

# Analysis of Critical Path Method (Cpm) to Optimized Project Scheduling (Evidence from KLM Building Firm in ADO/ODO- OTA Local Government, Ogun State, Nigeria)

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## ABSTRACT

Network analysis makes use of critical path method to effectively manage and execute projects. Every project must be properly planned, scheduled and its completion time accurately estimated. As a result critical path method (CPM) is useful tool in project management and scheduling. This study employed critical path method to estimate the duration of a project in a building construction project using a case study of KLM Building Firm. The research design adopted was analytical, as it was suitable for the nature of the work. Secondary data on project activities were obtained from the construction site and used for the analysis. The (TORA) software were used to run the analysis. The result shows that the CPM is high efficient in estimating project completion time. The initial completion time of 45 weeks were reduced to 31 weeks by applying the CPM techniques. Based on this findings, it is recommended that management adopt CPM for proper decision-making, as its helps to save labour cost, reduce project during and increase organizational productivity.

**Keywords:** Critical path, Project Management, Scheduling, Earliest, Events, Latest Events

## INTRODUCTION

Coordinating a project that requires managing of numerous activities across an organization is one of the most arduous duties a manager can carry out. Many elements must be taken into consideration when determining how to coordinate these tasks, by setting a practical schedule, and monitoring the project's progress[5].

A project is a combination of many resources (labour, equipment, facilities, support services) within an organization to achieve laid down objectives [7]. Project scheduling as to do with finding the timeline, resources, labour, and materials required for each project activity.

The practice enables the completion of the project, minimizes delays, and reduce negative effects on quality, cost and time [2].

Completing a project within a defined time frame and budget is a challenging task. A widely recognised issues in many projects within Nigeria is the increase in both cost and time, especially as the project complexity expands. Several factors can cause delays, including consultants – related, client-related, labour-related and other external factors [3].

Critical paths method (CPM) is a useful techniques for effective and efficient management of various types of projects such as construction, engineering, facilities maintenance, research and development [6]. In construction sector, scheduling is important because it set time and sequence of the various stages and establishes the relationship activities to ensure that deadline are met. [4].

This Critical Path Method is applicable to a house construction project, in which the earliest event, times and the latest completion times of activities are computed.

## Brief History of the KLM Firm

KLM building firm is a vibrant construction company that has been in existence for more than thirty years in the building industry, with a clean record of excellence performance in delivery of construction services.

The firm focuses on private and public initiatives including building houses, maintenance, design and construction of modern housing units and among other services.

As stated by the Executive Manager, the controlling and scheduling work to ensure project delivery on time is their primary target in order to avoid cost overruns. This habit, which they have adopted as a standing rule and regulation, has made them well known in South Western Nigeria and beyond. The head office of KLM firm is located at 10-15, Fijabi Avenue, Agbara in Ogun State. It is about 2.5km away from Lagos Badagry Expressway. The staff of the company comprises of highly skilled professionals and seasoned engineers which cut across the various department of the organisation.

## Critical Path Method (CPM)

Critical Paths Method (CPM) is a techniques use to evaluate the time required to complete specific tasks before the entire project can be finished [7]. The critical paths method enables the project team to develop a planned schedule and monitor project performance effectively.

CPM allows project managers to identify and plan all tasks that must be completed as part of a project. It serves as the basis for both the preparation and resources planning [1]. The activities in CPM is centred on identifying critical tasks within project and highlighting important adjustments may be required to ensure the project is executed effectively and efficiently [8].

In today's modern world, planning has taken a centre stage and has become an integral of organisation part and individual activities. As a result, proper planning is essential, before the execution of any project. [10]. The Critical Path Method (CPM) is employed by project managers to break large and complex project into smaller activities, allocate resources appropriately and manage project phases in order to minimises the total cost and duration, thereby ensuring project timely delivery [9].

## MATERIAL AND METHODS

The analysis of the network model was being carried out by identifying and fixing all project activities in order to present a pictorial view of the various task, required to complete the project using the critical path method (CPM). The study employed an analytical research approach for the purpose of the modelling the critical path method. A analytical research was adopted because it involves critical thinking and systematic evaluation in carrying out the study. Method were apply sequentially, one after the other. The initial step was to define the activities of the project their precedence relationships and the time required for each activities. The project network was transformed, to show the precedence relationship among the activities. Lastly, diagram network computations were performed, that lead to the development of the project time schedule.

## Research Design

In this study, a structural analytical design was adopted by listing all the present activities, their predecessors and the estimation duration for each activity. The relationships among the activities were then transformed into network diagram. Each Activity of the project was represented by a directional arrow, which indicates the direction of project flow.

The computation of the critical path method focused on two major procedures: the forward pass and backward pass, together with the identification conditions for determining critical path.

Forward pass computation is as follow:

$$E_{sj} = \max_j (E_{si} + D_{ij}) \quad (i)$$

Where  $Es_j$  = earliest start time of activity

$D_{ij}$  = duration of activity I to activity j

$Max_i$  = pick maximum from the calculation where the activity has more than on precedence activity coming to it. The forward computation moves from the first even to the last event, setting the first event at zero  $Es_i = 0$ .

Backward pass computation is as follow:

$$Lc_i = \text{Min}_j (Lc_j - D_{ij}) \text{ (ii)}$$

Where:

$LC_i$  = latest completion time of activity

$D_{ij}$  = duration of activities I to activity j.

Critical path conditions are as follow:

$$Es_i = LC_i \text{ (iii)}$$

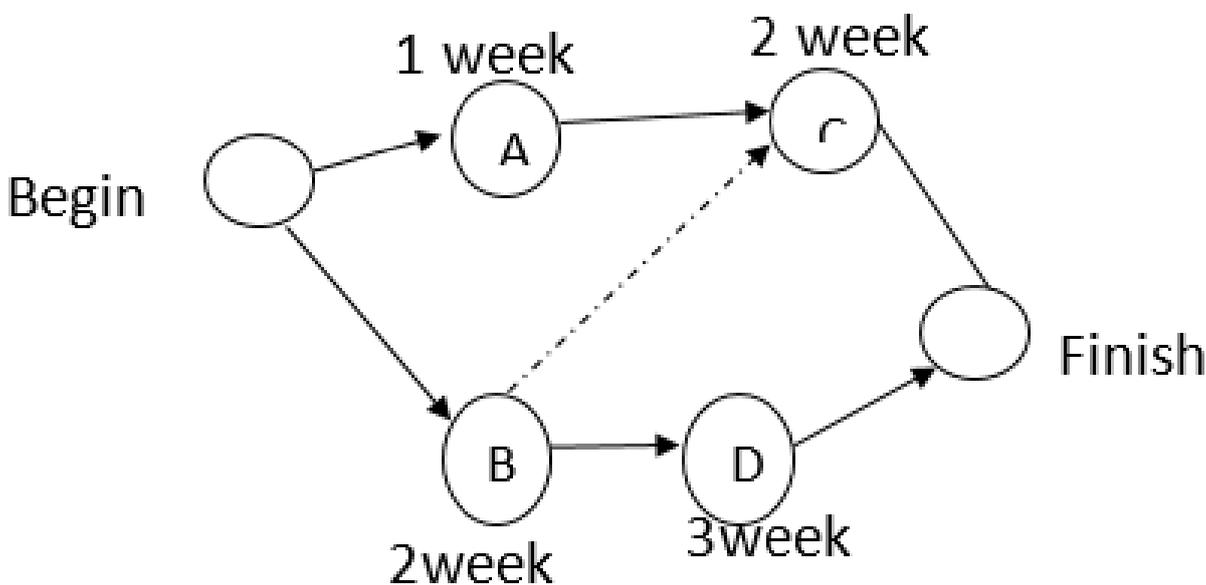
$$Es_j = LC_i \text{ (iv)}$$

$$Es_j - Es_i = LC_j - Lc_i = D_{ij} \text{ (v)}$$

Computation of total float or slack

$$LC_j - Es_i - D_{ij} \text{ (vi)}$$

**Figure 1: A typical network diagram**

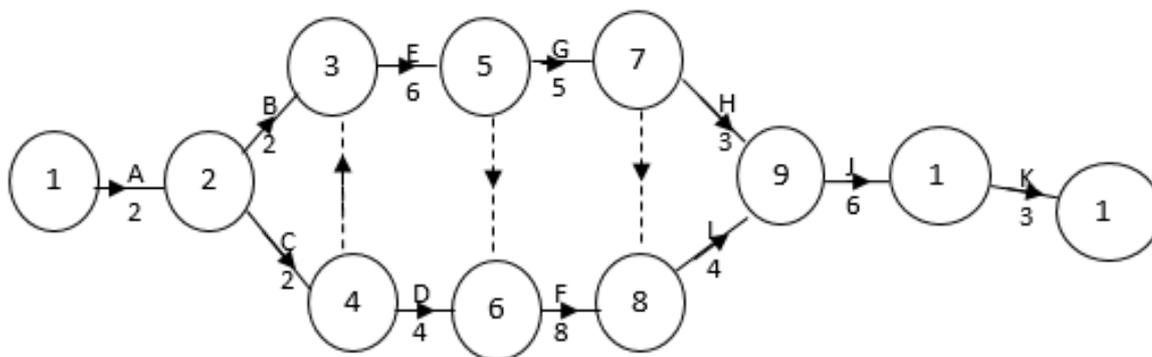


This study was carried out using data obtained from the area of study. The network flow was presented by indicating activities on nodes as well as dummy activities. The straight-line arrows represent actual activities, which the broken arrows indicate dummy activities which have zero duration. The forward pass computation was used to determine earliest starting time using the formular  $ES_j = \text{Max}_j (Es_i + D_{ij})$ . The obtained were place in square brackets and the minimum project during was determined time obtained. The backward pass calculation was carried out using the formular:  $LC_i = \text{Min}_j (LC_j - D_{ij})$ .

**Table 1: Description and Predecessor of Each Activity**

Node.	Activities	Description	Immediate Predecessor	Duration (weeks)
1.	A	Clearing of site	-	2
2.	B	Excavation/column base	A	2
3.	C	Concrete work	A	2
4.	D	Block work	C	4
5.	E	Fame/roof structure	B, C	6
6.	F	Electrical work	D, E	8
7.	G	Floor, wall & ceiling finishes.	E	5
8.	H	Window door and fillings	G	3
9.	I	Painting and decorations	G,F	4
10.	J	External work and clearing	I,H	6
11.	K	Standing over work	J	3

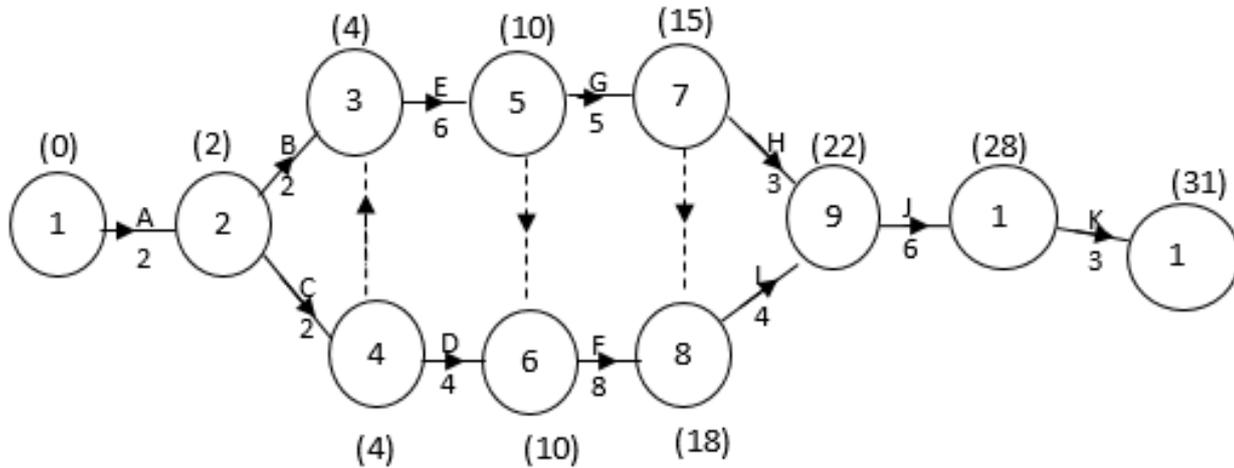
**Figure 2: Precedence Activities Network Flow and Their Duration**



The figure from the table 2 above shows the network flow by Table 1. The Node with the 1 inside a circle is a starting node of the project and node 11 is the end of the activities. The figure on the nodes are the duration in which the activities will be executed while the letters on the arc shows the activities before its completion.

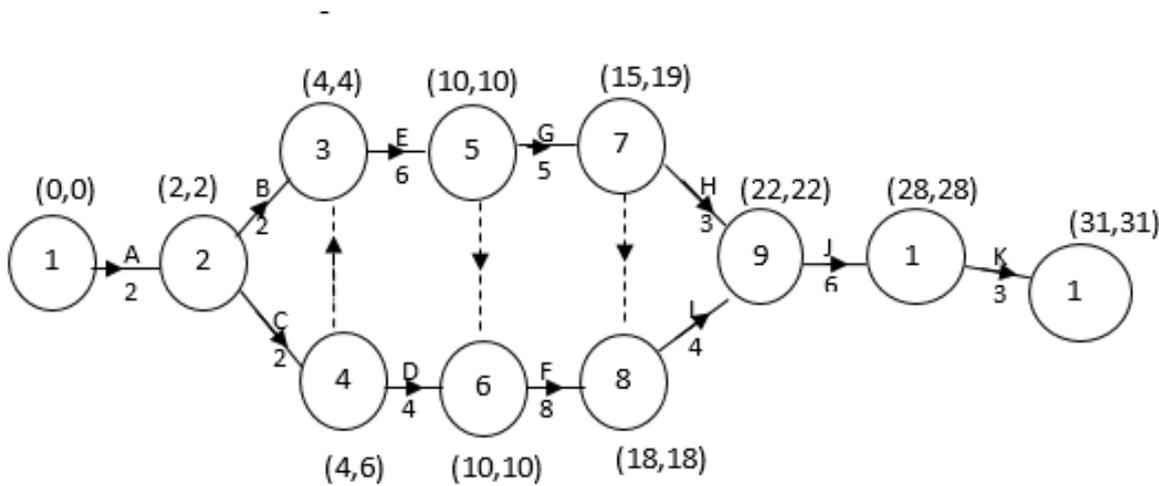
The dummy activities is the arc (arrow) with a dash and it has no duration. The purpose of dummy is to keep the logic of the arc flow in right direction from start to finished period. The temporary ordered routing Algorithm (TORA) software is used to analyzed the problem. The outcome of the results indicated in the second table.

**Figure 3: Forward pass computation of network diagram**



The figure 3 indicate the forward pass computation of the network using the earliest start formula. The figure on arc in the rectangular bracket are the earliest. Start of each activity. When two arcs or activities entered the node, the maximum duration is picked.

**Figure 4: Backward pass computation and optimal results**



The figure shows the backward pass of the activities and the minimum duration that was picked when two activities end on a particular node. The optimal results were placed in the same square bracket with forward pass results separated by a comma by putting it in right hand side of the bracket as shown in the figure 4 above.

**Table 2: The optimal table from TORA Output**

Activities	Duration	Earliest start	Latest Completion	Total Float	Free float
A	2	0	2	0	0
B	2	2	4	0	0
C	2	2	4	0	0
Dummy	0	4	4	0	0
D	4	4	10	2	0
E	6	4	10	0	0
Dummy	0	10	10	0	0

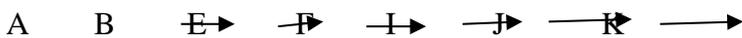
F	8	10	18	0	3
G	5	10	19	0	0
Dummy	0	10	19	4	3
H	3	15	22	0	0
I	4	18	22	0	0
J	6	22	28	0	0
K	3	31	31	0	0

From the table above which indicate the results obtained by TORA. Total float is the amount of time that a task can be delayed without affecting the completion date of the project or breach the constraints scheduled. The free float is how long a task can be delay without affecting the start date of its subsequent tasks and constraints scheduled. The zero (0) are the critical path which is the longest path of the project. Critical path guide the managers by making the project monitored easily and to be able to communicate to the stakeholders in term of project priority.

The critical path method (CPM) solution are:

The activities of the network found to be critical of the project are: A, B, E, F, I, J, K

The paths are:



$$2 + 2 + 6 + 8 + 4 + 6 + 3 = 31 \text{ Weeks}$$

From the above, the duration of the entire project was 45 weeks, hence there is an estimated reduction of 14 weeks when CPM was applied.

## DISCUSSION

The network analysis is widely adopted by project management and it has been the major brain behind the successful project in any organization. Since, the periods of completion and execution are not always easy due to unforeseen circumstances. This has lead to failure in the project and loss of financial resources, energy and time.

The study adopted critical path method (CPM) to KLM Building firm as case study.

The data used were collected from the onsite of the KLM building firm base on the previous activities carried out by the company.

The network analysis diagram were drawn and computed as show in the table above. The critical paths were calculated and the results indicated that applying critical paths method, the project will take 31 weeks compared to the initial duration of 45 weeks. This findings is in line with other scholars such as [6];[1] and [10]. Which had used CPM and found that is efficiency and good in managing project.

## CONCLUSION

The findings is based on how we can use critical paths method (CPM) on the activities of KLM building firm located at Agbara in Ado/Odo – Ota, Ogun state, Nigeria. The project has 11 events and 11 activities, the activities were computed and the result shows that 14 weeks duration were reduced from the initial project duration of 45 weeks. In conclusion, by applying CPM to this project, it save time, energy, cost and resources. The findings has greater effect by reducing the duration of the completion of the project from 45 weeks to 31 weeks at optimal level schedule completion time for KLM building firm project.

## RECOMMENDATION

It important to note that the critical path method (CPM) is good for estimation of project in KLM construction firm, as this will assist in monitoring their project. This study can also be extended or borrowed to others organization management because the use of critical paths method in network analysis is a good tools to estimate the any project completion period and execution.

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