Software Engineering (2)
Contents

Software Testing

Program testing goals

- To **demonstrate to the developer and the customer that the software meets its requirements.**
- To discover situations in which the **behavior of the software is incorrect, undesirable or does not conform to its specification.**

Validation and defect testing

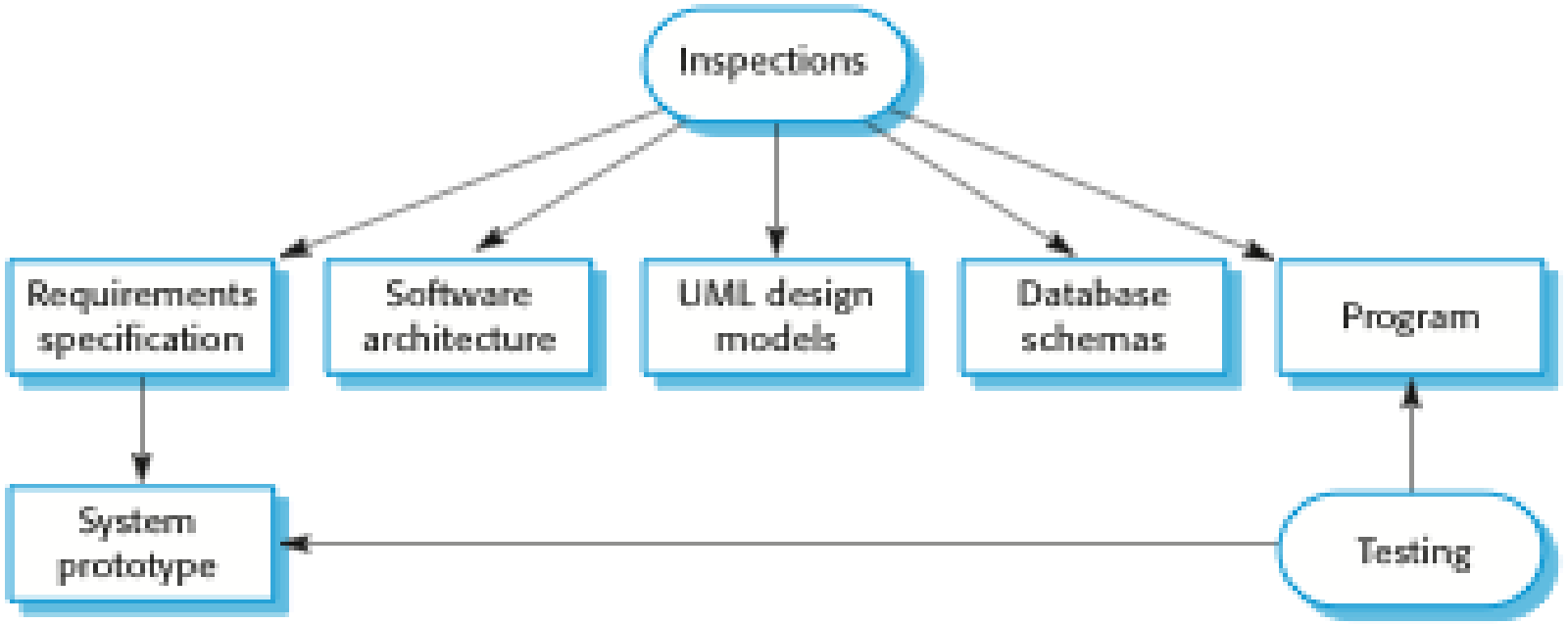
- The first goal leads to **validation testing**
  - You expect the system to perform correctly using a given set of test cases that reflect the system's expected use.
- The second goal leads to **defect testing**
  - The test cases are designed to expose defects. The test cases in defect testing can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

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.

Inspections and testing

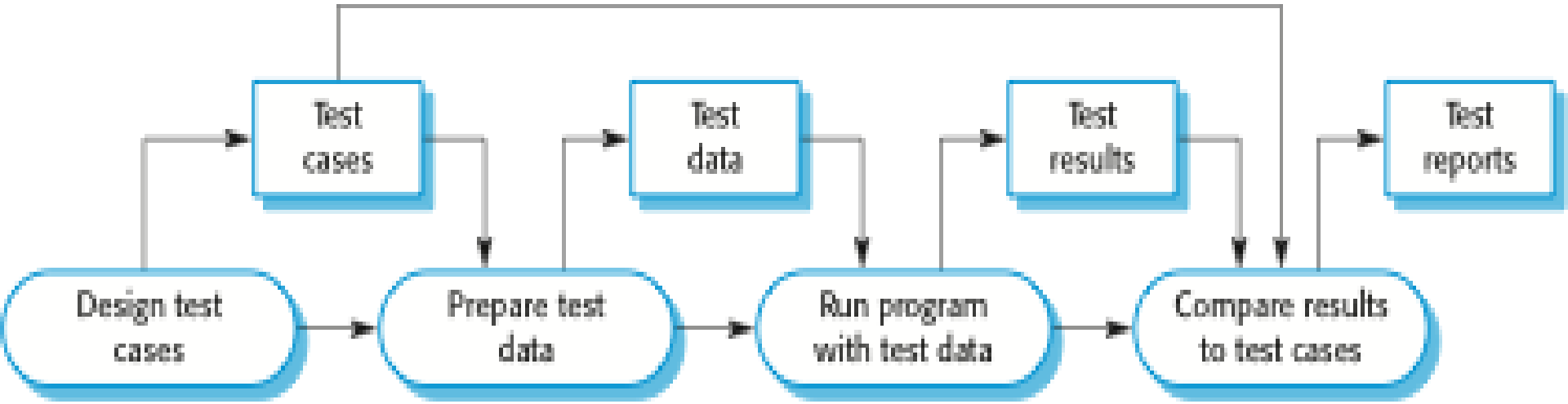
- **Software inspections** Concerned with **analysis of the static system representation** to discover problems **(static verification)**
- **Software testing** Concerned with exercising and **observing product behaviour (dynamic verification)**
  - The system is executed with test data and its operational behaviour is observed.



Inspections and testing

- Inspections 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



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.**

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 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.

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 or 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.

Unit test effectiveness

- 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.

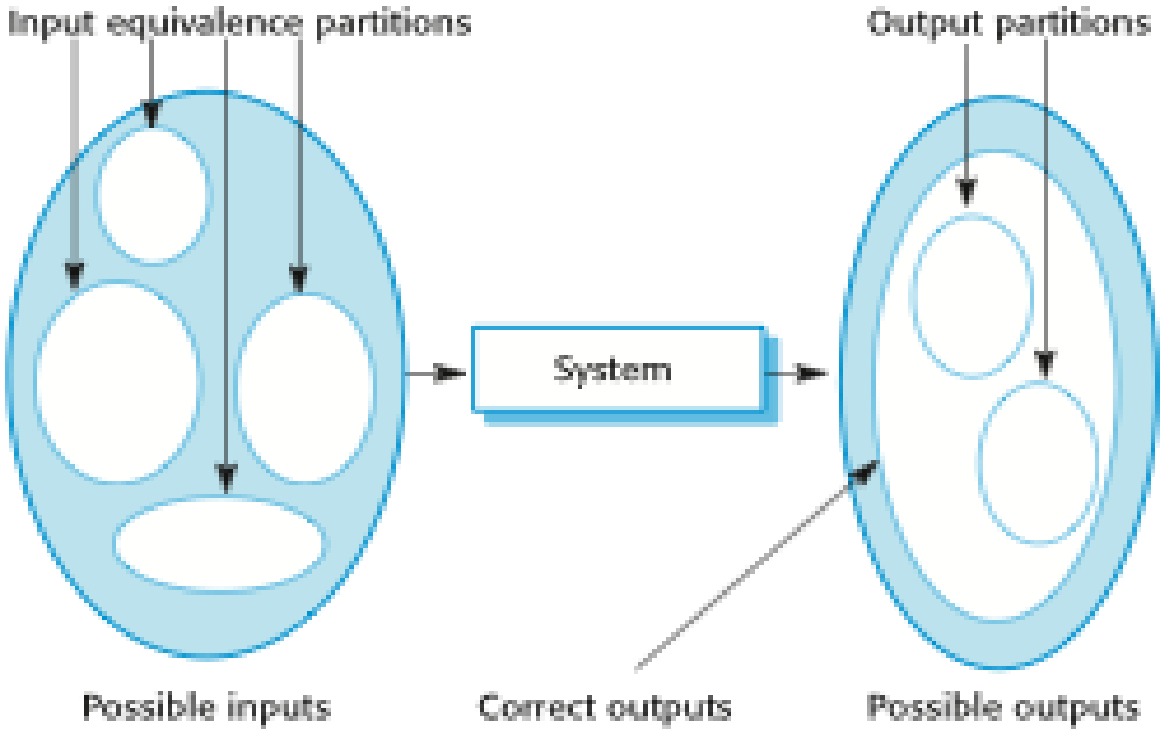
Testing strategies

- **Partition testing**, where you **identify groups of inputs that have common characteristics and should be processed in the same way.**
  - You should **choose tests from within each of these groups.**
- **Guideline-based testing**, 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.

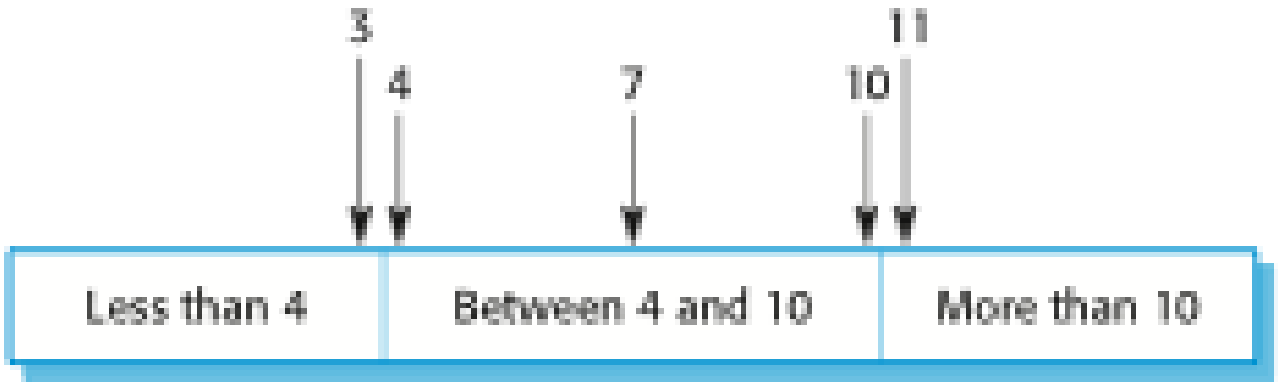
Partition testing

- 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**.

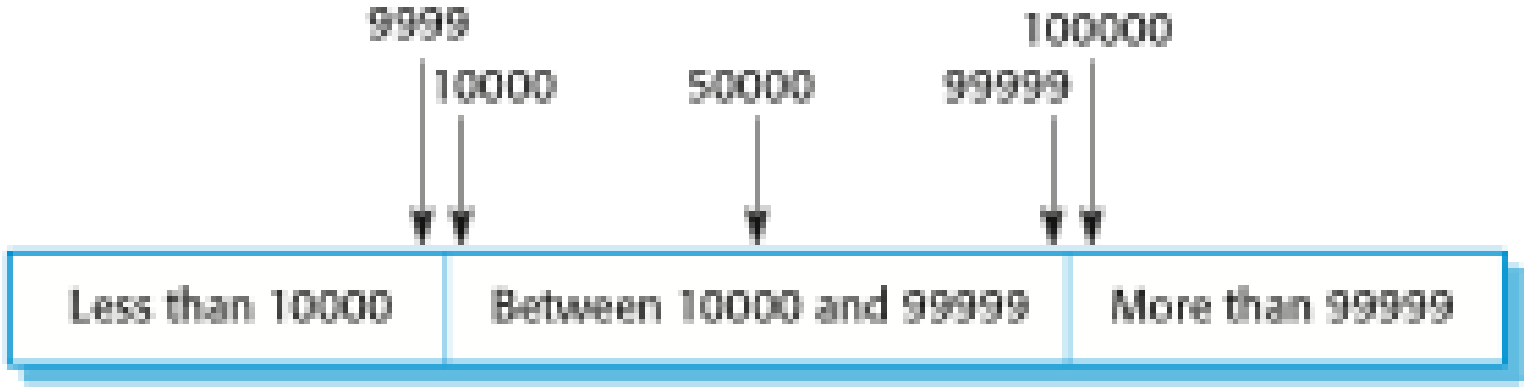
Equivalence partitioning



Equivalence partitions



Number of input values



Input values

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 unit tests on the individual objects within the component have been completed.

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 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.

System testing

- System testing **during development** involves **integrating components to create a version of the system** and then **testing the integrated system.**
- The focus in system testing is **testing the interactions between components**.
- System testing **checks that components are compatible, interact correctly and transfer the right data at the right time across their interfaces.**
- System testing **tests the emergent behavior of a system.**

System and component testing

- During system testing, **reusable components** that have been separately developed **and off-the-shelf systems may be integrated with newly developed components**. **The complete system is then tested**.
- **Components developed by different team members or sub-teams may be integrated at this stage**. System testing is a collective rather than an individual process.
  - In some companies, **system testing may involve a separate testing team with no involvement from designers and programmers.**

Use-case testing

- **The use-cases developed to identify system interactions can be used as a basis for system testing.**
- **Each use case usually involves several system components** so testing the use case forces these interactions to occur.
- **The sequence diagrams associated with the use case documents the components and interactions** that are being tested.

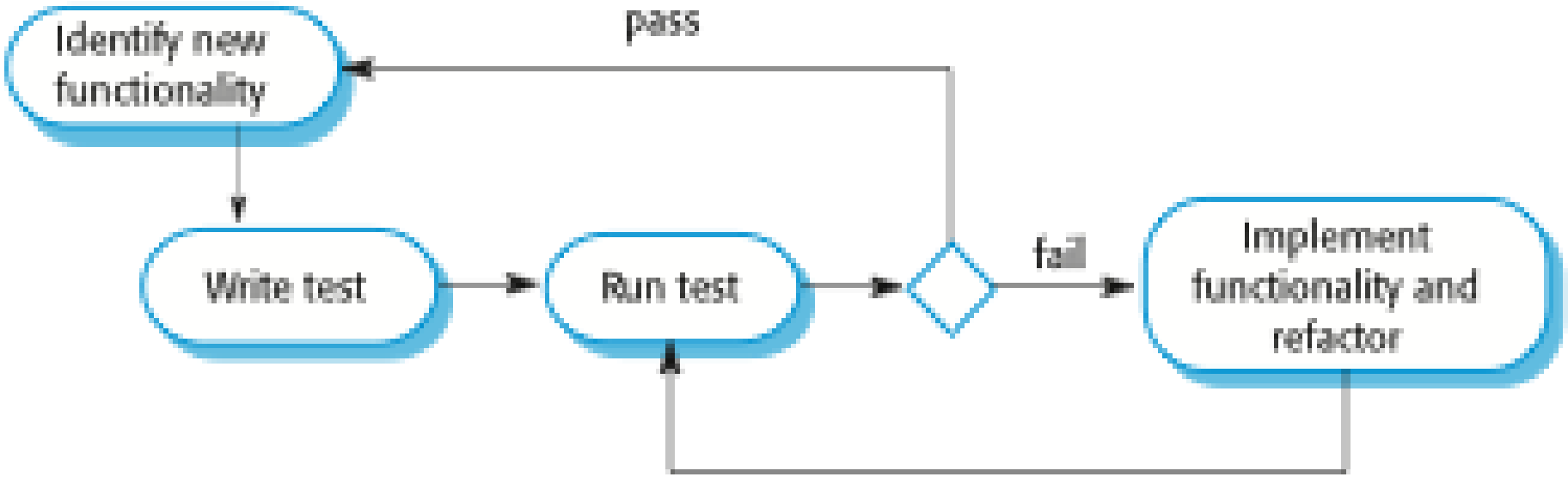
Testing policies

- **Exhaustive system testing is impossible so testing policies which define the required system test coverage may be developed**.
- Examples of testing policies:
  - **All system functions that are accessed through menus should be tested**.
  - **Combinations of functions** (e.g**. text formatting**) **that are accessed through the same menu must be tested**.
  - **Where user input is provided, all functions must be tested with both correct and incorrect input**.

Test-driven development

- Test-driven development **(TDD) is an approach to program development in which you inter-leave testing and code development**.
- **Tests are written before code** and ‘passing’ the tests is the critical driver of development.
- **You develop code incrementally, along with a test for that increment. You don’t move on to the next increment until the code that you have developed passes its test.**
- TDD was introduced as **part of agile methods such as Extreme Programming**. However, it can also be used in plan-driven development processes.

Test-driven development



Benefits of test-driven development

- **Code coverage**
  - **Every code segment** that you write **has at least one associated test** so all code written has at least one test.
- **Regression testing**
  - A regression test suite is **developed incrementally as a program is developed.**
- **Simplified debugging**
  - **When a test fails, it should be obvious where the problem lies. The newly written code needs to be checked and modified.**
- **System documentation**
  - **The tests themselves are a form of documentation** that describe what the code should be doing.

Regression testing

- Regression testing is **testing the system to check that changes have not 'broken' previously working code**.
- In a manual testing process, regression testing is expensive but, **with automated testing**, it is simple and straightforward. **All tests are rerun every time a change is made to the program.**
- **Tests must run 'successfully' before the change is committed.**

Release testing

- **Release testing** is the process of **testing a particular release of a system** that is **intended for use outside of the development team.**
- The **primary goal** of the release testing process is **to convince the supplier of the system that it is good enough for use.**
  - Release testing, therefore, has to show that the system delivers its specified functionality, performance and dependability, and that it does not fail during normal use.
- **Release testing is usually a black-box testing process where tests are only derived from the system specification.**

Release testing and system testing

- ✧ **Release testing** is a **form of system testing**.
- ✧ Important differences:
  - **A separate team that has not been involved in the system development, should be responsible for release testing.**
  - **System testing by the development team should focus on discovering bugs in the system (defect testing).**
  - The **objective of release testing is to check that the system meets its requirements and is good enough for external use (validation testing).**

Requirements based testing

- Requirements-based testing involves **examining each requirement and developing a test or tests for it**.
- **MHC-PMS requirements**:
  - If a patient is known to be allergic to any particular medication, then prescription of that medication shall result in a warning message being issued to the system user.
  - If a prescriber chooses to ignore an allergy warning, they shall provide a reason why this has been ignored.

Performance testing

- **Part of release testing may involve testing the emergent properties of a system, such as performance and reliability.**
- Tests should reflect the profile of use of the system.
- **Performance tests usually involve planning a series of tests where the load is steadily increased until the system performance becomes unacceptable**.
- **Stress testing is a form of performance testing where the system is deliberately overloaded to test its failure behavior.**

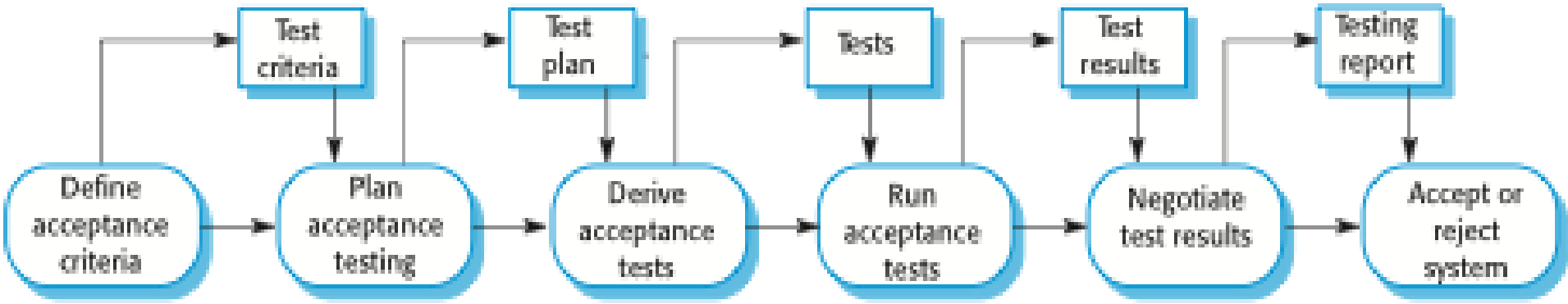
User testing

- User or customer testing is a stage in the testing process in which users or customers provide input and advice on system testing.
- User testing is essential, even when comprehensive system and release testing have been carried out.
  - The reason for this is that influences from the user's working environment have a major effect on the reliability, performance, usability and robustness of a system. These cannot be replicated in a testing environment.

Types of user testing

- **Alpha testing**
  - **Users** of the software work **with the development team** to **test the software at the developer's site.**
- **Beta testing**
  - A **release of the software is made available to users to allow them to experiment and to raise problems** that they discover with the system developers.
- **Acceptance testing**
  - **Customers test a system to decide whether or not it is ready to be accepted from the system developers and deployed in the customer environment.** Primarily for custom systems.

The acceptance testing process



Agile methods and acceptance testing

- In **agile** methods, the **user/customer is part of the development team** and is responsible for making decisions on the acceptability of the system.
- **Tests are defined by the user/customer** and are integrated with other tests in that **they are run automatically when changes are made**.
- **There is no separate acceptance testing process**.
- **Main problem** here is **whether or not the embedded user is 'typical' and can represent the interests of all system stakeholders.**