
澳 門 理 工 學 院
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# COMP223: Software Engineering

# Software Engineering Process

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# Software Process (Ch. 2)

# Introductions (1/4)

- Session objectives
  - Software process models;
  - Process activities;
  - Coping with change;
  - Process improvement.

- **Software process model:**
  - An abstract representation of a process.
  - Presents a description of a process from some particular perspective.
  - A structured set of activities required to develop a software system.

# Introductions (2/4)

- **The software process:** 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.

# Introductions (3/4)

- **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.

# Introductions (4/4)

- 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.

# Plan-driven vs. Agile processes

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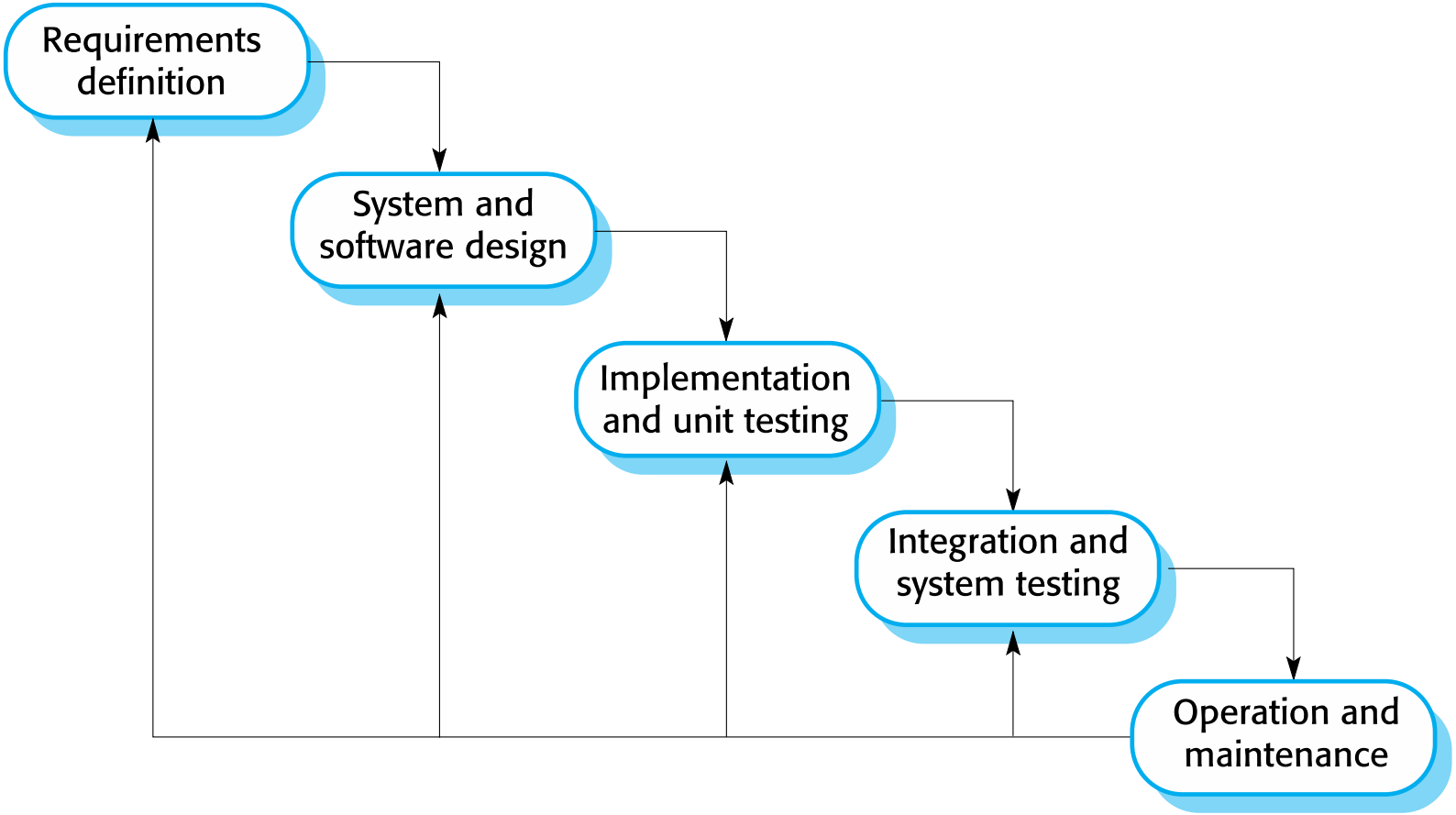
- In practice, most practical processes include elements of both plan-driven and agile approaches.
- There are no right or wrong software processes.

# Software process models (1/8)

- **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.

# Software process models (2/8)

- The waterfall model



# Software process models (3/8)

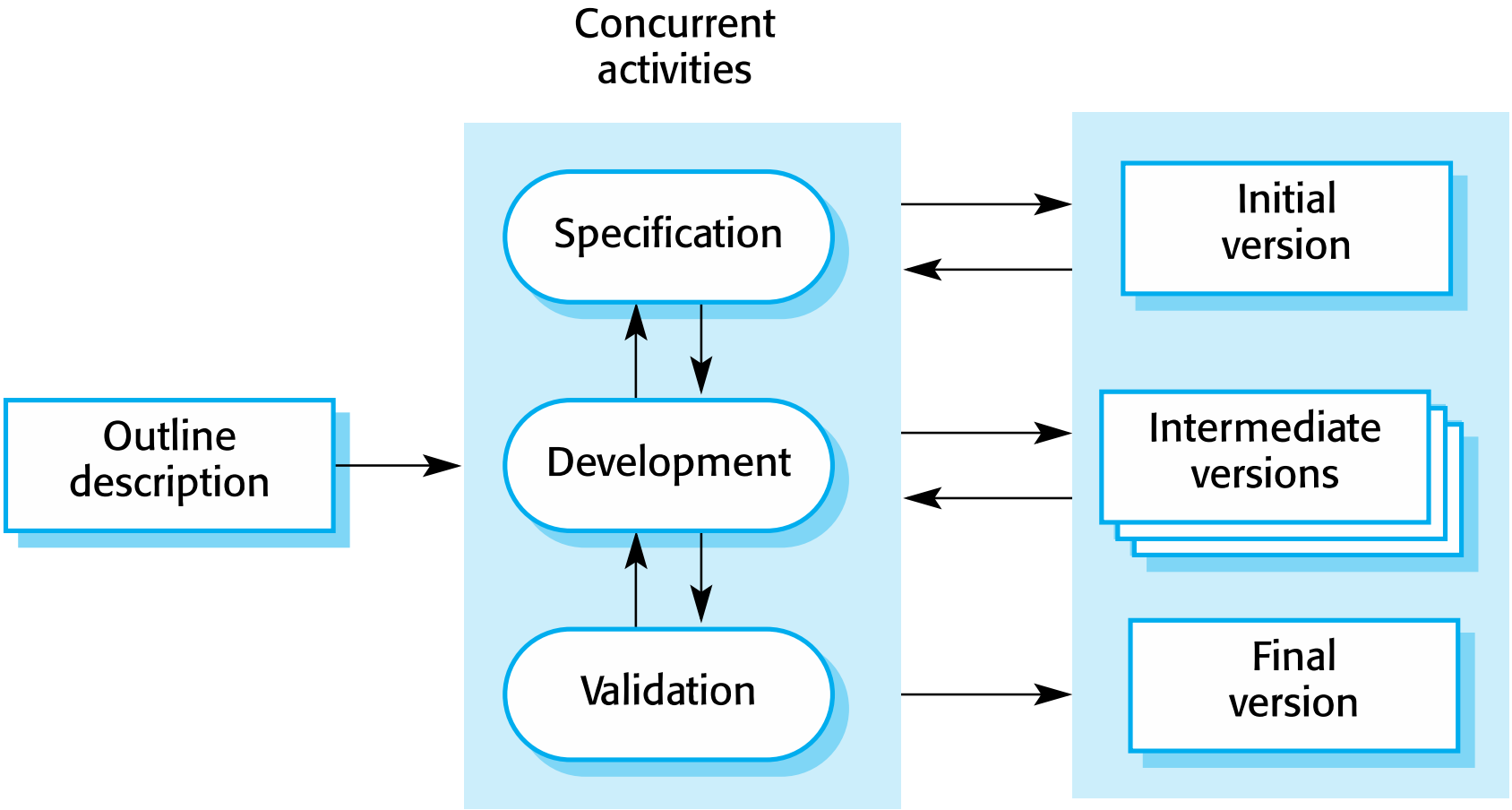
- **Waterfall model phases:** There are separate identified phases in the waterfall model:
  - Requirements analysis and definition
  - System and software design
  - Implementation and unit testing
  - Integration and system testing
  - Operation and maintenance
- The main drawback of the waterfall 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.

# Software process models (4/8)

- **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.

# Software process models (5/8)

- Incremental development



# Software process models (6/8)

- 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.

# Software process models (7/8)

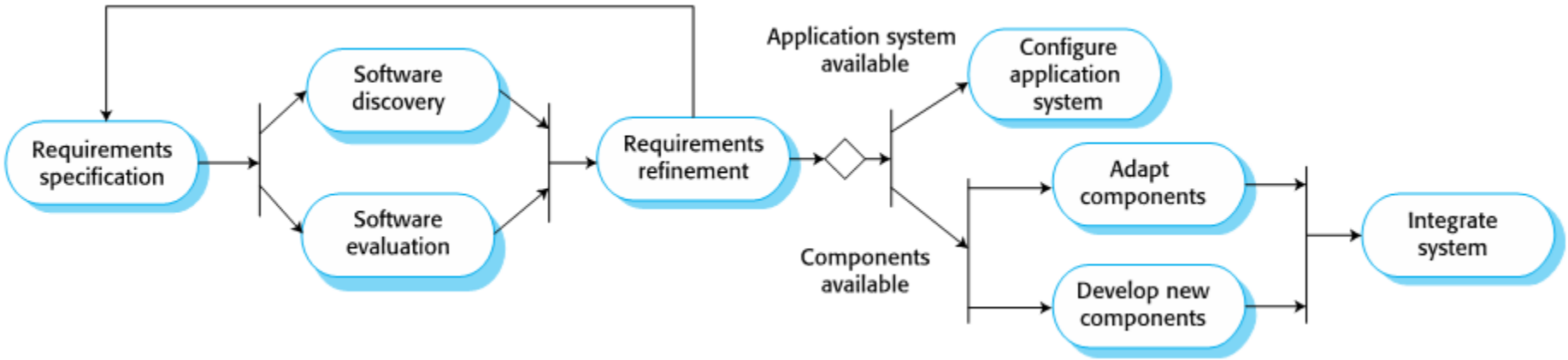
- Incremental development problems
  - The process is not visible.
    - Managers need regular deliverables to measure progress. If systems are developed quickly, it is not cost-effective to produce documents that reflect every version of the system.
  - System structure tends to degrade as new increments 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.

# Software process models (8/8)

- Integration and 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 behavior and functionality to a user's requirements.
  - Reuse is now the standard approach for building many types of business system.

# Reusable Software (1/2)

- 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.



# Reusable Software (2/2)

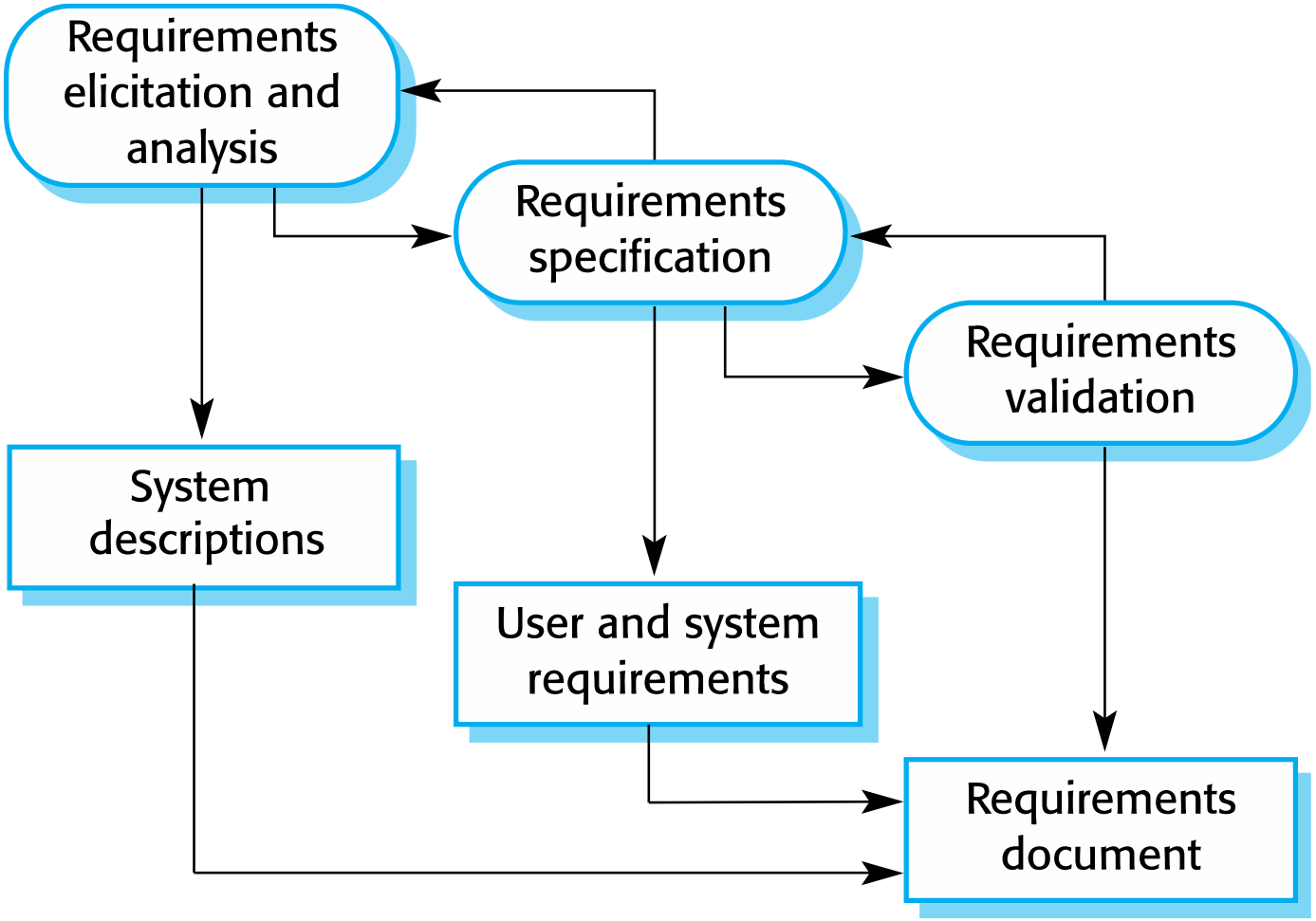
- Key process stages:
  - Requirements specification
  - Software discovery and evaluation
  - Requirements refinement
  - Application system configuration
  - Component adaptation and integration
- Advantages and disadvantages:
  - Reduced costs and risks as less software is developed from scratch.
  - 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 Activity (1/10)

- 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.

# Process Activity (2/10)

- The requirements engineering process

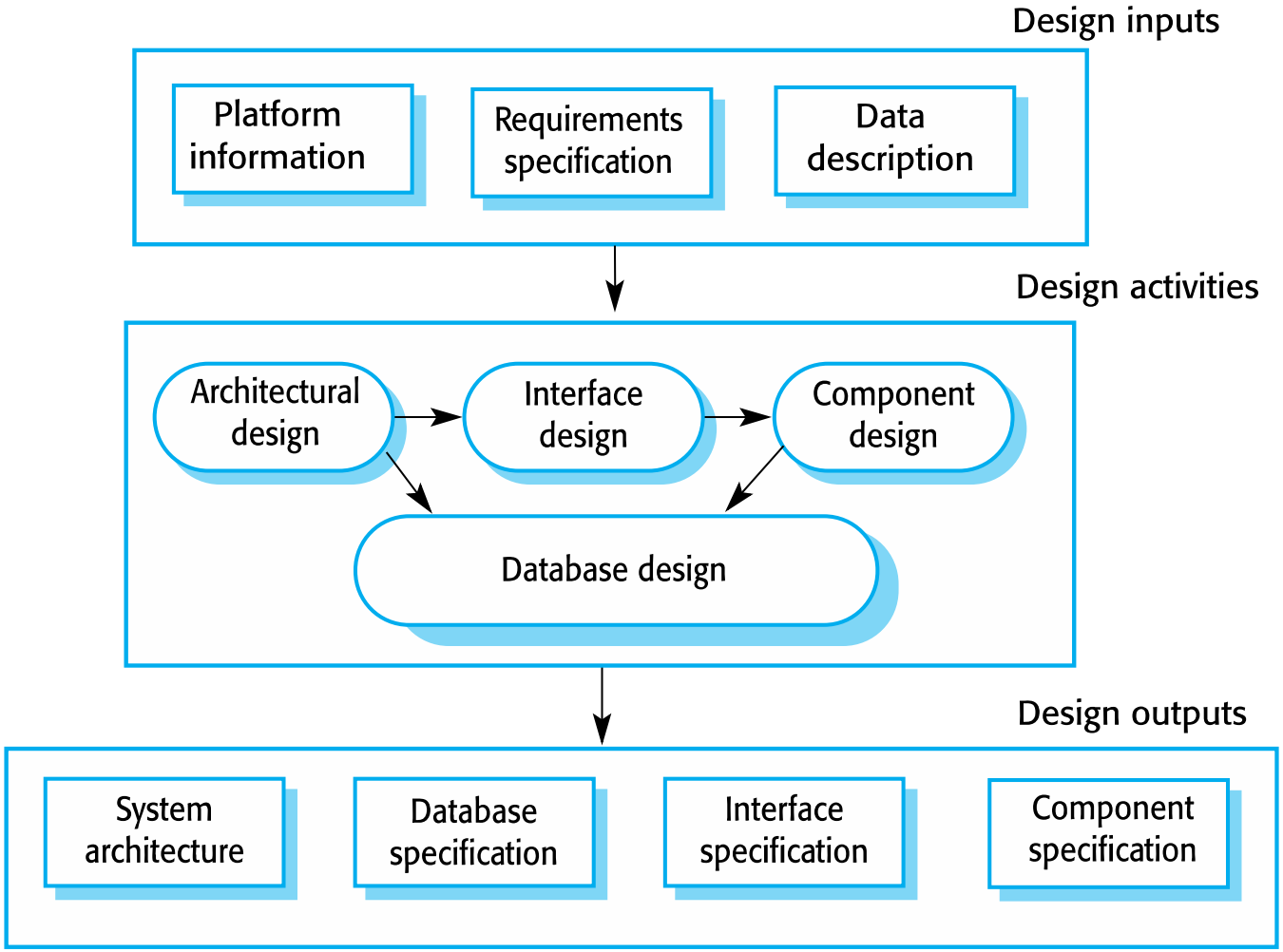


# Process Activity (3/10)

- 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
  - **Software design** − Design a software structure that realizes the specification
  - **Implementation** − Translate this structure into an executable program

# Process Activity (4/10)

- A general model of the design process



# Process Activity (5/10)

- **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.

# Process Activity (6/10)

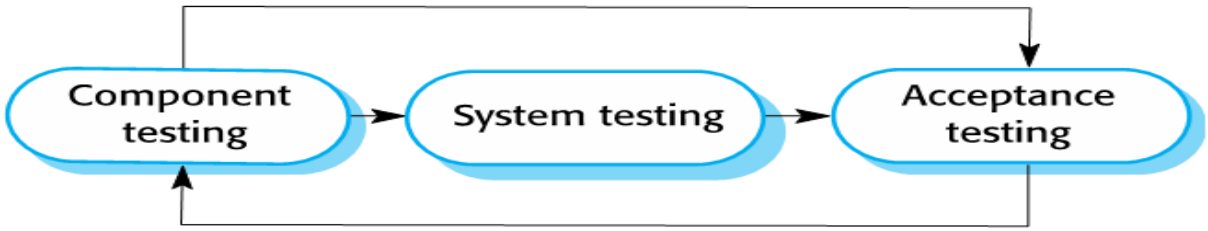
- System implementation
  - The software is implemented either by developing a program or programs or by configuring an application system.
  - Design and implementation are interleaved activities for most types of software system.
  - Programming is an individual activity with no standard process.
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

# Process Activity (7/10)

- 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.

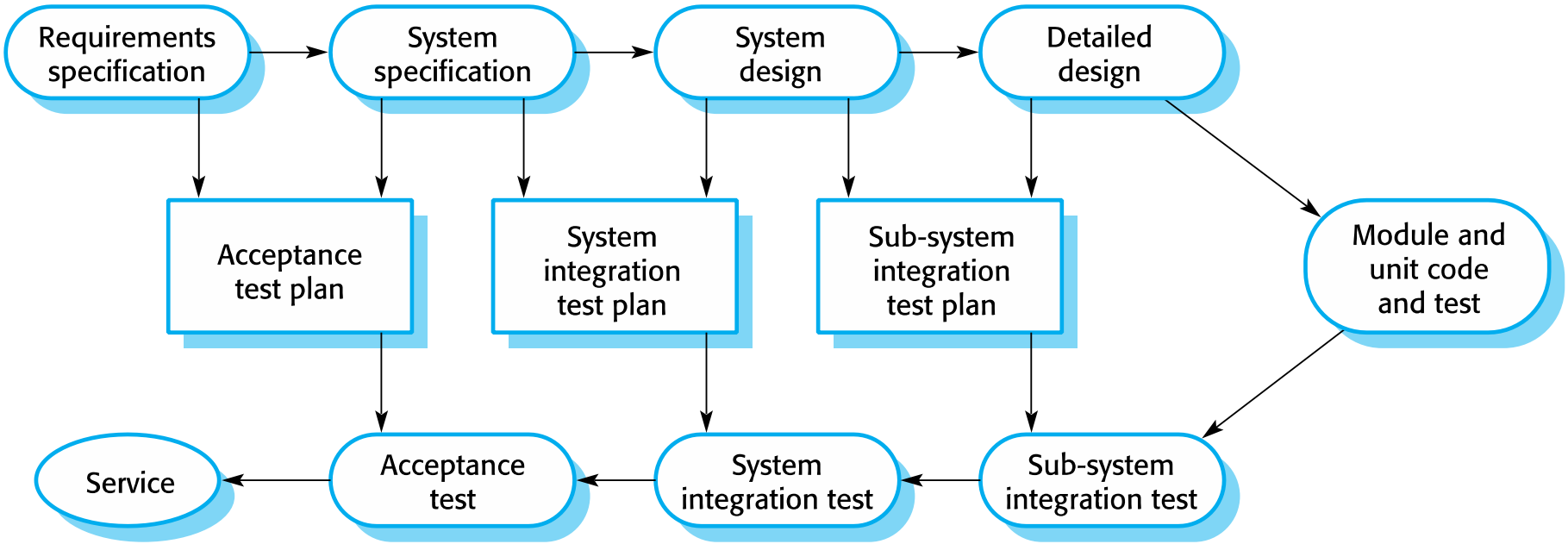
# Process Activity (8/10)

- 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 needs of customers.



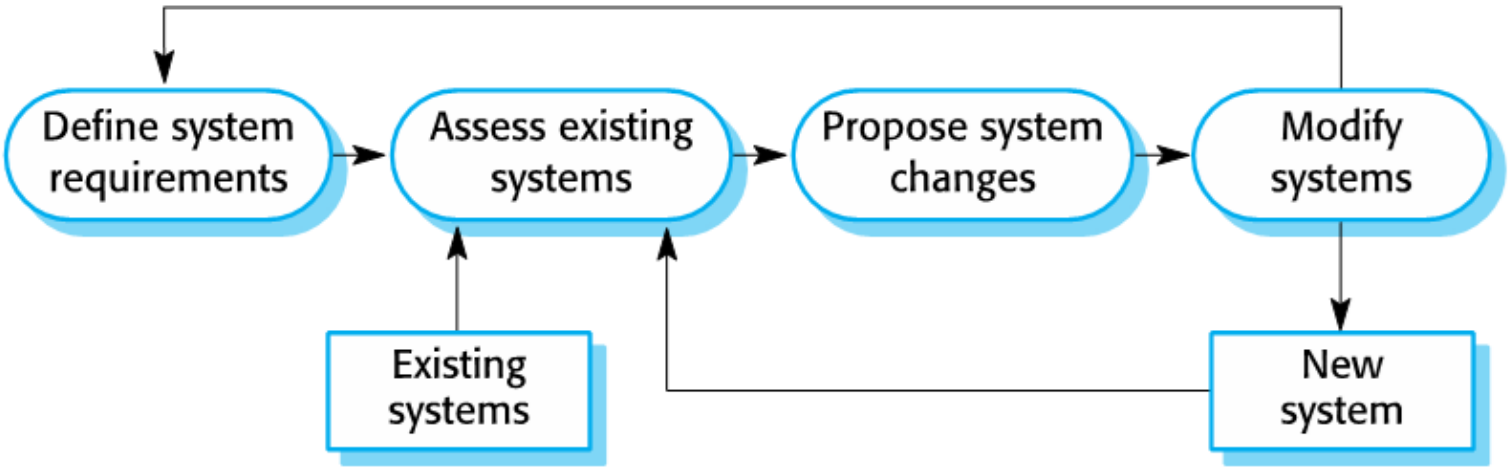
# Process Activity (9/10)

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



# Process Activity (10/10)

- Software evolution
  - Software is inherently **flexible** and can be changed.
  - 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.



# Coping with change (1/11)

- Change is inevitable in all large software projects.
  - Business changes lead to new and changed system requirements.
  - New technologies open up new possibilities for improving implementations.
  - Changing platforms require application changes.

- Change leads to rework so the costs of change include both rework (e.g. re-analyzing requirements) as well as the costs of implementing new functionality

# Coping with change (3/11)

- Reducing the costs of rework:
  - Change anticipation, where the software process includes activities that can anticipate possible changes before significant rework is required.
    - For example, a prototype system may be developed to show some key features of the system to customers.
  - Change tolerance, where the process is designed so that changes can be accommodated at relatively low cost.
    - This normally involves some form of incremental development. Proposed changes may be implemented in increments that have not yet been developed. If this is impossible, then only a single increment (a small part of the system) may have be altered to incorporate the change.

# Coping with change (4/11)

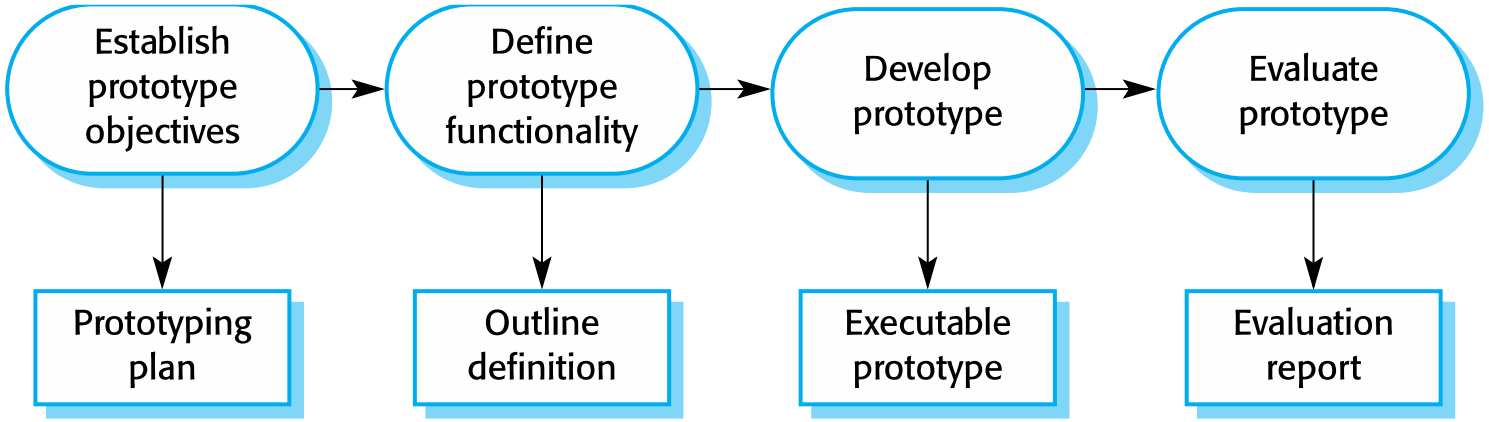
- Coping with changing requirements
  - System prototyping, where a version of the system or part of the system is developed quickly to check the customer's requirements and the feasibility of design decisions.
  - This approach supports change anticipation.
  - Incremental delivery, where system increments are delivered to the customer for comment and experimentation.
  - This supports both change avoidance and change tolerance.

# Coping with change (5/11)

- Software prototyping
  - A prototype is an initial version of a system used to demonstrate concepts and try out design options.
  - A prototype can be used in:
    - The requirements engineering process to help with requirements elicitation and validation;
    - In design processes to explore options and develop a UI design;
    - In the testing process to run back-to-back tests.
  - Benefits of prototyping
    - Improved system usability.
    - A closer match to real needs of customers.
    - Improved design quality.
    - Improved maintainability.
    - Reduced development effort.

# Coping with change (6/11)

- Prototype development
  - May be based on rapid prototyping languages or tools.
  - May involve leaving out functionality
    - Prototype should focus on areas of the product that are not well-understood;
    - **Error checking and recovery may not be included** in the prototype;
    - **Focus on functional** rather than non-functional requirements such as reliability and security.



# Coping with change (7/11)

- **Throw-away prototypes:** Prototypes should be discarded after development as they are not a good basis for a production system:
  - It may be impossible to tune the system to meet non-functional requirements;
  - Prototypes are normally undocumented;
  - The prototype structure is usually degraded through rapid change;
  - The prototype probably will not meet normal organisational quality standards.

# Coping with change (8/11)

- **Incremental delivery**
  - Rather than deliver the system as a single delivery, the **development and delivery is broken down into increments** with each increment delivering part of the required functionality.
  - **User requirements are prioritized** and the highest priority requirements are included in early increments.
  - Once the development of an increment is started, the requirements are frozen though requirements for later increments can continue to evolve.

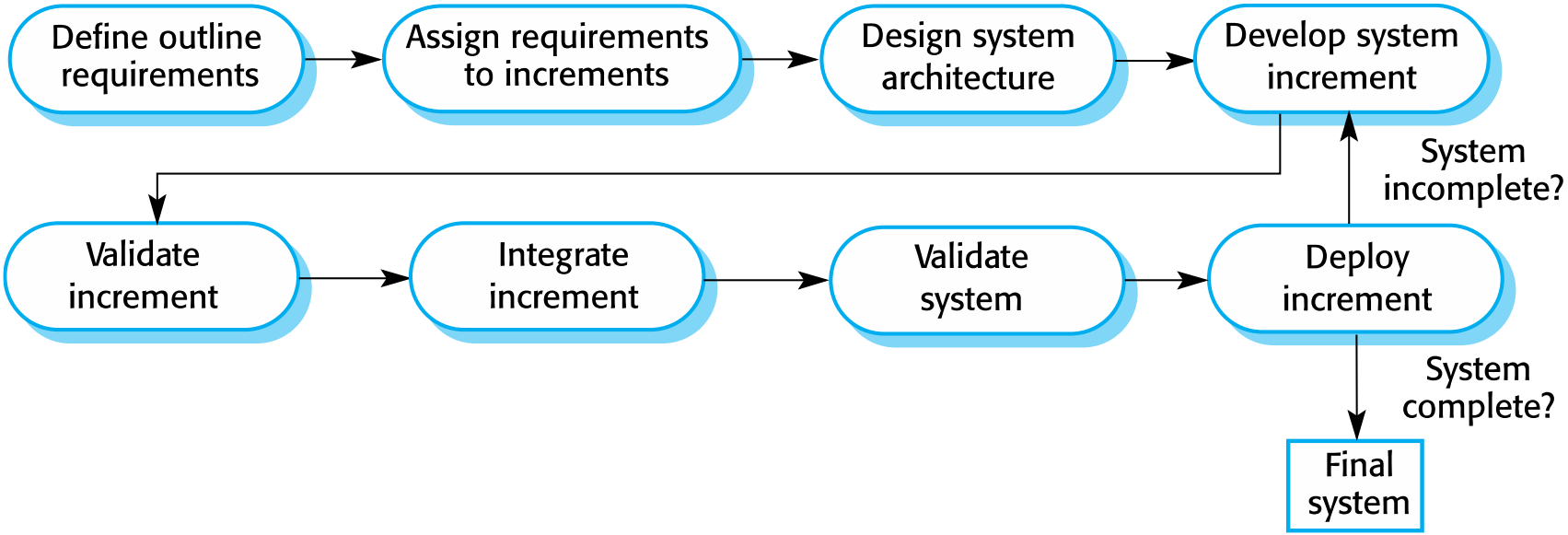
# Coping with change (9/11)

- Incremental development
  - Develop the system in increments and evaluate each increment before proceeding to the development of the next increment;
  - Normal approach used in agile methods;
  - Evaluation done by user/customer proxy.

- Incremental delivery
  - Deploy an increment for use by end-users;
  - More realistic evaluation about practical use of software;
  - Difficult to implement for replacement systems as increments have less functionality than the system being replaced.

# Coping with change (10/11)

- Incremental delivery Process

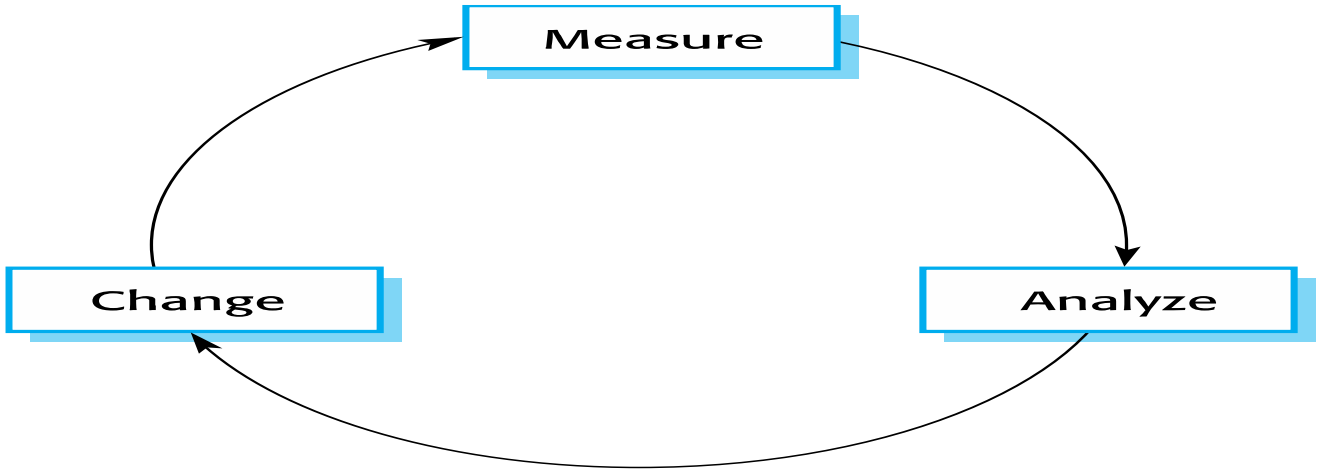


# Coping with change (11/11)

- Incremental delivery pros.
  - Customer value can be delivered with each increment so system functionality is available earlier.
  - Early increments act as a prototype to help elicit requirements for later increments.
  - Lower risk of overall project failure.
  - The highest priority system services tend to receive the most testing.
- Incremental delivery cons.
  - Most systems require a set of basic facilities that are used by different parts of the system.
  - The essence of iterative processes is that the specification is developed in conjunction with the software.

# Process improvement (1/7)

- Process Improvement
  - Many software companies have turned to software process improvement as a way of **enhancing the quality of their software (Q) , reducing costs (C) or accelerating their development processes (D).**
  - Process improvement means understanding existing processes and changing these processes to increase product quality and/or reduce costs and development time.



# Process improvement (2/7)

- Approaches to improvement
  - The process maturity approach, which focuses on improving process and project management and introducing good software engineering practice.
    - The level of process maturity reflects the extent to which good technical and management practice has been adopted in organizational software development processes.
  - The agile approach, which focuses on iterative development and the reduction of overheads in the software process.
    - The primary characteristics of agile methods are rapid delivery of functionality and responsiveness to changing customer requirements.

# Process improvement (3/7)

- Process improvement activities:
  - Process measurement
    - You measure one or more attributes of the software process or product. These measurements forms a baseline that helps you decide if process improvements have been effective.
  - Process analysis
    - The current process is assessed, and process weaknesses and bottlenecks are identified. Process models (sometimes called process maps) that describe the process may be developed.
  - Process change
    - Process changes are proposed to address some of the identified process weaknesses. These are introduced and the cycle resumes to collect data about the effectiveness of the changes.

# Process improvement (4/7)

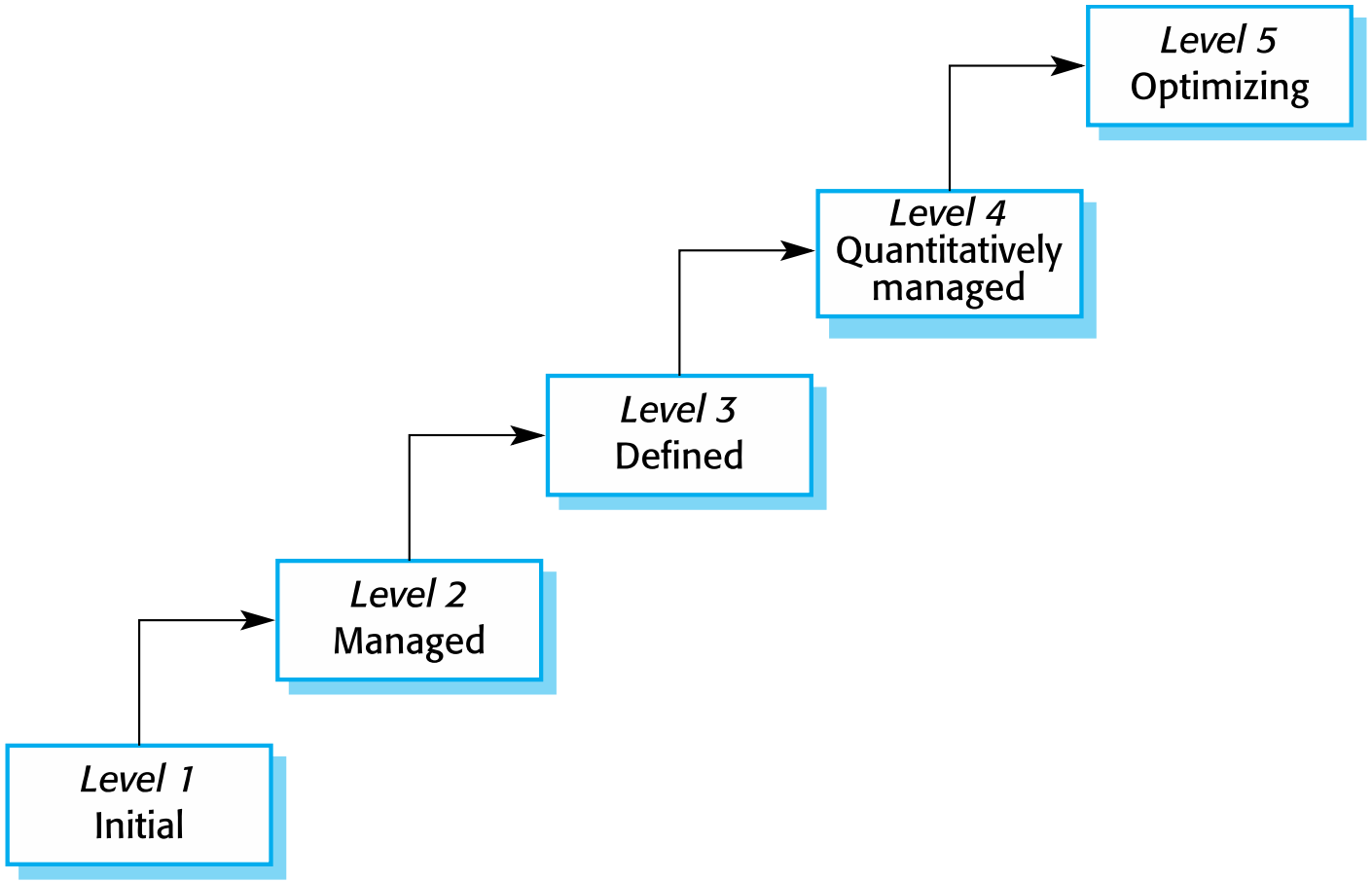
- Process measurement
  - Wherever possible, quantitative process data should be collected:
    - However, where organizations do not have clearly defined process standards this is very difficult as you do not know what to measure.
    - A process may have to be defined before any measurement is possible.
  - Process measurements should be used to assess process improvements
    - But this does not mean that measurements should drive the improvements. The improvement driver should be the organizational objectives.

# Process improvement (5/7)

- Process metrics
  - Time taken for process activities to be completed (ex. Calendar time or effort to complete an activity or process).
  - Resources required for processes or activities (ex. Total effort in person-days).
  - Number of occurrences of a particular event (ex. Number of defects discovered).

# Process improvement (6/7)

- Capability maturity levels



# Process improvement (7/7)

- The SEI (Software Engineering Institute) capability maturity model
  - **Initial:** Essentially uncontrolled
  - **Repeatable:** Product management procedures defined and used
  - **Defined:** Process management procedures and strategies defined and used
  - **Managed:** Quality management strategies defined and used
  - **Optimizing:** Process improvement strategies defined and used.

# Session Summary (1/3)

- 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.
- **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.

# Session Summary (2/3)

- **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.
- Processes should include activities such as prototyping and incremental delivery to cope with change.
- Processes may be structured for iterative development and delivery so that changes may be made without disrupting the system as a whole.

# Session Summary (3/3)

- The principal approaches to process improvement are agile approaches, geared to reducing process overheads, and maturity-based approaches based on better process management and the use of good software engineering practice.
- The SEI process maturity framework identifies maturity levels that essentially correspond to the use of good software engineering practice.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