The Test Plan

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Today’s Problem
How to Build Something Like this

- Requirements Spec.
- Design
  - High Level consistent views
  - Low Level
  - Code
  - Code must implement design

- Test Plan
  - Test Results must match required behavior
  - Test plan exercises this code

Focus on “How do you know”

- Requirements Spec.
- Design
  - High Level consistent views
  - Low Level
  - Code
  - Code must implement design

- Test Plan
  - Test Results must match required behavior
  - Test plan exercises this code
Requirements

- Functional
- Safety
- Robustness
- Performance
- Accuracy

Testplan

- Inputs
- Outputs
- Setup
- Knockdown

Timing limit must meet performance requirement

Test input/output behavior must match functional requirements

Inputs

Outputs

Timing

Setup

Knockdown
and these are the specific timing (accuracy) functional, ... requirements.

Functional

Test input/output behavior must match functional requirements

Timing limit must meet performance requirement

Inputs

Outputs
These are the test cases that are used to test for satisfaction of this requirement.
Testing is too long and hard to do all at once at the end of development

- Divide the job into subtasks
- Do some activities during development
  - Can do test planning during development
  - And *should* do so
- Phase testing at the end
  - Using test plans previously developed

**Testing Phases**

- **Unit/Module**
  - Comparing a code unit or module with design specifications.
  - planned during coding: done after coding
- **Integration**
  - Systematic combination of software components and modules
  - planned during design: done after unit/module V&V
- **Software System**
  - Comparing entire software system with requirements
  - planned during requirements: done after integration
- **System**
  - Comparing integrated hardware/software system to requirements
  - planned during informal requirements: after SW System
Reasoning during development

- Should be incremental
- After each phase
- During each phase
- Testing not possible
  - As usually construed
  - What can be done?
DEVELOPMENT PHASES

Requirements Specification

System Test Plan

SYSTEM TESTING

TESTING PHASES

System Testing

Analysis of requirements happens here
System Test Planning

Analysis of requirements
And System Test Planning
happen here

“Test First”
Software Development(?)
Test Plans and Test Planning

- Goal: Determine if the product satisfies the requirements that spawned its development
- Testing is done after the product is built
- Test planning commences during requirements
  - Testing can be an elaborate process
    » Best to plan it out
  - Testing can require elaborate harnesses
  - Testing difficulties can shape product requirements

Testing is Buying Knowledge

- The testing costs resources
- It should result in knowledge that is worth the cost
- The value of the knowledge is up to the buyer
- The cost of the knowledge is something that software engineers should be able to estimate

All suggest the value of planning it out far in advance
Requirement vs. Test Plans

• Requirements specify “What”
• Test Plans specify “How would I know it if I were to see it?”
• Structure of one often strongly shapes the structure of the other
Test Plans

- The problem: How to devise a strategy for testing that is cost effective?
  - Meets knowledge acquisition objectives passably well
  - At a cost that is acceptable
- A Test Plan is a key part of an overall software product
Test Plans Are (Software) Objects Themselves

- They have (knowledge acquisition) goals/requirements
- They have an architectural structure
- They have specific implementations in
  - Individual testcases
  - Instructions (i.e. code) for how to perform them
- They require evaluation at the end
  - How many cases failed?
  - And how?
  - What does this tell us
    » About the software being tested
    » The testplan itself

Testplan Structure MAY Mirror Structure of Requirements Specification

- A hierarchical decomposition
  - Maybe functional
  - Maybe some other aspect
- But logically it is a separate and distinct entity
- But with many relations shared with requirements
- Or the testplan might be structured differently
  - Depends upon requirements, architecture...
Possible conceptual approach

- Test plan and requirements are separate, isomorphic DAGs (side-by-side?)
- “Test Plan” field in each requirements element node
  - Points to corresponding test plan element
  - Which is the plan for testing that requirement element
- But Test Plan DAG is separate object
“Testable Requirements”

- Being sure requirements can be verified is a very important goal for requirements development
- How to be sure a requirement is testable?
- Try to build a testplan for it
- Important to worry about the cost of running the tests, though
### Test Plan Element: An Example Structure

<table>
<thead>
<tr>
<th>Goal Statement</th>
<th>Inputs</th>
<th>Setup procedure</th>
</tr>
</thead>
<tbody>
<tr>
<td>DATE</td>
<td>Subgoals</td>
<td></td>
</tr>
<tr>
<td>Parent Goal(s)</td>
<td>Required Output</td>
<td></td>
</tr>
<tr>
<td>Exception Recovery</td>
<td>Required Timing</td>
<td>Knockdown Procedure</td>
</tr>
</tbody>
</table>

### Example relations to requirement element

- **Inputs field of Requirement element**
- **Robustness field of Requirement element**
- **Outputs field of Requirement element**
- **Timing field of Requirement element**
Example Structure of a Testplan Element Specification

- Goals/Requirements for this test case
- Requirements element (e.g. function) or aspect (e.g. security) being tested
- Needed resources (e.g. databases, users, computers, software)
- Setup procedure
- Input data, which may be
  - fixed, randomly selected, selected from a list
- Output results required
  - Speed required
  - Definition of what is “correct” output
    » fixed number, range, formula
- Response to failure(s)
- Cleanup/knockdown
- Evaluation: turning this data into information, maybe into knowledge.

These can be big cost items
Some Kinds of Test Element Goals

- Is the functionality correct?
- Does the software execute fast enough?
- Is the software easy enough to use to satisfy a particular class of stakeholders?
- Does the software “fail safe” under certain specific circumstances?

Some test plan elements can potentially test more than one of these.

It can be hard to observe results; specify how to observe the results

- Is the functionality correct?
  - May require specification of tolerance
- Does the software execute fast enough?
  - What does “fast enough” mean
- Is the software easy enough to use to satisfy a particular class of stakeholders?
  - Do you need to bring in some stakeholders??
- Does the software “fail safe” under certain specific circumstances?
  - Have to cause the software to fail
  - What are the circumstances; how specified
Easy Example: A Square Root function

- **Goal**: Determine that SQRT produces correct values quickly enough
- **Structure of the Test Plan**
  - SQRT for positive numbers
  - SQRT for negative numbers
  - SQRT for very large numbers
  - SQRT for very small numbers
  - SQRT for inputs of various types
    - Reals
    - Integers
    - Character strings
- **Resources**
  - Computer time
- **Failure response**: log it and continue

More detail

- **Goal**: Show that SQRT produces accurate results in acceptable time, when applied to positive numbers
  - Set time bound at 2 ms.
  - Establish accuracy as up to 7 decimal places
- **Testcases**
  - For 1000 randomly generated numbers (0, 10**25)
    - Generate input number
    - Start the clock
    - Apply SQRT function
    - Capture the output
      - Numerical result
      - Elapsed time
    - Evaluate the numeric result
      - Compare it to a table
      - Square it and compare it to input
    - Generate report
  - Produce summary of generated reports
- **Evaluate summary with respect to goal**
Non-Trivial Programs Are Much Harder

- Some Problems:
  - How to phase test case execution
  - Which characteristics to focus on when
  - Combining types of tests
  - Some tests require elaborate setup
  - Sometimes failures are hard to detect
  - What to do when failures are detected

Financial issues may be the most important here.
Testing is BUYING knowledge. Do what is most cost effective first

More Realistic Example:
Student Online Course Registration

- Consider all of the functions
- Timing requirements are variable
- Accuracy may be hard to determine
- Interfaces to other systems must be tested
- Robustness testing/stress testing
- Etc.
Example: “Select a Course”

- **Goal:** Request for a course is handled correctly, quickly
- **Requirements element:** (point to function in reqts. Spec.)
- **Needed resources**
  - Course availability database, student status database
- **Setup procedure:** link to needed databases
- **Input data, which may be**
  - Choose some available courses
  - Choose some that are not available
  - Choose some that the student needs permission for
  - Some where students is not eligible to register
- **Output results required**
  - Speed must be < 1 second
  - Register only eligible students in available courses....
- **Response to failure**
  - Ineligible student, illegal course number, course full,