Assembly line balancing

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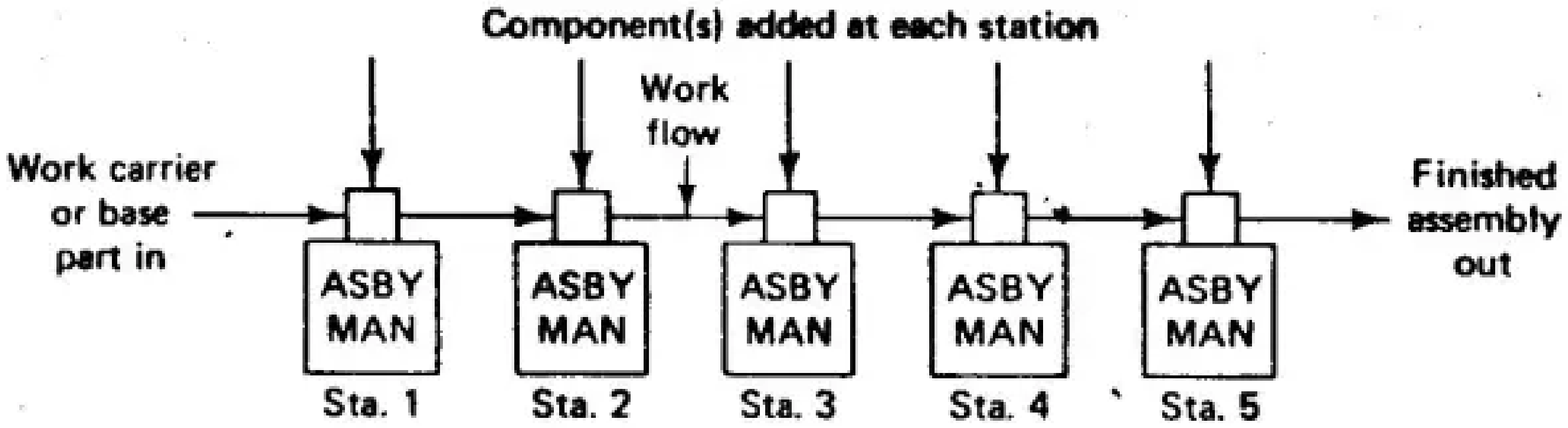
Recap: assembly systems

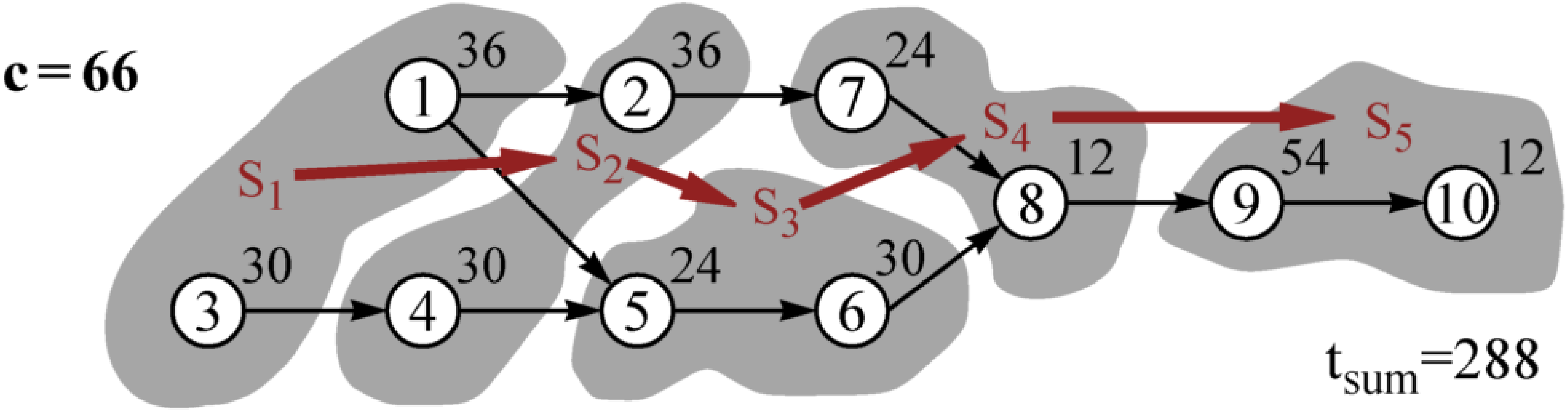
1. Manual single-station assembly
   – Single workplace station → full assembly
   – Complex product, small quantities, extremely high variance
   – One or more workers
2. Manual assembly line
   – Multiple workstation → part of assembly/subassembly
   – Product passes along the line
   – One or more workers per station
   – Medium batch size, possible high variance
3. Automated assembly line
   – Automated methods for assembly
   – Less human workers as possible
   – High production rate, low variance

Manual assembly lines



- Conveyor belt?
- Problems?
- Solutions?

SALBP



c = 66
36
36
24
1
2
7
S4
S5
S2
12
54
12
S1
S3
8
9
10
30
30
24
30
3
4
5
6
tsum=288

SALBP

- Simple assembly line balancing problem
  - SALBP-F
  - SALBP-1
  - SALBP-2
  - SALBP-E

- Other assembly line balancing problem
  - ARALBP
  - SDALBP
  - SUALBSP
  - ASALBP…

Line balancing problem

- Things to keep in mind:
  - List of parts
  - Connections
  - Assembly operations
  - Precedence constraints
  - Desired production rate
  - Manual/automatic assembly
  - Efficiency

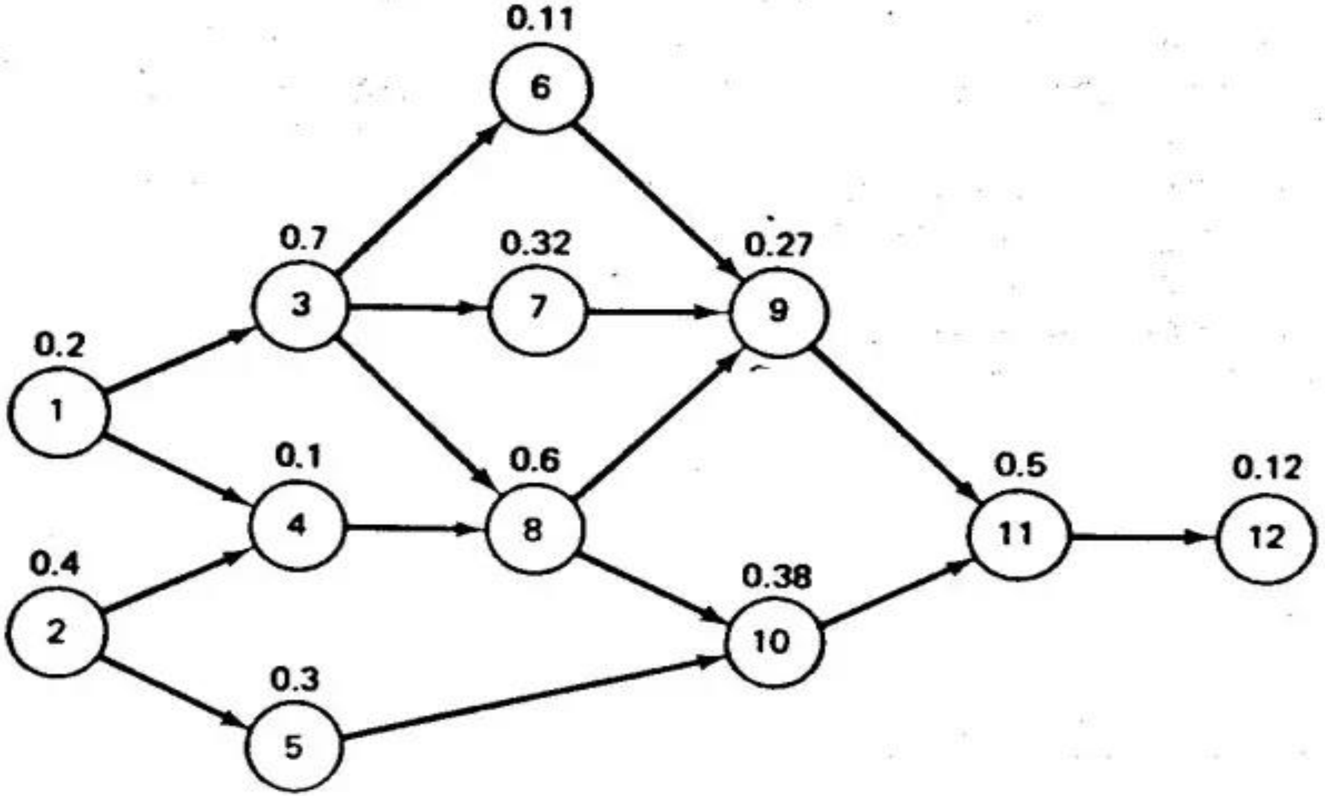
Example

No.	Element description	T_{ej}	Must be preceded by:
1	Place frame on workholder and clamp	0.2	—
2	Assemble plug, grommet to power cord	0.4	—
3	Assemble brackets to frame	0.7	1
4	Wire power cord to motor	0.1	1, 2
5	Wire power cord to switch	0.3	2
6	Assemble mechanism plate to bracket	0.11	3
7	Assemble blade to bracket	0.32	3
8	Assemble motor to brackets	0.6	3, 4
9	Align blade and attach to motor	0.27	6, 7, 8
10	Assemble switch to motor bracket	0.38	5, 8
11	Attach cover, inspect, and test	0.5	9, 10
12	Place in tote pan for packing	0.12	11

$$T_{wc} = \sum_{j=1}^{n_e} T_{ej}$$

$$T_c \leq \frac{E}{R_p}$$

Precedence constraints



Other constraints

- Zoning constraint
  - Positive
  - Negative
- Position constraint

(Not to be considered in course/examples/test)

→ But important to consider for the project!

Methods for line balancing

1. Largest-candidate rule
2. Kilbridge and Wester’s method
3. Ranked positional weights method

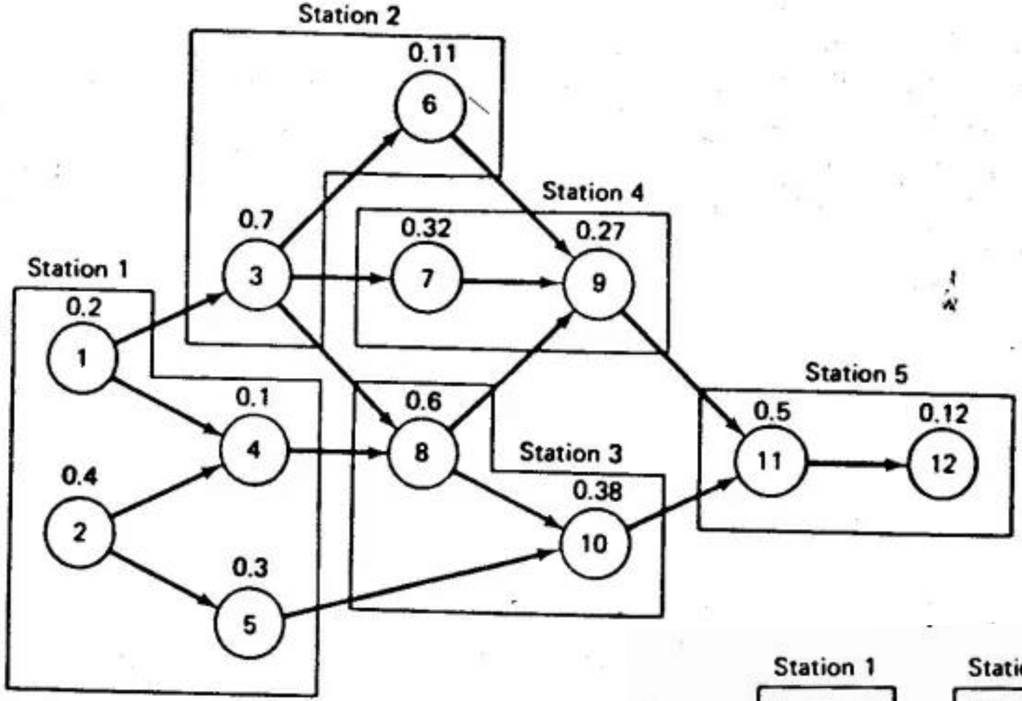
Largest-candidate rule (LCR)

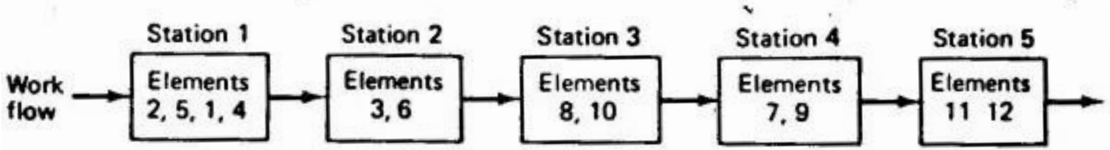
T_c = 1 min, E = 1

Work element	T_e	Immediate predecessors
3	0.7	1
8	0.6	3, 4
11	0.5	9, 10
2	0.4	—
10	0.38	5,8
7	0.32	3
5	0.3	2
9	0.27	6, 7, 8
1	0.2	—
12	0.12	11
6	0.11	3
4	0.1	1,2

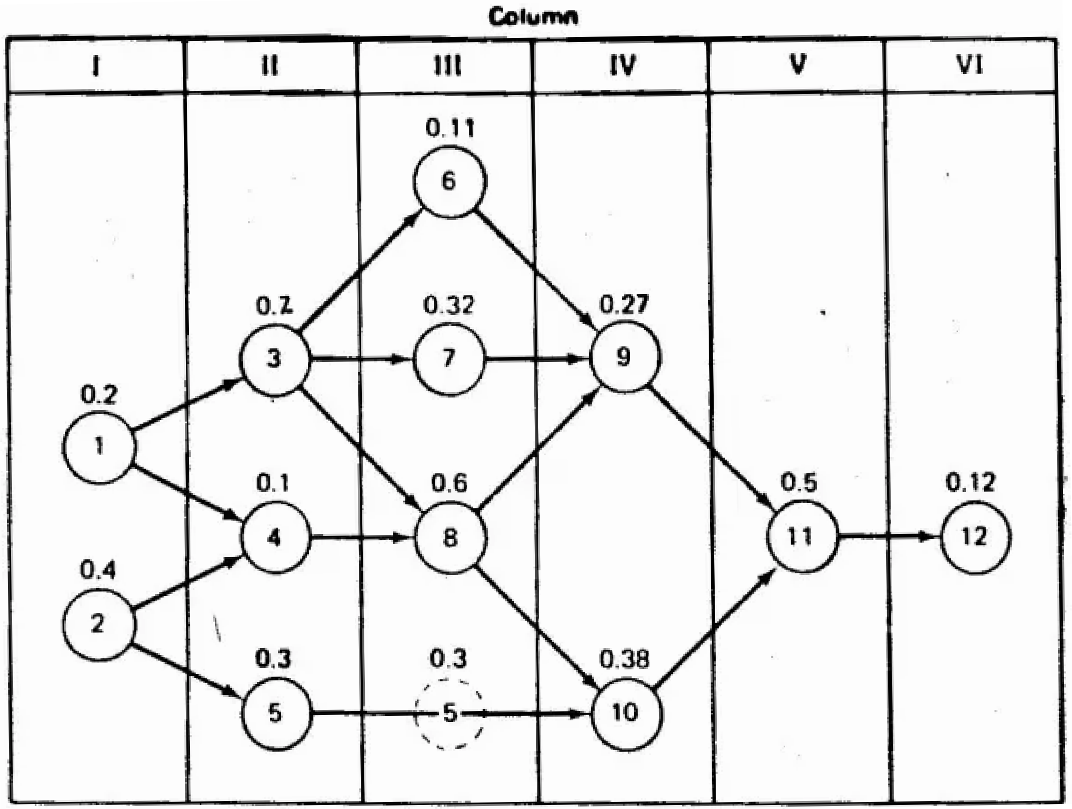
Station	Element	T_e	ΣT_e at station
1	2	0.4	
	5	0.3	
	1	0.2	
	4	0.1	1.00
2	3	0.7	
	6	0.11	0.81
3	8	0.6	
	10	0.38	0.98
4	7	0.32	
	9	0.27	0.59
5	11	0.5	
	12	0.11	0.62

Solution


Station 1
Station 2
Station 3
Station 4
Station 5
0.2
0.4
0.7
0.1
0.3
0.11
0.32
0.6
0.27
0.38
0.5
0.12
1
2
3
4
5
6
7
8
9
10
11
12


Work flow
Station 1
Elements 2, 5, 1, 4
Station 2
Elements 3, 6
Station 3
Elements 8, 10
Station 4
Elements 7, 9
Station 5
Elements 11 12

Kilbridge and Wester's (K&W)



Work element	Column	T_e	Sum of column T_es
1	I	0.2	
2	I	0.4	0.6
3	II	0.7	
4	II	0.1	
5	II,III	0.3	1.1
6	III	0.11	
7	III	0.32	
8	III	0.6	1.03
9	IV	0.27	
10	IV	0.38	0.65
11	V	0.5	0.5
12	VI	0.12	0.12

Solution

Station	Element	T_e	ΣT_e at station
1	1	0.2	
	2	0.4	
	4	0.1	
	5	0.3	1.00
2	3	0.7	
	6	0.11	0.81
3	7	0.32	
	8	0.6	0.92
4	9	0.27	
	10	0.38	0.65
5	11	0.5-	
	12	0.12	0.62

Ranked positional weights (RPW)

Element	RPW	T_e	Immediate predecessors
1	3.30	0.2	—
3	3.00	0.7	1
2	2.67	0.4	—
4	1.97	0.1	1,2
8	1.87	0.6	3,4
5	1.30	0.3	2
7	1.21	0.32	3
6	1.00	0.11	3
10	1.00	0.38	5,8
9	0.89	0.27	6,7,8
11	0.62	0.5	9,10
12	0.12	0.12	11

Solution

Station	Element	T_e	ΣT_e at station
1	1	0.2	
	3	0.7	0.9
2	2	0.4	
	4	0.1	
	5	0.3	
	6	0.11	0.91
3	8	0.6	
	7	0.32	0.92
4	10	0.38	
	9	0.27	0.65
5	11	0.5	
	12	0.12	0.62

Model variations

1. Single-model line
2. Batch-model line
3. Mixed-model line

Computerized line balancing methods

1. COMSOAL
2. CALB
3. ALPACA

(Not investigated in this course)