Automatic Test Case Generator in XML from Specifications in Rosetta

Masters Thesis Defense

by

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Overview

- Introduction
- Problem Statement
- Background Details
  - Details of Rosetta
  - Details of XML
- Test Scenarios
- Test Requirements
- Abstract Test Vectors
- Concrete Test Vectors
- Summary and Future Work

Introduction

- Importance of Testing
- General Testing Techniques
  - Implementation Based Techniques
  - Specification Based Techniques
- Complex Systems
  - Problem: Difficulty in Representation
  - Possible solution: Increasing the Abstraction Levels
  - Solution: System Level Design Languages
  - Rosetta

Introduction...

- General Testing Technique
  - Test cases executed on the developed product
- Problem - Tedious and Repetitious
  - Why? – Underlying Implementation Changes
- Solution - Automatic Test Case Generation
- Tools - Automatic Test Case Generator

Problem Statement...

- Automatic Test Case Generators - Problems
  - Test cases in language dependent format
  - Problem integrating third party tools
- Answer - Language Independence
- Uses - Simulation Environment Independent
- Proposed Solution
  - Specifications in Rosetta
  - Test cases in XML

Background … Details Of Rosetta

- Facet
  - Basic unit of specification
  - Component representation from a particular perspective

facet <*facet-label*> *(parameters)* is

<*declarations*>

begin <*domain*>

<*terms*>

end facet <*facet-label*>

Details of Rosetta...

- *facet-label* - Provides Unique Name
- *parameters* - Facet Interfaces
  - <*variable-name*> :: mode type
    - input_voltage :: in real
- *declarations* - Define Local Variables
- *domain* - Provides Definitions and Vocabulary
- *terms* - Define Behavior modeled by Facet
  - Type – boolean or facet
  - label::term
    - Term – expression

XML (Extensible Markup Language) Details...

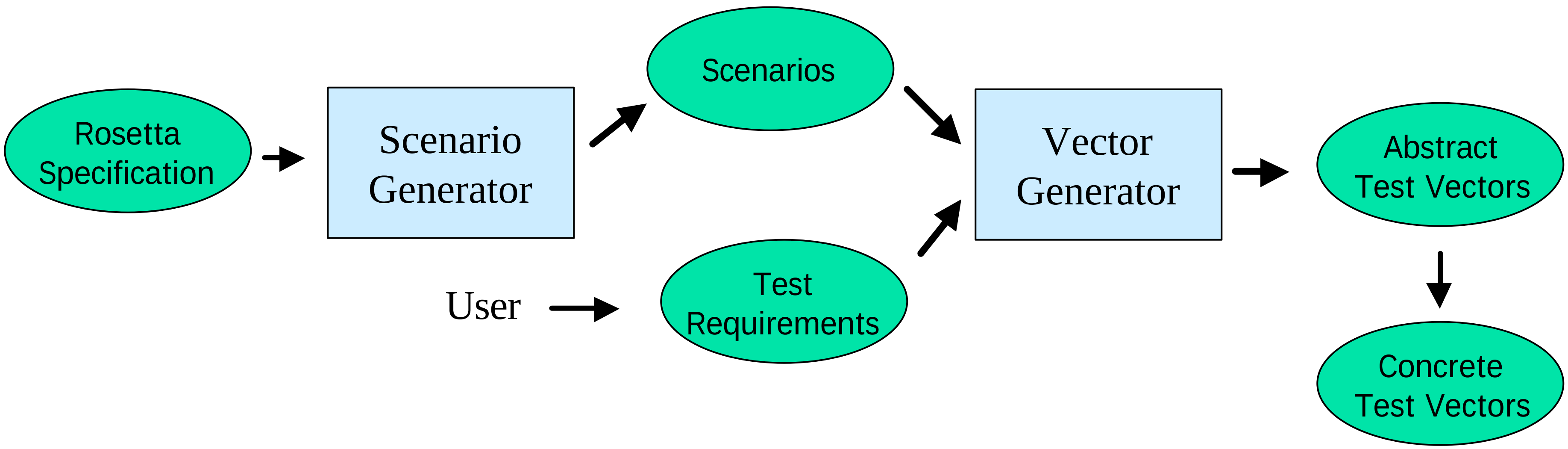
- Similar to HTML but uses custom tags
- W3C standard

```
<person>
    <name>
        <firstname> Albert </firstname>
        <lastname> Einstein </lastname>
    </name>
    <profession> Scientist </profession>
</person>
```

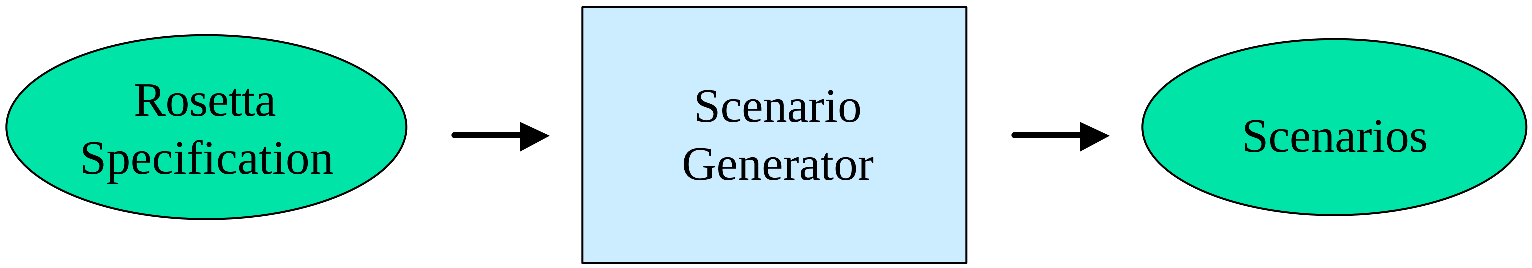
DTD, XSLT, DOM

- DTD – Document Type Definition
  - Template for XML
  - Determines Elements order
  - Uses – Exchange format
- XSLT – Extensible Style Sheet Transformation
  - Transform XML documents
  - Contains templates and associated rules
- DOM – Document Object Model
  - XML Document in memory
  - Object Tree Representation

Overview Of DVTG



Phase 1. Generation of Scenarios



Test Scenarios

- Test Scenario
  - A boolean condition
  - Consists input and acceptance criteria
  - Represents class of tests
- Rosetta Expressions - Contains logical and relational operators
- Sample Expression - P(x) or Q(y)
  - P(x), Q(y) – Predicates over x and y

Test Scenarios...

- Driving Values - Input Parameters
  - Drive the system to a particular state
- Driven Values - Output Parameters
  - Values to be observed
- Controllable Predicates:
  - Consists of *driving variables*
  - Predicate variables controllable
- Non-Controllable predicates:
  - Consists of *driven variables*

Test Scenarios...

- Algorithmic Details
  - All possible test cases generated – Truth table
  - Redundant test cases removed
    - Using Driving and Driven variables concept
  - Predicate has only driving variables
    - No test cases
  - Predicate has only driven variables
    - All test cases
- Relevance to Rosetta
  - Terms – Boolean Expressions – true

OR Operator

P(x), Q(y) - predicates over x and y.

P(x)	Q(y)	P(x) or Q(y)
0	0	0
0	1	1
1	0	1
1	1	1

Test scenarios when P(x) or Q(y) is true:

(P(x) = false) and (Q(y) = true) …(1)

(P(x) = true) and (Q(y) = false) …(2)

(P(x) = true) and (Q(y) = true) …(3)

x → Driving → P(x) controllable

x → Driven → P(x) un-controllable

Or Operator...

P(x) or Q(y)

P(x) → true *or* Q(y) = true / Q(y) = false } true

P(x) → false *or* Q(y) = true => true

Q(y) = false => false

(P(x) = false) and (Q(y) = true) …(1)

(P(x) = true) and (Q(y) = false) …(2)

(P(x) = true) and (Q(y) = true) …(3)

X	Y	Test Condition Considered		
0	0	(1)	(2)	(3)
0	1		(2)	
1	0	(1)		
1	1			

0 -- Driven Variable

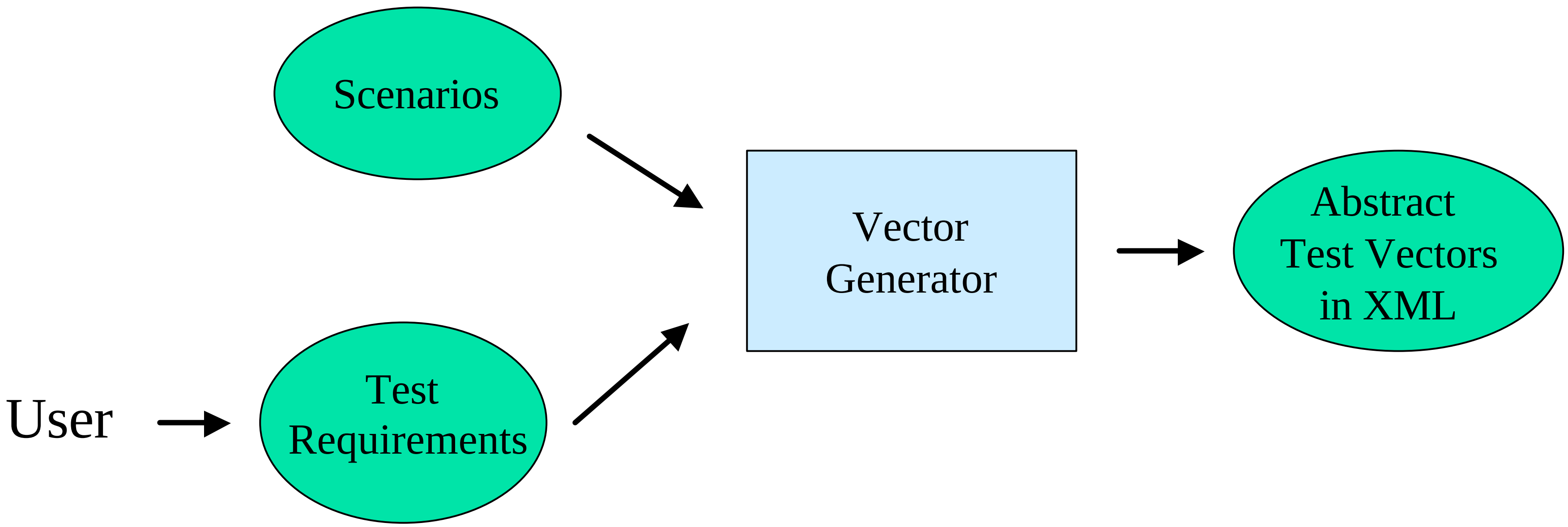
1 -- Driving Variable

Test Scenarios Example

```
package schmidt_trigger is
begin logic
facet schmidt_trigger(input_voltage::in real;
                      output_value::out bit)
  b :: bit;
  begin state_based
  L1: (input_voltage > 0.0) and (input_voltage < 5.0);
  L2: if (input_voltage < 1.0)
          then (b' = 0)
          else if (input_voltage > 4.0)
              then (b' = 1)
              else (b' = b)
      end if;
  L3: output_value' = b';
end facet schmidt_trigger;
```

```
package schmidt_trigger is
begin logic
facet schmidt_trigger(input_voltage::in real;
                      output_value::out bit)
  b :: bit;
  begin state_based
  ACCEPT_1: (input_voltage < 1.0) and (b' = 0);
  ACCEPT_2: (input_voltage > 4.0) and (b' = 1);
  ACCEPT_3: (input_voltage >= 1.0) and
            (input_voltage =< 4.0) and
              (b' = b);
  ACCEPT_4: (output_value' = b');
end facet schmidt_trigger;
```

Phase 2. Abstract Test Vector Generation.



Test Requirements

- Purpose - Limits number of test cases
- Constraints – Input parameters
- How are they Specified - User
- Classification
  - General Test Requirements
  - Initial Vectors and Test Cases

General Test Requirements

- Purpose: Initializes values to input parameters.
- Function Signature:
  - test_req(var, lower_bound, upper-bound, increment :: number) :: bit

test_req(var1,1,2,1)

test_req(var2,5,10,2)

→

var1 = 1, var2 = 5

var1 = 1, var2 = 7

var1 = 1, var2 = 9

var1 = 2, var2 = 5

var1 = 2, var2 = 7

var1 = 2, var2 = 9

Initial Vectors and Test Cases

- Problem – Systems in a particular state
- How are they specified
  - init(seq::number, vector::univ)
  - test_init(seq::number, vector::univ)

init(1,(A=0) and (B=1))

test_init(1, (A=2) and (B=3)

test_req(B,4,6,1)

→

A = 0 and B = 1 (from init function)

A = 2 and B = 3 (from test_init function)

B = 4

A = 2 and B = 3 (from test_init function)

B = 5

Sample Test Requirements file

```
package schmidt_trigger is
begin logic
facet schmidt_trigger(input_voltage::in real;
              output_value::out bit)
    b :: bit;
    begin state_based
    ACCEPT_1: (input_voltage < 1.0) and (b' = 0);
    ACCEPT_2:  (input_voltage > 4.0) and (b' = 1);
    ACCEPT_3:  (input_voltage >= 1.0) and
               (input_voltage =< 4.0) and
                 (b' = b);
    ACCEPT_4: (output_value' = b');
 end facet schmidt_trigger;
 end package schmidt_trigger;
```

```
facet schmidt_trigger_REQ is
test_req( variable, lower_bound,
        upper_bound, increment::real);

begin state_based

  L1: test_req(input_voltage,0.0,5.0,0.5);

end facet schmidt_trigger_REQ;
```

Abstract Test Vectors in XML

- Contain expected output values for input values
- Language independent, simulation environment independent

<! ELEMENT vectorslist (vector)*>

<! ELEMENT vector (condition)* >

<! ELEMENT condition (parameter, value)*>

<! ELEMENT parameter (#PCDATA)>

<! ELEMENT value (#PCDATA)>

<! ATTLIST parameter mode CDATA #REQUIRED>

Sample XML Abstract Test Vector

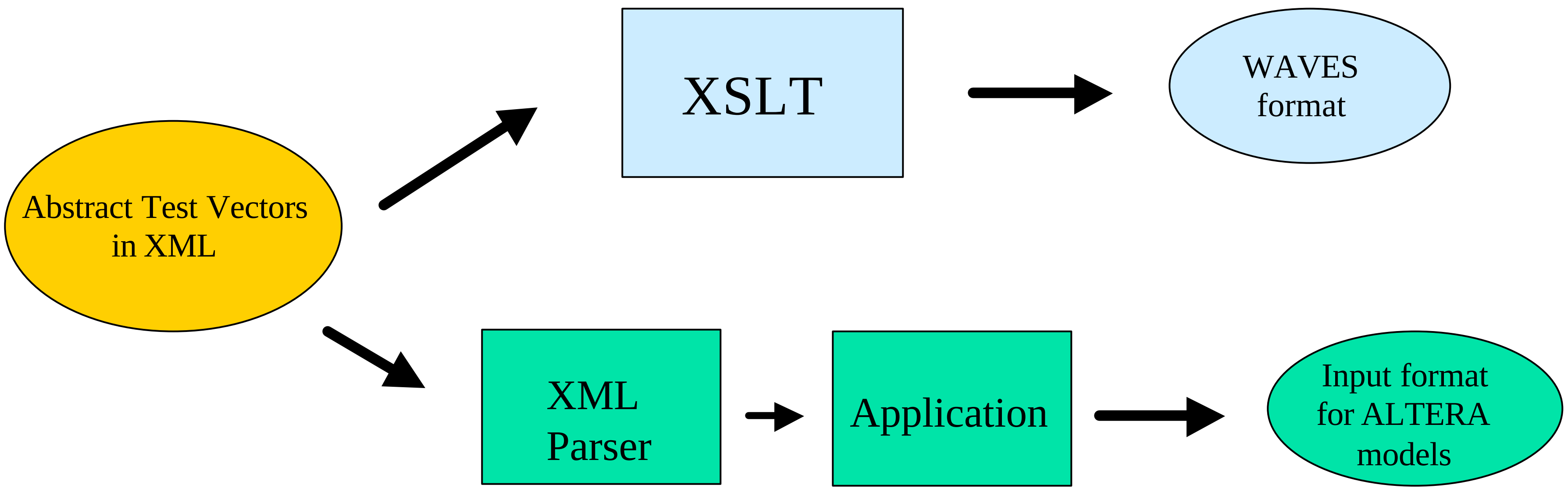
input_voltage = 4.0 output_value = 1.0

```
<vectorslist>
    <vector>
        <condition>
            <parameter mode = "in"> input_voltage </parameter>
            <value> 4.0 </value>
        </condition>
        <condition>
            <parameter mode = "out"> output_value </parameter>
            <value> 1.0 </value>
        </condition>
    </vector>
</vectorslist>
```

Concrete Test Vectors

- Rosetta
  - No simulation environment
  - Need a format for testing
- WAVES format
  - VHDL implementations
  - IEEE standard
- ALTERA
  - Comes with simulation environment
  - Format for input test cases

Phase 3. Generation of Concrete Test Vectors



Generation Of Concrete Test Vectors

Abstract Test Vector

```
<vectorslist>
  <vector>
    <condition>
       <parameter> input_voltage </parameter>
       <value> 4.0 </value>
    </condition>
    <condition>
       <parameter> output_value </parameter>
       <value> 1.0 </value>
    </condition>
  </vector>
</vectorslist>
```

→

XSLT

```
 ………………………….
 ………………………….
<xsl:template match = “/vectorslist/vector”>
  <xsl:apply-templates select= “condition/value”>
  </xsl:apply-templates>
 ……..
 ……..
     </xsl:template>
     …………………
<xsl:template match = “condition/value”>
    <xsl:value-of select = “.”/>
    <xsl:text >&#9;</xsl:text>
</xsl:template>
```

Concrete Test Vectors

XSLT → WAVES format

input_voltage	output_value
0.0	0.0
0.5	0.0
1.0	0.0
1.5	0.0
2.0	0.0
2.5	0.0
3.0	0.0
3.5	0.0
4.0	1.0
4.5	1.0

DOM → Input format for ALTERA's models

```
START    0.0
STOP   4.5
INTERVAL   0.5

INPUTS  input_voltage
OUTPUTS output_value
```

Optimized True Points

- Purpose: Single optimized value instead of a range of values
- Algorithm used: Simplex Algorithm
  - Relational expressions converted into path constraints

Branch Predicate	Path Constraint	rel
x1 > x2	x1 – x2	>
x1 >= x2	x1 – x2	>=
x1 < x2	x2 – x1	>
x1 =< x2	x2 – x1	>=
x1 = x2	abs(x1 – x2)	=
x1 /= x2	abs(x1 – x2)	/=

Optimized True Points

Cost Functions for each path constraint

Path Constraints	Cost Function
$g_i(x) > 0$	$G(g_i(x),w_i) = \exp(-w_i(g_i(x)))$
$g_i(x) >= 0$	$G(g_i(x),w_i) = \exp(-w_i(g_i(x))+1.0)$
$g_i(x) = 0$	$G(g_i(x),w_i) = \exp(-w_i(g_i(x))-1.0)$
$g_i(x) /= 0$	$G(g_i(x),w_i) = \exp(-w_i\ \mathrm{abs}(g_i(x)))$

$$R = \sum_{i=1}^{n} G(g_i(x), w_i)$$

Testing

- Testing
  - schmidt – trigger, alarm clock specification
  - Regression Testing
- Industry Application
  - Edaptive

Conclusions

- Specification based techniques – More abstraction
- Automatic Test Data Generator – Helpful in Testing
- Framework has been Designed

- Concrete Test Vectors -
  - WAVES format
  - Input format for simulating ALTERA MODELS

Future Work

- Support - Structural specifications
- Test Requirements format - XML
- Automated Test Harness – From XML

Acknowledgements...

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