Chapter - 3

Project Time Management

LEARNING OBJECTIVES

After reading this chapter, you will be able to:

- Understand the importance of project schedules and good project time management
- 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 relationship between estimating resources and project schedules
- Explain how various tools and techniques help project managers perform activity duration estimating
- Use a Gantt chart for planning and tracking schedule information, find the critical path for a project, and describe how critical chain scheduling and the Program Evaluation and Review Technique (PERT) affect schedule development
- Discuss how reality checks and discipline are involved in controlling and managing changes to the project schedule
- Describe how project management software can assist in project time management and review words of caution before using this software

Project Scheduling

- Project Scheduling in a project refers to **roadmap of all activities** to be done with specified order and within time slot allotted to each activity.
- Project managers tend to define various tasks, and project milestones and arrange them keeping various factors in mind.
- They look for **tasks lie in critical path in the schedule**, which are necessary to complete in specific manner (because of task interdependency) and strictly within the time allocated.
- Arrangement of tasks which lies **out** of critical path are **less likely to impact** over all schedule of the project.

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✓ **For scheduling a project, it is necessary to -**

- Break down the project tasks into smaller, manageable form
- Find out various tasks and correlate them
- Estimate time frame required for each task
- Divide time into work-units
- Assign adequate number of work-units for each task
- Calculate total time required for the project from start to finish

Importance of Project Schedules

- Managers often cite delivering projects on time as one of their biggest challenges
- Average time overrun from 1995 CHAOS report was 222%; improved to 163% in 2001 study
- Time has the least amount of flexibility; it passes no matter what
- Schedule issues are the main reason for conflicts on projects, especially during the second half of projects

Project Time Management Processes

- Recall the triple constraint of project management balancing scope, time, and cost goals and note the order of these items.
- Ideally, the project team and key stakeholders first define the project scope, then the time or schedule for the project, and then the project cost.
- There are **six** main processes involved in project time management:

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1. ***Defining activities*** involves identifying the specific activities that the project team members and stakeholders must perform to produce the project deliverables. An **activity** or **task** is an element of work normally found on the work breakdown structure (WBS) that has an expected duration, a cost, and resource requirements. The main outputs of this process are an activity list,
   activity attributes, and milestone list.
2. ***Sequencing activities*** involves identifying and documenting the relationships between project activities. The main outputs of this process include project schedule network diagrams and project document updates.

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3. Estimating activity resources involves estimating how many **resources** people, equipment, and materials a project team should use to perform project activities. The main outputs of this process are activity resource requirements, a resource breakdown structure, and project document updates.

4. ***Estimating activity durations*** involves estimating the number of work periods that are needed to complete individual activities. Outputs include activity duration estimates and project document updates.

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5. ***Developing the schedule*** involves analyzing activity sequences, activity resource estimates, and activity duration estimates to create the project schedule. Outputs include a project schedule, a schedule baseline, schedule data, and project document updates.

6. *Controlling the schedule* involves controlling and managing changes to the project schedule. Outputs include work performance measurements, organizational process assets updates, change requests, project management plan updates, and project document updates.

Defining Activities

- An activity or task is an element of work normally found on the work breakdown structure (WBS) that has an expected duration, a cost, and resource requirements
- 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 schedules grow out of the basic documents that initiate a project:
- Project charter includes the start and end dates and budget information
- Scope statement and WBS help define what will be done

Activity Sequencing

- Involves reviewing activities and determining dependencies

- **Mandatory dependencies:** inherent in the nature of the work being performed on a project, sometimes referred to as hard logic
  - Example: write code, then test code
- **Discretionary dependencies:** defined by the project team., sometimes referred to as soft logic and should be used with care since they may limit later scheduling options
  - Example: good practice to get sign-offs *before* performing the work
- **External dependencies:** involve relationships between project and non-project activities
  - Example: tasks dependent of delivery of hardware from an outside vendor
  - **You *must* determine dependencies in order to use critical path analysis**

Project Network Diagrams

- Project network diagrams are the preferred technique for showing activity sequencing
- A project network diagram is a schematic display of the logical relationships among, or sequencing of, project activities

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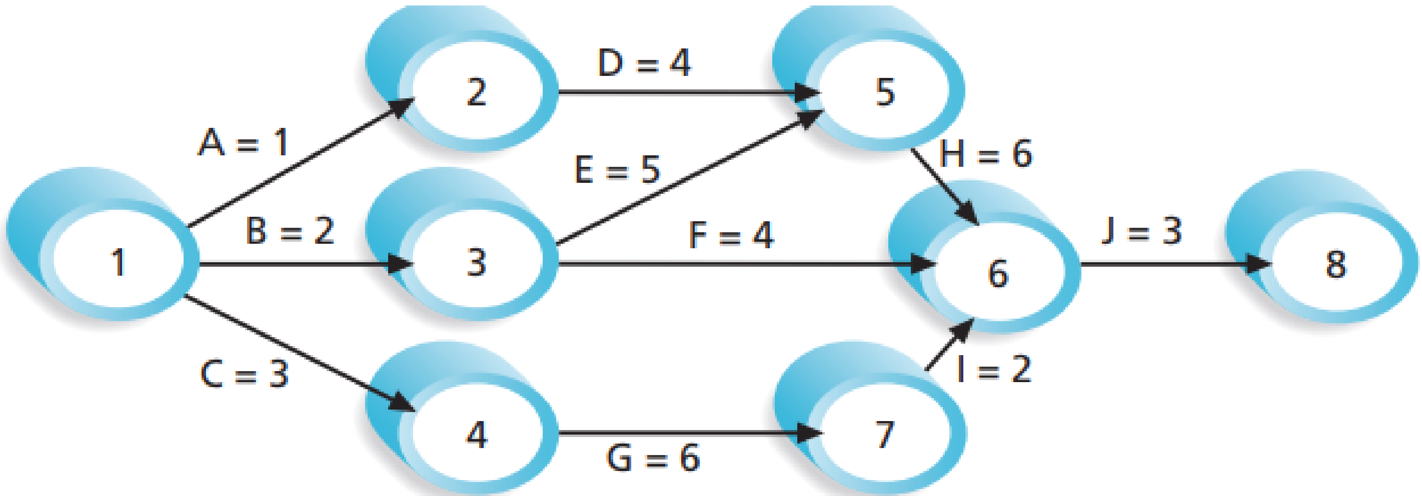

Note: Assume all durations are in days; A=1 means Activity A has a duration of 1 day.

FIGURE 6-2 Activity-on-arrow (AOA) network diagram for Project X

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- The format of this network diagram uses the **activity-on-arrow (AOA)** approach or the **arrow diagramming method (ADM)** a network diagramming technique in which activities are represented by **arrows** and connected at points called nodes to illustrate the sequence of activities.
- Can only show finish-to-start dependencies.
- A **node** is simply the starting and ending point of an activity.
- The first node signifies the start of a project, and the last node represents the end of a project.

Process for Creating AOA Diagrams

1. Find all of the activities that start at node 1. Draw their finish nodes and draw arrows between node 1 and those finish nodes. Put the activity letter or name and duration estimate on the associated arrow.
2. Continuing drawing the network diagram, working from left to right. Look for bursts and merges. A **burst** occurs when a single node is followed by two or more activities. A **merge** occurs when two or more nodes precede a single node.
3. Continue drawing the project network diagram until all activities that have dependencies are included in the diagram.
4. As a rule of thumb, all arrowheads should face toward the right, and no arrows should cross in an AOA network diagram.

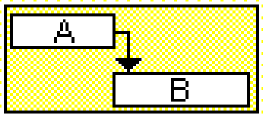
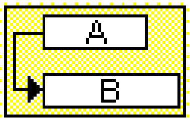
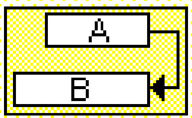
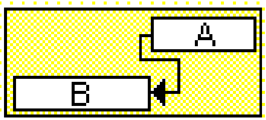
Precedence Diagramming Method (PDM)

- 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.

Figure 6-3 illustrates the types of dependencies that can occur among project activities. After you determine the reason for a dependency between activities (mandatory,

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.

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- The **four types of dependencies** or relationships between activities include:

- **Finish-to-start dependency:** a relationship where the "from" activity or predecessor must finish before the "to" activity or successor can start. For example, you cannot provide user training until after software, or a new system, has been installed. Finish-to-start is the most common type of relationship, or dependency, and AOA network diagrams use only finish-to-start dependencies.
- **Start-to-start dependency:** a relationship in which the "from" activity cannot start until the "to" activity or successor is started. For example, on several information technology projects, a group of activities all start simultaneously, such as the many tasks that occur when a new system goes live.

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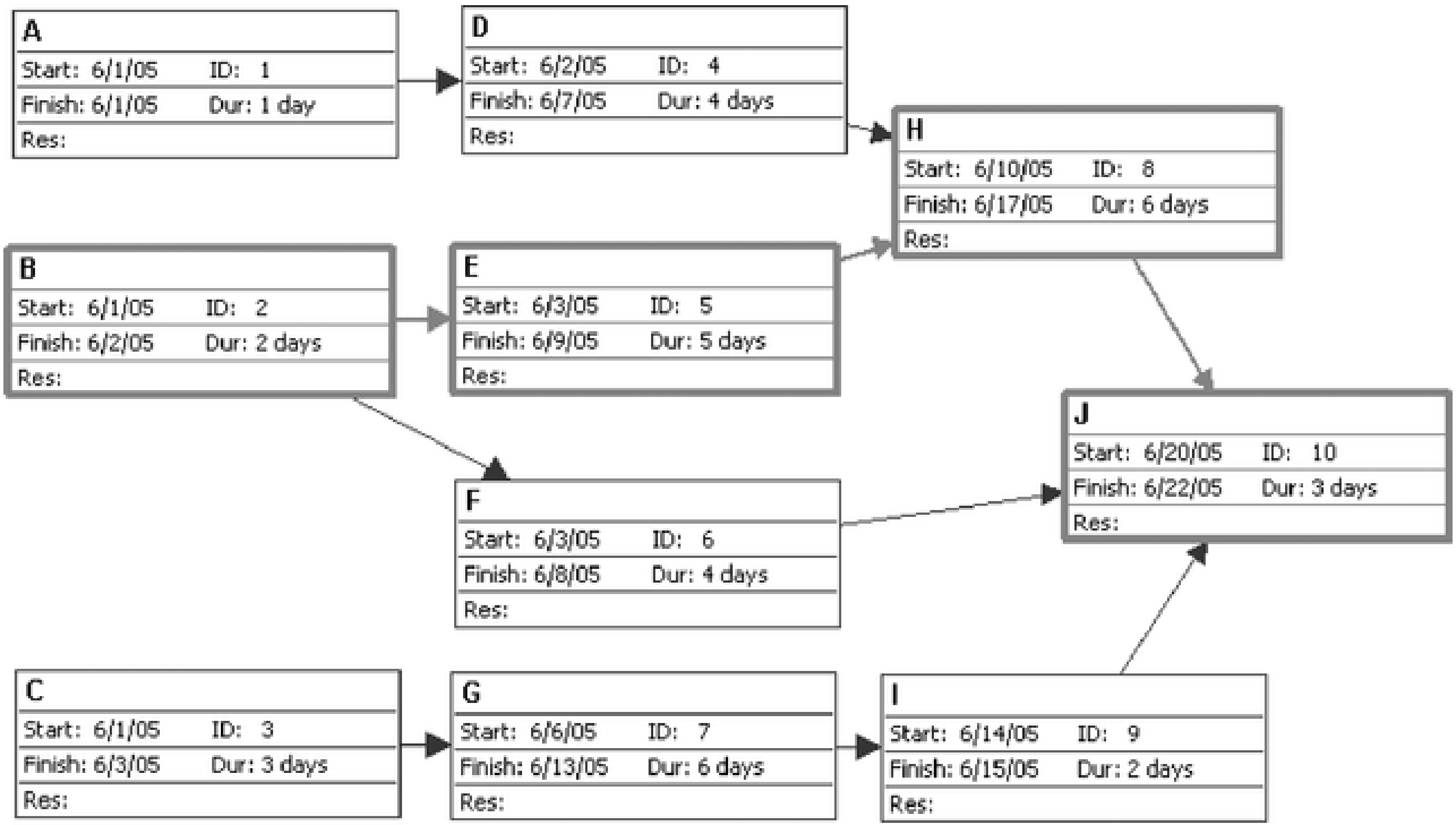
- **Finish-to-finish dependency:** a relationship where the "from" activity must be finished before the "to" activity can be finished. One task cannot finish before another finishes. For example, quality control efforts cannot finish before production finishes, although the two activities can be performed at the same time.
- **Start-to-finish dependency:** a relationship where the "from" activity must start before the "to" activity can be finished. This type of relationship is rarely used, but it is appropriate in some cases. For example, an organization might strive to stock raw materials just in time for the manufacturing process to begin. A delay in the manufacturing process starting should delay completion of stocking the raw materials. Another example would be a babysitter who wants to finish watching a young child but is dependent on the parent arriving. The parent must show up or "start" before the babysitter can finish his or her oversight.

Figure 6-4. Sample PDM Network Diagram



Activity Resource Estimating

- Before estimating activity durations, you must have a good idea of the quantity and type of resources that will be assigned to each activity.
  - **resources** are people, equipment, and materials
- Consider important issues in estimating resources
  - How difficult will it be to do specific activities on this project?
  - Anything unique about the project?
  - What is the organization's history in doing similar activities?
  - Are the required resources available? Level of experience for each person? Can the organization acquire more resources?
- A **resource breakdown structure** is a hierarchical structure that identifies the project's resources by category and type.

Estimating Activity Durations

- **Duration** includes the actual amount of time worked on an activity *plus* the elapsed time.
- **Effort** is the number of workdays or work hours required to complete a task.
- Effort does not normally equal duration.
- People doing the work should help create estimates, and an expert should review them.

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- Instead of providing activity estimates as a discrete number, such as four weeks, it's often helpful to create a **three-point estimate**
  - an estimate that includes an **optimistic**, **most likely**, and **pessimistic** estimate, such as three weeks for the optimistic, four weeks for the most likely, and five weeks for the pessimistic estimate

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- The **optimistic** estimate is based on a **best-case scenario**, while
- the **pessimistic** estimate is based on a **worst-case scenario**.
- The **most likely** estimate, as it sounds, is an estimate based on a most likely or **expected** scenario.
- Three-point estimates are needed for PERT and Monte Carlo simulations

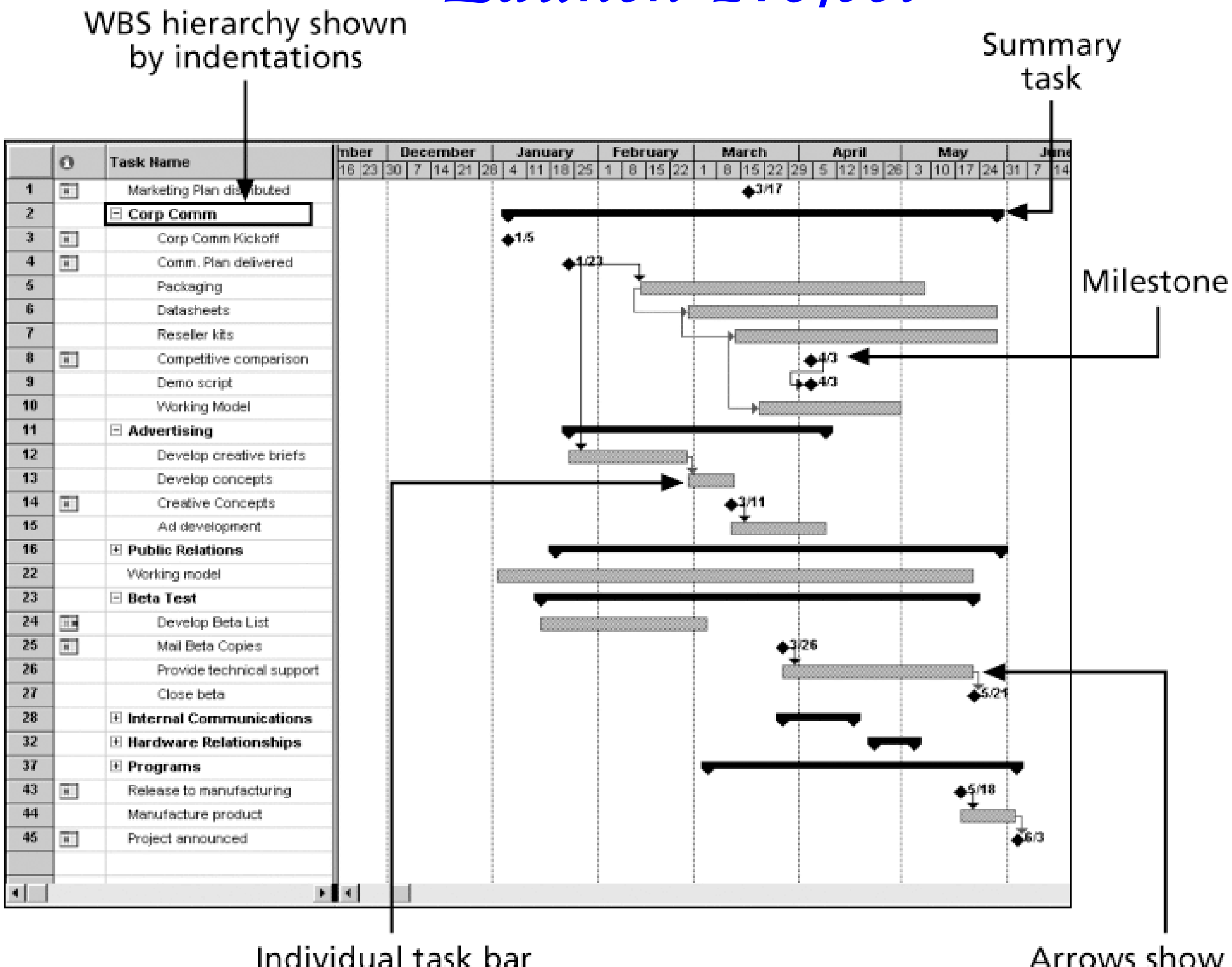
Developing the Schedule

- Uses results of the other time management processes to determine the start and end date of the project
- Ultimate goal is to create a <u>realistic</u> project schedule that provides a basis for monitoring project progress for the time dimension of the project
- **Important tools and techniques**:
  - Gantt charts
  - Critical path analysis
  - Critical chain scheduling
  - PERT analysis

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:
  - A black diamond: a milestones
  - Thick black bars: summary tasks
  - Lighter horizontal bars: durations of tasks
  - Arrows: dependencies between tasks

Figure 6-6. Gantt Chart for Software Launch Project



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

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- To make milestones meaningful, some people use the SMART criteria to help define them.
  - The **SMART criteria** are guidelines suggesting that milestones should be:
    Specific
  - **M**easurable
  - **A**ssignable
  - **R**ealistic
  - **T**ime-framed

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- For example, **distributing a marketing plan** is specific, measurable, and assignable if everyone knows what should be in the marketing plan, how it should be distributed, how many copies should be distributed and to whom, and who is responsible for the actual delivery.
- Distributing the marketing plan is realistic and able to be time-framed **if it is an achievable event and scheduled at an appropriate time.**

Best Practice

- Schedule risk is inherent in the development of complex systems. Luc Richard, the founder of www.projectmangler.com, suggests that project managers can reduce schedule risk through project milestones, a best practice that involves identifying and tracking significant points or achievements in the project. The five key points of using project milestones include the following:
  1. Define milestones early in the project and include them in the Gantt chart to provide a visual guide
  2. Keep milestones small and frequent
  3. The set of milestones must be all-encompassing
  4. Each milestone must be binary, meaning it is either complete or incomplete.
  5. Carefully monitor the critical path

Figure 6-7 shows a Tracking Gantt chart

- **Tracking Gantt chart** a Gantt chart that compares planned and actual project schedule information.
- The planned schedule dates for activities are called the **baseline dates**, and the entire approved planned schedule is called the **schedule baseline**.
- The Tracking Gantt chart includes columns (hidden in Figure 6-7) labeled Start and Finish to represent actual start and finish dates for each task, as well as columns labeled Baseline Start and Baseline Finish to represent planned start and finish dates for each task. In this example, the project is completed, but several tasks missed their planned start and finish dates

Figure 6-7 shows a Tracking Gantt chart

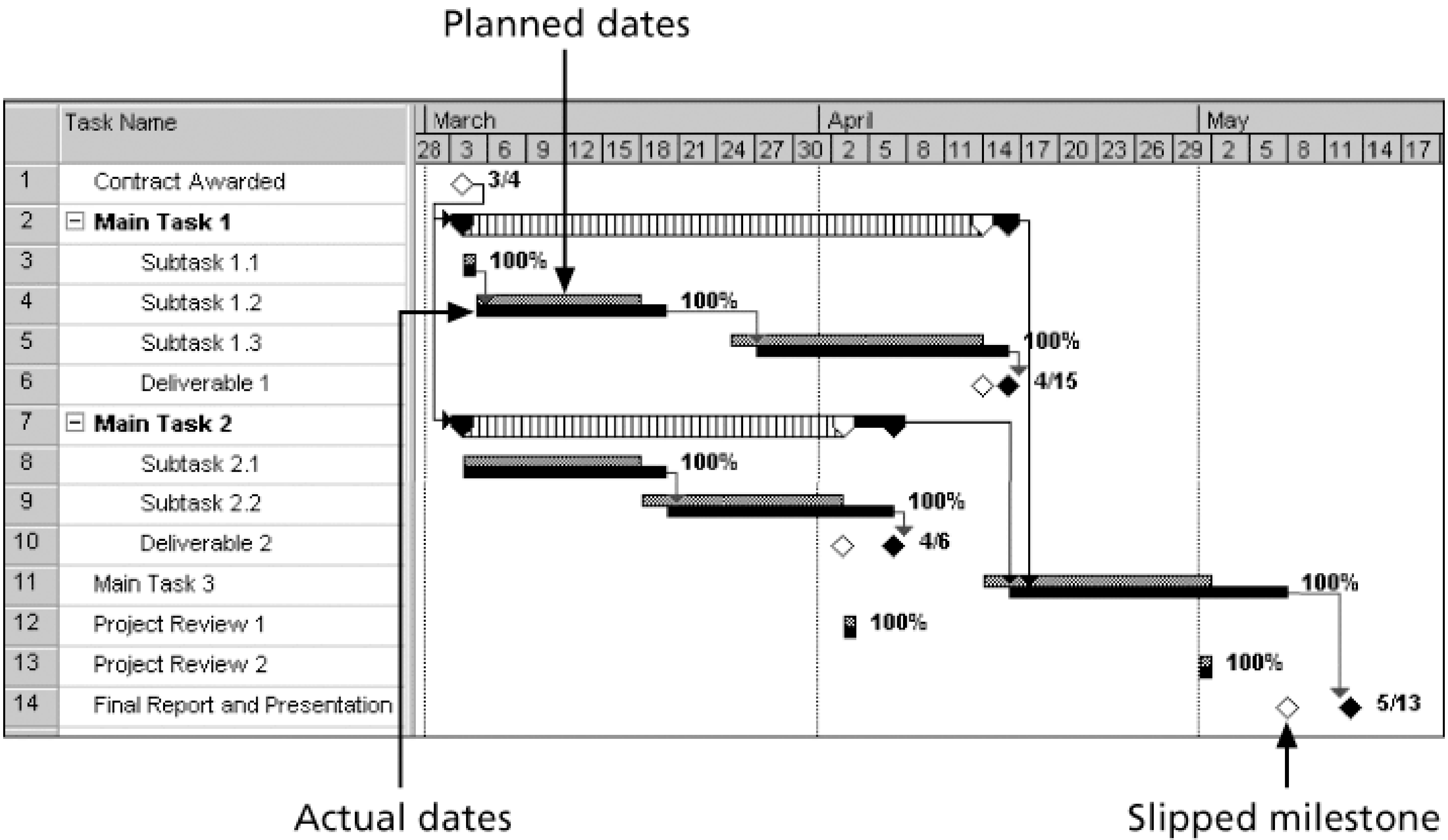


Figure 6-7 shows a Tracking Gantt chart

- Notice that the Gantt chart in Figure 6-7 often shows two horizontal bars for tasks. The top horizontal bar represents the planned or baseline duration for each task. The bar below it represents the actual duration. Subtasks 1.2 and 1.3 illustrate this type of display.
- A white diamond on the Tracking Gantt chart represents a **slipped milestone**. A slipped milestone means the milestone activity was actually completed later than originally planned. For example, the last task provides an example of a slipped milestone since the final report and presentation were completed later than planned. Percentages to the right of the horizontal bars display the percentage of work completed for each task. For example, 100 percent means the task is finished, 50 percent means the task is still in progress and is 50 percent completed.

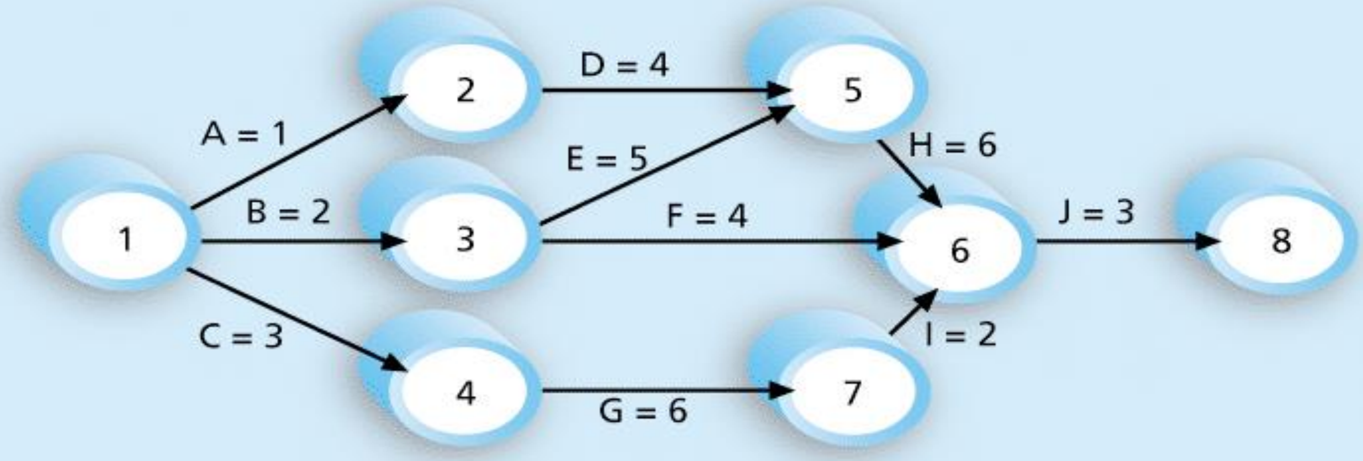
Critical Path Method (CPM)

- **CPM** is a network diagramming technique used to predict total project duration
- A **critical path** for a project is the series of activities that determines the ***earliest time*** by which the project can be completed
- The critical path is the ***longest path*** through the network diagram and has the least amount of slack or float
- **Slack** or **float** is the amount of time an activity may be delayed without delaying a succeeding activity or the project finish date

Calculating the Critical Path

- First develop a good network diagram
- Add the duration estimates for all activities on each path through the network diagram
- The **longest path is the critical path**
- If one or more of the activities on the critical path takes longer than planned, the whole project schedule will slip *unless* the project manager takes corrective action

Figure 6-8. 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.

Using Critical Path Analysis to Make Schedule Trade-offs

- **Free slack** or **free float** is the amount of time an activity can be delayed without delaying the early start of any immediately following activities
- **Total slack** or **total float** is the amount of time an activity may be delayed from its early start without delaying the planned project finish date
- A **forward pass** through the network diagram determines the early start and finish dates
- A **backward pass** determines the late start and finish dates

Scheduling with activity time

Activity	Immediate predecessors	Completion Time (week)
A	-	5
B	-	6
C	A	4
D	A	3
E	A	1
F	E	4
G	D,F	14
H	B,C	12
I	G,H	2
	Total ……	51

This information indicates that the total time required to complete activities is 51 weeks. However, we can see from the network that several of the activities can be conducted simultaneously (A and B, for example).

Earliest start & earliest finish time

- We are interested in the longest path through the network, i.e., the critical path.

- Starting at the network's origin (node 1) and using a starting time of 0, we compute an ***earliest start*** (ES) and ***earliest finish*** (EF) time for each activity in the network.

- The expression EF = ES + t can be used to find the earliest finish time for a given activity.

  For example, for activity A, ES = 0 and t = 5; thus the earliest finish time for activity A is

$$EF = 0 + 5 = 5$$

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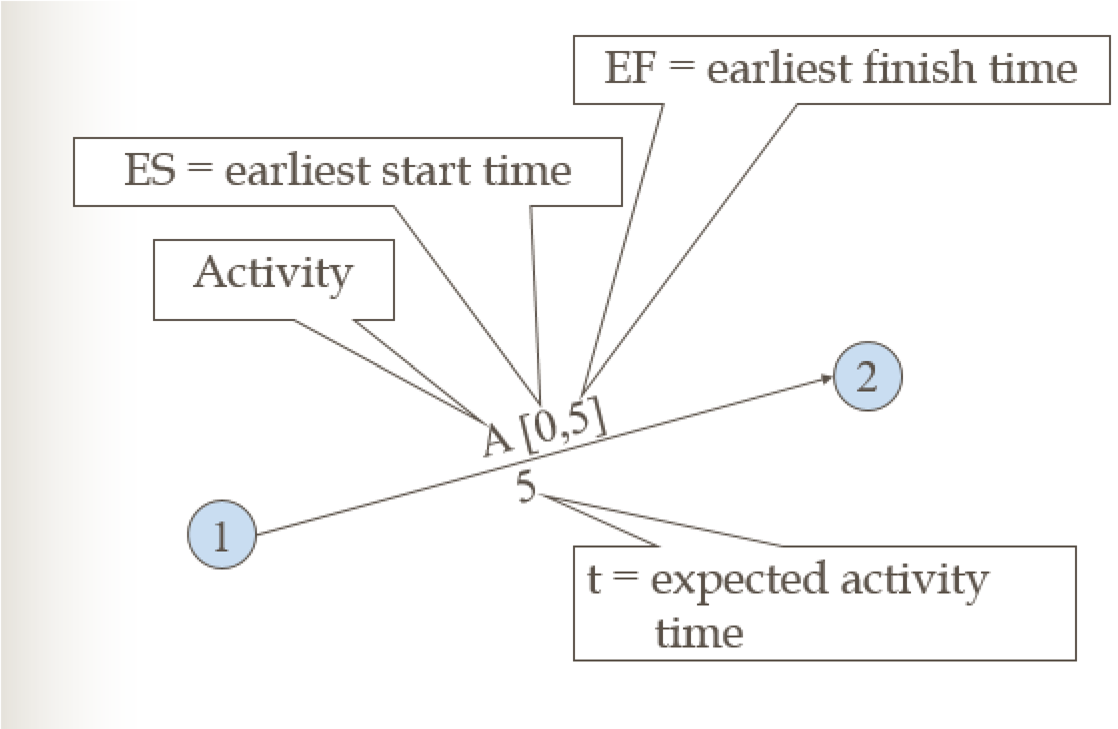
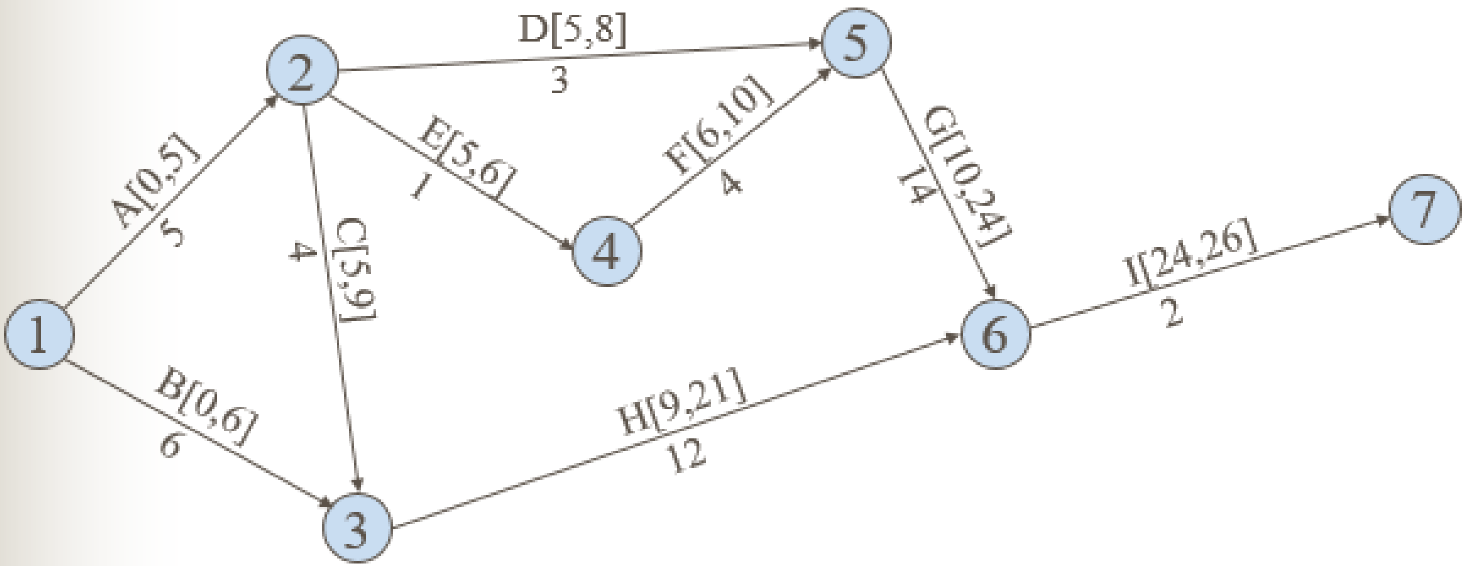


EF = earliest finish time
ES = earliest start time
Activity
A [0,5]
2
5
1
t = expected activity time

Cont'd

Network with ES & EF time



<u>Earliest start time rule</u>:

The earliest start time for an activity leaving a particular node is equal to the **largest** of the earliest finish times for all activities entering the node.

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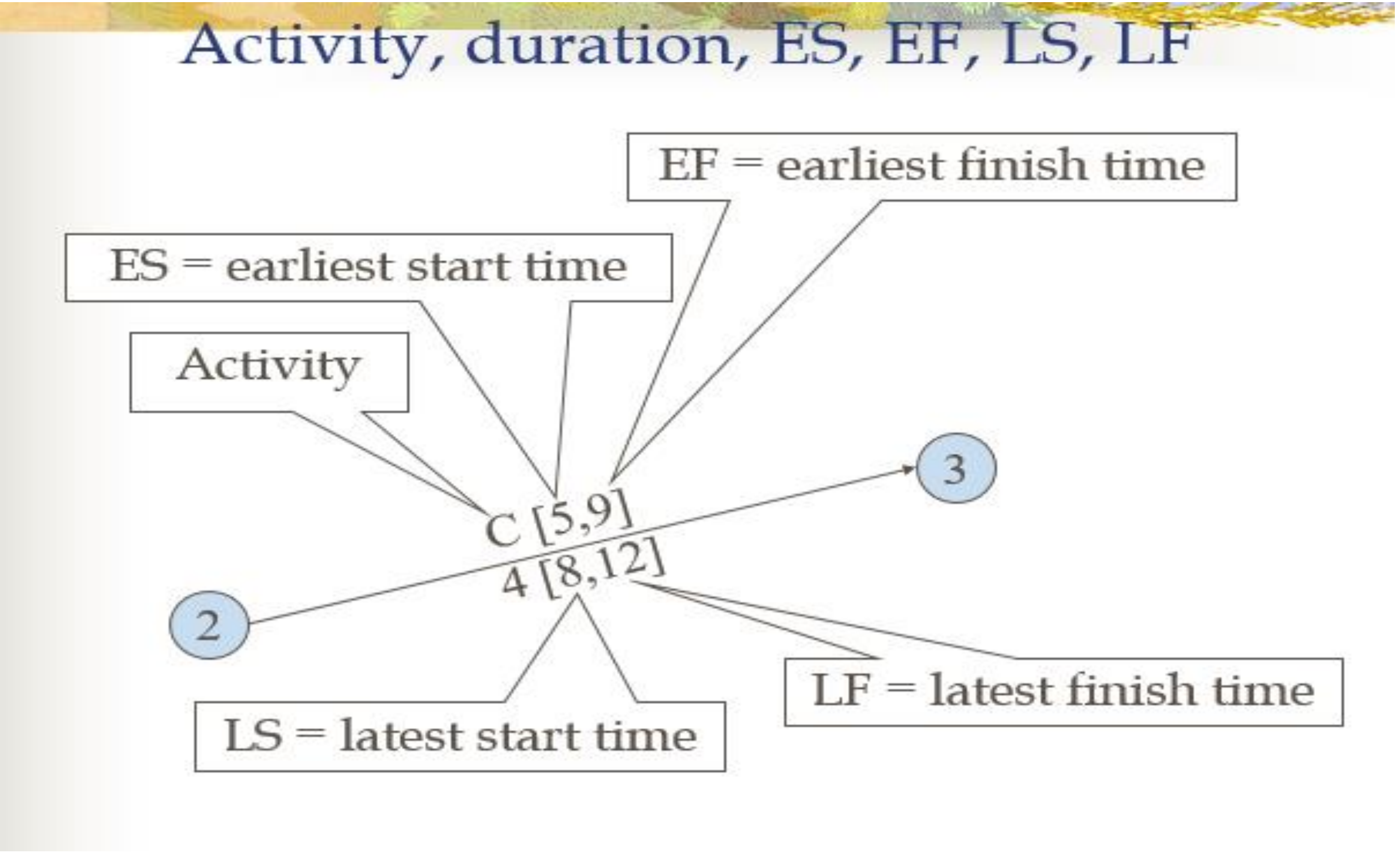
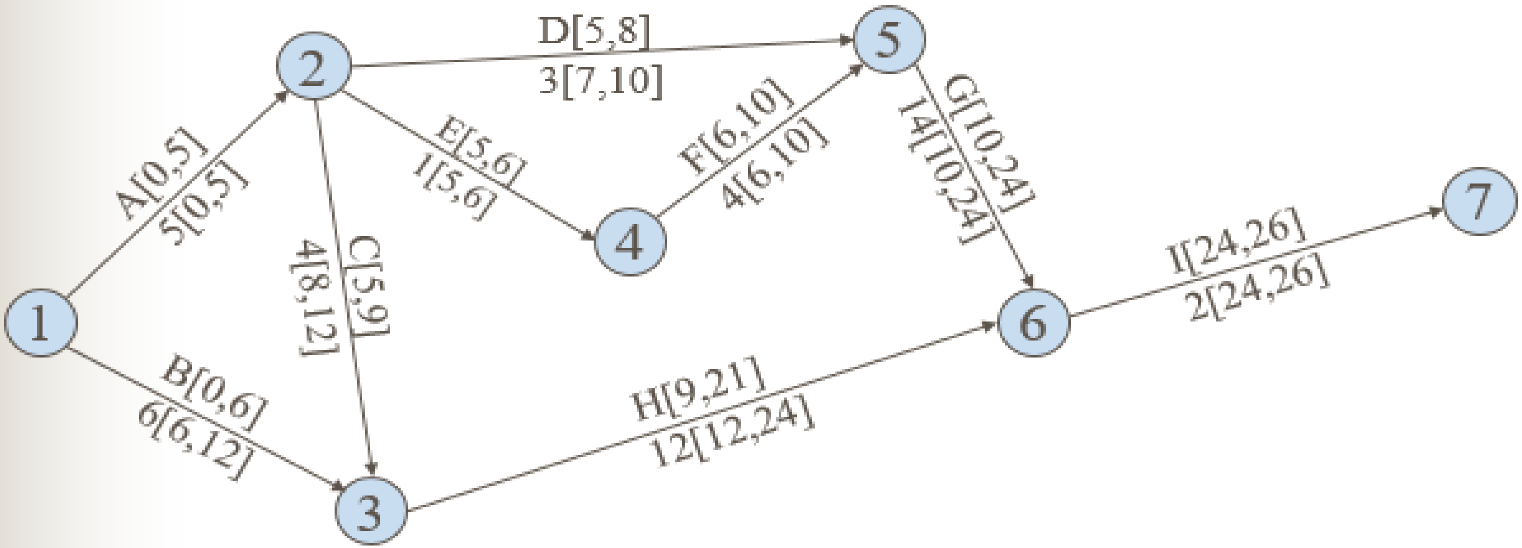


Activity, duration, ES, EF, LS, LF
EF = earliest finish time
ES = earliest start time
Activity
3
C [5,9]
4 [8,12]
2
LF = latest finish time
LS = latest start time

Cont'd

Network with LS & LF time



Latest finish time rule:

The latest finish time for an activity entering a particular node is equal to the **smallest** of the latest start times for all activities leaving the node.

Latest start & latest finish time

- To find the critical path we need a backward pass calculation.
- Starting at the completion point (node 7) and using a ***latest finish*** time (LF) of 26 for activity I, we trace back through the network computing a ***latest start*** (LS) and latest finish time for each activity
- The expression **LS = LF – t** can be used to calculate latest start time for each activity. For example, for activity I, LF = 26 and t = 2, thus the latest start time for activity I is

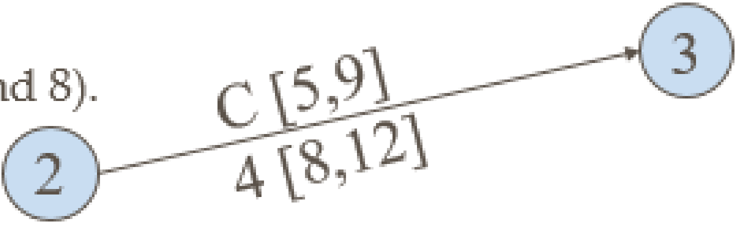
$$LS = 26 - 2 = 24$$

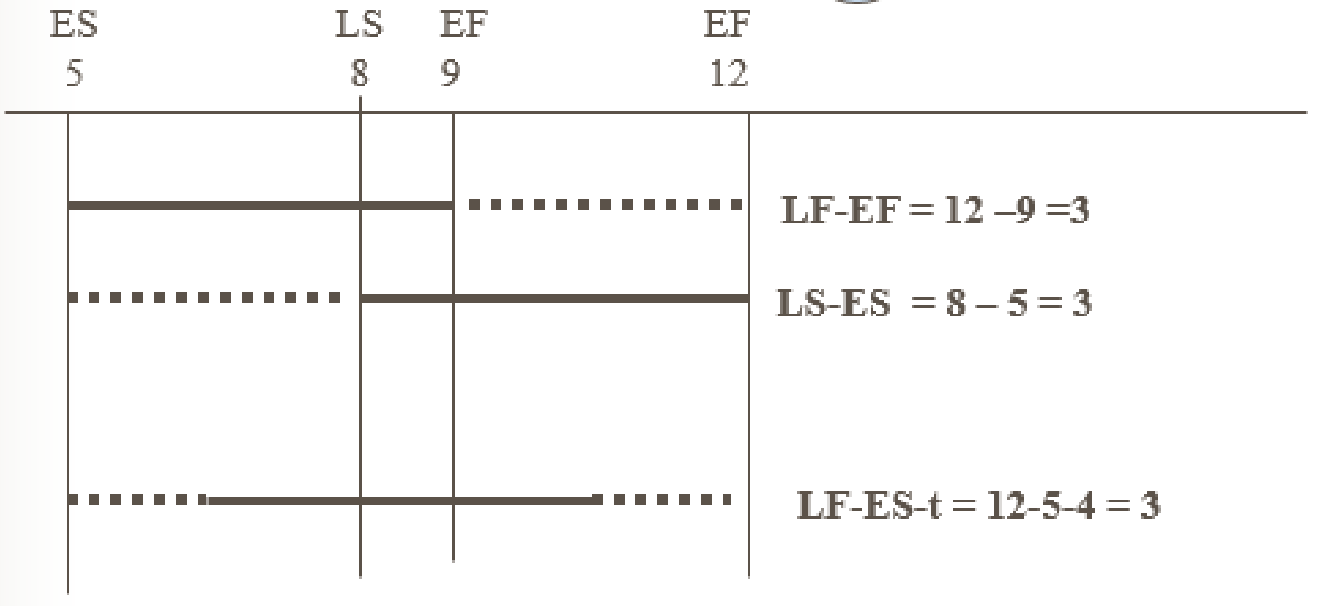
Slack or Free Time or Float

Slack is the length of time an activity can be delayed without affecting the completion date for the entire project.

For example, slack for C = 3 weeks, i.e Activity C can be delayed up to 3 weeks

(start anywhere between weeks 5 and 8).





Activity schedule for our example

Activity	Earliest start (ES)	Latest start (LS)	Earliest finish (EF)	Latest finish (LF)	Slack (LS-ES)	Critical path
A	0	0	5	5	0	Yes
B	0	6	6	12	6	
C	5	8	9	12	3	
D	5	7	8	10	2	
E	5	5	6	6	0	Yes
F	6	6	10	10	0	Yes
G	10	10	24	24	0	Yes
H	9	12	21	24	3	
I	24	24	26	26	0	Yes

IMPORTANT QUESTIONS

- **What is the total time to complete the project?**
  - 26 weeks if the individual activities are completed on schedule.

- **What are the scheduled start and completion times for each activity?**
  - ES, EF, LS, LF are given for each activity.

- **What activities are *critical* and must be completed as scheduled in order to keep the project on time?**
  - Critical path activities: A, E, F, G, and I.

- **How long can *non-critical* activities be delayed before they cause a delay in the project's completion time**
  - Slack time available for all activities are given.

Figure 6-9. Calculating Early and Late Start and Finish Dates

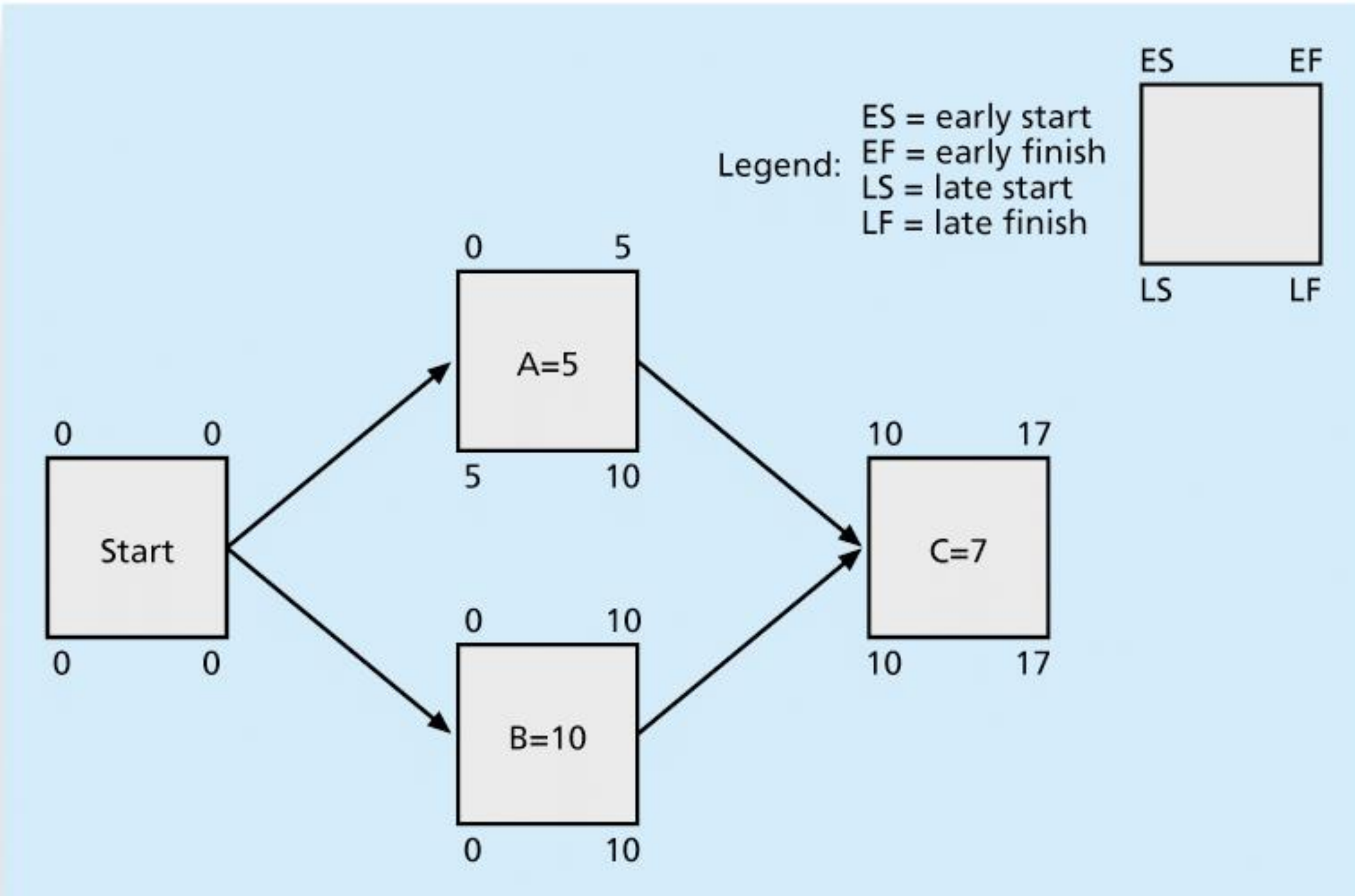
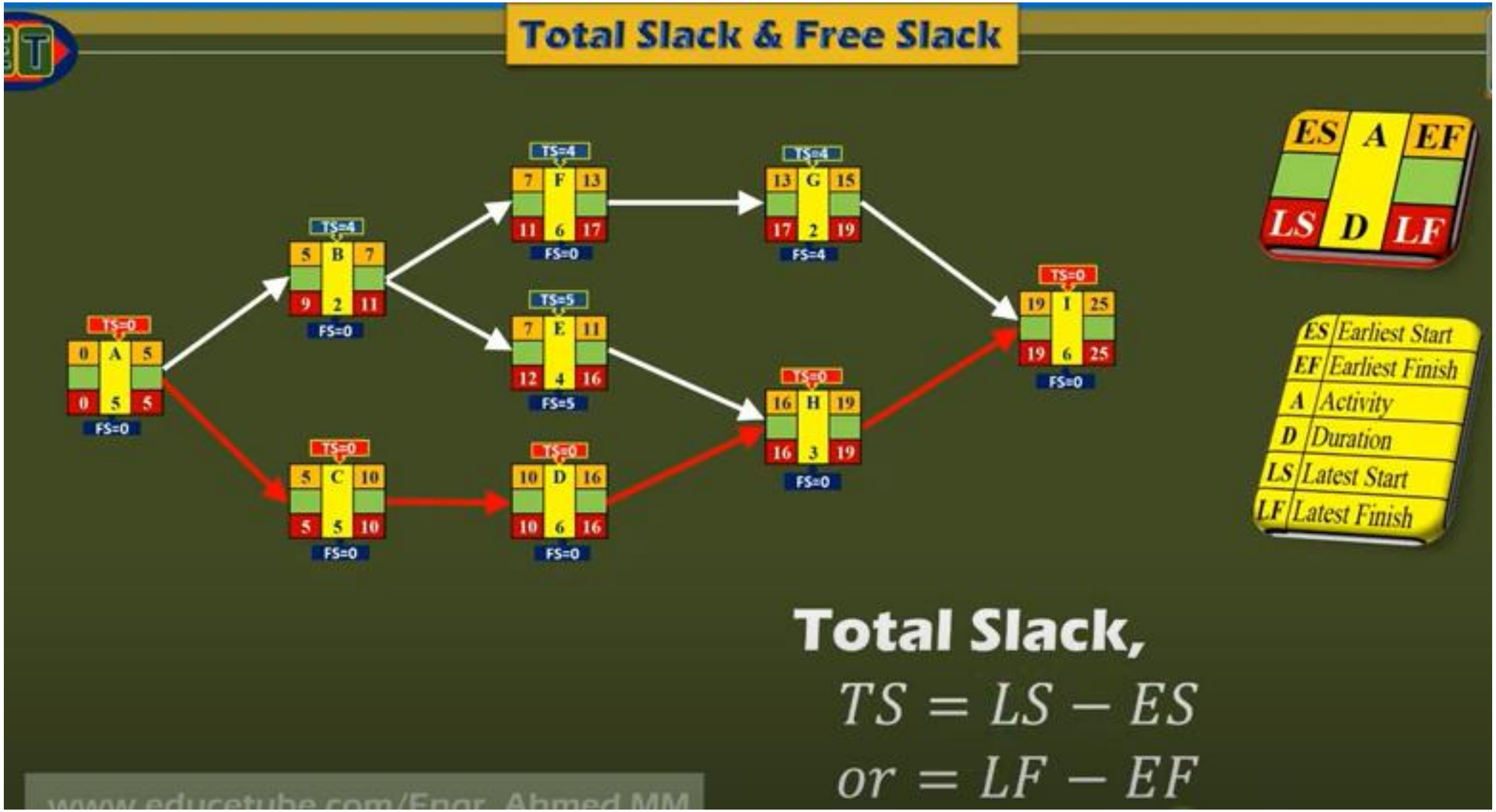


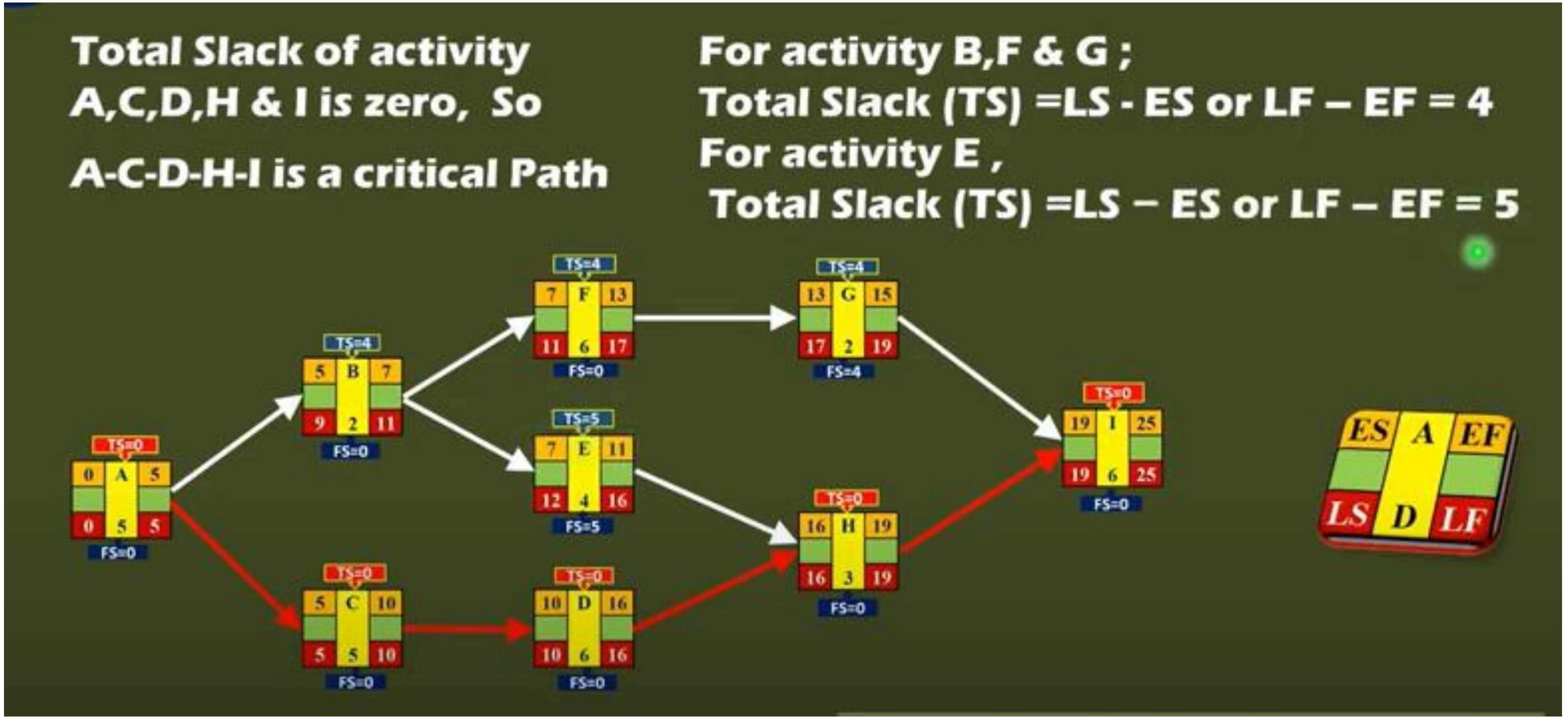
Table 6-1. Free and Total Float or Slack for Project X

Task Name	Start	Finish	Late Start	Late Finish	Free Slack	Total Slack
A	8/3/09	8/3/09	8/5/09	8/5/09	0d	2d
B	8/3/09	8/4/09	8/3/09	8/4/09	0d	0d
C	8/3/09	8/5/09	8/5/09	8/7/09	0d	2d
D	8/4/09	8/7/09	8/6/09	8/11/09	2d	2d
E	8/5/09	8/11/09	8/5/09	8/11/09	0d	0d
F	8/5/09	8/10/09	8/14/09	8/17/09	7d	7d
G	8/6/09	8/13/09	8/10/09	8/17/09	0d	2d
H	8/12/09	8/19/09	8/12/09	8/19/09	0d	0d
I	8/14/09	8/17/09	8/18/09	8/19/09	2d	2d
J	8/20/09	8/24/09	8/20/09	8/24/09	0d	0d

Additional example to calculate free slack and total slack



Additional example to calculate free slack and total slack



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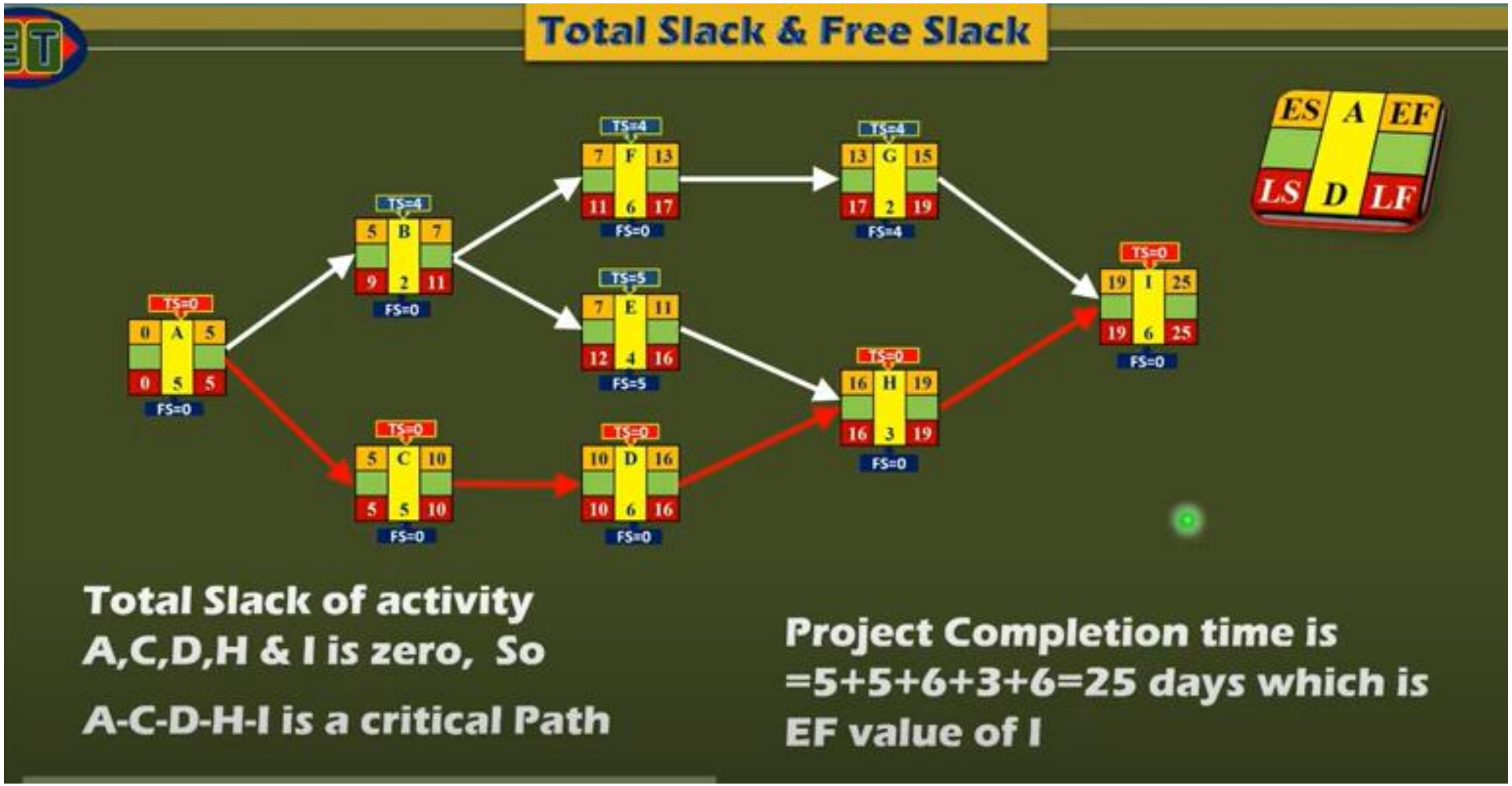

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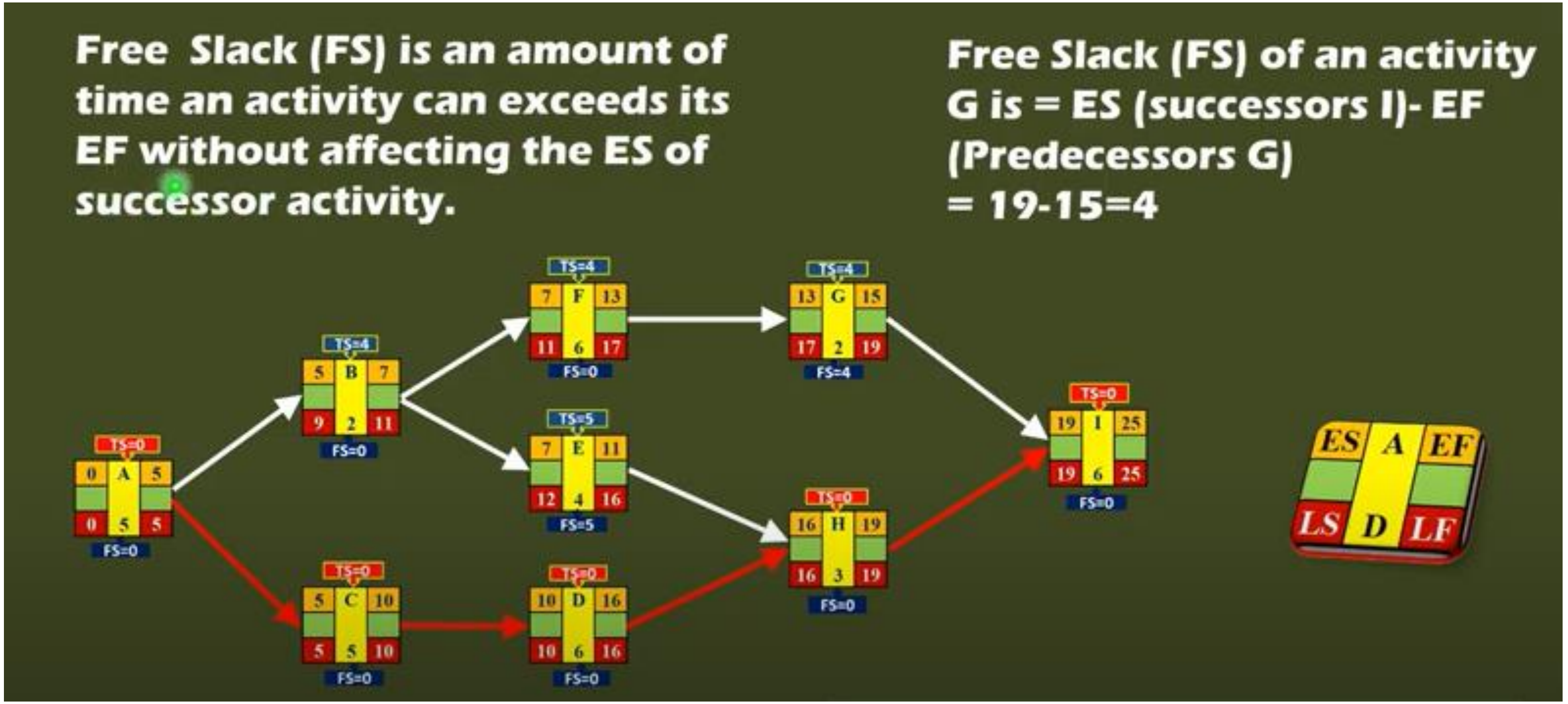
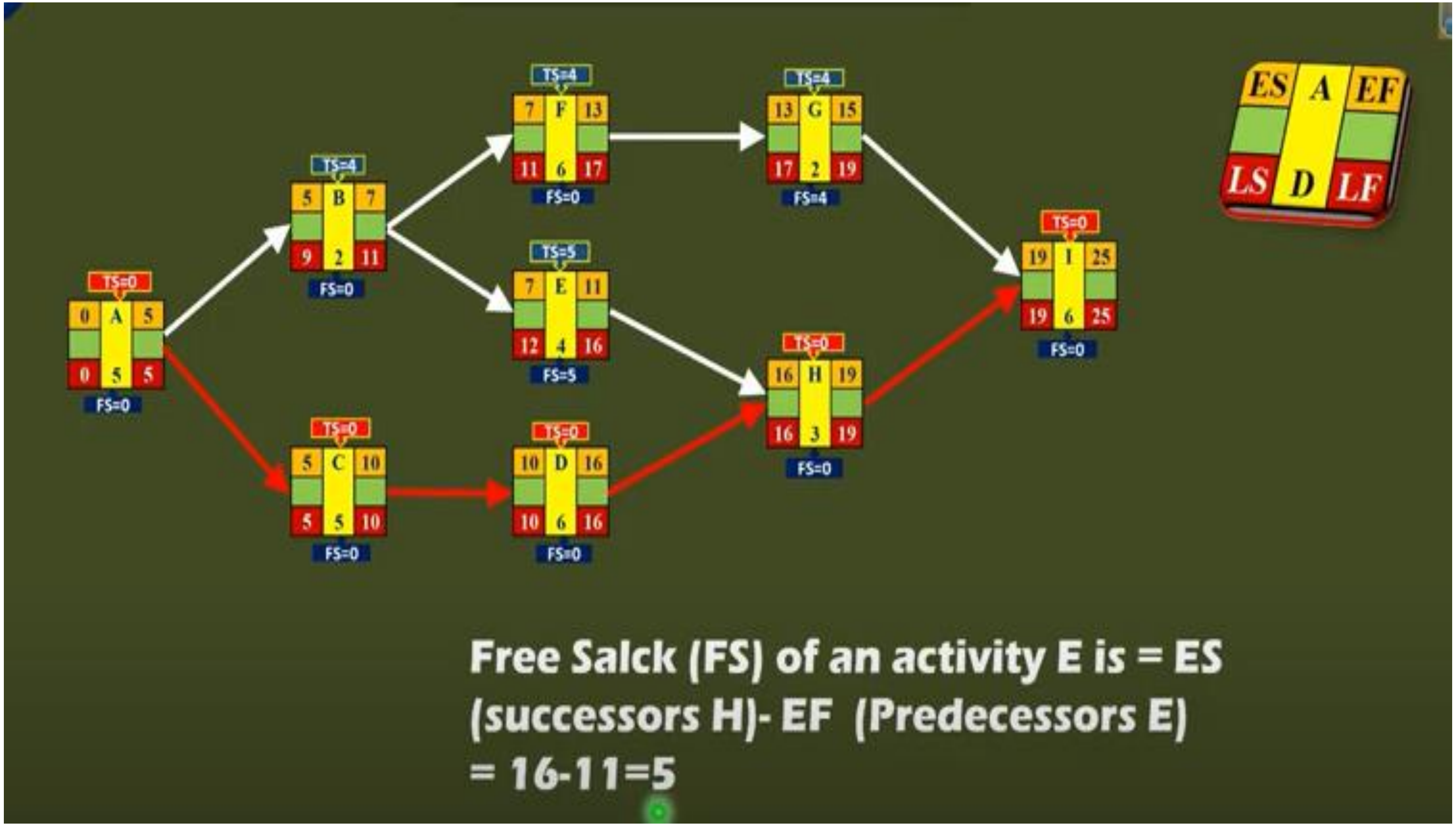


Additional example to calculate free slack and total slack



Importance of Float (Slack) and Critical Path

1. Slack or Float shows how much allowance each activity has, i.e how long it can be delayed without affecting completion date of project

2. Critical path is a sequence of activities from start to finish with zero slack. Critical activities are activities on the critical path.

3. Critical path identifies the minimum time to complete project

4. If any activity on the critical path is shortened or extended, project time will be shortened or extended accordingly

Importance of Float (Slack) and Critical Path

5. So, a lot of effort should be put in trying to control activities along this path, so that project can meet due date. If any activity is lengthened, be aware that project will not meet deadline and some action needs to be taken.

6. If can spend resources to speed up some activity, do so only for critical activities.

7. Don't waste resources on non-critical activity, it will not shorten the project time.

8. If resources can be saved by lengthening some activities, do so for non-critical activities, up to limit of float.

9. Total Float belongs to the path

Using the Critical Path to Shorten a Project Schedule

- Three main techniques for shortening schedules
  - Shortening durations of critical activities/tasks by **adding more resources** or changing their scope

  1. Crashing activities by obtaining the greatest amount of schedule compression for the least incremental cost

    - Results: shortens time, but increases costs

  2. Fast tracking activities by doing them in parallel or overlapping them

    - Disadvantage can end up lengthening the project due to the increased risks and sometimes results in rework

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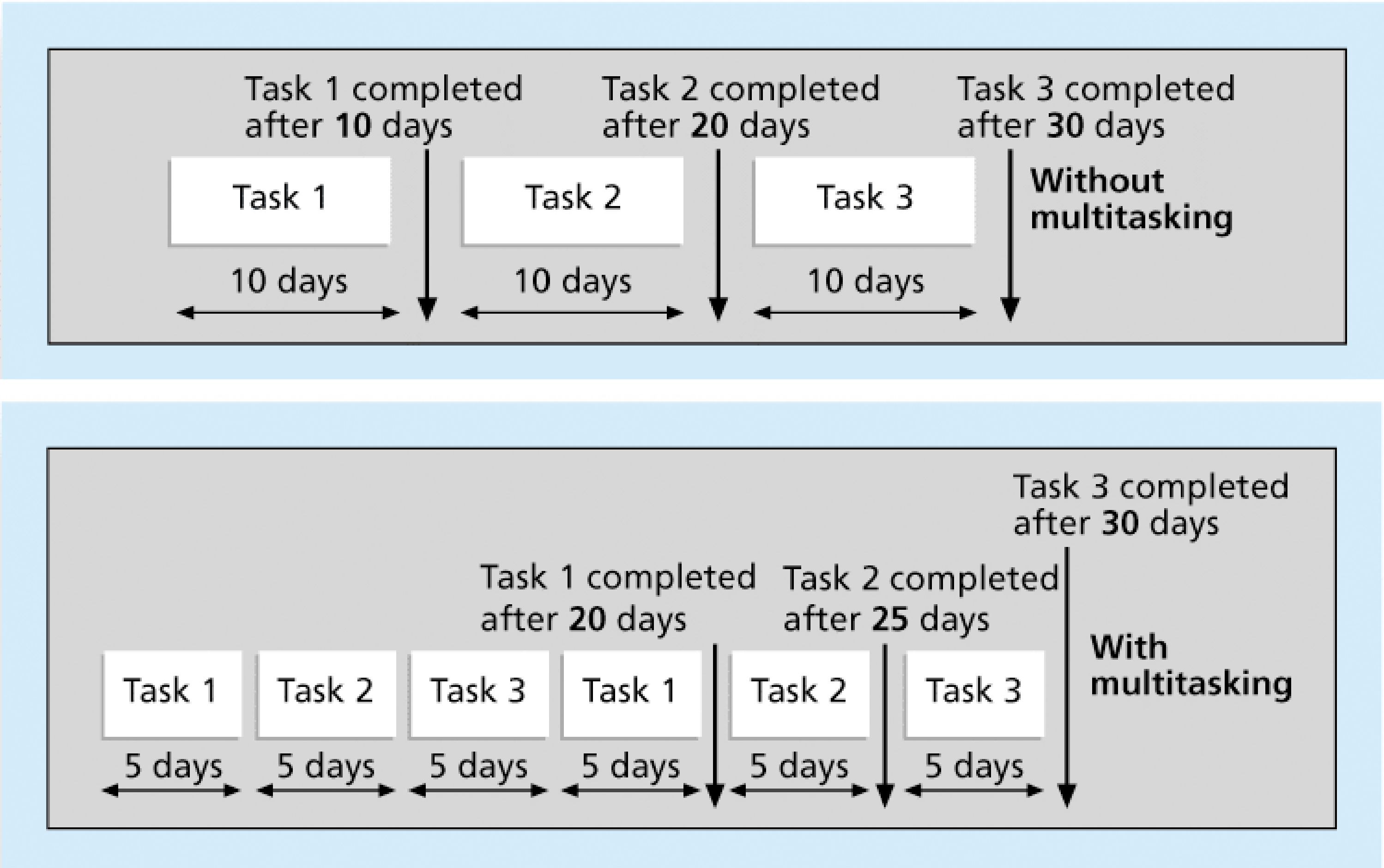
➢ *Importance of Updating Critical Path DataImportance of Updating Critical Path Data*

- It is important to update project schedule information to meet time goals for a project
- The critical path may change as you enter actual start and finish dates
- If you know the project completion date will slip, **negotiate** with the project sponsor
  - Ask for more time
  - Ask for more resources/money to stay on track
  - Ask to reduce scope

cont'd

- **3. 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
- Uses the **Theory of Constraints (TOC)**
  - A management philosophy developed by Eliyahu M. Goldratt and introduced in his book *The Goal*
- Attempts to minimize **multitasking**
  - When a resource works on more than one task at a time
  - Due to the nature of starting/stopping tasks it may take even longer
  - See chart on next page
- Uses limited time buffers

Figures 6-10.a and b. Multitasking Example



Cont'd

➢ *Buffers and Critical Chain*

- A **buffer** is additional time to complete a task
- **Murphy's Law** states that if something can go wrong, it will
- **Parkinson's Law** states that work expands to fill the time allowed
- In traditional estimates, people often add a buffer to each task and use it if it's needed or not
- Critical chain scheduling removes buffers from individual tasks and instead creates
  - a **project buffer** or additional time added before the project's due date
  - **feeding buffers** or additional time added before tasks on the critical path

Program Evaluation and Review Technique (PERT) For Dealing With Uncertainty

- So far, times can be estimated with relative certainty, confidence
- For many situations this is not possible, e.g Research, development, new products and projects etc.
- Use 3 time estimates

  m= most likely time estimate, mode.

  a = optimistic time estimate,

  b = pessimistic time estimate, and

Expected Value (TE) = (a + 4m + b) /6

PERT For Dealing With Uncertainty

- **Advantage:** he main advantage of PERT is that it attempts to address the risk associated with duration estimates.
- **Disadvantage**: takes time to do the calculations

PERT Formula and Example

- PERT weighted average **=**

$$\text{PERT weighted average} = \frac{\text{optimistic time} + 4X\ \text{most likely time} + \text{pessimistic time}}{6}$$

- Example:

PERT weighted average =

$$\frac{8\ \text{workdays} + 4\ X\ 10\ \text{workdays} + 24\ \text{workdays}}{6} = \mathbf{12\ days}$$

where optimistic time = 8 days

most likely time = **10 days**, and

pessimistic time = 24 days

➢ Instead of using the most likely duration estimate of 10 workdays, the project team would use 12 workdays when doing critical path analysis. for the above example.

Schedule Control Suggestions

- Perform reality checks on schedules
- Allow for contingencies
- Don’t plan for everyone to work at 100% capacity all the time
  - There are things a person does in their work day:
    - Meetings
    - Email
    - Talking with the boss
    - At Toyota in our plans we used 6 hour days allowing for 2 hours of the other stuff
- Hold progress meetings with stakeholders and be clear and honest in communicating schedule issues

Controlling the Schedule

- Goals are to know the status of the schedule, influence factors that cause schedule changes, determine that the schedule has changed, and manage changes when they occur
- Tools and techniques include
  - Progress reports
  - A schedule change control system
  - Project management software, including schedule comparison charts like the tracking Gantt chart
  - Variance analysis, such as analyzing float or slack
  - Performance management, such as earned value (chapter 7)

Reality Checks on Scheduling

- First review the draft schedule or estimated completion date in the project charter
- Prepare a more detailed schedule with the project team (people who do the work)
- Get stakeholders' approval
- Make sure the schedule is realistic and followed
- Allow for contingencies throughout the life of the project
- Alert top management well in advance if there are schedule problems

Reality Checks on Scheduling

- Be proactive in managing stakeholder expectations
- Verify actual work performed, not just what people report
  - How? Ask a person who is dependent on the other person's work.
- Be honest – top management hate surprises
- Keep firm dates for key project milestones
- Avoid scope creep by managing change control