Engineering Management

Project Management

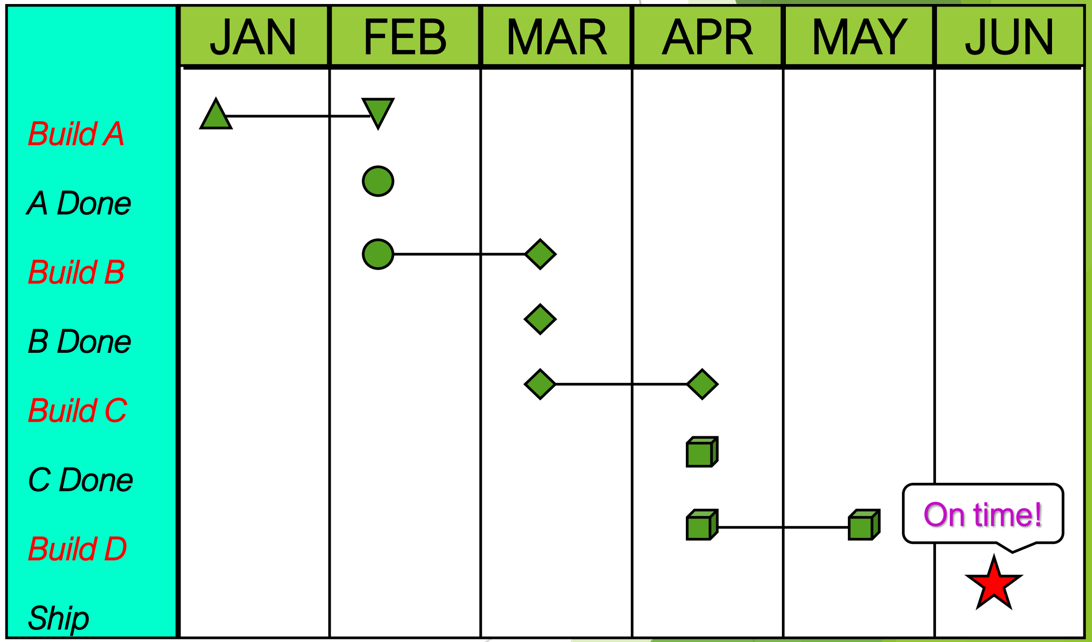
Project management

Projects

Projects are unique, one-time operations designed to accomplish a set of objectives in a limited time frame.

Examples of projects include constructing a shopping complex, merging two companies, putting on a play, and designing and running a political campaign.

Examples of projects within business organizations include designing new products or services, designing advertising campaigns, designing information systems, reengineering a process, designing databases, software development, and designing web pages.

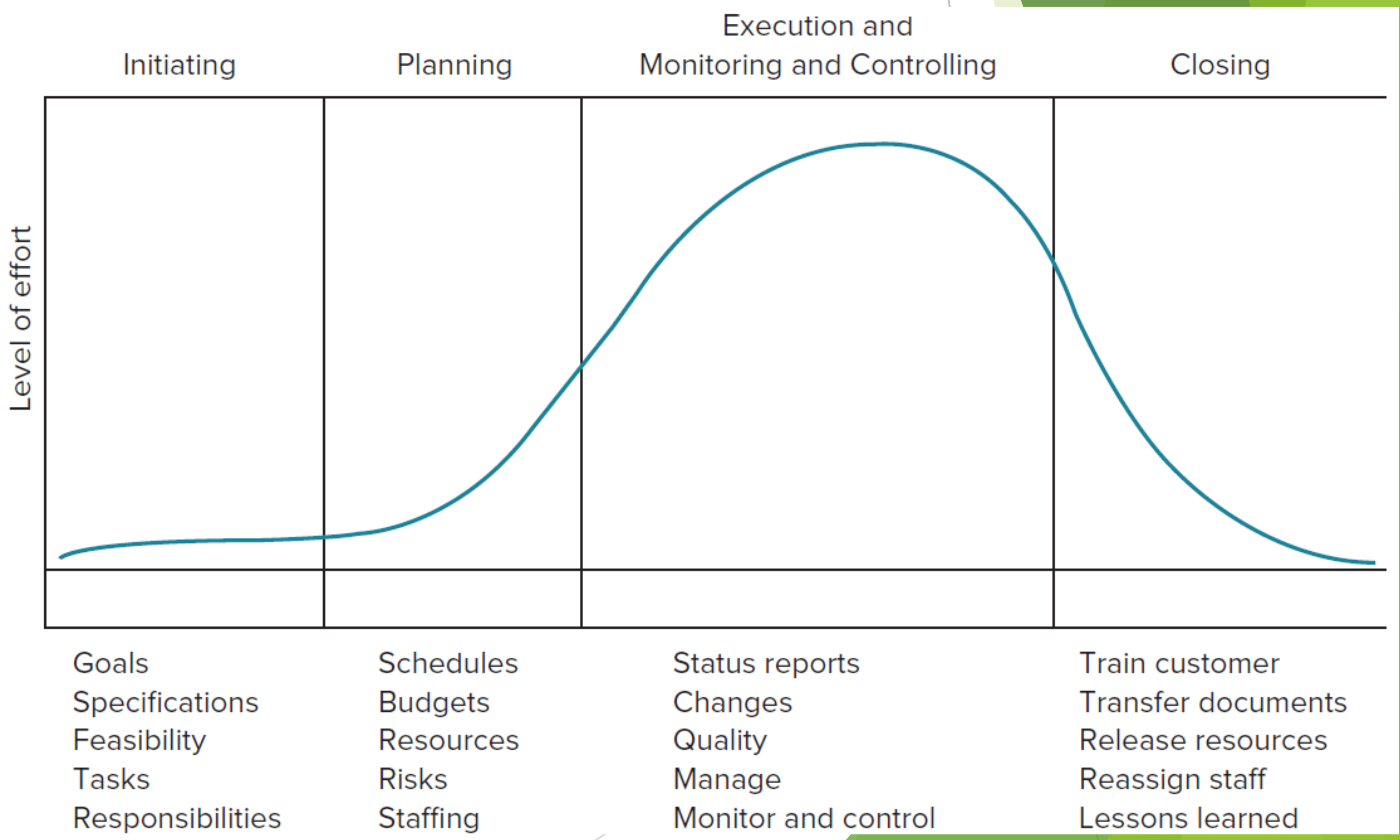


PROJECT LIFE CYCLE

The size, length, and scope of projects vary widely according to the nature and purpose of the project.

Nevertheless, all projects have something in common:

They go through a life cycle, which typically consists of five phases.



PROJECT LIFE CYCLE

1. Initiating - This begins the process by outlining the expected costs, benefits, and risks associated with a project.

   It includes defining the major project goals and choosing a project manager.

2. Planning - This phase provides details on deliverables, the scope of the project, the budget, schedule and milestones, performance objectives, resources needed, a quality plan, and a plan for handling risks.

   The accompanying documents generated in the planning phase will be used in the executing and monitoring phases to guide activities and monitor progress. Members of the project team are chosen.

PROJECT LIFE CYCLE

3. Executing - In this phase, the actual work of the project is carried out.

   The project is managed as activities are completed, resources are consumed, and milestones are reached.

   Management involves what the Project Management Institute refers to as the nine management areas: project integration, scope, human resources, communications, time, risk, quality, cost, and procurement.

PROJECT LIFE CYCLE

4. Monitoring and Controlling - This phase occurs at the same time as project execution.

   It involves comparing actual progress with planned progress and undertakes corrective action if needed, as well as monitoring any corrective action to make sure it achieves the desired effect.

5. Closing - This phase ends the project.

   It involves handing off the project deliverables (assuming the project hasn't been canceled), obtaining customer acceptance, documenting lessons learned and releasing resources.

Key Decisions in Project Management

Much of the success of projects depends on key managerial decisions over a sequence of steps:

- Deciding which projects to implement.
- Selecting the project manager.
- Selecting the project team.
- Planning and designing the project.
- Managing and controlling project resources.
- Deciding if and when a project should be terminated.

The Project Manager

The project manager bears the ultimate responsibility for the success or failure of the project.

He or she must be capable of working through others to accomplish the objectives of the project. The project manager is responsible for effectively managing each of the following:

1. The work, so that all of the necessary activities are accomplished in the desired sequence, and performance goals are met.

2. The human resources, so that those working on the project have direction and motivation.

3. Communications, so that everybody has the information needed to do the work.

The Project Manager

4. **Quality**, so that performance objectives are realized.

5. **Time**, so that the project is completed on schedule.

6. **Costs**, so that the project is completed within budget.

7. **Scope**, so the project stays within the prescribed scope, and “scope creep” doesn’t occur without commensurate changes to the schedule (if needed) and the budget.

Project management tools

Project Management Tools:

- Work Breakdown Structure
- Gantt Charts
- PERT and CPM

Project management tools

- Work Breakdown Structure

Work breakdown structure (WBS) A hierarchical listing of what must be done during a project.

This methodology establishes a logical framework for identifying the required activities for the project.

The first step in developing the work breakdown structure is to identify the major elements of the project. These are the Level 2 boxes.

Project management tools

- Work Breakdown Structure

The next step is to identify the major supporting activities for each of the major elements - the Level 3 boxes.

Then, each major supporting activity is broken down into a list of the activities that will be needed to accomplish it - the Level 4 boxes.

For purposes of illustration, only a portion of the Level 4 boxes are shown.)

Usually there are many activities in the Level 4 lists.

Large projects involve additional levels, but the figure gives you some idea of the concept of the work breakdown structure.

Project management tools

- Work Breakdown Structure

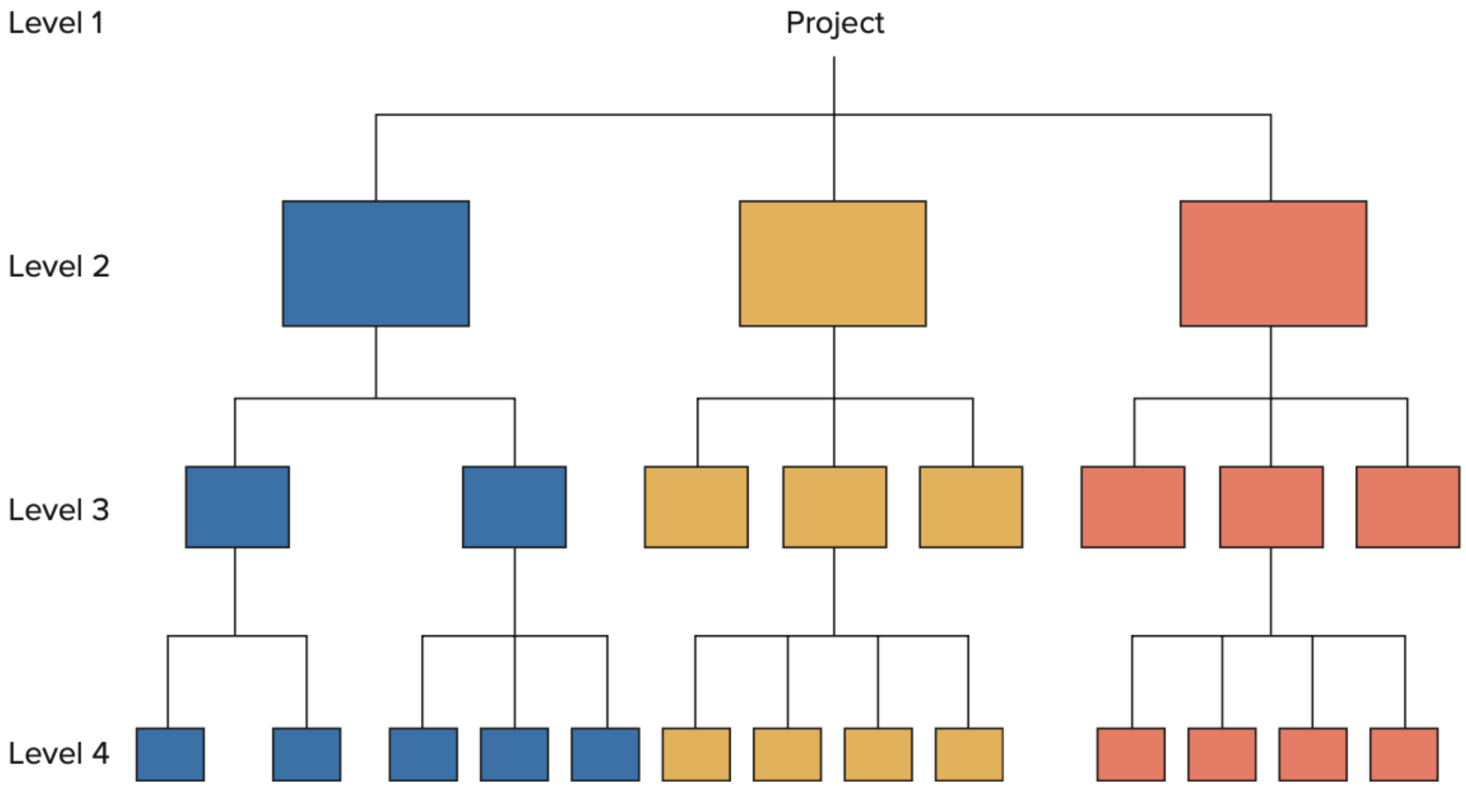


FIGURE 17.2 Schematic of a work breakdown structure

Project management tools

- Gantt Chart

The Gantt chart is a popular visual tool for planning and scheduling simple projects. It enables a manager to initially schedule project activities and then to monitor progress over time by comparing planned progress to actual progress.

The figure illustrates a Gantt chart for a bank’s plan to establish a new direct marketing department.

To prepare the chart, the vice president in charge of the project had to first identify the major activities that would be required.

Next, time estimates for each activity were made, and the sequence of activities was determined.

Project management tools

- Gantt Chart

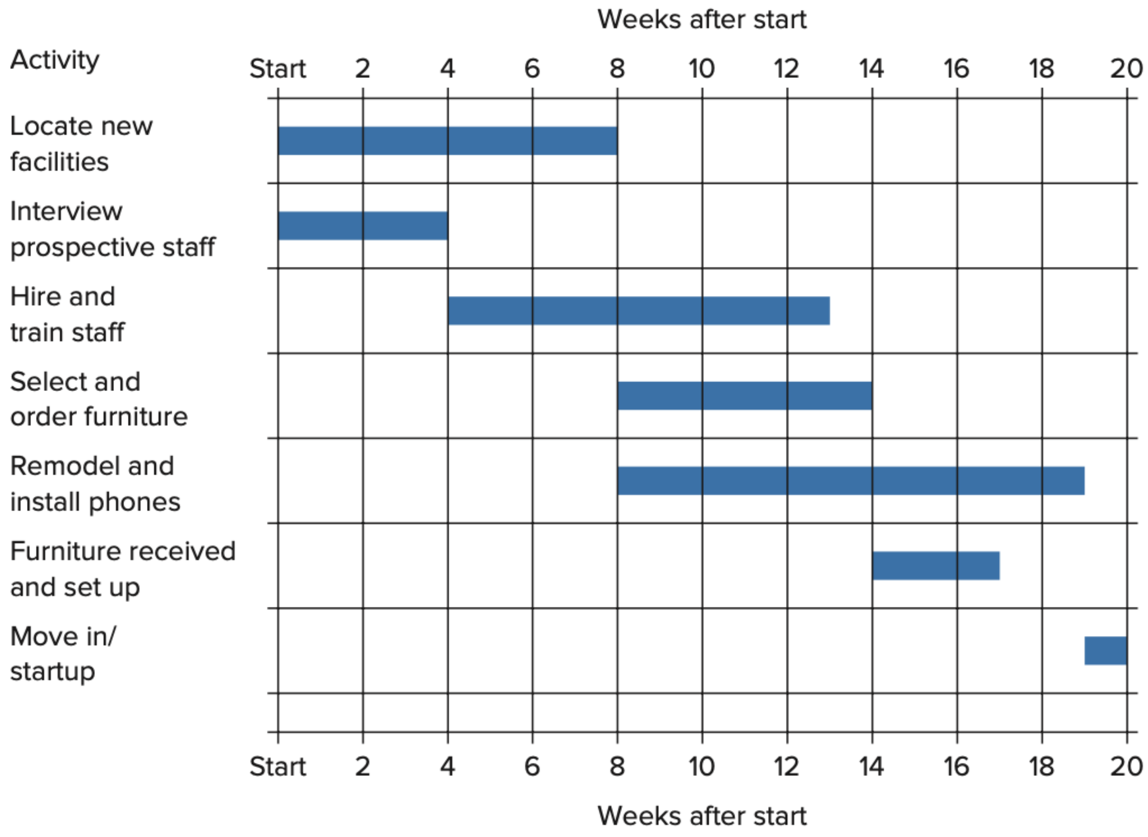
Once completed, the chart indicated which activities were to occur, their planned duration, and when they were to occur.

Then, as the project progressed, the manager was able to see which activities were on schedule and which were behind schedule.

Project management tools

- Gantt Chart

FIGURE 17.3
Gantt chart for bank example



Project management tools

- PERT and CPM

PERT (**Program Evaluation and Review Technique**) and CPM (**Critical Path Method**) are two of the most widely used techniques for planning and coordinating large-scale projects.

By using PERT or CPM, managers are able to obtain:

- A graphical display of project activities
- An estimate of how long the project will take
- An indication of which activities are the most critical to timely project completion
- An indication of how long any activity can be delayed without delaying the project

Project management tools

Critical Path Analysis

- Also called critical path method - is a network diagramming technique used to predict total project duration.

- A critical path is the series of activities that determine the earliest time by which the project can be completed.

- The longest path or the path containing the critical tasks is what is driving the completion date for the project.

Project management tools

Critical Path Analysis

The Network Diagram

One of the main features of PERT and related techniques is their use of a network (or precedence) diagram to depict major project activities and their sequential relationships.

There are two slightly different conventions for constructing these network diagrams.

Under one convention, the arrows designate activities; under the other convention, the nodes designate activities.

Project management tools

Critical Path Analysis

The Network Diagram

These conventions are referred to as:

Activity-on-Arrow (AOA) and Activity-on-Node (AON)

Project management tools

Critical Path Analysis

The Network Diagram

Activity

A specific **task or set of tasks** that are required by the project, use up resources, and take time to complete.

Event

The **result** of completing one or more activities. An identifiable end state that occurs at a particular time. Events use no resources.

Project management tools

Critical Path Analysis

The Network Diagram

Network

The arrangement of all activities (and, in some cases, events) in a project arrayed in their logical sequence and represented by arcs and nodes.

This arrangement (network) defines the project and the activity precedence relationships.

Networks are usually drawn starting on the left and proceeding to the right.

Arrowheads placed on the arcs are used to indicate the direction of flow - that is, to show the proper precedences.

Project management tools

Critical Path Analysis

The Network Diagram

Network (Contd.)

Before an event can be realized—that is, achieved—all activities that immediately precede it must be completed.

These are called its predecessors.

Thus, an event represents an instant in time when each and every predecessor activity has been finished.

Project management tools

Critical Path Analysis

The Network Diagram

Path

The series of **connected activities** (or intermediate events) between any two events in a network.

Critical Activities, events, or paths that, if **delayed**, will delay the completion of the project.

A project's critical path is understood to mean that sequence of critical activities (and critical events) that connects the project's start event to its finish event and which cannot be delayed without delaying the project.

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Critical Path Analysis

The Network Diagram

To transform a project plan into a network, one must know what activities comprise the project and, for each activity, what its predecessors (or successors) are.

An activity can be in any of these conditions:
(1) it may have a successor(s) but no predecessor(s);
(2) it may have a predecessor(s) but no successor(s); and
(3) it may have both predecessor(s) and successor(s).

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Critical Path Analysis

The Network Diagram

The first of these is an activity that starts a network.
The second ends a network.
The third is in the middle.
Figure 8.1 shows each of the three types of activities.

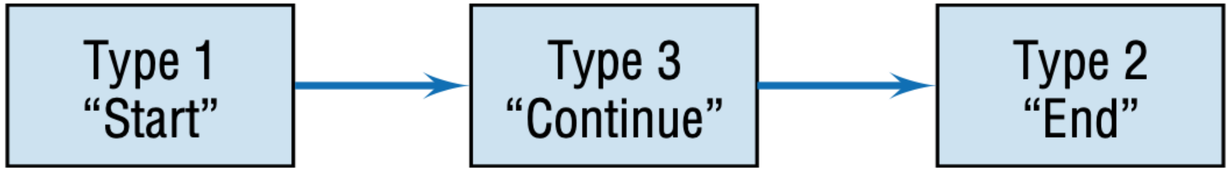

FIGURE 8.1 Three sequential activities, AON format.

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Critical Path Analysis

The Network Diagram

Activities are represented here by rectangles (one form of what in a network are called "nodes") with arrows to show the precedence relationships.

When there are multiple activities with no predecessors, it is usual to show them all emanating from a single node called "START", as in Figure 8.2.

Similarly, when multiple activities have no successors, it is usual to show them connected to a node called "END".

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Critical Path Analysis

The Network Diagram

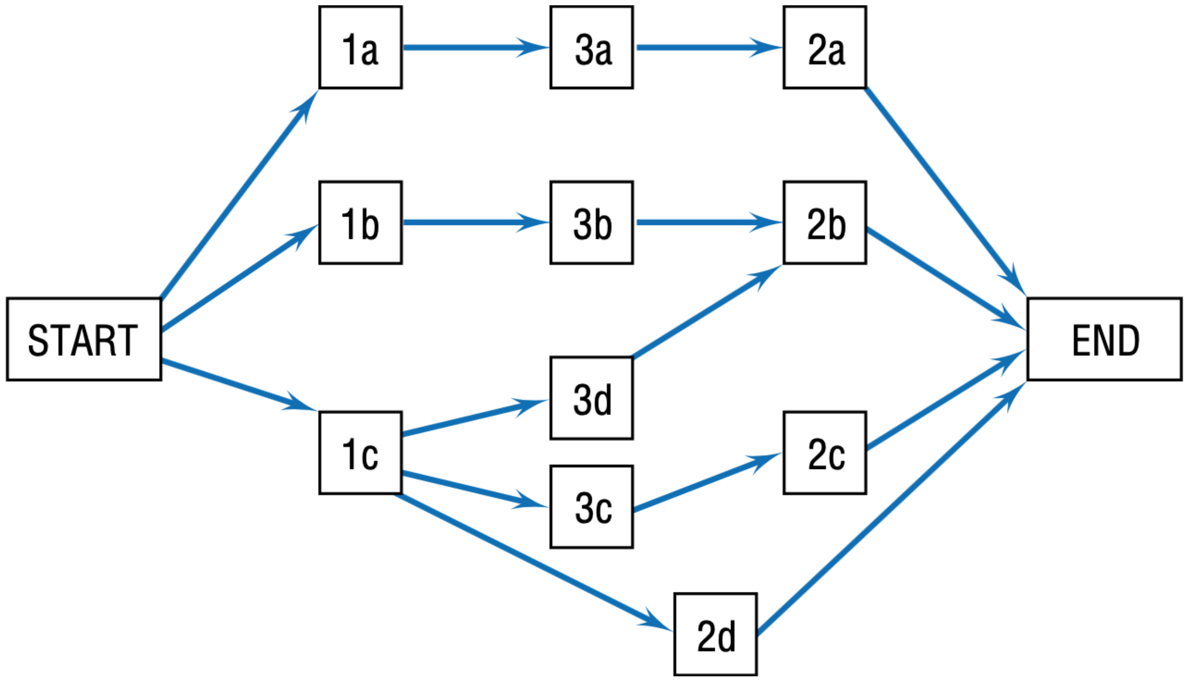

FIGURE 8.2 Activity network, AON format.

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Critical Path Analysis

The Network Diagram

In the preceding examples, **rectangles (nodes) represented the activities**; hence, it was called an **activity-on-node (AON)** network.

Another format for drawing networks is activity-on-arrow (AOA), as shown in Figure 8.3.

Here, the **activities are shown on the arrows**, and the **(circular) nodes represent events**.

If the project begins with multiple activities, they can all be drawn emanating from the initial node, and multiple activities can terminate in a single node at the end of the project.

Project management tools

Critical Path Analysis

The Network Diagram

In the preceding examples, **rectangles (nodes) represented the activities**; hence, it was called an **activity-on-node (AON)** network.

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Project management tools

Critical Path Analysis

The Network Diagram

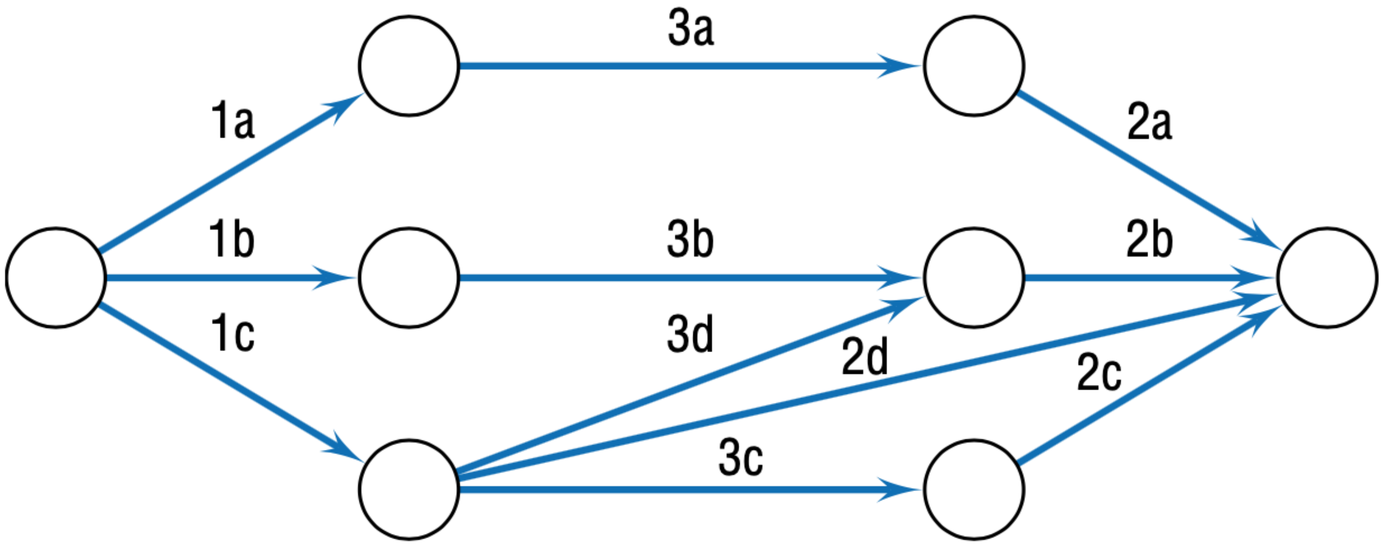

FIGURE 8.3 Activity network, AOA format.

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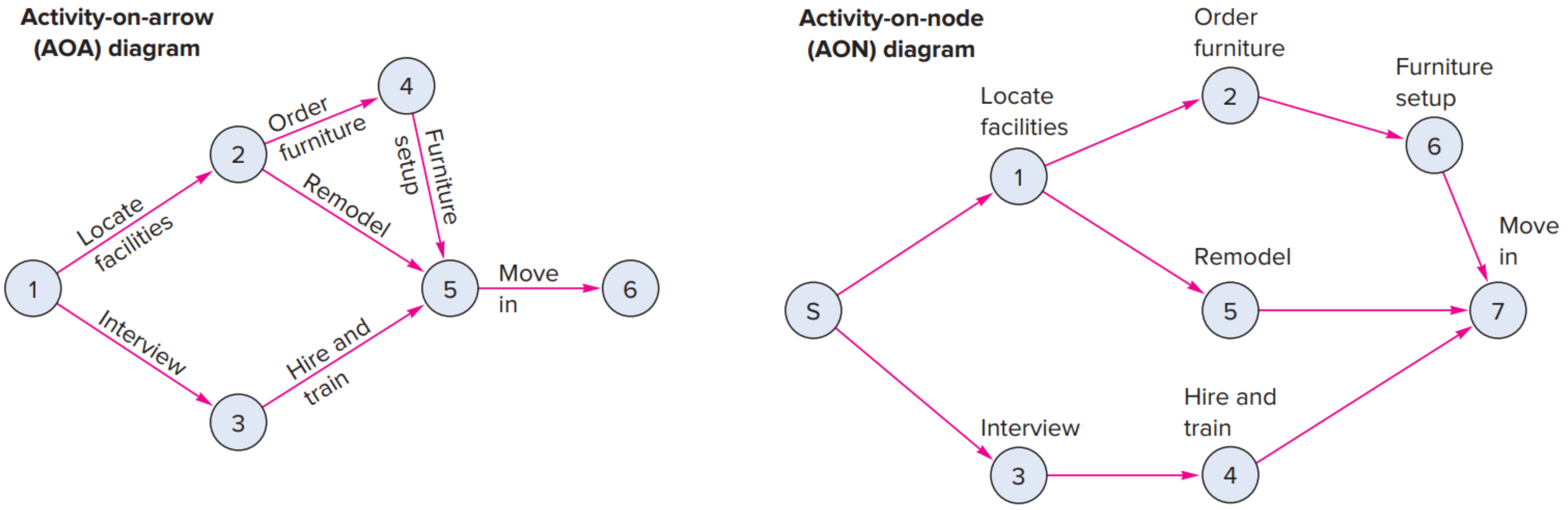
Critical Path Analysis

The Network Diagram

FIGURE 17.4 A simple project network diagram



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Critical Path Analysis

The Network Diagram

Tasks	*Precedence*	*Time*
a	—	5 days
b	—	4 days
c	a	6 days
d	b	2 days
e	b	5 days
f	c,d	8 days

Project management tools

Critical Path Analysis

The Network Diagram

Tasks	*Precedence*	*Time*
a	—	5 days
b	—	4 days
c	a	6 days
d	b	2 days
e	b	5 days
f	c,d	8 days

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Critical Path Analysis

The Network Diagram

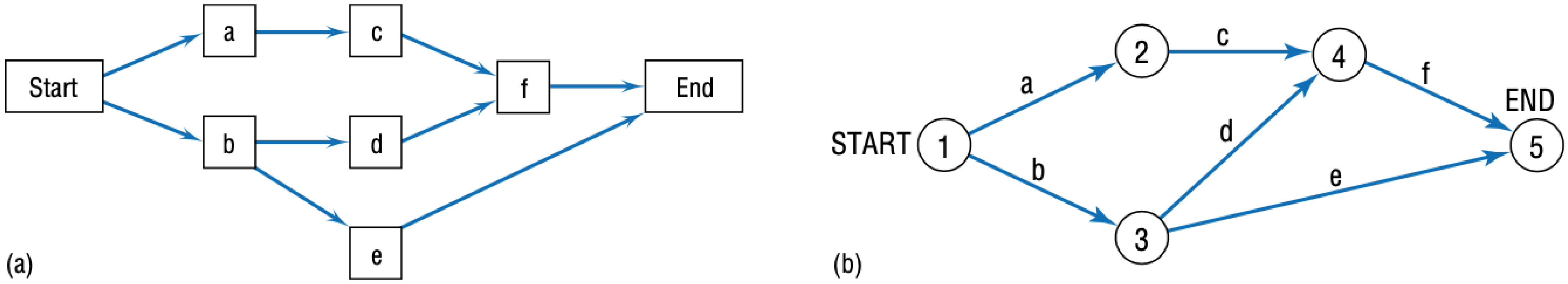

FIGURE 8.7 Sample of network construction.

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Critical Path Analysis

The Network Diagram

Paths that are shorter than the critical path can experience some delays and still not affect the overall project completion time as long as the ultimate path time does not exceed the length of the critical path.

The allowable slippage for any path is called slack, and it reflects the difference between the length of a given path and the length of the critical path.

The critical path, then, has zero slack time.

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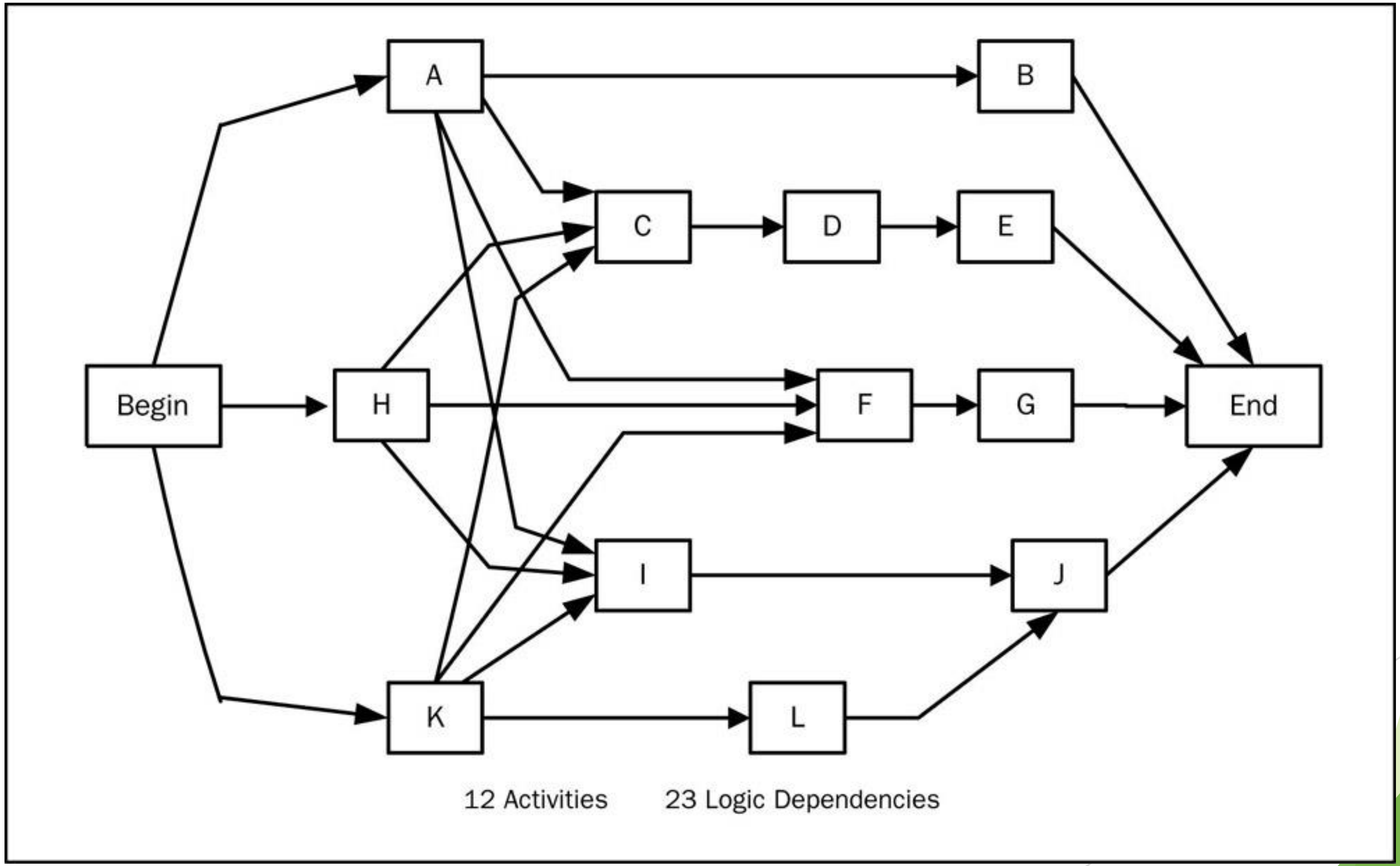
Critical Path Analysis



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- Draw Precedence diagram and find critical path and expected project duration

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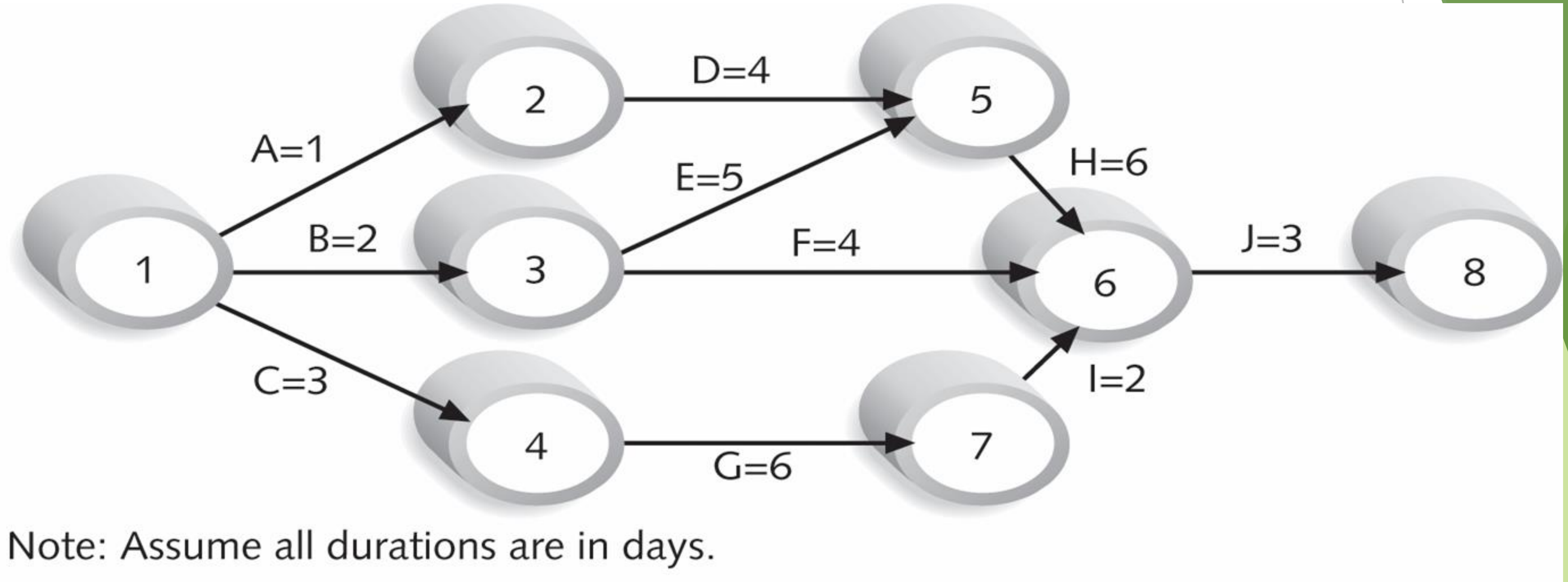
ACITIVITY	Duration	Immediate Predecessor
A	1 Day	n/a
B	2 Days	n/a
C	3 Days	n/a
D	4 Days	A
E	5 Days	B
F	4 Days	B
G	6 Days	C
H	6 Days	D, E
I	2 Days	G
J	3 Days	H, F, I

Project management tools

Critical Path Analysis



Path 1 : A – D – H - J

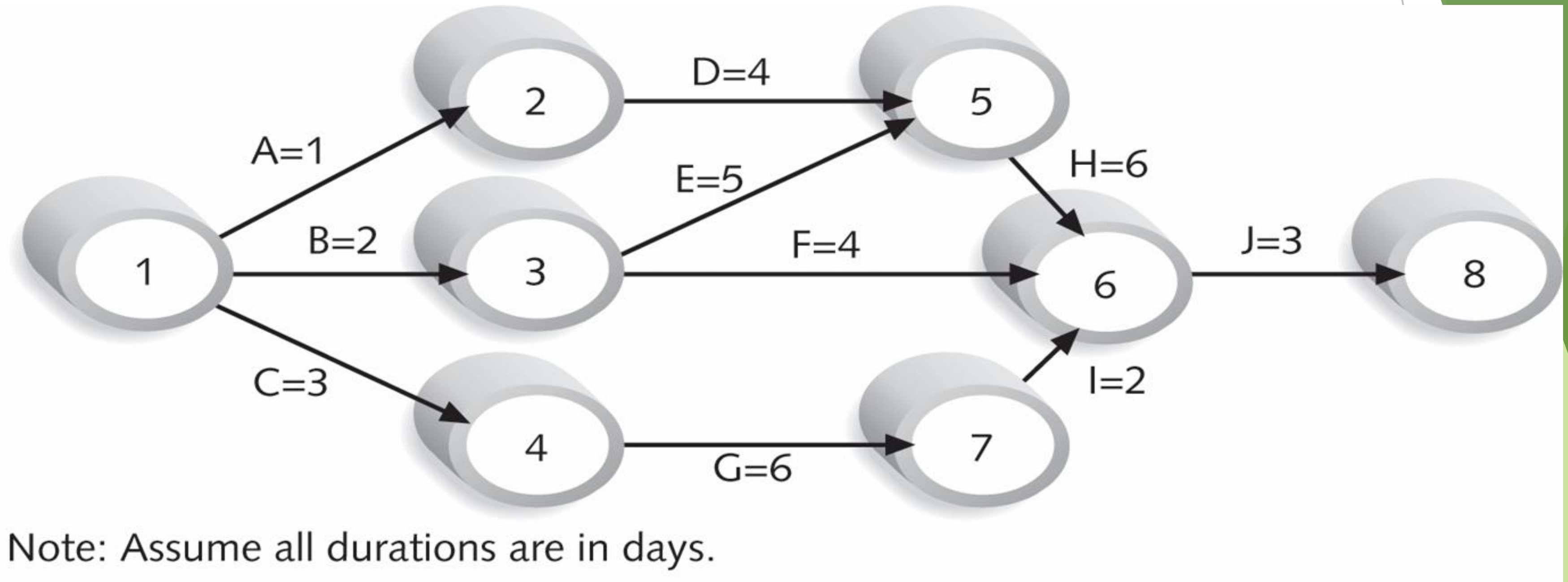
Path 2 : B – E – H - J

Path 3 : B – F – J

Path 4 : C – G – I - J

Project management tools

Critical Path Analysis



Path 1 : A – D – H - J Length 1 : 1+4+6+3 = 14 days

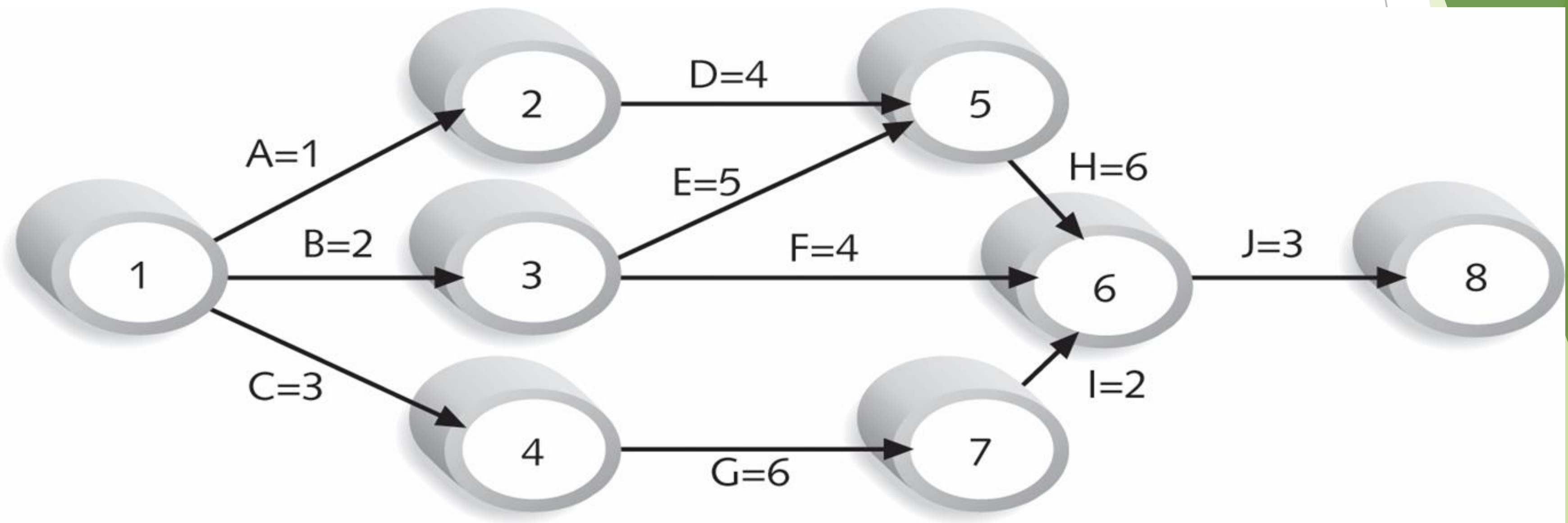
Path 2 : B – E – H - J Length 2 : 2+5+6+3 = 16 days

Path 3 : B – F – J Length 3 : 2+4+3 = 9 days

Path 4 : C – G – I - J Length 4 : 3+6+2+3 = 14 days

Project management tools

Critical Path Analysis



Note: Assume all durations are in days.

Path 1:	A-D-H-J	Length = 1+4+6+3 = 14 days
Path 2:	**B-E-H-J**	**Length = 2+5+6+3 = 16 days**
Path 3:	B-F-J	Length = 2+4+3 = 9 days
Path 4:	C-G-I-J	Length = 3+6+2+3 = 14 days

Because the critical path is the longest path through the network diagram, Path 2, B-E-H-J, is the critical path for Project X.

Project management tools

Critical Path Analysis

Identifying the Critical Path; Computing Project Duration and Slack Times for Deterministic Times Given the additional information on the bank network of Figure 17.4 shown in Figure 17.5, determine the following.

a. The length of each path
b. The critical path
c. The expected length of the project
d. The amount of slack time for each path

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Critical Path Analysis

FIGURE 17.5
AOA diagram

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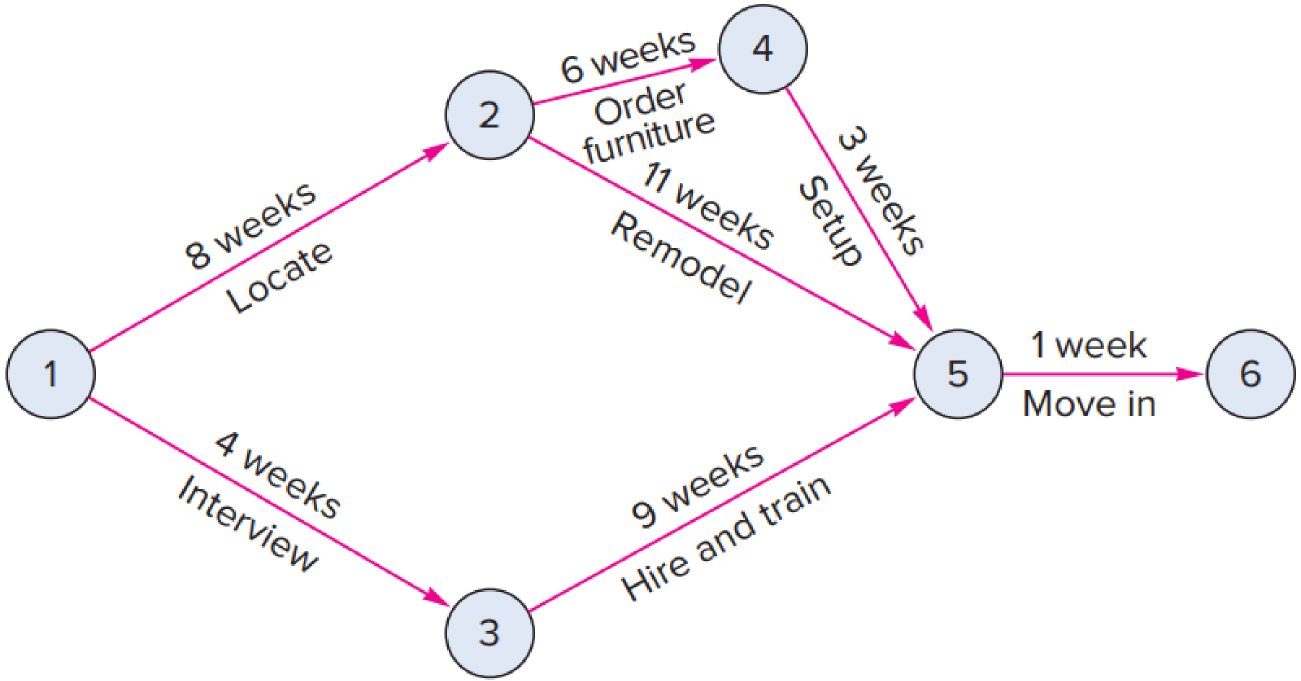

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Critical Path Analysis

SOLUTION

a. As shown in the following table, the path lengths are 18 weeks, 20 weeks, and 14 weeks.

b. Path 1–2–5–6 is the longest path (20 weeks), so it is the critical path.

c. The expected length of the project is equal to the length of the critical path (i.e., 20 weeks).

d. We find the slack for each path by subtracting its length from the length of the critical path, as shown in the last column of the table. (*Note:* It is sometimes desirable to know the slack time associated with activities. The next section describes a method for obtaining those slack times.)

Path	Length (weeks)	Slack
1–2–4–5–6	8 + 6 + 3 + 1 = 18	20 − 18 = 2
1–2–5–6	8 + 11 + 1 = 20*	20 − 20 = 0
1–3–5–6	4 + 9 + 1 = 14	20 − 14 = 6

*Critical path length.

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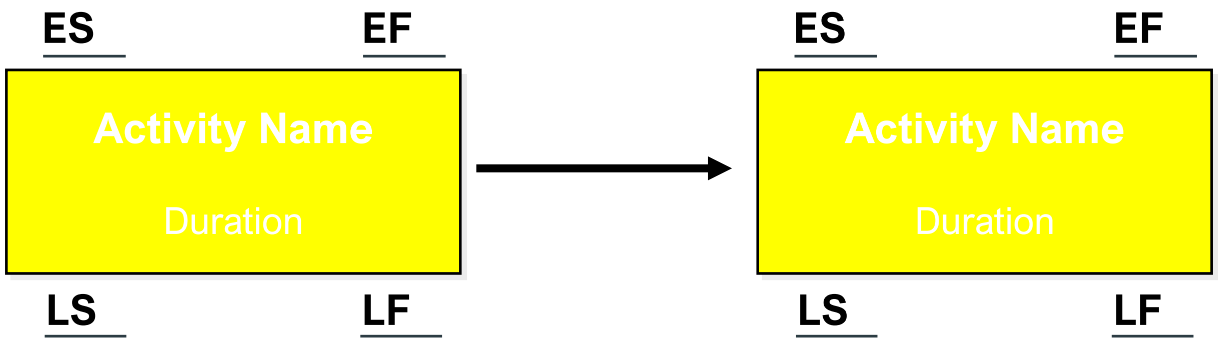
Critical Path Analysis



Notes :

ES : Earliest Start

EF : Earliest Finish

Notes :

LS : Latest Start

LF : Latest Finish

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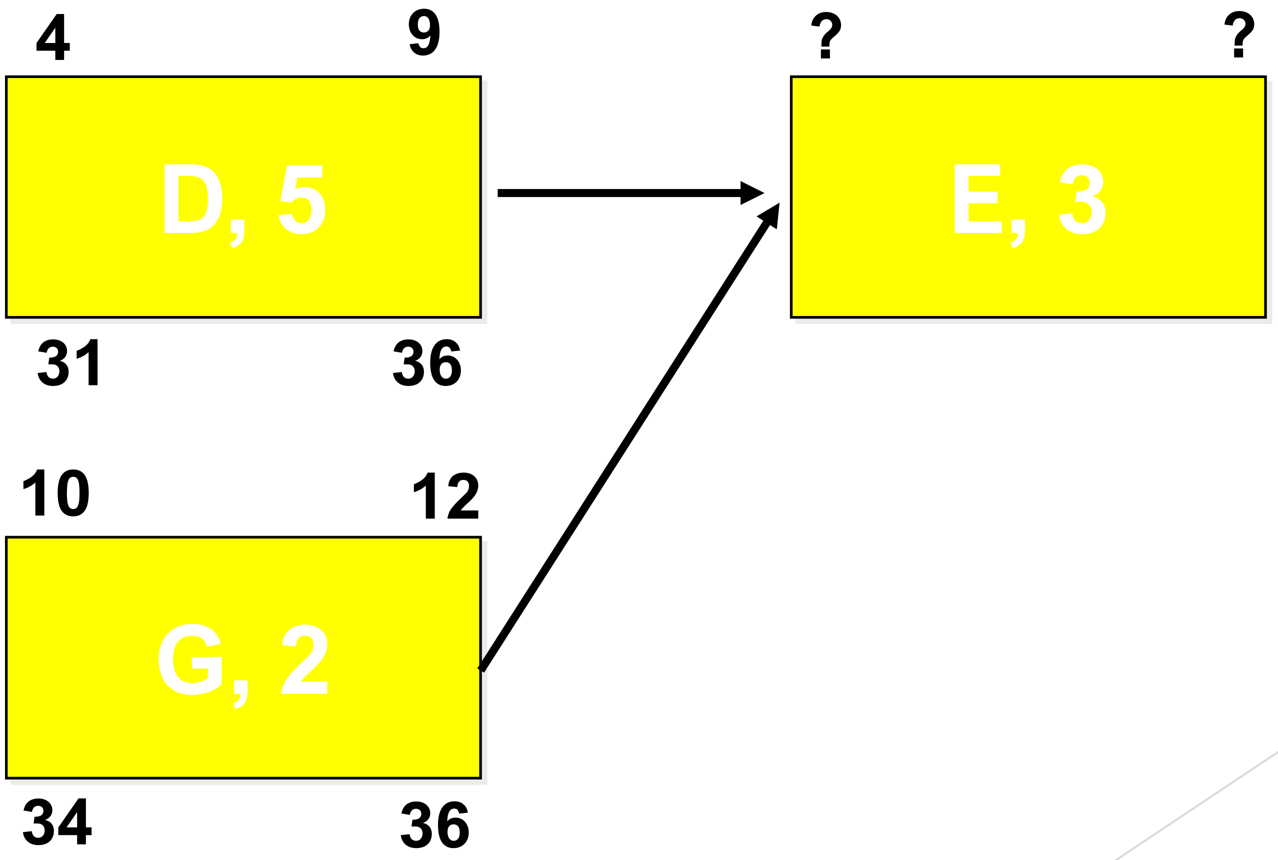
Critical Path Analysis

Forward Calculation



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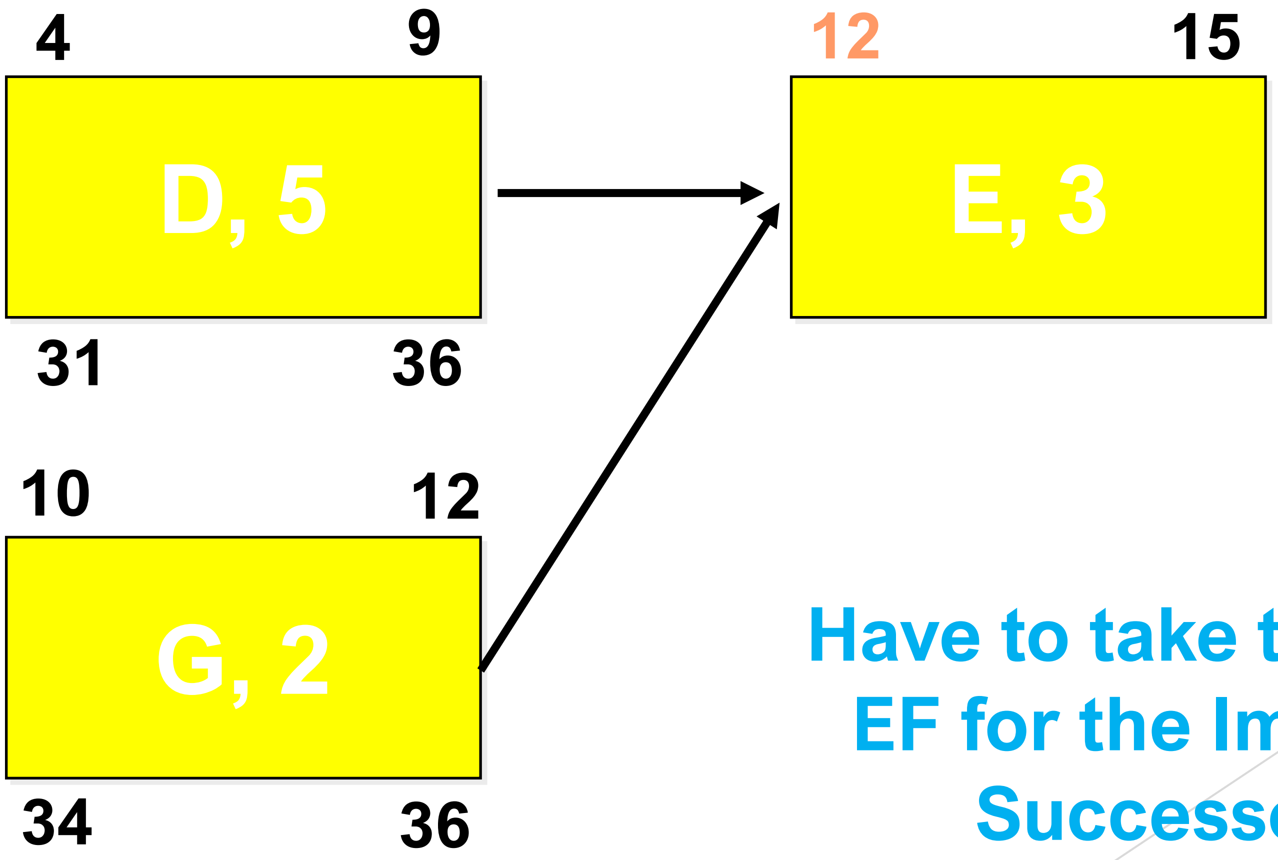
Critical Path Analysis

Forward Calculation



Have to take the Higher EF for the Immediate Successor (E)

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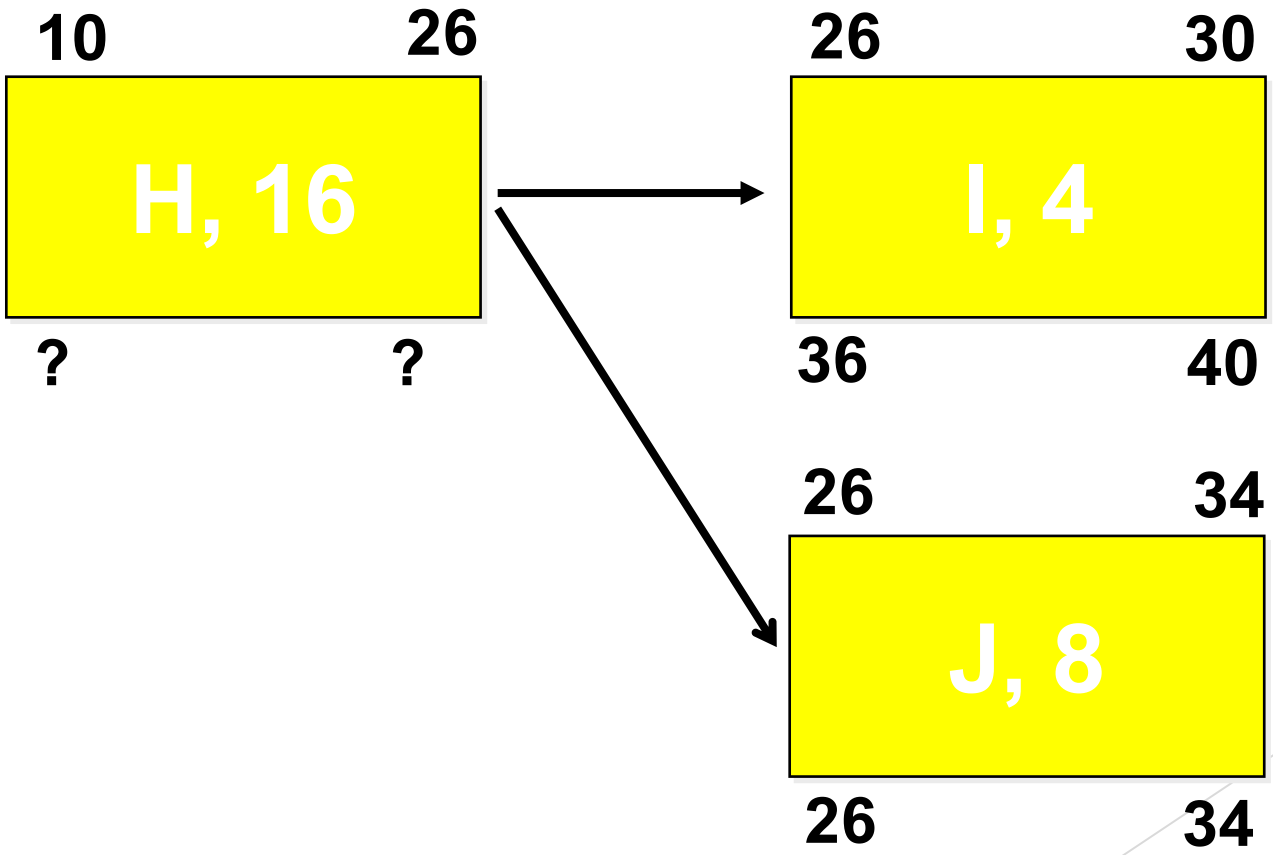
Critical Path Analysis

Backward Calculation



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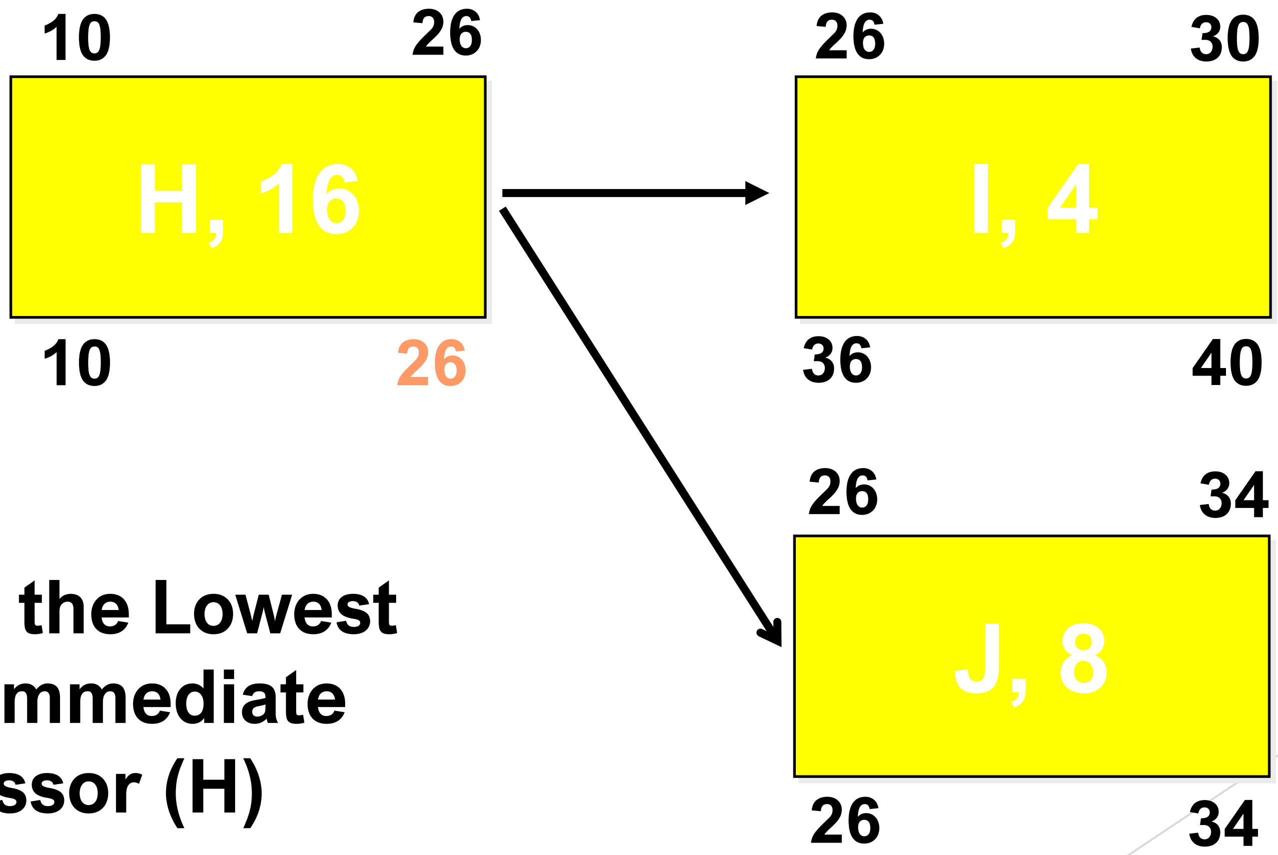
Critical Path Analysis

Backward Calculation



Have to take the Lowest LS for the Immediate Predecessor (H)

Project management tools

Critical Path Analysis

Sample Problem #1

Activity	Immediate Predecessor(s)	Duration (Weeks)		Activity	Immediate Predecessor(s)	Duration (Weeks)
N		5		G	B	**2**
A	N	4		H	B	**16**
B	N	10		I	H	**4**
C	N	7		J	H	**8**
D	A	5		K	I, J, L	**5**
E	D, G	3		L	C	**9**
F	**E**	**6**		**M**	**J, L**	**10**

Project management tools

Critical Path Analysis

Sample Problem #1

a) Draw the network diagram and find the critical path and project completion time.
b) Calculate float/ slack of the all activities.
c) Can activity I be delayed without delaying the project completion time? If so, how many weeks? How much dollar can be saved by keeping the project completion time unchanged, if $2500 can be saved for each delayed week of activity I?
d) What is the impact on the project if activity F needs a delayed time 2 weeks and extra time 5 weeks?
e) The PM wants to delay the duration of the activity M from 10 weeks to 16 weeks. What is the impact on the project completion time?

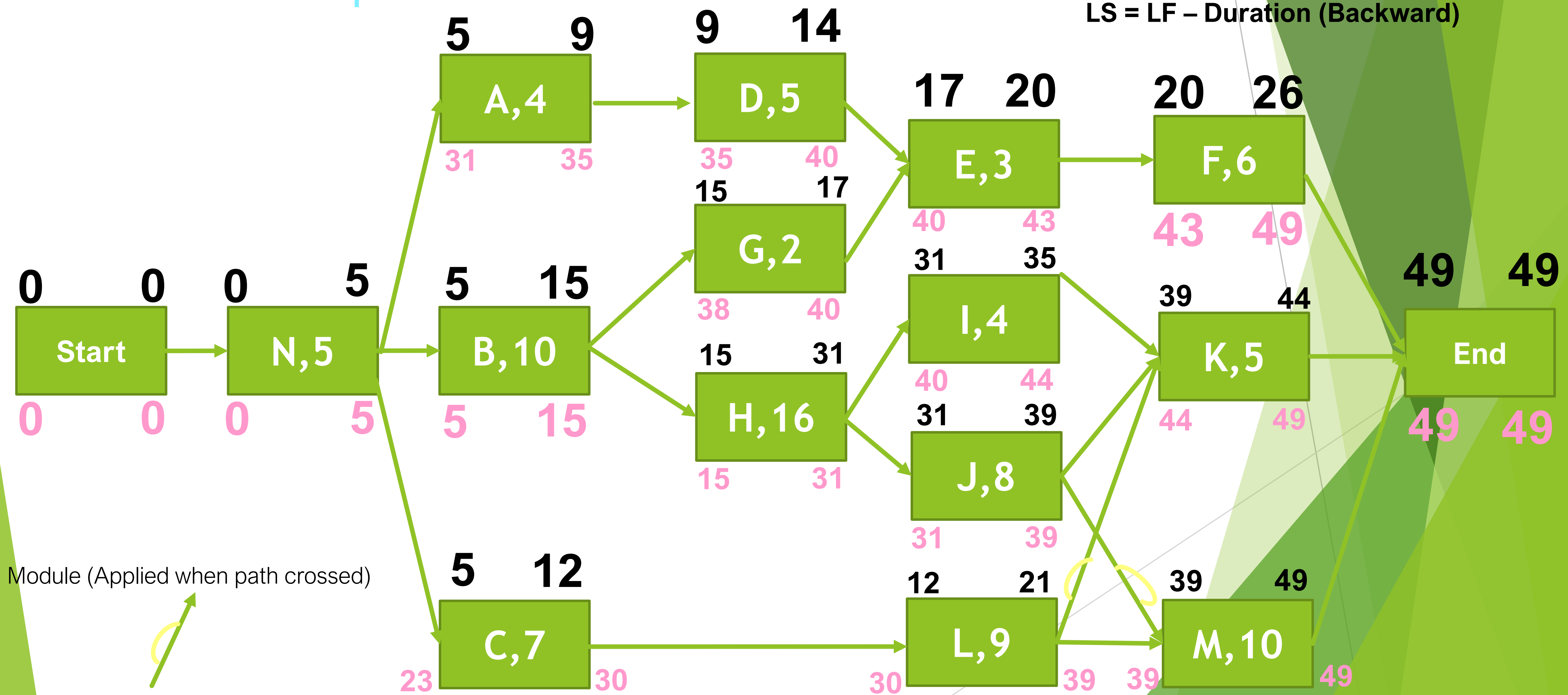
Project management tools

Critical Path Analysis

Sample Problem #1

EF = ES + Duration (Forward)

LS = LF – Duration (Backward)



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Critical Path Analysis

Sample Problem #1

Project Completion Time = 49 weeks

Slack = LS – ES ||| LF - EF

$\text{Slack}_A = 31 - 5 = 26$

$\text{Slack}_B = 5 - 5 = 0$

$\text{Slack}_C = 23 - 5 = 18$

$\text{Slack}_D = 35 - 9 = 26$

$\text{Slack}_E = 40 - 17 = 23$

$\text{Slack}_F = 43 - 20 = 23$

$\text{Slack}_G = 38 - 15 = 23$

$\text{Slack}_H = 15 – 15 = 0$

$\text{Slack}_I = 40 – 31 = 9$

$\text{Slack}_J = 31 – 31 = 0$

$\text{Slack}_K = 44 – 39 = 5$

$\text{Slack}_L = 30 – 12 = 18$

$\text{Slack}_M = 39 – 39 = 0$

$\text{Slack}_N = 0 – 0 = 0$

Project management tools

Critical Path Analysis

Sample Problem # 1

Project Completion Time = 49 weeks

Path 1 = N – A – D – E – F = 23 weeks
Path 2 = N – B – G – E – F = 26 weeks
Path 3 = N – B – H – I – K = 40 weeks
Path 4 = N – B – H – J – K = 44 weeks
Path 5 = N – B – H – J – M = 49 weeks
Path 6 = N – C – L – K = 26 weeks
Path 7 = N – C – L – M = 31 weeks

Critical Path = Path 5 = N+B+H+J+M = 49 weeks

Critical Activities = B, H, J, M, and N (Where the Slack is 0)
Non-Critical Activities = A, C, D, E, F, G, I, K, and L

Project management tools

Critical Path Analysis

Sample Problem #1

c) Can activity I be delayed without delaying the project completion time?

If so, how many weeks?

How much dollar can be saved by keeping the project completion time unchanged, if $2500 can be saved for each delayed week of activity I?

Yes, the Activity "I" can be delayed as it is a non-critical activity. It can be delayed upto the value of slack that is for 9 weeks.

Activity I has a slack of 9 weeks, so, $2500*9= $22,500/- can be saved by keeping the project completion time unchanged.

Project management tools

Critical Path Analysis

Sample Problem #1

d) What is the impact on the project if activity F needs a delayed time 2 weeks and extra time 5 weeks?

According to the question, activity F needs to delay by 2+5= 7 weeks, it is possible by keeping the project completion time unchanged as F is a non-critical activity with a slack of 23 weeks.

Project management tools

Critical Path Analysis

Sample Problem #1

e) The PM wants to delay the duration of the activity M from 10 weeks to 16 weeks. What is the impact on the project completion time?

According to the question, if the Project Manager wants to delay the duration of the activity M from 10 weeks to 16 weeks, then it will delay the entire duration of the project.

As activity M, falls under critical activity of the project, therefore the Slack of activity M is 0.

It will eventually increase the project duration to more 6 days (a total of 49+6 = 55 days) to complete the project in this situation.

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Critical Path Analysis

Sample Problem # 2

Activity	Immediate Predecessor(s)	Duration (Weeks)		Activity	Immediate Predecessor(s)	Duration (Weeks)
A		4		F	B	6
B		10		G	C	2
C		7		H	F	8
D	A	5		I	F, G	11
E	B	3		J	D, E	8

Project management tools

Critical Path Analysis

Sample Problem # 2

a) Draw a network diagram and find the critical path and project completion time.

b) Calculate float/ slack of the all activities.

c) If \$1000 can be saved for each delayed day of activity H, then how much dollar can be saved keeping the project completion time unchanged?

d) Activity G needs a delayed time of two weeks and an extra time of five weeks. Is it possible by keeping the project completion time unchanged? Explain.

e) The PM wants to shorten the duration of the activity I from 11 weeks to 9 weeks. What is the impact of this change on project completion time

END OF THE CHAPTER