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Corporate Technology

A scenario-based test approach for testing reactive concurrent systems

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ETSI MBT User Conference 2011
October 18–20, 2011, Berlin, Germany

Outline

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- Motivation
- Scenario-based testing
- Case study: clinical imaging device
- Modeling test scenarios
- Tool snapshot
- Conclusions

Motivation

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Limits of current MBT approaches and tools

- Rely on **models** that are expensive to create
- Focus on **structural coverage** of model, but not fault detection
- Insufficient support for **concurrent** interactions

Ways out from the MBT crisis

- Simplify models to carry only essential parts
- Support concurrency directly in the model
- Provide sound test implementations with known fault detection

Scenario-based Testing

What is scenario-based testing?

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Cam Kaner on Scenario Testing, STQE Magazine, Sep./Oct. 2003

CEM KANER ON SCENARIO TESTING

- The scenario is a story about someone trying to accomplish something with the product under test.
- Scenarios are useful to connect to documented software requirements, especially requirements modeled with use cases.
- A scenario test provides an end-to-end check on a benefit that the program is supposed to deliver.

→ **Here we use scenarios to systematically test for the correct implementation of requirements in the system.**

Scenario-based Testing

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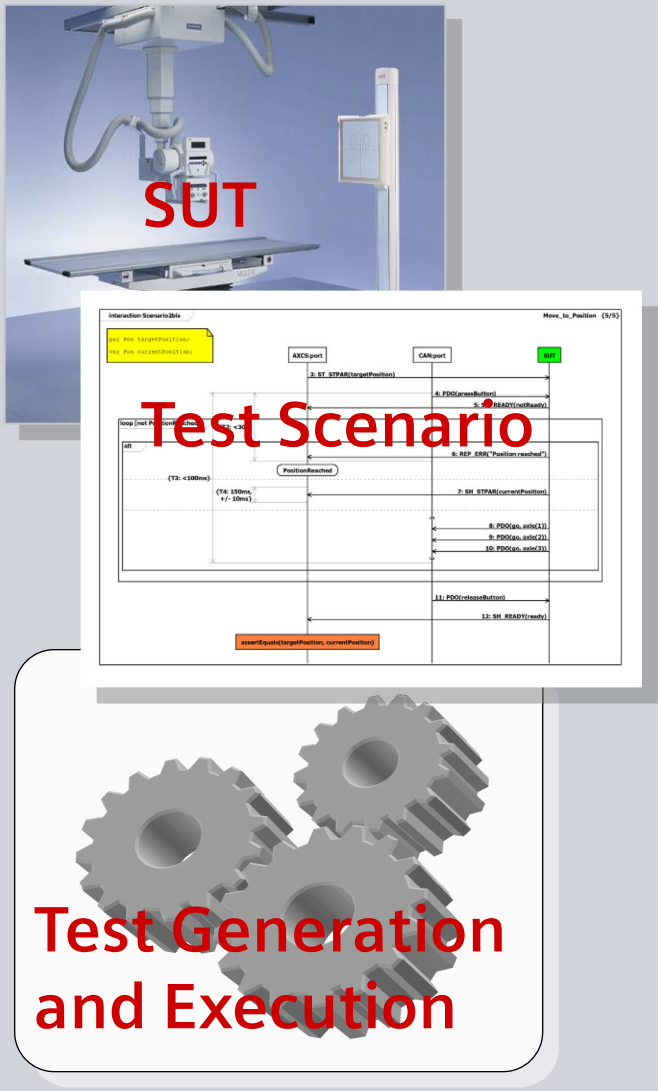
- Support for **embedded software testing** of mechatronic components
  - Event-triggered systems
  - Asynchronous, i.e. message-passing
  - Multiple ports / interfaces
  - Concurrent messages

- **Test scenario** derived from a use case
  - Detailed interactions at SUT interfaces
    → Partial system spec
  - Specified as UML sequence diagrams (MSC)

- **Test generation** produces typically one test implementation per test scenario



Case study: Digital radiographic system Ysio

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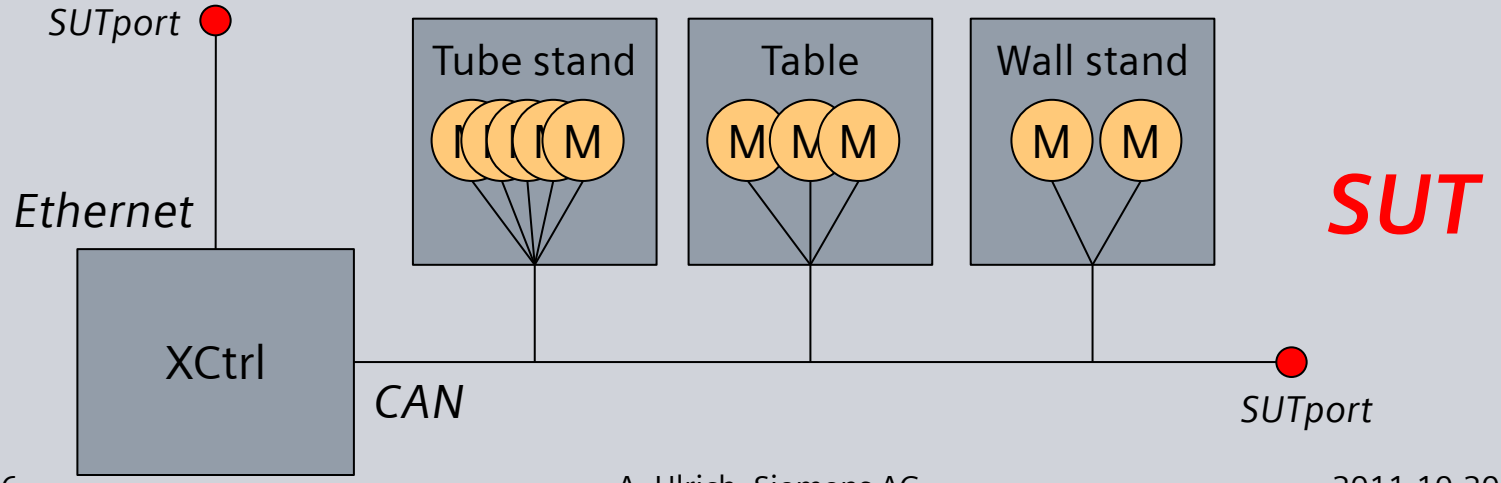
- **Ysio**
  - Latest generation of clinical X-ray devices
  - Digital image processing
  - Operates fully automatically
- **System integration testing** of a controller unit
  - Ethernet, TCP/IP interface: commands
  - CANopen interface: resulting interactions



Modeling test scenarios – Overview

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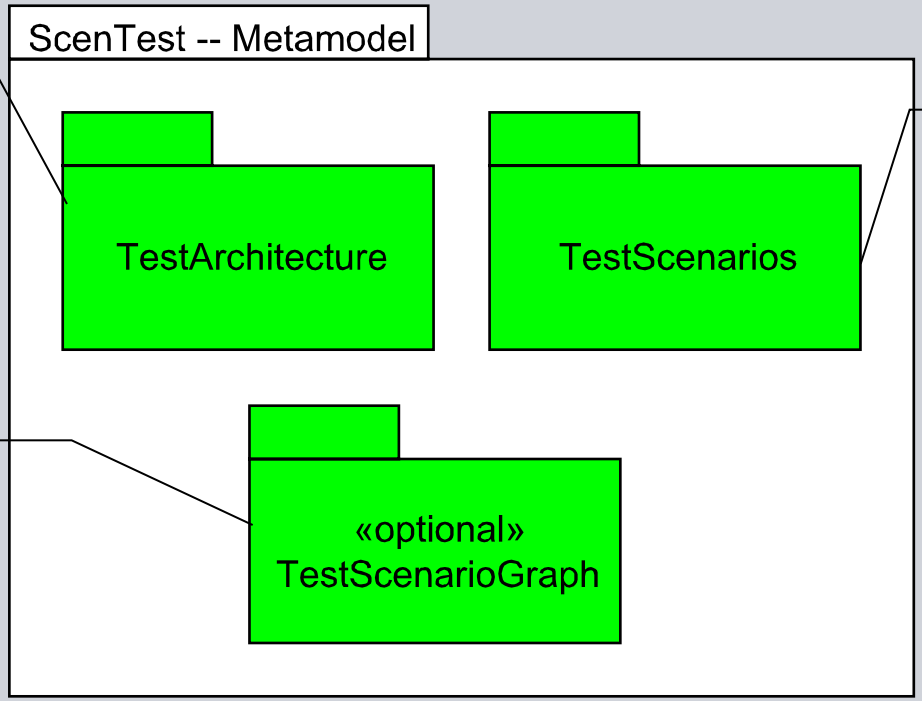
Static view on the SUT with its external ports and events / messages.



Set of scenarios that describe interactions at the SUT's ports (black-box approach).
Each scenario represents a test.

Optional graph that links scenarios together.
Useful when describing choices over SUT inputs.
Used for generating tests across scenarios.

Modeling test scenarios – Test architecture

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- SUT is modeled as a **single instance**, even if comprised of several distributed components

- **All ports / interfaces** of the SUT that are exposed in testing must be defined together with its events / messages
  - Points of control and observation – SUT inputs and outputs
  - Points of observation – SUT outputs only

→ **Multi-port system**
→ **Black-box testing approach**

- Assigning event / message types to port types enables validation of test scenario models → e.g. misuse of messages at a given port

Modeling test scenarios – Test scenarios

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- A scenario describes the behavior of a (possibly distributed) SUT as it is observable at its (multiple) ports by an **assumed ideal global tester**
- A scenario describes the **expected behavior** of the SUT
  - Hence, any deviation observed in testing is a **failure**
  - Derived from system requirements and use cases
- Modeling notation
  - UML sequence diagram (MSC)
  - UML interaction overview diagram (optional)
- **One scenario** relates to **one executable test**

Modeling test scenarios – Feature overview

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- Basic concepts for behavioral modeling taken from CSP – Communicating Sequential Processes (Hoare 1978)
  - (MSC) Sequence → (CSP) Prefixing, sequence
  - (MSC) Loop → (CSP) Recursion
  - (MSC) Alternative → (CSP) Non-deterministic choice
  - (MSC) Parallel → (CSP) Concurrency (interleaving)
  - (MSC) *Unless* → (CSP) Interruption

- **Not all concepts are expressible in UML2/MSC!**

- Some extensions to cope with testing
  - Optional messages → variant of alternative
  - Unless → Exceptional behavior within a defined scope
  - Requirement tracing
  - Ignore messages → ignore superfluous SUT outputs

Scenario based testing for Ysio, Example 1

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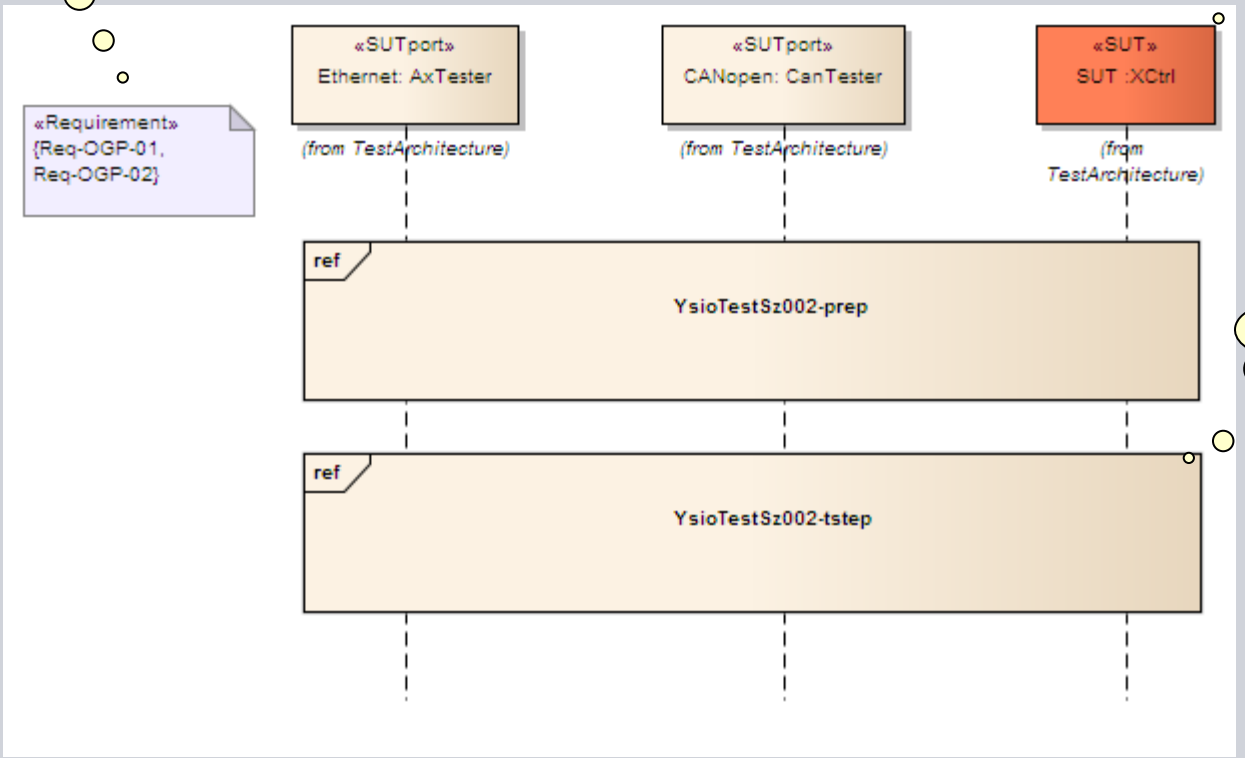
Requirement tracing

Single SUT lifeline



References to sub-scenarios

Scenario based testing for Ysio, Example 2

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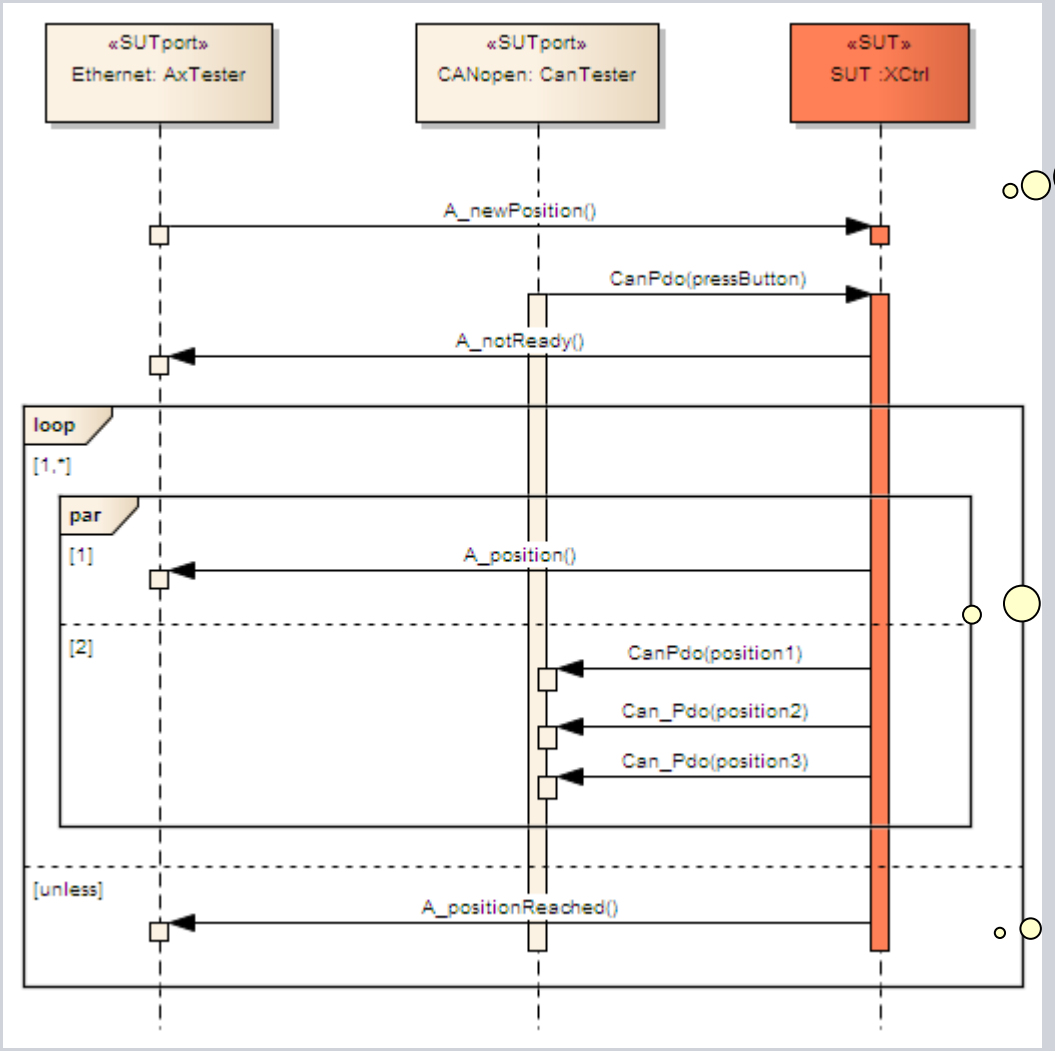

Flow of system interactions

Concurrency occurs naturally at different system ports

Termination of infinite loop

Implementing scenario-based testing – The *ScenTest* Tool

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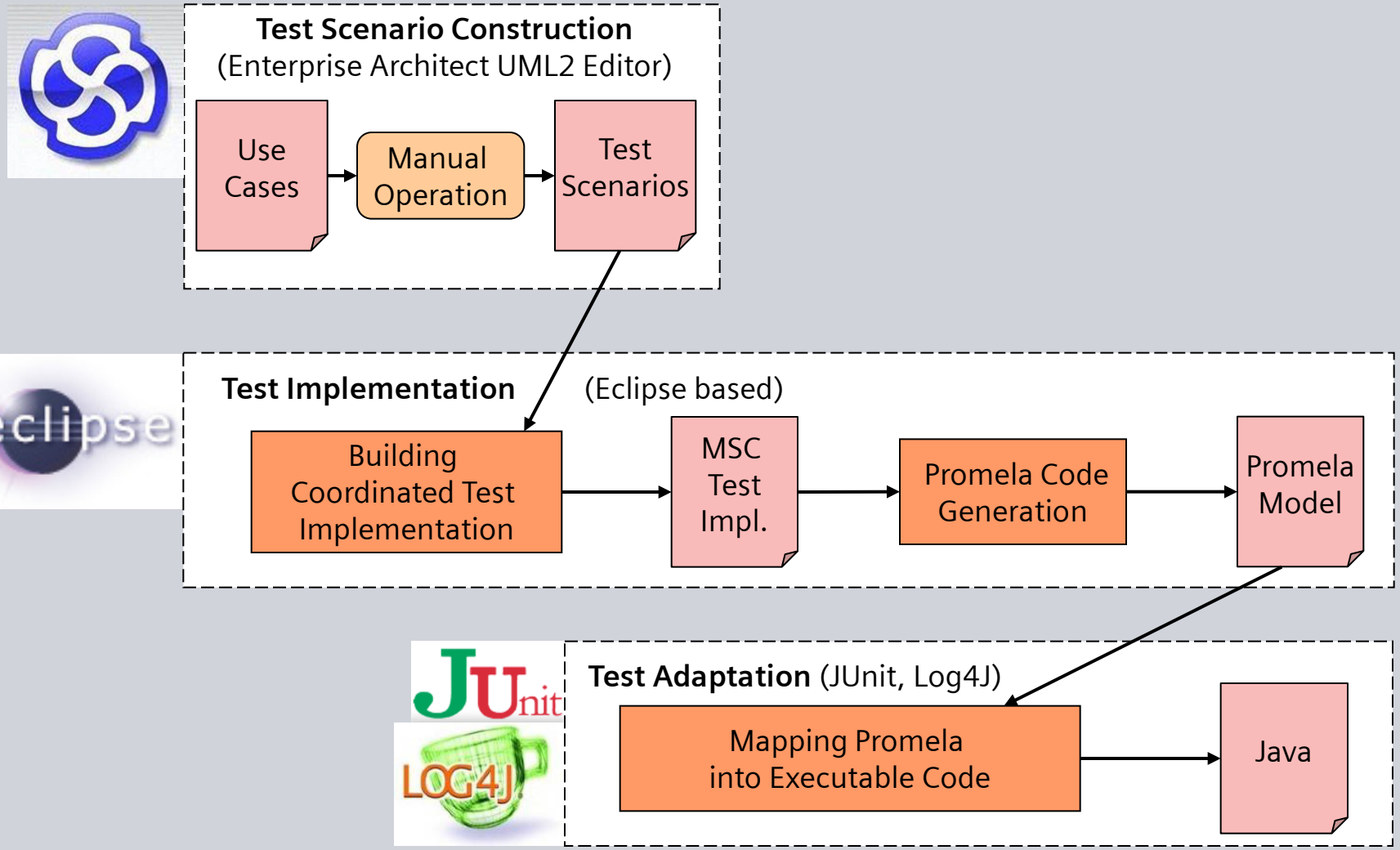

ScenTest Tool Snapshot

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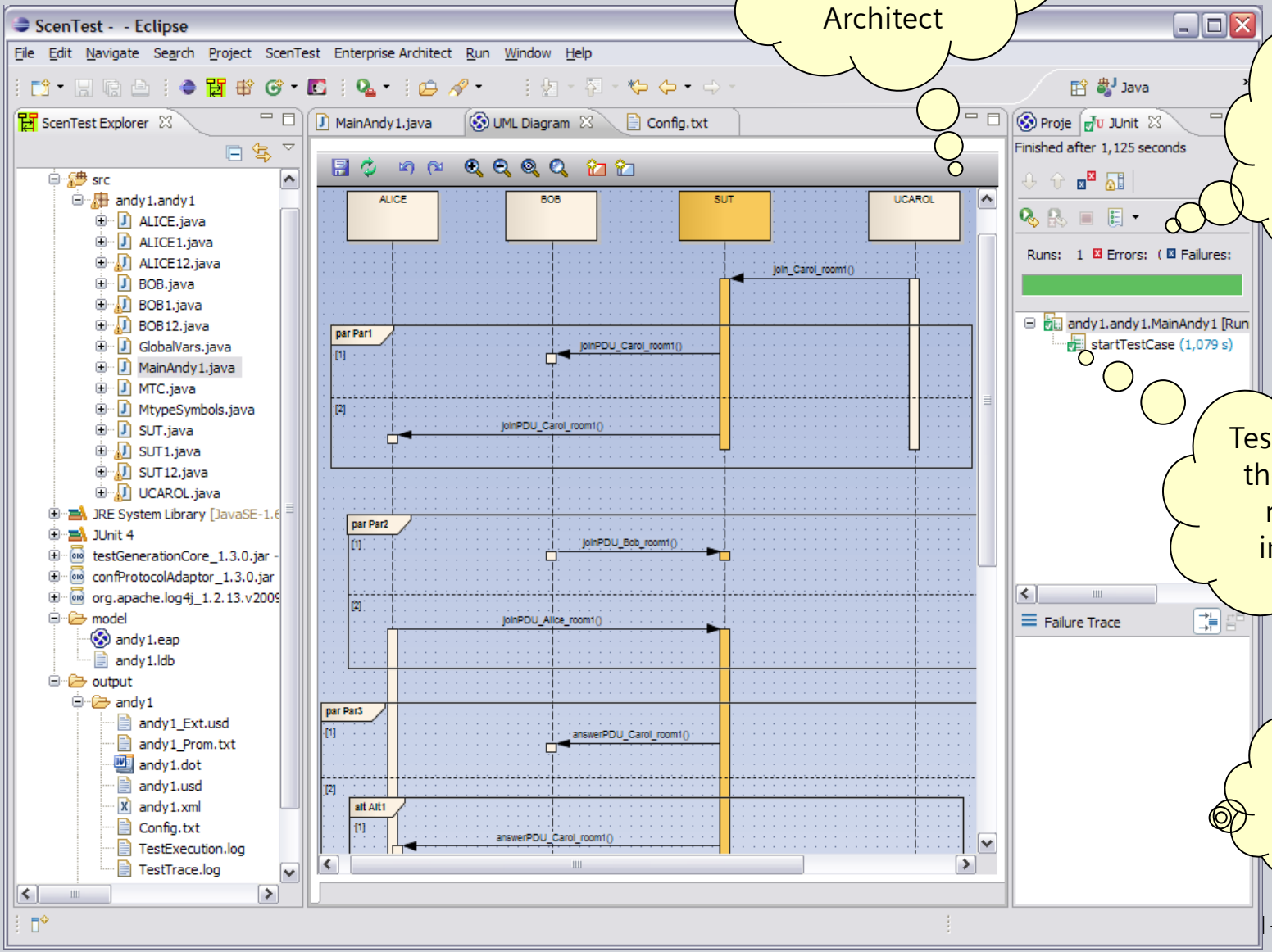

Conclusions

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Test scenarios

- Describe interactions of SUT with its environment
  - Expected behavior
  - Concurrency in case of multi-port SUTs
  - Can be linked with requirements
- Simple mean to lift the specification of tests to model level
- Highly accepted by practitioners

Tooling

- Similar approach has been tried in functional HiL testing of embedded SW, see e.g. EXAM tool by VW/Audi
- However, no commercial tool for integration testing based on message passing exists so far
- Build your own tool gradually with increasing demands for new features

Thank you for your attention!

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