Testing the robustness of communicating autonomous systems

Software Verification Techniques course

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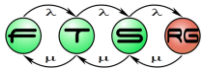


Outline

- The testing approach
- The role of models
- The testing strategy
  - Types of test sequences
  - View of robustness testing in the state space
- Modelling conventions
- Test sequence generation

The testing approach

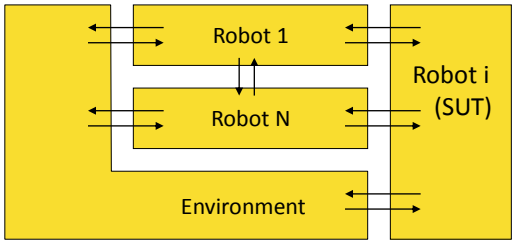
- Model based testing
  - Model = specification of interactions (cooperation) of autonomous robots (components)
- Overall test objective:
  - Checking whether the implementation of the tested robots (IUT: implementation under test) conforms to the model
    - Exercising the IUT by executing and checking interactions generated on the basis of the model
    - Test case = sequence of interactions relevant for the IUT
    - Test suite = test cases that satisfy given coverage criteria
- Test environment: Test harness (incl. test execution tool)
  - Replaces the environment of the IUT (its interacting partners and external environment)
  - Executes the interactions from the generated test cases that are relevant for the IUT

The role of models

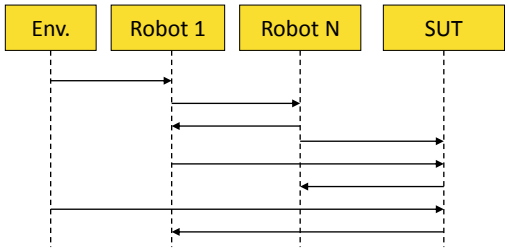
- Closed (live) model of a system and its environment
  - Interacting robots (components)
    - One or more of them is selected as subsystem under test (its model)
  - Environment (external, non-deterministic)
  - Configuration (parameters of the robots)
- Modular modelling approach
  - Modules: Robots, and the environment
  - Interfaces: Interaction points (typically „ports”)
- Model based test generation
  - Test case: Trajectory in the state space of the model
  - To execute the test: the interactions that are relevant for the IUT are selected and performed on its ports

The structure of models

- Structure of the model:

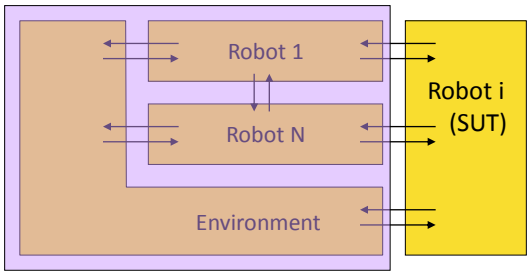


- Test case: Generated sequence of interactions:

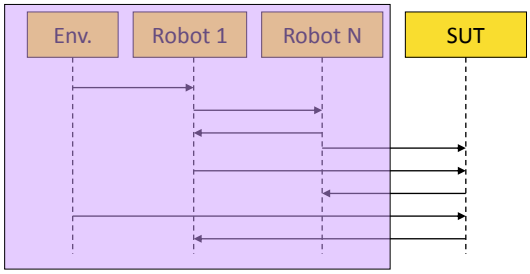


The configuration of the test environment

- Test harness:
  - Here: for testing robot i only; subsystems consisting of more robots can also be tested



- Test case executed by the test harness:

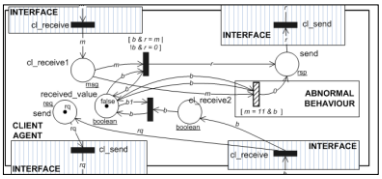


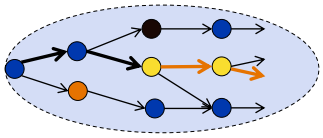
Testing strategy

- Goal: Robustness testing with respect to extreme cases in cooperation scenarios
- Testing strategy: Each test sequence consists of two parts:
  1. Driving the SUT to states in which it is able to receive message
     - through normal states,
     - through stressful states,
     - through boundary conditions,
     - using boundary messages
  2. Sending invalid messages and observing the reactions of the SUT
     - violating the message structure
     - applying extreme values
     - using invalid timing
- Coverage metrics: relevant states, conditions, messages
- Automated tool: Test sequence generation on the basis of Coloured Petri Net model of communicating systems
  - Challenge: Reachability of the specified state(s) of the SUT

Test sequences

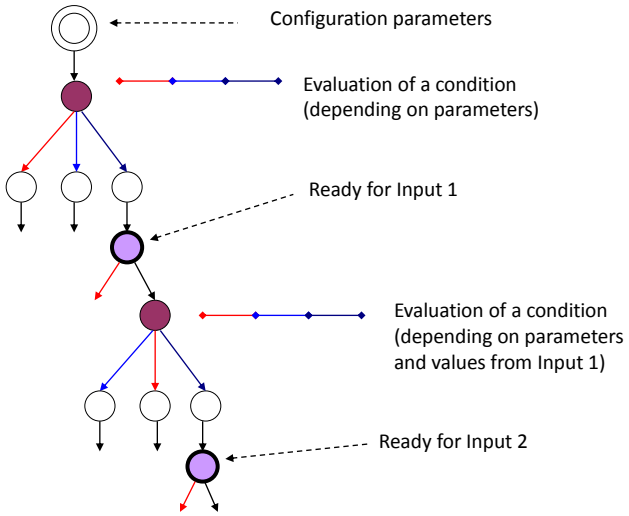
Generated test sequences: Sequences of messages needed to follow specific trajectories in the state space of the SUT





- Sending invalid input to the SUT in a normal state in which the SUT is ready to receive a message
- Sending invalid input to the SUT after reaching stressful state
- Sending invalid input to the SUT after boundary conditions
- Sending invalid input to the SUT after boundary messages
- Forcing the SUT to a specified stressful state
- Forcing the SUT to a specified abnormal behaviour

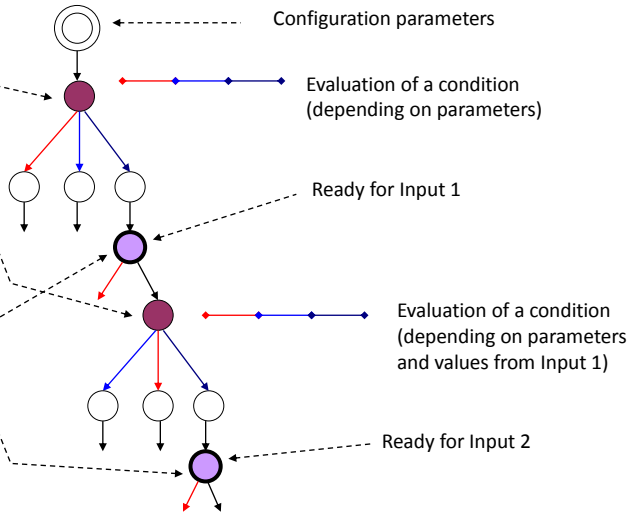
View of robustness testing in the state space



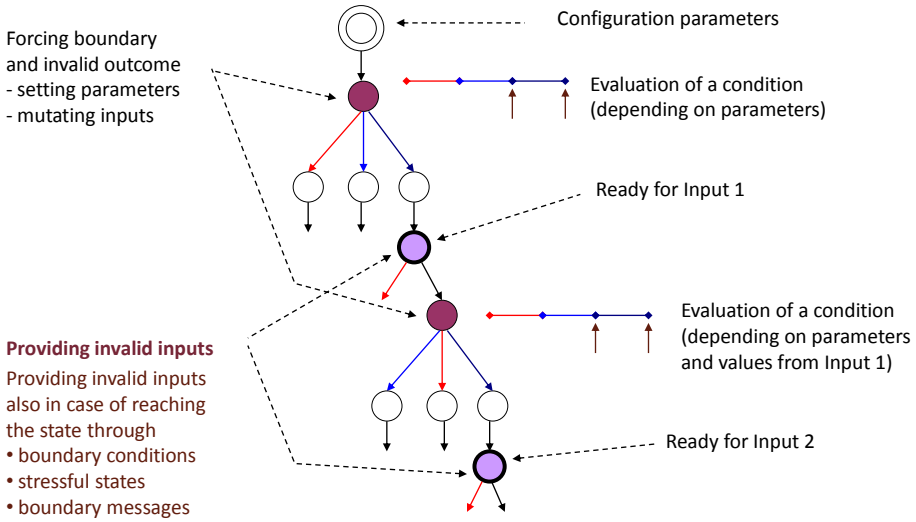
View of robustness testing in the state space

Forcing boundary
and invalid outcome
- setting parameters
- mutating inputs

Providing invalid inputs



View of robustness testing in the state space



Providing invalid inputs

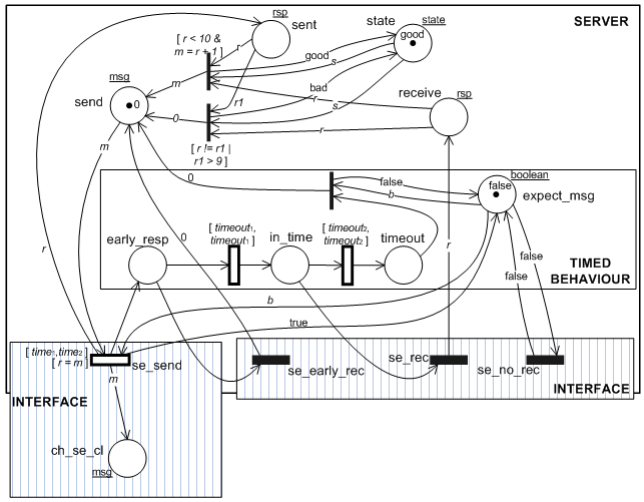
Providing invalid inputs also in case of reaching the state through
- boundary conditions
- stressful states
- boundary messages

Modelling conventions

- Identification of the modules that model the IUT
- Identification of interfaces of the IUT
  - Relevant state for interaction (when the IUT is able to be receive input)
    - To drive the IUT to this state
  - Type of input (signal, message, call etc.)
    - To derive valid / invalid inputs
- Identification of states when conditions are evaluated (that process inputs from interactions)
  - Relevant state in which the condition is evaluated
    - To drive the IUT to this state
  - Normal behaviour determined by the decision
    - To generate inputs for boundary condition
    - To generate inputs to violate the condition (implicit abnormal behaviour)
  - Explicit abnormal behaviour determined by the decision
    - To generate inputs that check this behaviour

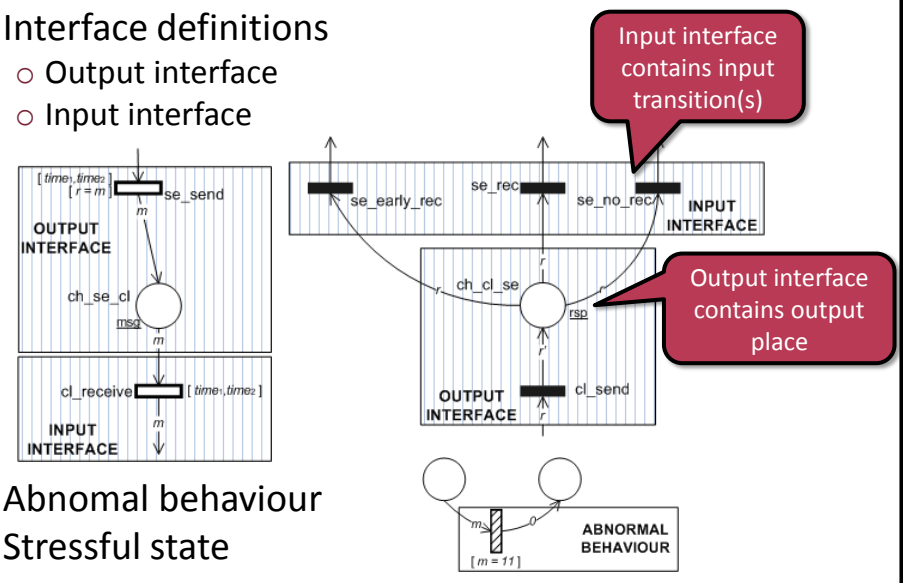
Modelling conventions

- Modular (and hierarchical) models



Modelling conventions

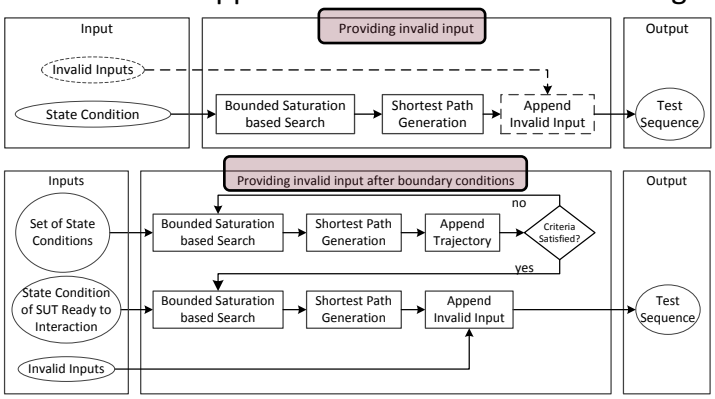
- Interface definitions
  - Output interface
  - Input interface



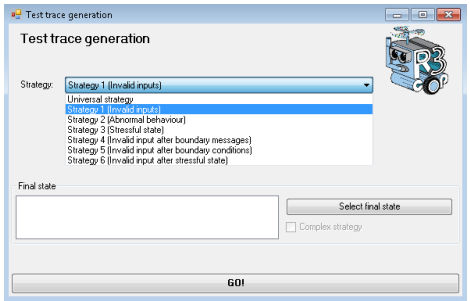
- Abnomal behaviour
- Stressful state

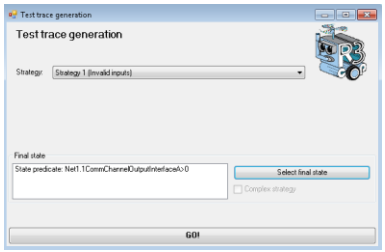
Algorithmic background

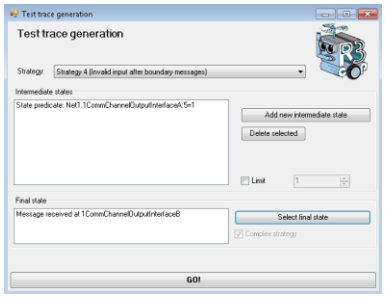
- Goal: Generating trajectory to reach specified states
- Symbolic algorithms
  - Saturation based state space exploration (search in the state space)
  - Saturation based shortest path generation
- Combination of approaches for different test strategies



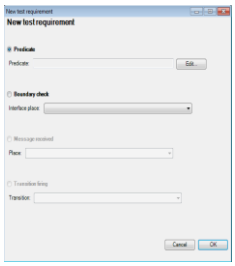
Test generator tool



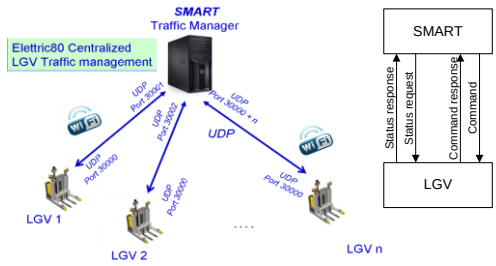




1. Selecting the strategy
2. Setting the parameters (state conditions of final and intermediate states)



Example: Test case generation



Here: Testing reaction to invalid inputs after boundary conditions of normal behaviour