Chapter 3

Networking Media

Cabling Media

- Cables ferry signals between computers
- Allowing communication between users
- “Highway of the network”
Wireless Media

- Used due to:
  - Distance limitations
  - Physical obstructions
  - Mobile users

Network Cabling

- Tangible physical media
- Data enters & leaves user machines
- “Glue” that bonds networks together
- Differing physical characteristics
- Limitations of each type
# Primary Cable Types

- Three major types:
  - Coaxial cable
  - Twisted pair cable (TP)
    - Unshielded (UTP)
    - Shielded (STP)
  - Fiber-optic cable

# General Cable Characteristics

- Bandwidth
  - Bits or bytes/unit time
  - Megabytes per second (Mbps)
- Attenuation
  - Signal weakens becomes unreadable
  - Maximum segment length
  - Hardware to capture & regenerate
General Cable Characteristics

• Maximum # of segments
  – Latency
    • Longest tolerable delay of signal arrival
  – Maximum # of devices per segment
• Insertion loss
  – Each device attached adds to attenuation
  – True maximum = rated max - \( I \) (insertion loss)

General Cable Characteristics

• Interference susceptibility
  – Electromagnetic (EMI)
    • Transformers, motors
  – Radio frequency (RFI)
    • TV, radio stations
• Four levels
  – None, low, moderate, high
Connection Hardware

• Connectors must match cable type
• Connector cost must be considered
• Ease of attachment
• Specialized equipment required
• Should you build or buy?

Cable Grade

• Building & fire code requirements
• Combustibility & toxicity ratings
• Type of cladding
• Type of insulation
• Polyvinyl chloride (PVC) not used
Plenum

- Space between false & real ceiling
- Cables here must be plenum-rated
- Coated with Teflon
- Low combustibility & toxicity
- Conduit not required

Cable Bend Radius

- Damaged or destroyed when exceeded
- Fiber optic & heavy duty coaxial
- Generally more than 60° per foot
- Understand specific cable limits
- Do not exceed these limits
Material Costs

- Cables have cost per unit length
- Remember building & fire codes
- Cable is less than half total cost
- Plan ahead for faster technology
- More expensive cable now will save reinstallation costs later

Installation Costs

- Labor & equipment costs can mount up
- Figure costs of:
  - Design
  - Materials
  - Installation
  - Troubleshooting
Coaxial Cable

• For years “coax” was king
• Easy to install
• Inexpensive
• Easy way to extend the network
• “Thinnet”, “thinaux”

Coaxial Cable (cont.)

![Coaxial Cable Diagram]

Figure 3-1 Coaxial cable
Coaxial Cable (cont.)

- Single conducting core
- Surrounded by insulation
- Overlaid with metal braided shield
- Covered by outer wrapper (sheath)
- Good protection from EMF, RFI

Types of Coaxial Cable

- Thin Ethernet
  - “Thinnet, thinwire, cheapernet”
  - 10Base2
- Thick Ethernet
  - “Thicknet, thickwire”
  - 10Base5
IEEE

- Institute of Electrical & Electronics Engineers
- Designate cable as: 10Base2, 10Base5
- Total bandwidth: 10 megabits per second
- Base: type of signaling
- Maximum segment length: 2, 5 meters

Thinwire Ethernet

Figure 3-2  BNC cable connector
Thin Ethernet Environment

• Radio Government specifications (RG)
• Thinnet is RG-58
  – 50 ohm impedance
    • Electrical resistance to current flow
• Central conductor varies
  – Solid, braided

Thickwire Ethernet

• Rigid coaxial cable
• Covered with bright yellow Teflon
• “Frozen yellow garden hose”
• “Standard Ethernet” was 1st used
• Now least used
Thinwire Connection

Figure 3-3  BNC T-connector

Thickwire Connection

Figure 3-4  Thicknet cable transceiver with detail of a vampire tap piercing the core
Thickwire Environment

- Vampire tap attaches to cable
- Transceiver attaches to tap
- Attachment Unit Interface (AUI) attaches from transceiver to NIC
- Transceiver cables can be 50’ long

Thickwire Network

Figure 3-5 Thickwire Ethernet
Thickwire Ethernet Properties

Table 3-3  Thickwire Ethernet Characteristics

<table>
<thead>
<tr>
<th>Characteristic</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Maximum cable length</td>
<td>500 meters (1,640 feet)</td>
</tr>
<tr>
<td>Bandwidth</td>
<td>10 Mbps.</td>
</tr>
<tr>
<td>Bend radius</td>
<td>90 degrees/ft.</td>
</tr>
<tr>
<td>Install/maintain</td>
<td>Hard to install and remove. Rigid.</td>
</tr>
<tr>
<td>Cost</td>
<td>More expensive than thinwire, cheaper than fiber.</td>
</tr>
<tr>
<td>Connector type</td>
<td>BNC (British Naval Connector)</td>
</tr>
<tr>
<td>Interference rating</td>
<td>Good; lowest of all electrical cable types.</td>
</tr>
</tbody>
</table>

Ethernet Coax Requirements

- Each cable end needs a connector
- Female BNC for thick & thinwire
- Terminator on ends of connectors
  - To “soak up” signal
  - Prevent “bounce”
Deciding on Coaxial Media

- Handles moderate to serious bandwidth
- Supports medium to long runs
  - Thin 185 meters
  - Thick 500 meters
- Affordable
- Resistant to interference
  - Eavesdropping

Twisted Pair Cable

- Basic twisted pair (TP)
  - One or more pairs of wire
  - Twisted around one another
  - Resistant to interference
  - Limits signals influence on other pair
    - “Crosstalk”
Twisted Pair Types

- Unshielded twisted pair
  - UTP
- Shielded twisted pair
  - STP
- 1, 2, 4, 6, 8 pairs network cable
- Available in 50-100 pair cable

STP & UTP Cable

![Diagram of STP & UTP Cable]

Figure 3-6  STP and UTP cable
Unshielded Twisted Pair (UTP)

- IEEE Ethernet specification
- 10BaseT
- T means UTP
- Most popular form of LAN cabling
- Maximum segment length of 100 meters

Unshielded Twisted Pair (UTP)

- Electronic Industries Association (EIA)
- Telecommunication Industries Association (TIA)
- American National Standards Institute (ANSI)
- ANSI/EIA/TIA 568 Standard
## Shielded Twisted Pair (STP)

- Wire braid shield
- Metal foil shield
- Reduces crosstalk & interference
- Improves transmission characteristics
- No standard comparable to 568

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## RJ-45 Plug & Jack

![RJ-45 connector and jack](image)

*Figure 3-7*  
RJ-45 connector and jack
Twisted Pair Elements

- Distribution racks
- Punchdown blocks
- Patch panels
- Wall plates
- Jack couplers

**Figure 3-8** Punchdown block (left) and patch panel (right)
10BaseT Ethernet

Table 3-4 10BaseT Ethernet Characteristics

<table>
<thead>
<tr>
<th>Characteristic</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Maximum cable length</td>
<td>100 meters (328 feet)</td>
</tr>
<tr>
<td>Bandwidth</td>
<td>10 Mbps</td>
</tr>
<tr>
<td>Bend radius</td>
<td>8 degrees/ft</td>
</tr>
<tr>
<td>Install/maintain</td>
<td>Easy to install, no need to reroute. The most flexible.</td>
</tr>
<tr>
<td>Cost</td>
<td>Least expensive of all cabling options.</td>
</tr>
<tr>
<td>Connector type</td>
<td>RJ-45 for device and wall-plate connections.</td>
</tr>
<tr>
<td>Interference rating</td>
<td>Low: most susceptible of all electrical cable types.</td>
</tr>
</tbody>
</table>

Fiber-Optic Cable

- Bundle of glass or plastic fibers
- Sends signals on pulses of light
- Immune to interference
- Eliminate electronic eavesdropping
- High bandwidth, speed, long distance
Fiber-Optic Cable

- Plastic fiber has higher attenuation
- Plastic fiber more damage resistant
- Plastic fiber spans less distance
- One direction per fiber in both types
- Send & receive fiber in both types
Fiber-Optic Cable Connectors

- ST straight tip
- SC straight connection
- MIC medium interference connector
- SMA subminiature type A

<table>
<thead>
<tr>
<th>Characteristic</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Maximum cable length</td>
<td>2 km (6,562 feet) to 100 km (62.14 miles)</td>
</tr>
<tr>
<td>Bandwidth</td>
<td>100 Mbit/s to 1 Gbps</td>
</tr>
<tr>
<td>Bend radius</td>
<td>30 degrees/ft.</td>
</tr>
<tr>
<td>Install/maintain</td>
<td>Difficult to install and reroute, sensitive to strain and bending</td>
</tr>
<tr>
<td>Cost</td>
<td>Most expensive of all cabling options</td>
</tr>
<tr>
<td>Connector type</td>
<td>Several types: ST, SC, MIC, and SMA</td>
</tr>
<tr>
<td>Interference rating</td>
<td>None; least susceptible of all cable types</td>
</tr>
</tbody>
</table>
Fiber-Optic Cable

- Single Mode - single fiber core
  - Laser based
  - Longer distances
- Multi-mode - two or more fiber cores
  - Light emitting diodes
  - Shorter distances

Cable Selection Criteria

- Bandwidth - how fast the network?
- Budget - how many $ for cabling?
- Capacity - how much, flow of traffic
- Environment - interference, security
Cable Selection Criteria (cont.)

- Placement - cable routing, building codes
- Scope - how many devices?
- Span - how much distance?
- Extremes
  - Fiber-optic
  - UTP, thinnet

Cable Comparison

Table 3-6: Comparison of General Cable Characteristics

<table>
<thead>
<tr>
<th>Type</th>
<th>Maximum Length</th>
<th>Bandwidth</th>
<th>Install</th>
<th>Interference</th>
<th>Cost</th>
</tr>
</thead>
<tbody>
<tr>
<td>UTP</td>
<td>100m</td>
<td>10–100 Mbps</td>
<td>Easy</td>
<td>High</td>
<td>Cheapest</td>
</tr>
<tr>
<td>STP</td>
<td>100m</td>
<td>16–1,000 Mbps</td>
<td>Moderate</td>
<td>Moderate</td>
<td>Moderate</td>
</tr>
<tr>
<td>10Base2</td>
<td>185m</td>
<td>10 Mbps</td>
<td>Easy</td>
<td>Moderate</td>
<td>Cheap</td>
</tr>
<tr>
<td>10Base5</td>
<td>500m</td>
<td>10 Mbps</td>
<td>Hard</td>
<td>Low</td>
<td>Expensive</td>
</tr>
<tr>
<td>Fiber</td>
<td>2–100 km</td>
<td>100 Mbps–10 Gbps</td>
<td>Very hard</td>
<td>None</td>
<td>Most expensive</td>
</tr>
</tbody>
</table>
The IBM Cable System

- Unique connectors
- Both male & female combined
- Types 1-9
- American Wire Gauge (AWG) standards
- Large wire diameter = smaller AWG #

### IBM Cable

<table>
<thead>
<tr>
<th>Type</th>
<th>Standard Rating</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Type 1</td>
<td>STP</td>
<td>Two pair 22 AWG wires, with outer braided shield. Used for computers and distribution panels (MAUs).</td>
</tr>
<tr>
<td>Type 2</td>
<td>Voice/data grade</td>
<td>Voice/data shielded cable, two pair 22 AWG wires for data, four pair 26 AWG for voice.</td>
</tr>
<tr>
<td>Type 3</td>
<td>Voice grade</td>
<td>Four UTP 22 or 24 AWG solid core wires (single twisted bundle for all strands).</td>
</tr>
<tr>
<td>Type 4</td>
<td>Undefined</td>
<td>Two 62.5/125-micron multimode optical fiber (most common fiber-optic cable for networking).</td>
</tr>
<tr>
<td>Type 5</td>
<td>Fiber-optic cable</td>
<td>Two 62.5/125-micron multimode optical fiber (most common fiber-optic cable for networking).</td>
</tr>
<tr>
<td>Type 6</td>
<td>Data patch cable</td>
<td>Two 26 AWG TP with dual foil and braided shield.</td>
</tr>
<tr>
<td>Type 7</td>
<td>Undefined</td>
<td>Two 26 AWG TP with dual foil and braided shield.</td>
</tr>
<tr>
<td>Type 8</td>
<td>Carpet cable</td>
<td>Flat jacket surrounds cable for under-carpet use. Two STP 26 AWG (rated for 3 distance of Type 1).</td>
</tr>
<tr>
<td>Type 9</td>
<td>Plenum cable</td>
<td>Teflon-coated two STP AWG 22 pair with foil and braided shielding.</td>
</tr>
</tbody>
</table>
Wireless Networking

- Intangible media
- Use is increasing
- Cost is decreasing
- Hybrid networks use cable & wireless
- Mobile users

The Wireless World

- Temporary connections to wired LAN
- Backup connectivity to wired LAN
- Extend span of wired LAN
- Permit users to roam
- More expensive
Wireless Applications

- Mobile users - doctors, delivery persons
- Disaster areas - FEMA, battery power
- Changing environments - film studios
- Customer service - Hertz check in
- Impossible wiring - historical buildings

Types of Wireless Networks

- LAN’s - remote users
  - Impossible wiring
- Extended LAN’s - beyond span limits
- Mobile computing - radio
  - Cellular phones
Wireless LAN Applications

- Use of an antenna and emitter by user
- Use of a transceiver by cabled LAN
- Access point device by cabled LAN
- Access point device has antenna, transceiver

Access Point Device

Figure 3-10  Wireless portable computer connecting to a cabled network access point
### Wireless LAN Transmission
- Send & receive signals via atmosphere
- Waves in the electromagnetic spectrum
- Frequency measured in Hertz
- High frequency: less distance, fast data
- Low frequency: more distance, slow data

### Wireless LAN Technologies
- Infrared
- Laser
- Narrowband, single-frequency radio
- Spread-spectrum radio