Project Time Management

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Learning Objectives

- Define **activities** as the basis for developing project schedules

- Describe how project managers use **network diagrams** and **dependencies** to assist in activity sequencing

- Understand the need for **resources estimating** and **duration estimating** before producing the schedule

- Understand the following techniques in **schedule development and control**:
  - **Gantt chart** for planning and tracking schedule information
  - **Critical path method**
  - **Critical chain scheduling**

Importance of Project Schedules

- Managers often cite delivering projects on time as one of their biggest challenges.

- Time has the least amount of flexibility; it passes no matter what happens on a project.

- Schedule issues are the main reason for conflicts on projects, especially during the second half of projects

Individual Work Styles and Cultural Differences Cause Schedule Conflicts

- One dimension of the Meyers-Briggs Type Indicator focuses on peoples' attitudes toward structure and deadline.

- Judgment type people prefer to follow schedules, meet deadlines and have closure. Perception types prefer to keep things open and flexible; deadlines are a signal to start rather than to complete a project.

- Different cultures and even entire countries have different attitudes about schedules.

Media Snapshot

- In contrast to the 2002 Salt Lake City Winter Olympic Games, planning and scheduling was very different for the 2004 Summer Olympic Games held in Athens, Greece.

- Many articles were written before the opening ceremonies predicting that the facilities would not be ready in time.

- Many people were pleasantly surprised by the amazing opening ceremonies, beautiful new buildings, and state-of-the-art security and transportation systems in Athens.

- The Greeks even made fun of critics by having construction workers pretend to still be working as the ceremonies began

Project Time Management Processes

- **Activity definition**: identifying the specific activities/tasks that the project team members and stakeholders must perform to produce the project deliverables
- **Activity sequencing**: identifying and documenting the relationships between project activities
- **Activity resource estimating**: estimating how many **resources** a project team should use to perform project activities
- **Activity duration estimating**: estimating the number of work periods that are needed to complete individual activities
- **Schedule development**: analyzing activity sequences, activity resource estimates, and activity duration estimates to create the project schedule
- **Schedule control**: controlling and managing changes to the project schedule

Project Time Management Summary

Planning
Process: **Activity definition**
Outputs: Activity list, activity attributes, milestone list, requested
        changes
Process: **Activity sequencing**
Outputs: Project schedule network diagram, requested changes,
        updates to the activity list and attributes
Process: **Activity resource estimating**
Outputs: Activity resource requirements, resource breakdown structure
        requested changes, and updates to activity attributes
        resource calendars
Process: **Activity duration estimating**
Outputs: Activity duration estimates, updates to activity attributes
Process: **Schedule development**
Outputs: Project schedule, schedule model data, schedule baseline,
        requested changes, and updates to resource requirements,
        activity attributes, the project calendar, project
        management plan

Monitoring and Controlling
Process: **Schedule control**
Outputs: Performance measurements, requested changes, recommended
        corrective actions, and updates to the schedule model data,
        schedule baseline, organizational process assets, activity list
        and attributes, the project management plan

Project Start   **Project Finish**

Project Time Management

Activity Definition

- Project schedules grow out of the basic documents that initiate a project
  - □ Project charter includes start and end dates and budget information
  - □ Scope statement and WBS help define what will be done

- Activity definition involves developing a more detailed WBS and supporting explanations to understand all the work to be done so you can develop realistic cost and duration estimates

Project Time Management Processes

- The basis for creating a project schedule is derived from four project time management processes

  - ☐ **Activity definition** – further defining the scope

  - ☐ **Activity sequencing** – further defining the time

  - ☐ **Activity resource** and **activity duration** (further defining the time and cost)

Activity Definition

- Activity definition involves developing a **more detailed** WBS

- An *activity list* is a tabulation of activities to be included on a project schedule that includes:
  - The activity name
  - An activity identifier or number
  - A brief description

- *Activity attributes* provide more information such as
  - Predecessors
  - Successors
  - Logical relationships
  - Leads and lags (Lead: 10FS-10%; Lag: 12FS+5days)
  - Resource requirements
  - Constraints
  - Imposed dates
  - Assumptions

Milestones

- A **milestone** is a <u>significant</u> event that normally has no duration

  - Not every deliverable or output created for a project is a milestone

- It often takes several activities and a lot of work to complete a milestone

- They're useful tools for setting schedule goals and monitoring progress

- Examples include obtaining customer sign-off on key documents or completion of specific products

Activity Sequencing

- After defining project activities, the next step is activity sequencing

  - Involves reviewing the activity list and attributes, project scope statement, milestone list and approved change requests to determine the relationships between activities

- A **dependency** or **relationship** is the sequencing of project activities or tasks

- You *must* determine dependencies in order to use critical path analysis

Three Types of Dependencies

- ***Mandatory* dependencies**:
  - ☐ inherent in the nature of the work being performed on a project
  - ☐ sometimes referred to as **hard logic**

- ***Discretionary* dependencies**:
  - ☐ defined by the project team, usually based on best practices
  - ☐ sometimes referred to as **soft logic**

- ***External* dependencies**:
  - ☐ involve relationships between project and nonproject activities, e.g. dependency on a supplier

Network Diagrams

- Network diagrams are the preferred technique for showing activity **sequencing**

- A *network diagram* is a schematic display of the logical relationships among, or sequencing of, project activities

- Two main formats
  - *Precedence diagramming method (PDM) or AON*
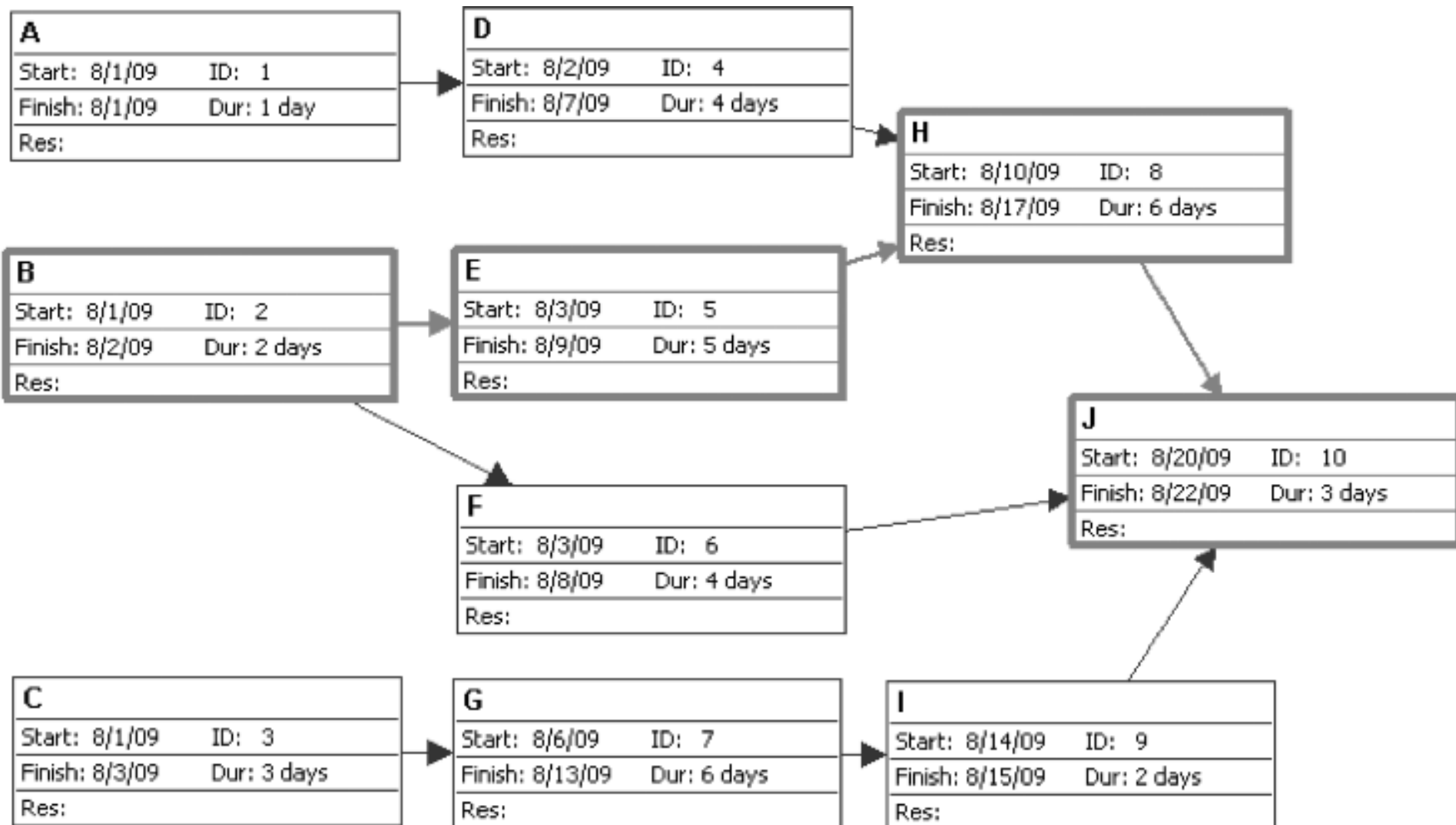 - *Arrow diagramming method (ADM) or AOA*

Project X

Activity	Duration	Dependency
A	1	
B	2	
C	3	
D	4	A
E	5	B
F	4	B
G	6	C
H	6	D,E
I	2	G
J	3	F, H, I

Precedence Diagramming Method (PDM)

- Also called *activity-on-node (AON)* network diagrams

- **Activities** are represented by **boxes**

- Arrows show relationships between activities

- More popular than ADM method and used by project management software

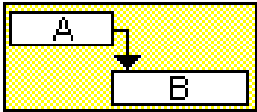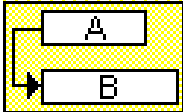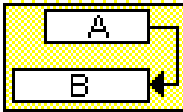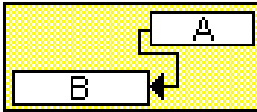- Better at showing **different types of dependencies**

Sample PDM Network Diagram

A
Start: 8/1/09	ID: 1
Finish: 8/1/09	Dur: 1 day
Res:	

D
Start: 8/2/09	ID: 4
Finish: 8/7/09	Dur: 4 days
Res:	

H
Start: 8/10/09	ID: 8
Finish: 8/17/09	Dur: 6 days
Res:	

B
Start: 8/1/09	ID: 2
Finish: 8/2/09	Dur: 2 days
Res:	

E
Start: 8/3/09	ID: 5
Finish: 8/9/09	Dur: 5 days
Res:	

J
Start: 8/20/09	ID: 10
Finish: 8/22/09	Dur: 3 days
Res:	

F
Start: 8/3/09	ID: 6
Finish: 8/8/09	Dur: 4 days
Res:	

C
Start: 8/1/09	ID: 3
Finish: 8/3/09	Dur: 3 days
Res:	

G
Start: 8/6/09	ID: 7
Finish: 8/13/09	Dur: 6 days
Res:	

I
Start: 8/14/09	ID: 9
Finish: 8/15/09	Dur: 2 days
Res:	

Task Dependency Types

Task dependencies

The nature of the dependencies between linked tasks. You link tasks by defining a dependency between their finish and start dates. For example, the "Contact caterers" task must finish before the start of the "Determine menus" task. There are four kinds of task dependencies in Microsoft Project:

Task dependency	Example	Description
Finish-to-start (FS)		Task (B) cannot start until task (A) finishes.
Start-to-start (SS)		Task (B) cannot start until task (A) starts.
Finish-to-finish (FF)		Task (B) cannot finish until task (A) finishes.
Start-to-finish (SF)		Task (B) cannot finish until task (A) starts.

Examples of Dependencies

- ***Finish-to-start***
  - ☐ User training can only be provided after system is installed.

- ***Start-to-start***
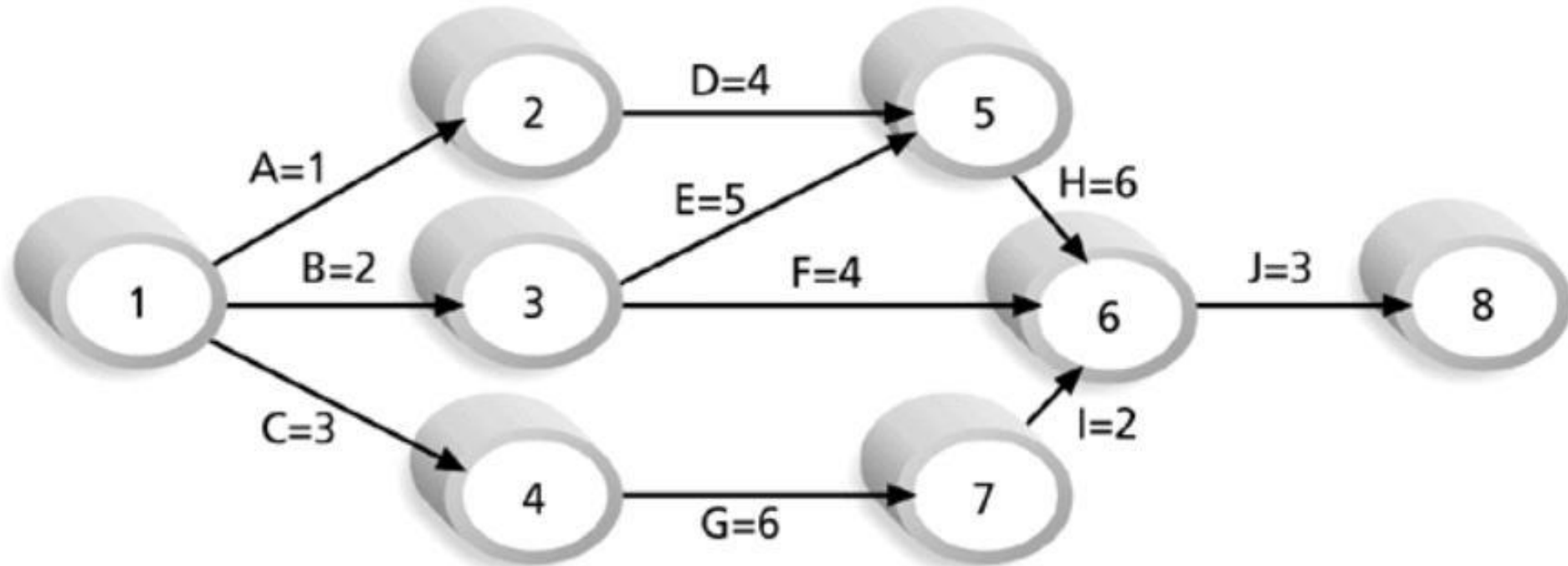 - ☐ When system goes live (production starts), support task starts

- ***Finish-to-finish***
  - ☐ Program documentation finishes when programming task finishes

- ***Start-to-finish***
  - ☐ Stock raw materials (task B) just in time for manufacturing (task A). Delay in manufacturing starting should delay stocking of raw materials

Sample Activity-on-Arrow (AOA) Network Diagram for Project X

Note: Assume all durations are in days; A=1 means Activity A has a duration of 1 day.

Arrow Diagramming Method (ADM)

- Also called *activity-on-arrow (AOA)* network diagrams

- **Activities** are represented by **arrows**

- Nodes or circles are the starting and ending points of activities

- Can only show **finish-to-start** dependencies

Estimate Activity Resources

- Before estimating activity durations, you must have a good idea of the **quantity** and **type** of resources that will be assigned to each activity

- A ***resource breakdown structure (RBS)*** is a hierarchical structure that identifies the project's resources **by category** and type

Resource Breakdown Structure (RBS)
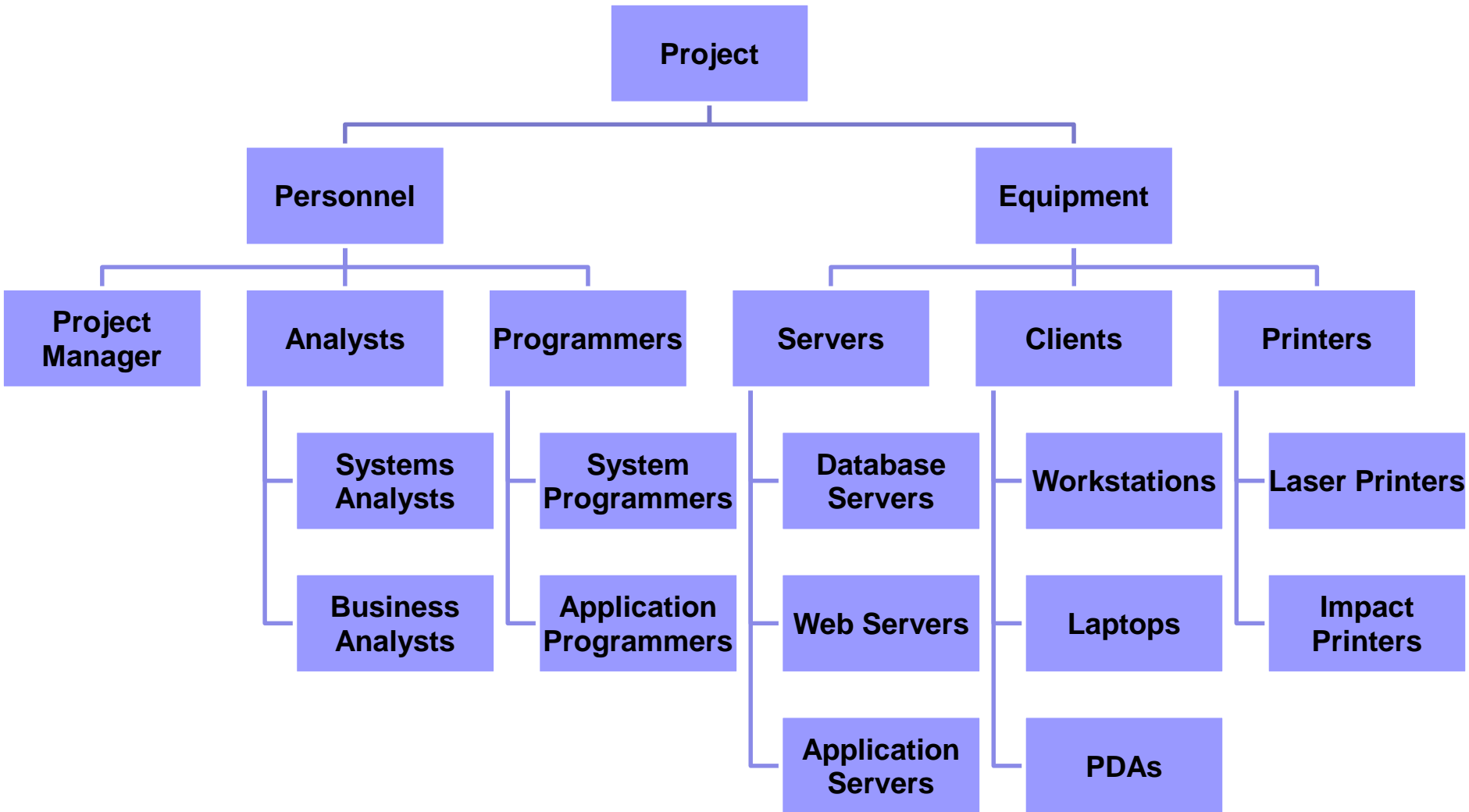
Estimate Activity Durations

- ***Duration*** includes the actual amount of time worked on an activity **plus elapsed time.**

- ***Effort*** is the number of **workdays** or work hours required to complete a task.

- Effort does not normally equal duration

Three-Point Estimates

■ To improve the **accuracy** of the estimate, it's often helpful to create a ***three-point estimate***

☐ An estimate that includes 3 estimates:

■ Optimistic (e.g. 3 wks)

■ Most likely (e.g. 4 wks)

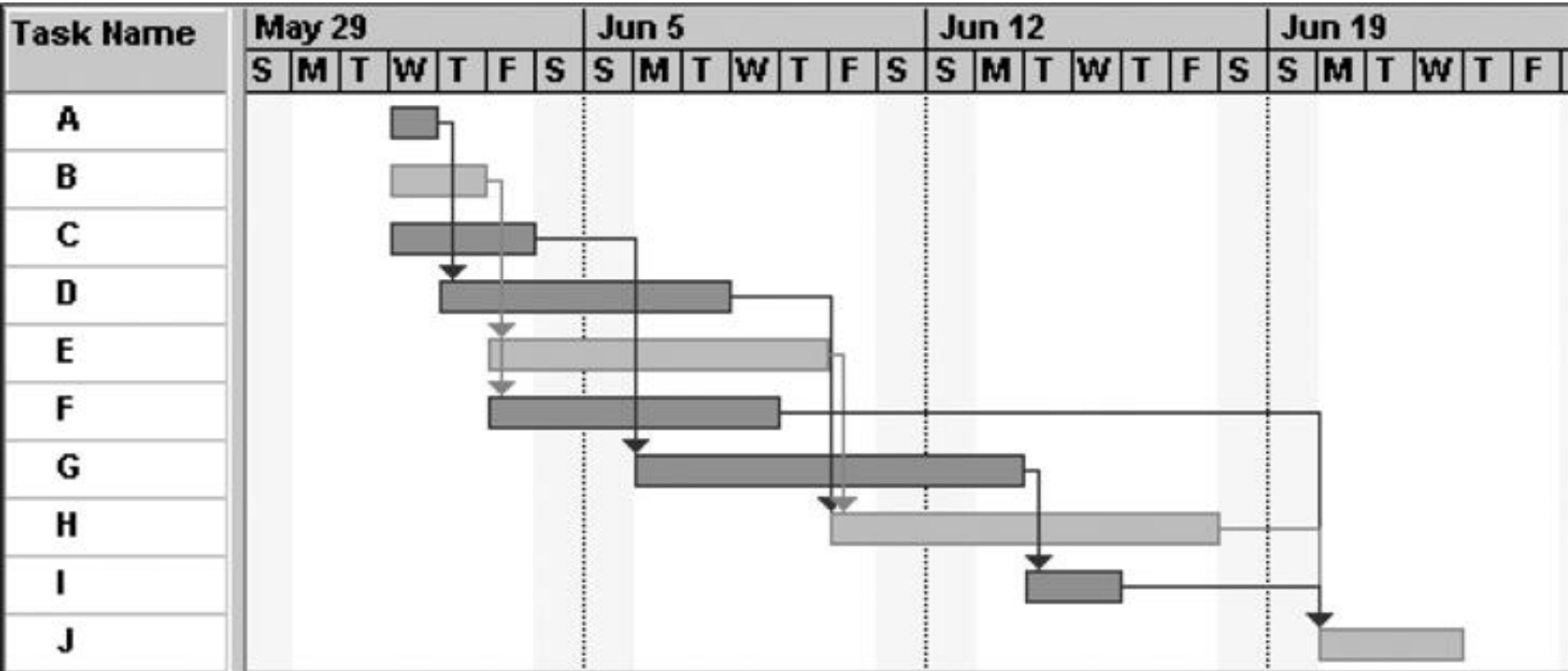■ Pessimistic (e.g. 5 wks)

Develop Schedule

- Uses results of the other time management processes to determine
  - the start date
  - the end date

  of the activities and the project.

- Important tools and techniques include
  - *Gantt charts*
  - *Critical path analysis*
  - *Critical chain scheduling*

Gantt Charts

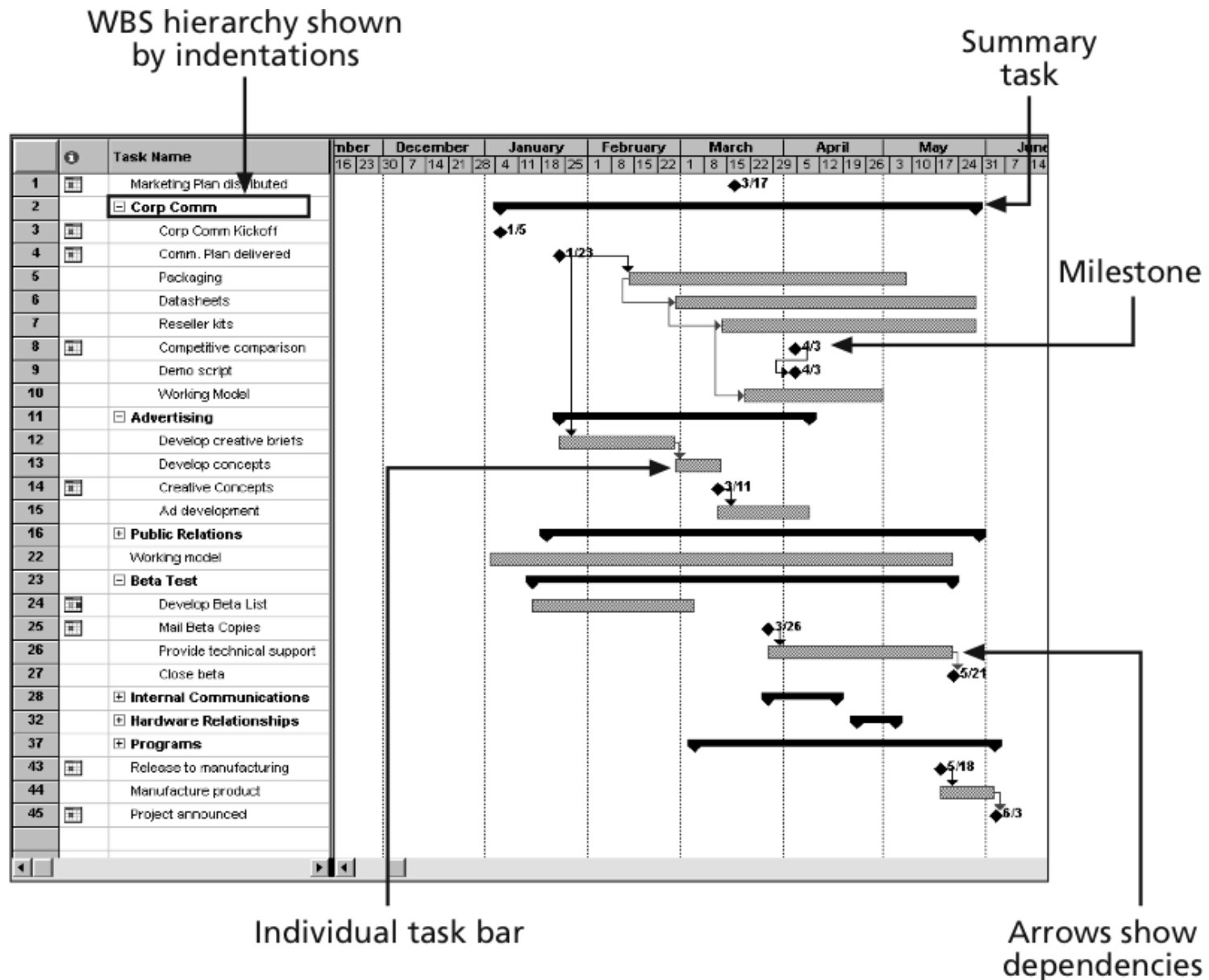- ***Gantt charts*** provide a standard format for displaying project schedule information by listing project activities and their corresponding start and finish dates in a calendar format.

- Symbols include:
  - ☐ **Black diamonds**: milestones
  - ☐ **Thick black bars**: summary tasks
  - ☐ **Lighter horizontal bars**: durations of tasks
  - ☐ **Arrows**: dependencies between tasks

Gantt Chart for Project X

Gantt Chart for Software Launch Project

WBS hierarchy shown by indentations

Summary task

Milestone

Individual task bar

Arrows show dependencies

|	ⓘ	Task Name	November	December	January	February	March	April	May	June
1	▣	Marketing Plan distributed					◆3/17			
2		⊟ Corp Comm								
3	▣	Corp Comm Kickoff		◆1/5						
4	▣	Comm. Plan delivered			◆1/23					
5		Packaging								
6		Datasheets								
7		Reseller kits								
8	▣	Competitive comparison					◆4/3			
9		Demo script					◆4/3			
10		Working Model								
11		⊟ Advertising								
12		Develop creative briefs								
13		Develop concepts								
14	▣	Creative Concepts					◆3/11			
15		Ad development								
16		⊞ Public Relations								
22		Working model								
23		⊟ Beta Test								
24	▣	Develop Beta List								
25	▣	Mail Beta Copies					◆3/26			
26		Provide technical support								
27		Close beta							◆5/21	
28		⊞ Internal Communications								
32		⊞ Hardware Relationships								
37		⊞ Programs								
43	▣	Release to manufacturing							◆5/18	
44		Manufacture product								
45	▣	Project announced								◆6/3

Adding Milestones to Gantt Charts

- Many people like to focus on meeting milestones, especially for large projects.

- Milestones emphasize important events or accomplishments on projects.

- Normally create milestone by entering tasks with a zero duration, or you can mark any task as a milestone.

SMART Criteria

- Milestones should be:
  - ☐ **S**pecific
 - ☐ **M**easurable
  - ☐ **A**ssignable
  - ☐ **R**ealistic
  - ☐ **T**ime-framed

Sample Tracking Gantt Chart

Planned dates

Actual dates

Slipped milestone
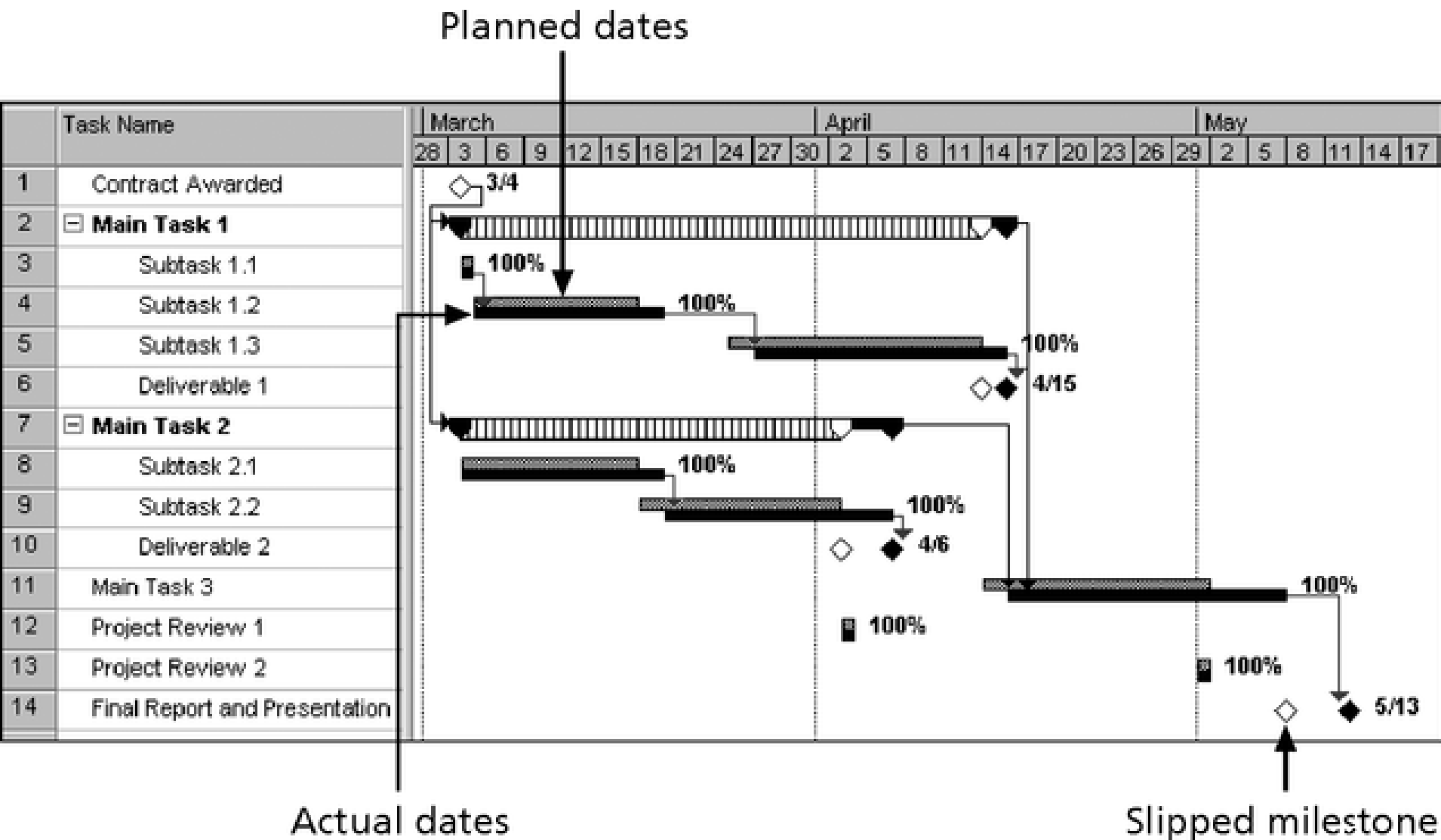
Critical Path Method (CPM)

- ***CPM*** calculates the **starting and ending times** for each activity, determines which activities are critical to the completion of a project.

- The ***critical path*** is the sequence of activities with the **longest** overall duration.

- ***Slack*** or ***float*** is the amount of time an activity may be delayed without delaying
  - a succeeding activity (***free slack*** or ***free float***) or
  - the project finish date (***total slack*** or ***total float***)

Determining the Critical Path for Project X
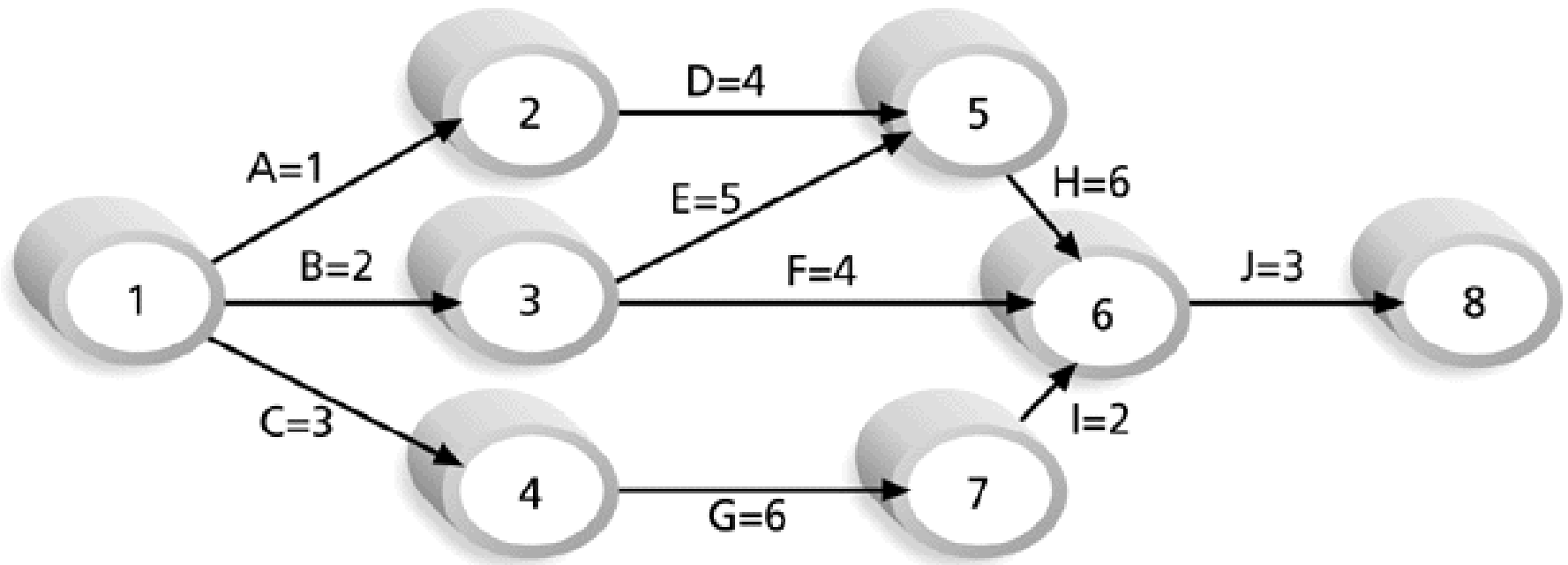
Note: Assume all durations are in days.

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

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

Different Dates of an Activity

Legend:
ES = early start
EF = early finish
LS = late start
LF = late finish

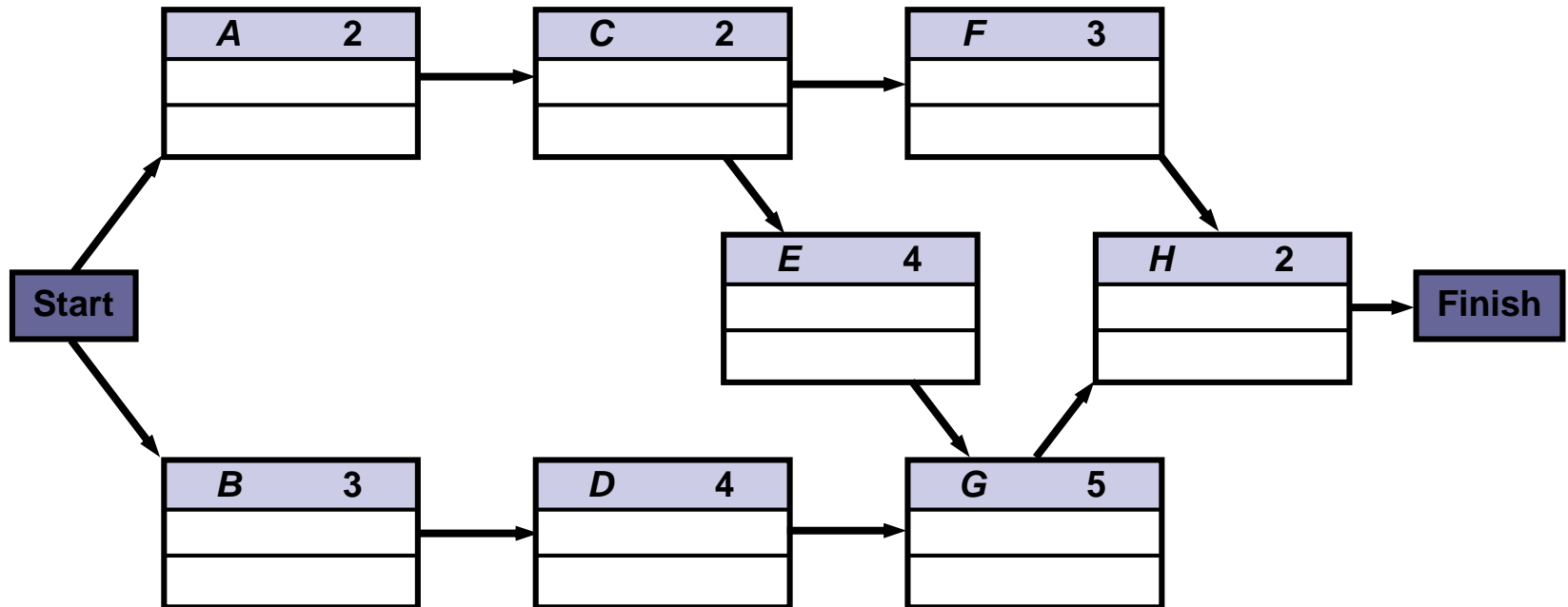| ES		EF
LS		LF

Critical Path Analysis

- A ***forward pass*** through the network diagram determines the early start and finish dates

- A ***backward pass*** determines the late start and finish dates

How to Find the Critical Path

- General Foundry's network with expected activity times

How to Find the Critical Path

■ To find the critical path, need to determine the following quantities for each activity in the network

1. *Earliest start time* (*ES*): the earliest time an activity can begin without violation of immediate predecessor requirements

2. *Earliest finish time* (*EF*): the earliest time at which an activity can end

3. *Latest start time* (*LS*): the latest time an activity can begin without delaying the entire project

4. *Latest finish time* (*LF*): the latest time an activity can end without delaying the entire project

How to Find the Critical Path

- In the nodes, the activity time and the early and late start and finish times are represented in the following manner

ACTIVITY	t
ES	**EF**
LS	**LF**

- Earliest times are computed as
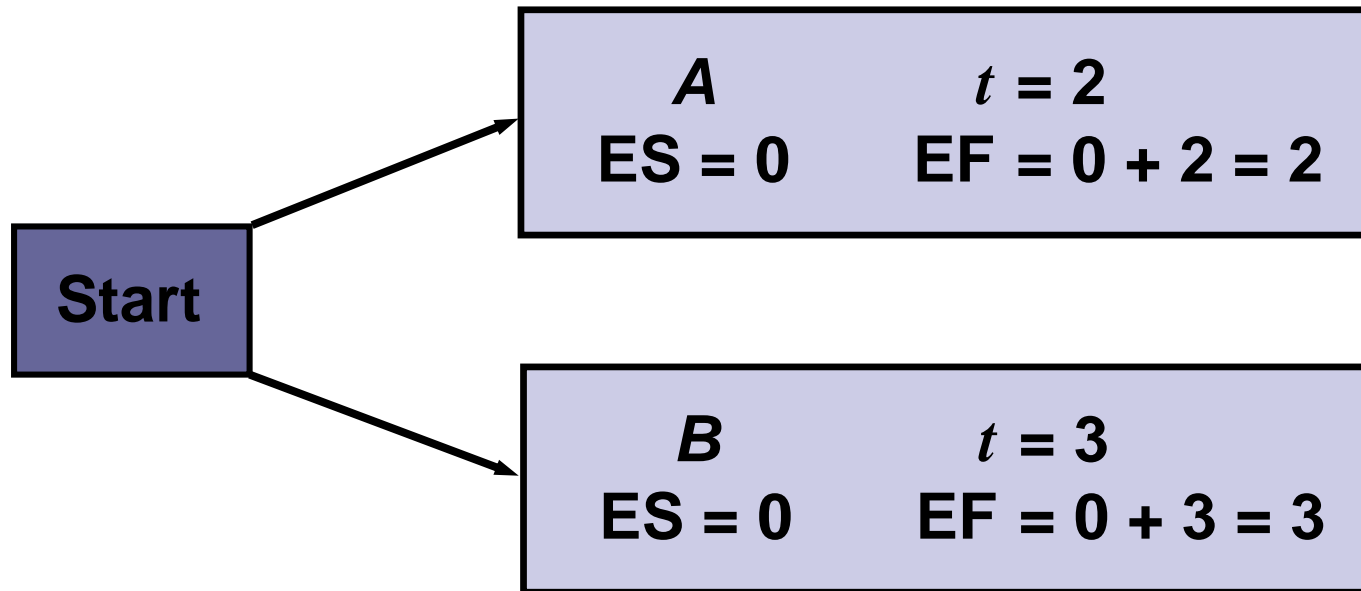
Earliest finish time = Earliest start time + Expected activity time

EF = ES + t

Earliest start = Largest of the earliest finish times of immediate predecessors

ES = Largest EF of immediate predecessors

How to Find the Critical Path

- At the start of the project we set the time to zero
- Thus ES = 0 for both *A* and *B*

```
                          ┌─────────────────────────────────────────┐
                          │       A              t = 2               │
                   ──────▶│  ES = 0        EF = 0 + 2 = 2            │
        ┌──────────┐     ╱└─────────────────────────────────────────┘
        │  Start   │────
        └──────────┘     ╲┌─────────────────────────────────────────┐
                   ──────▶│       B              t = 3               │
                          │  ES = 0        EF = 0 + 3 = 3            │
                          └─────────────────────────────────────────┘
```

How to Find the Critical Path

- General Foundry's ES and EF times
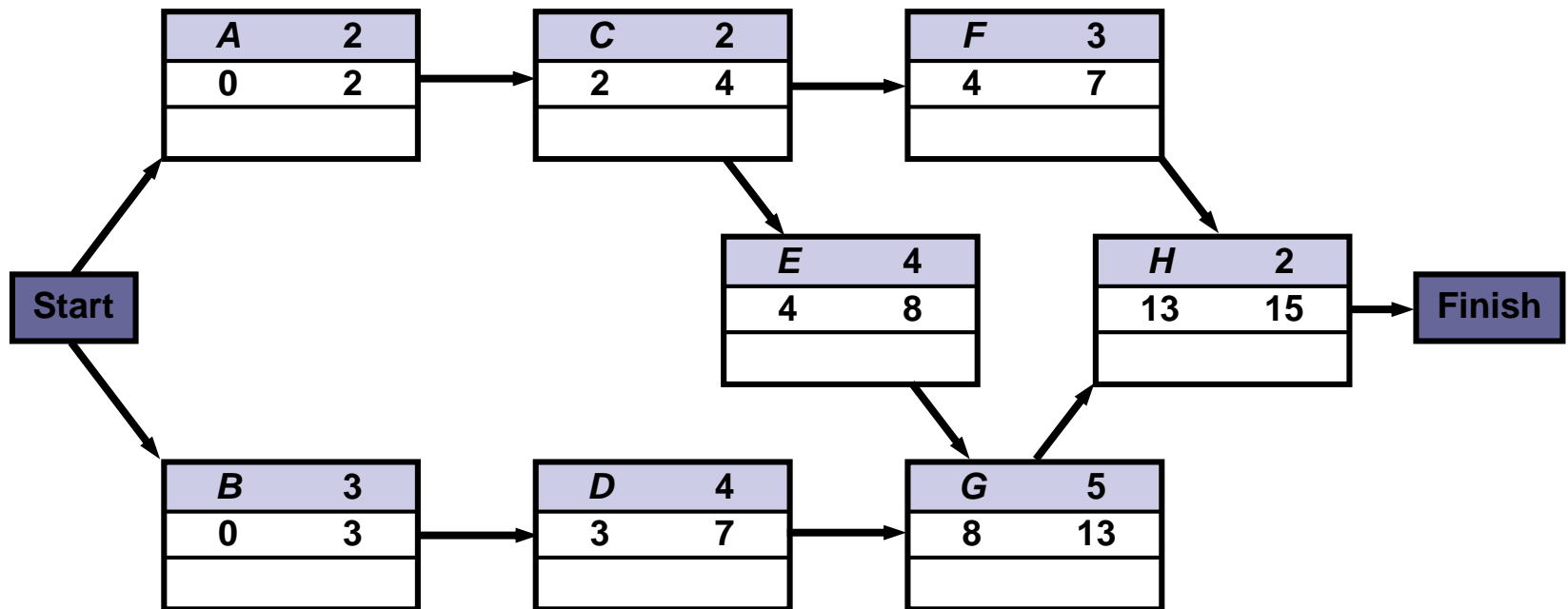
Figure 13.4

How to Find the Critical Path

- Latest times are computed as

Latest start time = Latest finish time
– Expected activity time

LS = LF – t

Latest finish time = Smallest of latest start times
for following activities

LF = Smallest LS of following activities

- For activity *H*

LS = LF – t = 15 – 2 = 13 weeks

How to Find the Critical Path

- General Foundry's LS and LF times

A	2
0	2
0	2

C	2
2	4
2	4

F	3
4	7
10	13

E	4
4	8
4	8

H	2
13	15
13	15

B	3
0	3
1	4

D	4
3	7
4	8

G	5
8	13
8	13

Start   **Finish**
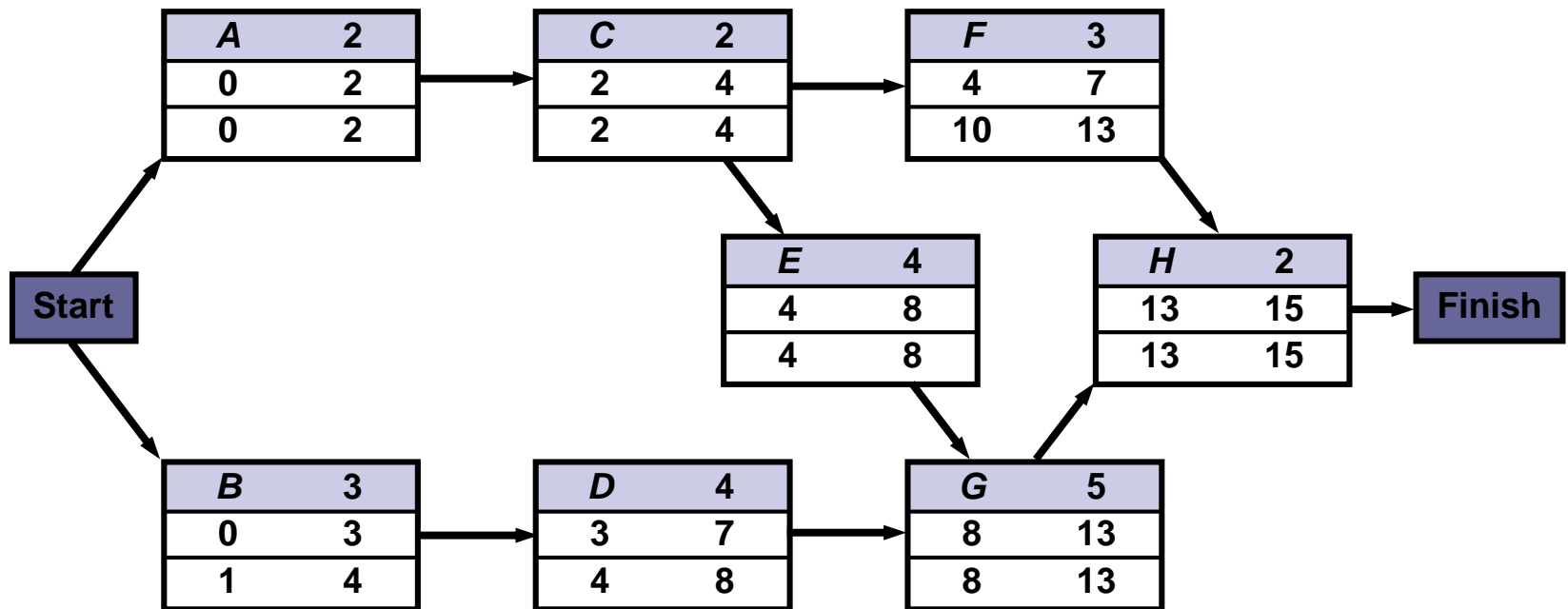
Figure 13.5

How to Find the Critical Path

- Once ES, LS, EF, and LF have been determined, it is a simple matter to find the amount of *slack time* that each activity has

$$\text{Slack} = \text{LS} - \text{ES, or Slack} = \text{LF} - \text{EF}$$

- From the Table in the next slide we see activities *A*, *C*, *E*, *G*, and *H* have no slack time
- These are called *critical activities* and they are said to be on the *critical path*
- The total project completion time is 15 weeks
- Industrial managers call this a boundary timetable

How to Find the Critical Path

- General Foundry'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

How to Find the Critical Path

- General Foundry's critical path
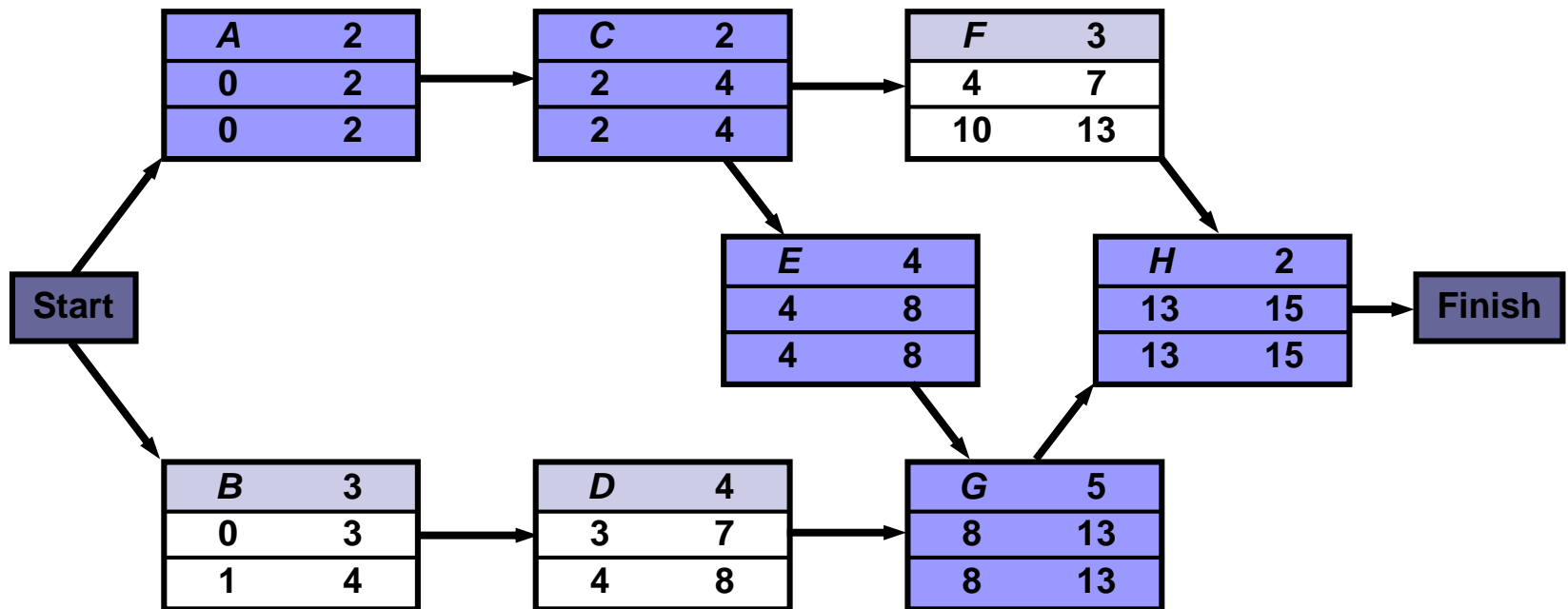

Figure 13.6
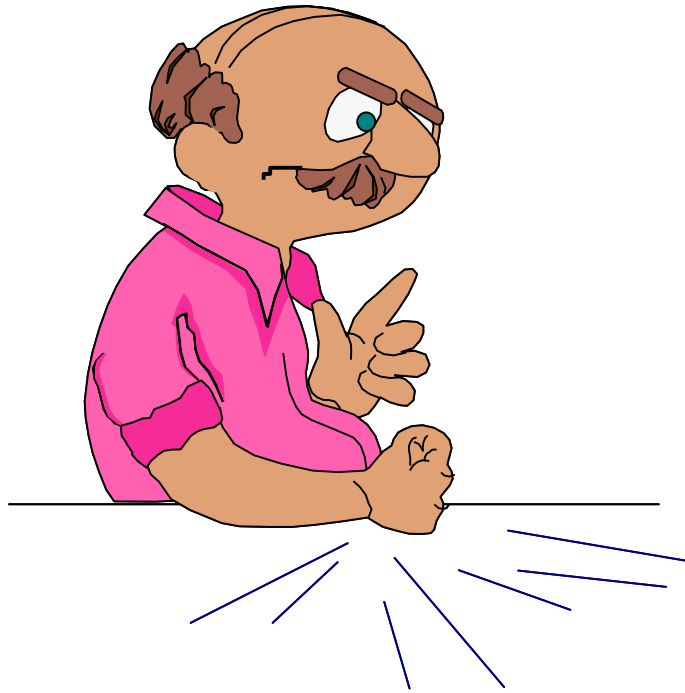
Can you do that faster ??!!!

Shortening a Project Schedule

- **To shorten the project schedule without** changing the project scope
- Techniques
  - *Crashing*
    - Look at **cost and schedule** trade-offs
    - E.g. add/move resources, change the sequence of activities
    - Usually result in increased costs
    - Doesn't always come up with a reasonable result
  - *Fast tracking*
    - Perform sequential critical path activities **in parallel** or overlap them
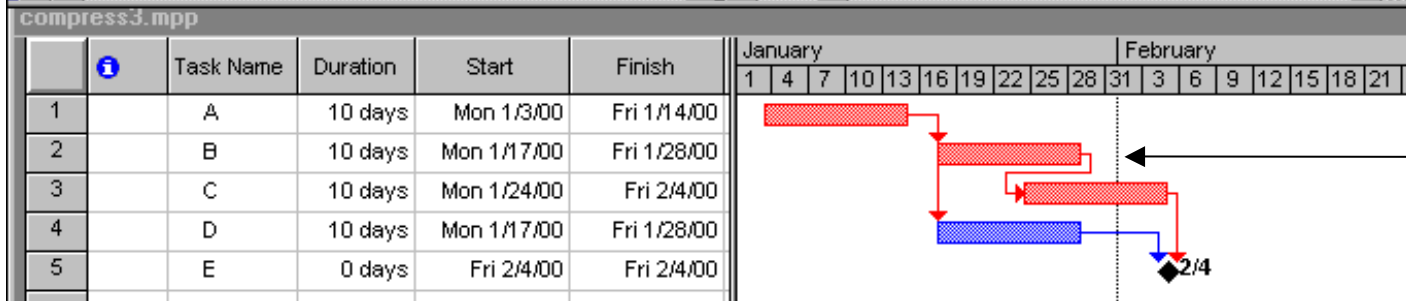   - Can result in rework and increased risk, also need better communication

Crashing and Fast Tracking
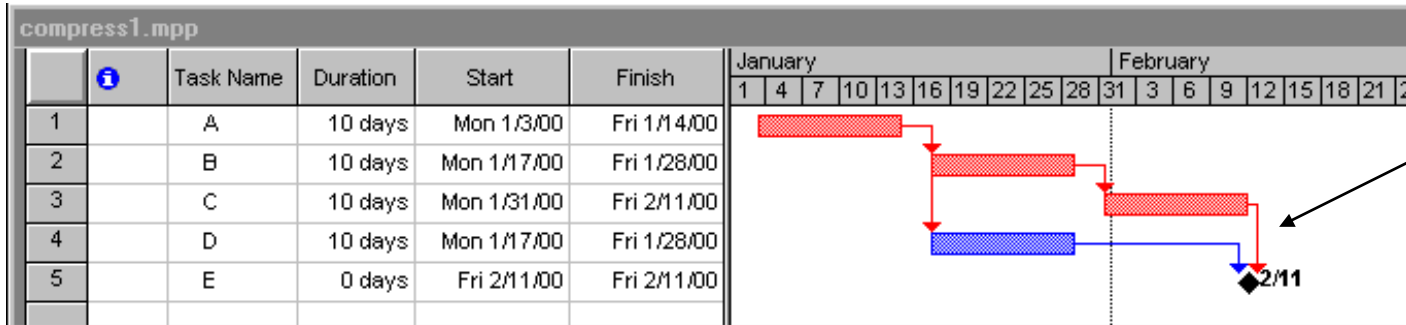
Original schedule
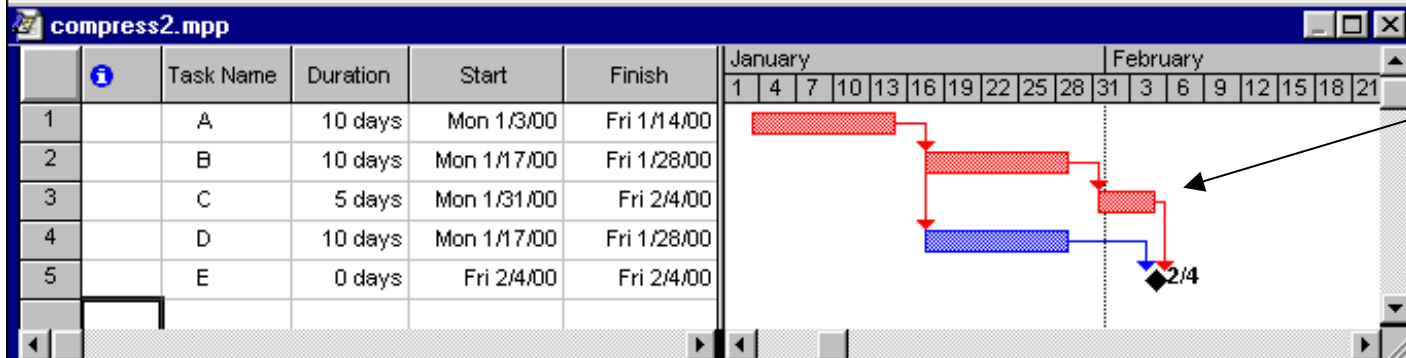
Shortened duration thru crashing

Overlapped Tasks or fast tracking

Critical Chain Scheduling

- ***Critical chain scheduling***
  - A method of scheduling that considers **limited resources** when creating a project schedule and includes **buffers** to protect the project completion date

Resource Leveling

- Done after CPM

- Used to address:
  - Situation where **critical resources** are only available at certain times, or in limited quantities
  - Situations where we want to keep selected resource usage at a **constant** level

Schedule Control

- Check to see if schedule is realistic

- Track status by progress reports

- Variance analysis, such as analyzing float or slack

- Hold progress meetings with stakeholders

- Manage changes to schedule

To Sum Up

- Activity
- Milestone
- **Dependency**
  - ☐ Mandatory, Discretionary, External
  - ☐ FS, SS, FF, SF
- **Network Diagram**
  - ☐ Precedence Diagramming Method (PDM)
  - ☐ Arrow Diagramming Method (ADM)
- **Resource Breakdown Structure (RBS)**
- Duration Vs Effort
- Three-point Estimate
- **Gantt Chart**
- **Critical Path Analysis**
  - ☐ Slack/Float
- **Critical Chain Scheduling**
- Resource Leveling
- Crashing Vs Fast Tracking