Critical Chain Project Management: Conceptualization

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Abstract : ***Critical Chain Project Management is a concept based on scheduling and managing the projects. It was given by Eliyahu Goldratt in the year 1997, in order to improve the traditional methods of project management. The aim of this paper is to give an overview about the concept of CCPM from its origin to its future potential based on studies from research papers, manuscripts, articles and case studies. The paper is also going to show different methodologies used to apply CCPM in brief. The paper draws the focus on uncertainty and their causes in traditional methods and their solutions with the help of Critical Chain Project Management. The paper concludes the improvement in project productivity and success rate with adoption of design project management process.***

IndexTerms - scheduling, project management, uncertainty, CCPM

I. INTRODUCTION

Construction is considered as backbone for every nation's economy. Delay in projects can cause cost and time over-run and results in loss of stakeholders. It is therefore essential to have a proper management. Until 1997, traditional methods were used for project management and scheduling. According to a study by Standish Group, by using traditional practices only 44% of projects typically finished on time. Projects typically complete at 222% of the duration originally planned, 189% of the original budgeted cost, 70% of projects fall short of their planned scope , and 30% were cancelled before completion.

The idea of Critical Chain Project Management was first introduced by Eliyahu Goldratt as a new method of managing projects at International Jonah Conference in 1990. But it wasn't popular and didn't came into limelight till 1997 when Eliyahu Goldratt decided to repeat his successful business novel " THE GOAL ".This time the novel was based on " Critical Chain". In his book, he mentioned Theory Of Constraints (TOC). Through publication of his book " Critical Chain ", the concept of management became well known .Since then the concept of Critical Chain Project Management is under continuous modification and improvement. The thing that should be kept in mind is that CCPM is all about improvement of traditional methods. It is not divergent from traditional methods.

II. PROJECT MANAGEMENT

Project Management is not only based on task and resources but also on human behaviour. There are certain laws which are applied on human behaviour like Murphy's Law, Parkinson's Law, Student's Syndrome, etc. The completion of a task depends on the time you begin to work.

The two situations that can arise while performing a certain task are:

1. You start working late as you know you have enough time to complete your task and thus it results into late completion of work due to some uncertainty. This is known as Students Syndrome. i.e. the students start their work at last time or at end moment.

2. Another possibility is, you start doing your task as per your schedule and you finish it on time or before the due date. Still it's not going to be advantageous because in that extra time you will try to do something more. You will try to fill that gap by doing some extra work or enhancing the previous work which is unnecessary .Also it will increase the cost by some extent. This is known as Parkinson's Law.

3. Murphy's Law says that, "If anything is supposed to go wrong, it will go wrong ".

   Thus, it was against the idea of providing safety time in traditional practices.

The efficiency of project will decrease and project will be finished late due to uncertainties. Thus, aim of CCPM is to eliminate such situations and provide a better alternative on traditional techniques

III. CONCEPT

The concept of CCPM considers some important theories like Theory of Constraint, Common cause variation, Statistical laws governing common cause variation, etc. Before learning the application of CCPM, it is mandatory to know the effects of following theories on Schedule and Project management.

3.1 Theory of Constraints

The Theory of Constraints (TOC) says that "Constraints must exist on the output of each and every system ".In brief, it means in a series of chain, there is always one weak link. We need to identify that weak link and improvise it for efficient results. These theories can be used by following steps:

- Step 1-Recognition of system's constraint
- Step 2-Utilization of the constraint
- Step 3-Inferior everything else to the constraint
- Step 4-Elevation of constraint
- Step 5-If the constraint is broken out, go back to step 1

3.2 Common Cause Variation

There are two types of variation: Common cause variation and special cause variation. Common Cause Variation is part of the system as a whole. Special Cause Variation has a specific source such as a team, an employee, a machine, or a circumstance.

Common Cause Variation applies to projects because it affects the time needed to perform part of any project. Let's say you have several teams. On the surface, they work independently, but one team can't start working until the other team has finished its work. The obvious effect of variation will be seen on the succeeding task.

3.3 Statistical laws Governing Common Cause variation

Let's suppose we have a chain of activities. Each activity in the chain has a 50% likelihood of finishing within a day. But there's a 90 percent probability that the activities will take two days. Supposing that there are four activities in the chain, scheduling them to take eight days makes sense on the surface. However, there's a strong possibility that we could finish sooner.

If we use the statistical law of aggregation, we can achieve a 90 percent probability by scheduling the activities at 50 percent of the worst-case estimate of eight days. Just to be on the safe side, we can add a two-day buffer. Thus, instead of scheduling eight days for the chain of activities, we can schedule them for six days.

IV. BUFFER

Buffer is the extra time provided in schedule to keep a project on track. Buffer isn't a new concept. Its modification of safety time. In traditional practices, safety time was added at the end of each task to eliminate risk of uncertainty. But every task isn't critical and thus that safety time wasn't used at its full potential. So, CCPM improvised the concept of safety time and called it as buffer. In buffer, we don't assign extra time at the end of each task for risk assessment. Buffer is nothing but storage of time which is used when certain tasks are at risk of uncertainties or delays. There are 3 important types of buffer: Project Buffer, Feeding Buffer, and Resource Buffer.

4.1 Project Buffer :-

The purpose of Project Buffer is to save the whole project from over running of time.

4.2 Feeding Buffer :-

The purpose of Feeding Buffer is to provide extra time to non-critical chain activity so that succeeding critical chain activities can start without any interruptions.

4.3 Resource Buffer :-

The resources buffer will assure that critical resources are ready when it is time to work on critical chain task.

The thing of concern is calculation of buffer. Researchers have come up with different methodologies for calculation of buffer. Every method aims to make CCPM more practicable and applicable. Following are the few methods to calculate buffer:

1) Cut and Paste method by Sarkar (2012):

$$\text{Buffer size} = \frac{\text{sum of safety time remaining after computing 50\% probability network}}{2}$$

2) Root Square Error method by Sarkar (2012):

$$\text{Buffer size} = \sqrt{[\sum (Ui)^2]}$$

$$Ui = Si - Ai$$

Where, Ui = uncertainty of task, i

Si = safe estimate of task, i

Ai = average duration estimate of task, i

3) Min's Fuzzy Approach buffer sizing technique:

Min's fuzzy approach can be used as an assistance tool in the scheduling process. Activities' duration in this technique is determined using fuzzy members unlike the traditional techniques that scheduled durations using stochastic variables and buffer size solved by applying probability distributions. Although Min's technique allow subcontractors to take a rational buffer size according to their low, medium or high risk considerations by applying β risk coefficient parameter, if schedulers are the risk chasers, will take tiny value of and have a small buffer size that can't absorb scheduling deviations and buffer theory will fail in achieving Project completion date.

V. BENEFITS OF USING CCPM:

1) Eliminate Overly Long Estimates of How Long Things Take:-

Project managers are already very well aware that the minimum time things take and the actual time it takes to get them done can vary greatly. As a result, they tend to play it safe when it comes to time estimates. With project participants and project managers tacking on a contingency time to be sure work will finish on schedule, overall projects end up covering a whole lot more time than they really need to.

2) Saved from delays due to multi-tasking :-

We usually think of multitasking as being a “good thing,” but in the context of projects, it causes delays. It’s easy to understand why. Let’s suppose that you are busy with four activities and that each of them takes a week to finish. Because you’re multitasking, you don’t finish any of them in a week. You split your day up into segments, and each task ends up taking four weeks to complete.

3) Free from Students syndrome :-

Students Syndrome is based on principle that students start to prepare in the end. In similar way even if there’s a lot of time to complete the task , it will be started late thinking there’s enough time. Thus, it will result in delay of completion date of project.

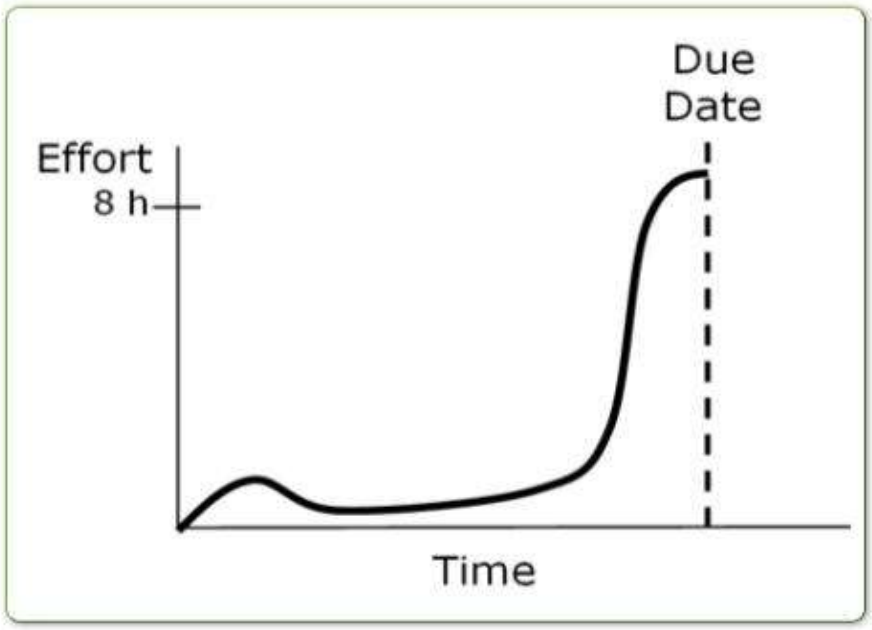
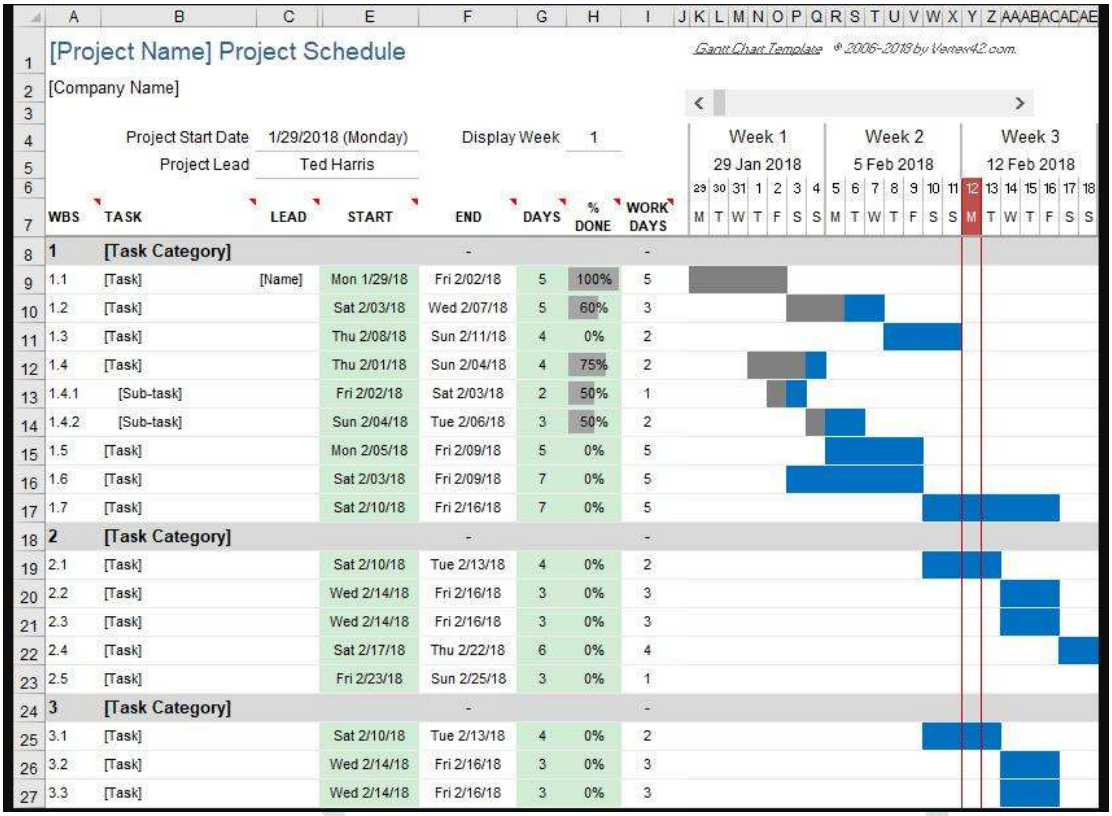


fig-1 Student’s Syndrome during exam

4) Monitoring all the activities and progress of project :-

For that purpose, Gantt charts are used. Gantt charts represents a series of horizontal lines to show the amount of work done or production completed in certain period of time in relation to the amount planned for those period.



[Project Name] Project Schedule

Gantt Chart Template © 2006-2018 by Vertex42.com.

[Company Name]

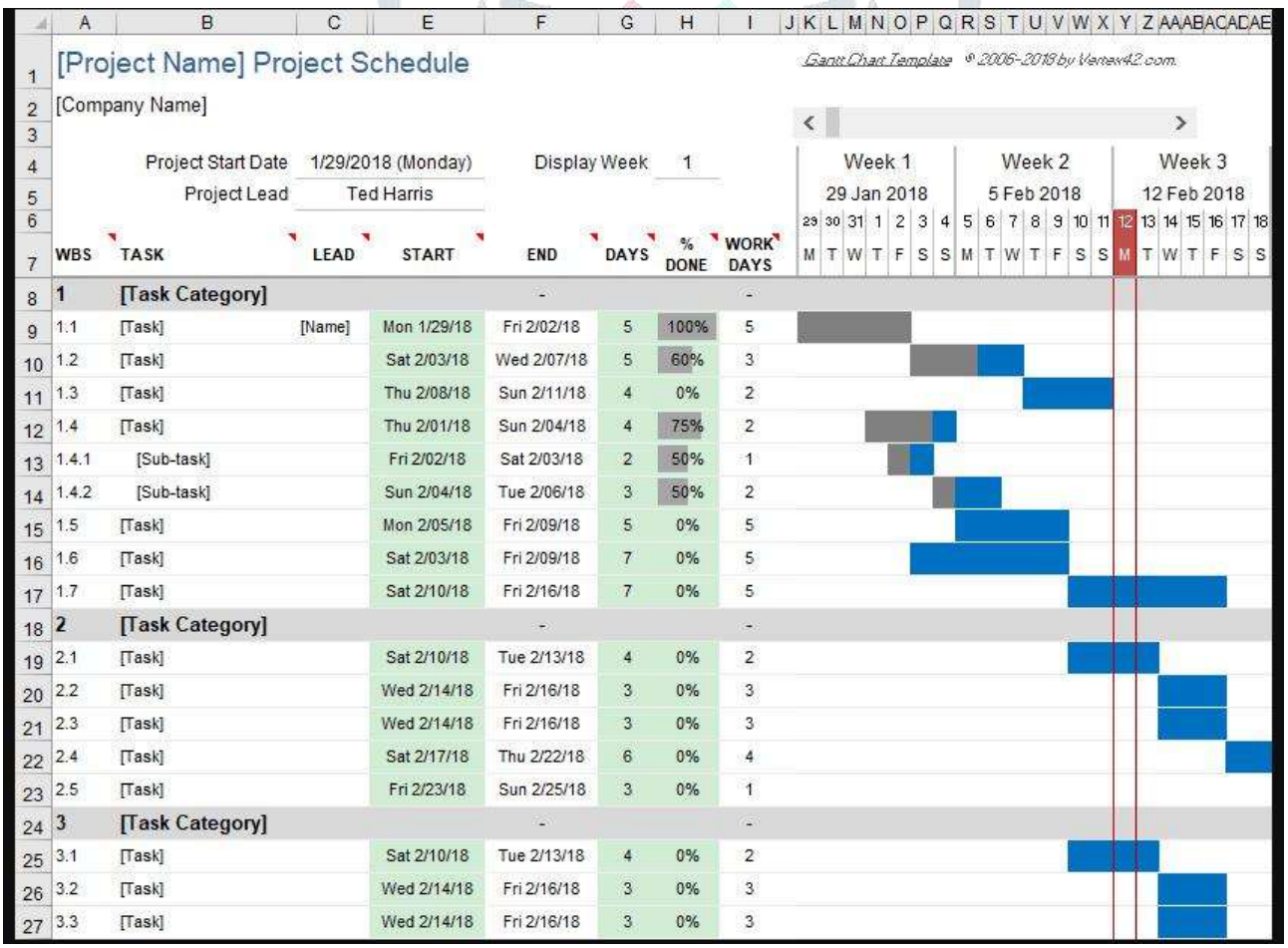
Project Start Date 1/29/2018 (Monday) Display Week 1

Project Lead Ted Harris

WBS	TASK	LEAD	START	END	DAYS	% DONE	WORK DAYS
1	[Task Category]			-			-
1.1	[Task]	[Name]	Mon 1/29/18	Fri 2/02/18	5	100%	5
1.2	[Task]		Sat 2/03/18	Wed 2/07/18	5	60%	3
1.3	[Task]		Thu 2/08/18	Sun 2/11/18	4	0%	2
1.4	[Task]		Thu 2/01/18	Sun 2/04/18	4	75%	2
1.4.1	[Sub-task]		Fri 2/02/18	Sat 2/03/18	2	50%	1
1.4.2	[Sub-task]		Sun 2/04/18	Tue 2/06/18	3	50%	2
1.5	[Task]		Mon 2/05/18	Fri 2/09/18	5	0%	5
1.6	[Task]		Sat 2/03/18	Fri 2/09/18	7	0%	5
1.7	[Task]		Sat 2/10/18	Fri 2/16/18	7	0%	5
2	[Task Category]			-			-
2.1	[Task]		Sat 2/10/18	Tue 2/13/18	4	0%	2
2.2	[Task]		Wed 2/14/18	Fri 2/16/18	3	0%	3
2.3	[Task]		Wed 2/14/18	Fri 2/16/18	3	0%	3
2.4	[Task]		Sat 2/17/18	Thu 2/22/18	6	0%	4
2.5	[Task]		Fri 2/23/18	Sun 2/25/18	3	0%	1
3	[Task Category]			-			-
3.1	[Task]		Sat 2/10/18	Tue 2/13/18	4	0%	2
3.2	[Task]		Wed 2/14/18	Fri 2/16/18	3	0%	3
3.3	[Task]		Wed 2/14/18	Fri 2/16/18	3	0%	3

Week 1 29 Jan 2018 | Week 2 5 Feb 2018 | Week 3 12 Feb 2018

fig-2 Monitoring activities by MS Project



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1.2	[Task]		Sat 2/03/18	Wed 2/07/18	5	60%	3
1.3	[Task]		Thu 2/08/18	Sun 2/11/18	4	0%	2
1.4	[Task]		Thu 2/01/18	Sun 2/04/18	4	75%	2
1.4.1	[Sub-task]		Fri 2/02/18	Sat 2/03/18	2	50%	1
1.4.2	[Sub-task]		Sun 2/04/18	Tue 2/06/18	3	50%	2
1.5	[Task]		Mon 2/05/18	Fri 2/09/18	5	0%	5
1.6	[Task]		Sat 2/03/18	Fri 2/09/18	7	0%	5
1.7	[Task]		Sat 2/10/18	Fri 2/16/18	7	0%	5
2	[Task Category]			-			-
2.1	[Task]		Sat 2/10/18	Tue 2/13/18	4	0%	2
2.2	[Task]		Wed 2/14/18	Fri 2/16/18	3	0%	3
2.3	[Task]		Wed 2/14/18	Fri 2/16/18	3	0%	3
2.4	[Task]		Sat 2/17/18	Thu 2/22/18	6	0%	4
2.5	[Task]		Fri 2/23/18	Sun 2/25/18	3	0%	1
3	[Task Category]			-			-
3.1	[Task]		Sat 2/10/18	Tue 2/13/18	4	0%	2
3.2	[Task]		Wed 2/14/18	Fri 2/16/18	3	0%	3
3.3	[Task]		Wed 2/14/18	Fri 2/16/18	3	0%	3

Week 1 29 Jan 2018 | Week 2 5 Feb 2018 | Week 3 12 Feb 2018

VI. CCPM SOFTWARE'S:

CCPM can be used with the help of following software's:

a) MS Project

b) Primavera

c) Prochain TM

d) LYNX Scheduler

e) Concerto TM

f) Project Scheduler 8TM ,etc.

VII. SCHEDULING USING CCPM :

Scheduling in CCPM can be done by adopting these steps given below :

a) By the use of SOR determine the resources which are required to execute the project and calculate all the quantity of materials which will be used in construction.

b) Compute 50% duration estimate of each and every task and then identify the primary resources constraints in the construction projects.

c) Afterwards, identify the resources conflict and do further pace to resolve them. Nevertheless, starts the task which shows more resources conflict.

d) Now, recognize the critical chain as the longest chain of dependent function.

e) Project buffer is to be added after critical chain is ended.

f) Whenever, non-critical chain task tries to feed into critical chain then add Feeding Buffer.

g) To avoid poor multitasking within project, time constraint should be adjusted. Especially in the case of tasks having no predecessor.

h) To track the project progress and to control the plans make use of buffer management.

VIII. ESTIMATION

In traditional practices, estimation for duration of completion of project is considered as 95%. While in CCPM duration of completion of project is estimated 50%. In traditional techniques, safety time was added while in CCPM, buffers are added. But the most important thing is estimation of duration to complete a specific task. If the estimation for duration of task is wrong, even CCPM is not going to save the project and make it complete on time. That estimation can be done by proper field knowledge and experience.

IX. CONCLUSION

After going through vast ride of overview and comparison, it concludes that using, resource based scheduling instead of task based scheduling is more fruitful. CCPM eliminates all the laws acting on traditional practices which were responsible for the late completion of project. Also it is been discussed that CCPM is nothing but a modification of traditional techniques. Till now many researchers have given different methods to improvise it and make it more efficient. The research is still going on. It still requires more work and efforts. The software's which work with CCPM can be improvised further. For now, this is the best way of managing projects. Among all the nations, Japan has taken full advantage of CCPM. Even their local constructions are according to CCPM technique. It is suggested that every construction industry should adopt this technique and researchers must be looking forward to improvise it.

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