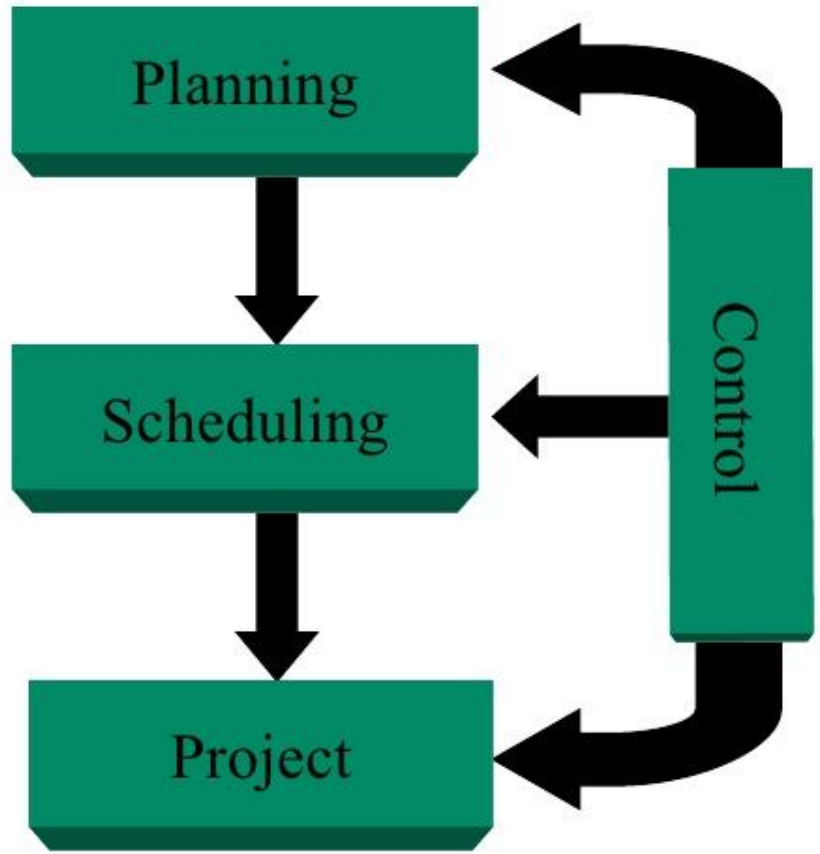
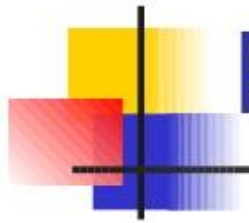
PROJECT MANAGEMENT TOOLS

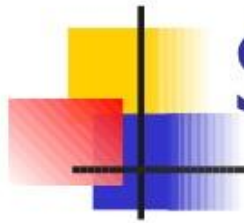
Project Management Activities and Decisions





Planning

- Identify the project customer
- Establish the end product or service
- Set project objectives
- Estimate total resources and time required
- Decide on the form of project organization
- Make key personnel appointments
- Define major tasks required
- Establish a budget



Scheduling

- Develop a detailed work breakdown structure
- Estimate time required for each task
- Sequence the task in the proper order
- Develop a start/stop time for each task
- Develop a detailed budget for each task
- Assign people to tasks

Control

- Monitor actual time, cost, and performance
- Compare planned to actual figures
- Determine whether corrective action is needed
- Evaluate alternative corrective actions
- Take appropriate corrective action

Scheduling Methods

- Two main types of scheduling methods are in use. They are generally classified as
- 1. Gantt charts
- 2. Network Methods
    a. CPM
    b. PERT

Project Management Tools

- Bar Chart
- Net work Models

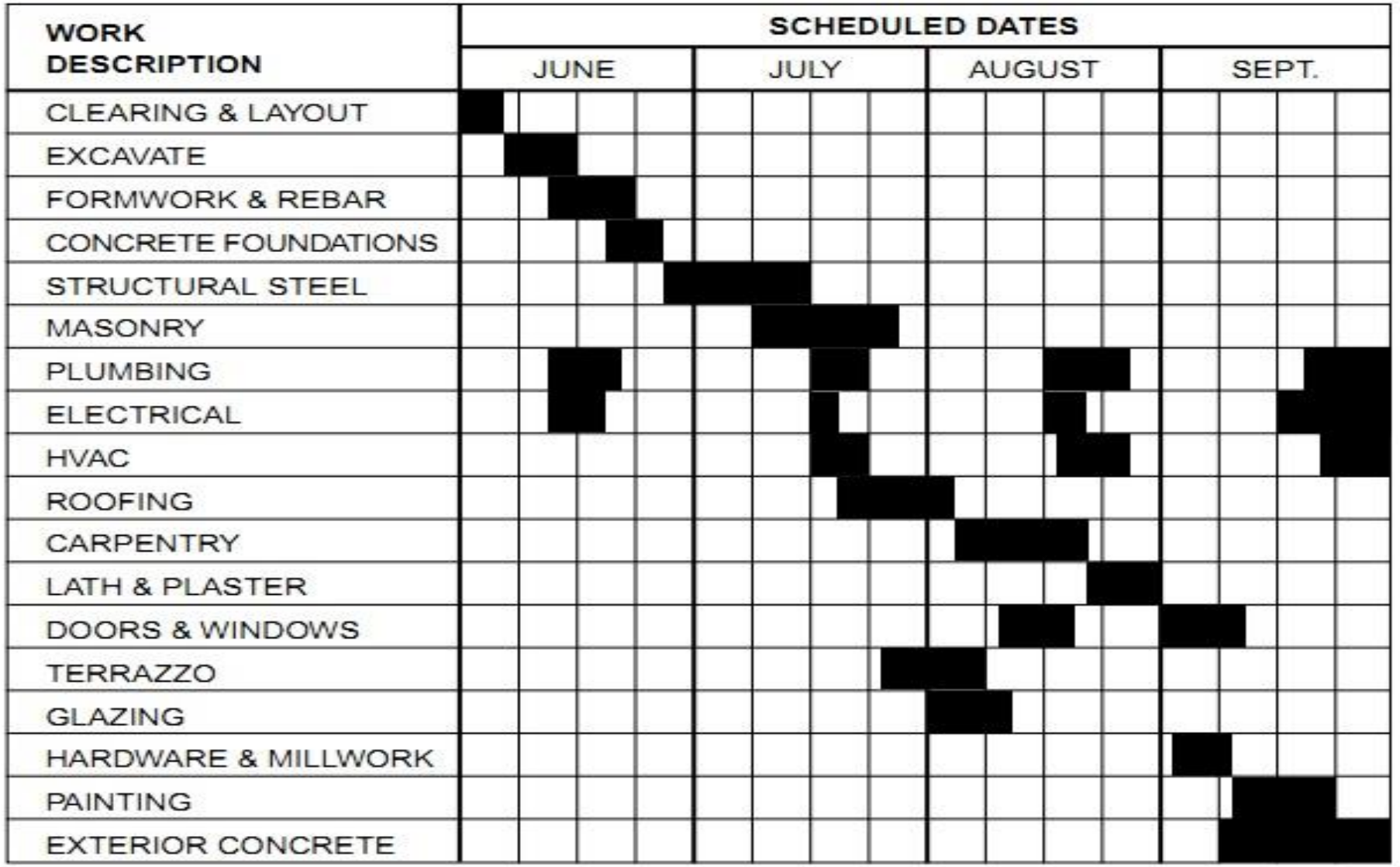
1) CPM (Critical Path Method)
2) PERT (Programme Evaluation and Review Technique)

- ERP (Enterprise Resource Planning) Soft ware – Eg.Primavera, MS-Project

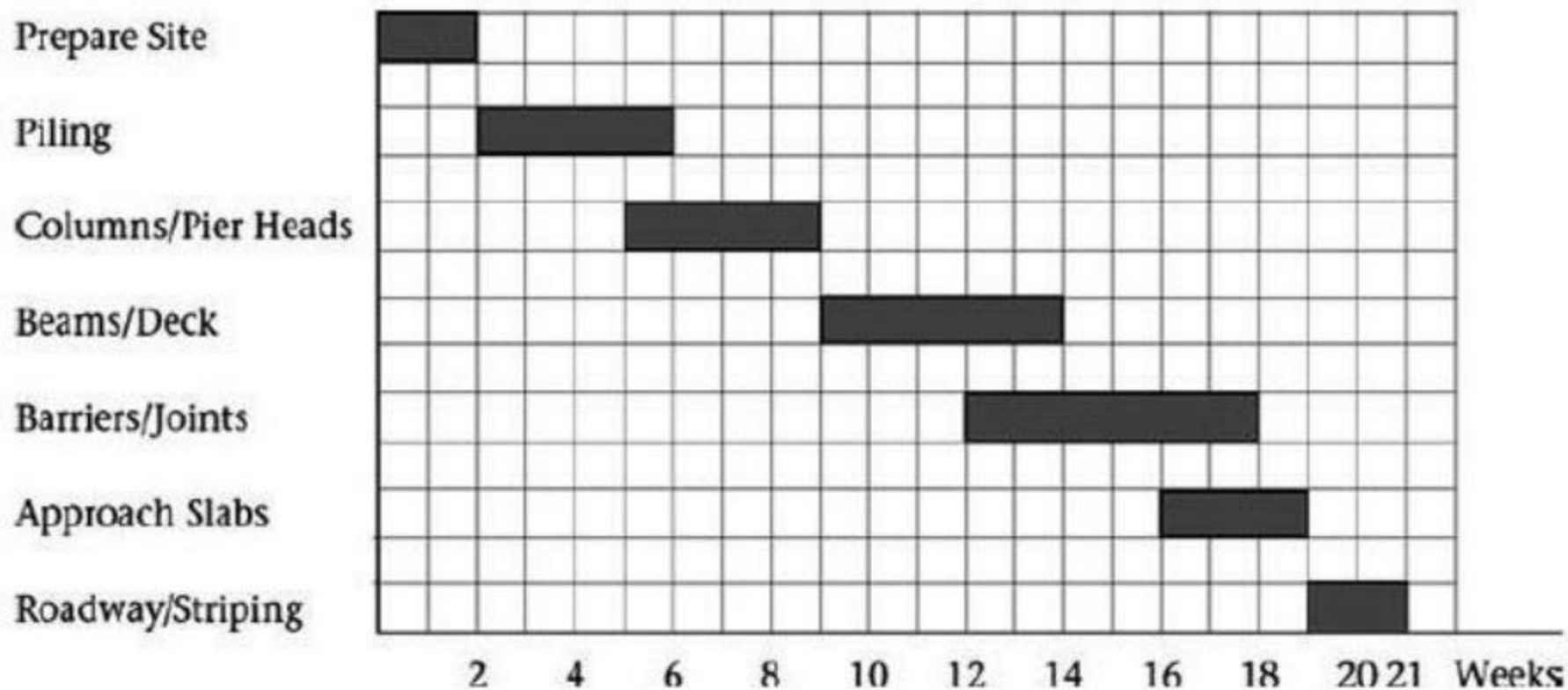
Bar Chart

- Designed by Mr. Henry L Gantt (1910)
- The time duration of an activity is represented by horizontal line
- The length of the time is proportional to the time duration of the activity.
- Since several activities are represented on the same chart a rectangular frame work is chosen
- The activities are listed from top to bottom on the extreme left hand side of the frame work. An activity duration flows from left to right.

Bar Chart


WORK DESCRIPTION
SCHEDULED DATES
JUNE
JULY
AUGUST
SEPT.
CLEARING & LAYOUT
EXCAVATE
FORMWORK & REBAR
CONCRETE FOUNDATIONS
STRUCTURAL STEEL
MASONRY
PLUMBING
ELECTRICAL
HVAC
ROOFING
CARPENTRY
LATH & PLASTER
DOORS & WINDOWS
TERRAZZO
GLAZING
HARDWARE & MILLWORK
PAINTING
EXTERIOR CONCRETE

Activity ID	Activity Name	TIMESCALE (WEEKS)																				
		1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21
WBS 1 : GROUND WORKS																						
1	Excavation																					
2	Backfill and Compaction																					
WBS 2 : STRUCTURAL WORKS																						
3	Reinforced Concrete Works																					
4	Steel Works																					
WBS 3 : FINISHING WORKS																						
5	Brick Laying																					
6	Wall Plastering																					
7	Painting																					
8	Floor Covering																					
WBS 4 : ELECTRICAL WORKS																						
9	Conduit Works																					
10	Cable Pulling																					
WBS 5 : MECHANICAL WORKS																						
11	Plumbing Works																					
12	Fittings																					



Bar chart representing the summary activities for constructing a bridge

Bar Chart

Advantages

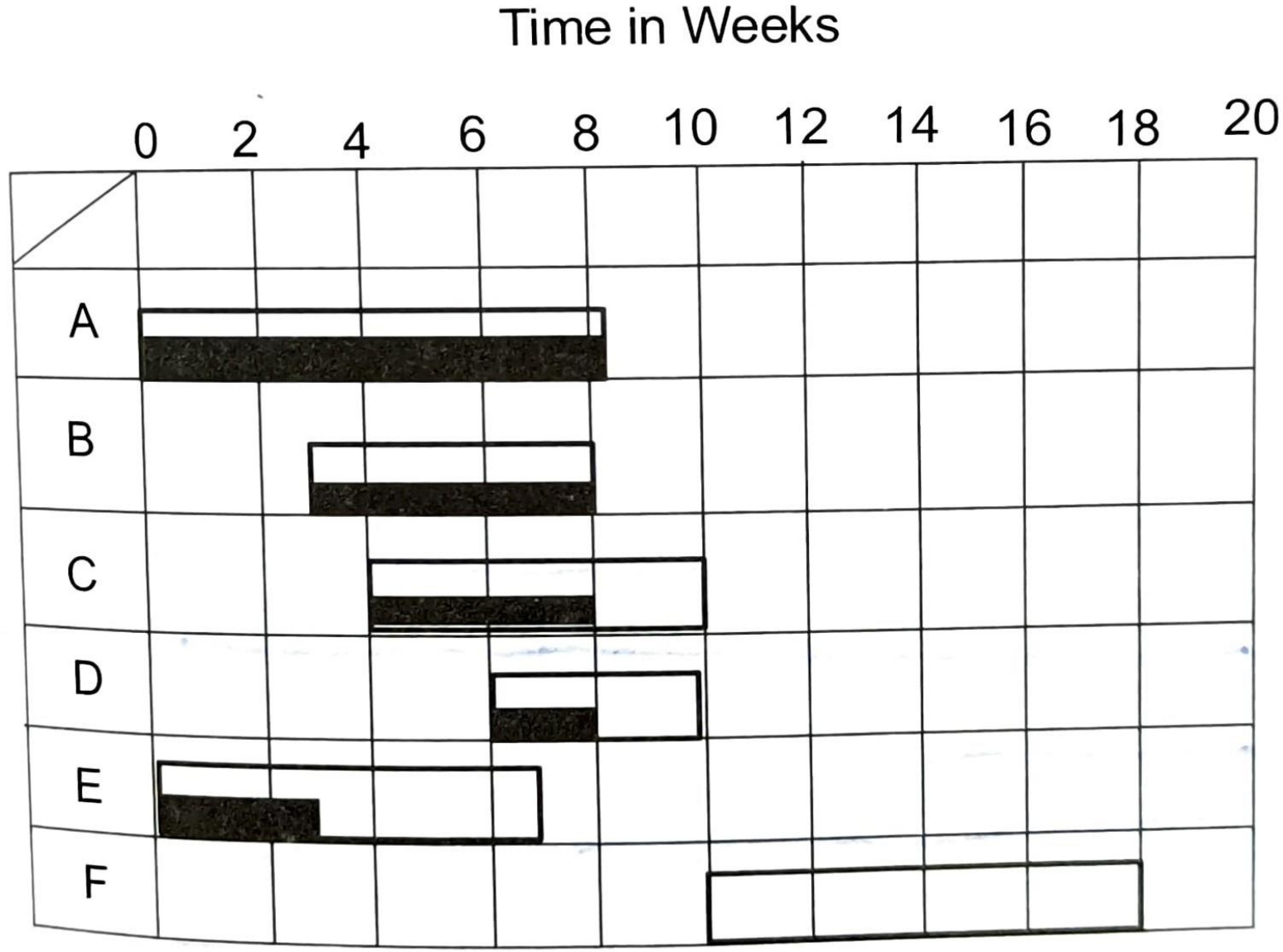
- Easy to construct
- Simple to understand
- Gives an overall view
- Shows ES & EF
- Suitable for lesser activities
- Progress chart can be overlaid
- Easy to make presentations

Limitations

- Not suitable for large no. of activities
- Inter relationship not known
- Re-scheduling difficult
- Float not known
- Not suitable for multidisciplinary activities
- Impact of delay not known
- LS and LF not known
- Quantum of work not known
- Large display area required
- Critical activities not known
- Difficult for delay and deviations
- No optimization

MODIFIED GANTT CHART

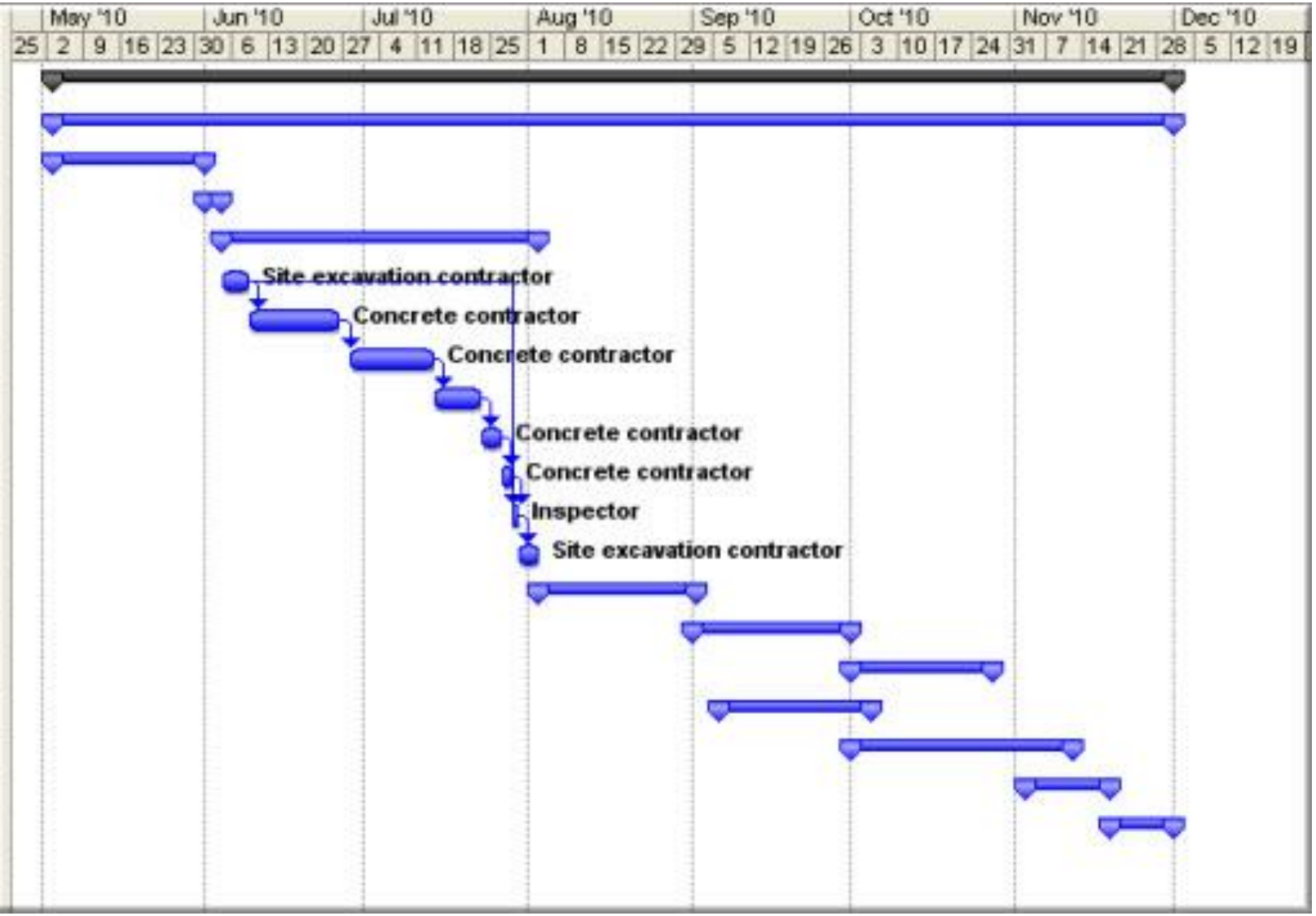
- In Gantt Bar Chart actual quantities of work done at certain stage is not shown
- Mostly some changes are unavoidable in some works. But Gantt Bar Chart cannot give any assistance under such circumstances.
- The UpToDate position pf various works completed can be shown by modifying the Gant Bar Chart.
- Modified Gant Chart provides control of work progress which in turn makes the engineer to take necessary steps to speed up the work

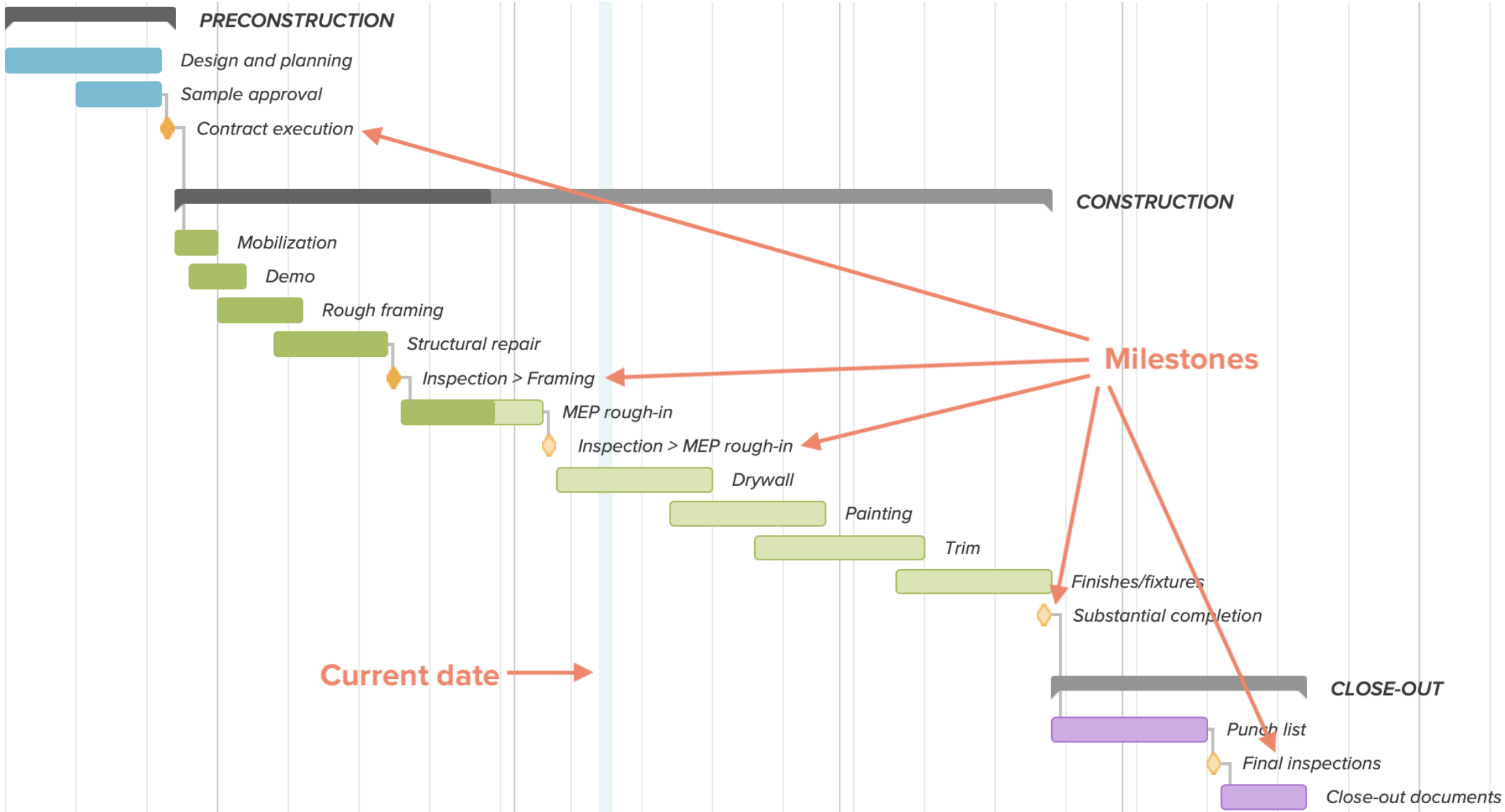

Time in Weeks
0
2
4
6
8
10
12
14
16
18
20
A
B
C
D
E
F

MILE STONE CHART

- Improvement over the bar chart
- Partially shows relationship between activities
- A milestone is used to represent groups of activities, significant events or commitments in a project.
- A milestone chart shows a group of milestones in an organized way similar to a Gantt chart, with one milestone per line vertically with a description on the left and the milestone located horizontally along a time scale showing when it occurs.
- Milestone differ from the bars in a Gantt Chart in the fact that they show only a single date and are usually depicted as a triangle instead of a bar

	Task Name	Duration
0	**Residential Construction**	**152 days**
1	**Single Family House - Architect Desigr**	**152 days**
2	**General Conditions**	**21 days**
12	**Site Work**	**3 days**
16	**Foundation**	**42 days**
17	Excavate for foundations	3 days
18	Form basement walls	13 days
19	Place concrete for foundations & b	12 days
20	Cure basement walls for 7 days	7 days
21	Strip basement wall forms	2 days
22	Waterproof/insulate basement wal	2 days
23	Perform foundation inspection	1 day
24	Backfill foundation	2 days
25	**Framing**	**22 days**
36	**Dry In**	**22 days**
44	**Exterior Finishes**	**19 days**
47	**Utility Rough-Ins and Complete Co**	**21 days**
56	**Interior Finishes**	**30 days**
100	**Landscaping and Grounds Work**	**12 days**
105	**Final Acceptance**	**8 days**




PRECONSTRUCTION
Design and planning
Sample approval
Contract execution
CONSTRUCTION
Mobilization
Demo
Rough framing
Structural repair
Inspection > Framing
MEP rough-in
Inspection > MEP rough-in
Drywall
Painting
Trim
Finishes/fixtures
Substantial completion
Milestones
Current date
CLOSE-OUT
Punch list
Final inspections
Close-out documents

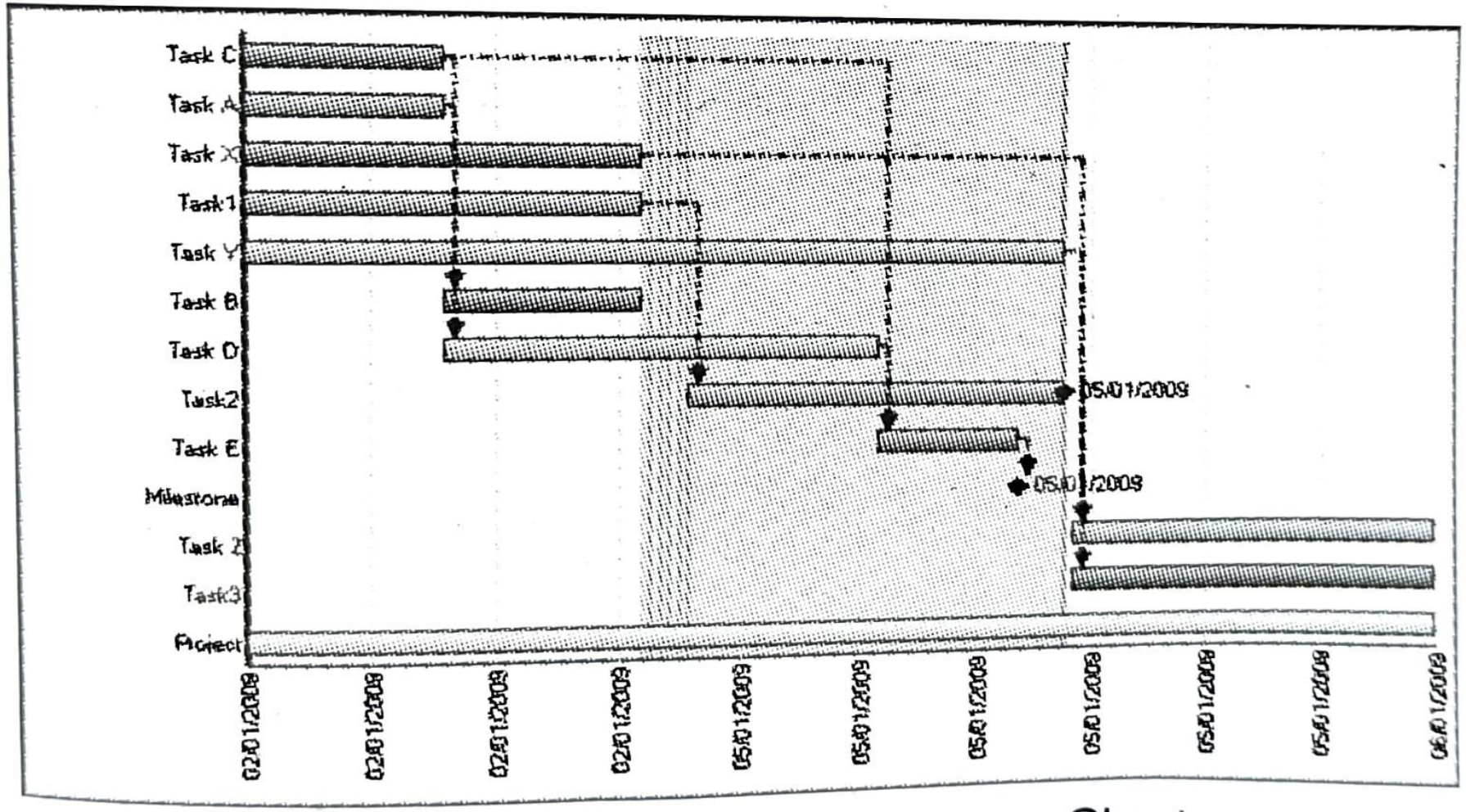


Fig.1.3 Example for a Milestone Chart

What is a network?

A graphical presentation or an arrow diagram

presented to the management

in respect of a project

which consists of all details regarding consumption of **time** and **cost** not only for each activity but also for the whole project

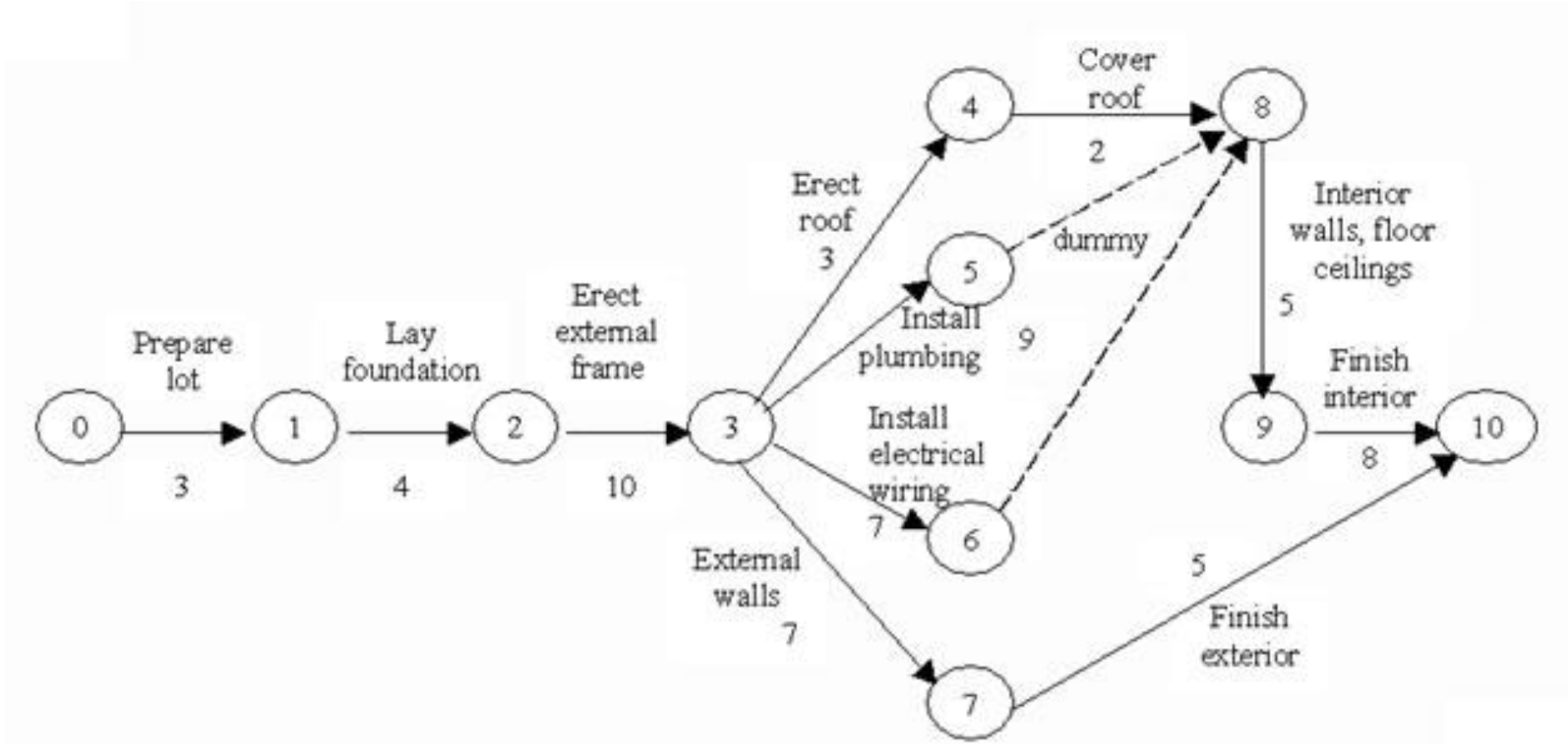
so that management can manipulate the resources and cost can be controlled in a more effective manner.

NETWORK

- A network is a graphical and logistical model or plan which lists the sequence of various operations (with interdependencies) which is required to achieve the final achievement of the project
- For complex projects the method of planning ,scheduling ,controlling the progress of work are done by network techniques.

Steps Involved In Process Of Network Analysis

- Identify the jobs, events or activities.
- Arrange the jobs in logical sequence.


Prepare lot
3
Lay foundation
4
Erect external frame
10
Erect roof
3
Cover roof
2
Install plumbing
9
dummy
Install electrical wiring
7
External walls
7
Interior walls, floor ceilings
5
Finish interior
8
Finish exterior
5
0
1
2
3
4
5
6
7
8
9
10

Objectives of Network Analysis

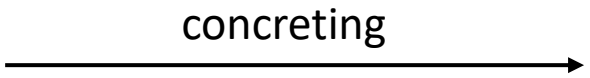
Network Analysis is a successful technique frequently used to plan, monitor and control the projects involving thousands of activities.

1. To minimize project cost.
2. To minimize the project time.
3. To ensure optimum utilization of human and other resources.
4. To ensure minimum conflicts and unnecessary delays.

TERMS USED IN NETWORK

Activity:

- performance of specified task such as concreting, excavation, bending of reinforcement etc.
- It requires time and for its completion and is represented by an arrow
- The length, shape and orientation has no significance



Event:

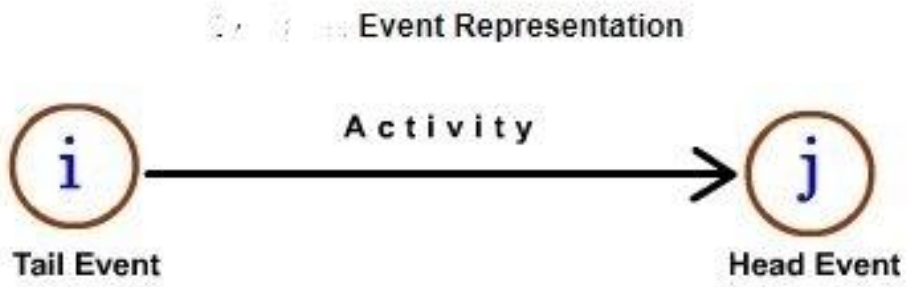
- Also called node
- Represents instant in time when certain activity has been started or completed
- An event describes start or completion of task.
- Represented by a circle

TYPE OF EVENTS

- **Tail event**
- **Head event**
- **Dual role event**
- **Burst and merge event**

TAIL EVENT and HEAD EVENT

- An event which marks the beginning of the activity is called tail event
- An event which marks the completion of the activity is called head event

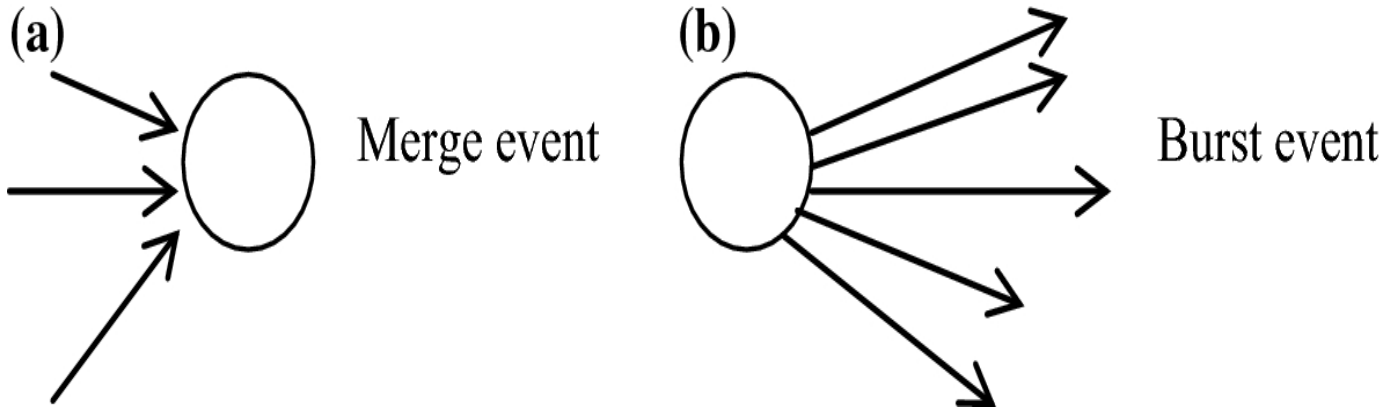


DUAL ROLE EVENT

- If an event acts as the tail event for some activity and as head activity for some other activity it is called dual role event

BURST EVENT AND MERGE EVENT

- The nodes to which a number of activities converge are called merge event
- The nodes from which a number of activities emerge is called burst event



Initial Event:

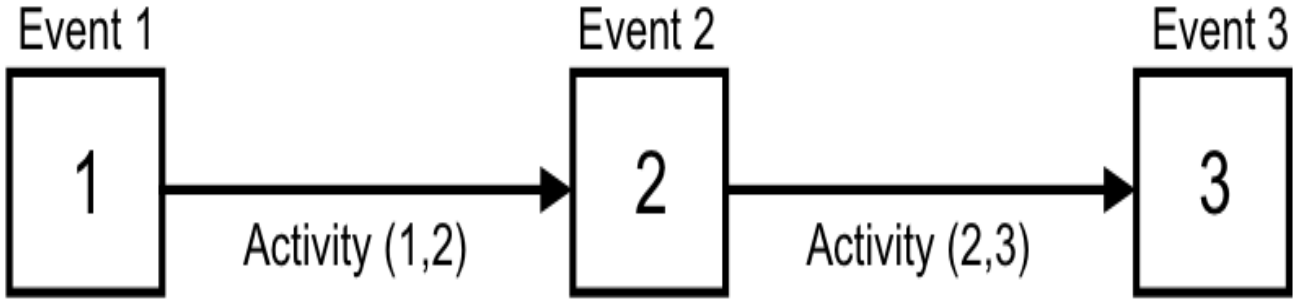
- Has only tail arrows
- Marks the beginning of the project
- Must be only one such event in project network.

Final Event:

- Has only arrow heads
- Indicate the end of project
- only one such event in project network.

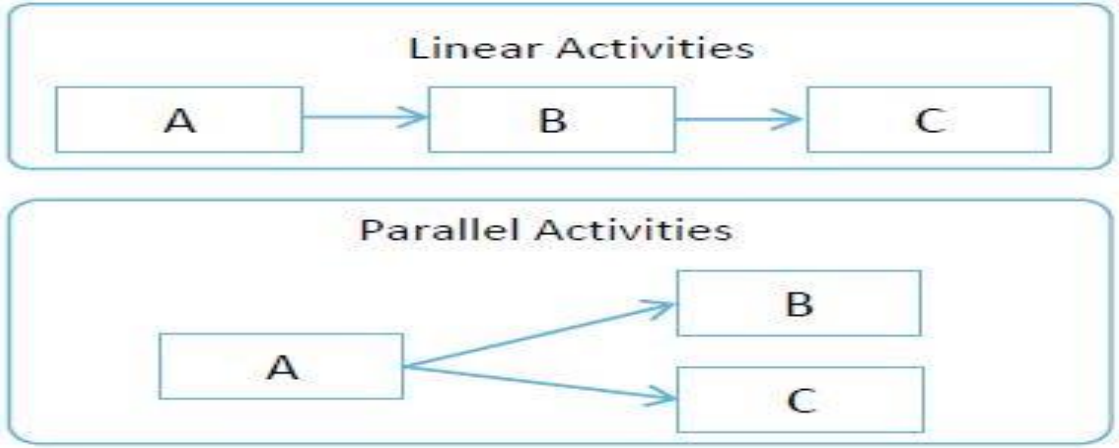
INTERELATIONSHIP OF EVENTS

- Successor events: the event follows a particular event in the sequence of their completion is called successor event .Event 2 is a successor to event 1
- Predecessor event: the event that occurs before a particular event in a sequence of their completion are called predecessor event .Event 1 is a predecessor to event 2



INTERELATIONSHIP OF ACTIVITIES

- Parallel activities or concurrent activities: activities which can be carried out simultaneously and independendent of each other. Activities B,C can be started simultaneously.
- Serial activities: these are the activities which are performed only by succession. Activity A and B occur serially or one after another



Dummy Activity

An activity which doesn’t consume any time and productive time and cost. It should be represented by dotted line but not by any alphabet.

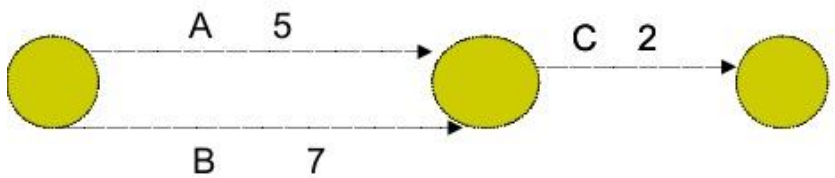
It should be introduced to maintain preceding and succeeding relation.

Example of dummy activity

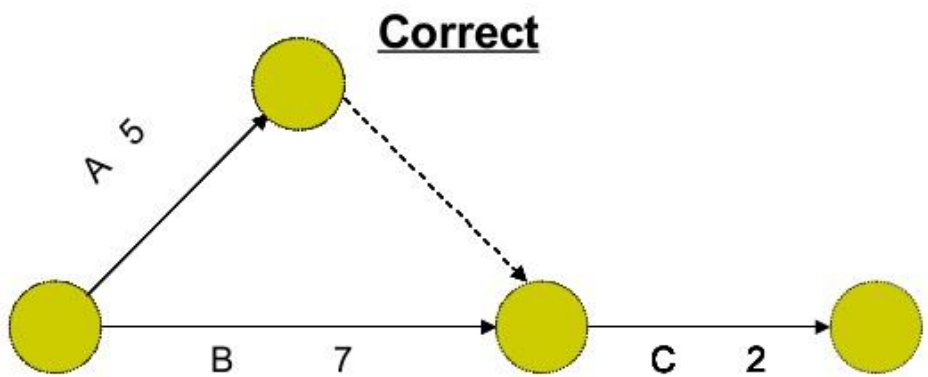
- Case 1- If two activities have same tail event and same head event with different consumption of time, then in order to maintain the relation we should introduce a dummy activity.

Activity	Predecessor	Time(Days)
C	A,B	2
D	C	

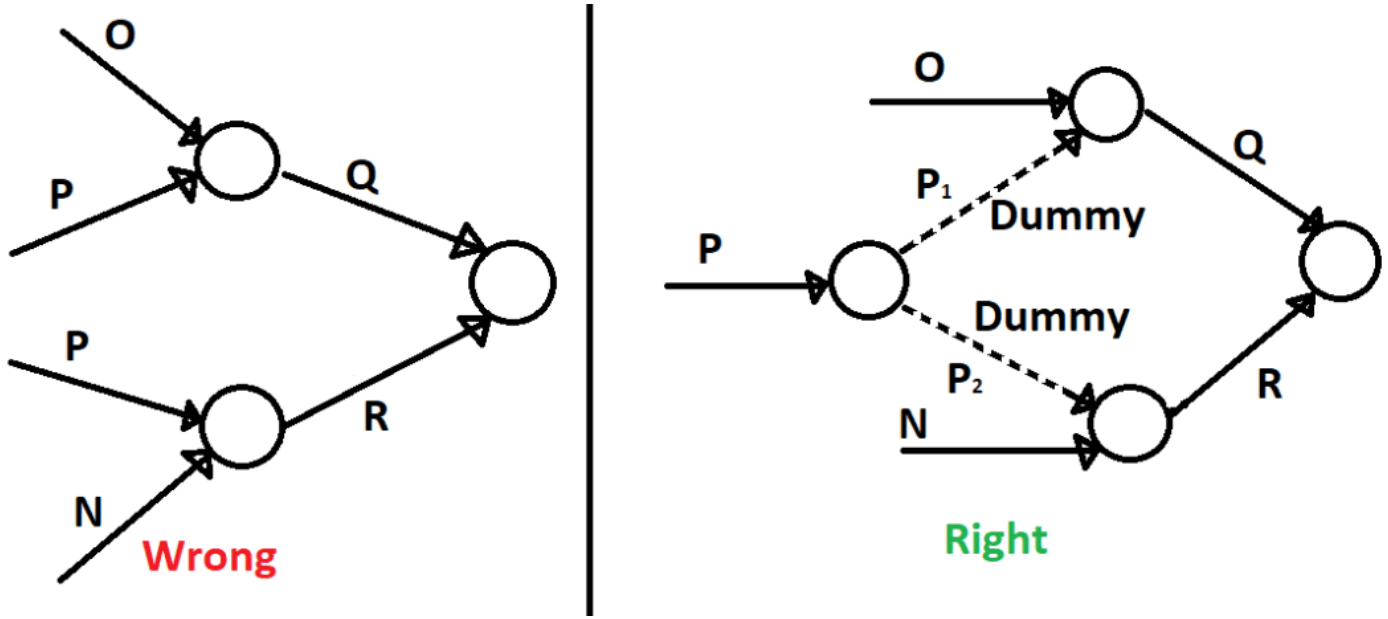
Incorrect



Correct



- Case2 –dummies are used to clearly represent the logic of the network when an activity is common to 2 sets of operations running parallel to each other.

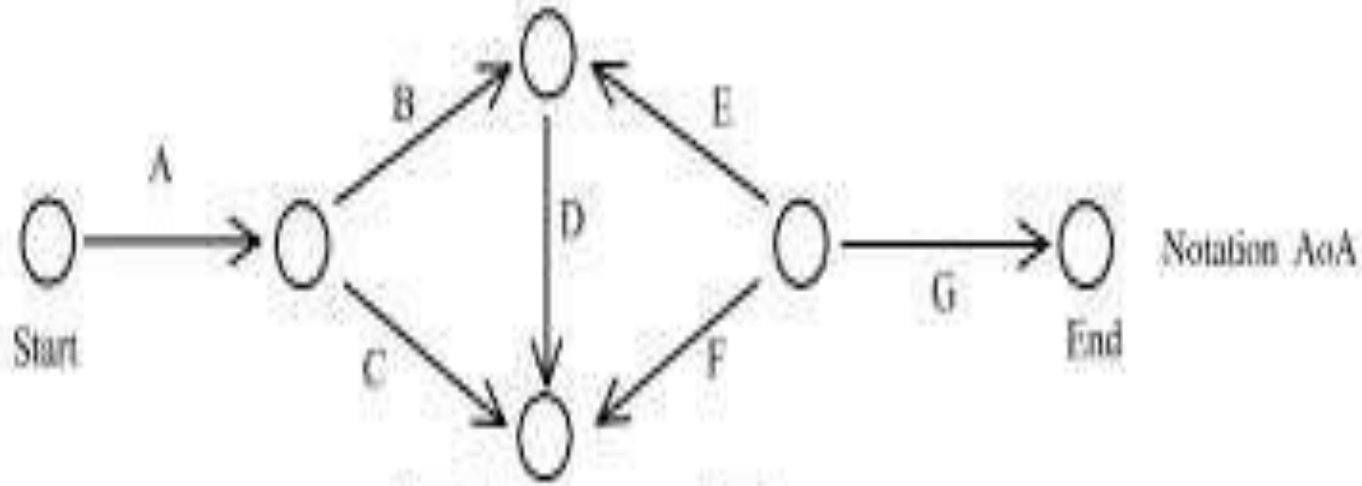


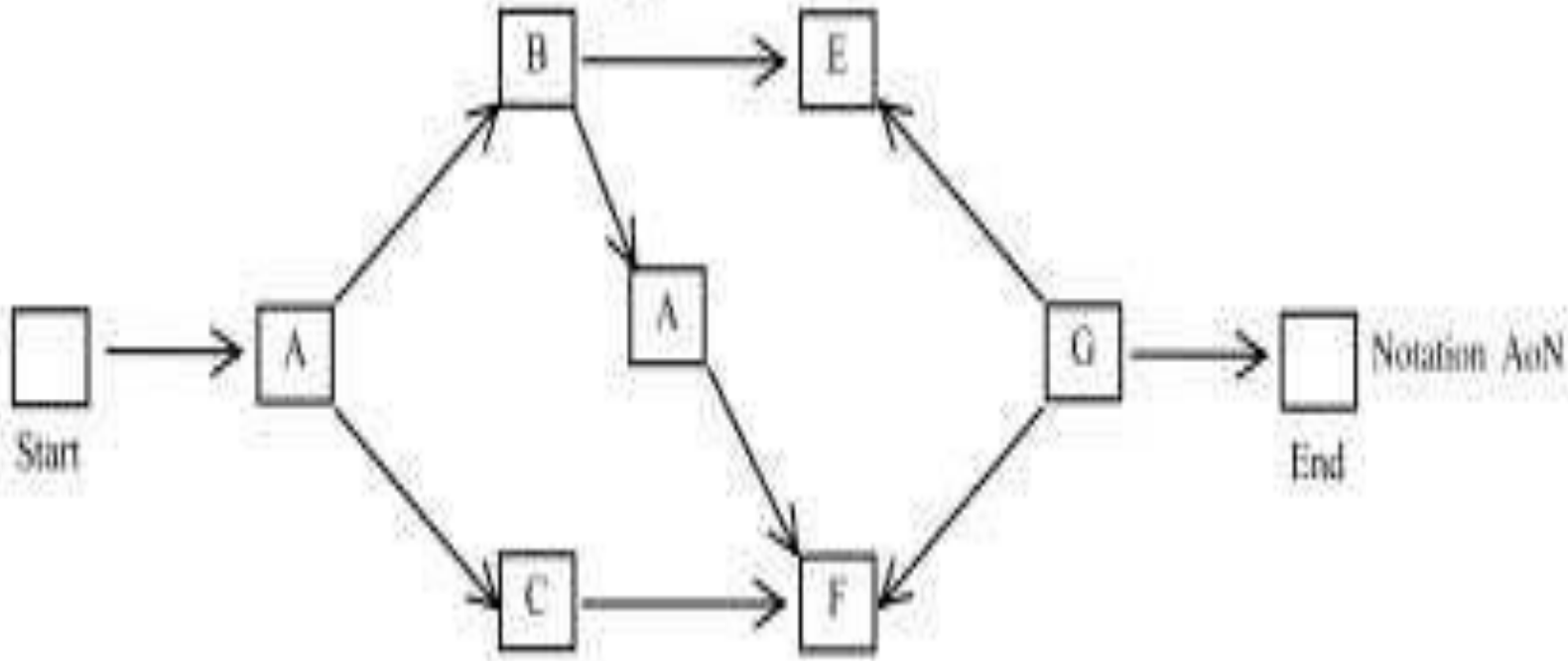
Types of Network

Activity on Arrow system(AOA)

Activity on Node system(AON)

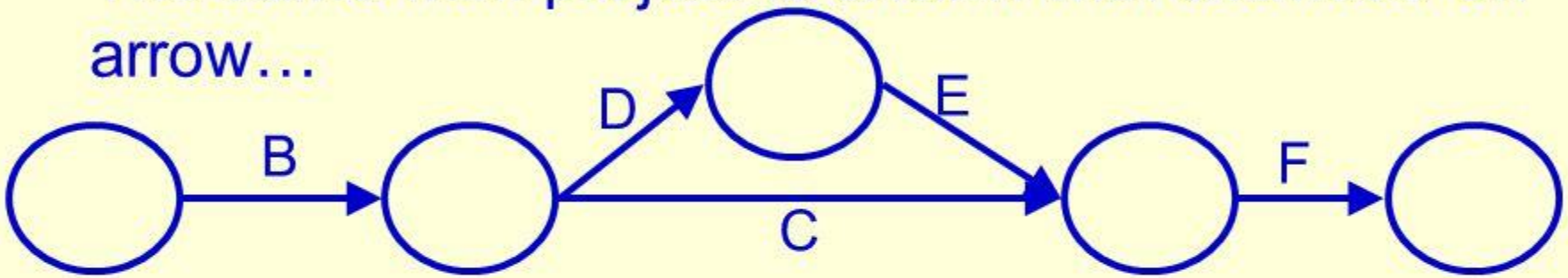
- ***AOA system:*** an activity is represented by an arrow drawn from left to right. Description of an activity is written above the arrow and time for completing is written below the Activity. An event or node is represented in circle.
- ***AON System:*** the activities are represented on the nodes or events and arrows are used to indicate the interrelationship between the activities.


A
B
C
D
E
F
G
Start
End
Notation AoA

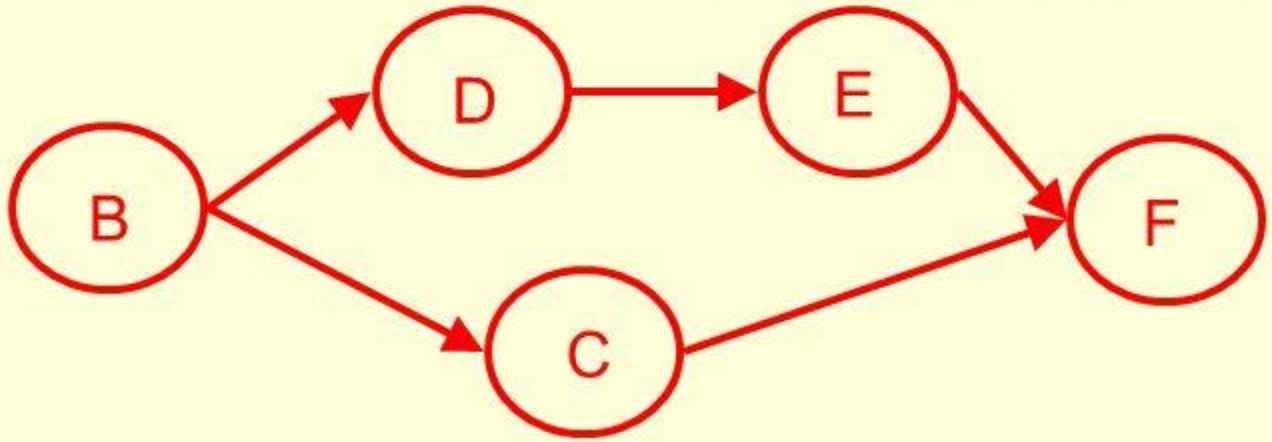

A
B
C
A
E
F
G
Start
End
Notation AoN

AOA vs. AON

The same mini-project is shown with activities on arrow…

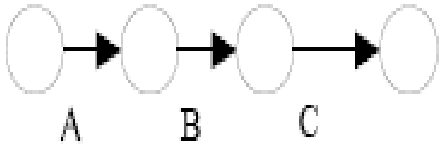


…and activities on node.



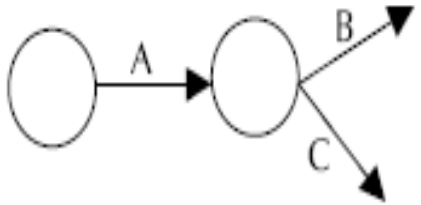
Different cases of AOA

(a)



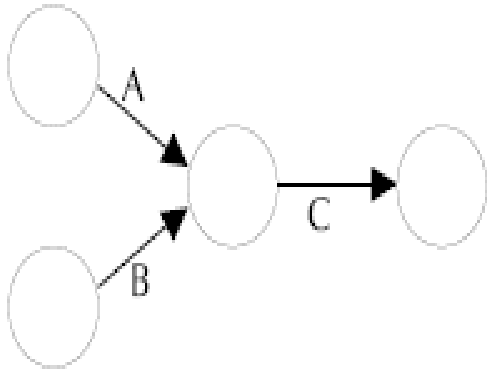
Activity B can be performed only after completing activity A, and activity C can be performed only after completing activity B.

(b)



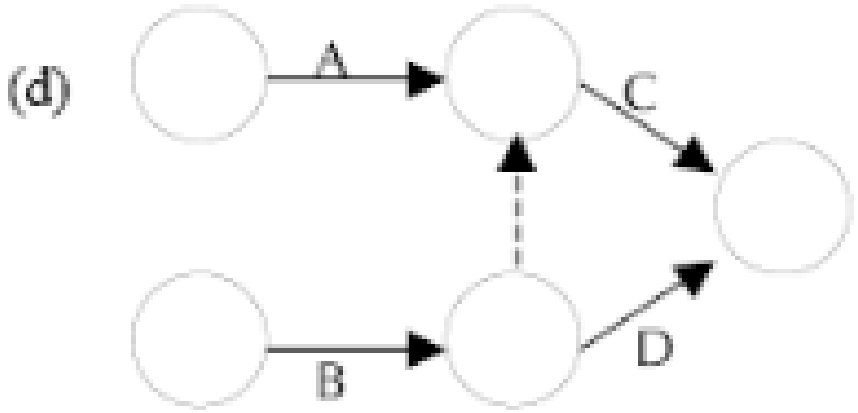
Activities B and C can start simultaneously only after completing A.

(c)



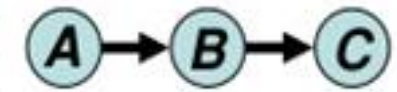
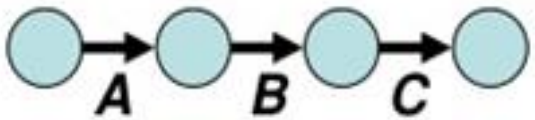
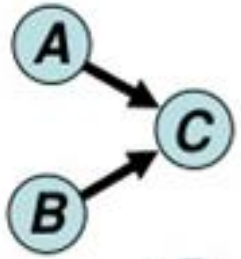
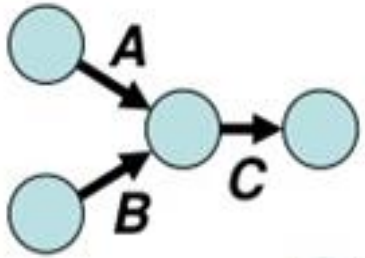
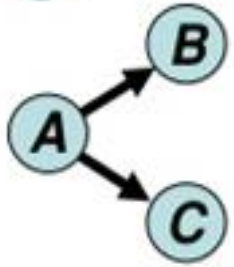
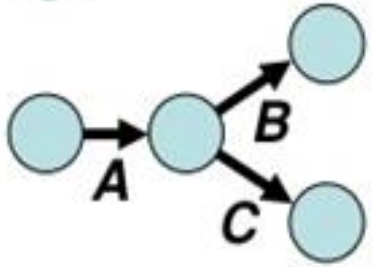
Activities A and B must be completed before start of activity C.

Different cases of AOA



Activity C must start only after completing activities A and B. But activity D can start after completion of activity B.

A Comparison of AON and AOA Network Conventions

Activity on Node (AON)	Activity Meaning	Activity on Arrow (AOA)
(i) 	A comes before B, which comes before C	
(ii) 	A and B must both be completed before C can start	
(iii) 	B and C cannot begin until A is completed	

TOOLS AND TECHNIQUES

Comparison Between AON and AOA

Activity-on-Node	Activity-on-Arrow
✓ Is the common method used by both practitioners and PM software.	✓ Is less commonly used than AON
✓ Precedence diagramming method (PDM).	✓ Arrow diagramming method (ADM) or activity-on-line.
✓ Uses boxes to represent activities.	✓ Uses arrows to represent activities.
✓ Uses arrows to show dependencies.	✓ Connects arrows at nodes to show dependencies.
✓ Does not use dummy activities.	✓ Uses dummy activities.
✓ Uses FS, FF, SS, and SF relationships.	✓ Uses only FS relationships.
✓ FS is the most common relationship used.	

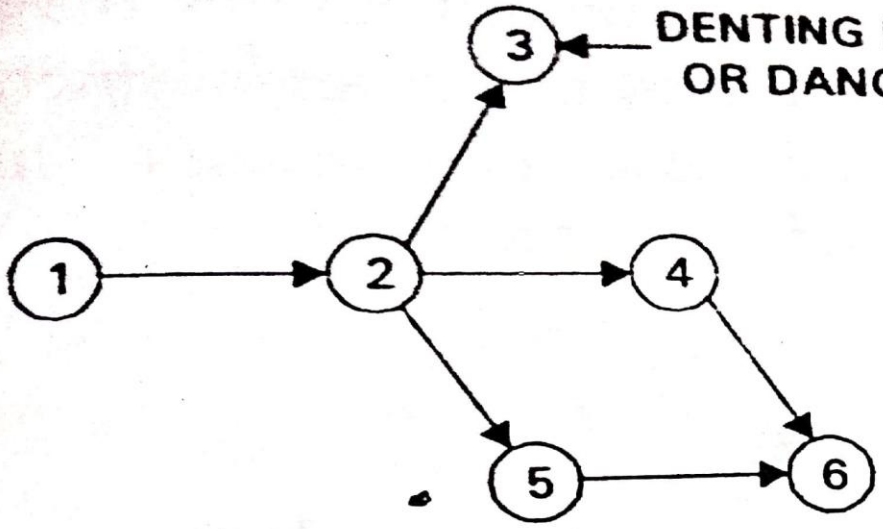
Rules for developing a network

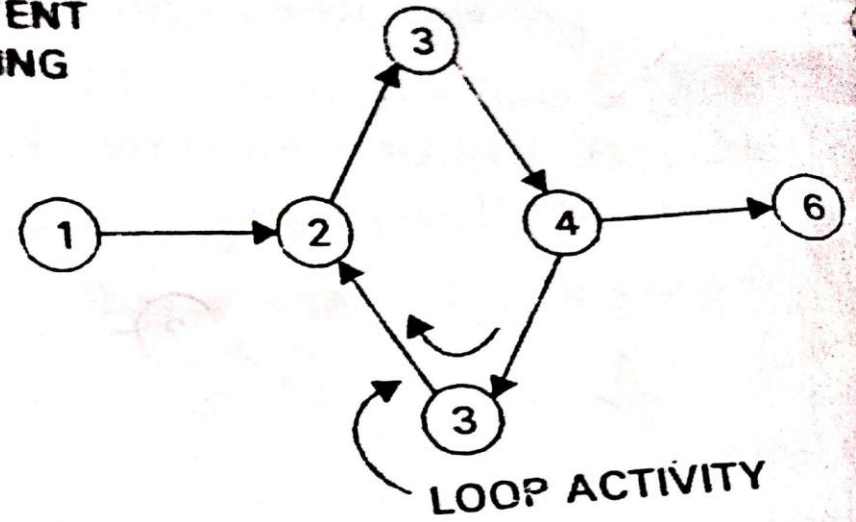
- No activity can start all preceding activities are completed
- A dummy activity is represented either to show dependency or to avoid duplicating while numbering the activities
- Sequential arrangements of activities in the network depends on precedence concurrence and subsequence
- In network diagram there shall be one start and one finish.

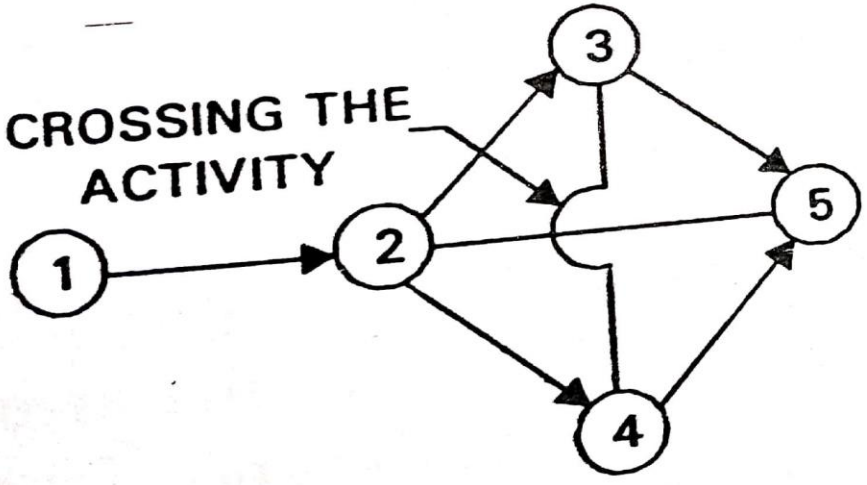
RULES FOR DRAWING A NETWORK

- A network will have only one intial node .It have only one out going arrows
- A network will have only one final node.final node will have only incoming arrows
- No activity can start until its tail event has occurred
- An event cannot occur until all the activities leading upto it are completed
- No event can occur twice .hence no network looping is not permitted
- An arrow should represent a singular situation.
- The network should be drafted such that all activities are completed to reach end objective
- All interdependicies are shown by dummies
- Time flow shown from left to right.

- No dangling event or denting event is allowed
- Looping not allowed
- Avoid crossing of the activities as much as possible
- No curved activities are alllowed it is straight.







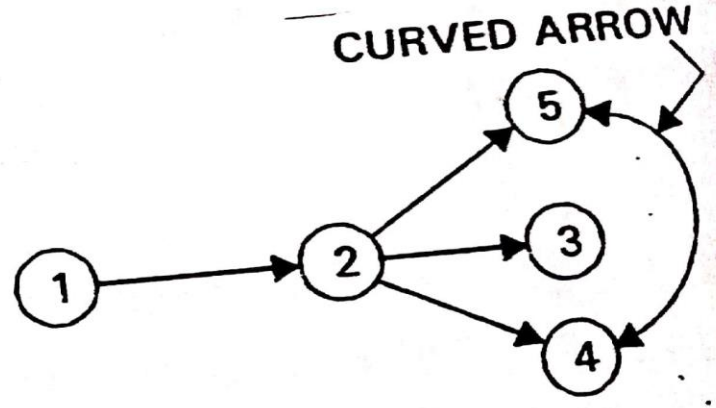


Fig. 1.6

Advantages of network techniques over conventional techniques

- Interrelationship of all operations are clearly shown logically while bar chart does not show this, hence planner has to remember dependencies in various operations ,in large projects it becomes difficult.
- When delays occur the critical operations calls out extra attention while in bar charts it is impossible to find interdependencies
- Planning analyzing and scheduling are separated using networks it allows greater concentration on planning aspects

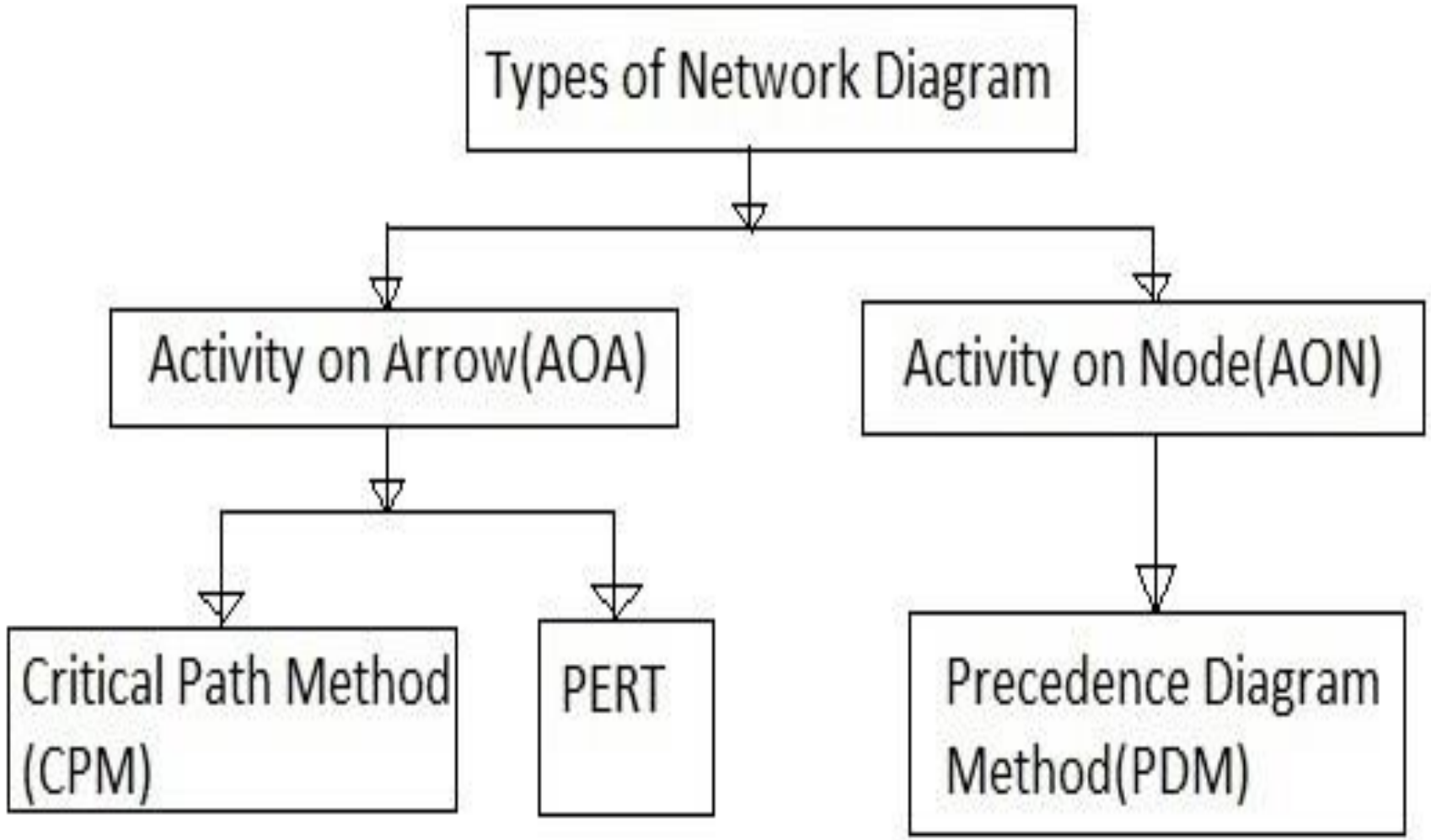

Types of Network Diagram
Activity on Arrow(AOA)
Activity on Node(AON)
Critical Path Method (CPM)
PERT
Precedence Diagram Method(PDM)

Fig-1

CPM (Critical Path Method)

- The two common network model concepts are Critical Path Method (CPM) and Programme Evaluation and Review Technique (PERT).
- The critical path method (CPM) is a project modelling technique developed in the late 1950s by Morgan R. Walker of DuPont and James E. Kelley Jr. of Remington Rand. Kelley attributed the term "critical path" to the developers of the Programme Evaluation and Review Technique (PERT) which was developed at about the same time by Booz Allen Hamilton and the U.S. Navy.

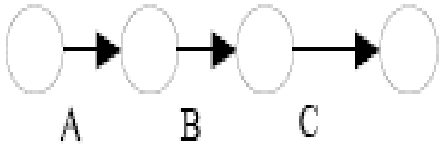
- Critical Path Analysis is commonly used with all forms of projects, including construction, aerospace and defence, software development, research projects, product development, engineering and plant maintenance, among others.
- Any project with interdependent activities can apply this method of mathematical analysis.
- The first time CPM was used was for a major skyscraper development in 1966 while constructing the former World Trade Centre Twin Towers in New York City.

- Critical Path Method (CPM) is an algorithm needed for planning, arranging, scheduling, coordinating, and governing of a project.
- It is presumed that in this method, the activity time is specified and fixed.
- It is used to calculate the quickest and latest start time for each task CPM helps to distinguish critical and non-critical tasks, reduces time and bypasses queue formation in the process.
- It is essential to identify critical activities because if any such activity is hindered, it will disorder the whole process.
- In this process, first, the list of all the activities is prepared, followed by the time required by each of these activities, Then the dependency connecting the activities is decided.
- Here, the series of the activity in a network is defined as 'path'.

- CPM is an activity based deterministic network model applied for projects in which we have previous experience or having activities whose resource and time requirement can be precisely estimated.
- We use single time estimation for each activity.
- Activities are represented by arrow marks, nodes with circles and the duration of an activity with an arrow mark.

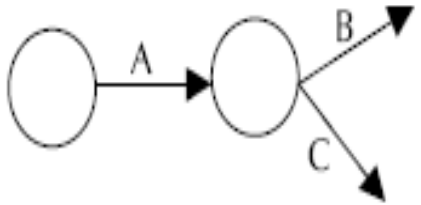
Different cases of AOA

(a)



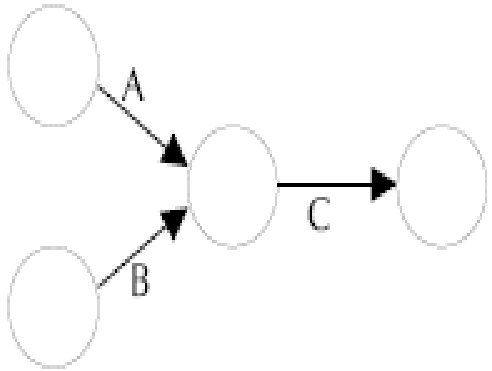
Activity B can be performed only after completing activity A, and activity C can be performed only after completing activity B.

(b)



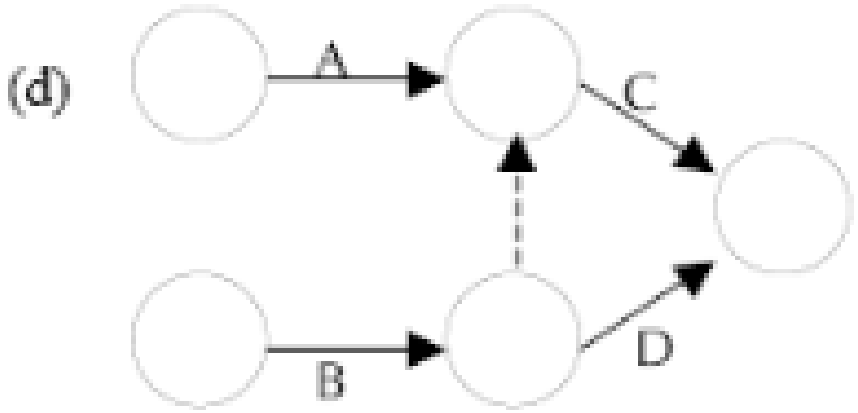
Activities B and C can start simultaneously only after completing A.

(c)



Activities A and B must be completed before start of activity C.

Different cases of AOA



Activity C must start only after completing activities A and B. But activity D can start after completion of activity B.

CRITICAL PATH METHOD (CPM)

- The CPM's development were initiated by E.I du pont de Neumours company in 1956.
- It is the activity oriented network which consist of a number of a well recognized jobs, task or activities.
- CPM is generally used for simple, repetitive types of projects for which the activity time and cost are known mean it is of deterministic nature.
- It uses in the projects like construction of building, road, bridge, yearly closing of accounts by a company can be handled by CPM.
- Thus it is deterministic rather then probabilistic model.

TERMS USED IN CPM

- **Duration (t):** The time required for completing an activity is known as its duration. Depending on the type of project and project duration, the unit of time may be hours, days, weeks or years. CPM being a deterministic model, we consider only single time estimate for activities.
- **Project Duration:** It is the optimal (minimum) time required for the completion of a project. If there is free float in the critical path, it is an indication that there is still scope for achieving optimisation of project duration shou duration.

Critical Path

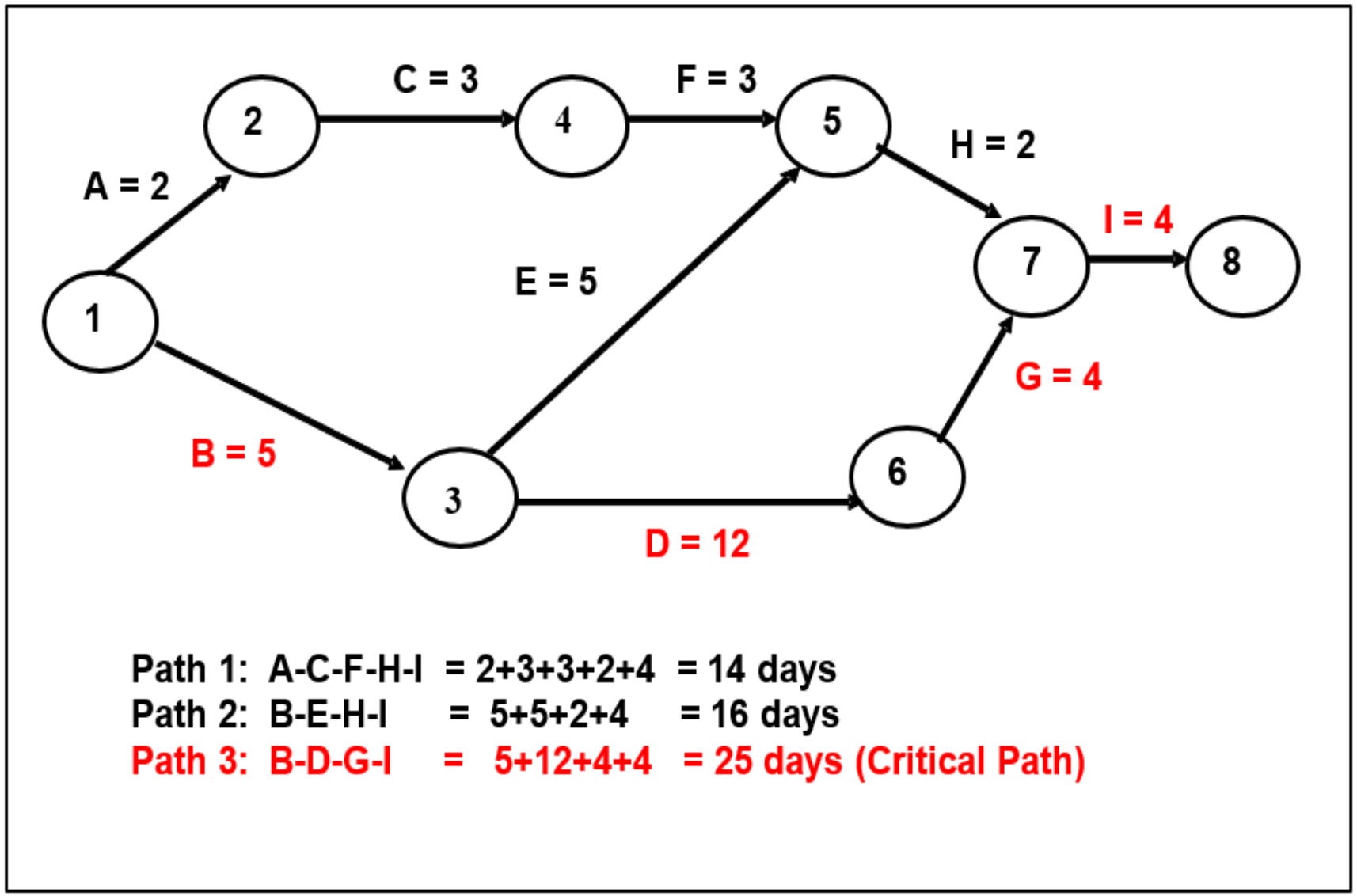
- This is the path in a CPM network beginning from the starting event and extending up to the finishing event of the project.
- The activities lying along this path have their free float minimum i.e, zero. Such activities are called critical activities.
- We must remember that the sum of the duration of activities along this path should be the project duration.
- For manual analysis of critical path; find out all the paths from the starting event to the finishing event (All projects will have only one starting event and finishing event).
- Navigating through nodes having zero free float, calculate the sum of the duration of activities lying in various paths.
- We can see that there will be utmost only one path having total duration of activities equal to project duration. This is the critical path.
- If there are alternate paths through events having zero free float and total duration along the path equivalent to project duration, then that paths can also be termed as critical path.

Critical Path

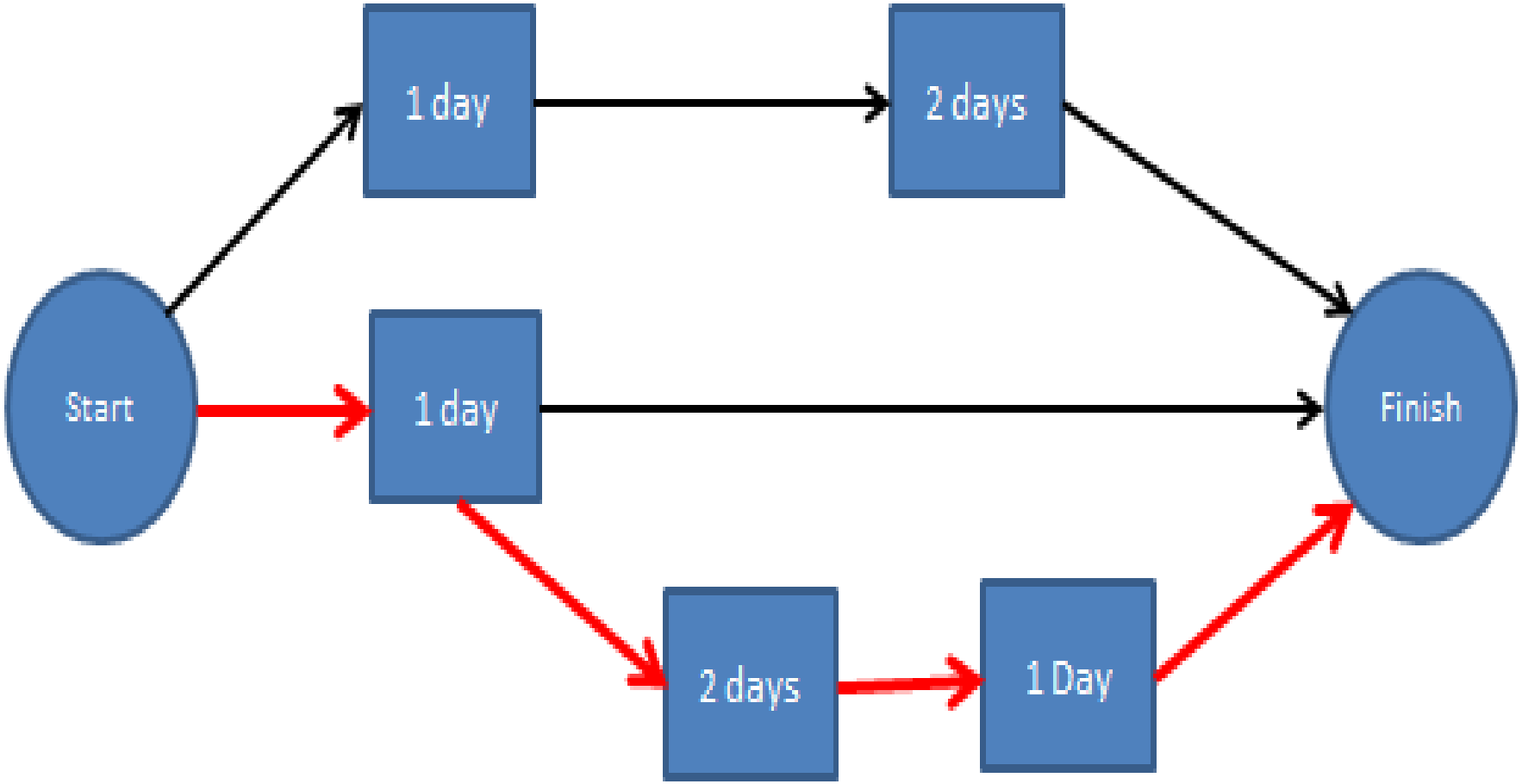
- The events which have no float or slack are the critical events.
- If TE=TL .These events must be completed on schedule, if the project is to be completed in minimum total time.
- The path joining the critical events is called critical path of the network.
- **Critical activities:** the activities lying on the critical path is called critical activities.

Critical Path

- **A path is a sequence of connected activities running from the start to the end node in a network**
- **The critical path is the path with the longest duration in the network**
- **A project cannot be completed in less than the time of the critical path (under normal circumstances)**



Path 1: A-C-F-H-I = 2+3+3+2+4 = 14 days
Path 2: B-E-H-I = 5+5+2+4 = 16 days
Path 3: B-D-G-I = 5+12+4+4 = 25 days (Critical Path)



Critical Path = 4 Days

Earliest Possible Occurrence (EPO) T_E

- This refers to the earliest possible occurrence of an event i.e. the earliest time the activities ending at that node can finish.

  Mathematically $T^j_E = T^i_E + t_{ij}$

  (Take the largest of all such values)

- i.e. T_E of the finishing event j of the activity ij is the largest value of T_E of the starting event i of all the activities finishing at event plus the duration t_{ij} of the respective activities starting from event i. (T^j_E should be read as EPO of event j or T_E of event j).

Latest Possible Occurrence (LPO) - T_L

- This time refers to the latest possible occurrence of an event without extending the project duration ie. the latest permissible finish of all the activities terminating at an event without affecting the project duration.

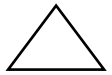
  Mathematically it is represented as $T^i_L = T^j_L - t_{ij}$

  (Take the smallest of all such values).

That is the T_L of the starting event i of the activity ij is the smallest value of T_L of the finishing event j minus the duration t_{ij} of all respective activities finishing at j. (T^i_L should be read as LPO of event i or T_L of event i).

- **Earliest event occurrence time (TE)**: It is the earliest time that the event start can occur. It is denoted by TE

- **Latest allowable event occurrence time(TL):** It is the latest time the event can occur.

TE  TL 

TERMS USED IN CPM

- **Restraint:** Similar to dummy activity but It has duration which can be either be negative or positive .It is used to fix intermediate dates within the network and thereby fix the relative start or finish of parallel activities when these activities are not coincident.

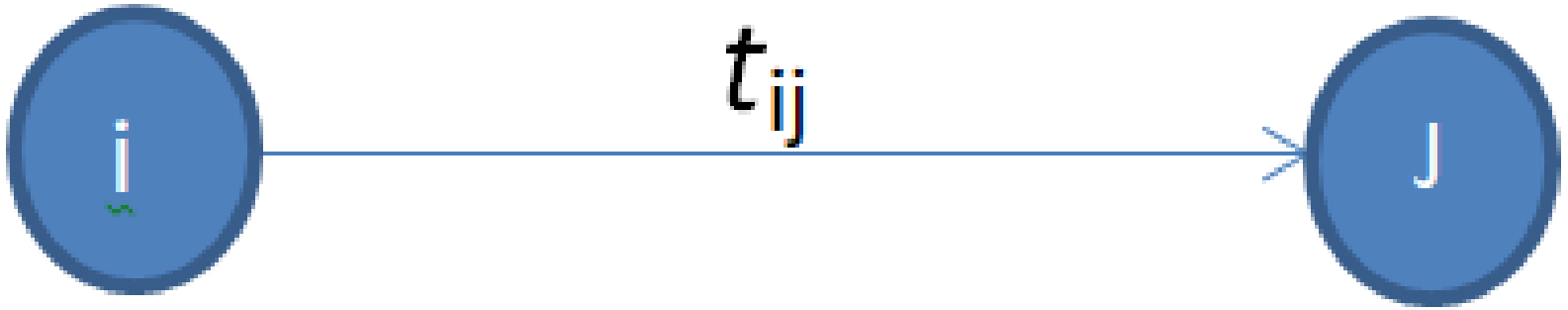
Terminologies

ij **- Represents activity**

i **– Starting Node or Event of activity** ***ij***

j **– Finishing node or Event of activity** ***ij***

t_{ij} **– Time required for activity** ***ij (Duration)***



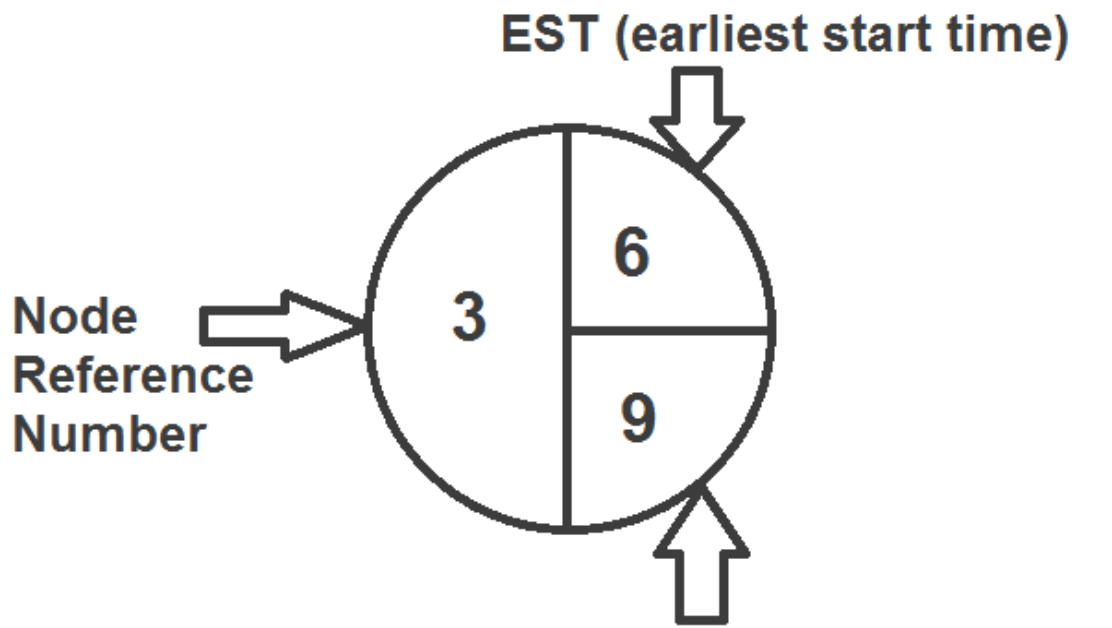
Earliest start time (EST):

- It is the earliest possible time for the activity to start without changing the sequence of the activities in the network. it is denoted by EST

$$EST_{ij} = T^{i}_{E}$$

- i.e. the earliest possible occurrence of the starting event i of activity ij.

A Node in a Network Diagram



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- **<u>Earliest Finish Time (EFT):</u>** It is the earliest time by which the activity can be completed is denoted by EFT.

EFT of an activity= EST + Duration of activity

$$EFT_{ij} = T^{i}_{E} + t_{ij}$$

i.e EPO of starting node i of activity ij plus time required for activity ij

- **<u>Latest start time (LST):</u>**It is the latest time which an activity can be started without delaying the project. It is denoted by LST.

$$LS_{ij}=T^{j}_{L}-t_{ij}$$

- LPO of the finishing node j of activity ij minus time required for that activity t_{ij}.
- In general LST of activity ij need not be T^{i}_{L}.

- **<u>Latest finish time (LFT):</u>**it is the latest time by which an activity can be completed without delaying the project. It is denoted by LFT.

$$LF_{ij}=T^{j}_{L}$$

LPO of the finishing node j of activity ij

FLOAT

- Spare time associated with an activity
- Excess time available with an activity in addition to the minimum time required for the completion of that activity without affecting the scheduled completion of that project.
- If activity is delayed within the limit of free float, it will not affect the project duration.
- During rescheduling or when there is scarcity for resources the activities having zero free float (critical activities) are given priority over the activates having free float.
- In PERT network the term used for float is Slack time.

Types

1. Total Float
2. Free Float
3. Independent Float
4. Interfering float

Total Float:

- Total float is calculated taking the maximum time permissible between the starting node and finishing node of an activity i.e. by assuming the starting node happening at the earliest possible time (EPO) and the finishing node at the latest possible time (LPO).
- Total float cannot be a negative value.
- It is the difference between the maximum time allowed for an activity and its duration time.
- It is the amount of time by which the activity can be started without causing the project to last longer.

TF =LST-EST

=LFT-EFT

Total Float (TF) of an activity ij, $TF_{ij} = (T^j_L - T^i_E) - t_{ij}$

- If TF is –ve, time availability is less than activity duration
  - ➢Super critical activity
  - ➢Special attention need to be provided.

- If TF is zero, time availability is equal to activity duration
  - ➢Critical activity
  - ➢Normal attention
  - ➢Critical path

- If TF is +ve, time availability is more than activity duration
  - ➢Sub critical activity
  - ➢Freedom and relaxation can be allowed.

Free Float:

- Free float is the float available with an activity when both its starting node and finishing node happens at the EPO of the respective nodes.
- Free float of an activity must not be less than zero.
- The situation where free float becomes negative arises when the LPO of any event is less than its EPO due to allowable time constraint in the contract. Under such circumstances, more resources should be pumped in and the duration should be cut short even if it affects profitability. This operation in known as Time Cost Trade off or Project Crashing.
- The free float of an activity is an amount of time by which the activity completion time can be delayed without interfering with the start of succeeding activities. It is denoted by FF.

FF= TE-EFT

Free Float (FF) of an activity ij, $FF_{ij} = (T^{j}_{E}-T^{i}_{E})- t_{ij}$

Interfering float

- It is the difference between total float and the free float.
- It is the amount of time by which the completion time can be delayed with interfering the start (earliest start) of succeeding activity.

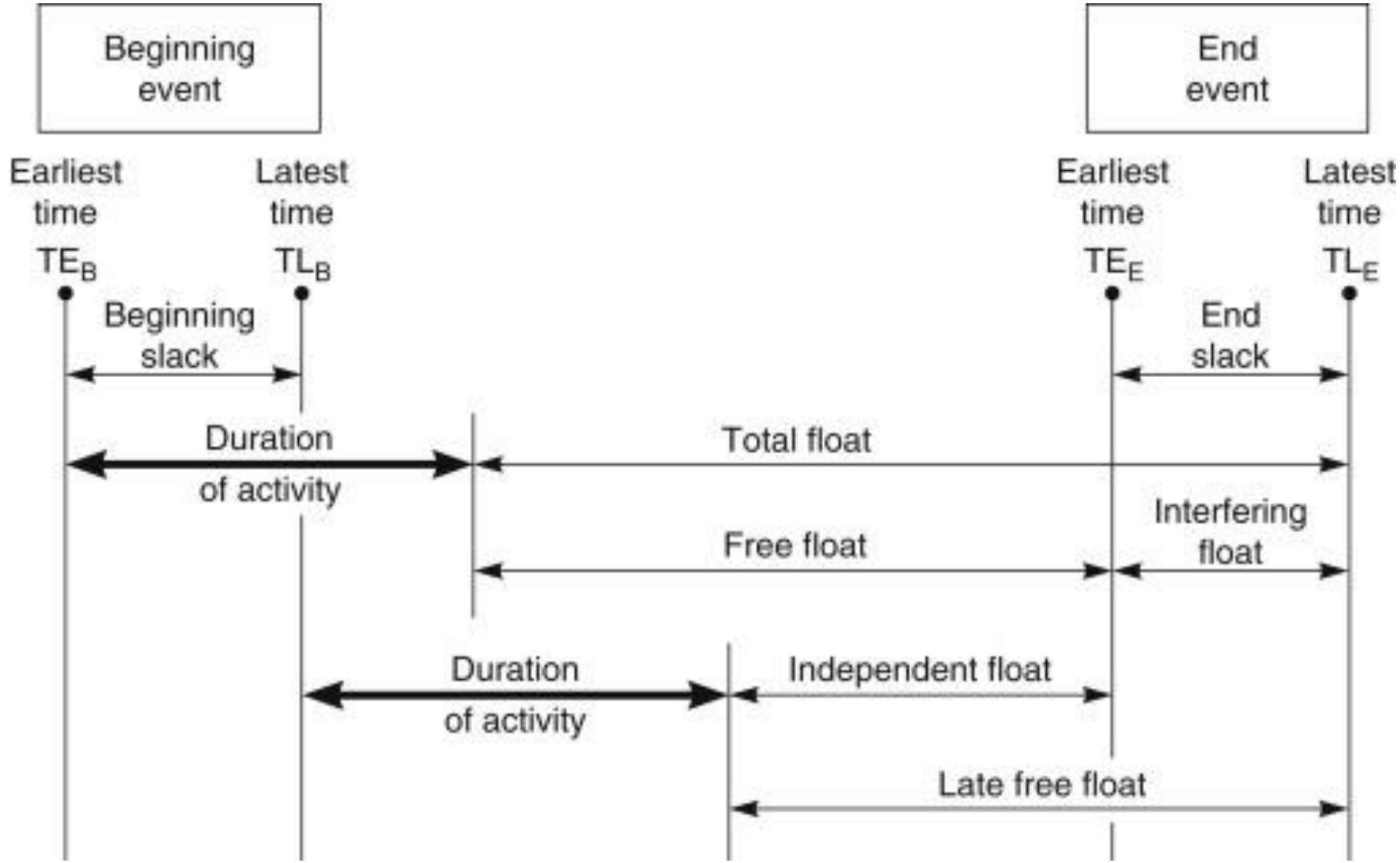
IF=TF-FF

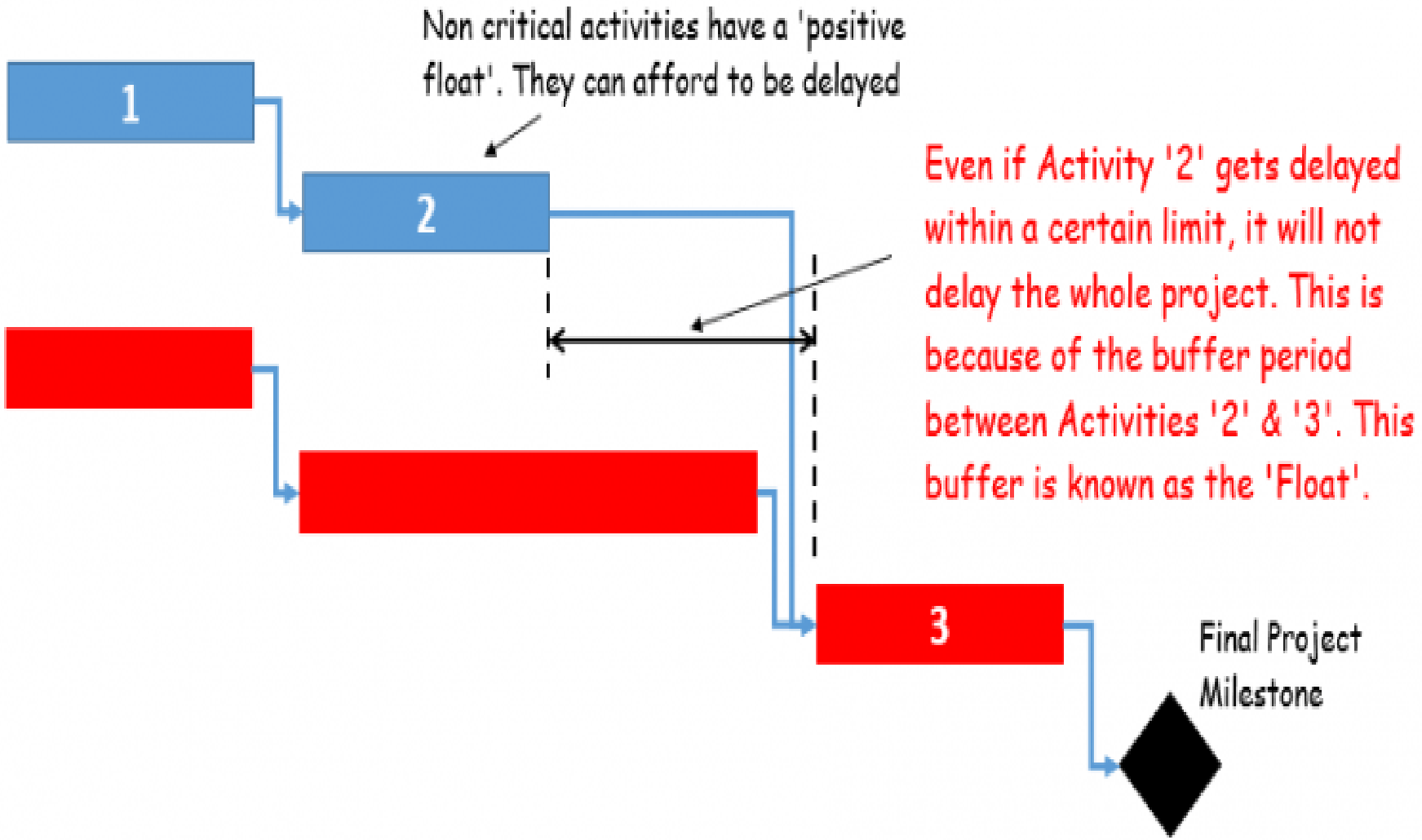
Independent float

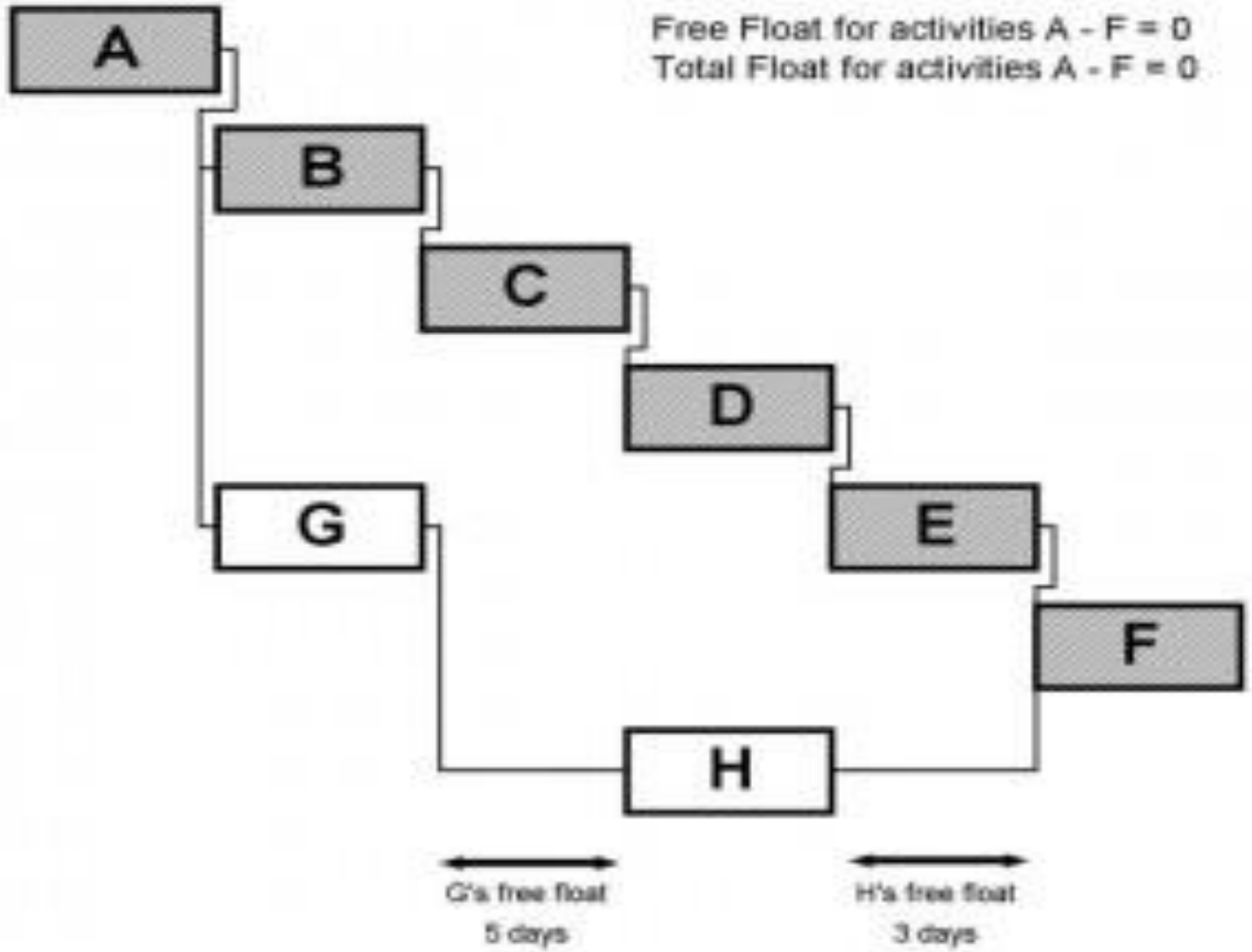
- It is the float available with an activity considering the worst situation i.e. with the starting event of the activity happening at its LPO and the finishing event happening at its EPO.

Independent Float (IF) of the activity ij, $IF_{ij} = (T^{j}_{E}-T^{i}_{L})- t_{ij}$

Independent float may be negative in certain cases. If Independent float is available, still there is a scope for optimisation, since this float hat can be freely used for other purposes.


Beginning event
End event
Earliest time TE_B
Latest time TL_B
Earliest time TE_E
Latest time TL_E
Beginning slack
End slack
Duration of activity
Total float
Free float
Interfering float
Duration of activity
Independent float
Late free float

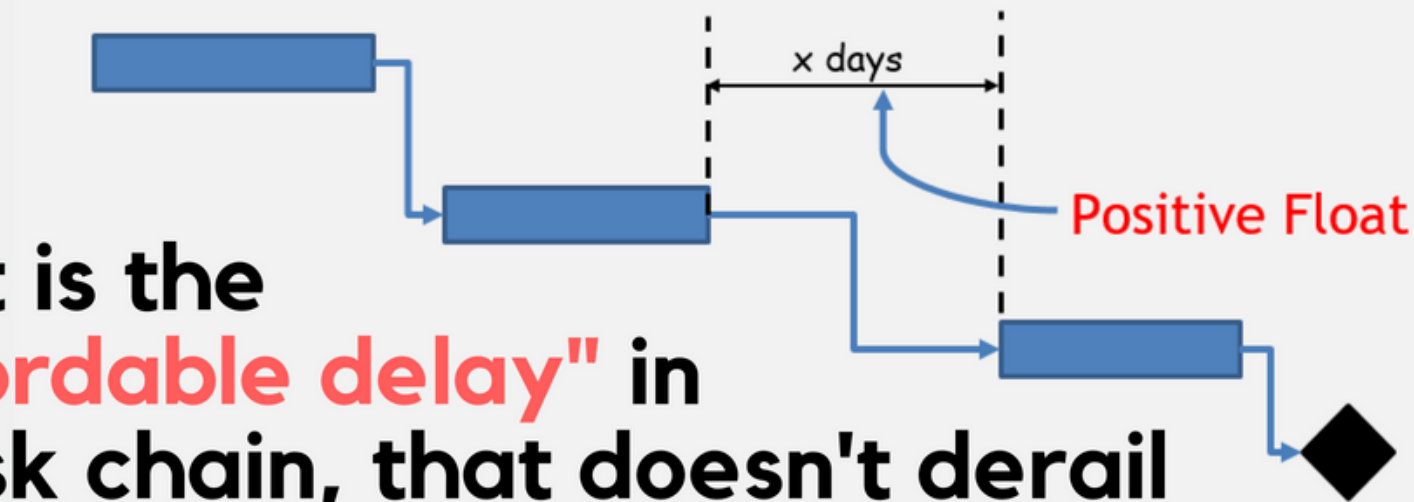

Non critical activities have a 'positive float'. They can afford to be delayed
1
2
3
Final Project Milestone
Even if Activity '2' gets delayed within a certain limit, it will not delay the whole project. This is because of the buffer period between Activities '2' & '3'. This buffer is known as the 'Float'.



G's Free Float = 5 days
G's Total Float = 8 days

H's Free Float = 3 days
H's Total Float = 3 days

Free Float / Slack in Project Schedule



Float is the "affordable delay" in a task chain, that doesn't derail the overall project timeline.

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PROGRAMME EVALUATION AND REVIEW TECHNIQUE (PERT)

- PERT is develop in 1957 by U.S NAVY for scheduling the research and development work for polarize the missile program.
- Its uses event oriented network in which the successive events are joined by arrows.
- Its is preferred to those projects in which the time for various activities are not pre defined.
- There is no significant to guideline.

PERT (Programme Evaluation and Review Technique)

- PERT was developed primarily to simplify the planning and scheduling of large and complex projects. It was developed for the U.S. Navy Special Projects Office in 1957 to support the U.S. Navy's Polaris nuclear submarine project.
- It is an event based probabilistic network model, and has found applications all over the industry.
- Program (Project) Evaluation and Review Technique (PERT) is an operation to understand the planning, arranging, scheduling, D coordinating, and governing of a project. This program helps to fo understand the least and minimum time taken to complete the whole project. PERT was developed, with the aim to optimise the cost and time of a project. In PERT, the project is segregated into events and activities. After discovering a proper sequence, the network is built. Then, the time for each task is calculated, and a path is regulated.

- It incorporates uncertainty by making it possible to schedule a project while not knowing the details and durations of all the activities precisely. It is more of an event-oriented technique rather than being start-and completion-activity oriented like CPM, and is used more in projects where time is the major factor rather than cost.
- It is applied on very large-scale, one-time, complex, non-routine infrastructure and on Research and Development (R&D) projects where we cannot deterministically estimate the time required for each activity. In such projects, the occurrences of events are more important.

- PERT and CPM are complementary tools, because CPM employs one time estimation and one cost estimation for each activity.
- PERT may utilize three time estimates

  optimistic time (t_o)

  most likely time (t_m), and

  pessimistic time (t_p)

  and no costs for each activity.
- It is a probabilistic model.

- The optimistic time (to) is an estimate of the minimum time required for an activity if nothing exceptionally go wrong. Ideal Conditions are assumed to prevail during the execution of activity..

- The pessimistic time (tp) is an estimate of the maximum time required for an activity if nothing exceptionally goes wrong. Abnormal situations are assumed to prevail during excavation. Major Catastrophies like labour strike or unrest.
- The most likely time (tm) is based on experience and Judgement being based on the time required if the activity is repeated a number of times under essentially the same conditions. This time signifies the most frequently occurring time.

- From the three-time estimate, the expected time t of the activity is determined by taking the weighted average of the three times.
- The weight is assigned based on its probability.
- The highest probability of completing an activity is the most likely time; hence t_m, is assigned a weight of 4.
- Chances of completing an activity by the two extreme cases t_o and t_p are comparatively less and hence by statistical analysis they are assigned the weight 1.
- Thus the weighted average is taken as,

$$\text{The expected time } t_e=(t_o,+4t_m,+t_p)/6$$

- After converting the three time estimate to single expected time, the analysis of the PERT network is done as in the case of CPM. That is why they are said to be complimentary to each other.

CPM

- Network model
- Deterministic model. Time required for the activity can be assessed with some amount of accuracy from past experience.
- Developed mainly for the projects of DuPont
- Involves predictable activities
- Activity oriented
- Single time estimation

PERT

- Network model
- Probabilistic model. Time required for the activity is uncertain. Expected time is determined based on probability.
- Developed for the Polaris project of the US Navy.
- Involves unpredictable activities
- Event oriented
- Three time estimation

CPM

- Applied to projects with previous experience or repetitive jobs like construction projects
- Time is equated as money
- Crashing concept or time cost trade off concept is applicable
- Differentiates critical and non critical activities
- he excess time associated with an activity is called Float.
- it is basically a project planning tool for cost and time

PERT

- Applied to R&D, research, or one-time projects where past experience is little.
- Happening of events given emphasis
- Crashing concept not applicable. Money and time are not interlinked.
- No differentiation between critical and non-critical path
- The term used to indicate spare time with an activity is called slack time.
- it is basically a project time control tool

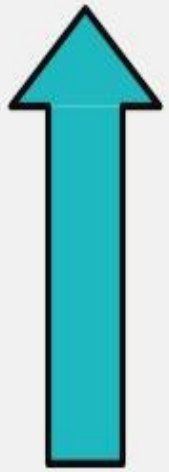
Advantages of network model

- Dependencies of activities can be clearly explained.
- Float or slack time can be effectively used for resource planning and re-scheduling of projects.
- It is easy to control the project.
- Addition of supplementary tasks during the execution of the project is easy.
- Suitable when number of activities are more and for multidisciplinary activities.
- Easy for software development.
- Has a wide range of applications in logistic management, project management and analysing the power supply, water distribution system, traffic network etc.

Limitations of Network model

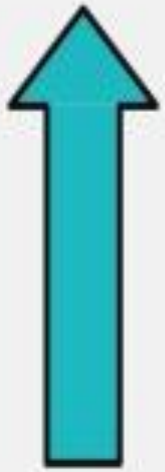
- When large numbers of activities are involved, assistance of computers and any ERP software is required for analysing the project.
- ERP software is costly.
- Understanding a network needs more skill than interpreting a bar chart.
- It is not easy to visualise like a bar chart.
- Very good experience is required in handling large projects and foxing dependencies.

Advantages of CPM



- Consistent framework for planning, scheduling, monitoring, and controlling project
- Helps proper communications between departments and functions
- Determines expected project completion date.

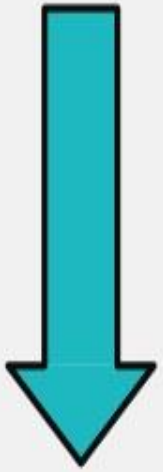
Advantages of CPM



- Determines the dates on which tasks must be started if the project is to stay on schedule
- Shows which tasks must be coordinated to avoid resource or timing conflicts
- Shows which tasks may run in parallel to meet project completion date

Disadvantages of CPM

- Reliability of CPM largely based on accurate estimates and assumptions made
- CPM does not guarantee the success of project
- Resources may not actually be as flexible as management hope when they come to address network float



Disadvantages of CPM

- Too many activities may the network diagram too complicated
- Activities might themselves have to be broken down into mini projects

Project Crashing

- Project crashing is another technique for shortening or compressing the project duration by reducing the time required for one or more critical activities by putting in more resources at the least cost possible.
- The aim of crashing is to achieve the maximum decrease in schedule for minimum additional cost.
- Project crashing is achieved by putting more resources in the critical path, increasing productivity, working overtime with additional supervision, outsourcing of work, and modification of specification and design, such as changing to pre-fab construction, early procurement of items etc.
- Project crashing should not, however, compromise with safety or quality.

Certain problems which arise due to fast tracking and project crashing are:

- Non-critical activities may become critical
- Resource utilisation may not be optimum
- Reduced productivity Chances for poor quality
- Chances for compromising with safety and hazards.
- Incurring additional cost may not be a cost-effective operation
- Project implementation becomes complex
- Contingency requirements are high
- Reductions in human resource out turn due to lack of working space and inexperienced workers

RESOURCE

- A resource is a physical variable such as men (skilled, unskilled, labour technical/ Supporting staff etc). materials, machines (tools, plant, equipment etc) and money.
- These resources are directly responsible for converting plans and specifications into a finished product.
- But all resources may not be available in abundance.
- Availability of man power, and heavy equipments and special equipment may be restricted in certain cases there may be space limitations which prevent more than one or two jobs simultaneously.
- So it is quite pertinent that various activities of the project are to be rescheduled such a way the demand of various resources is more or less uniform all along the project period and thus objective can be accomplished by net work technique.

- RESOURCE ALLOCATION
- RESOURCE SMOOTHING
- RESOURCE LEVELLING

RESOURCE ALLOCATION

- Resource allocation simply means deciding what resources each activity of the project requires. For this resource usage profile is drawn either on earliest start of each activity or latest start of each activity basis.
- The process of resource allocation consists of fitting activities into pattern of resource availability with in stipulated time period and it is achieved by the following ways namely

    A. Resource smoothing

    B. Resource Levelling

RESOURCE SMOOTHING

- The total project duration is not changed but some of the activity start times are shifted by their available float so that more or less uniform demand is generated and their is called resource smoothing.
- Resource smoothing is used when time constraint takes priority.
- The objective is to complete the work by the required date while avoiding peaks and troughs of resource demand.
- Resource levelling is used when limits on the availability of resources are paramount

RESOURCE LEVELLING

- The activity start times are so rescheduled that the peak demand does not exceed the available limit of resource. If it does not give the desirable result by consideration of floats the total project duration to minimum extent may be extended and this is called resource levelling.
- In the resource levelling philosophy, the resource demand is maintained as somewhat uniform within the normal maximum availability. Here the constraint is the maximum resource available and the project duration may extent depending on resource availability.
- The resource smoothening philosophy is adopted where the constraint is project duration. Without altering the project duration, the demand for resources is normalised to a somewhat uniform demand.

RESOURCE LEVELLING

1. Resource limited scheduling technique; Importance is given to the limited resources
2. Removes all resource conflicts
3. May not require additional resources
4. Activities may be shifted beyond the float available while rescheduling the activities
5. Generally, the project duration gets extended
6. May change the critical path No change in critical path

RESOURCE SMOOTHING

1. Time limited scheduling technique; Importance is given to the duration of the project
2. Removes as much resource conflicts as possible; but, may not remove all resource conflicts
3. May require additional resources to address left over resource conflicts
4. Activities are shifted only to the extent of the float available
5. The project duration remains the same
6. No change in critical path

JOB LAYOUT

- Job layout is the detailed layout of the project site, earmarking the construction area, locations for various construction activities, places for stocking of materials, locations of plants & equipment, layout of roads, entry & exit points, emergency assembly area, service points like water, electricity, fire hydrants, locations of temporary buildings like workers rest area, site office, stores, watchmen shed etc. prepared based on a detailed planning.
- It is usually displayed as a legend or display board at major locations for the information of everyone involved in the project.

- Job layout ensures safety at work place as it avoids conflicting actions and helps in scheduling activities as per planning.
- Efficient job layouts will economise the activities by decreasing the lead distance and saving more in terms of time and money.
- Accidents can be better controlled by strictly enforcing activities as per the job layout.

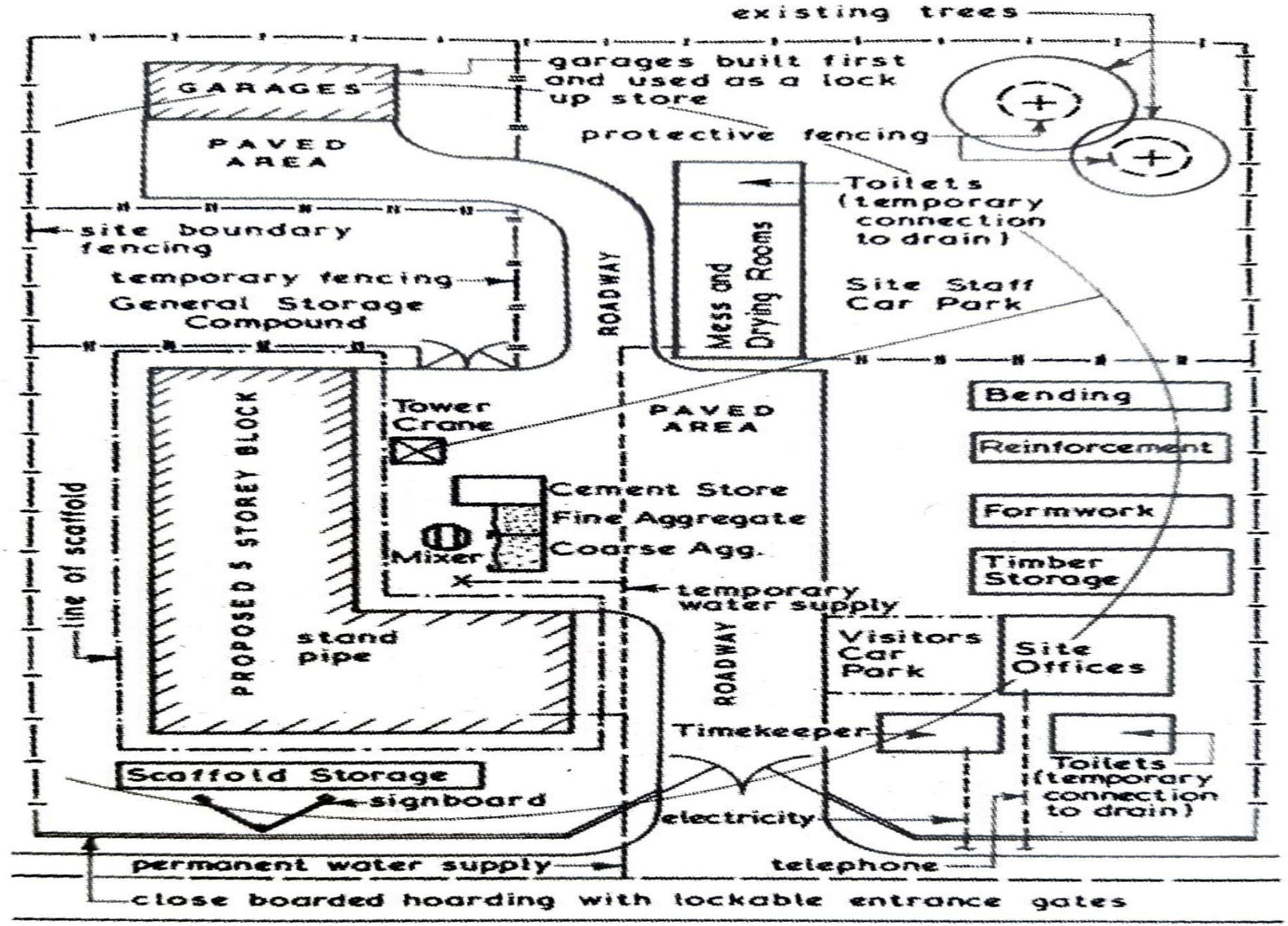


Fig 1.11 Job layout of a Project Site

Work Study

- The main purpose of work study is to analyse the performance of project equipment and labour from time to time and compare their out with standard output.
- In the case of smaller output the individual case is investigated in detail and corrective measures are taken.
- Though work studies are specifically made in production industries where operating of same nature are involved, the same technique or analysis introduced in the field of construction also work study is further categorised as

    1. Motion study or Method study.
    2. Time study or work measurement

Motion Study or Method Study:

- Motion study is a scientific study of the motions of the workers or the method of work in a particular productive work with a view to simplify and minimum the effort and thereby increases the productivity in short motion study or method study mainly concerned with finding better ways of doing things.

- The following steps are involved in motion studies:

i. Selecting the job which is required to be improved

ii. Recording the relevant information about operation in the existing method such as

a. What exactly is required to be done.

b. In what way it is necessary to be done.

c. How and where it is to be done

d. When it is to be done.

iii. Analysing the facts recorded and deciding whether each of the operations or motions are really necessary and whether they can be more easily operated or replaced by different methods.

iv. Developing a new method after studying the existing method as well as alternative methods available. This helps in achieving higher productivity

Time Study or Work Measurement:

- Time studies are helpful in finding out methods which are least time consuming and therefore economical.
- These are helpful in establishing standard time of an operation which is the time taken by an average worker in carrying out a job under standard conditions, without adversely affecting his health.
- The efficiency of workers can be measured by comparing the time actually taken by them in comparing the job with the standard time for Job.

The steps involved in time studies are:

1. Selecting the job which is required to be studied and improved.
2. Recording the relevant information about each operation in the existing method and identifying the various elements in each operation.
3. Recording the time taken to perform each element of the operation and determining the time allowed for each operation.
4. Arriving at the time of each operation.
5. Finding the standard time for the job as a whole.

Advantages of Time Study:

1. Developing the desired system and method with the lowest cost.
2. Standardising the system and method.
3. Determining the time required by a qualified person working at normal pace to do a specific operation.
4. Estimating the effective persons to carryout a particular operation.
5. Comparing of equipment performance on unit cost of production basis.
6. Selecting the type and amount of equipment for carrying out a specific work.