Defect testing

- **Testing is the process of exercising a program with the specific intent of finding errors prior to delivery to the end user.**

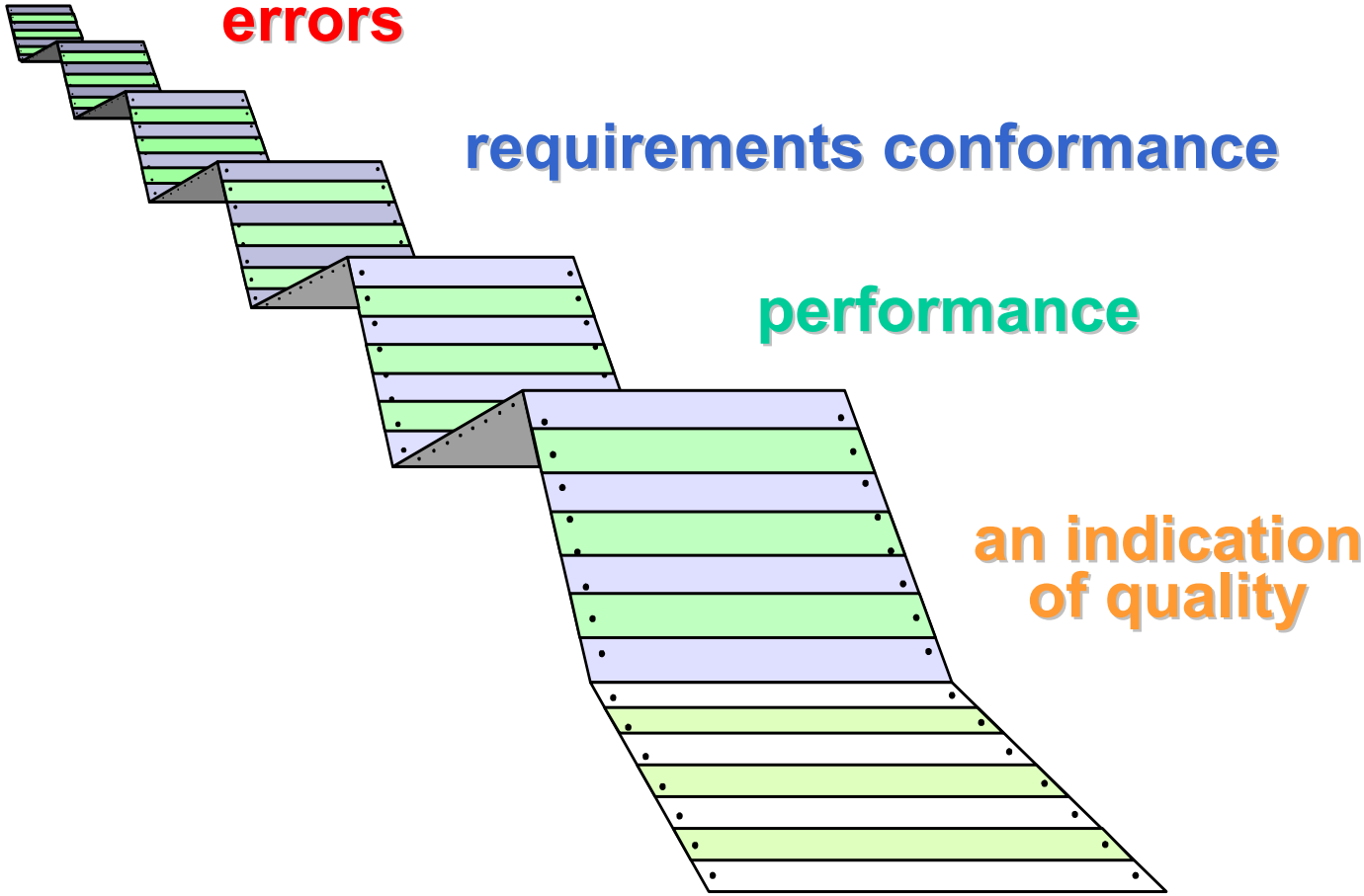
Objectives

- To understand testing techniques that are geared to discover program faults
- To introduce guidelines for interface testing
- To understand the principles of CASE tool support for testing

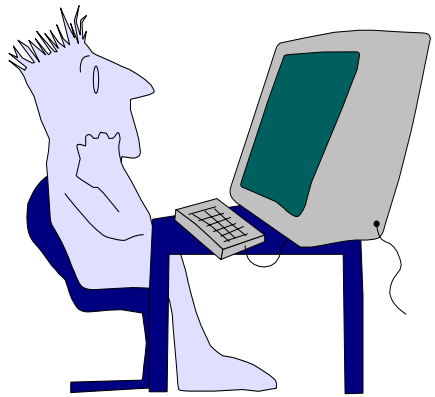
Topics covered

- Defect testing
  - Exhaustive Testing
  - Black-box testing
  - Equivalence partitioning
  - White-box ‘Structural’ testing
  - Path testing
- Integration testing
- Interface testing
- Stress testing
- Object-oriented (OO) testing
- Monkey testing
- Testing workbenches

What Testing Shows

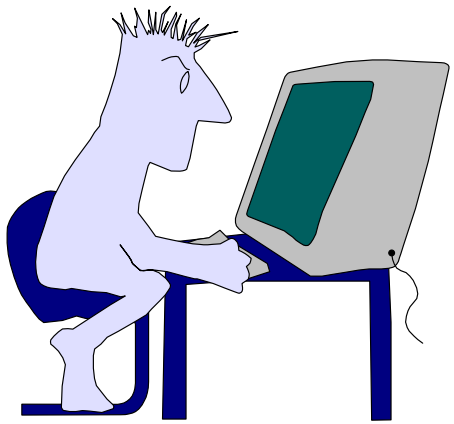


Who Tests the Software



Developer

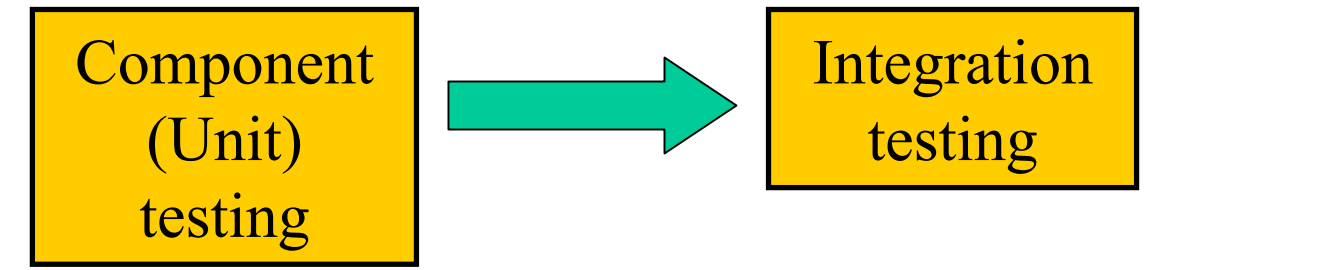
- understands the system
- has the source code
- white-box ‘Unit’ testing
- will test "gently“
- driven by delivery ‘schedule’ constraint



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 phases

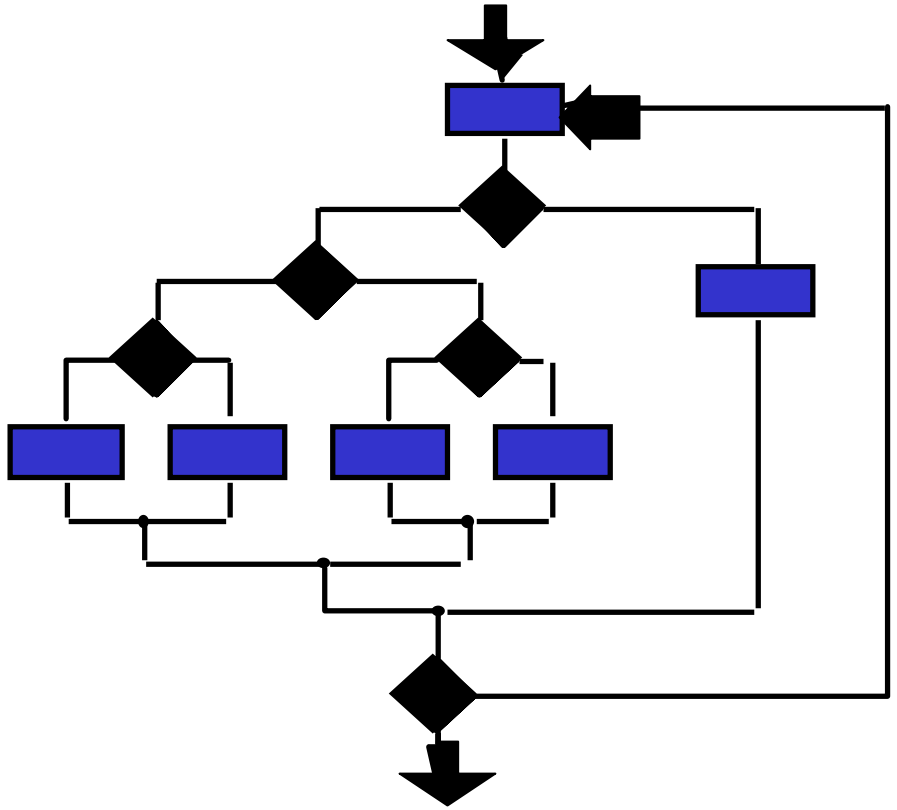


The testing process

- 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

- Integration testing (Acceptance testing, Black-box testing)
  - Testing of groups of components integrated to create a system or sub-system
  - The responsibility of an independent testing team
  - Tests are based on a system specification (Acceptance testing)

Exhaustive Testing

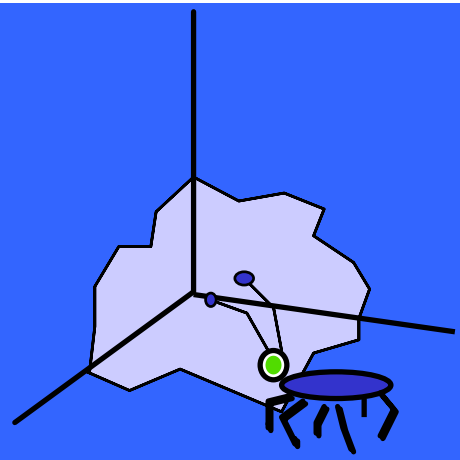


If there are 10^{14} possible paths and we execute one test per millisecond, it would take 3,170 years to test this program!!

Test Case Design

"Bugs lurk in corners and congregate at boundaries ..."

Boris Beizer



OBJECTIVE	to uncover errors
CRITERIA	in a complete manner
CONSTRAINT	with a minimum of effort and time

Test data and test cases

- *Test data*
  - Inputs to test the system
- *Test cases 'Test scenario' includes:*
  - Inputs to test the system
  - and the predicted outputs

The defect testing process

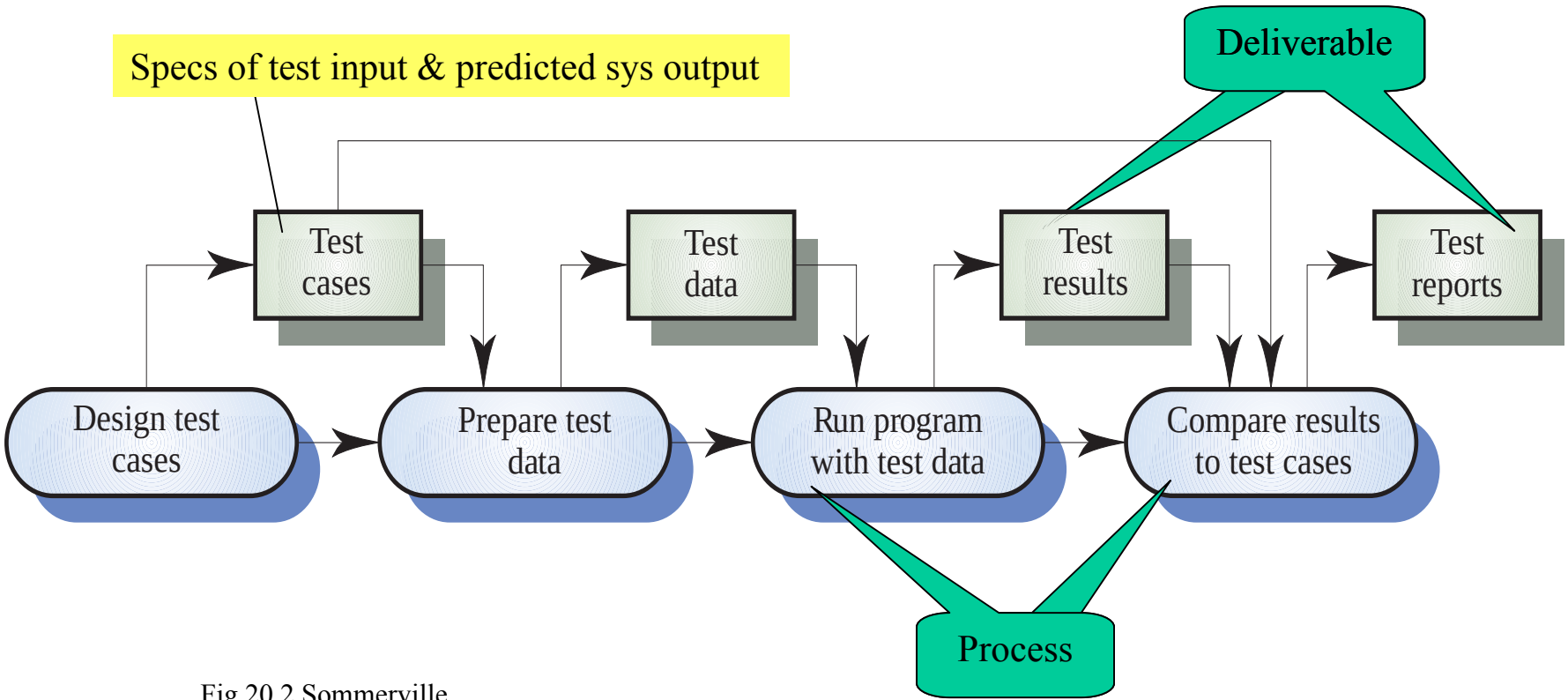


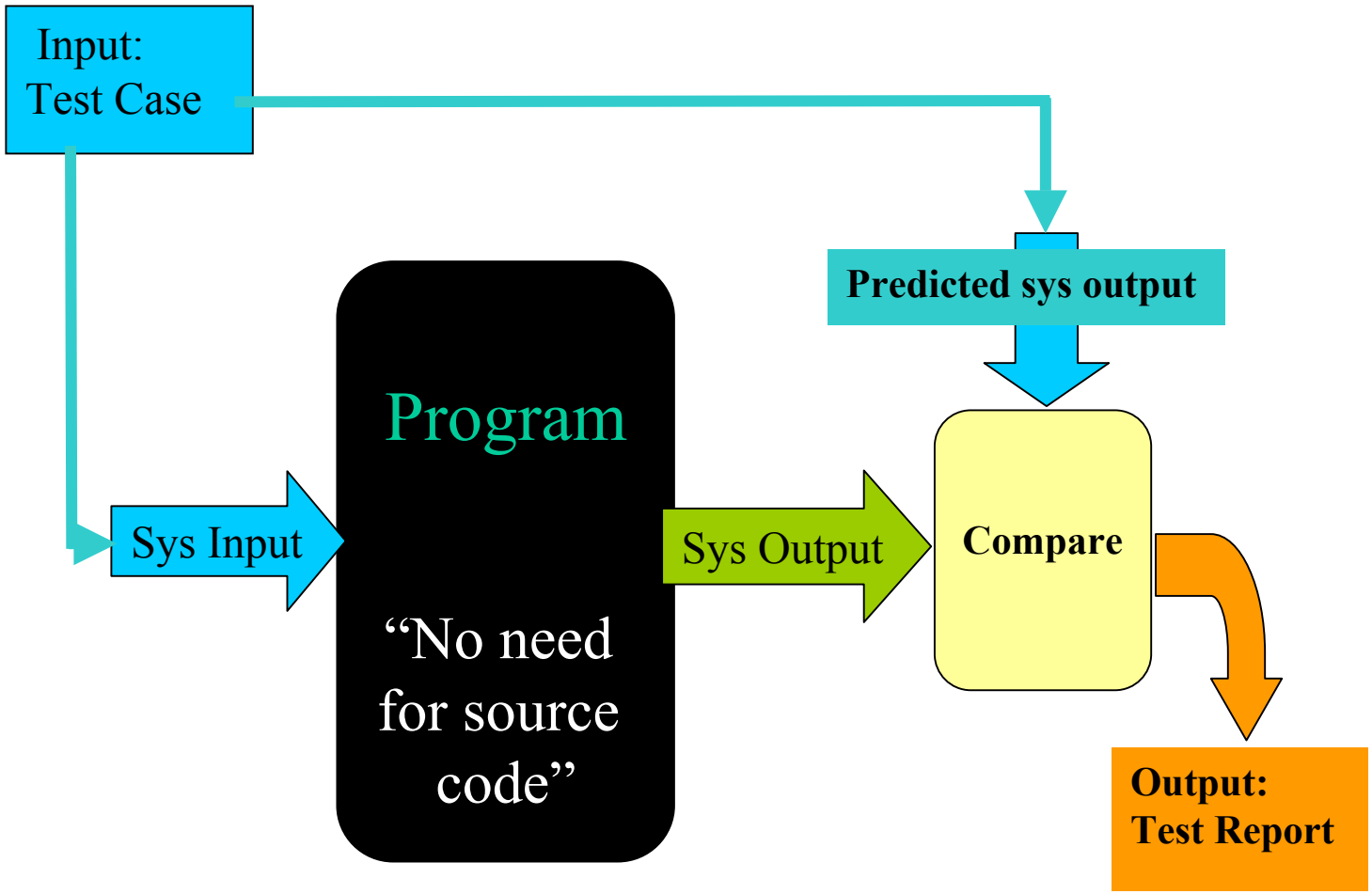
Fig 20.2 Sommerville

Black-box testing

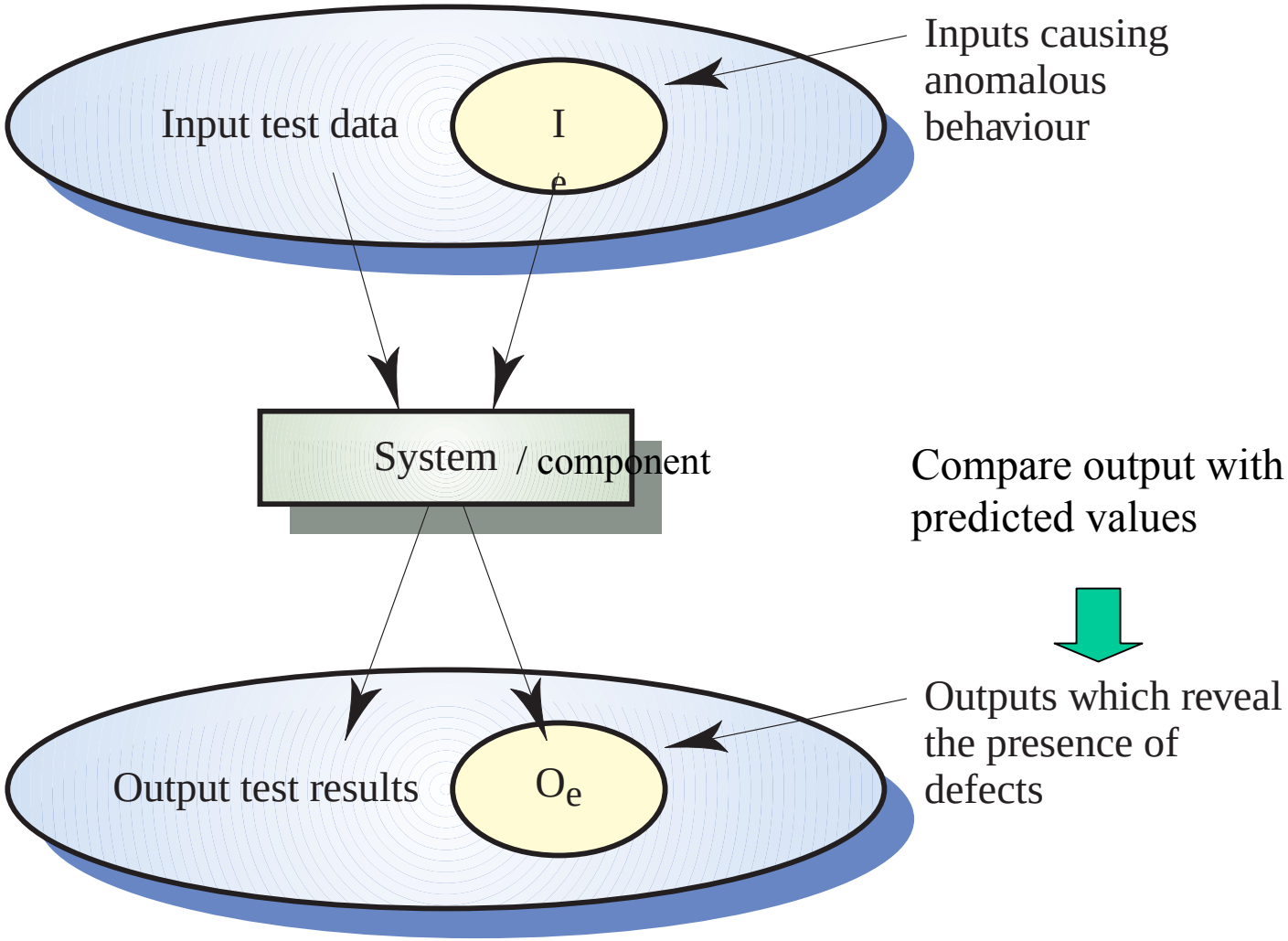
- Program is considered as a ‘black-box’
- No need to know or access source code
- Functionality testing
- No implementation testing (implementation testing needs source code)
- Test cases are based on the system specification
- Test planning can begin early in the software process

Black-box Testing

"Functionality testing"



Black-box Testing



Equivalence partitioning

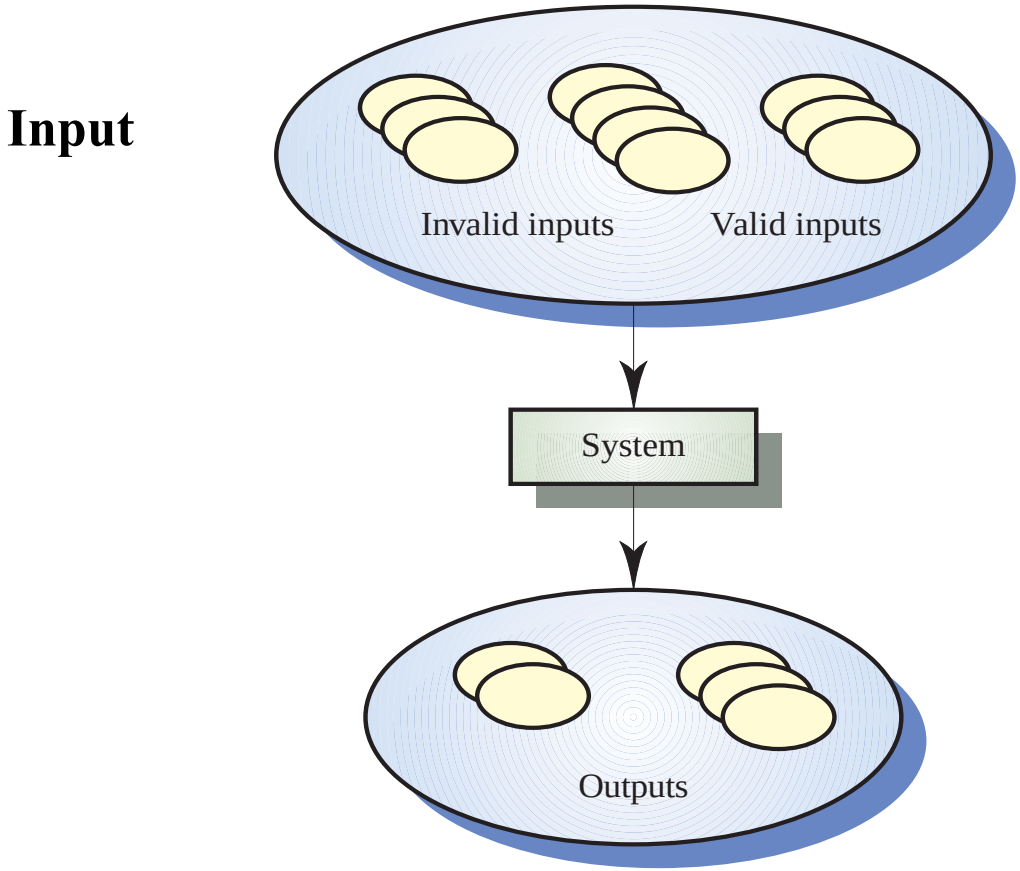
- Objective:

Reduce the number of test cases

Equivalence partitioning - cont.

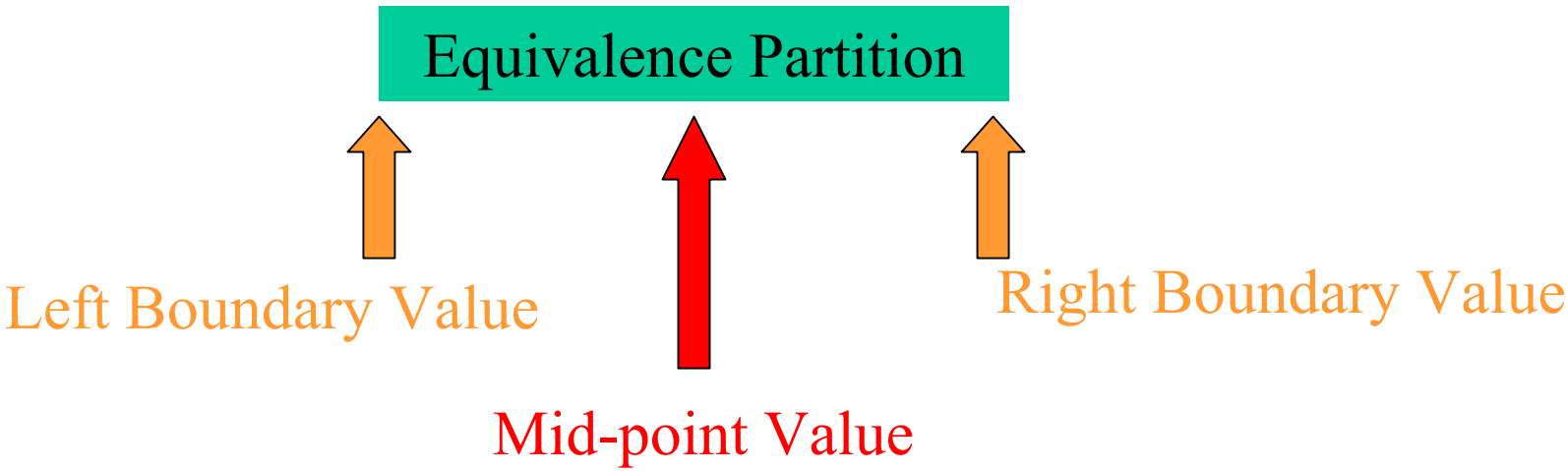
- A way to derive test cases
- Is a black-box testing method
- Input data with common characteristics (positive numbers, negative numbers, strings without blanks, etc)
- Each of these classes is an equivalence partition
- Program behaves in an equivalent way for each member of an Equivalence partition
- Divides the input domain into classes of data form which test cases can be derived

Equivalence partitioning – cont.



Equivalence partitioning - cont.

- Guide lines for test case selection for partitions
  - At the **boundaries** of the partition
  - Close to **mid-point** of the partition

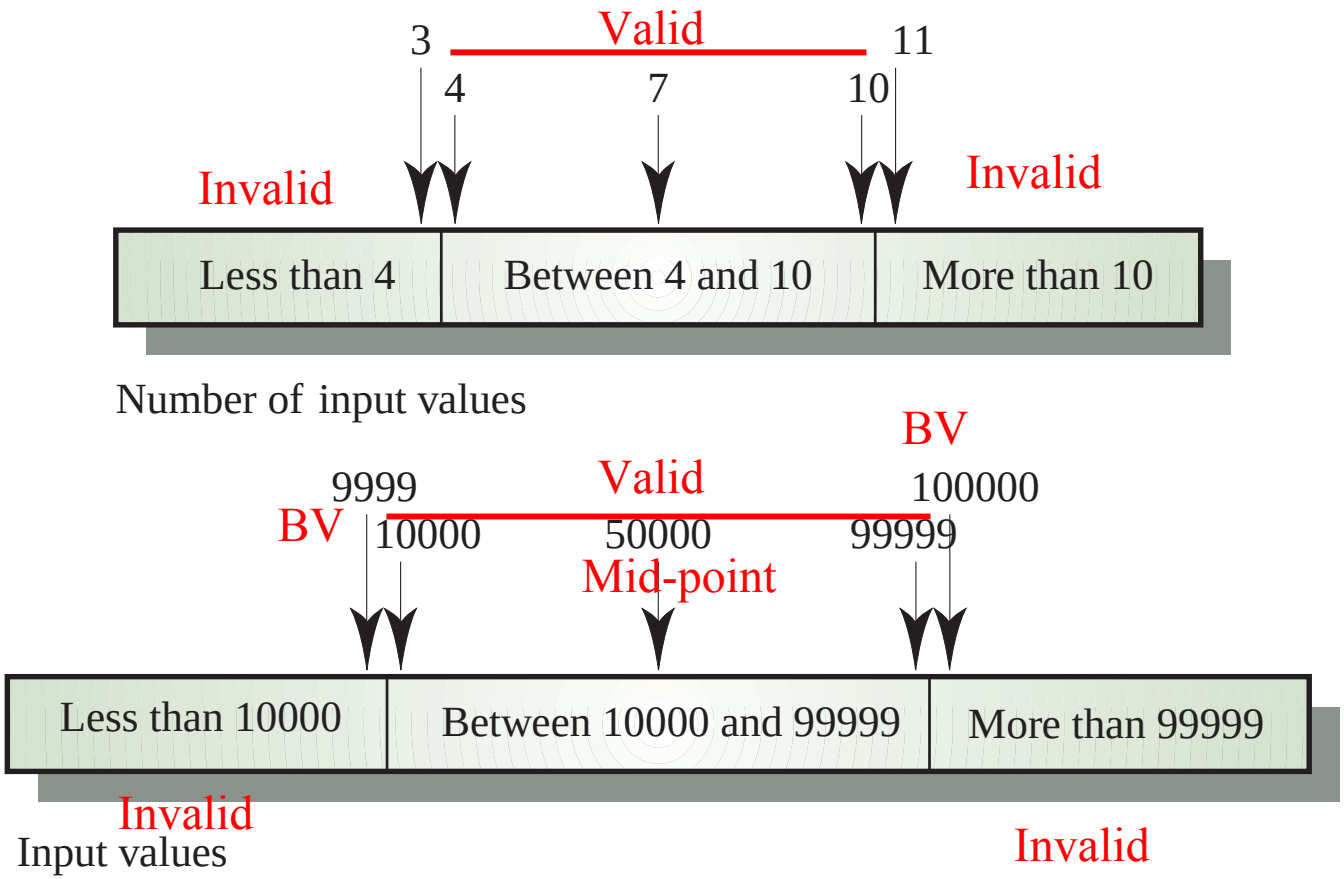


Equivalence partitioning - Example 1

- Program specs states:
  - Accepts 4 to 10 inputs
  - Each input is 5-digit integer greater than 10,000

- Partition system inputs and outputs into ‘equivalence sets’

Equivalence partitioning - cont. Example



Equivalence partitioning - cont. Example 1

- If input is a 5-digit integer between 10,000 and 99,999, equivalence partitions are (fig 20.5 Sommerville)
  - <10,000,
  - 10,000 - 99, 999
  - and > 99, 999
- Test cases - 6 cases
  - 00000, (invalid special value that may be checked)
  - 09999, (invalid left boundary value)
  - 10000, (valid left boundary value)
  - 50000, (valid mid value)
  - 99999, (valid right boundary value)
  - 100000, (invalid right boundary value)

Remember: Bugs lurk in corners & congregate at boundaries

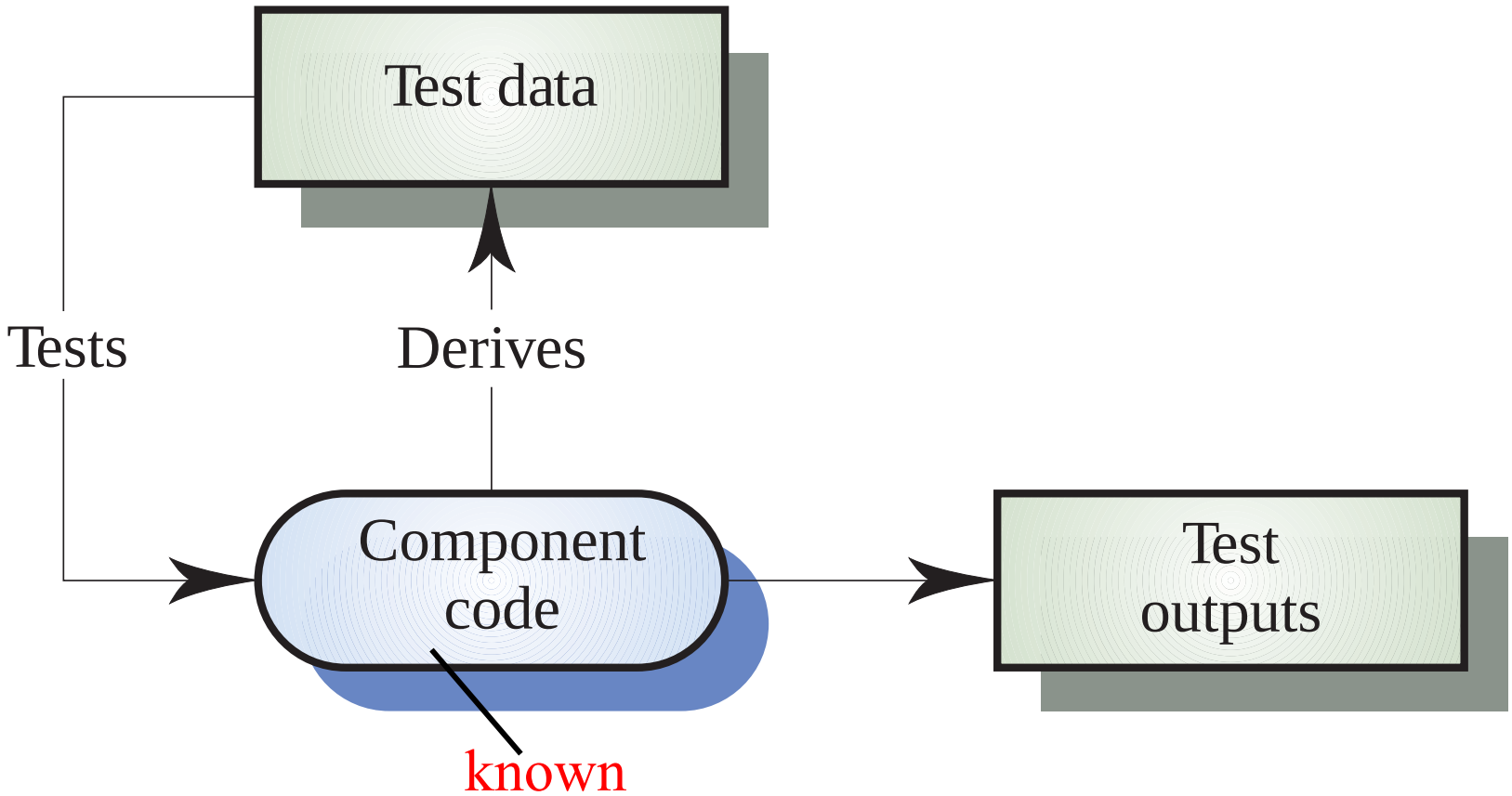
Structural testing 'White-box testing'

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

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

- Fig 20.8

White-box testing



Path testing

- Each path through the program is executed **at least once**
- For loops & conditions
- Used at unit testing and module testing levels

Program flow graphs

- Flow Graph:
  - nodes representing program decisions
  - arcs representing the flow of control
  - Ignore sequential statements (assignments, procedures calls, I/O)

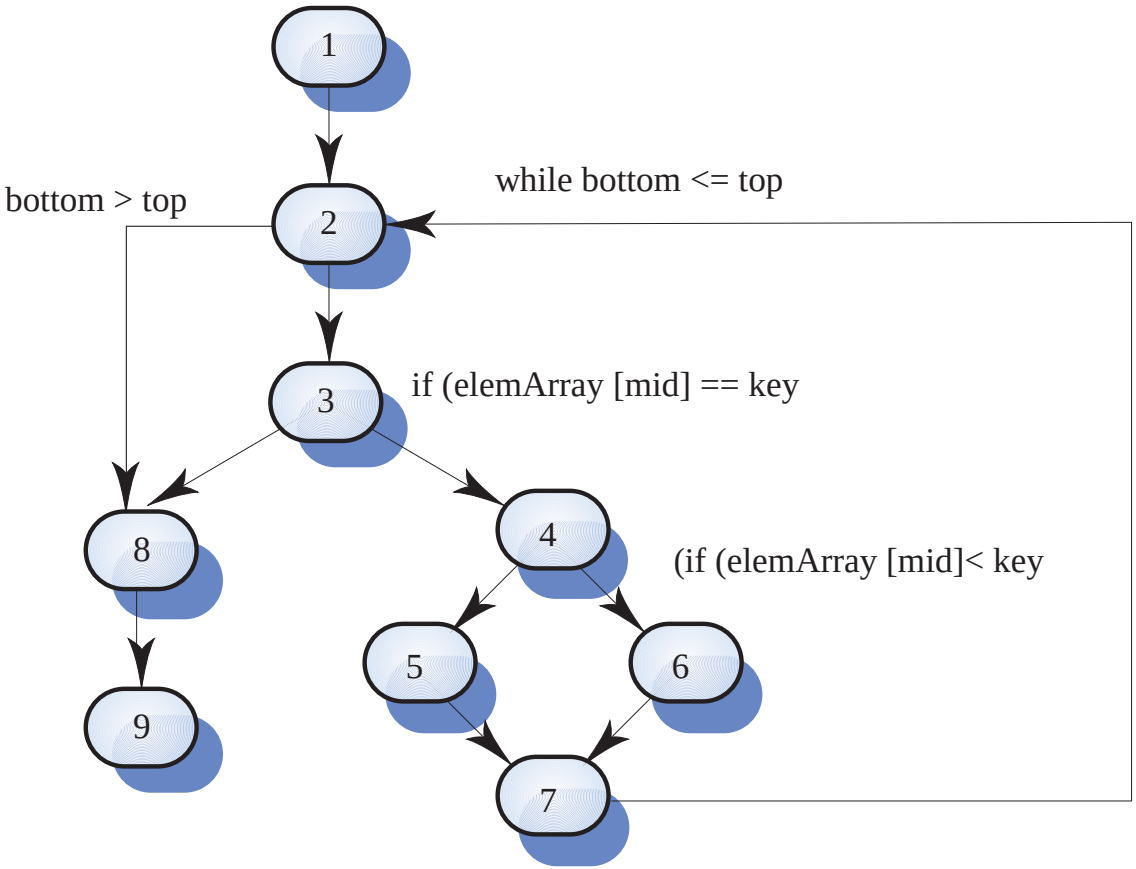
- Statements with conditions are therefore nodes in the flow graph

- **Cyclomatic complexity =**
  Number of edges - Number of nodes + 2

Cyclomatic complexity

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

Path testing
Binary search flow graph



Independent paths

- **Cyclomatic complexity = 11 - 9 + 2 = 4**

- Thus 4 independent paths:
- 1, 2, 3, 8, 9
- 1, 2, 3, 4, 6, 7, 2
- 1, 2, 3, 4, 5, 7, 2
- 1, 2, 3, 4, 6, 7, 2, 8, 9

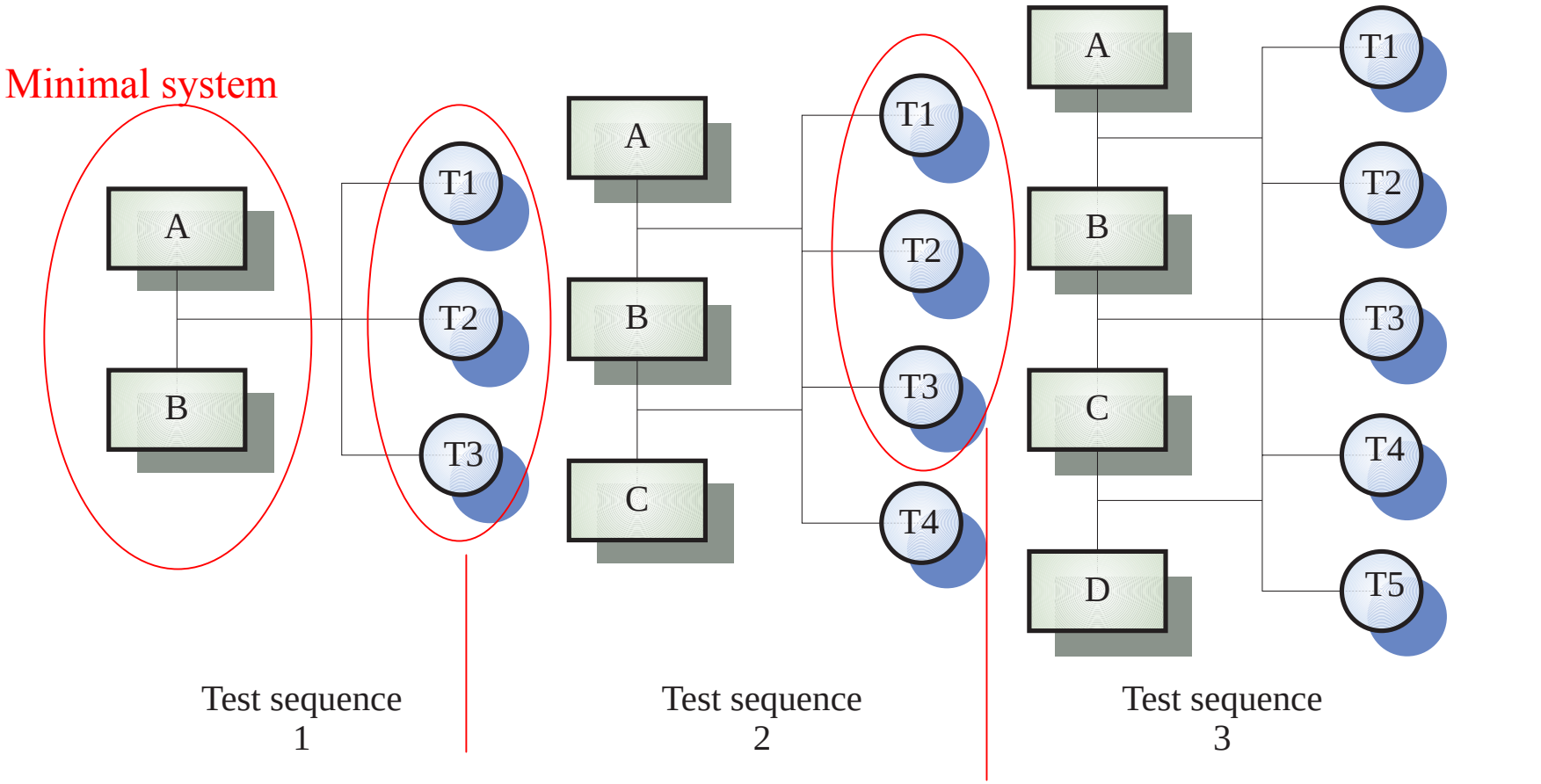
- Test cases should be derived so that all of these paths are executed

Integration testing **(black-box)**

- Tests complete systems or subsystems composed of integrated components
- Integration testing should be **black-box** testing with tests derived from the **specification**
- Main difficulty is localising errors
- Incremental integration testing reduces this problem

Incremental integration testing

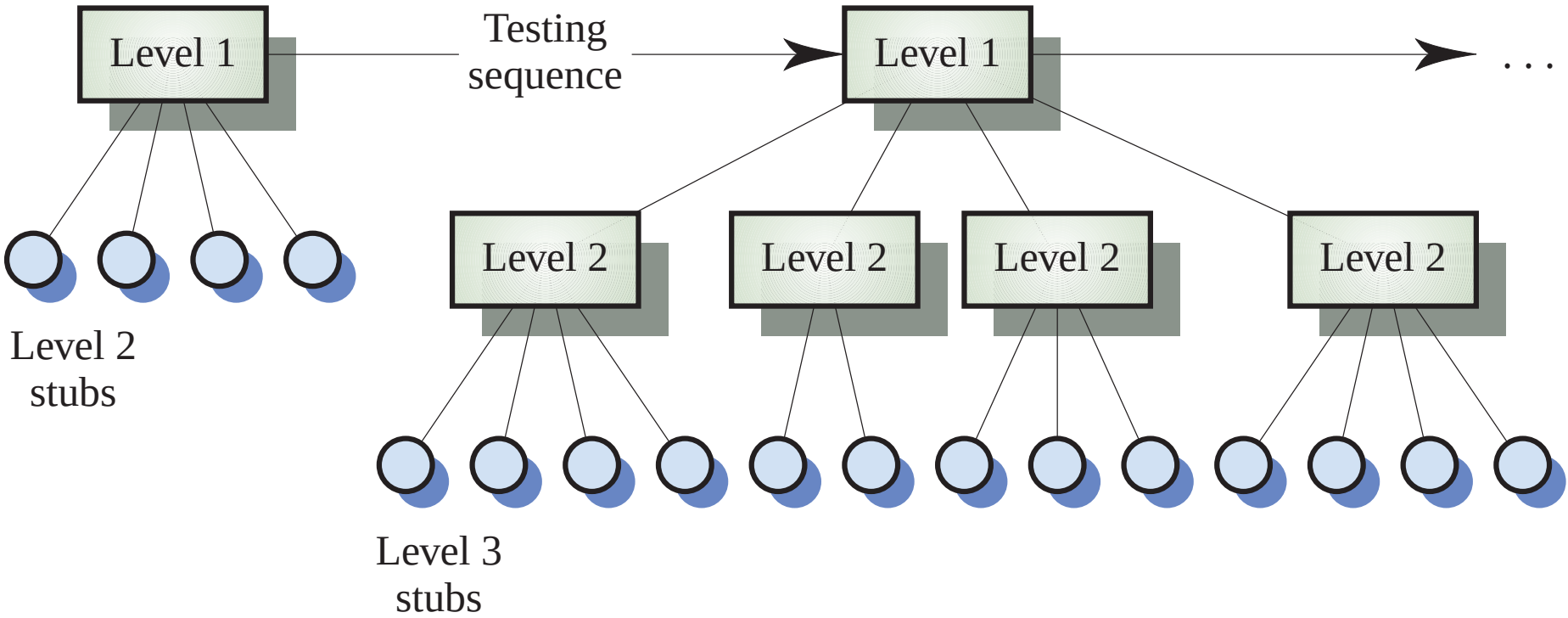
Recall: XP Continuous Integration of: Stories + (Acceptance & Unit Tests)



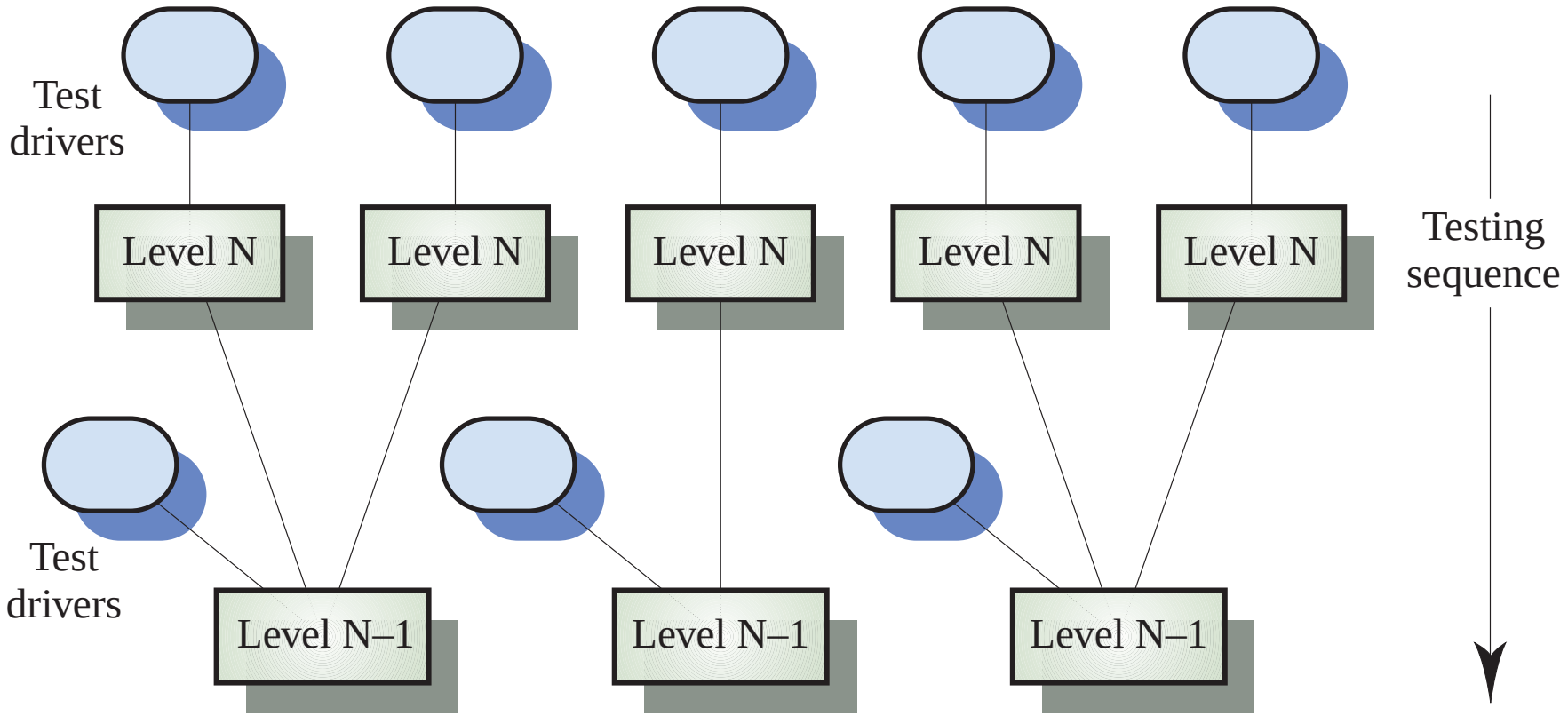
Approaches to integration testing

- 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

Top-down integration testing



Bottom-up integration testing



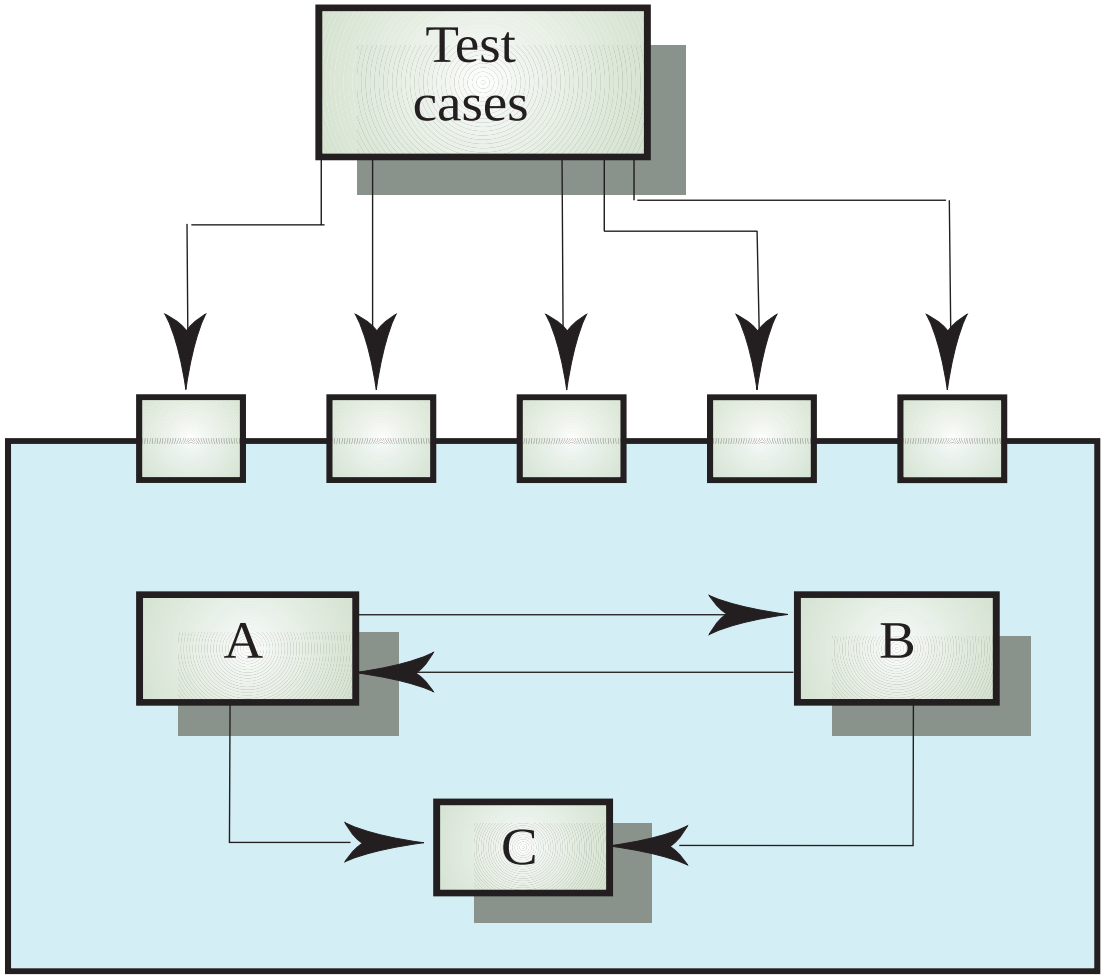
Testing approaches

- Architectural validation
  - Top-down integration testing is better at discovering errors in the system architecture
- System demonstration
  - Top-down integration testing allows a limited demonstration at an early stage in the development
- Test implementation
  - Often easier with bottom-up integration testing

Interface testing

- Takes place when modules or sub-systems are integrated to create larger systems
- Objectives are to detect faults due to interface errors or invalid assumptions about interfaces
- Particularly important for object-oriented development as objects are defined by their interfaces

Interface testing



Interfaces types

- Parameter interfaces
  - Data passed from one procedure to another
- Shared memory interfaces
  - Block of memory is shared between procedures
- Message passing interfaces
  - Sub-systems request services from other sub-systems

Interface testing guidelines

- Design tests so that parameters to a called procedure are at the extreme ends of their ranges

- Use stress testing in message passing systems

Stress testing

- Exercises the system beyond its maximum design load.
- Stressing the system often causes defects to come to light
- Stress testing failure behaviour..
  - Systems should **not fail catastrophically**.
  - Stress testing checks for unacceptable loss of service or data

- Particularly relevant to distributed systems which can exhibit severe degradation as a network becomes overloaded

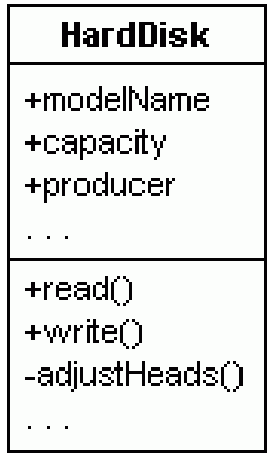
Object-oriented (OO) testing

- The components to be tested are object classes that are instantiated as objects

Object-oriented testing: Testing levels

- Testing operations (methods) associated with objects

  Remember: XP Unit Testing by developers on operations



- Testing object classes
- Testing clusters of cooperating objects
- Testing the complete OO system

Object class testing

- Complete test coverage of a class involves:
  - Testing all operations (methods) associated with an object
  - Setting and interrogating all object attributes
  - (Recall: XP Unit testing for all methods and attributes of a class)

- **Inheritance makes it more difficult** to design object class tests
  - the information to be tested is **not localised**

Key points

- Test parts of a system which are commonly used rather than those which are rarely executed
- Equivalence partitions are sets of test cases where the program should behave in an equivalent way
- Black-box testing is based on the system specification
- Structural testing identifies test cases which cause all paths through the program to be executed

Key points

- Test coverage measures ensure that all statements have been executed at least once.
- Interface defects arise because of specification misreading, misunderstanding, errors or invalid timing assumptions
- To test object classes, test all operations, attributes and states
- Integrate object-oriented systems around clusters of objects