Software Reliability Engineered Testing

“The bitterness of poor quality remains long after the sweetness of meeting the schedule has been forgotten.”

--Anonymous
Review of yesterday’s talk

• *Software Reliability* corresponds to *functional requirements* as well
  – Behavior of the system is the key

• *Cost* is a major barrier in terms of achieving high *Software Quality* and *Reliability*

• *Automation* is a long term investment, with potentially high returns

• *Formal methods* (or pseudo-formal methods) are not only good for *correctness*, they may also aid in *automation*
What is SRET?

• **Software Reliability Engineered Testing (SRET)**
  – An engineered *Test Process* that utilizes *Quantitative Planning* and *Tracking*
  – Considers *Reliability Objectives* and *Operational Profiles*
  – Devised at *AT&T Bell Labs* during the early 90s
  – Major contributor: *John D. Musa* (one of the creators of the field of *Software Reliability Engineering* (SRE))
Preliminaries

• Failure
  – “the departure of program behavior during execution from user requirements” ... a user–oriented concept

• Fault
  – “the defect in the program that causes the failure when executed” ... a developer–oriented concept

• Software Reliability
  – “The probability of execution without failure for some specified interval, called mission time.”

• Types of testing SRET can be applied to
  – Feature (function), Load, Regression, Certification, Acceptance
Preliminaries ... contd.

• Execution time
  – “actual time used by the processor in executing a program’s instructions”

• Failure Intensity
  – “failure per unit execution time”

• Operational Mode
  – “a distinct pattern of system use and/or environment that needs separate testing because it is likely to stimulate different failures”

• Operation Profile
  – “set of operations and their probabilities of occurrence”

• Severity Class
  – “a set of failures that affect users to the same degree”
SRET – The phases

• Definition of necessary reliability
  – Determine Operational Modes
  – Define Failure in terms of Severity Classes
  – Set Failure Intensity Objectives (FIO)
  – Engineer Reliability Strategies

• Develop Operational Profiles

• Prepare for Testing
  – Specify Test Cases
  – Define Test Procedure
  – Execute Tests

• Interpret Failure Data
SRET – The phases ... contd.

Define necessary Reliability

Develop Operational Profiles

Prepare for Testing

Execute Tests

Interpret Failure data

Requirements and Architecture

Design and Implementation

System Test and Acceptance Test
Example: *Fone Follower*

- A system that lets telephone calls follow users anywhere in the world
  - Users dial into a voice response system and enter the numbers at which they plan to be at various times
  - Calls can be forwarded to fixed lines as well as cell phones
  - In case of *Call Forwarding No Reply (CFNR)*, calls are forwarded to a pager service
  - In case the pager service does not respond, calls are forwarded to voice mail

- So how do we apply *SRET* to the *Fone Follower* project?
Fone Follower
Defining necessary Reliability ... (1)

• Operational Modes

  – Definition review: “a distinct pattern of system use and/or environment that needs separate testing because it is likely to stimulate different failures”

  – Peak Hours: Heavy incoming calls and entries traffic. No administration or audit functions permitted

  – Prime Hours: Average incoming calls and entries traffic. Administration functions permitted, but audit functions limited

  – Off Hours: Low incoming calls and entries traffic. Low administration traffic, extensive audit traffic
Defining necessary Reliability ... (2)

- Defining Failure in terms of Severity Classes
  - Definition review: “a set of failures that affect users to the same degree”
  - Class 1: Failure prevents calls from being forwarded
  - Class 2: Failure prevents phone number entries
  - Class 3: Failure makes system administration more difficult, although it remains possible through alternate means. E.g. UI doesn’t work, but terminal does
  - Class 4: Failure affects an operation that is deferrable, such as preventive maintenance
Fone Follower

Defining necessary Reliability ... (3)

• Set Failure Intensity Objectives (FIO)
  – Definition review: Failure Intensity = “No. of failures per unit execution time”

• FIO is derived from:
  – Specific user needs
  – Existing system reliability
Fone Follower
Defining necessary Reliability ... (4)

• Engineer Reliability Strategies
  – Fault Prevention
  – Fault Removal
  – Fault Tolerance
  – Objective: “... finding the right balance among them to achieve the failure intensity objective in the required time; at minimum cost”
Fone Follower
Develop Operational Profiles ... (1)

• Definition Review
  – “set of operations and their probabilities of occurrence”

• How?
  – Identify the initiator operation
  – List the operations
  – Determine the occurrence rate per clock hour of the operations
  – Determine the occurrence probabilities
### Fone Follower

Develop Operational Profiles ... (2)

<table>
<thead>
<tr>
<th>Operation</th>
<th>Occurrence Probability</th>
</tr>
</thead>
<tbody>
<tr>
<td>Process voice call, no pager, answer</td>
<td>0.21</td>
</tr>
<tr>
<td>Process voice call, pager, answer</td>
<td>0.19</td>
</tr>
<tr>
<td>Process fax call</td>
<td>0.17</td>
</tr>
<tr>
<td>Process voice call, pager, answer on page</td>
<td>0.13</td>
</tr>
<tr>
<td>Process voice call, no pager, no answer</td>
<td>0.10</td>
</tr>
<tr>
<td>Process voice call, pager, no answer on page</td>
<td>0.10</td>
</tr>
<tr>
<td>Enter forwarders</td>
<td>0.09</td>
</tr>
<tr>
<td>Audit section - phone number database</td>
<td>0.009</td>
</tr>
<tr>
<td>Add subscriber</td>
<td>0.0005</td>
</tr>
<tr>
<td>Delete subscriber</td>
<td>0.0005</td>
</tr>
<tr>
<td>Recover from hardware failure</td>
<td>0.000001</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>1</strong></td>
</tr>
</tbody>
</table>

Fone Follower
Prepare for Testing ... (1)

• Specify Test Cases
  – Select operations according to their occurrence probabilities
    • E.g. for Fone Follower, since connect call has an occurrence probability of 0.71, 71% of TCs were for this operations
  – Definition: Level – “a value or a range of values of an input variable for which failure behavior is expected to be the same because of processing similarities”
  – TC selection is done using Levels

• Why use Levels???
• Define Test Procedure
  – **Definition:** “the specification of the set of runs and environment associated with an operational mode”
  – A set of runs is specified statistically by using operation occurrence rates
  – Occurrence rates are used to select test cases randomly from the prepared set
  – Why use *Statistics* and *Randomization*??

• Execute Tests
  – *Feature Testing* is followed by *Load Testing*
  – *Operational Modes* dictate *Load Testing*
Fone Follower
Interpret Failure Data ... (1)

- Consider Trends
Fone Follower

Interpret Failure Data ... (1)

Reliability Demonstration Chart
Rview: SRET – The phases

• Definition of *necessary reliability*
  – Determine *Operational Modes*
  – Define *Failure* in terms of *Severity Classes*
  – Set *Failure Intensity Objectives* (FIO)
  – Engineer *Reliability Strategies*

• Develop *Operational Profiles*

• Prepare for *Testing*
  – Specify *Test Cases*
  – Define *Test Procedure*
  – Execute Tests

• Interpret *Failure Data*