KS SUPPLY CHAIN FUNDAMENTALS

10 Scheduling

SS 2025

PLM Institute of
Production and
Logistics Management

Learning goals

After this lecture you should be able to...

- ...explain what scheduling involves and the areas in which scheduling problems have to be solved.
- ...solve simple machine scheduling problems.
- ...understand network diagrams.
- ...determine the critical path.

Literature

Stevenson, WJ: Operations Management. McGraw-Hill Education Ltd; latest edition - Chapters 16, 17

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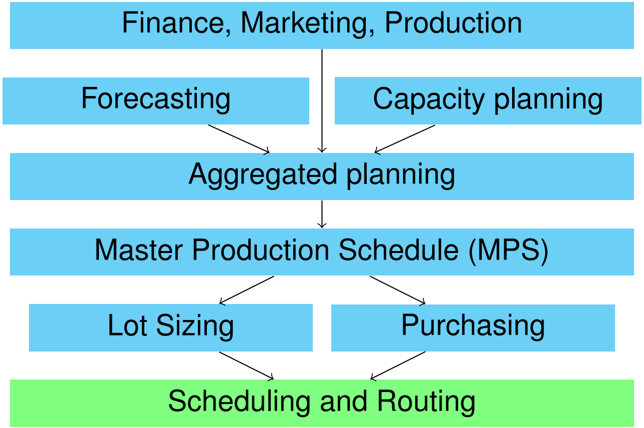
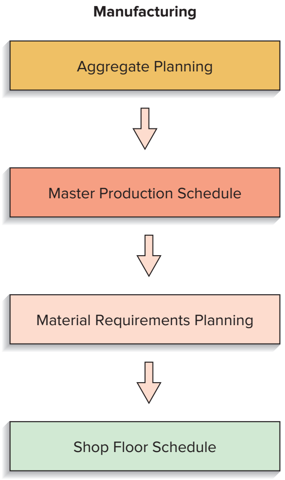
Introduction

- Scheduling is a very large research area.
- It ranges from sequencing, to personnel scheduling, operating room planning and project scheduling.
- Scheduling concerns the timing of the use of resources.
- Gantt charts are often used to represent scheduling plans.

Classification: operative planning



The scheduling hierarchy (production planning)



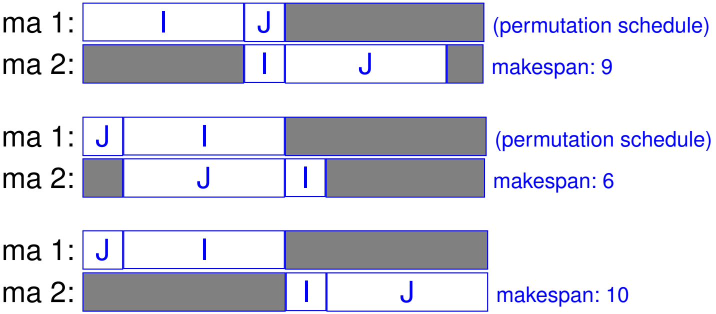
Stevenson (2017)

Sequencing

Example

	Machine 1	Machine 2
Job I	4	1
Job J	1	4

Both jobs are to be processed on machine 1 and then on machine 2. Different options (shown as Gantt charts):



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Sequencing: terminology

- **Flow Shop** all n (*jobs*) have to be processed on all m machines in the same order. Each job is processed only once on each machine $\rightarrow$ assembly line
- **Job Shop** not all n jobs require all m machines. Some may require the same machine multiple times and different jobs may require machines in different orders.

Sequencing: performance measures

- **Completion time**: Exact time when the final job finishes processing on the final machine.
- **Flow time**: Duration between the release of a job and the time of its completion.
- **Tardiness**: Difference between (*due date*) and completion date.
- **Makespan**: Duration for the completion of all jobs, from the release date of the first job to the completion date of the last.

Sequencing: goals

- **Minimization of flow times** The goal is either to minimize the maximum flow time or minimize the average flow time of all n jobs.
- **Maximization of "punctuality"** If every job has a known *due date* then this goal can be set, e.g., by minimizing the total tardiness or minimizing the number of tardy jobs.

Simple priority rules

1. **First-come, first-served (FCFS)**: The job that reaches the machine is scheduled first.
2. **Shortest processing time (SPT)**: Highest priority is given to the job that has the shortest operating time (processing time).
3. **Earliest due date (EDD)**: The job with the earliest due date receives the highest priority.

Example: single machine problem (1)

5 jobs that arrive at the machine in the order given below.

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

⋆ **First-come first served**

FCFS	1	2	3	4	5	sum	avg.
Flow time F_i	11	40	71	72	74	268	53.6
Lateness $T_i = \max\{F_i - d_i, 0\}$	0	0	40	39	42	121	24.2
tardy jobs	3						

Example: single machine problem (2)

job	1	2	3	4	5
t_i	11	29	31	1	2
d_i	61	45	31	33	32

⋆ **Shortest processing time (SPT)**

SPT	4	5	1	2	3	sum	avg.
F_i	1	3	14	43	74	135	27
$T_i = \max\{F_i - d_i, 0\}$	0	0	0	0	43	43	8.6
tardy jobs	1						

⋆ **Earliest due date (EDD)**

EDD	3	5	4	2	1	sum	avg.
F_i	31	33	34	63	74	235	47
$T_i = \max\{F_i - d_i, 0\}$	0	1	1	18	13	33	6.6
tardy jobs	4						

Example: summary

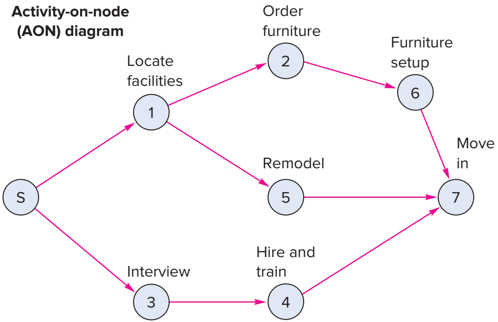
Rule	Average Flow time	Average Tardiness	Tardy Jobs
FCFS	53.6	24.2	3
SPT	27	8.6	1
EDD	47	6.6	4

Note: A solution obtained using the SPT rule is optimal for the goal of minimizing the average flow time.

Project scheduling

... with precedence relations

Display as a network (Activity on Node - AON)



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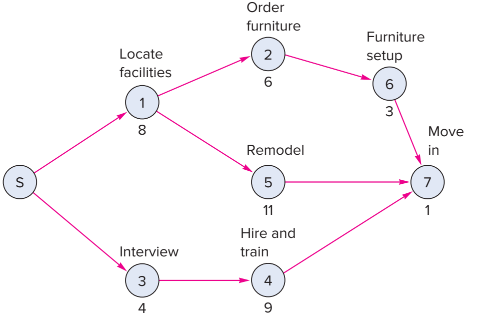
Example (network diagrams)

A bank is planning a new direct marketing department. The vice president responsible identifies the important activities to implement the project, decides the order in which they should be processed, and estimates the length of each activity in weeks (Numbers below the nodes)

	Activity	Length
1	Locate facilities	8
2	Order furniture	6
3	Interview	4
4	Hire and train	9
5	Remodel	11
6	Furniture setup	3
7	Move in	1



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Example (network diagrams)

Determine the expected project duration as well as the critical path.

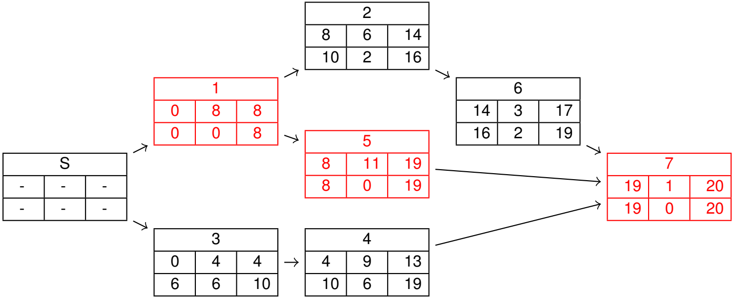
Critical path: The path through the network that does not contain any slack.

Aktivität		
ES	L	EF
LS	S	LF

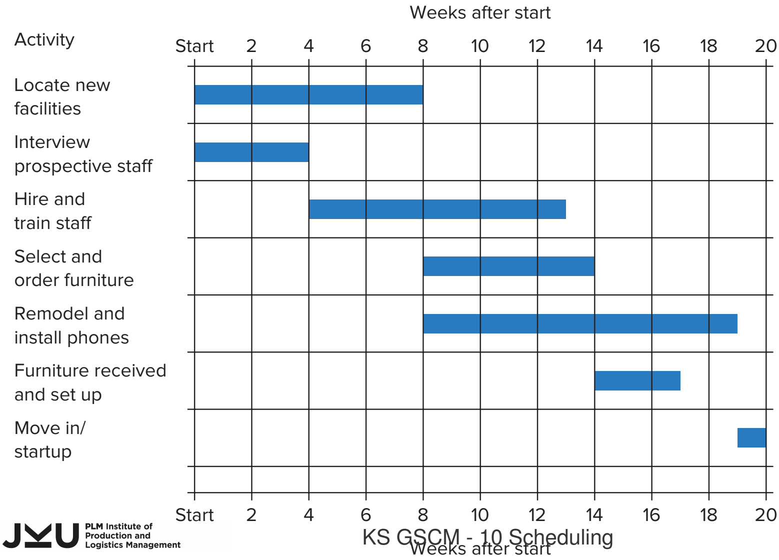
ES = Earliest starting time.
L = Length
EF = Earliest finishing time.
LS = Latest starting time.
S = Slack
LF = Latest finishing time.

Algorithm

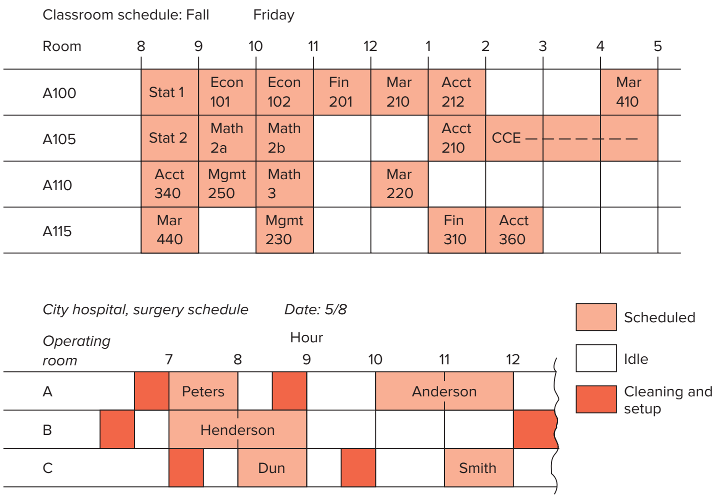
1. Forward Pass: determine ES and EF
2. Backward Pass: determine LF and LS
3. Calculate slack: S = LS-ES



Solution as Gantt Chart (ES)



Additional scheduling examples



Stevenson (2017)

Summary

- Scheduling is a very large area and often concerns planning problems on an operational level (e.g., production planning in the context of sequencing/machine scheduling).
- Gantt Charts are used to display solutions of different types of scheduling problems.
- Simple sequencing problems can be solved to optimality using simple priority rules (depends on the objective).
- Determining the critical path helps to identify processes that are critical with respect to their timing (slack = 0).