Line balancing

San Aziz

2018-12-18

MÄLARDALEN UNIVERSITY
SWEDEN

What is line balancing?

What is line balancing?

- When we balance a line, we devide the work elements into workstations.
- The goal is to achieve the output with the minimal number of workstations.
- Two techniques for line balancing
  - RPW (Ranked Positional Weight).
  - Largest work-element time rule.

MÄLARDALEN UNIVERSITY
SWEDEN

RPW (Ranked Positional Weight)

RPW (Ranked Positional Weight).

RPW (Ranked Positional Weight)

- Ranked Positional Weight indicate how important a work-element is. Large RPW means high important.
- The work element with the largest RPW will be in the first workstation.
- The work element with next largest RPW will be in the earliest possible workstation, as long as:
  - The maximum cycle time for the line is not exceed in the workstation.
  - All the work element´s previous work elements are in the same or earlier workstations.

Work element	Time	RPW
A	40	244
B	30	96
C	50	108
D	40	60
E	6	26
F	25	43
G	15	33
H	20	20
I	18	18

MÄLARDALEN UNIVERSITY
SWEDEN

Largest work-element time rule

Largest work-element time rule

Largest work-element time rule

- Same process as RPW, but instead of choosing the work element with the largest RPW, we choose the work element with the largest time.

Work element	Time	RPW
A	40	244
B	30	96
C	50	108
D	40	60
E	6	26
F	25	43
G	15	33
H	20	20
I	18	18

- As long as all the work element´s previous work elements are in the same or earlier workstations and the maximum cycle time for the line is not exceed in the workstation.

MÄLARDALEN UNIVERSITY
SWEDEN

Steps to follow for line balancing

Process for line balancing

Steps to follow when balancing a line

1. Construct a precedence diagram.
2. Calculate the cycle time for the line.
3. Calculate the theoretical minimum number of stations that the line consist of.
4. Use RPW or largest work-element time rule to devide the work elements into workstations.

MÄLARDALEN UNIVERSITY
SWEDEN

Example: Line balancing

Example: Line balancing

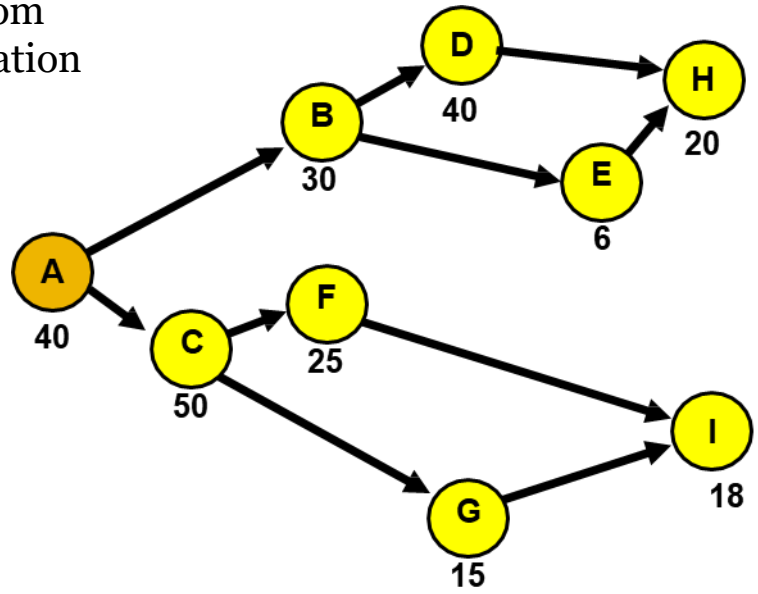
Find a line balancing solution for Green Grass Inc. Use the RPW technique

Work Element	Description	Time (sec)	Immediate Predecessor(s)
A	Bolt leg frame to hopper	40	None
B	Insert impeller shaft	30	A
C	Attach axle	50	A
D	Attach agitator	40	B
E	Attach drive wheel	6	B
F	Attach free wheel	25	C
G	Mount lower post	15	C
H	Attach controls	20	D, E
I	Mount nameplate	18	F, G
		Total 244	

Example: Line balancing

1. **Construct a precedence diagram.**

Precedence diagram from the example 2, presentation about Layout



Work Element	Description	Time (sec)	Immediate Predecessor(s)
A	Bolt leg frame to hopper	40	None
B	Insert impeller shaft	30	A
C	Attach axle	50	A
D	Attach agitator	40	B
E	Attach drive wheel	6	B
F	Attach free wheel	25	C
G	Mount lower post	15	C
H	Attach controls	20	D, E
I	Mount nameplate	18	F, G
		Total 244	

Example: Line balancing

2. **Calculate the cycle time for the line.**

Cycle time = 60 sec (from the example 2, presentation about Layout)

Example: Line balancing

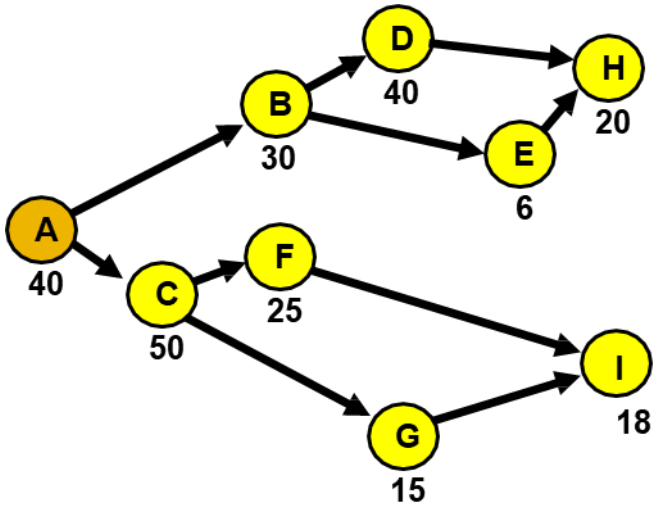
3. **Calculate the theoretical minimum number of stations that the line consist of.**

Theoretical minimum no of stations, TM = 5 (from the example 2, presentation about Layout)

Example: Line balancing

4. **Use RPW or largest work-element time rule to devide tasks into workstations.**

We use RPW. We have not RPW for the work elements, therefore we need to start by calculating RPW for all work elements.

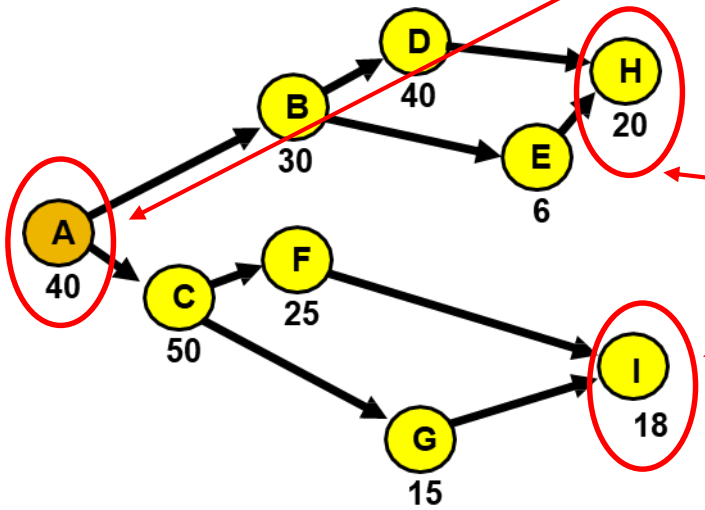


Work Element	Description	Time (sec)	Immediate Predecessor(s)
A	Bolt leg frame to hopper	40	None
B	Insert impeller shaft	30	A
C	Attach axle	50	A
D	Attach agitator	40	B
E	Attach drive wheel	6	B
F	Attach free wheel	25	C
G	Mount lower post	15	C
H	Attach controls	20	D, E
I	Mount nameplate	18	F, G
		Total 244	

Example: Line balancing

4. **Use RPW or largest work-element time rule to devide tasks into workstations.**

We use RPW. We start by calculating RPW for all work elements.



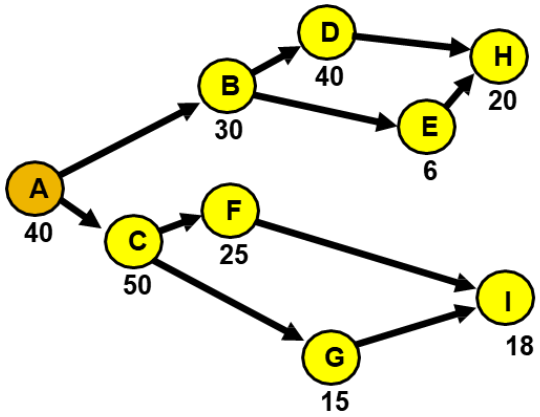
Example: RPW for the work element A will be the sum of all work elements that we need to perform before A, including the time for A. RPW for A = 244.

Example: RPW for I will be 18, because we do not need to perform any work elements before I. The same for the H. RWP for H will be 20.

Example: Line balancing

4. **Use RPW or largest work-element time rule to devide tasks into workstations.**

We use RPW. We start by calculating RPW for all work elements.

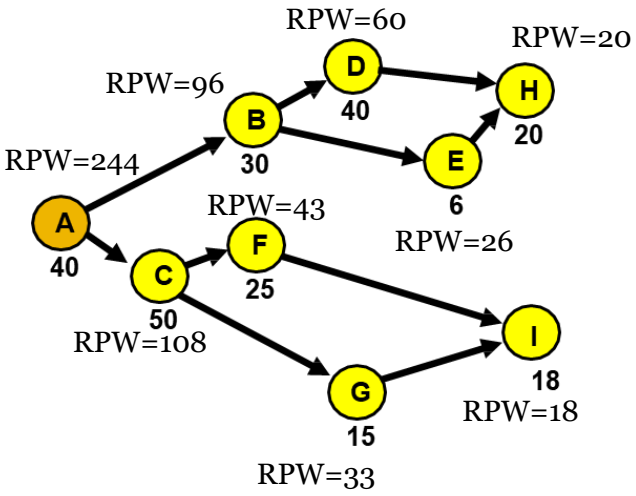


- **RPW for A** = 40 + 30 + 40 + 6 + 20 + 50 + 25 + 15 + 18 = **244**
- **RPW for B** = 30 + 40 + 6 + 20 = **96**
- **RPW for C** = 50 + 25 + 15 + 18 = **108**
- **RPW for D** = 40 + 20 = **60**
- **RPW for E** = 6 + 20 = **26**
- **RPW for F** = 25 + 18 = **43**
- **RPW for G** = 15 + 18 = **33**
- **RPW for H** = **20**
- **RPW for I** = **18**

Example: Line balancing

4. Use RPW or largest work-element time rule to devide tasks into workstations.

We use RPW. Devide all work elements into workstations.

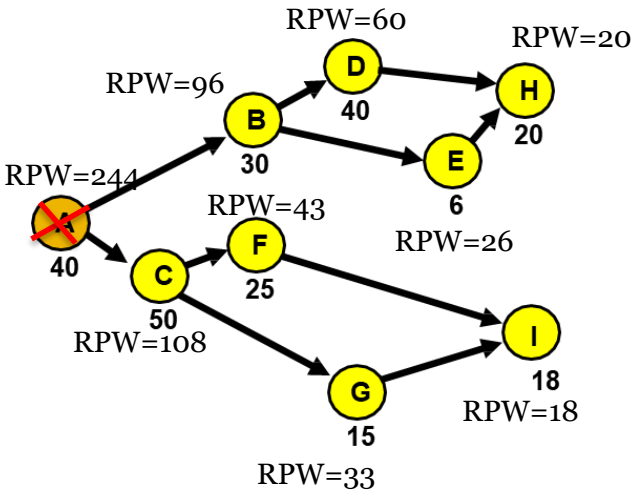


- A has the largest RPW and shall be in the workstation 1.
- Next largest RPW are C and B. We can not have B or C in this workstation because the maximum cycle time of the line is 60 seconds.
- We can not have other stations than B and C because we need to perform B and/or C so we can continue with the other work elements. The candidate is only A and we choose it.
- The cumulative cycle time for workstation 1 is 40 seconds.
- Idle time is 60 - 40 = 20 seconds. Because the cycle time of the line is 60 seconds.

Example: Line balancing

4. Use RPW or largest work-element time rule to devide tasks into workstations.

We use RPW. Devide all work elements into workstations.

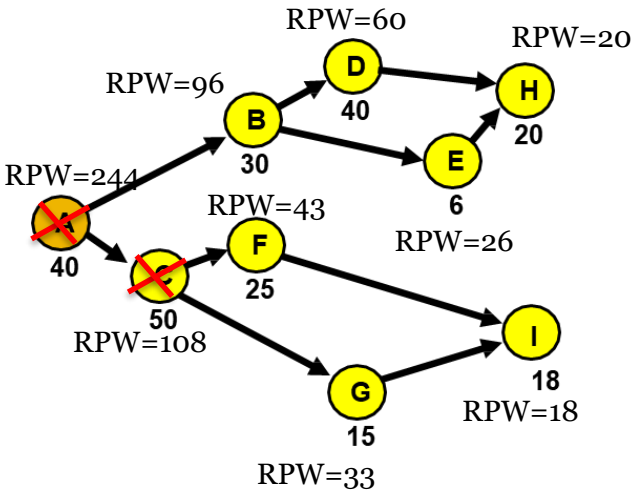


- The next largest RPW is C and then B.
- We can not have C and B together in this station, because the maximum cycle time is 60 seconds of the line.
- The candidates are C and B and we choose C because C has the highest time.
- The cumulative cycle time for workstation 2 is 50 seconds.
- Idle time 60 – 50 = 10 seconds. Because the cycle time of the line is 60 seconds.

Example: Line balancing

4. Use RPW or largest work-element time rule to devide tasks into workstations.

We use RPW. Devide all work elements into workstations.

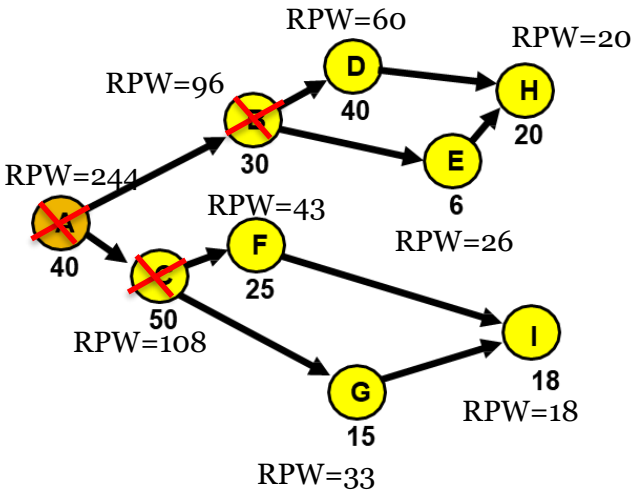


- The next largest RPW is B.
- The time for B is 30 seconds, that mean we maybe can have more work elements in this station.
- Next largest RPW is D, but we can not have this because the cycle time exceed 60 seconds for this workstation.
- Next largest RPW are F and G.
- Now we have three candidates for this workstation: B, F, G. We choose B because B has highest time.
- Cumulative cycle time for workstation 3 is now 30 seconds and idle time 60 – 30 = 30 seconds.

Example: Line balancing

4. Use RPW or largest work-element time rule to devide tasks into workstations.

We use RPW. Devide all work elements into workstations.

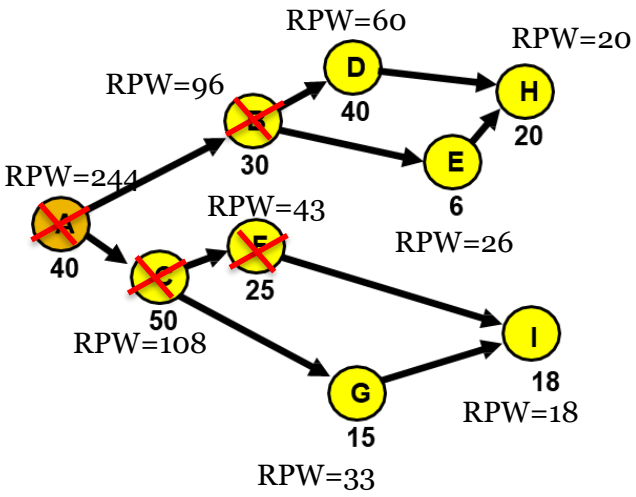


- The cumulative cycle time for workstation 3 is 30 seconds.
- That mean we maybe can have more work elements in this workstation.
- Next largest RPW is D, but we can not have D because cycle time exceed 60 seconds.
- Next largest RPW are F, G, E.
- We choose F because of highest time.
- Cumulative cycle time for this station is now 30+25 = 55 seconds.
- Idle time 60 – 55 = 5 seconds.

Example: Line balancing

4. Use RPW or largest work-element time rule to devide tasks into workstations.

We use RPW. Devide all work elements into workstations.

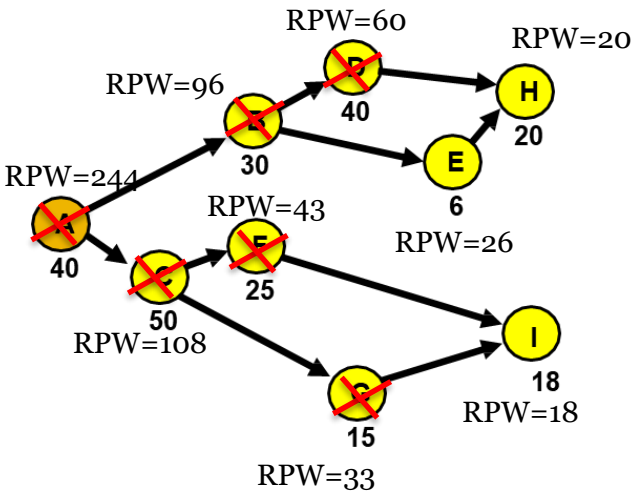


- The next largest RPW are D, G and E.
- We choice D because of highest cycle time.
- The cycle time for workstation 4 is now 40 seconds and that mean we maybe can have mor work elements in this workstation.
- Next largest RPW are G and E. We choose G because of highest time.
- The cumulative cycle time for this workstation is now 40+15 = 55 seconds.
- Idle time 60 – 55 = 5 seconds.

Example: Line balancing

4. Use RPW or largest work-element time rule to devide tasks into workstations.

We use RPW. Devide all work elements into workstations.

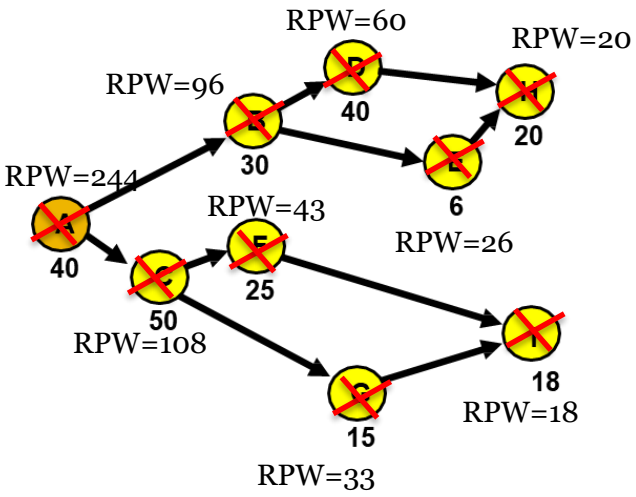


- The next largest RPW are E, H and I.
- The candidates are E and I.
- We can not have H like a candidate, because if we have H like a candidate we need to choose it, because H has highest Cycle time. But we can not choose H because we need to perform E before H and therefore the candidates are E and I.
- We choice I because of highest cycle time.
- Cumulative cycle time for workstation 5 is now 18 seconds.
- Idle time 60 – 18 = 42 seconds.

Example: Line balancing

4. Use RPW or largest work-element time rule to devide tasks into workstations.

We use RPW. Devide all work elements into workstations.



- The cumulative cycle time for workstation 5 is 18 seconds.
- That mean we can have H and I in this station.
- The total cumulative cycle time for this station is 44 seconds.
- Idle time 60 – 44 = 16 seconds.

Example: Line balancing

4. Use RPW or largest work-element time rule to devide tasks into workstations.

We use RPW. Devide all work elements into workstations.

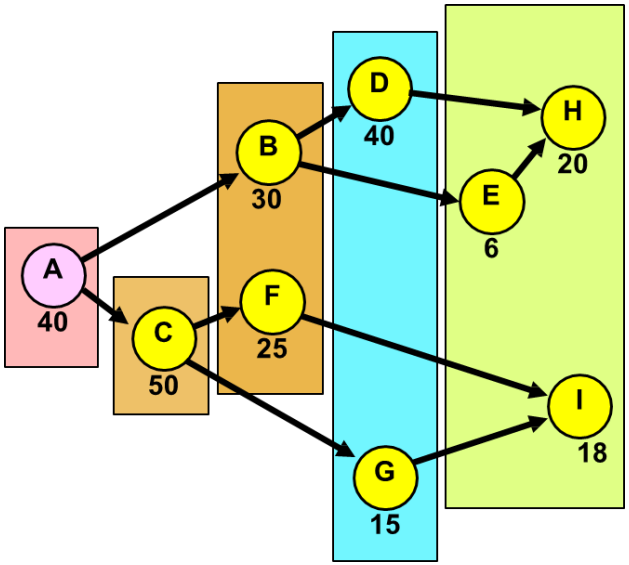
Station	Candidates	Choice	Cumulative cycle time	Idle time
S1	A	A	40	20
S2	B,C	C	50	10
S3	B, F, G	B	30	30
	E, F, G	F	55	5
S4	D, E, G	D	40	20
	E, G	G	55	5
S5	E, I	I	18	42
	E	E	24	36
	H	H	44	16

The worker at station S5 can do element I at any time but can not start element H until element E is finished.

Example: Line balancing

4. **Use RPW or largest work-element time rule to devide tasks into workstations.**

We use RPW. Devide all work elements into workstations.



Example: Line balancing

4. Use RPW or largest work-element time rule to devide tasks into workstations.

We use largest work-element time rule to devide all work elements into workstations.

- Same process as RPWT, but instead of choosing the work element with the highest RPW, we choose the work element with the largest time.
- As long as the predecessors for the task are in the same or earlier work-stations.

Chapters in coursebook

- **CHAPTER 5:** MANAGING PROCESS CONSTRAINTS