

Project Management

Objectives

- To introduce software project management and to describe its distinctive characteristics
- To discuss project planning and the planning process
- To show how graphical schedule representations are used by project management
- To discuss the notion of risks and the risk management process

Topics covered

- Management activities
- Project planning
- Project scheduling
- Risk management

Software project management

- Concerned with activities involved in ensuring that software is delivered on time and on schedule and in accordance with the requirements of the organisations developing and procuring the software
- Project management is needed because software development is always subject to budget and schedule constraints that are set by the organisation developing the software

Software management distinctions

- The product is intangible
- The product is uniquely flexible
- Software engineering is not recognized as an engineering discipline with the same status as mechanical, electrical engineering, etc.
- The software development process is not standardised
- Many software projects are 'one-off' projects

Management activities

- Proposal writing
- Project planning and scheduling
- Project costing
- Project monitoring and reviews
- Personnel selection and evaluation
- Report writing and presentations

Management commonalities

- These activities are not peculiar to software management
- Many techniques of engineering project management are equally applicable to software project management
- Technically complex engineering systems tend to suffer from the same problems as software systems

Project staffing

- May not be possible to appoint the ideal people to work on a project
 - Project budget may not allow for the use of highly-paid staff
 - Staff with the appropriate experience may not be available
 - An organisation may wish to develop employee skills on a software project
- Managers have to work within these constraints especially when (as is currently the case) there is an international shortage of skilled IT staff

Project planning

- Probably the most time-consuming project management activity
- Continuous activity from initial concept through to system delivery. Plans must be regularly revised as new information becomes available
- Various different types of plan may be developed to support the main software project plan that is concerned with schedule and budget

Types of project plan

Plan	Description
Quality plan	Describes the quality procedures and standards that will be used in a project.
Validation plan	Describes the approach, resources and schedule used for system validation.
Configuration management plan	Describes the configuration management procedures and structures to be used.
Maintenance plan	Predicts the maintenance requirements of the system, maintenance costs and effort required.
Staff development plan.	Describes how the skills and experience of the project team members will be developed.

Project planning process

```
Establish the project constraints
Make initial assessments of the project parameters
Define project milestones and deliverables
while project has not been completed or cancelled do
    Draw up project schedule
    Initiate activities according to schedule
    Wait ( for a while )
    Review project progress
    Revise estimates of project parameters
    Update the project schedule
    Re-negotiate project constraints and deliverables
    if ( problems arise ) then
        Initiate technical review and possible revision
    end if
end loop
```

Project plan structure

- Introduction
- Project organisation
- Risk analysis
- Hardware and software resource requirements
- Work breakdown
- Project schedule
- Monitoring and reporting mechanisms

Activity organization

- Activities in a project should be organised to produce tangible outputs for management to judge progress
- *Milestones* are the end-point of a process activity
- *Deliverables* are project results delivered to customers
- The waterfall process allows for the straightforward definition of progress milestones

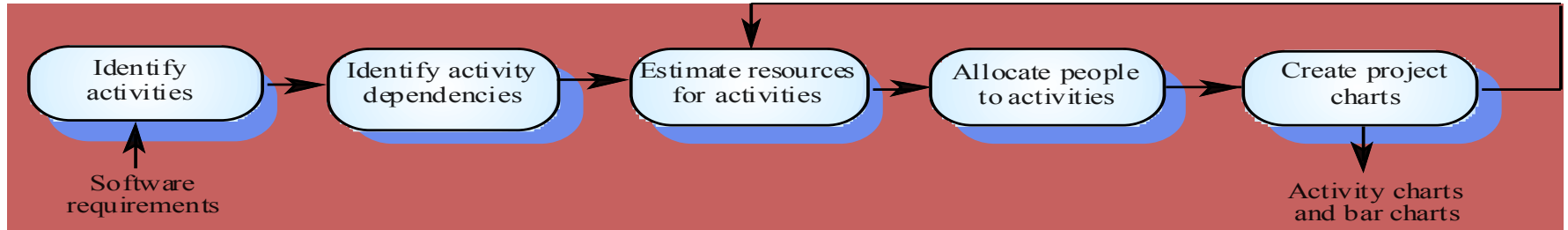
Milestones in the RE process



Project scheduling

- Split project into tasks and estimate time and resources required to complete each task
- Organize tasks concurrently to make optimal use of workforce
- Minimize task dependencies to avoid delays caused by one task waiting for another to complete
- Dependent on project managers intuition and experience

The project scheduling process



Scheduling problems

- Estimating the difficulty of problems and hence the cost of developing a solution is hard
- Productivity is not proportional to the number of people working on a task
- Adding people to a late project makes it later because of communication overheads
- The unexpected always happens. Always allow contingency in planning

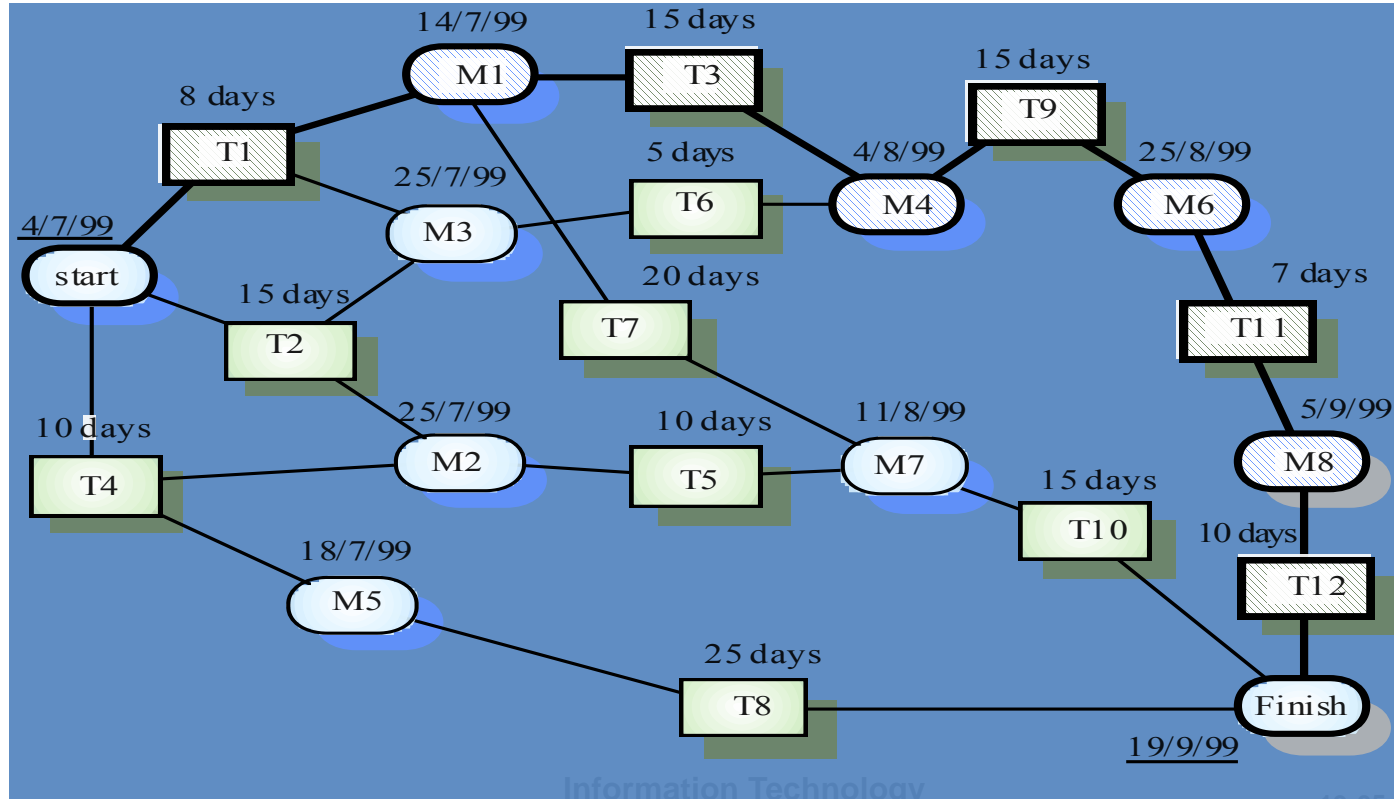
Bar charts and activity networks

- Graphical notations used to illustrate the project schedule
- Show project breakdown into tasks. Tasks should not be too small. They should take about a week or two
- Activity charts show task dependencies and the critical path
- Bar charts show schedule against calendar time

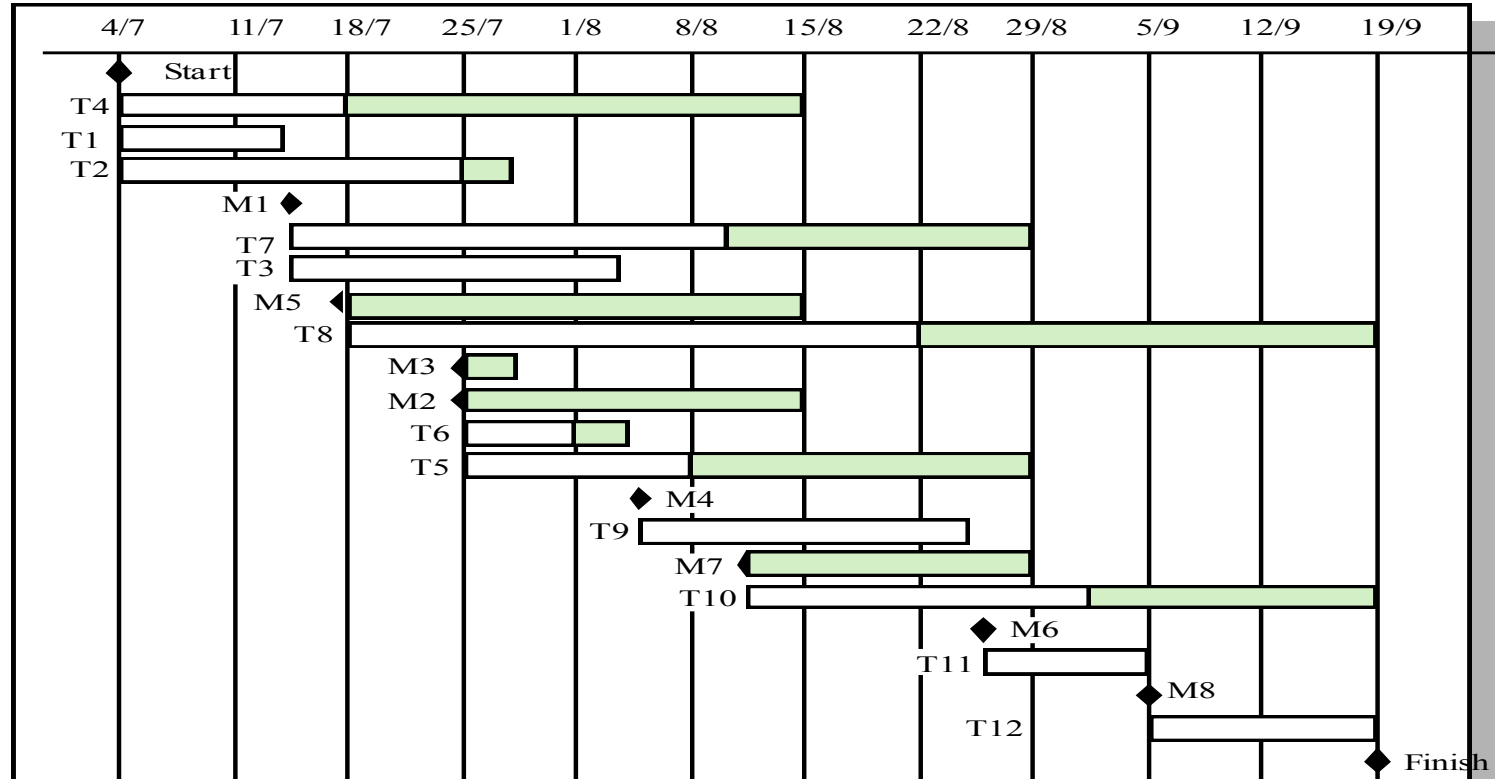
Task durations and dependencies

Task	Duration (days)	Dependencies
T1	8	
T2	15	
T3	15	T1 (M1)
T4	10	
T5	10	T2, T4 (M2)
T6	5	T1, T2 (M3)
T7	20	T1 (M1)
T8	25	T4 (M5)
T9	15	T3, T6 (M4)
T10	15	T5, T7 (M7)
T11	7	T9 (M6)
T12	10	T11 (M8)

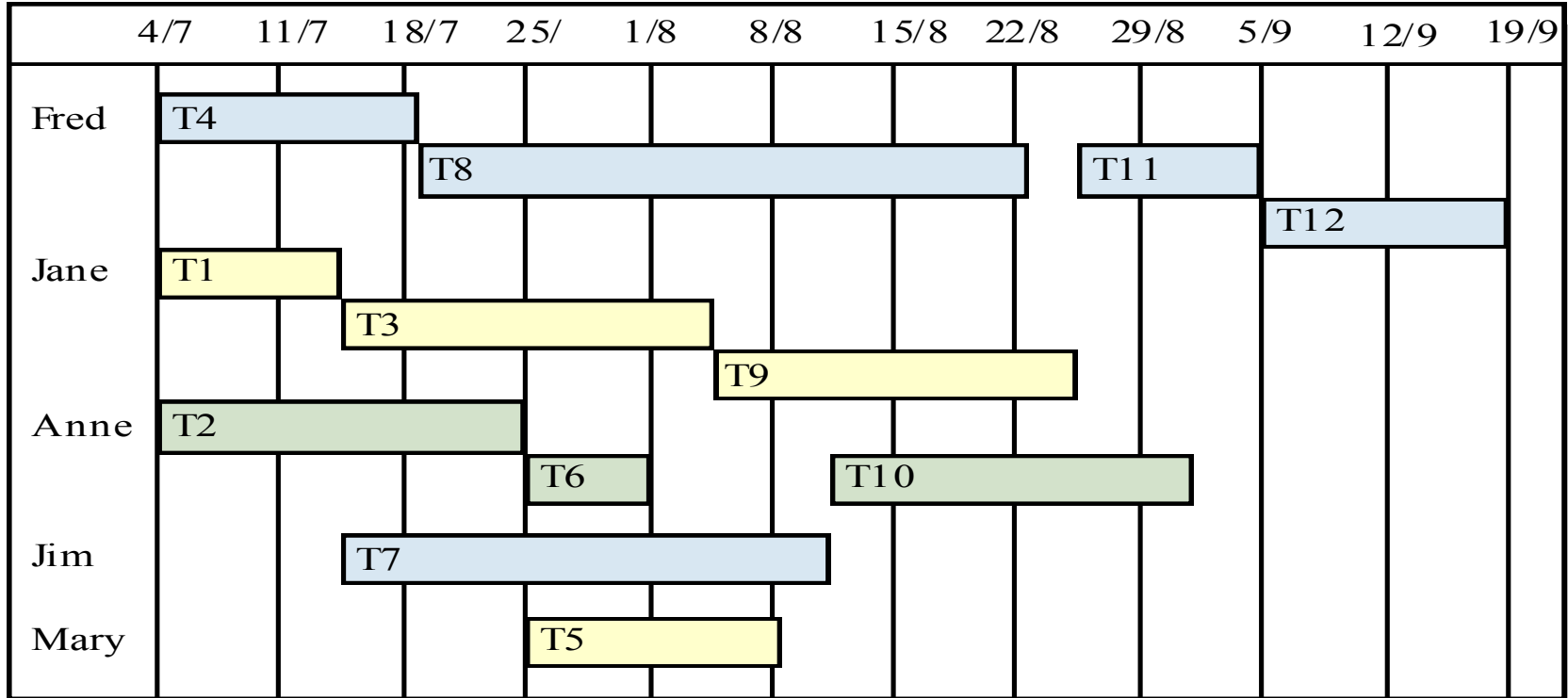
Activity network



Activity timeline



Staff allocation



Risk management

- Risk management is concerned with identifying risks and drawing up plans to minimise their effect on a project.
- A risk is a probability that some adverse circumstance will occur.
 - Project risks affect schedule or resources
 - Product risks affect the quality or performance of the software being developed
 - Business risks affect the organisation developing or procuring the software

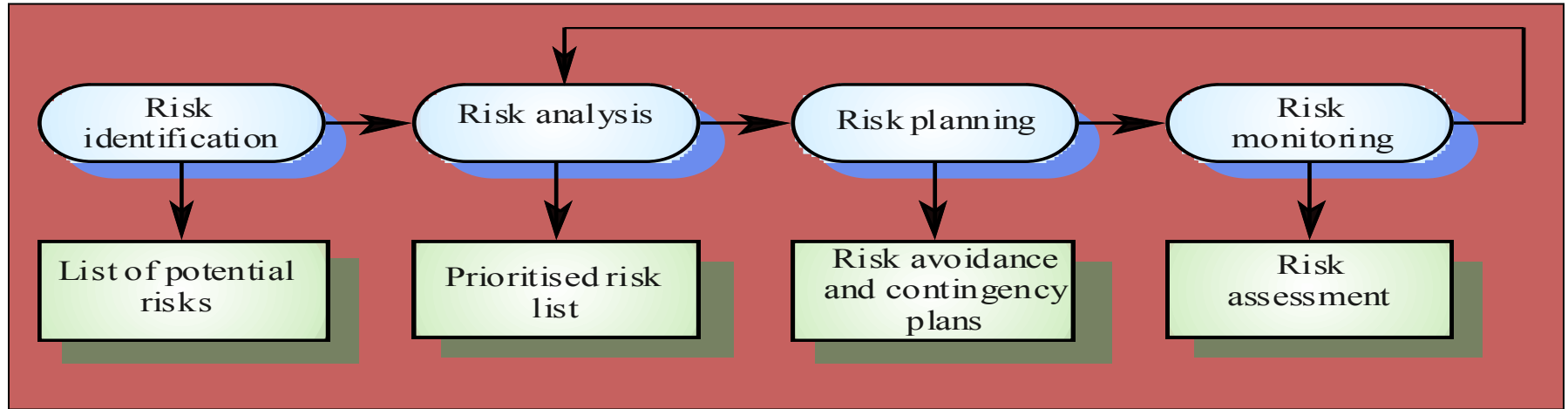
Software risks

Risk	Risk type	Description
Staff turnover	Project	Experienced staff will leave the project before it is finished.
Management change	Project	There will be a change of organisational management with different priorities.
Hardware unavailability	Project	Hardware which is essential for the project will not be delivered on schedule.
Requirements change	Project and product	There will be a larger number of changes to the requirements than anticipated.
Specification delays	Project and product	Specifications of essential interfaces are not available on schedule
Size underestimate	Project and product	The size of the system has been underestimated.
CASE tool under-performance	Product	CASE tools which support the project do not perform as anticipated
Technology change	Business	The underlying technology on which the system is built is superseded by new technology.
Product competition	Business	A competitive product is marketed before the system is completed.

The risk management process

- Risk identification
 - Identify project, product and business risks
- Risk analysis
 - Assess the likelihood and consequences of these risks
- Risk planning
 - Draw up plans to avoid or minimise the effects of the risk
- Risk monitoring
 - Monitor the risks throughout the project

The risk management process



Risk identification

- Technology risks
- People risks
- Organisational risks
- Requirements risks
- Estimation risks

Risks and risk types

Risk type	Possible risks
Technology	The database used in the system cannot process as many transactions per second as expected. Software components which should be reused contain defects which limit their functionality.
People	It is impossible to recruit staff with the skills required. Key staff are ill and unavailable at critical times. Required training for staff is not available.
Organisational	The organisation is restructured so that different management are responsible for the project. Organisational financial problems force reductions in the project budget.
Tools	The code generated by CASE tools is inefficient. CASE tools cannot be integrated.
Requirements	Changes to requirements which require major design rework are proposed. Customers fail to understand the impact of requirements changes.
Estimation	The time required to develop the software is underestimated. The rate of defect repair is underestimated. The size of the software is underestimated.

Risk analysis

- Assess probability and seriousness of each risk
- Probability may be very low, low, moderate, high or very high
- Risk effects might be catastrophic, serious, tolerable or insignificant

Risk analysis

Risk	Probability	Effects
Organisational financial problems force reductions in the project budget.	Low	Catastrophic
It is impossible to recruit staff with the skills required for the project.	High	Catastrophic
Key staff are ill at critical times in the project.	Moderate	Serious
Software components which should be reused contain defects which limit their functionality.	Moderate	Serious
Changes to requirements which require major design rework are proposed.	Moderate	Serious
The organisation is restructured so that different management are responsible for the project.	High	Serious
The database used in the system cannot process as many transactions per second as expected.	Moderate	Serious
The time required to develop the software is underestimated.	High	Serious
CASE tools cannot be integrated.	High	Tolerable
Customers fail to understand the impact of requirements changes.	Moderate	Tolerable
Required training for staff is not available.	Moderate	Tolerable
The rate of defect repair is underestimated.	Moderate	Tolerable
The size of the software is underestimated.	High	Tolerable
The code generated by CASE tools is inefficient.	Moderate	Insignificant

Risk planning

- Consider each risk and develop a strategy to manage that risk
- Avoidance strategies
 - The probability that the risk will arise is reduced
- Minimisation strategies
 - The impact of the risk on the project or product will be reduced
- Contingency plans
 - If the risk arises, contingency plans are plans to deal with that risk

Risk management strategies

Risk	Strategy
Organisational financial problems	Prepare a briefing document for senior management showing how the project is making a very important contribution to the goals of the business.
Recruitment problems	Alert customer of potential difficulties and the possibility of delays, investigate buying-in components.
Staff illness	Reorganise team so that there is more overlap of work and people therefore understand each other's jobs.
Defective components	Replace potentially defective components with bought-in components of known reliability.
Requirements changes	Derive traceability information to assess requirements change impact, maximise information hiding in the design.
Organisational restructuring	Prepare a briefing document for senior management showing how the project is making a very important contribution to the goals of the business.
Database performance	Investigate the possibility of buying a higher-performance database.
Underestimated development time	Investigate buying in components, investigate use of a program generator.

Risk monitoring

- Assess each identified risks regularly to decide whether or not it is becoming less or more probable
- Also assess whether the effects of the risk have changed
- Each key risk should be discussed at management progress meetings

Risk factors

Risk type	Potential indicators
Technology	Late delivery of hardware or support software, many reported technology problems
People	Poor staff morale, poor relationships amongst team member, job availability
Organisational	organisational gossip, lack of action by senior management
Tools	reluctance by team members to use tools, complaints about CASE tools, demands for higher-powered workstations
Requirements	many requirements change requests, customer complaints
Estimation	failure to meet agreed schedule, failure to clear reported defects

Key points

- Good project management is essential for project success
- The intangible nature of software causes problems for management
- Managers have diverse roles but their most significant activities are planning, estimating and scheduling
- Planning and estimating are iterative processes which continue throughout the course of a project

Key points

- A project milestone is a predictable state where some formal report of progress is presented to management.
- Risks may be project risks, product risks or business risks
- Risk management is concerned with identifying risks which may affect the project and planning to ensure that these risks do not develop into major threats

Software testing

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
- To understand the essential characteristics of tool used for test automation

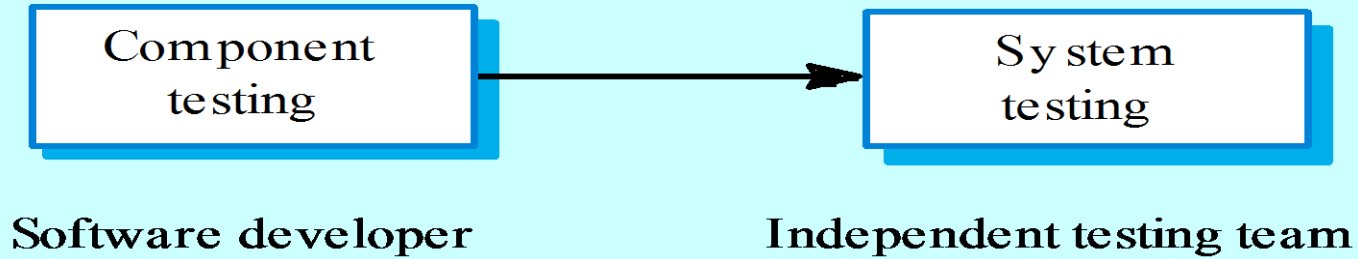
Topics covered

- System testing
- Component testing
- Test case design
- Test automation

The testing process

- Component testing
 - Testing of individual program components;
 - Usually the responsibility of the component developer (except sometimes for critical systems);
 - Tests are derived from the developer's experience.
- System 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.

Testing phases



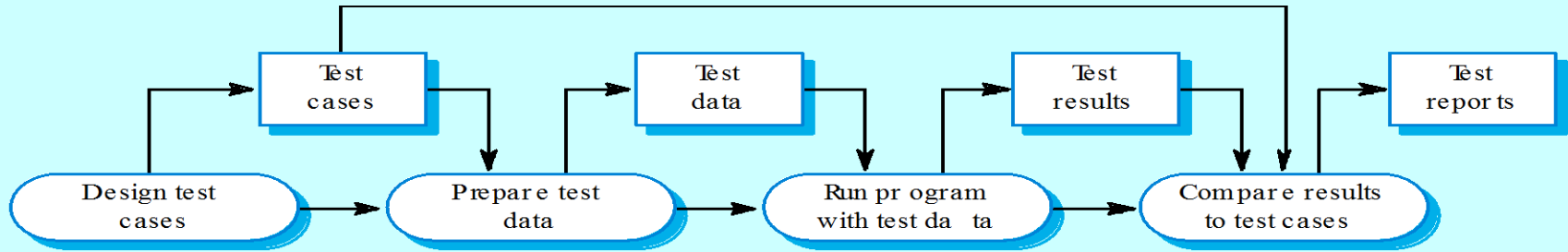
Defect testing

- 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 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.

The software testing process



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.

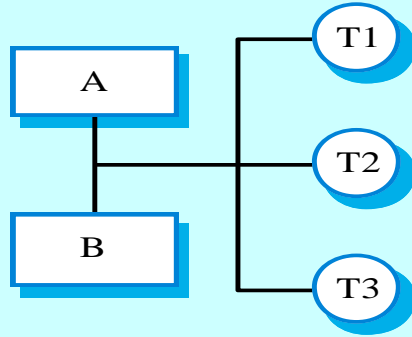
System testing

- 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.

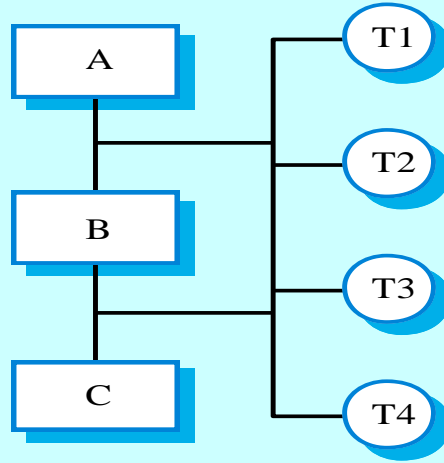
Integration testing

- Involves building a system from its components and testing it for problems that arise from component interactions.
- Top-down integration
 - Develop the skeleton of the system and populate it with components.
- Bottom-up integration
 - Integrate infrastructure components then add functional components.
- To simplify error localisation, systems should be incrementally integrated.

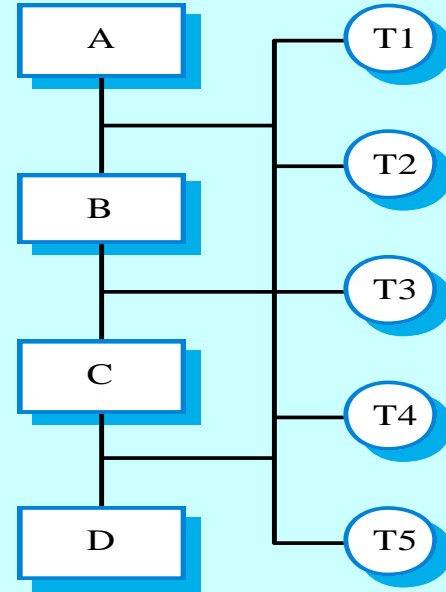
Incremental integration testing



Testsequence 1



Testsequence 2



Testsequence 3

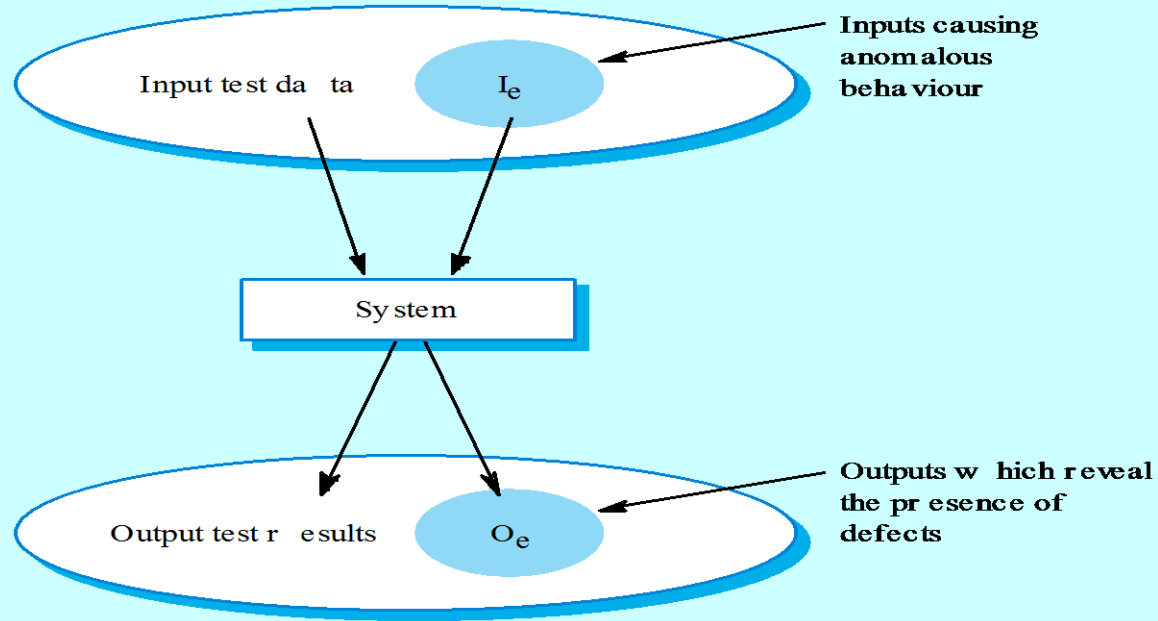
Testing approaches

- 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.
- Test observation
 - Problems with both approaches. Extra code may be required to observe tests.

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



Testing guidelines

- Testing guidelines are hints for the testing team to help them choose tests that will reveal defects in the system
 - Choose inputs that force the system to generate all error messages;
 - Design inputs that cause buffers to overflow;
 - Repeat the same input or input series several times;
 - Force invalid outputs to be generated;
 - Force computation results to be too large or too small.

Testing scenario

A student in Scotland is studying American History and has been asked to write a paper on Frontier mentality in the American West from 1840 to 1880. To do this, she needs to find sources from a range of libraries. She logs on to the LIBSYS system and uses the search facility to discover if she can access original documents from that time. She discovers sources in various US university libraries and downloads copies of some of these. However, for one document, she needs to have confirmation from her university that she is a genuine student and that use is for non-commercial purposes. The student then uses the facility in LIBSYS that can request such permission and registers her request. If granted, the document will be downloaded to the registered library's server and printed for her. She receives a message from LIBSYS telling her that she will receive an e-mail message when the printed document is available for collection.

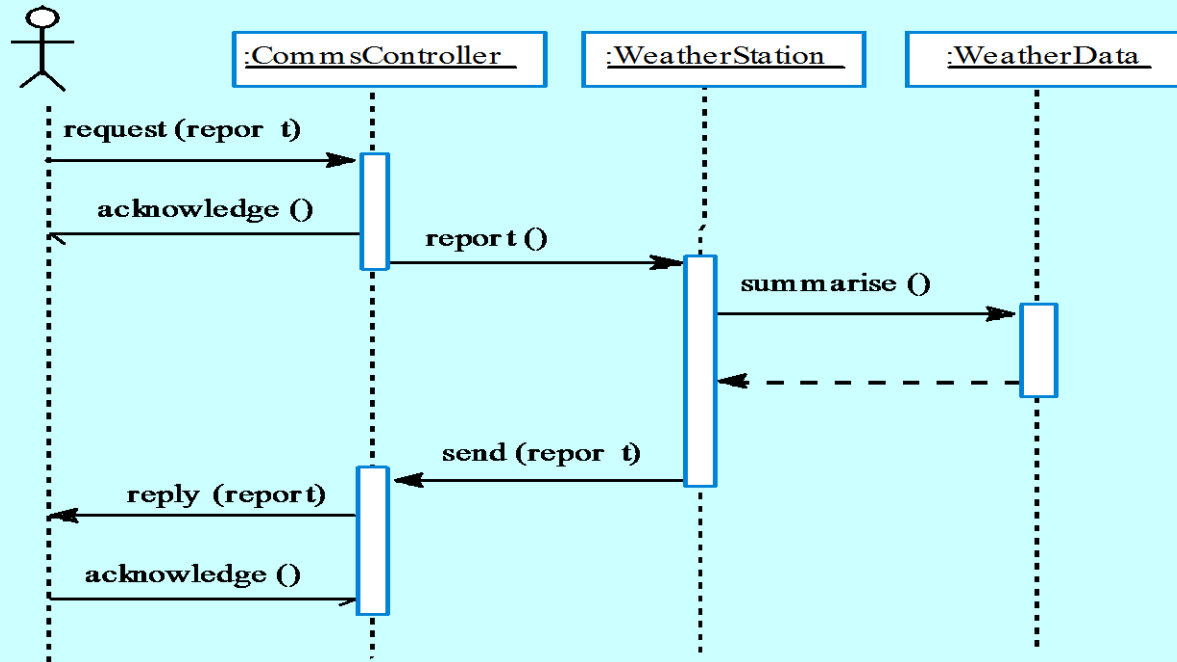
System tests

1. Test the login mechanism using correct and incorrect logins to check that valid users are accepted and invalid users are rejected.
2. Test the search facility using different queries against known sources to check that the search mechanism is actually finding documents.
3. Test the system presentation facility to check that information about documents is displayed properly.
4. Test the mechanism to request permission for downloading.
5. Test the e-mail response indicating that the downloaded document is available.

Use cases

- Use cases can be a basis for deriving the tests for a system. They help identify operations to be tested and help design the required test cases.
- From an associated sequence diagram, the inputs and outputs to be created for the tests can be identified.

Collect weather data sequence chart



Performance testing

- Part of release testing may involve testing the emergent properties of a system, such as performance and reliability.
- Performance tests usually involve planning a series of tests where the load is steadily increased until the system performance becomes unacceptable.

Stress testing

- Exercises the system beyond its maximum design load. Stressing the system often causes defects to come to light.
- Stressing the system test failure behaviour.. Systems should not fail catastrophically. Stress testing checks for unacceptable loss of service or data.
- Stress testing is particularly relevant to distributed systems that can exhibit severe degradation as a network becomes overloaded.

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.

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.

Weather station object interface

WeatherStation
identifier
reportWeather () calibrate (instruments) test () startup (instruments) shutdown (instruments)

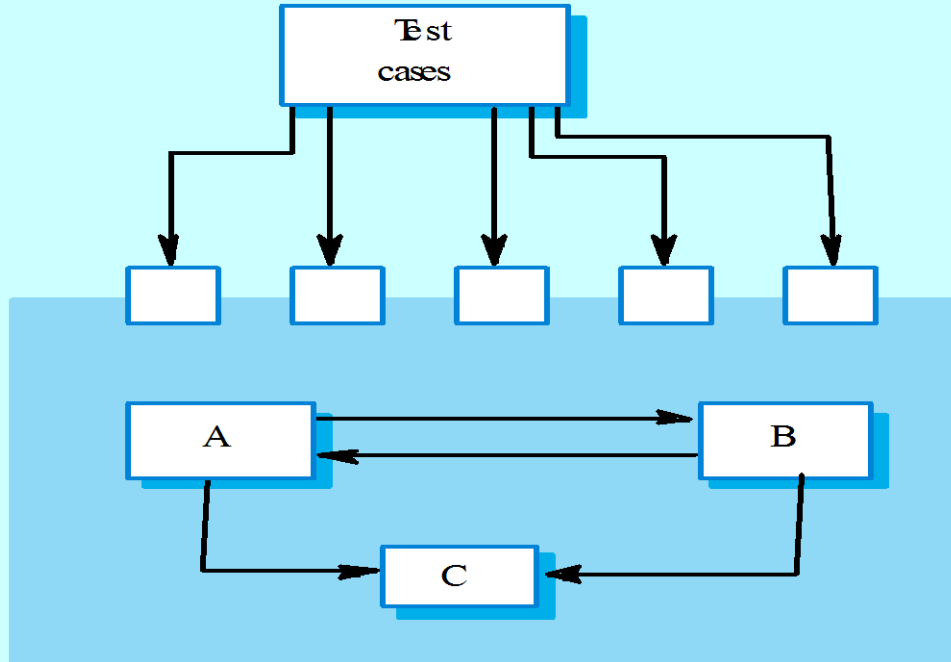
Weather station testing

- Need to define test cases for reportWeather, calibrate, test, startup and shutdown.
- Using a state model, identify sequences of state transitions to be tested and the event sequences to cause these transitions
- For example:
 - Waiting -> Calibrating -> Testing -> Transmitting -> Waiting

Interface testing

- 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



Interface types

- Parameter interfaces
 - Data passed from one 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-system.s

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.

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.

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.

LIBSYS requirements

The user shall be able to search either all of the initial set of databases or select a subset from it.

The system shall provide appropriate viewers for the user to read documents in the document store.

Every order shall be allocated a unique identifier (ORDER_ID) that the user shall be able to copy to the account's permanent storage area.

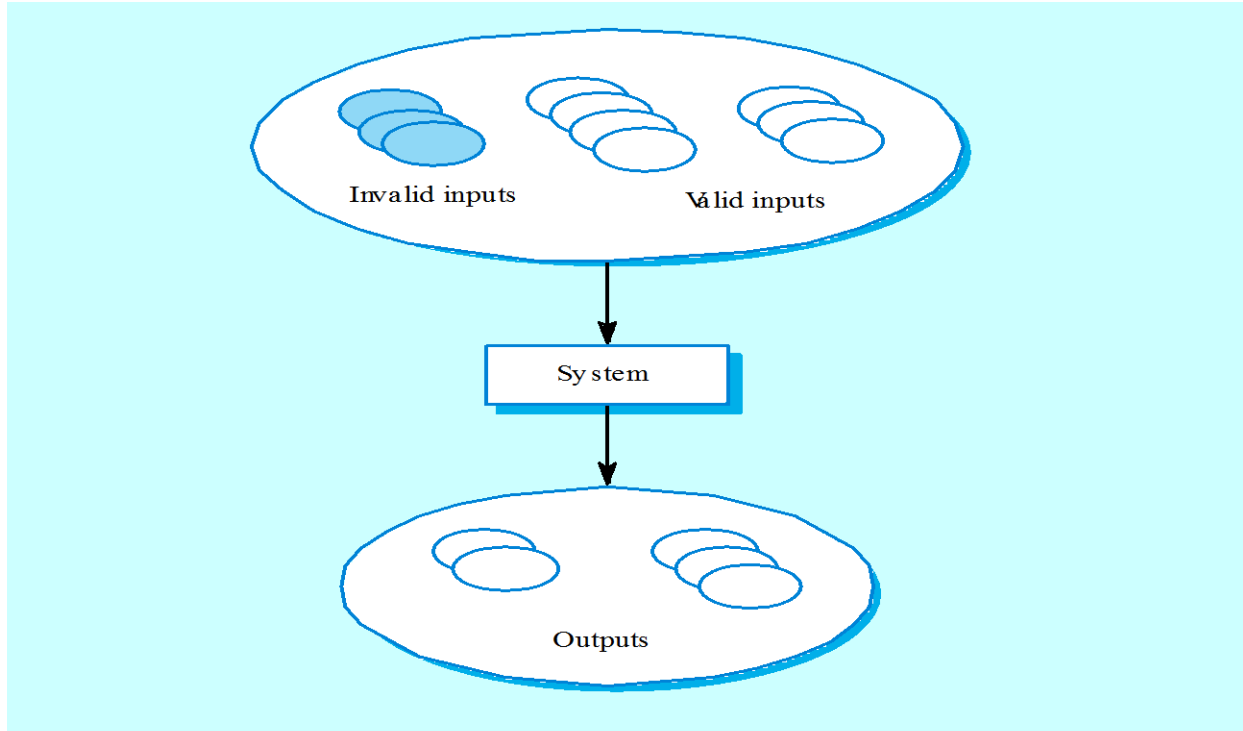
LIBSYS tests

- Initiate user search for searches for items that are known to be present and known not to be present, where the set of databases includes 1 database.
- Initiate user searches for items that are known to be present and known not to be present, where the set of databases includes 2 databases
- Initiate user searches for items that are known to be present and known not to be present where the set of databases includes more than 2 databases.
- Select one database from the set of databases and initiate user searches for items that are known to be present and known not to be present.
- Select more than one database from the set of databases and initiate searches for items that are known to be present and known not to be present.

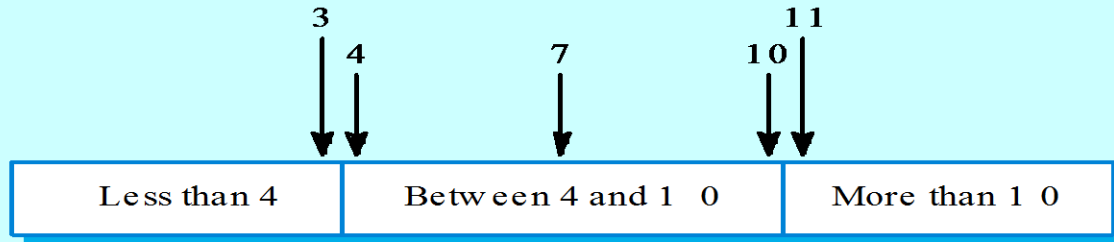
Partition testing

- 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.

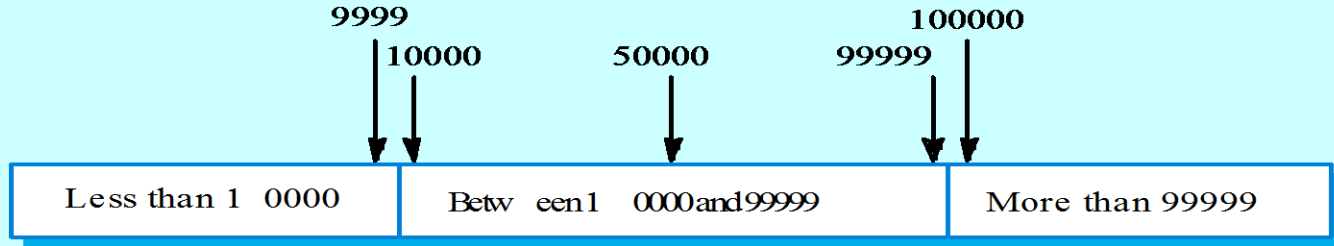
Equivalence partitioning



Equivalence partitions



Number of input values



Input values

Search routine specification

Search routine - input partitions

- Inputs which conform to the pre-conditions.
- Inputs where a pre-condition does not hold.
- Inputs where the key element is a member of the array.
- Inputs where the key element is not a member of the array.

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.

Search routine - input partitions

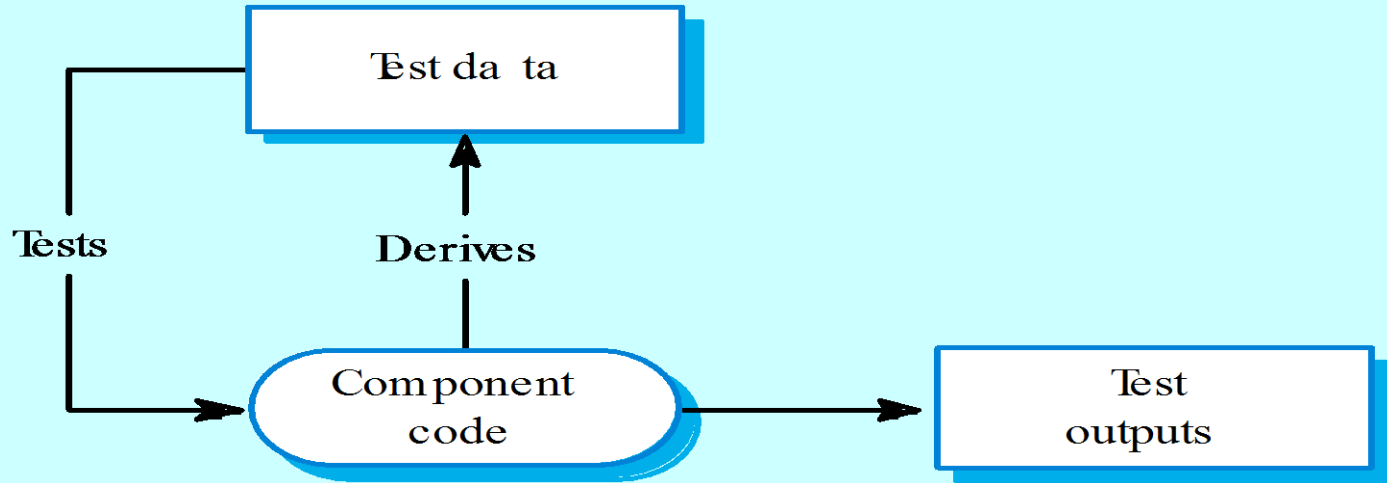
Sequence	Element
Single value	In sequence
Single value	Not in sequence
More than 1 value	First element in sequence
More than 1 value	Last element in sequence
More than 1 value	Middle element in sequence
More than 1 value	Not in sequence

Input sequence (T)	Key (Key)	Output (Found, L)
17	17	true, 1
17	0	false, ??
17, 29, 21, 23	17	true, 1
41, 18, 9, 31, 30, 16, 45	45	true, 7
17, 18, 21, 23, 29, 41, 38	23	true, 4
21, 23, 29, 33, 38	25	false, ??

Structural 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).

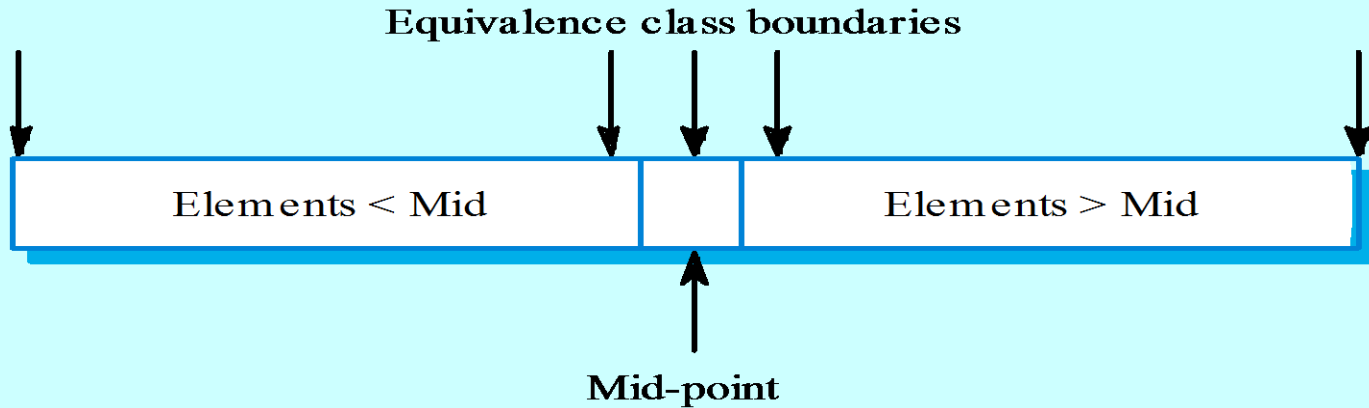
Structural testing



Binary search - equiv. partitions

- Pre-conditions satisfied, key element in array.
- Pre-conditions satisfied, key element not in array.
- Pre-conditions unsatisfied, key element in array.
- Pre-conditions unsatisfied, key element not in array.
- Input array has a single value.
- Input array has an even number of values.
- Input array has an odd number of values.

Binary search equiv. partitions



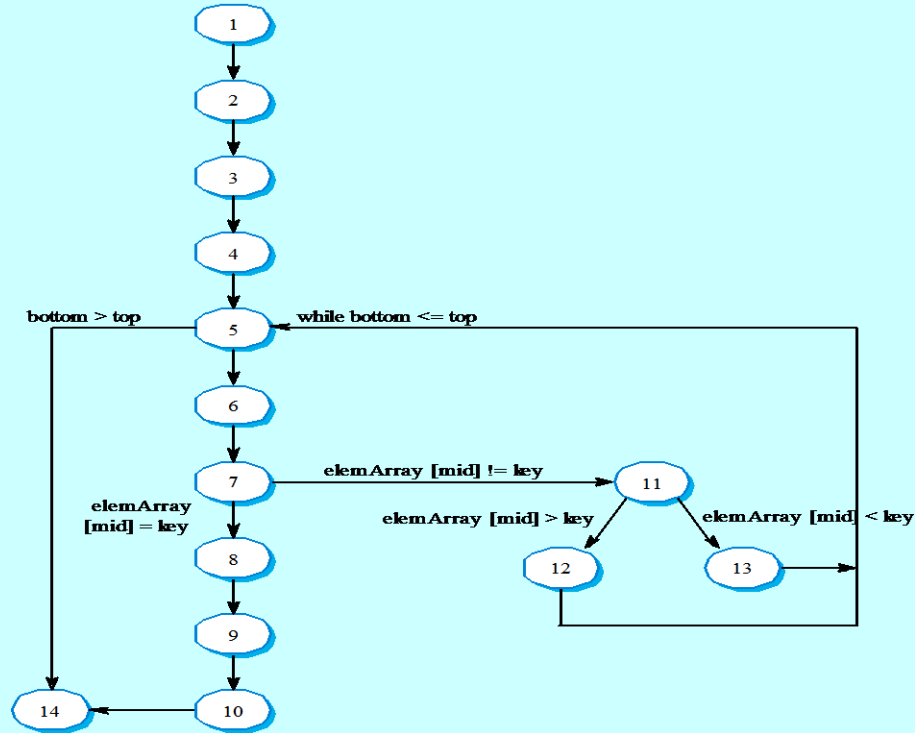
Binary search - test cases

Input array (T)	Key (Key)	Output (Found, L)
17	17	true, 1
17	0	false, ??
17, 21, 23, 29	17	true, 1
9, 16, 18, 30, 31, 41, 45	45	true, 7
17, 18, 21, 23, 29, 38, 41	23	true, 4
17, 18, 21, 23, 29, 33, 38	21	true, 3
12, 18, 21, 23, 32	23	true, 4
21, 23, 29, 33, 38	25	false, ??

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.

Binary search flow graph



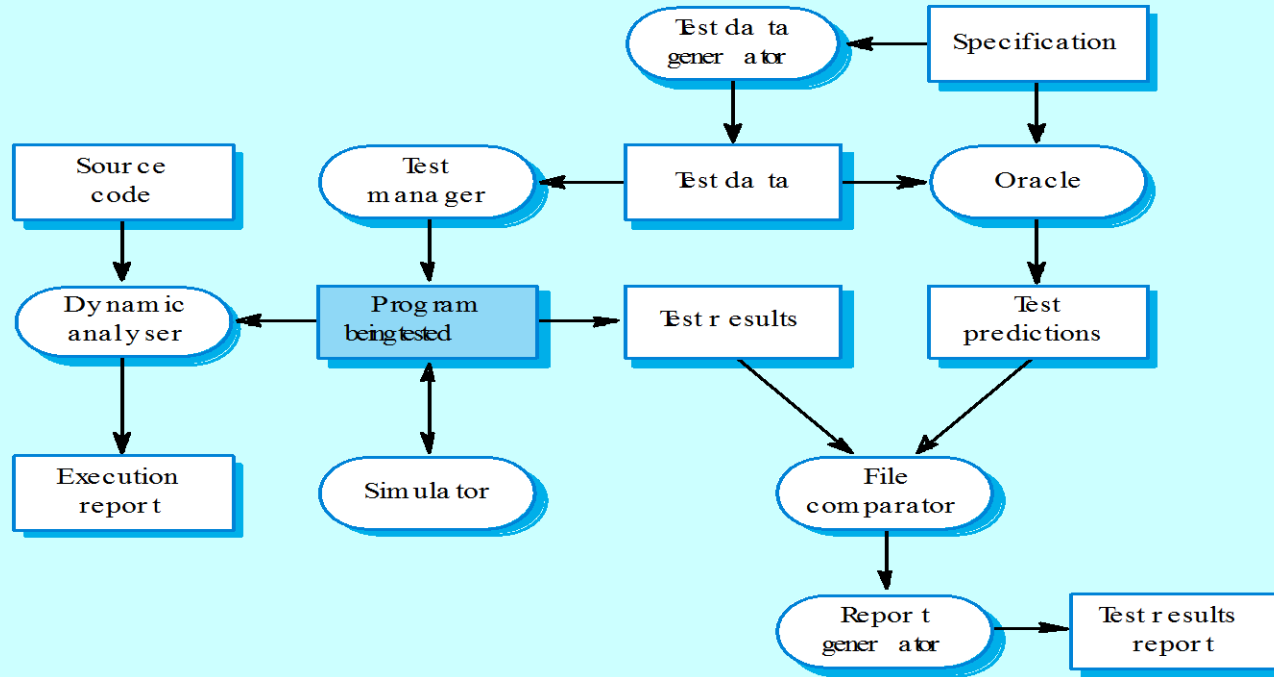
Independent paths

- 1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 14
- 1, 2, 3, 4, 5, 14
- 1, 2, 3, 4, 5, 6, 7, 11, 12, 5, ...
- 1, 2, 3, 4, 6, 7, 2, 11, 13, 5, ...
- Test cases should be derived so that all of these paths are executed
- A dynamic program analyser may be used to check that paths have been executed

Test automation

- Testing is an expensive process phase. Testing workbenches provide a range of tools to reduce the time required and total testing costs.
- Systems such as Junit support the automatic execution of tests.
- Most testing workbenches are open systems because testing needs are organisation-specific.
- They are sometimes difficult to integrate with closed design and analysis workbenches.

A testing workbench



Testing workbench adaptation

- Scripts may be developed for user interface simulators and patterns for test data generators.
- Test outputs may have to be prepared manually for comparison.
- Special-purpose file comparators may be developed.

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.
- Use experience and guidelines to design test cases in defect testing.

Key points

- Interface testing is designed to discover defects in the interfaces of composite components.
- 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.
- Test automation reduces testing costs by supporting the test process with a range of software tools.