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A STUDY ON THE APPLICATION AND IMPLEMENTATION OF NETWORK ANALYSIS IN THE FIELD OF CONSTRUCTION

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Abstract- Project completion on time and within a specified budget is not an easy task. Project planning and scheduling plays an important role in determining the time and cost of a project. This study is aimed to find the minimum cost and time to complete the building of a project. Critical path method (PCM) and Project evaluation and review technique(PERT) are used for the analysis of this project. The implementation is done using java programming.
Keywords – Construction planning, Critical Path Method, Project Evaluation and Review Techniques.

1. INTRODUCTION

Project completion on time and within a specified budget is not an easy task. So the delay in completion of work can increase the complexity of the project completion. There are a varied number of factors that can cause the delay in construction such as contractor delay, client delay, consultant delay, labour related delays, legal delays and various other external factors. These legal delays cause time overrun, cost overrun and other related problems. This is caused because of some project activities which are critical, in the sense that the delay in their commencement will result in the delay of the entire project completion on time. Therefore, scheduling of project and proper planning is important, which will eventually help to overcome this problem.

A project can be a set of large number of activities performed in the certain sequence which determine logically or technologically and which is needed to be completed within a specified cost and time by meeting the performance standards.

The project can be of various types like, developing a software program, building of a house or an office, designing of plans, System installations, Administrative, event or relocation, new product development, research, development of new drug and many others.

Network models are conventional means of finding the most skillful way to link a number of activities directly or indirectly in order to satisfy supply and demand requirements at different activity locations and project scheduling.

For years, the following are the two approaches used in project planning, scheduling, handling and controlling the construction of projects, they are Critical Path Method (CPM) and Project Evaluation and Review Technique (PERT). These approaches help the project managers to evaluate early times and late times at which the activities can start and finish, to calculate the activity floats and the slacks, determine the critical activities, and to evaluate the changes in the time duration, to understand the logical relations and cost of the overall project duration. CPM and PERT both are network based techniques and therefore they help in monitoring and programming the stages involved in the progress in order to complete the project within the specified deadline.

If there is any delay in the completion of project it is specified by these methods and it is useful to calculate the normal time and the critical path in which the process can be completed within the given time. If the duration is more than the specified time it might lead to delay in the completion of project as a whole. It also helps in allocating the resources, such as manpower and equipment which helps in to minimise the total cost of the building project by determining the optimal trade between time involved and various costs. Even though PERT and CPM differ in the terminologies up to some extent in the construction of network but their objectives are same. Even the analysis used in both techniques are same but the CPM activity times are assumed to be proportional to the amount of resources allocated to them, by varying the level of resources the activity time and the project completion time can be varied. So CPM assumes from previous experience with similar projects where the relationships between activity times and resources are taken. On the other side PERT deals with uncertainties in activity times during its analysis. It determines the probabilities of completing various stages of the project within the specified time. It is also used to calculate the expected time for the completion of project. PERT plays an important role in identifying the bottlenecks in a project, which means it helps in identifying the activities which cause the delay in completing the project on schedule. This helps manager to take the necessary steps to reduce possible delays so that the project can be completed on time. Manager can reduce the project time by adding more resources to an activity in the form of additional labour and adding extra resources. This managerial decision of adding additional resources, overtime and labour will increase the overall cost of the project by reducing the overall project duration on critical path. This concept is knowns as crashing. This helps in balancing the cost and time and to obtain an optimum schedule.

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2. LITERATURE REVIEW

Network Analysis is done in lots of fields to reduce the time and cost of completing the given project and to determine and overcome the activities which causes anomaly in achieving the goal before it take places. The fields which are highly likely to use Network Analysis and have paper on it are Maintenance Schedule of Hydropower Turbine, Construction of Chemical Plant, Development of Missile, Construction of Stadium, Construction of Bridges and Roads, Data Mining, Supply chain Management in many Manufacturing Companies and there are several other fields where there is a list of activities to be done to complete a project. Our paper is based on a brief application of Network Analysis in Construction of a House of 1000sq. ft. area.

Activity: A graphical method for showing dependencies between tasks (activities) in a project.

Activity Time: The time to complete a particular activity. The activity time can be deterministic or uncertain (probabilistic). When the activity time is deterministic, the activity is completed in a constant time. When the activity time is probabilistic, the activity is completed in a random time value that may have a certain probability distribution.

Path: A sequence of activities in a project leading from the start activity to the completion activity of the project.

Critical Path: A path that has the longest total activity time.

Critical Activity: Any activity on the critical path.

Start Activity: The activity that has no immediate predecessor is called a start activity of the project.

End Activity: The activity that is not a predecessor of any other activity is called an end activity of the project.

Deterministic Project: A project that all activities finish in constant times.

Immediate Predecessor: The immediate predecessors of an activity are the activities that must immediately precede the activity.

Earliest start (ES): This is the earliest possible time that an activity can begin. All immediate predecessors must be finished before an activity can start.

Earliest finish (EF): This is the earliest possible time that an activity can be finished (= earliest start time + activity completion time).

Latest start (LS): This is the latest time that an activity can begin and not delay the completion time of the overall project. If the earliest start and latest start times are the same then the activity is critical.

Latest finish (LF): This is the latest time that an activity can be finished and not delay the completion time of the overall project (= latest start time + activity completion time). As with start times, the activity is critical if the earliest finish and latest finish times are the same.

Optimistic time: This is the shortest possible time in which the activity can be completed, and assumes that everything has to go perfect.

Most-likely time: This is the most likely time in which the activity can be completed under normal circumstances.

Pessimistic time: This is the longest possible time the activity might need, and assumes a worst-case scenario.

3. RESEARCH METHODOLOGY

To schedule the Activities in the network we require the time estimate for each activity when it is done in normal way. The Information provided in the table below is for constructing a 1000 sq. ft. house. The below table shows the construction of house beginning with the activity A and ending with activity O with its preceding activity and estimated time to complete that particular activity.

Activity Code	Activity Description	Preceding Activity	Estimated time
A	Site Clearing	--	04
B	Foundation	A	30
C	Frame Works	B	15
D	Super Stretcher Walls	C	10
E	Roofing and lintels	D	15
F	Celling c e Slabs	D	20
G	Door and Windows frame	EF	05
H	Electricals	G	10
I	Plumbing	G	12
J	Plastering	HI	38
K	Flooring	J	45
L	Painting	K	20
M	Interior Fixture	L	10
N	Exterior Fixture	L	07
O	Landscaping	N	26

Based on the above table we have constructed the Network diagram.

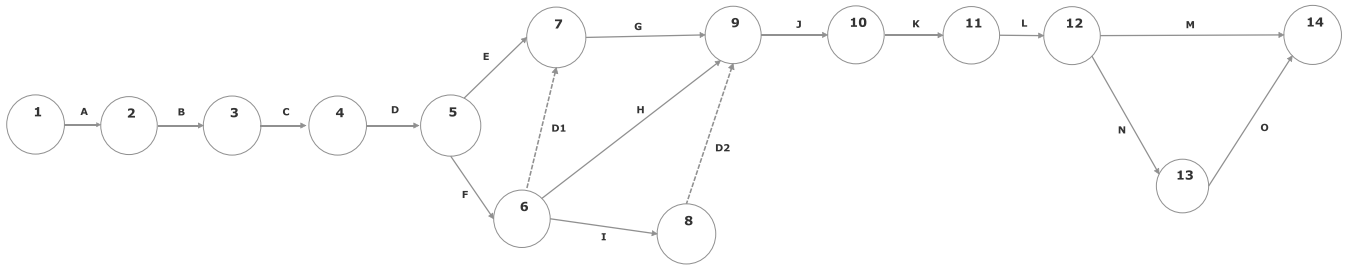

Figure 1.1

Critical path method is very efficient for projects which are done at large scale. If ES and EF are the early start and early finish, LS and LF are the latest start and latest finish of an activity (i-j). TF, IF, FF are the Total Float, Independent Float and Free Float of the corresponding activity.

Total Float of an activity is the amount of time by which it may be extended or delayed without delaying completion of the project, assuming no extension or delay in any other activity.

Free Float is the time by which the completion of an activity can be delayed beyond the earliest finish time without affecting the earliest start of a subsequent activity.

Independent Float of an activity is calculated assuming the worst circumstances, i.e. the activity's predecessor's finish at their latest times and we want subsequent activities to begin at their earliest times. If this is possible, and there is still time to spare, then this is called independent float.

Critical Path is the sequence of critical activities that form a continuous path between the start of a project and its completion. In simple words critical in the sense that if any activity in this sequence is delayed, the completion of entire project will be delayed.

The formulas for the ES, EF, LS, LF, TF, IF, FF are given as follows.

$(ES)_{ij}=E_i$

$(EF)_{ij}=(ES)_{ij} + T_{ij}$

$(LS)_{ij}=L_i$

$(LF)_{ij}=(LS)_{ij} + T_{ij}$

$(TF)_{ij}=(LS)_{ij} - (ES)_{ij} = L_i - T_{ij} - E_i$

$(IF)_{ij}= E_j - L_i - T_{ij}$

$(FF)_{ij}= E_j - E_i - T_{ij}$

The following table (Table 1.1) shows the calculations of the network analysis of the above diagram (Figure 1.1) using CPM.

i-j	Time	ES	EF	LS	LF	TF	IF	FF
1-2	4	0	4	0	4	0	0	0
2-3	30	4	34	4	34	0	0	0
3-4	15	34	49	34	49	0	0	0
4-5	10	49	59	49	59	0	0	0
5-6	20	59	79	59	79	0	0	0
5-7	15	59	74	71	86	12	5	5
6-7	0	79	79	86	86	7	0	0
6-8	12	79	91	79	91	0	0	0
6-9	10	79	89	81	91	2	2	2
7-9	5	79	84	86	91	7	0	7
8-9	0	91	91	91	91	0	0	0
9-10	38	91	129	91	129	0	0	0
10-11	45	129	174	129	174	0	0	0
11-12	20	174	194	174	194	0	0	0
12-14	10	194	204	217	227	23	23	23
12-13	7	194	201	194	201	0	0	0
13-14	26	201	227	201	227	0	0	0

Table 1.1

Critical Path of Figure 1.2 is 1-2-3-4-5-6-8-9-10-11-12-13-14

PERT is a statistical tool, used in project management, which was designed to analyze and represent the tasks involved in completing a given project.
The following table (Table 1.2) shows the calculations of the network analysis for the Figure 1.1 using CPM.

i-j	OT	MT	PT	ET	SD	ES	EF	LS	LF	TF	IF	FF
1-2	2	4	6	4	0	0	4	0	4	0	0	0
2-3	25	30	35	30	1	4	34	4	34	0	0	0
3-4	12	15	18	15	1	34	49	34	49	0	0	0
4-5	9	10	17	11	1	49	60	49	60	0	0	0
5-6	14	20	26	20	2	60	80	60	80	0	0	0
5-7	12	15	24	16	2	60	76	71	87	11	4	4
6-7	0	0	0	0	0	80	80	87	87	7	0	0
6-8	9	12	15	12	1	80	92	80	92	0	0	0
6-9	7	10	13	10	1	80	90	82	92	2	2	2
7-9	3	5	7	5	0	80	85	87	92	7	0	7
8-9	0	0	0	0	0	92	92	92	92	0	0	0
9-10	32	38	44	38	2	92	130	92	130	0	0	0
10-11	41	45	49	45	1	130	175	130	175	0	0	0
11-12	17	20	29	21	2	175	196	175	196	0	0	0
12-13	5	7	9	7	0	196	203	196	203	0	0	0
12-14	8	10	18	11	1	196	207	219	230	23	23	23
13-14	23	26	35	27	2	203	230	203	230	0	0	0

Table 1.2

Critical Path of Figure 1.3 is 1-2-3-4-5-6-8-9-10-11-12-13-14
The implementation of CPM and PERT shown in Table 1.1 and Table 1.2 is done using Java Programming Language.

4. FINDINGS

Using Network Analysis on construction of house, we found the minimum time required to complete the project on time. So for the activity where the total float is zero, such activities can't be delayed and for the activities whose total float are not zero can be delayed by their respective number of days without effecting the overall project completion time.
Currently we have worked on the time estimates of the project, we intend to continue to work on the cost analysis in order to strike a balance between time and cost.

5. CONCLUSION

This study is based on the network analysis of construction showing how the activities are taking place and how much time it requires to complete it. Using Network Analysis tools, we improve the way of planning and implementing the Project. This helps to remove the chances of having redundant activities before the construction begins which in tern reduces the overall cost of the making of a project. This also helps to find out the estimated time within which we can complete the Construction for a Client.

6. REFERENCES

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