RESEARCH ARTICLE

Project Management techniques: PERT and CPM

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ABSTRACT

Project Evaluation and Review Technology (PERT) and Critical Path Method (CPM) are two most of the valuable and useful techniques for the planning, scheduling and managing large projects in terms of cost, path and time. These two methodologies help project managers to keep a sight on the progress of entire project. There are situations when it is too difficult to estimate the time of some activities and deal with the impact of several uncertain factors, PERT is a technique through which a manger can calculate the approximate probability of completion of a project within the required time and CPM helps him in selecting the most nearest path among the several paths. For using PERT/CPM technology of operational research, this paper has taken one common example with complete process to help project manager in completing a large scale projects in shortest period of time.

Keywords: PERT/CPM, project planning, double mark network diagram, probability

INTRODUCTION

A project is a series of activities directed to accomplishment of a desired objective. Every organization works for their customer satisfaction to achieve higher profit and productivity. Network analysis and research techniques are the general name given to certain specific processes which can be used for planning, management and control of project. A project is a temporary endeavor undertaken to create a unique product or service which is designed to achieve a specific and unique outcome and which operates with in time, quality and cost constraints and which is often used to introduce change. The task of managing a large scale project includes several tasks such as scheduling a number of activities throughout the enterprise; planning for the execution of the entire process, time estimation etc. To provide some ease to the project manager two operational research techniques called PERT and CPM has worked together to assist manager in successfully fulfilling all his responsibilities. PERT and CPM has been used for a variety of project including the following types:

- Construction of a new plant.
- Movie productions.
- Government based projects.
- Building a ship.
- Conducting an advertising campaign etc.

PERT and CPM:
History of PERT and CPM:

In 1950, the Navy's special project, office of USA charged with developing the Polaris submarine weapon system concerned about the growing nuclear arsenal of Soviet Union was on completing the program in the shortest possible time. The Navy's office has then developed a statistical technique for measuring and forecasting progress in research and development programs. The navy used to coordinate the efforts of some 3000 contractors involved with the project. Experts credited PERT with shortening the project duration by two years. Since then, all government contractors have been required to use PERT or a similar project analysis technique for all major government contracts.CPM was developed by Du Pont and the emphasis was on the tradeoff between the cost of the project and its overall completion time. For example, for certain activities it may be possible to decrease their completion time by spending more money-How does this affect the overall completion of the project?

PERT: Project Evaluation and Review Technique

PERT is a technique of project management which is used to plan, schedule, organize and coordinate all the activities in a proper manner

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within a project. PERT analyzes the tasks with their respective completion time involved in completion of a project, and to find out the minimum time needed to complete the project. PERT has based on three time estimates: Optimistic time, most likely time and Pessimistic time. For these time estimates PERT uses a beta probability distribution. According to Beta distribution, the expected time for each activity can be approximated by using the following weighted average formula:

Expected time (E) = (Optimistic time+4*Most likely time+ Pessimistic time)/6

This expected time has used to calculate the minimum possible time of project completion. To calculate the variance for each activity completion time, if three standard deviation times were selected for the optimistic and pessimistic times, then there are six standard deviations between them, so the variance is given by:

Variance= [(Pessimistic-Optimistic)/6]

The variation in the project completion time can be calculated by summing the variances in the completion time of the activities in the critical path.

CPM:

CPM is for projects that are made up of a number of individual activities. If some of the activities require other activities to finish before they can start then the project becomes a complex web of activities. Risk analysis modules can be used as an enhancement of CPM. In such case, the assumption is that deterministic analysis can provide a solid basic schedule and budget unless risk events interfere. Either way, potential risk events, their likelihoods and their anticipated effects are listed in a risk register.

Free float (slack): This is the Amount of time by which an activity or a task can be delayed without causing any delay to its subsequent tasks.

Total float: Project completion date.

Critical path – In the project management, the sequence of activities which are organized and scheduled in a well defined manner to complete that project is known as critical path. This critical path also defines the minimum possible completion time of that project. A project can have several nearest critical path but for project completion, path with the minimum possible time has been selected.

Critical activity-activity with zero float

Basic technique-The essential technique for CPM is to construct a model of the project that includes

the following:

- List of all activities required to complete the project.
- The time duration that each activity will take to complete.
- The dependencies between the activities and
- Logical endpoints such as milestones or deliverable items.

Comparison of PERT and CPM:

To compare the use of PERT & CPM, we are here taking a simple cookie-baking project: the complete statement of work can be easily described by the recipe of making cookies, from which the work breakdown structure can be developed. Two cooks and one oven with limited capacity have worked as resources for this project and the ingredients are the raw materials to be used in preparing the cookie dough. As listed in Table, the activities take a total of 88 minutes of resource time. But there are some activities which can be performed parallel; so that cooks should complete the project in less than 88 minutes.

Using CPM to schedule and control a project-

Table regarding the planning of activities to complete the project:

Description of Activity	Duration (minutes)	Immediate Predecessor(s)
Preheat oven	17 minutes	—
Assemble Ingredients	10 minutes	—
Mix dough	3 minutes	B
Shape first plate of cookies	2 minutes	C
Bake first plate	14 minute	A, D
Cool first plate	11 minutes	E
Shape second plate of cookies	2 minutes	C
Bake second plate	14minutes	E, G
Cool second plate	11 minutes	H
Store cookies	4 minutes	F, I
	Total time=88 minutes	

Figure illustrates the network diagram for this project:
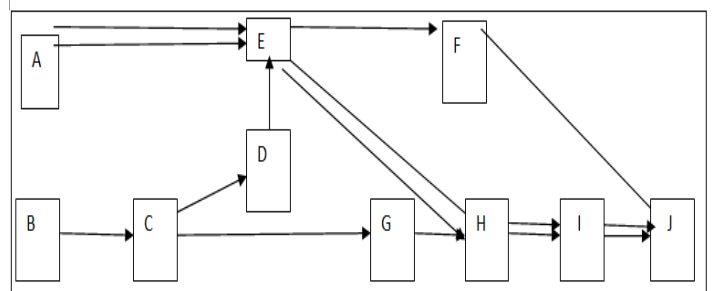
All the paths can be explicitly defined in minutes as follows:

A-E-F-J=17+14+11+4=**46**

A-E-H-I-J=17+14+14+11+4=**60**
B-C-D-E-F-J=10+3+2+14+11+4=**44**
B-C-D-E-H-I-J=10+3+2+14+14+11+4=**58**
B-C-G-H-I-J = 8 + 2 + 4 + 12 + 10 + 3 = **44**

The critical path of any project is the longest path through the entire system, with the minimum completion time for the overall project. The critical path in this project is A-E-H-I-J that determines the project can be completed in 60 minutes which is less than the total time of 88-minute of resource-usage time.

Table illustrates the calculation of slack (float) for individual activities:

Activity	Early Start time	Early Finish time	Late Start time	Late Finish time	Slack
A	8:00	8:17	8:00	8:17	0
B	8:00	8:10	8:01	8:11	2
C	8:10	8:13	8:11	8:14	2
D	8:13	8:15	8:14	8:16	2
E	8:16	8:30	8:16	8:30	0
F	8:30	8:40	8:44	8:55	14
G	8:13	8:15	8:28	8:30	16
H	8:30	8:44	8:30	8:44	0
I	8:44	8:55	8:44	8:55	0
J	8:55	8:59	8:55	8:59	0

The main goal behind the designing of CPM was to address time-cost trade-offs, For example, How a fan can be used to increase the speed of cooling process. This kind of a project requires a contingency planning in the first or initial phase of a project. So that, the project manager can easily identify the potential problems and their related solutions along with the costs required for extra resources.

Using PERT to schedule and control a project-
Now, we will use the same cookie-baking project example but this time PERT method will be used to find out the critical path with the minimum possible time of project completion.
Table below gives all the values of three time estimates for each activity within the project. Where,
  m stands for Most likely time of an activity.
  o stands for Optimistic time estimate.
  p stands for Pessimistic time estimate.
  E stands for expected time.
 Vt stands for Variance.
  St stands for Standard deviation.
The expected time for each activity (Et) are calculated from the formula for the flexible beta distribution. With a reasonably large number of activities, summing the means tends to approximate a normal distribution, and statistical estimates of probability can be applied.
The mean is calculated as $[(o + 4m + p) /6]$, an average heavily weighted toward the most likely time, m. The standard deviation for an activity is $[(p - o) /6]$, or one-sixth of the range. The variance (Vt) is square of standard deviation (St).

Description of Activity	Duration (minutes)					
	o	m	p	Et	Vt	St
Preheat oven	11	15	19	15.00	1.78	1.33
Assemble ingredients	7	8	11	8.33	0.44	0.66
Mix dough	1	2	3	2.00	0.11	0.33
Shape first plate of cookies	2	4	10	4.67	1.78	1.33
Bake first plate	9	12	17	12.33	1.78	1.33
Cool first plate	6	10	10	9.33	0.11	0.33
Shape second plate	4	4	8	4.67	0.11	0.33
Bake second plate	9	12	17	12.33	1.78	1.33
Cool second plate	6	10	10	9.33	0.11	0.33
Store cookies	3	3	9	4.00	1	1
Total times	58	80	114			

The network diagram for this project can be depicted by the following figure (The diagram will be similar as the CPM method)
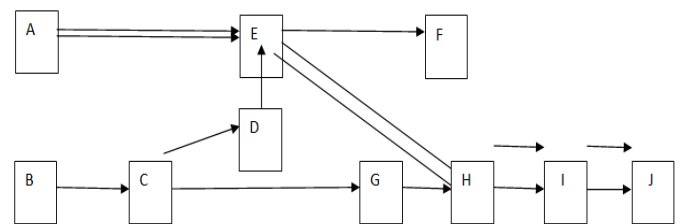
Critical Path = A–E–H–I–J (On the basis of expected time)

Using these new estimates for activity duration, the activity paths through the system have not changed, but the estimates of total time (T) are as follows:

A-E-F-J=15.00+12.33+9.33+4.00=**40.66minutes**
A-E-H-I-J=15.00+12.33+12.33+9.33+4.00=**53minutes**
B-C-D-E-F-J=8.33+2.00+4.67+12.33+9.33+4.00=**40.66minutes**
B-C-D-E-H-I-J=8.33+2.00+4.67+12.33+12.33+9.33+4.00=**53minutes**
B-C-G-H-I-J = 8.33+2.00+4.67+12.33+9.33+4.00=**40.66 minutes**

There are two factors that should be considered coincidental to the comparison of PERT and CPM in the example. First, there are two critical paths of T = 53 minutes each in the PERT analysis. Second, all the other paths have the same duration of T = 40.66 minutes. These concepts are neither more nor less likely to happen under PERT as opposed to CPM; they are strictly a function of the numbers in the estimates.

Frequently, PERT and CPM are two project management tools which are used together to overcome the difficulties such as risks, project completion date, costs of extra resources, Progress monitoring and so on of a project manager occurring at the time of project management. There are many commercial software packages exist to help the project manager in estimating both costs and time incurred to date through-out the entire project duration.

RESULT

After all the research, We found out that if we follow CPM method to manage this project then the estimated time for the completion of the project will be 60 days while through PERT method, it will take 53 days to complete. Hence, for this project PERT will be the right choice. However now a day's both these techniques are used together to find the complete solution.

CONCLUSION

In every business, organization or enterprise, Projects are the basic fundamentals. Therefore the management of these projects is an important part of every enterprise. In each and every stage of a project, For example, whether it is a launch of a new product or organizing a marketing campaign or advertising for the new product, Project management is the basic need to make everything organized and successful.

After doing all the research, we have reached at the conclusion that CPM is a technique that is used in projects that have predictable activities and tasks such as in construction projects.CPM is a deterministic tool that provides an estimate of time and cost to spend in order to complete the project. This method helps project planners to control the entire process of project in terms of cost and time.

PERT, on the other hand, is a probabilistic tool which is used in projects that have unpredictable tasks and activities such as research and development tasks. This technique is completely rely on three time estimates for further calculations to complete the project: the most probable (most likely time), the most promising (Optimistic time), and the most unfavorable (Pessimistic time).

Now a day's both these tools are used together to complete large scale project. Generally, In projects that are going to run for a longer period of time to complete and also which are difficult to estimate like in research, PERT is most suitable tool; whereas in conventional projects with predictable activities and tasks, CPM is most suitable.

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