Project Management

3

PowerPoint presentation to accompany
Heizer, Render, Munson
Operations Management, Twelfth Edition
Principles of Operations Management, Tenth Edition

PowerPoint slides by Jeff Heyl

Outline

- Global Company Profile: Bechtel Group
- The Importance of Project Management
- Project Planning
- Project Scheduling
- Project Controlling
- Project Management Techniques: CPM
- Determining the Project Schedule

Bechtel Projects

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

Learning Objectives

When you complete this chapter you should be able to:

- **3.1** ***Use*** a Gantt chart for scheduling
- **3.2** ***Draw*** Activity On Node (AON) networks
- **3.3** ***Complete*** forward and backward passes for a project
- **3.4** ***Determine*** a critical path and project completion time

Importance of Project Management

- Bechtel Project Management
  - International workforce, construction professionals, cooks, medical personnel, security
  - Strategic value of time-based competition
  - Quality mandate for continual improvement

Importance of Project Management

Statistics showing the value of project management are:

- Only **21%** of companies have standardized project management systems like waterfall and agile in place
- **1 in 6** IT projects have a cost overrun of **200%**
- IT projects with a budget of at least **$1 million** are **50%** more likely to fail to meet business objectives
- **41%** of businesses with a high project failure rate blame a lack of involvement from higher-ups in project management
- **41%** of organizations reporting poor project performance say they don't get enough support from project management and project sponsors
- Project management challenges cost businesses **$109 million** for every **$1 billion** invested in a project

(sources: Gallup, Wellingtone, PMP Gartner, PMI, UM Saint Louis)

Project Characteristics

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

Examples of Projects

- Building Construction

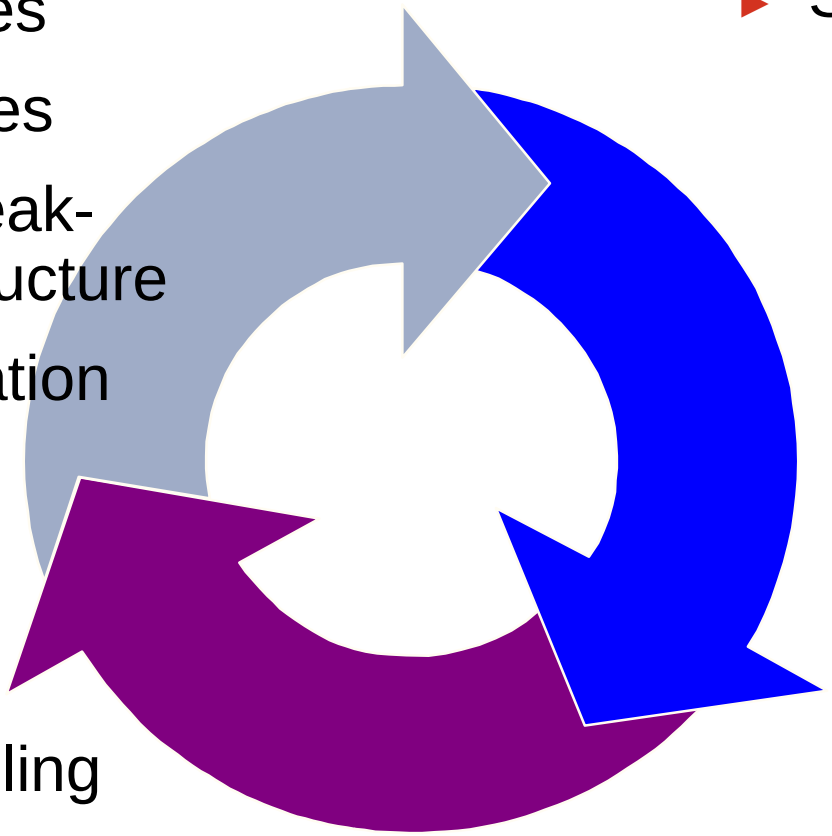
- Research Project

Management of Projects

1. *Planning* - goal setting, defining the project, team organization
2. *Scheduling* - relate people, money, and supplies to specific activities and activities to each other
3. *Controlling* - monitor resources, costs, quality, and budgets; revise plans and shift resources to meet time and cost demands

Project Management Activities

- Planning
  - Objectives
  - Resources
  - Work break-down structure
  - Organization
- Scheduling
  - Project activities
  - Start and end times
  - Network



- Controlling
  - Monitor, compare, revise, action

Project Planning, Scheduling, and Controlling

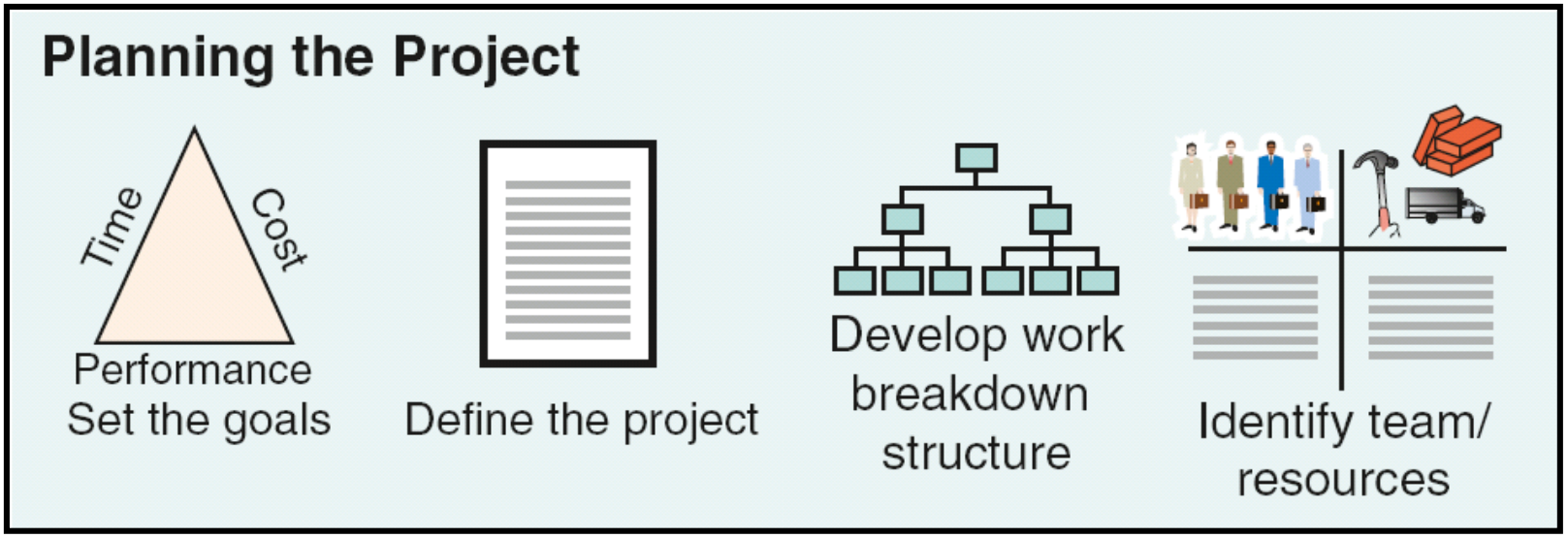


Figure 3.1

Project Planning, Scheduling, and Controlling

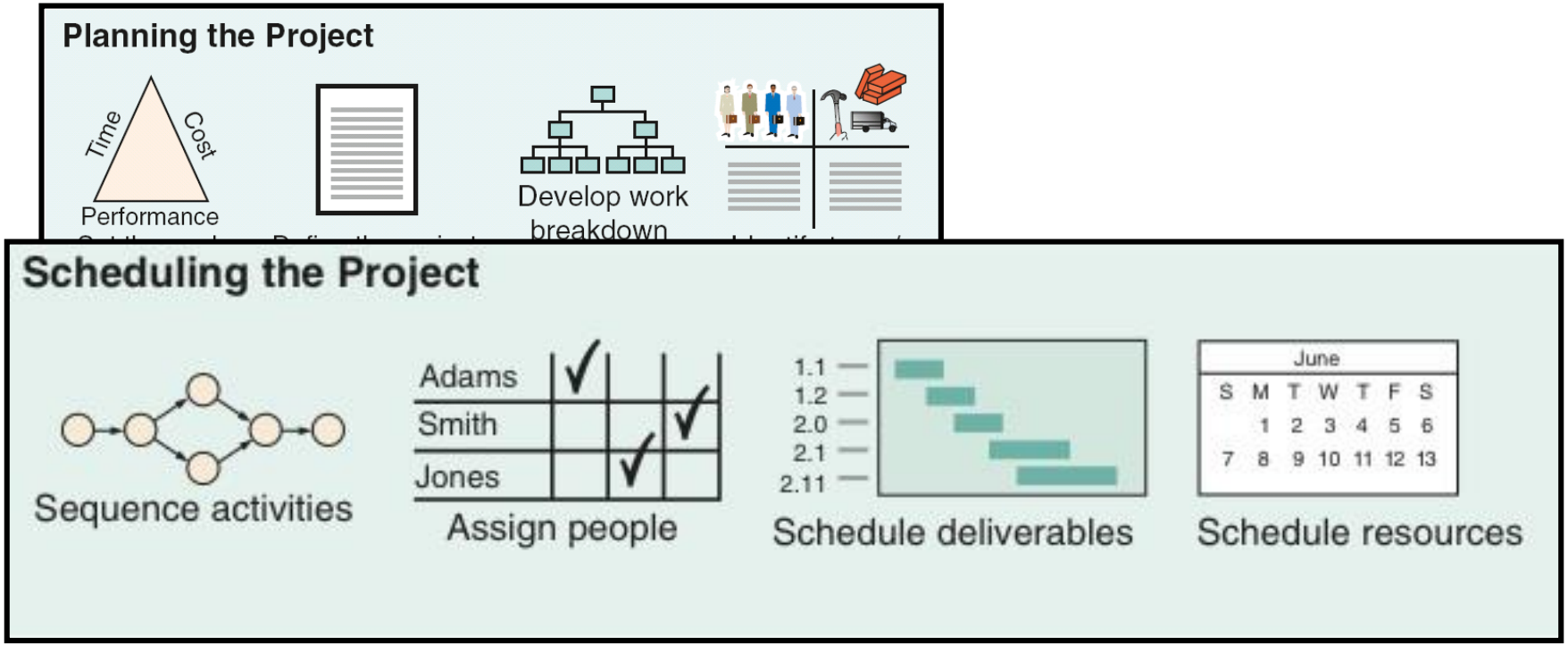


Figure 3.1

Project Planning, Scheduling, and Controlling

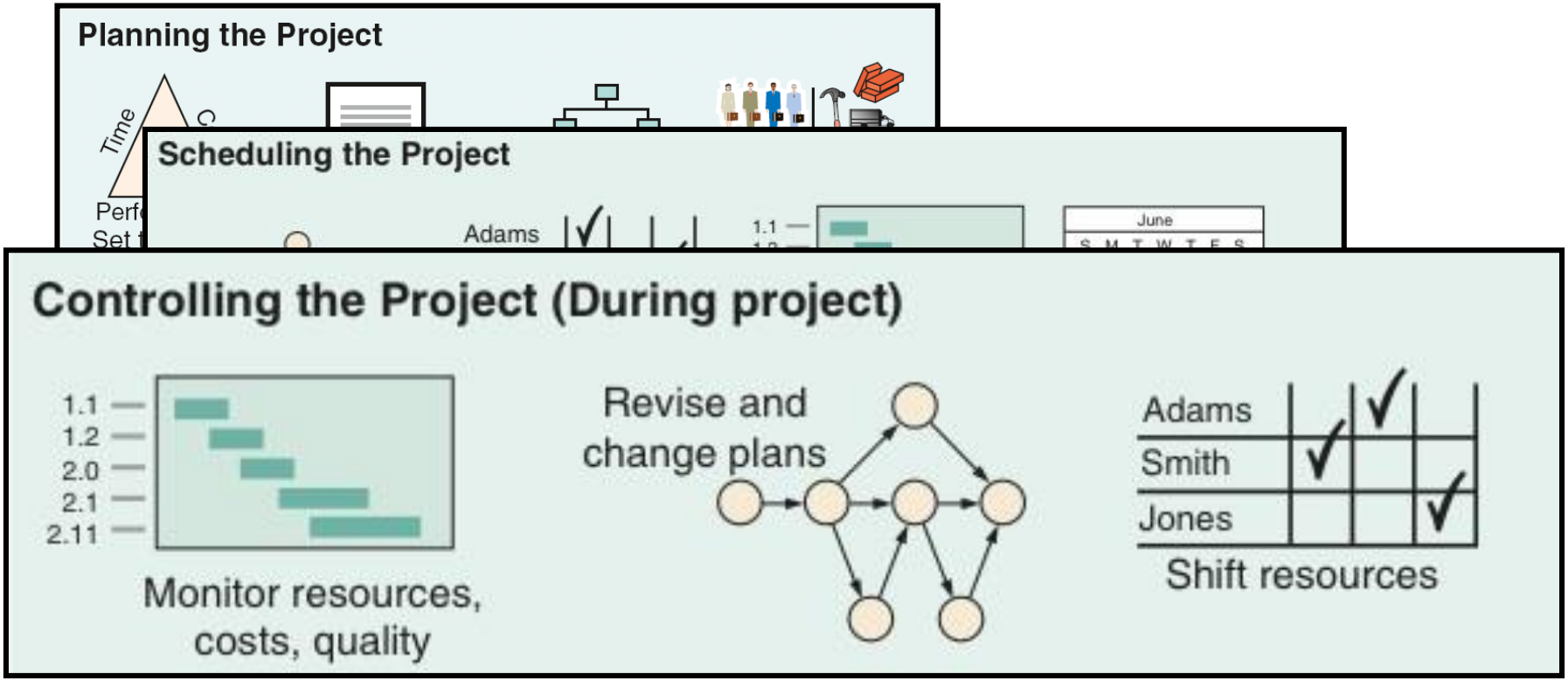


Figure 3.1

Project Planning, Scheduling, and Controlling

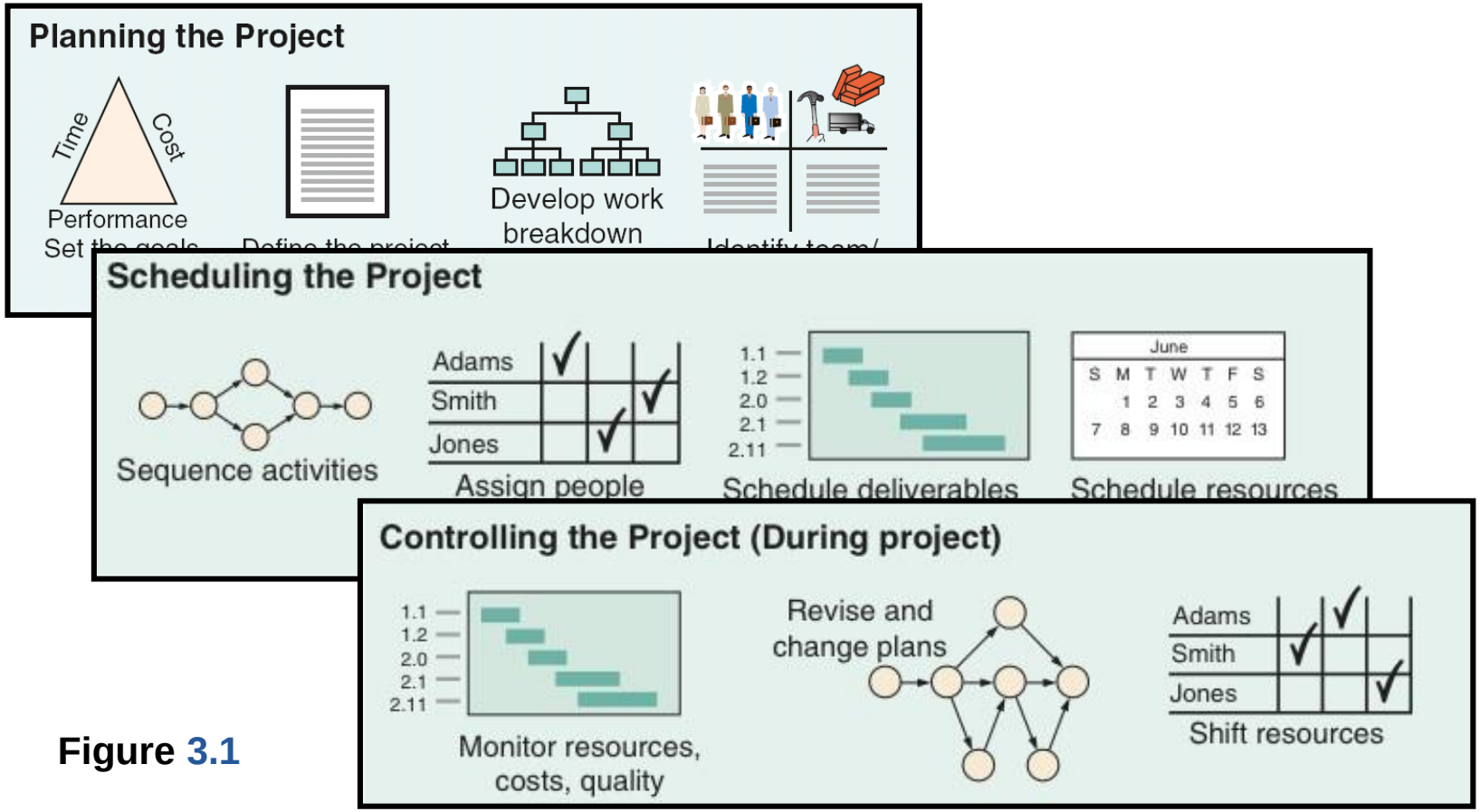
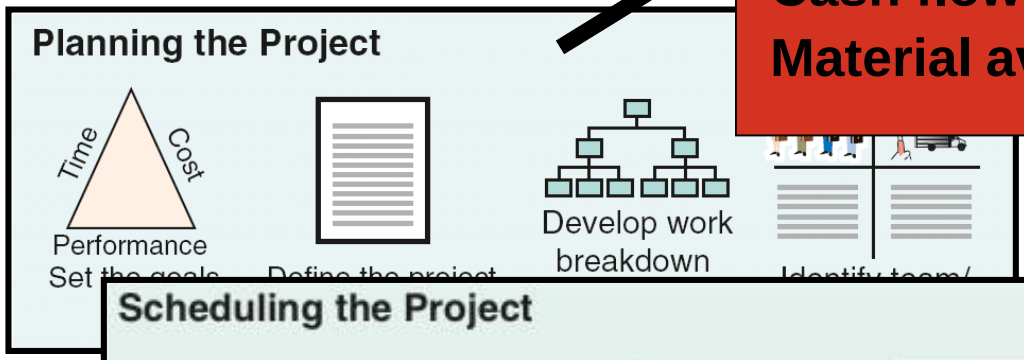
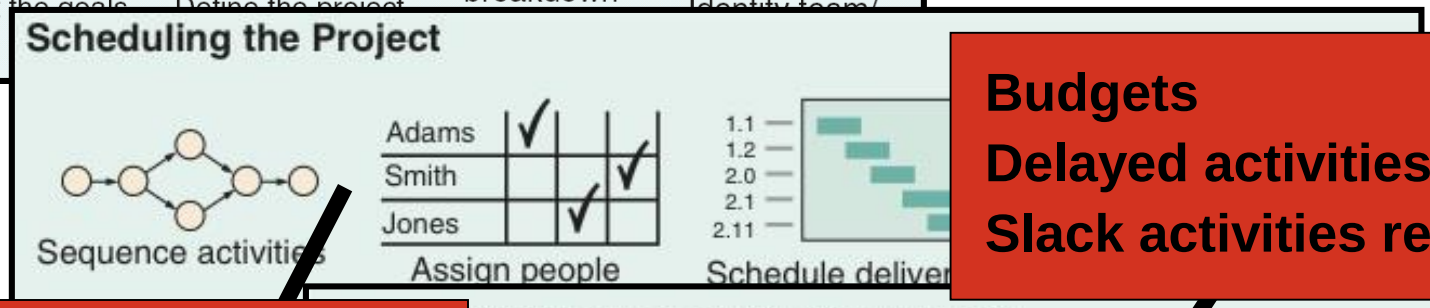


Figure 3.1

Project Scheduling, ng

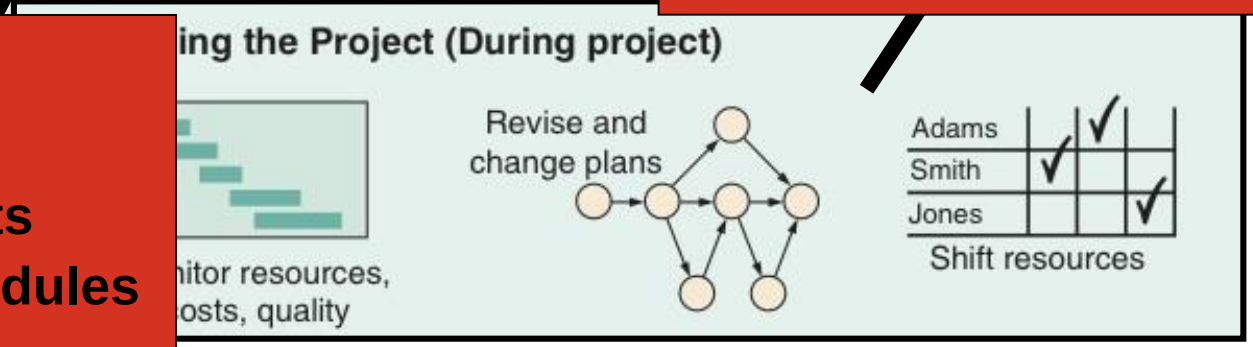
Time/cost estimates
Budgets
Engineering diagrams
Cash flow charts
Material availability details





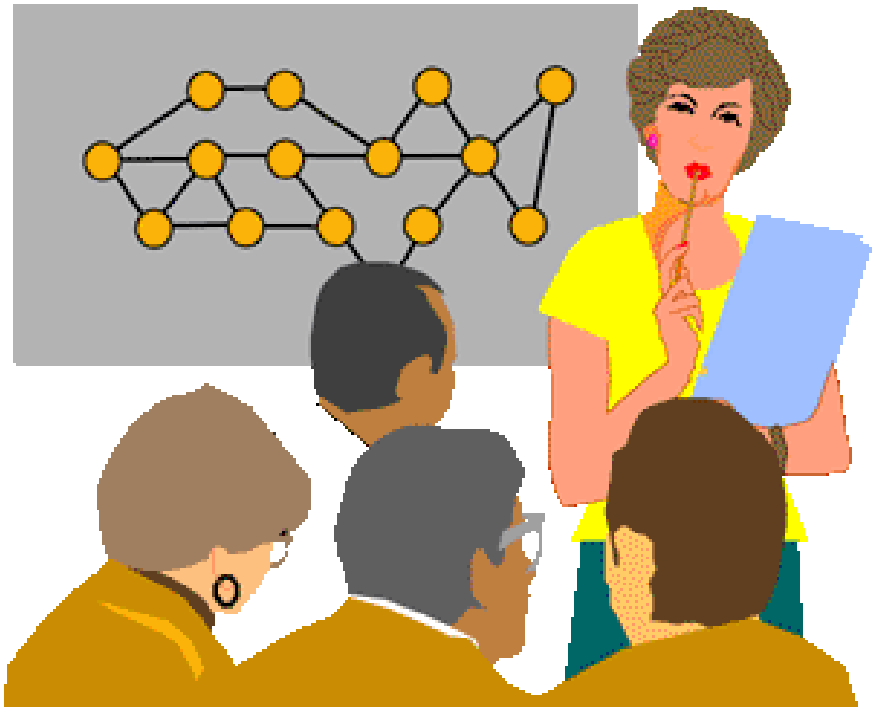
Budgets
Delayed activities report
Slack activities report

CPM/PERT
Gantt charts
Milestone charts
Cash flow schedules



Project Planning

- Establishing objectives
- Defining project
- Creating work breakdown structure
- Determining resources
- Forming organization



Defining Project: Project Charter

- Contain the essence of the project.
- Provide a shared understanding of the project.
- Act as a contract between the project sponsor, key stakeholders and the project team.
- The project charter is usually a short document that refers to more detailed documents.

Project Charter

Project Charter Example

Project Name	IVR Project		
Project Sponsor	Dave Sponsor	Project Manager	Alice Michaels
Date of Project Approval	8th Mar 2015	Last Revision Date	17th Apr 2015
Project Description	To introduce a new automated telephone system to ensure all calls get answered.		
Scope	A IVR system will be introduced to assist the sales team in taking orders, and also to ensure no orders are missed. The system is only to help the sales team at this stage, other teams such as support are out of scope.		
Business Case	To increase orders per sales team member by 20% from current levels. To reduced unhandled calls to 0%. To increase customer satisfaction by 10 points.		
Constraints (in priority order)	Time	4 months	
	Budget	4 developers + 1 sales team rep	
	Scope	TBD	
	Quality	Prioritize time & budget over quality	
Project Deliverables	An IVS system to assist the sales team + training for the sales team + support during the first operational month of the system.		
Benefits (measurable results)	See KPIs below + business case above		
	KPI	Baseline	Goal
	Orders per sales person pd	20	24
	Unhandled calls pd	11	0
	Customer satisfaction	17	27
Steering Committee	CEO	Project Team	Sales Rep
	Finance Director		4x developers TBD
	Sales Director		
Key Stateholders	Name	Success Criteria	
Risks	No team members have any previous experience of IVR setup, so there is a chance we've hugely underestimated the work involved.		

Project Charter

Project Name			
Project Description			
Project Manager		Date Approved	
Project Sponsor		Signature	

Business Case	Expected Goals/Deliverables

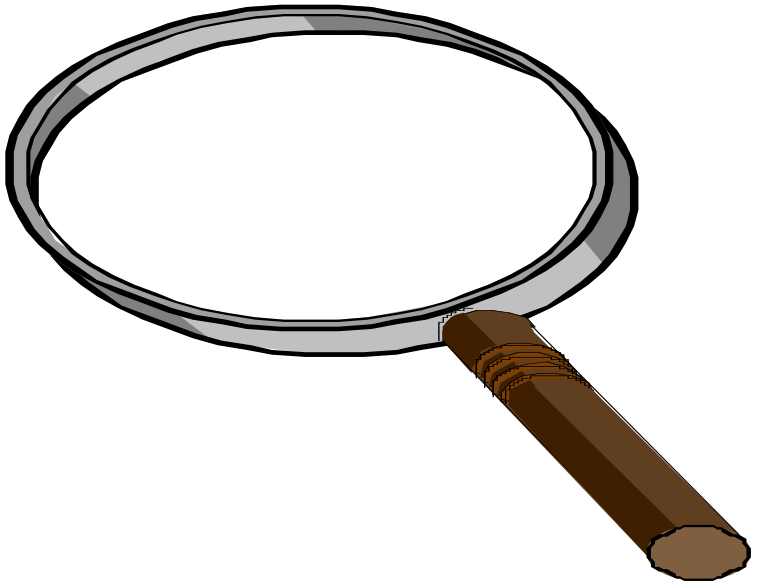
Team Members

Name	Role

Risks and Constraints	Milestones

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 Most Helpful 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

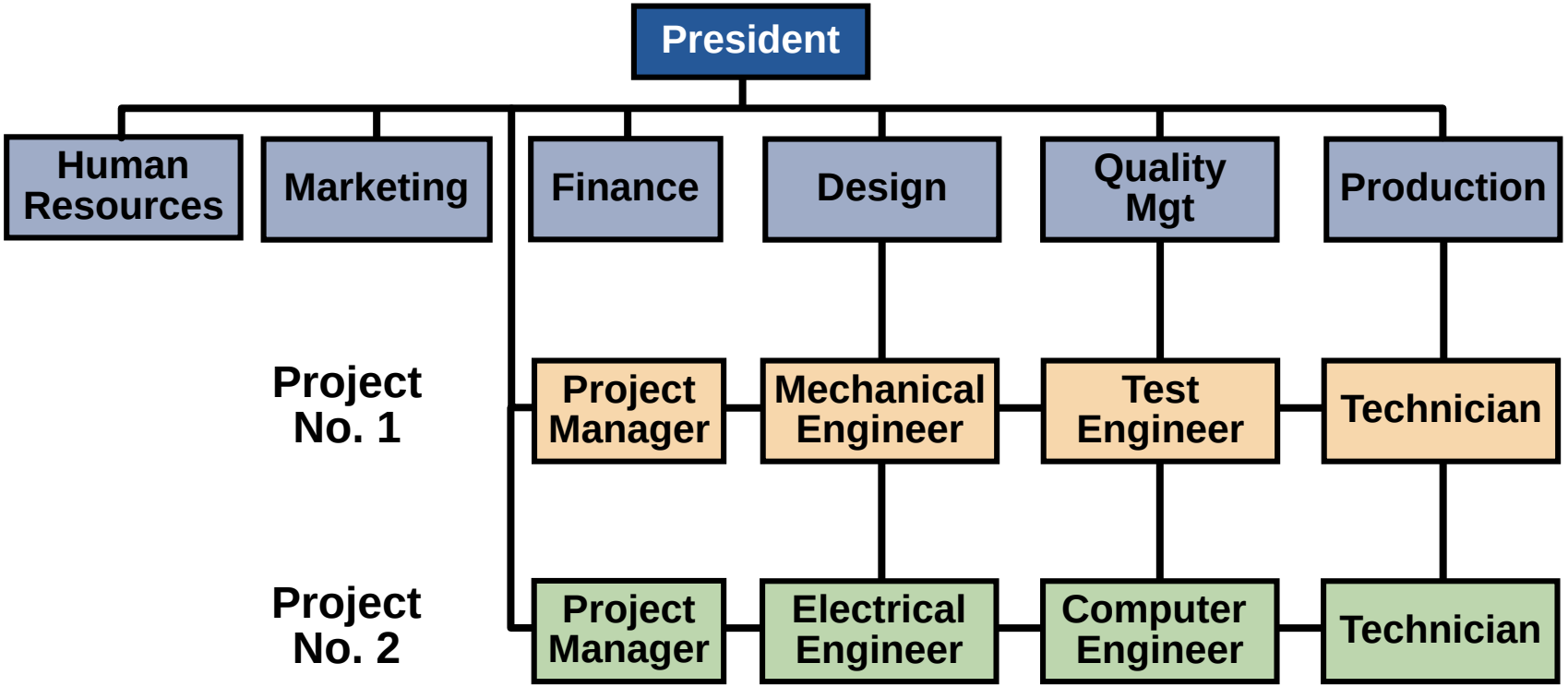
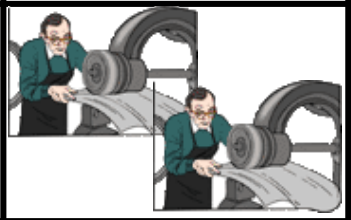
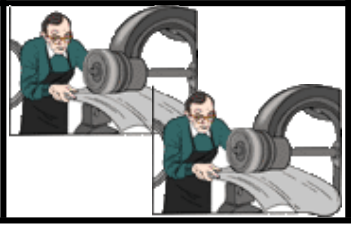


Figure 3.2

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

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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

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

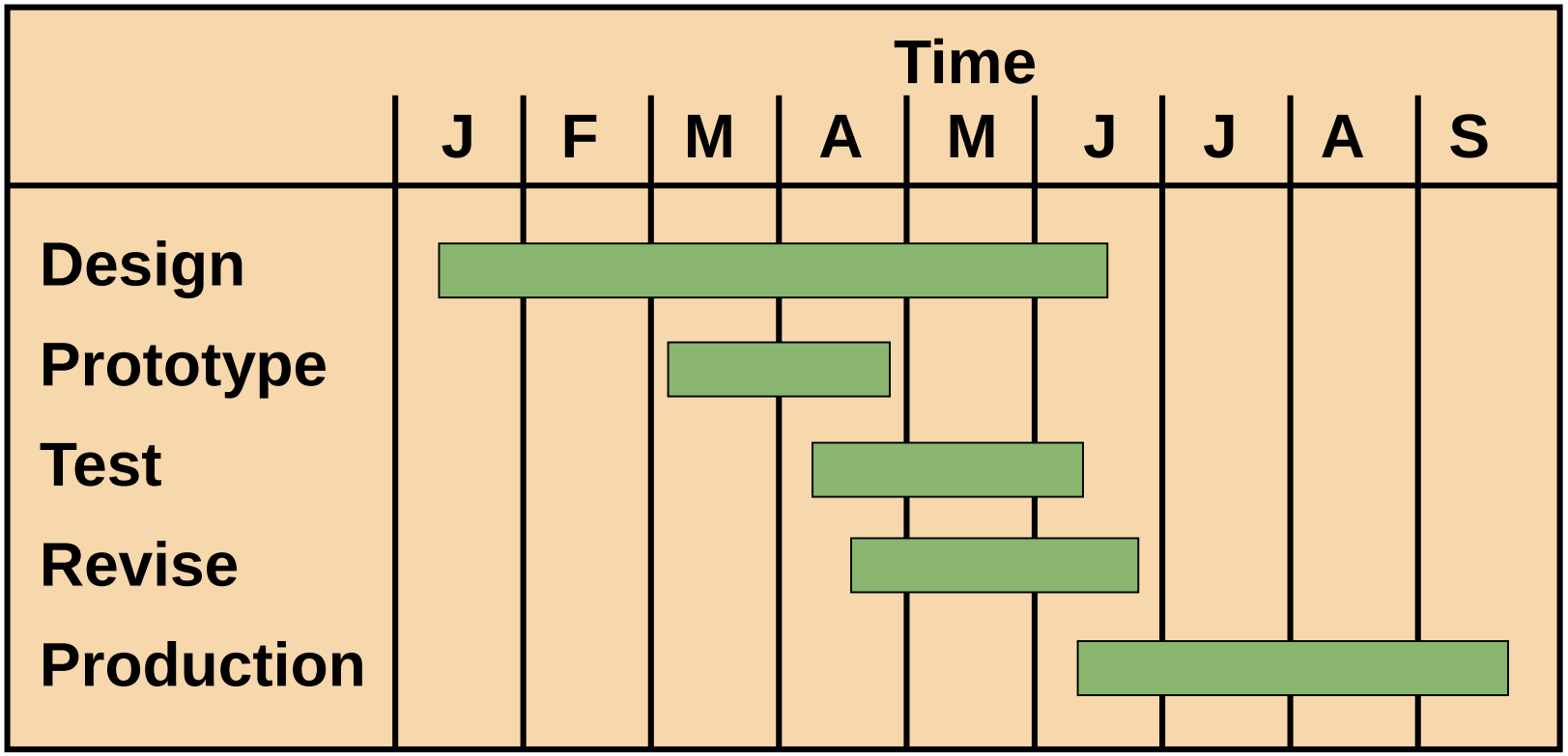
Purposes of Project Scheduling

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

Project Management Techniques

- Gantt chart
- Critical Path Method (CPM)

A Simple Gantt Chart



Gantt Chart

`No.	Activities	Resp.Person	Mar	Apr	May	Jun	Jul	Aug
1	Planning	Mana		100%			Current 30 June	
2	Kick off 1 April	Manee		100%				
3	Site Visit	Piti				100%		
4	Analysis of information / Solution development	Choojai				50%		
5	Test Solution	Chaotoh					0%	
6	Select Solution	Winai					0%	
7	Standardized process and documenting	Somkid					0%	

Plan Actual

Critical Path Method: CPM

- Network technique
- Developed by DuPont in 1957
- Consider precedence relationships and interdependencies
- Use of a fixed estimate of activity times

Six Steps of 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

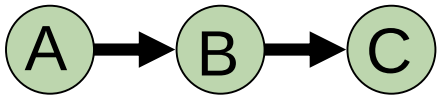
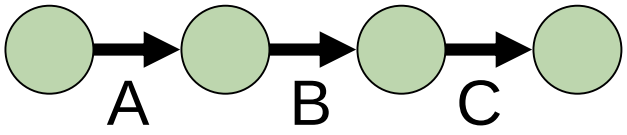
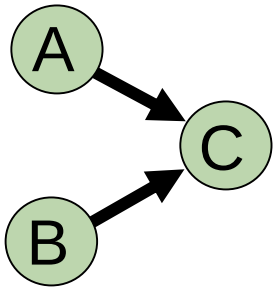
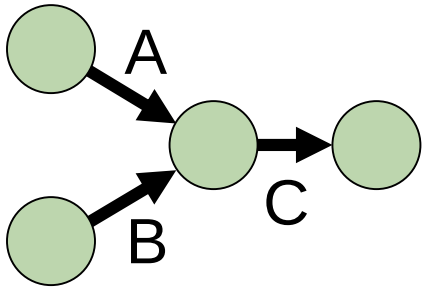
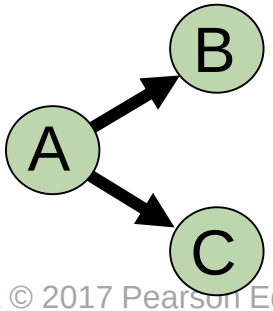
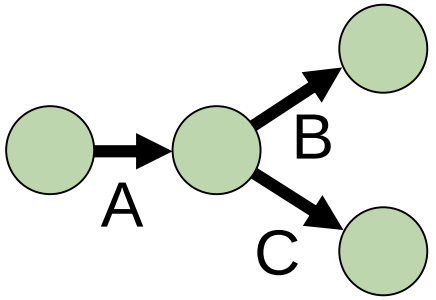
Six Steps of CPM

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 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. Is the project on schedule, behind schedule, or ahead of schedule?
5. Is the money spent equal to, less than, or greater than the budget?
6. Are there enough resources available to finish the project on time?
7. 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	

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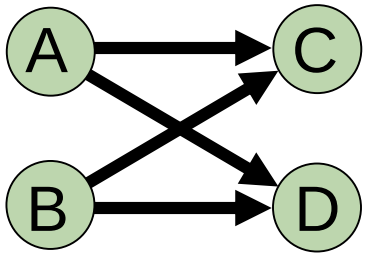
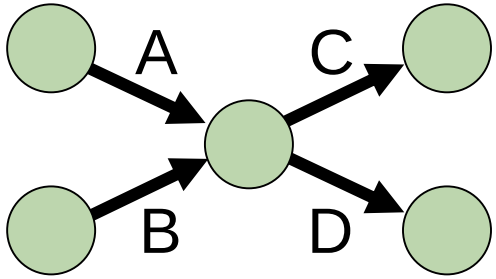
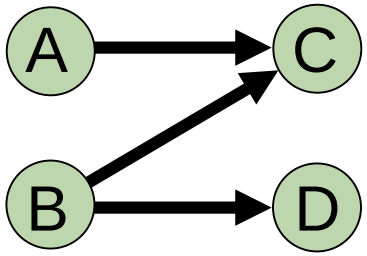
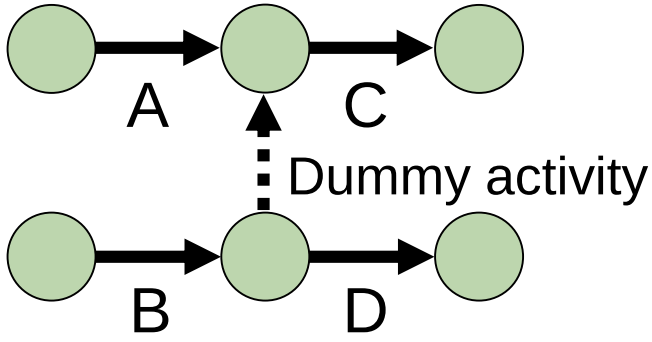
(d) 	C and D cannot begin until both A and B are completed	
(e) 	C cannot begin until both A and B are completed D cannot begin until B is completed A dummy activity is introduced in AOA	

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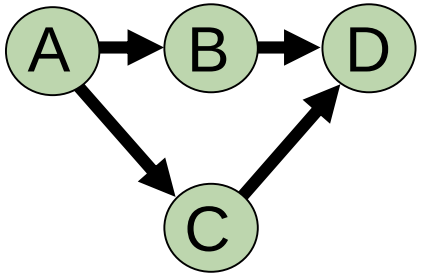
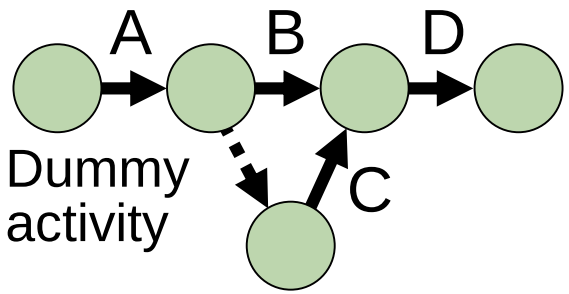
Activity on Node (AON)	Activity Meaning	Activity on Arrow (AOA)
(f) 	B and C cannot begin until A is completed D cannot begin until both B and C are completed A dummy activity is again introduced in AOA	

AON Example

Table 3.1 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

AON Network for Milwaukee Paper

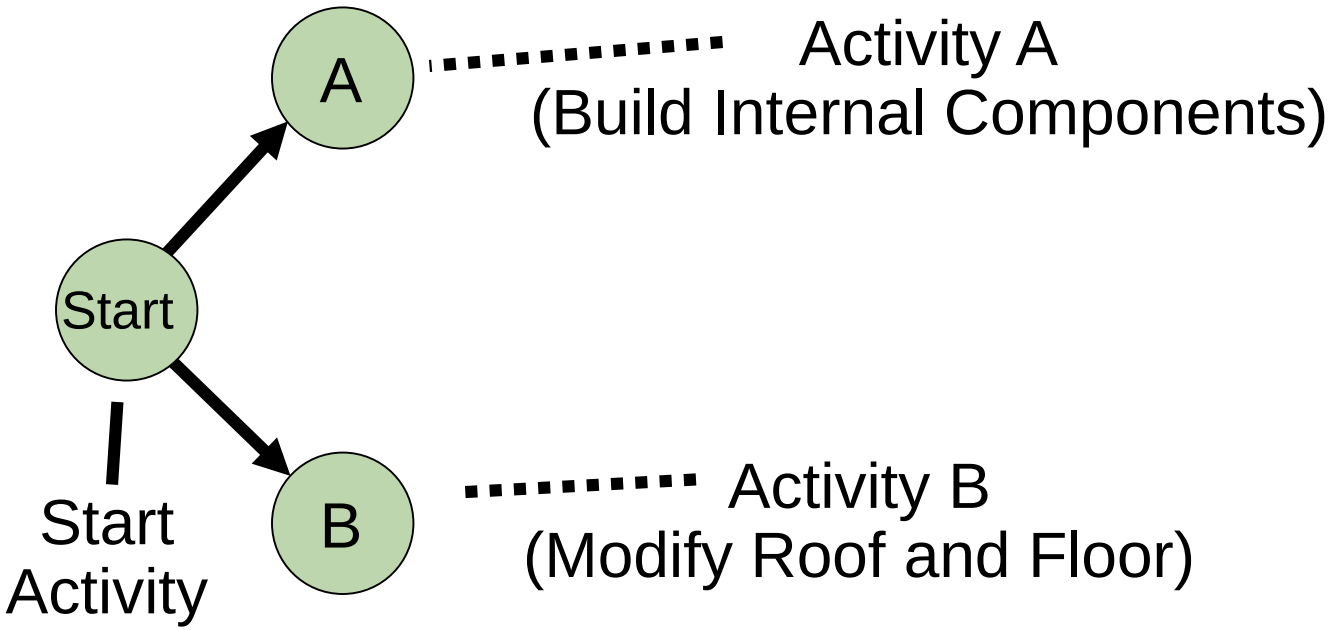


Figure 3.5

AON Network for Milwaukee Paper

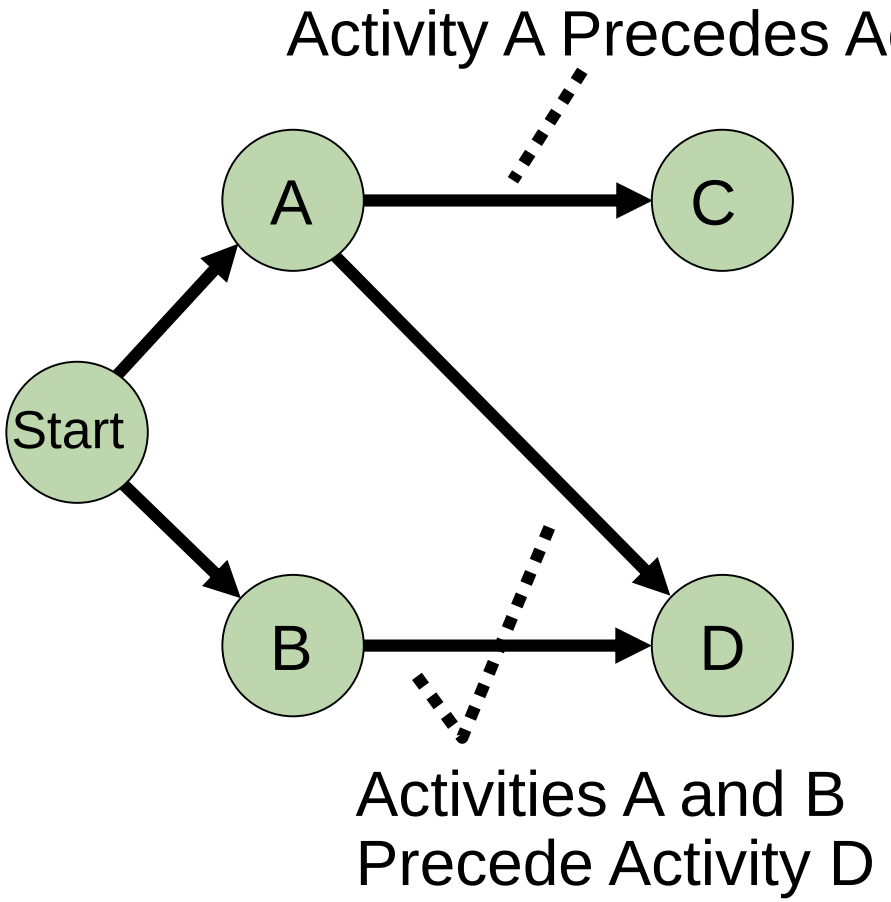


Figure 3.6

AON Network for Milwaukee Paper

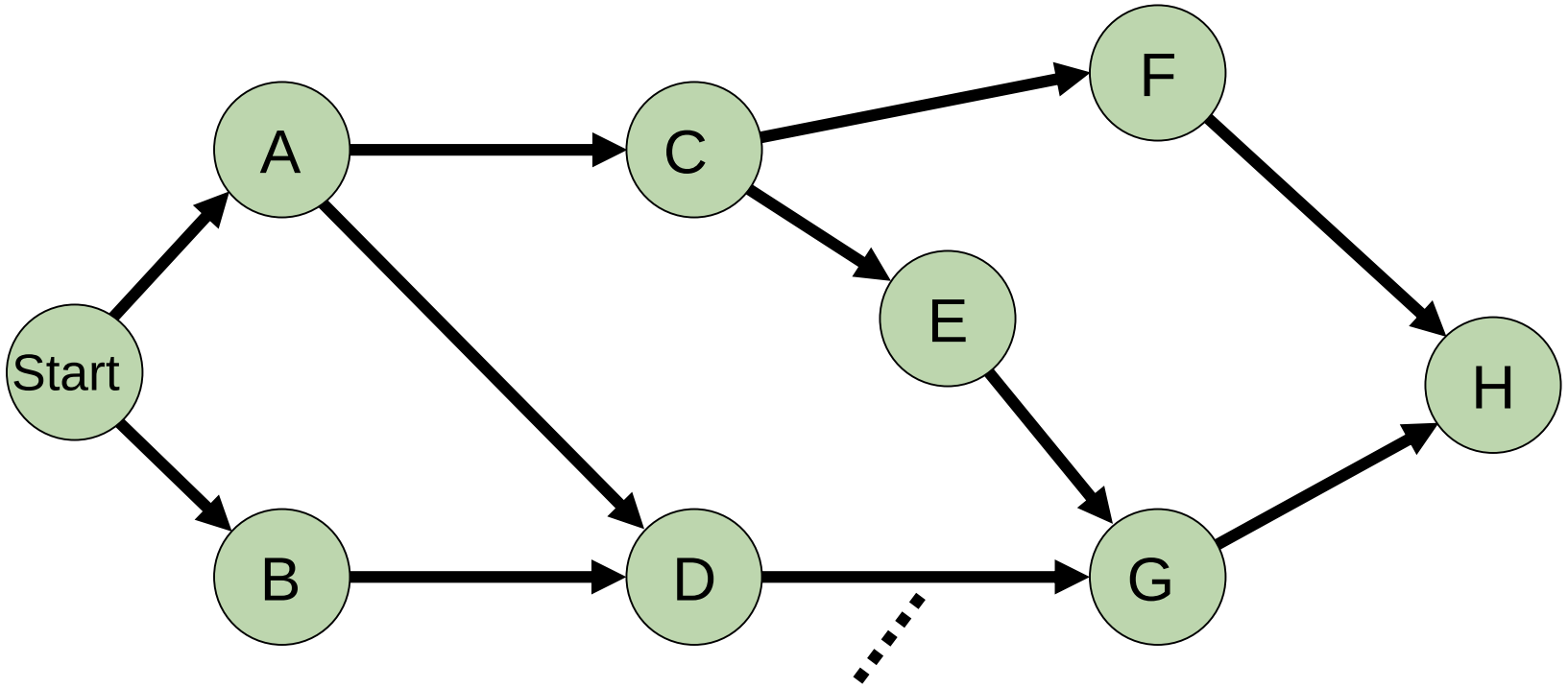


Figure 3.7

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

Table 3.2 Time Estimates for Milwaukee Paper Manufacturing

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

Determining the Project Schedule

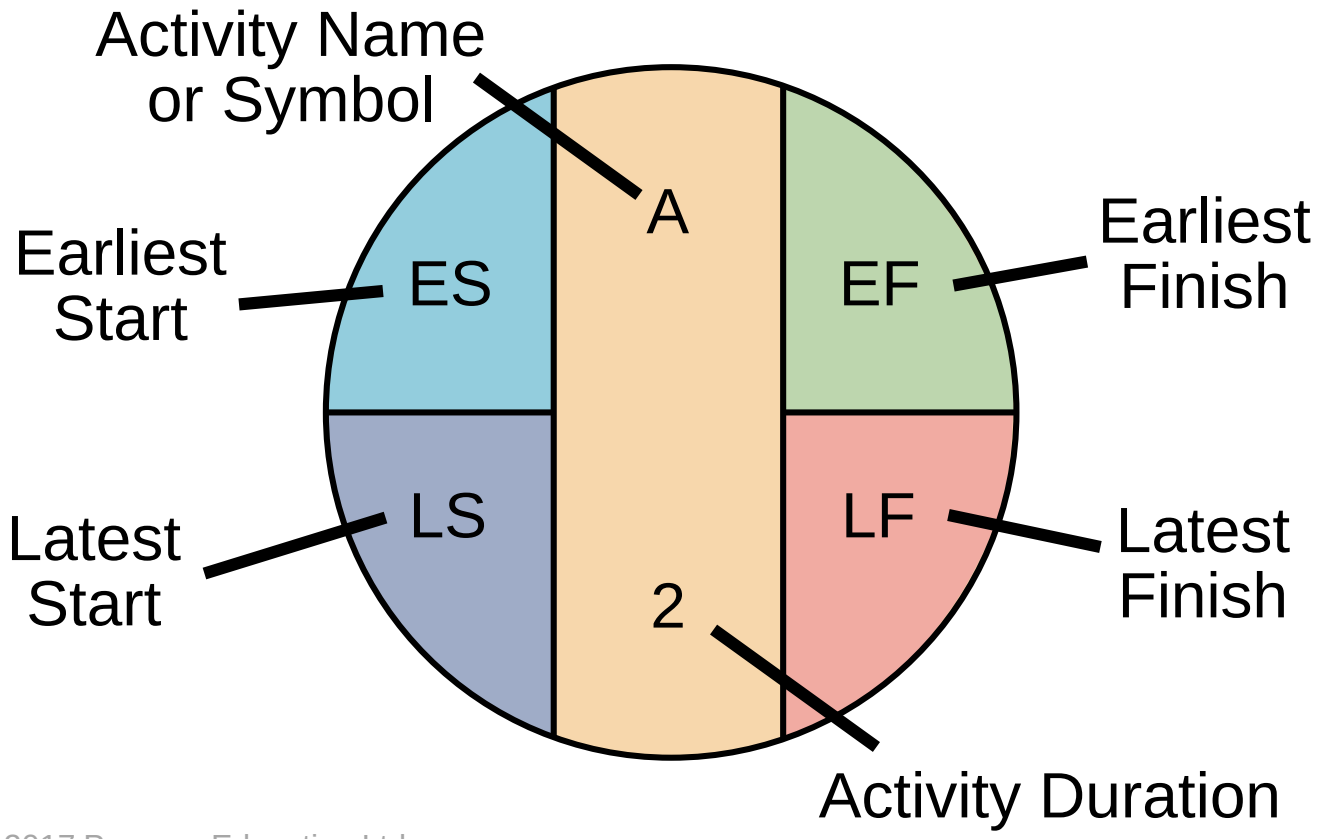
Perform a Critical Path Analysis

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

Activity Format

Figure 3.9



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

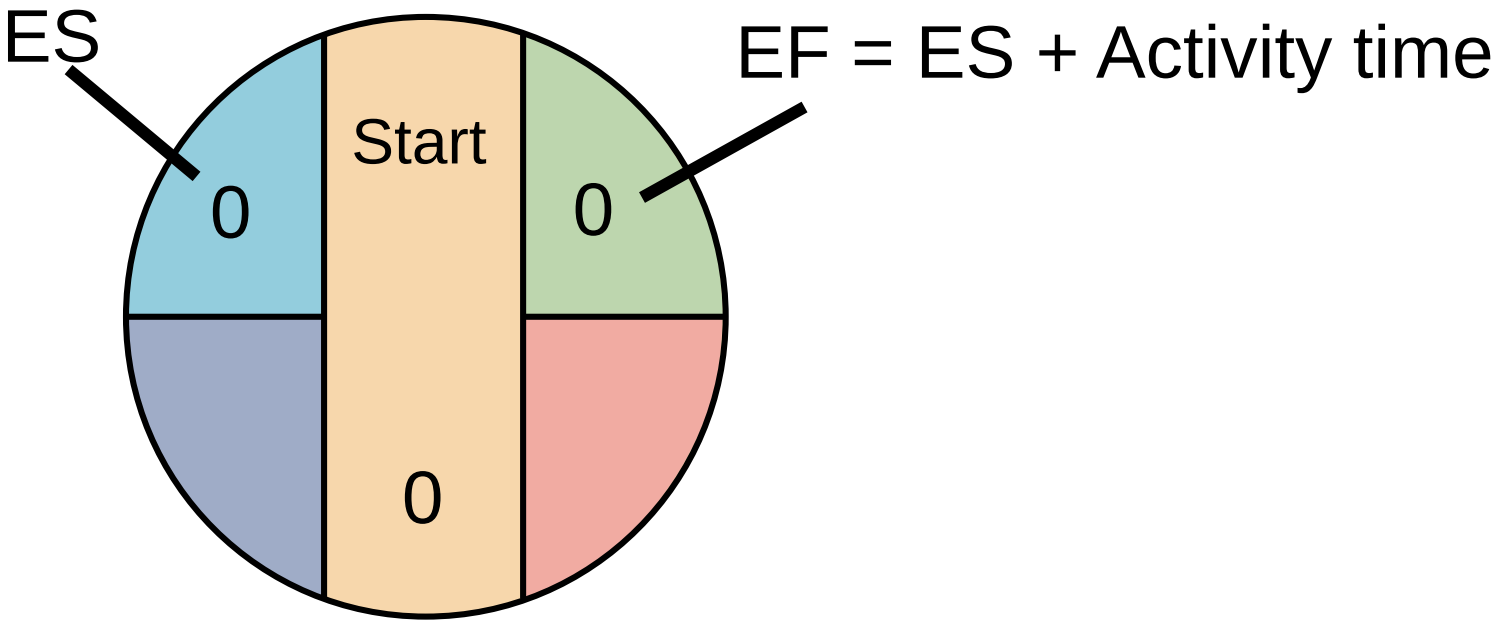
Begin at starting event and work forward

Earliest Finish Time Rule:

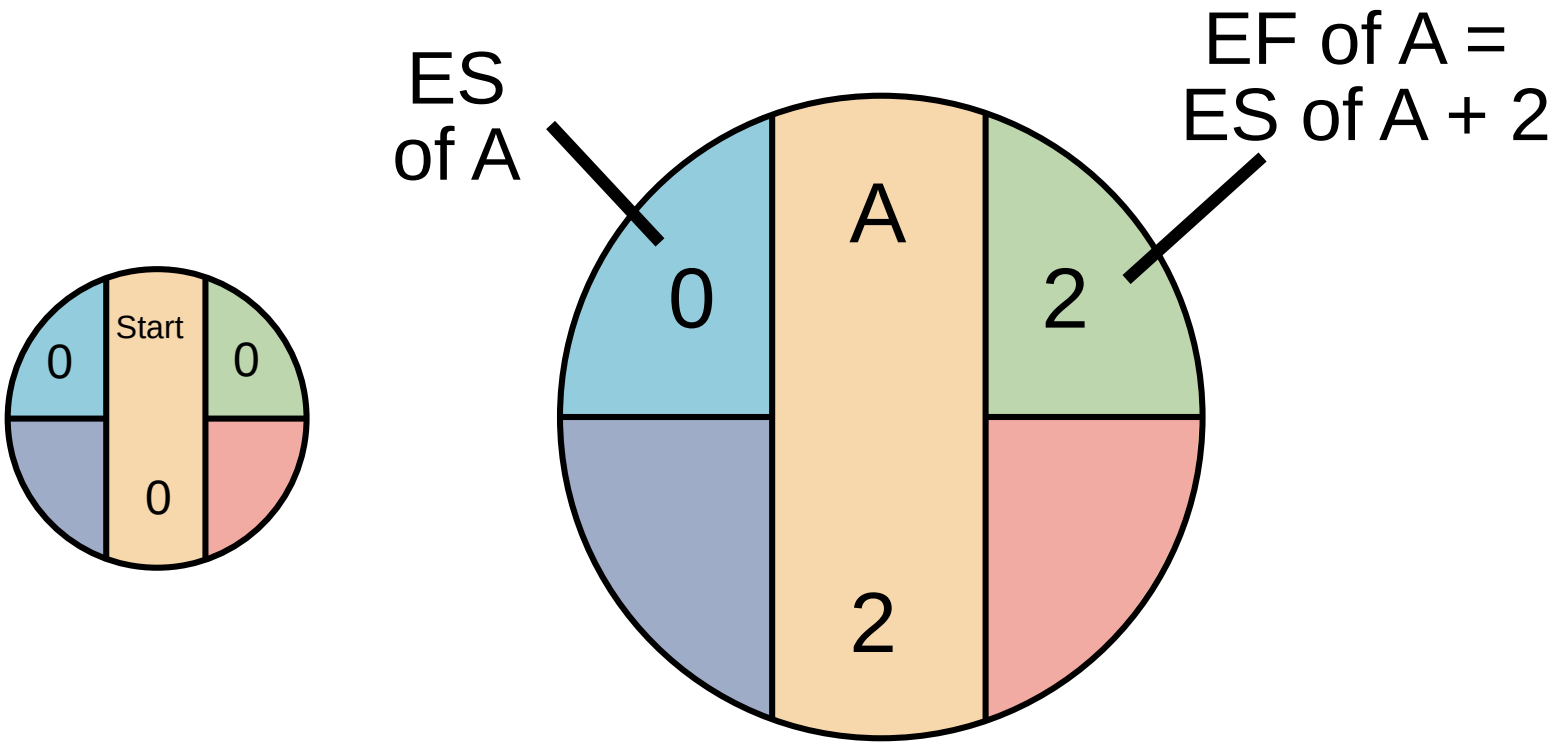
- The earliest finish time (EF) of an activity is the sum of its earliest start time (ES) and its activity time

EF = ES + Activity time

ES/EF Network for Milwaukee Paper



ES/EF Network for Milwaukee Paper



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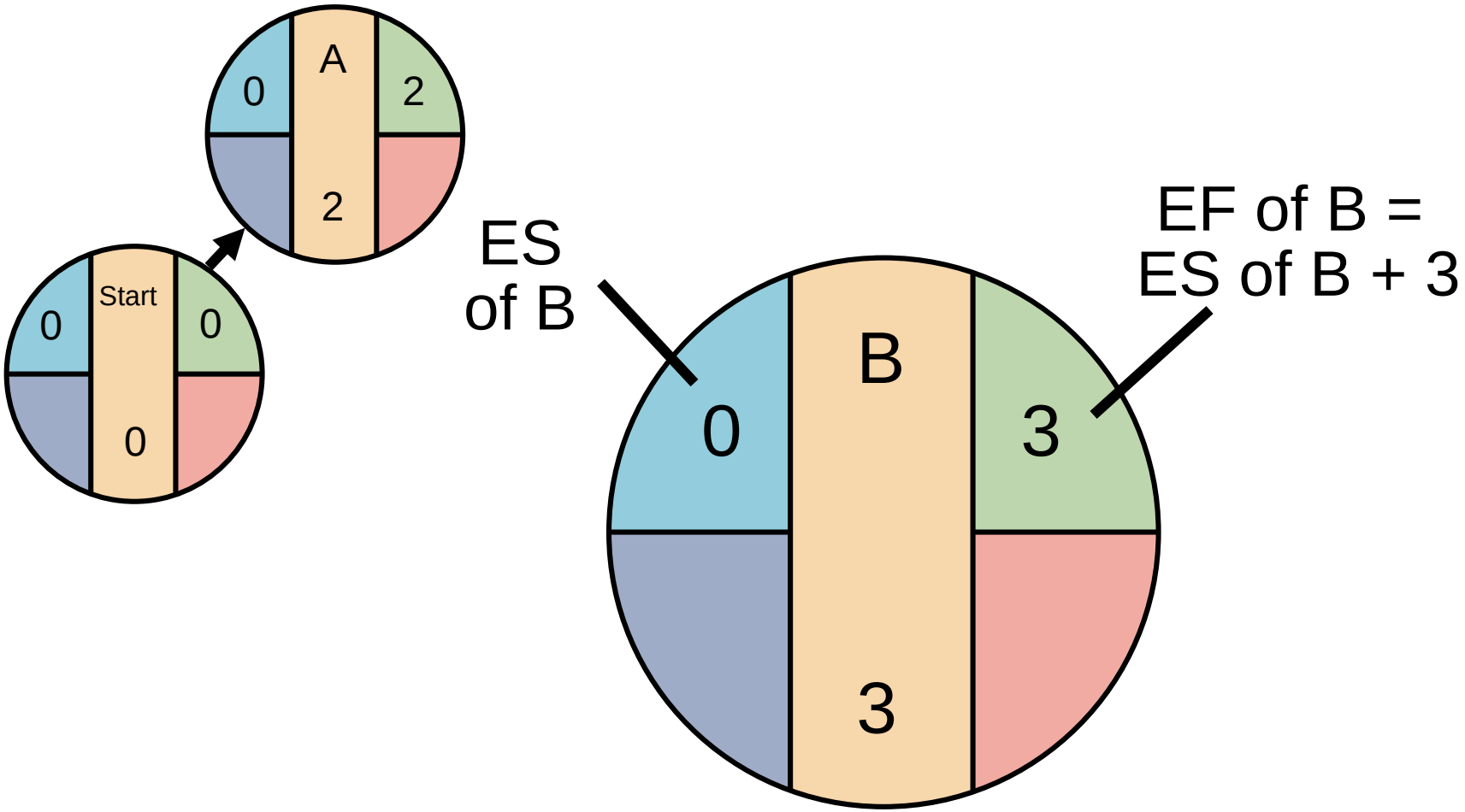

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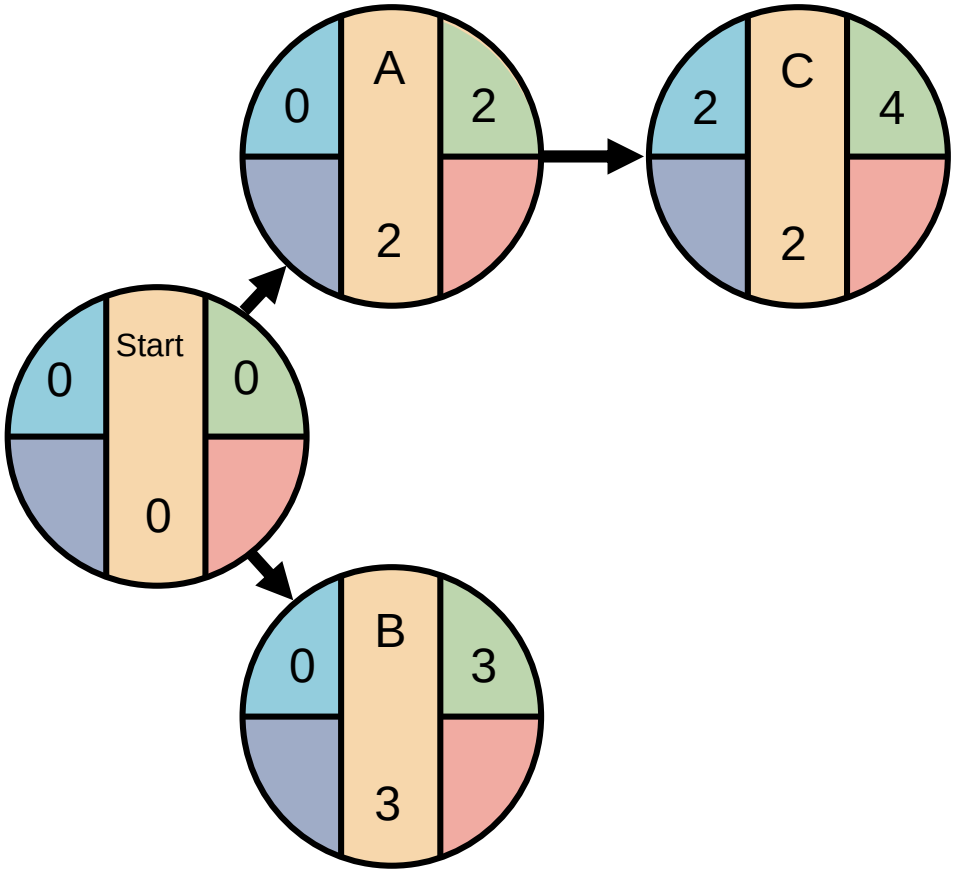

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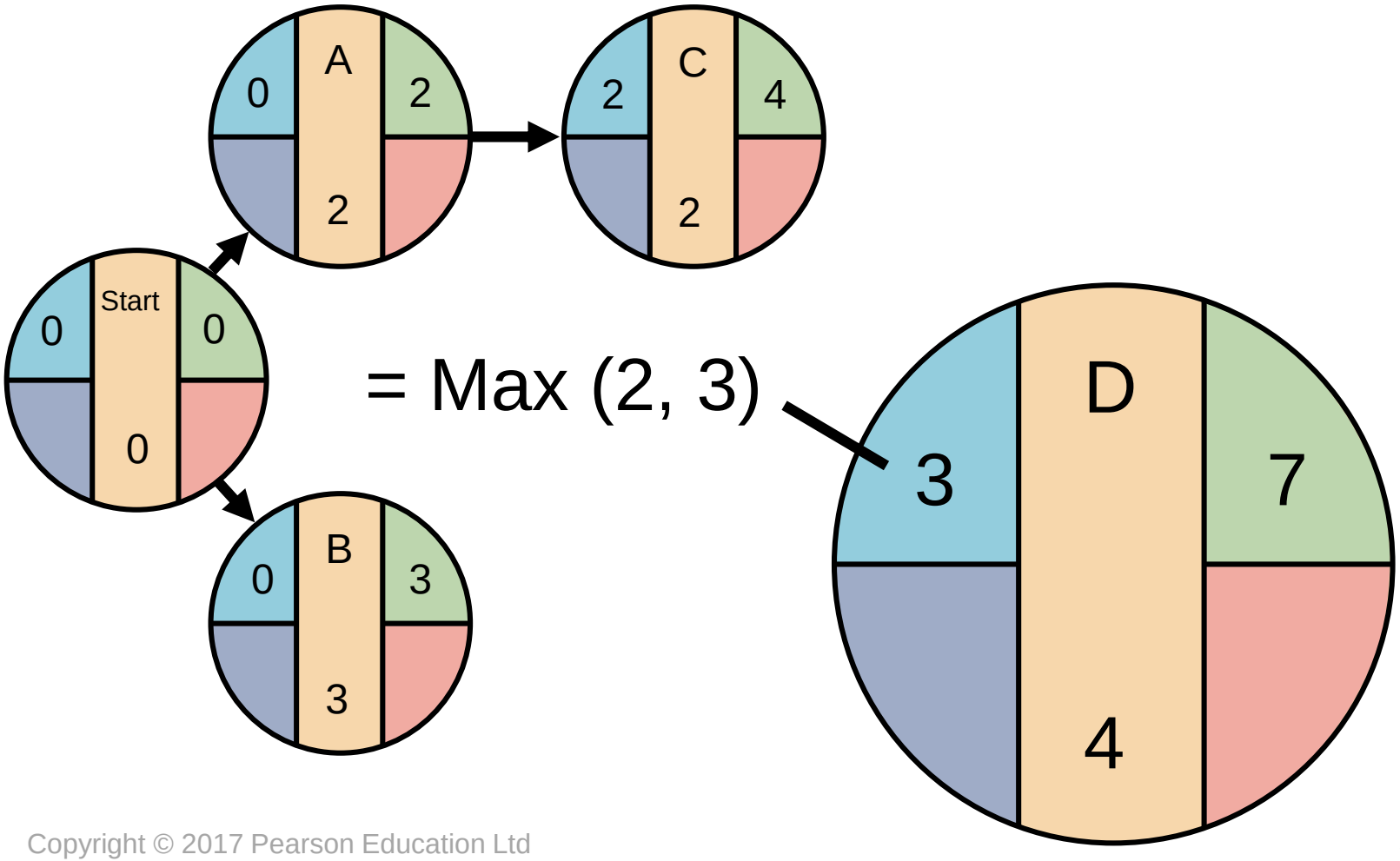

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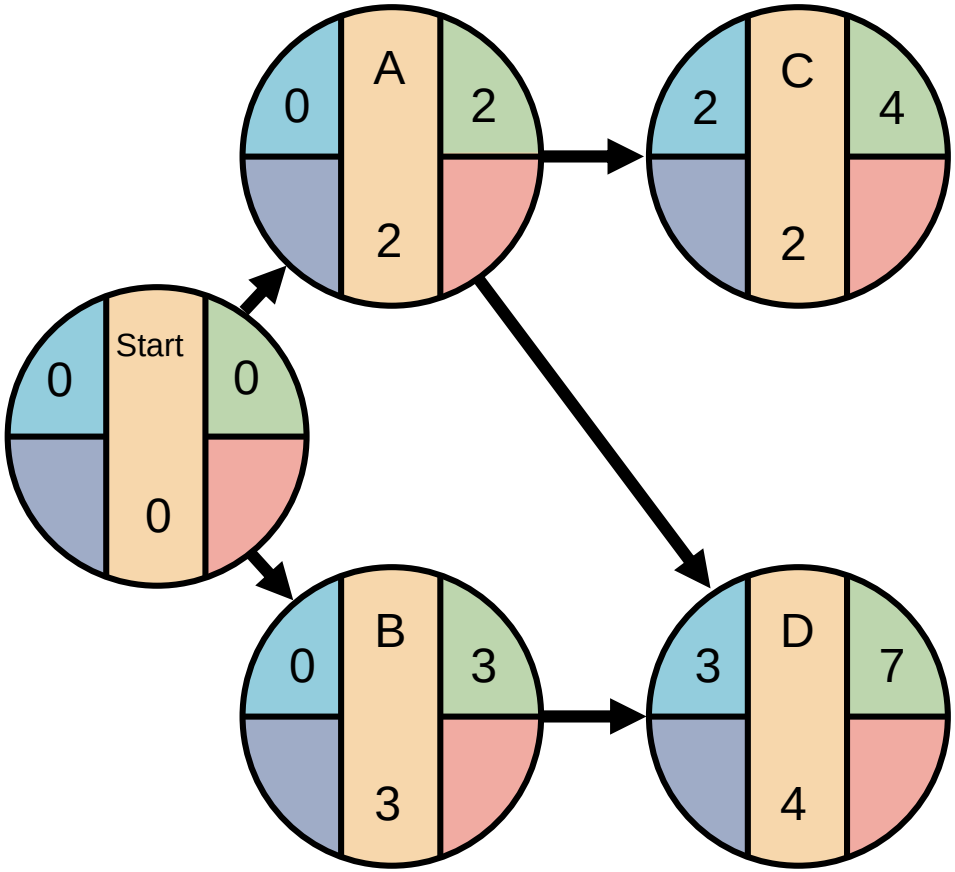


ES/EF Network for Milwaukee Paper

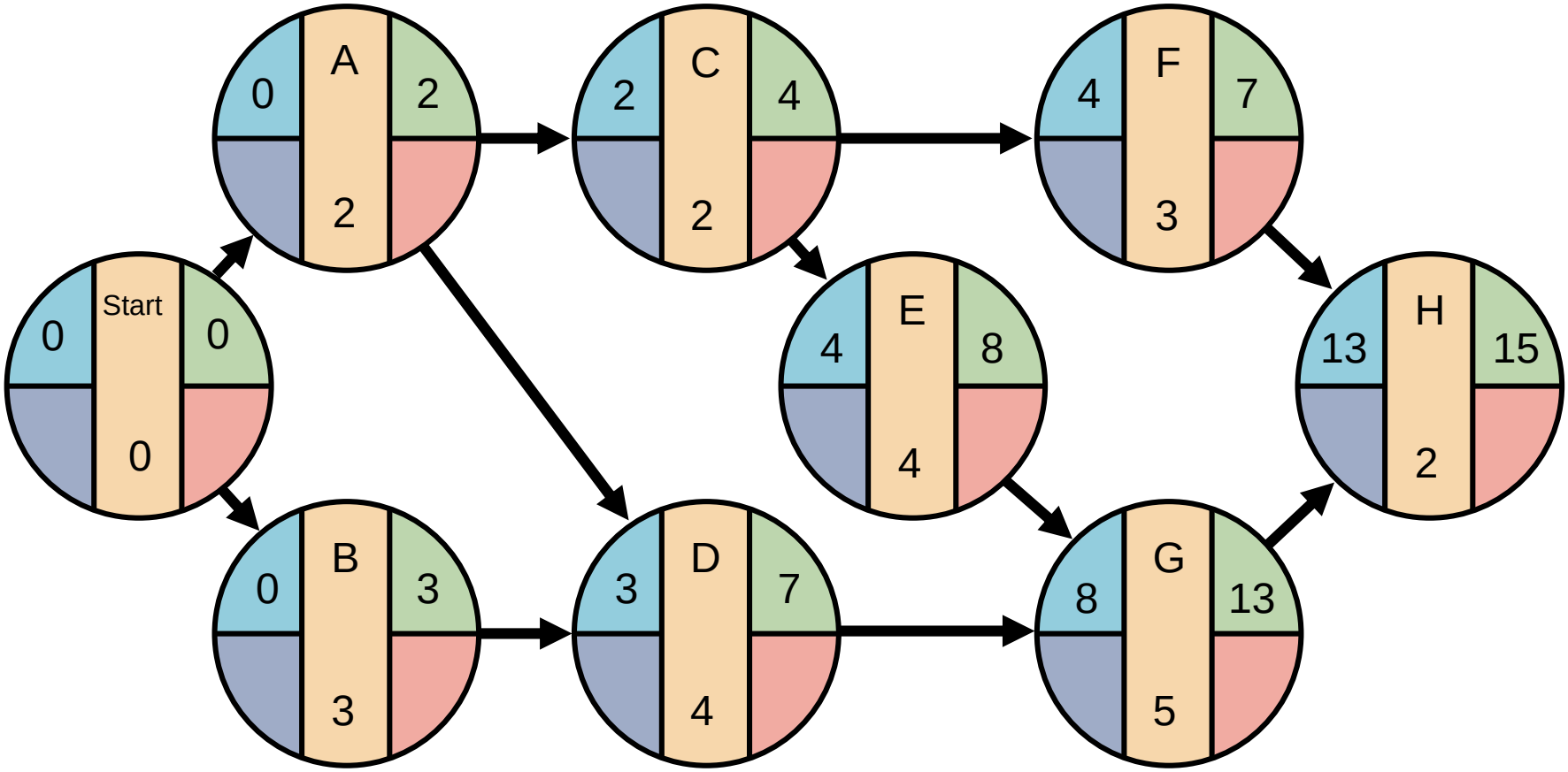


Figure 3.10

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

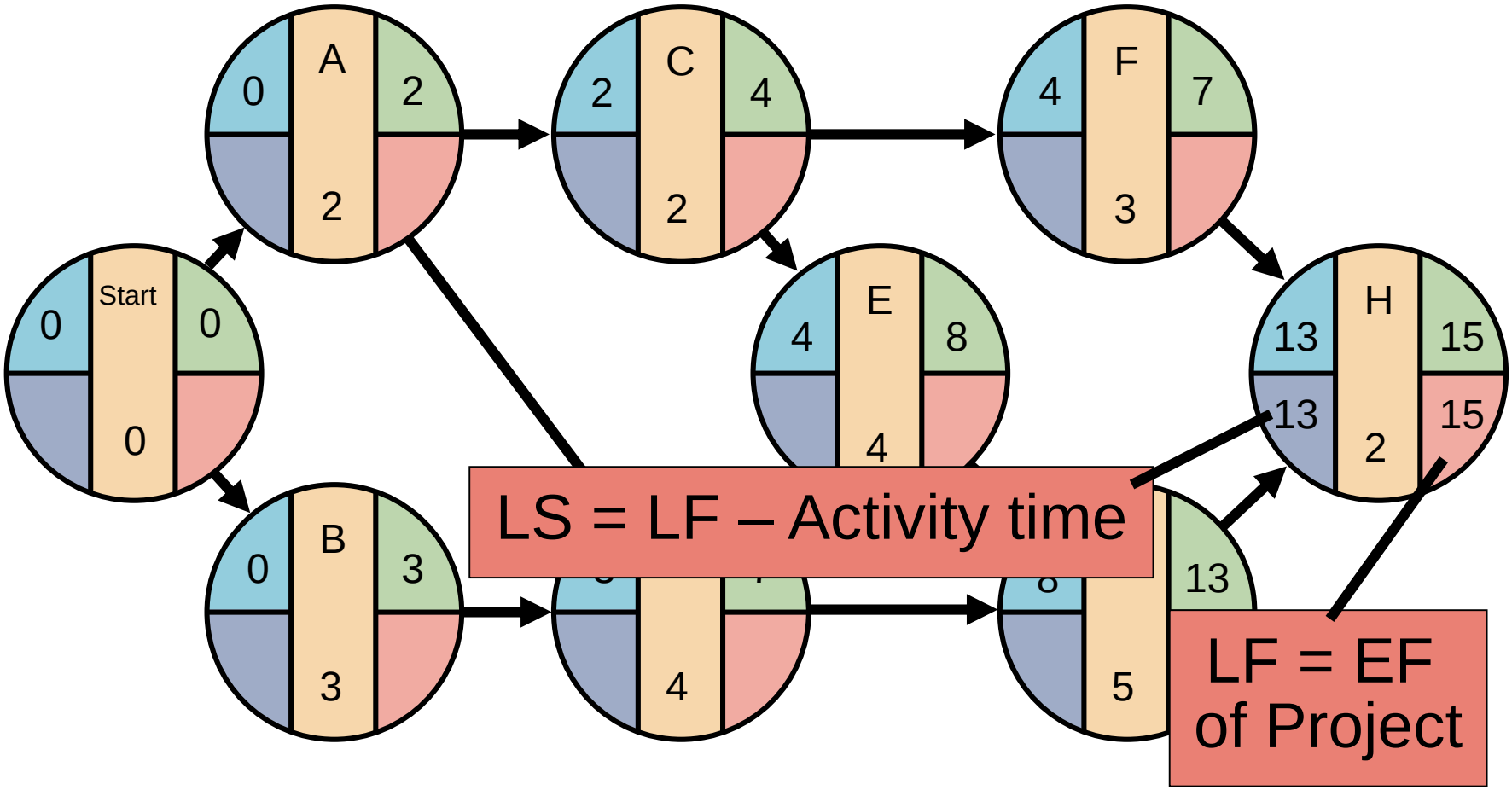
Begin with the last event and work backwards

Latest Start Time Rule:

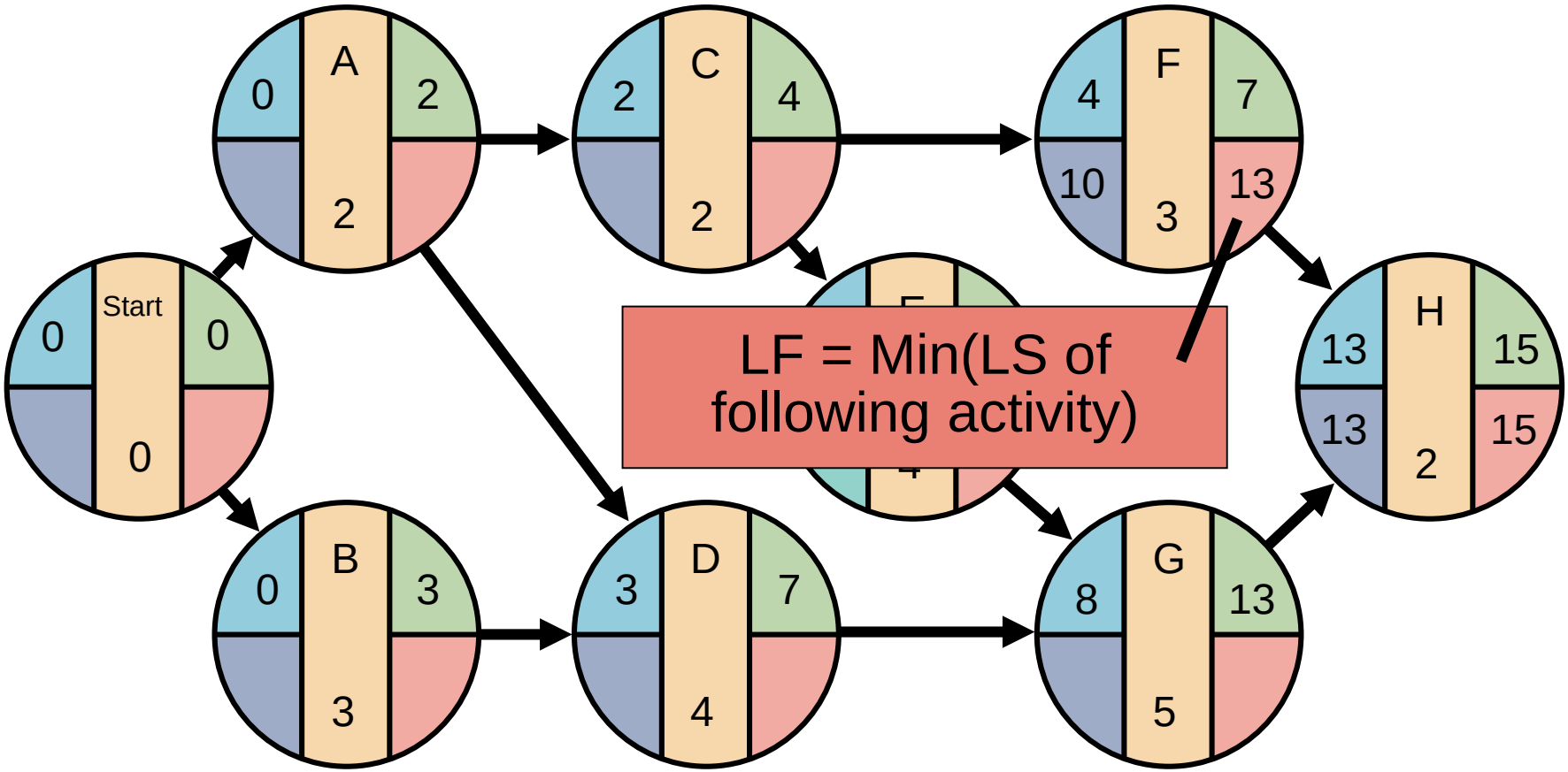
- The latest start time (LS) of an activity is the difference of its latest finish time (LF) and its activity time

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

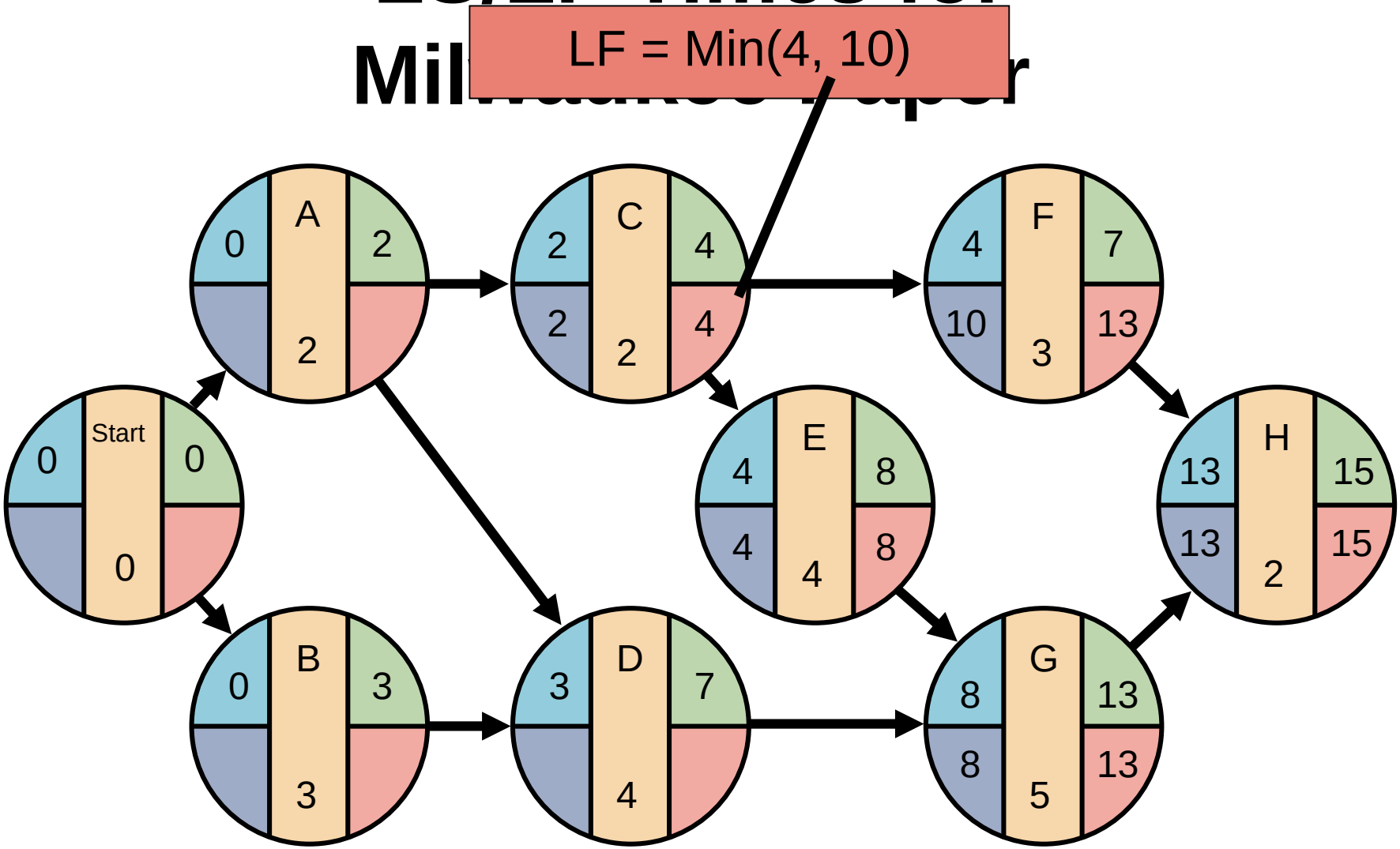
LS/LF Times for Milwaukee Paper



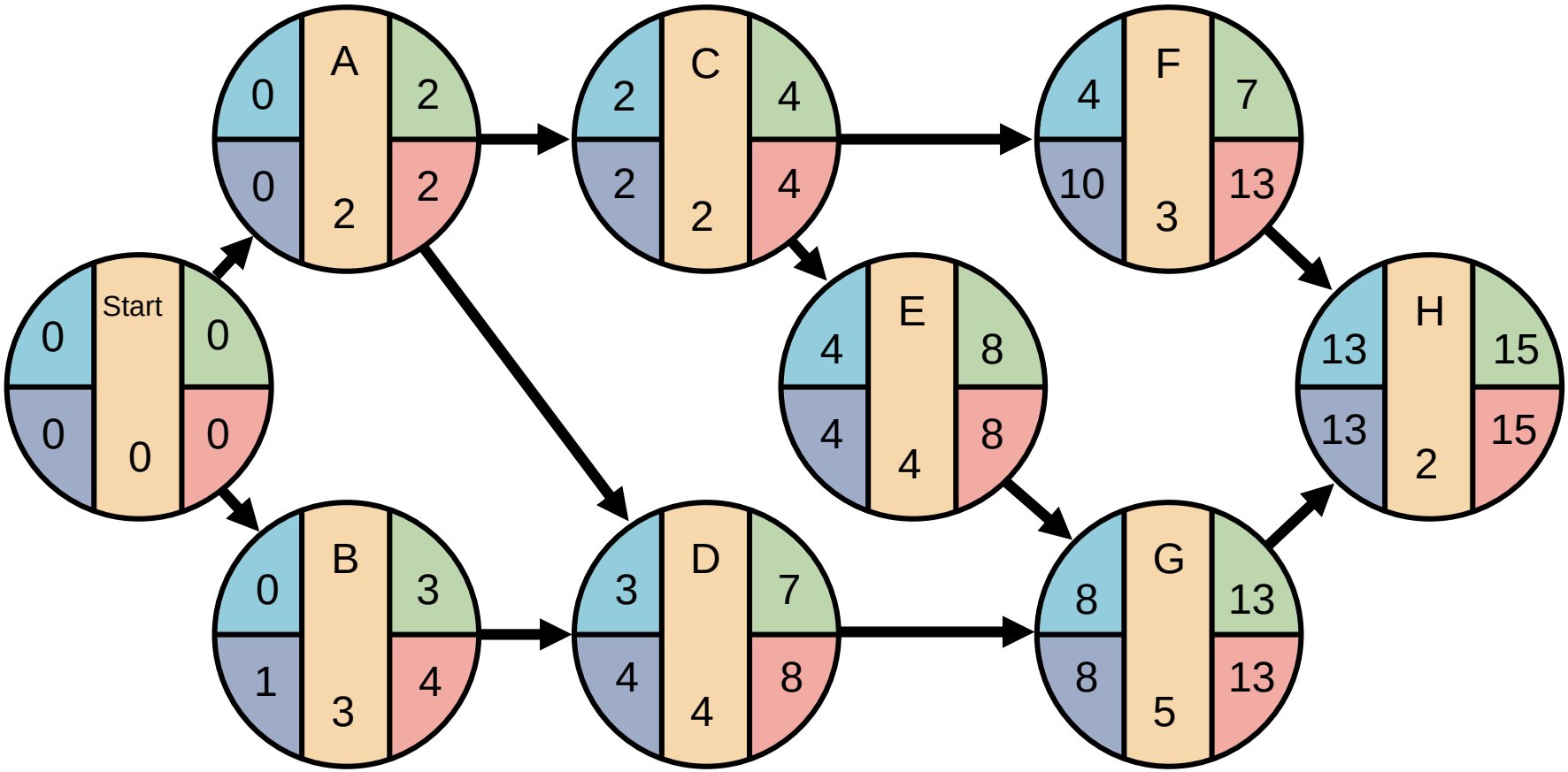
LS/LF Times for Milwaukee Paper



LS/LF Times for Mil[illegible]r



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

TABLE 3.3 Milwaukee Paper's Schedule and Slack Times

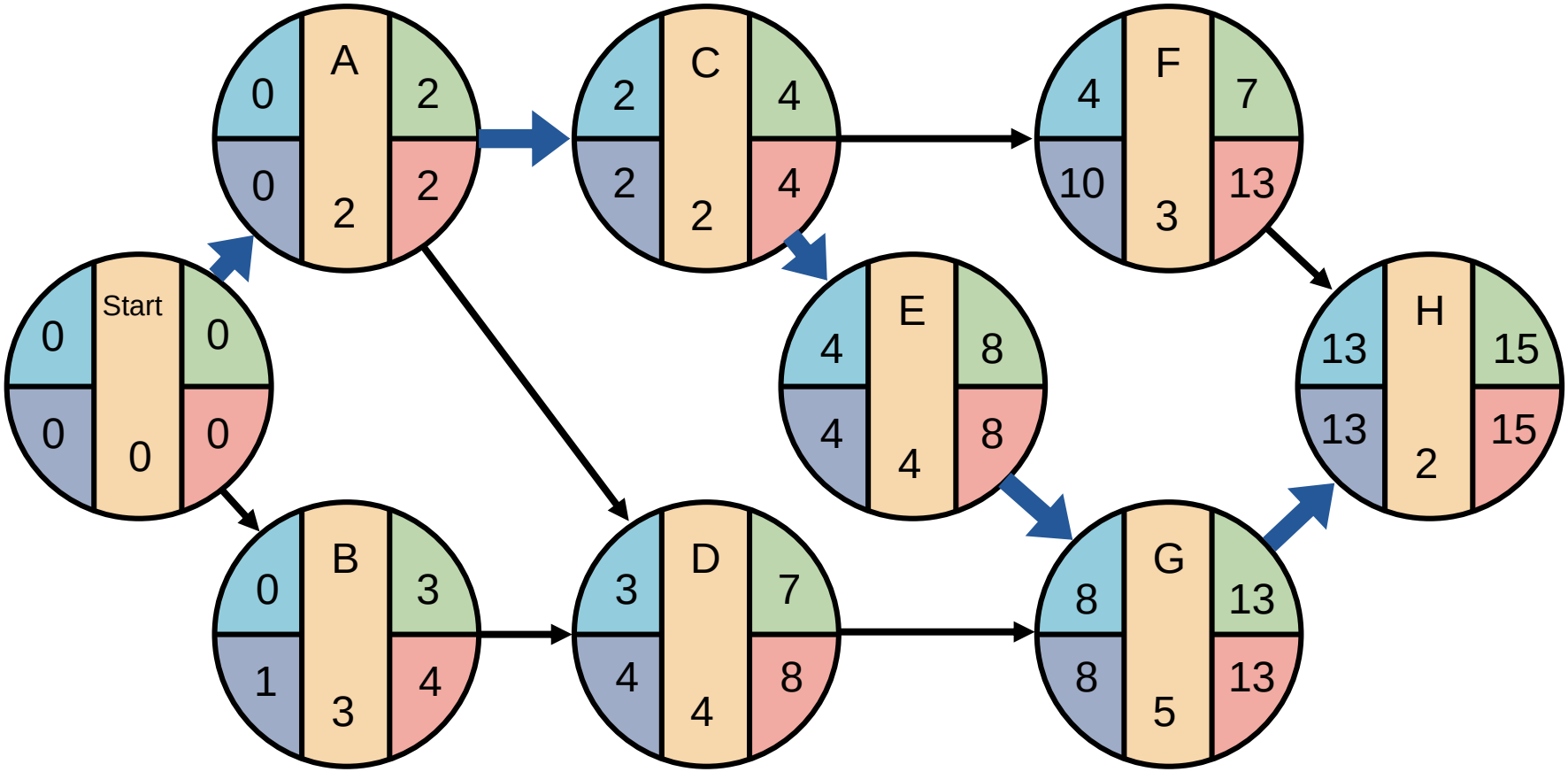
ACTIVITY	EARLIEST START ES	EARLIEST FINISH EF	LATEST START LS	LATEST FINISH LF	SLACK LS – ES	ON CRITICAL PATH
A	0	2	0	2	0	Yes
B	0	3	1	4	1	No
C	2	4	2	4	0	Yes
D	3	7	4	8	1	No
E	4	8	4	8	0	Yes
F	4	7	10	13	6	No
G	8	13	8	13	0	Yes
H	13	15	13	15	0	Yes

Activities with zero slack are on the critical path. It:

- Starts at the first activity in the project
- Terminates at the last activity in the project
- Includes only critical activities

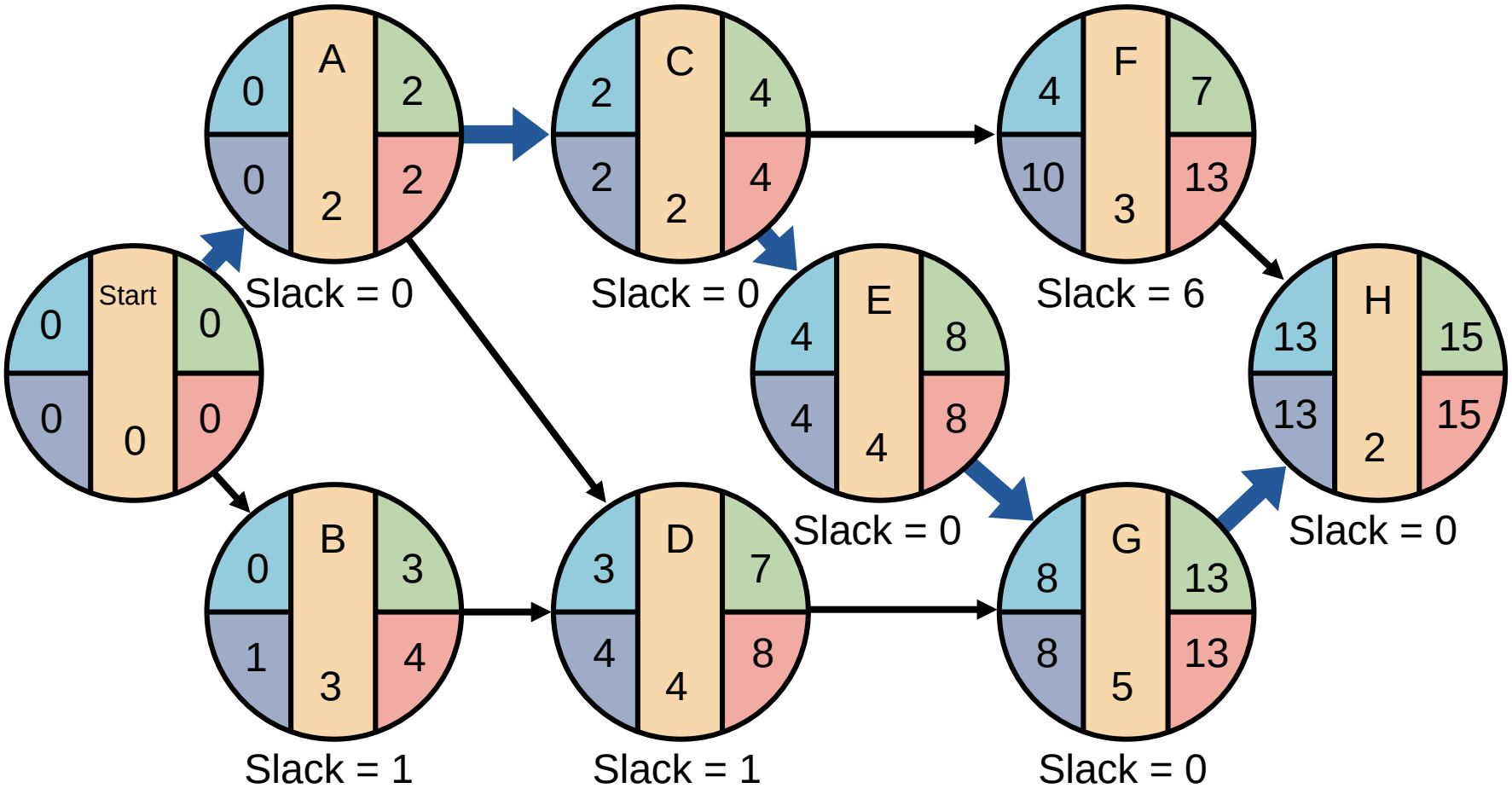
ACTIVITY	EARLIEST START ES	EARLIEST FINISH EF	LATEST START LS	LATEST FINISH LF	SLACK LS – ES	ON CRITICAL PATH
A	0	2	0	2	0	Yes
B	0	3	1	4	1	No
C	2	4	2	4	0	Yes
D	3	7	4	8	1	No
E	4	8	4	8	0	Yes
F	4	7	10	13	6	No
G	8	13	8	13	0	Yes
H	13	15	13	15	0	Yes

Critical Path for Milwaukee Paper



Critical Path and Slack Times for Milwaukee Paper

Figure 3.16



Advantages of 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 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 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 path or critical path

Exercise 1

An equipment development project

Activity	Designation	Predecessors	Time (weeks)
Design	A	-	21
Build prototype	B	A	5
Evaluate equipment	C	A	7
Test prototype	D	B	2
Write equipment report	E	C, D	5
Write method report	F	C, D	8
Write final report	G	E, F	2

1. What is the critical path? And 2. What is the project completion time?

Exercise 2

A hospital building project

Activity	Designation	Predecessors	Time (days)
Buy the land	A	None	40
Get construction permission	B	A	30
Excavate	C	B	10
Erect building	D	C	100
Electrical work	E	D	10
Plumbing work	F	D	20
Paint interior	G	D	10
Clean up building	H	E, F, G	5
Move in furniture	I	H	5

1. What is the critical path? And 2. What is the project completion time?

Project Controlling

- Close monitoring of resources, costs, quality, budgets
- Feedback enables revising the project plan and shift resources
- Computerized tools produce extensive reports

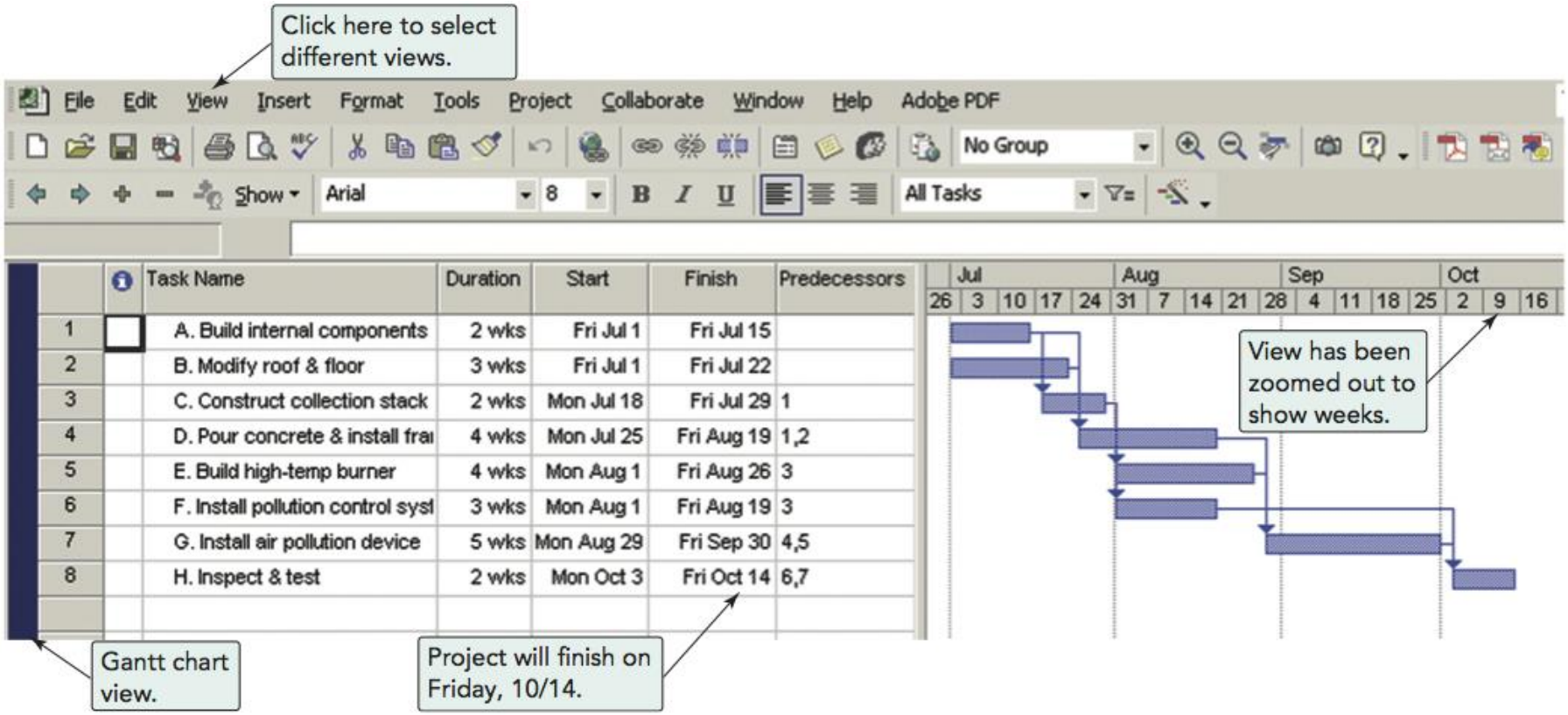
Project Control Reports

1) Detailed cost breakdowns for each task
2) Labor requirements
3) Cost and hour summaries
4) Raw materials and expenditure forecasts
5) Variance reports
6) Time analysis reports
7) Work status reports

Project Management Software

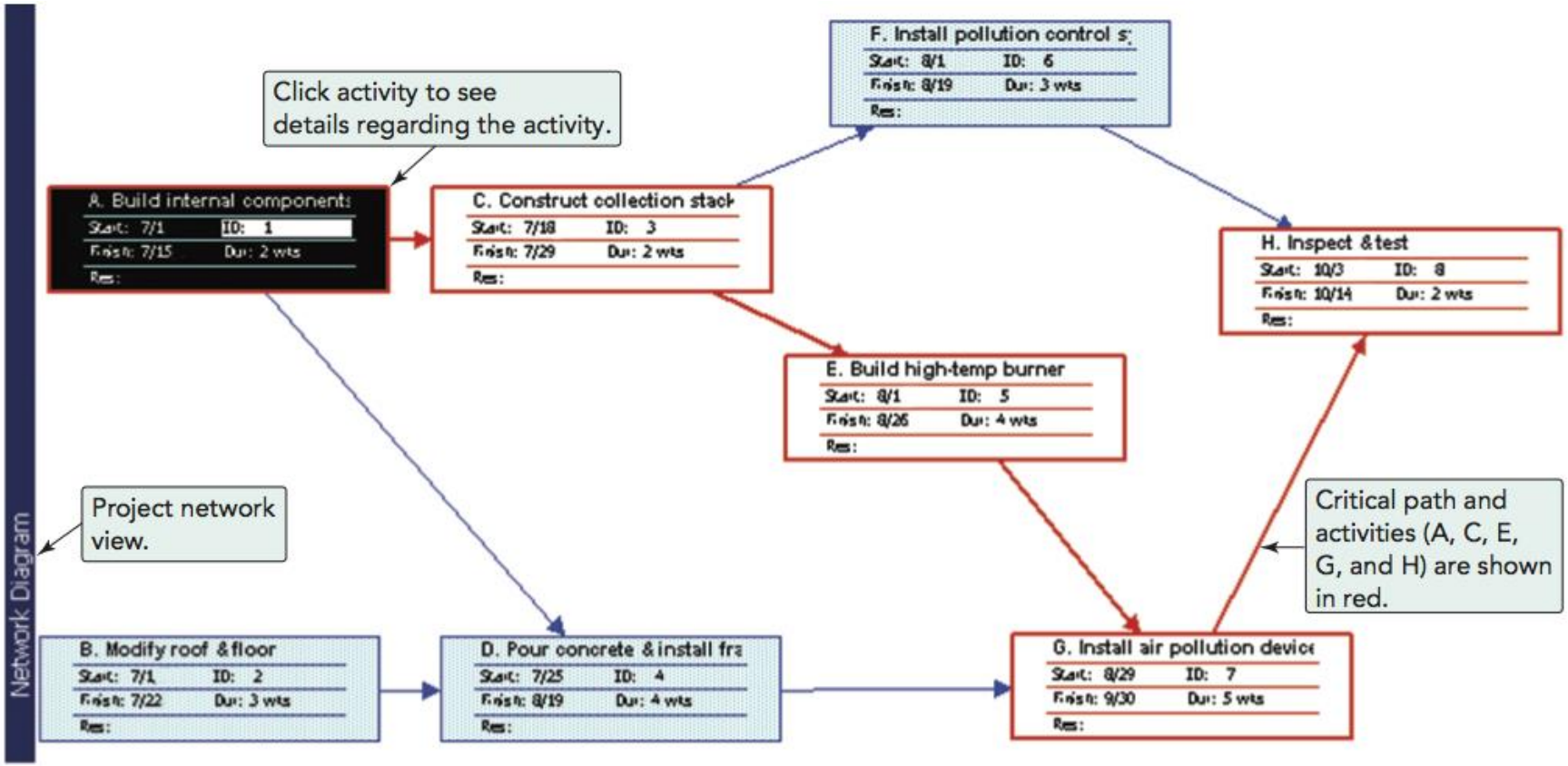
- There are several popular packages for managing projects
  - Oracle Primavera
  - MindView
  - HP Project
  - Fast Track
  - Microsoft Project

Using Microsoft Project



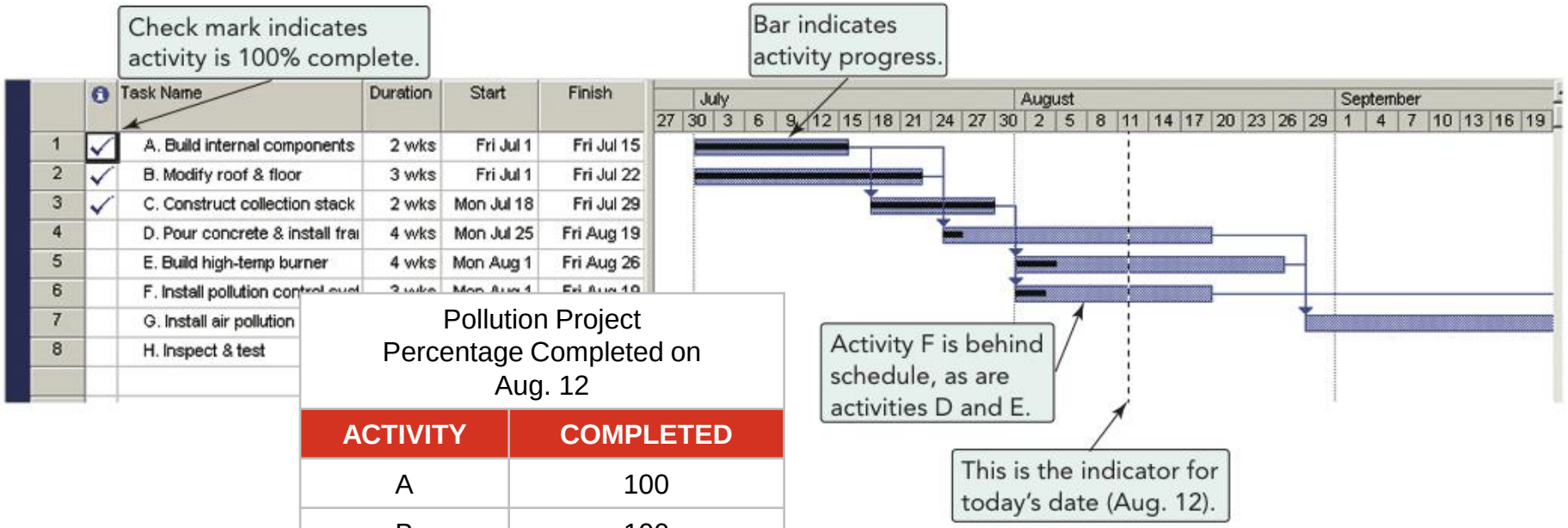
Program 3.1

Using Microsoft Project



Program 3.2

Using Microsoft Project



Pollution Project
Percentage Completed on
Aug. 12

ACTIVITY	COMPLETED
A	100
B	100
C	100
D	10
E	20
F	20
G	0
H	0

Program 3.3

Cost–Time 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

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

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

Step 2: Using current activity times, find the critical path and identify the critical activities

Steps in Project Crashing

Step 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

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

Crash and Normal Times and Costs for Activity B

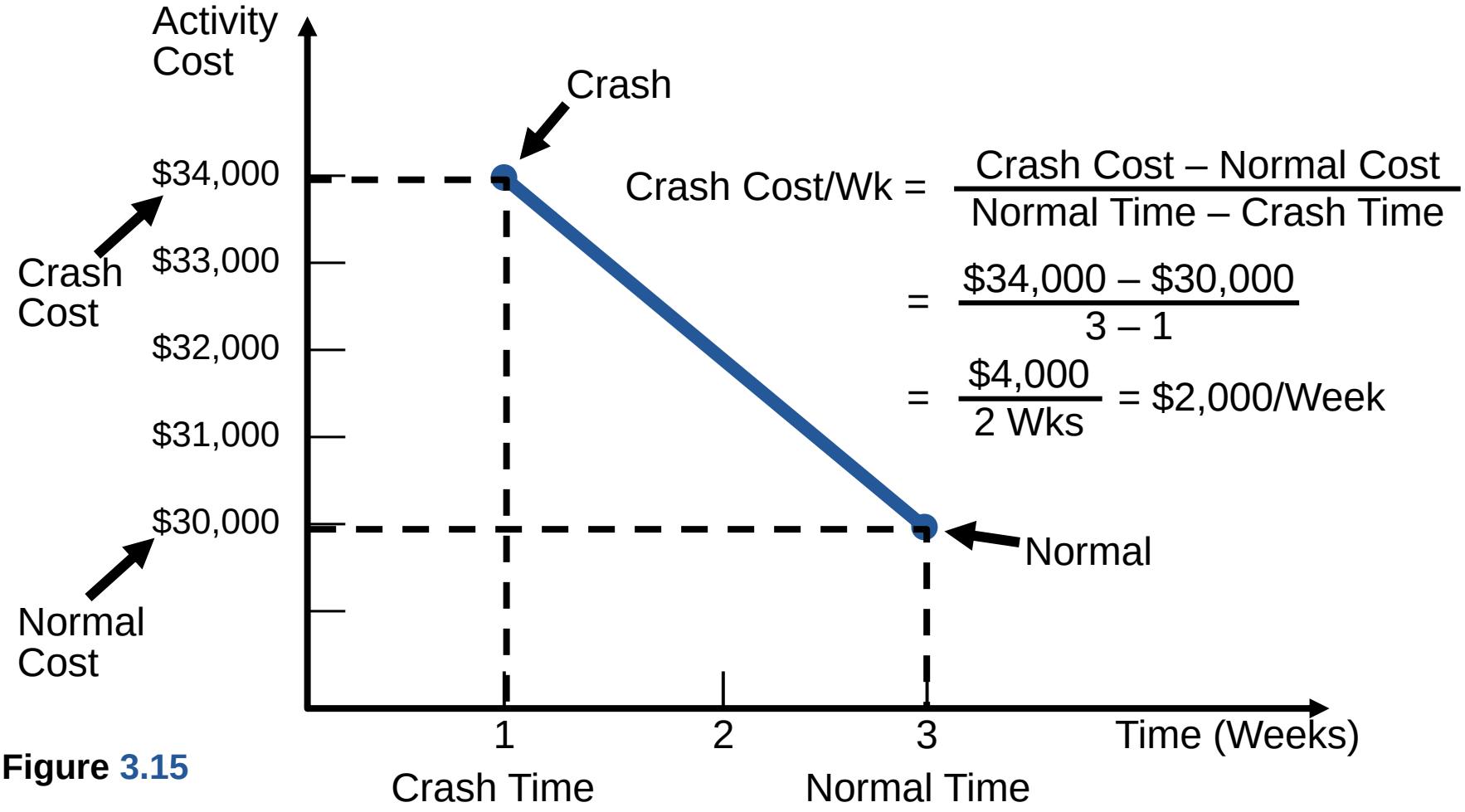


Figure 3.15

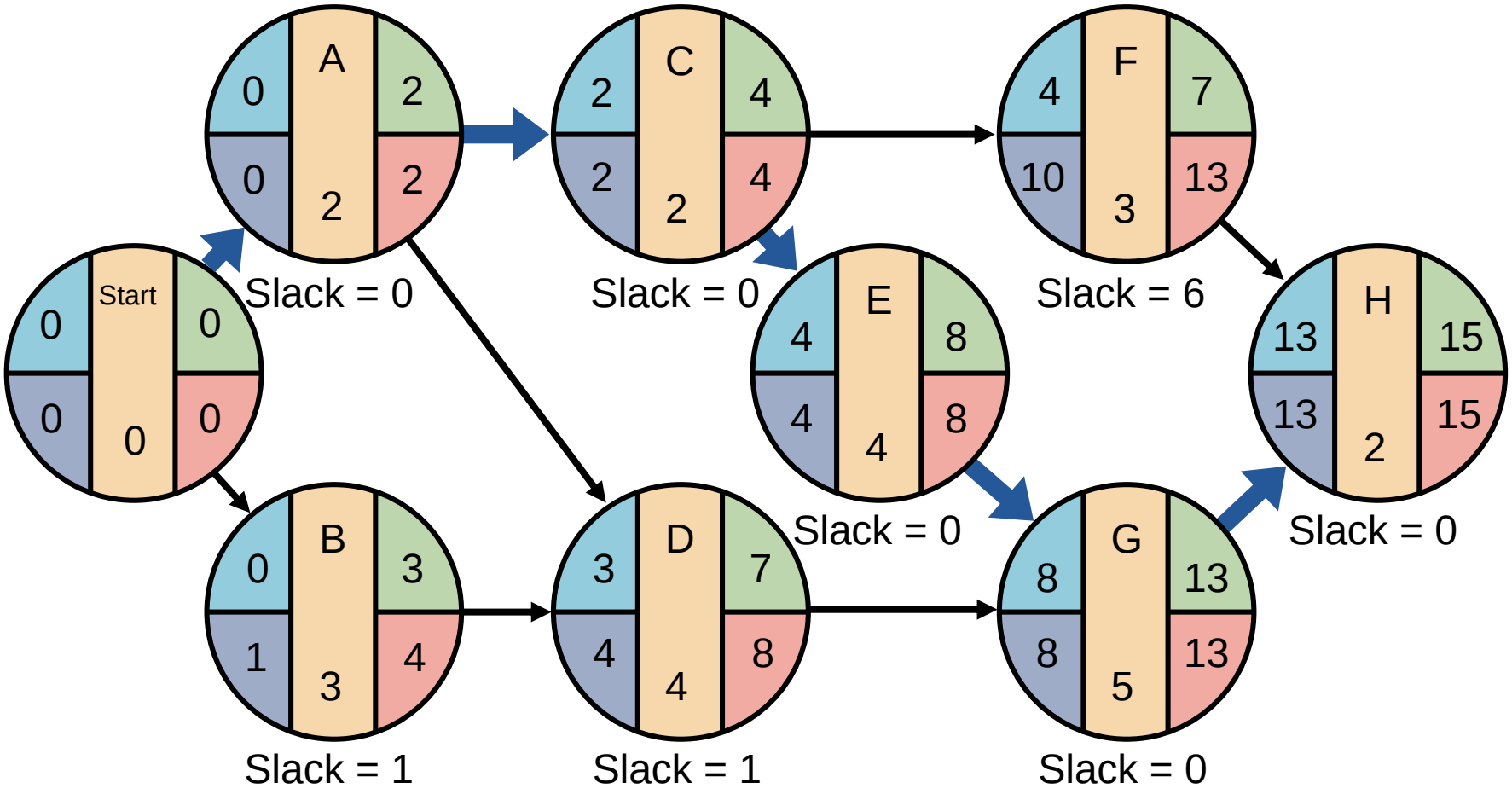
Crashing The Project

TABLE 3.5 Normal and Crash Data for Milwaukee Paper Manufacturing

ACTIVITY	TIME (WEEKS)		COST ($)		CRASH COST PER WEEK ($)	CRITICAL PATH ?
	NORMAL	CRASH	NORMAL	CRASH		
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	3	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

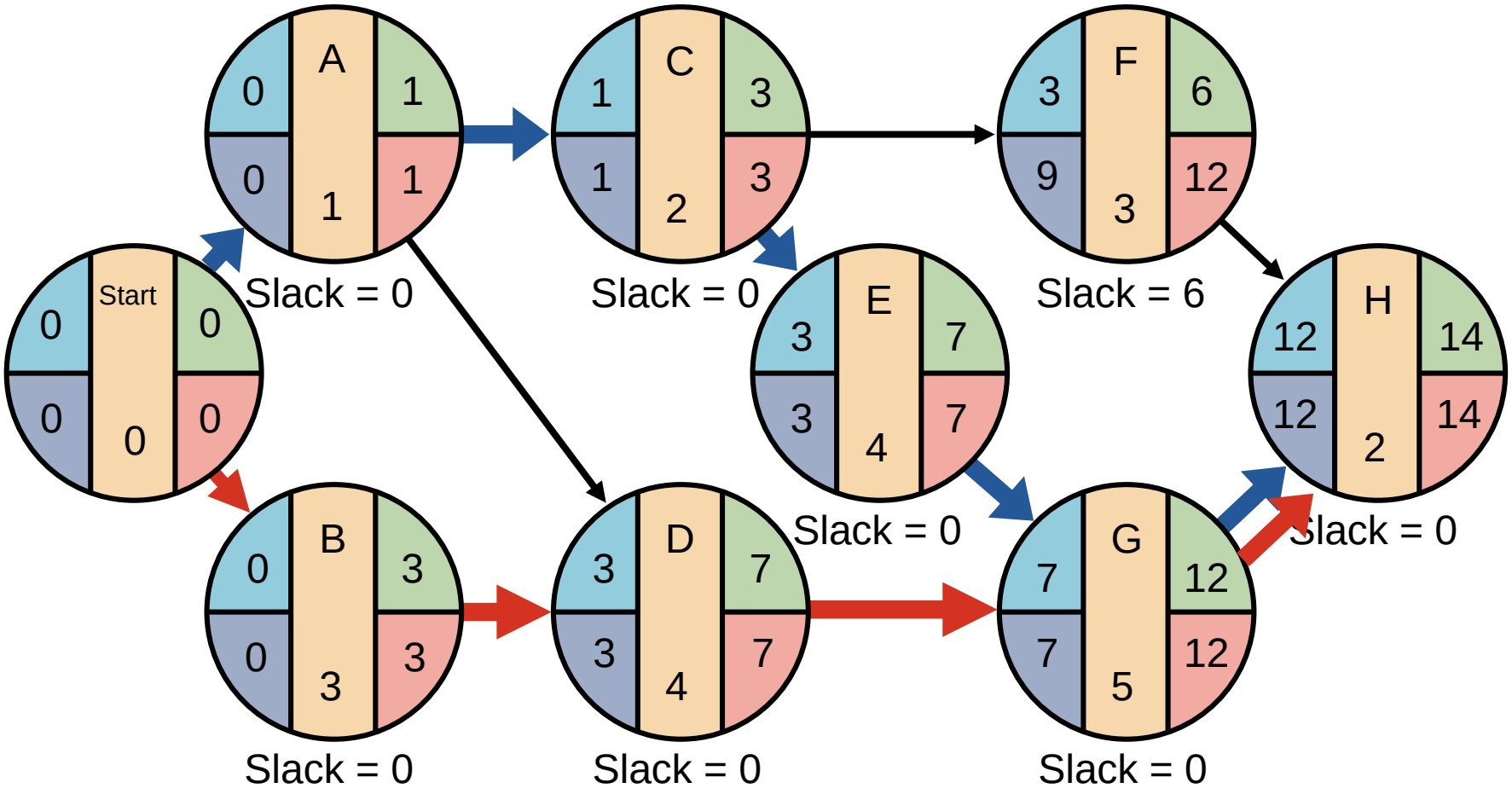
Critical Path and Slack Times for Milwaukee Paper

Figure 3.16



Two Critical Paths and Slack Times for Milwaukee Paper after crashing 1 week at Activity A

Figure 3.16



Crashing The Project

TABLE 3.5 Normal and Crash Data for Milwaukee Paper Manufacturing (Revised)

ACTIVITY	*TIME (WEEKS)*		*COST ($)*		CRASH COST PER WEEK ($)	CRITICAL PATH ?
	NORMAL	CRASH	NORMAL	CRASH		
A	2	1	22,000	22,750	750	Yes
B	3	1	30,000	34,000	2,000	Yes
C	2	1	26,000	27,000	1,000	Yes
D	4	3	48,000	49,000	1,000	Yes
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

If the project must be completed in week 13, which activities must be crashed?