Seamless and Unified TTCN-3 Test Environment for Spatially Distributed IoT, 5G and Radio Technologies

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Supervised by Prof. Dr.-Ing. Axel Sikora
Who we are?

- Institute of Reliable Embedded Systems & Communication Electronics (ivESK)
  - Prof. Dr.-Ing. Axel Sikora

- Embedded software engineering
- Stack development
- Test & verification
- HW-SW co-design
- Embedded platforms - embedded Linux
- Embedded security

Team: 12 full time engineers / PhD candidates
~10 graduate / under graduate students

Industrial Partners
Agenda

• Introduction
• Problem Analysis
• Seamless and Unified Test Environment
• Virtual Testbed for Embedded Networking Nodes (VTENN)
• Automated Physical Testbed (APTB)
• Example test case
• Conclusion
Introduction

- Spatially Distributed Wireless Networks (SDWN) technologies for IoT and Industry 4.0 use cases
  - Devices are usually,
    - spatially distributed
    - battery driven
    - resource constrained
    - less expensive
  - They require wireless connectivity with,
    - low data rate
    - narrow bandwidth
    - wide coverage
    - long battery life
    - low cost

Which is the suitable wireless connectivity for this use case?

- Short Range Wireless Networks (SRWN)
- Low Power Wide Area Networks (LPWAN)
- Cellular IoT (cIoT) Networks (also specified as 5G technologies)
Motivation

- Role of functional testing in SDWN
  - during system development life cycle
  - for systematic comparison

- Challenges of functional testing in SDWN
  - communication devices are resource constrained
  - connectivity is via wireless channel
  - operate in complex topologies
  - complex mechanisms such as MAC, routing, network management

Need of **seamless and unified** test environment for SDWN
Problem Analysis

- Existing functional test solutions
  - technology specific
  - start testing at system level
- Generic test platforms with different levels of abstraction
- Testcases are described differently

<table>
<thead>
<tr>
<th>System Aspects</th>
<th>Network Simulation</th>
<th>Network Virtualization</th>
<th>Network Emulation</th>
<th>Field Tests</th>
</tr>
</thead>
<tbody>
<tr>
<td>Microcontroller</td>
<td></td>
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<td></td>
<td>real</td>
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<td></td>
<td>Protocol</td>
<td>abstracted</td>
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<tr>
<td></td>
<td>implementation</td>
<td></td>
<td></td>
<td></td>
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<td>Hardware Abstraction Layer</td>
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<td>Transceiver IC</td>
<td></td>
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<td>abstracted</td>
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<td>real</td>
<td>real</td>
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<td>Radio Channel</td>
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Seamless and unified test environment - Requirements

• Flexible and shall provide a **uniform environment**

• It should use an identical test description language and should **support identical test case description** in various abstraction levels

• The environment should have an **option to control System Under Test (SUT) remotely**

• The environment needs a **centralized control**

• The environment should have an **identical performance measurement and analysis options**
Seamless and unified test environment - Novel architecture

- Test description and execution
- Test ports/inter-faces (i/p)
- Network virtualization
- Network emulation
- Field test
- Test ports/inter-faces (o/p)
- System under test
- Measurement devices & analysis tools
Seamless and unified test environment - implementation

- Network simulation
- Virtual testbed
- Emulated testbed
- Field testbed

In house developments

Virtual Testbed for Embedded Networking Nodes (VTENN)

Automated Physical Testbed (APTB)

Logo Source https://www.nsnam.org
https://projects.eclipse.org/projects/tools.titan
Seamless and unified test environment – TTCN-3 Integration

Eclipse Titan TTCN-3 Framework

Run time configuration

Main Test Component

CTI

CI

Host 1

Dispatcher

LCM

Dispatcher interface

Test ports
( LCM/ Serial / TCP)

Host 2

Test Interface

SUT on various test platforms

Network manager

Upper Tester

SUT

Simulation / Virtual testbed / Emulated testbed/ Field testbed
Virtual Testbeds

- Virtualized Testbed for Embedded Networking Nodes (VTENN)
- Virtual nodes in PC environment, where each node execute the original embedded code
- Different nodes are running in parallel and are connected via so called virtual interfaces
**Emulated Testbed**

- Automated Physical TestBeds (APTB)
- Automated testing environment with physical networking nodes
- Wired connection of RF elements
- Antenna outputs to RF waveguide
- Static and dynamic path characteristics
## Automated Test Flow

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<thead>
<tr>
<th>Test Case Scenario Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>RF characteristics</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Configuration of SUT</th>
</tr>
</thead>
<tbody>
<tr>
<td>Test Interface</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Test Execution</th>
</tr>
</thead>
<tbody>
<tr>
<td>Simulation</td>
</tr>
</tbody>
</table>

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<thead>
<tr>
<th>Monitoring and Measurements</th>
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<tbody>
<tr>
<td>Logs and Statistics</td>
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<th>Test Result Analysis</th>
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<tbody>
<tr>
<td>System / Functional Tests</td>
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Continuous Integration

Unified test case description
Example testcase – LPWAN & cIoT

- Key performance metrics measurements
- Functional behaviour tests

Performance measurements

System Tests
- RF coverage
- signal quality
- packet loss rate
- payload flexibility
- energy consumption measurements

Protocol Tests
- NB-IoT L1 procedures
- NB – IoT Initial Access
- NB-IoT L2 procedure (RRC, NAS)

LPWAN & cIoT Test and Verification
Conclusion

• Significantly contribute to fulfil the lack of seamless and unified test environment for spatially distributed wireless networks
  • novel unified function test environment architecture
  • unified test case description and test method
  • support to use same code branch on various test platforms
Thanks!

Q&A