Critical path (CRM) method

Identifying the critical path

There will be at least one path through the network that defines the duration of the project. This is known as the critical path. The critical path is the longest path through the network. Any delay to any activity on this critical path will delay the completion of the project.

The significance of the critical path is two-fold.

- In managing the project, we must pay particular attention to monitoring activities on the critical path so that the effects of any delay or resource unavailability are detected and corrected at the earliest opportunity.
- In planning the project, it is the critical path that we must shorten if we are to reduce the overall duration of the project.

Figure shows the activity span. This is the difference between the earliest start date and the latest finish date and is a measure of the maximum time allowable for the activity.

Activity float:

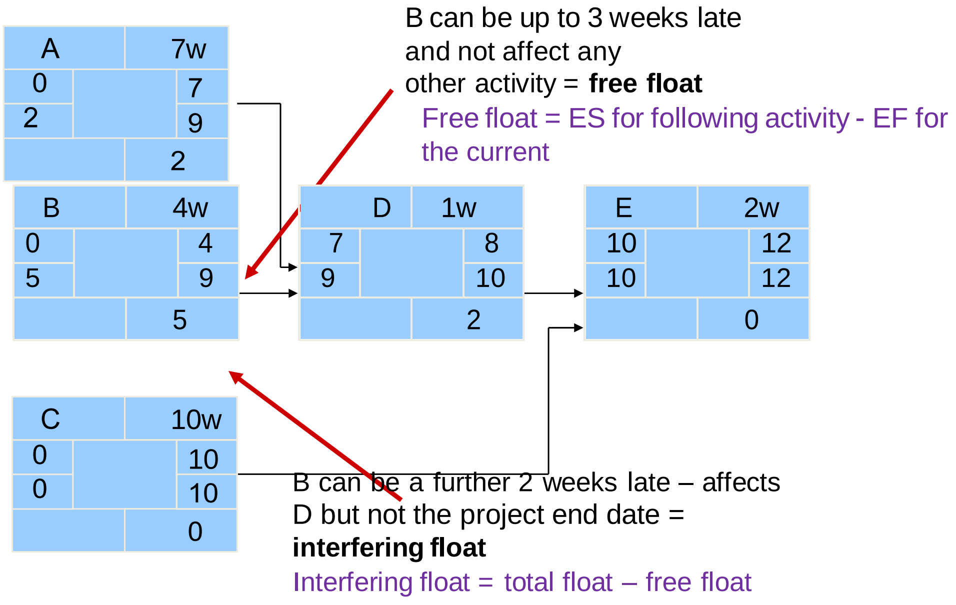
- Although the total float is shown for each activity, it really 'belongs' to a path through the network. Activities A and C in Figure each have 2 weeks' total float. If, however, activity A uses up its float (that is, it is not completed until week 8) then activity B will have zero float (it will have become critical). In such circumstances it may be misleading and detrimental to the project's success to publicize total float!
- There are a number of other measures of activity float, including the following:
- *Total float:* the difference between an activity's earliest start date and its latest start date is known as the activity's float – it is a measure of how much the start or completion of an activity may be delayed without affecting the end date ofthe project.

  Total float = LF – ES – duration (or LS-ES or LF-EF)
- *Free float:* the time by which an activity may be delayed without affecting any subsequent activity. It is calculated as the difference between the earliest completion date for the activity and the earliest start date of the succeeding activity. This might be considered a more satisfactory measure of float for publicizing to the staff involved in undertaking the activities.
- • *Interfering float:* the difference between total float and free float. This **is quite**commonly used, particularly in association with the free float. Once the free float has been used (or if it is zero), the interfering float tells us by how **much** the activity may be delayed without delaying the project end date - even though it will delay the start of subsequent activities.

- Calculate the free float and interfering float for each of the activities shown inthe activity network (Figure).

Free and interfering float

Total float = LF – ES – duration



Shortening the project duration

- If we wish to shorten the overall duration of a project we would normally consider attempting to reduce activity durations. In many cases this can be doneby applying more resources to the task - working overtime or procuring additional staff, for example. The critical path indicates where we must look to save time - if we are trying to bring forward the end date of the project, there is clearly no point in attempting to shorten non-critical activities. Referring to Figure , it can be seen that we could complete the project in week 12 by reducing the duration of activity F by one *week* (to 9 weeks).

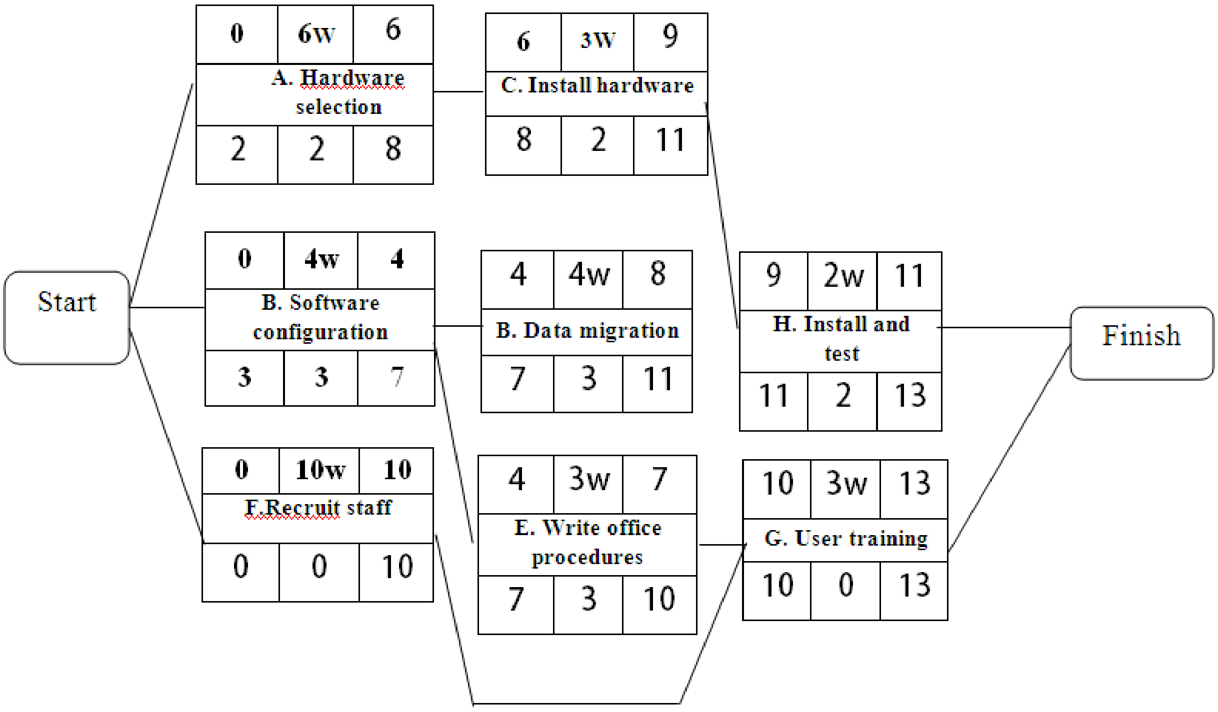


Figure: The Critical path

Exercise

- Referring to Figure , suppose that the duration for activity F is shortened to 8 weeks. Calculate the end date for the project.
- What would the end date for the project be if activity F were shortened to 7 weeks? Why?
- As we reduce activity times along the critical path we must continually check for any new critical path emerging and redirect our attention where necessary.
- There will come a point when we can no longer safely, or cost-effectively, reduce critical activity durations in an attempt to bring forward the project end date. Further savings, if needed, must be sought in a consideration of our work methods and by questioning the logical sequencing of activities. Generally, timesavings are to be found by increasing the amount of parallelism in the network and the removal of bottlenecks (subject always, of course, to resource and quality constraints).

Activity on Arrow Networks

- The project scheduling techniques model the project's activities and their relationships as a network. In the network, time flows from left to right.
- The two best known being **CPM (Critical Path Method) and PERT (Program Evaluation Review Technique).**

- Both of these techniques used an ***activity-on-arrow*** **approach** to visualizing theproject as a network where activities are drawn as arrows joining circles, or nodes which represent the possible start and/or completion of an activity or set of activities.
- More recently a variation on these techniques, called ***precedence network,*** has become popular. This method uses ***activity-on-node*** **networks** where activities are represented as nodes and the links between nodes represent precedence (or sequencing) requirements.
- This latter approach avoids some of the problems inherent in the activity-on- arrow representation and provides more scope for easily representing certain situations. It is this method that is adopted in the majority of computer applications currently available. These three methods are very similar and it must be admitted that many people use the same name (particularly CPM) indiscriminately to refer to any or all of the methods.
- In the following sections of this chapter, we will look at the critical path methodapplied to activity-on-arrow networks

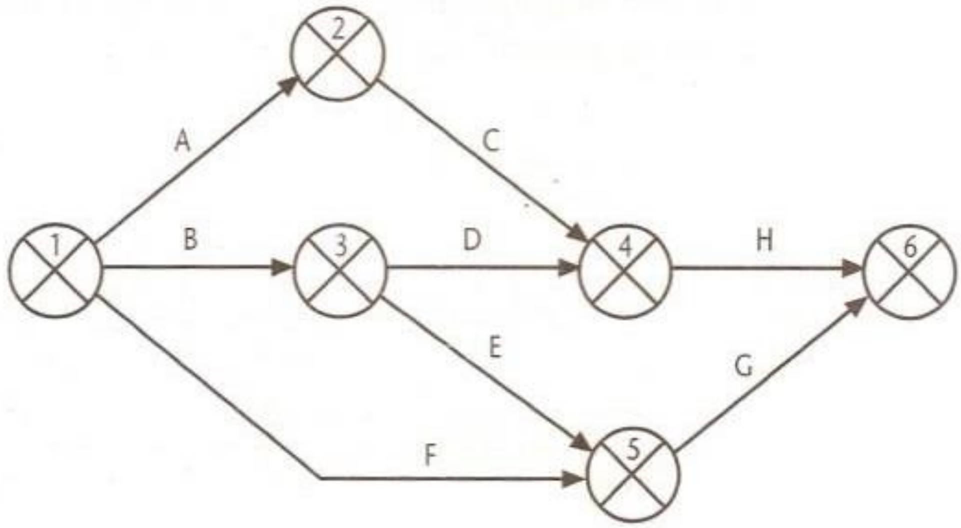


Figure: An activity on-arrow network

Activity-on-arrow network rules and conventions

- A project network may have only one start node
- A project network may have only one end node
- A link has duration
- Nodes have no duration
- Time moves from left to right
- Nodes are numbered sequentially

- A network may not contain loops

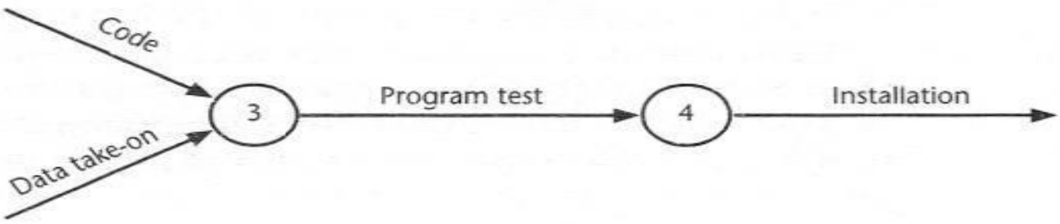


Figure: Fragment of CPM network

A network may not contain loops Figure demonstrates a loop in a network. Aloop is an error in that it represents a situation that cannot occur in practice. While loops, in the sense of iteration, may occur in practice, they cannot be directly represented in a project network.

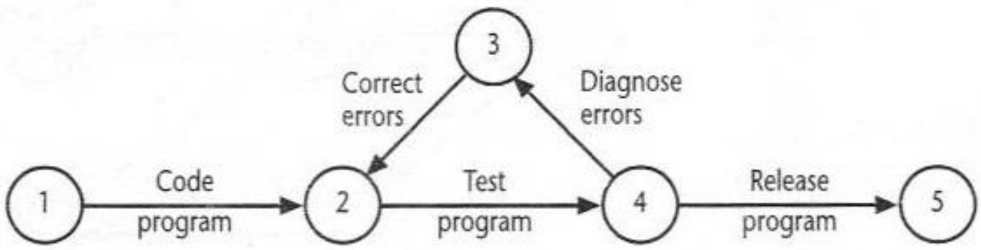


Figure: A loop represents an impossible sequence

A network should not contain dangles. A dangling activity such as 'Write user manual' in Figure should not exist as it is likely to lead to errors in subsequentanalysis.

- Redraw the network with a final completion activity — which, at least in thiscase, is probably a more accurate

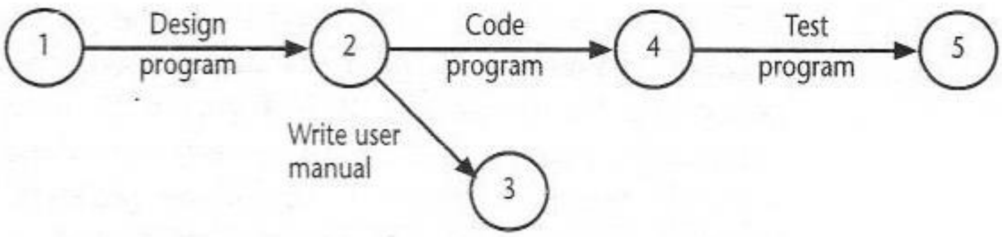


Figure: A dangle

Using dummy activities

When two paths within a network have a common event although they are, in other respects, independent, a logical error such as that illustrated in Figure might occur. Suppose that, in a particular project, it is necessary to specify a certain piece of hardware before placing an order for it and before coding the software. Before coding the software it is also necessary to specify the appropriate data structures, although clearly we do not need to wait for this to be done before the hardware is ordered.

Figure is an attempt to model the situation described above, although it is incorrect in that it requires both hardware specification and data structure design to be completed before eitheran order may be placed or software coding may commence.

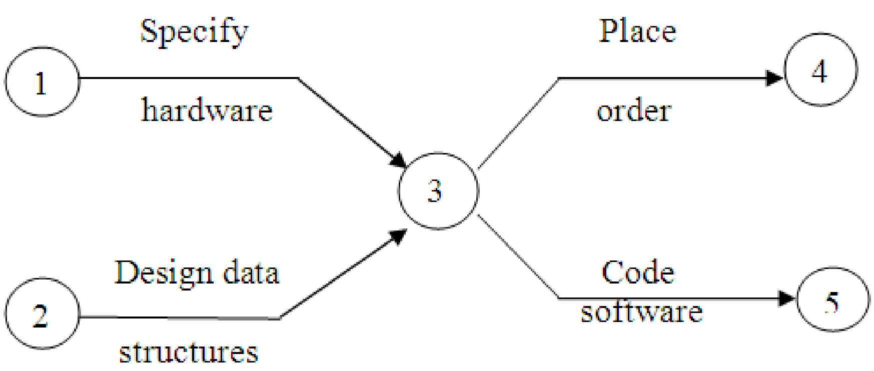


Figure: Two paths with a common node

We can resolve this problem by separating the two (more or less) independent paths and introducing a dummy activity to link the completion of 'specify hardware' to the start of the activity 'code software'. This effectively breaks the link between data structure design and placing the order and is shown in Figure.

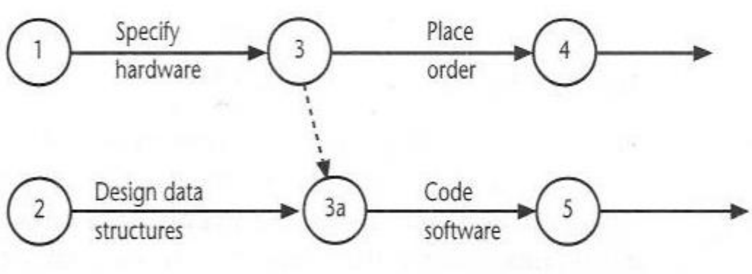


Figure: Two paths linked by a dummy activity

Dummy activities, shown as dotted lines on the network diagram, have a zero duration and use no resources. They are often used to aid in the layout of network drawing as in Figure. The use of a dummy activities where two activities share the same start and end nodes makes it easier to distinguish the activity end-points.

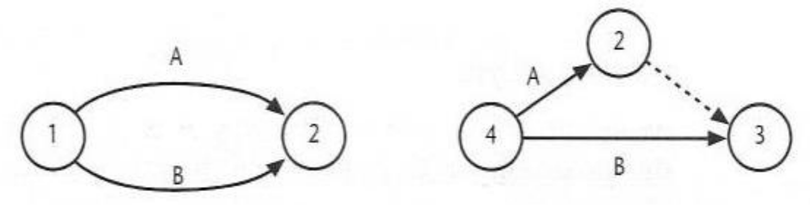


Figure: Another use of a dummy activity

Activity labeling

There are a number of differing conventions that have been adopted for entering information on an activity-on-arrow network. Typically the diagram is used to record information about the events rather than the activities – activity-based information is generally held on a separate activity table.