SEMESTER EXAM SERIES
SOFTWARE ENGINEERING
IN
6 HOURS
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Unit-1(Introduction)

- Introduction to Software Engineering,
- Software Components,
- Software Characteristics,
- Software Crisis,
- Software Engineering Processes,
- Similarity and Differences from Conventional Engineering Processes, Software Quality Attributes,
- Software Development Life Cycle (SDLC)
- Models:
  - Water Fall Model,
  - Prototype Model,
  - Spiral Model,
  - Evolutionary Development Models,
  - Iterative Enhancement Models.

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Unit-2(Software Requirement Specifications (SRS))

- Requirement Engineering Process:
  - Elicitation,
  - Analysis,
  - Documentation,
  - Review and Management of User Needs,
- Feasibility Study,
- Information Modeling,
- Data Flow Diagrams,
- Entity Relationship Diagrams,
- Decision Tables,
- SRS Document,
- IEEE Standards for SRS.
- Software Quality Assurance (SQA): Verification and Validation,
- SQA Plans, Software Quality Frameworks, ISO 9000 Models, SEI-CMM Model

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Unit-3(Software Design)

- **Basic Concept of Software Design**,
  - Architectural Design,
  - Low Level Design: Modularization, Design Structure Charts, Pseudo Codes, Flow Charts,
  - Coupling and Cohesion Measures,
- **Design Strategies**
  - Function Oriented Design,
  - Object Oriented Design,
  - Top-Down and Bottom-Up Design.
- Software Measurement and Metrics:
  - Various Size Oriented Measures: Halestead's Software Science,
  - Function Point (FP) Based Measures,
  - Cyclomatic Complexity Measures: Control Flow Graphs.

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Unit-4(Software Testing)

- Testing Objectives,
  - Unit Testing,
  - Integration Testing,
  - Acceptance Testing,
  - Regression Testing,
- Testing for Functionality and Testing for Performance,
- Top-Down and Bottom-Up
- Testing Strategies:
  - Test Drivers and Test Stubs,
  - Structural Testing (White Box Testing),
  - Functional Testing (Black Box Testing),
  - Test Data Suit Preparation,
  - Alpha and Beta Testing of Products.
- Static Testing Strategies: Formal Technical Reviews (Peer Reviews), Walk Through, Code Inspection, Compliance with Design and Coding Standards.

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Unit-5(Software Maintenance)

- Software as an Evolutionary Entity,
- Need for Maintenance,
- Categories of Maintenance: Preventive, Corrective and Perfective Maintenance,
- Cost of Maintenance,
- Software Re-Engineering,
- Reverse Engineering.
- Software Configuration Management Activities,
- Change Control Process,
- Software Version Control,
- Resource Allocation Models,
- Software Risk Analysis and Management.

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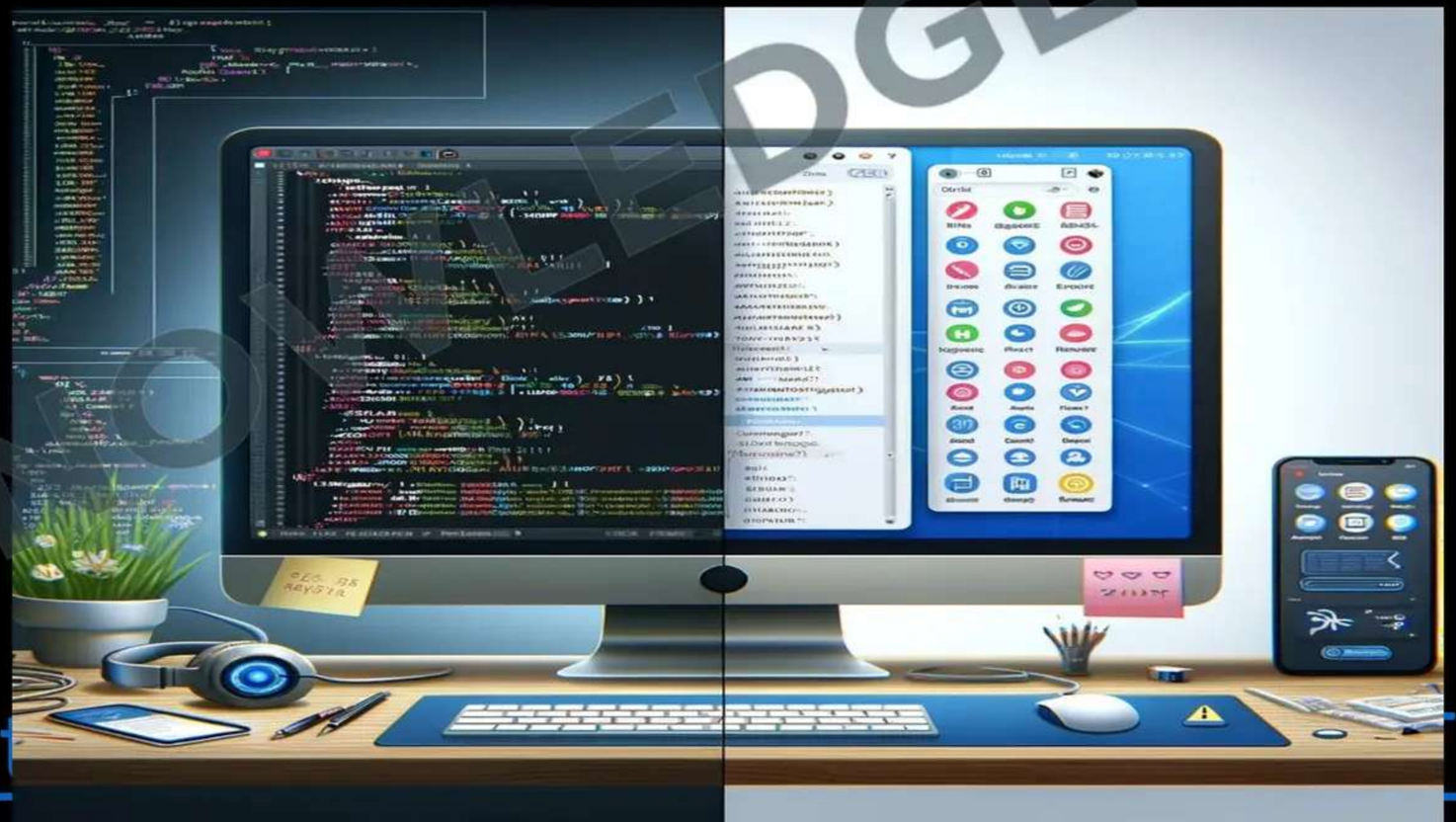
What is Software

- Program: A step by step instructions to perform a specific task on a computer in a programming language is called program, i.e. set of instructions.
- Software: Is a program along with proper documentation (requirement analysis, design, coding, testing) and user manuals which mainly includes installation guide and other manuals.
- Software = Program + documentation



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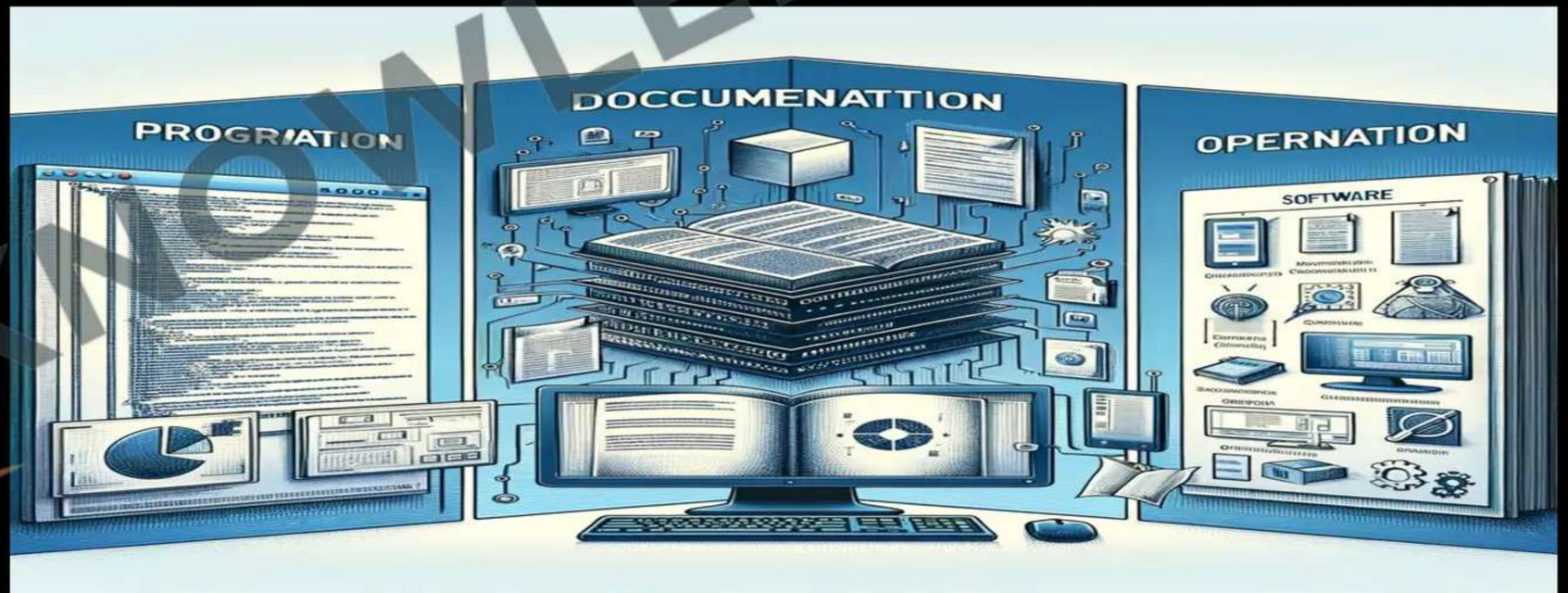
Software Components

- A program is a subset of software and it becomes software only if documentation and an operating procedure manual are prepared.
  - **Program**
  - **Documents**
    - Software documentation consist all the description, programs, graphics and instructions pertaining to design, coding, testing and preparation of software.
  - **Operating Procedure(User Manual & Operational Manual)**
    - Provides information about what software is how to work with it how to install it on your system and how to control all the activities of the software.



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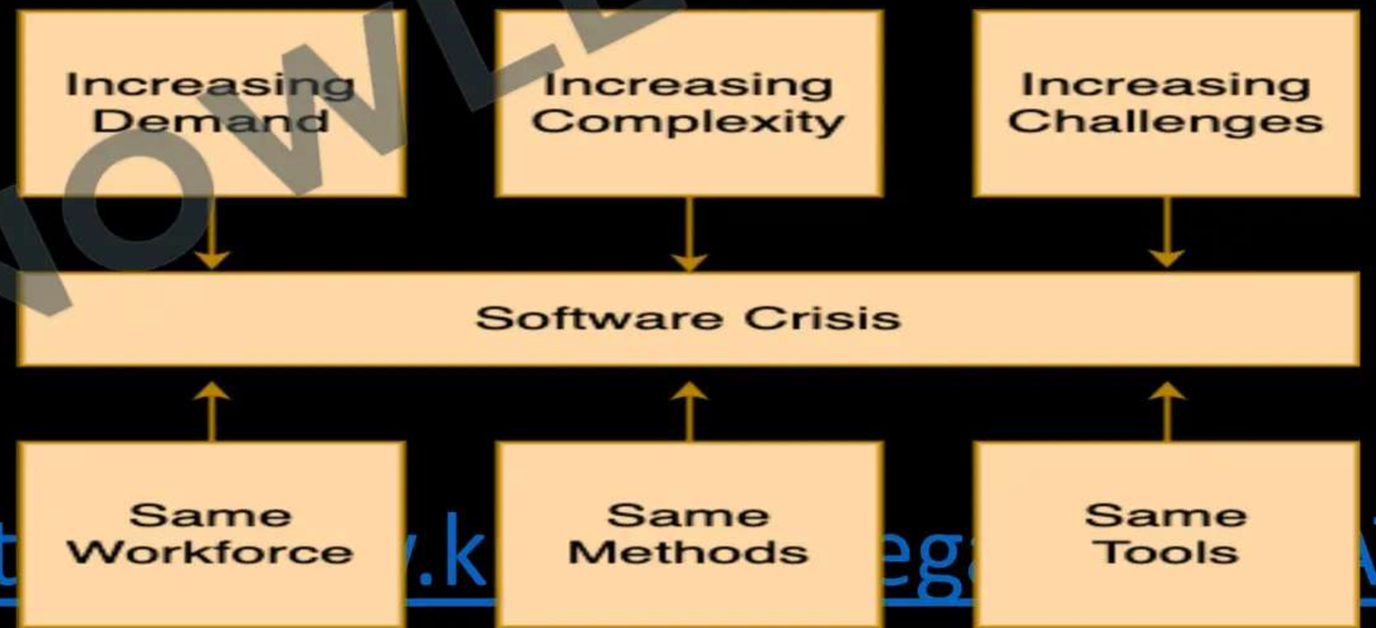
Software Crisis

- Problems with software?
  - The major problem with current scenario in Software industry is, software usually overrun their development cost, they exceed their development duration limits, are usually of poor quality.
  - As long as there were no machines, programming was no problem at all; when we had a few weak computers, programming became a mild problem, and now we have gigantic computers, programming has become an equally gigantic problem.— *Edsger Dijkstra*, *The Humble Programmer (EWD340)*, *Communications of the ACM*



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What is Software Engineering

- In software industry we understand that there is an urgent need to use a proper strategies, process and development cycles so that we can produce, or we can design quality products that are within budget, with in time and must satisfy the requirement of their users.

- Software engineering is the systematic application of engineering principles and methods to the design, development, testing, and maintenance of software products. It involves the use of various tools, techniques, and methodologies to manage the software development process and ensure the quality, reliability, and maintainability of software products.

Characteristics of software

1. Software Development vs. Manufacturing:

1. Software is crafted through a process of coding and development.
2. Unlike physical products, it isn't produced in factories through a manufacturing process.

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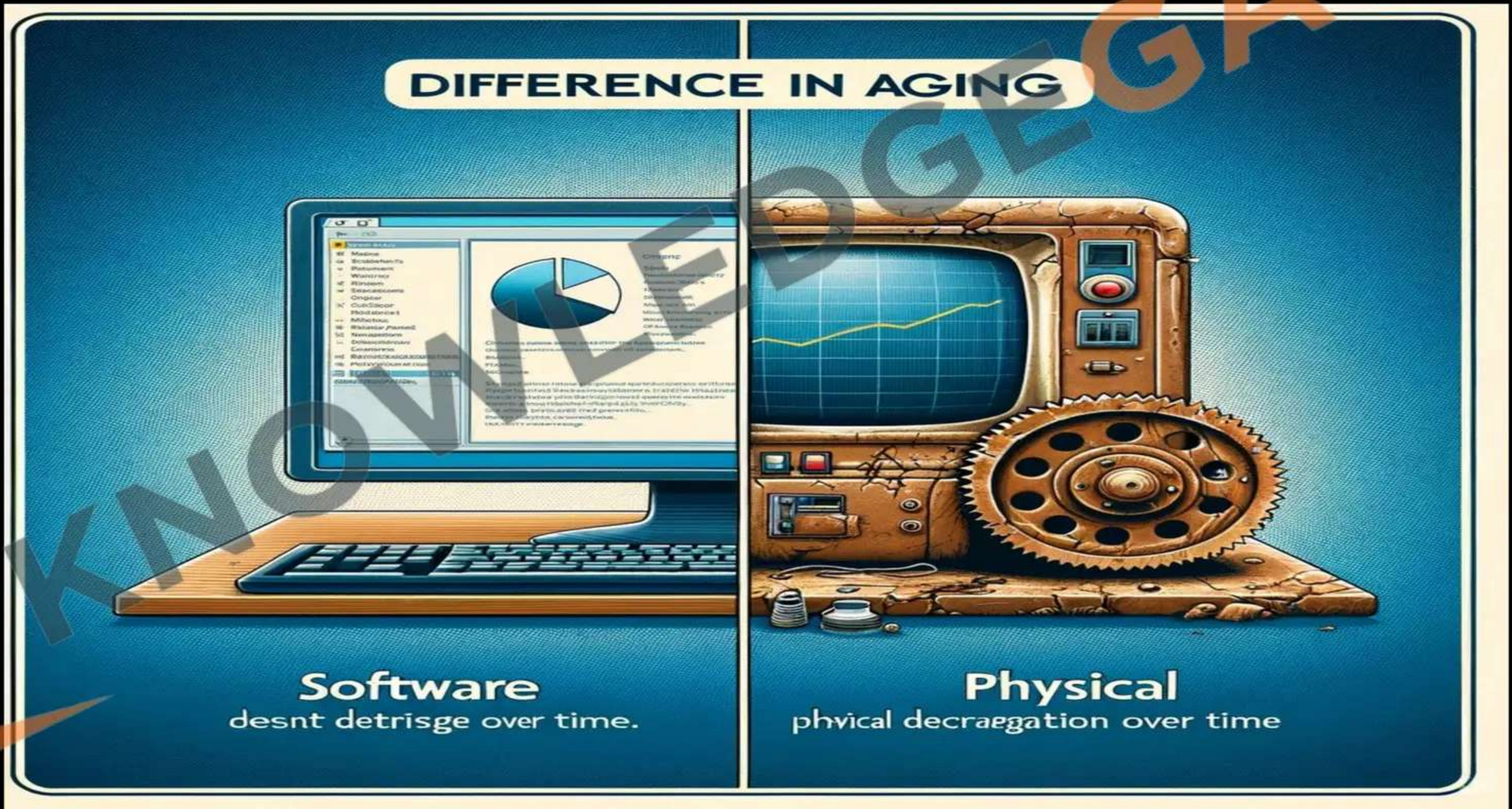
Characteristics of software

2. No Physical Wear and Tear:

1. Software doesn't deteriorate over time like physical objects.
2. Its performance doesn't degrade due to physical use.



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Characteristics of software

3. Custom-Built Nature:

1. Most software is specially designed to meet specific needs.
2. It's often not just a combination of pre-existing components but requires unique coding and design.

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Characteristics of software

4. Intangibility of Software:

1. Software can't be touched or handled physically.
2. It exists as code and functions within computers or digital devices.

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Major Problems in Software Development

- **Inadequate Requirements Gathering**:
  - Ambiguous or incomplete requirements
  - Lack of communication between stakeholders

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Major Problems in Software Development

- **Poor Project Management**:
  - Inadequate planning, monitoring, and control
  - Lack of risk assessment and mitigation
  - Multiplicity of software development life cycle
  - Selection of wrong technology or tool for development

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Major Problems in Software Development

- **Insufficient Time and Budget**:
  - Unrealistic deadlines and resource constraints
  - Inefficient resource allocation and prioritization

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Major Problems in Software Development

- **Lack of Skilled Personnel**:
  - Inadequate expertise in the development team
  - High turnover rates and loss of experienced staff

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Major Problems in Software Development

- **Resistance to Change**:
  - Difficulty in adapting to new technologies or processes
  - Reluctance to modify established practices or mindsets
  - Rapid technology advancement

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Similarity and Differences from conventional Engineering Process

- **Nature of the Product**:
  - **Similarity**: Both processes aim to create high-quality, reliable products
  - **Difference**: Conventional engineering focuses on physical systems, while software engineering deals with intangible software systems

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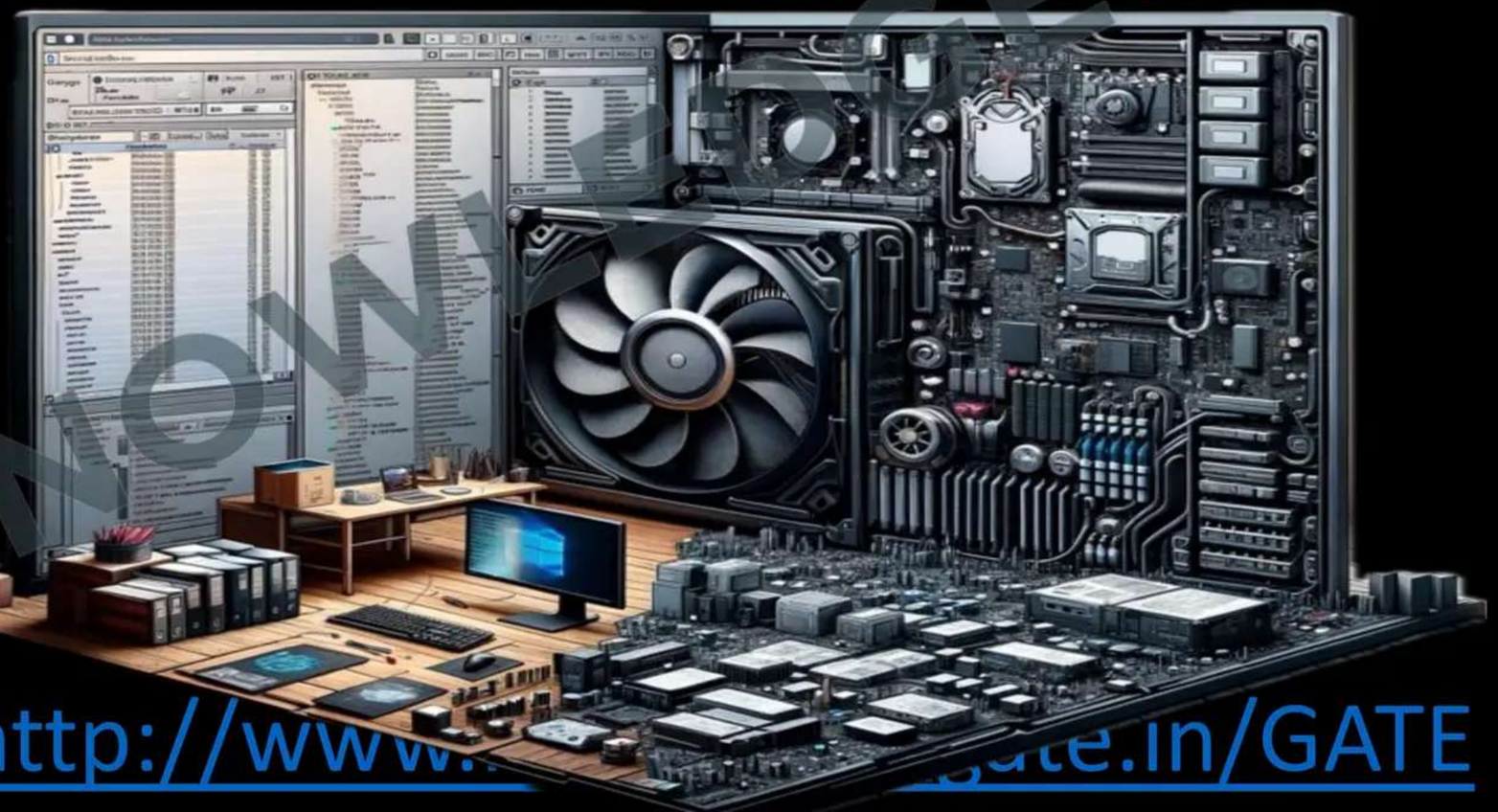
Similarity and Differences from conventional Engineering Process

- **Design Flexibility and Iteration**:
  - **Similarity**: Both processes involve iterative design and prototyping
  - **Difference**: Software engineering allows for greater flexibility and ease of modification due to the non-physical nature of software



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Similarity and Differences from conventional Engineering Process

- **Quality Assurance and Testing**:
  - **Similarity**: Both processes emphasize the importance of testing and quality assurance to ensure product performance and reliability
  - **Difference**: Conventional engineering often involves physical testing of prototypes, while software engineering relies on various types of software testing, such as unit, integration, and system testing

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- **Project Management and Collaboration**:
  - **Similarity**: Both processes require effective project management, team collaboration, and communication among stakeholders
  - **Difference**: Software engineering projects may involve distributed teams and rely more heavily on digital communication and collaboration tools

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- **Maintenance and Evolution**:
  - **Similarity**: Both processes involve maintenance and support activities to ensure the ongoing performance and reliability of the product
  - **Difference**: Software engineering typically demands more frequent updates, patches, and evolution due to the rapidly changing nature of technology and user requirements

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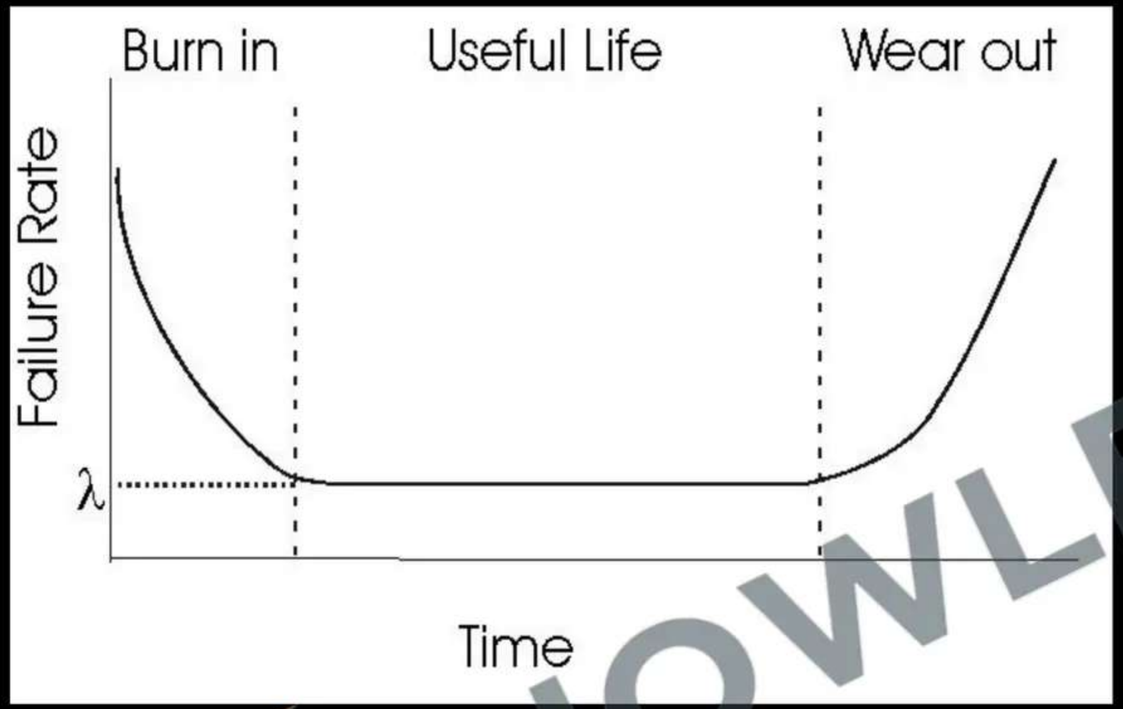
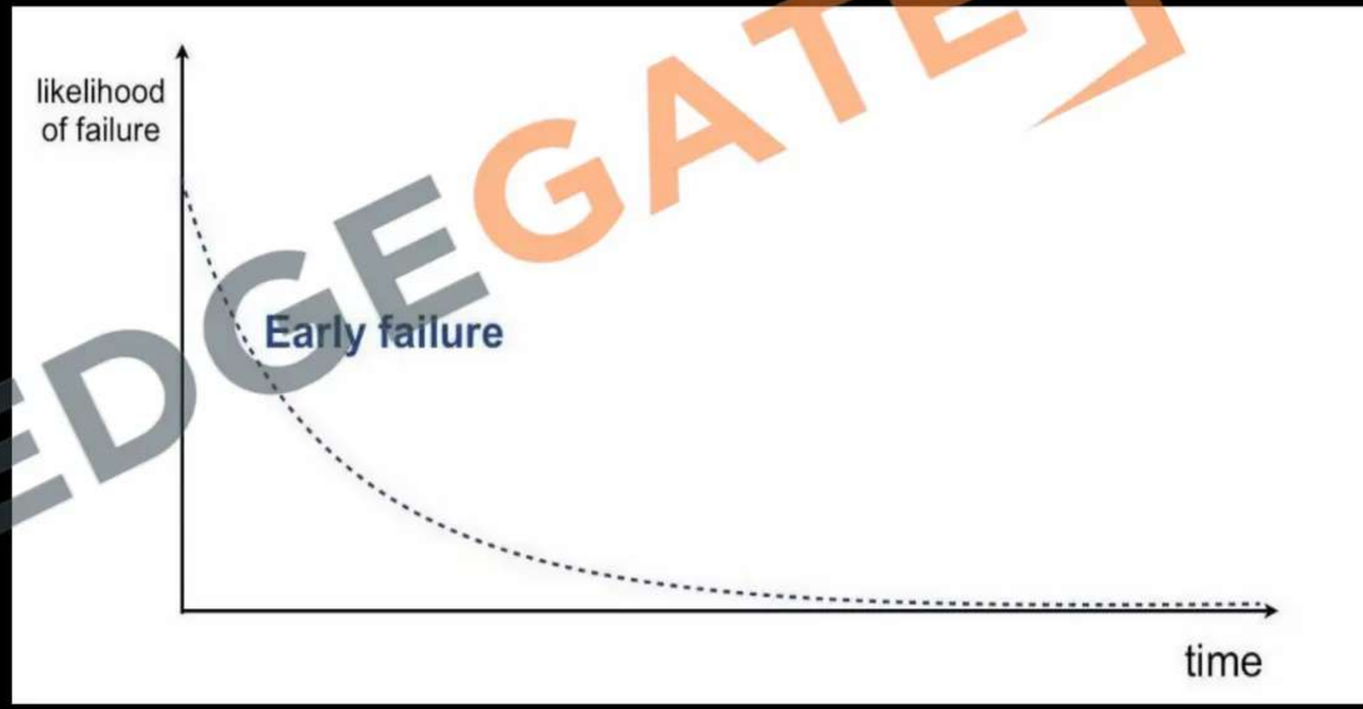
- For hardware Same production cost every time, for software production cost only for the first time and then only maintenance cost. This life cycle of the hardware follows the bath tub curve, while in the life cycle of software failure intensity goes down with time





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Software Quality Attributes

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Software Quality Attributes

- **Correctness**: The ability of the software to perform its intended tasks effectively and meet user requirements.
- **Usability**: The ease with which users can learn, operate, and navigate the software.
- **Reliability**: The software's consistency in producing accurate results and maintaining performance over time.
- **Efficiency**: The optimal use of system resources, such as memory and processing power, to achieve desired outcomes.

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- **Maintainability**: The ease of updating, modifying, and fixing the software to accommodate changing requirements or fix issues.

- **Portability**: The ability of the software to operate on different platforms or environments without significant modifications.

- **Scalability**: The software's capacity to handle increased workloads or user demands without compromising performance.

- **Security**: The software's ability to protect against unauthorized access, data breaches, and other potential threats.

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- **Modularity**: The degree to which the software's components are organized into separate, manageable units that can be independently developed or updated.

- **Reusability**: The potential for the software's components to be used in other applications or contexts, reducing development time and costs.

- **Testability**: The ease with which the software can be tested to ensure it meets its requirements and performs as expected.

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Software Process

- A software process (also known as software methodology) is a set of related activities that leads to the production of the software. These activities may involve the development of the software from the scratch, or, modifying an existing system.

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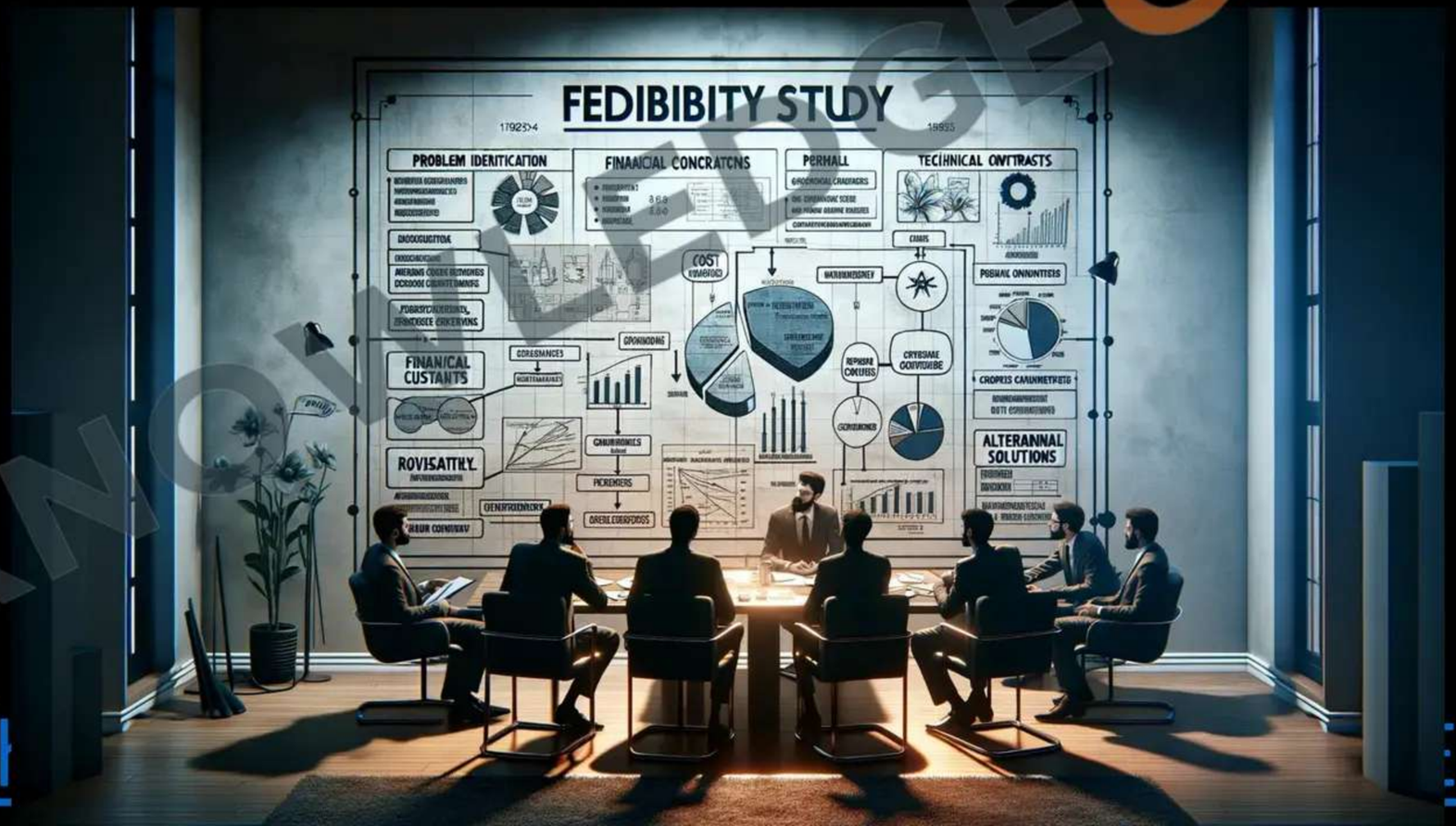
- **Feasibility study**
  - Find abstract definition of the problem
  - Majorly checking the financial and technical feasibility
  - Analysis of cost and befit ratio
  - Checking availability of infrastructure and human resource
  - Examination of alternative solution strategies



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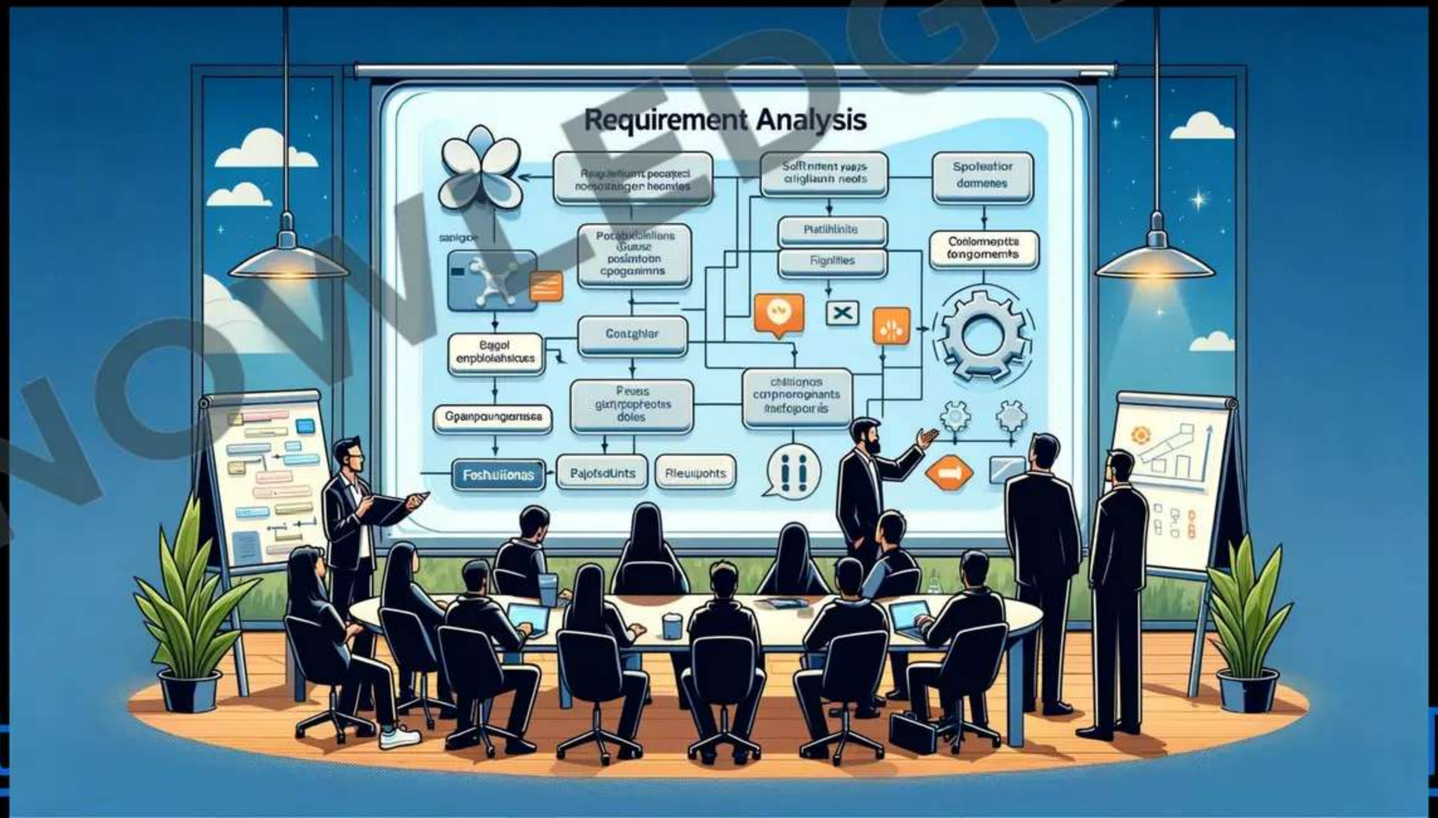
- **Requirement analysis and specification**
  - Try to understood the exact and complete requirement of the customer and document them properly.
  - Try to collect and analysis all data related to the project.
  - In last, a large document will be written in the natural language which will describe what the system will do without describing it how, called SRS Software Requirement Specification.
  - Very critical phase because, a small error hear can result of sever problem in later stages



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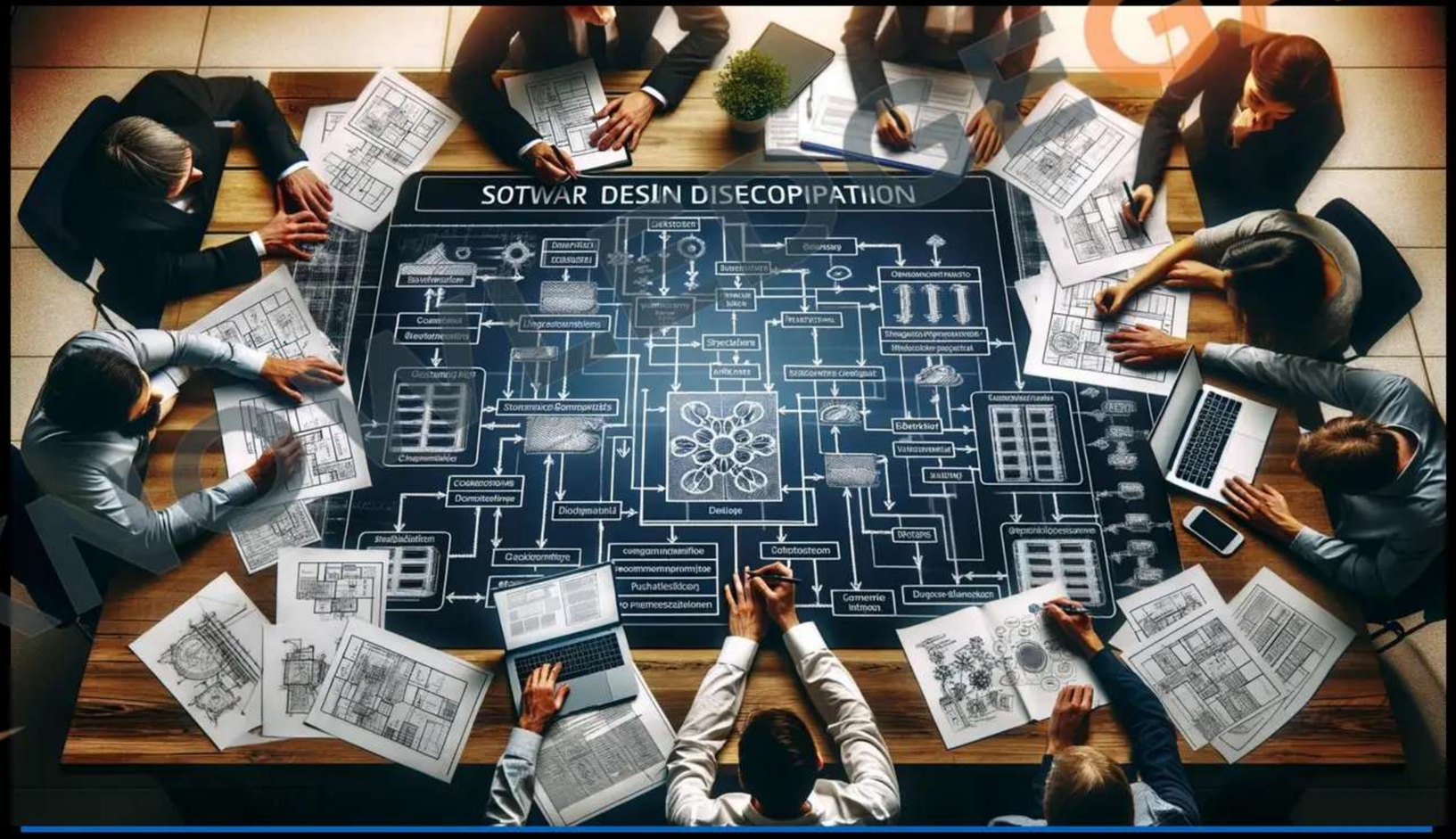
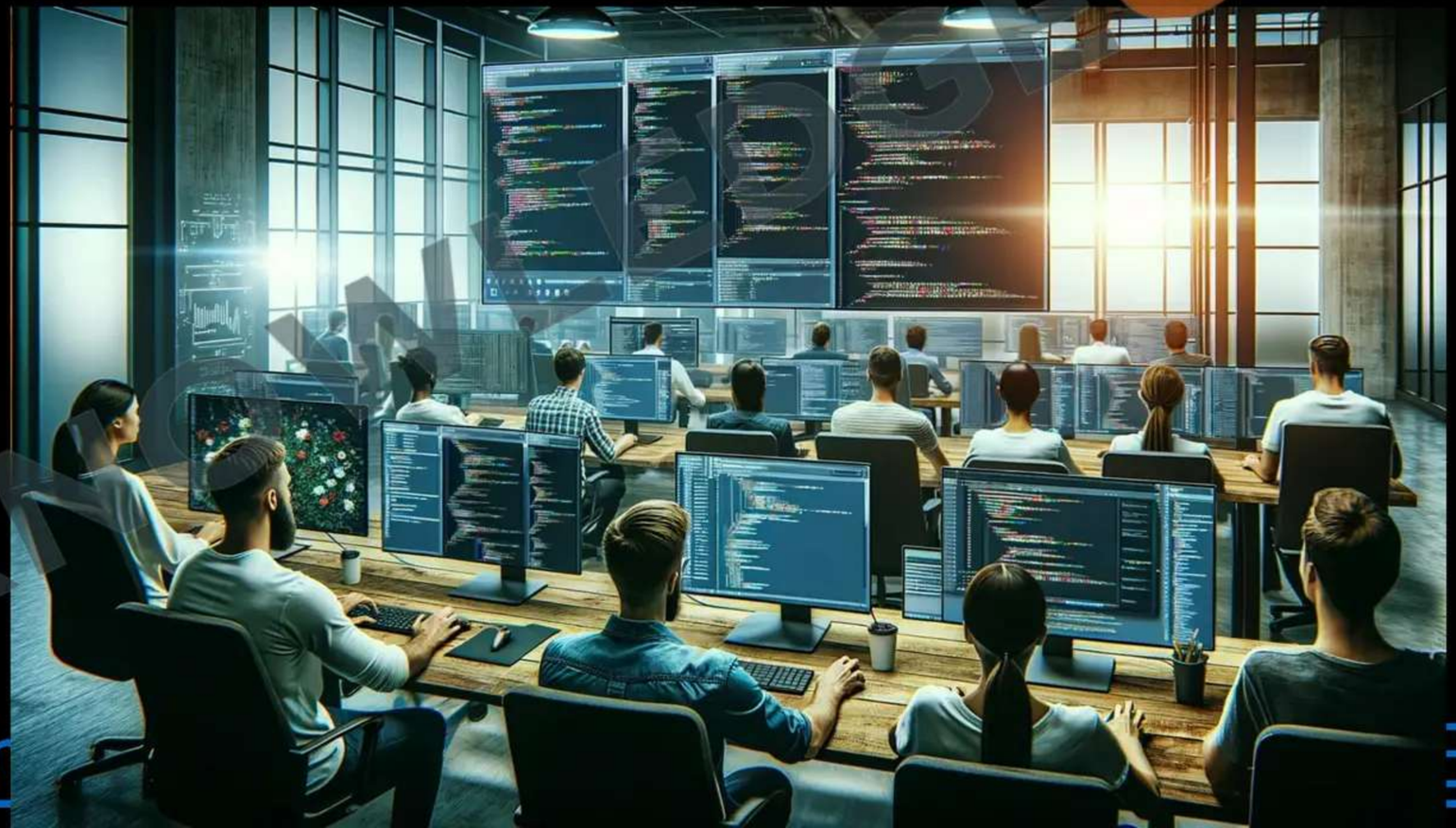
- **Designing**
  - We transform the requirements into a structure that is suitable for implementation of the code in a specific programming language.
  - Overall architecture and the algorithmic strategy are chosen (Coupling and cohesion).
  - Lastly will prepare a document called SDD (software design description), which will describe how the system will perform functionality.



- **Coding**
  - Goal of coding is to translate the design of the system into a code of programming language.
  - It affects both testing and maintenance, so also critical feature.
  - We will be discussing some guidelines for how to write maintainable and readable code.



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- **Testing**
  - Because of human errors there will be a bug or fault in the code and if that bug/fault is executed it become a failure.
  - Software testing is a process of executing a program with the intention of finding bugs or fault in the code.

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- **Implementation**
  - Software is installed on the user site and training of the user and h/w requirement check is done.

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- **Maintenance**
  - Any change made in the software after its official release is called maintenance. It could be because of various reasons.
    - Adaptive
    - Corrective
    - Perfective

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SOFTWARE DEVELOPMENT LIFE CYCLE

- Software development organization follows some process when developing a s/w product, in mature organization this is well defined and managed.

- In SDLC we development s/w in a systematic and disciplined manner. SDLC will define entry and exit for every stage. It makes assessment possible, time prediction, cost prediction, scheduling, to identify faults early possible.

- Selection of a correct development model play an important role in cost, quality, overall success of the project.

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Waterfall Model

- Developed in the 1970s by Winston W. Royce.
- Inspired by manufacturing and construction processes, where each step relies on the completion of the previous one.

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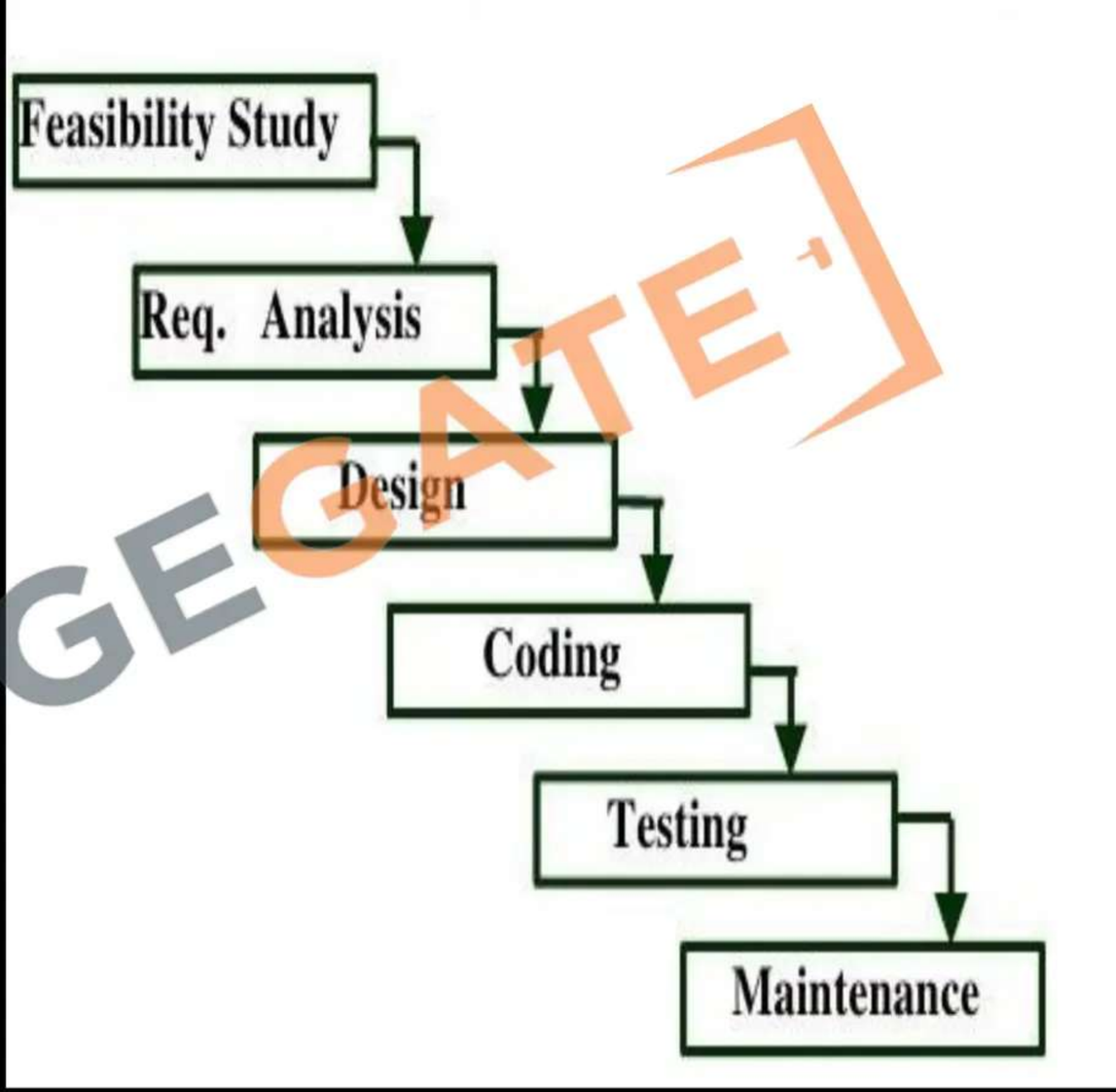
- It is a simplest SDLC in which phases are organised in a linear and sequential order.
- It is called waterfall model as its diagrammatic representation resembles as like a waterfall, also known as classical life cycle model.
- This type of model is basically used for the Small to medium-sized projects with clear, well-defined requirements. When the technology and tools to be used are well-known and stable.
- Projects where minimal changes are expected during the development process, and predictability is prioritized over adaptability.



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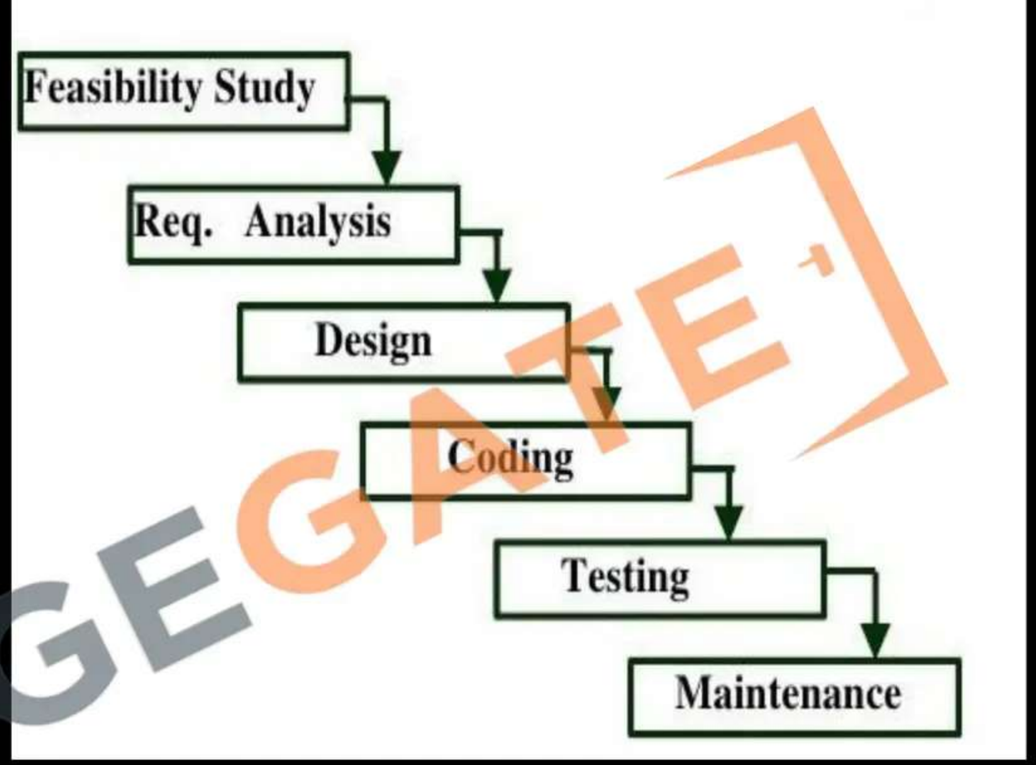
Advantage

- Easy to understand and implement, with well-defined stages and clear milestones.
- Each phase has well defined input and output, phases are processed and completed one at a time. Phases do not overlap.
- Low cost and easy to schedule, as all staff do not work concurrently on the same project, so can work on different projects.



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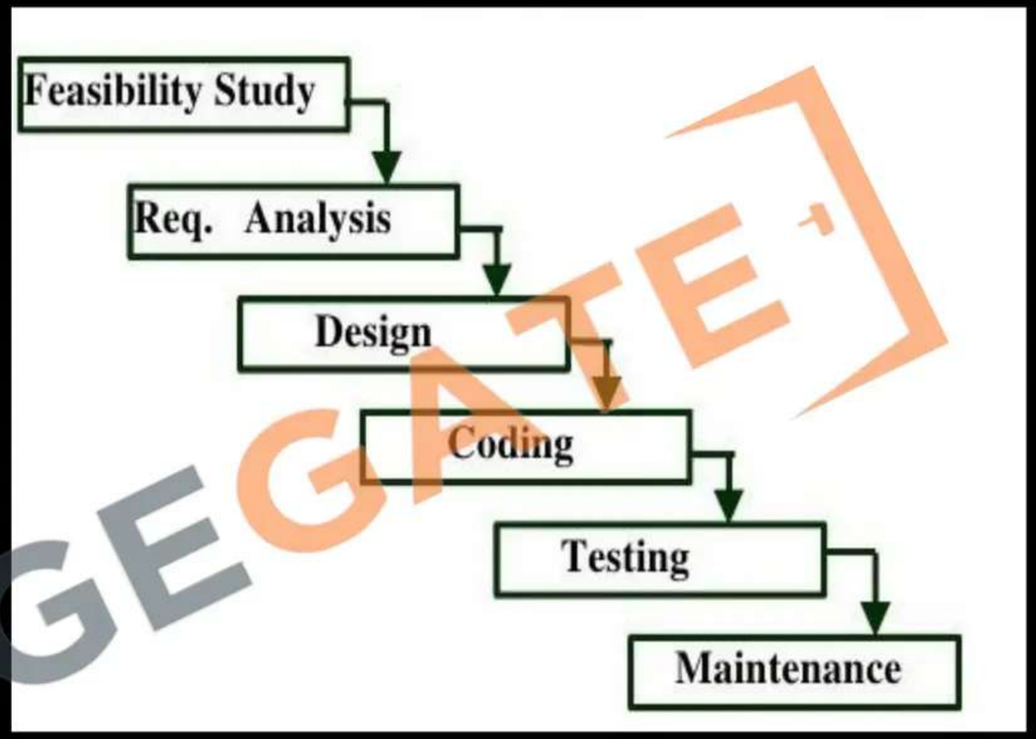
Disadvantage

- Not suitable to accommodate any change or iteration once development has begun. It is always difficult to acquire of the requirement in the starting.
- Working version is produced in the last level, so not good for large size sophisticated projects.
- High amounts of risk and uncertainty.



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PROTOTYPE MODEL

- key design details to consider when designing a 3bhk flat in brief:
- **Living Room**: Sofa set, coffee table, entertainment center, lighting, natural light, TV unit, indoor plant/art piece, coordinated color scheme.
- **Dining Area**: Space for 4-6 seater dining table, lighting fixture, storage space, mirror/artwork.
- **Kitchen**: Storage cabinets, refrigerator, stove, oven, ventilation, lighting, durable countertops and backsplash.
- **Master Bedroom**: Space for queen/king-sized bed, wardrobe, dressing table, natural light, coordinated color scheme.
- **Other Bedrooms**: Space for single/double bed, wardrobe, natural light, coordinated color scheme.
- **Bathrooms**: Space for shower, sink, toilet, ventilation, storage space, water-resistant materials.
- **Balcony**: Space for seating/table, natural light, outdoor view, coordinated color scheme.

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PROTOTYPE MODEL

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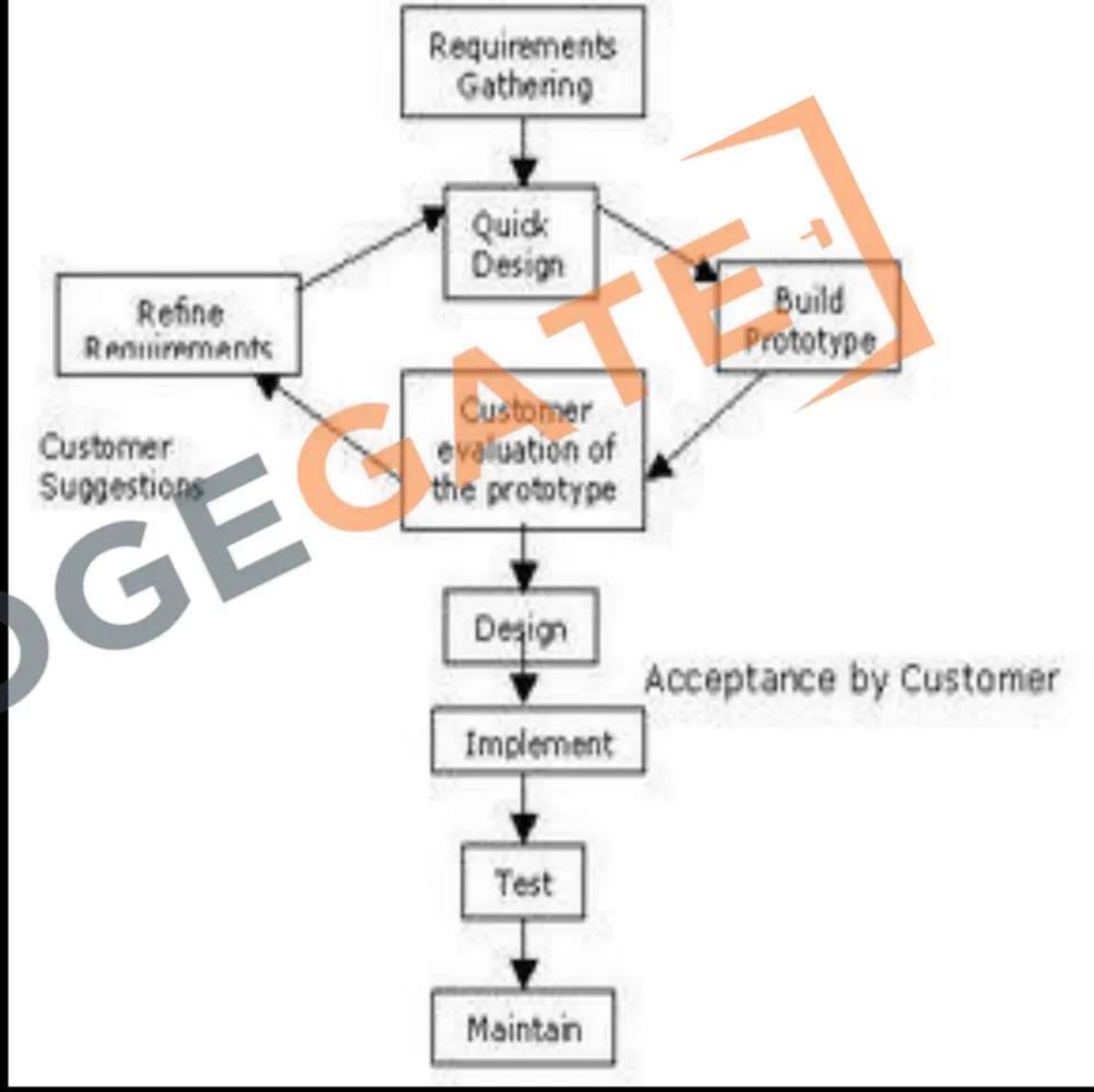
PROTOTYPE MODEL

PROTOTYPE MODEL

- Most of the customer are not sure about the functionality they require from the software, as a result the final s/w is not according to exact demand.
- It is an iterative approach, which involves developing an early working model of the software based on the currently known requirements with limited functionalities, low reliability and untrusted performance.
- Refining it through user feedback, and repeating the process until a satisfactory solution is achieved.



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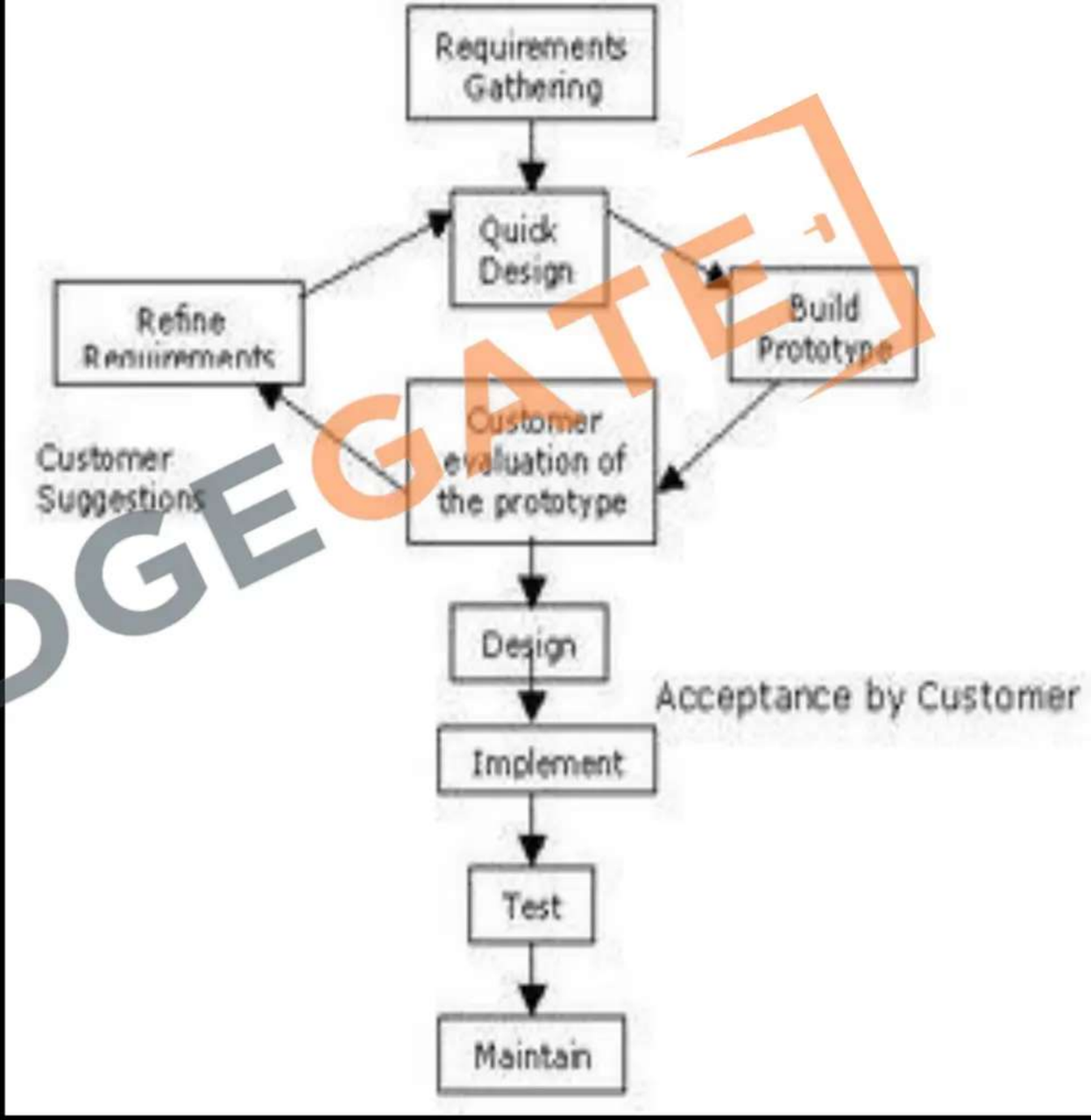
- Then shown to the user, as per the feedback of the user prototype is rebuilt and modified and again shown to the user, the process continue till the customer is not satisfied.
- After this process the final SRS document is developed.
- Developing the prototype help in building the actual design.
- Prototype model is of two types
  - Evolutionary prototype
  - Throwaway prototype



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Evolutionary prototype

- Also known as incremental or iterative prototyping, develops a working prototype, gradually improving and refining it based on user feedback.
- Prototype evolves into the final product over time with feature additions and modifications. Accommodates changing requirements during the development process.

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Throwaway prototype

- Throwaway prototyping, also known as rapid or exploratory prototyping, involves creating a temporary, simplified version of the software to validate the feasibility of specific features, test ideas, or gain user feedback on the initial design. The throwaway prototype is not intended to be used in the final product; instead, it is discarded once it has served its purpose.
- Once the developers have gathered the necessary information, they can then start developing the actual software product from scratch, using the lessons learned from the prototype. This approach is particularly useful for testing complex or risky features, as it helps to minimize the potential impact of these features on the overall project.

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- **Advantage**
  - Customer get a chance to see the product early in the life cycle, and give important feedback.
  - There is a scope to accommodate new requirements.
  - Developer and more confident, and hence risk is reduced.

- **Disadvantage**
  - After seeing the early prototype use demand the actual system soon.
  - If not managed properly the iterative process can run for a long time.
  - If user is not satisfied, he may lose its interest in the project.

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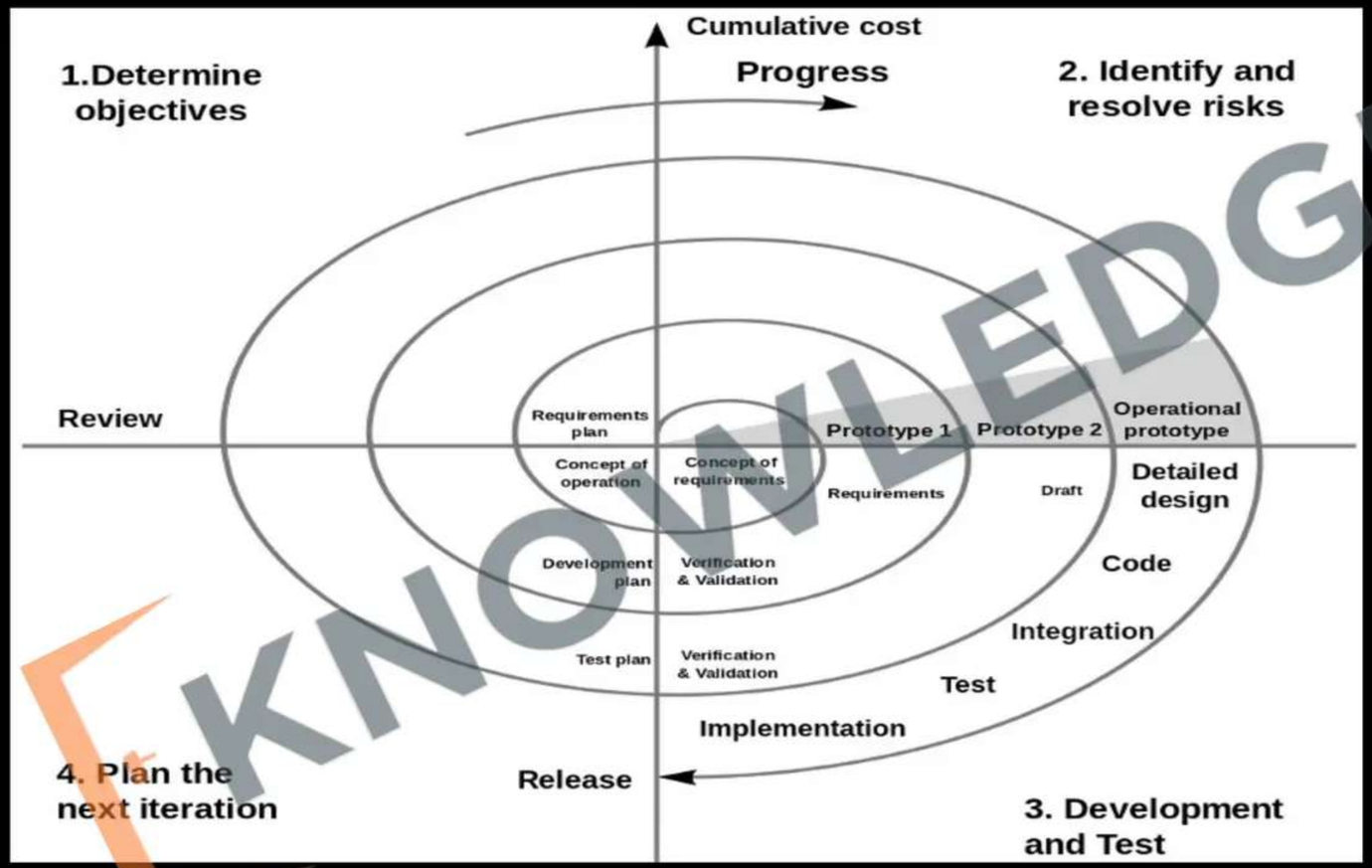
Spiral Model

- Barry boehm recognised the project risk factor into a life cycle model, the result was the spiral model, which was presented in 1986.



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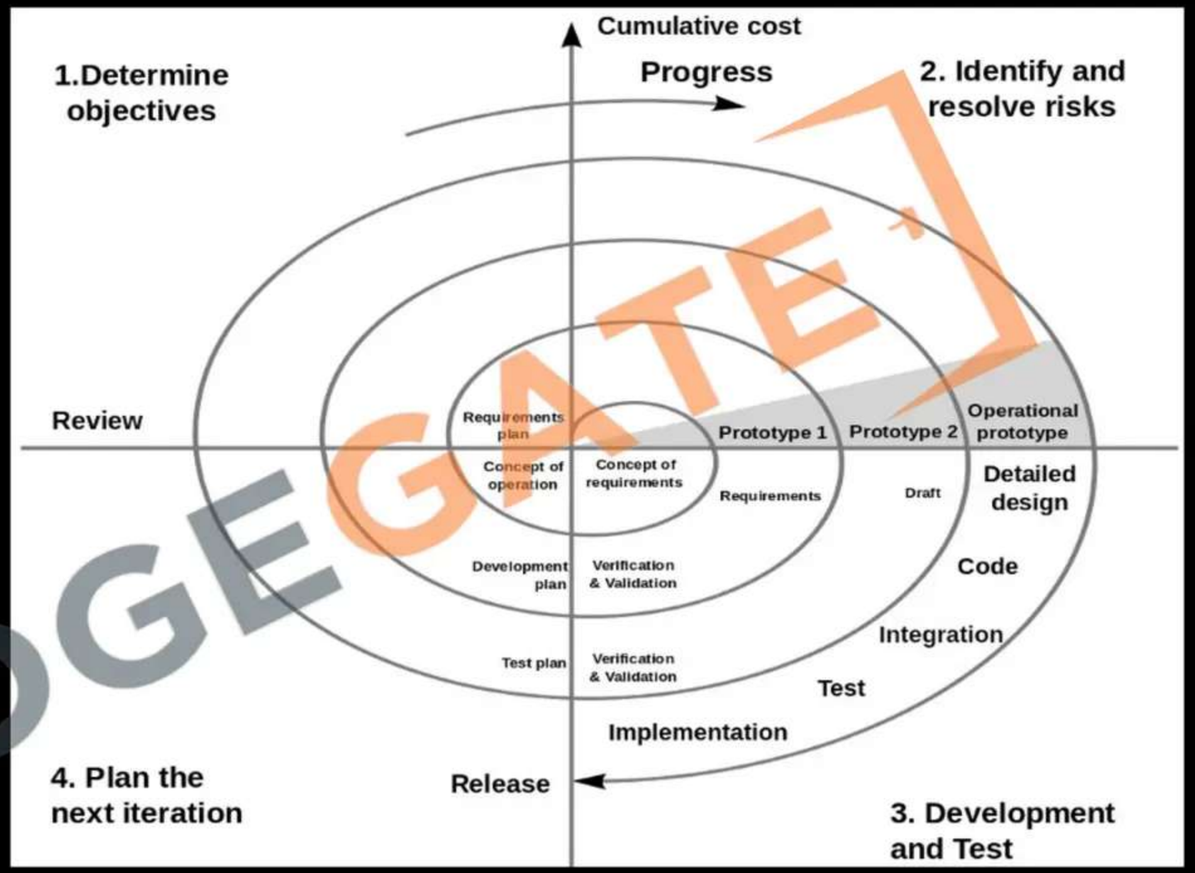
- The radial dimensions of the model represent the cumulative costs.
- Each path around the spiral is the indicative of the increased cost.
- The angular dimensions represent the progress made in the completing each cycle, each loop of the spiral from X-axis clockwise through 360 represent one phase, which is divided into four sectors
  - Determining objectives and planning the next phase
  - Risk analysis
  - Engineering the product, develop and test the product
  - Customer evaluation



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- **Advantages**
  - Provide early and frequent feedback of the customer, Additional Functionality can be added at a later date.
  - Management control of quality, correctness, cost, schedule is improved through review at the conclusion of each iteration.
  - Resolve all the possible risk involved in the product early in the life cycle.
  - Allows for incremental releases and testing.

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- **Disadvantages**
  - Not suitable for small size project as the cost of risk analysis may exceed the actual cost of the project, High administrative overhead.
  - It is complex and time-consuming to use.
  - Risk analysis requires highly specific expertise.

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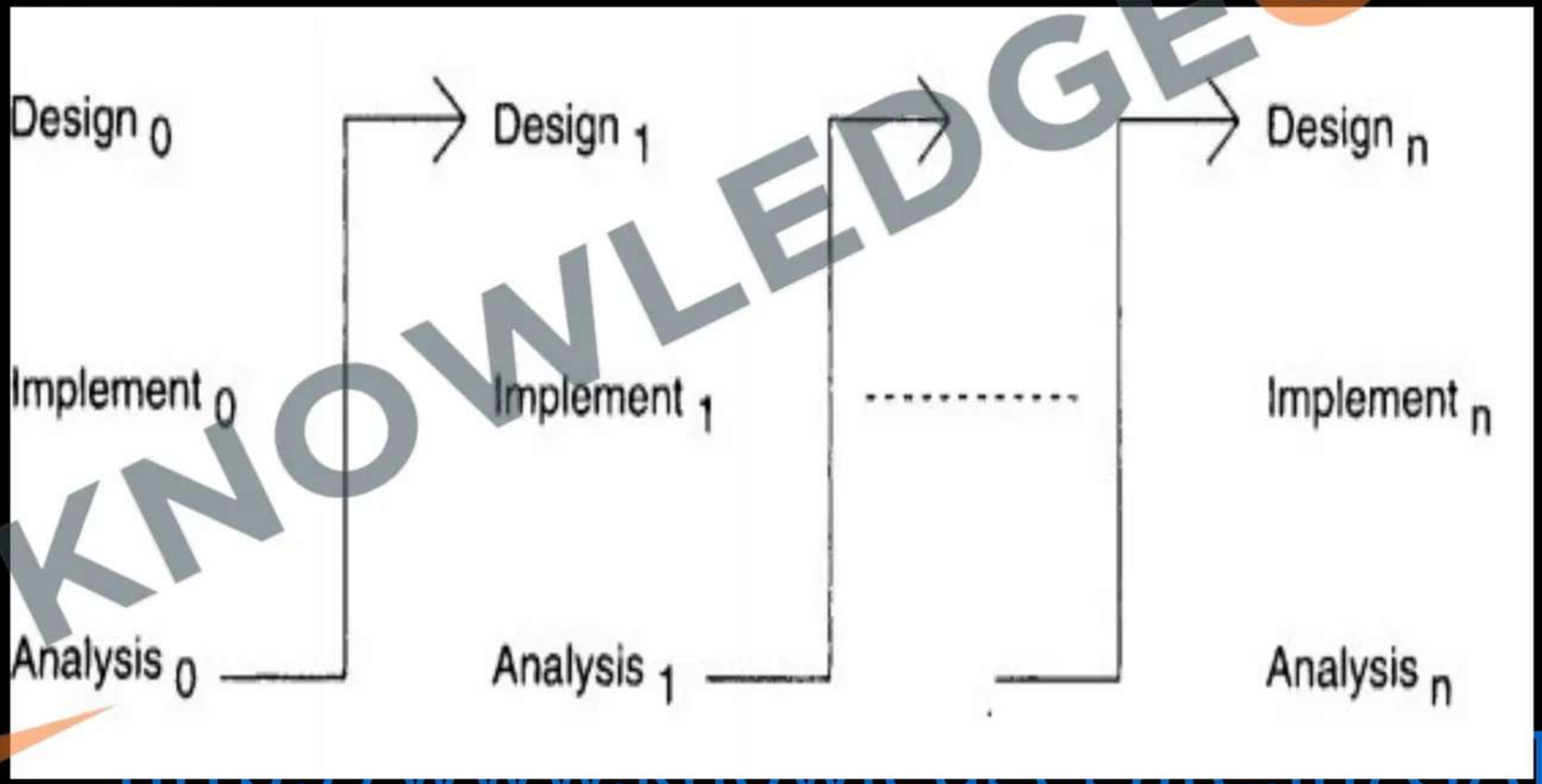
Incremental Process / Incremental Development Model

- Incremental development is based on the idea of developing an initial implementation, exposing this to user feedback, and evolving it through several versions until an acceptable system has been developed.
- In incremental model the whole requirement is divided into various builds. Multiple



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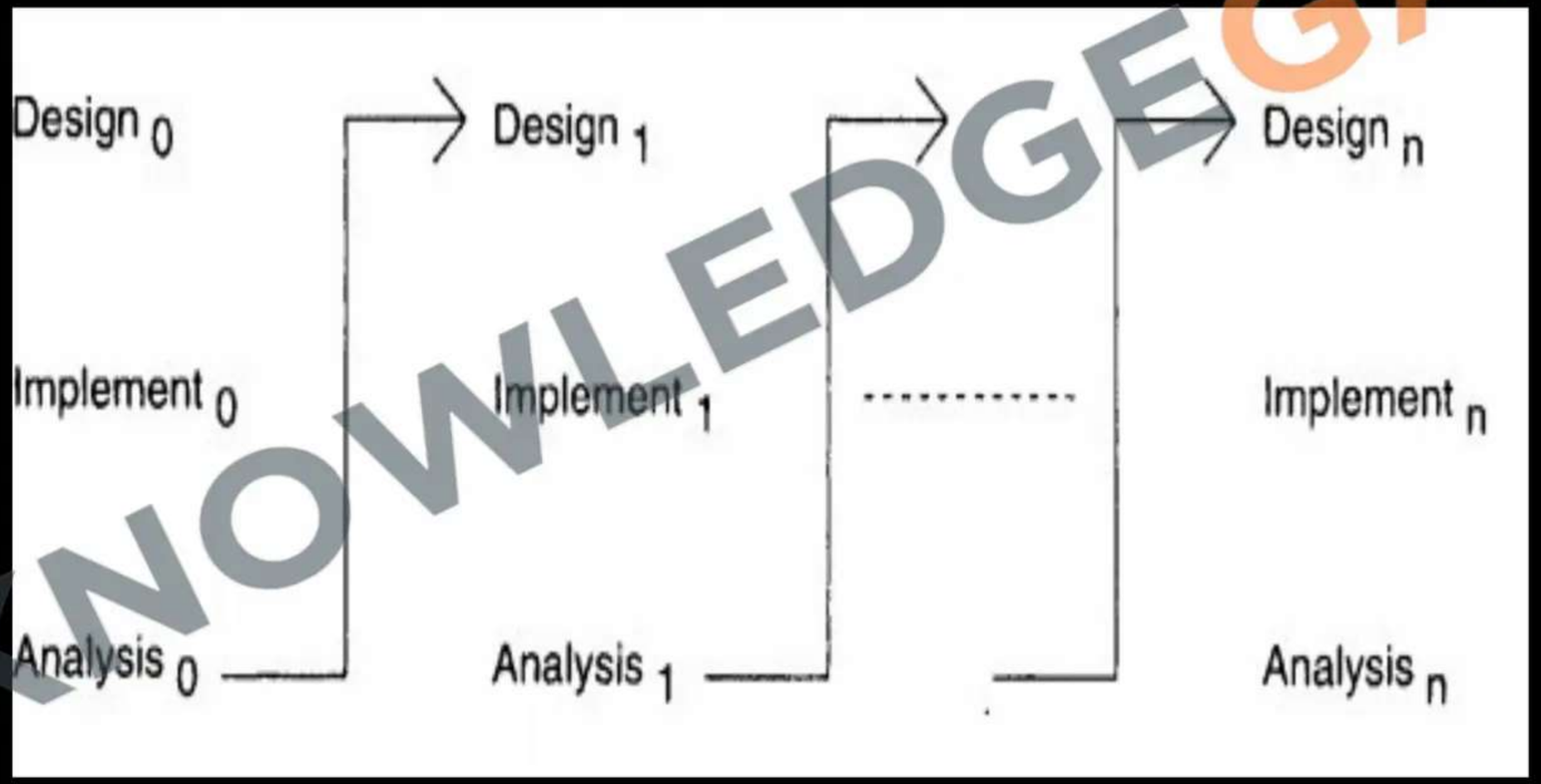
- Development cycles take place here, making the life cycle a “multi-waterfall” cycle.
- Cycles are divided up into smaller, more easily managed modules. Each module passes through the requirements, design, implementation and testing phases.



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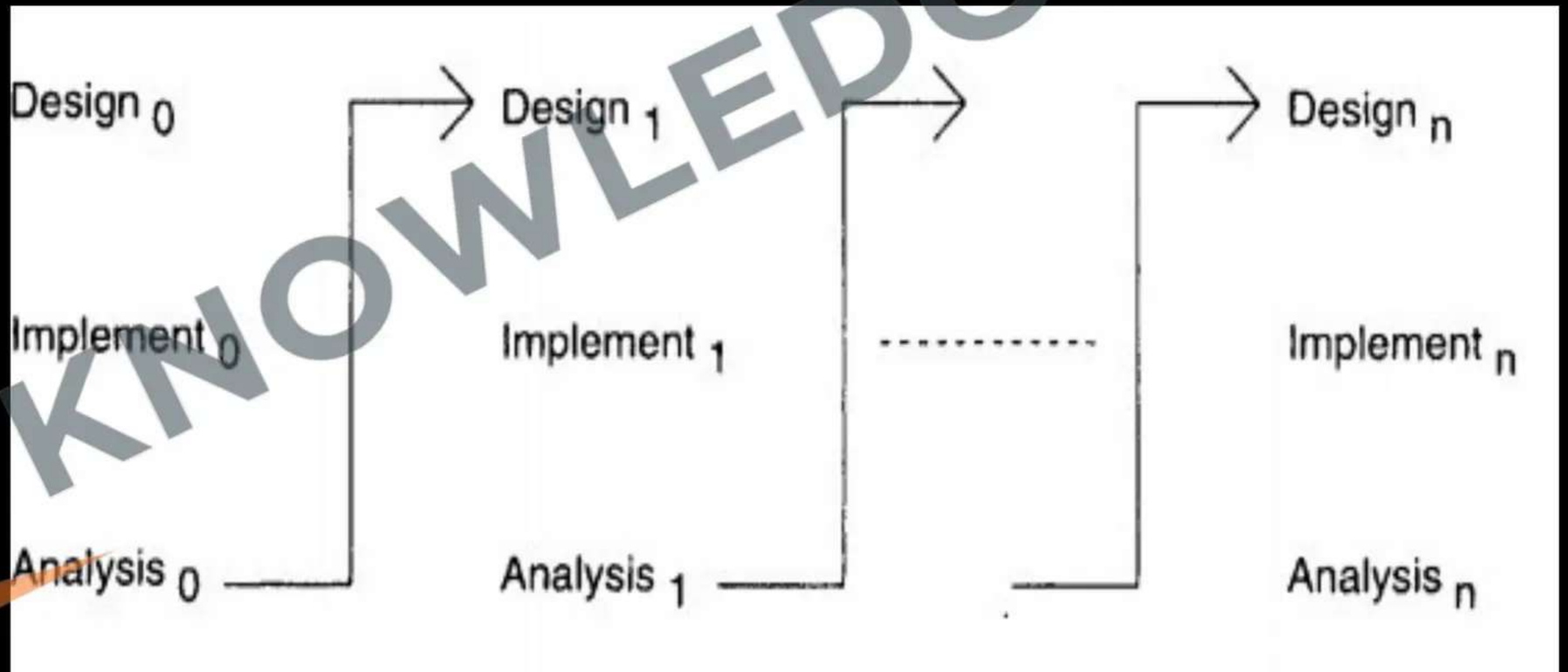
- A working version of software is produced during the first module, so you have working software early on during the software life cycle.
- Each subsequent release of the module adds function to the previous release. The process continues till the complete system is achieved.
- Generally, the early increments of the system should include the most important or most urgently required functionality.
- tries to combine the benefits of both prototyping and the waterfall model.



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Advantages of Incremental model:

- Generates working software quickly and early during the software life cycle.
- This model is more flexible – less costly to change scope and requirements.
- It is easier to test and debug during a smaller iteration.
- In this model customer can respond to each built.
- Easier to manage risk because risky pieces are identified and handled during it'd iteration.

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Disadvantages of Incremental model

- Needs good planning and design.
- Needs a clear and complete definition of the whole system before it can be broken down and built incrementally.
- Total cost is higher than waterfall.

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Aspect	Evolutionary Development Models	Iterative Enhancement Models
Focus	Adaptation and evolution of software in response to changing requirements and user feedback.	Continuous improvement and refinement of a software system in iterations.
Initial Release	May start with a basic prototype or a partially functional system to gather feedback.	Begins with a basic version of the software, usually with minimal functionality.
Development Approach	Develops through repeated cycles (e.g., prototypes or increments) with each cycle refining and expanding the software.	Focuses on enhancing and refining an existing system through multiple iterations.
Feedback Integration	Heavily relies on user feedback to guide each evolutionary stage, often with significant changes between stages.	Uses feedback to make improvements in each iteration, usually with smaller, incremental changes.
Examples	Prototyping Model, Spiral Model, Agile Development, RAD.	Agile Development (as a specific approach focusing on enhancement and refinement), Iterative Development Model.

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Unit-2(Software Requirement Specifications (SRS))

- Requirement Engineering Process:
  - Elicitation,
  - Analysis,
  - Documentation,
  - Review and Management of User Needs,
- Feasibility Study,
- Information Modeling,
- Data Flow Diagrams,
- Entity Relationship Diagrams,
- Decision Tables,
- SRS Document,
- IEEE Standards for SRS.
- Software Quality Assurance (SQA): Verification and Validation,
- SQA Plans, Software Quality Frameworks, ISO 9000 Models, SEI-CMM Model

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Requirement Analysis

- The hardest part of building a software is deciding precisely what is to be built. Requirement engineering is the disciplined application of proven principle, methods, tools and notations to describe a proposed system's intended behaviour and its associated constraints.

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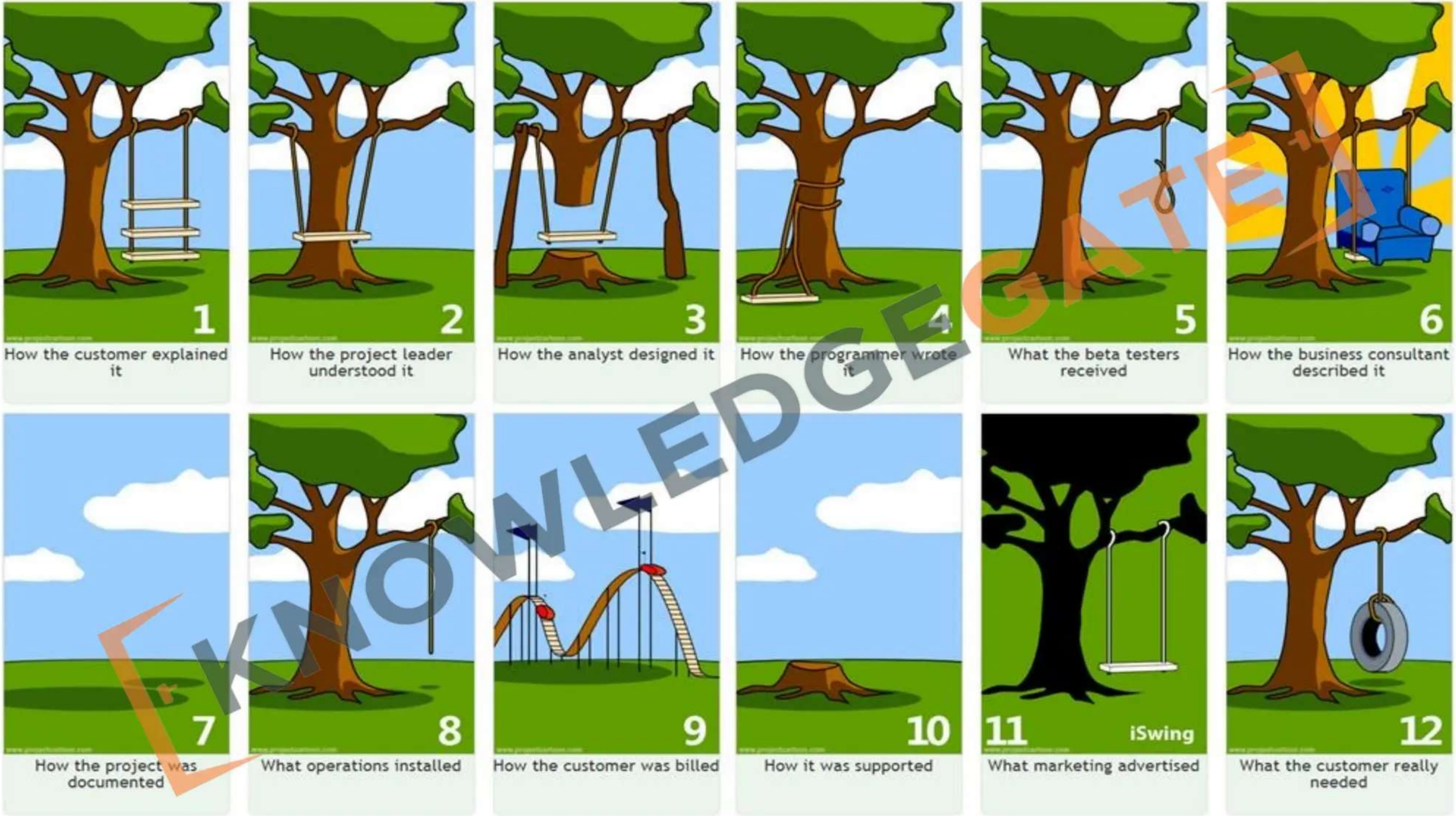

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Difficulties of Requirement Engineering

- **Requirement are difficult to uncover**: no one give the complete requirement in the first time, if someone does then also requirement are incomplete

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- **<u>Requirement Changes</u>**: with the development process requirements get added and changed as the user begins to understand the system and his or her real need

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- **<u>Tight project schedule</u>**: have insufficient time to do a decent job

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- **<u>Communication Barrier</u>**: user and developer have different technical background and tastes

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- **<u>Lack of resources</u>**: there may not be enough resources to build software that can do everything the customer wants

- Types of requirement
  - **Known requirement**: Which is already known to the stake holder
  - **Unknown Requirement**: Forgotten by stake holder because that are not needed right now
  - **Undreamt Requirement**: Stakeholder is unable to think of new requirement due to limited domain knowledge

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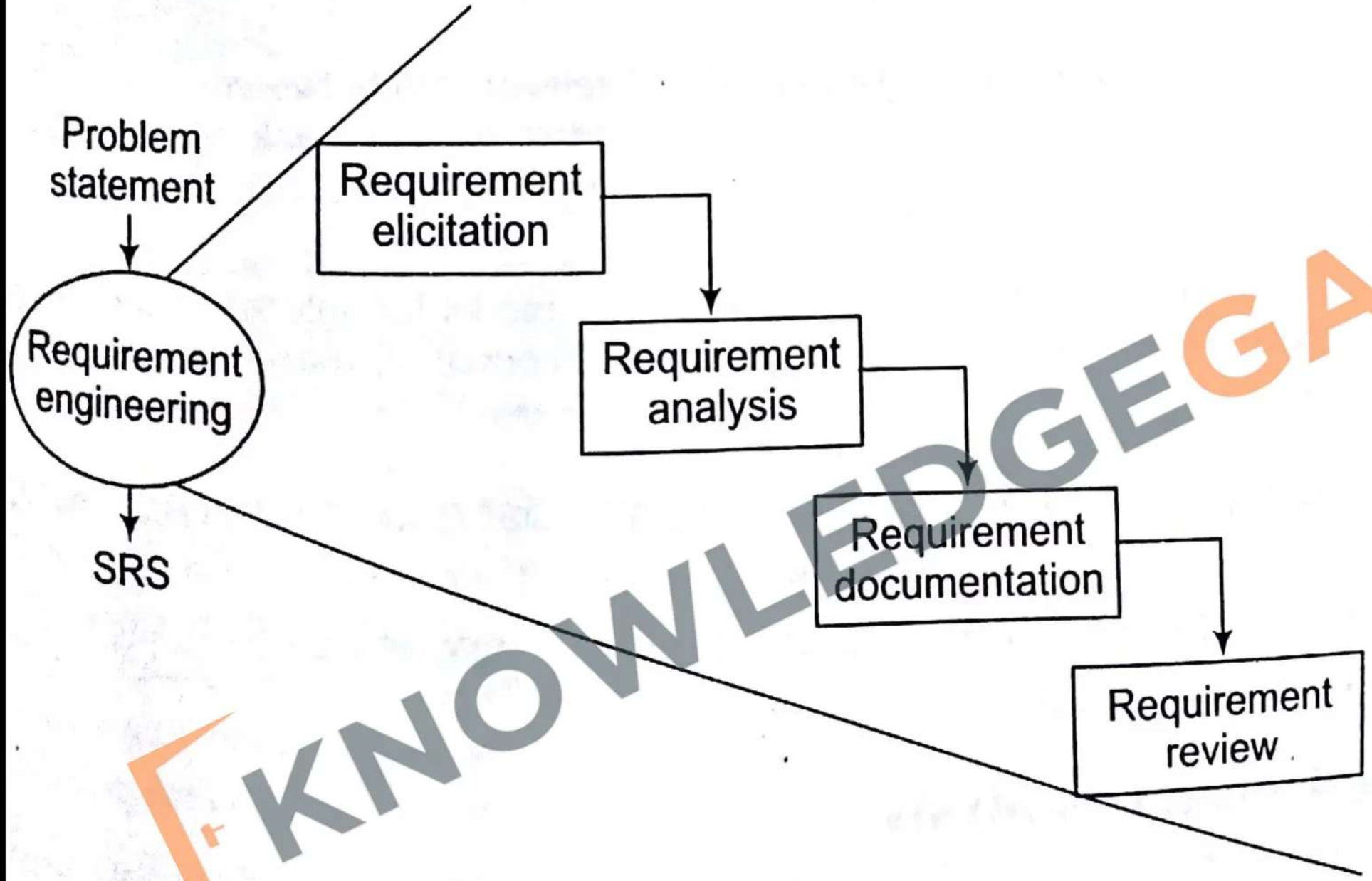

Various steps of analysis and specifications

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- There are majorly four steps in requirement analysis
  - **Requirement Elicitation**: Gathering of Requirement
  - **Requirement Analysis**: Requirements are analysed to identify inconsistences, defects etc and to resolve conflicts
  - **Requirement documentation**: Here we document all the refined requirement properly
  - **Requirement Review**: Review is carried out to improve the quality of the SRS

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Methods of requirement elicitation

- Is the most difficult, most critical, most error-prone and communication intensive aspect of the s/w development. It can only succeed only through an effective customer developer partnership.

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- **Interview**
  - Both parties would like to understand each other
  - Interview can be of two types open-ended or structured
  - In open ended, there is no present agenda, context free questions can be asked to understand the problem, to have an over view over the situation
  - In structured interview, agenda is pre-set.

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- **Brain Storming**
  - A kind of group discussion, which lead to ideas very quickly and help to promote creative thinking
  - Very popular now a days and is being used in most of the organizations
  - All participants are encouraged to say whatever idea come to their mind and no one will be criticized for any idea no matter how goofy it seems

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- **Delphi technique**
  - Here participants are made to write the requirement on a piece of paper, then these requirements are exchanged among participants who gave their comments to get a revised set of requirements. This process is repeated till the final consensus is reached

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- **FAST (facilitated application specification technique)**
  - This approach encourages the creation of joint team of customer and developer who works together to understand correct set of requirements
  - Everyone is asked to prepare a list of
    - What surrounds the system
    - Produced by the system
    - Used by the system
    - List of service, constraints, and performance criterion
    - Then we divide these lists into smaller list to work in smaller teams

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- **QFD (quality functional deployment)**
  - Its emphases to incorporate the voice of the customer with importance
  - Then according to customer, a value indicating a degree of importance, is assigned to each requirement. Thus, the customer, determine the importance of each requirement on a scale of 1 to 5 as:
    - **5 points**: very important
    - **4 points**: important
    - **3 points**: not important but nice to have
    - **2 point**: not important
    - **1 point**: unrealistic, requires further explanation

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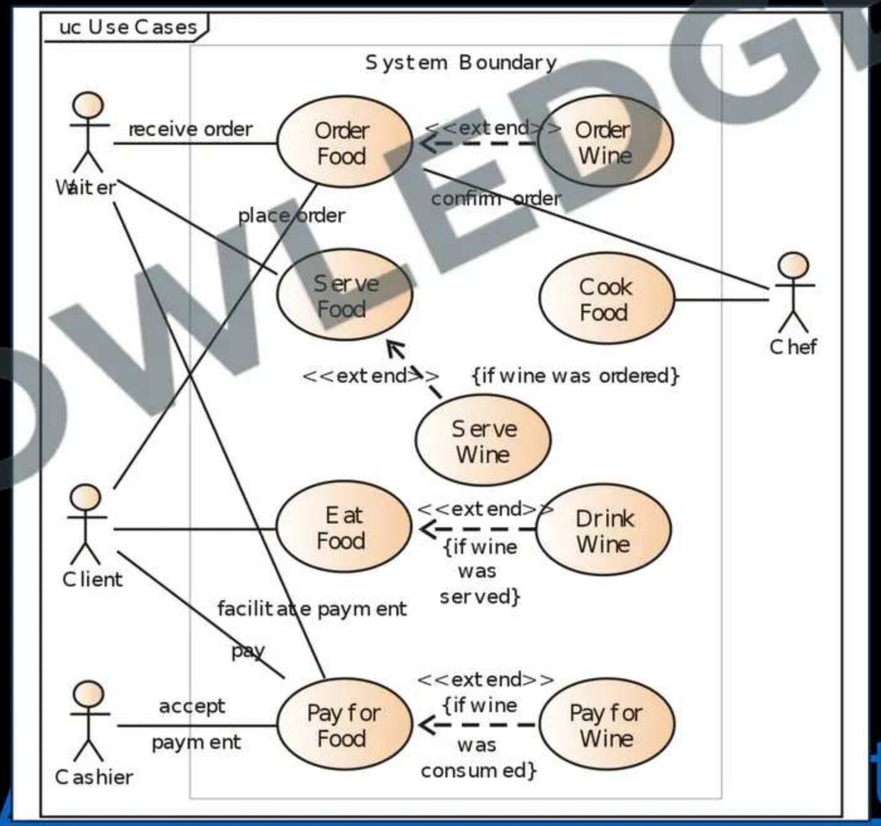
- **Use case approach**
  - These are structured description of the user requirement. It is a narrative which describe the sequence of events from user's perspective
  - Use case diagrams are graphical representation to show the system at different levels
  - They are some times supportive my the activity diagrams, to understand the work flow



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Requirement analysis

- In this phase we analysis all the set of requirements to find any inconsistency or conflicts.
- In requirement gathering phase our all concentration was on getting all the set of requirements but now, we see how many requirements are contradictory to each other or requires further exploration to be considered further.
- Different tools can be used Data flow diagram, Control flow diagram, ER diagram etc

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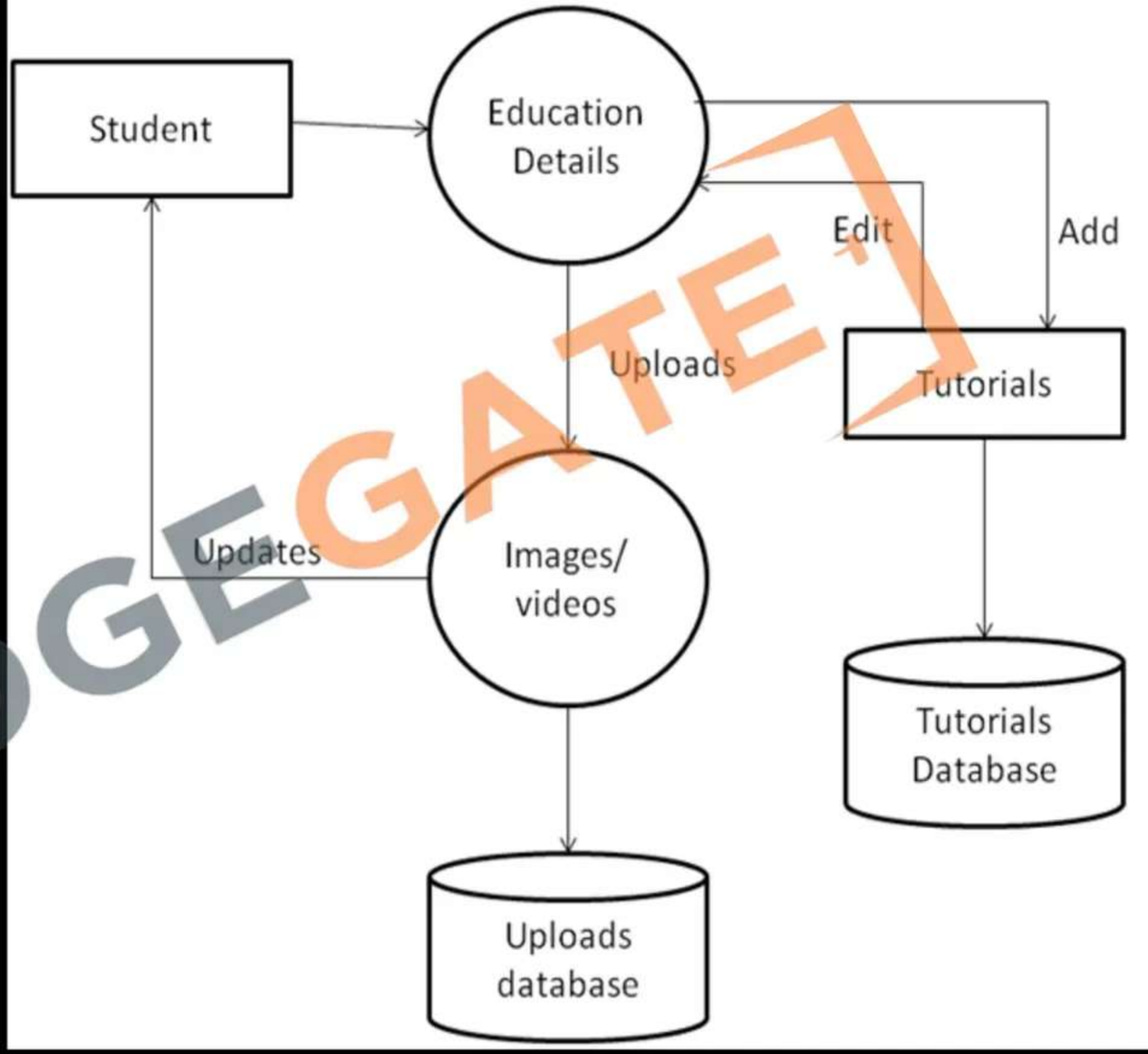
Data Flow Diagram

- A data flow diagram or bubble chart is a graphical representation of the flow of data through a system. It clarifies systems requirements and identify major transformations.

- DFD represent a system at different level of abstraction. DFD may be Partitioned into levels that represent increasing information flow and functional details



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- Components of DFD
  - Function/Process
  - Data Store
  - External Entity
  - Data Flow

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DFD uses hierarchy to maintain transparency thus multilevel DFD's can be created. Levels of DFD are as follows:

- **<u>0-level DFD</u>**: It represents the entire system as a single bubble and provides an overall picture of the system.

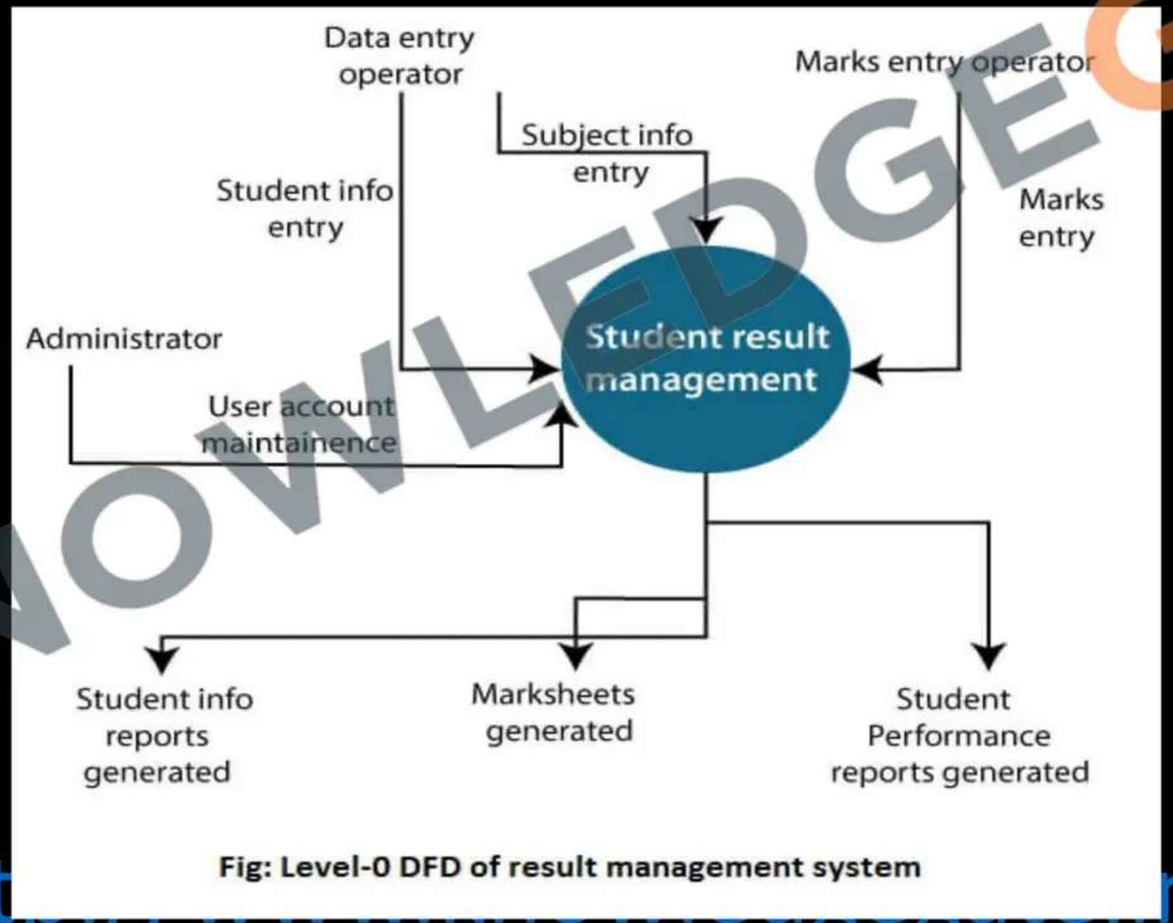

Fig: Level-0 DFD of result management system

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- **<u>1-level DFD</u>**: It represents the main functions of the system and how they interact with each other.

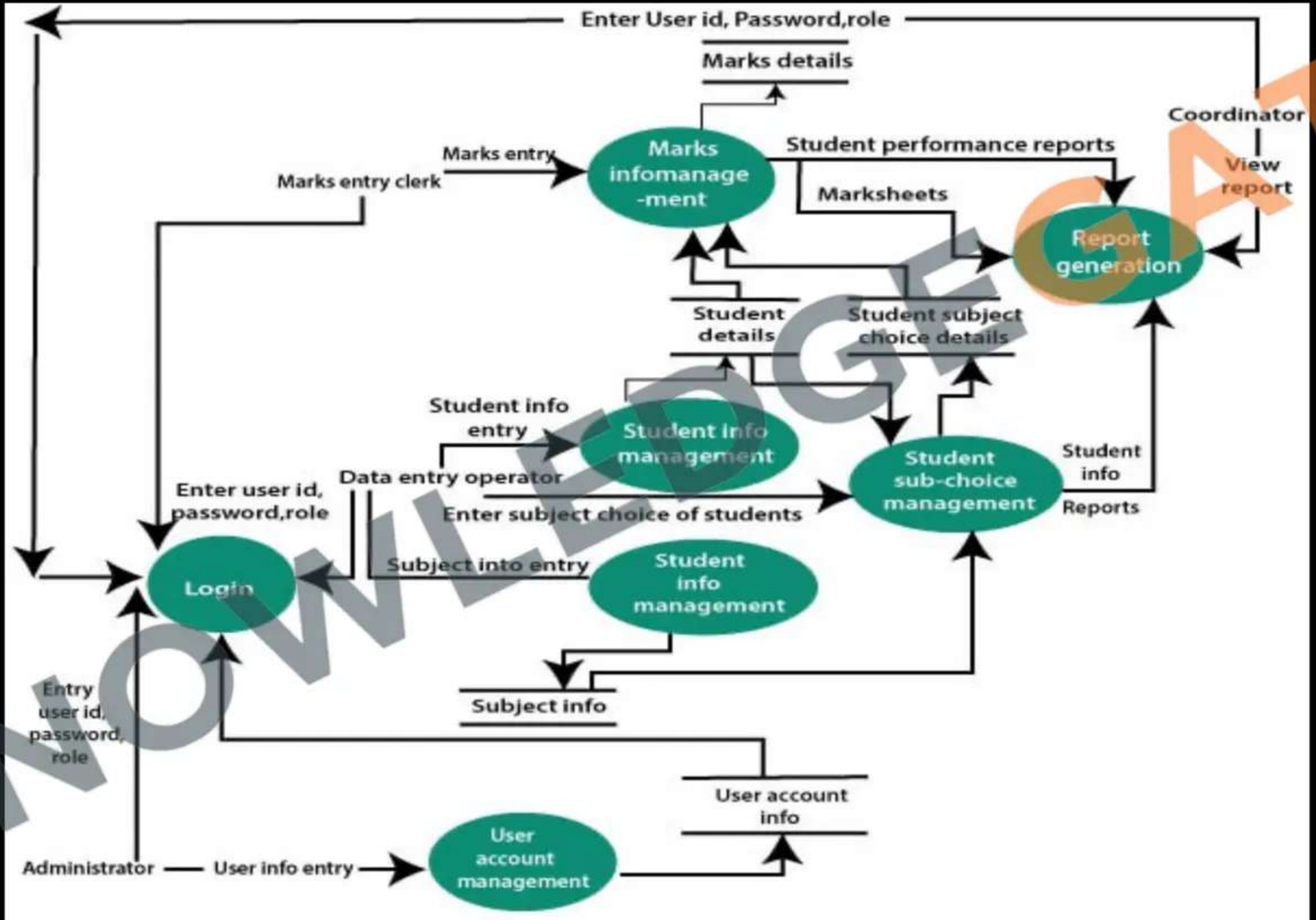

Fig: Level-1 DFD of result management system

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- **<u>2-level DFD</u>**: It represents the processes within each function of the system and how they interact with each other.

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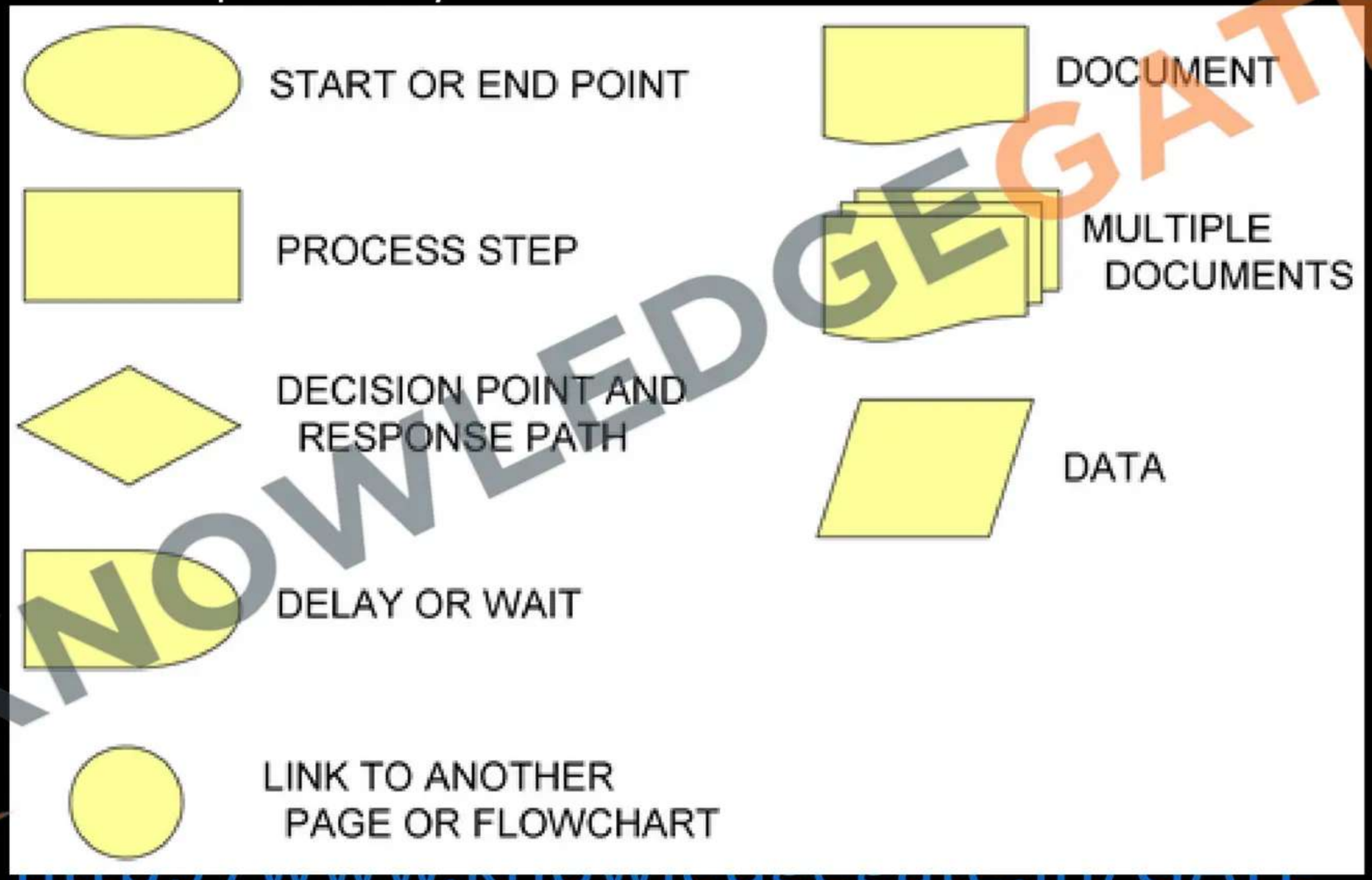
Control Flow Diagram/Control flow chart/Flow Chart

- A flow chart is a graphical representation of how control flow during the execution of a program. It use the following symbols to represent a system's control flow.



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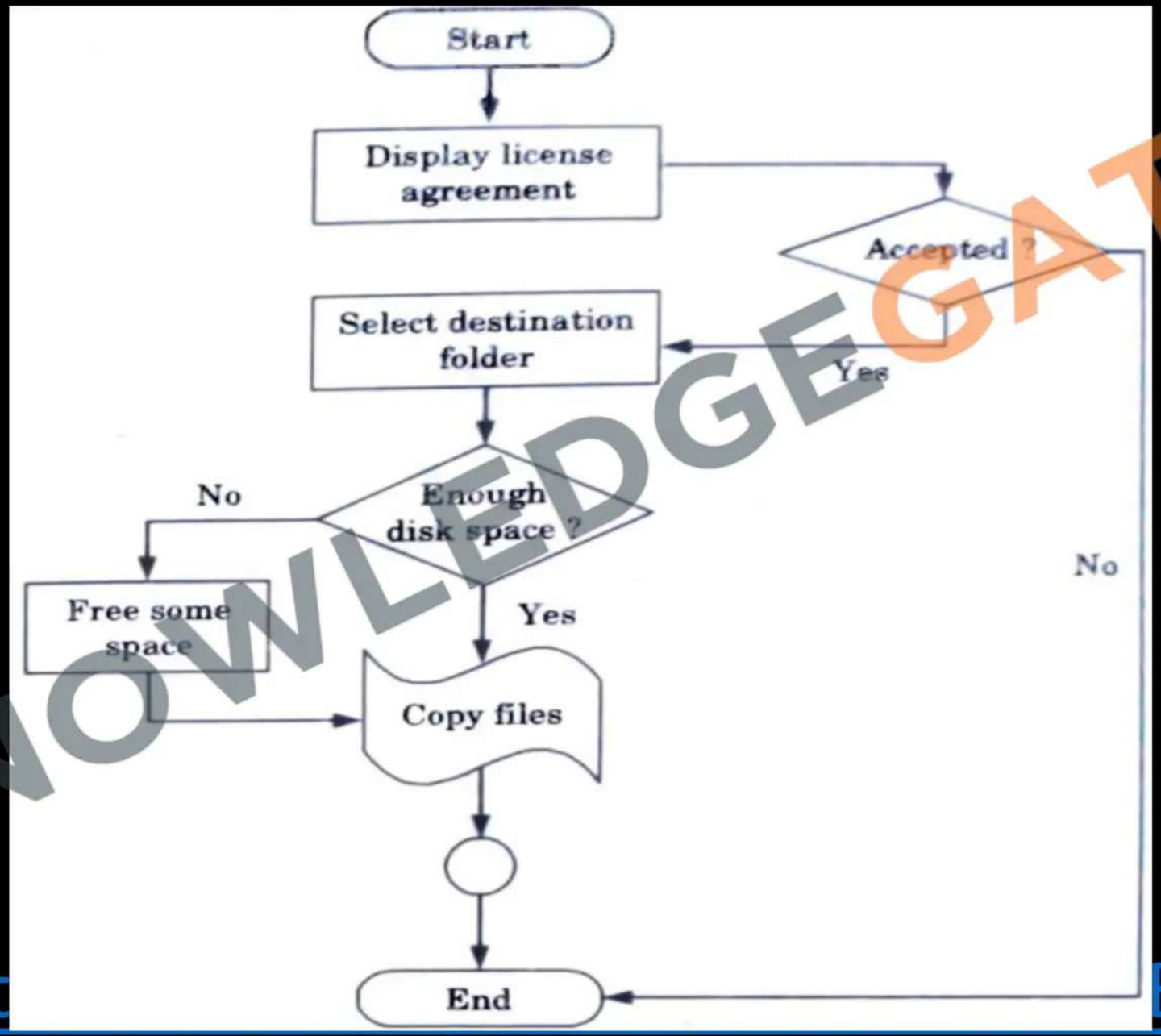
- Flow Chart of software installation



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Data Dictionary

- **Purpose**: Serves as a repository for data item details in Data Flow Diagrams, ensuring consistent definitions between customers and developers.
- **Content**: Includes data item name, aliases, and purpose, promoting clear understanding.
- **Relationships & Range**: Records data item relationships and value ranges (e.g., marks between 0-100).
- **Data Flows & Structures**: Tracks process interactions with data items and documents their structure or composition.
- **Role in Requirements**: Essential in initial stages for defining customer data items, aligning developer and customer understanding.

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Data Dictionary

Data Dictionary outlining a Online Gaming Service

Data Item	Data Type	Data Format	Number of Bytes for Storage	Size for Display	Description	Example	Validation
MemberID	String	XNNNNNN	7	7	Unique Identifier For Member	M123456	
First Name	String		25	25	First Name of Member	Scott	
Surname	String		25	25	Last Name of Member	Daniels	
D.O.B	Floating Point (Date Format)	DD/MM/YYYY	4	10	Birth Date of Member	02/04/1990	Date < Today - 15 years
Platinum Membership?	Boolean	X	1	1	True (T) or False (F)	T	
Subscription Cost	Floating Point (Currency Format)	$NN.NN	4	6	Cost of Members Subscription	$27.50	Cost > 0 Cost < $50.00
Available Game Packs	Array (String)		25 * Number of Games	25 * Number of Games	Names of Game Packs	Open World Game Pack	

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Entity Relationship Diagram

- ER Diagram a non-technical design method works on conceptual level based on the perception of the real world.

- E-R data model was developed to facilitate software designers by allowing specification of an enterprise schema that represents *the overall logical structure of a database*.

- Three main constructs are data entities, their relationships and their associated attributes

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S. No.	Component name	Symbol	Description
1.	Rectangles		Represents entity sets
2.	Ellipses		Represents attributes
3.	Diamonds		Represents relationship sets
4.	Lines		Links attributes to entity sets and entity sets to relationship sets
5.	Double ellipses		Represents multivalued attributes
6.	Dashed ellipses		Represents derived attributes
7.	Double rectangles		Represents weak entity sets
8.	Double lines		Represents total participation of an entity in a relationship set

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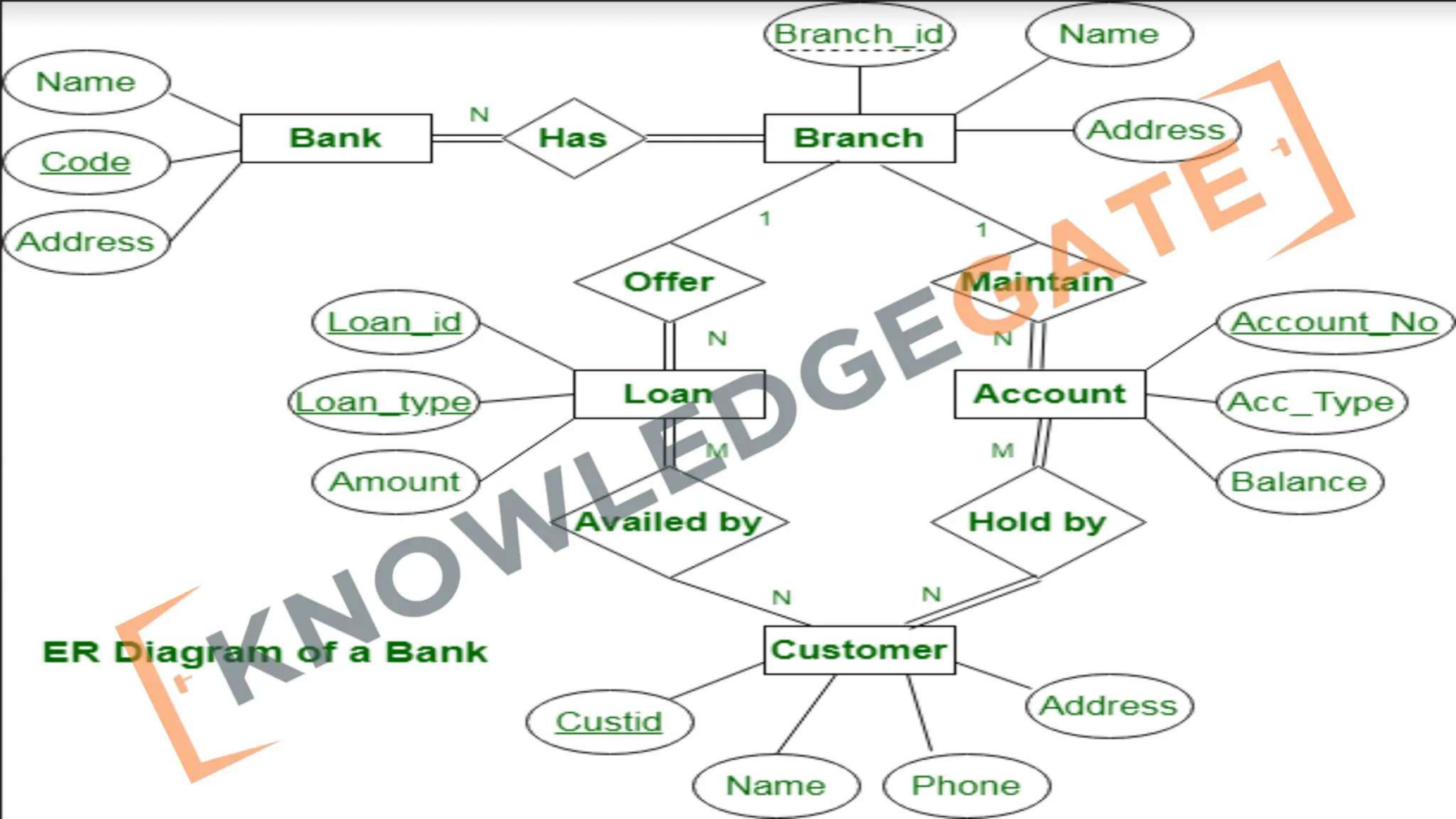

ER Diagram of a Bank

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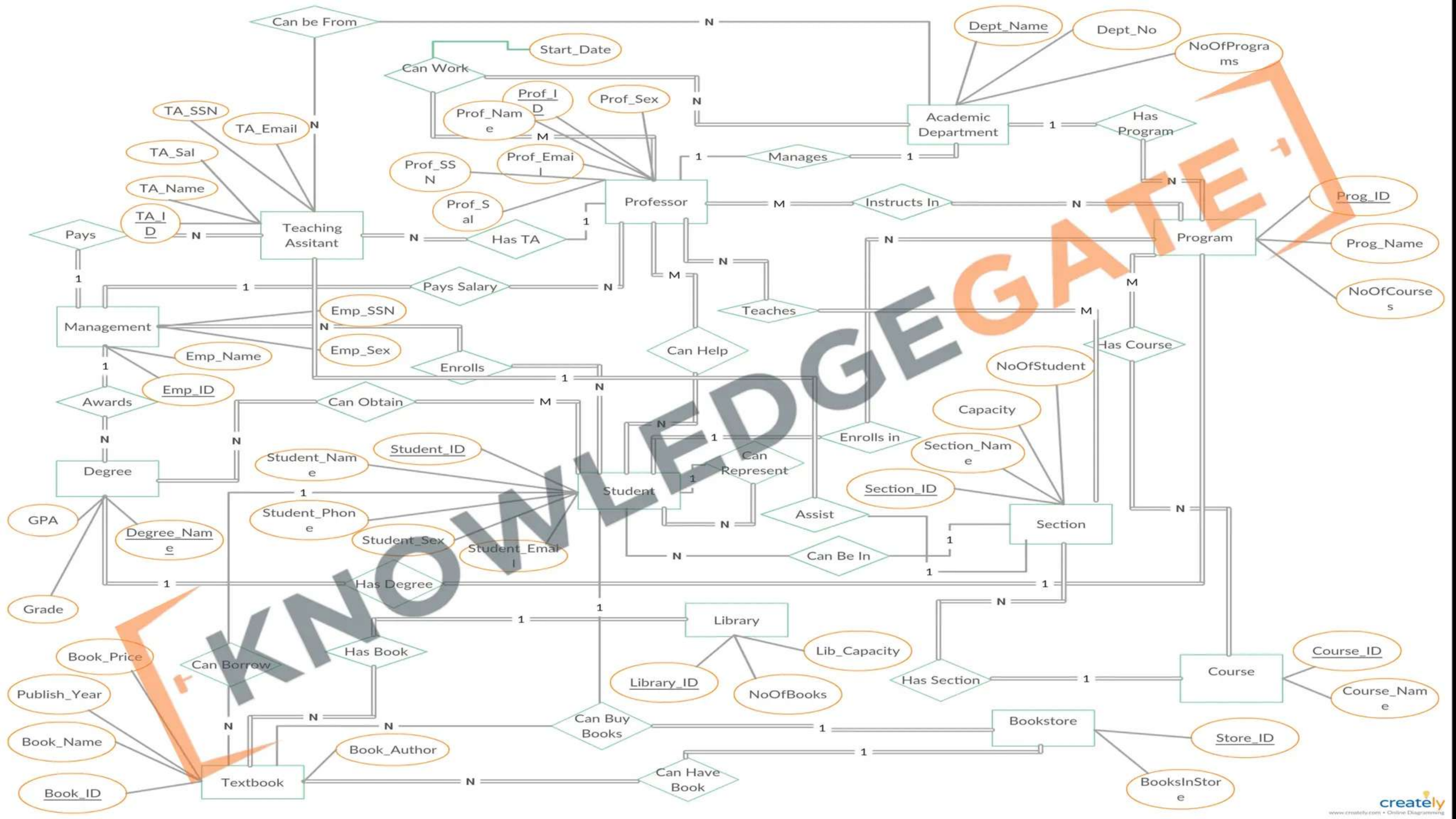
Can be From
Dept_Name
Dept_No
NoOfPrograms
Start_Date
Can Work
Prof_ID
Prof_Name
Prof_Sex
Academic Department
Has Program
TA_SSN
TA_Email
TA_Sal
TA_Name
TA_ID
Prof_SSN
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NoOfCourses
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Has TA
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Pays Salary
Management
Emp_SSN
Emp_Name
Emp_Sex
Emp_ID
Teaches
Has Course
Enrolls
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NoOfStudent
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Book_Name
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Decision Tables

- A decision table is a brief visual representation for specifying which actions to perform depending on given conditions.
- A decision table is a good way to settle with different combination inputs with their corresponding outputs.
- Decision tables are very much helpful in requirements management and test design techniques. It provides a regular way of starting complex business rules, that is helpful for developers as well as for testers.

	Conditions/ Courses of Action	Rules					
		1	2	3	4	5	6
Condition Stubs	Employee type	S	H	S	H	S	H
	Hours worked	<40	<40	40	40	>40	>40
Action Stubs	Pay base salary	X		X		X	
	Calculate hourly wage		X		X		X
	Calculate overtime						X
	Produce Absence Report		X				

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Aspect	Decision Table	Decision Tree
Structure	Tabular format, lists conditions, actions, and rules.	Tree-like diagram, shows decision paths with branches.
Decision Making	Based on various combinations of conditions leading to specific actions.	Based on sequential decisions leading to outcomes.
Ease of Use	Simple for representing complex logical relationships, can become cumbersome with many variables.	More intuitive for visualizing decision paths, can become complex with many branches.
Application	Preferred in scenarios where all possible combinations of conditions and outcomes need clear representation.	Ideal for situations where decision-making process is more sequential and hierarchical.

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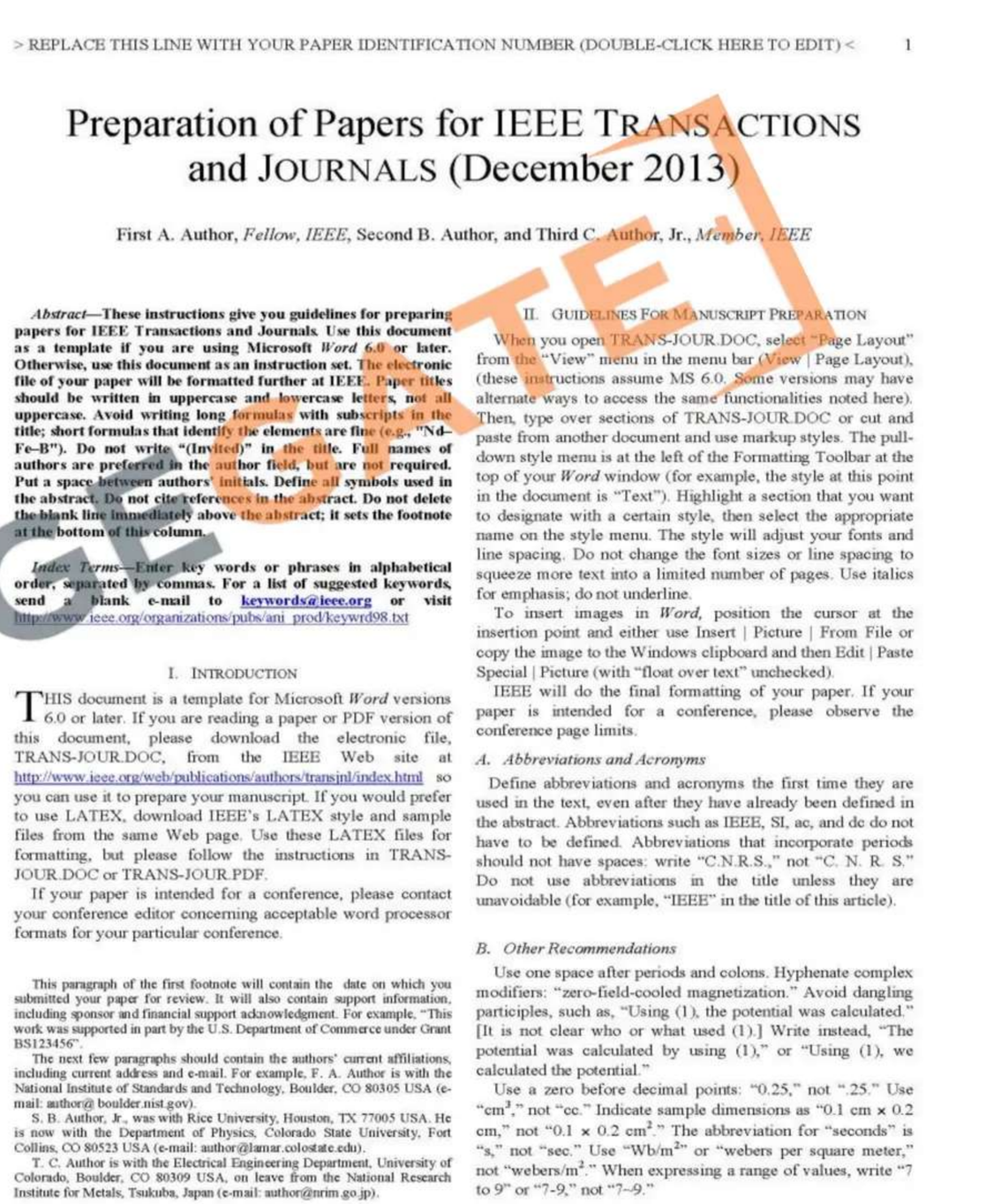
Requirement Documentation

- After have final set of requirements it is also necessary to document them properly in a standard format, so that can be understood easily even by non-technical person.
- Here IEEE provides standard for SRS documents in IEEE830, using which we can make SRS document more readable, modifiable, and a format which can be followed through the world.



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Preparation of Papers for IEEE TRANSACTIONS and JOURNALS (December 2013)

First A. Author, *Fellow, IEEE*, Second B. Author, and Third C. Author, Jr., *Member, IEEE*

***Abstract*—These instructions give you guidelines for preparing papers for IEEE Transactions and Journals. Use this document as a template if you are using Microsoft *Word* 6.0 or later. Otherwise, use this document as an instruction set. The electronic file of your paper will be formatted further at IEEE. Paper titles should be written in uppercase and lowercase letters, not all uppercase. Avoid writing long formulas with subscripts in the title; short formulas that identify the elements are fine (e.g., "Nd–Fe–B"). Do not write "(Invited)" in the title. Full names of authors are preferred in the author field, but are not required. Put a space between authors' initials. Define all symbols used in the abstract. Do not cite references in the abstract. Do not delete the blank line immediately above the abstract; it sets the footnote at the bottom of this column.**

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I. INTRODUCTION

THIS document is a template for Microsoft *Word* versions 6.0 or later. If you are reading a paper or PDF version of this document, please download the electronic file, TRANS-JOUR.DOC, from the IEEE Web site at http://www.ieee.org/web/publications/authors/transjnl/index.html so you can use it to prepare your manuscript. If you would prefer to use LATEX, download IEEE's LATEX style and sample files from the same Web page. Use these LATEX files for formatting, but please follow the instructions in TRANS-JOUR.DOC or TRANS-JOUR.PDF.

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This paragraph of the first footnote will contain the date on which you submitted your paper for review. It will also contain support information, including sponsor and financial support acknowledgment. For example, "This work was supported in part by the U.S. Department of Commerce under Grant BS123456".

The next few paragraphs should contain the authors' current affiliations, including current address and e-mail. For example, F. A. Author is with the National Institute of Standards and Technology, Boulder, CO 80305 USA (e-mail: author@ boulder.nist.gov).

S. B. Author, Jr., was with Rice University, Houston, TX 77005 USA. He is now with the Department of Physics, Colorado State University, Fort Collins, CO 80523 USA (e-mail: author@lamar.colostate.edu).

T. C. Author is with the Electrical Engineering Department, University of Colorado, Boulder, CO 80309 USA, on leave from the National Research Institute for Metals, Tsukuba, Japan (e-mail: author@nrim.go.jp).

II. GUIDELINES FOR MANUSCRIPT PREPARATION

When you open TRANS-JOUR.DOC, select "Page Layout" from the "View" menu in the menu bar (View | Page Layout), (these instructions assume MS 6.0. Some versions may have alternate ways to access the same functionalities noted here). Then, type over sections of TRANS-JOUR.DOC or cut and paste from another document and use markup styles. The pull-down style menu is at the left of the Formatting Toolbar at the top of your *Word* window (for example, the style at this point in the document is "Text"). Highlight a section that you want to designate with a certain style, then select the appropriate name on the style menu. The style will adjust your fonts and line spacing. Do not change the font sizes or line spacing to squeeze more text into a limited number of pages. Use italics for emphasis; do not underline.

To insert images in *Word*, position the cursor at the insertion point and either use Insert | Picture | From File or copy the image to the Windows clipboard and then Edit | Paste Special | Picture (with "float over text" unchecked).

IEEE will do the final formatting of your paper. If your paper is intended for a conference, please observe the conference page limits.

A. Abbreviations and Acronyms

Define abbreviations and acronyms the first time they are used in the text, even after they have already been defined in the abstract. Abbreviations such as IEEE, SI, ac, and dc do not have to be defined. Abbreviations that incorporate periods should not have spaces: write "C.N.R.S.," not "C. N. R. S." Do not use abbreviations in the title unless they are unavoidable (for example, "IEEE" in the title of this article).

B. Other Recommendations

Use one space after periods and colons. Hyphenate complex modifiers: "zero-field-cooled magnetization." Avoid dangling participles, such as, "Using (1), the potential was calculated." [It is not clear who or what used (1).] Write instead, "The potential was calculated by using (1)," or "Using (1), we calculated the potential."

Use a zero before decimal points: "0.25," not ".25." Use "cm^3," not "cc." Indicate sample dimensions as "0.1 cm × 0.2 cm," not "0.1 × 0.2 cm^2." The abbreviation for "seconds" is "s," not "sec." Use "Wb/m^2" or "webers per square meter," not "webers/m^2." When expressing a range of values, write "7 to 9" or "7–9," not "7~9."

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IEEE Standard for SRS

1-**Introduction**

- 1.1-Purpose
- 1.2-Scope/Intended Audience
- 1.3-Definition, Acronyms and Abbreviation
- 1.4-References / Contact Information / SRS team member
- 1.5-Overview

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2-**Overall Description**

- 2.1-Product Perspective
- 2.2-Product Functions
- 2.3-User Characteristics
- 2.4-General Constraints
- 2.5-Assumptions and dependencies

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3-**Specific Requirement**

3.1-External interface requirements(user/hardware/software interface)

3.2-Functional requirements

3.3-Performance requirements

3.4-Design constraints(Standards compliance/hardware limitations)

3.5-Logical database requirements

3.6-Software system attributes(Reliability, availability, Security, Maintainability)

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4-**Change Management process**

5-**Document approval**

- 5.1-Tables, diagrams, and flowcharts
- 5.2-Appendices
- 5.3-Index

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Requirement Review

- Before finalising the requirement one more review specially by a third party, who a master in the industry is advisable, to have a fresh look over the system, and can mentions any points if missed by team.

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Software Quality Assurance (SQA)

- **Definition**: SQA is a process ensuring software products meet quality standards and requirements.
- **Objective**: Prevent defects, improve quality, and ensure customer satisfaction.
- **Process**: Implements quality control and management activities throughout development.
- **Techniques**: Uses code reviews, inspections, audits, and testing to evaluate software quality.

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- **Standards**: Adheres to international standards like ISO 9001, IEEE 730, and CMMI.

- **Quality Attributes**: Focuses on reliability, maintainability, usability, efficiency, and functionality.

- **Continuous Improvement**: Monitors processes and products to identify and implement improvements.

- **Metrics**: Employs metrics like defect density and code coverage to evaluate quality.

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- **Training**: Emphasizes skill development for developers and testers to meet quality standards.

- **Documentation**: Requires proper documentation for transparency and traceability.

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Verification/White Box

- Verification ensures that the software product is designed and developed according to the specified requirements and standards. “Are we building the product right”

- Process of Ensuring that the product meets its design specifications

- Focuses on static analysis techniques. Checks for consistency, completeness, and correctness
  - Code reviews
  - Static analysis tools
  - Inspection of requirements, design, and code documentation

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Validation/Black Box

- Validation ensures that the software product meets the end-user requirements and is fit for its intended purpose, “Are we Building the right product”. Ensures that the product meets its design specifications

- Focuses on static analysis techniques. Checks for consistency, completeness, and correctness
  - Code reviews
  - Static analysis tools
  - Inspection of requirements, design, and code documentation

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Software Quality Factors

- The various factors, which influence the software, are termed as software factors. They can be broadly divided into two categories.
  - The **first category** of the factors is of those that can be measured directly such as the number of logical errors.
  - **Second category** clubs those factors which can be measured only indirectly. For example, maintainability but each of the factors is to be measured to check for the content and the quality control.

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- Several models of software quality factors and their categorization have been suggested over the years. The classic model of software quality factors, suggested by McCall in 1977). The 11 factors are grouped into three categories .

  - **Product operation factors** – Correctness, Reliability, Efficiency, Integrity, Usability.

  - **Product revision factors** – Maintainability, Flexibility, Testability.

  - **Product transition factors** – Portability, Reusability, Interoperability.

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ISO 9000 Models in Software Engineering

- ISO 9000 is a series of international standards related to quality management and assurance. In the context of software engineering, these standards provide guidelines for implementing effective processes and ensuring high-quality software products.

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- **Key Components of ISO 9000**
  - **Quality Management System (QMS):**
    - Defines policies and objectives for quality, Documentation of procedures and processes, Monitoring, measurement, and analysis of processes, Improvement opportunities and corrective actions.
  - **Management Responsibility:**
    - Top management commitment to quality Establishment of a quality policy Ensuring adequate resources for QMS implementation Reviewing QMS performance regularly
  - **Resource Management:**
    - Provision of necessary resources (human, infrastructure, work environment) Competence and training of personnel Infrastructure maintenance and improvement
  - **Product Realization:**
    - Requirements determination and communication Product design and development Verification, validation, and testing Release, delivery, and post-delivery support
  - **Measurement, Analysis, and Improvement:**
    - Monitoring and measurement of processes and products Internal audits to ensure compliance Corrective and preventive actions Continual improvement of the QMS

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1. **ISO 9000 Principles**
    1. Customer focus
    2. Leadership
    3. Process approach
    4. Continual improvement

2. **ISO 9001:2015 - Quality Management Systems**
    1. Applicable to any organization size and industry
    2. Focus on customer satisfaction, regulatory compliance, and improvement
    3. Requirements cover context, leadership, planning, support, operation, evaluation, and improvement

3. **ISO/IEC/IEEE 90003:2018 - Software Engineering**
    1. Guidance for applying ISO 9001:2015 to software engineering
    2. Covers software development, supply, acquisition, operation, and maintenance
    3. Addresses both product and process quality aspects
    4. Applicable to various software development methodologies

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Benefits of ISO 9000 in Software Engineering

- Improved customer satisfaction
- Enhanced process efficiency and effectiveness
- Reduced risk of software failures and defects
- Increased marketability and competitiveness

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Implementation Steps for ISO 9000 in Software Engineering

- Obtain top management commitment
- Establish a quality management system
- Train and educate employees
- Document processes, procedures, and policies
- Monitor, measure, and analyze processes
- Implement improvements and corrective actions
- Conduct internal audits
- Seek third-party certification (ISO 9001)

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CAPABILITY MATURATY MODEL

- CMM is a strategy for improving the software process, to generate quality software.
- The Capability Maturity Model (CMM) is a development model created after a study of data collected from organizations that contracted with the U.S. Department of Defence, who funded the research. The term "maturity" relates to the degree of formality and optimization of processes, from ad hoc practices, to formally defined steps, to managed result metrics, to active optimization of the processes.
- It is use to judge the maturity of s/w process an organization and to identify the key practise that are required to increase the maturity of theses process. There are five levels of the CMM

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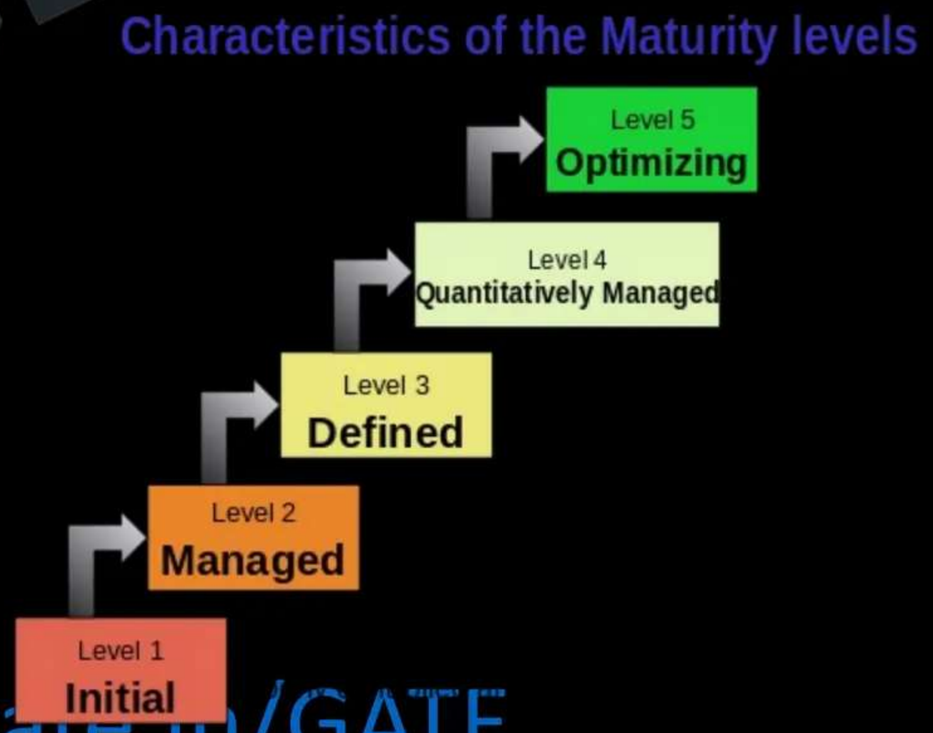
- **Initial (process unpredictable and poorly controlled)**
  - No engineering management, everything done on ad hoc basis
  - Software process is unpredictable with respect to time and cost
  - It depends on current staff, as staff change so does the process



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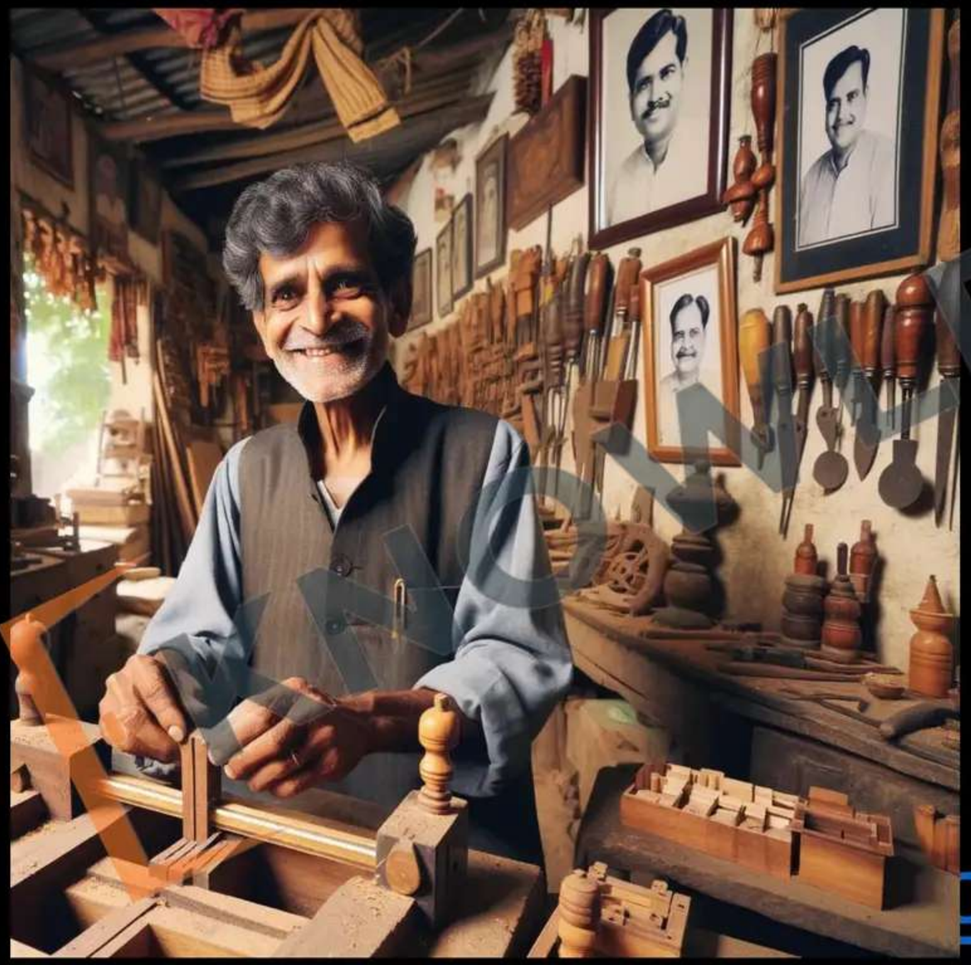
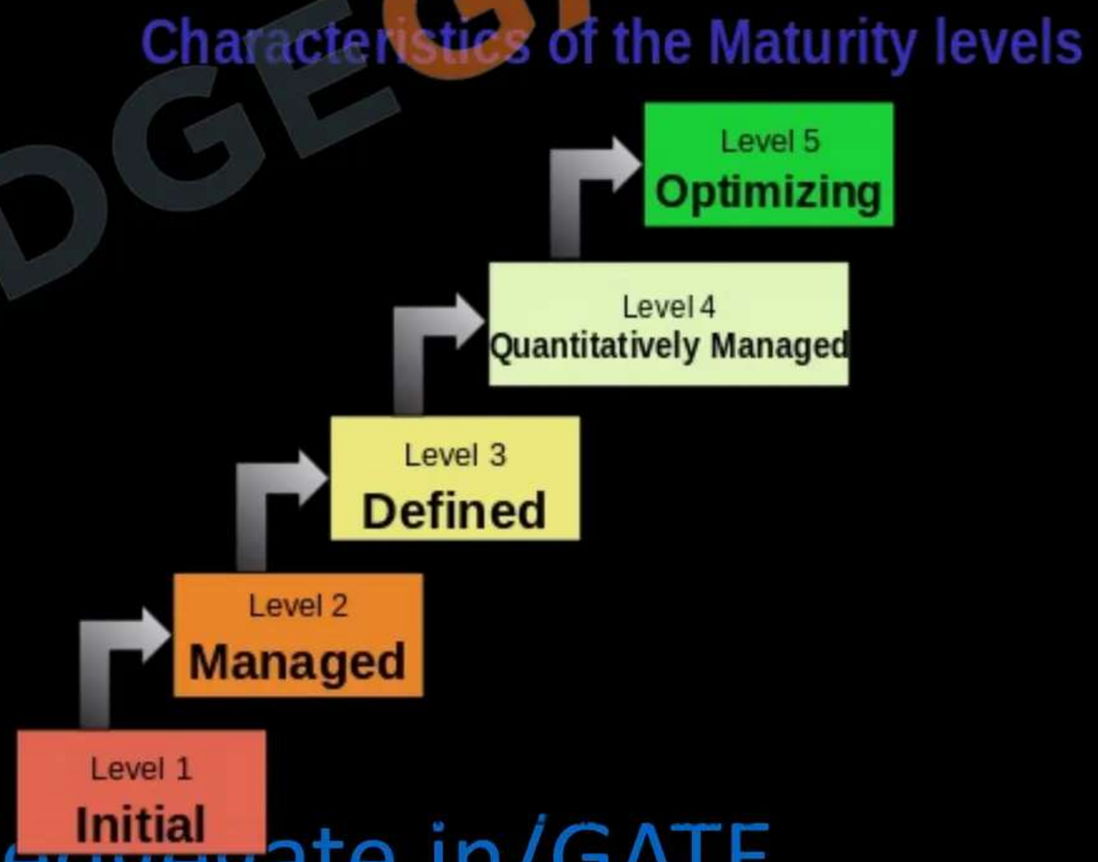
- **Repeatable (basic project management)**
  - Planning and managing of new projects are based on the experience with the similar projects
  - Realistic plans based on the performance based on the previous projects





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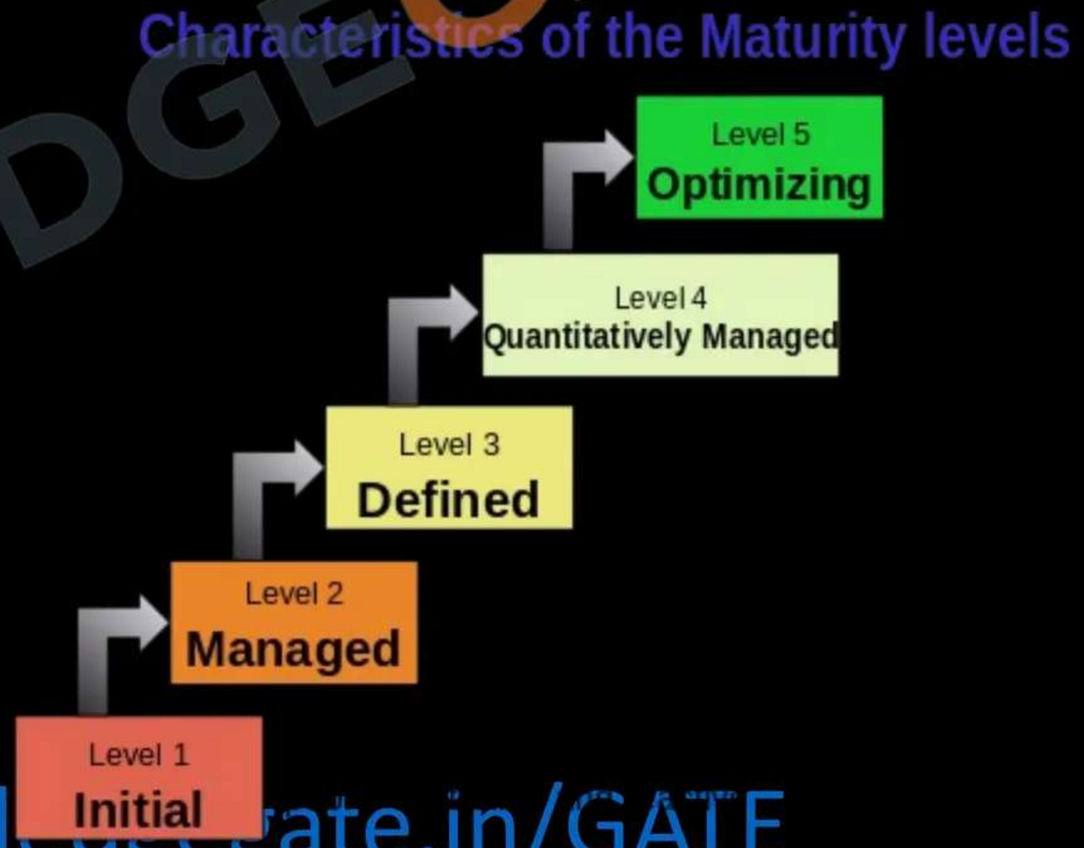
- **Defined (process standardization)**
  - Process of developing and maintaining s/w across the organization is documented including engineering and management.
  - Training programs are implemented to ensure that the staff have skills and knowledge required
  - Risk management



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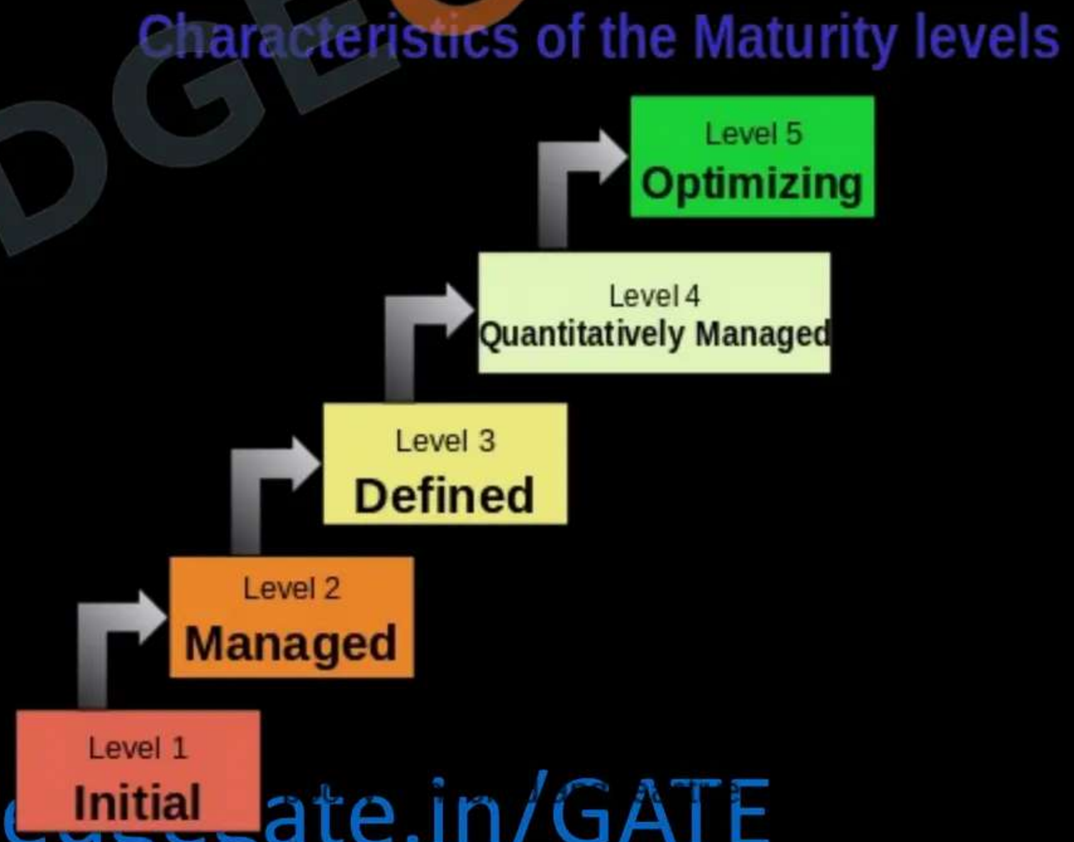
- **Managed (Quantitative measurement)**
  - Organization set quantitative goals for both product and process.
  - Here process is predictable both with respect to time and cost



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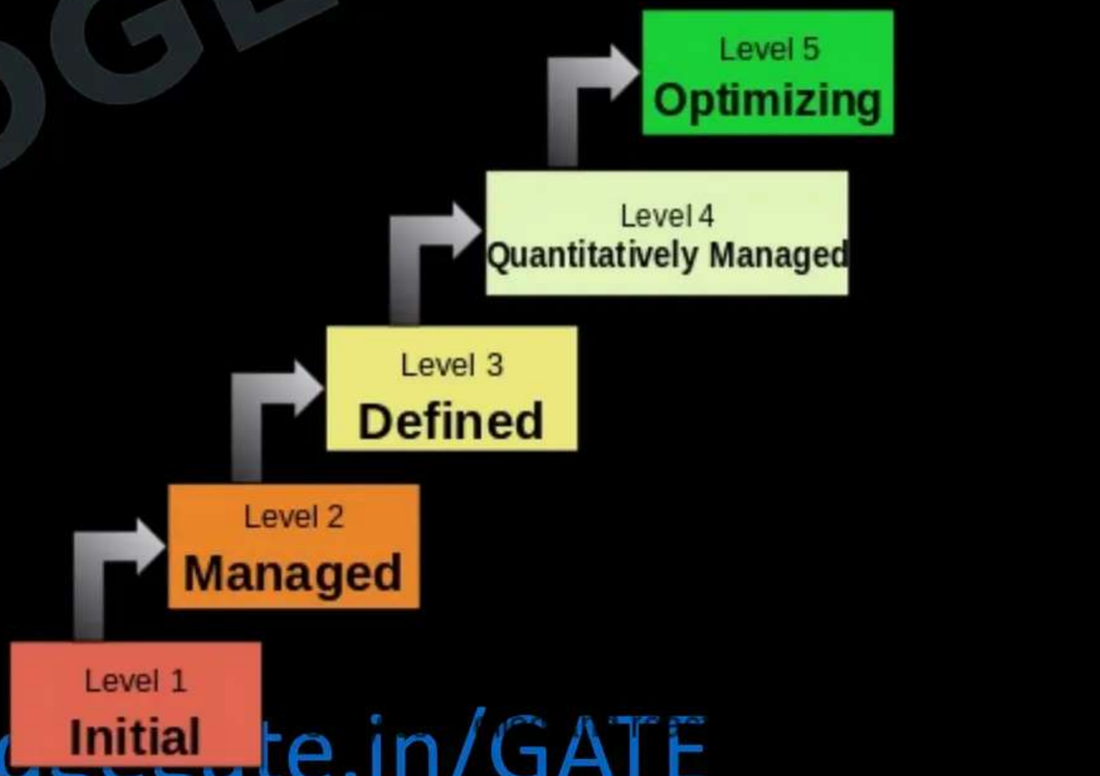
- **Optimized (continuous process improvement)**
  - Here organization analysis defects to determine their causes and goals is to preventing the occurrence of defects
  - Here company continuously improve the process performance of their projects



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Unit-3(Software Design)

- **Basic Concept of Software Design**,
  - Architectural Design,
  - Low Level Design: Modularization, Design Structure Charts, Pseudo Codes, Flow Charts,
  - Coupling and Cohesion Measures,
- **Design Strategies**
  - Function Oriented Design,
  - Object Oriented Design,
  - Top-Down and Bottom-Up Design.
- Software Measurement and Metrics:
  - Various Size Oriented Measures: Halestead's Software Science,
  - Function Point (FP) Based Measures,
  - Cyclomatic Complexity Measures: Control Flow Graphs.

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Design

- In software design phase input is SRS document and output is SDD.
- Software designing is most creative process, where we actually decide how a problem will be solved.

SRS ⟹ **Design** ⟹ **SDD**

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Characteristics of a Good SDD

- The SDD must contain all the requirement which were given in SRS.
- The design document must be readable, easy to understand and maintainable.
- It must describe a complete picture of data, functional and behavioural domain.

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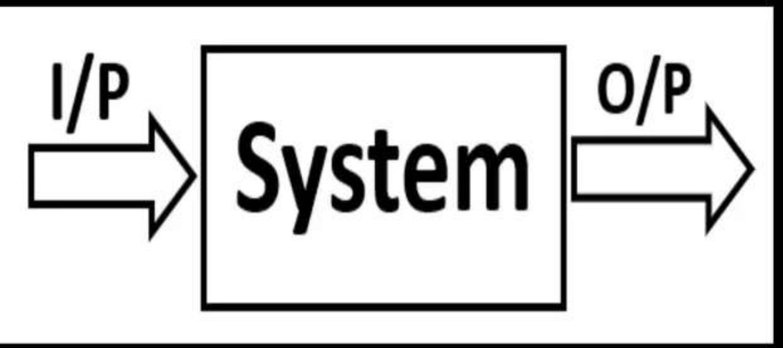
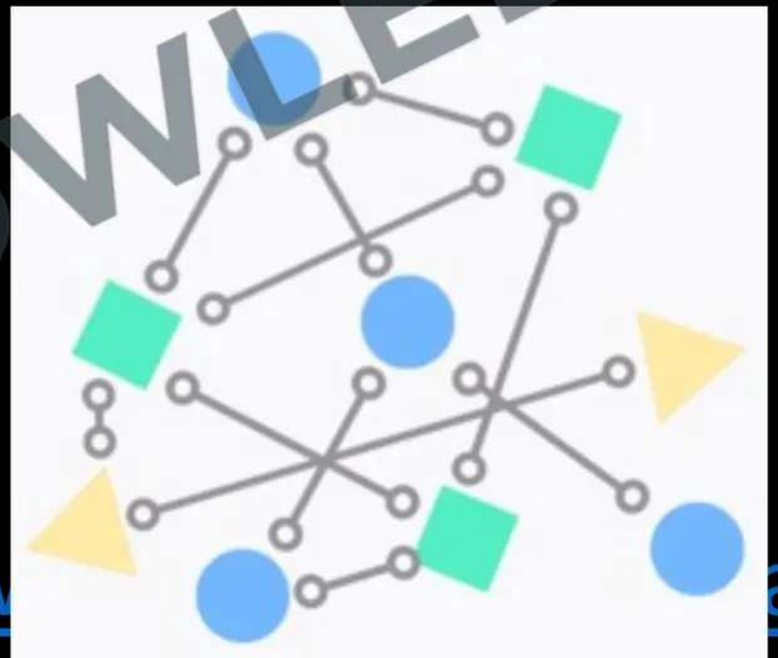
Steps of design

- Software designing is a 3-step process

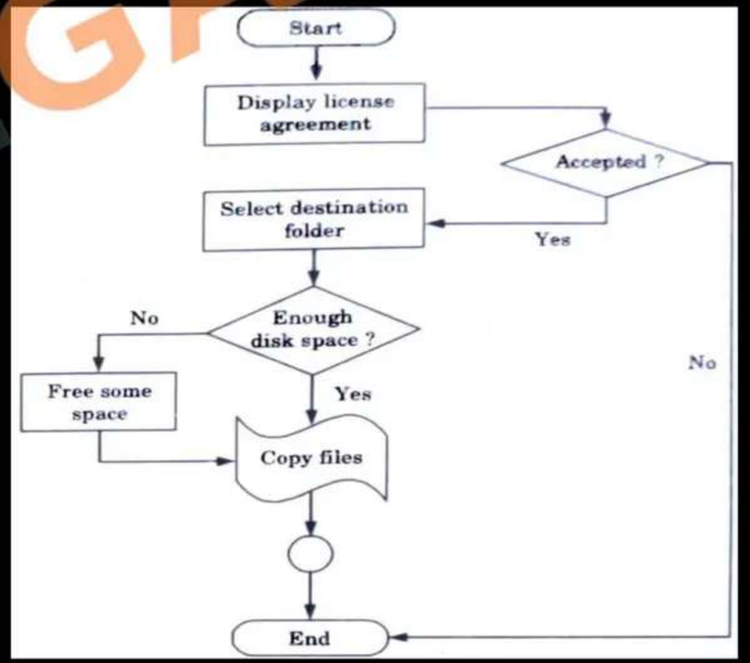
Interface Design



Architectural Design



Details Design



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Interface design

- In this, we treat system as a whole and understand the relationship between the system & environment.
- Here we treat system as a black box and do not concentrate how a function will be implemented but we decide what is input & what should be the output according to user requirement or SRS

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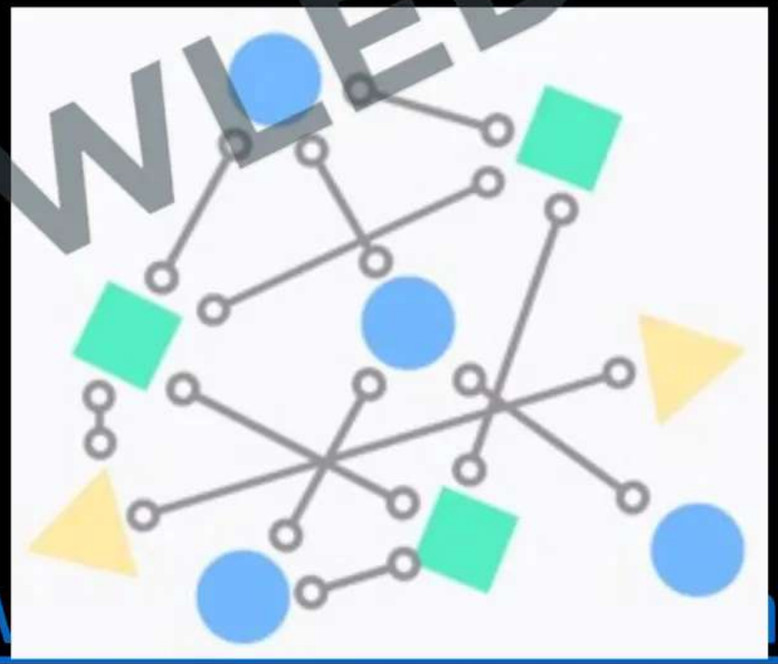
Architectural design

- In this we understand what are the major modules that must be implemented in the system and what are their responsibility and how they will communicate with each other.
- We do not give stress on individual modules but concentrate coupling and cohesion between the modules. Here we treat modules as black box.



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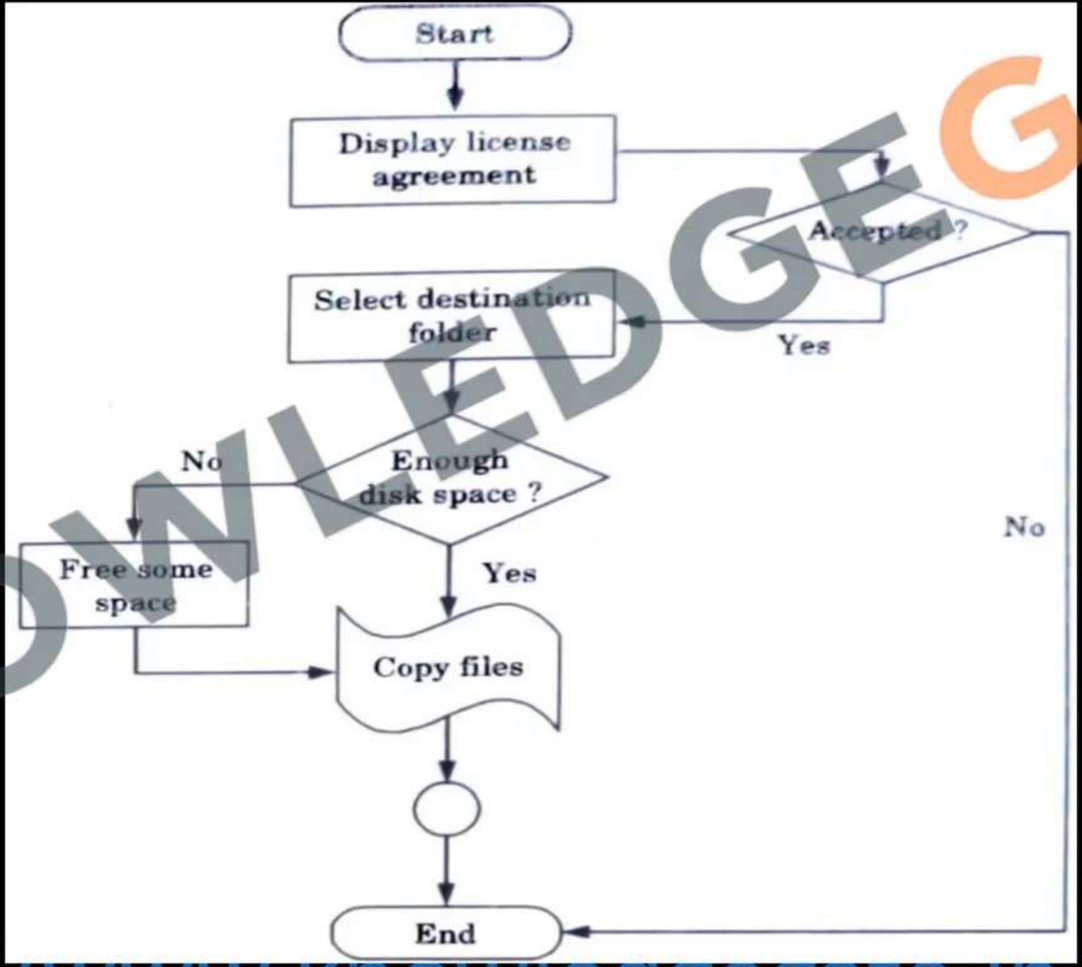
Detailed design/Low level design

- In this, specification of internal elements of all modules their functions, their processing methods, data structure, algorithms, everything is defined properly.



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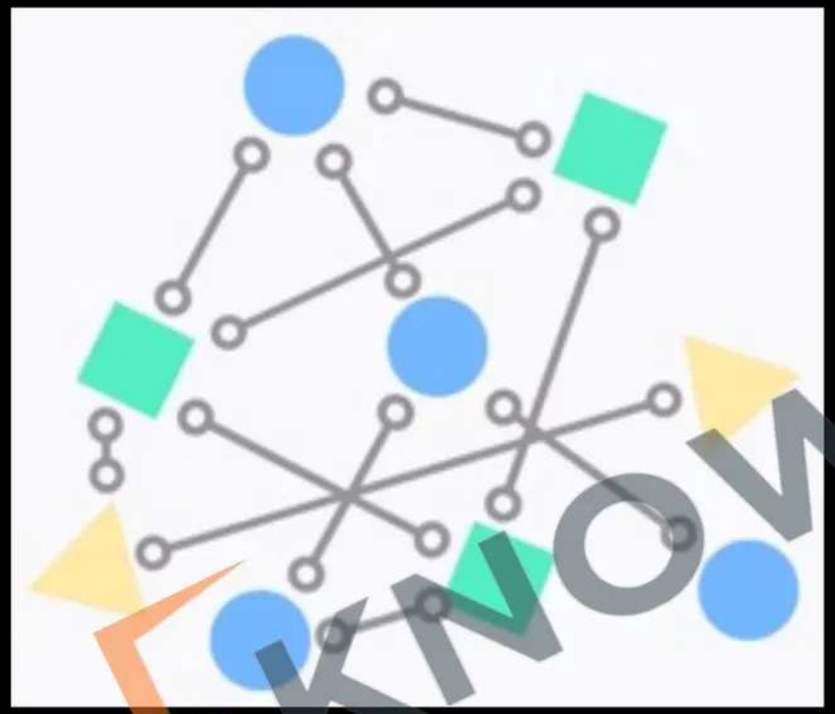
Modularity

- In modular architecture, we understand that a system is composed of well defined conceptually simple and independent units interacting through a well-defined interface.



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- Advantage of having modular architecture
  - Easy to understand and explain
  - It is easy to design and document
  - It is easy to code and test.
  - It is easy to maintain.

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Design Structure Charts

- **Structure Chart** represent hierarchical structure of modules. It breaks down the entire system into lowest functional modules, describe functions and sub-functions of each module of a system to a greater detail.
- Structure Chart partitions the system into black boxes (functionality of the system is known to the users but inner details are unknown). Inputs are given to the black boxes and appropriate outputs are generated.

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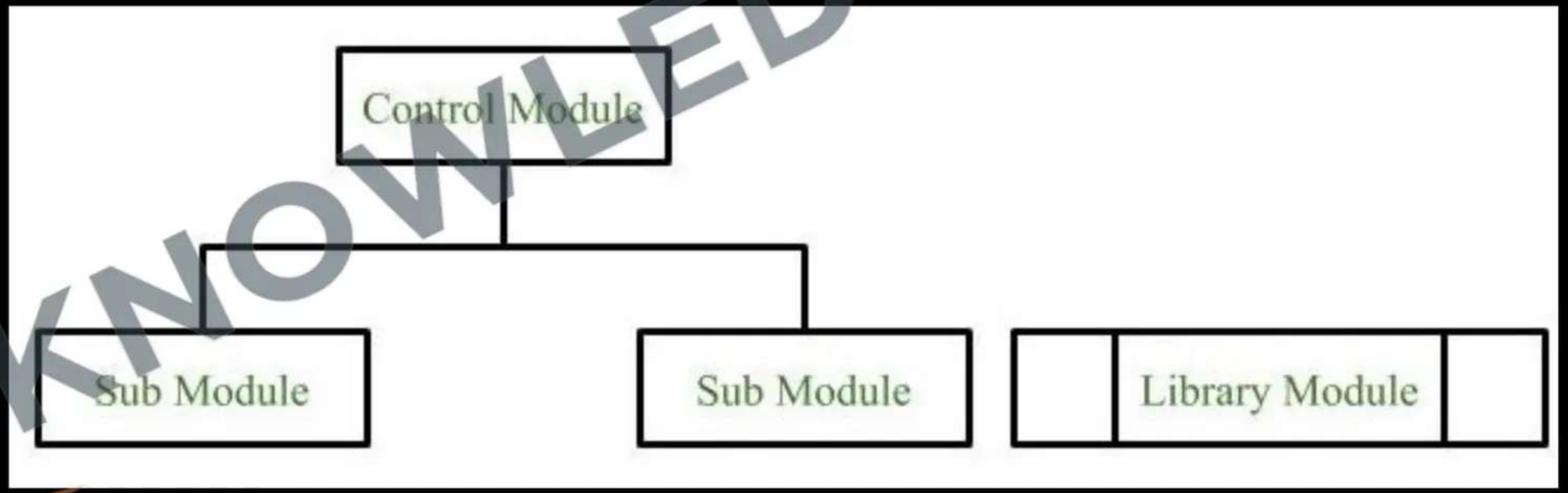
Symbols used in construction of structured chart

- **Module**: It represents the process or task of the system. It is of three types.
  - **Control Module**: A control module branches to more than one sub module.
  - **Sub Module**: Sub Module is a module which is the part (Child) of another module.
  - **Library Module**: Library Module are reusable and invokable from any module.



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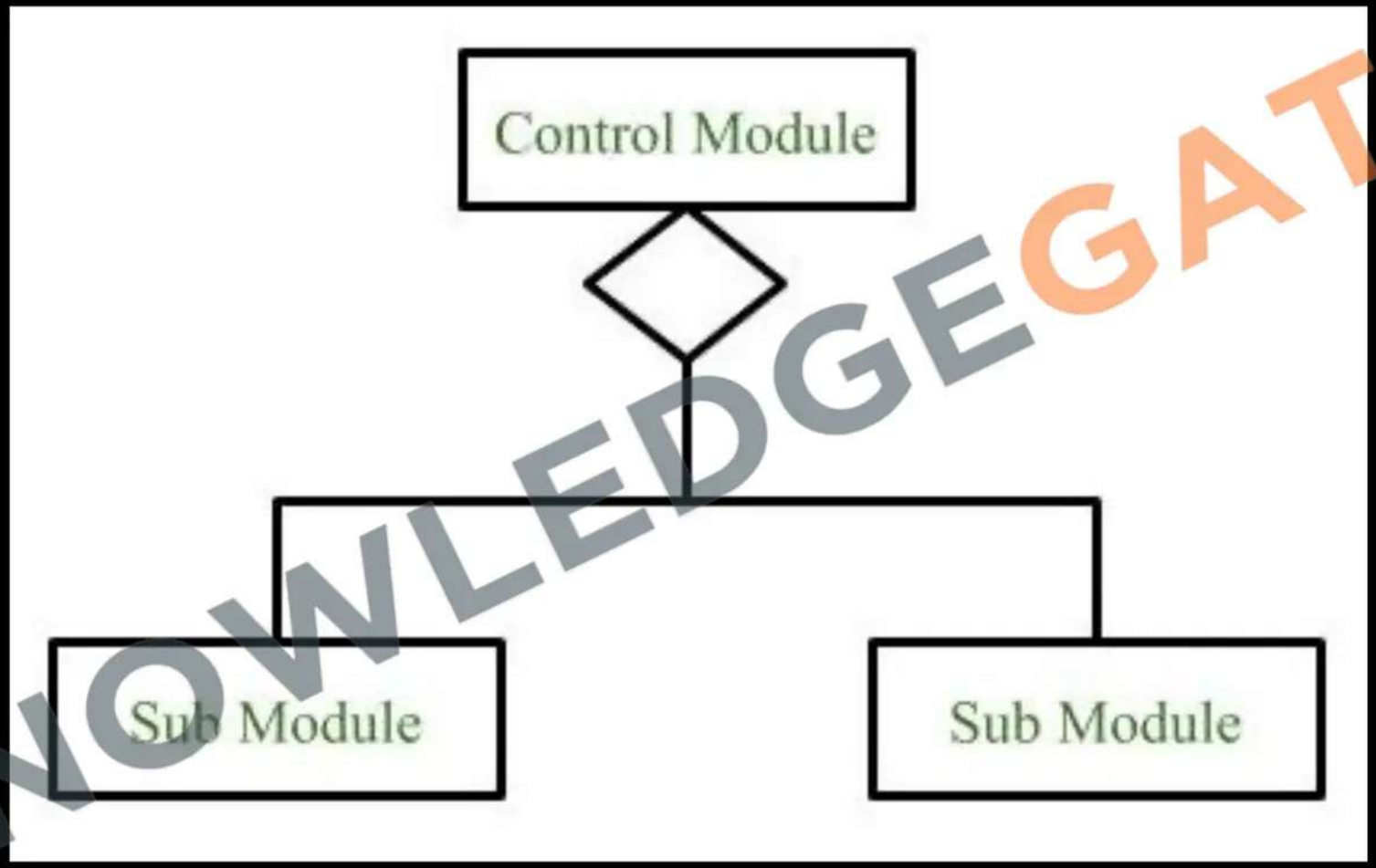
- **Conditional Call:** It represents that control module can select any of the sub module on the basis of some condition.



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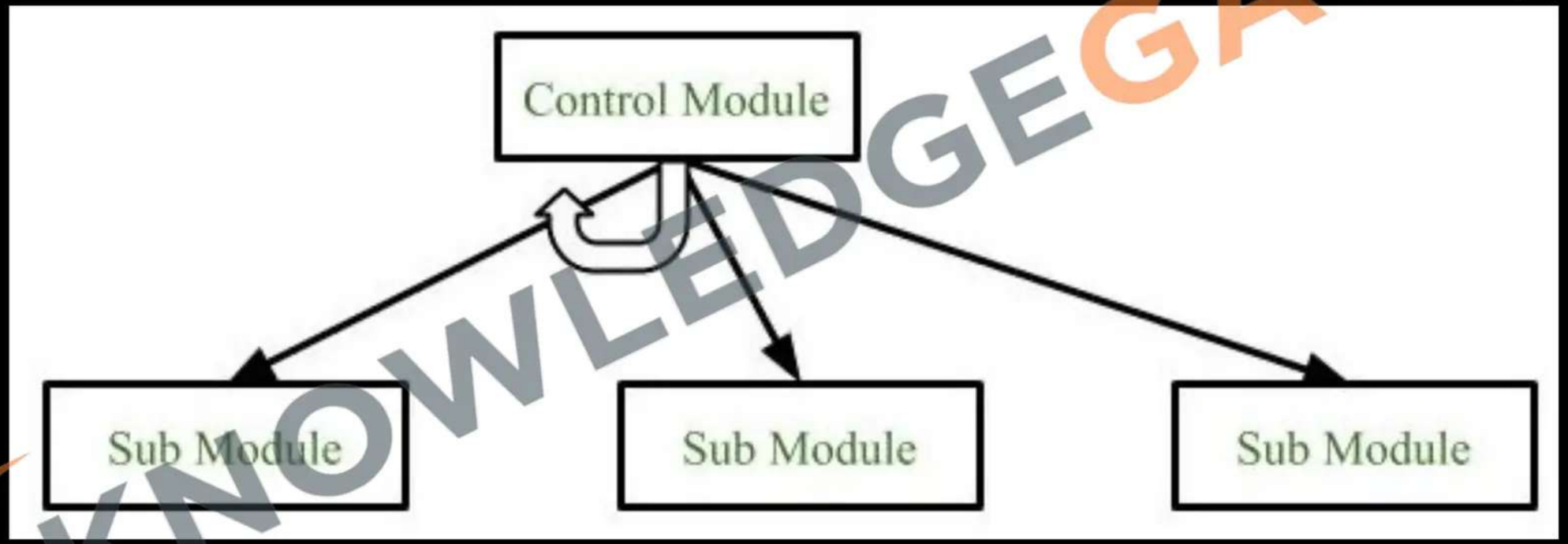
- **<u>Loop (Repetitive call of module)</u>:** It represents the repetitive execution of module by the sub module. A curved arrow represents loop in the module. All the sub modules cover by the loop repeat execution of module.



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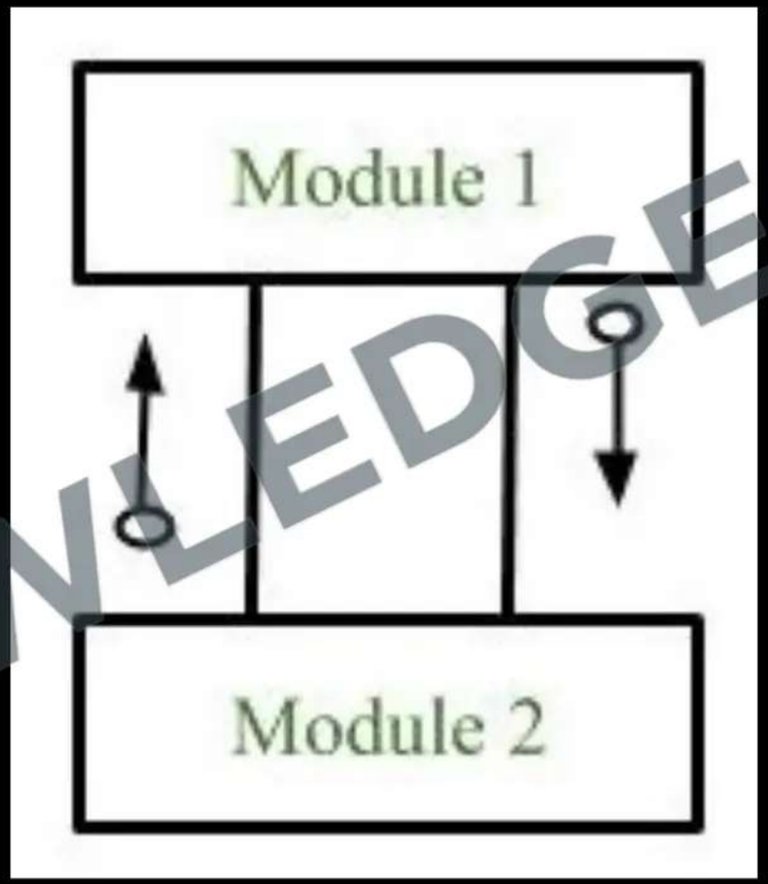
- **<u>Data Flow</u>:** It represents the flow of data between the modules. It is represented by directed arrow with empty circle at the end.



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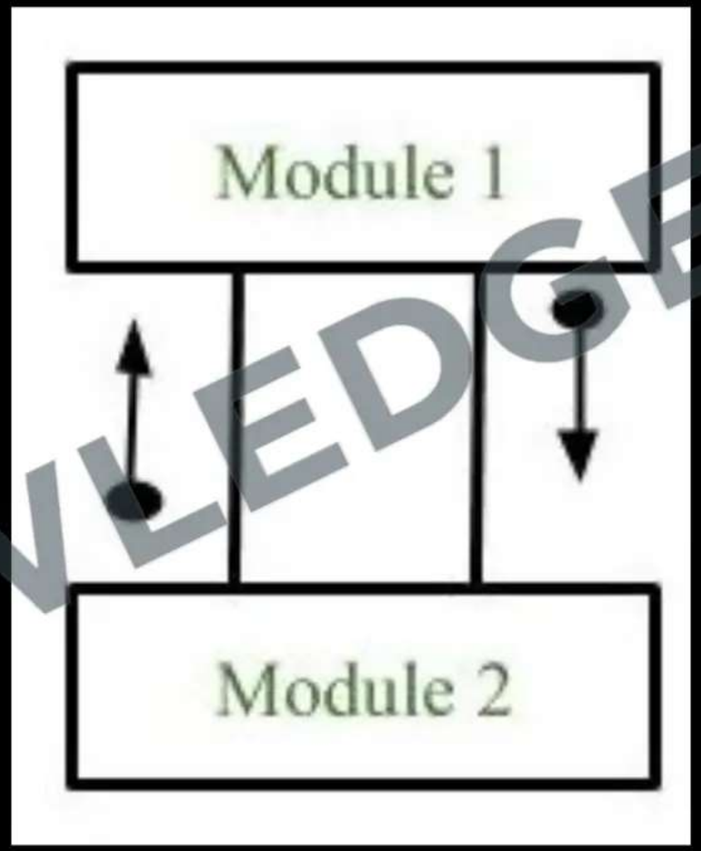
- **<u>Control Flow</u>:** It represents the flow of control between the modules. It is represented by directed arrow with filled circle at the end.



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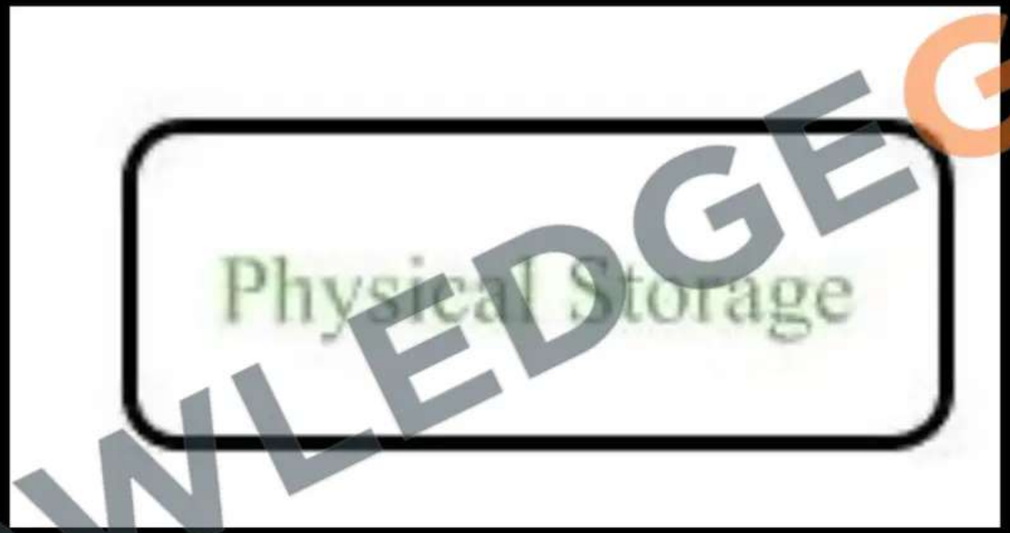
- **<u>Physical Storage</u>:** Physical Storage is that where all the information are to be stored.



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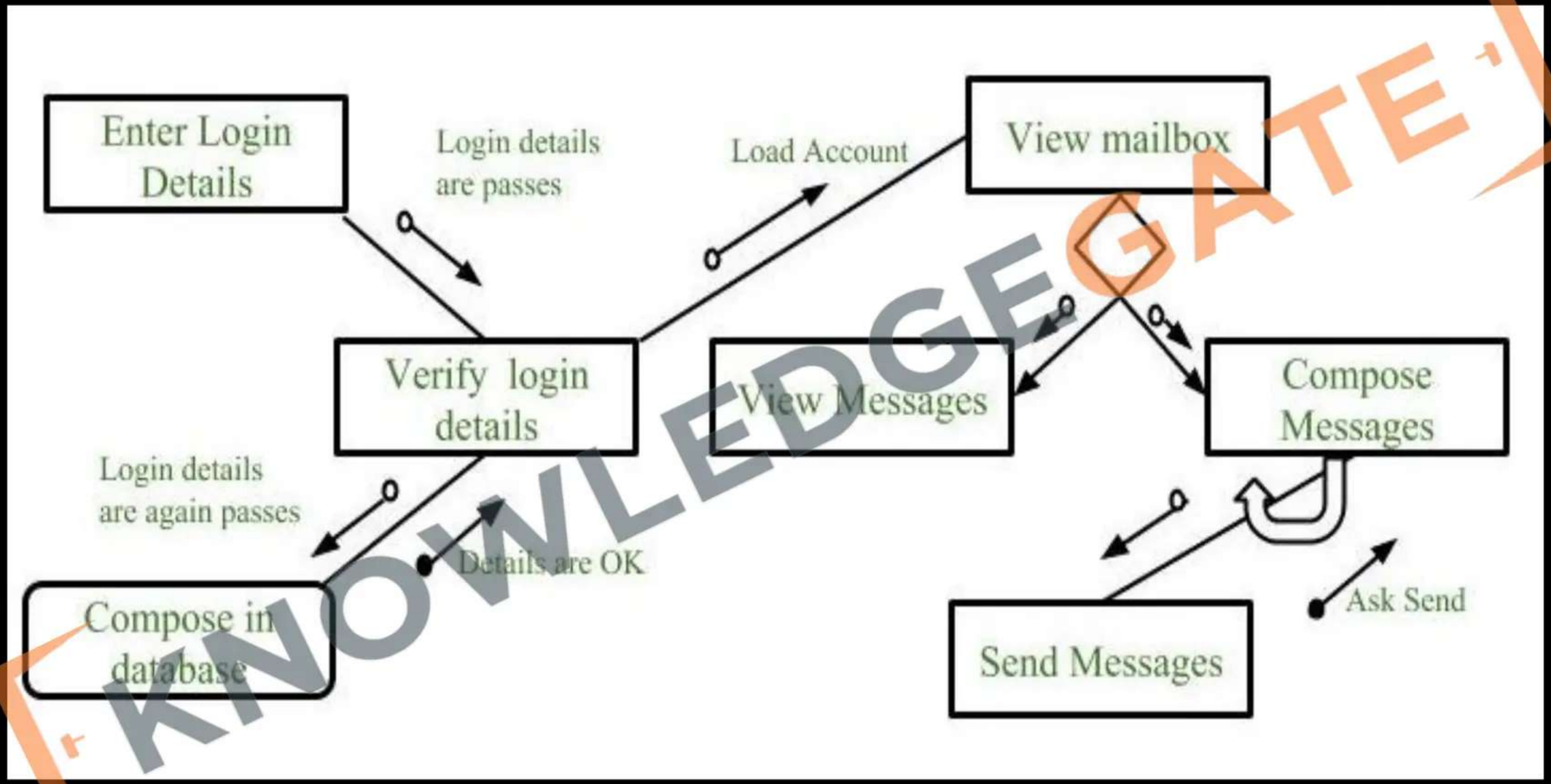
- **Structure chart for an Email server**



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Benefits of Design Structure Charts in Software Engineering

- Improved understanding of system architecture
- Simplified communication between team members
- Easier identification of potential issues and dependencies
- Support for modular and maintainable software design

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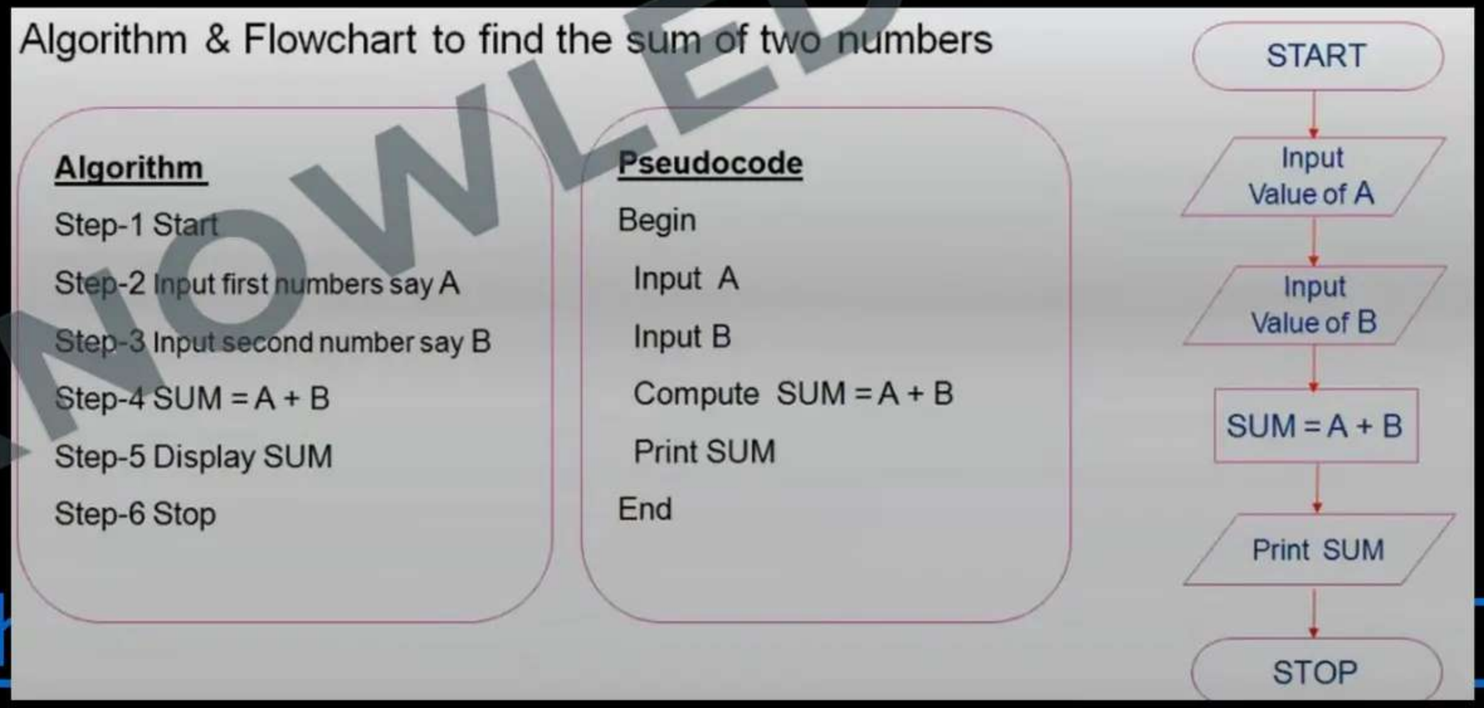
Pseudocode

- Pseudocode is a simplified, informal representation of an algorithm or a program that uses a mix of natural language and programming constructs.
- It is used to illustrate the high-level structure and logic of an algorithm without the syntactic details of a specific programming language.
- Pseudocode helps developers plan and discuss algorithms, making it easier to understand and translate into actual code later in the software development process.



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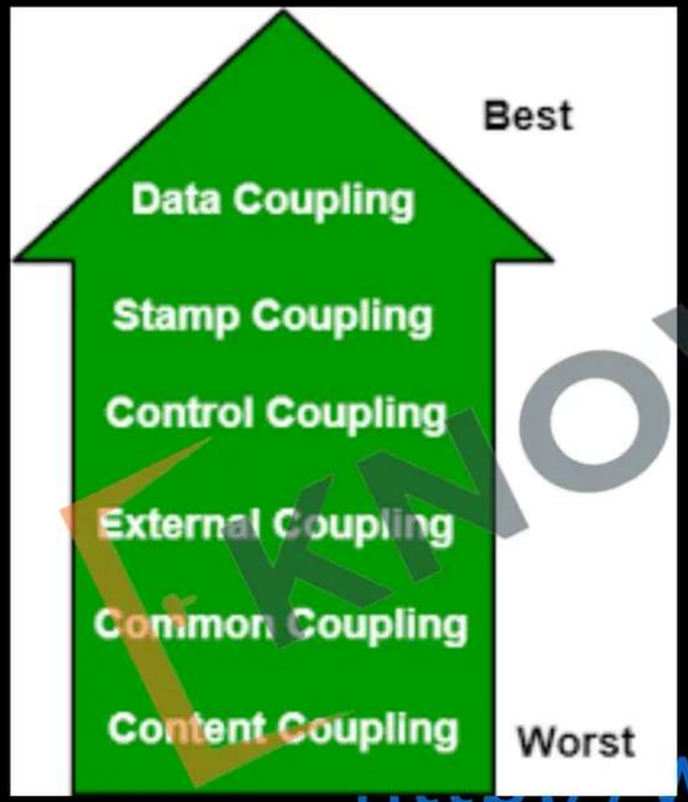
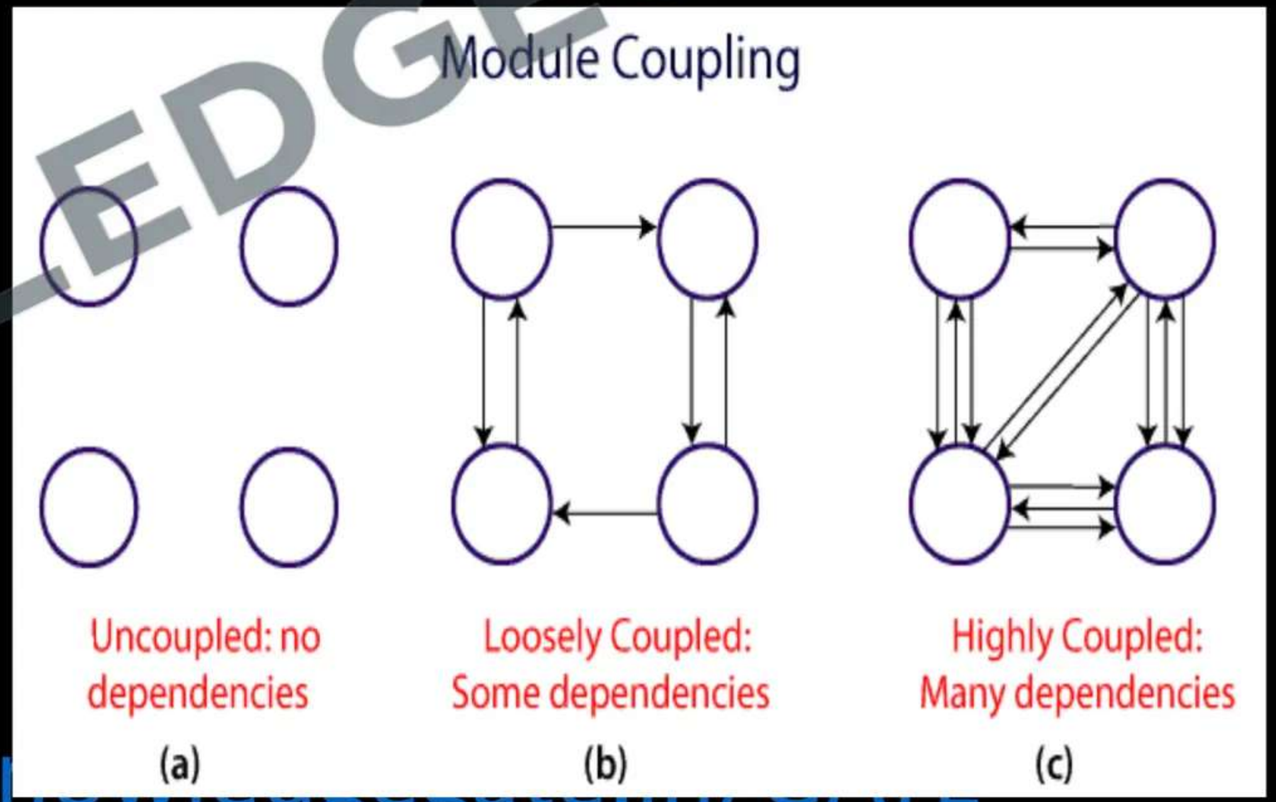
Coupling and cohesion

- Coupling and cohesion are two parameters on which we can understand the quality of modularity in the design of a software

- **Coupling**
  - The measure of interdependence of one module over another module





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- **Types of coupling**
  - **<u>Data Coupling</u>**: Here two modules communicate with each other only by-passing data. it is most desired type of coupling. e.g. addition by using call by value is an example of data coupling.

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- **Stamp Coupling**: When two modules communicate with each other by passing of data structure is called stamp coupling. e.g. addition of two value but by call by reference.

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- **Control Coupling**: The module is set to be controlled coupled if they communicate using control information with each other. e.g. dependence of two modules on each other because of flag.

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- **External Coupling**: in case of external coupling two modules on each other external to the logic of software (mostly because of hardware issue). e.g. data bus, CPU, main memory etc.

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- **<u>Common Coupling</u>**: Two modules are set to be common coupled if they share some global data. e.g. synchronization issue between the processes.

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- **Content Coupling**: when one module is a part or context of another module then it is called content coupling it is worst type of coupling.

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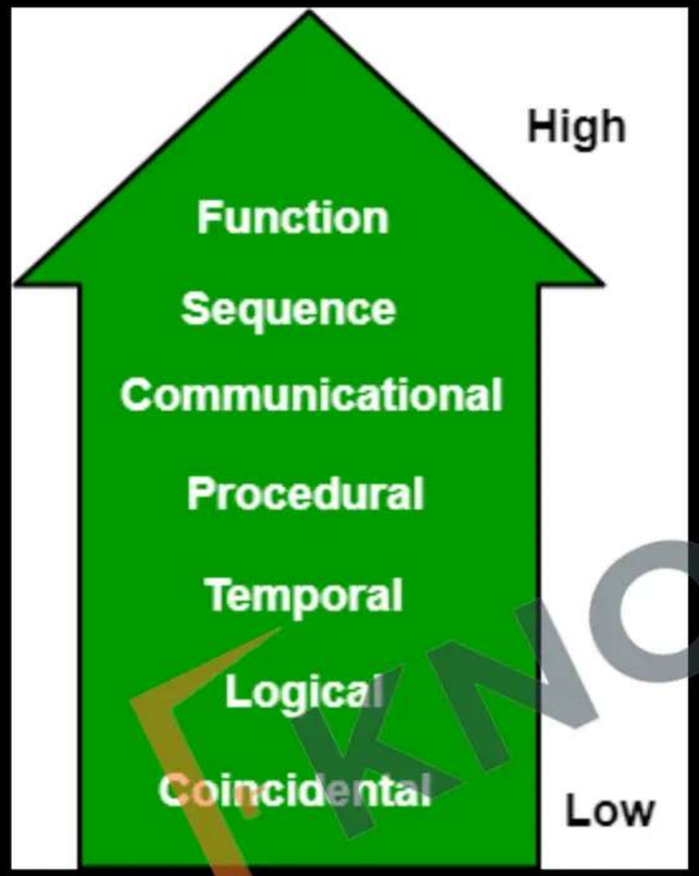
Cohesion

- We mean the measure of functions strength of the module.



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- **Types of cohesion**
  - **Coincidental Cohesion**: as the name suggest is the worst kind of cohesion where the only relationship between the functions which are present in a module is random or coincidental.

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- **Logical Cohesion**: All the elements of a module perform similar or slightly similar operations, for e.g. if mouse, printer, scanner functions are written in the same module.

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- **Temporal Cohesion**: In case of temporal cohesion functions are related by a fact that all the task must be executed in the same time span. so, there is a flow control between the functions. for e.g. two functions first which catch the exception and second which flash an error message.

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- **Procedural Cohesion**: Here functions of a module are related to each other through a flow control i.e. they are part of an algorithm or procedure. for e.g. two functional first which check the file access permission and second which opens the file.

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- **Communicational Cohesion**: in case of communicational cohesion different functions are operating on the same data structure. for e.g. push and pop.

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- **Sequential Cohesion**: here sequence is very important and the functions are the part of sequence along with data dependency for e.g. function1 which provides the data and function2 which process the data.

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- **Functional Cohesion**: in functional cohesion, different functions of a module cooperate with each other. perform a single function. for e.g. a module which control mouse must have different functions like accessing the location of the track ball, then decoding it on the screen and give an appropriate cursor movement

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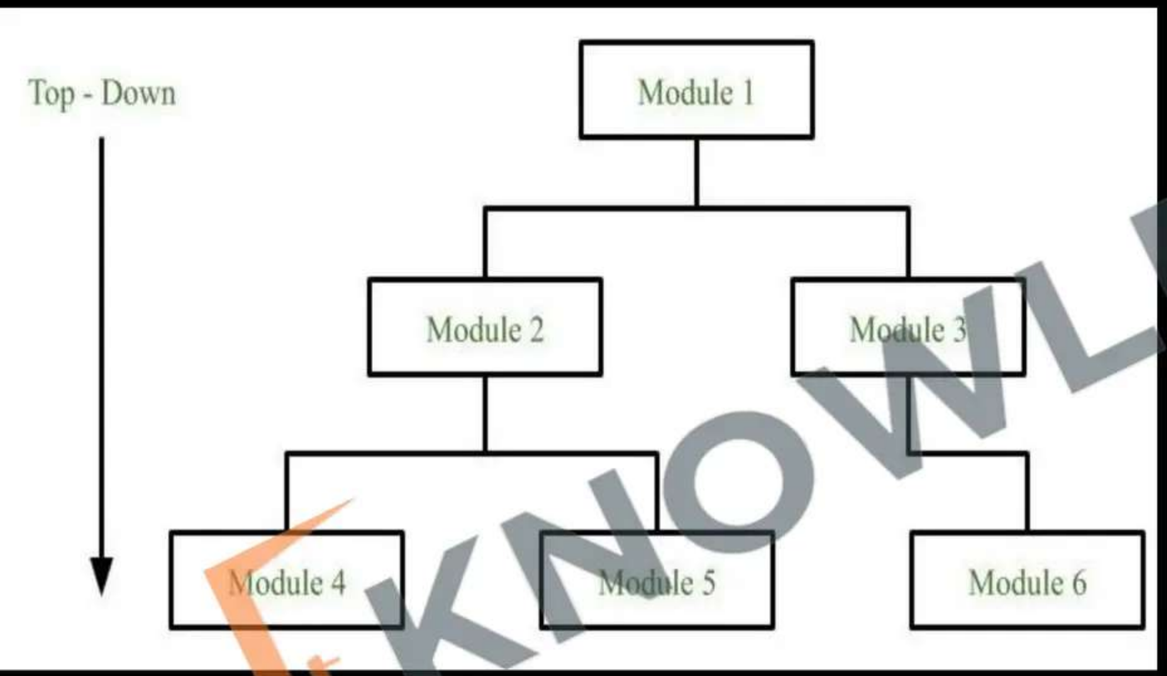
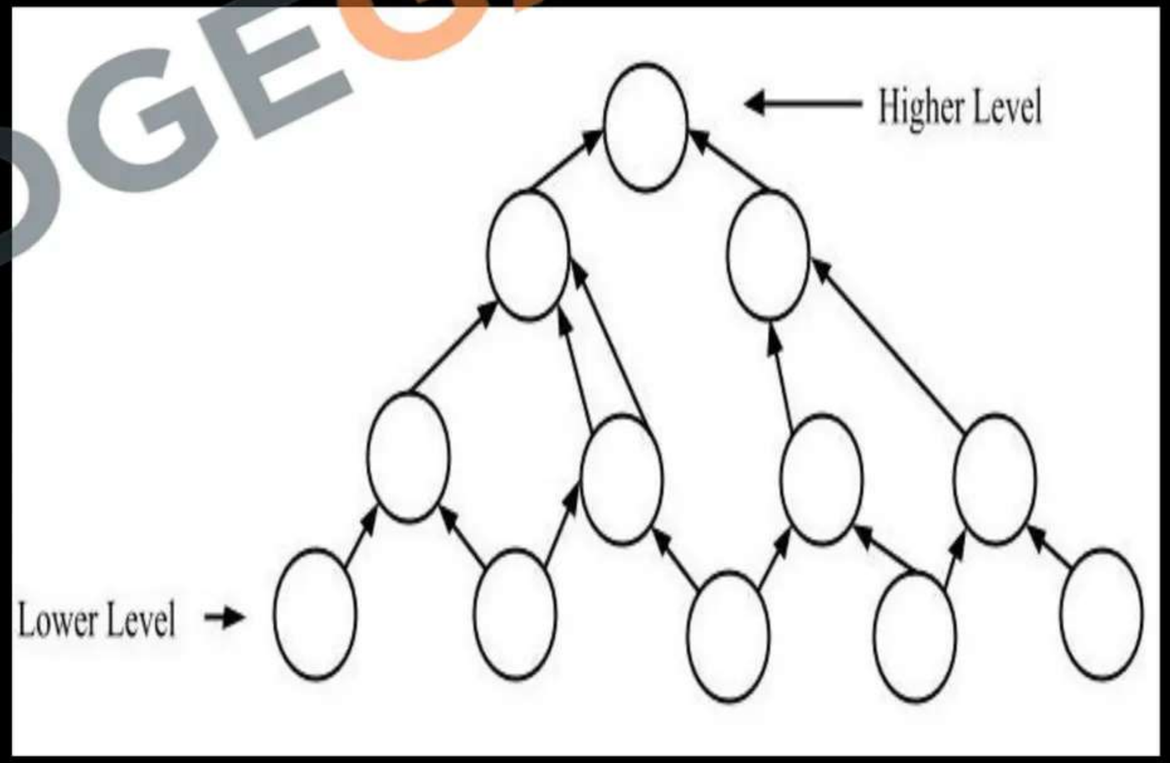
Design Approach

- There are two popular approach using which design is done

Top down approach



Bottom Up approach



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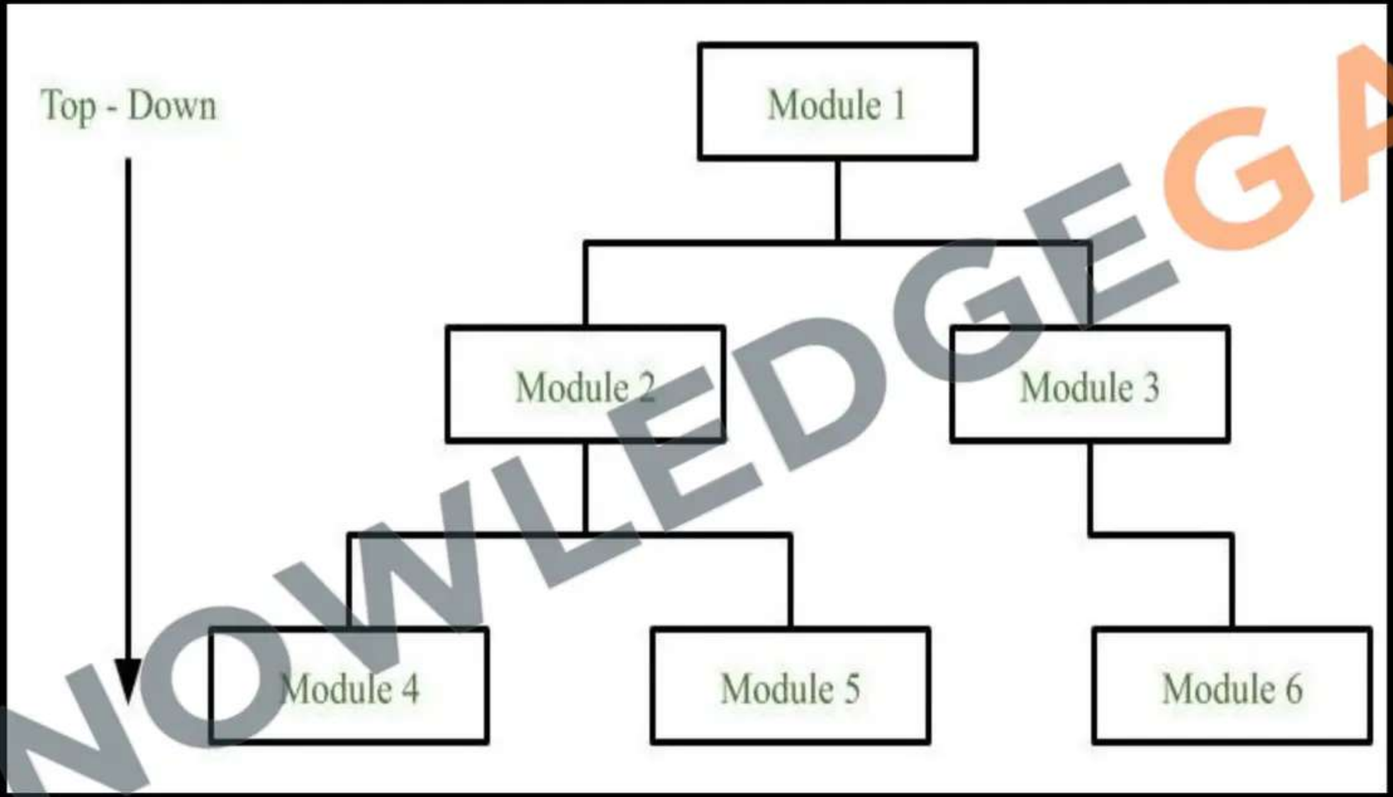
- In top down approach, the problem is divided into small no of programs according to user requirements and we repeat the process until the problem become so easy till we can solve it directly.



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- **Advantage**
  - More Systematic.
  - Easy to understand and provide a modular architecture.
  - In correspondence with user requirement cost and time prediction is possible.
  - Should be used with small and medium size products.
  - Used mostly.

- **Disadvantage**
  - When a problem is very complex and very large then we can not understand the entire problem as a whole.

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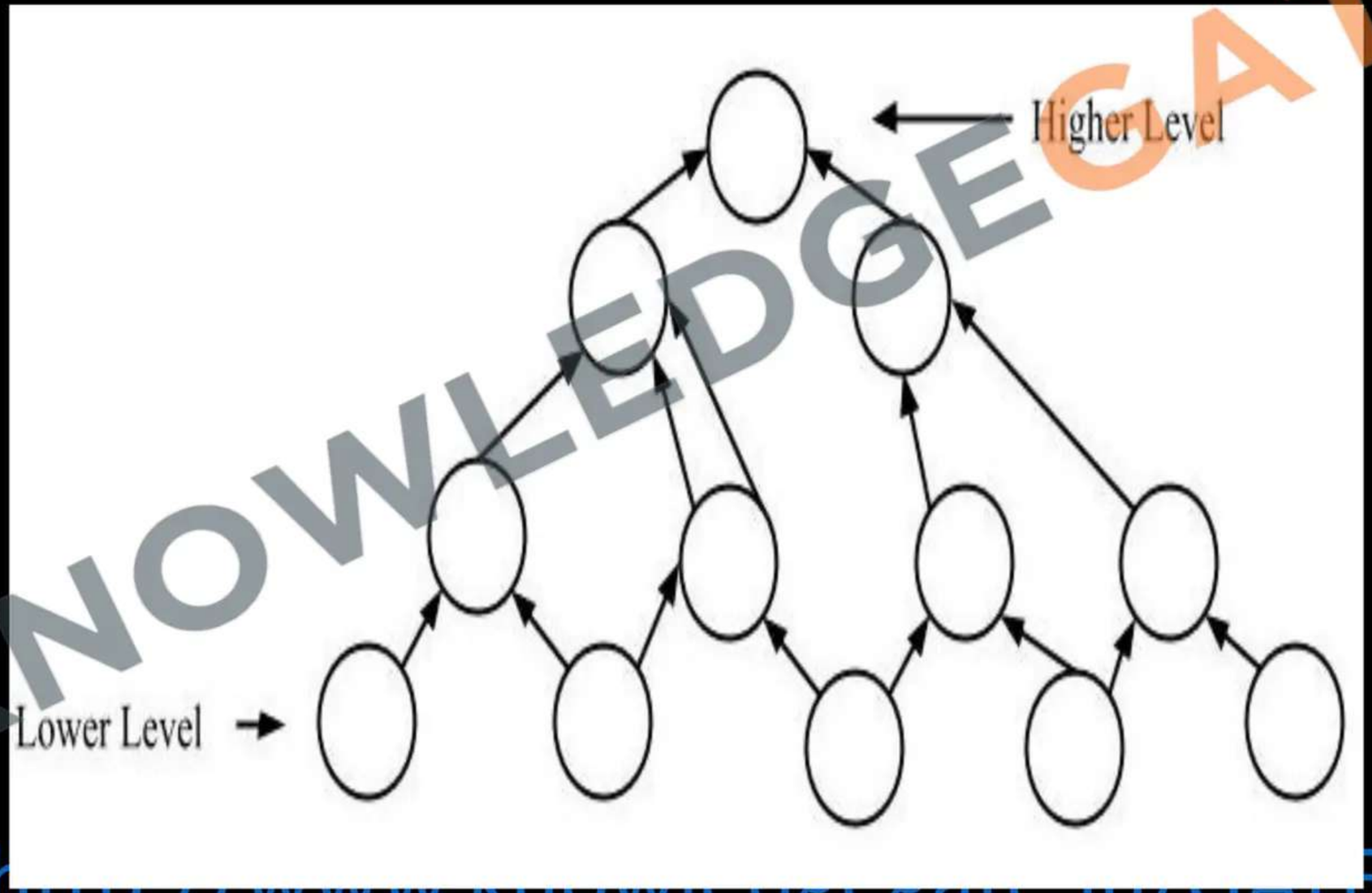
- **Bottom Up**: This approach is important as the s/w grows in complexity in a systematic fashion. if the problem is very difficult to understand instead of understanding the entire problem, we must solve some sub-problem and then should keep repeating the process until the entire problem is solved.



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- **Advantage**
  - Should be used on large size projects.
  - Easy to use by designers as we work in incremental fashion.

- **Disadvantage**
  - it has complex architecture very difficult to understand and manage.

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Estimation model

- Here we try to estimate about two things time and cost of development

- Majorly estimation can be divided into four types
  - Post estimation
  - Base estimation
  - Decomposition
  - Empirical model

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Post / Delayed estimation

- In case of a friendly partly and known technology, we do not estimate either the time or the cost, because we know that cost will support as in every situation.

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Base estimation

- In base estimation we predict the cost and time of the entire project based on the experience which we have gained from the previous projects.

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Decomposition based estimation

- It is used for large projects where decomposition of the problem into smaller problems is done, usually it is done on two bases.
- **Direct Estimation(White Box):** Size oriented metrices (KLOC)
- **Indirect Estimation(Black Box):** Function oriented metrices (FP)

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- Effort = Size / Productivity
- Productivity = Size / Effort
- Size = Effort X Productivity
- Cost = Effort X Pay
- Duration = Effort / Team Size
- Team Size = Effort / Duration
- Effort = Duration X Team Size

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Q Consider a banking application which required 4 modules as follows:

User Interface = 5400 LOC

Database = 8500 LOC

Server = 7300 LOC

Client = 5500 LOC

Find the total expenditure of company if productivity of the person is 870 Loc per month. Consider the salary of each developer is 1500 US dollar per month.

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Q Consider a application which contain 3 modules M_1, M_2, M_3 having following size

M_1 – 14.4 KLOC

M_2 – 21.5 KLOC

M_3 – 8.4 KLOC

if the cost of writing 1KLOC is 50 dollars. Find the cost of the application. if the productivity of the developer is 4 KLOC per month. Find the effort, if the project is required to be completed in month then predict the team size.

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Q Consider a application which if required to be developed by drdo contain 3 modules M_1, M_2, M_3 having following size

M_1 – 4600 LOC optimistic developer

M_2 – 6900 LOC most likely developer

M_3 – 8600 LOC pessimistic developer

What is the expected size of application

In general if the software development effort is 10 person-month, find the productivity.

if the development is required to be done in 2 months then find the team size?

$$\text{Size} = (S_{optimistic} + 4 \times S_{likely} + S_{pessimistic})/6$$

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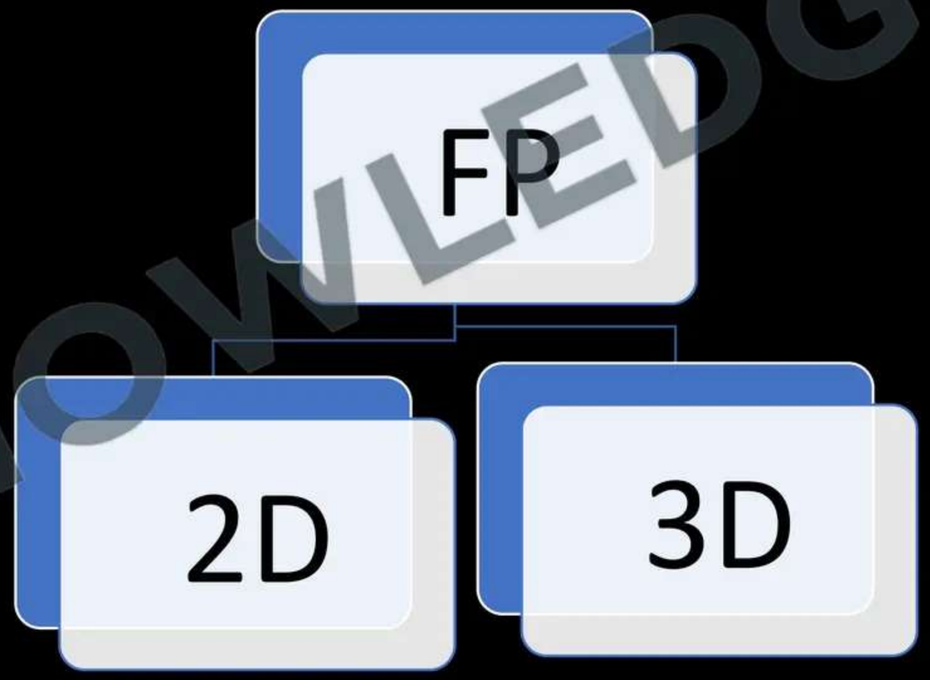
Indirect Estimation

- Here we use functional points to predict the cost of development, it is a better technique in general compare to kloc because it considers the logical complexity of the product, as in general it is not necessary that the larger the project the more complex it will be code.

- (size oriented, function oriented, extended functions point matrices) here we say that the size of the software is directly dependent on the number and type of different functions it performs.



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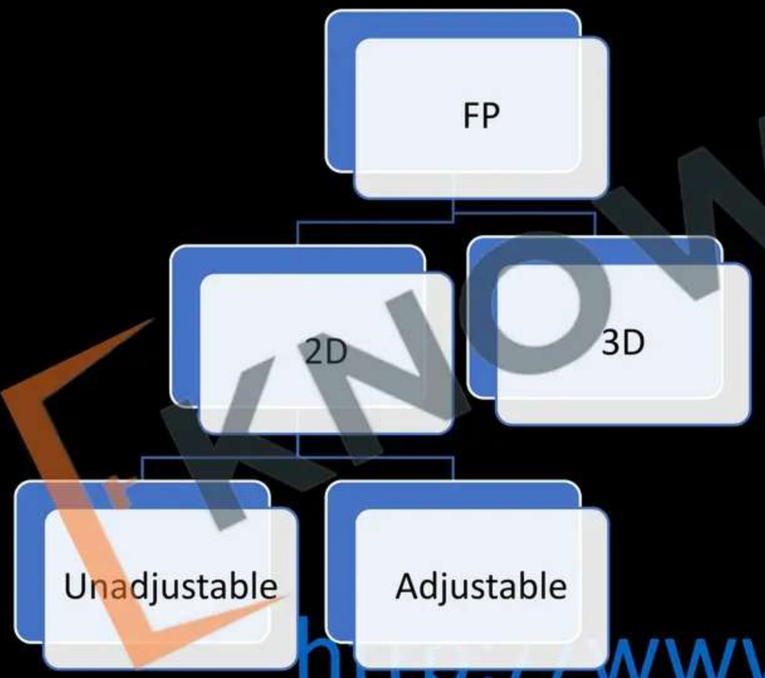
- 2D- in 2D FP we consider only information domain where we consider mainly five factors, as follows:
  - **No of inputs**: Each user data input is counted
  - **No of outputs**: Output refers to reports, screen and error messages
  - **No of inquiries**: The no of distinct interactive queries made by user which requires specific actions by the system
  - **No of files**: Each logical file. So either can be data structure or physical files
  - **No of external interfaces**: Data files on tapes, disk etc. and other interfaces that are used to transmit information to other systems are counted



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Function point calculation

Measurement parameters	Simple	Average	Complex
i/p	3	4	6
o/p	4	5	7
Inquires	3	4	6
Files	7	10	15
External interface	5	7	10

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- In Unadjustable case
  - FP= total_count

- In Adjustable case
  - FP= total_count * EAF(error adjustable factor/Cost adjustment Factor)
  - EAF = 0.65 + 0.01*$\sum_{i=1}^{i=14} f_i$
  - In FP analysis 14 factors are indirectly involved to estimate the size of the software.

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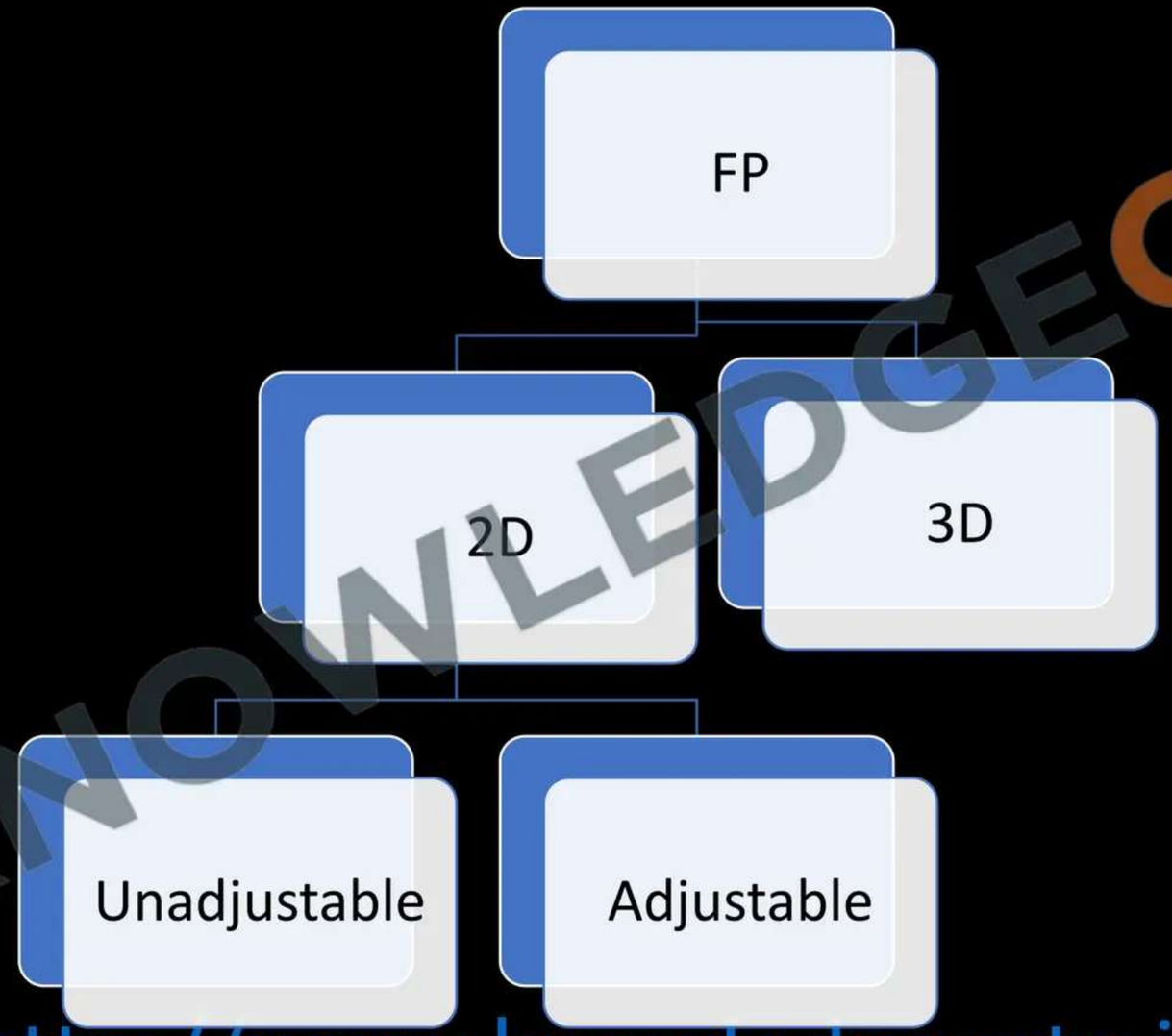
- 3D- In 3D FP we consider only information domain where we consider mainly five factors, and along with Function domain and behaviour domain.



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Empirical models

- Empirical models are estimation models which uses empirically derived formulas for predicting based on LOC or FP.
- Different authors provides different mathematically derived formula based on either LOC or FP.
- Out of all COCOMO models in most versatile and universally accepted

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COCOMO(1981)

- COCOMO model (construction cost model) is the most widely used estimating technique. It is a regression-based model developed by barry boehm, he postulated that there are essentially three important classes of the software.

  - **Organic(application)**
  - **Semidetached(utility)**
  - **Embedded(system)**

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- In order to classify a product into any of the three proposed classes, we take into consideration the characteristics of the product as well as those of the development team.

- Data processing and scientific program are considered to be application programs. Complier, linkers etc are utility programs. Operating system and real time system programs are system programs.

- According to the brooks the relative level of the product complexity for the three categories of product are in the ratio 1:3:9 for application, utility and system programs relatively

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- **Organic**: Relatively small group work in a familiar environment to develop well understood application program, here little innovation is required, constraints and deadlines are few and the development environment is stable.

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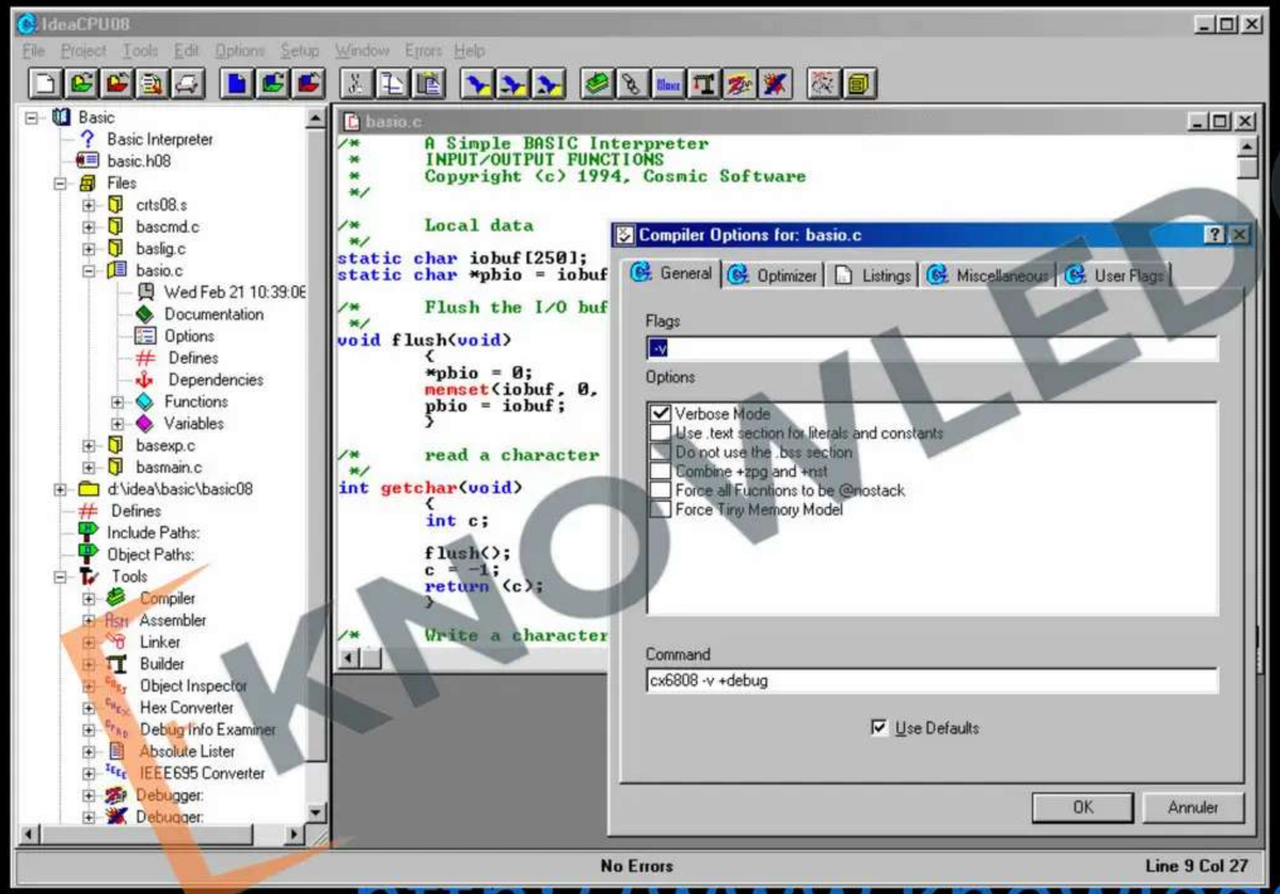
- **Semidetached**: Project teams consist of a mixture of experienced and inexperienced staff. It is of medium size, some innovation is required, constraints and deadlines are moderate and the development environment is somewhat fluid.



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- **Embedded**: the s/w is strongly coupled to complex h/w, such as air traffic control, ATM's or weapon systems. The project team is large, a great deal of innovation is required, constraints and deadlines are tight and the development environment consist of many complex interfaces, including those with h/w and with customer.

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Basic COCOMO

- A simple and static cost estimation model that calculates project effort and duration based on the size of the software, measured in thousands of lines of code (KLOC)
- Provides a rough order-of-magnitude estimate of project effort and duration
- Uses three modes: Organic, Semi-Detached, and Embedded

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Basic COCOMO

Software Project	a_b	b_b	c_b	d_b
Organic	2.4	1.05	2.5	0.38
Semidetached	3.0	1.12	2.5	0.35
Embedded	3.6	1.20	2.5	0.32

- $D_E = a_b\ (KLOC)^{bb}$
- $D_D = c_b\ (KLOC)^{db}$
- Team Size = D_E / D_D

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Software Project	a_b	b_b	c_b	d_b
Organic	2.4	1.05	2.5	0.38
Semidetached	3.0	1.12	2.5	0.35
Embedded	3.6	1.20	2.5	0.32

20KLOC	Organic	Semidetached	Embedded
Effort	55.75 PM	85.95 PM	131 PM
Duration	11.52 M	11.8 M	11.89 M
Team Size	5	7	11

- $D_E = a_b\ (KLOC)^{bb}$
- $D_D = c_b\ (KLOC)^{db}$
- Team Size = D_E / D_D

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Intermediate COCOMO

- **Definition**: An extension of the Basic COCOMO model that refines effort and duration estimates by considering additional project factors, such as product attributes, hardware constraints, and personnel/team attributes.

- Introduces 15 cost drivers to adjust the estimation, these drivers plays a major role in computation of effort estimation.

- Effort Adjustment Factor (EAF) accounts for the influence of cost drivers.

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Mode	a	b
Organic	3.2	1.05
Semi-detached	3.0	1.12
Embedded	2.8	1.20

20 KLOC / EAF=1.25	Organic	Semidetached	Embedded
Effort	92.9 PM	107.4 PM	127.4 PM

- $D_E = a\,(KLOC)^b$ X EAF(Error Adjustment Factor)

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- $D_E = a\,(KLOC)^b$ X EAF(Error Adjustment Factor)

Mode	a	b
Organic	3.2	1.05
Semi-detached	3.0	1.12
Embedded	2.8	1.20

20 KLOC / EAF=1.25	Organic	Semidetached	Embedded
Effort	92.9 PM	107.4 PM	127.4 PM

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- $D_E = a\,(KLOC)^b$ X EAF(Error Adjustment Factor)

Mode	a	b
Organic	3.2	1.05
Semi-detached	3.0	1.12
Embedded	2.8	1.20

20 KLOC / EAF=1..675	Organic	Semidetached	Embedded
Effort	124 PM	116.7 PM	170.76 PM

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Detailed COCOMO

- **Definition**: The most comprehensive and accurate COCOMO model that divides a software project into multiple components or modules, and accounts for interactions between cost drivers and project phases.

- Estimates effort and duration for each component using the Intermediate COCOMO model, then sums them up.

- Considers software reuse, hardware constraints, and personnel/team attributes in estimation.

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Other Empirical models

- $E = 5.2 \times (KLOC)^{0.91}$ Waltson & Felix Model
- $E = 5.2 + 0.73 \times (KLOC)^{1.16}$ Bailey-Basili Model
- $E = 3.2 \times (KLOC)^{1.05}$ Simple Bohem Model
- $E = 5.288 \times (KLOC)^{1.047}$ Doty Model

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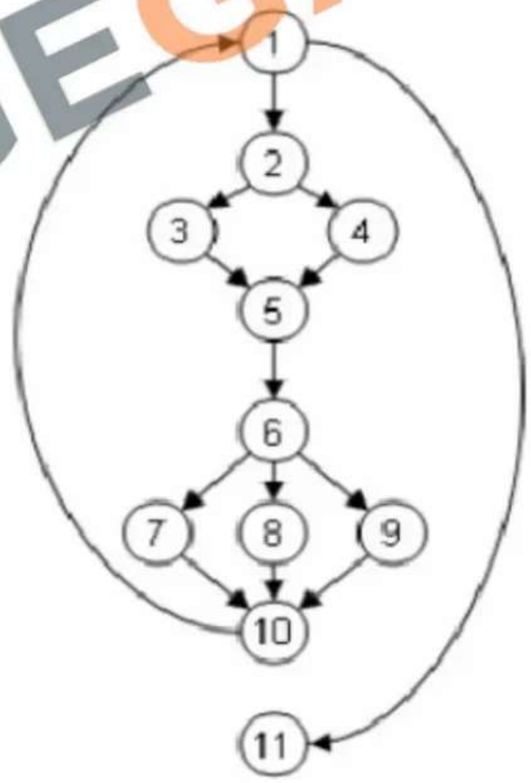
Cyclomatic Complexity

- Cyclomatic complexity is a software metric that measures the complexity of a program's control flow by counting the number of linearly independent paths through the source code.

Node	Statement
(1)	`while(x<100){`
(2)	`  if (a[x] % 2 == 0) {`
(3)	`  parity = 0;`
	`  }`
	`  else {`
(4)	`  parity = 1;`
(5)	`  }`
(6)	`  switch(parity){`
	`  case 0:`
(7)	`  println( "a[" + i + "] is even");`
	`  case 1:`
(8)	`  println( "a[" + i + "] is odd");`
	`  default:`
(9)	`  println( "Unexpected error");`
	`  }`
(10)	`  x++;`
	`}`
(11)	`p = true;`



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Need:

- Assess code maintainability and readability
- Identify potential errors and areas of high risk
- Determine testing effort required
- Aid in refactoring efforts to simplify code

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Objective:

- Quantify the complexity of a program or function
- Facilitate better decision-making in software development
- Improve overall code quality and understandability

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Process:

- Identify the program's decision points (such as if, while, and for statements)
- Calculate the number of linearly independent paths by counting the decision points and adding one
- Interpret the resulting value:
  - Low value: lower complexity, easier to maintain and test
  - High value: higher complexity, harder to maintain and test, may require refactoring

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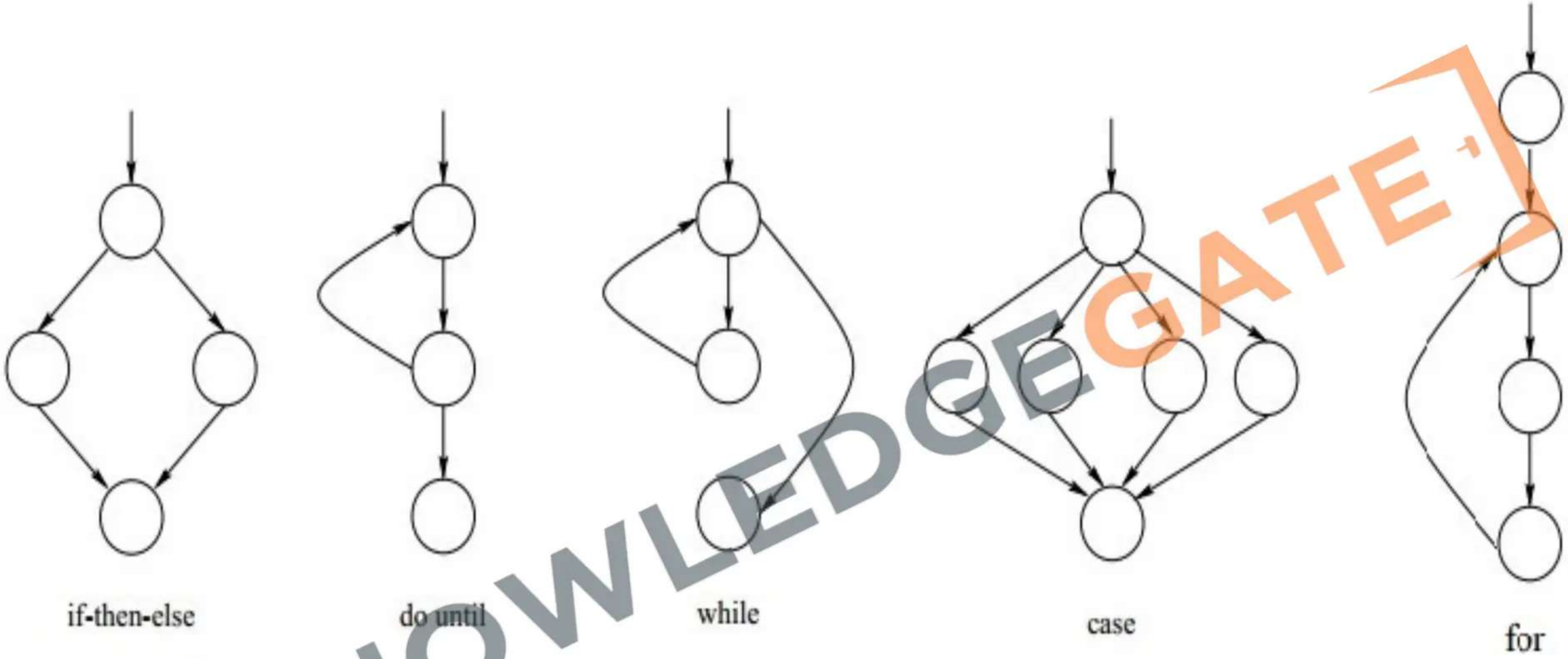

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- **Given a control flow graph G of a program, the cyclomatic complexity V(G) can be computed as:**

- **V(G) = E – N + 2**, where E is the number of edges and N is the total number of nodes

- **V(G) = V(G) = Total number of bounded areas + 1**
- Any region enclosed by nodes and edges can be called as a bounded area.

- The cyclomatic complexity of a program can also be easily computed by computing the number of decision statements of the program.

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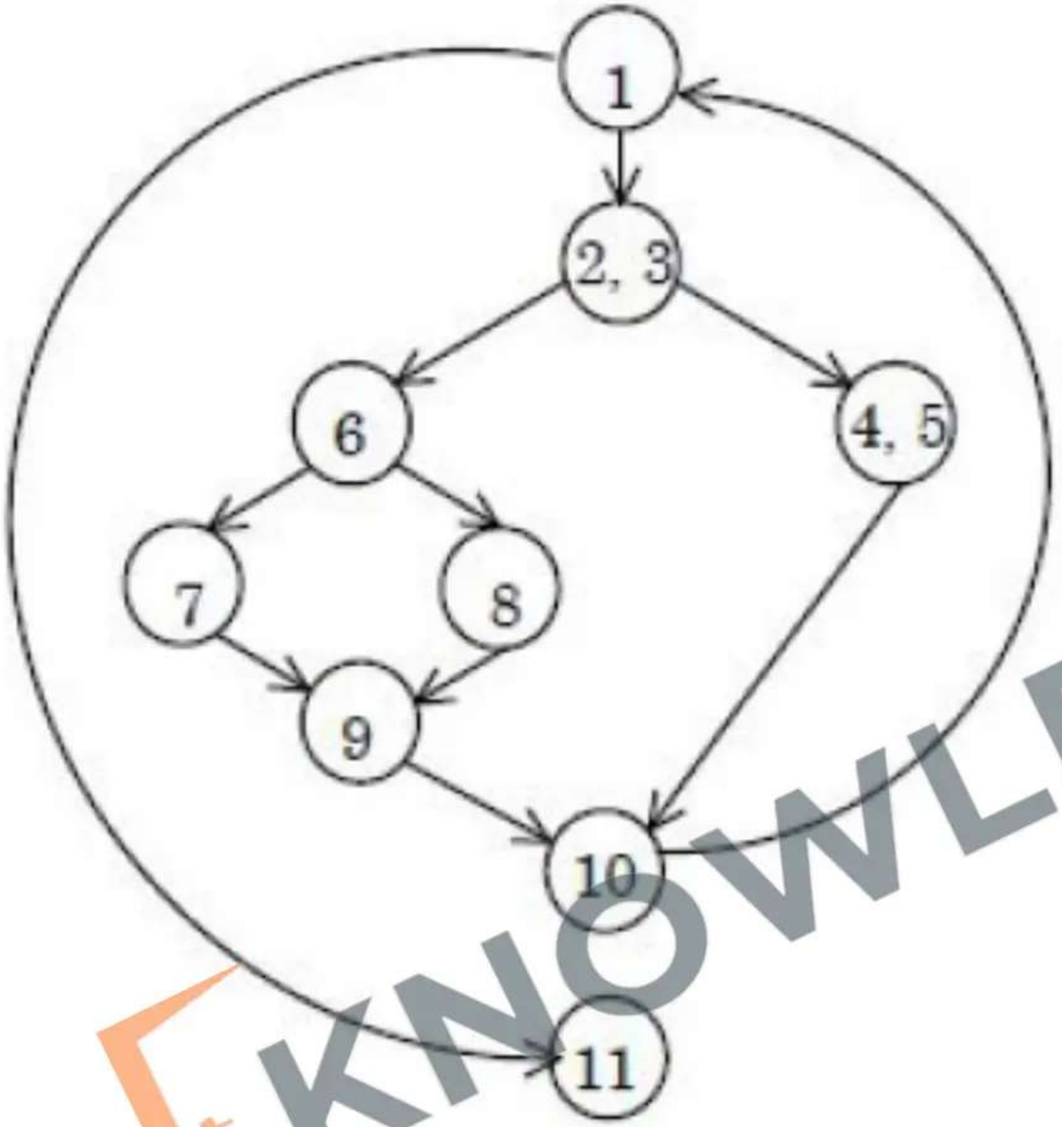

Flowgraph F

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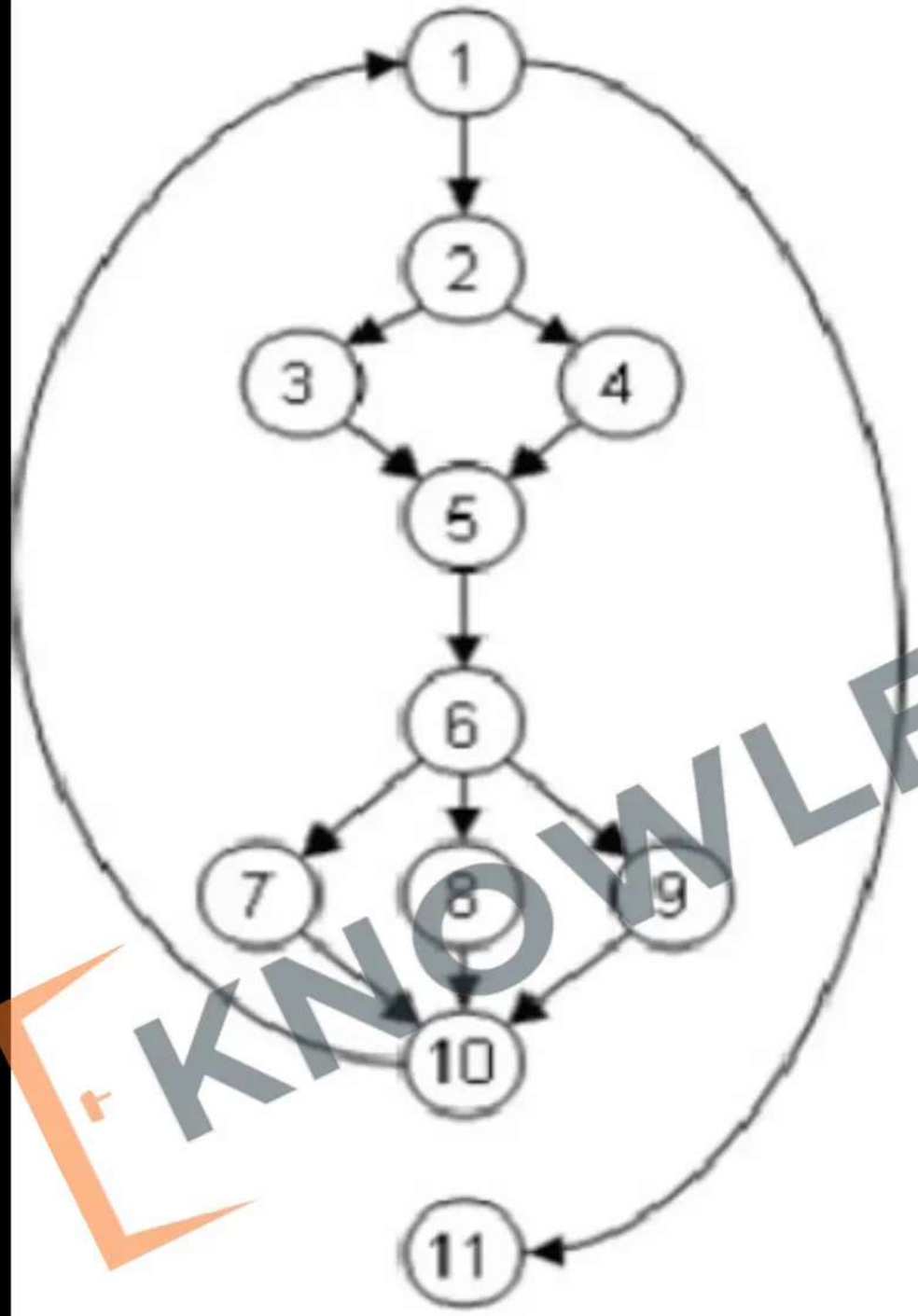

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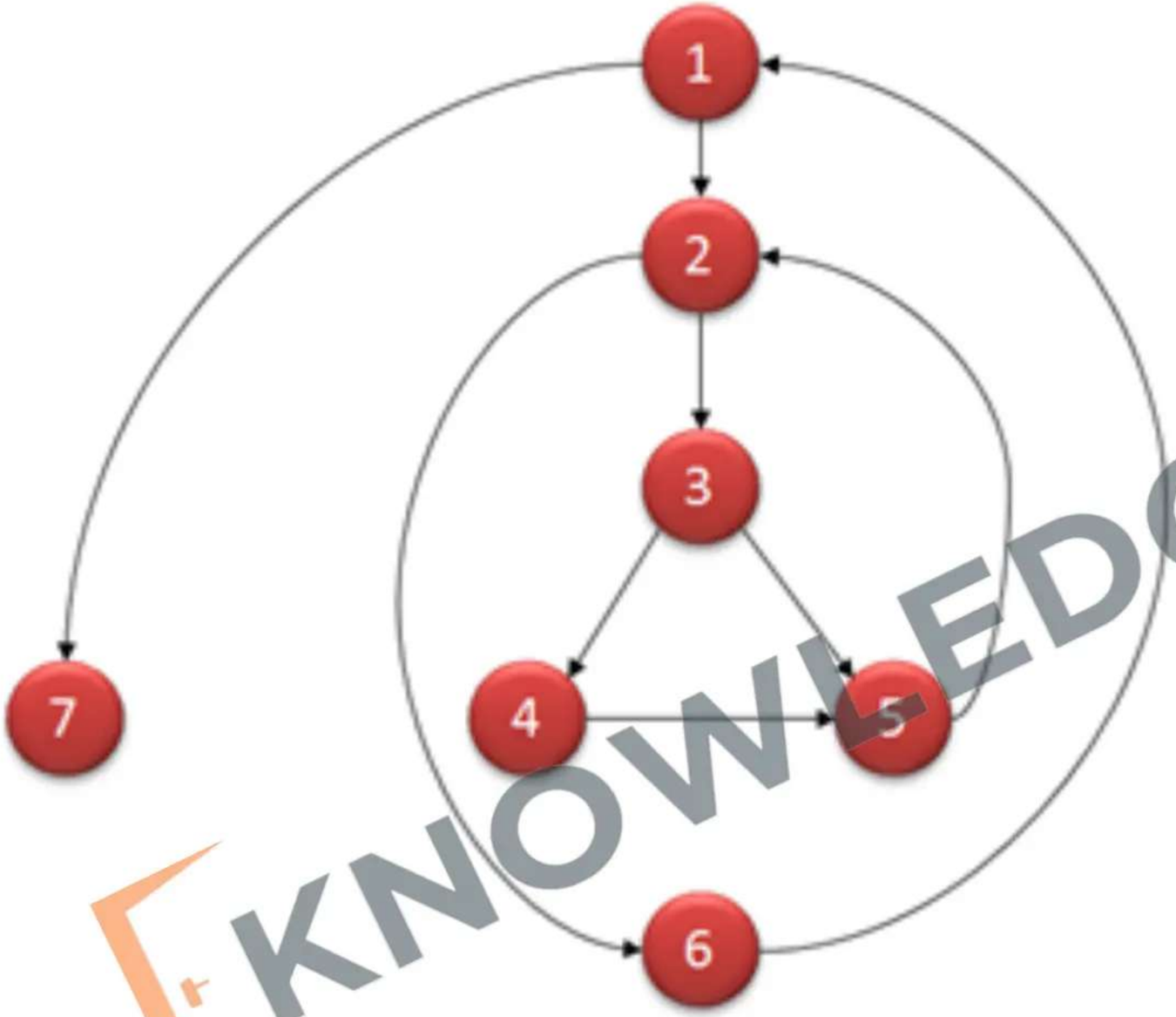

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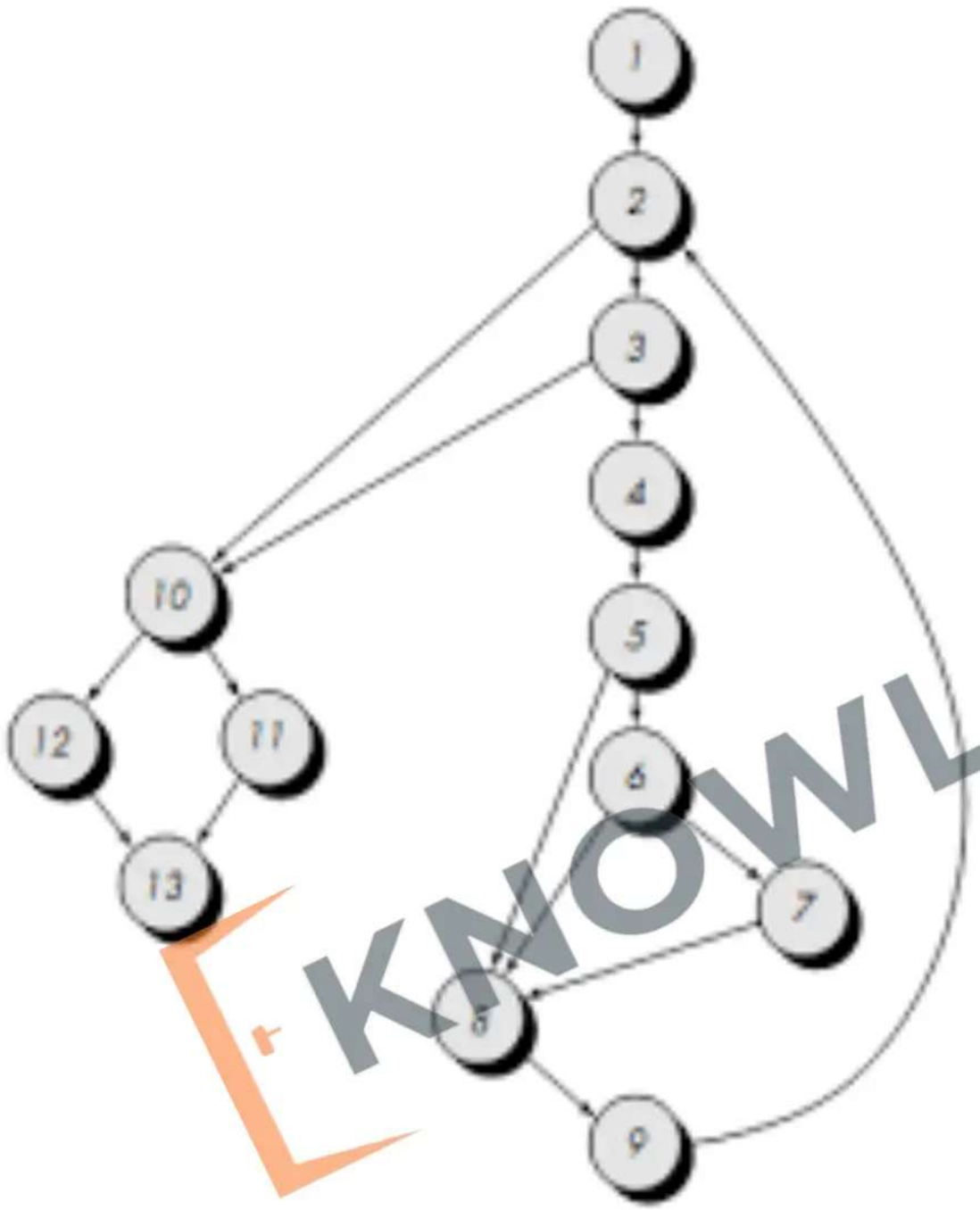

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Unit-4(Software Testing)

- Testing Objectives,
  - Unit Testing,
  - Integration Testing,
  - Acceptance Testing,
  - Regression Testing,
- Testing for Functionality and Testing for Performance,
- Top-Down and Bottom-Up
- Testing Strategies:
  - Test Drivers and Test Stubs,
  - Structural Testing (White Box Testing),
  - Functional Testing (Black Box Testing),
  - Test Data Suit Preparation,
  - Alpha and Beta Testing of Products.
- Static Testing Strategies: Formal Technical Reviews (Peer Reviews), Walk Through, Code Inspection, Compliance with Design and Coding Standards.

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Coding

- It is a phase where we translate a design or algorithm into a code of a particular programming language.
- It is a technical phase so there is not much in software engineering to given guideline in this phase, still we can give characteristics of good code.
- **Characteristics of Good Coding**
  - It must be simple, easy to understand (unconditional jumps must be avoided)
  - It must be readable, i.e. we must use proper space and comments lines and write code in hierarchical fashion
  - Usability try to code in modular fashion so that we can reuse the previous code.

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Compliance with Design and Coding Standards

- **Definition**:
  - Compliance with design and coding standards refers to adhering to a set of rules, guidelines, and best practices that govern the process of designing and writing software code, ensuring consistent, high-quality, and maintainable software products.

- **Importance**:
  - Improves code readability and maintainability
  - Facilitates collaboration and communication among team members
  - Minimizes the introduction of defects and vulnerabilities
  - Reduces development time and costs

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- **Design Standards**:
  - **Architectural consistency**: Ensuring that the overall structure of the software adheres to established patterns and principles
  - **Component modularity**: Encouraging a modular design that promotes separation of concerns and code reusability
  - **Interface design**: Defining clear, consistent, and easy-to-understand interfaces for components or modules
  - **Scalability and performance**: Designing software to handle future growth and changing requirements without negatively impacting performance

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- **Coding Standards**:
  - **Naming conventions**: Establishing consistent rules for naming variables, functions, classes, and other code elements
  - **Formatting**: Defining guidelines for indentation, whitespace, and code layout to improve readability
  - **Comments and documentation**: Providing clear, concise, and accurate inline comments and external documentation
  - **Error handling**: Implementing proper error handling and reporting mechanisms to improve software robustness and reliability

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- **Compliance Enforcement**:
  - **Code reviews**: Conducting regular peer reviews to ensure adherence to design and coding standards
  - **Automated tools**: Using static code analysis and linter tools to identify deviations from established standards
  - **Continuous integration**: Integrating and testing code changes frequently to catch issues early in the development process
  - **Training and education**: Providing team members with training and resources to stay up-to-date on best practices and standards

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- **Challenges**:
  - Balancing strict adherence to standards with development speed and flexibility
  - Ensuring that standards evolve as new technologies and best practices emerge
  - Obtaining buy-in from all team members and fostering a culture of compliance

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Testing

- Because of human error there will be a bug or fault in the code and if that bug/fault is executed it become a failure.
- Software testing is a process of executing a program with the intention of finding bugs or fault in the code.
- It is generally very difficult to test a software exhaustibility or completely because the i/p space is very large. So, we have to write test cases wisely so that in minimum test we can provide the maximum reliability.

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Preparation for Testing

- Before we start test, we must have written, complete & approved copy of SRS.
- The budget, time & schedule for the testing must be written and document with proper timeliness & milestones which are to be achieved.
- We must have a proper assembled team with we understood responsibilities.
- We must have a written document of limitation property and scope of testing.

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- There are two methods of arranging testing
  - **Skilled based approach**: In this, a person works on a specific technology for a long time. here the person has a chance to become a true specialist in that particular area or technology
  - **Project based approach**: Here we assign test team to a project so that they can have a much deeper and better understand of that particular project which increases the chance of success.

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Objective of testing

- To check weather software is build accordance with the requirement or not.
- It guarantees to give a more reliable or better-quality product to the customer which will ensure its satisfaction.
- It also helps in software quality assurance where we understood what are the frequent or normal mistakes we do.

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Principle of software testing/guidelines

1. Testing must be based on user requirement
2. Test time, resource cost is limited.
3. It is impossible to check entire i/p space.
4. Testing must start after a proper test plan.
5. The possibility of existence of more error in a module id directly proportional to error already being found.
6. Testing must be done by a third party (at least not developer)
7. Assign best person of the company during testing.
8. Tester must have a destructive attitude towards the code.
9. We must perform both functional and non-functional testing
10. We must give emphasize on automated test tools but the final testing must be done by the humans

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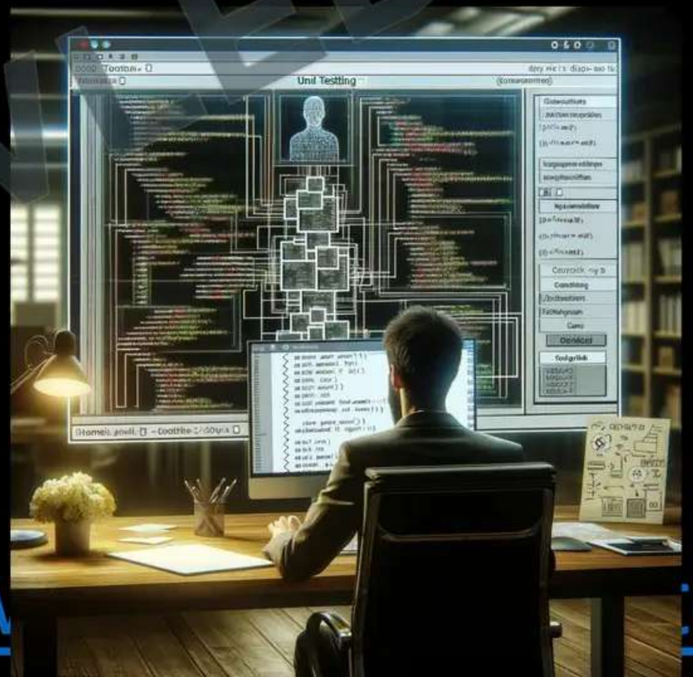
Unit Testing

- **Definition**: It is the first level of testing that involves testing individual components or units of code to ensure they work correctly in isolation. It is concerned for the testing only a specific module.
- **Purpose**: To verify that each unit of code performs its intended function and to catch bugs early in the development process. Will check internal logic of module and Functionality and interface with the other module
- **Test Cases**: Writing small, specific test cases that cover different input scenarios and edge cases for each unit of code.



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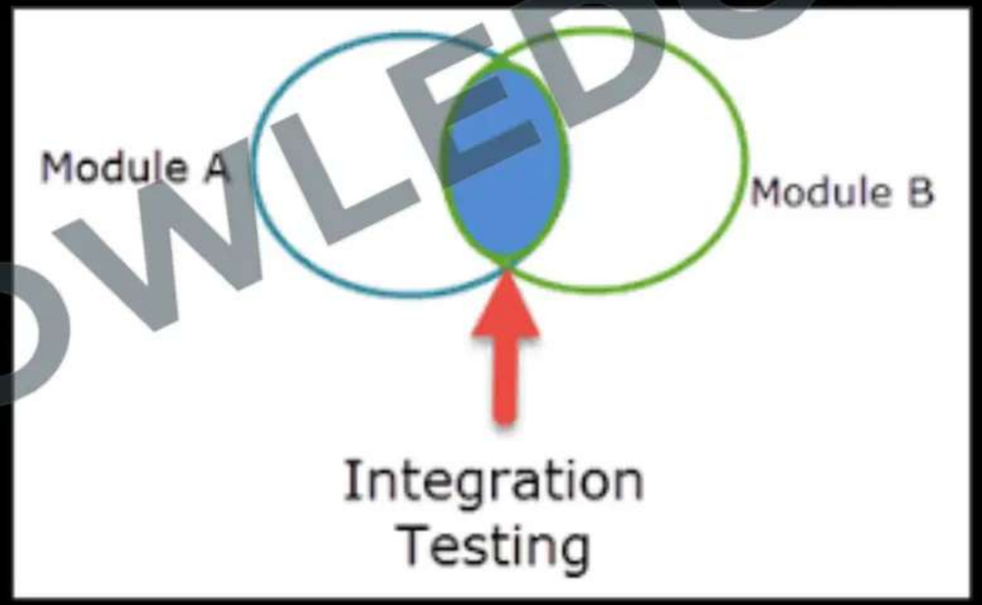
Integration Testing

- Integration testing is a phase in software testing in which individual software modules are combined and tested as a group.

- The primary objective of integration testing is to test the module interfaces, i.e. there are no errors in the parameter passing, when one module invokes another module. To verify the functional, performance, and reliability between the modules that interact with each other.



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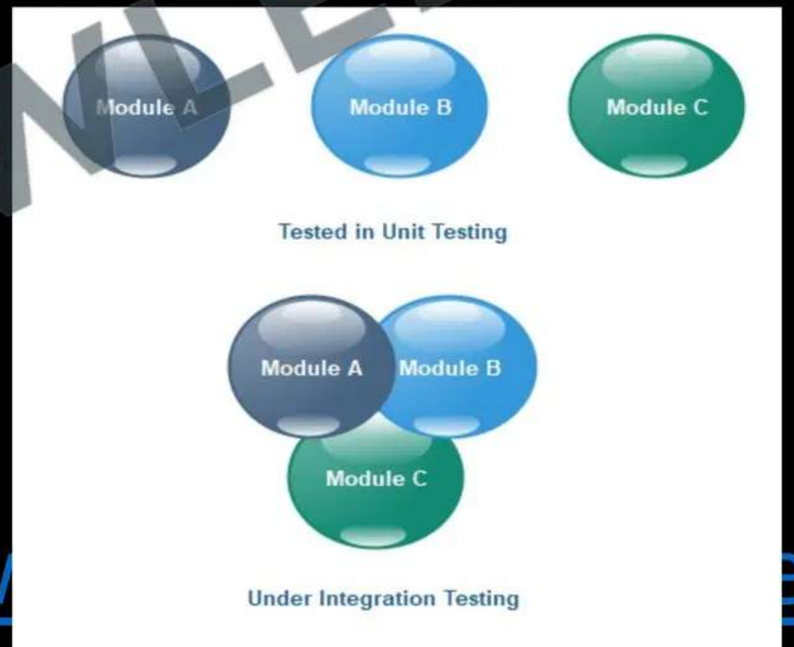
Integration Testing

- Integration testing is the phase in software testing in which individual software modules are combined and tested as a group. It occurs after unit testing and before validation testing.
- Purpose is to expose faults in the interaction between integrated units.
- It can be time-consuming and costly due to the complexity of inter-module dependencies. It requires a lot of coordination between different teams. The sequence of tasks is crucial for integration testing which may cause delays if not planned properly.



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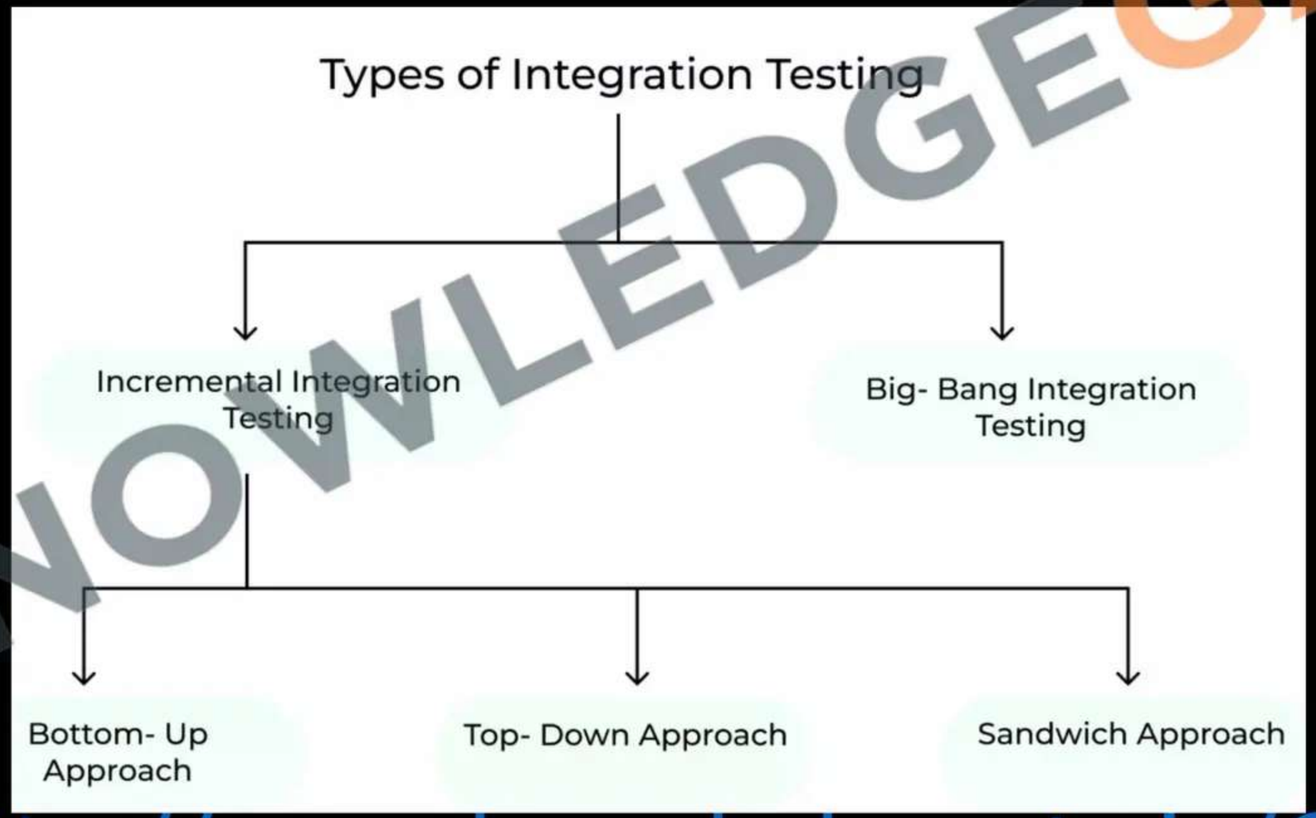
- Types of Integration Testing:
  - Big Bang Integration Testing
  - Top-Down Integration Testing
  - Bottom-Up Integration Testing
  - Sandwich/Hybrid Integration Testing



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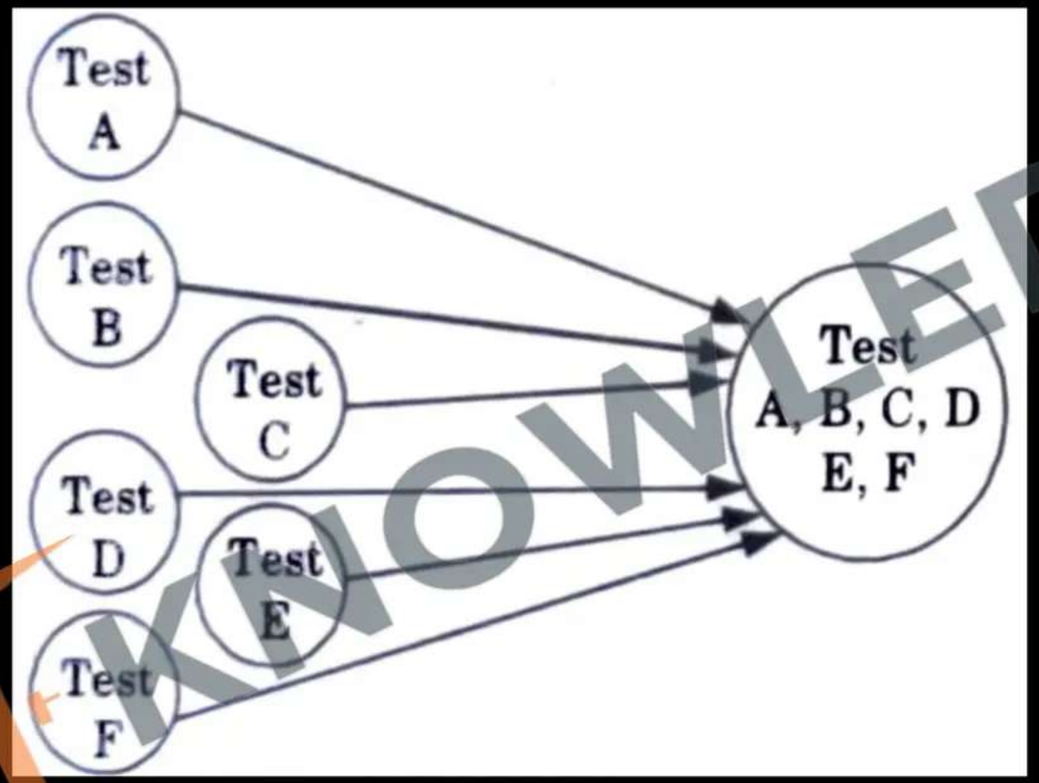
Big-Bang

- Is a type of integration testing where all the modules are integrated simultaneously and then tested as a complete system,



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- **Simplicity:** It is easier to set up because testing starts only after all the modules have been integrated.

- **Suitability:** It is better suited for smaller systems where the modules are heavily interlinked.

- **Efficiency:** It can potentially save time, as testing is conducted after the entire software has been developed and integrated.

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- **Issue Detection and Resolution:** It can be challenging to isolate and fix bugs because of the high level of integration.

- **High Risk:** There's a high risk involved as any significant issues are only found late in the development process, which can lead to project delays.

- **Resource Consumption:** It can be resource-intensive, requiring a significant amount of time and effort to find and fix bugs.

- **Inefficiency in Large Systems:** It's inefficient for larger systems where problems can become increasingly complex and hard to identify when all modules are integrated at once.

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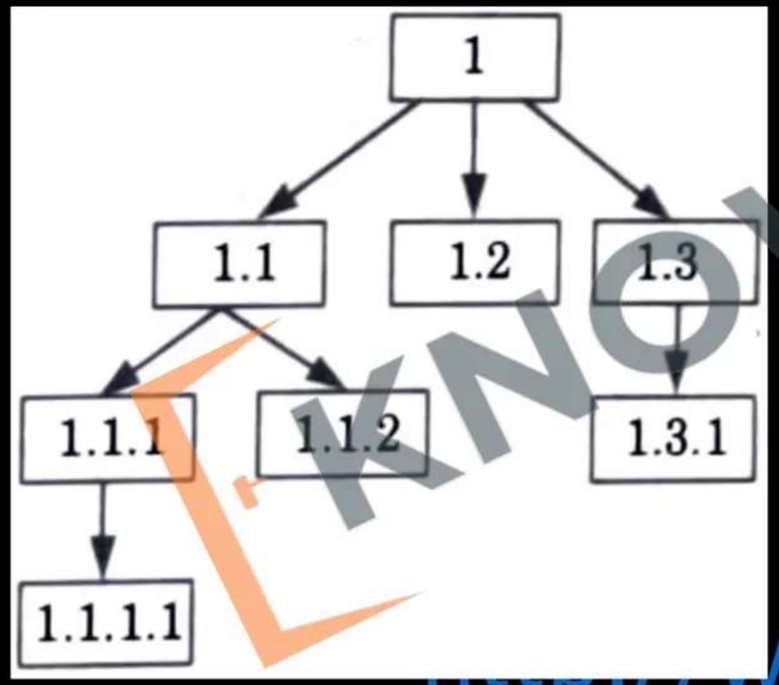
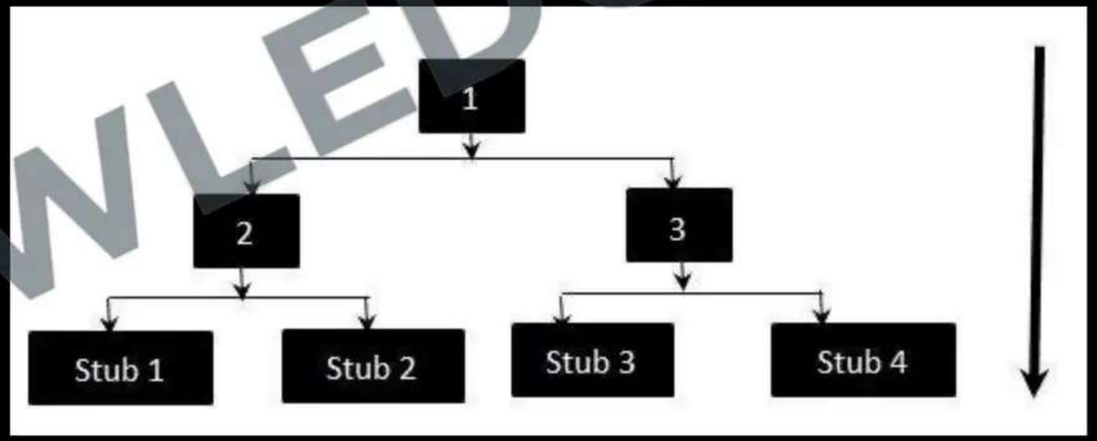
Top to Bottom

- Top-Down Integration Testing is a method of software integration testing where the top-level modules are tested first and the lower-level modules are tested step by step after that. This process continue until all components are integrated and then whole system has been completely tested.

- Stub modules may be used to simulate the effect of lower-level modules that have not yet been integrated and are called by the routines under test.





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Advantages of Top-Down Integration Testing

- **Early Defect Identification:** Critical high-level design and control flow issues can be detected at an early stage.

- **Facilitates Progressive Testing:** Testing is easier and more systematic, progressing from top-level modules to lower-level modules.

- **Supports Early Demonstration:** The basic functionality of the system can be demonstrated early in the testing process, even if lower-level modules are not yet developed or tested.

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Disadvantages of Top-Down Integration Testing

- **Stub Development:** Stubs need to be created for simulating lower-level modules, which may require additional time and resources.

- **Late Detection of Lower-Level Bugs:** Bugs in lower-level modules may not be found until the later stages of testing, which can lead to delays.

- **Incomplete Testing:** Due to reliance on stubs, some types of errors can be difficult to detect until full functionality is integrated.

- **Difficulty in Test Management:** The complexity and dependencies between different modules can make test management challenging.

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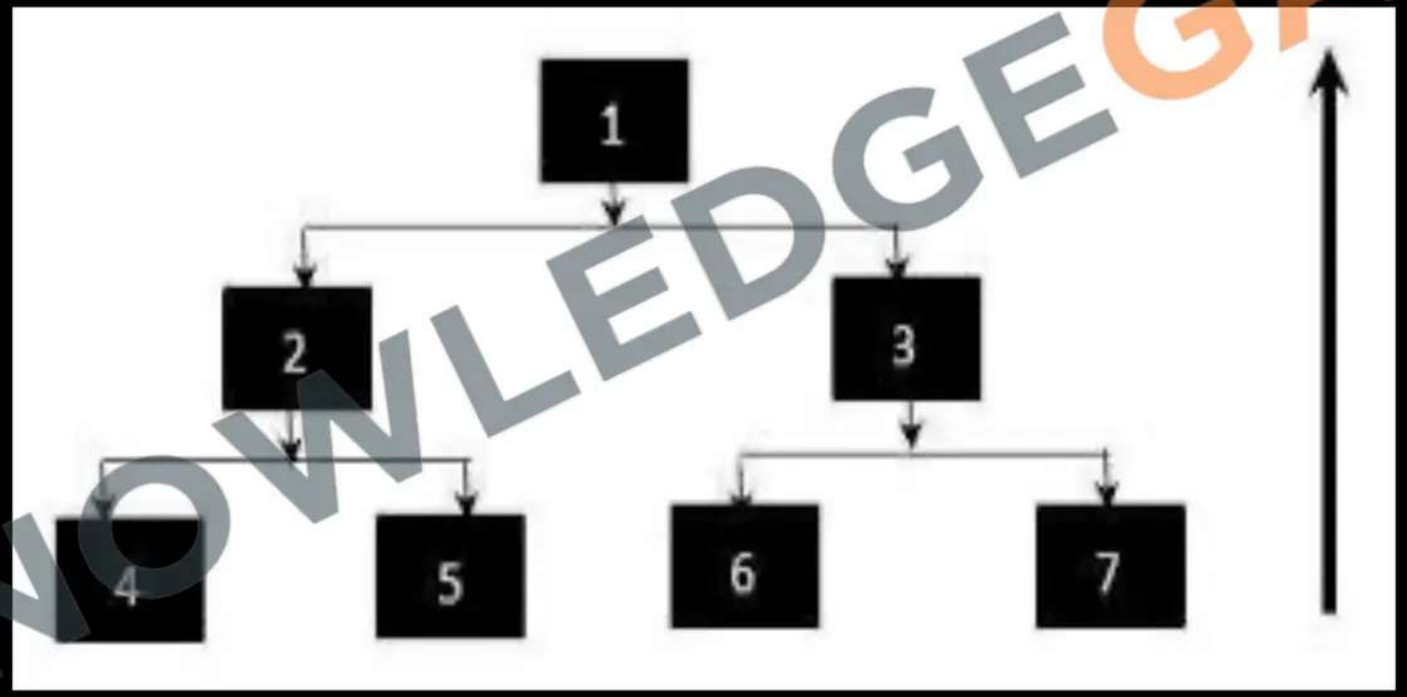
Bottom to Top

- Bottom-Up Integration Testing is a strategy in software testing where the lower-level modules are tested first and then integrated and tested with the higher-level modules. This approach often uses "driver" modules for testing and simulation.



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Advantages of Bottom-Up Integration Testing

- **Early Problem Detection:** It allows early detection of faults and failures in the lower-level modules of the software.

- **No Need for Stubs:** Unlike top-down testing, bottom-up testing doesn't require the use of stubs as testing begins from the lower-level modules.

- **Simultaneous Development and Testing:** Different modules can be tested in parallel, potentially speeding up the testing process.

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Disadvantages of Bottom-Up Integration Testing

- **Delay in Higher-Level Module Testing:** Testing of higher-level modules is delayed as lower-level modules need to be tested first.
- **Need for Drivers:** Drivers need to be created to simulate higher-level modules, which can require additional time and resources.
- **Late Detection of Higher-Level Bugs:** Issues in the integration of high-level modules may not become apparent until late in the testing process.
- **Incomplete System Overview:** Early stages of testing do not provide a complete view of the system, which may make it harder to assess overall functionality and performance.

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Sandwich/Hybrid integration testing

- The combination of top down and bottom integration testing is called sandwich integration.
- This system is viewed as a three layer just like a sandwich, the upper layer of sandwich use top down integration the lower layer of the sandwich integration use bottom up integration and Stubs and drivers are used to replace the missing modules in the middle layers.

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- **Combines Strengths:** It combines the advantages of both Top-Down and Bottom-Up testing approaches to achieve more comprehensive testing coverage.

- **Time-Efficiency:** The simultaneous testing at both ends can help to reduce the overall testing time.

- **Variety of Scenarios:** This approach allows for a wide range of testing scenarios and can lead to more thorough verification of the system's functionality.

- **Flexibility:** It offers flexibility in the testing process, as it can be adjusted according to the nature of the software and the resources available.

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System Testing

- System testing is a level of software testing where the complete and integrated software system as a whole is tested to evaluate its compliance with specified requirements in SRS.
- It is a crucial step before the software gets deployed to the user, aiming to catch any defects that might have slipped through the earlier stages of testing.
- System testing is performed in an environment that closely resembles the real-world or production environment.
- Generally, it is performed by independent testers who haven't been involved in the development phase to ensure unbiased testing.
- It may include functional testing, usability testing, performance testing, security testing, and compatibility testing.

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User Acceptance Testing

- **Definition and Purpose:** User Acceptance Testing (UAT) is the final testing phase before software deployment, aiming to validate if the system meets the business requirements and is fit for use.
- **Participants:** Usually performed by clients or end-users, UAT evaluates the software's functionality in a real-world scenario.

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- **Focus:** Emphasizing the software's user-friendliness, efficiency, and effectiveness, UAT goes beyond purely technical aspects to assess overall user experience.

- **Documentation:** During UAT, all scenarios, outcomes, and user feedback are recorded to inform potential changes and improvements.

- **Outcome:** Successful UAT culminates in user sign-off, signifying the system meets the set acceptance criteria and is ready for release.

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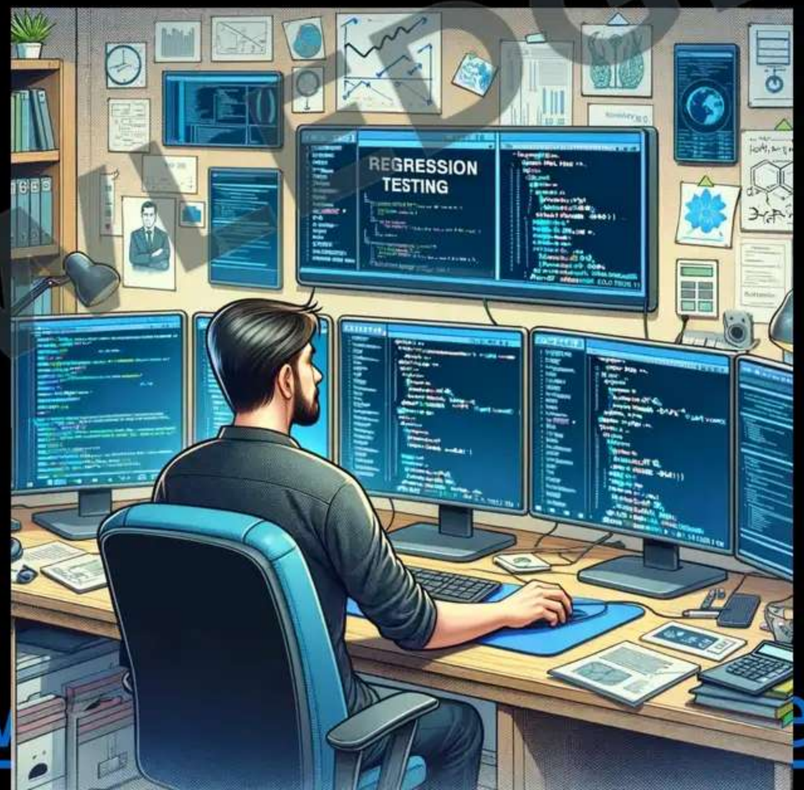
Regression Testing

- **Definition:** Regression testing is a type of software testing carried out to ensure that previously developed and tested software still functions as expected after making changes, such as updates or bug fixes.

- **Purpose:** The main goal is to identify any issues or defects introduced by changes in the software, and to ensure that the changes have not disrupted any existing functionality.



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- **Types:** Types of regression testing include unit regression, partial regression, and complete regression testing.

- **Test Cases:** Regression testing generally involves re-running previously completed tests and verifying that program behavior has not changed as a result of the newly introduced changes.

- **Automation:** Due to the repetitive nature of these tests, regression testing is often automated to improve efficiency and accuracy.

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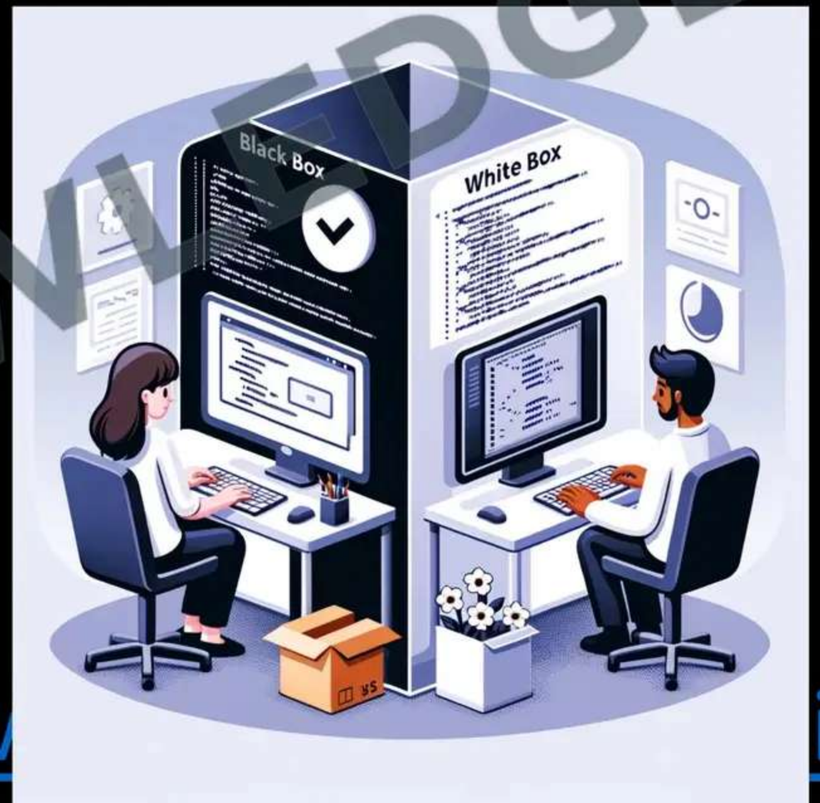
Black box Testing/ White box Testing

- **Black Box Testing(Validation)** – Where we treat system as a whole, and check system according to user requirement (are we making the right product), i.e. we check o/p for every i/p

- **White Box Testing(Verification)** – Here we go inside a system and check how actual functionality is performed(are we making the product right)



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Alpha Testing/ Beta Testing

- Any type of testing which is done on developer side is called alpha testing, usually performed with artificial test cases.

- Any type of testing which is done at customer side is called beta testing, usually performed with real time data.

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Stress Testing

- Stress testing is also known as endurance testing.
- Stress testing evaluates system performance when it is stressed for short periods of time.
- Stress tests are black box tests which are designed to impose a range of abnormal and even illegal input conditions so as to stress the capabilities of the software.

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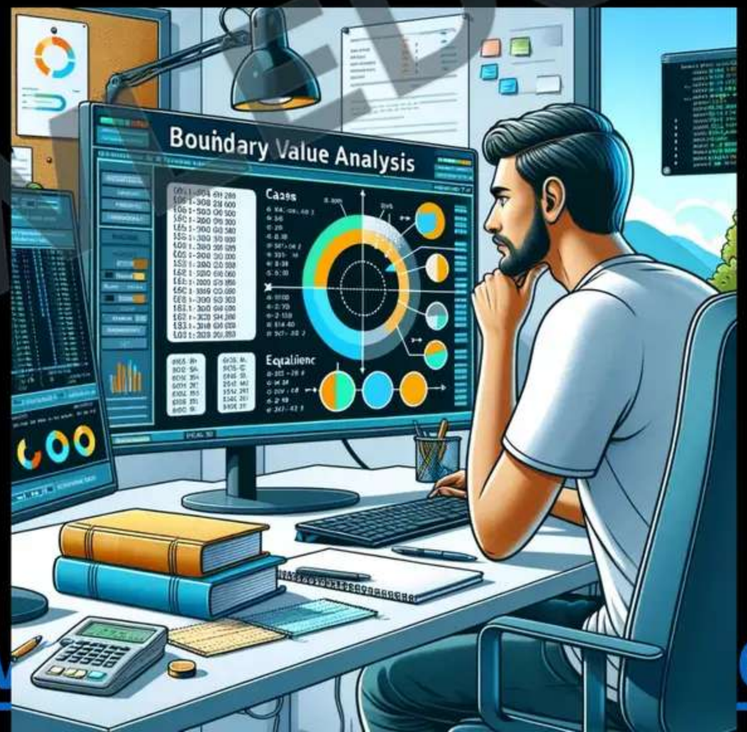
Boundary value analysis

- Boundary Value Analysis is a software testing technique that focuses on the values at the boundaries of the input domain.
- The theory behind BVA is that errors are more likely to occur at the extremes of an input domain rather than in the center. Hence, it's generally more useful to focus on testing the boundary values.
- BVA is used for testing ranges and data array elements in a software application.



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- In practice, BVA can be applied by identifying all the boundaries and then creating test cases for the boundary values and just above and below the boundary values.
- Example: Let's consider a simple application that accepts an integer input from 1 to 100.
- The boundary values here would be 0 (just below the valid range), 1 (lower limit), 100 (upper limit), and 101 (just above the valid range).
- You would then create test cases to input these values and verify the system's behavior.

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Equivalence partitioning

- Equivalence Partitioning is a black box testing technique that divides the input data of a software unit into partitions of equivalent data.
- The logic behind EP is that the system should handle all the equivalent data in the same way, thus you can save testing effort by testing only one value from each partition.
- It helps to reduce the total number of test cases from an infinite pool to a more manageable number.
- This technique can be used for both valid and invalid data input.

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- Example: Let's consider the same application that accepts an integer input from 1 to 100.
- The equivalence classes here would be: less than 1 (invalid), between 1 and 100 (valid), and greater than 100 (invalid).
- You would then create test cases to input a value from each of these classes (for example, 0, 50, and 101) and verify the system's behavior.

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Graph-Based Testing Methods

- Uses graphical representation for software testing.
- Nodes represent states; edges represent transitions.
- Example: For a web app with Login, Dashboard, and Logout screens, draw nodes for each and edges for transitions. Test paths like Login -> Dashboard -> Logout.

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Formal Technical Review (Peer Reviews)

- A Formal Technical Review (FTR) is a structured, systematic, and disciplined approach to examining and evaluating software artifacts, such as code, design documents, or requirements specifications, with the primary goal of identifying and addressing defects, inconsistencies, or areas for improvement.
- FTRs are conducted by a team of peers, consisting of the artifact's author and other software professionals, who analyze the work product and provide constructive feedback to ensure high-quality software development.
- Formal Technical Reviews play a crucial role in improving software quality, detecting issues early in the development lifecycle, promoting knowledge sharing, and fostering collaboration within software engineering teams.

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- Types of Formal Technical Reviews
  - Code reviews
  - Walkthroughs
  - Inspections
  - Pair programming

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- The Formal Technical Review Process
  - A. **Planning**
    - 1. Establish objectives
    - 2. Select participants
    - 3. Set schedule
  - B. **Preparation**
    - 1. Distribute materials
    - 2. Review guidelines
    - 3. Allocate time for individual review
  - C. **Conducting the review**
    - 1. Discuss objectives
    - 2. Review findings
    - 3. Make decisions on action items
  - D. **Post-review activities**
    - 1. Document review results
    - 2. Implement action items
    - 3. Monitor follow-up actions

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- **Roles in Formal Technical Reviews**
  - A. Review leader
  - B. Author
  - C. Reviewers
  - D. Recorder

- **Benefits of Formal Technical Reviews**
  - A. Improved code quality
  - B. Early defect detection
  - C. Knowledge sharing
  - D. Increased team collaboration

- **Challenges and Best Practices in Formal Technical Reviews**
  - A. Time management
  - B. Maintaining a constructive environment
  - C. Addressing bias
  - D. Ensuring consistency in review standards

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Walk Through

- In software engineering, a walkthrough is a type of informal review process in which the author of a software artifact, such as code, design documents, or requirements specifications, presents their work to a group of peers.
- The main purpose of a walkthrough is to identify defects, inconsistencies, or areas for improvement through a collaborative discussion.
- Walkthroughs are typically less formal than other review methods, such as inspections, and focus on knowledge sharing, collaboration, and training among team members.

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Walkthrough Process

- A. Planning
  - 1. Define objectives
  - 2. Select participants
  - 3. Schedule the walkthrough
- B. Preparation
  - 1. Distribute materials
  - 2. Review guidelines
  - 3. Allocate time for individual review
- C. Conducting the walkthrough
  - 1. Present the work product
  - 2. Discuss findings
  - 3. Record issues and suggestions
- D. Post-walkthrough activities
  - 1. Summarize findings
  - 2. Assign action items
  - 3. Monitor follow-up actions

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- Roles in Walkthroughs
  - A. Presenter
  - B. Reviewers
  - C. Recorder

- Benefits of Walkthroughs
  - A. Early defect detection
  - B. Knowledge sharing
  - C. Team collaboration
  - D. Training and mentoring

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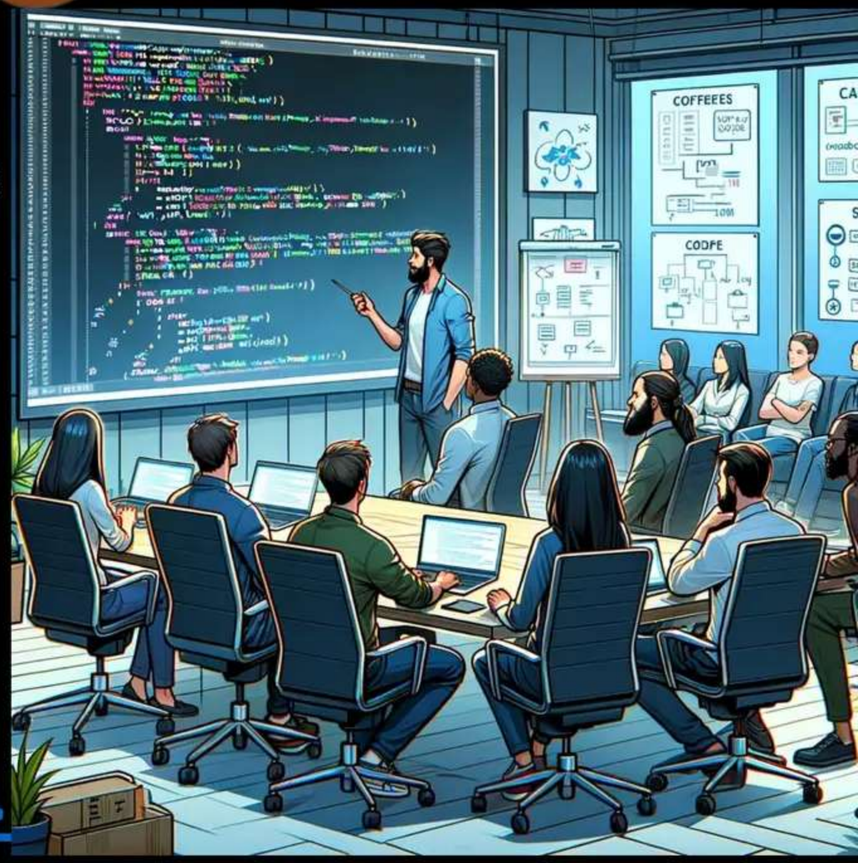
Code Inspection

- **Definition**:
  - Code inspection is a systematic review process in which a team of developers evaluates a software product's source code for potential issues, such as errors, vulnerabilities, and deviations from coding standards.
- **Objectives**:
  - Improve code quality
  - Detect and fix defects early in the development cycle
  - Share knowledge and best practices among team members
  - Enforce coding standards and guidelines



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- Process:
  - **Planning**: Select the code to be inspected, define goals, and assemble the inspection team
  - **Preparation**: Team members review the code individually to identify potential issues
  - **Inspection Meeting**: The team discusses the identified issues, and the moderator notes down agreed-upon action items
  - **Rework**: The original developer addresses the identified issues and submits the revised code
  - **Follow-up**: The moderator verifies that all action items have been addressed and closes the inspection

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- Inspection Team Roles:
  - **Author**: The developer who wrote the code being inspected
  - **Moderator**: The person who leads the inspection process and ensures it runs smoothly
  - **Reviewers**: Other developers who provide insights and suggestions for improvements
  - **Recorder**: The person responsible for documenting the issues found and decisions made during the inspection

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- **Benefits**:
  - Enhanced code quality and maintainability
  - Reduced development costs and project risks
  - Faster time-to-market due to early detection of defects
  - Improved team collaboration and learning

- **Limitations**:
  - Time-consuming process
  - Possibility of human errors or oversights
  - Potential for conflict among team members
  - May not catch all types of defects, such as performance or concurrency issues

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Unit-5(Software Maintenance)

- Software as an Evolutionary Entity,
- Need for Maintenance,
- Categories of Maintenance: Preventive, Corrective and Perfective Maintenance,
- Cost of Maintenance,
- Software Re-Engineering,
- Reverse Engineering.
- Software Configuration Management Activities,
- Change Control Process,
- Software Version Control,
- Resource Allocation Models,
- Software Risk Analysis and Management.

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Why Software Maintenance

- **Always Changing**: Software keeps changing to work better for people who use it. This is like how animals and plants change to survive in the world.
- **Getting More Complex**: Software used to be simple, but now it can do many things and connects people all over the world. This is like how nature has many different animals and plants living together.
- **Survival of the Fittest**: Good software will keep being used, while bad software will go away. This is like how strong animals and plants in nature can live longer and make more babies.

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- **Categories of Software Maintenance –** Maintenance can be divided into the following:
  - **Corrective maintenance:** Corrective maintenance of a software product may be essential either to rectify some bugs observed while the system is in use, or to enhance the performance of the system.
  - **Adaptive maintenance:** This includes modifications and updation when the customers need the product to run on new platforms, on new operating systems, or when they need the product to interface with new hardware and software.
  - **Perfective maintenance:** A software product needs maintenance to support the new features that the users want or to change different types of functionalities of the system according to the customer demands.

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- The key software maintenance issues are both managerial and technical. e.g. alignment with customer priorities, staffing, which organization does maintenance, estimating costs.

- Key technical issues are: limited understanding, impact analysis, testing, maintainability measurement.

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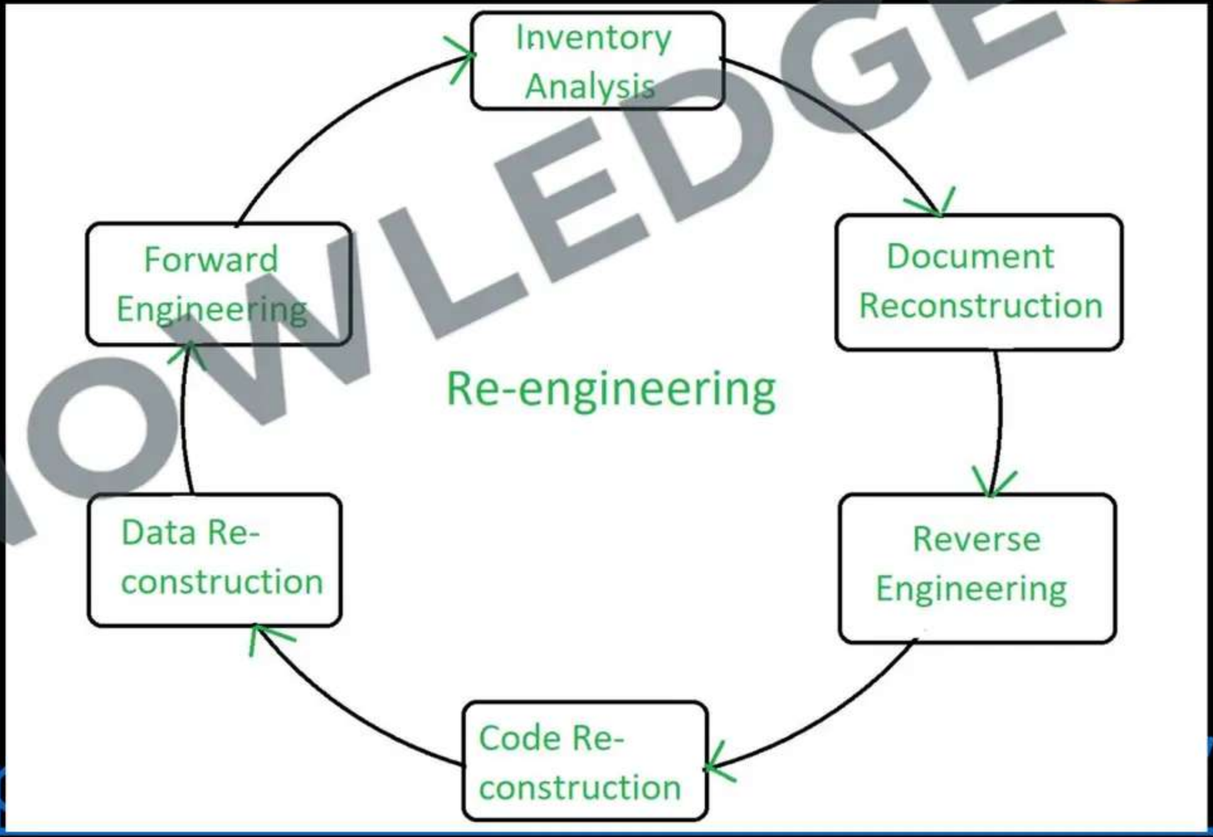
Software Re-Engineering

- Software re-engineering is the process of examining and modifying an existing software system to improve its functionality, performance, or adaptability without changing its core function.
- It's often undertaken to restructure a legacy system to enhance understandability, maintainability, and to upgrade to newer technologies or software practices.



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Software Re-Engineering Activities

- **Reverse Engineering**: This is the process of deconstructing a system to understand its components and their relationships, often to create documentation for a system where none exists or is out of date.

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- **Restructuring**: This involves transforming the existing source code into a more maintainable form, often while preserving its functionality. This can include activities such as code refactoring, where the code is reorganized to be more understandable or efficient.

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- **Forward Engineering**: After understanding and possibly restructuring the system, changes are made to the system to improve it or adapt it to new requirements or technologies. This can include implementing new features, improving performance, or changing the system to use a new technology stack.

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- **Re-documentation**: This involves updating or creating new documentation for the system. This can be especially important if the original documentation was lost, out of date, or if the system has been significantly changed during the re-engineering process.

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- **Benefits of re-engineering phases**:

  - **Cost**: Re-engineering of an existing software system costs significantly less than new system development.
  - **Lower Risks**: Software re-engineering is based on incremental improvement of systems, rather than racial system replacement. The risk of losing critical software knowledge is drastically reduced.
  - **Better use of existing Staff**: The skill of existing staff can be better utilized by re-engineering.
  - **Incremental Development**: The development is not carried out as a whole. It is in stages.

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- **<u>Reverse Engineering</u> –** Reverse Engineering is processes of extracting knowledge or design information from anything man-made and reproducing it based on extracted information. It is also called back Engineering.

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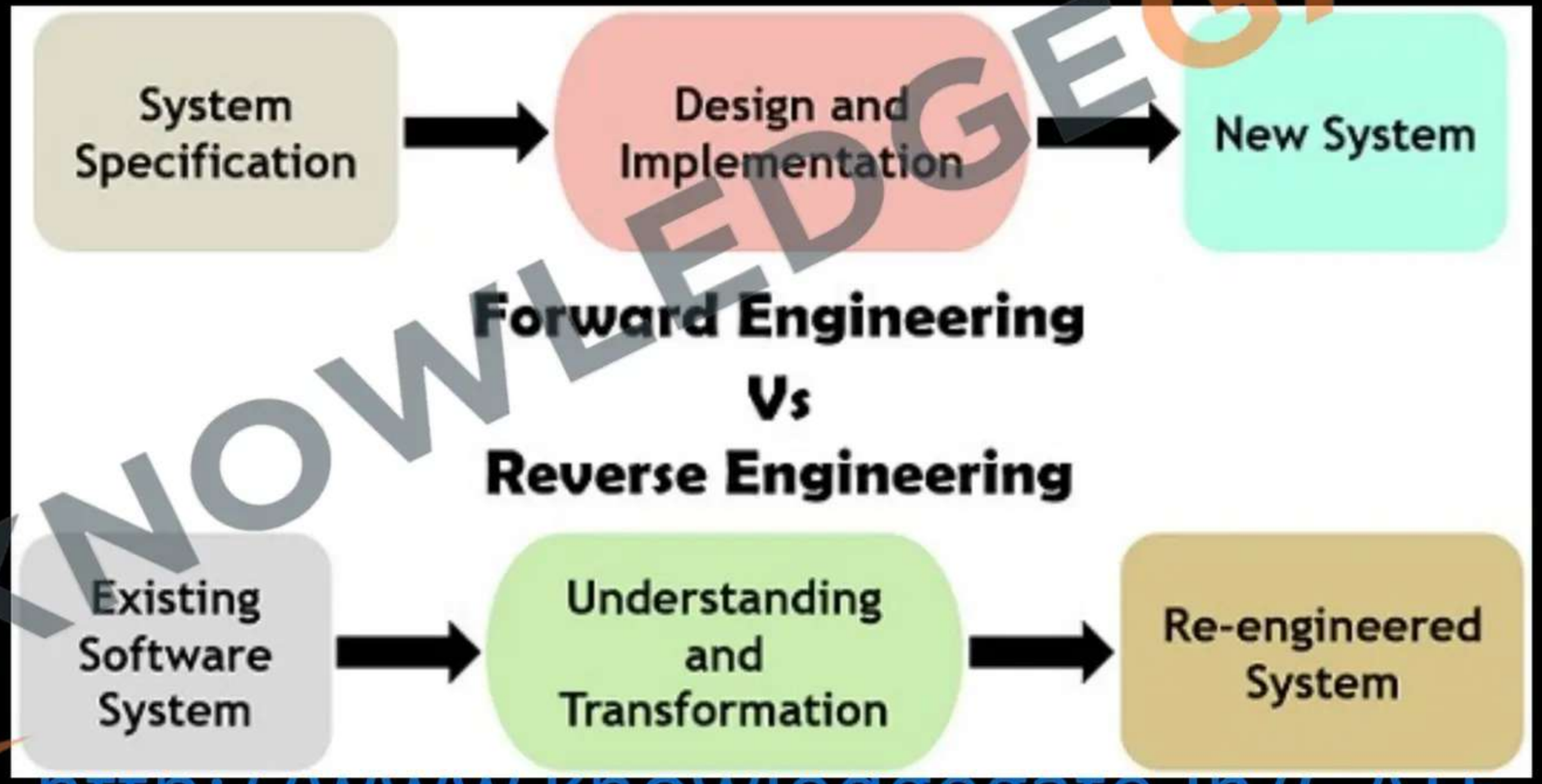
- **Software Reverse Engineering –** Software Reverse Engineering is the process of recovering the design and the requirements specification of a product from an analysis of it's code. Reverse Engineering is becoming important, since several existing software products, lack proper documentation, are highly unstructured, or their structure has degraded through a series of maintenance efforts.



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- **Steps of Software Reverse Engineering**

1. Collecting Information
2. Examining the Information
3. Extracting the Structure
4. Recording the Functionality
5. Recording Data Flow
6. Recording Control Flow
7. Review extracted Design
8. Generate Documentation

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- **Why Reverse Engineering?**

1. Providing proper system documentation.
2. Recovery of lost information.
3. Assisting with maintenance.
4. Facility of software reuse.
5. Discovering unexpected flaws or faults.

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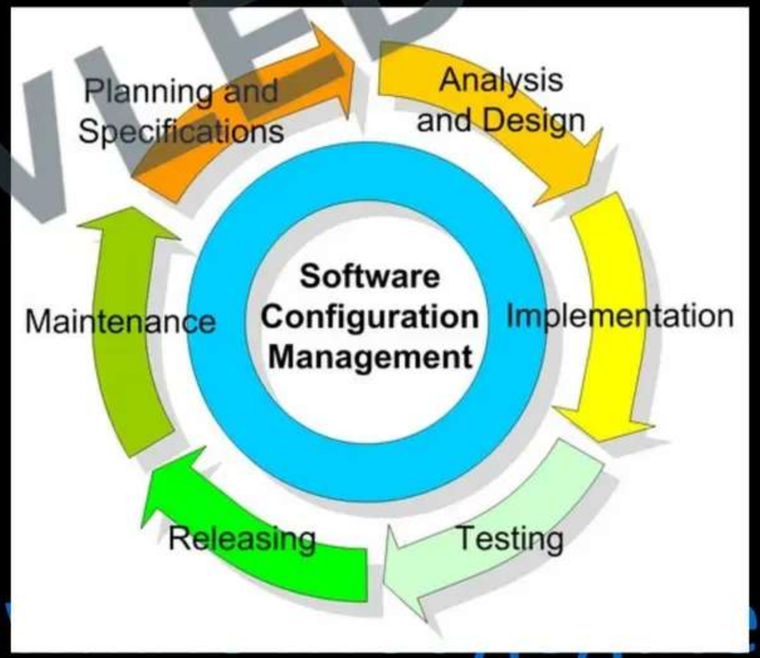
Software Configuration Management Activities

- The primary reasons for Implementing Software Configuration Management System are:
  - There are multiple people working on software which is continually updating.
  - It may be a case where multiple version, branches, authors are involved in a software project, and the team is geographically distributed and works concurrently.
  - Changes in user requirement, policy, budget, schedule need to be accommodated.
  - Software should able to run on various machines and Operating Systems.
  - Helps to develop coordination among stakeholders.
  - SCM process is also beneficial to control the costs involved in making changes to a system.



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Software Configuration Management

- Can be defined as a process of defining and implementing a standard configuration, which results into the primary benefits such as easier setup and maintenance, less down-time, better integration with enterprise management, and more efficient and reliable backups and also maximize productivity by minimizing mistakes.
- SCM is used to track and manage the emerging product and its versions.
- SCM ensures that all people involved in the software process know what is being designed, developed, built, tested and delivered.
- Through SCM, the design requirements can be traced to the final software product.

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Objectives Software Configuration Management

- Remote system administration
- Reduced user down-time
- Reliable data backups
- Easy workstation setup
- Multi-User support

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- **Tasks in SCM process**
  - **Configuration Identification:**
    - Configuration identification is a method of determining the scope of the software system.
    - With the help of this step, you can manage or control something even if you don't know what it is.

  - **Baseline:**
    - A baseline is a formally accepted version of a software configuration item.
    - It is designated and fixed at a specific time while conducting the SCM process. It can only be changed through formal change control procedures.

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- **Change Control:**
  - Change control is a procedural method which ensures quality and consistency when changes are made in the configuration object.
  - In this step, the change request is submitted to software configuration manager.

- **Configuration Status Accounting:**
  - Configuration status accounting tracks each release during the SCM process.
  - This stage involves tracking what each version has and the changes that lead to this version.

- **Configuration Audits and Reviews:**
  - Software Configuration audits verify that all the software product satisfies the baseline needs.
  - It ensures that what is built is what is delivered.

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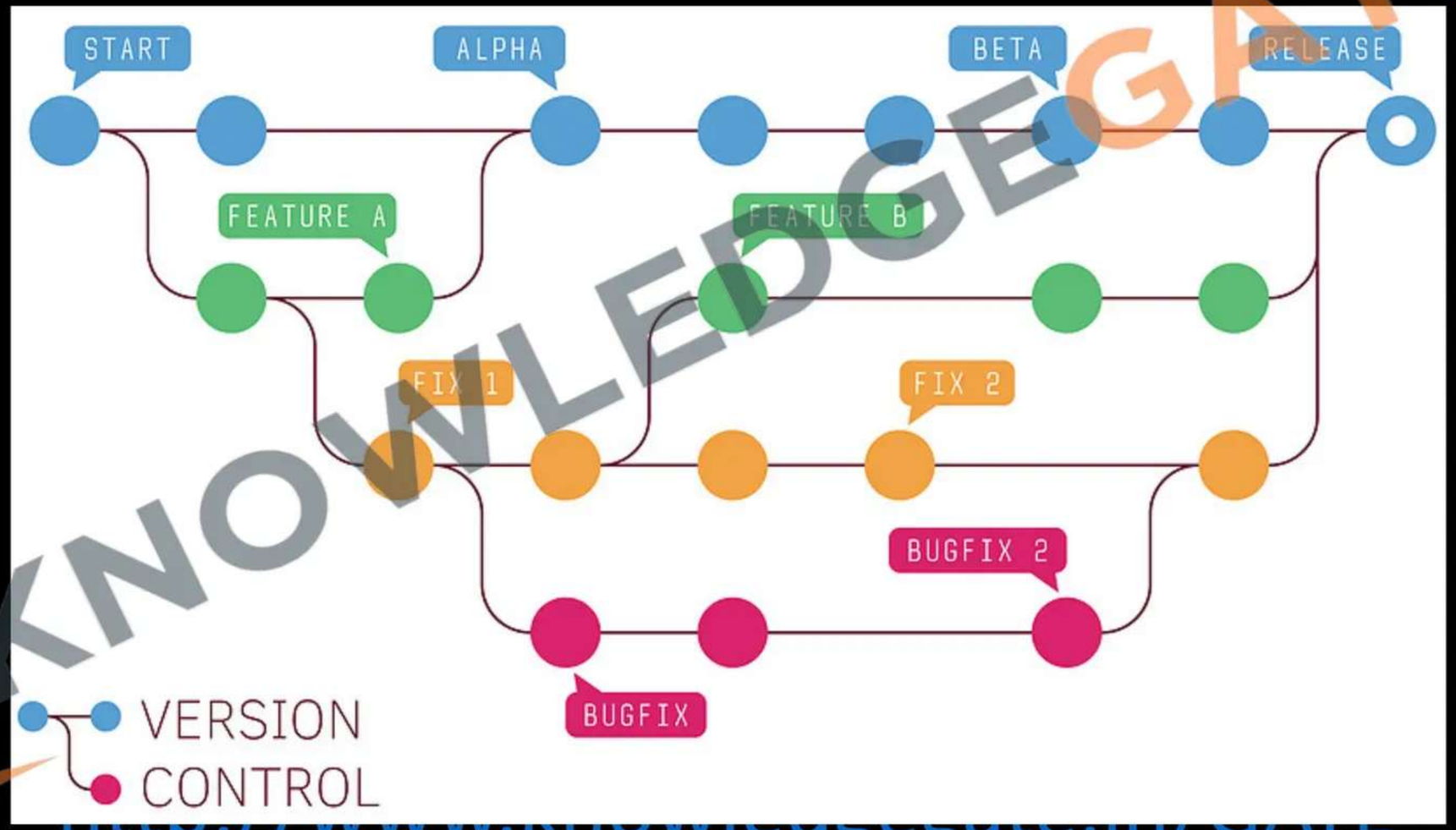
Software version control

- Version control is a way to keep track of changes in computer programs. It helps people work together on a project without causing problems. They can see what changes were made, when, and by whom. It also lets them go back to an older version if something goes wrong.



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- **Identifying New Versions**: Each time changes are made and saved, the version control system creates a new, unique version of the software. This helps developers track the software's evolution and easily manage multiple versions.

- **Numbering Scheme**: Version control systems assign a specific numbering or naming scheme to each version (e.g., 1.0, 1.1, 1.2, or 2.0). This helps developers and users identify the software's progression and understand the scope of changes between versions.

- **Visibility**: Version control makes the entire history of the software project visible to all team members. This enhances collaboration and helps developers understand the context and impact of past changes on the current codebase.

- **Tracking**: Version control systems keep detailed records of who made each change, when it was made, and the specific modifications. This level of tracking helps maintain accountability and facilitates communication among team members.

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Resource Allocation Models

- Resource allocation models in software engineering refer to strategies or methods used to distribute various types of resources effectively across different aspects of a software project. These resources could include things like personnel, time, budget, computing resources, etc.
- These models help project managers in decision-making processes to ensure the efficient use of resources, meet project deadlines, maintain the quality of the software product, and stay within the budget.

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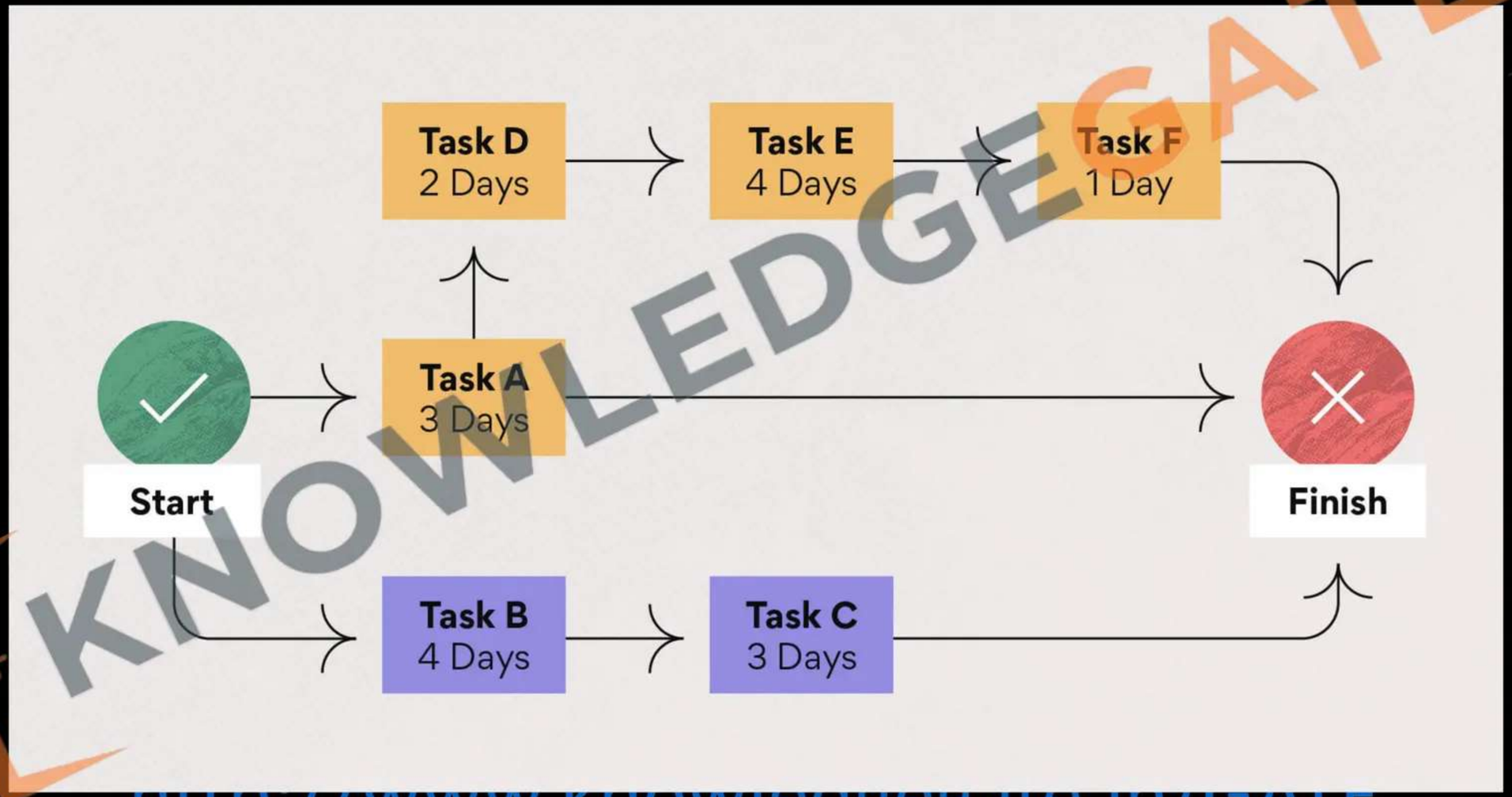
- **<u>Critical Path Method (CPM)</u>**: This is a step-by-step technique used in project management for scheduling project activities. It identifies critical and non-critical tasks to prevent conflicts and bottlenecks.



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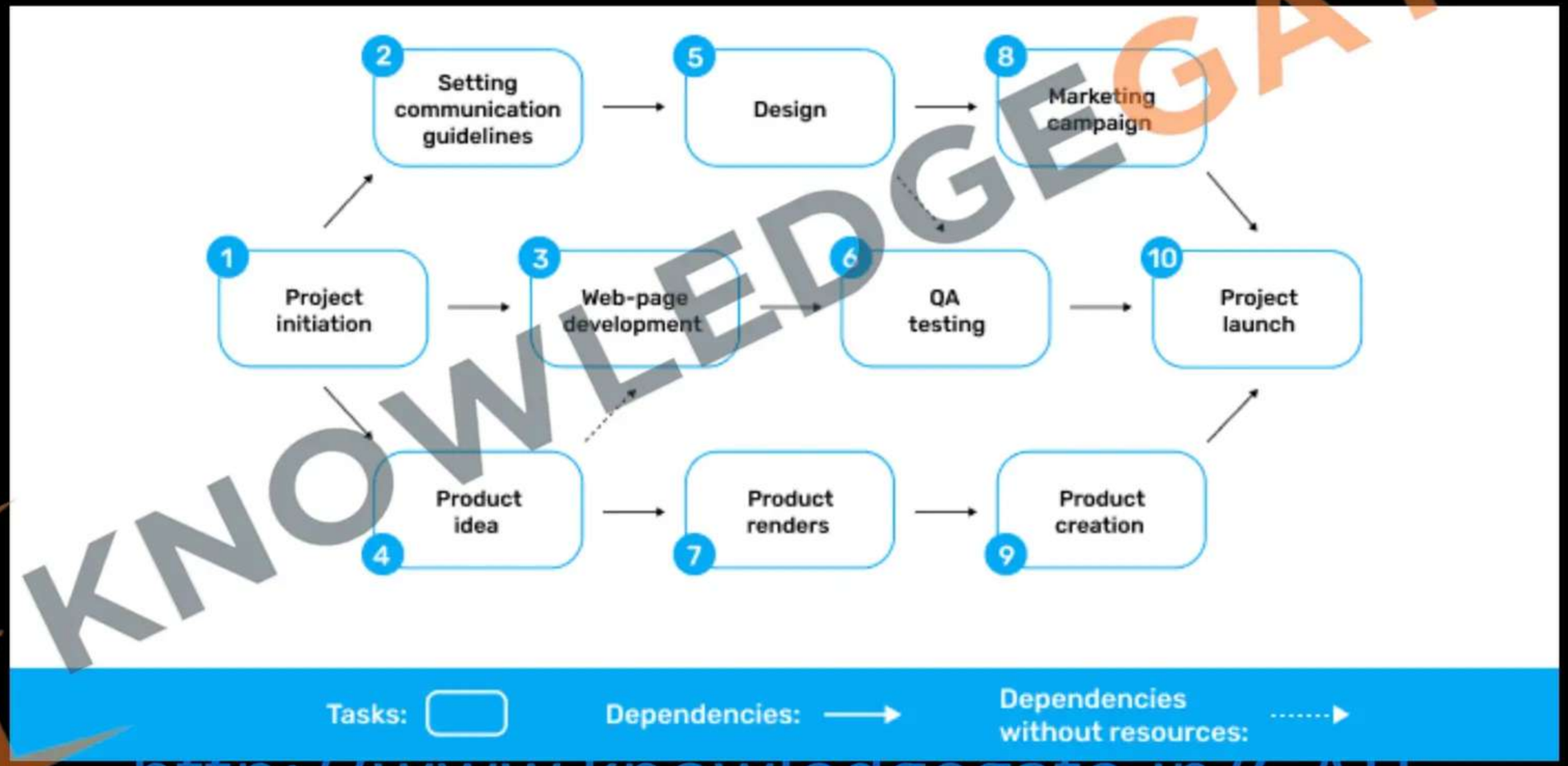
- **<u>Program Evaluation and Review Technique (PERT)</u>**: This is a statistical tool used in project management, designed to analyze and represent the tasks involved in completing a given project. It helps to estimate the minimum time needed to complete the project.



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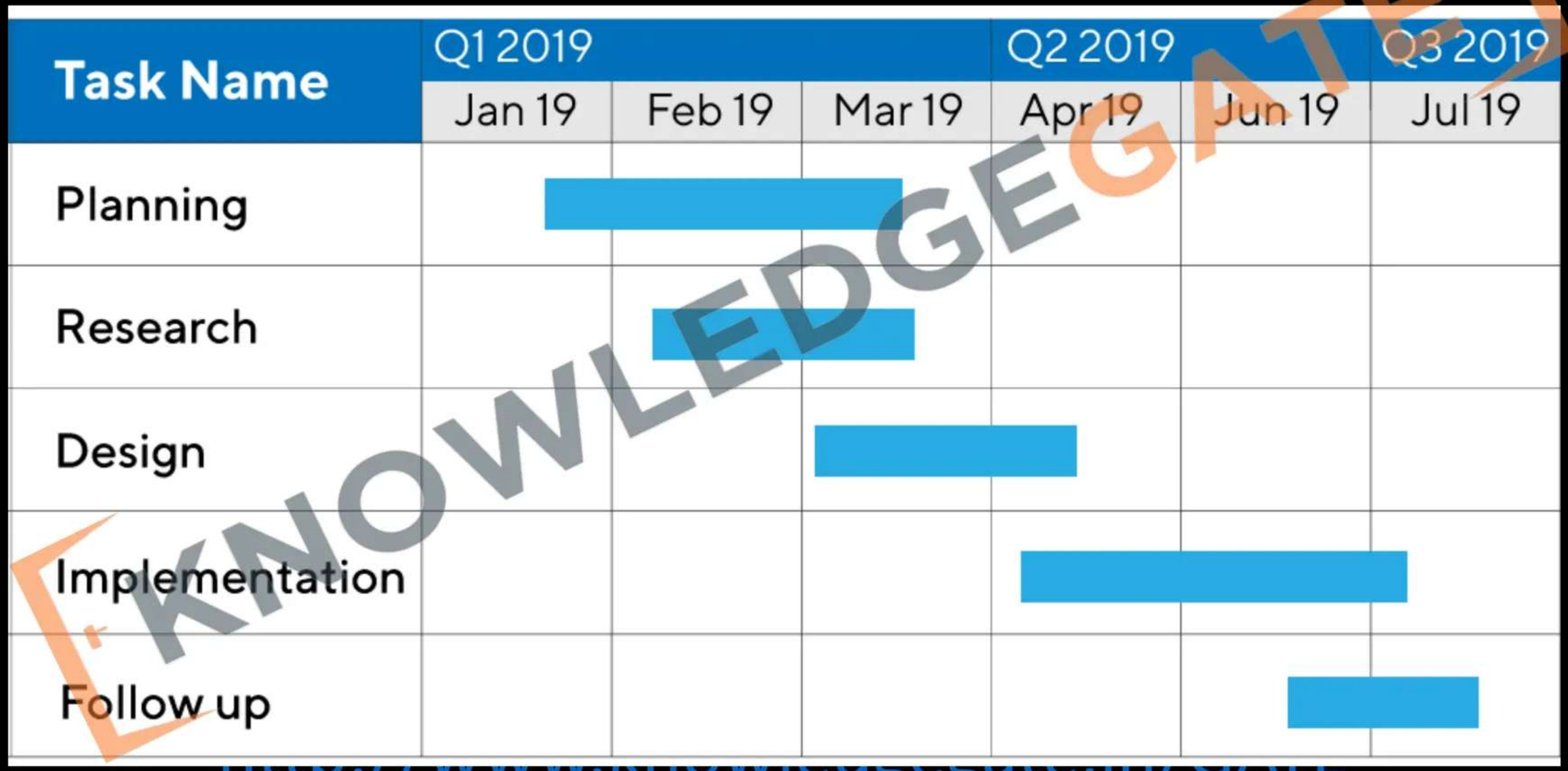
- **Gantt Chart**: It's a type of bar chart that illustrates a project schedule. This chart lists the tasks to be performed on the vertical axis, and time intervals on the horizontal axis.



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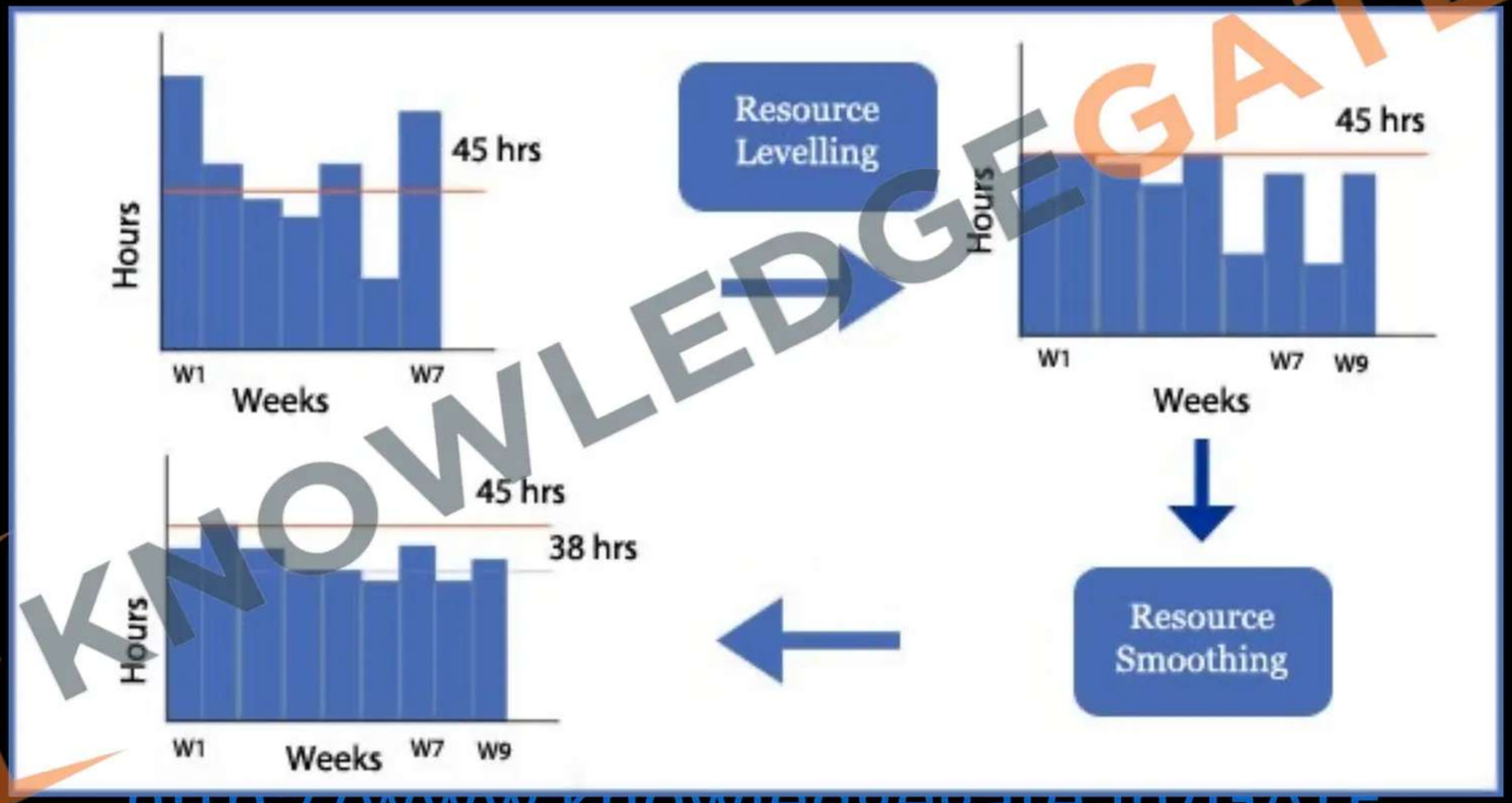
- **Resource Leveling**: Also known as resource smoothing, it's a technique in project management that involves adjusting the project schedule to balance the demand for project resources with the available supply.



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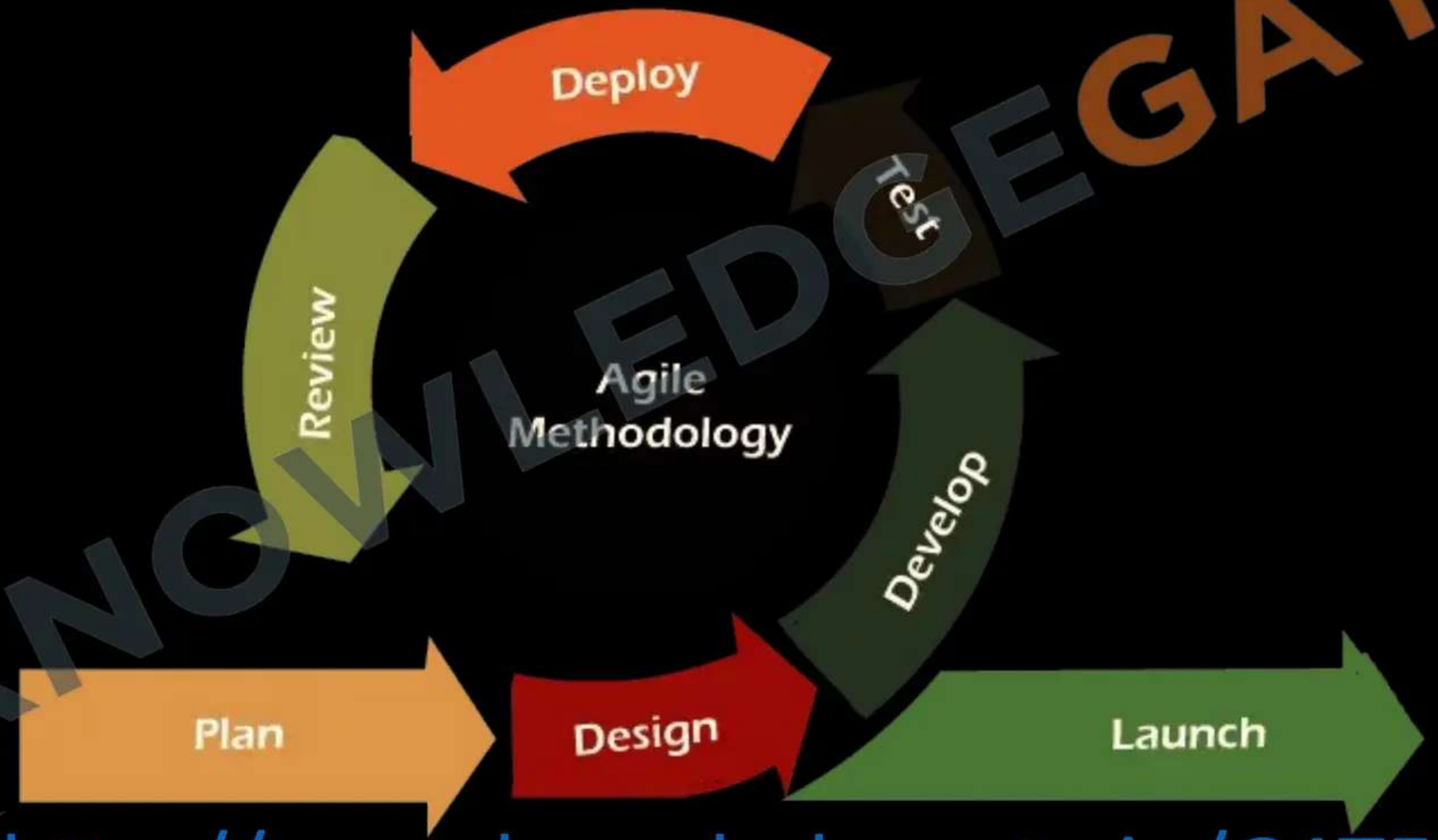
- **<u>Allocation Models in Agile Methodology</u>**: In agile teams, resources might be allocated based on different factors such as team velocity, priority of user stories, and size of tasks.



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Software Risk Analysis and Management

- Risk management is the process of identifying risk, assessing risk hat could negatively impact a software project's success and taking steps to reduce this to acceptable level.

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- Here are the key components:
  - **Risk Identification**: This is the initial process of determining risks that could potentially prevent the program, enterprise, or investment from achieving its objectives. It includes documenting and communicating the concern.

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- **Risk Analysis**: Once risks are identified, they are analyzed to identify the qualities of the risk such as its likelihood of occurrence, severity of impact, what precipitates the risk, and other characteristics. This can be done quantitatively or qualitatively.

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- **Risk Assessment/Evaluation**: This involves comparing the identified and analyzed risk against predefined criteria such as acceptable risk levels and priorities. It's used to make decisions about the impact of the risk and whether it's acceptable or if it needs to be treated.

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- **Risk Mitigation**: This is the process of prioritizing, evaluating, and implementing actions that reduce or control the risks. It can involve risk avoidance, risk transfer, risk acceptance, or risk limitation.

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- **Risk Monitoring**: This is the process of monitoring identified and mitigated risks, as well as identifying new risks. This is an ongoing process throughout the lifecycle of the project.

- In a nutshell, Software Risk Analysis and Management aims to anticipate what might not go as planned and prepare a response to those scenarios, so that action can be taken to resolve risk events that do occur or to minimize their impact.

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