

# Towards Additive Manufacturing industrialization: efficient nesting and scheduling of irregular parts



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**IDEAS TO IMPACT**

MIT Portugal  
2024 Annual Conference

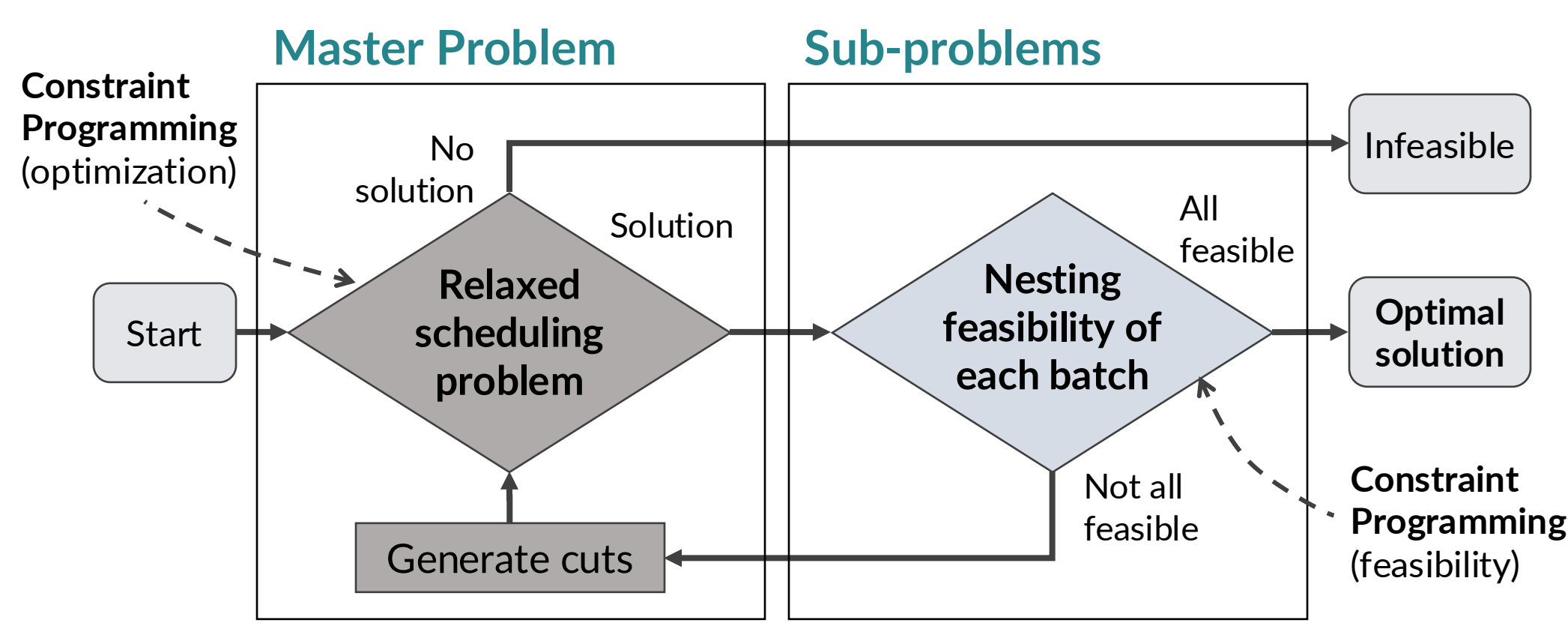
## BACKGROUND

Additive Manufacturing has the potential for addressing key challenges in supply chain efficiency and environmental sustainability. Realizing its potential, however, demands customized solutions for production scheduling and nesting problems.

To cut costs and avoid wasting space, the two problems must be solved simultaneously, and parts' irregularities must be considered in the nesting problem.

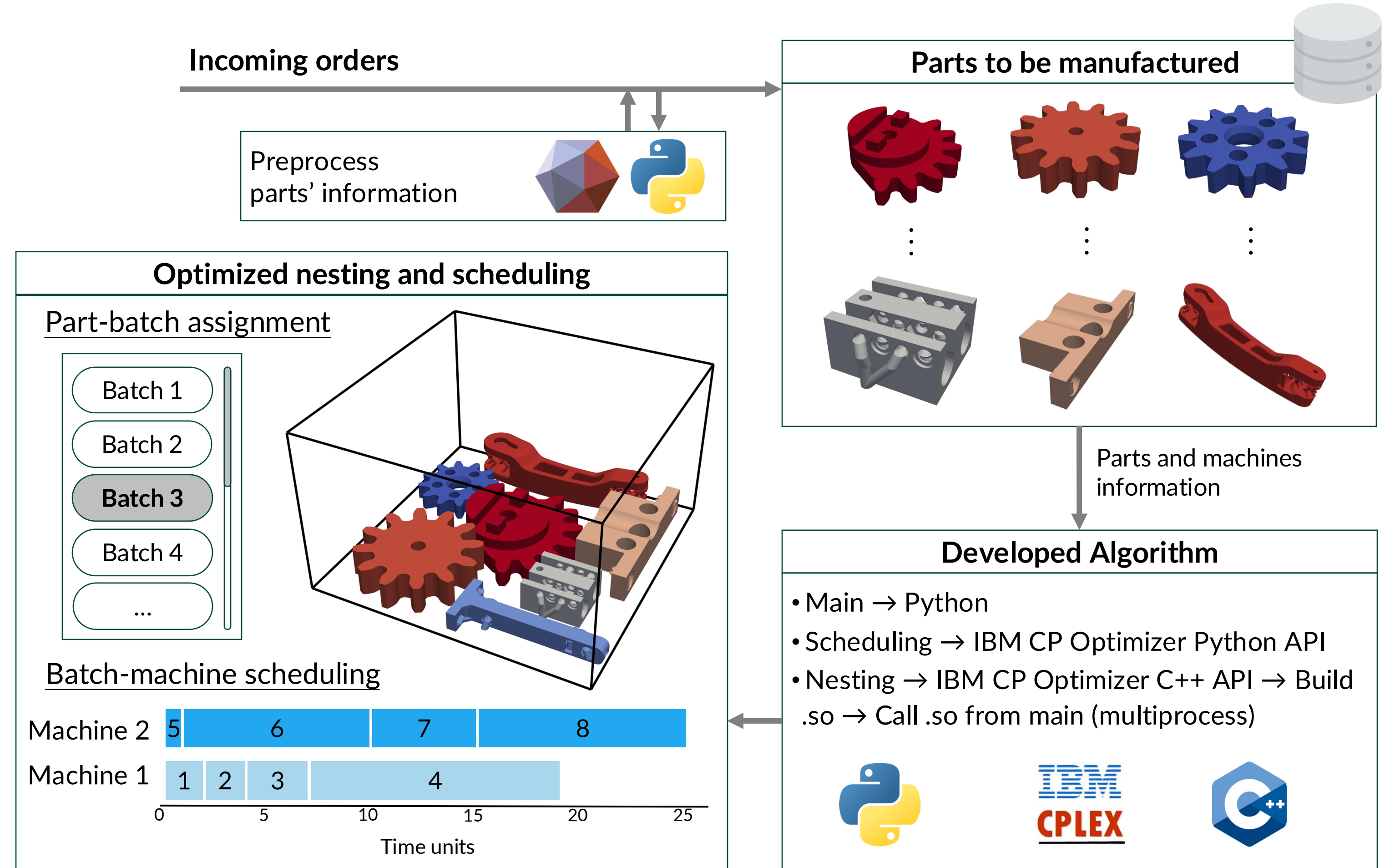
## METHODS

Developed Algorithm - efficient exact method to obtain optimal solutions



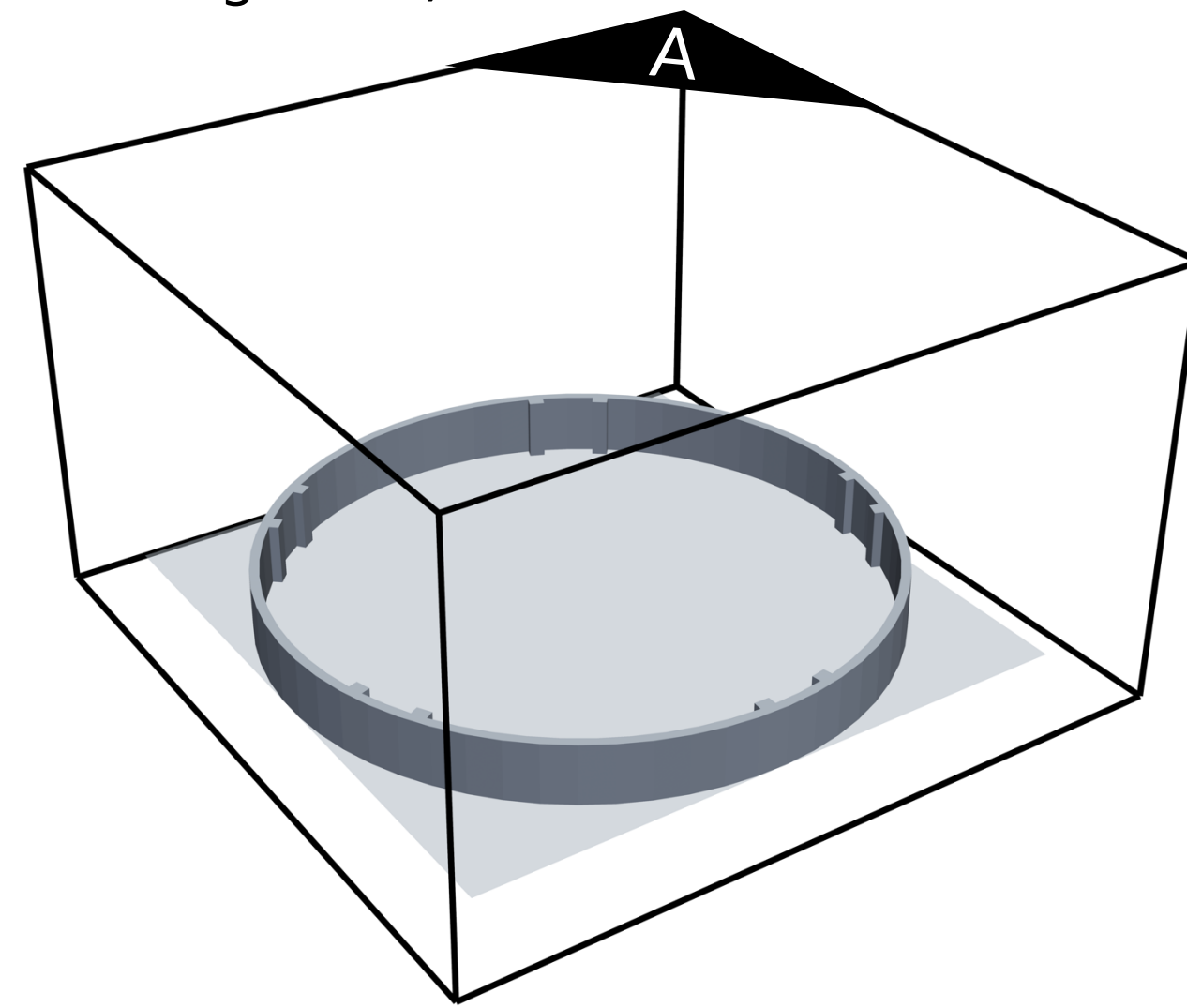
- Minimization of tardiness while nesting irregular-shaped parts using logic-based Benders.
- Two-dimensional nesting using dotted-board model, no-fit polygon, and inner-fit polygon concepts, as well as a custom global constraint.
- Build platform: 20x20x12cm.
- Parts (STL files) from Thingiverse (support structures created via Autodesk Meshmixer).

## PROPOSED ARCHITECTURE LEVERAGING THE POWER OF MULTITHREADING

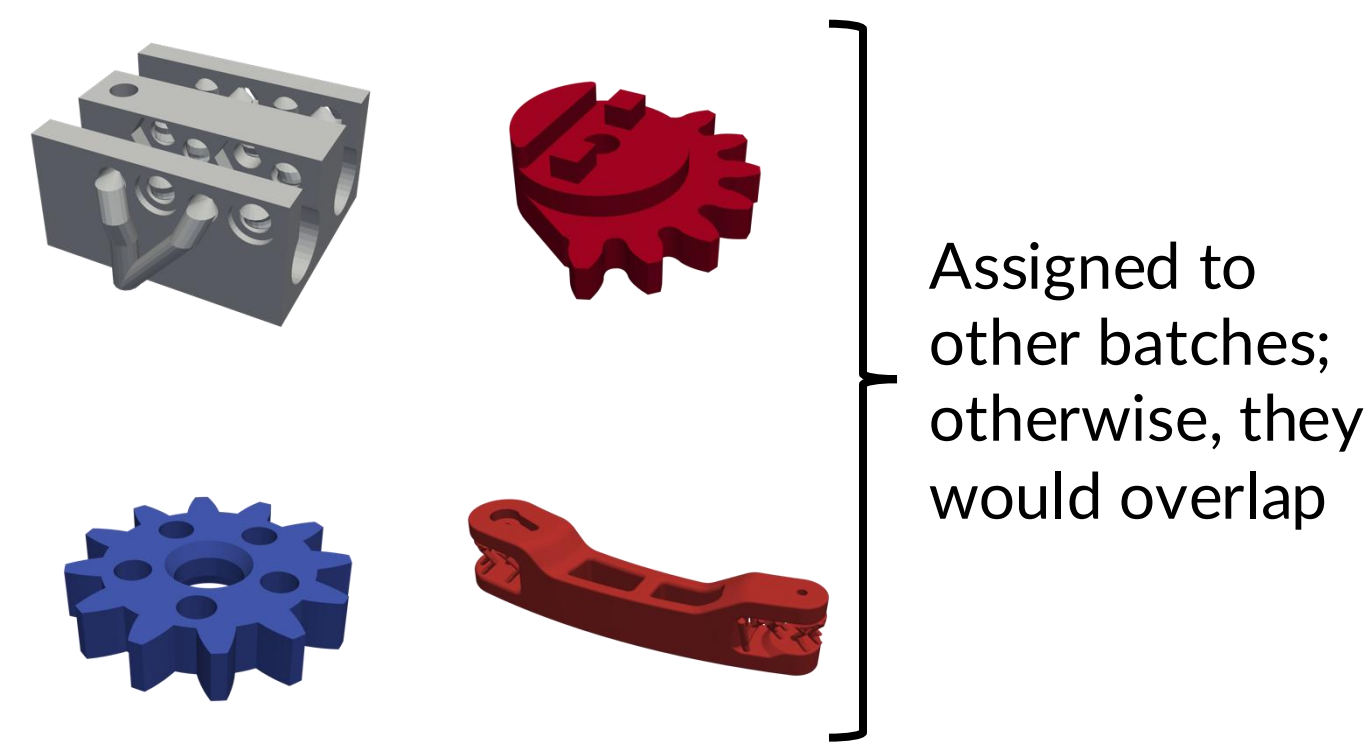
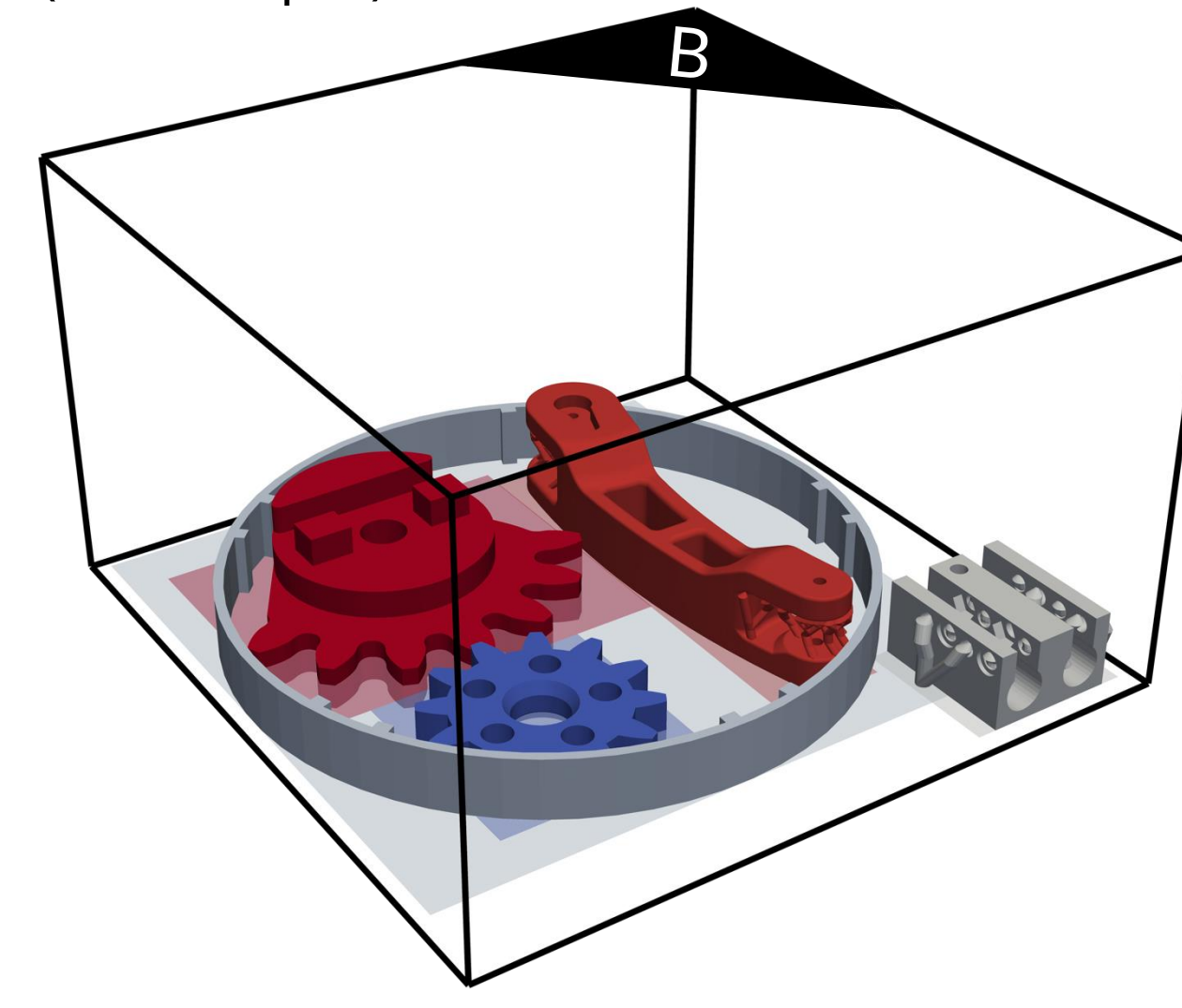


integrated  
scheduling and  
irregular part  
nesting improves  
machine utilization  
and customer  
satisfaction

Previous approaches  
(Bounding boxes)



Our approach  
(True shapes)



For the same instance, considering parts' irregularities and holes over bounding boxes allows for more efficient arrangements, positively impacting scheduling

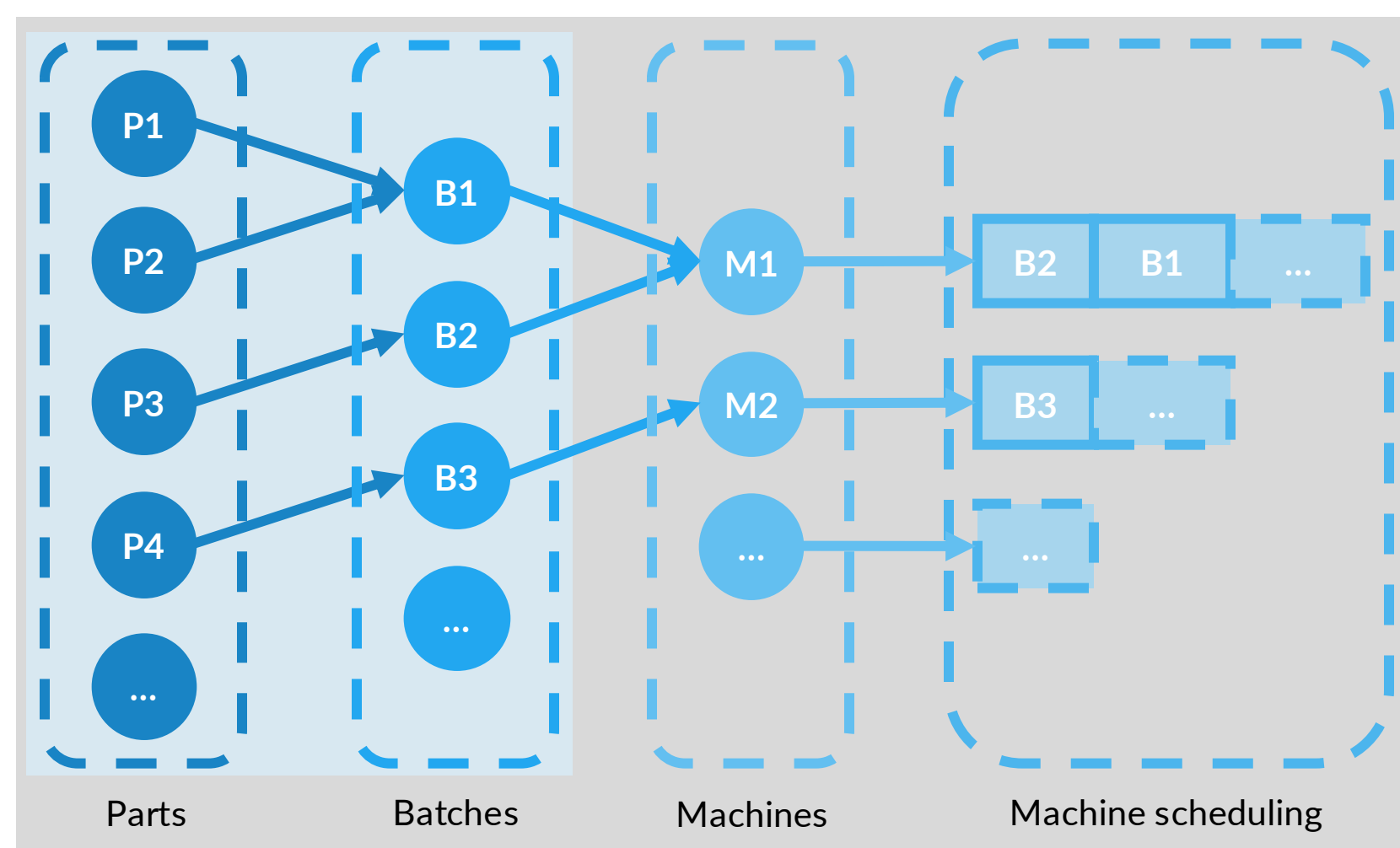
## Key results

Up to **30%** increase in machine utilization

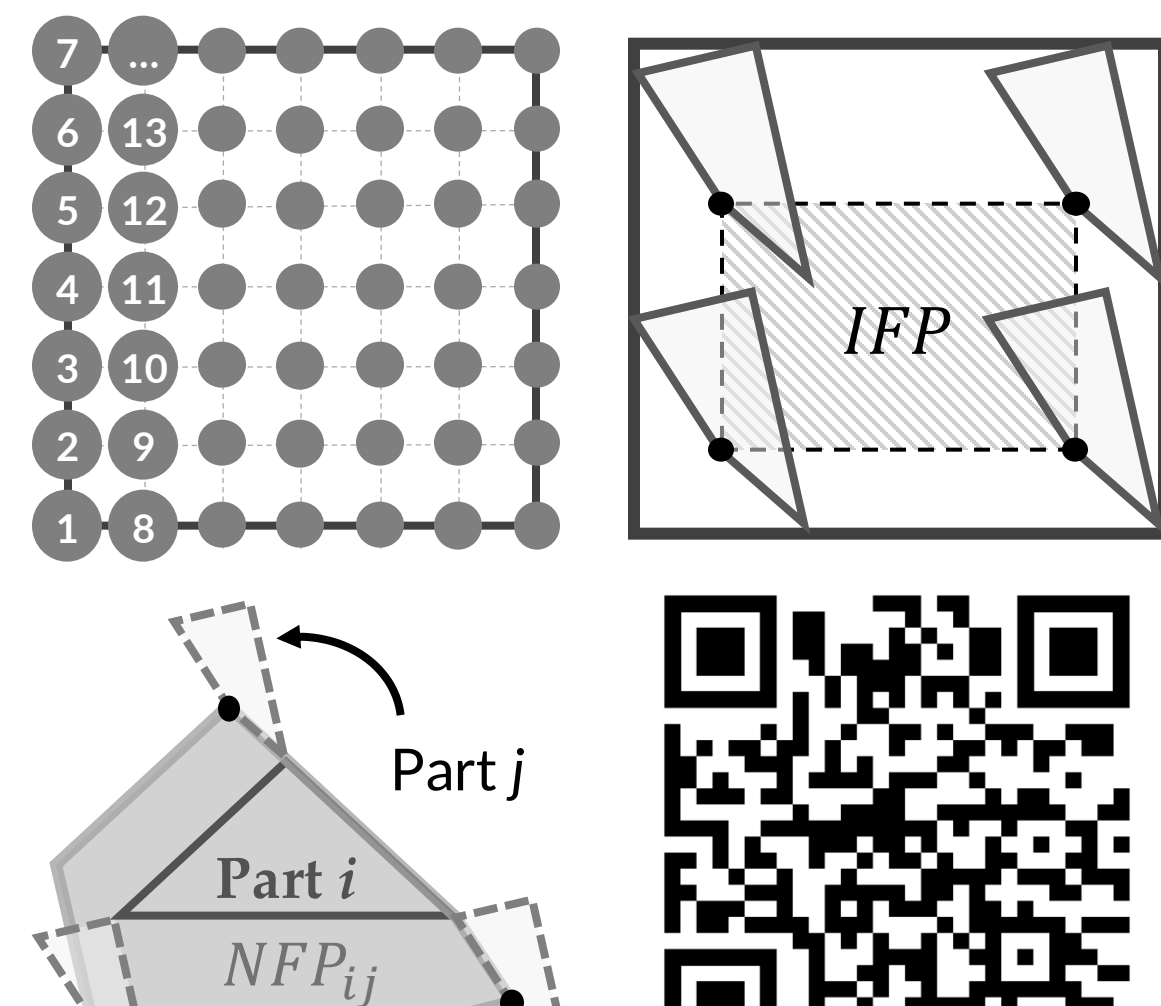
Average decrease of **35%** in late orders

Up to **20%** decrease in processing times

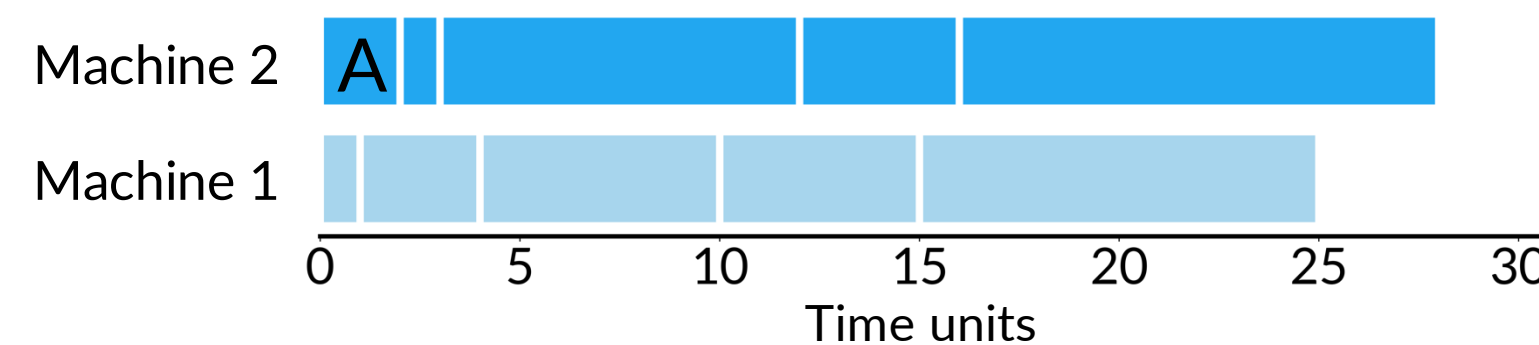
### Nesting and scheduling problems in Additive Manufacturing



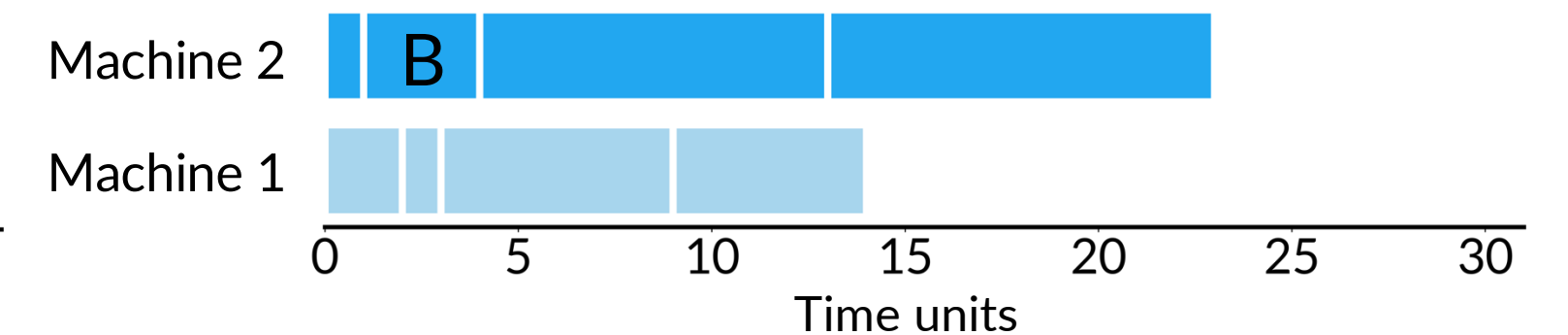
### Dotted-board model for nesting



### Production scheduling considering bounding boxes



### Production scheduling considering irregular shapes



### % improvement of considering irregular shapes over bounding boxes

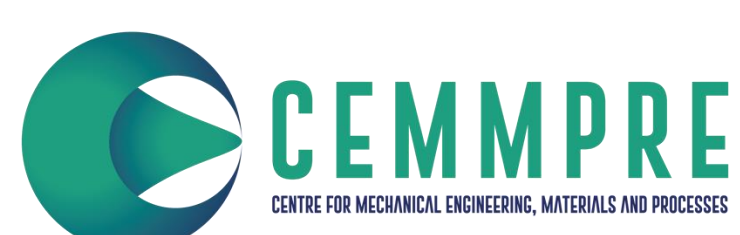
# parts	Machine utilization		Completion times		Tardiness	
	Av.	Range	Av.	Range	Av.	Range
20	19.6	[11.1, 28.6]	7.6	[2.1, 7.6]	18.9	[8.1, 25.8]
30	22.9	[5.9, 70.0]	16.3	[0.0, 58.2]	38.2	[7.1, 90.0]
50	27.3	[3.8, 100.0]	19.5	[0.4, 55.0]	45.7	[29.4, 65.7]
120	31.2	[26.6, 33.3]	22.4	[16.5, 40.5]	49.0	[40.0, 58.8]

These results are highly dependent on how irregular the parts are, as well as on the distribution of release and due dates

### References:

1. Nascimento, P., Silva, C., Mueller, S., & Moniz, S. (2023). Nesting and Scheduling for Additive Manufacturing: An Approach Considering Order Due Dates. In J. P. Almeida, C. S. Geraldas, I. C. Lopes, S. Moniz, J. F. Oliveira, & A. A. Pinto (Eds.), *Operational Research, IO 2021*. Springer Proceedings in Mathematics & Statistics (pp. 117–128). Springer, Cham.
2. Pinto, M., Silva, C., Thürer, M., & Moniz, S. (2024). Nesting and scheduling optimization of additive manufacturing systems: Mapping the territory. *Computers & Operations Research*, 165, 106592.
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