Scheduling & Resource Levelling

Slides available at
tomlogan.co.nz/edi_slides.pdf

Handout available at
tomlogan.co.nz/edi_notes.pdf

Building a house

- What are the steps?
  - Foundation
  - Design
  - Paint
  - Walls and ceiling
  - Roof
  - Wiring
  - Plumbing
  - etc

Scheduling:

How long will the project take?

When do you need to start each of the activities to finish on time?

Resource levelling is taking resource constraints into consideration

Learning Objectives

- Understand the precedence diagram method (PDM)
- Be able to construct a resource unconstrained schedule using the PDM
- Understand how resource levelling provides a resource constrained schedule

Example

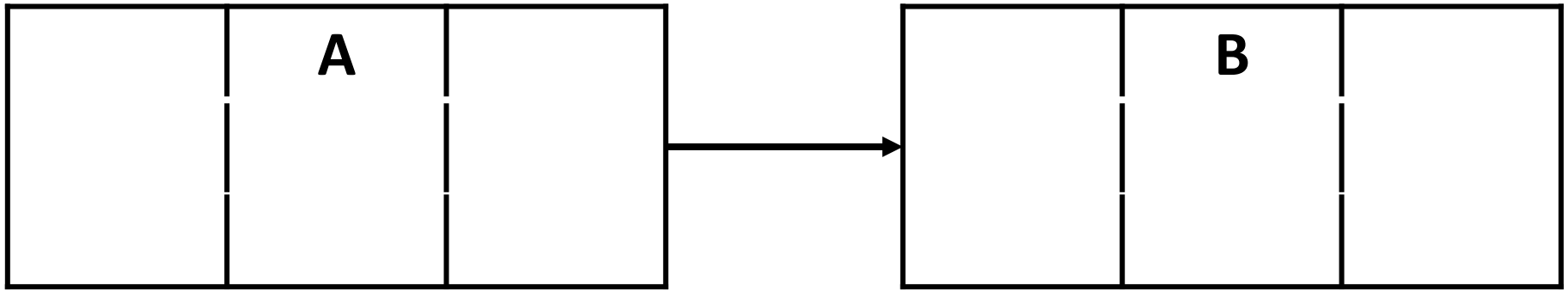
Say we have five activities (sub tasks that make up some project):

Activity ID	Predecessor	Expected time (days)
A	-	8
B	A	4
C	B, E	5
D	-	3
E	D	2

Precedence Diagram Method (PDM)

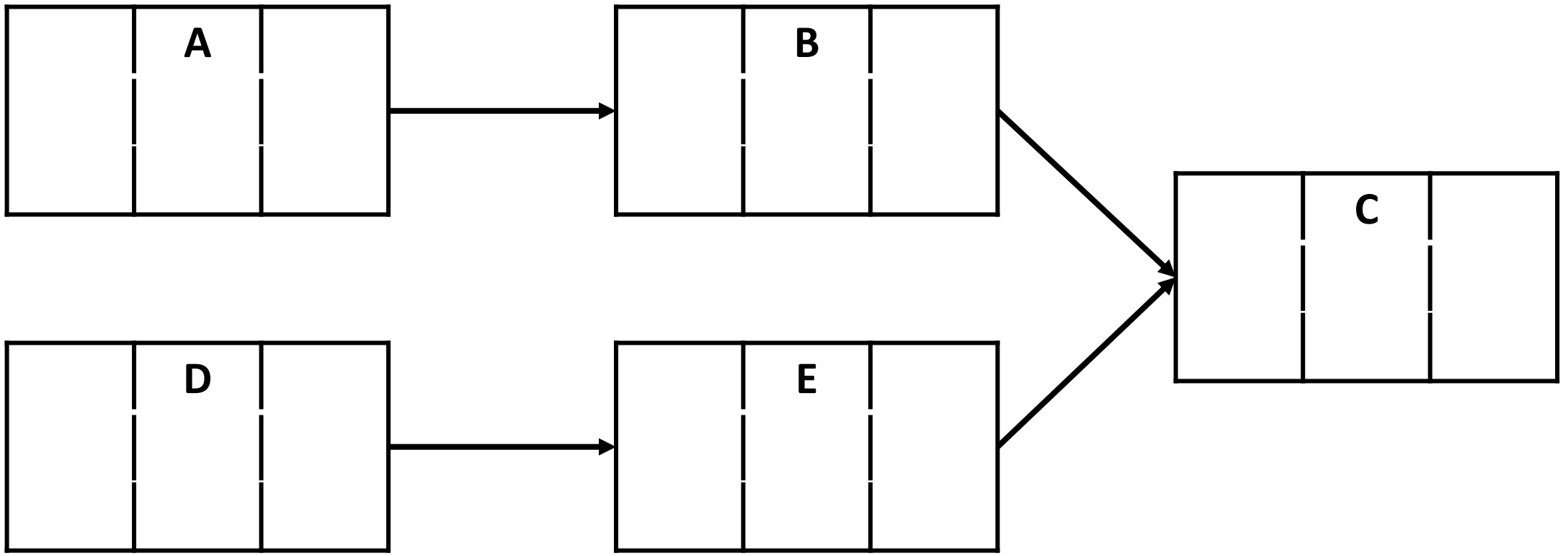
Precedence diagram conceptualises which activities precede and succeed one another.

We say A precedes B (or B requires A to finish before it can start):



Example: PDM

Activity ID	Predecessor
A	-
B	A
C	B, E
D	-
E	D

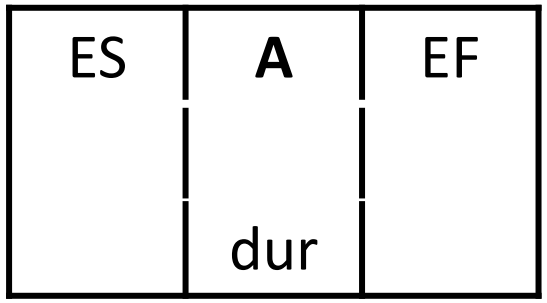


PDM

- Scheduling: When should we start each activity so the project finishes on time
- Precedence diagram helps determine this

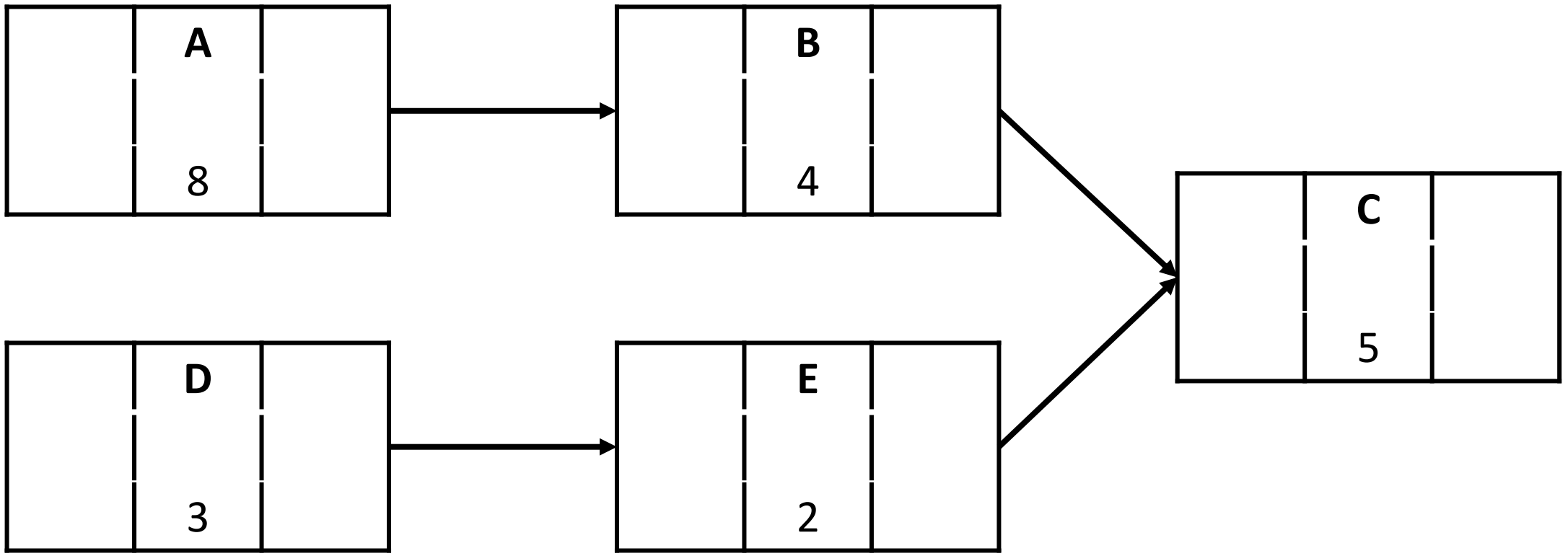
PDM: Early start and finish

- First step is to determine the earliest that an activity can start
- Early start (ES)
- What's the ES of A?



Example: PDM

Activity ID	Expected time (days)
A	8
B	4
C	5
D	3
E	2



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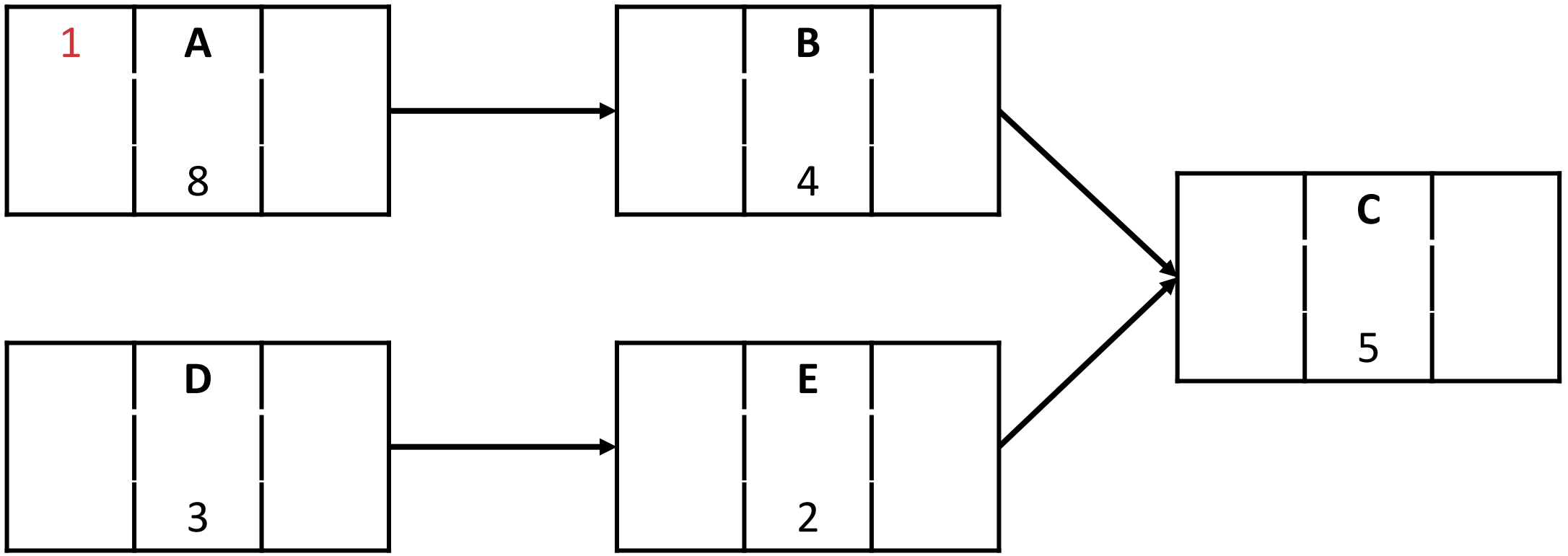
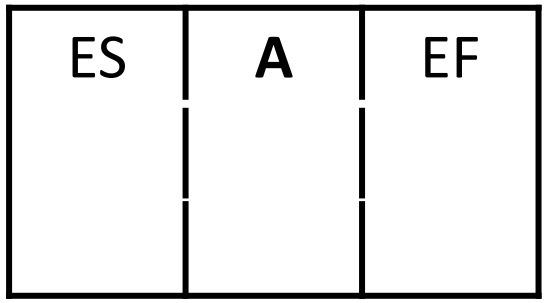


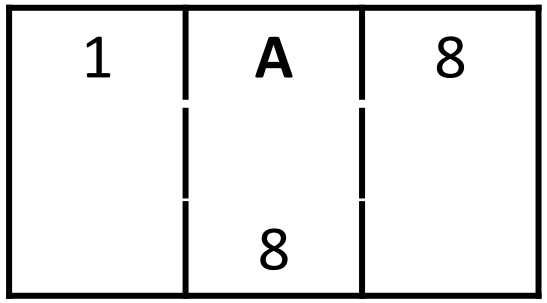
PDM: Early start and finish

- First step is to determine the earliest that an activity can start
- Early start (ES)
- ES = max of
  - First time step
  - Early finish of predecessor + 1



PDM: Early start and finish

- Then we can determine the earliest date each activity can finish
- Early finish (EF)
- EF = ES + duration – 1
- EF(A) = 8 because A is completed on the eighth day



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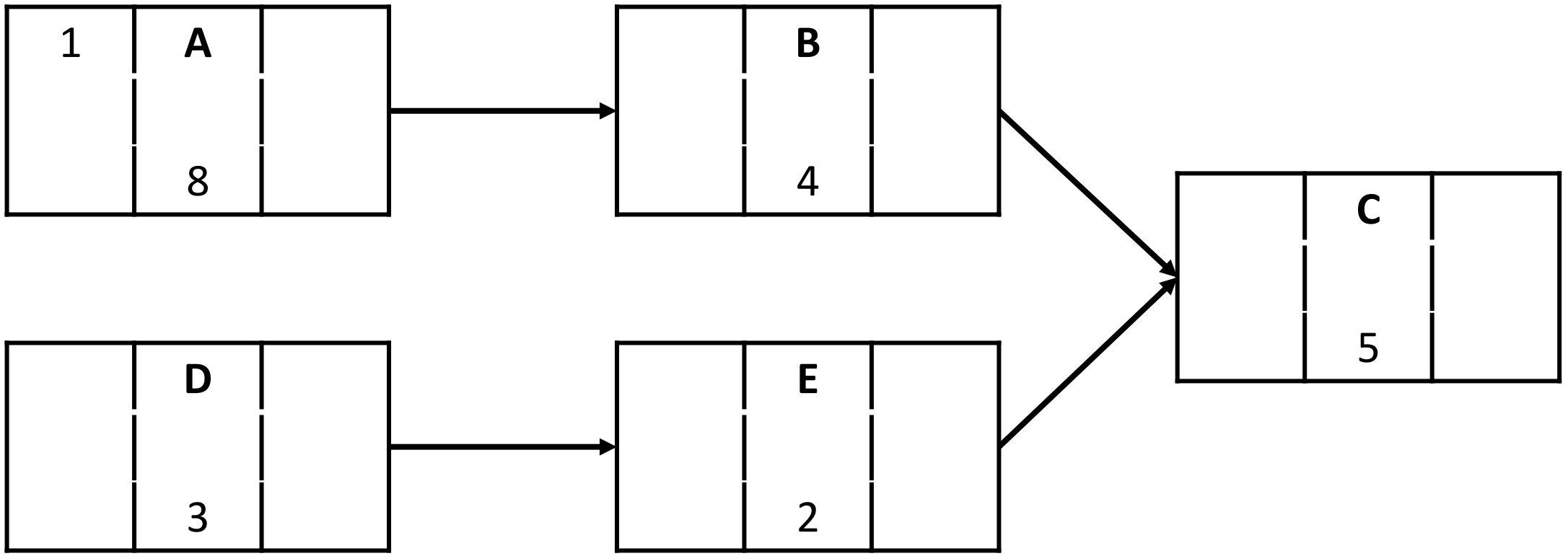
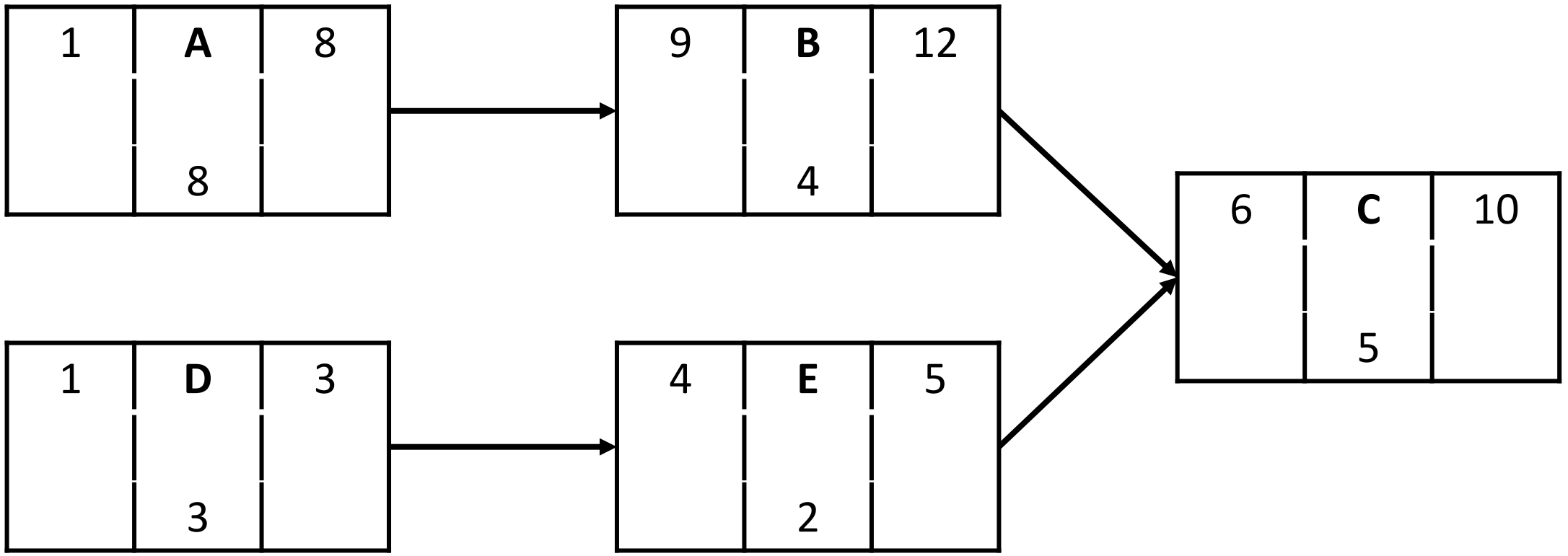
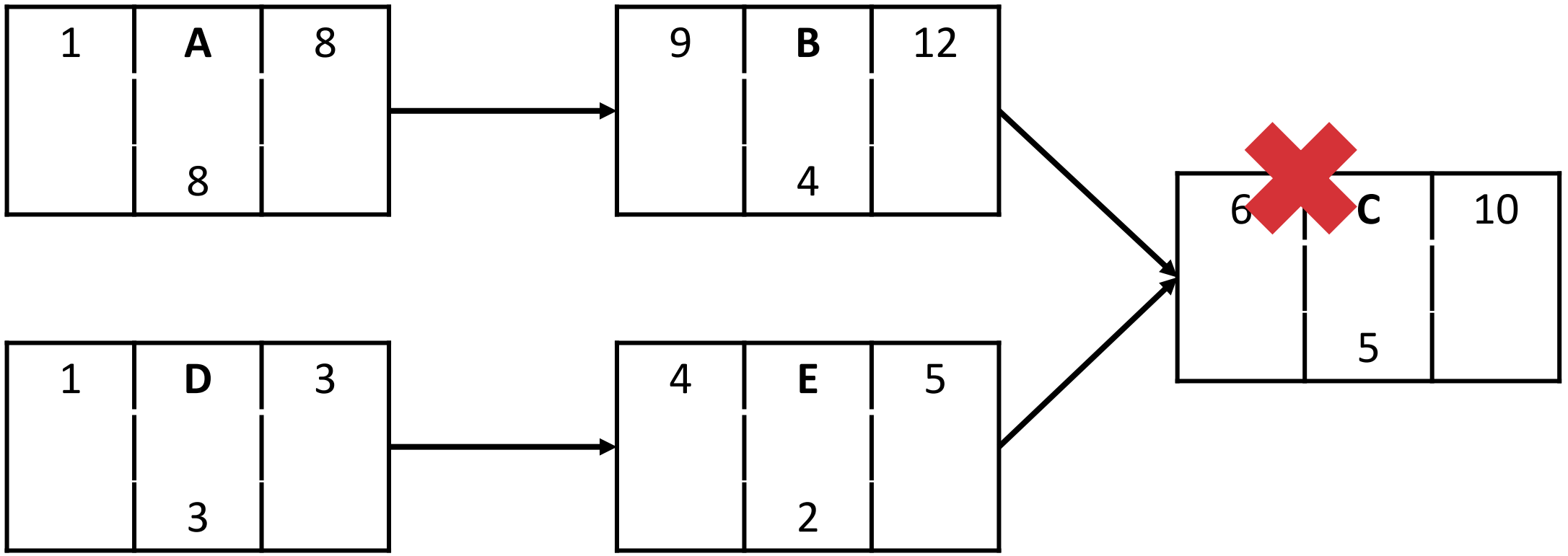


Example: Forward pass



Example: Forward pass



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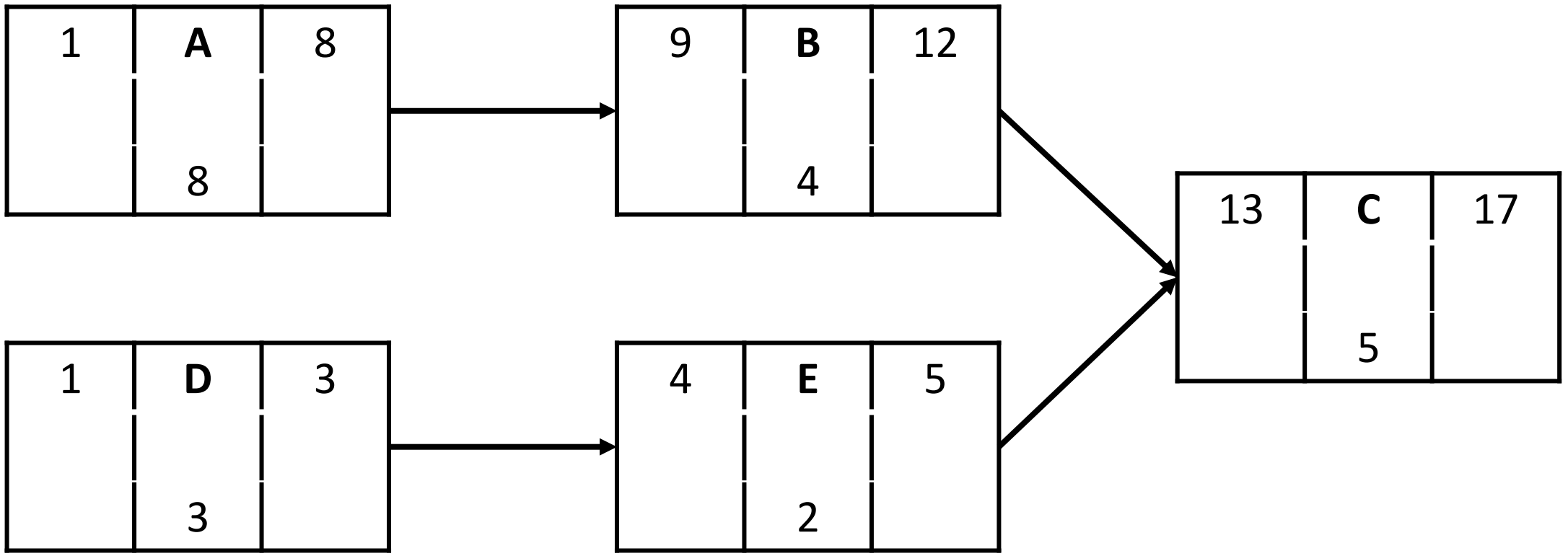
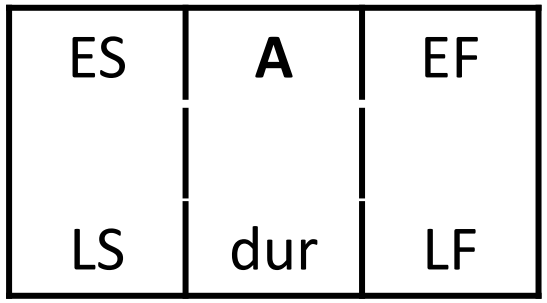
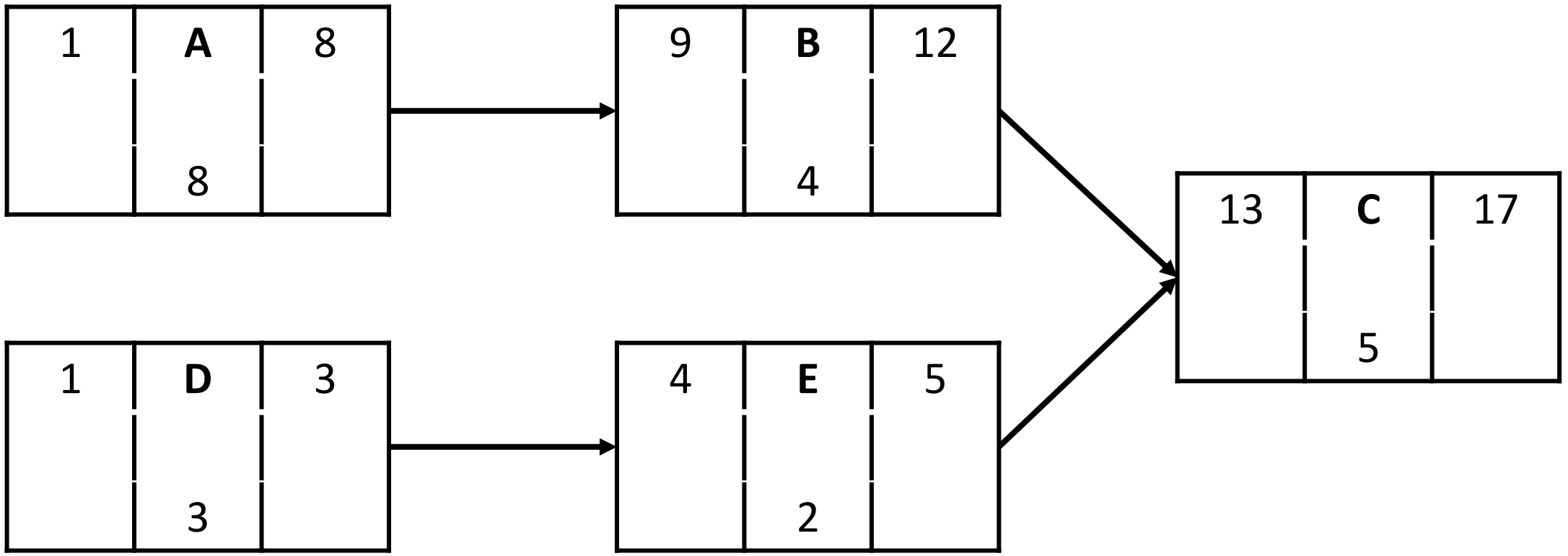


PDM: Late start and finish

- Calculating the ES and EF is known as the forward pass
- ES tells us the earliest we can start an activity
- We also want some wiggle room – when is the latest we can start an activity without affecting the deadline?
- LS (late start)
- What is the LS of A?

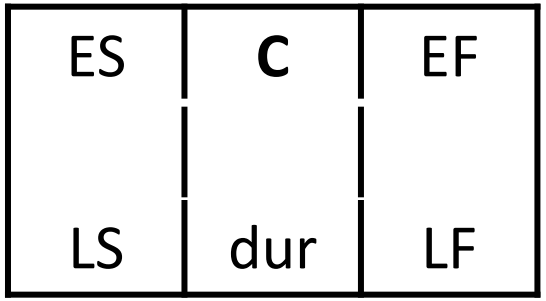


Example: PDM

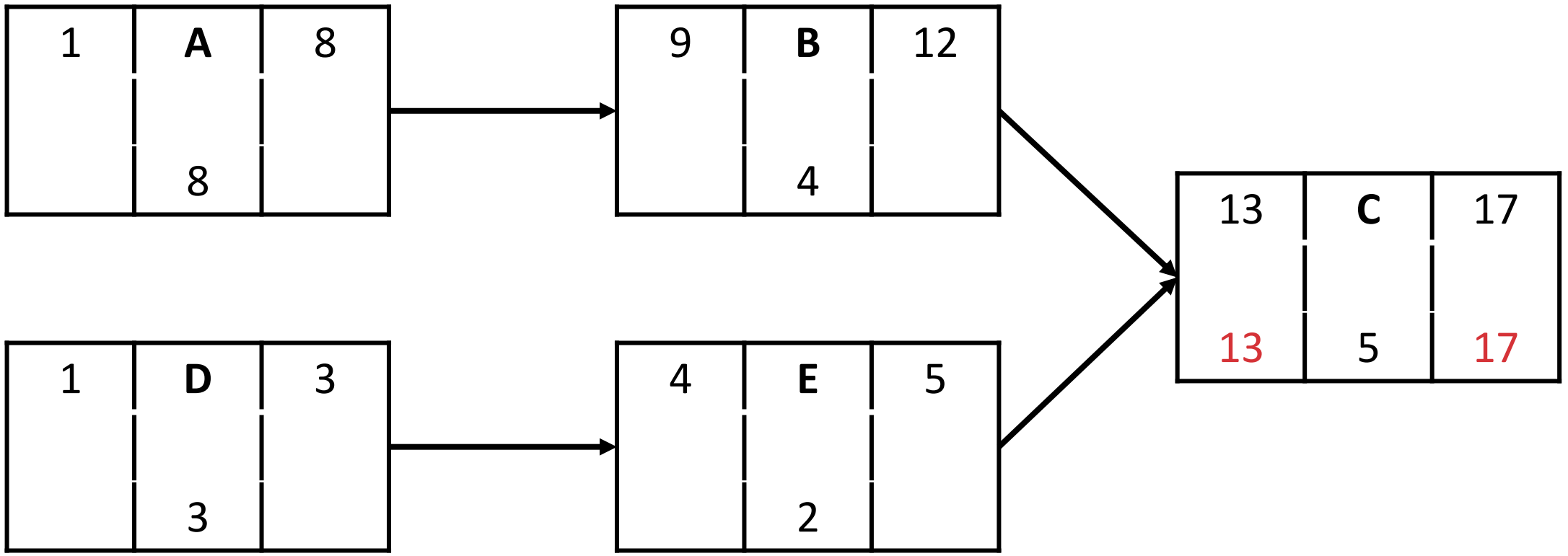


PDM: Late start and finish

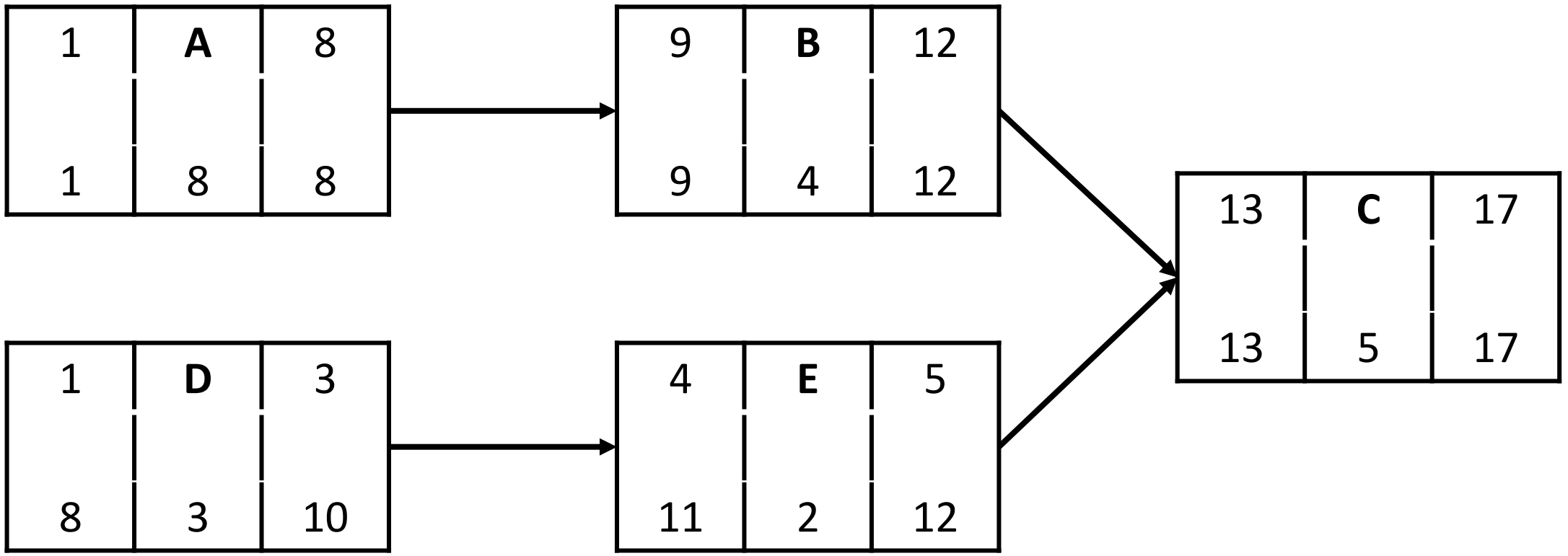
- Need to work backwards (hence backward pass)
- What is the LS of C?
- First – what is the late finish (LF) of C
- LF = min of
  - Project finish date (if unspecified, default is to use the largest EF)
  - Late start of successor - 1
- LS = LF – duration + 1



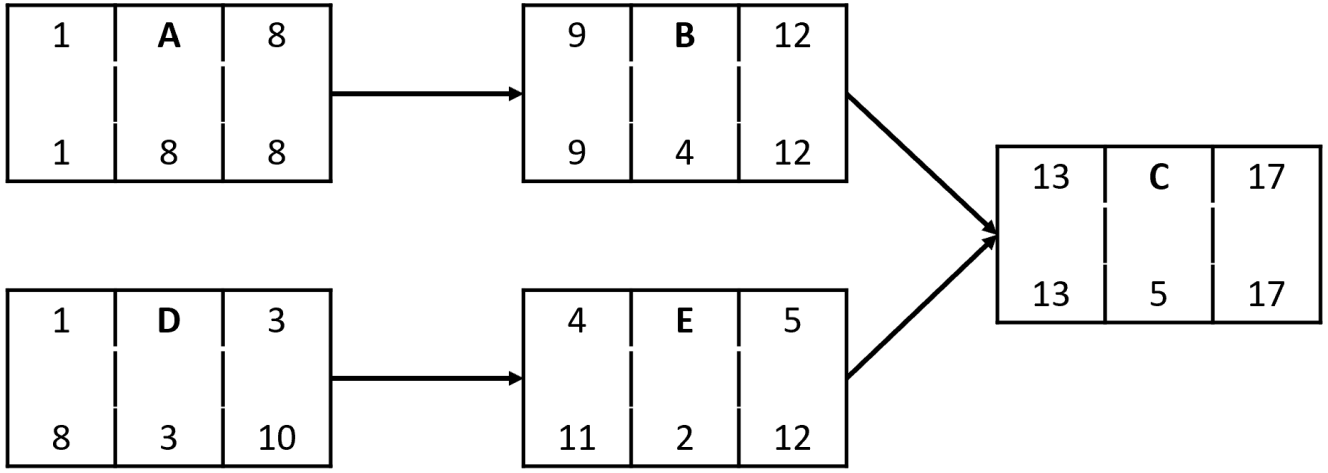
Example: Backward pass



Example: Backward pass



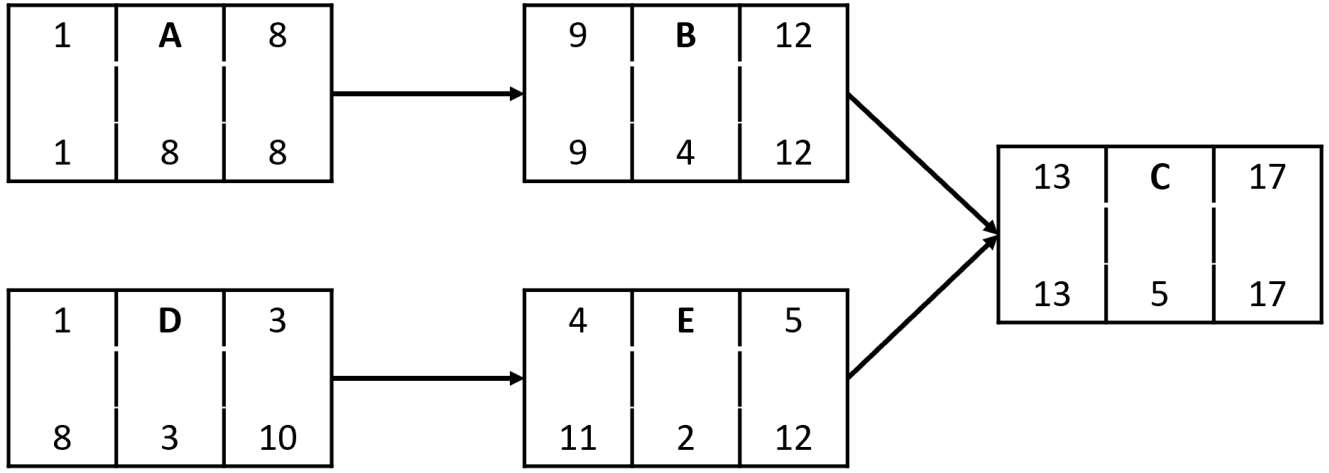
PDM: Float



- Note the EF and LF are the same for some activities
- This means there is no “wiggle room” – any delay will delay the entire project
- Float is the number of days an activity can be delayed without impacting the project
- Float = ?

ES	**A**	EF
	float	
LS	dur	LF

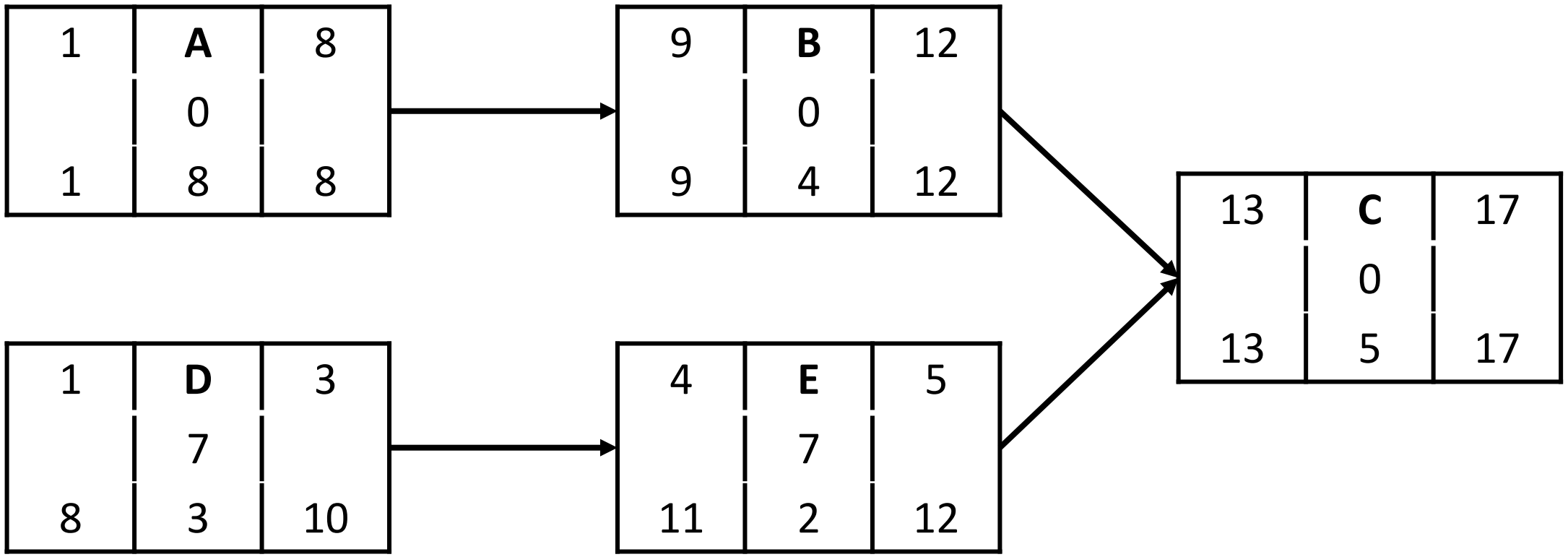
PDM: Float



- Note the EF and LF are the same for some activities
- This means there is no “wiggle room” – any delay will delay the entire project
- Float is the number of days an activity can be delayed without impacting the project
- Float = LF – ES – duration + 1

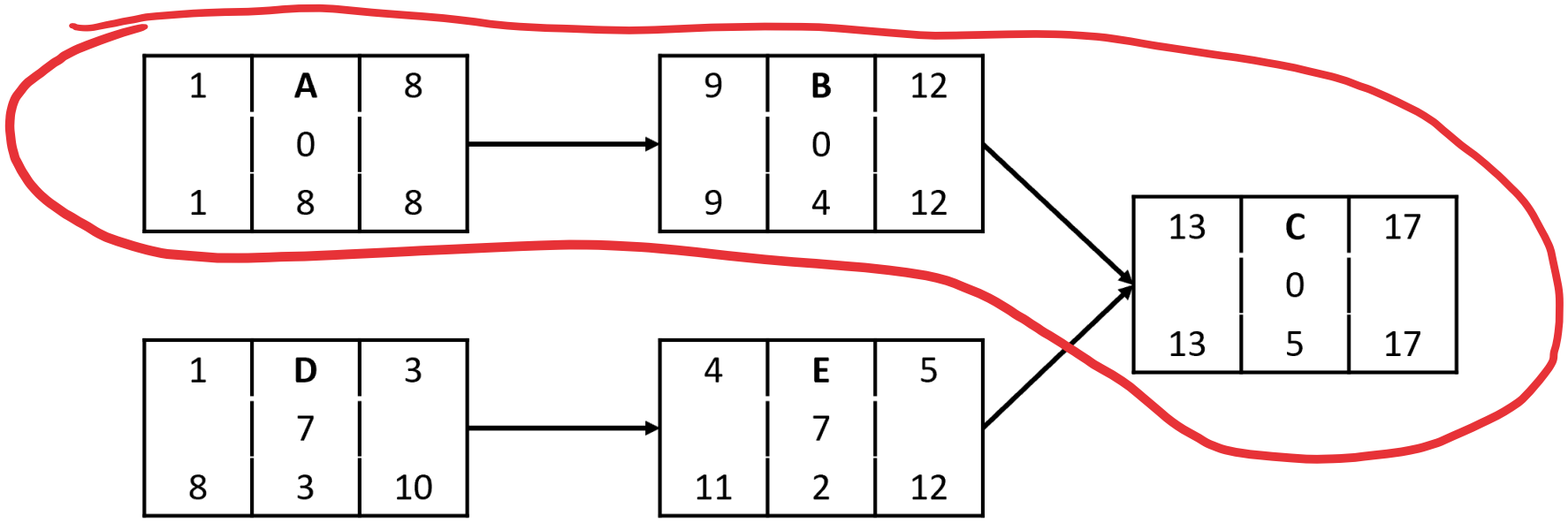
ES	**A**	EF
	float	
LS	dur	LF

Example: Float



Critical path

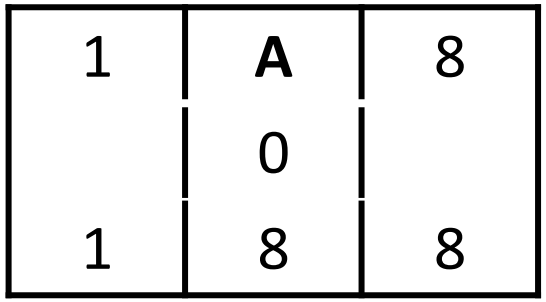
- The series of activities with float = 0 is the critical path
- The critical path is the one that dictates when the project will be complete
- Any delays to the critical path affect the project deadline



Resource constraining

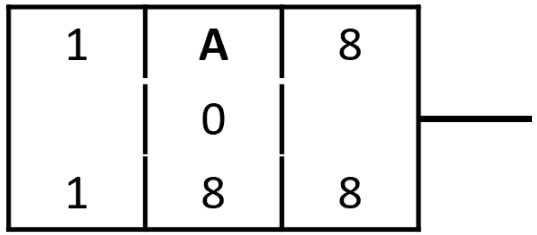
- This has given us a schedule that is resource unconstrained
- However, there are likely constraints on resources
- Resources = labour, equipment, material
- Resource levelling is used to determine a resource constrained schedule
- Software is required for the optimization

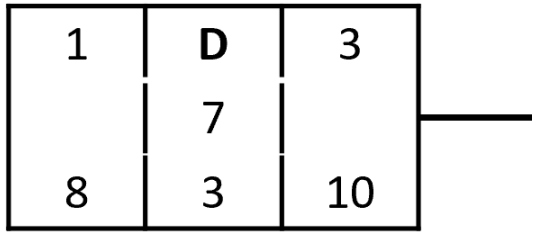
Resource levelling: essentials



- (first determine the resource unconstrained schedule)
- For each activity: what resources are required at each timestep
  - E.g. activity A requires a digger (excavator) for the first four days
- Consider each time step sequentially:
  - What resources are needed by the activities currently scheduled?
  - Are the required resources available?
  - If not, assign the resources to the activity with the highest priority (common to use the lowest float)
  - Activity without resources is pushed to start at the next time step
  - Repeat for the next timestep

Resource levelling: example





- Let’s say that
  - Activity A is the foundations of a road
  - Activity D is the swale (stormwater ditch) off the road
- Both require diggers
  - A requires it for the first four time steps
  - D requires it for the first two
- Only one digger is available
- D must therefore start on day 5 – this is the resource start (RS)

Resource levelling

- Two alternatives
  - Limited resources – delay project completion
  - Meet deadline – identify resource limitations

- Options for manager
  - Get more resources
  - Extend deadline
  - New project plan

In-class problem – 5-10min – work with others as you'd like

Draw the precedence diagram for the following house construction problem and determine the float of each activity.

	Activity	Immediate predecessor	Time (days)
1	Walls and ceiling	2	5
2	Foundation	None	3
3	Roof timbers	1	2
4	Roof sheathing	3	3
5	Electrical Wiring	1	4
6	Roof shingles	4	8
7	Exterior Siding	8	5
8	Windows	1	2
9	Paint	6, 7, 10	2
10	Inside wall board	8, 5	3

Key concepts

- Construct a precedence diagram from activity list
- Calculate the float for each activity
- Understand the differences between and uses of ES, EF, LS, LF, RS, RF
- Understand how resource levelling determines a resource constrained schedule