PRODUCT-LINE TESTING BASED ON EVOLVING REQUIREMENTS
Towards Requirements as Tests

Debjyoti Bera
27.09.2022
This talk focuses on trending system and test quality metrics. The diagram illustrates the testing workflow with components such as requirements, test specs, test runner, and system release. The products and software versions include:

Products:
- Azurion 3F12
- Azurion 3F15
- Azurion 5C12
- Azurion 5C20
- Azurion 5F20
- Azurion 7F12
- Azurion 7C12
- Azurion 7C20
- Azurion 7B 12-12
- Azurion 7B 20-12
- Azurion 7B 20-15

Software Versions:
- R1.0.0, R1.1.0, SP 1.0... R14.0.0
INNOVATIONS AROUND TESTING HARDLY KEEP UP...

"Relax, our engineers found 90 percent of the flaws."
GAP BETWEEN REQUIREMENTS AND TESTS

Requirements

Functionality <X>
Goal
Pre-conditions
Default Settings

Description
- The system shall .... periodically
- When the user does ... Then ....
- After initialization the user may ...
- During normal operation, the system will ....
- If the user selects, then ...
- ...
- The user may only be allowed ... if...

Test Scenarios

Test Scenario 1
Test Scenario 2
Test Scenario 3
Test Scenario 4
Test Scenario N

Start-Up and Preset Selections
Ordering Products
Payment and Returns
Canceling an Order
4 PAINS OF TESTING

Translation of informal requirements to test scenarios

Do the test scenarios satisfy the requirements?

What are the implications of adding a new requirement or updating existing ones?
4 PAINS OF TESTING

Translation of informal requirements to test scenarios

Do the test scenarios satisfy the requirements?

Which tests and configurations must be selected for execution to cover for a change to requirements?

What are the implications of adding a new requirement or updating existing ones?
OUR MISSION

Improve efficiency and effectiveness of testing after a specification change

Our Approach

Constraint: Link as close as possible to technologies and WoW in Industry
**METHOD:** AUTOMATED REQUIREMENTS-DRIVEN TESTING

- **Dashboard Test Quality Metrics**
  - Dynamic Traceability (behavior)
  - Test Coverage Metrics
  - Test Specification Quality

- **Impact Analysis and Test Selection**
  - Regression Test Selection
  - Progression Test Selection
  - Impacted Test Selection

1. Requirements → **Traceability and Test Generation** → SCL
   - System Constraints Language
     - incl. variability and configuration modeling

2. Extract

3. Missing Test Generation per system configuration

4. **Impact Analysis and Test Selection**
   - Selected Test Sets and System Configurations

- **Test Runner**

- **System Under Test**
THE SYSTEM CONSTRAINTS LANGUAGE

Capture System Requirements as Constraints over System Actions

Five classes of Functional Constraints (> 25 templates and Extendable):

- **Future**: Something in the present causes another thing in the future.
- **Past**: Something is possible now due to something done in the past.
- **Past-Future**: Some things in the past and future are coupled.
- **Existential**: Something always happens.
- **Choice**: Something thing or another eventually happens.

Trigger Action:
- Turns on the coffee machine
- Selects a product
- Makes payment
- Login to safe mode

Observable Action:
- Coffee machine shows ready
- Coffee is delivered

Capture System Requirements as Constraints over System Actions

Functionality \(<X>\)

**Goal**

**Pre-conditions**

**Default Settings**

**Description**

- The system shall .... periodically
- When the user does ... Then ....
- After initialization the user may ...
- During normal operation, the system will ....
- If the user selects, then ...
- ...
- The user may only be allowed ... if...
SPECIFY AS YOU THINK

R1. Turning On
R2. Order Selection
R3. Water Delivery
R4. Espresso Delivery
R5. Capuccino Delivery
R6. Order Cancellation

if the customer performs act act-seq ready should be shown

Many Extensions

- Data associated with Actions
- Sequences of Actions
- Hierarchy and Compositionality
- Timing Constraints
CAPTURING SYSTEM VARIABILITY

SCL Constraints

R1. Turning On
R2. Order Selection
R3. Water Delivery
R4. Espresso Delivery
R5. Capuccino Delivery
R6. Order Cancellation

Generated Specification Models
(per System Configuration)

Basic2021
Economy2021
Premium2022

Specify > Analyze > Create > Select > Execute > Decide
GENERATING MISSING TEST SCENARIOS

SCL Specifications

Delta Test Generation

Coverage and Statistics

Existing Tests

Missing Test Scenarios (per system configuration)

- Scenario: coffeeMachine1 -
  - When the user starts the coffee machine
  - Then the coffee machine shows loading screen
  - And the coffee machine displays advertisement
  - And the coffee machine is ready
  - And the coffee machine shows the selection menu

- Scenario: coffeeMachine9 -

- Scenario: coffeeMachine21 -
  - When the user selects capuccino
  - Then the coffee machine shows loading screen

  - When the user selects medium sugar strength
  - And the user selects medium milk strength
  - And the user selects medium coffee strength
  - Then the coffee machine delivered capuccino
  - And the coffee machine shows thank you screen
  - And the coffee machine is ready
  - And the coffee machine shows the selection menu
ENABLING DYNAMIC TRACEABILITY (BEHAVIOR)

Conformance Checking Report

<table>
<thead>
<tr>
<th>Requirement</th>
<th>State Coverage</th>
<th>Transition Coverage</th>
<th>Test Coverage</th>
</tr>
</thead>
<tbody>
<tr>
<td>OrderCappuccinoByCard</td>
<td>83.3333</td>
<td>41.6667</td>
<td>25</td>
</tr>
<tr>
<td>CoffeePaymentFailureAndCancellation</td>
<td>100</td>
<td>62.5000</td>
<td>12.5000</td>
</tr>
</tbody>
</table>

Constraint: cappuccino is delivered after a card payment

Conforming Test Scenario:
- the user turns on coffee machine
- the coffee machine shows ready
- the user orders cappuccino
- the user pays by card
- the coffee machine reports payment succeeded
- the coffee machine prepares cappuccino
- the coffee machine delivers cappuccino
SO FAR, WE HAVE SEEN
DEALING WITH IMPACT OF A SPECIFICATION CHANGE
IMPACT OF A SPECIFICATION CHANGE

Behavior Impact

Impact of specification changes
IMPACT OF A SPECIFICATION CHANGE

New Test

New function

For Premium and Economy Configurations

Removed Behavior

New Behavior

Legend
- node_added / data_added
- node_updated / data_updated
- node_deleted / data_deleted
- no_changes
- selected
- highlighted

Specify  Analyze  Create  Select  Execute  Decide
## REGRESSION TEST-CONFIGURATION SELECTION

Select tests and configurations based on impact.

<table>
<thead>
<tr>
<th>Configuration</th>
<th>Selected Tests</th>
<th>Category</th>
</tr>
</thead>
<tbody>
<tr>
<td>BASIC_Y2022</td>
<td>□ Scenario Outline: The user orders Coffee and Pays for it unsuccessfully</td>
<td>PROGRESSION</td>
</tr>
<tr>
<td></td>
<td>□ Scenario Outline: The user orders Coffee and Pays more than needed</td>
<td></td>
</tr>
<tr>
<td></td>
<td>□ Scenario Outline: The user orders Coffee and Pays by Coins for it successfully the Coffee is delivered</td>
<td></td>
</tr>
<tr>
<td>PREMIUM_Y2022</td>
<td>□ Scenario Outline: The user orders Capuccino and Pays for it unsuccessfully</td>
<td>REGRESSION AND PROGRESSION</td>
</tr>
<tr>
<td></td>
<td>□ Scenario Outline: The user orders Capuccino and Pays for it successfully by card and the Capuccino is delivered</td>
<td></td>
</tr>
<tr>
<td></td>
<td>□ Scenario Outline: The user orders Coffee and Pays by card for it successfully the Coffee is delivered</td>
<td></td>
</tr>
<tr>
<td></td>
<td>□ Scenario Outline: The user orders Water and it is delivered without payment</td>
<td></td>
</tr>
<tr>
<td></td>
<td>□ Scenario Outline: The user orders Capuccino and pays more than needed the money is returned and the Capuccino is delivered</td>
<td></td>
</tr>
<tr>
<td>BASIC_Y2022</td>
<td>□ Scenario Outline: The user orders Coffee and Pays by card for it successfully the Coffee is delivered</td>
<td>REGRESSION AND PROGRESSION</td>
</tr>
<tr>
<td></td>
<td>□ Scenario Outline: The user orders Water and it is delivered without payment</td>
<td></td>
</tr>
</tbody>
</table>
LOOKING AHEAD

How do customers use the system?
What has changed in the system software?
How has the system performed during testing?

When do I stop testing?
Trending System and Test Quality Metrics

Additional Sources of Data
- Installed Base
- System
- Source Code
- Configurations
- Models
- Report Data
- Execution Data
- Test Specification
- Automation

Field Data
TAKE AWAY

When do I stop testing?
Trending System and Test Quality Metrics

Testing Workflow

Requirements

Test Specs

Test Runner

System Release