Unit 4

Software Project Management

Unit Outcomes (UOs) :

After completion of this unit, students will be able to :

4.1 Prepare schedule for software development activities

4.1 Responsibilities of software project manager

- A project manager is the person who is responsible for accomplishing the stated project objectives.
- Software project managers take the overall responsibility of project success.
- The job responsibility of a project manager ranges from invisible activities like building up team spirit to highly visible customer presentations. (Planning to Deployment).
- A project manager bridging the gap between the production team and client.
- He managing the constraints of the project management triangle, which are cost, time, scope, and quality.
- General activities of manager like → project proposal writing, project cost estimation, scheduling, project staffing, software process tailoring, project monitoring and control, software configuration management, risk management, interfacing with clients, managerial report writing and presentations, etc.
- All the above activities are mainly classified into: *project planning, project monitoring* and *control activities*. Project planning activity starts before development, while monitoring and control starts after development.
- Key among his or her duties is the recognition of risks that affect the success of the running project (risk management). It follows that a project manager is one who is responsible for making decisions both large and small, in such a way that risk is controlled and minimized.
- Time and cost estimation are also important factors of project manager responsibilities.
- Follow project status and modify it to ensure success.
- Every decision taken by the project manager should be taken in such a way that it directly benefits the project.
- He sets up development milestones and entry or exit criteria.

The skills required in project manager to manage the projects, are

- He must have theoretical knowledge of different project management techniques.
- A good decision making capabilities also required in project manager.
- He should be client representative and has to determine and implement the exact needs of the client, and capable of understanding and discussing the problems with customers.

- He should have the management skills like ask the questions and resolve conflicts regarding project.
- Successful project manager one who focuses on risk management.
- He should have team leadership skill so the project which is divided into different persons are managed well and completed as per schedule.
- He should have the experience in the related area of the developing project.
- Monitoring and scheduling the progress of the project.
- Evaluating performance of each milestone of the project.
- Some skills like tracking and controlling the progress of the project, customer interaction, managerial presentations, and team building are acquired through experience.

4.1.2 Scheduling

- Project-task scheduling is an important project planning activity. It involves deciding which tasks would be taken up when.
- Project scheduling is a tool that distributes estimated efforts across the project duration and allocates these efforts to specific tasks.
- In order to schedule the project activities, a software project manager needs to do the following :
  - ➥ Identify all the tasks needed to complete the project.
  - ➥ Break down large tasks into small activities.
  - ➥ Determine the dependency among different activities.
  - ➥ Establish the most likely estimates for the time durations necessary to complete the activities.
  - ➥ Allocate resources to activities.
  - ➥ Plan the starting and ending dates for various activities.
  - ➥ Determine the critical path.
- Among all of the above activities: identifying tasks and breaking down them into small activities done through work breakdown structure (WBS). PERT and CPM used to sequence the activity and estimating time and project schedule is developed through Microsoft project tool.

❖ **Work breakdown structure (WBS)**

- Work Breakdown Structure (WBS) is used to decompose a given task set recursively into small activities.
- The WBS is a uniform, consistent, and logical method for dividing the project into small, manageable components forpurposes of planning, estimating, and monitoring.
- An effective WBS encourages a systematic planning process, reduces the omission of key project elements, and simplifies the project by dividing it into manageableunits.
- A WBS will provide a roadmap for planning, monitoring, and managingall factors of the project like → resource allocation, scheduling, budgeting, productivity, performance etc.
- WBS can be shown graphically in a hierarchical tree structure and developed top to bottom manner.
- The root of the tree is labelled by the problem name.

- Each node of the tree is broken down into smaller activities that are made the children of the node.
- Each activity is recursively decomposed into smaller sub-activities until at the leaf level.
- WBS can be done by the decision of the project manager.

Types of WBS

- There are three types of WBS as follows:

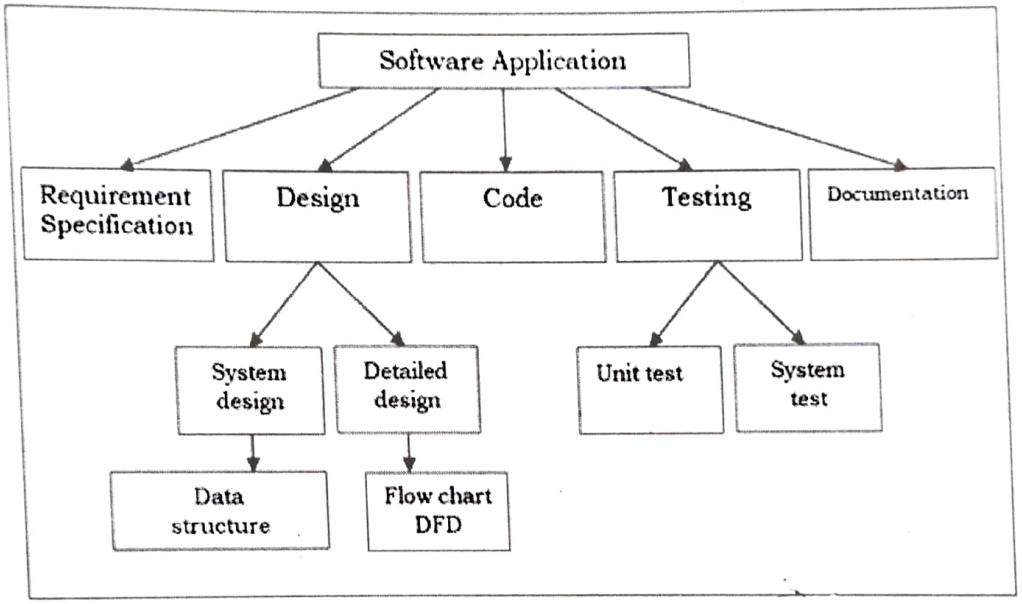
i. **Process WBS :** it decomposes large processes into smaller ones. Each process finally decomposed in the task.

ii. **Product WBS :** it decomposes large entity into smaller components. It is used by system engineers.

iii. **Hybrid WBS :** in includes both process and product elements into single WBS.

- There are two methods of WBS presentation :

1. **Tree structure**

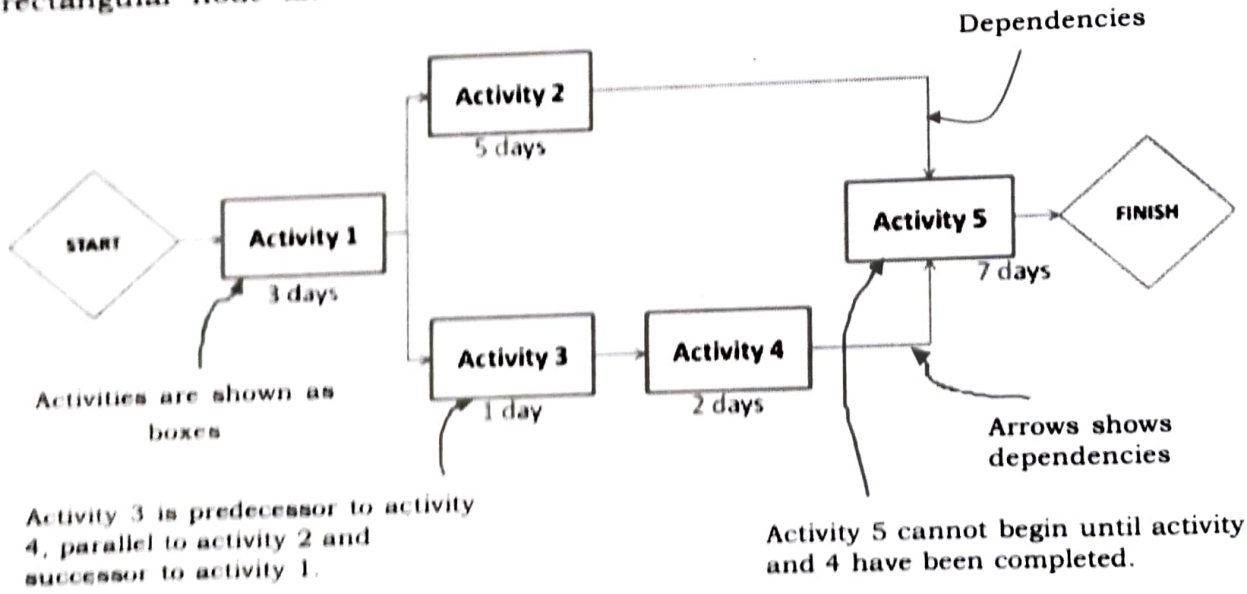


2. **Indented list form**

Level	Tasks
0	Top level Process (Product)(Software application)
1	Requirement Specification
2	Design 2.1 System Design 2.1.1 Data structure 2.2 Detailed design 2.2.1 Flow chart, DFD
3	Code
4	Testing 4.1 Unit test 4.2 System test
5	Documentation

- **Disadvantages**
  - It specifies tasks only, not the process by which task is carried out.
  - It doesn't specify the person who is doing the task.
  - WBS is project specific, so inter project comparison is difficult.
  - In WBS, only the list of tasks and deliverables are prescribed, not how the particular work will be completed
  - WBS doesn't provide any sequence or plan for the tasks.

- **Activity network**
  - In project management, an activity is a task that needs to be accomplished within defined period of time or by deadline to achieve goal.
  - Activities in a project are graphically represented using activity network diagram.
  - Activity network is a network graph using nodes with interconnecting edges to represent tasks and their planned sequence of completion, interdependence and interrelationship that must be accomplished to reach the project goals.
  - An Activity Network Diagram helps to find out the most efficient sequence of events needed to complete any project. It enables you to create a realistic project schedule by graphically showing:
    - The total amount of time needed to complete the project
    - The sequence in which tasks must be carried out
    - Which tasks can be carried out at the same time
    - Which are the critical tasks that you need to keep an eye on.
  - At the time of drawing activity network diagram, each activity is represented by a rectangular node and the duration of the activity is shown alongside each task.



  - The Activity Network diagram displays interdependencies between tasks through the use of boxes and arrows. Arrows pointing into a task box come from its predecessor tasks, which must be completed before the task can start. Arrows pointing out of a task box go to its successor tasks, which cannot start until at least this task is complete.

Activity Network Diagram Drawing Rules

- All the preceding activities must be completed before the project completed.
- The arrows represent the logical precedence of the project.
- The task which is dependent on other tasks cannot start until the tasks on which it depended are completed.

Applications

- Activity Networks and PERT (Programming Evaluation and Review Technique) Charts are typically used to document complex projects in a visual manner.
- They are also used to establish the critical path of a project.

Critical Path Method (CPM)

- The CPM method was discovered by M.R.Walker in 1957. Critical path method is a network analysis technique.
- Critical path is the sequence of activities with the longest duration. A delay in any activity on this path will result in a delay for the whole project. The activities on the critical path are critical activities.
- CPM used to calculate project completion time.
- CPM used to predict the project duration by finding out sequence of activities has the least amount of scheduling flexibilities.
- The project manager identifies the critical activities of the project.
- CPM deals with both cost and time.
- CPM is used to calculate expected completion time of the project.
- It is based on single time estimation.

Need of CPM

- Planning resource requirements.
- Control resource allocation.
- Prediction of deliverables.
- Internal and external program review.
- Performance evaluation.

Advantages

- It provides clear, concise and unambiguous way of documenting project plans, schedules, time and cost.
- It is mathematically easy and simple.
- It is useful to new project managers.
- It displays dependencies which help in scheduling.
- It determines slack time. Which is the total time for that task may be delayed to complete.
- It can display parallel running activity.
- It is widely used in industry purpose.

➥ **Disadvantages**

- It is too complex for large projects.
- It doesn't handle the scheduling of people and resource allocation.
- Critical path should be calculated carefully.
- Calculation of estimating the completion time is difficult.
- Activity time estimates are subjective and depend on judgment.

➥ **Applications**

- Used in construction activities.
- Used in medical and surgical sector.
- Used in transportation activities and oil refineries.

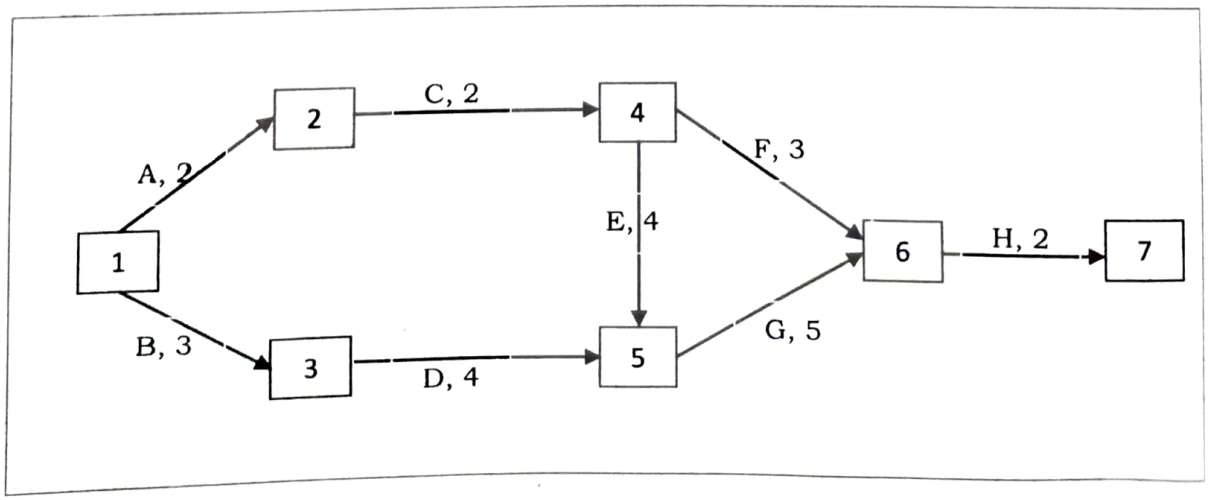
➥ **Example**

Find critical path (project completion time) for the air pollution control system having different activities listed below :

Activity	Description	Time	Immediate Predecessor
A	Build internal components	2	None
B	Modify roof and floor	3	None
C	Construct collection stack	2	A
D	Pour concrete and install frame	4	B
E	Build high-temperature burner	4	C
F	Install control system	3	C
G	Install air pollution device	5	D,E
H	Inspection and testing	2	F,G

- For above problem, first we have to draw the activity network diagram.
- In that diagram each activity is listed on arc. Activities are arranged according to precedence given above.

(This type of network diagram is called Activity on Arc (AoA), Activity on Nodes (AoN) is also another form of network diagram which is drawn at the end of this chapter.)

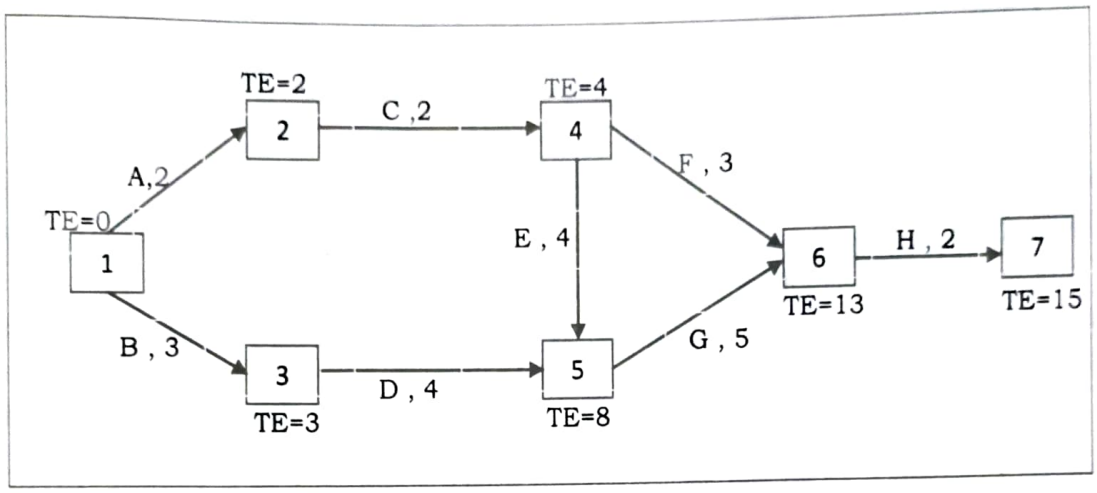


To process for CPM, we have to compute earliest completion time (TE) and Latest completion time (TL) for each node. Earliest completion time (TE) is calculated in forward pass and Latest completion time (TL) is calculated in backward pass.

TE(Node 1) = 0

TE(Node i) = max{t(p)}, $i \neq 1$

Where t(p) denotes the sum of time durations for a path p and where the maximum is taken overall path from node 1 to node i. when we assign a value to the sink node (last node), this value is the earliest completion time for the entire project. Now calculate TE for the above network diagram.

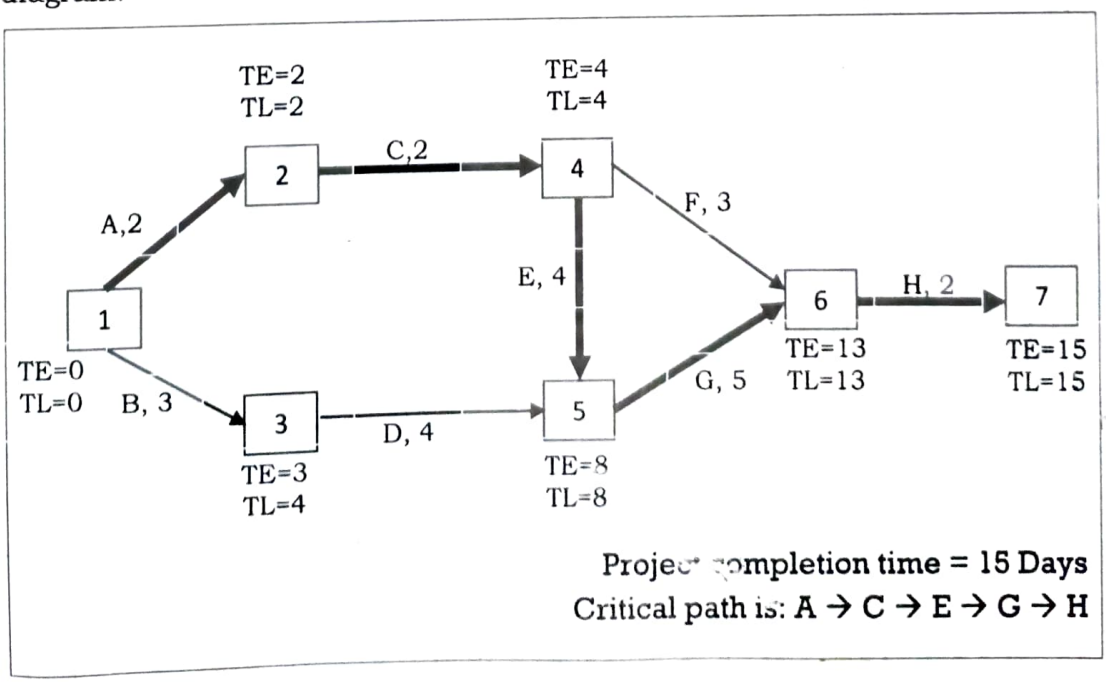


Now we can next calculate latest completion time (TL) associated with each node. That is the latest time an activity can be completed without causing delay in the earliest completion date of the project. TL value of the sink node (last node) is equals its TE value.

TL(Last node) = TE(Last node)

TL(Node i) = TE(Last node) – max{t(p)} i ≠ last node

Where t(p) denotes the sum of time durations for a path p from node i to last node, and maximum is taken overall such paths and subtracted from TE(Last node). Now calculate TL for the above diagram.

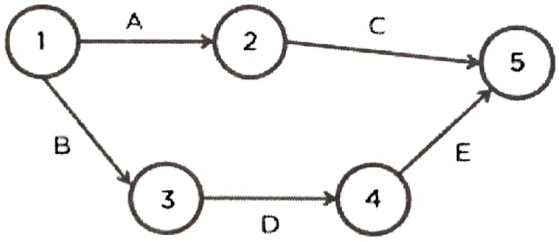


After computed TE and TL values for each node, we can determine the critical path. Critical path is a path in which each node has its TE value equals to its TL value. (Or the path in which each node has slack time equals 0. Slack time = TL – TE). In above figure, the dark arrows show the critical path for given problem.

> ✎ ***Note:*** **(Friends,** આપણે ઉપરના **example** માં **AoA (Activity On Arc)** પદ્ધતિથી **Activity Network** પદ્ધતિથી **Activity Network** દોર્યો. આપણે **AoN** પદ્ધતિથી પણ **Activity Network** દોરી આ જ **example** ગણી શકીએ છીએ. બંને પદ્ધિતથીઓમાં **TE** અને **TL** ની ગણતરી સમાન જ છે.)

❖ PERT Chart A

- The full form of PERT is '**Program Evaluation and Review Technique**'. Sometimes also referred as 'Project Evaluation and Review Technique'. It was developed in 1958 by U.S. navy.
- It is a visual tool for project planning.
- PERT chart is a project management tool used to schedule, organize and coordinate tasks within a project.
- It provides a graphical representation of a project's timeline that enables project managers to break down each individual task in the project for analysis.
- A PERT chart allows a manager to evaluate the time and resources necessary to complete a project.
  - Steps to create PERT chart
    - Identify all of the project's activities or tasks.
    - Determine dependency between different activities.
    - Draw chart (like activity network)
    - Establish timelines for activities.



In above figure, a sample demonstration of PERT chart where node 1 is starting activity and node 5 is last activity (in case of AON method). Activity 2 and 3 are successor of activity 1 with time durations A and B. And after completion of activity C and E, we can say that the project is completed.

> ☛ ***Note :*** (PERT Chart is drawn using activity network diagram that we have discussed already in previous topic)

➥ Advantages of PERT chart

- Easy to schedule project planning and coordinate team members.
- PERT analysis incorporates data and information supplied by a number of departments
- Improves communication between team members.
- ERT charts are useful input for what-if analyses.

Disadvantages of PERT chart

- Creating PERT chart for a big project is time consuming and a complex task.
- It does not focus on budget or cost estimation.
- Need continuous reviews and update to make it accurate.
- It can be confusing for stakeholders to interpret.

GANTT chart :

- It was proposed by Henry Gantt in 1914.
- It is also called time line chart.
- It s mainly used to allocate resources to activities (Resource Planning).
- The resources allocated to activities include staff, hardware, and software etc.
- A Gantt chart is a special type of bar chart where each bar represents an activity.
- It is one of the most popular and useful ways of showing activities displayed against time.
- The bars are drawn along a time line. Activities against time are drawn in bar chart. The length of each bar is proportional to the duration of time planned for the corresponding activity.
- The slack time for a particular task is also shown in the bars.
- The chart is prepared by the project manager.

How to plan GANTT chart

- Identify all the tasks.
- If possible, break down the tasks into smaller tasks.
- Determine the total estimated completion time for each task.
- Plot activities on GANTT chart. Draw milestones at applicable places.

Advantages

- It is very simple to understand and easy to use.
- It is used in monitoring the progress of the project.
- GANTT chart mainly used for resource allocation.
- Useful for planning and guiding projects, understating critical paths & planning resources.

Disadvantages

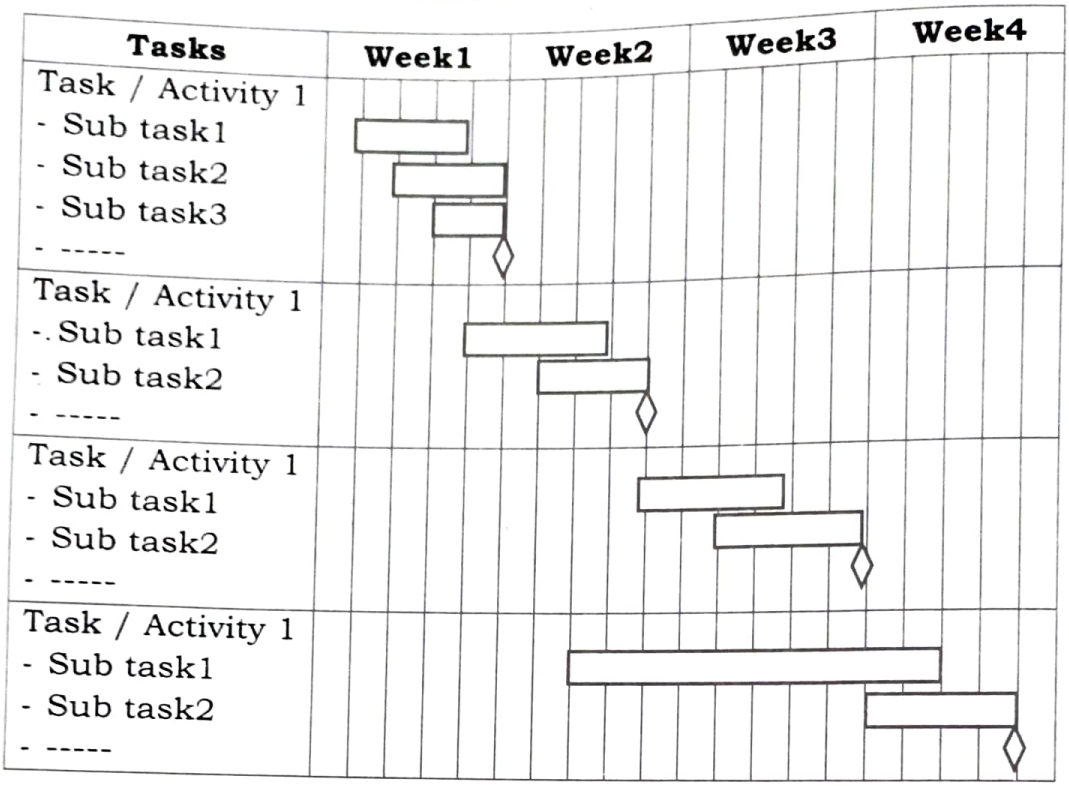
- It doesn't show interdependencies of activities.
- It doesn't show precedence relationship among activities.
- Not suitable for large projects.
- It can't calculate shortest time for any activity in the project.

Application

- Usedin industry to plan and schedule the activities and milestones.
- It is used for task management and resource management.
- Used in project planning and tracking.

- In some situation GANTT chart is used to manage complex project tasks.
- Helps software project manager to better time management.

➥ **Example (a simple frame work that shows the GANTT chart):**



GANTT chart example

☛ **(Hint : GANTT** ચાર્ટ દોરવા માટે સૌપ્રથમ તમારા નક્કી કરેલ પ્રોજેક્ટ અથવા એપ્લિકેશનનો કુલ સમયગાળો નક્કી કરવો. ત્યારબાદ પ્રોજેક્ટને નાના-નાના કાર્યો **(sub tasks)** માં વિભાજિત કરવો. હવે દરેક કાર્યને યોગ્ય અને અનુરૂપ સમયગાળો ફાળવવો. સમયને અનુરૂપ દરેક કાર્ય માટે બાર ચાર્ટ દોરવો. એટલું અવશ્ય ધ્યાન રાખવું કે એક કરતા વધુ કાર્યો માટે બાર ચાર્ટ દોરવો. એટલું અવશ્ય ધ્યાન રાખવું કે એક કરતાં વધુ કાર્યો કોઈ સરખા સમયગાળા દરમિયાન હોઈ શકે છે. અંતમાં એટલું તપાસવું કે પ્રોજેક્ટના દરેક કાર્ય માટે કોઈ સમયગાળો અવશ્ય ફાળવેલો હોવો જોઈએ તેમજ સમયને અનુરૂપ તે કાર્યનો બારચાર્ટ દોરેલ હોવો જોઈએ તેમજ દરેક કાર્ય પ્રોજેક્ટના કુલ સમયગાળા દરમિયાન પૂર્ણ થઈ જવા જોઈએ.)

➥ **Difference between PERT and CPM**

PERT	CPM
→ Full form → Program Evaluation and Review Technique	→ Full form → Critical Path Method
→ It is probabilistic model.	→ It is deterministic model.
→ It has non-repetitive nature of job.	→ It has repetitive nature of job.
→ It generally don't use dummy activities.	→ It can use dummy activities.
→ It is event oriented technique.	→ It is activity oriented technique.
→ Better suitable for research and development type projects.	→ Better suitable for construction projects.

Difference between GANTT chart and PERT chart

GANTT chart	PERT chart
→ Developed by Henry Gantt in 1914.	→ Developed by U.S. navy in 1958.
→ It is represented graphically using bar chart.	→ It is represented graphically using network diagram.
→ It focuses on time required to complete a task.	→ It focuses on dependency of relationship.
→ Critical path cannot be easily found in it.	→ Critical path can be found easily.
→ Simpler to prepare compare with PERT chart.	→ Hard to prepare compare with GANTT chart.

Project Monitoring and Control (PMC)

- Planning is one of the most important project activities. And without proper planning, project monitoring and control is not possible.
- **Monitoring** –collecting, recording, and reporting information concerning project performance that project manager and others wish to know.
- **Controlling** – it uses data from monitoring activity to bring actual performance from planned performance.
- Project monitoring and planning (PMC) activities take place in parallel with project execution, so the implementation should be corrective at appropriate level.
- The main purpose is to - *to ensure quality of final product.*

Why there is a need of PMC

- Simply because we know that things don't always go according to plan.
- To detect and react appropriately to deviations and changes to plans.

What do we monitor and control

- We need to monitor→men, machine, money, material, space, time, tasks, quality, performance and we need to control→ time, cost and performance.
- PERT chart is mainly used for project monitoring and control.

Monitoring and controlling project work includes following activities:

- Comparing the work that is occurring to the project management plan.
- Assessing work performance information to determine if any corrective or preventative actions are necessary.
- Analyzing, tracking, monitoring, and reporting on project risks.
- Providing status reports, accomplishments, and issue reports.
- Monitoring the implementation of approved changes.
- Do scope verification process, schedule control, quality control and cost control.
- Making sure that approved defect repairs have been made.

- Take corrective actions when needed.
- Monitoring and controlling outputs related to risk managementinclude updating the risk register.
- Monitoring and controlling outputs related to communications management include performance reports, forecasts, and resolved issues.
- Techniques used for project monitoring and control activity are: Earned Value Analysis (EVA) and Critical ratio.
- A way of measuring overall performance (not individual task) is using an aggregate performance measure -*Earned Value.*
- *Earned Value Analysis (EVA)* is an industry standard method of measuring project's progress at any given point of time.
- Earned value of work performed (value completed) for those tasks in progress, found by multiplying the estimated percent physical completion of work for each task by the planned cost for those tasks. The result is amount that should be spent on the task so far. This can be compared with actual amount spent.
- Especially for large projects, it may be worthwhile calculating a set of critical ratios for all project activities
- The *critical ratio* is:

$$\frac{\text{Actualprogress}}{\text{scheduledprogree}} * \frac{\text{Budgetedcost}}{\text{Actualcost}}$$

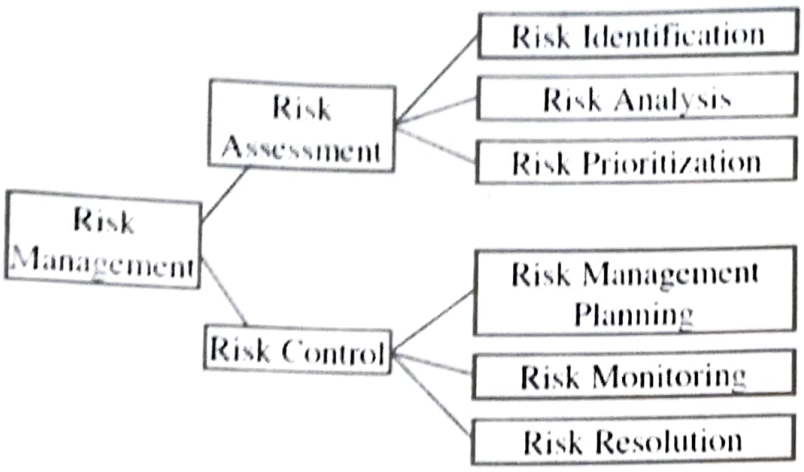
- If ratio is 1 everything is probably on target.
- The further away from 1 the ratio is, the more we may need to investigate.
- Continuous monitoring gives the project management team insight the health of the project, and identifies any areas that can require special attention.

4.1.3 Risk Management :

- Tomorrow's problem is today's risk.
- **Software risk is a problem that could cause some loss or threaten the success of software project, but which hasn't happened yet.**
- This risk may affect negatively to the cost, schedule, technical success or quality of the project.
- Risk management is the process of identifying, addressing and eliminating the problems of risks before they can damage the project.

➥ **Objectives of the risk management**

- Identify potential problems and deal with them when they are easier to handle before they become critical.
- Focus on the project's objectives and consciously look for things that may affect project quality.
- Allow early identification of risks and provide management decisions to the solutions.
- Increase the chance of project success.



Risk management activities

❖ Risk assessment

- It is the process of examining a project and identifying areas of potential risk.
- Risk assessment simply means to identify and analyze risks in a systematic way. It describe the overall process or method to identify risk and problem factors that might cause harm.
- It includes the following activities:
  - i. Risk identification
  - ii. Risk analysis
  - iii. Risk prioritization

(i) Risk identification

- It is a systematic attempt to specify threats of the project plan.
- The purpose of risk identification is → to develop list of risk items also called risk statement.
- So some common risks areas are found and checklist is prepared.
- If we want to identify the important risks which may affect the project, it is necessary to categorize risks into different classes.
- The project manager can then examine which risks from each class are relevant to the project.
- There are three main categories of risks which can affect a software project:

1. Project risks

→ Project risks threaten the project. They concerned various forms of budgetary, schedule, personnel, resource, and customer-related problems.

→ An important project risk is schedule slippage. Because it is very difficult to monitor and control this risk.

2. Technical risks

→ Risks that threaten the quality of the product. These risks concern potential design, implementation, interfacing, testing, and maintenance problems.

→ It also covers the specification risks.

→ Most technical risks occur due to the development team's insufficient knowledge about the project.

3. Business risks

→ Risks that threaten the development (or client) organization.

→ This type of risks include risks of building an excellent product that no one thinks, losing budgetary or personnel commitments, etc.

- The output of this activity is the list of risks.

(ii) Risk analysis

- When the risks have been identified, all risks are analyzed using different criteria.
- The purpose of this activity is → to examine how project outcomes might change with modification of risk input variables.
- The input of this activity is the list of risks developed in risk identification and output is the ranking of the risks and further analysis of description and probability of the risks.
- The main activities of this process are:
  - Group similar risks – detect duplicates and group similar risk items.
  - Determine risk drivers – determine risk parameters that affect identified risks.
  - Determine source of risks – find out causes of risks.
  - Estimate risk exposure – doing by measuring the probability and consequences of a risk.
  - Evaluate against criteria – each risk item is evaluated using the predefined criteria, which are important for the specific risk.

(iii) Risk prioritization

- It helps the project focus on its most severe risks by assessing the risk exposure.
- This process can be done in a quantitative way, by estimating the probability (0.1 – 1.0) and relative loss, on a scale of 1 to 10.
- The higher the exposure, the more the risk should be tackled.
- Another way of handling risk is the risk avoidance (do not do risky things).

❖ **Risk control (OR Risk Mitigation)**

- Risk control is the process of managing risks to achieve the desired outcomes.
- It simply means to reduce adverse effects and impact of risks that are harmful to project.
- Risk mitigation plan helps establish procedures to avoid risks, minimize risks, or reduce the impact of the risks on organizations.
- It guides organizations on how they can bear and control risks.
- Risk control (Mitigation) activity includes the following:
  i. Risk management planning
  ii. Risk monitoring
  iii. Risk resolution

(i) Risk management planning

- It produces a plan for dealing with each significant risk.
- In involves identification of strategies to deal with risk. These strategies fall into following categories:
  - Risk avoidance – simply "don't do the risky things". We may avoid risks by not undertaking certain projects.Risk avoidance attempts to reduce the probability of a risk.
  - Risk minimization (risk reduction) – to reduce the impact of the risk.
  - Risk contingency plan – which deals with a risk if it occurs.

(ii) Risk monitoring

- Risk monitoring is the continuous process of reassessing risks as the project proceeds and when the conditions change.
- Projects can be evaluated periodically to manage the risks and reduce their impact on the project.
- Each key risk should be discussed at management progress meetings.

(iii) Risk resolution

- When a risk occurred, it has to be solved. Risk resolution is the execution of the plans for dealing with each risk.
- The project manager has to decide the plan for resolving the risks.
- The input of this activity is → risk action plan and the outputs are:
  - Risk status
  - Acceptable risks
  - Reduced rework
  - Corrective actions
  - Problem prevention

ASSIGNMENT

MCQs

1. IN CPM, the critical activities have slack time = ...
   (a) 0 (b) 1 (c) Minimum (d) maximum
2. Which of the following is a project scheduling method ?
   (a) RM **(b) PERT** (c) AON (d) Mitigation
3. The critical path of a network is ..... .
   (a) shortest path (b) path with most activities
   (c) path with fewer activities **(d) path with longest time activities**
4. The full form of CPM is ..... .
   (a) Critical Project Management (b) Crash Project Method
   (c) Critical Path Method (d) Critical Path Management
5. Risk management is one of the important tasks for a ..... .
   (a) project manager (b) client
   (c) investor (d) tester

6. In a particular situation, if we think 'don't do risky things'. Then which type of risk management we are doing at there ?
   (a) risk resolution (b) risk monitoring
   (c) risk avoidance (d) risk reduction
7. When we are thinking to build an excellent product that no one thought. At that time, which type of risk is associated ?
   (a) technical risk (b) project risk
   (c) artificial risk **(d) business risk**

True/False

1. Activity network diagram used to determine critical path. **Answer : True**
2. In CPM, the shortest path is the critical path. **Answer : False**
3. PERT chart is a special type of bar chart used for resource allocation. **Answer : False**
4. Risk avoidance is the best technique to resolve risks in software development. **Answer : False**

Short Questions

1. Define scheduling.
2. What is risk in respect to software engineering?OR Define risk.
3. What is risk identification ?
4. Give the full form of :
   - WBS
   - PMC
   - AOA
   - AON
   - PERT
   - CPM
   - EVA
5. Define risk mitigation.
6. List different risk assessment activities.

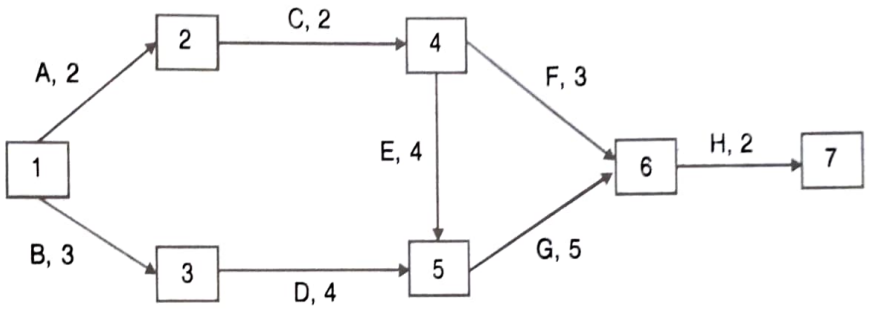
Descriptive Questions

1. Discuss the responsibilities of software project manager.
2. Discuss the skills needed in software project manager.
3. Explain WBS.
4. Draw activity network diagram of given table.
5. What do you mean by project monitoring and control ? **OR** Explain PMC.
6. Explain the use of GANTT chart in detail.
7. Write a short note on activity network.
8. Define risk. Explain important categories of risk that can affect software development.
9. Define risk. Explain risk identification of risk management.
10. Explain risk assessment.
11. Write a short note on risk management.

12. Draw activity network diagram for the following system.

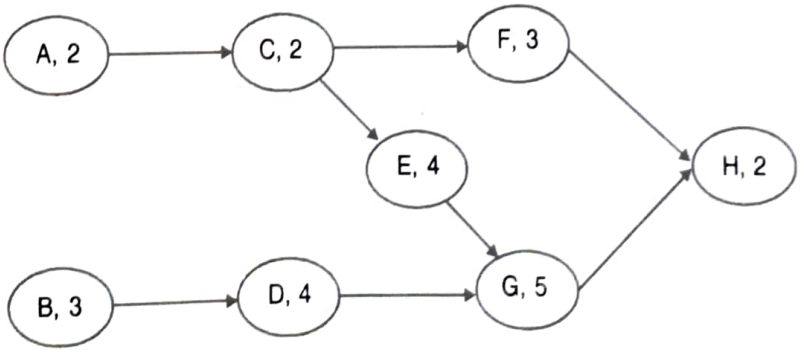
Activity	Description	Time	Immediate Predecessor
A	Build internal components	2	None
B	Modify roof and floor	3	None
C	Construct collection stack	2	A
D	Pour concrete and install frame	4	B
E	Build high-temperature burner	4	C
F	Install control system	3	C
G	Install air pollution device	5	D,E
H	Inspection and testing	2	F,G

Activity network for the above system using AoA (Activity On Arc) method is drawn below :



OR

Activity network for the above system using AoN (Activity On Node) method is drawn below:



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