Overview on Automotive Ethernet

Vector India Conference 2019
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Simple Question! What are you doing?

- IEEE
- GEPOF
- Ethernet
- RTPGE
- 802.3bp
- 802.3bw
- 1TPCE
- 1000BASE-T1
- BroadR-Reach
- OABR
- OPEN
- 100BASE-T1
- IP
Wired Acronyms And Terms – Let’s Sort The Terms

- IEEE 802.3 Task Force names

**1TPCE** = One (1) Twisted Pair 100 Megabit (C = century = 100) Ethernet

- RTPGE = Reduced Twisted Pair Gigabit Ethernet
- GEPOF = Gigabit Ethernet Over Plastic Optical Fiber
IEEE 802.3xx → Name of a project within an IEEE Working Group

- 802.3bp
  - bp = Reduced Twisted Pair Gigabit Ethernet
- 802.3bw
  - bw = One (1) Twisted Pair 100 Megabit (C = century = 100) Ethernet
  - bv = Gigabit Ethernet Over Plastic Optical Fiber
Wired Acronyms And Terms – Let’s Sort The Terms

- Name of the physical layer
  - **100BASE-T1** = 100 Megabit Baseband One Pair
  - **1000BASE-T1** = 1 Gigabit Baseband One Pair
  - **1000BASE-RH** = Gigabit Ethernet Over Plastic Optical Fiber
Introduction

Wired Acronyms And Terms – Let’s Sort The Terms

- Organizations and Technology

- OABR, (OPEN Alliance) BroadR-Reach
  - Early name for 100BASE-T1 when IEEE has not been involved and OPEN Alliance introduced Broadcom’s BroadR-Reach technology to the automotive world.

- OPEN, OPEN Alliance = One Pair Ethernet Network Alliance

- BroadR-Reach

- OPEN

- OABR
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Who Are The Actors

Organizations

**One Pair Ethernet Network Alliance**
- “One voice” from the automobile industry
- Two types of membership (companies)
  - Promoters (16)
  - Adopters (359)
- Hosts 14 Technical Committees (TC)
  - Address all open items, not harmonized within other documents. E.g. compliance tests, interoperability tests, minimum requirements, ...

**Institute of Electrical and Electronics Engineers**
- 802.3 „Home“ of Ethernet
Who Are The Actors

Separate Areas of Activity

"Channel"
- 15 meter
- Single UTP
- EMC
- ...

Conformance/Interoperability tests

7 Application
6 Presentation
5 Session
4 Transport
3 Network

2 Data Link
1 Physical

MAC

PHY

2 Data Link
1 Physical

PHY

MAC
OPEN Alliance hands over all documents to ISO for long term availability
OPEN Alliance still creates/maintains the documents
ISO standard is ISO 21111 Road vehicles – In-vehicle Ethernet and its parts
  Part 1*** : General information and definitions
  Part 2***: System requirements and physical layer interfaces
  Part 3**: Optical 1-Gbit/s physical layer
  Part 4**: General requirements and test methods of optical gigabit ethernet components
  Part 5***: Optical 1-Gbit/s physical layer system specification and interoperability test plan
  Part 6*: Electrical 100-Mbit/s physical layer device specification and conformance test plan
  Part 7*: Electrical 100-Mbit/s physical layer system specification and interoperability test plan
  Part 8*: Electrical 100-Mbit/s component requirements and test methods
  Part 9*: Bridge specification and conformance test plan
  Part 10*: General device requirements and test methods
  Part 11****: Electrical 1-Gbit/s physical layer device specification and conformance test plan
  Part 12****: Electrical 1-Gigabit/s physical layer system specification and interoperability test plan
  Part 13****: Electrical 1-Gigabit/s component requirements and test methods

*New Project; ** Committee Draft; *** Approved New Work Item; **** Preliminary Work Item
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4. Ethernet vs. Traditional Bus Systems
5. Protocols And Their Applications
Technology

What is 100BASE-T1

- Combination of existing technologies!
- IEEE 100BASE-TX
  - Dual simplex
  - MLT-3 (Multi Level Transmission)
    - 125 MspS, 65~80 MHz bandwidth
  - Two twisted pairs
  - No error correction coding
  - No Echo and crosstalk cancelation in DSP
  - Decision Feedback Equalization (DFE)
What is 100BASE-T1

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- **IEEE 100BASE-TX**
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  - MLT-3 (Multi Level Transmission)
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  - Two twisted pairs
  - No error correction coding
  - No Echo and crosstalk cancelation in DSP
  - Decision Feedback Equalization (DFE)
- **IEEE 1000BASE-T**
  - Full Duplex
  - 4D-PAM5
    > 125 Mps, 65~80 MHz bandwidth
  - Four twisted pairs
  - Partial response transmit filter
  - Additional level for error correction coding
  - Echo and crosstalk cancelation in DSP
  - Decision Feedback Equalization (DFE)
Technology

What is 100BASE-T1

- 100BASE-T1
  - Full Duplex
  - PAM3, 66.7 Msps, 27 MHz bandwidth
  - Single twisted pairs
  - Echo cancelation
  - Decision Feedback Equalization (DFE)

3B2T: $\text{TA}_1 \ -1 \ -1 \ -1 \ 0 \ -1 \ 1 \ 0 \ -1 \ 1 \ -1 \ 1 \ 0 \ 1 \ 1$

PAM3: $\text{TA}_1 \ -1 \ -1 \ -1 \ 0 \ -1 \ 1 \ 0 \ -1 \ 1 \ -1 \ 1 \ 0 \ 1 \ 1$

MAC  PHY  PHY  MAC

MII  Full duplex PHY  MII
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Switched Networks
Ethernet vs. Traditional Bus Systems

Connecting Networks – IP vs. MAC

- ECU #A
- ECU #B
- ECU #D
- Switch
- Ethernet
- Gateway/Router
- IP

- ECU #A
- ECU #B
- ECU #D
- Switch
- Ethernet
- Gateway/Router
Signals And PDUs (Protocol Data Unit)

Ethernet vs. Traditional Bus Systems

Unicast or Groupcast

ECU #A

Switch

PDU #1
Signal A, B, C

PDU #2
Signal D, E, F

PDU #3
Signal G, H, I

ECU #B

Ethernet
Signals And PDUs (Protocol Data Unit)

Ethernet vs. Traditional Bus Systems

ECU #A

Switch

Unicast or Groupcast

ECU #B

Head

PDU #3
Signal G, H, I

PDU #2
Signal D, E, F

PDU #1
Signal A, B, C

Ethernet
Signals And PDUs (Protocol Data Unit)

Unicast or Groupcast

ECU #A

PDU #3
Signal G, H, I

PDU #1
Signal A, B, C

Switch

ECU #B

Ethernet
Service Oriented Communication and Service Discovery

- Request a service (optional)
- Announce/offer a service (cyclic)
- Exchange connection information and subscribe the service (cyclic)
- Event/data
  - Remote Procedure Call (RPC)
  - Request
  - Response

ECU #A
- Client

Switch

ECU #B
- Server

Ethernet
Ethernet vs. Traditional Bus Systems

How to Access The Network?

ECU #A

Switch

ECU #B

Ethernet

Switch

ECU #C

Tool
How to Access The Network?

Ethernet vs. Traditional Bus Systems

ECU #A
Switch
ECU #B
Switch
ECU #C
Ethernet

Tool
Protocols And Their Applications

Bird View – High Speed Link

- Broadcom BroadR-Reach, 100 Mbit/s, full duplex, twisted pair
  - Bird View has been Day-One application for 100BASE-T1
  - Replace expensive shielded cable
  - Bi-Directional communication
- Utilizing high bandwidth
- MAC based Video streaming, time critical
- Enhanced by ADAS functionality (additional cameras, radar, lidar, ...)
  - High resolution and frame rate, less compression
  - Requires 1000 Mbit/s and more

![Diagram of CAN and Ethernet connections to ECU](image)
In-Vehicle Computing Layer

- High resources
  - (Virtual) ECUs / Function oriented
- Environmental data model
- Closed-loop controls
- Smart Sensor/Actor

Infrastructure – Connect Application Server

- Offboard
  - Very high computing power

- In-Vehicle
  - Next Generation Automotive Ethernet phys offer 2.5, 5 or more Gbit/s (e.g. 10BASE-T1S)

- (Virtual) ECUs / Function oriented

- Closed-loop controls
- Smart Sensor/Actor
For more information about Vector and our products please visit

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