World Journal of Engineering Research and Technology
WJERT
www.wjert.org
SJIF Impact Factor: 5.218

PROJECT PLANNING USING HEURISTICS APPROACH: A CASE STUDY OF GAP INTERNATIONAL LIMITED

[1]*Elijah P. T. and [2]Etebu O. M. O.

Department of Mechanical Engineering, Faculty of Engineering, Nigeria Maritime University, Okerenkoko, Delta State, Nigeria.

Article Received on 24/07/2019 **Article Revised on 13/08/2019** **Article Accepted on 03/09/2019**

***Corresponding Author**
Elijah P. T.
Department of Mechanical Engineering, Faculty of Engineering, Nigeria Maritime University, Okerenkoko, Delta State, Nigeria.

ABSTRACT

The sequence of activities from the beginning of a project to its completion is essentially the same, whether it's a small two or three-day project or a large project that spans for several months. These activities are grouped into four different phase which are the initiation phase, planning phase, execution phase, and the close out or termination phase. This research work focused on both the planning and execution phases. The research was aimed at providing a suitable project planning and scheduling advisory system. The critical path method (CPM) was employed in achieving it. Network diagram for the reconstruction was developed and the models for the activities were also obtained and then the Excel program was used to simulate the models to give results for critical paths, shortest project duration, and project completion date.

KEYWORDS: Project, Planning, GAP, Heuristics, and Critical path.

1. INTRODUCTION

The essential features of a project are its uniqueness and novel organization to achieve a beneficial change. A project can be defined as an endeavour in which human, material and financial resources are organized in a novel way, to undertake a unique scope of work, of a given specification, within constraints of cost and time so as to achieve a beneficial change defined by quantitative and qualitative objectives.[1]

Many organizations use project management to manage their activities such as building a football stadium, roads and bridges, administering a large research contract, performing major transplant surgery, establishing a production line, or earning a university degree.[2,3] Most of these organizations manage multiple projects simultaneously. A multi-project organization is usually capacity driven because it often uses common resources.[1,3,4] Good management of the scarce resources is of crucial importance for reliable due date and price quotation, for good material mix and for a good delivery performance. Time is more and more a competitive edge, and a good control in capacity management.[5]

To solve the problem in which the environment is assumed to be static, various algorithm have been utilized and these grouped into three: heuristic, probalistic and classic algorithms.[6] Heuristic algorithms are flexible and are adapted for different optimization and decision making problems like planning, scheduling, etc.[7] Heuristic algorithms are considered more intelligent and advanced methods capable of handling uncertain and incomplete information in ever changing environments with the aim of obtaining optimal solutions.[7] These algorithms (heuristic) required additional learning stage and have very high computational cost.[6]

Capacity in a multi-project organization cannot be managed in a traditional single project-oriented approach as noted.[4] The portfolio management team plays a central role in project based management evaluates this portfolio-based management approach using a number of case studies.[2] Most companies in these case studies indicate that this organizational structure would benefit the company performance.

Several authors wrote on project planning which are stated thus: Tobinson, (2013)[5] worked on applicability of approach in planning and scheduling project. Suitable heuristic method was applied in solving scheduling problem for optimum resource level for project execution in order to analyze sensitivity of resource aiming at reducing project completion time. Resource utilization and constraining index in the search for optimal solution was adopted for this scheduling project.

Matthias and Jurgen, (2010)[7] worked on a heuristic approach to project stapling. A matrix organization where employees are both members and project team was considered. With different skills the employees have, needed by the projects, helps to minimize the number of assignments of employees to projects. This minimum lost network flow model was presented and heuristic solution was needed for it.

Safavi and Smith, (2010)[8] researched on heuristic search approach to planning and scheduling software manufacturing projects. Formulation of scheduling problems, unsatisfiable resource requests as a result of difference in goals, technical judgement, and uncertainty in budget results in the need to use software project planning and scheduling as the tool is not static since schedules is continually revised over and over in the course of project.

Mac, et al., (2016)[6] carried our research on heuristic approaches in robot path planning: a survey. The four (4) essential requirements such as perception, localization, cognition and path-planning, motion control in which path planning is very vital and interesting part are autonomous navigation of a robot in research. Classical and Heuristic methods were the adopted planning techniques in which the former consist of cell composition, potential field method, sub-goal network and road map, the latter i.e. the heuristic-based algorithms in robot path planning was the focus of this work and comprises of neutral network, fuzzy logic, nature-inspired algorithms and hybrid algorithms. Even though potential field method gave good results, was considered too.

Jafarazadeh and Flemmings, (2018)[9] worked on an exact Geometry-based algorithm for path planning. To find the shortest collision free path from a start to a goal point in a two dimensional environment for convex and non-convex obstacles, path algorithm carted SPP was utilized. This generates a safe, smooth and obstacle-free path which is designed for sparsely populated environments, capable of eliminating some constraints that doesn't play any role to give optimal path. The performance is seen in the classic, heuristic and probabilistic approaches which were compare analytically.

Stallmayer, (2014)[10] researched on heuristic approach to efficient appointment scheduling at short-stay unit. Heuristic approach was adopted and various models generated using the case study and data collected for the simulation of the resulted models using computer software. The developed scheduling heuristic approach result in maximizing the bed for the AMC short-stay unit and reduces the capacity thereby keeping the fraction very low.

Ge and Cui, (2000)[11] utilized linear programming in his model formulation on Analytical techniques and heuristics abound. He commented that while there is no difficulty in problem formulation, there are a large number of variables and constrains even for small-sized problems and as such, the model has very little practical application;[12] even in the early days did not recommend any single one as the best for all projects but rather recommended that the best test of 'goodness' of a particular approach should be the one, which produces 'reasonable' schedules for actual projects;[7] in one of his studies tried many heuristics in different problems and found that a particular heuristic may produce a good result in one problem and fail in another and Akpan (2000)[1] said in order to be certain of achieving the 'best' solution, it might be necessary to try different heuristics and to select the best, which may give the optimal or near-optimal result; Russel, (1986)[13] concentrated mostly on comparing the effectiveness of one heuristic rule relative to another; Davis and Patterson, (1975)[14] concerned with the effectiveness of these rules relative to the optimum; Kurtulus and Davis (1982)[4] conducted similar studies for the multi-project-scheduling situation and noted that the shortest activity for shortest project (SASP) and maximum total work contents (MAXTWK) were found to be superior to the other scheduling rules; Huq and Bernardo (1995)[15] found that MINSLK performs better as compared to FCFS (first come first serve), EDD (early due date) and SPT (shortest processing time) in their selection of shop control procedures on the sensitivity of job mix and load capacity bottlenecks on inventory and due date performance in a manufacturing system.[1]

In this research work, project capacity planning in the construction industry is investigated through the civil engineering and project. Planning unit of GAP international limited. Project executed by the company are broken down into activities prior to execution. The activities are assigned special identification numbers called "Activity ID". The activities are timed for execution in hierarchical order of their priorities (i.e. precedence relation and maximum work content per period) starting from the engineering and design stage to the final clean up and demobilization of the projects site.[16]

Data for analysis in this research work was the duration of different activities of GAP International limited on one of the shell petroleum Development Company's terminal (FOCADOS terminal) in Ayakoromo, Delta State. The project is specifically based on the reconstruction of the terminal's fire protection system, changing the pipe from epoxy coated carbon steel to heavy wall carbon steel.

Project Capacity Planning comes under the realm of resource allocation problems and generally, this can take any of these forms; optimizing time or other characteristics related to it, based on unlimited resources availability, optimizing the resources (under imposed limits) for the realization of the least project duration.

Resource optimization problems in project are mostly classified into three main groups as follows: Time/cost trade-off analysis; unconstrained (unlimited) resource optimization; and constrained (limited) resource Planning levels for portfolio management can be distinguished into two as noted[2]: Rough-Cut Capacity Planning (RCCP) in which addresses medium term Capacity Planning Problems projects are split up into relatively large work packages which are planned over time taking into account the availability of scarce resources and Resource-Constrained Project Scheduling Problem (RCPSP) which addresses the operational, short-term scheduling and work packages are split up into smaller activities which are scheduled over time.[16]

2. MATERIALS AND METHODS

2.1 Study Location

Shell Petroleum Development Company at FOCADOS terminal has fire protection system installed along side with the piping facilities that carry its petroleum products.

2.2 Data Collection

Project planning in the construction industry has been investigated through the civil engineering and project planning unit of GAP international limited. Project executed by the company are broken down into activities prior to execution assigned special identification numbers called "Activity ID". Data of activities for the project of reconstruction of the terminal's fire protection system has been collected from the office of the civil engineering and project planning unit of GAP international limited shown in Table 1.

Table 1: Showing activities and resource data for the case study.

Activities	Nodes		Duration (weeks)	No. of shifts
	Starting	Ending		
Mobilization	1	2	1	1
Engineering Design	1	3	2	1
Scarification & draining pipelines	1	4	4	1
Setting out	2	5	8	1
Cracking of road surface & concrete walls	3	5	9	1
Laying of pipeline	5	7	7	1
Casting and laying of Kreb& slabs	3	6	3	1
Installation and coating of pipelines	4	6	6	1
Charging line with foam seal chemical & Testing	5	7	5	1
Clean up and Demobilization	7	8	10	1

2.3 Method of Data Analysis

The project is broken into job which in turn divided into events and events to construct a network diagram and followed by resource allocation in heuristic sense. The network diagram analysis is used to establish the critical path to give optimum solution. The heuristic rule technique involves the following steps: Determination of the Earliest Finish Time required in the operation of each activity; feasible set of Allow to Work (ATW) windows S can easily be constructed by setting S_j equal to r_j and setting $C_j$as large as possible:

C_j = min (d_j, min k_{1J}; - $J_k r_k$ – 1) (1)

To determine earliest finish time

EFT=EST + Duration (2)

To determine late start time:

LST = LFT – Duration (3)

To determine total float time

TF = LET – EST- Duration (4)

Determination of the critical path or activities

TF= LFT – EST – Duration = 0 (5)

Determination of the critical cost: sum up the duration of the activities on the critical path. Time is money (resource) as such referred to as cost.

Other important formulae or Equations are follows:

$$\text{(P): min} \sum_{t=1}^{T}\sum_{k=1}^{K} C_{kt}\ U_{kt}, \quad (6)$$

Subject to

$$\sum_{t=r_j}^{d_j} x_{jt} = 1 \qquad \forall j, \quad (7)$$

$$x_{jt} \le \frac{1}{p_j} \qquad \forall j,\ t, \quad (8)$$

$$U_{kt} \ge \sum_{j=1}^{n} q_{kj}\ x_{jt} - Q_{kt} \quad \forall k,\ t, \quad (9)$$

$$x_{jt}, U_{kt} \ge 0 \qquad \forall j,\ k,\ t, \quad (10)$$

$$x_{jt} \leq \frac{s_{jt}}{p_j} \qquad \forall j,\, t, \tag{11}$$

Where parameter S_{jt} indicates whether processing of job J_j is allowed in week t:

$$s_{jt} = \begin{cases} 1 & if\ S_j \leq t \leq C_{j,} \\ 0 & otherwise \end{cases} \tag{12}$$

$$\sum_{\tau=r_j}^{t-1} \chi_{iT} \geq y_{jt} \quad \forall (i, j) \in \rho, \quad r_j \leq t \leq d_{i,} \tag{13}$$

$$\sum_{\tau=r_j}^{t} \chi_{jt} \leq y_{jt} \qquad \forall j, t, \tag{14}$$

$$y_{jt} \in \{0,\ 1\}. \tag{15}$$

2.4 Solution Techniques

The models will be solved using excel and manually to get the results and discussion there about.

3. ANALYSIS, PRESENTATION OF RESULTS AND DISCUSSION

Table 1 was used to develop the network diagram of the GAP.

International Limited as shown in Figure 1.

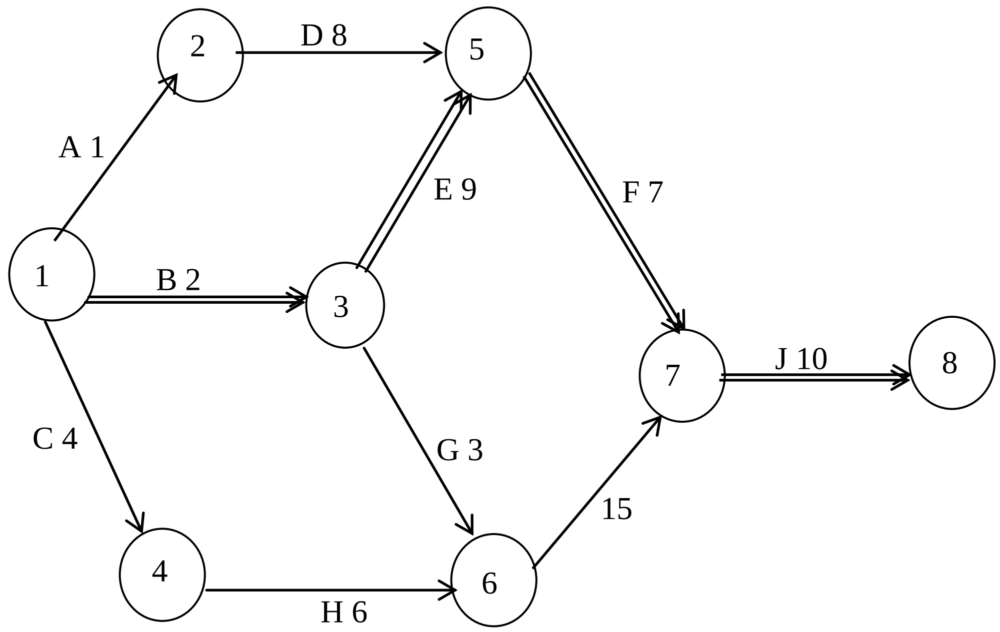

Figure 1: Network diagram for the case study project.

Table 2: Summary of Excel Result showing the critical path for the fire protection system renewal project.

N	t	Start	End	EST	EFT	LST	LFT	TF	C_j
A	1	1	2	0	1	2	3	2	
B	2	1	3	0	2	0	2	0	(1-3)
C	4	1	4	0	4	3	7	3	
D	8	2	5	1	9	3	11	2	
E	9	3	5	2	11	2	11	0	(3-5)
F	7	5	7	11	18	11	18	0	(5-7)
G	3	3	6	2	5	10	13	8	
H	6	4	6	4	10	7	13	3	
I	5	6	7	10	15	13	18	3	
J	10	7	8	18	28	18	28	0	(7-8)

3.2 DISCUSSIONS

The first activity which takes a week is the mobilization of all the necessary resource needed for the project such materials includes pipes, new flanges, values, red oxide coating, and so on, machinery such as trolleys, pumps, vice, and so on, and man such as expatriate, quantity survey, fitters, and so on. The next activity is draining of foam seal chemical from the pipe line and storing them in a tank as it is expensive which the first critical activity in the project is. Delay in the draining of the foam seal chemical from the line may become diluted thus not fit for extinguishing fire. Also spillage may occur in the work activity. From the table 2, earliest time can be finished in two (2) weeks. The latest time must not exceed two weeks. Based on table 2, the Critical Path is (1-3), (3-5), (5-7), (7-8), or (B-E), (E-F), (F-3).

3.2.1 Study of Analysis of Float

Based on statistical total float analysis, figure 1 shows change in the critical path and hence increase the overall project time may result if activities are expanded or moved by the number of available time. It must be realized that float can appear at the beginning of a project (early activities), that is, the starting of the activity can be delayed after the tail events is reached; or it can appear in the activity, so that the duration time is increased beyond that initially planned; or it can appear after the activity is finished, while other activities are being concluded to reach the head events. It is important to note that all critical activities have zero total floats in their schedules. In the planning stage it may be decided to increase the duration of these activities (for instance reducing resources).

It is also important to note that if the target date is greater than the total project time, then all activities will have positive float, whilst if the target time is less than the total project time, the critical path and possibly some other activities will have negative float. Negative float is the time by which its associated activity must be reduced for the project to meet the target time.

4.1 CONCLUSION

Planning and scheduling advisory system (i.e. showing the critical paths, total duration and date of project completion) was successfully accessed with Microsoft Excel and manually for the reconstructed fire protection line. The project completion date was also determined from the design models after simulation with Excel. Construction industries can easily improve client satisfaction with regards to delivery date. Earliest finish time and total float (which determine the critical path) which were obtained both manually as shown in Table 1 seems to have satisfied this objective.

Nomenclature

Symbol	Meaning	Units
EST	Earliest start time	s
EFT	Earliest finish time	s
LST	Earliest start time	s
LFT	Latest finish time	s
TF	Total Float	s
FF	Free Flout	s
Jn	Set of n-Jobs	-
Rk	Plans on k-resources	-
T	Time Horizon	s
Qkt	Capacity of Resources in week, t	tons
Xjkt	Fraction of job Jj performed on Resource Rk in week,t	%
$^{I}/_{Pj}$	Maximum fraction done per week	%
C_{kt} U_{kt}	Cost of U_{kt} hours of non-regular capacity of resources, R_k in week, t	$
S	Set allow to work (ATW) window	-
A	Activities	-

5. REFERENCES

1. E.O.P Akpan, "Priority rules in project scheduling: A case for random activity selection". *Journal of Production Planning and Control*, 2000; 11(2): 165-170,
2. G.F. Okarafor, "Project management and the Nigeria economy", *Journal of Project Management Technology*, 1997; 1(1): 15.
3. E.O.P Akpan, "Optimum resource determination for project scheduling", *Journal of Production Planning and Control*, 1997; 8(5): 462-469.

4. I.S. Kurtulus, and E.W. Davis, E. W, "Multi-project scheduling categorization of heuristic rules performance", *Management Science*, 1982; 28: 161-172.
5. A.B. Tobinson, "Applicability of heuristic approach in planning and scheduling project", *Journal of Industrial Engineering Letters*, 2013; 3(4): 43-50.
6. T. Mac, C. Copot, D.T. Twing, and R.O. Keyser, "Heuristic approaches in robot path planning: A survey", 2016.
7. W. Matthias, and Z. Jurgen, "A heuristic approach to project staffing", *Electronic Notes in Discrete Mathematics*, 2010; 36(1): 775-782.
8. A. Safavi, and S.F. Smith, "A heuristic search approach to planning and scheduling software manufacturing projects in Golumbic M. C. (eds)", *Advances in Artificial Intelligence,* New York : Springer, 2010; 247-268.
9. A. Jafarazadeh, and C.H. Flenings, "An exact geometry-based algorithm for path planning", *.International Journal of Applied Mathematical and Computational Science*, 2018; 28(3): 493-504.
10. A. Stallmeyer, "A heuristic approach to efficient appointment scheduling at short-stay units", *Final project*, AMC University of Twente, Amsterdam, 2014.
11. S.S. Ge, and Y.J. Cui, "New potential functions for mobile robot path planning". *IEEE Transactions on Robotics and Automation*, 2000; 16(5): 615-620.
12. J.E. Kelly, "Critical path and scheduling: Mathematical basis", *project management handbook*, Hants: Gower Technical Limited, 1963.
13. R.A. Russel, "A comparison of heuristic for scheduling projects with cash flows and restrictions", *Management Science*, 1986; 32: 1291-1295.
14. E.W. Davis, and J.H. Patterson, "A comparison of heuristics and optimum solutions in resource-constrained", *Project Scheduling*, 1975; 7(21): 718-722.
15. Z. Huq, and J.J. Bernardo, "The sensitivity of job mix and load capacity bottle necks on inventory and due date performance in a manufacturing system". *Production Planning and Control*, 1995; 6: 516-529.
16. J.E. Kelly, "The critical path method, resource planning and scheduling, in Muth and Thompson" (eds) industrial scheduling (prentice-hall, Englewood Cliffs, NJ). Chapter 21, 1963.