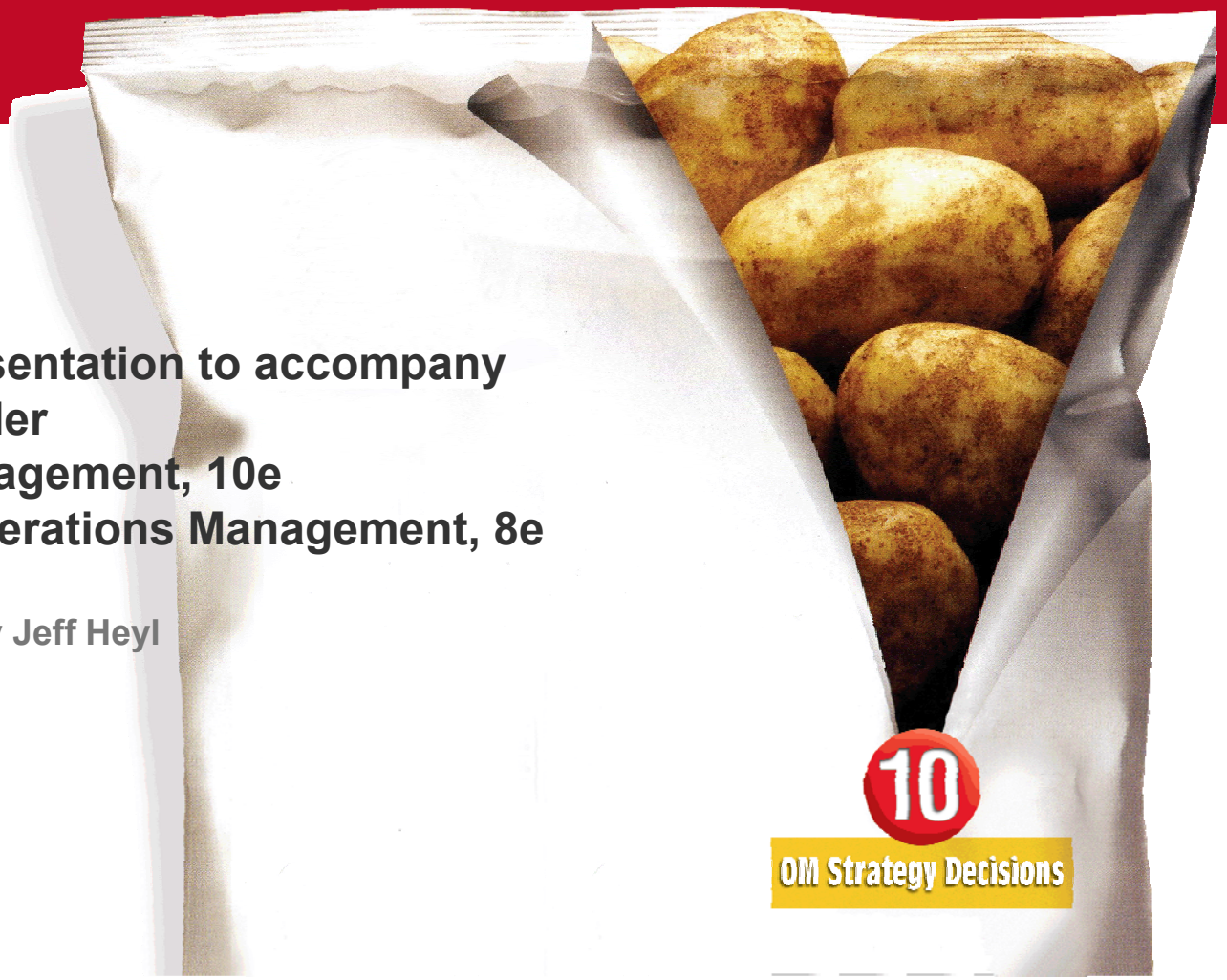
3 Project Management



PowerPoint presentation to accompany
Heizer and Render
Operations Management, 10e
Principles of Operations Management, 8e

PowerPoint slides by Jeff Heyl

Project Characteristics

- **Single unit**
- **Many related activities**
- **Difficult production planning and inventory control**
- **General purpose equipment**
- **High labor skills**

Examples of Projects

- Building Construction

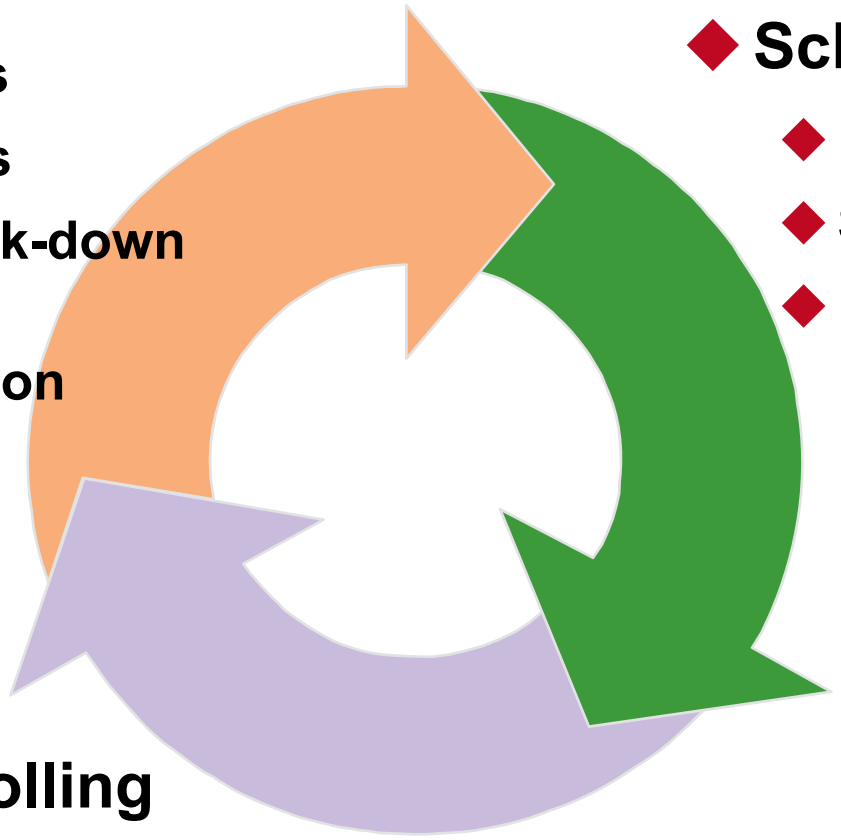
- Research Project

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 structure
  - Organization



- Scheduling
  - Project activities
  - Start & end times
  - Network
- Controlling
  - Monitor, compare, revise, action

Project Planning, Scheduling, and Controlling

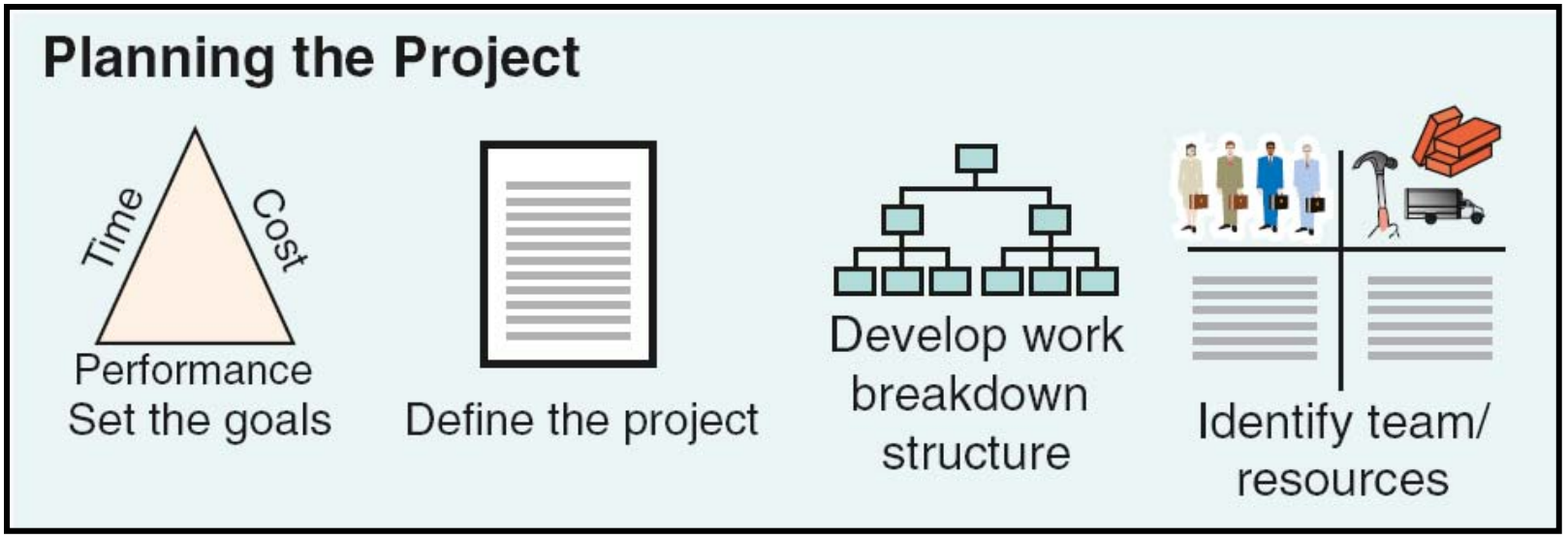


Figure 3.1

Before project	Start of project Timeline	During project

Project Planning, Scheduling, and Controlling

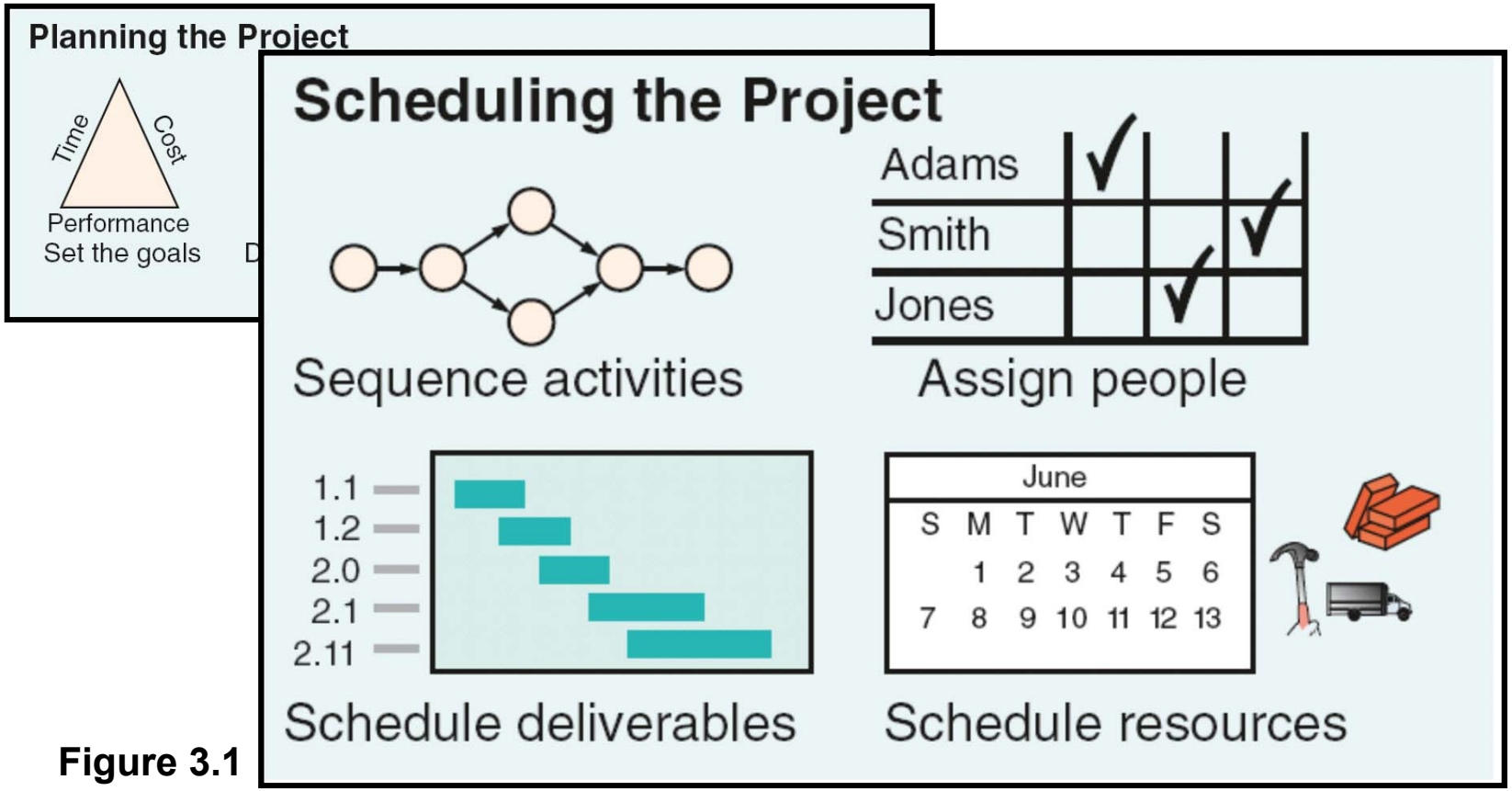


Figure 3.1

Before project	Start of project	During project
	Timeline	

Project Planning, Scheduling, and Controlling

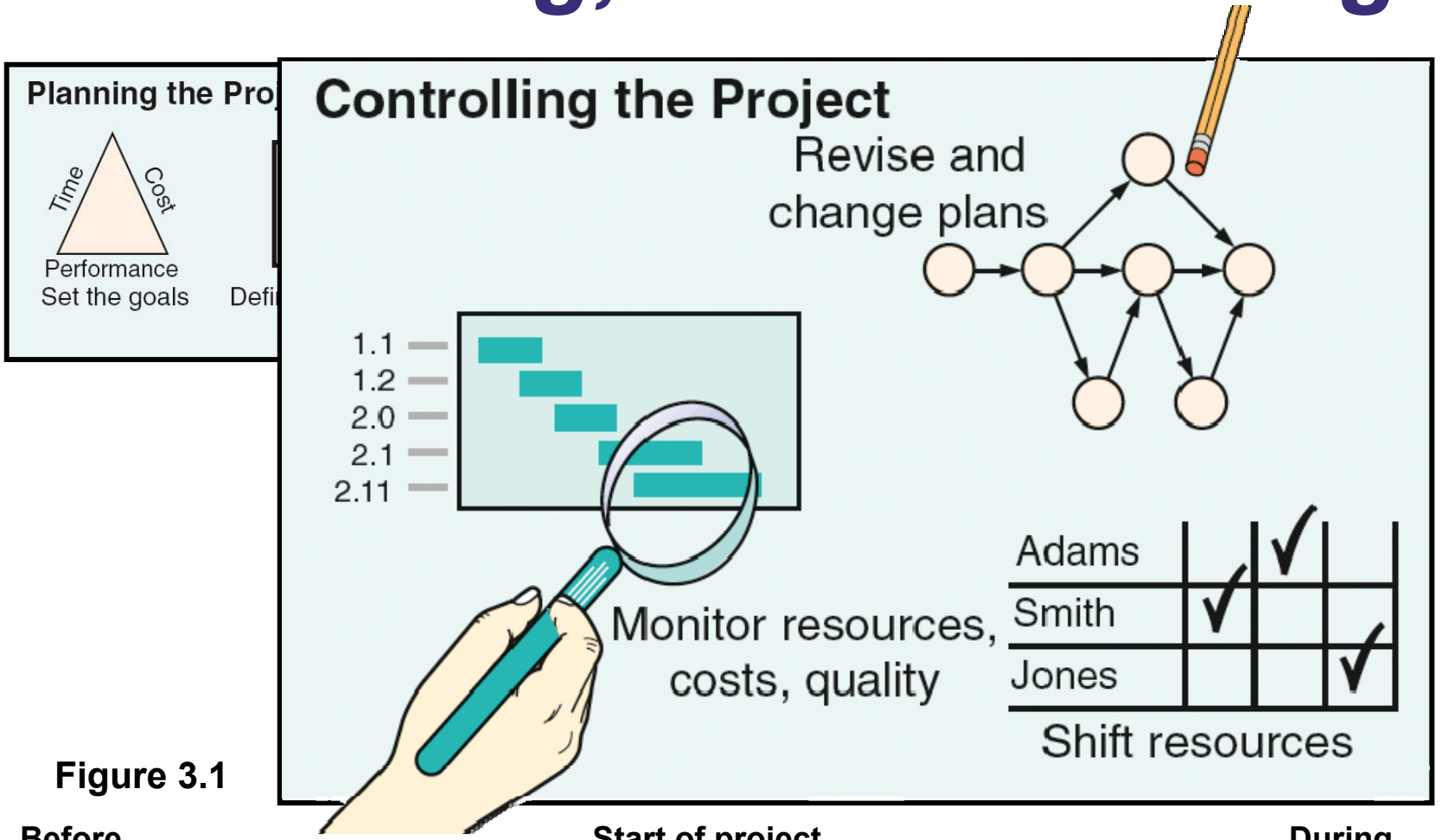


Figure 3.1

Project Planning, Scheduling, and Controlling

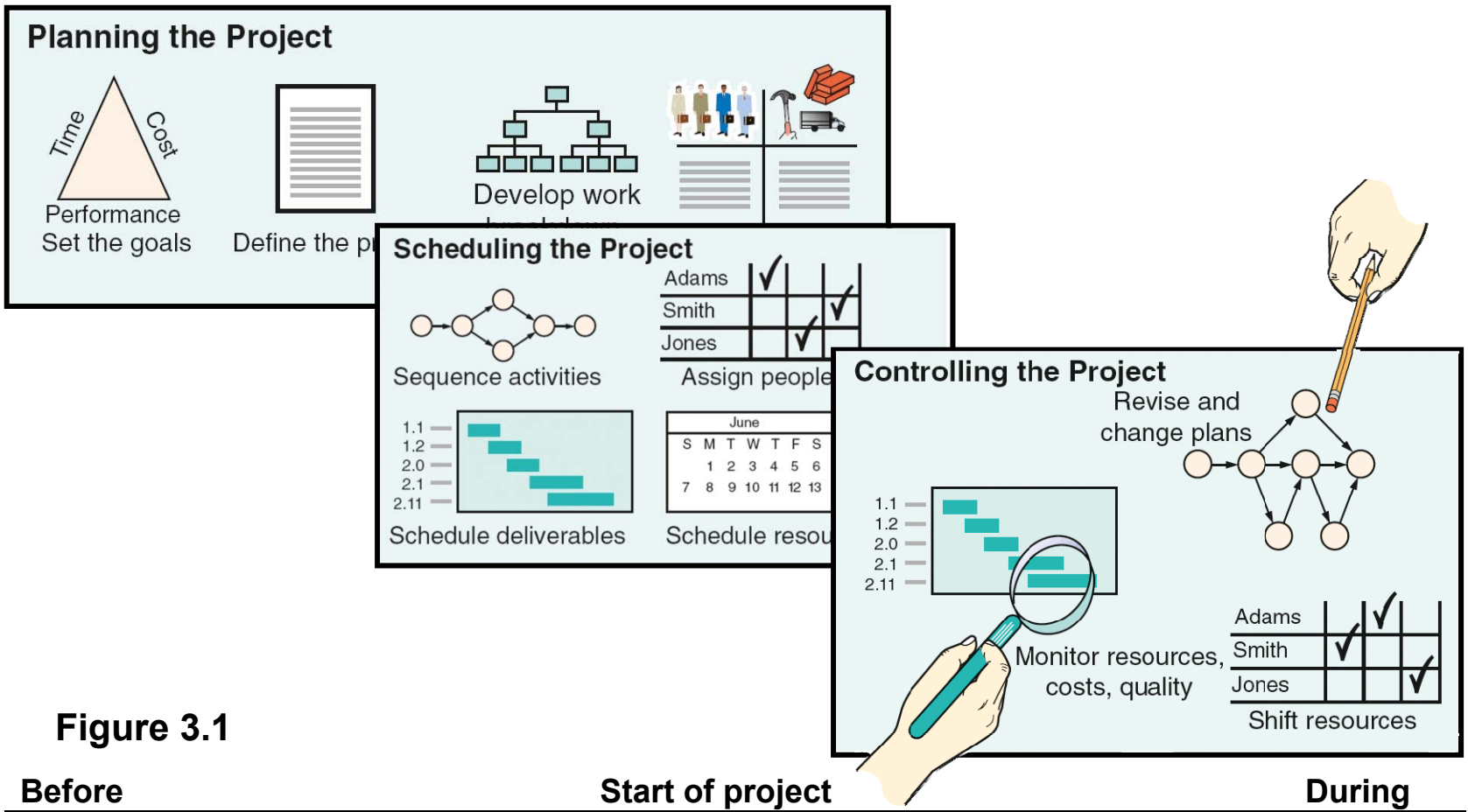


Figure 3.1

Project Scheduling, ng

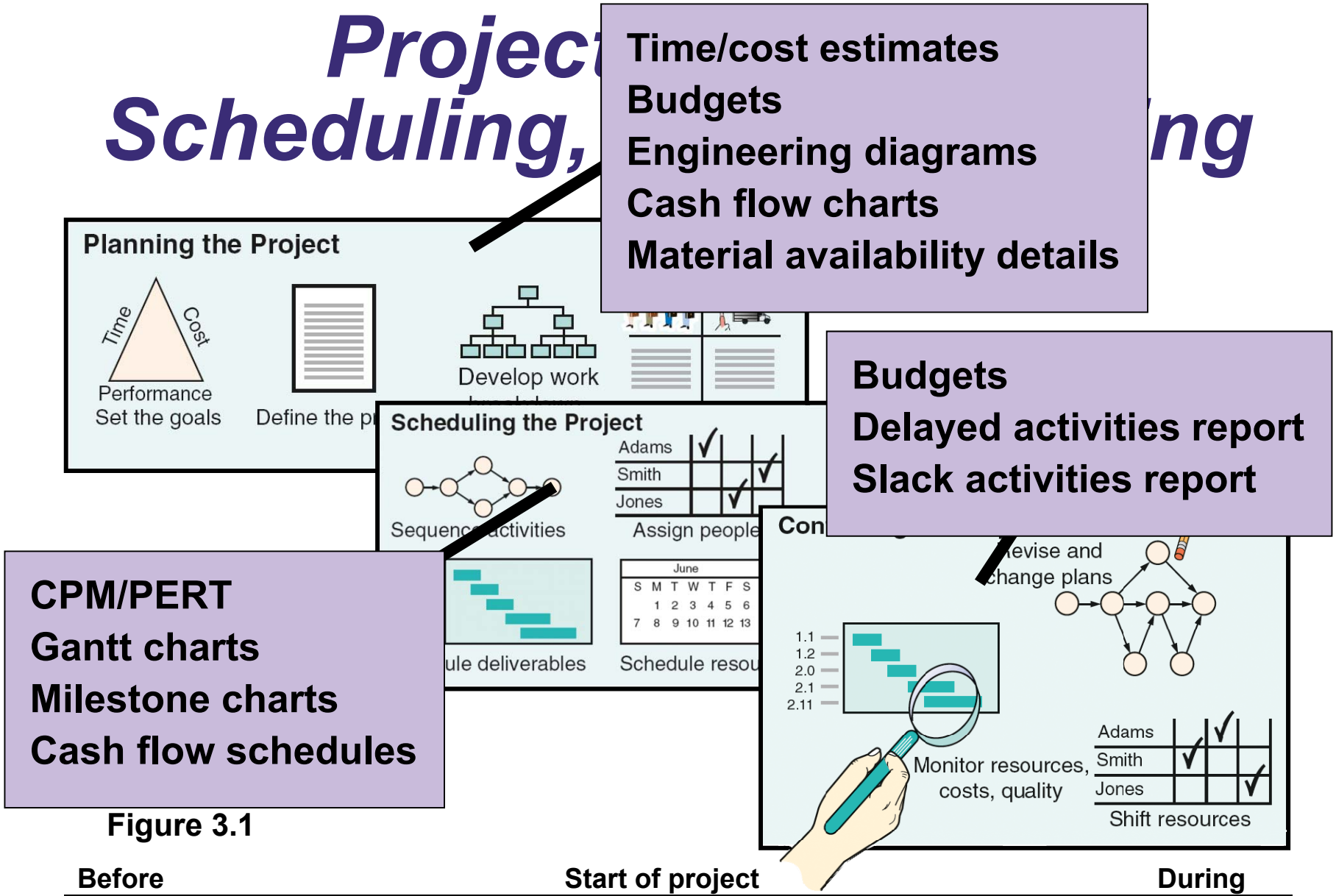
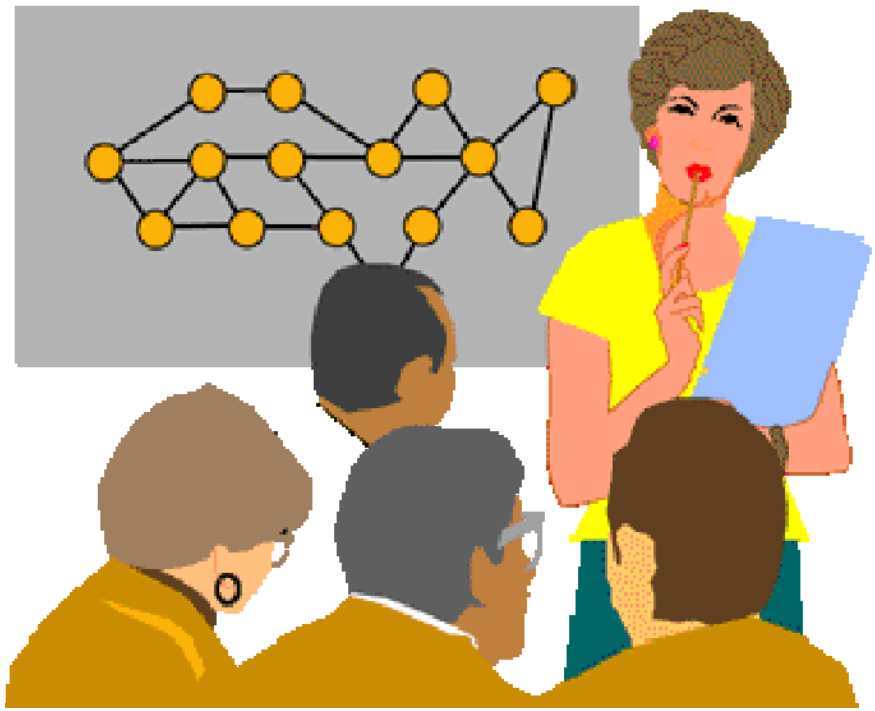


Figure 3.1

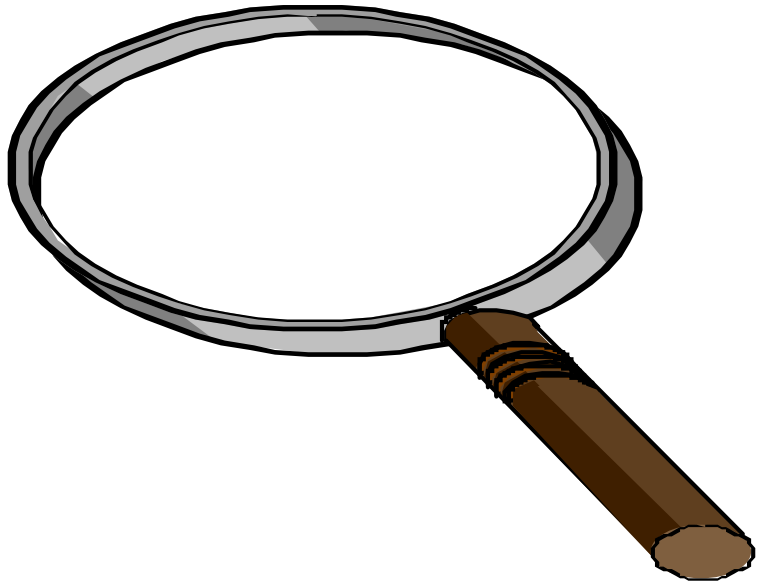
Project Planning

- 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'



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**

A Sample Project Organization

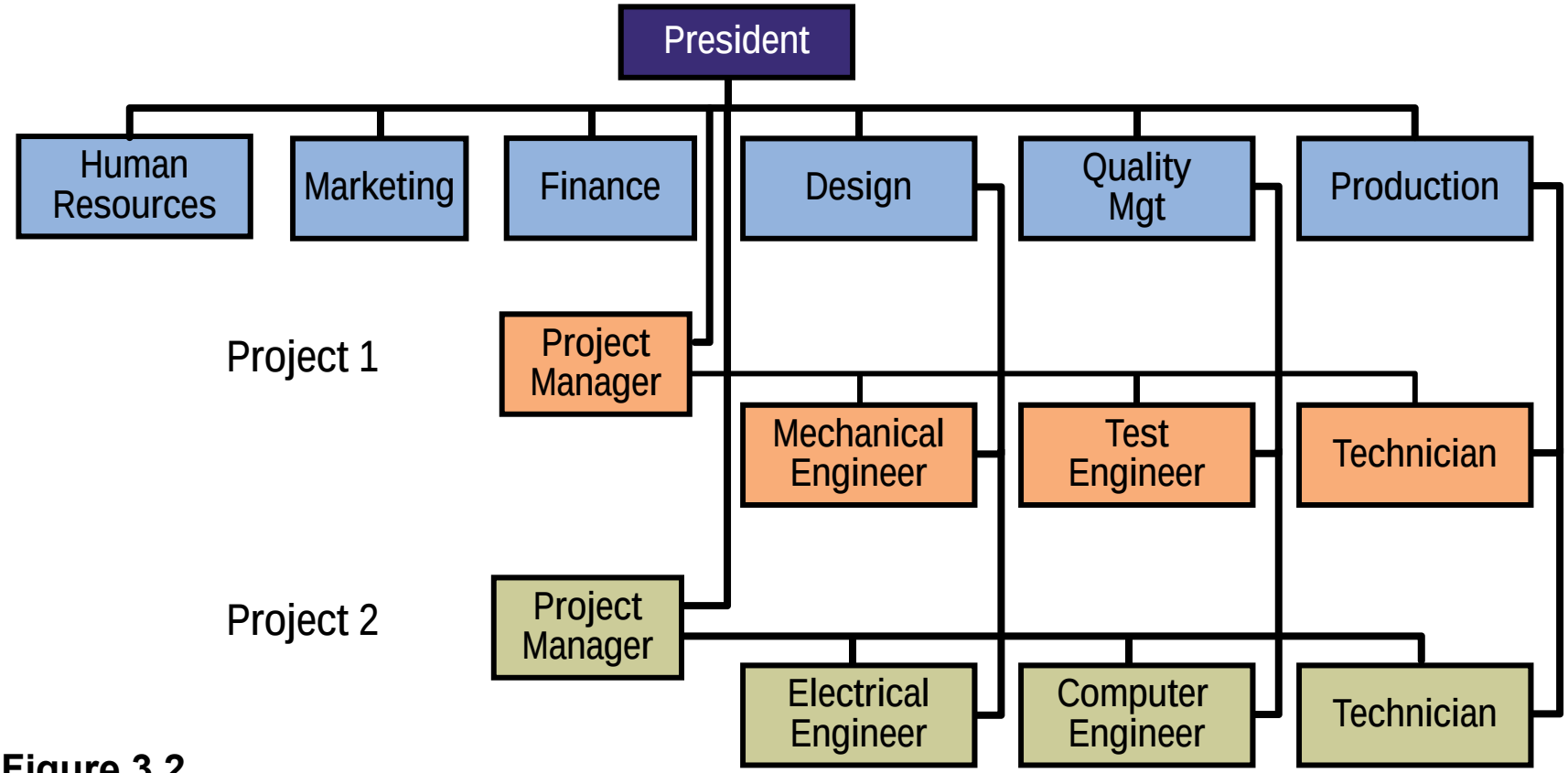
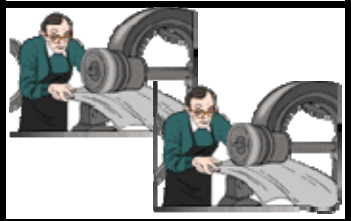
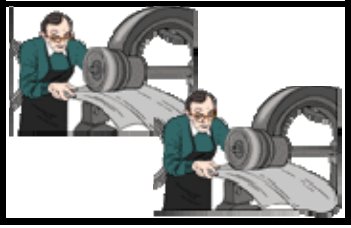


Figure 3.2

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:

1. **All necessary activities are finished in order and on time**
2. **The project comes in within budget**
3. **The project meets quality goals**
4. **The people assigned to the project receive motivation, direction, and information**

The Role of the Project Manager

Highly visible
Responsible for

1. **All necessary**
   and on time
2. **The project co**
3. **The project m**
4. **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

- Project managers face many ethical decisions on a daily basis
- The Project Management Institute has established an ethical code to deal with problems such as:

1. Offers of gifts from contractors
2. Pressure to alter status reports to mask delays
3. False reports for charges of time and expenses
4. Pressure to compromise quality to meet schedules

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

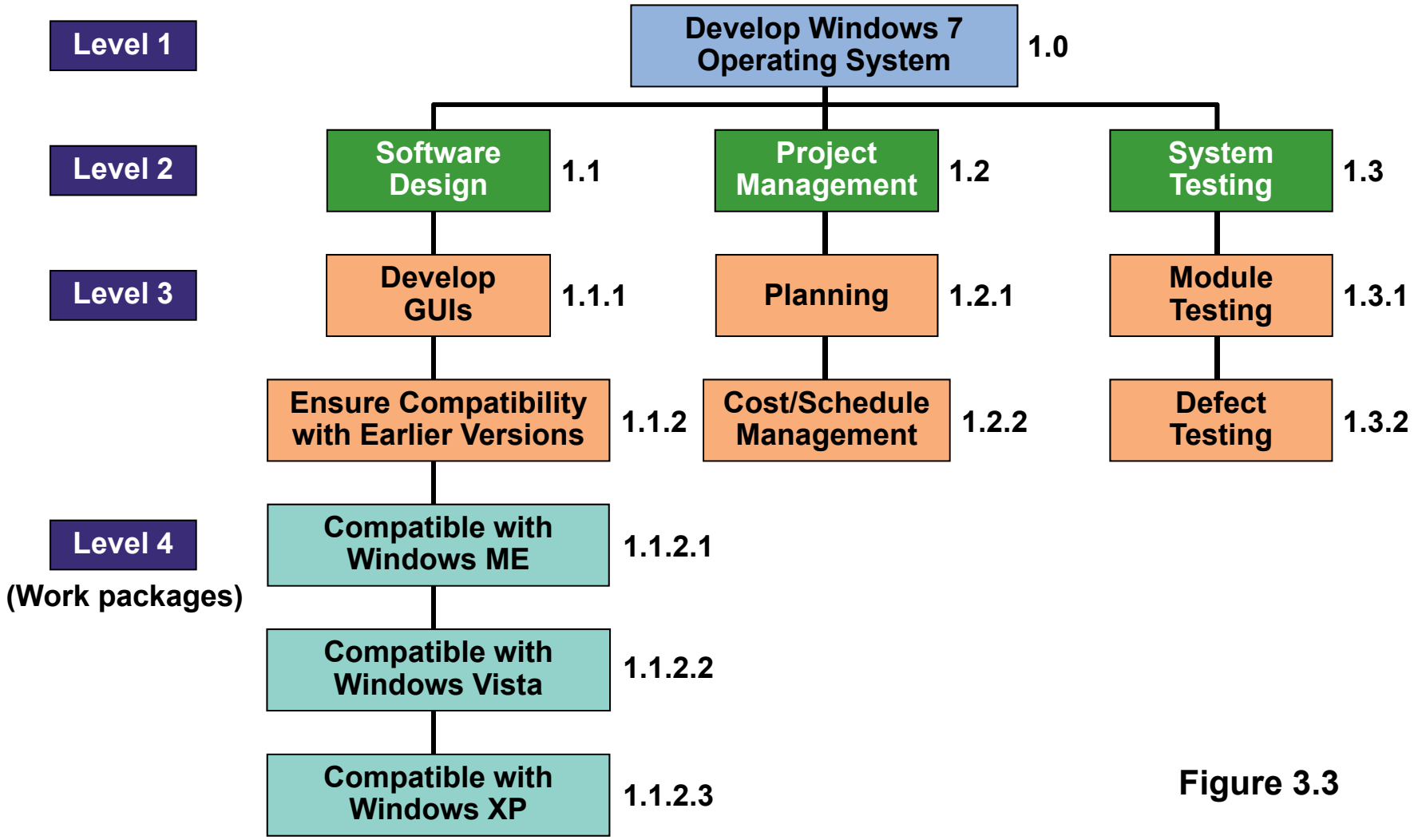


Figure 3.3

Project Scheduling

- Identifying precedence relationships
- Sequencing activities
- Determining activity times & costs
- Estimating material & worker requirements
- Determining critical activities

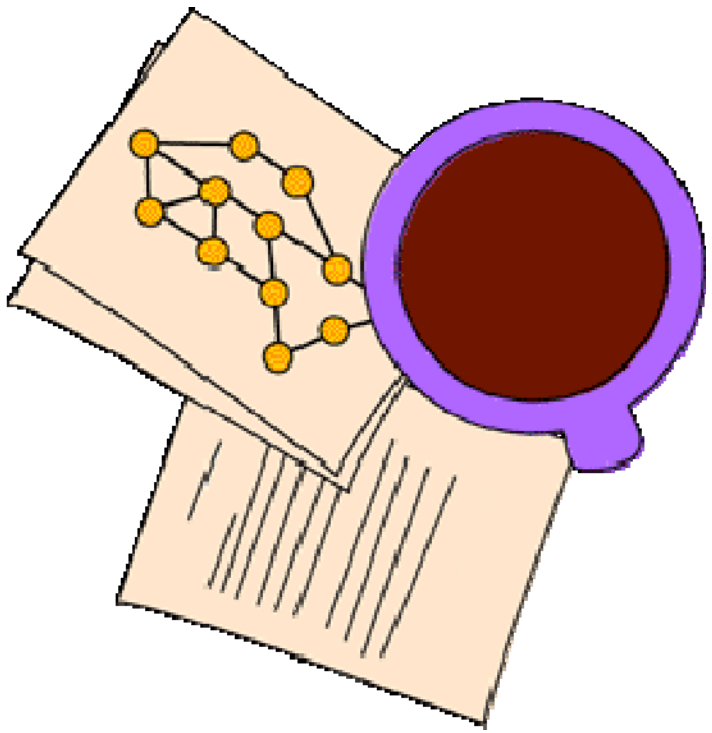
Purposes of Project Scheduling

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

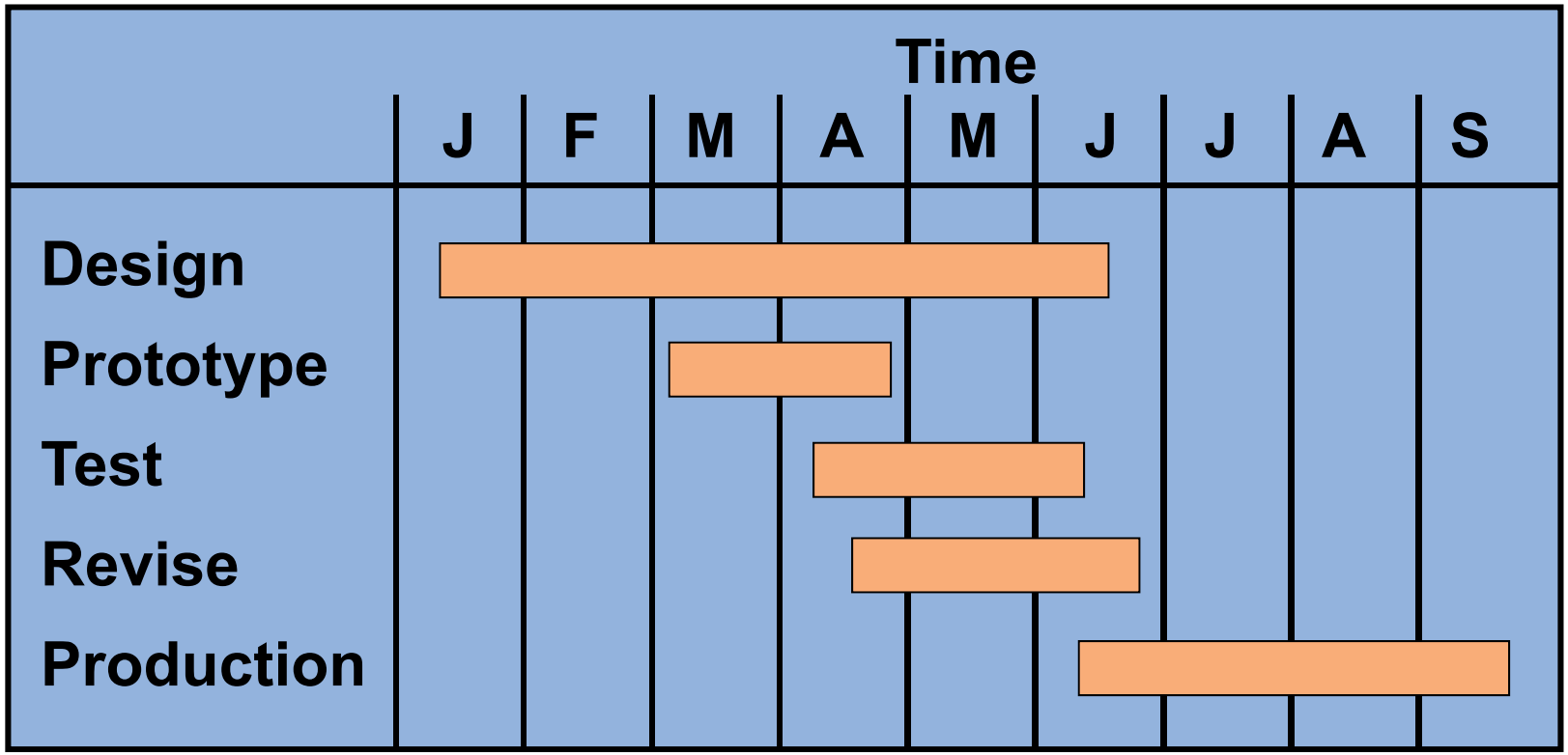
1. **Ensure that all activities are planned for**
2. **Their order of performance is accounted for**
3. **The activity time estimates are recorded**
4. **The overall project time is developed**

Project Management Techniques



- Gantt chart
- Critical Path Method (CPM)
- Program Evaluation and Review Technique (PERT)

A Simple Gantt Chart



Service For a Delta Jet

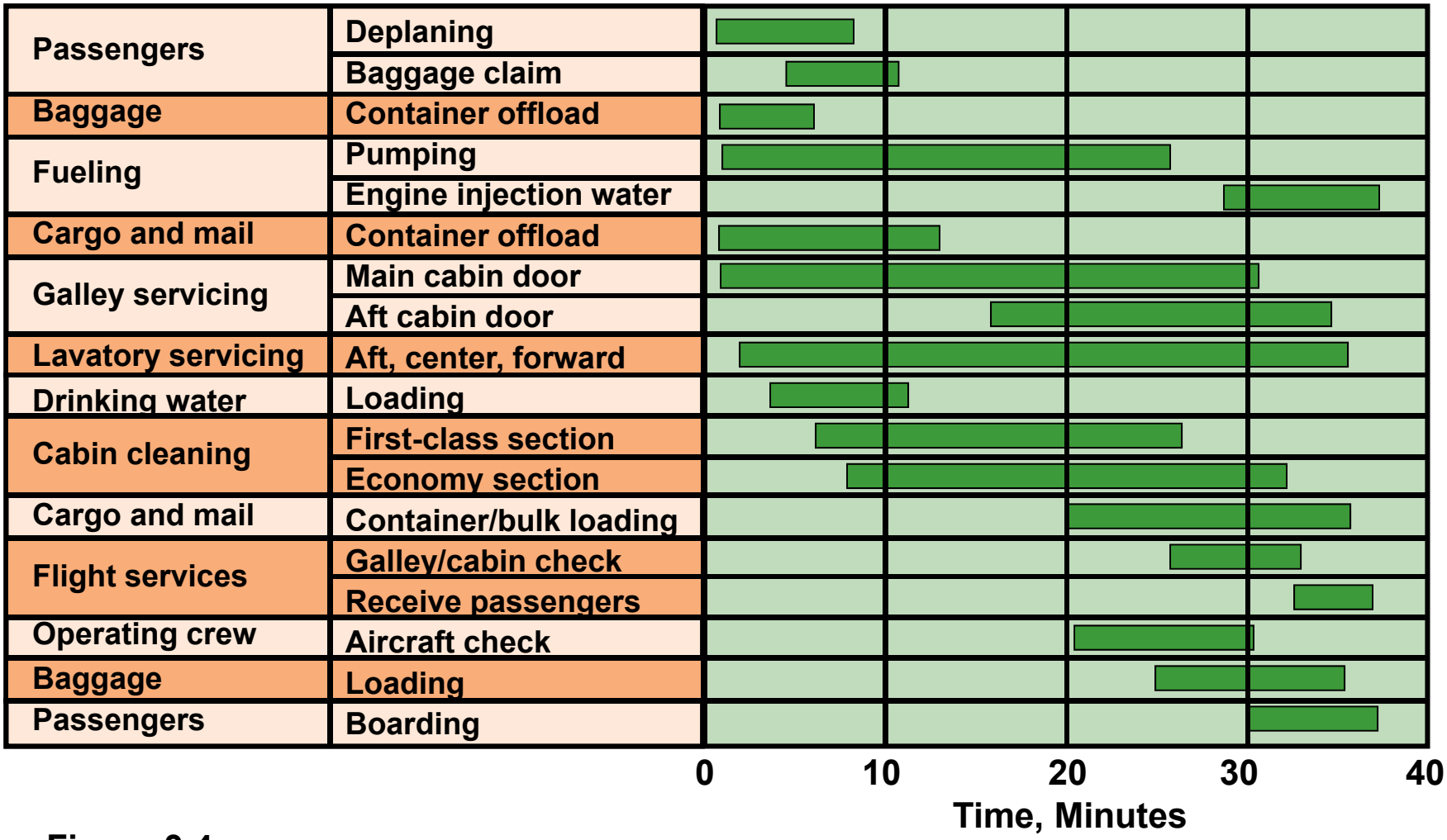


Figure 3.4

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

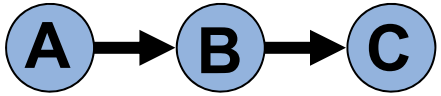
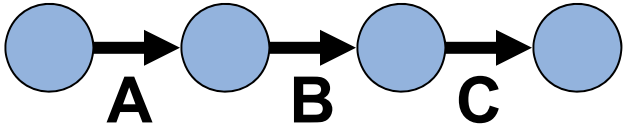
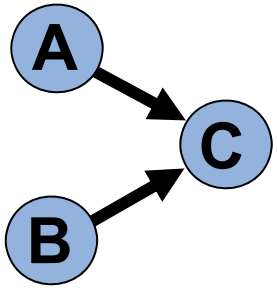
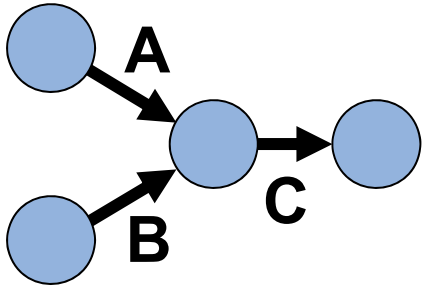
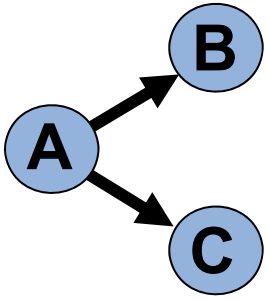
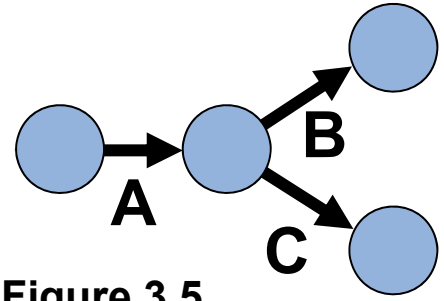
Activity on Node (AON)	Activity Meaning	Activity on Arrow (AOA)
(a) 	A comes before B, which comes before C.	
(b) 	A and B must both be completed before C can start.	
(c) 	B and C cannot begin until A is completed.	

Figure 3.5

A Comparison of AON and AOA Network Conventions

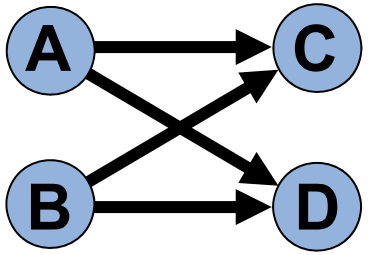
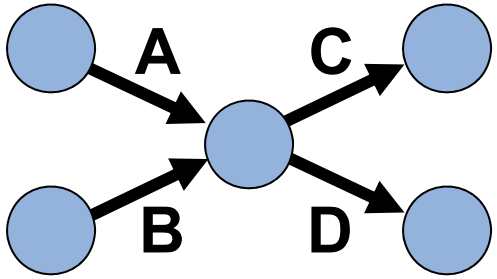
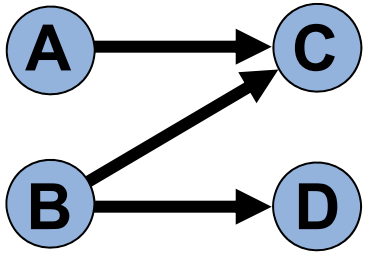
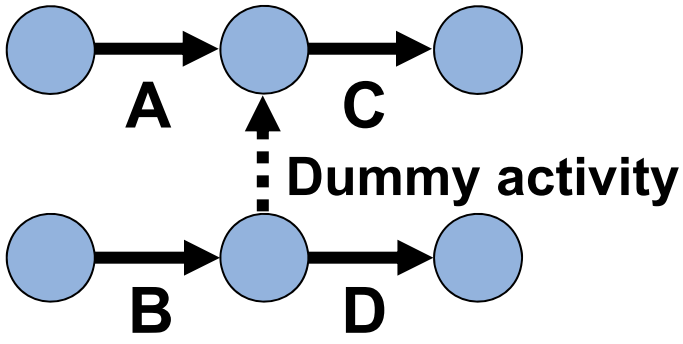
Activity on Node (AON)	Activity Meaning	Activity on Arrow (AOA)
(d) 	C and D cannot begin until both A and B are completed.	
(e) 	C cannot begin until both A and B are completed; D cannot begin until B is completed. A dummy activity is introduced in AOA.	

Figure 3.5

A Comparison of AON and AOA Network Conventions

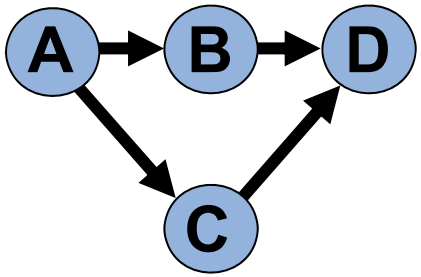
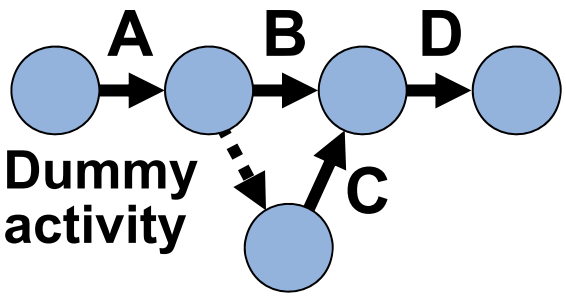
Activity on Node (AON)	Activity Meaning	Activity on Arrow (AOA)
(f) 	B and C cannot begin until A is completed. D cannot begin until both B and C are completed. A dummy activity is again introduced in AOA.	

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

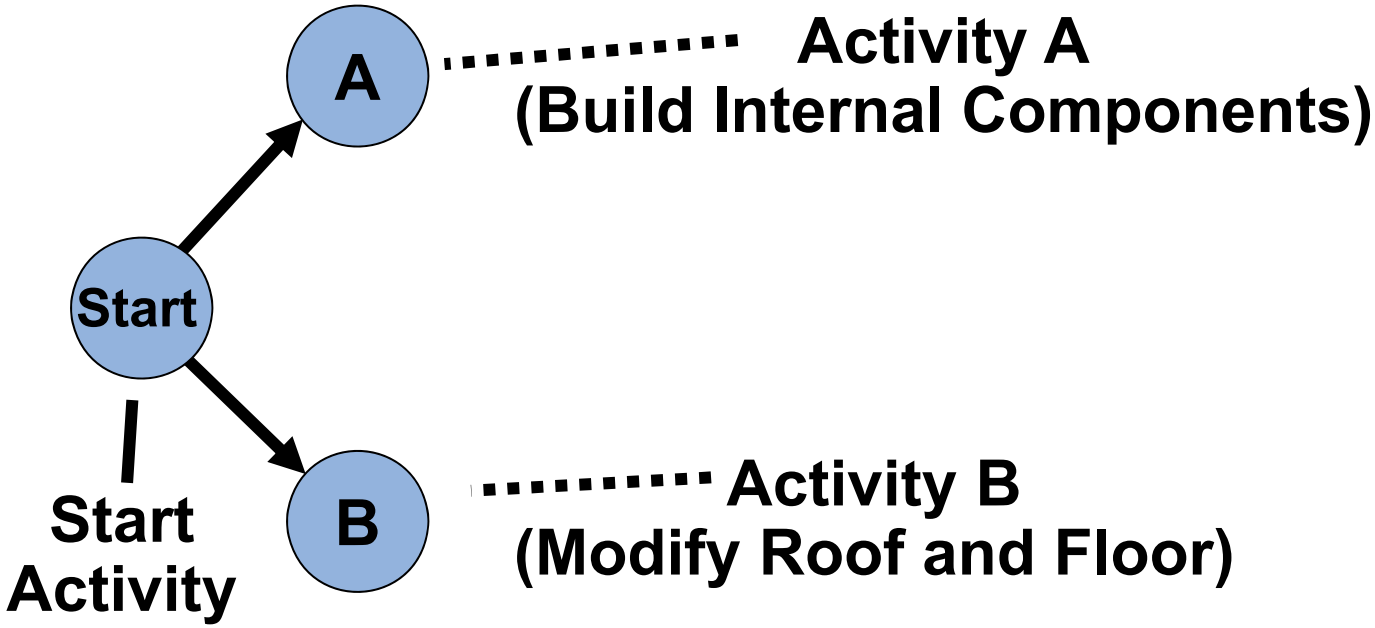


Figure 3.6

AON Network for Milwaukee Paper

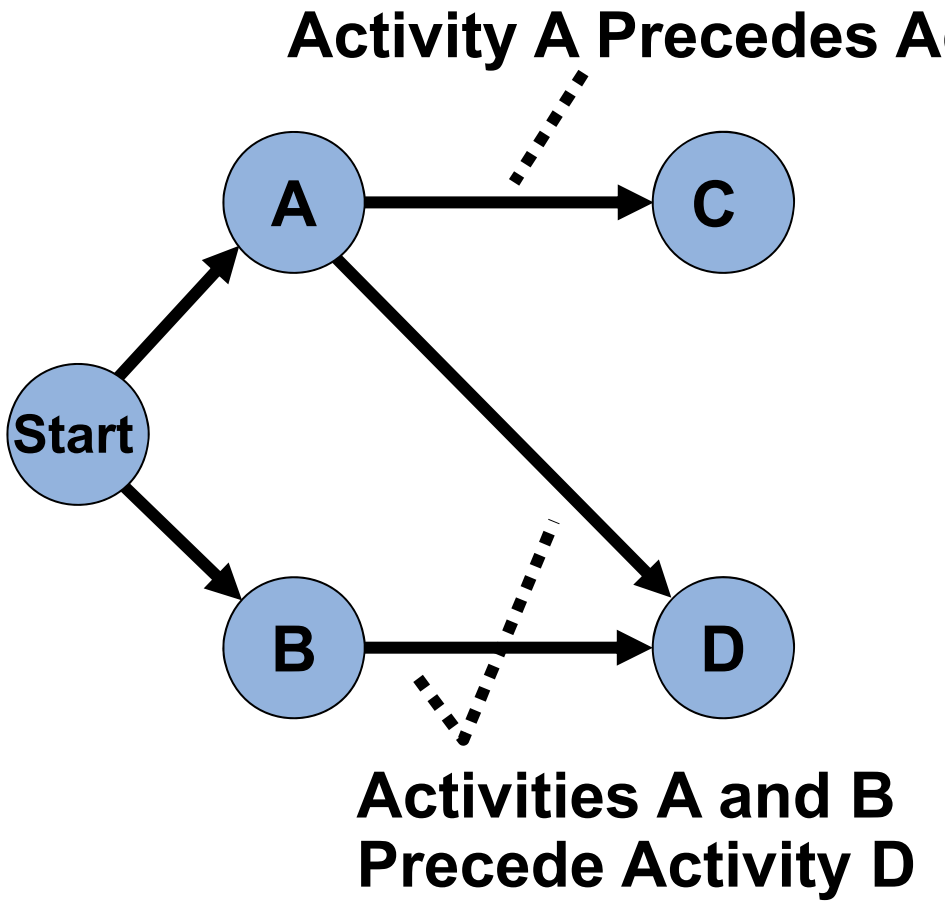


Figure 3.7

AON Network for Milwaukee Paper

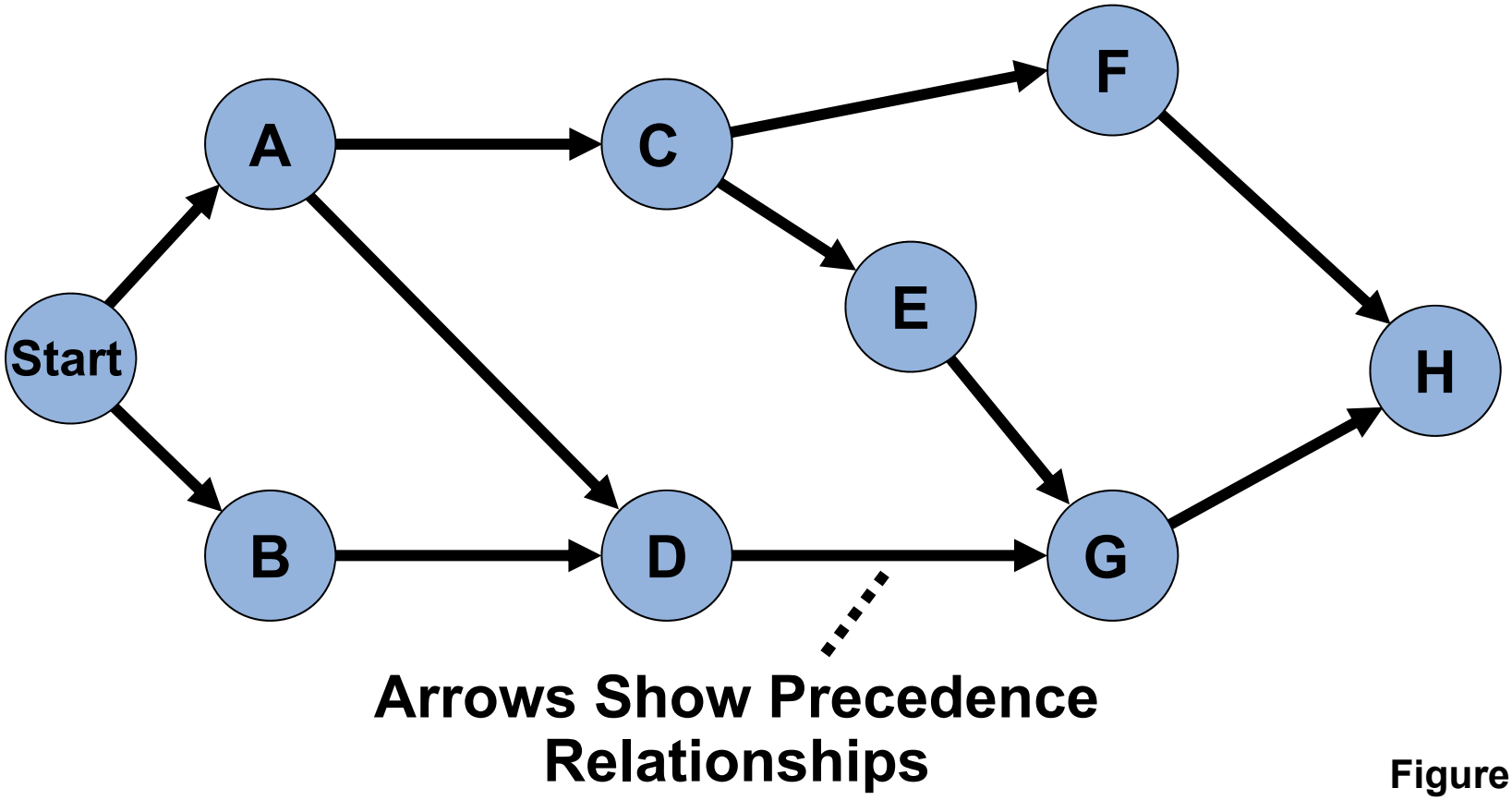


Figure 3.8

AOA Network for Milwaukee Paper

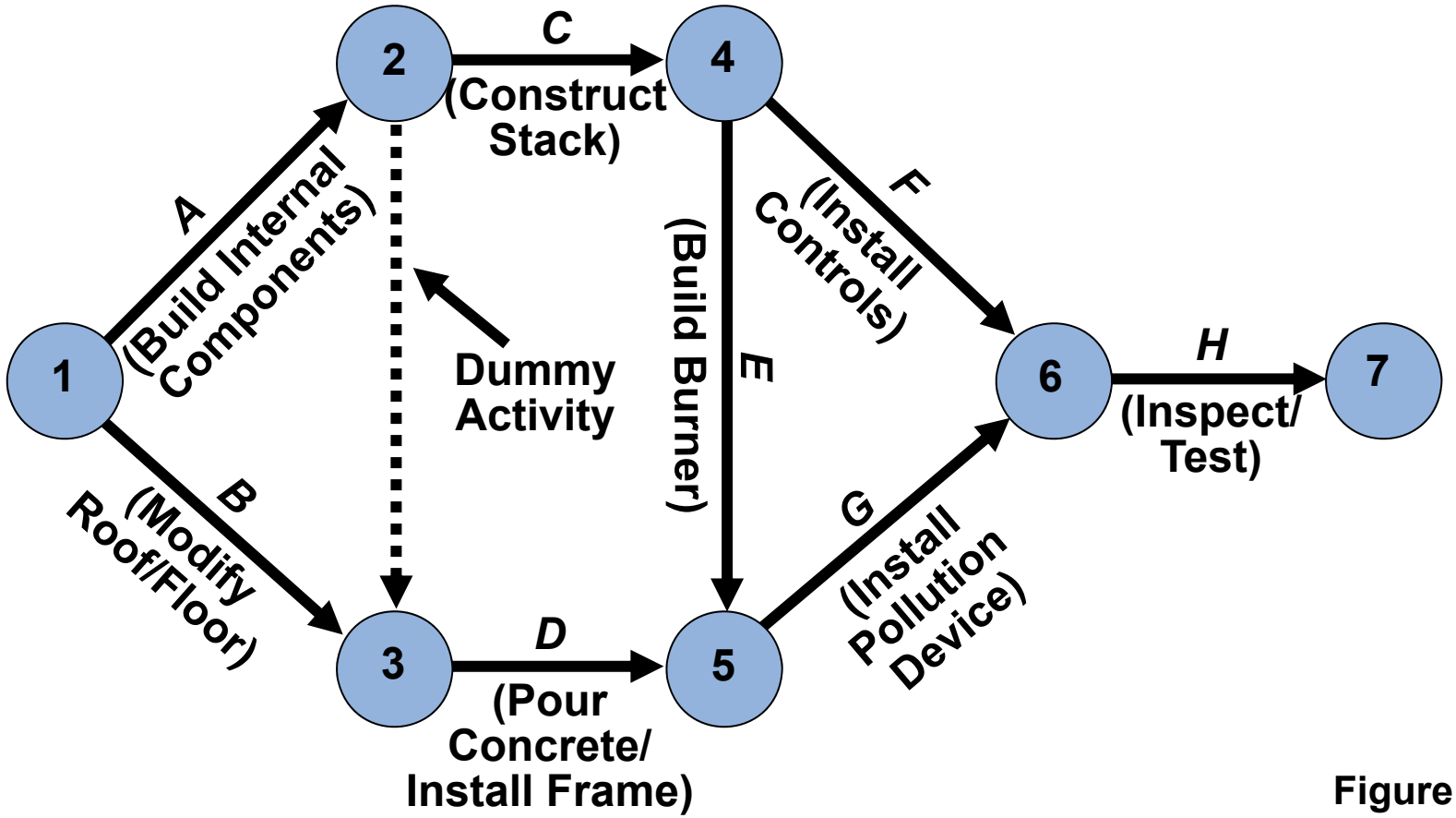


Figure 3.9

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**

Table 3.2

Determining the Project Schedule

Perform a Critical Path Analysis

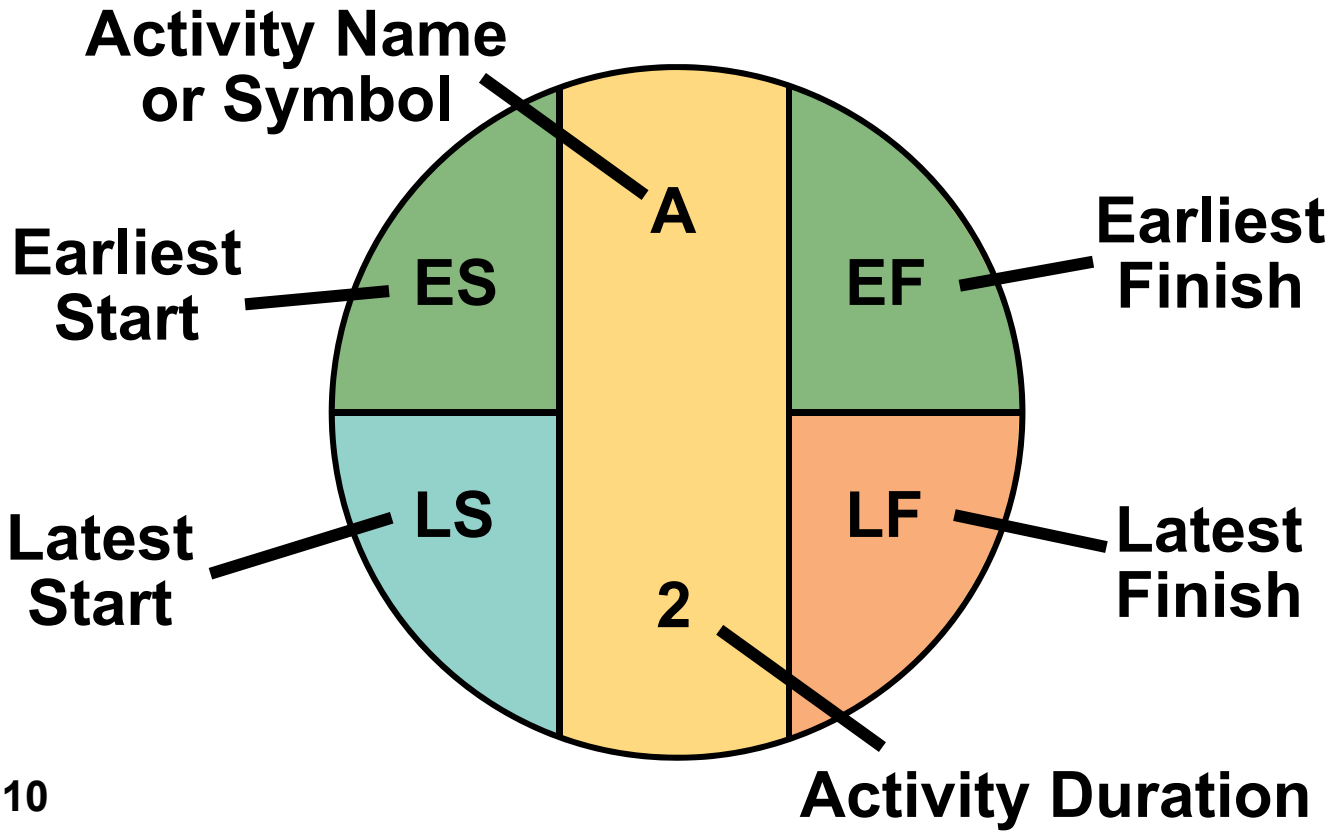


Figure 3.10

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

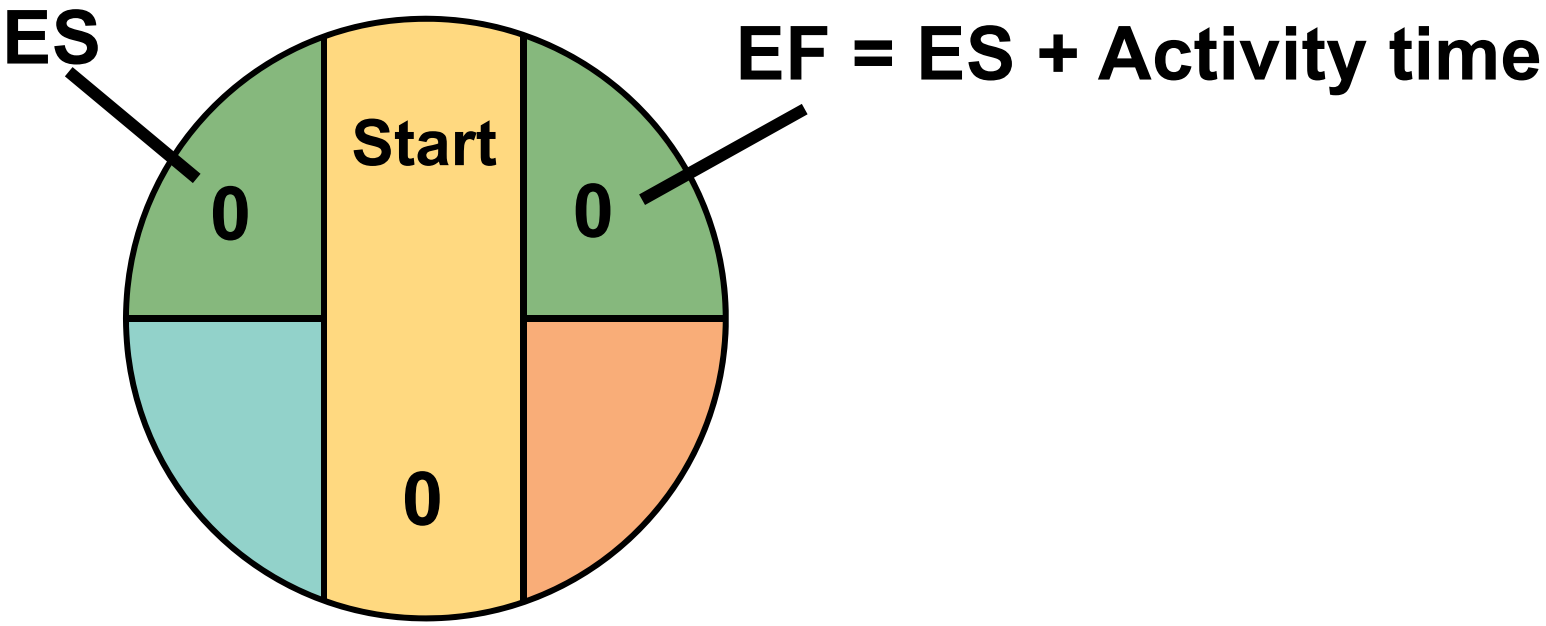
Begin at starting event and work forward

Earliest Finish Time Rule:

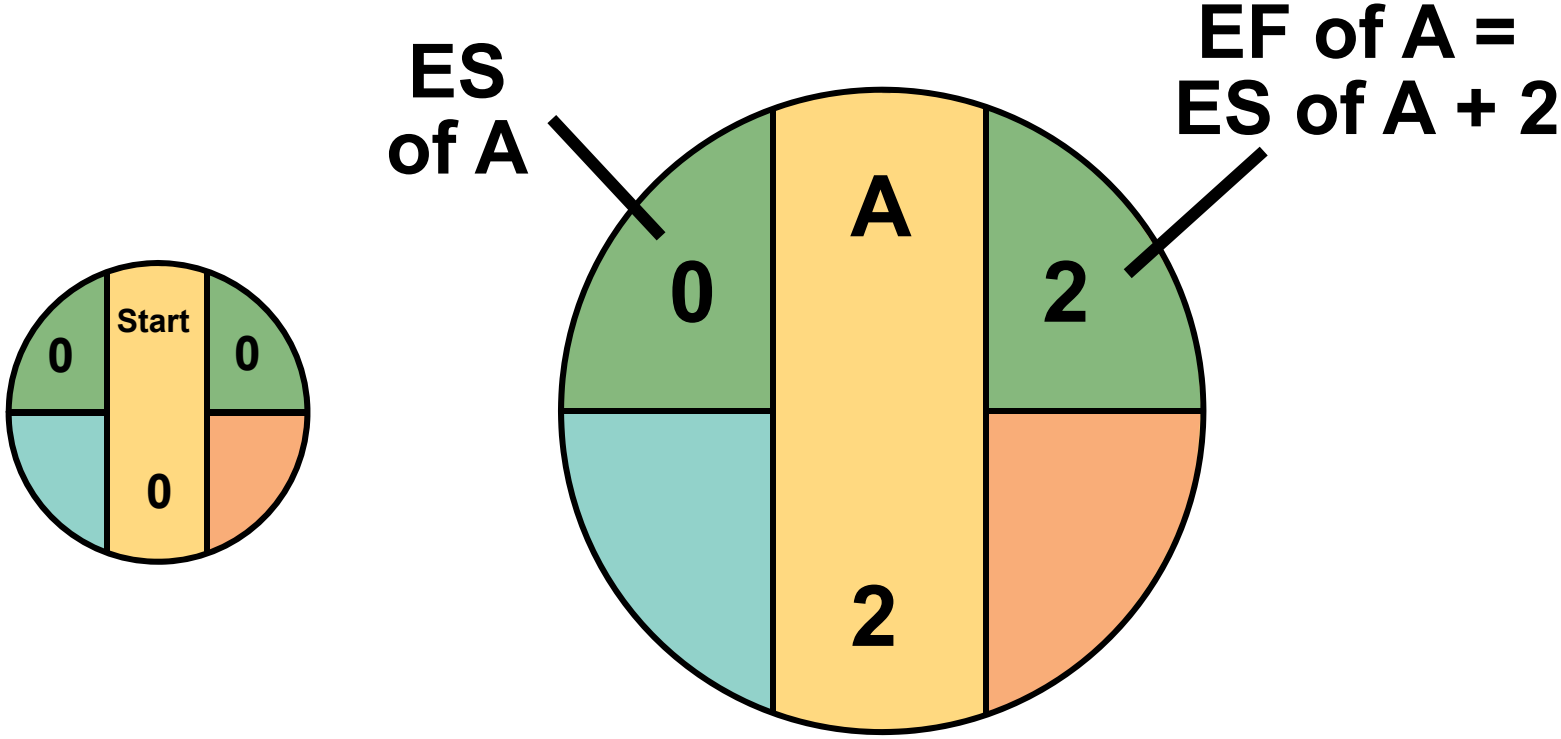
- **The earliest finish time (EF) of an activity is the sum of its earliest start time (ES) and its activity time**

EF = ES + Activity time

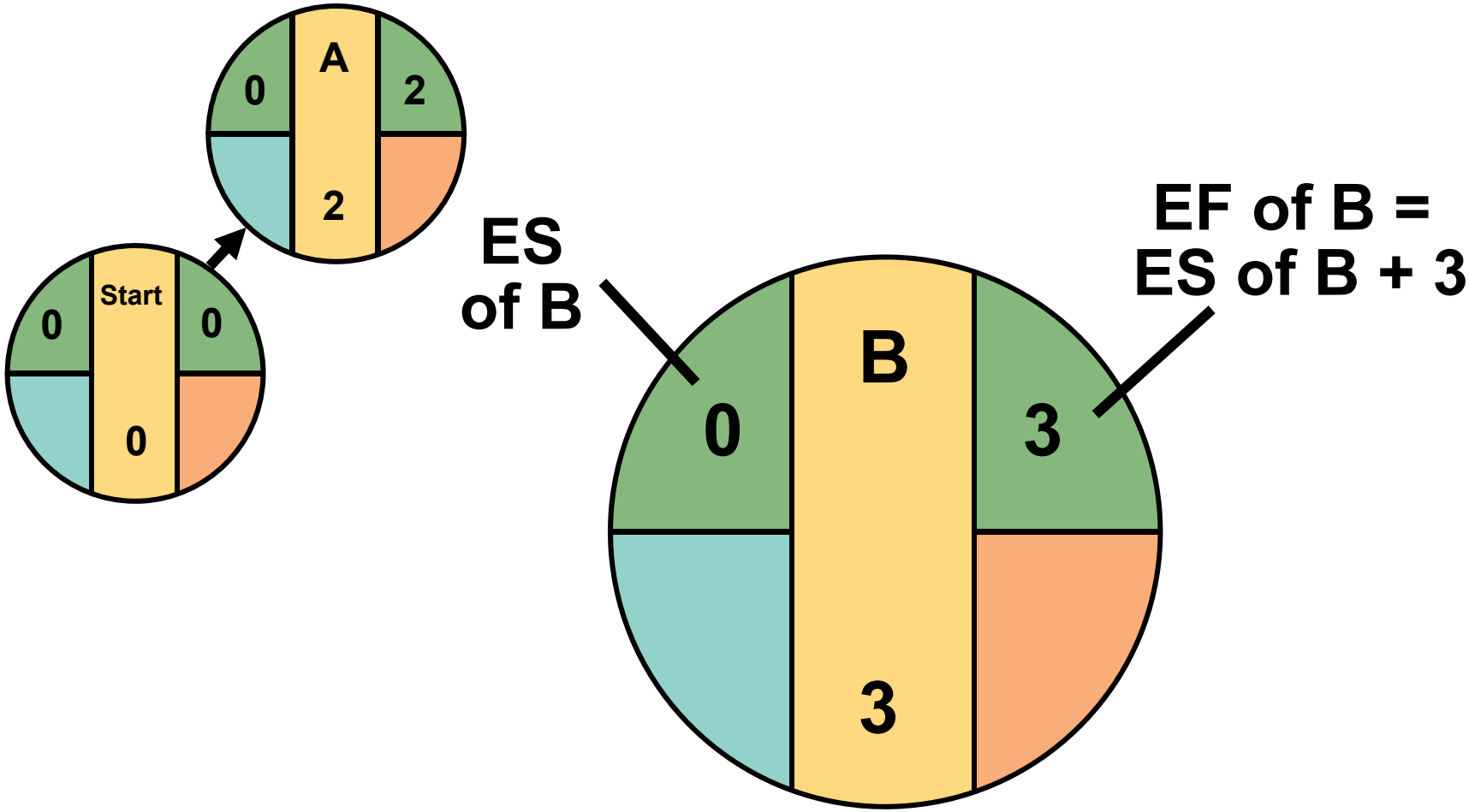
ES/EF Network for Milwaukee Paper



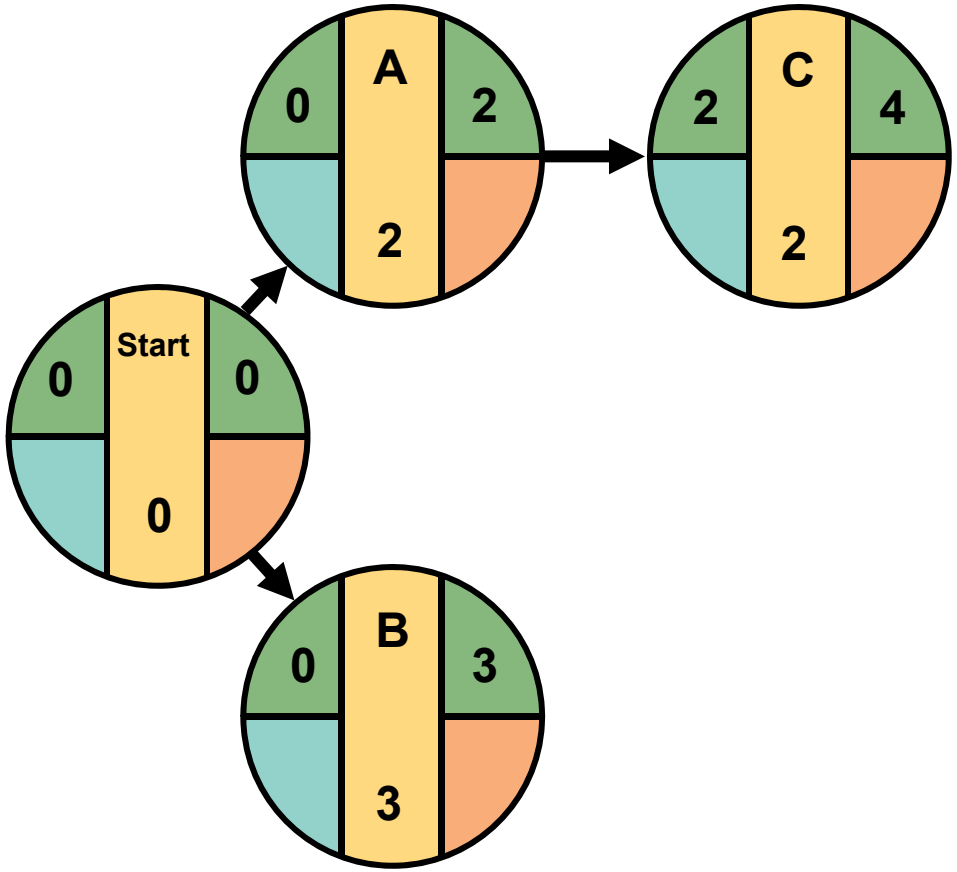
ES/EF Network for Milwaukee Paper



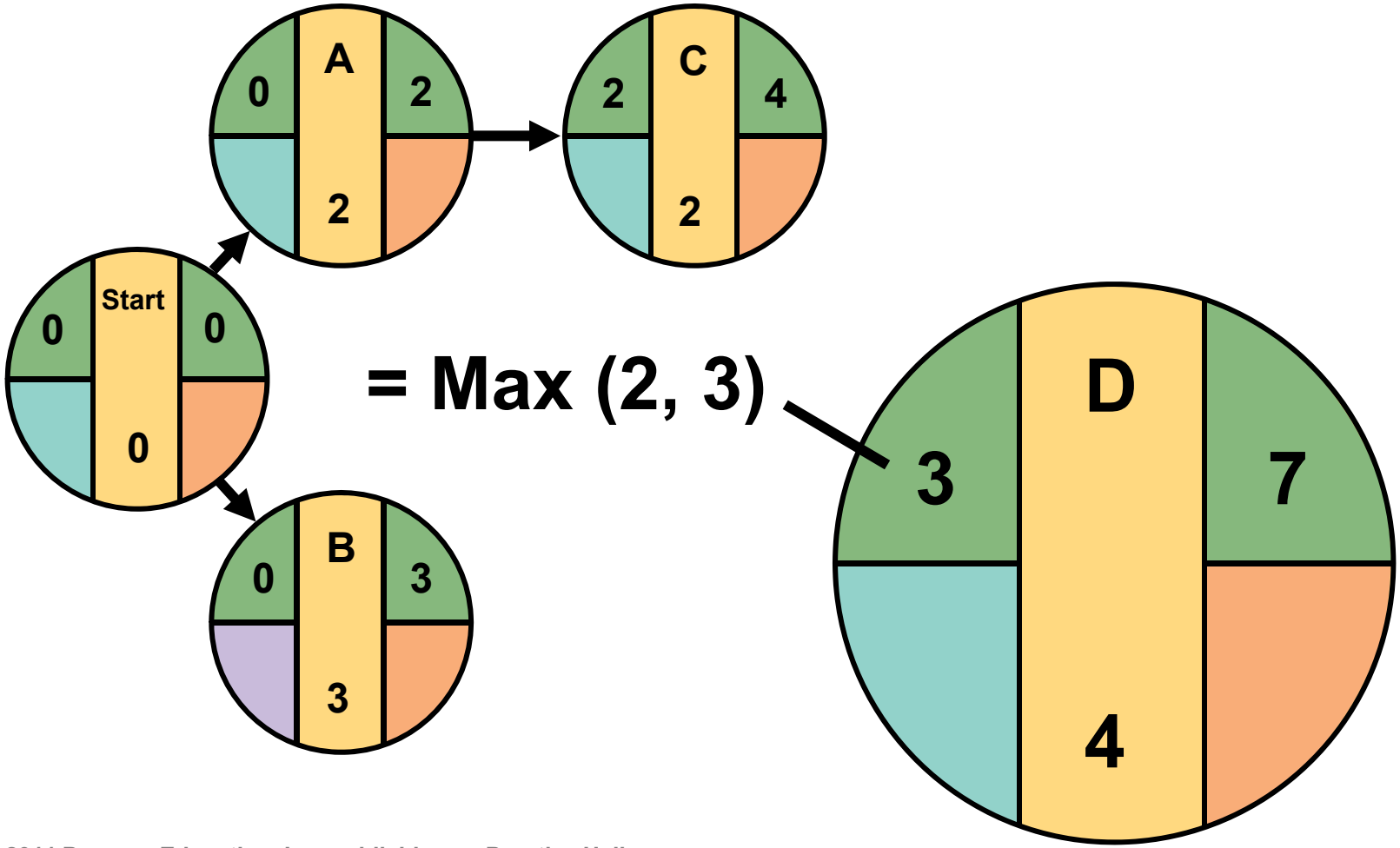
ES/EF Network for Milwaukee Paper



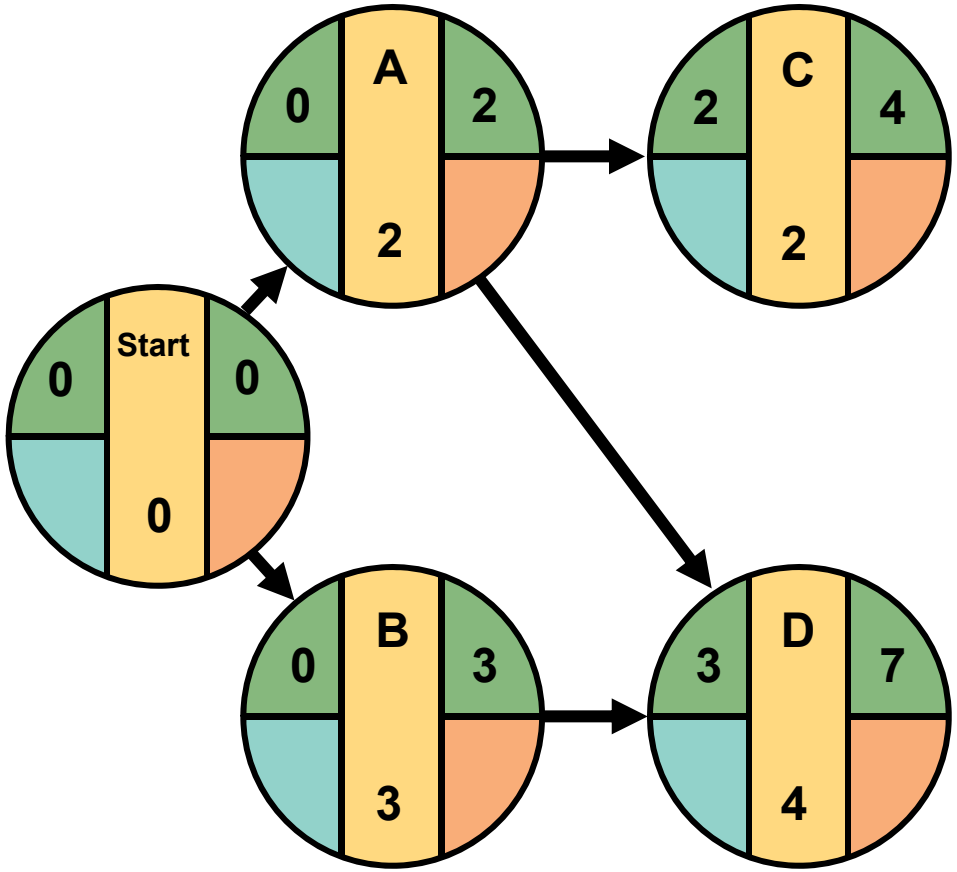
ES/EF Network for Milwaukee Paper



ES/EF Network for Milwaukee Paper



ES/EF Network for Milwaukee Paper



ES/EF Network for Milwaukee Paper

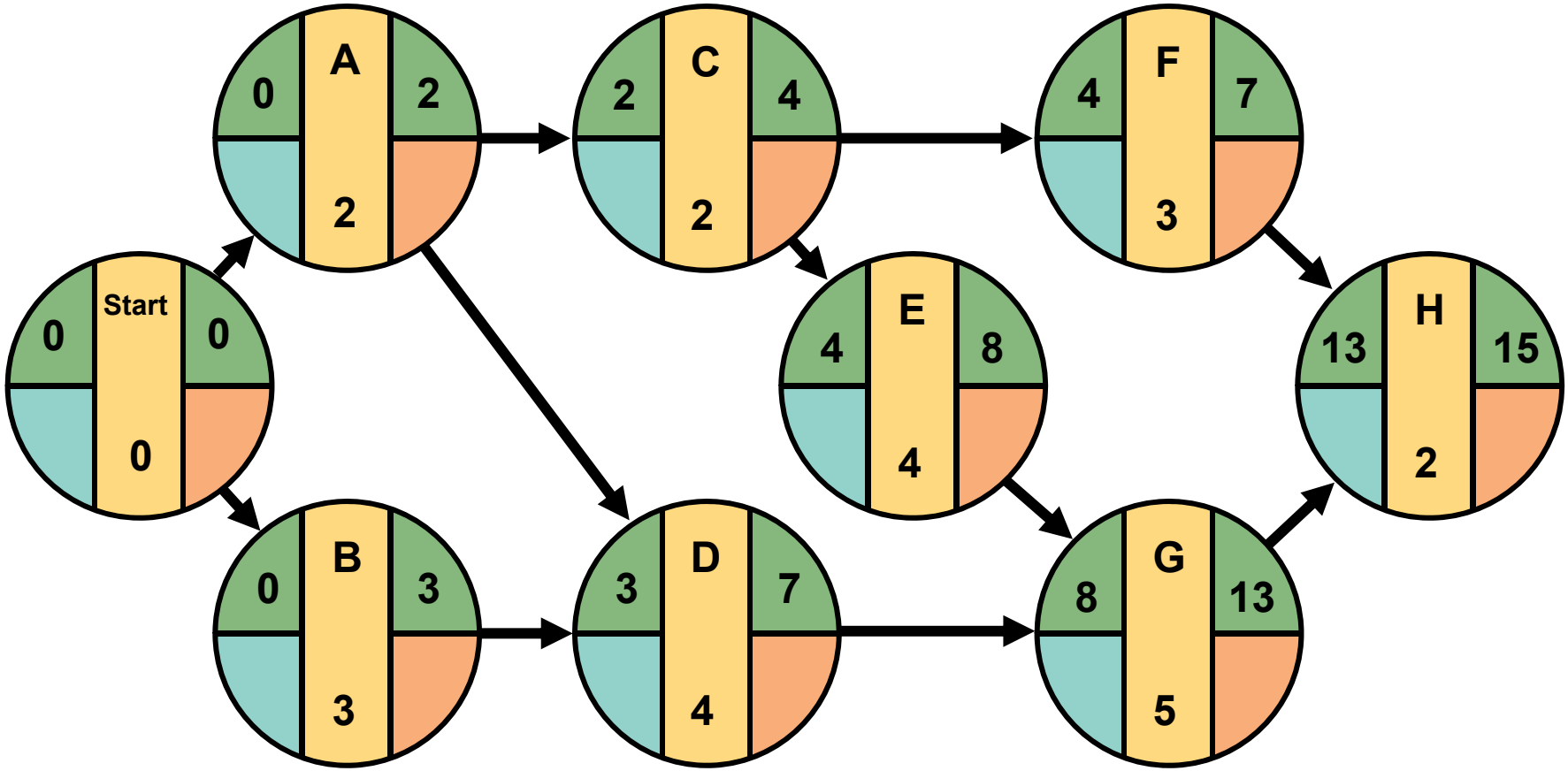


Figure 3.11

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

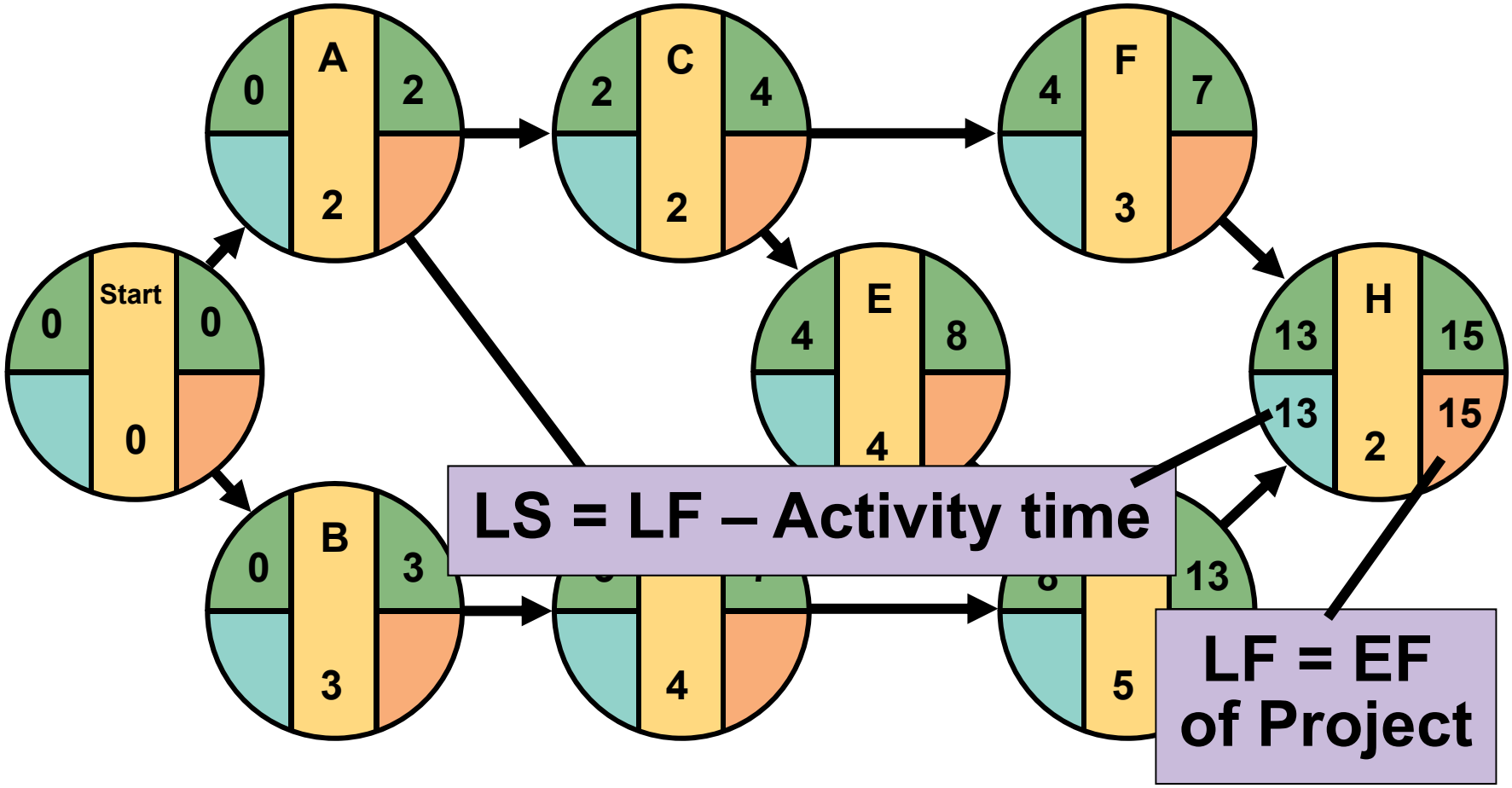
Begin with the last event and work backwards

Latest Start Time Rule:

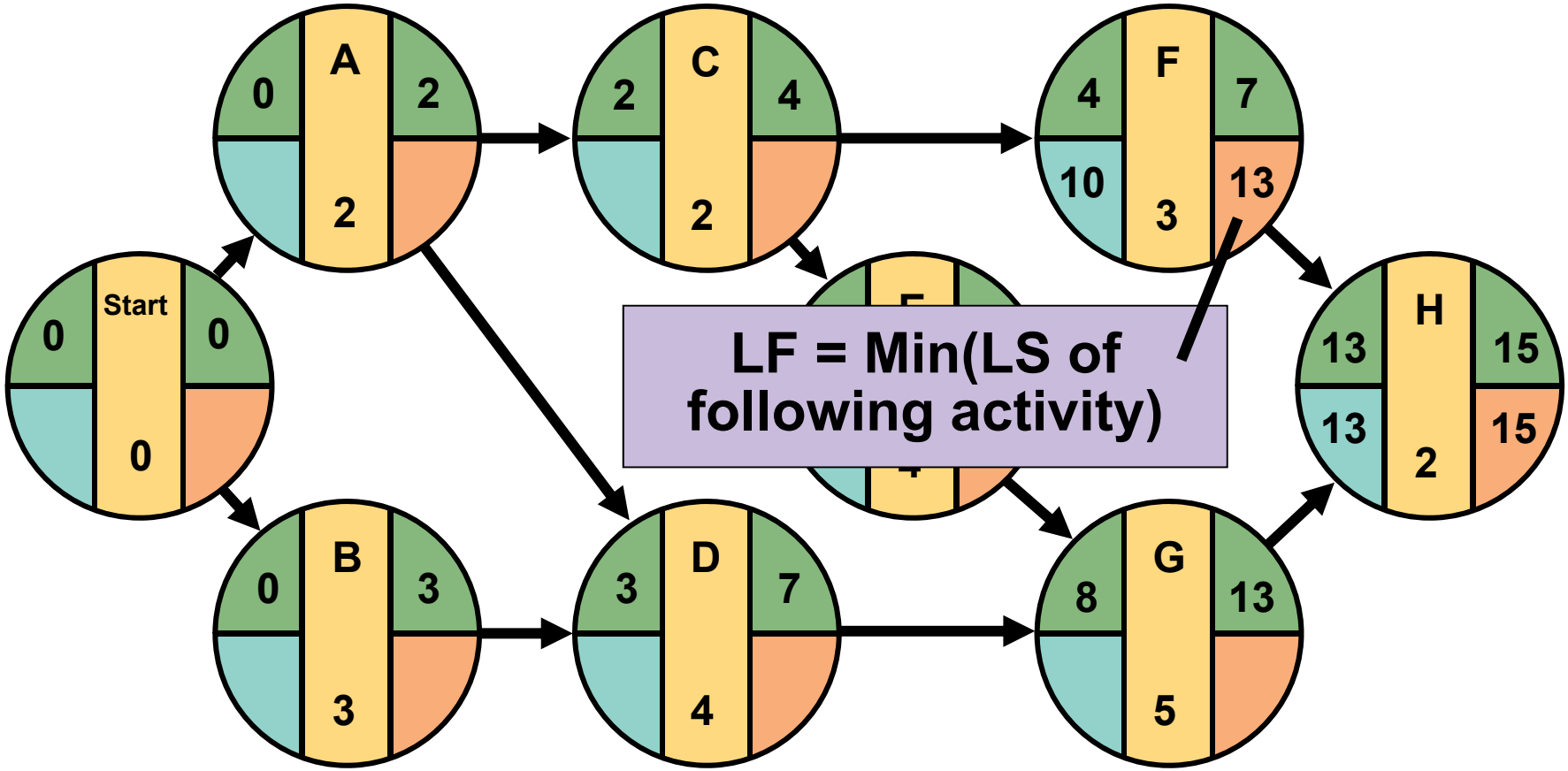
- **The latest start time (LS) of an activity is the difference of its latest finish time (LF) and its activity time**

$$LS = LF - \text{Activity time}$$

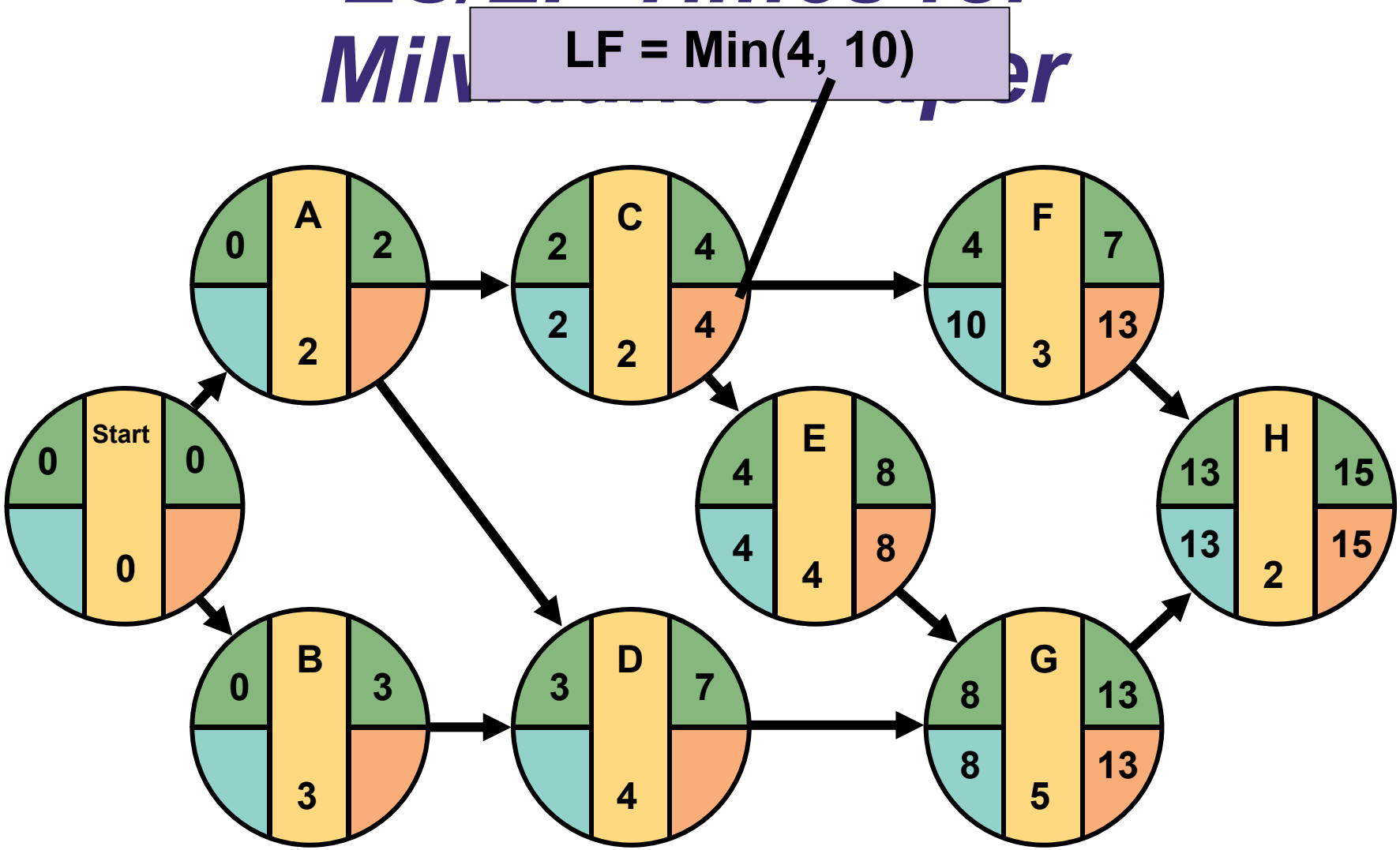
LS/LF Times for Milwaukee Paper



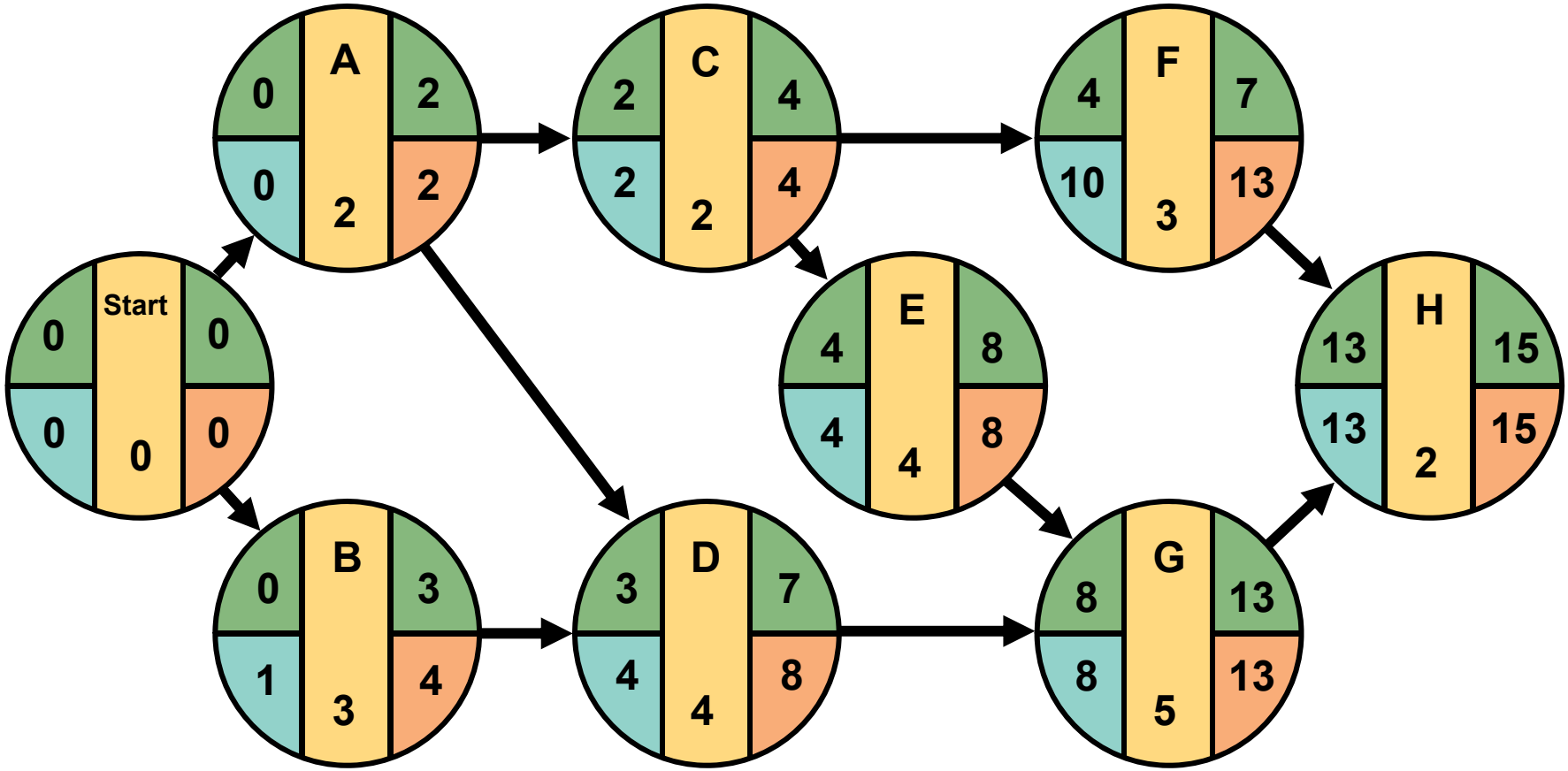
LS/LF Times for Milwaukee Paper



LS/LF Times for Milw



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**

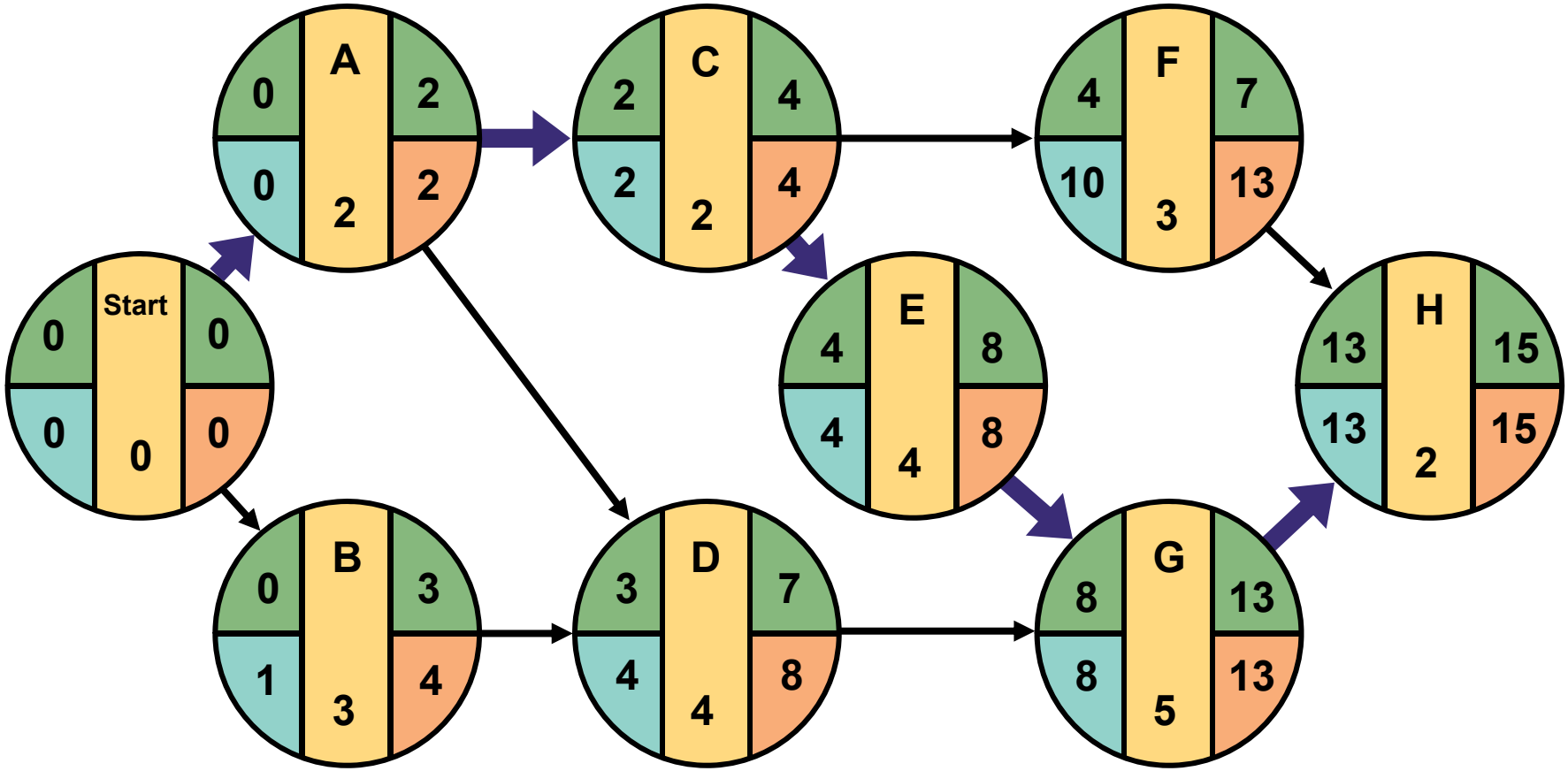
Slack = LS – ES or Slack = LF – EF

Computing Slack Time

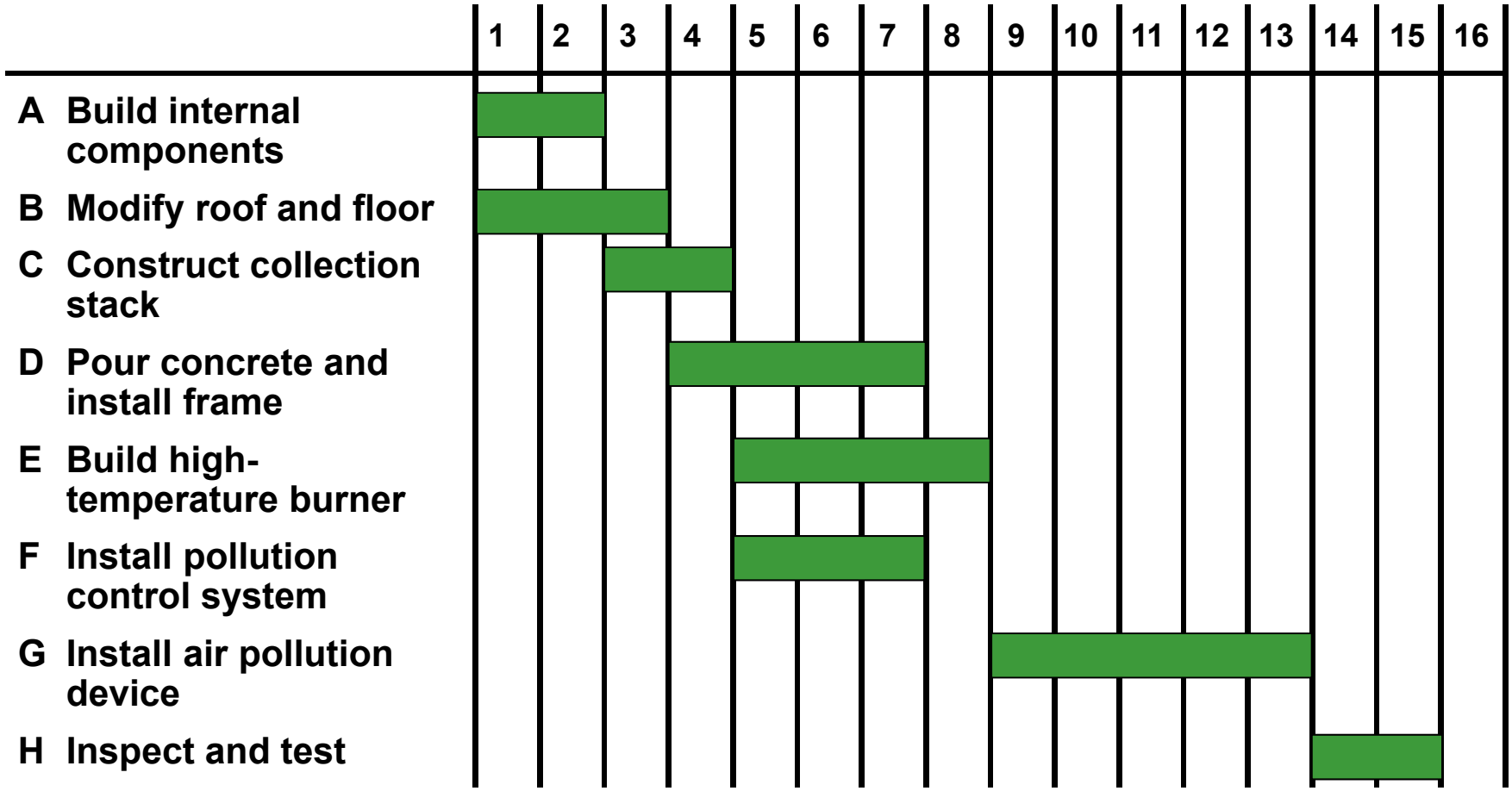
Activity	Earliest Start ES	Earliest Finish EF	Latest Start LS	Latest Finish LF	Slack LS – ES	On Critical Path
A	0	2	0	2	0	Yes
B	0	3	1	4	1	No
C	2	4	2	4	0	Yes
D	3	7	4	8	1	No
E	4	8	4	8	0	Yes
F	4	7	10	13	6	No
G	8	13	8	13	0	Yes
H	13	15	13	15	0	Yes

Table 3.3

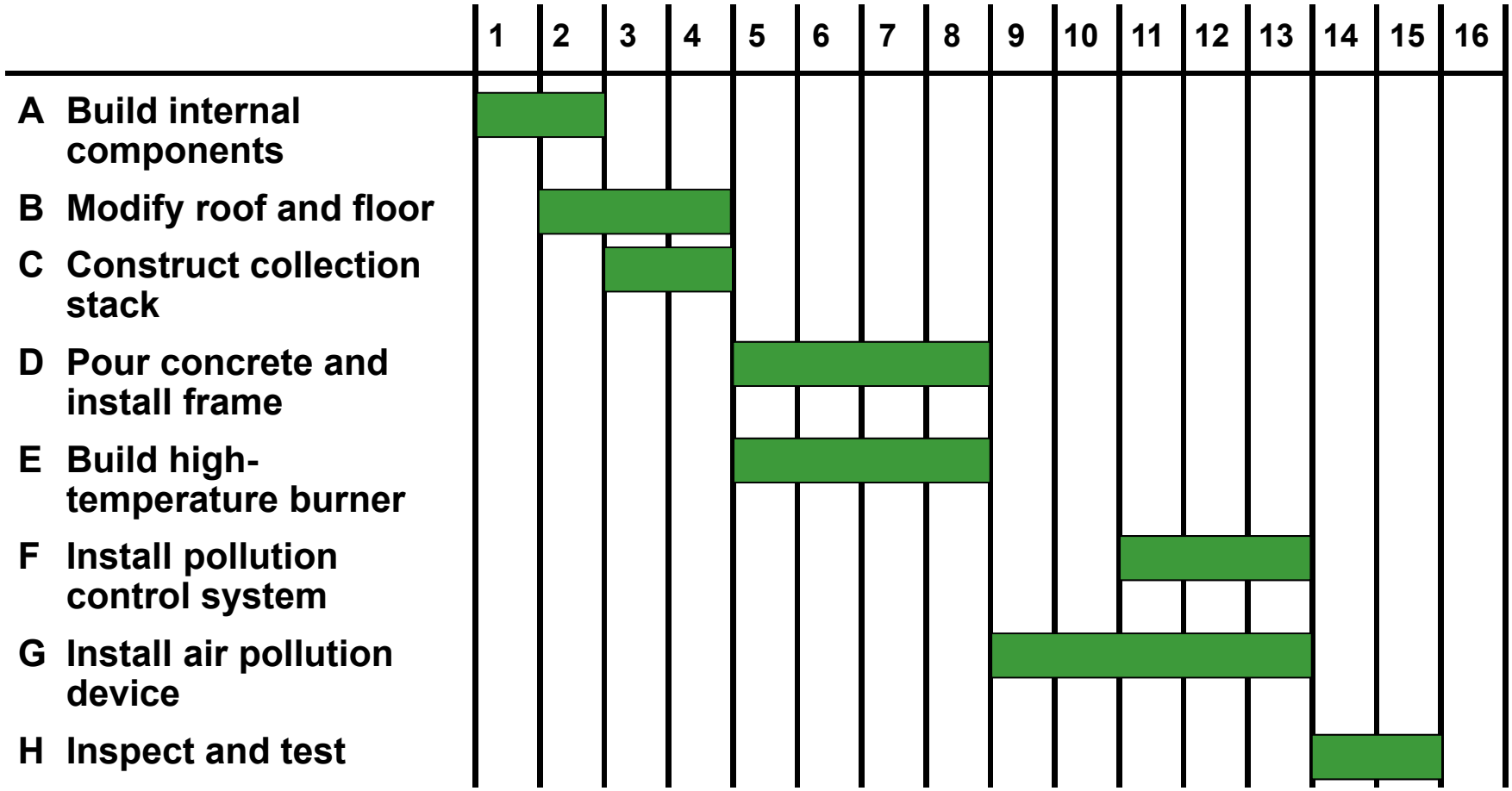
Critical Path for Milwaukee Paper



ES – EF Gantt Chart for Milwaukee Paper



LS – LF Gantt Chart for Milwaukee Paper



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:

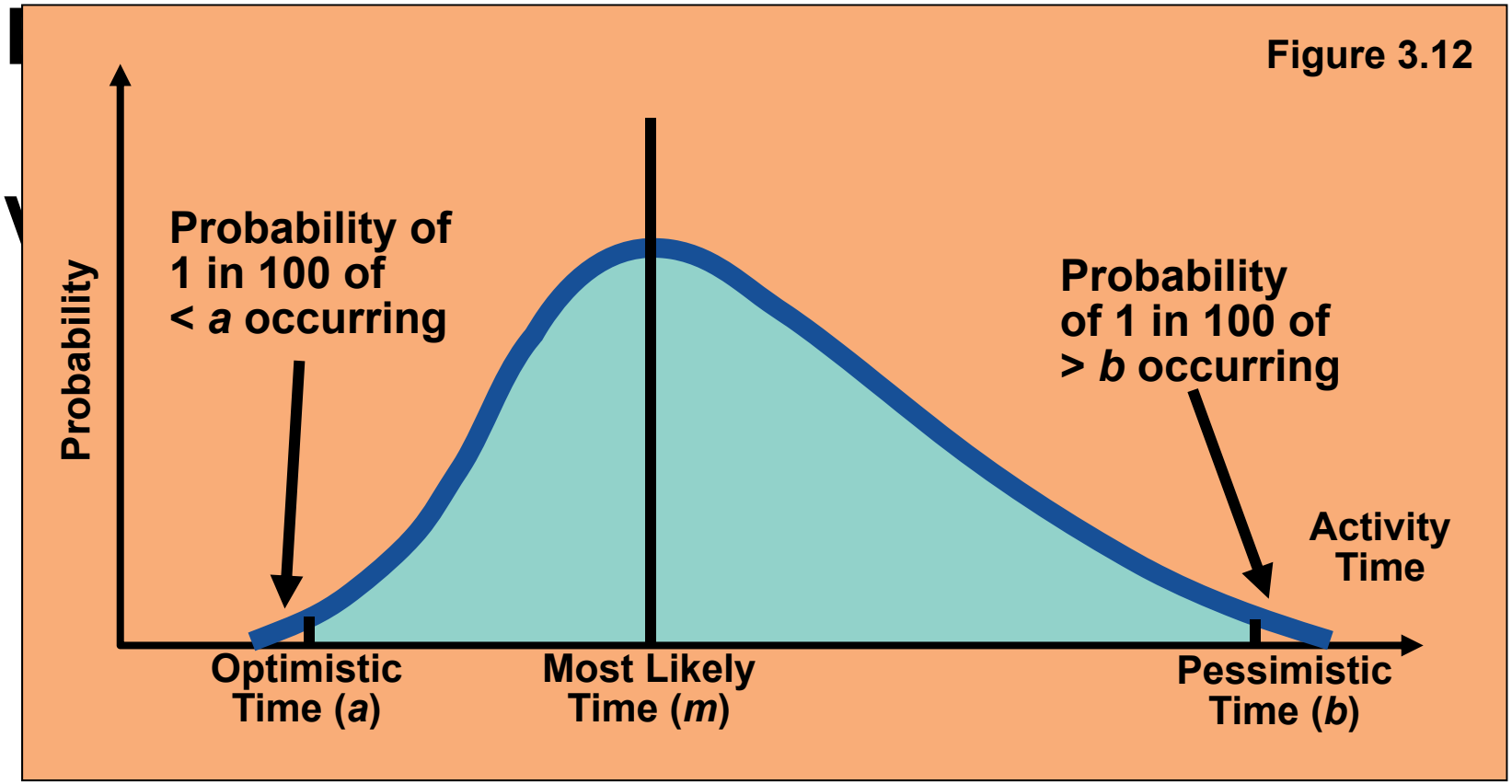
$$t = (a + 4m + b)/6$$

Variance of times:

$$v = [(b - a)/6]^2$$

Variability in Activity Times

Estimate follows beta distribution



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

σ_p^2 = Project variance

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

Probability of Project Completion

Project variance is computed by

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

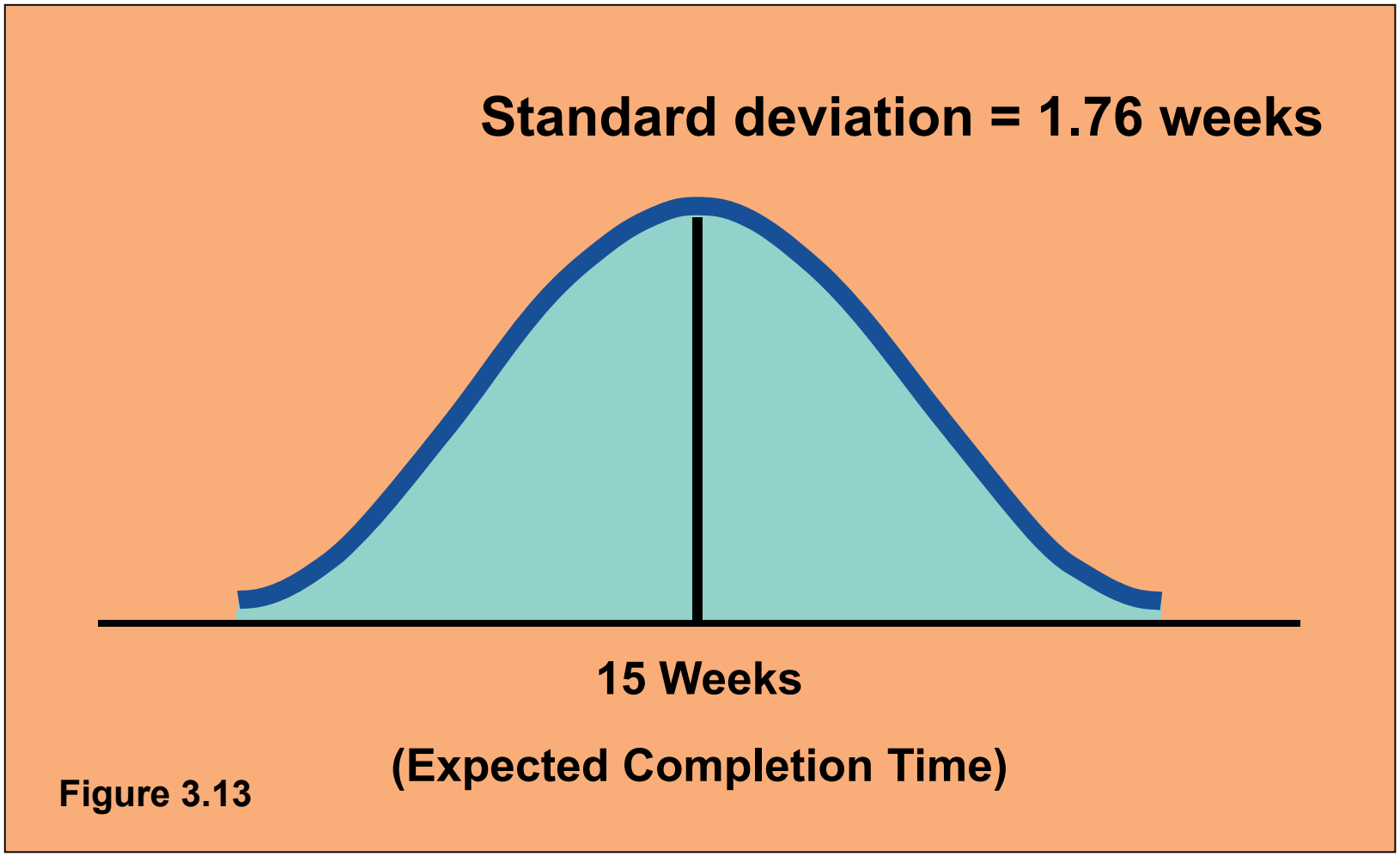


Figure 3.13

Probability of Project Completion

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

$$Z = \begin{pmatrix} \text{due} \\ \text{date} \end{pmatrix} - \begin{pmatrix} \text{expected date} \\ \text{of completion} \end{pmatrix} / \sigma_p$$

$$= (16 \text{ wks} - 15 \text{ wks})/1.76$$

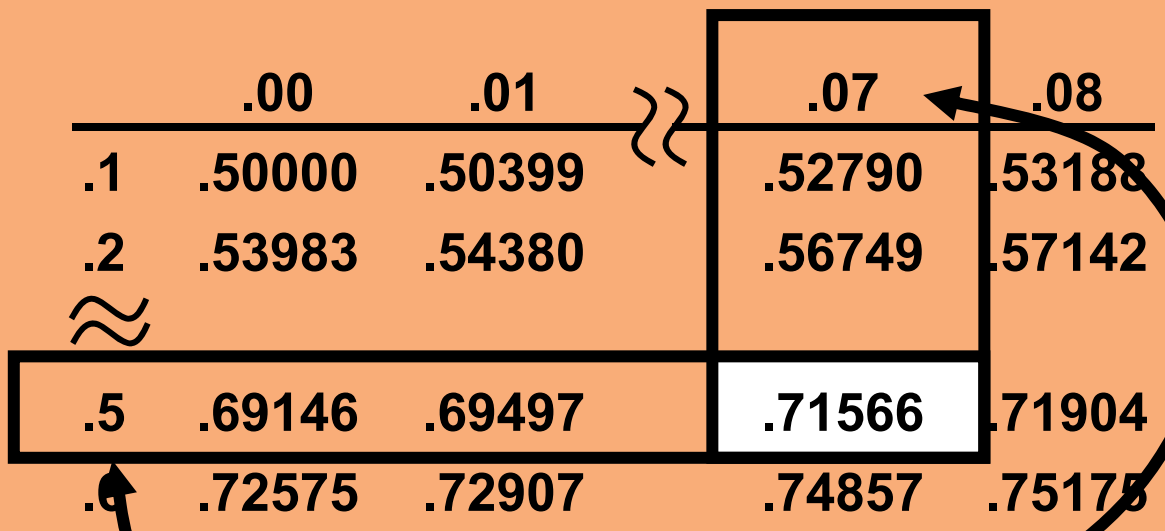
$$= 0.57$$

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
be co
dead

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

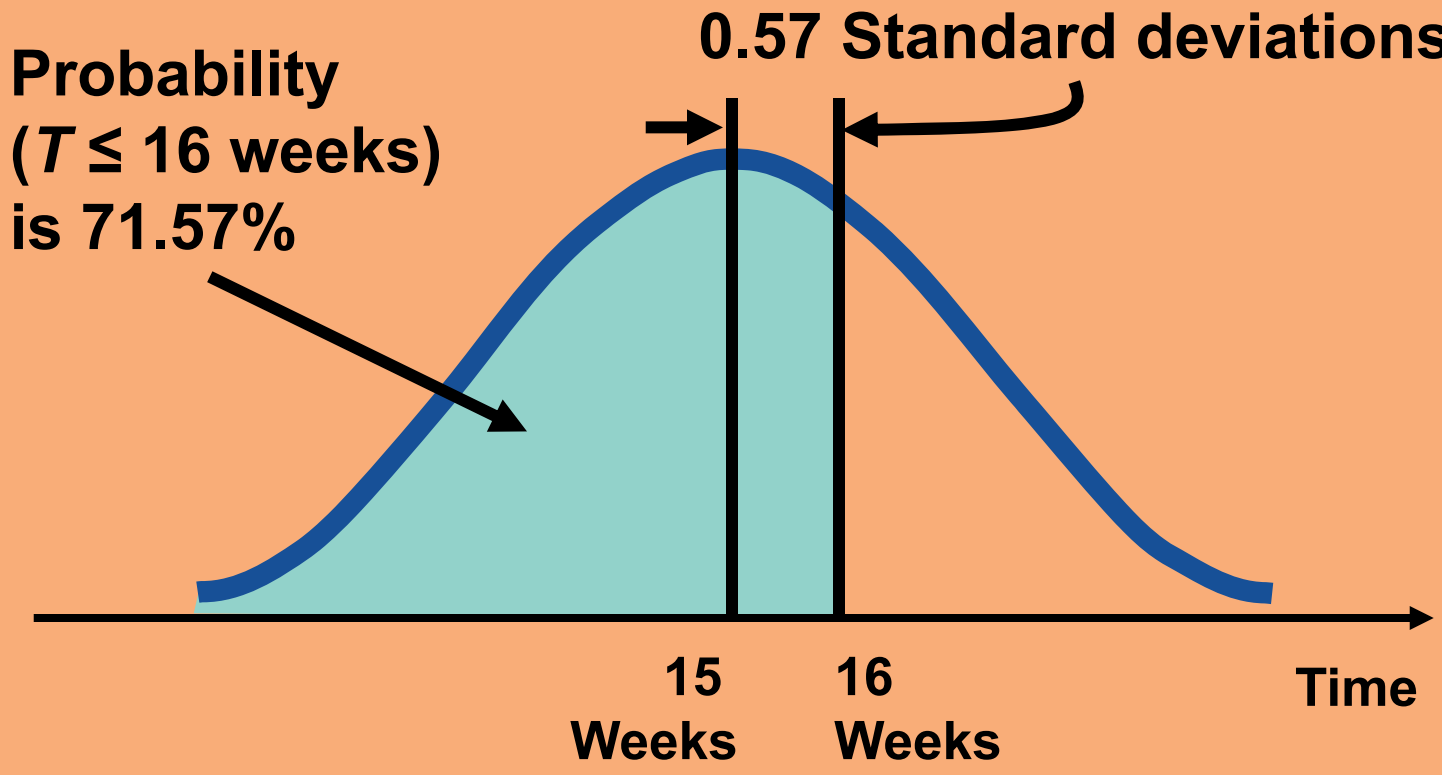


Figure 3.14

Determining Project Completion Time

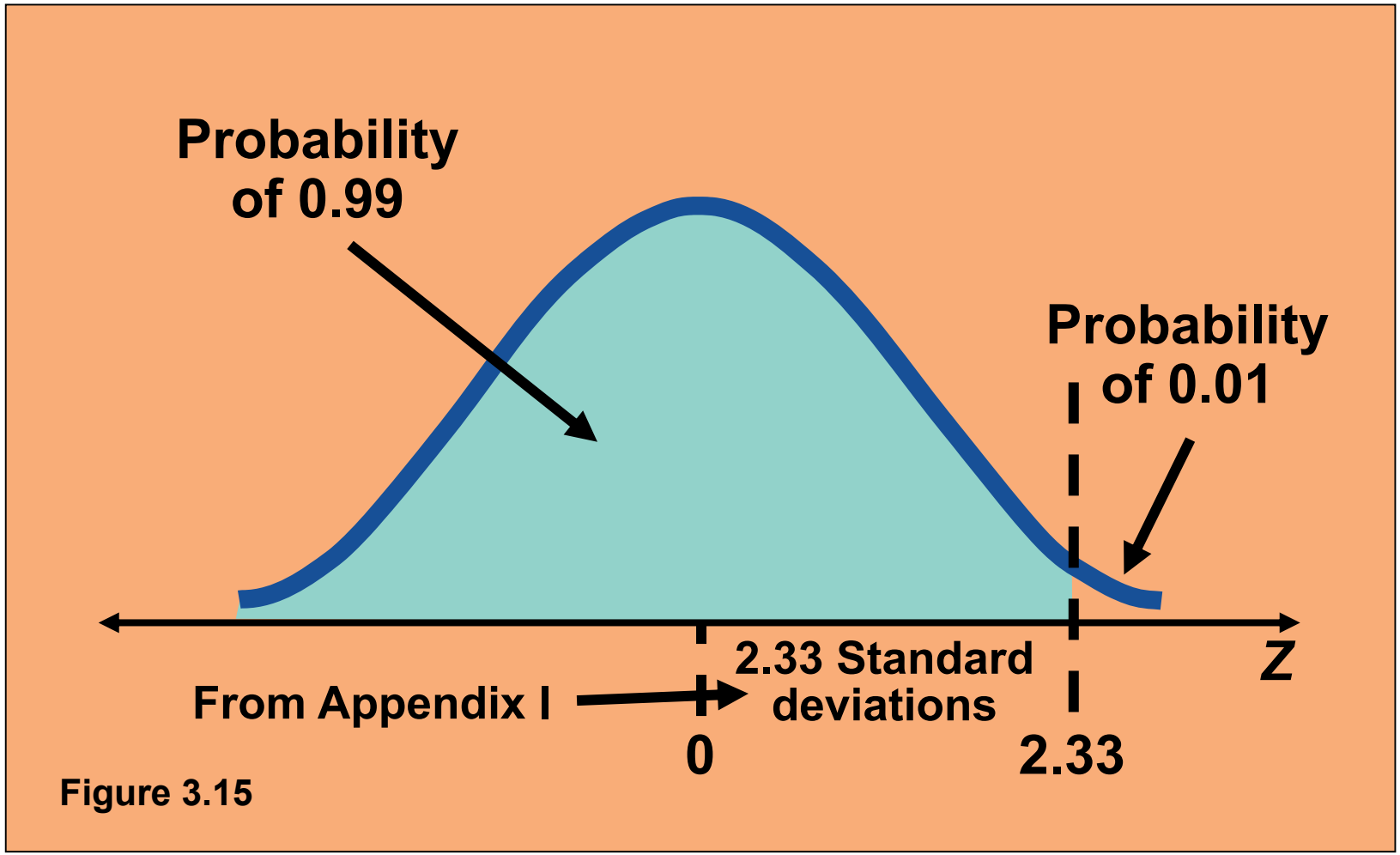


Figure 3.15

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

1. The project's expected completion time is 15 weeks
2. There is a 71.57% chance the equipment will be in place by the 16 week deadline
3. Five activities (A, C, E, G, and H) are on the critical path
4. Three activities (B, D, F) are not on the critical path and have slack time
5. A detailed schedule is available

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**

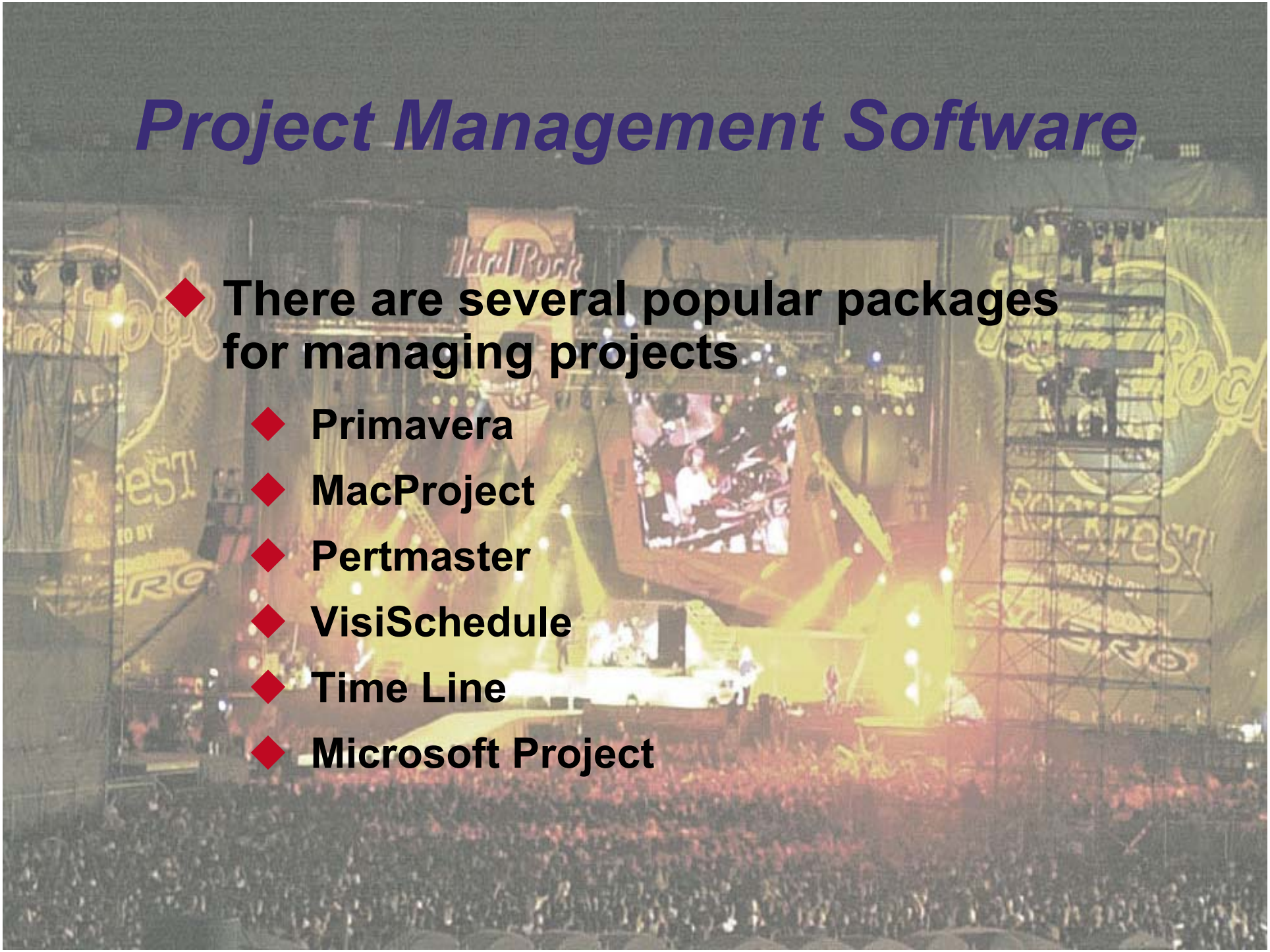
Advantages of PERT/CPM

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

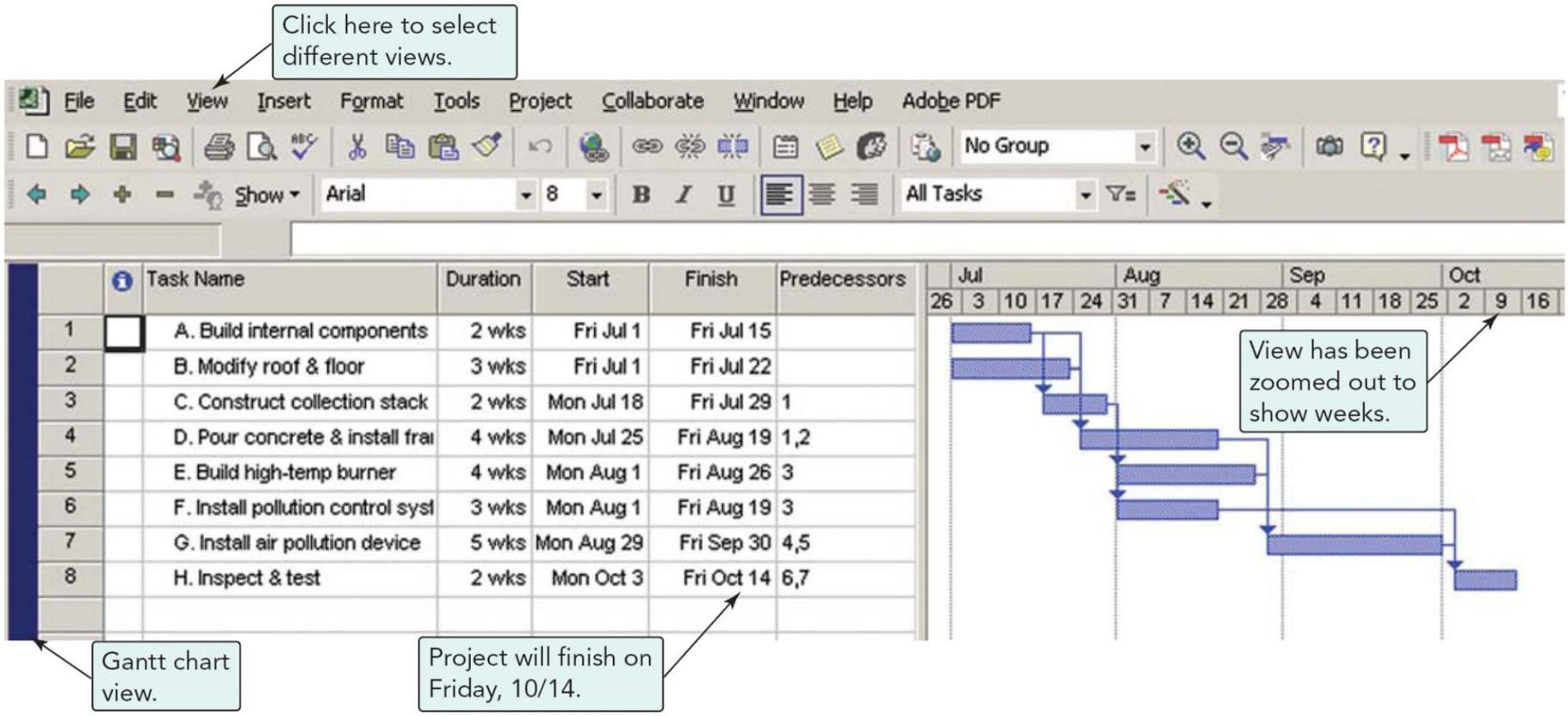
1. **Project activities have to be clearly defined, independent, and stable in their relationships**
2. **Precedence relationships must be specified and networked together**
3. **Time estimates tend to be subjective and are subject to fudging by managers**
4. **There is an inherent danger of too much 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