Software Engineering

Software Development Process Models

Lecturer: Massimo Mecella

Summary

- Modeling the Software Development Process
  - Generic Software Process Models
  - Waterfall model
  - Process Iteration
  - Incremental model
  - Reuse
  - Formal model
  - Extreme Programming
  - Spiral model
- Process activities

To model the software process

- Software products are not **tangible**
- In order to manage a software project the project manager needs *special* methods
- The **monitoring** is based on the explicit definition of **activities** to be performed and **documents** to be produced
- Produced **documents** allow to **monitor** the **evolution** of the process and provide means to evaluate its quality

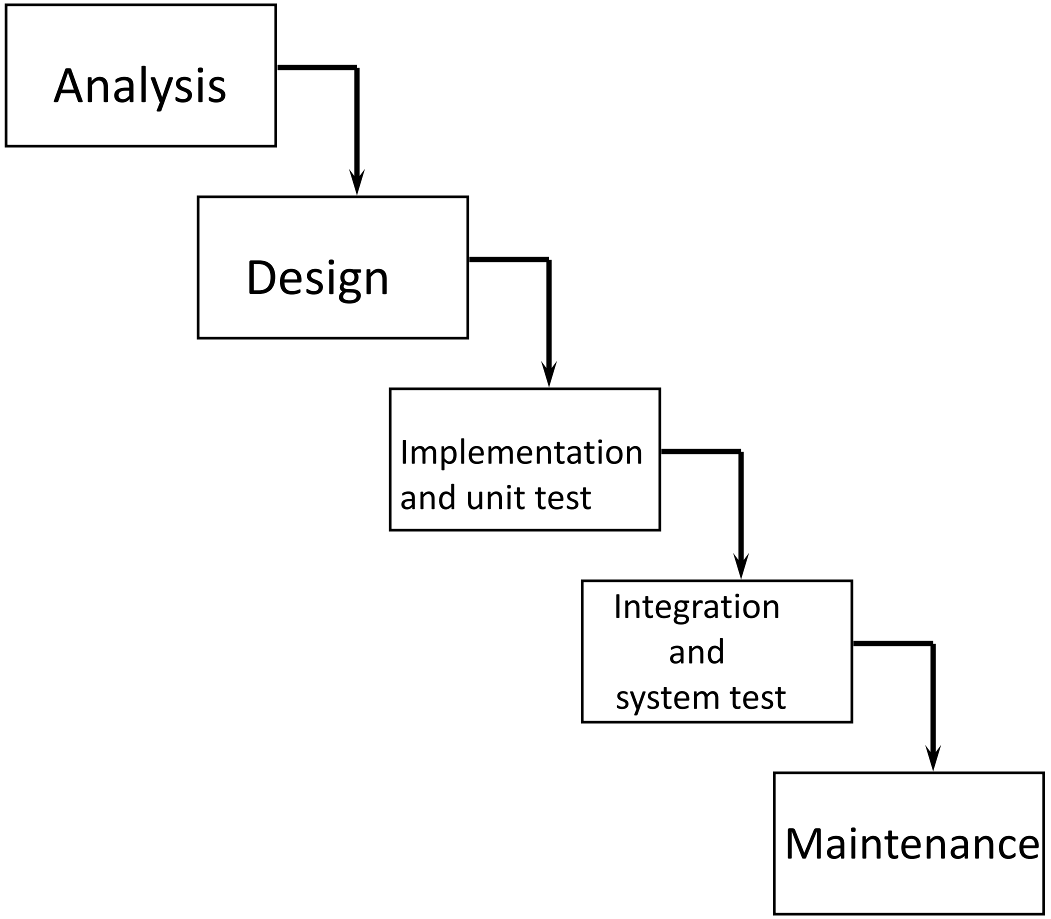
Process documents

- Software Development Process Models, and their instances, differ from each other for the foreseen activities and for the documents that are produced
- Management likes documentation, while developers hate it:
  - Both are wrong views
- The good compromise
  - Produce documentation useful for the project

Generic software process models

- The waterfall model
  - Separate and distinct phases of specification and development
- Evolutionary development
  - Specification, development and validation are interleaved.
- Component-based software engineering
  - The system (part of) is assembled from existing components.
- Formal models
  - Requirements are expressed in a formal language
- There are many variants of these models
  - e.g., formal development where a waterfall-like process is used but the specification is a formal specification that is refined through several stages to an implementable design

Waterfall process



Waterfall model phases

1. Requirements analysis and definition
2. System and software design
3. Implementation and unit testing
4. Integration and system testing
5. Operation and maintenance

Each phase has to be complete before moving onto the next phase

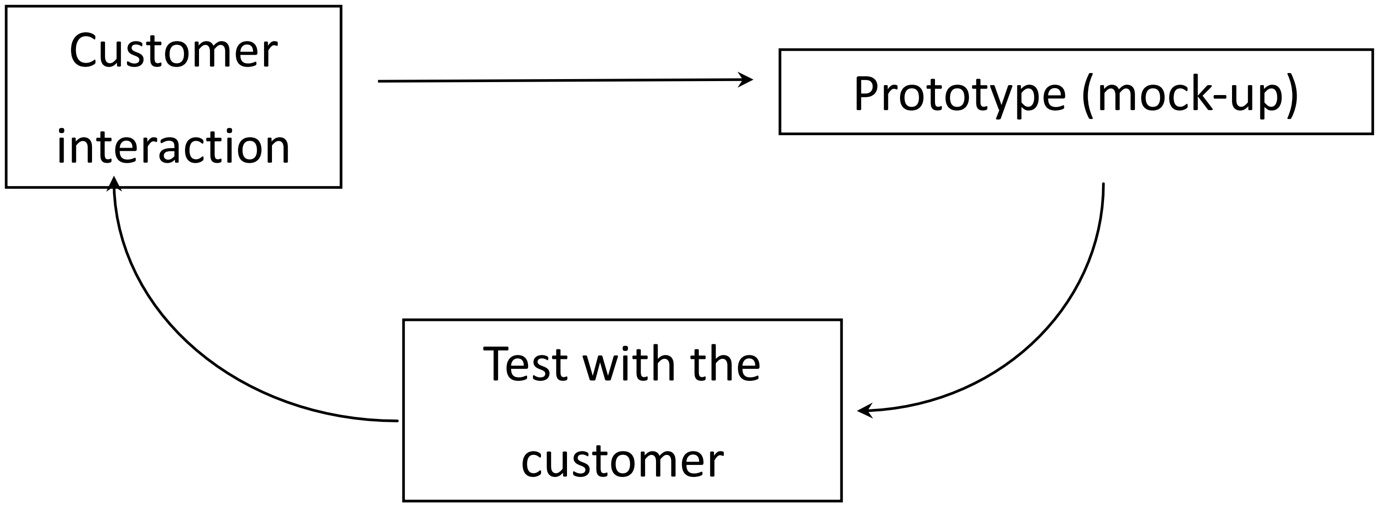
Waterfall model problems

- One of the main drawback of the waterfall model is the difficulty of accommodating **changes** after the process is underway
- Iterations are always around
- Initial **uncertainty**: the end user has not a clear vision of the overall system
- Customer has to wait till a working version of the system is available discovering an error in this phase is dangerous
- Programmers have to wait the analysis phase before starting their job

Process iteration

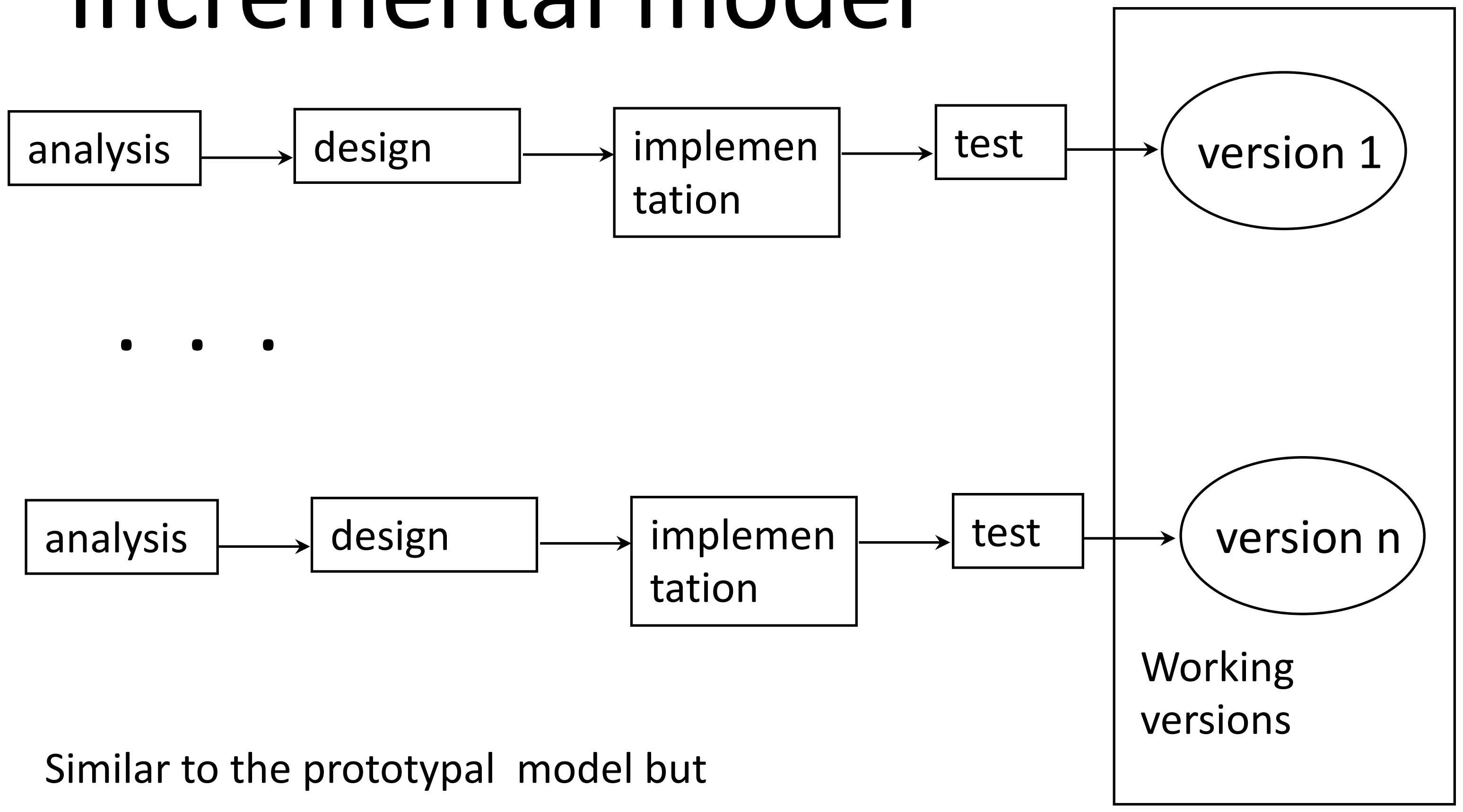
- System requirements **ALWAYS** evolve in the course of a project so process iteration where earlier stages are reworked is always part of the process for large systems
- Iteration can be applied to any of the generic process models
- Two (related) approaches
  - Incremental delivery
    - Prototypal model
    - Incremental model
  - Spiral development

Prototypal model



- Working prototype: implements only some basic functions (user interface)
- Main objective: collecting and disambiguating requirements involving the customer
- SW tools (e.g., Balsamiq Mockups)

Incremental model

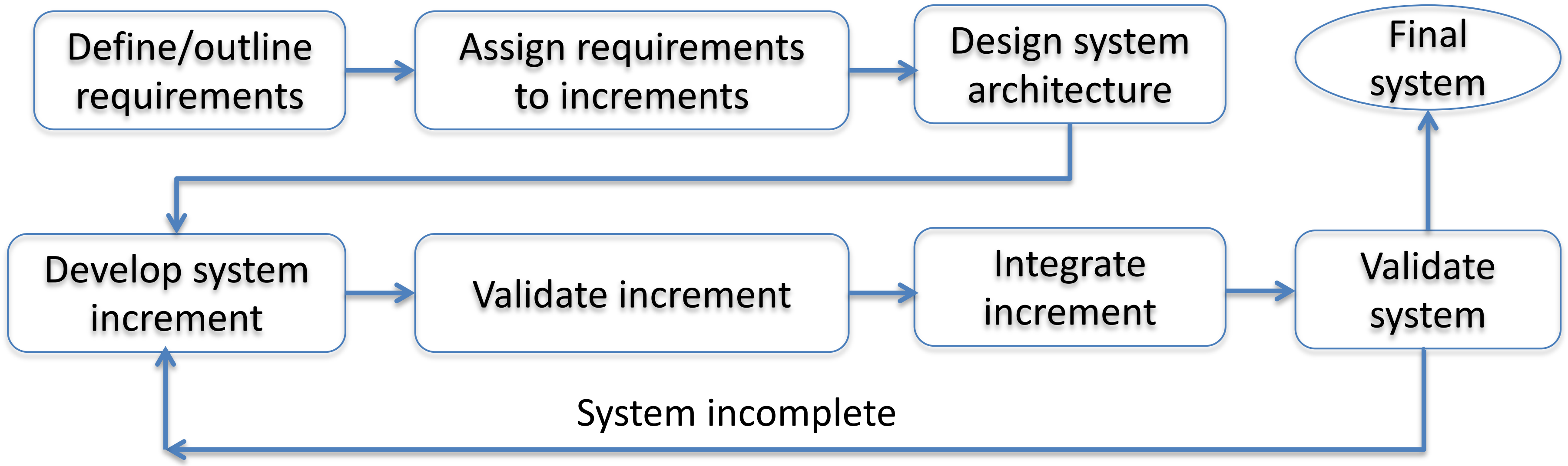


Similar to the prototypal model but

- Intermediate versions are full working

- It allows for a more accurate design

Incremental development



Incremental development and delivery

- Delivering **part of** the required functionality
- User requirements are **prioritised** 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

Incremental development advantages

- Customer value can be delivered with each increment so system functionalities are 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

Formal methods

- Logic or algebraic formalisms for requirement specification, development, and test
- They do not use the natural language (ambiguous)
- Some formal languages do exist (e.g., `Z’, ‘Z++’, …)
- An example (with an invented syntax)

Formal methods: sort example

void Sort(int a[], int n)

// it sorts the array in ascending order

pre: $\forall$ i $\forall$j (i $\geq$ 0 $\wedge$ i $\leq$ n-1 $\wedge$ j $\geq$ 0 $\wedge$ j $\leq$ n-1 $\wedge$ i $\neq$ J) $\rightarrow$ a[i] $\neq$ a[j]

post: ($\forall$ i (i > 0 $\wedge$ i $\leq$ n-1) $\rightarrow$ a[i] > a[i-1])

//1.output array elements are sorted

($\forall$ K (K $\geq$ 0 $\wedge$ K $\leq$ n-1) $\rightarrow$ $\exists$ L (L $\geq$ 0 $\wedge$ L $\leq$ n-1 $\wedge$ a[K] = old(a[L])))

//2. elements in the output belong to the input

($\forall$ R (R >= 0 && R $\leq$ n-1) $\rightarrow$ $\exists$ S (S $\geq$ 0 $\wedge$ S $\leq$ n-1 $\wedge$ old(a[R]) = a[S]))

//3.elements in the input belong to the output

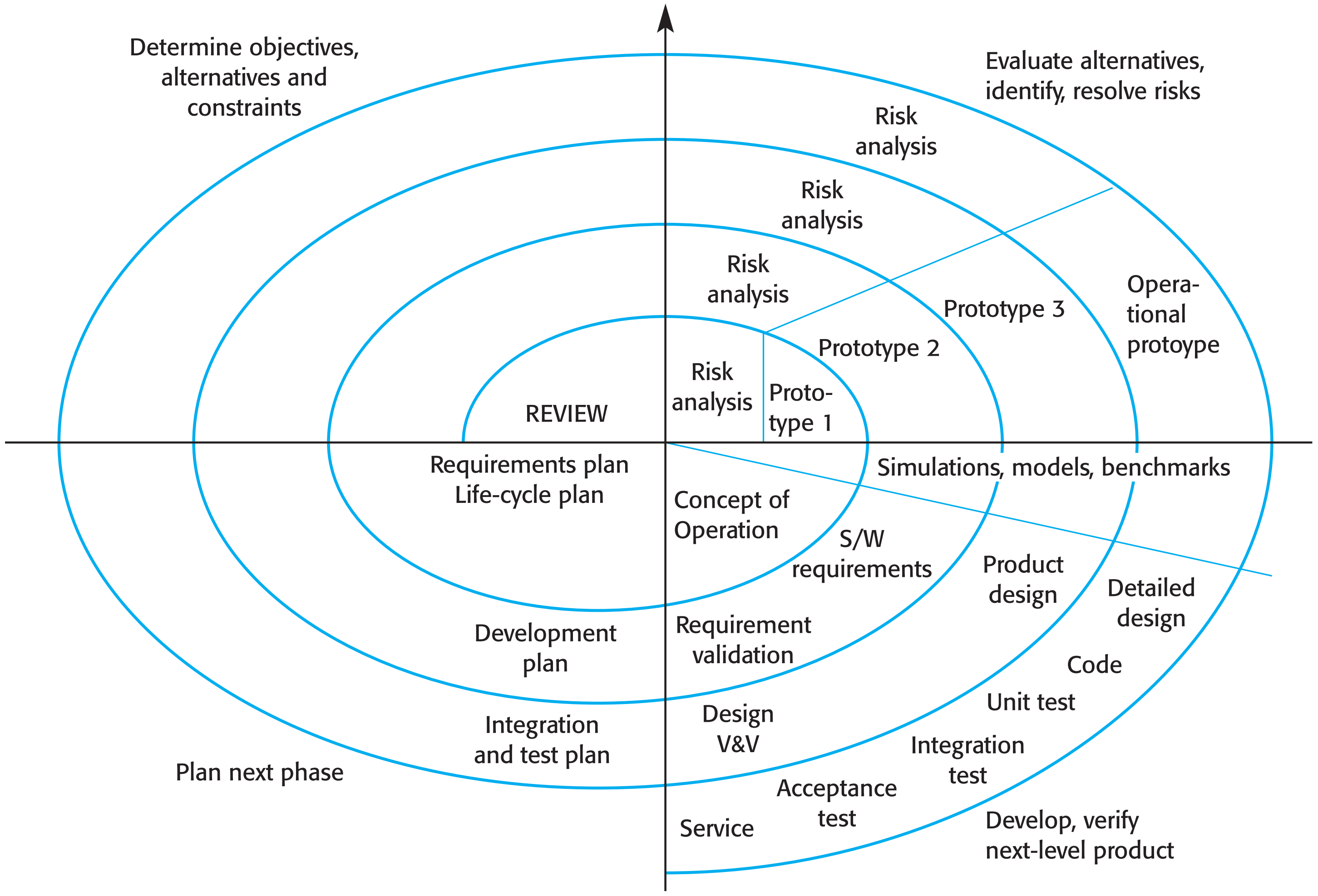
Extreme programming

- Part of the Agile model family
- An approach based on the development and delivery of very small increments of functionality
- Relies on constant code improvement, user involvement in the development team, and pairwise programming

Spiral development

- Process is represented as a spiral (rather than as a sequence) of activities
- Each loop in the spiral represents a phase in the process
- No fixed phases such as specification or design
  - loops in the spiral are chosen depending on what is required.
- Risks are explicitly assessed and resolved throughout the process

Spiral model of the software process



Spiral model sectors

- Objective setting
  - Specific objectives for the phase are identified.
- Risk assessment and reduction
  - Risks are assessed and activities put in place to reduce the key risks.
  - Example from a security project (Panoptesec): data masking
- Development and validation
  - A development model for the system is chosen which can be any of the generic models.
- Planning
  - The project is reviewed and the next phase of the spiral is planned.

Core process activities

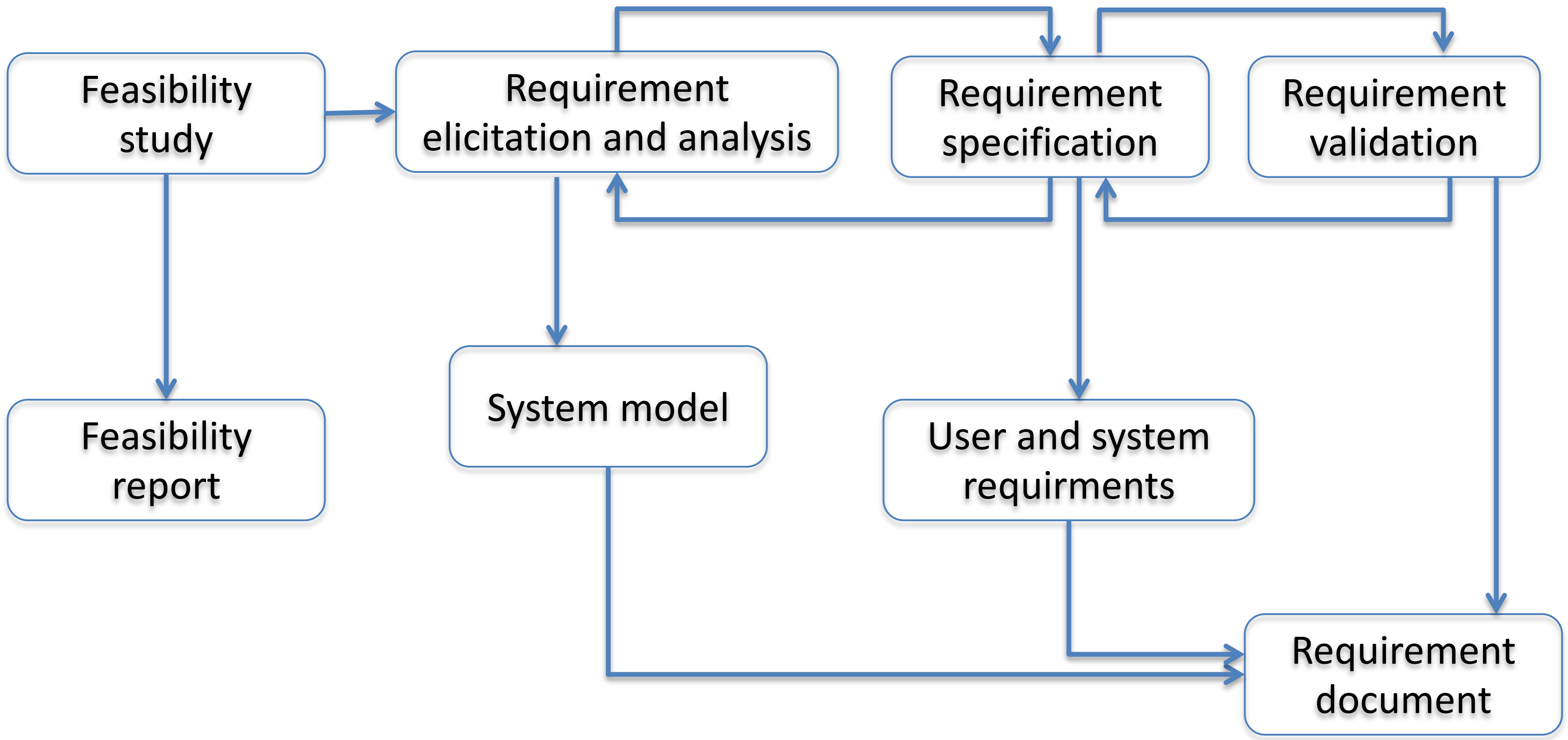
Process activities

- Let us quickly review the main involved activities
  - Software specification (requirements engineering)
  - Software design and implementation
  - Software validation
  - Software evolution

Software specification

- The process of establishing what services are required and the constraints on the system operation and development
  - Functional requirements
  - Non-functional requirements
    - Quality requirements!
- Requirements engineering process
  - Feasibility study
  - Requirements elicitation and analysis
  - Requirements specification
  - Requirements validation !!!

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

Design activities

- Architectural design
- Interface design
  - Sw interfaces
  - User interfaces
- Component design
- Data structure design
- Algorithm design

Structured design

- Systematic approaches to software design
- The design is usually documented as a set of graphical models
- Possible models (UML encompasses most of them)
  - Object model
  - Sequence model
  - State transition model
  - Structural model
  - Data-flow model

Programming and debugging

- Translating a design into a program and removing (as many as possible) errors from that program
- Programming is a personal activity - there is no generic programming process (!!!!!)
- Programmers carry out some program testing **to discover faults** in the program and remove these faults in the debugging process

The debugging process

- Locate errors
- Design error repair
- Repair error
- Re-test the program
  - For the error fix
  - For new errors introduced by the fix (**regression test**)

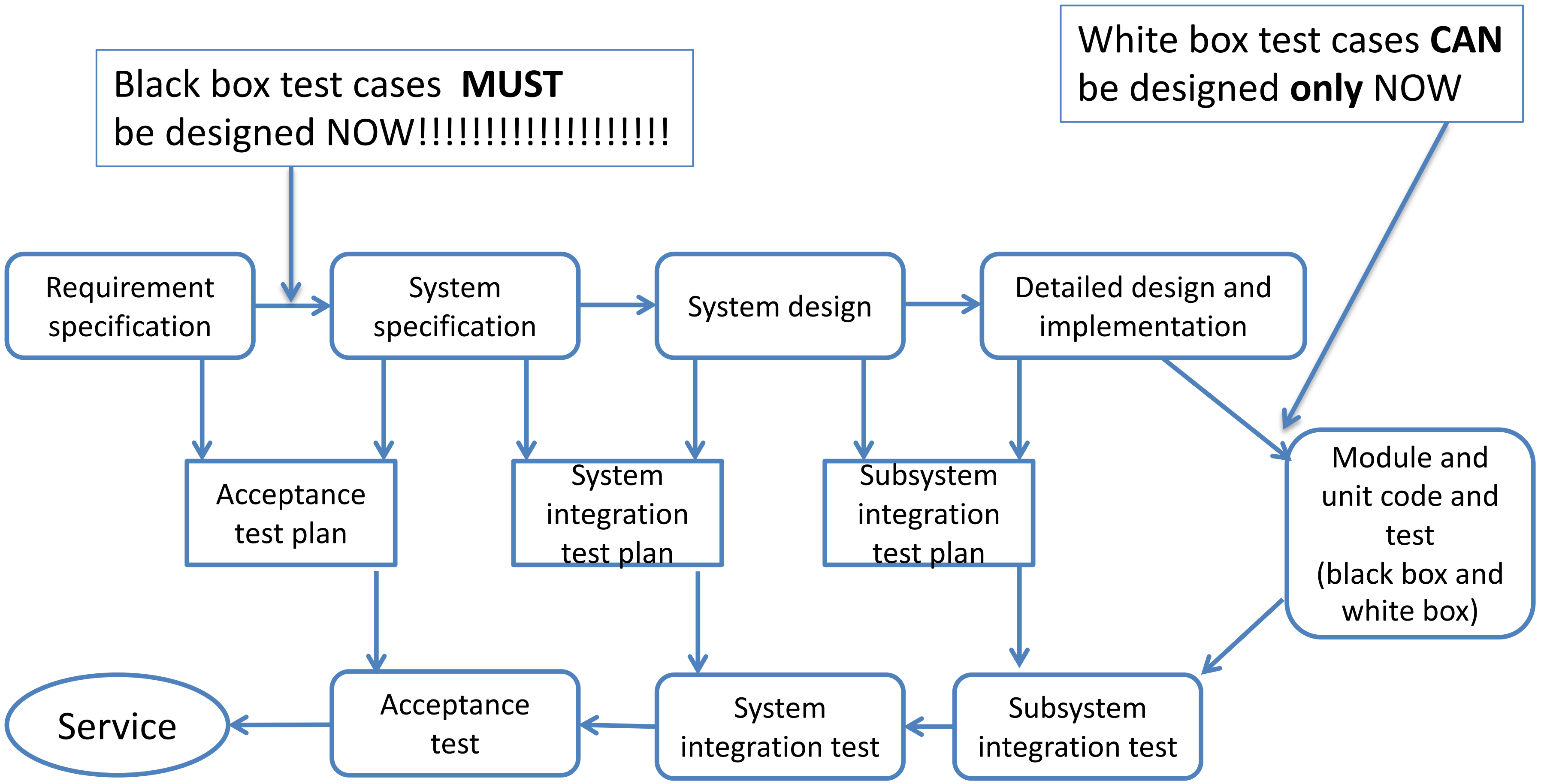
Software validation

- Verification and Validation (V & V) is intended to show that a system:
  - conforms to its specification (verification) and
  - meets the requirements of the system customer (validation)
- 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 stages

- Component or unit testing
  - Individual components are tested independently
  - Components may be functions or objects or coherent groupings of these entities
- System testing
  - Integration test
  - Testing of the system as a whole (functional and non functional requirements)
- Acceptance testing
  - Testing with customer data to check that the system meets the customer’s needs

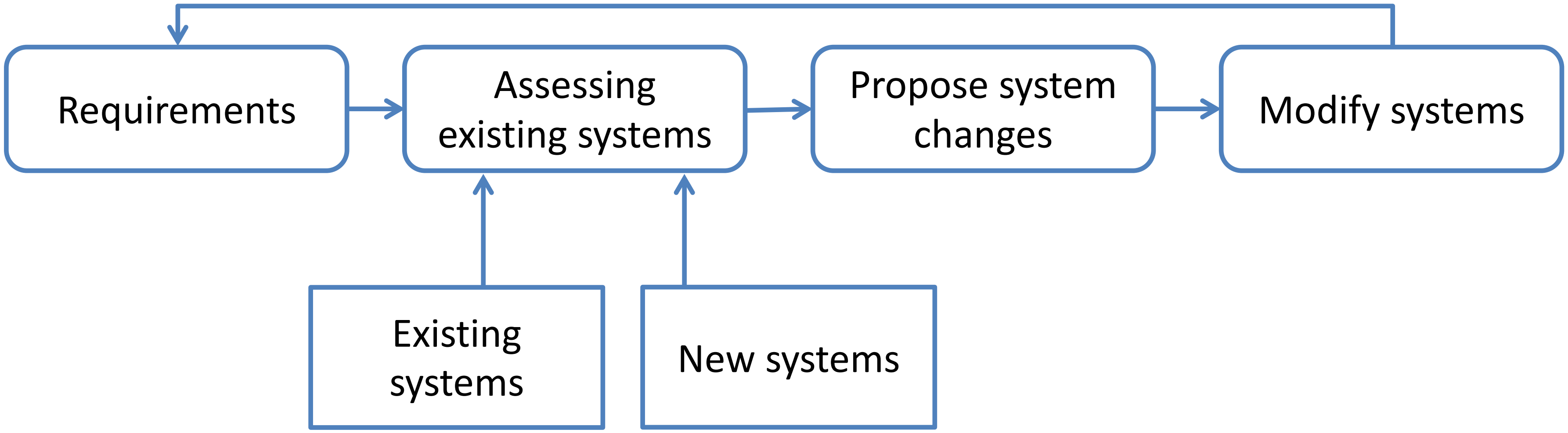
Testing phases


White box test cases **CAN** be designed **only** NOW
Black box test cases **MUST** be designed NOW!!!!!!!!!!!!!!!!!!!
Requirement specification
System specification
System design
Detailed design and implementation
Acceptance test plan
System integration test plan
Subsystem integration test plan
Module and unit code and test (black box and white box)
Service
Acceptance test
System integration test
Subsystem integration test

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


Requirements
Assessing existing systems
Propose system changes
Modify systems
Existing systems
New systems