VISIBLE DEPENDENCIES (PRECEDENCE RELATIONSHIPS) BETWEEN THE WORK BREAKDOWN STRUCTURE (PERT AND CPM)

K Reamesh[1]
[1]*Asst.prof of Mathematics, SNDTIT,Raipur(India)*

ABSTRACT

The term project has been defined by many authors, and each one has defined it from his own point of view and in the perspective of his own field of activity. Most often a project is defined as a combination of interrelated activities which must be executed in a certain order before the entire task is completed. The salient characteristics of a project are. A project has identifiable beginning and end points; it is and entity by itself. It is not a permanent entity; it is usually a non-repetitive task. It can be broken down into identifiable activities which require time and resources for their execution. It is scheduled to be completed by a target date. .The objectives are clear and outpour or end product definite usually involves heavy investment. Each project, whether high or small, has three basic requirements Execution of project activities and hence completion of the project is always subject to some uncertainties and risks.

Activities:

The Critical Path Method (CPM) is one of several related techniques for doing project planning. 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.

CPM can help you figure out:

- how long your complex project will take to complete
- which activities are "critical," meaning that they have to be done on time or else the whole project will take longer

If you put in information about the cost of each activity, and how much it costs to speed up each activity, CPM can help you figure out:

- whether you should try to speed up the project, and, if so,

- What is the least costly way to speed up the project.

An activity is a specific task. It gets something done. An activity can have these properties:

- names of any other activities that have to be completed before this one can start
- a projected normal time duration

If you want to do a speedup cost analysis, you also have to know these things about each activity:

- a cost to complete
- a shorter time to complete on a crash basis
- the higher cost of completing it on a crash basis

CPM analysis starts after you have figured out all the individual activities in your project.

I. IMPORTANCE

The complexities of the present-day management problems and the business competitions have added to the pressure on the brains of decision-makers. In a large and complex project involving number of interrelated activities, requiring a number of men, machines and materials, it is not possible for the management to make and execute an optimum schedule just by intuition based on the organizational capabilities and work experienced. Managements are, thus always on the lookout for some methods and techniques which may help in planning, scheduling and controlling the project. The aim of planning is to develop a sequence of activities of the project, so that the project completion time and cost are properly balanced and the excessive dement of key resources is avoided. To meet the object of systematic, planning the managements have evolved a number of techniques applying network strategy. As already explained, PERT and CPM are two such widely applied techniques used for planning, scheduling and controlling of large and complex projects. With slight modifications both have given rise to several other network techniques, such as Programme Evaluation procedure, Resource allocation for Multi-Project Scheduling, Least cost estimation and scheduling and Scheduling and control by automated network system.

Followings Are The Main Objectives Of Network Analysis:

a. To minimize idle resources.
b. To minimize the total project cost.
c. To trade off between time and cost of project.
d. To minimize production delays, interruptions and conflicts.
e. To minimize the total project duration.

(A) To Minimize Idle Resources:

Allowing for large variations in the use of limited resources may disturb the whole plan. Thus, efforts should be made to avoid the cost incurred due to idle resources.

(B) To Minimize The Total Project Cost:

The total cost of the project can be calculated and then efforts can be made to minimize the total cost by calculating the cost of delay in the completion of an activity of the project in addition to the cost of the resources required to carry out the jobs at various speeds (i.e. normal or over time rates of pay).

(C) To Trade Off Between Time And Cost Of Project:

The idea of trade off between time and cost of project is centred on the idea that duration of same activities can be cut down if additional resources are allocated to them.

For technical reasons, the durations may not be reduced indefinitely. Similarly, there is also a most cost efficient duration called 'normal point' & stretching the activity beyond it may lead to [a] rise in direct costs.

(D) To Minimize Production Delays, Interruption And Conflict:

This is achieved by identifying all activities involved in the project, their precedence constraints, etc.

(E) To Minimize Idle Resources:

Allowing for large variations in the use of limited resources may disturb the whole plan. Thus, efforts should be made to avoid the cost incurred due to resources.

Example 1: Activities, Precedence, And Times

This first example involves activities, their precedence (which activities come before other activities), and the times the activities take. The objective is to identify the critical path and figure out how much time the whole project will take.

Example 1 Step 1: List The Activities

CPM analysis starts when you have a table showing each activity in your project. For each activity, you need to know which other activities must be done before it starts, and how long the activity takes.

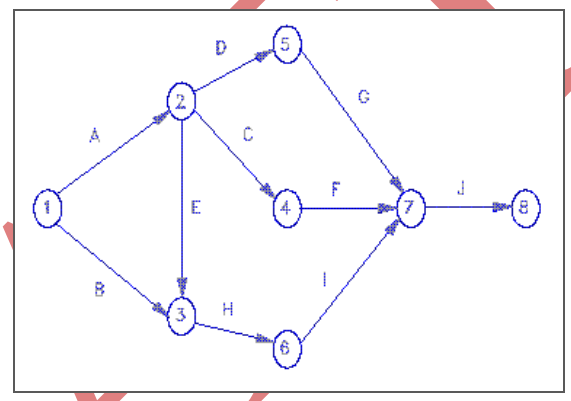
Here's the Example:

Activity	*Description*	*Required Predecessor*	*Duration*
A	Product design	(None)	5 months
B	Market research	(None)	1
C	Production analysis	A	2
D	Product model	A	3

E	Sales brochure	A	2
F	Cost analysis	C	3
G	Product testing	D	4
H	Sales training	B, E	2
I	Pricing	H	1
J	Project report	F, G, I	1

Example 1 Step 2: Draw the Diagram

Draw by hand a network diagram of the project that shows which activities follow which other ones. This can be tricky. The analysis method we'll be using requires an "activity-on-arc" (AOA) diagram. An AOA diagram has numbered "nodes" that represent stages of project completion. You make up the nodes' numbers as you construct the diagram. You connect the nodes with arrows or "arcs" that represent the activities that are listed in the above table.



Some conventions about how to draw these diagrams:

- All activities with no predecessor come off of node 1.
- All activities with no successor point to the last node, which has to have highest node number.

In this example, A and B are the two activities that have no predecessor. They are represented as arrows leading away from node 1.

J is the one activity that has no successor, in this example. It therefore points to the last node, which is node 8. If there were more than one activity with successor, all of those activities' arrows point to the highest number node.

Students sometimes make the mistake of creating a diagram with several starting or ending nodes. *Don't* do this.

The trickiest part for me of building the above diagram was figuring what to do with activity H. I had drawn an arrow for activity B coming off node 1 and going to mode 3. I had later drawn an arrow for activity E coming off node 2 and going to node 6. Since H requires both B and E, I had to erase my first E arrow and redraw it so it pointed to the same node 3 that B did. H then comes off of node 3 and goes to node 6.

When designing these diagrams, work in pencil.

Example 1 Step 3: Set up the CPM spreadsheet

There are specialized commercial programs for doing CPM analysis. Rather than purchase and learn one of those, we'll leverage the spreadsheet knowledge we already have. We will use one freeware program written for this course and made available to you through the Internet.

Start up a new blank spreadsheet. If you are viewing this document on the web, minimize your browser window and then start *Excel*. That way you can switch from one to the other by pressing Alt+Tab.

In a blank spreadsheet, type the word "Activities" in cell A1. In row 2, type the names of the activities, or their letters. (To make my spreadsheet screen shots fit better on these pages, I set the column widths to 4. You do not have to do this.)

	A	B	C	D	E	F	G	H	I	J
1	Activities									
2	A	B	C	D	E	F	G	H	I	J

In row 3, type "Nodes". In row 4, type in each activity's start node -- where the tail of its arrow is. Below that, in row 5, type each activity's end node -- where the head of its arrow is. Do this carefully. Mistakes here mess up everything that follows.

To the right, in K2 and K3, type the words "Start" and "End" to label those rows.

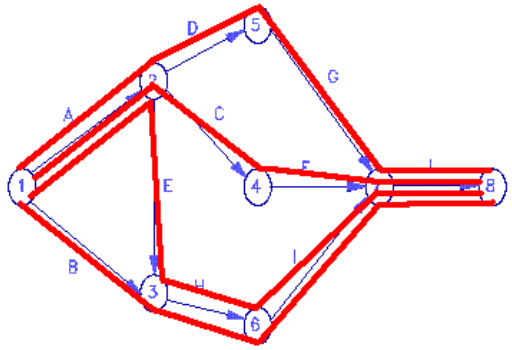
	A	B	C	D	E	F	G	H	I	J	K
1	Activities										
2	A	B	C	D	E	F	G	H	I	J	
3	Nodes										
4	1	1	2	2	2	4	5	3	6	7	Start
5	2	3	4	5	3	7	7	6	7	8	End

In cell A6, type "Times". In row 7, type the time each activity takes. Then, select the range of cells containing the node numbers and copy it to the clipboard.

	A	B	C	D	E	F	G	H	I	J	K
1	Activities										
2	A	B	C	D	E	F	G	H	I	J	
3	Nodes										
4	1	1	2	2	2	4	5	3	6	7	Start
5	2	3	4	5	3	7	7	6	7	8	End
6	Times										
7	5	1	2	3	2	3	4	2	1	1	

Example 1 Step 4: Use Path find to Get the Paths

Path find is a computer program that helps you find and enter into the spreadsheet all of the possible paths through your diagram along the arrows from the first node to the last. You could do this by hand, of course. This diagram shows the four possible paths in this example.



The four paths are A D G J, A C F J, A E H I J, and B H I J. We'll code them in the spreadsheet with a matrix of 0's and 1's. Rather than do this all by hand, we'll get Path find help do it.

To use Path find, start up your Internet connection and your browser (unless, of course, you are reading this document on the Internet already). Go to http://hspm.sph.sc.edu/Courses/J716/CPM/Pathfind.html

Loading this html file into your browser starts Path find, which is a Java applet that runs inside your browser. When Path find is loaded:

1. Click in Path find's upper text area.
2. Paste the range you just copied from your spreadsheet into that upper text area. (Click in the text area and press Ctrl+V or Shift+Insert.)
3. Click on Path find's button. Path find's lower text area will give you a block of numbers, all highlighted so you can copy them.
4. Copy the highlighted numbers to the clipboard for pasting later into your spreadsheet. (Ctrl+C or Ctrl+Insert copies what is highlighted.)

You can now close the Path find web page, if you wish.

Example 1 Step 5: Paste the Path Information into Your Spreadsheet

When you're done with Path find, go back to your spreadsheet. Move your cell selector to cell A8. Type "Paths" in that cell. Then move the cell selector toA9, as shown here:

	A	B	C	D	E	F	G	H	I	J	K
1	Activities										
2	A	B	C	D	E	F	G	H	I	J	
3	Nodes										
4	1	1	2	2	2	4	5	3	6	7	Start
5	2	3	4	5	3	7	7	6	7	8	End
6	Times										
7	5	1	2	3	2	3	4	2	1	1	
8	Paths										
9											

Paste to that cell, to see this:

	A	B	C	D	E	F	G	H	I	J	K
1	Activities										
2	A	B	C	D	E	F	G	H	I	J	
3	Nodes										
4	1	1	2	2	2	4	5	3	6	7	Start
5	2	3	4	5	3	7	7	6	7	8	End
6	Times										
7	5	1	2	3	2	3	4	2	1	1	
8	Paths										
9	1	0	1	0	0	1	0	0	0	1	
10	1	0	0	1	0	0	1	0	0	1	
11	0	1	0	0	0	0	0	1	1	1	
12	1	0	0	0	1	0	0	1	1	1	

The pasted cells are all 0's and 1's. Each row represents a path. The 1's indicate which activities are in that particular path. For example, row 9 (cells A9:J9) has 1's under activities A, C, F, and J. This says that this path includes activities A, C, F, and J. This corresponds to the path through the middle of the diagram that goes: 1 -A-> 2 -C-> 4 -F-> 7 -J-> 8.

The diagram above shows four paths from node 1 to node 8. Sure enough, Path find gives you four rows of 0's and 1's, one row for each path.

Example 1 Step 6: Calculate the Paths' Times

Move the cell selector to K9. Type =SUMPRODUCT(A9:J9,$A$7:$J$7) in that cell.

	A	B	C	D	E	F	G	H	I	J	K	L	M
1	Activities												
2	A	B	C	D	E	F	G	H	I	J			
3	Nodes												
4	1	1	2	2	2	4	5	3	6	7	Start		
5	2	3	4	5	3	7	7	6	7	8	End		
6	Times												
7	5	1	2	3	2	3	4	2	1	1			
8	Paths												
9	1	0	1	0	0	1	0	0	0	1	=sumproduct(A9:J9,$A$7:$J$7)		
10	1	0	0	1	0	0	1	0	0	1			
11	0	1	0	0	0	0	0	1	1	1			
12	1	0	0	0	1	0	0	1	1	1			

This formula multiplies each entry in row 9 by the corresponding entry in row 7. Because the entries in row 9 are all 0's and 1's, this has the effect of selecting the times from row 7 that go with the activities represented in row 7, and adding all those times.

When you enter the formula, the number 11 should appear in K9. That's the time it would take to complete activities A, C, F, and J. You can verify that A takes 5 months, C takes 2, F takes 3, and J takes 1, for a total of 11.

To fill in the other paths' times, copy cell K9, then paste it to K9:K12. The $ signs in the formula see to it that each path's 1's are multiplied by the corresponding numbers in row 7.

	A	B	C	D	E	F	G	H	I	J	K
1	Activities										
2	A	B	C	D	E	F	G	H	I	J	
3	Nodes										
4	1	1	2	2	2	4	5	3	6	7	Start
5	2	3	4	5	3	7	7	6	7	8	End
6	Times										
7	5	1	2	3	2	3	4	2	1	1	
8	Paths										
9	1	0	1	0	0	1	0	0	0	1	11
10	1	0	0	1	0	0	1	0	0	1	13
11	0	1	0	0	0	0	0	1	1	1	5
12	1	0	0	0	1	0	0	1	1	1	11

Example 1 Step 7: Identify the Critical Path

The critical path is the path that takes the longest. In this example, the critical path is the one in row 10, which takes 13 months. The project will therefore take 13 months, if everything is done on schedule with no delays. The time a project takes is equal to the time of its critical path.

The 1's in row 10 tell us that the critical path is 1 -A-> 2 -D-> 4 -G-> 7 -J-> 8. As managers, we must be sure that activities A, D, G, and J are done on time. If any of those activities is late, the project will be late.

Other paths are not critical because they can waste some time without slowing the project. For example, activity C, in row 9's path, can take up to two extra months and not hold up the project.

To make it easier to see what activities are in each path, go to cell A14. Type =if(A9=1,A$2,"") there. The letter A should appear in cell A14.

This =if(A9=1,A$2,"") function works this way: Inside the parentheses are three expressions separated by commas. The first expression (A9=1) is something that can be either true or false. If the expression is true, the second expression (A$2) is shown in the cell. Otherwise, the third expression ("") is shown in the cell.

In A14, the expression A9=1 is true, so the cell shows what is in A2, which is the letter "A". If A9 had not contained a 1, the A14 would have shown a blank, which is what "" means.

Copy A14 to the clipboard. Then, starting in A14, select a range of cells that goes over to column J and down four rows. The selected range should be the same size as the space that the paths' 1's and 0's take up.
Paste. You should get this:

	A	B	C	D	E	F	G	H	I	J	K
1	Activities										
2	A	B	C	D	E	F	G	H	I	J	
3	Nodes										
4	1	1	2	2	2	4	5	3	6	7	Start
5	2	3	4	5	3	7	7	6	7	8	End
6	Times										
7	5	1	2	3	2	3	4	2	1	1	
8	Paths										
9	1	0	1	0	0	1	0	0	0	1	11
10	1	0	0	1	0	0	1	0	0	1	13
11	0	1	0	0	0	0	0	1	1	1	5
12	1	0	0	0	1	0	0	1	1	1	11
13											
14	A		C			F				J	
15	A			D			G			J	
16		B						H	I	J	
17	A				E			H	I	J	

Now you can see which activities are in each path. If your results do not look like the above, make sure that there is one $ in your formula, and that it's in front of the 2 and not in front of the A.

Go to cell J13 and type "Max". Then go to cell K13. Type =MAX(K9:K12) to display the longest path time.

K13 = =MAX(K9:K12)

	A	B	C	D	E	F	G	H	I	J	K
1	Activities										
2	A	B	C	D	E	F	G	H	I	J	
3	Nodes										
4	1	1	2	2	2	4	5	3	6	7	Start
5	2	3	4	5	3	7	7	6	7	8	End
6	Times										
7	5	1	2	3	2	3	4	2	1	1	
8	Paths										
9	1	0	1	0	0	1	0	0	0	1	11
10	1	0	0	1	0	0	1	0	0	1	13
11	0	1	0	0	0	0	0	1	1	1	5
12	1	0	0	0	1	0	0	1	1	1	11
13										Max	13

Move to cell K14 and type =IF(K9=K$13,"Critical","") there.

	A	B	C	D	E	F	G	H	I	J	K	L
1	Activities											
2	A	B	C	D	E	F	G	H	I	J		
3	Nodes											
4	1	1	2	2	2	4	5	3	6	7	Start	
5	2	3	4	5	3	7	7	6	7	8	End	
6	Times											
7	5	1	2	3	2	3	4	2	1	1		
8	Paths											
9	1	0	1	0	0	1	0	0	0	1	11	
10	1	0	0	1	0	0	1	0	0	1	13	
11	0	1	0	0	0	0	0	1	1	1	5	
12	1	0	0	0	1	0	0	1	1	1	11	
13										Max	13	
14	A		C			F				J	=if(K9=$K$13,"Critical","")	
15	A			D			G			J		
16		B						H	I	J		
17	A				E			H	I	J		

This will put the word "Critical" next to a path whose time equals the maximum of all the path times. Otherwise, it will put in a blank, as it does here, because the 11 in K9 does not equal the 13 in K13.

Copy K14 to the clipboard. (It will seem strange to copy what appears to be an empty cell, but do it anyway.) Select cells K14 to K17, and paste.

	A	B	C	D	E	F	G	H	I	J	K
1	Activities										
2	A	B	C	D	E	F	G	H	I	J	
3	Nodes										
4	1	1	2	2	2	4	5	3	6	7	Start
5	2	3	4	5	3	7	7	6	7	8	End
6	Times										
7	5	1	2	3	2	3	4	2	1	1	
8	Paths										
9	1	0	1	0	0	1	0	0	0	1	11
10	1	0	0	1	0	0	1	0	0	1	13
11	0	1	0	0	0	0	0	1	1	1	5
12	1	0	0	0	1	0	0	1	1	1	11
13										Max	13
14	A		C			F				J	
15	A			D			G			J	Critical
16		B						H	I	J	
17	A				E			H	I	J	

You're done! You've found the time the project will take, and you have identified the critical path, which tells you which activities must be done on time to make the project finish in the least time.

II. ADVANTAGES

- PERT chart explicitly defines and makes visible dependencies (precedence relationships) between the work breakdown structure (commonly WBS) elements.
- PERT facilitates identification of the critical path and makes this visible.
- PERT facilitates identification of early start, late start, and slack for each activity.
- PERT provides for potentially reduced project duration due to better understanding of dependencies leading to improved overlapping of activities and tasks where feasible.
- The large amount of project data can be organized & presented in diagram for use in decision making.

III. DISADVANTAGES

- There can be potentially hundreds or thousands of activities and individual dependency relationships.
- PERT is not easily scalable for smaller projects.
- The network charts tend to be large and unwieldy requiring several pages to print and requiring specially sized paper.
- The lack of a timeframe on most PERT/CPM charts makes it harder to show status although colours can help (e.g., specific colour for completed nodes).

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