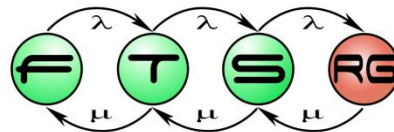


Model-based Regression Testing of Autonomous Robots

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Zoltan Micskei, Istvan Majzik

Fault Tolerant Systems Research Group



DOI: [10.1007/978-3-319-68015-6_8](https://doi.org/10.1007/978-3-319-68015-6_8)

CONTEXT AND MOTIVATION

Context: R3-COP and R5-COP projects



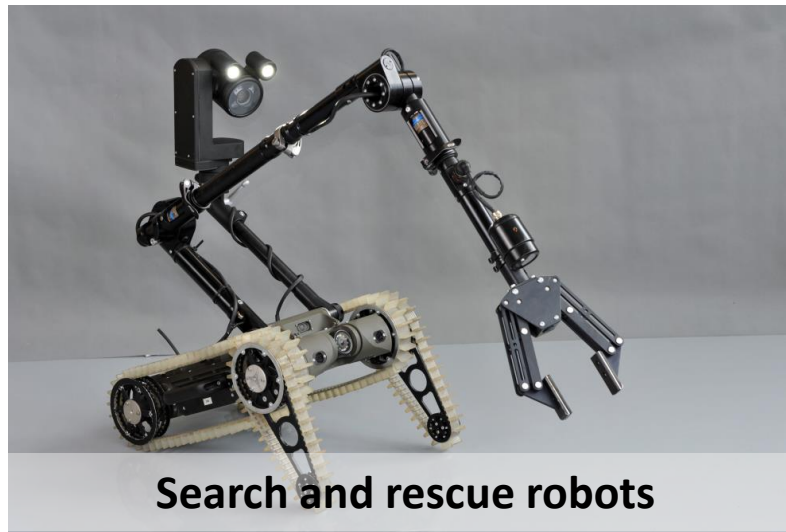
Household service robots

<http://www.care-o-bot.de>



Automated forklifts

<http://www.elettric80.com/>

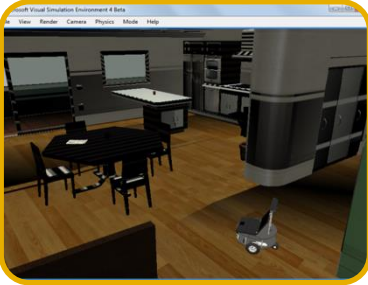


Search and rescue robots

<http://www.piap.pl>

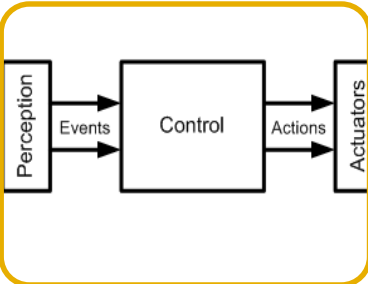


Testing approaches



Simulating robot and environment

- Not yet widespread (but changing)



Replaying captured sensor data

- Based on real data, but coverage?



Testing with real robot in “real” environment

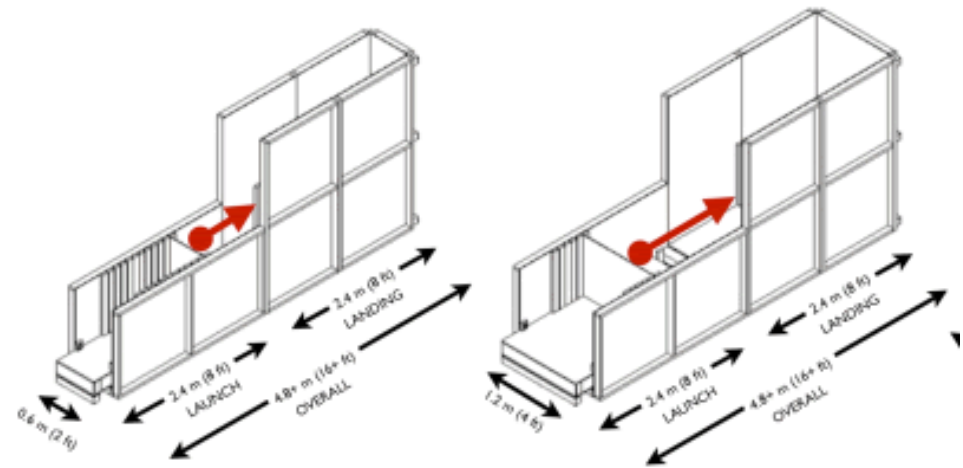
- Expert operators, experience-based
- Resource- and time-intensive

Standard test method: DHS-NIST-ATSM

- Testing robots in physical environment
- Standardized apparatus and procedure
- E.g.: ramp, gap, sand, sign, door opening

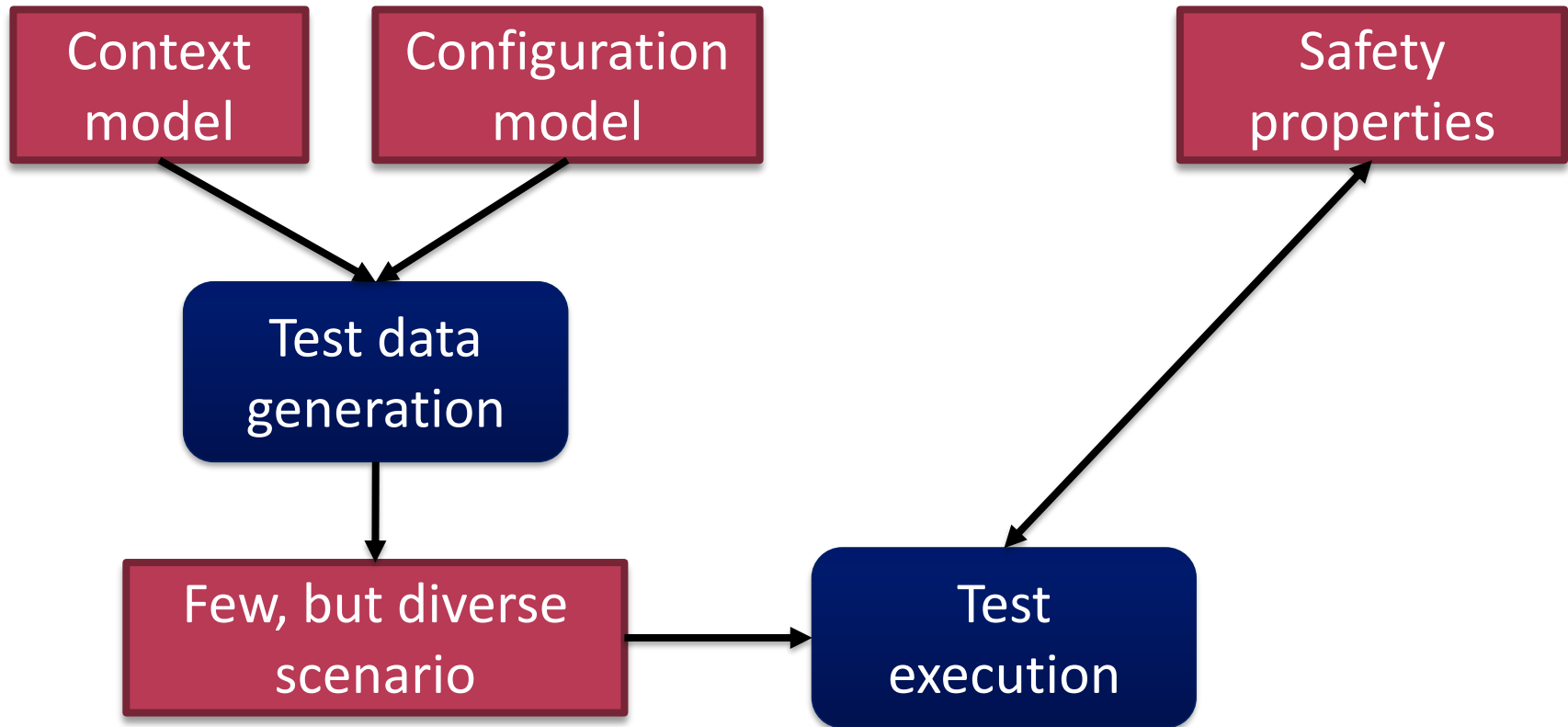
Mobility: Confined Area Terrains		Manipulator Dexterity	
	Continuous Pitch/Roll Ramps (ASTM E2826-11)		Strength at Reach (Balloting)
	Crossing Pitch/Roll Ramps (ASTM E2827-11)		Inspection (Balloting)
	Symmetric Stepfields (ASTM E2828-11)		Retrieving/Inserting Objects (Validating)
	Gravel (Balloting)		Pushing/Pulling/Rotating Forces (Validating)
	Sand (Balloting)		Door Opening and Traversal (WK27852)
	Mud (Prototyping)		Tools Deployment: Disruptor Aiming (Validating)

Source: NIST. [Guide for Evaluating, Purchasing, and Training with Response Robots Using DHS-NIST-ASTM International Standard Test Methods](#), 2014



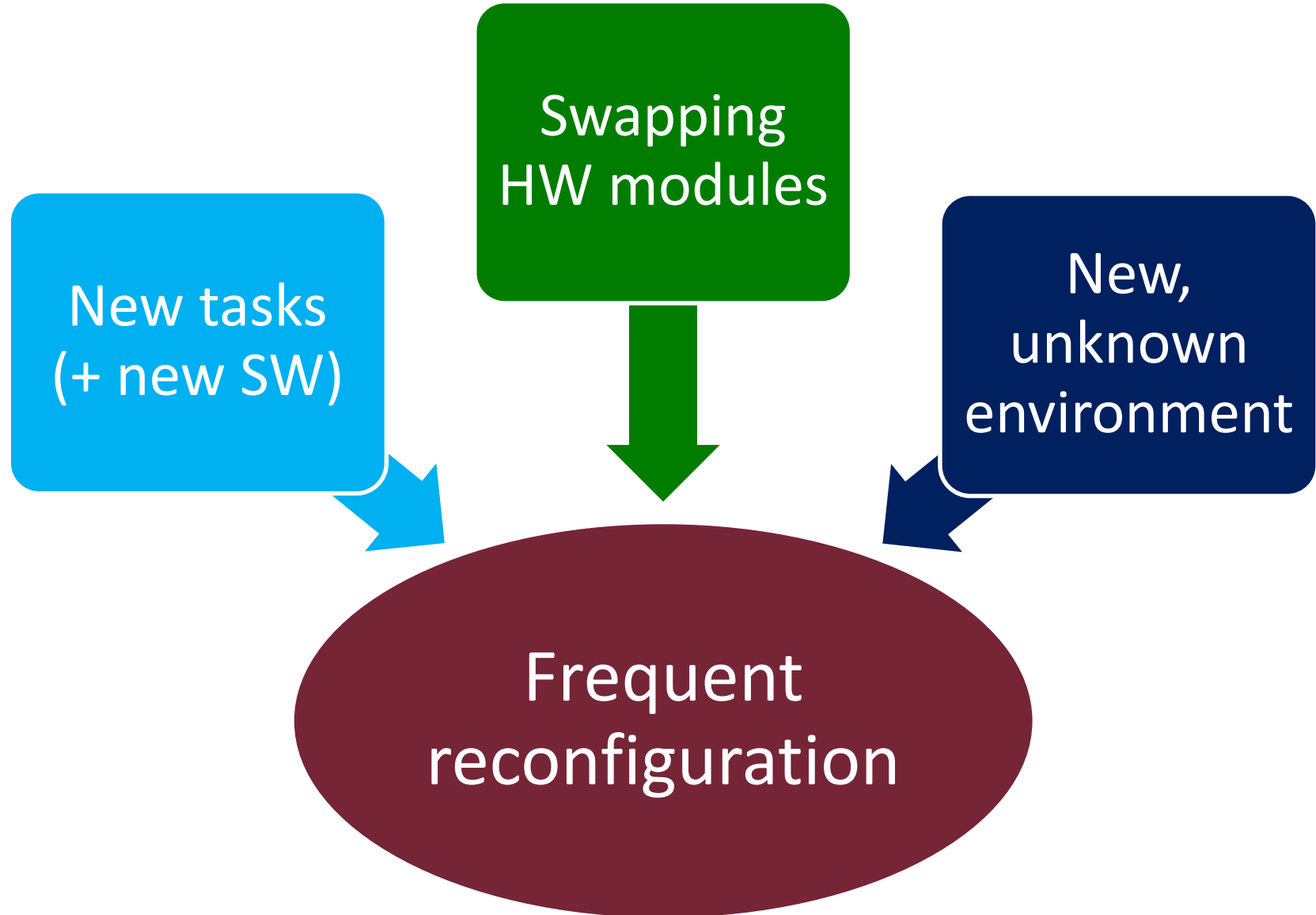
Source: ASTM E2801-11, [Standard Test Method for Evaluating Emergency Response Robot Capabilities: Mobility: Confined Area Obstacles: Gaps](#), ASTM International, West Conshohocken, PA, 2011

Previous work: Model-based approach



Z. Micskei, Z. Szatmári, J. Oláh, I. Majzik: **A Concept for Testing Robustness and Safety of the Context-Aware Behaviour of Autonomous Systems**, TruMAS 2012. [DOI](#)

New challenges: autonomy, modularity...



PROPOSED APPROACH

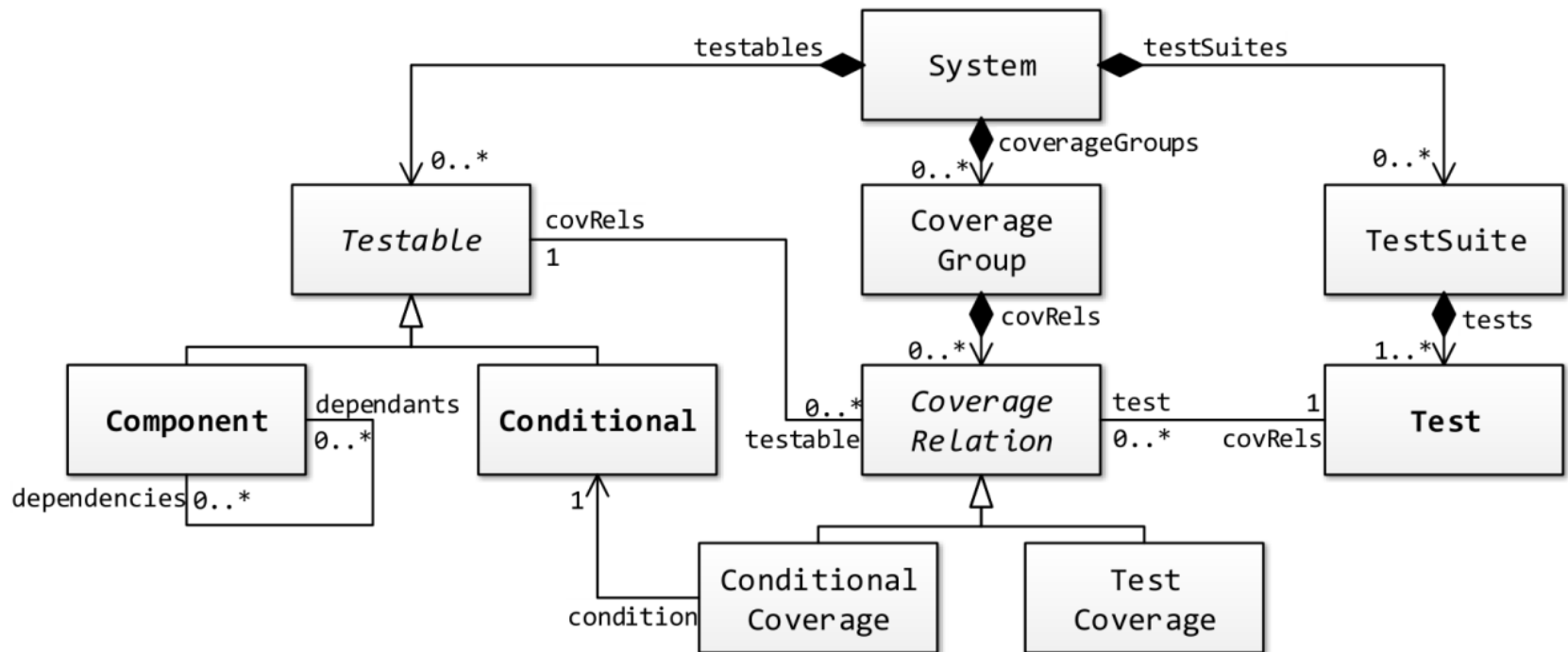
Reconfiguration → Regression testing

- Regression test selection (RTS)
 - Rich related work for code
 - Categorization: Re-usable, Re-testable, Obsolete, New
- Model-based development
 - Domain-specific languages (DSL)

How to perform regression test selection on DSLs?

Regression test selection metamodel

Represent changes in different DSLs in one model



E.g.: (Config) Robot has a motor.

(Context) Test scenario 1 has sand terrain.

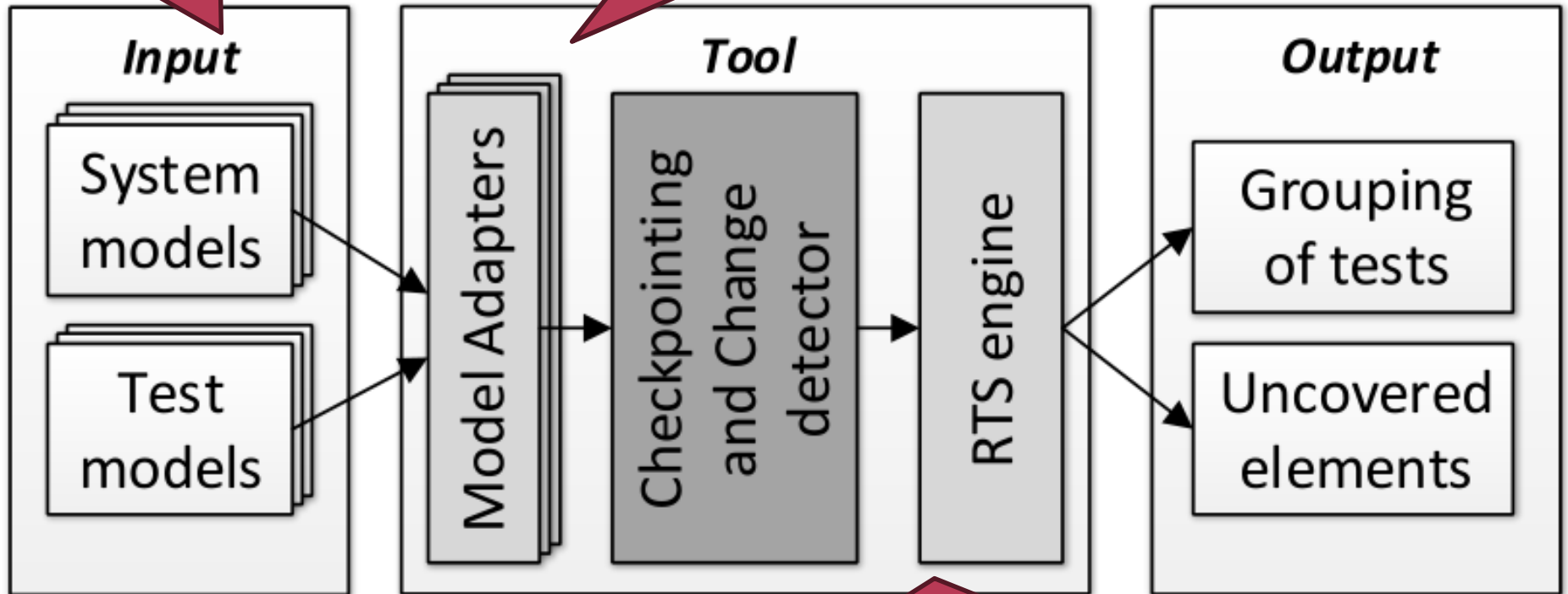
(Mapping) Motor is tested by sand in test scenario 1.

Architecture of the prototype tool

Input: Models describing the application + tests

Adapters to various models and changes

Output: classification of existing test cases



RTS algorithm is implemented only once

Proposed Workflow

Context and
Component
Models

Model
Transfor-
mation

Change in
the Input
Models

Reduced
Set of
Necessary
Tests

MDD/DSL expert

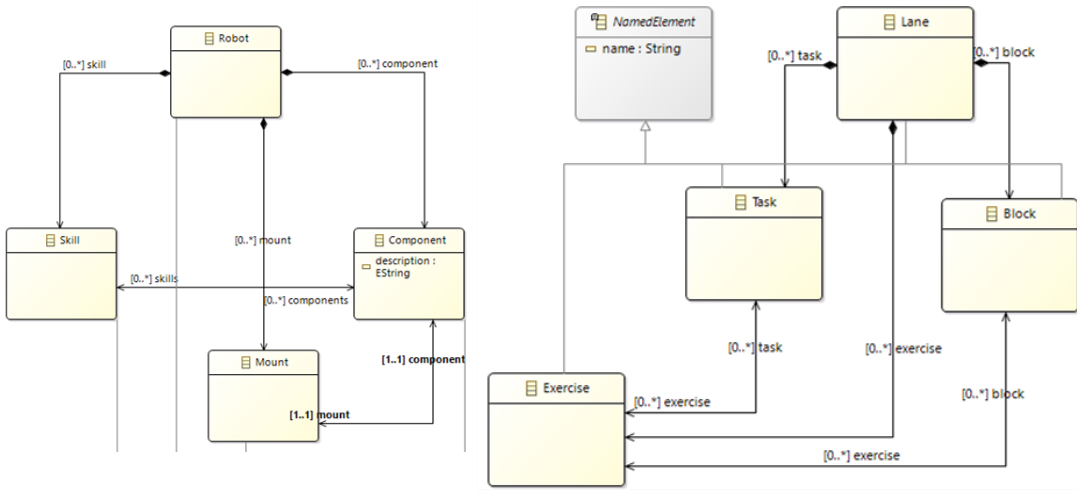
Test engineer

EXPERIENCES AND EVALUATIONS

Experiences

- Used technologies **scale well** (EMF, VIATRA...)
(see paper for evaluations)
- **Generic approach** proved useful
 - Several DSLs, several iterations
- Not easy to get **abstraction level** right

Model-based regression testing in action



- ◆ Capability Mapping Gripping:Grab-cone
- ◆ Capability Mapping Lighting:Path-narrow-line-follow-low-light
- ◆ Capability Mapping Precision-movement:Path-narrow-line-follow
- ◆ Capability Mapping Precision-movement:Path-narrow-line-follow-low-light
- ◆ Capability Mapping Line-following:Path-narrow-line-follow
- ◆ Capability Mapping Line-following:Path-line-follow

Input

Property	Value
Coverage Relations	
Dependants	
Dependencies	◆ Component Scout
Modification	■ Change
Name	■ Distance-calculation
Relation Ids	■ Autonomy, UltraSoundSensor
Re Test All	■ false

r5cop [Eclipse Application] C:\Program Files\Java\jre1.8.0_71\bin\javaw.

R5-COP Incremental Test Analysis Tool
2017-01-17T13:39:58.268

Tasks to re-run:

D
G

Output

Summary

Context: R3-COP and R5-COP projects



<http://www.care-o-bot.de>



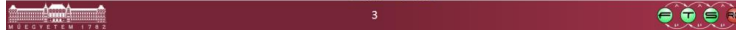
<http://www.electric80.com/>



<http://www.pisap.pl>

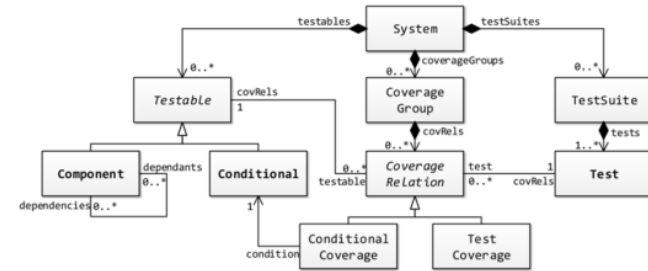


R5-COP

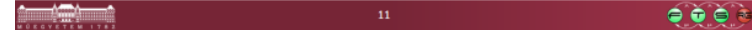


Regression test selection metamodel

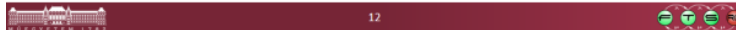
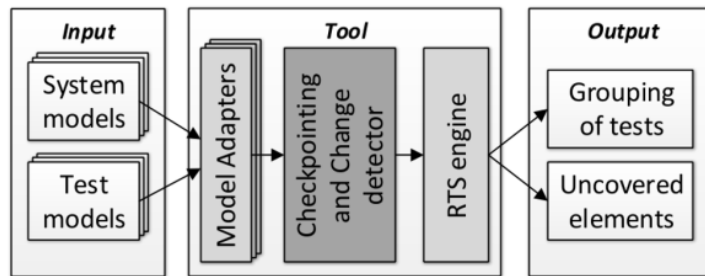
Represent changes in different DSLs in one model



Example: Motor is tested by sand in test scenario 1.



Architecture of the prototype tool



Model-based regression testing in action

Tasks to re-run:
D
G

- Capability Mapping Gripping:Grab-cone
- Capability Mapping Lighting:Path-narrow-line-follow-low-light
- Capability Mapping Precision-movement:Path-narrow-line-follow
- Capability Mapping Precision-movement:Path-narrow-line-follow-low-light
- Capability Mapping Line-following:Path-narrow-line-follow
- Capability Mapping Line-following:Path-line-follow

Input Output

