ETHERNET ECU CONFORMANCE TESTING AND NETWORK VALIDATION

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Automotive Ethernet Symposium 2019
AGENDA

OPEN Alliance TC8 ECU Test

• Motivation and Scope

• Experiences and Challenges

Network Level Validation

• Motivation and Outlook

Conclusion
OPEN ALLIANCE TC8 TEST - MOTIVATION

- Motivation of OPEN Alliance
  - Specifications for conformance and interoperability
    - Adapted to automotive requirements
  - Utilization of scalability and flexibility of Ethernet
  - Cost effective communication networks

- Motivation of TC8 ECU Test
  - Conformance validation of Ethernet and TCP/IP implementation
  - Early testing on ECU level during development
    - Comprising hardware, software and configuration
### OPEN ALLIANCE TC8 TEST - SCOPE

- Test scope of the OPEN Alliance ECU Test

<table>
<thead>
<tr>
<th>Protocol Layer</th>
<th>Test Group</th>
</tr>
</thead>
<tbody>
<tr>
<td>Physical Layer</td>
<td>PMA Interoperability</td>
</tr>
<tr>
<td>Data Link Layer</td>
<td>L2-Switch (e.g. IEEE 802.1Q) ARP</td>
</tr>
<tr>
<td>TCP/IP Protocol Layers</td>
<td>IPv4 ICMPv4 UDP TCP DHCPv4 Client IPv4 Auto-Configuration</td>
</tr>
<tr>
<td>Application Layer Automotive Protocols</td>
<td>SOME/IP-SD SOME/IP ETS</td>
</tr>
</tbody>
</table>

![Diagram showing protocol layers and their corresponding test groups.](image)
OPEN ALLIANCE TC8 TEST - PROCESS

- First test with early development sample
  - Test coverage according to available functionality
- Regression tests for relevant (HW, SW) changes

- Test house quality assurance process
  - Objective: Comparable and reliable test results
  - OPEN Alliance TC13
    - Round robin test on PHY level
    - PHY samples from different manufacturers
    - Currently in progress
OPEN ALLIANCE TC8 TEST - STATUS

- OPEN Alliance Automotive Ethernet ECU Test Specification
  - Released: Version 2.0 (August 2017)

- Maintenance and development of the ECU test specification
  - Transition to ISO 21111
    - Based on current TC8 version
  - Revision by TC8
    - Started in November 2018
    - Release version 3.0 planned in 2019
OPEN ALLIANCE TC8 TEST – CHALLENGES & EXPERIENCES

- Physical Layer Test – Challenges
  - Test cases require a variety of test setups
    - Most test setups require different measurement equipment
  - Test fixture design adaptation to the individual ECU connector
    - Qualification of each test fixture
  - Diagnostic functionality not standardized by OPEN Alliance
    - Often realized with proprietary implementations
    - Partly covered by AUTOSAR TC v1.2.0
  - Diagnostic/test port conflict
OPEN ALLIANCE TC8 TEST – CHALLENGES & EXPERIENCES

- Physical Layer Test – Experiences
  - Interoperability issues of ECU PHY and link partner
    - In case of different PHY manufacturers
  - MDI Return Loss above limit
    - Instable link during PHY start-up
      - Causing link-up times out of limits
  - Limitations of diagnostic PHY features
    - e.g. cable diagnostics: limited “short” detection
  - Test reality vs. test specification
    - e.g. realization of signal quality degradation
OPEN ALLIANCE TC8 TEST – CHALLENGES & EXPERIENCES

- Physical Layer Test – 1000BASE-T1 & Multi-Gigabit
  - Incorporation of 1000BASE-T1 scope into TC8 test specification v3.0
    - Test results currently validated against preliminary specification and 1000BASE-TX limits
  - Challenges in view of higher data rates
    - Increased requirements on measurement equipment
    - Test fixture qualification
    - Sensitivity against interferences
  - Test equipment solutions available
    - 100BASE-T1 and 1000BASE-T1

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OPEN ALLIANCE TC8 TEST – CHALLENGES & EXPERIENCES

- Switch Tests – Challenges
  - Switch configuration and diagnostic information access
    - Not defined by OPEN Alliance
  - Performance/stress tests
    - Test system performance capabilities
  - Test runtime
    - e.g. high number of combinations (Switch Ports, Src/Dst MAC, VLAN ID, Priority)
  - TSN features
    - High precision synchronization (HW timestamps)
OPEN ALLIANCE TC8 TEST – CHALLENGES & EXPERIENCES

- Protocol Layer Test – Upper Tester (ETM)
  - ETM specified in AUTOSAR TC v1.1.0
    - Only 2 protocols supported (UDP, TCP)
      - Adaptations of several test groups and test execution procedures necessary
      - Limits test automation
  - ETM specified in AUTOSAR TC v1.2.0
    - Supports more protocols
    - Supports physical layer diagnostic functionality
    - Protocols not yet supported: ARP, SOME/IP
  - ETM version compatibility issues
OPEN ALLIANCE TC8 TEST – CHALLENGES & EXPERIENCES

- Protocol Layer Test
  - ECU configuration
    - ETM configuration
      - Incl. consistency with tester
    - TCP/IP parameters
  - ECU integration
    - Wakeup and restbus simulation
      - Potential interferences with test execution (shared interface usage)
    - Interpretation range of test and protocol specifications
  - ECU implementation vs. protocol specifications vs. test evaluation
VALIDATION ON NETWORK LEVEL - MOTIVATION

- Network level tests currently not in the scope of OPEN Alliance
  - Network Test originally planned within TC8 but not pursued
    - High complexity due to wide variety of network architectures and configurations
    - Covered by OEM specific integration and system test

- Validation scopes
  - Network component interoperability
  - Robustness and availability of network
  - Network parameter configuration
  - Time synchronization performance
  - Communication schedule
  - Data integrity
Bit Error Rate (BER)
- Definition: Number of received bits in a time interval that have been altered during the transmission on a communication channel

Causes for bit errors include
- Noise
- Interference
- Distortion
- Bit synchronization

Determination of BER under worst case conditions to ensure reliable network communication
CONCLUSION

- Validation of Automotive Ethernet implementations necessary
- OPEN Alliance TC8 covers Ethernet ECU conformance testing
  - ECU testing for current data rates already well established
- Test process is complex and presents various challenges
  - No out-of-the-box solution with full coverage
  - Higher data rates present further challenges
  - Continuous development and maintenance of test specifications
- Network level validation
  - Variety of scopes depending on architecture and application
  - No general specification available
  - Individual test solutions required
Thank you very much for your attention!

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