Chapter 2 – Software Processes

Topics covered

- ✧ Software process models
- ✧ Process activities
- ✧ Coping with change
- ✧ Process improvement

فرایند

✧فرهنگ فارسی معین:

(فَ یَ) مجموعه عملیات و مراحل لازم برای رسیدن به یک هدف مشخص

مثال: فرایند تعویض لاستیک پنچر شده، فرایند پخت دلمه، فرایند ثبت‌نام دانشجو، فرایند تولید نرم‌افزار

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.

Software process descriptions

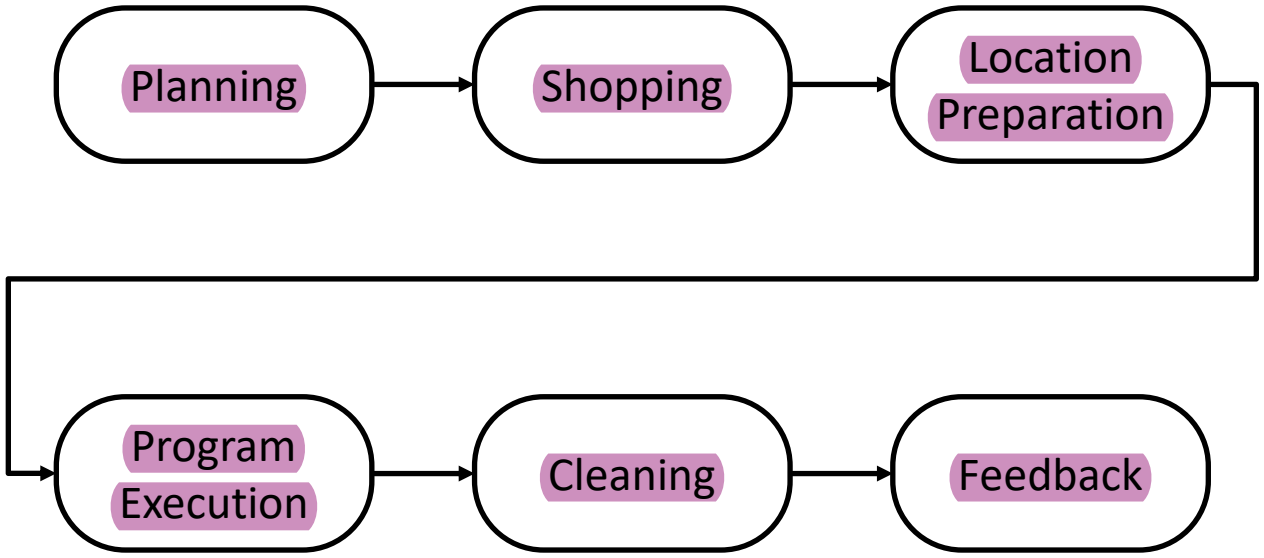
- When we describe and discuss processes, we usually talk about the activities in these processes such as specifying a data model, designing a user interface, etc. and the ordering of these activities.
- Process descriptions may also include:
  - Products, which are the outcomes of a process activity;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

Example of a process

✧ Let’s practice!

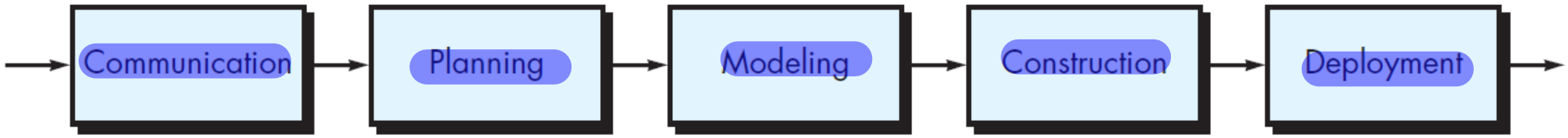
✧ Preparing for a birthday party

Birthday party



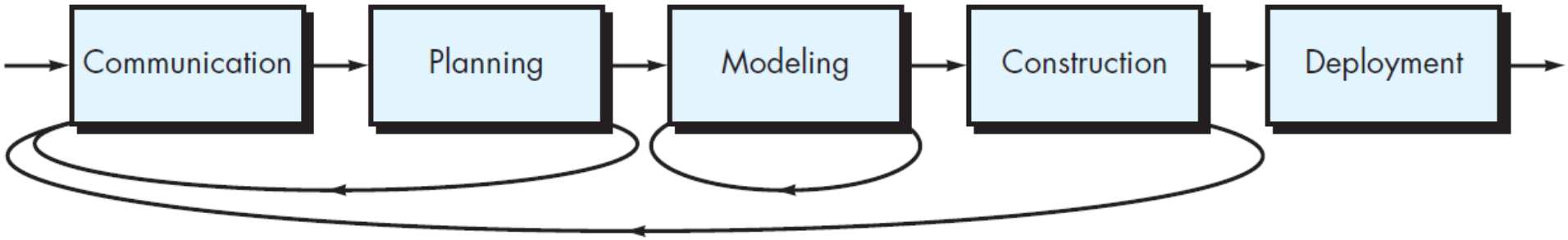
Process flow – linear process flow

- A *linear process flow* executes each of the activities in sequence, beginning with communication and culminating with deployment



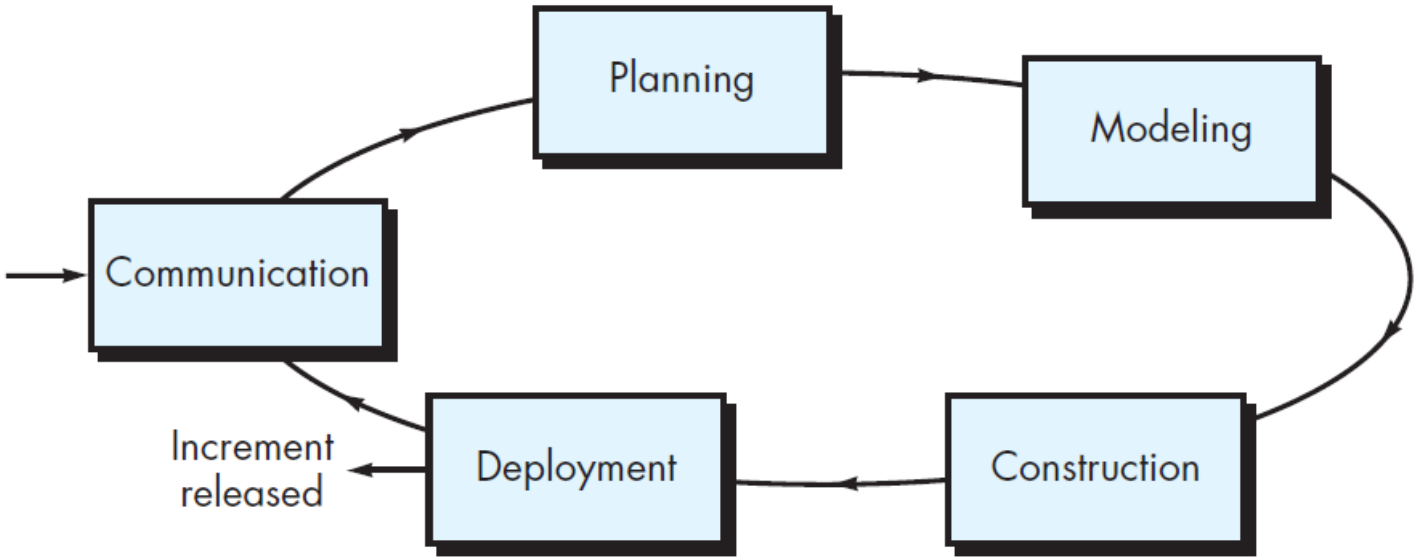
Process flow – iterative process flow

✧ An *iterative process flow* repeats one or more of the activities before proceeding to the next



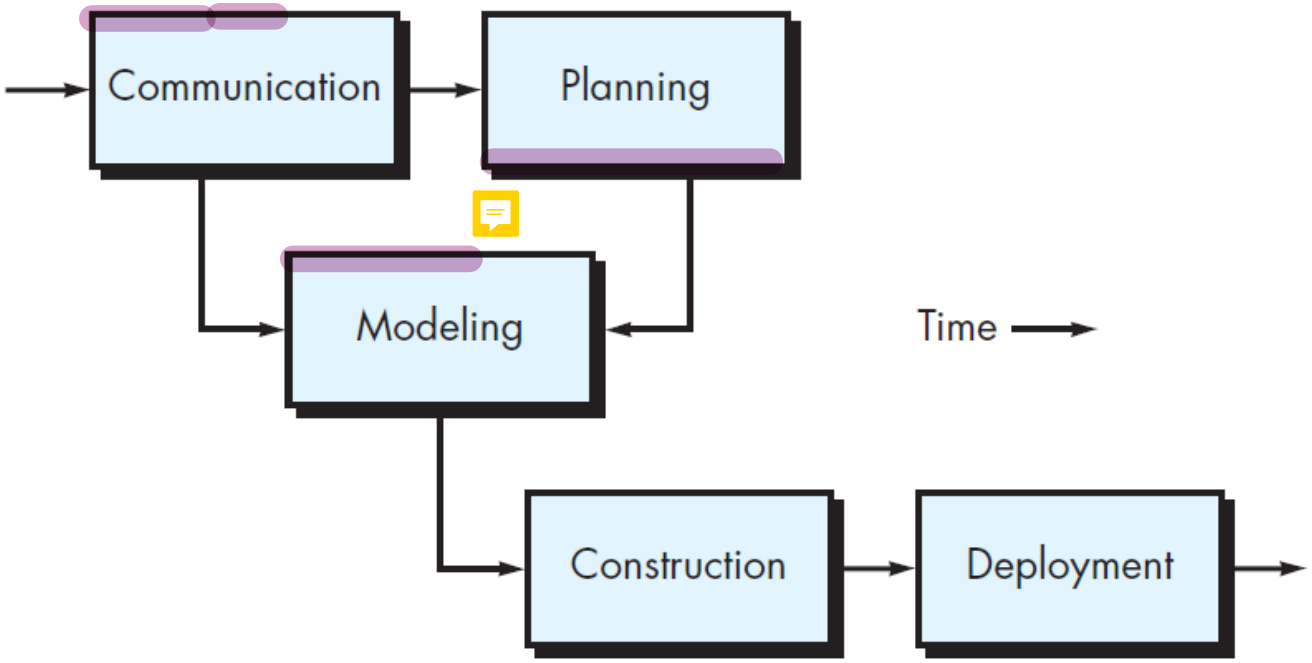
Process flow – evolutionary process flow

- An *evolutionary process flow* executes the activities in a "circular" manner. Each circuit through the five activities leads to a more complete version of the software.



Process flow – parallel process flow

- A *parallel process flow* executes one or more activities in parallel with other activities



Plan-driven and agile processes

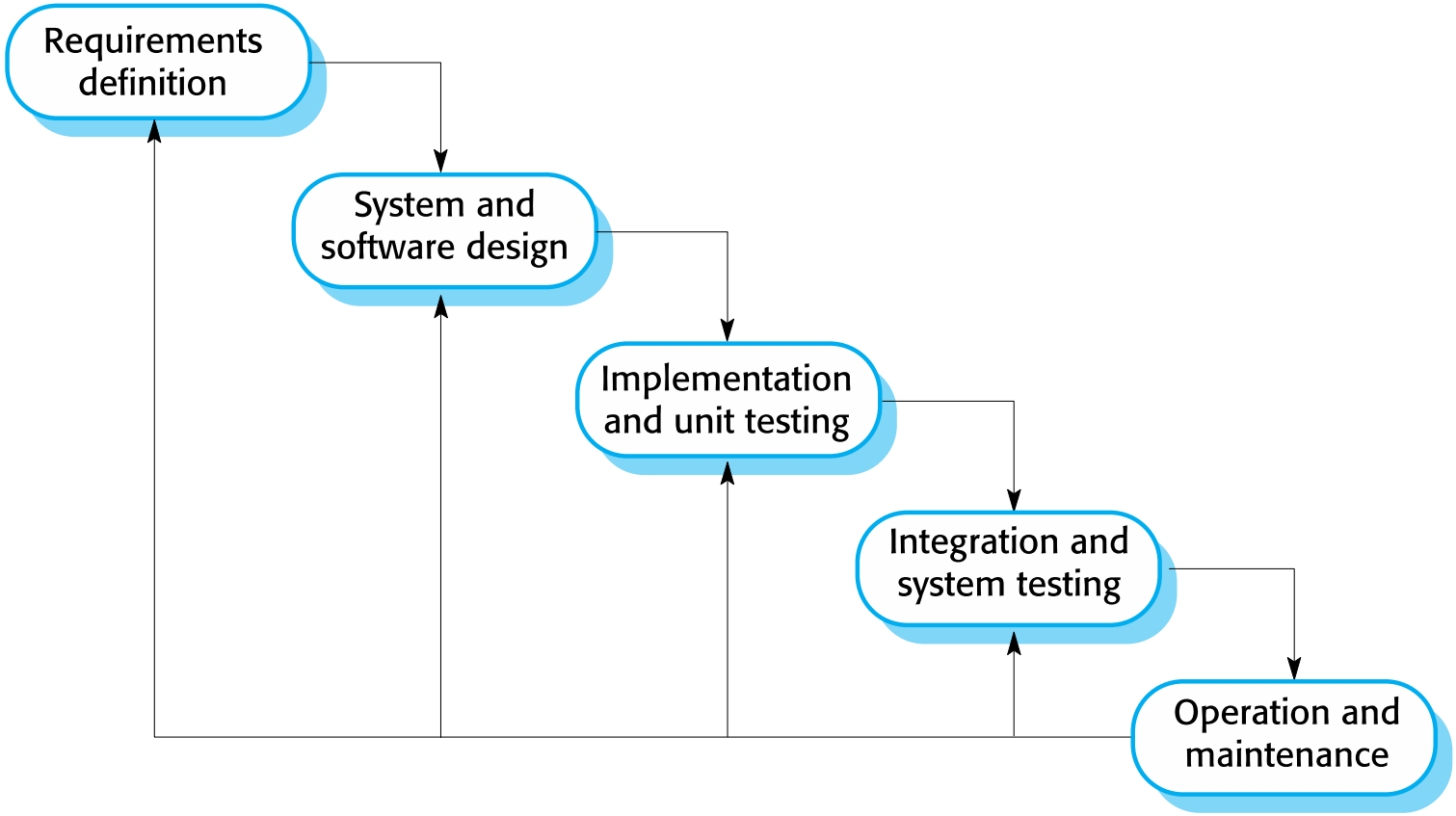
- Plan-driven processes
  - All activities are planned in advance and progress is measured against this plan.
- Agile processes
  - planning is incremental
    - Easier to change the process to reflect changing customer requirements.
- In practice, most practical processes include elements of both plan-driven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

Software process models

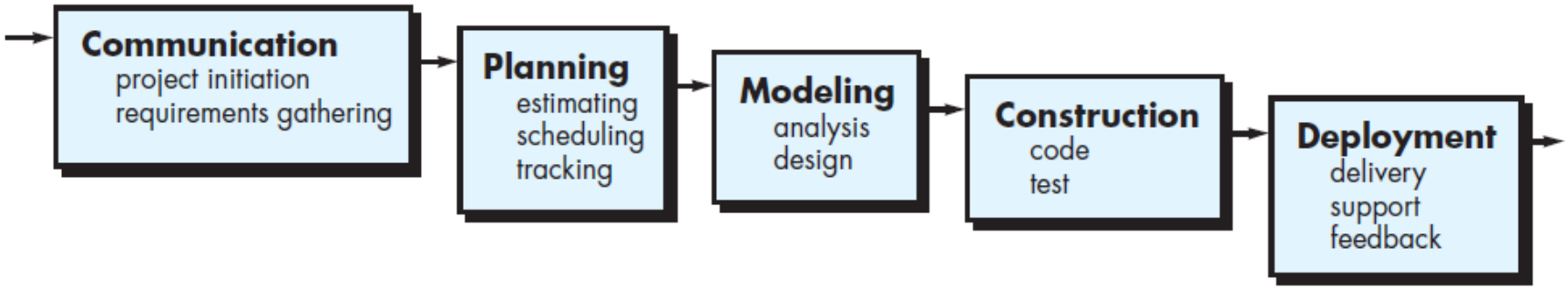
Software process models

- 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 (classic life cycle)



The waterfall model (classic life cycle)



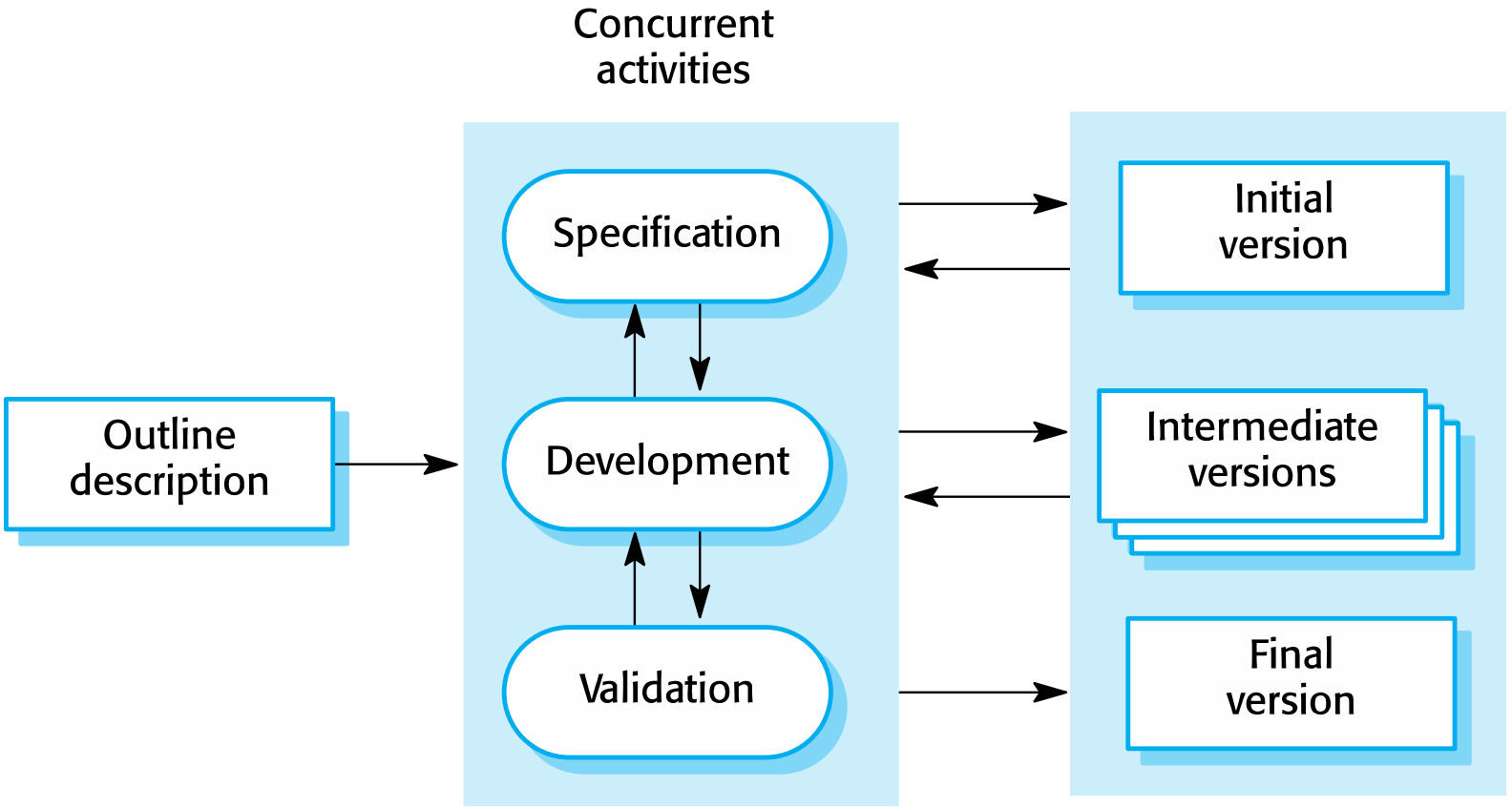
Waterfall model phases

- 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
- Main drawback
  - Difficulty of accommodating change after the process is underway.
    - 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.
  - Appropriate when
    - Requirements are well-understood
    - Changes will be fairly limited during the design process
  - Few business systems have stable requirements.
- Mostly used for
  - Large systems engineering projects
    - System is developed at several sites
    - The plan-driven nature of the waterfall model helps coordinate the work

Incremental development



Incremental development benefits

- Lower cost to accommodate changes.
  - The amount of analysis and documentation that has to be redone is much less than is required with the waterfall model.
- 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.

Incremental development problems

- Less suitable for systems that are
  - Large
  - Complex
  - Long-lifetime
  - Different teams develop different parts

- Large complex systems need
  - Stable framework
  - Clear division of responsibilities

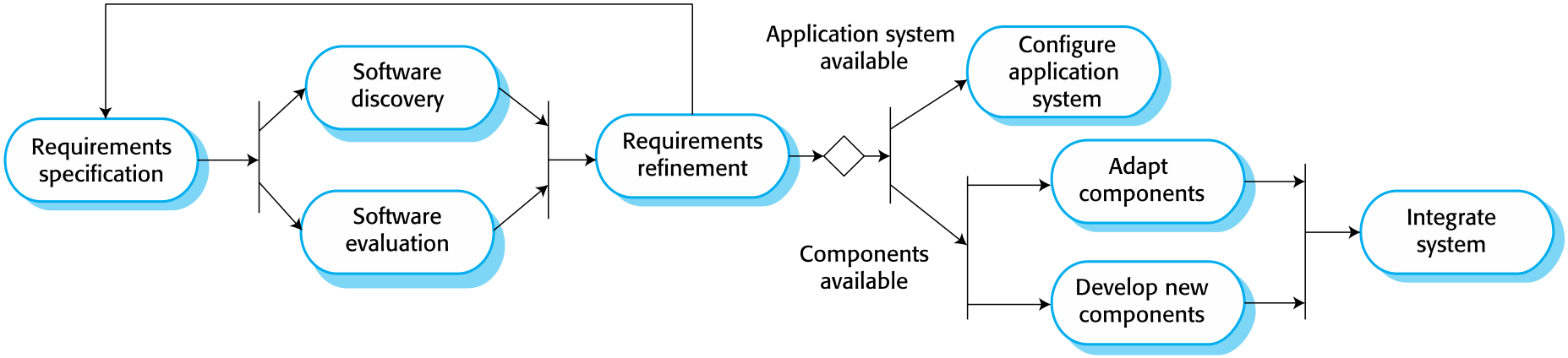
Integration and configuration

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

Types of reusable software

- Stand-alone application systems (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

Reuse-oriented software engineering

✧ Benefits:

- Reduces amount of software to be developed
  - Reduced cost
  - Reduced risk
  - Usually results in faster delivery of software

✧ Problems:

- Requirements compromises
  - Software may not meet user needs
  - No control over component evolution

Process activities

Process activities

✧ Four basic process activities:

- Specification, development, validation and evolution are organized differently in different development processes.
- In the waterfall model, they are organized in sequence
- In incremental development, they are inter-leaved

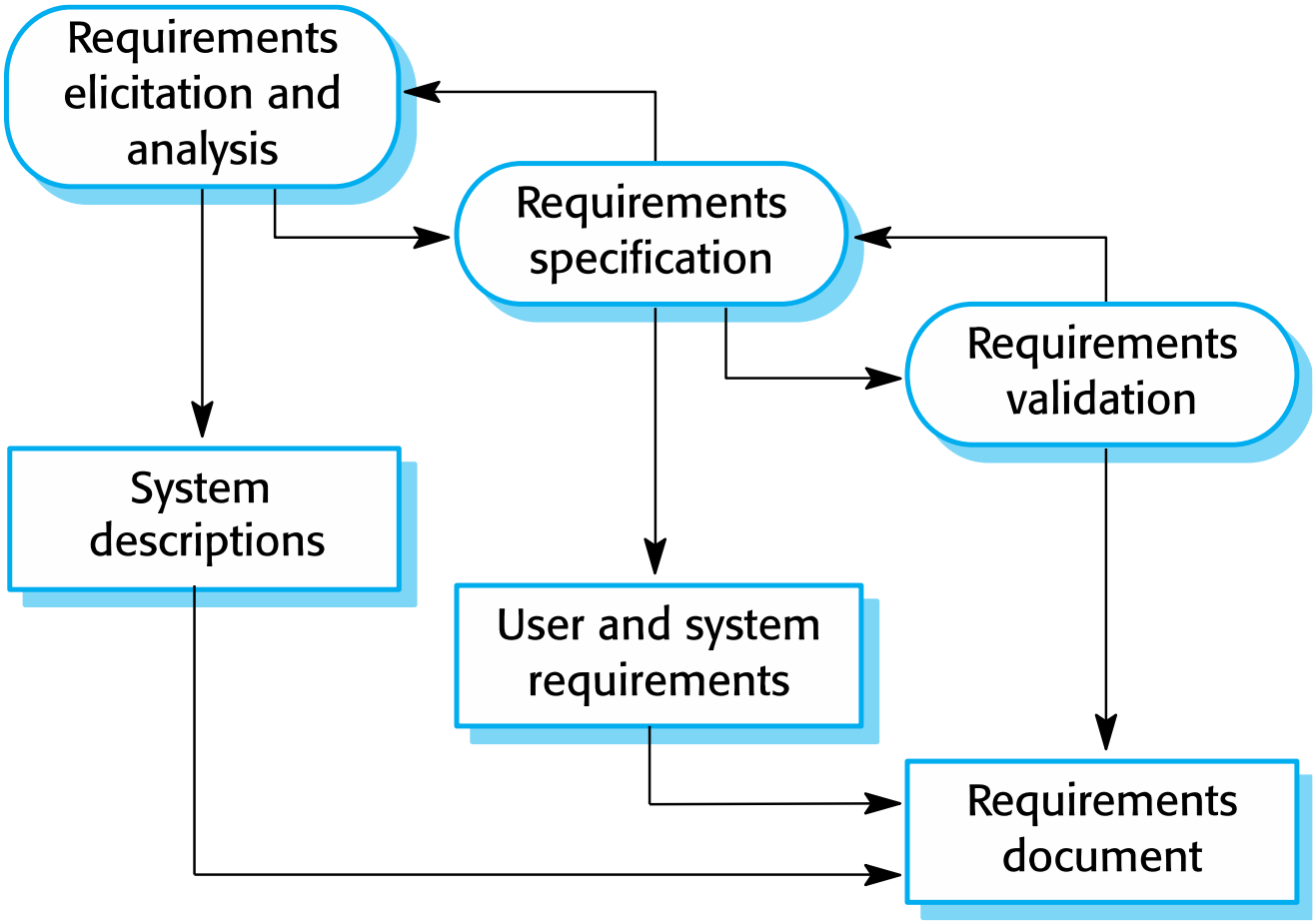
✧ Real software processes are inter-leaved sequences

- Technical, collaborative, managerial activities
- To develop a software

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

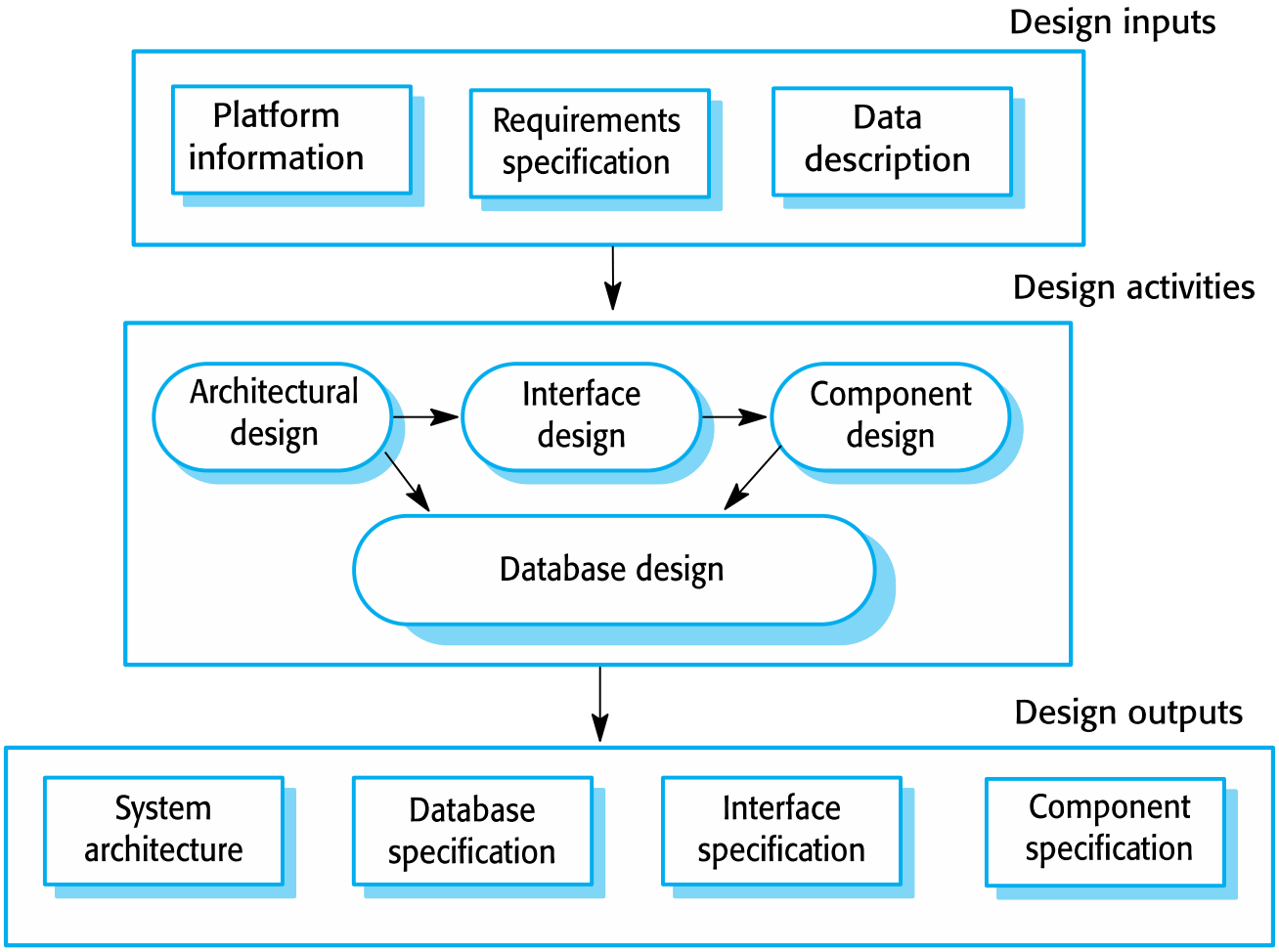
The requirements engineering process



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

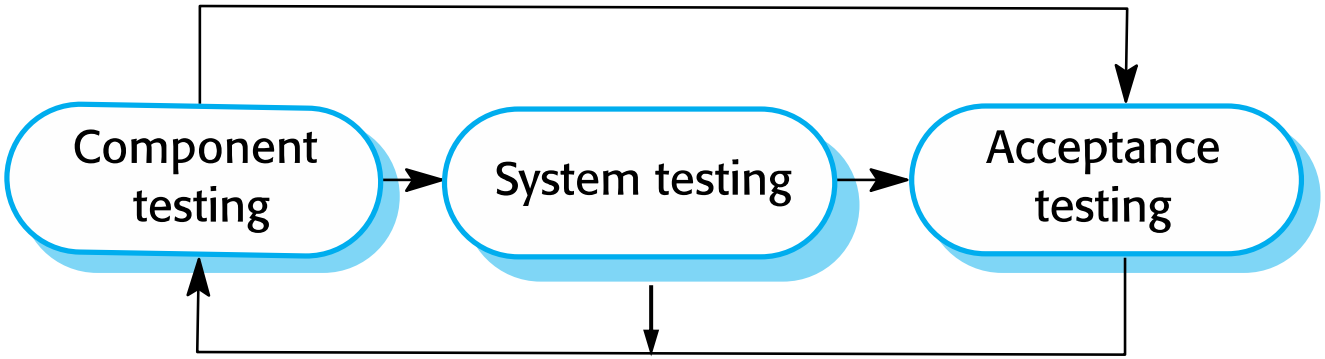
System implementation

- 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 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.

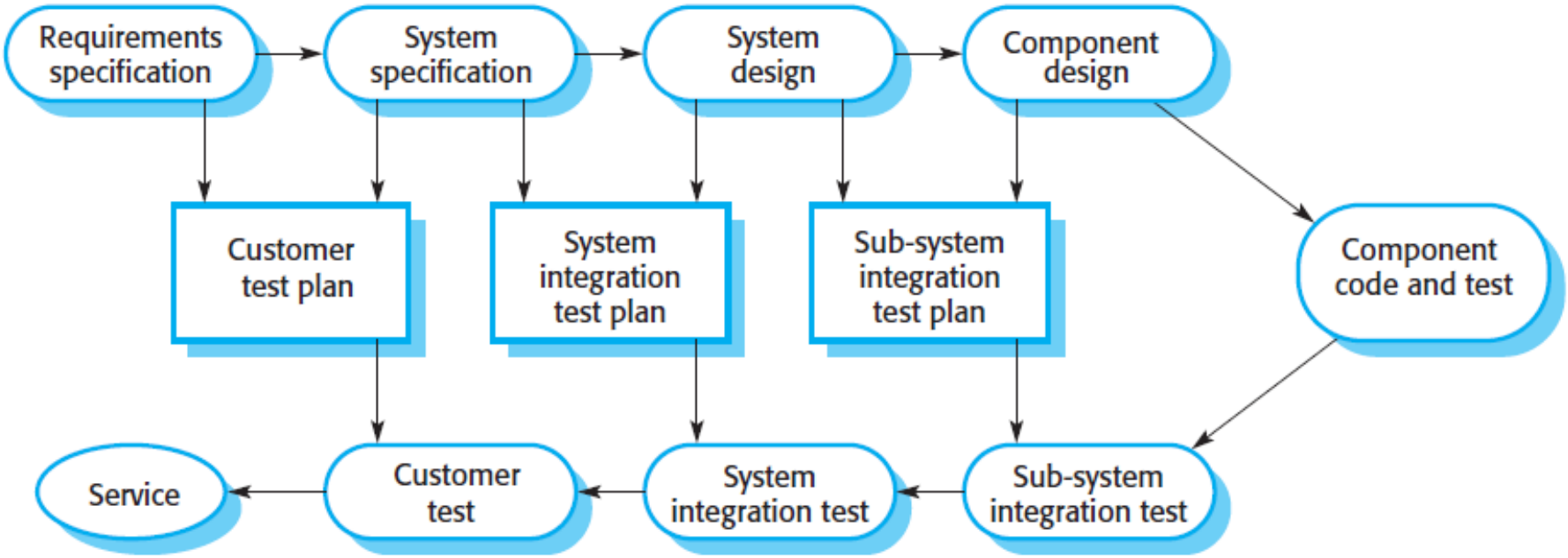
Stages of testing



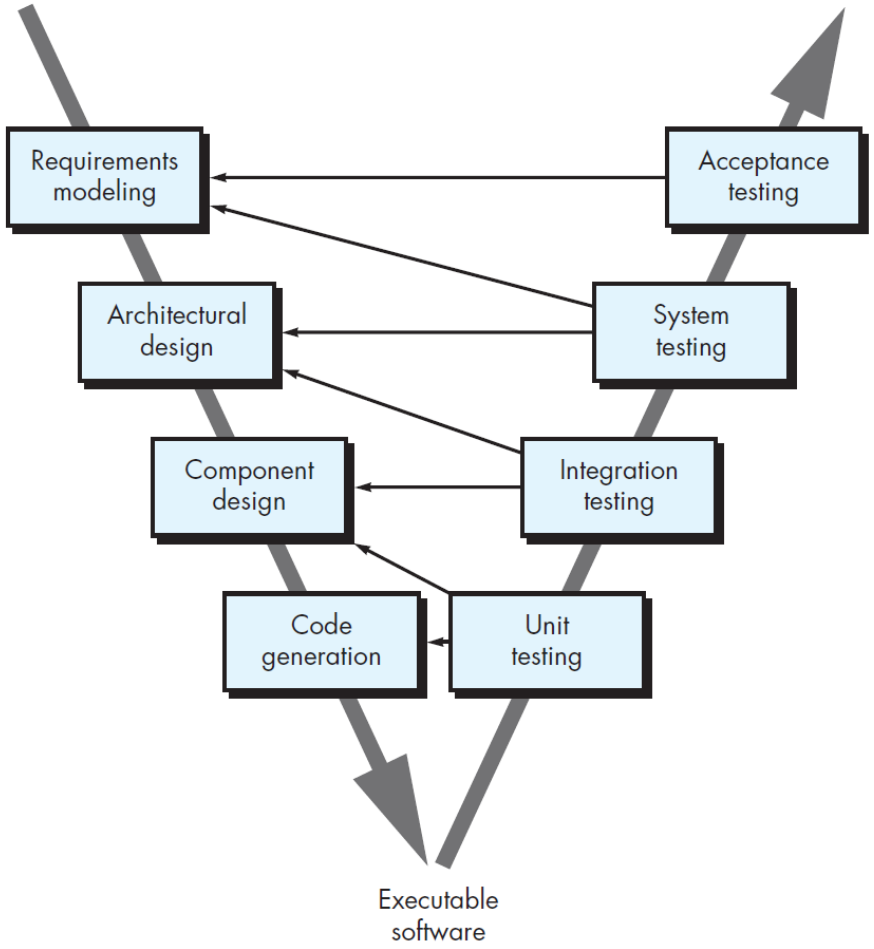
Testing stages

- 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)



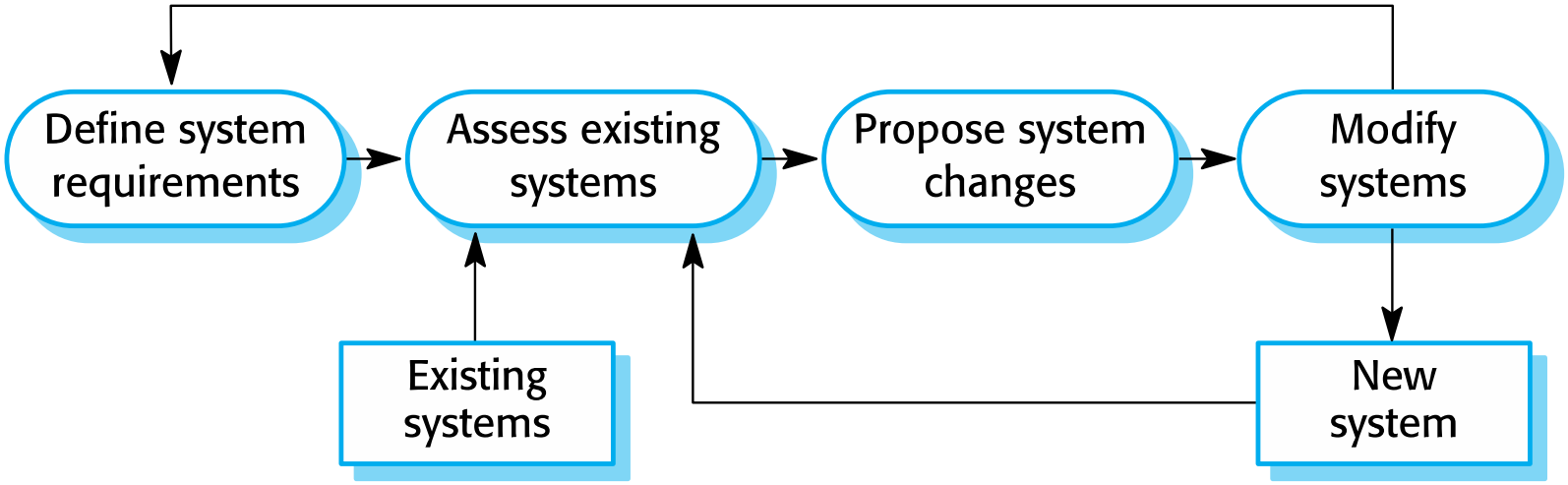
Testing phases in a plan-driven software process (V-model)



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



Coping with change

Coping with change

- 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-analysing requirements) as well as the costs of implementing new functionality

Reducing the costs of rework

1) 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.


Software Engineering
Ian Sommerville


#HondaEV


Honda e
PROTOTYPE
Honda Design

Software prototyping

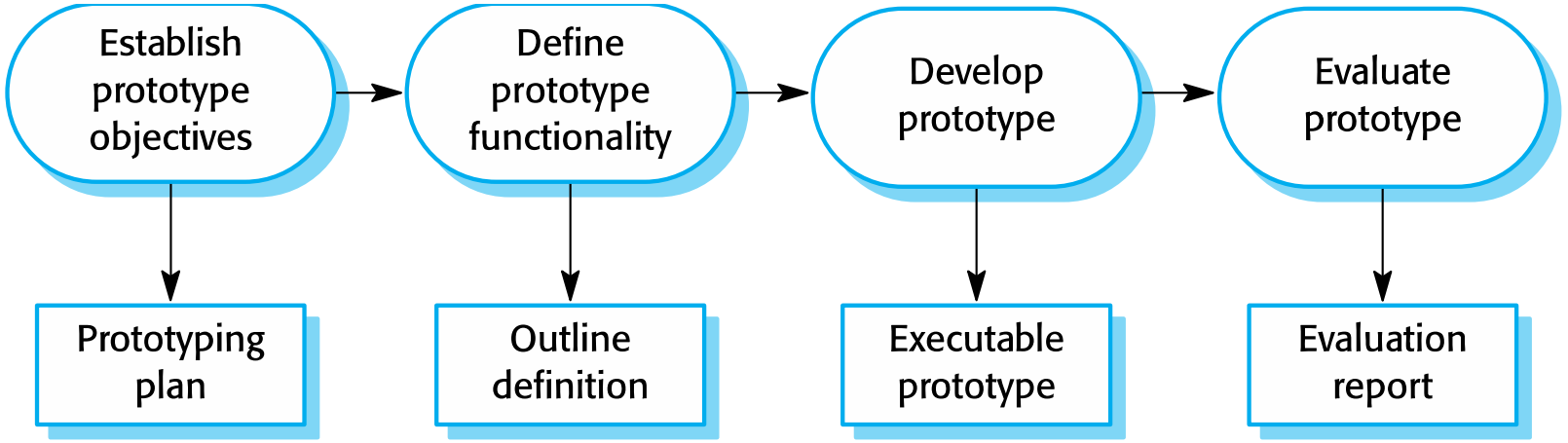
- A prototype is an initial version of a system used to demonstrate concepts and try out design options.

- 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;

Benefits of prototyping

- Improved system usability.
- A closer match to users' real needs.
- Improved design quality.
- Improved maintainability.
- Reduced development effort.

The process of prototype development



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

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 organizational quality standards.

Reducing the costs of rework

2) 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 or few increments (a small part of the system) may have to be altered to incorporate the change.

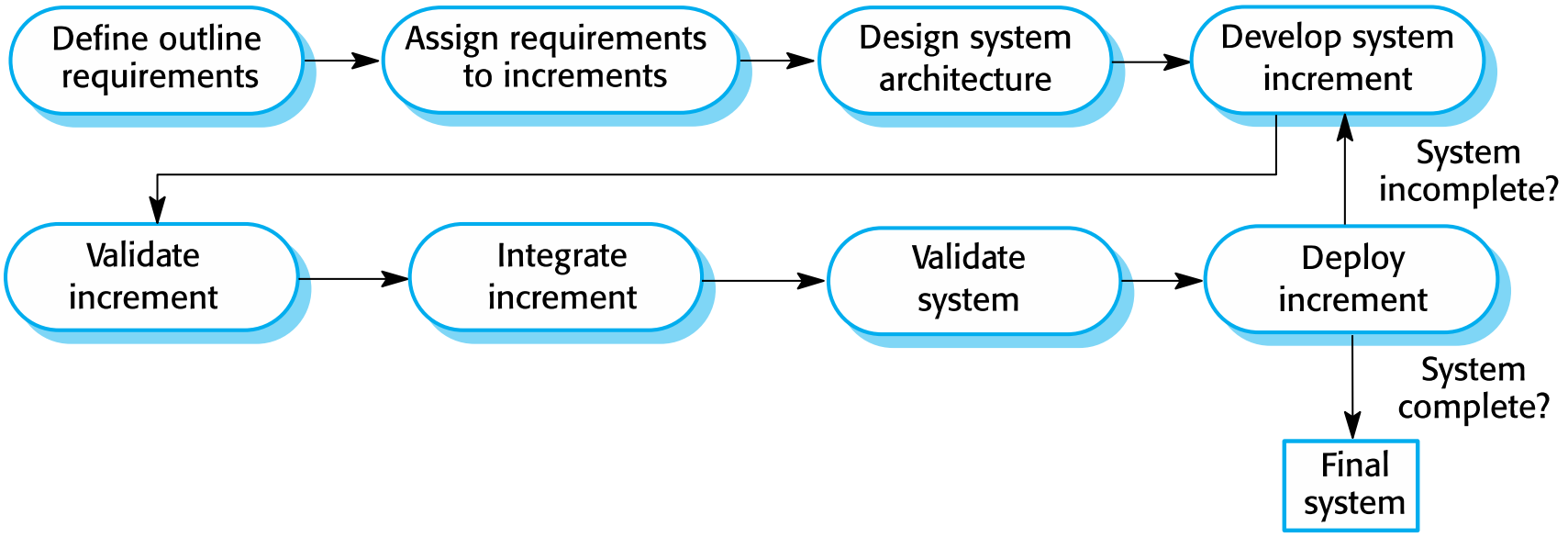
Incremental delivery

- Rather than deliver the system as a single delivery
  - Development and delivery is broken down into increment
  - Each increment delivering part of the required functionality
- User requirements are prioritised
  - Highest priority requirements are included in early increments
- Once the development of an increment is started
  - Requirements are frozen
  - Requirements for later increments can continue to evolve

Incremental development and delivery

- Incremental development
  - Develop the system in increments
    - 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
    - Increments have less functionality than the system being replaced.

Incremental delivery



Incremental delivery advantages

- 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.
- The highest priority system services tend to receive the most testing.
- Lower risk of overall project failure.

Incremental delivery problems

- Most systems require a set of basic facilities that are used by different parts of the system.
  - As requirements are not defined in detail until an increment is to be implemented, it can be hard to identify common facilities that are needed by all increments.
- The essence of iterative processes is that the specification is developed in conjunction with the software.
  - However, this conflicts with the procurement model of many organizations, where the complete system specification is part of the system development contract.

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.

Process improvement

Process improvement

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

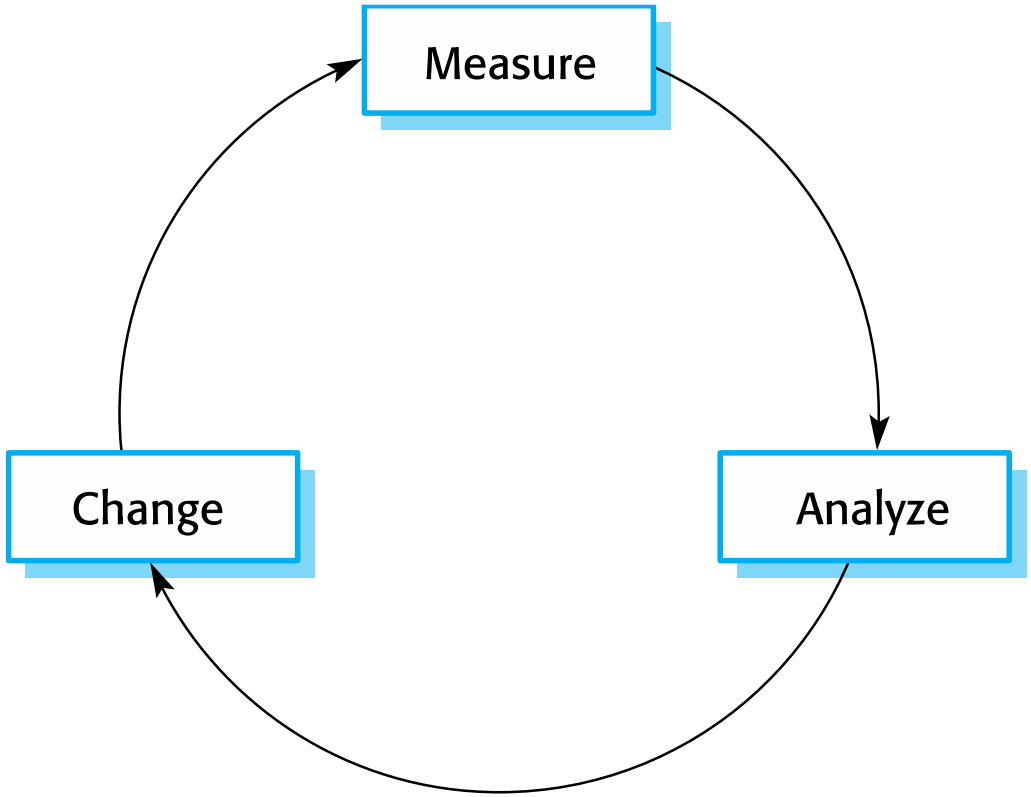
Approaches to improvement

- 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 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.

The process improvement cycle



Process measurement

- Wherever possible, quantitative process data should be collected
  - However, where organisations do not have clearly defined process standards this is very difficult as you don't 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 metrics

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

Key points

- Processes should include activities to cope with change. This may involve a prototyping phase that helps avoid poor decisions on requirements and design.
- Processes may be structured for incremental development and delivery so that changes may be made without disrupting the system as a whole.
- 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.