Critical Path Method (CPM)

Critical Path Method (CPM) is a method used in project planning, generally for project scheduling for the on-time completion of the project. It actually helps in the determination of the earliest time by which the whole project can be completed. There are two main concepts in this method namely critical task and critical path. **Critical task** is the task/activity which can't be delayed otherwise the completion of the whole project will be delayed. It must be completed on-time before starting the other dependent tasks.

Critical path is a sequence of critical tasks/activities and is the largest path in the project network. It gives us the minimum time which is required to complete the whole project. The activities in the critical path are known as critical activities and if these activities are delayed then the completion of the whole project is also delayed.

Activity	**Duration (in weeks)**	**Precedents**
A	6	–
B	4	–
C	3	A
D	4	B
E	3	B
F	10	–
G	3	E, F
H	2	C, D

Major steps of the Critical Path Method:

1. Identifying the activities
2. Construct the project network
3. Perform time estimation using forward and backward pass
4. Identify the critical path

The table given above contains the activity label, its respective duration (in weeks) and its precedents. We will use critical path method to find the critical path and activities of this project.

Rules for designing the Activity-on-Node network diagram:

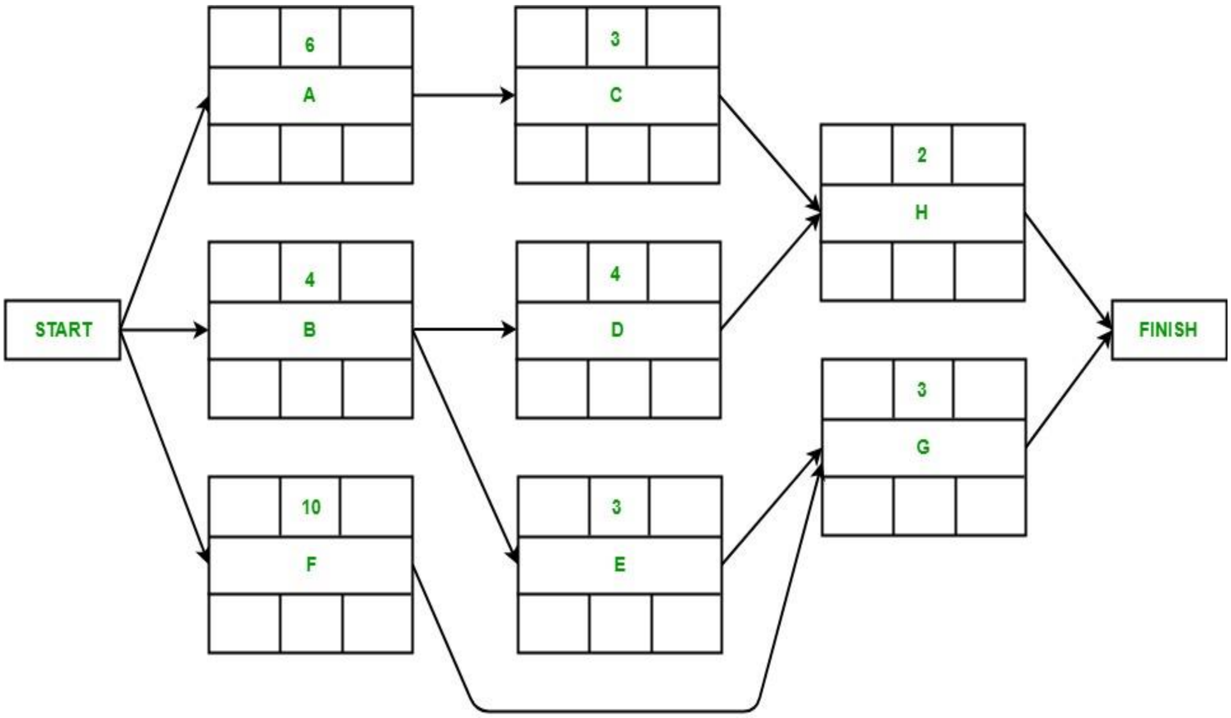
- A project network should have only one start node
- A project network should have only one end node
- A node has a duration
- Links normally have no duration
- “Precedents” are the immediate preceding activities
- Time moves from left to right in the project network
- A network should not contain loops
- A network should not contain dangles

Node Representation:

Earliest Start	Duration	Earliest Finish
	Activity Label	
Latest Start	Float	Latest Finish

- **Activity label** is the name of the activity represented by that node.
- **Earliest Start** is the date or time at which the activity can be started at the earliest.
- **Earliest Finish** is the date or time at which the activity can completed at the earliest.
- **Latest Start** is the date or time at which the activity can be started at the latest.
- **Latest Finish** is the date or time at which the activity can be finished at the latest.
- **Float** is equal to the difference between earliest start and latest start or earliest finish and latest finish.

Activity-On-Node diagram:

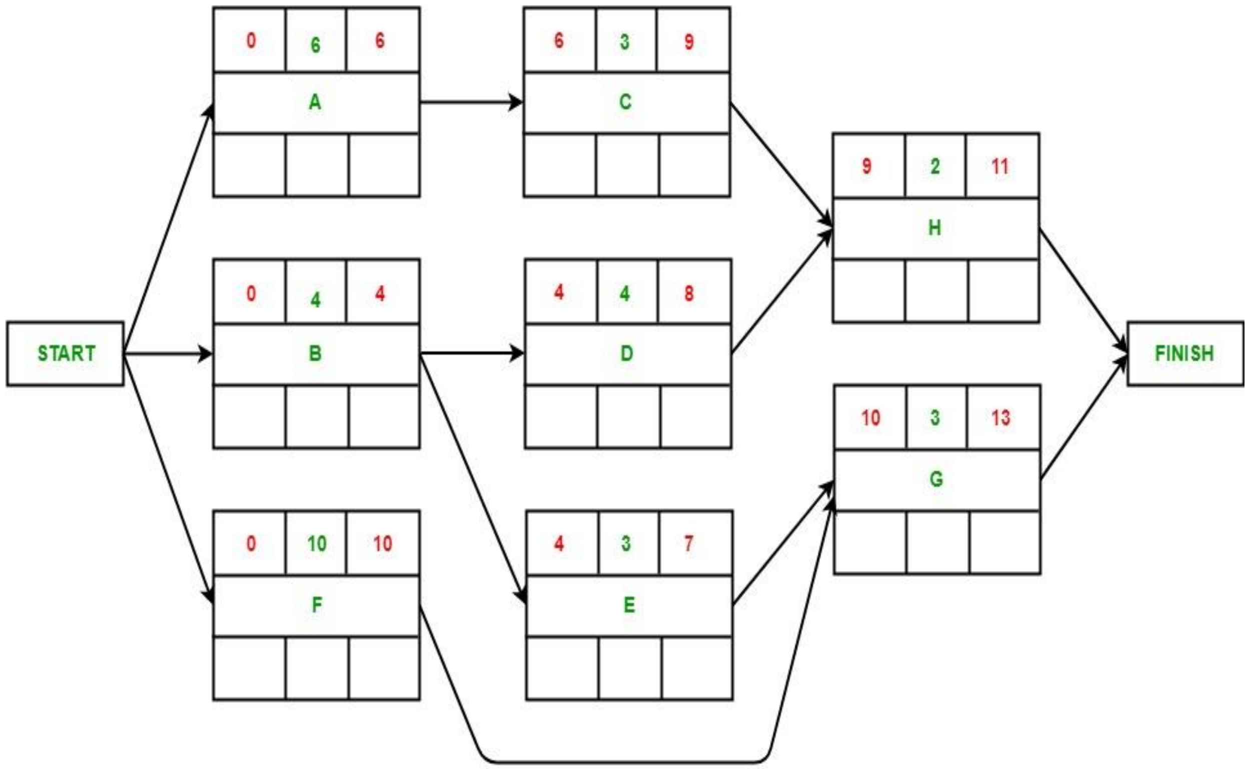


Forward Pass:

The forward pass is carried out to calculate the earliest dates on which each activity may be started and completed.

1. Activity A may start immediately. Hence, earliest date for its start is zero i.e. ES(A) = 0. It takes 6 weeks to complete its execution. Hence, earliest it can finish is week 6 i.e. EF(A) = 6.
2. Activity B may start immediately. Hence, earliest date for its start is zero i.e. ES(B) = 0. It takes 4 weeks to complete its execution. Hence, earliest it can finish is week 4 i.e. EF(B) = 4.
3. Activity F may start immediately. Hence, earliest date for its start is zero i.e. ES(F) = 0. It takes 10 weeks to complete its execution. Hence, earliest it can finish is week 10 i.e. EF(F) = 10.

4. Activity C starts as soon as activity A completes its execution. Hence, earliest week it can start its execution is week 6 i.e. ES(C) = 6. It takes 3 weeks to complete its execution. Hence, earliest it can finish is week 9 i.e. EF(C) = 9.
5. Activity D starts as soon as activity B completes its execution. Hence, earliest week it can start its execution is week 4 i.e. ES(D) = 4. It takes 4 weeks to complete its execution. Hence, earliest it can finish is week 8 i.e. EF(D) = 8.
6. Activity E starts as soon as activity B completes its execution. Hence, earliest week it can start its execution is week 4 i.e. ES(E) = 4. It takes 3 weeks to complete its execution. Hence, earliest it can finish is week 7 i.e. EF(E) = 7.
7. Activity G starts as soon as activity E and activity F completes their execution. Since, activity requires the completion of both for starting its execution, we would consider the MAX(ES(E), ES(F)). Hence, earliest week it can start its execution is week 10 i.e. ES(G) = 10. It takes 3 weeks to complete its execution. Hence, earliest it can finish is week 13 i.e. EF(G) = 13.
8. Activity H starts as soon as activity C and activity D completes their execution. Since, activity requires the completion of both for starting its execution, we would consider the MAX(ES(C), ES(D)). Hence, earliest week it can start its execution is week 9 i.e. ES(H) = 9. It takes 2 weeks to complete its execution. Hence, earliest it can finish is week 11 i.e. EF(H) = 11.



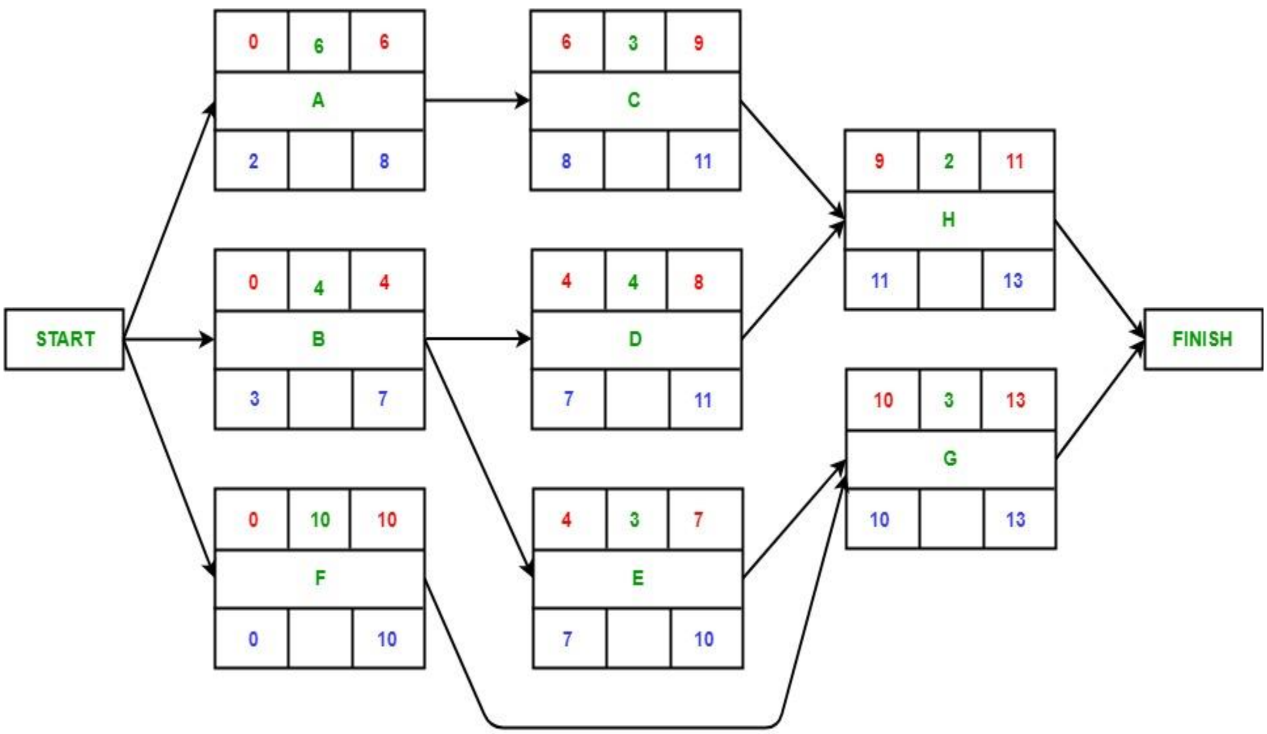
Backward Pass:

The backward pass is carried out to calculate the latest dates on which each activity may be started and finished without delaying the end date of the project.

Assumption: Latest finish date = Earliest Finish date (of project).

1. Activity G's latest finish date is equal to the earliest finish date of the precedent activity of finish according to the assumption i.e. LF(G) = 13. It takes 3 weeks to complete its execution. Hence, latest it can start is week 10 i.e. LS(G) = 10.
2. Activity H's latest finish date is equal to the earliest finish date of the precedent activity of finish according to the assumption i.e. LF(H) = 13. It takes 2 weeks to complete its execution. Hence, latest it can start is week 11 i.e. LS(H) = 11.
3. The latest end date for activity C would be the latest start date of H i.e. LF(C) = 11. It takes 3 weeks to complete its execution. Hence, latest it can start is week 8 i.e. LS(C) = 8.

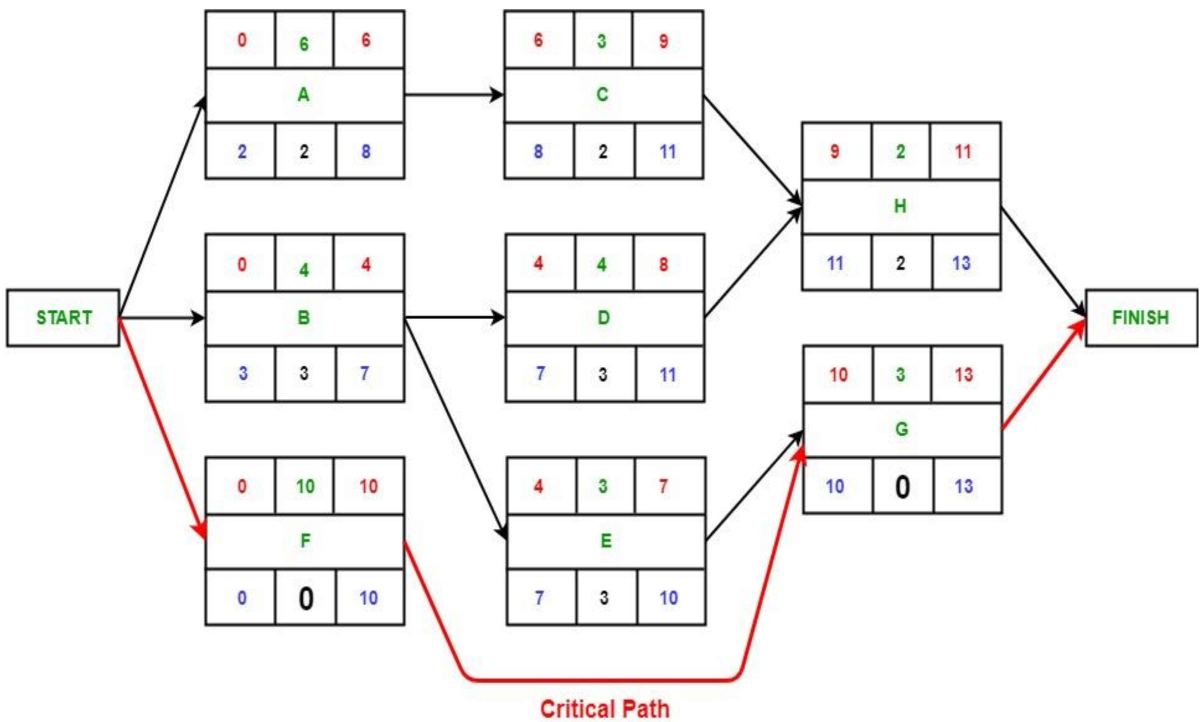
4. The latest end date for activity D would be the latest start date of H i.e. LF(D) = 11. It takes 4 weeks to complete its execution. Hence, latest it can start is week 7 i.e. LS(D) = 7.
5. The latest end date for activity E would be the latest start date of G i.e. LF(G) = 10. It takes 3 weeks to complete its execution. Hence, latest it can start is week 7 i.e. LS(E) = 7.
6. The latest end date for activity F would be the latest start date of G i.e. LF(G) = 10. It takes 10 weeks to complete its execution. Hence, latest it can start is week 0 i.e. LS(F) = 0.
7. The latest end date for activity A would be the latest start date of C i.e. LF(A) = 8. It takes 6 weeks to complete its execution. Hence, latest it can start is week 2 i.e. LS(A) = 2.
8. The latest end date for activity B would be the earliest of the latest start date of D and E i.e. LF(B) = 7. It takes 4 weeks to complete its execution. Hence, latest it can start is week 3 i.e. LS(B) = 3.



Identifying Critical Path:

Critical path is the path which gives us or helps us to estimate the earliest time in which the whole project can be completed. Any delay to an activity on this critical path will lead to a delay in the completion of the whole project. In order to identify the critical path, we need to calculate the activity float for each activity.

Activity float is actually the difference between an activity's Earliest start and its latest start date or the difference between the activity's Earliest finish and its latest finish date and it indicates that how much the activity can be delayed without delaying the completion of the whole project. If the float of an activity is zero, then the activity is an critical activity and must be added to the critical path of the project network. In this example, activity F and G have zero float and hence, are critical activities.



***

Project Evaluation and Review Technique (PERT) is a procedure through which activities of a project are represented in its appropriate sequence and timing. It is a scheduling technique used to schedule, organize and integrate tasks within a project. PERT is basically a mechanism for management planning and control which provides blueprint for a particular project. All of the primary elements or events of a project have been finally identified by the PERT.

In this technique, a PERT Chart is made which represent a schedule for all the specified tasks in the project. The reporting level of the tasks or events in the PERT Charts is somewhat same as defined in the work breakdown structure (WBS).

Characteristics of PERT:

The main characteristics of PERT are as following:

- It serves as a base for obtaining the important facts for implementing the decision-making.
- It forms the basis for all the planning activities.
- PERT helps management in deciding the best possible resource utilization method.
- PERT take advantage by using time network analysis technique.
- PERT presents the structure for reporting information.
- It helps the management in identifying the essential elements for the completion of the project within time.

Advantages of PERT:

- Estimation of completion time of project is given by the PERT.
- It supports the identification of the activities with slack time.
- The start and dates of the activities of a specific project is determined.
- It helps project manager in identifying the critical path activities.
- PERT makes well organized diagram for the representation of large amount of data.

Disadvantages of PERT:

- The complexity of PERT is more which leads to the problem in implementation.
- The estimation of activity time are subjective in PERT which is a major disadvantage.
- Maintenance of PERT is also expensive and complex.
- The actual distribution of may be different from the PERT beta distribution which causes wrong assumptions.
- It under estimates the expected project completion time as there is chances that other paths can become the critical path if their related activities are deferred.

PERT Planning Process:

Project Evaluation and Review Technique (PERT) depicts the activities and schedule of the activities or tasks through a network diagram. PERT is used to estimate the complete time of the project.

PERT Planning comprises of the following steps:

1. Identification of definite activities and breakthroughs:

It is convenient to list all the tasks and breakthroughs required to complete the project in the table. The breakthroughs represent the starting point and deadline of one or more activities. With the help of identification of activities, tasks at later stage can be expanded to build information on sequence and duration.

2. Determining the proper sequence of the activities:

This step in PERT planning process is used to regulate the sequence of activities. Activities can be serial or parallel, the sequence represents the dependency of one activity on other activity. As in the first step the identification of the activities is done, it is necessary to identify the relationships between activities in this step. The analysis of exact order in which the activities performed are required for other tasks.

3. Construction of network diagram:

A network diagram is drawn with the help of the activity identification and activity sequence information. In the network diagram, the activities are illustrated by arrowed lines and breakthroughs are illustrated by circles. To convert the tabular activity information into a network diagram, various CASE tools like MS-PROJECT are available which simplify the process of conversion easily.

4. Estimation of the time required for each activity:

All activities in the project are illustrated by the persistent or steady unit of time. PERT has the capacity to deal with ambiguity and unpredictability in the completion time of the activities. The commonly used unit in software engineering for the activity completion time is weeks.

5. Determination of Critical Path:

Critical path is the path which takes the maximum amount of time. There are many paths in the network diagram which demonstrates the start and end events of the project. Critical path is determined by adding the time taken by the activities in each sequence and then determining the longest path in the project. Total calendar time needed for the project is given by the critical path.

6. Updation of PERT chart:

PERT charts are modified as the project work progresses. As the project work continues, many changes to the PERT chart are made such as addition of resources and changes in the estimation time by the actual time.

The main objective in the analysis through PERT is to find out the completion for a particular event within specified date. The PERT approach takes into account the uncertainties. The three time values are associated with each activity

1. **Optimistic time** – It is the shortest possible time in which the activity can be finished. It assumes that everything goes very well. This is denoted by t_0.

2. **Most likely time** – It is the estimate of the normal time the activity would take. This assumes normal delays. If a graph is plotted in the time of completion and the frequency of completion in that time period, then most likely time will represent the highest frequency of occurrence. This is denoted by t_m.

3. **Pessimistic time** – It represents the longest time the activity could take if everything goes wrong. As in optimistic estimate, this value may be such that only one in hundred or one in twenty will take time longer than this value. This is denoted by t_p. In PERT calculation, all values are used to obtain the percent expected value.

1. **Expected time** – It is the average time an activity will take if it were to be repeated on large number of times and is based on the assumption that the activity time follows Beta distribution, this is given by $t_e = (t_0 + 4 t_m + t_p) / 6$

2. The variance for the activity is given by $\sigma^2 = [(t_p – t_o) / 6]^2$