INSTITUTO SUPERIOR DE TECNOLOGIAS AVANÇADAS DE LISBOA

Software Engineering

João Caldeira

Invited Professor

Email. joaocarlos.caldeira@my.istec.pt

Mob. +351 917769544

November 2, 2022

ISTEC INSTITUTO SUPERIOR DE TECNOLOGIAS AVANÇADAS DE LISBOA

Software Engineering Process

November 2, 2022

Software Engineering

Set of activities

- **Requirements**
  - End-User / customer business needs
- **Specification**
  - The functionality of the software and constraints on its operation must be defined
- **Design & Implementation**
  - The functionality of the software and constraints on its operation must be defined
- **Verification & Validation**
  - The software must be validated to ensure that it does what the end-user / customer wants
- **Evolution**
  - The software must evolve to meet changing customer needs

Software Engineering Process

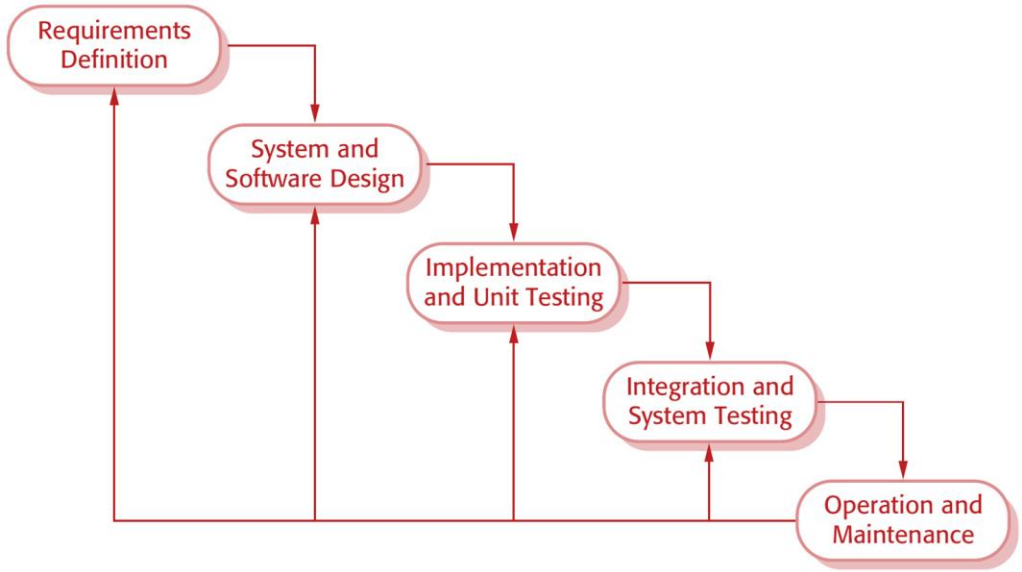
Generic Software Process Models

- **The waterfall model**
  - The fundamental process activities of specification, development, validation, and evolution are represented as separate process phases such as requirements specification, software design, implementation, testing, etc…
- **Incremental development**
  - This approach interleaves the activities of specification, development, and validation
  - The system is developed as a series of versions (increments), with each version adding functionality to the previous version
- **Integration and Configuration (Reuse-oriented software engineering)**
  - This approach is based on the existence of a significant number of reusable components
  - Focuses on integrating components into a system rather than developing from scratch

Software Engineering Process

Waterfall Model Phases

1. **Requirements analysis and definition**
   - The system's services, constraints, and goals are established by consultation with system users
2. **System and software design**
   - The systems design process allocates the requirements to either hardware or software systems by establishing an overall system architecture. Software design involves identifying and describing the fundamental software system abstractions and their relationships
3. **Implementation and unit testing**
   - Software design is realized as a set of programs or program units. Unit testing involves verifying that each unit meets its specification
4. **Integration and system testing**
   - The individual program units or programs are integrated and tested as a complete system to ensure that the software requirements have been met
5. **Operation and maintenance**
   - Normally (although not necessarily), this is the longest life cycle phase. The system is installed and put into practical use. Maintenance involves correcting errors which were not discovered in earlier stages of the life cycle



Software Engineering Process

Waterfall Model Problems

1. Inflexible partitioning of the project into distinct stages makes it difficult to respond to changing customer requirements.
   - One phase has to be complete before moving onto the next

2. This model is only appropriate when the requirements are well-understood and changes will be fairly limited
   - Few business systems have stable requirements

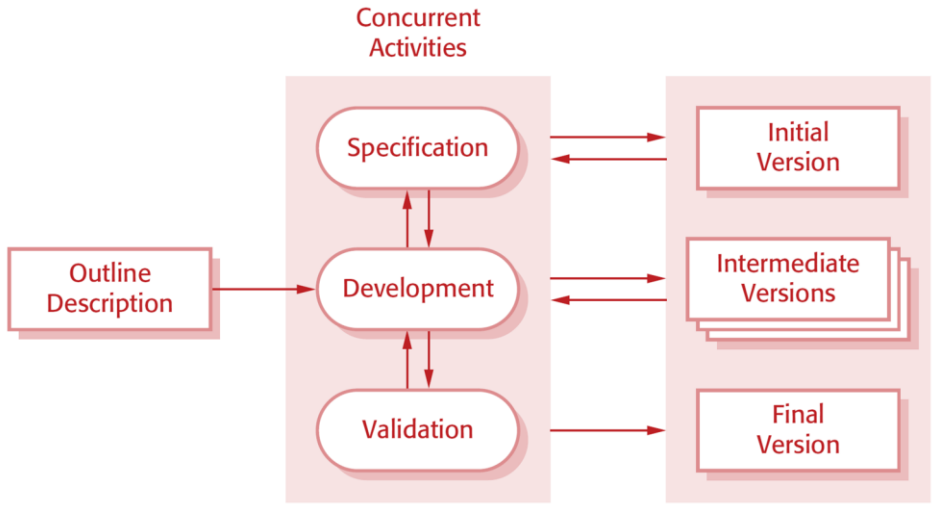
3. The waterfall model is mostly used for large systems/projects where a system is developed at several sites

Software Engineering Process

Incremental Development Model

- Incremental development is based on the idea of developing an initial implementation, exposing this to user comment and evolving it through several versions until an adequate system has been developed

- Specification, development, and validation activities are interleaved rather than separate, with rapid feedback across activities



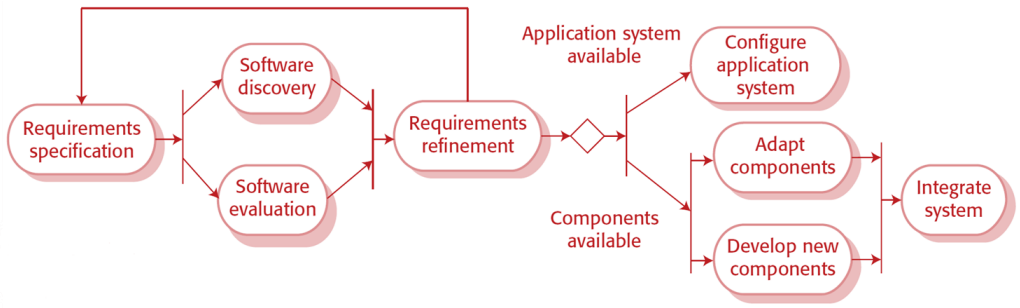
- **Benefits over Waterfall**
  - The cost of accommodating **changing customer requirements is reduced**. The amount of analysis and documentation that has to be redone is **much less than is required with the waterfall model**.
  - **It is easier to get customer feedback** on the development work that has been done. Customers can comment on demonstrations of the software and see how much has been implemented. Customers find it difficult to judge progress from software design documents
  - More rapid delivery and deployment of useful software to the customer is possible, even if all of the functionality has not been included. **Customers are able to use and gain value from the software earlier** than is possible with a waterfall process

Software Engineering Process

Integration and Configuration

- In software projects, there is some software reuse
- Developers look for these, modify them as needed, and integrate them with the new code that they have developed
- Since 2000, software development processes that focus on the reuse of existing software have become widely used
- Reuse-oriented approaches rely on a base of reusable software components and an integrating framework for the composition of these components

- **Software components frequently reused**
  - **Stand-alone application** systems that are configured for use in a particular environment. These systems are general-purpose systems that have many features, but they have to be adapted for use in a specific application.
  - **Collections of objects** that are developed as a component or as a package to be integrated with a component framework such as the **Java Spring framework**
  - **Web services** that are developed according to service standards and that are available for remote invocation over the Internet



Software Engineering

Set of activities

- **Requirements**
  - End-User / customer business needs
- **Specification**
  - The functionality of the software and constraints on its operation must be defined
- **Design & Implementation**
  - The functionality of the software and constraints on its operation must be defined
- **Verification & Validation**
  - The software must be validated to ensure that it does what the end-user / customer wants
- **Evolution**
  - The software must evolve to meet changing customer needs

Software Engineering Process

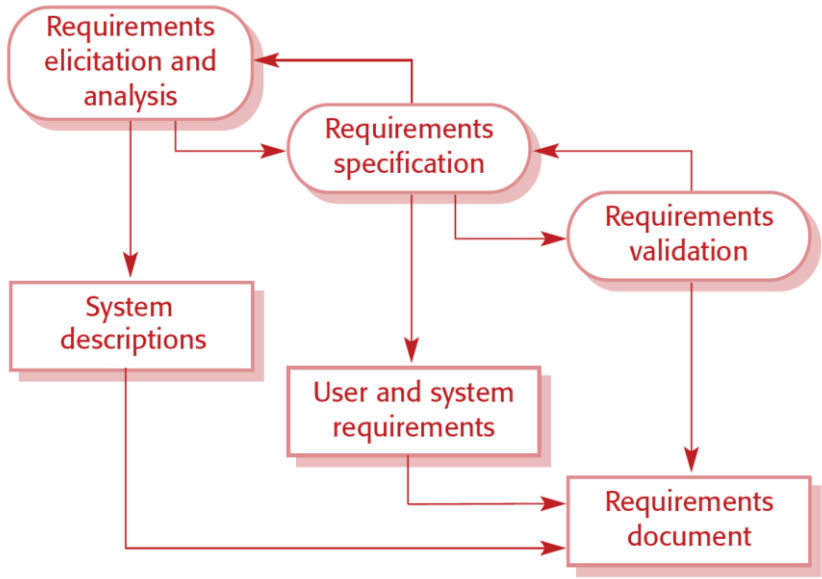
Software Specification

There are three main activities in the requirements engineering process:

1. **Requirements elicitation and analysis.** This is the process of deriving the system requirements through observation of existing systems, discussions with potential users and procurers, task analysis, and so on. This may involve the development of one or more system models and prototypes. These help you understand the system to be specified

2. **Requirements specification.** Requirements specification is the activity of translating the information gathered during requirements analysis into a document that defines a set of requirements. Two types of requirements may be included in this document. User requirements are abstract statements of the system requirements for the customer and end-user of the system; system requirements are a more detailed description of the functionality to be provided

3. **Requirements validation.** This activity checks the requirements for realism, consistency, and completeness. During this process, errors in the requirements document are inevitably discovered. It must then be modified to correct these problems

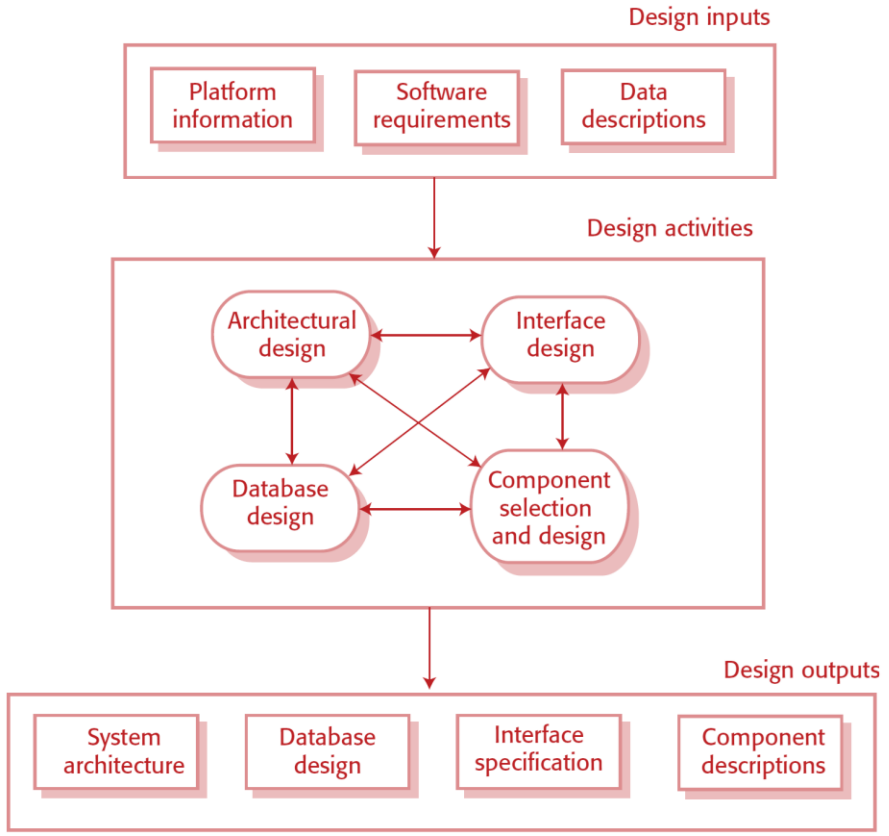


Software Engineering Process

Software Design and Implementation

The activities in the design process vary, depending on the type of system being developed. Usually, four activities that may be part of the design process for information systems:

1. **Architectural design.** Where you identify the overall structure of the system, the principal components (sometimes called subsystems or modules), their relationships, and how they are distributed
2. **Database design.** Where you design the system data structures and how these are to be represented in a database. Again, the work here depends on whether an existing database is to be reused or a new database is to be created
3. **Interface design.** Where you define the interfaces between system components. This interface specification must be unambiguous. With a precise interface, a component may be used by other components without them having to know how it is implemented. Once interface specifications are agreed, the components can be separately designed and developed.
4. **Component selection and design.** Where you search for reusable components and, if no suitable components are available, design new software components. The design at this stage may be a simple component description with the implementation details left to the programmer. Alternatively, it may be a list of changes to be made to a reusable component or a detailed design model expressed in the UML. The design model may then be used to automatically generate an implementation.



Software Engineering Process

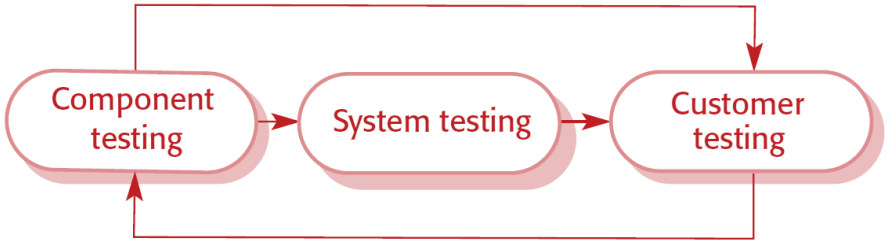
Software Testing

The stages in the testing process are:

1. **Component testing.** The components making up the system are tested by the people developing the system. Each component is tested independently, without other system components. Components may be simple entities such as functions or object classes or may be coherent groupings of these entities

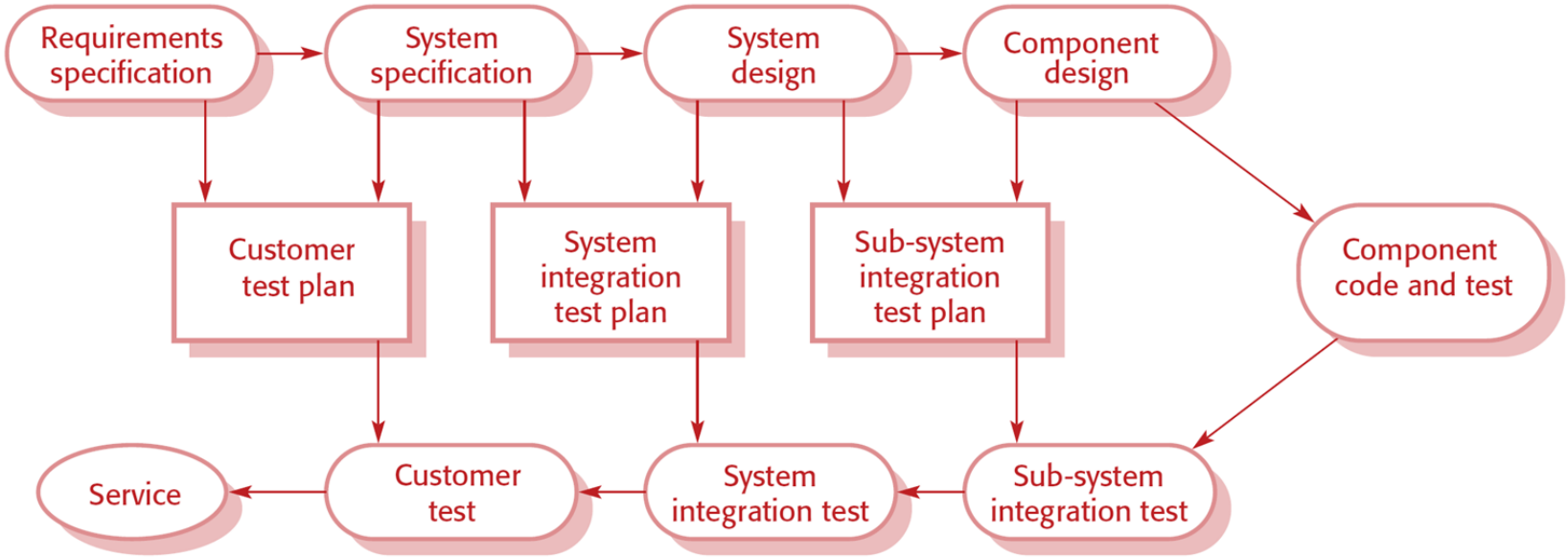
2. **System testing.** System components are integrated to create a complete system. This process is concerned with finding errors that result from unanticipated interactions between components and component interface problems. It is also concerned with showing that the system meets its functional and non-functional requirements and testing the emergent system properties

3. **Customer testing.** This is the final stage in the testing process before the system is accepted for operational use. The system is tested by the system customer (or potential customer) rather than with simulated test data. For custom-built software, customer testing may reveal errors and omissions in the system requirements definition, because the real data exercise the system in different ways from the test data



Software Engineering Process

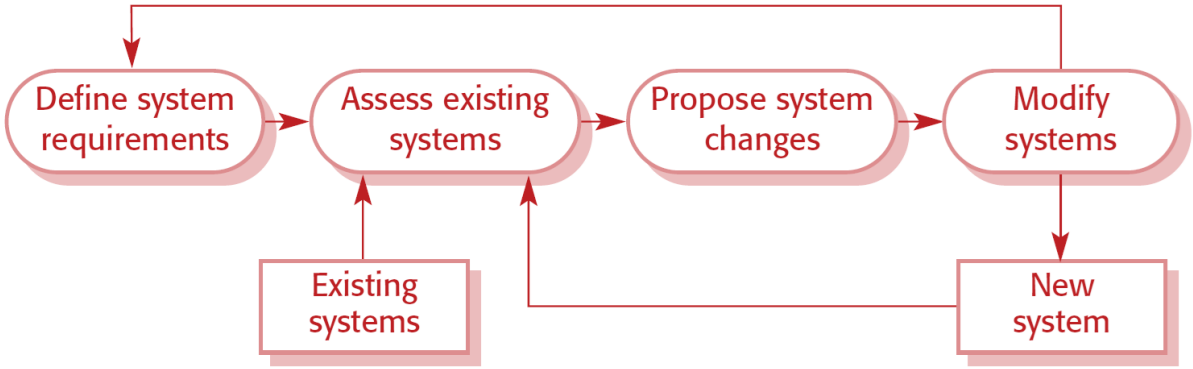
Software Testing Phases – Plan-Driven Software Process



Software Engineering Process

Software Evolution

- The flexibility of software is one of the main reasons why more and more software is being incorporated into large, complex systems
- Once a decision has been made to manufacture hardware, it is very expensive to make changes to the hardware design
- However, changes can be made to software at any time during or after the system development
- This distinction between development and maintenance is increasingly irrelevant
- Rather than two separate processes, it is more realistic to think of software engineering as an evolutionary process



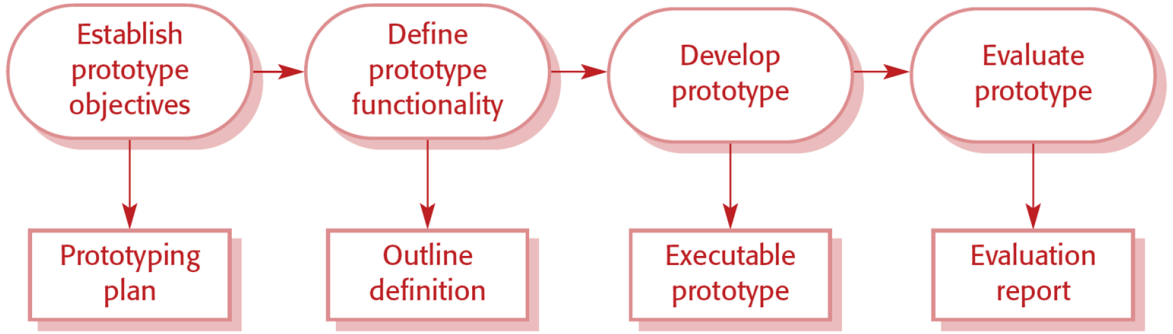
Software Engineering Process

Coping with Change – Prototype Development

A software prototype can be used in a software development process to help anticipate changes that may be required:

1. In the requirements engineering process, a prototype can help with the elicitation and validation of system requirements

2. In the system design process, a prototype can be used to explore software solutions and in the development of a user interface for the system



Software Engineering Process

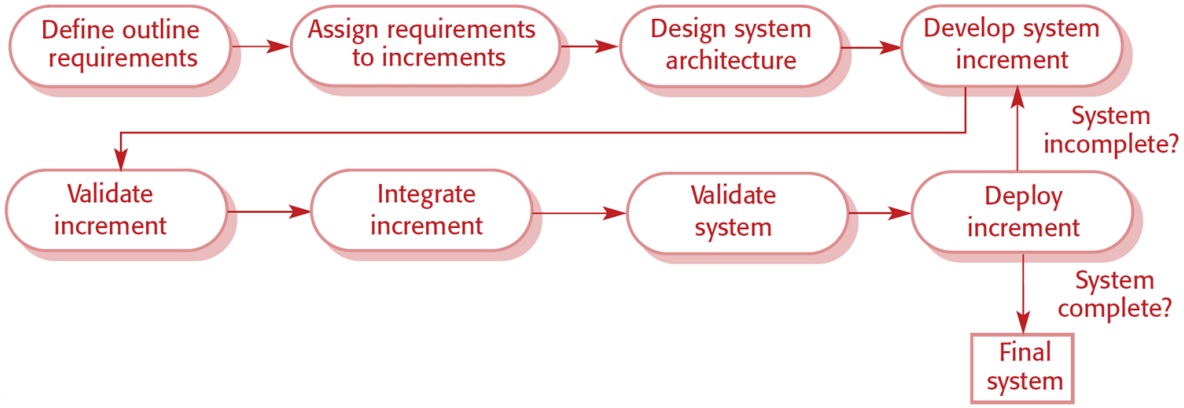
Incremental Delivery

Incremental delivery has a number of advantages:

1. Customers can use the early increments as prototypes and gain experience that informs their requirements for later system increments

2. Customers do not have to wait until the entire system is delivered before they can gain value from it. The first increment satisfies their most critical requirements, so they can use the software immediately

3. The process maintains the benefits of incremental development in that it should be relatively easy to incorporate changes into the system

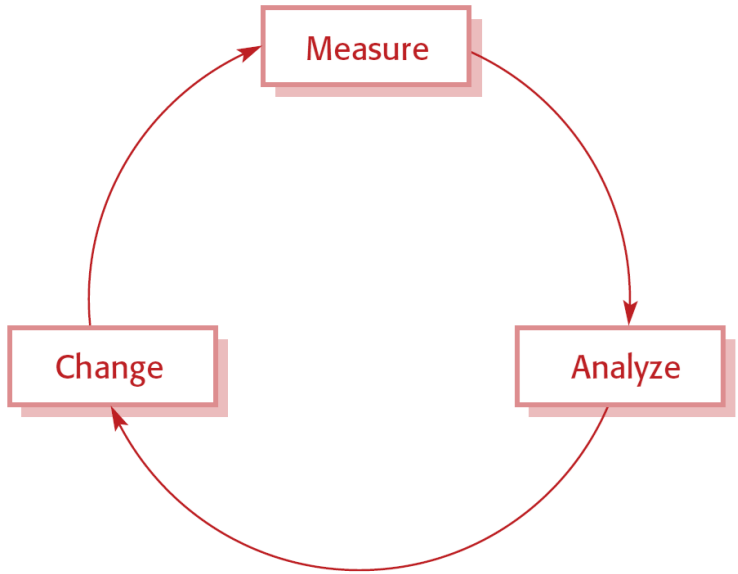


Software Engineering Process

Process Improvement Cycle

The general process improvement process underlying the process maturity approach is a cyclical process, as the stages in this process are:

1. **Process measurement.** You measure one or more attributes of the software process or product. These measurements form a baseline that helps you decide if process improvements have been effective
2. **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 during this stage
3. **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

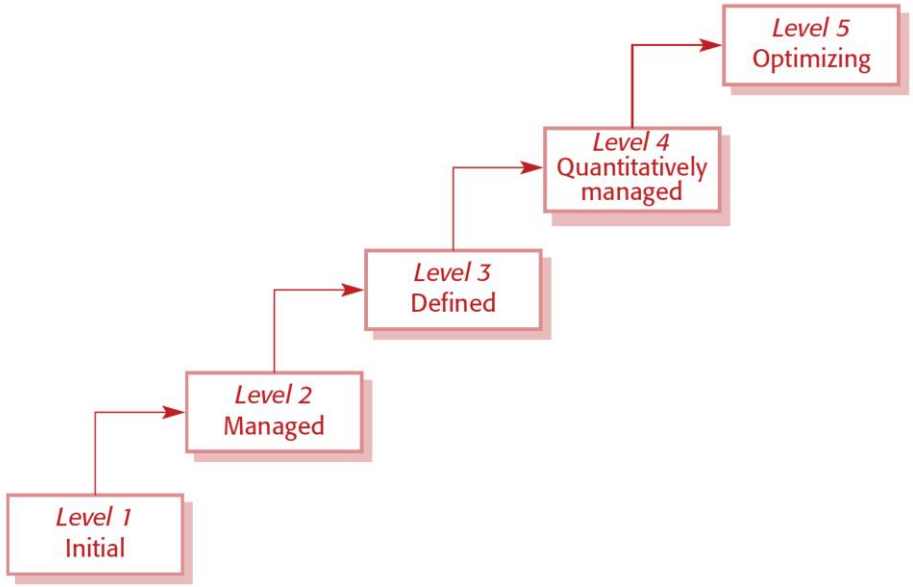


Software Engineering Process

Capability Maturity Levels

The levels in the process maturity model are:

1. **Initial.** The goals associated with the process area are satisfied, and for all processes the scope of the work to be performed is explicitly set out and communicated to the team members
2. **Managed.** At this level, the goals associated with the process area are met, and organizational policies are in place that define when each process should be used. There must be documented project plans that define the project goals. Resource management and process monitoring procedures must be in place
3. **Defined.** This level focuses on organizational standardization and deployment of processes. Each project has a managed process that is adapted to the project requirements from a defined set of organizational processes. Process assets and process measurements must be collected and used for future process improvements
4. **Quantitatively managed.** At this level, there is an organizational responsibility to use statistical and other quantitative methods to control subprocesses. That is, collected process and product measurements must be used in process management
5. **Optimizing.** At this highest level, the organization must use the process and product measurements to drive process improvement. Trends must be analyzed, and the processes adapted to changing business needs



Software Engineering Process

Agile Methods

- **The philosophy behind agile methods is reflected in the agile manifesto (http://agilemanifesto.org)**
- **This manifesto states:**

  - Individuals and interactions over processes and tools
  - Working software over comprehensive documentation
  - Customer collaboration over contract negotiation
  - Responding to change over following a plan

Software Engineering Process

Agile Methods

- All agile methods suggest that software **should be developed and delivered incrementally**
- These methods are based on different agile processes but they share a set of principles, based on the agile manifesto, and so they have much in common.

- Agile methods have been particularly successful for two kinds of system development:

1. Product development where a software company is developing a small or medium-sized product for sale. Virtually all software products and apps are now developed using an agile approach

2. Custom system development within an organization, where there is a clear commitment from the customer to become involved in the development process and where there are few external stakeholders and regulations that affect the software

Software Engineering Process

Agile Development Techniques

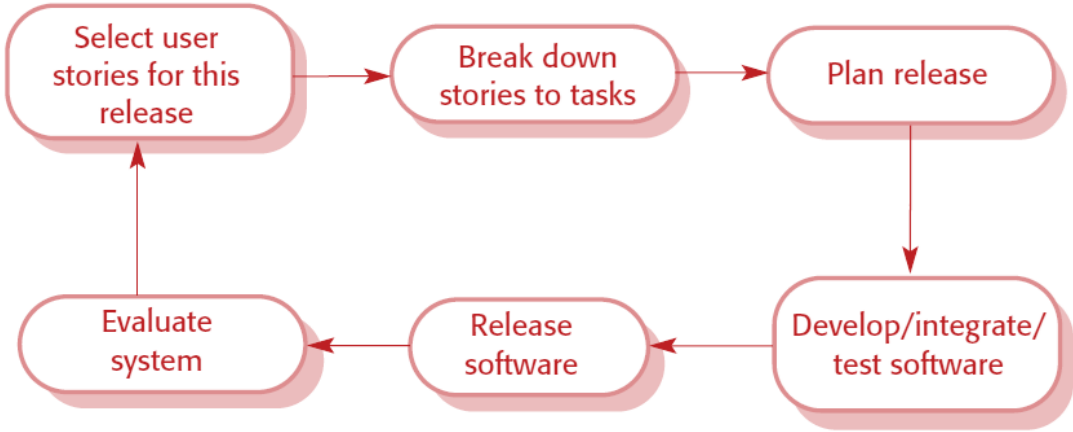
- **XP (Extreme Programming)**
- **User Stories**
- **Refactoring**
- **Test-first development**
- **Pair programming**

Software Engineering Process

Agile Development Techniques

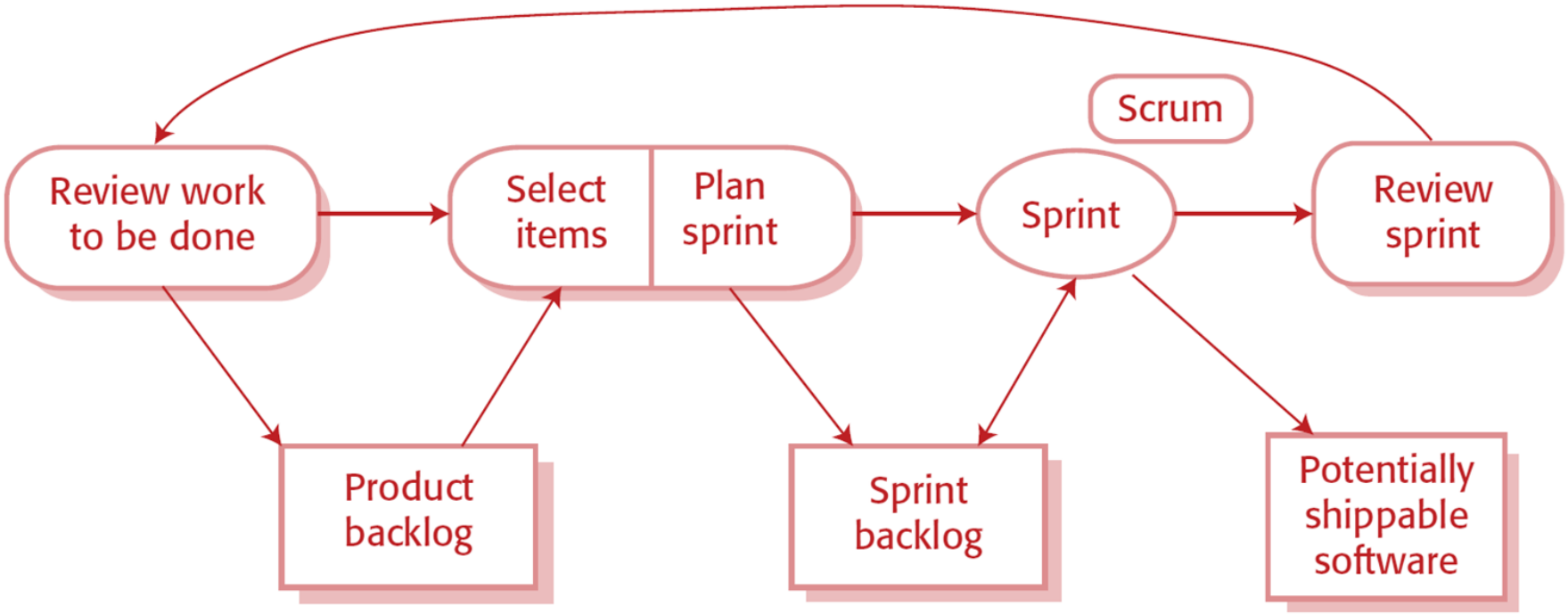
User Stories

- Software requirements always change
- To handle these changes, agile methods do not have a separate requirements engineering activity. Rather, they integrate requirements elicitation with development
- To make this easier, the idea of "user stories" was developed where a user story is a scenario of use that might be experienced by a system user



Software Engineering Process

Agile Project Management



Software Engineering Process

Agile Project Management

Scrum Term	Definition
Development team	A self-organizing group of software developers, which should be no more than seven people. They are responsible for developing the software and other essential project documents
Potentially shippable product increment	The software increment that is delivered from a sprint. The idea is that this should be "potentially shippable," which means that it is in a finished state and no further work, such as testing, is needed to incorporate it into the final product. In practice, this is not always achievable
Product backlog	This is a list of "to do" items that the Scrum team must tackle. They may be feature definitions for the software, software requirements, user stories, or descriptions of supplementary tasks that are needed, such as architecture definition or user documentation
Product owner	An individual (or possibly a small group) whose job is to identify product features or requirements, prioritize these for development, and continuously review the product backlog to ensure that the project continues to meet critical business needs. The Product Owner can be a customer but might also be a product manager in a software company or other stakeholder representative
Scrum	A daily meeting of the Scrum team that reviews progress and prioritizes work to be done that day. Ideally, this should be a short face-to-face meeting that includes the whole team
ScrumMaster	The ScrumMaster is responsible for ensuring that the Scrum process is followed and guides the team in the effective use of Scrum. He or she is responsible for interfacing with the rest of the company and for ensuring that the Scrum team is not diverted by outside interference. The Scrum developers are adamant that the ScrumMaster should not be thought of as a project manager. Others, however, may not always find it easy to see the difference.
Sprint	A development iteration. Sprints are usually 2 to 4 weeks long
Velocity	An estimate of how much product backlog effort a team can cover in a single sprint. Understanding a team's velocity helps them estimate what can be covered in a sprint and provides a basis for measuring improving performance

Software Engineering Process

Problems of Agile Methods

- **For large, long-lifetime systems that are developed by a software company for an external client, using an agile approach presents a number of problems :**
  - The informality of agile development **is incompatible with the legal approach to contract** definition that is commonly used in large companies
  - Agile methods **are most appropriate for new software development rather than for software maintenance**. Yet the majority of **software costs in large companies come from maintaining** their existing software systems
  - Agile methods **are designed for small co-located teams**, yet much software development **now involves worldwide distributed teams**