Automotive Ethernet Technology Overview

① **Above network layer**
Functional specification of software for automotive.

② **Data-Link layer:**
Functional specification of time synchronization for time sensitive network.
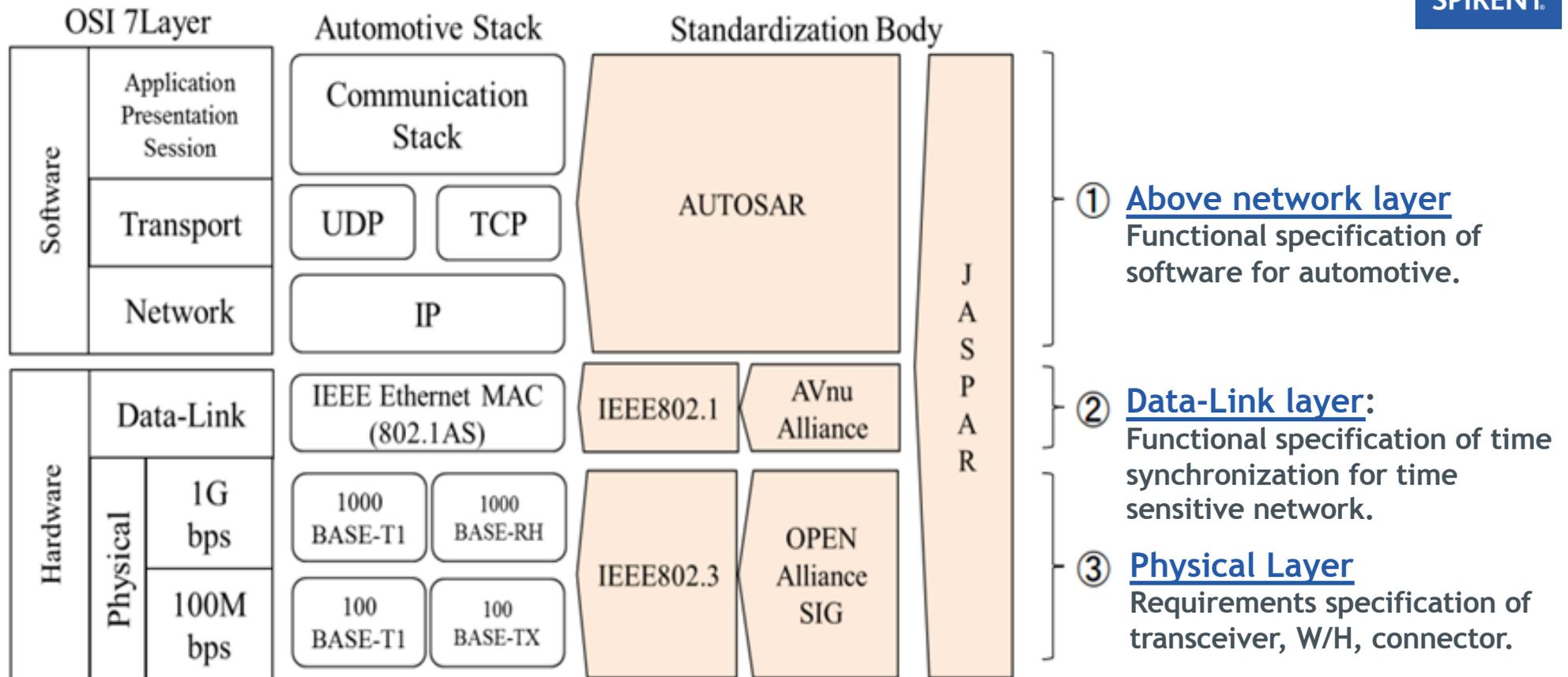
③ **Physical Layer**
Requirements specification of transceiver, W/H, connector.

https://standards.ieee.org/events/automotive/2015/12_A_Study_of_Ethernet_Protocol_for_Automotive_Application.pdf

Testing In-Vehicle Technologies

- **Physical layer Interfaces**
  - Standard Ethernet (10/100/1000BaseT)
  - 2-wire Ethernet (OPEN Alliance BroadR-Reach)
    - 100M
    - 1G
  - Wi-Fi
  - Multi-Gig
  - Noise Immunity

Replace the PHY, Nothing Else Changes

100 Mbps symmetrical operation using standard Ethernet PHY components

Full Duplex 100 Mbps single pair operation achieved

Only change is to wire-side, MAC-side remains the same
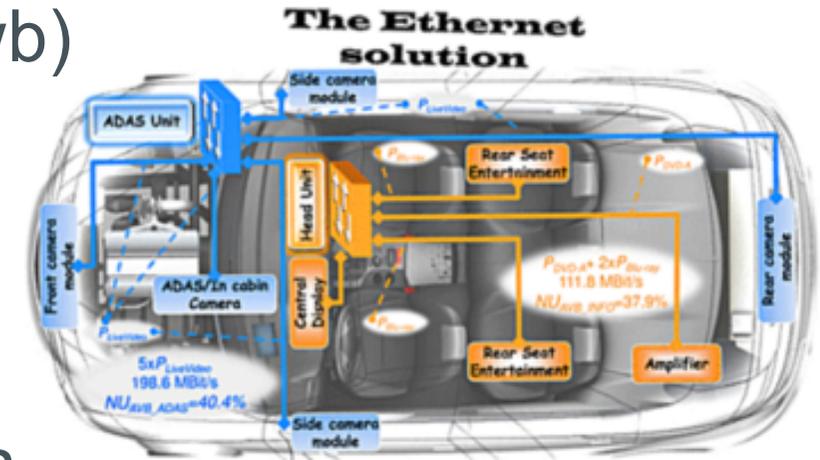
- **Layer 2-7 communication protocols**
  - Ethernet
  - IP and related higher layers
  - Time Sensitive Networks - TSN (former Audio Video Bridging - AVB)
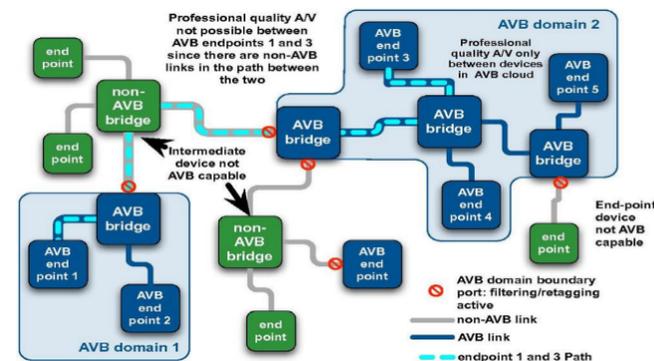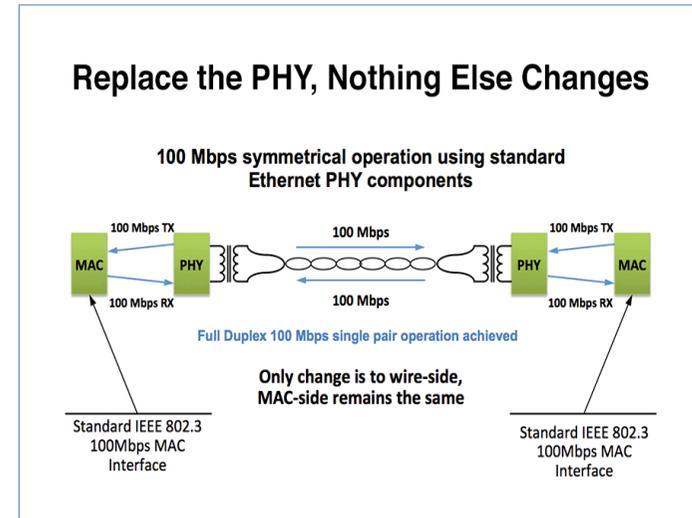
Automotive Ethernet Test Solutions

- **Automotive Ethernet Test Suites (TTwb)**

- **BroadR-Reach 100M Test Solution**

- **1000Base-T1 Test Solution**

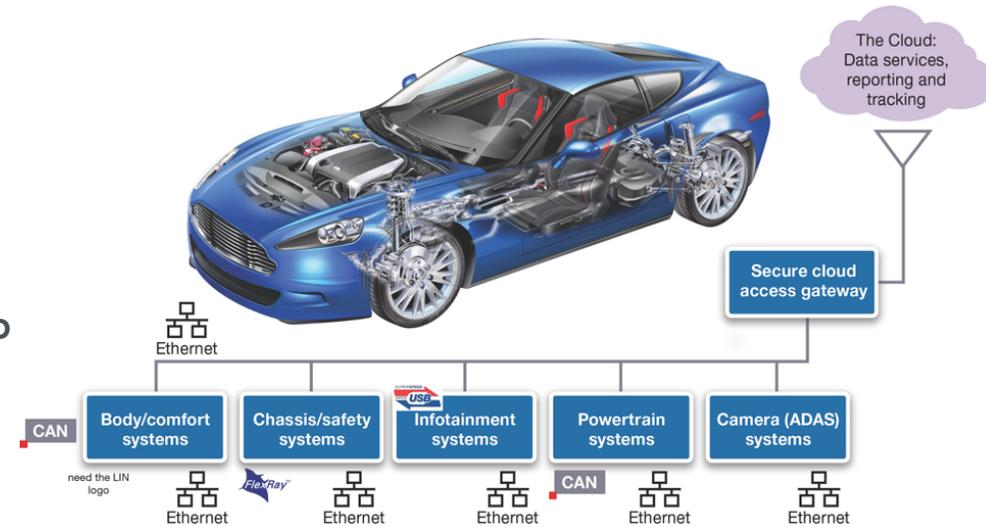- **Automotive Noise Impairment Solution**

Automotive Ethernet Test Solutions

■ Open Alliance (TC8) Compliance Test Suites (TTwb)

- ECU Test Specification

- Network Test Specification

  o ARP, DHCP, ICMPv4, IPv4, UDP, TCP

- SOME/IP

■ AUTOSAR Compliance Test Suites

OPEN Alliance SIG Conformance Test Suite Pack Coverage

ARP	DHCP	ICMPv4	IPv4	IPv4 Autoconf	UDP	TCP	SOME/IP
49	90	20	53	56	57	276	127

- Approx. 730 test cases

- Implementation of OPEN Alliance Automotive Ethernet ECU Test Specification TC8 2.0
  - Ipv6 still not part of the standard – 265 test cases ready to submit

- Full Automation – Test suites prepared automation via Upper Tester Procedures → OPEN references testability module from AUTOSAR

- Separate Integration Services available for Device Under Test
  - TTsuite-ETM (tests to validate the Upper Tester functionality)

AUTOSAR Conformance Test Suite Pack Coverage

IPv4 17   **UDP** 46   **TCP** 44

- Approx. 100 test cases

- Implementation of Acceptance Tests for Classic Platform Release 1.2
  - Acceptance Test Specification of IPv4, UDP, TCP communication AUTOSAR TC Release 1.2.0

- Prepared for test automation via test stubs using the AUTOSAR Testability Protocol and Service Primitives (Upper Tester)

- Separate Integration Services available for Device Under Test
  - TTsuite-ETM (tests to validate the Upper Tester functionality)

- Includes frameworks for individual adaptation for customer configurations

- Validated at AUTOSAR Plugfest end of 2015

connecting
a smarter future

AUTOSAR

Platform - Software

- ## Base Software (included with every kit: AUTO-Cxx-KIT-xx)
  - BPK-1001A   Packet Generator / Analyzer Base Package A

- ## STC SW Kits
  - AUTO-C1-SW-01   Automotive C1 - Advanced L2/3 Performance Test's
  - AUTO-C50-SW-01   Automotive C50 - Advanced L2/3 Performance Test's
  - STC Advanced L2/3 Performance SW Kit includes:
    - BPK-1001A   PACKET GENERATOR AND ANALYZER BASE PACKAGE A
    - TPK-1000   RFC-2544 WITH VLAN NETWORK DEVICE BENCHMARK TEST PACKAGE
    - TPK-1001   RFC-2889 WITH VLAN SWITCHING BENCHMARK TEST PACKAGE
    - BPK-1003A   IGMP MLD HOST IP MULTICAST BASE PACKAGE A
    - BPK-1155A   IEEE 1588V2 NETWORK-BASED TIMING & SYNCHRONIZATION BASE PKG
    - BPK-1170A   802.1X BASE PKG A
    - BPK-1302A   DYNAMIC PROTOCOL GENERATOR (DPG) BASE PKG A

Platform

Hardware

- **Base Hardware**
  - SPT-C1 Appliance
  - SPT-C50 Appliance
  - NIC-43 (10/100Mbps BROADR-REACH 2-WIRE ETHERNET NIC 4-PORTS)
  - NIC-33 (1Gbps COPPER Ethernet NIC 4-PORTS)
  - NIC-65 (1Gbps SFP Ethernet NIC 4-PORTS)
- **Automotive Base Kits**
 - Up to 18 Kits combining different NIC Configurations

AVB/TSN Products

TSN Advantage

- Inherently, Ethernet is a best effort networking technology

- Ethernet Time Sensitive Networking (TSN) Standards enable Ethernet to become a _deterministic_ networking technology

  - Synchronization of network elements: end-points, switches and gateways

  - Controlled and accountable delay (latency)

  - Prioritization of traffic classes

  - Guaranteed bandwidth reservation

  - Redundancy
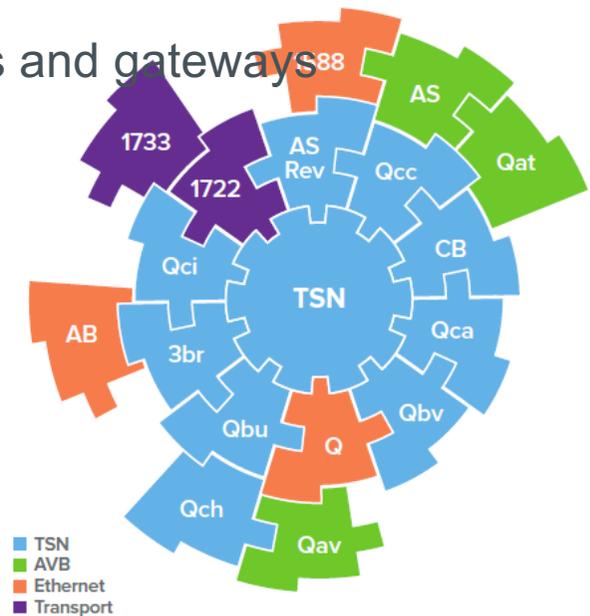
Market Needs

- Each market based on their needs adapts parts of the relevant TSN standards

- Industry compliance and interoperability

  - Avnu defines the test specs for compliance and interoperability for each market

- Test solutions required

  - Conformance

    - Ensures compliance and interoperability

  - Performance

    - Validating throughput, latency, scalability and synchronization behavior under load

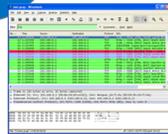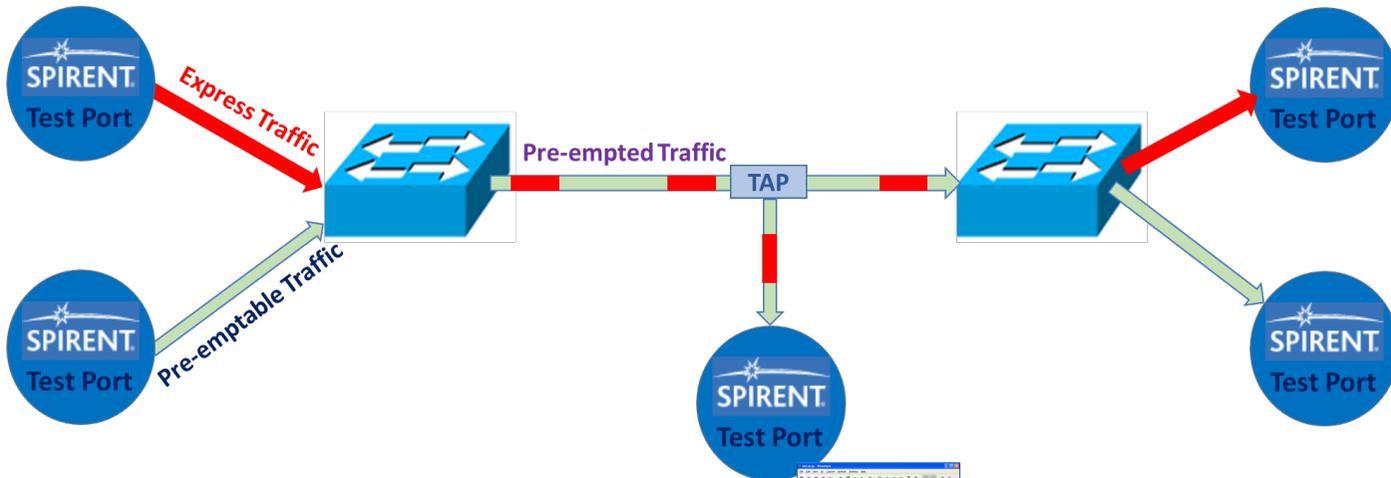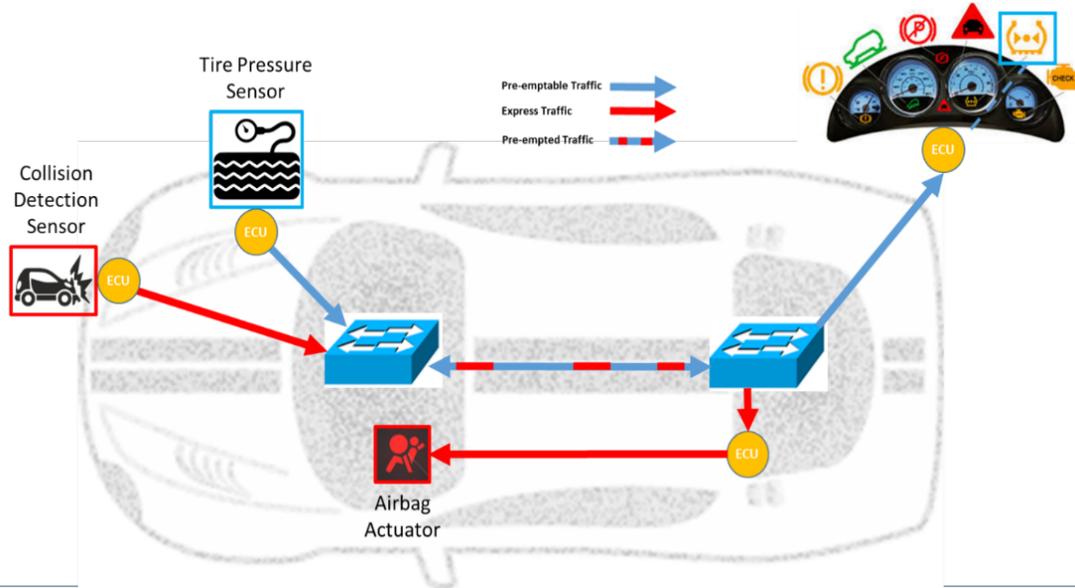   - Functional and negative testing

  - Impairment

AVB Protocol Emulation

- Emulation of multiple talker or listeners on each port
- Standards supported:
  - IEEE 802.1BA: Audio Video Bridging (AVB) Systems
    - IEEE 802.1AS: Timing and Synchronization for Time-Sensitive Applications (gPTP)
    - IEEE 802.1Qat: Stream Reservation Protocol (SRP)
    - IEEE 802.1Qav: Forwarding and Queuing for Time-Sensitive Streams (FQTSS)
    - IEEE 1722/1733: Layer 2/3 AVB Transport Protocol
- Mixed AVB and non-AVB traffic generation capability
- AVB specific metrics and statistics measurements
- Highly accurate and precise timing measurements
  - Verification of precise synchronization and presentation time

Use Case: Pre-emption Testing – Creating a pre-empted traffic profile between switch egress ports

Express Traffic

Pre-emptable Traffic

Pre-empted Traffic

Pre-empted Traffic

TAP

- Wireshark / PCAP
- Packet Statistics

Tire Pressure Sensor

Collision Detection Sensor

Airbag Actuator

Pre-emptable Traffic
Express Traffic
Pre-empted Traffic

First authorized manufacturer to license Avnu automotive AVB

Spirent Communications has become the **first authorized test equipment manufacturer to license Avnu automotive AVB test plans**, available in Spirent's Avnu Automotive AVB Conformance Test Suite Pack.

"The cooperation with Spirent has been a great experience and will further contribute to the open interoperability of networked A/V devices utilizing AVB, helping to provide the highest quality streaming A/V experience" says Joe Leong, Avnu Alliance Certification Program Manager.

https://www.spirent.com/Newsroom/Press_Releases/Releases/2016/September/09-19-16_Avnu-alliance

Avnu Automotive AVB Conformance Test Suite Pack Coverage

AS	FQTSS	1722	Exceptions	Diagnostic	Startup
98	23	73	29	24	18

- Implementation of Avnu Automotive Test Plans
- Included test suites (approx. **260** test cases)
  - TTsuite-AVB-AS (**end station** + **bridge**), TTsuite-AVB-FQTSS (**bridge**)
  - TTsuite-AVB-1722 (end station), TTsuite-AVB-Exceptions (end station + bridge)
  - TTsuite-AVB-Diagnostic (end station), TTsuite-AVB-Startup (end station)
- All test suites are prepared for test automation and include frameworks for individual adaptation

TSN Conformance Test Suite Pack Coverage

… currently under development

Preemption 53

Time Aware Shaper 50

Filtering & Policing 100

Redundancy 80

- Implementation of test cases for
  - Pre-emption (IEEE802.1Qbu & 802.3br)
  - Time Aware Shaper (IEEE802.1Qbv)
  - Filtering & Policing (IEEE802.1Qci)
  - Frame Replication and Elimination for Reliability (IEEE802.1CB)