CPM Inputs and Outputs

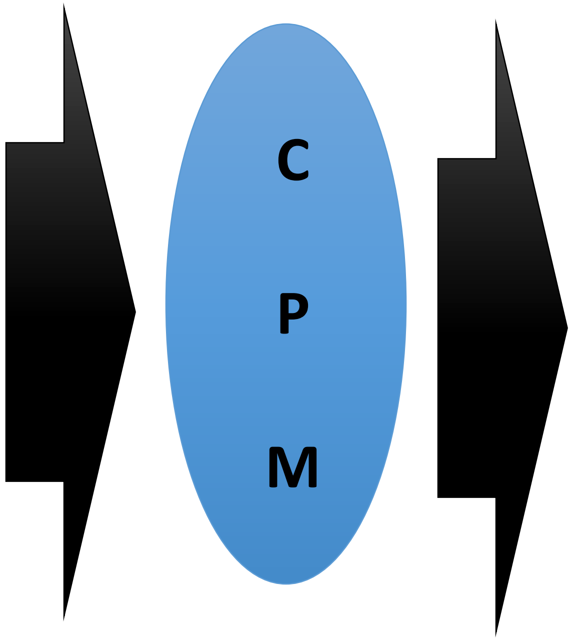
INPUTS

From Planning I:

- **Activities**
- **Relationships**
- **Network Representation**

From Planning II:

- **Durations**
- **Resources**



OUTPUTS

Start and Finish dates

Early and Late times

Critical Activities

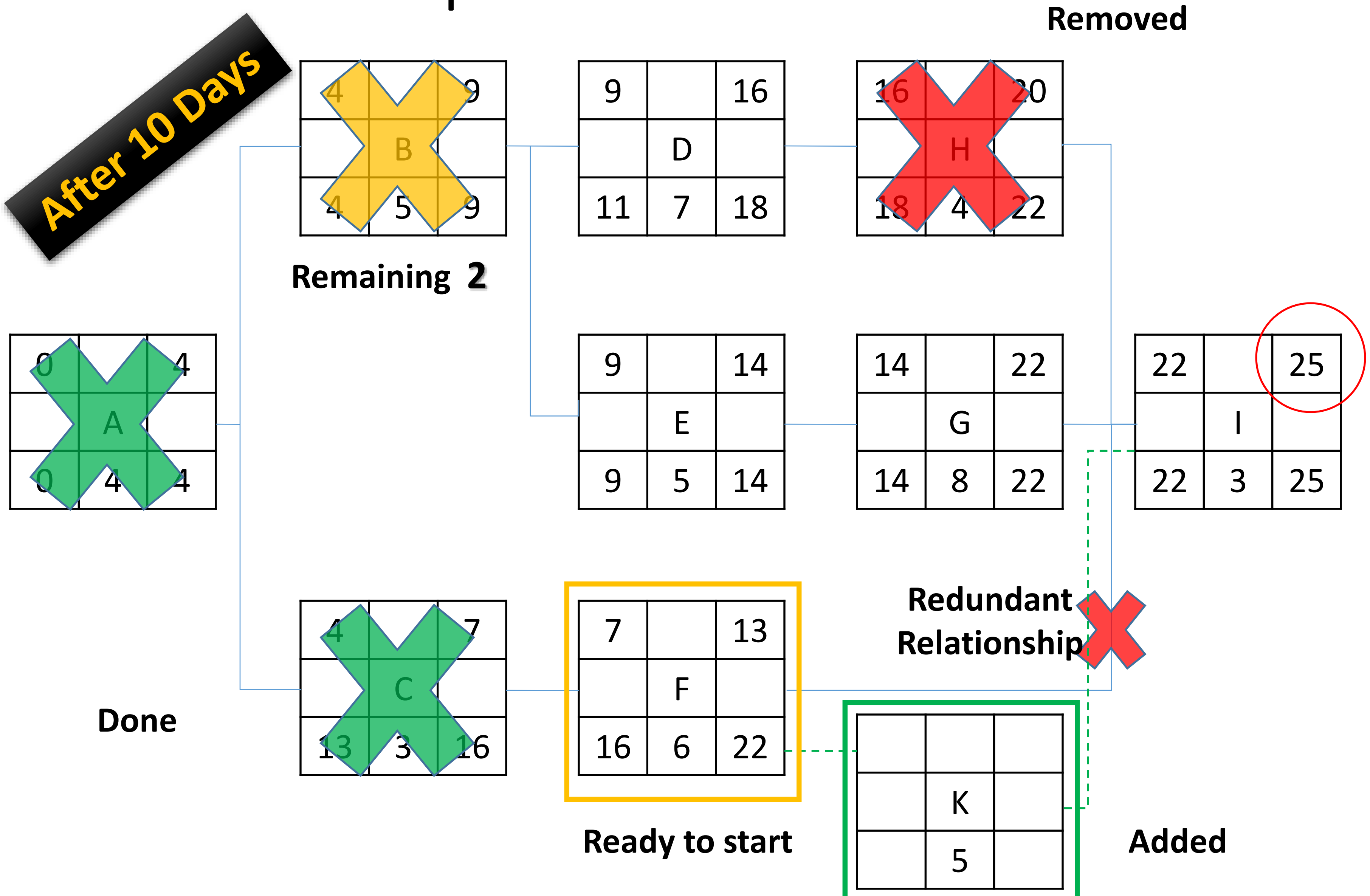
Project Duration

Bar chart (based on schedule)

Resource Histograms (Usage)

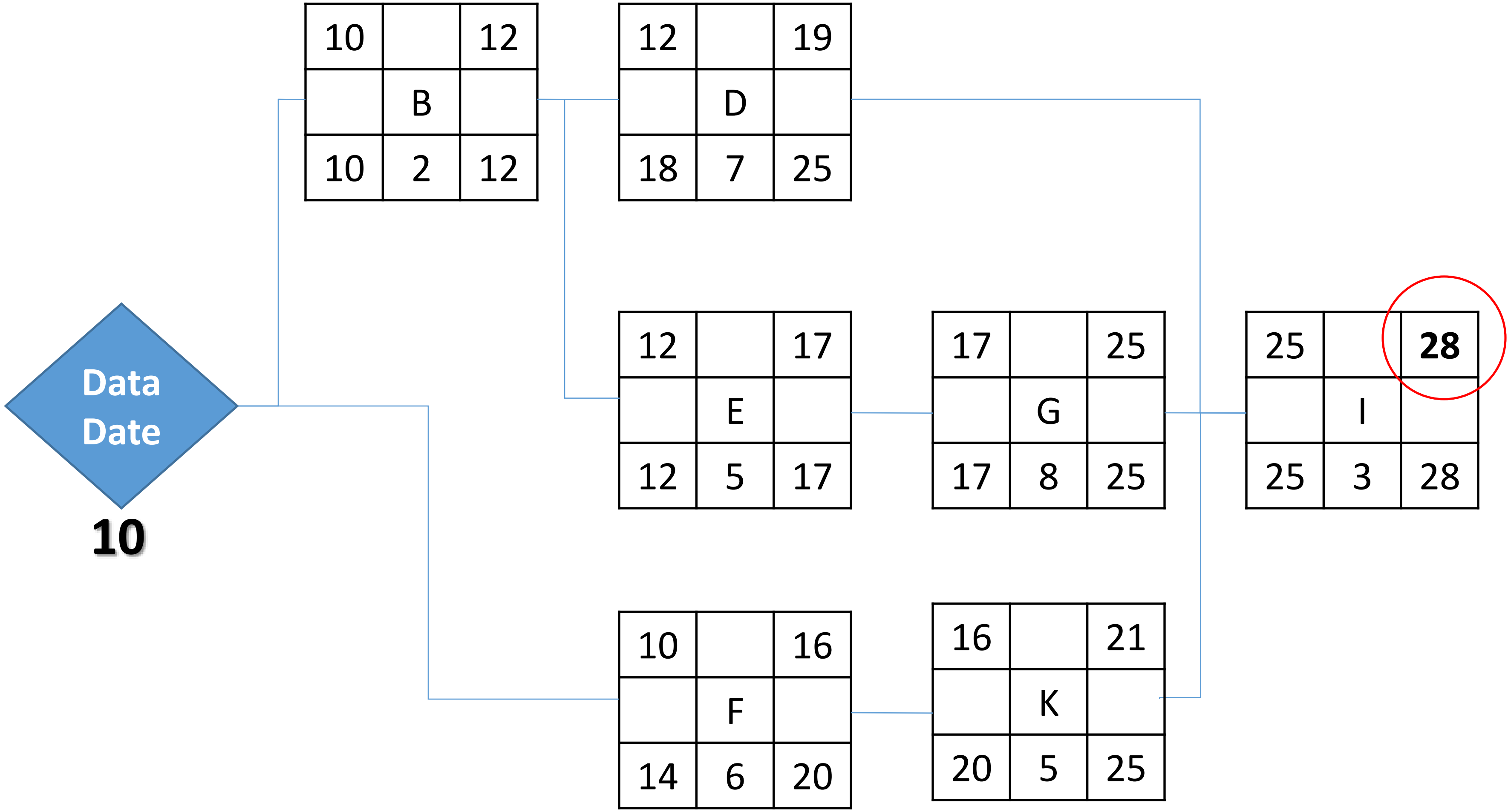
What about Deadline ???

The schedule update



Example

How to go back to 25 ???



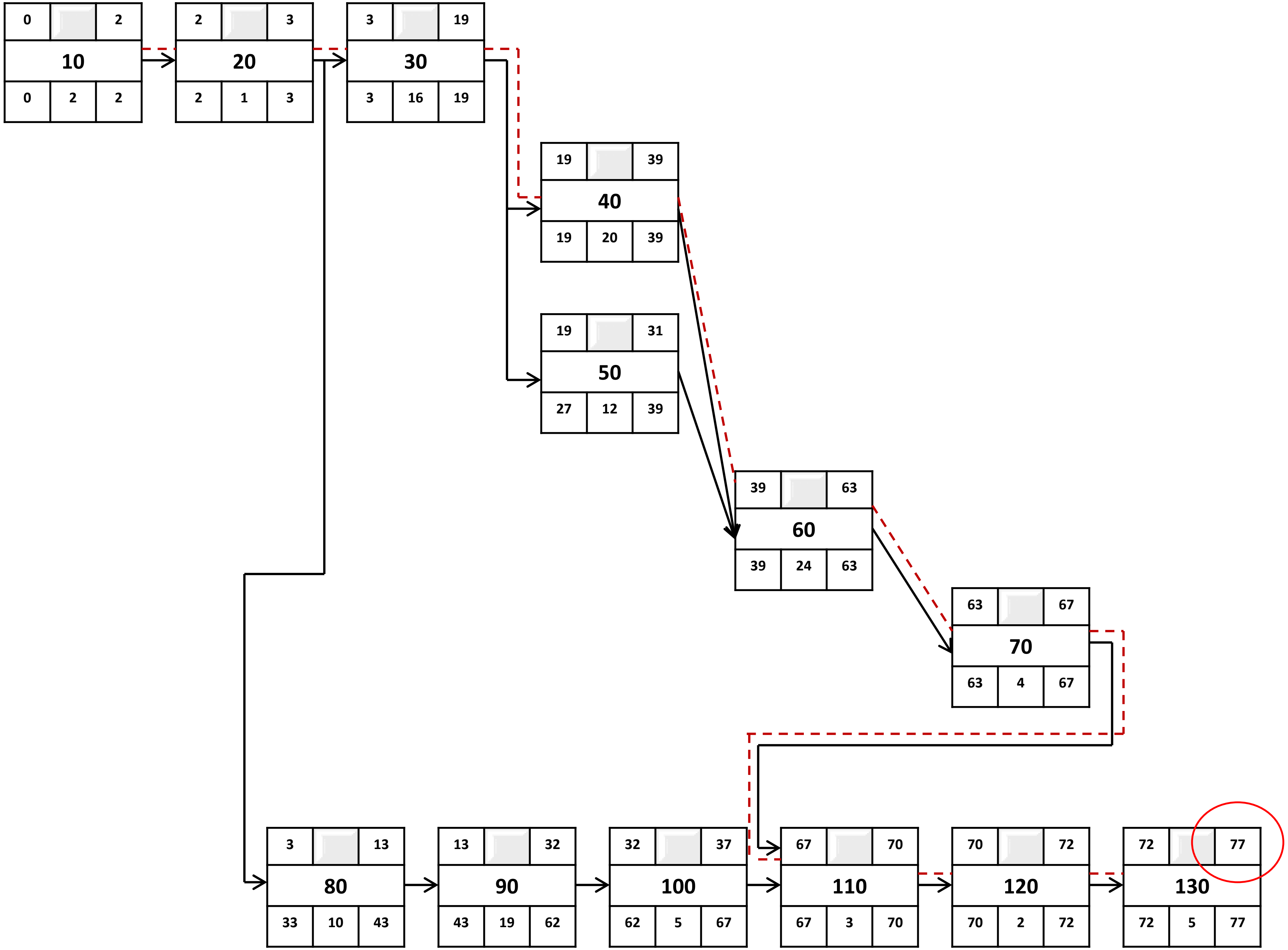
Two ways to reduce duration

- Further breakdown of project work
- Use “**Crashing”** or Time-Cost-Tradeoff **“TCT”**

More Breakdown of Work <u>Example</u>

A 4-Km pipeline and control room project

No.	Activity Name	Duration	Preceding
10	Move in	2	-
20	Survey & General Layout	1	10
30	Locate & Clear (4 KM)	16	20
40	Excavate (4 KM)	20	30
50	Prepare Pipes for (4 KM)	12	30
60	Lay Pipes for (4 KM)	24	40, 50
70	Local Test for (4 KM)	4	60
80	Foundation for Control Room	10	20
90	Finishing Control Room	19	80
100	Installing Control Equipment	5	90
110	Testing Control with Pipe Line	3	70, 100
120	Clean up	2	110
130	Contingency	5	120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3 16 19
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39 24 63
63 67
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63 4 67
3 13
80
33 10 43
13 32
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32 37
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62 5 67
67 70
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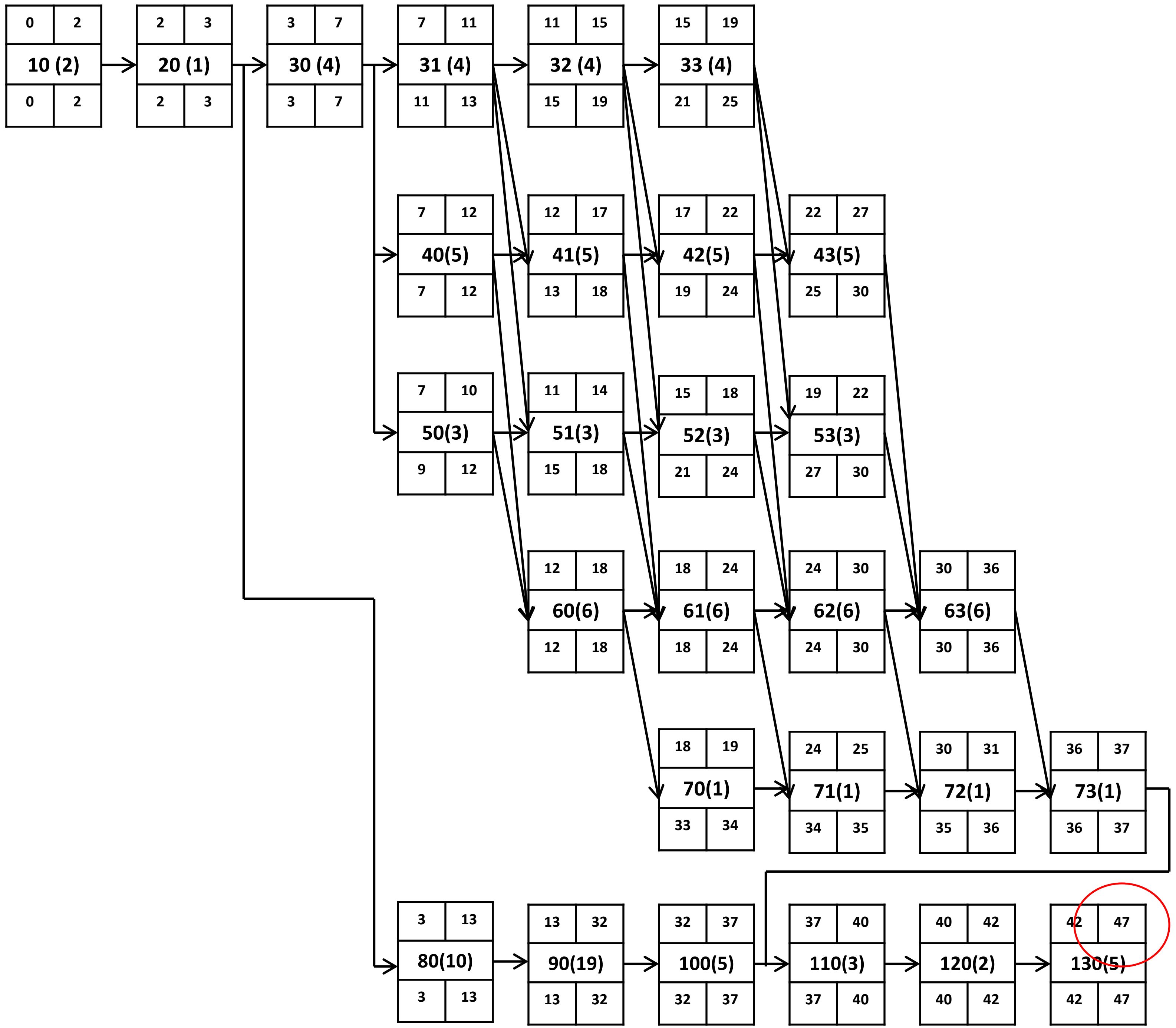
67 3 70
70 72
120
70 2 72
72 77
130
72 5 77



0 2 10 (2) 0 2
2 3 20 (1) 2 3
3 7 30 (4) 3 7
7 11 31 (4) 11 13
11 15 32 (4) 15 19
15 19 33 (4) 21 25
7 12 40(5) 7 12
12 17 41(5) 13 18
17 22 42(5) 19 24
22 27 43(5) 25 30
7 10 50(3) 9 12
11 14 51(3) 15 18
15 18 52(3) 21 24
19 22 53(3) 27 30
12 18 60(6) 12 18
18 24 61(6) 18 24
24 30 62(6) 24 30
30 36 63(6) 30 36
18 19 70(1) 33 34
24 25 71(1) 34 35
30 31 72(1) 35 36
36 37 73(1) 36 37
3 13 80(10) 3 13
13 32 90(19) 13 32
32 37 100(5) 32 37
37 40 110(3) 37 40
40 42 120(2) 40 42
42 47 130(5) 42 47

Crashing and TCT

- **Both crashing and TCT deals with**

Shortening Project Duration

- **Crashing →** Try to reduce project time to reach a certain duration (deadline) and provides the corresponding (cost).

- **TCT →** Try to reduce project cost and provides the corresponding project duration (recommend duration).

Both follow same approach/procedure of buying time with minimum increase in cost

Crashing and TCT

- Activity time-cost relationship?

  Linear vs. Discrete

  (Cheap & Slow versus Fast & Expensive)

- Cost Slope for an activity?

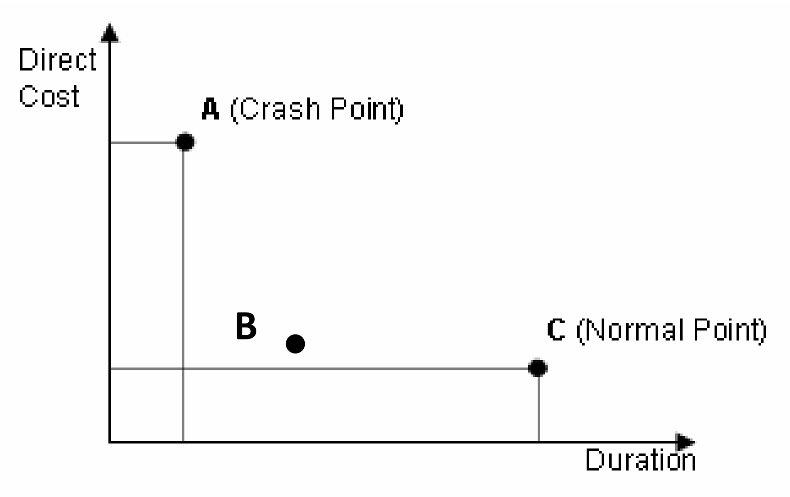
  How much extra cost is needed to reduce activity’s duration by one unit time (e.g., day)?

- Project time-cost relationship?

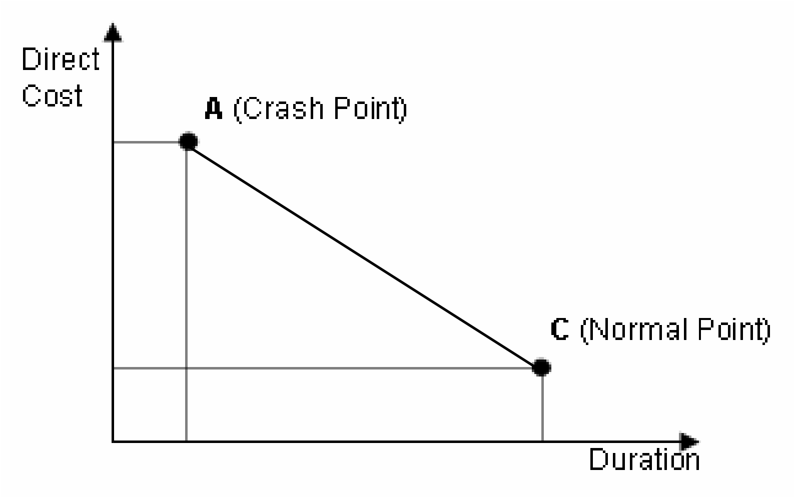
- Strategy to meet deadline?

Activity time-cost relationship

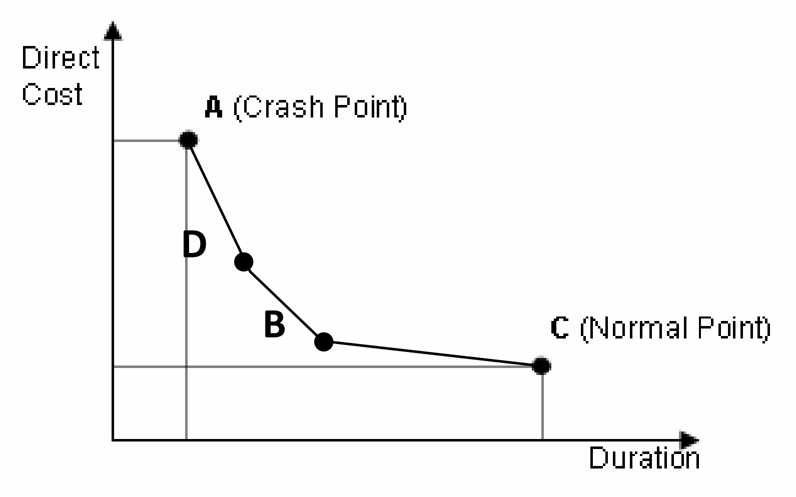
Cheap & Slow versus Fast & Expensive



Discrete



Linear



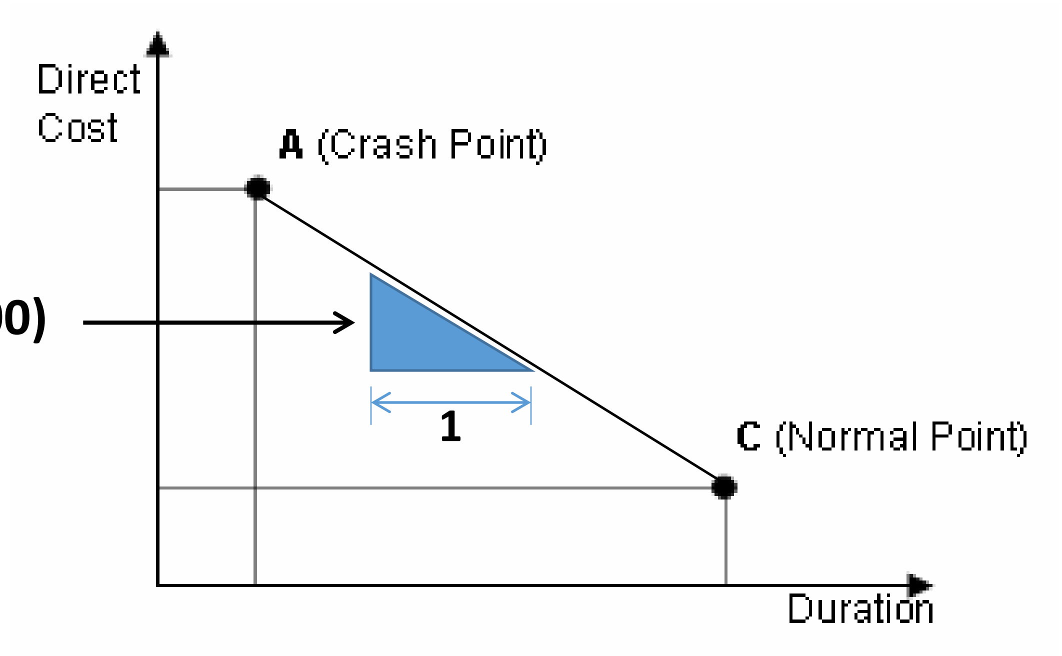
Curve linear

Activity (X)

Cost Slope

For Activity (X)

Cost slope (e.g.,$ 1000)



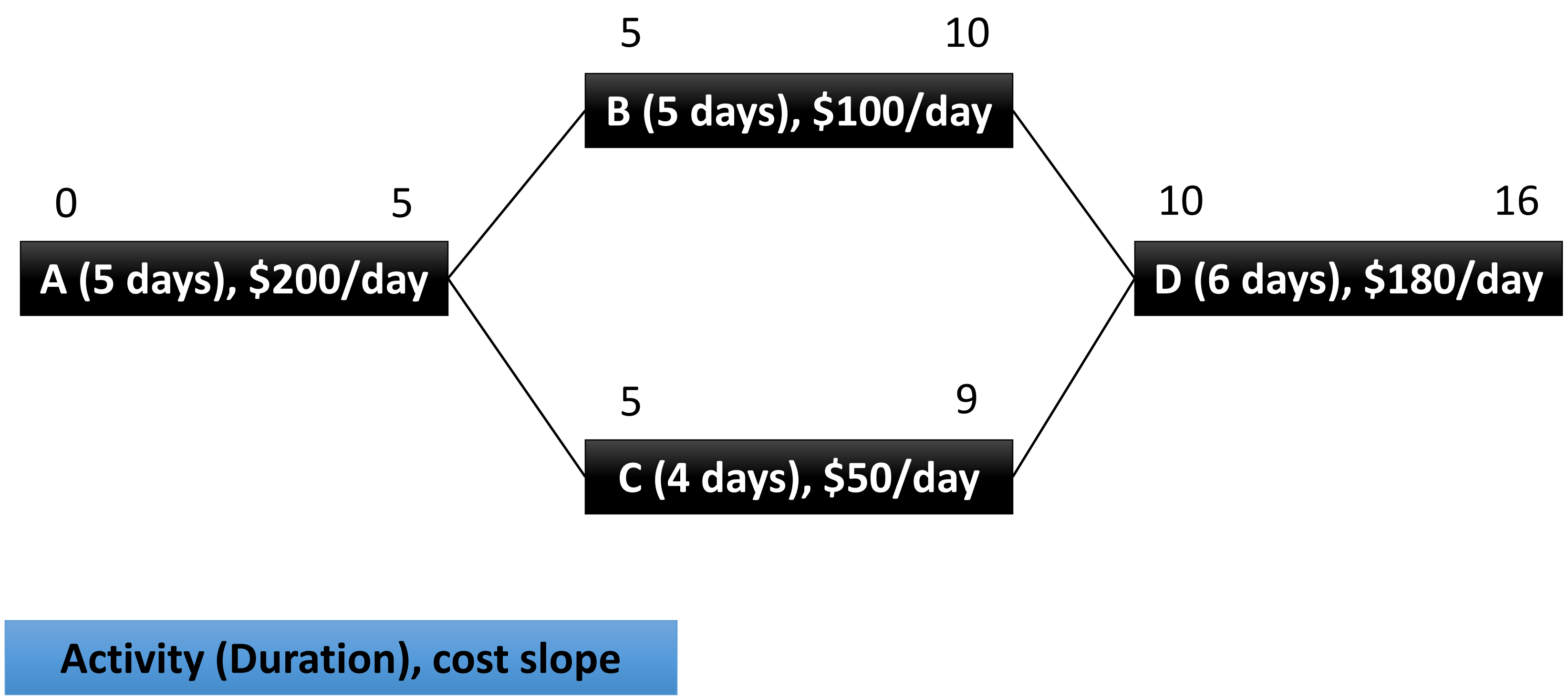
$$\textbf{Cost slope} = \frac{\text{(Crashed Cost – Normal Cost)}}{\text{(Normal Duration – Crashed Duration)}}$$

$/Unit time

From Activity to Project Level

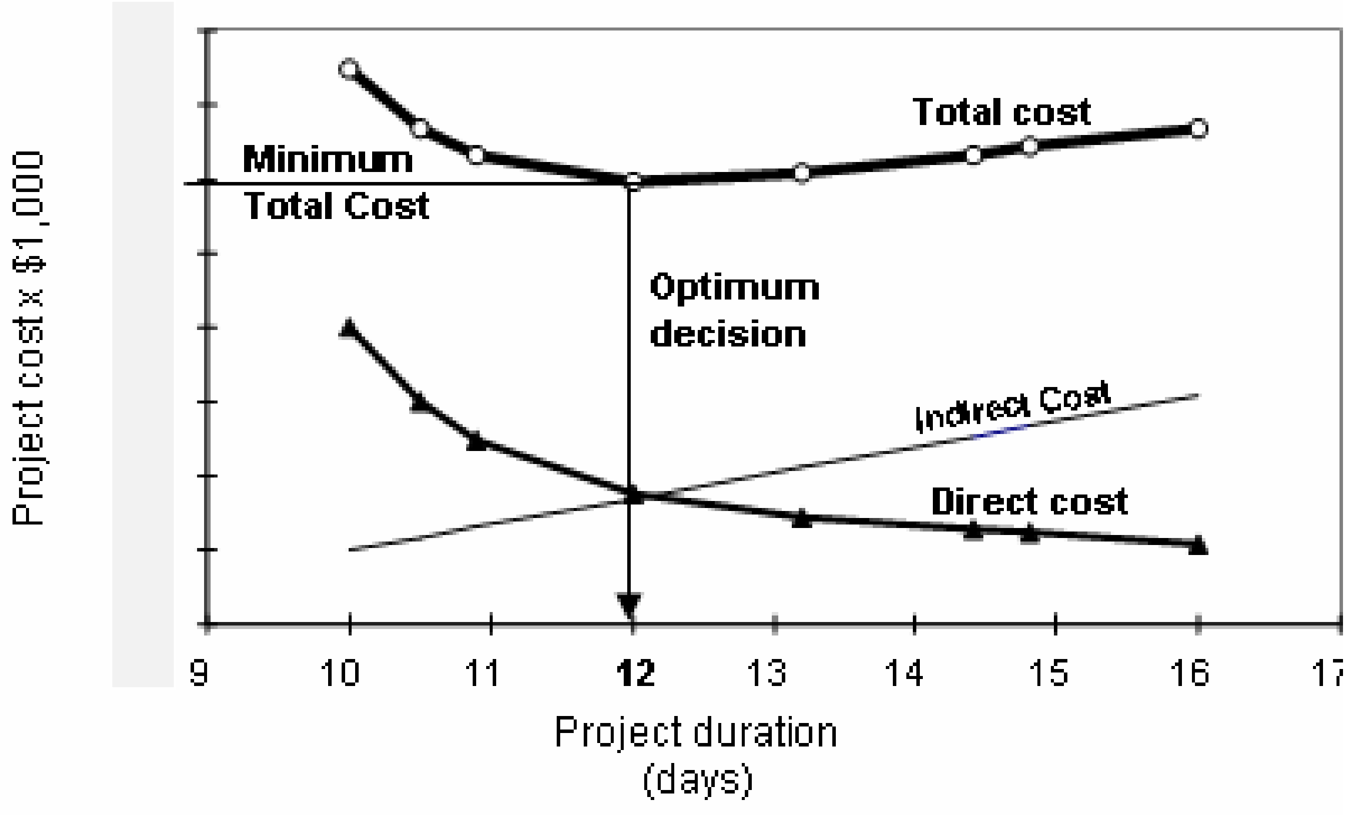
Project Time-Cost Relationship

Example 1: Durations and cost slopes are shown for the following network. We need to meet a 12-day deadline.



From Activity to Project Level

Project Time-Cost Relationship



Strategy to meet deadline

1. Search for critical activities as they control the project (use normal durations) ;
2. Calculate cost slope for critical activities;
3. Crash critical path at lowest cost by reducing the duration of its critical activities with least cost slope until its crashed duration is reached or until the critical path changes. (take care if multiple critical paths exists)
4. Calculate the cost increase due to crashing by multiplying the crashed time by corresponding cost slope.
5. Repeat steps (1 to 4) as many time needed either to reach the deadline or to see the whole time-cost relationship.

Example

The durations and direct costs for each activity in the network of a small construction contract under both normal and crash conditions are given in the table (in the next slide). Establish the least cost for expediting the contract. Determine the optimum duration of the contract assuming the indirect cost is LE 125/day.

Example

No.	Preceding	Normal		Crashed	
		Duration (days)	Direct Cost (LE)	Duration (days)	Direct Cost (LE)
A	-	12	7000	10	7200
B	A	8	5000	6	5300
C	A	15	4000	12	4600
D	B	23	5000	23	5000
E	B	5	1000	4	1050
F	C	5	3000	4	3300
G	E,C	20	6000	15	6300
H	F	13	2500	11	2580
I	D,G,H	12	3000	10	3150

Example

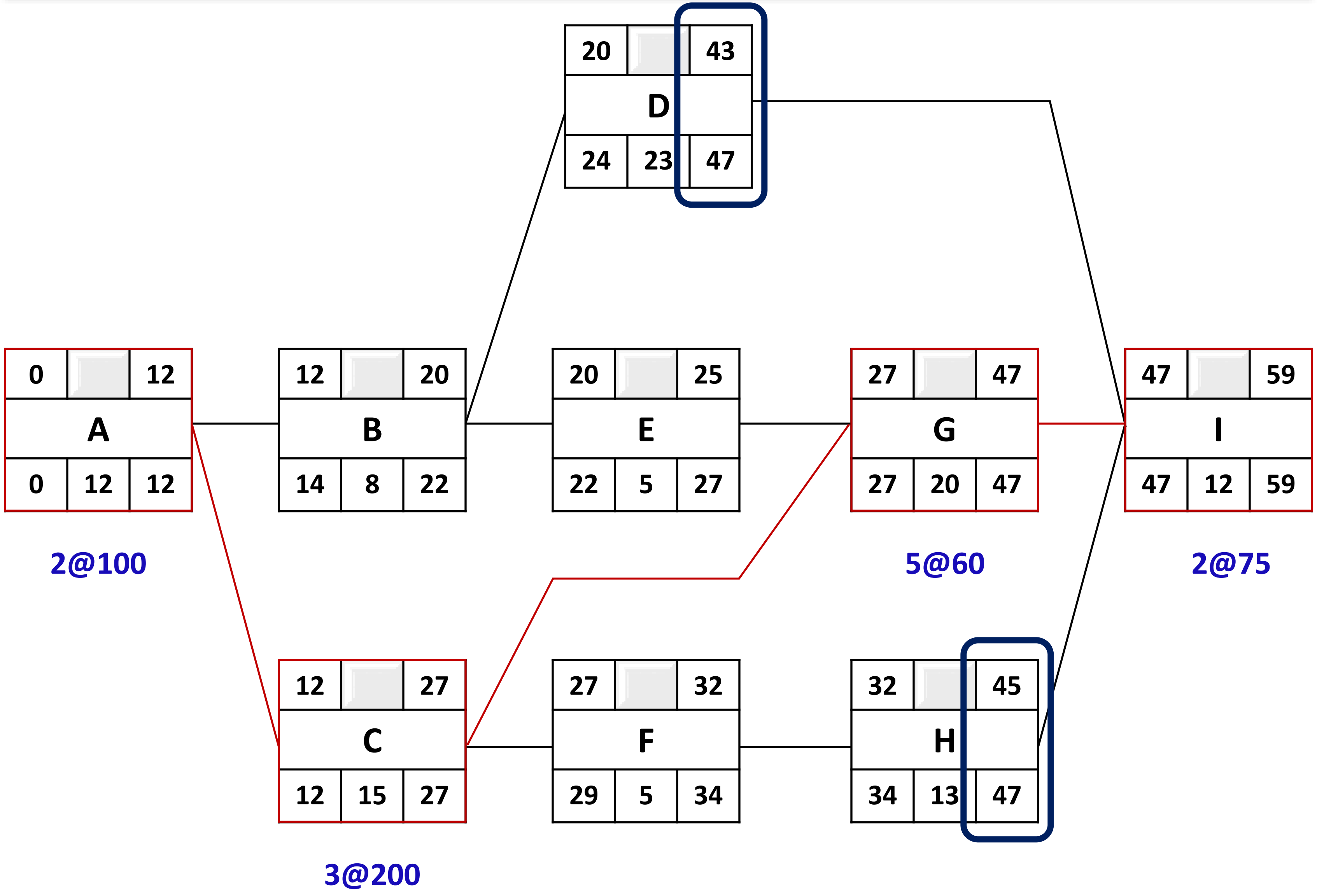
No.	Preceding	Normal		Crashed		Cost Slope	Allowable crash time
		Duration (days)	Direct Cost (LE)	Duration (days)	Direct Cost (LE)		
A	-	12	7000	10	7200	**100**	**2**
B	A	8	5000	6	5300	**150**	**2**
C	A	15	4000	12	4600	**200**	**3**
D	B	23	5000	23	5000	-	-
E	B	5	1000	4	1050	**50**	**1**
F	C	5	3000	4	3300	**300**	**1**
G	E,C	20	6000	15	6300	**60**	**5**
H	F	13	2500	11	2580	**40**	**2**
I	D,G,H	12	3000	10	3150	**75**	**2**

36,500

1- Crash A, C, G, or I   (why?)

2- Select G (why?)

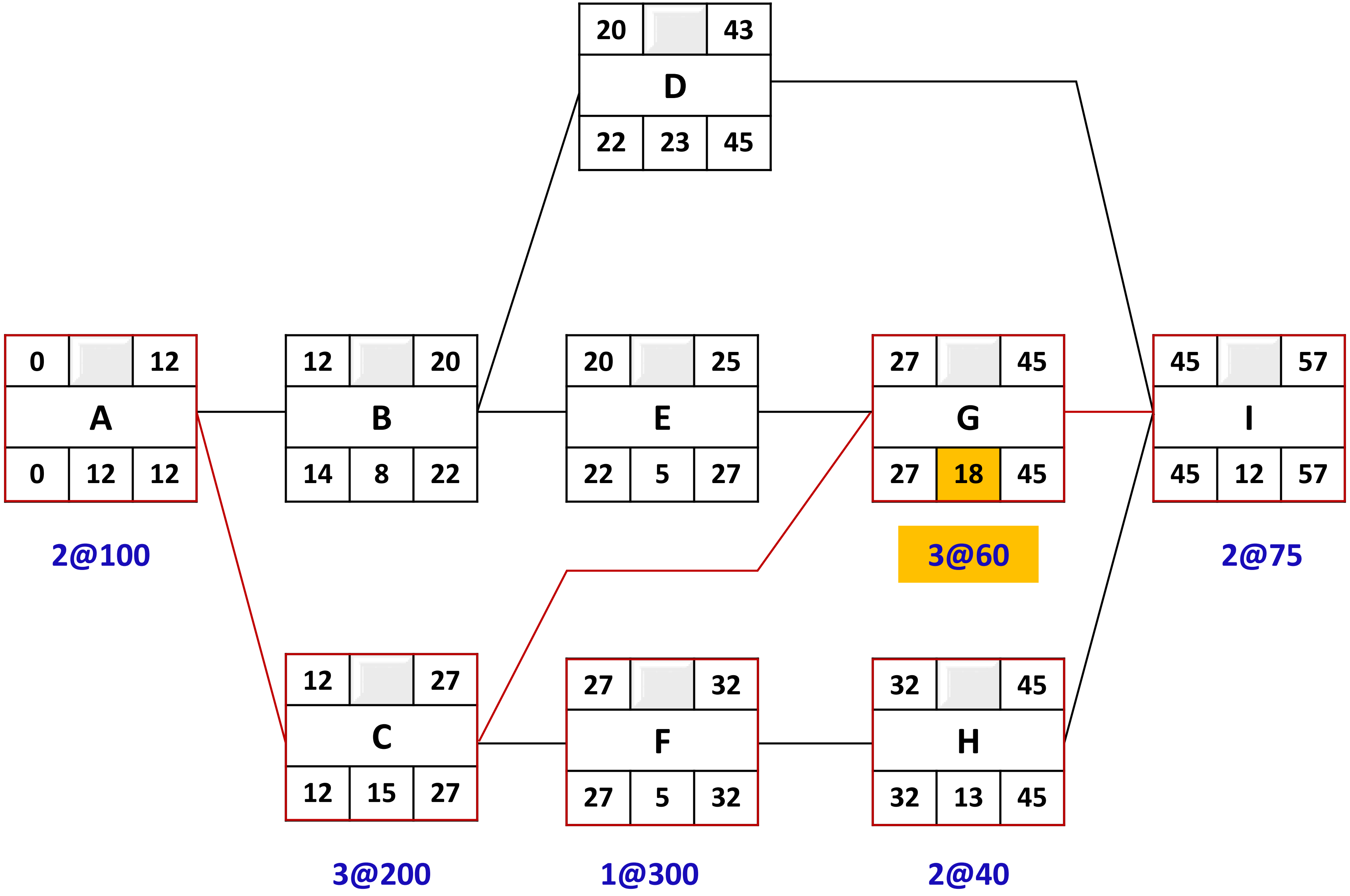
3- Crash G by only 2 days not 5 (why?)



Summary of results

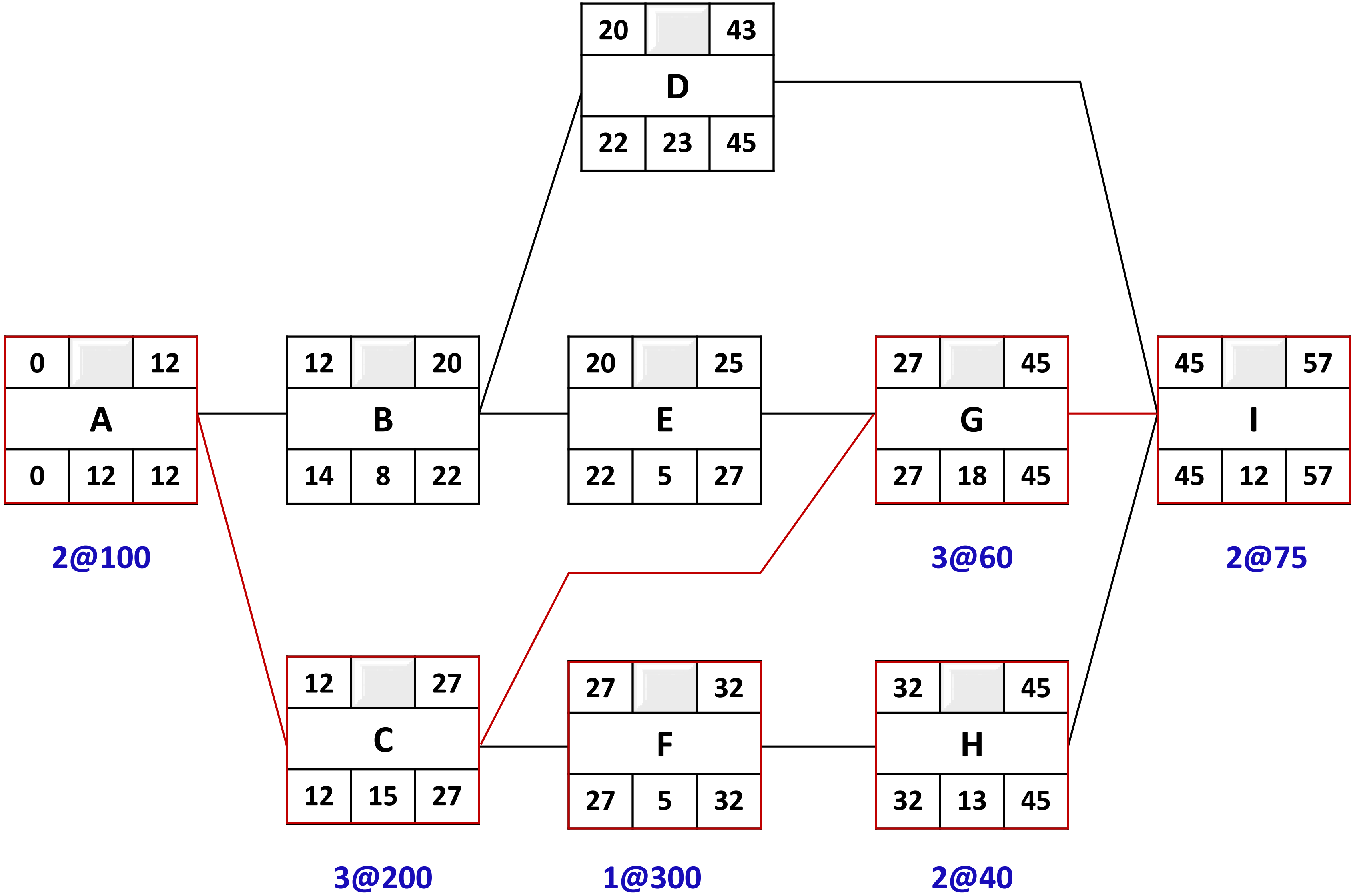
cycle	Proj. Dur.	Proj. direct Cost	Proj. indirect Cost	Total Cost	Critical path(s) to be crashed	Activit(ies) to be crashed	Crashing time	Extra direct cost
0	**59**	**36,500**	**59x125**	**43,875**	ACGI	G	2	2x60 =120
1	57	36,620	57x125	43,745				

Update the schedule



1- Crash path ACGI concurrently with path ACFHI (why?)

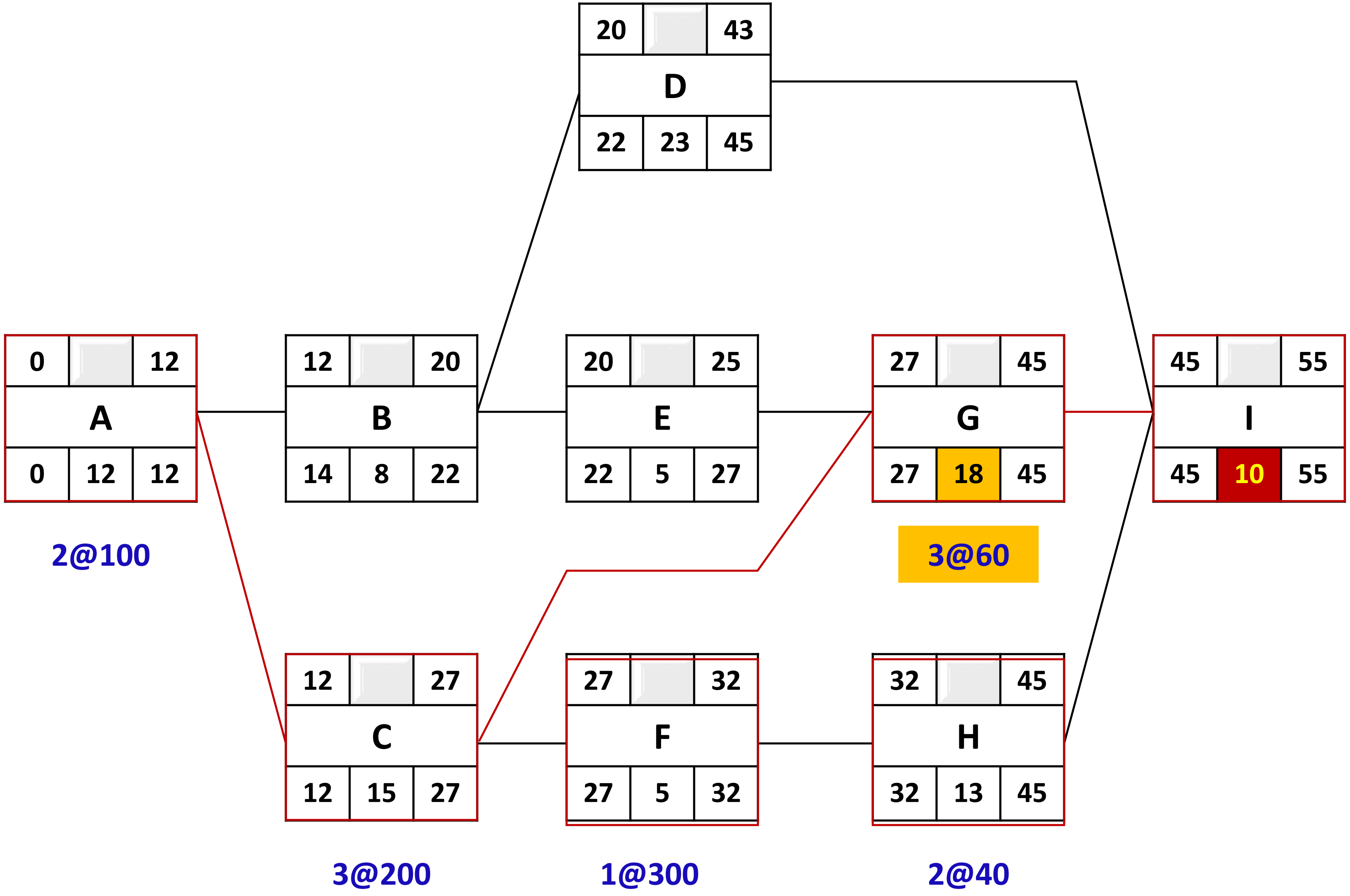
2- Select I (why?) and crash it by 2 days (why?)



Summary of results

cycle	Proj. Dur.	Proj. direct Cost	Proj. indirect Cost	Total Cost	Critical path(s) to be crashed	Activit(ies) to be crashed	Crashing time	Extra direct cost
0	**59**	**36,500**	**59x125**	**43,875**	ACGI	G	2	2x60 =120
1	57	36,620	57x125	43,745	ACGI ACFHI	I	2	2x75=150
2	55	36,770	55x125	43,645				

Update the schedule

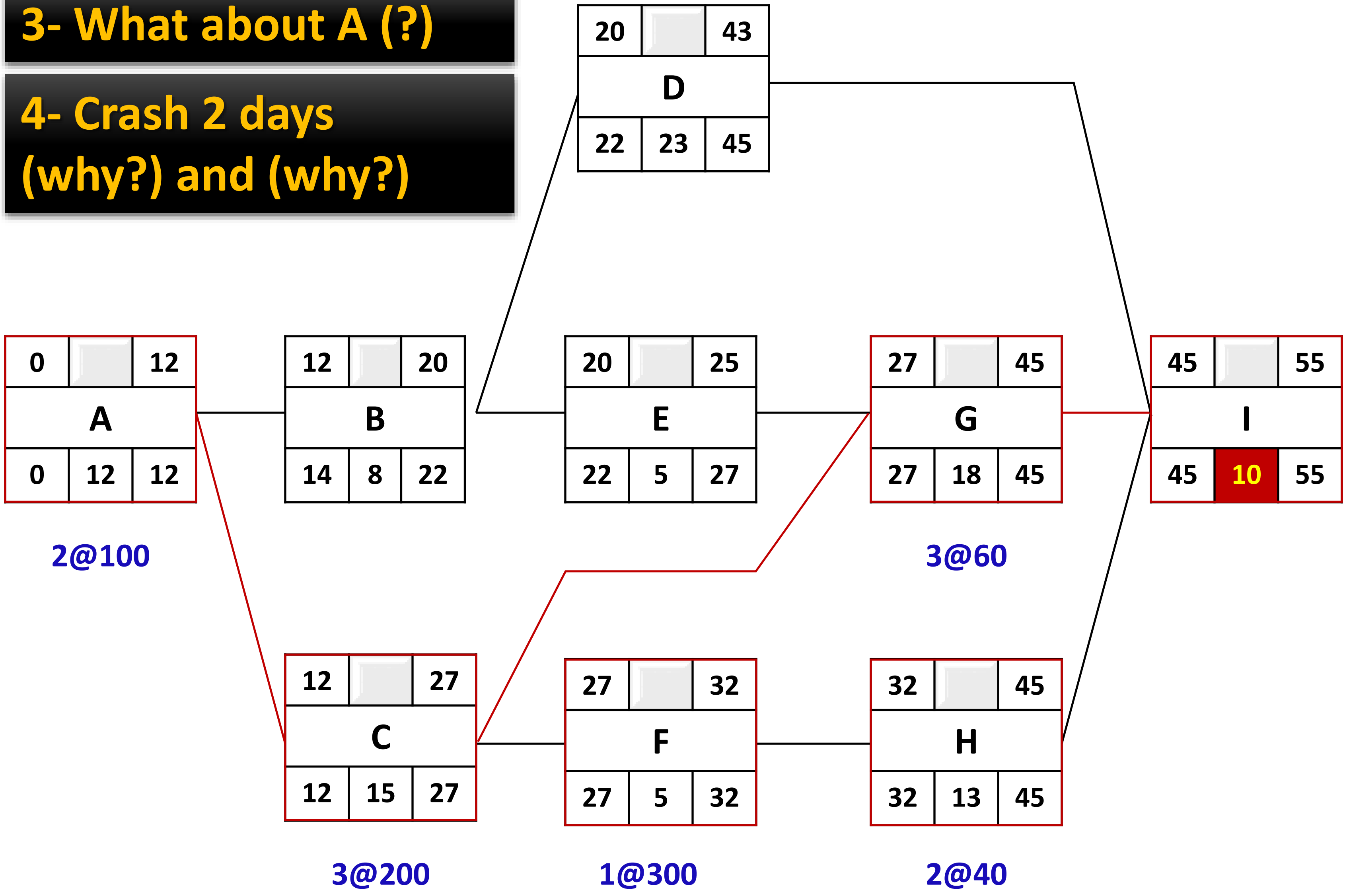


1- Crash path ACGI concurrently with path ACFHI

2- Select H from path ACFHI and G from path ACGI   (why?)

3- What about A (?)

4- Crash 2 days (why?) and (why?)



Summary of results

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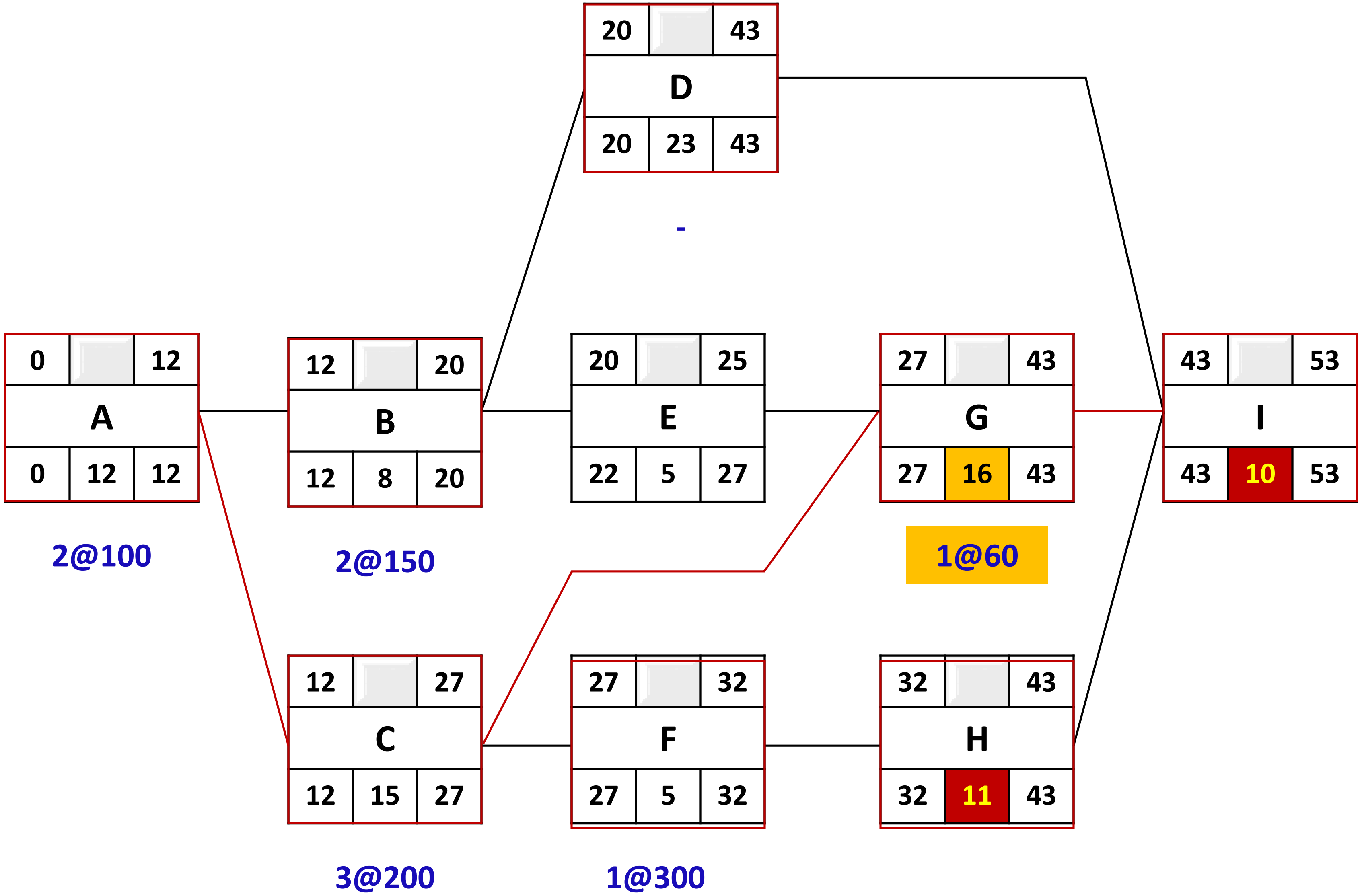
1	57	36,620	57x125	43,745	ACGI ACFHI	I	2	2x75=150
2	55	36,770	55x125	43,645	ACGI ACFHI	G H	2	2x60 + 2x40= 200
3	53	36,970	53x125	43,595				

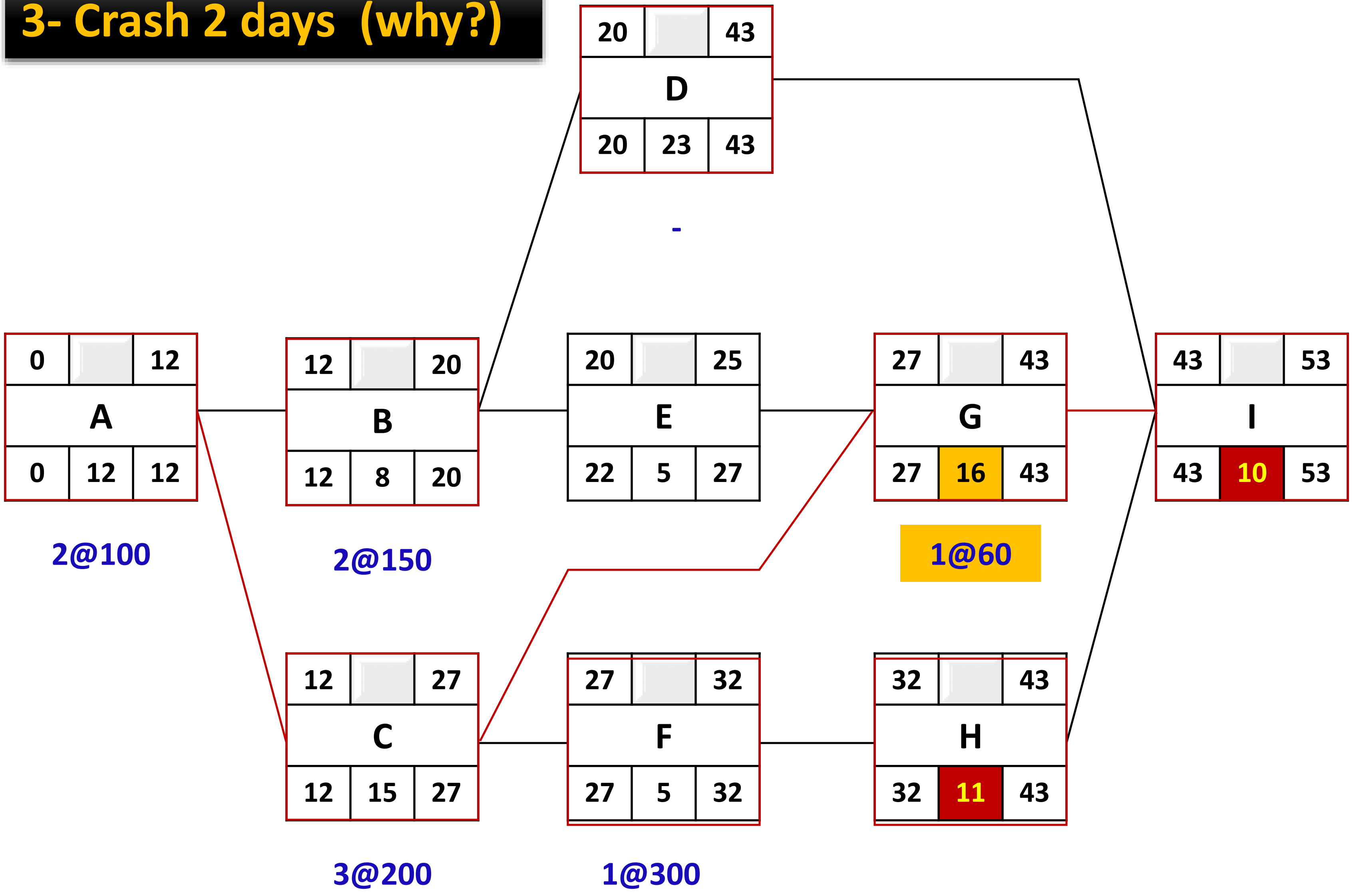
Update the schedule



1- Crash paths ACGI, ACFHI, and ABDI

2- Select A from path ACFHI, ACGI, & ABDI (why?)

3- Crash 2 days (why?)



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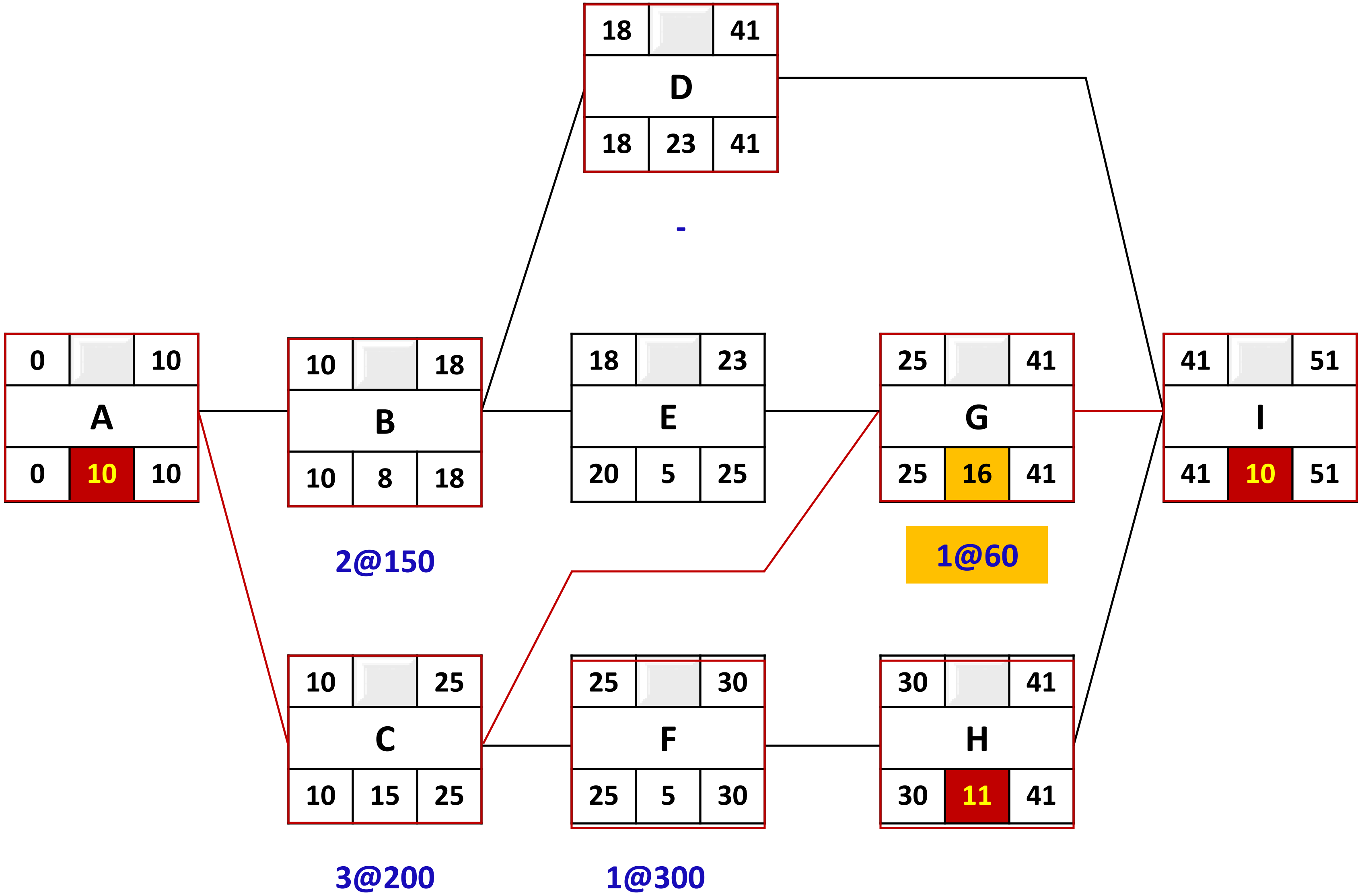
1	57	36,620	57x125	43,745	ACGI ACFHI	I	2	2x75=150
2	55	36,770	55x125	43,645	ACGI ACFHI	G H	2	2x60 + 2x40= 200
3	53	36,970	53x125	43,595	ACGI ACFHI ABDI	A	2	2x100=200
4	51	37,170	51x125	43,545				

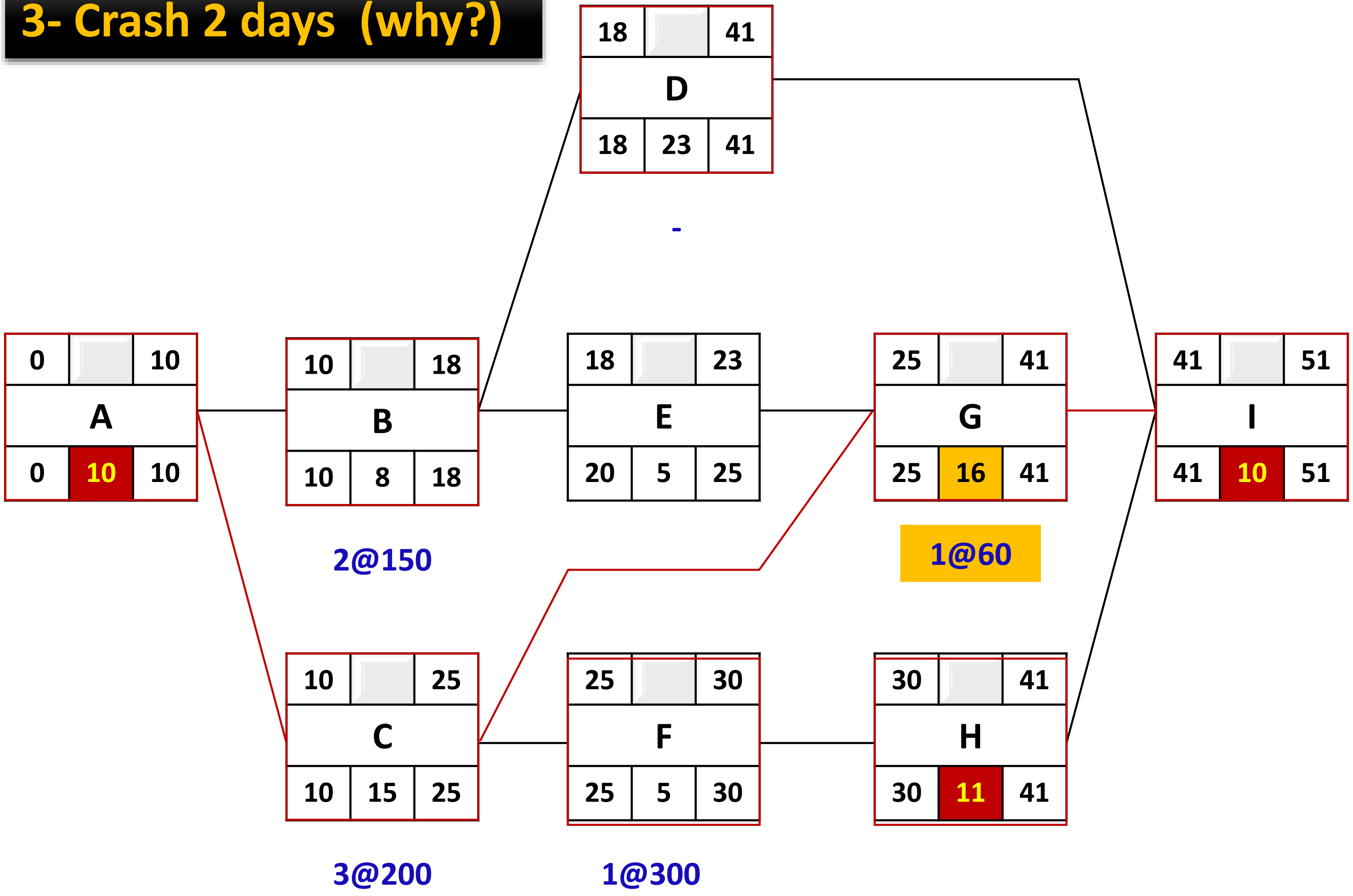
Update the schedule



1- Crash paths ACGI, ACFHI, and ABDI

2- Select C from paths ACFHI and ACGI & B from ABDI (why?)

3- Crash 2 days (why?)



Summary of results

cycle	Proj. Dur.	Proj. direct Cost	Proj. indirect Cost	Total Cost	Critical path(s) to be crashed	Activit(ies) to be crashed	Crashing time	Extra direct cost
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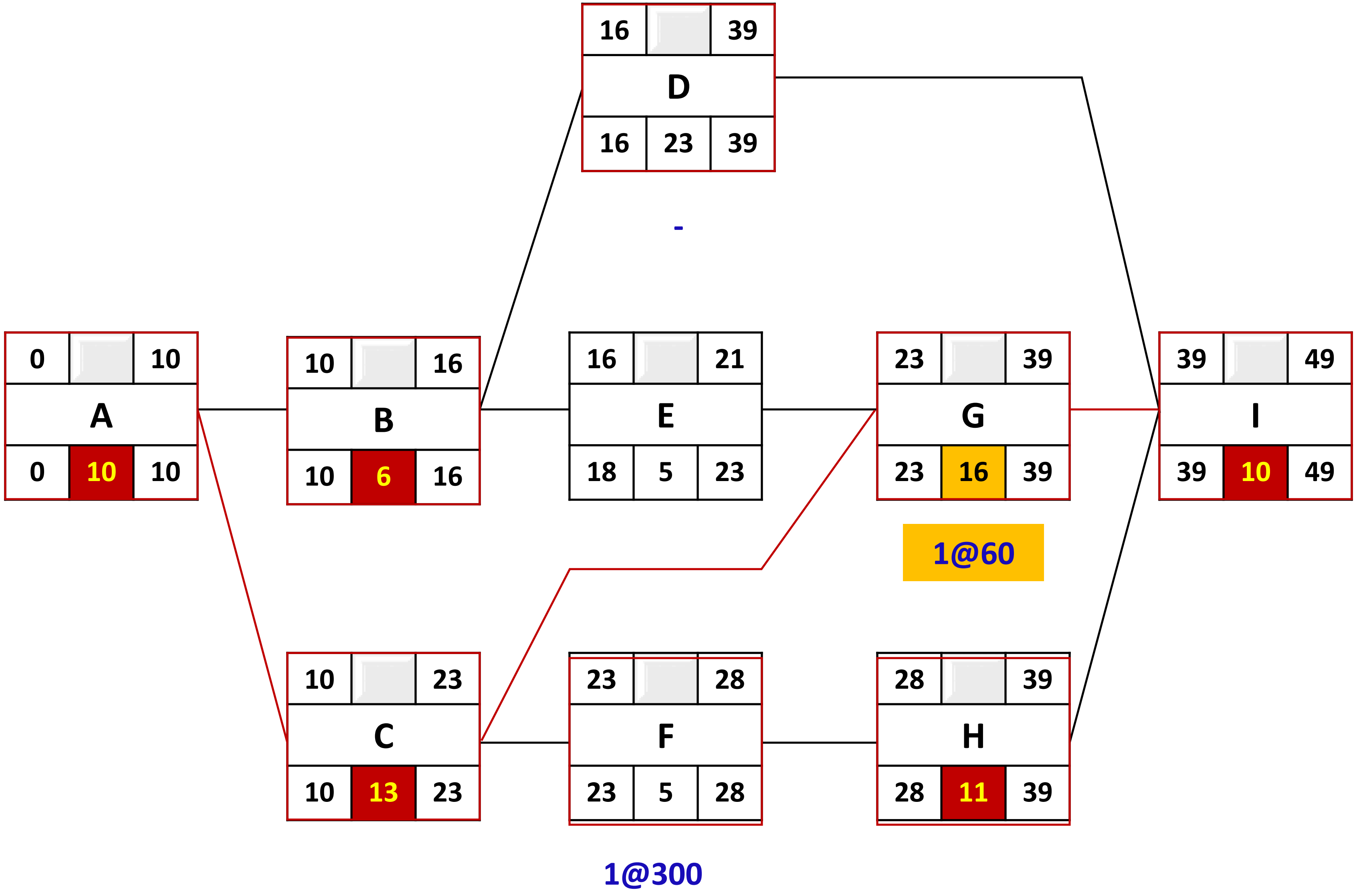
1	57	36,620	57x125	43,745	ACGI ACFHI	I	2	2x75=150
2	55	36,770	55x125	43,645	ACGI ACFHI	G H	2	2x60 + 2x40= 200
3	53	36,970	53x125	43,595	ACGI ACFHI ABDI	A	2	2x100=200
4	51	37,170	51x125	43,545	ACGI ACFHI ABDI	C B	2	2x200+ 2x150=700
5	49	37,870	49x125	**43,995**				

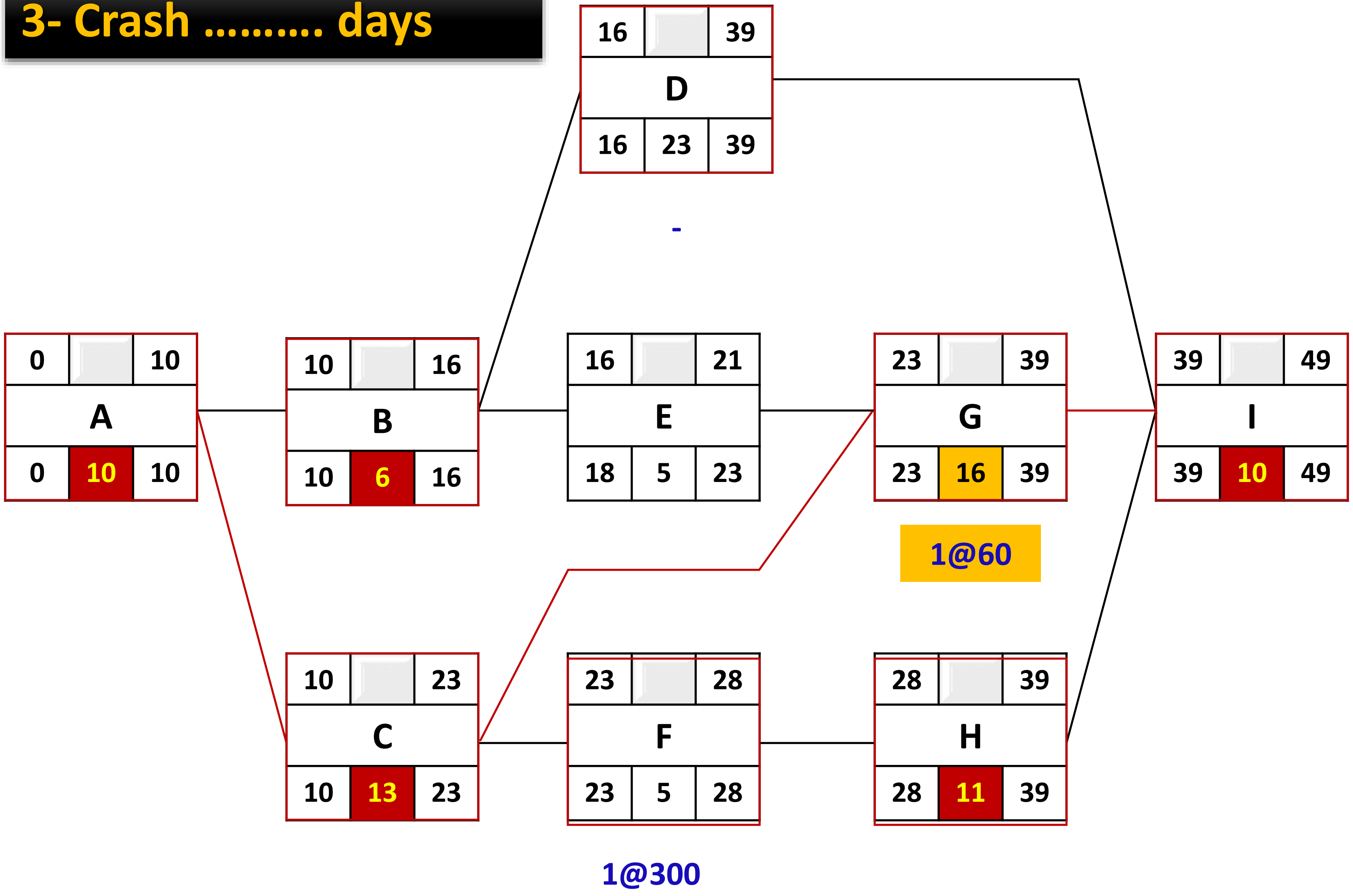
Update the schedule

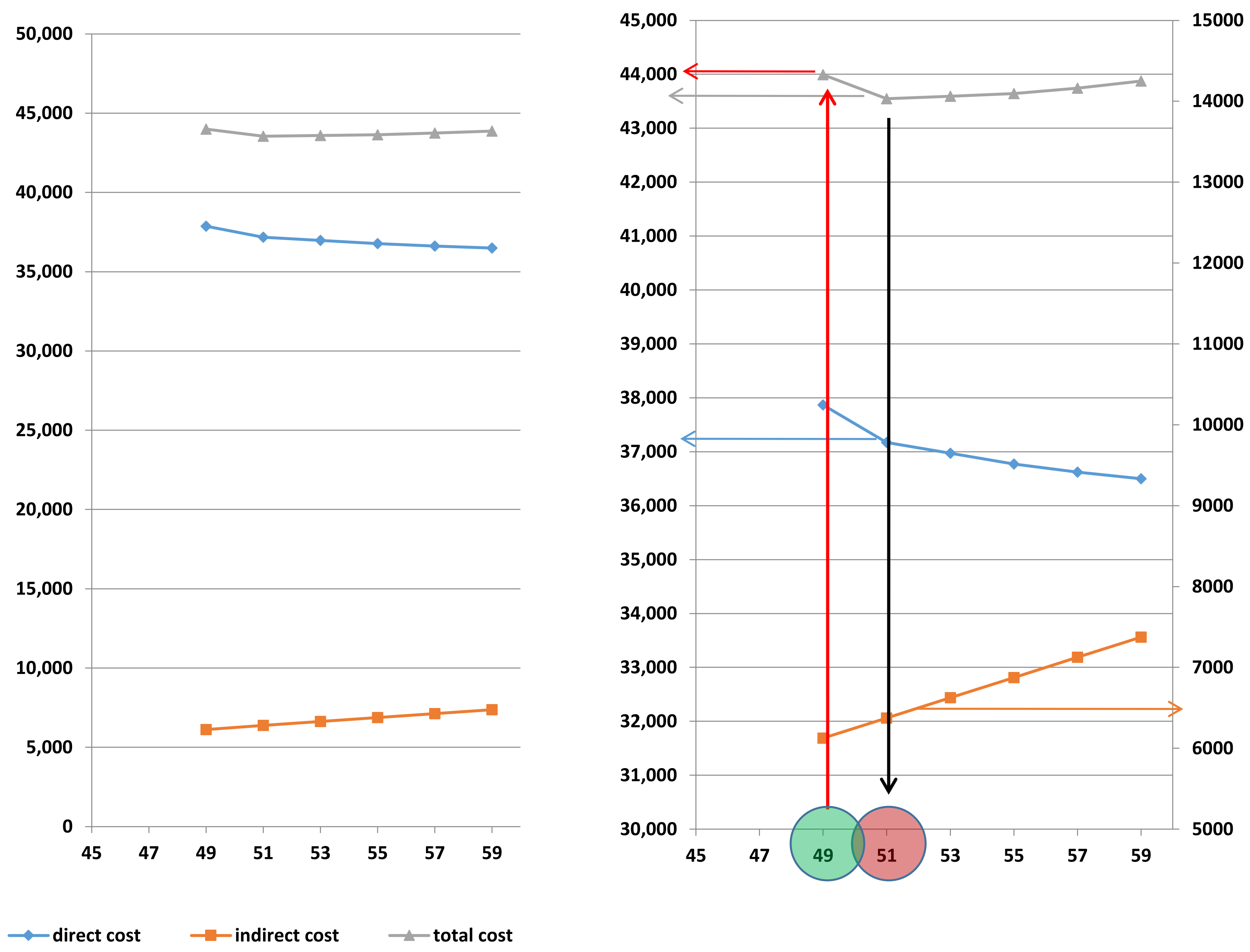


1- Crash paths ……………

2- Select activities ……………

3- Crash ………. days





50,000
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6000
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45 47 49 51 53 55 57 59
direct cost
indirect cost
total cost

Paths Method

A (100,2)	B (150,2)	D (-,-)	I(75,2)						
12	8	23	12			55	**55**		
A (100,2)	B (150,2)	E(50,1)	G(60,5)	I(75,2)					
12	8	5	~~20~~ **18**	12		~~57~~	**55**		
A(100,2)	C(200,3)	G(60,5)	I(75,2)						
12	15	~~20~~ **18**	12			~~59~~	**57**		
A(100,2)	C(200,3)	F(300,1)	H(40,2)	I(75)					
12	15	5	13	12		57	**57**		

Paths Method

A (100,2)	B (150,2)	D (-,-)	I(75,2)						
12	8	23	~~12~~ **10**			55	~~55~~	**53**	
A (100,2)	B (150,2)	E(50,1)	G(60,5)	I(75,2)					
12	8	5	~~20~~ **18**	~~12~~ **10**		57	~~55~~	**53**	
A(100,2)	C(200,3)	G(60,5)	I(75,2)						
12	15	~~20~~ **18**	~~12~~ **10**			59	~~57~~	**55**	
A(100,2)	C(200,3)	F(300,1)	H(40,2)	I(75)					
12	15	5	13	~~12~~ **10**		57	~~57~~	**55**	

- **CPM → determine activities ST & FN times→ Total Project Duration**
- **TCT → Change activities duration →change ST & FN times→ New Schedule that meet minimum cost**
- **Crashing → Change activities duration →change ST & FN times→ New Schedule that meet deadline**
- **Leveling → Delay activities → change ST & FN times → New Schedule meets available resources**
- **Smoothing → Delay non-critical activities → change ST & FN times → New Schedule with better resource distribution (less fluctuation)**

They are all <u>SCHEDULING</u> techniques