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DEVELOPMENT OF A COMPUTER APPLICATION THAT AUTOMATES THE ACKOFF OPTIMIZATION ALGORITHM

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Abstract: The subject of operations research II includes the deterministic project programming tool or critical path model, known as CPM (Critical Path Method), which allows a systematic analysis of the activities of a graph, identifying the critical operations that constitute the critical paths of a project, this is starting information to start another important point that is related to the minimum cost, a parametric linear programming problem whose operational resolution process can be complicated, which is why the Ackoff heuristic algorithm is used and Sasieni which admits meeting the objective of reducing the total duration of the project so that the total additional reduction cost is the minimum.

In the classroom with a duration of 90 minutes, the resolution of said algorithm allows for a limited and reduced analysis of problems. This has motivated the creation of a computer application in Excel that allows students to raise awareness about problems, analyze a greater number of exercises, transmit the knowledge and provide feedback to students from an economic perspective that emulates the reality they will face in the near future.

Keywords: CPM project scheduling, Ackoff algorithm, Excel, Macros.

INTRODUCTION

Small or large projects have common characteristics since they are composed of various activities that have different durations, some of them have a sequential relationship and associated economic costs for their execution.

A concern for completing the project on time is important, as is completing the project within the budgeted funding; However, on repeated occasions there is a requirement on the part of the principals to reduce these times in exchange for economic incentives, this implies an increase in the resources dedicated to its materialization, accelerating execution means increasing the associated costs; Therefore, the challenge is to reduce the execution time to the minimum possible cost. The Ackoff Algorithm allows us to specify this and verify if it is indeed economically convenient to shorten the project execution time.

In the classroom, the development of this tool is a laborious process where the starting point is to create the graph with the normal times of each of the activities that compose it, taking into account the predecessor activities, which finally allows us to obtain the critical path(s) of the project and its duration; This process alone usually means a class; Once this step is completed, we will only be able to start the algorithm that accelerates the duration of the project. To deliver these contents and solve an exercise requires a professorship or more.

For this reason and with the objective of being able to simulate a project with a number of approximately ten activities that allows us to develop the analysis and a greater number of problems, it has been carried out using a computer program implemented in Excel through Visual Basic Application (VBA), which results in faster results.

DEVELOPMENT

CPM or critical path method, considers that the durations and costs of activities can be predicted well enough to be able to use deterministic estimates; For this, there are two key concepts for the application of the method, which are the earliest time for the activity, this being the most immediate moment in which said event can occur, and the later time for the task, which is related to the last moment in which the event can occur. which said event can occur without delaying the total duration of the project; With this data, the duration of each task and the predecessor activities, we can create the graph and calculate the total slack, defined as the maximum time

in which an activity can be delayed without altering the end date of the plan. In this regard, when the total slack is zero, it indicates that it is a critical activity within the project, therefore, the achievement of critical activities constitutes the critical path, the longest path in a network is called the critical path. This path is important because it determines the length of the project, if any of the activities on the critical path are delayed, the entire project is delayed and vice versa.

To carry out the Ackoff algorithm, the starting values are the CPM graph and the estimates of each of the activities that contain a project, which considers for each one, different execution times that obey normal time (t_N), and accelerated (t_I), corresponding to each one a different direct cost, given that accelerating an operation implies that we must inject resources that increase the associated costs. In this regard, a task requires a minimum execution time to materialize that cannot be reduced even if we increase the resources. This minimum time for carrying out the activity, with the maximum use of available resources, is called intensive time and the corresponding cost is the intensive cost (CI). On the other hand, the execution time with the minimum use of resources is called normal time and the associated cost is the normal cost (CN). The CPM assumes that the normal and intensive estimates have a linear relationship as shown in figure 1, which allows us to obtain the unit acceleration cost:
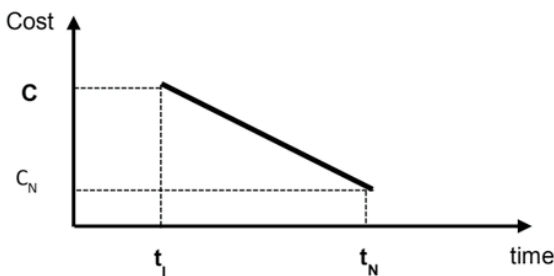

Figure 1: Time – normal and intensive cost

The steps to carry out the algorithm are as follows:

1. We identify the tasks that the project has.

2. The calculation of the unit acceleration cost must be carried out for each activity that belongs to the network.

Unit acceleration cost (ki) is:

$$k_i = \frac{C_I - C_N}{t_N - t_I} \qquad (1)$$

3. With the current times of the activities, the total slack must be calculated. If these yield a value of zero, these tasks will be defined as critical in the project. These operations integrate the critical path(s) in the grid.

The total clearances (TSij):

$$TSij = LFj - (ESI + dij). \qquad (2)$$

Where:

LFi, j = Latest moment of completion of the activity (i,j)

ES i,j= Earliest moment of start of the activity (i,j)

di,j = Duration of activity (i,j)

4. We obtain the shortening times of each of the operations. Shortening time (TAi):

$$TA_i = t_N - t_I \qquad (3)$$

5. Later we identify the paths that the project has.

6. We take all the information to an organized table to proceed with the shortening.

7. To accelerate the project by one unit of time, the following question must be answered:

Is there only one critical path?

If the answer is Yes, select the critical activity, and accelerate when:

a) It can still be accelerated.

b) Has the lowest acceleration cost per

period.

If the answer is No then there is more than one critical path, in which case one activity from each critical path must be accelerated such that:

a) Each selected activity can still be accelerated.

b) The total cost per unit of time is the lowest of all activities

c) Consider that the same activity can belong to more than one critical path at the same time, the combinations of activities to be reduced are analyzed and the one with the lowest cost is chosen.

8. Update activity times and calculate the new total project time. If the desired delivery date has already been achieved, stop the process. If not, go back to step 7.

9. When there are no more critical activities that can be accelerated and that result in a reduction in project time, the process ends.

10. Calculate the acceleration cost by adding the unit costs per accelerated activity for each period.

All the steps reported in the previous paragraph are those that are carried out in the classroom where the student must follow them to obtain the results, generally and due to the laborious nature of the process, the times required are approximately two classes or up to three to be able to finish. just a problem posed.

The fact of automating the execution of the algorithm with the computer program carried out in this work means freeing up valuable time in the classroom to be able to address both the awareness of exercises and also increase the number of problems allowing various types to be carried out. Another important point to highlight is that the implementation facilitates the possibility of transmitting experience and feedback of the economic judgment that this means, currently due to lack of time it is often not possible to deliver this to the students, limiting our delivery as educators.

COMPUTATIONAL APPLICATION

Before the computer application starts, the activity data is recorded on the first sheet of the spreadsheet, formed as a matrix according to activity and according to item, which is illustrated in Figure 2.

Once the application is started, the data is read into a program matrix, which indexes the costs and durations according to activity and according to item. Next, the application automatically calculates the unit costs from the data recorded in the input matrix, then organizes them in a matrix, according to route and according to activity, and then registers them on the first sheet of the spreadsheet, as illustrated. in Figure 3.

Immediately afterwards, the computational application begins a multi-step iteration, during which the application searches for the activity with the highest unit cost, and if it presents time slack, it subtracts a unit of time and adds the cost that it accrues to the cost. total. To do the latter, the application discounts time units from a slack matrix, according to the step of the iteration (rows) and according to activity, a matrix that has been created from the input data and taking into account equation (2). and shown in Figure 4.

A	B	C	D	E	F	G	H	I
1	1	2	0	1	1	1	1	
1	1	2	0	1	1	1	0	
1	0	2	0	1	1	1	0	
1	0	1	0	1	1	0	0	
1	0	1	0	1	0	0	0	
1	0	0	0	1	0	0	0	

Figure 4. Activities slack matrix

Once the time discount has been carried

Y	Z	AA	AB	AC	AD
Activity	Activity Predecessor	Normal Duration (t/branch)	Normal Cost (s/branch)	Intensive Duration (t/branch)	Intensive Cost (s/branch)
A	---	4	1400	3	2000
B	A	2	1500	1	2000
C	A	3	1500	1	2500
D	B, C	1	600	1	600
E	B, C	3	1300	2	2000
F	A	2	300	1	500
G	D	2	800	1	1200
H	E	2	600	1	1000
I	B	0	0	0	0

Figure 2. Activity data matrix

	A	B	C	D	E	F	G	H	I	J
1	Route	A	B	C	D	E	F	G	H	I
2	A -C- E - G	600		500		700		400		
3	A -D	600								
4	A-C-F-H	600		500			200		400	
5	A-B-I-E-G	600	500			700		400		
6	A-B-I-F-H	600	500				200		400	

Figure 3. Matrix of unit costs of activities

out, the application internally builds a matrix of durations, in unitary time units, indexed according to path and according to iteration step (column), and then records the entire matrix in the first sheet of the spreadsheet, as shown in Figure 5.

L	M	N	O	P	Q	R	S
A	1400	1400	2000	2000	2000	2000	2000
B	1500	1500	1500	1500	2000	2000	2500
C	1500	1500	1500	1500	1500	1500	1500
D	600	600	600	600	600	600	600
E	1300	1300	1300	1300	1300	2000	2000
F	300	300	300	500	500	500	500
G	800	1200	1200	1200	1200	1200	1200
H	600	600	600	600	600	600	600
I	0	0	0	0	0	0	0
Total	8000	8400	9000	9200	9700	10400	10900

Figure 6. Total cost matrix

A – C – E - G	12	12	12	12	12	12	12
A - D	5	4	4	4	4	3	3
A – C – F - H	11	11	10	10	10	10	10
A – B – I – E -G	11	11	11	10	10	10	10
A – B – I – F - H	10	10	10	10	9	9	8

Figura 5. Route duration matrix

A second action that the computer application undertakes once the time discount has been carried out is to add the accrued unit cost to the total cost, a situation that is recorded in an internal matrix, indexed according to activity and according to iteration. Once the cost of an iteration step has been added, the entire matrix is recorded on the first sheet of the spreadsheet, as illustrated in Figure 6.

It is worth mentioning that by applying the algorithm with the computer program for the resolution of Ackoff, it is expected to obtain the previously expressed benefits of both the sensitivity of the problems, a greater number of exercises in the time allocated to the program for this purpose, and guiding students in the analysis. economic with the purpose of developing studies of the results and mobilizing the knowledge acquired in the

different subjects previously taken.

CONCLUSIONS

The liberalization of time available in the classroom brings benefits for students since they have the possibility of developing a greater variety of problems, raising awareness of them and analyzing exercises in a more in-depth way.

The available time obtained thanks to the application of the program and automation of the Ackoff algorithm allows students to provide feedback and delve into aspects such as economic analysis that without this tool in a traditional class this instance could not be achieved.

This work opens a window to subsequent applications in other subjects, exploring carrying out this program with a greater number of project operations that simulate reality and allows students to make decisions that will serve them in their future work.

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