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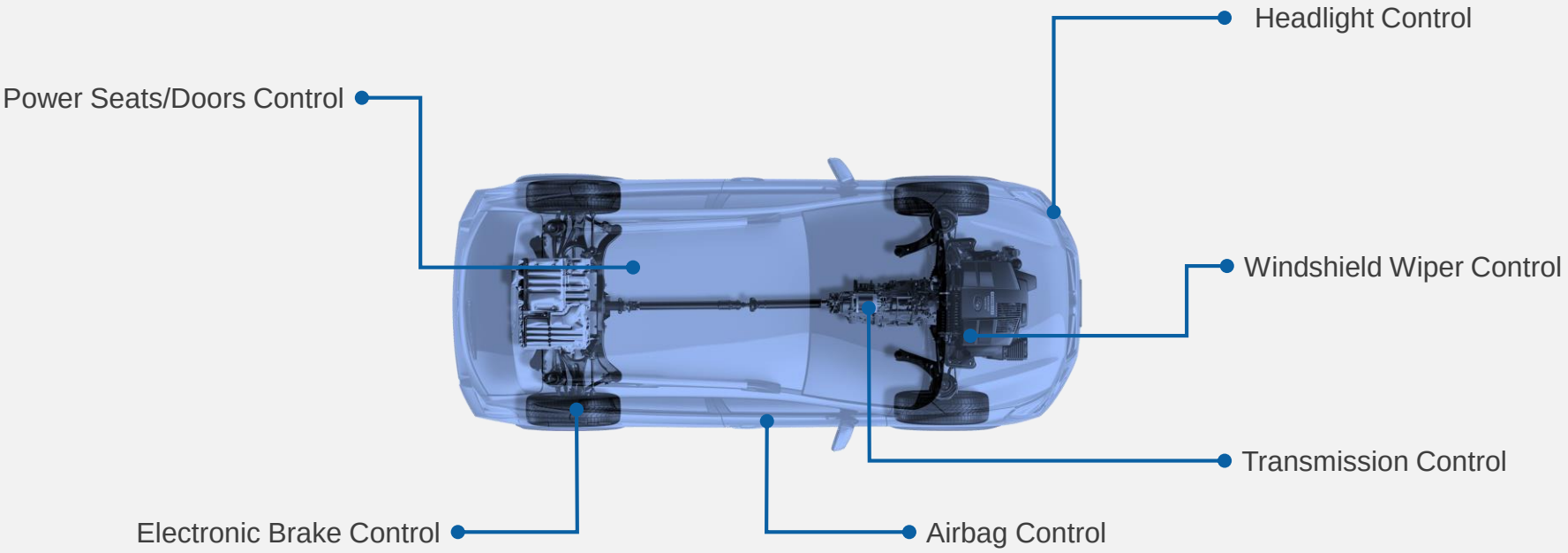
Introduction to Automotive Ethernet for Deterministic Control and Increased Bandwidth

Smarter Test for Smart Vehicles

Nicholas KEEL

Group Manager – DAQ and Control Product Management

Increasing Vehicle Complexity



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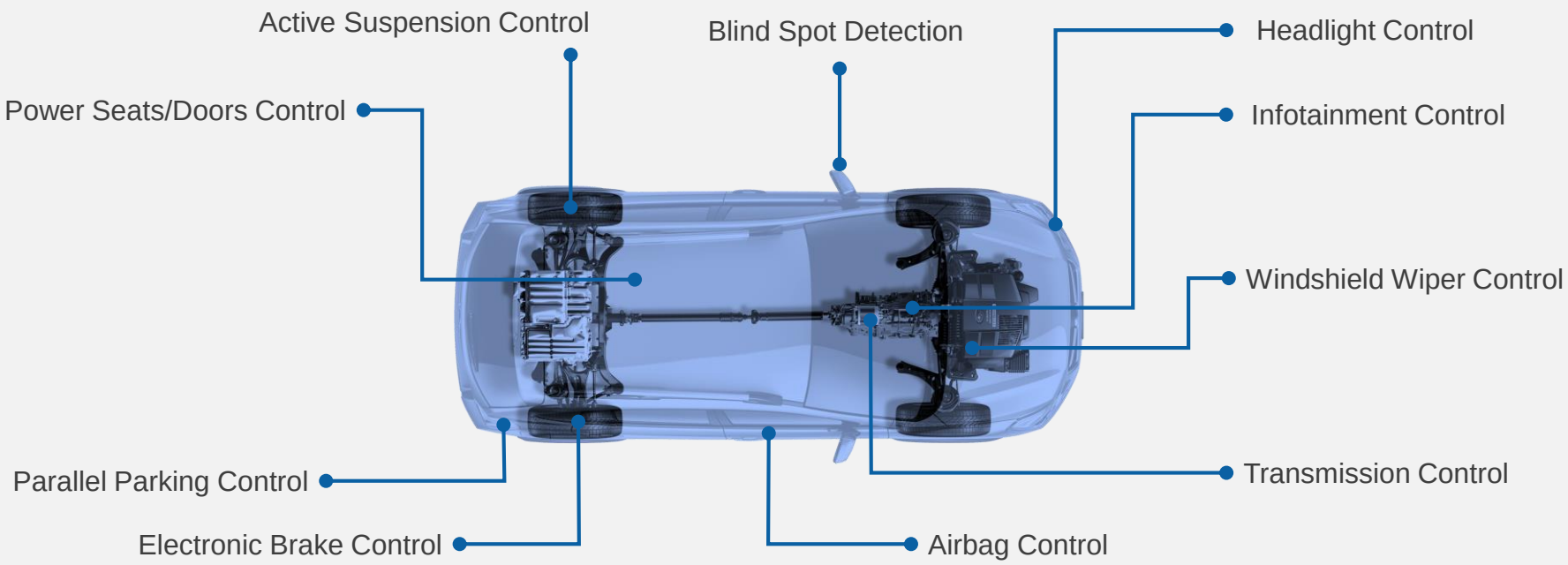

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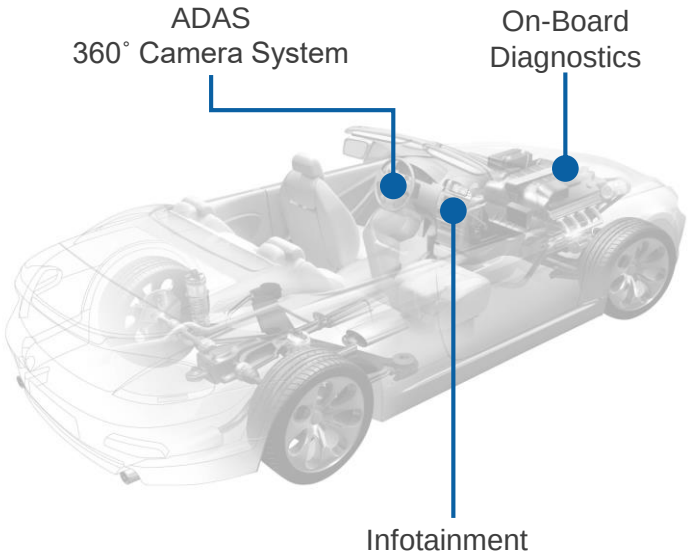
Innovation is Driving Increasing Data



Cars are innovating quickly

- Electric, autonomous, vehicle-to-vehicle/infrastructure, infotainment/connectivity, ...

This results in more data

- Cameras w/ 4k uncompressed video, Lidar, Internet traffic, ...

While retaining determinism and robustness of CAN or FlexRay

Within vehicle, Ethernet is solving these challenges

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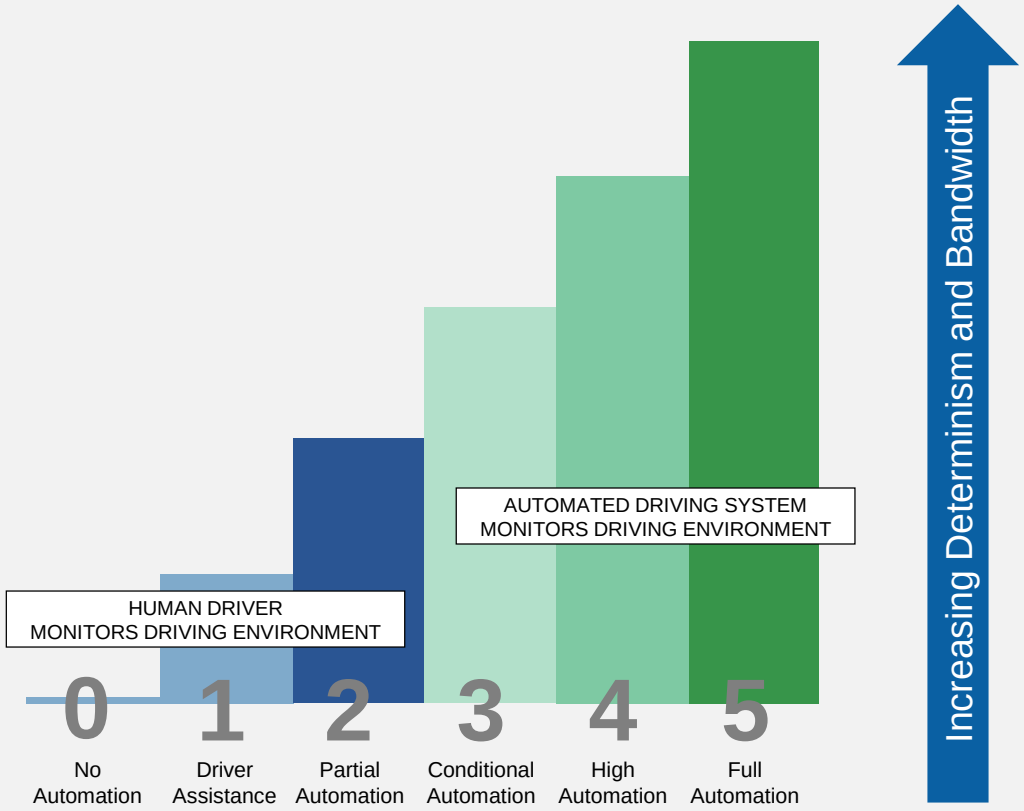
SAE INTERNATIONAL

AUTOMATED DRIVING



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Automotive Ethernet Adoption

Source: Strategy Analytics Oct 2015

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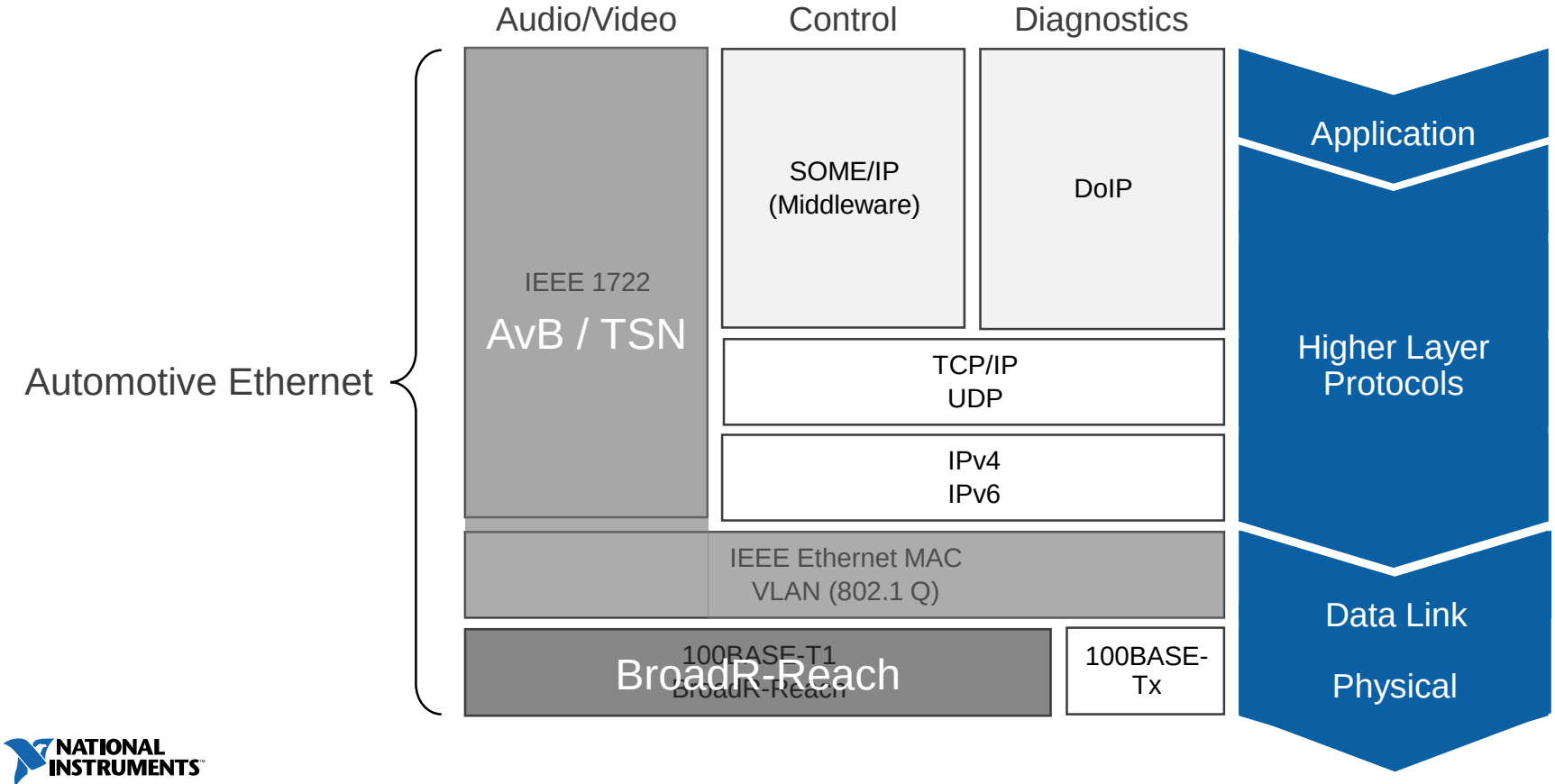
Generalized Automotive Ethernet Protocol Stack



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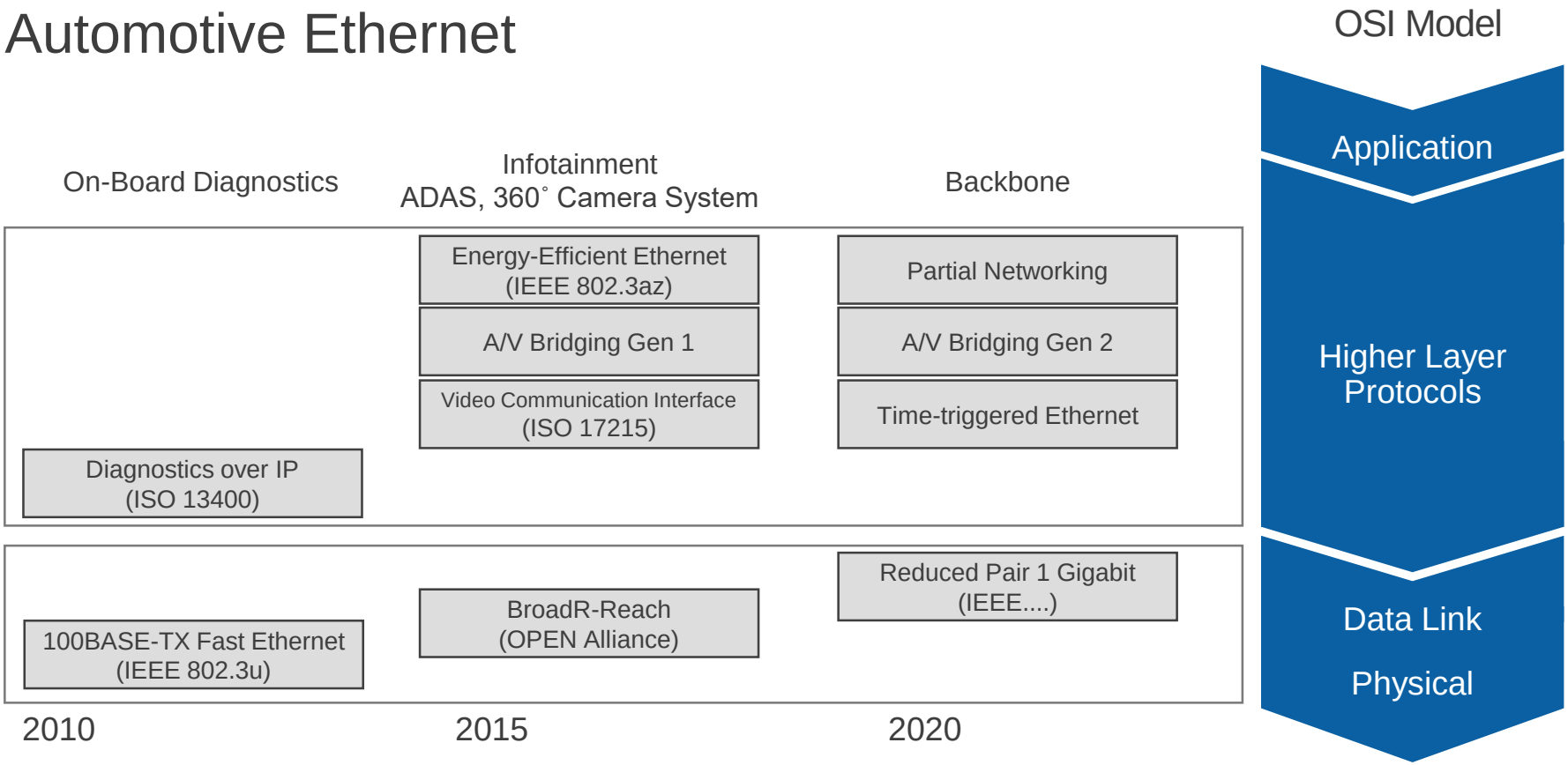
Automotive Ethernet



Adapted from Ixia Automotive Ethernet Whitepaper, May 2014

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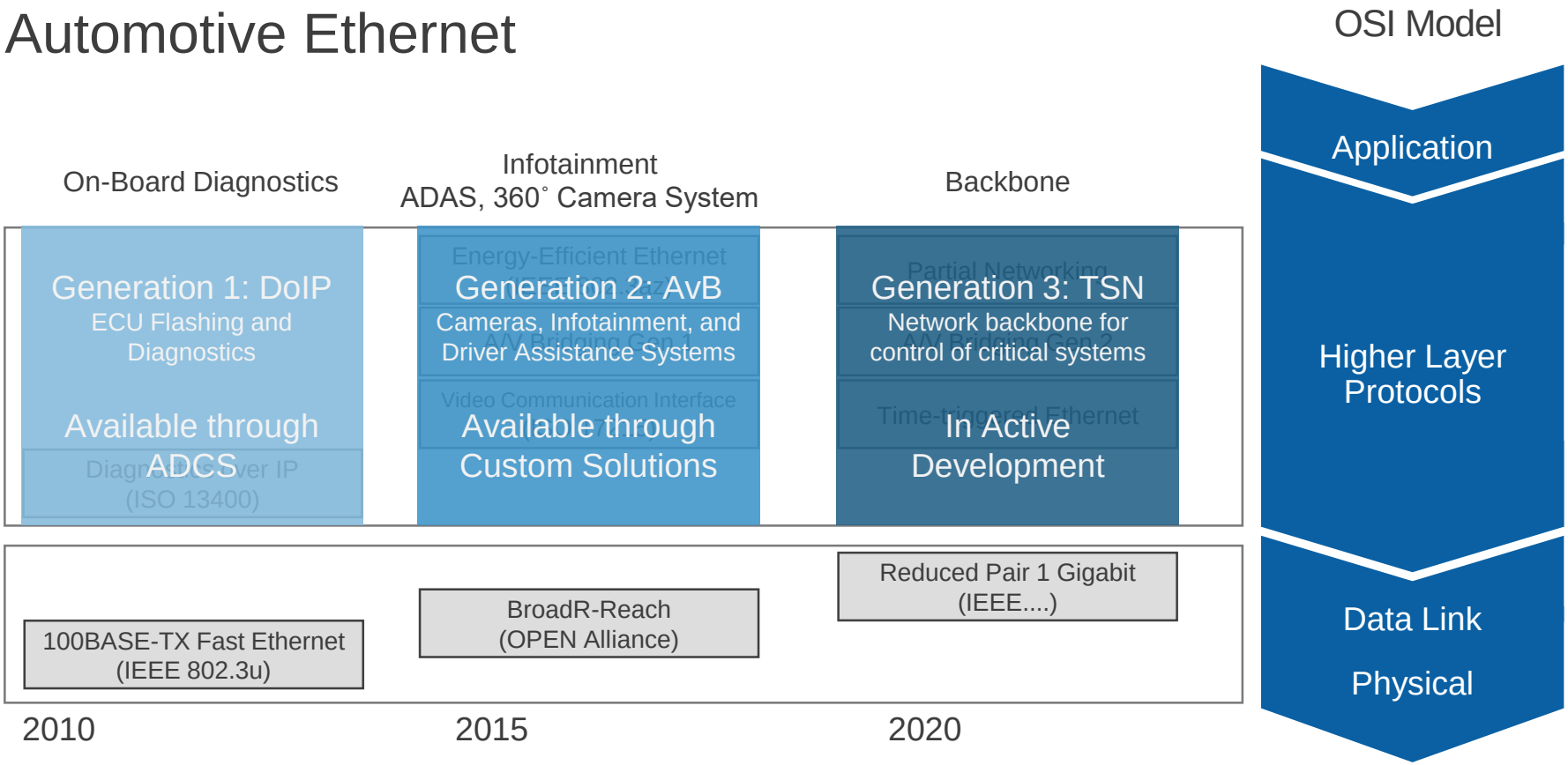

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NI's Role in Standardization of Automotive Ethernet

IEEE Standards - Editors

Avnu Alliance Board of Directors

- Interoperable ecosystem servicing the precise timing and low latency requirements using open standards through certification
- Automotive Ethernet AVB Functional and Interoperability Specification Revision 1.4

OPEN Alliance SIG Adopter

- Driving industry standards for an open scalable Ethernet-based network

AUTOSAR Associate Partner

- Ethernet support since AUTOSAR 4.0

1st Generation: Connect Single Computer to ECU

Cable uses conventional Ethernet signals

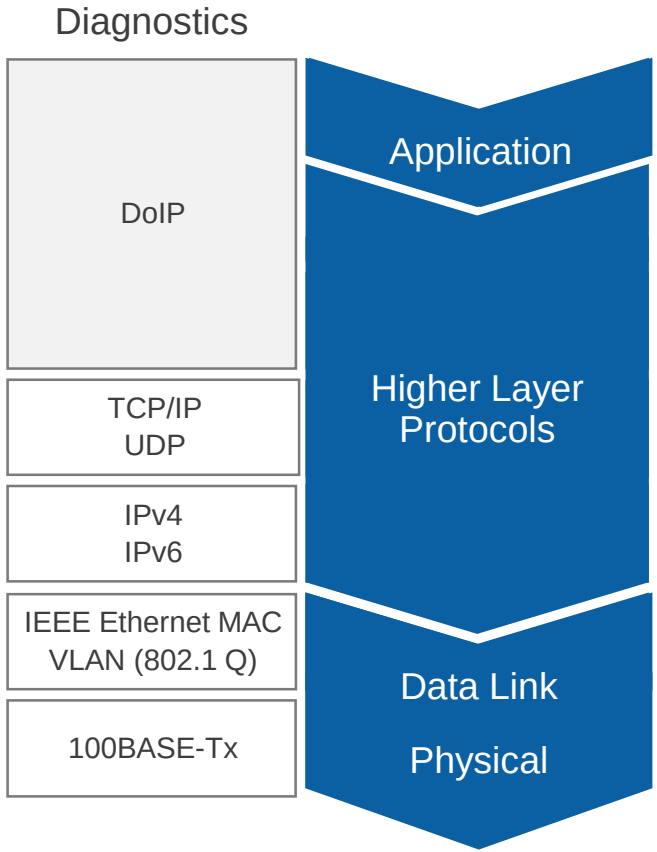
- Same as wireless router, computer, PXI/CompactRIO, etc

NI ECU Measurement and Calibration Toolkit

- XCP on TCP/IP or UDP
- ASAM MCD 2MC databases (i.e. .A2L)

NI Automotive Diagnostics Command Set

- Diagnostics over IP (ISO 13400)
- Automotive diagnostic connector (OBD)



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IEEE Standards for 2nd Generation

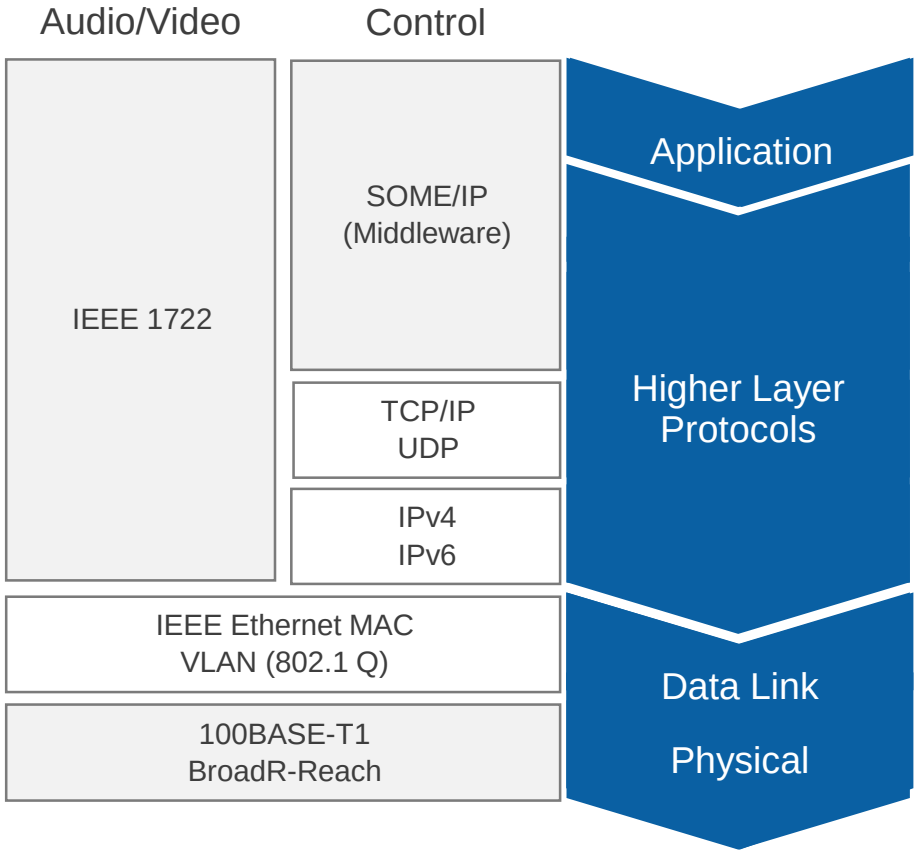
IEEE 802.3: Ethernet MAC and PHY

- 100BASE-T1 (802.3bw-2015):
  100 Mb/s single-pair copper PHY
- 1000BASE-T1 (802.3bp, 3Q2016):
  1000 Mb/s single-pair copper PHY

IEEE 802.1: Bridge, Audio/Video Bridging (AVB) task group

- Time synchronization (802.1AS-2011)
  - Hardware based, using IEEE 1588
- Stream Reservation Protocol (SRP)
  - In bridge standard (802.1Q-2012)
  - Determinism sufficient for infotainment and driver assist

IEEE 1722-2011: Protocol for audio/video data



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Why Not Use Conventional Ethernet In-vehicle?

Too heavy

Too expensive

- Automotive components count pennies

Not robust in automotive environment

- PHY: Temperature extremes, noise, EMC, ...
- Switch: Failure of cable or chip

Not deterministic

- Bounded latency from transmit of data to receive

Typical Wiring Harness in a Car

Image Source: Molex

Cabling is the 3rd highest cost component in a car

- Engine (1st)
- Chassis (2nd)

Harness are built ONE at a time with 50% of cost in labor

Cabling is the 3rd heaviest component in car

- Chassis (1st)
- Engine (2nd)

Reducing cable weight has a direct impact on fuel economy

Reduced Twisted Pair Gigabit PHY – IEEE 802.3 Call for Interest

Automotive Copper PHYs

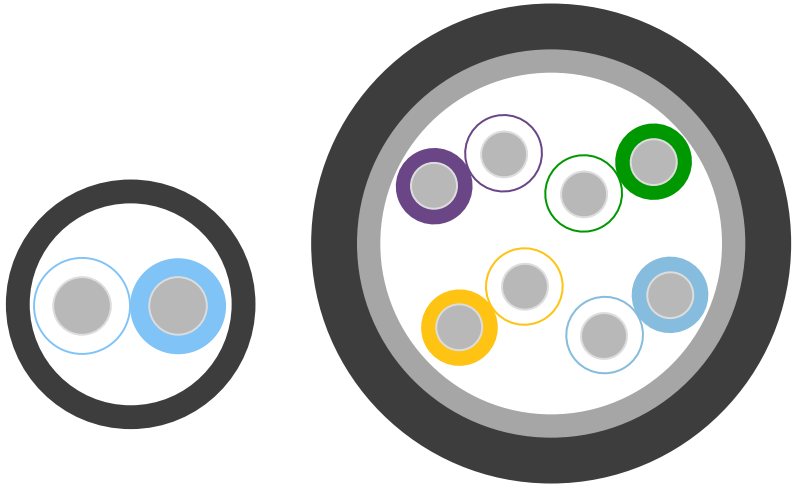
Started with BroadR-Reach PHY

- 2011 product from Broadcom, 100 Mb/s
- Single unshielded twisted pair (UTP)
- Balanced (consistent twist)

Meets PHY requirements

- ✓ Low weight
- ✓ Low cost
- ✓ Environmental

Max 15m per cable



Automotive Ethernet

Conventional Ethernet

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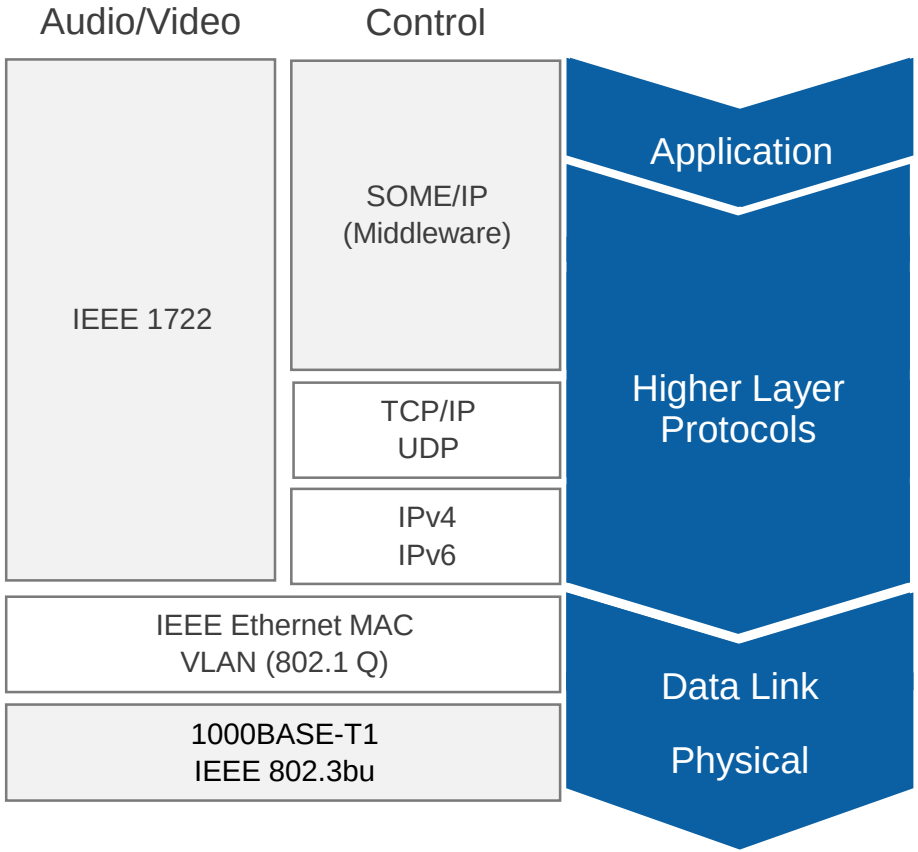
IEEE Standards for 3rd Generation

IEEE 802.3: Ethernet MAC and PHY

- Power over Data Lines, PoDL (802.3bu, 1Q2017)
  - DC power over single-pair copper PHYs
- Call for interest: 10BASE-T1 for lowest-cost 10 Mb/s copper

IEEE 802.1: Bridge

- AVB task group renamed to Time-Sensitive Networking (TSN) task group
  - Reflects expansion to automotive control (e.g. automated driving), as well as industrial/embedded control, mobile fronthaul (5G), ...



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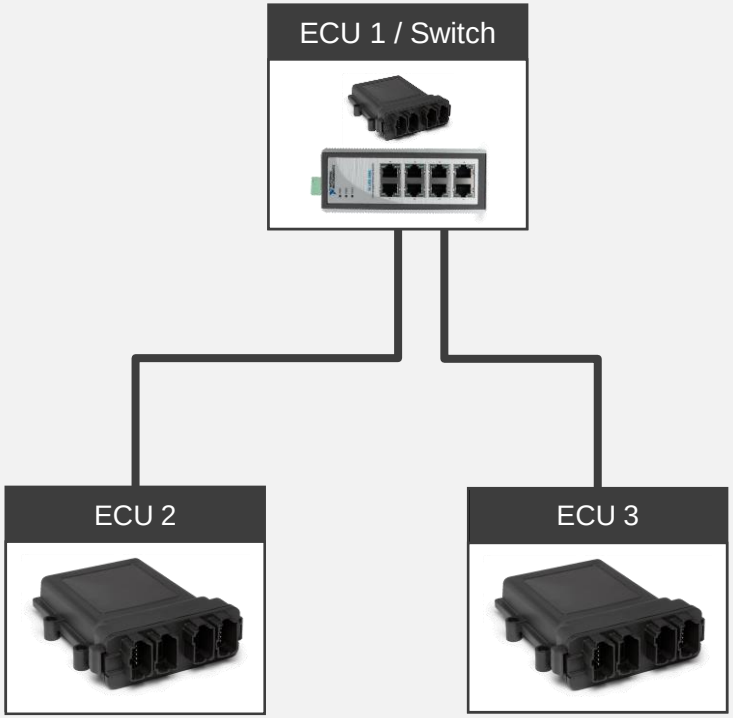
Basic Automotive Ethernet Network



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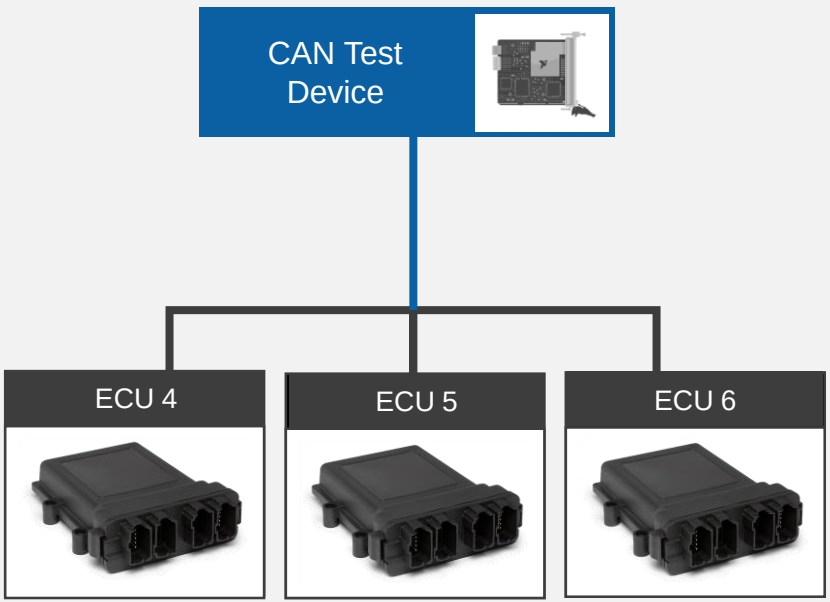
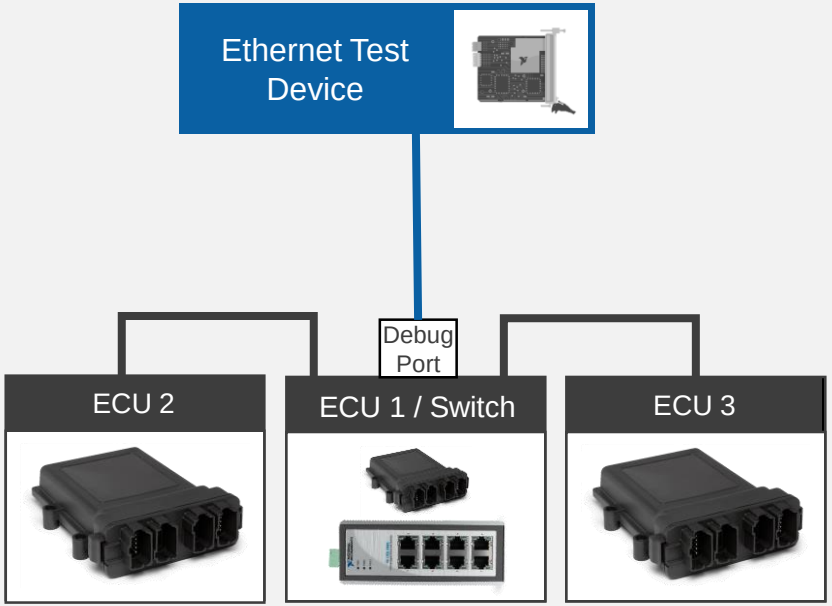
Comparing Test Networks





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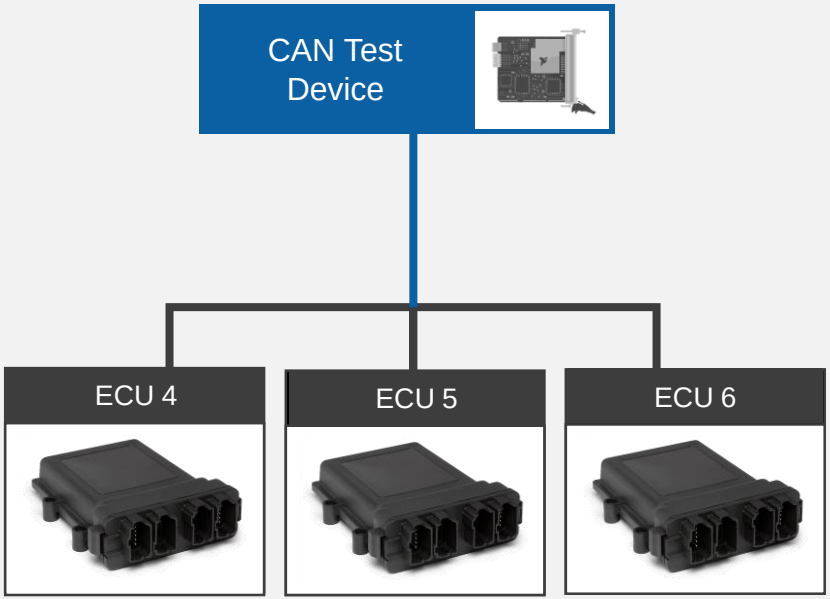

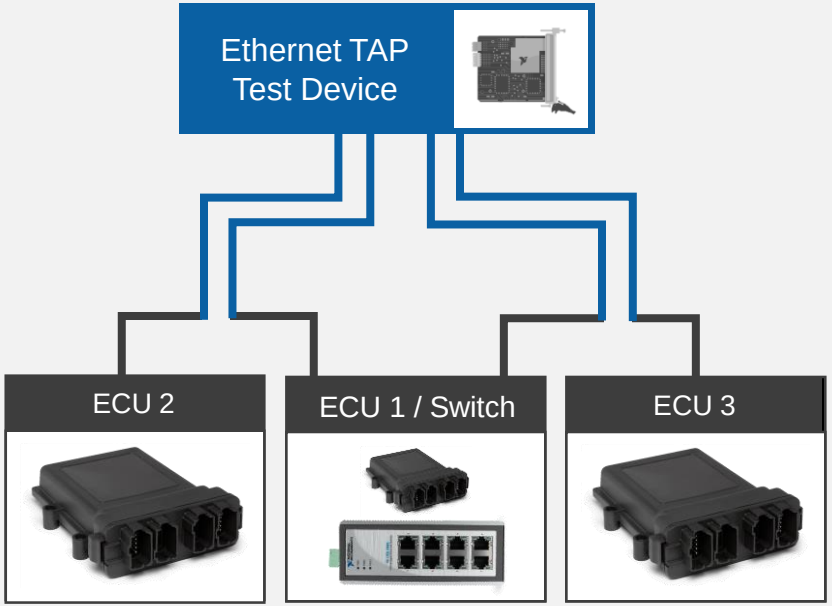

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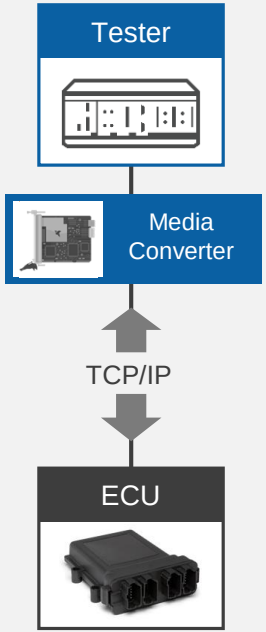
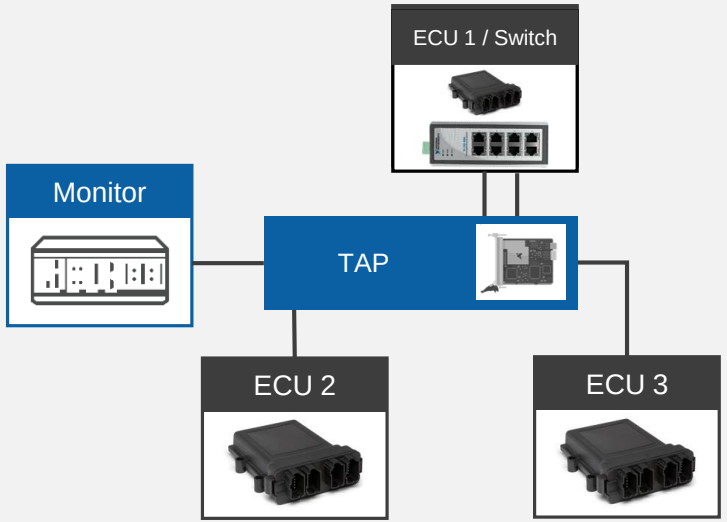
Typical Automotive Ethernet Testing Cases

Basic Functional Test



Monitoring and Logging



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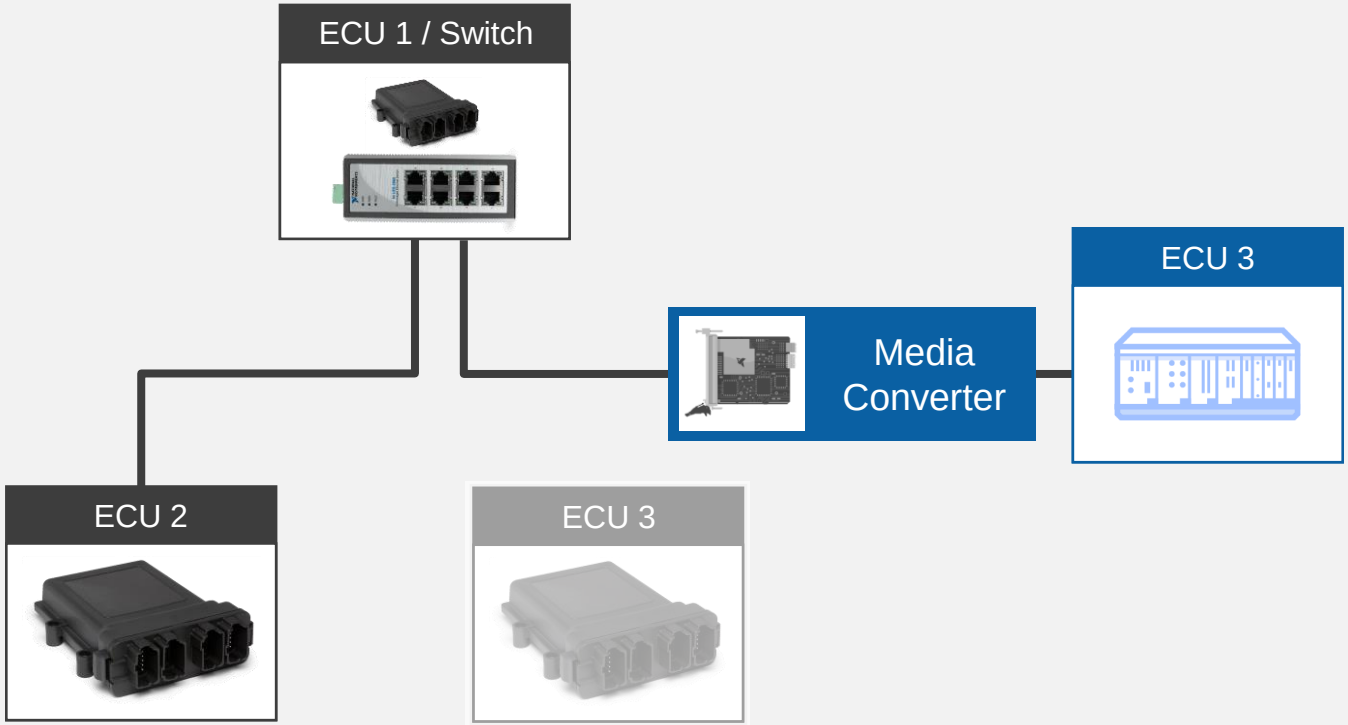
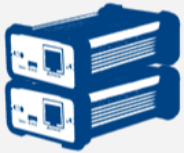
Simulating an ECU



Current Automotive Ethernet Solution Paths from NI

Media Converter

- Connect BroadR-Reach to Traditional GigE
- Timing Agnostic
- Limited TSN or AVB Functionality Today
- Best Ease of Implementation
- Most Cost Effective
- Available from Partners with no additional software required



High-Speed Serial

- Connect directly to Physical Layer via SFP
- Custom Solutions Required for 802.1AS Timing on PXIe
- Transmitting/Receiving UDP packets via FPGA
- Implement standards on FPGA
- Most flexible and software upgradable solution

Partner Solutions

- Typically designed to a specific physical layer
- Offers ability for OEM specific customization
- Implementation can vary based on customer requests

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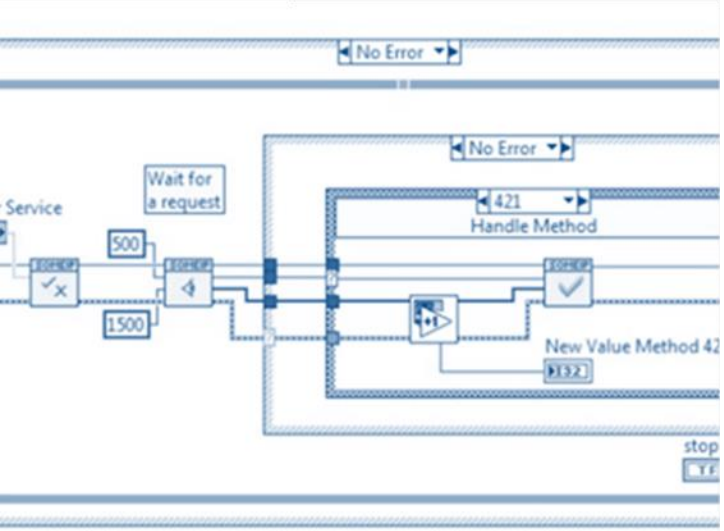
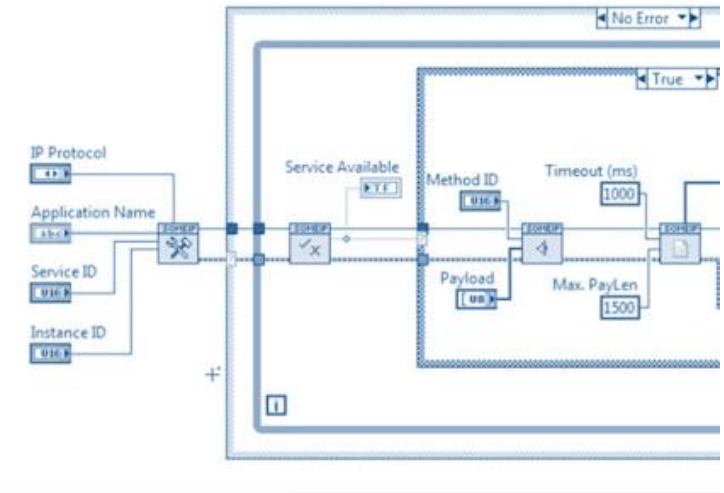
100BASE-T1 Media Converter

IVN-8561

Q1 2018

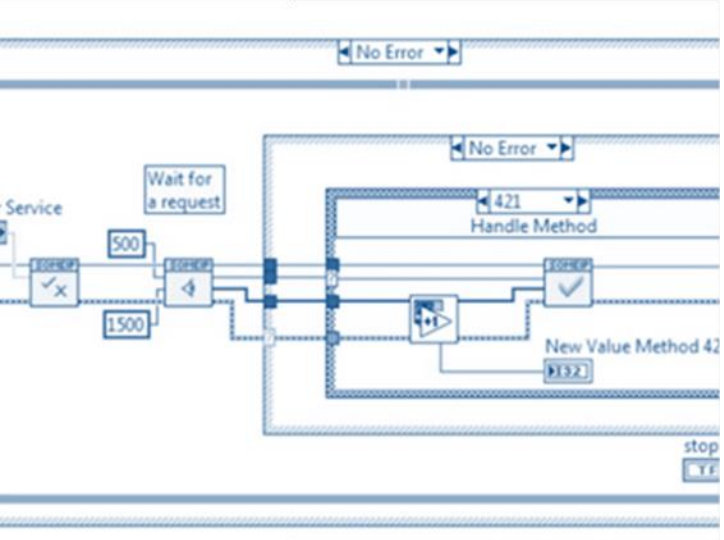
- Converts the Unshielded Twisted Pair (UTP) Automotive Ethernet to Standard 100Base-TX Ethernet
- 2-Ports 100BASE-T1
  - NXP TJA1100
- 2-Ports 100BASE-TX
- 5 V Power Input
  - Included USB Type-C Cable with retention
- Master/Slave configuration of each 100BASE-T1 port

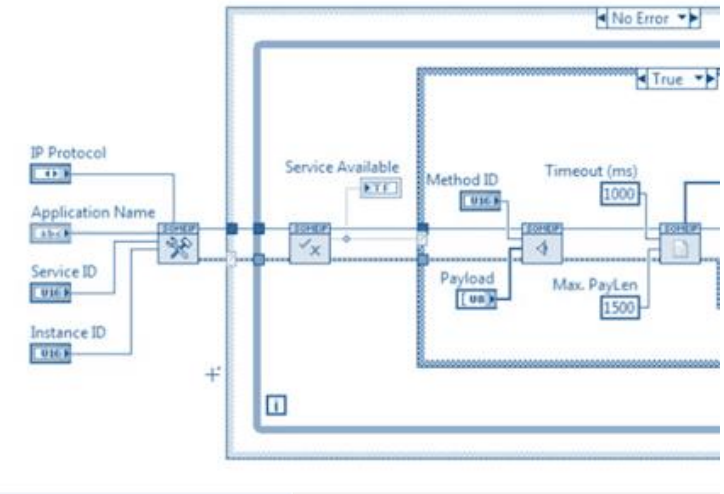




Automotive Ethernet Examples

- First examples available
- Updates and additional examples throughout 2017
- Directly NI R&D Supported
- Available through “LabVIEW Automotive Ethernet” community page
- Supports Windows and Linux RT
- Built on top of current ethernet drivers, does not require new driver

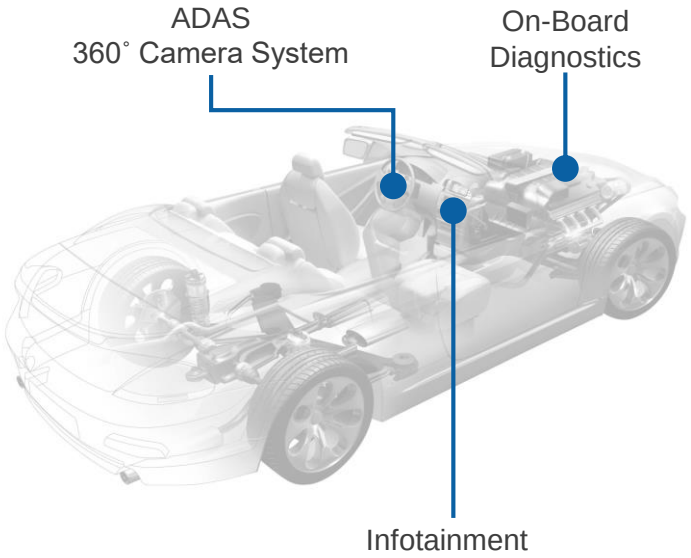




Automotive Ethernet Examples

- **Current LabVIEW UDP/TCP Examples**
- **Examples for Raw Ethernet frames**
- AVTP (Audio Video Transport Protocol) Examples
  - Also refer to by IEEE 1722 or “AVB”
  - Includes ACF (Control), AAF (Audio), and CVF (Video) frame formats
- Signal conversion of encapsulated CAN/LIN frames within Ethernet frames
- SOME/IP Client and Server Examples

Conclusion



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This results in more data

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While retaining determinism and robustness of CAN or FlexRay

Within vehicle, Ethernet is solving these challenges **and NI is helping lead the way**

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