When a Network is No Longer Just a Network

Merging AV and Network Infrastructure

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When a Network is No Longer Just a Network

Merging AV and Network Infrastructure
Agenda

• Networks
  • Supporting the Enterprise with Network Cable
  • Compression vs Uncompressed

• Video Signals
  • HDMI
  • USB 3.1 Type C
  • EDID
  • HDCP
  • IP Control

• CAT Cable for Video Over Twisted Pair
  • Shielded Cable

• Streaming Video

• Designs
Networks
What can you use a network for?

- Audio Signals
- VOIP
- Video
- Data
- Lighting
- VTC
- Control
- Multiple devices on a single network
VoIP

• VOIP – Voice over Internet Protocol is the delivery of voice communications over the Internet
• Public Switched Telephone Network (PSTN) is the worldwide topology that connects all telephones
• PSTN today is 99% digital with the Plain Old Telephone System (POTS) the only analog component remaining
Streaming Video

• Streaming is becoming more and more popular
• Movies, Concerts, Educational Lectures, Video Conferencing, and Events are becoming more common via Streaming Video
• It is easily accessible and a common method for content delivery with a variety of different devices
Recording and the “Flip Classroom”
Data

• Access to files, folders, and content allows for greater collaboration and requires a secure network connection

• Live information and mission critical applications demand up to the second statistics and video data
Control

• More and more devices are capable of being controlled remotely over network connections
• Computers, Thermostats, Displays, Lights, Room Schedulers, Sound Systems, and Security Systems comprise the most commonly connected network devices and are used in a variety of applications
Audio

• Audio expansion now occurs using network cables
• Signals are sent over the network to different devices with almost zero latency
• Dante enabled devices can send audio signals over CAT5e, CAT6, or fiber optic cables
Multiple Types of Devices

- Networks need to be capable of handling multiple types of devices and environments where BYOD is common
LED Lighting

• Control and power lighting fixtures via POE
• Energy efficient LEDs provide cost savings, easy installation, and enhanced flexibility with projects of all sizes
Wireless

• Devices that don’t have physical connections rely on wireless connectivity to send and receive Audio Visual data
The Biggest Question

- Bandwidth and Data Rate
- 1Gigabit E
- 10 Gigabit E
- 40 Gigabit E
Video Signals
Digital Signals – HDMI

- HDMI is an uncompressed digital video signal
  - Designed for the consumer market
- Adds support for:
  - Audio – stereo and surround formats (PCM, Dolby, DTS)
  - YCbCr color space – optional
  - HDCP – optional but recommended
  - CEC – Consumer Electronic Control – optional
  - InfoFrames
HDMI – Connectors, Distance, Communication

HDMI specification does not define transmission distance
- Cable performance has a direct bearing on distance

EDID information is sent from the display to the source
- Required by HDMI specifications

Mini
- Added in HDMI version 1.3

Micro
- Max resolution 1080p
Resolutions

• Old Resolutions
• New standard 1080p
• Headed to 4K/UHD and 8K
4K Signal Parameters

• 4K DCI is 4096x2160
  • Four times the resolution of 2K DCI
  • Targeted towards digital cinema

• 4K refresh rates
  • Varies – 24 Hz up to 60 Hz

• Color bit depth
  • 8-Bit, 10-bit, and 12-bit

• Aspect Ratio
  • 17:9 – same as 2K
Ultra HD Video Signal Parameters

- Ultra HD is 3840x2160
  - Four times the resolution of 1080p
  - Targeted towards consumer and broadcast markets
- Ultra HD refresh rates
  - Varies – 24 Hz up to 60 Hz
- Color bit depth
  - 8-Bit, 10-bit, and 12-bit
- Aspect Ratio
  - 16:9 – same as 1080p
4K and Ultra HD Resolution Comparison

- **SD**: (720 x 480)
- **HD**: (1280 x 720)
- **Full HD**: (1920 x 1080)
- **2K**: (2048 x 1080)
- **Ultra HD (UHD)**: (3840 x 2160)
8K Ultra HD Video Signal Parameters

- **8K Ultra HD Super Hi-Vision is 7680x4320**
  - 16 times the resolution of 1080p
  - Designed to be superior to the human visual system
    - Shoots at 2x the rate of normal video so movement is smooth and realistic

- **Aspect Ratio**
  - 16:9

- **8K refresh rates**
  - Varies – up to 120 Hz

- **Color bit depth**
  - 8-bit, 10-bit, and 12-bit

- **Chroma sampling**
  - 4:4:4, 4:2:2, or 4:2:0
HDMI 2.0 and HDMI 2.1

- **New functionality includes**
  - Enables transmission of HDR – High Dynamic Range video
  - Signaling speed to 18 Gbps
  - 4K@50Hz/60Hz, (2160p)
    - 4 times the clarity of 1080p/60 video resolution
  - Up to 32 audio channels with up to 1536 kHz audio sample frequency
    - 32 channels @ 48kHz each
  - Dual video streams on same screen, 4 audio streams
  - Support widescreen 21:9 format
  - Dynamic sync of audio/video
  - CEC extensions with expanded control via single point

- **Backwards compatible**
Digital Signals – USB

• Over the years speeds have increased and USB supports video and audio transfer
  • USB 2.0 - 480 Mbps
  • USB 3.0 - 5 Gbps
  • USB 3.1 - 10 Gbps

• Providing additional options for transporting video and audio
USB Type-C

• Send Data, Video, Audio, and Power
• Latest, high speed, reversible USB
• 10Gbps data rate (V3.1), V3.0 = 5Gbps
• Deliver up to 100 watts! Devices negotiate...
• Supports “alternate modes”... like DisplayPort
• “…beyond 20 Gbps in the future.”
  – Pres. USB-IF
EDID – Extended Display Identification Data

• EDID contains the following information:
  • Sink identity – device type, model number, etc.
  • Sink capability – video/audio
    • Video timing parameters, color space, audio formats, etc.
• EDID also defines the data structure
  • Block 0 – 128 byte of hexadecimal data
  • Block 1 – additional 128 byte of hexadecimal data
    • Block 1 was added in version 1.3
EDID – Sequence

1. Power on PC or activate external graphics card
2. Computer requests EDID data from display
3. Display sends EDID data to computer
4. Computer attempts to match display parameters
HDCP – High-bandwidth Digital Content Protection

• HDCP protocol is a 3-phase process
  • Authentication
  • Content encryption
  • Renewability

• This can take a few moments depending on the number of downstream devices
HDCP Handshakes

• I/O authentication
HDCP Handshakes With Products That Are Not HDCP Compliant

• Visual confirmation
Uncompressed Video Over Twisted Pair
Twisted Pair Transmission

- **Distance**
  - 328 feet (100 meters) between endpoints
Why Use Twisted Pair?

• One twisted pair cable can carry multiple signals
  • Video
  • Audio
  • Bidirectional RS-232 control and IR
  • Ethernet
  • Remote Power
CAT Cable
Twisted Pair Transmission

• **Cable**
  • Supports CATx cable
  • Solid conductor, shielded twisted pair cable with shielded connectors should always be used
  • Skew-free cable **should not** be used with XTP Systems
Twisted Pair Signal Transmission

• Shielded cable protects against outside interference from:
  • Air conditioning units
  • Power from adjacent cabling
  • Crosstalk from other cables or within the same cable
  • Radio interference from walkie-talkies

• Symptoms of noisy environments
  • Image drop-out or flashing
  • No image at all
Twisted Pair Shielding

• Different types of twisted pair shielding

<table>
<thead>
<tr>
<th>Cable Name</th>
<th>Outer Shielding</th>
<th>Individual Pair Shielding</th>
</tr>
</thead>
<tbody>
<tr>
<td>U/UTP</td>
<td>None</td>
<td>None</td>
</tr>
<tr>
<td>F/UTP</td>
<td>Foil</td>
<td>None</td>
</tr>
<tr>
<td>U/FTP</td>
<td>None</td>
<td>Foil</td>
</tr>
<tr>
<td>S/FTP</td>
<td>Braided</td>
<td>Foil</td>
</tr>
<tr>
<td>SF/UTP</td>
<td>Braided &amp; Foil</td>
<td>None</td>
</tr>
</tbody>
</table>
Twisted Pair Signal Transmission

- **Types of Category cable**

<table>
<thead>
<tr>
<th>Cable</th>
<th>Gauge</th>
<th>Conductor</th>
<th>Outer Shield</th>
<th>Pair Shielding</th>
<th>Required Bandwidth</th>
<th>Crosstalk Loss</th>
</tr>
</thead>
</table>
Twisted Pair Installation

• Cable infrastructure and patch points
  • Up to 2 patch points recommended
IP Control

- Devices on the Network are capable of communication, configuration, and control
- Devices will often have internal webpages for configuration
Room Scheduling
Room Management
Wireless Video Applications

- Point-to-point applications where source video signal is converted to a modulated RF signal for wireless transmission to a receiver connected to a display

- BYOD applications where computing device encodes and transmits video content over a Wi-Fi network to a receiver connected to a display
Radio Frequency Spectrum

- 500MHz to 5GHz balances capacity and range
- Transmits through common obstacles, such as walls, with low to moderate loss
Radio Frequency Spectrum

- 60 GHz used for higher data carrying capacity
  - Cannot penetrate solid objects
Wireless Technologies

Compressed and Uncompressed
MIMO – Multiple-input, Multiple-output

- Smart antenna technology using multiple antennas on both transmitter and receiver to improve performance
  - Spatial multiplexing
    - Same frequency, different information on each antenna
    - Each signal travels multiple paths from Tx to Rx
    - DSP – Digital Signal Processor in receiver separates the signals into parallel paths and restores the original signal
## Proprietary Wireless Protocols

<table>
<thead>
<tr>
<th>Wireless Interface</th>
<th>Frequency Band</th>
<th>Computing Hardware Required</th>
<th>Uncompressed Video</th>
</tr>
</thead>
<tbody>
<tr>
<td>AirPlay</td>
<td>Wi-Fi</td>
<td>Apple Products</td>
<td>No</td>
</tr>
<tr>
<td>Chromecast</td>
<td>Wi-Fi</td>
<td>PC, tablet, smartphone</td>
<td>No</td>
</tr>
<tr>
<td>Miracast</td>
<td>Wi-Fi</td>
<td>PC, tablet, smartphone</td>
<td>No</td>
</tr>
<tr>
<td>WiDi</td>
<td>Wi-Fi</td>
<td>Intel Products</td>
<td>Yes</td>
</tr>
<tr>
<td>WiGig</td>
<td>Wi-Fi, 60 GHz</td>
<td>PC, tablet, smartphone</td>
<td>Yes</td>
</tr>
<tr>
<td>UWB</td>
<td>3.1 – 10.6 GHz</td>
<td>None</td>
<td>Yes</td>
</tr>
<tr>
<td>WHDI</td>
<td>5 GHz</td>
<td>None</td>
<td>Yes</td>
</tr>
<tr>
<td>WirelessHD</td>
<td>60 GHz</td>
<td>None</td>
<td>Yes</td>
</tr>
</tbody>
</table>
eLink 100 – 1 to 1 Link

• eLink supports robust wireless extension up to 100 feet (30m)
• Includes normally anticipated obstructions – walls, furniture
eLink 100 – Channel Use

- Multiple eLink systems can operate within same 150 foot (45m) radius
- ns overlap
Streaming Video
Why Streaming?
• Uncompressed content is too large to send over a network

<table>
<thead>
<tr>
<th>Signal</th>
<th>Sampling</th>
<th>Bits per Color</th>
<th>Horizontal Pixels</th>
<th>Vertical Lines</th>
<th>Frames per Second</th>
<th>Approx. Data Rate</th>
</tr>
</thead>
<tbody>
<tr>
<td>NTSC</td>
<td>(4:2:2)</td>
<td>8</td>
<td>720</td>
<td>486</td>
<td>30</td>
<td>126 Mbps</td>
</tr>
<tr>
<td>ATSC 720p</td>
<td>(4:2:2)</td>
<td>10</td>
<td>1280</td>
<td>720</td>
<td>60</td>
<td>1.5 Gbps</td>
</tr>
<tr>
<td>ATSC 1080p</td>
<td>(4:2:2)</td>
<td>10</td>
<td>1920</td>
<td>1080</td>
<td>60</td>
<td>2.97 Gbps</td>
</tr>
<tr>
<td>XGA</td>
<td>(4:4:4)</td>
<td>8</td>
<td>1024</td>
<td>768</td>
<td>60</td>
<td>1.1 Gbps</td>
</tr>
<tr>
<td>SXGA+</td>
<td>(4:4:4)</td>
<td>8</td>
<td>1400</td>
<td>1050</td>
<td>60</td>
<td>2.1 Gbps</td>
</tr>
<tr>
<td>WUXGA</td>
<td>(4:4:4)</td>
<td>8</td>
<td>1920</td>
<td>1200</td>
<td>60</td>
<td>3.3 Gbps</td>
</tr>
</tbody>
</table>

100 BaseT Networks do not support streaming uncompressed NTSC video

Gigabit Networks do not support streaming uncompressed computer graphics
Streaming Video
Application Focus – Compression

- Design focus on core application requirements
  - Viewing expectations
  - Connection bandwidth
  - Interaction or workflow
- Select components
- Focus on one or two performance areas
Steps in Streaming Media

• Encode
• Transport
• Decode
Encoding Process

RGB → Process → Y'CbCr → Compress → RTP H.264/AAC → Encapsulated Video
Decoding Process

1. RTP H.264/AAC → De-Encapsulate
2. Compressed
3. De-Compress
4. Y’CbCr
5. Process
6. RGB
Encoding Considerations

• Sampling
• Color space conversion RGB to Y’CbCr
• Chrominance subsampling
• Bit depth

Encoding processes affect quality
Color Bit Depth

• 24-bit color allocates 8 bits per channel for both RGB and Y’CbCr color space
  • 8x3 = 24-bit color

Range for each color = 0-255 or 256

- Each pixel is represented by 3 groups of 8 bits, for a total of 24 bits
- Each group can represent up to 256 colors
- The sum of all 3 groups (colors) are able to represent $256^3$ or 16,777,216 colors
# Example Chrominance Subsampling

<table>
<thead>
<tr>
<th>Component Color Space</th>
<th>4:4:4</th>
<th>4:2:2</th>
<th>4:1:1</th>
</tr>
</thead>
<tbody>
<tr>
<td>Y′</td>
<td>Y′</td>
<td>Y′</td>
<td>Y′</td>
</tr>
<tr>
<td>Cb</td>
<td>Cb</td>
<td>Cb</td>
<td>Cb</td>
</tr>
<tr>
<td>Cr</td>
<td>Cr</td>
<td>Cr</td>
<td>Cr</td>
</tr>
<tr>
<td>Y′</td>
<td>Y′</td>
<td>Y′</td>
<td>Y′</td>
</tr>
</tbody>
</table>

*Cb Cr are sampled at full resolution. Note: this yields no reduction.*

<table>
<thead>
<tr>
<th>Y′</th>
<th>Y′</th>
<th>Y′</th>
<th>Y′</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cb</td>
<td>Cb</td>
<td>Cb</td>
<td>Cb</td>
</tr>
<tr>
<td>Cr</td>
<td>Cr</td>
<td>Cr</td>
<td>Cr</td>
</tr>
<tr>
<td>Y′</td>
<td>Y′</td>
<td>Y′</td>
<td>Y′</td>
</tr>
</tbody>
</table>

*Y′ is sampled at full resolution and Cb Cr are sampled at ½. Note: this yields a 1.5:1 reduction.*

<table>
<thead>
<tr>
<th>Y′</th>
<th>Y′</th>
<th>Y′</th>
<th>Y′</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cb</td>
<td>Cb</td>
<td>Cb</td>
<td>Cb</td>
</tr>
<tr>
<td>Cr</td>
<td>Cr</td>
<td>Cr</td>
<td>Cr</td>
</tr>
<tr>
<td>Y′</td>
<td>Y′</td>
<td>Y′</td>
<td>Y′</td>
</tr>
</tbody>
</table>

*Y′ is sampled at full resolution and Cb Cr are sampled at ¼. Note: this yields a 2:1 reduction.*
Compression Artifacts
Compression Codecs

• Why are there so many different compression codecs?
  • They are developed for a variety of reasons
    • Commercial
    • Technical
    • Political
Many Considerations for Codec Selection

• Image Quality
• Streaming Latency
• Scalability Requirements – number of endpoints
• Network
  • Bandwidth Availability
  • Network QoS
• Compatibility
• Which requirements are more important?
• What is good enough?
Image Quality – Considerations

- Viewing device – screen size
- Uninterrupted quality – error concealment
- Resolution – maintain native or reduced
- Production environment – editing, broadcast, studio
Latency – Considerations

• The amount of delay can vary based on:
  • Compression and encoding method
  • Network environment: Private, Public

• Delay can be important or unimportant to the application

<table>
<thead>
<tr>
<th>Low Latency “Interaction”</th>
<th>High Latency “Accessibility, One-way”</th>
</tr>
</thead>
<tbody>
<tr>
<td>Interactive:</td>
<td>Availability:</td>
</tr>
<tr>
<td>• Real-time communication</td>
<td>• Broad range of users</td>
</tr>
<tr>
<td>• Collaboration</td>
<td>• Across the Internet</td>
</tr>
<tr>
<td>• Control equipment remotely</td>
<td>• Variety of endpoints – PCs, Mobile devices</td>
</tr>
<tr>
<td>• Mission critical and Life safety</td>
<td>• Immediacy or “on demand”</td>
</tr>
</tbody>
</table>
Network Paths

Identifying the Operating Boundaries
What Kind of Network Will I Be Streaming On?

Enterprise Streaming
• Streaming is co-mingled with data and voice traffic
• Building or campus LAN
• Streaming occurs inside the Enterprise

Public Networks
• Streaming is delivered outside the firewall
• Internet or public network provider is used
• VPN – Virtual Private Network may be used
Amazon barges into the content delivery network business

When you’ve got computing infrastructure like Amazon does, it’s a competitive weapon. Amazon is proving that today by using its infrastructure to launch a new business in content delivery. In doing so, it is aiming squarely at rivals such as Akamai Technologies and Limelight Networks.

Content delivery networks set up servers across geographies that can deliver network-clogging data such as videos. They prevent Internet traffic jams by positioning the video servers closer to consumers who are doing the downloading.

Previously, Seattle-based Amazon showed how it could use its data centers — built to serve the mainstream Amazon.com e-commerce business — to launch Amazon Web Services, which hosts sites for other companies. Its S3 storage service and EC2 on-demand computing services can help start-ups get off the ground by outsourcing the web hosting and storage chores that small businesses don’t want to deal with.

Amazon said the service will be available later this year in North America, Europe and Asia. Smaller websites that use lots of voice, video or graphics could tap Amazon to ensure that they can deliver high-quality
Common Transport Protocols
What is HTTP Tunneling Streaming?

- HTTP tunneling is the process in which communications are encapsulated by using HTTP protocol.
- An HTTP tunnel is often used for network locations which have restricted connectivity or are behind firewalls or proxy servers.
What is RTSP Streaming

• Real Time Streaming Protocol (RTSP) is a network control protocol designed for use in entertainment and communications systems to control streaming media servers
• It works like a remote control for media streaming

Data Rate? Resolution? Audio?
RTMP Push Streaming and its benefits

- RTMP Push Streaming allows content to be pushed to a CDN (Content Delivery Network) to wait for a client to request it.
- This uses 0 bandwidth until it is requested.
- This allows content to pass through the local firewall and remain available until it is requested.
Streaming to YouTube Live

1. Go to www.youtube.com and log in to your account.
2. Click on the Upload button on the top right corner
3. Click on the Get started button of Live Streaming

4. There are two options for live streaming:
   A. Stream now - for instant live streaming – see step 5
   B. Events - to scheduled live events – see step 12

   A. For Stream Now page, enter basic information about the live stream, and scroll down to
   the Encoder Setup:

<table>
<thead>
<tr>
<th>Encoder Setup</th>
</tr>
</thead>
<tbody>
<tr>
<td>Server URL</td>
</tr>
<tr>
<td>rtsp://a.01mp.youtube.com/live2</td>
</tr>
<tr>
<td>Stream name/key</td>
</tr>
<tr>
<td>----------------</td>
</tr>
<tr>
<td>Reveal</td>
</tr>
</tbody>
</table>

   1. Copy and paste the Server URL and Stream Name/key to the SMP Streaming data fields, then Click Apply.
   2. On the SMP Streaming, click “Start RTMP stream” button to activate the stream.
   3. After a few seconds, the button will change to red and indicate the RTMP stream is now live.

   B. For Events workflow on the Youtube page:
   1. Click New live event to start a new event
   2. Enter the event Title, Start Date/Time, and a Description.
   3. Click Create Event
Streaming Application

- **Lectern**
  - Camera
  - Encoder
  - Wireless Microphone

- **Facility LAN**
  - Ethernet

- **Internet**
  - Ethernet

- **Live Stream**
  - Content Delivery System
  - Ethernet

- **Remote Viewer**
  - Laptop
  - Tablet
  - Phone
  - Display

- **Overflow Room**
  - Decoder
  - HDMI
Designs
Small Meeting Room

AV Requirements

AV Sources
• Multiple Laptops

Output Devices
• 4K Display

Technical Requirements

• Users will have ability to connect to system with laptops using HDMI, DisplayPort, or VGA
• Auto-switching between inputs
• System will use internal speakers of display for Audio support
Small Meeting Room
Executive Meeting Room

- Elegant meeting room with two displays
- Diverse connectivity at the table that supports HDMI, DisplayPort, and VGA
- PC and Blu-ray player will be available in the room
Executive Meeting Room
Lecture Hall

Technical Requirements

- Point-to-point communications with support for HD 4K video, mono audio, and RS-232 control
- Long range transmission with little or no interference from a wide variety outside interference
Lecture Hall
Church Streaming

Technical Requirements

- Audio and Video recording with displays used for presentation, information, and digital signage
- Streaming capabilities with live content sent to a lobby display, internal and external streaming servers
Church Streaming

Laptop

Camera

Microphone

Wireless Rx

Internet

YouTube LIVE

Main Displays – 1080p

Lobby Display – 1080p

Main Displays – 1080p
When a Network is No Longer Just a Network

Merging AV and Network Infrastructure