Software Quality Engineering

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Testing, Quality Assurance, and Quantiable Improvement
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Tian Siyuan tiansiyuan@gmail.com

Chapter 7. Testing Activities, Management, and Automation

- Major Testing Activities
- Test Management
- Testing Automation

Test Planning and Preparation

- Major testing activities:
  - test planning and preparation
  - execution (testing)
  - analysis and followup
- Test planning:
  - goal setting
  - overall strategy
- Test preparation:
  - preparing test cases & test suite(s)

    (systematic: model-based; our focus)
  - preparing test procedure

Test Planning

- Goal setting and strategic planning.
- Goal setting
  - quality perspectives of the customer
  - quality expectations of the customer
  - mapping to internal goals and concrete

    (quantified) measurement.
  - e.g., customer’s correctness concerns

    => specific reliability target
- Overall strategy, including:
  - specific objects to be tested.
  - techniques (and related models) to use.
  - measurement data to be collected.
  - analysis and followup activities.
  - key: plan the "whole thing"!

Test Preparation

- Procedure for test preparation
  - preparing test cases (model-based)
    - individual test cases
    - test case allocation
  - preparing test procedure
    - basis for test procedure
    - order, flow, followup
- General concepts
  - test run: operation instances
  - input variable: test point
  - input space: all possible input variable values
  - test case: static object + input to enable test to start -> execute -> finish.

Individual Test Case Preparation

- Individual test cases (micro-level) vs. test suite (macro-level)
- From multiple sources:
  - actual runs (usage-based).
  - implementation-based (white-box).
  - specification-based (black-box).
  - may use similar/earlier products.
  - (direct) record and replay (less often).
  - (via) formal models (OP, CFT, BT, etc.)
- Defining input values (model => test cases):
  - initial/intermediate/interactive input

    (expected output too?)
  - exercise path/slice/track/etc
  - in testing terminology: sensitization

Test Cases Based on Formal Models

- Most organized, systematic test cases are derived from formal testing models:
  - directly via newly constructed models.
  - indirectly via exist test cases, etc.
- Model construction steps:
  - information source identification and data collection
  - analysis and initial model construction
  - model validation and improvement
- Model usage:
  - defining test cases.

    (details with individual models/techniques)
  - indirectly in analysis/followup (Part IV).

Test Suite Preparation

- Test suite (macro-level)
  - existing suite: what and where?
    - suitability? selection/screening?
  - construction/generation of new ones
  - organization & management:

    often hierarchical, e.g., *sc; sn; vn*.
- Adding new test cases
  - estimate # of new test cases
  - specify new (individual) test cases
  - integrate to existing test cases
- Allocation to systems/operations
  - OP-/structure-based allocation
  - both old and new test cases in suite

Test Procedure Preparation

- Key consideration: sequencing:
  - general: simple to complex.
  - dependency among test cases.
  - defect detection related sequencing.
  - sequence to avoid accident.
  - problem diagnosis related sequencing.
  - natural grouping of test cases.
- Other considerations:
  - effectiveness/efficiency concerns.
  - smooth transition between test runs.
  - management/resource/personnel/etc.

Test Execution

- Major testing activities:
    - test planning and preparation
    - execution (testing)
    - analysis and followup
- Test execution:
    - execution planning and management
    - related activities: important part
        - failure identification and measurement
        - other measurement

Test Execution

- General steps
    - allocating test time (& resources)
    - invoking test
    - identifying system failures

      (& gathering info. for followup actions)
- Allocating test time
    - OP-based: systems/features/operations
        - also coverage concerns for critical parts
    - coverage-based: func./struc. areas
    - alternative: bottom-up approach
        - individual test cases => test time
        - sum-up => overall allocation
        - by OP or coverage areas

Test Execution

- Invoking test (OP-based)
    - OP) input variables (test points)
    - follow probabilistic distributions

      (could be dynamically determined)
    - sequence (what to test first?):

      COTS, product, supersystem
- Invoking test (coverage-based)
    - organize sensitized testcases
    - sequence => coverage hierarchies
- Common part: Retest due to
    - defect fix => verify fix
    - code-base or feature change
    - general regression test

Test Execution

- Identifying system failures (oracle problem):
    - similar for OP-/coverage-based
    - analyze test output for deviations
    - determine: deviation == failure ?
    - handling normal vs. failed runs
        - non-blocking failure handling
- Solving oracle problem:
    - theoretically undecidable.
    - some cases obvious: crash, hang, etc.
    - practically based on heuristics:
        - product domain knowledge
        - cross-checking with other products
        - implementation knowledge & internals
        - limited dynamic consistency checking

Test Execution

- Failure observation and measurement:
  - Determine: deviation == failure ?
  - Establish when failure occurred
    - used in reliability and other analysis
  - Collect failure information (e.g., ODC):
    - what/where/when/severity/etc.
- Defect handling and test measurement:
  - defect status and change (controlled)
  - information gathering during testing
  - Followup activities:
    - fix-verification cycle
    - other possibilities (defer, invalid, etc.)

Test/Failure Measurement

- Example template: (Table 7.1, p.93)
  - information collected at test execution
- rid - run identification, consisting of:
  - sc - scenario class,
  - sn - scenario number,
  - vn - variation number with a particular scenario,
  - an - attempt number for the specific scenario variation
- timing - start time t0 and end time t1
- tester - the tester who attempted the test run
- trans - transactions handled by the test run
- result - result of the test run (1 indicates success and 0 for failure)

Testing Analysis and Followup

- Major testing activities:
  - test planning and preparation
  - execution (testing)
  - analysis and followup
- Test analysis and followup:
  - execution/other measurement analyzed
  - analysis results as basis for followup
  - feedback and followup:
    - decision making (exit testing? etc.)
    - adjustment and improvement.

Testing Analysis and Followup

- Input to analysis
  - test execution information
  - particularly failure cases
  - timing and characteristics data
- Analysis and output
  - basic individual (failure) case
    - problem identification/reporting
    - repeatable problem setup
  - overall reliability and other analysis?

    (Chapter 22 and Part IV)
- Followup activities
  - defect analysis and removal (& re-test).
  - decision making and management.
  - test process and quality improvement.

Testing Analysis and Followup

- For individual test runs:
  - success: continue with normal testing.
  - failure: see below.
- Analysis and followup for failed runs:
  - understanding the problem by studying the execution record.
  - recreating the problem (confirmation).
  - problem diagnosis
    - may involve multiple related runs.
  - locating the faults.
  - defect fixing (fault removal)
    - commonly via add/remove/modify code
    - sometimes involve design changes
  - re-run/re-test to confirm defect fixing.

Testing Analysis and Followup

- Analysis and followup for overall testing:
  - reliability analysis and followup.
  - coverage analysis and followup.
  - defect analysis and followup.
  - focus of Part IV.
- Analyses: Different focuses:
  - overall reliability and coverage for usage-based and coverage-based testing.
  - detailed defect analysis.
- Followup activities: Similar.
  - decision making and management.
  - test process and quality improvement.

Test Management

- People’s roles/responsibilities in formal and informal testing.
- In informal testing:
  - "run-and-observe" by testers.
  - "plug-and-play" by users.
  - informal testing with ad-hoc knowledge
  - deceptively "easy", but not all failures or problems easy to recognize.
- In formal testing:
  - testers, and organized in teams.
  - management/communication structure.
  - role of "code owners" (multiple roles?)
  - 3rd party (IV&V) testing.
  - career path for testers.

Test Management

- Test team organization:
  - vertical: project oriented
    - product domain knowledge,
    - staffing/resource management hard.
  - horizontal: task oriented
    - even distribution of staff/resources
    - lack of internal knowledge/expertise
  - Mixed models might work better.
- Users and 3rd party testers:
  - user involvement in beta-testing and other variations (e.g., ECI in IBM)
  - IV&V with 3rd party testing/QA
  - impact of new technologies:

        - CBSE, COTS impact
        - security, dependability requirements.

Test Automation

- Basic understanding:
    - automation needed for large systems.
    - fully automated: impossible.
    - focus on specific needs/areas.
- Key issues to consider:
    - specific needs and potentials.
    - existing tools available/suitable?
        - related: cost/training/etc.
    - constructing specific tools?
    - additional cost in usage & support.
    - impact on resource/schedule/etc.

Test Automation

- Automation by test activity areas:
    - automated test planning&preparation.
    - automated test execution.
    - automated test measurement, analysis, and followup.
    - slightly different grouping due to tightly coupling for measurement & analysis.
- Automation for test execution.
    - many debuggers: semi-automatic.
    - task sequencing/scheduling tools.
    - load/test generator: script) runs
    - generally easier to obtain test scripts.

Test Automation: JUnit Example

- P. Louridas, "JUnit: Unit Testing and Coding in Tandem" IEEE Software, Vol.22, No.4., pp.12-15, July/Aug., 2005. (A nice short survey about JUnit.)
- JUnit example (Fig.1 in paper above)
    - JUnit test setup:

      initialize some complex numbers
    - JUnit test cases:
        - execution using "assertEquals(x, y)"
        - base test case: x, y numbers
        - general cases: "expected" = op-result?
    - Sum up: test cases => test suite
- Still need:
    - oracle/"expected" above
    - test cases <= techniques (Chapter 8-12)

Test Automation

- Automation for test planning/preparation:
    - test planning: Human intensive not much can be done (~ inspection and FV).
    - test model construction: similar to above.
        - automation possible at a small scale.
    - test case generation: focus.
- Test case generation:
    - from test model to test cases.
    - specific to individual techniques
        - e.g., cover checklist items, paths, etc.
    - various specific tools.
    - key: which specific testing technique sup-

ported by the specific tool?

Test Automation

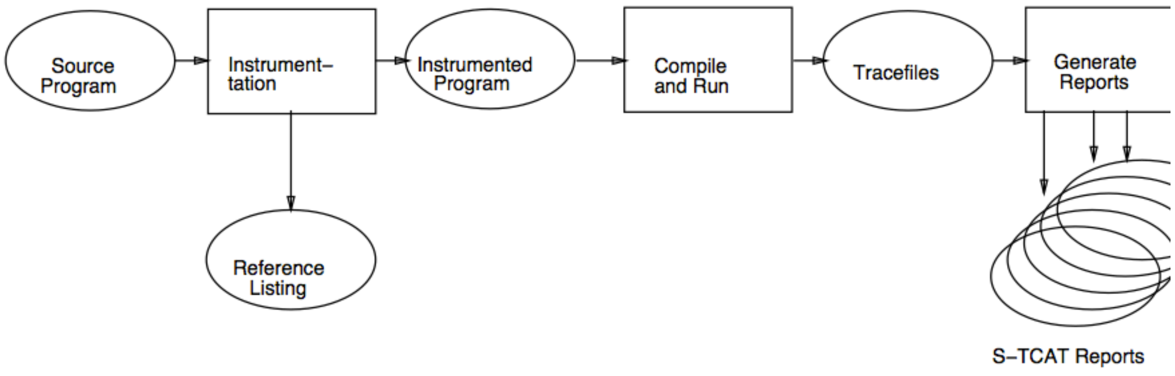
- Test measurement, analysis, and followup.
  - analyses dictate measurements needed.
  - most common: reliability/coverage.
  - defect measurement needed in most cases:
    - defect tracking tools.
- Reliability analysis related tools:
  - analysis/modeling tools.
  - collecting execution/input/etc. data.
  - more in Chapter 22.

Test Automation

- Coverage-based testing: measuring coverage and compare to pre-set goals.
- Test coverage steps:
  - preparation: program instrumentation.
  - measurement step: run and collect data.
  - analysis step: analysis for coverage.
- Test coverage tools:
  - different levels/definitions of coverage

    => different tools.
  - example tools:
    - McCabe: execution (control flow) path
    - S-TCAT: functional coverage
    - A-TAC: data flow coverage.

Test Automation: Coverage Example



- Test coverage analysis with S-TCAT (Fig 7.1, p.100).
  - S-TCAT: functional coverage
  - results - 2 reports:
    1. list of covered functions
    2. function-#times-used

Summary

- Test activities:
  - planning&preparation: focus of Part II.
  - execution&measurement: common.
  - analysis&followup: focus of Part IV.
- Test management:
  - different roles and responsibilities.

    - good management required.
- Test automation:
    - set realistic expectations.
    - specific areas for automation, esp. in execution, measurement, and analysis.