Trace-Based Test Selection to Support Continuous Integration in the Automotive Industry

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Distributed Embedded Software

- Multitude of Electronic Control Units (ECUs) with different purposes
- ~10 disjunct communication systems
- Complex functions (esp. Driver’s Assistants) require diverse sensory input

⇒ Emphasis on distributed computing and communication
⇒ Importance of Integration Tests
  ⇒ Testing on the target hardware
  ⇒ Black-Box-Testing of changes in singular ECUs
Motivation

Advantages of CI

- Fast Feedback to Developers
- Easier Fault Analysis
- Permanently stable builds
- More thorough testing

Disadvantages / Costs

- Difficult synchronization
- Possible Build Downtimes when Interfaces Change
- Bigger effort for testing

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Motivation

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How much bigger exactly?

- 200 Tests per Function
- 50 Functions in Driver’s Assistance Domain
- 1-5m per Test

→ 10.000 Minutes per Integration

Not counting:

- Test Case Redundancy for HW/SW Variance
- Parallel SW Development

→ Very Thorough Test Case Selection is necessary!
Idea: What happens in the system when a signal is received?

Sample Test Case:
- Activate ACC → Expect ACC Status Lamp in Tacho to be on
- Deactivate ACC → Expect ACC Status Lamp in Tacho to be off
Idea: What happens in the system when a signal is received?

Active Cruise Control revisited

- System Input: „ACC active Button on Steering Wheel pressed“
- **Gateway**: forwarding to **Application Module**
- **Application Module**: Set flag for System Active, send Message „ACC active Light on“ to **Gateway**
- **Gateway**: forward Message „ACC active Light on“ to **Tacho**
- **Tacho**: turn on „ACC active“ Light
- Participating ECUs: **Gateway**, **Application Module**, **Tacho**

→ Changes in other ECUs do not affect this Test Case!
Trace-Based Test Selection

Background
Motivation
Approach
Results
Test Suite Reduction for ACC

Average Reduction: 82.3%
Full Test Suite: 186 Test Cases
Number of Keywords: 54
Number of ECUs: 12

### Changed ECU

<table>
<thead>
<tr>
<th>Changed ECU</th>
<th>Selected Tests</th>
<th>Reduction Rate</th>
</tr>
</thead>
<tbody>
<tr>
<td>Airbag Control</td>
<td>1</td>
<td>99,5%</td>
</tr>
<tr>
<td>Ultrasound</td>
<td>1</td>
<td>99,5%</td>
</tr>
<tr>
<td>Navi</td>
<td>3</td>
<td>99,84%</td>
</tr>
<tr>
<td>Radar</td>
<td>5</td>
<td>99,73%</td>
</tr>
<tr>
<td>Camera</td>
<td>5</td>
<td>99,73%</td>
</tr>
<tr>
<td>Gateway</td>
<td>7</td>
<td>96,2%</td>
</tr>
<tr>
<td>Gearstick</td>
<td>7</td>
<td>96,2%</td>
</tr>
<tr>
<td>Gear Control</td>
<td>18</td>
<td>90,3%</td>
</tr>
<tr>
<td>Brake Control</td>
<td>32</td>
<td>82,8%</td>
</tr>
<tr>
<td>Engine Control</td>
<td>58</td>
<td>68,8%</td>
</tr>
<tr>
<td>Tacho</td>
<td>76</td>
<td>59,1%</td>
</tr>
<tr>
<td>Application Module</td>
<td>183</td>
<td>0,016%</td>
</tr>
</tbody>
</table>

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Conclusion and Future Work

- Automotive Systems are highly distributed
  - Integration Testing increasingly important
- Continuous Integration’s benefits are costly in the domain
  - Thorough Test Case Selection is a necessity
- We can drastically reduce the workload by only selecting tests that change parameters in the modified ECU
- Application to more Functions
- Further Automatization of the preparation
- Expansion to „White-Box“ testing (i.e. inclusion of software libraries on ECUs) in planning
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Thank you for your attention!