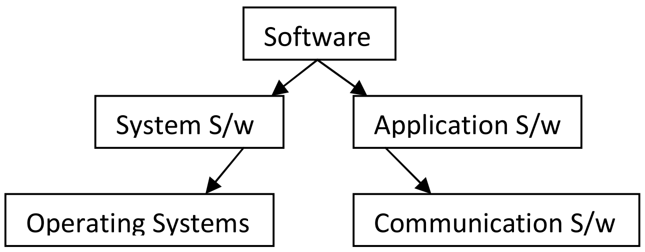
Chapter 1
Introduction to Software Engineering

Definition: Software – A Software is a set of instructions or computer programs instructing a computer to do specific tasks. The theory of software was first proposed by Allen Turing in 1935. Software products may be developed for a particular customer or may be developed for a general market.

Classification of Software



System Software – Set of programs to control and manage the operations of computer hardware.
Example: Operating Systems, device drivers (printers) etc.

Application Software – It is created to perform specific tasks for a user. Example: MS Word, Photoshop etc

Characteristics of Software

1. Software is engineered not manufactured.
2. Software is intangible – It has no mass, no volume, no color, no odor and it cannot be touched.
3. Software does not wear out, failed components must be re-engineered.
4. Maintainability – Software should meet the changing needs of customers.
5. Usability – The software should have appropriate user interface and enough number of documentations.
6. Dependability – Means reliability, it should be safe and secure to use the software without causing system failure.

What is Software Engineering?
A systematic approach to the development, operation, maintenance and retirement of software.

Definition by IEEE (Institute of Electrical and Electronics Engineers): The application of systematic, disciplined, quantifiable approach to the development, operation, maintenance of software that is the application of engineering to the software.

Goals of Software Engineering

- To improve the quality of the software product
- To increase productivity and
- To give job satisfaction to the Software engineers.

Key Challenges of Software Engineering

i. The legacy challenge: The challenging method of maintaining and updating the software in such a way that high costs are avoided and essential business services continue to be delivered.
ii. The Heterogeneity challenge: Systems are required to operate as distributed systems across networks. The challenge of developing techniques to build dependable software which is flexible to cope with is called heterogeneity.
iii. The delivery challenge: A challenge of shortening delivery time for large and complex systems without compromising system quality.

Software Product

Software products are software systems that are delivered to a customer with documentation which describes how to install and use this system.

Software products may be classified into two types.

Generic Products	Bespoke (Customized) Products
These products are developed in organizations and sold in the open market to any customer who is able to buy them.	These products are developed for a single customer according to their specification.
These are stand alone systems; the target is generally how many copies are being sold.	These are customized products
These products are developed for anonymous customers	These products are designed as per customer's requirement by software contractor.
Example: Operating Systems, Word Processors, drawing packages etc	Example : Payroll system, Inventory system, Air traffic control system etc

Software Process

The process involves translating user needs into software requirements, transforming software requirements into design, implementing design in code, testing the code and installing then checking out the software for operations.

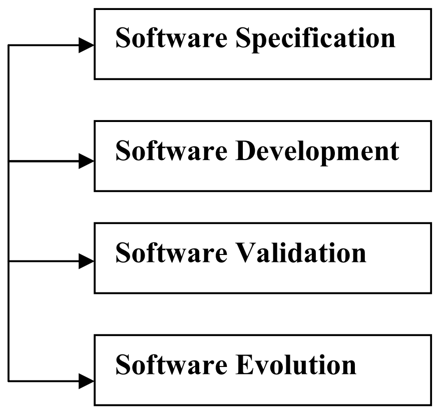
There are 4 fundamental process activities

--Software Specification: Functions of the software and its constraints will defined.

--Software development: The software to meet the specification must be produced.

--Software validation: The software must be validated to ensure what customer wants.

--Software Evolution: The software must evolve to meet changing customer needs.



Characteristics of Software Process

Reliability- To what extents can the process errors be avoided.

Supportability- To what extents can the process activities be supported.

Understandability – To what extent is the process easy to understand.

Maintainability- To what extent can the process help in reflecting organizational requirements.

Rapidity- How fast can a process complete the task and deliver a system

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SDLC (Software Development Life Cycle)

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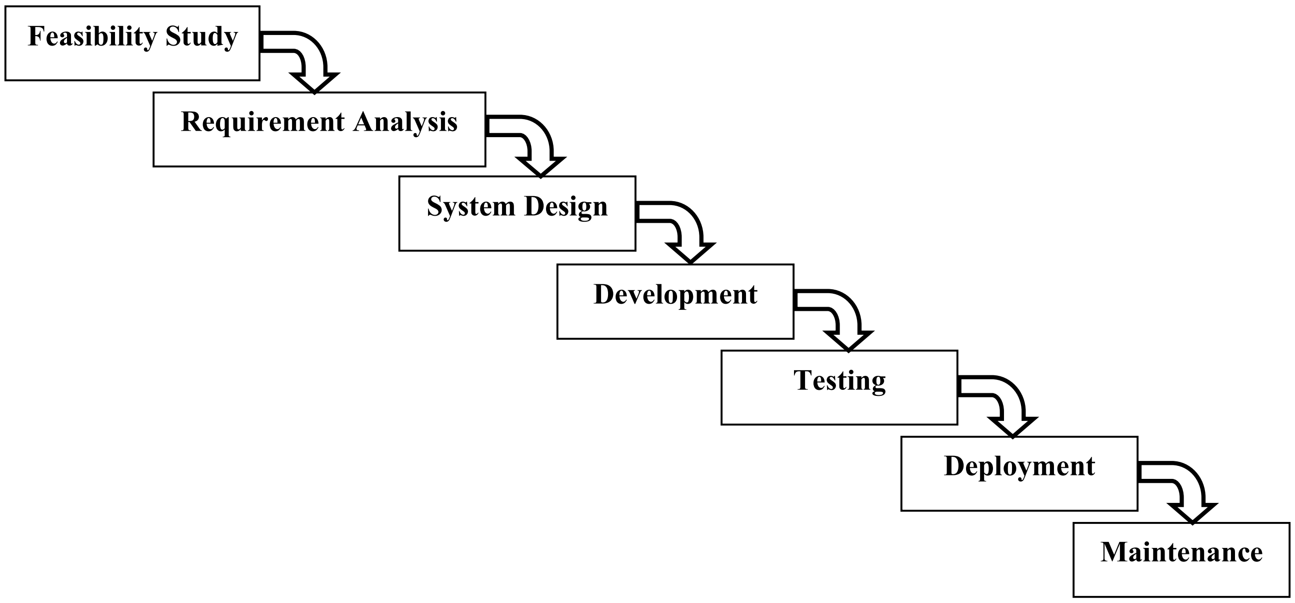
SDLC is a sequence of activities carried out by analyst, designer and user to develop and implement an information system. These activities can be carried out in different stages.

SDLC can be broadly classified into 7 phases.

1. Feasibility Study: The main aim is to determine whether the product is financially worthwhile and technically feasible.
2. Requirement analysis: In this phase the aim is to find exact requirement of the customers, Requirements are classified into a) Functional Requirements (Input /Output needs) and b) Non-functional requirements (Constraints like time, cost etc). Finally a SRS document is prepared as an output.

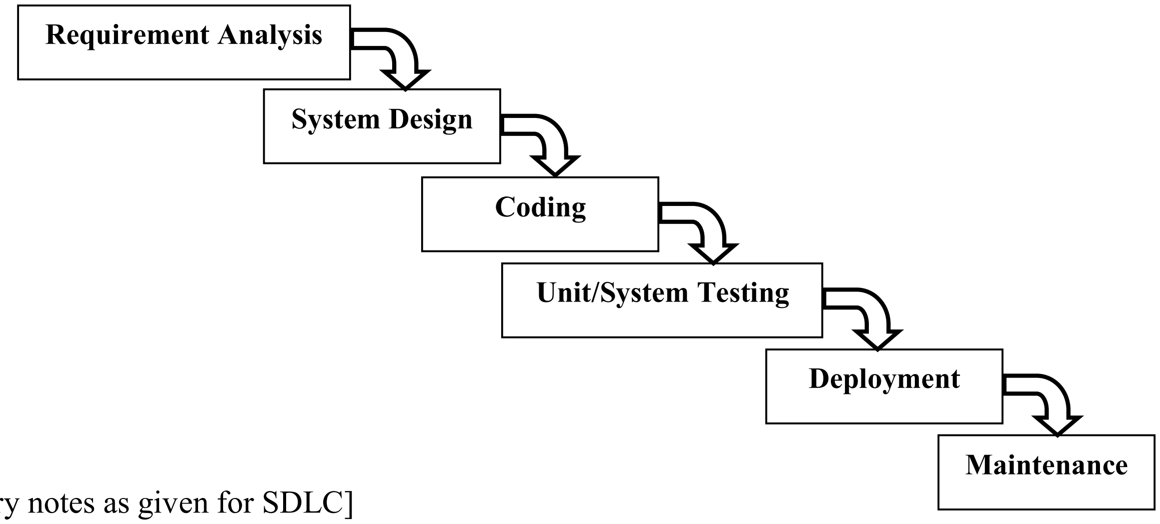


3. System Design: Software architecture is derived from SRS document. A new system is designed according to the needs of the user.
4. Development: This is the actual phase where the system is developed. The whole design is built and implemented.
5. Testing: During implementation phase each module of the design is coded and each module is unit tested individually. This is to check if each individual module works correctly. This is the most critical phase.
6. Deployment: The developed system is handed over to the client. The old system is dispensed and the new system is put to operations and used.
7. Software Maintenance: In this phase adding enhancements, improvements and updates to the new versions are done.

Different types of SDLC Models are: 1) Waterfall Model, 2) Prototype model, 3) Prototype model, 4) Iterative enhancement model

Waterfall Model

This model is a software life cycle where the stages are depicted as cascading from one to another. It was described by W.W. Royce in 1970. As the figure implies one development stage should be completed before the next begins.



[Follow the same theory notes as given for SDLC]

Advantages of Waterfall Model

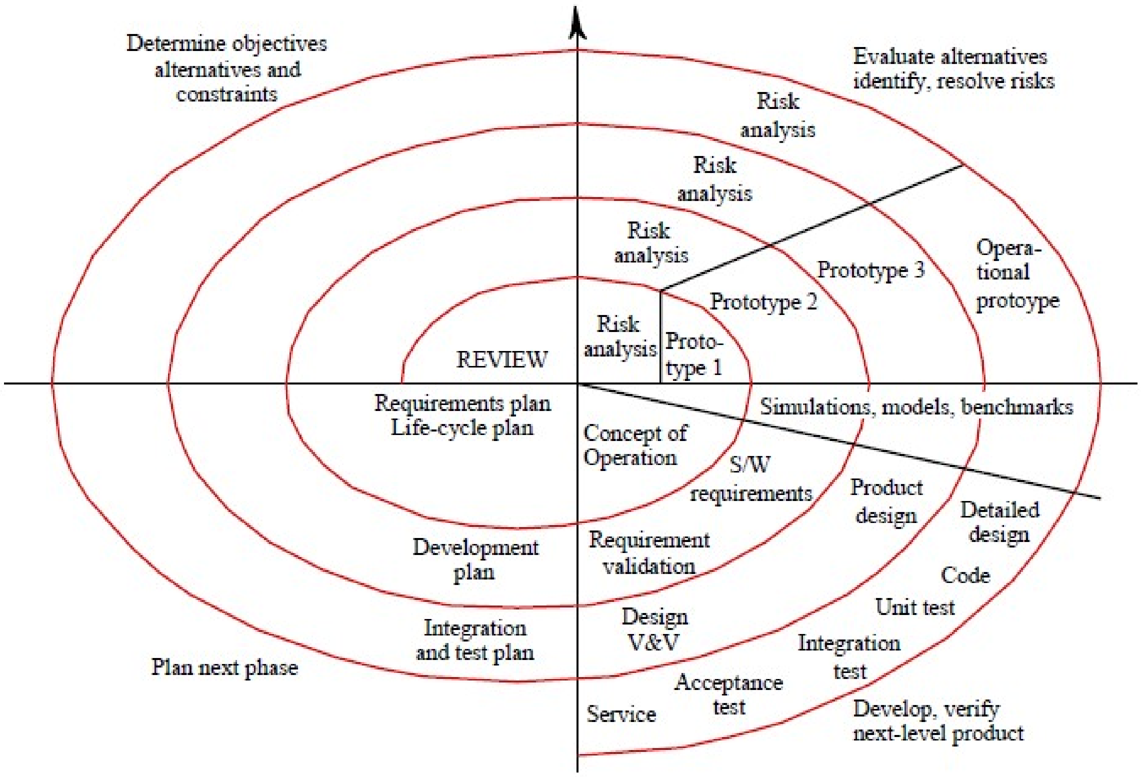
i. Easy to explain to the user.
ii. Stages and activities are well defined
iii. Verification at each stage ensures early detection of errors
iv. Widely used to identify and meet the milestones
v. Establishes communication between customer and developer to meet the specifications.

Disadvantages of Waterfall Model

i. The next stage begins only after the previous stage is complete, making it rigid.
ii. User training is not given much importance.
iii. Interaction with the user takes place right at the beginning and then at the time of deployment, which creates a gap between the phases.
iv. Due to its cascading flow there is very little interaction from the user.

Boehmia's Spiral Model

- Spiral model was proposed by Boehm in 1988.
- Each loop in the spiral represents a phase of the software process.
- Innermost loop is concerned with system feasibility, next loop system requirement, followed by system design and so on



Each loop is split into 4 sectors:

1. Objective setting – Project risks are identified, alternative strategies depending on these risks may be planned.
2. Risk assessment and reduction - Project risks are identified → detailed analysis carried → steps taken to reduce risks.

Ex: A prototype system (Toy like implementation with limited functional capabilities and low reliability just for the purpose of examining)

3. Development and Validation – Choosing the most appropriate development model.
4. Planning – Project is reviewed and decisions are made whether to continue with further loop of the spiral.

Advantages of Spiral Model

i. High amount of risk analysis
ii. Supports large and high risk projects
iii. Spiral model is one of the most flexible SDLC models.
iv. Changes can be introduced later in the life cycle as well
v. Project monitoring is easy as each loop requires a review from concerned people.

Disadvantages of Spiral model

i. When to stop the spiral process is not clear.
ii. Cost involved in this model is usually high.
iii. Does not work well for smaller projects.
iv. Project's success is highly dependent on the risk analysis phase.

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Prototype Model

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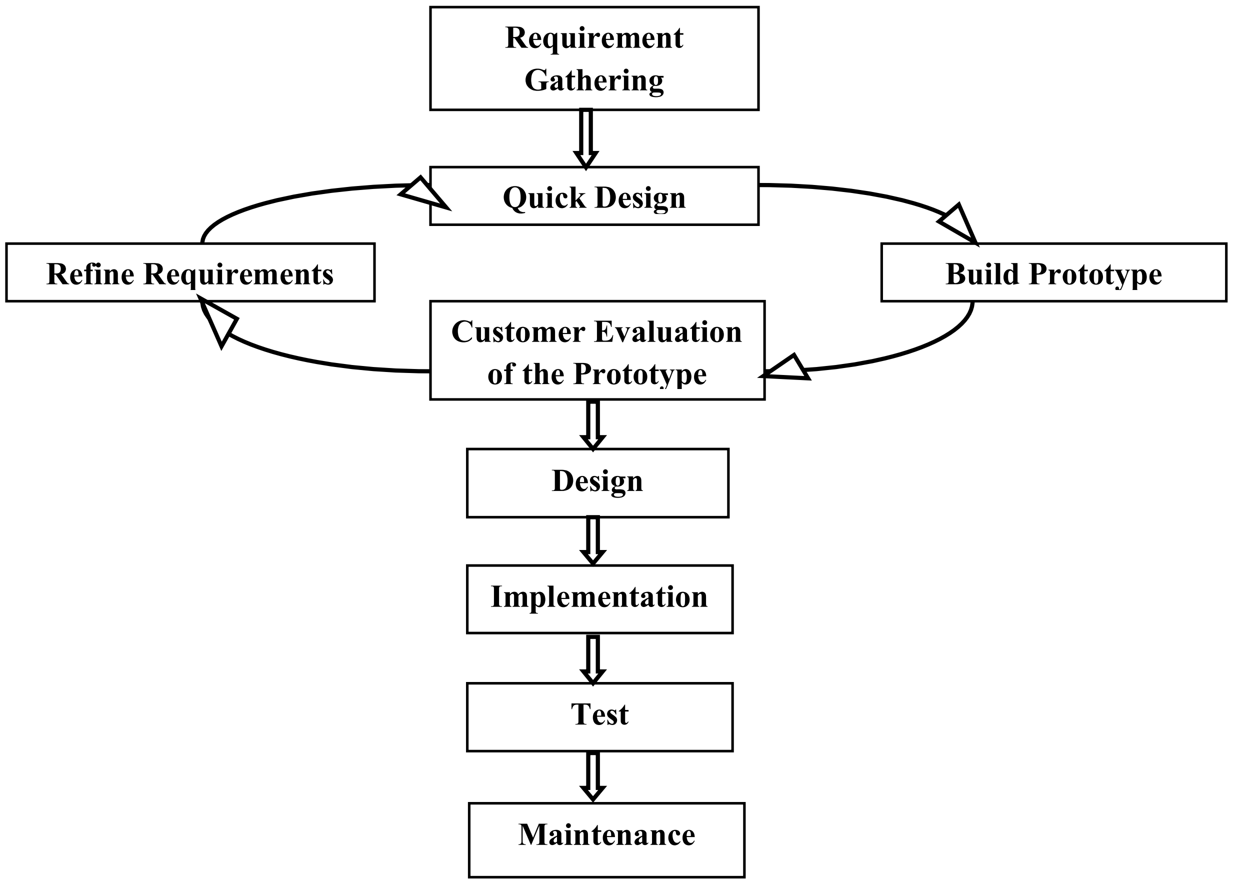
Prototype is a **partially developed product /dummy model** that allow customers and developers to analyze if the proposed system is suitable for the finished product.

- A prototype is a **toy implementation** which is built before starting actual development.
- The reason for developing a prototype is it is impossible to "get it right" the first time; we must plan to throw away the first product in order to develop a good product.
- The developed prototype is submitted to the customer/user for evaluation, based on the customer feedback the model is modified/refined. The cycle continues until the customer approves the prototype.



Advantages of Prototype Model

i. Modification in prototype is faster.
ii. Helps determine feasibility of the system.
iii. Software Developers commitment is higher.

Disadvantages of Prototype Model

i. Prototyping tools are expensive.
ii. Design and code for the prototype is usually thrown away.
iii. In order to get the prototype work quickly the quality is compromised.

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Risk Management

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What is a Risk?

"Risk is the potential future harm that may arise from some present action".

What is Risk management?

Identifying risks and drawing up plans to minimize their effect on the project is called Risk management.

Risk management plays an important role in software development. There are several **types of risks**:

1) Project risks –Affects project resources/schedule.
2) Product risks- Affects quality or performance of software being developed.
3) Business risks- Affects organization development.
4) Generic risks- Affects overall project. Example: Loss of team members, loss of funding.

Process of risk management

1. Risk Identification: Project, product and business risks are identified.
2. Risk analysis: Consequences of risks are assessed.
3. Risk planning: Addresses the risk either by avoiding it or minimizing its effects.
4. Risk monitoring: Risk is constantly assessed and information about the risk becomes available.

CASE (Computer aided software engineering)

Computer-aided software engineering (CASE) is software to support software development. It provides automated support for software process activities. Ex: Automated translators to generate new versions of a program

Important Questions [2 Marks]

1. Define Software Engineering.
2. Write the goals of Software Engineering.
3. Define Software. Write its classification.
4. What is Software product?
5. Differentiate Generic and Bespoke products.
6. Mention any 4 characteristics of Software.
7. What is Prototype model?
8. What is Risk? Mention the various types.
9. What is feasibility study?
10. Define CASE.

Important Questions

1. Explain different phases of SDLC with a neat diagram.
2. Explain Waterfall model with Spiral model with its advantages and disadvantages.
3. What is Software Process? What are the activities involved in software process?
4. What are the key challenges facing Software Engineering?
5. Write short notes on Risk management.

Chapter 2

System Engineering

Definition: System – A System is a collection of inter related components that work together to achieve some objective.
A system may include software, mechanical, electrical and electronic hardware and be operated by people. Example – Security Camera.

Definition: System Engineering – The activity of designing, implementing, validating, installing and maintaining systems as a whole is known as System Engineering.

Emergent properties

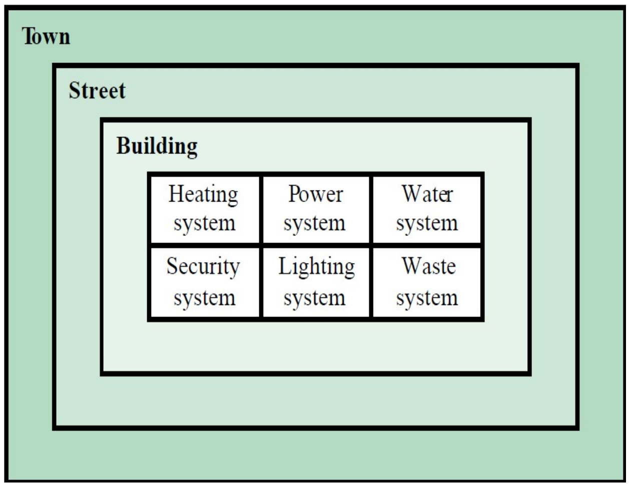
Properties of the system as a whole rather than properties that can be derived from the properties of components of a system. Some examples of emergent properties are:
The overall weight of the system
• This is an example of an emergent property that can be computed from individual component properties.
The reliability of the system
• This depends on the reliability of system components and the relationships between the components.
The usability of a system
• This is a complex property which is not simply dependent on the system hardware and software but also depends on the system operators and the environment where it is used.

System and their Environment

* Systems are not independent but exist in an environment
* System's function may be to change its environment.
* Environment affects the functioning of the system.
* When a System is a part of another system, it is called the sub-system.

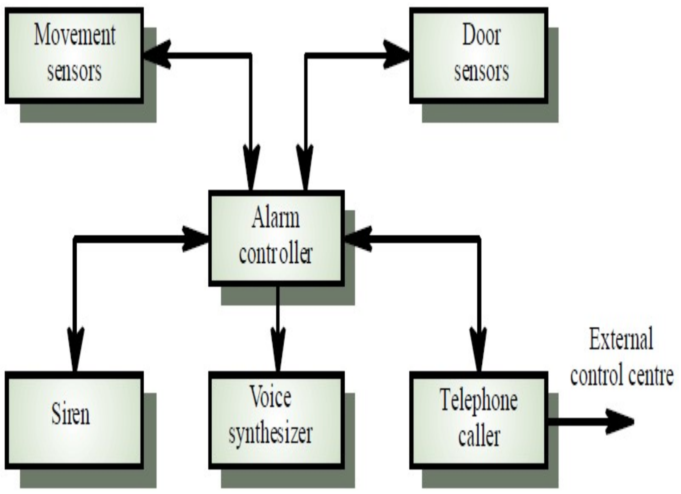
Example of System that includes Subsystem (System Hierarchies)

- The heating System, Power System, Water System so on is all Sub-Systems within the building.
- The building is located in a street, which is in a town and so on.
- The system engineer should not only consider the system as complete entity but must also have knowledge of the Environment where the system needs to be installed.



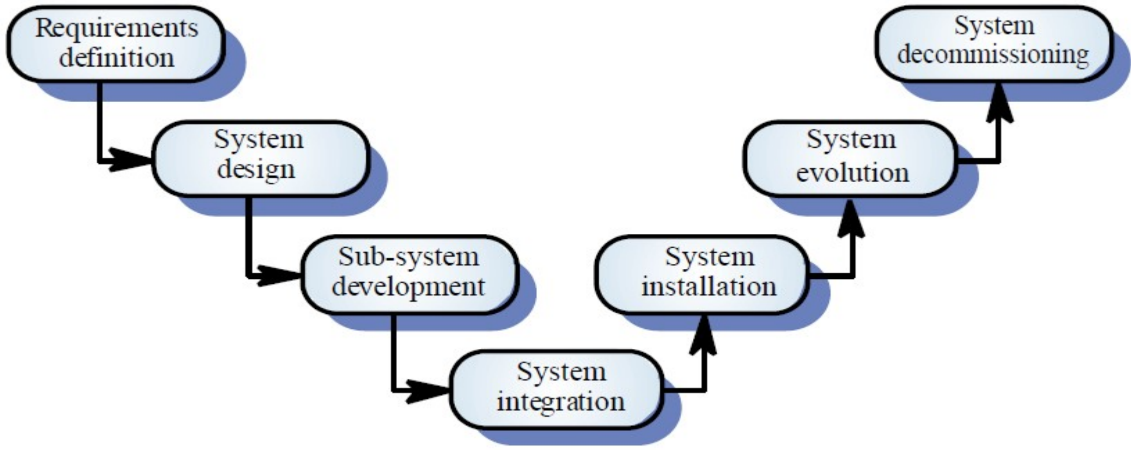
A Simple Intruder Alarm System

Sub system functionality in the intruder alarm.
→Sensor
• Movement sensor, door sensor
→Actuator
• Siren (Emits audible warning)
→Communication
• Telephone caller (makes external calls)
→Co-ordination
• Alarm controller
(Controls system operations)
→Interface
• Voice synthesizer.
(Notifies location of the suspect intruder)



System Engineering Process

It is a process that ensures that the customer's needs are satisfied throughout a system's entire life cycle.

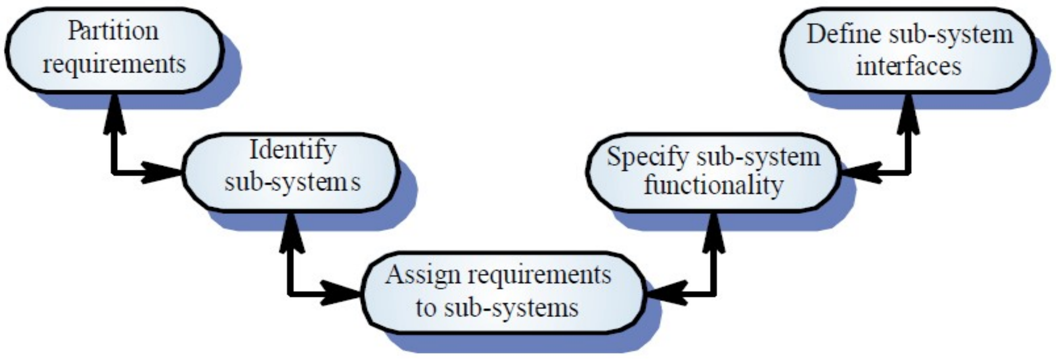


System Requirements Definition
Three types of requirement defined at this stage
• Abstract functional requirements- System functions are defined in an abstract level
• System properties - Non-functional emergent requirements for the system such as reliability, usability etc in general are defined
• System behavior- It is important to specify what the system must not do and what it should do.

System Design Process
The Activities involved in this process are:

- Partition requirements
- Identify sub-systems
- Assign Requirements to sub system

- Specify sub system functionality
- Define sub-system interfaces


Partition requirements
Identify sub-systems
Assign requirements to sub-systems
Specify sub-system functionality
Define sub-system interfaces

1. **Partition Requirements**: Analyze the requirements and organize them into related groups.
2. **Identify sub-systems**: Identify sub-systems that can individually or collectively meet the requirements.
3. **Assign Requirements to subsystem**: Assign the requirements to each identified sub-system.
4. **Specify sub-system functionality**: Relationship between the sub-systems should be identified at this stage which can collectively meet the system requirements.
5. **Define sub-system interface**: Once defining the sub-system interface have been agreed, parallel development of the sub-system becomes possible.

Sub-system development

- Typically parallel projects developing the hardware, software and communications
- It may involve some COTS (Commercial Off-the-Shelf) components.
- COTS systems may not meet the requirements exactly but it is worth to modify and use.
- It is cheaper to buy existing products rather than develop special purpose components.
- The sub-system development activity involves developing each of the sub-systems identified during system design.

System Integration

The process of putting hardware, software and people together to make a system**.**
Integration can be done in 2 ways:
1. Big Bang Method- All the sub-systems are integrated in the same way.
2. Incremental Integration- Sub-systems are integrated one at a time; it reduces the cost of Error location.

Once the components have been integrated, System Testing takes place.

System Installation

It is the activity of installing the system in the environment in which it is intended to operate.
Some of the problems that can arise during installations are:

- Environmental assumptions may be incorrect.
- May be human resistance to the introduction of a new system.
- System may have to coexist with alternative systems for some time.
- May be physical installation problems (e.g. cabling problems).
- Operator training has to be identified.

System Evolution

- Large systems have a long lifetime. They must evolve to meet changing requirements

Evolution is inherently costly for the following reasons:

- Changes must be analyzed from a technical and business perspective
- Sub-systems interact so unanticipated problems can arise
- System structure is corrupted as changes are made to it, hence its cost changes.
- Existing systems which must be maintained are sometimes called legacy systems.

System Decommissioning

- System Decommissioning means taking the system out of service after the end of its useful operational lifetime.
- Example : For hardware systems this may involve de-assembling and recycling materials.
- May require data to be restructured and converted so that it can be used in some other system.

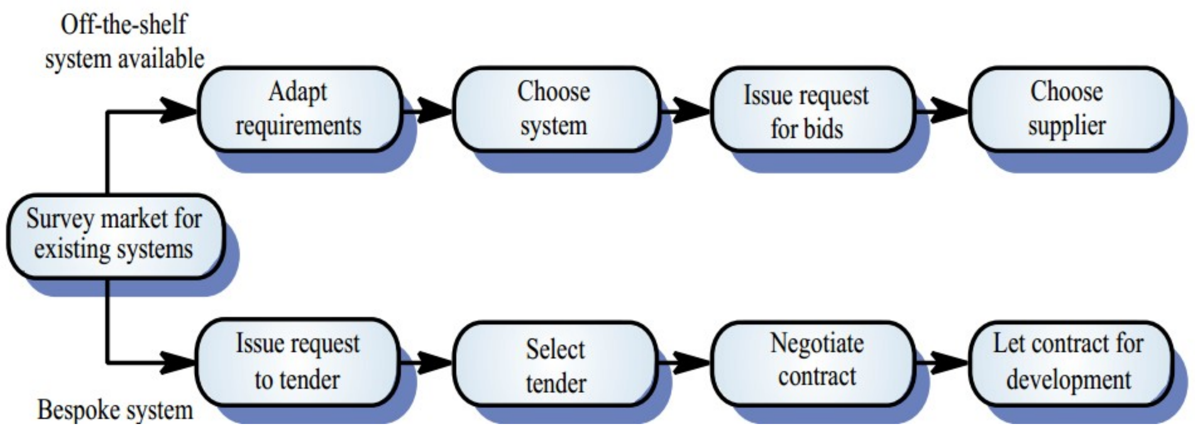
System Procurement

Definition: Acquiring a system for an organization to meet some need/requirement is called System Procurement.

Some System specification and architectural design is usually necessary before procurement

• You need a specification to let a contract for system development

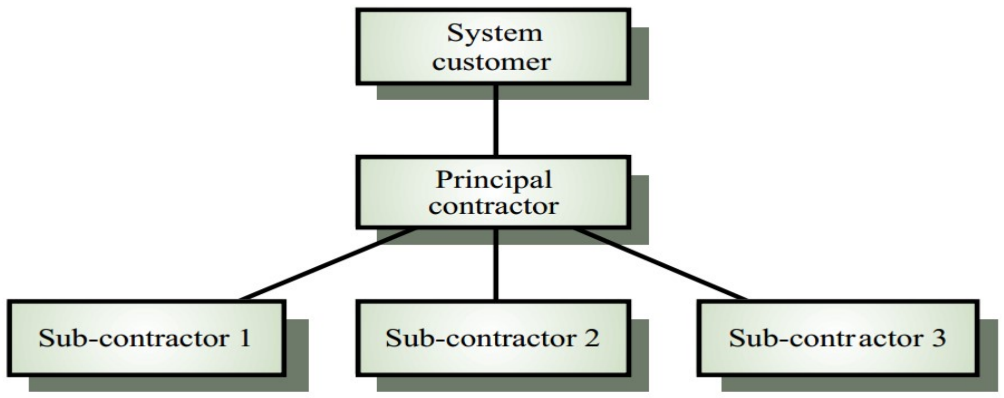
• The specification may allow you to buy a commercial off-the-shelf (COTS) system, always cheaper than developing a system from scratch.



Procurement issues

- Requirements may have to be modified to match the capabilities of off-the-shelf components.
- There is usually a contract negotiation period to agree changes after the contractor to build a system has been selected

Contractor/Sub-contractor model



- The procurement of large hardware/software systems is usually based around some principal contractor.
- Sub-contracts are issued to other suppliers to supply parts of the system.
- Customer leases with the principal contractor and does not deal directly with sub-contractors.

Human Factors

$$\begin{tikzcd}
 & \text{Human Factors} \arrow[dl] \arrow[d] \arrow[dr] & \\
\text{Process changes} & \text{Job changes} & \text{Organizational changes}
\end{tikzcd}$$

Process changes: In a organization a change in the process can result in job loss of the workers, as they lack training in the new system which becomes difficult for them to cope.

Job changes: As new and faster systems are introduced, the workers may have to change the way they work.

Organizational changes: If a organization is dependent on a complex system, those who know how to operate the system have a great deal of power in the organization.
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[Note: System Architectural model of a ship to be written in notes. Pg 2.10-2.11]

Chapter 3

Software Requirement Analysis and Specification

Definition: Software Requirement- The process of establishing the services that the customer requires from a system and the constraints under which it operates and is developed.
Requirements may serve a dual function
• May be the basis for a bid for a contract - therefore must be open to interpretation.
• May be the basis for the contract itself - therefore must be defined in detail.
Both these statements may be called requirements

Definition: Software Requirement Specification – A structured document setting out detailed descriptions of the system services written as a contract between client and contractor.

Classification of Software Requirements

1. **Functional Requirements**

Statements of services the system should provide how the system should react to particular inputs and how the system should behave in particular situations.

2. **Non-Functional Requirements**

Constraints on the services or functions offered by the system such as timing constraints, cost constraints, constraints on the development process, standards etc.

3. **System requirements**

A structured document setting out detailed descriptions of the system services written as a contract between client and contractor

4. **User Requirements**

Statements in natural language plus diagrams of the services the system provides and its operational constraints. It is written for customers.

Functional Requirements and Non Functional Requirements

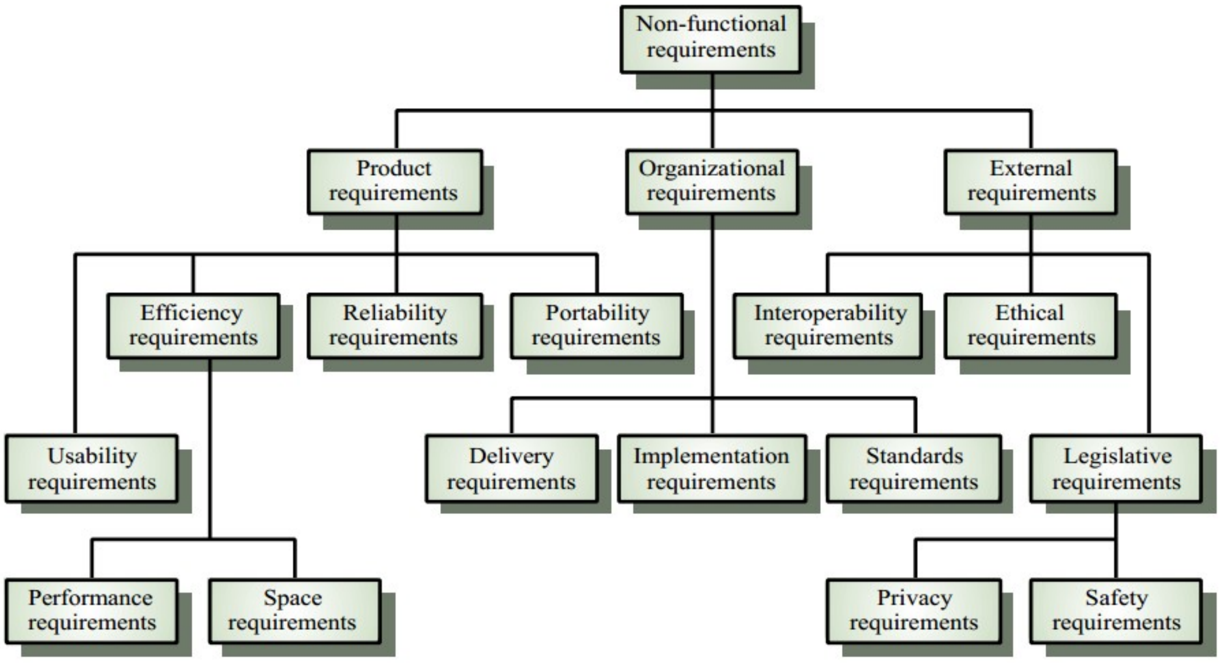
Functional Requirements:
*Statements of services the system should provide how the system should react to particular inputs and how the system should behave in particular situations.
*The Functional requirements of the system describe what the system should do.
*It depends on the type of software, expected users and the type of system where the software is used.
*Functional user requirements may be high-level statements of what the system should do but it should describe the system services in detail.

Non - Functional Requirements:
*Non-functional requirements may be more critical than functional requirements. If these are not met, the system is useless.
*Constraints on the services or functions offered by the system such as timing constraints, cost constraints, storage constraints, constraints on the development process, standards etc.

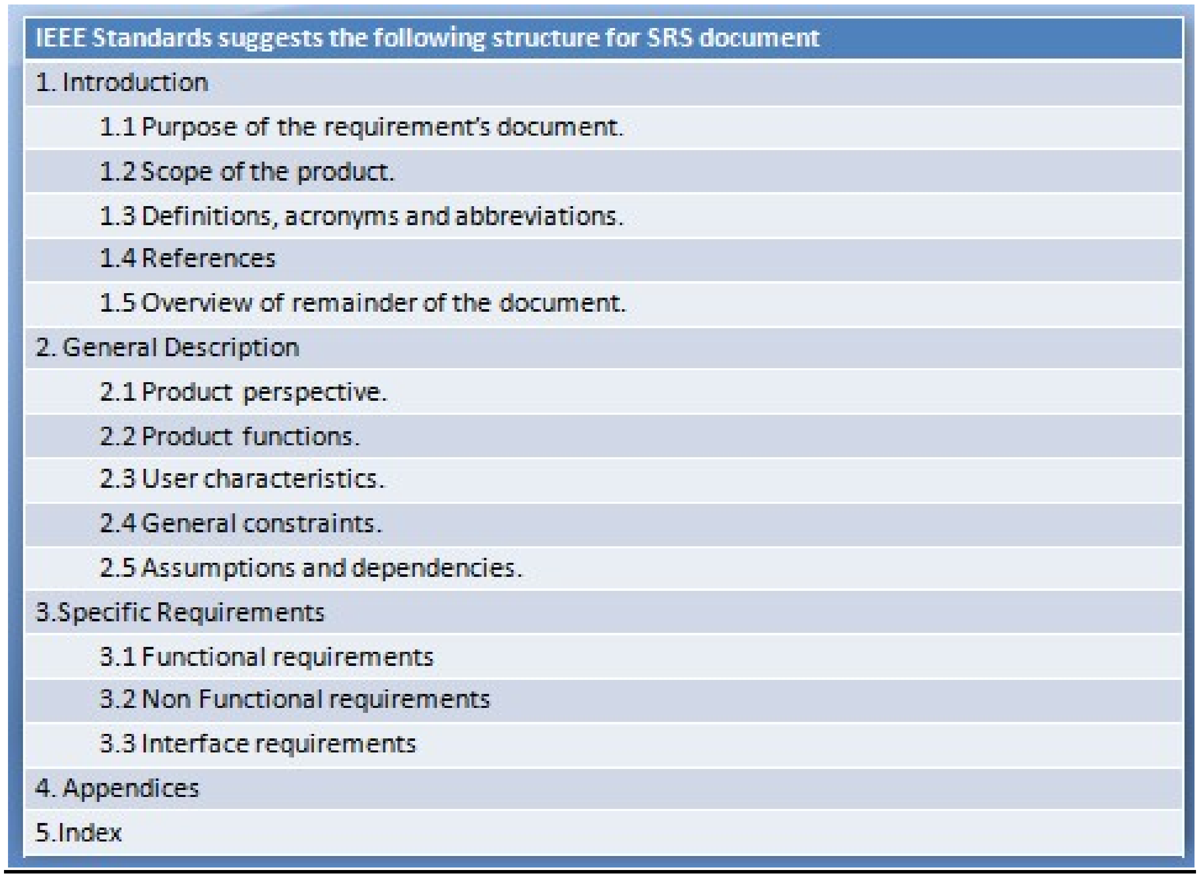
Classification of Software Requirements

Product requirements • Requirements which specify that the delivered product must behave in a particular way e.g. execution speed, reliability etc.
Organizational requirements • Requirements which are a consequence of organizational policies and procedures e.g. process standards used, implementation requirements etc.

External requirements
• Requirements which arise from factors which are external to the system and its development process e.g. interoperability requirements, legislative requirements etc.



Software Requirement Specification
Outline Structure of Software Requirement Specification



IEEE Standards suggests the following structure for SRS document
1. Introduction
1.1 Purpose of the requirement's document.
1.2 Scope of the product.
1.3 Definitions, acronyms and abbreviations.
1.4 References
1.5 Overview of remainder of the document.
2. General Description
2.1 Product perspective.
2.2 Product functions.
2.3 User characteristics.
2.4 General constraints.
2.5 Assumptions and dependencies.
3.Specific Requirements
3.1 Functional requirements
3.2 Non Functional requirements
3.3 Interface requirements
4. Appendices
5.Index

Definition: SRS is a formal document, which acts as a representation of software that enables the users to review whether it (SRS) is according to their requirements.
A structured document setting out detailed descriptions of the system services written as a contract between client and contractor.

Various other **Purposes** served by SRS are listed below.

1. **Feedback:** Provides a feedback, which ensures to the user that the organization (which develops the software) understands the issues or problems to be solved and the software behavior necessary to address those problems.
2. **Decompose problem into components:** Organizes the information and divides the problem into its component parts in an orderly manner.
3. **Input to design:** Contains sufficient detail in the functional system requirements to devise a design solution.
4. **Basis for agreement between the** user and **the organization:** Provides a complete description of the functions to be performed by the system.
5. **Reduce the development effort:** Enables developers to consider user requirements before the designing of the system commences. As a result, 'rework' and inconsistencies in the later stages can be reduced.
6. **Estimating costs and schedules:** Determines the requirements of the system and thus enables the developer to have a 'rough' estimate of the total cost and schedule of the project.

<u>Characteristics of SRS</u>

1. **Correct:** Correctness ensures that all specified requirements are performed correctly to meet the software.
2. **Unambiguous:** SRS is unambiguous when every stated requirement has only one interpretation. This implies that each requirement is uniquely interpreted.
3. **Complete:** SRS is complete when the requirements clearly define what the software is required to do. This includes all the requirements related to performance, design and functionality.

<u>Components of SRS</u>

Functionality
Environment and System Objectives
System Delivery and Installation
Design constraints
External interface requirements
Conceptually, any SRS should have these components. Now we will discuss them one by one.

1. Functionality:

- Procedures for starring up and closing down the system.
- Operations on Normal condition.
- Operations on abnormal conditions.

2. **Environment and System Objectives**

- Physical Attributes of the environment : size, shape and locality
- Safety/Security/Hazards

3. System Delivery and Installation

- Examples of these requirements are: Deadlines/ Quality assurance/ document structure/ standards/training/manuals/ support and maintenance.

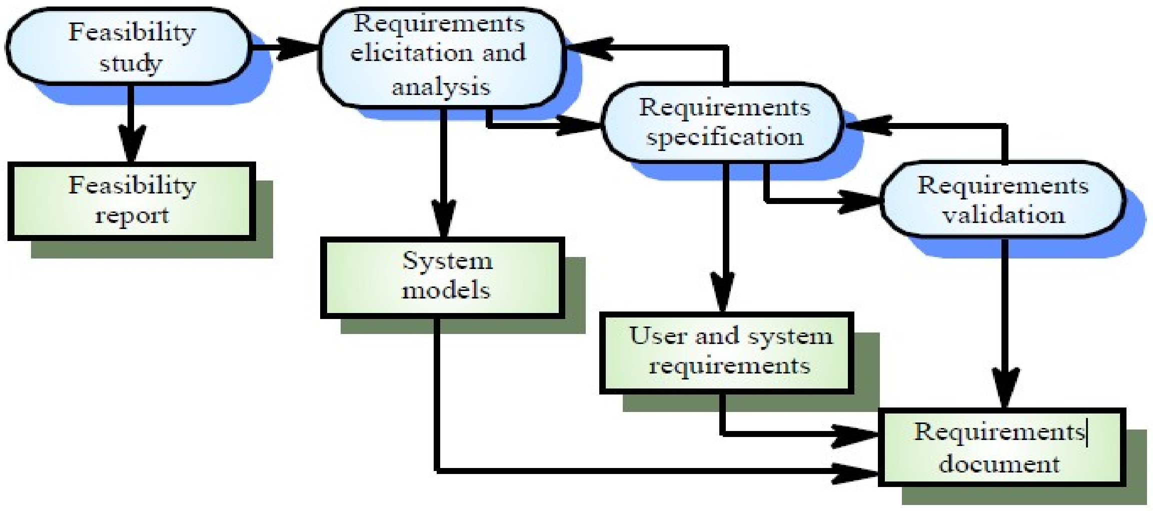
4. Design Constraints

- Hardware/Software standards, particular libraries, operating systems to be used and compatibility issues.

5. Functional Constraints

- Properties are: Performance, efficiency, response times, safety, security, reliability, quality and dependability.

The requirements engineering process



The process of establishing the services that the customer requires from a system and the constraints under which it operates is called **Requirement Engineering process.**

1. **Feasibility study:** The study determines whether or not a system is financially worthwhile and technically feasible.

It is the study that checks A) If the system contributes to organizational objectives. B) If the system can be engineered using current technology and within budget. C) Based on information assessment (what is required), information collected a brief report is written.

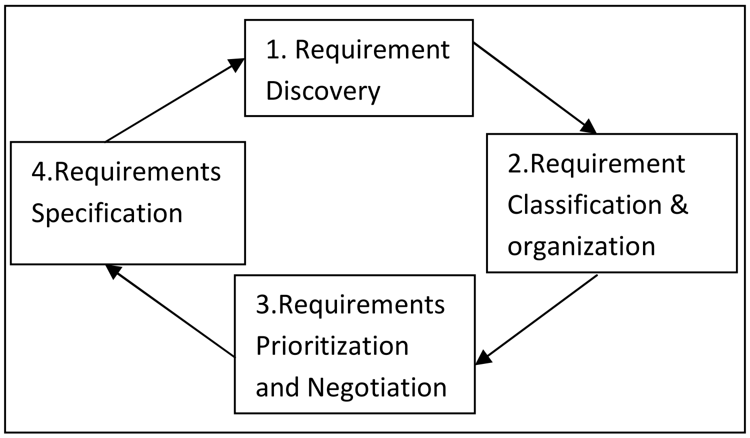
A feasibility study is conducted to answer many questions like

- What are current process problems?
- How will the proposed system help?
- What will be the integration problems?
- Is new technology needed? What skills?
- What facilities must be supported by the proposed system?

2. **Requirement Elicitation and Analysis:**

Activities involved in Elicitation and Analysis are

- ➢ Requirement Discovery
- ➢ Requirement classification and organization
- ➢ Requirement prioritization and negotiation
- ➢ Requirement Specification


1. Requirement Discovery
2.Requirement Classification & organization
3.Requirements Prioritization and Negotiation
4.Requirements Specification

The process involves technical staff working with customers to find out about the application domain, the services that the system should provide and the system's operational constraints.

It may involve end-users, managers, engineers involved in maintenance, domain experts, trade unions, etc. These are called ***stakeholders.***

The various activities involved in Requirement Analysis and Elicitation are :

- ➢ Domain Understanding : The analyst must understand the Background Knowledge of the application.
- ➢ Requirement Collection : Gathering the requirement by involving the users and stakeholders.
- ➢ Requirement classification : Organizing the requirements gathered from different sources.
- ➢ Requirement conflicts : Involves stakeholders and engineers to solve the problems that contradict the organization and business rules.
- ➢ Requirement prioritization : Discovering the most important requirements by interacting with stakeholders and organizing them into most priority order.
- ➢ Requirement validation : Checks stakeholder's expectation on the system with gathered requirements.

Techniques for Requirement Elicitation and Analysis
1. View point oriented elicitation
2. Scenarios
3. Ethnography

1. View point oriented elicitation

Stakeholders represent different ways of looking at a problem or problem viewpoints.
There are 3 types of viewpoints:

1. Interactive View points : Represents people or other systems that interact directly with the system. EX : In a bank ATM , the banks customer and banks account database.
2. Indirect view points : Represents stakeholders who do not use the system directly but influence the system in some way. EX : Management of the bank and bank security staff.
3. Domain view points : Represents domain characteristics and constraints that influence system requirements. EX: Standards that have been developed for inter banking communication like ATM.

The example used here is an auto-teller system which provides some automated banking services. Services include cash withdrawal, message passing (send a message to request a service), ordering a statement and transferring funds.

Auto- teller Viewpoints

Bank customers
Representatives of other banks
Hardware and software maintenance engineers
Marketing department
Bank managers and counter staff
Database administrators and security staff
Communications engineers
Personnel department

2. Scenarios

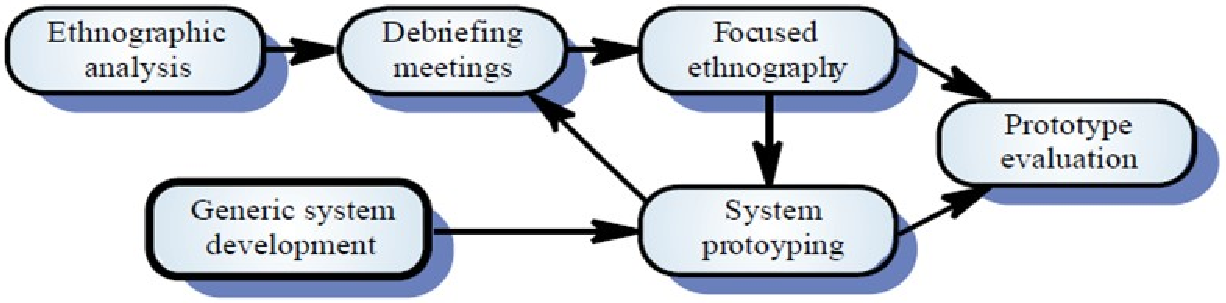
Scenarios are descriptions of how a system is used in practice.
They are helpful in requirements elicitation as people can relate to these more readily than abstract statement of what they require from a system.
Scenarios are particularly useful for adding detail to an outline requirements description.

Scenario Descriptions

- System state at the beginning of the scenario
- Normal flow of events in the scenario
- What can go wrong and how this is handled
- Other concurrent activities
- System state on completion of the scenario

3. Ethnography

Definition: “Ethnography is an observational technique that is used to understand social and organizational requirement.”



Ethnographic studies have shown that work is usually richer and more complex than suggested by simple system models. These are the Requirements that are derived from the way that people actually work.
Ethnographic requirements are derived from cooperation and awareness of other people's activities.

Requirements Specification Methods

Specification Method	**Description**
Structured Natural language	This approach depends on defining standard forms or templates to express the requirements specification in natural language.
Design description language	This approach uses a language like a programming language but with more abstract features to specify the requirements by defining an operational model of the system.
Graphical notations	It has much complex graphical vocabulary and is most widely used by specialists.
Mathematical specifications	These are notations based on mathematical concepts such as finite-state machines or sets.

Requirement Validation
Requirement Validation is concerned with demonstrating the requirements that define the system which customer really wants. Requirements error costs are high so validation is very important i.e. fixing a requirements error after delivery may cost up to 100 times the cost of fixing an implementation error.

Requirement Validity Checks

Requirement Validity Checks	Description
1.Validity Checks	Aims to ensure that the system meets all functional, behavioral and performance requirements.
2.Consistency Checks	Requirements collected must be consistent and should not lead to conflict.
3.Realism Checks	These checks take into account the budget and schedule for the system development.
4.Verifiability	At the completion of the system, it must be possible to demonstrate that the delivered system meets all the requirements.

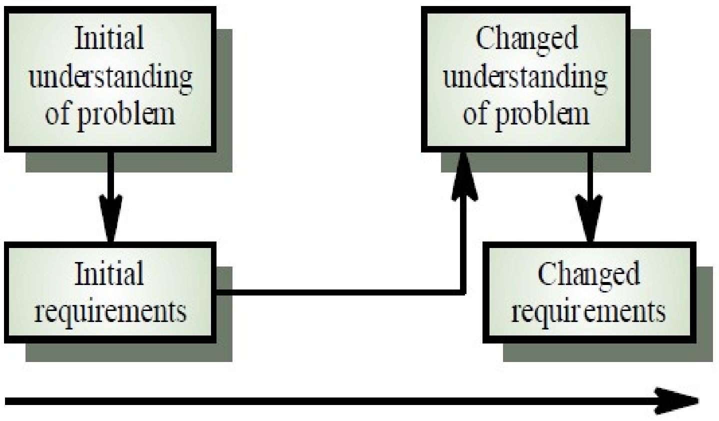
Requirement Validation techniques
1. Requirement Reviews **2.Prototyping** **3.Test Case Generation**

Requirements reviews
- Systematic manual analysis of the requirements
- Reviews here can also check for a)Verifiability, b)Comprehensibility, c)Traceability and d)Adaptability

Prototyping
- Using an executable model of the system to check requirements.

Test-case generation
- Developing tests for requirements to check testability, if a test is difficult or impossible to design that means requirements are unrealistic.

Requirement Management
Requirement Evolution
Based on the Requirement Evolution, requirements are classified into 2 types :
1) Enduring Requirements
2) Volatile Requirements


Initial understanding of problem
Changed understanding of problem
Initial requirements
Changed requirements

Enduring requirements- Stable requirements derived from the core activity of the customer organization. E.g. a hospital will always have doctors, nurses, etc. May be derived from domain models.
Volatile requirements - Requirements which change during development or when the system is in use. In a hospital, requirements derived from health-care policy etc

System Models to be written from text book 3.7

SOFTWARE LIFE CYCLE

1) First phase : Requirement analysis and specification.

•This stage contains functional and non-functional requirements.

Processing and input/output needs.	Constraints of the system such as type and capacity of machine, response time, recovery and failure modes

2) Second phase : System and software design.

• Taking input from SRS, system architecture is produced.

• Designers describe units or modules.

3)Third phase : Implementation and integration of software units.

•Design is translated into programs or units.

•Each unit is tested individually to ensure it matches with the design.

•Common coding errors found here are typing mistakes, statement omission, wrong logical operator.

•Pre-defined strategy (top-down/bottom-up) are used.

Final phase : Software use or operation and maintenance.
2 types of maintenance- Corrective maintenance (modification due to error discovery) and adaptive maintenance (alterations due to system requirements).

Based on SDLC we have several models

✓Waterfall model (Notes Xerox)
✓Bohemia's Spiral model
✓Iterative enhancement model

The above are also called as Process models

Software Process : Description of process is given by

1.Specification – what the system should do and its development constraints.
2.Design- structure of software systems.
3.Validation- checking the software to make sure it is what the customer wants.
4.Evolution- changing the software in response to changing demand.

Software models are an abstract representation of a software process.

BOHEMIA'S SPIRAL MODEL

•Proposed by Boehm in 1988.
•Each loop in the spiral represents a phase of the software process.
•Innermost loop is concerned with System feasibility, next loop system requirement, next loop system design and so on

Each loop is split into 4 sectors :
1.Objective setting – Project risks are identified, alternative strategies depending on these risks may be planned.
2.Risk assessment and reduction - Project risks are identified → detailed analysis carried → steps taken to reduce risks.
Ex: A prototype system (Toy like implementation with limited functional capabilities and low reliability just for the purpose of examining)
3.Development and Validation – Choosing the most appropriate development model.
4.Planning – Project is reviewed and decisions are made whether to continue with further loop of the spiral.

Advantages and disadvantages (text)

RISK MANAGEMENT

➢Identifying risks and drawing up plans to minimize their effect on the project is called Risk management.

Categories of risk can be defined as follows :

1)Project risks –affects resources/schedule.

2)Product risks- affects quality /performance of software being developed.

3)Business risks- affects organization development.

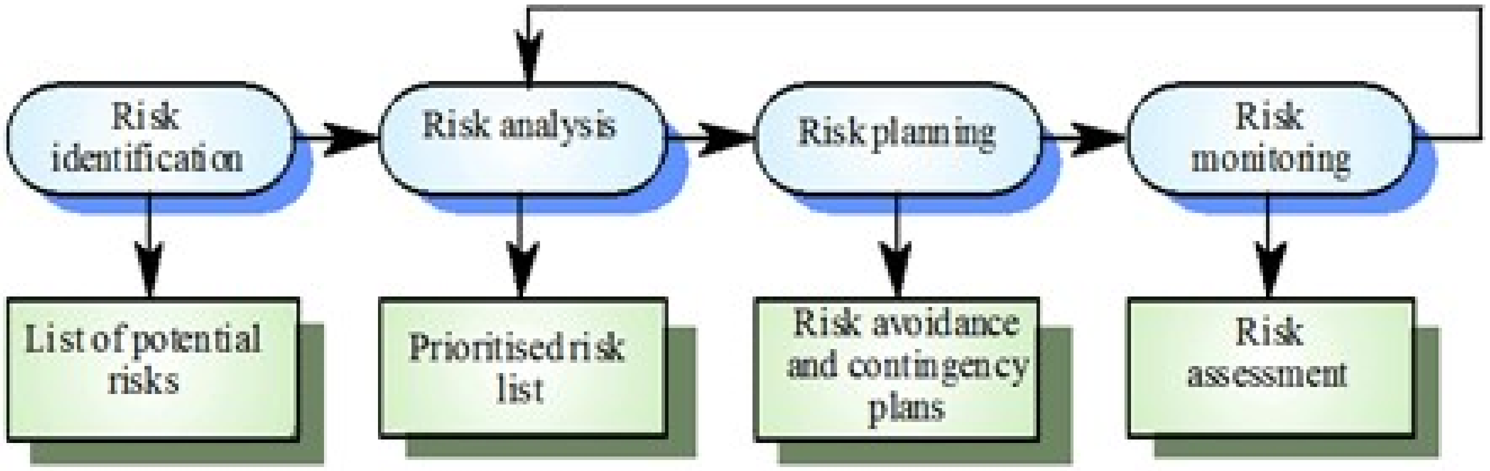
➢Process of risk management

1.Risk Identification: Project, product and business risks are identified.

2.Risk analysis : Consequences of risks are assessed.

3.Risk planning : Addresses the risk either by avoiding it or minimizing its effects.

4.Risk monitoring : Risk is constantly assessed and information about the risk becomes available.



Risk Identification

•This may be carried out as a brainstorming approach or may simply be based on a manager’s experience. They include :

1. Technology risks : Risks which derive from the software or hardware technologies.
2. People risks : Associated with people in the development team.
3. Organizational risks : organizational environment where the software is being developed.
4. Requirement risks : derived from changes to the customer requirement.
5. Estimation risks : management estimates of system characters and resources.

Risk Analysis

It relies on the judgement and experience of the project manager.

The probability of the risk might be assessed as :

- Very low (<10%)
- low (10-25%)
- moderate (25-50%)
- high(50-75%)
- Very high (>75%)

Risk Planning

The strategies are divided Into 3 :

a)Avoidance strategies – dealing with defective components.

b)Minimization strategies – strategy for staff illness.

c)Contingency plans – strategy for organizational financial problems.

WHAT IS SOFTWARE? WHAT ARE THE 2 TYPES OF SOFTWARE PRODUCTS?

Software is not just the programs but also all associated documentation and configuration data which is needed to operate programs correctly.

Software products may be developed for a particular customer or may be developed for a general market.

Software products may be

- Generic – Stand alone systems.
  Developed to be sold to a range of different customers.
  Sold on the open market to any customer who is able to buy them.

  Examples : product include database, word processors, drawing packages etc
- Bespoke (customized) -Software contractor develops for customer.
  -Developed for a single customer according to their specification.
  -Air traffic control system, control system for electronic system.

WHAT ARE THE KEY CHALLENGES FACING SOFTWARE ENGINEERING

❖Coping with legacy systems, coping with increasing diversity and coping with demands for reduced delivery times

❖ Legacy challenge

• Old, valuable systems must be maintained and updated

❖ Heterogeneity challenge

• Systems are distributed and include a mix of hardware and software

❖Delivery challenge

• There is increasing pressure for faster delivery of software

WHAT IS CASE (COMPUTER AIDED SOFTWARE ENGINEERING)

Software systems which are intended to provide automated support for software process activities.

CASE systems are often used for method support

Upper-CASE

• Tools to support the early process activities of requirements and design

Lower-CASE

• Tools to support later activities such as programming

•Debugging and testing

ATTRIBUTES OF GOOD SOFTWARE

The software should deliver the required functionality and performance to the user and should be maintainable, dependable, efficient and usable

a)Maintainability

- Software must evolve to meet changing needs

b) Dependability

- Software must be trustworthy

c) Efficiency

- Software should not make wasteful use of system resources

d)Usability

- Software must be usable by the users for which it was designed

PROFESSIONAL AND ETHICAL RESPONSIBILITY

Software engineers must behave in an honest and ethically responsible way if they are to be respected as professionals.

Ethical behavior is more than simply upholding the law.

1.Confidentiality : Engineers should normally respect the confidentiality of their employers or clients irrespective of whether or not a formal confidentiality agreement has been signed.

2.Competence : Engineers should not misrepresent their level of competence. They should not knowingly accept work which is out with their competence.

3.Intellectual property rights : Engineers should be aware of local laws governing the use of intellectual property such as patents, copyright, etc. They should be careful to ensure that the intellectual property of employers and clients is protected.

4.Computer misuse : Software engineers should not use their technical skills to misuse other people's computers. Computer misuse ranges from relatively trivial (game playing on an employer's machine, say) to extremely serious (dissemination of viruses).

System Engineering

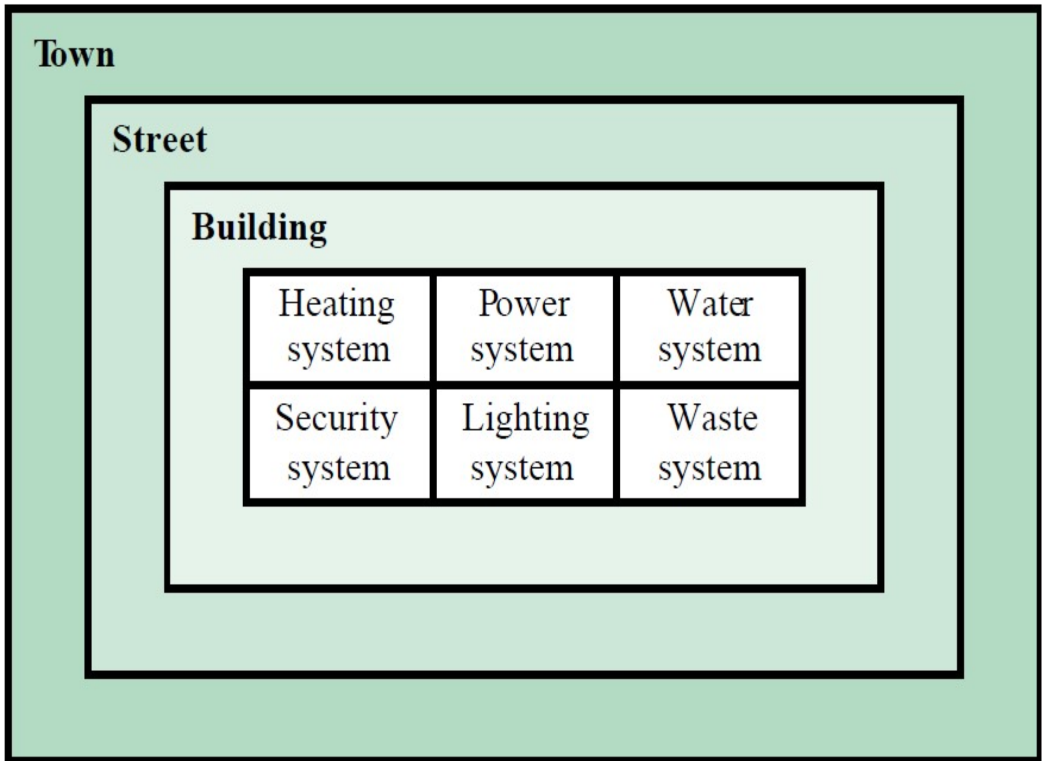
Definition System: A System is a collection of inter related components that work together to achieve some objective.

A system may include software, mechanical, electrical and electronic hardware and be operated by people. Example – Security Camera

Definition: System Engineering – The activity of designing, implementing, validating, installing and maintaining systems as a whole is known as System Engineering.

SYSTEMS AND THEIR ENVIRONMENT

* Systems are not independent but exist in an environment
* System’s function may be to change its environment.
* Environment affects the functioning of the system.
e.g. system may require electrical supply from its environment.



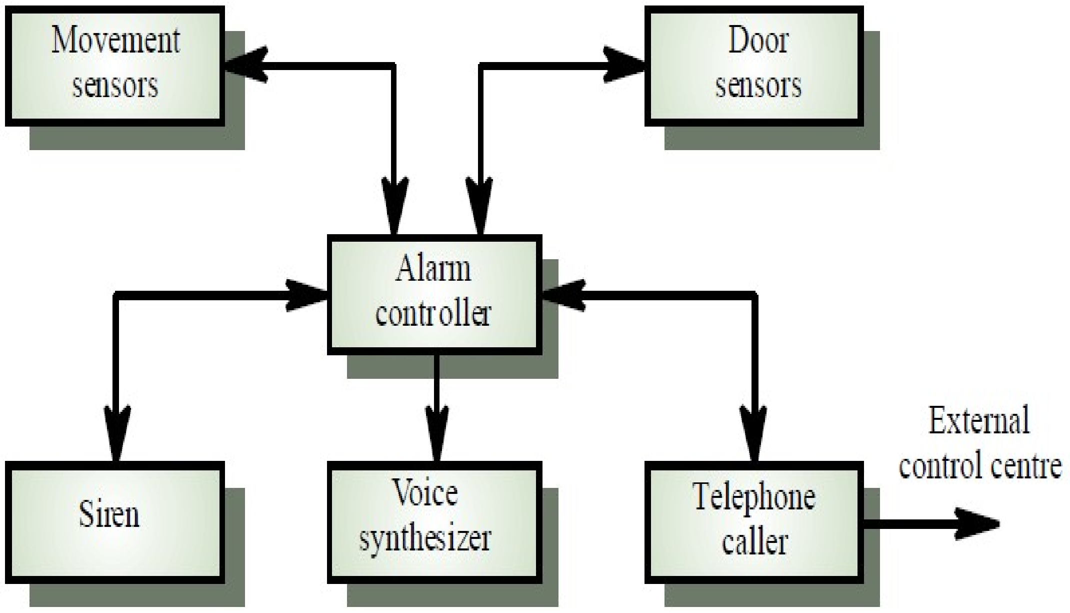
SYSTEM MODELING

•An architectural model presents an abstract view of the sub-systems making up a system.
•May include major information flows between subsystems.
•Usually presented as a block diagram.
•May identify different types of functional component in the model.

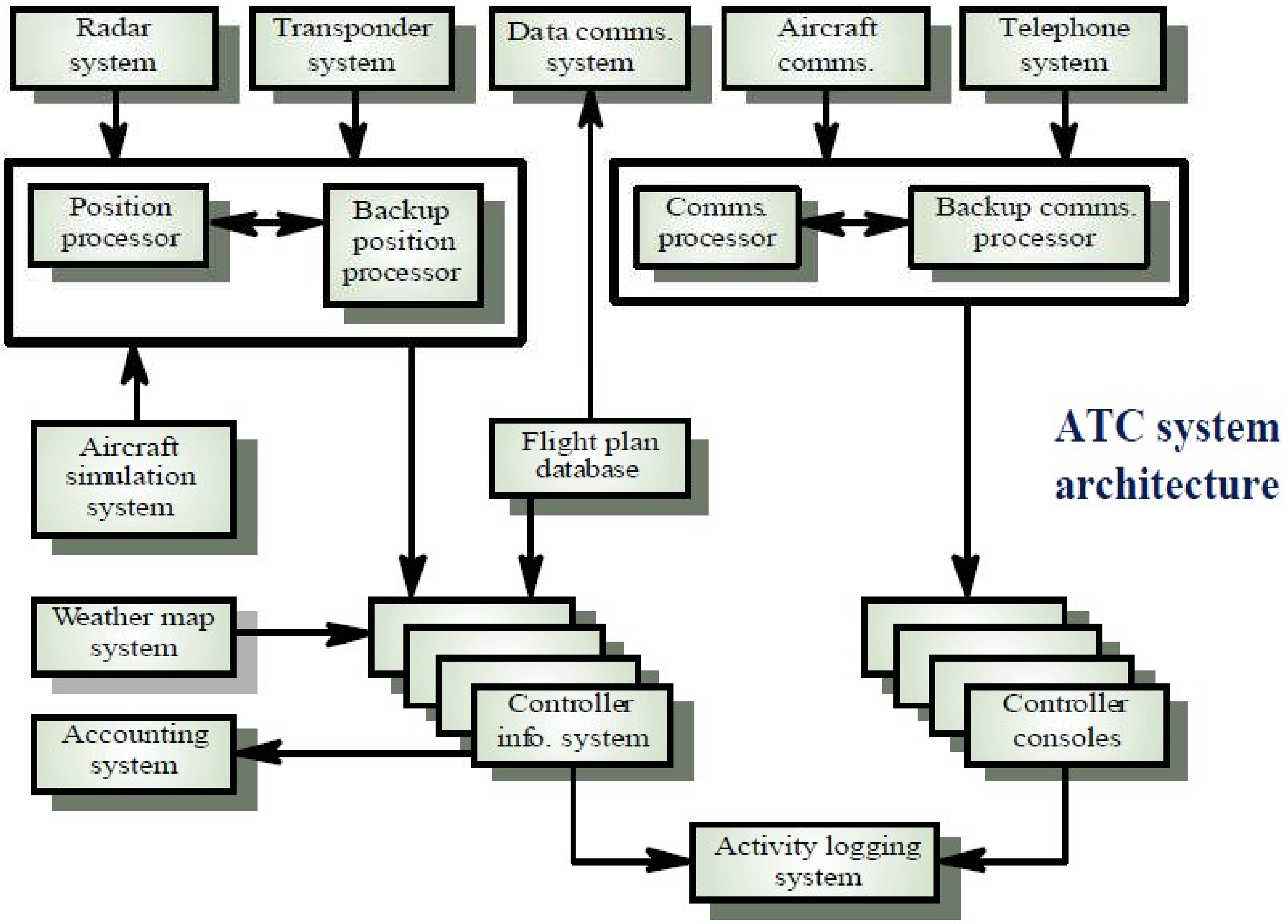
A SIMPLE INTRUDER ALARM SYSTEM

Sub system functionality in the intruder alarm.

→Sensor
• Movement sensor, door sensor
→Actuator
• Siren (Emits audible warning)
→Communication
• Telephone caller(makes external calls)
→Co-ordination
• Alarm controller
(Controls system operations)
→Interface
• Voice synthesizer.
(notifies location of the suspect intruder)



ARCHITECTURE OF ATC(AIR TRAFFIC CONTROL SYSTEM)



Functional system components

- Sensor components
- Actuator components
- Computation components
- Communication components
- Co-ordination components
- Interface components

System components

→Sensor components

• Collect information from the system’s environment e.g. radars in an air traffic control system

→Actuator components

• Cause some change in the system’s environment e.g. valves in a process control system which increase or decrease material flow in a pipe

→Computation components

• Carry out some computations on an input to produce an output e.g. a floating point processor in a computer system

→Communication components

• Allow system components to communicate with each other e.g. network linking distributed computers.

→ Co-ordination components

• Co-ordinate the interactions of other system components e.g. scheduler in a real-time system.

→ Interface components

• Facilitate the interactions of other system components e.g. operator interface

→All components are now usually software controlled.

Component types in alarm system

→ Sensor

• Movement sensor, Door sensor

→ Actuator

• Siren

→ Communication

• Telephone caller

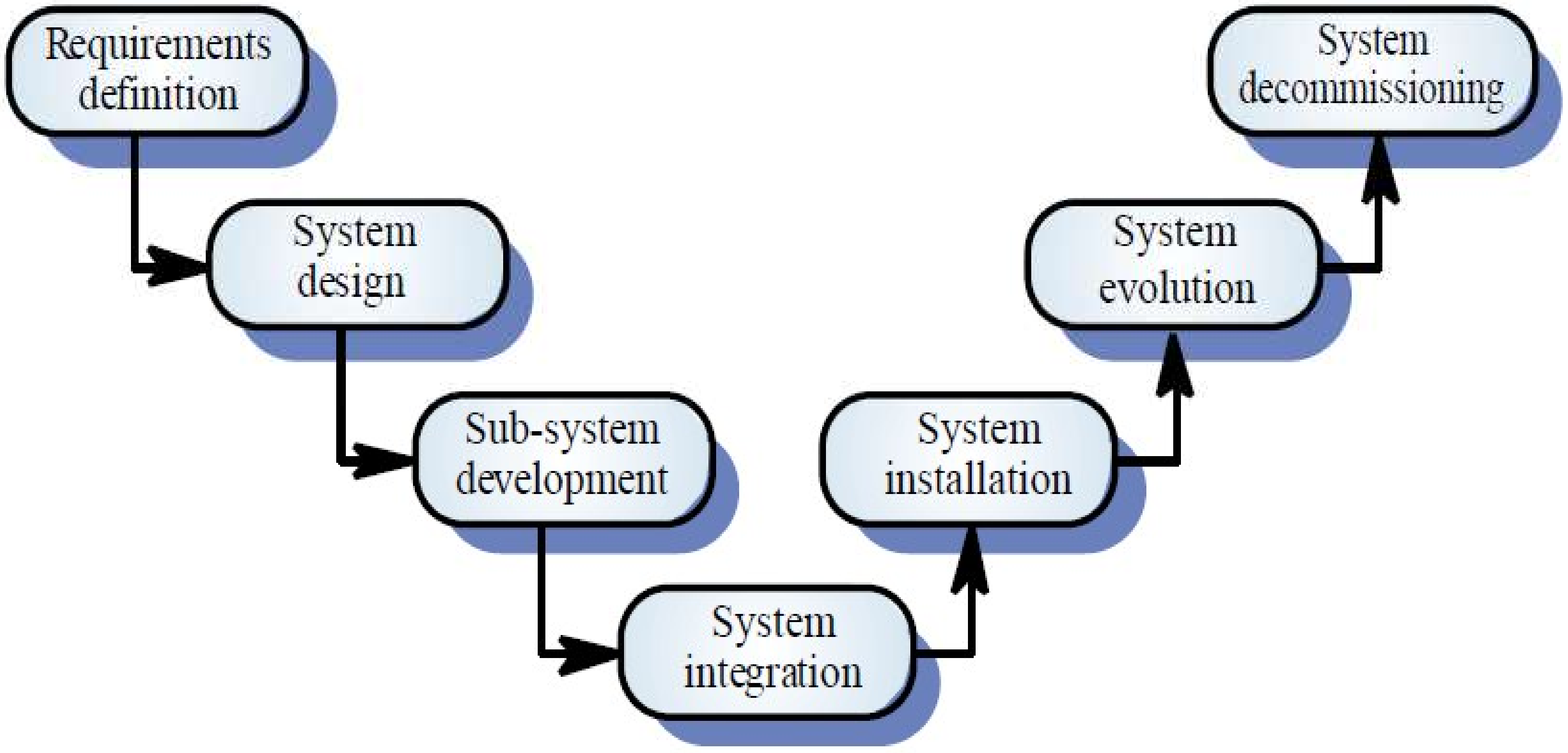
→ Coordination

• Alarm controller

→ Interface

• Voice synthesizer

THE SYSTEM ENGINEERING PROCESS



System requirements definition

Three types of requirement defined at this stage

• Abstract functional requirements. System functions are defined in an abstract way

• System properties. Non-functional requirements for the system in general are defined

• Undesirable characteristics. Unacceptable system behavior is specified.

System objectives

Functional objectives

• To provide a fire and intruder alarm system for the building which will provide internal and external warning of fire or unauthorized intrusion.

Organizational objectives

• To ensure that the normal functioning of work carried out in the building is not seriously disrupted by events such as fire and unauthorized intrusion.

The system design process

•Partition requirements

•Organize requirements into related groups

• Identify sub-systems

• Identify a set of sub-systems which collectively can meet the

•system requirements

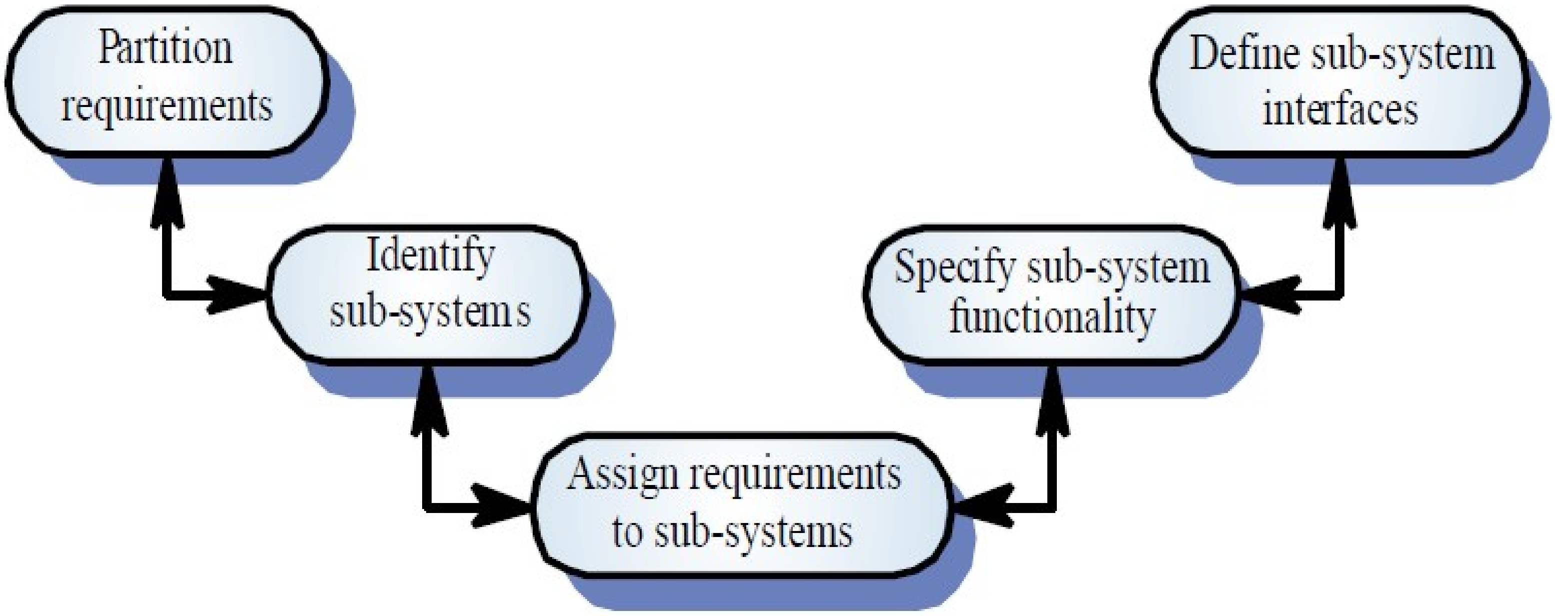
Assign requirements to sub-systems

• Causes particular problems when COTS are integrated

Specify sub-system functionality

Define sub-system interfaces

• Critical activity for parallel sub-system development


Partition requirements
Identify sub-systems
Assign requirements to sub-systems
Specify sub-system functionality
Define sub-system interfaces

System design problems

Requirements partitioning to hardware, software and human components may involve a lot of negotiation.

Difficult design problems are often assumed to be readily solved using software.

Hardware platforms may be inappropriate for software requirements so software must compensate for this.

Sub-system development

Typically parallel projects developing the hardware, software and communications

May involve some COTS (Commercial Off-the-Shelf) systems procurement.

Lack of communication across implementation teams.

Bureaucratic and slow mechanism for proposing system changes means that the development schedule may be extended because of the need for rework.

System integration

The process of putting hardware, software and people together to make a system.

Should be tackled incrementally so that sub-systems are integrated one at a time.

Interface problems between sub-systems are usually found at this stage.

May be problems with uncoordinated deliveries of system components.

System installation

Environmental assumptions may be incorrect
May be human resistance to the introduction of a new system
System may have to coexist with alternative systems for some time
May be physical installation problems (e.g. cabling problems)
Operator training has to be identified.

System operation

Will bring unforeseen requirements to light
Users may use the system in a way which is not anticipated by system designers.
May reveal problems in the interaction with other systems.

- Physical problems of incompatibility
- Data conversion problems
- Increased operator error rate because of inconsistent interfaces

System Evolution

•Large systems have a long lifetime. They must evolve to meet changing requirements
Evolution is inherently costly.

- Changes must be analyzed from a technical and business perspective
- Sub-systems interact so unanticipated problems can arise
- System structure is corrupted as changes are made to it, hence its cost changes.

Existing systems which must be maintained are sometimes called legacy systems.

System Decommissioning

Taking the system out of service after its useful Lifetime.
May require removal of materials (e.g. dangerous chemicals) which pollute the environment.

- Should be planned for in the system design by encapsulation.

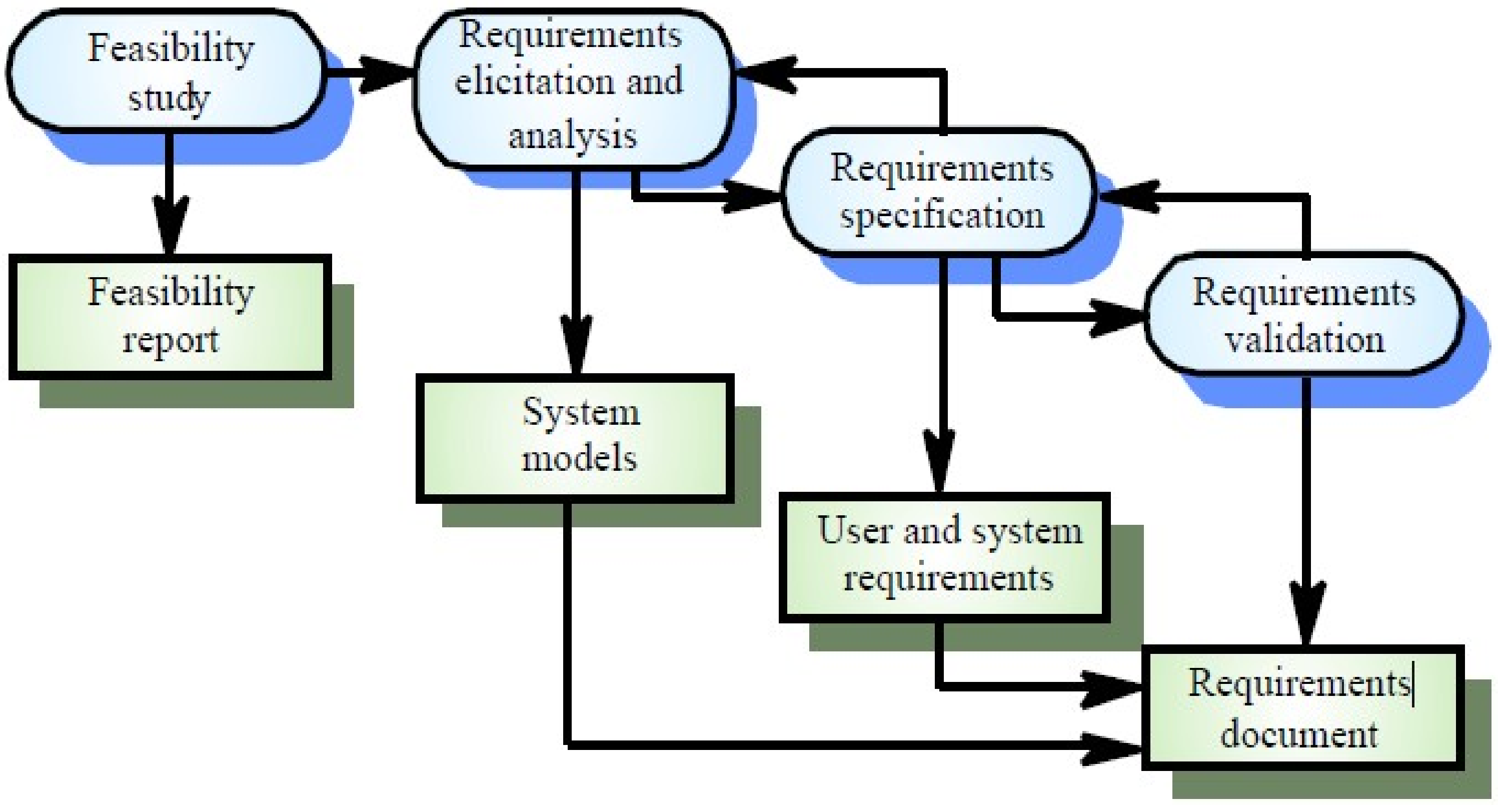
May require data to be restructured and converted to be used in some other system.

STRUCTURE OF SRS DOCUMENT

[AN OUTLINE OF SRS DOCUMENT]

IEEE Standards suggests the following structure for SRS document
1. Introduction
1.1 Purpose of the requirement’s document.
1.2 Scope of the product.
1.3 Definitions, acronyms and abbreviations.
1.4 References
1.5 Overview of remainder of the document.
2. General Description
2.1 Product perspective.
2.2 Product functions.
2.3 User characteristics.
2.4 General constraints.
2.5 Assumptions and dependencies.
3.Specific Requirements
3.1 Functional requirements
3.2 Non Functional requirements
3.3 Interface requirements
4. Appendices
5.Index

The requirements engineering process



The process of establishing the services that the customer requires from a system and the Constraints under which it operates is called Requirement Engineering process.

Feasibility studies

- A feasibility study decides whether or not the proposed system is worthwhile
- A short focused study that checks
  - If the system contributes to organisational objectives
  - If the system can be engineered using current technology and within budget
  - If the system can be integrated with other systems that are used

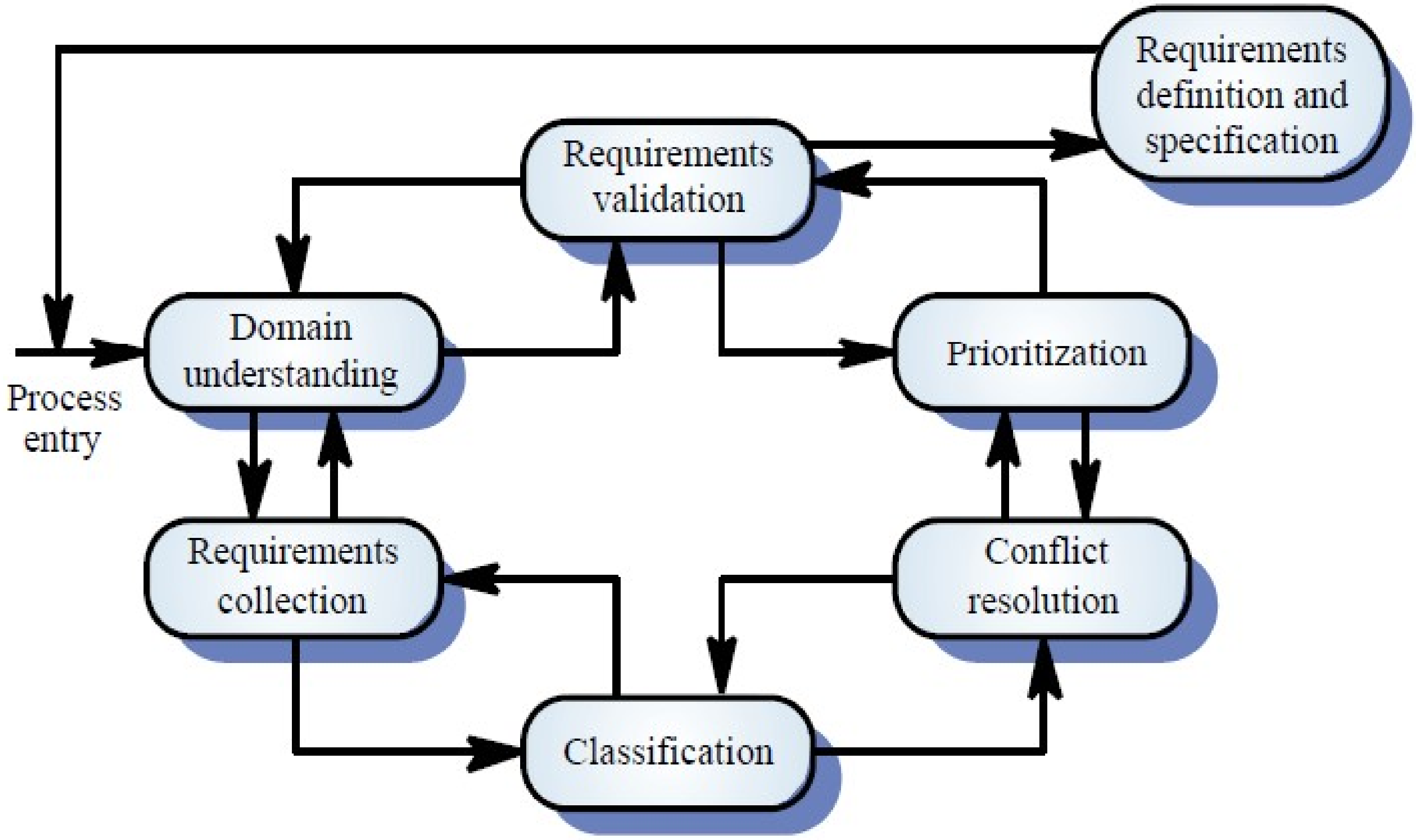
Feasibility study implementation

- Based on information assessment (what is required), information collection and report writing
- Questions for people in the organisation
  - What if the system wasn't implemented?
  - What are current process problems?
  - How will the proposed system help?
  - What will be the integration problems?
  - Is new technology needed? What skills?
  - What facilities must be supported by the proposed system?

Elicitation and analysis

- Sometimes called requirements elicitation or requirements discovery
- Involves technical staff working with customers to find out about the application domain, the services that the system should provide and the system's operational constraints
- May involve end-users, managers, engineers involved in maintenance, domain experts, trade unions, etc. These are called *stakeholders*

The requirements analysis process



- Domain Understanding : The analyst must understand the Background Knowledge of the application.

- Requirement Collection : Gathering the requirement by involving the users and stakeholders.

- Requirement classification : Organizing the requirements gathered from different sources.

- Requirement conflicts : Involves stakeholders and engineers to solve the problems that contradict the organization and business rules.

- Requirement prioritization : Discovering the most important requirements by interacting with stakeholders and organizing them into most priority order.

- Requirement validation : Checks stakeholder’s expectation on the system with gathered requirements.

Problems of requirements analysis

- Stakeholders don’t know what they really want
- Stakeholders express requirements in their own terms
- Different stakeholders may have conflicting requirements
- Organisational and political factors may influence the system requirements
- The requirements change during the analysis process. New stakeholders may emerge and the business environment change

These are some of the reasons why Elicitation and analysis is a difficult task.

TECHNIQUES FOR REQUIREMENT ELICITATION AND ANALYSIS

1. VIEW POINT ORIENTED ELICITATION
2. SCENARIOS
3. ETHNOGRAPHY

1. VIEW POINT ORIENTED ELICITATION

Stakeholders represent different ways of looking at a problem or problem viewpoints. There are 3 types of viewpoints:

1. Interactive View points : Represents people or other systems that interact directly with the system. EX : In a bank ATM , the banks customer and banks account database.

2. Indirect view points : Represents stakeholders who do not use the system directly but influence the system in some way. EX : Management of the bank and bank security staff.

3. Domain view points : Represents domain characteristics and constraints that influence system requirements. EX : Standards that have been developed for inter banking communication like ATM.

2. SCENARIOS

- Scenarios are descriptions of how a system is used in practice
- They are helpful in requirements elicitation as people can relate to these more readily than abstract statement of what they require from a system
- Scenarios are particularly useful for adding detail to an outline requirements description

Scenario descriptions

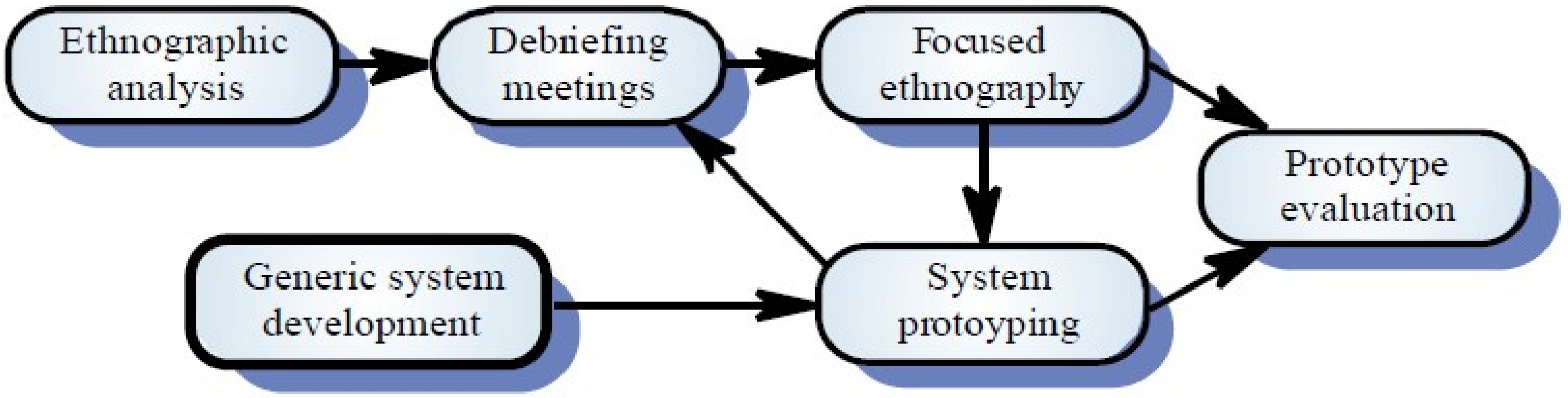
- System state at the beginning of the scenario
- Normal flow of events in the scenario
- What can go wrong and how this is handled
- Other concurrent activities
- System state on completion of the scenario

3.ETHNOGRAPHY

“Ethnography is an observational technique that can used to understand social and organizational requirement.”

- A social scientists spends a considerable time observing and analysing how people actually work
- People do not have to explain or articulate their work
- Social and organisational factors of importance may be observed
- Ethnographic studies have shown that work is usually richer and more complex than suggested by simple system models

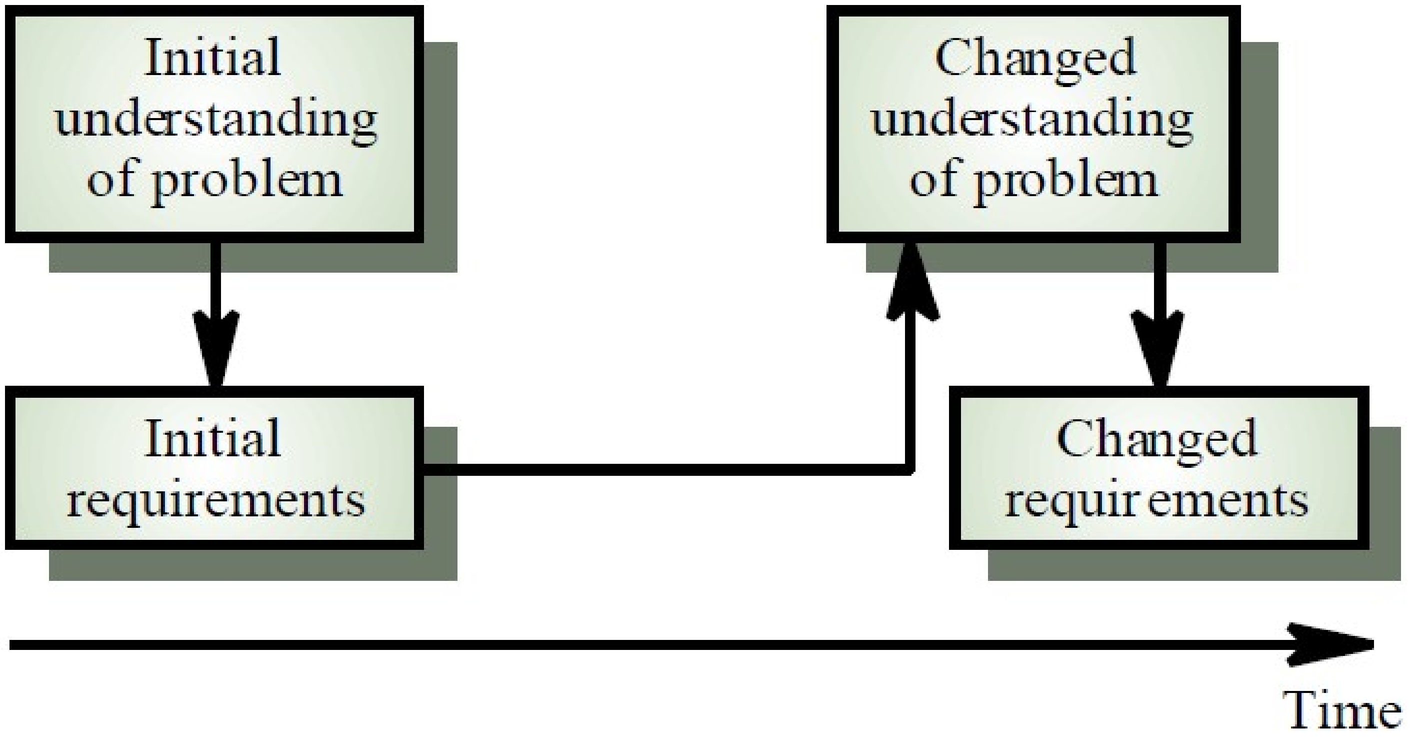
Ethnography and prototyping



Scope of ethnography

- Requirements that are derived from the way that people actually work rather than the way I which process definitions suggest that they ought to work
- Requirements that are derived from cooperation and awareness of other people's activities

Requirements evolution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Initial requirements
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Time

Requirement Evolution

Based on the Requirement Evolution, requirements are classified into 2 types:

- **Enduring Requirements**
- **Volatile Requirements**

Enduring and volatile requirements

- Enduring requirements. Stable requirements derived from the core activity of the customer organisation. E.g. a hospital will always have doctors, nurses, etc. May be derived from domain models
- Volatile requirements. Requirements which change during development or when the system is in use. In a hospital, requirements derived from health-care policy

CLASSIFICATION OF VOLATILE REQUIREMENT

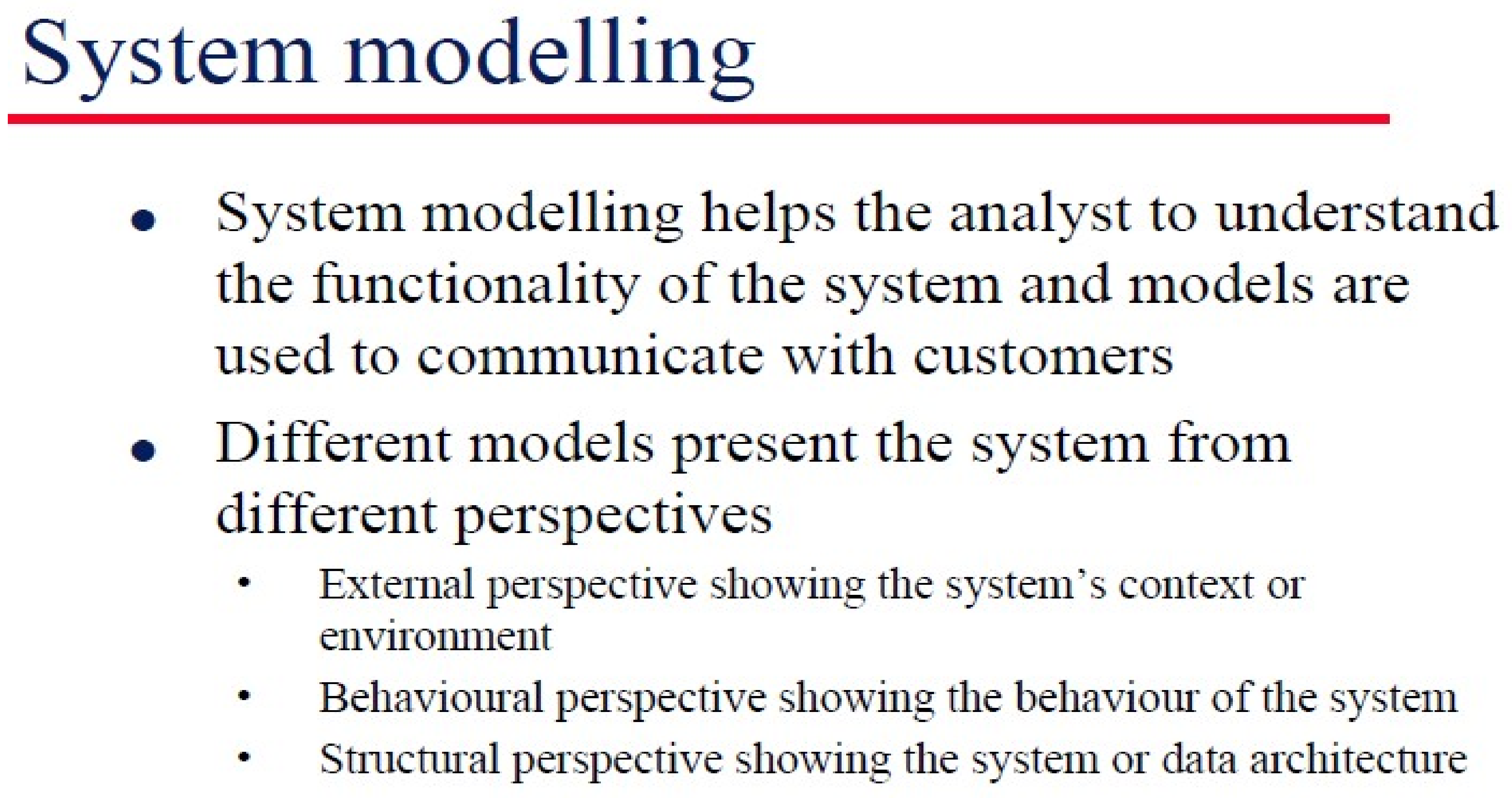
- Mutable requirements
  - Requirements that change due to the system's environment
- Emergent requirements
  - Requirements that emerge as understanding of the system develops
- Consequential requirements
  - Requirements that result from the introduction of the computer system
- Compatibility requirements
  - Requirements that depend on other systems or organisational processes

Requirements management planning

- During the requirements engineering process, you have to plan:
  - Requirements identification
    - » How requirements are individually identified
  - A change management process
    - » The process followed when analysing a requirements change
  - Traceability policies
    - » The amount of information about requirements relationships that is maintained
  - CASE tool support
    - » The tool support required to help manage requirements change

SYSTEM MODELS

Definition : *" System models are graphical representation that describes business processes, the problem to be solved and the system that is to be developed."*



System modelling

- System modelling helps the analyst to understand the functionality of the system and models are used to communicate with customers
- Different models present the system from different perspectives
  - External perspective showing the system's context or environment
  - Behavioural perspective showing the behaviour of the system
  - Structural perspective showing the system or data architecture

CHAPTER 4

SOFTWARE PROTOTYPING

PROTOTYPE DEFINITION :

A prototype is an enact able mock-up , toy like implementation and dummy model that enables evaluation of features or functions through user and developer interaction with operational scenario.

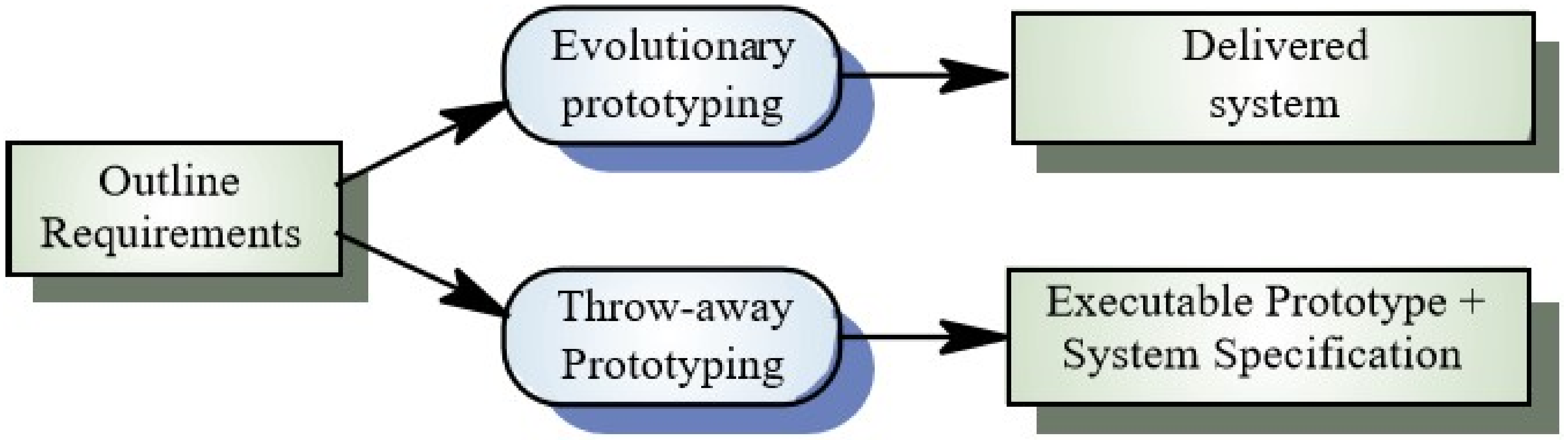
PROTOTYPE CHARACTERISTICS

- It is an incomplete model.
- It represents only few aspects of final solution.
- It is beneficial in research oriented products.
- It helps to drive towards refine requirements and evolve final systems.
- It incurs additional development efforts.

Prototyping objectives

- The objective of *evolutionary prototyping* is to deliver a working system to end-users. The development starts with those requirements which are best understood.
- The objective of *throw-away prototyping* is to validate or derive the system requirements. The prototyping process starts with those requirements which are poorly understood

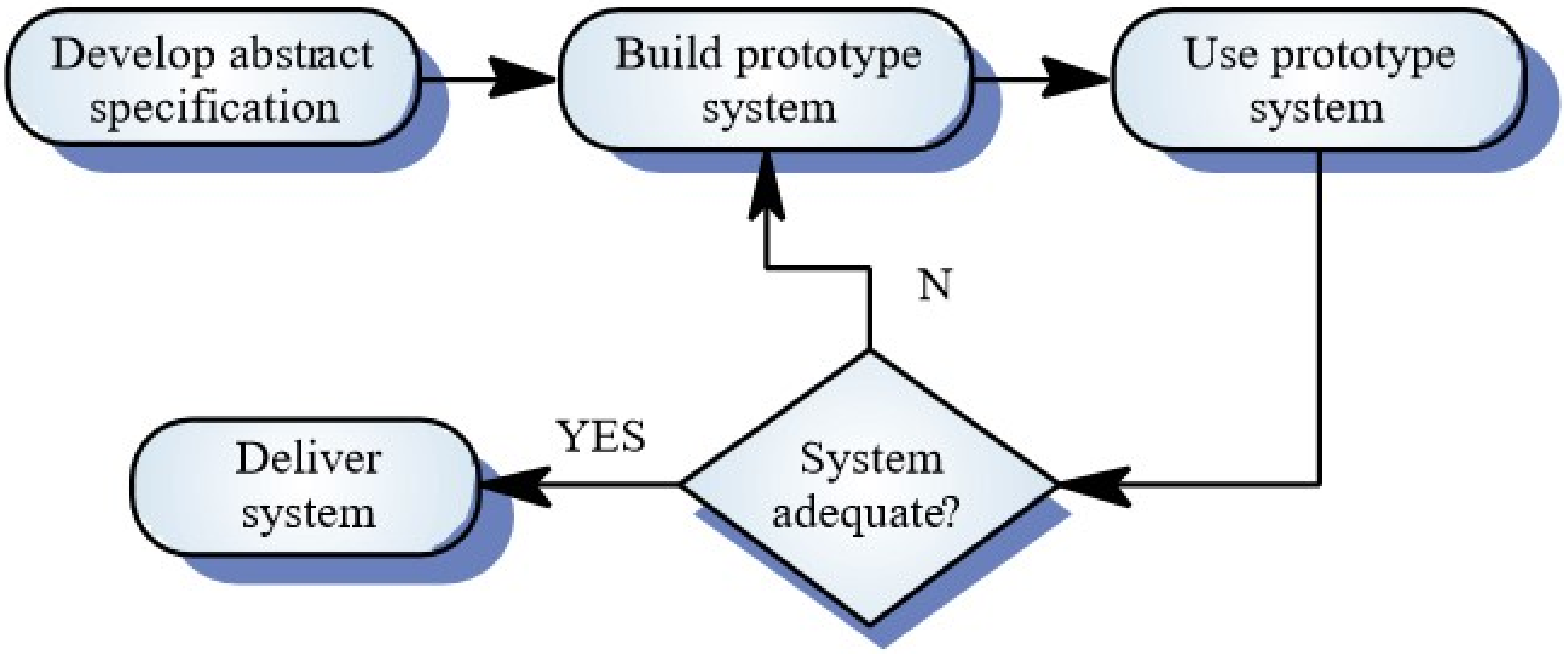
Approaches to prototyping



Evolutionary prototyping

- Must be used for systems where the specification cannot be developed in advance e.g. AI systems and user interface systems
- Based on techniques which allow rapid system iterations
- Verification is impossible as there is no specification. Validation means demonstrating the adequacy of the system

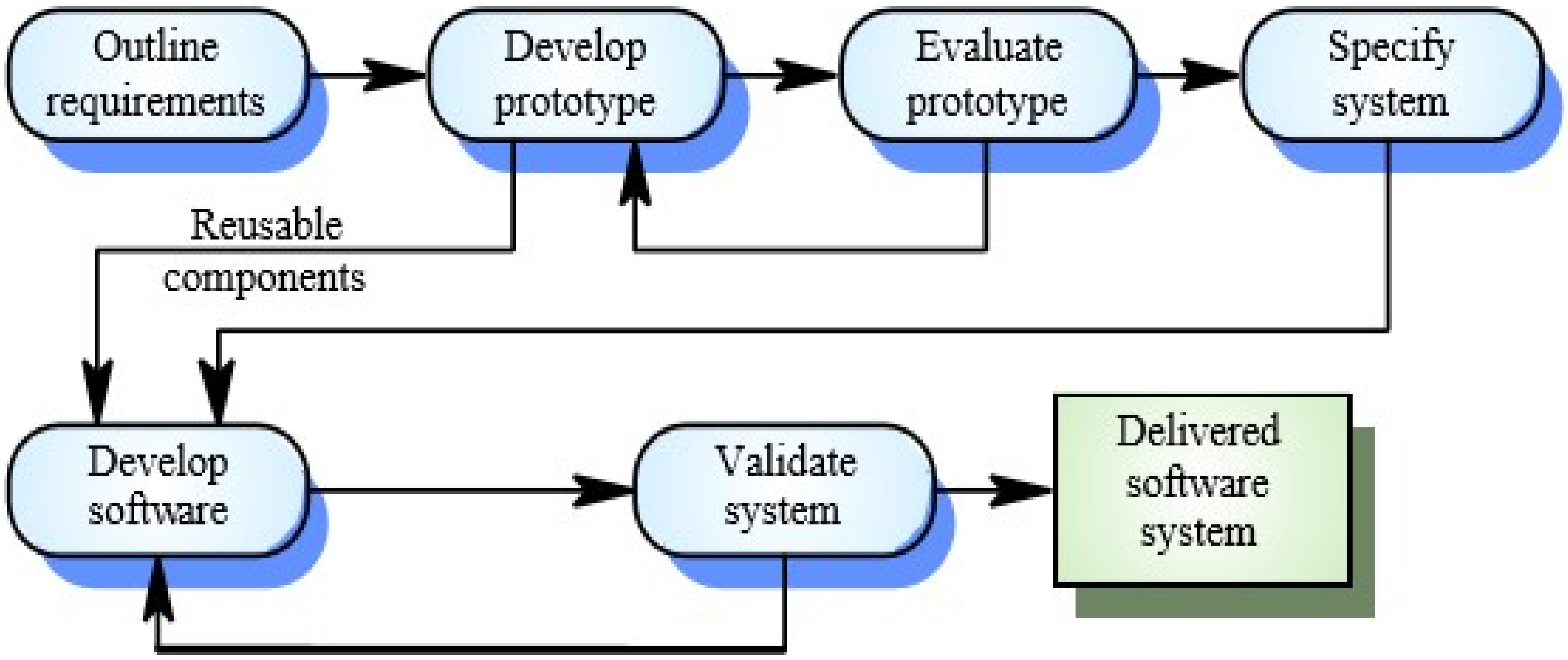
Evolutionary prototyping



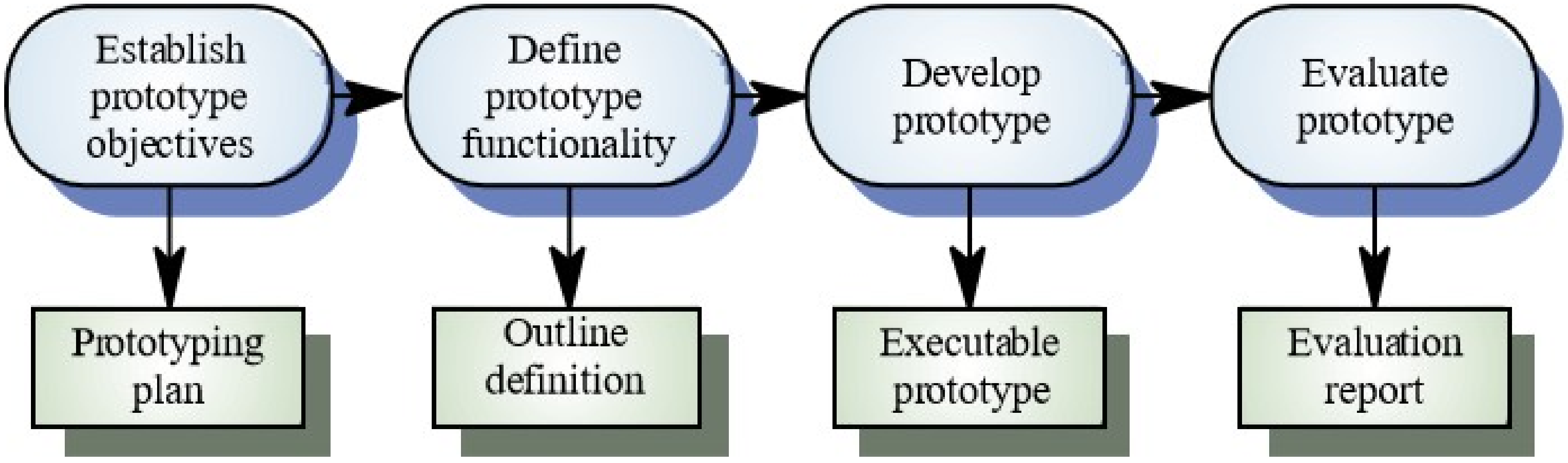
Throw-away prototyping

- Used to reduce requirements risk
- The prototype is developed from an initial specification, delivered for experiment then discarded
- The throw-away prototype should NOT be considered as a final system
  - Some system characteristics may have been left out
  - There is no specification for long-term maintenance
  - The system will be poorly structured and difficult to maintain

Throw-away prototyping



Prototyping process

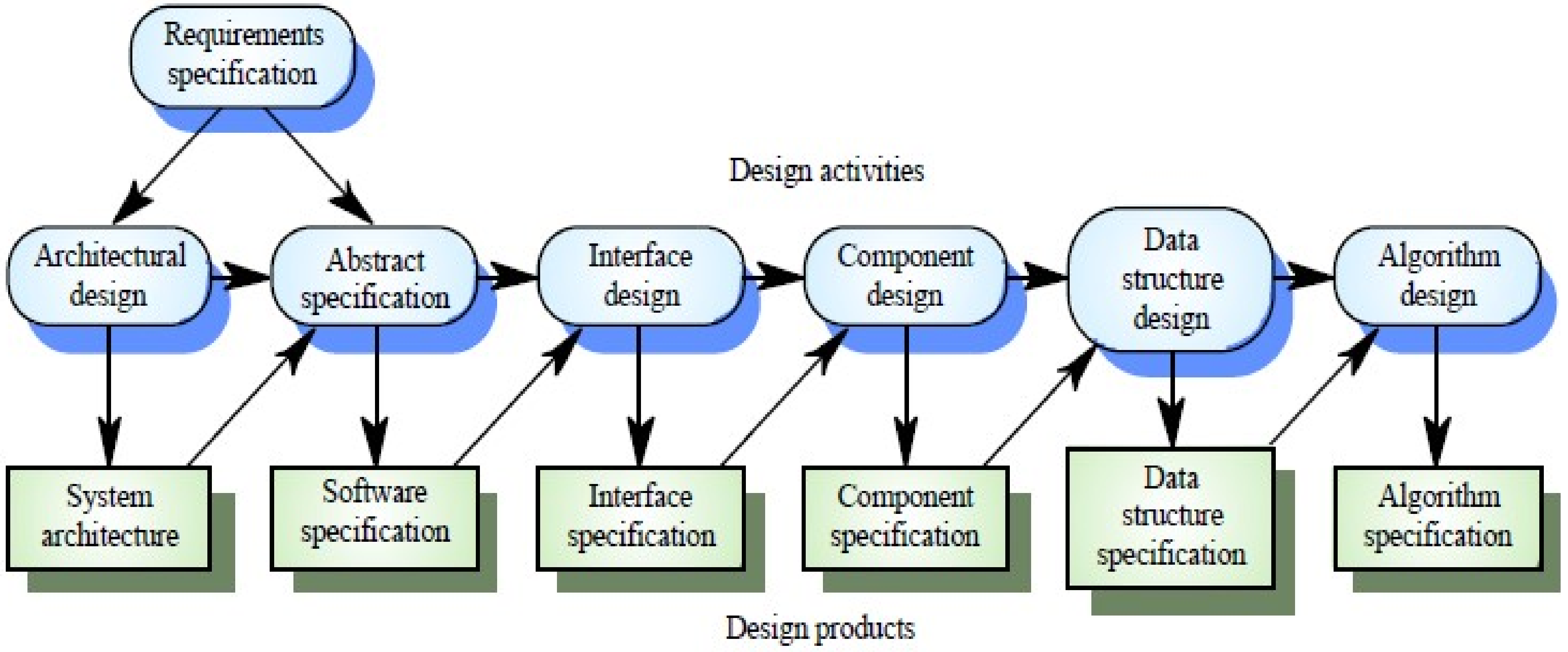


SOFTWARE DESIGN

DEFINITION :

Software design creates a representation or model of the software which involves creativity rules, customer requirements and technical considerations in the development of the system.

The software design process



DESIGN QUALITY

Categorized into 4

1. Cohesion
2. Coupling
3. Understandability
4. Adaptability

1. **Cohesion :** **Measures the semantic strength of relationship between components within a functional unit.**

Seven levels of Cohesion

1.Coincidental Cohesion

2.Logical Cohesion

3.Temporal Cohesion

4.Communicational Cohesion

5.Procedural Cohesion

6. Sequential Cohesion

7.Functional Cohesion

1. **Coupling :** Measures the strength of all relationship between functional unit.

Coupling is divided into

1. Tight Coupling
2. Loose Coupling

Classification of failures

Failures are classified into 7 categories

1. Transient Failure

- Occurs for input values, Occurs for short period of time. Example : Network issues

2.Permanent Failure

- Occurs for all input values. Example : If print operation shows an error, printing fails.

3. Recovery Failure

- Occurs when system recovers without operator intervention. Example: Press ctrl+alt+del

4. Unrecoverable Failure

- System can recover with operator intervention.

Example : Restarting system when system hangs

Conti…

5. Corrupting Failure

- Failure corrupts the system state or data. Example: A programmer running a wrong data structure repeatedly will corrupt the software.

6. Non Corrupting Failure

- Failure does not corrupt the system state or data. Example : A wrong key pressed during the operation of the computer may hang the current process but will not affect working of computer in use.

7. Cosmetic Failure

- Causes minor irritations or incorrect results. Example : Dragging an icon from one point to another may result in the icon bouncing back to its original position instead of its destination

Software Reliability Metrics

Definition :

Metrics are units of measurement of a system. System reliability is measured by counting the number of operational failures. They have come up on hardware reliability and not applicable to software.

There are 6 metrics for reliability

1. **ROCOF** – Rate of occurrence of failure.
2. **MTTF** – Mean time to failure
3. **MTTR** – Mean time to repair
4. **MTBF** – Mean time between failure
5. **POFOD** – Probability of failure on Demand.
6. **AVAIL** - Availability