</td>
</tr>
</tbody>
</table>
Multimode Step Index Fiber

- Index of refraction is constant throughout the glass, and sharply falls at the perimeter of the fiber, where the cladding starts
  - Light entering the fiber travels in a straight line until it strikes the core/cladding boundary, at which point it is reflected back into the core of the fiber

- Light bounces from wall-to-wall of the fiber as it travels towards its destination

SOURCE

MODAL DISPERSION

<table>
<thead>
<tr>
<th>CORE DIAMETER (microns)</th>
<th>50</th>
<th>62.5</th>
<th>85</th>
<th>100</th>
</tr>
</thead>
<tbody>
<tr>
<td>CLADDING DIAMETER (microns)</td>
<td>125</td>
<td>140</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Multimode Step Index Fiber

- Multimode step index fiber has a wide core diameter
  - Common core widths are 50, 62.5, 85, and 100 microns
  - Light enters the fiber at more than one angle
  - Light reflects off of the core/cladding boundary at different angles
  - Resulting in multiple paths or modes

- The distance light travels in each mode is not the same
  - Not all light arrives at the destination at the same time
  - Results in "modal dispersion"
    - Pulses of light are separate at the point of entry into the fiber
    - Light become smeared together at the receiving end

- Multimode step index fiber is not recommended for use in LANs
  - Not specified in any of the ISO/IEC standards
Multimode Graded Index Fiber

- Allows multiple modes/paths of propagation like the multimode step index fiber
- Graded index fiber has a variable index of refraction from the center of the core to the outside wall
- Light rays traveling through the graded index fiber, instead of being reflected as in the step index multimode fiber, are bent by the changing index of refraction
Multimode Graded Index Fiber

- Variable index of refraction speeds up or slows down the rays of light, depending on the angle of entry
  - Time of travel between the beginning and end of the fiber is the same for all signals
  - Modal dispersion is greatly reduced

- Multimode graded index fiber is used for inside/single-plant applications
  - Bandwidth/distance (measure of dispersion) is 10-100 MHz/km
  - With Repeaters needed every 10km, bandwidth <10MHz
Single-Mode Step Index Fiber

- Single-mode step index fiber has a small core diameter, approximately the same size as the light wavelength.

- Because the fiber is so narrow, light is forced to travel in a single path (single-mode), with no internal reflections, along the axis of the fiber.

- Can carry a light signal longer distance than multimode fiber
  - Because a stronger and more well defined light signal is delivered to the receiving end
    - Although less initial light, less light attenuation than because reflections are eliminated
    - Less modal dispersion single-mode fiber
Single-Mode Step Index Fiber

- More expensive

- With laser diode light source, bandwidth/distance (measure of dispersion) is 400-1000 MHz/km

- With LED light source, bandwidth/distance (measure of dispersion) is approx 300 MHz/km
Fiber Optic Cable Installation

• Properties particular to fiber optic cable can cause installation problems

• Intrinsic Power Loss
  – As light travels through the core, it loses speed through absorption, reflection, and scattering

• Connector/Coupling Loss
  – Results in reduced signal power
  – Causes:
    • Poorly terminated connector couplings
    • Misalignment of two fiber segments
    • Scratches and dirt are introduced during the splicing process
  – Solutions:
    • Ensuring good terminations and splices
    • Using clean components
    • Keeping dirt and dust to a minimum

• Microbending
  – Minute deviations in fiber caused by excessive bends, pinches, and kinks
  – To minimize this problem:
    • Using cable with reinforcing fibers
    • Avoiding pulling the cable excessively or bending it too sharply around any corners
Cable Nomenclature

<table>
<thead>
<tr>
<th>1</th>
<th>1 Megabit/sec</th>
</tr>
</thead>
<tbody>
<tr>
<td>10</td>
<td>10 Megabit/sec</td>
</tr>
<tr>
<td>100</td>
<td>100 Megabit/sec</td>
</tr>
<tr>
<td>1000</td>
<td>1 Gigabit/sec</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>T</th>
<th>Twisted Pair</th>
</tr>
</thead>
<tbody>
<tr>
<td>2</td>
<td>Thin Coax</td>
</tr>
<tr>
<td>5</td>
<td>Thick Coax</td>
</tr>
<tr>
<td>F,SX,FX</td>
<td>Optical Fiber</td>
</tr>
</tbody>
</table>

Base  Baseband
Broad Broadband
## Cable Summary

<table>
<thead>
<tr>
<th>Cable Type</th>
<th>Specification</th>
<th>Maximum Length</th>
</tr>
</thead>
<tbody>
<tr>
<td>unshielded twisted pair</td>
<td>10BaseT</td>
<td>100 meters</td>
</tr>
<tr>
<td>thin coaxial</td>
<td>10Base2</td>
<td>185 meters</td>
</tr>
<tr>
<td>thick coaxial</td>
<td>10Base5</td>
<td>500 meters</td>
</tr>
<tr>
<td>fiber optic</td>
<td>10BaseF</td>
<td>2000 meters</td>
</tr>
</tbody>
</table>
Guidelines for installing Cable

• Use the correct amount of cable
  – Plan using distance along cable paths, NOT direct distance
  – Leave appropriate slack
  – Avoid excess cable

• Plan the cable runs
  – Use cable tray or conduit where necessary
  – Use plenum-grade cable for open overhead installation
  – Prevent inductive interference
    • Avoid running unshielded cable in parallel with power lines
    • Stay at least 3 feet away from fluorescent lights
  – Insure ALL connections and junctions are accessible

• Test every part of a network during installation
  – Even with brand new cable
  – Problems are more difficult to isolate later
Guidelines for installing Cable 2

• If it is necessary to run cable across the floor, cover the cable with cable protectors.

• Label both ends of each cable.

• Use cable ties (not tape) to keep cables in the same location together.
Wireless Media

• Wireless Media use different portion of the Electromagnetic spectrum to transfer data
  – Radio signals
    • Broadcast systems (e.g. commercial radio)
    • Direct line-of-sight (e.g. microwave link)
    • Satellite
  – Infrared light

• Each node has a transceiver and antenna (or emitter/receiver) to send and receive the data

• Wireless applications
  – Long range connectivity
  – Mobile platforms (e.g. laptop computers)
  – Avoidance of cabling constraints in close quarters
  – Old buildings with difficult/impossible cable paths

• Disadvantages.
  – Cost
  – Poor security
  – Susceptible to a more sources of interference
  – Slow speed due to bandwidth limitations
  – Static bandwidth
Wireless Media

- Interference problem with other wireless systems
  - Cellular/cordless phones *(radio)*
  - Pagers *(radio)*
  - Garage door openers
  - Home entertainment remote controls *(IR)*
  - Other wireless networks *(IR)*

- Use signal encoding to minimize interference with other users
  - No recognized standards for data encoding
  - Emerging de-facto standards based commonality within product line
  - New WI-FI standard, IEEE 802.11b High Rate uses 2.4 GHz frequency and DSSS radio mode
Radio-based Media

• Transmission Directivity
  – Broadcast
  – Line-of-sight
    • Radio signals degraded
    • Light frequencies are completely blocked, by obstacles
  – Function of antenna design & frequency used

• Frequency Use
  – Conventional (single-frequency)
  – Spread spectrum

• US Government frequency allocation
  – Radio-based LANs currently restricted to the industrial, scientific, and medical (ISM) bands
    • (902-928 MHz, 2.4 - 2.5 GHz, and 5.8 - 5.9 GHz)
    • Transmitter power is limited to 1 watt or less

• Current radio-based LANs do not require a license for operation
  – Federal Communications Commission (FCC)'s Part 15 regulation for unlicensed operation
The WI-FI Standard

• Earlier wireless networking components would only work with equipment from the same manufacturer
  – companies created proprietary wireless protocols for use on their equipment
  – forced users to buy the same company’s equipment

• IEEE 802.11, or Wireless Fidelity (WI-FI), is a new standard for interoperability among wireless networking equipment.
  – Wireless Ethernet Compatibility Alliance (WECA), set the standard and tests new products for conformity to the WI-FI standard
  – WECA made up of several large companies such as 3Com, Lucent, and Cisco

• WI-FI has the same performance as a wired 10BaseT LAN connection

• WI-FI forces wireless networking manufacturers into pricing competition with one another
Infrared Light

• Light frequencies are much higher than radio frequencies
  – Not allocated by FCC
  – Operator's license is not required

• Light within the infrared band is invisible to the human eye.

• Preferred technology for:
  – Motion sensors
  – Remote controls for home entertainment systems

• IR systems are immune to radio or electrical interference

• IR systems are sensitive to vibration

• IR transmissions
  – Point-to-point (a focused beam)
  – Broad-beam with up to 360 degrees coverage