

# Automotive Ethernet AVB Landscape

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## ABSTRACT

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 is now well-established. The IEEE 802.1 Audio/Video Bridging (AVB) Task Group<sup>1</sup> and several other related IEEE Working Groups have developed 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.

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## 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, remote amplifiers, adaptive sound fields, backup cameras, and navigation have become commonplace options in many mainstream automobiles. Rear Seat Entertainment (RSE) units are growing in sophistication with more sources requiring more connections. All these drive the desire for a single, unified network for automotive infotainment.

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, packet-switched networks were not used in multimedia applications due to their non-deterministic nature. The recent work of two IEEE working groups (IEEE 802 and 1722) offers a standards-based approach for highly reliable networked transmission for low-latency time-synchronized 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. This paper will focus on the use cases and benefits of in-vehicle networking with AVB along with the future applications that can be affected and enhanced.

## ETHERNET AVB AT-A-GLANCE

Ethernet AVB is an enhancement to the Ethernet suite of open standards that provide quality of service (QoS) guarantees, a network time synchronization service, and a related transport protocol for transmission of time-sensitive traffic that together allow a network to handle audio-visual (AV) data. In the automotive environment, it can also satisfy more generalized time-sensitive networking requirements, opening up the possibility of a single network that handles infotainment, body control, driver assistance and even safety-critical functions.

To do this, AVB uses a number of important concepts. It introduces stream *tagging* and *labeling* with appropriate *queuing* and *forwarding* rules, to specify that some data streams are time-sensitive and distinct from the ordinary traffic that gets carried on a best-effort basis. The idea of *reservation* means that the network can set aside a certain amount of guaranteed bandwidth to handle this time-sensitive traffic. The concept of *network time*, along with rigorous latency specifications, enables synchronized AV playback through simultaneous media rendering.

Finally, there are standardized methods for discovery, enumeration and control, allowing systems to be built and configured quickly and easily.

More details about the individual parts of the standard and associated technologies can be found in the technology overview at the end of this document.

1. Now known as the "IEEE 802.1 Time-Sensitive Networking Task Group" (TSN) since the protocols being developed are also useful for control networks in vehicular and industrial applications.

## AVB BENEFITS FOR AUTOMOTIVE MARKETS

### *Simpler Cabling Lowers Weight and Increases Reliability*

A networked approach to cabling reduces the component cost and design complexity of the in-vehicle wiring harness. It boosts reliability by cutting the number and type of interconnects while reducing weight (and potentially cost) which leads to increased fuel efficiency.

The use of multiplexed or networked based control communication in vehicles is already commonplace, starting with basic control messaging and the widespread adoption of CAN. As the A/V content associated with infotainment systems has increased, it has become impractical to continue with point-to-point dedicated connections such as shielded LVDS cables.

### *A Healthy Ecosystem*

The creators of AVB chose to base it on the IEEE 802 architecture for more than just sound technical reasons. Ethernet (IEEE 802.3) and WiFi (IEEE 802.11) as tied together by IEEE 802.1 switches are together the most robust, most deployed, most familiar networking system on earth. Ethernet, in particular, scales from 2 Mb/s to above 100 Gb/s and can use virtually any copper or fiber optic connection technology. The decision to create an open, standard technology was intended to build on these advantages. Open standards foster strong, competitive ecosystems, and multiple silicon providers have already deployed AVB into their products. Further, the AVnu Alliance<sup>2</sup> has defined a usage profile for automotive AVB and is developing an associated certification process. This will allow OEMs to specify compliance and interoperability requirements that can be met by a variety of Tier-1 automotive suppliers, who in turn can architect their solutions without dependence on a single technology provider.

This approach contrasts sharply with the previous situation in the automotive industry. The predominant technology for in-vehicle infotainment networking in the recent past was MOST®, but many have felt that the proprietary nature of the MOST technology has slowed development and hampered its adoption. As early as November 2008, the Hansen Report observed that "...industry players today believe that compared with CAN, LIN, and FlexRay, MOST is not nearly open enough." [1] The report goes on to predict that "Without more openness and greater affordability, MOST could in several years give way to alternatives, for example Ethernet." This prediction is now coming to pass, as MOST gets overtaken by newer, more open technologies.

### *Certified Interoperability*

AVB is not just open - it is a set of IEEE standards backed by a robust and rigorous set of conformance and interoperability (C&I) specifications defined in their respective Protocol Implementation Conformance Statements (PICS). The AVnu compliance and interoperability specifications extend the IEEE PICS to include those specific to various use cases, including automotive, professional

audio, and professional video. Furthermore, AVnu has defined test procedures and certification methodologies so that interoperability can be trusted across a broad ecosystem of A/V devices.

The result is that OEMs get assurances that their products will work with other ANvu-certified devices; and auto makers get a fertile ecosystem of suppliers that grows and quickly reaches critical mass.

### *Predictability and High Reliability*

The AVB core technologies of fast automatic reconfiguration, stream tagging, reservation, traffic shaping, and universal timing allow the construction of networks with the demanding predictability and reliability requirements of the automotive industry.

Ethernet systems can consist of any kind of topology of bi-directional links: daisy-chain, tree, ring, even a fully interconnected mesh. Overlaying this topology is one or more virtual networks (VLANs), each consisting of a single "spanning tree" (a network where there is exactly one path of one or more hops between any two devices). When a physical link fails, the spanning trees are automatically (and very quickly) rebuilt by using any available redundant paths to bypass the failure. A simple example is a ring of two-port Ethernet devices: on startup, the system will automatically disable just one of the bidirectional links in the ring so that it appears to be a daisy chain. If one of the active links fails, the network enables the formerly disabled link and connectivity is restored.

The IEEE 802.1Qav Queuing and Forwarding for Time Sensitive Streams (FQTSS) is key to this predictability. It provides traffic shaping services and prioritizes tagged stream traffic through the network, ensuring that best effort data does not interfere with time-sensitive content, nor do different streams interfere with each other. This mechanism requires that the bandwidth needed for the active streams on each link is known. These bandwidth reservations can be preconfigured statically for a minimal startup, and this is the default functionality in automotive use cases.

The IEEE 802.1Q Stream Reservation Protocol (SRP) can be used to add a further layer of flexibility. It allows endpoints to dynamically reserve and release stream bandwidth, enabling reliable A/V streaming without the need for the OEM to perform extensive hand tuning of the network for every different option package or future configuration of the vehicle. Implementation of SRP is optional in the automotive use case.

### *Many-to-Many Configuration Flexibility*

Creating an in-vehicle network that deals with a broad range of content and control signals is a challenging task. The network needs to play back AV program material from a variety of sources to a number of destinations, provide features such as program muting in the event of an incoming cellphone call, and deliver content like warning indicators and turn-by-turn navigation commands that must be assured a timely delivery. This requires a network that is configured with reservations to cope with these requirements from the outset.

Implementation of SRP is optional and not required in automotive use case. The need for many-to-many communication is one of the fundamental attractions for auto makers of moving to a networked AV system and away from point-to-point connections.

2. <http://www.avnu.org>