Dr. Vishwanath Karad
MIT WORLD PEACE UNIVERSITY | PUNE
TECHNOLOGY, RESEARCH, SOCIAL INNOVATION & PARTNERSHIPS

Unit-III

System Development Life Cycle (SDLC)

Prof. Shankar Mali

The Software Process

- A process is a collection of activities, actions and tasks that are performed when some work product is to be created.

- Framework is a Standard way to build and deploy applications. Software Process Framework is the foundation of complete software engineering process. Software process framework includes set of all umbrella activities. It also includes number of framework activities that are applicable to all software projects.

Definition of Software Process

- A **framework** for the activities, actions, and tasks that are required to build high-quality software.
- Software Process defines the approach that is taken as software is engineered.

Software Process Framework

A generic process framework encompasses five activities which are given below one by one:

Communication:

In this activity, heavy communication with customers and other stakeholders, as well as requirement gathering is done.

Planning:

In this activity, we discuss the technical related tasks, work schedule, risks, required resources, etc.

Modeling:

Modeling is about building representations of things in the 'real world'. In modeling activity, a product's model is created in order to better understand the requirements.

Software Process Framework

Construction:

In software engineering, construction is the application of set of procedures that are needed to assemble the product. In this activity, we generate the code and test the product in order to make better product.

Deployment:

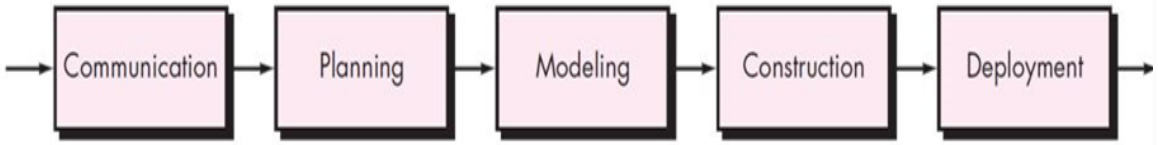
In this activity, a complete or non-complete product or software is represented to the customers to evaluate and give feedback. On the basis of their feedback, we modify the product for supply of better product.

A Generic Process Model

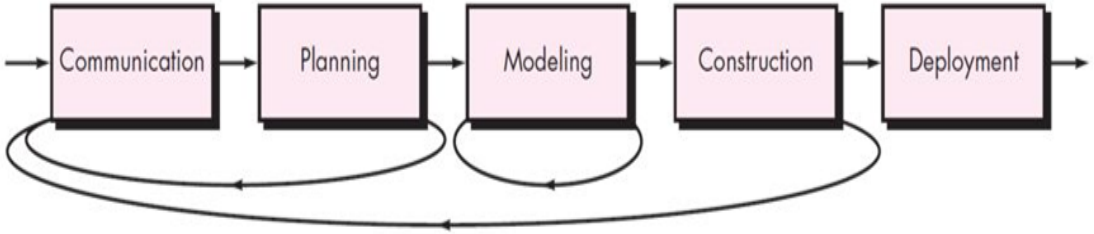
- A generic process framework for software engineering defines **five framework activities-communication, planning, modeling, construction, and deployment.**
- In addition, a set of umbrella activities- project tracking and control, risk management, quality assurance, configuration management, technical reviews, and others are applied throughout the process.
- Next question is: how the framework activities and the actions and tasks that occur within each activity are organized **with respect to sequence and time**?

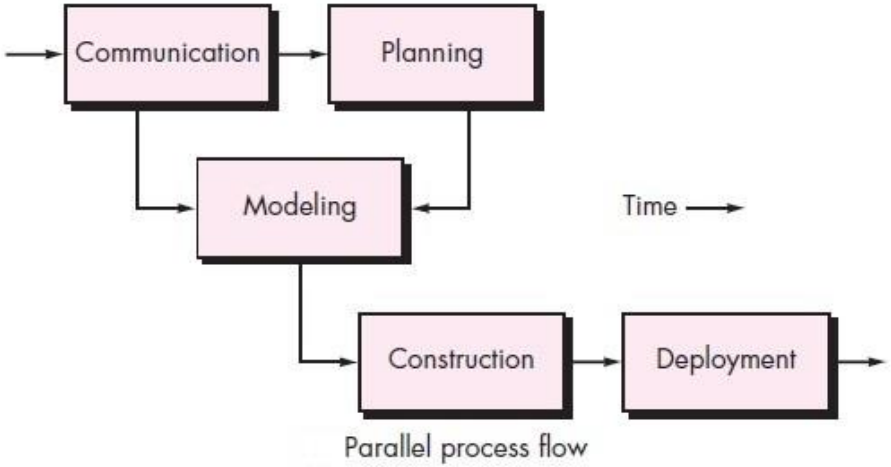
Process Flow

- Linear process flow

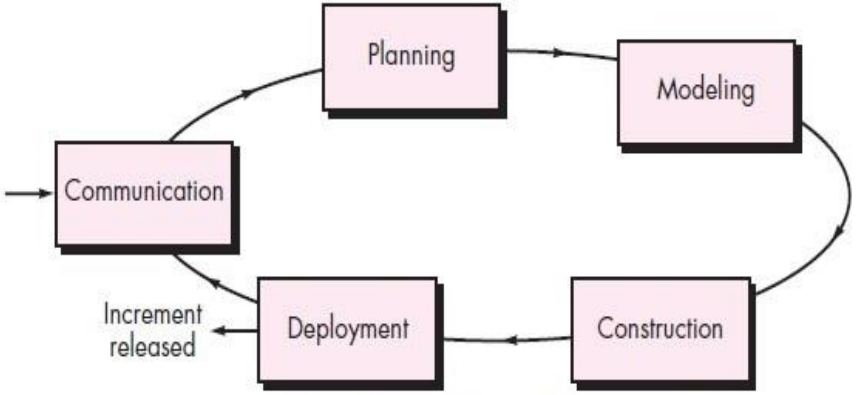


- Iterative process flow





Parallel process flow



Evolutionary process flow

3

Process Flow

- Linear process flow executes each of the five activities in sequence.
- An iterative process flow repeats one or more of the activities before proceeding to the next.
- An evolutionary process flow executes the activities in a circular manner. Each circuit leads to a more complete version of the software.
- A parallel process flow executes one or more activities in parallel with other activities (modeling for one aspect of the software in parallel with construction of another aspect of the software).

Adapting a Process Model

Depends on :

- overall flow of **activities, actions, and tasks** and the interdependencies among them
- the degree to which actions and tasks are defined within each framework activity
- the degree to which work products are identified and required
- the manner which quality assurance activities are applied
- the manner in which project tracking and control activities are applied
- the overall degree of detail and rigor with which the process is described
- the degree to which customer and other stakeholders are involved with the project
- the level of autonomy given to the software team
- the degree to which team organization and roles are prescribed

Prescriptive Models & Specialized Process Models

WATERFALL MODEL

INCREMENTAL PROCESS MODEL

- The Incremental Model
- The RAD Model

EVOLUTIONARY PROCESS MODELS

- Prototyping.
- The Spiral model
- The Concurrent Development Model

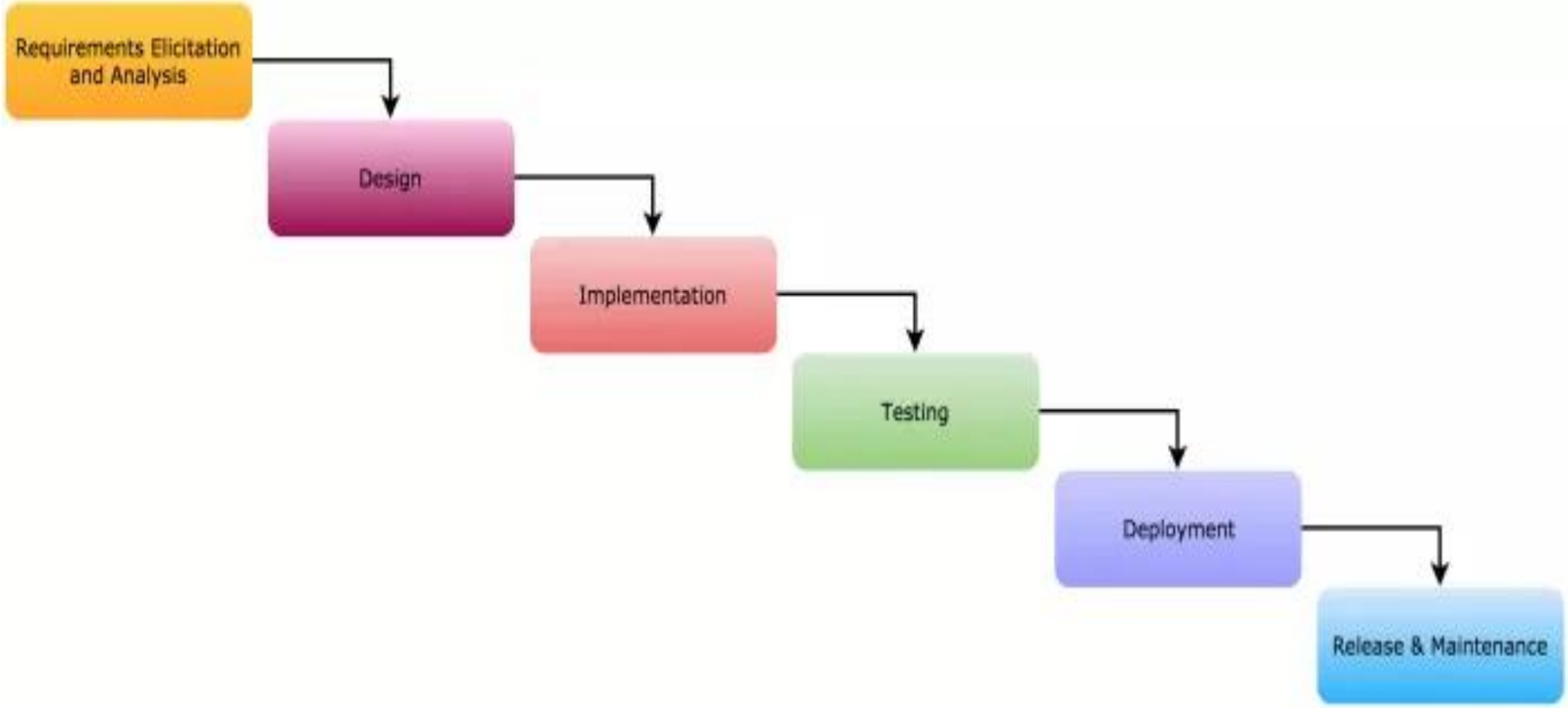
SPECIALIZED PROCESS MODELS.

- Component-based Development
- The Formal Methods Model
- Aspect-Oriented Software Development

THE UNIFIED PROCESS.

AGILE PROCESS

The Waterfall Model



The Waterfall Model

1) **Requirement Gathering and analysis**: Here requirements of the system or project that is to be developed are captured from client and all these requirements are documented in a requirement specification document to prepare a SRS. This SRS is verify by the client and after acceptance next phase begins.

2) **System Design**: Here a design of the system is prepared. Plan system hardware and software requirements. It helps in defining the overall system architecture.

3)**Implementation**: Once the design of a system is prepared, the system is broken into small programs called units, which are integrated in the next phase. In this phase the software is coded and simple unit testing is performed.

The Waterfall Model

4)**Testing**: After testing all the units are integrated into a system and system testing is performed. This is used to find any bugs or failure in the system or to verify that system is built as per the requirements of client.

5)**Deployment**: Once the testing phase is done, the product or software is deployed or installed in the customer environment.

6)**Maintenance:** Maintenance is required to fix the issues and to release improved versions to enhance the product.

The Waterfall Model

Advantages:

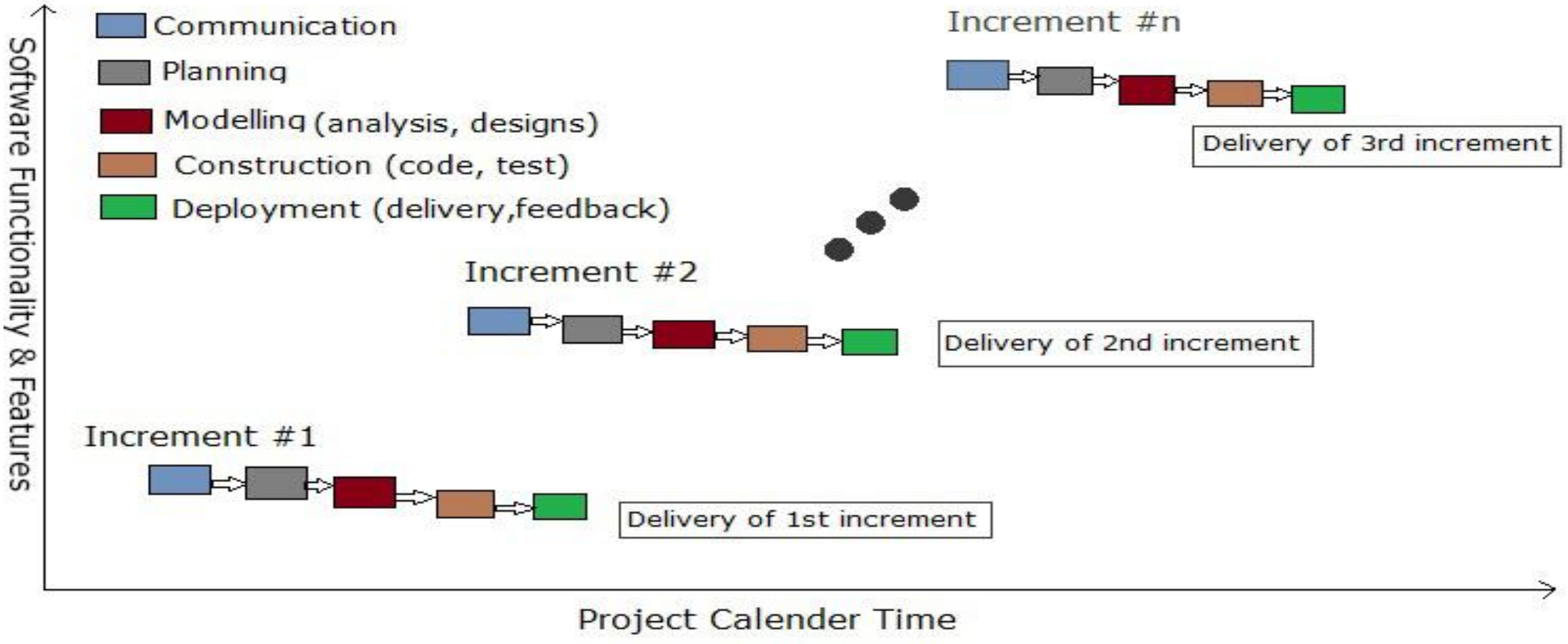
- Model is simple, easy to understand.
- Waterfall model is useful for smaller projects and it gives an appropriate result.
- System Requirements are documented and understood by projects team members
- Each phase works independently and do not overlap the other phases.
- Customer interaction is only at in the beginning and at the last phase of the project.

The Waterfall Model

Problems/Disadvantages:

- This model is not desirable for complex and bigger project where requirement changes frequently and risk factor is higher.
- This model also not good for ongoing projects.
- Customer interaction is less and it cannot adopt the changes in system requirements.
- This model requires more documentation which is not suitable for big projects.
- Customer feedback only at the end of the product.
- Small change makes lot of problems in the development

The Incremental Model



Incremental model

- The incremental model applies the waterfall model incrementally.
- The series of releases is referred to as "**increments**", each increment providing more functionality to the customers.
- The product is defined as finished only when it satisfies all of its requirements.
- It involves both development and maintenance.
- After **the first increment**, a **core product** is delivered, which can already be used by the customer. Based on customer feedback, a plan is developed for the next increments, and modifications are made accordingly.
- The incremental philosophy is also used in the **agile process model**.

Incremental model: Characteristics

Characteristics of Incremental Model

1. System is broken down into many **mini development projects**.
2. Partial systems are built to produce the final system.
3. First tackled **highest priority requirements.**
4. The requirement of a portion is frozen **once the incremented portion is developed**.

Tasks involved:

Communication: helps to understand the objective.

Planning: required as many people (software teams) work on the same project but different function at same time.

Modeling: involves business modeling, data modeling, and process modeling.

Construction: this involves the reuse software components and automatic code.

Deployment: integration of all the increments

Advantages & Disadvantages

Advantages of Incremental model:

i) Generates working software quickly and early during the software life cycle.

ii) This model is more flexible – less costly to change scope and requirements.

iii) It is easier to test and debug during a smaller iteration.

iv) In this model customer can respond to each built.

v) Lowers initial delivery cost.

Disadvantages of Incremental model:

i) Needs good planning and design.

ii) Needs a clear and complete definition of the whole system before it can be broken down and built incrementally.

iii) Total cost is higher than other traditional model

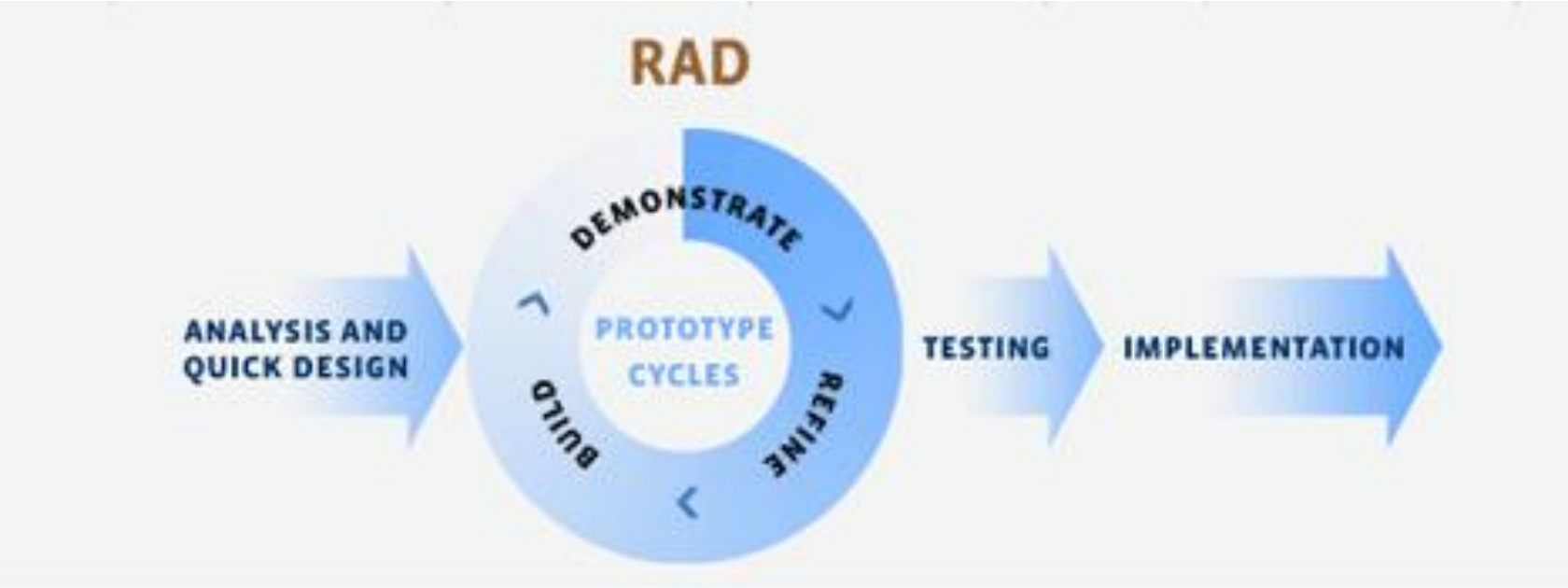
When to use Incremental Model ?

- When the requirements of the complete system are clearly defined and understood.
- Major requirements are defined; however, some details can evolve with time.
- There is a need to get a product to the market early.
- A new technology is being used
- Resources with needed skill set are not available
- There are some high risk features and goals.

RAD Model

- RAD is a **Rapid Application Development model**.
- Using the RAD model, software product is developed in a **short period** of time.
- The initial activity starts with the **communication** between customer and developer.
- **Planning** depends upon the initial requirements and then the requirements are divided into groups.
- Planning is more important to work together on different modules
- Rapid application development emphasizes working software and user feedback over strict planning and requirements recording.

RAD Model


RAD
ANALYSIS AND QUICK DESIGN
DEMONSTRATE
REFINE
BUILD
PROTOTYPE CYCLES
TESTING
IMPLEMENTATION

RAD Model

1. **Figure out the requirements : Identify why the** software or app is built and what the project is supposed to accomplish.

Involve users, developers, and designers to discuss the purpose of the system and a estimated project timeline. The budget is a strong constraint.

2. Build prototypes: Team will start working on building functional models right away. The engineers and designers will create and improve upon working prototypes

3. Get user feedback :

RAD calls for ongoing collaboration between your team and users in order to create a high-quality system. The users will be the ones providing feedback to improve your prototypes.

A general model of the design process

4. Do it again : Repeat steps two and three until you feel like your project is done or until you have all working parts assembled together to meet a client's requirements.

5. Test, test, test :

Run the system through different scenarios and make sure it accomplishes the system's goal.

RAD Model

Advantages of RAD Model

- The process of application development and delivery are **fast**.
- This model is **flexible**, if any **changes** are required.
- Reviews are taken from the clients at the staring of the development hence there are lesser chances to miss the requirements.
- Always having something to show your client means you can get their **feedback** and quickly implement any changes

Disadvantages of RAD Model

- The **feedback** from the user is required at **every development phase**.
- This model is not a good choice for **long term and large projects**.

When is RAD useful?

- When a **quick delivery** of a product is needed for a customer.
- When there are **going to be changes** made to the prototype throughout the process before the final product is completed.
- When there are plenty of **knowledgeable developers and engineers** on hand and the customer must also remain committed to the process and the schedule.
- When either of these two components is not available, the RAD formula can fail.

Evolutionary Process Models

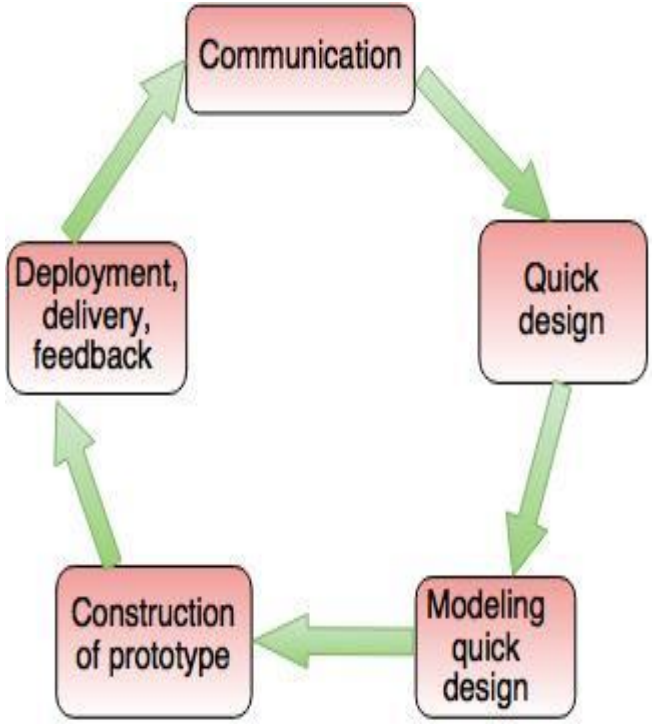
- This model divides the development cycle so that users are able to get access to the product at the end of each cycle.
- Evolutionary models are iterative type models.
- They allow to develop more complete versions of the software.
- The users provide feedback on the product for planning stage of the next cycle and the development team responds, often by changing the product, plans or process.

Following are the evolutionary process models.

1. The prototyping model
2. The spiral model
3. Concurrent development model

Evolutionary Models: Prototyping

- Prototype is defined as first or preliminary form using which other forms are copied or derived.
- Prototype model is a set of **general objectives** **for software**.
- It does **not identify** the requirements like detailed input, output.
- It is software working model of limited functionality.
- Working programs are quickly produced.



Construction of prototype

Fig. - The Prototyping Model

Prototyping Model

1.Communication: Developer and customer meet and discuss the overall objectives

2. Quick design

- Quick design is implemented when requirements are known.
- It includes only the important aspects like input and output format of the software and focusses on those aspects which are visible to the user rather than the detailed plan.
- It helps to construct a prototype.

3. Modeling quick design

- This phase gives the clear idea about the development of software
- It allows the developer to better understand the exact requirements.

4. Construction of prototype

- The prototype is evaluated by the customer itself.

5. Deployment, delivery, feedback

- If the user is not satisfied then it refines according to the requirements of the user.
- The process of refining the prototype is repeated until all the requirements of users are met.
- When the users are satisfied with the developed prototype then the system is developed on the basis of final prototype.

Prototyping Model

Advantages of Prototyping Model

- Prototype model need not know the detailed input, output, processes, adaptability of operating system and full machine interaction.
- In the development process of this model **users are actively involved**.
- The development process is the best platform to understand the system by the user.
- Errors are detected much earlier.
- Gives quick user feedback for better solutions.
- It identifies the missing functionality easily and identifies confusing or difficult functions.

Disadvantages of Prototyping Model:

- The client involvement is more and it is not always considered by the developer.
- It is a slow process because it takes more time for development.
- Many changes can disturb the rhythm of the development team.
- It is a thrown away prototype when the users are confused with it.

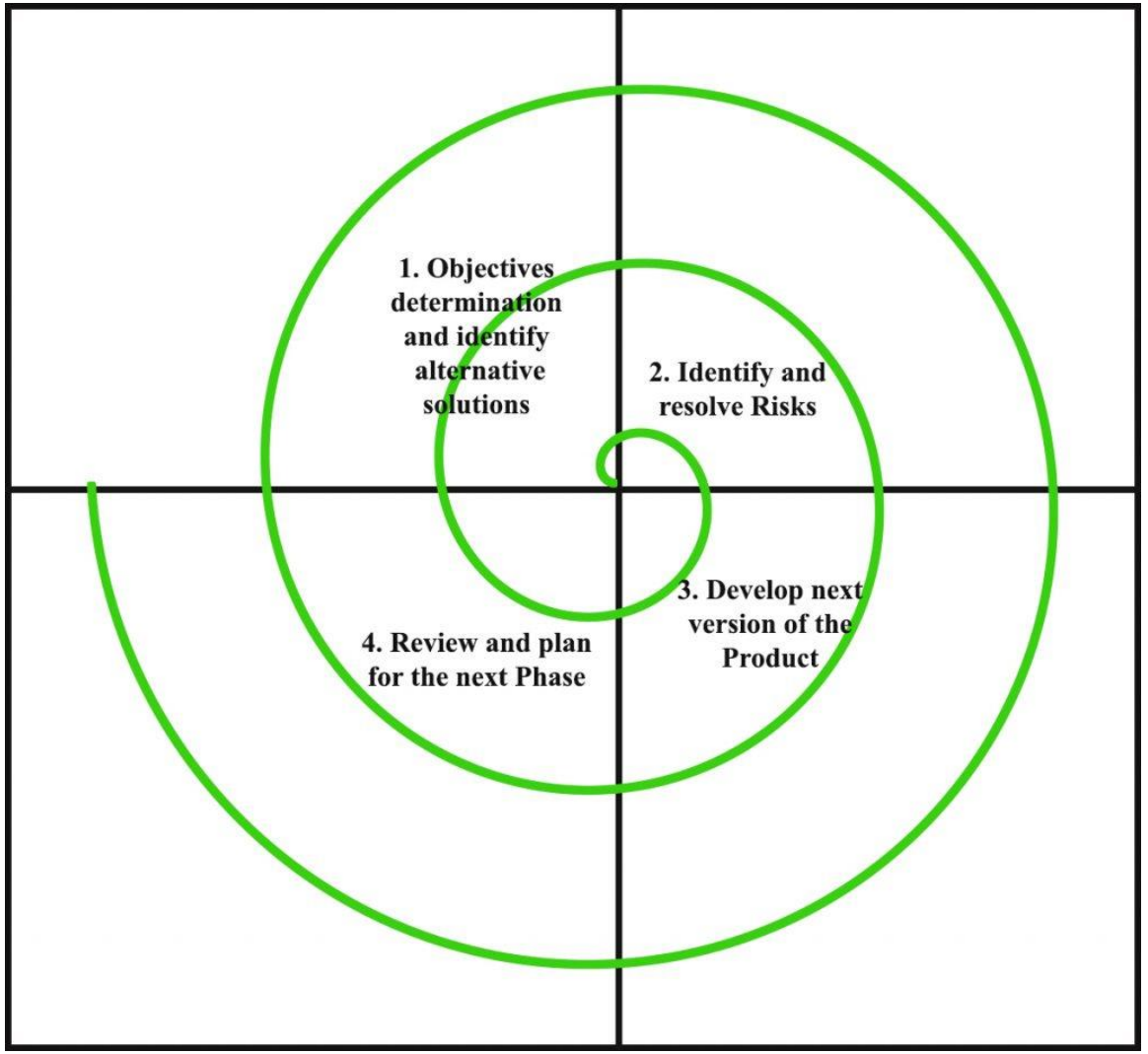
Prototype vs Incremental Model

- Prototype Model: Instead of freezing the requirements before a design or coding can proceed, a throwaway prototype is built to understand the requirements.
- Incremental model : the whole requirement is divided into various builds. Multiple development cycles take place here, making the life cycle a “multi-waterfall” cycle. Cycles are divided up into smaller, more easily managed modules.

Spiral Model

- Spiral model is a risk driven process model -which means that the overall success of a project highly depends on the risks analysis phase.
- Requires skills and expertise.
- It is used for generating the large software projects.
- In spiral model, an alternate solution is provided if the risk is found in the risk analysis, then **alternate solutions** are suggested and implemented.
- It is a combination of prototype and sequential model or waterfall model.
- In one iteration all activities are done, for large project's the output is small.
- Turns out costlier

Spiral Model



Stages in Spiral Model

Each phase of the Spiral Model is divided into four quadrants as shown in the above figure. The functions of these four quadrants are discussed below-

Objectives determination and identify alternative solutions: Requirements are gathered from the customers and the objectives are identified, elaborated, and analyzed at the start of every phase. Then alternative solutions possible for the phase are proposed in this quadrant.

Identify and resolve Risks: During the second quadrant, all the possible solutions are evaluated to select the best possible solution. Then the risks associated with that solution are identified and the risks are resolved using the best possible strategy. At the end of this quadrant, the Prototype is built for the best possible solution.

Develop next version of the Product: During the third quadrant, the identified features are developed and verified through testing. At the end of the third quadrant, the next version of the software is available.

Review and plan for the next Phase: In the fourth quadrant, the Customers evaluate the so far developed version of the software. In the end, planning for the next phase is started.

Spiral model

- **Advantages of Spiral Model**
- It reduces high amount of risk.
- It is good for large and critical projects.
- It gives strong approval and documentation control.
- In spiral model, the software is produced early in the life cycle process.

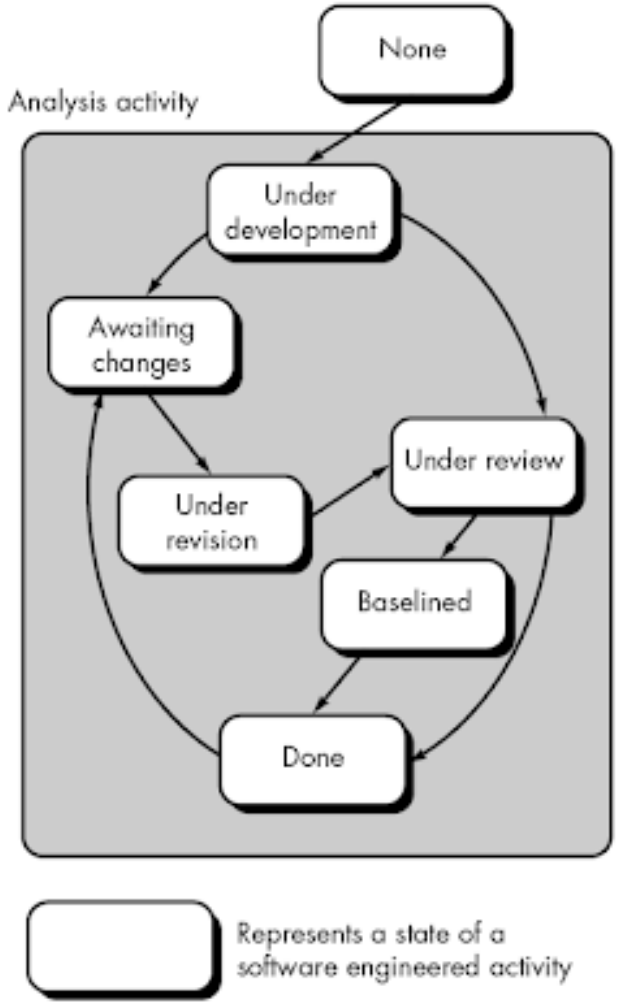
Disadvantages of Spiral Model

- It can be costly to develop a software model.
- It is not used for small projects.

Concurrent Development Model

- The *concurrent development model*, sometimes called *concurrent engineering*, can be represented schematically as a series of framework activities, Software engineering actions of tasks, and their associated states.
- The concurrent model is often more appropriate for system engineering projects where different engineering teams are involved and is more complex

Concurrent Development Model



Concurrent Development Model

- The activity—analysis—may be in any one of the states noted at any given time. Similarly, other activities (e.g., design or customer communication) can be represented in an analogous manner. All activities exist concurrently but reside in different states. For example, early in a project the customer communication activity (not shown in the figure) has completed its first iteration and exists in the awaiting changes state. The analysis activity (which existed in the none state while initial customer communication was completed) now makes a transition into the under development state. If, however, the customer indicates that changes in requirements must be made, the analysis activity moves from the under development state into the awaiting changes state.

concurrent development model

Advantages of the concurrent development model

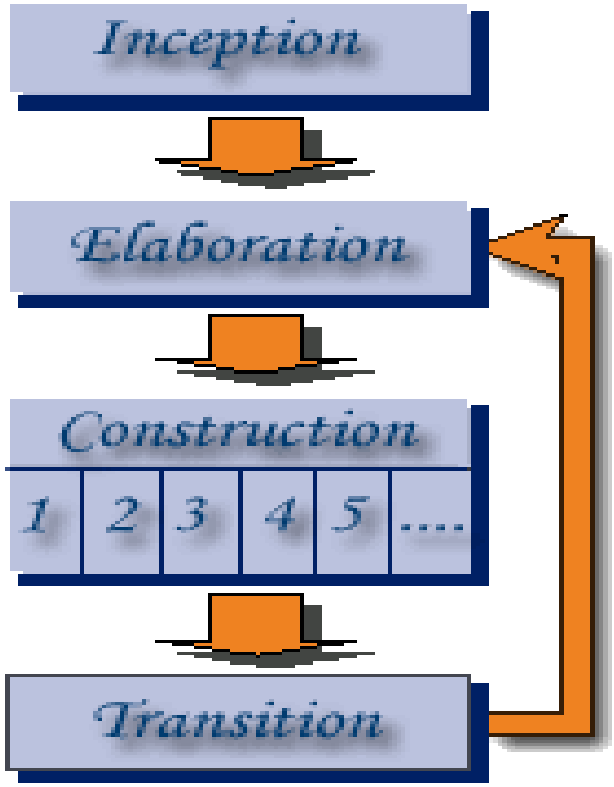
- This model is applicable to all types of software development processes.
- It is easy for understanding and use.
- It gives immediate feedback from testing.
- It provides an accurate picture of the current state of a project.

Disadvantages of the concurrent development model

- It needs better communication between the team members. This may not be achieved all the time.
- It requires to remember the status of the different activities.

The Unified Process

- Unified Process is based on the enlargement and refinement of a system through multiple iterations, with cyclic feedback and adaptation.
- The system is developed incrementally over time, iteration by iteration, and thus this approach is also known as iterative and incremental software development.
- The iterations are spread over four phases where each phase consists of one or more iterations



Inception

- Inception —the first and the shortest phase in the project. It is used to prepare basis for the project, including preparation of business case, establishing project scope and setting boundaries, outlining key requirements, and possible architecture solution together with design tradeoffs, identifying risks, and development of initial project plan—schedule with main milestones and cost estimates. If the inception phase lasts for too long, it is like an indicator stating that the project vision and goals are not clear to the stakeholders. With no clear goals and vision the project most likely is doomed to fail. At this scenario it is better to take a pause at the very beginning of the project to refine the vision and goals. Otherwise it could lead to unnecessary make-overs and schedule delays in further phases.

Elaboration

- Elaboration —during this phase the project team is expected to capture a majority of system's requirements (e.g., in the form of use cases), to perform identified risk analysis and make a plan of risk management to reduce or eliminate their impact on final schedule and product, to establish design and architecture (e.g., using basic class diagrams, package diagrams, and deployment diagrams), to create a plan (schedule, cost estimates, and achievable milestones) for the next (construction) phase.

Construction

- Construction —the longest and largest phase within Unified Process. During this phase, the design of the system is finalized and refined and the system is built using the basis created during elaboration phase. The construction phase is divided into multiple iterations, for each iteration to result in an executable release of the system. The final iteration of construction phase releases fully completed system which is to be deployed during transition phase, and

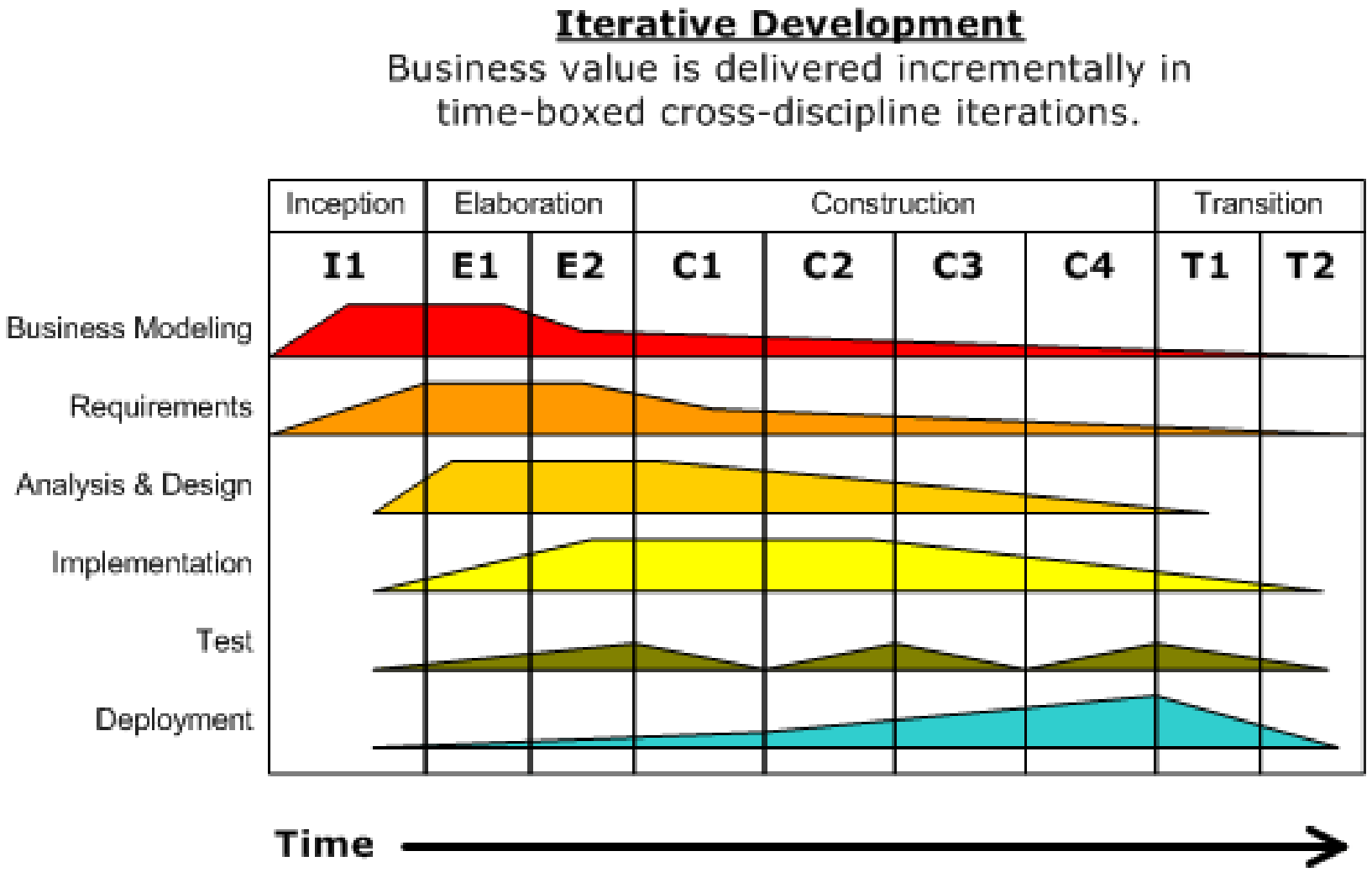
Transition

- Transition —the final project phase which delivers the new system to its end-users. Transition phase includes also data migration from legacy systems and user trainings.

Phases in the Unified Process

- The disciplines and phases of Unified Process are given in Fig. where the phases are columns and the disciplines are rows. It clearly shows that the relative effort across disciplines changes over time from iteration to iteration, e.g., initial iterations apply greater relative effort on requirements and design while the latter—more on testing and deployment.

Phases in the Unified Process (Cont...)



Static workflows in the Unified Process

This focuses on activities that take place during the development process – and called workflows

There are six core process workflows identified in the process and three core supporting workflows.

Workflow	Description
Business modelling	The business processes are modelled using business **use cases**.
Requirements	Actors who interact with the system are identified and use cases are developed to model the system requirements.
Analysis and design	A design model is created and documented using architectural models, component models, object models and sequence models.
Implementation	The components in the system are implemented and structured into implementation sub-systems. Automatic code generation from design models helps accelerate this process.

Static workflows in the Unified Process

Workflow	Description
Testing	Testing is an iterative process that is carried out in conjunction with implementation. System testing follows the completion of the implementation.
Deployment	A product release is created, distributed to users and installed in their workplace.
Configuration and change management	This supporting workflow managed changes to the system
Project management	This supporting workflow manages the system development
Environment	This workflow is concerned with making appropriate software tools available to the software development team.

Unified Process good practice

- **Develop software iteratively :** Plan increments based on customer priorities and deliver highest priority increments first.
- **Manage requirements :**Explicitly document customer requirements and keep track of changes to these requirements.
- **Use component-based architectures :**Organize the system architecture as a set of reusable components.
- **Visually model software :** Use graphical UML models to present static and dynamic views of the software.
- **Verify software quality:** Ensure that the software meet's organizational quality standards.
- **Control changes to software :**Manage software changes using a change management system and configuration management tools.

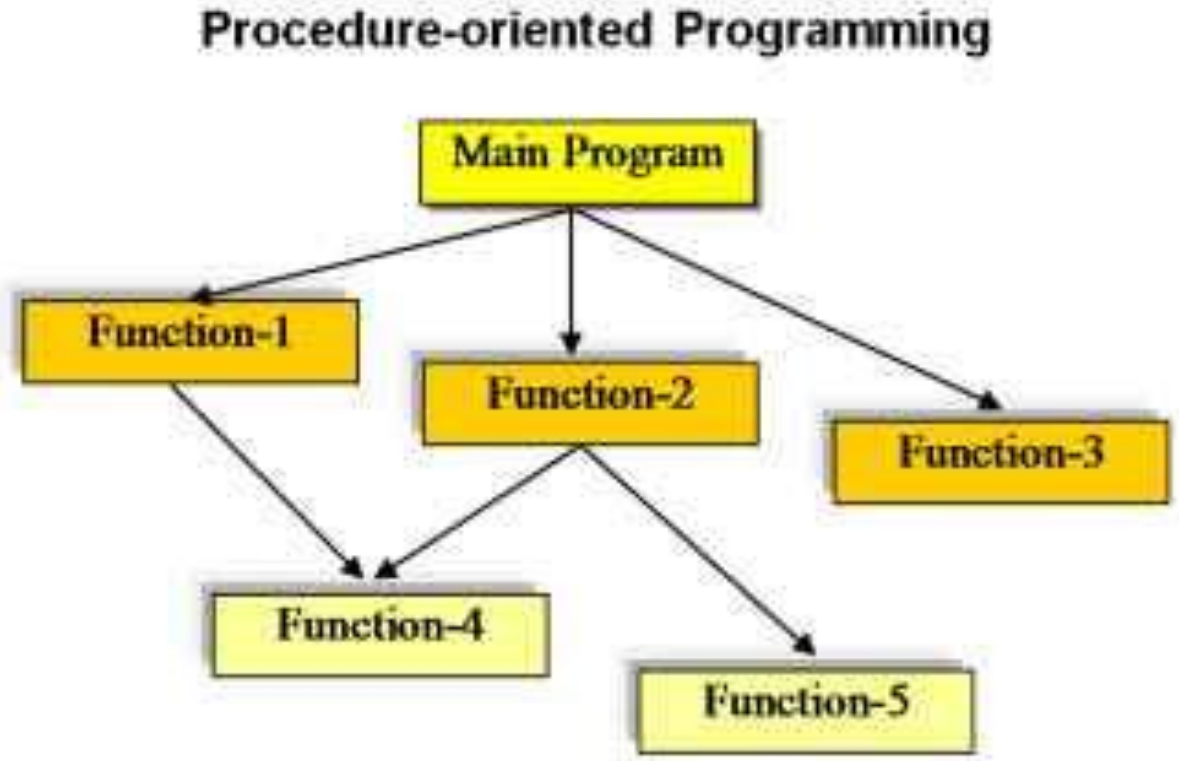
How to choose an appropriate process model?

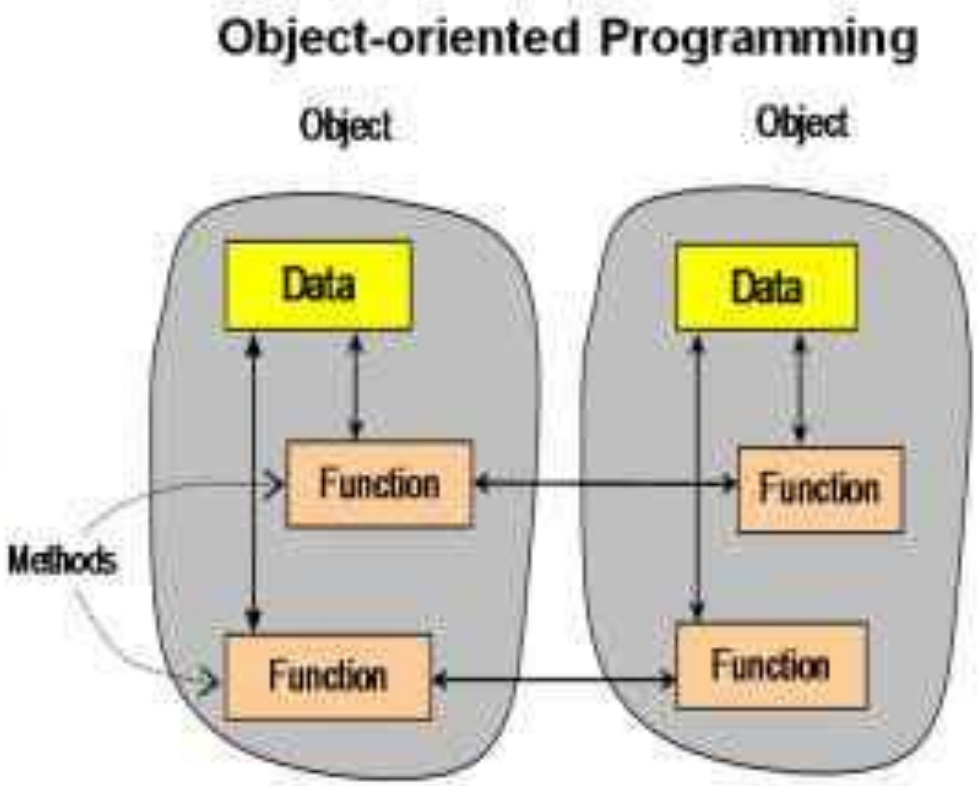
- **Characteristics of the software to be developed:** . for product and embedded development, the Iterative Waterfall model can be preferred. The evolutionary model is suitable to develop an object-oriented project. User interface part of the project is mainly developed through prototyping model.
- **Characteristics of the development team:** If the development team is experienced in developing similar software, then even an embedded software can be developed using the Iterative Waterfall model. If the development team is entirely novice, then even a simple application may require a prototyping model.
- **Risk associated with the project:** If the risks are few and can be anticipated at the start of the project, then prototyping model is useful. If the risks are difficult to determine at the beginning of the project but are likely to increase as the development proceeds, then the spiral model is the best model to use.
- **Characteristics of the customer:** If the customer is not quite familiar with computers, then the requirements are likely to change frequently as it would be difficult to form complete, consistent and unambiguous requirements. Thus, a prototyping model may be necessary to reduce later change requests from the customers.
  - the evolutionary model is useful as the customer can experience a partially working software much and reduces the customer's trauma of getting used to an entirely new system.

Summary

- Process is a means to achieve project objectives of high Quality
- Software process models are abstract representations of these processes
- Process models define generic process, which can form basis of project process
- Process typically has stages, each stage focusing on an identifiable task
- Many models for development process have been proposed
- Waterfall model, Evolutionary development and component-based software Engineering, Iterative process models are some process model.
- The Rational Unified Process is a generic process model that separates activities from phases
- A prototype can be used to give end-users a concrete impression of the system's capabilities

Structured Vs Object Oriented Programming





Structured Vs Object Oriented Programming

- Definition

Structured programming is a programming paradigm which divides the code into modules or function, while OOP is a programming paradigm based on the concept of objects, which contain data in the form of fields known as attributes, and code in the form of procedures known as methods. Thus, this explains the main difference between structured and object oriented programming.

- Main Focus

Furthermore, structured programming focuses on dividing the program into a set of functions in which each function works as a subprogram while object oriented programming focuses on representing a program using a set of objects which encapsulates data and object.

- Modification

Moreover, it is difficult to modify the structured programs while it is easier to modify the Object Oriented programs.

Structured Vs Object Oriented Programming

- Communication

In structured programming, the main method communicates with the functions by calling those functions in the main program whereas, in object oriented programming, the objects communicate with each other by passing messages. Hence, this is an important difference between structured and object oriented programming.

- Access Specifiers
- There are no access specifiers in structured programming while there are access specifiers such as private, public and protected in Object Oriented Programming. Thus, this is also an important difference between structured and object oriented programming.
- Security
- Besides, data is not secure in structured programming, but it is secure in object oriented programming.

Structured Vs Object Oriented Programming

- Code Reusability

Also, it is difficult to reuse code in structured programming, whereas it is easier to reuse code in object oriented programming.

- Conclusion

Overall, structured and object oriented programming are two major programming paradigms. The main difference between structured and object oriented programming is that structured programming helps to develop a program using a set of modules or functions while object oriented programming helps to construct a program using a set of objects and their interactions.

Sr.No	Comparison Parameter	Procedural Programming	Object-Oriented Programming
1	Definition	Based on the concept of a Procedure call, Procedural Programming is one type of programming paradigm or programming model based on Structured Programming.	Based on the concept of Object, which contains data and code, Object-Oriented Programming is one type of programming paradigm or programming model.
2	Short-Form	Procedural Oriented Programming Model is called as POP.	Object-Oriented Programming Model is called as OOP.
3	Approach	POP follows Top-Down approach.	OOP follows Bottom-Up approach.
4	Access Modifiers	POP languages do not support any kind of access modifiers.	OOP languages supports different kinds of access modifiers. Example: Java supports access modifiers like public, private, and protected.
5	Security	Due to unavailability of any kind of access modes, POP is less secure.	Due to availability of access modifiers classes can contain private variables and methods, hence OOP is more secure.

Sr.No	Comparison Parameter	Procedural Programming	Object-Oriented Programming
6	Main Concept	Main concept of POP is Procedures. Procedures are sequence of actions that need to be performed. Data is generally stored in variables in the form of Methods.	Main concept of OOP is Objects and classes. Data is generally stored in the form of Attributes and in the terms of objects.
7	Importance	Key Difference between both the approaches is the importance, In POP, importance is given to the functions over data. Importance is given to the sequence that need to be followed.	In OOP, importance is given to the data, the way one stores the data and how securely data is accessed. Security and accessibility of data is very important aspect in OOP.
8	Real World Orientation	POP is not inclined with real world orientation because while understanding POP concepts, one cannot relate it with real world examples.	OOP approach itself is derived from looking at real world examples. Hence, OOP concepts can easily be understood using comparison with real world.

Sr.No	Comparison Parameter	Procedural Programming	Object-Oriented Programming
9	Complexity	POP programs is less complex to write because there is no need to define classes or access specifiers. But after writing once, it is hard to read the program or to update the program relative to OOP.	OOP program is relatively complex to write because of availability of classes, Inheritance, access specifiers and other OOP paradigms. But it is easy to update the program or read the program.
10	Data Movement	Data can move freely from one function to another because there is not any access specifiers.	Data cannot move freely in OOP because of access specifiers. But objects can communicate with each other through member functions.
11	Data Sharing	Data can be shared with global scope or local scope.	Data can be shared with global, local, and class level scope.
12	Code Reusability	Code reusability is very limited in POP. It can only be achieved through functions.	Code reusablitity is one of the aim of OOP. It can be achieved using the concept of Inheritance.

Sr. No	Comparison Parameter	Procedural Programming	Object-Oriented Programming
13	Overloading	The concept of overloading is not present in POP.	The overloading can be achieved in the form of Operator-Overloading and Function-Overloading in OOP.
14	Virtual Function and Virtual Classes	Concept of virtual function or virtual classes is not available in POP.	There are many object-oriented programming systems available that uses virtual functions and virtual classes.
15	Size Of Problem	POP is generally preferred when the size of the problem is very small.	OOP is preferred when one have to implement large tasks and systems.
16	Speed	POP program generally runs faster than OOP.	OOP is relatively slow in execution compared to POP.
16	Programming Languages	POP languages: C, COBOL, Pascal, FORTRAN, BASIC, etc.	OOP Languages: C++, Python, Java, Kotlin, JavaScript, Dart, Solidity, etc.

References

- Roger S Pressman, Software Engineering: A Practitioner's Approach, Mcgraw-Hill, ISBN: 0073375977, Seventh Edition, 2014

- Pankaj Jalote, Software Engineering: A Precise Approach, Wiley India.2010.

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Unit-I End