Advaiya

Project Scheduling Techniques: Probabilistic and Deterministic

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Project scheduling and types of project schedule

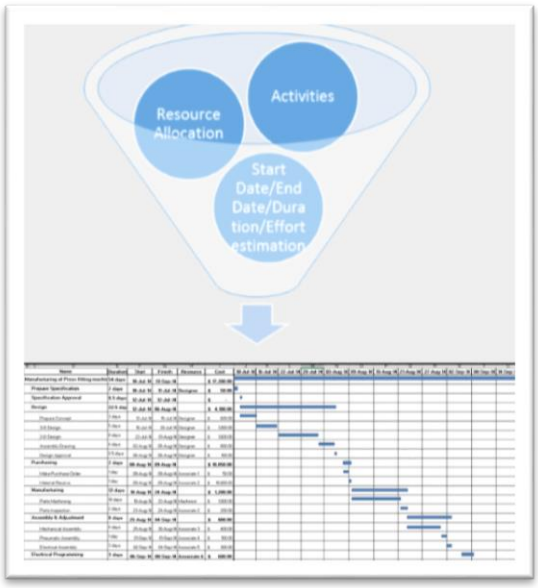
Overview

A project is an activity that focuses to create a unique product or service in a definite time period. Project management is a systematic approach to guide project processes for achieving the target, and project schedule is one of the most important tools that guides for effective project management.

Project scheduling encompasses mapping and planning of every phase of a project's lifecycle from initiation to its' subsequent completion. It should include all terminal elements of the project, containing its budget, duration, work breakdown structure, etc. When performed successfully, it will allow more efficient time and resource provision to ensure that the project is managed in a smooth and efficient manner.

Time and task management are the knowledge areas in project management, which define what work is to be done, when is to be done, and who should be doing. A project schedule generally consists of a hierarchy of work to be performed - an estimation of resources required to perform tasks, duration and effort involved in performing those tasks, and cost incurred in completing the work.

In scheduling tool like MS Project, the hierarchy of work, known as the Work Breakdown Structure (WBS), can be easily developed and thus helps in managing the work easily. The tool helps in estimating the dates and cost of each activity which in aggregate calculates the estimated start and finish date of the project along with the total cost estimation of the project.



Project scheduling techniques

There are various methods involved in displaying and analysing project schedules.

- Methods of displaying project schedules - Milestone Chart, Task List, Gantt Bar, Network Diagram, 2-D Task List, among others.
- Methods of analysing project schedules - Critical Path, Critical Chain, PERT, Resource Levelling, Schedule Acceleration, among others.

These methods can be broadly classified under:

1. Deterministic Scheduling
2. Probabilistic Scheduling

Deterministic Scheduling

Introduction

Deterministic scheduling is the most commonly used scheduling technique. In this method, the schedule developed is a network of activities linked by dependencies.

How it works?

The values such as duration, start and finish dates for activities, are deterministic in nature and thus each one is allocated a single value estimation. The estimated values roll up to the project level to define project duration, along with start and finish dates. The statistical tool generally used is Critical Path Method (CPM). As shown in the below figure (*Figure 1*), the critical path of a project is indicated in red colour.

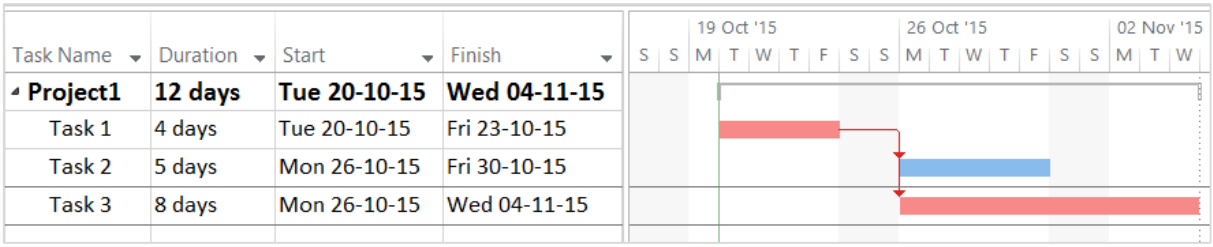


Figure 1: Schedule with Critical Path --> Red Bars showing Critical Path

According to CPM, the project is always driven by a list of connected activities having the longest path, known as the critical path. The project duration, start and finish dates are calculated from the critical path. The focus is majorly on how the project is performing on the critical path activities, rather than focusing on all activities.

MS Project automatically develops the Gantt Chart based on the estimate inputs, like activities and duration, along with the constraints like start or finish dates.

Estimations in deterministic scheduling require experience and references of past data. The chances of successfully completing the project, as per the schedule, greatly depend on the estimations that are deterministic in nature. The number of critical activities may be less than or equal to the total number of project activities.

Consider an example of developing a project schedule with three tasks – design, procurement and development. Following table gives the estimations:

Tasks	Duration	Priority/Relationship
Design	4 days	Start
Procurement	5 days	Will start after Task 1 is complete
Development	8 days	Will start after Task 1 is complete

The project duration is estimated using CPM through the below network diagram:

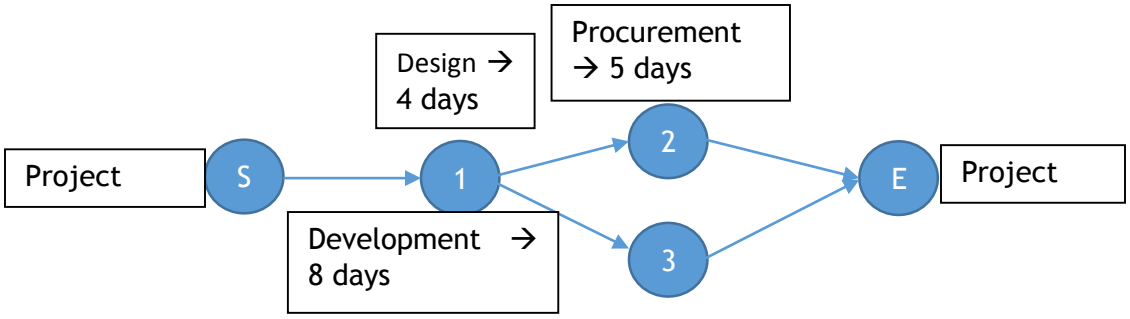


Figure 2: Network Diagram

There are two paths in the above project:

S → 1 → 2 = 9 days

1 → 3 → E = 12 days

According to CPM, the path with the longest duration is considered as the critical path and the project duration is equal to the duration of the longest path.

Linking various tasks/activities and developing the network diagram using MS Project is an automatic process. This is simply done by defining the predecessor/successor relations. The critical path also gets derived from the network diagram automatically.

Here the critical path is S → 1 → 3 → E and the project duration is 12 days.

According to the above example, total duration of the project will be 12 days. The activities on the critical path need to be completed for the said duration to complete the project in 12 days, else the project will get delayed.

The schedule estimated is deterministic in nature. This type of scheduling is used where one knows what exactly is going to happen. This method is helpful where the projects are of similar or repeat nature.

Viewing & having an analysis of the critical path in MS project can be done in no time - just by selecting Critical Path option.

Simply having a glance on different Gantt chart representations, Project Managers can understand the current status of the project. This also helps them in taking a decision over which part or project activities need to be focused on.

Probabilistic Scheduling

Introduction

This scheduling technique involves same activities as in deterministic scheduling, such as listing of tasks, allocating resources, estimating duration, defining start and completion dates, and based on the inputs develop a Gantt chart. The only difference lies in the way of estimating duration and statistical tool used to develop the schedule.

The three-point estimate in deterministic scheduling - the best case, the worst case and the most likely.

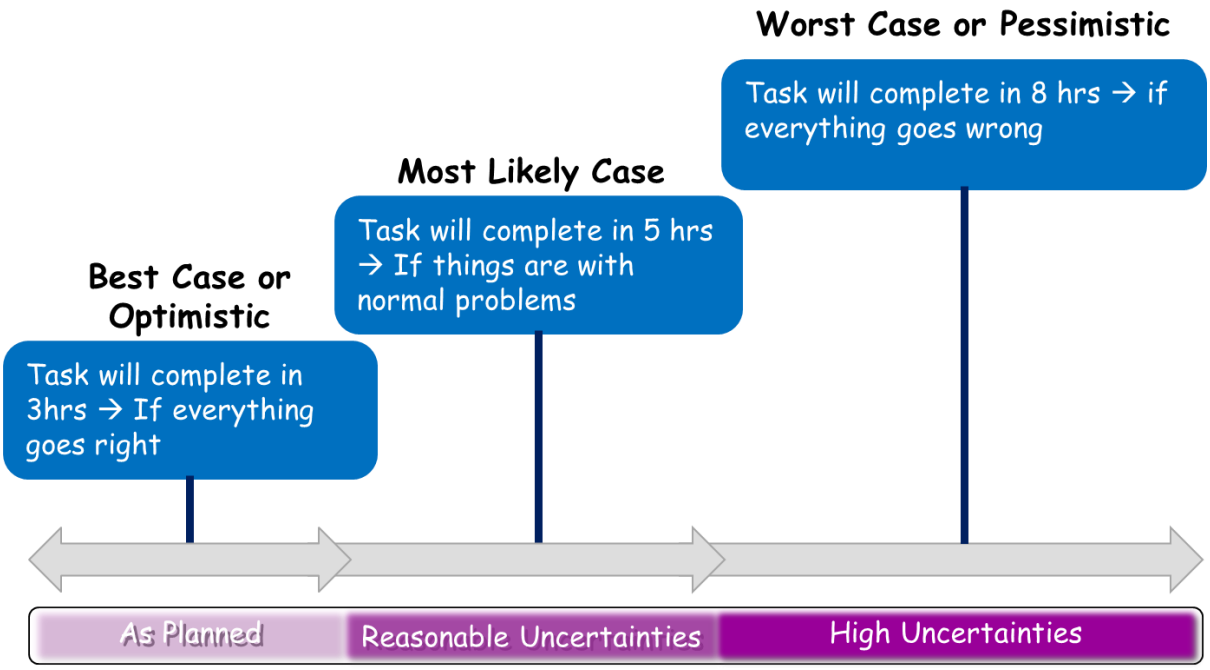


Figure 2: Best Case, Most Likely Case & Worst Case Estimation

Best case is the estimation where everything goes right, most likely case estimate is where activities go on with normal problems and opportunities, and the worst case is where everything goes wrong.

Statistical tools like PERT (Programmable Evaluation and Review Technique), Monte Carlo Simulation, GERT (Graphical Evaluation and Review Technique), are used do estimate project duration, task dates, project dates, and develop the Gantt chart.

PERT

The program (or project) evaluation and review technique, commonly abbreviated as PERT, is a statistical tool for project management, analysis and representation of tasks involved in completing a given project.

Monte Carlo Simulation

Monte Carlo are a comprehensive range of computational algorithms that are determined by repeated random sampling to achieve numerical results.

GERT

Graphical Evaluation and Review Technique, commonly known as GERT, is a technique of network analysis used in project management that allows probabilistic treatment of both network logic and estimation of activity duration.

How it works?

In order to understand how a probabilistic schedule is developed, understanding of the working of statistical tools is necessary.

How PERT is used to determine the schedule?

The estimation done in PERT is 3-points estimate – Pessimistic (P), Optimistic (O) & Most Likely (M) for each task. In PERT analysis, the duration of a task is assumed to have a beta probability distribution. According to this distribution, the expected task duration and variance of the task completion can be calculated using the following formula:

Expected Task duration (d) = (O+4M+P)/6

Variance (v) = $((P-O)/6)^2$

Consider the above example and estimate the project duration.

Task Name	Duration (in Days)			Priority/Relationship
	Optimistic (O)	Most likely (M)	Pessimistic (P)	
Task 1	3	4	6	Start
Task 2	3.5	5	8	Will start after Task 1 is complete
Task 3	6	8	10	Will start after Task 1 is complete

Apply the above formula to calculate the activity duration (d) and variance (v):

Task Name	Duration (in Days)			Expected Task Duration (d)	Variance (v)
	Optimistic	Most likely	Pessimistic		
Task 1	3	4	6	4	0.25
Task 2	3.5	5	8	5	0.125
Task 3	6	8	10	8	0.45

The project duration is estimated using the Critical Path Method (CPM). The CPM in this example is S → 1 → 3 → E, as determined from the network diagram (*Figure* 2). The expected project duration in the above example is the sum of expected task durations of Task 1 and Task 3.

Expected project duration (μ) = 4 + 8 = 12 days

The variability or standard deviation of the project duration is calculated by the following formula:

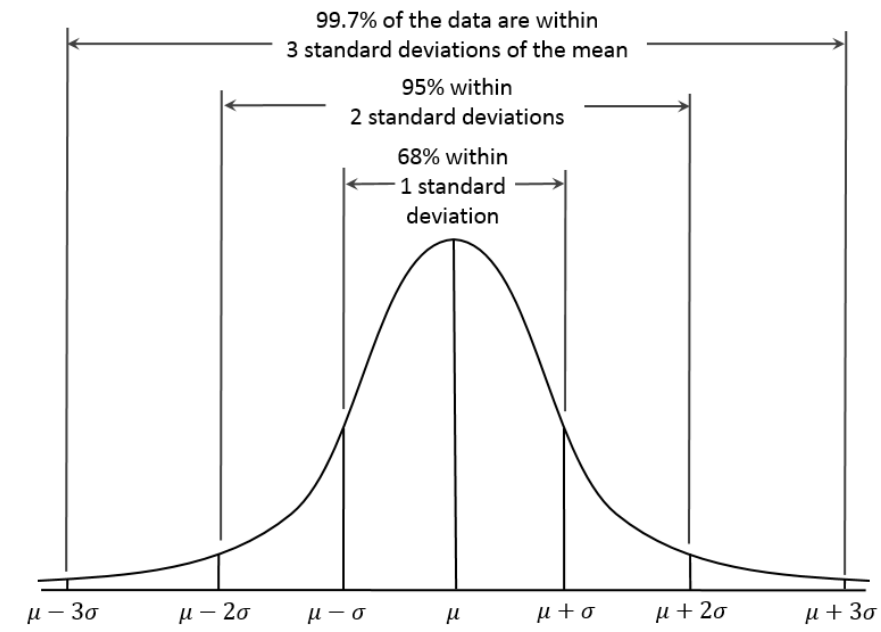
Variability in Project Duration (σ) = (Sum of variance of tasks on CPM) $^{1/2}$

$$= (0.25 + 0.45)^{1/2}$$

$$= 0.87$$

The probability that the project can be completed in 12 days, within the expected project duration (μ) is 50%. PERT analysis answers questions such as – what would be the probability of project completion on time, or conversely, and what the project completion time would be, given a certain probability.

The probability distribution used is normal distribution as represented below:



In the above example, the probability that the project can be completed between 9.39 days to 14.61 days is 99.7%, 10.26 days to 13.74 days is 95% & 11.13 days to 12.87 days is 68%.

This method of scheduling focuses on generating a realistic schedule by taking into consideration the risk factors that may have a positive or negative impact on the project. It tries to capture risks and uncertainties associated with the project tasks and the overall project. The schedule is created with some buffer time to deal with risks and uncertainties.

Conclusion

The most widely used scheduling technique is deterministic scheduling. In deterministic scheduling the risks are handled as static entities. The task and project duration are fixed values. This type of scheduling is mostly used where the projects done are similar in nature and the project manager has an end to end visibility of the projects. The better visibility lets the project manager do a confident risk assessment. While developing the schedule, he/she takes into account all those factors, which give him/her the confidence over the project plan.

In probabilistic schedule, risks are stochastic processes having probabilistic outcomes. The project duration is not a fixed value, but a value determined from the probability distribution with some confidence level associated. This type of scheduling is used where there is more uncertainty in the project. While developing the project plan, the project manager has to consider various factors, which are uncertain in themselves. Probabilistic scheduling gives a realistic view of the project plan, helping project managers predict the uncertainty and its effect on the plan.