Electronics and
Computer Science

University of Southampton

Planning Project Schedule

COMP6204: Software Project Management and Secure Development

Dr A. Rezazadeh (Reza)
Email: ra3@ecs.soton.ac.uk or ar4k06@soton.ac.uk

October 24

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Overview

- Objectives
- Processes and Outputs for Project Schedule Management
- Schedule/Time Planning
- Identification of Activities
- Sequencing Activities
- Network Diagram
- Activity Attributes
- Milestone List

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Objectives

- Understand how a project schedule is created
- Learn duration estimation techniques
- Learn project schedule creation in the form of a Network Diagram and a Gantt Chart
- Understand the Critical Path Method for schedule creation
- Learn what is meant by Float in a project
- Know how the schedule of a project can be compressed

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Planning Processes and Outputs for Project Schedule Management

Knowledge area	Planning process	Outputs
Project schedule management	Plan schedule management	Schedule management plan
		Activity list
		Activity attributes
	Define activities	Milestone list
		Change requests
	Sequence activities	Project schedule network diagrams
	Estimate activity durations	Activity duration estimates
		Basis of estimates
	Develop schedule	Schedule baseline
		Project schedule
		Schedule data
		Project calendars

Schedule/Time Planning

- In scope planning we determine the work that needs to be delivered on the project.
- Next, we need to know what activities/tasks need to executed, how much time each would take, in what sequence they would be carried out, and by how many resources.
  - All these questions are answered in schedule/time planning.
- The main planning tasks performed include planning schedule management, defining activities, sequencing activities, estimating activity durations, and developing the project schedule
- The main documents produced are a schedule management plan, an activity list and attributes, a milestone list, a project schedule network diagram, activity duration estimates, a schedule baseline, a project schedule, and project calendar

Identification of Activities

- A WBS ends with work packages. These are the smallest pieces of deliverables on a project.
- In Schedule Planning, we start with the work packages and identify the tasks/activities that need to be performed in order to deliver the work packages.
  - The difference between a work package and activity is that the prior is an output, while the latter is an action performed by the project team members.
  - An *activity* is a distinct, scheduled portion of work performed during the course of a project.

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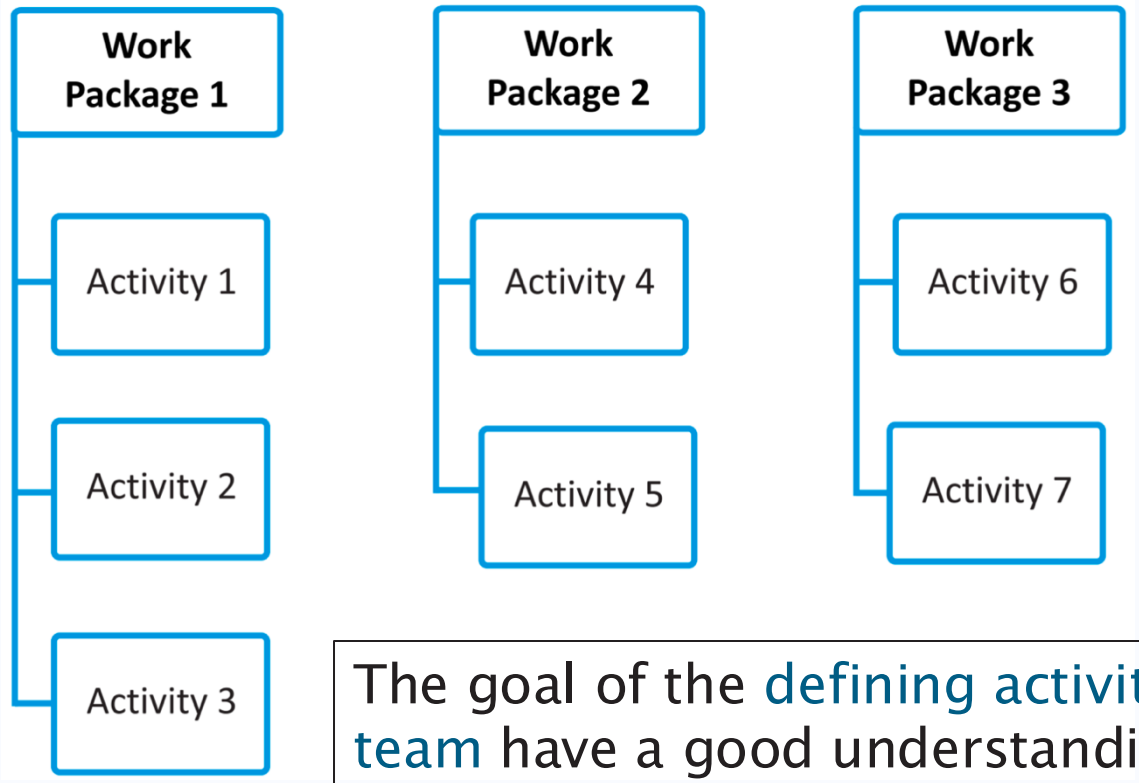
Identification of Activities – An Example

- For example, if we make a WBS for a home interior project, one of the work packages would be the dining table in the house.
  - This is a deliverable, as the dining table would be delivered to the customer.
  - In order to make the dining table, the project team would need to procure wood, cut it to size, and assemble it. These would make the activities.
- This means that there would be one more level of decomposition below the WBS as shown below.
  - This level will include the project activities.

Identification of Activities – An Illustration



The goal of the defining activities is to ensure that project team have a good understanding of all the work they must do as part of the project scope so that they can start scheduling the work.

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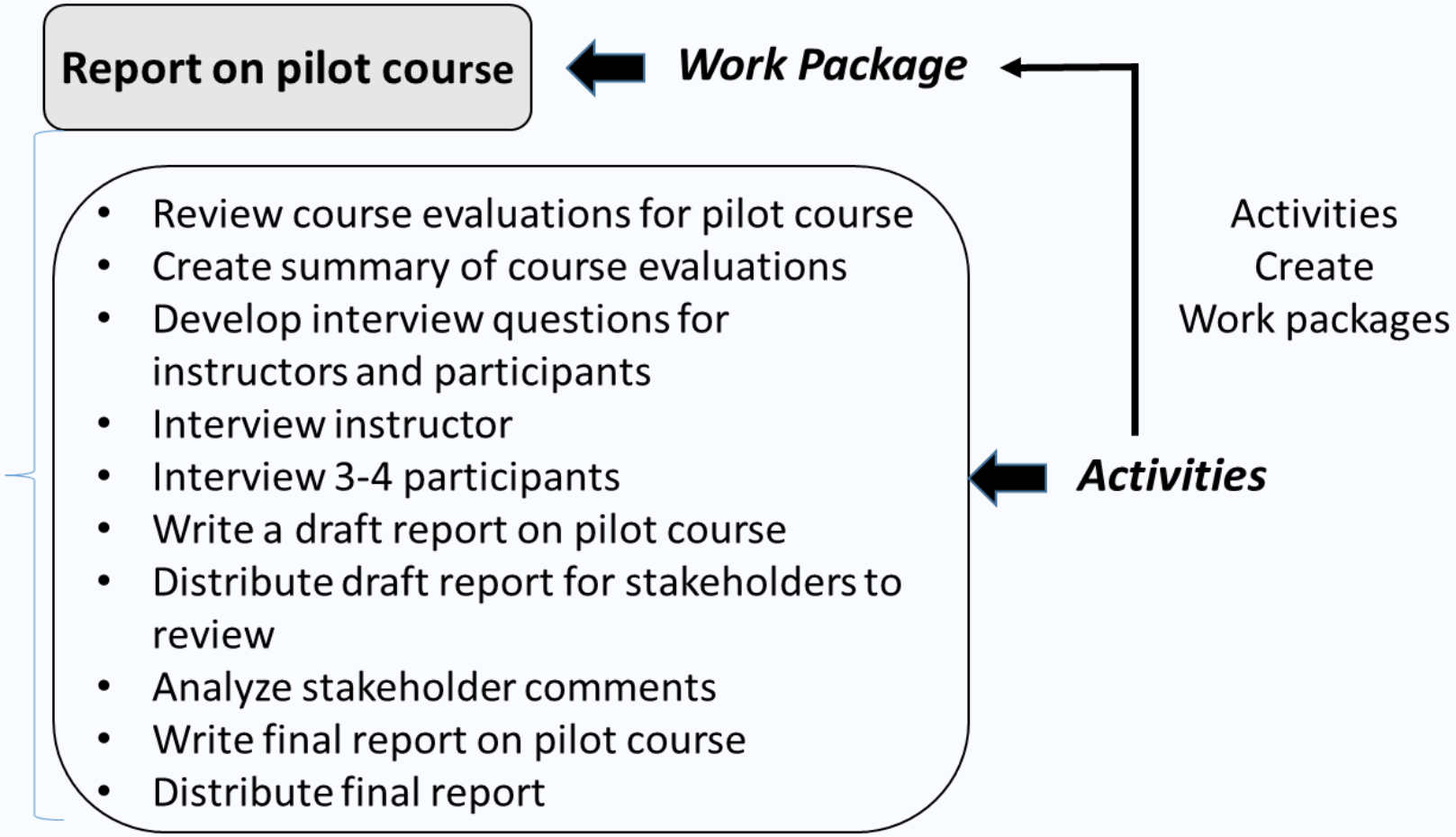
Report on Pilot Course Activity List



Sequencing Activities

- Once the activities have been identified they need to be put in the sequence they should occur.
- In this process we may realise that some activities are dependent while others are independent.
- This will give us an idea on which activity can happen first, what happens next, and what can happen in parallel. Questions to consider:
  - Does a certain activity have to be finished before another one can start?
  - Can the project team do several activities in parallel?
  - Can some activities overlap?
- Sequencing activities has a significant impact on developing and managing a project schedule.

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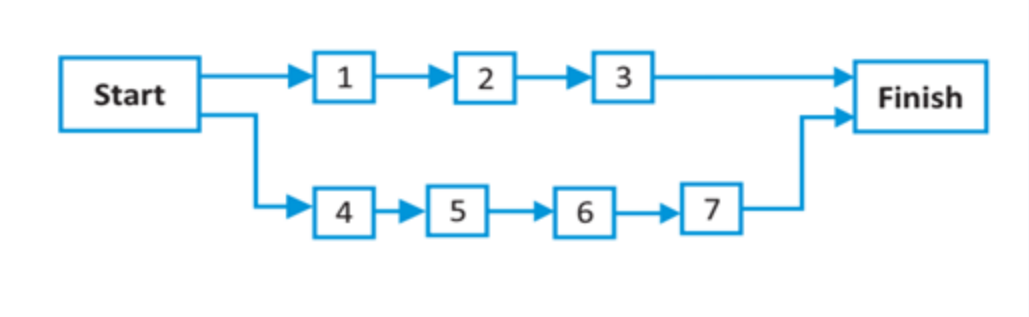
Sequencing of Activities – An Example

- Let's assume that we've identified seven activities to be part of our project.
  - We consider only seven for the sake of simplicity.
  - The seven activities are – 1 through 7.
- From our understanding of the project requirements, we realise that activities 1 and 4 are independent and can be started as soon as the project starts.
  - Activity 2 depends on 1 and can only happen after 1 is completed.
  - Activity 3 can only happen after activity 2 has completed. Similarly, activity 5 depends on 4, 6 depends on 5 and 7 depends on 6.



Network Diagram

- The diagram shown above is called a Network Diagram.
- The Network Diagram shows activity dependencies in a project.
- Each node (box) shows an activity, and each arrow shows a dependency.
  - The dependencies can be of various types.
- None of the elements from WBS will directly appear in the Network Diagram.
- However, the activities appearing in the Network Diagram are linked to the work packages in WBS.

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Reasons for Creating Dependencies

- Mandatory dependencies are inherent in the nature of the work being performed on a project
  - You cannot hold training classes until the training materials are ready
- Discretionary dependencies are defined by the project team
  - A project team might follow *good practice* and not start detailed design work until key stakeholders sign off on all of the analysis work.

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Reasons for Creating Dependencies – Cont.

- External dependencies involve relationships between project and non-project activities
  - The installation of new software might depend on delivery of new hardware from an external supplier.
  - Even though the delivery of the new hardware might not be in the scope of the project, it should have an external dependency added to it because late delivery will affect the project schedule
- Internal dependencies are within the project team's control, such as *testing a machine* that must be first assembled, where all the work is done inside the team.

Activity Attributes

- Along with the activities, we also need to document some details about each activity, like we did for a work package in the WBS dictionary.
- This description is kept in Activity Attributes.
- These attributes contain all the details that need to be documented for the activities for better understanding during execution.

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Creating the Activity List and Attributes

- The *activity list* is a tabulation of activities to be included on a project schedule
- It should include the activity name, an activity identifier or number, and a brief description of the activity
- The *activity attributes* provide ***schedule-related*** information about each activity, such as predecessors, successors, logical relationships, leads and lags, resource requirements, constraints, imposed dates, and assumptions related to the activity
  - Both *activity list* and *activity attributes* should be in agreement with the WBS and WBS dictionary and be reviewed by key project stakeholders.

Milestone List

- A *milestone* is a significant point or event in a project
- It often takes several activities and a lot of work to complete a milestone, but the milestone itself is like a marker to help identify necessary activities
- There is usually no cost or duration for a milestone
- Project sponsors and senior managers often focus on major milestones when reviewing projects
- Sample milestones for many projects include:
  - Sign-off of key documents
  - Completion of specific products
  - Completion of important process-related work, such as awarding a contract to a supplier

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Sample Milestone List

Milestone	Initial Estimated Completion Date*
Draft survey completed	8/3
Survey comments submitted	8/8
Survey sent out by IT	8/10
Percentage of survey respondents reviewed	8/17
Survey report completed	8/22
Survey results reported to steering committee	8/24
*Note: Dates are in U.S. format. 8/3 means August 3.	

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Milestones List – Best Practice

- The **SMART** criteria suggest that milestones should be:
  - **S**pecific
  - **M**easurable
  - **A**ssignable
  - **R**ealistic
  - **T**ime-framed

difference between workpackage and milestone

workpackage based on output while milestone based on duration

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Milestones List – Best Practice

- You can also use milestones to help reduce schedule risk by following these best practices:
  - Define milestones early in the project and include them in the Gantt chart to provide a visual guide
  - Keep milestones small and frequent
  - The set of milestones must be all-encompassing
  - Each milestone must be binary, meaning it is either complete or incomplete
  - Carefully monitor the milestones on the critical path

Project Schedule - Second Session

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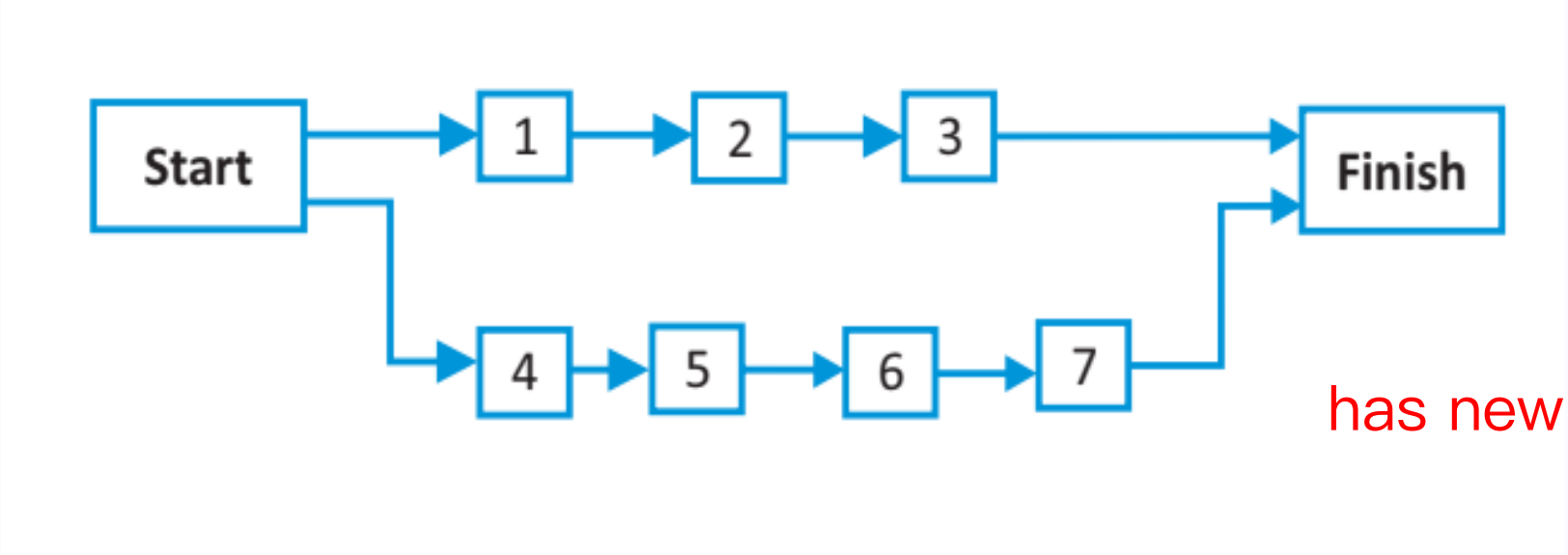
Overview

- Sequencing using Network Diagram – Activity on node (AON)
- AON Rules & Terminology
- Sequencing Activities In AON – Relation Between Activities
- AoN – Lag & Lead
- Estimating Duration of Activities
- Parametric Estimate
- PERT (Program Evaluation & Review Technique)
- Scheduling – Critical Path, Float and Slack

Sequencing using Network Diagram – Activity on node (AON)



has new version(google)

- AON is a network diagramming technique in which boxes represent activities.
- This approach is more widely used as it can show all dependency types.
  - *Activity on arrow* is an older approach that used less often

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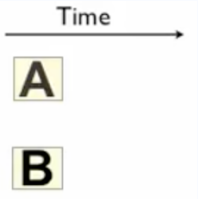
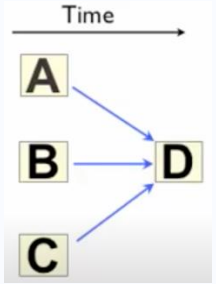
AON – Some Rules

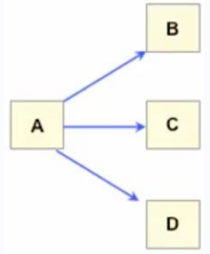
- Networks typically flow from left to right.
- An activity cannot begin until all of its preceding activities are complete.
- Arrows indicate precedence and can cross over each other.
- Identify each activity with a unique identifier; this identifier must increment (1.2.3, A,B,C, etc.) as the network proceeds.
- Looping is not allowed.
- *Conditional statements* are not allowed.
- You can use start and stop nodes.

AON – Terminology

- Activity: An Element of project that require time to complete.
- Parallel (concurrent) activities: activities than can occur independently and, if desired at the same time.
- Merge activity: an activity has two or more preceding activities on which depends.
- Brust activity: an activity that has more than one activity immediately following it.
- Milestone: a point in time when an activity started or completed. It does not consume time.



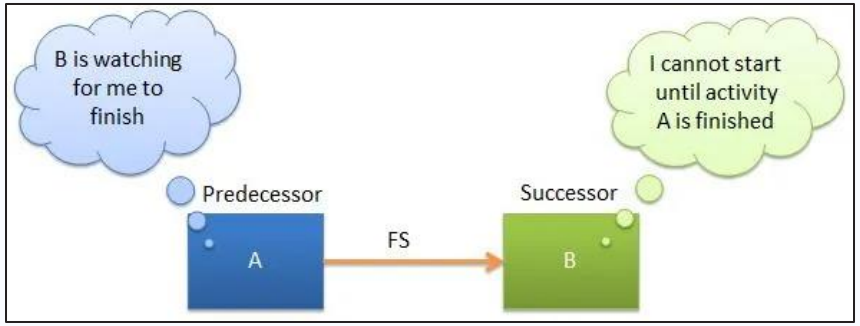




Sequencing Activities In AON – Relation Between Activities

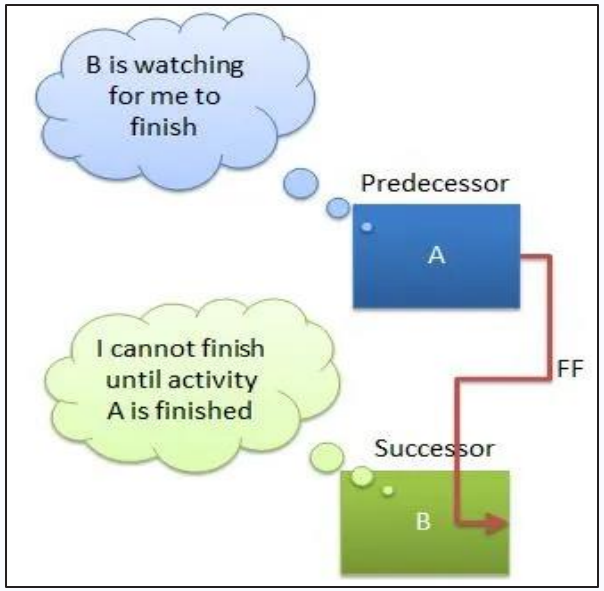
- There are four types of dependencies in an AoN representing project activities. They are:

1. **Finish-to-start (FS)** – Successor activity cannot **start** until the predecessor activity **finish**.



   - Example: development of a software module can only start after the design has been completed.

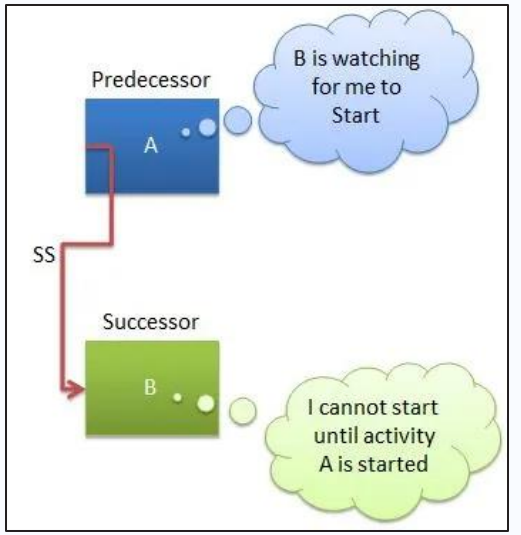
2. **Finish-to-finish (FF)** – Successor activity cannot **be completed** until the predecessor activity **has completed**.



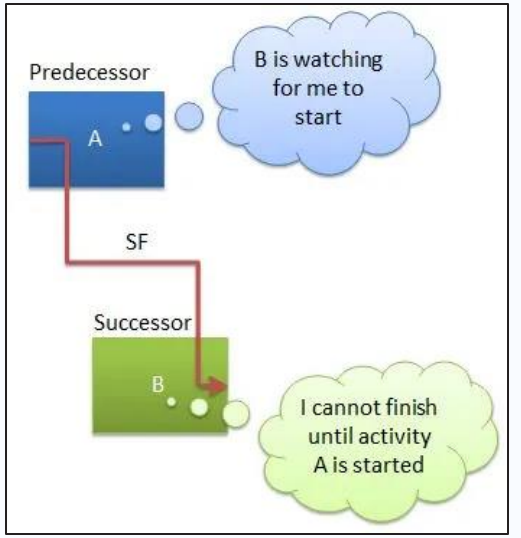
   - Creation of a user manual of a product can occur in parallel with its development but it cannot be completed until the development is also complete, as there could be changes that need to be included in the manual.

Sequencing Activities In AON – Relation Between Activities

3. **Start-to-start (SS)** – Successor activity cannot **start** until the predecessor activity **start**.
   - The sales team can't start selling the product until the basic product road map documentation starts.



4. **Start-to-finish (SF)** – Successor activity cannot **be completed** until the predecessor activity **start**.
   - The first security guard shift (successor) cannot finish until the second security guard shift (predecessor) starts.



AoN – Lag & Lead

- In a network diagram the most commonly used dependency is Finish-to-start (F-S).
  - In this dependency, the successor activity can start as soon as the predecessor activity finishes.
- However, there are instances when we need to wait between the finish of the predecessor and start of the successor.
  - This is called Lag. Lag may be found in activities with all relationship types (F-S, S-S, F-F and S-F)
- There are times when we can start an activity a little ahead of its predecessor's finish by taking a little higher risk in an F-S dependency.
  - This is called Lead and is exactly opposite of Lag. Lead is only found in F-S relationships
  - Sometimes in scheduling tools, like Microsoft Project, it called negative Lag.

Example of Lead & Lag

- The photo shoot will take four days, and the photo editing will take six days. Instead of waiting until the end of the 4-day photo shoot to begin editing the pictures, we start editing after the first day of shooting.
  - This brings the total duration from ten days down to seven days by leveraging the lead.
- The photo proofs are sent to the customer upon completion of the shoot, however, there is a 15-day lag associated with the customer review before the printing of the photos can begin.

Estimating Duration of Activities

- Once we have identified the activities and their sequences, we need to know their duration in order to set calendar dates.
  - Activity duration depends on two things – effort and resources.
  - Effort is the "man-days" or "man-hours" to complete an activity.
  - Effort is the number of work units required to complete the activity.
- After estimating the effort required, the duration can be computed based on the number of resources working on the activity.
- For example, if the effort is 8-man hours then the duration would be 1 day if one resource works on the activity.
- It will be about 0.5 day if two resources work on it and so on.

add resources can not make sure the time is reduced according to the added resources

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Effort Estimation

Duration = Effort / Number of Resources

- The key inputs required for effort estimation will come from historical data, subject matter experts, and the team members performing the activity.

- There are several methods for estimating the effort of an activity.
- Effort estimates are often provided as discrete estimates, such as 8 hours, 80 hours, and so on.

Parametric Estimate

- Parametric estimating is a statistical and accuracy-based technique for calculating the time, cost, and resources needed for project success.

$$\text{Parametric Estimate} = \text{Thumb Rule per unit} \times \text{Number of Unit}$$

- This is called a Parametric Estimate and is generally the most accurate because the thumb rule is made using data from past projects and expert judgement.
- Example: A network engineer is capable of laying 25 meters of fibre optic cable per hour, on average. The project requires her to lay 2,000 meters of cable.

2,000 / 25 = 80 hours of work

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Parametric Estimate – Another method

$$E_{parametric} = A_{old} / P_{old} \times P_{curr},$$

where,

$E_{parametric}$ = parametric estimate

A_{old} = historical amount of cost or time

P_{old} = historical value of the parameter

P_{curr} = value of the parameter in the current project

Example 1: Construction Cost Using a Parametric Estimate

- For similar types of buildings, the average construction cost amounted to $200 per square foot in the past (= cost per parameter unit).
- The new building is supposed to have a total area of 3,000 square feet (= parameter value in the new project).
- The calculation of the order of magnitude of the construction cost, using a parametric estimate (deterministic) determined with the rule of three, is as follows:
- Estimated construction cost = $200 x 3,000 sq ft = $6,000,000.

PERT (Program Evaluation & Review Technique)

- In the previous estimation, we used historical data from past projects and/or expert judgement to arrive at an estimate.
  - This is only possible when such work has been performed in the past.
- If the activity is a totally new one or differs enough from the one done in the past, then we may not be able to produce an accurate figure for the effort estimation.
- In such cases, we can use PERT.
  - PERT also can be used when there is a high degree of uncertainty
- This technique suggests the use of *three estimates* – **Optimistic** (O), **Most Likely** (M) and **Pessimistic** (P).

PERT (Program Evaluation & Review Technique)

- An Optimistic estimate is an estimate of the earliest possible completion duration of an activity.
- A Pessimistic estimate is an estimate of the latest possible completion duration of an activity.
- A Most Likely estimate is an estimate of the most probable completion date of an activity.

$$\text{PERT Estimate} = (O + 4M + P) / 6$$

- It is also called weighted average

PERT Calculation – An Example

- For example, if an activity has the following estimates:
- 0 = 5 days
- M = 8 days
- P= 10 days
- Then, PERT Estimate is

$$\text{Pert} = (5 + (4 \times 8) + 10) / 6 = 47 / 6 = 7.833 \text{ days}$$

PERT estimate – Risk Factor

- When using a PERT estimate, we are also interested in knowing how much risk is involved in the activity's estimate.
  - That determine the probability of completing the project on time.
- This is done by calculating the Standard Deviation of a PERT estimate.
- Formula for calculating standard deviation is give below:

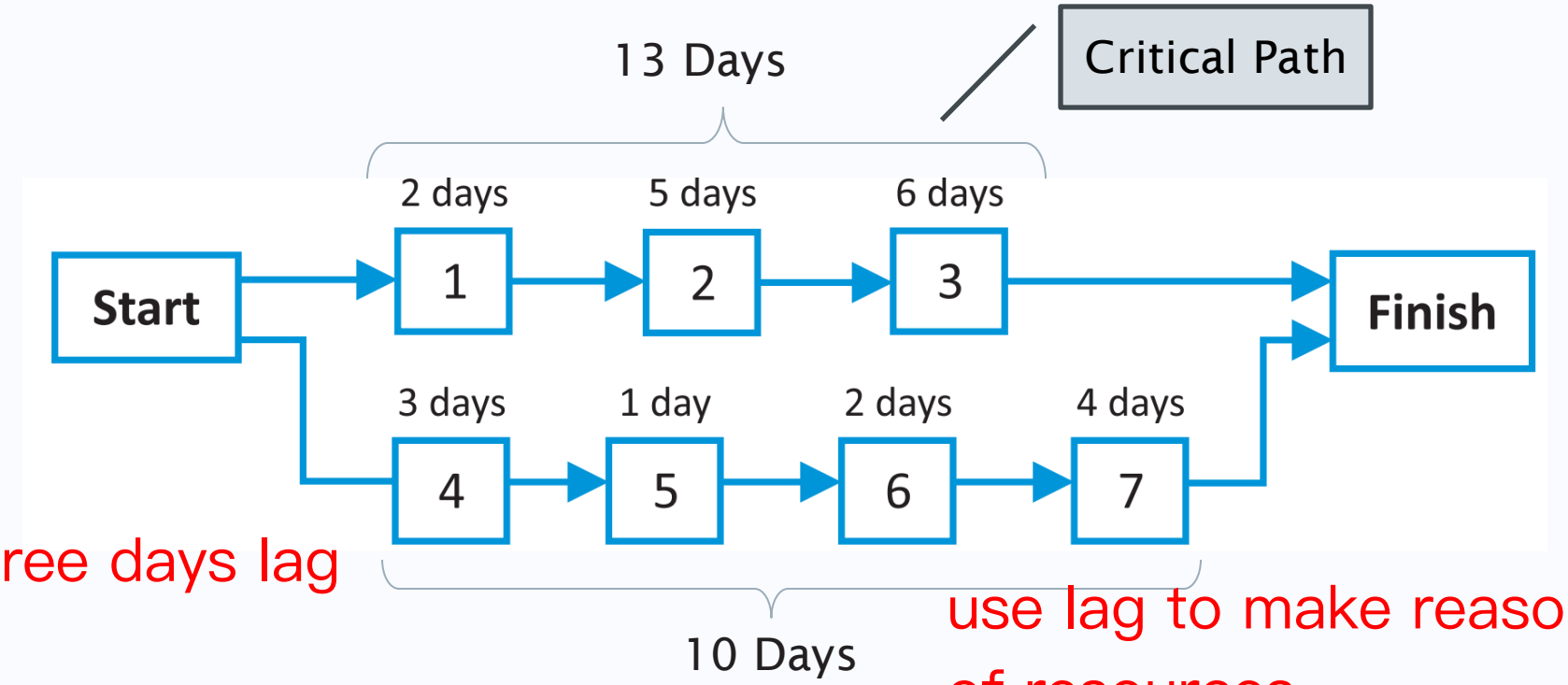
$$\text{Standard Deviation} = (P - O) / 6$$

- In the above example, the Standard Deviation = (10 -5) / 6 = 5 /6 = 0.833
- It means that the activity can be completed within 7.833 +/- 0.833 days or anywhere between 7 and 8.666 days

positive risk and negative risk

Scheduling

- So far, we have the activities, their dependencies and durations.
- Now it is possible to set calendar dates and finalize the project schedule.



can have three days lag

use lag to make reasonable use of resources

Scheduling – Critical Path

- A critical path is the longest path in the project's network diagram that dictates how long a project would take.
- It also tells a project manager which activities are on the critical path, and that he or she has to spend more monitoring and controlling time on these activities.
  - In the above diagram, the project manager's time is best spent on monitoring activities 1, 2 and 3 as any delay in these activities would delay the project.
- Activities on the critical path cannot be delayed without delaying the entire project.
  - Hence, they do not have any "float" or "slack", or the "float" or "slack" is zero.

Float and Slack

- Float and slack are two terms that measure the amount of flexibility or buffer time that an activity has in a project schedule.
- They indicate how much an activity can be delayed or extended without affecting the project completion date or the start of another activity.
- Float and slack are often used interchangeably, but they have some subtle differences.
- Float is usually applied to the whole project or a path of activities, while slack is applied to a single activity or a pair of activities.

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Why are float and slack important?

- Calculating float and slack can help you optimise your project schedule and resources.
- By knowing the float and slack of each task, you can *prioritise* the critical tasks that have no or low float and slack
- Manage the expectations of your stakeholders.
- Adjust the non-critical tasks that have high float and slack.

Project Schedule - Third Session

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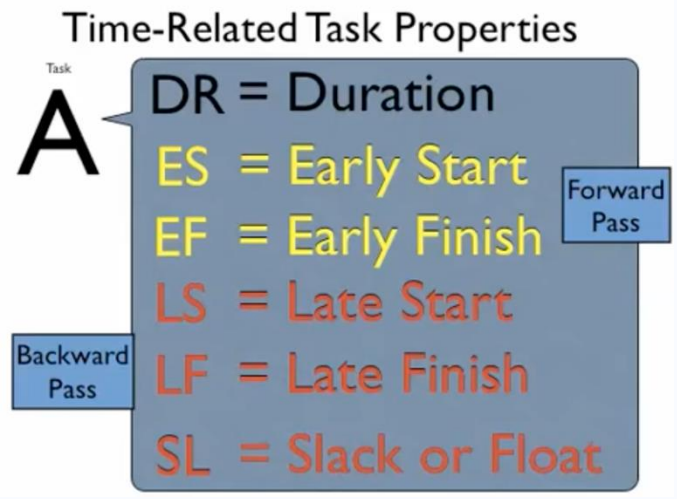
Overview

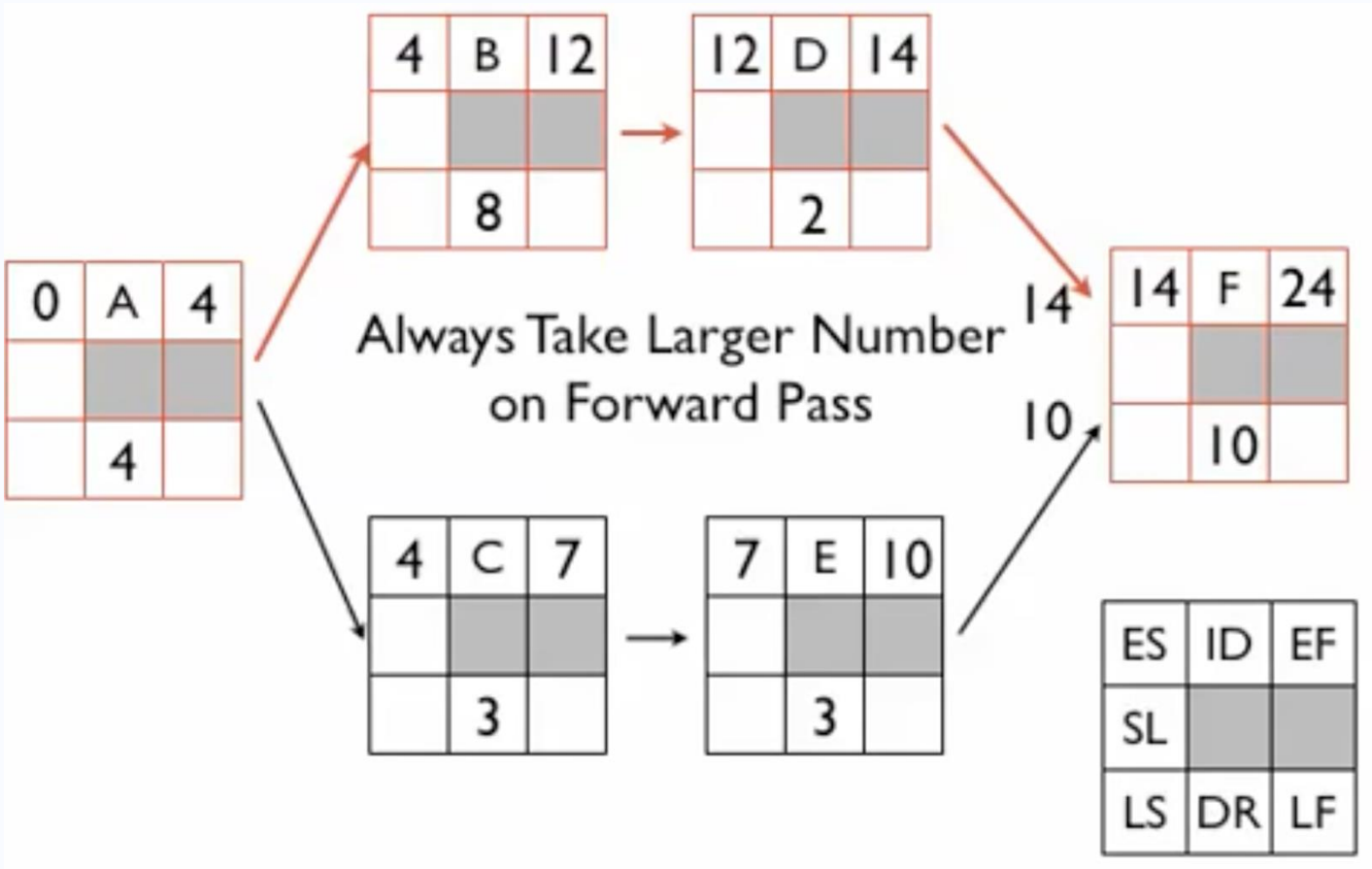
- Calculating float and slack using a network diagram
- Near Critical Path
- Using a Gantt Chart for showing the Project Schedule
- Schedule Compression
- The critical path - Inherent drawbacks
- Critical Chain Scheduling
- Tasks Scheduling & Multitasking
- Critical Chain – Buffers

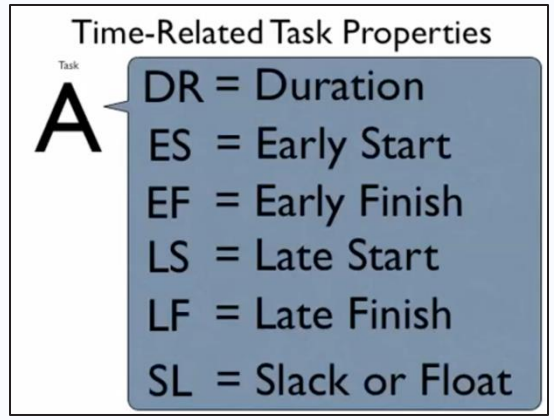
Calculating float and slack using a network diagram

- To calculate the float and slack using a network diagram, you need to perform two calculations: the forward pass and the backward pass.
- The forward pass calculates the earliest start and finish dates of each task, starting from the project start date.
- The backward pass calculates the latest start and finish dates of each task, starting from the project end date.
- The difference between the earliest and latest dates is the float or slack of each task.



Forward Pass





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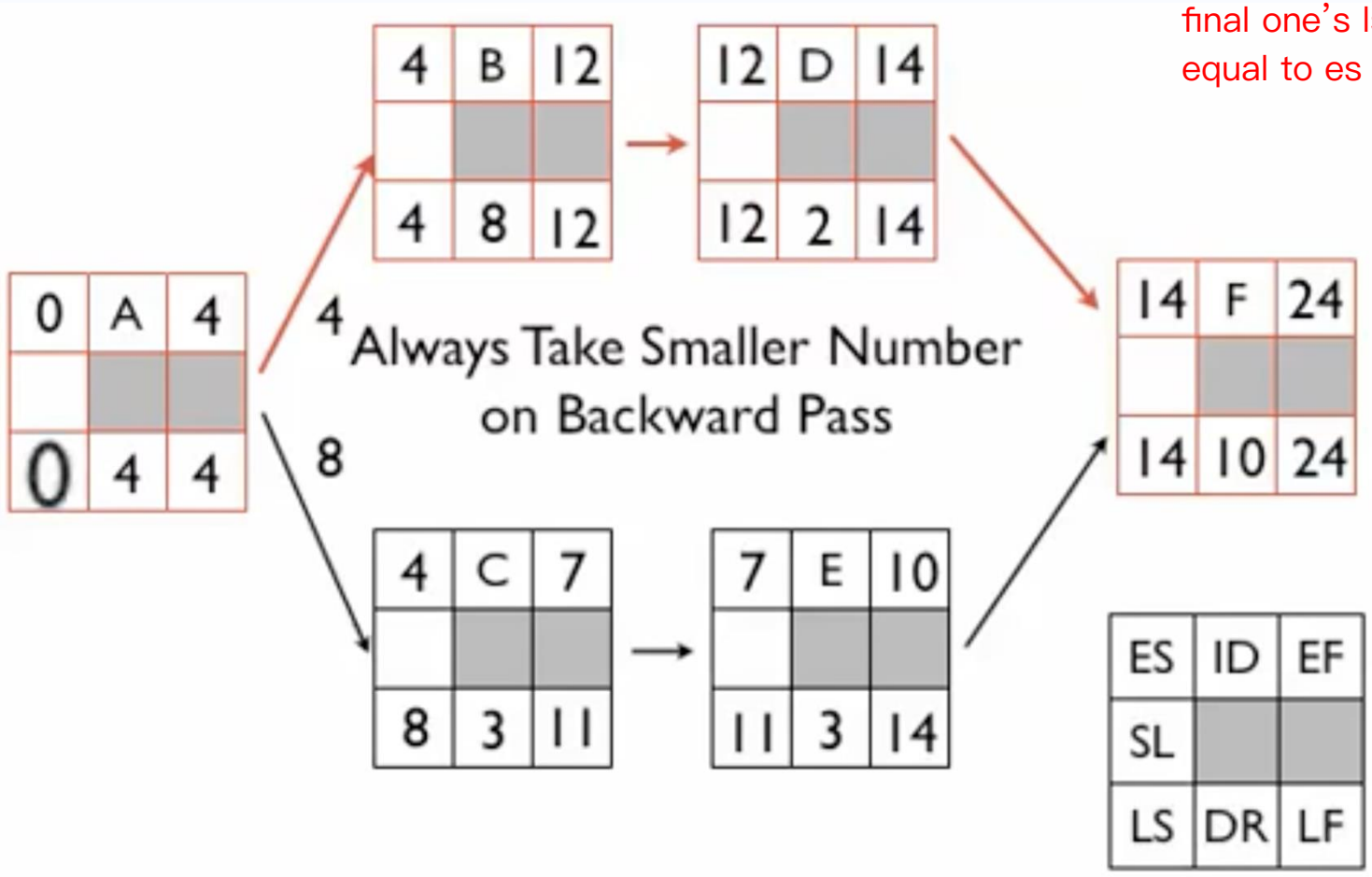
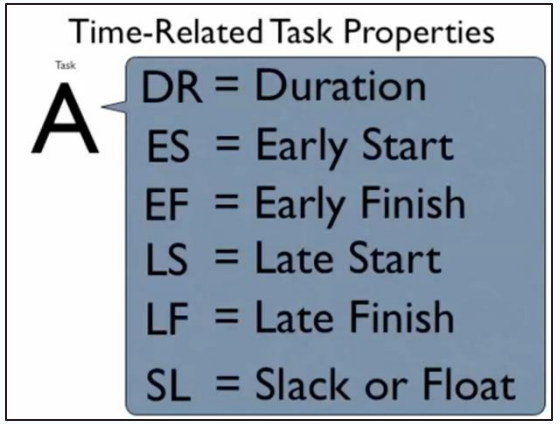
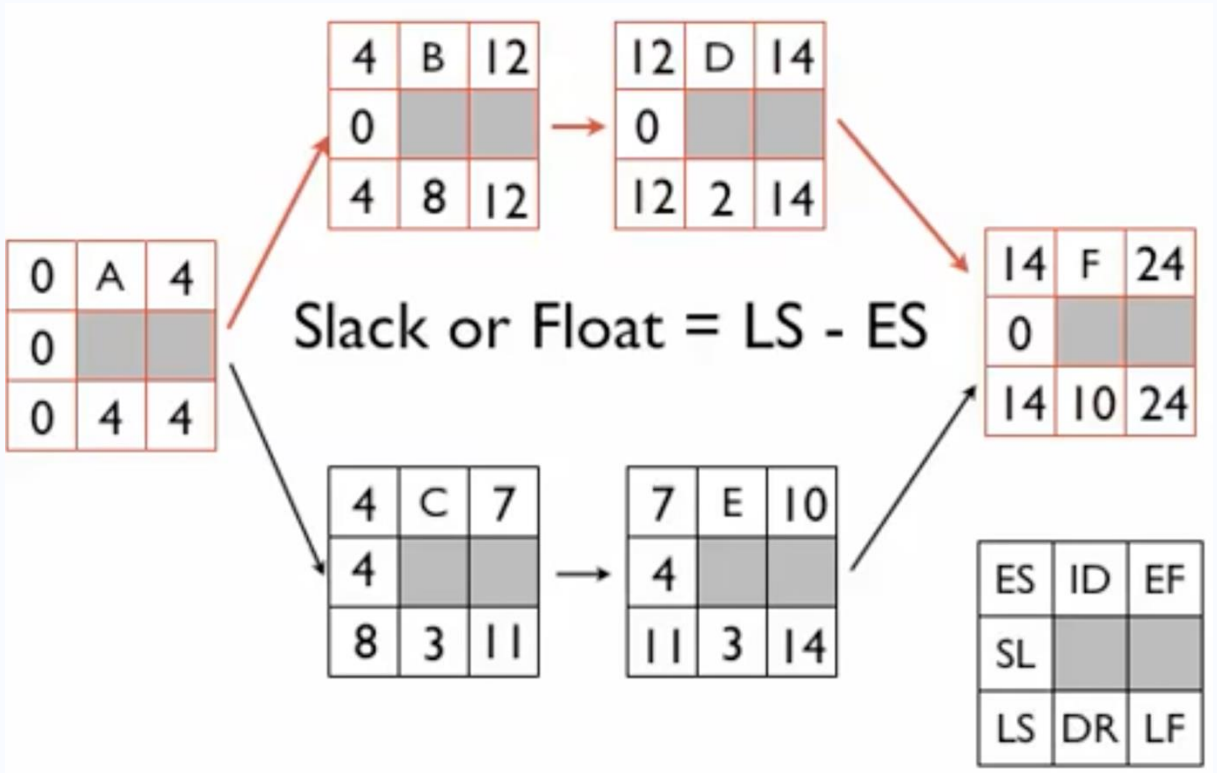
Backward Pass

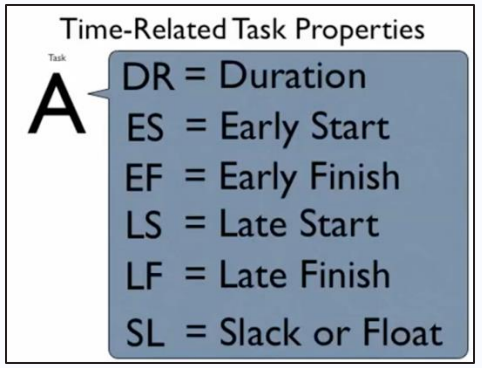


no delay is allowed so the final one's ls and lf are equal to es and ef.



Backward Pass - Slack





Although we talk of float per activity, it is actually the float of the entire path. It is the path C,D that can be delayed by up to 4 days and not each activity on the path.

AON Network Diagram –Draw the Diagram

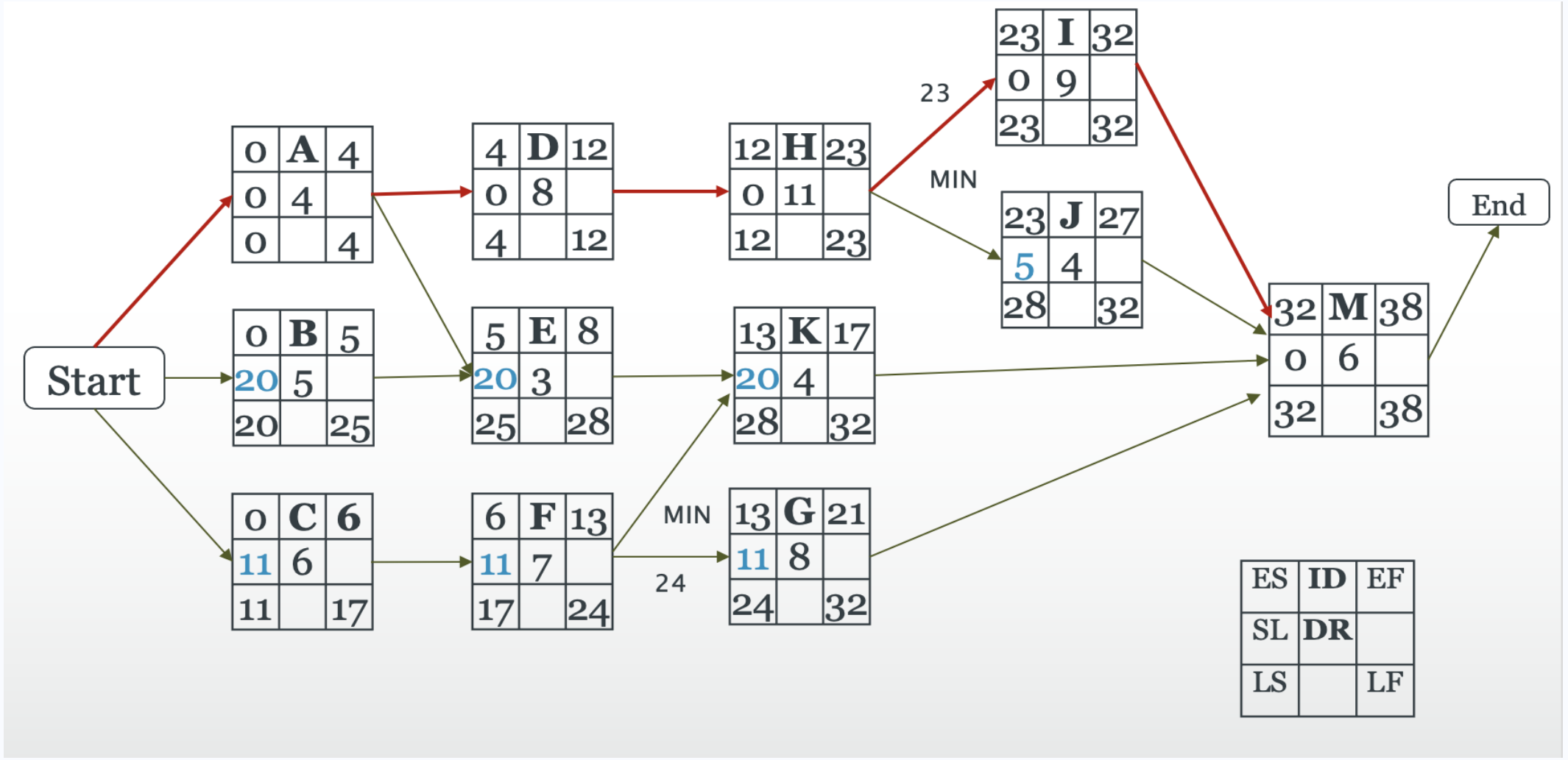
exam!

An Exercise: Can you draw an AON for the following activities?

Activity	A	B	C	D	E	F	H	K	G	I	J	M
Duration (days)	4	5	6	8	3	7	11	4	8	9	4	6
Following Activity	D,E	E	F	H	K	K,G	I,J	M	M	M	M	--

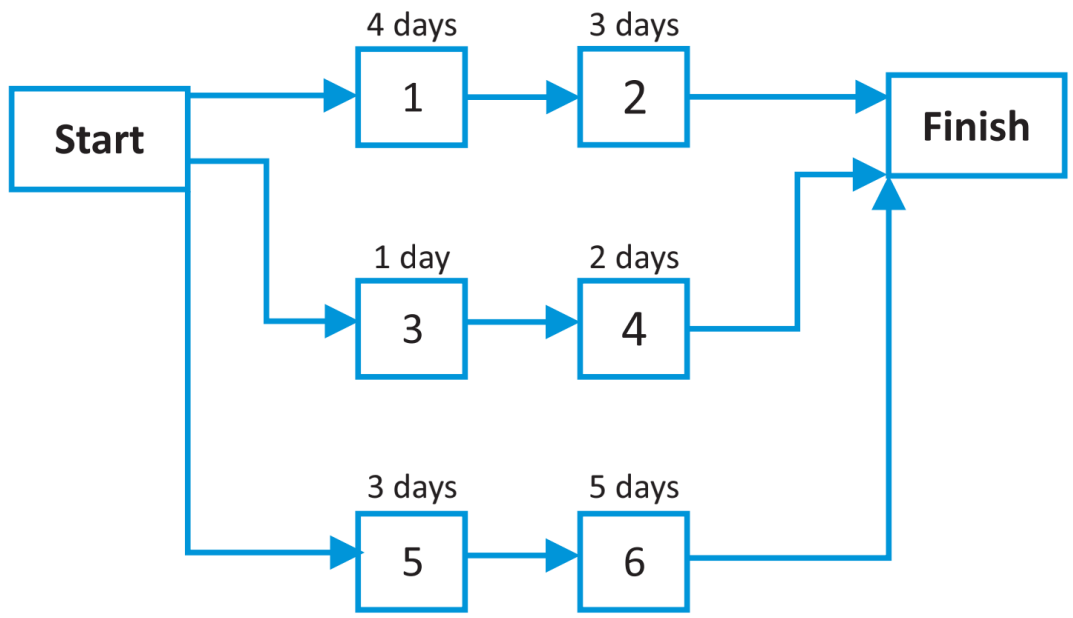
understand of the lag to arrange in the graph

Solution



Near Critical Path

- Here we have three paths in the network diagram.
- The critical path is 5-6 as it takes 8 days.
- The other two paths, 1-2 and 3-4 take 7 days and 3 days, respectively.
- However, path 1-2 is very close to the critical path as it has a float of only 1 day.
- Such paths that are close to the critical path are each called Near Critical Path.



Activities on the near critical path are the project manager's next priority to monitor as they could possibly become the critical path in future.

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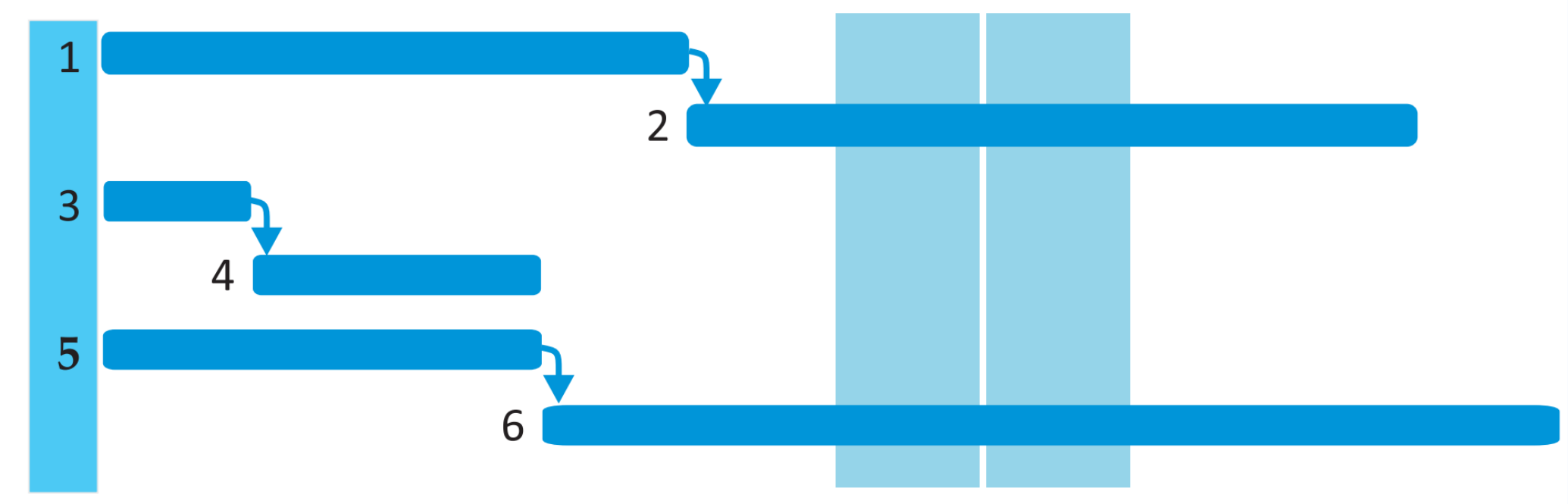
Some Extra Notes

- A project can have multiple critical paths.
  - That would increase the risk of the project because the project manager now needs to worry about multiple paths that could possibly delay the project.
- Similarly, a project can also have multiple near critical paths.

Using a Gantt Chart for showing the Project Schedule



- The difference between a Gantt chart and a network diagram is that the bars in Gantt chart change in length based on the activity duration and we can show progress using a Gantt chart

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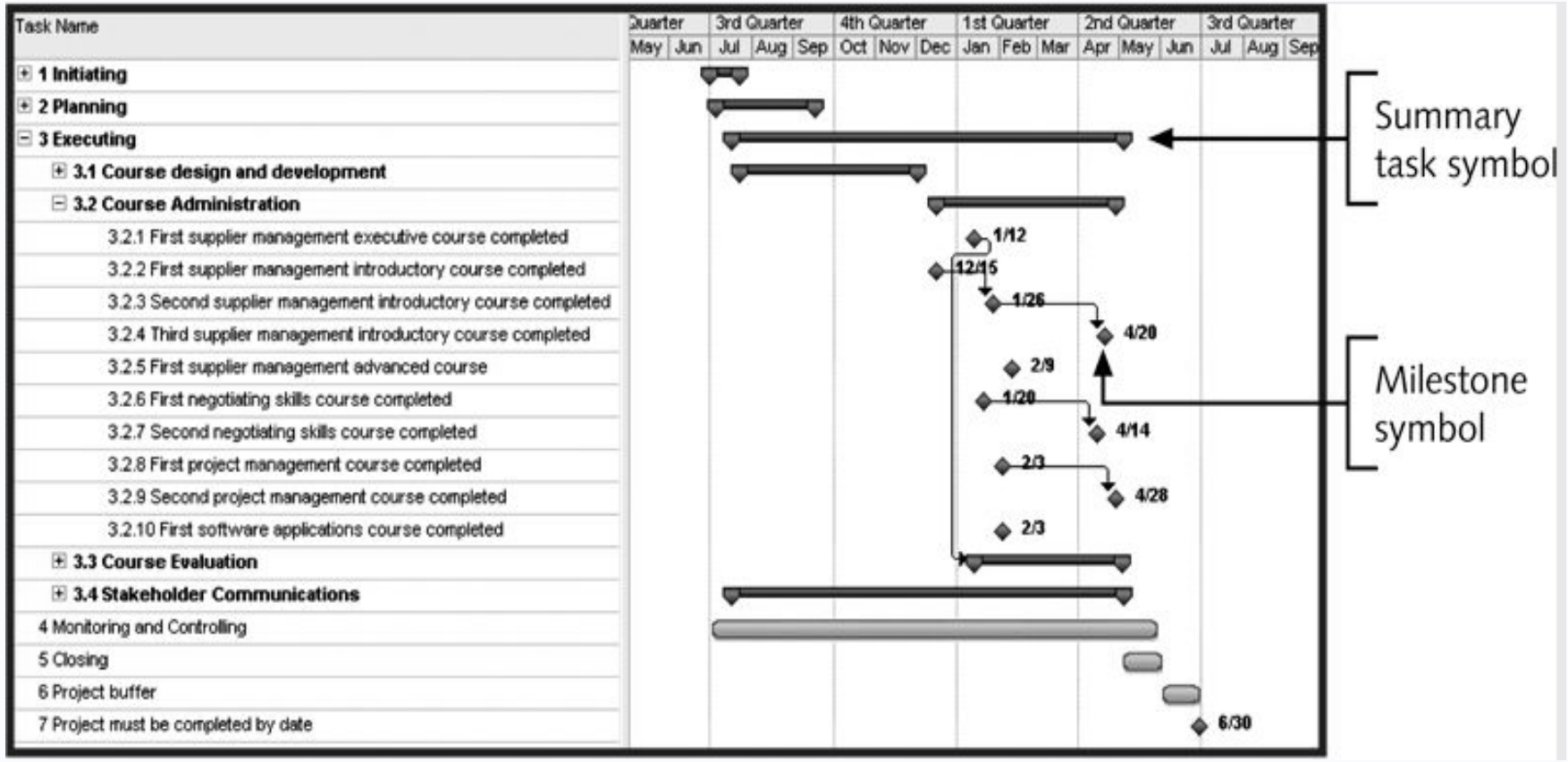
Sample Gantt Chart Showing Summary Tasks and Milestones



Developing the Project Schedule

- *Schedule development* uses the results of all the preceding project time management processes to determine the start and end dates of project activities and of the entire project.
- The resulting project schedule is often shown on a *Gantt chart*, a standard format for displaying project schedule information by listing project activities and their corresponding start and finish dates in a calendar format.
- The ultimate goal of schedule development is to create a realistic project schedule that provides a basis for monitoring project progress for the time dimension of the project.

Schedule Compression

- If the developed schedule does not fit within the expected timelines, we need to compress the schedule.
- There are two primary ways of doing this:
  1. Crashing – One way to compress the schedule is by increasing the resources working on the critical path activities.
     - These resources can either be picked up from the non-critical activities or they could be hired from outside the project.
     - This action generally increases the project costs and is called Crashing.
  2. Fast Tracking – If there is a possibility of removing some discretionary dependencies and doing some activities in parallel it is called Fast Tracking.
     - This leads to higher risks in the project as there is a possibility of rework because some dependencies have been removed.

increase the risk

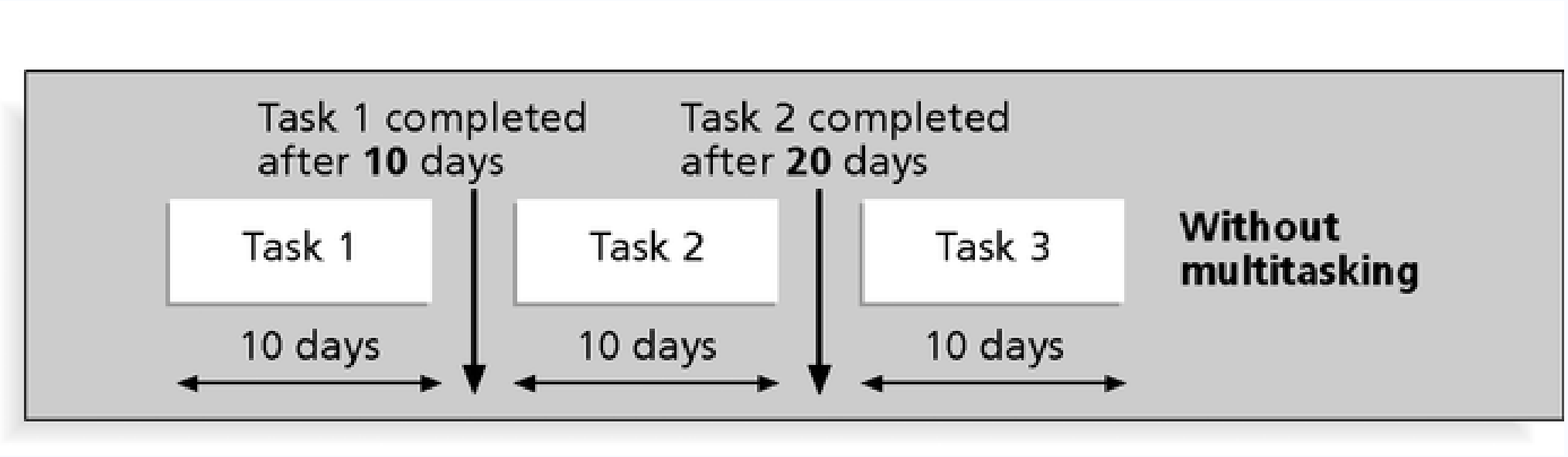
The critical path - Inherent drawbacks

- Any delay in any critical activity will delay the project.
- It assumes an unlimited supply of resources.
  - For this reason, the chances of completing the project within the schedule are low.
- Since the duration of the critical path is the duration of the project, project managers tend to inflate the duration of activities on a critical path to keep an extra margin for completing the project.
  - These miscalculations affect the schedule.
  - Therefore, the critical path method was upgraded to remove these drawbacks and named the critical chain method.

Critical Chain Scheduling

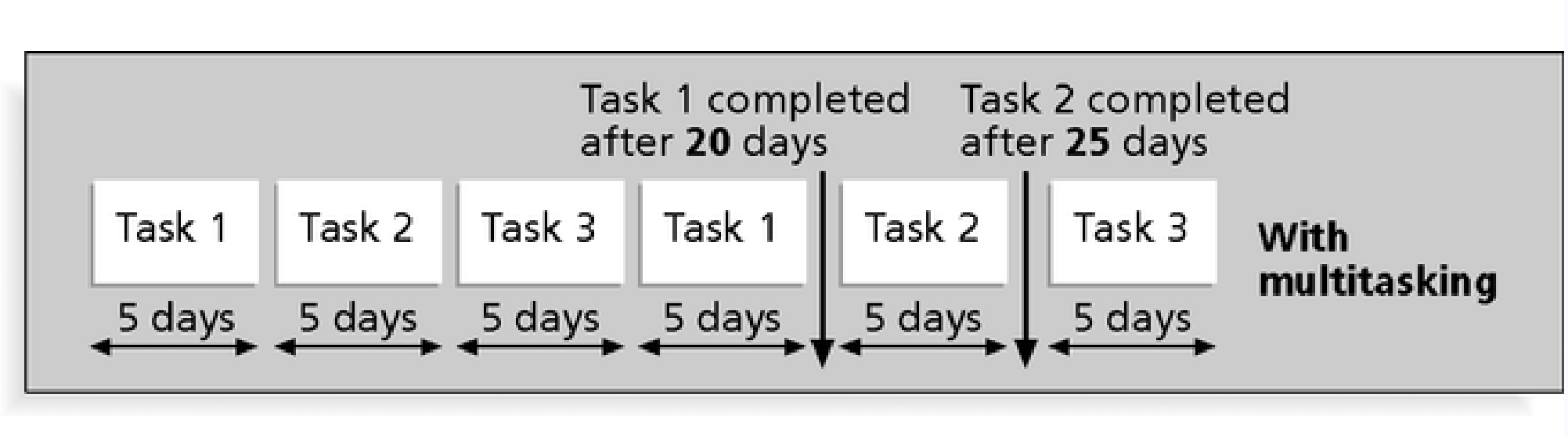
- Critical chain scheduling is a method of scheduling that considers limited resources when creating a project schedule and includes buffers to protect the project completion date.
  - Critical chain takes CPM a step further by adding time buffers to account for limited resources.
  - It attempts to minimize multitasking, which occurs when a resource works on more than one task at a time

Tasks Scheduling Without Multitasking



Three Tasks Without Multitasking

Tasks Scheduling With Multitasking



Three Tasks With Multitasking – The effect of multitasking on the completion date

if you have task dependency or resources are not enough that you need to switch between tasks

Critical Chain – Buffers

- 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 activity 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.

The critical chain – More on Buffers

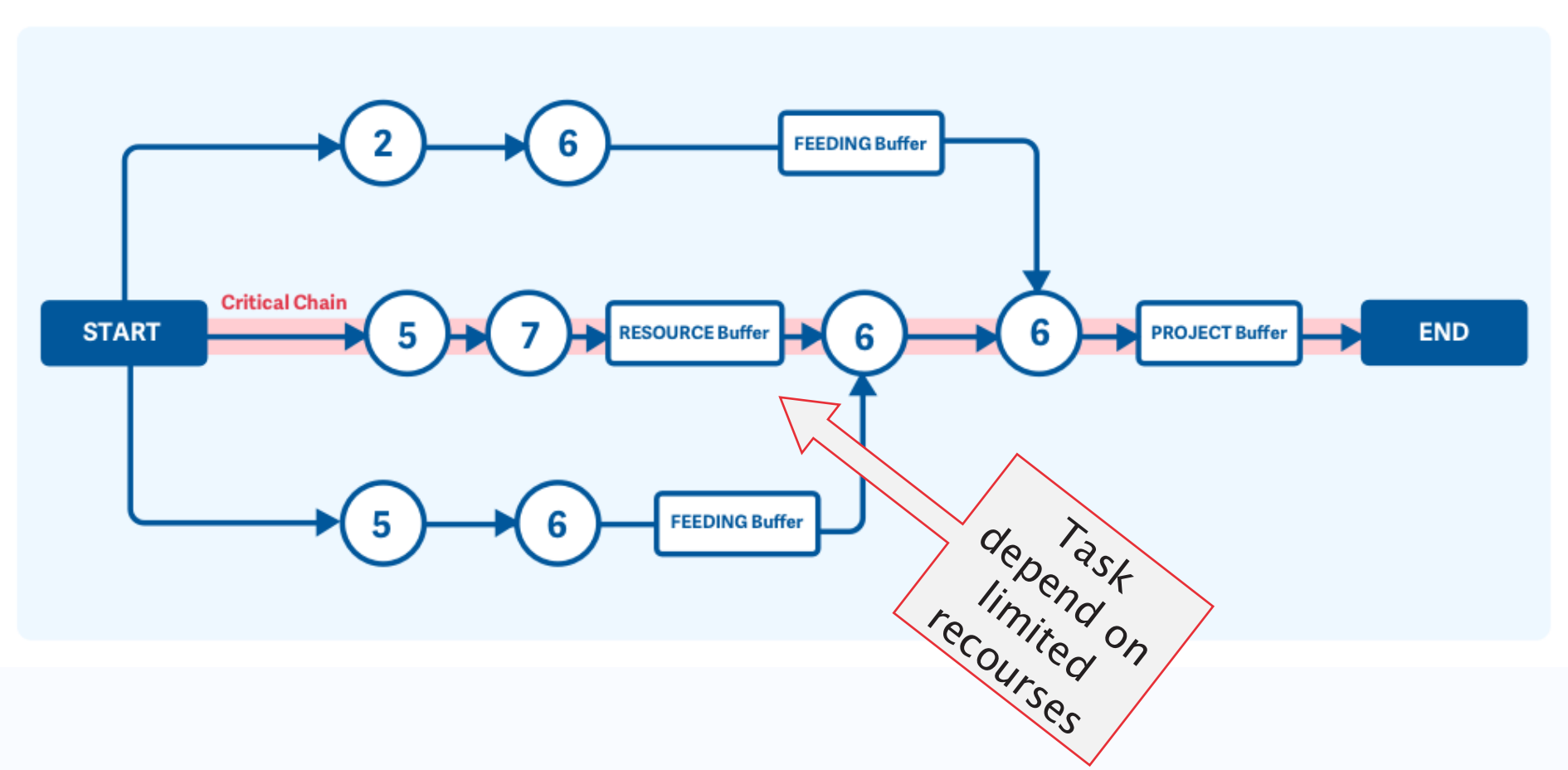
- In the critical chain method, instead of the term "float" the term "buffer" Is used. There are three types of buffer:

  1. Project Buffer
  2. Feeding Buffer
  3. Resource Buffer

- The Project Buffer is added at the end of the project. Any activities which are delayed will eat up this buffer.
- The Feeding Buffer is added to the non-critical chain so any activities that get delayed will use the feeding buffer.
- The Resource Buffer is a resource that is kept alongside the critical chain to ensure continuity of the work.

avoid resources deadlock

Critical chain – Example of Buffers



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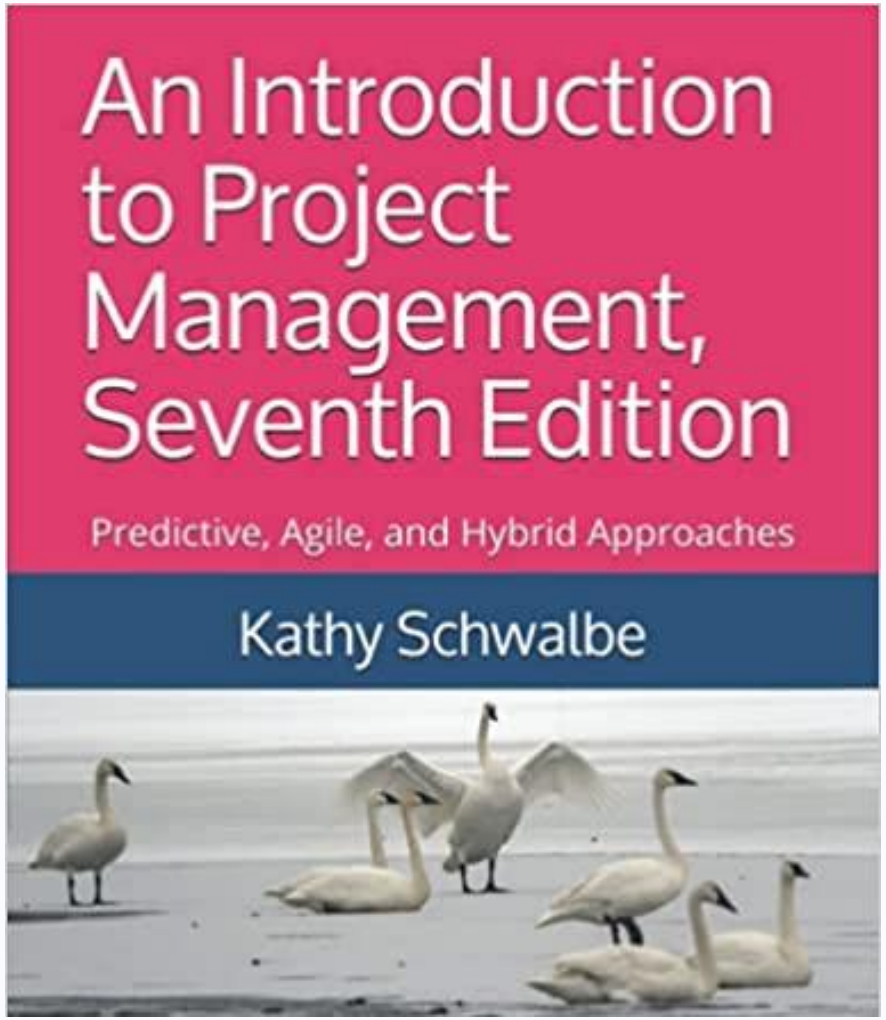
Reference

- Chapter 5: Planning Projects, Part 2 (Schedule and Cost Management)



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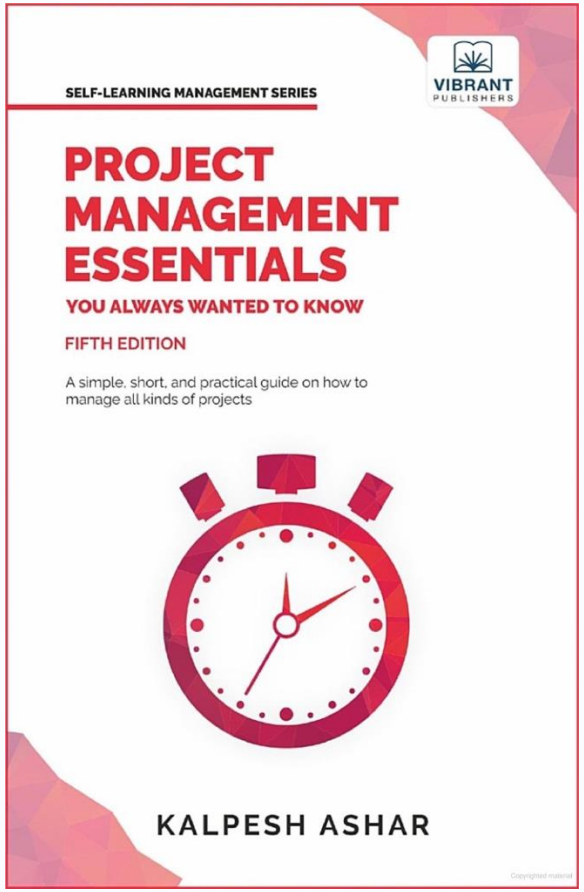
Reference

- Chapter 3 of:
  Project Management Essentials You Always Wanted To Know, 5ed



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YOUR QUESTIONS