EN.601.422 / EN.601.622

Software Testing & Debugging

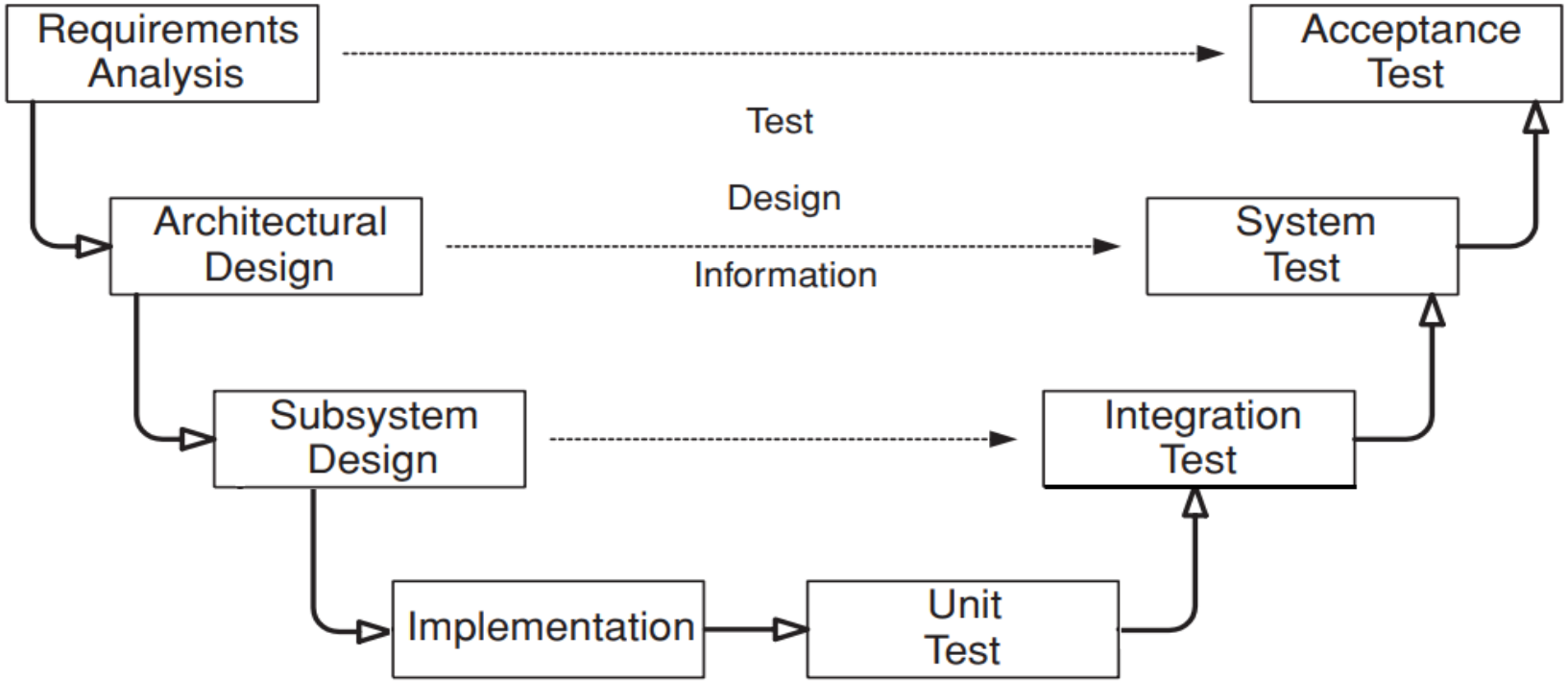
The Goal of Software Testing

- In the last class we discussed:
  - Why software testing matters
  - “the goal of software testing”
    - show presence of bugs, not their absence
  - Fault vs error vs failure
  - Testing is a destructive process!
  - Verification vs. Validation

Plan for Today

- The **V** model, Test early rather than late
- RIPR Fault/Failure Model
- Oracle problem
- Warming up with JUnit
- Review Few (More) Testing principles
- Exercise

The V Model

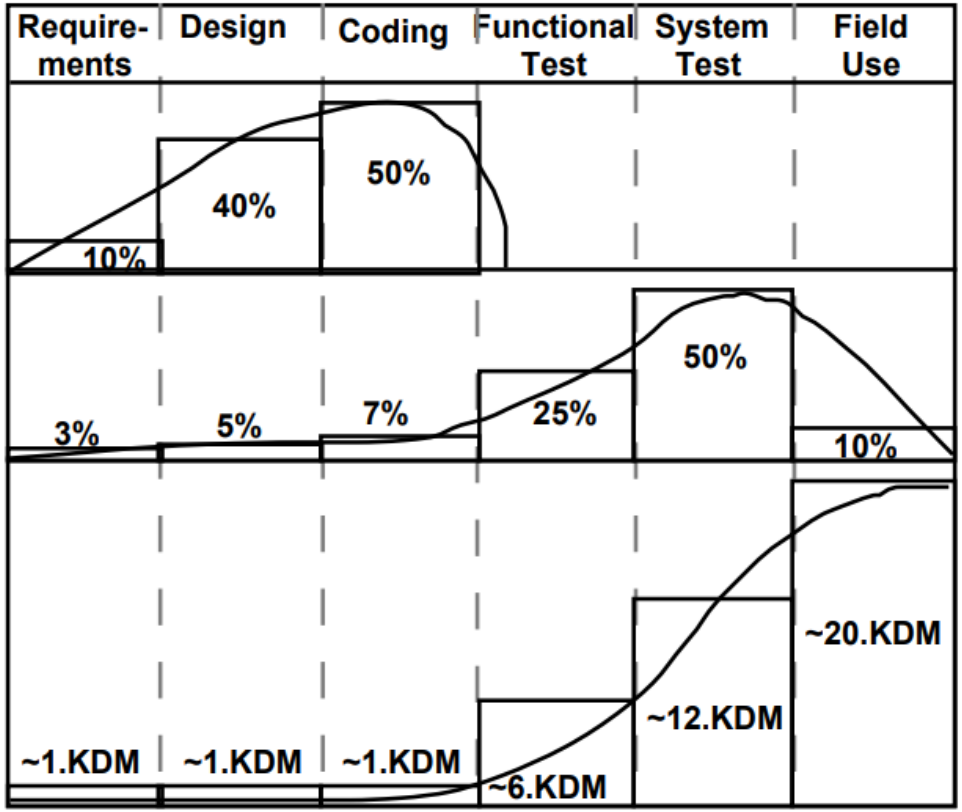


Read more at https://en.wikipedia.org/wiki/V-Model_(software_development)

Testing Levels

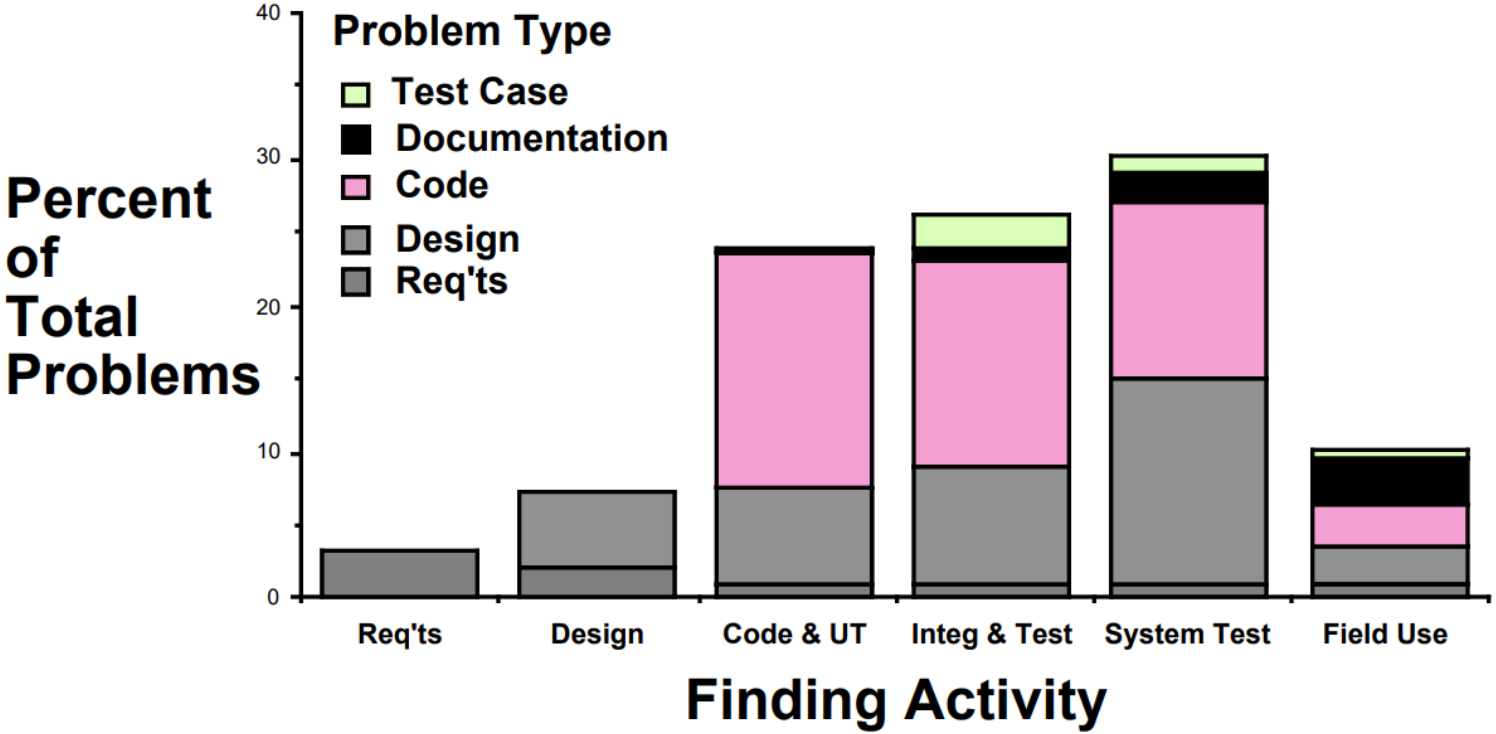
- **Acceptance Testing**: assess software with respect to user's needs
  - Alpha & Beta Testing
- **System Testing**: assess software with respect to architectural design and overall expected behavior
- **Integration Testing**: assess software with respect to sub-system design
- **Unit Testing**: assess software with respect to implementation of isolated modules/units

Faults as a Cost Driver

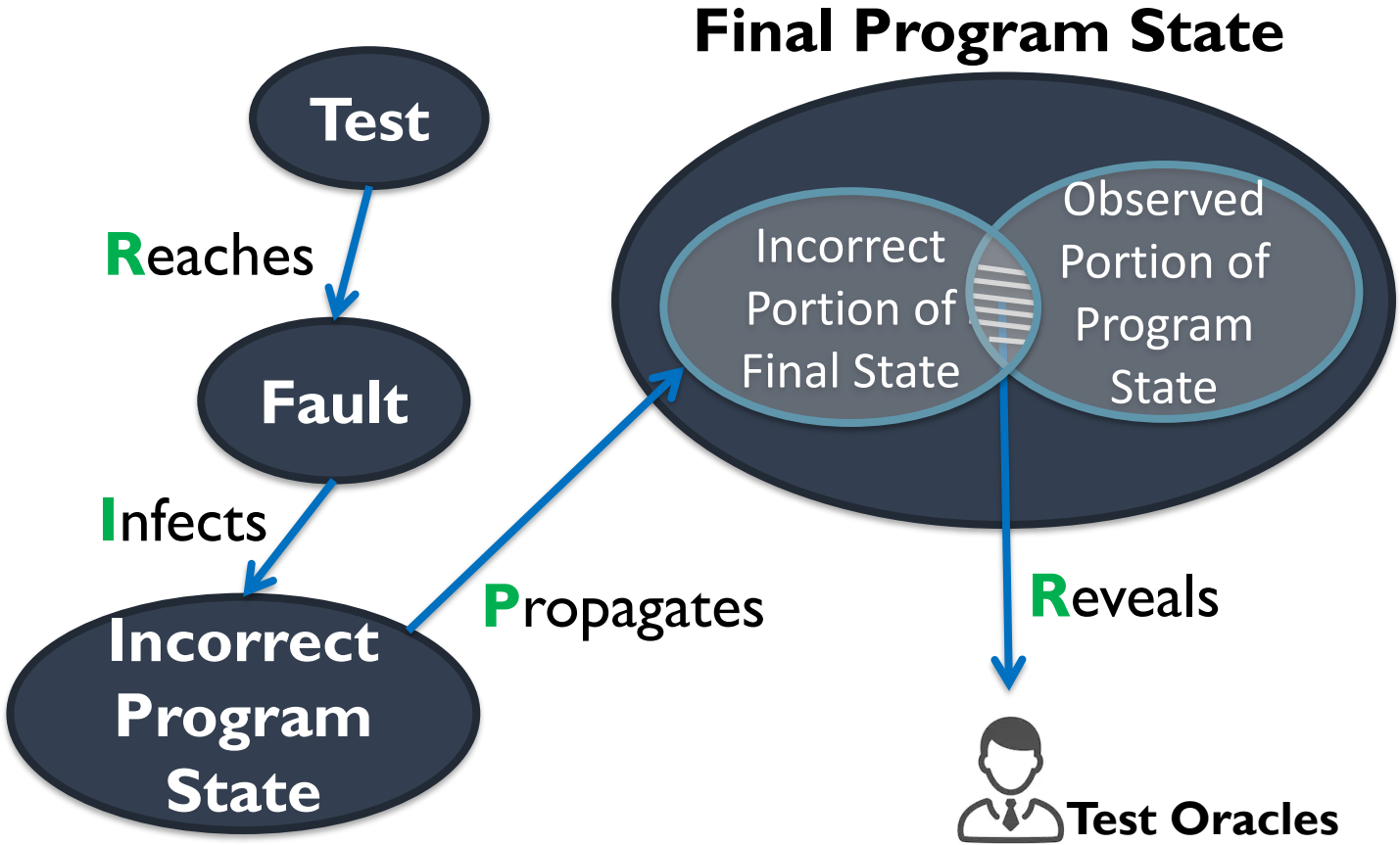


Software Engineering Institute; Carnegie Mellon University; Handbook CMU/SEI-96-HB-002

Problem Type vs. Finding Activity



RIPR or Fault/Failure Model



RIPR Model

- **Reachability**: The location or locations in the program that contain the fault must be reached
- **Infection**: The state of the program must be incorrect
- **Propagation**: The infected state must cause some output or final state of the program to be incorrect
- **Reveal**: The tester must observe part of the incorrect portion of the program state

Test Automation

- **Two Types of Testing**:
  - Manual
  - Automated
- **Test Automation**: automation of testing-related activities
  - **Generation**: generate test cases automatically
  - **Execution**: run tests on the software under test (SUT)
  - **Evaluation**: evaluate test results i.e., does the test case pass or fail

Test Evaluation

- **Test Oracle:** a mechanism for determining whether a test has passed or failed. An oracle can be:
  - Expected output value
  - A program
  - Documentation that gives specific correct outputs for specific given inputs
  - A (human) domain expert who can tell whether test output is correct or not
  - Any other way or combination of the above that can tell that output is correct or not

Examples

- Unit Testing:
  - E.g., **assertEquals(4, sum(2, 2))**: 4 is the oracle and hard coded!
  - Is the above oracle complete?

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```
public class MyClass {
   int c;

   public int sum(int a, int b) {
      c  = 10;
      return a + b;
   }
   ...
}
```

More Examples (Other Types of Testing)

- System Testing:
  - E.g., Testing Google search engine with a query
  - What set of results should it return exactly for the query?
- Security Testing:
  - E.g., a test case that simulates a sql injection attack
  - How and what test oracle would you write? i.e., what is exactly the expected behavior?
- Usability testing:
  - E.g., testing the Graphical User Interface of a web app for user friendliness
  - A test case would be accomplishing a task using the GUI. Was it user friendly enough?

Test Oracles

- A *complete* Oracle would be based on the entire final state after running a test case
  - Impractical/impossible
- Weak (partial) oracles:
  - Usually, good enough in practice
  - Examples:
    - check for expected output
    - check for software crashes
    - Etc.

Test Evaluation

- One of the most challenging problems in software testing
- Much harder than it might seem; it might not be straightforward what the correct/expected output is/should be
- Requires knowledge of domain, user interfaces, psychology etc.
- This is known as:

The Oracle Problem!

https://en.wikipedia.org/wiki/Test_oracle

xUnit

- xUnit is the collective name for several unit testing frameworks
  - SUnit was the first one for smalltalk
  - Ported to Java (JUnit) by Kent Beck and Erich Gamma which gained wide popularity
- Available as a library that can be added to your Java project

Follow this JUnit Code Skeleton (for now)

```
public class ClassNameTest {
   @Test
   public void testFunctionNameDescription () {
        // make use of a variety of assert statements provided
   }
   // more test functions
}
```

Testing Principle 1

A necessary part of any test case is a definition of the expected output/behavior

Testing Principle 2

A test case must not have any logic in it (e.g., must not calculate anything); A test case must merely set things up, make calls, and verify the results.

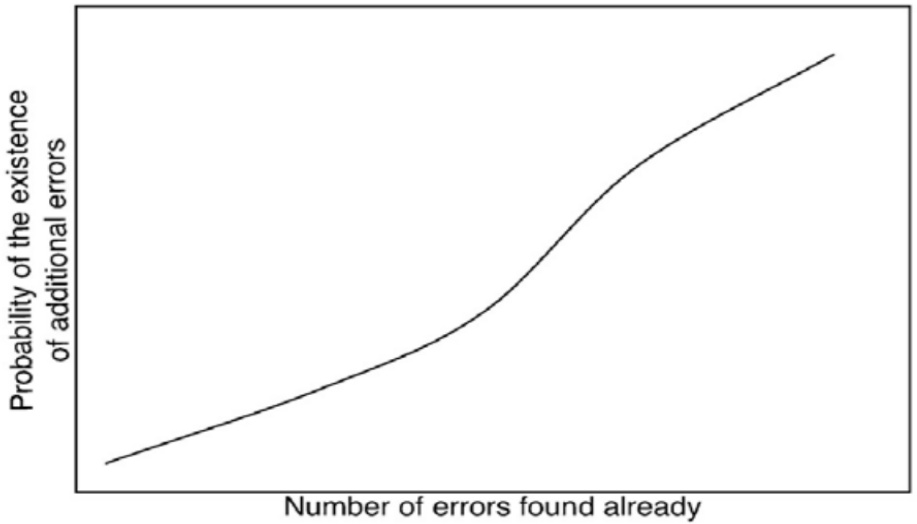
Testing Principle 3

(Ideally) a programmer should avoid attempting to test her own program

Debugging is best done by the original developer though

Testing Principle 4

- Faults are not uniformly distributed
  - The probability of the existence of more errors in a section of a program is proportional to the number of errors already found in that section.



Testing Principle 5

- Examining a program to see if it does what it is supposed to do is only half the battle; the other half is seeing whether the program also does not what it is not supposed to do

More Testing Principles

- Discussed in the last class:
  - Test early
  - Pesticide Paradox
  - Absence of Error Fallacy
  - Testing is context dependent