CS 208
Software Engineering

Scheduling and Critical Path Method

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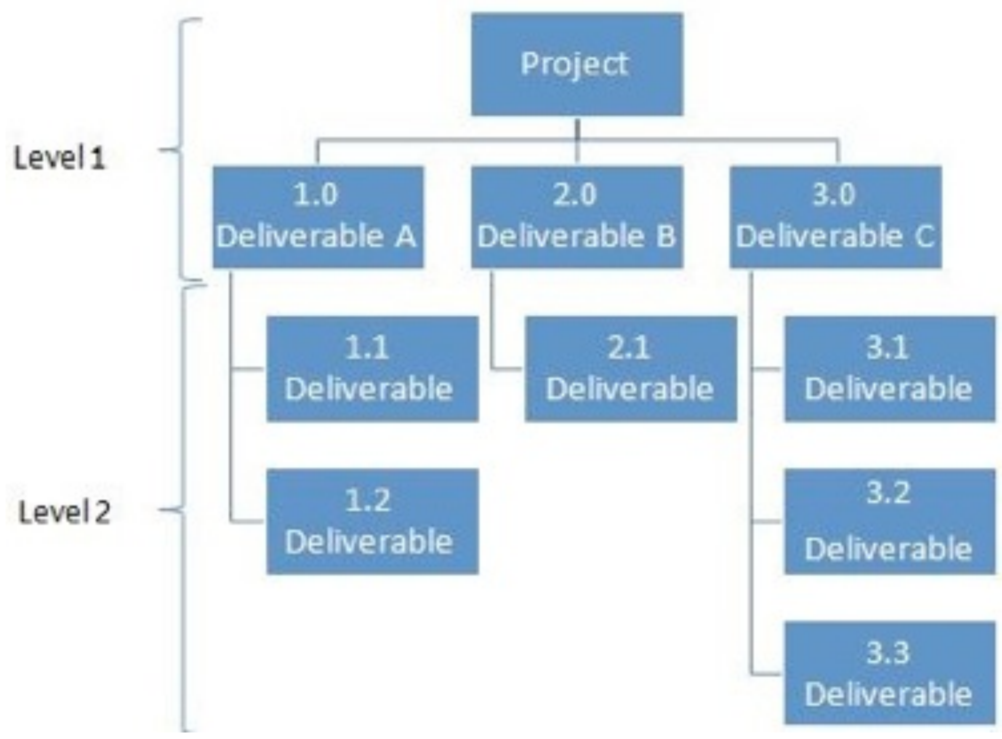
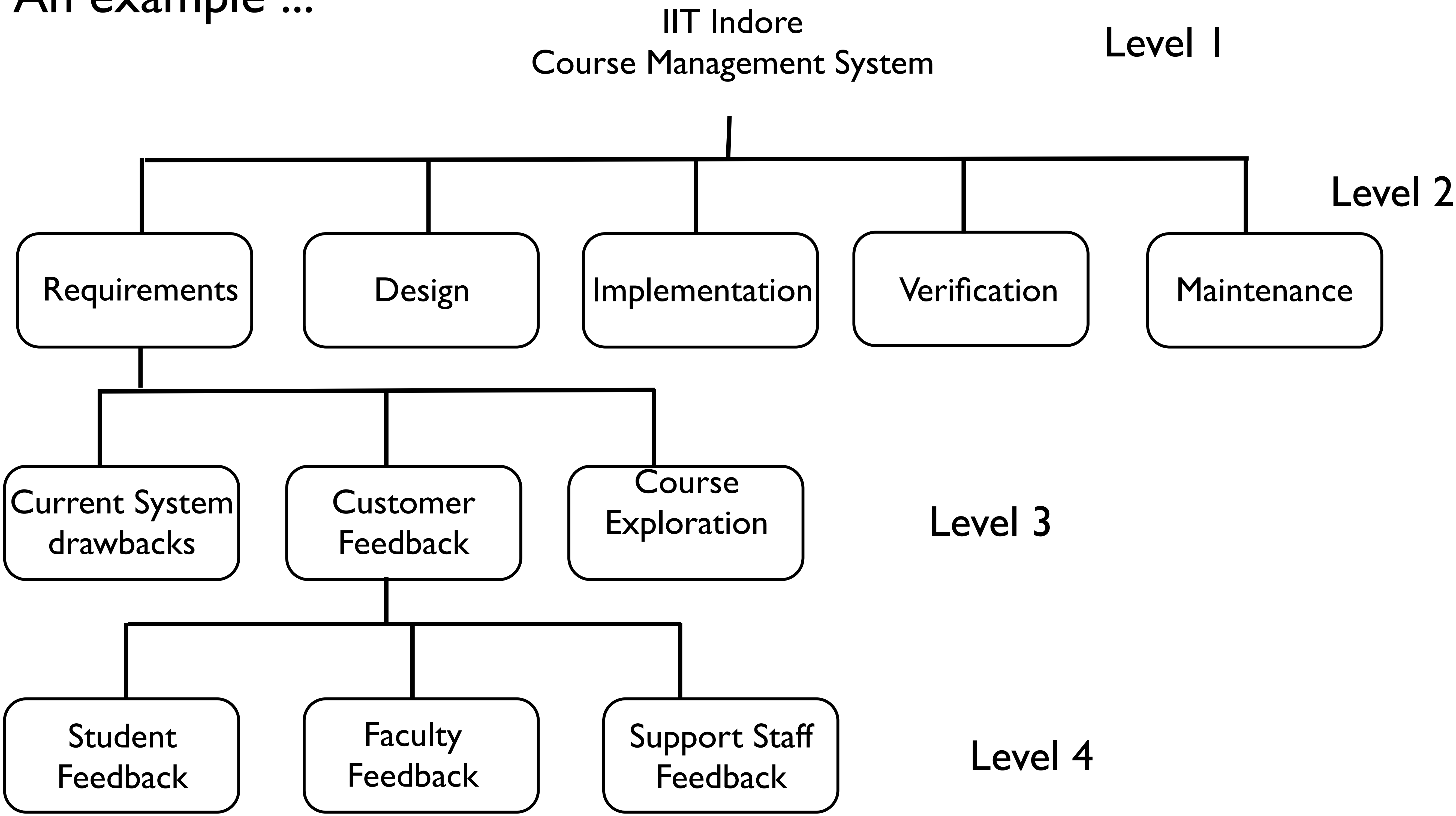
Work Breakdown Structure

A work breakdown structure (WBS) is a chart in which the critical work elements, called tasks, of a project are illustrated to portray their relationships to each other and to the project as a whole.



A WBS takes the form of a tree diagram with the "trunk" at the top and the "branches" below. The primary requirement or objective is shown at the top, with increasingly specific details shown as the observer reads down.

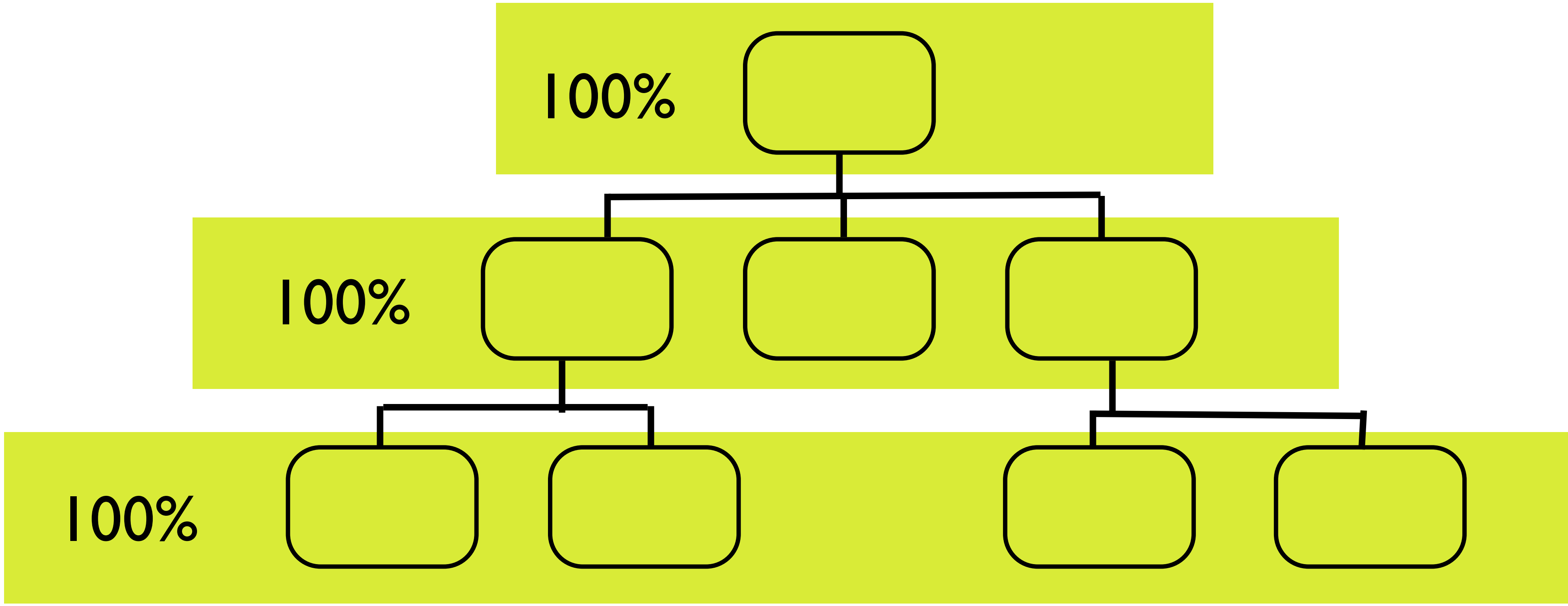
An example ...



- 50 hours
- 10 persons
- survey material

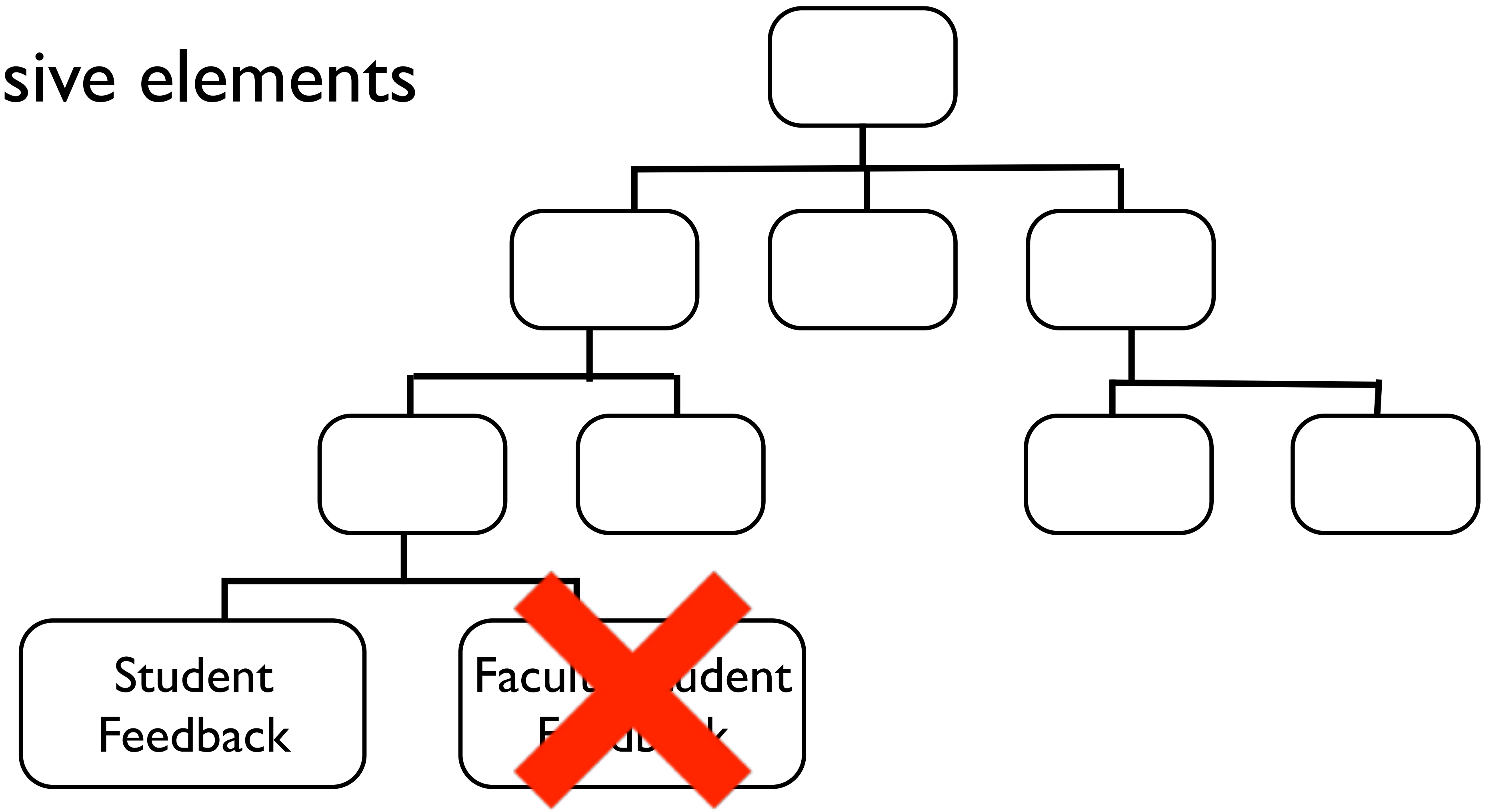
Design Principles

- The 100% rule



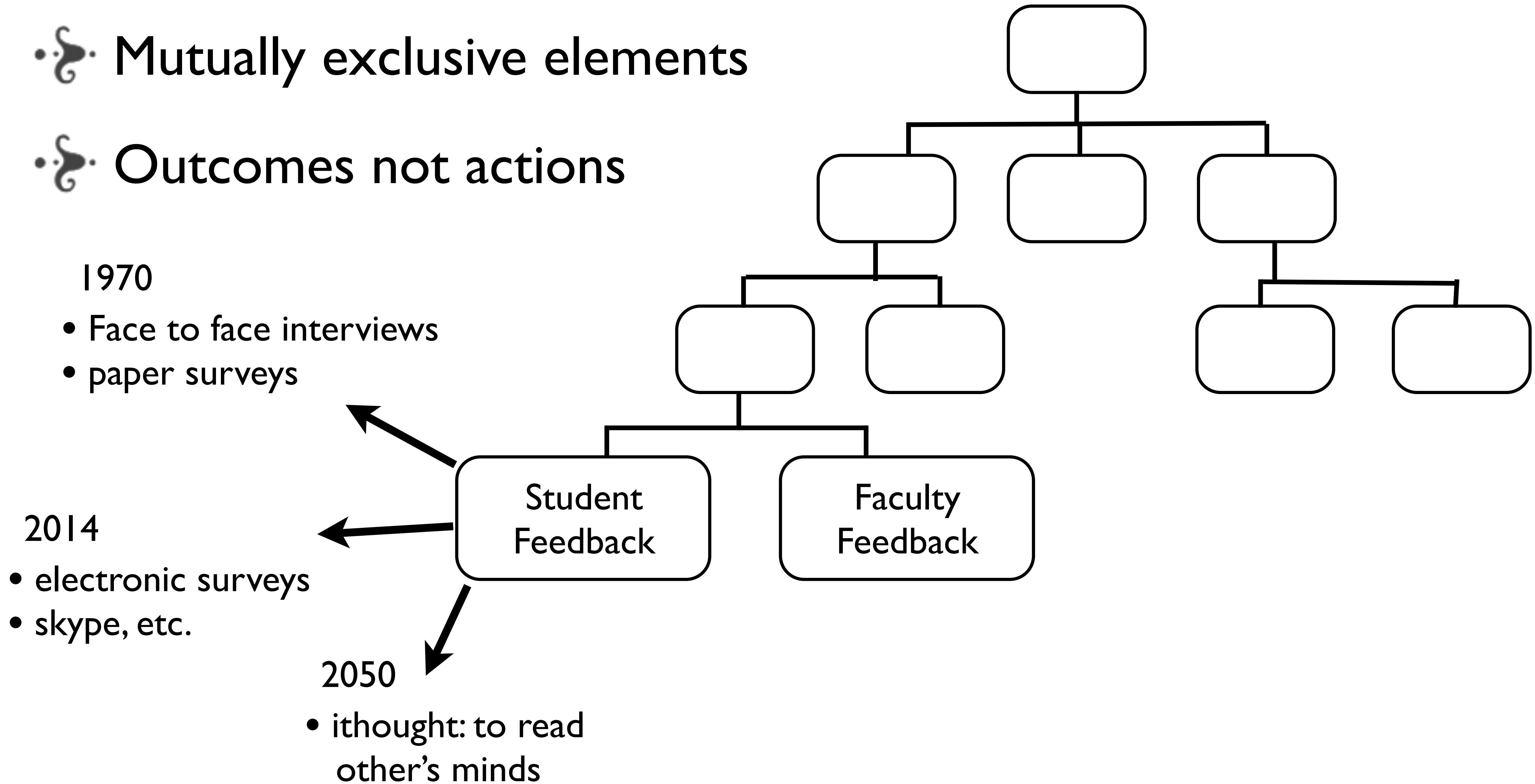
Design Principles

- The 100% rule
- Mutually exclusive elements



Design Principles

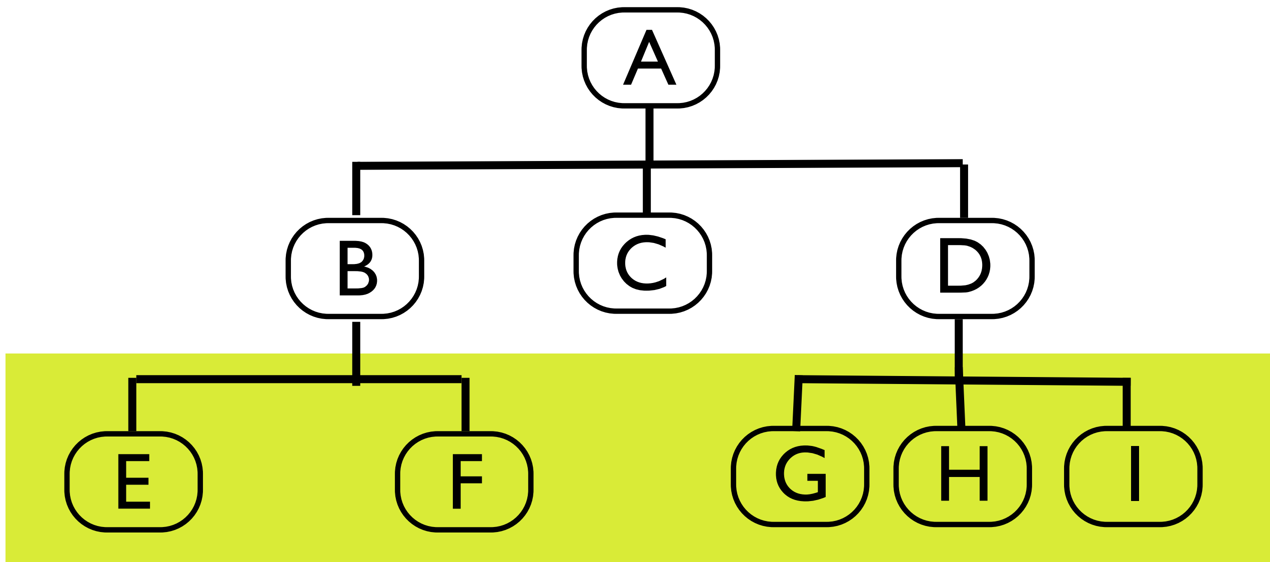
- The 100% rule
- Mutually exclusive elements
- Outcomes not actions



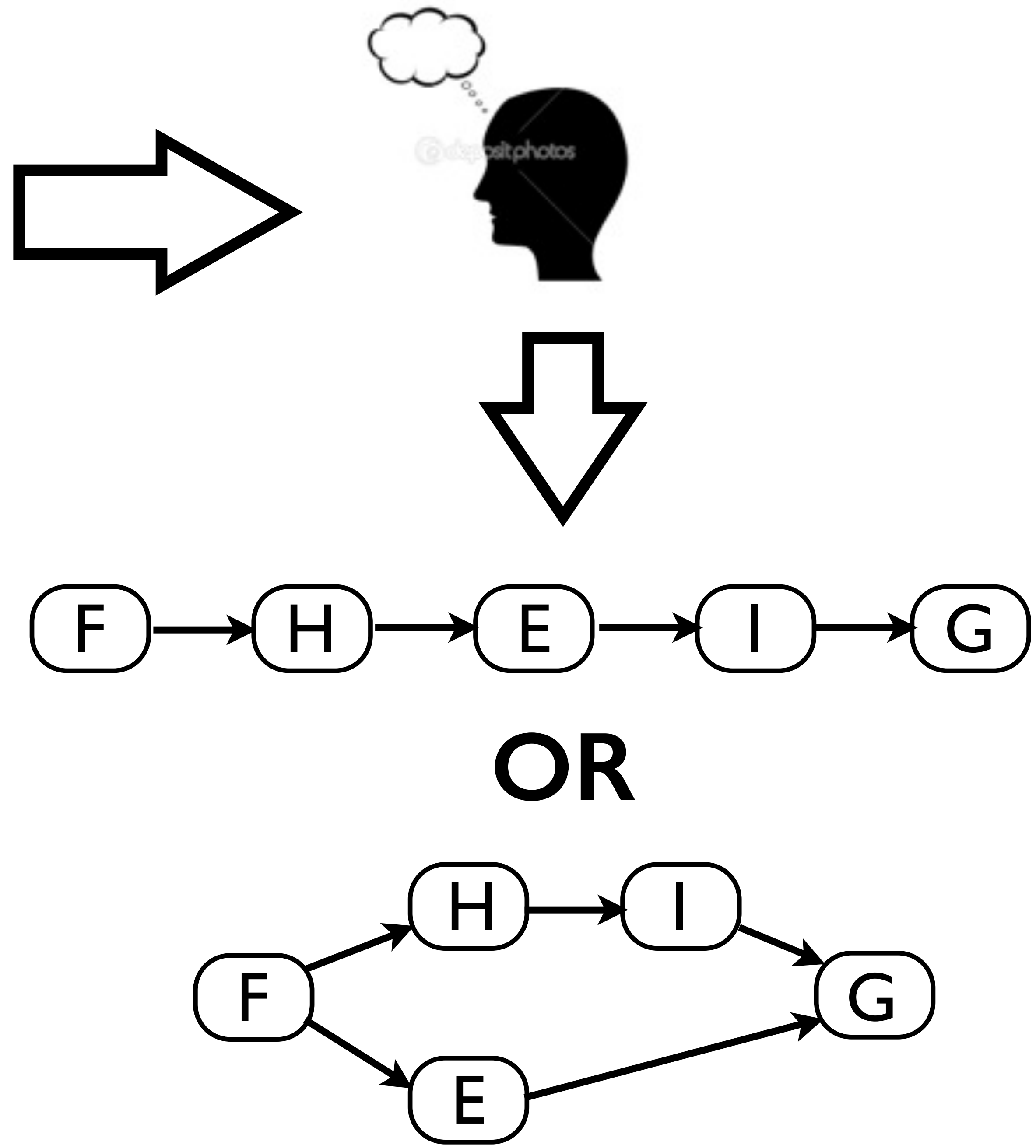
Design Principles

- The 100% rule
- Mutually exclusive elements
- Outcomes not actions
- Completion criteria
    - 80 hour rule
    - produces deliverables that can be measured
    - can be sub-contracted

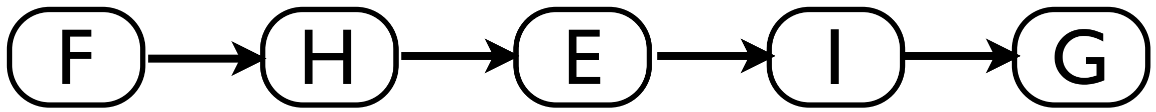
Network-based scheduling

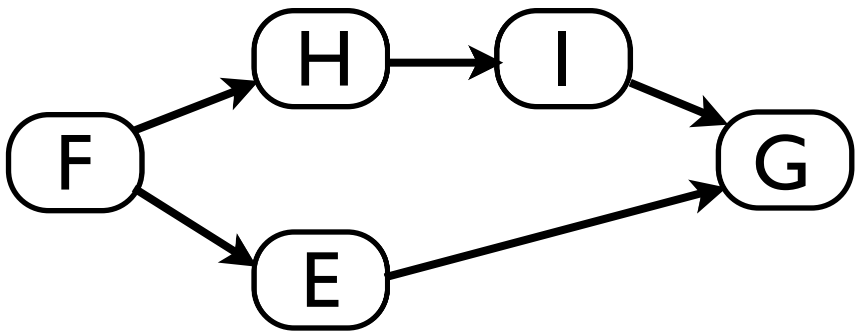


Work breakdown structure



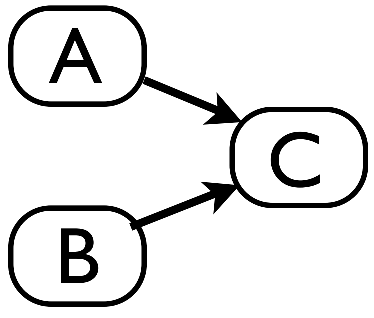
Determining the sequence of operations ...





the sequencing is done
on the basis of dependency.

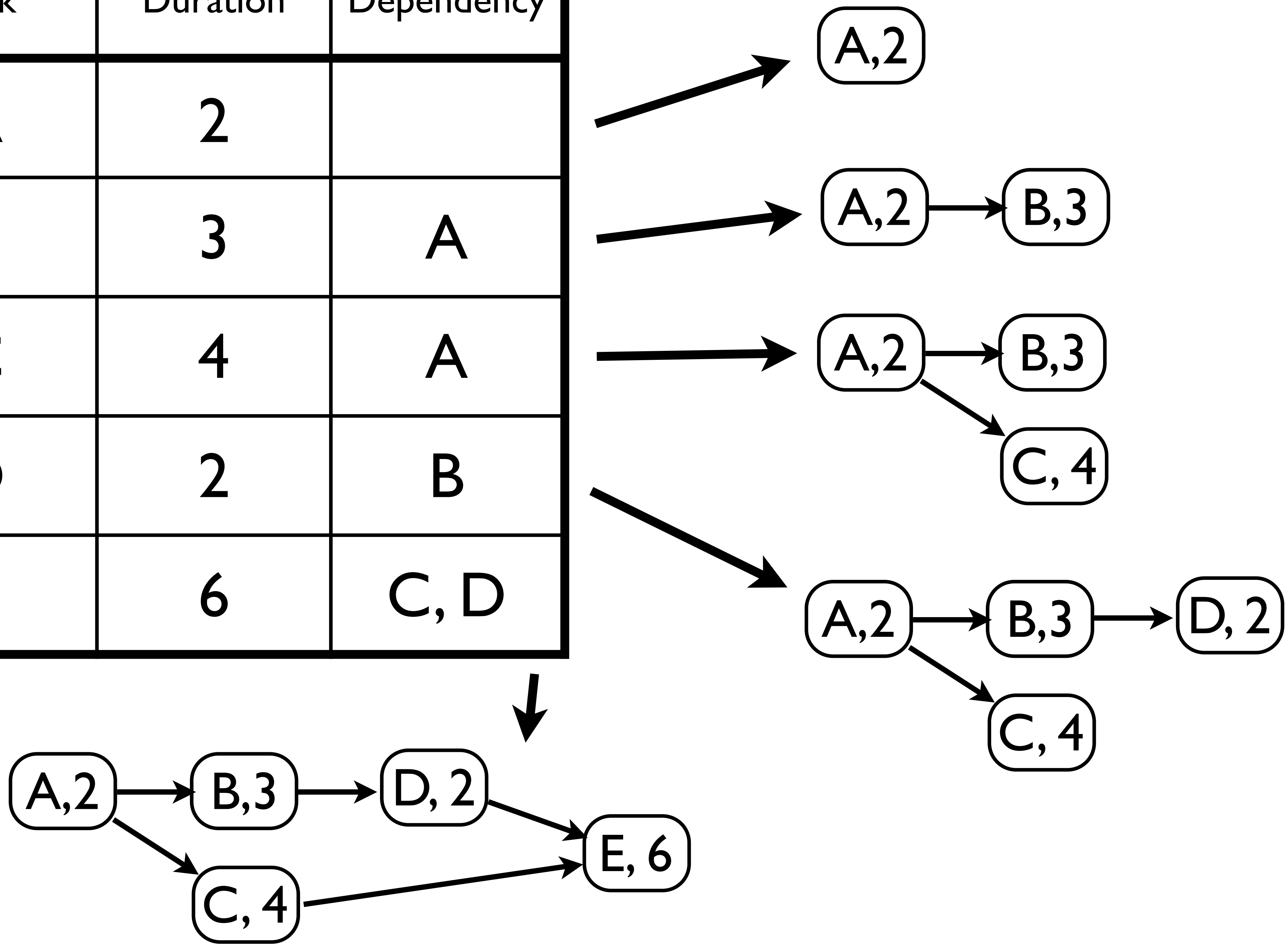
e.g. if C depends on the
outputs of A and B



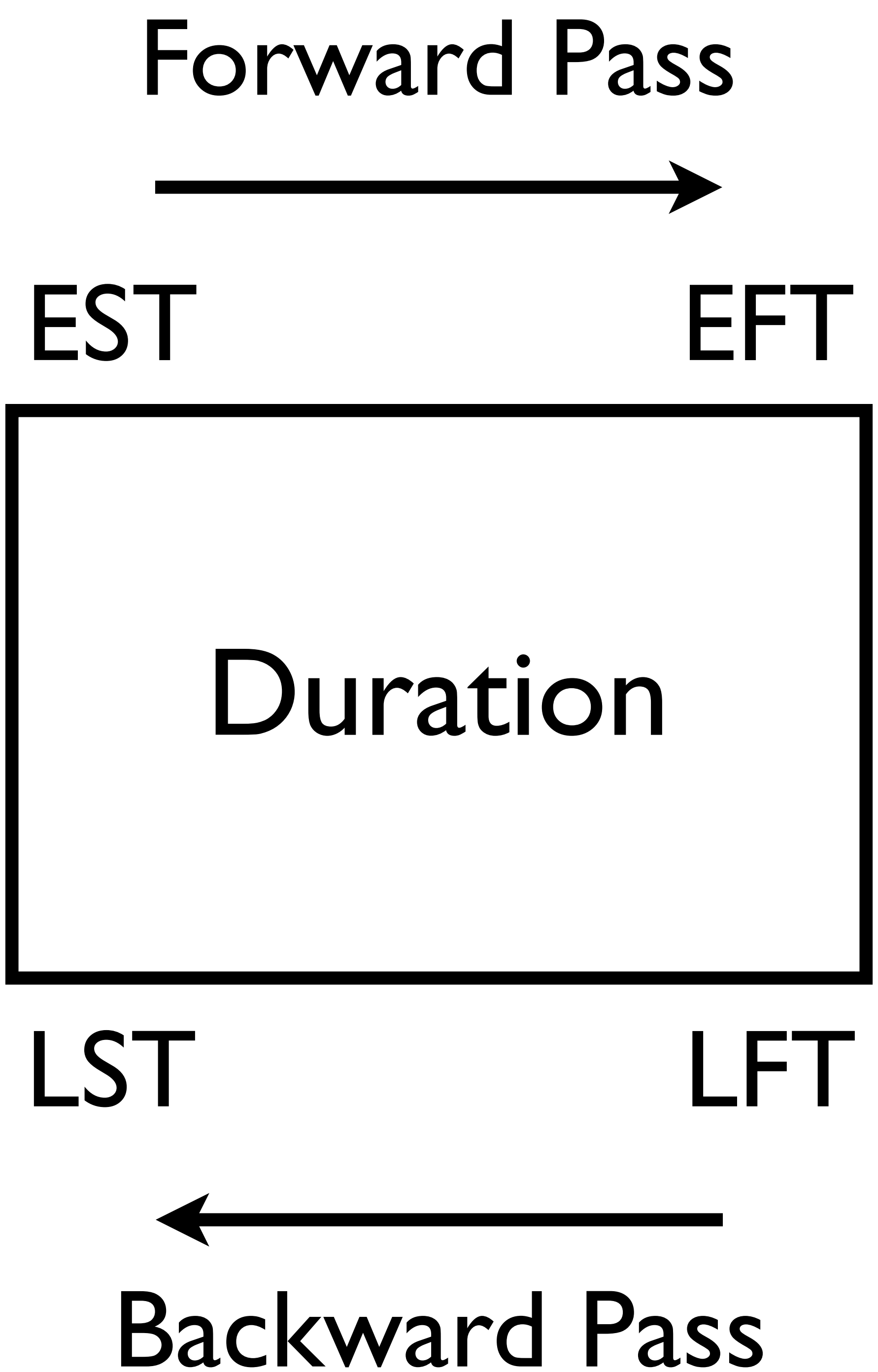
- Technical constraints
- Management constraints
- Inter-project constraints
- Data constraints

Forming the network ...

Task	Duration	Dependency
A	2	
B	3	A
C	4	A
D	2	B
E	6	C, D



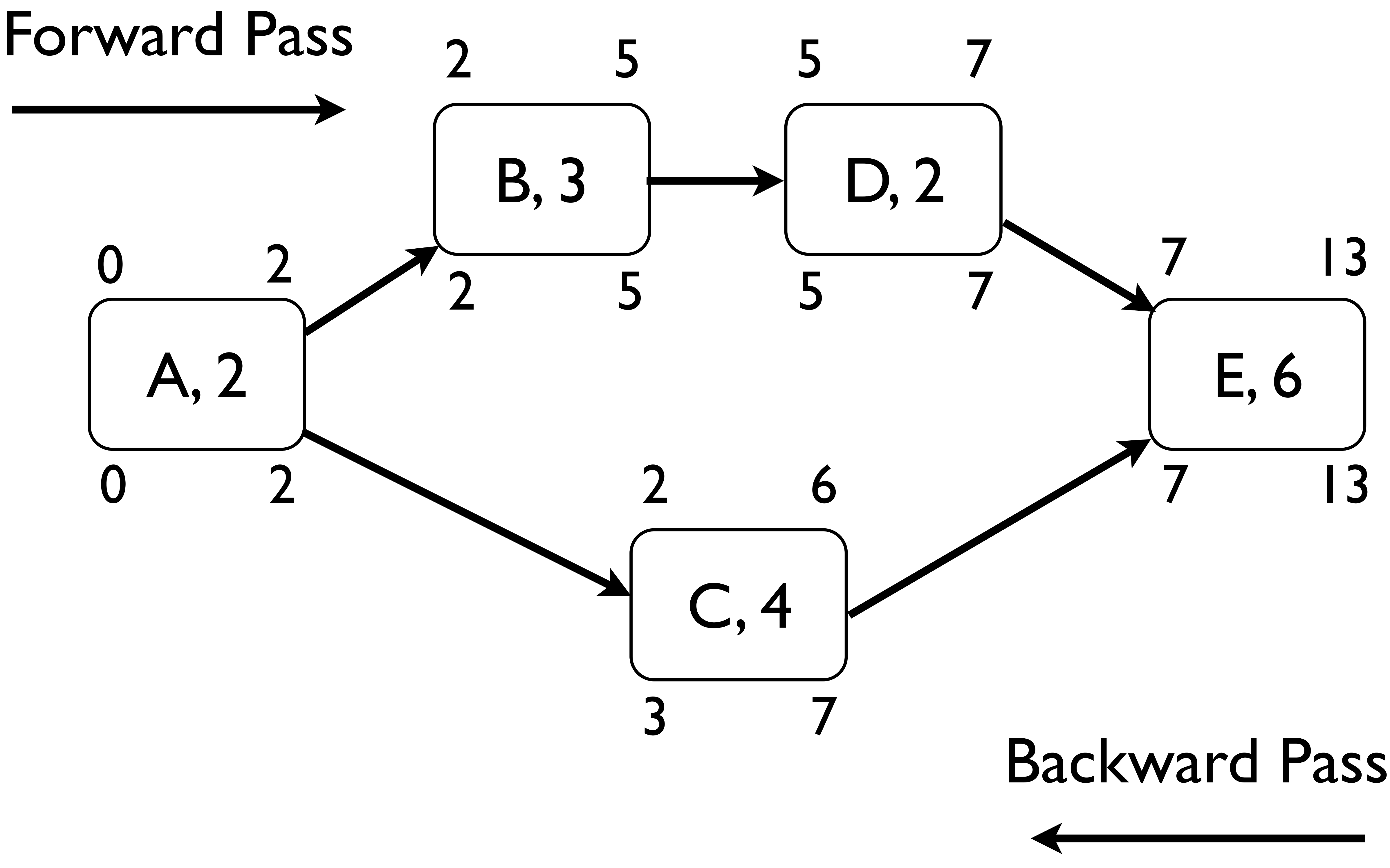
Estimating the start time, end time ...



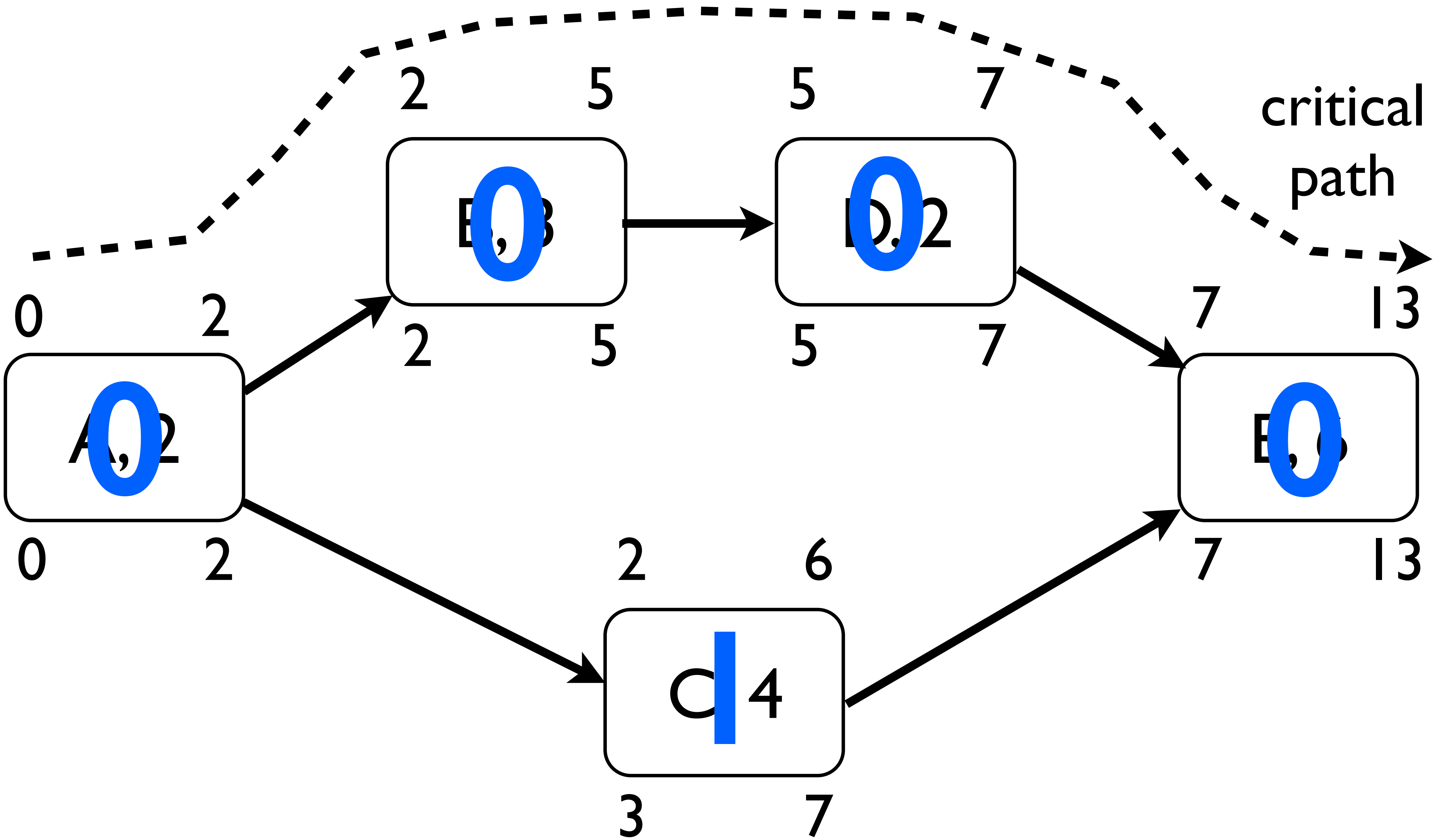
EST: Earliest Start Time
EFT: Earliest Finish Time

LFT: Latest Finish Time
LST: Latest Start Time

Estimating the start time, end time ...



Calculating slack, and critical path ...



slack = LST - EST = LFT - EFT

Exercise

Find the critical path for the following:

Task	Duration	Dependency
A	3	
B	4	A
C	2	A
D	6	C
E	8	C
F	4	B
G	3	D, E
H	7	F, G

Handling resources using CPM

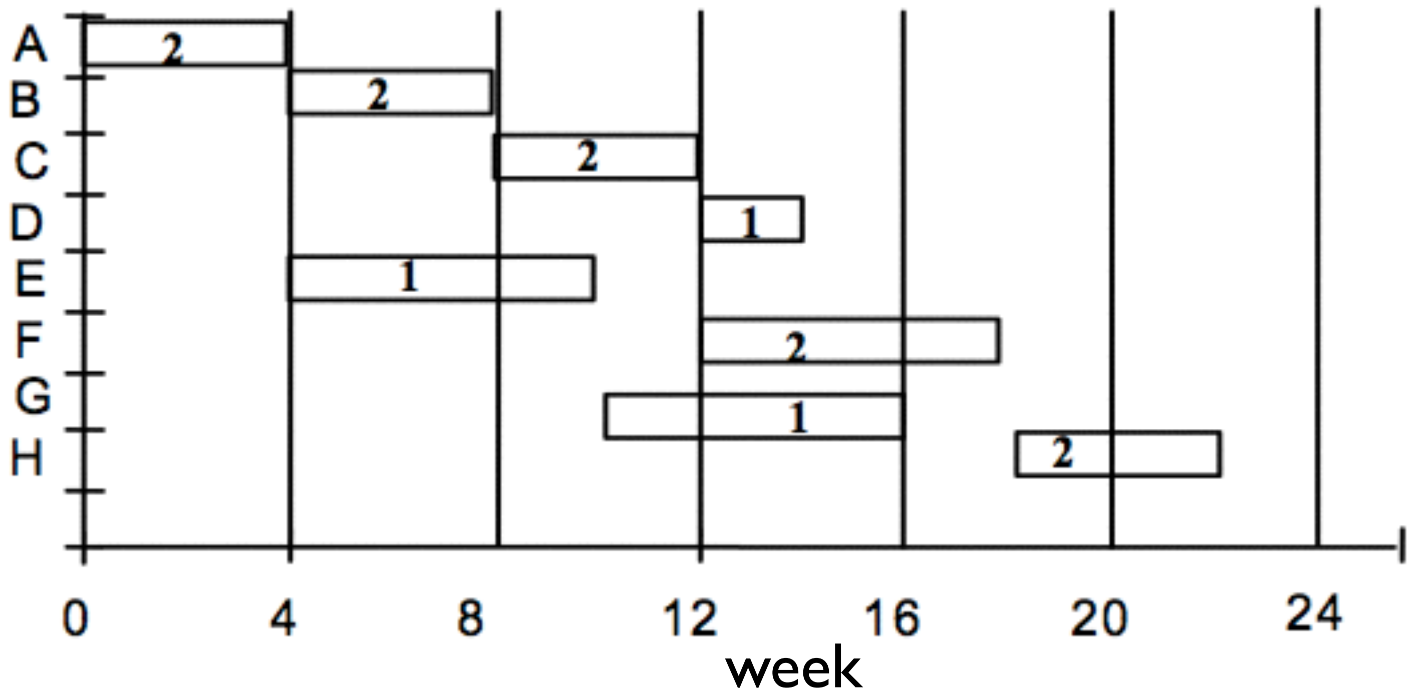
- The critical path method is a very handy tool for effectively distributing resources
- We will examine two example scenarios where resources are re-distributed and utilised respectively for the benefit of the project
- In the first scenario there is minor reorganisation of the schedule to better utilise the resources
- In the second scenario the project is ‘crashed’ to increase savings

Example scenario

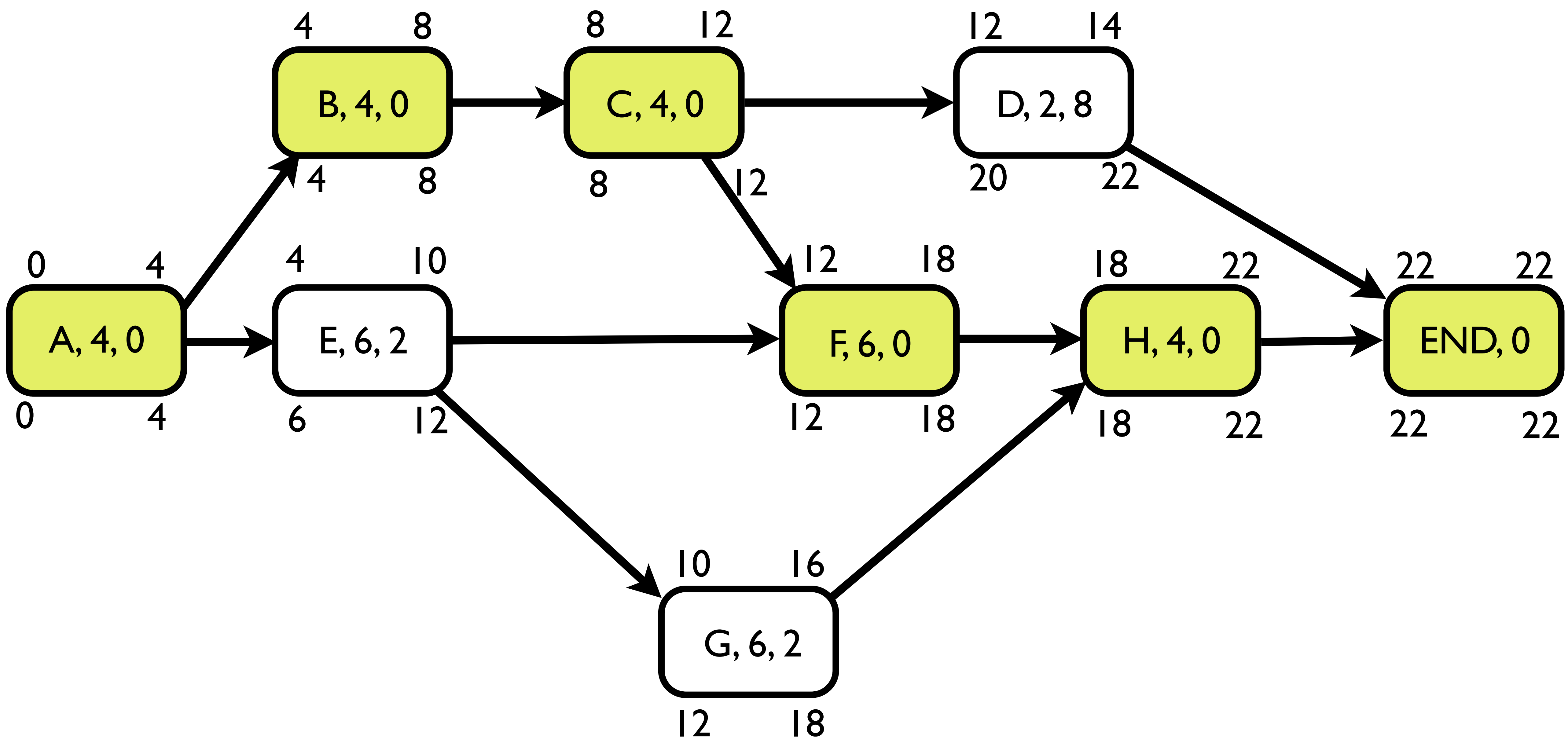
Task	Duration	Dependency	Personnel
A	4		2
B	4	A	2
C	4	B	2
D	2	C	1
E	6	A	1
F	6	C, E	2
G	6	E	1
H	4	F, G	2

Maximum personnel employed per week = 3

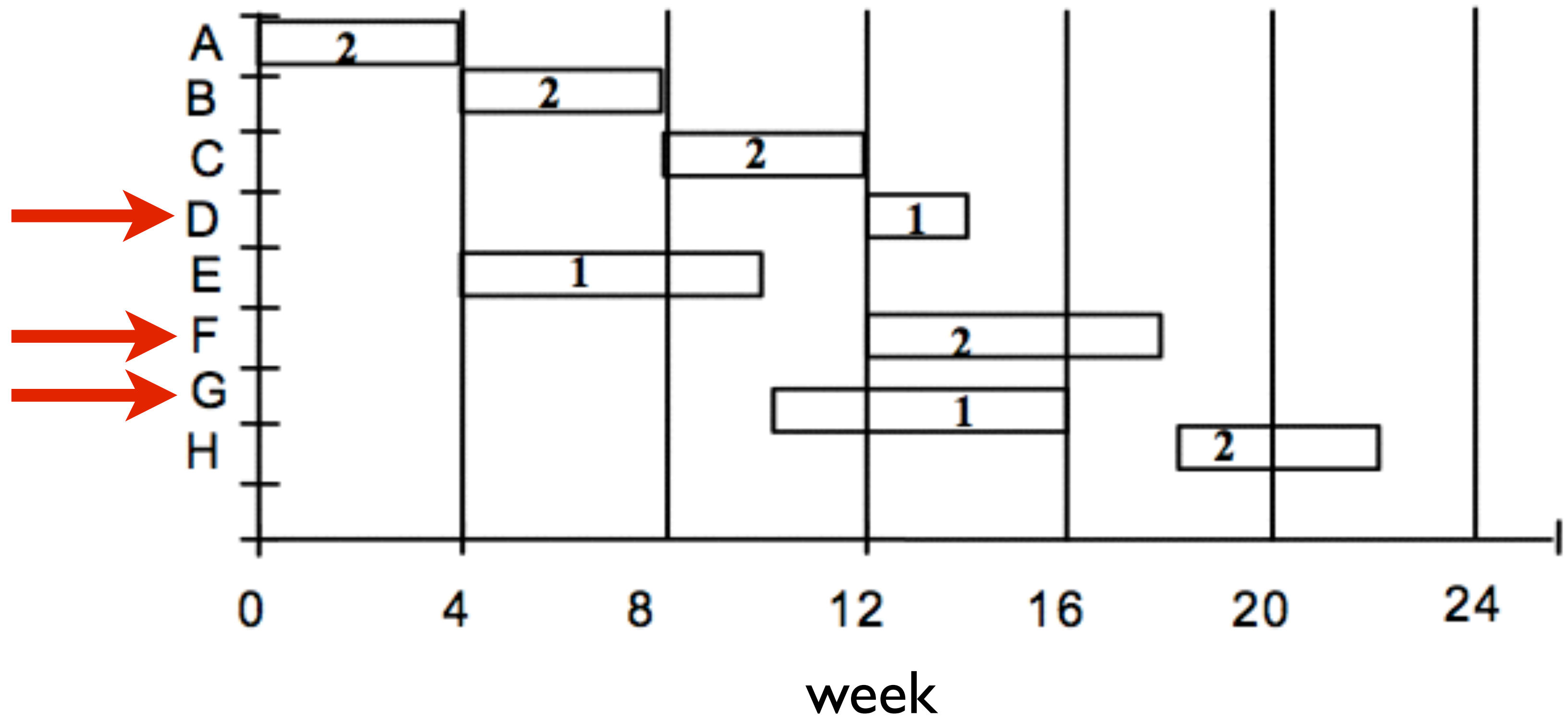
Amount of money spent per week on project = $3000



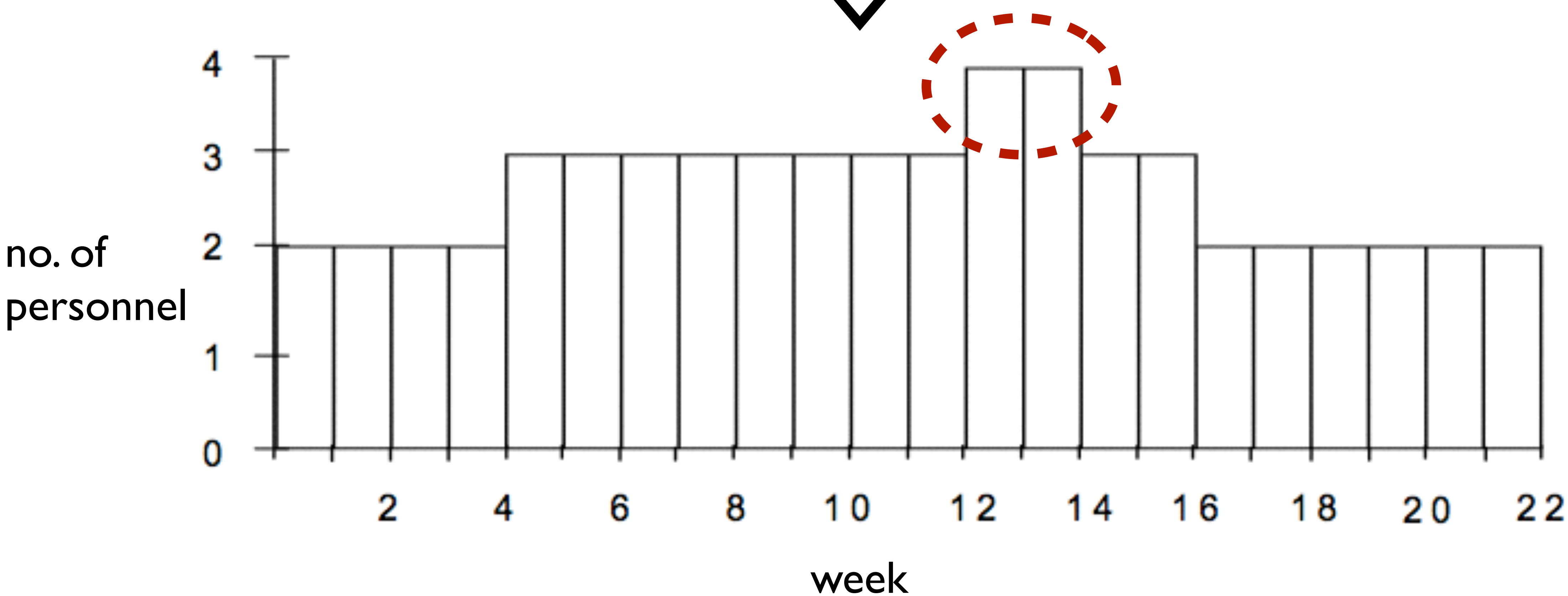
A
B
C
D
E
F
G
H
2
2
2
1
1
2
1
2
0
4
8
12
16
20
24
week

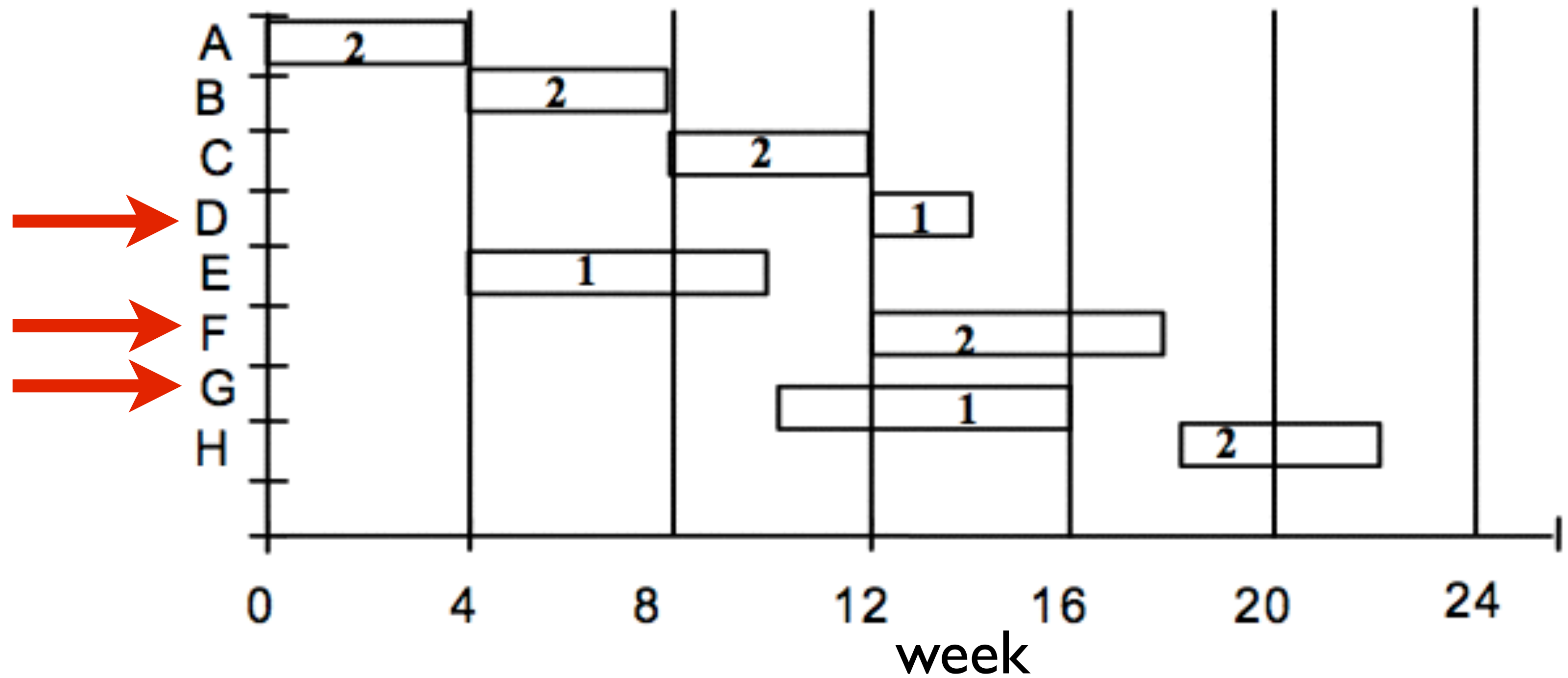


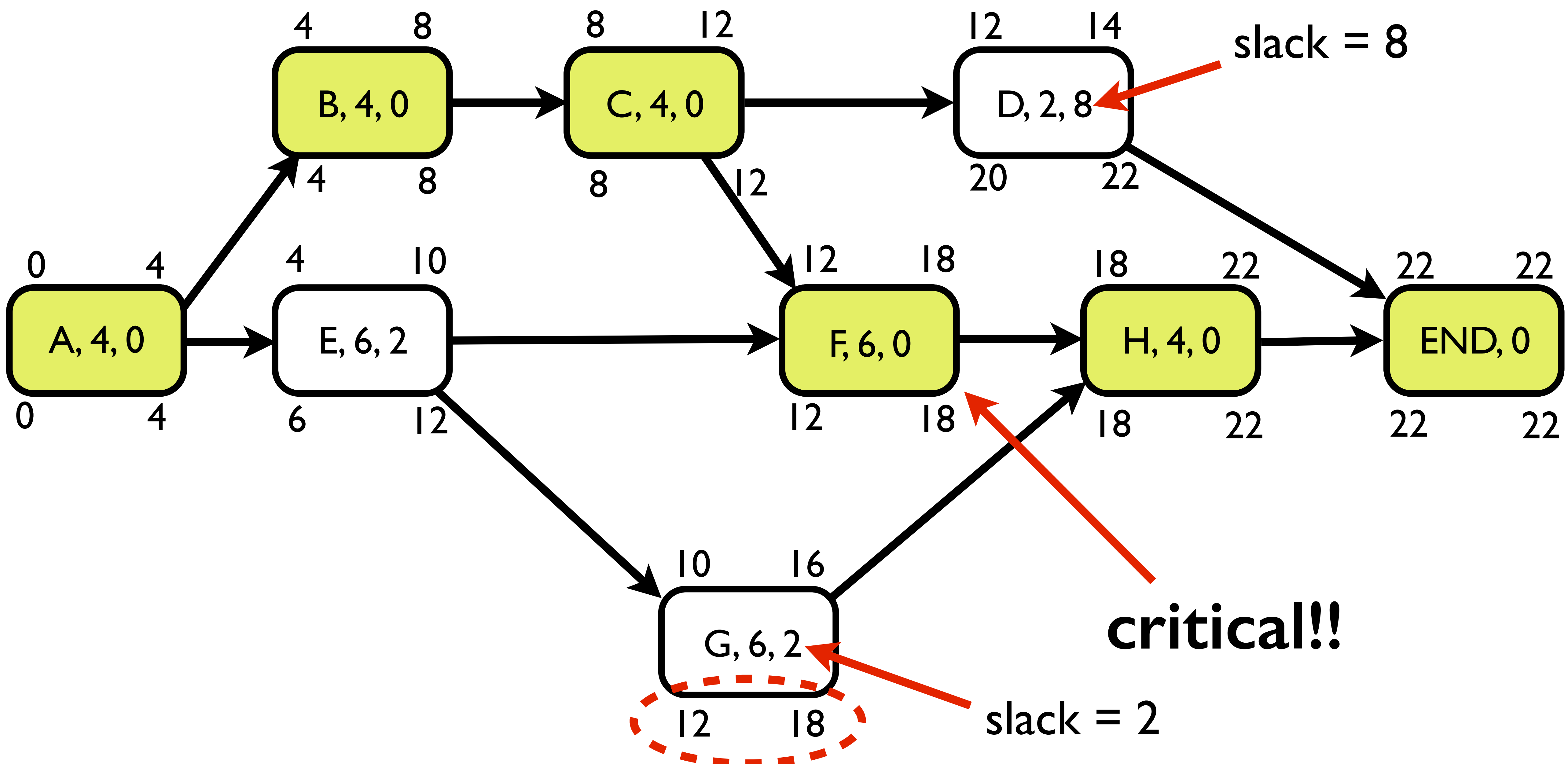
A, 4, 0
B, 4, 0
C, 4, 0
D, 2, 8
E, 6, 2
F, 6, 0
G, 6, 2
H, 4, 0
END, 0
0 4
0 4
4 8
4 8
8 12
8 12
12 14
20 22
4 10
6 12
12 18
12 18
10 16
12 18
18 22
18 22
22 22
22 22

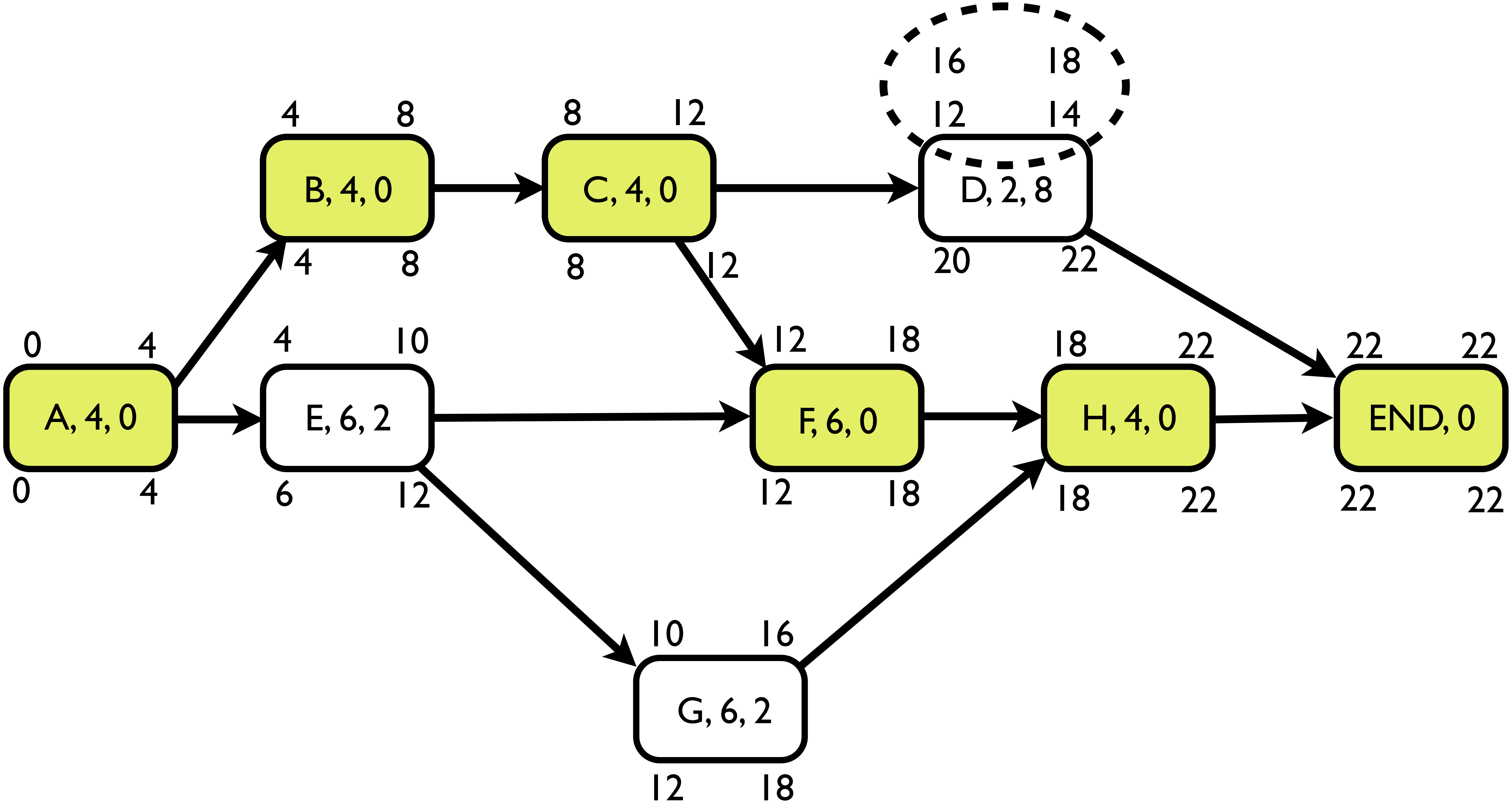


maximum personnel employed = 3

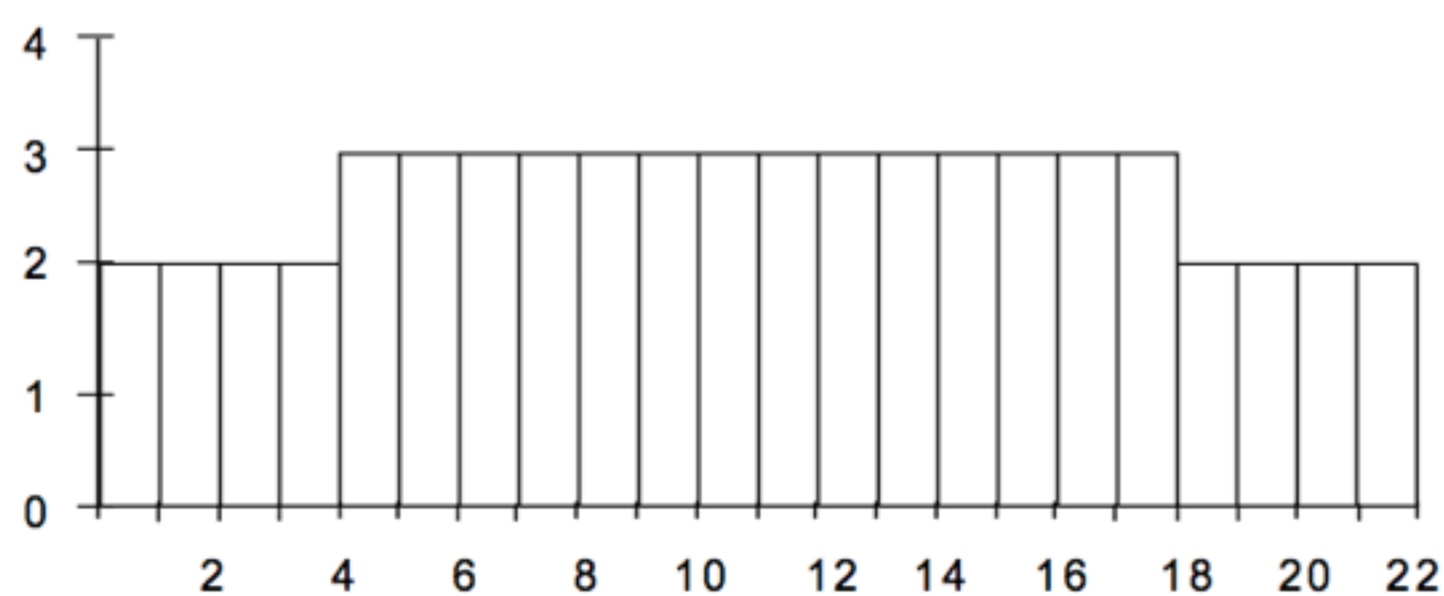



A
B
C
D
E
F
G
H
2
2
2
1
1
2
1
2
0
4
8
12
16
20
24
week


A, 4, 0
B, 4, 0
C, 4, 0
D, 2, 8
E, 6, 2
F, 6, 0
G, 6, 2
H, 4, 0
END, 0
slack = 8
slack = 2
critical!!



16 18
12 14
D, 2, 8
20 22
4 8
B, 4, 0
4 8
8 12
C, 4, 0
8 12
0 4
A, 4, 0
0 4
4 10
E, 6, 2
6 12
12 18
F, 6, 0
12 18
18 22
H, 4, 0
18 22
22 22
END, 0
22 22
10 16
G, 6, 2
12 18



0
1
2
3
4
2 4 6 8 10 12 14 16 18 20 22

‘Crashing’ a project

Crashing a project implies employing more personnel or purchasing more equipment to speed up the project.

Task	Duration	Dependency	Personnel
A	4		2
B	4	A	2
C	4	B	2
D	2	C	1
E	6	A	1
F	6	C, E	2
G	6	E	1
H	4	F, G	2

Task	Extra Personnel	Cost
B	1	CA$ 2000
D	1	CA$ 2500
G	1	CA$ 1000

The extra personnel will reduce the duration of the task by 1 week

If reducing the task duration by 1 week reduces the project duration by 1week, money saved would be $3000

how can we accomplish this?

select a critical task to crash

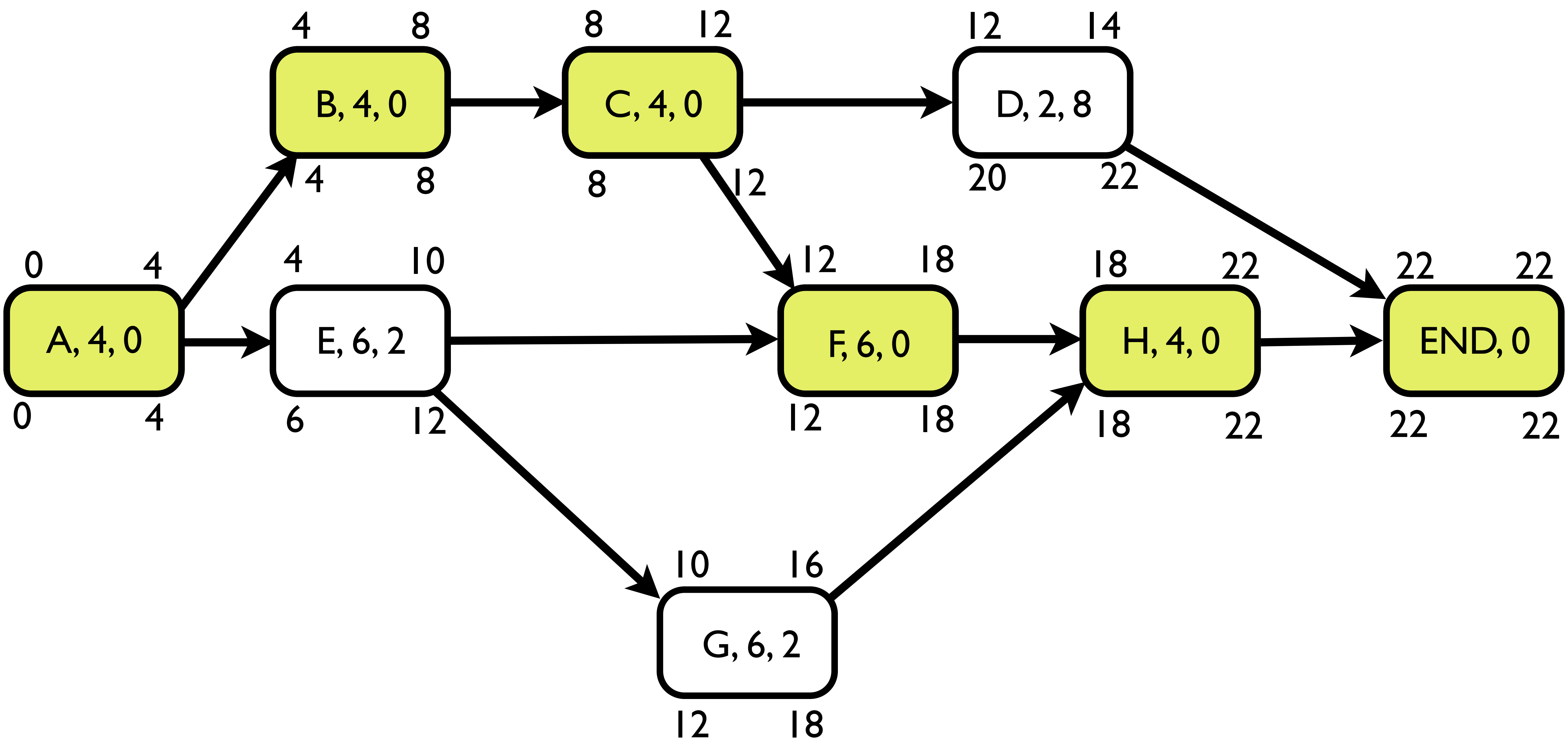
savings = $3000

expense = $2000

net savings = $1000

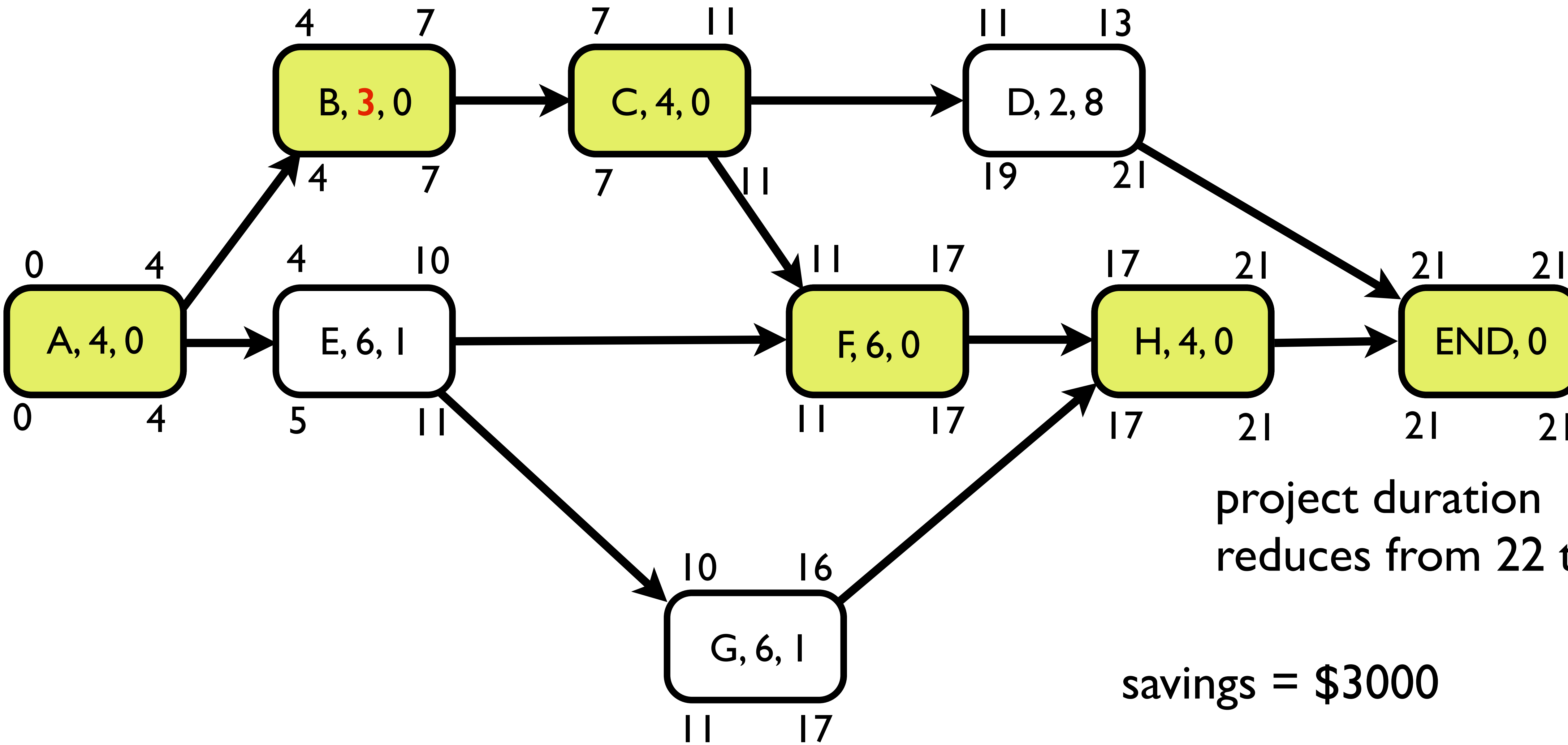
Steps to crash a project ...

- Step 1: crash an activity on the critical path. If the crash does not lead to savings: STOP
- Step 2: crash the most effective task until further crashing it leads to no savings OR it ceases to be on the critical path
- Step 3: the crash in step 2 may create a new critical path. Repeat the same set of steps on the new path



A, 4, 0
0
4
0
4
B, 4, 0
4
8
4
8
C, 4, 0
8
12
8
12
D, 2, 8
12
14
20
22
E, 6, 2
4
10
6
12
F, 6, 0
12
18
12
18
G, 6, 2
10
16
12
18
H, 4, 0
18
22
18
22
END, 0
22
22
22
22

crash B: reduce its duration from 4 to 3



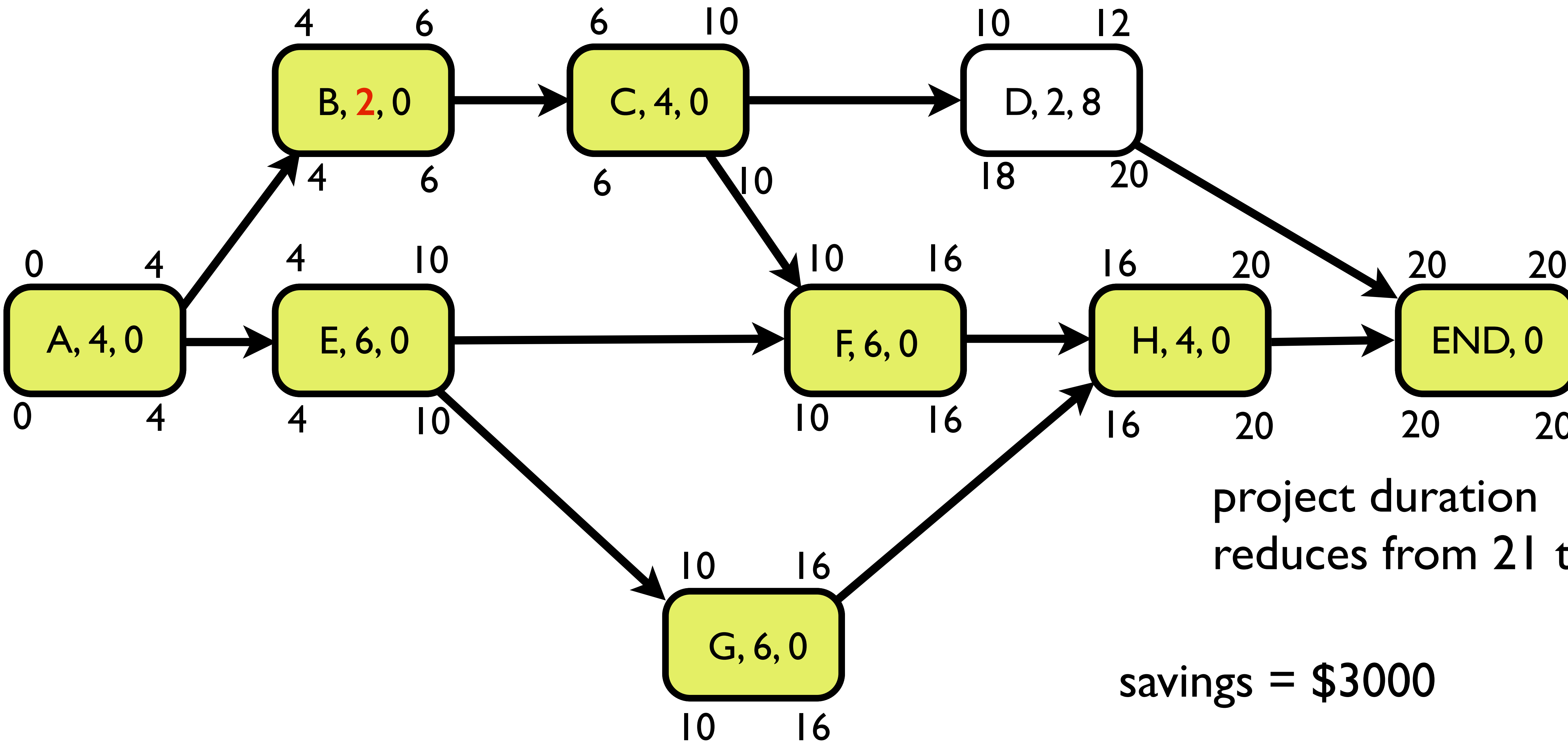
project duration reduces from 22 to 21

savings = $3000

expense = $2000

net savings = $1000

crash B: reduce its duration from 3 to 2



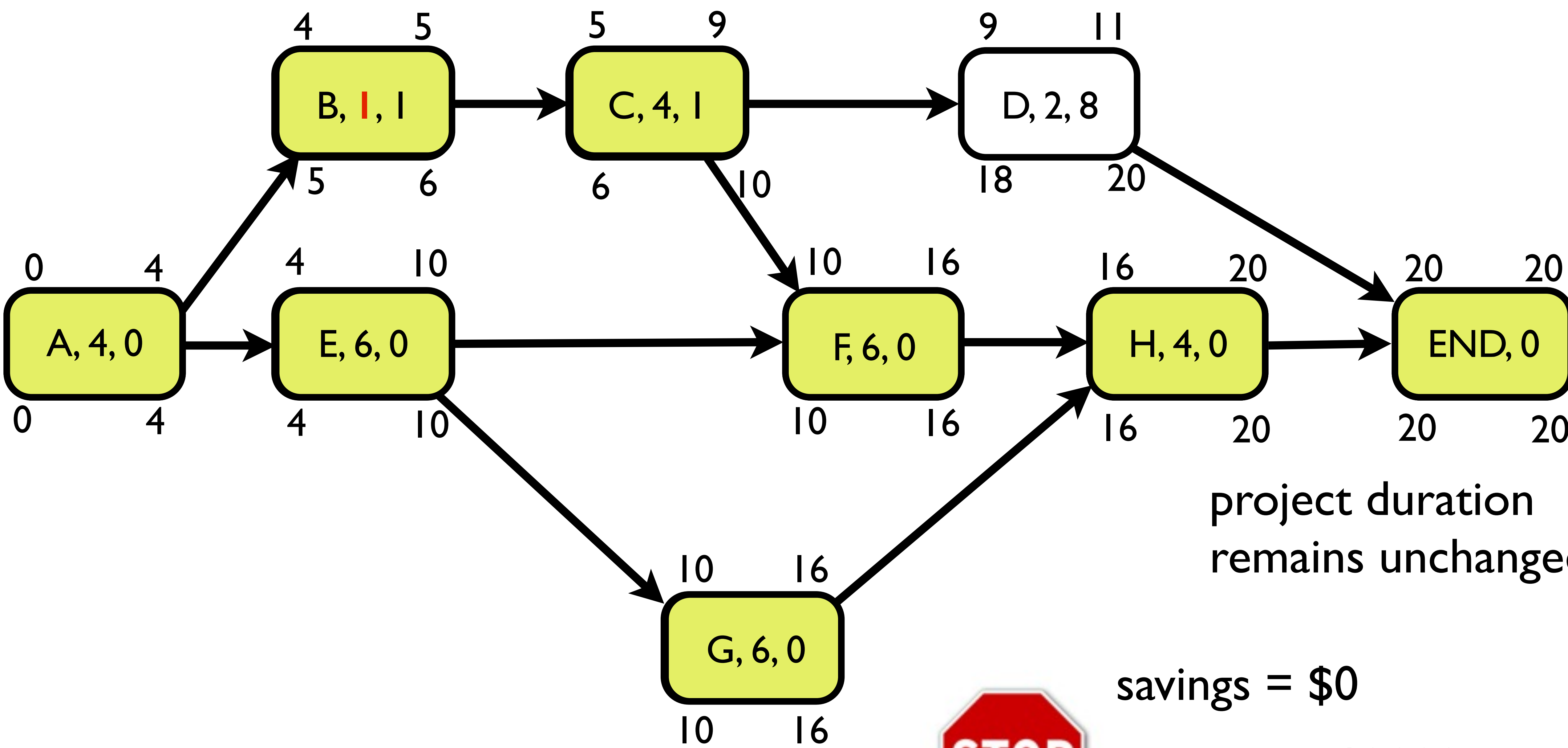
project duration
reduces from 21 to 20

savings = $3000

expense = $2000

net savings = $1000

crash B: reduce its duration from 2 to 1



project duration
remains unchanged

savings = $0

expense = $2000

net loss = $2000

Why do we adjust schedule/resources?

- Impact of project pressures (e.g., schedule pressure) on developers' actions/ decisions

- Project behind schedule:
  Developers work longer hours
  Concentrate only on essential tasks

- Barry Boehm found number of staff-hours devoted to project increased by 100%

- Schedule pressure affects Productivity
  Schedule pressure => increased error rate
  => rework on project: negative effect

- People under schedule pressure work faster; not better … diminished software quality results