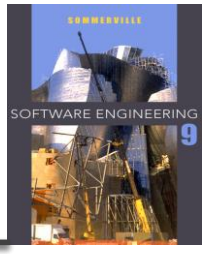
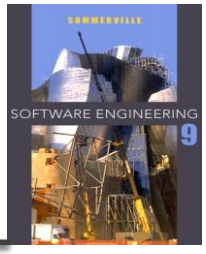
Lecture 1- Introduction

Topics covered

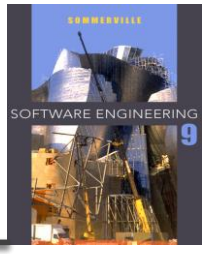


- ✧ Professional software development
  - What is meant by software engineering.
- ✧ Software Processes
- ✧ Case studies
  - An introduction to three examples that are used in later chapters in the book.



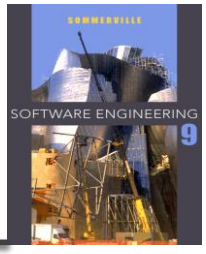
1.Professional software development

Software engineering



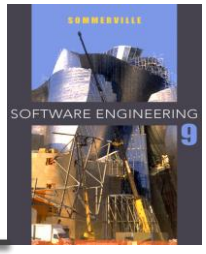
- The economies of ALL developed nations are dependent on software.
- More and more systems are software controlled
- Software engineering is concerned with theories, methods and tools for professional software development.
- Expenditure on software represents a significant fraction of GNP in all developed countries.

Software products



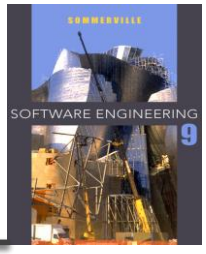
- Generic products
  - Stand-alone systems that are marketed and sold to any customer who wishes to buy them.
  - Examples – PC software such as graphics programs, project management tools; CAD software; software for specific markets such as appointments systems for dentists.
- Customized products
  - Software that is commissioned by a specific customer to meet their own needs.
  - Examples – embedded control systems, air traffic control software, traffic monitoring systems.

Product specification



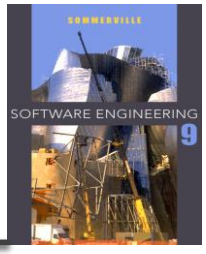
- Generic products
  - The specification of what the software should do is owned by the software developer and decisions on software change are made by the developer.
- Customized products
  - The specification of what the software should do is owned by the customer for the software and they make decisions on software changes that are required.

Frequently asked questions about software engineering



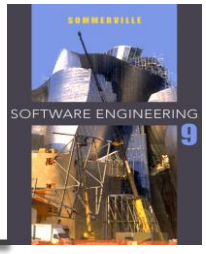
Question	Answer
What is software?	Computer programs and associated documentation. Software products may be developed for a particular customer or may be developed for a general market.
What are the attributes of good software?	Good software should deliver the required functionality and performance to the user and should be maintainable, dependable and usable.
What is software engineering?	Software engineering is an engineering discipline that is concerned with all aspects of software production.
What are the fundamental software engineering activities?	Software specification, software development, software validation and software evolution.
What is the difference between software engineering and computer science?	Computer science focuses on theory and fundamentals; software engineering is concerned with the practicalities of developing and delivering useful software.
What is the difference between software engineering and system engineering?	System engineering is concerned with all aspects of computer-based systems development including hardware, software and process engineering. Software engineering is part of this more general process.

Essential attributes of good software



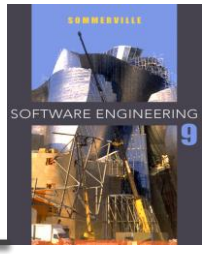
Product characteristic	Description
Maintainability	Software should be written in such a way so that it can evolve to meet the changing needs of customers. This is a critical attribute because software change is an inevitable requirement of a changing business environment.
Dependability and security	Software dependability includes a range of characteristics including reliability, security and safety. Dependable software should not cause physical or economic damage in the event of system failure. Malicious users should not be able to access or damage the system.
Efficiency	Software should not make wasteful use of system resources such as memory and processor cycles. Efficiency therefore includes responsiveness, processing time, memory utilisation, etc.
Acceptability	Software must be acceptable to the type of users for which it is designed. This means that it must be understandable, usable and compatible with other systems that they use.

Software engineering



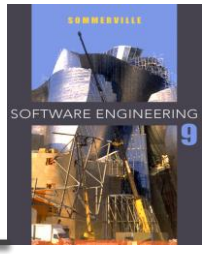
- Software engineering is an engineering discipline that is concerned with all aspects of software production from the early stages of system specification through to maintaining the system after it has gone into use.
- Engineering discipline
  - Using appropriate theories and methods to solve problems bearing in mind organizational and financial constraints.
- All aspects of software production
  - Not just technical process of development. Also project management and the development of tools, methods etc. to support software production.

Importance of software engineering



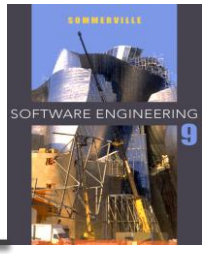
- More and more, individuals and society rely on advanced software systems. We need to be able to produce reliable and trustworthy systems economically and quickly.
- It is usually cheaper, in the long run, to use software engineering methods and techniques for software systems rather than just write the programs as if it was a personal programming project. For most types of system, the majority of costs are the costs of changing the software after it has gone into use.

Software process activities



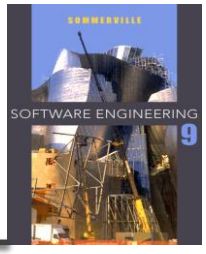
- Software specification, where customers and engineers define the software that is to be produced and the constraints on its operation.
- Software development, where the software is designed and programmed.
- Software validation, where the software is checked to ensure that it is what the customer requires.
- Software evolution, where the software is modified to reflect changing customer and market requirements.

Application types



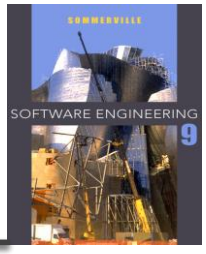
- ✧ Stand-alone applications
  - These are application systems that run on a local computer, such as a PC. They include all necessary functionality and do not need to be connected to a network.
- ✧ Interactive transaction-based applications
  - Applications that execute on a remote computer and are accessed by users from their own PCs or terminals. These include web applications such as e-commerce applications.
- ✧ Embedded control systems
  - These are software control systems that control and manage hardware devices.

Application types



- Batch processing systems
  - These are business systems that are designed to process data in large batches. They process large numbers of individual inputs to create corresponding outputs.
- Entertainment systems
  - These are systems that are primarily for personal use and which are intended to entertain the user.
- Systems for modeling and simulation
  - These are systems that are developed by scientists and engineers to model physical processes or situations.

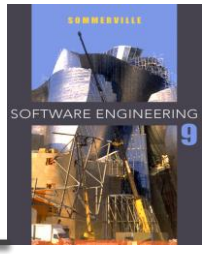
Application types



✧ Data collection systems

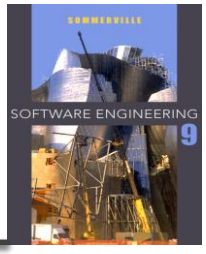
- These are systems that collect data from their environment using a set of sensors and send that data to other systems for processing.

Software engineering fundamentals



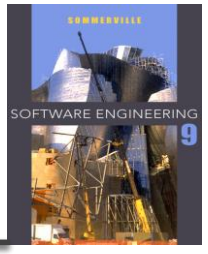
- Some fundamental principles apply to all types of software system, irrespective of the development techniques used:
  - Systems should be developed using a managed and understood development process. Of course, different processes are used for different types of software.
  - Dependability and performance are important for all types of system.
  - Understanding and managing the software specification and requirements (what the software should do) are important.
  - Where appropriate, you should reuse software that has already been developed rather than write new software.

Software engineering and the web



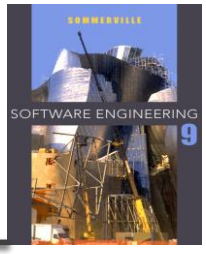
- The Web is now a platform for running application and organizations are increasingly developing web-based systems rather than local systems.
- Web services (discussed in Chapter 19) allow application functionality to be accessed over the web.
- Cloud computing is an approach to the provision of computer services where applications run remotely on the ‘cloud’.
  - Users do not buy software buy pay according to use.

Web software engineering



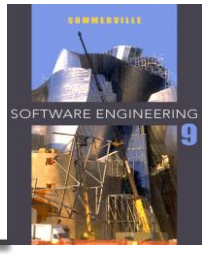
- Software reuse is the dominant approach for constructing web-based systems.
  - When building these systems, you think about how you can assemble them from pre-existing software components and systems.
- Web-based systems should be developed and delivered incrementally.
  - It is now generally recognized that it is impractical to specify all the requirements for such systems in advance.
- User interfaces are constrained by the capabilities of web browsers.
  - Technologies such as AJAX allow rich interfaces to be created within a web browser but are still difficult to use. Web forms with local scripting are more commonly used.

Web-based software engineering



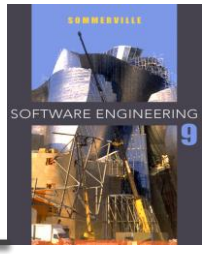
- Web-based systems are complex distributed systems but the fundamental principles of software engineering discussed previously are as applicable to them as they are to any other types of system.
- The fundamental ideas of software engineering, discussed in the previous section, apply to web-based software in the same way that they apply to other types of software system.

Key points

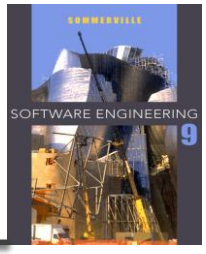


- Software engineering is an engineering discipline that is concerned with all aspects of software production.
- Essential software product attributes are maintainability, dependability and security, efficiency and acceptability.
- The high-level activities of specification, development, validation and evolution are part of all software processes.
- The fundamental notions of software engineering are universally applicable to all types of system development.

Key points

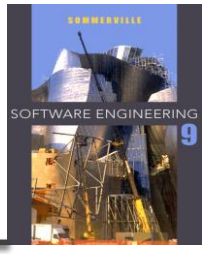


- There are many different types of system and each requires appropriate software engineering tools and techniques for their development.
- The fundamental ideas of software engineering are applicable to all types of software system.



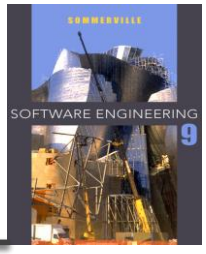
2.Software Processes

The software process



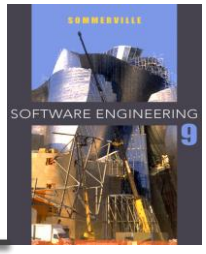
- A structured set of activities required to develop a software system.
- Many different software processes but all involve:
  - Specification – defining what the system should do;
  - Design and implementation – defining the organization of the system and implementing the system;
  - Validation – checking 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



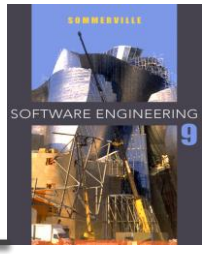
- When we describe and discuss processes, we usually talk about the activities in these processes such as specifying a data model, designing a user interface, etc. and the ordering of these activities.
- Process descriptions may also include:
  - Products, which are the outcomes of a process activity;
  - 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



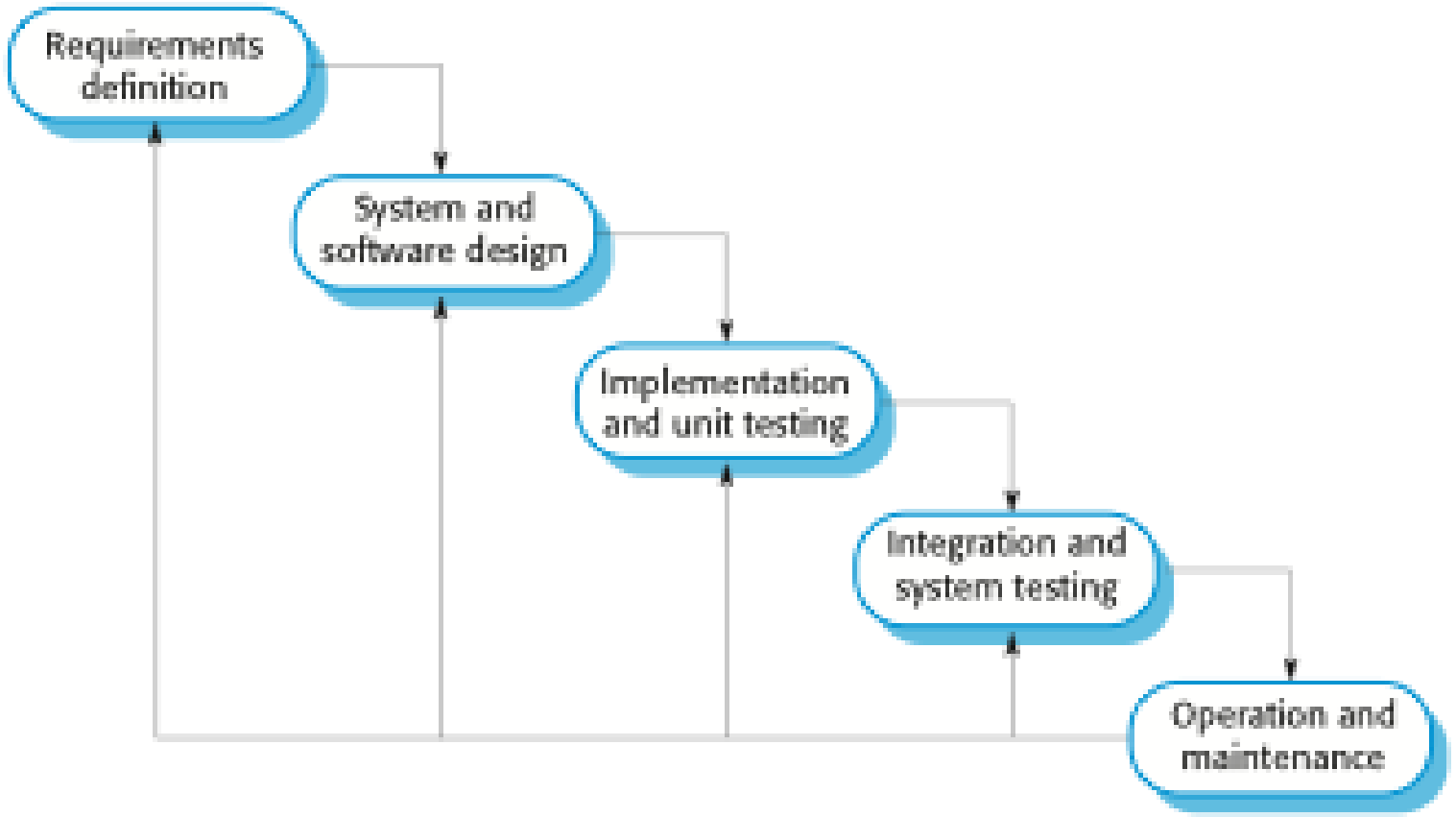
- Plan-driven processes are processes where all of the process activities are planned in advance and progress is measured against this plan.
- In agile processes, planning is incremental and it is easier to change the process to reflect changing customer requirements.
- In practice, most practical processes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

Software process models

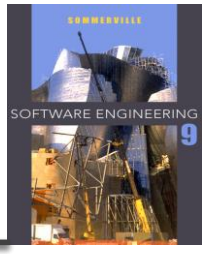


- The waterfall model
  - Plan-driven model. Separate and distinct phases of specification and development.
- Incremental development
  - Specification, development and validation are interleaved. May be plan-driven or agile.
- Reuse-oriented software engineering
  - The system is assembled from existing 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

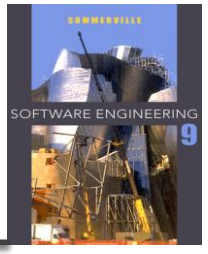


Waterfall model phases



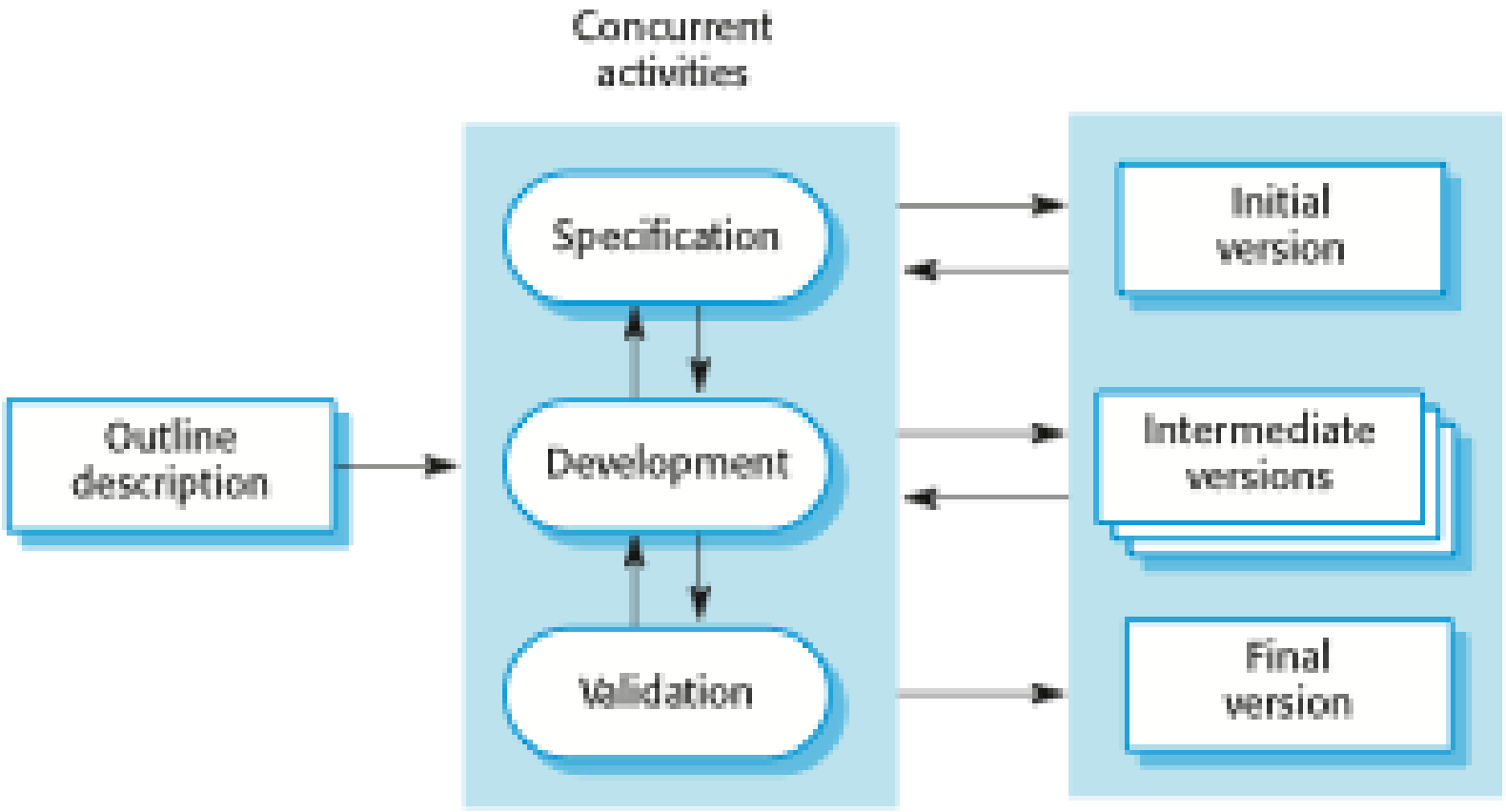
- There are separate identified phases in the waterfall model:
  - Requirements analysis and definition
  - System and software design
  - Implementation and unit testing
  - Integration and system testing
  - Operation and maintenance
- The main drawback of the waterfall model is the difficulty of accommodating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

Waterfall model problems

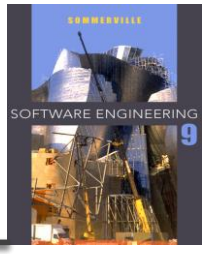


- Inflexible partitioning of the project into distinct stages makes it difficult to respond to changing customer requirements.
  - Therefore, this model is only appropriate when the requirements are well-understood and changes will be fairly limited during the design process.
  - Few business systems 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

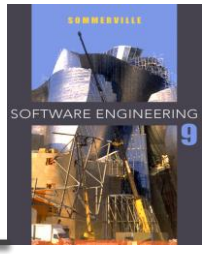


Incremental development benefits



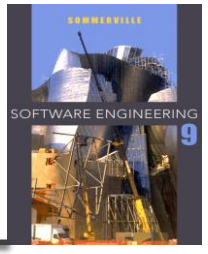
- The cost of accommodating changing customer requirements is reduced.
  - The amount of analysis and documentation that has to be redone is much less than is required with the waterfall model.
- It is easier to get customer feedback on the development work that has been done.
  - Customers can comment 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



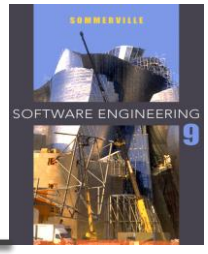
- The process is not visible.
  - Managers need regular deliverables to measure progress. If systems are developed quickly, it is not cost-effective to produce documents that reflect every version of the system.
- System structure tends to degrade as new increments are added.
  - Unless time and money is spent on refactoring to improve the software, regular change tends to corrupt its structure. Incorporating further software changes becomes increasingly difficult and costly.

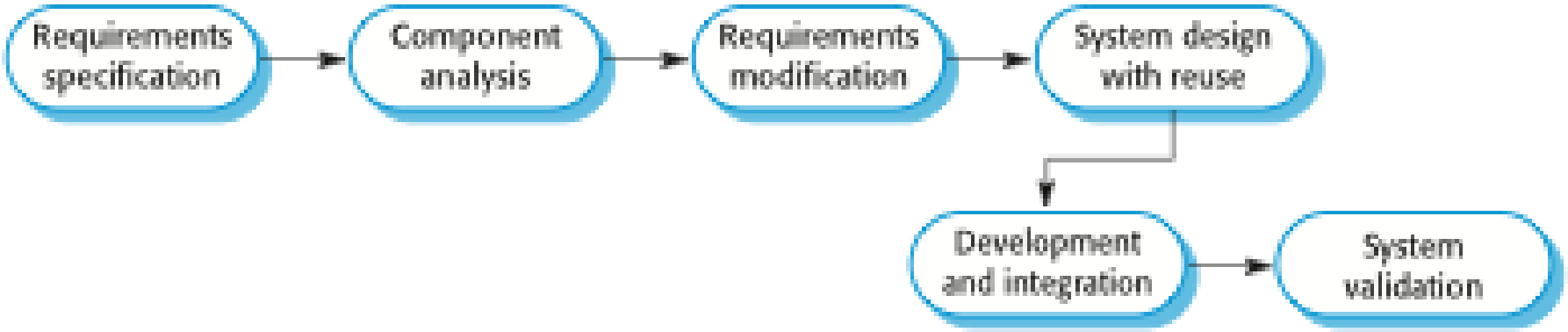
Reuse-oriented software engineering



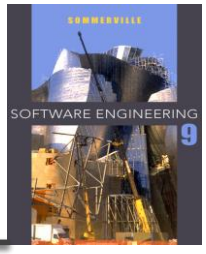
- Based on systematic reuse where systems are integrated from existing components or COTS (Commercial-off-the-shelf) systems.
- Process stages
  - Component analysis;
  - Requirements modification;
  - System design with reuse;
  - Development and integration.
- Reuse is now the standard approach for building many types of business system
  - Reuse covered in more depth in Chapter 16.

Reuse-oriented software engineering



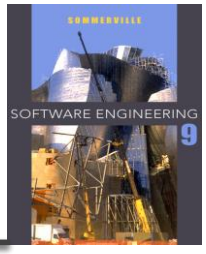


Types of software component



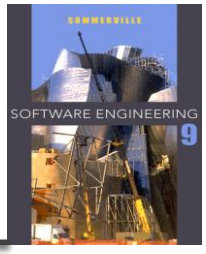
- Web services that are developed according to service standards and which are available for remote invocation.
- Collections of objects that are developed as a package to be integrated with a component framework such as .NET or J2EE.
- Stand-alone software systems (COTS) that are configured for use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

Process activities



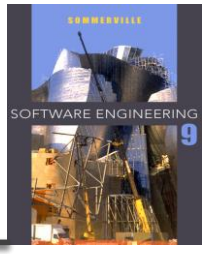
- Real software processes are inter-leaved sequences of technical, collaborative and managerial activities with the overall goal of specifying, designing, implementing and testing a software system.
- The four basic process activities of specification, development, validation and evolution are organized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

Software specification



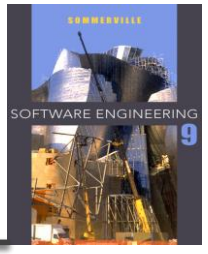
- The process of establishing what services are required and the constraints on the system's operation and development.
- Requirements engineering process
  - Feasibility study
    - Is it technically and financially feasible to build the system?
  - Requirements elicitation and analysis
    - What do 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



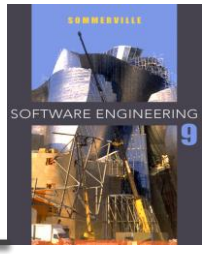
- The process of converting the system specification into an executable system.
- Software design
  - Design a software structure that realises the specification;
- Implementation
  - Translate this structure into an executable program;
- The activities of design and implementation are closely related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

Design activities



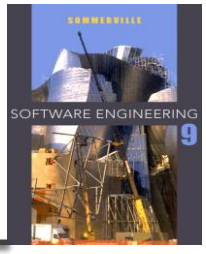
- *Architectural design,* where you identify the overall structure of the system, the principal components (sometimes called sub-systems or modules), their relationships and how they are distributed.
- *Interface design,* where you define the interfaces between system components.
- *Component design,* where you take each system component and design how it will operate.
- *Database design,* where you design the system data structures and how these are to be represented in a database.

Software validation



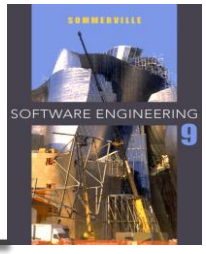
- Verification and validation (V & V) is intended to show that a system conforms to its specification and meets the requirements of the system customer.
- Involves checking and review processes and system testing.
- System testing involves executing the system with test cases that are derived from the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

Testing stages



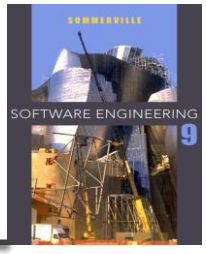
- ✧ Development or component testing
  - Individual components are tested independently;
  - Components may be functions or objects or coherent groupings of these entities.
- ✧ System testing
  - Testing of the system as a whole. Testing of emergent properties is particularly important.
- ✧ Acceptance testing
  - Testing with customer data to check that the system meets the customer’s needs.

Software evolution



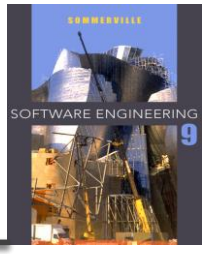
- Software is inherently flexible and can change.
- As requirements change through changing business circumstances, the software that supports the business must also evolve and change.

Key points

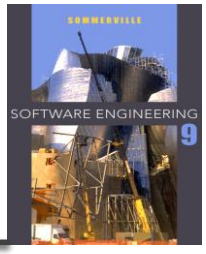


- Software processes are the activities involved in producing a software system. Software process models are abstract representations of these processes.
- General process models describe the organization of software processes. Examples of these general models include the ‘waterfall’ model, incremental development, and reuse-oriented development.

Key points

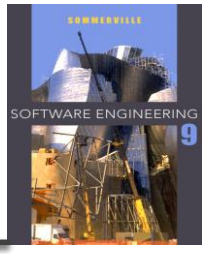


- Requirements engineering is the process of developing a software specification.
- Design and implementation processes are concerned with transforming a requirements specification into an executable software system.
- Software validation is the process of checking that the system conforms to its specification 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.



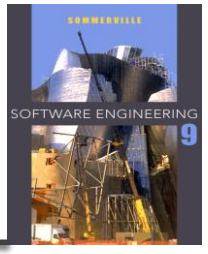
3.Case Studies

Case studies



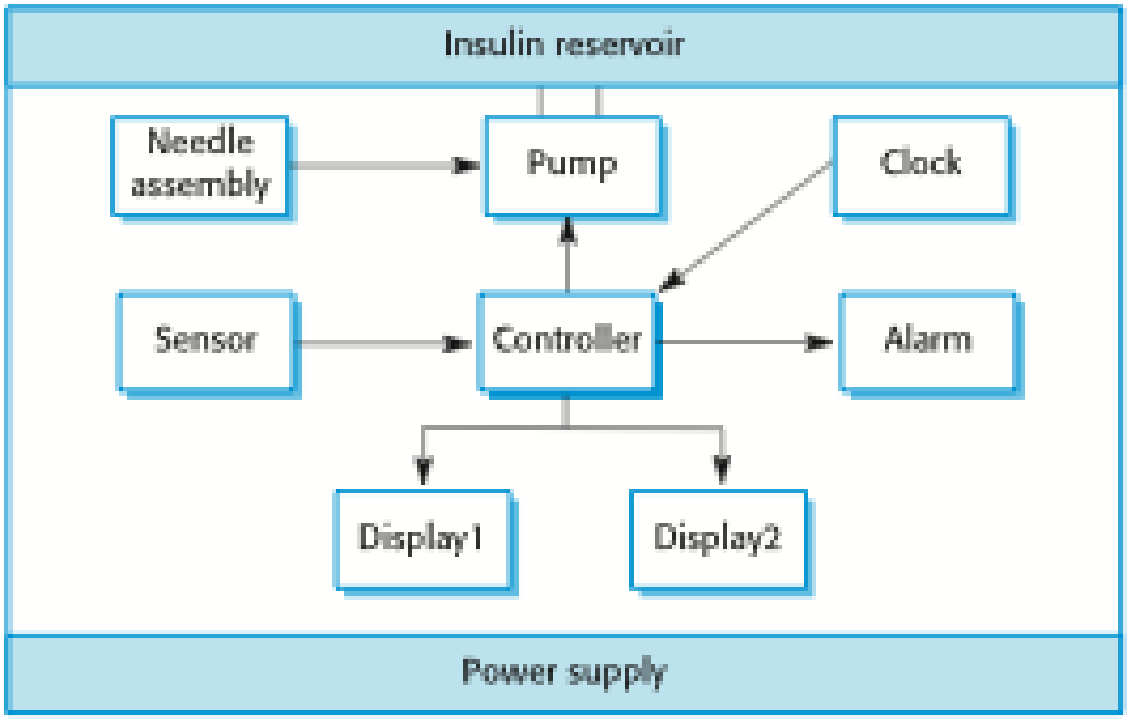
- A personal insulin pump
  - An embedded system in an insulin pump used by diabetics to maintain blood glucose control.
- A mental health case patient management system
  - A system used to maintain records of people receiving care for mental health problems.
- A wilderness weather station
  - A data collection system that collects data about weather conditions in remote areas.

Insulin pump control system

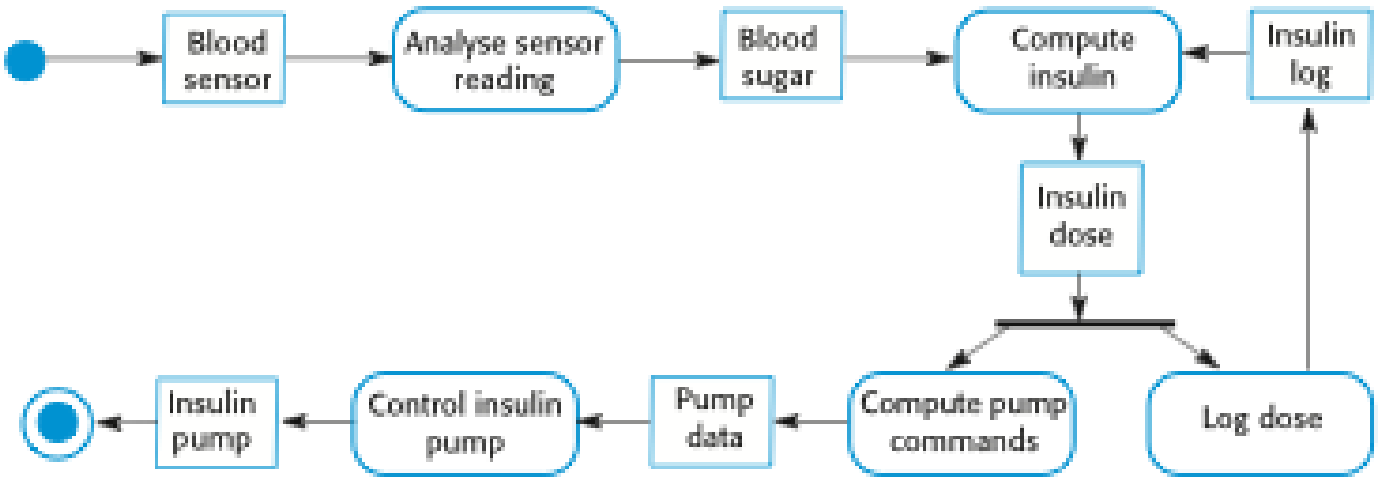


- Collects data from a blood sugar sensor and calculates the amount of insulin required to be injected.
- Calculation based on the rate of change of blood sugar levels.
- Sends signals to a micro-pump to deliver the correct dose of insulin.
- Safety-critical system as low blood sugars can lead to brain malfunctioning, coma and death; high-blood sugar levels have long-term consequences such as eye and kidney damage.

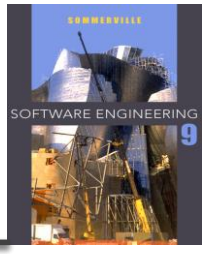
Insulin pump hardware architecture



Activity model of the insulin pump

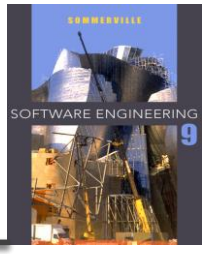


Essential high-level requirements



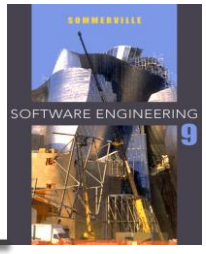
- The system shall be available to deliver insulin when required.
- The system shall perform reliably and deliver the correct amount of insulin to counteract the current level of blood sugar.
- The system must therefore be designed and implemented to ensure that the system always meets these requirements.

A patient information system for mental health care



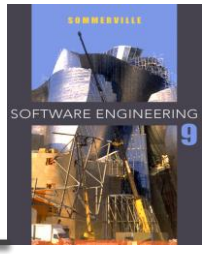
- A patient information system to support mental health care is a medical information system that maintains information about patients suffering from mental health problems and the treatments that they have received.
- Most mental health patients do not require dedicated hospital treatment but need to attend specialist clinics regularly where they can meet a doctor who has detailed knowledge of their problems.
- To make it easier for patients to attend, these clinics are not just run in hospitals. They may also be held in local medical practices or community centres.

MHC-PMS



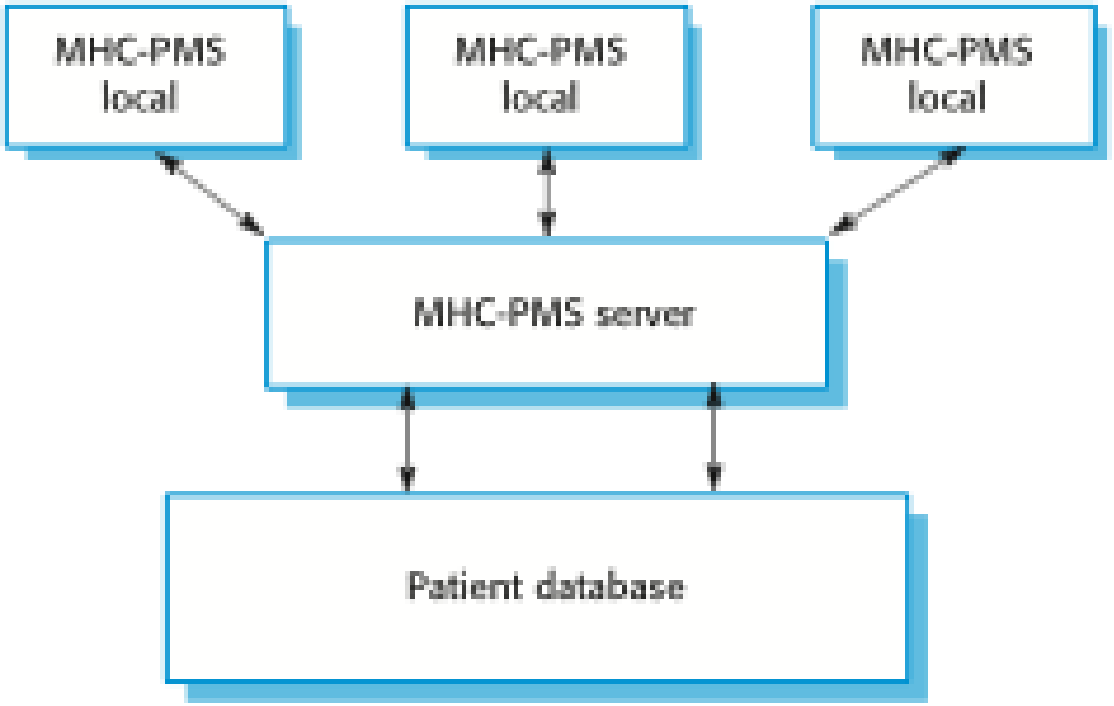
- The MHC-PMS (Mental Health Care-Patient Management System) is an information system that is intended for use in clinics.
- It makes use of a centralized database of patient information but has also been designed to run on a PC, so that it may be accessed and used from sites that do not have secure network connectivity.
- When the local systems have secure network access, they use patient information in the database but they can download and use local copies of patient records when they are disconnected.

MHC-PMS goals

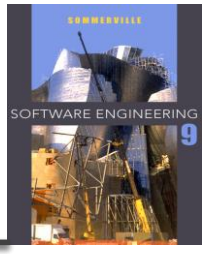


- To generate management information that allows health service managers to assess performance against local and government targets.
- To provide medical staff with timely information to support the treatment of patients.

The organization of the MHC-PMS

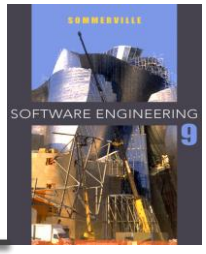


MHC-PMS key features



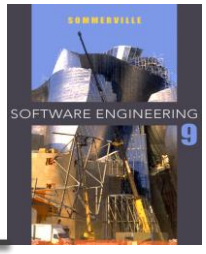
- ✧ Individual care management
  - Clinicians can create records for patients, edit the information in the system, view patient history, etc. The system supports data summaries so that doctors can quickly learn about the key problems and treatments that have been prescribed.
- ✧ Patient monitoring
  - The system monitors the records of patients that are involved in treatment and issues warnings if possible problems are detected.
- ✧ Administrative reporting
  - The system generates monthly management reports showing the number of patients treated at each clinic, the number of patients who have entered and left the care system, number of patients sectioned, the drugs prescribed and their costs, etc.

MHC-PMS concerns



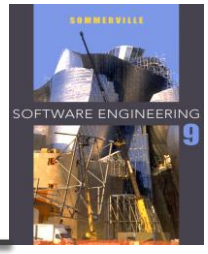
- Privacy
  - It is essential that patient information is confidential and is never disclosed to anyone apart from authorised medical staff and the patient themselves.
- Safety
  - Some mental illnesses cause patients to become suicidal or a danger to other people. Wherever possible, the system should warn medical staff about potentially suicidal or dangerous patients.
  - The system must be available when needed otherwise safety may be compromised and it may be impossible to prescribe the correct medication to patients.

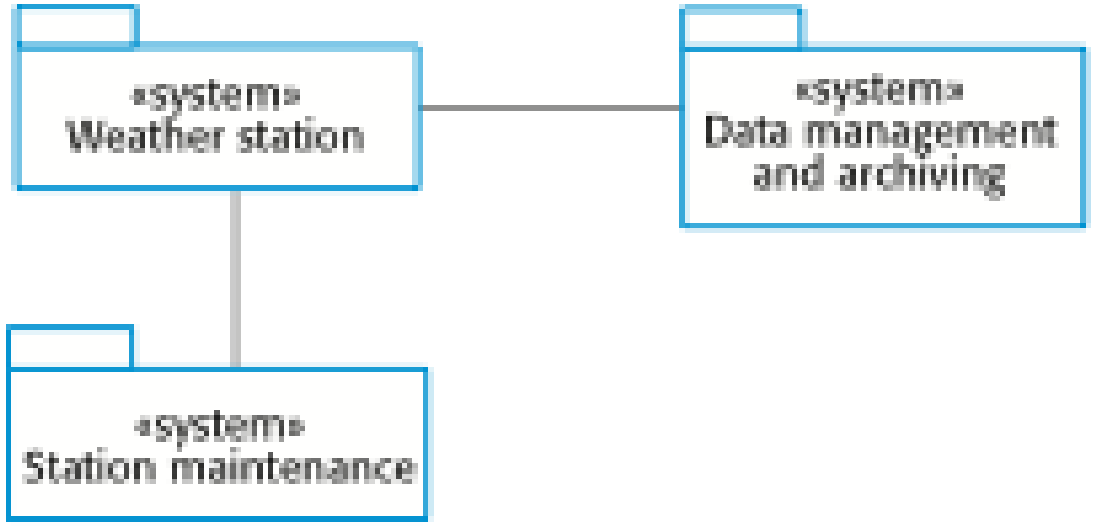
Wilderness weather station



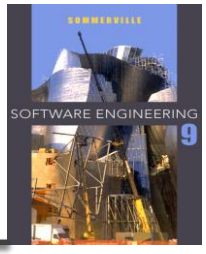
- The government of a country with large areas of wilderness decides to deploy several hundred weather stations in remote areas.
- Weather stations collect data from a set of instruments that measure temperature and pressure, sunshine, rainfall, wind speed and wind direction.
  - The weather station includes a number of instruments that measure weather parameters such as the wind speed and direction, the ground and air temperatures, the barometric pressure and the rainfall over a 24-hour period. Each of these instruments is controlled by a software system that takes parameter readings periodically and manages the data collected from the instruments.

The weather station's environment



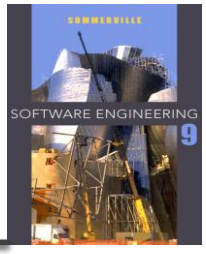


Weather information system



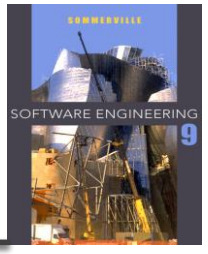
- The weather station system
  - This is responsible for collecting weather data, carrying out some initial data processing and transmitting it to the data management system.
- The data management and archiving system
  - This system collects the data from all of the wilderness weather stations, carries out data processing and analysis and archives the data.
- The station maintenance system
  - This system can communicate by satellite with all wilderness weather stations to monitor the health of these systems and provide reports of problems.

Additional software functionality



- Monitor the instruments, power and communication hardware and report faults to the management system.
- Manage the system power, ensuring that batteries are charged whenever the environmental conditions permit but also that generators are shut down in potentially damaging weather conditions, such as high wind.
- Support dynamic reconfiguration where parts of the software are replaced with new versions and where backup instruments are switched into the system in the event of system failure.

Key points



- Software engineers have responsibilities to the engineering profession and society. They should not simply be concerned with technical issues.
- Professional societies publish codes of conduct which set out the standards of behaviour expected of their members.
- Three case studies are used in the book:
  - An embedded insulin pump control system
  - A system for mental health care patient management
  - A wilderness weather station