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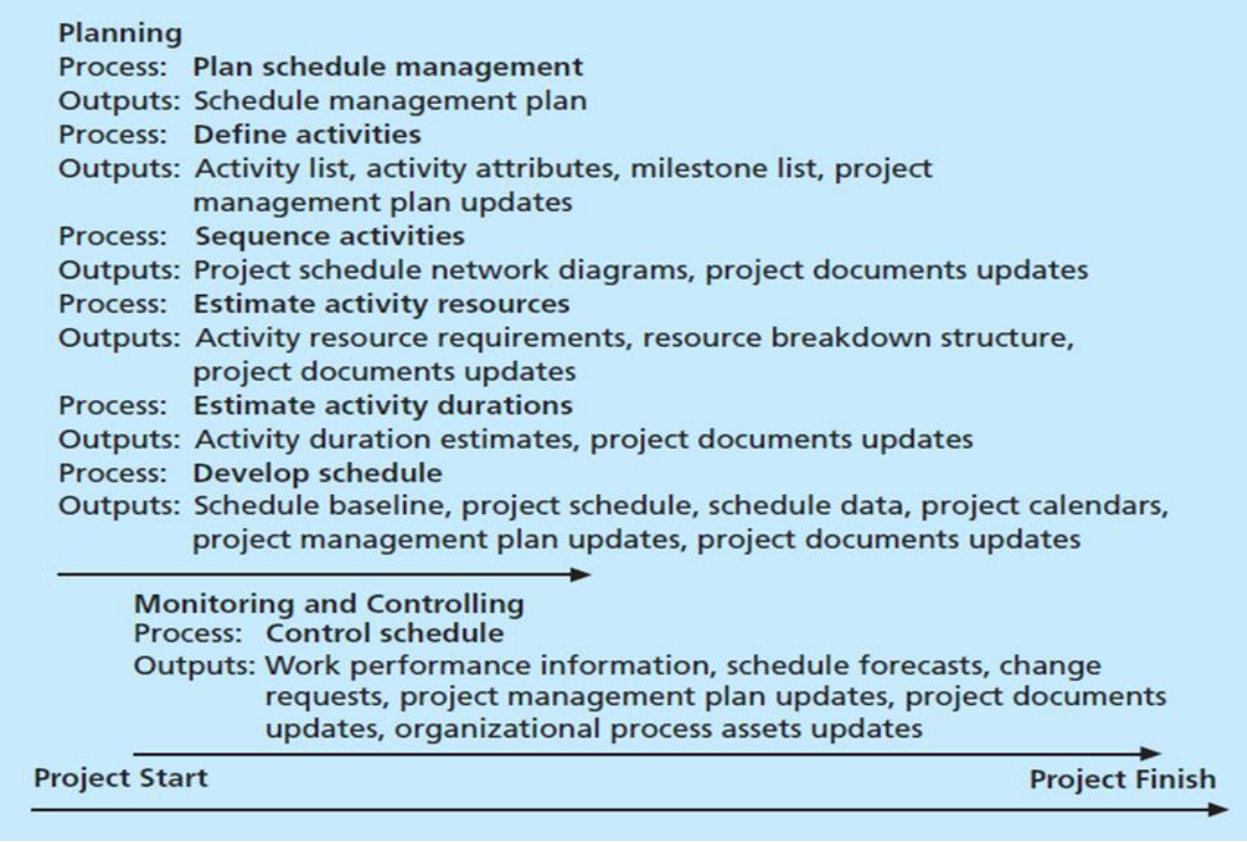
Project schedule management

Managers often cite the need to deliver projects on time as one of their biggest challenges and the main cause of conflict. Time has the least amount of flexibility; it passes no matter what happens on a project. Project schedule management, involves the processes required to ensure timely completion of a project. Six main processes are involved in project schedule management:

1. **Planning schedule management** involves determining the policies, procedures, and documentation that will be used for planning, executing, and controlling the project schedule.
2. **Defining activities** involves identifying the specific activities that the project team members and stakeholders must perform to produce the project deliverables.
3. **Sequencing activities** involves identifying and documenting the relationships between project activities. Requirements, a resource breakdown structure, and project documents updates.
4. **Estimating activity durations** involves estimating the number of work periods that are needed to complete individual activities.
5. **Developing the schedule** involves analyzing activity sequences, resource requirements, and activity duration estimates to create the project schedule.
6. **Controlling the schedule** involves controlling and managing changes to the project schedule.



Planning Schedule Management

- Planning how the schedule will be managed throughout the life of the project
- The project charter often mentions planned project start and end dates, which serve as the starting points for a more detailed schedule
- Inputs are project management plan, project charter, enterprise environmental factors, and organizational process assets
- Tools used are expert judgment, analytical techniques, and meetings
- Output: Schedule management plan
- A schedule management plan includes:
  - Project schedule model development
  - Level of accuracy and units of measure
  - Control thresholds
  - Rules of performance measurement
  - Reporting formats
  - Process descriptions
- **Project schedule model development**: Many projects include a schedule model, which contains project activities with estimated durations, dependencies, and other planning information that can be used to produce a project schedule.
- **Level of accuracy and units of measure**: This section discusses how accurate schedule estimates should be and determines whether time is measured in hours, days, or another unit.
- **Control thresholds**: Variance thresholds, such as ±10 percent, are established for monitoring schedule performance.
- **Rules of performance measurement:** For example, if team members are expected to track the percentage of work completed, this section specifies how to determine the percentages.
- **Reporting formats:** This section describes the format and frequency of schedule reports required for the project.
- **Process descriptions:** The schedule management plan also describes how all of the schedule management processes will be performed.

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. The project team reviews the schedule management plan, scope baseline, enterprise environmental factors, and organizational process assets to begin defining activities. Outputs of this process include an activity list, activity attributes, a milestone list, and project management plan updates.

- 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 of the activity
- **Activity attributes** provide more information such as predecessors, successors, logical relationships, leads and lags, resource requirements, constraints, imposed dates, and assumptions related to the activity
- A **milestone:**
    - **It** is a significant event that normally has no duration
    - 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
- Activity information is a required input to the other time management processes. You cannot determine activity sequencing, resources, or durations, develop the schedule, or control the schedule until you have a good understanding of project activities.The goal of defining activities is to ensure that the project team completely understands all the work it must do as part of the project scope so the team can start scheduling the work.
- For example, a WBS item might be "Produce study report." The project team must understand:
    - How long should the report be?
    - Does it require a survey or extensive research to produce?
    - What skill level does the report writer need to have?
    - Further defining the task will help the project team determine how long it will take to do and who should do it
- Defining activities also results in supporting detail to document important product information as well as assumptions and constraints related to specific activities.
- The project team should review the activity list and activity attributes with project stakeholders before moving on to the next step in project time management.
- If the team does not review these items, it could produce an unrealistic schedule and deliver unacceptable results.

Sequencing Activities

Also known as determining the dependencies of the activities. Inputs to the activity sequencing process include the schedule management plan, activity list and attributes, project scope statement, milestone list, and organizational process assets. The sequencing process involves evaluating the reasons for dependencies and the different types of dependencies

Dependencies

- A dependency or relationship is the sequencing of project activities or tasks.
- For example, does a certain activity have to be finished before another can start? Can the project team do several activities in parallel? Can some overlap?
- Determining these relationships or dependencies among activities has a significant impact on developing and managing a project schedule
- Three types of Dependencies:
    - Mandatory dependencies: inherent in the nature of the work being performed on a project
    - 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

- External dependencies: involve relationships between project and non-project activities
- Internal dependencies involve relationships between project activities that are generally inside the project team's control. For example, if software is developed by the team, they can create dependencies such as performing unit testing before system testing.

Examples of dependencies

Mandatory dependencies

Ex: you can not test code until after the code is written.

Discretionary dependencies

Ex: Project team not start detailed design of a new IS until the users sign off on all of the analysis work.

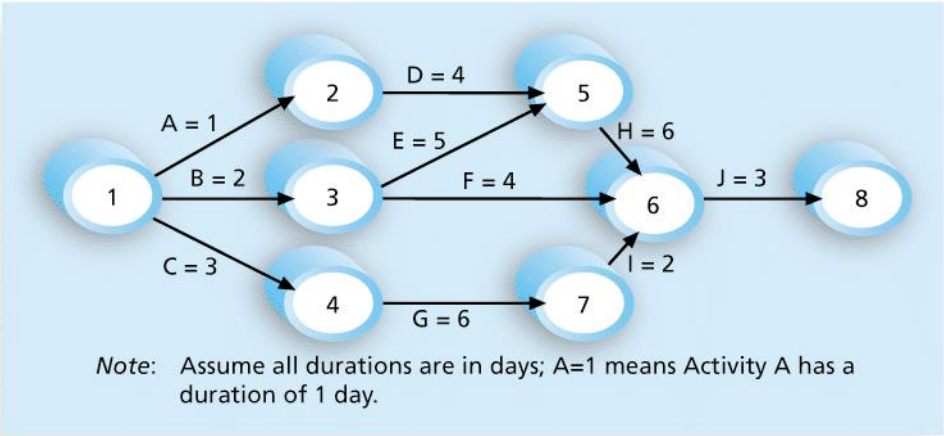
External dependencies

Ex: installation of a new operating system and other software may depend on delivery of new hardware from an external vendor.

Network Diagrams

- Network diagrams are the preferred technique for showing activity sequencing
- A **network diagram** is systematic display of the logical relationships among project activities and their sequencing
- Two main formats are the arrow and precedence diagramming methods

Figure 6-2. Network Diagram for Project X



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

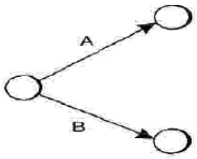
Process for Creating AOA Diagrams

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. Continue drawing the network diagram, working from left to right. Look for bursts and merges. **Bursts** occur when a single node is followed by two or more activities. A **merge** occurs when two or more nodes precedes a single node.
3. Continue drawing the project network diagram until all activities are included on the diagram that have dependencies.
4. As a rule of thumb, all arrowheads should face toward the right, and no arrows should cross on an AOA network diagram. You may need to redraw the diagram to make it look presentable

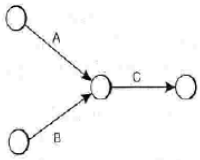
Relationship Among Activities

- **Concurrent activities**: activities that can be carried out concurrently are called concurrent activities. Two activities can be carried out concurrently since they do not depend on each other.
- **Preceding Activity**: for a given activity that occurs immediately before it, is its preceding activity.
- **Succeeding Activity**: for a given activity, the activity that follows immediately after it, is its succeeding activity.
- **Dummy Activity**: imaginary activity included in a network. Does not consume resources. Included in a network to maintain the network logic and to avoid ambiguity. Represented by a dotted arrow.

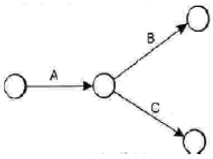
Activity 'A' must be completed before activity 'B' can begin



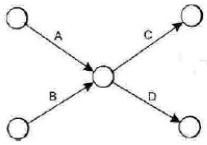
Activities 'A' and 'B' are concurrent activities i.e. they can be performed concurrently.



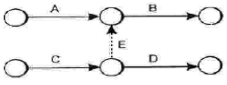
Activities 'A' and 'B' can be performed concurrently. But activity 'C' can start only after both the activities 'A' and 'B' are completed.



Activities 'B' and 'C', can be performed concurrently. But both can start only after activity 'A' is completed.



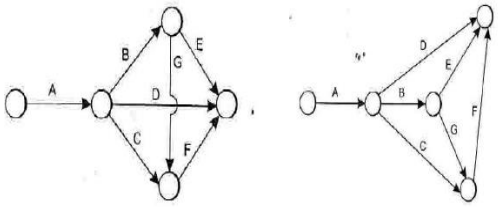
Activities 'A' and 'B' are concurrent activities. Similarly, activities 'C' and 'D' are also concurrent activities. But, 'C' and 'D' can start only after both 'A' and 'B' are completed.



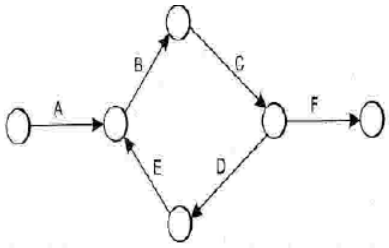
'E' is a dummy activity. Activity 'D' can start after 'C' is completed. But for activity 'B' to start, both 'A' and 'C' should be completed.

Rules for Drawing Network Diagrams

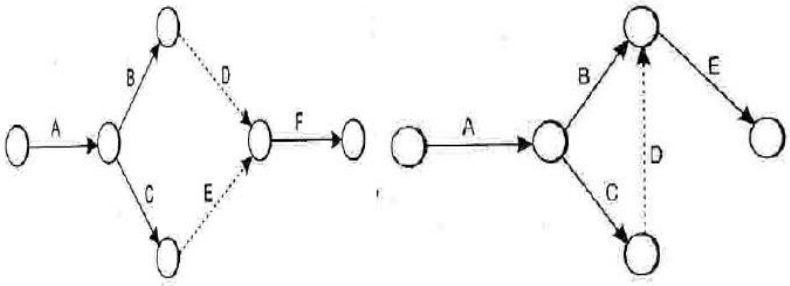
- All activities shall be represented by way of straight arrows pointing towards the right.
  - *Flow of network from the left towards the right*
- There shall not be any criss-crossing of arrows.



- The arrows of a network shall not form loops.



- There shall not be unnecessary dummy activities in the network



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

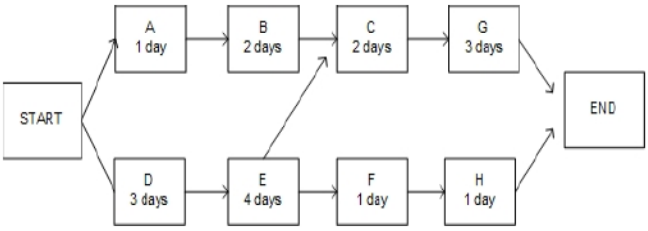


Figure 6-3. Task Dependency Types

Task dependencies

The nature of the relationship between two 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)	A → B	Task (B) cannot start until task (A) finishes.
Start-to-start (SS)	A → B	Task (B) cannot start until task (A) starts.
Finish-to-finish (FF)	A → B	Task (B) cannot finish until task (A) finishes.
Start-to-finish (SF)	A → B	Task (B) cannot finish until task (A) starts.

Estimating Activity Resources

Before you can estimate the duration for each activity, you must have a good idea of the quantity and type of resources (people, equipment, and materials) that will be assigned to each activity. The nature of the project and the organization will affect resource estimates. Expert judgment, an analysis of alternatives, estimating data, and project management software are tools that can assist in resource estimating. The people who help determine what resources are necessary must have experience and expertise in similar projects and with the organization performing the project.

Important questions to answer when estimating activity resources include:

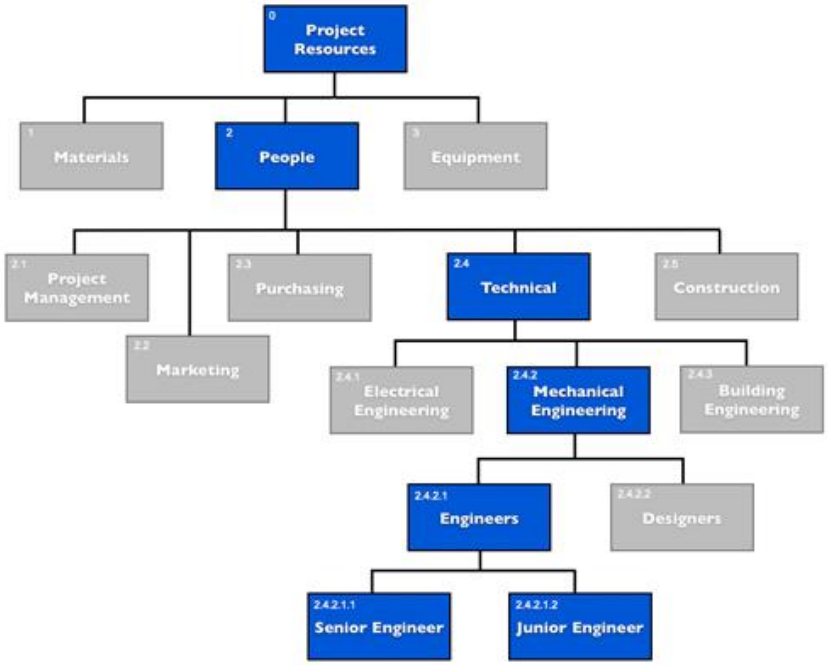
- How difficult will specific activities be on this project?
- Is anything unique in the project's scope statement that will affect resources?
- What is the organization's history in doing similar activities? Has the organization done similar tasks before?

- Does the organization have people, equipment, and materials that are capable and available for performing the work? Could any organizational policies affect the availability of resources?
- Does the organization need to acquire more resources to accomplish the work? Would it make sense to outsource some of the work? Will outsourcing increase or decrease the amount of resources needed and when they will be available?

Inputs such as a project's schedule management plan, activity list, activity attributes, resource calendars, risk register, activity cost estimates, enterprise environmental factors, and organizational process assets such as policies regarding staffing and outsourcing. During the early phases of a project, the project team may not know which specific people, equipment, and materials will be available. The resource estimates should also be updated as more detailed information becomes available. The main outputs of the resource estimating process include a list of activity resource requirements, a resource breakdown structure, and project documents updates.

- A resource breakdown structure is a hierarchical structure that identifies the project's resources by category and type.

A resource breakdown structure: Example



Estimating 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

- People doing the work should help create estimates, and an expert should review them
- There are several inputs to activity duration estimates, including the schedule management plan, activity list, activity attributes, activity resource requirements,

resource calendars, project scope statement, risk register, resource breakdown structure, enterprise environmental factors, and organizational process assets.

- In addition to reviewing past project information, the team should review the accuracy of the duration estimates thus far on the project
- The outputs of activity duration estimates include the estimates themselves and project documents updates.
- Duration estimates are often provided as a discrete number, such as four weeks; as a range, such as three to five weeks; or as a three-point estimate.
    - A three-point estimate 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

Three-Point Estimates

- 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
- 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 realistic project schedule that provides a basis for monitoring project progress for the time dimension of the project. Important tools and techniques include Gantt charts, critical path analysis, and critical chain scheduling, and 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

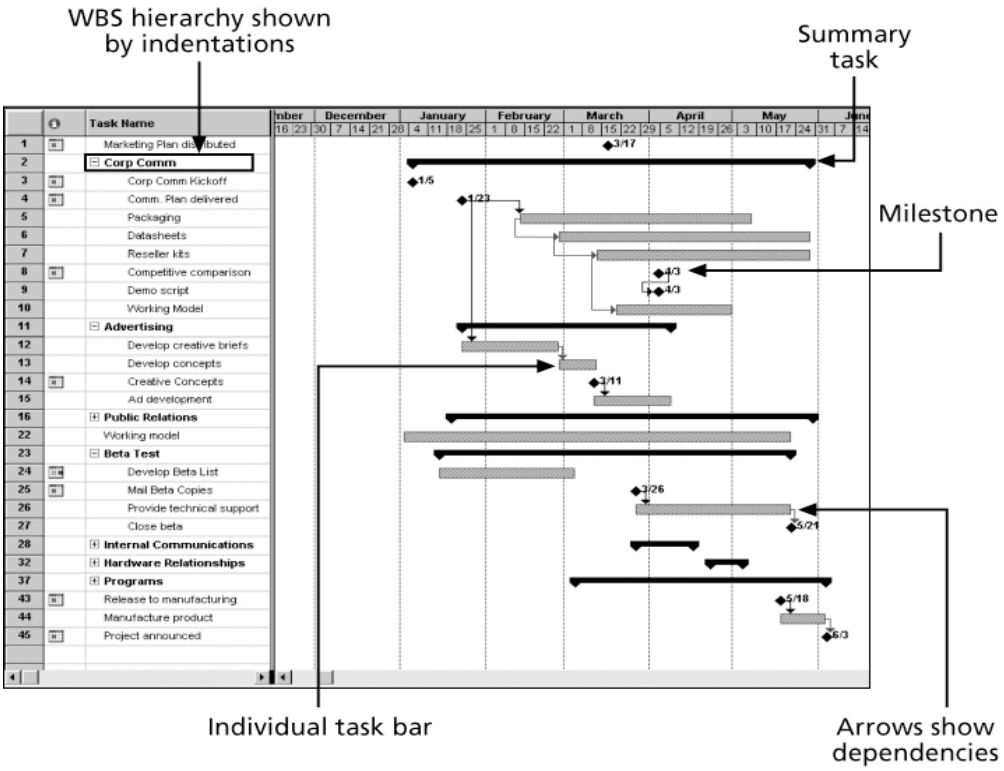


Figure : Gantt Chart for Software Launch Project

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

SMART Criteria

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

Network Based Scheduling

- **Two popular network scheduling techniques:**

✓ Critical Path Method (CPM)

✓ Programme Evaluation Review Technique (PERT)

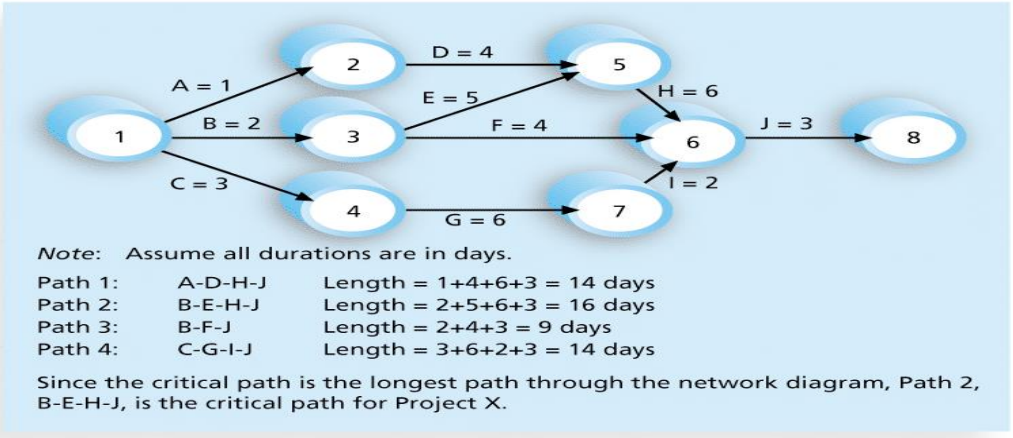
Critical Path Method (CPM)

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 : Determining 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

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
  - **Crashing** activities by obtaining the greatest amount of schedule compression for the least incremental cost
  - **Fast tracking** activities by doing them in parallel or overlapping them

Importance of Updating Critical Path Data

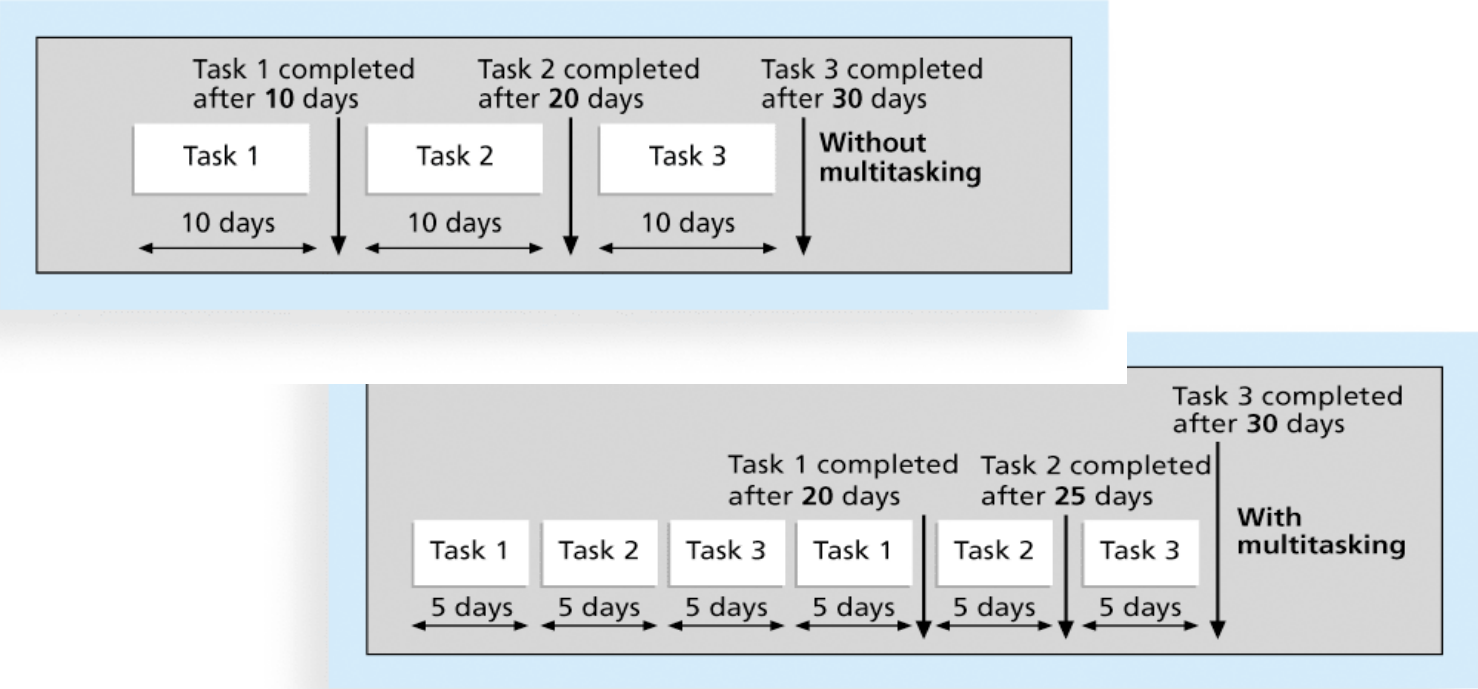
1 It is important to update project schedule information to meet time goals for a project
2 The critical path may change as you enter actual start and finish dates

3 If you know the project completion date will slip, negotiate with the project sponsor

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
- Attempts to minimize **multitasking**
  - when a resource works on more than one task at a time

Figures a and b. Multitasking Example



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)

- **PERT** is a network analysis technique used to estimate project duration when there is a high degree of uncertainty about the individual activity duration estimates
- PERT uses **probabilistic time estimates**
  - duration estimates based on using optimistic, most likely, and pessimistic estimates of activity durations, or a three-point estimate
- PERT weighted average **=**

$$\frac{\text{optimistic time} + 4\text{X most likely time} + \text{pessimistic time}}{6}$$

- Example:

PERT weighted average =

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

where optimistic time= 8 days
most likely time = **10 days**, and
pessimistic time = 24 days

Therefore, you'd use **12 days** on the network diagram instead of 10 when using PERT for the above example