Chapter 3

Basic Networks

Basic Network

- A **network** is a logical and chronological graphic representation of the activities (and events) composing a project.
- Network diagrams are the preferred technique for showing activity sequencing.
- Two main formats are the arrow and precedence diagramming methods.

Network Diagrams

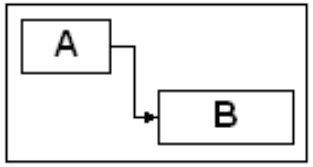
- Two classic formats
  - AOA: Activity on Arrow
  - AON: Activity on Node
- Each task labeled with
    - Identifier (usually a letter/code)
    - Duration (in std. unit like days)
- There are other variations of labeling
- There is 1 start & 1 end event
- Time goes from left to right

Arrow Diagramming Method (ADM)

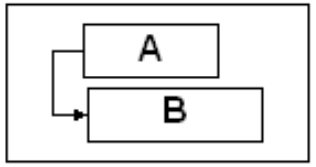
- Also called activity-on-arrow (AOA) network diagram or (I-J) method (because activities are defined by the form node, I, and the to node, J)
- Activities are represented by arrows.
- Nodes or circles are the starting and ending points of activities.
- Can only show finish-to-start dependencies.

Task Dependency Relationships

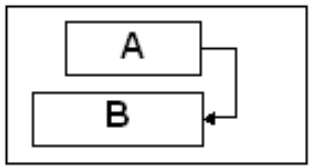
- Finish-to-Start (FS)
  - B cannot start till A finishes
  - A: Construct fence; B: Paint Fence



- Start-to-Start (SS)
  - B cannot start till A starts
  - A: Pour foundation; B: Level concrete

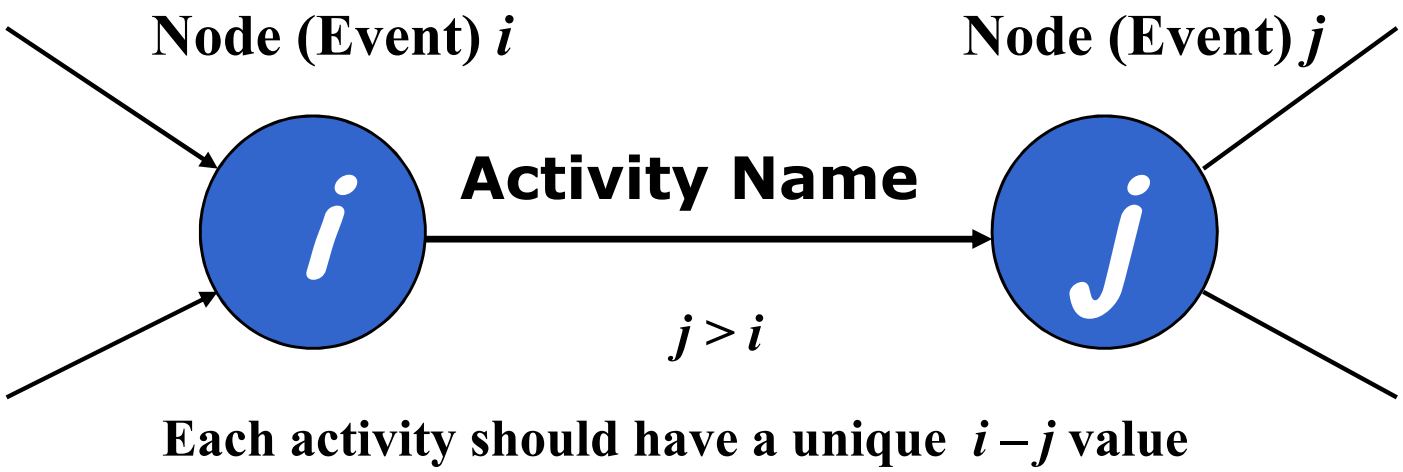


- Finish-to-Finish (FF)
  - B cannot finish till A finishes
  - A: Add wiring; B: Inspect electrical



- Start-to-Finish (SF)
  - B cannot finish till A starts (rare)

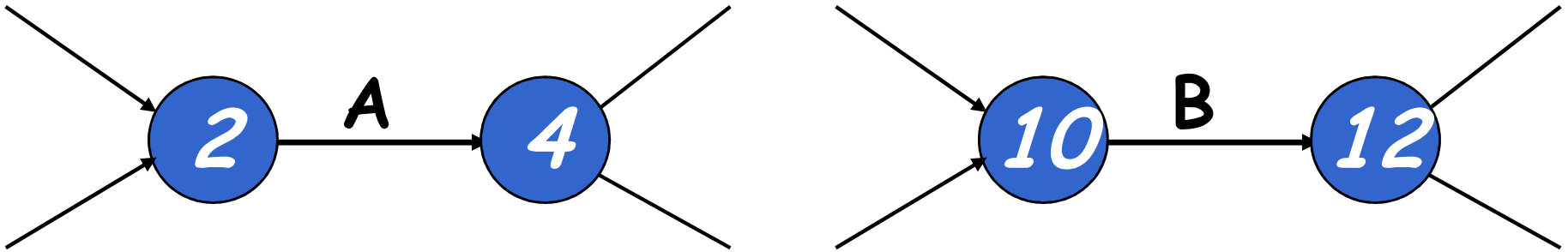
Basic Logic Patterns for Arrow Diagrams



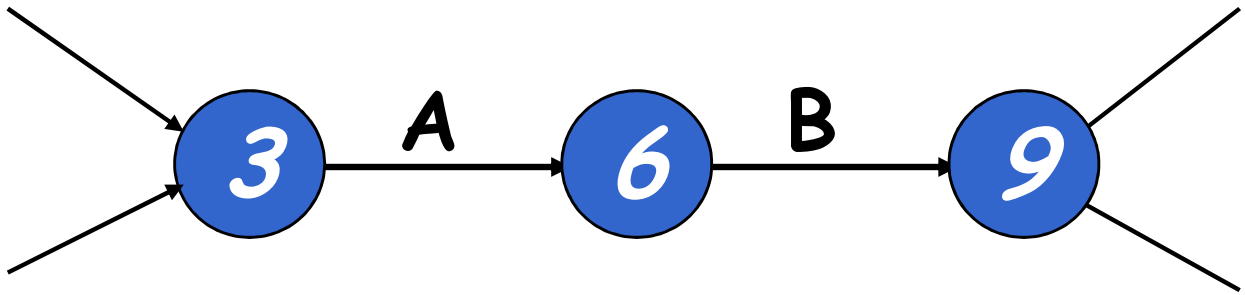
Each activity should have a unique $i-j$ value

(a) Basic Activity

Basic Logic Patterns for Arrow Diagrams (cont.)

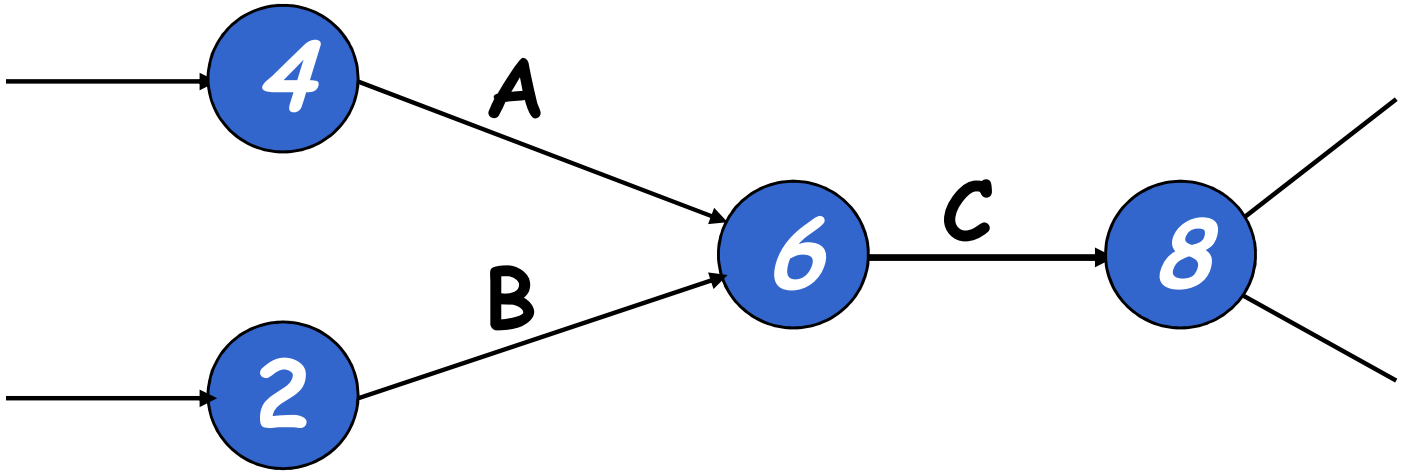


(b) Independent Activities



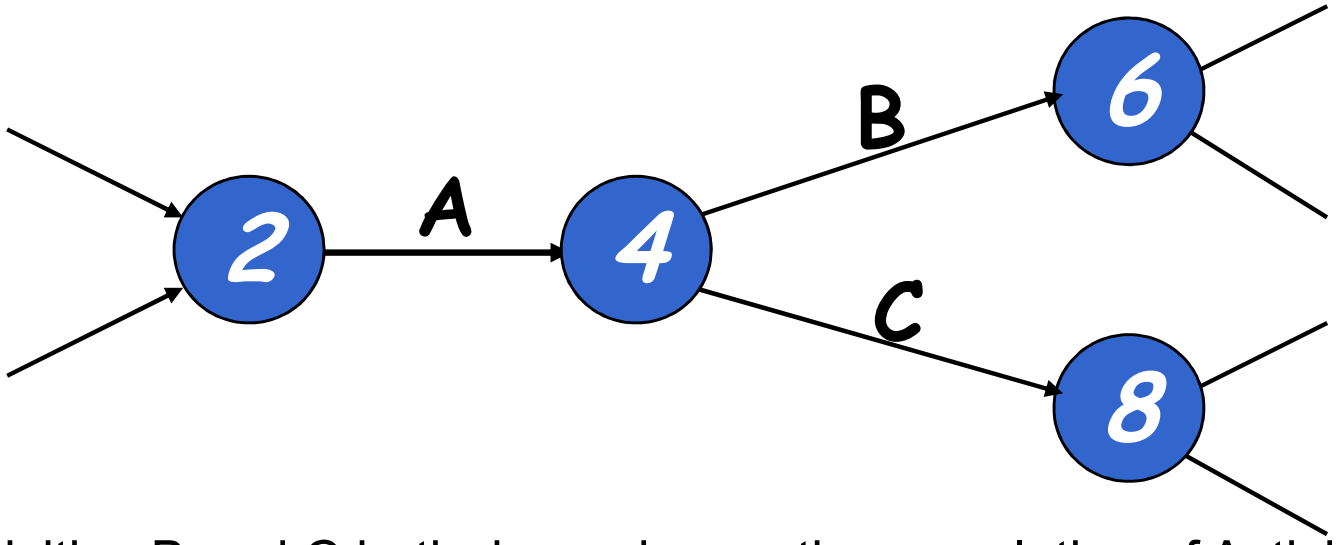
(c) Dependent Activities

Basic Logic Patterns for Arrow Diagrams (cont.)



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

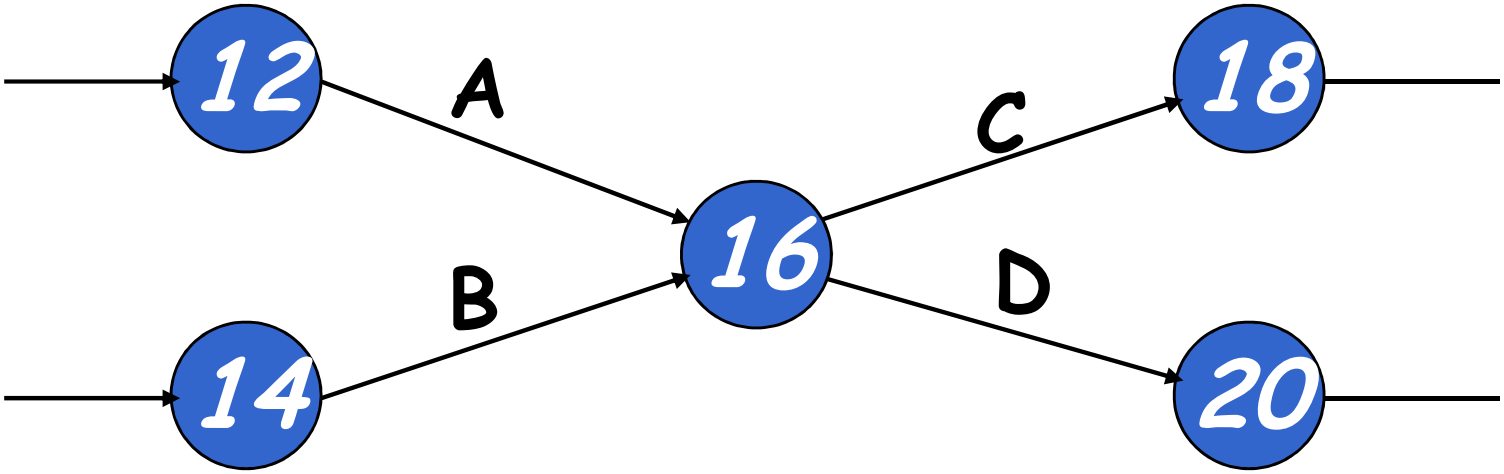
(d) A Merge



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

(e) A Burst

Basic Logic Patterns for Arrow Diagrams (cont.)



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

(f) A Cross

EXAMPLE 3.1

Draw the arrow network for the project given next.

ACTIVITY	IPA[a]
A	—
B	A
C	A
D	B
E	C, D

Solution

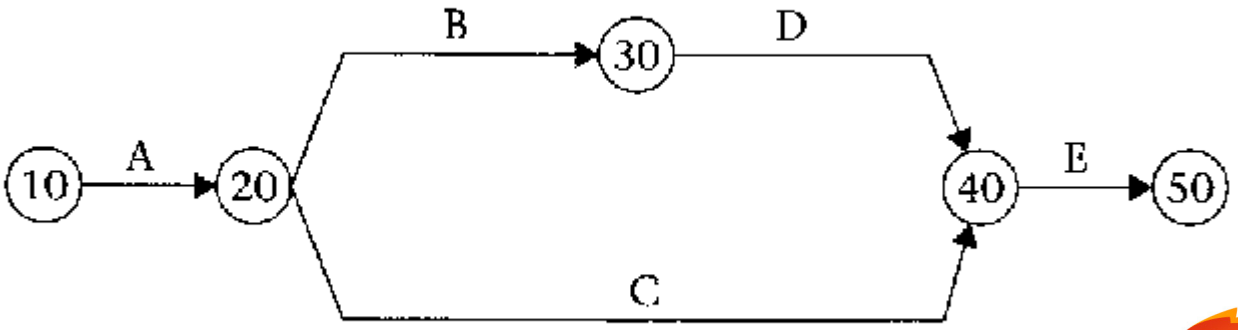


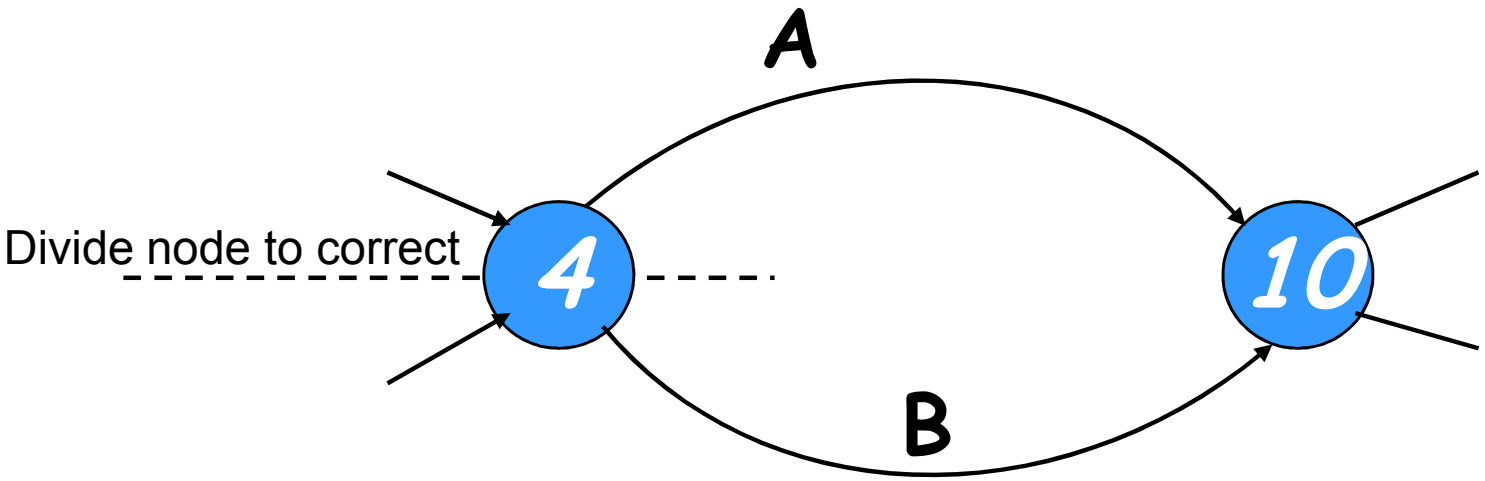
FIGURE 3.1 Solution for example 3.1: a simple arrow netwc

Dummy activity (fictitious)

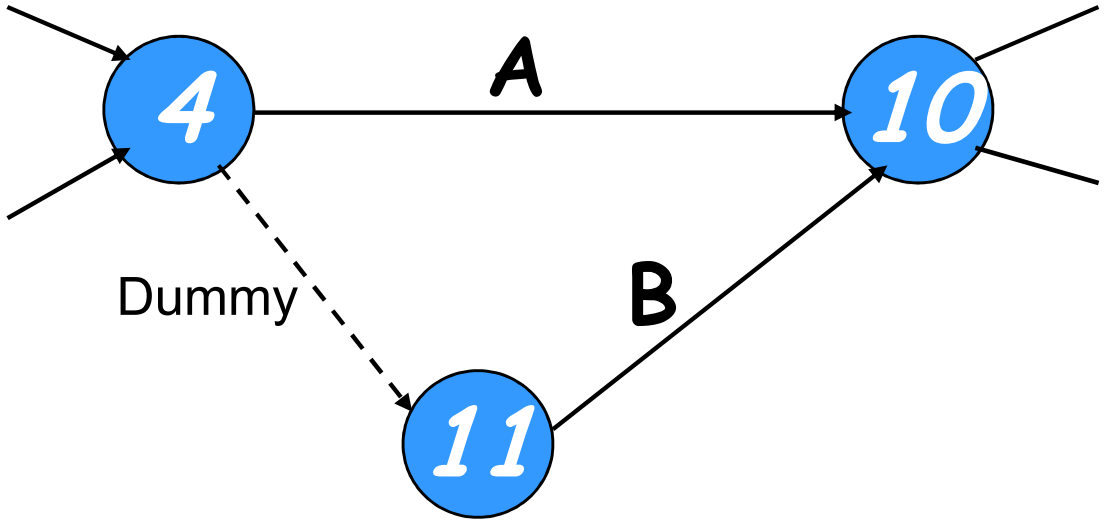
Used to maintain unique numbering of activities.

Used to complete logic, duration of “0”

The use of dummy to maintain unique numbering of activities



(a) Incorrect Representation



(b) Correct Representation

EXAMPLE 3.2

Draw the arrow network for the project given next.

ACTIVITY	IPA
A	—
B	A
C	A
D	B, C

Solution A

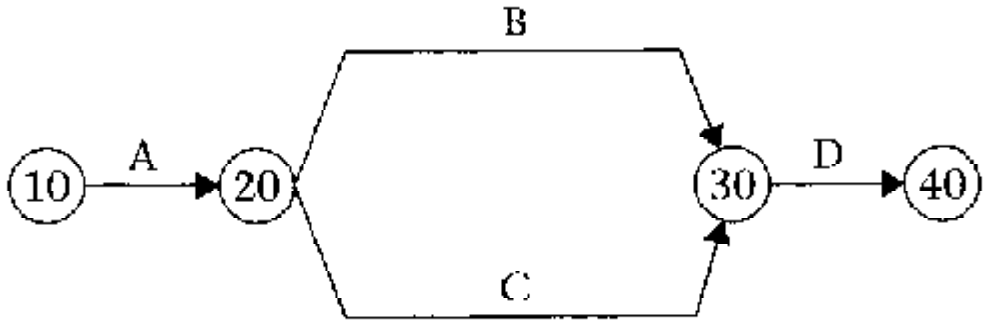


FIGURE 3.2a Improper solution for example 3.2

Solution A

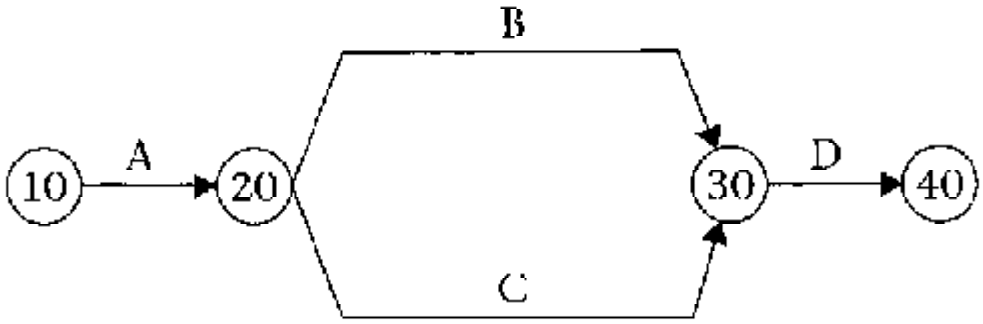


FIGURE 3.2a Improper solution for example 3.2

Solution B

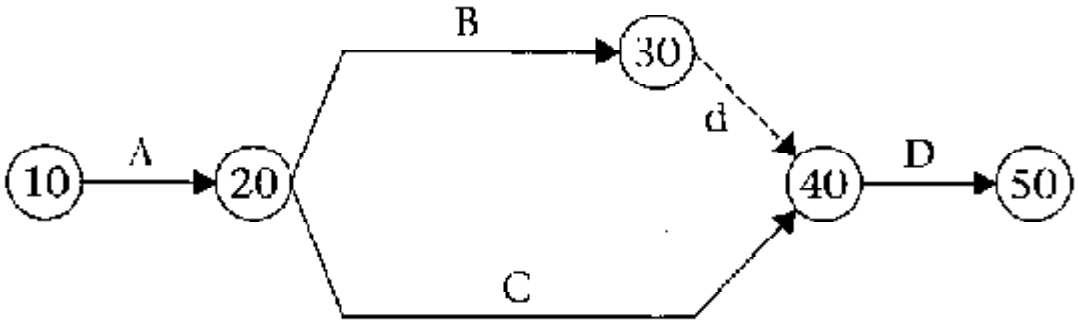


FIGURE 3.2b Proper solution for example 3.2

Other Solutions

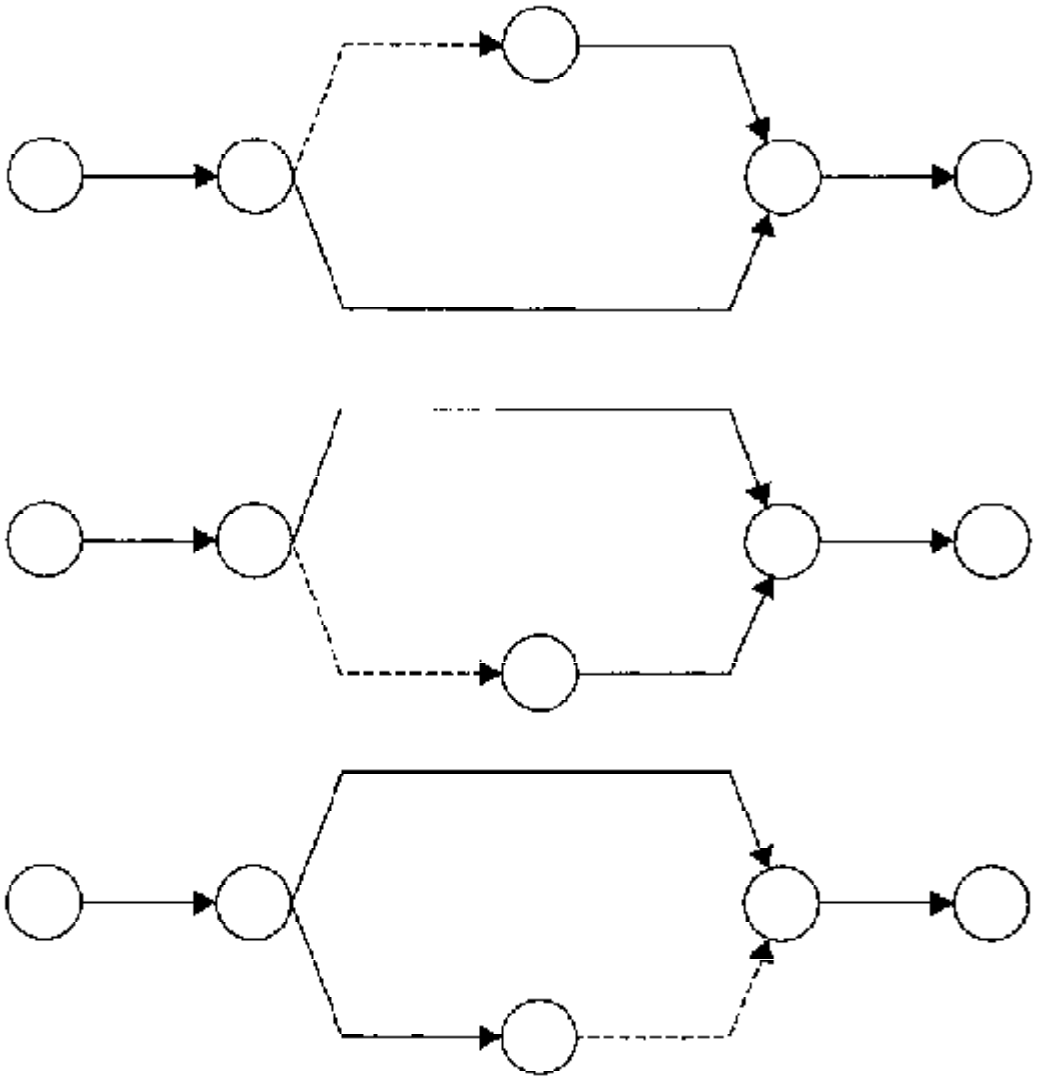


FIGURE 3.2c Other proper solutions for example 3.2

EXAMPLE 3.4

Draw the arrow network for the project given next.

ACTIVITY	IPA
A	—
B	A
C	A
D	B
E	B, C
F	C

Solution

The solution requires two dummy activities (or simply *dummies*).

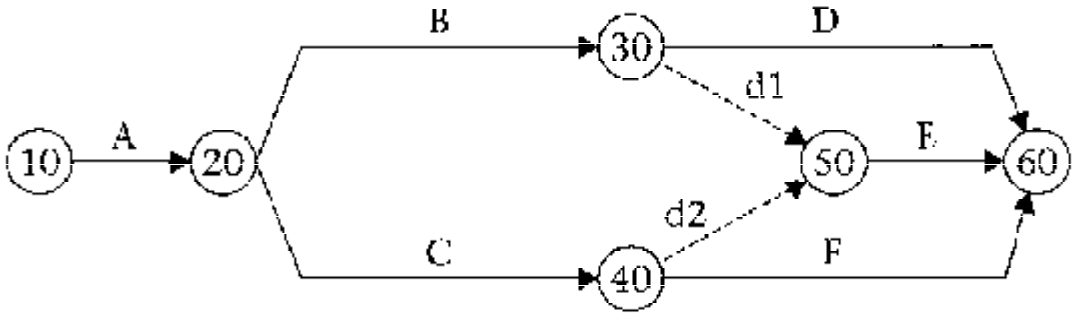


FIGURE 3.4 Solution for example 3.4

EXAMPLE 3.7

Draw the arrow network for the project given next.

ACTIVITY	IPA	ACTIVITY	IPA
A	—	H	C, D
B	A	I	D
C	A	J	E, F, G
D	A	K	F, G, H
E	B	L	H, I
F	B, C	M	K, L
G	C		

Solution

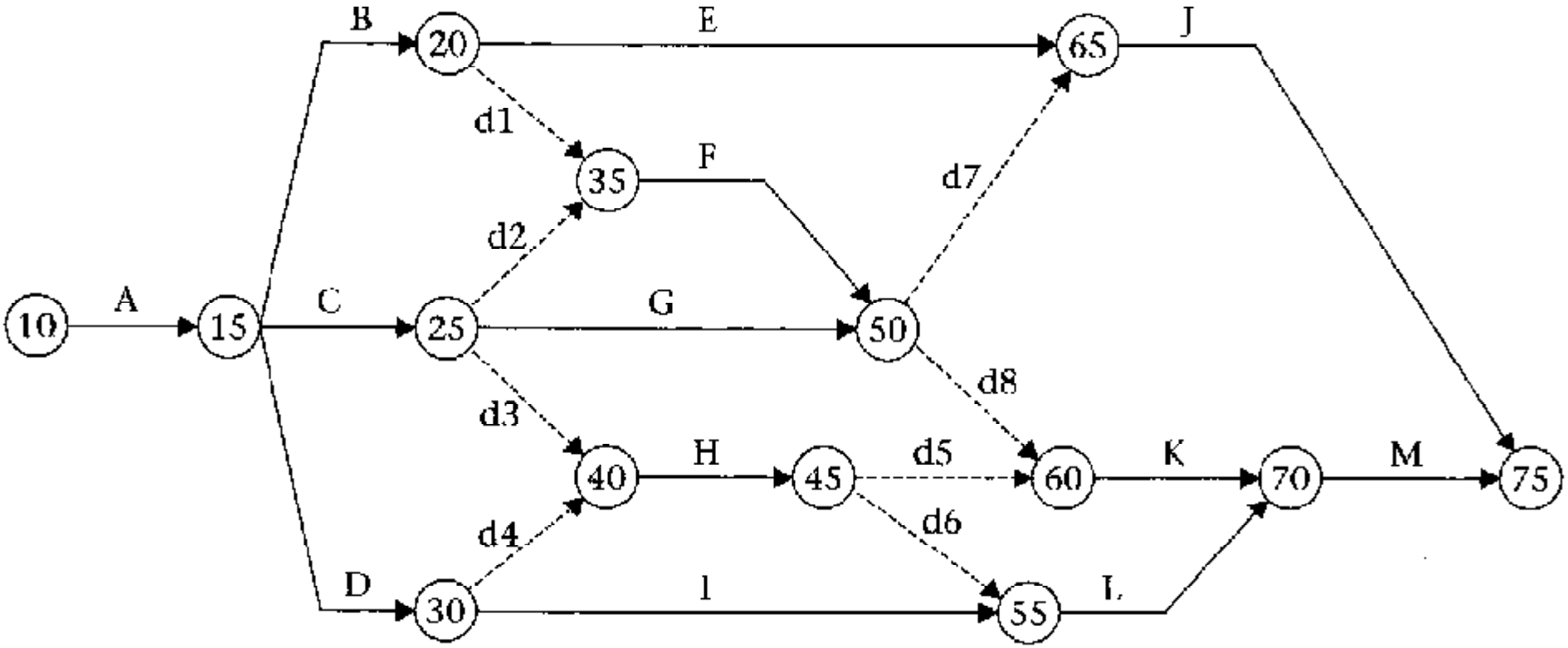


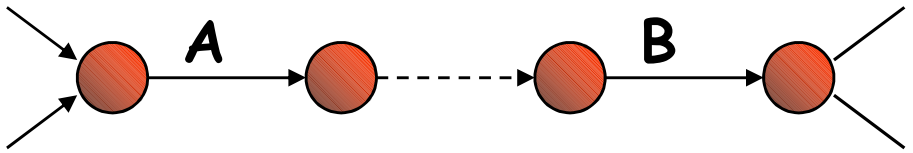
FIGURE 3.7 Solution for example 3.7

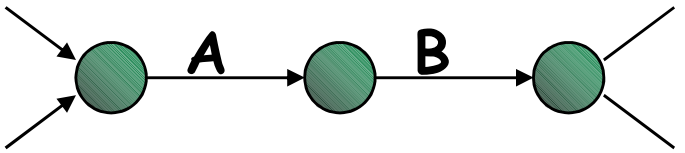
Removal of Redundant Dummies

Original Diagram

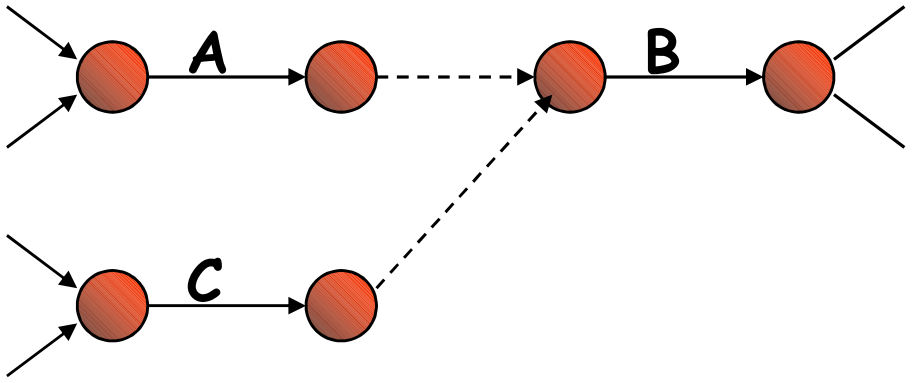
Diagram after removal of redundant dummies

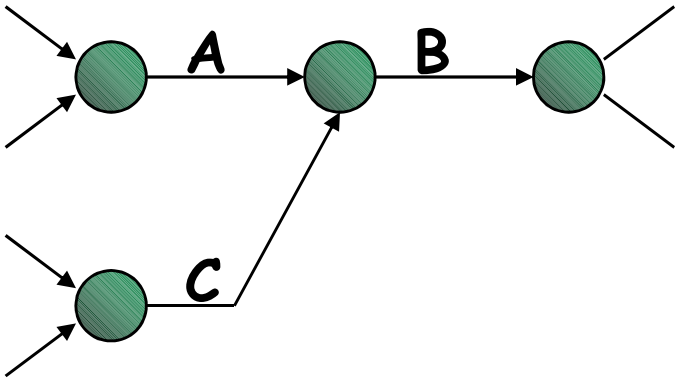
(a)





(b)



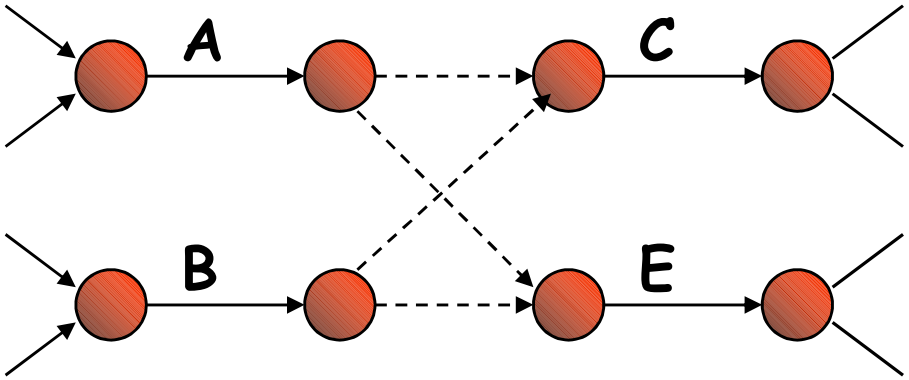


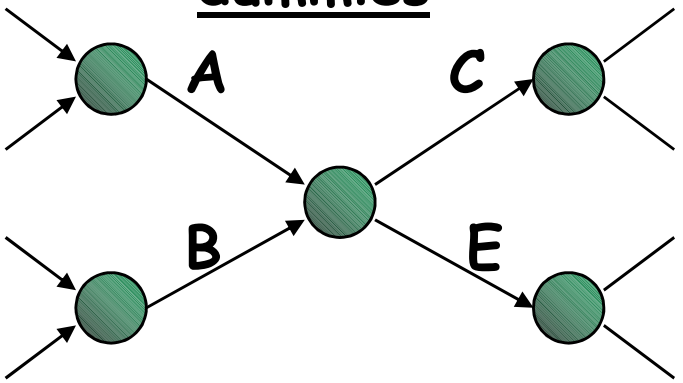
Removal of Redundant Dummies (cont.)

Original Diagram

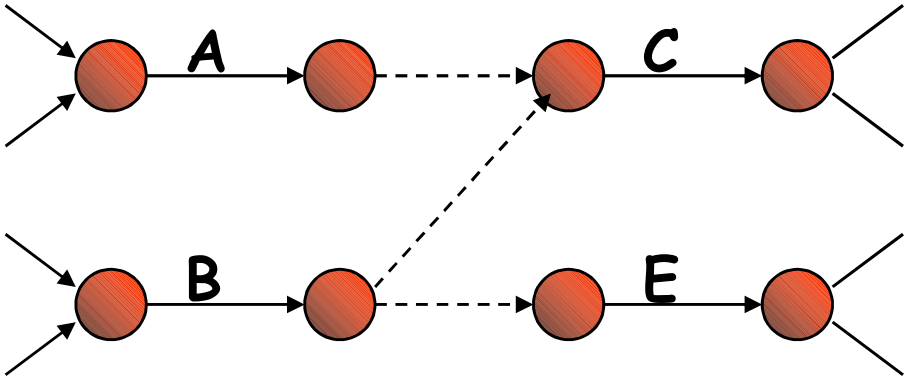
Diagram after removal of redundant dummies

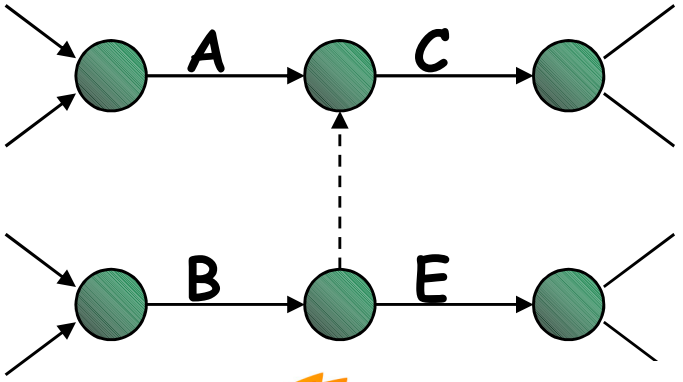
(c)



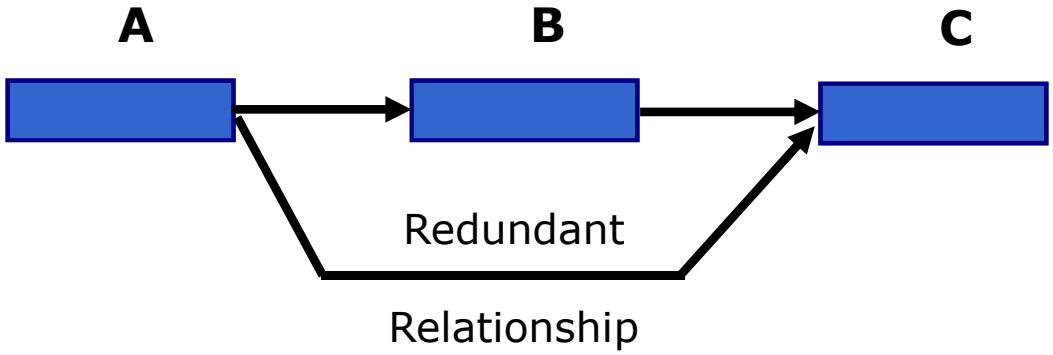


(d)





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

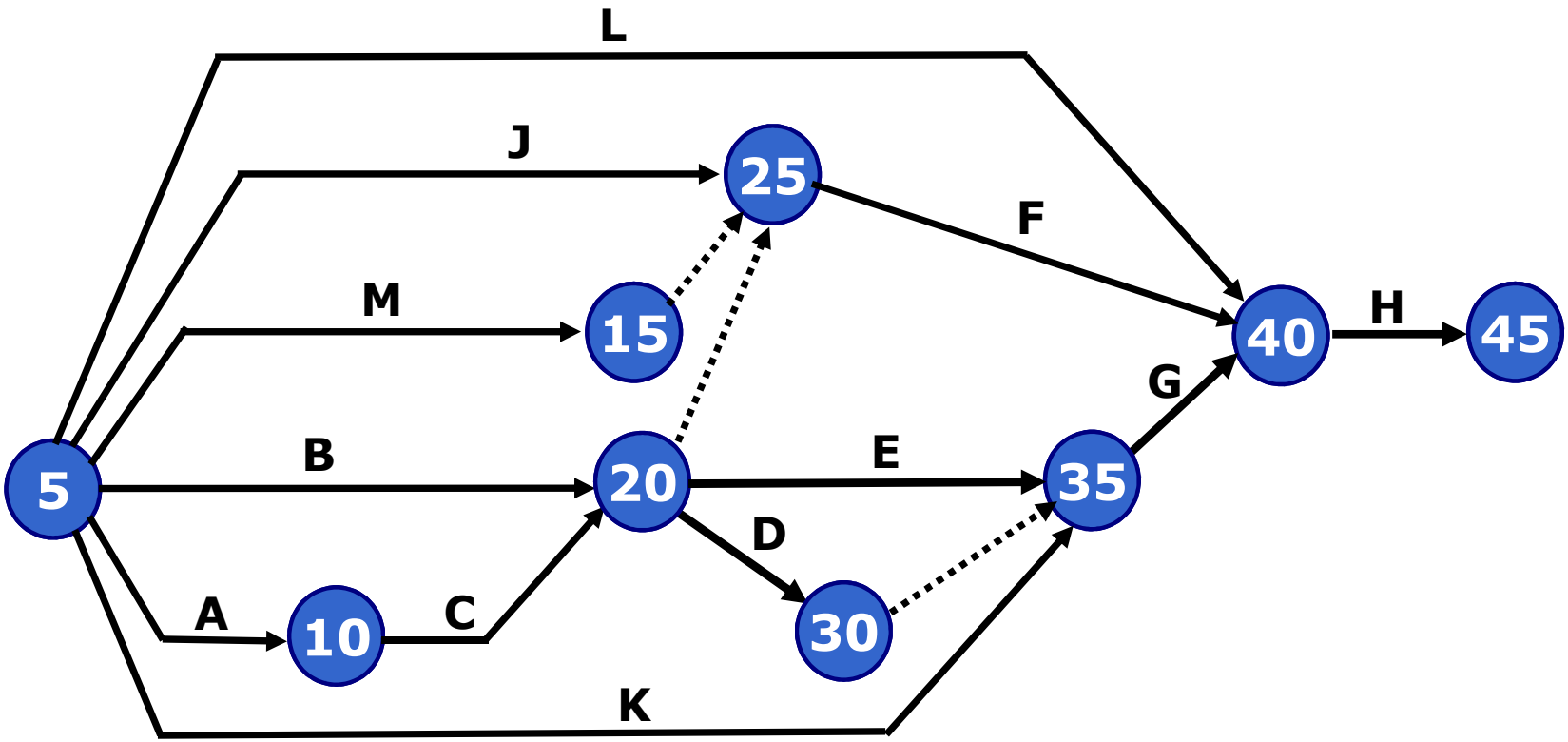


Activity List with Dependencies:

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:

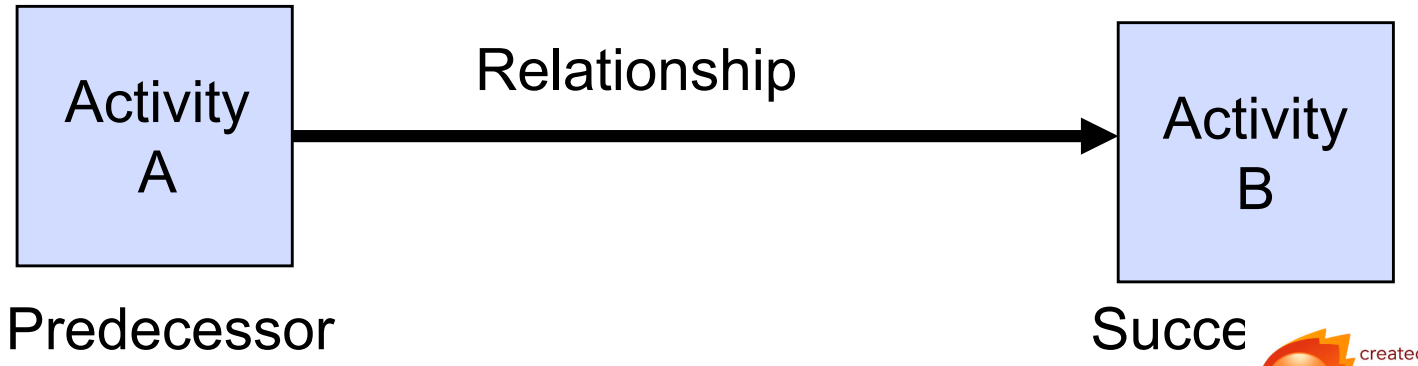
Activity	Description	Depends Upon
A	Site Clearing	-----
B	Removal of Trees	-----
C	Excavation for Foundations	A
D	Site Grading	~~A~~, B, C
E	Excavation for Utility Trenches	~~A~~, B, C
F	Placing formwork & Reinforcement	B, C, J, M
G	Installing sewer lines	~~B~~, ~~C~~, D, E, K
H	Pouring concrete	~~D~~,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



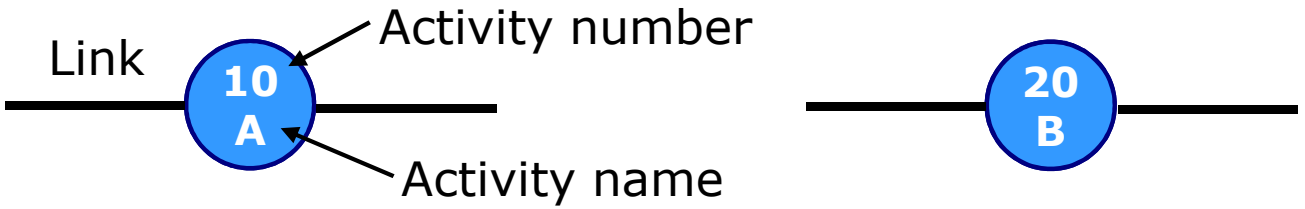
AOA Representation

Precedence Diagramming Method (PDM)

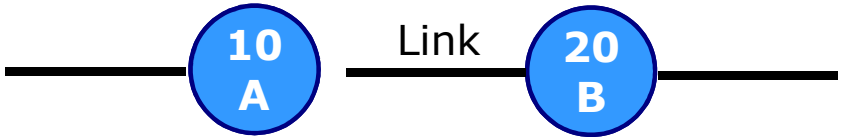
- Activities are represented by boxes.
- Arrows show relationships between activities.
- More popular than ADM method and used by project management software.
- Better at showing different types of dependencies.



Activity-on-Node (AON):

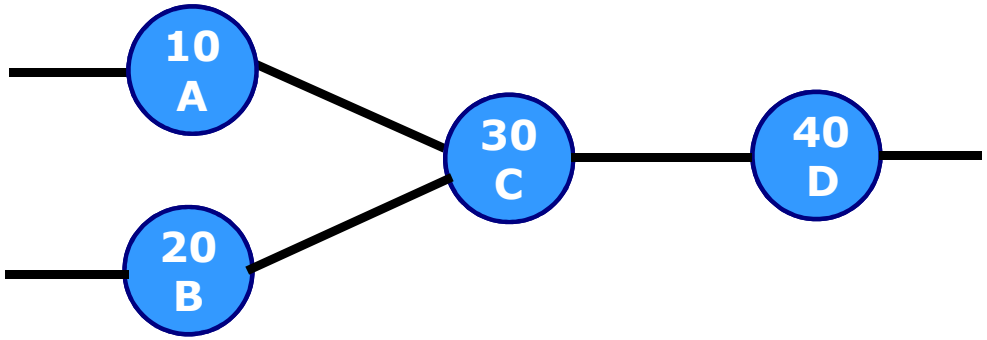


a) Independent Activities



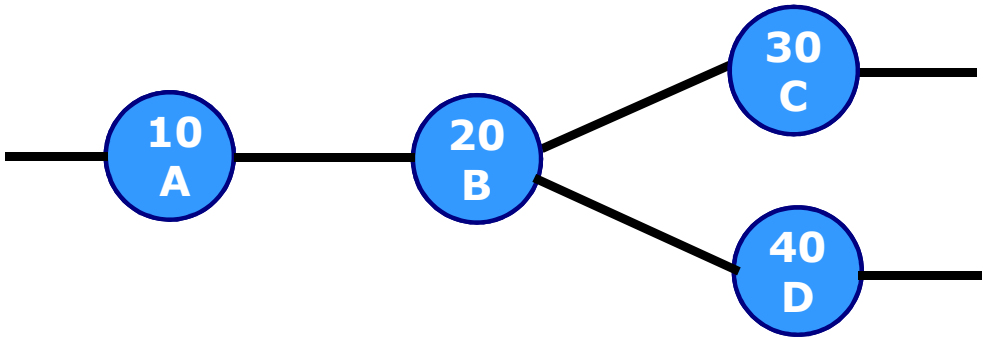
B depends on A

b) Dependent Activities



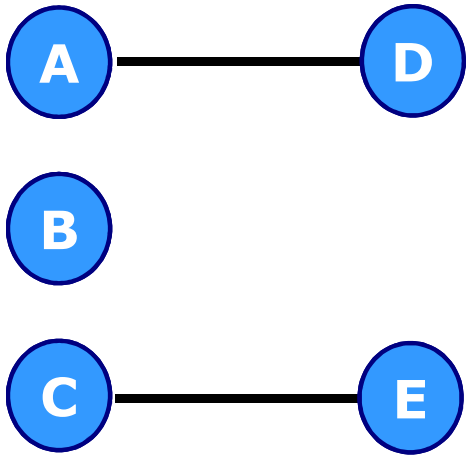
C depends on A & B
D depends on C

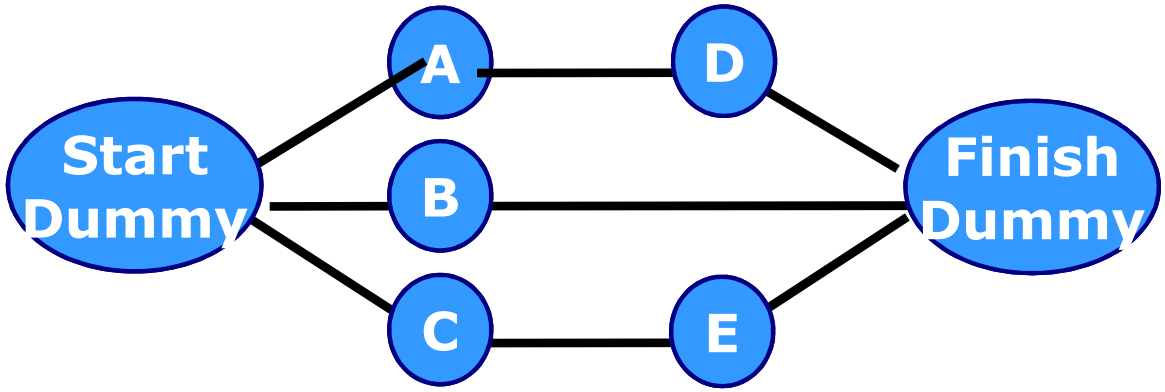
c) A Merge Relationship



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

d) A Burst Relationship





e) Start & Finish Dummy Activities

EXAMPLE 3.1

Draw the arrow network for the project given next.

ACTIVITY	IPA[a]
A	—
B	A
C	A
D	B
E	C, D

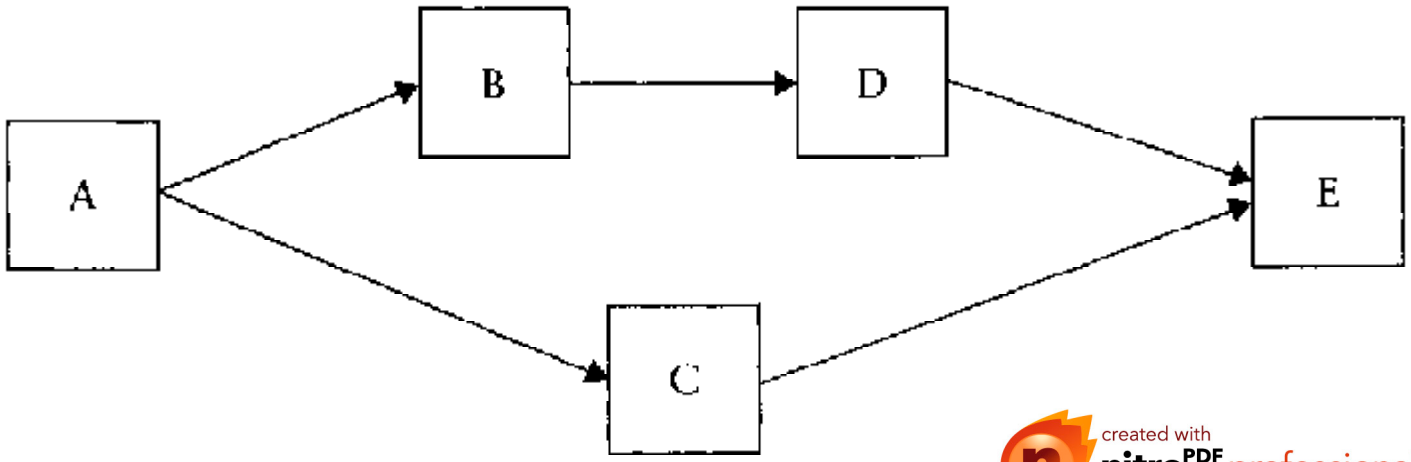


FIGURE 3.9 Solution for example 3.1 as a node network

EXAMPLE 3.2

Draw the arrow network for the project given next.

ACTIVITY	IPA
A	—
B	A
C	A
D	B, C

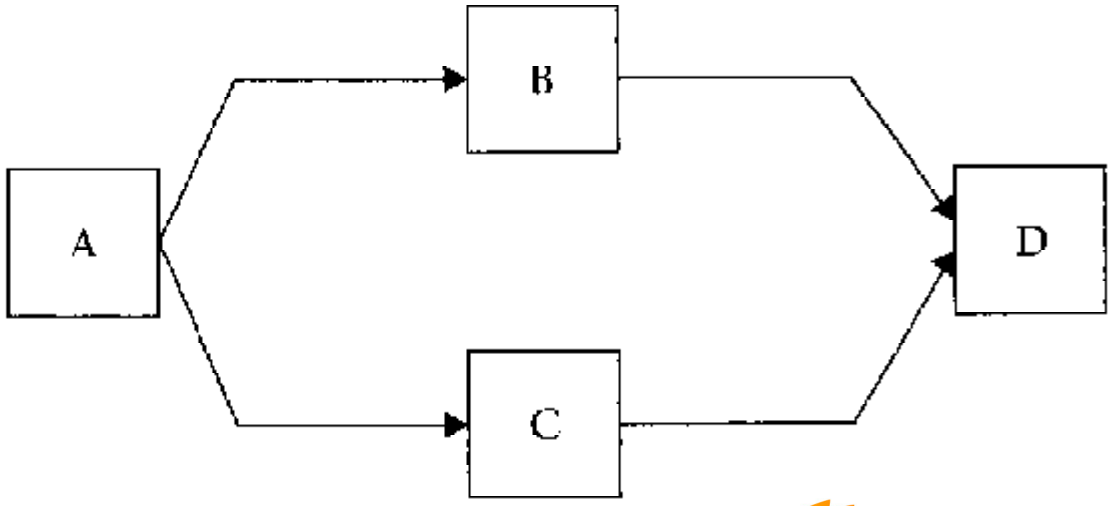


FIGURE 3.10 Solution for example 3.2 as a node netw

EXAMPLE 3.4

Draw the arrow network for the project given next.

ACTIVITY	IPA
A	—
B	A
C	A
D	B
E	B, C
F	C

The solution requires two dummy activities (or simply *dummies*).

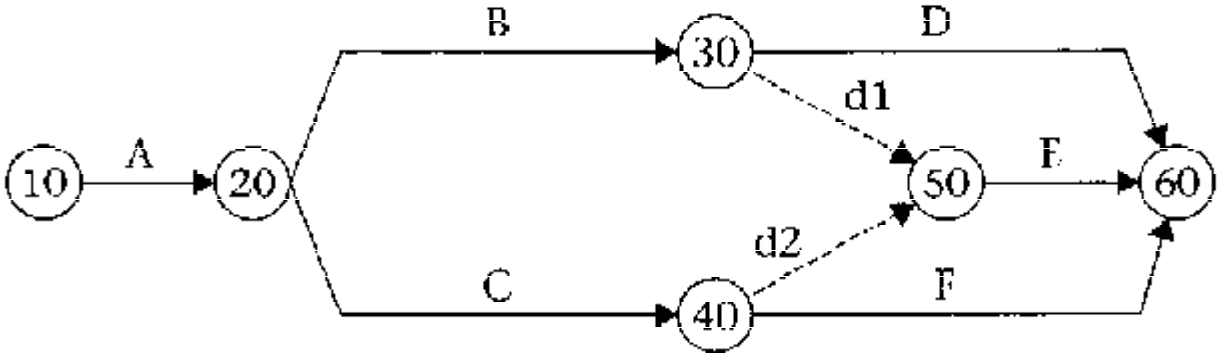


FIGURE 3.4 Solution for example 3.4 as a arrow network

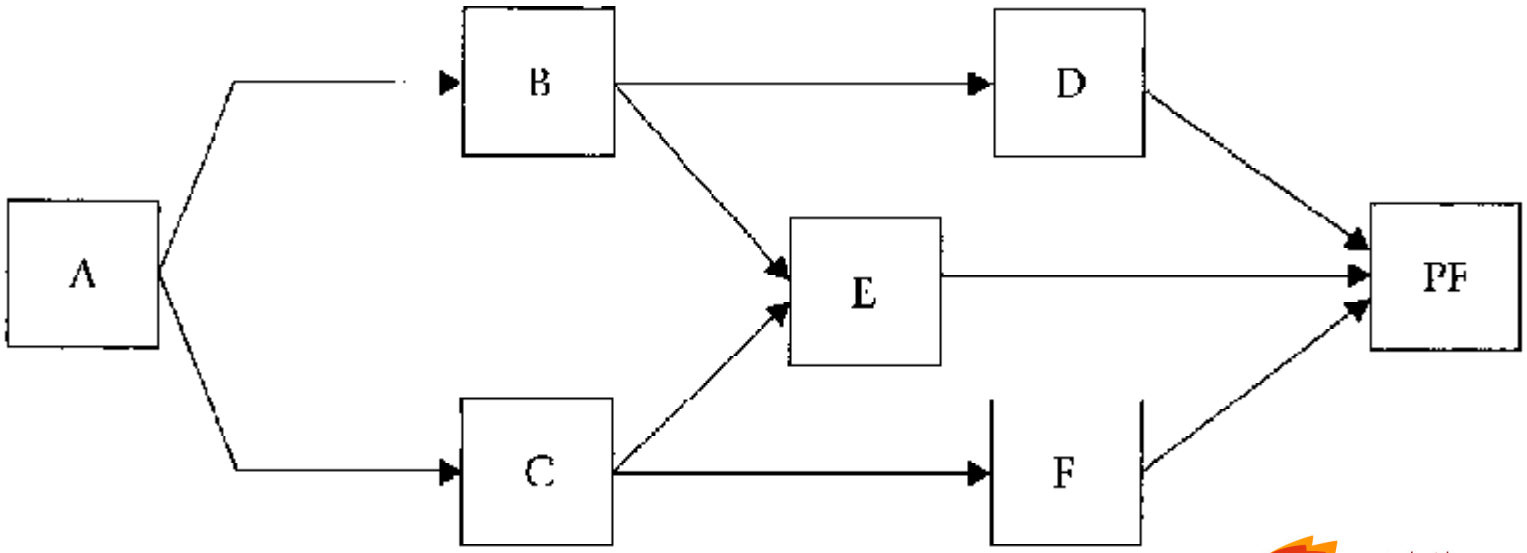


FIGURE 3.12 Solution for example 3.4 as a node network

EXAMPLE 3.7

Draw the arrow network for the project given next.

ACTIVITY	IPA	ACTIVITY	IPA
A	—	H	C, D
B	A	I	D
C	A	J	E, F, G
D	A	K	F, G, H
E	B	L	H, I
F	B, C	M	K, L
G	C		

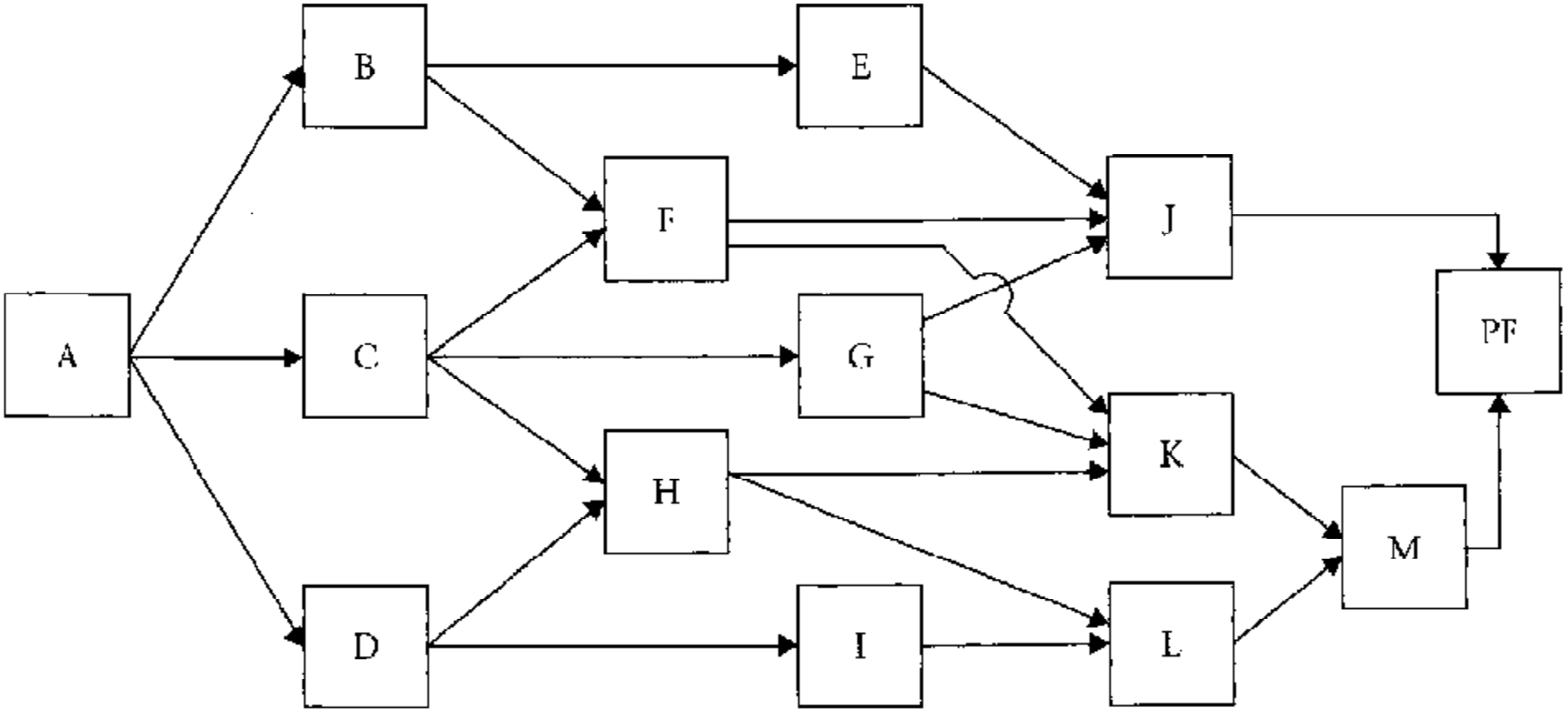


FIGURE 3.15 Solution for example 3.7 as a node network

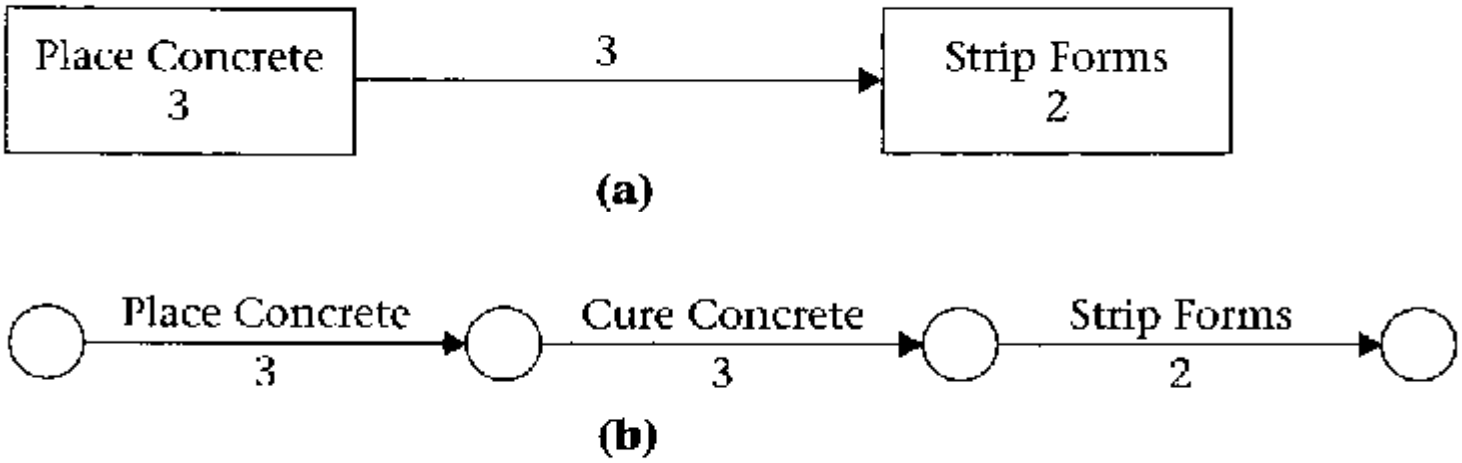


FIGURE 3.16 (a) A lag in a node network; (b) a lag in an arrow network

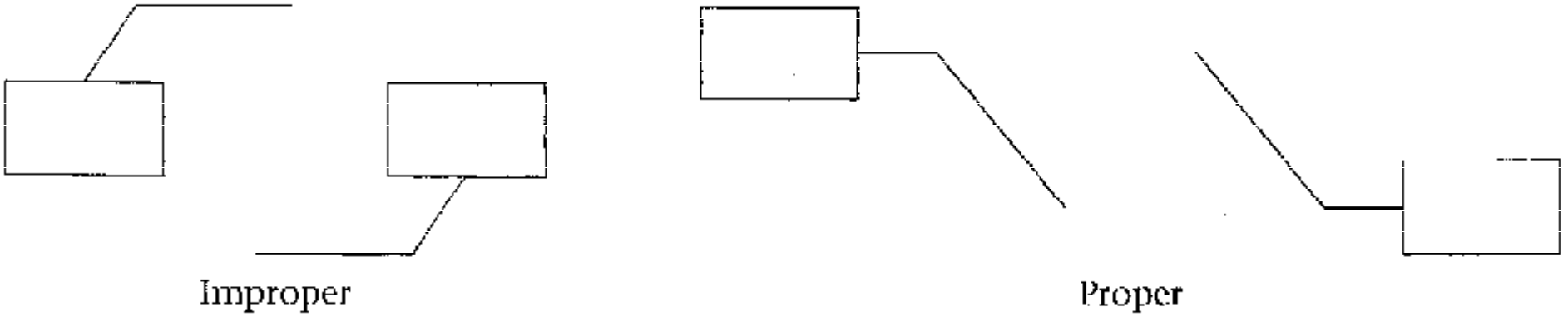


FIGURE 3.17 Node connection in node networks

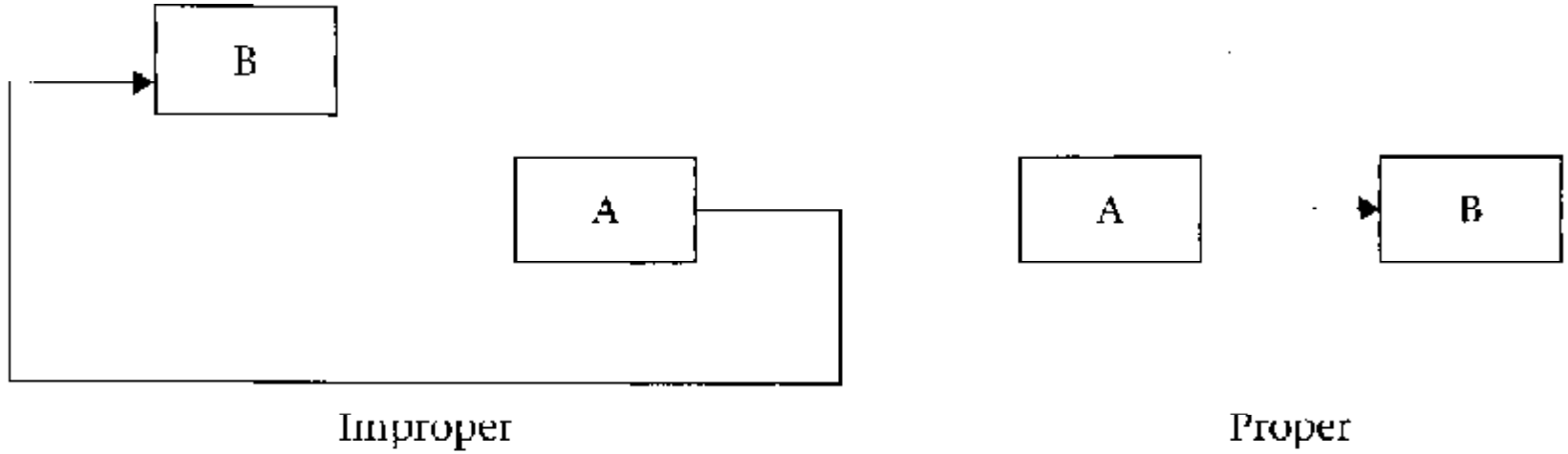


FIGURE 3.18 Node order in node networks

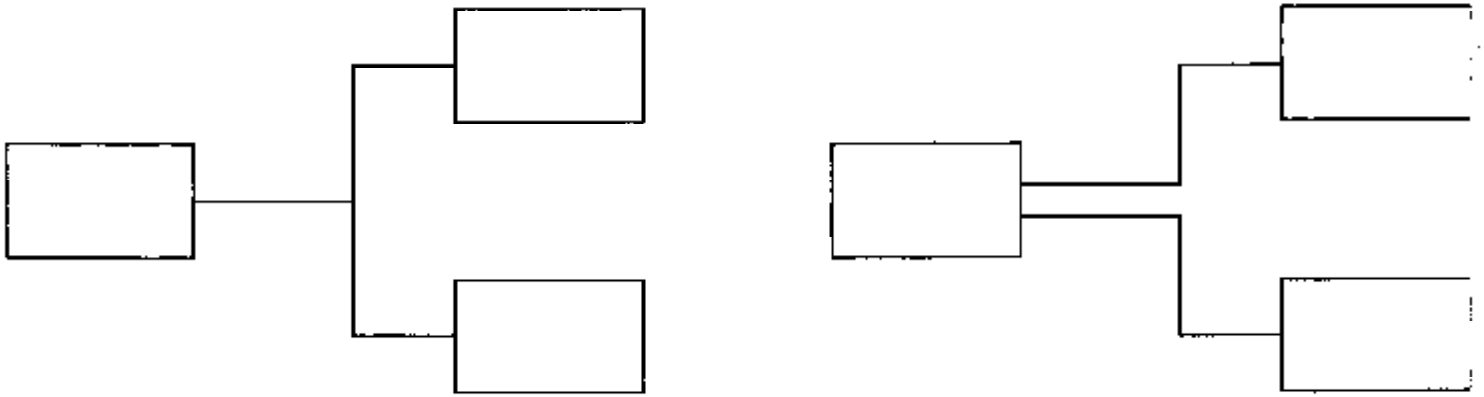


FIGURE 3.19 Relationship lines in node networks

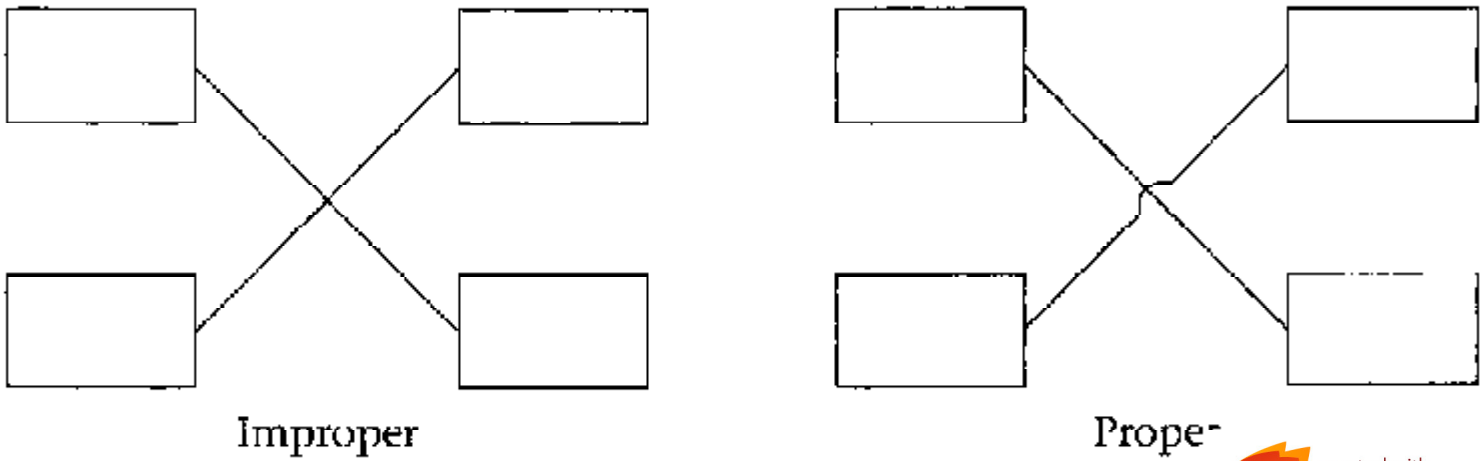


FIGURE 3.20 Intersecting relationship lines in node networks

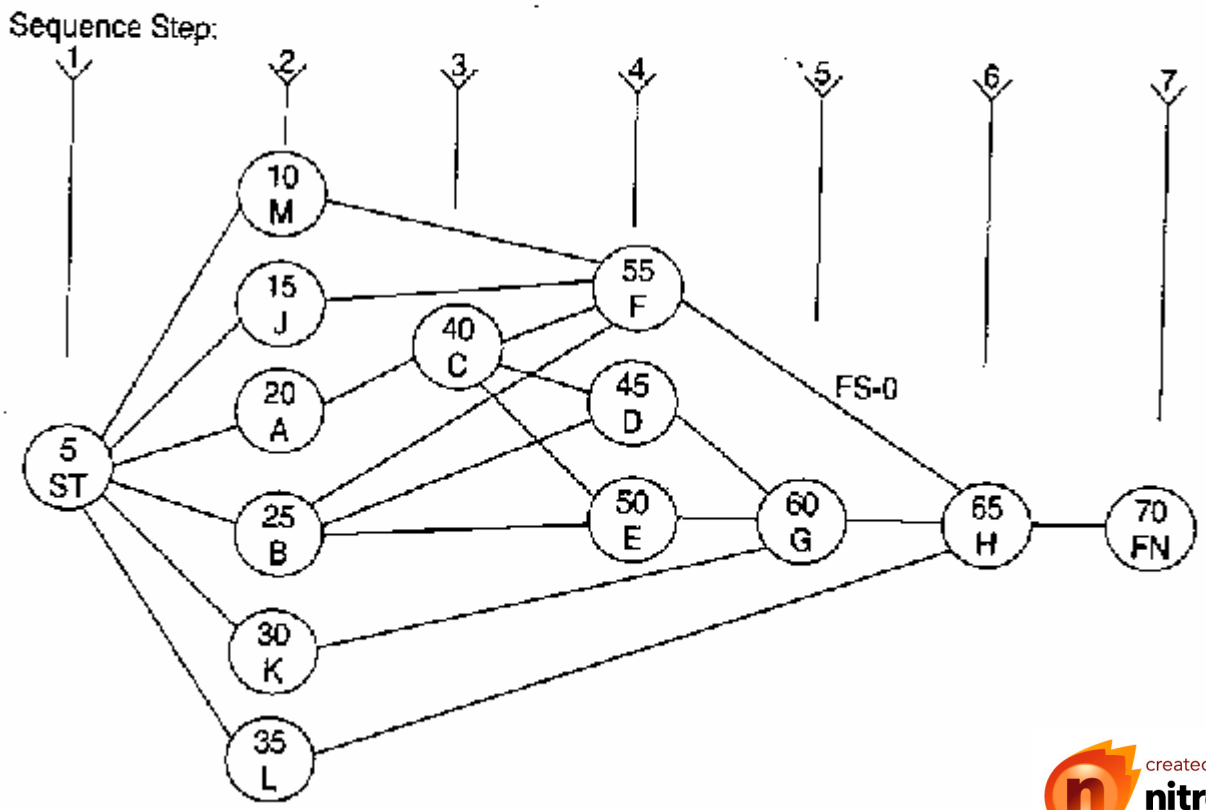
3. Draw the Project Network: Activity-on-Node (**AON**):

Placing Activities in Sequence Steps (Method 2):

Activity	IPAs	Sequence Step
Start (ST)	-----	1
A	ST	1 + 1 = 2
B	ST	1 + 1 = 2
C	A	2 + 1 = 3
D	B, C	3 + 1 = 4
E	B, C	3 + 1 = 4
F	B, C, J, M	3 + 1 = 4
G	D, E, K	4 + 1 = 5
H	F, G, L	5 + 1 = 6
J	ST	1 + 1 = 2
K	ST	1 + 1 = 2
L	ST	1 + 1 = 2
M	ST	1 + 1 = 2

3. Draw the Project Network: Activity-on-Node (**AON**):

Placing Activities in Sequence Steps:

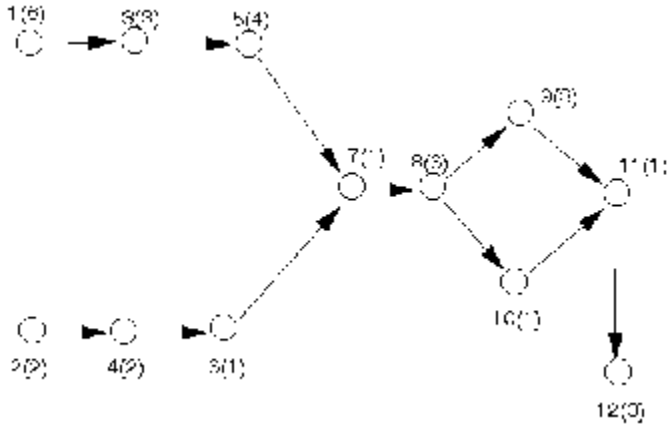


Network Diagrams

- AOA consists of
  - Circles representing Events
    - Such as ‘start’ or ‘end’ of a given task
  - Lines representing Tasks
    - Thing being done ‘Build UI’
  - a.k.a. Arrow Diagramming Method (ADM)
- AON
  - Tasks on Nodes
    - Nodes can be circles or rectangles (usually latter)
    - Task information written on node
  - Arrows are dependencies between tasks
  - a.k.a. Precedence Diagramming Method (PDM)

Activity on Node & Activity on Arrow

- Activity on Node
- A completion of an activity is represented by a node



- Activity on Arrow
- An arrow represents a task, while a node is the completion of a task
- Arrows represent order of events

Network Diagrams

- Advantages
  - Show precedence well
  - Reveal interdependencies not shown in other techniques
  - Ability to calculate critical path
  - Ability to perform “what if” exercises

- Disadvantages
  - Default model assumes resources are unlimited
    - You need to incorporate this yourself (Resource Dependencies) when determining the “real” Critical Path
  - Difficult to follow on large projects