Standardization for efficient testing of Automotive Ethernet ECUs

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Overview

Motivation

- Need for testing
- Benefits of standardized tests

• Pilot project

- Demonstrate standardized testing
- Three-party project setup
- Technical approach

Test Results

- Test statistics
- Lessons learned
- Conclusion



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Need for testing

Automotive Ethernet ECU Testing Challenges:

- Find and solve issues as early as possible in the development process. The sooner a problem is solved, the lower the monetary impact
- Testing the TCP/IP stack is a difficult task much more complex than other automotive protocols such as CAN or FlexRay
- Retain high test coverage with rising complexity and functionalities, while even decreasing the test periods and costs



High quality, reliability, and safety of a car can only be assured by proper testing of all components.

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Current state of testing Automotive Ethernet

First OEMs introducing Automotive Ethernet have understood the need for testing. Therefore they developed network acceptance tests:

- Protocol conformance tests
- OEM specific tests (configuration/project)

OEM defined network acceptance tests:

- Each OEM has to specify and maintain test specification
- BSW suppliers have to test for each OEM differently
- Test tool suppliers have to develop for each OEM differently
- Test houses have to test for each OEM differently



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Benefits of standardized tests

Standardization

- Improvement in quality
 - Sharing know-how
 - Separation between development and testing
- Cost-effective
 - Shared development costs
 - Shared maintenance costs
 - High re-use of available test suites form the IT and telecom domains

It brings independent test houses into play

- ISO 17025: Neutrality, Transparency, Reproducibility of Results
- Extensive testing experience, a lots of Lessons Learned
- Reduction of the validation efforts
- OEMs can focus on essential customer functions



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Advantages for all stakeholders

For OEMs:

- Less work in creating test specifications, less maintenance, comparable and reliable test results
- OEMs save time/costs by not having to run network acceptance tests, which can be ran by test houses
- Open market for test suites and test execution
- ✓ For software suppliers (such as EB):
- Implementation and Integration of generic test stub only one time.
- Stack can be tested with different test suites, increasing the test coverage.
- ✓ For test suite suppliers (such as Ixia):
- No need to develop test suites for each OEM low barrier to enter the market
- Test suite uses the same standardized test module for all ECUs.
- For test houses (such as C&S):
- One specification that can be applied to all customers (different OEMs and Tier1s)
- One tool suite can be used for multiple OEMs, while an open market for tool suite selection exists

For all: Standardization enables a wide range of re-use, thus increasing quality and decreasing costs.



Pilot Project – improving automotive testing

Goals:

- Demonstrate the efficiency of standardized Automotive Ethernet ECU tests
- Work with latest draft test specifications from standardization bodies
- Cover as much as possible of OEM acceptance tests
- Help improve test process, test case standardization and provide test results

Project requires key competences from multiple scopes:

- 1. Need an automotive Ethernet stack
- 2. Need a test tool with high coverage of current results
- 3. Need an independent 3rd party certified professional to run the test cases



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Three-party project setup

Ixia – Network Test Products

- 20+ years of IP/Ethernet network testing experience
- TCP/IP, security, voice/video, routing & switching, WiFi, Wireless (3G/4G/LTE), ...
- Ixia IxANVL, IxNetwork

Elektrobit – ECU Software

- 25+ years of Automotive experience
- OSEK/VDX, AUTOSAR, OEM basic software solutions, CAN, FlexRay, LIN, IP/Ethernet
- EB tresos AutoCore IP Stack



C&S – Test House

- 20+ years of Automotive testing experience
- High quality standard
 ISO/IEC 17025 accredited
 test laboratory
- Advanced high quality test
 & measurement equipment

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Technical details

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Considered standardization bodies for protocol conformance

- OPEN (One Pair EtherNet) Alliance
 - Focused on Automotive Ethernet based networks
 - Premium members include OEM, Tier Is, and technology partners
 - Originally focused on standardizing Automotive Ethernet, expanded to ECU testing
 - Creating standardized tests for in it's Technical Committee no. 8 (TC8) for: TCP, UDP, IPv4, ARP, ICMP, DHCP, IPv4 AUTOCONF, SOME/IP
- AUTOSAR (AUTomotive Open System ARchitecture)
 - Defines an open and standardized automotive **software architecture**
 - Premium members include OEM, Tier Is, and technology partners
 - Defined in WP-T first version of Acceptance Tests for the basic software (BSW)
 - Defines communication stack for Ethernet and TCP/IP
 - Creating standardized Acceptance Tests in WP-T for TCP, UDP and IPv4







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Technical approach

The goal is to demonstrate how standardization makes testing of Automotive Ethernet ECUs more efficient.

- Current state: each OEM defines its own network acceptance tests
- Desired state:
 - Acceptance tests are fully standardized by relevant bodies, i.e.,
 - test cases
 - test methods (stub and protocol)
 - test processes
 - Acceptance test show conformance of the stack, and not specific OEM configurations
 - Acceptance tests need to be executed:
 - deployment on each particular hardware
 - during each ECU integration step

Standardized test cases

- Must have accurate description, test steps, fail/pass criteria and reference to standard
- Derived from existing work in the IT and Telecom domains
- Reviewed by multiple companies, providing higher quality
- Allows OEM specific test cases to be reduced to a minimum





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Standardized test stub and test control protocol

TCP is a complex protocol, which cannot be fully tested using a "black-box only" approach. It needs to be able to cause DUT protocol implementation to move to certain states



AUTOSAR – stub will be called Ethernet Testability Module (ETM), implemented using BSW OPEN Alliance – same stub definition and protocol is intended to be used

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Proposed standardized test process



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Pilot Project Results

Pilot Project - test case execution

- Pilot Project test execution started already on draft test specifications
 - AUTOSAR "Acceptance Test Specification of UDP, TCP and IP communication"
 "Testability Protocol and Service Primitives"
 - OPEN Alliance "ECU and Network Test, Test Specification ECU"
- Test cases have been executed at **C&S** on the **EB** TCP/IP Stack using Ixia IxANVL
- Test cases cover the main protocols including
 - ARP, ICMP, IPv4, UDP, TCP, DHCP, IPv4 Autoconfig and SOME/IP + Service Discovery
- In total 560 test cases have already been executed
 - Over 80% test cases coverage of the draft specifications at October 2015
 - 100% test case coverage targeted by the end of 2015
 - From experience: 3 days averaged for test setup and test execution

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Status of draft test cases standardization *



- AUTOSAR product first release "Acceptance Test R1.1" at end of October 2015 public
- OPEN Alliance Test Specification ECU first release will be at the start of November 2015 public

AUTOSAR

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OPEN

Review of standardized test cases

In IETF specification requirements are differently qualified – MUST, SHOULD, MAY * This classification is now also applied in the test case specification



*) IETF Specification definition see https://tools.ietf.org/html/rfc2119

First results – standardized test cases

- Gaps in test specification identified
 - Some "MUST" test cases require optional features
- Further test case categorization needed
 - For a certain ECU, only a subset of test cases is applicable
 - Failed test results need to be investigated although not all relevant for the ECU
 - OEMs/Tier1s have to select test cases they need based on their detailed project requirements
 - Recommendation: standardize applicable categories to simplify the selection of test cases
- Wide Coverage of Test Standardization achievable
 - All protocol conformance tests can be standardized
 - Only a small number of test cases are OEM specific configuration or robustness tests
 - Robustness test cases could also be standardized

First results – standardized test stub and control protocol

- Functionality of test stub and test control protocol
 - Only 10 commands needed to execute all AUTOSAR TCP/UDP tests
 - Already specified within AUTOSAR Specification
 - Further commands and extensions needed to execute all OPEN test cases
 - Not yet specified, needs to be aligned with AUTOSAR Specification
- Test stub needs to be included in ECU for testing
 - At least until Start of Production, maybe longer
 - Low memory footprint achieved in the stub
 - No additional buffers required for testing
 - Very simple state machine
 - Security issues (keeping the test stub) vs. Probe Effect (removing it)

Conclusion

- Pilot Project demonstrated
 - Most test cases are already applicable and useful
 - Test stub and test control protocol efficiently implemented
 - AUTOSAR and OPEN standards some overlaps and gaps
 - OEM-specific tests can be minimized significantly
- Recommendations
 - Consolidate standardization activities
 - Extend standard for further protocols, IPv6, NDP etc.
 - Broad contribution to standardization by all stakeholders
 - Use standards, reduce OEM specific tests to a minimum
- Outlook
 - Extend Pilot Project for AVB and AVnu, Linux, robustness testing



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Thank you!

More @

EB: <u>www.automotive.elektrobit.com/ethernet</u> Ixia: <u>www.ixiacom.com/automotive-ethernet</u> C&S: <u>www.cs-group.de/testing</u>



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We take you to the fast lane!

