Faculty of Computers and Information

Software Engineering II

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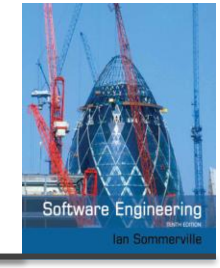


Course Description

The purpose of the course is to understand and complete the general principles of SE-1 concepts.

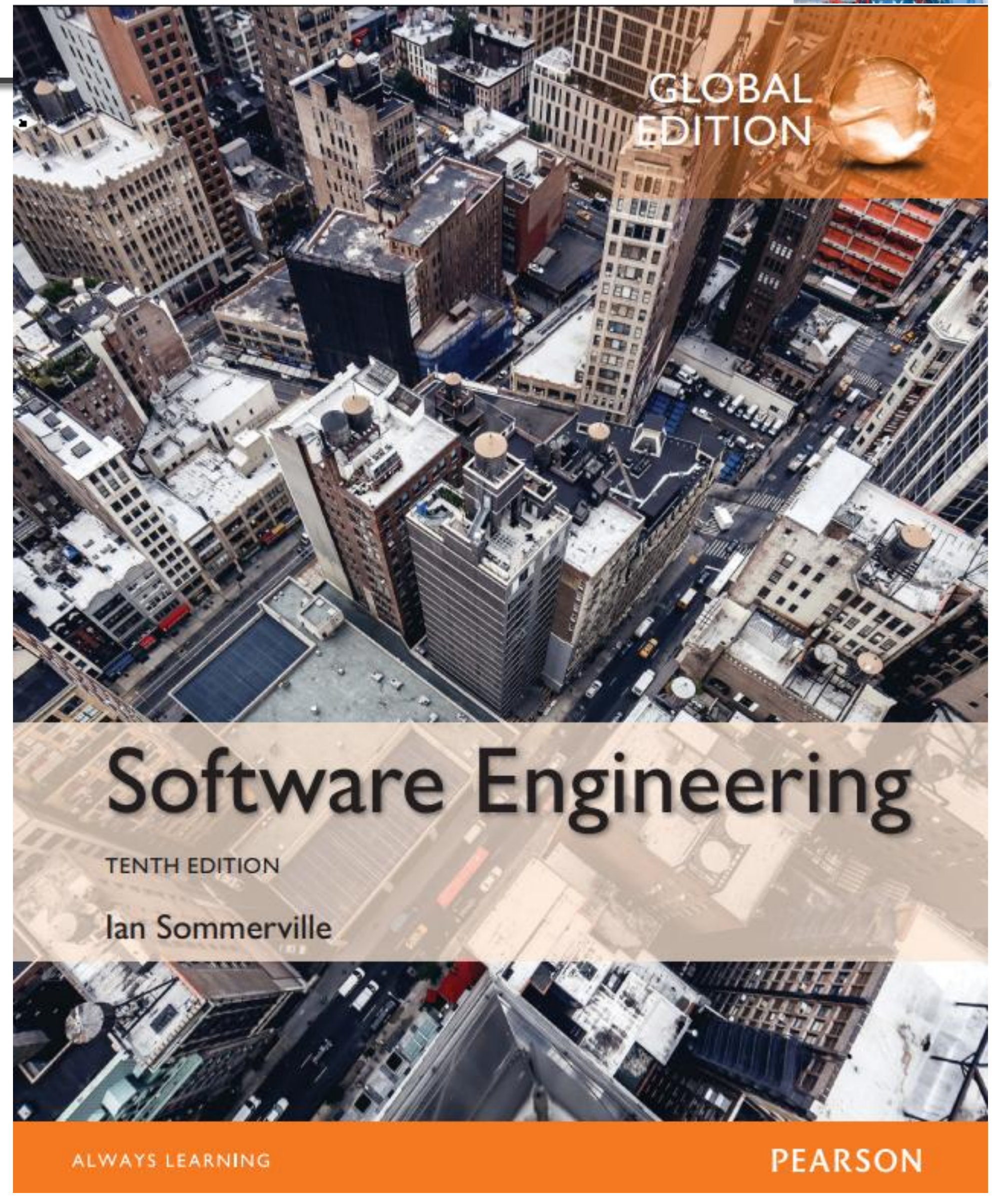
We selected some topics for studying, including

- Software Testing
- Software management
- Advanced software engineering

Textbook

no specific book

Recommended Reading:



Part 1 Introduction to Software Engineering

Chapter 1 Introduction
Chapter 2 Software processes
Chapter 3 Agile software development
Chapter 4 Requirements engineering
Chapter 5 System modeling
Chapter 6 Architectural design
Chapter 7 Design and implementation
Chapter 8 Software testing
Chapter 9 Software evolution

Part 2 System Dependability and Security

Chapter 10 Dependable systems
Chapter 11 Reliability engineering
Chapter 12 Safety engineering
Chapter 13 Security engineering
Chapter 14 Resilience engineering

Part 3 Advanced Software Engineering

Chapter 15 Software reuse
Chapter 16 Component-based software engineering
Chapter 17 Distributed software engineering
Chapter 18 Service-oriented software engineering
Chapter 19 Systems engineering
Chapter 20 Systems of systems
Chapter 21 Real-time software engineering

Part 4 Software Management

Chapter 22 Project management
Chapter 23 Project planning
Chapter 24 Quality management
Chapter 25 Configuration management

Prerequisites

Introductory course in SE, Probability and statistics, Theory of systems, Programming skills, Operating systems, Logic Systems, Computer Architecture, …

Homework

Homework will be assigned weekly.

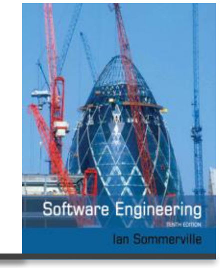
Note late homework will not be accepted.

Examination

At least one-hour midterm exam is tentatively scheduled for week seven of the quarter. The actual data for the exam will be determined by the progress in the course.

✧ Grading

- ✧ **The composition of the final grade is:**
- ✧ **Homework + group (project) + Midterm Exam 40%**
- ✧ **Final Exam 60%**



Chapter 8 – Software Testing

Topics covered

- ✧ Development testing
- ✧ Test-driven development
- ✧ Release testing
- ✧ User testing

Program testing

- Testing is intended to **show that a program does what it is intended to do** and **to discover program defects** before it is put into use.
- When you test software, you execute a program using artificial data.
- You check the results of the test run for **errors**, **anomalies** or **information about the program's** non-functional attributes.
- Can reveal the **presence of errors NOT their absence.**
- Testing **is part of a more general** verification and validation process, which also includes static validation techniques.

Program testing goals

- To demonstrate to **the developer and the customer** that the software **meets its requirements**.
  - For custom software, this means that there should be at least one test for every requirement in the requirements document.
  - For generic software products, it means that there should be tests for all of the system features, plus combinations of these features, that will be incorporated in the product release.
- To discover **situations** in which the behavior of the software is incorrect, undesirable or does not conform to its specification.
  - Defect testing is concerned with rooting out undesirable system behavior such as system crashes, unwanted interactions with other systems, incorrect computations and data corruption.

Validation and defect testing

- The first goal leads to **validation testing**
  - You expect the system to perform correctly using a **given set of test cases** that reflect the system's expected use.
- The second goal leads to **defect testing**
  - The test cases are designed to expose defects. The **test cases** in defect testing can be deliberately obscure and need not reflect how the system is normally used.

Testing process goals

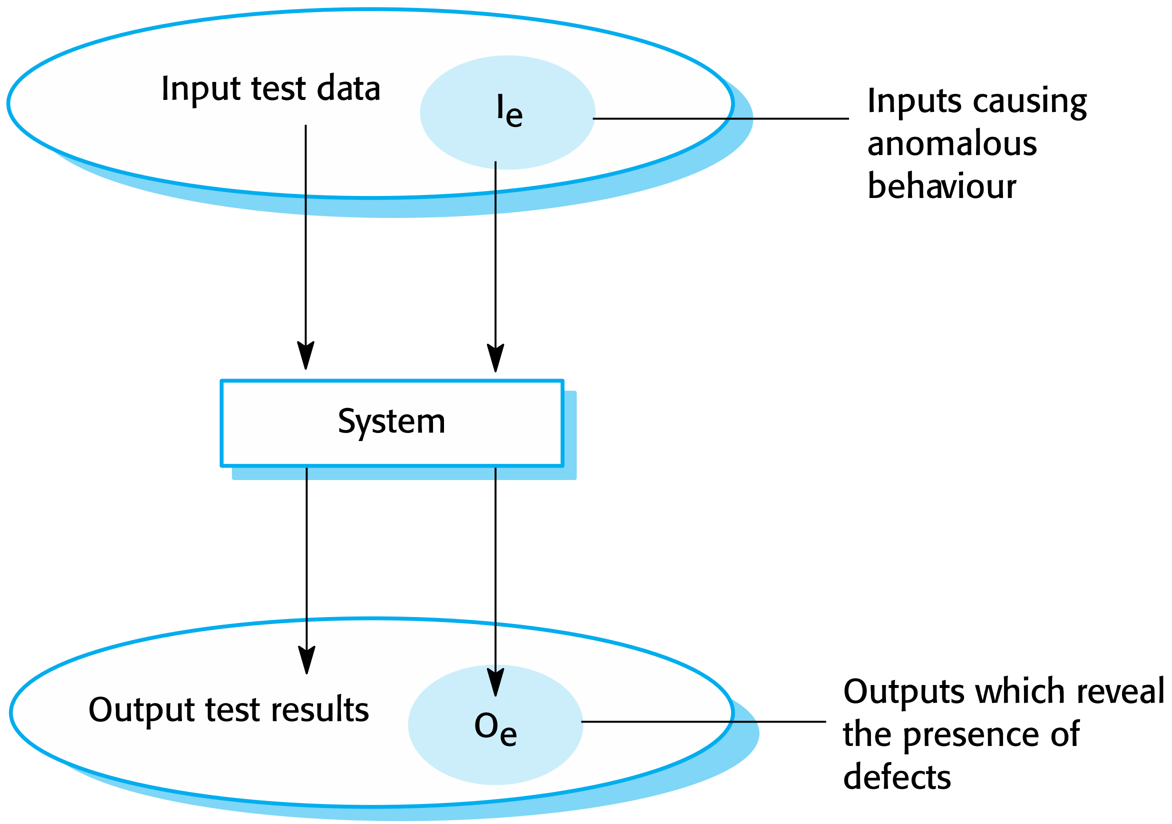
✧ Validation testing

- To demonstrate to the developer and the system customer that the software meets its requirements
- A successful test shows that the system operates as intended.

✧ Defect testing

- To discover **faults** or **defects** in the software where its behaviour is incorrect or not in conformance with its specification
- A successful test is a test that makes the system perform incorrectly and so exposes a defect in the system.

An input-output model of program testing



Verification vs validation

- **Verification**:
  "Are we building the **product right**".
- The software **should conform to its specification**.
- **Validation**:
  "Are we building **the right product**".
- The software **should do what the user really requires**.

V & V confidence

- ✧ Aim of V & V is to establish **confidence** that the system is ‘fit for purpose’.
- ✧ The level of required confidence depends on the **system’s purpose,** the **expectations of the system users**, and the **current marketing environment** for the system:

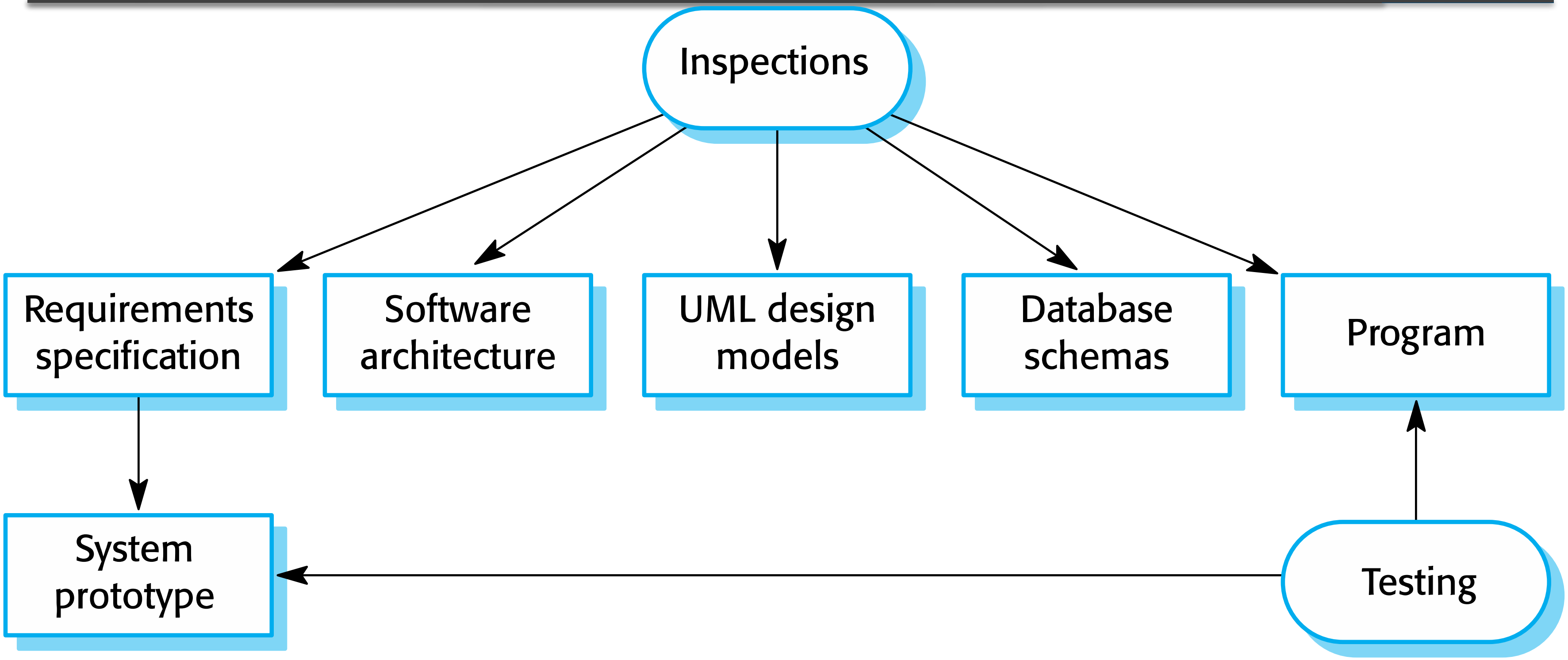
  Software purpose
    - The level of confidence depends on how critical the software is to an organisation.
  - User expectations
    - Users may have low expectations of certain kinds of software.
  - Marketing environment
    - Getting a product to market early may be more important than finding defects in the program.

Inspections and testing

As well as software testing, the verification and validation process may involve software **inspections** and reviews.

- ✧ Software inspections Concerned with analysis of the static system representation to discover problems (static verification)
  - May be supplement by tool-based document and code analysis.
  - Discussed in Chapter 15.
- ✧ Software testing Concerned with exercising and observing product behaviour (dynamic verification)
  - The system is executed with test data and its operational behaviour is observed.

Inspections and testing



Inspections mostly focus on the source code of a system, **but any readable representation of the software,** such as its requirements or a design model, **can be inspected**.

When you inspect a system, you use knowledge of the system, its application domain, and the programming or modeling language to **discover errors.**

Software inspections

- These involve people examining the source representation with the aim of discovering anomalies and defects.
- Inspections not require execution of a system so may be used before implementation.
- They may be applied to any representation of the system (requirements, design,configuration data, test data, etc.).
- They have been shown to be an effective technique for discovering program errors.

Advantages of inspections

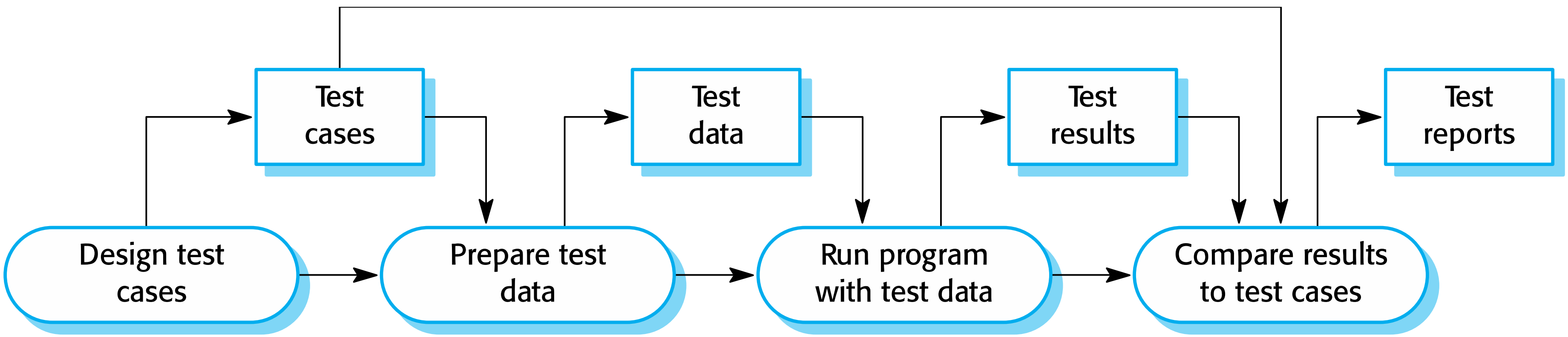
- During testing, errors can mask (hide) other errors. **Because inspection is a static process, you don't have to be concerned with interactions between errors.**
- **Incomplete versions of a system can be inspected without additional costs**. If a program is incomplete, then you need to develop **specialized test harnesses to test the parts that are available**.
- As well as searching for program defects, **an inspection can also consider broader quality attributes of a program**, such as compliance with standards, portability and maintainability.

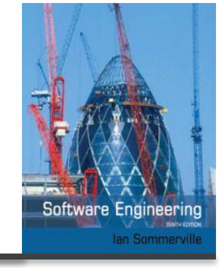
Inspections and testing

- Inspections and testing are complementary and not opposing verification techniques.
- Both should be used during the V & V process.
- Inspections can check conformance with a specification but not conformance with the customer's real requirements.
- Inspections cannot check non-functional characteristics such as performance, usability, etc.

A model of the software testing process

Figure 8.3 is an abstract model of the traditional testing process, as used in plan driven development.





Test cases are specifications of the inputs to the test and the expected output from the system (the test results), plus a statement of what is being tested.

Test data are the **inputs** that have been devised to test a system.

Test data can sometimes be generated automatically, but automatic test case generation is impossible.

Stages of testing

- Typically, a commercial software system has to go through three stages of testing:

- **Development testing**, where the system is tested during development to discover bugs and defects.
- **Release testing**, where a separate testing team test a complete version of the system before it is released to users.
- **User testing**, where users or potential users of a system test the system in their own environment.

Development testing

Development testing

- Development testing includes all testing activities that are carried out by the team developing the system.
  - **Unit testing**, where individual program units or object classes are tested. **Unit testing should focus on testing the functionality of objects or methods.**
  - **Component testing**, where several individual units are integrated to create composite components. **Component testing should focus on testing component interfaces**.
  - **System testing**, where some or all of the components in a system are integrated and the system is tested as a whole. **System testing should focus on testing component interactions**.

Unit testing

✧ Unit testing is the process of testing individual components in isolation.

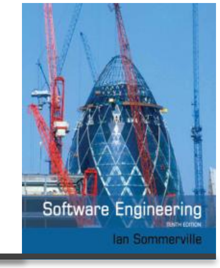
✧ It is a defect testing process.

✧ Units 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.

Object class testing

- Complete test coverage of a class involves
  - Testing all operations associated with an object
  - Setting and interrogating all object attributes
  - Exercising the object in all possible states.
- Inheritance makes it more difficult to design object class tests as the information to be tested is not localised.



The weather station object interface

Consider, for example, the weather station object

WeatherStation
identifier
reportWeather ( ) reportStatus ( ) powerSave (instruments) remoteControl (commands) reconfigure (commands) restart (instruments) shutdown (instruments)

Weather station testing

It has a single attribute, which is its identifier. This is a constant that is set when the weather station is installed. You therefore only need a test that checks if it has been properly set up. You need to define test cases for all of the methods associated with the object such as reportWeather and reportStatus. Ideally, you should test methods in isolation, but, in some cases, test sequences are necessary. For example, to test the method that shuts down the weather station instruments (shutdown), you need to have executed the restart method.

Weather station testing

- Need to define test cases for reportWeather, shutdown, ..
- Using a state model, identify sequences of state transitions to be tested and the event sequences to cause these transitions
- For example:
  - Shutdown -> Running-> Shutdown
  - Configuring-> Running-> Testing -> Transmitting -> Running
  - Running-> Collecting-> Running-> Summarizing -> Transmitting -> Running

Automated testing

- ✧ Whenever possible, unit testing should be automated so that tests are run and checked without manual intervention.
- ✧ In automated unit testing, you make use of a test automation framework (such as **JUnit**) to write and run your program tests.
- ✧ Unit testing frameworks provide generic test classes that you extend to create specific test cases.
- ✧ They can then run all of the tests that you have implemented and report, often through some GUI, on the success of otherwise of the tests.

Automated test components

- **A setup part**, where you initialize the system with **the test case**, namely **the inputs** and **expected outputs**.
- **A call part,** where you call the object or method to be tested.
- **An assertion part** where you compare the result of the call with the expected result. If the assertion evaluates to true, the test has been successful if false, then it has failed.

Choosing unit test cases

- The test cases should show that, when used as expected, the component that you are testing does what it is supposed to do.
- If there are defects in the component, these should be revealed by test cases.
- This leads to **2 types of unit test case:**
  - The first of these should **reflect normal operation** of a program and should show that the component works as expected.
  - The other kind of test case should be **based on testing experience of where common problems arise**. It should **use abnormal inputs to check that these are properly processed and do not crash the component**.

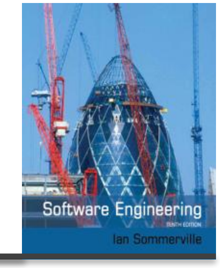
Testing strategies

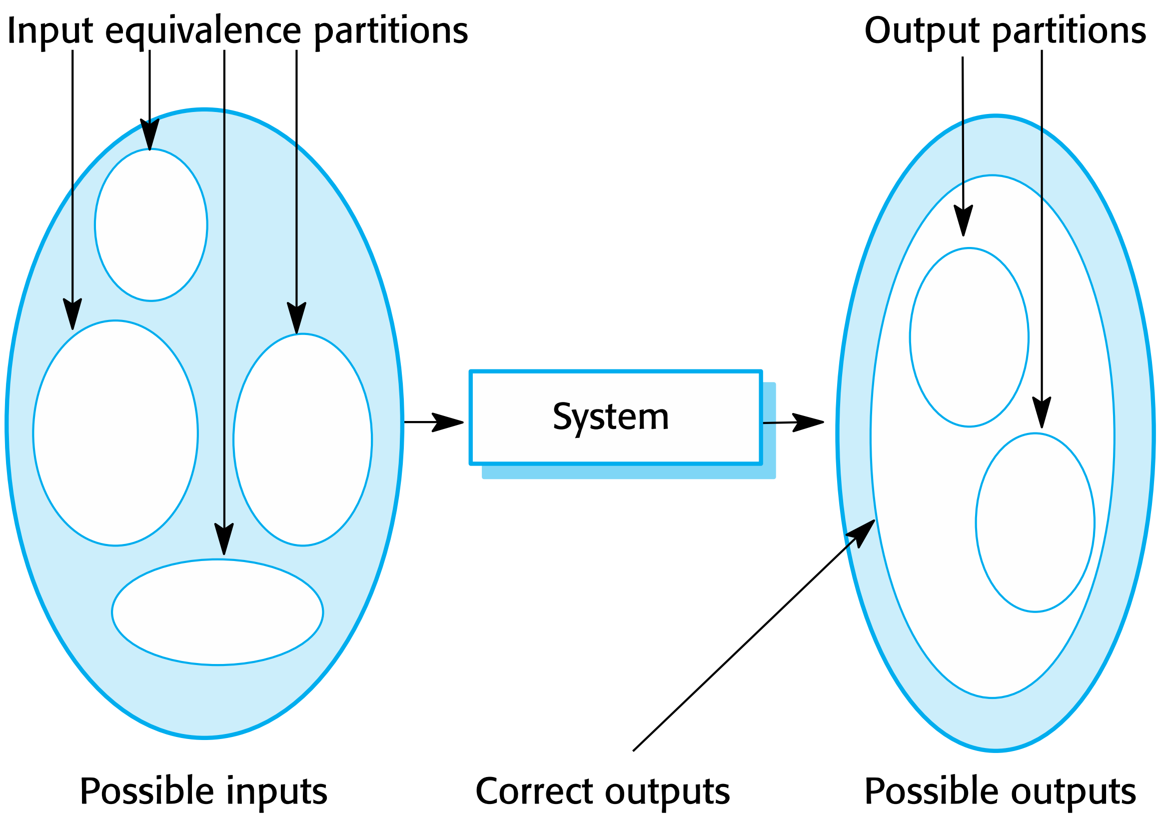
- **<u>Partition testing</u>**, where you **<u>identify groups of inputs</u>** that have common characteristics and should be processed in the same way.
  - You should choose tests from within each of these groups.
- **<u>Guideline-based testing</u>**, where you use testing guidelines to choose test cases.
  - These guidelines reflect previous experience of the kinds of errors that programmers often make when developing components.

Partition testing

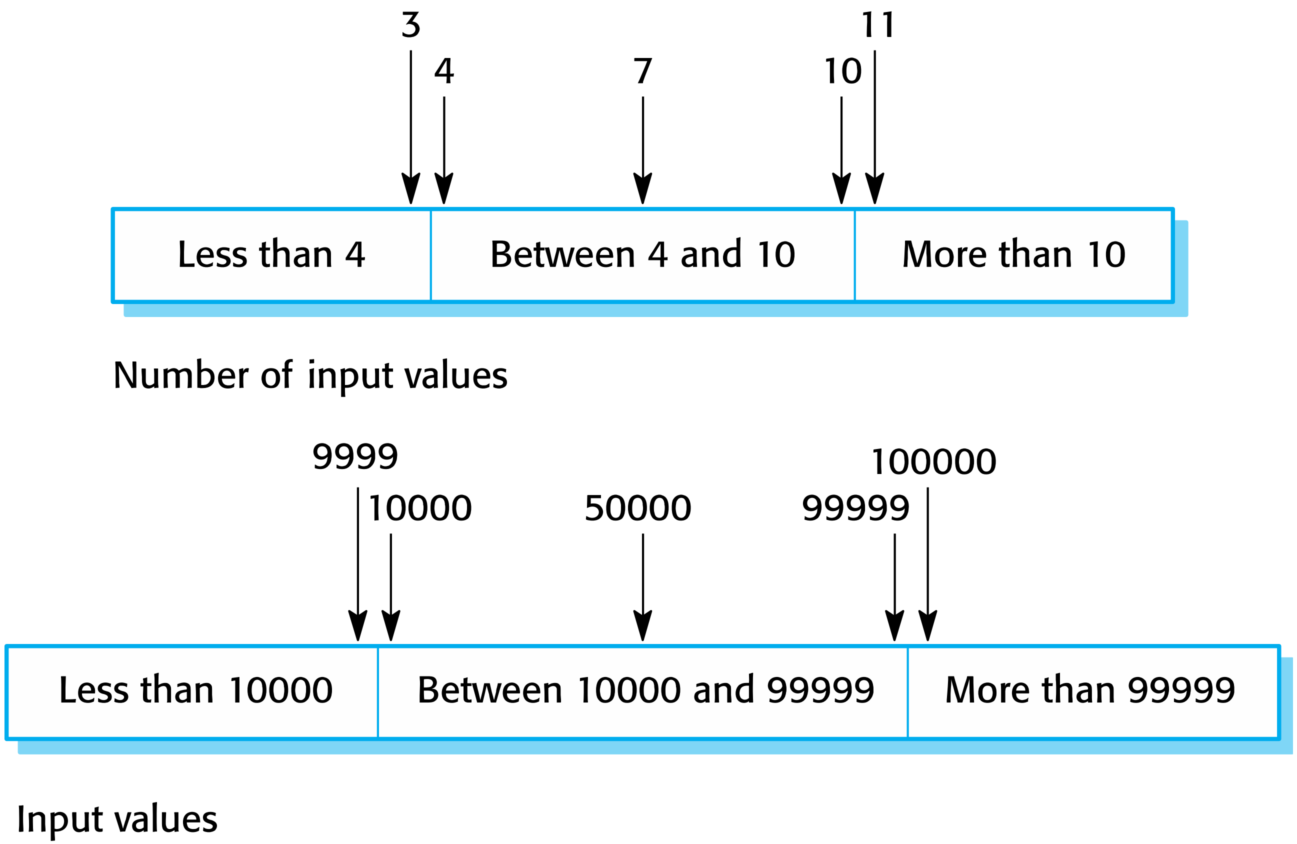
- Input data and output results often fall into different classes where all members of a class are related.
- Each of these classes is an equivalence partition or domain where the program behaves in an equivalent way for each class member.
- Test cases should be chosen from each partition.

Equivalence partitioning





Equivalence partitions



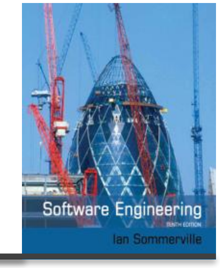
Testing guidelines (sequences)

- Test software with sequences which **have only a single value.**
- Use sequences of **different sizes** in different tests.
- Derive tests so that **the first, middle and last elements** of the sequence are accessed.
- Test with sequences of **zero length.**

General testing guidelines

- ✧ Choose inputs that force the system to generate all error messages
- ✧ Design inputs that cause input buffers to overflow
- ✧ Repeat the same input or series of inputs numerous times
- ✧ Force invalid outputs to be generated
- ✧ Force computation results to be too large or too small.

Component testing



- ✧ Software components are often composite components that are made up of several interacting objects.
  - For example, in the weather station system, the reconfiguration component includes objects that deal with each aspect of the reconfiguration.
- ✧ You access the functionality of these objects through the defined component interface.
- ✧ Testing composite components should therefore focus on showing that the component interface behaves according to its specification.
  - You can assume that **<u>unit tests on the individual objects within the component have been completed.</u>**

Interface testing

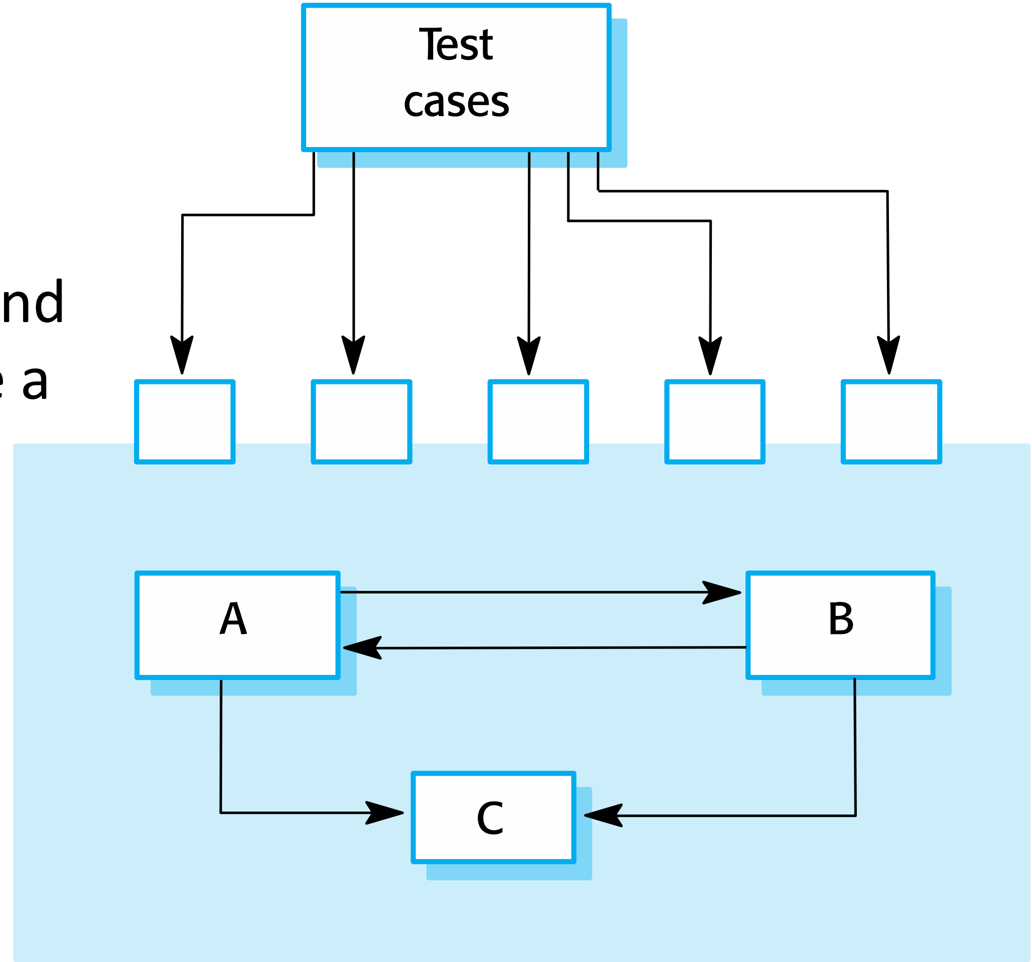
- Objectives are to detect faults due to interface errors or invalid assumptions about interfaces.
- Interface types
  - Parameter interfaces Data passed from one method or procedure to another.
  - Shared memory interfaces Block of memory is shared between procedures or functions.
  - Procedural interfaces Sub-system encapsulates a set of procedures to be called by other sub-systems.
  - Message passing interfaces Sub-systems request services from other sub-systems

Interface testing

Figure 8.7 illustrates the idea of component interface testing.

Assume that components A, B, and C have been integrated to create a larger component or subsystem.

The test cases are not applied to the individual components **but rather to the interface of the composite component** created by combining these components.



Interface errors

- ✧ Interface misuse
  - A calling component calls another component and makes an error in its use of its interface e.g. parameters in the wrong order.
- ✧ Interface misunderstanding
  - A calling component embeds assumptions about the behaviour of the called component which are incorrect.
- ✧ Timing errors
  - The called and the calling component operate at different speeds and out-of-date information is accessed.

Interface testing guidelines

- ✧ Design tests so that parameters to a called procedure are at the extreme ends of their ranges.
- ✧ Always test pointer parameters with null pointers.
- ✧ Design tests which cause the component to fail.
- ✧ Use stress testing in message passing systems.
- ✧ In shared memory systems, vary the order in which components are activated.