CPM: Critical Path Method

DEVELOPING THE PROJECT PLAN

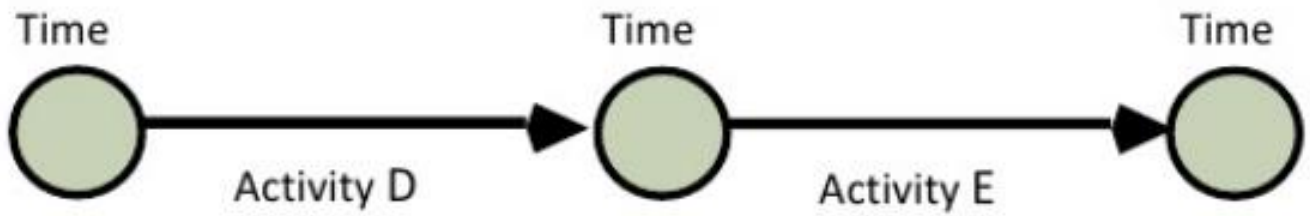
- **The Project Network**
  - **A flow chart that graphically depicts the sequence, interdependencies, and start and finish times of the project job plan of activities that is the *critical path* through the network**
    - **Provides the basis for scheduling labor and equipment**
    - **Provides an estimate of the project's duration**
    - **Provides a basis for budgeting cash flow**
    - **Highlights activities that are "critical" and should not be delayed**
    - **Help managers get and stay on plan**

PROJECT NETWORKS

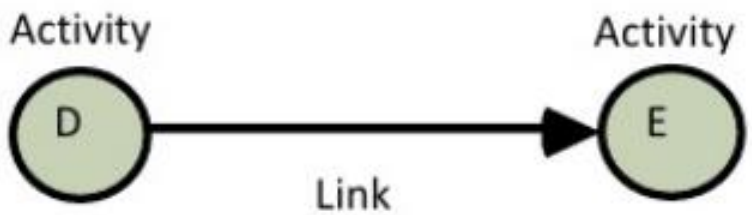
- Two types of project networks
  - Activity-on-Arc (AOA)
    - On this diagram, the activity is represented on an arc, while a node is used to separate an activity from its immediate predecessors.
  - Activity-on-Node (AON)
    - On this diagram, the activity is represented by the node, while the arc is used to show the precedence relationship between the activities.

Two Types of Network Models

Activity-on-Arc (AOA)



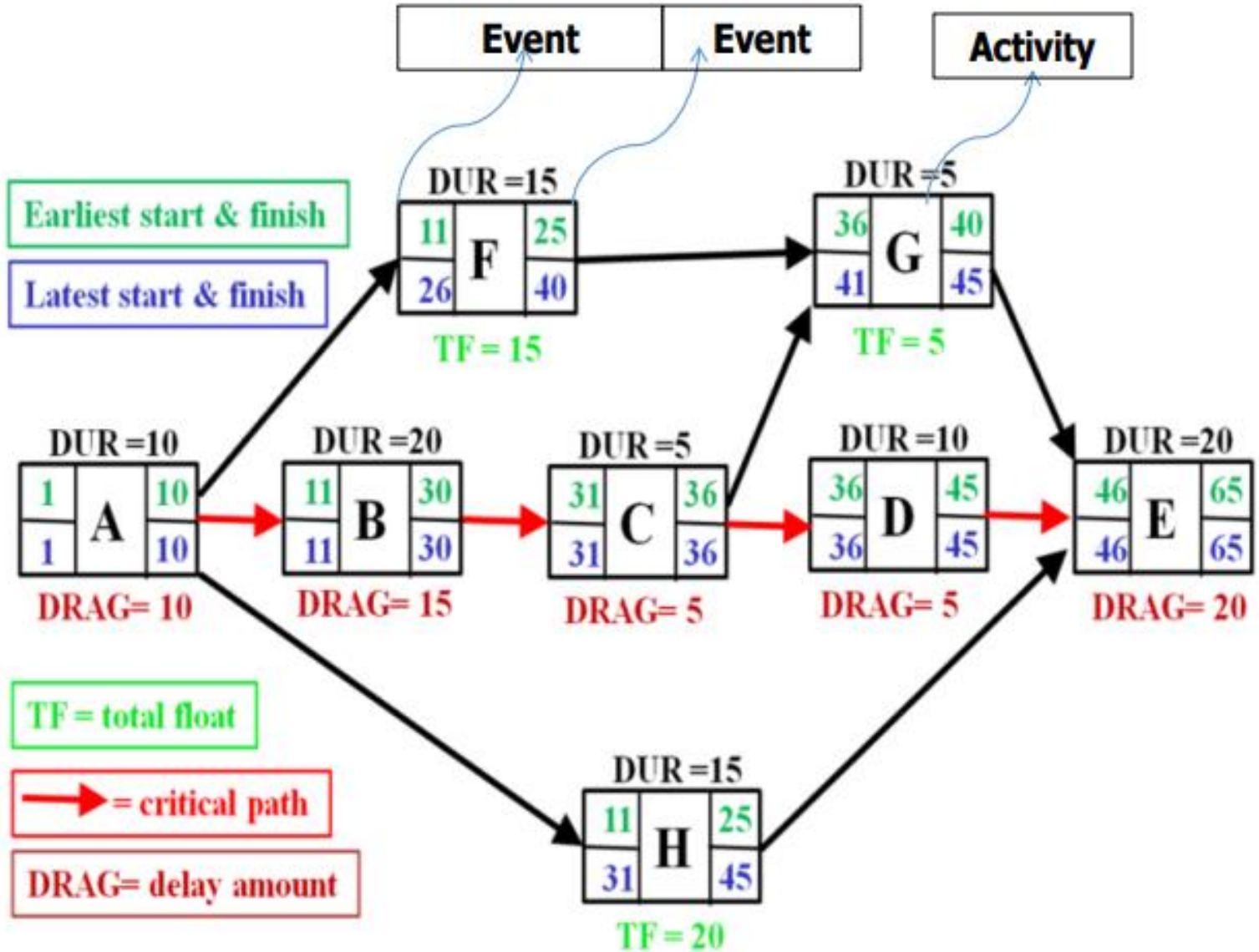
Activity-on-Node (AON)



We will use this!

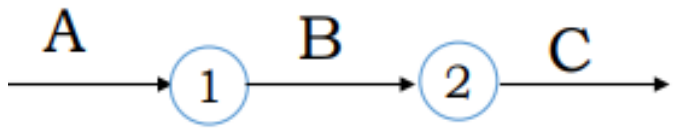
CONSTRUCTING A PROJECT NETWORK

- **EVENT**
  - A point in time when the activity is started or finished; does not consume time
- **ACTIVITY**
  - An element of the project that require time; may or may not required resources
  - Description of activities should use verb/noun format; develop project specifications
- **MERGE ACTIVITY**
  - More than one activity immediately preceding it (more than one arrow flowing to it)
- **PARALLEL ACTIVITIES**
  - Activities that can take place at the same time, if the manager wishes; may or may not occur simultaneously
- **PATH**
  - A sequence of connected, dependent activities
- **CRITICAL PATH**
  - Longest path (s) through the network; if an activity on the path is delayed, the project is delayed the same amount of time.
- **BURST ACTIVITY**
  - More than one activities immediately following it (more than one dependency arrow flowing from it)
- **DUMMY ACTIVITY**
  - A dummy activity, which is normally depicted by a dashed arrow, consumes no time or resources.


Event
Event
Activity
Earliest start & finish
Latest start & finish
DUR =15
11
F
25
26
40
TF = 15
DUR =5
36
G
40
41
45
TF = 5
DUR =10
1
A
10
1
10
DRAG= 10
DUR =20
11
B
30
11
30
DRAG= 15
DUR =5
31
C
36
31
36
DRAG= 5
DUR =10
36
D
45
36
45
DRAG= 5
DUR =20
46
E
65
46
65
DRAG= 20
TF = total float
= critical path
DRAG= delay amount
DUR =15
11
H
25
31
45
TF = 20

Activity–On–Arc Network Fundamentals

Predecessor, Successor & Concurrent or Parallel activities



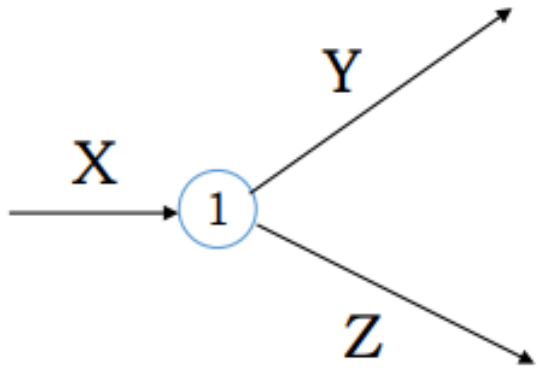
A is preceded by nothing

B is preceded by A

C is preceded by B

(A)

Y and Z are preceded by X

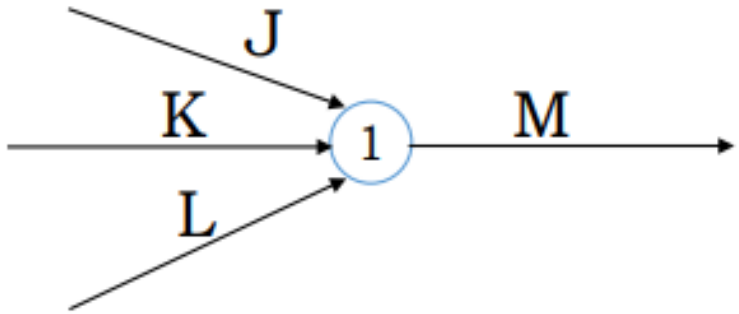


Y and Z can begin at the same time, if you wish

(B)

Activity – On – Arc Network Fundamentals

Predecessor, Successor & Concurrent or Parallel activities

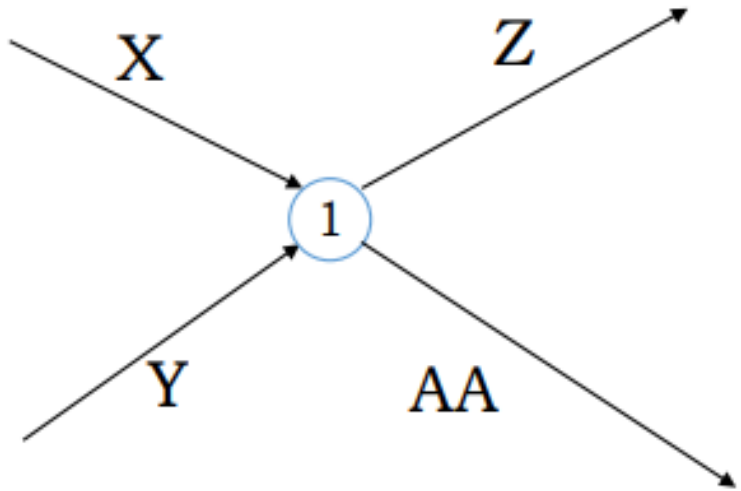


J,K & L can begin at the same time, if you wish (they need not occur simultaneously)

All (J,K,L) must be completed before M can begin

(C)

Z is preceded by X and Y



'AA' is preceded by X and Y

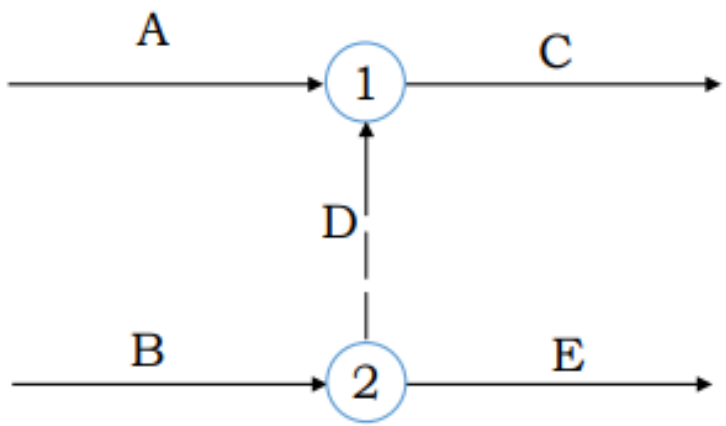
(D)

Activity – On – Arc Network Fundamentals

Predecessor, Successor & Concurrent or Parallel activities

Use of Dummy activity:

1. Activity 'C' can start immediately after 'A' and 'B' are completed.
2. Activity 'E' can start immediately after only 'B' is completed.



Here, 'D' is a Dummy Activity.

imp

BASIC RULES: Developing a project network

EIGHT RULES APPLY:

1. Networks typically flow from left to right.
2. An Activity cannot begin until all preceding activities have been completed.
3. Arrows on networks indicate precedence and flow. Arrows can cross over each other.
4. Each activity should have a unique identification number.
5. An activity identification number must be larger than that of any activities preceding it.
6. Looping in not allowed (in other words recycling through a set of activities cannot take place).
7. Conditional statements are not allowed (i.e. this type of statement should not appear: if successful, do something; if not, do nothing)
8. When there are multiple starts, a common start node can be used to indicate a clear project beginning on the network. Similarly, a single project end, node can be used to indicate a clear ending.

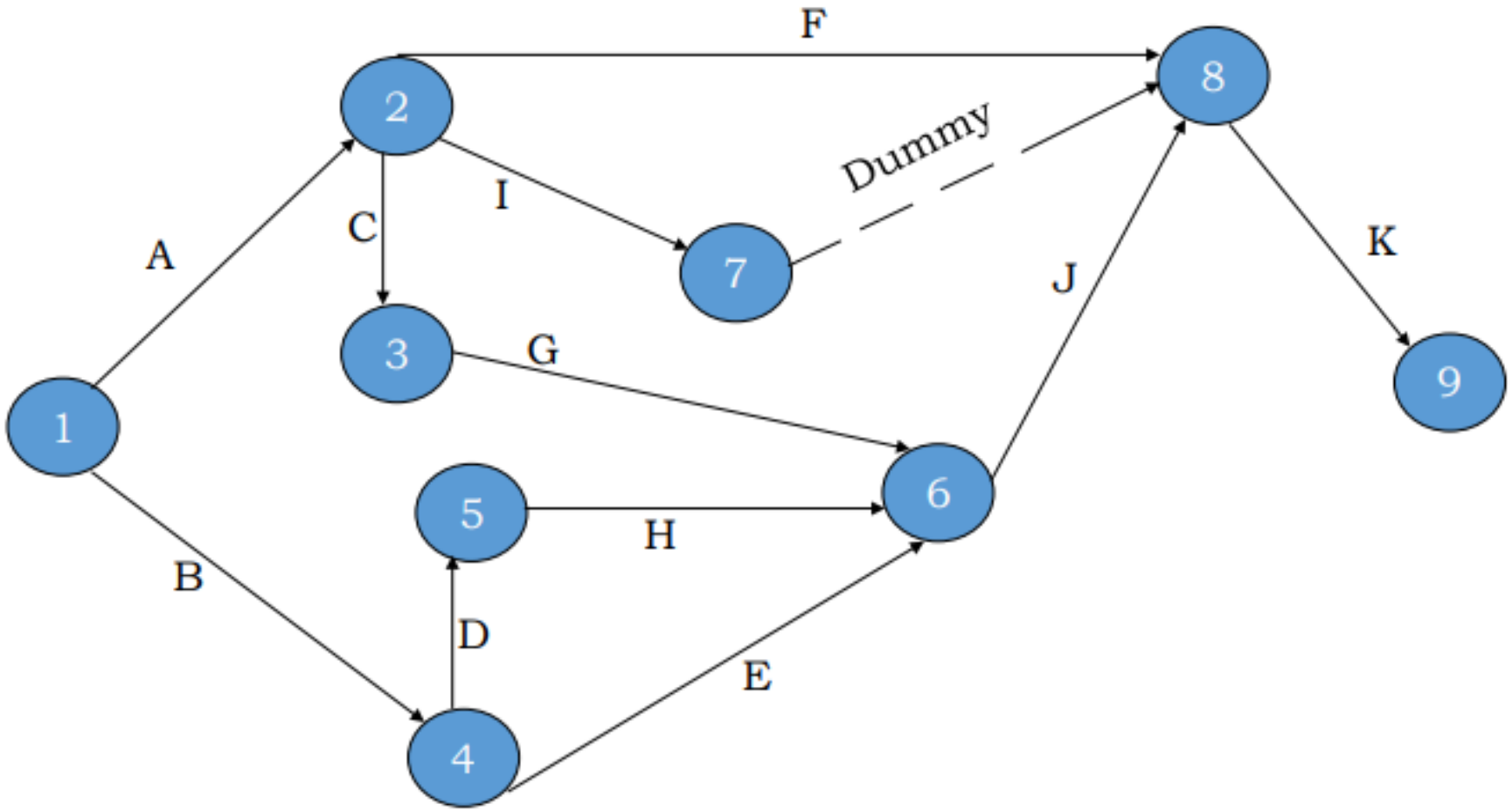
Example: (AON Network)

Consider the following data:

Activity	Description	Immediate Predecessor(s)
A	Select administrative and medical staff	-
B	Select site and do site survey	-
C	Select equipment	A
D	Prepare final construction plans and layout	B
E	Bring utilities to the site	B
F	Interview applicants and fill positions in nursing, support staff, maintenance, & security	A
G	Purchase and take delivery of equipment	C
H	Construct the hospital	D
I	Develop an information system	A
J	Install the equipment	E, G, H
K	Train nurses and support staff	F, I, J

Draw the AON network Diagram.

AOA Network:



PRACTICE QUESTION # 1

Develop the network by yourself.

Activity	Description	Immediate Predecessor(s)
A	Procurement of parts for sub – assembly '1'	None
B	Procurement of parts for sub – assembly '2'	None
C	Procurement of parts for sub – assembly '3'	None
D	Building sub – assembly '1'	A
E	Building sub – assembly '2'	B
F	Building sub – assembly '4'	D,E
G	Building sub – assembly '3'	B,C
H	Building the final product	F,G
I	Final Test	H

PRACTICE QUESTION # 2

Network Information		
Country Engineers Design Department		
ACTIVITY	**DESCRIPTION**	**PROCEDING ACTIVITY**
A	Application Approval	None
B	Construction Plans	A
C	Traffic Study	A
D	Service Availability Check	A
E	Staff Report	B,C
F	Commission Approval	B,C,D
G	Wait for Construction	F
H	Occupancy	E,G

PROJECT NETWORK ANALYSIS: CRITICAL PATH METHOD (CPM)

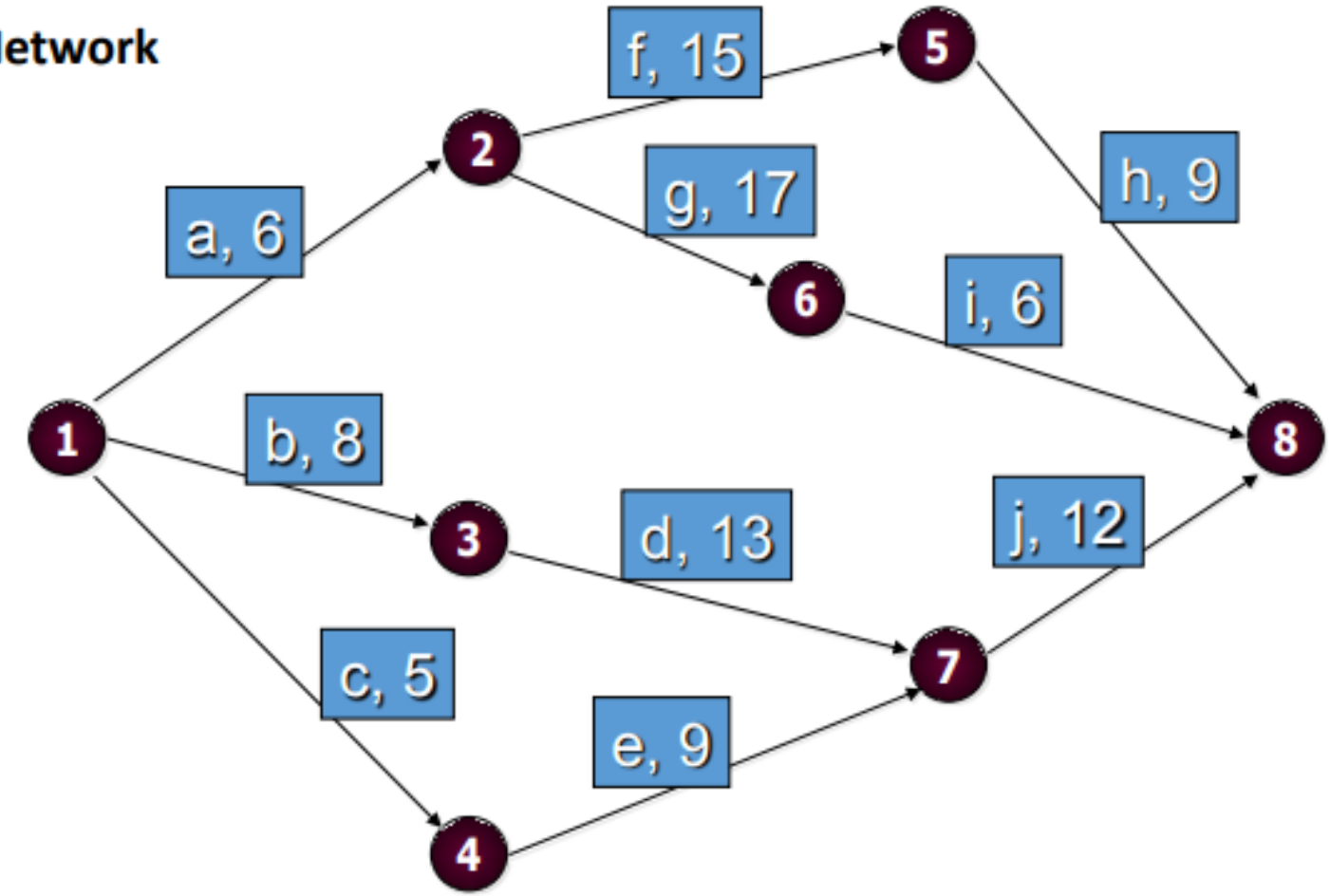
- In 1957 the Critical Path Method (CPM) was developed as a network model for project management. CPM is a deterministic method that uses a fixed time estimate for each activity. While CPM is easy to understand and use, it does not consider the time variations that can have a great impact on the completion time of a complex project.

SIX STEPS COMMON TO PERT/CPM

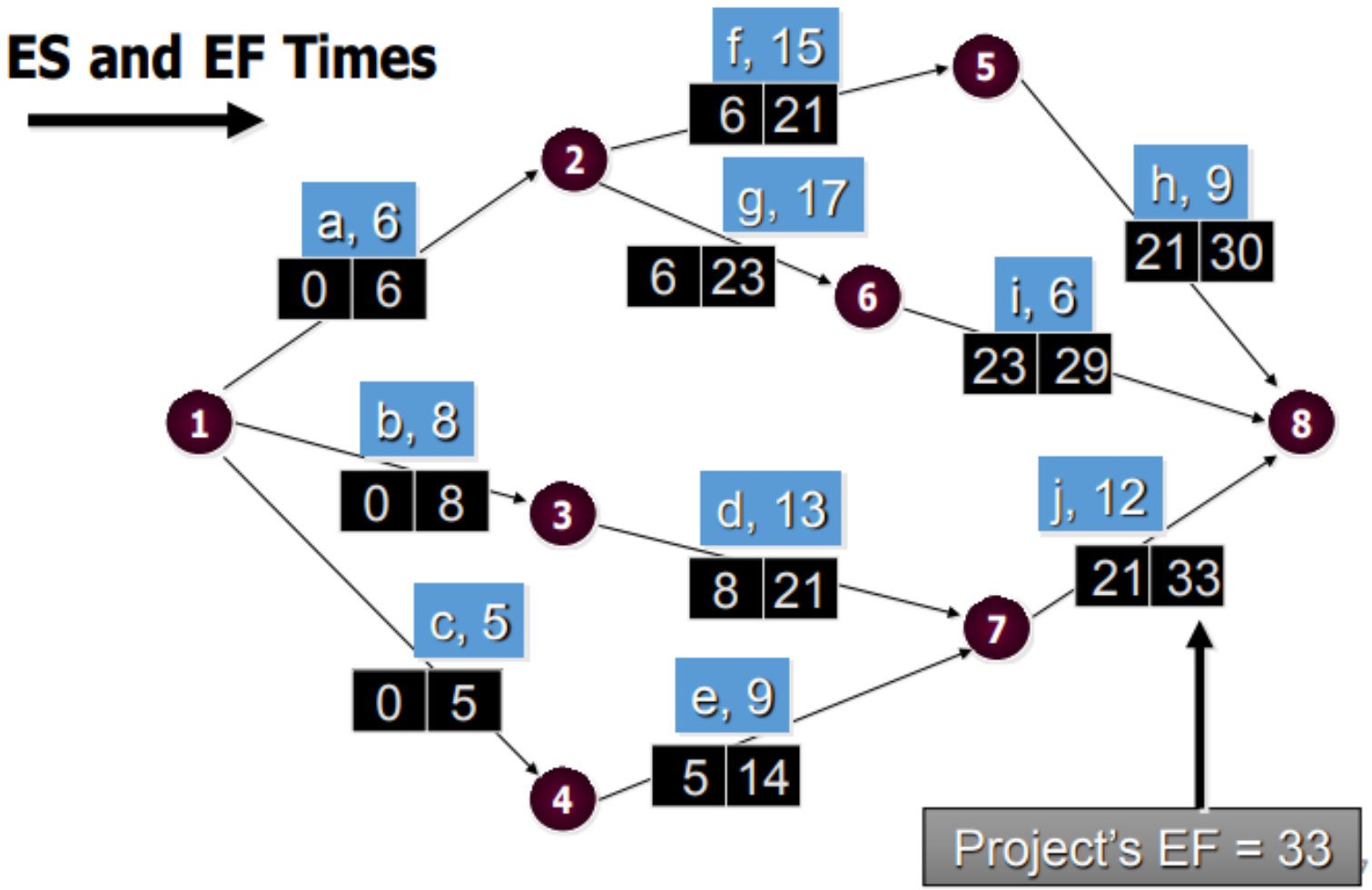
1. Define the project and all significant activities/tasks.
2. Develop relationships among the activities. Identify precedence relationships.
3. Draw the network.
4. Assign time and/or cost estimates to each activity.
5. Compute the longest time path (*critical path*) through the network.
6. Use the network to help plan, schedule, monitor, and control the project.

CPM: EXAMPLE

CPM Network

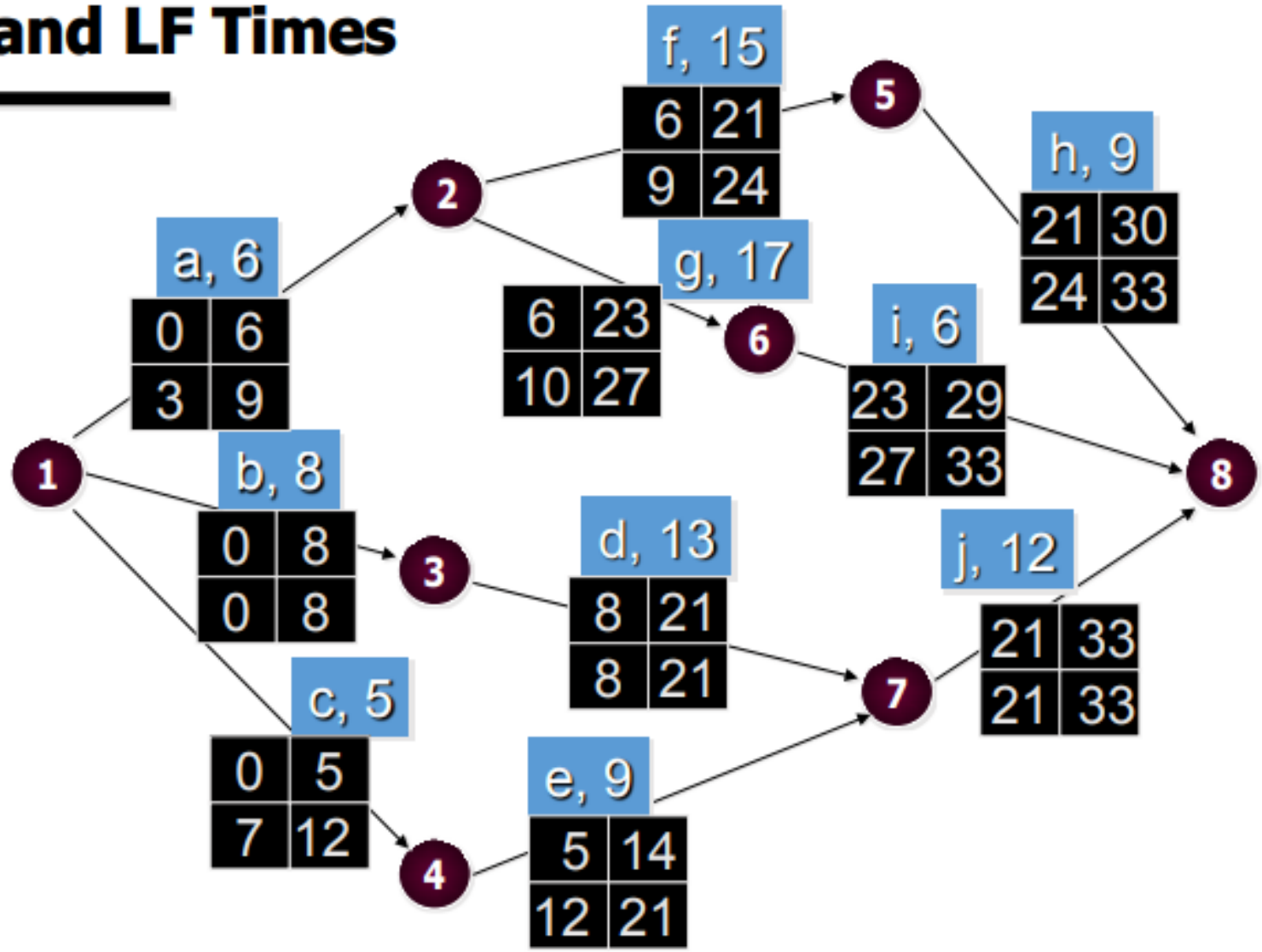


CPM: EXAMPLE


ES and EF Times
a, 6
0 6
f, 15
6 21
g, 17
6 23
h, 9
21 30
i, 6
23 29
b, 8
0 8
d, 13
8 21
j, 12
21 33
c, 5
0 5
e, 9
5 14
1
2
3
4
5
6
7
8
Project's EF = 33

CPM: EXAMPLE ...

LS and LF Times

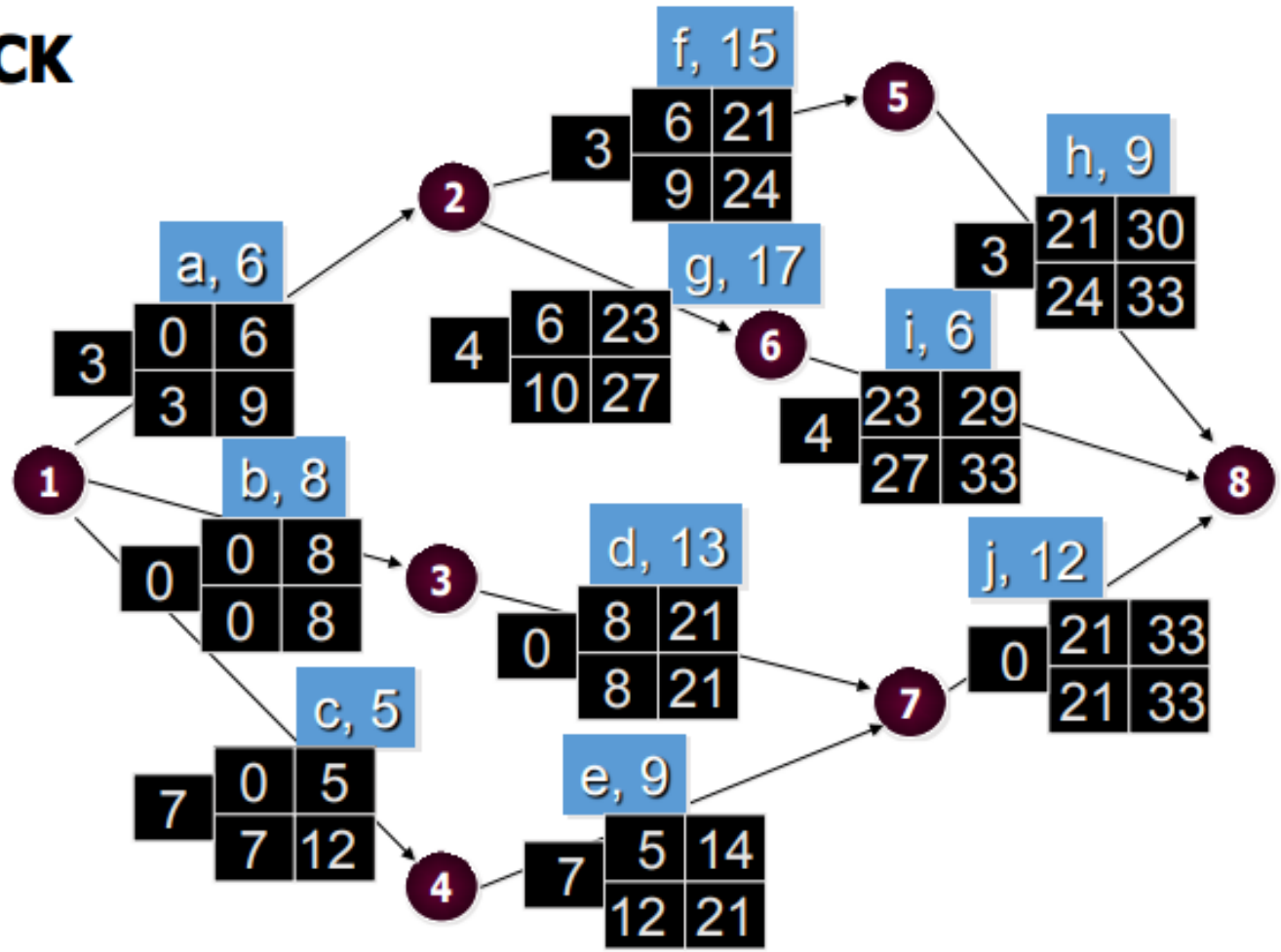


CPM / PERT TECHNIQUES: FUNDAMENTALS ...

- **Slack or Float – SL**
  - **Forward & Backward Passes Computed**
  - **Possible to determine which activities can be delayed by computing "Slack" or "Float"**
  - **LS – ES = SL**
  - **LF – EF = SL**
  - **Total Slack: tells us the amount of time an activity can be delayed; not delay project**

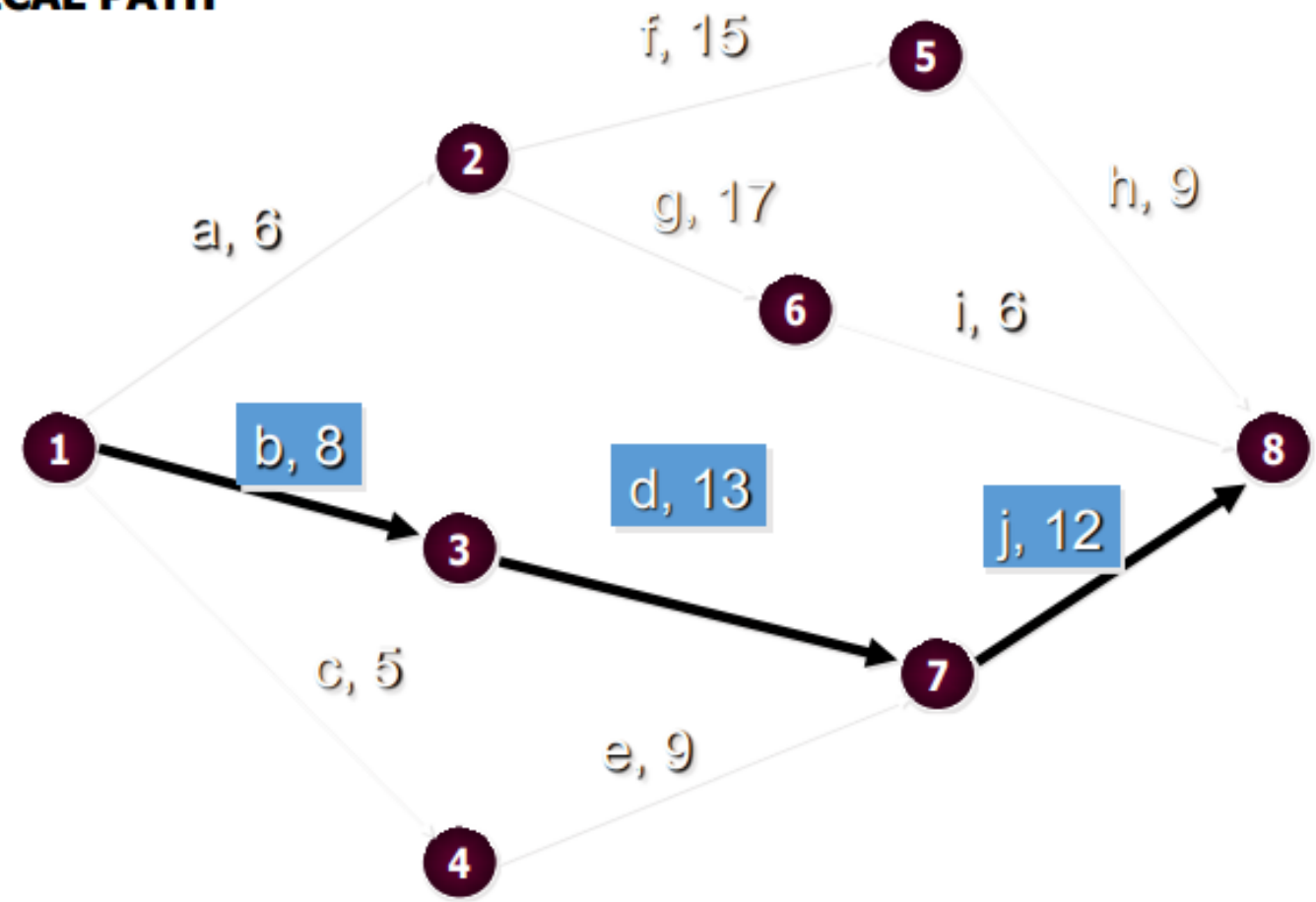
CPM EXAMPLE ...

SLACK



CPM EXAMPLE ...

CRITICAL PATH



CPM EXAMPLE …

Critical Path:

1 → 3 → 7 → 8

Activities on the Critical Path:

b→ d → j

Total Project Time:

8+13+12 = 33