Planning and Scheduling Techniques

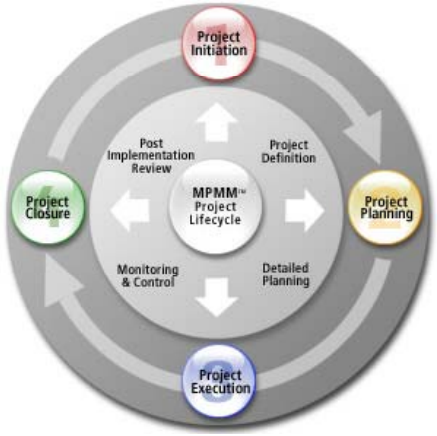
Planning

Chapter 2

Project Planning

- Project ‘‘a temporary endeavor undertaken to create a unique product, service, or result’’
- Project management is the planning, organizing, directing, and controlling of company resources for a relatively short-term objective that has been established to complete specific goals and objectives.

Project Life Cycle



Five Process group

Project initiation
- Selection of the best project given resource limits
- Recognizing the benefits of the project
- Preparation of the documents to sanction the project
- Assigning of the project manager

Project planning
- Definition of the work requirements
- Definition of the quality and quantity of work
- Definition of the resources needed
- Scheduling the activities
- Evaluation of the various risks

Project execution
- Negotiating for the project team members
- Directing and managing the work
- Working with the team members to help them improve

Project monitoring and control
- Tracking progress
- Comparing actual outcome to predicted outcome
- Analyzing variances and impacts
- Making adjustments

Project closure
- Verifying that all of the work has been accomplished
- Contractual closure of the contract
- Financial closure of the charge numbers
- Administrative closure of the paper work

Planning

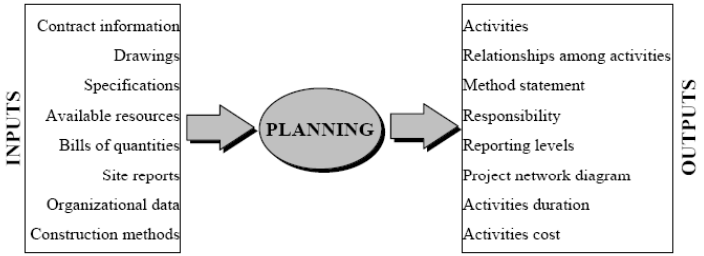
- Planning involves the breakdown of the project into definable, measurable, and identifiable tasks/activities, and then establishes the logical interdependences among them.
- Planning answers the following questions:
  - What is to be done?
  - How to do it?
  - Who does it?
  - "when" (in general terms: start and finish).

Planning

- Plans involve four main steps:
  1. Performing breakdown of work items involved in the project into activities.
  2. Identifying the proper sequence by which the activities should be executed.
  3. Activities representation.
  4. Estimating the resources, time, and cost of individual activities.
- Planning requires a rigorous effort by the planning team.

Planning

- The inputs and outputs of the planning process are:



Scheduling

- Project scheduling is the determination of the timing and sequence of operations in the project and their assembly to give the overall completion time.

- To calculate the project completion
- To calculate the start or end of a specific activity
- To predict and calculate the cash flow
- To improve work efficiency
- To resolve delay claims
- To serve as an effective project control tool

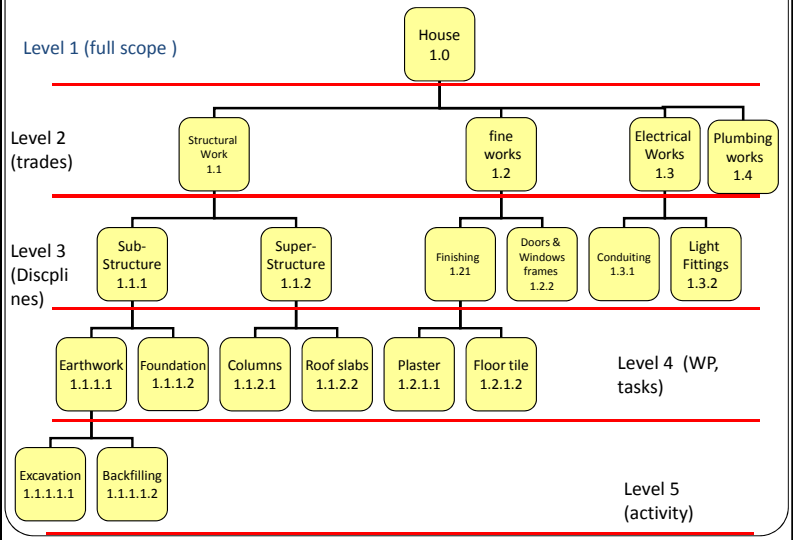
Why scheduling ?

Common Scheduling techniques

- The scheduling techniques widely used in construction management are:
  - Network Analysis CPM/PERT, Bar Charts
  - Line of Balance and Resource levelling
  - Others (Q-scheduling, etc..)

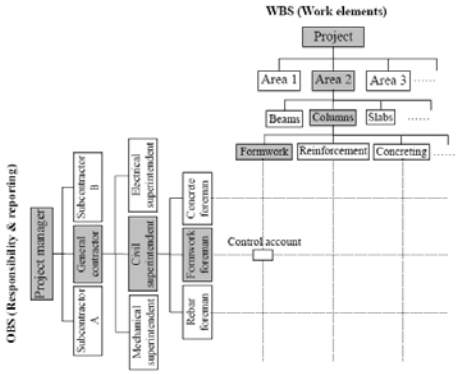
Work Breakdown Structure (WBS)

- The WBS is described as a hierarchical structure which is designed to logically subdivide all the work-elements of the project into a graphical presentation.
- WBS is used to break down the project from one main and relatively big entity into smaller, defined, manageable and controllable units, usually called work groups or tasks.
- A list of project's activities is developed from the work packages.
- Example a house construction project



OBS

- The WBS elements at various levels can be related to the contractor's organizational breakdown structure (OBS), which defines the different responsibility levels and their appropriate reporting.

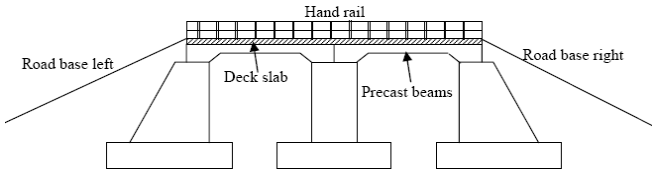


Activity

- Production activities: activities that involve the use of resources such as labor, equipment, material, or subcontractor. (e.g: excavation, formwork, reinforcement, concreting, etc)
- Each production activity can have a certain quantity of work, resource needs, costs, and duration.
- Other activities are:
  - **Procurement activities**
  - **Management activities**

Example: Double-span bridge

- Figure below shows a double-span bridge. Break the construction works of the bridge into activities.



Example: Double-span bridge

Activity	Description
10	Set-up site
14	Procure reinforcement
16	Procure precast beams
20	Excavate left abutment
30	Excavate right abutment
40	Excavate central pier
50	Foundation left abutment
60	Foundation right abutment
70	Foundation central pier
80	Construct left abutment
90	Construct right abutment
100	Construct central pier
110	Erect left precast beams
120	Erect right precast beams
140	Fill left embankment
150	Fill right embankment
155	Construct deck slab
160	Left road base
170	Right road base
180	Road surface
190	Bridge railing
200	Clear site

Activity relationships

- To identify the relationships among activities,
  - Which activities must be finished before the current one can start?
  - What activity(ies) may be constructed concurrently with the current one?
  - What activity(ies) must follow the current one?

Example

- Suppose that a site preparation and concrete slab foundation construction project consists of nine different activities:
  - A. Site clearing (of brush and minor debris),
  - B. Removal of trees,
  - C. General excavation,
  - D. Grading general area,
  - E. Excavation for utility trenches,
  - F. Placing formwork and reinforcement for concrete,
  - G. Installing sewer lines,
  - H. Installing other utilities,
  - I. Pouring concrete.

Example

- Precedence relations for Example above:

Activity	Description	Predecessors
A	Site clearing	---
B	Removal of trees	---
C	General excavation	A
D	Grading general area	A
E	Excavation for utility trenches	B,C
F	Placing formwork and reinforcement for concrete	B,C
G	Installing sewer lines	D,E
H	Installing other utilities	D,E
I	Pouring concrete	F,G

- HW :Determine the relationships between activities of the Double span bridge project

Logical relationship considering resource constraints

- For efficient use of resources or in case of constrained resources, it might be beneficial to consider the resources when determining the logical relationship among the activities that use the same resources.
- Example: consider construction a simple project consists of three units and each unit has three sequential activities

Logical relationship considering resource constraints

Activity	description	Predecessors (unconstrained resources)	Predecessors (constrained resources)
A1	Excavate unit 1	-	-
B1	Concreting unit 1	A1	A1
C1	Brickwork unit 1	B1	B1
A2	Excavate unit 2	-	A1
B2	Concreting unit 2	A2	B1, A2
C2	Brickwork unit 2	B2	C1, B2
A3	Excavate unit 3	-	A2
B3	Concreting unit 3	A3	B2, A3
C3	Brickwork unit 3	B3	C2, B3

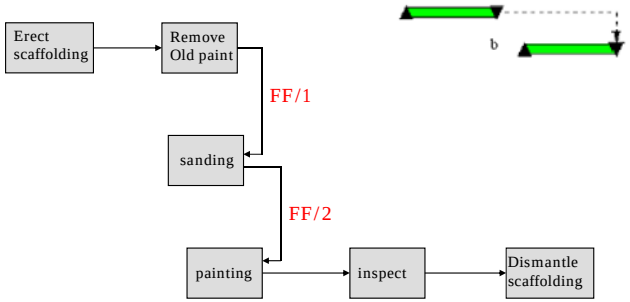
- Logical relationships considering constrained and unconstrained resources

Types of activities relationships

- Relationships are defined from the predecessor to the successor activity.
- Four types of relationships exist
- a) Finish to start (FS).
  - The successor activity can begin only when the current activity completes.
  - Example: the plaster must be finished before the tile can start.

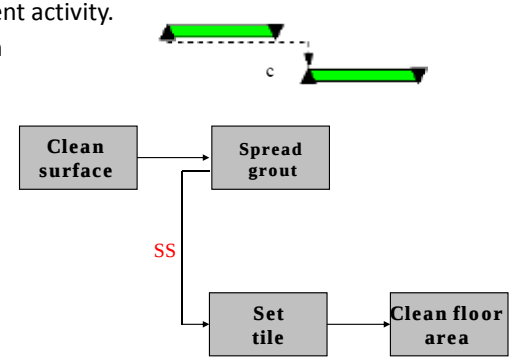
Types of activities relationships

- b) Finish to finish (FF).
  - The finish of the successor activity depends on the finish of the current activity.
  - Can be used where activities can overlap to a certain limit.



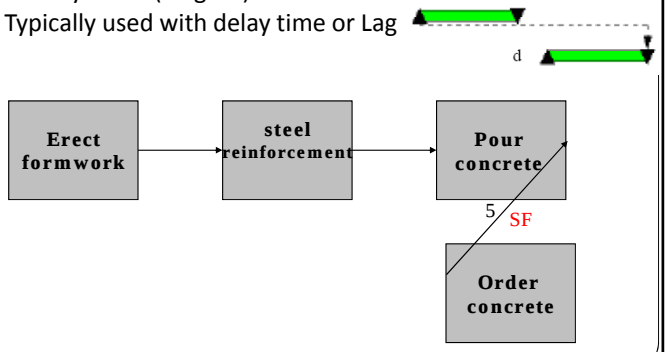
Types of activities relationships

- c) Start to start (SS).
  - The start of the successor activity depends on the start of the current activity.
  - Uncommon



Types of activities relationships

- d) Start to finish (SF).
  - The successor activity cannot finish until the current activity starts (illogical)
  - Typically used with delay time or Lag



Networks

- A network is a logical and graphic representation of the activities (and events) composing a project.
- A project network is a set of arrows and nodes.
- Network diagrams are the preferred technique for showing activity sequencing.
- There are two ways that are commonly used to draw a network diagram for a project.

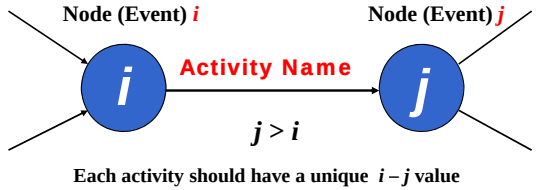
Two classic representations

- **AOA:** Activity on Arrow
- **AON:** Activity on Node
- A matter of preference which one to use
- Each Activity labeled with Identifier (usually a letter/code) and duration (in std. unit like days)
- There is one start & one end event
- Time goes from left to right

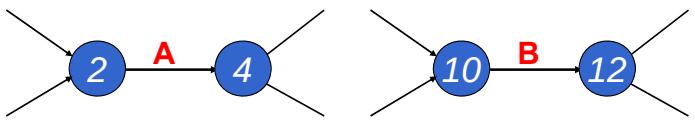
Activity-on-arrow (AOA)

- Also called arrow diagramming method (ADM) network diagram or (I-J) method (because activities are defined by the form node, I, and the to node, J)
- Activities are represented by arrows.
- Nodes or circles are the starting and ending points of activities.
- It can only show finish-to-start dependencies

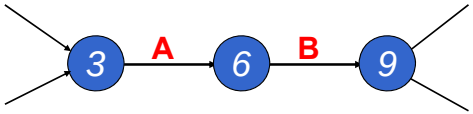
Basic Logic Patterns for Arrow Diagrams



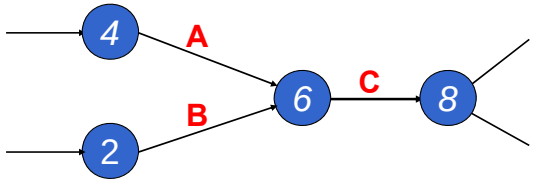
(a) Basic Activity



(b) Independent Activities

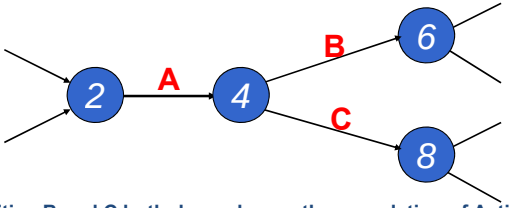


(c) Dependent Activities



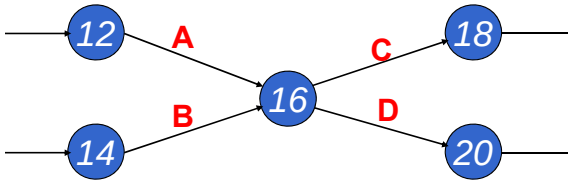
Activity C depends upon the completion of both Activities A & B

(d) A Merge



Activities B and C both depend upon the completion of Activity A

(e) A Burst



Activities C and D both depend upon the completion of activities A and B

(f) A Cross

Information required for drawing networks

- List of individual activities
- Activity interdependencies
- Activity time estimates.

Ground rules for developing a network :

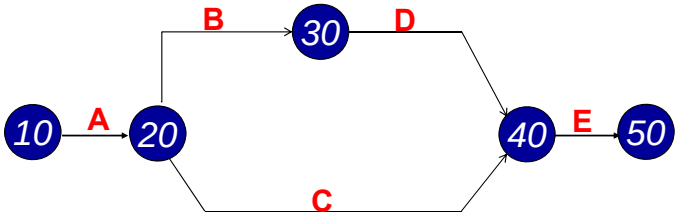
- Each event should have preceding and succeeding event
  - commencement ⟶ completion
- Events should have a distinct number

Example

Draw the arrow network for the project given next.

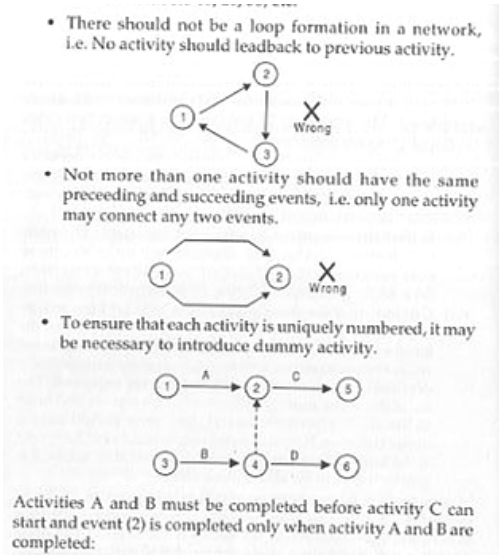
Activity	IPA
A	-
B	A
C	A
D	B
E	C,D

Solution



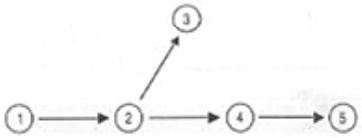
Some rules/laws

- The Network must have definite points of beginning and finish.
- There should not be a loop formation in a network, No activity should lead back to previous activity “No looping”
- Not more than one activity should have the same preceding and succeeding events, i.e only one activity may connect any two events.
- To ensure that each activity is uniquely numbered, it may be necessary to introduce dummy activity

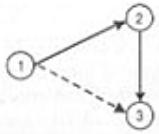


- The Network must be continuous. No activity should be disconnected.

It is called dangling. It is an error in a network.

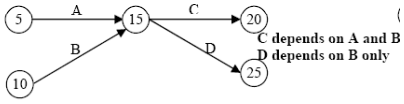


- Unnecessary insertion of a dummy activity results in redundancy.

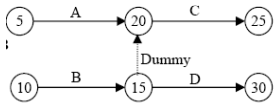


Dummy activity (fictitious)

- The dummy activity is an activity with zero duration, consumes no resources, drawn as dashed lines, and used to adjust the network diagram.
- A dummy activity is also used when one activity depends upon two preceding activities and another activity depends only upon one of these two preceding activities



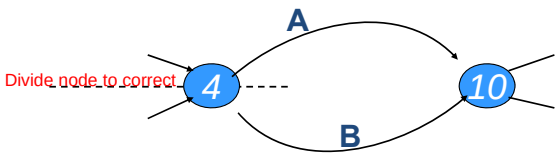
(a) Incorrect Representation



(b) Correct Representation

Dummy activity (fictitious)

- **Used to maintain unique numbering of activities.**



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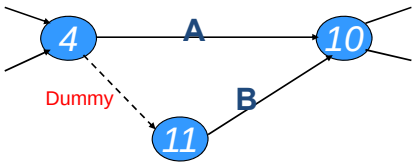


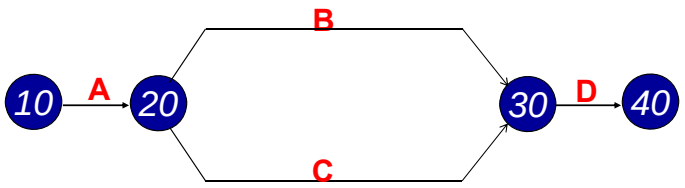
(b) Correct Representation

Example

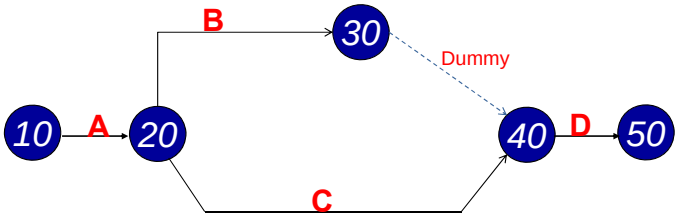
Draw the arrow network for the project given next.

Activity	IPA
A	-
B	A
C	A
D	B,C

Solution



Improper solution



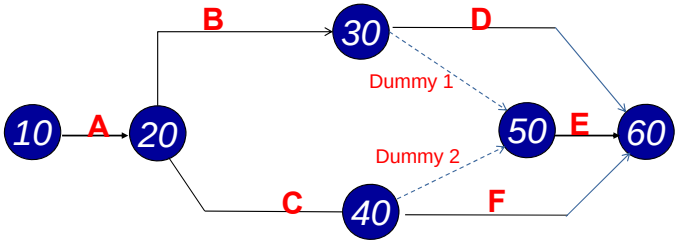
proper solution

Example

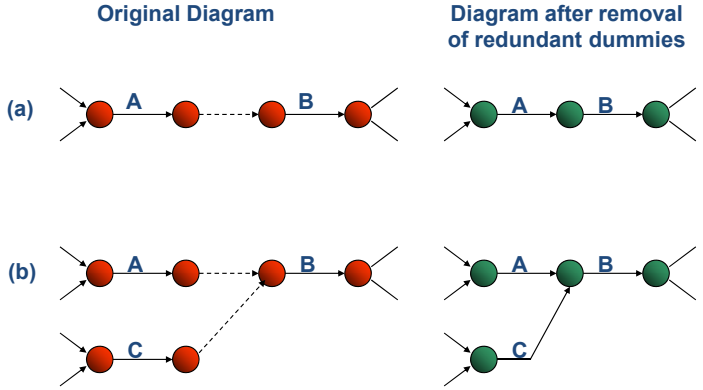
Draw the arrow network for the project given next.

Activity	IPA
A	-
B	A
C	A
D	B
E	B,C
F	C

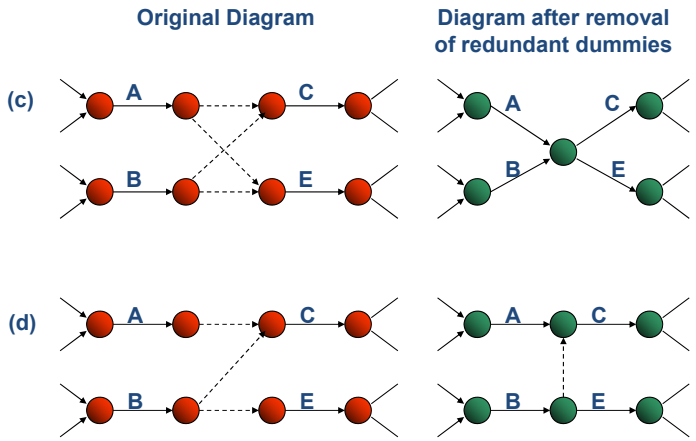
Solution



Removal of Redundant Dummies

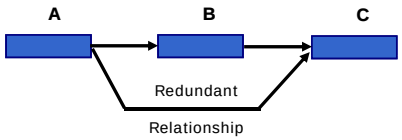


Removal of Redundant Dummies



Redundant Relationship

Activity	Depends Upon	Immediately Preceding Activity (IPA)
A	-----	-----
B	A	A
C	~~A~~, B	B



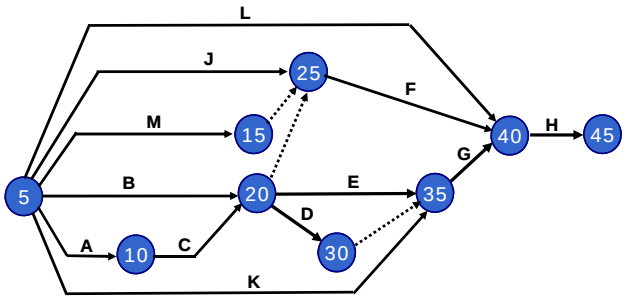
Activity List with Dependencies

Activity	Description	Depends Upon
A	Site Clearing	-----
B	Removal of Trees	-----
C	Excavation for Foundations	A
D	Site Grading	A, B, C
E	Excavation for Utility Trenches	A, B, C
F	Placing formwork & Reinforcement	B, C, J, M
G	Installing sewer lines	B, C, D, E, K
H	Pouring concrete	D, E, F, G, L
J	Obtain formwork & reinforcing steel	-----
K	Obtain sewer lines	-----
L	Obtain concrete	-----
M	Steelworker availability	-----

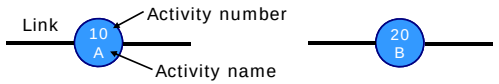
Removing Redundant Relationships:

Activity	Description	Depends Upon
A	Site Clearing	-----
B	Removal of Trees	-----
C	Excavation for Foundations	A
D	Site Grading	~~A~~, B, C
E	Excavation for Utility Trenches	~~A~~, B, C
F	Placing formwork & Reinforcement	B, C, J, M
G	Installing sewer lines	~~B~~, ~~C~~, D, E, K
H	Pouring concrete	~~D~~, ~~E~~, F, G, L
J	Obtain formwork & reinforcing steel	-----
K	Obtain sewer lines	-----
L	Obtain concrete	-----
M	Steelworker availability	-----

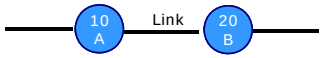
AOA Representation of the above example



NODE NETWORKS (AON)



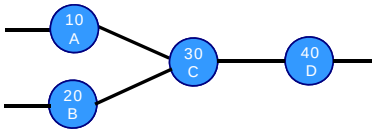
a) Independent Activities



B depends on A

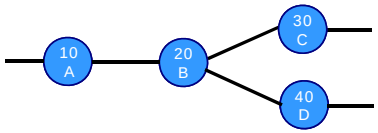
b) Dependent Activities

NODE NETWORKS (AON)



C depends on A & B
D depends on C

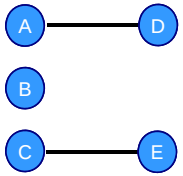
c) A Merge Relationship

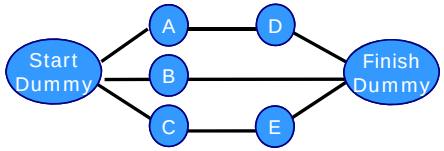


B depends on A
C depends on B
D depends on B

d) A Burst Relationship

NODE NETWORKS (AON)





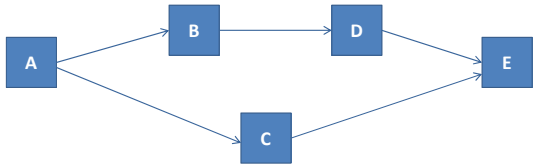
e) Start & Finish Dummy Activities

Example

Draw the node network for the project given next.

Activity	IPA
A	-
B	A
C	A
D	B
E	C,D

Solution

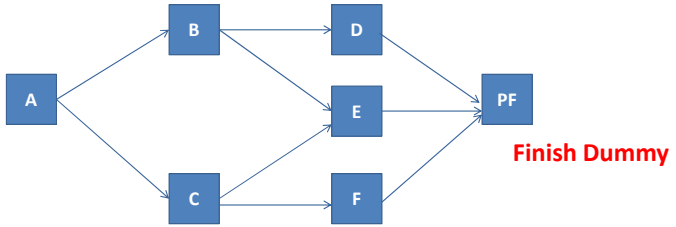


Example

Draw the node network for the project given next.

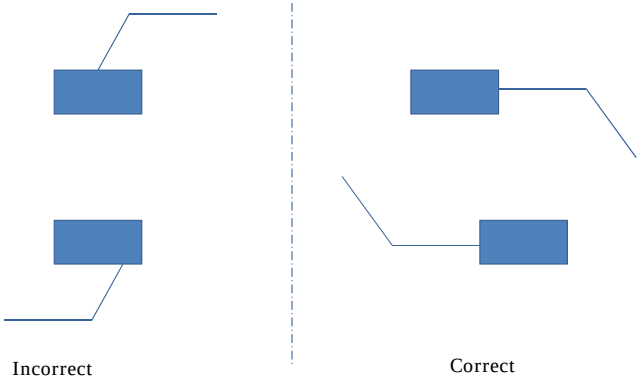
Activity	IPA
A	-
B	A
C	A
D	B
E	B,C
F	C

Solution



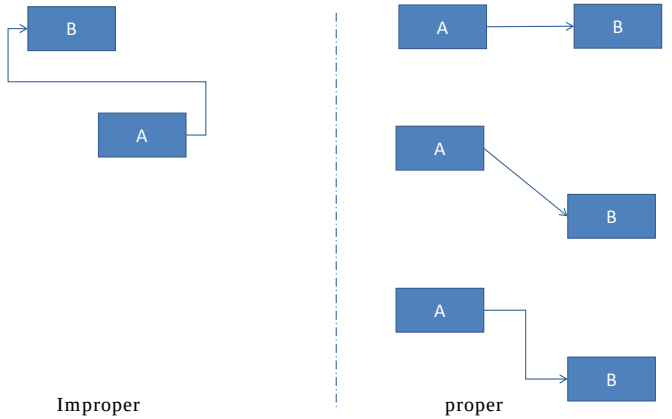
Finish Dummy

Recommendations for Proper Node Diagram Drawing



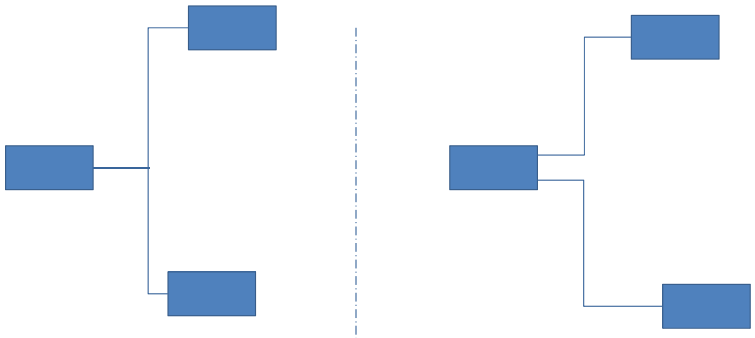
Incorrect Correct

Recommendations for Proper Node Diagram Drawing



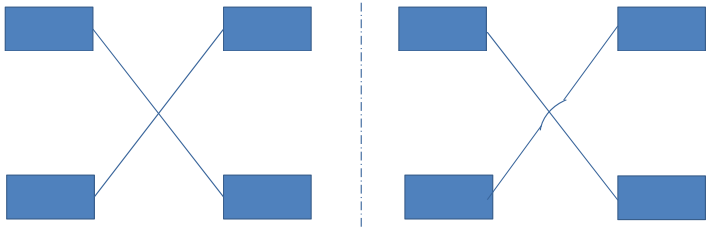
Improper proper

Recommendations for Proper Node Diagram Drawing



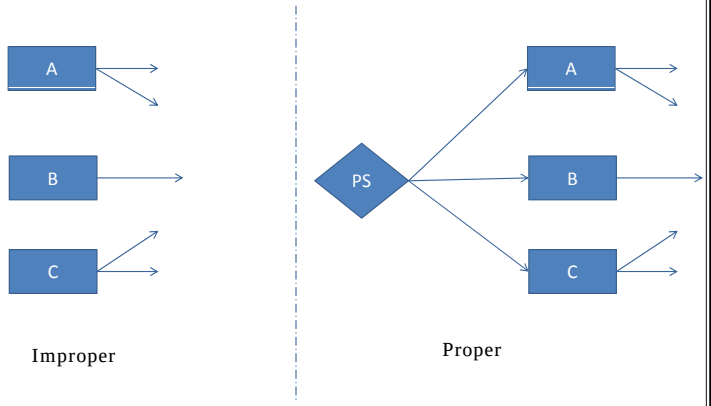
Improper Proper

Recommendations for Proper Node Diagram Drawing



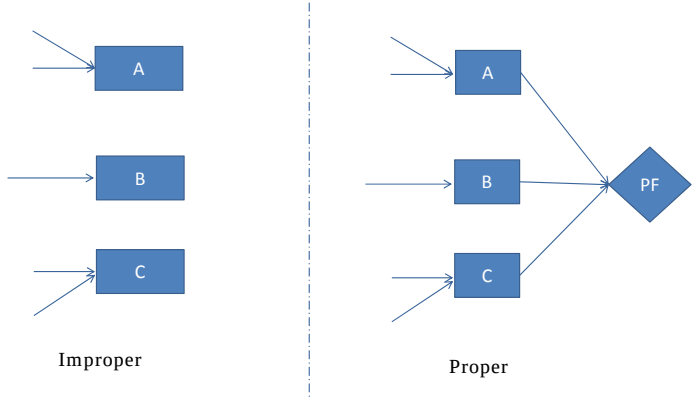
Improper Proper

Recommendations for Proper Node Diagram Drawing



(a) Do not **start** a network with more than one node

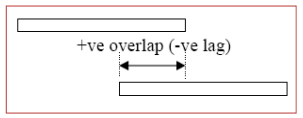
Recommendations for Proper Node Diagram Drawing



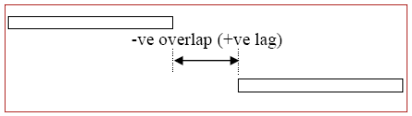
(a) Do not **end** a network with more than one node

Overlap or lag

- Overlap between activities (negative lag) is defined as how much a particular activity must be completed before a succeeding activity may start.
- A negative overlap (positive lag) means a "waiting time" is required between the two activities



negative lag



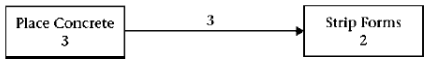
positive lag

Lags and leads

- In some situations, an activity cannot start until a certain time after the end of its predecessor.
- A typical example:
  1. Form the concrete column
  2. Install steel reinforcement (rebar).
  3. Place the concrete
  4. Wait for the concrete to set (attain sufficient strength) This is a **Lag**
  5. Strip the forms

Lags and leads

- A lag is defined as a minimum waiting period between the finish (or start) of an activity and the start (or finish) of its successor.
- A node network can accommodate such a lag if we simply put the lag on the relationship line between Place Concrete and Strip Forms



- Lead simply means a negative lag. It is seldom used in construction. A positive time gap (lag) means ‘‘after’’ and a negative time gap (lead) means ‘‘before.’’

Comparison between AOA and AON

- Both networks can be used to represent a project network,
  - AON are more easily to draw and to read.
  - There is no need for the use of dummy activities in AON representation.
  - AON allows for lag representation
  - AON allows for the representation of the four types of relationships while AOA allows only for the finish to start relationship. In AOA, an activity can only start when all its predecessors have finished.

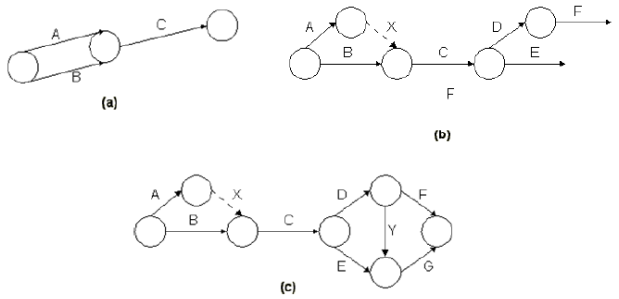
Example

- Construct an AOA and AON networks for the activities listed

Activity	Predecessors
A	-
B	-
C	A, B
D	C
E	C
F	D
G	D, E

AOA solution

- Begin by drawing activities A, B and C as shown in (a)
- Placing activity G presents a problem shown in (b)



AON solution

- Include project start and finish nodes
- Dummy activities are not required for expressing precedence relationships

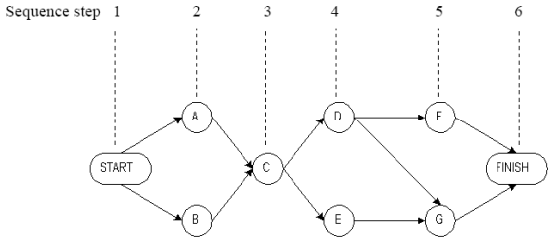


Figure 3.17: An AON Network