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Operations planning and scheduling

Yuji Yamamoto

PPU426

Today's topic

- What is operations planning and scheduling?
- How to cope with mismatch between demand and supply?
- Production planning
- Scheduling
- Job shop scheduling theories

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Production planning and scheduling

Demand

1,400pcs/m
for coming
months

Production
planning

How many to make?
How much to work?

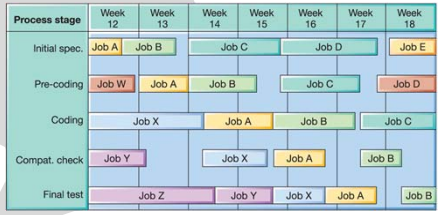
Lets make 1,200pcs/m
with overtime!

Resource
planning

MPS

What model to
make until when?

Scheduling



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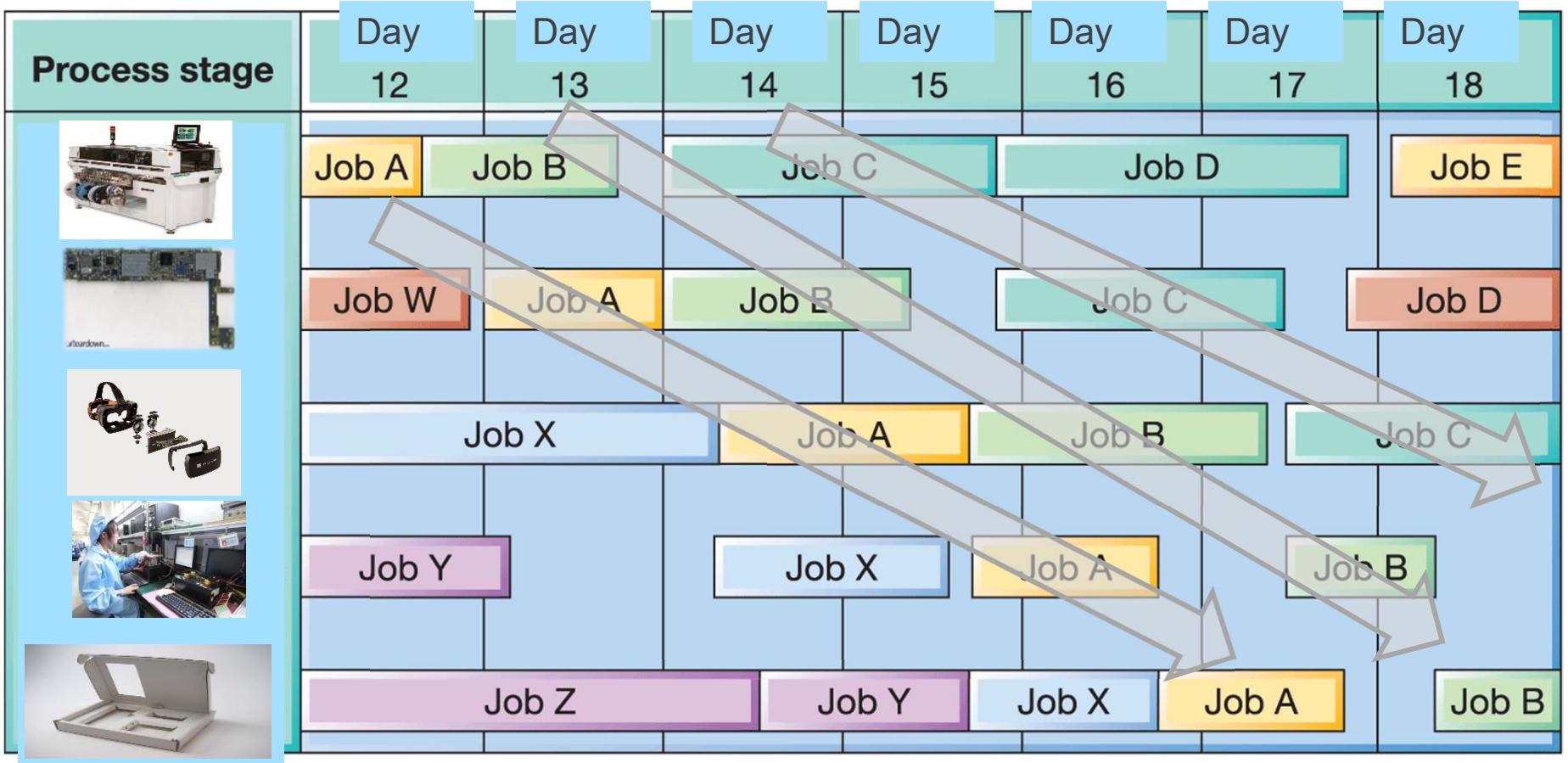
Example of scheduling for line production

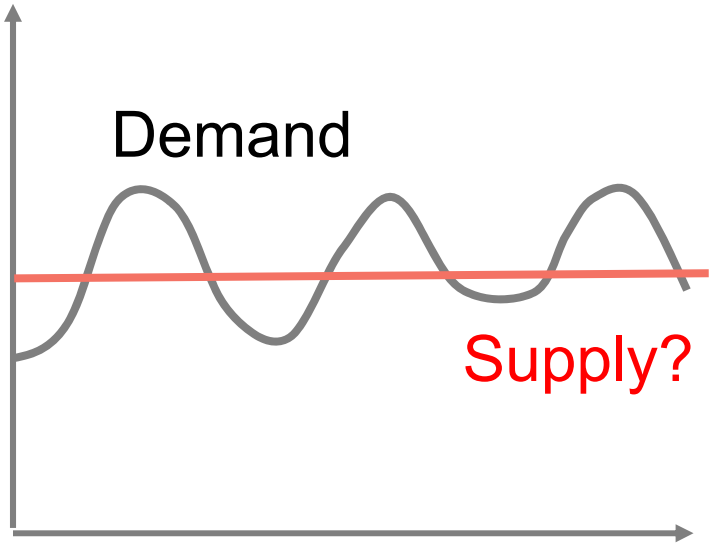
Gant Progress chart (note: Job A = Model A)



What is operations planning and scheduling?

Operations planning and scheduling is the process of making sure that demand and supply plans are in balance, from aggregate level down to the short-term scheduling level.

How to cope with mismatch between demand and supply?



- Coping with supply side
- Coping with demand side

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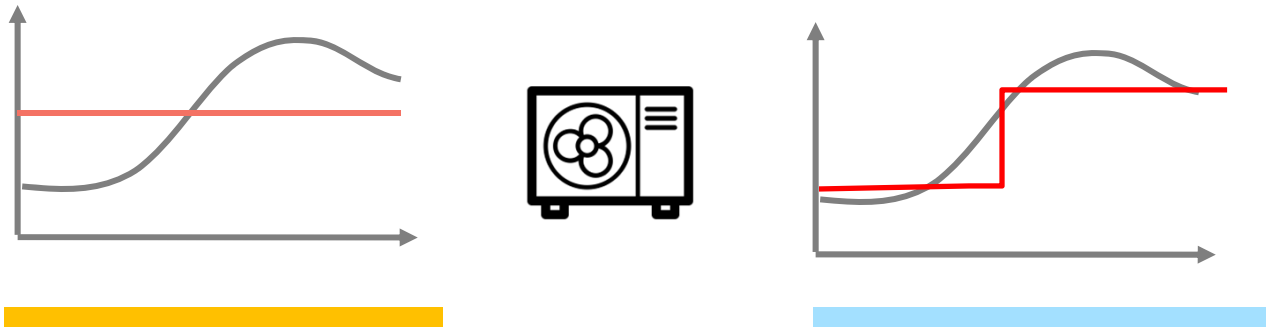
Cope with the mismatch from supply side

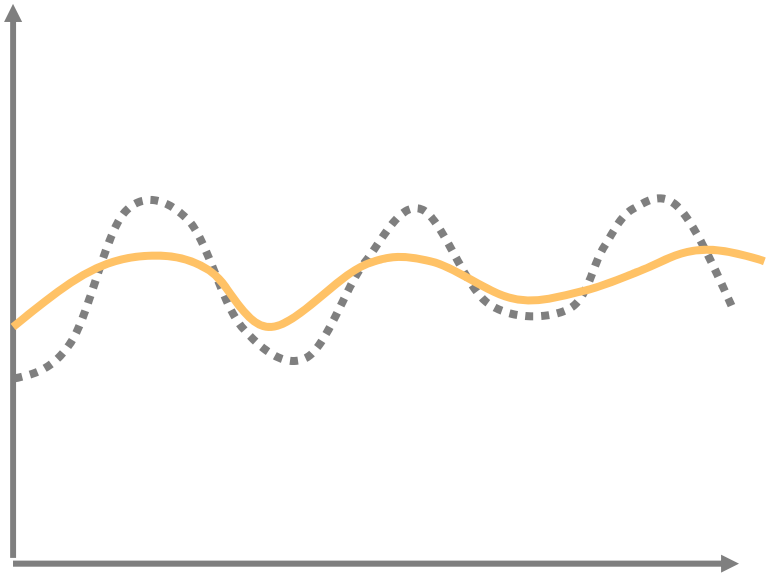
- Anticipation inventory
- Workforce adjustment (layoff/hire)
- Workforce utilization (overtime/undertime)
- Part-time workers
- Subcontractors



Cope with the mismatch on demand side

Demand management:

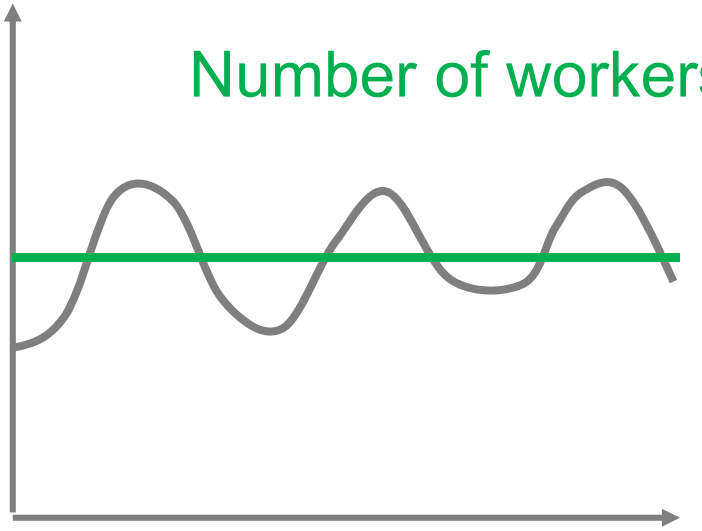
Try to change the demand pattern so that the supply side can cope with it easier



- Promoting pricing
- Reservation
- Complementary products
- Backlogs
- etc.

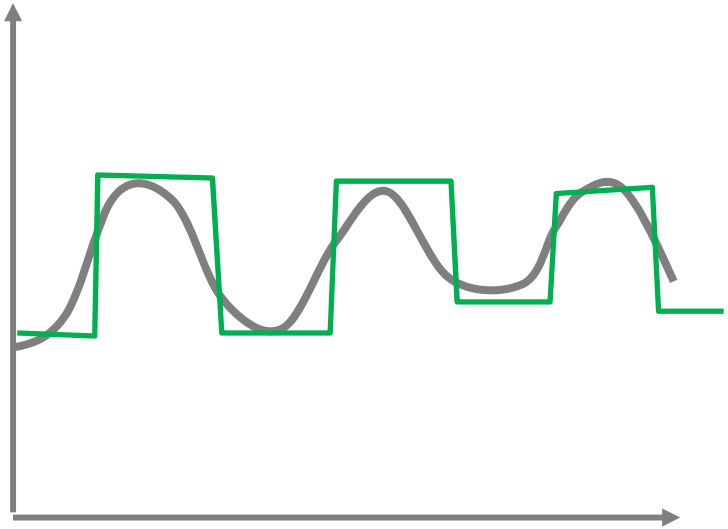
Workforce planning strategies

Level strategy



- Overtime cost
- Undertime cost

Chase strategy



- Layoff cost
- Hiring cost

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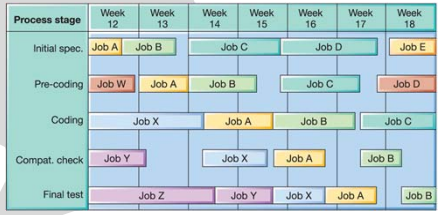

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Production planning

	HISTORY									
SALES	J	F	M	A*	M	J	J	A	S	3 Mos**
New forecast	45	55	60	70	85	95	130	110	70	150
Actual sales	52	40	63							
Diff for month	7	–15	3							
Cum		–8	–5							
OPERATIONS										
New Plan	75	75	75	75	75	85	85	85	75	177
Actual	75	78	76							
Diff for month	0	3	1							
Cum		3	4							
INVENTORY										
Plan	85	105	120	125	115	105	60	35	40	198
Actual	92	130	143							

Oct
Nov
Dec

Workforce planning

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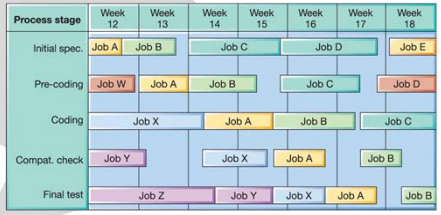

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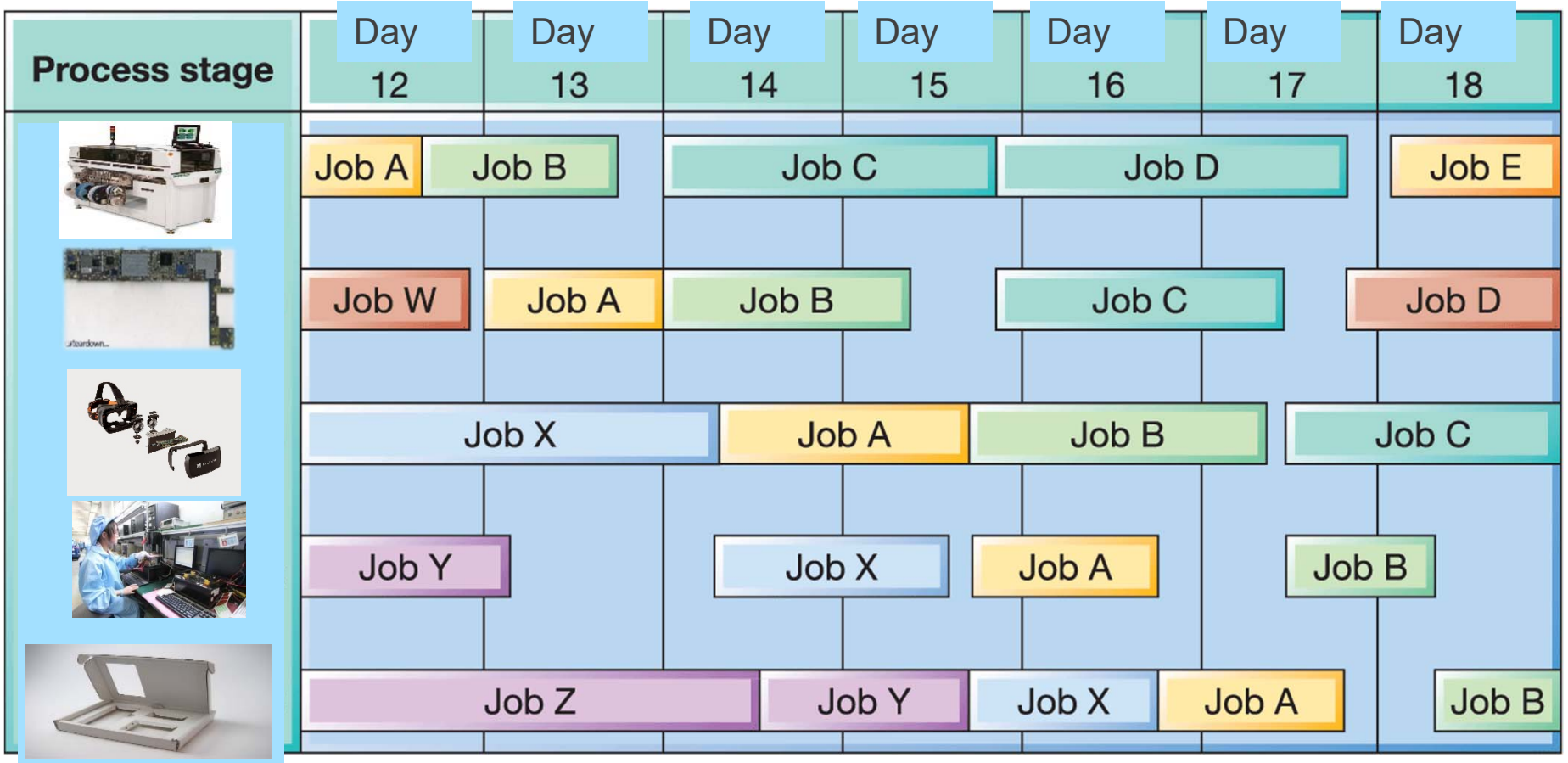

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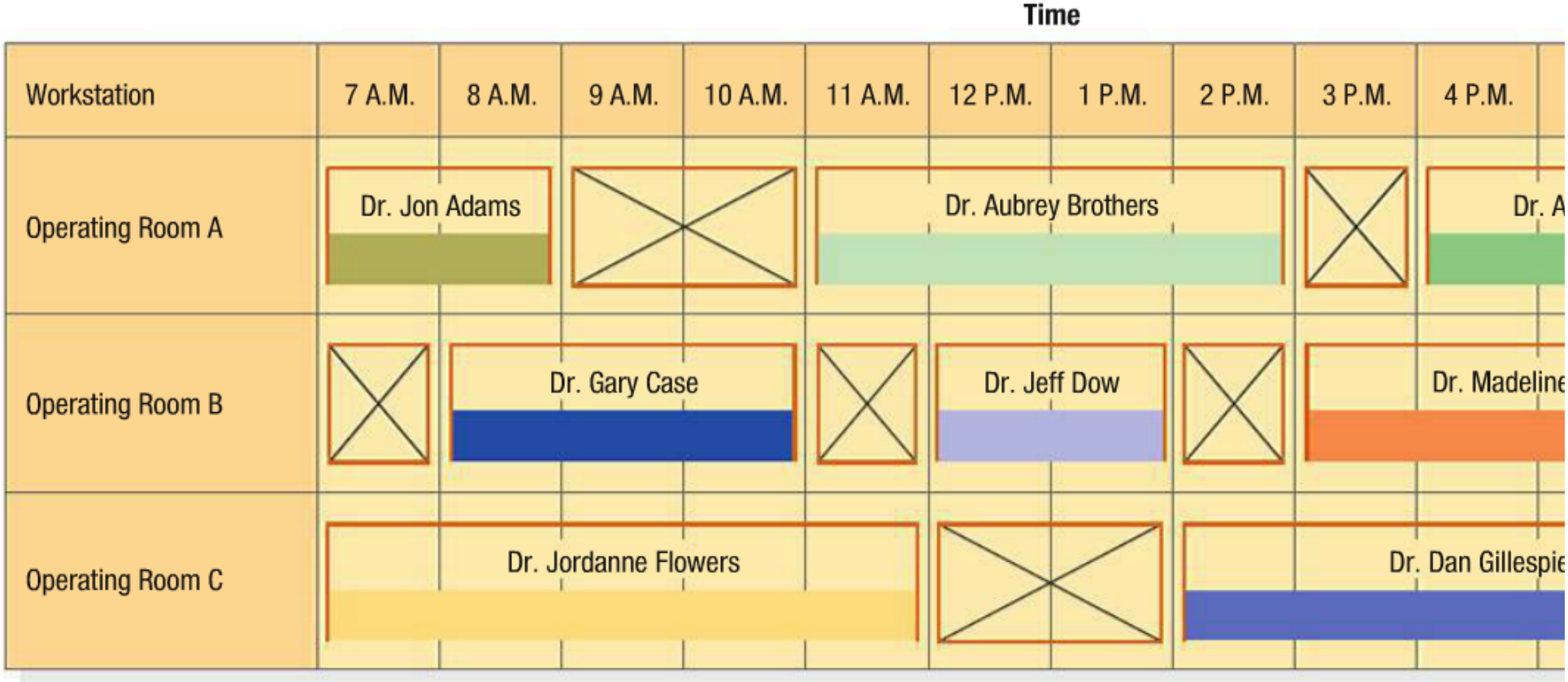
Example of scheduling for work stations

Gant Workstation chart



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- Job shop scheduling theories

Based on supplemental material

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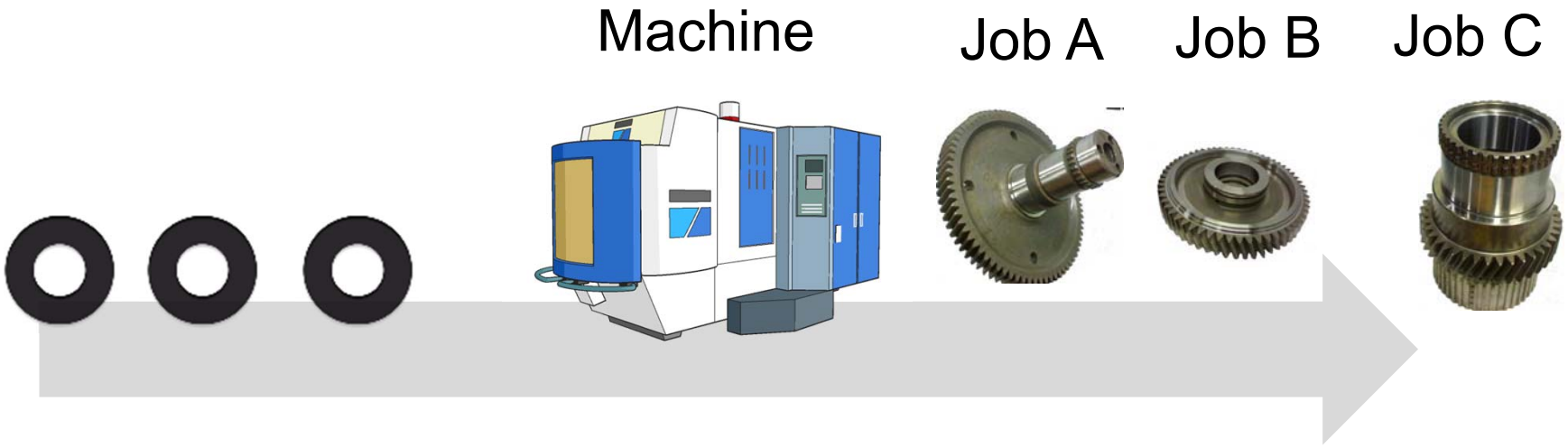
Job shop schedulering problem

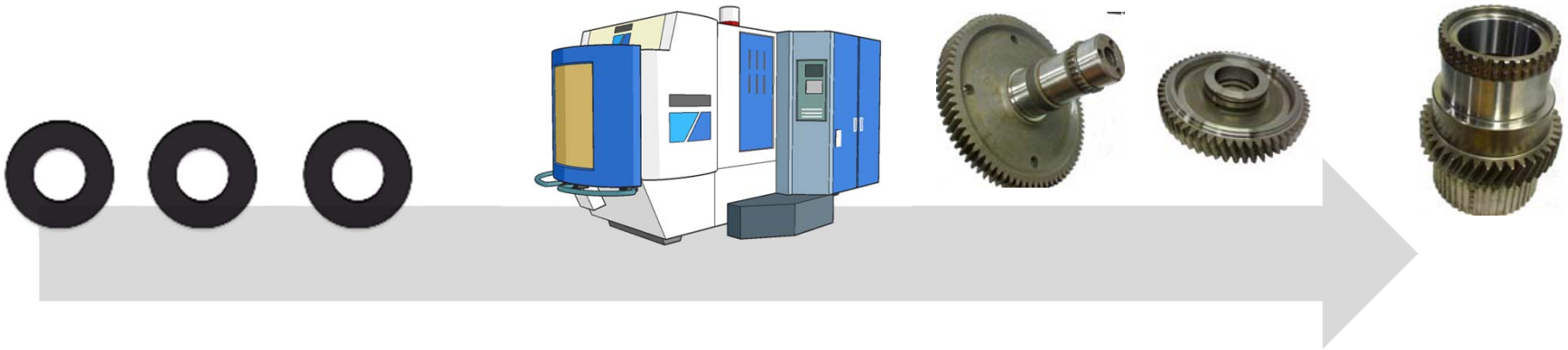
- one machine situation



Different job has different process time and due date…

In which order shall we produce?

In which order to produce?



Possible objectives:

- Minimize number of delay
- Minimize the largest delay
- Minimize average delay time
- Minimize flow time
- Minimize idle time
- etc.

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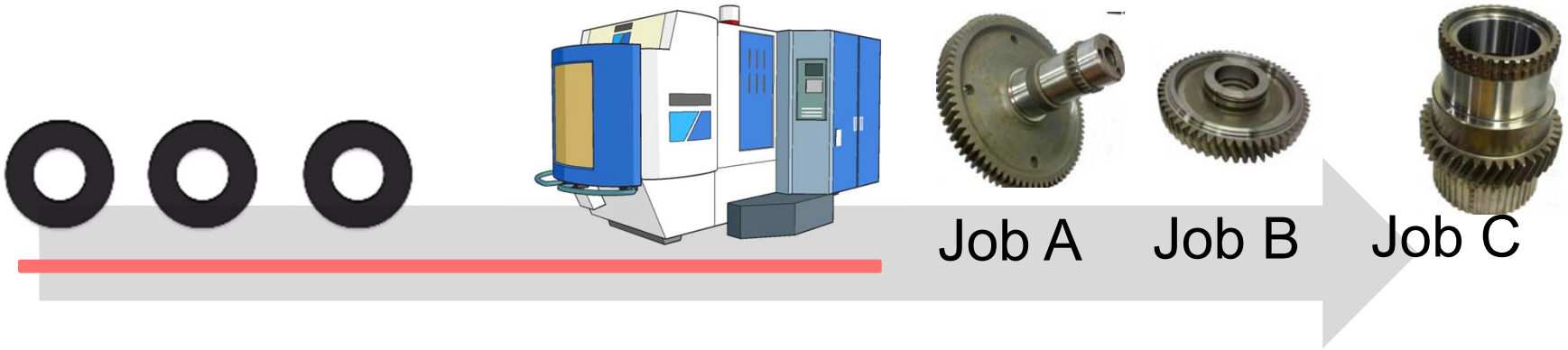
Terminology



Process time:

Time a machine takes to do a certain job

5 6 7

If sequence A - B - C,

Flow time:

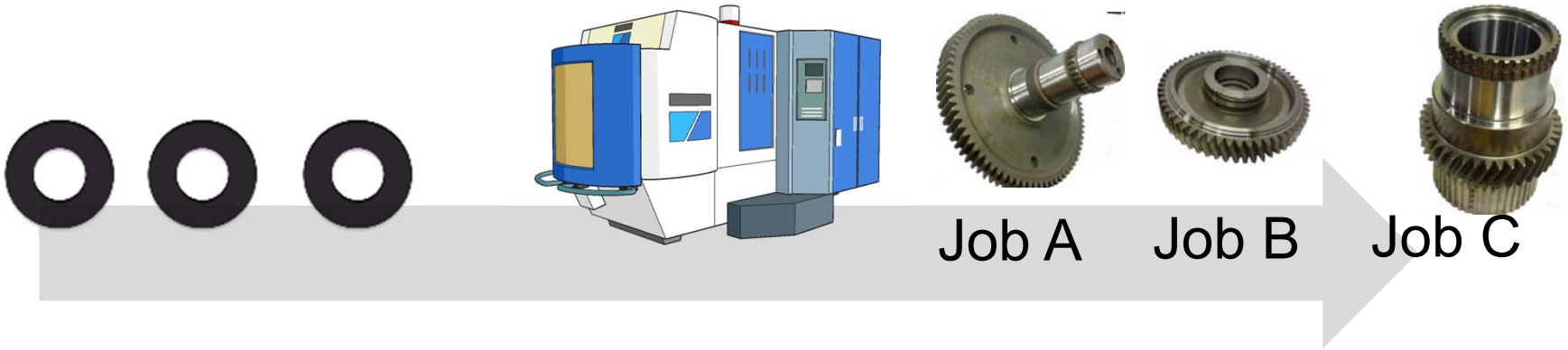
Time a job spends in the system

Flow time Job A 5

" Job B 5 6

" Job C 5 6 7

Terminology



Makespan:

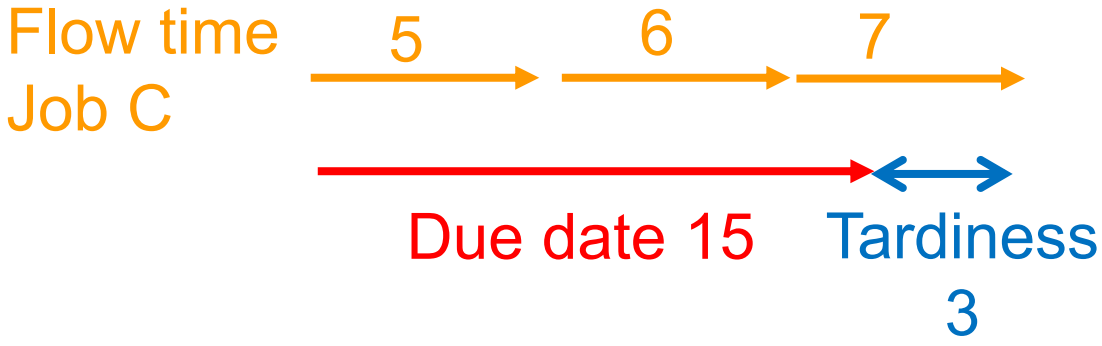
Time to complete all jobs

5+6+7

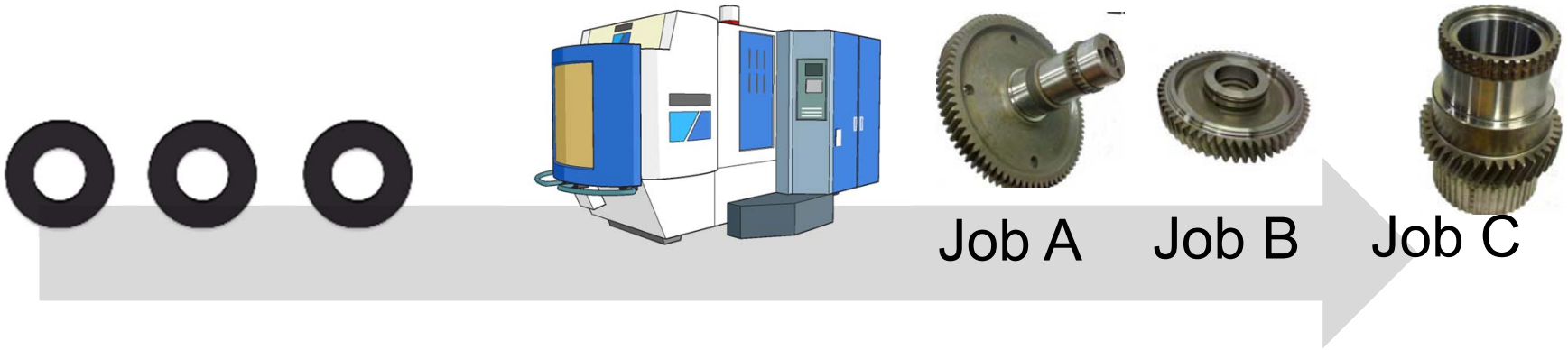
= Flow time of the last job

Tardiness:

How much the flow time differs (delays) from the due date



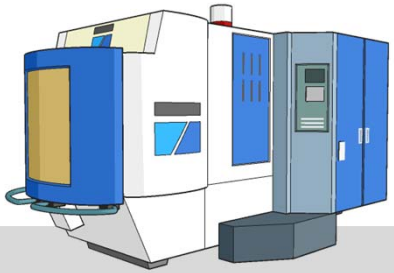
Specific sequencing rules



- FCFS (First-come, First-served)
- SPT (Shortest processing time)
- EDD (Earliest due date)
- CR (Critical ratio)

$$CR = \frac{\text{Due date} - \text{Current time}}{\text{Processing time}}$$

Comparison of sequencing rules



Job 1
Job 2
Job 3
Job 4
Job 5

Example:

Job Number	*Processing Time*	*Due Date*
1	11	61
2	29	45
3	31	31
4	1	33
5	2	32

FCFS (First-come First-served)

(Flow time)

Sequence	*Completion Time*	*Due Date*	*Tardiness*
1	11	61	0
2	40	45	0
3	71	31	40
4	72	33	39
5	74	32	42
Totals	268		121

Mean flow time = 268/5 = 53.6,

Average tardiness = 121/ 5 = 24.2,

Number of tardy jobs = 3.

SPT (Shortest Processing time)

Job	*Processing Time*	*Completion Time*	*Due Date*	*Tardiness*
4	1	1	33	0
5	2	3	32	0
1	11	14	61	0
2	29	43	45	0
3	31	74	31	43
Totals		135		43

Mean flow time = 135/5 = 27.0,

Average tardiness = 43/5 = 8.6,

Number of tardy jobs = 1.

EDD (Earliest Due Date)

Job	*Processing Time*	*Completion Time*	*Due Date*	*Tardiness*
3	31	31	31	0
5	2	33	32	1
4	1	34	33	1
2	29	63	45	18
1	11	74	61	13
Totals		235		33

Mean flow time = 235/5 = 47.0,

Average tardiness = 33/5 = 6.6,

Number of tardy jobs = 4.

CR (Critical Ratio)

$$CR = \frac{\text{Due date} - \text{Current time}}{\text{Processing time}}$$

1. On the current time, calculate CR for each job
2. Choose the job that has the smallest CR
3. Erase the job and update the current time
4. Go to step 1

Note: If a certain CR is minus (delayed), chose that job first.
If more than one jobs are minus, chose based on SPT.

Current time: $t = 0$

Job	*Processing Time*	*Due Date*	*Critical Ratio*
1	11	61	61/11 (5.545)
2	29	45	45/29 (1.552)
1st 3	31	31	31/31 (1.000)
4	1	33	33/1 (33.00)
5	2	32	32/2 (16.00)

Current time: $t = 31$

Job	*Processing Time*	*Due Date − Current Time*	*Critical Ratio*
1	11	30	30/11 (2.727)
2nd 2	29	14	14/29 (0.483)
4	1	2	2/1 (2.000)
5	2	1	1/2 (0.500)

Current Time: $t = 60$

	Job	*Processing Time*	*Due Date − Current Time*	*Critical Ratio*
	1	11	1	1/11 (.0909)
3rd	4	1	−27	−27/1 < 0
4th	5	2	−28	−28/2 < 0

Note: If a certain CR is minus (delayed), chose that job first.
If more than one jobs are minus, chose based on SPT.

CR (Critical Ratio)

Result:

Job	*Processing Time*	*Completion Time*	*Tardiness*
3	31	31	0
2	29	60	15
4	1	61	28
5	2	63	31
1	11	74	13
Totals		289	87

Mean flow time = 289/5 = 57.8.

Average tardiness = 87/5 = 17.4.

Number of tardy jobs = 4.

Comparison of sequencing rules - result

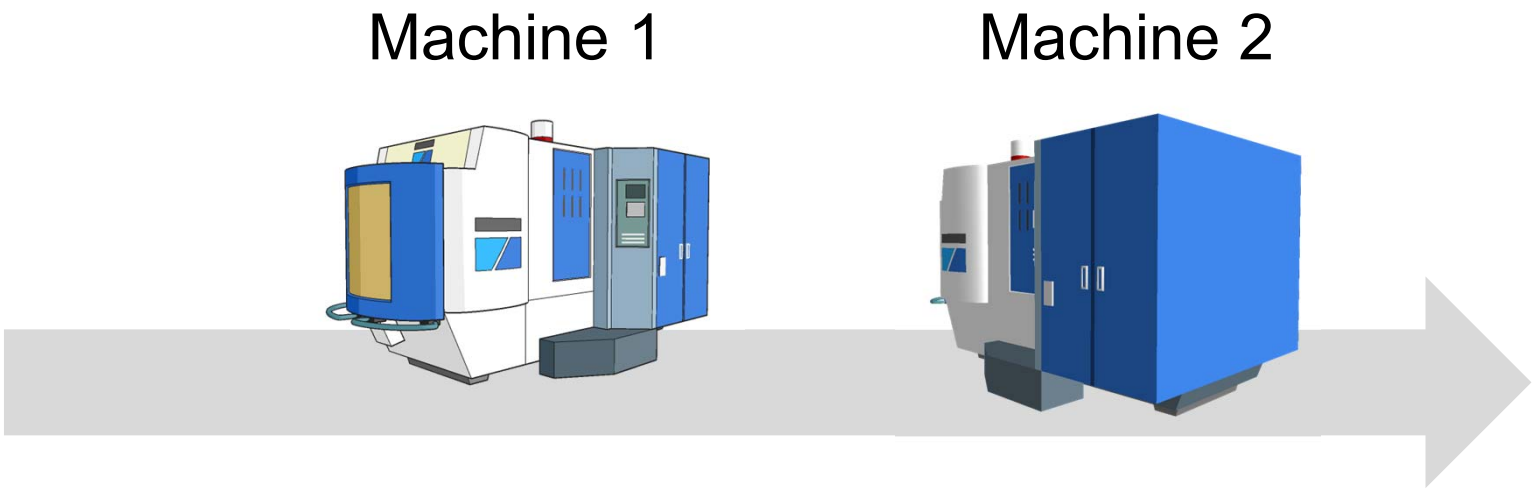
Rule	*Mean Flow Time*	*Average Tardiness*	*Number of Tardy Jobs*
FCFS	53.6	24.2	3
SPT	27.0	8.6	1
EDD	47.0	6.6	4
CR	57.8	17.4	4

Theorem:

- SPT is the rule that minimizes mean flow time
- EDD is the rule that minimizes largest lateness

(See the mathematical proofs in the supplement material)

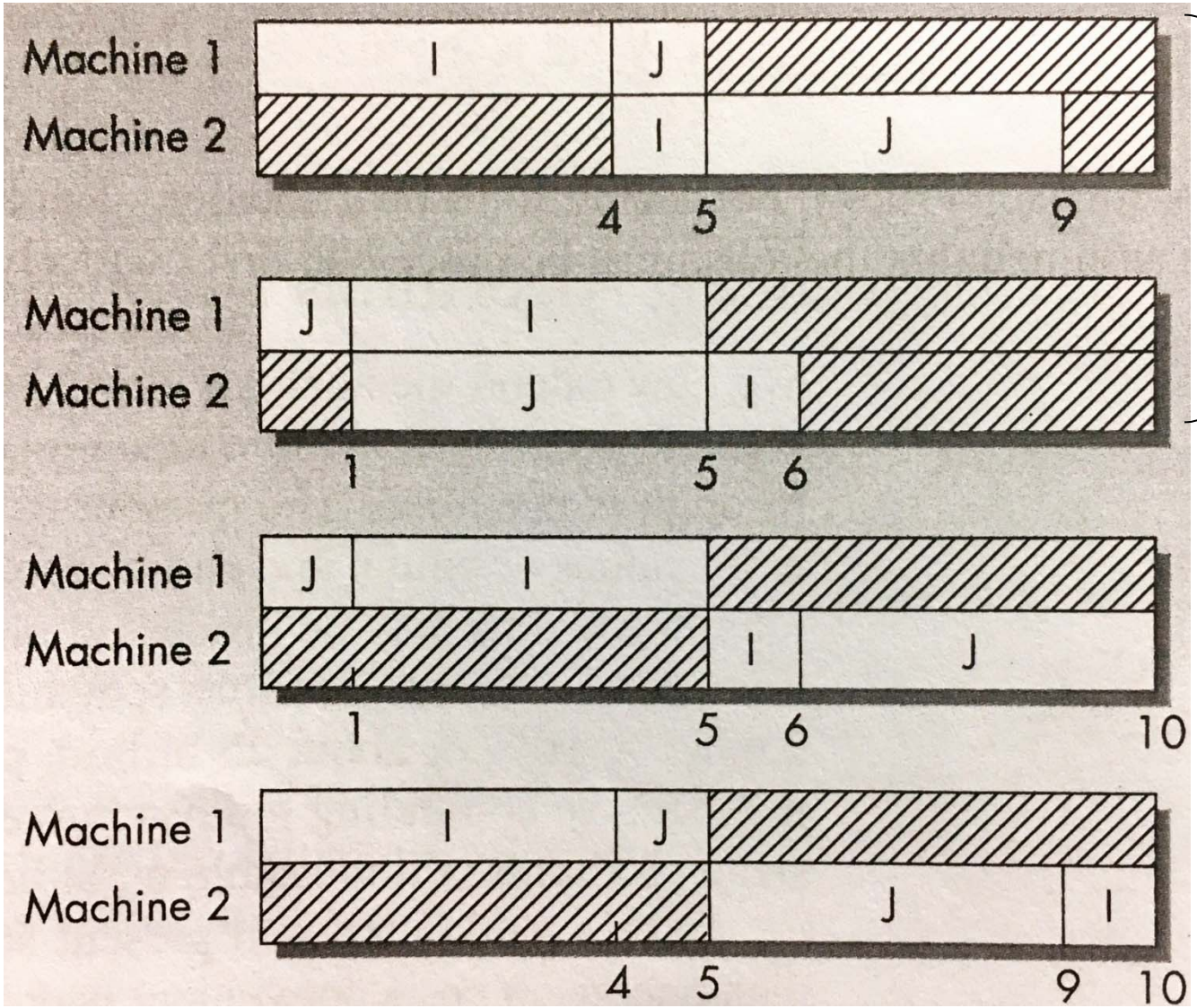
Sequencing algorism for two machines



Job I	4	1
Job J	1	4

Which schedule makes the shortest makespan?

Possible schedules



Permutation schedule

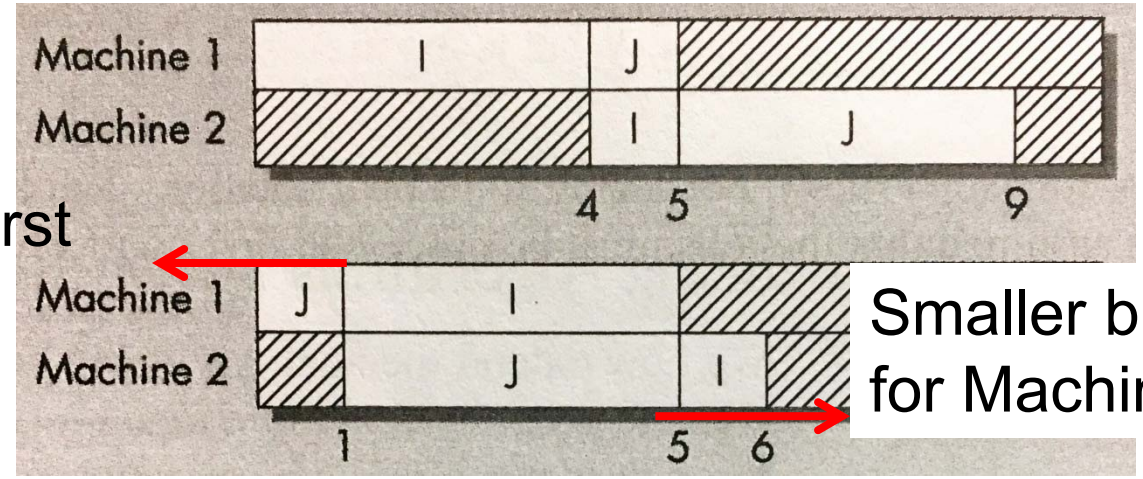
Always better than non-permutation schedule

Sequencing algorism for two machines

Johnson's rule:

Job i precedes job $i+1$ if $\min(A_i, B_{i-1}) < \min(A_{i+1}, B_i)$

A_i = Processing time of job i on machine A (or 1)
B_i = Processing time of job i on machine B (or 2)



Smaller block first for Machine 1

Smaller block last for Machine 2

Sequencing algorism for two machines

Johnson's rule:

Easy way to implement this rule:

1. List the processing time for all jobs for two machines
2. Find the smallest processing time.
3. If it is for the first machine, put it in the first.
   If it is for the second machine, put it in the last.
4. Remove the job in the list.
5. Go to 2.

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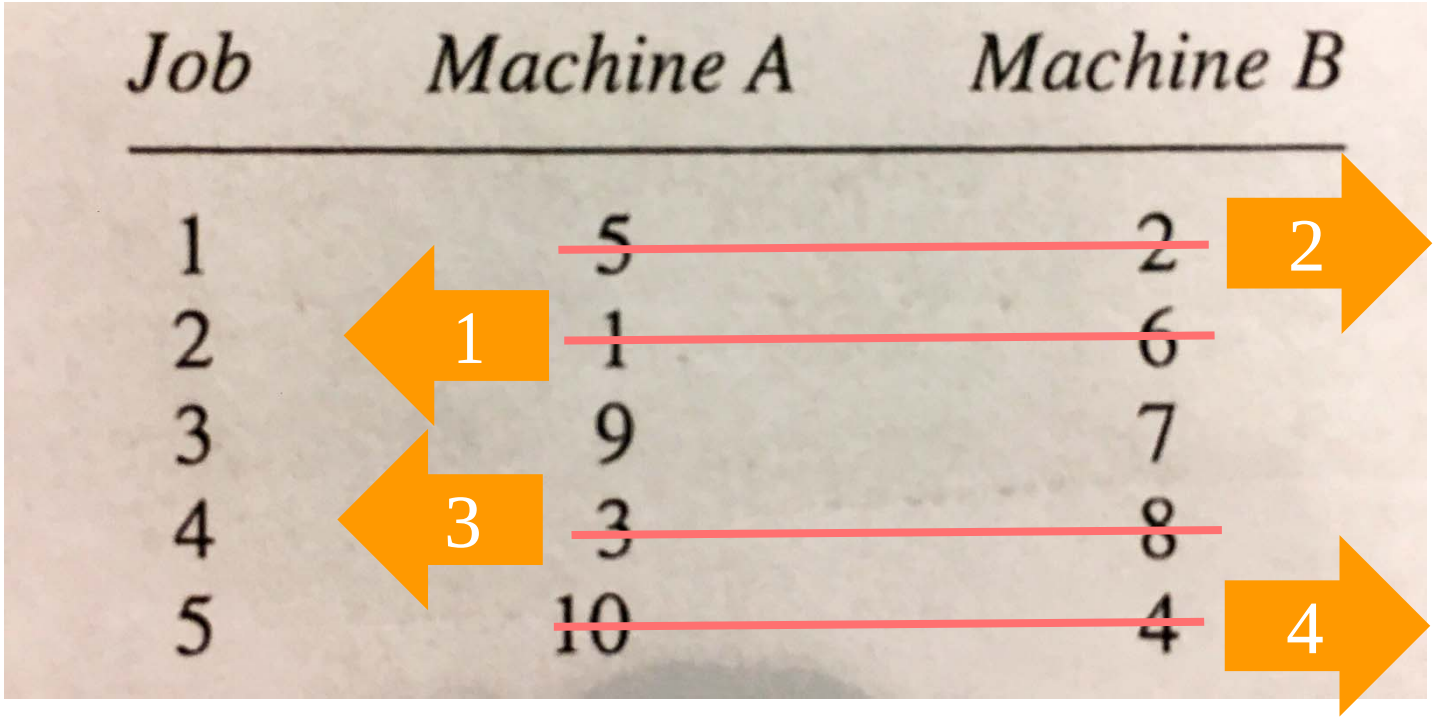
Sequencing algorism for two machines

Johnson's rule:



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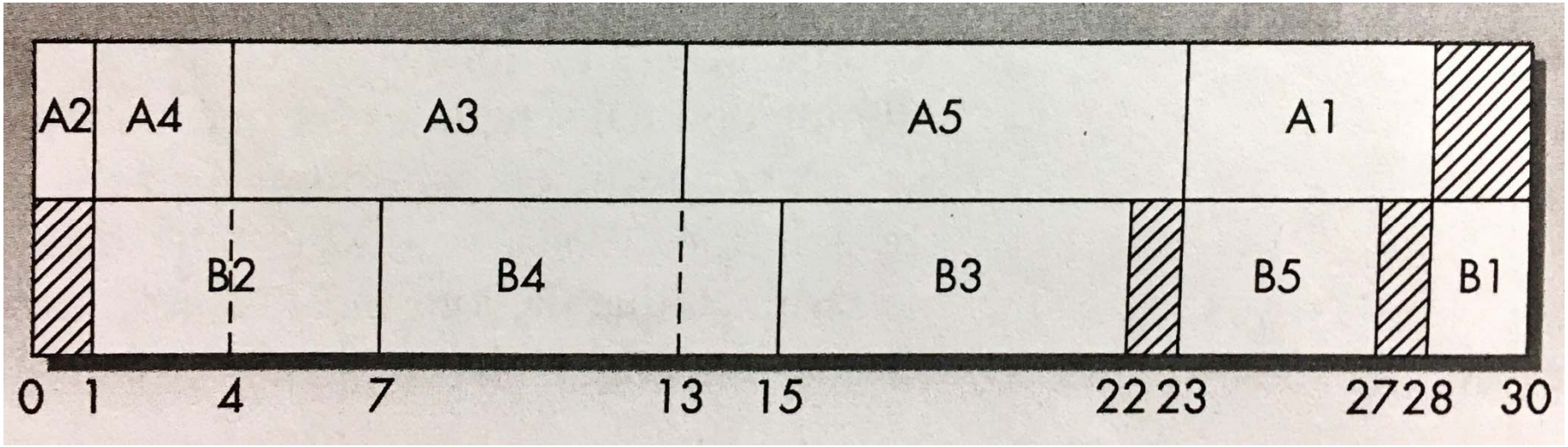

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