Decentralized Model-Based Testing of Distributed Systems

Presented by João Pascoal Faria and Bruno Lima

Speaker

J. Pascoal Faria

FEUP / INESC TEC

Associate Professor for Software Engineering at FEUP & researcher at INESC TEC.

15+ years of research experience in test automation.

President of CS/03 – Sectorial Commission for Quality in ICT, of the Portuguese Quality Institute (IPQ)

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Outline

Previous Work

    UML Checker

    Industry Survey

Current Work

    Testing Distributed Systems

    Observability Analysis & Enforcement

    Controllability Analysis & Enforcement

    Looking for More Case Studies

Paris, 16-18 October 2018

Previous Work

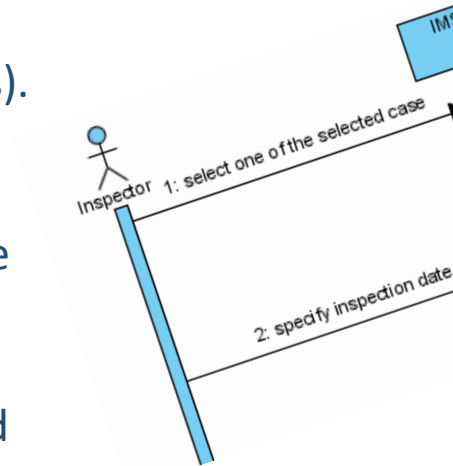# Previous Work: UML Checker[1] (1/2)

What: Toolset for automatically testing OO implementations against behavior specifications given by test-ready UML sequence diagrams (SDs).

How:

- A plug-in for the Enterprise Architect modeling tool that, with a single click, generates extended JUnit test cases from the SDs in the model, executes them on the Java implementation under test, and presents back visually in the model test results and coverage info.
- A runtime test library based on AspectJ, that provides significant extensions to JUnit to handle internal interaction checking (method calls), test stubs, and user interaction testing.

Why: Improve the reliability of OO implementations and the consistency with design specifications.
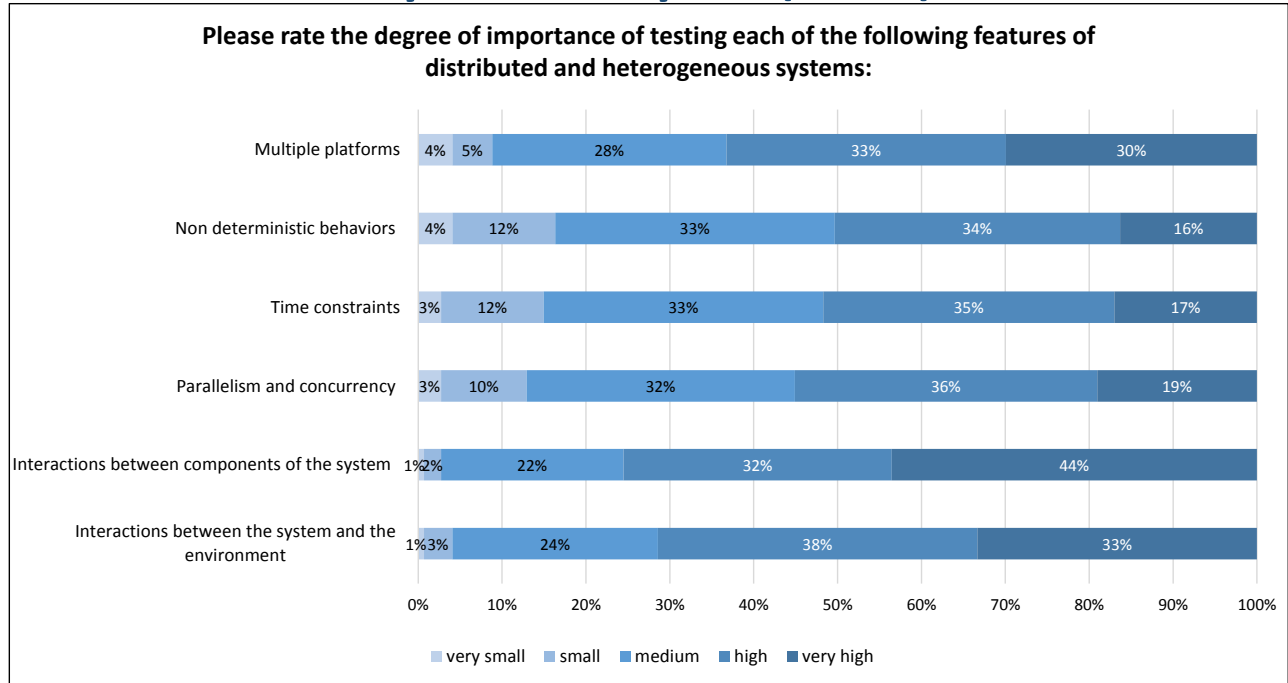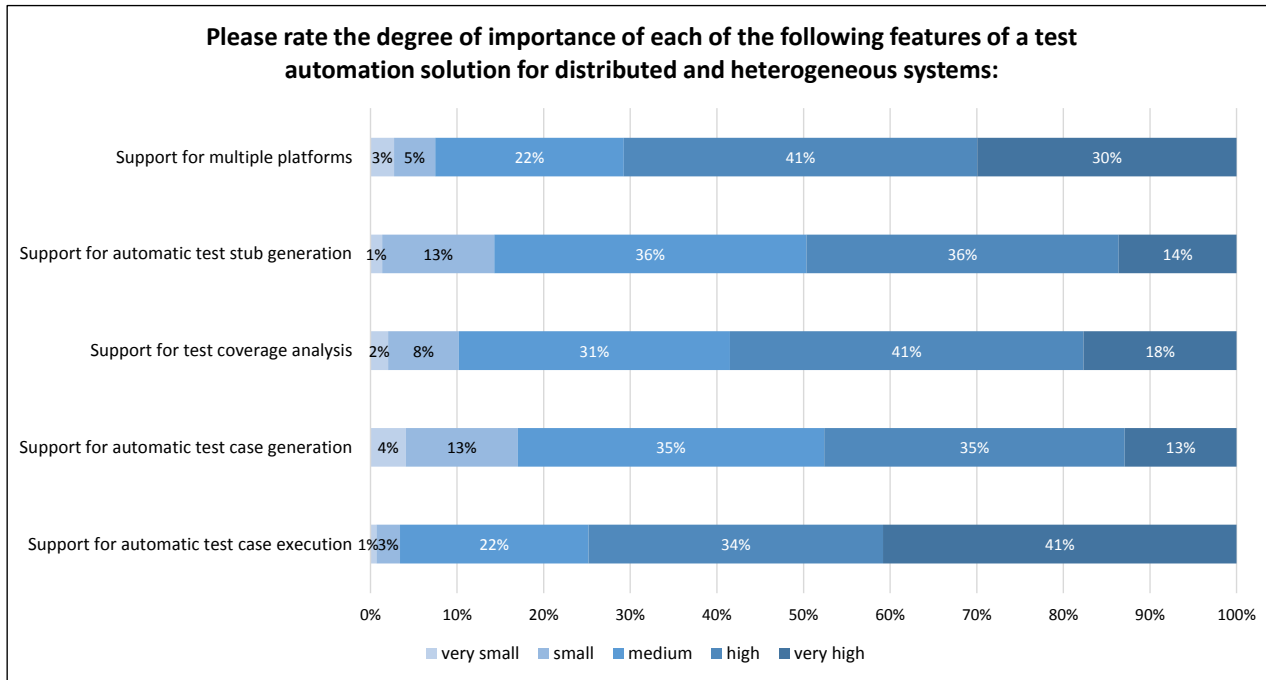
https://blogs.fe.up.pt/sdbt

Previous Work: UML Checker[1] (2/2)
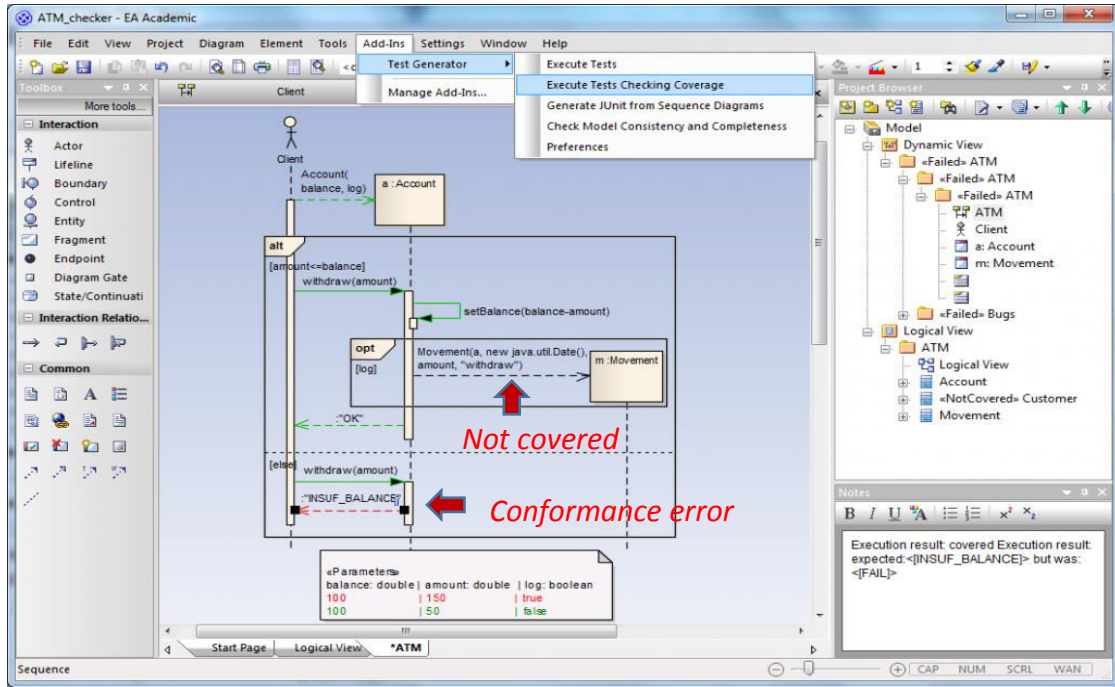
Previous Work: Industry Survey[2] (1/2)

147 valid responses by professionals attending UCAAT 2015 and Testing Portugal 2015

Please rate the degree of importance of testing each of the following features of distributed and heterogeneous systems:

Feature	very small	small	medium	high	very high
Multiple platforms	4%	5%	28%	33%	30%
Non deterministic behaviors	4%	12%	33%	34%	16%
Time constraints	3%	12%	33%	35%	17%
Parallelism and concurrency	3%	10%	32%	36%	19%
Interactions between components of the system	1%	2%	22%	32%	44%
Interactions between the system and the environment	1%	3%	24%	38%	33%

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Previous Work: Industry Survey[2] (2/2)

Please rate the degree of importance of each of the following features of a test automation solution for distributed and heterogeneous systems:

Feature	very small	small	medium	high	very high
Support for multiple platforms	3%	5%	22%	41%	30%
Support for automatic test stub generation	1%	13%	36%	36%	14%
Support for test coverage analysis	2%	8%	31%	41%	18%
Support for automatic test case generation	4%	13%	35%	35%	13%
Support for automatic test case execution	1%	3%	22%	34%	41%

Current Work

Current Work: Testing Distributed Systems

Testing nowadays distributed, heterogeneous and time-constrained systems, such as IoT systems, is particularly important and challenging.

Some of the challenges are:

- the difficulty to test the system as a whole due to the number and diversity of individual components;

- the difficulty to coordinate and synchronize the test participants and interactions, due to the distributed nature of the system;

- the difficulty to test the components individually, because of the dependencies on other components.

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Current Work: Distributed Scenario-based Testing Approach [3]

Visual Modeling Environment

**Visual Behavioral Model
(Test Scenarios (UML SD))**

**Local Observability & Controllability Analysis
& Enforcement**

Test results   Test ready model

**Decentralized Test Input Generation and Conformance
Checking Engine**

Central Tester

Local Tester 1   **Local Tester i**   **Local Tester i**

Component **U**nder **T**est i

CUT_1 CUT_n

Distributed system Under Test

1. Specification of test scenarios using an industry standard notation (e.g. UML SDs).

2. Pre-processing of test scenarios, to ensure readiness for decentralized testing.

3. Automatic translation of test scenarios into executable tests.

4. Distributed test execution, with local testers running close to the distributed CUTs, coordinated by a central tester, to increase test effectiveness and efficiency.
   - Better fault detection and localization
   - Minimal communication overhead

5. Automatic mapping of test results back onto the visual model.

Current Work: Observability Analysis & Enforcement [4,5]
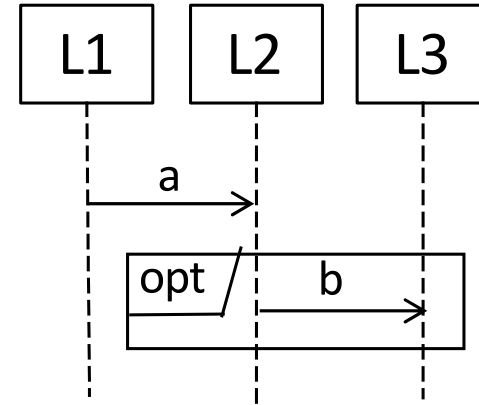
Non-locally observable
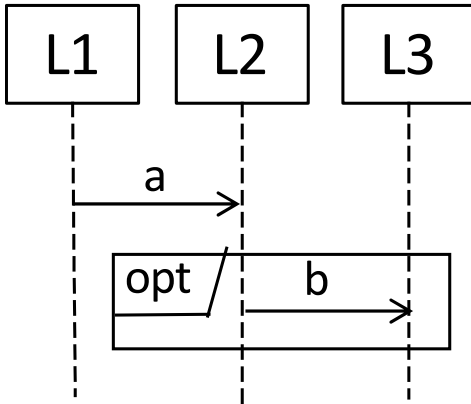
Current Work: Observability Analysis & Enforcement [4,5]
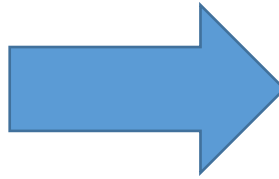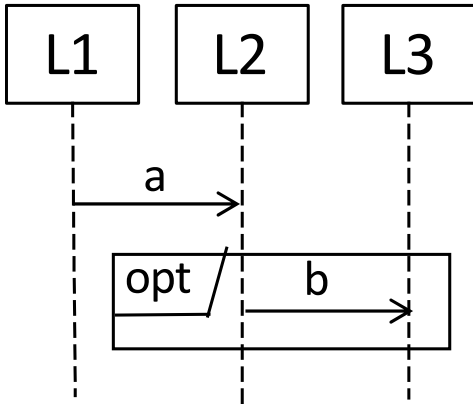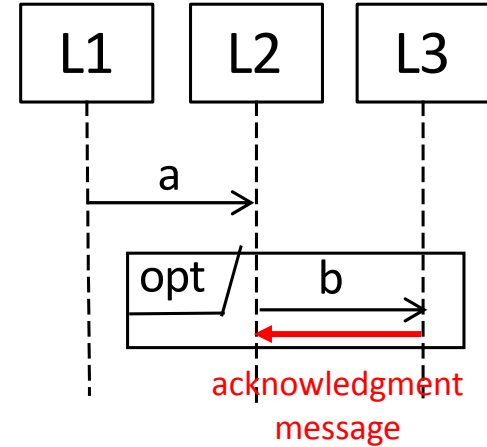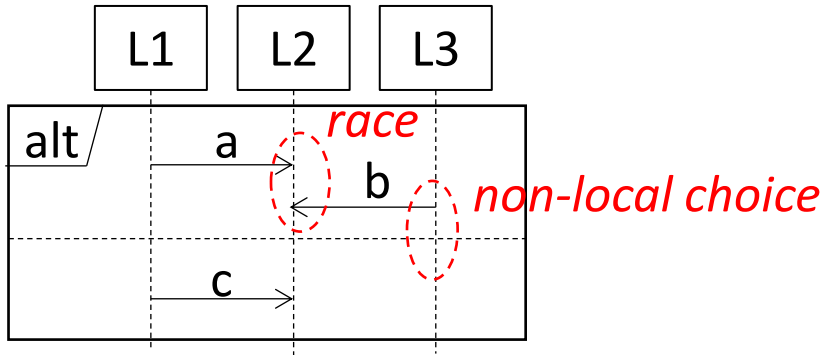
Non-locally observable

Locally observable

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Current Work: Observability Analysis & Enforcement [4,5]
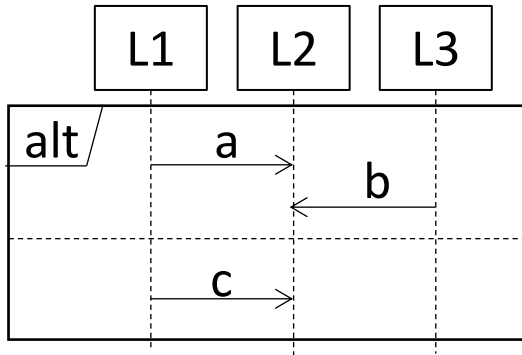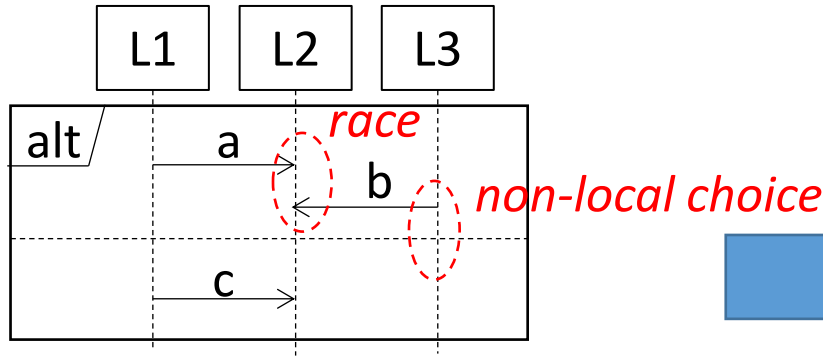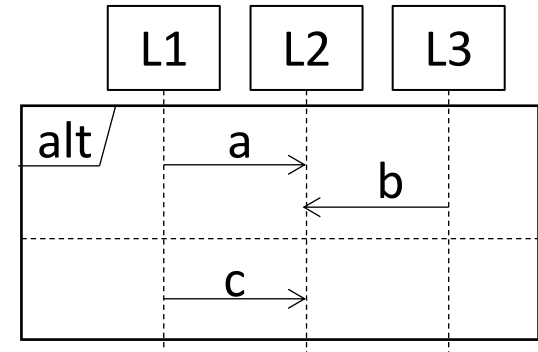
Current Work: Controllability Analysis & Enforcement [4,5]

Non-locally controllable

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Current Work: Controllability Analysis & Enforcement [4,5]

Non-locally controllable

L1   L2   L3
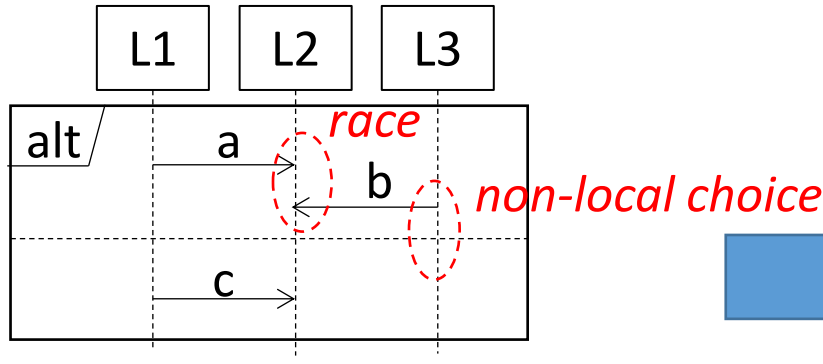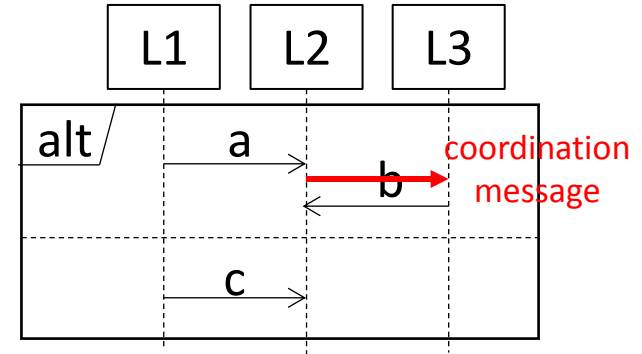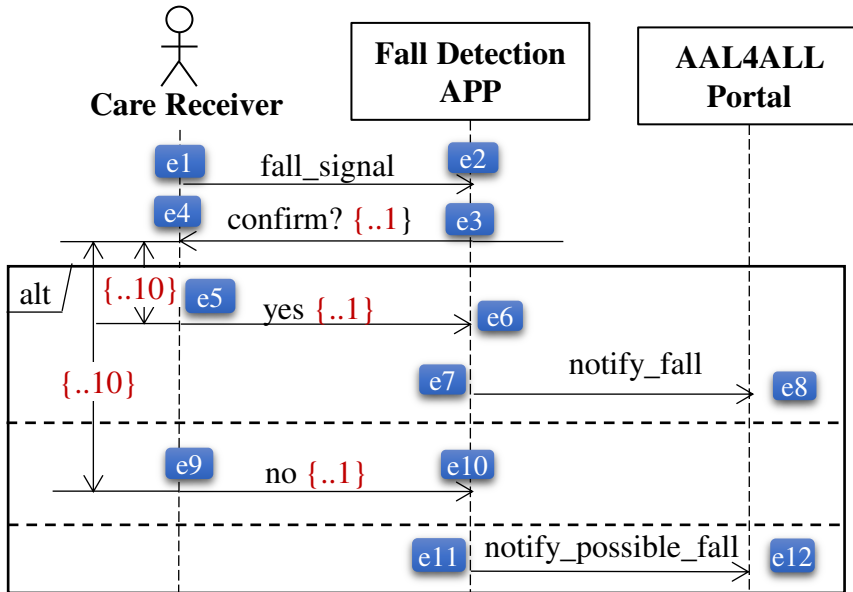
alt

a   *race*

b   *non-local choice*

c

Locally controllable

L1   L2   L3

alt

a

b

c

Current Work: Controllability Analysis & Enforcement [4,5]

Non-locally controllable

L1 L2 L3

alt

a

race

b

non-local choice

c

Locally controllable

L1 L2 L3

alt

a

b — coordination message

c

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Current Work: Controllability Analysis & Enforcement [4,5]

Non-locally controllable

Care Receiver — Fall Detection APP — AAL4ALL Portal

e1 — fall_signal — e2
e4 — confirm? {..1} — e3

alt
{..10} — e5 — yes {..1} — e6
e7 — notify_fall — e8
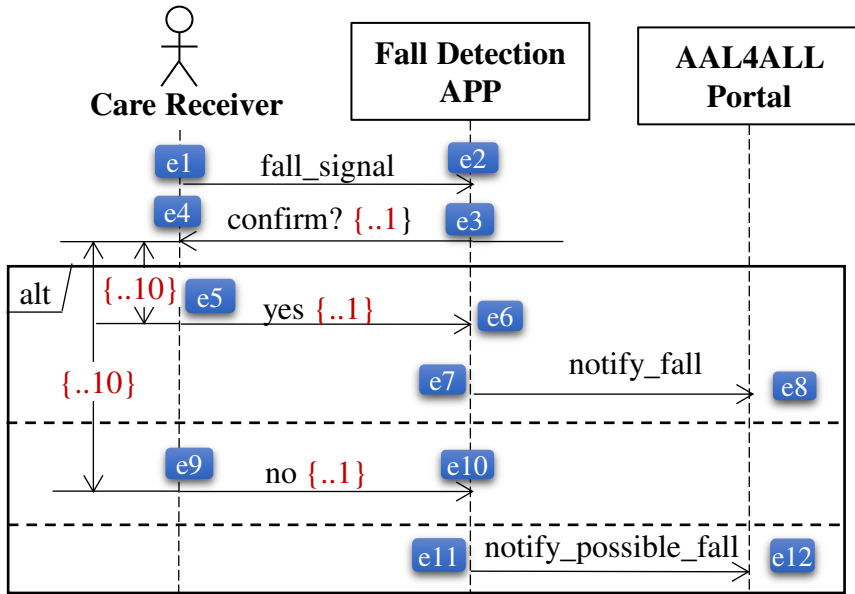
{..10}
e9 — no {..1} — e10

e11 — notify_possible_fall — e12

Current Work: Controllability Analysis & Enforcement [4,5]

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Non-locally controllable

Locally controllable
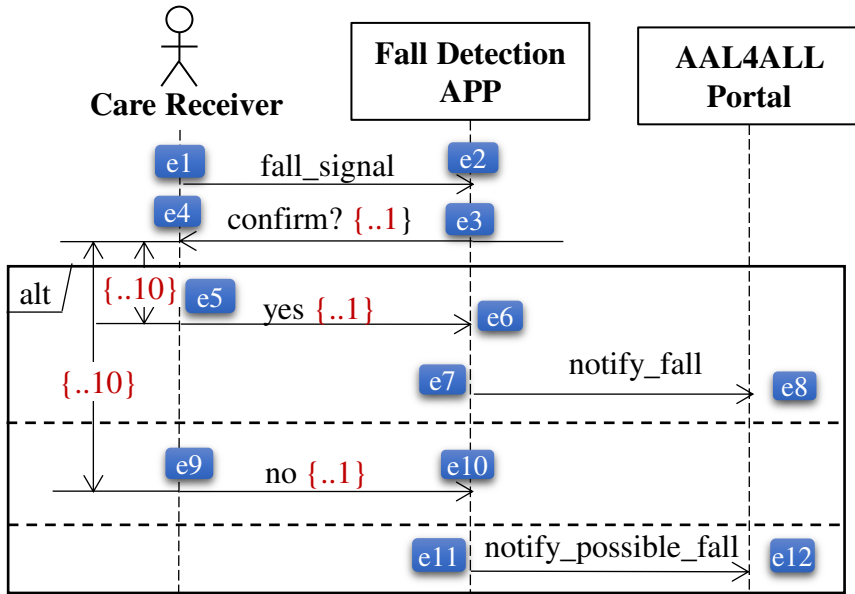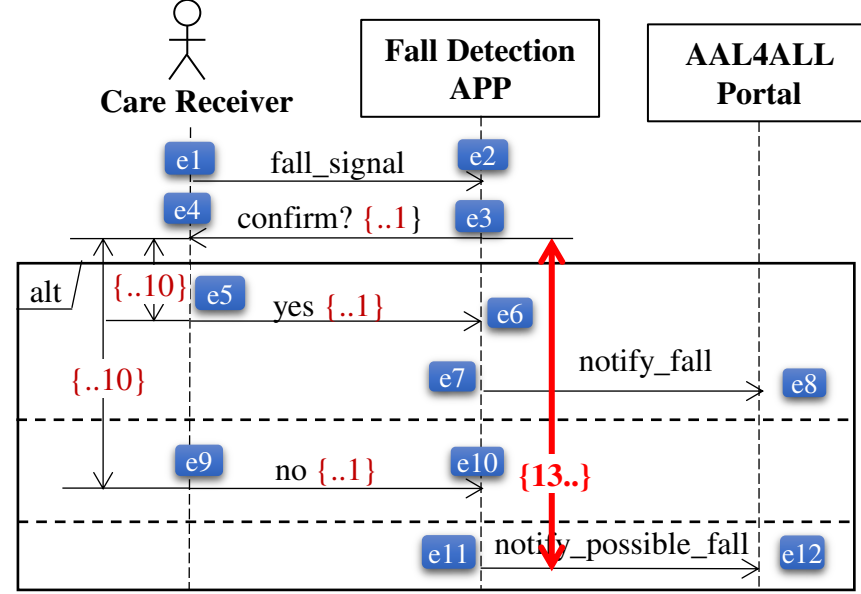
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Current Work: Looking for more Case Studies

What we need:

Real world case studies of distributed, heterogeneous and time-constrained IoT systems that require testing.

Optionally, already defined test scenarios in natural language or diagrams (otherwise, they will be collaboratively created).

What you'll get:

Short term: Formalized test scenarios, already verified and improved regarding their feasibility and adequacy for decentralized test execution (pre-processing stage).

Mid/long term: Infrastructure for automatic, decentralized, test execution of those scenarios.

References

[1] Faria, João Pascoal, and Ana CR Paiva. "A toolset for conformance testing against UML sequence diagrams based on event-driven colored Petri nets." International Journal on Software Tools for Technology Transfer 18, no. 3 (2016): 285-304.

[2] Lima, Bruno, and João Pascoal Faria. "A Survey on Testing Distributed and Heterogeneous Systems: The State of the Practice." In International Conference on Software Technologies, pp. 88-107. Springer, Cham, 2016.

[3] Lima, Bruno, and João Pascoal Faria. "Automated testing of distributed and heterogeneous systems based on UML sequence diagrams." In International Conference on Software Technologies, pp. 380-396. Springer, Cham, 2015.

[4] Lima, Bruno Carvalhido, and J. Faria. "Conformance Checking in Integration Testing of Time-constrained Distributed Systems based on UML Sequence Diagrams." (2017).

[5] Lima, Bruno Miguel Carvalhido, and João Carlos Pascoal Faria. "Towards decentralized conformance checking in model-based testing of distributed systems." In 2017 IEEE International Conference on Software Testing, Verification and Validation Workshops (ICSTW), pp. 356-365. IEEE, 2017.

Future Events

QUATIC 2019

12th International Conference on the Quality of Information and Communications Technology

Ciudad Real, Spain, September 10-13, 2019

ICST 2020

13th IEEE International Conference on Software Testing, Varification and Validation

Porto, Portugal, March 23-27, 2020

Questions?