AVnu Alliance™ White Paper

AVB for Automotive Use

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Executive Summary

With the explosion of demand for connectivity and multimedia in the automobile, the need for standards-based A/V networking that can be easily deployed has been growing. The IEEE 802.1 Audio/Video Bridging (AVB) task group is developing a series of network enhancements that provide the components for highly reliable audio and video applications. This paper outlines these new technologies and their benefits when used for in-vehicle applications.

About AVnu Alliance

The AVnu Alliance is an industry forum dedicated to the advancement of professional-quality audio video transport by promoting the adoption of the IEEE 802.1 Audio Video Bridging (AVB), and the related IEEE 1722 and IEEE 1733, standards over various networking link-layers. The organization will create compliance test procedures and processes that help ensure AVB interoperability of networked A/V devices, helping to provide high quality streaming A/V experience. The Alliance will promote awareness of the benefits of AVB technologies and intends to collaborate with other organizations and entities to make use of this work in their respective efforts to provide a better end-user A/V experience.

The Alliance is focused on applications of these technologies in the Automotive, Professional, and Consumer Electronics markets.

Introduction

Over the last ten years, consumer demand had driven a large increase in audio and video features and options in the automobile. Once only found in luxury cars, features such as DVD playback, backup cameras, and navigation have become commonplace options in many mainstream automobiles. Rear Seat Entertainment (RSE) units are growing in sophistication with more sources and choices at your fingertips. Each of these options has added to the need and desire for a common networking architecture in the automobile.

While automotive OEMs around the globe have embraced the concept of low-bandwidth vehicle communication networking with Controller Area Network (CAN) being adopted almost universally, the unique and varied challenges in vehicle multimedia networking (e.g., bandwidth, QOS, scalability, cost, economies of scale, open vs. proprietary, and supplier choice) has left the door open for much debate over the best solution for multimedia from both a technical and commercial perspective.

Historically, the implementation of packet-switched networks has been avoided for vehicle multimedia applications due to their non-deterministic nature. The recent work of the IEEE Audio Video Bridging (AVB) task group offers a draft standards-based approach for highly reliable networked transmission for low-latency applications like those found within an automobile. While these AVB protocols can be used on more than one physical layer type, this paper will focus on the application of AVB over Ethernet. Wired Ethernet networks employing AVB protocols are very well suited to automotive deployment due to both simplified cabling and reliability of a hard-wired solution.

A primary market focus of the AVnu Alliance is the successful deployment of AVB for streaming audio/video into the automotive space. This whitepaper outlines the features and benefits of in-vehicle networking using the AVB technologies.

Benefits

Simpler cabling lowers weight and increases reliability

The use of multiplexed or networked based control communication in vehicles has become commonplace. This started with basic control messaging and the widespread adoption of the CAN. As the A/V content associated with infotainment systems has increased, it has also become increasingly impractical to continue with point-to-point dedicated connections such as shielded LVDS cables for audio and video content. Practical limitations to a non-networked approach to increasing infotainment content include wiring harness packaging/routing, wire & connector cost, reliability issues associated with the increasing number of connections, and the increasing weight and resulting impact on fuel efficiency.

Standard technology provides the basis for multiple suppliers

The predominant technology today for in-vehicle infotainment networking is MOST®, but many have felt that the proprietary nature of the MOST technology has slowed development and hampered its adoption As reported in the Nov 2008 Hansen Report "...industry players today believe that compared with Can LIN, and FlexRay, MOST is not nearly open enough." The report goes on further to state "Without more openness and greater affordability, MOST could in several years give way to alternatives, for example Ethernet." The draft IEEE standards from the AVB Task Group provide open standards for high-performance networked A/V using an array of potential link layer technologies. With only a small silicon change and the addition of software protocols, many small microcontrollers and DSPs that are

Ethernet capable today could in the future easily support these new technologies. If multiple silicon providers deploy AVB into their products, Tier-1 suppliers will have a wealth of silicon choices, allowing them to architect their products for the most optimized solution, and no longer be dependent on a single silicon provider.

Predictability and high reliability

The automobile is a very dynamic environment with many different sources and quick changes of configurations. Audio systems do not just play back program material, but also content like warning indicators and turn-by-turn navigations commands that must be assured a timely delivery. One long-standing problem with switched Ethernet for audio and video applications has been the indeterminate nature of data delivery across the network. One solution to this problem is to hand-tune the network configuration; however there could potentially be a different network configuration for every use case and combination of automobile option packages.

The IEEE 802.1Qat Stream Reservation Protocol (SRP) provides mechanisms for reserving stream bandwidth that allows endpoint applications to configure the routes, eliminating the need for specific network engineering. SRP checks for end-to-end bandwidth availability before an A/V stream starts. If bandwidth is available, it is "locked down" along the entire path until explicitly released. SRP works hand-in-hand with the IEEE 802.1Qav Queuing and Forwarding Protocol (Qav). Qav schedules time-sensitive A/V streaming data, ensuring timeliness through the network. Regular non-steaming traffic such as IP-based control or meters is treated in such a way that it cannot interfere with reserved AVB traffic. Utilizing the AVB protocols, intelligent devices communicate with the network to provide reliable A/V streaming without the need for the OEM to perform extensive hand tuning of the network for every different option package or configuration of the vehicle.

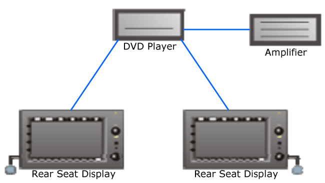
Low Latency

Many automotive applications require very low-latency such as back-up cameras, Bluetooth microphones, Driver Assist cameras and sensors, etc. SRP and the Qav protocols ensure end-to-end timely delivery time of all media streams. Without these protocols, standard switched Ethernet requires buffering at the end nodes because there is uncertainty as to when a media packet is received due to intervening traffic or switch queueing. In order to provide smooth streaming, buffering more samples is required, adding latency to increase the reliability. This buffering requirement has led many suppliers to shy away from traditional Ethernet for time-critical applications in the automobile. With the additional functionality of SRP and Qav, this is no longer a concern and switched Ethernet can now be a consideration for the most sensitive low-latency use cases.

Precise Synchronization

All networked audio or video systems must provide some mechanism for clock generation and recovery. The IEEE 802.1AS Precision Time Protocol (PTP) provides a common time-reference base to all nodes on the network. Based upon work originally designed for industrial controls, PTP distributes a network time-reference base that is accurate to less than one micro-second between any two nodes. By precisely time-stamping special packets as they leave and arrive at the interface or PHY, PTP can measure and compensate for all queuing and time-of-flight transmission delays. This precise synchronization has two primary purposes: it provides a common time base for sampling data at a source device and presenting those streams at multiple destination devices with the same relative timing and it allows multiple streams to be synchronized with each other (e.g., front and rear audio). To make use of 802.1AS, streams are expected to include a presentation time which then is used to regenerate the sample clock by means of cross-time stamping with the network time. With 802.1AS and presentation time-encapsulated streams, an AVB network inherently supports an arbitrary number of different media sample rates and clock sources as the destination devices will each synchronize to their corresponding source device. An AVB network also then provides the mechanism to synchronize different paths through the network. As an example, imagine that two RSE displays are showing the video playback of a DVD whilst the audio is transmitted on a totally separate path to the amplifier. The mechanisms described above allow all three to be precisely synchronized.

Fig 1. DVD player with multiple audio/video paths



Scalable, versatile topologies

Unlike MOST, where the total network bandwidth is shared among all connected devices, AVB networks utilize bandwidth only between source and destination node connections. This conservation of bandwidth allows substantially more data to flow on an AVB network vs. a MOST network even at equivalent network bitrates. Topologies such as stars and trees are easily supported.

Fig 2 MOST ring topology. All devices see entire network traffic from every other devices

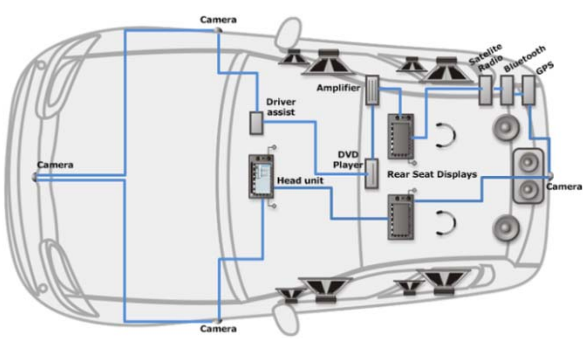
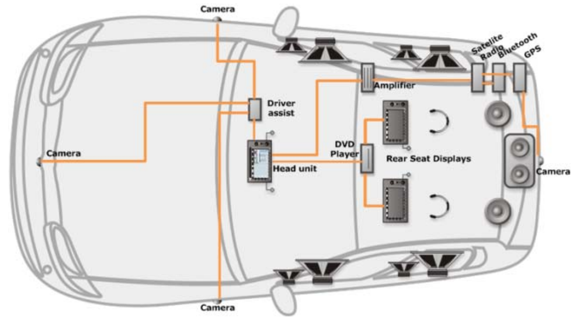


Fig 3 Possible AVB architecture. In this example, the camera signals from the front of the car only pass to the drives assistance module.



Designers also have a flexible choice of compatible speeds, for example a given vehicle design can easily mix and match high-bandwidth gigabit links with lower-bandwidth 100Mbps. Substantial technological investment by the networking community has ensured this interoperability at the same time that speeds have been pushed upward to 10Gbps and even 100 Gbps. By comparison, the three published speeds of MOST - MOST25, MOST50, and MOST150 - are not compatible. The entire network must be at the same speed, reducing flexibility and adding unnecessary cost into the low-bandwidth devices to meet the needs of high-bandwidth devices.

Diagnostics

Vehicle diagnostics are highly desired by automotive OEMS to troubleshoot vehicle problems at automotive OEM assembly lines and dealer service stations. No physical diagnostics exist for CAN and only ring break diagnostics exist for MOST.

On the other hand, modern Ethernet PHYs have substantial physical layer diagnostic capabilities which include: automatic detection and compensation of swapped pairs, cable breaks, and detection and compensation for kinks and impedance mismatches which can reduce bandwidth. Utilizing these commonplace Ethernet diagnostics, both assembly and service issues can be more quickly found and fixed.

Brief Technology Overview

For a more thorough treatment of the AVB technologies, see [whitepaper on AVnu website].

Four IEEE 802.1 AVB draft standards form the foundation of the technology promoted by the AVnu Alliance and—like other 802.1 standards—describe interworking/bridging between various network link technologies. It's important to note, however, that this is not intended to imply that the services provided by the AVB standards over every kind of network link are identical, since each link technology has different characteristics.

Below are the four foundational standards. As of July 2009 all were in draft form with expected completion in 2010 and 2011:

- IEEE 802.1AS (PTP): "Timing and Synchronization for Time-Sensitive Applications in Bridged Local Area Networks." This auto-selects a device to be the master clock, which then distributes time throughout the bridged LAN / IP subnet to all other nodes. The 802.1AS clock is not used as a media clock. Rather, the 802.1AS time is used as a shared clock reference between nodes which is used to port a media clock from talker to listener. Such a reference removes the need to fix the latency of packet delivery, or compute long running averages in order to estimate the actual media rate of the transmitter in the presence of substantial network jitter. IEEE 802.1AS is based on the ratified IEEE 1588-2008 standard.
- IEEE 802.1Qat (SRP): "Virtual Bridged Local Area Networks - Amendment 9: Stream Reservation Protocol (SRP) ." This allows a stream reservation to be established between a talker and listener in a bridged LAN / IP subnet.
- IEEE 802.1Qav (Qav): "Virtual Bridged Local Area Networks - Amendment 11: Forwarding and Queuing for Time-Sensitive Streams." This describes a token-bucket method for shaping network traffic such that the latency and bandwidth of reserved streams can be controlled.
- IEEE 802.1BA: "Audio/Video Bridging (AVB) Systems"

There are also two draft standards that rely on IEEE 802.1 AVB to provide professional quality Audio/Video.

- IEEE 1722: "Layer 2 Transport Protocol for Time-Sensitive Streams." Allows easier porting of applications currently using IEEE 1394 (FireWire®) to AVB.
- IEEE 1733: extends RTCP for RTP streaming over AVB-supported networks.

Conclusion

The new technology from the IEEE AVB task group provides a critical component for successful deployment of Ethernet in the vehicle for applications such as infotainment and drivers assistance. The reliable delivery of low-latency precisely synchronized audio and video combined with the massive industry investment provides a compelling solution for next-generation systems. The AVB protocols are an open standard, allowing multiple suppliers to deliver silicon solutions for automotive usage. For more information, please contact the AVnu Alliance at www.AVnu.org.