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Concepts

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Constraint Based Production Scheduling





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Key Points



- We introduce the core concepts used in scheduling
- Different layers of description
 - Why we are scheduling (orders, products, processes)
 - What we are doing (jobs, tasks)
- Temporal Relations
- Process description
- Problem classification
- Visualization

Outline



Core Concepts

- Jobs and Tasks

- Orders, Products, Processes

- Temporal Relations

- Processes, Bill of Materials

- Problem Classification

- Key Visualization Methods

- Summary

Most basic description of scheduling problem



- Job
 - Collection of activities required to manufacture one object/lot/order
 - Overall start/end determined by starts and ends of its tasks
- Task
 - Individual activities required for manufacture
 - Have defined start, end (typical: variables) and duration (sometimes fixed)
 - Often performed on one specific resource (more on that later)
- Very compact representation of scheduling problem
- But, where does the data come from?

Outline



Core Concepts

Temporal Relations

- Relations between Tasks

- Relation between Tasks and Jobs

- Jobs: Release and Due Date

Processes, Bill of Materials

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Temporal Relations

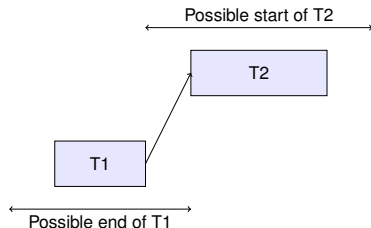


- Temporal constraints between tasks and/or jobs
- Defined by the manufacturing process
- In simple cases, a single sequence of process steps performed in that order
- Each task must finish before the next one can start

The Most Common Relation: EndBeforeStart



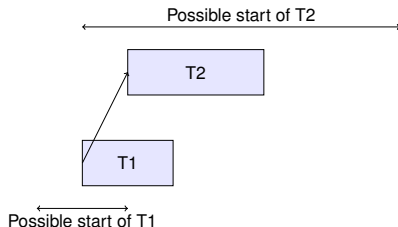
- States that one task (T1) must end before the next one (T2) can start
- Typical for manufacturing process based on the same item
- Addition: offset
 - For example cooling, drying time outside a machine



Less Common: startBeforeStart

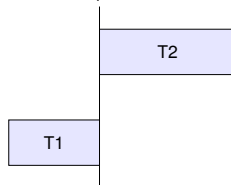


- States that one task (T2) can start any time after the start of another task (T1)
- Uncommon in manufacturing, occurs in project management
- Example later on on assembly line balancing



- Sometimes, two steps must follow each other immediately
- The item made would spoil
- Product specific
- There is no space to hold item
- Machine specific, buffers
- End of one task (T1) must be equal to start of next task (T2)
- May mean delay of start of task T1

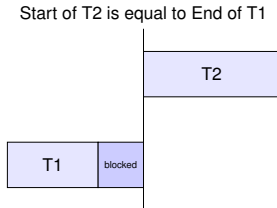
Start of T2 is equal to End of T1



Blocking



- Sometimes, two steps must follow each other immediately
- There is no space to hold store item between machines
- Keep item on previous machine until needed
- That machine is now blocked
- Duration of task T1 is extended
- Use with caution!



More General: Relations between Intervals



- First introduced by Allen (1983)
- 13 relations between intervals
- Allows composition of relations
- Constraint reasoning on sets of relations

Relation	Illustration	Interpretation
$X < Y$ $Y > X$		X precedes Y Y is preceded by X
$X m Y$ $Y mi X$		X meets Y Y is met by X (<i>i</i> stands for <i>inverse</i>)
$X o Y$ $Y oi X$		X overlaps with Y Y is overlapped by X
$X s Y$ $Y si X$		X starts Y Y is started by X
$X d Y$ $Y di X$		X during Y Y contains X
$X f Y$ $Y fi X$		X finishes Y Y is finished by X
$X = Y$		X is equal to Y

from Wikipedia: [https://en.wikipedia.org/wiki/](https://en.wikipedia.org/wiki/Allen%27s_interval_algebra)

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Core Concepts

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Problem Classification

- Job-Shop

- Flow-Shop

- Open-Shop

- RCPSP

- α, β, γ Notation

Key Visualization Methods

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- We introduced the key concepts for scheduling problems
- Orders, products, processes
- Jobs and tasks
- Existing problem classifications
 - Academic
 - Limited practical usefulness
- Key visualization methods