ਜਗਤ ਗੁਰੂ ਨਾਨਕ ਦੇਵ
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ਪਟਿਆਲਾ

JAGAT GURU NANAK DEV
PUNJAB STATE OPEN UNIVERSITY, PATIALA

(Established by Act No. 19 of 2019 of the Legislature of State of Punjab)

The Motto of the University

(SEWA)

SKILL ENHANCEMENT EMPLOYABILITY WISDOM ACCESSIBILITY

B.Sc. (Data Science)
Discipline Specific Elective (DSE)
Semester V
Course: Software Project Management
Course Code: BSDB33503T

ADDRESS: C/28, THE LOWER MALL, PATIALA-147001
WEBSITE: www.psou.ac.in

The Study Material has been prepared exclusively under the guidance of Jagat Guru Nanak Dev Punjab State Open University, Patiala, as per the syllabi prepared by Committee of Experts and approved by the Academic Council.

JAGAT GURU NANAK DEV PUNJAB STATE OPEN UNIVERSITY PATIALA

(Establised by Act No.19 of 2019 of Legislature of the State of Punjab)

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	Section-B

JAGAT GURU NANAK DEV PUNJAB STATE OPEN UNIVERSITY PATIALA

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PREFACE

Jagat Guru Nanak Dev Punjab State Open University, Patiala was established in Decembas 2019 by Act 19 of the Legislature of State of Punjab. It is the first and only Open Universit of the State, entrusted with the responsibility of making higher education accessible to all especially to those sections of society who do not have the means, time or opportunity to pursue regular education.

In keeping with the nature of an Open University, this University provides a flexible education system to suit every need. The time given to complete a programme is double the duration of a regular mode programme. Well-designed study material has been prepared in consultation with experts in their respective fields.

The University offers programmes which have been designed to provide relevant, skill-based and employability-enhancing education. The study material provided in this booklet is self instructional, with self-assessment exercises, and recommendations for further readings. The syllabus has been divided in sections, and provided as units for simplification.

The Learner Support Centres/Study Centres are located in the Government and Government aided colleges of Punjab, to enable students to make use of reading facilities, and for curriculum-based counselling and practicals. We, at the University, welcome you to be a part of this institution of knowledge.

Prof. G. S. Batra,

Dean Academic Affairs

B.Sc. (Data Science)
Discipline Specific Elective (DSE)
Semester V
BSDB33503T: Software Project Management

Total Marks: 100
External Marks: 70
Internal Marks: 30
Credits: 4
Pass Percentage: 40%

Objective
To understand the fundamental principles of Software Project Management. This course will enable students to comprehend the fundamentals of managing and optimizing the software development process, contract administration, costing and budgeting.

INSTRUCTIONS FOR THE PAPER SETTER/EXAMINER
The syllabus prescribed should be strictly adhered to.
The question paper will consist of three sections: A, B, and C. Sections A and B will have four questions from the respective sections of the syllabus and will carry 10 marks each. The candidates will attempt two questions from each section.
Section C will have fifteen short answer questions covering the entire syllabus. Each question will carry 3 marks. Candidates will attempt any ten questions from this section.
The examiner shall give a clear instruction to the candidates to attempt questions only at one place and only once. Second or subsequent attempts, unless the earlier ones have been crossed out, shall not be evaluated.
The duration of each paper will be three hours.

INSTRUCTIONS FOR THE CANDIDATES
Candidates are required to attempt any two questions each from the sections A and B of the question paper and any ten short questions from Section C. They have to attempt questions only at one place and only once. Second or subsequent attempts, unless the earlier ones have been crossed out, shall not be evaluated.

Section - A

Unit -I Software Project Management, Project Evaluation and Planning - Activities in Software Project Management, Overview of Project Planning, Stepwise planning, Software processes and process models.

Unit -II Estimation and Budgeting of Projects, Cost Benefit Analysis, Cash Flow Forecasting, Cost-Benefit Evaluation Techniques, Risk Evaluation. Project costing, COCOMO 2, Staffing pattern, Effect of schedule compression.

Unit -III: Project Sequencing and Scheduling Activities, Scheduling resources, Critical path analysis, Network Planning, Risk Management, Managing Risks, Risk Planning and Control.

Unit -IV: Project Monitoring and Control- Collecting Data, Visualizing Progress, Cost Monitoring, review techniques, project termination review, Earned Value analysis.

Section- B

Unit -V: Configuration Management: Software Configuration Management (SCM) — Baselines, SCM Process; Version Control; Change Control; Configuration Audit; Status Reporting; Goals of SCM.

Unit VI: Team Development: Basic Concepts; Organization Types — Centralized-control team organization, Decentralized-control team organization, Mixed-control team organization; Dispersed and Virtual Teams, Communication Plans, Leadership.

Unit -VII: Agile Software Development: Scrum, Extreme Programming , Lean development, Kanban, DevOps. People Management- Introduction, Understanding Behavior, Organizational Behavior, Selecting the Right Person for The Job. Managing knowledge in Agile projects.

Unit -VIII: Software Quality Assurance: Software Quality Assurance Activities; Software Quality Standards — ISO Standard, Capability Maturity Model (CMM), Comparison between ISO 9001 & SEI CMM.

Suggested Readings

Zykov SV, Singh A, Agile Enterprise Engineering: Smart Application of Human Factors: Models, Methods,
Practices, Case Studies, Springer.
Royce, Software Project Management, Pearson Education. 1968
Ian Sommerville, Software Engineering, Seventh Edition, Pearson Education. 2005
R.S. Pressman, Software Engineering: A Practitioner's Approach, Sixth Edition, Tata McGraw-Hill, 2009

Unit-1

1.1 SOFTWARE PROJECT MANAGEMENT

1.2 PROJECT EVALUATION AND PLANNING

1.3 SOFTWARE PROCESSES AND PROCESS MODELS

1.1 SOFTWARE PROJECT MANAGEMENT

Software Project Management refers to the process of planning, organizing, and controlling the resources and activities involved in the development and maintenance of software projects. It encompasses the application of knowledge, skills, tools, and techniques to meet the specific goals of a software project within specified constraints, such as time, budget, and quality.

The primary objective of software project management is to successfully deliver software solutions that meet the client's requirements while adhering to the project's scope, schedule, and budget. It involves coordinating various activities, such as requirement analysis, design, coding, testing, deployment, and maintenance, while ensuring effective communication and collaboration among team members. The software project management includes following steps:

- **Planning:** Defining project objectives, scope, deliverables, and creating a comprehensive project plan. This involves identifying tasks, estimating resources, establishing timelines, and setting project milestones.
- **Risk Management:** Identifying potential risks and uncertainties that may impact project success. Risk management involves assessing risks, developing mitigation strategies, and monitoring and controlling risks throughout the project lifecycle.
- **Resource Management:** Allocating and managing resources effectively, including human resources, hardware, software, and facilities, to ensure the project's smooth execution.
- **Communication and Collaboration:** Facilitating effective communication and collaboration among team members, stakeholders, and clients. This includes regular status updates, progress reporting, and managing expectations.
- **Quality Management:** Ensuring that the software project meets the required quality standards and customer expectations. Quality management involves defining quality goals, establishing quality assurance processes, and conducting testing and reviews to identify and resolve defects.
- **Change Management:** Managing changes to project scope, requirements, or schedule, and assessing their impact on the project. Change management involves documenting and evaluating change requests, obtaining necessary approvals, and implementing changes effectively.
- **Monitoring and Control:** Monitoring project progress against the plan, tracking key metrics, and taking corrective actions to address deviations from the plan. This

includes monitoring project risks, budget, schedule, and quality, and adjusting the project plan as needed.

Effective software project management requires a combination of technical knowledge, leadership skills, and project management methodologies. Various project management frameworks, such as Agile, Waterfall, or Hybrid, can be applied depending on the project's requirements and characteristics. Additionally, project management tools and software are often used to facilitate planning, tracking, and collaboration among team members. Overall, software project management aims to ensure successful project outcomes by effectively managing resources, risks, schedules, and quality throughout the software development lifecycle.

1.1.1 SOFTWARE PROJECT MANAGEMENT TEAM

A software project management team is responsible for planning, executing, and controlling software development projects. The team typically consists of individuals with various roles and responsibilities, working together to ensure the successful completion of the project. Here are some key roles commonly found in a software project management team:

- **Project Manager:** The project manager is responsible for overall project planning, coordination, and execution. They define project objectives, create the project plan, allocate resources, monitor progress, manage risks, and ensure timely delivery of the software product. The project manager serves as the primary point of contact for stakeholders and facilitates effective communication among team members.
- **Business Analyst:** The business analyst gathers and analyzes user requirements, translates them into functional specifications, and ensures that the software solution aligns with the business needs. They act as a liaison between the project team and stakeholders, bridging the gap between technical and non-technical stakeholders.
- **Software Architect:** The software architect designs the overall structure and framework of the software solution. They make high-level design decisions, define the system architecture, and ensure that the software components and modules integrate seamlessly. The software architect guides the technical aspects of the project and collaborates with development teams.
- **Development Team:** The development team comprises software engineers, programmers, and developers who are responsible for coding, implementing, and testing the software solution. They follow the project plan, develop software modules

according to specifications, and ensure code quality and adherence to coding standards.

- **Quality Assurance (QA) Team:** The QA team is responsible for testing and ensuring the quality of the software solution. They develop test plans, execute test cases, identify and report defects, and collaborate with the development team to resolve issues. The QA team ensures that the software meets the specified requirements and adheres to quality standards.
- **User Experience (UX) Designer:** The UX designer focuses on creating an optimal user experience for the software solution. They conduct user research, design user interfaces, and ensure usability and accessibility. The UX designer collaborates with the development team to implement user-centric design elements.
- **Technical Leads:** Technical leads are experienced professionals who provide technical expertise and guidance to the development team. They assist in solving technical challenges, review code, ensure best practices are followed, and mentor team members. Technical leads play a crucial role in maintaining code quality and driving technical excellence.
- **Project Coordinator/Administrator:** The project coordinator or administrator supports the project manager by handling administrative tasks, scheduling meetings, managing project documentation, tracking project finances, and assisting in project reporting. They provide overall project coordination and ensure smooth project operations.

These roles may vary depending on the size and complexity of the software project. In smaller teams or organizations, some roles may be combined or performed by the same individuals. The effectiveness of the software project management team relies on the collaboration, communication, and collective expertise of its members in delivering successful software projects.

1.1.2 ROLE OF SOFTWARE PROJECT MANAGER

The role of a Software Project Manager is crucial in ensuring the successful planning, execution, and delivery of software development projects. Here are some key responsibilities and roles of a Software Project Manager:

1. **Project Planning and Scope Management:** The Project Manager is responsible for defining project objectives, scope, deliverables, and success criteria. They work closely with stakeholders to gather requirements, analyze them, and create a

comprehensive project plan. The Project Manager ensures that the project plan aligns with business goals, identifies dependencies, and manages scope changes effectively.

2. **Team Management:** The Project Manager is responsible for assembling and managing the project team. They assign tasks, set clear expectations, and ensure that the team has the necessary skills and resources to perform their roles effectively. The Project Manager fosters a positive team environment, promotes collaboration, and motivates team members to achieve project goals.
3. **Risk Management:** The Project Manager identifies and manages project risks. They conduct risk assessments, create risk mitigation strategies, and monitor risks throughout the project lifecycle. The Project Manager ensures that appropriate contingency plans are in place to address potential issues or challenges.
4. **Schedule and Time Management:** The Project Manager develops a project schedule, establishes milestones, and tracks progress against the plan. They identify critical paths, manage dependencies, and ensure that the project is progressing on time. The Project Manager handles time management, ensures adherence to deadlines, and takes corrective actions when necessary.
5. **Budget and Resource Management:** The Project Manager is responsible for managing the project budget and resources effectively. They estimate project costs, allocate resources, and track expenses. The Project Manager monitors resource utilization, manages vendor relationships, and ensures optimal utilization of available resources within budget constraints.

Figure2: Role of Software Project Manager

6. **Communication and Stakeholder Management:** The Project Manager serves as the primary point of contact for stakeholders. They establish communication channels, facilitate regular project status updates, and ensure effective communication between

team members, stakeholders, and management. The Project Manager manages stakeholder expectations, addresses concerns, and resolves conflicts.

7. **Quality Assurance and Quality Control:** The Project Manager is responsible for ensuring quality throughout the project lifecycle. They establish quality standards, define testing and quality assurance processes, and monitor the adherence to quality requirements. The Project Manager coordinates with the Quality Assurance team to plan and execute testing activities and ensure that deliverables meet the defined quality criteria.
8. **Project Reporting and Documentation:** The Project Manager maintains project documentation, including project plans, status reports, meeting minutes, and change requests. They provide regular project progress reports to stakeholders and management, highlighting achievements, risks, and issues. The Project Manager ensures that project documentation is organized, accessible, and up to date.
9. **Continuous Improvement:** The Project Manager promotes a culture of continuous improvement. They conduct project retrospectives, capture lessons learned, and implement process enhancements to improve project delivery efficiency and effectiveness. The Project Manager encourages innovation, fosters a learning environment, and shares best practices across the project team.

The role of a Software Project Manager requires a combination of technical expertise, leadership skills, and project management capabilities. They play a critical role in coordinating resources, managing risks, and ensuring successful software project outcomes.

1.2 PROJECT EVALUATION AND PLANNING

Software project evaluation and planning involve specific considerations and steps tailored to the unique characteristics of software development projects. Here are some key aspects to focus on in software project evaluation and planning:

1. **Requirements Gathering and Analysis:** Thoroughly understand the project requirements by engaging stakeholders and end-users. Gather and document functional and non-functional requirements, define use cases, and ensure clarity and completeness of the requirements.
2. **Technical Feasibility Assessment:** Evaluate the technical feasibility of the project by analyzing factors such as the availability of suitable technologies, required infrastructure, integration possibilities with existing systems, and scalability requirements.

3. **Resource Identification and Allocation:** Identify the necessary resources for the project, including software developers, testers, project managers, and other team members. Determine their roles, responsibilities, and allocation throughout the project's lifecycle.
4. **Project Methodology Selection:** Choose an appropriate software development methodology based on the project's requirements, team size, and complexity. Common methodologies include Waterfall, Agile (e.g., Scrum, Kanban), or a hybrid approach. Define the project management framework, communication channels, and workflow to be followed.
5. **Work Breakdown Structure (WBS) and Task Estimation:** Create a WBS by breaking down the project into smaller, manageable tasks. Estimate the effort, duration, and dependencies for each task using techniques like expert judgment, historical data, or parametric estimation. This helps in setting realistic timelines and allocating resources effectively.
6. **Risk Identification and Mitigation:** Identify potential risks and uncertainties specific to software projects, such as technical challenges, changes in requirements, or external dependencies. Assess the impact and likelihood of each risk and develop mitigation strategies to minimize their negative consequences.
7. **Quality Assurance and Testing Planning:** Define the testing approach, including types of testing (e.g., unit, integration, system, acceptance), test environments, and test data requirements. Establish quality assurance processes, including code reviews, automated testing, and continuous integration/continuous delivery (CI/CD) practices.
8. **Communication and Collaboration:** Establish effective communication channels within the project team and with stakeholders. Define the frequency and methods of communication, including regular progress meetings, status reports, and collaborative tools for documentation and sharing project artifacts.
9. **Project Tracking and Monitoring:** Establish mechanisms to track project progress, identify deviations from the plan, and take corrective actions when necessary. Use project management tools to monitor tasks, track milestones, manage risks, and ensure project documentation is up to date.
10. **Deployment and Rollout Planning:** Define the approach for software deployment, including user training, data migration, and system integration. Plan for post-deployment activities like user support, bug fixing, and ongoing maintenance.

Remember that the specific details and steps may vary based on the project's size, complexity, and organizational processes. Adapt the evaluation and planning activities to

align with the software development methodology chosen and the unique requirements of your project.

1.2.1 SOFTWARE PROJECT PLANNING

Software project planning involves the systematic and organized process of defining project objectives, scope, resources, timelines, and deliverables to ensure successful project execution. It sets the foundation for the entire software development lifecycle. Here is an overview of the key elements involved in software project planning:

1. **Project Objectives and Scope:** Clearly define the objectives and scope of the software project. Determine the desired outcomes, functionalities, and features that the software should deliver. Identify any constraints, limitations, or exclusions that define the boundaries of the project.
2. **Project Requirements:** Gather and document detailed requirements by engaging stakeholders and end-users. Understand their needs, expectations, and desired functionalities. Specify functional and non-functional requirements, including usability, performance, security, and scalability aspects.
3. **Work Breakdown Structure (WBS):** Break down the project into smaller, manageable tasks and components. Develop a hierarchical structure that decomposes the project into work packages, sub-tasks, and deliverables. This helps in organizing and planning the project activities.
4. **Task Estimation:** Estimate the effort, resources, and time required to complete each task in the WBS. Use estimation techniques such as expert judgment, historical data, or analogous estimation to determine realistic durations and resource allocations. Ensure that the estimates consider the complexity, dependencies, and skill levels required for each task.
5. **Project Schedule:** Create a project schedule that outlines the timeline for executing the tasks and milestones. Define dependencies between tasks, critical path analysis, and resource allocation. Utilize project management tools or software to develop a visual representation of the schedule, such as Gantt charts or project network diagrams.
6. **Resource Planning:** Identify the resources needed for the project, including personnel, hardware, software, and facilities. Determine the skills and expertise required for each role or team member. Allocate resources based on availability, competencies, and workload. Ensure that the necessary resources are secured throughout the project lifecycle.

7. **Risk Management:** Identify potential risks and uncertainties that may impact project success. Assess the likelihood and impact of each risk and develop mitigation strategies or contingency plans. Regularly monitor and review risks during the project to address emerging issues or new risks.
8. **Quality Assurance and Testing:** Plan for quality assurance activities throughout the project. Define quality standards, testing methodologies, and acceptance criteria. Incorporate quality checkpoints, code reviews, and software testing at appropriate stages. Establish metrics to measure and track quality objectives.
9. **Communication and Stakeholder Management:** Develop a communication plan to facilitate effective communication and collaboration among team members and stakeholders. Identify communication channels, frequency, and methods for status updates, meetings, and reporting. Engage stakeholders and ensure their involvement and feedback throughout the project.
10. **Project Documentation:** Establish documentation standards and templates for capturing project artifacts, including requirements documents, design specifications, test plans, and user documentation. Maintain proper version control and document revision history to track changes and updates.
11. **Project Monitoring and Control:** Set up mechanisms to monitor project progress, track milestones, and ensure adherence to the project plan. Establish project control processes to address deviations, manage changes, and maintain project scope, schedule, and budget.

Remember that software project planning is an iterative process, and adjustments may be necessary as the project progresses. Regularly review and update the project plan to reflect changing requirements, risks, and constraints. Effective project planning helps ensure the successful delivery of high-quality software within the defined time and resource constraints.

1.2.2 STEPWISE PLANNING IN SOFTWARE PROJECT DEVELOPMENT

Software project development involves a stepwise planning process to ensure a systematic and organized approach to building software solutions. Here are the key steps involved in software project planning:

1. **Define Project Objectives and Scope:** Clearly identify the goals, objectives, and expected outcomes of the software project. Define the scope of the project by determining the functionalities, features, and boundaries of the software solution.

2. **Gather Requirements**: Engage with stakeholders and end-users to gather and document detailed requirements. Understand their needs, expectations, and desired functionalities. Specify functional and non-functional requirements that will guide the software development process.
3. **Analyze and Prioritize Requirements:** Analyze the collected requirements to identify dependencies, conflicts, and gaps. Prioritize requirements based on their importance, feasibility, and impact on the software solution. This helps in focusing development efforts on critical aspects and managing trade-offs.
4. **Define Project Deliverables:** Based on the requirements analysis, determine the key deliverables of the project. This may include system architecture design, software modules, user interfaces, documentation, test cases, and deployment packages.
5. **Create a Work Breakdown Structure (WBS):** Break down the project into smaller, manageable tasks and activities. Develop a hierarchical structure that decomposes the project into work packages, sub-tasks, and deliverables. This helps in organizing and planning the project activities.
6. **Task Estimation**: Estimate the effort, resources, and time required to complete each task in the WBS. Use estimation techniques such as expert judgment, historical data, or analogous estimation to determine realistic durations and resource allocations. This helps in creating a project schedule and managing resources effectively.
7. **Develop a Project Schedule:** Create a project schedule that outlines the sequence of tasks, milestones, and dependencies. Utilize project management tools or software to develop a visual representation of the schedule, such as Gantt charts or project network diagrams. Set realistic timelines and ensure that tasks are scheduled in an optimal sequence.
8. **Allocate Resources:** Identify the resources required for the project, including personnel, hardware, software, and facilities. Determine the skills and expertise needed for each role or team member. Allocate resources based on availability, competencies, and workload. This ensures that the necessary resources are secured throughout the project.
9. **Risk Management:** Identify potential risks and uncertainties that may impact project success. Assess the likelihood and impact of each risk and develop mitigation strategies or contingency plans. Regularly monitor and review risks during the project to address emerging issues or new risks.

10. **Define Quality Assurance and Testing:** Plan for quality assurance activities throughout the project. Define quality standards, testing methodologies, and acceptance criteria. Incorporate quality checkpoints, code reviews, and software testing at appropriate stages. Establish metrics to measure and track quality objectives.
11. **Communication and Stakeholder Management:** Develop a communication plan to facilitate effective communication and collaboration among team members and stakeholders. Identify communication channels, frequency, and methods for status updates, meetings, and reporting. Engage stakeholders and ensure their involvement and feedback throughout the project.
12. **Document Project Artifacts:** Establish documentation standards and templates for capturing project artifacts, including requirements documents, design specifications, test plans, and user documentation. Maintain proper version control and document revision history to track changes and updates.
13. **Project Monitoring and Control:** Set up mechanisms to monitor project progress, track milestones, and ensure adherence to the project plan. Establish project control processes to address deviations, manage changes, and maintain project scope, schedule, and budget.

By following these stepwise planning activities, software development projects can be well-organized, efficient, and successful in delivering high-quality software solutions.

1.2.3 PROJECT MANAGEMENT TOOLS

Software project management involves the use of various techniques and tools to plan, execute, and monitor software development projects. Here are explanations of some commonly used tools and techniques in software project management:

1. Gantt Chart: A Gantt chart is a visual representation of project tasks displayed along a timeline. It shows the start and end dates of each task, dependencies between tasks, and the overall project timeline. Gantt charts help project managers and teams visualize project schedules, identify critical tasks, track progress, and manage dependencies.Here are the key details about Gantt charts in software project management:

- **Structure:** A Gantt chart consists of a horizontal timeline representing the project duration and vertical bars representing individual tasks or activities. Each task is represented by a bar, and the length of the bar corresponds to the duration of the task.

The tasks are typically listed on the left side of the chart, and the timeline is shown along the top or bottom.

- **Task Dependencies:** Gantt charts allow you to define dependencies between tasks. Dependencies determine the order in which tasks need to be completed. For example, if Task B depends on Task A, Task B cannot start until Task A is completed. Dependencies are indicated by arrows or linking lines between the bars representing the tasks.
- **Duration and Milestones:** Each task on the Gantt chart is assigned a duration, which represents the estimated time required to complete the task. It can be shown as a specific timeframe or in units of time (e.g., days, weeks). Milestones are significant events or deliverables within the project and are represented as diamonds or other distinct markers on the chart.
- **Progress Tracking:** Gantt charts help track project progress by visually indicating the completed and ongoing tasks. As tasks are completed, the corresponding bars are shaded or marked as complete, providing a clear visual representation of the progress made. This allows project managers to identify any delays or deviations from the planned schedule.
- **Resource Allocation:** Gantt charts can also be used to allocate and manage project resources. By assigning resources to specific tasks, you can identify resource constraints, overlaps, or bottlenecks. This helps in optimizing resource allocation and ensuring that resources are utilized efficiently.
- **Schedule Adjustments:** Gantt charts allow project managers to make schedule adjustments easily. If there are changes to the project timeline or task dependencies, the Gantt chart can be updated accordingly by modifying the duration, linking lines, or adding new tasks. This helps in assessing the impact of changes on the overall project schedule.
- **Communication and Collaboration:** Gantt charts serve as effective communication tools, allowing project managers to share project schedules with stakeholders, team members, and clients. The visual representation makes it easier for everyone to understand the project timeline and dependencies. Gantt charts facilitate discussions about project progress, potential delays, and resource allocation.
- **Software and Tools:** Various project management software and tools provide Gantt chart features, making it convenient to create and update Gantt charts. These tools often include additional functionalities like resource management, task dependencies, progress tracking, and collaboration features.

Gantt charts are widely used in software project management as they provide a clear and intuitive visualization of project schedules. They help in planning, tracking, and managing projects effectively, improving communication, and ensuring that projects are completed on time.

2. Logic Network: A logic network, also known as a network diagram or project network, is a graphical representation of project activities and their interdependencies. It illustrates the sequence and relationships between tasks using nodes (representing activities) and arrows (representing dependencies). Logic networks help in understanding the flow and logic of a project, identifying critical paths, and managing task dependencies.

Here are the key details about network diagrams in software project management:

Node Representation: In a network diagram, tasks or activities are represented by nodes or boxes. Each node represents a specific task or activity in the project. The nodes are usually labeled with a unique identifier or task name for easy reference.

Task Dependencies: Network diagrams highlight the dependencies between tasks. Dependencies determine the order in which tasks must be completed. They are indicated by arrows or lines connecting the nodes. There are four types of task dependencies:

Finish-to-Start (FS): The dependent task cannot start until the preceding task is finished.

Start-to-Start (SS): The dependent task can start at the same time as the preceding task.

Finish-to-Finish (FF): The dependent task must finish at the same time as the preceding task.

Start-to-Finish (SF): The dependent task cannot finish until the preceding task starts.

Duration and Estimation: Each task node in the network diagram is assigned a duration, representing the estimated time required to complete the task. The duration can be shown as a specific timeframe or in units of time (e.g., days, weeks). It helps in determining the project schedule and critical path.

Critical Path: The critical path is the sequence of tasks that determines the project's minimum duration. It represents the longest path through the network diagram, considering task durations and dependencies. Tasks on the critical path have zero slack or float, meaning any delay in these tasks will directly impact the project's overall duration.

Slack or Float: Slack or float is the amount of time a task can be delayed without affecting the project's overall duration. Non-critical tasks have slack, which allows flexibility in their start or finish dates. Slack is calculated by analyzing the differences between the earliest and latest start or finish times for each task.

Resource Allocation: Network diagrams can also be used to identify resource allocation and constraints. By assigning resources to specific tasks, you can analyze resource utilization and availability, ensuring that resources are optimally allocated throughout the project.

Schedule Optimization: Network diagrams help in identifying the most efficient project schedule. By analyzing task dependencies, durations, and critical path, project managers can determine the optimal sequence of tasks and allocate resources accordingly. It allows for effective schedule optimization and helps in avoiding unnecessary delays or bottlenecks.

Communication and Collaboration: Network diagrams serve as effective communication tools to convey project timelines, dependencies, and critical paths to stakeholders, team members, and clients. They facilitate discussions about project progress, resource allocation, and potential schedule adjustments.

Software and project management tools often include features to create and update network diagrams. These tools enable project managers to visualize and manage task dependencies, critical paths, and resource allocation, improving overall project planning and execution. Overall, network diagrams provide a clear and structured representation of project tasks, dependencies, and critical paths in software project management. They aid in planning, scheduling, and tracking projects, ensuring efficient resource allocation and timely completion of tasks.

3.Product Breakdown Structure (PBS): A Product Breakdown Structure is a hierarchical representation of the deliverables or components of a software product. It breaks down the product into smaller, manageable elements, allowing for better understanding and organization of the project scope. PBS helps in defining the product's structure, identifying deliverables, and establishing a clear understanding of the work required.

Here are the key details about the Product Breakdown Structure:

Hierarchical Structure: The PBS is organized in a hierarchical manner, starting from the top-level product or system and breaking it down into progressively detailed

components. Each level of the structure represents a decomposition of the higher-level component into smaller, more manageable parts.

Deliverable-Oriented: The PBS focuses on the deliverables or outputs of the project rather than the activities or processes involved in producing them. It identifies the tangible components that need to be developed or delivered as part of the project. The top level of the PBS represents the final product or system, while the lower levels represent the sub-components or elements that make up the final deliverable.

Decomposition: The decomposition process continues until the components are small enough to be easily managed, defined, and assigned to project team members. The level of detail in the PBS depends on the project's complexity and the desired granularity of control and management.

Hierarchical Numbering: Each component in the PBS is assigned a unique identifier or code to facilitate organization and reference. This hierarchical numbering system helps in identifying the parent-child relationships between components and allows for easy navigation and cross-referencing within the PBS.

Scope Definition: The PBS plays a crucial role in defining the project scope. By identifying and decomposing the product or system into its constituent parts, it helps ensure that all necessary components are considered and included in the project scope. It provides a clear understanding of what needs to be delivered to meet the project objectives.

4.Work Breakdown Structure (WBS) Relationship: The PBS is closely related to the Work Breakdown Structure (WBS). The WBS is a breakdown of the project work into smaller, manageable tasks or work packages. The WBS represents the "how" or the activities required to complete the components identified in the PBS. The PBS and WBS together provide a comprehensive view of the project scope, deliverables, and associated tasks.

Communication and Stakeholder Alignment: The PBS serves as a communication tool to facilitate understanding and alignment among project stakeholders. It provides a common language and visualization of the project components, enabling effective communication and collaboration between project teams, clients, and other stakeholders.

Change Management: The PBS can be modified or updated as the project progresses and new information becomes available. Changes in project scope, requirements, or

deliverables may require adjustments in the PBS to reflect the evolving product or system structure.

The Product Breakdown Structure is a valuable tool in project management, especially during the planning and scoping phases. It helps ensure a comprehensive understanding of project deliverables, facilitates effective communication, and supports efficient project execution and control.

5. Work Breakdown Structure (WBS): A Work Breakdown Structure is a hierarchical representation of project work. It decomposes the project into smaller, manageable tasks or work packages. WBS helps in organizing project work, defining responsibilities, estimating effort and resources, and tracking progress at a granular level. It provides a framework for effective project planning and control.

6. Resource Histogram: A Resource Histogram is a visual representation of resource utilization over time. It shows the availability and allocation of resources (such as team members or equipment) for project tasks. Resource histograms help project managers in resource planning, identifying resource bottlenecks, and balancing resource workloads.

Here are the key details about the Resource Histogram:

Resource Allocation: A Resource Histogram displays the allocation of resources, such as human resources, equipment, or materials, to project tasks or activities. It shows which resources are assigned to specific activities and the amount of effort or time allocated to each task.

Time Period: The horizontal axis of the Resource Histogram represents the project timeline, divided into appropriate time periods, such as weeks or months. Each time period represents a specific duration within the project.

Resource Utilization: The vertical axis of the Resource Histogram represents the level of resource utilization. It typically uses a scale to measure the allocation or workload of resources. The scale can be represented as percentages, units of measurement (e.g., hours), or any other relevant metric.

Bar Representation: The Resource Histogram uses bars or columns to represent the amount of resource allocation or workload for each time period. The height or length of the bars corresponds to the allocated resources or workload for a specific task or activity. The bars can be stacked or side by side, depending on the visualization requirements and the number of resources involved.

Resource Constraints: The Resource Histogram helps identify resource constraints and potential bottlenecks within the project. By analyzing the resource allocation levels, project managers can determine if resources are over-allocated or underutilized. Over-allocated resources may indicate a need for resource leveling or adjustment of project schedules to avoid resource shortages or burnout.

Resource Balancing: The Resource Histogram aids in balancing workloads and optimizing resource allocation. By visualizing the resource allocation across tasks and time, project managers can identify areas where resources can be reallocated or redistributed to ensure a more balanced utilization of resources. This helps in avoiding resource overloading or underutilization, leading to improved project efficiency.

Resource Planning and Management: The Resource Histogram supports resource planning and management activities. It allows project managers to assess the availability and utilization of resources during specific project phases or timeframes. It also helps in identifying resource gaps or surpluses, allowing proactive resource planning and allocation adjustments.

Communication and Decision-making: The Resource Histogram serves as a communication tool to share resource allocation information with stakeholders, team members, and clients. It helps in illustrating resource constraints, justifying resource needs, and facilitating discussions on resource allocation decisions. It enhances transparency and collaboration among project stakeholders.

Project management software often includes features to create Resource Histograms automatically, utilizing resource allocation data from the project schedule or resource management modules. These tools provide dynamic and interactive visuals, allowing project managers to update resource allocations in real-time and assess the impact on the overall resource utilization. The Resource Histogram is a valuable tool for visualizing and managing resource allocation in projects. It assists in identifying resource constraints, optimizing resource utilization, and facilitating effective resource planning and decision-making throughout the project lifecycle.

7. Critical Path Analysis (CPA): Critical Path Analysis is a technique used to determine the sequence of tasks that directly impact the project's overall duration. It identifies the critical path, which is the longest continuous path of dependent tasks with zero float or slack. CPA helps in understanding project timelines, identifying tasks that are critical to project completion, and managing project schedules to meet deadlines.

These tools and techniques are commonly used in software project management to plan, schedule, track progress, and manage resources effectively. Each tool serves a specific purpose in different phases of the project lifecycle, providing valuable insights and support for project managers and teams.

1.3 SOFTWARE PROCESSES AND PROCESS MODULES

Software processes refer to a set of activities, methods, and practices that are followed to develop, maintain, and deliver software products. They provide a structured approach to software development and help ensure that projects are executed efficiently, consistently, and with high quality. Software process models, on the other hand, are specific representations or frameworks that define the sequence and interactions of different software process activities.

1.3.1 CHARACTERISTICS OF SOFTWARE PROCESS

Software processes exhibit certain characteristics that distinguish them from other types of processes. Here are some key characteristics of software processes:

- **Iterative and Incremental:** Software processes often involve iterations and incremental development. They break down the development process into smaller cycles or increments, allowing for continuous refinement, feedback, and improvement.
- **Adaptive and Flexible:** Software processes are adaptable and flexible to accommodate changing requirements, evolving technologies, and customer feedback. They allow for adjustments and modifications throughout the development lifecycle.
- **Collaboration and Communication:** Software processes emphasize collaboration and communication among team members, stakeholders, and customers. Effective communication channels and collaboration tools are used to facilitate information sharing, decision-making, and coordination.
- **Documentation:** Software processes emphasize the importance of documentation at various stages of development. Documentation helps in capturing requirements, design decisions, coding standards, test cases, and user manuals. It ensures clarity, traceability, and knowledge transfer among team members.
- **Quality Focus:** Software processes place a strong emphasis on ensuring quality throughout the development lifecycle. Quality assurance activities, such as code reviews, testing, and continuous integration, are integrated into the process to detect and resolve defects early on.

- **Risk Management:** Software processes include risk management activities to identify, assess, and mitigate risks that may impact project success. Risk analysis, contingency planning, and risk mitigation strategies are employed to minimize the negative impact of uncertainties.
- **Continuous Improvement:** Software processes promote continuous improvement by capturing lessons learned from previous projects, analyzing process metrics, and implementing process enhancements. They aim to enhance efficiency, productivity, and quality in subsequent projects.
- **Stakeholder Involvement:** Software processes encourage stakeholder involvement throughout the development process. Feedback and input from stakeholders, including end-users, customers, and domain experts, are sought at different stages to ensure that the developed software meets their needs and expectations.
- **Clear Roles and Responsibilities:** Software processes define clear roles and responsibilities for team members involved in the development process. Each role has defined tasks, deliverables, and areas of responsibility, ensuring clarity and accountability.
- **Process Measurement and Metrics:** Software processes incorporate process measurement and metrics to track progress, assess performance, and identify areas for improvement. Metrics such as effort estimation accuracy, defect density, and productivity are used to measure process effectiveness.

These characteristics highlight the unique aspects of software processes and reflect the dynamic and evolving nature of software development. Understanding and applying these characteristics can help organizations and development teams adopt effective software processes and improve their overall software development capabilities.

1.3.2 PROCESS MODELS

1. **Waterfall Model:** The waterfall model is a sequential and linear approach to software development. It consists of distinct phases, including requirements gathering, design, implementation, testing, deployment, and maintenance. Each phase is completed before moving on to the next, and it emphasizes documentation and formal reviews.
2. **Agile Model**: Agile methodologies, such as Scrum, Kanban, and Extreme Programming (XP), are iterative and incremental approaches to software development. They focus on flexibility, adaptability, and collaboration. Agile models involve breaking the project into small increments or iterations, with each iteration

delivering a working software increment. Requirements and solutions evolve through collaboration with stakeholders.

3. **Spiral Model:** The spiral model combines elements of both waterfall and iterative approaches. It involves a series of iterations or cycles, each consisting of four primary activities: identification of objectives, risk analysis and resolution, development and testing, and customer evaluation. The spiral model emphasizes risk management and allows for early feedback and changes.
4. **V-Model:** The V-Model is a variant of the waterfall model. It emphasizes testing and verification activities at each stage of the development process. The V-Model incorporates a corresponding testing phase for each development phase, with testing activities being conducted in parallel with the corresponding development activities.
5. **Iterative Model:** The iterative model is characterized by repeating cycles of development, where each cycle involves a set of development activities, such as requirements analysis, design, implementation, and testing. Each iteration results in a partial working solution that is refined and expanded upon in subsequent iterations until the final product is achieved.
6. **Rapid Application Development (RAD):** RAD is an accelerated software development approach that focuses on quickly building prototypes and involves iterative development with active user involvement. RAD aims to deliver a working software solution in a shorter timeframe by prioritizing user feedback and incorporating changes early in the development process.
7. **Incremental Model:** The incremental model involves the incremental development and delivery of the software. It breaks the project into multiple smaller modules or increments, where each increment represents a partial software solution with increasing functionality. Each increment is developed and delivered in a sequence, gradually adding new features until the complete software system is achieved.

These are just a few examples of software process models, and each model has its strengths, weaknesses, and appropriate use cases. Organizations and development teams can choose the most suitable process model based on project requirements, team dynamics, and the nature of the software being developed. Additionally, hybrid models can be created by combining different elements from multiple process models to meet specific project needs.

UNIT-2

2.1 ESTIMATION AND BUDGETING OF PROJECTS

2.2 COST BENEFIT ANALYSIS

2.3 CASH FLOW FORECASTING

2.4 COST-BENEFIT EVALUATION TECHNIQUES

2.5 RISK EVALUATION

2.6 PROJECT COSTING

2.7 COCOMO 2

2.8 STAFFING PATTERN

2.9 EFFECT OF SCHEDULE COMPRESSION.

2.1 ESTIMATING AND BUDGETING OF PROJECT

Project management relies heavily on estimation and budgeting. It helps in setting achievable project targets. Project managers can create a detailed plan by calculating the time, effort, and money needed to complete each task or activity. This plan guarantees the use of all necessary assets, the development of workable schedules, and the elimination of all foreseeable threats and roadblocks. They involve calculating how much money will be needed for a project and coming up with a strategy to use that money wisely. The basic procedures for creating a project budget and schedule are as follows:

1. **Define project scope:**Outline the project's goals, outputs, and the tasks that must be completed. This will serve as the cornerstone upon which the project's budget and estimates can be built.

2. **Identify project activities:**Break the task down into smaller, more doable pieces. This can help you estimate how long each task will take and how much effort and supplies you'll need.

3. **Estimate activity durations:**Calculate how long you think it will take you to do everything. Take into account the task's complexity, its interdependencies, the available tools, and the dangers and unknowns.

4. **Estimate resource requirements:**Locate the people and things that will be required to complete each task. Some examples of such costs are personnel, tools, materials, programmes, and space. Find out how much time and how many resources were used.

5. **Determine resource costs:**Put a price tag on each asset depending on its going rate or current market value. Think about any out-of-pocket fees you might incur, like for further instruction, repairs, or administration, when allocating funds to use those assets.

6. **Calculate activity costs:**To calculate how much each task will cost, multiply the expected time required by the price per unit of the necessary resources. Expenses like travel and the payment of subcontractors should also be factored in.

7. **Identify project risks:** The budget of the project could be negatively affected by a number of factors that need to be considered. Think about how probable each risk is and how much damage it could cause.

8. **Develop a contingency reserve:**Set aside some money in case something

unexpected happens. The size of this buffer should be determined by the degree of uncertainty and the nature of the risks involved in the project.

9. **Consolidate activity costs:**Estimate the total cost of the project by adding up the prices of all its components. The total expected cost of the project is the sum of the budget and the buffer for unforeseen circumstances.

10. **Review and refine the budget:**Check the preliminary spending plan to make sure it's realistic, full, and accurate. Respond appropriately to input from stakeholders, limits, and shifts in the project's scope.

11. **Establish a baseline budget:**When the project's financial plan is complete, it should serve as the standard against which future progress is evaluated. A formal change control mechanism should be implemented for any budget adjustments.

12. **Monitor and control costs:**Compare the actual money spent throughout the project with the planned sums. Find any discrepancies and make the required adjustments to keep the project's budget on track.

Budgeting and planning include multiple rounds of estimation. Estimates and budgets need to be revised as the project develops to account for new knowledge, shifting priorities, and unforeseen events. Accurate estimating and budgeting are vital for the success of any project and can only be achieved through open lines of communication and close collaboration with all parties involved.

2.2 COST BENEFIT ANALYSIS

A cost-benefit analysis (CBA) is a method for weighing the pros and cons of a potential action in order to determine whether or not it is economically viable. It's useful for figuring out if a project or choice is economically feasible and if the advantages of a given course of action are worth the associated costs. A cost-benefit analysis is a method for calculating the monetary worth of a potential action or investment. The decision-makers can weigh the costs and benefits systematically and objectively thanks to this tool.

Here's an overview of the steps involved in conducting a cost-benefit analysis:

1. Identify the project or decision: Identify the specific choice or project that is being evaluated. Some examples of this would be starting a new marketing campaign or putting money into a capital project.

2. Identify costs: Compute the full scope of your project's expenses. These fall into two distinct classes:

a. **Direct costs:**Expenses that can be directly attributable to the project itself, such as personnel, supplies, machinery, and upkeep.

b. **Indirect costs:**Overheads and training costs are examples of indirect costs that can be impacted by a project but aren't incurred specifically for it.

3. Quantify costs: Put a dollar amount on each item of the cost you compiled in the previous step. Gathering this information may include looking at past records, conducting market research, or consulting with experts.

4. Identify benefits: Determine how much value was added as a direct result of the project or choice. Benefits can be either measurable in monetary terms, such as an increase in sales or a decrease in expenses, or intangible, such as an increase in customer loyalty.

5. Assign monetary value to benefits: Put a dollar amount on each perk. It can be difficult to put a monetary value on intangible advantages, but doing so is essential. Market analysis, customer surveys, and even the advice of professionals are all useful tools for this.

6. Determine the time frame: Determine how long we will be looking at costs and benefits for. Think about how long this project will run or how long this choice is likely to have an effect.

7. Calculate net present value (NPV): Future costs and benefits are discounted to their current value using a discount rate. This takes into consideration the fact that a dollar received or spent in the future is worth less than a dollar obtained or spent right now. The opportunity cost of capital, or the least acceptable rate of return, is reflected in the discount rate.

8. Compare costs and benefits: Value the expenses and benefits at their present prices and compare the results. Projects and choices are economically viable if their benefits outweigh their costs. If the drawbacks are more severe than the benefits, it may be time to look elsewhere.

9. Consider sensitivity analysis: Analyze how the findings would vary if you altered the discount rate, cost estimations, or benefit projections. This aids in comprehending how shifts in these variables could affect the cost-benefit analysis as a whole.

10. Make an informed decision: The cost-benefit analysis should help you

decide whether or not the project or choice is worth pursuing. In addition to the financial analysis, think about other, non-monetary elements such social and environmental impacts and strategic implications.

2.3 CASH FLOW FORECASTING

Estimating and projecting cash inflows and expenditures for a firm or project over a given time period is known as cash flow forecasting. It assists with cash flow management and gives insight into a company's future liquidity. A company's liquidity status can be better understood and better financial decisions can be made with the help of a cash flow projection. It helps organisations prepare for unexpected expenses, manage liquidity, and meet their financial commitments. Here is a rundown of what you may expect from a cash flow forecast:

1. **Gather historical data:**Gather all relevant financial records, such as bank statements, sales records, and expense reports, from the past several years. The information here will be used as a foundation for more precise cash flow projections in the future.

2. **Identify cash flow categories:**Split cash inflows into three buckets: operational (including sales and expenses like payroll and supplier payments), investing (including capital expenditures and asset purchases), and financing (e.g., loans, equity investments, and dividend payments).

3. **Project future sales revenue:**Use data from past trends, market research, the sales pipeline, and other sources to project future sales income. Think about things like the time of year, the economy, consumer preferences, and business developments.

4. **Estimate cash inflows:**Find out how much money will come in from things like accounts receivable, loans, investments, and other sources. Think about the likelihood and timing of these influxes.

5. **Forecast cash outflows:** Estimate your anticipated cash outflows, including operating expenses, loan payments, supplier payments, inventory purchases, taxes, and any other relevant expenses. Consider the timing and frequency of these outflows.

6. **Consider timing and seasonality:**Think about when your cash will be coming in and going out. It's possible for cash inflows and outflows to be periodic (like rent payments) or occasional (like a tax refund), or both (e.g., equipment purchase or loan repayment).

7. **Incorporate contingency and risk:**Prepare for the possibility of unforeseen events influencing cash flows, such as economic downturns, customer defaults, supplier troubles, or regulatory shifts. Think about the unknowns that could have an impact on your cash flow forecast.

8. **Calculate net cash flow:** Subtract cash outflows from cash inflows to get the net cash flow for the period. Your company's cash flow position over time will become clearer with this information.

9. **Track and monitor actual cash flows:** You can spot discrepancies between your projected and actual cash flows by comparing the two over time. You should revise your forecasts for future cash flows on a regular basis to account for real data.

10. **Assess and manage cash flow gaps:**Locate potential times of cash flow surplus or deficit. Options for filling cash flow shortages include acquiring extra funding, renegotiating payment terms with suppliers, and decreasing costs.

11. **Review and revise forecast:**Keep your cash flow projections under constant scrutiny and improvement as new data becomes available and as circumstances shift. Incorporate the most recent information, market conditions, and company performance into your forecasts.

2.4 COST BENEFIT EVALUATION TECHNIQUES

In order to determine whether or not a project or choice is financially viable, experts employ cost-benefit evaluation tools. Financial feasibility and decision attractiveness can be assessed quantitatively with the help of these methods. In order to make educated choices, it is crucial to take into account a variety of evaluation strategies and to interpret the results in light of other qualitative aspects and strategic concerns. Some methods for weighing costs and benefits are listed below.

1. **Net Present Value (NPV):**The net present value (NPV) of a project is the sum of its cash inflows minus its cash outflows, discounted to account for the passage of time. It does a subtraction between the present value of expenditures and benefits. If the NPV is positive, then the project can be considered financially feasible; if it is negative, then it is possible that the project will not generate enough profit.

2. **Return on Investment (ROI):**Return on investment (ROI) is calculated by comparing the net profit (benefit) generated by an

investment with its initial cost (cost). Percentages are used to show the value. A larger return on investment is preferable.

3. **Benefit-Cost Ratio (BCR):**Project benefits and costs are evaluated against one another using BCR. Present value is determined by comparing the overall benefits to the total costs. If the Benefit-Cost Ratio (BCR) is greater than 1, the project will generate a positive return on investment.

4. **Payback Period:**How long it takes for a project's cash inflows to cover the initial investment is measured in terms of its payback period. It is determined by dividing the initial expenditure by the anticipated yearly cash inflows. Payback periods that are shorter than the investment's ROI are preferable.

5. **Internal Rate of Return (IRR):**Present cash inflows are equal to present cash outflows at the discount rate known as internal rate of return (IRR). It is a measure of the rate of profit the project is expected to bring in. A project is economically viable if its internal rate of return (IRR) is larger than either the minimum acceptable rate of return or the cost of capital.

6. **Break-Even Analysis:**A break-even analysis calculates the volume of sales or quantity of units that must be produced in order for a project to break even. By analysing the correlation between these three variables, risk and potential profit may be calculated for the project.

7. **Sensitivity Analysis:**An important part of any project is the sensitivity analysis, which measures how much different adjustments can alter the final results. It aids in evaluating the project's susceptibility to alternative scenarios and pinpointing the most crucial elements influencing its financial feasibility by changing aspects such as expenses, prices, or demand.

8. **Cost-effectiveness Analysis (CEA):**For projects or social initiatives in the public sector where the outcomes cannot be measured in monetary terms, cost-effectiveness analysis (CEA) is frequently utilised. It assesses how much different approaches to the same problem would cost and how well they would work.

2.5 RISK EVALUATION

The purpose of risk evaluation is to determine the chance of a risk occurring,

its possible impact, and the degree of ambiguity around the risk. It's useful for identifying threats, ranking them, and coming up with plans to deal with them. The process of assessing risk is never complete and always needs fine-tuning. In order to maximise the likelihood of a project's or organization's success, it is important to systematically evaluate and mitigate risks. The process of assessing risk entails the following steps:

1. **Identify risks:** Risks that could have an impact on the project, the decision, or the organisation should be identified and recorded. Methods for accomplishing this include holding brainstorming sessions, talking to specialists, looking at data from the past, and using risk checklists. Think about potential opportunities and challenges from within and without.

2. **Assess risk likelihood:** Determine how likely it is that each highlighted risk will actually materialise. You can assess the likelihood using past data, statistical analysis, expert opinion, or standard industry practises. Determine how likely something is by assigning it a high, medium, low, or percentage value.

3. **Assess risk impact:** Think about how each identified risk might affect your project or business. Think about the effects on things like timeline, budget, quality, reputation, safety, legal compliance, and stakeholder satisfaction, as well as their knock-on effects. Give it a high, medium, low, or no impact rating, or a dollar amount to signify its magnitude.

4. **Determine risk severity:** Add together the results of the likelihood and effect analyses to get a sense of how serious each highlighted risk really is. The likelihood and impact ratings can be multiplied, or a risk matrix can be used to map the ratings to predetermined risk severity levels. This is useful for ranking dangers according to how serious they could be.

5. **Evaluate risk tolerance:** Think about how much risk the company is willing to take. Find out how much danger the project or business can afford to take. Proactively addressing some risks may be necessary, while accepting others, if their impact is manageable, is an option.

6. **Analyze risk interdependencies:** Think about how various dangers are connected to one another. Think about how the presence of one risk might affect or set off other hazards. Think about the potential

knock-on impacts that interrelated hazards could have. This aids in forming all-encompassing plans for dealing with hazards and learning from their experiences.

7. **Review risk mitigation measures:** Check how well your current safeguards are working to reduce potential dangers. Find out if these are enough to handle the problems you've discovered, or if you need to take more precautions. Think about how different mitigation techniques might affect your project's or company's overall goals and evaluate their cost-effectiveness.

8. **Prioritize risks:** Evaluate the risks, determine which ones are most important, and assign priorities accordingly. Prioritize the threats that are more likely to materialise and would have a major effect on the achievement of the project's or the organization's goals. This aids in focusing limited efforts on the most pressing threats.

9. **Develop risk response strategies:** Create risk response strategies for each priority risk based on the results of the risk assessment. Avoidance, reduction, mitigation, insurance, contracts, acceptance, and contingency planning are all examples of possible approaches to dealing with risk. Establish a plan for putting the risk response techniques into action, including who will do what and when.

10. **Monitor and review risks:** The identified risks should be tracked and reviewed regularly throughout the project or decision's lifecycle. Determine if there have been any shifts in the risk's likelihood, impact, or the efficacy of mitigation efforts. As new data becomes available or as circumstances shift, the risk assessment and mitigation plans must be updated.

2.6 PROJECT COSTING

Estimating and allocating expenses to activities or project components is known as "project costing." The process entails cataloguing and assessing all of the money that will be spent on the project. Project costing is a useful tool for estimating how much money will be needed for a project, keeping tabs on spending, and keeping costs under control. It's a crucial part of managing projects since it allows businesses to save money through better resource allocation and spending decisions. Maintaining the project's financial health and accomplishing the project's goals within the set budget can be accomplished by careful monitoring and control of expenditures. Here are

the main processes involved in estimating project costs:

1. **Define project scope:** Outline the project's goals, outputs, and steps in detail. With this, it will be possible to determine how much each part of the project will cost.
2. **Identify cost categories:** Identify the various types of project expenses. Expenses like this may be broken down into three categories: direct (labour, materials, and equipment), indirect (overhead), and contingency.
3. **Break down the project:** Subdivide the overall project into manageable chunks. This allows for more precise cost estimation by highlighting the individual expenditures associated with each component.
4. **Estimate labor costs:** Calculate the time and money spent on labour by adding up the hours or days spent on each task and then multiplying by the hourly or daily rates in effect. Think about how knowledgeable and experienced the team is.
5. **Estimate material costs:** Determine the materials or resources that will be needed for each task, and make a rough estimate of how much will be needed. To calculate the total cost of materials, find the unit price and multiply by the required amount.
6. **Estimate equipment costs:** In order to complete the job, it will be necessary to acquire certain tools and gear. Estimate the depreciation, maintenance, and repair costs, as well as the rental or purchase price of the equipment.
7. **Consider subcontractor costs:** Costs for any outside help, such as subcontractors or suppliers, should be estimated. Included in this may be the price of labour, the price of materials, and any other fees specified in the contract.
8. **Account for indirect costs:** Consider the project's indirect costs or overhead as well. Utilities, administrative fees, insurance premiums, and the upkeep of physical structures are all examples of indirect costs.
9. **Assess contingency reserves:** Create a safety net for the project by setting aside money in case of emergencies or modifications in the

project's scope. The contingency reserve, which is usually a percentage of the total estimated cost of the project, is used to cover any unforeseen costs that may arise.

10. **Sum up the costs:**Calculate the overall project cost by adding up all of the individual activity costs. This allows us to evaluate the project's financial viability and make informed decisions.

11. **Review and refine the cost estimate:**Check the budget to see if it's complete, accurate, and in line with the project's goals. Make adjustments to the estimate in light of comments, expert opinions, current market rates, and shifts in project needs.

12. **Establish a baseline budget:**Once the cost estimate is complete, it should be used as the starting point for the project's budget. A formal change control mechanism should be implemented for any budget adjustments.

13. **Track and control costs:**Compare actual costs with projected costs throughout the project. Make sure expenses don't go overboard by keeping a close eye on them. Examine any unexpected price increases or decreases and make adjustments to the project budget as needed.

2.7 COCOMO 2

Constructive Cost Model 2 (or COCOMO 2) is an updated version of Barry W. Boehm's original COCOMO software estimation model from the 1980s. Software development project estimation can be made with the help of COCOMO 2, a parametric model. It factors in a wide range of project features and other variables that can affect the time and effort required to develop software. Some highlights of COCOMO 2 include:

COCOMO 2 consists of three modes, each suitable for different levels of project detail and information availability:

a. **Application Composition Mode:** Suitable for estimating large-scale projects with well-defined requirements and available component-based software.

b. **Early Design Mode:** Applicable during the early stages of a project, when limited information is available and design decisions are being made.

c. **Post-architecture Mode:** Used once the project architecture has been defined, providing a more detailed estimation.

Effort Estimation:

COCOMO 2 calculates effort estimates in thousands of lines of code increments (KLOC). The complexity of the product, the needed reliability, the size of the database, the adaptability of the development process, and the cohesiveness of the team are just few of the variables taken into account by the model. A system of equations and calibration factors are used to produce an effort estimate.

Schedule Estimation:

Based on the projected work, COCOMO 2 generates a tentative timeline for the project. The model takes into account things like the development team's productivity, the ratio of development time to total time spent on the project (including testing and documentation), and the team's experience and skill.

Cost Estimation:

COCOMO 2 estimates the project's overall cost based on the projected effort and schedule. The estimated price tag takes into account a wide range of variables, including the price of labour, the price of materials, the cost of support and training, and so on.

Risk Assessment:

Potential risks to the project's effort, schedule, and budget are identified and quantified in COCOMO 2's risk assessment. The model incorporates multiple risk factors and offers recommendations for handling these unknowns.

Calibration:

COCOMO 2 is a parametric model that may be adjusted for use with a variety of different businesses and endeavours. In order to better predict the outcomes of future initiatives, the model can be fine-tuned utilising data from completed projects.

The COCOMO 2 framework makes it possible to make accurate time, cost, and effort predictions for software development projects. It's useful for software development teams and project managers in terms of budgeting, allocating resources, and managing risks. To get the most precise and trustworthy estimates, nevertheless, COCOMO 2 should be used in conjunction with human judgement and other estimating methods.

2.8 STAFFING PATTERN

The term "staffing pattern," which also goes by the names "staffing plan" and "organisational staffing," describes how an organisation allocates its employees and other resources to achieve its daily tasks and long-term goals. Workforce planning entails figuring out how many people will be needed, what they'll be doing, and how they should be distributed across various departments. A thorough familiarity with the requirements, workforce competencies, and long-term goals of the firm is essential for developing an efficient staffing pattern. It should help the company run smoothly and effectively, contributing to the broader strategic objectives. To keep the staffing pattern adaptable to shifting business needs and market conditions, it is critical to review and make adjustments on a regular basis. The following are the most important factors to consider while designing a staffing pattern:

1. **Workload Analysis:**Examine the responsibilities and activities of the company carefully. Determine which tasks, initiatives, or duties must be completed. To estimate the number of workers required, think about how much time and effort each task will take.

2. **Job Analysis and Job Descriptions:**Clearly outline the duties associated with each position in the company. Create detailed position descriptions that include tasks, requisite abilities, qualifications, and reporting relationships.

3. **Skills and Competencies:**Create a list of all the required abilities, knowledge, and experience for each open position. Think about what kind of technical knowledge, experience, and people skills you'll need to get the job done.

4. **Staffing Levels:**Find out how many workers you should hire so that you can get everything done and reach your objectives. Think about things like what needs to be produced or provided, what customers want, what the standards are in the industry, and what the rules and regulations are.

5. **Staffing Ratios:**Find the right proportions of workers to be assigned to each job function. Take the manager-to-worker, supervisor-to-employee, or administrative-to-clinical-assistant ratio, for instance. These proportions are useful for facilitating effective management, teamwork, and communication.

6. **Staffing Flexibility:**Take into account the requirement for adaptable staffing in light of inevitable workload swings, seasonal changes, and unforeseen events. Some ways to prepare for this eventuality include maintaining a roster of seasonal or part-time workers, encouraging job-sharing, and developing back-up plans.

7. **Workforce Planning:**Plan for the long term workforce demands by conducting long-term planning. Think about issues including company expansion, organisational development, technology progress, retirement and employee turnover, and succession planning.

8. **Recruitment and Selection:**Formulate plans for filling the vacant roles through employee recruitment, selection, and onboarding. Think about the possibilities for advancement within the company, as well as external hiring strategies, including the use of job boards, social media, and professional networks.

9. **Training and Development:**Create training and development plans for your staff to help them improve their abilities and productivity. Training new employees is important, but so are chances for ongoing professional development that can help employees grow in their roles and adapt to new demands as they arise.

10. **Performance Management:**Create training and development plans for your staff to help them improve their abilities and productivity. Training new employees is important, but so are chances for ongoing professional development that can help employees grow in their roles and adapt to new demands as they arise.

11. **Organizational Structure:**Check that reporting structures and organisational structures are reflected in the personnel pattern. Establish a structure of authority and lines of communication that will allow for efficient collaboration and decision-making.

12. **Evaluation and Adjustment:**Staffing levels should be monitored and adjusted on a regular basis to ensure optimal performance. Keep an eye on KPIs, do a satisfaction survey with your staff, and get input from key players to figure out where you can make changes.

2.9 EFFECT OF SCHEDULE COMPRESSION

When a project's timetable is compressed, the duration is shortened without sacrificing the project's scope or quality. It's common practise to do this in

order to adapt to shifting priorities or fulfil stringent deadlines. There are pros to a compressed timeline, such as a quicker time to market or better responsiveness to customers, but there are also potential drawbacks. It's important to proceed with caution and thorough planning when compressing schedules, even though it may be required to do so to accomplish business objectives. In order to reduce risks and provide desirable results, project managers need to analyse the potential effects, maintain open lines of communication with all involved parties, and put plans into action. Possible outcomes of timetable cramming include the following:

1. **Increased Resource Intensity:**When a schedule needs to be shortened, it's often necessary to do more work in less time. Higher resource intensity may ensue, with team members putting in extra time and effort despite feeling more pressure and the possibility of burnout. Maintaining team productivity and morale requires careful management of available resources and the amount of work being done.

2. **Risk of Quality Compromise:**The quality of outputs may suffer if deadlines are pushed too tightly. Time constraints during the planning, development, testing, and review phases increase the likelihood of mistakes and oversights. To keep the intended quality level, it is crucial to keep a close eye on quality assurance activities and to provide sufficient time and resources for them.

3. **Increased Project Complexity:**A project's complexity might increase if the timeline is compressed. The likelihood of encountering difficulties with coordination, dependencies, and rework rises when the order of events changes, when tasks overlap, or when they are developed simultaneously. The effects of compression on the complexity of a project must be thoroughly analysed, and risks must be managed proactively.

4. **Impact on Stakeholder Expectations:**If milestones, delivery dates, or the scope of the project must be altered as a result of schedule compression, it may have an effect on the expectations of the stakeholders. Negative effects on project relationships can be mitigated through clear explanation of the need for compression, careful management of stakeholder expectations, and thoughtful negotiation of trade-offs.

5. **Potential Cost Increase:** Costs may rise in some circumstances if

timelines are shortened. Project activities may need to be sped up by allocating more resources to it, paying employees overtime, or acquiring supplies and services more quickly. Managers of projects must weigh the costs of a shortened timeline against the benefits of lower expenses and improved quality.

6. **Limited Risk Response Time:**Constraints on time can make it harder to deal with problems that arise during a project. The project's capacity to anticipate, assess, and manage risks may suffer as a result. In order to lessen the effects of delays caused by unforeseen events within the condensed timeline, project managers should place a premium on risk management and create backup plans.

7. **Reduced Flexibility:**The project team's ability to respond to changes, adapt to new needs, and incorporate feedback throughout execution might be hampered by a too-tight schedule. In order to address potential issues and keep the project on pace, it is crucial to properly manage change requests, prioritise activities, and keep lines of communication open.

UNIT-3

3.1 SOFTWARE PROJECT SEQUENCING

3.2 SOFTWARE SCHEDULING ACTIVITIES

3.3 SCHEDULING RESOURCES

3.4 CRITICAL PATH ANALYSIS (CPA)

3.5 NETWORK PLANNING

3.6 RISK MANAGEMENT

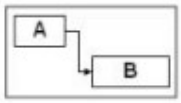
3.7 RISK PLANNING & CONTROL

3.1 SOFTWARE PROJECT SEQUENCING

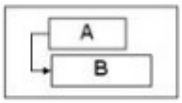
Software project sequencing refers to the process of determining the order in which tasks or activities should be executed within a software development project. It involves identifying dependencies between tasks and establishing a logical sequence to ensure smooth progression of the project.The sequencing of software project tasks is typically done using project management techniques such as the Critical Path Method (CPM) or the Program Evaluation and Review Technique (PERT). These techniques help in identifying the critical path, which is the sequence of tasks that determines the project's overall duration.Here are the key steps involved in software project sequencing:

1. **Task Identification:** The first step is to identify all the tasks or activities required to complete the software project. This involves breaking down the project into smaller, manageable tasks that can be executed independently.
2. **Task Dependency Determination:** Once the tasks are identified, the next step is to determine the dependencies between them. Task dependencies can be categorized as:

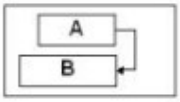
   Finish-to-Start (FS): Task B cannot start until Task A finishes

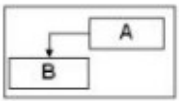
   Start-to-Start (SS): Task B can start only when Task A starts.

   Finish-to-Finish (FF): Task B cannot finish until Task A finishes.

   Start-to-Finish (SF): Task B can finish only when Task A starts.

3. **Constructing the Network Diagram:** The network diagram, also known as the project schedule network diagram or the precedence diagram, represents the sequence of tasks and their dependencies. It visualizes the project's flow and helps in identifying the critical path.
4. **Determining Task Durations:** Each task needs to have an estimated duration or effort assigned to it. This information is typically obtained from project team

members or based on historical data. Task durations are important for calculating the overall project timeline and critical path.

5. **Calculating the Critical Path:** The critical path represents the longest sequence of dependent tasks that determines the project's minimum duration. It is calculated by considering the tasks with zero slack or float, meaning any delay in these tasks would directly impact the project's timeline.
6. **Sequencing and Scheduling:** Once the critical path is identified, the project manager or scheduler arranges the remaining non-critical tasks around it. This involves scheduling tasks based on their dependencies, durations, and resource availability.
7. **Monitoring and Controlling:** Throughout the software project's execution, progress is monitored, and any changes or delays are tracked. Project managers use techniques like Earned Value Management (EVM) to measure actual progress against planned progress and make adjustments as necessary.

By following the steps above, software project sequencing helps in organizing and prioritizing tasks, optimizing resource allocation, and ensuring timely completion of the project.

3.2 SOFTWARE SCHEDULING ACTIVITIES

Software scheduling activities refer to the process of planning and organizing tasks within a software development project to ensure that they are executed in a timely and efficient manner. Scheduling activities involve assigning resources, estimating task durations, determining task dependencies, and creating a timeline for project completion.

Here are some key activities involved in software scheduling:

1. **Task Identification:** The first step in scheduling activities is to identify all the tasks or activities required to complete the software project. This involves breaking down the project into smaller, manageable tasks that can be assigned and scheduled.
2. **Task Sequencing:** Once the tasks are identified, the next step is to determine the order or sequence in which the tasks should be executed. This is typically done by analyzing task dependencies and identifying the critical path. Task dependencies determine which tasks must be completed before others can begin.

3. **Resource Assignment**: Scheduling activities also involve assigning resources to tasks. Resources can include developers, designers, testers, and other team members involved in the project. The availability and skill set of resources need to be considered when assigning tasks to ensure efficient utilization of resources.
4. **Estimating Task Durations:** Each task needs to have an estimated duration or effort assigned to it. This estimation is typically done based on historical data, expert judgment, or input from team members. Task durations are important for creating a realistic project timeline and allocating resources effectively.
5. **Creating a Timeline:** Once the task sequencing, resource assignment, and task duration estimation are done, a project timeline or schedule is created. The timeline specifies the start and end dates for each task, taking into account the dependencies and resource availability. The timeline helps in visualizing the project's progress and identifying any potential bottlenecks or delays.
6. **Monitoring and Controlling:** Throughout the software project's execution, the schedule is monitored and controlled to ensure that tasks are progressing as planned. Any changes, delays, or resource constraints are identified, and adjustments are made

to the schedule as necessary. This may involve reassigning resources, re-sequencing tasks, or updating task durations.

7. **Risk Management:** Scheduling activities also involve considering potential risks and uncertainties that may impact the project timeline. Risks such as scope changes, resource unavailability, or technical challenges need to be identified and managed proactively to minimize their impact on the schedule.

Effective software scheduling activities help in optimizing resource utilization, meeting project deadlines, and managing stakeholder expectations. It ensures that tasks are executed in a logical sequence, taking into account dependencies, resource availability, and estimated task durations.

Gantt chart

A Gantt chart is a popular scheduling tool used in software project management to visually represent the project timeline and task dependencies. It provides a graphical overview of project activities, their start and end dates, and their interdependencies. Here's an explanation of how Gantt charts are used in scheduling software projects:

Figure: Temple for Gantt Chart

- Task Identification: Identify all the tasks required to complete the software project. Break down the project into smaller, manageable tasks that can be executed independently.
- Task Sequencing: Determine the dependencies between tasks. Identify which tasks must be completed before others can start. Task dependencies can be categorized as finish-to-start (FS), start-to-start (SS), finish-to-finish (FF), or start-to-finish (SF).

- Gantt Chart Creation: Create a Gantt chart using project management software or specialized Gantt chart tools. The chart typically consists of a horizontal timeline representing the project duration and vertical bars representing each task.
- Task Representation: Represent each task as a horizontal bar on the Gantt chart. The length of the bar corresponds to the task's duration, and the positioning reflects the task's start and end dates.
- Task Dependencies: Connect the tasks on the Gantt chart with dependency lines to indicate the relationships and dependencies between them. Dependency lines illustrate which tasks are dependent on the completion of other tasks.
- Milestones and Deliverables: Identify milestones or important project deliverables on the Gantt chart by adding vertical markers. Milestones represent significant project achievements or events and help track progress.
- Resource Allocation: Optionally, allocate resources to tasks on the Gantt chart. This can be done by assigning specific team members or resource types to tasks to ensure proper resource utilization and scheduling.
- Schedule Adjustments: As the project progresses, update the Gantt chart to reflect actual progress. Adjust task durations, start dates, and dependencies as needed based on the real-time status of tasks.
- Critical Path Analysis: Analyze the critical path on the Gantt chart to identify the sequence of tasks that determine the project's minimum duration. The critical path consists of tasks with no slack or float, meaning any delay on these tasks will delay the overall project.
- Progress Tracking: Use the Gantt chart to track the progress of tasks. Update the chart regularly to reflect completed tasks, in-progress tasks, and any delays or changes to the schedule.
- Communication and Reporting: Share the Gantt chart with project stakeholders, team members, and clients to communicate project status, timelines, and dependencies. Gantt charts provide a visual representation that is easy to understand and facilitates effective communication.

By using Gantt charts, software project managers can effectively plan, schedule, and track project activities, ensuring that tasks are executed in a coordinated and timely manner. Gantt charts help in visualizing the project timeline, identifying task dependencies, and facilitating communication and coordination among project stakeholders.

Example: Consider a project with five tasks: Requirements Analysis, Design, Development, Testing, and Deployment. Each task is represented as a horizontal bar, indicating its start and end dates.

Table: Gantt Chart example

Task	Start Date	End Date
Requirements Analysis	01/01/2023	01/10/2023
Design	01/11/2023	01/20/2023
Development	01/21/2023	02/10/2023
Testing	02/11/2023	02/20/2023
Deployment	02/21/2023	02/28/2023

In this example, the Gantt chart displays five tasks: Requirements Analysis, Design, Development, Testing, and Deployment. Each task is represented as a horizontal bar, indicating its start and end dates. Here are some additional details:

- The Requirements Analysis task starts on January 1, 2023, and ends on January 10, 2023.
- The Design task starts on January 11, 2023, and ends on January 20, 2023.
- The Development task starts on January 21, 2023, and ends on February 10, 2023.
- The Testing task starts on February 11, 2023, and ends on February 20, 2023.
- The Deployment task starts on February 21, 2023, and ends on February 28, 2023.

This Gantt chart provides a visual representation of the project timeline and the sequential order of tasks. It helps project managers and team members understand the project schedule, task dependencies, and overall progress.

3.3 SCHEDULING RESOURCES

Scheduling resources for a software project involves assigning and managing the available resources, such as developers, testers, designers, and other team members, in a way that maximizes their productivity and ensures efficient project execution. Here are some key steps involved in scheduling resources for a software project:

Resource Identification: Identify the resources needed for the software project based on the project requirements, scope, and deliverables. Determine the specific skills, expertise, and roles required for each task or activity.

1. **Resource Availability and Constraints:** Assess the availability of the identified resources and consider any constraints that may impact their availability, such as part-time availability, multiple project assignments, or vacation schedules. Take into account any external dependencies or limitations.
2. Resource Allocation: Assign resources to specific tasks or activities based on their skills, availability, and expertise. Consider their workload, availability during critical project phases, and any dependencies between tasks that require specific resources.
3. **Resource Leveling:** Optimize resource allocation to balance workloads and avoid resource overutilization or underutilization. Level resources by adjusting task assignments, durations, or dependencies to ensure a consistent and sustainable workload distribution.
4. **Collaborative Planning:** Involve the project team members in the resource scheduling process to gather their input, consider their preferences, and accommodate their expertise. Collaboration ensures a more accurate assessment of resource availability and improves team engagement.
5. **Resource Monitoring and Tracking:** Continuously monitor and track the progress of assigned tasks and the utilization of resources. Regularly communicate with team members to gather updates, address any issues or roadblocks, and ensure that resource allocation remains aligned with project requirements.
6. **Adjustments and Reassignments:** Anticipate and address changes in resource availability or project requirements. Adjust resource allocations and reassign tasks as necessary to accommodate unexpected events, changes in priorities, or evolving project needs.
7. **Communication and Coordination:** Maintain effective communication and coordination among team members to ensure a smooth workflow and minimize resource conflicts. Regularly update the project schedule and resource assignments, and communicate any changes or adjustments to the team.
8. **Tools and Software:** Utilize project management tools and software that provide resource management capabilities, such as resource allocation, tracking, and visualization of resource utilization. These tools help streamline the resource scheduling process and provide visibility into resource allocation and availability.
9. **Continuous Improvement:** Regularly review and analyze the effectiveness of resource scheduling and utilization. Identify areas for improvement, learn from

past experiences, and implement lessons learned in future projects to optimize resource allocation and enhance project performance.

By effectively scheduling and managing resources, software projects can optimize productivity, reduce resource conflicts, and improve overall project success rates. It ensures that the right resources are allocated to the right tasks at the right time, enabling efficient project execution and timely delivery.

3.4 CRITICAL PATH ANALYSIS (CPA)

Critical path analysis (CPA) is a project management technique used to identify the sequence of tasks that directly impacts the overall project duration. It helps in determining the longest path of dependent tasks and identifies which tasks are critical for the project's timely completion. In software project management, critical path analysis is commonly employed to plan and schedule activities effectively. Here's how it works:

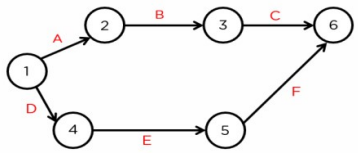
1. **Task Identification:** Begin by identifying all the tasks required to complete the software project. Break down the project into smaller, manageable tasks that can be executed independently.
2. **Task Dependency Determination:** Determine the dependencies between tasks. Identify which tasks must be completed before others can start. Task dependencies can be categorized as finish-to-start (FS), start-to-start (SS), finish-to-finish (FF), or start-to-finish (SF).
3. **Network Diagram Construction:** Construct a project schedule network diagram (also known as a precedence diagram or a PERT chart) to visualize the sequence of tasks and their dependencies. The network diagram represents the flow of tasks and their interrelationships.
4. **Task Duration Estimation:** Estimate the duration or effort required to complete each task. This estimation can be based on historical data, expert judgment, or input from team members. Task durations are important for calculating the project timeline.
5. **Forward and Backward Pass:** Perform a forward pass and a backward pass calculation on the network diagram. The forward pass determines the earliest start and finish times for each task, considering task durations and dependencies. The backward pass determines the latest start and finish times, considering the project deadline.

6. **Slack Calculation:** Calculate the slack (also known as float) for each task. Slack represents the amount of time a task can be delayed without impacting the project duration. Tasks with zero slack are critical as any delay in these tasks would directly affect the project's timeline.
7. **Critical Path Identification:** Identify the critical path by examining the tasks with zero slack. The critical path is the longest sequence of dependent tasks that determines the project's minimum duration. Any delay in a task on the critical path will cause a delay in the overall project completion.
8. **Schedule Optimization:** Analyze the critical path to identify opportunities for schedule optimization. By focusing resources and efforts on critical tasks, you can expedite the project timeline and reduce the overall project duration.
9. **Monitoring and Controlling:** Throughout the project execution, monitor the progress of tasks on the critical path and track any changes or delays. Regularly update the project schedule and adjust task priorities as necessary to maintain alignment with the critical path.

By leveraging critical path analysis, software project managers can effectively prioritize tasks, allocate resources, and manage project timelines. It helps in identifying potential bottlenecks, managing dependencies, and ensuring timely completion of critical tasks for successful project delivery.

Understand CPM Diagram:

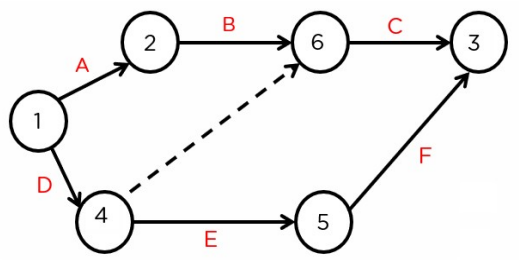
Before delving into the CPM approach, it is essential to grasp two fundamental concepts: Events and Activities. To gain a clearer understanding of these concepts, let's examine the network diagram, which serves as the output of the process.



Events and Activities, some of the most crucial elements of the process, are represented in this output.A circle is used to depict events, which take place at the beginning and end of an activity. The head event is Event 2, and Event 1 is the tail event. The events in this example are 1, 2, 3, 4, 5, and 6. 1 will be referred to as the tail event and 2 will be referred to as the head event, taking into account nodes 1 and 2 and the link between them.

Activities are the use of resources such as time, money, and energy needed to finish the project. In our example, the actions between each event are denoted by the letters A, B, C, D, E, and F.

Dummy Activity:A relationship between two events is represented by a dummy activity. The dotted line in the example below denotes the connection between nodes 4 and 6.There will be no value in the interaction between these nodes.



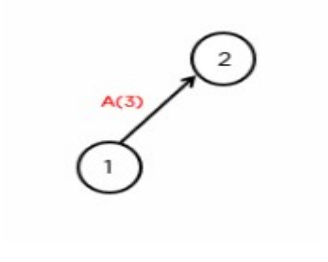
Rules for Critical Path Method

- The starting and terminating nodes of the network must be distinct. In the case of our example, event 1 stands in for a distinct starting point, and event 6 stands in for a distinct completion node.
- No activity in the network can be represented by more than one arc (the line linking the events with an arrow).
- Nodes at the beginning and finish of an activity cannot be the same.

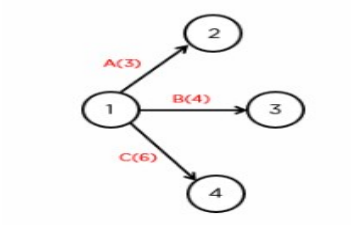
Activity List:

Name of Activity	Predecessor Node	Duration (Year)
A		3
B		4
C		6
D	B	3
E	A	9
F	A	1
G	B	4
H	C,D	5
I	C,D	4
J	E	3
K	F,G,H	6
L		3
M	I	6
N	J,K	9

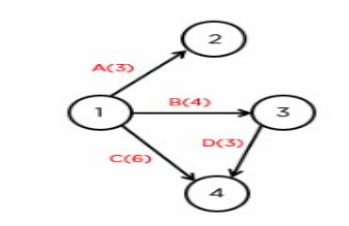
Let's examine the activities and their recent predecessors first. The predecessors of Activities A, B, and C are not immediately preceding. This implies that there will be unique arcs linking to each of them. Nodes 1 and 2 will be drawn first because they serve as the beginning point. We'll provide the duration and the activities on the arc.



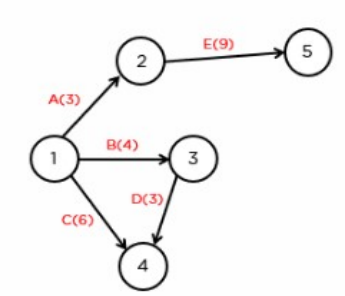
We must also keep in mind that both nodes E and F have A as their immediate predecessor. Let's also sketch the arcs for nodes B and C.



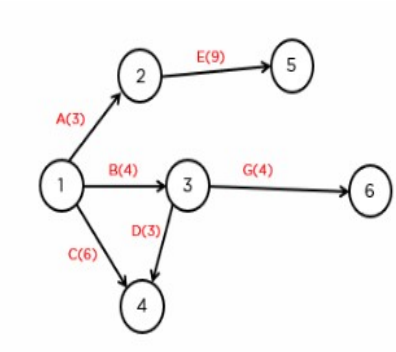
Earlier we can draw the nodes for activity D, we need to know that activity B comes before it and that activities C and D together serve as activities H and J's immediate predecessors. This indicates that at some time, both C and D must connect. We'll thus use events 3 and 4 to create an arc.



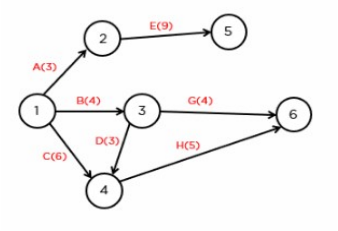
We have now finished critical path method activities A, B, C, and D. Let's go on to activity E now. Activity A comes before activity E, which then immediately comes before activity J. We can draw an arc like this since this is a stand-alone activity.



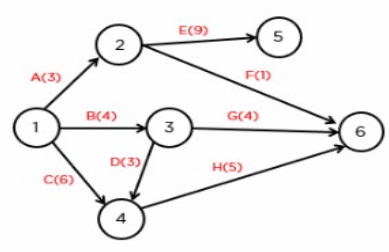
If we look at action F, it is preceded by activity A, and a combination of F, G, and H serve as the activities K and L's immediate predecessors. So let's hold off on raising it. Let's concentrate on activity G instead. B is put before it. So let's sketch it in that manner.



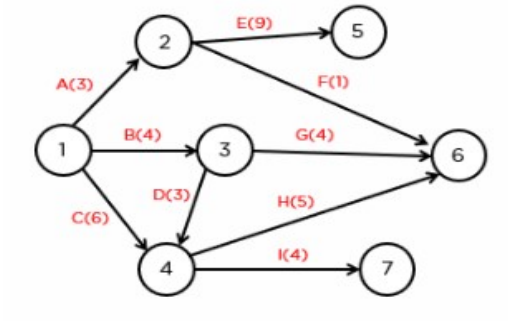
Let's look at activity H right now. It will operate as the immediate predecessor for K and L, along with F and G, and is preceded by both C and D. Thus, nodes 4 and 6 can be connected.



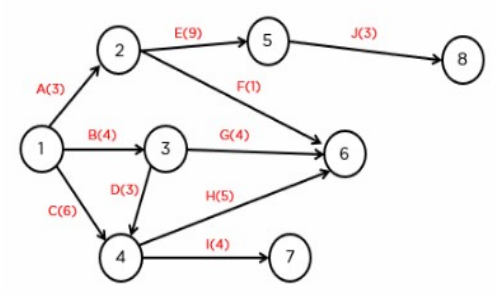
After completing that, let's return to action F. We can join nodes 2 and 6 to meet the conditions needed for activities K and L because we know where activities G and H connect to.



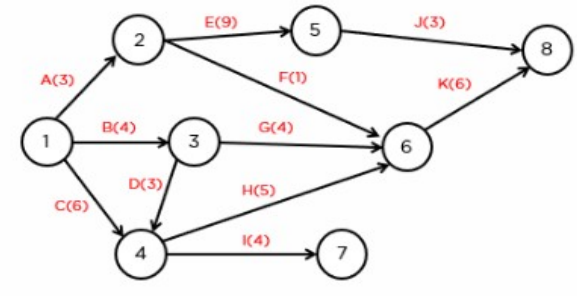
After that, we have activity I. Activities C and D come before activity I. Additionally, it serves as activity M's direct predecessor. Since it is a stand-alone activity, we can depict it in this way.



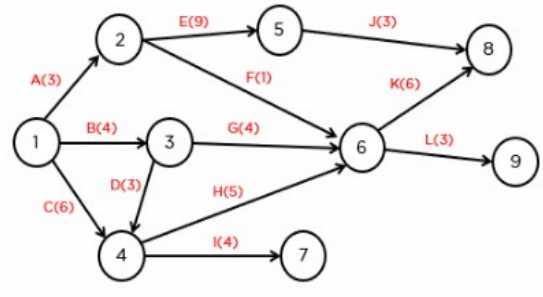
Let's go on to activity J now. Activity E comes before activity J. We can also observe that activity J and K together will function as activity N's immediate antecedent. This is the arc that we can then draw.



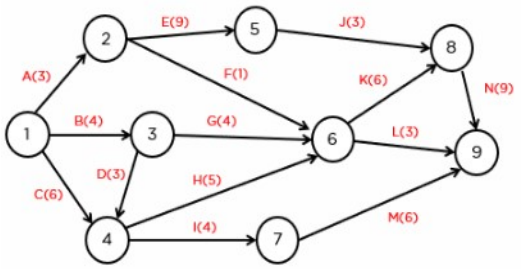
Moving on to activity K now. Here, we can see that F, G, and H come before K. Additionally, it serves as activity N's direct antecedent. Therefore, we'll link nodes 6 and 8.



Let's move on to activity L next. Now, the table demonstrates that no other activity has L, M, or N as an immediate precursor. As a result, it will probably connect to the last node. Activities by F, G, and H come before L. This is one way to draw the arc.



Now move on to task M. Activity I comes before this one. For activity N, we can similarly connect an arc from node 8 to node 9.



3.5 NETWORK PLANNING

Network planning, also known as network analysis or network scheduling, is a project management technique used in software project management to plan and schedule tasks based on their dependencies. It involves creating a graphical representation of the project tasks and their relationships, known as a network diagram or a project schedule network diagram. Network planning helps in visualizing the project flow, identifying critical paths, and optimizing project timelines. Here's how it works:

1. **Task Identification:** Identify all the tasks required to complete the software project. Break down the project into smaller, manageable tasks that can be executed independently.
2. **Task Dependency Determination:** Determine the dependencies between tasks. Identify which tasks must be completed before others can start. Task dependencies can be categorized as finish-to-start (FS), start-to-start (SS), finish-to-finish (FF), or start-to-finish (SF).
3. **Network Diagram Construction:** Construct a project schedule network diagram (also known as a precedence diagram or a PERT chart) to represent the sequence of tasks and their dependencies. The network diagram typically consists of nodes representing tasks and arrows representing the dependencies between them.

4. **Node Labeling:** Assign unique identifiers or labels to each node in the network diagram. The labels can be alphanumeric codes or task names, making it easier to refer to specific tasks during project discussions and scheduling.
5. **Estimating Task Durations:** Estimate the duration or effort required to complete each task. This estimation can be based on historical data, expert judgment, or input from team members. Task durations are important for calculating the project timeline.
6. **Determining Early Start and Early Finish:** Perform a forward pass calculation on the network diagram to determine the earliest start and earliest finish times for each task. Consider task durations and dependencies to calculate these values.
7. **Determining Late Start and Late Finish:** Perform a backward pass calculation on the network diagram to determine the latest start and latest finish times for each task. Consider project deadlines and dependencies to calculate these values.
8. **Slack Calculation:** Calculate the slack (also known as float) for each task. Slack represents the amount of time a task can be delayed without impacting the project duration. It is calculated by finding the difference between the late start and early start times or the late finish and early finish times.
9. **Critical Path Identification:** Identify the critical path by examining the tasks with zero slack. The critical path is the longest sequence of dependent tasks that determines the project's minimum duration. Any delay in a task on the critical path will cause a delay in the overall project completion.
10. **Schedule Optimization:** Analyze the critical path to identify opportunities for schedule optimization. By focusing resources and efforts on critical tasks, you can expedite the project timeline and reduce the overall project duration.
11. **Monitoring and Controlling:** Throughout the project execution, monitor the progress of tasks and track any changes or delays. Regularly update the project schedule and adjust task priorities as necessary to maintain alignment with the network plan.

Network planning allows software project managers to effectively schedule tasks, manage dependencies, and optimize project timelines. It provides a visual representation of the project's flow, identifies critical paths, and helps in resource allocation and project coordination for successful project completion.

3.6 RISK MANAGEMENT

In software project management, a risk refers to an uncertain event or condition that, if it occurs, could have a positive or negative impact on the project's objectives. Risks are future-oriented and involve a level of uncertainty and potential consequences. They can arise from various sources, including technical factors, organizational factors, external factors, or project-specific circumstances.

Risk management is a crucial aspect of software project management that involves identifying, assessing, and mitigating potential risks that may impact the success of a project. It includes activities such as risk planning, risk identification, risk analysis, risk response planning, and risk monitoring and control.

Here's an overview of the key components of risk management in software project management:

1. **Risk Planning:** Risk planning involves establishing the overall approach and strategy for managing risks throughout the project. It includes defining the risk management objectives, outlining the roles and responsibilities of the project team members involved in risk management, and establishing the risk management process.
2. **Risk Identification:** The process of risk identification involves identifying and documenting potential risks that may arise during the software project. This can be done through techniques such as brainstorming sessions, reviewing historical project data, conducting interviews with project stakeholders, and analyzing similar projects. Risks can be categorized as technical risks, organizational risks, schedule risks, budget risks, or external risks.
3. **Risk Analysis:** Risk analysis involves assessing the identified risks to understand their potential impact on the project objectives. This includes analyzing the likelihood of occurrence and the potential consequences of each risk. Quantitative techniques, such as probability and impact assessment, can be used to prioritize risks based on their severity.
4. **Risk Response Planning:** After analyzing the risks, risk response planning focuses on developing strategies to address and mitigate the identified risks. This includes defining risk response actions, such as risk avoidance, risk transfer, risk mitigation, or risk acceptance. Risk response plans outline specific actions, responsibilities, and timelines for implementing risk mitigation measures.

5. **Risk Monitoring and Control:** Once the risk response plans are in place, it is important to monitor and control the risks throughout the project lifecycle. This involves regularly reviewing and updating the risk register, tracking the status of identified risks, and implementing risk response actions as necessary. Risk monitoring ensures that new risks are identified, existing risks are reassessed, and the effectiveness of risk mitigation measures is evaluated.
6. **Contingency Planning:** Contingency planning involves preparing alternative plans to address risks that may materialize despite risk management efforts. This includes developing backup strategies, identifying alternative resources, and establishing fallback options to minimize the impact of risks on the project.
7. **Communication and Documentation:** Effective communication is crucial in risk management. It involves sharing risk information with project stakeholders, keeping them informed about the identified risks, mitigation strategies, and any changes in the risk profile. Documentation of risks, risk response plans, and mitigation actions ensures transparency and provides a reference for future projects.
8. **Lessons Learned:** At the conclusion of the project, it is essential to conduct a lessons learned session to capture and document the experiences and insights gained from managing risks. This information can be used to improve risk management practices in future projects.

By incorporating risk management practices, software project managers can proactively identify and address potential risks, reducing the likelihood of negative impacts on project schedules, budgets, and quality. Effective risk management helps in enhancing project success rates and delivering software projects on time and within budget.

3.7 RISK PLANNING & CONTROL

Risk control in software project management involves implementing measures to mitigate, monitor, and respond to identified risks throughout the project lifecycle. It focuses on minimizing the impact and likelihood of risks and ensuring that risk response plans are effectively executed. Here are some key steps involved in risk control:

1. **Risk Response Execution:** Implement the risk response plans developed during risk planning. Carry out the actions defined in the plans to address and mitigate the identified risks. This may involve implementing preventive measures, deploying contingency plans, or transferring risks to external parties.

2. **Change Management:** Monitor and manage changes that may impact risk levels. Evaluate the potential risks associated with proposed changes and assess their impact on the project's overall risk profile. Make informed decisions on whether to accept, modify, or reject changes based on their potential impact on project objectives.
3. **Risk Monitoring:** Continuously monitor the identified risks and their associated indicators or triggers. Establish a process to gather data and information related to risk events or emerging risks. Regularly assess risk indicators to proactively identify any signs of risks materializing or evolving.
4. **Risk Reporting:** Communicate risk-related information to relevant stakeholders, including project team members, clients, and management. Provide timely updates on the status of risks, progress in risk response activities, and any changes in the risk landscape. Clear and concise risk reports help stakeholders stay informed and make informed decisions.
5. **Contingency Planning:** Regularly review and update contingency plans to ensure they remain effective and aligned with the evolving risk landscape. Identify new potential risks that may arise during the project and develop appropriate response strategies. Periodically test and validate contingency plans to verify their feasibility and efficiency.
6. **Lessons Learned:** Capture and document lessons learned from risk control activities. Analyze the effectiveness of risk response plans, evaluate the outcomes of implemented measures, and identify areas for improvement. Apply the lessons learned to future projects to enhance risk control practices and decision-making.
7. **Risk Documentation Updates:** Maintain an updated risk register or risk log throughout the project. Document changes in risk status, new risks identified, and modifications to risk response plans. Ensure that risk documentation remains accessible and serves as a reference for project stakeholders.
8. **Stakeholder Engagement:** Engage project stakeholders throughout the risk control process. Encourage proactive risk identification and reporting by team members and stakeholders. Foster a culture of risk awareness and open communication to ensure that risks are promptly addressed and controlled.
9. **Continuous Risk Analysis:** Continuously analyze the effectiveness of risk control measures and adjust them as needed. Evaluate whether the implemented responses are adequately mitigating risks or if alternative strategies should be considered. Regularly review and update risk assessments to ensure the project's risk profile remains accurate and up to date.

By implementing effective risk control measures, software project managers can minimize the impact of identified risks, maintain project objectives, and increase the chances of successful project completion. Risk control activities should be integrated into the overall project management process and executed throughout the project lifecycle to ensure ongoing risk management and project success.

UNIT-4

4.1 PROJECT MONITORING AND CONTROL

4.2 DATA COLLECTION

4.3 VISUALIZING PROGRESS

4.4 COST MONITORING

4.5 REVIEW TECHNIQUES

4.6 PROJECT TERMINATION REVIEW

4.7 **EARNED VALUE ANALYSIS**

4.1 PROJECT MONITORING AND CONTROL

Software project monitoring and control is a crucial aspect of project management in the software development lifecycle. It involves tracking and evaluating the progress, performance, and adherence to plans and standards throughout the course of a software project. The primary goal is to ensure that the project stays on track, meets its objectives, and stays within the defined scope, schedule, and budget.

The key activities involved in software project monitoring and control typically include:

1. **Collecting Data:** This involves gathering relevant data and information about the project's progress, activities, resources, and other key metrics. Data collection can be done through various means, such as project status reports, team meetings, time tracking tools, issue tracking systems, and task management software. Accurate and up-to-date data is essential for effective project monitoring and control.
2. **Visualizing Progress:** Visual representations, such as Gantt charts, Kanban boards, or burndown charts, can help project managers and stakeholders visualize the project's progress. These visual tools provide a clear overview of tasks, milestones, and their status, making it easier to identify any delays or bottlenecks.
3. **Cost Monitoring:** Keeping track of project costs is crucial to ensure that the project remains within the allocated budget. Cost monitoring involves tracking expenses, analyzing budget utilization, and comparing it against planned costs. This helps in identifying cost overruns and taking corrective actions, such as optimizing resource allocation or adjusting project scope.
4. **Review Techniques:** Regular project reviews are conducted to assess the project's progress, performance, and adherence to plans. Techniques like milestone reviews, phase gate reviews, or sprint reviews are used to evaluate the project at specific stages or milestones. These reviews involve examining the project's deliverables, identifying issues or risks, and making necessary adjustments to keep the project on track.
5. **Project Termination Review:** Project termination reviews, also known as post-implementation reviews, are conducted after the project is completed or terminated. It involves assessing the project's overall performance, identifying lessons learned, and documenting best practices for future projects. The termination review helps in evaluating the project's success, identifying areas for improvement, and capturing valuable insights for the organization.
6. **Earned Value Analysis:** Earned Value Analysis (EVA) is a technique used to assess the project's performance in terms of cost and schedule. It involves comparing the

planned value (PV), actual cost (AC), and earned value (EV) of completed work to determine the project's progress and efficiency. EVA provides insights into cost and schedule variances, allowing project managers to take corrective actions to bring the project back on track.

These techniques and practices play a vital role in monitoring and controlling software projects, enabling project managers to track progress, identify issues, and make informed decisions to ensure project success.

4.2 DATA COLLECTION

Collecting data is a critical step in project monitoring and control as it provides the necessary information to assess project progress, performance, and adherence to plans. Here are some key aspects to consider when collecting data in project monitoring and control:

- **Define Data Requirements:** Determine the specific data points and metrics that need to be collected to effectively monitor the project. This will vary depending on the project's objectives, scope, and requirements. Common data requirements include task completion status, effort expended, resource utilization, cost information, quality metrics, and milestone achievements.
- **Identify Data Sources:** Identify the sources from which the required data can be collected. This may include project management tools, time tracking systems, version control systems, collaboration platforms, issue tracking systems, or financial systems. Ensure that the selected data sources provide accurate and reliable information.
- **Establish Data Collection Mechanisms:** Determine how the data will be collected from the identified sources. This can involve manual data entry, automated data extraction, or integration between different systems to collect data in a seamless manner. Explore available APIs, data connectors, or custom scripts to automate the data collection process where possible.
- **Set Data Collection Frequency:** Define the frequency at which data will be collected. This can vary based on the project's needs, but it is generally advisable to collect data regularly to ensure up-to-date information. Daily, weekly, or monthly data collection cycles are common, depending on the project's duration and complexity.
- **Validate Data Accuracy:** Ensure the accuracy and integrity of the collected data. Validate the data against the actual progress, activities, and inputs from project team members. Perform data checks and audits to identify any inconsistencies, errors, or

missing information. Address any data quality issues to maintain the reliability of the collected data.

- **Store and Manage Data:** Establish a centralized repository or data management system to store and organize the collected data. This can be a dedicated project management tool, a database, or a spreadsheet. Ensure proper data governance practices are followed, including data security, access controls, and data backup procedures.
- **Standardize Data Format and Units:** Maintain consistency in the format and units of the collected data. This ensures uniformity and facilitates easier analysis and reporting. Define standards for data representation, such as date formats, naming conventions, and measurement units, and communicate them to the project team.
- **Document Data Collection Process:** Document the process of data collection, including the sources, methods, frequency, and validation procedures. This documentation helps in ensuring consistency, training new team members, and providing an audit trail for future reference.

Remember, collecting data is just the first step. Once the data is collected, it needs to be analyzed, visualized, and interpreted to gain meaningful insights and drive decision-making in project monitoring and control.

4.3 VISUALIZING PROGRESS TECHNIQUES

Visualizing progress is a crucial aspect of project monitoring and control as it provides a clear and concise representation of the project's status, tasks, and milestones. Here are some commonly used techniques for visualizing progress in project monitoring and control:

- **Gantt Charts:** Gantt charts are widely used to visualize project schedules and progress. They represent tasks as horizontal bars along a timeline, showing their start and end dates. Dependencies between tasks are displayed using arrows. Gantt charts provide a comprehensive overview of task durations, overlaps, and critical paths. They help stakeholders understand the project timeline, identify potential delays, and monitor task progress.
- **Kanban Boards:** Kanban boards are visual boards that represent tasks as cards moved across different columns or swimlanes. Each column represents a stage of work, such as "To Do," "In Progress," and "Completed." Kanban boards provide a visual representation of the project's workflow and allow team members to track the

status of tasks at a glance. They are particularly useful for agile or iterative project management approaches.

- **Burndown Charts:** Burndown charts display the remaining work or effort against time. They are commonly used in agile projects to track the progress of completing backlog items or sprints. Burndown charts show the ideal progress line and the actual progress line, allowing project teams to assess whether they are on track to complete the work within the desired timeframe. They help identify any deviations from the planned work and adjust the project accordingly.
- **Milestone Charts:** Milestone charts focus on significant project milestones or deliverables. They present milestones as markers along a timeline, indicating when they are expected to be achieved. Milestone charts provide a high-level view of project progress, emphasizing major achievements and their corresponding dates. They help stakeholders understand the project's key milestones and track the overall project progress.
- **Dashboard Reports:** Dashboard reports offer a consolidated view of various project metrics and key performance indicators (KPIs). They present data in the form of graphs, charts, or tables, providing a visual snapshot of project health. Dashboard reports can include metrics such as task completion status, budget utilization, resource allocation, and risk levels. They enable stakeholders to quickly assess project performance and make data-driven decisions.
- **Heatmaps:** Heatmaps visually represent the intensity or magnitude of certain project attributes or metrics. They use color gradients to depict varying levels of performance, such as task completion rates, resource utilization, or defect density. Heatmaps make it easier to identify areas of concern or improvement by highlighting patterns or outliers in the data.
- **Progress Dashboards:** Progress dashboards are interactive visual displays that provide real-time updates on project progress and key metrics. They often include charts, graphs, and progress bars to represent various aspects of the project. Progress dashboards allow stakeholders to drill down into specific areas of interest, compare actual progress against targets, and access detailed information.

When selecting visualization techniques, consider the needs of your project, the preferences of your stakeholders, and the level of detail required. Use visualizations that effectively communicate the project's status, progress, and key information to facilitate better decision-making and collaboration among project team members and stakeholders.

4.4 COST MONITORING

Cost monitoring is a crucial aspect of project monitoring and control as it helps ensure that the project remains within the allocated budget. Here are some key considerations for cost monitoring in project management:

Define the Budget: At the beginning of the project, establish a clear and detailed budget that outlines the estimated costs for various project components, such as personnel, equipment, software, and any external resources or services. The budget should also consider contingency reserves to account for unforeseen expenses.

Track Actual Costs: Continuously track and monitor the actual costs incurred throughout the project. This includes both direct costs (e.g., labor, materials) and indirect costs (e.g., overhead, administrative expenses). Collect cost data from various sources, such as invoices, timesheets, procurement records, and financial systems.

Compare Actual Costs to Planned Costs: Regularly compare the actual costs against the planned costs outlined in the budget. This allows you to identify any cost variances or deviations. Calculate the variance by subtracting the actual costs from the planned costs, and analyze the reasons behind the variances.

Analyze Cost Variances: Evaluate the reasons for cost variances and assess their impact on the project. Positive variances (when actual costs are lower than planned costs) may indicate cost savings, while negative variances (when actual costs exceed planned costs) may suggest budget overruns. Investigate the causes of variances, such as scope changes, resource inefficiencies, or unexpected expenses.

Implement Corrective Actions: Based on the analysis of cost variances, take appropriate corrective actions to address any budget deviations. This may involve revising the project plan, reallocating resources, renegotiating contracts, or implementing cost-saving measures. Ensure that corrective actions are feasible and aligned with project objectives.

Forecast Future Costs: Use the cost data and variances to forecast future costs and estimate the total project expenditure. Consider any anticipated changes or risks that may impact the project's financials. This helps in proactive cost management and aids in decision-making related to resource allocation, procurement, or scope adjustments.

Communicate Cost Performance: Regularly communicate the cost performance of the project to stakeholders, such as project sponsors, management, and team members. Provide

updates on the budget status, cost variances, and any actions taken to address deviations. Clear and transparent communication helps stakeholders understand the financial health of the project and fosters accountability.

Conduct Cost Reviews: Periodically conduct cost reviews or audits to evaluate the overall cost performance of the project. These reviews assess the effectiveness of cost monitoring and control measures, identify areas for improvement, and capture lessons learned for future projects.

Effective cost monitoring ensures that the project's financial resources are optimized, cost overruns are minimized, and the project stays within the approved budget. It enables project managers to make informed decisions, allocate resources efficiently, and maintain financial accountability throughout the project lifecycle.

4.5 REVIEW TECHNIQUES

Review techniques play a crucial role in project monitoring and control as they provide opportunities to assess project performance, identify areas for improvement, and ensure project objectives are being met. Here are some commonly used review techniques in project monitoring and control:

- **Performance Reviews:** Performance reviews assess the overall performance of the project team and individual team members. They typically involve evaluating key performance indicators (KPIs), such as task completion rates, adherence to schedules, and quality of deliverables. Performance reviews help identify areas of strength and areas that need improvement, enabling timely feedback and performance enhancement.
- **Quality Reviews:** Quality reviews focus on assessing the quality of project deliverables and processes. They involve evaluating adherence to quality standards, identifying defects or issues, and recommending corrective actions. Quality reviews can be conducted through inspections, peer reviews, or audits, and they help ensure that project outputs meet the required quality criteria.
- **Risk Reviews:** Risk reviews assess the effectiveness of risk management strategies and actions taken to mitigate project risks. They involve reviewing the identified risks, evaluating their impact and likelihood, and assessing the effectiveness of risk response plans. Risk reviews help in identifying new risks, adjusting risk management strategies, and ensuring that risks are appropriately managed throughout the project.

- **Stakeholder Reviews:** Stakeholder reviews involve gathering feedback and input from project stakeholders, including clients, sponsors, end-users, and other relevant parties. These reviews seek to understand stakeholder satisfaction, validate project deliverables against expectations, and identify areas where stakeholder requirements may have changed. Stakeholder reviews enable project teams to address stakeholder concerns, enhance collaboration, and maintain alignment with stakeholder needs.
- **Project Health Reviews:** Project health reviews provide a comprehensive assessment of the overall project performance, including areas such as scope management, schedule adherence, budget utilization, and resource allocation. They involve reviewing project documentation, metrics, and progress reports to gauge project health and identify any deviations from the project plan. Project health reviews help in proactively identifying potential issues, making informed decisions, and taking corrective actions to keep the project on track.
- **Project Closure Reviews:** Project closure reviews, also known as post-project reviews or project retrospectives, are conducted at the end of the project. They involve reflecting on the project's overall performance, capturing lessons learned, and identifying opportunities for future improvement. Project closure reviews provide valuable insights for future projects, help document best practices, and facilitate organizational learning.

These review techniques contribute to effective project monitoring and control by providing feedback, evaluating performance, identifying risks and issues, and promoting continuous improvement. Project managers can leverage these techniques to ensure project success, optimize performance, and deliver desired outcomes.

4.6 PROJECT TERMINATION REVIEW

A project termination review, also known as a project post-mortem or project closure review, is conducted at the end of a project to assess its overall success, identify lessons learned, and capture valuable insights for future projects. Here are the key aspects of a project termination review in project monitoring and control:

- **Define Objectives:** Determine the objectives of the project termination review. This may include assessing the project's performance against its objectives, evaluating the effectiveness of project management processes, identifying strengths and weaknesses, and capturing lessons learned for future projects.

- **Assemble Review Team:** Form a review team consisting of key stakeholders, project managers, team members, and other relevant individuals who were involved in the project. Ensure representation from different project areas to gather diverse perspectives and insights.
- **Review Project Objectives and Deliverables:** Evaluate the extent to which the project achieved its stated objectives and delivered the intended outcomes. Compare the actual results with the planned targets to identify any gaps or deviations.
- **Assess Project Performance:** Analyze the project's performance in terms of scope, schedule, budget, quality, and stakeholder satisfaction. Review project metrics, performance indicators, and key performance factors to assess the overall success of the project.
- **Identify Lessons Learned:** Identify and document the lessons learned from the project. Encourage open and honest discussions among the review team to capture valuable insights, best practices, challenges encountered, and areas for improvement. These lessons learned serve as valuable knowledge assets for future projects and contribute to organizational learning.
- **Evaluate Project Management Processes:** Evaluate the effectiveness of project management processes and methodologies employed during the project. Assess the adequacy of project planning, risk management, communication, resource allocation, and decision-making processes. Identify areas where improvements can be made to enhance future project performance.
- **Document Successes and Challenges:** Document the project's successes, achievements, and noteworthy accomplishments. Also, identify the challenges faced during the project, including any significant risks or issues encountered and how they were addressed. This documentation provides a comprehensive record of the project's journey.
- **Make Recommendations:** Based on the findings and insights from the project termination review, make recommendations for improvement. These recommendations can be specific to future projects, such as process refinements, resource allocation adjustments, or changes in project management practices. Ensure that the recommendations are actionable and contribute to enhancing project performance.
- **Communicate Findings:** Share the findings and recommendations from the project termination review with key stakeholders, project sponsors, and relevant teams.

Present the information in a clear and concise manner, highlighting the key takeaways, successes, and areas for improvement.

- **Implement Lessons Learned:** Ensure that the lessons learned and recommendations are incorporated into future project planning, execution, and monitoring processes. Share the insights across the organization to facilitate continuous improvement and promote knowledge sharing.

By conducting a thorough project termination review, organizations can leverage the experiences and knowledge gained from previous projects to enhance future project success rates, improve project management practices, and drive organizational growth.

4.7 **EARNED VALUE ANALYSIS**

Earned Value Analysis (EVA) is a project monitoring and control technique that helps assess the performance of a project in terms of cost and schedule. It integrates measurements of planned value, earned value, and actual cost to provide insights into project progress and forecast future performance. Here are the key aspects of Earned Value Analysis in project monitoring and control:

- **Planned Value (PV):** Also known as the Budgeted Cost of Work Scheduled (BCWS), Planned Value represents the authorized budget assigned to scheduled work for a specific time period. PV is determined by allocating the budgeted cost across the project schedule, indicating how much work was planned to be completed at a given point in time.

  *Planned Value (PV) = % of project completed (planned) * Project Budget*

- **Earned Value (EV):** Earned Value, also known as the Budgeted Cost of Work Performed (BCWP), represents the value of completed work at a specific point in time. It is determined by measuring the actual progress and quantifying it in monetary terms based on the project budget. EV provides an objective measure of the work accomplished.

  *Earned Value = % of completed work * BAC (Budget at Completion)*

- **Actual Cost (AC):** Actual Cost, also known as the Actual Cost of Work Performed (ACWP), represents the total cost incurred to complete the work performed until a specific point in time. AC includes direct and indirect costs associated with the project.

  Cost Variance (CV) = Earned value (EV) – Actual Cost (AC)

- **Cost Performance Index (CPI):** The Cost Performance Index is calculated by dividing the Earned Value (EV) by the Actual Cost (AC). CPI provides a measure of the cost efficiency of the project. A CPI greater than 1 indicates that the project is performing better than planned, while a CPI less than 1 indicates that the project is exceeding the budget.

Cost Performance Index (CPI) = Earned Value (EV) / Actual Cost (AC)

- **Schedule Performance Index (SPI):** The Schedule Performance Index is calculated by dividing the Earned Value (EV) by the Planned Value (PV). SPI provides a measure of the schedule efficiency of the project. An SPI greater than 1 indicates that the project is ahead of schedule, while an SPI less than 1 indicates that the project is behind schedule.

Schedule Performance Index (SPI) = Earned value (EV) / Planned Value (PV)

- **Variance Analysis:** Earned Value Analysis allows for variance analysis, which compares the planned and actual values to identify cost and schedule deviations. Key variance metrics include:
- **Cost Variance (CV):** CV is calculated by subtracting the Actual Cost (AC) from the Earned Value (EV). A positive CV indicates that the project is under budget, while a negative CV indicates that the project is over budget.
- **Schedule Variance (SV):** SV is calculated by subtracting the Planned Value (PV) from the Earned Value (EV). A positive SV indicates that the project is ahead of schedule, while a negative SV indicates that the project is behind schedule.
- **Forecasting:** EVA enables project managers to forecast future performance based on the project's current performance. By calculating the Cost Performance Index (CPI) and Schedule Performance Index (SPI) and extrapolating them, project managers can estimate the project's final cost and schedule outcomes.

Earned Value Analysis provides project managers with a comprehensive understanding of the project's cost and schedule performance. It helps identify potential issues early on, supports data-driven decision-making, and facilitates effective project control by enabling proactive management of cost and schedule variances.