

Critical Path Method

Introduction

If you have been into project management, I'm sure you have already heard the term 'critical path method.'

If you are new to the subject, it is best to start with understanding the 'critical path' and then move on to the 'critical path method.'

Critical path is the sequential activities from start to the end of a project. Although many projects have only one critical path, some projects may have more than one critical paths depending on the flow logic used in the project.

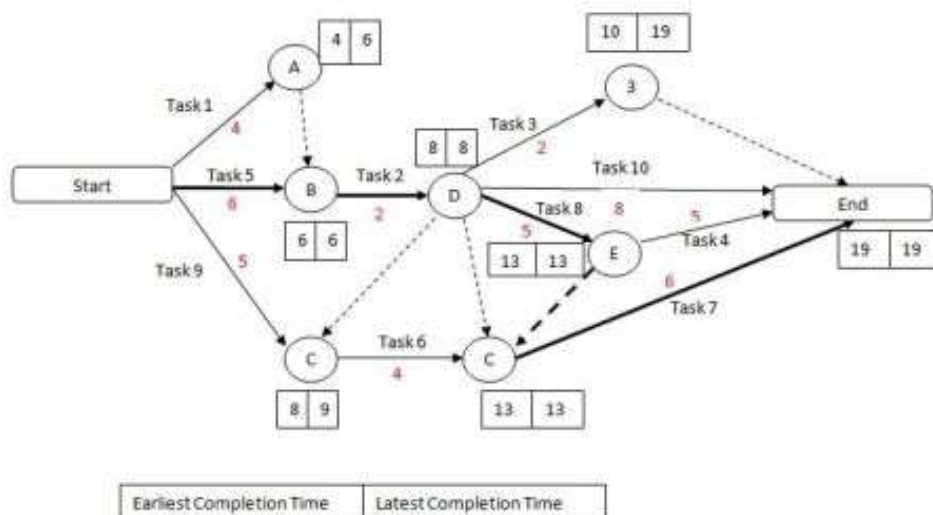
If there is a delay in any of the activities under the critical path, there will be a delay of the project deliverables.

Most of the times, if such delay is occurred, project acceleration or re-sequencing is done in order to achieve the deadlines.

Critical path method is based on mathematical calculations and it is used for scheduling project activities. This method was first introduced in 1950s as a joint venture between Remington Rand Corporation and DuPont Corporation.

The initial critical path method was used for managing plant maintenance projects. Although the original method was developed for construction work, this method can be used for any project where there are interdependent activities.

In the critical path method, the critical activities of a program or a project are identified. These are the activities that have a direct impact on the completion date of the project.



Key Steps in Critical Path Method

Let's have a look at how critical path method is used in practice. The process of using critical path method in project planning phase has six steps.

Step 1: Activity specification

You can use the Work Breakdown Structure (WBS) to identify the activities involved in the project. This is the main input for the critical path method.

In activity specification, only the higher-level activities are selected for critical path method.

When detailed activities are used, the critical path method may become too complex to manage and maintain.

Step 2: Activity sequence establishment

In this step, the correct activity sequence is established. For that, you need to ask three questions for each task of your list.

- Which tasks should take place before this task happens.
- Which tasks should be completed at the same time as this task.
- Which tasks should happen immediately after this task.

Step 3: Network diagram

Once the activity sequence is correctly identified, the network diagram can be drawn (refer to the sample diagram above).

Although the early diagrams were drawn on paper, there are a number of computer softwares, such as Primavera, for this purpose nowadays.

Step 4: Estimates for each activity

This could be a direct input from the WBS based estimation sheet. Most of the companies use 3-point estimation method or COCOMO based (function points based) estimation methods for tasks estimation.

You can use such estimation information for this step of the process.

Step 5: Identification of the critical path

For this, you need to determine four parameters of each activity of the network.

- Earliest start time (ES) - The earliest time an activity can start once the previous dependent activities are over.
- Earliest finish time (EF) - $ES + \text{activity duration}$.
- Latest finish time (LF) - The latest time an activity can finish without delaying the project.
- Latest start time (LS) - $LF - \text{activity duration}$.

The float time for an activity is the time between the earliest (ES) and the latest (LS) start time or between the earliest (EF) and latest (LF) finish times.

During the float time, an activity can be delayed without delaying the project finish date.

The critical path is the longest path of the network diagram. The activities in the critical path have an effect on the deadline of the project. If an activity of this path is delayed, the project will be delayed.

In case if the project management needs to accelerate the project, the times for critical path activities should be reduced.

Step 6: Critical path diagram to show project progresses

Critical path diagram is a live artefact. Therefore, this diagram should be updated with actual values once the task is completed.

This gives more realistic figure for the deadline and the project management can know whether they are on track regarding the deliverables.

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Advantages of Critical Path Method

Following are advantages of critical path methods:

- Offers a visual representation of the project activities.
- Presents the time to complete the tasks and the overall project.
- Tracking of critical activities.

Conclusion

Critical path identification is required for any project-planning phase. This gives the project management the correct completion date of the overall project and the flexibility to float activities.

A critical path diagram should be constantly updated with actual information when the project progresses in order to refine the activity length/project duration predictions.

Critical Path Method for Project management

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Critical Path Method (CPM) is a method used in project planning, generally for project scheduling for the on-time completion of the project. It 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.

Table of Content

- [What is a Critical task in project management?](#)
- [What is the Critical path in project management?](#)
- [Benefits of using the critical path method in project management:](#)
- [How to find the critical path in a project:](#)
- [Rules for Designing the Activity-on-Node network diagram:](#)
- [Node Representation:](#)
- [Activity-On-Node diagram:](#)
- [Forward Pass in Critical path in project management:](#)
- [Backward Pass in Critical path in project management:](#)

What is a Critical task in project management?

It is the task/activity that can't be delayed otherwise the completion of the entire project will be delayed. It must be completed on time before starting the other dependent tasks.

What is the Critical path in project management?

It 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 entire project. The activities in the critical path are known as critical activities and if these activities are delayed then the completion of the entire project is also delayed.

Benefits of using the critical path method in project management:

- Show the project schedule visually.
- Highlight important tasks with CPM.
- Use CPM to find and handle risks.
- CPM helps the project team communicate better.

How to find the critical path in a project:

- Step 1: Identify all tasks required to complete the project
- Step 2: Determine the sequence of tasks
- Step 3: Estimate the duration of each task
- Step 4: Draw a network diagram
- Step 5: Identify the critical path
- Step 6: Calculate the float
- Step 7: Monitor the critical path

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

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

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

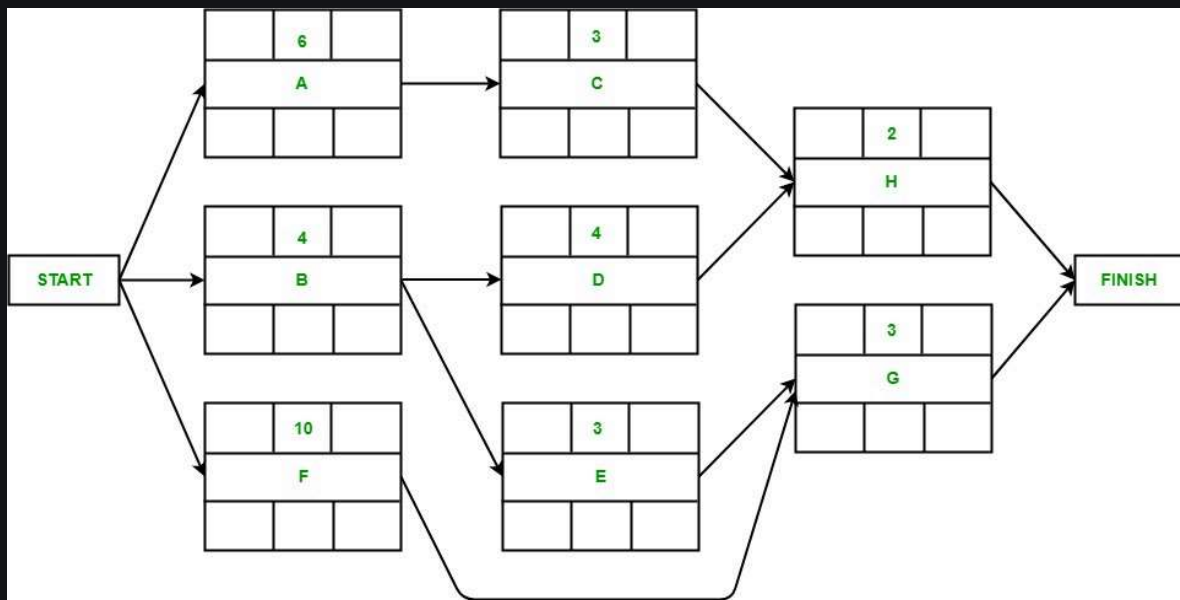
- A node has a duration
- Links normally have no duration
- “Precedents” are the immediate preceding activities
- Time moves from left to right in the project network
- A network should not contain loops
- A network should not contain dangles

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 be completed at the earliest.
- **Latest Start** is the date or time at which the activity can be started at the latest.
- **The latest Finish** is the date or time at which the activity can be finished at the latest.
- **Float** is equal to the difference between the earliest start and latest start or earliest finish and latest finish.

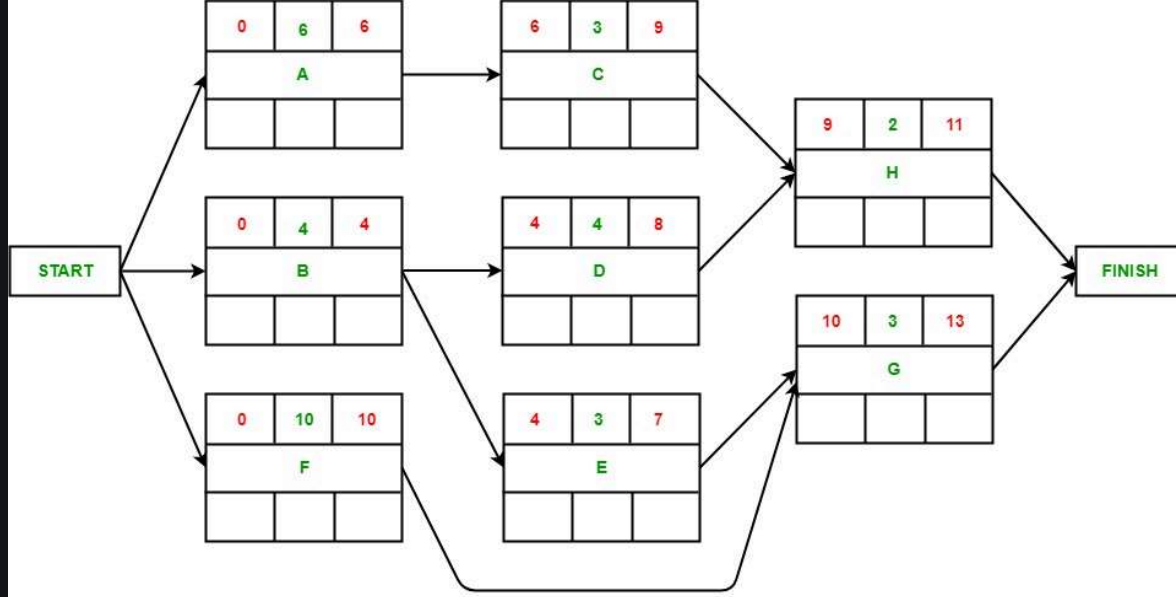
Activity-On-Arrow diagram:



Forward Pass in Critical path in project management:

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, the 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, the earliest date for its start is zero i.e. $ES(B) = 0$. It takes 4 weeks to complete its execution. Hence, the earliest it can finish is week 4 i.e. $EF(B) = 4$.
3. Activity F may start immediately. Hence, the earliest date for its start is zero i.e. $ES(F) = 0$. It takes 10 weeks to complete its execution. Hence, the 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, the earliest week it can start its execution is week 6 i.e. $ES(C) = 6$. It takes 3 weeks to complete its execution. Hence, the 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, the earliest week it can start its execution is week 4 i.e. $ES(D) = 4$. It takes 4 weeks to complete its execution. Hence, the 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, the earliest week it can start its execution is week 4 i.e. $ES(E) = 4$. It takes 3 weeks to complete its execution. Hence, the 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 the activity requires the completion of both for starting its execution, we would consider the $MAX(ES(E), ES(F))$. Hence, the earliest week it can start its execution is week 10 i.e. $ES(G) = 10$. It takes 3 weeks to complete its execution. Hence, the 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 the activity requires the completion of both for starting its execution, we would consider the $MAX(ES(C), ES(D))$. Hence, the earliest week it can start its execution is week 9 i.e. $ES(H) = 9$. It takes 2 weeks to complete its execution. Hence, the earliest it can finish is week 11 i.e. $EF(H) = 11$.

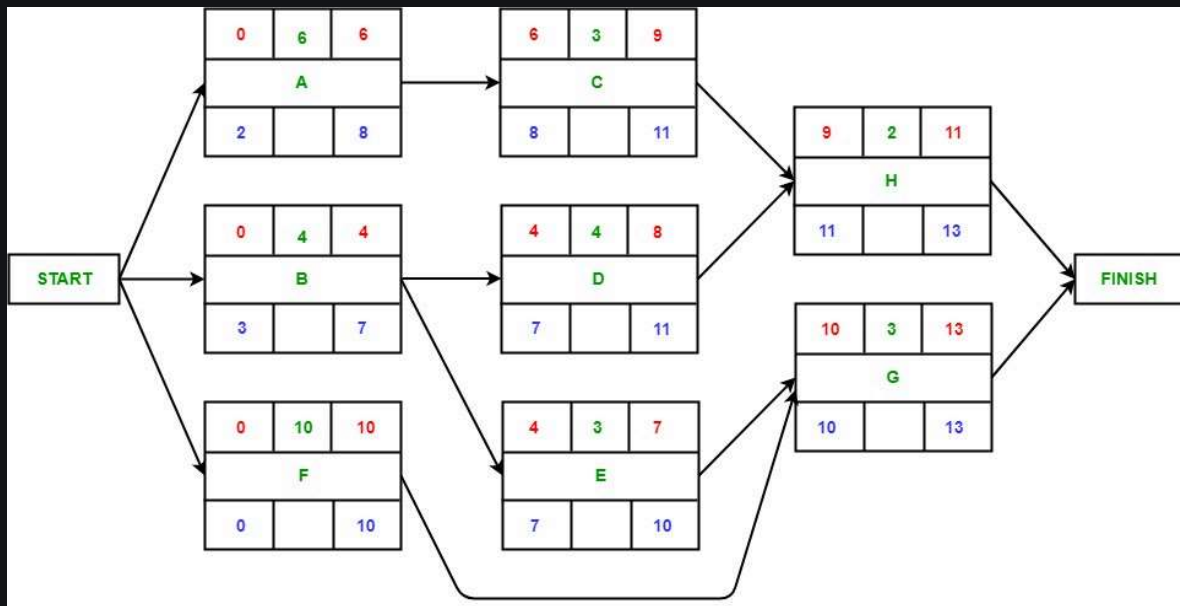


Backward Pass in Critical path in project management:

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).

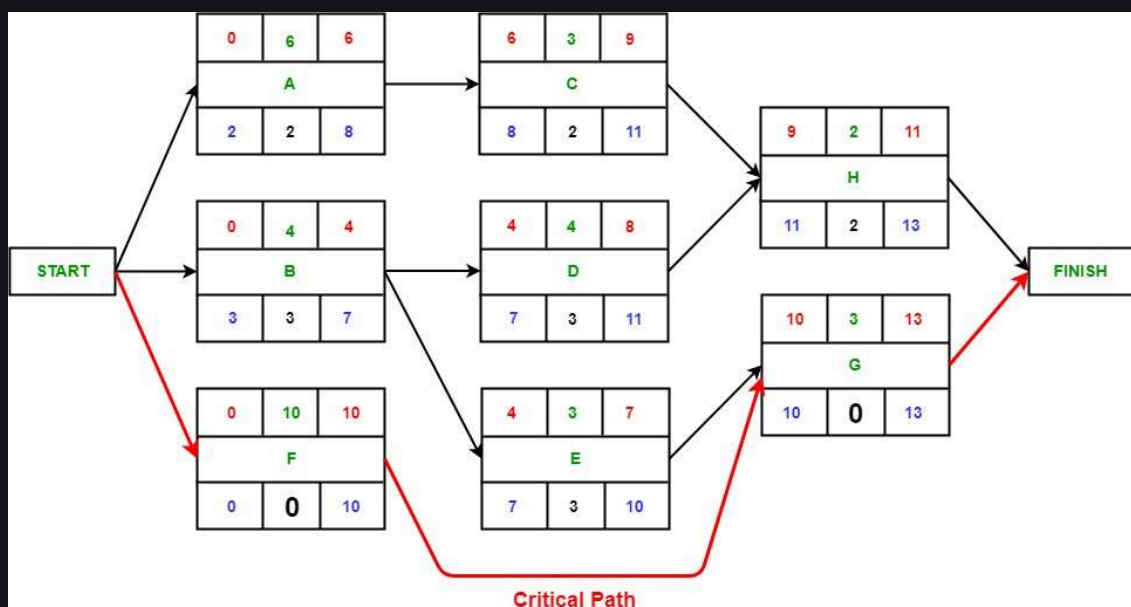
- Activity G's latest finish date is equal to the earliest finish date of the precedent activity of finish according to the assumption i.e. $LF(G) = 13$. It takes 3 weeks to complete its execution. Hence, the latest it can start is week 10 i.e. $LS(G) = 10$.
- Activity H's latest finish date is equal 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, the latest it can start is week 11 i.e. $LS(H) = 11$.
- 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, the latest it can start is week 8 i.e. $LS(C) = 8$.
- 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, the latest it can start is week 7 i.e. $LS(D) = 7$.
- 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, the latest it can start is week 7 i.e. $LS(E) = 7$.
- 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, the latest it can start is week 0 i.e. $LS(F) = 0$.
- The latest end date for activity A would be the latest start date of C i.e. $LF(C) = 8$. It takes 6 weeks to complete its execution. Hence, the latest it can start is week 2 i.e. $LS(A) = 2$.

- 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, the latest it can start is week 3 i.e. $LS(B) = 3$.



Backward Pass in Critical path in project management

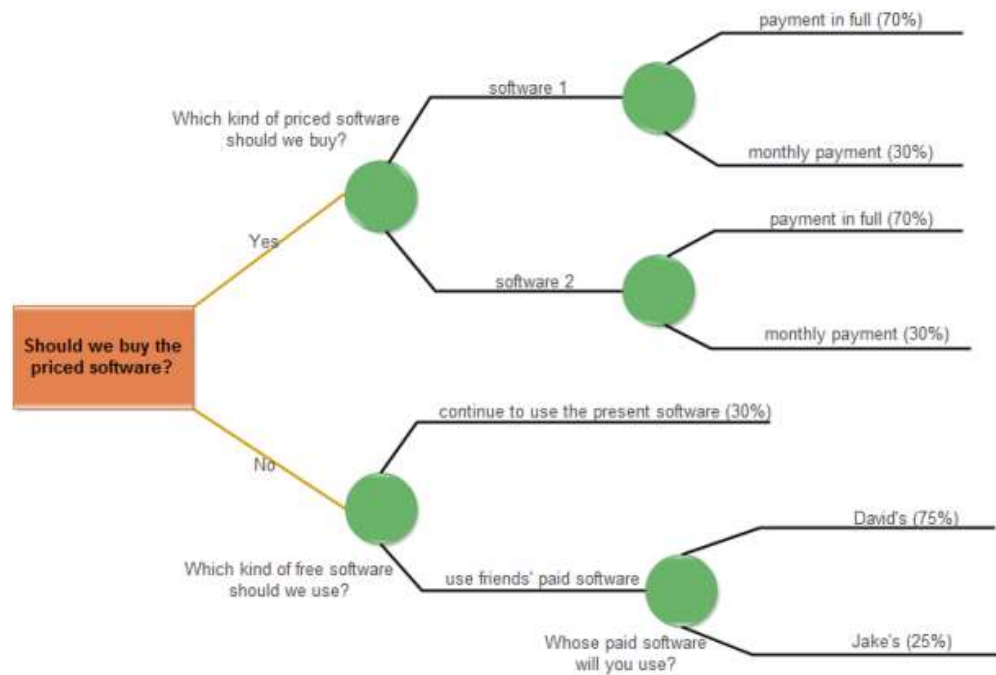
- Identifying Critical Path:** The critical path is the path that gives us or helps us estimate the earliest time in which the whole project can be completed. Any delay to an activity on this critical path will lead to a delay in the completion of the entire project. To identify the critical path, we need to calculate the activity float for each activity. Activity float is 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 how much the activity can be delayed without delaying the completion of the entire project. If the float of an activity is zero, then the activity is critical and must be added to the critical path of the project network. In this example, activities F and G have zero float and hence, are critical activities.



What is a Decision Tree?

At first, a decision tree appears as a tree-like structure with different nodes and branches. When you look a bit closer, you would realize that it dissects a problem or a situation in detail. It is based on the classification principles that predict the outcome of a decision, leading to different branches of a tree. It starts from a root, which gradually has different decision nodes. The structure has terminating nodes in the end.

Ideally, a decision tree can be used in almost every sector. This is because we can take any real-world or hypothetical instance and represent it as a decision tree diagram. To further understand what a decision tree is, let's consider this example. It asks a simple question – whether to buy software or not. If we buy a new tool, then it further leads to the comparison between the two options. If not, then we can either continue to use present software or borrow a friend's tool.



Why do we need a Decision Tree?

Since a decision tree provides a systematic map of the present scenario and the available options, it certainly has a wide range of applications. Following are some of the advantages and reasons for using a decision tree diagram.

- With the help of these tree diagrams, we can resolve a problem by covering all the possible aspects.
- It plays a crucial role in decision-making by helping us weigh the pros and cons of different options as well as their long-term impacts.
- No computation is needed to create a decision tree, which makes them universal to every sector.
- These prediction tree diagrams can be used to represent all kinds of categorical as well as continuous scenarios that can be tough to represent otherwise.
- In the present scenario, decision trees play a vital role in futuristic technologies like machine learning and artificial intelligence.
- They can represent both quantitative as well as qualitative data in a visually appealing manner and that too without applying too much computation.

One of the best parts about decision tree diagrams is that they are extremely easy to make and will not require extensive training. We will provide some decision tree examples and major symbols in the next section to teach you how to create your first decision tree.

Major Symbols of a Decision Tree

After learning what is a decision tree and its importance, let's dive into the details. Even if you have never worked on a classification mode can easily learn how to draw a decision tree diagram. To do this, you need to be familiar with the major symbols that are used in a decisic

Decision node

This indicates a situation when a decision has to be made and is represented by a closed square. This is how most of the decision tree dic



Chance node

Whenever we are uncertain about the outcome of a situation, we represent it with a chance node. It can lead to multiple outcomes, but m recommended to just lead to two results at once. It is represented by a circle.



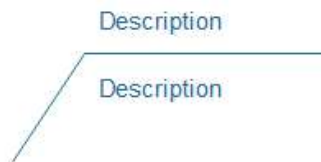
End node

These are the leaf nodes that represent the end of the decision diagram. No further branches are expected from an end node. A small tria for a terminator or end node.



Branches

Every time a decision is made, it leads to different nodes. A branch would connect these nodes and represent a situation or a result. Mostly written over the branch in normal text.



Rejected option

This is an optional symbol in a decision tree which is drawn after the entire diagram has been created. We simply mark it over the branch that we wish to no longer continue.

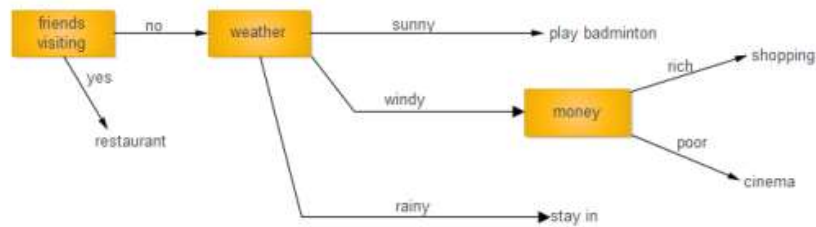


How does Decision Tree Work - Learn From Examples

By now, you would be able to understand what is a decision tree and its major symbols. To further learn about their working and applicati consider a few decision tree examples. In this way, you can understand how a decision tree can play a crucial role in different scenarios.

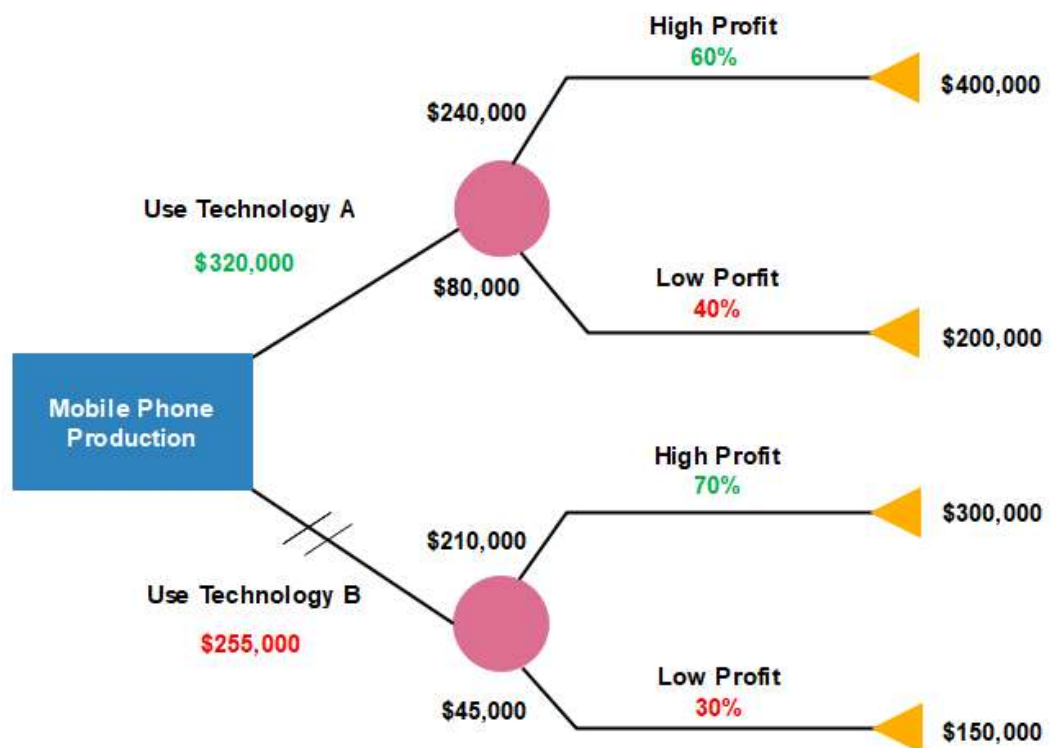
Planning a day

Let's start with a basic decision tree about planning the events of the day. As you can see, if a friend would visit, then we can just visit a res not, then it would depend on the weather. If it is rainy, then it is better to stay indoors while on a sunny day, we can go out and play. In case



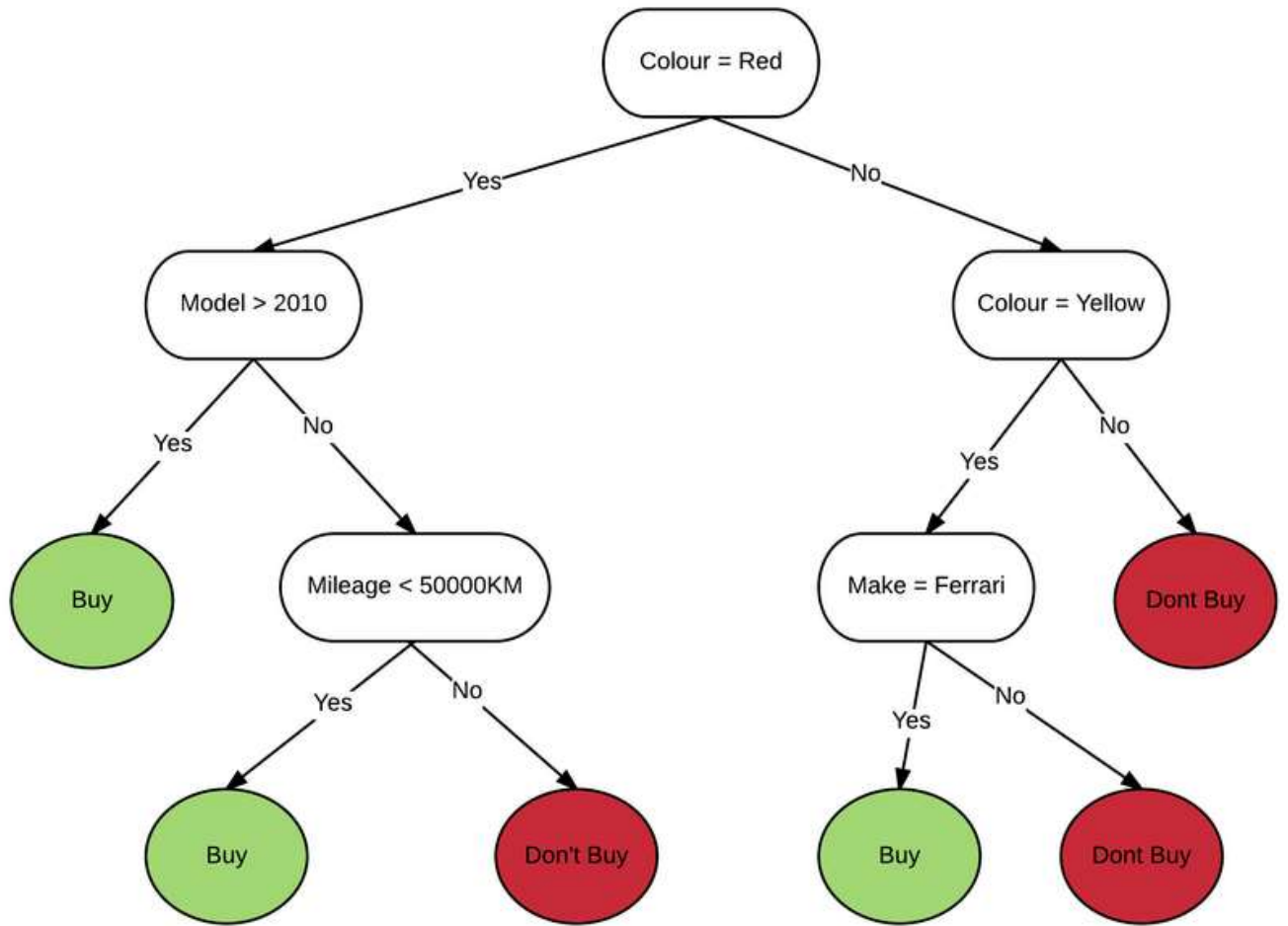
Production Unit Decision

This is a more advanced decision tree in which we will explore the options for mobile phone production. Each of the units has their high and low margins. In the end, we can see the terminator nodes with their results. On the basis of that, Technology A has been chosen while Technology B has been rejected.



Buying a car

As you can see, most of the decision tree examples are related to real-life problems and their visual representation. In this, we will consider preference for buying a car. If the color is red, then further constraints like built year and mileage is considered. If not, then the brand of the car is kept in mind. Wherever these conditions are not met, the car is not bought. On the other hand, it would be bought if it is red and newer than the car with good mileage, or a yellow Ferrari.



Money investment decision

This is another one of those decision tree examples that we face in real-world on a frequent basis. In this, we will consider different options investing money. If we just keep it in the savings account, then we will get a certain return. Another option involves investing money in stocks further dividing it into two sources by half. Since the return from the stocks is more, it seems like a better investment option.

