Critical Path Method and Critical Chain Project Management

Project schedule plan is the main plan included in any Project Management Plan. Project schedule is responsible for bringing project time, cost and quality under control. Project schedule links resources, tasks and time line together. Once a Project Manager has list of resources, work breakdown structure (WBS) and effort estimates, he is good to go for planning project schedule. Schedule network analysis helps Project Manager to prevent undesirable risks involved in the project. Critical Path Method (CPM) and Critical Chain Project Management (CCPM) are key elements of schedule network analysis. In the following sections we will explore these elements in details to understand their importance in keeping project on schedule to get increase in ROI.

Critical Path Method (CPM):

The Critical Path Method (CPM) is a schedule network analysis technique. CPM was developed by the DuPont Corporation in 1957.Critical path determines the shortest time to complete the project and it is the longest duration path through a network of tasks. Critical tasks (activities) are tasks (activities) on the critical path.

To understand CPM further let's first understand nature of the task. According to PMBOK every scheduled task can be defined by the following four parameters.
- *Early Start (ES):* Earliest possible point in time on which a task can start.
- *Early Finish (EF):* Earliest possible point in time on which a task can finish.
- *Late Start (ES):* Latest possible point in time on which a task can start.
- *Late Finish (EF):* Latest possible point in time on which a task can finish.

Early Start and finish dates are calculated by means of Forward Pass and Late Start and Late Finish dates are calculated by means of Backward Pass.

Many Tasks have some amount of buffer added to them referred as Slack Time or Float. Float time is amount of time a task can slip before it delays project schedule. There are two common types of floats.
- *Free Float:* Amount of time a single task can be delayed without delaying the early start of any successor task.
- *Total Float:* Amount of time a single task can be delayed without delaying project completion.
Mathematically Float is defined as: Float = LS - ES or LF - EF.

Critical path has zero or negative Total Float. A project can have several critical paths.

CPM Example:
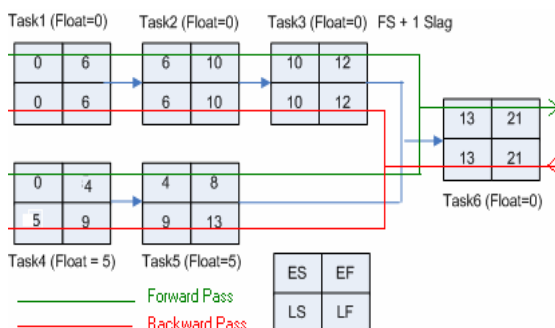
Task	Successor	Duration	Resource	Lag
Task1	Task2	6	R1	0
Task2	Task3	4	R2	0
Task3	Task6	2	R3	FS+1
Task4	Task5	4	R4	0
Task5	Task6	4	R2	0
Task6	-	8	R5	0

FS = Finish to Start

Critical Path = Task1+Task2+Task3+ Lag+ Task6 = 5+4+2+1+8 = **21 Days.**

The Gantt chart representation of the same is given below.

Project Duration = Task1+Task2+Task3+ Lag+ Task6 = 5+4+2+1+8 = 21 Days.

CPM is helpful in:
- Project Planning and control.
- Time-cost trade-offs.
- Cost-benefit analysis.
- Contingency planning.
- Reducing risk.

Limitations of CPM:
- CPM assumes low uncertainty in schedule dates.
- Does not consider resource dependencies.
- Less efficient use of buffer time.
- Less focus on non critical tasks that can cause risk.
- Based on only deterministic task duration.
- Critical Path can change during execution.

To overcome above limitations Critical Chain Project Management (CCPM) plays important role.

Critical Chain Project Management (CCPM):

According to PMBOK Critical chain method is a schedule network analysis technique that modifies the project schedule to account for limited resources. It mixes deterministic and probabilistic approaches to schedule network analysis. The critical chain concept was coined by Eliyahu Goldratt. Following few sections briefly describe the concepts Critical Chain depends on and are useful to understand the example that will follow shortly after that.

CCPM takes advantage of the best practices of:
- PMBOK: Planning and control processes.
- TOC (Theory of Constraints): Remove bottleneck to resolve constraints.
- Lean: Eliminate waste.
- Six Sigma: Reduce Variations.

CCPM helps to overcome following phenomenon.
- Parkinson's Law: Work expands to fill the available time.
- Student Syndrome: People start to work in full fledge only when deadline is near.
- Murphy's Law: What can go wrong will go wrong.
- Bad Multi Tasking: Bad multitasking can delay start of the successor tasks.

CCPM is based on:
- Resource constrained situations.
- Optimum use of Buffer (amount of time added to any task to prevent slippage of schedule)
  o Project Buffers (PB): Amount of buffer time at the end of the project.
  o Feeding Buffers (FB): Amount of buffer time at the end of a sequence of tasks.
  o Resource Buffers (RB): It is an alert that is used to indicate that resource is needed to perform a task. This alert can be set few days before a resource is actually needed.

CCPM Example:

We will consider the same example that was explained in section Critical Path Method Example. CCPM can be applied using following three steps:

1. Remove safety time and reduce tasks durations by 50%.
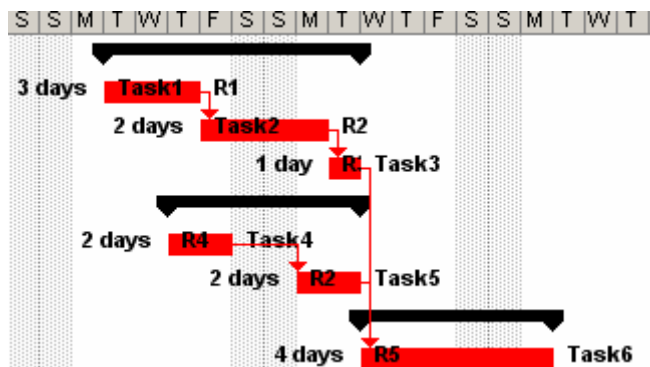
Project Duration = Task1+Task2+Task3+ Task6 = 3+2+1+4 = 10 Days.

Note:
• All safety time durations are removed. For example 1 day lag after Task 2 and 4 days after Task5 are removed.
• All tasks durations are reduced to half (50%). For example Task 1 is 3 Days instead of 6 days.

2. Create schedule on Late Finish dates and Remove resource constraints and identify critical chain.
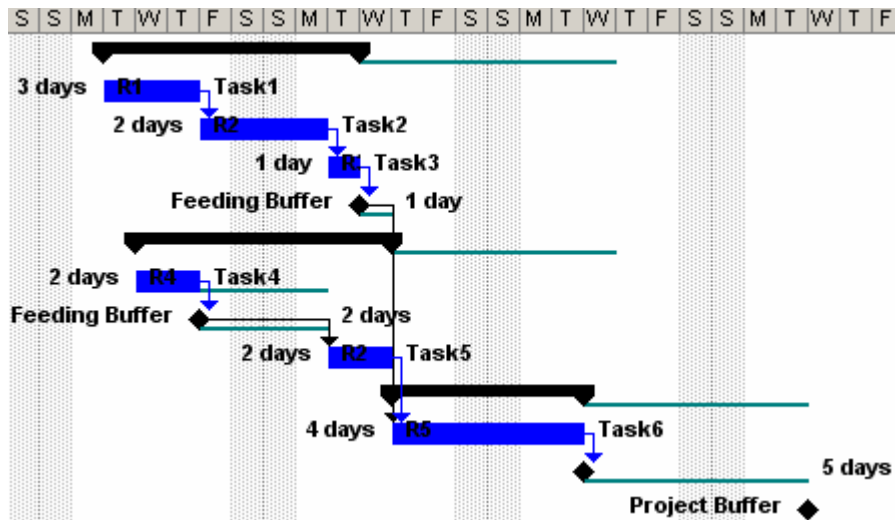

Project Duration = Task1+Task2+Task5+ Task6 = 3+2+2+4 = 11 Days.

Note:
• Task3, Task4 and Task 5 are moved to start from Late Finish dates.
• Task2 and Task5 are to be done by resource R2 and so that aligned to remove resource constraints.

3. Add Project Buffer of 50% of the tasks duration and add Feeder buffer to non critical chain.

Project Duration = Task1+Task2+Task5+ Task6 + PB = 3+2+2+4+5 = 16 Days.

Note:
- Project Buffer (PB) = 50% of Project Duration (11 Days) = 5.5 Days = 5 Days (Rounded).
- Feeder Buffer (FB) for non critical tasks on chain. For example Task 4 is added 2 days FB.
- Buffer calculation is done by taking 50% of project duration for simple case and by Square root of the sum of the squares method (SSQ) for aggressive case.

Comparison of CPM and CCPM results:

According to the results we found above, project duration by CPM traditional approach is 21 days and the project duration for the same amount of work by using CCPM is 16 Days.
Using CCPM:
- Project Duration can be reduced by 25-40%.
- Resources can be utilized effectively.
- Project is fully focused on both critical and non critical tasks

Implementation of CCPM:

CCPM is successfully implemented by US Navy, Lucent, NASA, US Air Force, Philips and many other organizations.

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