Operations Research

Unit-III (Part-2) Project Management

Outline

- ☑ *Global Company Profile: Bechtel Group*
- ☑ *The Importance of Project Management*
- ☑ *Project Planning*
  - ☑ *The Project Manager*
  - ☑ *Work Breakdown Structure*
- ☑ *Project Scheduling*

Outline - Continued

☑ *Project Controlling*

☑ *Project Management Techniques: PERT and CPM*

    ☑ *The Framework of PERT and CPM*

    ☑ *Network Diagrams and Approaches*

    ☑ *Activity-on-Node Example*

    ☑ *Activity-on-Arrow Example*

Outline - Continued

☑ **Determining the Project Schedule**

    ☑ *Forward Pass*

    ☑ *Backward Pass*

    ☑ *Calculating Slack Time and Identifying the Critical Path(s)*

☑ **Variability in Activity Times**

    ☑ *Three Time Estimates in PERT*

    ☑ *Probability of Project Completion*

Outline - Continued

☑ *Cost-Time Trade-Offs and Project Crashing*

☑ *A Critique of PERT and CPM*

☑ *Using Microsoft Project to Manage Projects*

    ☑ *Creating a Project Schedule Using MS Project*

    ☑ *Tracking Progress and Managing Costs Using MS Project*

Learning Objectives

When you complete this chapter you should be able to:

1. Create a work breakdown structure

2. Draw AOA and AON networks

3. Complete both forward and backward passes for a project

4. Determine a critical path

Learning Objectives

When you complete this chapter you should be able to:

5. **Calculate the variance of activity times**

6. **Crash a project**

7. **Use Microsoft Project software to create a project**

Bechtel Projects

- ☑ *Building 26 massive distribution centers in just two years for the internet company Webvan Group ($1 billion)*

- ☑ *Constructing 30 high-security data centers worldwide for Equinix, Inc. ($1.2 billion)*

- ☑ *Building and running a rail line between London and the Channel Tunnel ($4.6 billion)*

- ☑ *Developing an oil pipeline from the Caspian Sea region to Russia ($850 million)*

- ☑ *Expanding the Dubai Airport in the UAE ($600 million), and the Miami Airport in Florida ($2 billion)*

Bechtel Projects

- ☑ *Building liquid natural gas plants in Yemen $2 billion) and in Trinidad, West Indies ($1 billion)*

- ☑ *Building a new subway for Athens, Greece ($2.6 billion)*

- ☑ *Constructing a natural gas pipeline in Thailand ($700 million)*

- ☑ *Building 30 plants for iMotors.com, a company that sells refurbished autos online ($300 million)*

- ☑ *Building a highway to link the north and south of Croatia ($303 million)*

Strategic Importance of Project Management

☑ **Microsoft Windows Vista Project:**

    ☑ *hundreds of programmers*

    ☑ *millions of lines of code*

    ☑ *hundreds of millions of dollars cost*

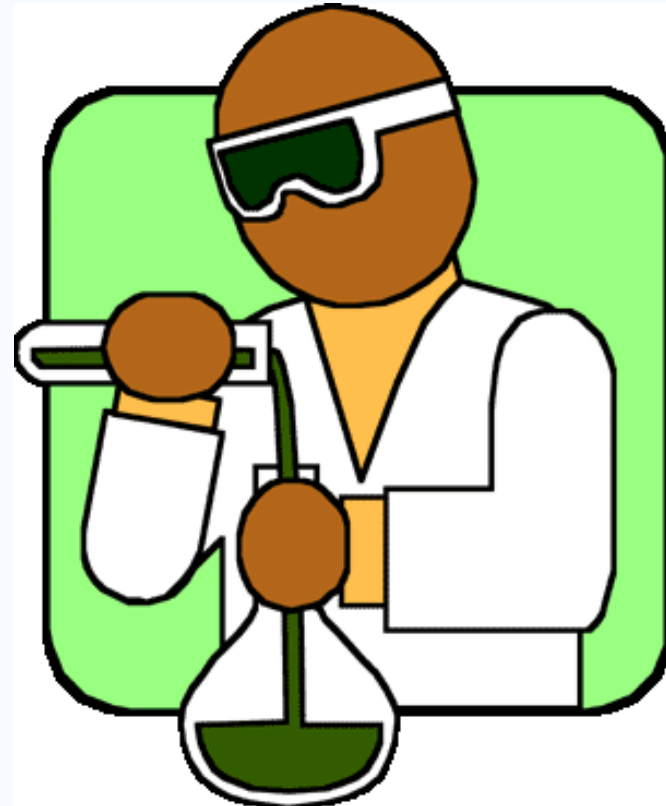☑ **Hard Rock Cafe Rockfest Project:**

    ☑ *100,000 + fans*

    ☑ *planning began 9 months in advance*

Project Characteristics

- ☑ *Single unit*

- ☑ *Many related activities*

- ☑ *Difficult production planning and inventory control*

- ☑ *General purpose equipment*

- ☑ *High labor skills*

Examples of Projects

☑ *Building Construction*

☑ *Research Project*

Management of Projects

1. *Planning* - goal setting, defining the project, team organization

2. *Scheduling* - relates people, money, and supplies to specific activities and activities to each other

3. *Controlling* - monitors resources, costs, quality, and budgets; revises plans and shifts resources to meet time and cost demands

Project Management Activities

☑ *Planning*
  ☑ *Objectives*
  ☑ *Resources*
  ☑ *Work break-down schedule*
  ☑ *Organization*

☑ *Scheduling*
  ☑ *Project activities*
  ☑ *Start & end times*
  ☑ *Network*

☑ *Controlling*
  ☑ *Monitor, compare, revise, action*
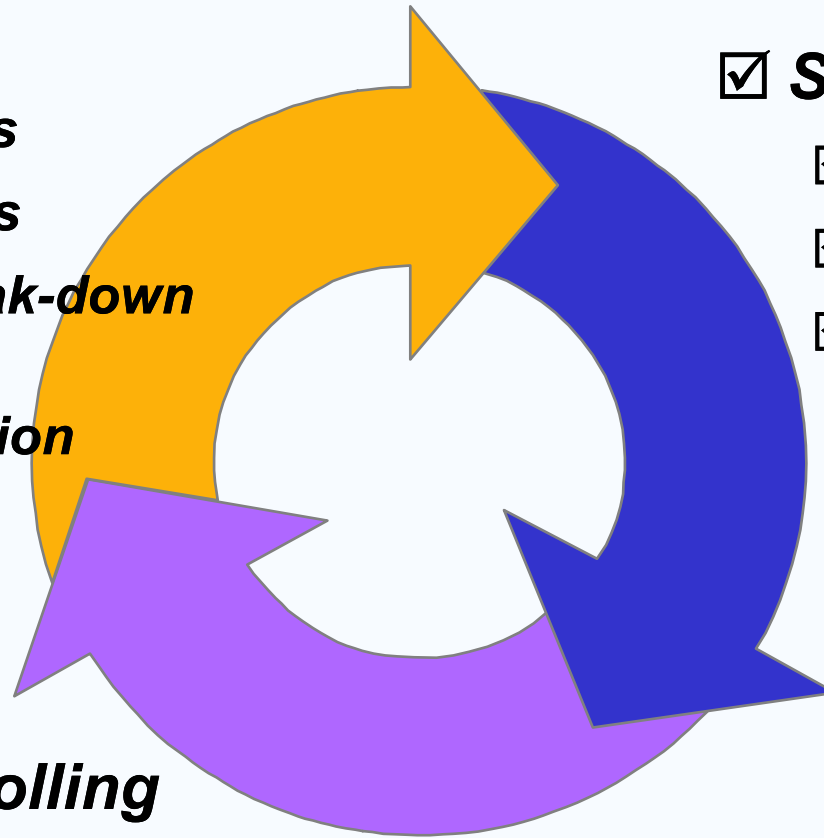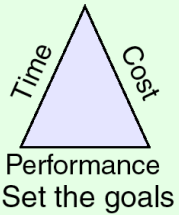
Project Planning, Scheduling, and Controlling
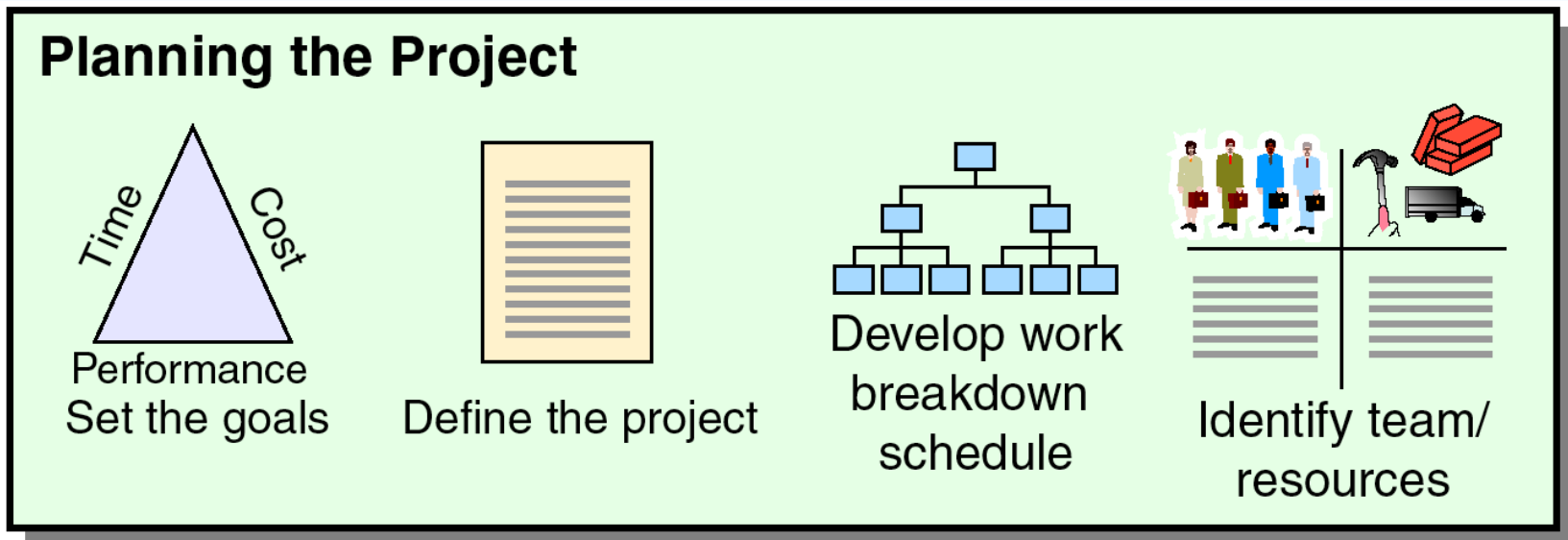
Planning the Project

Time Cost

Performance
Set the goals

Define the project

Develop work breakdown schedule

Identify team/resources

Figure 3.1

Before
project

Start of project
Timeline

During
project

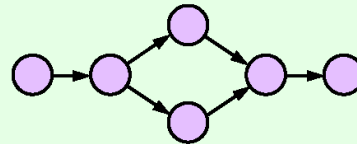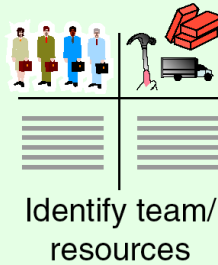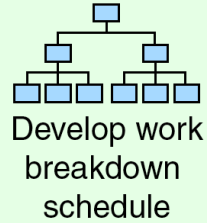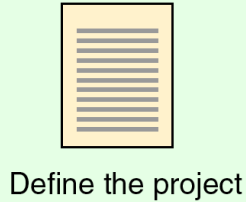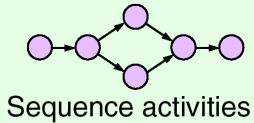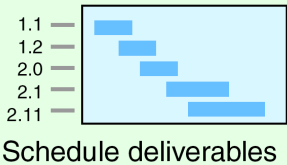# *Project Planning, Scheduling, and Controlling*

Planning the Project

Time / Cost / Performance
Set the goals

Define the project

Develop work breakdown schedule

Identify team/ resources

Scheduling the Project

Sequence activities

Assign people
- Adams ✓
- Smith ✓
- Jones ✓

Schedule deliverables
1.1
1.2
2.0
2.1
2.11

Schedule resources

June						
S	M	T	W	T	F	S
	1	2	3	4	5	6
7	8	9	10	11	12	13

Figure 3.1

Before project   *Start of project*   *During project*

Timeline

Project Planning, Scheduling, and Controlling

Planning the Project

Performance
Set the goals

Define the project

Develop work breakdown schedule
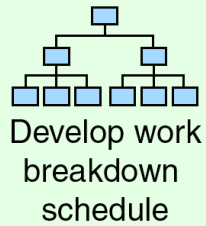
Identify team/ resources

Scheduling the Project

Sequence activities

Assign people

Schedule deliverables

Schedule resources

Controlling the Project

Revise and change plans

Monitor resources, costs, quality

Shift resources

Figure 3.1

Before project   *Start of project Timeline*   *During project*

Project Planning, Scheduling, and Controlling
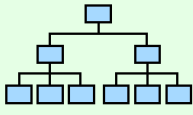
Planning the Project

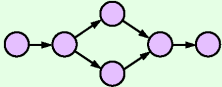Time / Cost / Performance
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Adams	✓		
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Jones		✓	

Assign people

1.1
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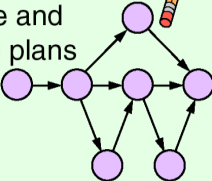
Schedule deliverables

June
S	M	T	W	T	F	S
			1	2	3	4
				5	6	
7	8	9	10	11	12	13

Schedule resources

Controlling the Project

Revise and change plans

1.1
1.2
2.0
2.1
2.11

Monitor resources, costs, quality

Adams	✓	✓	
Smith	✓		
Jones			✓

Shift resources

Figure 3.1

Project Scheduling, Tracking

Time/cost estimates
Budgets
Engineering diagrams
Cash flow charts
Material availability details

Planning the Project

Time · Cost
Performance
Set the goals

Define the p...

Develop work...

Scheduling the Project

Sequence activities

Adams	✓	
Smith		✓
Jones	✓	

Assign people

June
S	M	T	W	T	F	S
		1	2	3	4	5
7	8	9	10	11	12	13

...ule deliverables

Schedule resou...

Budgets
Delayed activities report
Slack activities report

Controlling the Project

Revise and change plans

1.1
1.2
2.0
2.1
2.11

Monitor resources, costs, quality

Adams	✓	
Smith	✓	
Jones		✓

Shift resources

CPM/PERT
Gantt charts
Milestone charts
Cash flow schedules
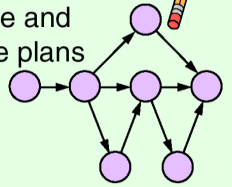
Figure 3.1

| Before | Start of project | During |
| project | Timeline | project |

Project Planning

- ☑ *Establishing objectives*
- ☑ *Defining project*
- ☑ *Creating work breakdown structure*
- ☑ *Determining resources*
- ☑ *Forming organization*
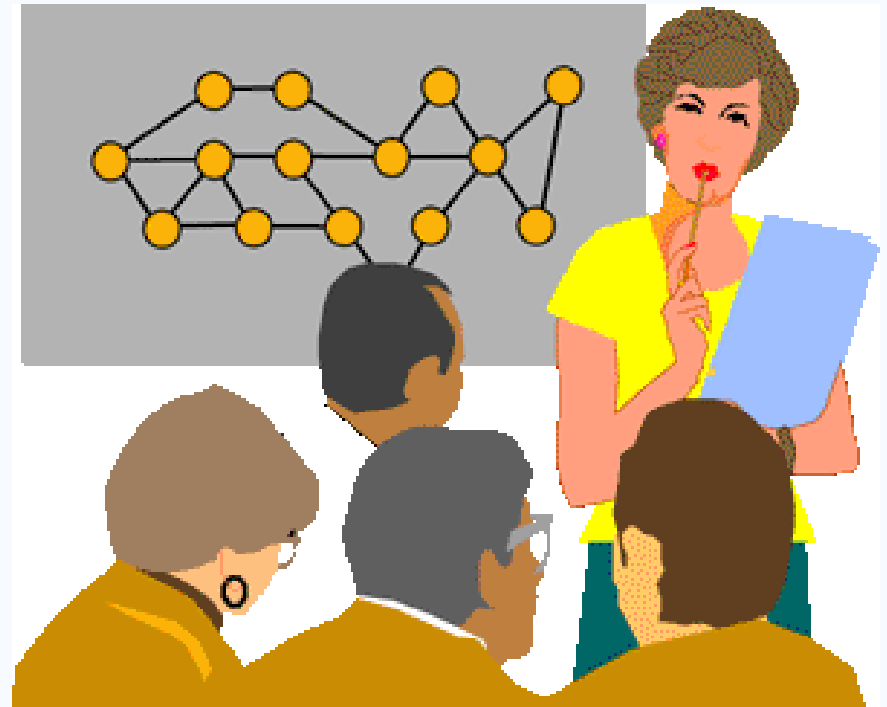
Project Organization

- ☑ *Often temporary structure*

- ☑ *Uses specialists from entire company*

- ☑ *Headed by project manager*

  - ☑ *Coordinates activities*

  - ☑ *Monitors schedule and costs*

- ☑ *Permanent structure called 'matrix organization'*
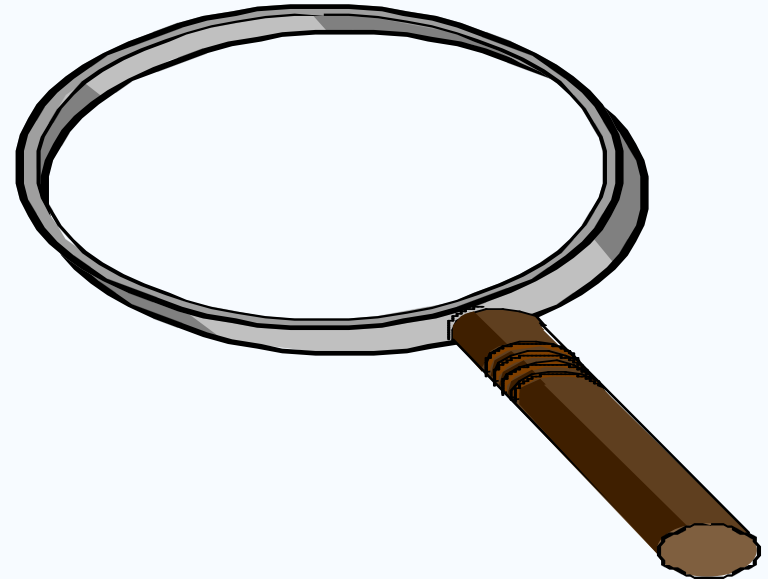
A Sample Project Organization

President

Human Resources | Marketing | Finance | Design | Quality Mgt | Production

Project 1
Project Manager — Mechanical Engineer — Test Engineer — Technician

Project 2
Project Manager — Electrical Engineer — Computer Engineer — Technician
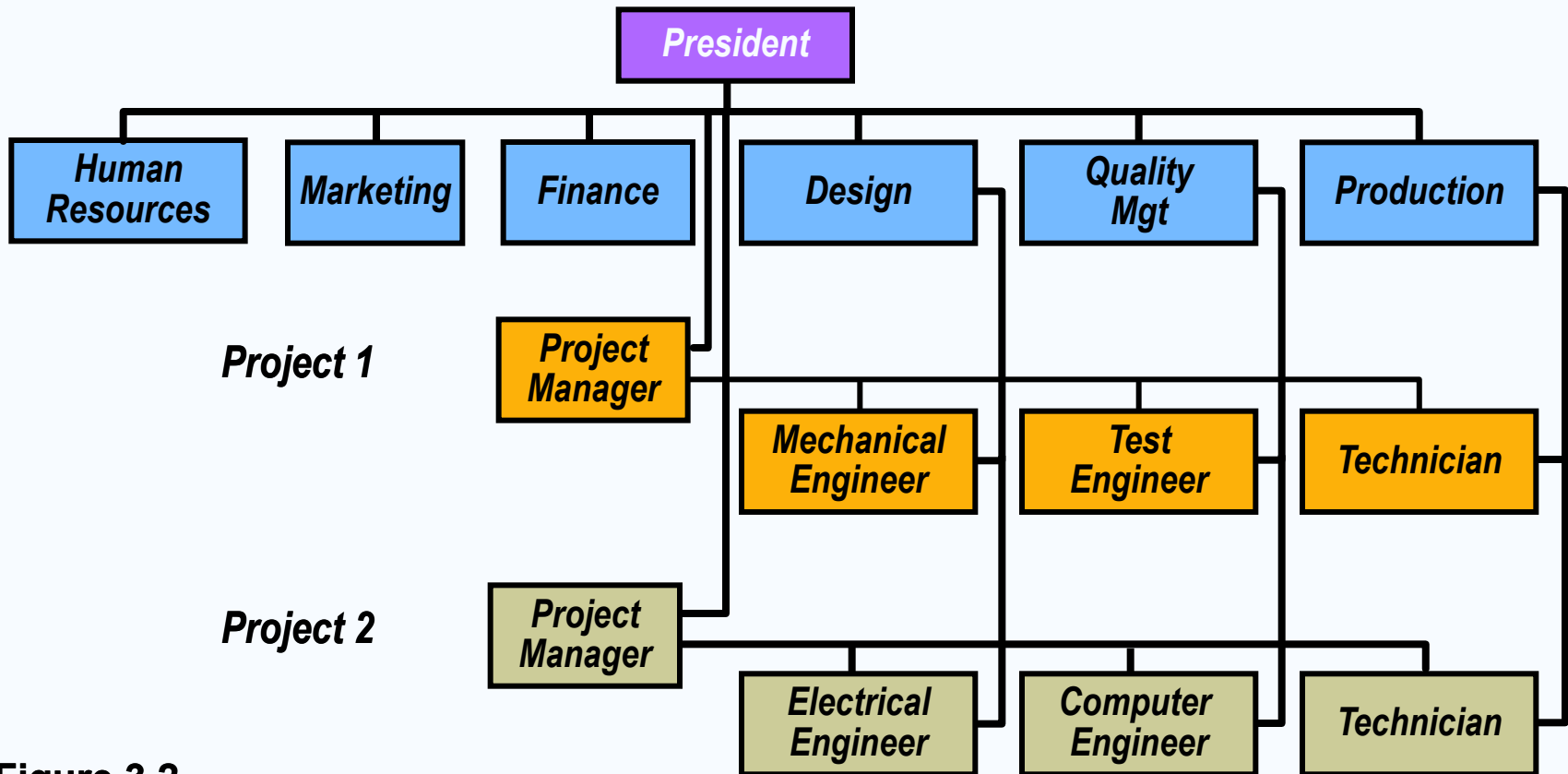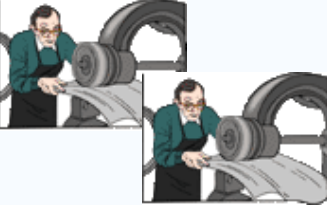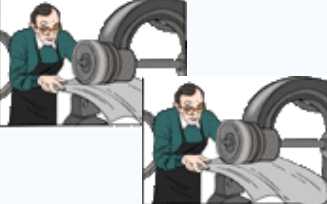
Figure 3.2

Project Organization Works Best When

1. **Work can be defined with a specific goal and deadline**

2. **The job is unique or somewhat unfamiliar to the existing organization**

3. **The work contains complex interrelated tasks requiring specialized skills**

4. **The project is temporary but critical to the organization**

5. **The project cuts across organizational lines**

Matrix Organization

	Marketing	Operations	Engineering	Finance
Project 1				
Project 2				
Project 3				
Project 4				

The Role of the Project Manager

Highly visible
Responsible for making sure that:

- ☑ *All necessary activities are finished in order and on time*

- ☑ *The project comes in within budget*

- ☑ *The project meets quality goals*

- ☑ *The people assigned to the project receive motivation, direction, and information*

The Role of the Project Manager

Highly visible
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☑ **All necessary activities are finished in order and on time**

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☑ **The people assigned to the project receive motivation, direction, and information**

Project managers should be:

☑ **Good coaches**

☑ **Good communicators**

☑ **Able to organize activities from a variety of disciplines**

Ethical Issues

- ☑ *Bid rigging – divulging confidential information to give some bidders an unfair advantage*

- ☑ *"Low balling" contractors – try to "buy" the project by bidding low and hope to renegotiate or cut corners*

- ☑ *Bribery – particularly on international projects*

- ☑ *Expense account padding*

- ☑ *Use of substandard materials*

- ☑ *Compromising health and safety standards*

- ☑ *Withholding needed information*

- ☑ *Failure to admit project failure at close*

Work Breakdown Structure

Level

1. Project

2.   Major tasks in the project

3.   Subtasks in the major tasks

4.   Activities (or work packages) to be completed

Work Breakdown Structure

Level	Level ID Number	Activity
1	1.0	Develop/launch Windows Vista OS
2	1.1	Develop of GUIs
2	1.2	Ensure compatibility with earlier Windows versions
3	1.21	Compatibility with Windows ME
3	1.22	Compatibility with Windows XP
3	1.23	Compatibility with Windows 2000
4	1.231	Ensure ability to import files

Figure 3.3

Project Scheduling

- ☑ *Identifying precedence relationships*

- ☑ *Sequencing activities*

- ☑ *Determining activity times & costs*

- ☑ *Estimating material & worker requirements*

- ☑ *Determining critical activities*

Purposes of Project Scheduling

1. *Shows the relationship of each activity to others and to the whole project*

2. *Identifies the precedence relationships among activities*

3. *Encourages the setting of realistic time and cost estimates for each activity*

4. *Helps make better use of people, money, and material resources by identifying critical bottlenecks in the project*

Scheduling Techniques

1. Ensure that all activities are planned for

2. Their order of performance is accounted for

3. The activity time estimates are recorded

4. The overall project time is developed

Project Management Techniques
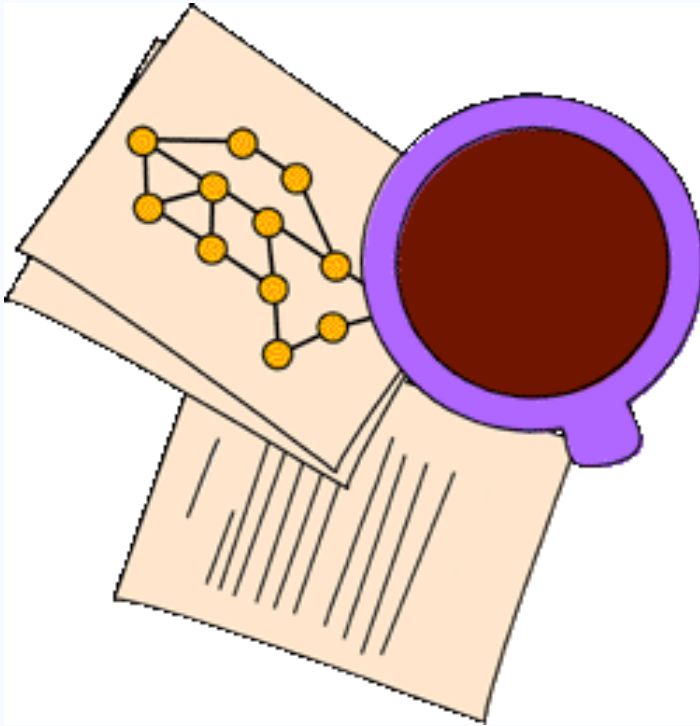
- ☑ *Gantt chart*
- ☑ *Critical Path Method (CPM)*
- ☑ *Program Evaluation and Review Technique (PERT)*

A Simple Gantt Chart

		Time							
	J	F	M	A	M	J	J	A	S
Design	▬▬▬▬▬▬▬▬▬▬▬								
Prototype		▬▬▬							
Test			▬▬▬						
Revise				▬▬▬					
Production						▬▬▬▬▬▬			

Service For A Delta Jet

		Time, Minutes
Passengers	**Deplaning**	
	Baggage claim	
Baggage	**Container offload**	
Fueling	**Pumping**	
	Engine injection water	
Cargo and mail	**Container offload**	
Galley servicing	**Main cabin door**	
	Aft cabin door	
Lavatory servicing	**Aft, center, forward**	
Drinking water	**Loading**	
Cabin cleaning	**First-class section**	
	Economy section	
Cargo and mail	**Container/bulk loading**	
Flight services	**Galley/cabin check**	
	Receive passengers	
Operating crew	**Aircraft check**	
Baggage	**Loading**	
Passengers	**Boarding**	

0   10   20   30   40

Time, Minutes

Figure 3.4

Project Control Reports

- ☑ *Detailed cost breakdowns for each task*
- ☑ *Total program labor curves*
- ☑ *Cost distribution tables*
- ☑ *Functional cost and hour summaries*
- ☑ *Raw materials and expenditure forecasts*
- ☑ *Variance reports*
- ☑ *Time analysis reports*
- ☑ *Work status reports*

PERT and CPM

☑ **Network techniques**

☑ **Developed in 1950's**

    ☑ **CPM by DuPont for chemical plants (1957)**

    ☑ **PERT by Booz, Allen & Hamilton with the U.S. Navy, for Polaris missile (1958)**

☑ **Consider precedence relationships and interdependencies**

☑ **Each uses a different estimate of activity times**

Six Steps PERT & CPM

1. **Define the project and prepare the work breakdown structure**

2. **Develop relationships among the activities - decide which activities must precede and which must follow others**

3. **Draw the network connecting all of the activities**

Six Steps PERT & CPM

4. Assign time and/or cost estimates to each activity

5. Compute the longest time path through the network – this is called the critical path

6. Use the network to help plan, schedule, monitor, and control the project

Questions PERT & CPM Can Answer

1. **When will the entire project be completed?**

2. **What are the critical activities or tasks in the project?**

3. **Which are the noncritical activities?**

4. **What is the probability the project will be completed by a specific date?**

Questions PERT & CPM Can Answer

5. Is the project on schedule, behind schedule, or ahead of schedule?

6. Is the money spent equal to, less than, or greater than the budget?

7. Are there enough resources available to finish the project on time?

8. If the project must be finished in a shorter time, what is the way to accomplish this at least cost?

A Comparison of AON and AOA Network Conventions

Activity on Node (AON)	Activity Meaning	Activity on Arrow (AOA)

(a) A → B → C | A comes before B, which comes before C | A   B   C

(b)   A → C, B → C | A and B must both be completed before C can start | A, B → C

(c)   A → B, A → C | B and C cannot begin until A is completed | A → B, C

Figure 3.5

A Comparison of AON and AOA Network Conventions

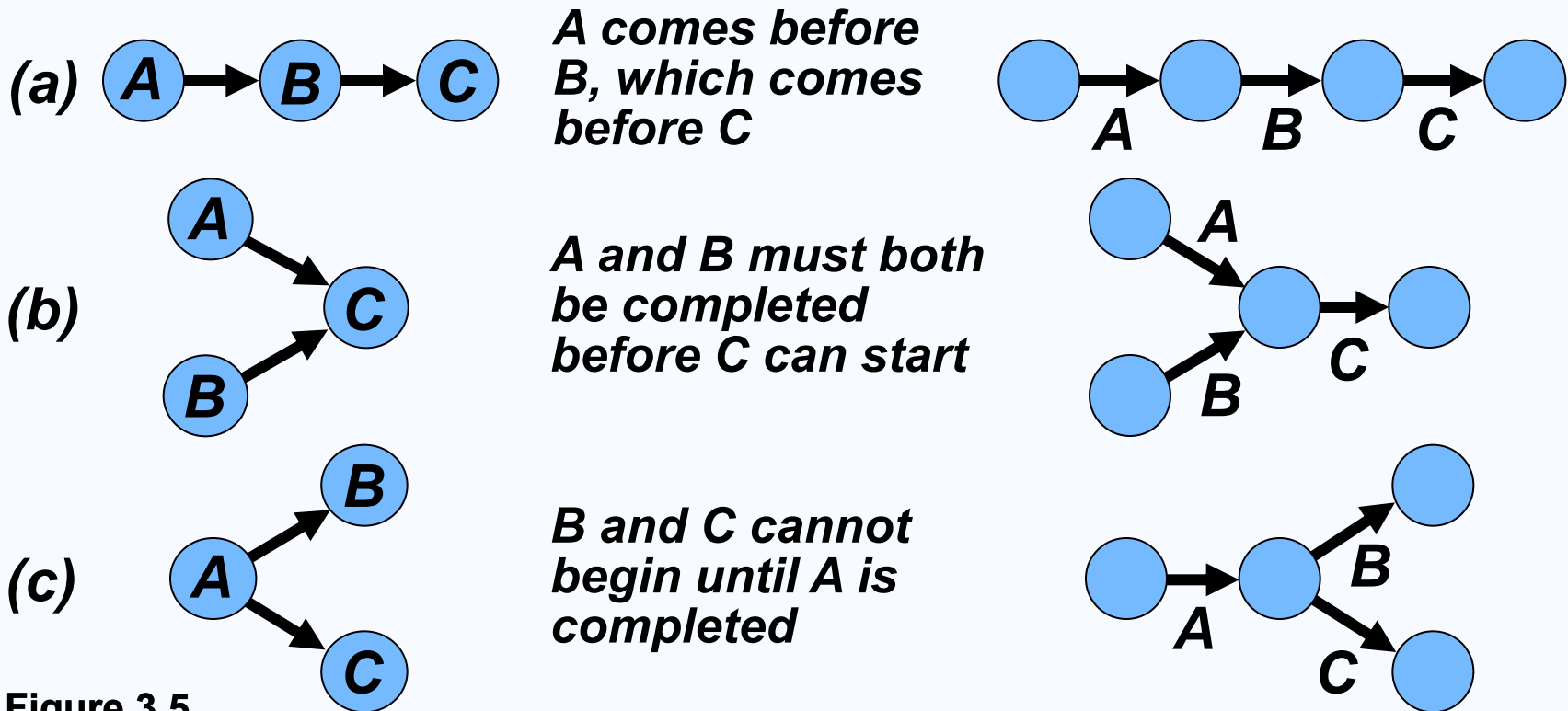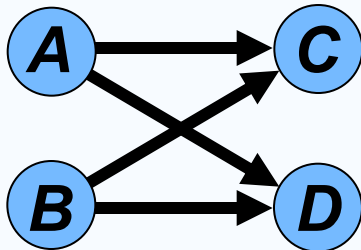| Activity on Node (AON)	Activity Meaning	Activity on Arrow (AOA)
(d)	C and D cannot begin until both A and B are completed	
(e)	C cannot begin until both A and B are completed; D cannot begin until B is completed. A dummy activity is introduced in AOA	Dummy activity
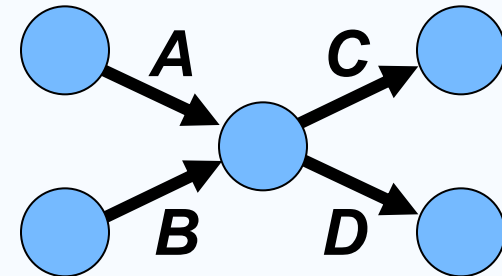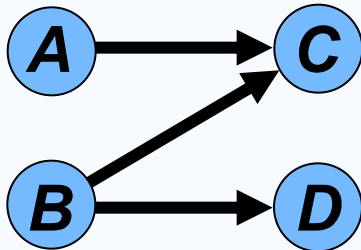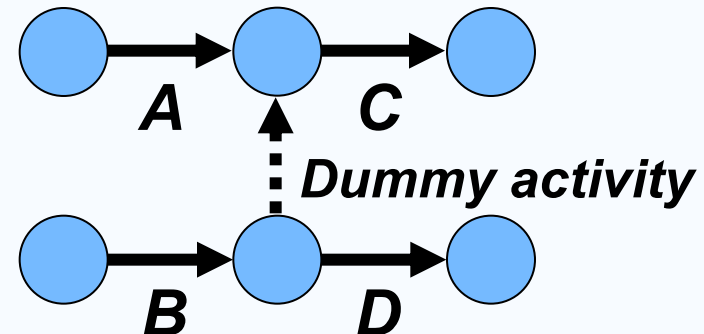
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A Comparison of AON and AOA Network Conventions

Activity on Node (AON)	Activity Meaning	Activity on Arrow (AOA)
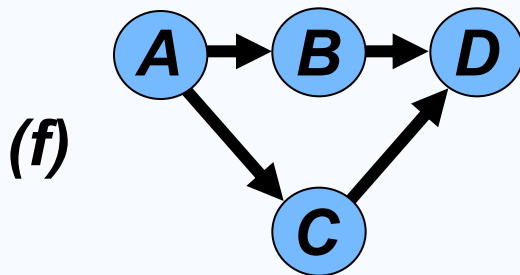
B and C cannot begin until A is completed. D cannot begin until both B and C are completed. A dummy activity is again introduced in AOA.

(f)
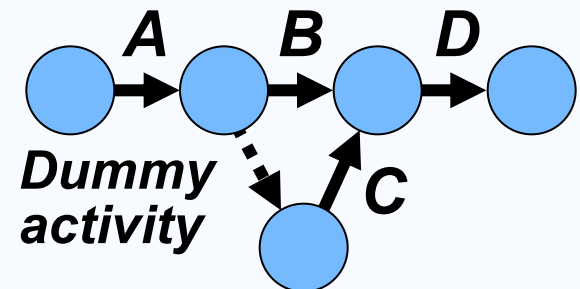
Figure 3.5

AON Example

Milwaukee Paper Manufacturing's Activities and Predecessors

Activity	Description	Immediate Predecessors
A	Build internal components	—
B	Modify roof and floor	—
C	Construct collection stack	A
D	Pour concrete and install frame	A, B
E	Build high-temperature burner	C
F	Install pollution control system	C
G	Install air pollution device	D, E
H	Inspect and test	F, G

Table 3.1

AON Network for Milwaukee Paper

A

Activity A
(Build Internal Components)

Start

Start Activity

B

Activity B
(Modify Roof and Floor)
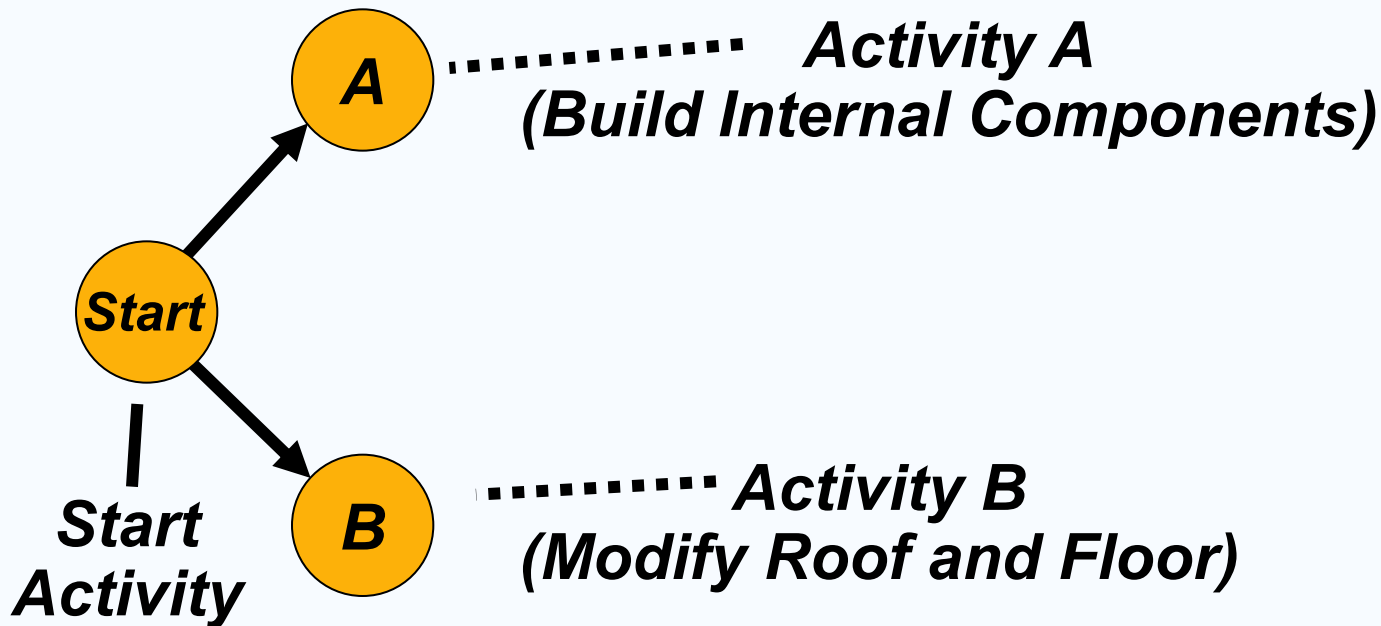
Figure 3.6

AON Network for Milwaukee Paper

Activity A Precedes Activity C

Activities A and B Precede Activity D
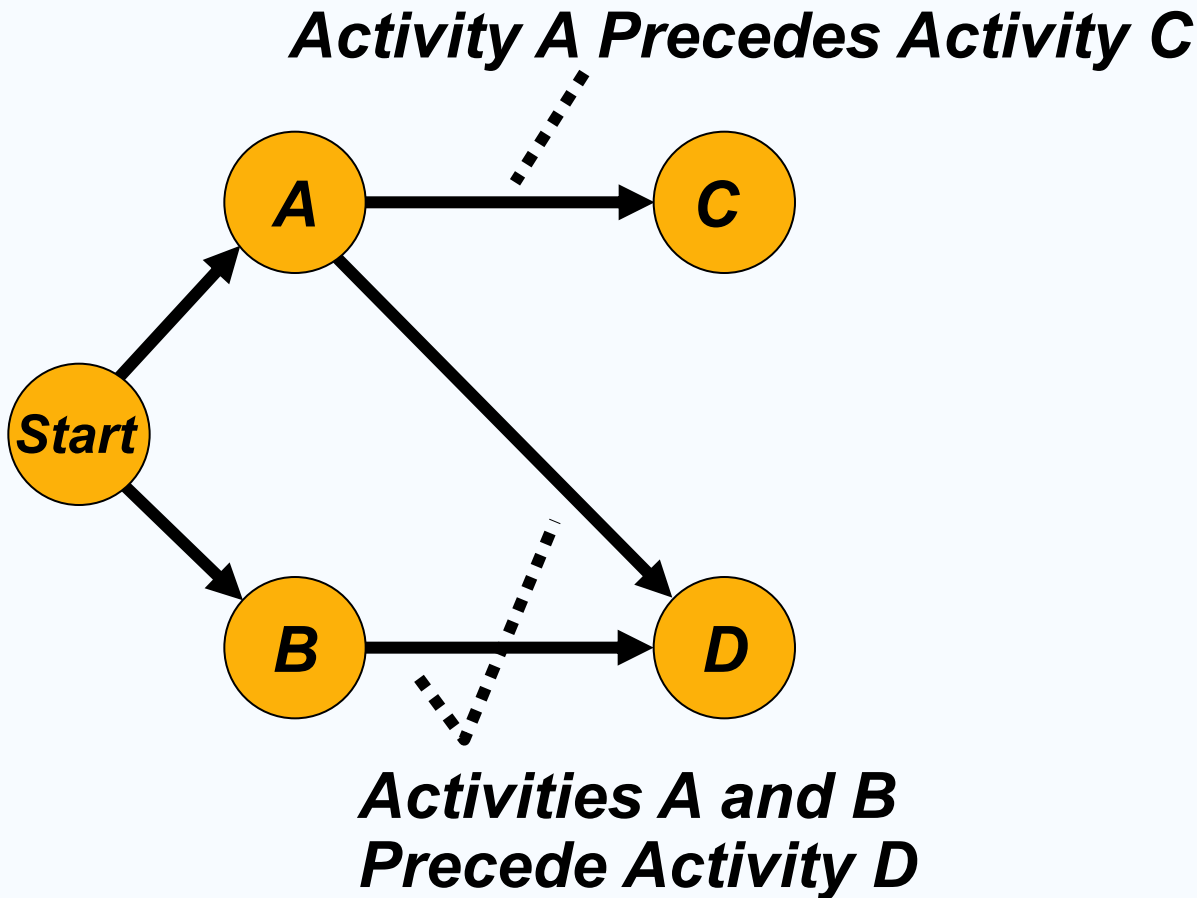
Figure 3.7

AON Network for Milwaukee Paper
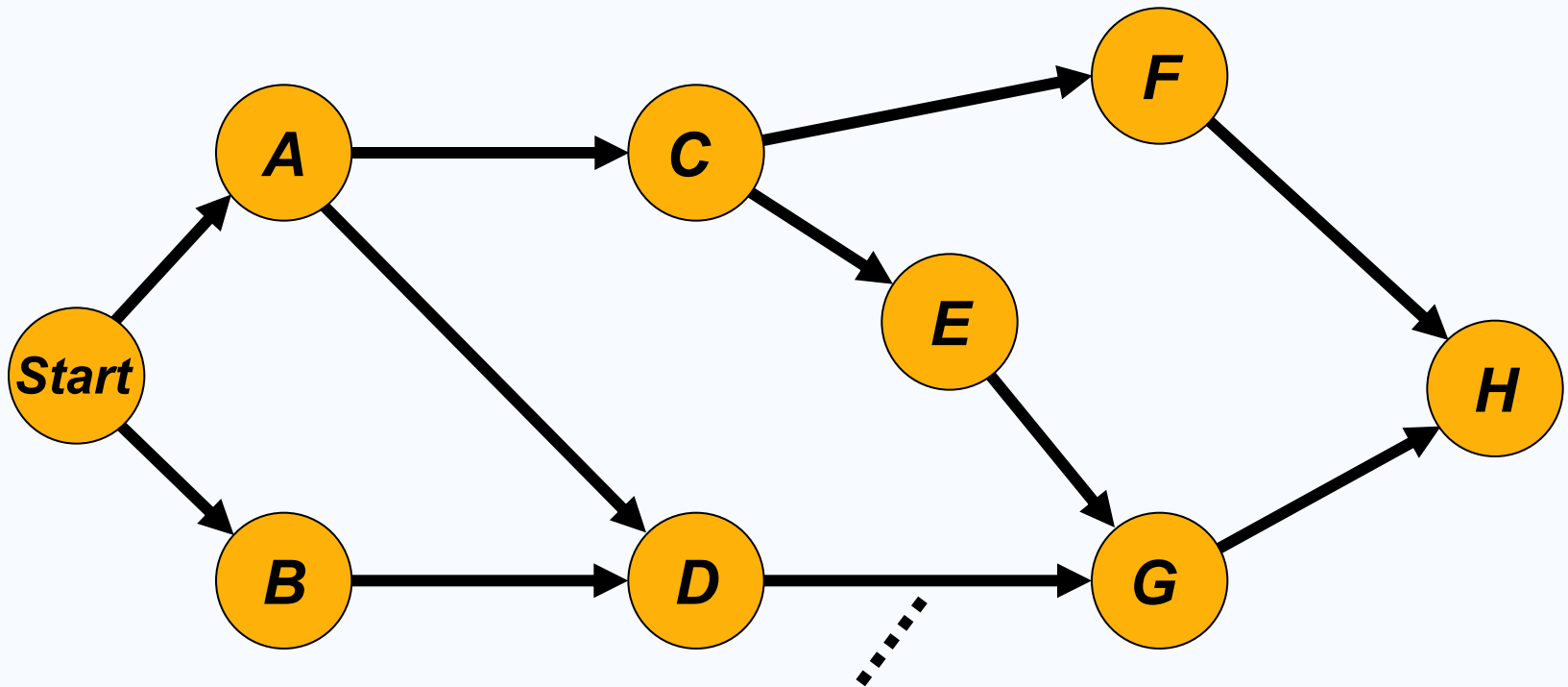
Arrows Show Precedence Relationships

Figure 3.8

AOA Network for Milwaukee Paper

2 (Construct Stack)

C

4

A (Build Internal Components)

1

B (Modify Roof/Floor)

3

D (Pour Concrete/Install Frame)

5

E (Build Burner)

F (Install Controls)

6

G (Install Pollution Device)

H (Inspect/Test)

7

Dummy Activity
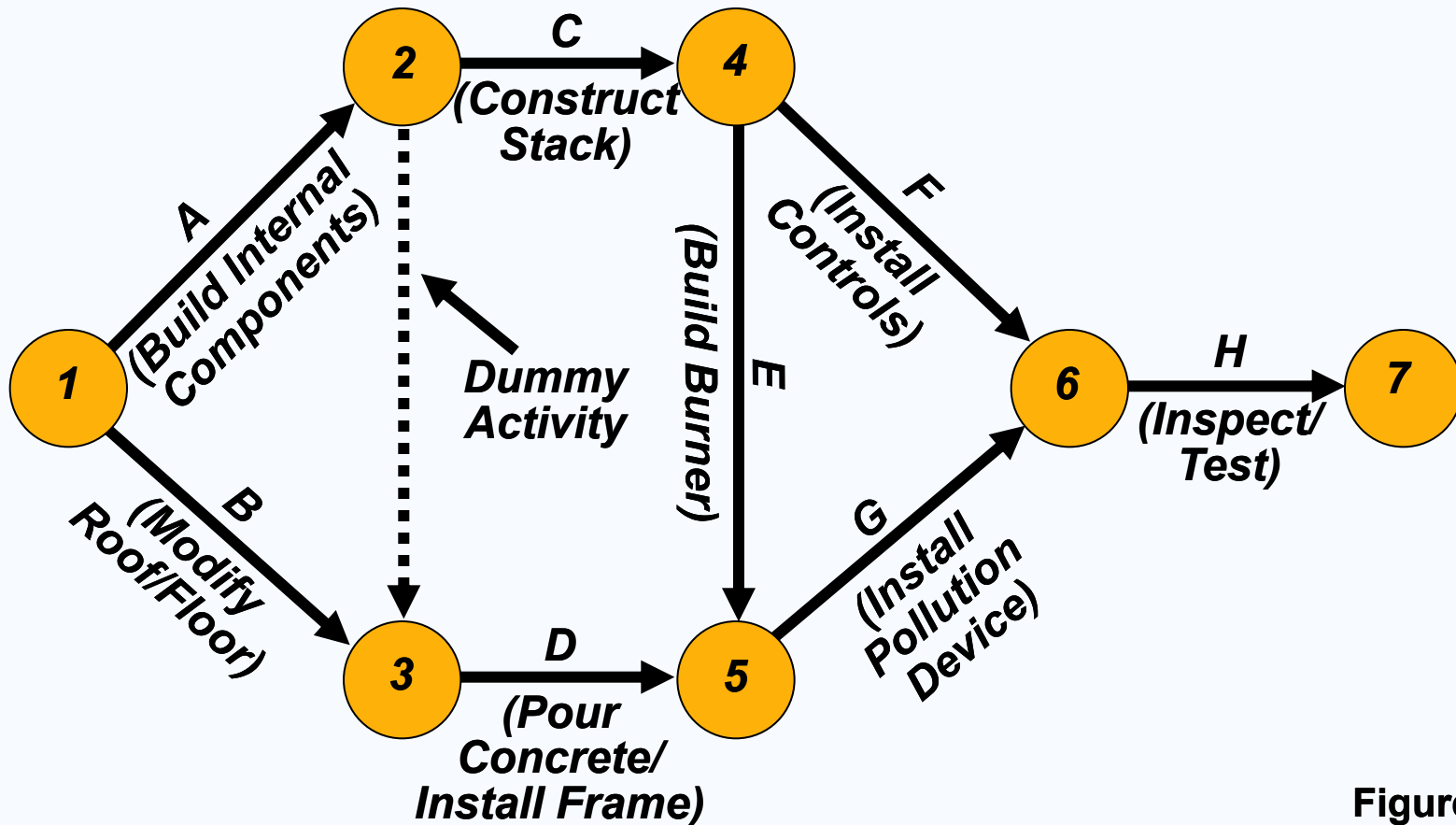
Figure 3.9

Determining the Project Schedule

Perform a Critical Path Analysis

- ☑ **The critical path is the longest path through the network**

- ☑ **The critical path is the shortest time in which the project can be completed**

- ☑ **Any delay in critical path activities delays the project**

- ☑ **Critical path activities have no slack time**

Determining the Project Schedule

Perform a Critical Path Analysis

Activity	Description	Time (weeks)
A	Build internal components	2
B	Modify roof and floor	3
C	Construct collection stack	2
D	Pour concrete and install frame	4
E	Build high-temperature burner	4
F	Install pollution control system	3
G	Install air pollution device	5
H	Inspect and test	2
	Total Time (weeks)	25

Table 3.2

Determining the Project Schedule

Perform a Critical Path Analysis

Earliest start (ES) = earliest time at which an activity can start, assuming all predecessors have been completed

Earliest finish (EF) = earliest time at which an activity can be finished

Latest start (LS) = latest time at which an activity can start so as to not delay the completion time of the entire project

Latest finish (LF) = latest time by which an activity has to be finished so as to not delay the completion time of the entire project

Determining the Project Schedule

Perform a Critical Path Analysis

Activity Name or Symbol

A

Earliest Start — ES

Earliest Finish — EF

Latest Start — LS

Latest Finish — LF

2

Activity Duration
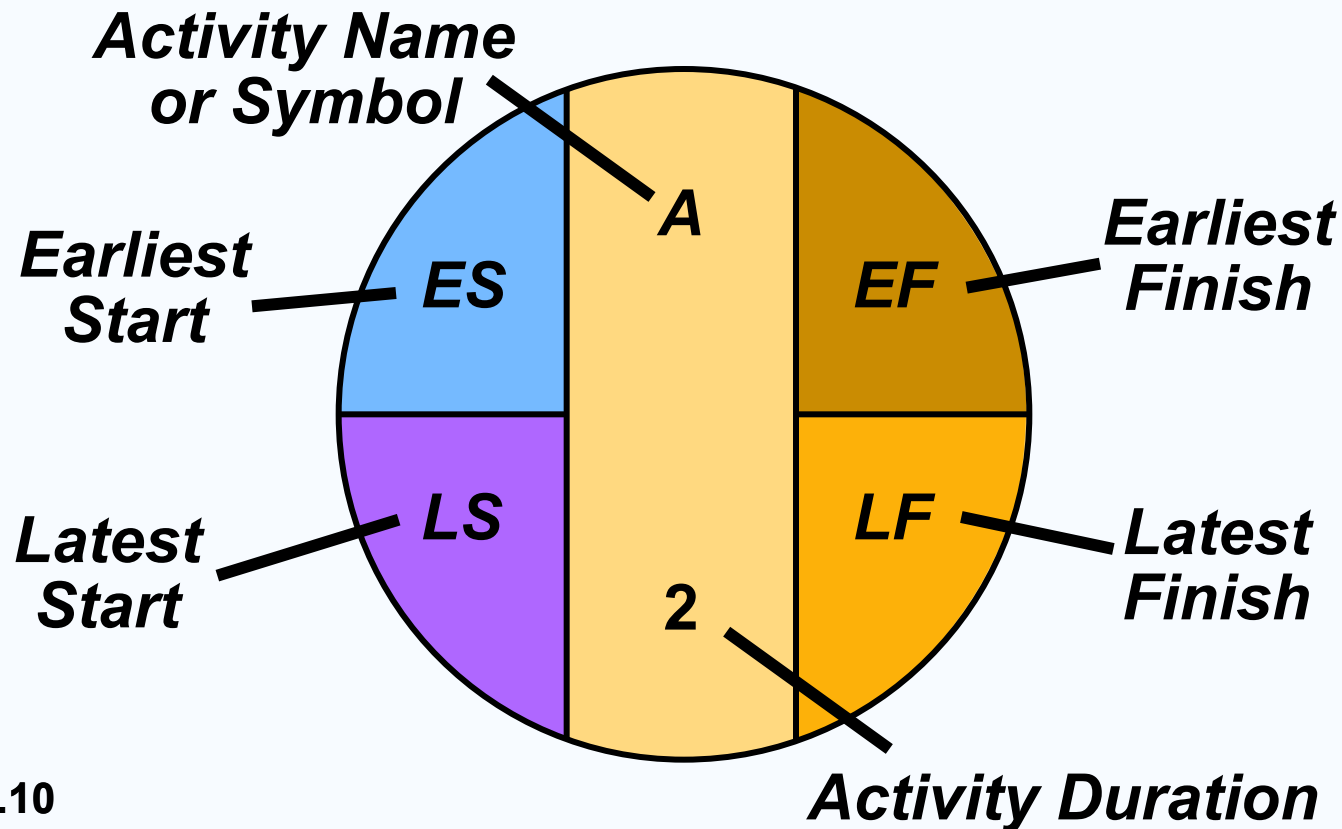
Figure 3.10

Forward Pass

Begin at starting event and work forward

Earliest Start Time Rule:

☑ *If an activity has only a single immediate predecessor, its ES equals the EF of the predecessor*

☑ *If an activity has multiple immediate predecessors, its ES is the maximum of all the EF values of its predecessors*

ES = Max {EF of all immediate predecessors}

Forward Pass

Begin at starting event and work forward

Earliest Finish Time Rule:

☑ *The earliest finish time (EF) of an activity is the sum of its earliest start time (ES) and its activity time*

$$EF = ES + Activity\ time$$

ES/EF Network for Milwaukee Paper
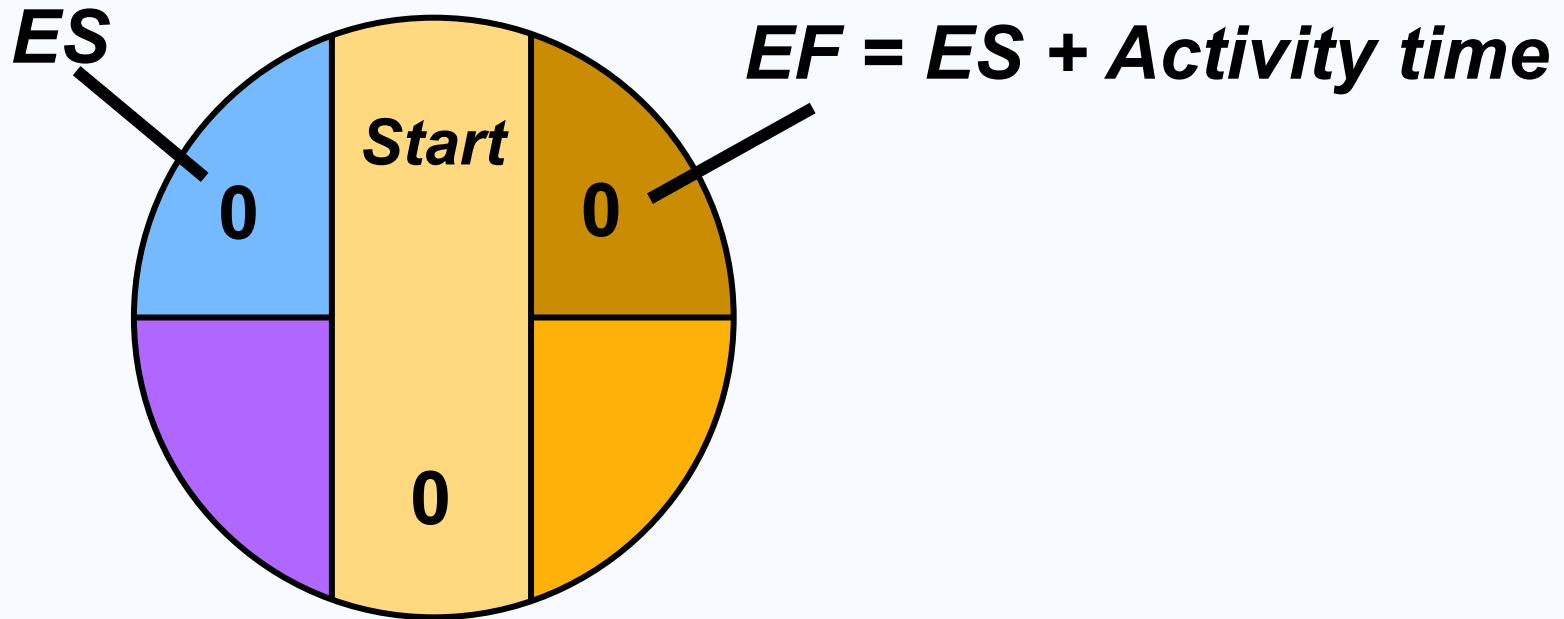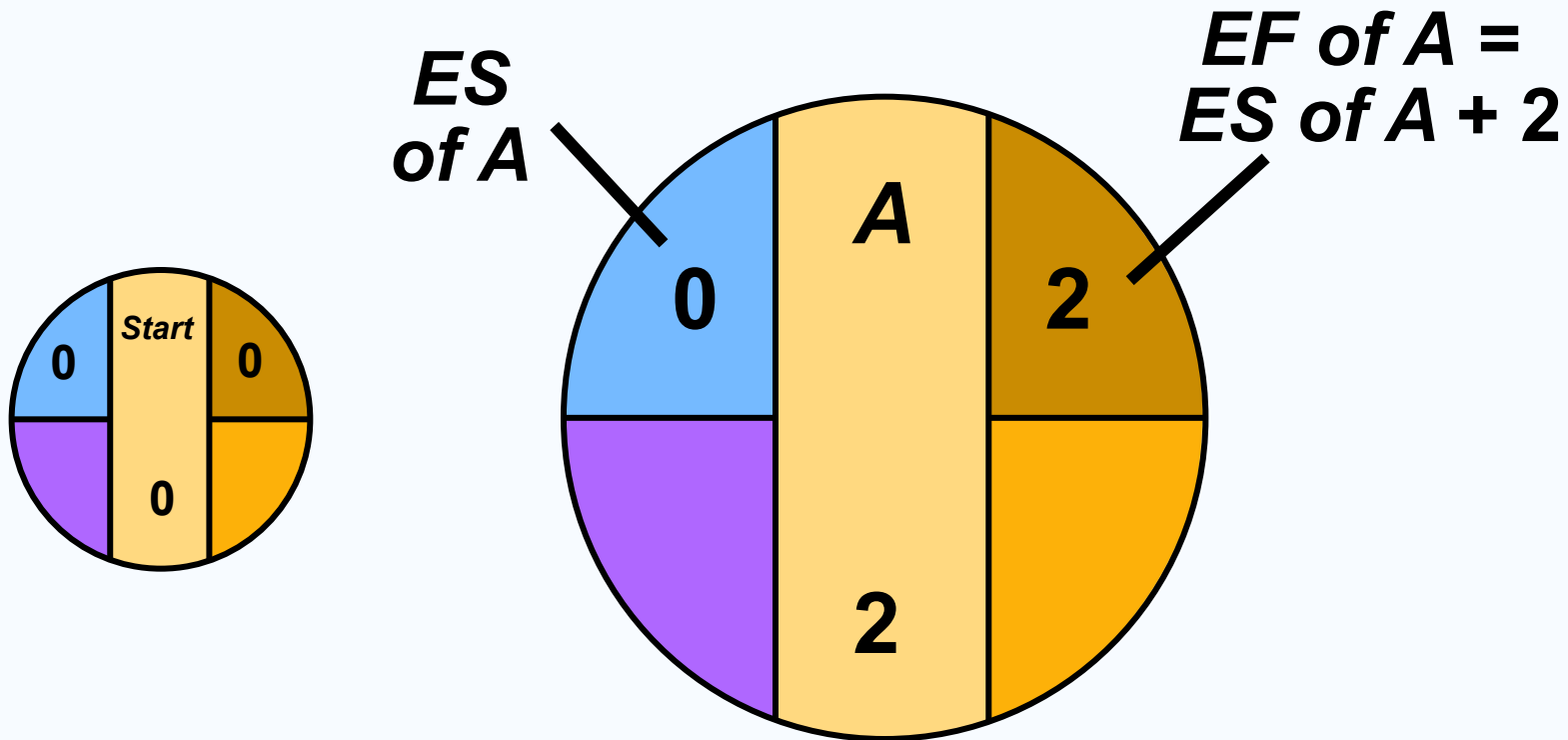
ES

Start

EF = ES + Activity time

0

0

0

ES/EF Network for Milwaukee Paper

ES/EF Network for Milwaukee Paper
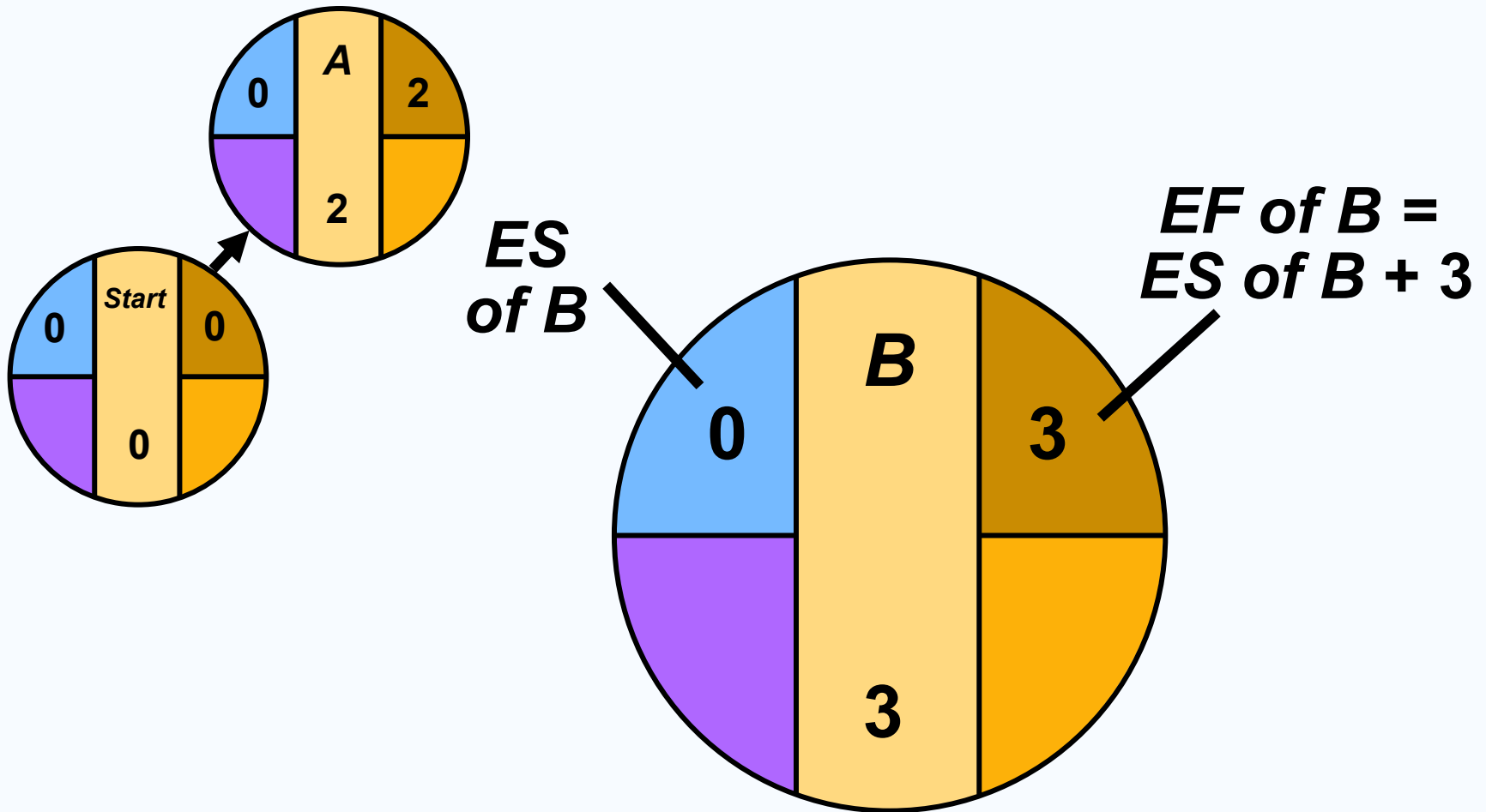
ES/EF Network for Milwaukee Paper
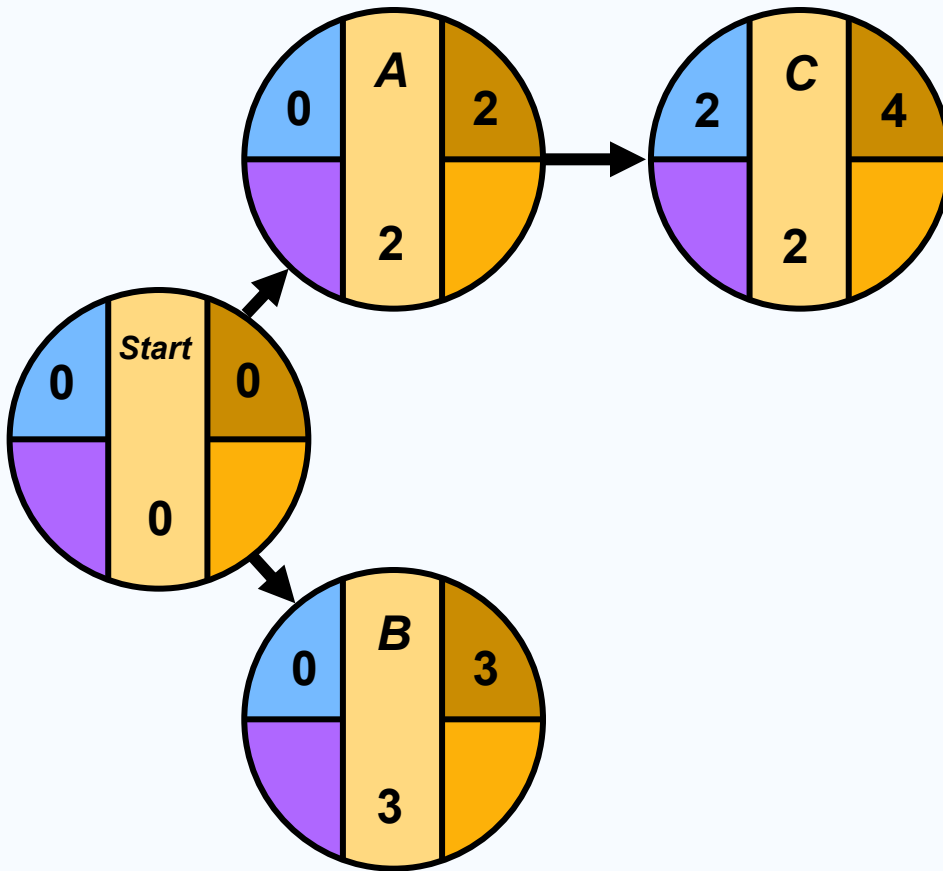
ES/EF Network for Milwaukee Paper
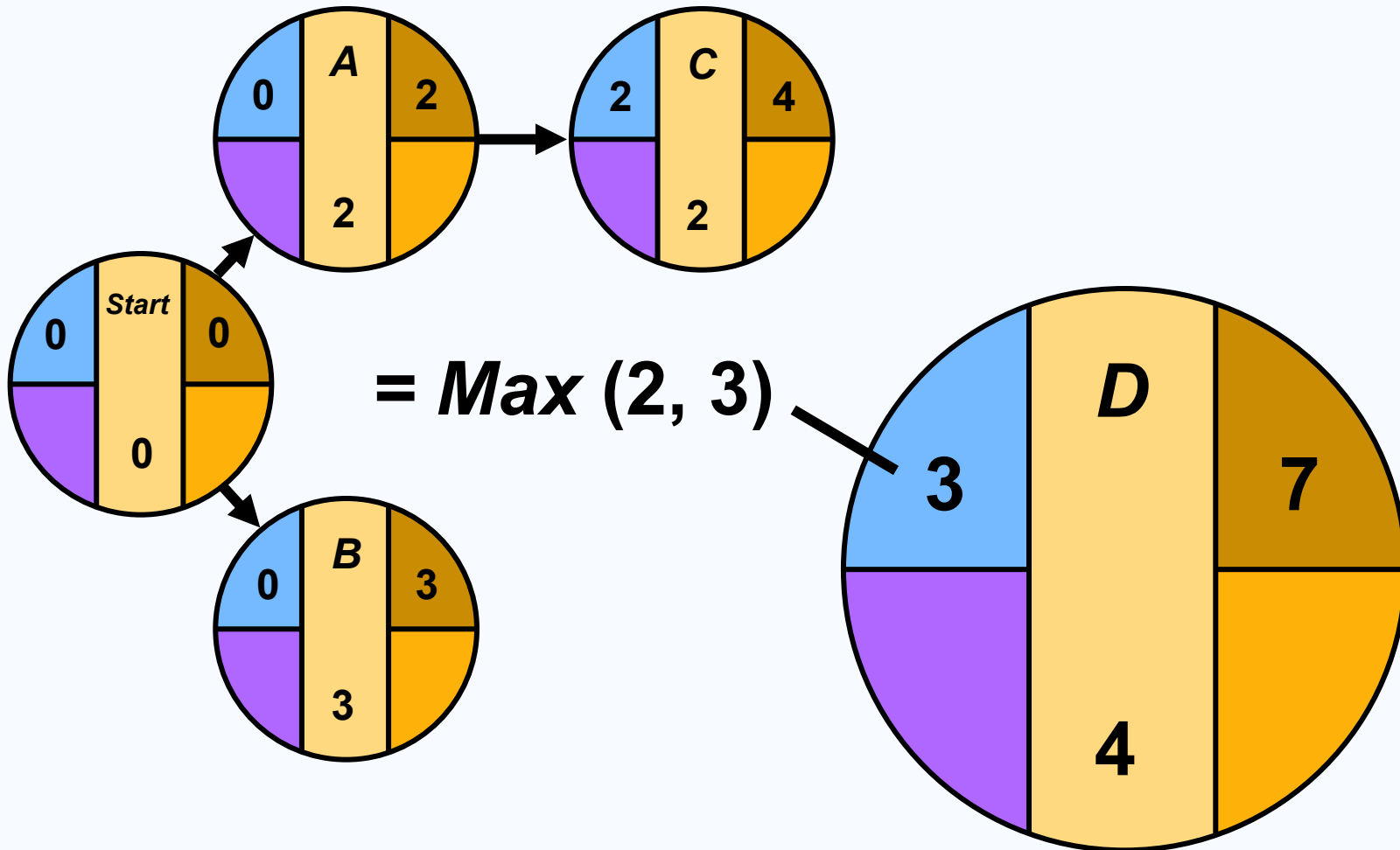
ES/EF Network for Milwaukee Paper
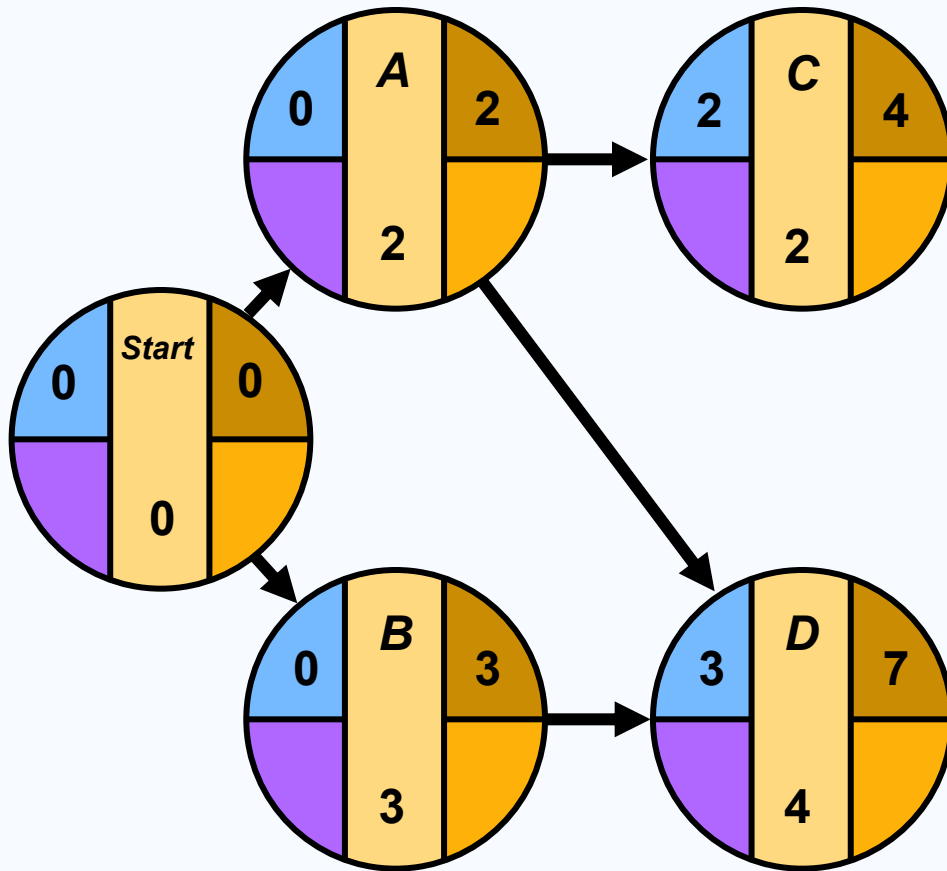
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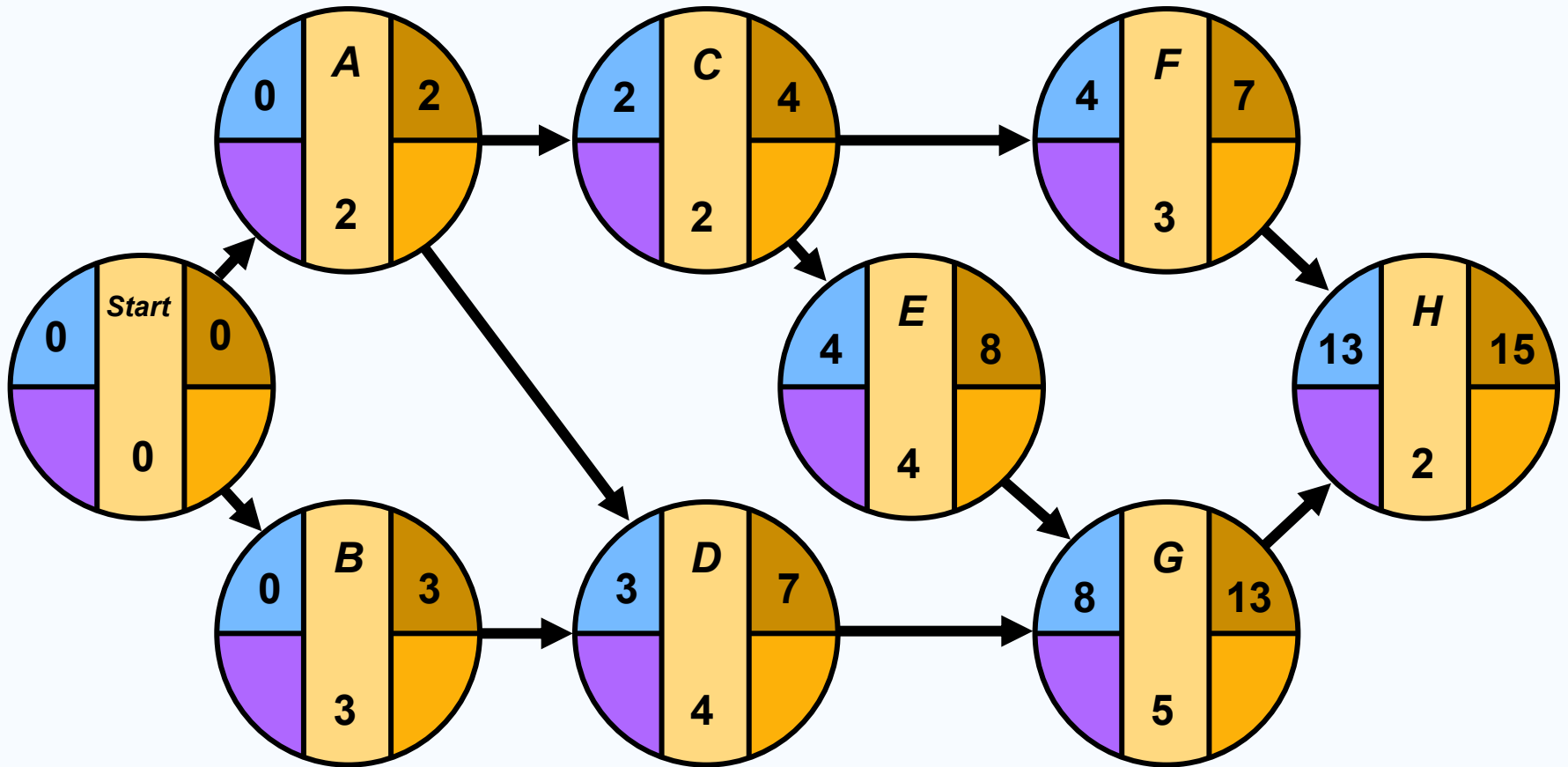
Figure 3.11

Backward Pass

Begin with the last event and work backwards

Latest Finish Time Rule:

- ☑ *If an activity is an immediate predecessor for just a single activity, its LF equals the LS of the activity that immediately follows it*

- ☑ *If an activity is an immediate predecessor to more than one activity, its LF is the minimum of all LS values of all activities that immediately follow it*

LF = Min {LS of all immediate following activities}

Backward Pass

Begin with the last event and work backwards

Latest Start Time Rule:

- ☑ *The latest start time (LS) of an activity is the difference of its latest finish time (LF) and its activity time*

$$LS = LF - Activity\ time$$

LS/LF Times for Milwaukee Paper

Start 0 | 0 | 0

A 0 | 2 | 2

C 2 | 4 | 2

F 4 | 7 | 3

E 4 | 8 | 4

H 13 | 15 | 13 | 15 | 2

B 0 | 3 | 3

LS = LF − Activity time

LF = EF of Project

LS/LF Times for Milwaukee Paper

LF = Min(LS of following activity)
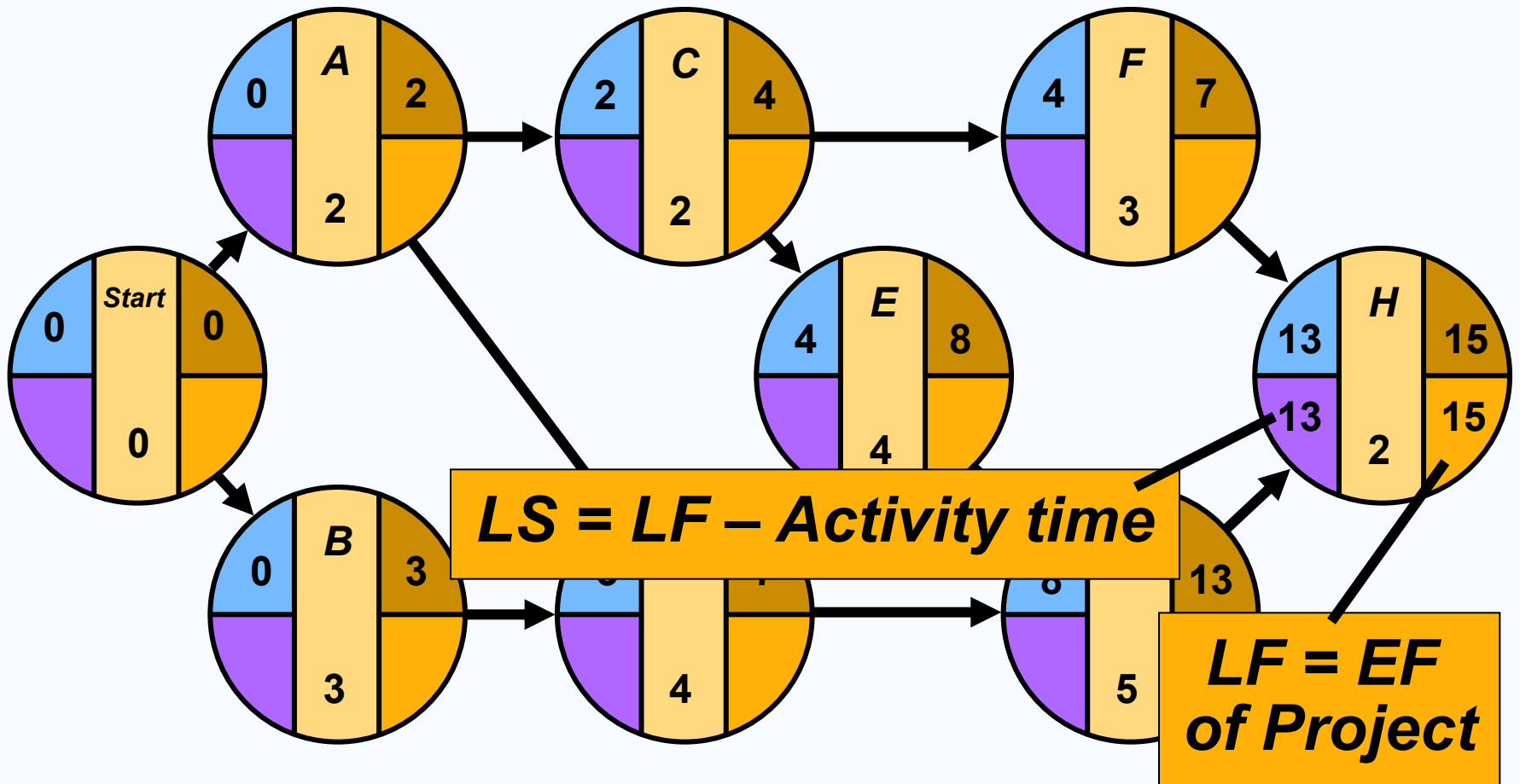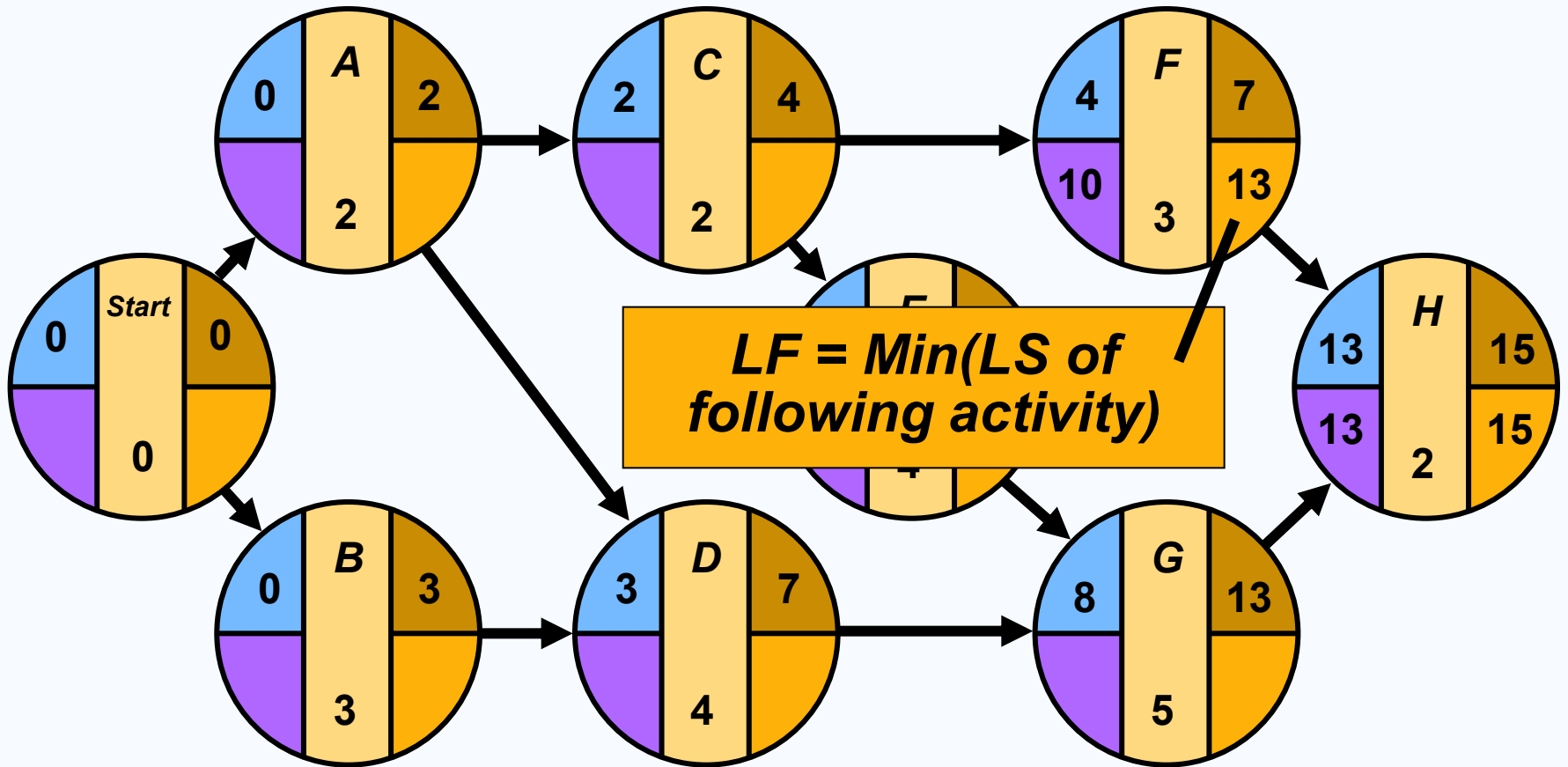
LS/LF Times for Milwaukee Paper

LF = Min(4, 10)
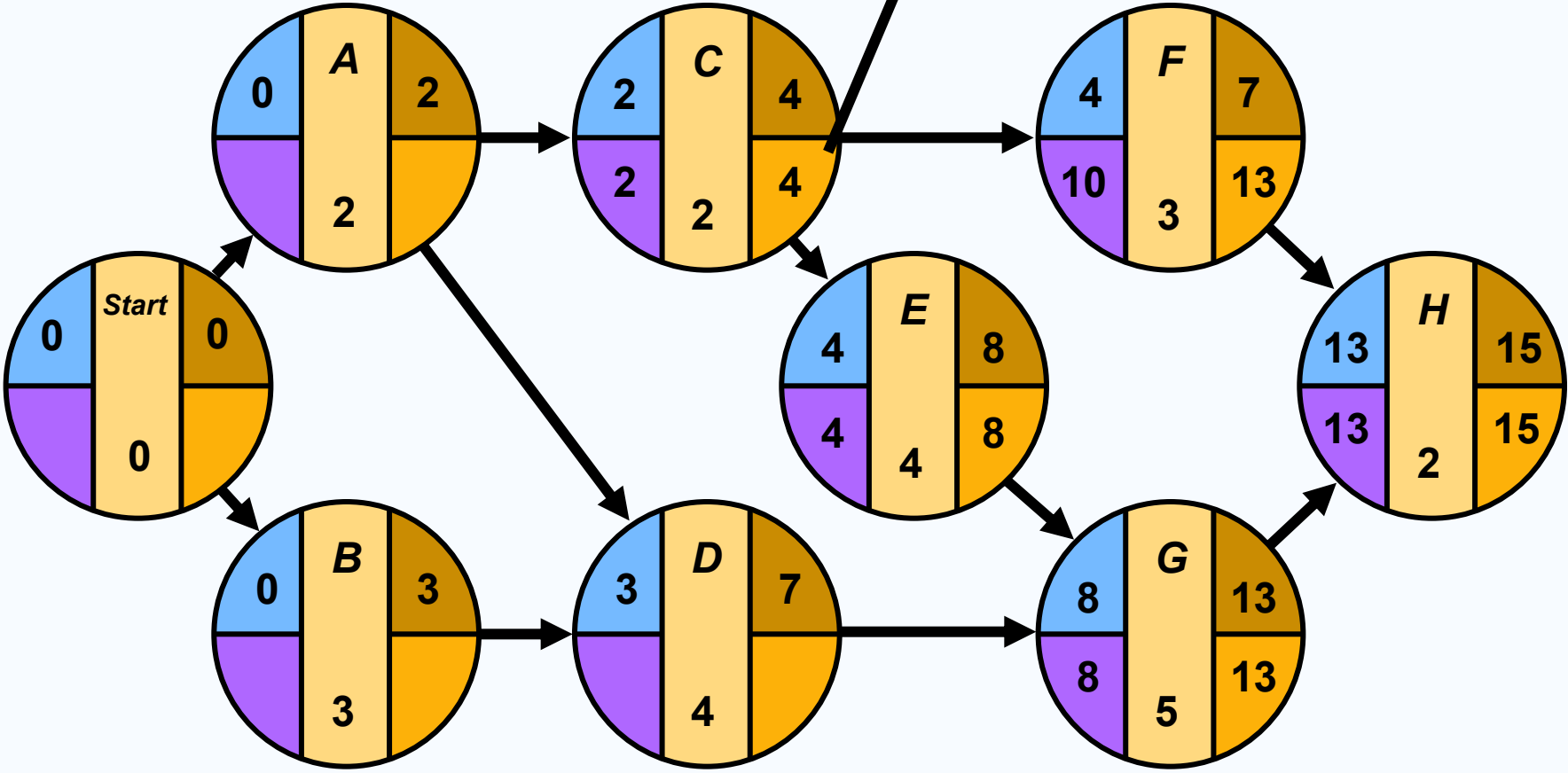
LS/LF Times for Milwaukee Paper
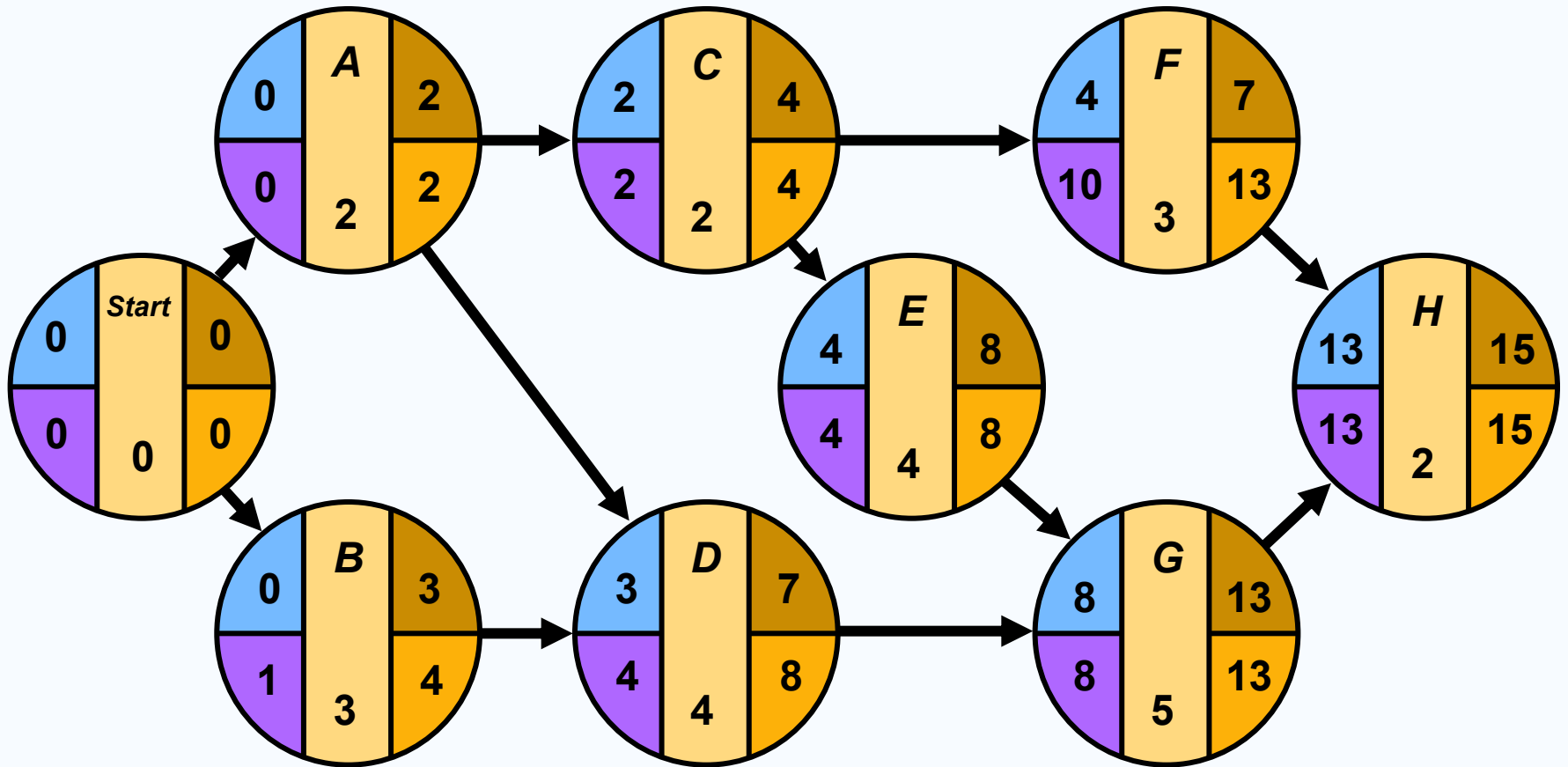
Computing Slack Time

After computing the ES, EF, LS, and LF times for all activities, compute the slack or free time for each activity

☑ **Slack is the length of time an activity can be delayed without delaying the entire project**

Slack = LS – ES   or   Slack = LF – EF

Computing Slack Time

Activity	Earliest Start ES	Earliest Finish EF	Latest Start LS	Latest Finish LF	Slack LS – ES	On Critical Path
A	0	2	0	2	0	Yes
B	0	3	1	4	1	No
C	2	4	2	4	0	Yes
D	3	7	4	8	1	No
E	4	8	4	8	0	Yes
F	4	7	10	13	6	No
G	8	13	8	13	0	Yes
H	13	15	13	15	0	Yes

Table 3.3

Critical Path for Milwaukee Paper

ES – EF Gantt Chart for Milwaukee Paper

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
A Build internal components	██	██														
B Modify roof and floor	██	██	██													
C Construct collection stack			██	██												
D Pour concrete and install frame				██	██	██	██									
E Build high-temperature burner					██	██	██	██								
F Install pollution control system					██	██	██									
G Install air pollution device									██	██	██	██	██			
H Inspect and test														██	██	

LS – LF Gantt Chart for Milwaukee Paper

		1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
A	Build internal components	▭															
B	Modify roof and floor		▭														
C	Construct collection stack			▭													
D	Pour concrete and install frame					▭											
E	Build high-temperature burner					▭											
F	Install pollution control system											▭					
G	Install air pollution device									▭							
H	Inspect and test														▭		

Variability in Activity Times

☑ *CPM assumes we know a fixed time estimate for each activity and there is no variability in activity times*

☑ *PERT uses a probability distribution for activity times to allow for variability*

Variability in Activity Times

- ☑ **Three time estimates are required**
    - ☑ *Optimistic time (a) – if everything goes according to plan*
    - ☑ *Pessimistic time (b) – assuming very unfavorable conditions*
    - ☑ *Most likely time (m) – most realistic estimate*

Variability in Activity Times

Estimate follows beta distribution
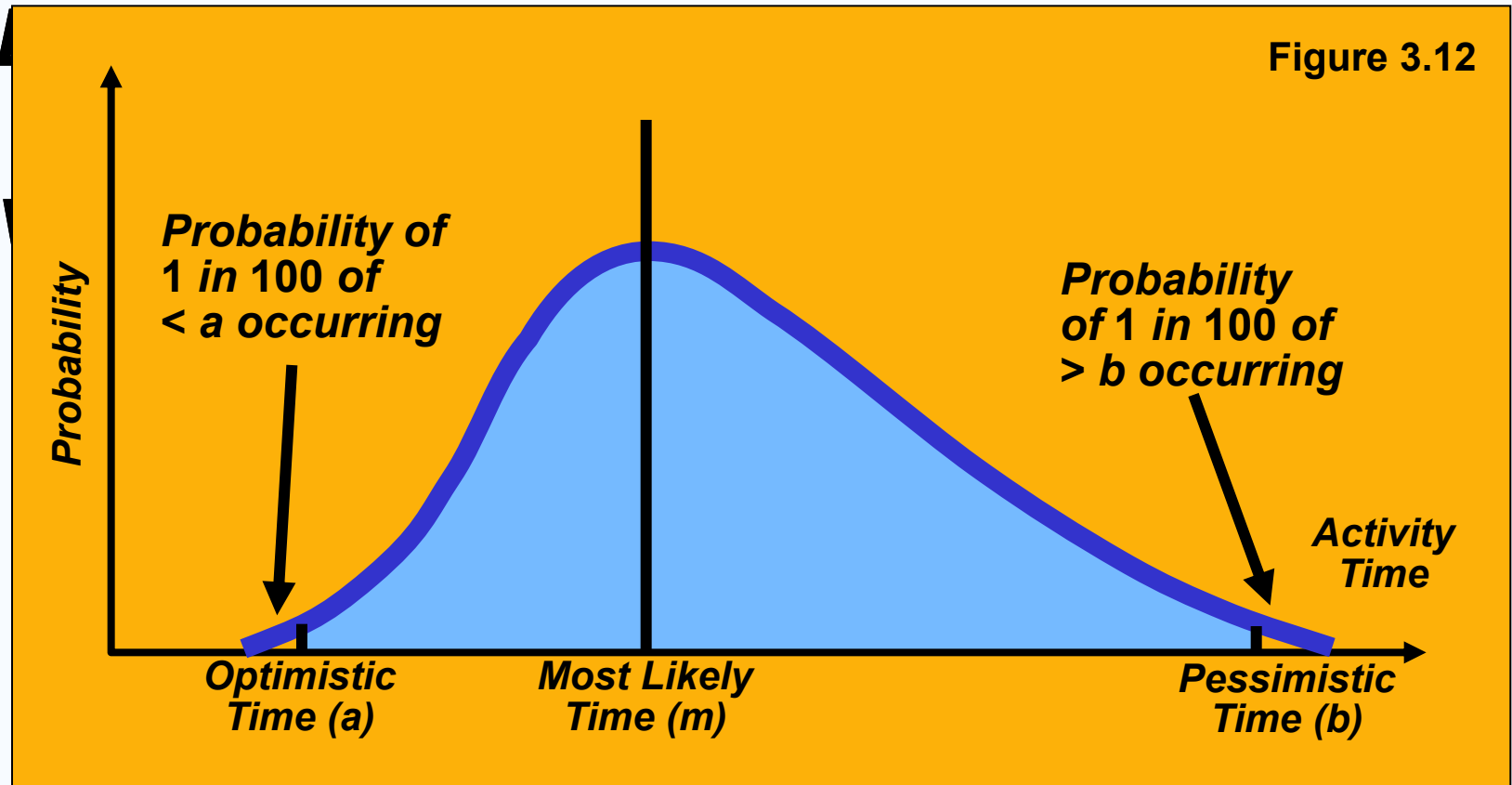
Expected time:
$$t = (a + 4m + b)/6$$

Variance of times:
$$v = [(b - a)/6]^2$$

Variability in Activity Times

Estimate follows beta distribution

Figure 3.12

Probability

Probability of 1 *in* 100 *of* < a occurring

Probability of 1 *in* 100 *of* > b occurring

Activity Time

Optimistic Time (a)

Most Likely Time (m)

Pessimistic Time (b)

Computing Variance

Activity	Optimistic a	Most Likely m	Pessimistic b	Expected Time $t = (a + 4m + b)/6$	Variance $[(b - a)/6]^2$
A	1	2	3	2	.11
B	2	3	4	3	.11
C	1	2	3	2	.11
D	2	4	6	4	.44
E	1	4	7	4	1.00
F	1	2	9	3	1.78
G	3	4	11	5	1.78
H	1	2	3	2	.11

Table 3.4

Probability of Project Completion

Project variance is computed by summing the variances of critical activities

$$\sigma_p^2 = \text{Project variance}$$

$$= \sum(\text{variances of activities on critical path})$$

Probability of Project Completion

Project variance is computed by summing the variances of critical activities

Project variance

$$\sigma_p^2 = .11 + .11 + 1.00 + 1.78 + .11 = 3.11$$

Project standard deviation

$$\sigma_p = \sqrt{\text{Project variance}}$$
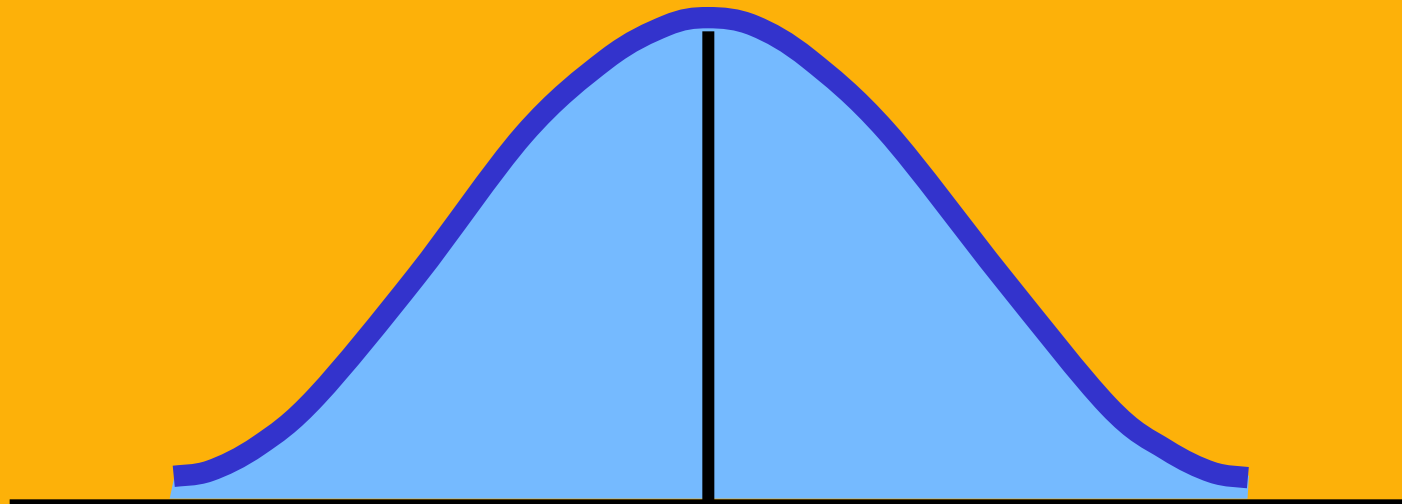
$$= \sqrt{3.11} = 1.76 \text{ weeks}$$

Probability of Project Completion

PERT makes two more assumptions:

- ☑ **Total project completion times follow a normal probability distribution**

- ☑ **Activity times are statistically independent**

Probability of Project Completion

Standard deviation = 1.76 weeks

15 Weeks

(Expected Completion Time)

Figure 3.13

Probability of Project Completion

What is the probability this project can be completed on or before the 16 week deadline?

$$Z = \left(\begin{array}{c} due \\ date \end{array} - \begin{array}{c} expected\ date \\ of\ completion \end{array} \right) / \sigma_p$$

$$= (16\ wks - 15\ wks)/1.76$$

$$= 0.57$$

Where Z is the number of standard deviations the due date or target date lies from the mean or expected date

Probability of Project Completion

What is the probability this project can be completed on or before the 16 week deadline?

From Appendix I

	.00	.01		.07	.08
.1	.50000	.50399		.52790	.53188
.2	.53983	.54380		.56749	.57142
.5	.69146	.69497		.71566	.71904
.6	.72575	.72907		.74857	.75175

= 0.57

Where Z is the number of standard deviations the due date or target date lies from the mean or expected date
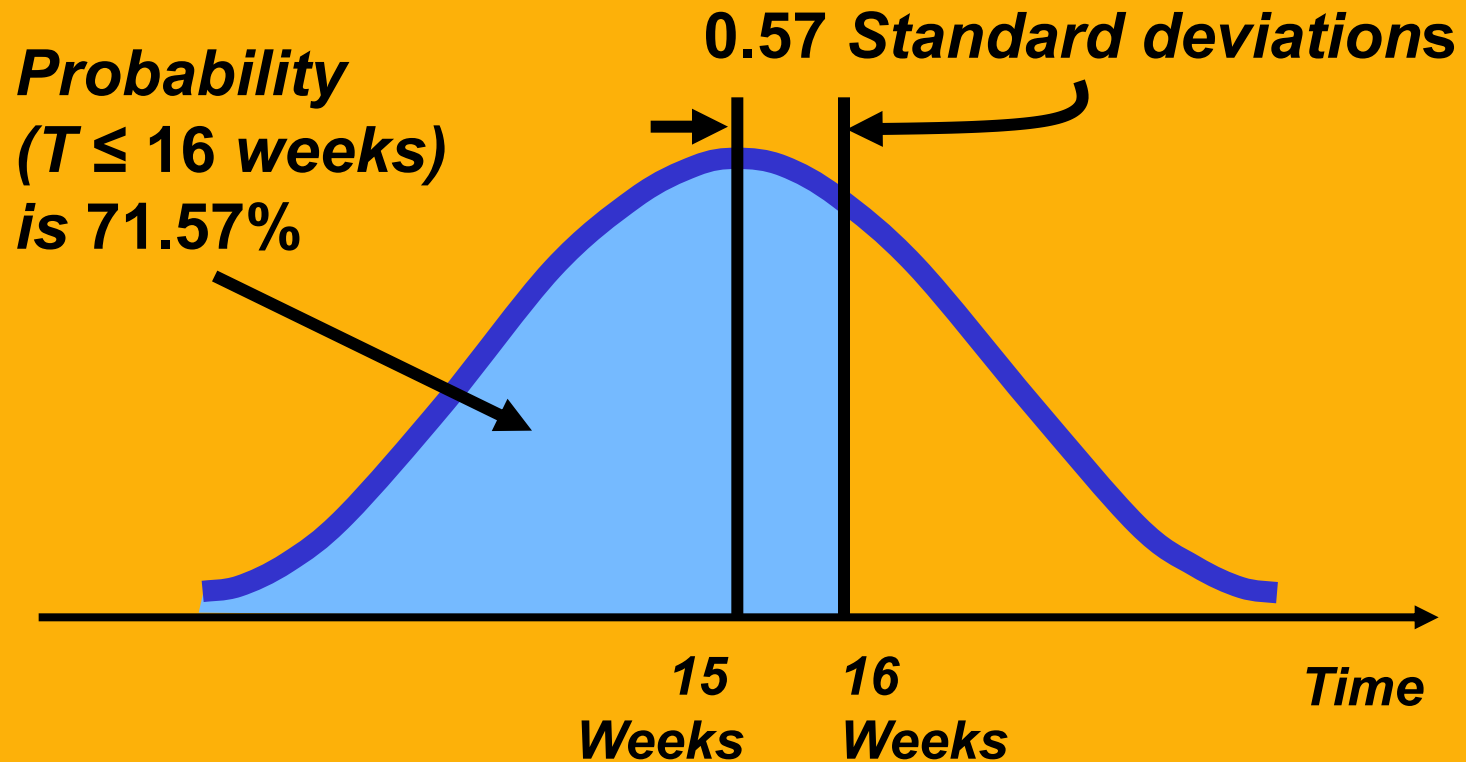
Probability of Project Completion

Probability *(T ≤ 16 weeks) is* **71.57%**

0.57 *Standard deviations*

15 Weeks

16 Weeks

Time

Figure 3.14

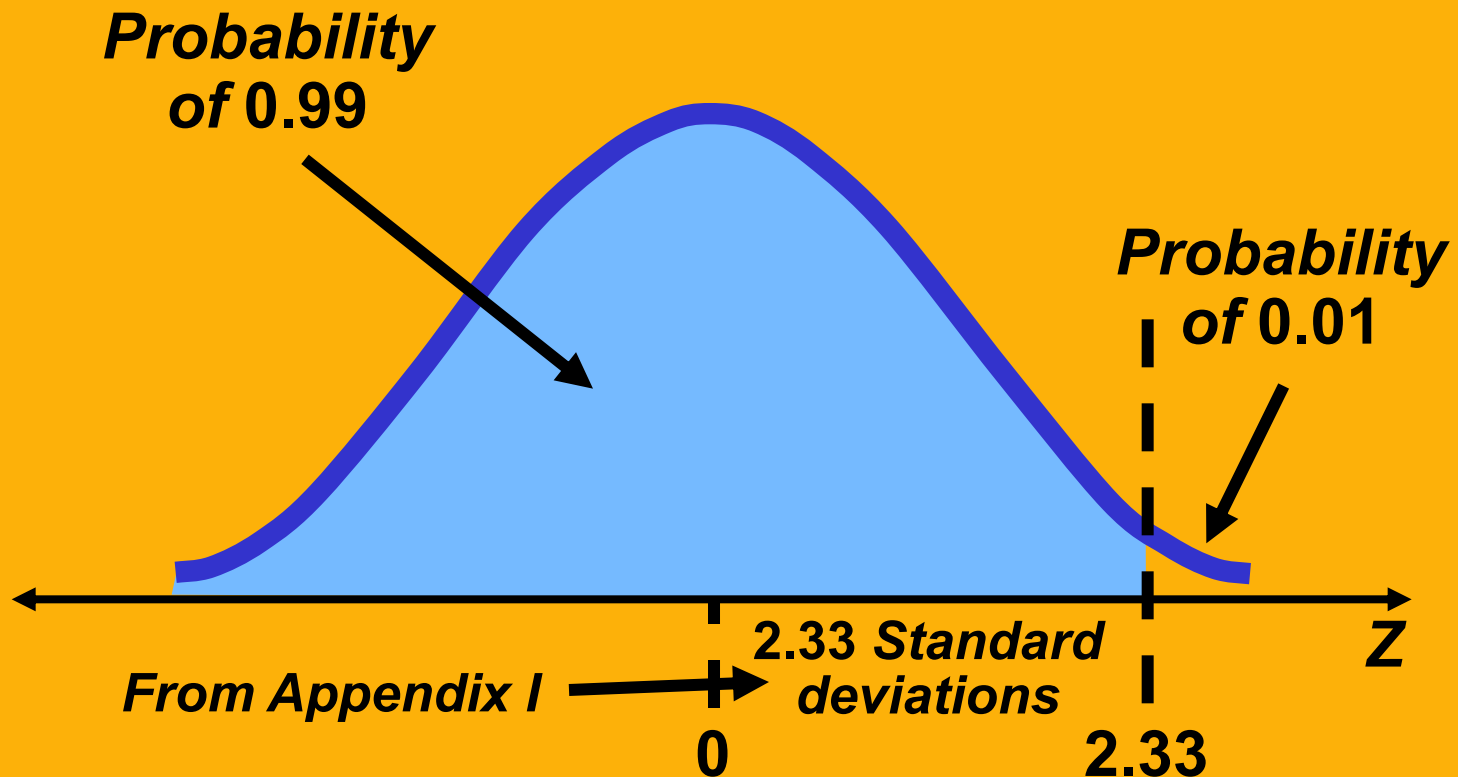**Determining Project Completion Time**

Figure 3.15

Variability of Completion Time for Noncritical Paths

- ☑ *Variability of times for activities on noncritical paths must be considered when finding the probability of finishing in a specified time*

- ☑ *Variation in noncritical activity may cause change in critical path*

What Project Management Has Provided So Far

- ☑ *The project's expected completion time is 15 weeks*

- ☑ *There is a 71.57% chance the equipment will be in place by the 16 week deadline*

- ☑ *Five activities (A, C, E, G, and H) are on the critical path*

- ☑ *Three activities (B, D, F) are not on the critical path and have slack time*

- ☑ *A detailed schedule is available*

Trade-Offs And Project Crashing

It is not uncommon to face the following situations:

- ☑ *The project is behind schedule*

- ☑ *The completion time has been moved forward*

Shortening the duration of the project is called project crashing

Factors to Consider When Crashing A Project

☑ *The amount by which an activity is crashed is, in fact, permissible*

☑ *Taken together, the shortened activity durations will enable us to finish the project by the due date*

☑ *The total cost of crashing is as small as possible*

Steps in Project Crashing

1. **Compute the crash cost per time period. If crash costs are linear over time:**

$$\text{Crash cost per period} = \frac{(\text{Crash cost} - \text{Normal cost})}{(\text{Normal time} - \text{Crash time})}$$

2. **Using current activity times, find the critical path and identify the critical activities**

Steps in Project Crashing

3. If there is only one critical path, then select the activity on this critical path that (a) can still be crashed, and (b) has the smallest crash cost per period. If there is more than one critical path, then select one activity from each critical path such that (a) each selected activity can still be crashed, and (b) the total crash cost of all selected activities is the smallest. Note that the same activity may be common to more than one critical path.

Steps in Project Crashing

4. **Update all activity times. If the desired due date has been reached, stop. If not, return to Step 2.**

Crashing The Project

Activity	Time (Wks) Normal	Crash	Cost ($) Normal	Crash	Crash Cost Per Wk ($)	Critical Path?
A	2	1	22,000	22,750	750	Yes
B	3	1	30,000	34,000	2,000	No
C	2	1	26,000	27,000	1,000	Yes
D	4	2	48,000	49,000	1,000	No
E	4	2	56,000	58,000	1,000	Yes
F	3	2	30,000	30,500	500	No
G	5	2	80,000	84,500	1,500	Yes
H	2	1	16,000	19,000	3,000	Yes

Table 3.5

Crash and Normal Times and Costs for Activity B

Activity Cost

$34,000 — Crash

$33,000

$32,000

$31,000

$30,000 — Normal

Crash Cost

Normal Cost

$$\text{Crash Cost/Wk} = \frac{\text{Crash Cost} - \text{Normal Cost}}{\text{Normal Time} - \text{Crash Time}}$$

$$= \frac{\$34,000 - \$30,000}{3 - 1}$$

$$= \frac{\$4,000}{2 \text{ Wks}} = \$2,000/\text{Wk}$$

1   2   3   Time (Weeks)

Crash Time   Normal Time
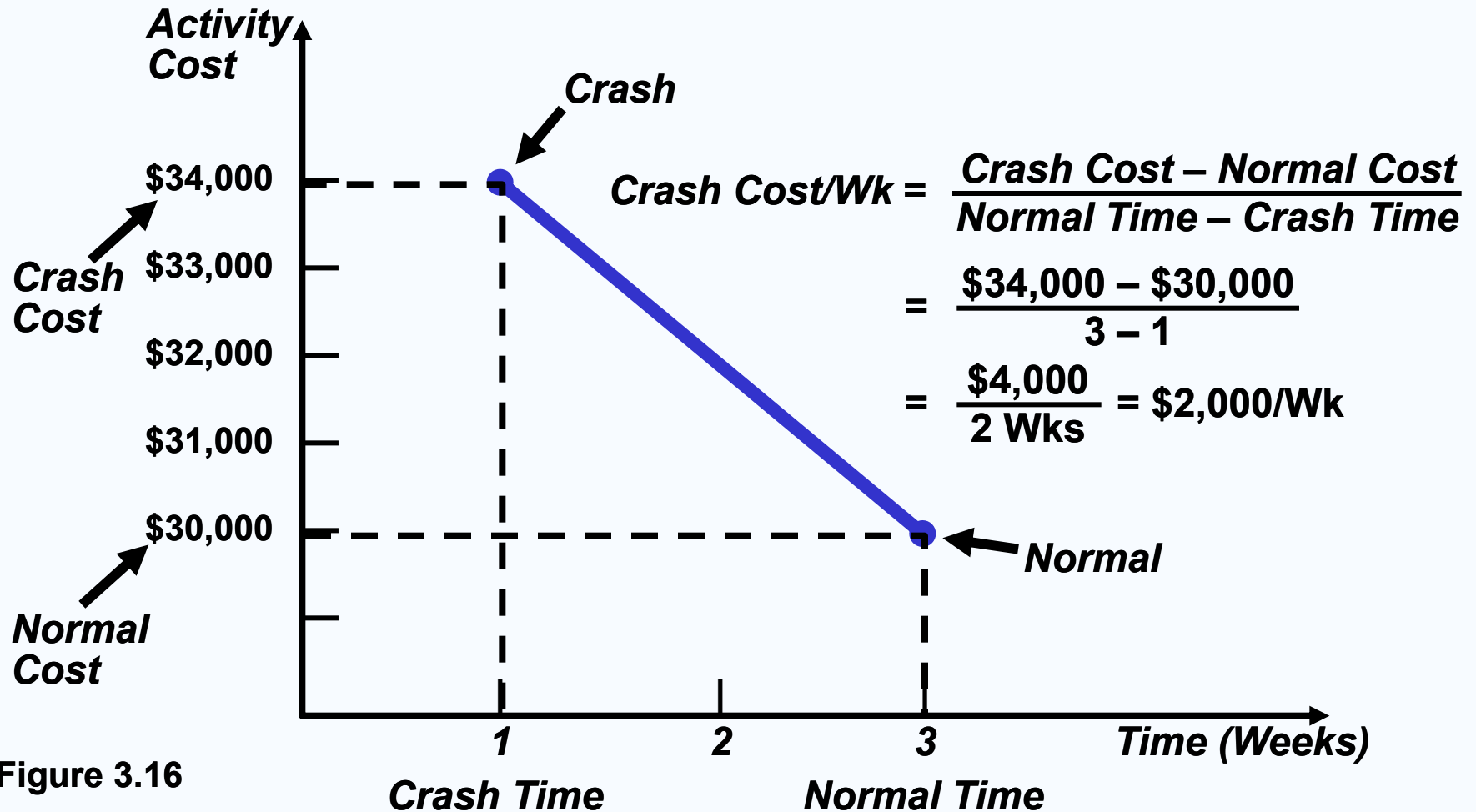
Figure 3.16

Critical Path And Slack Times For Milwaukee Paper
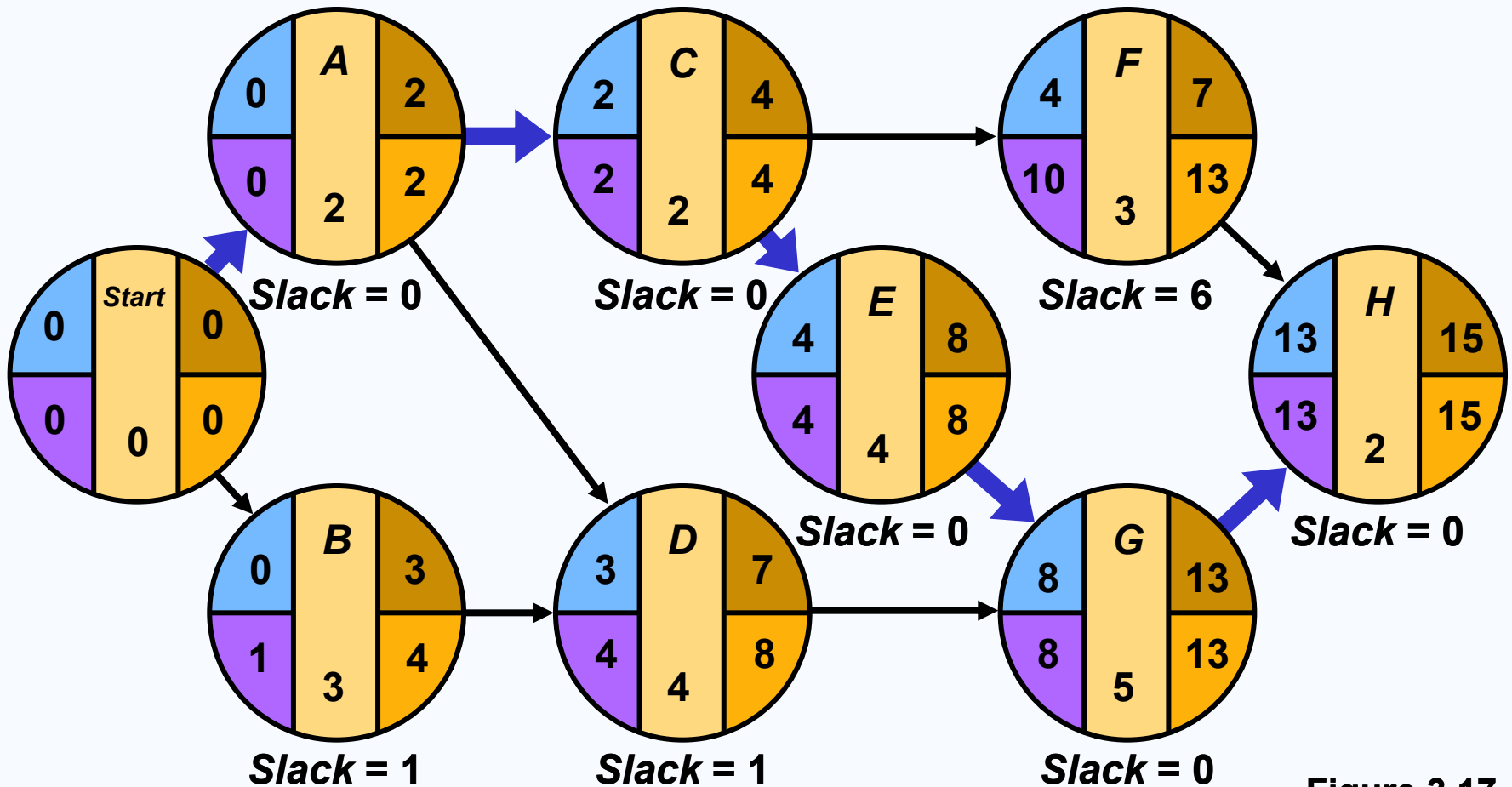
Figure 3.17

Advantages of PERT/CPM

1. **Especially useful when scheduling and controlling large projects**

2. **Straightforward concept and not mathematically complex**

3. **Graphical networks help highlight relationships among project activities**

4. **Critical path and slack time analyses help pinpoint activities that need to be closely watched**

Advantages of PERT/CPM

5. **Project documentation and graphics point out who is responsible for various activities**

6. **Applicable to a wide variety of projects**

7. **Useful in monitoring not only schedules but costs as well**

Limitations of PERT/CPM

1. **Project activities have to be clearly defined, independent, and stable in their relationships**

2. **Precedence relationships must be specified and networked together**

3. **Time estimates tend to be subjective and are subject to fudging by managers**

4. **There is an inherent danger of too much emphasis being placed on the longest, or critical, path**

Project Management Software

☑ **There are several popular packages for managing projects**

- ☑ *Primavera*
- ☑ *MacProject*
- ☑ *Pertmaster*
- ☑ *VisiSchedule*
- ☑ *Time Line*
- ☑ *Microsoft Project*

Using Microsoft Project

Program 3.1

Using Microsoft Project

Program 3.2

Using Microsoft Project

Program 3.3

Using Microsoft Project

Program 3.4

Using Microsoft Project

Program 3.5

Using Microsoft Project

This is the scheduled start time for activity.

Activity A is 100% complete.

This is the scheduled finish time for activity.

Program 3.6

Using Microsoft Project

Check mark indicates activity is 100% complete.

Bar indicates activity process.

		Task Name	Duration	Start	Finish
1	✓	A. Build internal components	2 wks	Fri Jul 1	Fri Jul 15
2	✓	B. Modify roof & floor	3 wks	Fri Jul 1	Fri Jul 22
3	✓	C. Construct collection stack	2 wks	Mon Jul 18	Fri Jul 29
4		D. Pour concrete & install frai	4 wks	Mon Jul 25	Fri Aug 19
5		E. Build high-temp burner	4 wks	Mon Aug 1	Fri Aug 26
6		F. Install pollution control syst	3 wks	Mon Aug 1	Fri Aug 19
7		G. Install air pollution device	5 wks	Mon Aug 29	Fri Sep 30
8		H. Inspect & test	2 wks	Mon Oct 3	Fri Oct 14

Activity F is behind schedule, as are activities D and E.

This is the indicator for today's date (Aug. 12).

Program 3.7