The Power of Sync in Networked Consumer Audio

11/14/14

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About AVnu Alliance

 The AVnu Alliance is a community creating an interoperable ecosystem of low-latency, time-synchronized, highly reliable networked devices using open standards. AVnu Alliance creates comprehensive certification programs to ensure interoperability of networked devices. The foundational technology enables deterministic synchronized networking based on IEEE Audio Video Bridging (AVB) / Time Sensitive Networking (TSN) base standards. The Alliance, in conjunction with other complimentary standards bodies and alliances, develops complete solutions in professional AV, automotive, industrial control and consumer segments.

Introduction

Today consumers own more devices than ever, have shifted their consumption from physical to digital content and home networks have become nearly ubiquitous. The convergence of these trends has created a desire for consumers to not only use the network to connect to the Internet and exchange data, but also distribute the digital content among their many devices, many of which are connected over a wireless network.

Significant effort has been invested to advance the state of the art for discovery, interoperability, media format compatibility, and stream quality. In parallel the network foundation has seen advancements in security, speed and overall bandwidth. With these advancements now in place, adding foundational support to the network to manage time-sensitive audio and video streams is the last critical piece toward a truly converged network for consumers and their content.

Audio Video Bridging (AVB) replaces both the physical complexity of analog cables and the network complexity of existing proprietary technologies with an open, standards-based media network. AVB standards enable interoperable platforms that offer bigger, better, faster, more flexible, and more affordable consumer audio networking solutions. This whitepaper will explore:

- What is AVB
- Why deploy AVB
- Use cases for AVB in the residential space
- AVnu Alliance's role in advancing AVB in the marketplace.

Better Networking for Home Media Streaming

Why do we need AVB?

While streaming audio and video to multiple devices on home networks has become common, the practice was pioneered using mostly proprietary technologies developed by specific companies to suit particular applications. These technologies are often unable to accommodate new applications, face significant incompatibility issues among brands and drive product costs due to limited options for sourcing of components and suppliers.

The most common example is wireless multiroom and home theater audio systems implemented in a handful of products offered by a single company. Common problems with these systems include:

- <u>Little or no interoperability among brands.</u> In most cases, the networked audio system permits use of only one brand of audio equipment within the system, or a limited number of brands that have licensed a particular technology. Adapters may be available, but most are expensive.

- <u>Drifting synchronization.</u> Without AVB technology on the network, systems today are not able to maintain quality, consistent synchronization, with the sync among various devices being off at startup and/or drifting over time. This causes comb filtering or echo effects as the audio in one room lags the audio in another.

- <u>Inability to use in stereo pairs or home theater systems.</u> Using two networked speakers in one room for stereo sound requires very tight synchronization. If the two speakers' internal clocks are not synchronized, it's likely that one speaker will eventually lag the other, creating phase cancellations and causing the stereo image to shift on each power up and/or over time. Many audio/video networking technologies are incapable of such

precise sync, and thus do not allow stereo pairing or the combination of wireless surround speakers with wired front speakers in a home theater system.

- Extra components often needed. The better the sync performance of these systems, the more often they tend to rely on a hub system that provides a separate network. This type of system often requires the purchase of a bridge component that connects to the home network. This component typically works with only one brand of networked audio equipment. If use of other components is desired, an expensive wireless adapter is usually required.

- Limited options, high cost. The few A/V networking technologies available for licensing, are controlled by single companies. This tends to raise costs and limit the number of available suppliers for chips, modules and finished circuit boards.

What is AVB?

Audio Video Bridging (AVB) was created to solve the problems that have arisen as more consumers get their audio and video content through a home network in addition to or instead of hard media such as CD, DVD and Blu-ray discs. AVB is the next generation of audio/video over Ethernet and other compatible media, such as wireless LAN. It is the common name for the set of technical standards developed by the IEEE 802.1 Audio Video Bridging Task Group and serves as an extension of the IEEE 802.1, 802.3 and 802.11 specifications used for most wired and wireless home networks. AVB combines precise, consistent time synchronization technology with network traffic management that gives priority to audio and video signals.

AVB standards add capabilities to the network providing three major enhancements:

1. Precise timing to support low-jitter media clocks and accurate synchronization of multiple audio streams;
2. A simple reservation protocol that allows an application on an endpoint device (speaker) to notify the various network elements in a path so that they can reserve the resources necessary to support a particular media stream; and
3. Queuing and forwarding rules that ensure that such a media stream will pass through the network within the delay specified by the reservation.

AVnu Alliance is a consortium of member companies working together to promote and administer the AVB standard. Similar to the WiFi Alliance or Bluetooth SIG, the AVnu Alliance facilitates a new certified AVB networking ecosystem that is built into standard networks, not around it; solving major technical and performance issues such as: real-time synchronization, bandwidth reservation, and traffic shaping all while reducing the total cost of ownership by minimizing deployment and maintenance time. AVnu Alliance has established a program that tests and certifies AVB products for interoperability and works with other certification and standards organizations on the right solutions for each market and product type.

A complete list of AVnu Alliance members can be found at: http://www.avnu.org/about_us/our_members

The AVB IEEE standards are available free of charge at:
http://standards.ieee.org/about/get/

AVB Time Synchronization Tutorial:
http://ieee802.org/1/files/public/docs2014/as-kbstanton-8021AS-tutorial-0714-v01.pdf

Examples of AVB in Consumer Audio/Video Applications

Multiroom Audio

Because AVB is an international, open standard, available for use by any company, multiroom audio systems utilizing AVB could potentially access a much larger and more diverse array of devices than proprietary technologies can.

For example, a multiroom audio system utilizing AVB might include:

- Wireless speakers from various companies, some used singly, others used in pairs for stereo
- A home theater receiver powering a surround-sound system
- A bedroom TV, which can play networked audio
- Wireless outdoor speakers
- Ceiling speakers powered by a networked, in-wall amplifier.
- Two laptop computers and a desktop computer
- A network-attached storage (NAS) drive used to store audio and video files
- Various smartphones and tablets

MULTIROOM AUDIO

No matter which devices are used, in which combination or in which room, and no matter what music, movies or TV shows are being accessed, all of the devices work together as easily and reliably as if they were from the same manufacturer. Any devices playing the same content will be synchronized to an accuracy of 1 μs. All the rooms will be in sync, and any speakers in stereo pairs will be synchronized as tightly as they would using standard speaker cables.

Not only does everything play back in sync, but any audio/video content played through a wired network connection will be not be affected by fluctuations in network traffic. The audio and/or video data packets will have priority, while non-A/V data packets will be buffered until the network bandwidth is sufficient to send them.

Perhaps most important, AVB can support any audio and video standards. In audio, it works with everything from MP3 files to high-resolution 24-bit/192-kilohertz audio with no fidelity loss whatsoever.

Wireless home theater

Except for a few proprietary systems using specific brands and models of wireless speakers, networked audio in home theaters has been limited mostly to streaming Internet content through a receiver, Blu-ray player or set-top box. Yet wireless speakers offer many advantages in home theater applications.

WIRELESS HOME THEATER

AVB has several applications in the home theater environment:

- Any combination of wired and wireless speakers, including rear surrounds, front speakers, subwoofers and even ceiling speakers
- Streaming devices such as set-top boxes, Blu-ray players, and receivers
- NAS drives used to store audio and video content

With an AVB receiver, any combination of wired and wireless speakers could be used. AVB would allow the receiver to calculate the latency of all speakers in the system, and then synchronize the speakers so the entire surround-sound system plays back with the same fidelity and phase accuracy as if it were wired.

AVB also makes it easy to create multiroom home theater and A/V systems. If a homeowner wishes to play a football game for guests in the living room and on an outdoor TV on the adjacent patio, AVB can assure that the sound and picture remain in sync and there are no echo or delay effects caused by one sound system lagging behind the other.

Wireless stereo

Audio enthusiasts and music lovers have waited decades for wireless audio that is completely transparent and unlimited in the types of signals it can carry. AVB delivers audio and video, with synchronization comparable to that of standard analog cables, yet without the degradation that long cable runs can introduce.

AVB technology can benefit several types of stereo audio products:

- Wireless speakers
- Preamps, integrated amps and receivers with interfaces for streaming
- NAS drives used for music storage
- High-end headphone amplifiers

Because the synchronization accuracy of AVB is approximately 1μs*, a pair of AVB wireless powered speakers can play together with essentially perfect sync. How much is a 1μs error? About the same difference you'd experience by moving one speaker 1/100th of an inch closer to you. This sync performance makes AVB suitable even for very high-end audio systems. And AVB's ability to transport any type of audio data including HD Audio without alteration makes it suitable for even the most demanding audio applications.

AVB also gives consumers the option to carry one of a stereo pair of speakers into a second room to create an ad hoc multiroom system. The speakers could be quickly configured for dual mono use through a smartphone or tablet app, or through a switch on the speakers. Thus, a system could serve for serious stereo listening but be temporarily expanded to multiroom whenever the user wishes.

AVB's network traffic management features assure that any device with a wired network connection will not have its audio program interrupted by excessive network traffic demands. The AVB devices on the network recognize the data rate demands of the audio stream and reserve resources so that other data cannot disrupt playback.

What is AVB, Exactly?

AVB is a group of specifications added to the 802.1, 802.3, and 802.11 networking specifications. AVB adds accurate synchronization and reliable data transfer for audio and/or video applications, addressing concerns about latency and synchronization of devices on the network.

Understanding how AVB works requires an understanding of two different but related concepts: latency and synchronization.

Latency. Latency is the delay between the origination of an audio and/or video signal or data packet within a source device, and the actual reproduction of the signal through an audio or video transducer (i.e., a speaker or video display). Latency on its own is generally not a problem, because it's usually on the order of fractions of a second, and no one notices if their audio or video program is delivered a fraction of a second late. However, unmanaged latency does become a problem when one device has to synchronize with another.

Synchronization. Synchronization, or sync, is the simultaneous occurrence of two or more events. In audio/video networking, this could mean speakers in several rooms playing a program at the exact same time; two speakers in the same room paired for stereo sound and remain perfectly in phase; or the audio in a video program occurring at the same time as the onscreen events that generated the audio – i.e., an actor's speech is heard at the precise moment his mouth opens, a phenomenon called "lip sync."

How AVB Achieves and Maintains Synchronization

Key to the concept of AVB is that all AVB devices in a network receive a master sync signal. All of the devices continue to run off their own internal clocks, but those clocks are resynchronized with the master clock approximately once per second. With AVB, it is impossible for one device's clock to drift out of sync with the others to a significant degree. The timing accuracy of AVB is within 1 μs, a much tighter spec then required by any audio, video or gaming application.

All AVB devices in a system automatically communicate with each other to determine which device has the most accurate internal clock. This clock is chosen as the grand master clock. Approximately once per second, it sends out an announcement of what the time is, and the other clocks in the system synchronize to it. If the device with the grand master clock is disconnected or powered down, the system automatically switches over to the best available clock on the network.

MASTER CLOCK
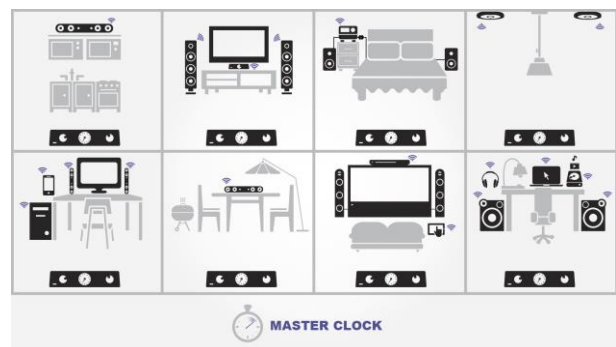
Because audio and video signals require many different clock rates, every AVB device in the network continues to generate audio and video timing signals using its own clock. The difference with AVB is that this clock will now be synchronized with the other AVB clocks on the network.

Once a network time reference has been established with the grand master clock, each AVB device will synchronize its media playback to this clock. A presentation time is added to the header of each media packet that informs the device when the media is to be played.

For example, a wireless speaker would receive a message with each media packet saying, in effect, "Play this sample when the network time is 8:11:35.023712." Because other audio devices in the system receive this same message, and are synchronized to the same grand master clock, playback is simultaneous in all devices.

Network Traffic Management for Wired Ethernet Backbone

To most home networks today, all data is the same. A data packet containing information from, say, a website or a document has the same priority as audio/video data. Yet delaying an audio or video signal by just a fraction of a second can cause a noticeable interruption, whereas a tiny delay in delivery of a web page or a document on its way to a printer would have no perceptible impact on performance.

With AVB wired networks (where the total bandwidth is fairly constant), bandwidth can be reserved for audio and video signals delivered through a wired connection. In fact, AVB actually tells AVB devices in the network -- including the source device, routers and bridges, and the destination device -- to reserve the necessary amount of bandwidth for the media being played. Other activities on the network are prevented from using this bandwidth as long as the media is playing. Once the media has stopped playing, the bandwidth is released. In the future, similar concepts could be used for wireless networks as well.

Because other devices cannot access the network resources reserved for media, excessive network traffic cannot cause a delay in the delivery of the audio or video stream. Instead, data that is less time-sensitive (web pages, e-mail, etc.) will be buffered and delayed until the network has enough resources to transport the data.

If the system detects that the network has insufficient resources to carry the media data without interruption, the source device receives an instruction to that effect. The source device (or the end user) may then decide to reduce the audio sample rate, video resolution, etc., to ensure uninterrupted playback. Specific actions are left up to the source device or the end user.

What Products Does AVB Work With?

AVB works with any type of device that connects to a network, using either a wired or wireless connection. For wireless devices, AVB primarily serves as a synchronization technology. For wired devices, it adds network traffic management for smoother audio/video reproduction.

A partial list of products that can benefit from AVB includes:

- Network routers
- Network bridges and wireless access points
- Wireless speakers
- Powered speakers with a network connection
- Preamps, integrated amps and receivers with interfaces for streaming
- Source devices with interfaces for streaming, such as streaming boxes and Blu-ray players
- Smart TVs
- NAS drives used for music storage

- Laptop and desktop computers
- Smartphones
- Tablets

AVB also works with any type of local-area network (LAN), including Ethernet, WiFi, coaxial cable networks, and networks that operate over home AC wiring.

Compatible with Many Existing A/V Network Technologies

Since AVB was originated in the IEEE, it is designed to be an augmentation to, rather than a replacement of, existing audio/video formats and technologies. AVB can be used in conjunction with these existing formats and technologies to provide synchronization and network traffic management at AVB's 1μs accuracy standard. This process could deliver AVB's networking performance while employing the same (or expanded) feature sets and the same user interface.

What Does a Manufacturer Need to Know? How Can I Get AVB into my Company's Products?

AVB compatibility is already becoming available in networking devices and chipsets. Because it is a license-free industry standard for which manufacturers are already in the process of developing product, there are numerous ways to incorporate AVB into products.

- <u>Full-scale AVB circuit development.</u> Companies that have the technical resources to implement their own AVB boards/modules can purchase AVB networking chips.

- <u>AVB network modules.</u> Companies who specialize in audio and/or video may choose to use AVB boards that include a network interface, a WiFi transmitter and I²S output.

- <u>Fully integrated audio boards with AVB.</u> Companies that specialize in acoustical design (i.e. speakers) may opt for fully integrated AVB boards that also include audio electronic components, such as DSP, amplification, etc.

- <u>Complete products with AVB.</u> ODMs can be expected to offer AVB as a feature in complete systems, such as wireless speakers, much along the same lines that they would offer licensed audio technologies -- but without the licensing fees, because AVB is an industry standard.

This arrangement, in which any manufacturer is free to implement these technologies as they wish, will give companies a wider choice of vendors for AVB than they would have when using proprietary audio/video networking technologies.

Control of AVB devices on a network may be through the devices themselves; through networked devices such as smartphones, tablets and computers; or through a combination of the two. Companies that sell AVB products may develop their own control apps and interfaces, or acquire and customize an application supplied by their AVB board vendor. Third-party apps may also be developed, along the lines of the universal remote control apps, now commonly used with smartphones and tablets.

Where Does AVnu Alliance Come In?

AVnu Alliance is a consortium of member companies working together to certify functionality and interoperability of AVB products.

An AVB product can be designed, manufactured and sold without the approval of AVnu Alliance. However, submitting the product for AVnu certification assures that it will operate correctly and at maximum performance when used with other AVnu-certified products.

After passing the tests, the manufacturer may submit the product to AVnu Alliance for certification and use of the certification mark. The certification mark assures consumers that the product will operate correctly in conjunction with other AVnu-certified products.

Conclusion

AVB is the easiest and most reliable way to assure that audio/video products, connected through a network, work correctly and achieve maximum possible performance. The technology has been consistently field-proven in the most demanding professional applications.

Because AVB is an industry standard, rather than a proprietary technology, it is open to all companies to use and develop as they wish. In addition, being part of the existing network standards it will become a common feature of network devices.

AVnu Alliance guarantees interoperability of AVB products with a simple certification process, and allows use of the AVnu logo on certified products to assure consumers that all of their networked audio and video components will work perfectly together, no matter the brand or manufacturer.