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PROJET MANAGEMENT (PERT/CPM)

Net work analysis: It is refers to a number of techniques for the planning and control of complex projects. The basis of network planning is the representation of sequential relationships between activities by means of a network of lines and circles. The idea is to link the various activities in such a way that the overall time spent on the project is kept to a minimum.

Features of Network Analysis:

Logical base of planning: Network analysis is highly applicable at several stages of project management right from early planning stage of selecting right option from various alternative to scheduling stage and operational stage.

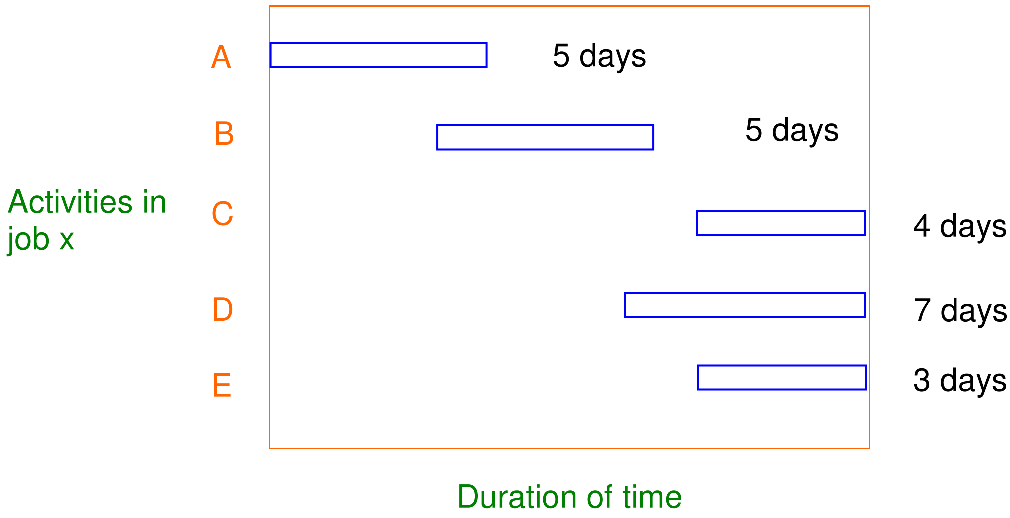
Simple in nature: Net work analysis is straightforward in concept and can be easily explained to any laymen. Data calculations are simple and for large projects computers can be used.

Improves coordination and communication: The graphs generated out of network analysis display simply and direct way the complex nature of various sub-divisions of project may, quickly perceive from the graph

Wider application: The network analysis is applied to many types of projects. Moreover, they may be applied at several levels within a given project from a single department working on a sub-system to multi-plant operations within corporation.

Gantt's bar chart: Before PERT and CPM were developed, Gantt charts and mile stone charts were used tools to monitor the project progress in complex projects. Gantt chart is a bar chart, which was developed by Henary Gantt around 1900.

It is consists of two coordinate axes, one represents the time and the other jobs or activities performed.

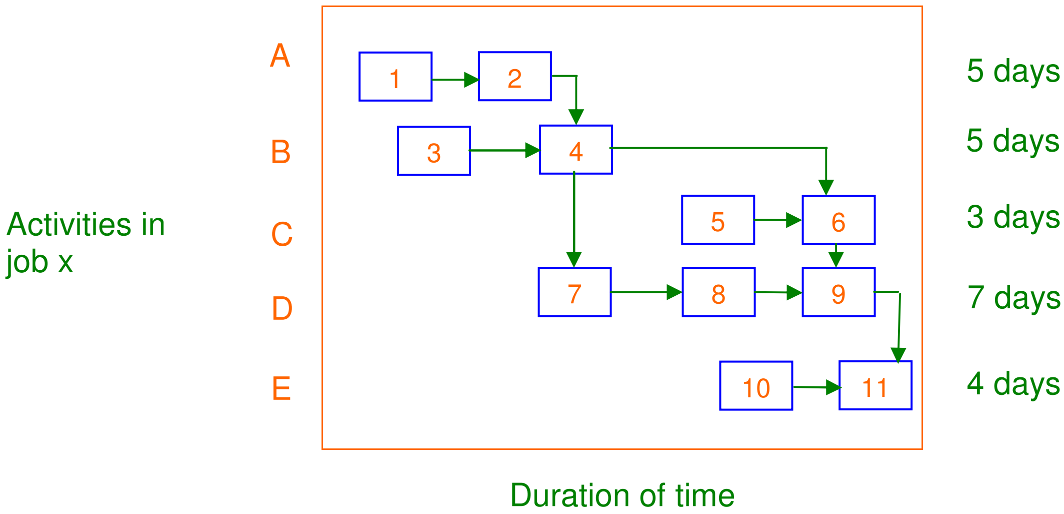


The above figure shows job x which contains five activities ABCDE the different time durations activity A is an independent activity followed by activities B, activity B is followed by activity C, activities D, E have no such sequence. Activities C,D and E reach completion together. However the total number o day taken for completing the job is 14 days.

Limitation of Gantt Chart:

1. This Gantt bar charts not useful for big projects, consisting of large number of complex activities
2. It does not show the relationship between various operations. It is very difficult to find the sequence of various operations on the Gantt chart or the most probable date of completion.
3. Does to indicate the progress of work
4. It cannot reflect uncertainty or tolerance in the duration time estimated for various activities
5. It simply a scheduling technique, but not effective planning tool.

Milestone chart: Milestone chart is an improvement over Gantt chart. It has becomes a good line between Gantt chart and PERT and CPM network. Every task represented by a bar in Gantt's bar chart, is subdivided in terms event or point in time.



In the Gantt's bar charts bar representing an activity is divided into certain milestones. They are identified with a major event, and consecutively numbered such a breakdown enhances the awareness about the inter dependencies among all milestones.

Network analysis undergone several changes and many variants exist, which evaluate the randomness due to imperfection in all human and physical systems. PERT and CPM continue to be very popular, in handling the basic factors like time, cost, resources, probabilities and combinations of all these factors.

PERT AND CPM:

PERT: Programme evaluation and review technique (PERT) is a tool to evaluate a given programme and review the progress made in it from time to time. A programme is also called a project. A project is defined as a set of activities with a specific goal occupying a specific period. It may be a small or big project, such as construction of a college building, roads, marriage, picnics etc.

It is concerned with estimating the time for different stages in such a programme or a project and find out what the critical path is, which consumes a maximum resources.

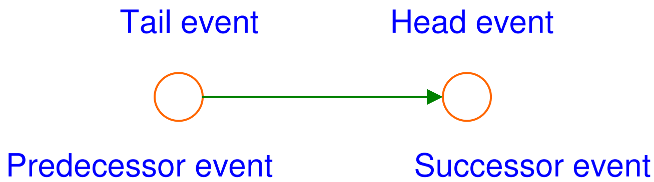
CPM: Critical path method assumes that the time required to complete an activity can be predicted fairly accurately, and thus, the costs involved can be quantified once the critical path has been identified. Since time is an important factor, CPM involves a trade-off between costs and time. It involves determining an optimum duration for the project, that is, a minimum duration that involves the lowest overall costs.

Application of PERT and CPM:

- Construction of projects such as building, highways, houses or bridges
- Preparation of bids and proposals for large projects such as multipurpose projects
- Maintenance and planning of oil refineries, ship repairs and other such as large operations
- Development of new weapon systems and new products and services
- Manufacture and assembly of large items such as aeroplanes or ships repairs and other such as large operations
- Simple projects such as home remodeling house keeping or painting and so on.

PERT Basic Terminology:

Event: A event is specific instant of time which indicates the beginning or end of the activity event is also known as a junction or node. It is represented by a circle and the event number is written with in the circle.



Activity: Every project consists of number of job operations or tasks which are called activity.

Ex: Start machine installation - An event
Machine installation - An activity
Completion of machine - An event

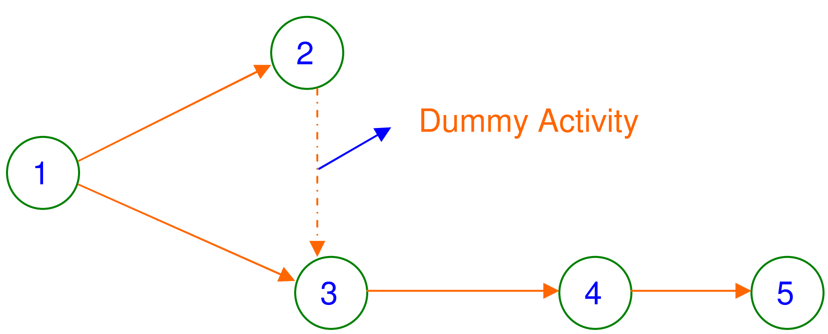
Classification of activities:

1) Critical activity
2) Non-Critical activity
3) Dummy activity

Critical activity: In a network diagram critical activities are those which if consume more than their estimated time, the project will be delayed. It shown with thick arrow.

Non-critical activity: Such activities have a provision of float or slack so that, even if they consume a specified time over and above the estimated time.

Dummy activity: When two activities start at the same instant of time like A and B the head event are jointed by dotted arrows and this is known as dummy activity.



CPM Basic terminology:

Critical Path: Critical path is that path which consumes the maximum amount of time or resources. It is that path which has zero slack value.

Slack: Slack means the time taken to delay a particular event without affecting the project completion time. If a path has zero slack that means it is the critical path.

Slack = LFT – EFT

Earliest Start Time (EST): It is the earliest possible time at which an activity can start, and is calculated by moving from first to last event in the network diagram.

Earliest Finish Time (EFT): It is the earliest possible time at which an activity can finish

EFT = EST + Duration of activity

Latest Start Time (LST): It is the latest possible time by which an activity can start without delaying the date of completion of the project.

LST = LFT – Duration of the activity

Latest Finish Time (LFT): It is the latest time by which the activity must be completed. So that the scheduled date for the completion of the project may not be delayed. It is calculated by moving backwards.

Float: Floats in the network analysis represent the difference between the maximum time available to finish the activity and the time required to complete it.

The basic difference between slack and float times is a slack is used with reference to event, float is use with reference to activity.

Floats are three types:

1) Total float 2) Free float 3) Independent float

1) Total float: It is the additional time which a non critical activity can consume without increasing the project duration. However total float may affect the floats in previous and subsequent activities.

Total float = LST – EST or LFT – EFT

2) Free float: Free float refers to the time by which an activity can expand without affecting succeeding activities.

Free float = EST of Head Event – EST of Trail Event – Activity duration

3) Independent float: This the time by which activity may be delayed or extended without affecting the preceding or succeeding activities in any away.

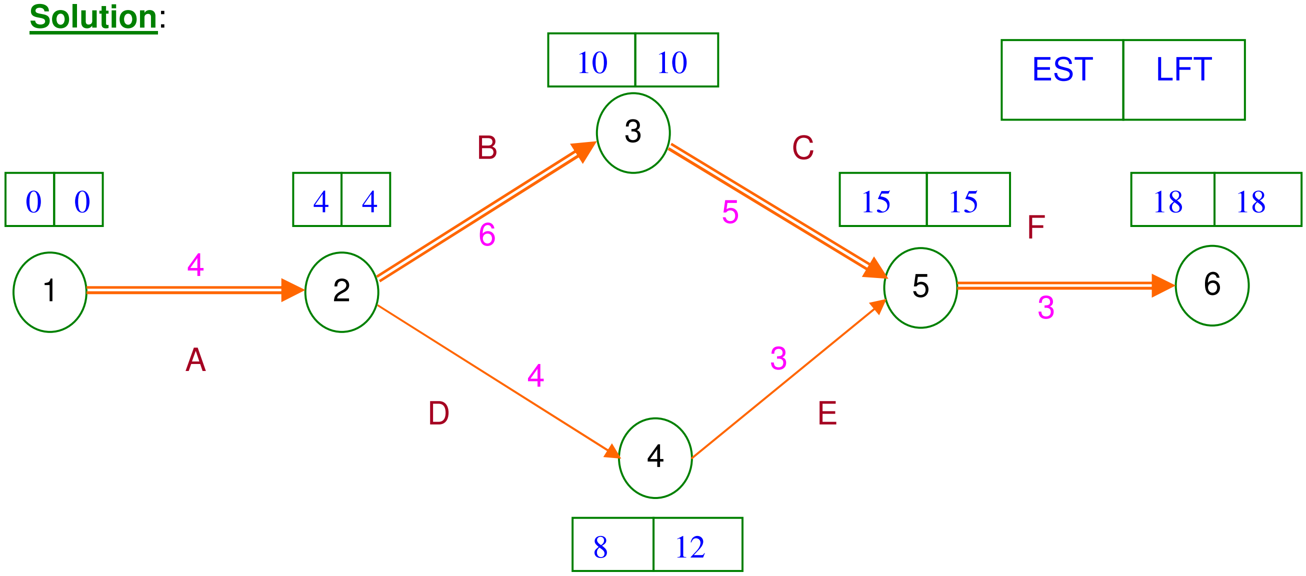
Independent float = EST of Head event – LFT of Trail event – Activity duration

Problems:

1) A small engineering project consists of 6 activities namely ABCDE & F with duration of 4, 6, 5, 4, 3 and 3 days respectively. Draw the network diagram and calculate EST, LST, EFT, LFT and floats. Mark the critical path and find total project duration.

Activity	A	B	C	D	E	F
Preceding activity	-	A	B	A	D	C,E
Duration	4	6	5	4	3	3

Solution:



Critical path = A-B-C-F

Project duration = 18 days

Activity	Duration	EST	LST	EFT	LFT	Total float	Free float	Independent float
A	4	0	0	4	4	0	0	0
B	6	4	4	10	10	0	0	0
C	5	10	10	15	15	0	0	0
D	4	4	8	8	12	4	0	0
E	3	8	12	11	15	4	4	0
F	3	15	15	18	18	0	0	0

Note: LST = LFT – activity duration

LFT = EST + activity duration

Total float = LST – EST or LFT – EFT

Free float = EST of Head Event – EST of Trail Event – Activity duration

Independent float = EST of Head event – LFT of Trail event – Activity duration

2) A small engineering project consists of six activities. The three time estimates in number days for each activity are given below.

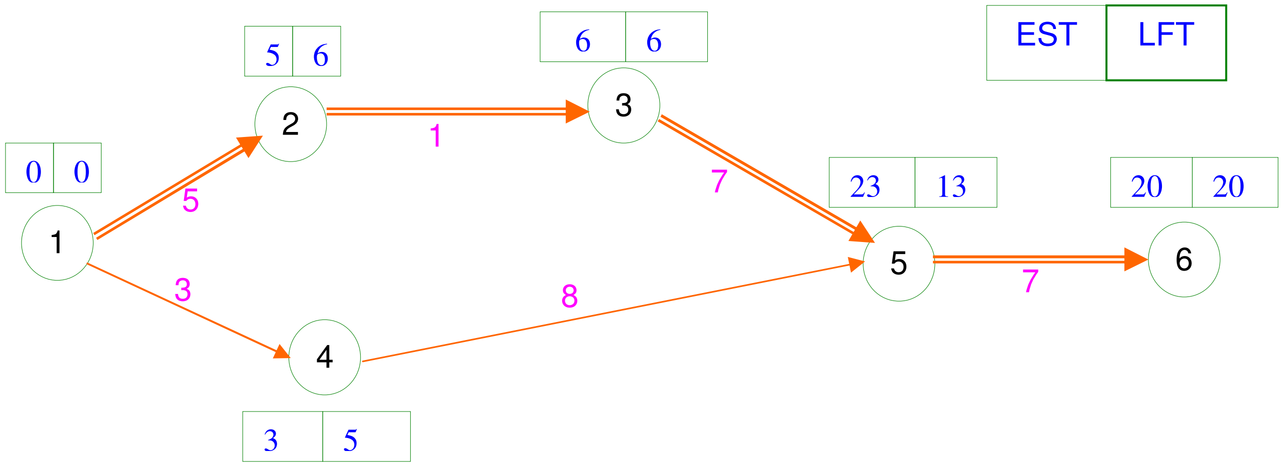
Activity	t_o	t_m	t_p
1-2	2	5	8
2-3	1	1	1
3-5	0	6	18
5-6	7	7	7
1-4	3	3	3
4-5	2	8	14

Find out:

1. Calculate the values of expected time (t_e), S.D (σt) and variance (v_i) of each activity
2. Draw the network diagram and mark t_e on each activity
3. Calculate EST and LFT and mark them on the net work diagram
4. Calculate total slack for each activity
5. Identify the critical path and mark on the net work diagram
6. Probability of completing project in 25 days.

Solution:

Activity	t_o	t_m	t_p	$t_e = \frac{t_o + 4t_m + t_p}{6}$ (Duration)	$S.D\ (\sigma t) = \frac{t_p - t_o}{6}$	$Variance\ (v_i) = (\sigma t)^2$
1-2	2	5	8	5	1	✓ 1
2-3	1	1	1	1	0	✓ 0
3-5	0	6	18	7	3	✓ 9
5-6	7	7	7	7	0	✓ 0
1-4	3	3	3	3	0	0
4-5	2	8	14	8	2	4



Activity	EST	LFT	LST	EFT	Slack
1-2	0	5	0	5	0
2-3	5	6	5	6	0
3-5	6	13	6	13	0
5-6	13	20	13	20	0
1-4	0	5	2	3	2
4-5	3	13	5	11	2

Critical path = 1-2-3-5-6 = 20 days

Probability for completing project in 25 days:

$$Z = \frac{t_s - t_e}{\sigma}$$

Here t_s = 25 days, t_e = 20 days, $\sigma = \sqrt{1+0+9+0} = \sqrt{10}$

$$z = \frac{25-20}{\sqrt{1+0+9+0}} = \frac{5}{\sqrt{10}} = \frac{5}{3.33} = 1.50$$

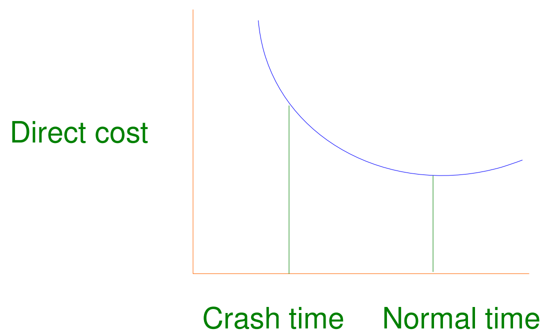
From the table value (z = 1.50) = **93.32%**

Project Management – II

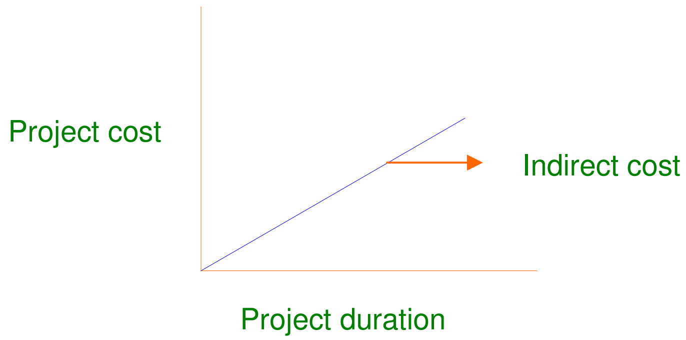
Project crashing: In this chapter, we will discuss the concepts of direct and indirect costs, the relationship between project time and project cost, the concept of cost slope and how the optimum cost and optimum duration are ensured for a given projects while crashing.

Project costs: Costs associated with any project can be classified into two categories a) Direct cost b) Indirect cost

a) Direct cost: These costs are those, which are directly proportional to the number of activities involved in the project Ex: Raw material cost



b) Indirect cost: In direct cost are those costs that are determined per day. Some of examples for indirect costs are supervisory personnel salary, supplies, rent, interest an borrowings, ads, depreciation. These costs are directly proportional to the number of days of the duration of the project. If the project duration is reduced the indirect cost also comes down.



Normal cost (N_c): It is the lowest cost of completing an activity in the minimum time, employing normal means i.e. not using overtime or other special resource.

Normal time (N_T): It is the minimum time required to achieve the normal cost

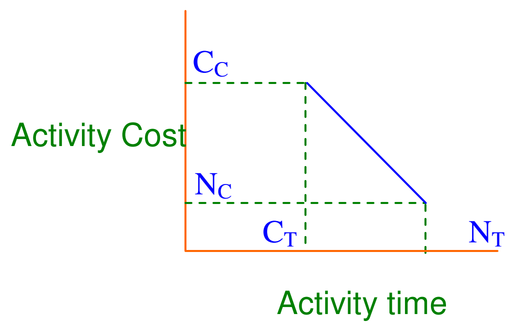
Crash cost (C_C): It is the least cost of completing an activity by employing all possible means like overtime, additional machinery, proper materials etc.

Crash time (C_T): It is the absolute minimum time associated with the crash cost.

Cost Slope: Cost Slope is the amount that has to be spent over and above the normal direct cost for reducing the duration by one unit of time (day, week etc.). Cost slope is defined as the additional cost for reducing one unit of time, assuming a given rate of increase in direct cost with a decrease in one unit of time.

$$Cost\ slope = \frac{Crash\ cost - Normal\ cost}{Normal\ time - Crash\ time}$$

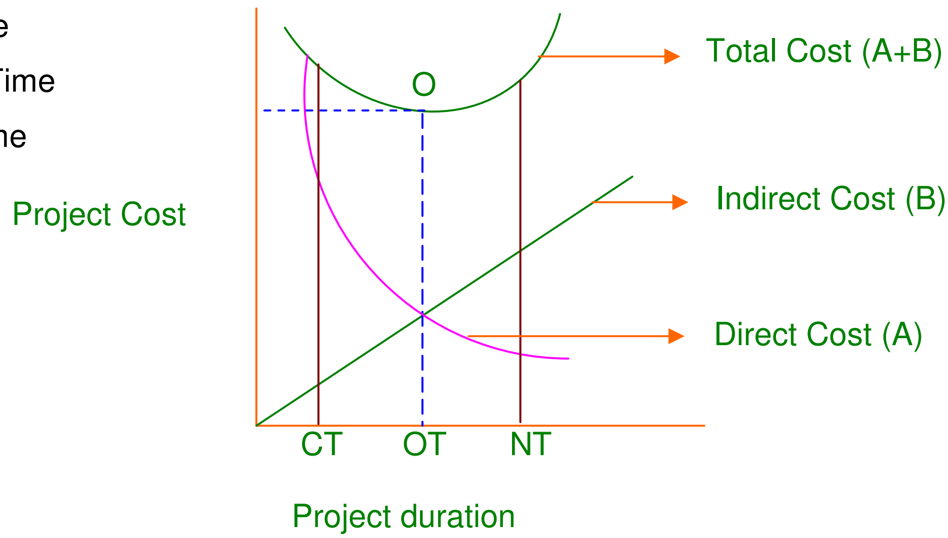
$$S = \frac{C_C - N_C}{N_T - C_T}$$



Crashing of Network: After identifying the critical path, it is necessary to identify the priority to crash the activities by calculating the cost slope.

For reducing the duration extra expenditure to be incurred, but to save resources, organizations keep this extra expenditure at a minimum.

CT = Crash Time
OT = Optimum Time
NT = Normal Time



When the direct cost (A) decrease with an increase in time, as the project duration increase, the indirect cost (B) like overheads, depreciation, insurance etc. increases. The total cost (A+B) curve is a flat U-shaped curve, with implies that only up to a particular point (O) the crashing is economical, not beyond. The time duration, which involves the least total cost, is the optimum duration at optimum cost. Crashing the duration of a project may not be possible beyond a particular point.

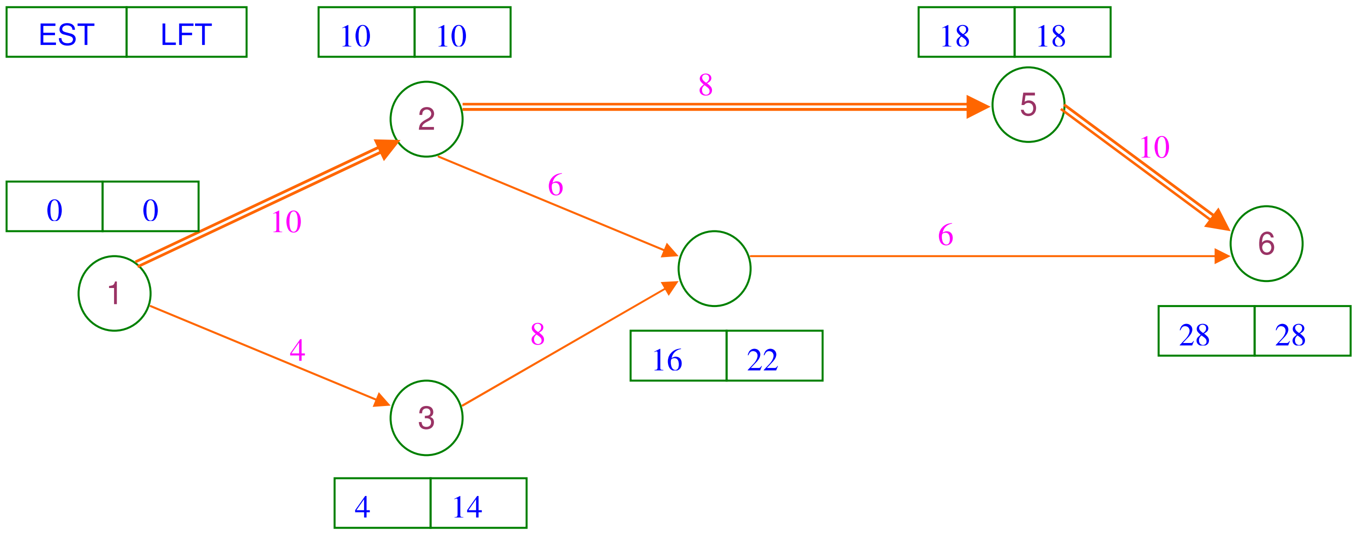
Problems:

1) Given the following data, work out the minimum duration of the project and corresponding cost

Activity	Job	Normal time	Crashing time	Normal cost	Crashing cost
A	1-2	10	6	400	600
B	1-3	4	2	100	140
C	2-4	6	4	360	440
D	3-4	8	4	600	900
E	2-5	8	6	840	1100
F	4-6	6	2	200	300
G	5-6	10	8	1200	1400

Solution:

Activity	Job	Normal time (N_T)	Crashing time (C_T)	Normal cost (N_C)	Crashing cost (C_C)	Cost Slope $= \frac{C_C - N_C}{N_T - C_T}$	Priorities
A	1-2	10	6	400	600	50	1
B	1-3	4	2	100	140	20	
C	2-4	6	4	360	440	40	
D	3-4	8	4	600	900	75	
E	2-5	8	6	840	1100	130	2
F	4-6	6	2	200	300	50	
G	5-6	10	8	1200	1400	100	3

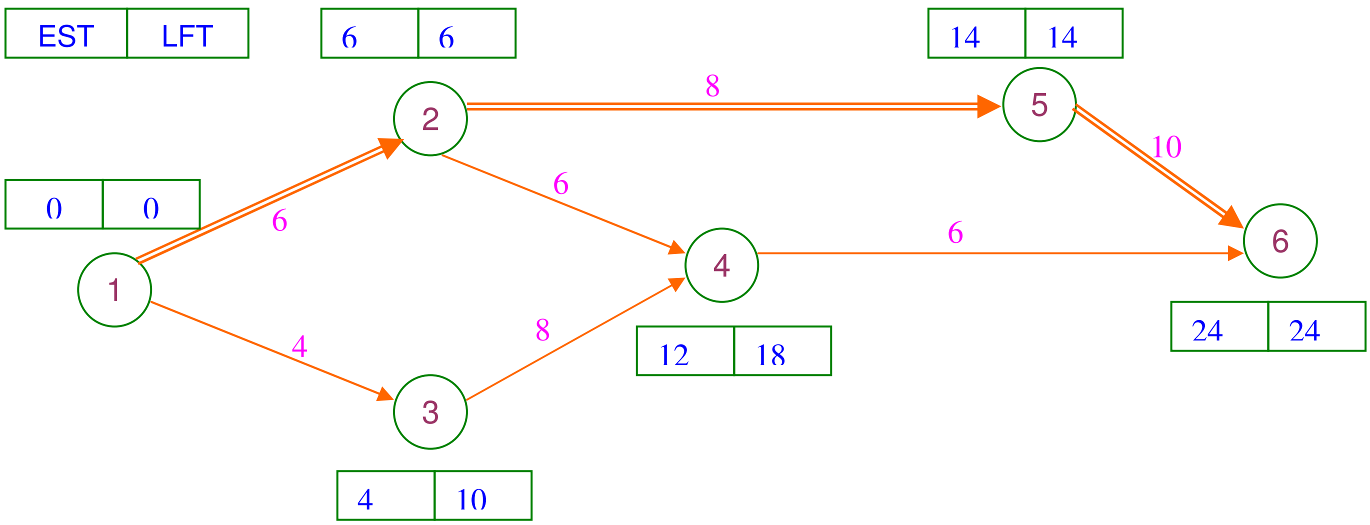


Critical path is 1-2-5-6 and Duration is 28 days

Total cost is = Direct cost + Indirect cost

= (10+4+6+8+8+6+10) + 0 = 52/-

1-2 activity crashing by 4 days:

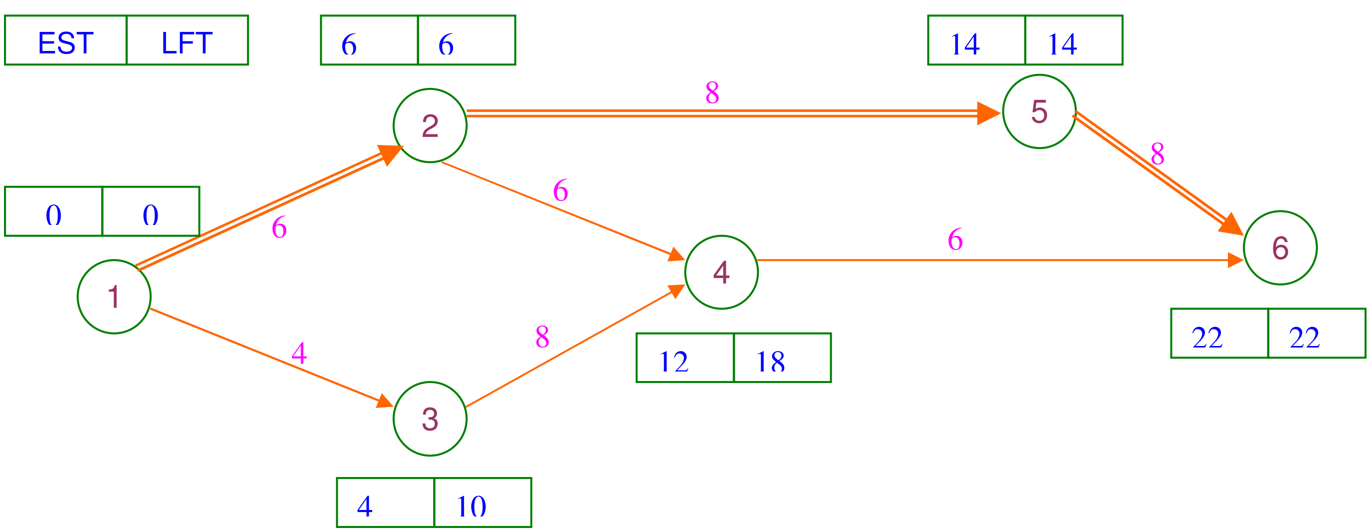


Critical path is 1-2-5-6 and Duration is 24 days

Total cost is = Direct cost + Indirect cost

=(52 + (4 x 50) + 0) = 252/-

5-6 activity crashing by 2 days:

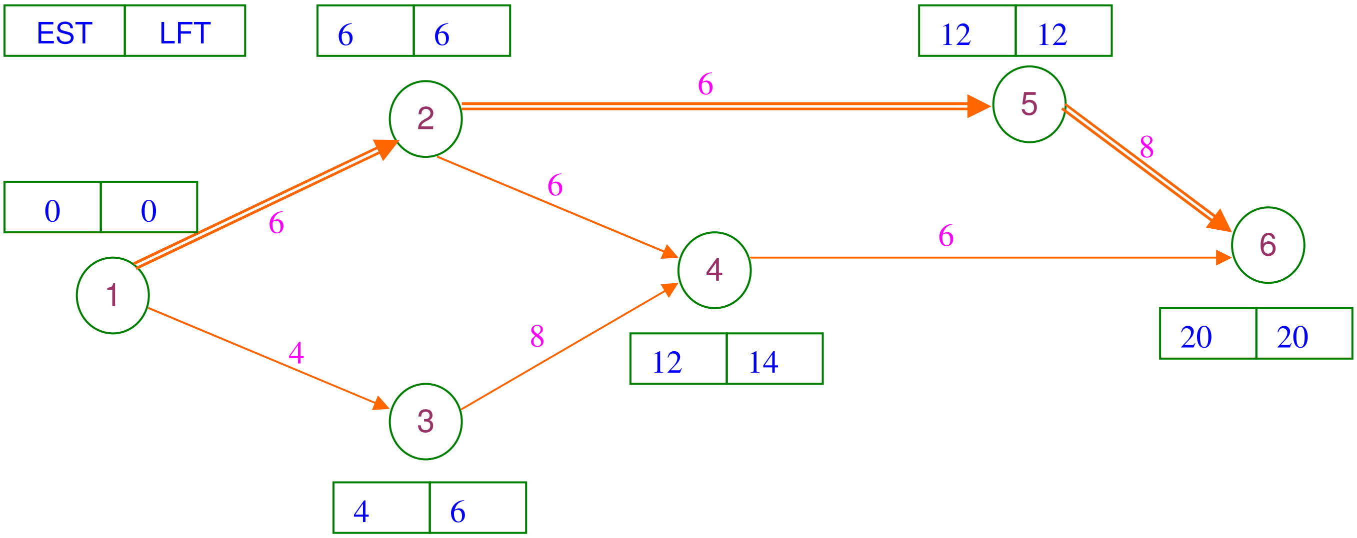


Critical path is 1-2-5-6 and Duration is 22 days

Total cost is = Direct cost + Indirect cost

=(252 + (2 x 100) + 0) = 452/-

2-5 activity crashing by 2 days:



Critical path is 1-2-5-6 and Project Duration is 20 days

Total cost is = Direct cost + Indirect cost

=(452 + (2 x 130) + 0) = 712/-

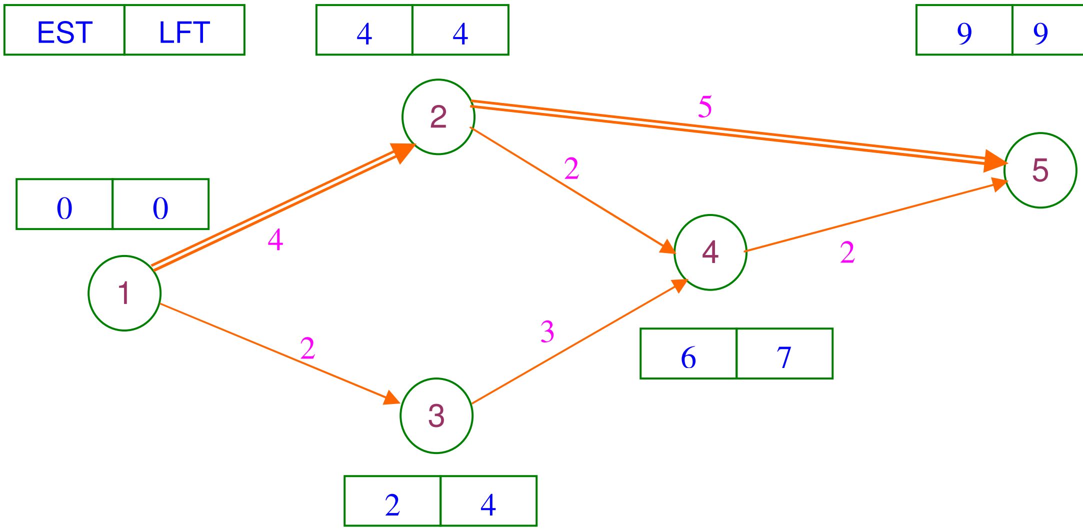
Optimum cost = 712/-
Optimum Duration = 20 days

2) The following table gives the information relating to a project. By using the given data calculate the optimum duration of the project. Where indirect cost is estimated Rs.2,000 per day.

Activity	Normal		Crash	
	Time(days)	Cost(Rs.)	Time(days)	Cost(Rs.)
1-2	4	1000	3	2000
1-3	2	1500	1	3500
2-4	2	500	1	900
2-5	5	1000	3	4000
3-4	3	1000	1	2000
4-5	2	800	1	1000

Solution:

Activity	Normal		Crash		$Cost\ Slope = \frac{C_C - N_C}{N_T - C_T}$	Priorities
	Time (days)	Cost (Rs.)	Time (days)	Cost (Rs.)		
1-2	4	1000	3	2000	1000	1
1-3	2	1500	1	3500	1000	
2-4	2	500	1	900	400	
2-5	5	1000	3	4000	1500	2
3-4	3	1000	1	2000	500	
4-5	2	800	1	1000	200	
Total direct cost		5800				



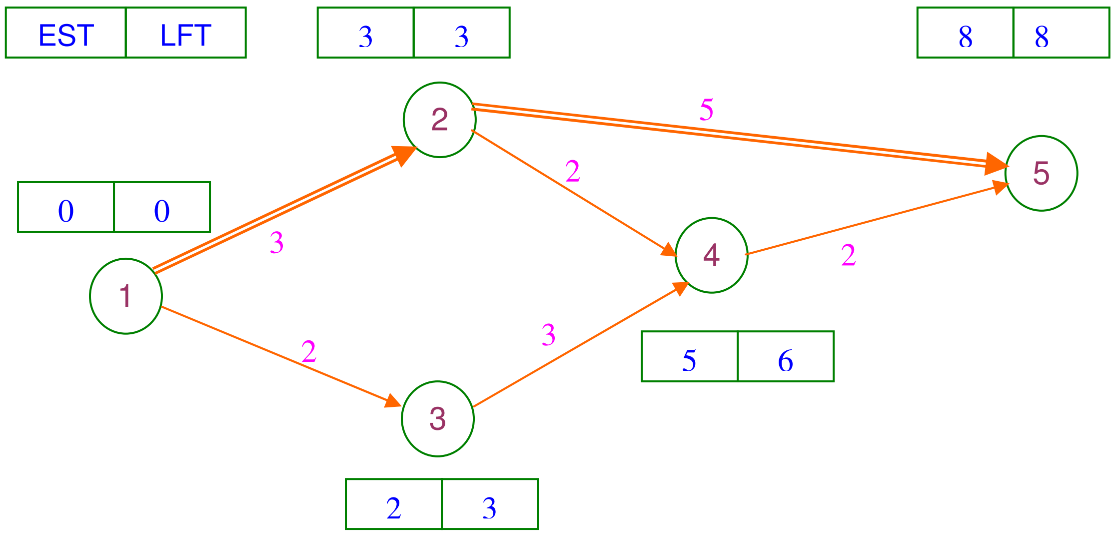
Critical path is 1-2-5 and Project Duration is 9 days

Total cost is = Direct cost + Indirect cost

= 5800+(2000x9)

=23,800/-

1-2 crashing by 1 day:



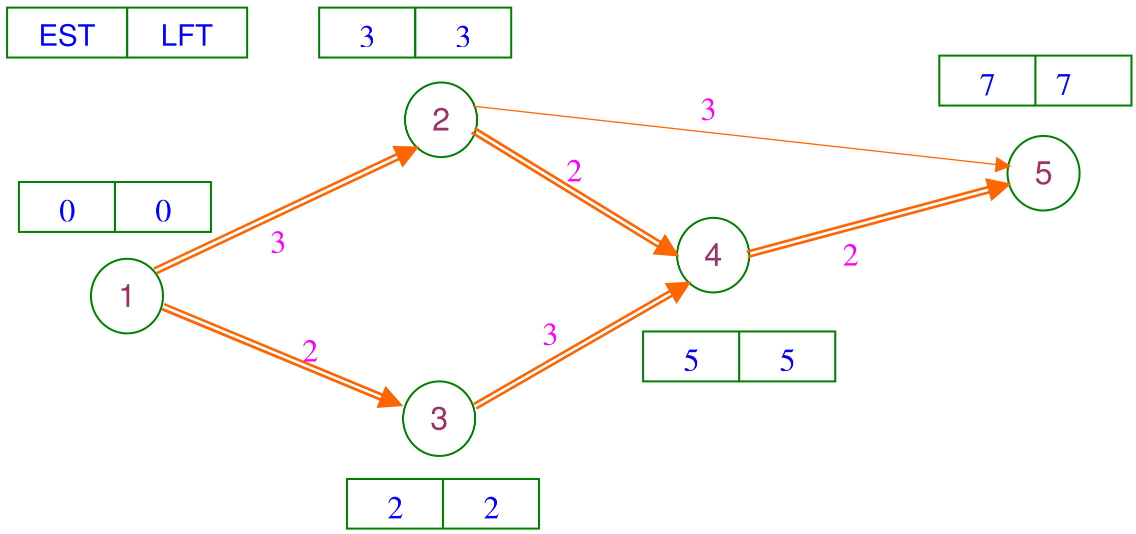
Critical path is 1-2-5 and Project Duration is 8 days

Total cost is = Direct cost + Indirect cost

= (5800+(1x1000))+(2000x8)

=22,800/-

2-5(a) crashing by 2 days:



Critical paths are 1-2-4-5 and 1-3-4-5 and duration is 7 days only.

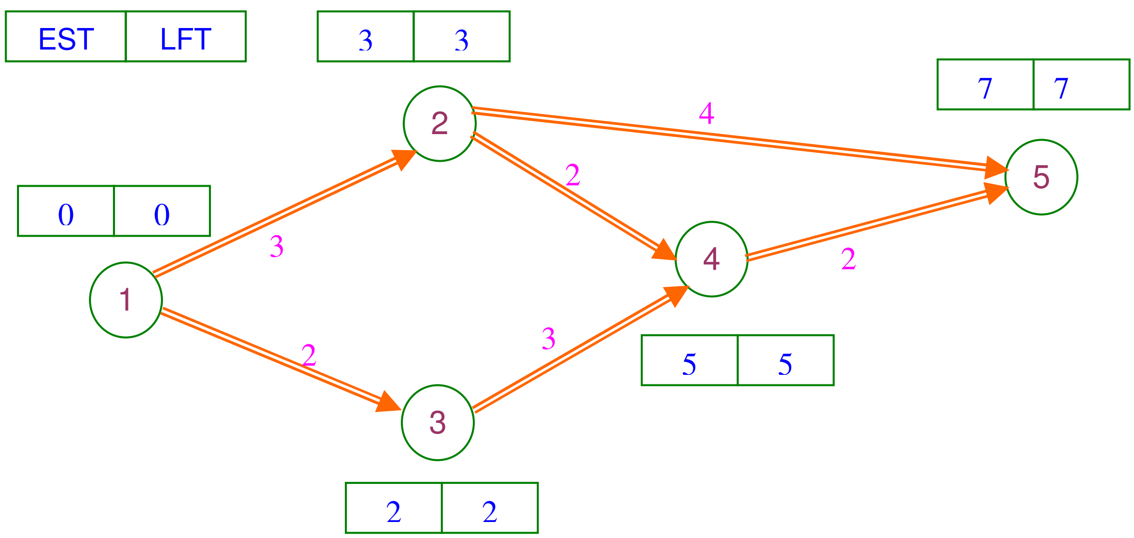
Total cost = Direct cost + Indirect cost

= (6800+(2x1500))+(2000x7)

= 23,800/-

Here project crashed by 2 days and total cost incurred by the firm is 23,800/- but duration is reduced by only one day. So it is suggested to crash the network by only one day, It can help to reduce the cost. So that 2-5 activity crashing by only 1 day.

2-5(b) activity crashing by 1 day only



Duration is 7 days

Total cost = Direct cost + Indirect cost

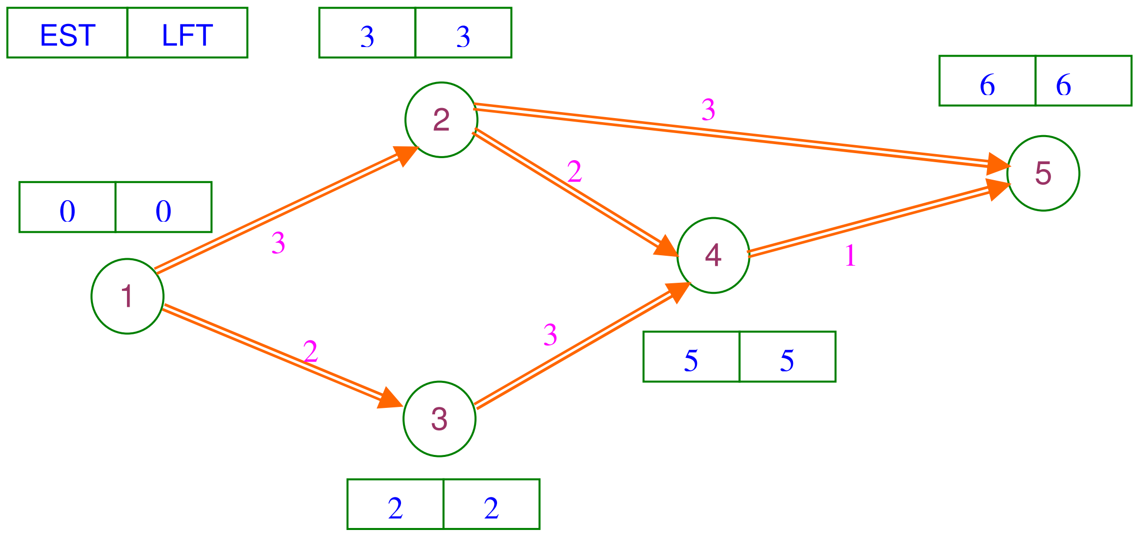
= (6800+(1x1500))+(2000x7)

= 8300 + 14000

= 22,300/-

All activities comes under the critical activities, the priority are changed according to the cost slope 4-5 activity having minimum cost slope. So that it is possible to crash out 4-5 activity by one day only and 2-5 by one day simultaneously

4-5 activity crashing by 1 day and 2-5 crashing by 1 day only:



Duration is 6 days

Total cost = Direct cost + Indirect cost

= (8,300+(1x1500)+(1x200))+(2000x6)

= (8300 + 1700) + (12000)

= 22,000/-

This network diagram not possible to crashing further, So that the project duration is 6 days and optimum cost is Rs.22,000/-

Optimum cost = 22,000/-

Optimum Duration = 6 days