Networking

• Part I
  – Network components
  – Network connections
  – Topologies
  – OSI Model
  – Ethernet

• Part II
  – Internet Protocol
  – Address assignment
  – Transport protocols
  – Network security
Network Components

Two main network building blocks:

• Nodes (devices that send and receive data)
  - Control CPUs, audio DSPs, projectors, etc.
  - Switches, hubs, routers, gateways, etc.

• Connections
  - Cat cable, fiber, Wi-Fi, etc.
NICs and MACs

• NIC - Network Interface Card
  – Hardware interface that sends network data
  – Every node has at least one NIC

• MAC address – Media Access Control address
  – Every node has a completely unique MAC address
  – 48 bit number, expressed as 12 hexadecimal digits
Networking Devices

Common networking devices

• Switches
• Routers
• Gateways
• Servers
Switches

• Physically connects multiple devices
• Collects and stores MAC addresses
• Forwards data to the appropriate MAC address
• Managed or unmanaged
Routers

- Forwards data among devices that aren’t physically connected
- Directs traffic that must go outside the LAN
- Uses IP addresses
Gateways

- Connects a private network to outside networks
- Forwards data to/from the routers below
- Can translate from one protocol to another
Blended Devices

- Networking devices don’t have to be separate physical devices
- A router may act as a switch, a gateway may act as a router, etc.
Servers

• Computer that provides services to other nodes
  – Example: Content server that houses large video files; mail server that receives and forwards email, etc.

• Can be hardware or software

• Thin server – server
Network Connections

• AV pros mostly deal with LAN network connections
• Three common methods:
  – Cat cable (copper twisted pair)
  – Optical fiber
  – Wi-Fi (radio frequencies)

Ch 6 – Pg 122-125
*Copper Twisted pair

- UTP (unshielded twisted pair)
- FTP (foil twisted pair)
- S/FTP (screened shielded twisted pair)
## *Copper Twisted Pair*

<table>
<thead>
<tr>
<th>Category Cable</th>
<th>Speed</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cat 1</td>
<td>Telephone and doorbell type connections</td>
</tr>
<tr>
<td>Cat 2</td>
<td>4 Mbps</td>
</tr>
<tr>
<td>Cat 3</td>
<td>10 Mbps</td>
</tr>
<tr>
<td>Cat 4</td>
<td>16 Mbps</td>
</tr>
<tr>
<td>Cat 5</td>
<td>100 Mbps</td>
</tr>
<tr>
<td><strong>Cat 5e</strong></td>
<td>100 Mbps and 1 Gbps</td>
</tr>
<tr>
<td><strong>Cat 6</strong></td>
<td>100 Mbps and 1 Gbps</td>
</tr>
<tr>
<td>Cat 6a</td>
<td>10 Gbps</td>
</tr>
<tr>
<td>Cat 8</td>
<td>25/40 Gbps (Data centers)</td>
</tr>
</tbody>
</table>

Note – Cat 7 (ISO Class F 10G/600 Mhz) and Cat 7A (ISO Class F 40G/1000 Mhz), was never recognized by TIA
<table>
<thead>
<tr>
<th>Standard</th>
<th>Bandwidth</th>
<th>Max. Throughput</th>
<th>TIA Recommendation</th>
</tr>
</thead>
<tbody>
<tr>
<td>Category 5e</td>
<td>100 MHz</td>
<td>1G (2.5G*)</td>
<td>Legacy</td>
</tr>
<tr>
<td>Category 6</td>
<td>250 MHz</td>
<td>1G (5G*)</td>
<td>Minimum</td>
</tr>
<tr>
<td>Category 6A</td>
<td>500 MHz</td>
<td>10G</td>
<td>Recommended</td>
</tr>
<tr>
<td>Category 8*</td>
<td>2 GHz</td>
<td>25/40G</td>
<td>Data Center Switch to Server</td>
</tr>
</tbody>
</table>

**Footage Mix %**

- Category 5e
- Category 6
- Category 6A

<table>
<thead>
<tr>
<th>Year</th>
<th>Category 5e</th>
<th>Category 6</th>
<th>Category 6A</th>
</tr>
</thead>
<tbody>
<tr>
<td>2010</td>
<td>100%</td>
<td>0%</td>
<td>0%</td>
</tr>
<tr>
<td>2015</td>
<td>80%</td>
<td>20%</td>
<td>10%</td>
</tr>
<tr>
<td>2020</td>
<td>60%</td>
<td>40%</td>
<td>20%</td>
</tr>
</tbody>
</table>

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Cat 5e

• Data transmission up to 100 Mbps
• 5e includes specifications for far end crosstalk

Cat 5e Cables
*Cat 6/6A

- Data transmission up to 1 Gbps
- Stringent crosstalk and noise specifications
- Should be shielded for AV signal delivery
- Cat 6a can transmit up to 10 Gbps
## RJ-45 Connectors

<table>
<thead>
<tr>
<th>T568A</th>
<th>T568B</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pin/Color</td>
<td>Pin/Color</td>
</tr>
<tr>
<td>1 – White with green stripe</td>
<td>1 – White with orange stripe</td>
</tr>
<tr>
<td>2 – Green</td>
<td>2 – Orange</td>
</tr>
<tr>
<td>3 – White with orange stripe</td>
<td>3 – White with green stripe</td>
</tr>
<tr>
<td>4 – Blue</td>
<td>4 – Blue</td>
</tr>
<tr>
<td>5 – White with blue stripe</td>
<td>5 – White with blue stripe</td>
</tr>
<tr>
<td>6 – Orange</td>
<td>6 – Green</td>
</tr>
<tr>
<td>7 – White with brown stripe</td>
<td>7 – White with brown stripe</td>
</tr>
<tr>
<td>8 – Brown</td>
<td>8 – Brown</td>
</tr>
</tbody>
</table>

Figure 1.114 T568A and T568B standards
Optical Fiber

- High bandwidth throughput over long distances
- Immune to EMI and RFI
- More secure than copper
Single Mode and Multimode

• Single mode
  – Small core
  – Light shoots straight down the cable
  – Capable of very long distances

• Multimode
  – Signals bounce off cladding
  – Slightly slower than single mode
  – Shorter cable runs than single mode
    (still much longer than copper)
Popular Fiber Connectors

• **ST (“stab and twist”)**
  – Often used on transmitter/receiver gear

• **LC (“push pull connector”)**
  – Very small, low loss

• **SC (“stab and click”)**
  – Larger than LC, good for tight spaces
## Wi-Fi

<table>
<thead>
<tr>
<th>IEEE Standard</th>
<th>802.11a</th>
<th>802.11b</th>
<th>802.11g</th>
<th>802.11n</th>
<th>802.11ac</th>
<th>802.11ax</th>
</tr>
</thead>
<tbody>
<tr>
<td>Year Released</td>
<td>1999</td>
<td>1999</td>
<td>2003</td>
<td>2009</td>
<td>2014</td>
<td>2019</td>
</tr>
<tr>
<td>Frequency</td>
<td>5Ghz</td>
<td>2.4GHz</td>
<td>2.4GHz</td>
<td>2.4Ghz &amp; 5Ghz</td>
<td>2.4Ghz &amp; 5Ghz</td>
<td>2.4Ghz &amp; 5Ghz</td>
</tr>
<tr>
<td>Maximum Data Rate</td>
<td>54Mbps</td>
<td>11Mbps</td>
<td>54Mbps</td>
<td>600Mbps</td>
<td>1.3Gbps</td>
<td>10-12Gbps</td>
</tr>
</tbody>
</table>

Wi-Fi 4  Wi-Fi 5  Wi-Fi 6
**Wi-Fi**

*11AX*

THE PATH TO TRULY BRILLIANT WI-FI

- **11b** (1999)
- **11a/5** (2003)
- **11n** (2009)
- **11ac** (2013)
- **11ax** (2019)

**Intel**

- 4x BETTER IN DENSE ENVIRONMENTS
  - Improve average throughput per user by at least four times in dense or congested environments

- FASTER THROUGHPUT
  - Deliver up to 40 percent higher peak data rates for a single client device

- INCREASE NETWORK EFFICIENCY
  - By more than four times

- EXTEND BATTERY LIFE
  - Of client devices
Wi-Fi Pros and Cons

• Pros
  – Convenience
  – Low cost infrastructure
  – Scalability

• Cons
  – Limited range
  – Susceptible to RFI
  – Slow
  – Insecure
**Physical and Logical Topologies**

Maps physical placement of network device & cable path

Maps flow of data within network
The Internet – Unknown Capacity
Big Packet loss and jitter (TCP/IP recovers)
High latency

Known High Capacity
Low or zero packet loss
Msec latency

Local Area Networks (LAN)

- Sends data to MAC addresses
- Fast, high capacity
- Requires direct physical connection
  - Device sends data to a MAC
  - Switch examines MAC and forwards data
LAN Topologies

- **Star** – nodes connect through a central point
  - Often extended

- **Meshed** – all nodes connect to each other
  - Expensive and rare; partial mesh is more common

- **Bus** – used for control systems

- **Ring** – WAN internet services use it to create redundancy
Wide Area Networks

- Can use device name translated via DNS
- Connected using routers
- Strips MAC addresses from data packets
- Slower than LANs; real-time AV transport not always possible
- Can be any size
WAN Topologies

Hub and spoke          Common Carrier          Meshed
Private and Public Wide Area Networks
Wireless LAN (WLAN)
OSI Model – Transport Layer

Application:
• Applications access network services

Presentation:
• Data translated to an intermediate form

Session:
• Two applications talk on different devices

Transport:
• End-to-end message delivery

Network:
• Data packets routed to addresses on network

Data link:
• Data transferred from one device to another

Physical:
• Data not changed in any way

1. Physical Layer - Ethernet frames are transmitted from a wireless router to a user’s laptop using the Physical Layer 802.11 wireless networking standard.

2. Data Link Layer - Within a LAN, data is addressed to a physical address - a MAC address. LAN switches can forward Ethernet frames to the MAC addresses of connected devices.

3. Network Layer - Prior to transmission, data is addressed to a logical network location - an IP address. Network routers will be able to identify the device the IP address refers to and send the data along the most logical route.

4. Transport Layer - During a web conference, audio and video are sent using the Transport Layer protocol User Datagram Protocol (UDP). UDP continuously sends the media packets to their destination without waiting for a receipt confirmation.

5. Session Layer - A user holds a web conference. The Session Layer protocol Session Description Protocol (SDP) invites other participant devices to the session and negotiates what kind of media each participant can send and receive.

6. Presentation Layer - A user needs to send private data over the Internet. The Presentation Layer protocol Transport Layer Security (TLS) is used to encrypt the data and decrypt it at its destination, hiding its contents during transport.

7. Application Layer - A user’s web browser requests information from another computer over the internet using the Application Layer protocol Hypertext Transfer Protocol (HTTP).
• TCP/IP and OSI networking model


RTP, SMPTE 2022, Streaming
Dante, Q-Sys
Cobranet, Ethersound, AVB
What is Ethernet?

• How data is sent across LANs
• Defined in the IEEE 802.3 suite
• Data is encapsulated in Ethernet frames
• Frames are generated by NICs
*Ethernet Speeds*

- Ethernet speed depends on NIC
- Some devices can’t handle high speed
- Some AV protocols require 1 Gbps or more
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Question?

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