Project Planning and Control Methods

Lecture #5

Initial Schedule Development

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Outline

- Introduction
- Define activities
- Determine dependencies
- Estimate activities
- Schedule the project
- Calculate lead and lag time
- Calculate other dependencies
- Using M.S. Project

Introduction

Where are we standing in our project planning and control methods?

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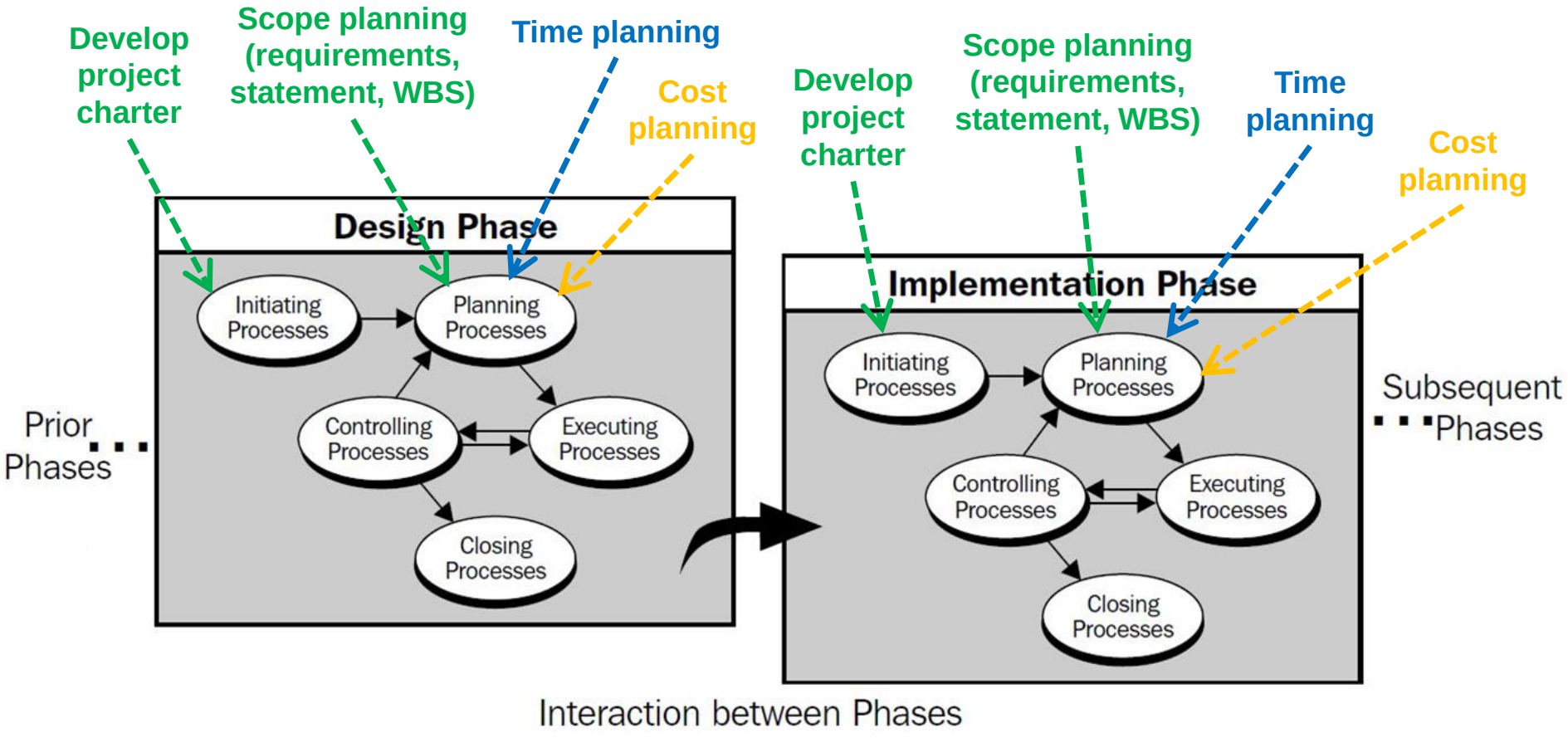


Interaction between Phases

Introduction

The critical path method (CPM) is an algorithm for scheduling a project and determining project's duration using following steps:

1. Define activities
2. Determine dependencies
3. Estimate activities
4. Schedule the project

CPM is the most common method for scheduling a project! At the rest of this lecture we are going to discuss different aspects of the CPM for developing our project schedule

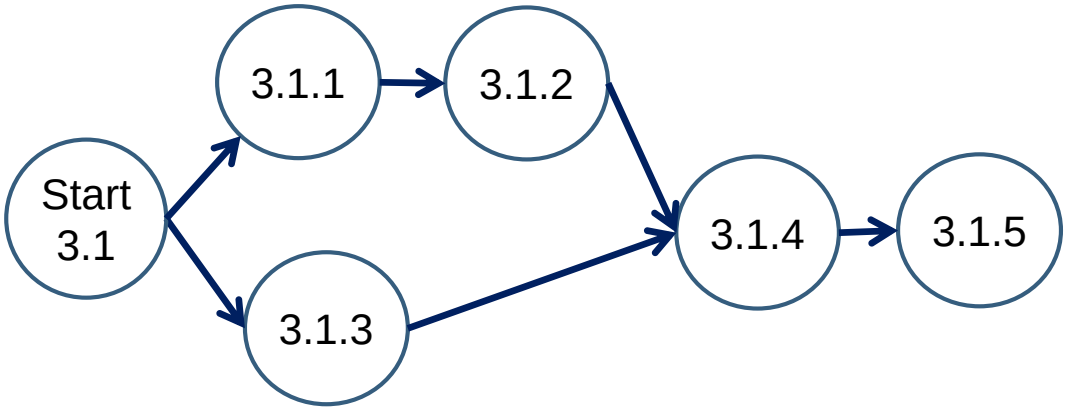
Define activities

1. Define activities: Identify list of all activities (work steps/ procedures) required to complete different work packages (presented in the WBS) base on your implementation method!
   - Organization's asset (set of procedures, templates, forms, and tools used in the organization), expert judgement and literature are the main tools used in for defining activities.
   - Example: 3.1. Prepare foundation form work:
     1) Extract foundation sizes from drawings
     2) Order form sheets required
     3) Hire two form-workers for the job
     4) Size the form-sheets
     5) Install form-sheets in place

Determine dependencies

2. Determine dependencies between the activities: Start determining dependencies at the activity level, not work packages. Why?

- Example: 3.1. Prepare foundation form-work :



Note: This form of dependency presentation is called "**Activities on Node**" (**AON**) network. More explanation on different forms of activity relationship and schedule presentation will be discussed later on.

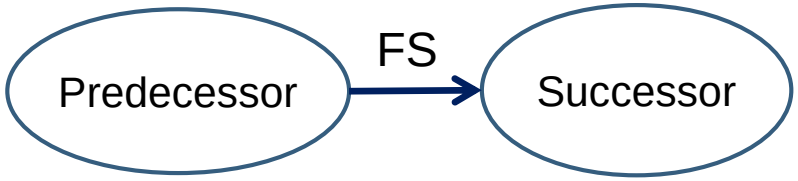
Determine dependencies

2. Different types of activity dependency:

2.1. Finish to Start (FS): Initiation of an activity (successor) depends on the completion of another activity (predecessor)

- This is the most common type of activity dependency. Many project manager insist just using this type of dependency claiming it can cover all situations (but we do not agree with it!). Examples:
  - Initiation of “Order form sheets” depends on “Extract foundation sizes from drawings”
  - Initiation of “Size form sheets” depends on “Order form sheets”
  - Initiation of “Size form sheets” depends on “Hire two form-workers for the job”

Activities are serial



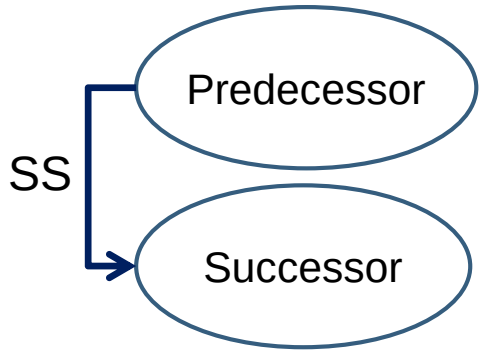
Determine dependencies

2. Different types of activity dependency (cont'd):

2.2. Start to Start (SS): The initiation of an activity (successor) depends upon the initiation of another activity (predecessor).

- One common application of this dependency is when an activity serves as a control for another activity. Examples:
  - Initiation of "control bolting quality" depends on the initiation of "bolting the structure"
  - Initiation of "in-place concrete casting" depends on the initiation of "install form sheets in place "

Activities are in parallel



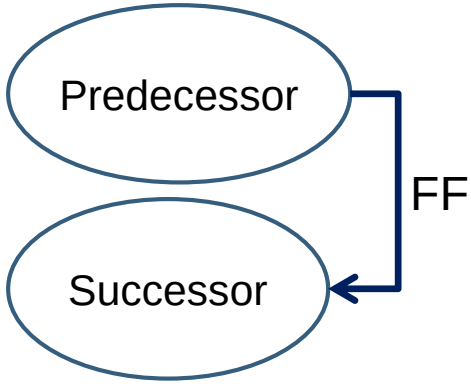
Determine dependencies

2. Different types of activity dependency (cont'd):

2.3. Finish to Finish (FF): The completion of an activity (successor) depends upon the completion of another activity (predecessor).

- One common application of this dependency is when an activity serves as a support for another activity. Examples:
  - Completion of "supply concrete from batch plant" depends on the completion of "in-place concrete casting"
  - Completion of "backfill the trench" depends on the completion of "laying down the pipe in the trench"

Activities are in parallel



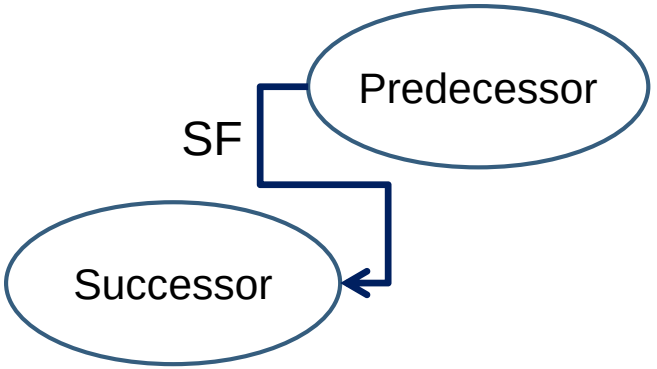
Determine dependencies

2. Different types of activity dependency (cont'd):

2.4. Start to Finish (SF): The completion of an activity (successor) depends upon the initiation of another activity (predecessor).

- This dependency is almost nonexistent in construction projects. Examples:
  - Completion of "bringing supplies from city A" depends on initiation of "demolishing bridge A".
  - Completion of "power plant A (a high cost power plant) operation" depends on the initiation of "power plant B (a new low cost power plant) operation".

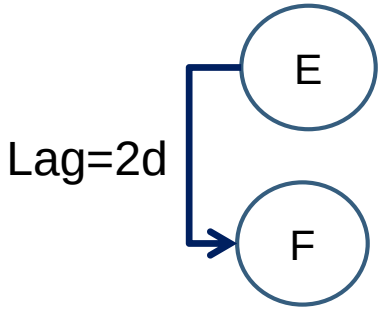
Activities are serial



Determine dependencies

2. Different types of activity dependency (cont'd):

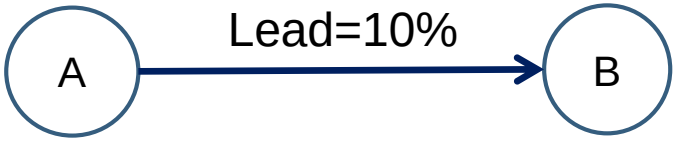
- **Lag time** (Lag): Represents the existing delay between two depended activities. Like lead time it also helps us to capture dependency between activities more realistically. For example if in an SS dependency the successor activity F can start 2 days after predecessor activity E begins, we can say that the relationship has a lat of 2 days:



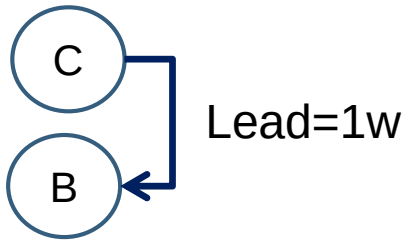
Determine dependencies

2. Different types of activity dependency (cont'd):

- **Lead time** (Lead)**:** Represents the overlap between two activities that are related by a dependency. It makes activity relationship more realistic. For example if in an FS dependency the successor activity B can start after predecessor activity A is 90% complete, we can say that the relationship has a lead of 10%:



Lead time also can be determined based on absolute time. For example if in an FF dependency the successor activity B can be finished 1 week before activity C is finished, we can say that the relationship has a lead of 1 week.



Estimate activities

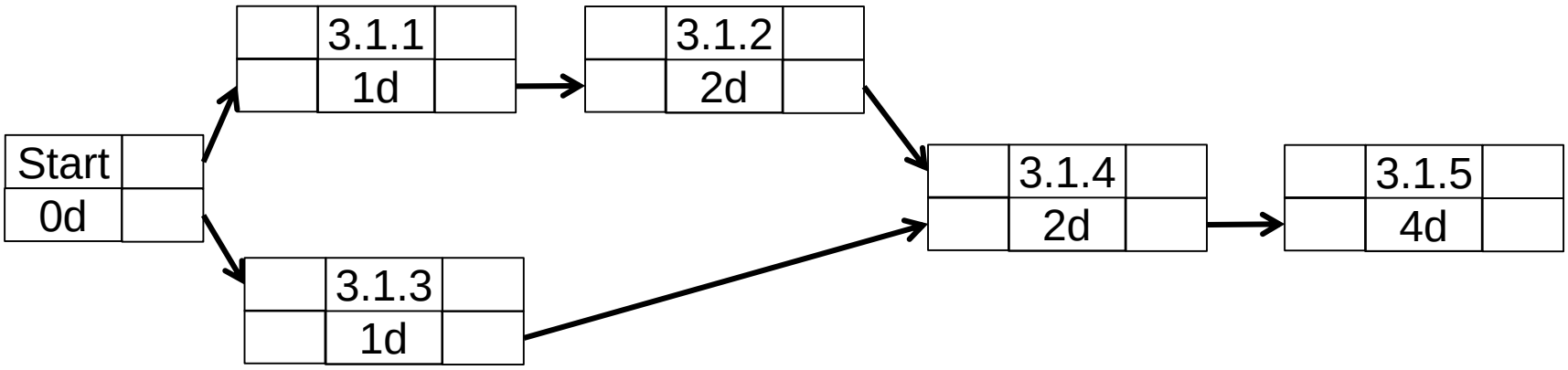
3. Estimate activities: Estimate normal resources required (or available) and time (duration) that each activity can be completed based on the estimated resources.

- Example: 3.1. Prepare foundation form work:
    1) Extract foundation sizes from drawings (1 engineer, 1 day)
    2) Order form sheets (1 purchaser, 2 day)
    3) Hire two form-workers for the job(1 HR-person, 1 day)
    4) Size form sheets (2 form-worker, 2 day)
    5) Install form sheets in place (2 form-worker, 4 days)

Schedule the project

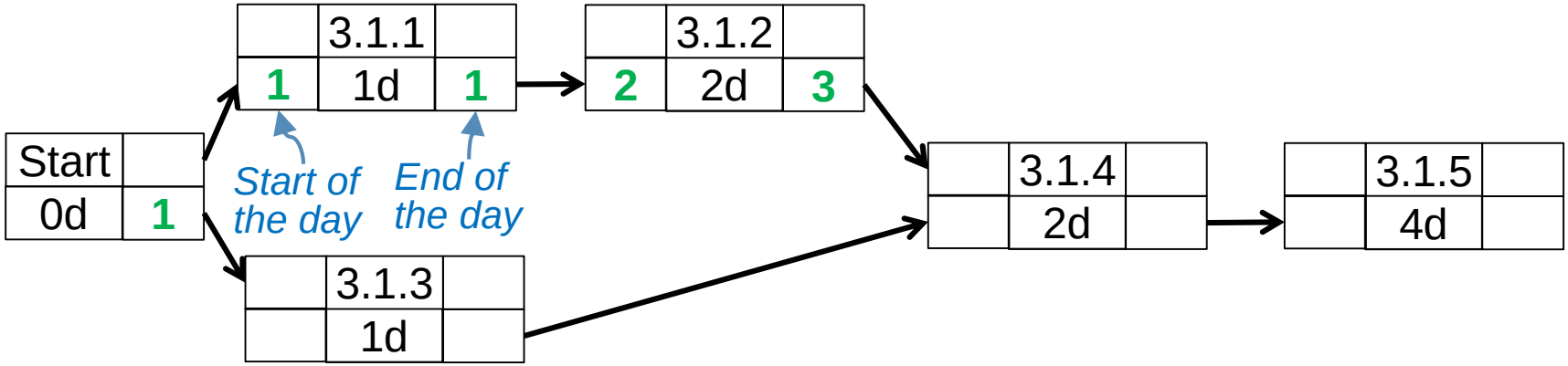
4. Schedule project:

- Calculating the project's schedule using "**forward pass**" or by summing up activity durations in different paths from the start to the finish and "**backward pass**" calculations by summing up activity durations in different paths from the finish to the finish. Example (Prepare foundation form work):



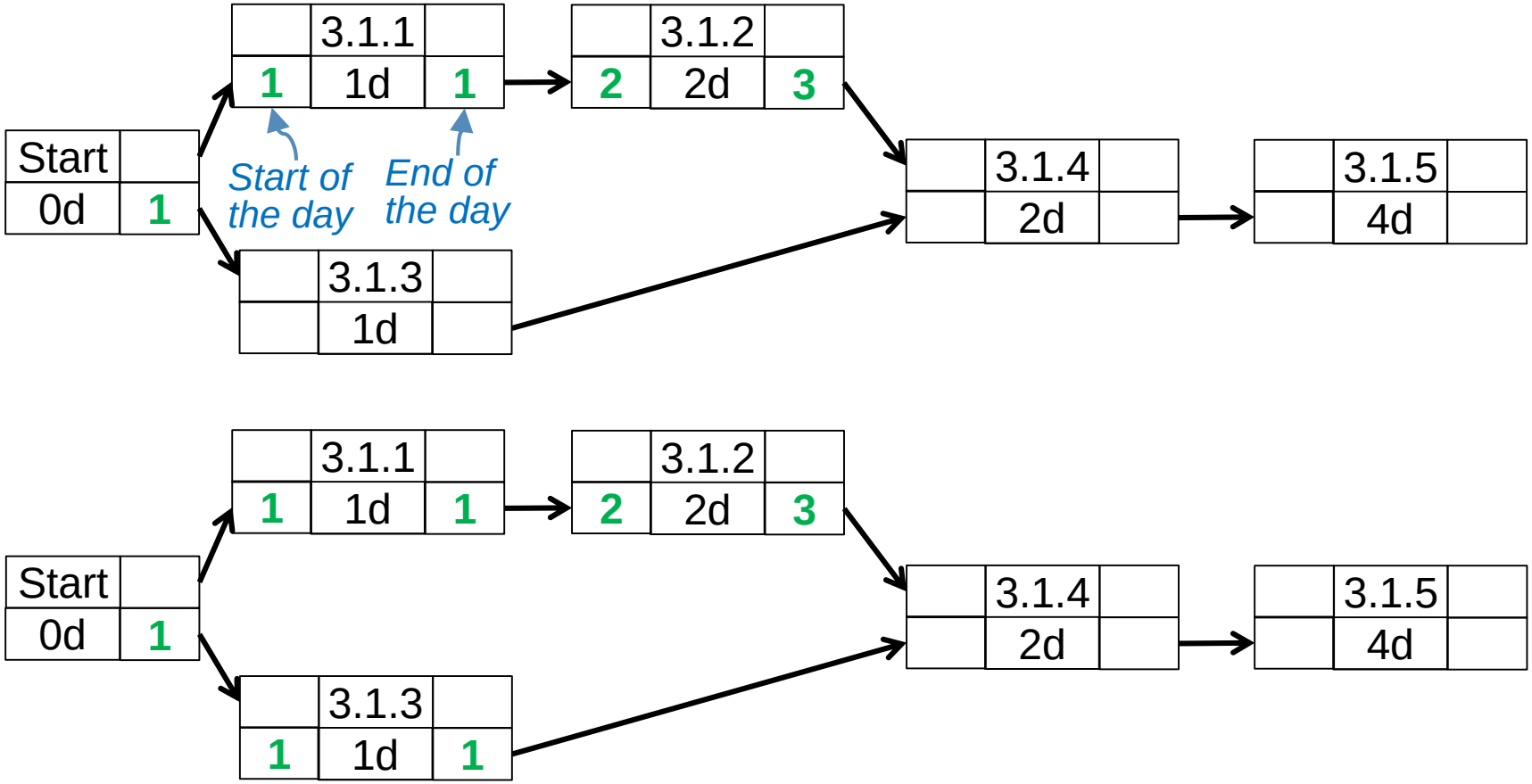
Schedule the project

- Forward pass (**Earliest start and finish**):



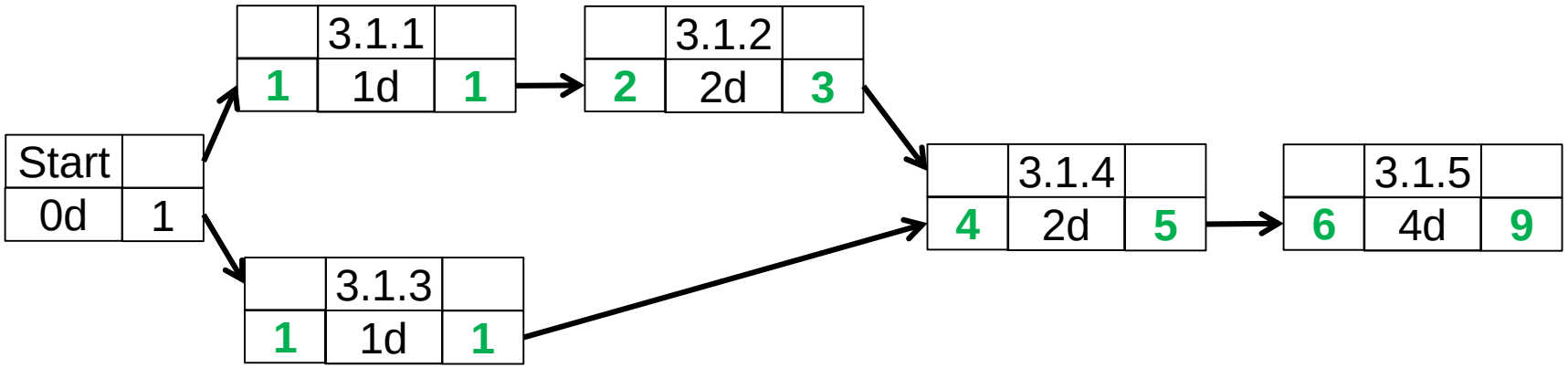
Schedule the project

- Forward pass (**Earliest start and finish**):



Schedule the project

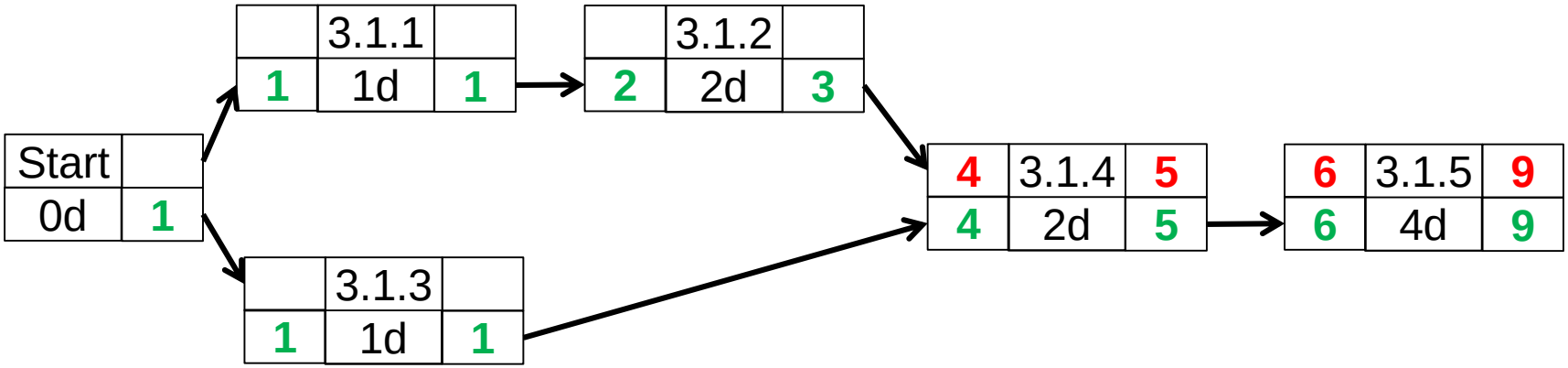
- Forward pass (**Earliest start and finish**) (cont'd):



- All "Prepare form work" activities will be completed at day 9!

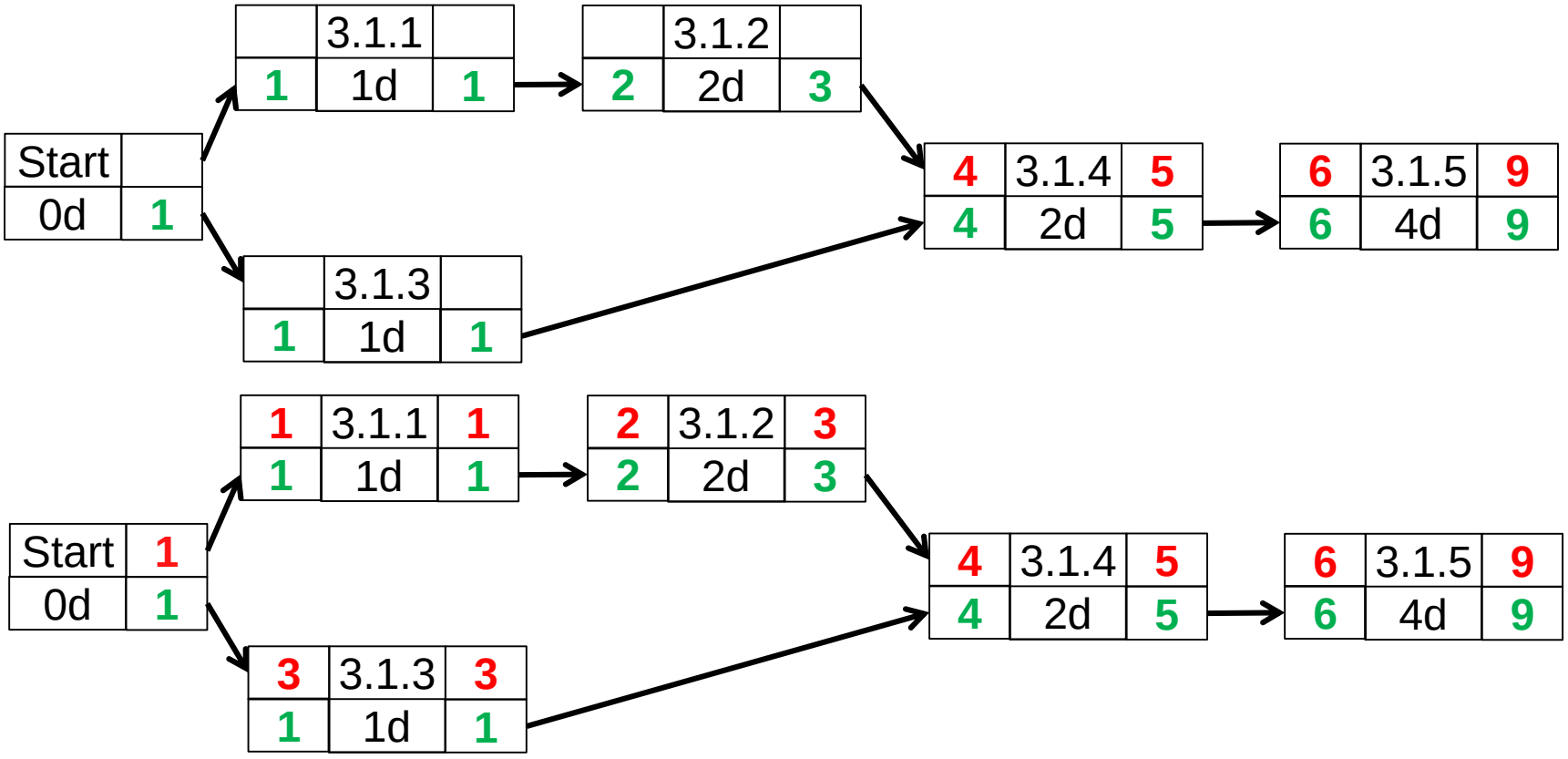
Schedule the project

- Backward pass (**Latest start and finish**):



Schedule the project

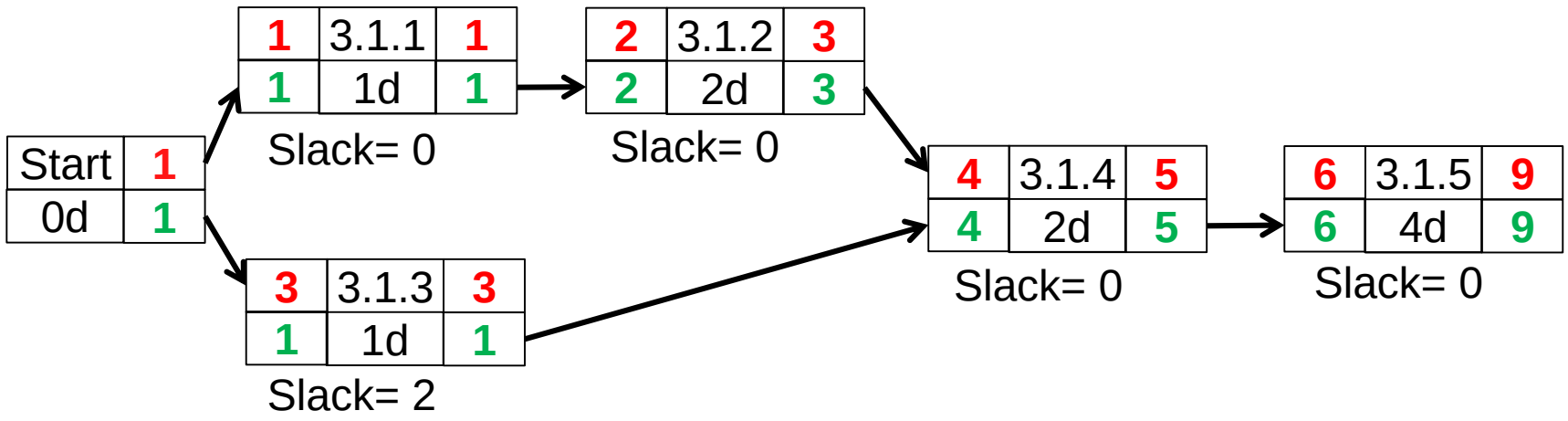
- Backward pass (**Latest start and finish**):



- The difference between results from forward pass and backward pass are used to calculate activity **slack (float)** and **critical path**!

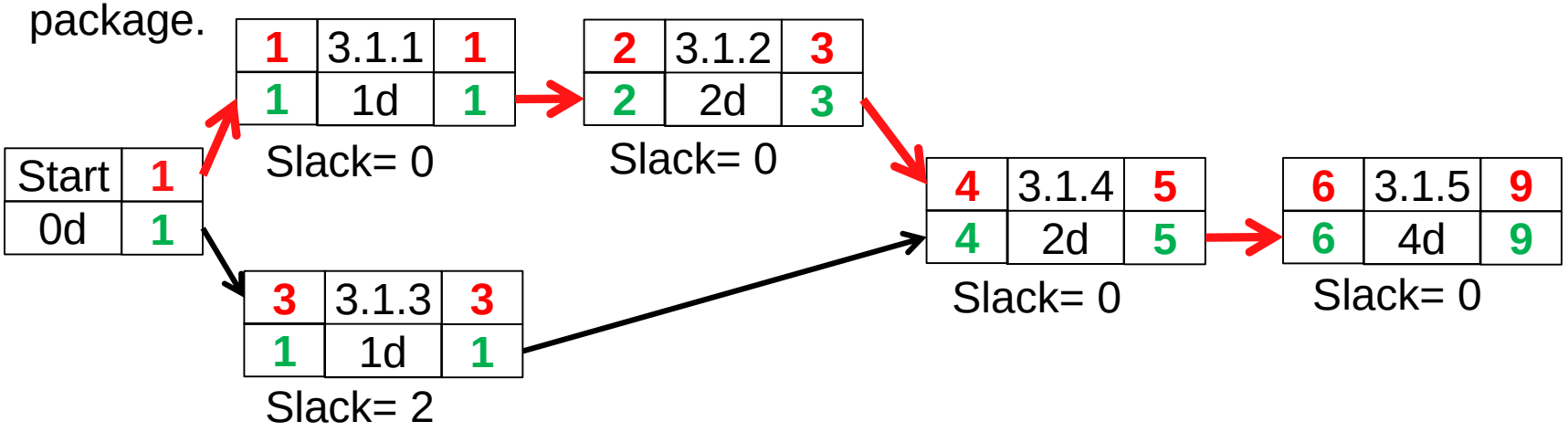
Schedule the project

- Calculate every activity's **slack time** by subtracting start time calculated in backward pass from start time calculated from forward pass *OR* by subtracting finish time calculated in backward pass from finish time calculated from forward pass.



Schedule the project

- Slack time represents how much flexibility we have on changing activity's start (and correspondingly finish) time with no effect on the final duration.
- Slack of 2 days shows that we have an allowance of 2 days to move the start time of the activity (from day 1 to day 3) with no effect on the final duration.
- Activities with zero slack are on the ***critical path***, i.e., any increase in any activity on the critical path will result in increase on the total time of the project. In our example any increase on the critical activities (i.e., activities on the critical path) will result in the increase in the total "prepare form work" work package.

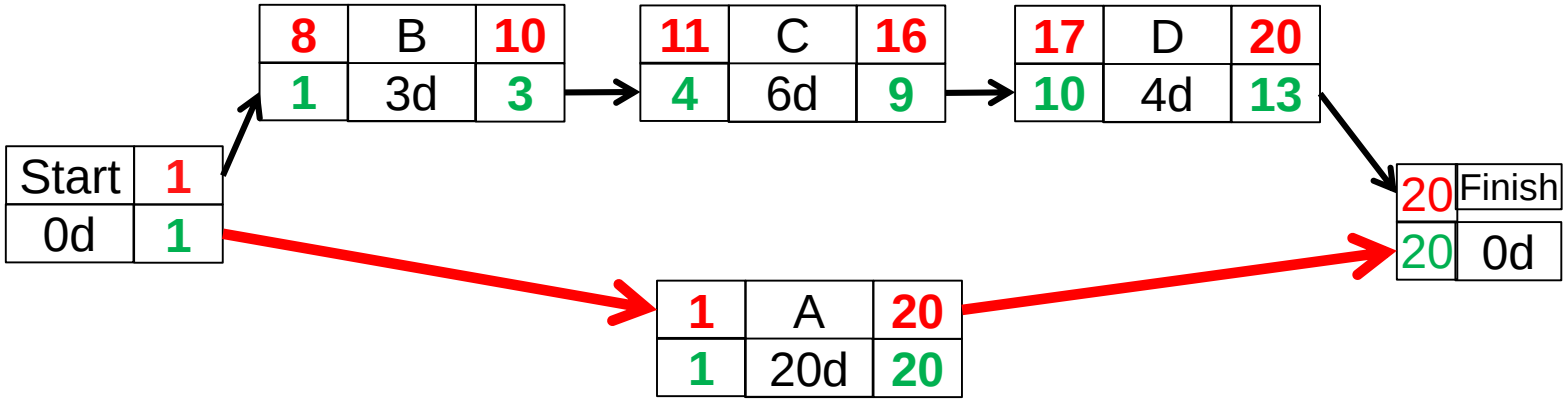


Schedule the project

Question: What is the difference between calculation result from forward pass (**earliest start and finish**) and backward pass (**latest start and finish**)? When should we use **earliest start and finish** result when should we use **latest start and finish** result?

Schedule the project

- **Example 1**: Cost expenditure structure for Early Vs Late schedule!



Task	Duration	Dependency	Early Start	Late Start	Cost k$
A	20		1	1	5
B	3		1	8	7
C	6	B	4	11	4
D	4	C	10	17	4

Schedule the project

- **Example 1 (cont'd)**: Cost expenditure structure for Early Vs Late schedule!

Early Start

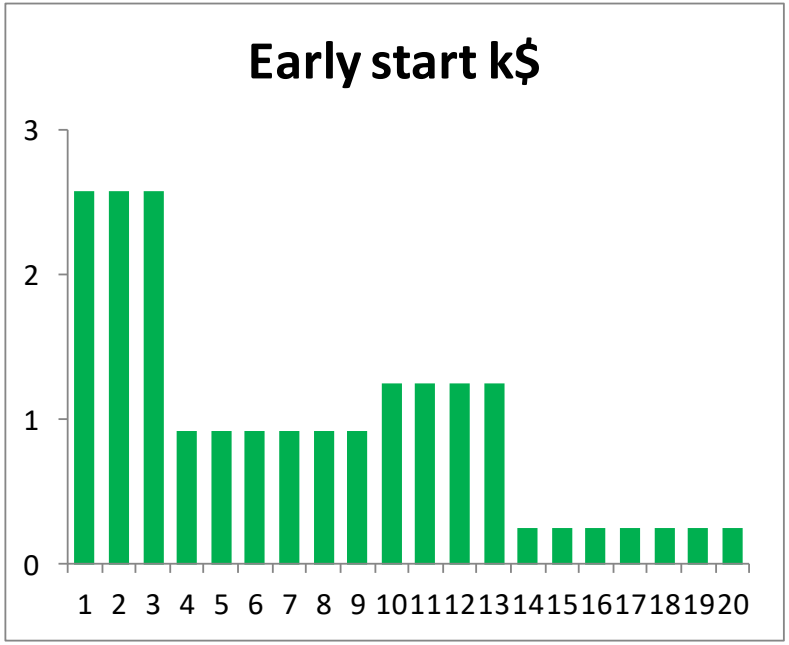
Task	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
A	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25
B	2.3	2.3	2.3																	
C				0.7	0.7	0.7	0.7	0.7	0.7											
D										1	1	1	1							
Total	**2.58**	**2.58**	**2.58**	**0.92**	**0.92**	**0.92**	**0.92**	**0.92**	**0.92**	**1.25**	**1.25**	**1.25**	**1.25**	**0.25**	**0.25**	**0.25**	**0.25**	**0.25**	**0.25**	**0.25**

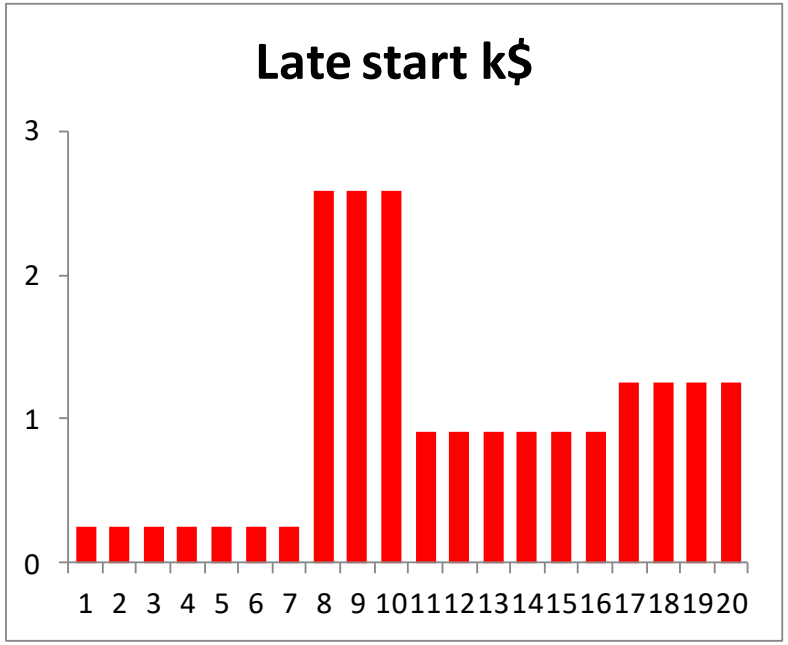
Late Start

Task	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
A	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25
B								2.3	2.3	2.3										
C											0.7	0.7	0.7	0.7	0.7	0.7				
D																	1	1	1	1
Total	**0.25**	**0.25**	**0.25**	**0.25**	**0.25**	**0.25**	**0.25**	**2.58**	**2.58**	**2.58**	**0.92**	**0.92**	**0.92**	**0.92**	**0.92**	**0.92**	**1.25**	**1.25**	**1.25**	**1.25**

Schedule the project

- **Example 1 (cont'd)**: Cost expenditure structure for Early Vs Late schedule!

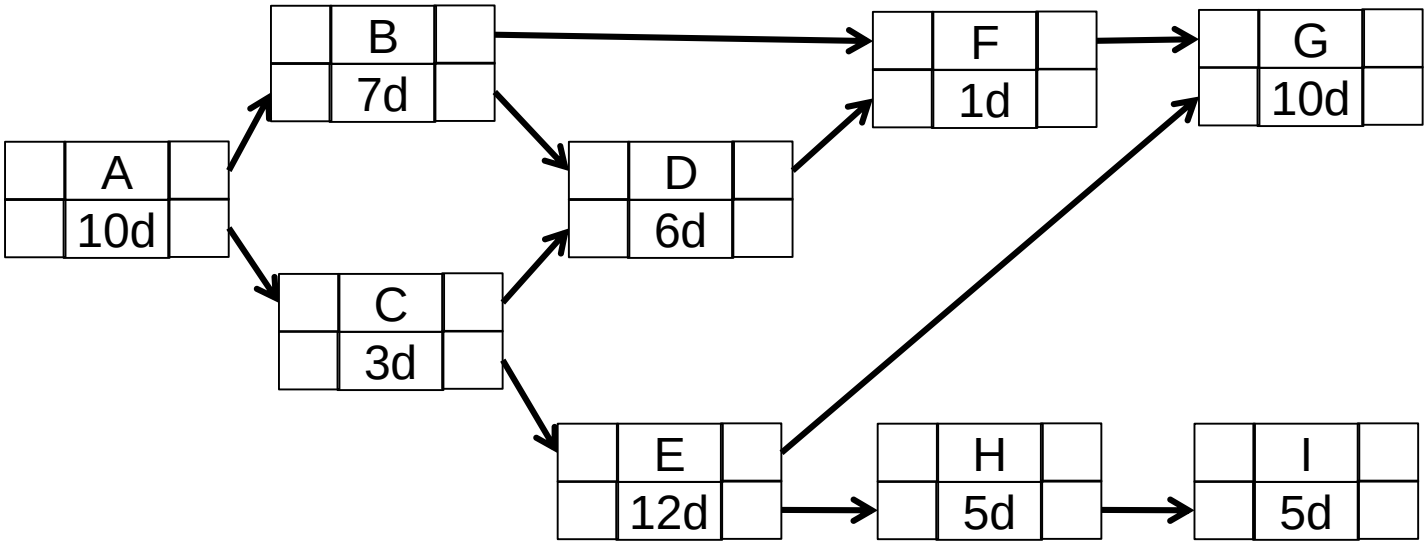




- Using early schedule we are shifting cash flow to the early stages while in late schedule we shift it to the late stages of the project. So late schedule brings us time value!
- When we are dealing with risky schedule (with stochastic duration which is not our case at the time), by adopting early schedule we are going to decrease the chance of possible delays (as a result of increase in durations)!

In class exercise 1

In the AON network below, calculate project duration and critical path!



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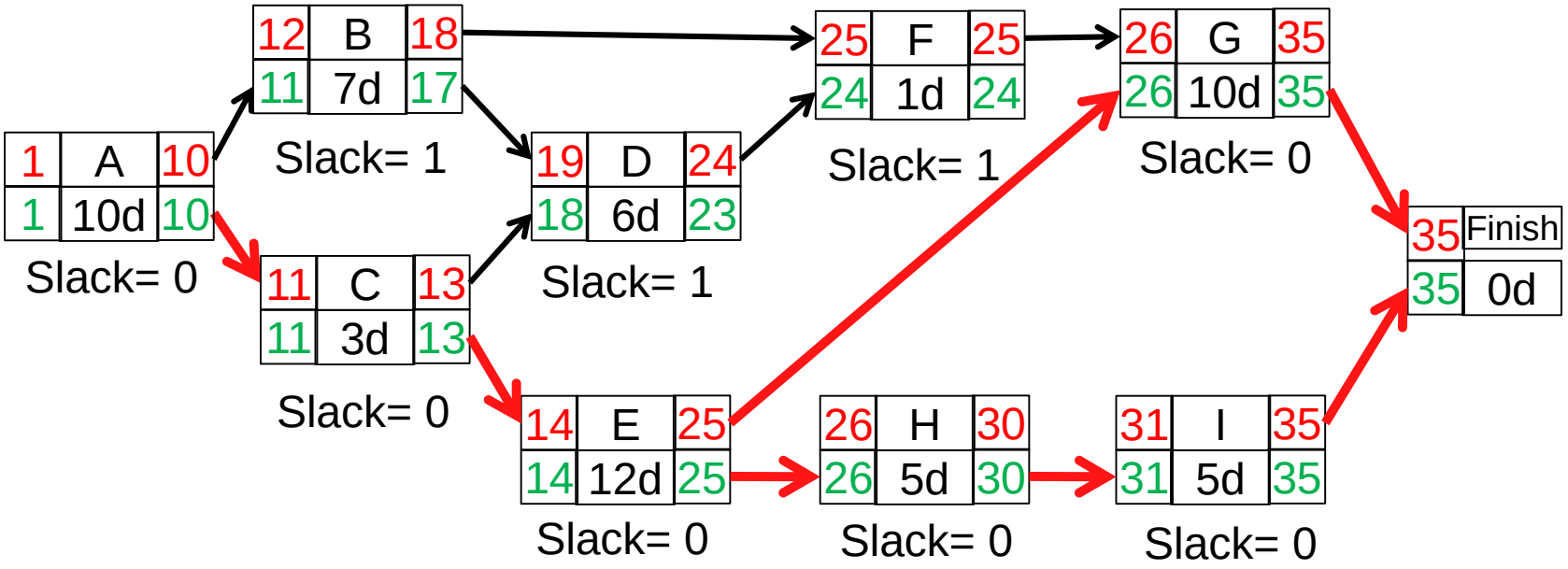
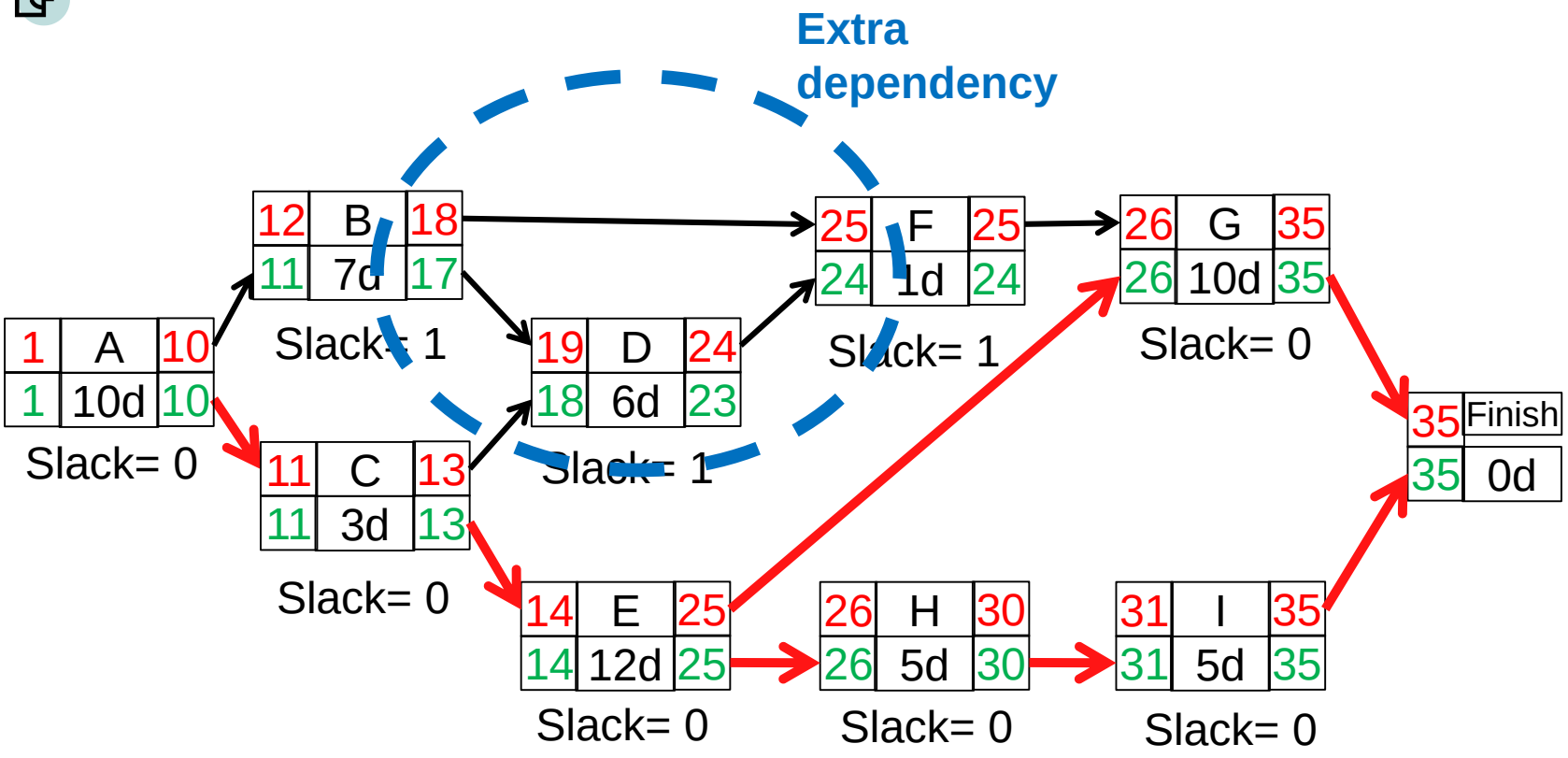


- **Note:** We might have several *Critical Paths* in a project.

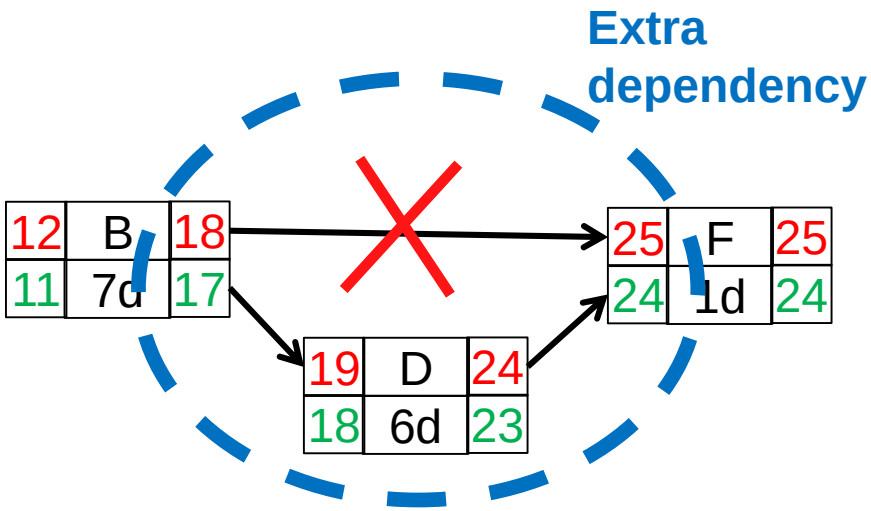
In class exercise 1

In the AON network below, calculate project duration and critical path!

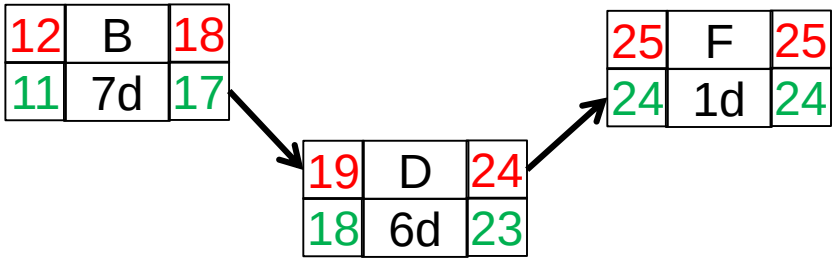


In class exercise 1

In the AON network below, calculate project duration and critical path!



- As a predecessor for D, B is an indirect predecessor for F, no need for drawing direct FS link between B and F! No change in the calculations!



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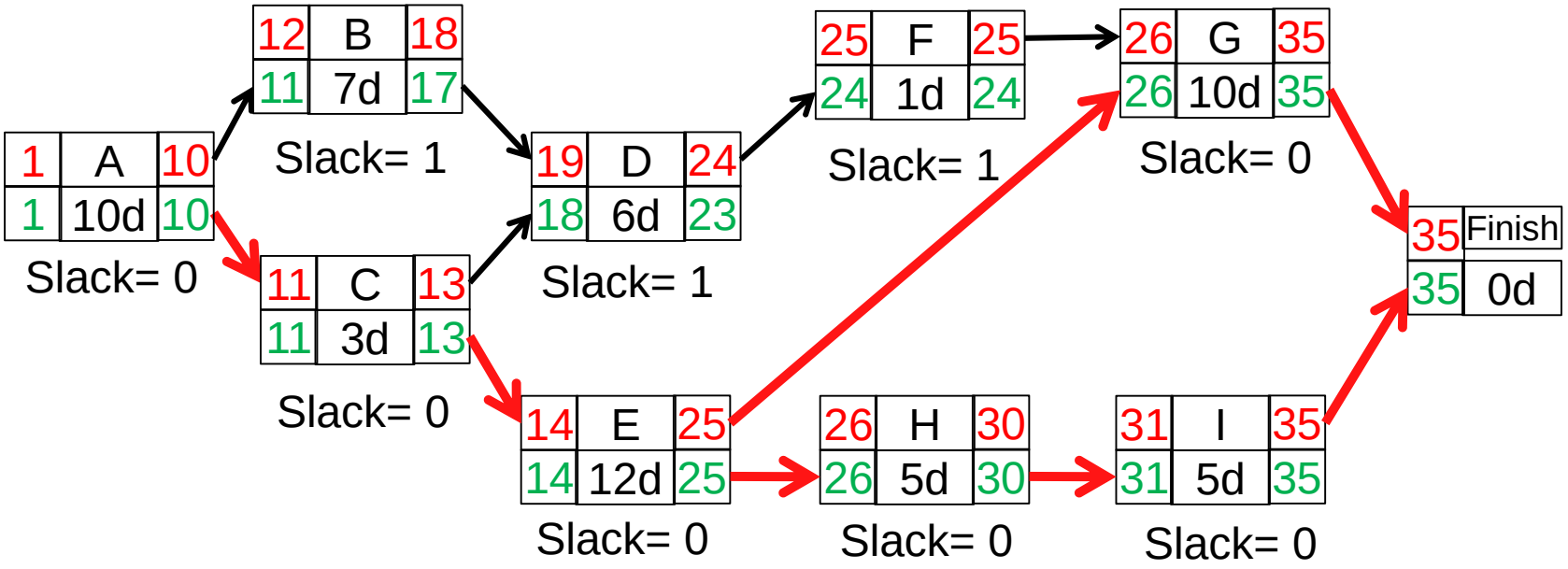
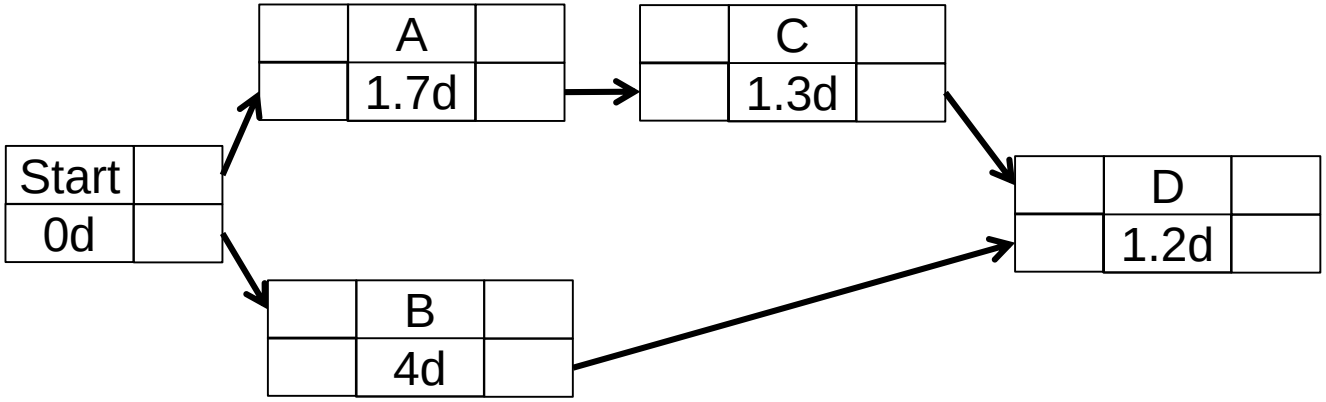


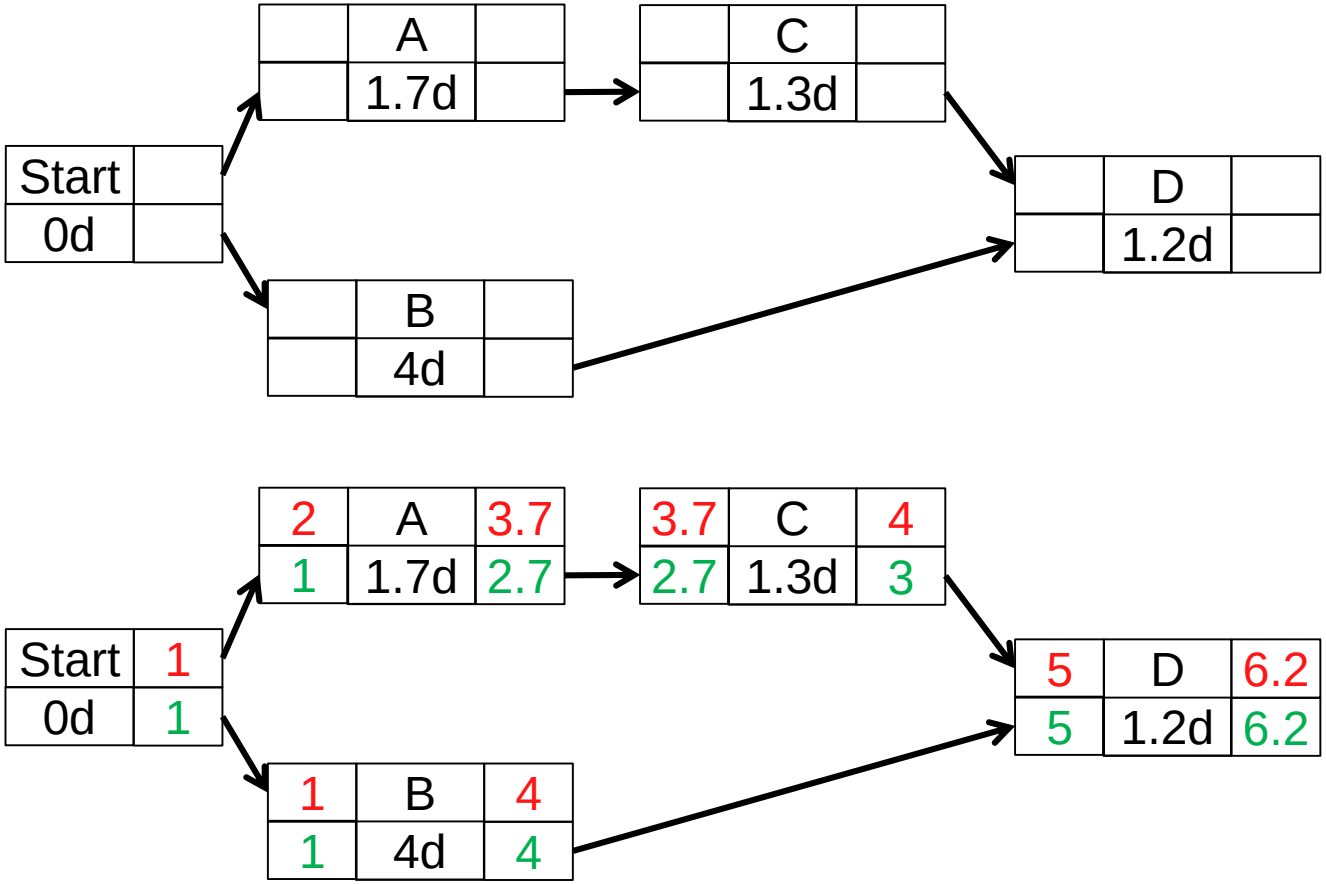
Schedule the project

- **Example**: Activities with fraction duration



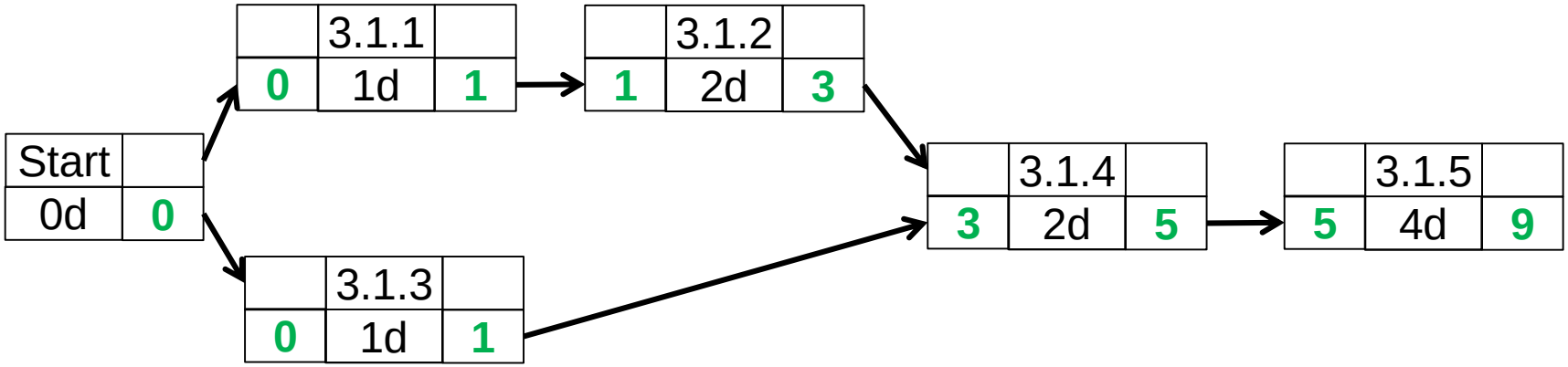
Schedule the project

- **Example**: Activities with fraction duration



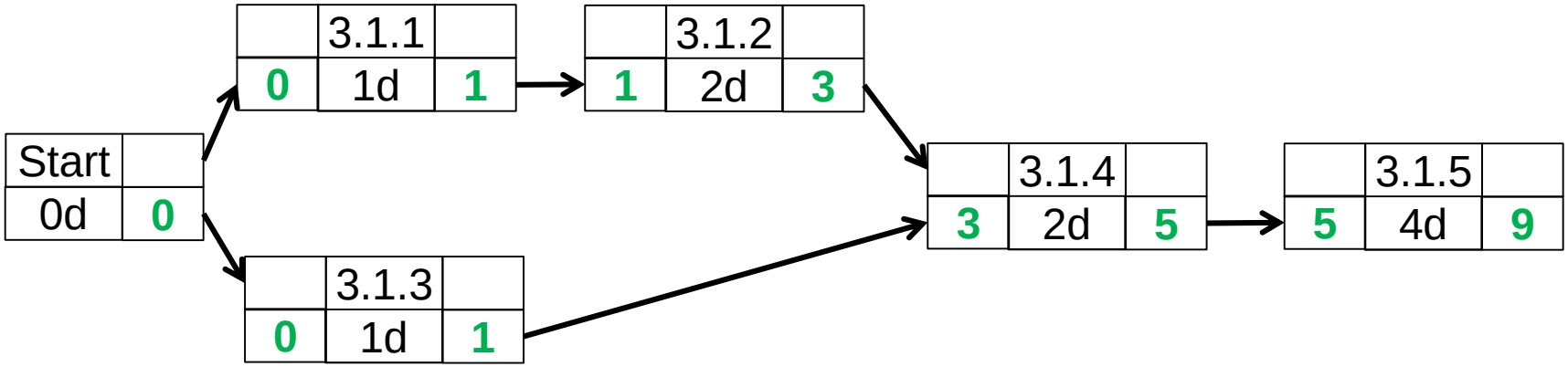
Schedule the project

- **Example**: Simplified calculation
  - Forward pass

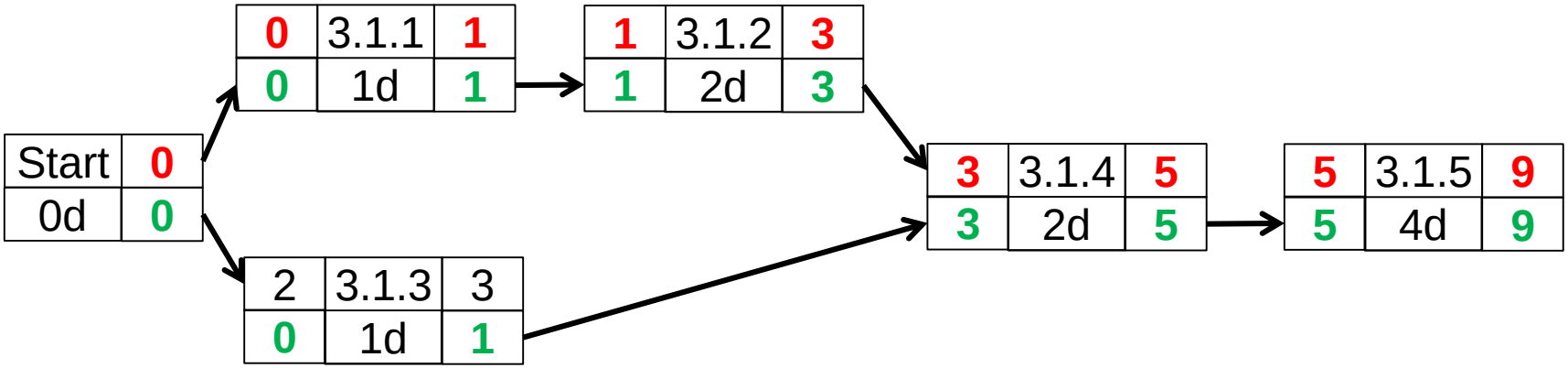


Schedule the project

- **Example**: Simplified calculation
  - Forward pass

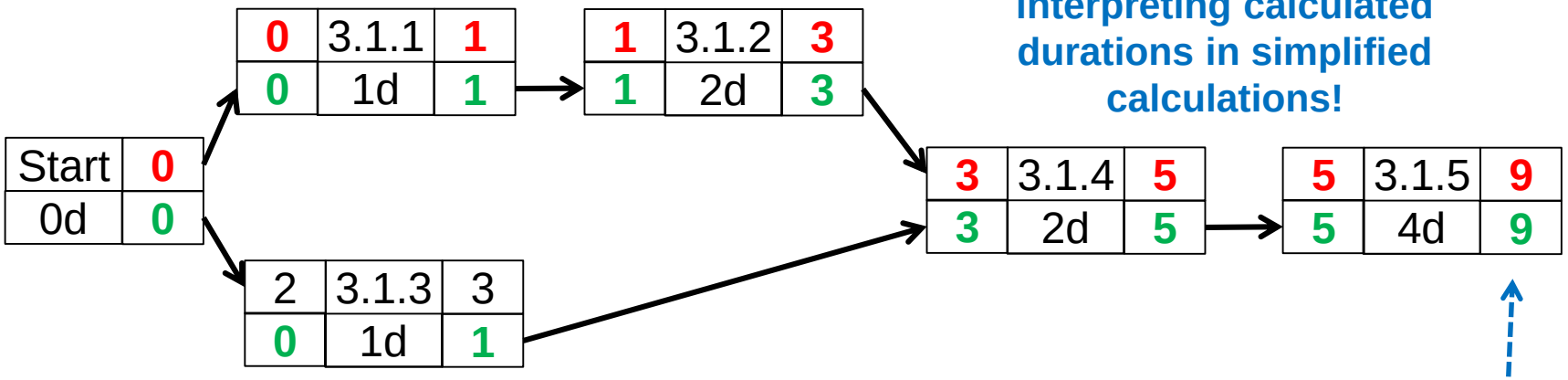


  - Backward pass



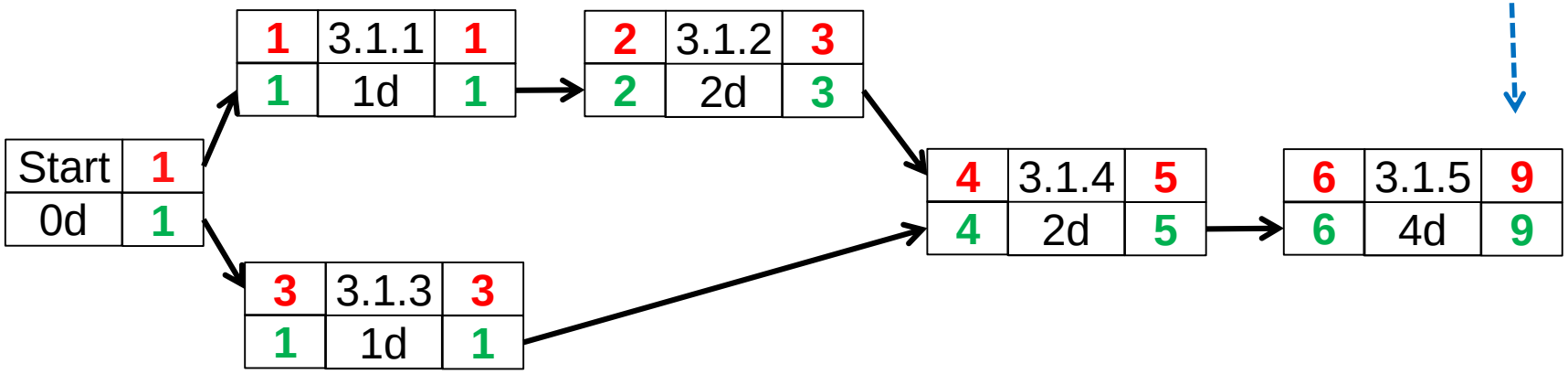
Schedule the project

- **Example**: Simplified calculation



Be careful when interpreting calculated durations in simplified calculations!

- **Result of regular calculations**



Similar final results

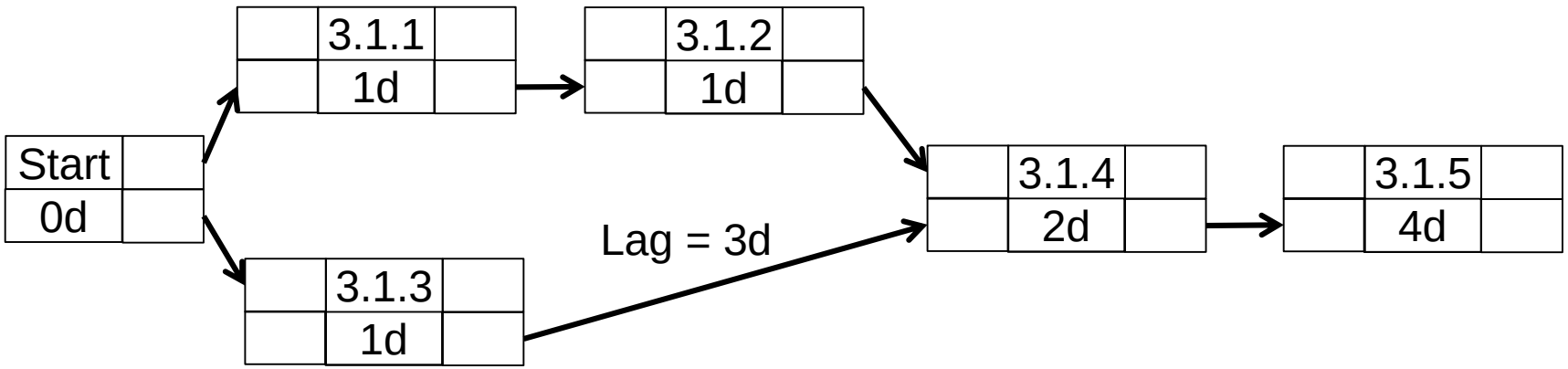
Calculate lead and lag time

In our form-work example, we considered 1 day of HR-person for hiring form-workers; however, after hiring form-workers we need to give 3 more days time to the form workers to come to the site and start the work. What will be the effect of this change to our “prepare foundation form work” work package?

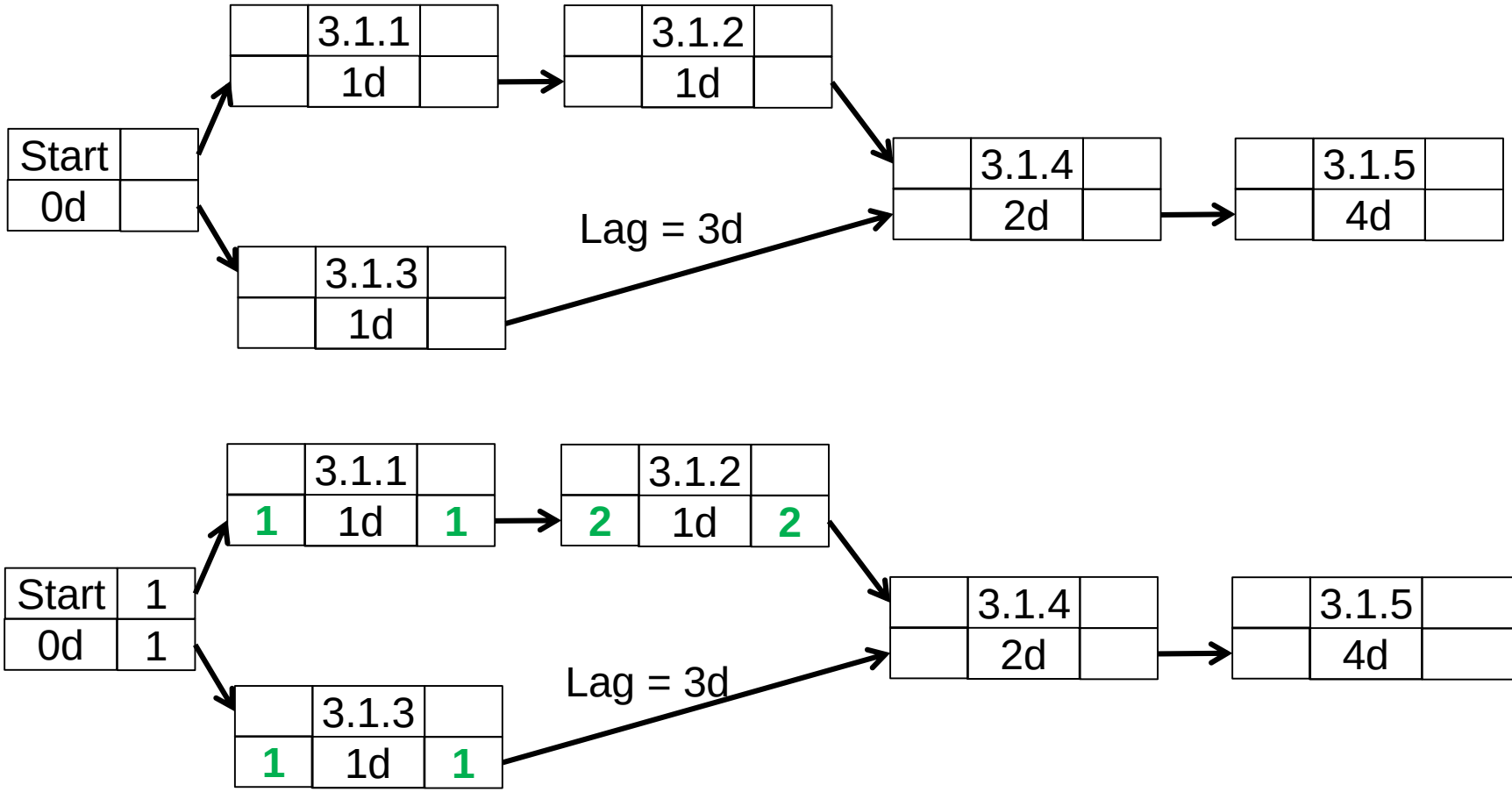
3.1. Prepare foundation form work :

1) Extract foundation sizes from drawings (1 engineer, 1 day)
2) Order form sheets (1 purchaser, 1day)
3) Hire two form-workers for the job(1 HR-person, 1 day)
4) Size form sheets (2 form-worker, 2 day)
5) Install form sheets in place (2 form-worker, 4 days)

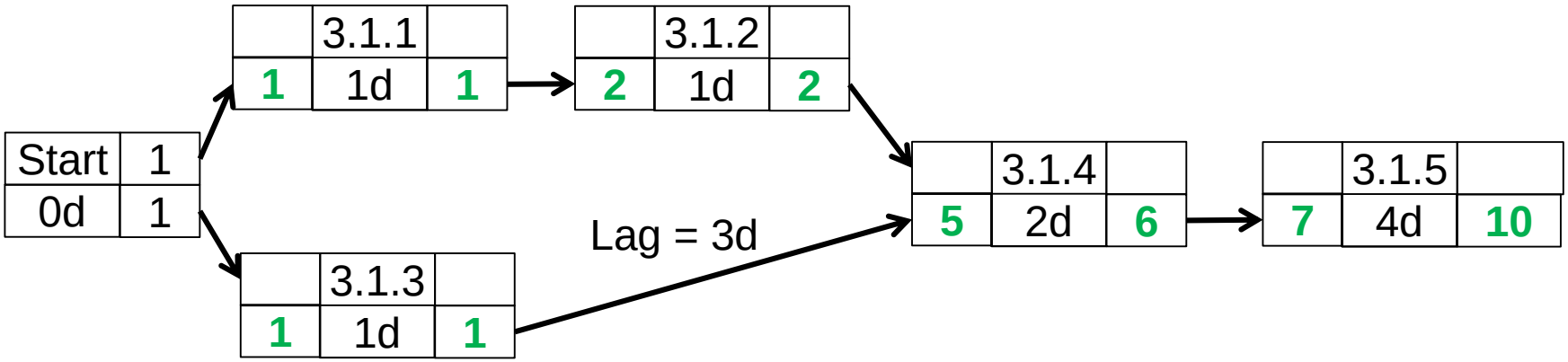
Calculate lead and lag time



Calculate lead and lag time



Calculate lead and lag time



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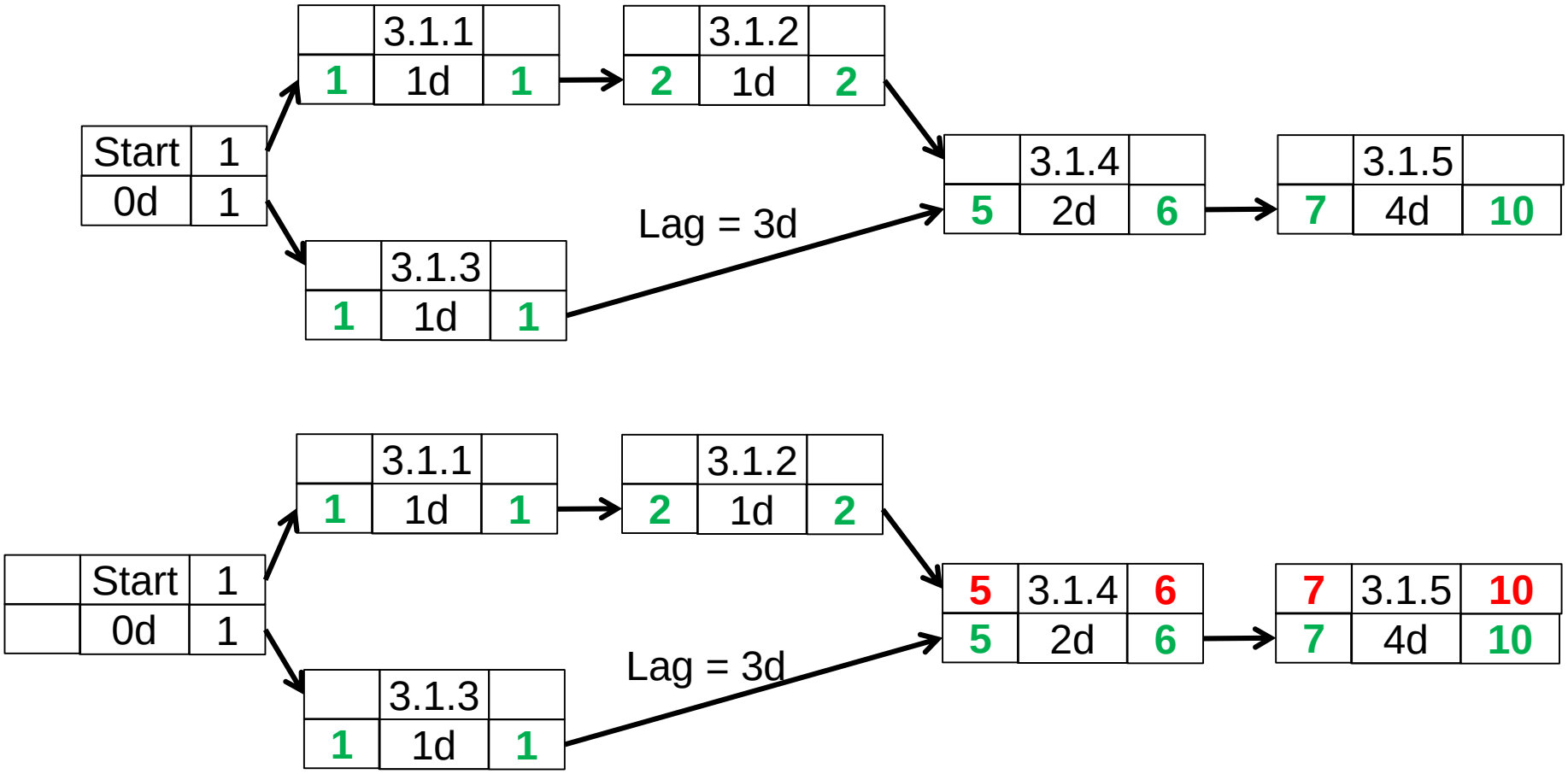
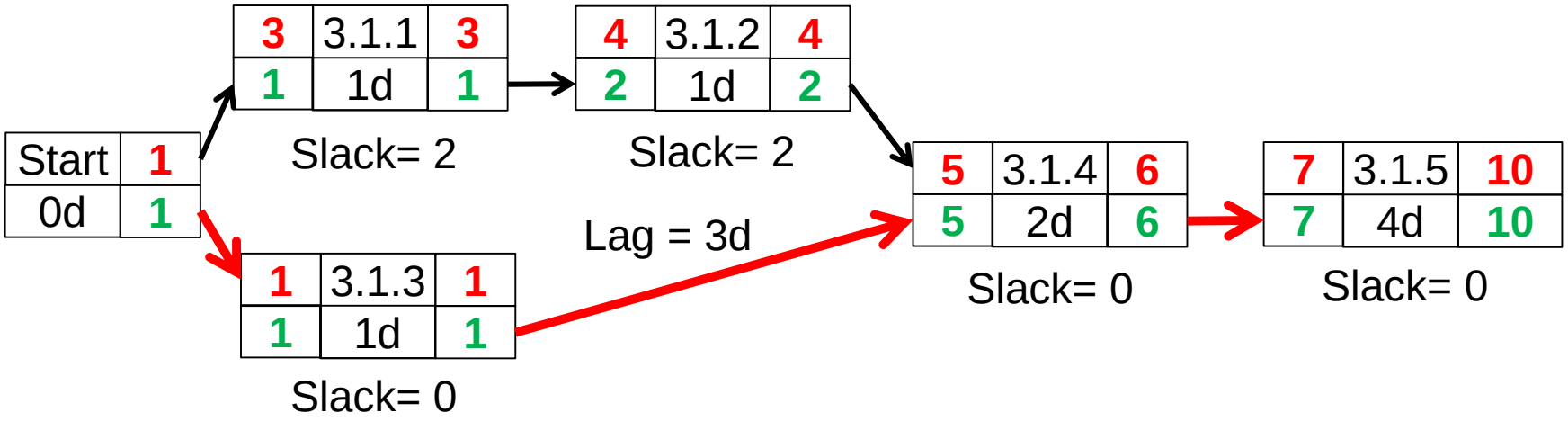


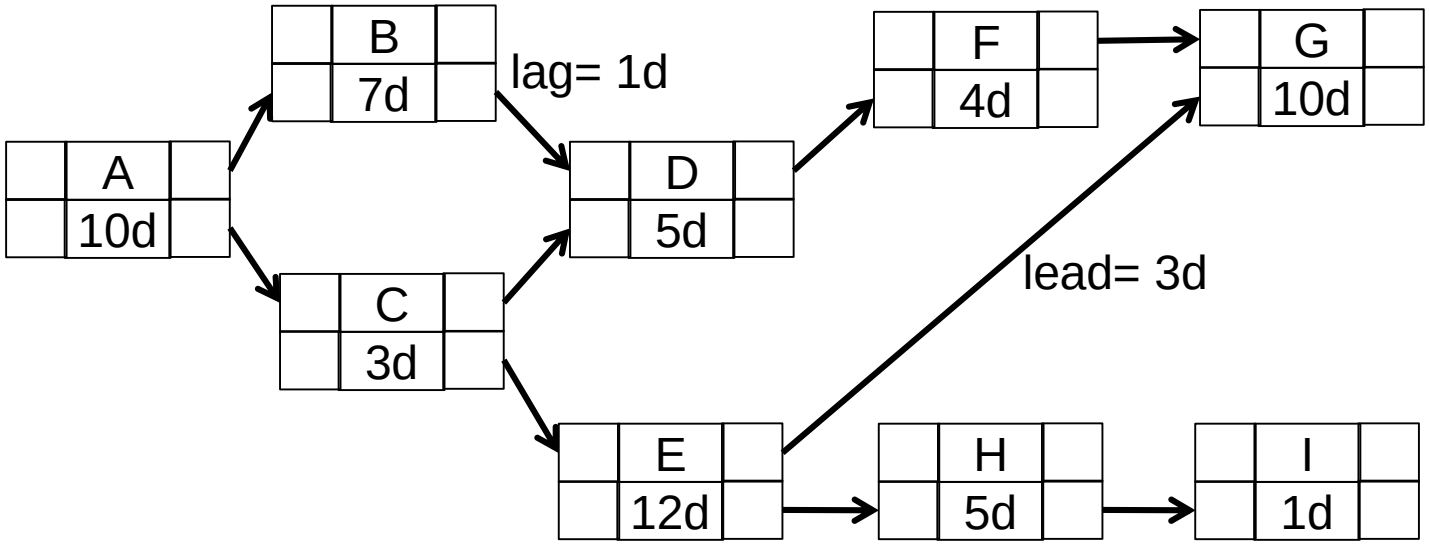
Calculate lead and lag time



- Similar method can be used for calculating the lead time, it just has opposite impact in our calculation compared to the lag time.

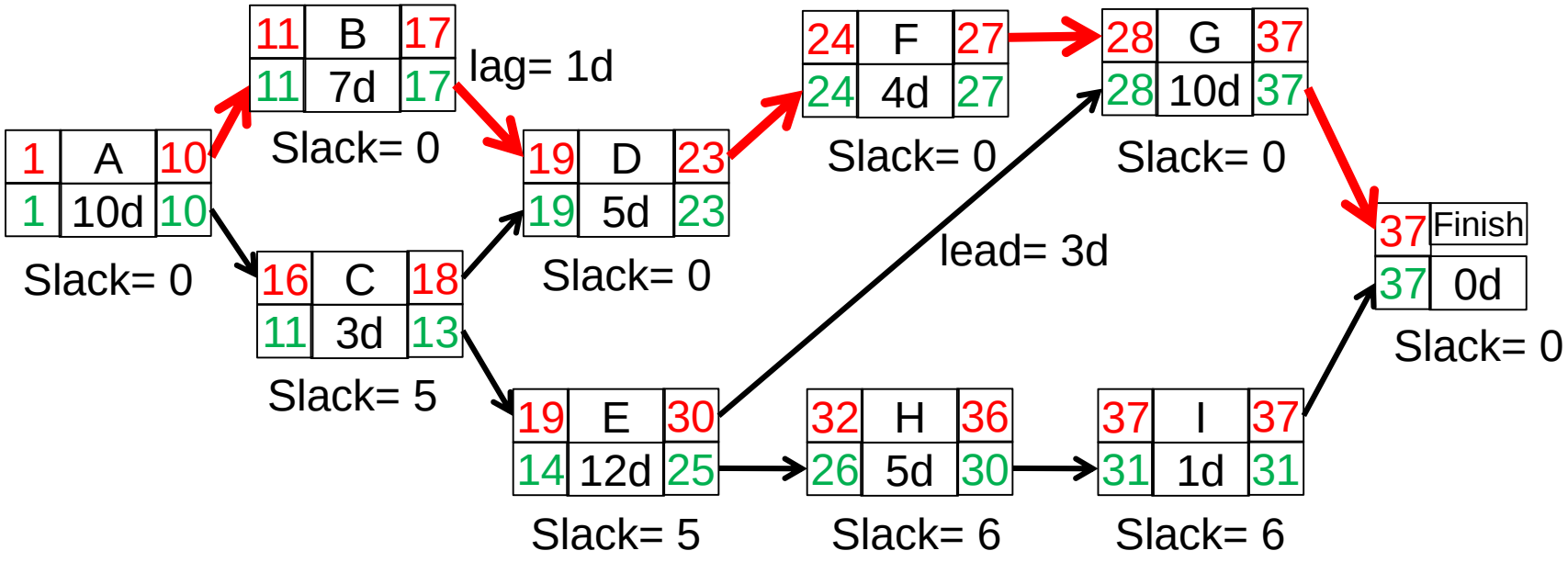
In class exercise 2

In the AON network below, calculate project duration and critical path by considering lag time and lead time!



In class exercise 2

In the AON network below, calculate project duration and critical path by considering lag time and lead time!



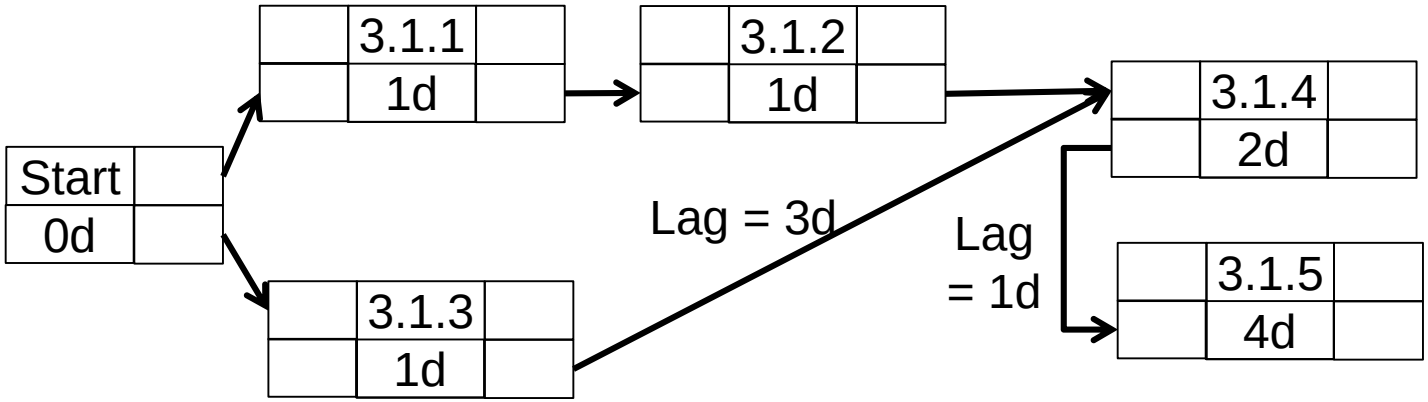
Calculate other dependencies

In our form-work example, consider after start of “size form sheet”, “Install form sheets in place” can be started (SS dependency) with one day delay (lag time).

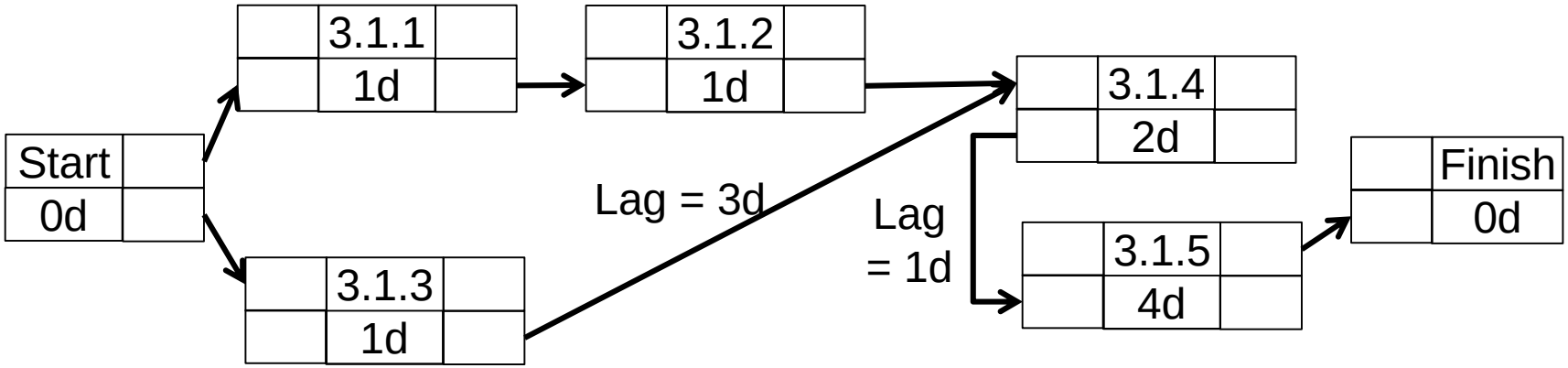
3.1. Prepare foundation form work :

1) Extract foundation sizes from drawings (1 engineer, 1 day)
2) Order form sheets (1 purchaser, 1 day)
3) Hire two form-workers for the job(1 HR-person, 1 day)
4) Size form sheets (2 form-worker, 2 day)
5) Install form sheets in place (2 form-worker, 4 days)

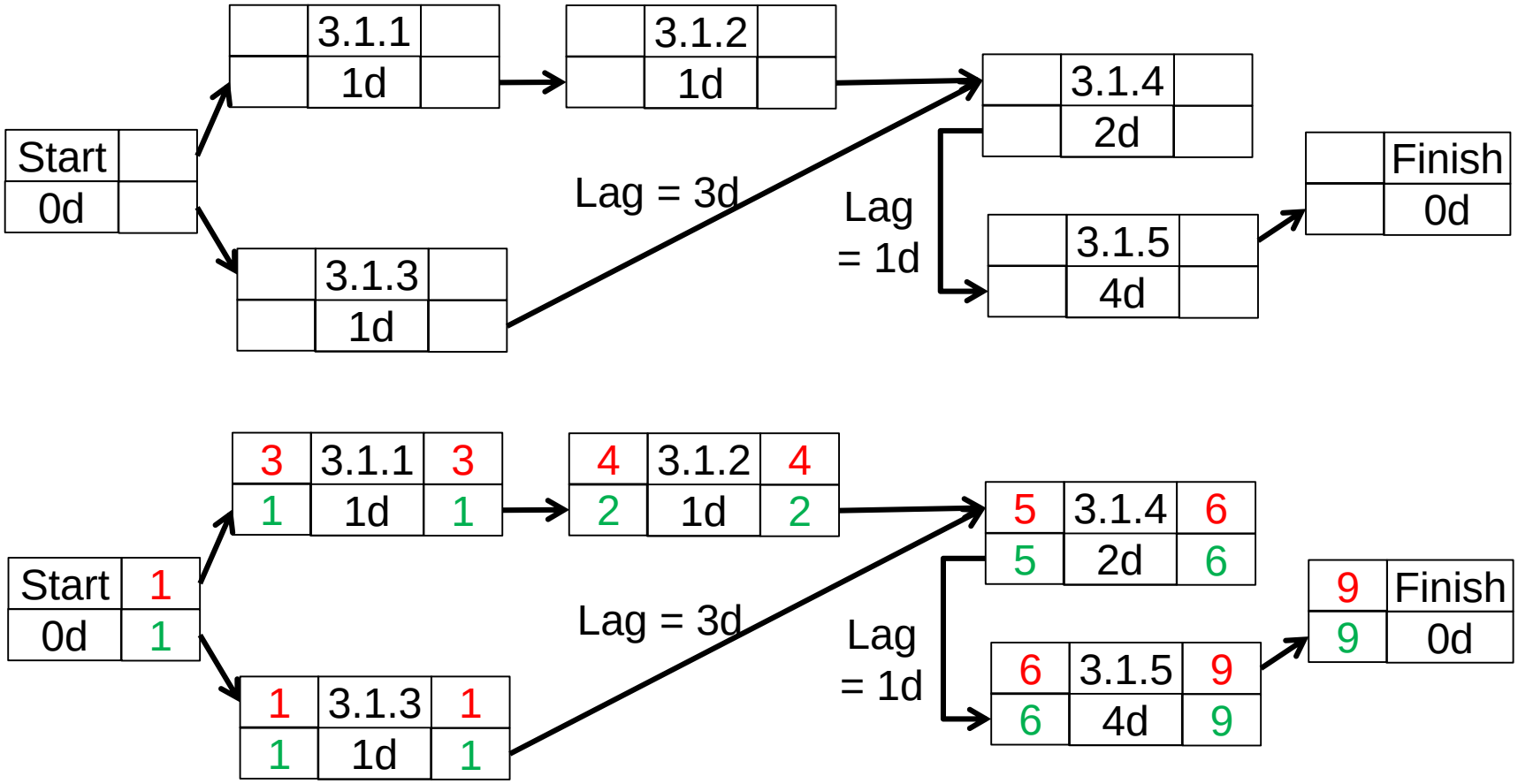
Calculate other dependencies



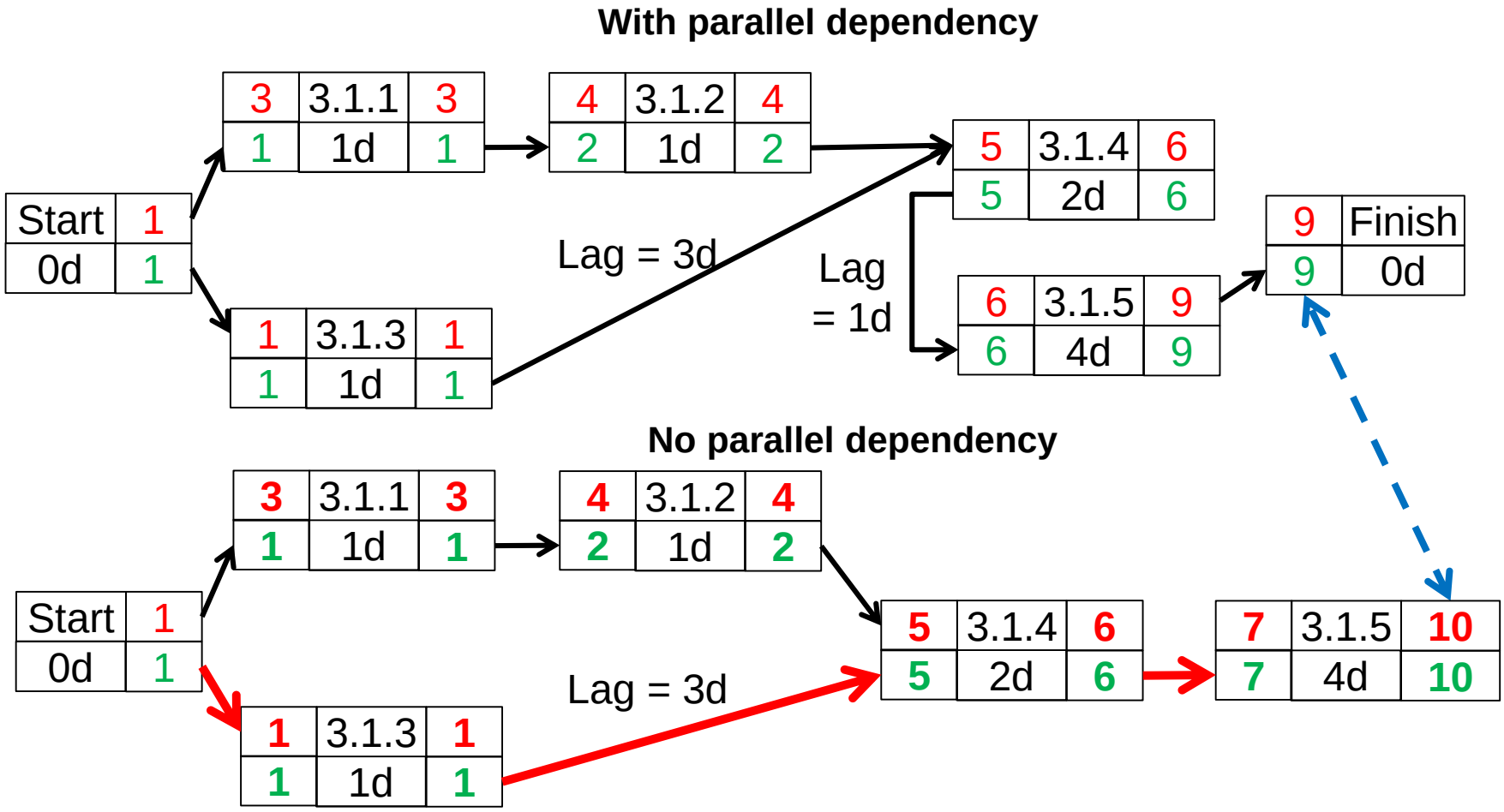
Calculate other dependencies



Calculate other dependencies



Calculate other dependencies

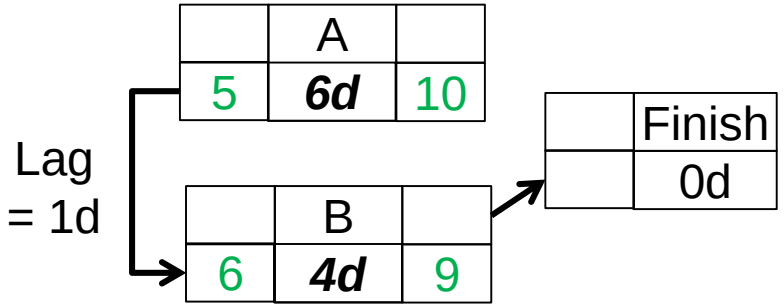


Using FF and SS dependencies will parallelize activities and results in decrease of project duration!

Calculate other dependencies

- Be careful when calculating SS dependencies and FF dependencies! Watch for the related activities' ***durations***!

In SS dependencies when a predecessor has a *longer* duration than its successor It is possible that the predecessor drives the duration. This is specially the case when SS dependency reaches the *Finish* node!



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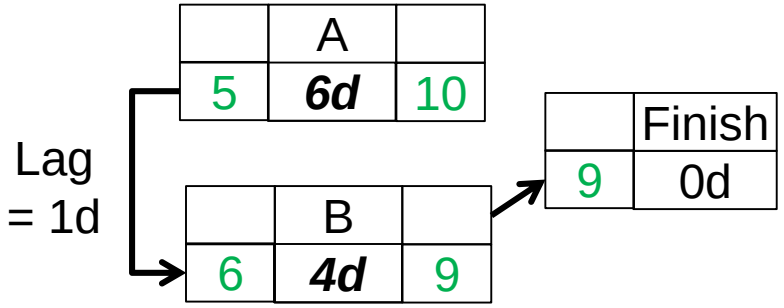

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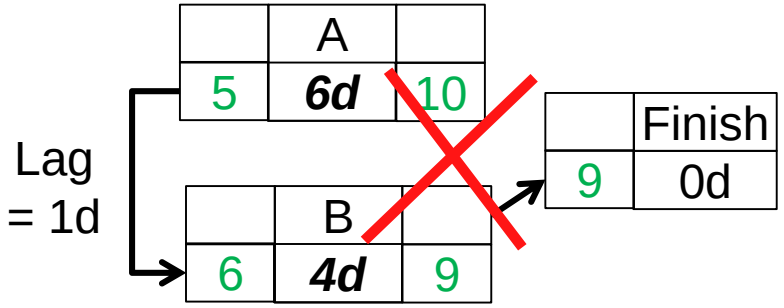

Results in a wrong finish time if we do not consider the link between A the Finish node

Calculate other dependencies

- Be careful when calculating SS dependencies and FF dependencies! Watch for the related activities' ***durations***!

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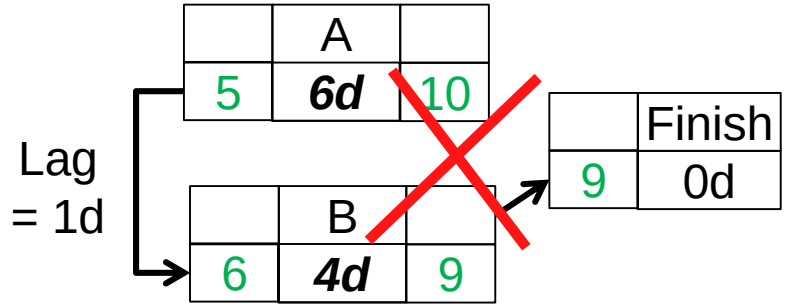

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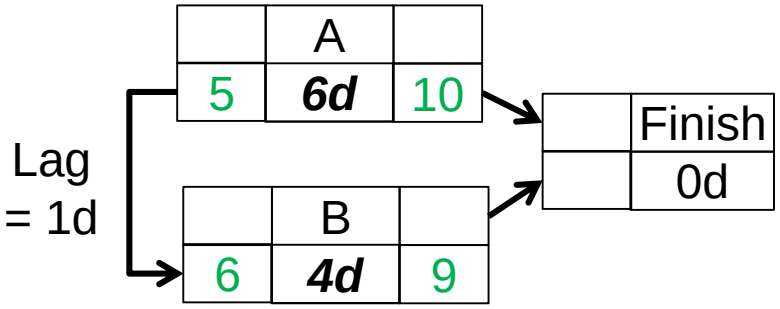

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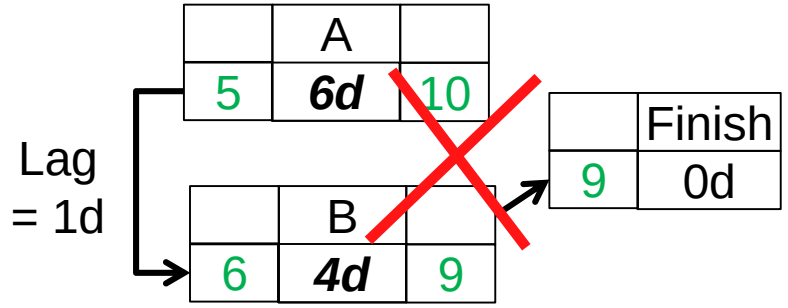

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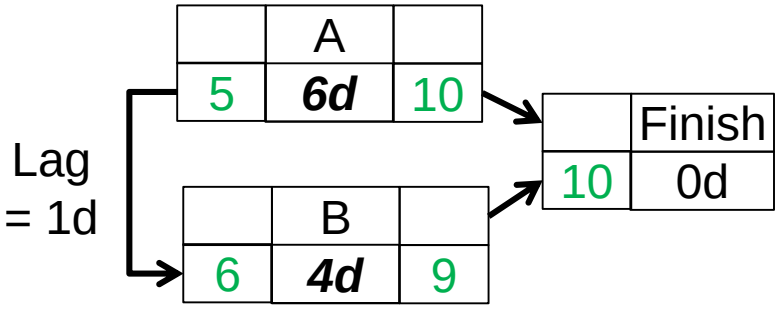
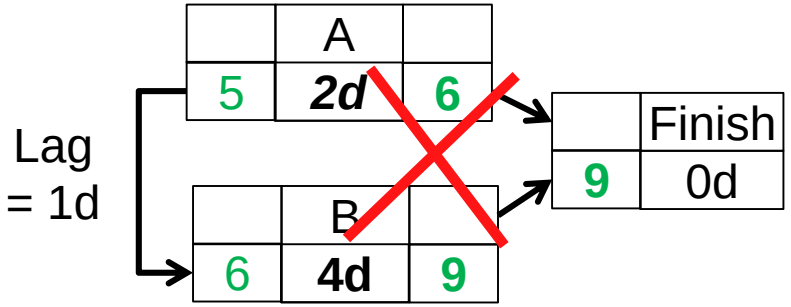


Results in a right time

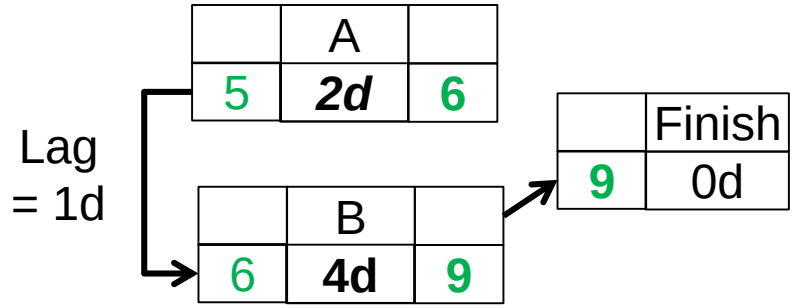
Calculate other dependencies

- Be careful when calculating SS dependencies and FF dependencies! Watch for the related activities' ***durations***!

In SS dependencies when a predecessor has a *shorter* duration than its successor there is no need for special consideration! Just follow your regular forward and backward passes.



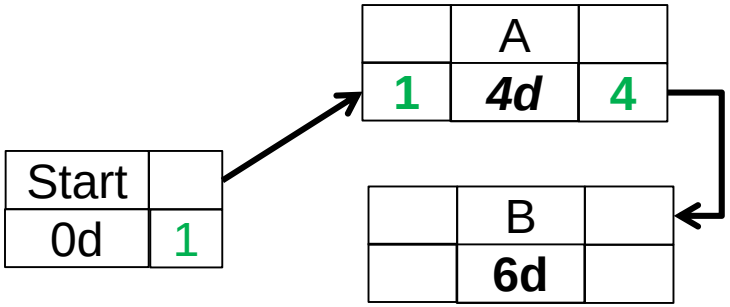
No need to link A with Finish node.



Following regular calculations results just fine!

Calculate other dependencies

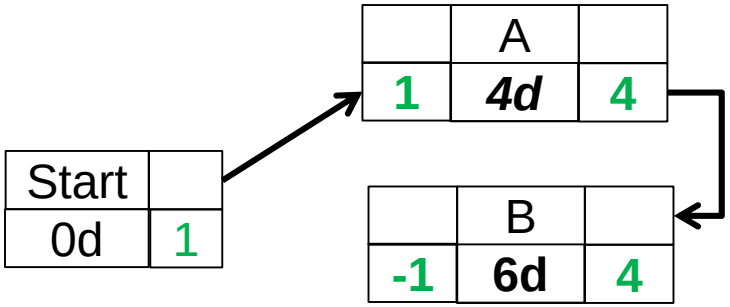
- Be careful when calculating SS dependencies and FF dependencies! Watch for the related activities' ***durations***!



In FF dependencies when a predecessor has a *shorter* duration than its successor It is possible that the successor affects previous calculations. This is specially the case when FF dependency reaches the *Start* node!

Calculate other dependencies

- Be careful when calculating SS dependencies and FF dependencies! Watch for the related activities' ***durations***!



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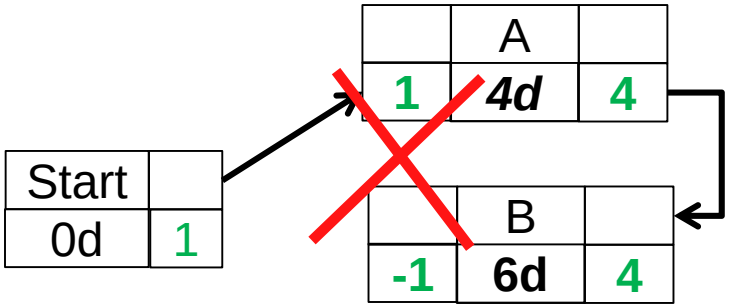
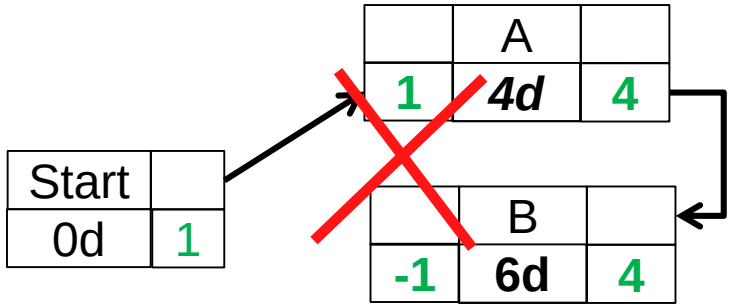


Results in a wrong start time for B if we do not consider the link between B and the virtual start!

In FF dependencies when a predecessor has a *shorter* duration than its successor It is possible that the successor affects previous calculations. This is specially the case when FF dependency reaches the *Start* node!

Calculate other dependencies

- Be careful when calculating SS dependencies and FF dependencies! Watch for the related activities' ***durations***!



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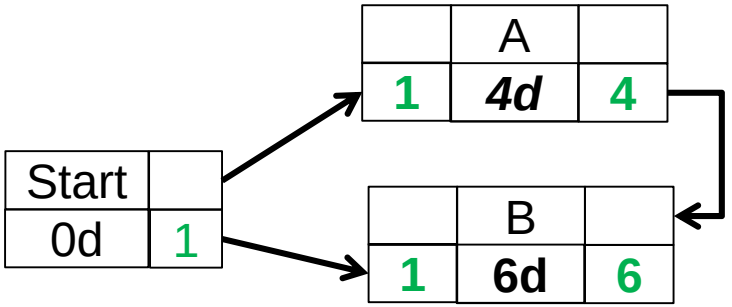
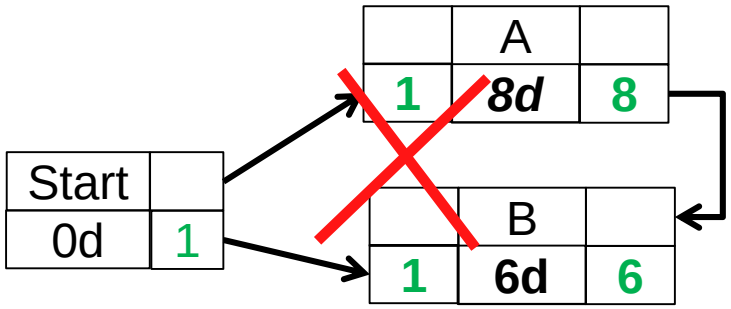


Results in a right time

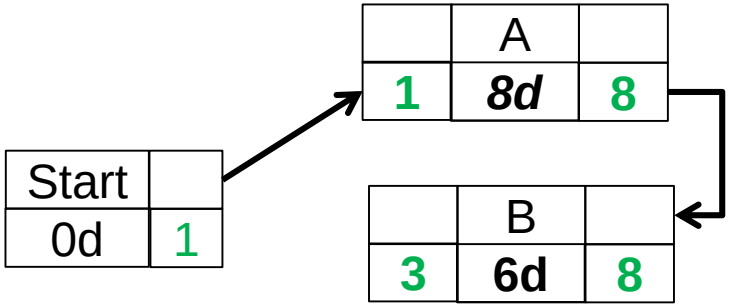
In FF dependencies when a predecessor has a *shorter* duration than its successor It is possible that the successor affects previous calculations. This is specially the case when FF dependency reaches the *Start* node!

Calculate other dependencies

- Be careful when calculating SS dependencies and FF dependencies! Watch for the related activities' ***durations***!



No need to link B with Start node. We will receive Wrong result.

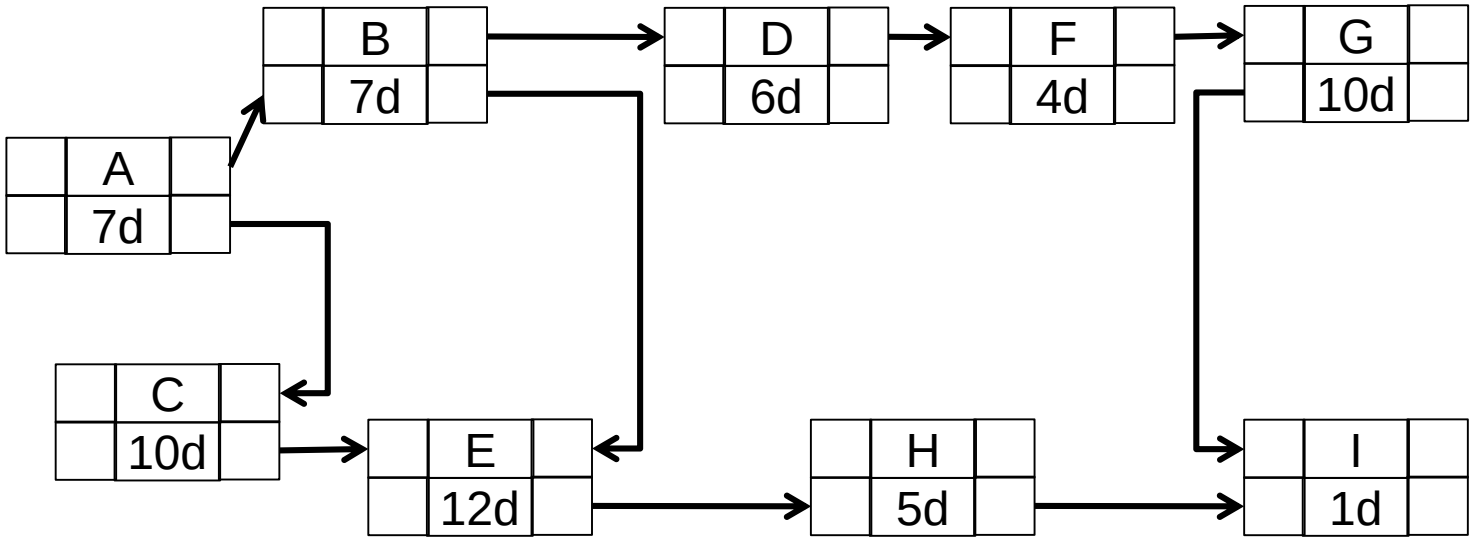


Following regular calculations results just fine!

In FF dependencies when a predecessor has a *longer* duration than its successor there is no need for special consideration! Just follow your regular forward and backward passes.

In class exercise 3

In the AON network below, calculate project duration and critical path by considering SS and FF dependencies!



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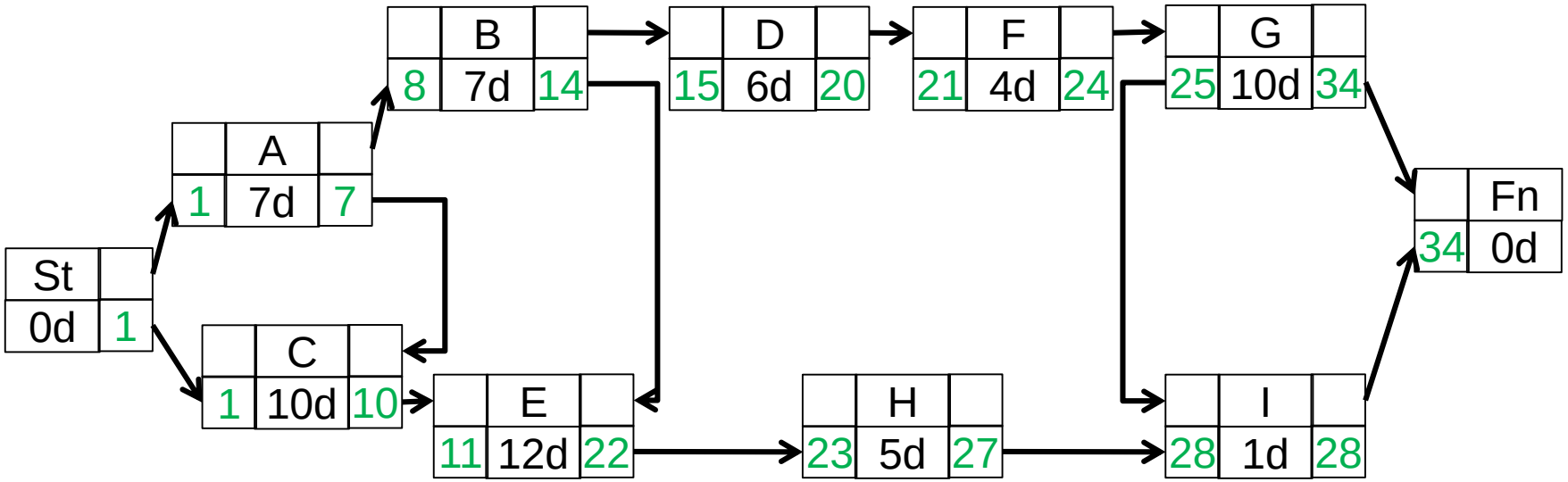

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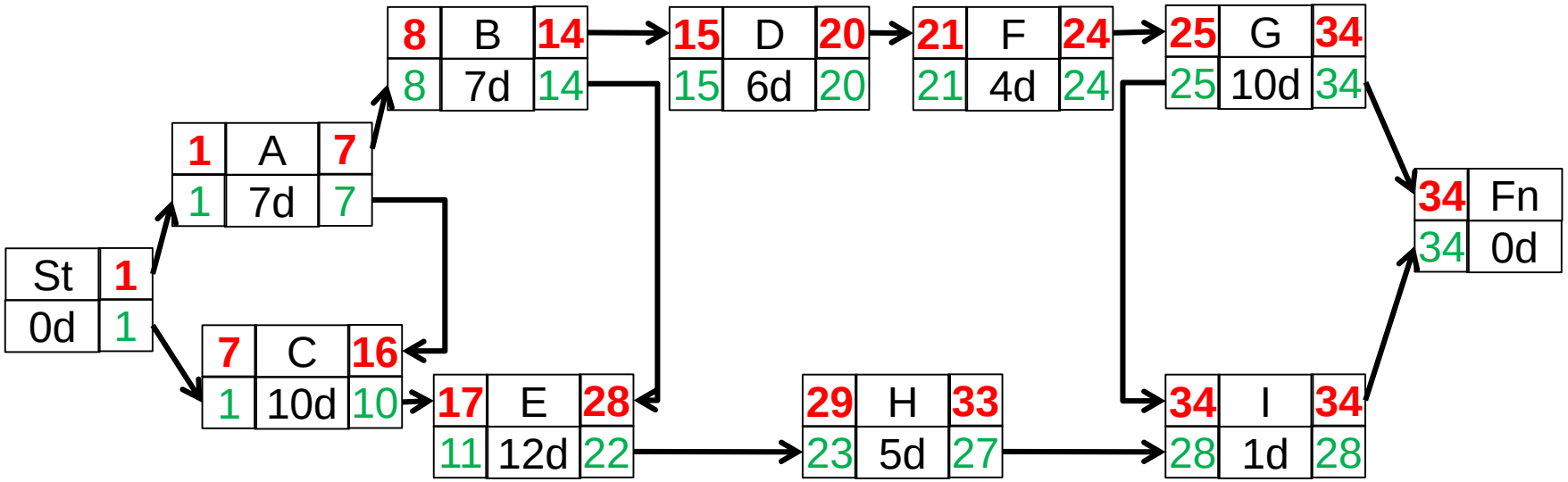
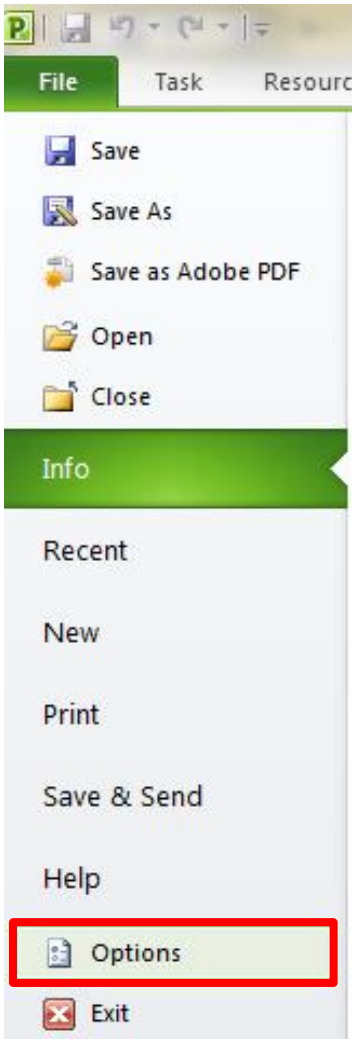
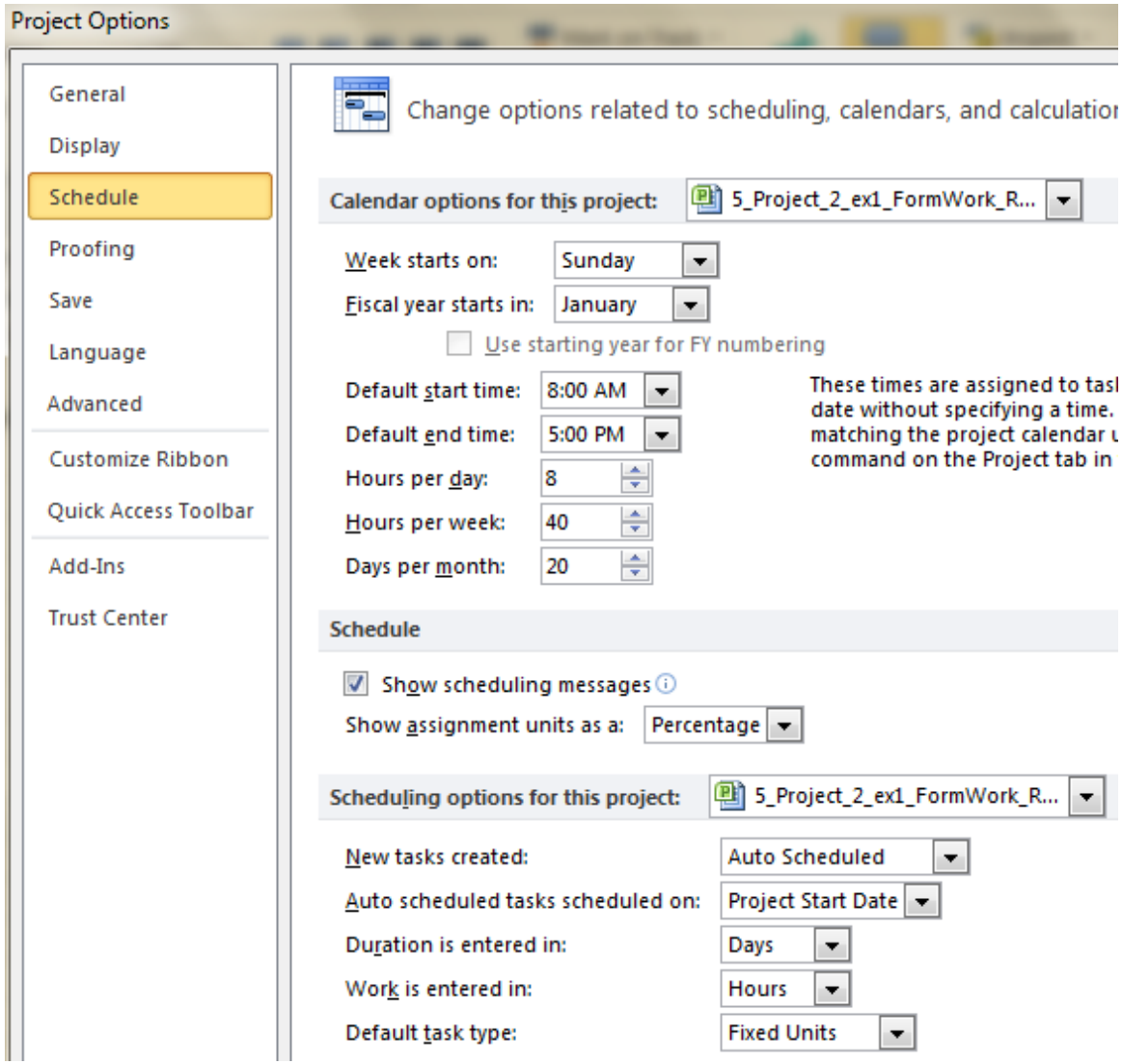


Using M.S. Project

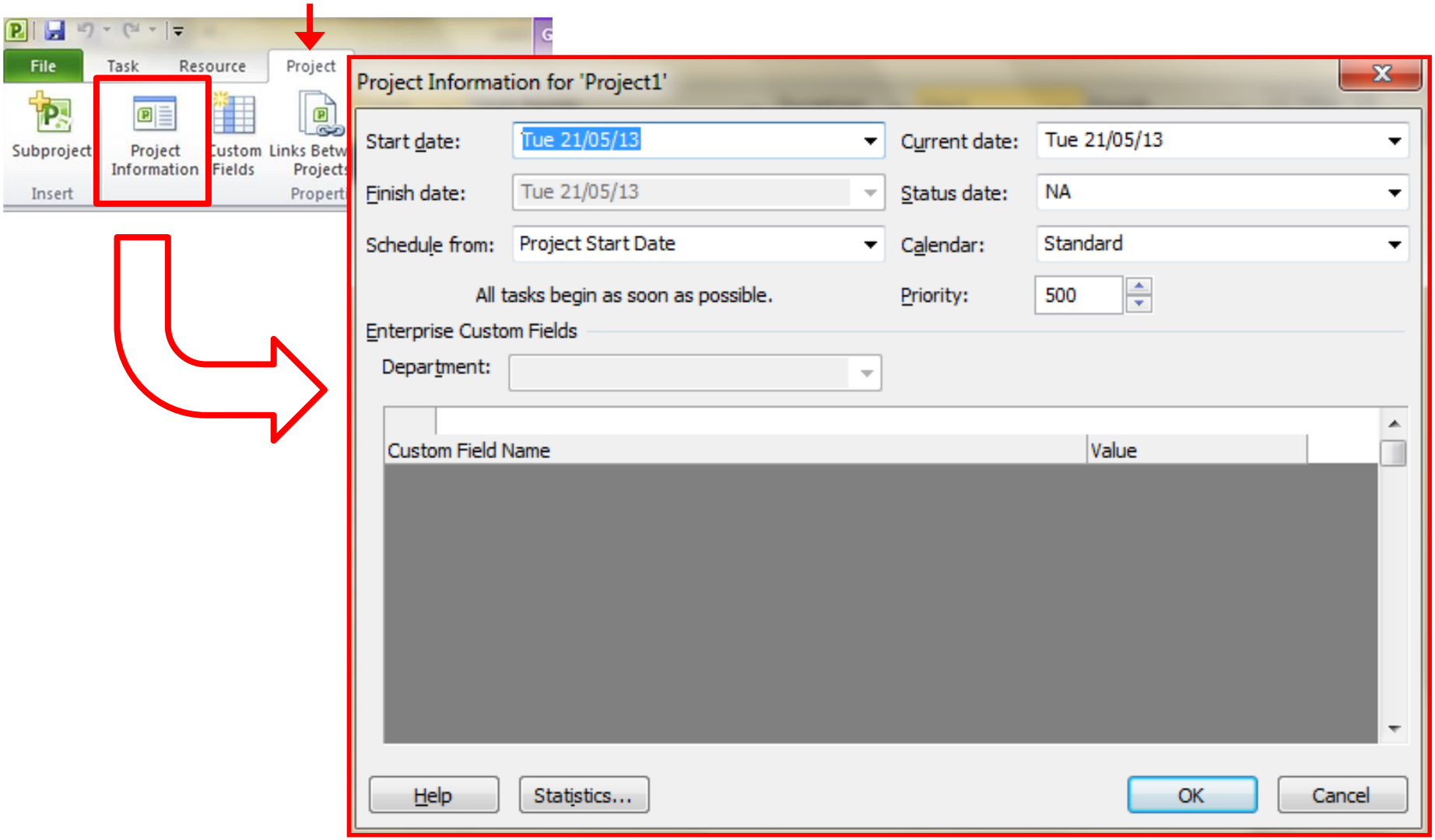
Project level information - setting





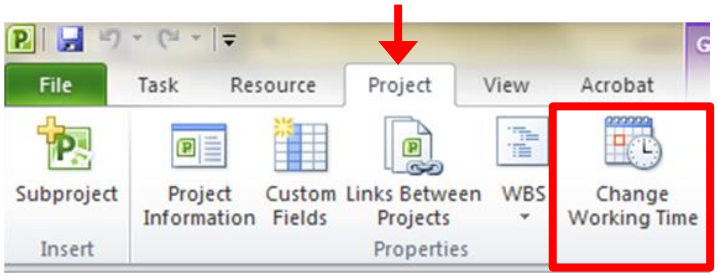
Using M.S. Project

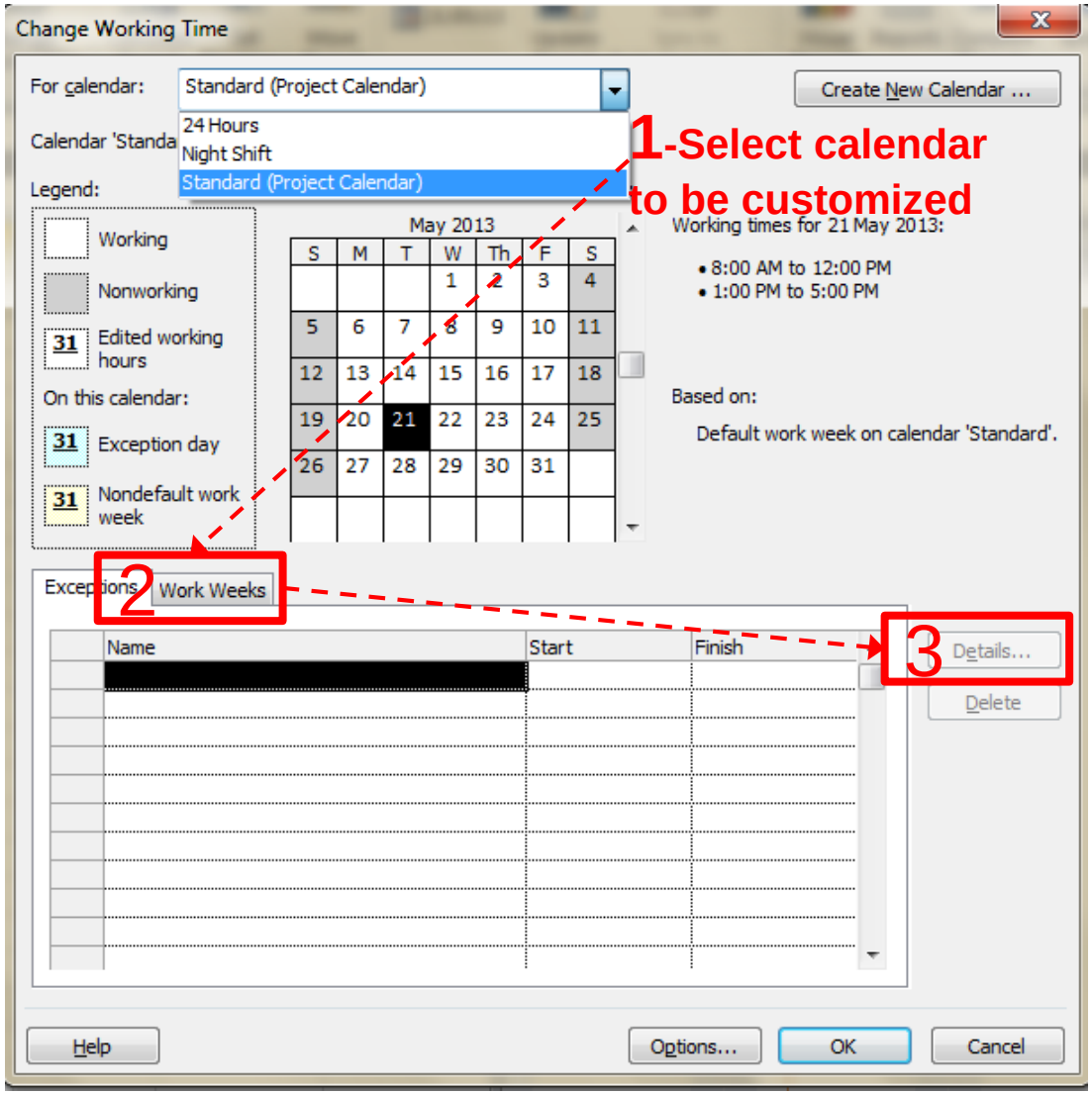
Project level information - project



Using M.S. Project

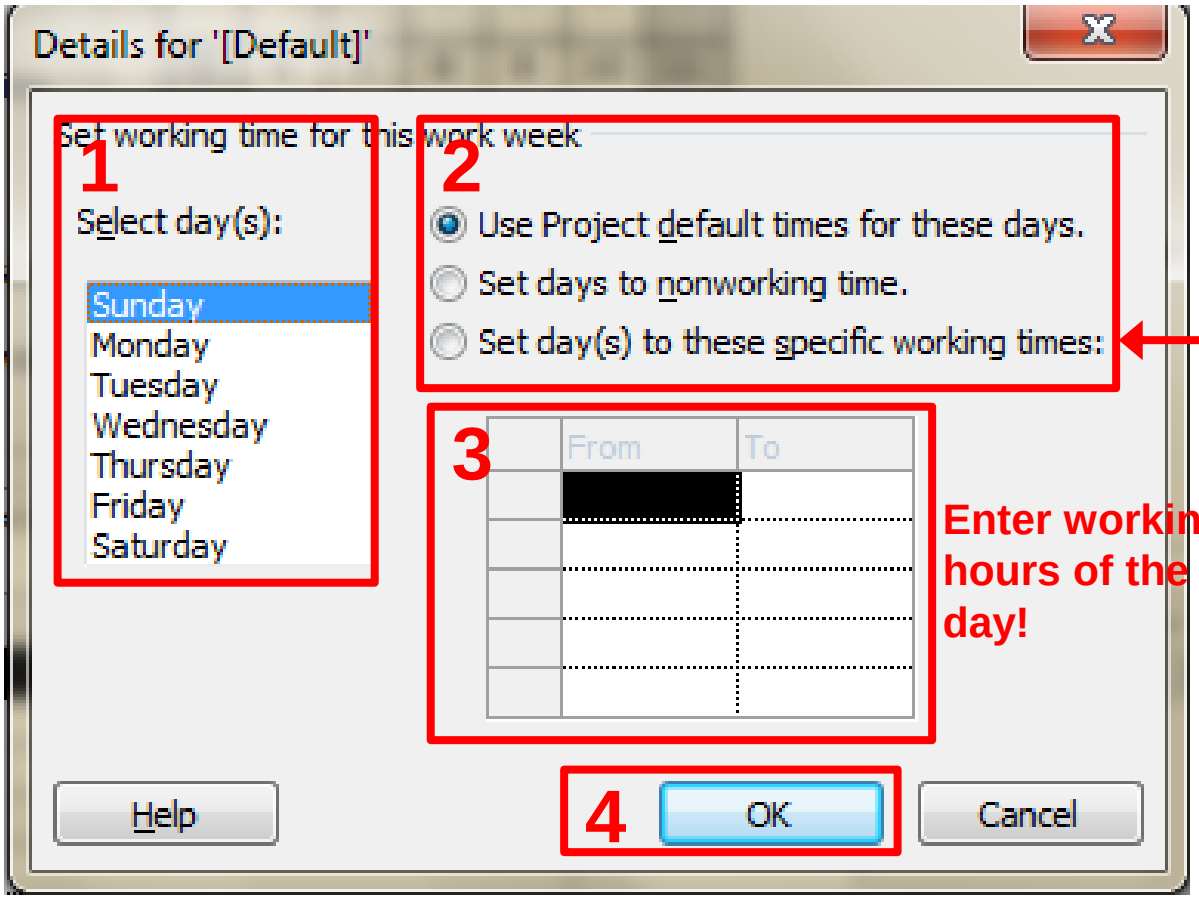
Project level information - calendar





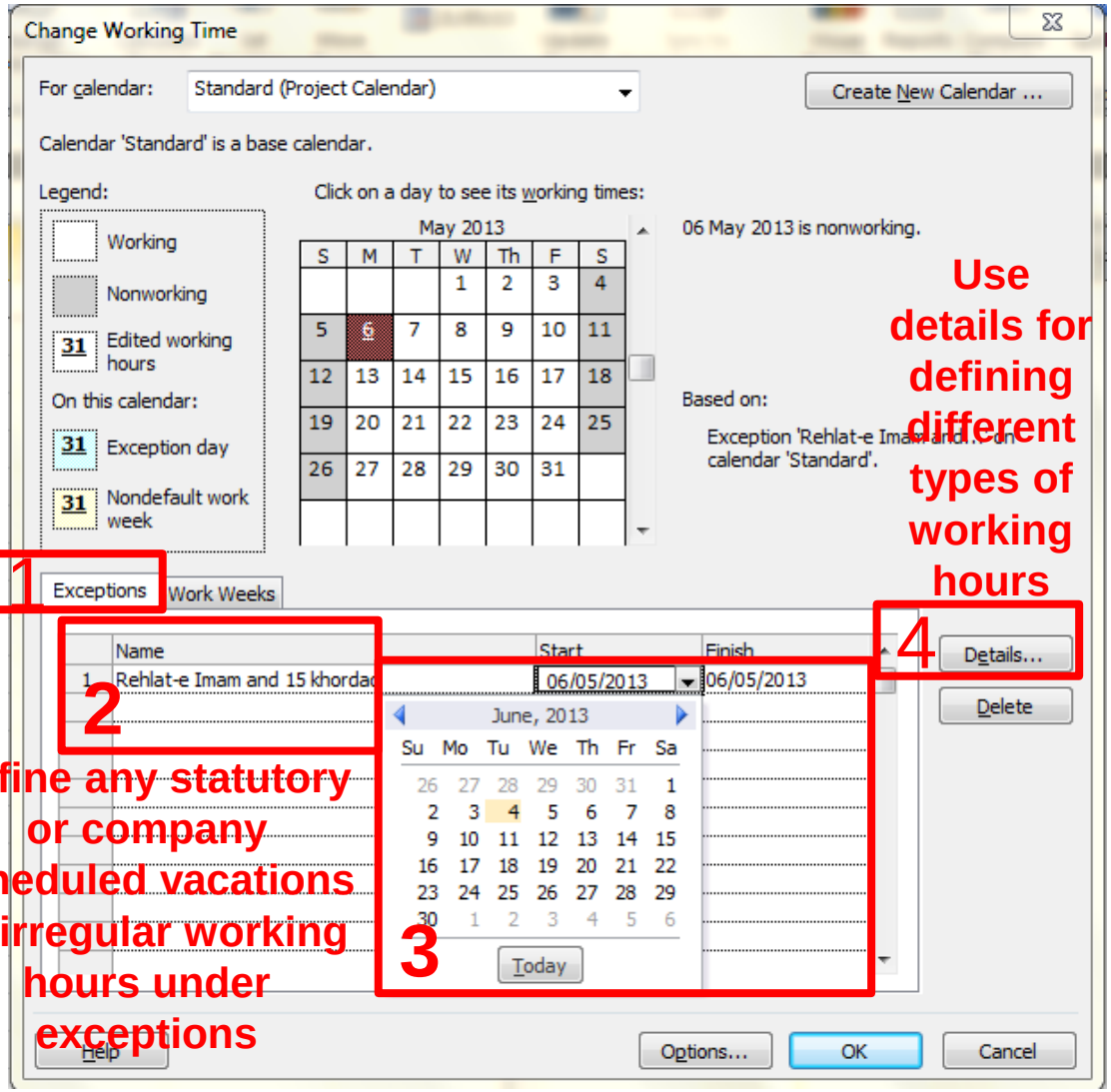
Using M.S. Project

Project level information - calendar

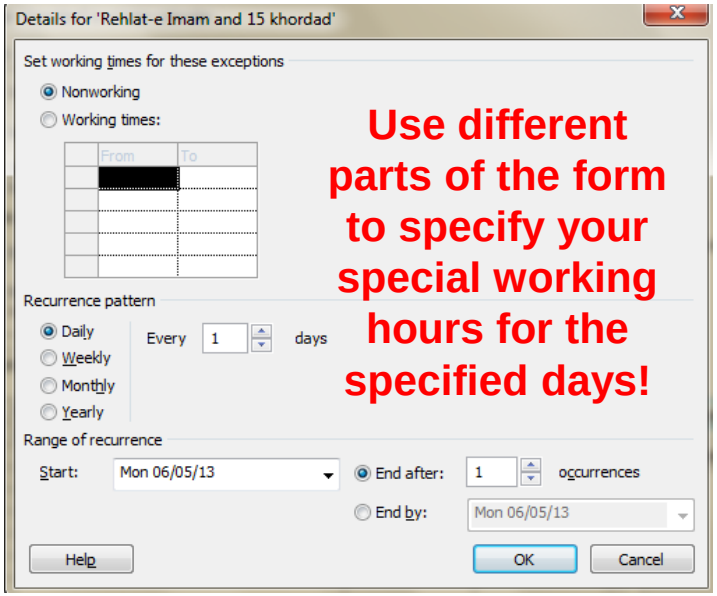


Using M.S. Project

Project level information - calendar

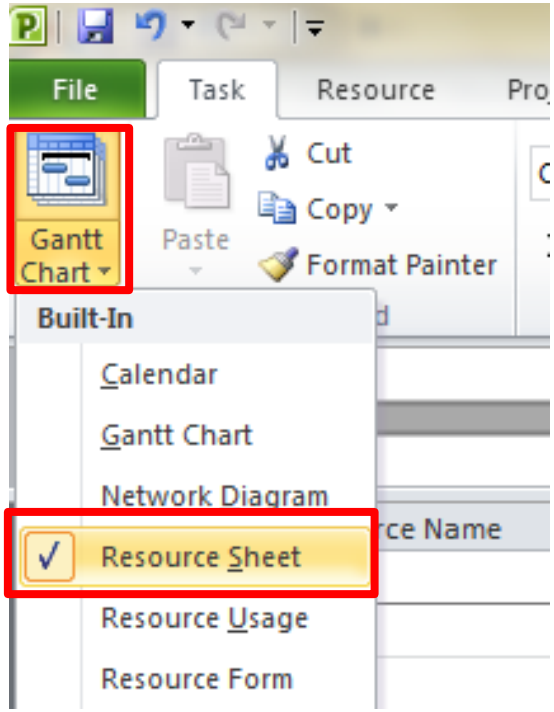


Use details for defining different types of working hours

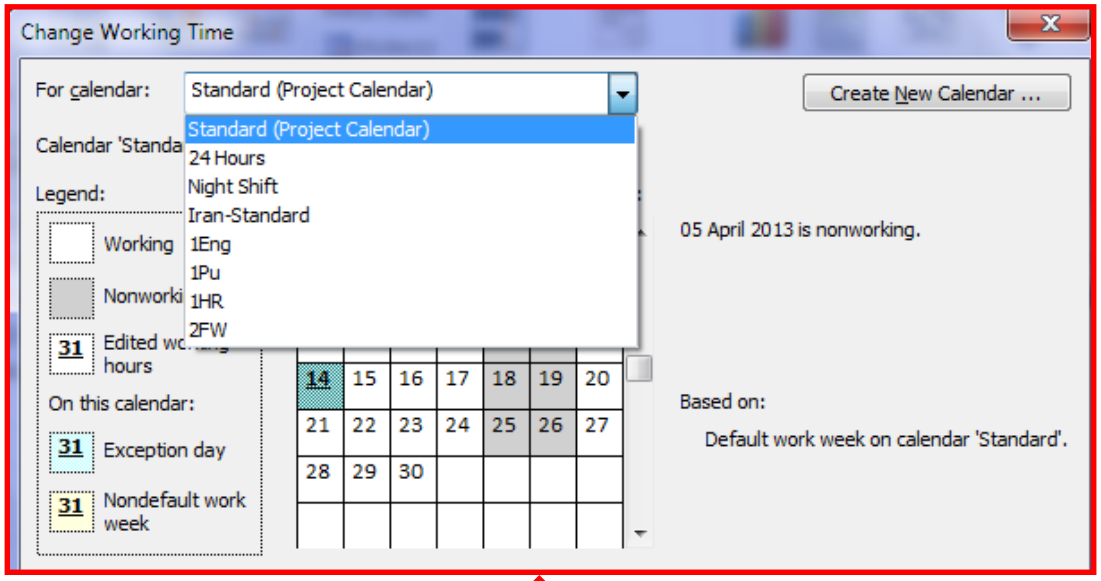


Use different parts of the form to specify your special working hours for the specified days!

Using M.S. Project
Defining resources



Adjust resource calendar if required!



	Resource Name	Type	Material Label	Initi	Max. Units	Std. Rate	Ovt. Rate	Cost/Use	Accrue At	Base Calendar	Code	Group
1	Eng	Work		E	100%	$20.00/hr	$30.00/hr	$0.00	Start	Standard	1	Design
2	Pu			P	100%	$10.00/hr	$15.00/hr	$0.00	Start	Standard	2	Procuremen
3	HR			H	100%	$10.00/hr	$15.00/hr	$0.00	Start	Standard	2	Procuremen
4	FW	Work		F	200%	$15.00/hr	$22.50/hr	$0.00	Start	Standard	3	Constructior

Work
Material
Cost

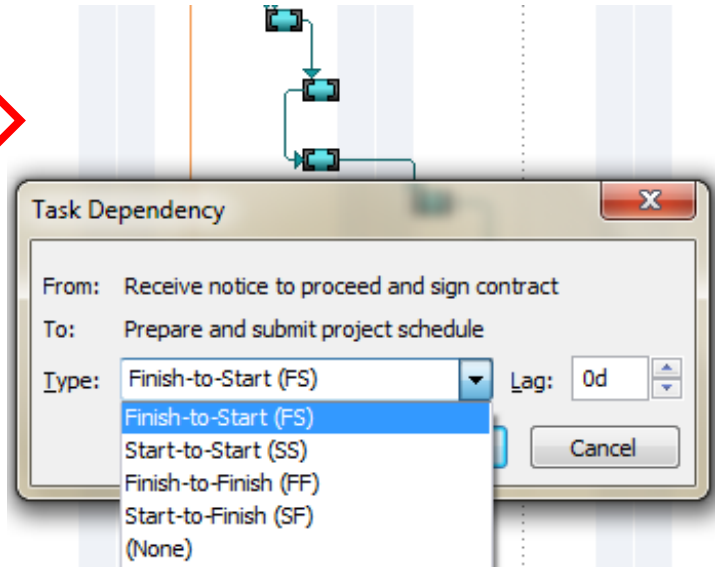
Using M.S. Project
Determine dependencies- MSP

Enter dependencies under Predecessor column

	WBS	Task Name	Predecessor
1	**1**	**Three-story Office Building (76,000 square feet)**	
2	**1.1**	**General Conditions**	
3	1.1.1	Receive notice to proceed and sign contract	
4	1.1.2	Submit bond and insurance documents	
5	1.1.3	Prepare and submit project schedule	4,3
6	1.1.4	Prepare and submit schedule of values	5
7	1.1.5	Obtain building permits	6SS
8	1.1.6	Submit preliminary shop drawings	7

Any time you need to edit inside a cell, use F2 key to go to the edit mode!!

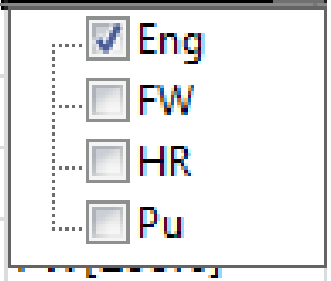
The default dependency is FS, if you need to adjust the dependency Dbl-Click on the dependency line to open Task Dependency form and adjust the dependency!



Using M.S. Project
Entering task info

- Enter duration and resource info

	Task Name	Duratic	Resource Names
1	Extract foundation sizes from drawings	1 day	Eng
2	Order form sheets required	1 day	
3	Hire two form-workers for the job	1 day	
4	Size the form-sheets	1 day	
5	Install form-sheets in place	2 days	



- Initial schedule is formed!

	Task Name	Predecessor	Duratic	Resource Names	Start	Finish
1	Extract foundation sizes from drawings		1 day	Eng	Sat 06/04/13	Sat 06/04/13
2	Order form sheets required	1	1 day	Pu	Sun 07/04/13	Sun 07/04/13
3	Hire two form-workers for the job		1 day	HR	Sat 06/04/13	Sat 06/04/13
4	Size the form-sheets	3FS+3 days,2	1 day	FW[200%]	Wed 10/04/1:	Wed 10/04/13
5	Install form-sheets in place	4SS+1 day	2 days	FW[200%]	Mon 15/04/1:	Tue 16/04/13

Using M.S. Project

Hands on MSP!

Thank you!