# Software Testing

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# Objectives

- To discuss the distinctions between validation testing and defect testing
- To describe the principles of system and component testing
- To describe strategies for generating system test cases

# Defect testing

- The goal of defect testing is to discover defects in programs
- A *successful* defect test is a test which causes a program to behave in an anomalous way
- Tests show the presence not the absence of defects

# Testing & Verification & Validation

- Testing = Verification + Validation
- **Verification**: Static Testing (no run)
- **Validation**: Dynamic Testing (Run code)

# Who Tests the Software

***Developer***

- understands the system
- has the source code
- white-box 'Unit' testing
- will test "gently"
- driven by delivery 'schedule' constraint

***Independent tester***

- must learn about the system
- has no source code
- black-box 'Acceptance' testing
- will attempt to break the sys (ME!!)
- driven by quality constraint

# Testing policies

- Only exhaustive testing can show a program is free from defects. However, exhaustive testing is impossible.
- Testing policies define the approach to be used in selecting system tests:
  - All functions accessed through menus should be tested;
  - Combinations of functions accessed through the same menu should be tested;
  - Where user input is required, all functions must be tested with correct and incorrect input.

# The testing process

- Component (Unit) testing: needs source code (White-box)
  - Testing of individual program components
  - Usually the responsibility of the component developer
  - Tests are derived from the developer's experience
- System Testing: Involves integrating components to create a system or sub-system. May involve testing an increment to be delivered to the customer.
  - Integration testing - the test team have access to the system source code. The system is tested as components are integrated.
  - Release testing - the test team test the complete system to be delivered as a black-box.

# Component testing

- Component or unit testing is the process of testing individual components in isolation.
- It is a defect testing process.
- Components may be:
  - Individual functions or methods within an object;
  - Object classes with several attributes and methods;
  - Composite components with defined interfaces used to access their functionality.

# System testing

- Involves integrating components to create a system or sub-system.
- May involve testing an increment to be delivered to the customer.
- Two phases:
  - Integration testing - the test team have access to the system source code. The system is tested as components are integrated.
  - Release testing - the test team test the complete system to be delivered as a black-box.

# Integration testing

- **Top-down integration testing**
  - Start with high-level system and integrate from the top-down replacing individual components by **stubs**
  - **Stubs** have the **same interface** as the components but **very limited functionality**
- **Bottom-up integration testing (XP)**
  - Integrate and test low-level components (or stories in XP), with **full functionality**, before developing higher level components, until the complete system is created
- In practice, combination of both

# Release testing

- The process of testing a release of a system that will be distributed to customers.
- Primary goal is to increase the supplier's confidence that the system meets its requirements.
- Release testing is usually black-box or functional testing
  - Based on the system specification only;
  - Testers do not have knowledge of the system implementation.

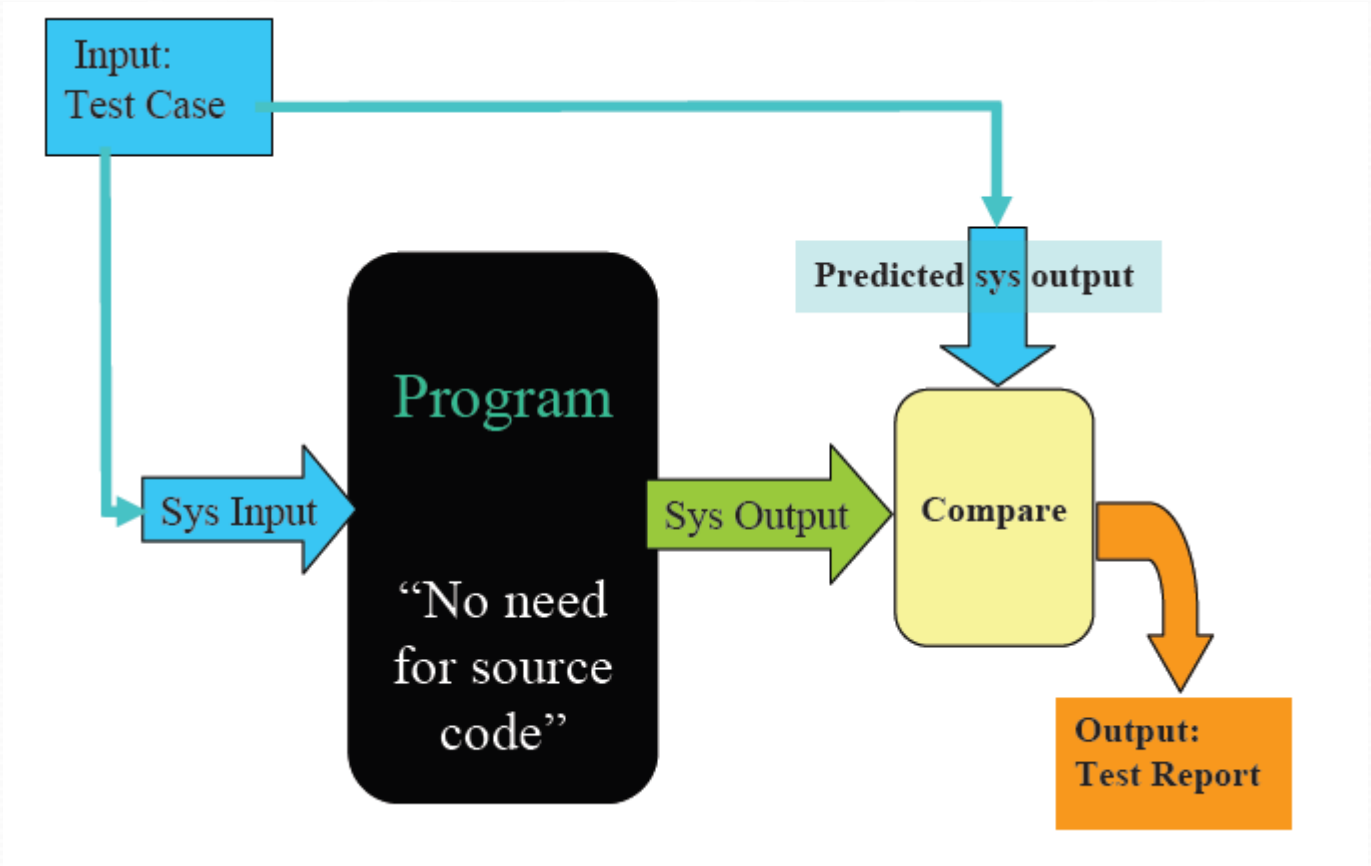
# Black-box testing

- Program is considered as a ‘black-box’
- No need to know or access source code
- Functionality testing
- No implementation testing (implementation testing needs source code)
- Test cases are based on the system specification
- Test planning can begin early in the software process

# Black-box testing

- Testers provide the system with inputs and observe the outputs
  - They can see none of:
    - The source code
    - The internal data
    - Any of the design documentation describing the system's internals

# Black-box testing



# Test case design

- Involves designing the test cases (inputs and outputs) used to test the system.
- The goal of test case design is to create a set of tests that are effective in validation and defect testing.
- Design approaches:
  - Requirements-based testing;
  - Partition testing;
  - Structural testing.
  - Path testing

# Requirements based testing

- A general principle of requirements engineering is that requirements should be testable.
- Requirements-based testing is a validation testing technique where you consider each requirement and derive a set of tests for that requirement.

# Partition testing

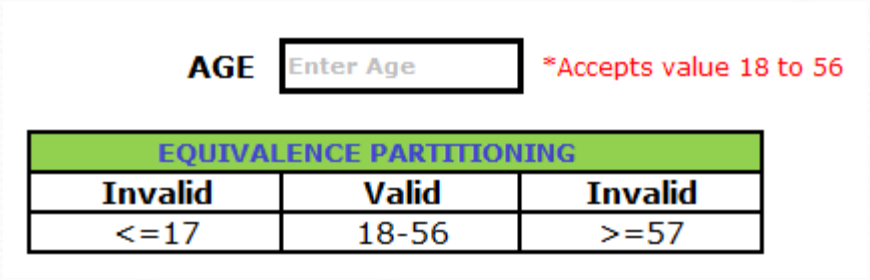
- Input data and output results often fall into different classes where all members of a class are related.
- Each of these classes is an equivalence partition or domain where the program behaves in an equivalent way for each class member.
- Test cases should be chosen from each partition.

# Equivalence partitioning

- Objective:

**Reduce** the number of test cases

# Example




| EQUIVALENCE PARTITIONING | | |
|---|---|---|
| **Invalid** | **Valid** | **Invalid** |
| <=17 | 18-56 | >=57 |

Assume, we have to test a field which accepts Age 18 – 56

- Valid Class: 18 – 56 = Pick any one input test data from 18 – 56
- Invalid Class 1: <=17 = Pick any one input test data less than or equal to 17
- Invalid Class 2: >=57 = Pick any one input test data greater than or equal to 57

# Structural testing: White-box testing

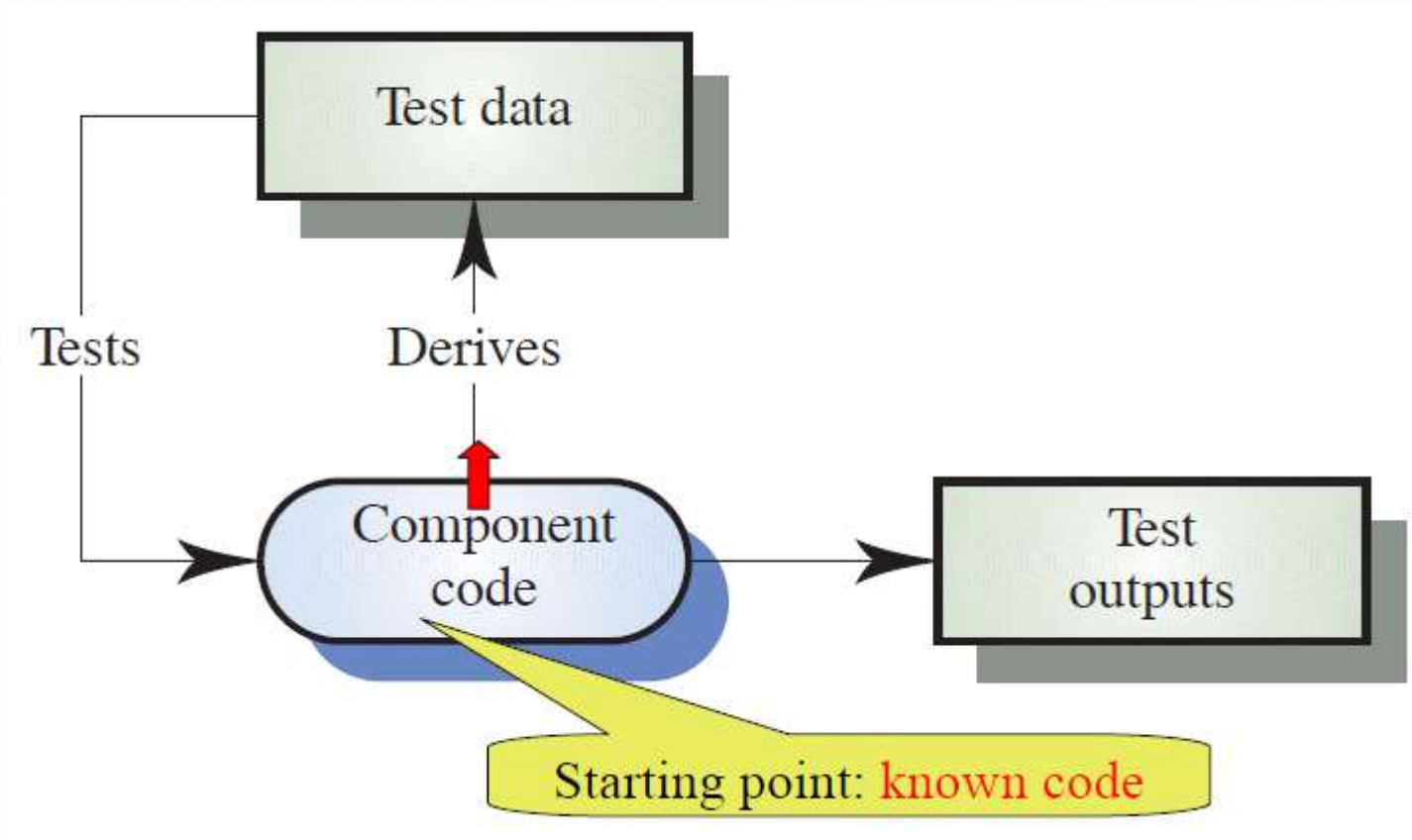
- Sometime called white-box testing.
- Derivation of test cases according to program structure. Knowledge of the program is used to identify additional test cases.
- Objective is to exercise all program statements (not all path combinations).

# Structural testing: White-box testing

- **Synonyms:**
  - **Glass-box, Clear-box, Transparent-box**
- For small program units
- Needs **source code**

- Objective: is to exercise **all program statements**
- (not all path combinations)

# Structural testing: White-box testing



# Path testing

- The objective of path testing is to ensure that the set of test cases is such that each path through the program is executed at least once.
- The starting point for path testing is a program flow graph that shows nodes representing program decisions and arcs representing the flow of control.
- Statements with conditions are therefore nodes in the flow graph.

# Program flow graphs

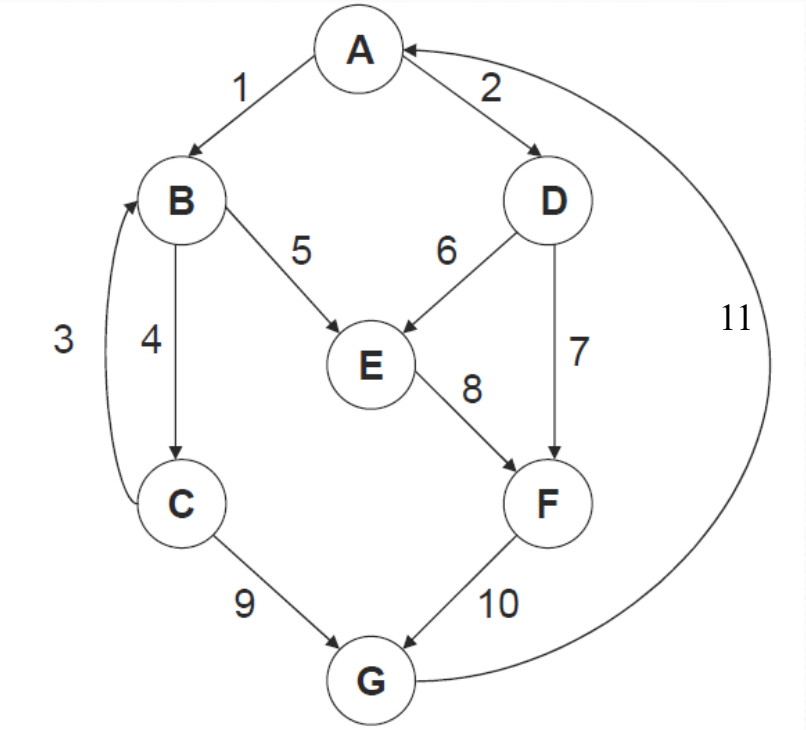
- **Flow Graph**:
  - nodes representing program decisions
  - arcs representing the flow of control
  - Ignore sequential statements (assignments, procedures calls, I/O)
- Statements with conditions are therefore nodes in the flow graph
- **Cyclomatic complexity =**

  **Number of edges - Number of nodes + 2**

# Cyclomatic complexity

- Cyclomatic complexity = **number of tests** to test all control statements
- Cyclomatic complexity = number of conditions in a program
- Although all paths are executed, all combinations of paths are not executed

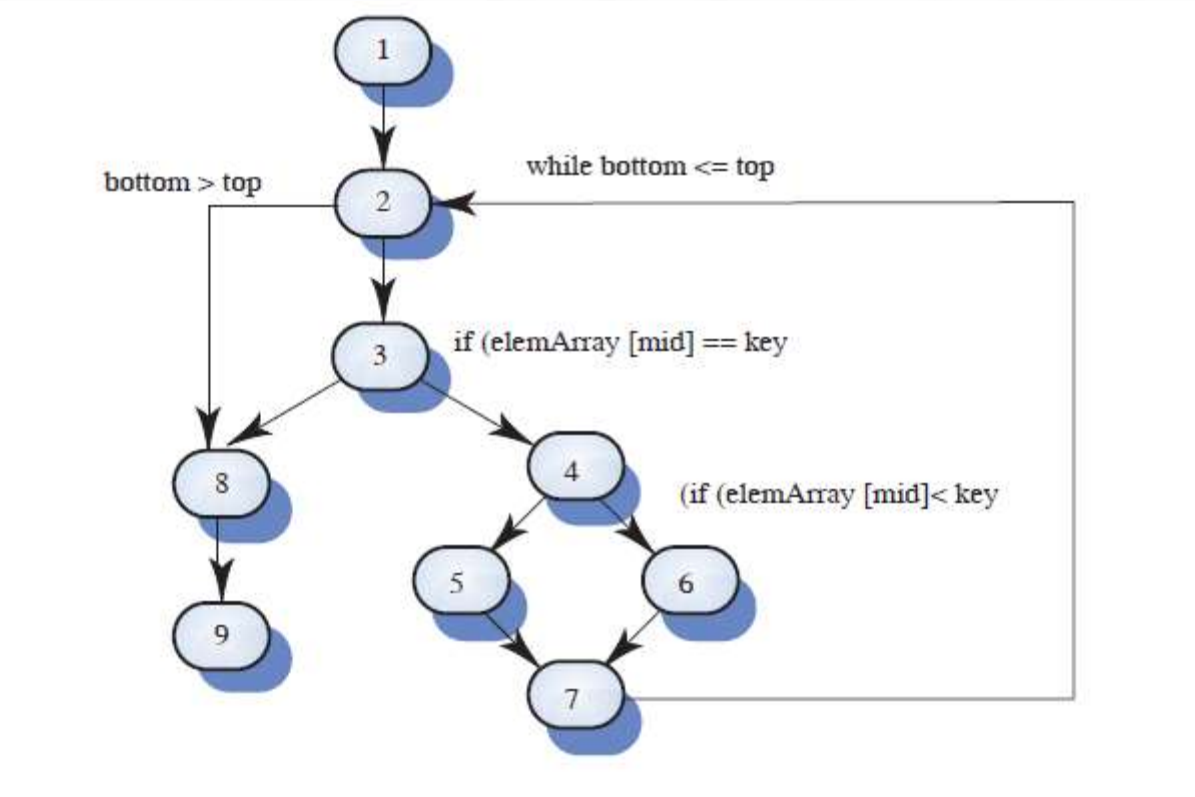
# Example




Path 1: A, B, C, G.
Path 2: A, B, C, B, C, G.
Path 3: A, B, E, F, G.
Path 4: A, D, E, F, G.
Path 5: A, D, F, G.
Path 6: A, D, F, G, A, B, C, G

Cyclomatic Complexity = 11 -7 + 2 = 6

# Binary search flow graph



# Independent paths

Cyclomatic Complexity = 11 -9 + 2 = 4

Independents Paths:

1-2-8-9
1-2-3-8-9
1-2-3-4-5-7-2-8-9
1-2-3-4-6-7-2-8-9

# Key points

- Testing can show the presence of faults in a system; it cannot prove there are no remaining faults.
- Component developers are responsible for component testing; system testing is the responsibility of a separate team.
- Integration testing is testing increments of the system; release testing involves testing a system to be released to a customer.

# Key points

- Use experience and guidelines to design test cases in defect testing.
- Equivalence partitioning is a way of discovering test cases - all cases in a partition should behave in the same way.
- Structural analysis relies on analysing a program and deriving tests from this analysis.