Testing I

Week 14

Agenda (Lecture)

- Concepts and principles of software testing
- Verification and validation
- Non-execution based testing
- Execution based testing
- Feasibility of testing to specification
- Feasibility of testing to code
- Black box testing

Agenda (Lab)

- Implementation
- Submit a weekly project progress report at the end of this week lab session

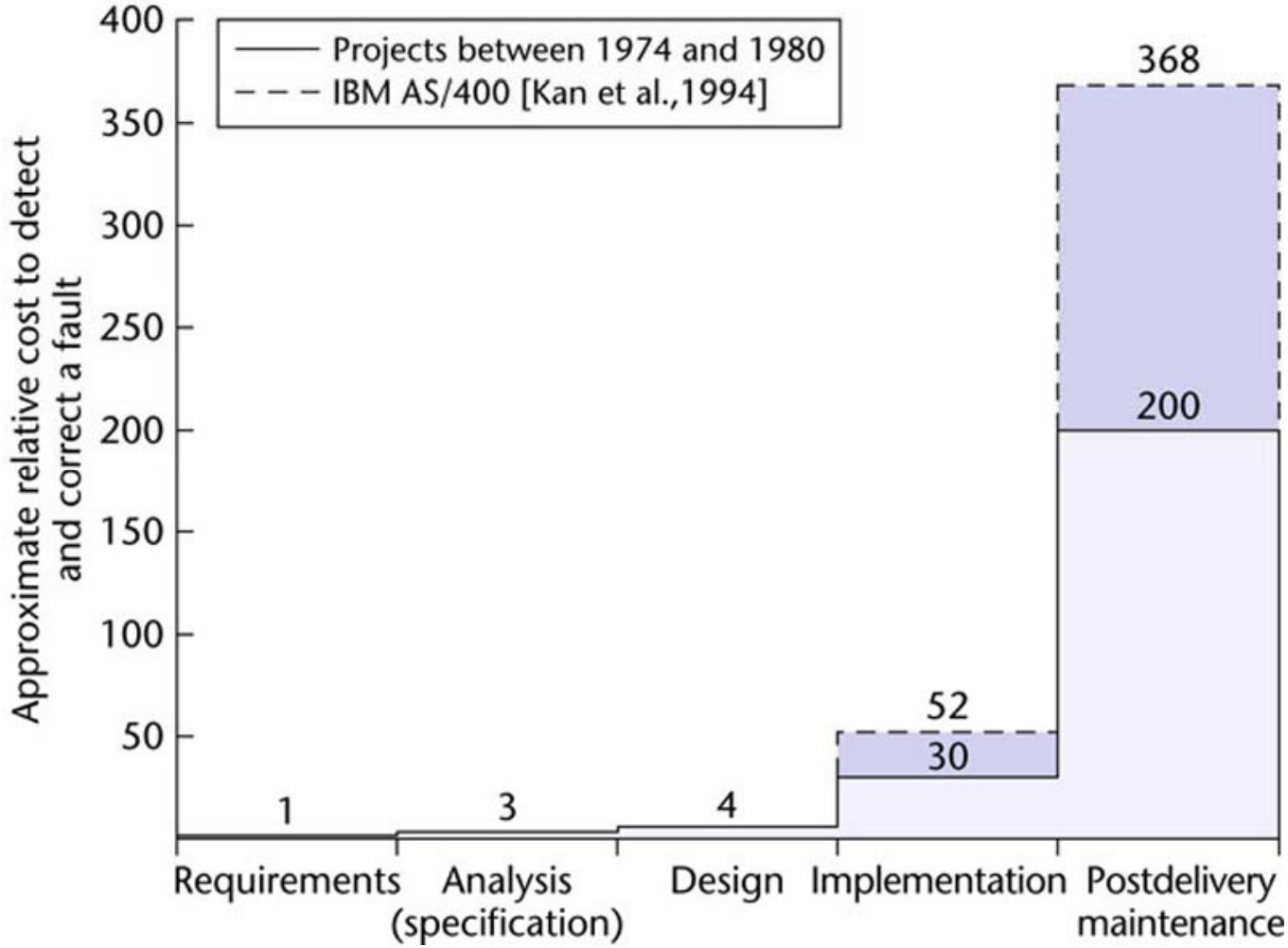
Software Test

- Software process and a testing phase
  - A separate testing phase?
- Testing
  - Non-execution based and execution based
- Mindset
  - *Test-oriented process models*

Verification vs. Validation

- Verification: "Are we building the product right?”
  - The software should conform to process that is chosen.
- Validation: "Are we building the right product?”
  - The software should do what the user really requires.
- Testing (V&V) is a whole life-cycle process
  - V & V must be applied at each stage in the software process

The Relative Cost of Finding a Fault at Each Phase



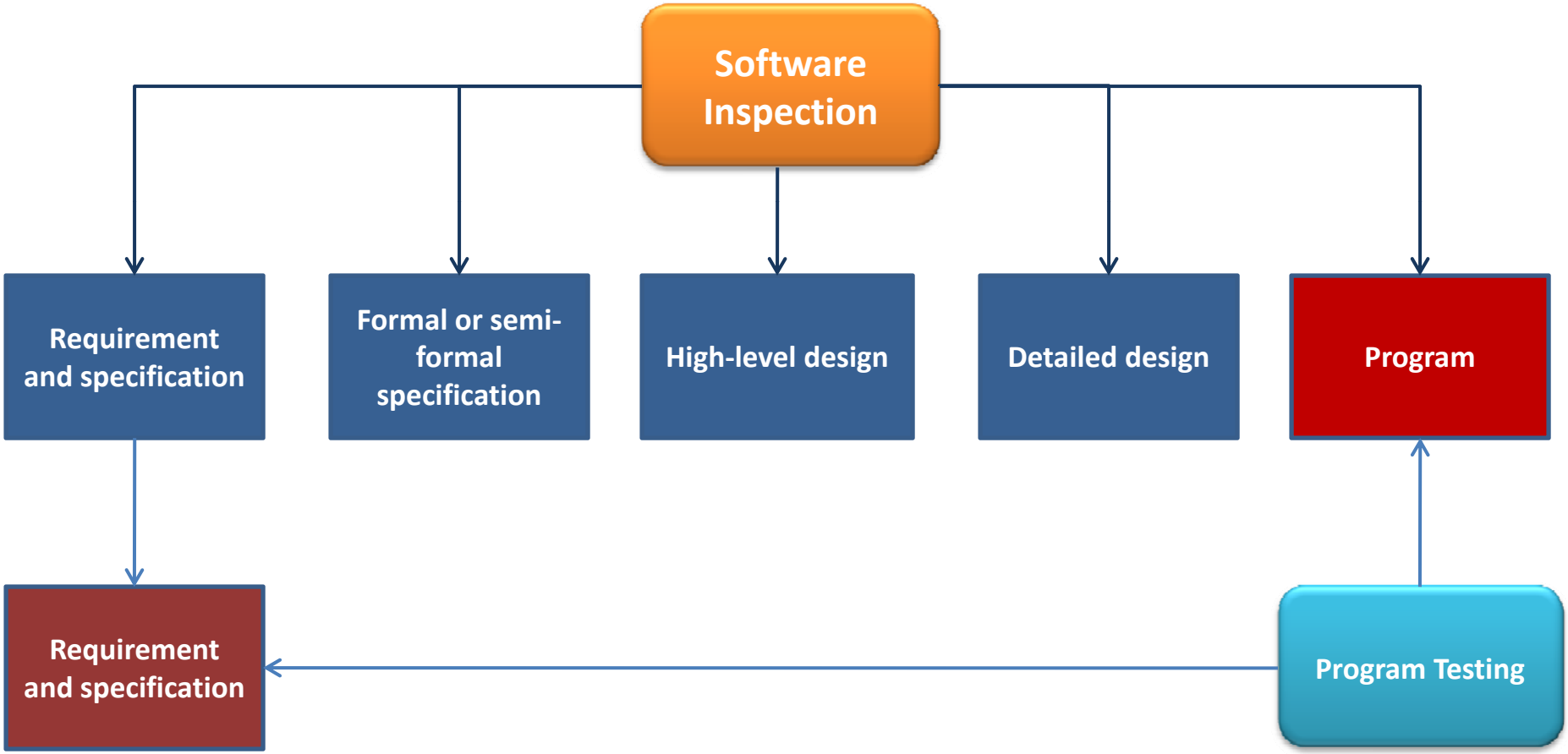
Non-execution Based Testing

- Testing software without running test cases
- Non-execution based testing includes reviewing software and analyzing software
- Applied to the early phases or workflows such as requirement, specification and design, and even implementation
- Process models and organizations provide guidelines for non-execution based testing
  - IEEE standard for software reviews [IEEE 1028]

Walk-through and Inspection

- Walk-through is less formal and inspection is more formal

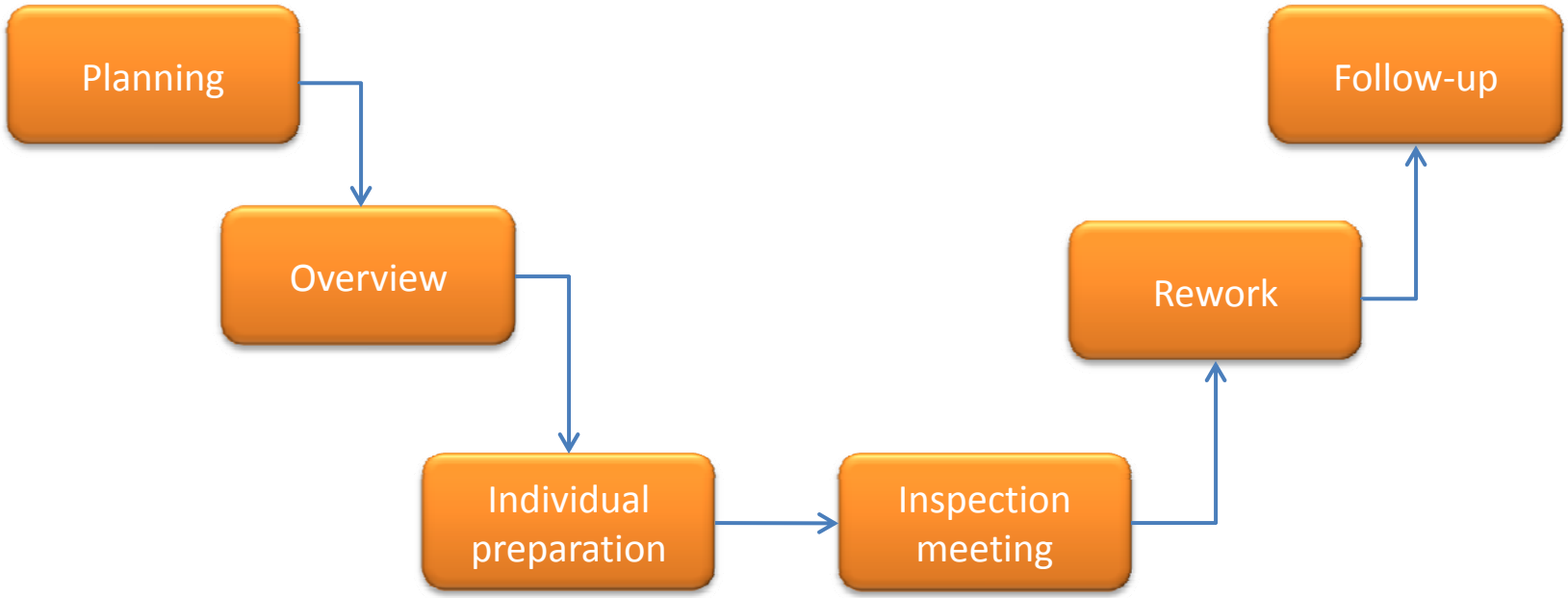
Inspections



Inspection Success

- Many different defects may be discovered in a single inspection.
- Using domain and programming knowledge reviewers are likely to have seen the types of error that commonly arise.

The Inspection Process



Walk-Through

- Less formal approach to review
- Uncover faults and record them for later correction

Case Studies

- 67 percent of all the faults were located by inspections before unit testing was started
- 82 percent of all detected faults were discovered during design and code inspections
- 93 percent of all detected faults were found during inspections
- At the JPL, on average, each 2-hour inspection exposed 4 major faults and 14 minor faults
  - Translated into dollar terms, this meant a savings of $25,000 per inspection

Execution-based Testing

- “Program testing can be a very effective way to show the presence of bugs, but it is hopelessly inadequate for showing their absence” – Dijkstra, 1972
- “Execution-based testing is a process of inferring certain behavioral properties of a product based on the results of executing the product in a known environment with selected inputs”
- Incremental approaches to the execution-based testing
  - Unit-testing
  - Integration testing
  - Product testing
  - Acceptance testing / alpha or beta testing

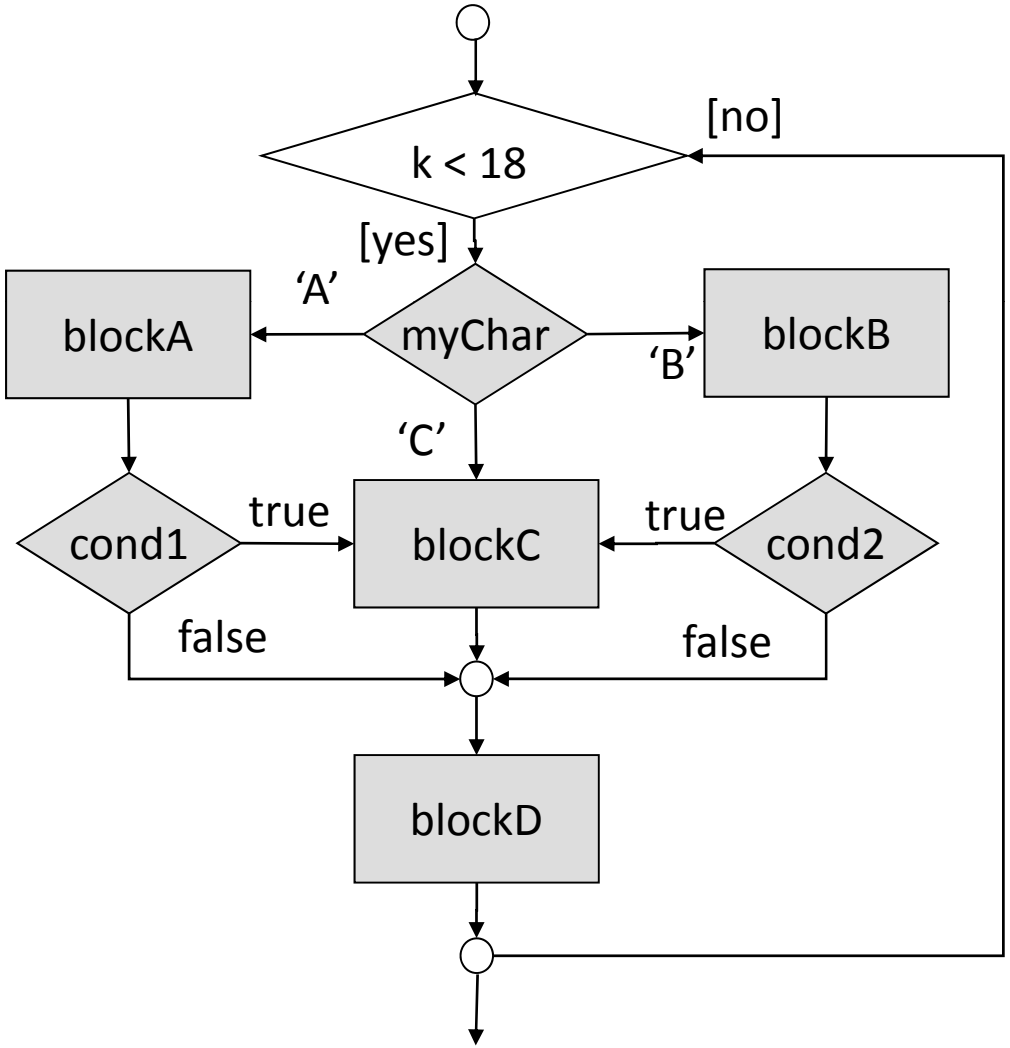
Feasibility of Testing to Specification

- Two inputs
  - One has five values
  - The other has seven values
  - How many test cases are needed
  - 5 X 7 = 35
- 30 inputs
  - Each input has four different values
  - How many test cases are required?
  - If a program has 1.1 X 10^{18} possible inputs and one test can be run every microsecond, how long would it take to execute all of the possible inputs?

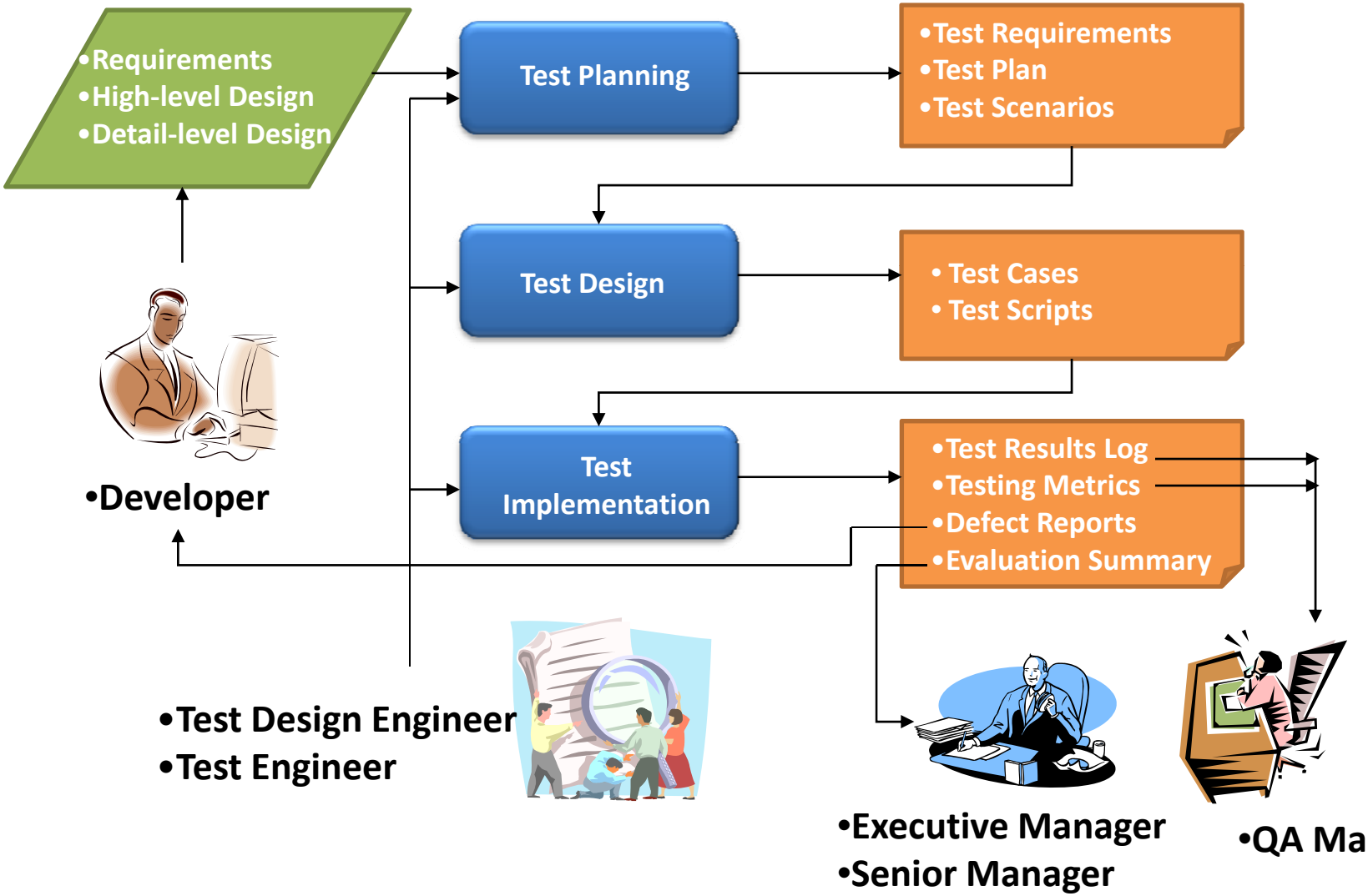
Feasibility of Testing to Code

```
Read (kmax) // kmax is an integer between  1 and 18
for (k = 0; k < kmax; k++) do
{
        read (myChar)           // myChar is the character A, B, or C
        switch (myChar)
        {
                case 'A':
                        block A;
                        if (cond1) blockC;
                        break;
                case 'B':
                        block B;
                        if (cond2) blockC;
                        break;
                case 'C':
                        block C:
                        break;
        }
}
```

Feasibility of Testing to Code



Testing Process

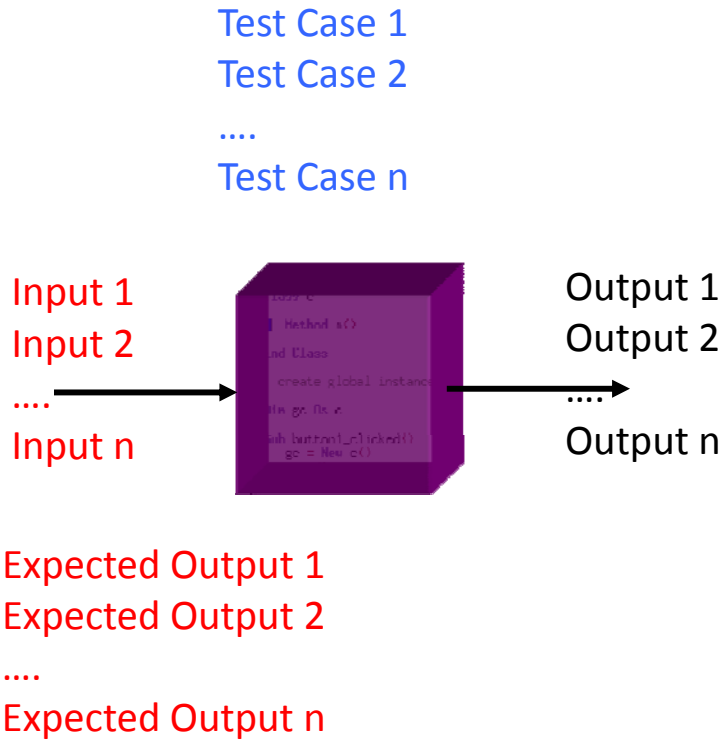


A Sample of Test Plan

1. INTRODUCTION
   - 1.1 PURPOSE
   - 1.2 BACKGROUND
   - 1.3 SCOPE
   - 1.4 PROJECT IDENTIFICATION
2. SCENARIOS FOR TEST
3. TEST STRATEGY
   - 3.1 TESTING TYPES
     - 3.1.1 FUNCTION TESTING
     - 3.1.2 NON-FUNCTION PROFILE
     - 3.1.3 RELIABILITY TESTING
     - 3.1.4 STRESS TESTING
     - 3.1.5 VOLUME TESTING
     - 3.1.6 ROBUSTNESS TESTING
     - 3.1.7 SECURITY TESTING
     - 3.1.8 INSTALLATION TESTING
   - 3.2 TOOLS
4. RESOURCES
   - 4.1 WORKERS
   - 4.2 SYSTEMS
5. PROJECT MILESTONES
6. DELIVERABLES
   - 6.1 TEST MODEL
   - 6.2 TEST LOGS
   - 6.3 DEFECT REPORTS

Black Box Testing

- Behavioral
- Functional
- Data-driven
- Input/output-driven



Black Box Testing (cont'd)

- Exhaustive black-box testing generally requires billions and billions of test cases
- The art of testing is to devise small, manageable set of test cases to maximize the chances of detecting a fault, while minimizing the chances of wasting a test case due to having the same fault detected by more than one test case
- Every test case must be chosen to detect a previously undetected fault

Equivalence Testing

- Equivalent partitioning
- A black-box testing method
- Divides input domain of a product into classes of data
- Equivalent classes are used to define test cases that uncover classes of error and reduce the total number of test cases that must be developed
  - With boundary value analysis
- An equivalence class represents a set of valid or invalid state for input conditions

Equivalence Testing - Example

- The possible blood sugar level (including safe, unsafe, and undesirable) is between 1 and 35.
- Equivalence classes for this example
  - Equivalence class1:
  - Equivalence class2:
  - Equivalence class3:

Boundary Value Analysis

- Maximize the chances of finding a fault
- Experience has shown that, when a test case on or just one side of the boundary of an equivalence class is selected, the probability of detecting a fault increases

Type of Equivalence Class

- A range of values
- A set of values
  - The input must be letter
- A specific value
  - The response must be followed by a # sign

How to Perform Equivalence Testing

- For each range (L, U)
  - Select five test cases: less than L, equal to L, greater than L but less than U, equal to U, and greater than U
- For each set S
  - Select two test cases: a member of S and a non-member of S
- For each precise value P
  - Select two test cases: P and anything else

Exercises

- How many minimum number of test cases should be prepared for a range (R1, R2) listed in either the input or output specifications?
- How many minimum of number test cases should be prepared when it is specified that an item must be a precise value?