
Lecture 1

Software Processes
Process Activities

Topics covered

- ✧ Software process models
- ✧ Process activities
- ✧ Agile methods
- ✧ Agile development techniques
- ✧ Agile project management
- ✧ Scaling agile methods

The software process

- ✧ A structured set of activities required to develop a software system.
- ✧ Many different software processes but all involve:
 - Specification – defining what the system should do;
 - Design and implementation – defining the organization of the system and implementing the system;
 - Validation – checking that it does what the customer wants;
 - Evolution – changing the system in response to changing customer needs.
- ✧ A software process model is an abstract representation of a process. It presents a description of a process from some particular perspective.

Software process descriptions

- ✧ When we describe and discuss processes, we usually talk about the activities in these processes such as specifying a data model, designing a user interface, etc. and the ordering of these activities.
- ✧ Process descriptions may also include:
 - Products, which are the outcomes of a process activity;
 - Roles, which reflect the responsibilities of the people involved in the process;
 - Pre- and post-conditions, which are statements that are true before and after a process activity has been enacted or a product produced.

Plan-driven and agile processes

- ✧ Plan-driven processes are processes where all of the process activities are planned in advance and progress is measured against this plan.
- ✧ In agile processes, planning is incremental and it is easier to change the process to reflect changing customer requirements.
- ✧ In practice, most practical processes include elements of both plan-driven and agile approaches.
- ✧ There are no right or wrong software processes.

Software process models

Software process models

✧ The waterfall model

- Plan-driven model. Separate and distinct phases of specification and development.

✧ Incremental development

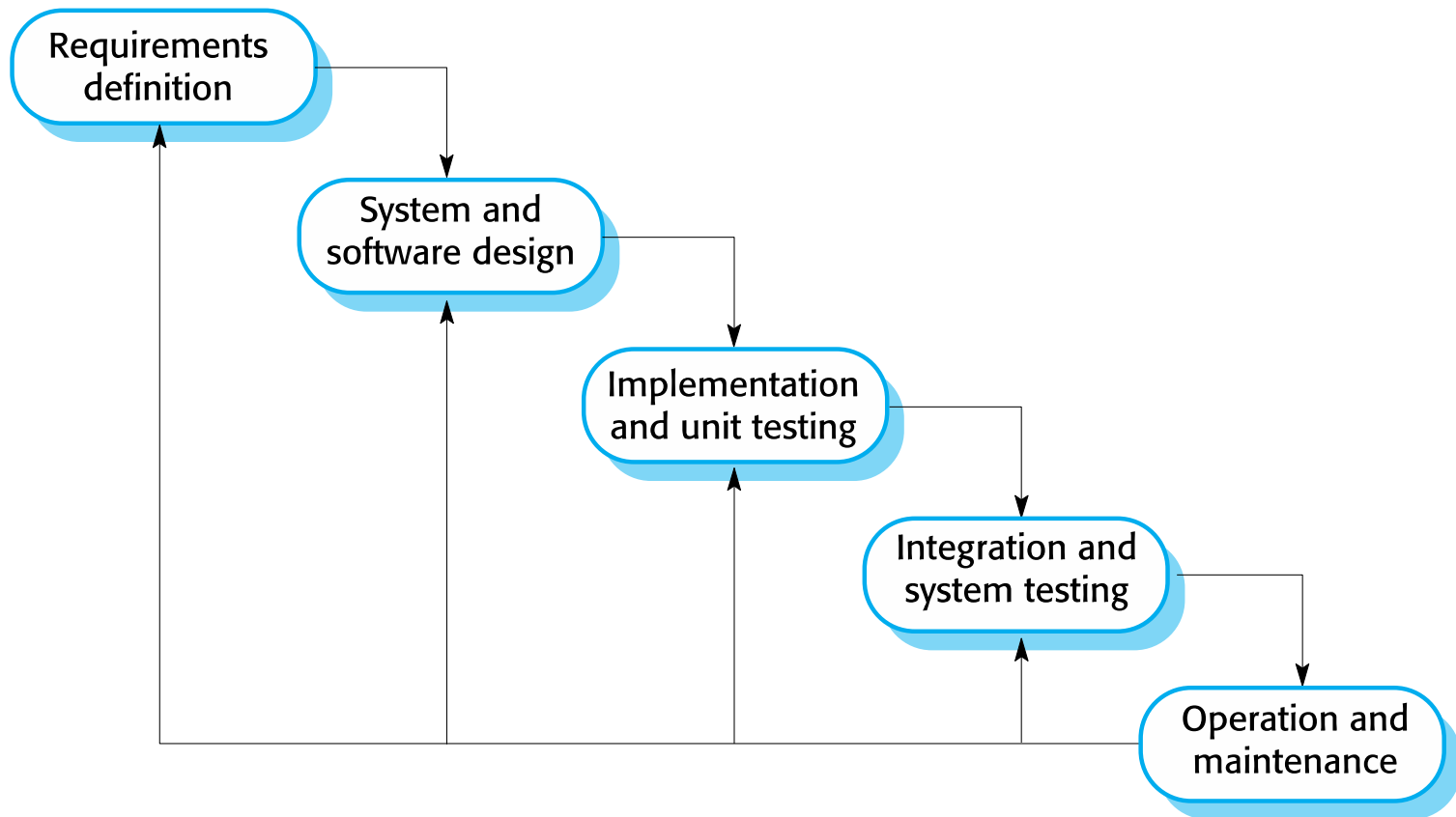
- Specification, development and validation are interleaved. May be plan-driven or agile.

✧ Integration and configuration

- The system is assembled from existing configurable components. May be plan-driven or agile.

✧ In practice, most large systems are developed using a process that incorporates elements from all of these models.

The waterfall model



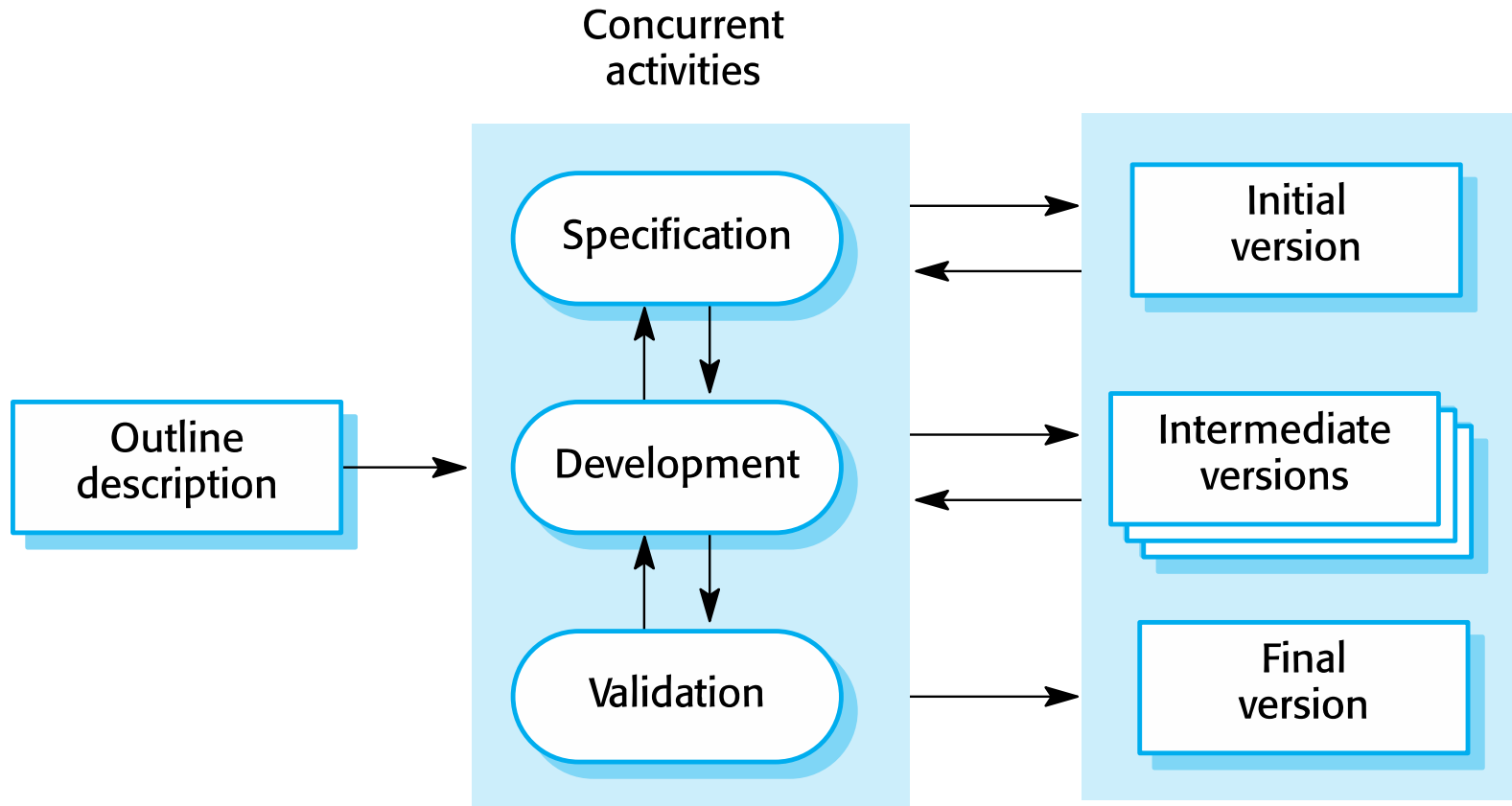
Waterfall model phases

- ✧ There are separate identified phases in the waterfall model:
 - Requirements analysis and definition
 - System and software design
 - Implementation and unit testing
 - Integration and system testing
 - Operation and maintenance
- ✧ The main drawback of the waterfall model is the difficulty of accommodating change after the process is underway. In principle, a phase has to be complete before moving onto the next phase.

Waterfall model problems

- ✧ Inflexible partitioning of the project into distinct stages makes it difficult to respond to changing customer requirements.
 - Therefore, this model is only appropriate when the requirements are well-understood and changes will be fairly limited during the design process.
 - Few business systems have stable requirements.
- ✧ The waterfall model is mostly used for large systems engineering projects where a system is developed at several sites.
 - In those circumstances, the plan-driven nature of the waterfall model helps coordinate the work.

Incremental development



Incremental development benefits

- ✧ The cost of accommodating changing customer requirements is reduced.
 - The amount of analysis and documentation that has to be redone is much less than is required with the waterfall model.
- ✧ It is easier to get customer feedback on the development work that has been done.
 - Customers can comment on demonstrations of the software and see how much has been implemented.
- ✧ More rapid delivery and deployment of useful software to the customer is possible.
 - Customers are able to use and gain value from the software earlier than is possible with a waterfall process.

Incremental development problems

✧ The process is not visible.

- Managers need regular deliverables to measure progress. If systems are developed quickly, it is not cost-effective to produce documents that reflect every version of the system.

✧ System structure tends to degrade as new increments are added.

- Unless time and money is spent on refactoring to improve the software, regular change tends to corrupt its structure. Incorporating further software changes becomes increasingly difficult and costly.

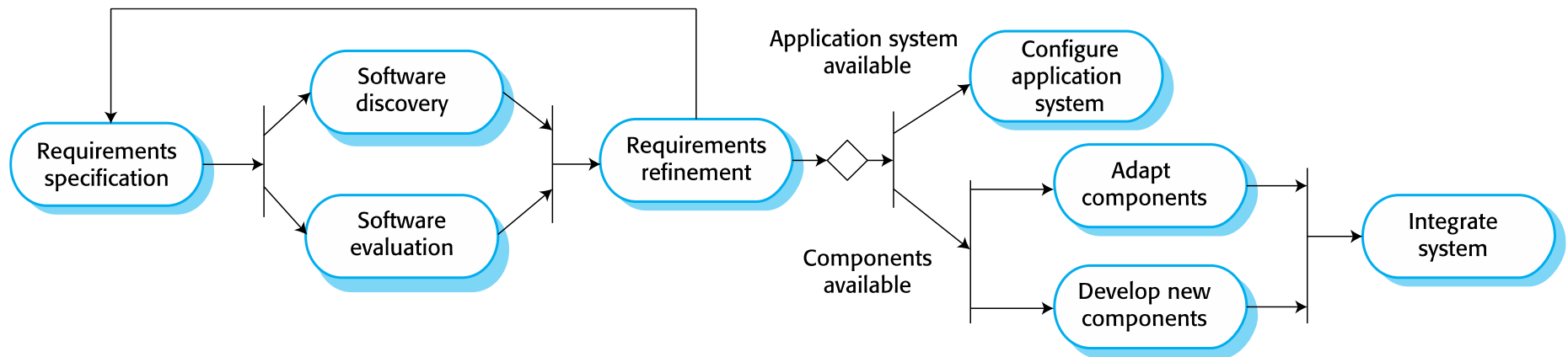
Reuse-oriented process (a.k.a. integration & configuration)

- ✧ Based on software reuse where systems are integrated from existing components or application systems (sometimes called COTS -Commercial-off-the-shelf) systems).
- ✧ Reused elements may be configured to adapt their behaviour and functionality to a user's requirements
- ✧ Reuse is now the standard approach for building many types of business system
 - Reuse covered in more depth in Chapter 15.

Types of reusable software

- ✧ Stand-alone application systems (sometimes called COTS) that are configured for use in a particular environment.
- ✧ Collections of objects that are developed as a package to be integrated with a component framework such as .NET or J2EE.
- ✧ Web services that are developed according to service standards and which are available for remote invocation.

Reuse-oriented software engineering



Key process stages

- ✧ Requirements specification
- ✧ Software discovery and evaluation
- ✧ Requirements refinement
- ✧ Application system configuration
- ✧ Component adaptation and integration

Advantages and disadvantages

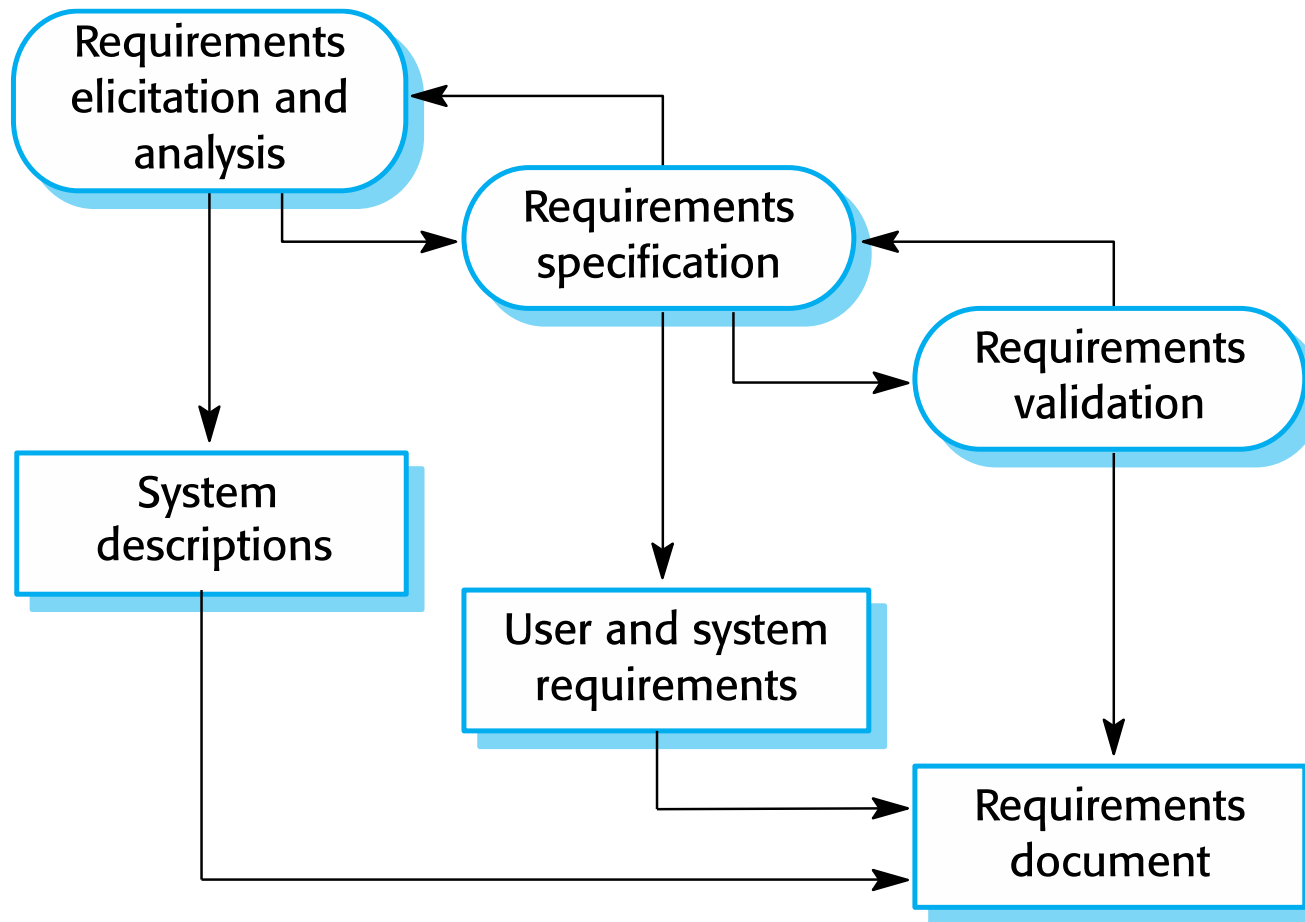
- ✧ Reduced costs and risks as less software is developed from scratch
- ✧ Faster delivery and deployment of system
- ✧ But requirements compromises are inevitable so system may not meet real needs of users
- ✧ Loss of control over evolution of reused system elements

Process activities

Process activities

- ✧ Real software processes are inter-leaved sequences of technical, collaborative and managerial activities with the overall goal of specifying, designing, implementing and testing a software system.
- ✧ The four basic process activities of specification, development, validation and evolution are organized differently in different development processes.
- ✧ For example, in the waterfall model, they are organized in sequence, whereas in incremental development they are interleaved.

The requirements engineering process



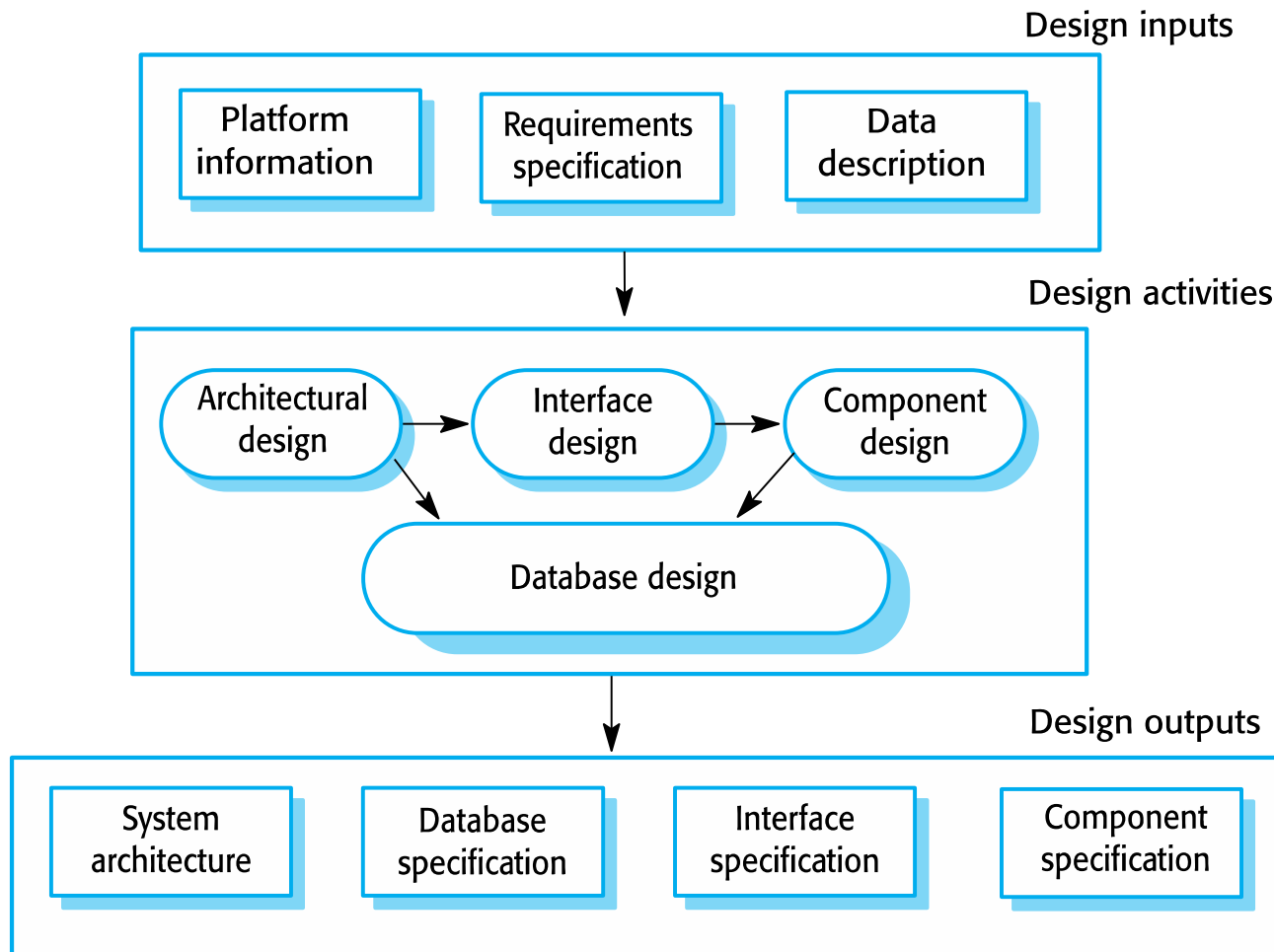
Software specification

- ✧ The process of establishing what services are required and the constraints on the system's operation and development.
- ✧ Requirements engineering process
 - Requirements elicitation and analysis
 - What do the system stakeholders require or expect from the system?
 - Requirements specification
 - Defining the requirements in detail
 - Requirements validation
 - Checking the validity of the requirements

Software design and implementation

- ✧ The process of converting the system specification into an executable system.
- ✧ Software design
 - Design a software structure that realises the specification;
- ✧ Implementation
 - Translate this structure into an executable program;
- ✧ The activities of design and implementation are closely related and may be inter-leaved.

A general model of the design process



Design activities

- ✧ *Architectural design*, where you identify the overall structure of the system, the principal components (subsystems or modules), their relationships and how they are distributed.
- ✧ *Database design*, where you design the system data structures and how these are to be represented in a database.
- ✧ *Interface design*, where you define the interfaces between system components.
- ✧ *Component selection and design*, where you search for reusable components. If unavailable, you design how it will operate.

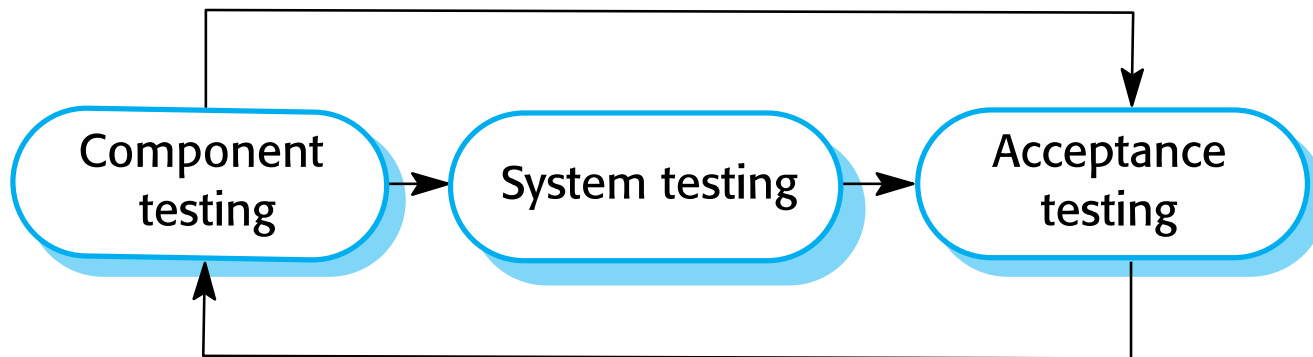
System implementation

- ✧ The software is implemented either by developing a program or programs or by configuring an application system.
- ✧ Design and implementation are interleaved activities for most types of software system.
- ✧ Programming is an individual activity with no standard process.
- ✧ Debugging is the activity of finding program faults and correcting these faults.

Software validation

- ✧ Verification and validation (V & V) is intended to show that a system conforms to its specification and meets the requirements of the system customer.
- ✧ Involves checking and review processes and system testing.
- ✧ System testing involves executing the system with test cases that are derived from the specification of the real data to be processed by the system.
- ✧ Testing is the most commonly used V & V activity.

Stages of testing



Testing stages

✧ Component testing

- Individual components are tested independently;
- Components may be functions or objects or coherent groupings of these entities.

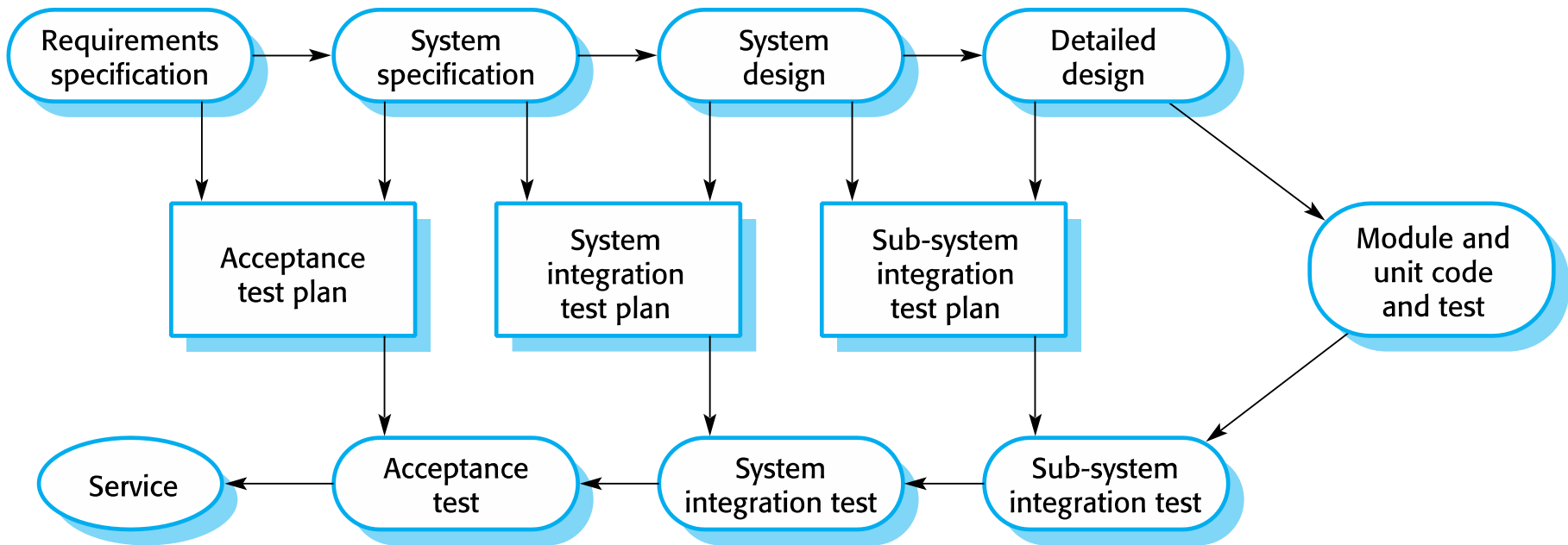
✧ System testing

- Testing of the system as a whole. Testing of emergent properties is particularly important.

✧ Customer testing

- Testing with customer data to check that the system meets the customer's needs.

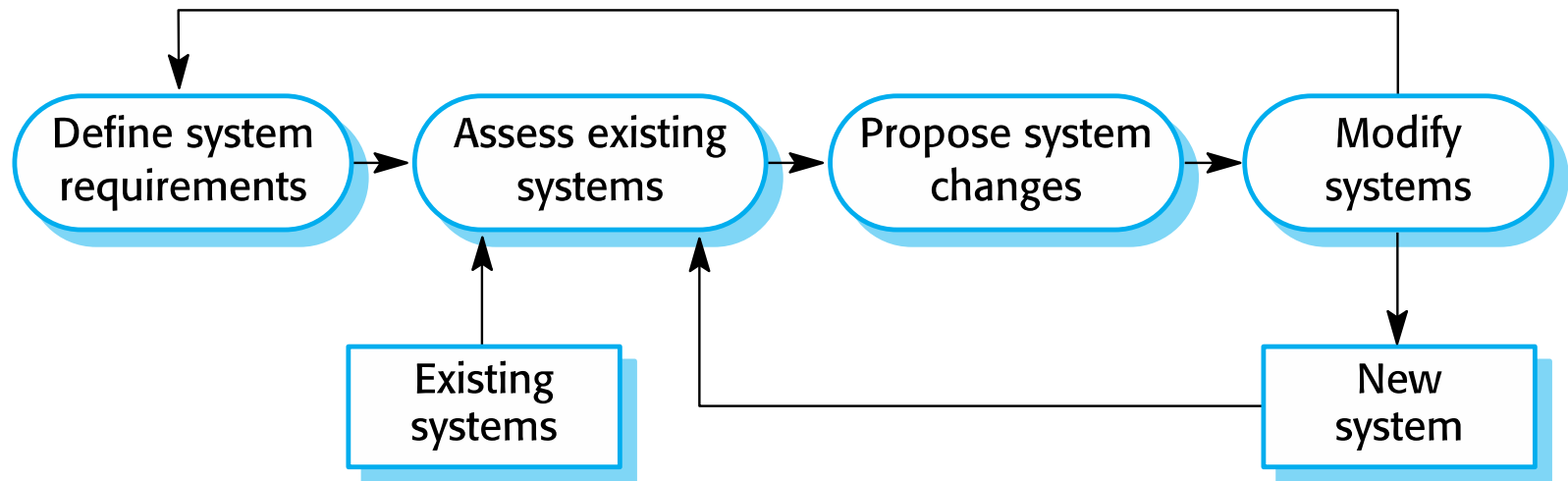
Testing phases in a plan-driven software process (V-model)



Software evolution

- ✧ Software is inherently flexible and can change.
- ✧ As requirements change through changing business circumstances, the software that supports the business must also evolve and change.
- ✧ Although there has been a demarcation between development and evolution (maintenance) this is increasingly irrelevant as fewer and fewer systems are completely new.

System evolution



Key points

- ✧ Software processes are the activities involved in producing a software system. Software process models are abstract representations of these processes.
- ✧ General process models describe the organization of software processes.
 - Examples of these general models include the 'waterfall' model, incremental development, and reuse-oriented development.
- ✧ Requirements engineering is the process of developing a software specification.

Key points

- ✧ Design and implementation processes are concerned with transforming a requirements specification into an executable software system.
- ✧ Software validation is the process of checking that the system conforms to its specification and that it meets the real needs of the users of the system.
- ✧ Software evolution takes place when you change existing software systems to meet new requirements. The software must evolve to remain useful.

Agile Software Development

Rapid software development

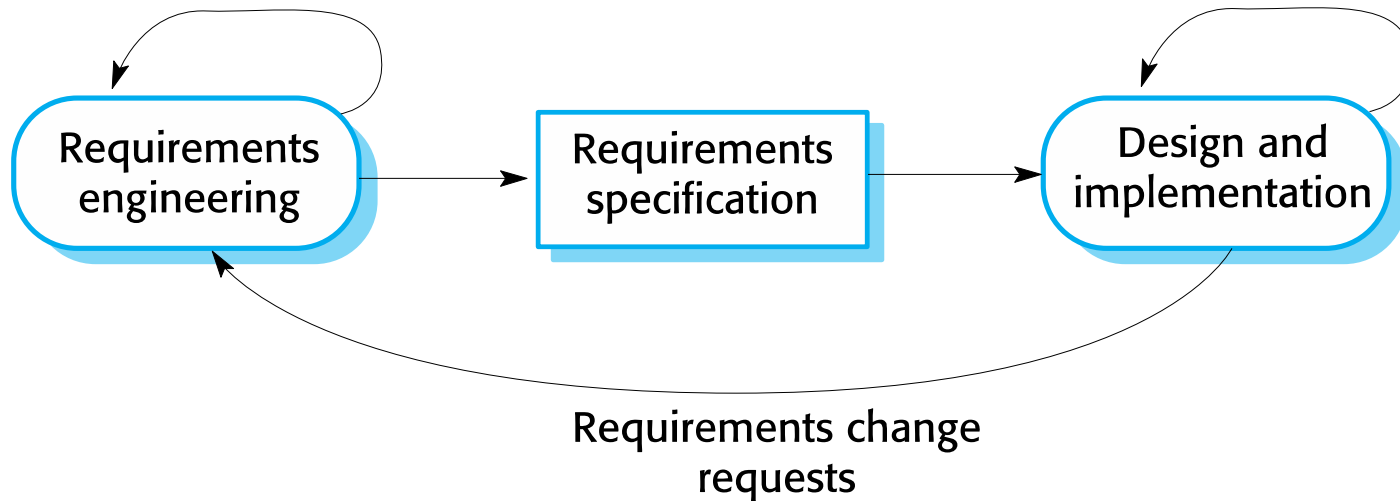
- ✧ Rapid development and delivery is now often the most important requirement for software systems
 - Businesses operate in a fast –changing requirement and it is practically impossible to produce a set of stable software requirements
 - Software has to evolve quickly to reflect changing business needs.
- ✧ Plan-driven development is essential for some types of system but does not meet these business needs.
- ✧ Agile development methods emerged in the late 1990s whose aim was to radically reduce the delivery time for working software systems

Agile development

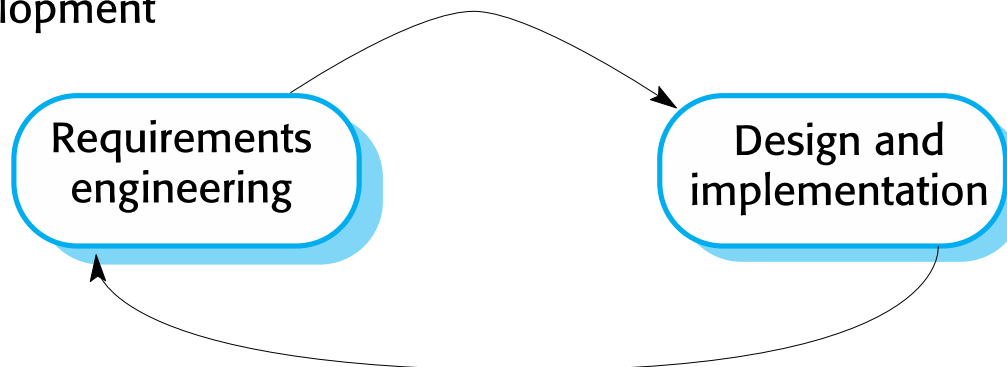
- ✧ Program specification, design and implementation are inter-leaved
- ✧ The system is developed as a series of versions or increments with stakeholders involved in version specification and evaluation
- ✧ Frequent delivery of new versions for evaluation
- ✧ Extensive tool support (e.g. automated testing tools) used to support development.
- ✧ Minimal documentation – focus on working code

Plan-driven and agile development

Plan-based development



Agile development



Plan-driven and agile development

✧ Plan-driven development

- A plan-driven approach to software engineering is based around separate development stages with the outputs to be produced at each of these stages planned in advance.
- Not necessarily waterfall model – plan-driven, incremental development is possible
- Iteration occurs within activities.

✧ Agile development

- Specification, design, implementation and testing are interleaved and the outputs from the development process are decided through a process of negotiation during the software development process.

Agile methods

Agile methods

- ✧ Dissatisfaction with the overheads involved in software design methods of the 1980s and 1990s led to the creation of agile methods. These methods:
 - Focus on the code rather than the design
 - Are based on an iterative approach to software development
 - Are intended to deliver working software quickly and evolve this quickly to meet changing requirements.
- ✧ The aim of agile methods is to reduce overheads in the software process (e.g. by limiting documentation) and to be able to respond quickly to changing requirements without excessive rework.

Agile manifesto

- ✧ *We are uncovering better ways of developing software by doing it and helping others do it. Through this work we have come to value:*
 - *Individuals and interactions over processes and tools*
 - Working software over comprehensive documentation*
 - Customer collaboration over contract negotiation*
 - Responding to change over following a plan*
- ✧ *That is, while there is value in the items on the right, we value the items on the left more.*

The principles of agile methods

Principle	Description
Customer involvement	Customers should be closely involved throughout the development process. Their role is provide and prioritize new system requirements and to evaluate the iterations of the system.
Incremental delivery	The software is developed in increments with the customer specifying the requirements to be included in each increment.
People not process	The skills of the development team should be recognized and exploited. Team members should be left to develop their own ways of working without prescriptive processes.
Embrace change	Expect the system requirements to change and so design the system to accommodate these changes.
Maintain simplicity	Focus on simplicity in both the software being developed and in the development process. Wherever possible, actively work to eliminate complexity from the system.

Agile method applicability

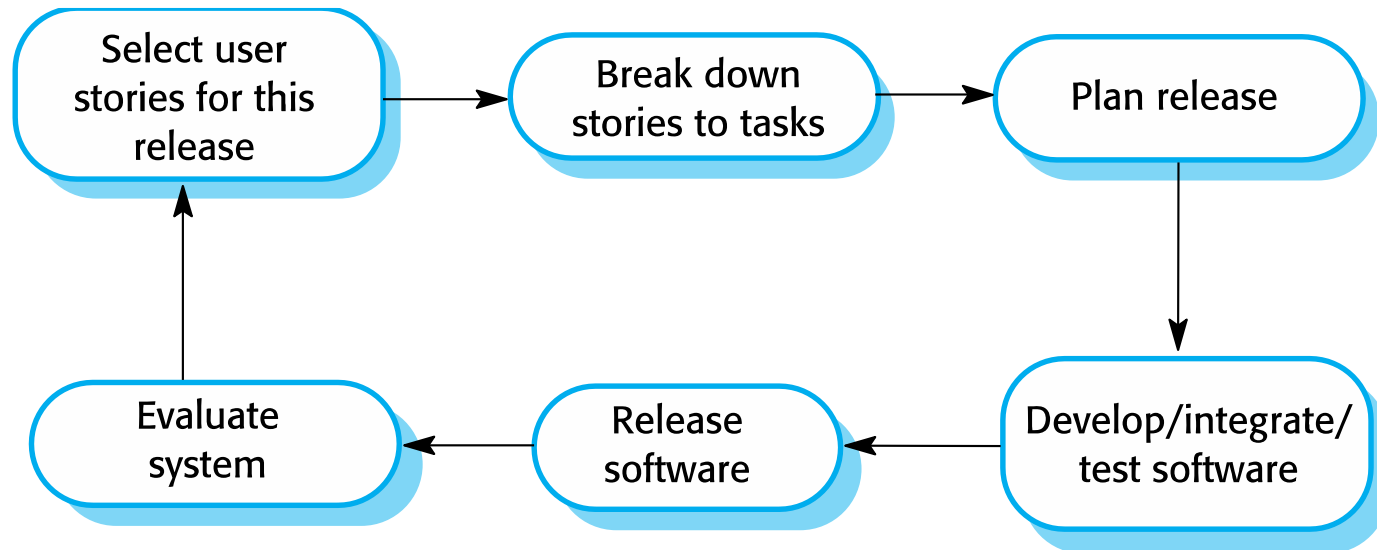
- ✧ Product development where a software company is developing a small or medium-sized product for sale.
 - Virtually all software products and apps are now developed using an agile approach
- ✧ Custom system development within an organization, where there is a clear commitment from the customer to become involved in the development process and where there are few external rules and regulations that affect the software.

Agile development techniques

Extreme programming

- ✧ A very influential agile method, developed in the late 1990s, that introduced a range of agile development techniques.
- ✧ Extreme Programming (XP) takes an 'extreme' approach to iterative development.
 - New versions may be built several times per day;
 - Increments are delivered to customers every 2 weeks;
 - All tests must be run for every build and the build is only accepted if tests run successfully.

The extreme programming release cycle



Extreme programming practices (a)

Principle or practice	Description
Incremental planning	Requirements are recorded on story cards and the stories to be included in a release are determined by the time available and their relative priority. The developers break these stories into development 'Tasks'. See Figures 3.5 and 3.6.
Small releases	The minimal useful set of functionality that provides business value is developed first. Releases of the system are frequent and incrementally add functionality to the first release.
Simple design	Enough design is carried out to meet the current requirements and no more.
Test-first development	An automated unit test framework is used to write tests for a new piece of functionality before that functionality itself is implemented.
Refactoring	All developers are expected to refactor the code continuously as soon as possible code improvements are found. This keeps the code simple and maintainable.

Extreme programming practices (b)

Pair programming	Developers work in pairs, checking each other's work and providing the support to always do a good job.
Collective ownership	The pairs of developers work on all areas of the system, so that no islands of expertise develop and all the developers take responsibility for all of the code. Anyone can change anything.
Continuous integration	As soon as the work on a task is complete, it is integrated into the whole system. After any such integration, all the unit tests in the system must pass.
Sustainable pace	Large amounts of overtime are not considered acceptable as the net effect is often to reduce code quality and medium term productivity
On-site customer	A representative of the end-user of the system (the customer) should be available full time for the use of the XP team. In an extreme programming process, the customer is a member of the development team and is responsible for bringing system requirements to the team for implementation.

XP and agile principles

- ✧ Incremental development is supported through small, frequent system releases.
- ✧ Customer involvement means full-time customer engagement with the team.
- ✧ People not process through pair programming, collective ownership and a process that avoids long working hours.
- ✧ Change supported through regular system releases.
- ✧ Maintaining simplicity through constant refactoring of code.

Influential XP practices

- ✧ Extreme programming has a technical focus and is not easy to integrate with management practice in most organizations.
- ✧ Consequently, while agile development uses practices from XP, the method as originally defined is not widely used.
- ✧ Key practices
 - User stories for specification
 - Refactoring
 - Test-first development
 - Pair programming

User stories for requirements

- ✧ In XP, a customer or user is part of the XP team and is responsible for making decisions on requirements.
- ✧ User requirements are expressed as user stories or scenarios.
- ✧ These are written on cards and the development team break them down into implementation tasks. These tasks are the basis of schedule and cost estimates.
- ✧ The customer chooses the stories for inclusion in the next release based on their priorities and the schedule estimates.

A 'prescribing medication' story

Prescribing medication

The record of the patient must be open for input. Click on the medication field and select either 'current medication', 'new medication' or 'formulary'.

If you select 'current medication', you will be asked to check the dose; If you wish to change the dose, enter the new dose then confirm the prescription.

If you choose, 'new medication', the system assumes that you know which medication you wish to prescribe. Type the first few letters of the drug name. You will then see a list of possible drugs starting with these letters. Choose the required medication. You will then be asked to check that the medication you have selected is correct. Enter the dose then confirm the prescription.

If you choose 'formulary', you will be presented with a search box for the approved formulary. Search for the drug required then select it. You will then be asked to check that the medication you have selected is correct. Enter the dose then confirm the prescription.

In all cases, the system will check that the dose is within the approved range and will ask you to change it if it is outside the range of recommended doses.

After you have confirmed the prescription, it will be displayed for checking. Either click 'OK' or 'Change'. If you click 'OK', your prescription will be recorded on the audit database. If you click 'Change', you reenter the 'Prescribing medication' process.

Examples of task cards for prescribing medication

Task 1: Change dose of prescribed drug

Task 2: Formulary selection

Task 3: Dose checking

Dose checking is a safety precaution to check that the doctor has not prescribed a dangerously small or large dose.

Using the formulary id for the generic drug name, lookup the formulary and retrieve the recommended maximum and minimum dose.

Check the prescribed dose against the minimum and maximum. If outside the range, issue an error message saying that the dose is too high or too low. If within the range, enable the 'Confirm' button.

Refactoring

- ✧ Conventional wisdom in software engineering is to design for change. It is worth spending time and effort anticipating changes as this reduces costs later in the life cycle.
- ✧ XP, however, maintains that this is not worthwhile as changes cannot be reliably anticipated.
- ✧ Rather, it proposes constant code improvement (refactoring) to make changes easier when they have to be implemented.

Refactoring

- ✧ Programming team look for possible software improvements and make these improvements even where there is no immediate need for them.
- ✧ This improves the understandability of the software and so reduces the need for documentation.
- ✧ Changes are easier to make because the code is well-structured and clear.
- ✧ However, some changes requires architecture refactoring and this is much more expensive.

Examples of refactoring

- ✧ Re-organization of a class hierarchy to remove duplicate code.
- ✧ Tidying up and renaming attributes and methods to make them easier to understand.
- ✧ The replacement of inline code with calls to methods that have been included in a program library.

Test-first development

- ✧ Testing is central to XP and XP has developed an approach where the program is tested after every change has been made.
- ✧ XP testing features:
 - Test-first development.
 - Incremental test development from scenarios.
 - User involvement in test development and validation.
 - Automated test harnesses are used to run all component tests each time that a new release is built.

Test-driven development

- ✧ Writing tests before code clarifies the requirements to be implemented.
- ✧ Tests are written as programs rather than data so that they can be executed automatically. The test includes a check that it has executed correctly.
 - Usually relies on a testing framework such as JUnit.
- ✧ All previous and new tests are run automatically when new functionality is added, thus checking that the new functionality has not introduced errors.

Customer involvement

- ✧ The role of the customer in the testing process is to help develop acceptance tests for the stories that are to be implemented in the next release of the system.
- ✧ The customer who is part of the team writes tests as development proceeds. All new code is therefore validated to ensure that it is what the customer needs.
- ✧ However, people adopting the customer role have limited time available and so cannot work full-time with the development team. They may feel that providing the requirements was enough of a contribution and so may be reluctant to get involved in the testing process.

Test case description for dose checking

Test 4: Dose checking

Input:

1. A number in mg representing a single dose of the drug.
2. A number representing the number of single doses per day.

Tests:

1. Test for inputs where the single dose is correct but the frequency is too high.
2. Test for inputs where the single dose is too high and too low.
3. Test for inputs where the single dose * frequency is too high and too low.
4. Test for inputs where single dose * frequency is in the permitted range.

Output:

OK or error message indicating that the dose is outside the safe range.

Test automation

- ✧ Test automation means that tests are written as executable components before the task is implemented
 - These testing components should be stand-alone, should simulate the submission of input to be tested and should check that the result meets the output specification. An automated test framework (e.g. JUnit) is a system that makes it easy to write executable tests and submit a set of tests for execution.
- ✧ As testing is automated, there is always a set of tests that can be quickly and easily executed
 - Whenever any functionality is added to the system, the tests can be run and problems that the new code has introduced can be caught immediately.

Problems with test-first development

- ✧ Programmers prefer programming to testing and sometimes they take short cuts when writing tests. For example, they may write incomplete tests that do not check for all possible exceptions that may occur.
- ✧ Some tests can be very difficult to write incrementally. For example, in a complex user interface, it is often difficult to write unit tests for the code that implements the 'display logic' and workflow between screens.
- ✧ It difficult to judge the completeness of a set of tests. Although you may have a lot of system tests, your test set may not provide complete coverage.

Pair programming

- ✧ Pair programming involves programmers working in pairs, developing code together.
- ✧ This helps develop common ownership of code and spreads knowledge across the team.
- ✧ It serves as an informal review process as each line of code is looked at by more than 1 person.
- ✧ It encourages refactoring as the whole team can benefit from improving the system code.

Pair programming

- ✧ In pair programming, programmers sit together at the same computer to develop the software.
- ✧ Pairs are created dynamically so that all team members work with each other during the development process.
- ✧ The sharing of knowledge that happens during pair programming is very important as it reduces the overall risks to a project when team members leave.
- ✧ Pair programming is not necessarily inefficient and there is some evidence that suggests that a pair working together is more efficient than 2 programmers working separately.

Key points

- ✧ Agile methods are incremental development methods that focus on rapid software development, frequent releases of the software, reducing process overheads by minimizing documentation and producing high-quality code.
- ✧ Agile development practices include
 - User stories for system specification
 - Frequent releases of the software,
 - Continuous software improvement
 - Test-first development
 - Customer participation in the development team.