Critical path analysis

Introduction

Critical path analysis is a project planning technique that can assist in identifying all the activities required for the successful completion of a project and the expected time required to complete the entire project. The critical path refers to the set of activities in which there is no slack; in other words, if any of the activities on the critical path over-runs its time, then the whole project will be delayed.

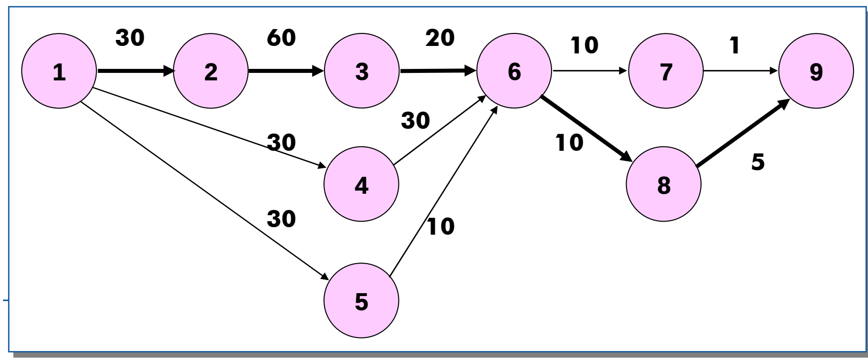
Networks and dependences

In a *network* the planned activities are linked logically - to show the dependences, that is, where tasks cannot be started until earlier tasks have been completed. Networks provide a model of the overall activity which are not necessarily time dependent and which can be more difficult to describe than can be achieved using a Gantt chart. On the other hand, they can easily show which activities are dependent on others and which are critical.

It is important to differentiate between events and activities. An *activity* needs time to undertake whereas an *event* is a milestone: a specific point in time such as the end of an activity. This may also be a signal for the next activity to commence.

Imagine that you are about to embark on a project and have identified the following activities:

Task Analysis Chart			
No.	**Task**	**Dependence**	**Duration**
A.	Consult with members		30 days
B.	Undertake research	Task 1	60 days
C.	Prepare draft proposals	Task 2	20 days
D.	Build alliances with stakeholders	Task 1	30 days
E.	Seek meetings with policy makers	Task 1	10 days
F.	Modify draft proposals	Tasks 3, 4,5	10 days
G.	Meet with Minister	Task 6	1 day
H.	Publish final proposals	Task 6	5 days
I.	Issue press release	Tasks 7, 8	1 day



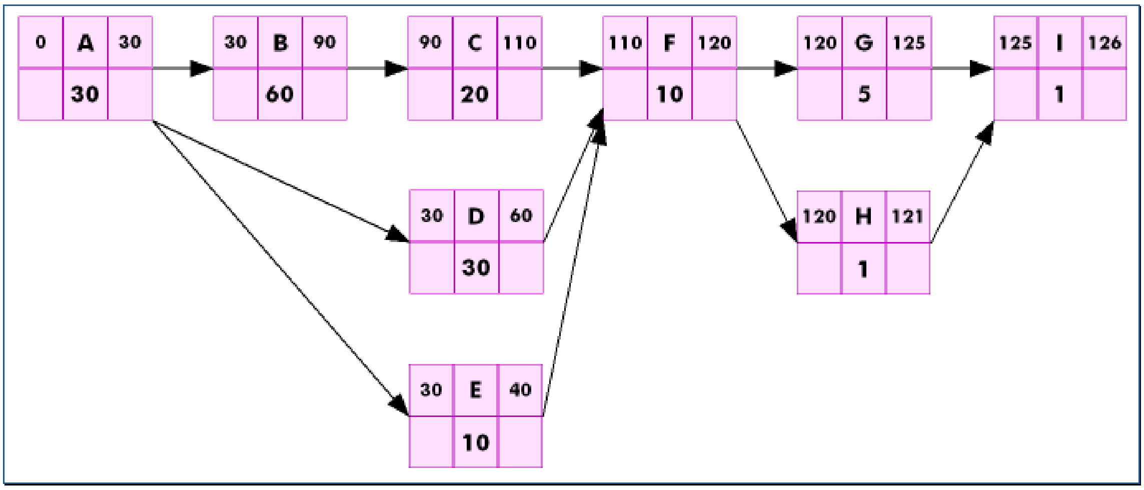
The network in the figure shows a typical set of activities (shown as lines, with their durations) and events (the end of an activity, shown as circles). The path requiring the longest time (and which will therefore delay the entire project if a delay in any activity occurs) is *critical* and is highlighted.

One effective way of setting out the model is to use boxes which show activities start times, durations and finish times.

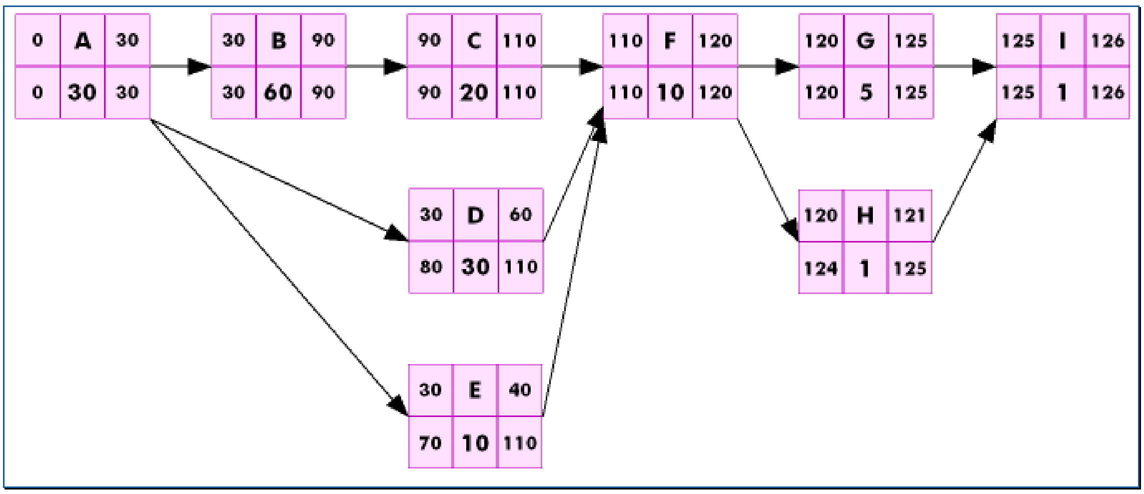
Earliest start time	Activity	Earliest finish time
Latest start time	Duration	Latest finish time

Start by setting these out showing which activities follow other activities and add the durations. Note that some activities can be undertaken in parallel but that others cannot start until specified earlier tasks have been completed.

Now, starting from the left, show the earliest possible start times in the left hand box and earliest possible finish times in the top right hand box. Note that the earliest start time for activity C is the earliest finish time for activity B.



This gives the earliest finish time for the entire project of 126 days. Now, starting from the right and working backwards, enter the latest permissible finish time in the bottom right hand corner and latest permissible start time in the bottom left hand corner.



The *critical path* can now be seen as the path which includes the *critical activities* of A, B, C, F, H and I. If there is any delay in any of these activities, the entire project will be delayed. There is, however, some *slack* for activities D, E and H.

Activity E, for example, could start up to 40 days late and still not delay the project (provided of course that it was completed in its allowed time).

Computerised project planning software makes the preparation of critical path networks very easy. Most have the facility to add resource requirements. Critical path can also be used to monitor progress and are easily amended if necessary.

Handling uncertainty

Invariably, the estimates of time required will be exactly that – estimates. They may be based on previous similar projects or they may have been determined by looking at the detailed requirements for each activity. For most projects undertaken by a BMO, Gantt charts and Critical Path Analysis will probably be quite sufficient. For larger projects, however, especially where the final completion date is critical, it may be necessary to use statistical methods or simulation methods to give a greater degree of confidence in the likely finish time. Programme evaluation and review technique (PERT), for example, requires the duration of each activity to be defined to give the most optimistic duration (with, say, only a 10% chance of doing better), the most likely duration and the most pessimistic duration (with, say, only a 10% chance of doing worse). These are then used to calculate the standard deviation and mean completion times each activity and so for the entire project

The mean time or expected time (t_e)is not the most likely time, but the average time if the activity is undertaken many times over. A close approximation for the expected time is given by the formula:

$$t_e = \frac{(t_o + 4t_m + t_p)}{6}$$

Where t_o is the most optimistic, t_p is the most pessimistic and t_m is the most likely time. If the optimistic and pessimistic times are equidistant from the most likely, than the expected time will equal the most likely. Frequently, however, the most pessimistic time will be further away.

Imagine for example, that you need to appoint a consultant to undertake part of your project. You know from experience that recruiting a consultant typically takes 10 weeks, by the time you have written terms of reference, identified suitable consultants, sent them the invitation to tender, given them time to prepare a proposal, selected the most appropriate, and given them time to start. If you can identify consultants quickly, give them a little less time than usual to respond, speed up the selection process, and they can start straight away, you may reduce the time required to eight weeks. On the other hand, you may take longer than expected to identify consultants who could pitch, longer to select the best consultant and they can't start for a month, giving a pessimistic time of 18 weeks. Thus the expected time for this activity would be

$$t_e = \frac{(8 + 4(10) + 18)}{6} = 11 \text{ weeks}$$

This is the time that you would use in your critical path analysis or your Gantt chart. You may think this is unnecessarily complicated, but if for example you were building a new office, using borrowed money, then any delays could have serious implications for the total cost.