“Automated Software Testing Increases Test Quality and Coverage Resulting in Improved Software Reliability.”

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Frank Salvatore
High Performance Technologies, inc.
3159 Schrader Road
Dover NJ, 07801
(973) 442-6436 ext 249
fsalvatore@hpti.com
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Background

- Phase I SBIR Completed in FY 2004 proving feasibility.
- Phase II SBIR to Start in FY 2006
- Sponsor: US ARMY ARDEC, Fire Control Systems & Technology Division (FCSTD)
- Contractors:
  - Cognitive Concepts, LLC Prime
  - High Performance Technologies, Inc (HPTi)
  - Software Silver Bullets
Project Purpose & Goals

- Generate an integrated process which enables any SW Development organization to apply Model based Specification and Testing (MST)
- Significantly advance the state of the practice for system level MST.
  - Create large models of complex system software behaviors that closely represent expected operational behavior of a specific system.
  - Automatically generate test cases from the model.
  - Define and store test scripts associated with every stimulus in the test population.
  - Generate executable test scripts.
- Implement the required tools that will enable bringing Model Based Specification and Testing technology to market.
- Reduce Software Life Cycle Maintenance Costs.
Software Reliability - Probability of failure-free software execution in a specified operating environment.

Software Reliability Engineering - Systems engineering process activities ensuring reliable software systems.

- **Assessment** - software reliability can be assessed (measured) only when the software is executing, either in a test lab or in the field.
- **Prediction** - prior to having executable software, assessment is done by inference via a forecast.
SRE Challenges

- Verifying the system does what users want.
- Integrating Requirements analysis and System Software testing.
- Determining what to measure and when to measure it.
- Limiting scope and breath of testing to stay on schedule.
SRE involves:

- Developing an operational, or usage, profile of the software system under test and
- Exercising random test cases from the profile to obtain a direct assessment of the reliability of a software system
Statistical Testing in a Nutshell

**Statistical Testing**
- Specification represented in the form of usage models
- System tests generated directly from usage models

**Markov-chain usage models**
- Black box state-based models that cover every possible state of *usage* for a software system
- External behavioral representation of system
- Composed of states (conditions) and arcs (stimuli)

**Software tool generates random test cases**
Industry practice for testing military applications uses a requirements-based approach.

- Test cases are defined for each requirement, or shall statement.
- Test cases are designed manually or with a software tool that is independent of the requirements tool.
- Test cases are scripted manually or with a tool that is not integrated with the test design tool.
- Tests are executed manually or in some cases the tests are automated utilizing a project specific test automation tool.

An innovative approach to requirements specification and testing
MBT is a black box representation of the expected behavior of system software.

A model-based specification is called a usage model specifying how the system is used, or behaves.

STATE MACHINE
Nodes are states-of-use
Arcs are possible stimuli
Probabilities \((p=1)\) define expected usage
Test case is a path from initial to terminal state
MST Overview

MST

- Provides a structured approach to requirements analysis and software test design.
- Ensures the system specification prescriptive and consistent to enable automatic generation of system software test cases.
- Facilitates an objective assessment of system software reliability.
- Enhanced communication between developers and testers.
- Eases the updating of test suites for changed requirements.
- Shorter schedules, lower cost, and better quality.
- A model of user behavior.
- Early exposure of ambiguities in specification and design.
Toolset Architecture

Model Specification Module → Model Analyzer
Model Analyzer → Test Case Analyzer
Test Case Analyzer → Test Generation Module
Test Generation Module → Test Cases
Test Cases → Test Execution Module

Software Requirements → Software Requirements Specific Script Library
Software Requirements Specific Script Library → Test Translation Module
Test Translation Module → Test Scripts
Test Scripts → Test Execution Module

Analysis Results → Analysis results
Analysis results → Analysis results

System Under Test
System Under Test

emulator
emulator

 simulator
 simulator

= general purpose module
= part of Test Generation Module
= project specific module

Test results returned
- drivers
- interfaces
- commands
- etc.
Model Specification Module

Capability:

- Tabular entry of system requirements.
- Definition of the system boundary by itemizing all input stimuli and responses.
- Specifying traceability via requirement tags.
- Enumeration of input stimulus sequences.
- Automatic analysis of the completed enumeration to verify coverage and to construct the usage model.
- Define usage variables and associate a unique set with each state in the model.
- Assigning probabilities to each transition in the usage model.
- XML schema for storing and managing the above data.
Test Generation and Analysis Module.

Capability:

- Provides Markov analysis of the usage model for properties useful for model validation and test planning.
- Enables test case generation via random walk, relative probability, and graph coverage algorithm.
- Enables test case management necessary for pass/fail recording and format conversion.
- Provides analysis of test results to compute coverage and reliability metrics.
Test Translation Module

Capability:

- Accepts operator input to build script fragments for each system stimulus and export the result to the script library.
- Reads stimulus mapping information from the script fragment library that maps the stimuli used in the model to codes readable by the Test Execution Module.
- Determines proper code sequences to perform the test cases created by the Test Case Generator.
- Generates test scripts for the Test Execution Module from the fusion of script fragments.
Test Execution Module

Capability:

- Executes target specific test scripts using hardware and software elements designed to interface with the system under test.
- Provides the operator an interface to observe the test steps being performed as well as enabling the operator to pause or restart testing.
- Logs any results generated from the testing in formats for human interpretation and for input to the Test Case Analysis and Generation Module.
Capability:

- Perform end-to-end testing of System Software.
- Record scripts from a PC keyboard and play them back to the keyboard port of a PC.
- Translate the serial communication between the Display Unit (DU) and the AFCS Computer Unit (ACU).
- In order to support the Enhanced Display System (EDS), the connection to the Auto Tester would be inserted between FBCB2 and the ACU, not between the EDU and FBCB2.
Automated Test Capability

Capability:

- Supports Developmental, Integration, and Formal Qualification Testing (FQT) of a Fire Control Software System.
- Provides and demonstrates a means to capture test cases and procedures in a reusable form.
- Supports management of test artifacts, including storage, retrieval, editing, merging, and searching.
- Perform end-to-end testing of a Fire Control system software.
- Monitors and records the system’s responses to stimulus, and, as necessary, emulates the appropriate response via a system interface to complete a given test case.
Applying MST to Achieve Software Safety

- Traditional approaches include static analysis
- MST provides a robust, dynamic approach
  - Models cover all usage states, including rare ones.
  - Statistical testing ensures that potentially hazardous unknown or unforeseen events are covered in the system test suite. Static analysis alone cannot predict the consequences of highly complex behaviors.
- MST is a supplement to, not a replacement for, methods such as Fault Tree Analysis and Hazard Analysis.
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Project starts FY06

Results will be provided in a final report and demonstration.

Advance the state of the practice for system level MST.
- Create large models of complex system software behaviors that closely represent expected operational behavior of a specific system.
- Automatically generate test cases from the model.
- Define and store test scripts associated with every stimulus in the test population.
- Generate executable test scripts.

Integrated Suite of Tools.
Questions?