WHITE PAPER

Automotive Ethernet: An Overview

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Introduction

Car technology is rapidly increasing. What was once science fiction, is quickly becoming science fact. Smartphone connectivity, high-powered entertainment systems, navigation, interactive systems feedback, driver responsive performance – the list of advancements goes on. The software used in cars is getting more complicated – and more connected.

All of these growing automotive applications are driving up the bandwidth requirements. In response, automotive manufacturers are adding more and more computer-based systems, applications, and connections. The cost of these electronics – and wiring harness to support them in terms of cabling, network interfaces, and onboard computing power – is growing. Ethernet deployment can, and will, reduce these costs. Recent technology developments make Ethernet viable for use in cars.

Close to 400 million automotive Ethernet ports will be in use by 2020 per estimates by Frost & Sullivan and Strategy Analysis.[1] By 2022, the total number of automotive Ethernet ports is expected to be higher than the total number of all other Ethernet ports combined.

Ethernet deployment can, and will, reduce these costs. Recent technology developments make Ethernet viable for use in cars.

Automotive Ethernet is not only for the “luxury” car market – trends indicate that a significant majority of car manufacturers are planning to move to Ethernet for all classes of cars. While BMW is the frontrunner in terms of adopting this technology, every car maker is making headway in this direction. This is evidenced by Hyundai using automotive Ethernet for infotainment systems in upcoming cars, and Volkswagen using automotive Ethernet for driver-assist systems.

A good majority of the players in the automotive market are involved in automotive Ethernet. We see them in the industry groups, the standards bodies, publishing test results, and promoting the standards. The main driving factors are cost reduction, efficiency, and reduced time to market.

This paper will discuss the coming automotive Ethernet revolution, and address the following areas:

- What is automotive Ethernet
- Who uses automotive Ethernet
- Why are they using automotive Ethernet
- How do you test automotive Ethernet

1. http://www.ieee802.org/3/cfi/0314_2/CFI_02_0314.pdf

Anatomy of Automotive Electronics

The electronics in a car are divided into “domains.” Traditionally, each of these domains has independent controls (whether they are mechanical, electrical, or computer controls). Today, there is a lot more interaction between the domains, but they still typically have independent computer systems.

To understand the requirements for Ethernet in car, the different domains and their requirements are introduced below.

Powertrain

The powertrain is the group of components that generate the energy to power to the vehicle on road. This obviously includes the engine, transmission, shafts, and wheels. But it also includes many other sensors and controls in order to improve the ride, reduce pollution, increase efficiency, and improve safety. Such sensors measure flow, pressure, speed, torque, angle, volume, position, and stability of various items.

Today’s powertrains have complex computer controls that maximize both power and efficiency. For example, to make sure that the right amount of fuel is injected into the engine pressure sensors measure the fuel pressure -- which affects the timing of the injection. For a more complex example, the engine timing – which is computer controlled – controls the valve timing by using inputs from many sensors that measure such things as the air mass in the intake manifold, fuel temperature, engine speed, accelerator pedal position, and engine torque.

The powertrain is the group of components that generate power and transmit it to the road.

The powertrain computer needs to control the exact times that sensors are read and needs low latencies (typically in microseconds) to get accurate results. The powertrain also needs fast control of the various controls (again with latencies typically in the microseconds).

Chassis

The chassis includes the internal framework that supports the powertrain, as well as all components required for driving other than the engine – including brakes, steering, and suspension. Similar to the powertrain, the sensors and controls for the chassis domain have exact timing requirements with controlled maximum latencies.

Body and Comfort

The body domain includes such things as heating and A/C, seat controls, window controls, lights, etc.

These controls and sensors typically require low bandwidth and can handle high latency (milliseconds).

Driver Assistance, and Driver/Pedestrian Safety

This domain includes systems designed to help the driver in the driving process, and systems designed to increase safety for the driver, passengers, and pedestrians.

Driver assistance systems include such items as in-vehicle navigation (using GPS or similar), cruise control, and automatic parking.

Driver and passenger safety assistance systems include lane departure warning systems, collision avoidance systems, intelligent speed adaptation or advice, driver drowsiness detection, and blind spot detection.

The driver assistance and safety system domain is one of the fastest advancing domains, with new technologies typically starting out in higher-end car models and making their way to the main stream.

These systems typically have their own sensors and their own dedicated computers, which implement controls that often interact with other systems (such as the powertrain, chassis, and human-machine interface). The driver assistance systems often require more computing power and higher bandwidth communications to sensors, but they can typically handle latencies in the hundreds of microseconds. The amount of bandwidth required by these systems is one of the main drivers for higher speed interfaces in the car, and the amount of bandwidth needed keeps increasing (for example, the number and resolution of cameras used in the car keeps increasing to produce such features as BMW's Surround View).

Driver assistance systems include such items as in-vehicle navigation (using GPS or similar), cruise control, and automatic parking.

Human-Machine Interface, Multimedia, and Telematics

The human-machine interface (HMI) is the portion of the automotive electronics that facilitates interaction between humans and other electronics. This domain presents information from the computers in other domains in a friendly and usable fashion, and lets the driver and passengers control the operations of the vehicle and infotainment systems.

The HMI domain is typically the one that connects to external devices via Bluetooth, Wi-Fi, or cellular networks (for example, OnStar is GM's remote support system that is integrated into their HMI system). In addition to other functions, this system can remotely diagnose car problems by gathering diagnostics data from the other domains.

Car manufacturers are working to improve the HMI to make it safer, more intuitive, and more appealing to customers. Often they create a more "gamified' user interface.

The HMI domain typically needs to communicate with all other domains in the vehicle. In addition, the HMI itself includes displays and controls in different parts of the vehicle, and these need to communicate with each other. Similar to the driver-assistance domain, the HMI domain can require high bandwidth – but is typically tolerant of latencies in the millisecond range.

Wiring Harness

The following is a typical wiring harness in a car:[2]

There are multiple proprietary standards for communication in a car, including analog signals on wires, CAN, FlexRay, MOST, and LVDS. Each vehicle component typically has its own dedicated wiring and communication requirements.

Due to this complex cabling, the wiring harness is the 3rd highest cost component in a car (behind the engine and chassis). Harnesses are built one at a time, and comprise 50% of the cost of labor for the entire car.

The wiring harness is also the 3rd heaviest component (behind the chassis and engine). Any technology that reduces this weight directly contributes to fuel economy.

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2. http://delphi.com/news/pressReleases/pressReleases_2011/pr_2011_06_07_001/

Domain	Description	End-to-End Latency Requirements	Bandwidth Requirements
Powertrain	Controls the components that generate power and transmit to the road.	< 10 us	Low
Chassis	Controls steering, brakes, suspension	< 10 us	Low
Body and Comfort	Radio, A/C, window, seat, and light controls	< 10 ms	Low
Driver Assistance and Driver Safety	Controls systems designed to increase safety	< 250 us or < 1 ms depending on system	20 – 100 Mbps per camera
Human-Machine Interface	Controls displays and other interfaces that interface with the driver or passengers	< 10 ms	Varies by system, but this growing

Summary of connectivity requirements by domain

Automotive Ethernet is a physical network that is used to connect components within a car using a wired network.

Defining Automotive Ethernet and the New Anatomy of an Automobile

What is Automotive Ethernet?

Automotive Ethernet is a physical network that is used to connect components within a car using a wired network. It is designed to meet the needs of the automotive market, including meeting electrical requirements (EMI/RFI emissions and susceptibility), bandwidth requirements, latency requirements, synchronization, and network management requirements.

To fully meet the automotive requirements, multiple new specifications and revisions to specification are being done in the IEEE 802.3 and 802.1 groups.

Until the specs get through the IEEE, there are some interim specs sponsored by special interest groups such as

- The OPEN (One-Pair Ethernet) group, which is sponsoring Broadcom's 100Mbps BroadR-Reach solution as a multi-vendor licensed solution. This 100Mbps PHY implementation uses technologies from 1G Ethernet to enable 100Mbps transmission over a single pair in both directions (using echo cancelling) using more advanced encoding to reduce the base frequency to 66MHz (from 125 MHz) allowing Ethernet to meet the automotive EMI/RFI specs.
- AVnu adopted Audio-Video bridging standards ahead of IEEE 802.1 standardization process.

Why Ethernet was Not Used in Cars until Now

Even though Ethernet has existed for over 20 years, it could not be previously used in automobiles due to the following limitations:

1. Ethernet did not meet the OEM EMI/RFI requirements for the automotive market. 100Mbps (and above) Ethernet have too much RF "noise," and Ethernet is also susceptible to "alien" noise from other devices in a car.
2. Ethernet could not guarantee latency down to the low microsecond range. This was required to replace communication to any sensor/control that needed fast reaction time.
3. Ethernet did not have a way to control bandwidth allocation to different streams so it could not be used to transmit shared data from multiple types of sources.
4. Ethernet did not have a way of synchronizing time between devices and having multiple devices sample data at the same time.

What are the Drivers of Automotive Ethernet?

The electronics in a car are getting more complicated with more sensors, controls, and interfaces with higher bandwidth requirements. The different computers and domains in the car need to increasingly communicate with one another. The complexity, cost, and weight of wiring harnesses has increased such that the wiring harness is the third costliest and third heaviest component in a car

The electronics in a car are getting more complicated with more sensors, controls, and interfaces with higher bandwidth requirements.

Today, multiple different proprietary standards for communication are used, with each component typically using a dedicated wire/cable. By moving to a single standard, all the communications from all the different components can coexist on the same switched Ethernet network, with a single pair going to each location in the car from a central switch.

A joint study by Broadcom and Bosch estimated that using "unshielded twisted pair (UTP) cable to deliver data at a rate of 100Mbps, along with smaller and more compact connectors can reduce connectivity cost up to 80 percent and cabling weight up to 30 percent."

What are Other Technologies Entering the Automotive Space?

The role of electronics, computers, and networks in cars is continuously increasing. The automobile is no longer a series of isolated simple systems – rather it is becoming part of the interconnected world.

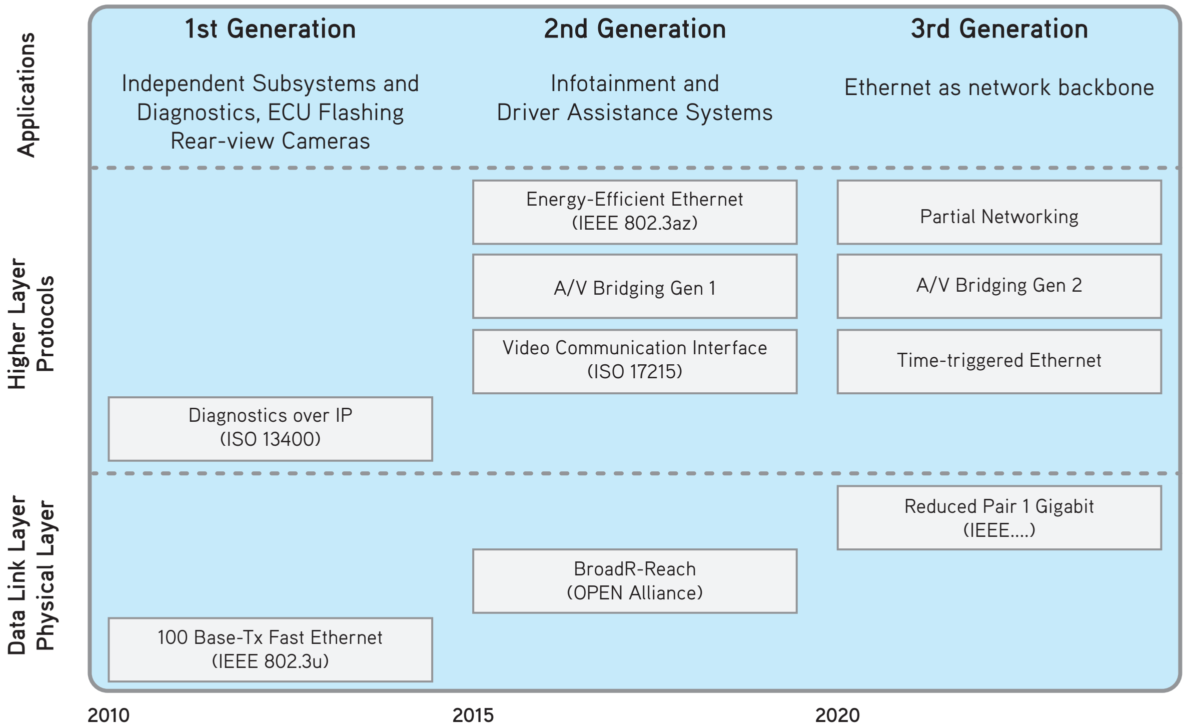
The following are examples of technologies which are being developed and/or deployed that relate to automotive networking:

1. "Connected cars" with internet access through cellular or Wi-Fi connections are starting to be available (aftermarket products have been available for a while). These systems will allow not only functions such as real time traffic information, communications, and video streaming; but also remote diagnostics and updating of firmware which require access to the internal networks and computers in the car.

2. V2V (vehicle to vehicle communications) will be used for cars to coordinate with each other. By knowing what other vehicles are doing and getting information about the relationship of vehicles to other objects, safe distances can be calculated and evasive maneuvers taken. The National Highway Traffic Safety Administration estimated that by using V2V technologies, 79% of target vehicle crashes would be avoided.
3. "Augmented Reality" dashboards will provide information about objects on the road. The driver looks towards an object and the car will provide information on the windshield showing distance, and could zoom in to see far away objects. And if there is a danger, an arrow could appear showing you how to avoid the danger. Such technologies are also considered for passengers as well.
4. Self-driving (autonomous) vehicles will be able to drive passengers and make deliveries without any driver. In California and Nevada, Google's self-driving cars have already driven over 300,000 miles on public highways and roads. By using cameras, radars, and lasers the cars can process and analyze information faster and more reliably than humans. These cars can make more efficient use of roads by "platooning" and parking very closely in spaces. GM, BMW, and Toyota have all published results of testing and many industry experts belief that by 2020 self-driving cars will be sold and driving on public roads.

Future Car Electronics Anatomy Using Automotive Ethernet

The diagram below shows the estimated progression of Automotive Ethernet from today (1st generation) through 2020 (3rd generation).



Automotive Ethernet Today

Today, Ethernet is only used in cars for diagnostics and firmware updates. 100Base-Tx is the typical standard used. This standard does not meet automotive EMI requirements, but as this interface is only used for diagnostics while the car is in a service location (not in motion), an exception was made to allow its use. Cars that use Ethernet for diagnostics typically have an RJ45 connector that is used to connect to an external computer that runs the diagnostics software. Firmware upgrades on some cars are also done through this interface due to its much higher speed.

Automotive Ethernet in 2015

By 2015, multiple car manufacturers will use Ethernet for cameras (driver assist) and video (infotainment) connections. The technology used is Broadcom's BroadR-Reach PHY technology (which is now an open standard supported by the OPEN Alliance) which meets automotive EMI requirements. The move to Ethernet is happening quickly, as the competing technology that supports the required bandwidth (MOST and LVDS serial protocols) are proprietary and expensive. In this model, Ethernet is used in point-to-point links and is not yet being used as a shared medium for different interfaces (so a single link is only used for the connection to one video or camera).

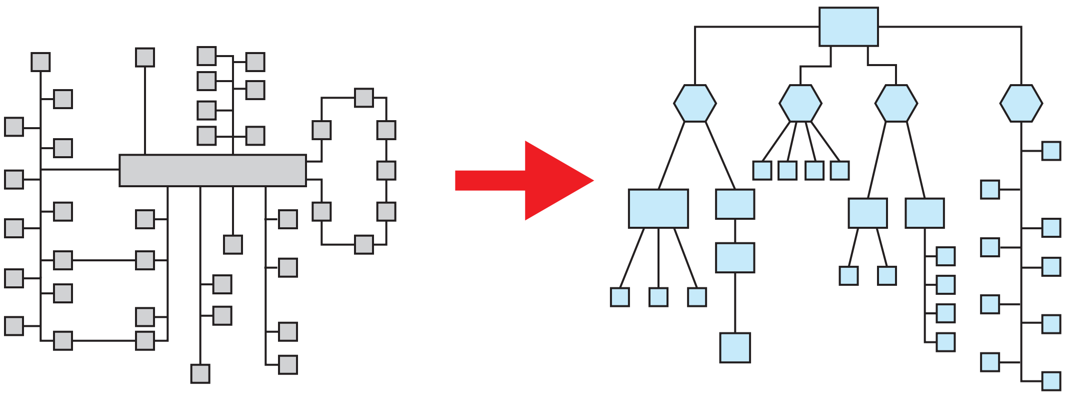
BMW and Hyundai are already using this technology in some of the models sold today.

By 2015, multiple car manufacturers will use Ethernet for cameras (driver assist) and video (infotainment) connections.

Automotive Anatomy in 2020

By 2020, it is estimated that 40% of the cost of a car will be in electronics (up from about 32% today). New safety, infotainment, and communication features and technologies will drive this increase.

By 2020, automotive wiring harnesses will change from heterogeneous networks of proprietary protocols (such as CAN and MOST) to hierarchical homogenous automotive Ethernet networks (see picture below). In the new model, switched 1GE automotive Ethernet will interconnect all the domains in the car (meaning that Ethernet will be a shared medium with signals controlling throttle sharing the same twisted pair as a request to change the radio station and the video for the kids in the back seat).



The new anatomy not only helps reduce cost and weight, but also makes it much easier for the different systems in the car (and outside of the car) to cooperate.

Enabling Technologies

Multiple technologies enable the new automotive anatomy described above. It is the combination of all the technologies below that enable the new vision.

AUTOSAR (Automotive Open System Architecture)

AUTOSAR is an open and standardized automotive software architecture, jointly developed by automobile manufacturers, suppliers, and tool developers. AUTOSAR includes the automotive TCP/UDP/IP stack that is used in automobiles. The automotive industry has effectively agreed on AUTOSAR as the standard, with different makers competing on implementation rather than on the standard itself.

The standard implementation allows many devices to run seamlessly on a single shared network.

One-Pair Ethernet (OPEN)

As the industry realizes that 100Mbps is enough for a video transmission, but not enough to act as a backbone in the car, the industry pushed for the creation of a task force in 802.3 (802.3bp) to define a standard for 1G over a single twisted pair for links of up to 15M for the automotive market.

Broadcom developed a proprietary PHY standard, BroadR-Reach, to enable longer distances of copper Ethernet connectivity at 100Mbps (up to 700M). This PHY uses technologies from 1GE copper including multi-level PAM-3 signaling and better encoding (to reduce the bandwidth required on the cable), and using echo cancellers so bidirectional data could be transmitted on a single pair. Due to the lower bandwidth (~27MHz bandwidth vs. 62.5MHz for 100Base-T), this standard met the automotive EMI requirements, and Broadcom started marketing this to the automotive world.

As BroadR-Reach was a single vendor solution, the OPEN sig was founded to make this a licensed open standard with sponsorship from major players in the automotive market. This technology is now available from Broadcom, NXP, and Freescale.

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Power-over-Ethernet

To further reduce the wiring needed in a car, PoE may be used to power the devices. The IEEE 801.3bu (1-Pair Power over Data Lines (PoDL)) Task Force is working on standardizing PoE over a single pair. This is a minor modification to current PoE and this standard is expected to be approved by 2015.

Energy-Efficient Ethernet

A car's electrical components don't all turn off when the engine is turned off. When the engine is off, the battery capacity is limited. In order to minimize power consumption when the engine is off (and when the engine is on), Energy-Efficient Ethernet (EEE), which turns off the network when it is not in use, is used. Those components that don't need to be powered on at all when the engine is off will have their network segments completely turned off. Those that need to be on will use EEE to minimize power consumption.

Time Synchronization

Some algorithms in a car require either simultaneous sampling of multiple sensors or knowing the time that a measurement was taken. As these measurements are taken in different nodes, time needs to be synchronized between all the nodes in the car down to sub-microseconds errors.

IEEE 802.1AS (Timing and Synchronization for Time-Sensitive Applications in Bridged Local Area Networks) is the standard chosen to synchronize timing. This standard uses a "profile" for IEEE 1588 v2 and introduces simpler/faster methods for choosing a master clock.

Time-Triggered Ethernet

Many controls in a car require a communication latency in the single microsecond range (so that the controller can quickly get the sensor readings or control a function). In traditional Ethernet, a new packet would have to wait until an existing packet is complete (and this can take hundreds of microseconds, even at gigabit speeds), so this did not meet the requirements.

To solve this problem, the IEEE 802.3br (Interspersed Express Traffic) task force is developing a system where high priority packets (called Express packets) can interrupt existing packets, and the interrupted packets continue after the express packet is completed. An interruptible packet can be interrupted multiple time to insert express packets. The express packets can guarantee latency in the single microsecond range.

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AV Bridging

Many driver assistance systems rely on getting data from cameras and other sensors in a timely manner. Unlike watching video on a computer, where buffering is used to compensate for the unreliable timing of the network, these AV systems require both controlled latencies and guaranteed bandwidth.

The IEEE 802.1 Audio Vide Bridging (AVB) Task Group (renamed to "Time-Sensitive Networking Task Group") is working on standards to meet these requirements:

- 802.1Qat (Stream Reservation) – a simple reservation protocol to notify the various network elements in a path to reserve the resources necessary to support a particular stream. More recent discussions are considering usage of pre-configured streams.
- 801.1Qav (Queuing and Forwarding for AV Bridges) – defines rules to ensure that an AV stream will pass through the network within the delay specified in the reservation.

The IEEE also standardized IEEE 1722 (Layer 2 Transport Protocol for Time Sensitive Applications in a Bridged Local Area Network) and 1733 (Layer 3 Transport Protocol for Time Sensitive Applications in Local Area Networks). These protocols use time (from IEEE 802.1AS) as well as the worst case transport delay to get a presentation time which is inserted in the packet. 1733 is used with RTP/RTCP and 1722 is used with IEC 61883 and other formats.

The AVnu Alliance is an industry forum dedicated to the advancement of AV transport through the adoption of the IEEE 802.1 AVB and related IEEE 1722 and 1733 standards. This alliance is heavily supported by the automotive industry

Diagnostics over IP

ISO 13400 is a standard adopted by the automotive industry to both read-out diagnostics data from the computers in the car and update firmware in the car. ISO 14229 defines the service primitives used by 13400. The protocols run over TCP/IP and are used both on dedicated diagnostics Ethernet connections as well as over-the-air systems such as GM's OnStar.

Market Landscape

In 2013 there were close to 85 million cars sold, and this number is growing at around 3.4% per year (over the last 8 years). By 2020 there will be over 105 million new cars sold worldwide. Here is a chart of auto sales in select locations over the last several years:

By 2020 there will be over 105 million new cars sold worldwide.

Year	Worldwide	China	US	Japan	Europe
2005	65,378,605	5,758,189	17,444,329	5,852,034	21,069,257
2006	67,934,506	7,215,972	17,048,981	5,739,520	21,851,445
2007	71,153,079	8,791,528	16,460,315	5,309,200	22,994,011
2008	68,032,740	9,380,502	13,493,165	5,082,233	21,859,239
2009	65,382,664	13,644,794	10,601,368	4,609,333	18,637,363
2010	74,662,939	18,061,936	11,772,219	4,956,148	18,798,802
2011	78,078,513	18,505,114	13,040,613	4,210,224	19,730,242
2012	82,059,897	19,306,435	14,785,936	5,369,721	18,658,263

Luxury cars: The luxury car market is growing with this category making close to 5% of all cars sold in 2012 (up from about 3% in 2010). Luxury cars have as much as five times the electronic components as non-Luxury cars.

Hybrid and Electric Vehicles: In 2012, close to 1.6 million hybrid or electric vehicles were sold worldwide. While only 2% of all cars sold were hybrid or electric, this segment of the market is growing at over 200% per year. Hybrid and Electric vehicles have 2-3 times the electronic components as gas-powered cars.

Number of Automotive Ethernet Nodes in a car: By 2020, low-end cars would have between 6 and 40 nodes in a vehicle. Luxury and Hybrid/Electric Vehicles can have 50 and 80 automotive Ethernet nodes in a vehicle.

Market Penetration of Automotive Ethernet: Frost & Sullivan predict that by 2020, 40% of automobiles sold will be using automotive Ethernet. They estimate that 300 million total Ethernet ports in cars sold in 2020. By 2025, the penetration rate is expected to increase to 80% by 2025.

Competing Technologies/Standards

Ethernet is the “new-comer” to the automotive market. The following technologies are actively being used in cars today:

- CAN (Controller Area Network) – Available since 1983, CAN is a shared serial bus running at up to 1Mbps. It was developed by Bosch and standardized in multiple ISO standards. It has the advantage of being fairly inexpensive and being very reliable. It has the disadvantages of relatively low bandwidth and being a shared media (rather than a switched network) where any transmission takes away from the total bandwidth. CAN is used in powertrain, chassis, and body electronics.
- LIN (Local Interconnect Network) – Available since 2001, LIN was developed by a consortium of automakers and technology partners. Like CAN, it is a serial bus. It runs at only 19,200 baud and requires only one shared wire (instead of the 2 for CAN). Unlike CAN, in which all nodes are “equal,” LIN is a master-slave architecture. Its main advantage is that it is lower cost than CAN. LIN is often used for body electronics (mirrors, power seats, accessories) as it is inexpensive and the bandwidth requirements are very low.
- FlexRay – Available since 2005, FlexRay is a shared serial bus running at up to 10Mbps. It was developed by the FlexRay consortium, a group of semiconductor, automobile, and infrastructure providers. Unlike CAN, there is no build it error recovery – rather error handling is left to the application layer. It has the advantage of having higher bandwidth than CAN, but the disadvantage of higher cost and being a shared media. FlexRay is used in high-performance powertrain and safety (drive-by-wire, active suspension, adaptive cruise control).
- MOST (Media Oriented Systems Transport) – Available since around 2001, MOST has a ring architecture running at up to 50Mbps using either fiber or copper interconnects. Each ring can contain up to 64 MOST devices. MOST has the advantage or relatively high bandwidth (in the automotive market), but is very high cost. It is only used for camera or video connections.
- LVDS (Low Voltage Differential Signaling) – Defined in 1994, LVDS has been gaining use in the automotive market as a replacement for most. Unlike MOST/LIN/FlexRay/MOST, LVDS is a point-to-point bus (not a shared bus). It has the advantage of much lower cost than MOST and many auto-makers have started using this for camera and video data. The disadvantage is that each LVDS bus can only be used to interface to only one camera or video output.

Ethernet is the “new-comer” to the automotive market.

Test Requirements

Conformance Testing

Developers and manufacturers rely on conformance testing to validate protocol compliance and interoperability. Conformance testing guarantees that whatever implementation is being enacted, it adheres to set standards. Resiliency to negative or unexpected protocol behavior is also a critical test target. The following conformance tests are needed and are already being used for automotive testing:

- TCP/UDP/IP conformance tests for automotive stacks and components
- AUTOSAR conformance
- AVB conformance
- IET conformance
- IEEE conformance

Protocol Validation and Performance Testing

There is a definite need for application level and protocol level performance testing. Such performance tests guarantee that, when used under real-world conditions, the applications work in a manner that is conducive to a quality user experience.

Such tests include the following:

- Application performance (automotive application).
- 802.1AS timing synchronization (accuracy and performance).
- A/V quality (MOS scoring).
- IET performance and timing.
- AUTOSAR performance.

PHY Testing

PHY manufacturers are asking for help in testing both 100Mbps (BroadR-Reach) and 1GE (802.3bp 1000Base-T1) PHYs. Physical testing might have a variety of purposes, such as:

- Verify that the requirements of a specification are met
- Demonstrate proof of concept
- Demonstrate the utility of a proposed implementation
- Provide standard data for engineering or quality assurance purposes
- Validate suitability for end-use

Switch testing

Automotive Ethernet switches will need to test the new AVB and IET support capabilities. The following will need to be tested:

- Queue reservation protocols

- Getting expected packet loss, bandwidth, and latency for each class of service
- Behavior when a device connected to the switch is misbehaving
- Test for failover and convergence times
- Negative test cases
- 2544/2889 testing with the above conditions

Stress and Reliability Testing of Components

Reliability is critical in automotive components. Every component needs to be tested beyond normal operation conditions. This often requires testing at extended temperatures/conditions with real software running on the device for long durations.

Security Testing

Cars are becoming more connected and software driven. There are already hacking manuals for some car models. Security is becoming more critical than ever before.

Car manufacturers need to ensure that cars have multiple failsafe systems to prevent intrusion, especially when it comes to the powertrain domain.

Manufacturing Test

The components, wiring harness, and complete car need to be validated. The tests need to validate that:

- Connections are correct
- Interconnects are working reliably (correct impedance, correct speed, no data loss)
- CPUs are working correctly
- The above work across different conditions.

Vehicle Diagnostics

Vehicle diagnostics can be in-vehicle diagnostics (built into one of the on-board computers) or external diagnostics (used to diagnose the network at a dealer). The external diagnostics can diagnose the entire car or a component.

Such diagnostic tests must be able to simulate the diagnostic equipment, as well as communicate in a meaningful manner with all the domains in the vehicle.

Conclusion

Automotive technology over time has changed cars from a simple internal combustion engine with wheels to a moving combination of integrated computer systems - such things as advanced driver assistance systems (ADAS), adaptive cruise control, hybrid engines, Internet access, and Bluetooth connection.

Cabling is the 3rd highest cost component in a car and the 3rd heaviest component in a car - only surpassed in both cases by the chassis and the engine. Simplifying and reducing cabling reduces not only fuel consumption and repair issues, but also manufacturing costs and production time.

The recent advancement in Audio Video Bridging standards (AVB) and reduced twisted pair Ethernet is driving the reality of deploying Ethernet in automobile. The industry is highly motivated by the significant benefits of expanded bandwidth, reduced labor cost and vehicle weight. Ethernet is poised to replace the disparate communication means, or to tie them together in a single backbone.

Automotive technology over time has changed cars from a simple internal combustion engine with wheels to a moving combination of integrated computer systems . . .

However, the convergence of automotive interfaces into Ethernet backbone has created unique test challenges - how do you ensure that all of these systems are working correctly, interrelating, and working seamlessly to guarantee a safe and high-quality automotive experience? Manufacturers need optimized bandwidth, reduce latency, verify clock and phase synchronization, and validate network security.

With Ixia's deep knowledge in testing IP/Ethernet, Ixia has been helping the leading automotive manufacturer to deploy the TCP/IP and Ethernet technology, including test solution in protocol conformance and traffic load test.

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