Understanding & Evaluating AV-over-IP

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Executive Summary

End users want AV (audio visual) and IT (information technology) services that are as predictable and work as easily as telephones and printers–industry wide. They also want the technology to work the same way. Systems should be easily used, supported and maintained–regardless of location. Solutions must be flexible, manageable, scalable, robust, easily deployed–attributes that reduce the total cost of ownership.

Over the past two decades, virtually every piece of office technology that required separate cabling has moved onto the network; a convergence that has drastically simplified deployment and reduced costs. Audio and video distribution are the last remaining enterprise systems.

AV-over-IP (Internet Protocol) describes the distribution of audio, video and control signals over the LAN (local area network) using IP switching and configuration protocols. With the arrival and rapid advancement of AV-over-IP technology traditional AV infrastructures are being replaced with IP-based infrastructures.

Our analysis shows that:

Explosive growth is expected in networked AV-over-IP deployments in 2019; while it is currently in the early adopter stage, it will become mainstream over the next five years.

AV-over-IP systems have the potential to reduce system costs by up to 40% compared with similar HDBaseT® systems.

Given the economies of scale in the Ethernet industry, cost savings could be expected to grow significantly over the next several years.

Ethernet-based packet switched networks allow many services and users to share the same network infrastructure.

Utilizing 10Gb endpoints for AV-over-IP will prevent real cost savings through convergence because the majority of existing networks will not support 10Gb.

AV-over-IP systems are more scalable and flexible because switching configurations are not confined to matrix switches.

Image compression technologies are critical to the AV-over-IP industry because, without compression, expensive network technologies would be required for transmitting video at ever faster rates.

Using AV-over-IP provides opportunities for new applications including IPTV (Internet Protocol Television), digital signage, and streaming.

Most AV systems should limit the latency of the AV-over-IP system to no more than 25ms.

Improved compression techniques allow users to experience high quality video and improve efficiencies and cost through reduced bandwidth requirements and lower latency.

As compression improves, and the network provides greater capacity, 8K is possible on existing 2.5 Gbps and 5 Gbps network infrastructure.

[1] HDBaseT is the global standard for the transmission of ultra-high-definition video & audio, Ethernet, controls, USB and up to 100W of power over a single, long-distance, cable.

Value of AV-over-IP

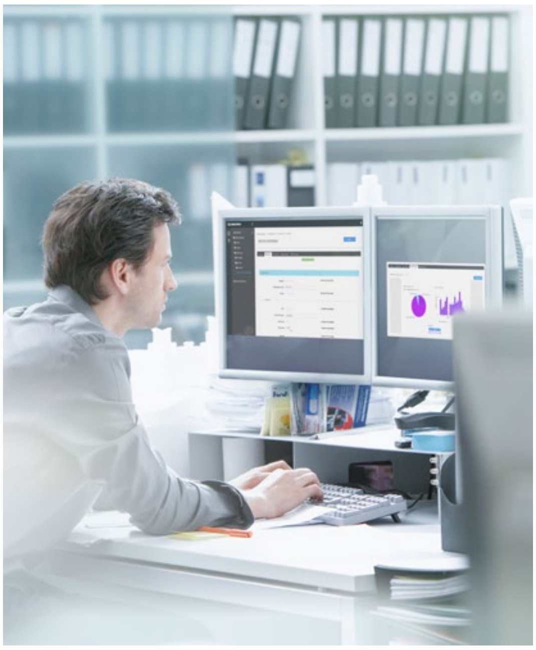
Organizations today are leveraging more media rich content than ever and expect the ability to share communications in real time. They are using such content as high definition videos to better educate and communicate with all of their constituencies internally and externally. To deliver this level of content in real-time requires robust, high-speed and scalable networks. Networks that must work with existing infrastructure, work within budget and be IT friendly. AV-over-IP technology meets all of these criteria.

Our analysis shows that **compared with similar HDBaseT systems, AV-over-IP systems have the potential to reduce costs by up to 40%.** Given the economies of scale in the Ethernet industry, those cost savings could be expected to grow significantly over the next several years.

To achieve the full value of those savings, AV infrastructure must be converged onto the existing network.

Organizations want to leverage their data networks as the transport infrastructure for AV, as well as to transport email, voice-over-IP, and file transfers. Integrating an appropriate AV-over-IP system into an IT environment helps ensure future flexibility and scalability, and keeps integration and operating costs down. The goal is effective use of low bandwidth, no latency, and high AV quality.

With AV-over-IP, IT professionals can manage their AV network with familiar switched technology, and not worry about costly port expansions when growth occurs.



Distributing AV-over-IP has many advantages:

- Significant cost savings versus use of traditional AV switchers
- Greater scalability and flexibility because switching configurations are not confined to standard port limitations
- Running on shared infrastructure allows much larger systems to be deployed cost effectively, creating new markets for AV-over-IP such as digital signage, IPTV, and broadcast TV
- Cost efficiencies of a shared infrastructure allow for much larger systems to be deployed and creates new markets for AV-over-IP such as digital signage, IPTV, and broadcast TV
- Effective use of low bandwidth, no latency, and high AV quality

Criteria For AV-over-IP Vendor Selection

Image Quality

Comparison of vendor image quality before and after transmission. Displays should be capable of 4K60 4:4:4 and HDR and have the ability to turn off all video processing. (Many modern displays will add a layer of processing to the image, which will hinder detailed evaluation.)

Key metrics

Readability of Excel® spreadsheet

Amount of detail in complex test images

Latency (must be below 25ms to prevent lag)

Clean switching between sources

Video Format and Quality

Support for the broadest range of video formats and highest image quality.

Key metrics

2160p (4K60 4:4:4) video support

High dynamic range (HDR) support

Support for less common resolutions and legacy devices

- Proper de-interlacing support for 480i and 1080i content from set-top boxes
- Support for many VESA resolutions beyond the standard 1080p and 4K formats (i.e. 1366x768 and 2560x1440)

Network Security

Support for network security at the product level, ensures devices are allowed on the network and cannot serve as a launchpad for attacks on the network.

Key metrics

Device authentication, typically 802.1X, a standard for port-based network access control

Support for Active Directory® credential management or LDAP-based authentication

Ability to encrypt all communication pathways, including control, video, and audio

IT Conformance

Any technology deployed on the network should conform to the organization's existing network structure and IT plans.

Key metrics

Support for multicast addressing in order to function with other traffic on the network

HTTPS-served webpages with proper certificate management to avoid security errors caused by webpage authentication issues

Stream bandwidth under 1Gbps to enable usage on standard gigabit networks

Proper routing controls of high-bandwidth AV traffic

- Layer-3 routing
- Time-to-live (TTL) settings
- DNS hostname registration for name-based routing, rather than fixed IP addressing

Secondary Functions

Supported secondary functionality.

Key metrics

Video walls

USB 2.0 routing

Breakaway audio

Dante® or AES-67 support for DSP integration

Audio downmixing

Management Tools and Control

Supported management tools (i.e. firmware, software, routing, reporting, etc.) and how they're managed (i.e. onsite, remotely).

Key metrics

Centralized controller to manage large deployments of devices (for visibility of audio and video signal status, streamlined configuration and management)

Ability to run without centralized controller (important for keeping costs low for smaller deployments)

Total System Cost

Cost of materials and labor for all components for an average customer.

Key metrics

Ability to re-use existing cabling to avoid labor and material costs of new cable runs

Cost of the endpoint video devices

Analysis of Currently Available Technologies

		Crestron DM-NVX-350	SVSI N2400	ZeeVee ZyPer4K (SDVoE)
Image quality	Video quality - Excel test	Pass	Some text unreadable	Pass
	Video quality - image test	Pass	Some image fidelity lost	Pass
Video support	2160p (4K60 4:4:4) support	Yes	Yes	Yes
	HDR Support	Yes	No	Yes
	Uncommon video format support	Yes	No proper de-interlacer for 1080i, 480i video	No proper de-interlacer for 1080i, 480i video
Security	802.1x Support	Yes	Yes	Yes
	Centralized password management	Active Directory	LDAP	AD
IT Conformance	Stream bandwidth	<1Gbps	<1Gbps	4-9Gbps
	Multicast support	Yes	Yes	Yes
	HTTPS webpages with certs	Yes	Yes	Yes
	TTL controls	Yes	Yes	No
	DNS hostname registration	Yes	Yes	Yes
Secondary Functions	Video wall functionality	Yes	Yes	Yes
	USB 2.0 routing	Yes	No, KVM only	Yes
	Breakaway audio	Yes	Yes	No
	Dante/AES-67 support	Dante with AES-67 compatibility mode	AES-67	No
	Downmix audio	Yes	Yes	No
Management tools	Controller for managing devices	Yes	Yes	Yes
	Operates without controller	Yes	Yes	Point to point only

Future of AV-over-IP

The future of AV-over-IP presents opportunities for both vendors and users.

In a newly announced study, UK-based research firm Futuresource finds that sales of AV-over-IP products (encoders/decoders) are experiencing a year-on-year increase of 130%, and are enabling a new era of AV control and distribution. **Expect explosive growth in networked AV-over-IP deployments in 2019. AV-over-IP is in the early adopter's stage, but will become mainstream over the next 5 years.**

Understanding AV-over-IP and its implications for AV and IT infrastructure will help organizations better adapt to the convergence of technologies and their applications in meeting environments.

The Audiovisual and Integrated Experience Association (AVIXA), released its 2017 AV industry economic outlook through 2022. Some highlights of the report:

Market trends: Use of the Cloud will become increasingly common in IoT-based (Internet of things) AV solutions, which will reduce operating costs.

Market outlook: The global AV industry generated $178B in 2016. While revenue from European operations decreased, the Asia-Pacific region experienced significant growth. The industry is expected to generate an additional $5B, with an annual increase of 4.7 percent through 2022.

Market dynamics: Security, surveillance, and life safety solutions generated $14.7B in 2016, with 50 percent of that total spent on security cameras. By 2022, the AV market will grow to $22.9B with the bulk of that gain going to AV capture and production equipment. AV revenue from hotels, casinos, and resort and cruise lines will increase to $14B by 2022, from $7B in 2014. The healthcare market will also see double-digit growth.

How AV-over-IP Works

There are two types of networking methods: circuit switching and packet switching. AV has primarily used circuit switching for AV switching networks – this is how HDBaseT systems work - and IT has traditionally used packet switching for data networks. In a circuit switched network, dedicated point-to-point connections are made to distribute streams of data. In a packet switched network, data is sliced into small packets and delivered to various destinations that request the data. **The key advantage of Ethernet-based packet switched networks is that they allow many services and users to share the same network infrastructure.**

Early telephone switchboards are a simple example of a circuit-switched network.

Traditional AV switchers have typically offered uncompressed video switching and rarely relied on coding to compress and transmit the AV and control signals. AV technology has become more IT capable. It can now encode/decode AV and control signals so they can be transmitted over a packet switched network. To distribute AV signals over a packet switched network, the signals must pass through a dedicated encoder that converts the signals to an IP compatible packet format. To receive the same signals on a display or speaker system, a decoder must also be used to convert the packets into compatible AV signals.

AV-over-IP Opens Up New Opportunities

Using AV-over-IP provides opportunities for new applications including IPTV (Internet Protocol Television)**, digital signage, and streaming.** The advantage of multi-purposing an AV-over-IP system is that its performance is far beyond what is required for those use cases. So, while a digital signage or IPTV system cannot perform the actions of an AV-over-IP system, the reverse is possible. This convergence will allow the number of technologies and endpoints on a network to further consolidate, saving costs.

IPTV

IPTV is a system through which television services are delivered over a packet-switched network such as a LAN, WAN, or the Internet, instead of being delivered through traditional cable television, satellite, or terrestrial formats. IPTV is widely deployed in end-user premises via set-top boxes or customer provided equipment. It's often used for media delivery on corporate and private networks, and is noted for providing live television and live media, time-shifted media (i.e. record and replay shows), and video-on-demand (browse and view from a stored-media catalog).

Digital signage

Digital signage enables organizations to configure AV-over-IP streaming platforms to tap into any enterprise digital signage system. Organizations can now decide exactly what is on the screens in their enterprises at all times. Networked AV content can be shared on displays in the lobby, conference rooms, break rooms, and training areas. Content can also be played from personal devices. Each location can have access to the same content at the same time. All that really matters is that the network is designed to handle the data load.

Streaming

Streaming is a technology used to deliver content to computers and mobile devices over the Internet. AV-over-IP technology takes streaming to a different level. Instead of placing transmitters and receivers adjacent to all the devices in a room, the AV-over-IP model calls for an encoder at each source device and a decoder at each destination device. The encoders and decoders are all connected to standard Ethernet switches. This allows organizations to connect as many encoders and decoders as the network design allows, and scale up at a lower cost. Streaming allows users to access content before the entire file is downloaded. It delivers data as needed. For streams, the data is automatically deleted after it's used. Live streaming is used to deliver Internet content in real-time. It's popular with live television shows and sporting events, and is now being used for gaming and apps. Downloads are quicker and use less data with on-demand streaming resources. A core set of features and functions are downloaded and then new content is streamed as users need it.

Evaluating Video Performance & Latency

Given that virtually every other technology has already converged onto the network, why did it take so long for AV? The simple answer is that the use cases for AV demand much higher video quality and lower latency than IPTV and video collaboration. So, the technology had to progress much further to achieve the performance required by the professional AV industry.

When AV transmission is one-way, and the user has no reference to the original content, several seconds of latency is acceptable because there's no way for the user to perceive it – this is how IPTV operates. When AV transmission is two-way, such as in video conferencing, 300-400ms of latency is acceptable because there's a natural pause in dialog between parties.

However, when the user is controlling interactive content, such as through a keyboard or mouse, performance drastically decreases when latency is higher than 50ms but also has effects as low as 16ms. For live performances, where the user can hear and see the original content (the image magnification scenario) latency should be less than 25ms.

The key point to remember is that the user perceives total system latency, which is the addition of all latencies in the video path. There are other components in most AV systems that will add to the total system latency, including video processor latency, display latency, and keyboard/mouse latency for interactive use cases.

Because of these added latencies, **we recommend that most AV-over-IP systems should limit latency to no more than 25ms.**

There are two main metrics used to evaluate AV-over-IP systems – image quality and latency.

Image quality is the measure of how well the received image represents the original image. (This is discussed more in the compression section below.)

Latency refers to the amount of time, usually measured in milliseconds, that it takes the content to travel through the system, from the source to a display. While there has always been some latency in traditional AV systems, it was usually low enough that it was not a concern for system designers. In the shift to AV-over-IP, some systems have added more latency than is acceptable for some use cases.

Video Quality & Compression

Compression is a reduction in the number of bits needed to represent data – in this case, video data. Compressing data can save storage capacity, speed-up file transfer, decrease network bandwidth costs, and lower the costs for storage hardware. Video compression has become commonplace as the data rate required for higher resolution video increases dramatically. In fact, compression is becoming so pervasive that the new HDMI 2.1 specification uses DSC (Display Stream Compression) to compress video signals even when transmitting over an HDMI cable.

Theoretical Bandwidth Required by Video Format Type

Video Format	Horizontal Resolution (Pixels)	Vertical Resolution (Pixels)	Bits per Pixel	Frequency (Hz)	Overhead Factor (See Footnotes)	Approximate Data Rate
720p	1280	720	24	60	1.50	1.99
1080p	1920	1080	24	60	1.50	4.48
4K30	3840	2160	24	30	1.50	8.96
HDMI 2.0 (4K60 - 4:2:0)	3840	2160	12	60	1.50	8.96
HDBaseT limit						9.00
2160p (4K60 – 4:4:4)	3840	2160	24	60	1.50	17.92
HDMI 2.1 (8K60 - 4:2:0)	7680	4320	12	60	1.50	35.83

Footnote: *This overhead factor is an approximation based on several items that increase overall data rate: 8b/10b conversion in HDMI, blanking intervals between each video frame & more.*

The most widely used CODEC (COder/DECoder) in the AV-over-IP industry is JPEG2000. It's been used for many years by the entertainment industry, but is being phased out for newer technologies such as DSC, Tico, JPEG-XS, and Crestron's Pixel Perfect Processing.

Because of the limitations on infrastructure speed in HDBaseT, many AV manufacturers are using lightweight compression codecs, such as Tico and DSC, to move 2160p video, even in circuit-switched HDBaseT systems.

These compression technologies are critical to the AV-over-IP industry because, without compression, expensive network technologies would be required for transmitting video at ever-faster rates. The chart below shows how far each compression technology will be able to compress video to fit into a given network technology.

Of course, compression doesn't matter as long as the signal gets decompressed without compromise. Most AV-over-IP hardware encodes AV signals using standard video codecs that compress the signals to a bit rate that can be utilized over a 1Gb network switch.

Network Bandwidth Compatibility by Video Format based on CODEC Compression Ratios

Video format name	Data Rate				
		2 to 1	5 to 1	20 to 1	20 to 1
	Uncompressed	DSC compression	JPEG-XS compression	JPEG2000 compression	Pixel Perfect Processing compression
1080p	4.48	2.24	0.90	0.22	0.22
4K30	8.96	4.48	1.79	0.45	0.45
HDMI 2.0 (4K60 - 4:2:0)	8.96	4.48	1.79	0.45	0.45
2160p (4K60 – 4:4:4)	17.92	8.96	3.58	0.90	0.90
HDMI 2.1 (8K60 - 4:2:0)	35.83	17.92	7.17	N/A	1.79

Minimum Required Network Type and Corresponding Cabling
■ 40Gb (Fiber) ■ 10Gb (Cat6a) ■ 5Gb (Cat6) ■ 2.5Gb (Cat5e) ■ 1Gb (Cat5e)

Compression is driving all industries and continues to improve exponentially. While some industries did benefit early from these technologies, others have waited for performance to meet industry-specific needs. The AV industry is a perfect example of this phenomenon. For decades, compression caused significant performance degradation, compromising image and audio quality, the core of the industry.

However, as compression technologies have radically changed over the last 10 years, key industry leaders have led the charge to provide flawless quality by leveraging compression. Undoubtedly, as customer's demand flexibility, reliability and a lower total cost, compression will play a critical role.

Improved compression techniques allow users to experience high quality video and improve efficiencies and cost through reduced bandwidth requirements and lower latency.

Running the Video Quality Tests

While some conclusions can be made by comparing device data sheets, other tests, such as video quality and latency, need to be experienced in person. Given that acquiring a full test setup is a challenge for many users, we'll present our results below, as well as our test methodology, so readers can duplicate it themselves.

The Test Setup

In order to run the video tests, two identical displays and a PC as a source are needed. The output of the PC is split so that one video path goes directly to a display and one goes through the AV-over-IP system to the other display. Display 1 is used as a reference monitor and Display 2 is used to analyze the output of the AV-over-IP system.

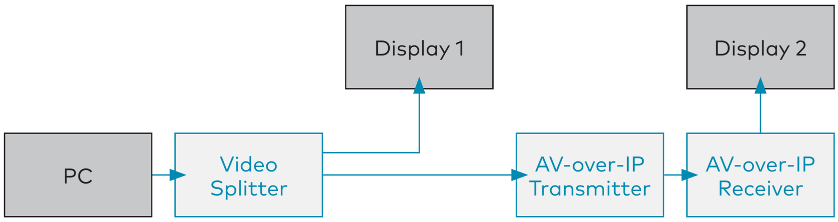


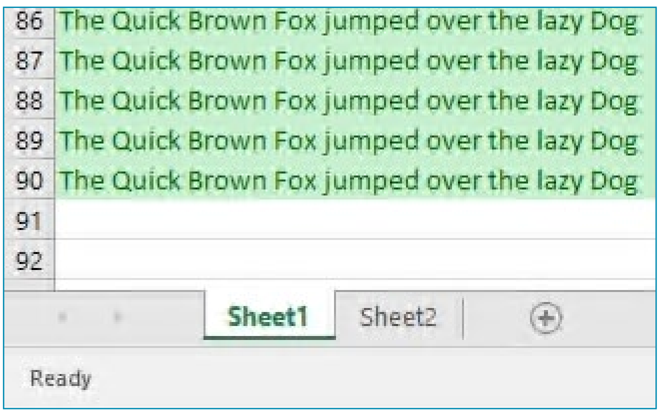
Image Test

In order to test performance of the AV-over-IP system for graphical image content, detailed images are designed to have very high complexity to simulate a "worst case" scenario for image and video content. In order to pass, all detail in the images should match the reference monitor.

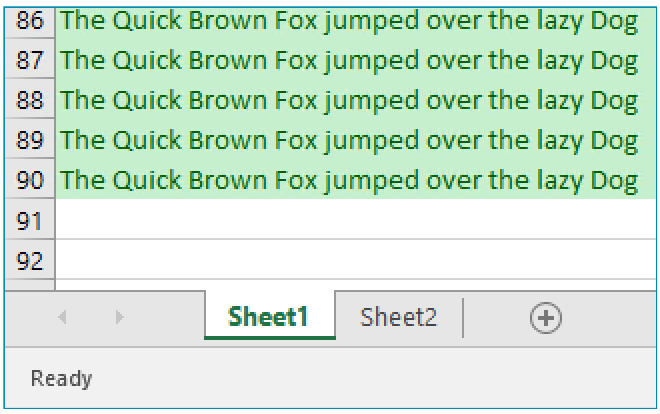
Excel Test

In order to test performance of the AV-over-IP system for computer graphics, the Excel spreadsheet is maximized so that it covers the whole screen. This spreadsheet is designed to have high complexity, with both fine text and color changes, to simulate a "worst case" scenario for PC content. In order to pass, all text in the Excel file on all tabs should be easily readable and comparable in quality to the reference monitor.

Poor Image Quality due to Artifacting



Excellent Image Quality



Comparing 1 Gbps vs 10 Gbps Networks

Currently, 1000Base-T Ethernet is ubiquitous and supports up to 1 Gbps (gigabit per second) of shared traffic to or from any node. The data rate of a 1080p60 video stream is about 4.5 Gbps uncompressed, and 4K60 4:4:4 (resolution of video) steps this up to 18 Gbps, which is far too high for gigabit networks without compression.

There are two ways around this issue:
(1) Increase the network speed or **(2)** compress the signal to bring it in under the 1 Gbps capacity. Upgrading a network to 10GbE (gigabit over Ethernet) may provide more options, but doing so may be restricted by existing cabling infrastructure and cost. CAT5e (short for Category 5 enhanced, a cabling infrastructure for 10Base-T Ethernet) won't support 10GbE and CAT6 UTP (unshielded twisted pairs) will only support up to 55m (meters) total distance between endpoints. For new installations that requires running CAT6a and/or fiber and go straight to 10GbE. Instead of incurring the expense of a network upgrade, another option for AV-over-IP is video compression.

Any AV-over-IP solution needs to be flexible, sustainable, easy-to-manage, and cost effective. IT managers want to maintain their efficiencies and implement technology that does not require a fork-lift for improvements. They are looking for solutions that conform to their existing network standards, most of which are currently built around CAT 5e/CAT 6 cabling and a 1 Gbps infrastructure to the endpoint. While the data center market is more focused on 10 Gbps, AV-over-IP is installed on the campus network, not in the data center.

When comparing a 1 Gbps network to a 10 Gbps network AV solution, it's time to move beyond the compression debate and ask how applications work in the real world:

Will the infrastructure need to be completely redesigned?

Are the solutions scalable?

Will the customer accept the proposed solution on their network?

The chart below, provided by Gartner, shows the Enterprise Ethernet Switch Market Worldwide, 2015 – 2022.

Table 3-2

Forecast: Enterprise Ethernet Switch Market by Location, Worldwide, 2015-2022							
Segment5	**Data**	**2018**	**2019**	**2020**	**2021**	**2022**	**CAGR 2017-2022**
Enterprise Ethernet Switches 100M - Campus	**End User Spending ($M)**	1,085.4	845.9	594.6	398.0	257.5	-26.9%
	Vendor Revenue ($M)	982.8	767.0	539.9	361.9	234.4	-26.8%
	Port Shipments (K)	116,348.5	104,526.1	81,795.7	60,074.6	41,633.2	-19.8%
Enterprise Ethernet Switches 1G - Campus	**End User Spending ($M)**	12,349.3	12,168.0	11,559.3	10,446.8	8,879.9	-5.5%
	Vendor Revenue ($M)	10,928.9	10,798.9	10,283.4	9,335.4	7,946.7	-5.3%
	Port Shipments (K)	413,056.3	439,262.6	456,279.3	450,571.7	415,749.8	2.0%
Enterprise Ethernet Switches 2.5/5G - Campus	**End User Spending ($M)**	148.3	344.6	724.8	1,287.2	2,293.3	190.3%
	Vendor Revenue ($M)	130.5	304.2	641.3	1,141.5	2,036.6	191.0%
	Port Shipments (K)	2,219.1	6,262.8	15,706.7	33,074.3	71,256.9	225.7%
Enterprise Ethernet Switches 10G - Campus	**End User Spending ($M)**	2,402.0	2,739.8	2,902.2	3,011.2	3,058.2	5.8%
	Vendor Revenue ($M)	2,092.1	2,388.2	2,533.0	2,631.6	2,676.6	6.0%
	Port Shipments (K)	23,980.1	29,712.4	35,457.6	39,825.6	43,168.1	16.6%
Enterprise Ethernet Switches 25G - Campus	**End User Spending ($M)**	0.0	0.0	6.9	12.2	22.0	NA
	Vendor Revenue ($M)	0.0	0.0	6.0	10.7	19.2	NA
	Port Shipments (K)	0.0	0.0	40.9	81.3	159.5	NA

Source: Gartner (September 2018)

Gartner research shows that between 2015 and 2018, 1 Gbps network switches outsold 10 Gbps switches 20:1. IT managers overwhelmingly install 1 Gbps ports in their campus environments because it leverages CAT 5e cabling. Ten-gigabit solutions typically require data center switches and CAT-6a/7 wiring or fiber to distribute AV signals between endpoints – the same type of dedicated infrastructure as traditional AV switches. There's virtually no quality, cost, scalability, or installation advantage to 10 Gbps AV networks over traditional AV matrix switchers.

Some may argue that 10 Gbps is the future since it provides a path to 8K. That, however, ignores the data shown in the compression section. Gartner research shows that 2.5 and 5 Gbps networks will be the future because they work on existing cabling. Beyond the network trends, compression technology is accelerating, since it's a limiting factor with all technology, not just AV. **As compression improves, and the network provides greater capacity, 8K is possible on existing 2.5 Gbps and 5 Gbps network infrastructure.**

An interesting trend can be gleaned from the data: **the majority of the growth in campus network infrastructure is around the newer NBASE-T (2.5Gb and 5Gb) technologies.** That growth is primarily driven by increases in the data rates of newer Wi-Fi® access points and the need to run on existing infrastructure. Even looking as far ahead as 2022, 1 Gbps ports are predicted to outsell 10 Gbps ports 10:1, without running new cabling.

It's for these reasons that **we believe utilizing 10Gb endpoints for AV-over-IP will prevent real cost savings from occurring through convergence,** because the majority of existing networks will not support 10G.

Comparing Costs Of Systems

HDBaseT has become the de facto standard for traditional AV systems to send video over structured cabling. HDBaseT systems are built as completely separate cabling infrastructure because of their circuit-switched nature.

While much of the focus of the market has been on costs of the endpoint devices, they represent only a fraction of the total installed system cost. The table below shows how to compare costs of an HDBaseT system vs. an AV-over-IP system; in this case, a 16-endpoint system, both on an independent network and a converged network. **The system costs shown below are representative of costs in each technology category, there is significant variability in costs among endpoint manufacturers even on the same system type.**

Moving from an HDBaseT to a 10G AV-over-IP system does not save costs. In fact, it increases costs significantly if fiber is required. Moving to a 1G AV-over-IP system does provide significant (21%) cost savings, and those savings are almost doubled (40%) when it runs on the converged network.

		Independent Networks			
	HDBaseT	**10G Fiber**	**10G Copper**	**1G**	**1G Converged Network**
New switch infrastructure	$400/port	$400/port	$200/port	$100/port	$0
New cable run labor	$100/run	$200/run	$100/run	$100/run	$0
New cable cost	$100/run	$200/run	$100/run	$50/run	$0
System management tools	$1,000	$1,000	$1,000	$1,000	$0
Endpoint cost	$1000/ea	$1400/ea	$1200/ea	$1000/ea	$1000/ea
Total System Cost	$26,600	$36,200	$26,600	$21,000	$16,000
Savings compared to HDBaseT		36%	0%	-21%	-40%

New switch infrastructure is required when building out an independent network. Gigabit infrastructure is the least expensive, followed by a 10G copper infrastructure. But 10G copper will only support signals traveling up to 55m, compared to 100m+ for the other technologies. Additionally, 10G fiber is more expensive due to the cost of 10G optics, which has remained high for many years. Finally, HDBaseT switching infrastructure is the most expensive because the electronics required to build it are more expensive than commodity Ethernet switches.

New cable runs are likely required for independent networks, and the cost for the cabling increases for HDBaseT and 10G systems. Labor and cost of cabling for fiber-based systems is the highest due to the more complex termination process. System management tools are required for infrastructure that is new or different from the existing infrastructure. This value is an approximate cost of the tools and labor required to deploy and monitor a system.

Endpoint cost is the actual installed cost of the AV endpoints. 10G endpoints are typically slightly more expensive than HDBaseT or 1G endpoints, and fiber endpoints add even more cost due to the fiber optics.

References

AMX – www.amx.com | Crestron – www.crestron.com | SDVoE – www.sdvoe.org | ZeeVee – www.zeevee.com
https://wp.cs.ucl.ac.uk/sebastianfriston/wp-content/uploads/sites/3/2014/09/The-Effects-of-Low-Latency-on-Pointing-and-Steering-Tasks.pdf

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