Testing Cyber-Physical Systems under Uncertainty

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ARTEMIS Spring Event, 14 April 2016

Acknowledgement: Materials are provided by U-Test consortium
Project facts:

Total cost: EUR 3 713 233,75
EU contribution: EUR 3 713 233,75
Coordinator: Oslo Medtech, Norway
Topic(s): ICT-01-2014 - Smart Cyber-Physical Systems
Funding scheme: RIA - Research and Innovation action

Overall project objective:
Improving CPS dependability via systematic and automated testing of Uncertainty in CPS

The consortium
Cyber-physical systems (CPS) in U-Test

Diverse types of CPS elements: sensors, actuators, controllers, gateways, cloud storage, etc.

Infrastructural resources are from IoT, Network functions and Clouds

Multi-level interactions in virtualized environments
Our CPS view

CPS Infrastructures

CPS Infrastructures

Virtual Verticals – V1, V2, ..., Vn

Virtual sensors
Virtual actuators
Communication protocol
Load balancer
Software-defined gateways
Cloud platform
VM
Docker
LXC

Physical gateways
Access points
Complex devices
Data center

Physical infrastructure layer

Virtual infrastructure (platform) layer

Sensors
Actuators
Our problem: Uncertainty

• The presence of uncertainty is pervasive in CPS
  • Strongly influence function, composition, business, and trustworthiness of CPS

• Emerging types of uncertainties due to the change of CPS
  • Conventional aspects, e.g., infrastructural physical resources and typical system/application operations
  • Emerging novel aspects: data uncertainties (data/data-centric CPS), actuations and elasticity of CPS resources, and data governance

• How to discover them and then deal with them?
  • Uncertainty analytics through testing
  • Also adaptation of CPS resources considering uncertainties
U-Taxonomy

- Infrastructure and Application Levels: focus on common and specific uncertainties within infrastructures and applications
Uncertainty Model

- Lifetime: 0..1
- Locality: 0..1
- Pattern: 0..1
- Risk: 0..1
- Random: 0..1
- Effect: 0..1
- Measurement: 0..1
- Cause: 0..1

Belief Model

- Belief
- Belief Statement
- Measurement: 0..1
- Uncertainty: 0..1
- Measure: 0..1

Characterizing Uncertainty

- Indeterminacy Source
  - Type: 0..1
  - Nature: «enumeration»
  - nondeterminism
  - insufficientResolution
  - missingInfo
  - composite
  - unclassified
Example

- FPX Geo Sports
  - UC1_INTE_1: Mixing connection with external sensor and X4 unit
  - BeliefAgent: Roland Norgren
  - IndeterminacySource: Human behaviour (Non-determinism) and Wireless Connection (InsufficientResolution)
  - Evidence: History log
  - Uncertainty (Occurrence): X4 connects with external sensor
  - Lifetime: from triggering external sensor’s connection to visualize the results within specific time constraint
  - Risk: Low
  - Random
  - Measure: Non-Specificity
  - Measurement: rare
Model-based and Search-based Testing

Uncertainty Reqs as text
- manually modelled using UMF
  - Test Ready Models as Stereotyped UML models
  - input
  - discover new uncertainties
  - output

UTF
  - generates Test Cases
  - discover new uncertainties

Test Driver
  - input
  - executes on System Under Test
  - collect results

Tools

- Modelbus
- Rational Software Architect

Files
Dynamic Testing Infrastructures for Uncertainty Testing

- Use information models for basic elements in IoT, network functions, and clouds
- Deploy a new CPS using virtualized components or configure existing CPS
- Deploy test utilities and perform tests on the fly
Summary: U-Test Results and methods

Key expected results:
- Understanding Uncertainty (U-Taxonomy)
- Modeling Framework
  - Extensible and Configurable
- Testing Framework
  - Extensible and Configurable
- Tools implementing Taxonomy and Frameworks
- Standards (Crosscutting)

Model-Based Testing:
- Abstraction
- Managing Complexity
- Automation
- Systematic

Search-Based Testing
- Optimization
- Smart Mechanisms
- Discovering unknown uncertainties
- Genetic Algorithms.....
Thank you for your attention!

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