20 Working together — scheduling operations in assisted order picking

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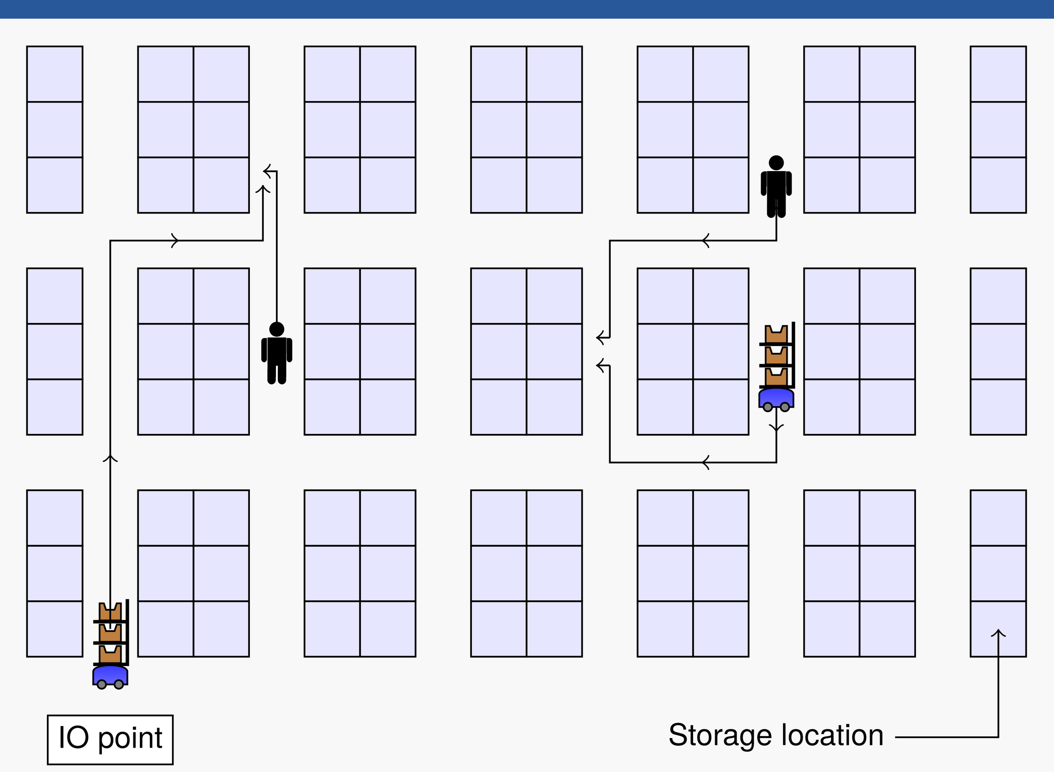
Introduction

- There is a need for more efficient ways to organize the order picking process as
  - *the number of daily orders to be processed increase*
  - *the required lead time becomes shorter*
- We propose/analyze
  - *an analytical model for assisted order picking systems*
  - *the effect of product allocation on the system makespan*

Assisted order picking (AOP)

- In AOP, humans and pick robots collaborate to pick orders
- The robots transports the picked products, whereas the humans pick the products from their storage location
- The advantages are
  - *Easy to apply and no reconfiguration of warehouse needed*
  - *The number of robots is scalable*
  - *Orders pickers can purely focus on picking*

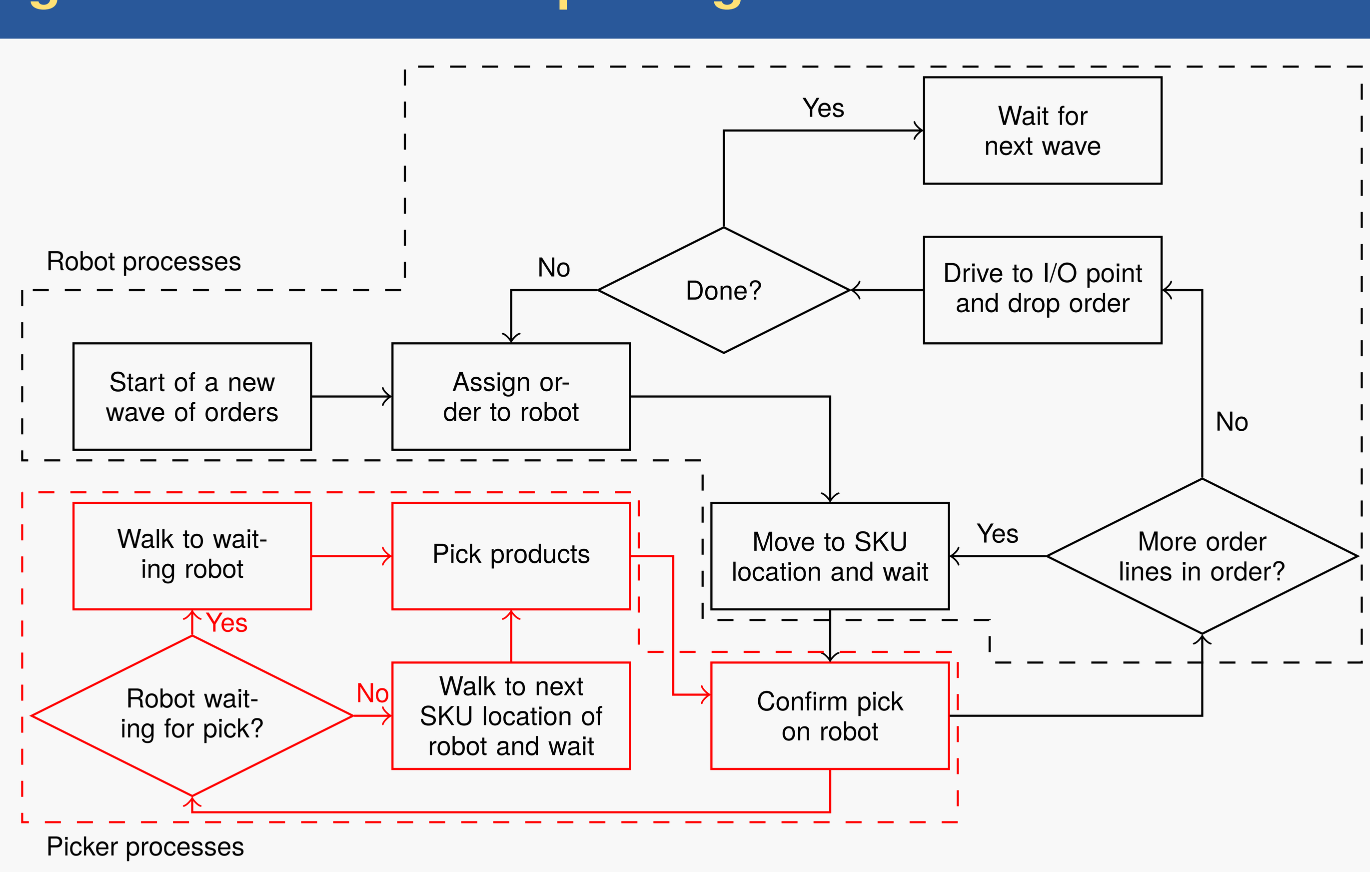
System layout



Research overview

- We study/model different operational settings for AOP
- The model gives insight into the performance
  - *different strategies (picker-in-lead, robot-in-lead)*
  - *configurations (order picking area, number of robots, number of orders)*
  - *product allocation (within-aisle, across-aisle, middle-aisle)*

Flow diagram assisted order picking



Solution model

- We minimize the makespan of an order wave, where each order can consists of multiple pick tasks

Min Makespan of an order wave

s.t. Every pick task for a robot has a successor & predecessor

Every pick task for a human has a successor & predecessor

|P| pickers start and finish at the IO point

|C| robots start and finish at the IO point

Each robot can work on one order at a time

A pick task completion time equals the maximum arrival time of the robot/human plus the time to pick

The decision variables are the pick task sequence for the robots/humans

Solution method

- Previous model computational difficult to solve with a regular MIP solver
- Regular sized instances can be solved with a good starting LB/UB and additional valid cuts

Calculate shortest tour to pick each order → Obtain minimum time to pick orders with only robots (LB) → Construct a feasible starting solution (UB) → Solve previous model with new starting LB/UB and cuts

Results

Number of orders in the wave (Robot-in-lead)

		10		25		50	
Size	**Storage**	Value	Gap	Value	Gap	Value	Gap
Small	Random	79.92	0.05	184.79	0.08	380.38	0.10
	Within	46.08	0.11	116.33	0.17	231.67	0.28
	Across	59.62	0.09	132.67	0.11	241.46	0.14
	Middle	74.59	0.06	173.36	0.08	340.90	0.07
Medium	Random	200.54	0.02	425.03	0.06	914.03	0.08
	Within	97.49	0.08	248.82	0.13	531.44	0.11
	Across	127.36	0.08	277.38	0.05	567.74	0.10
	Middle	95.13	0.05	225.44	0.08	517.64	0.10
Large	Random	381.05	0.02	797.56	0.07	1789.7	0.05
	Within	157.23	0.04	411.67	0.13	873.46	0.17
	Across	229.00	0.06	544.54	0.07	1148.8	0.09
	Middle	172.00	0.03	402.10	0.10	945.69	0.14

Number of orders in the wave (Picker-in-lead)

		10		25		50	
Size	**Storage**	Value	Gap	Value	Gap	Value	Gap
Small	Random	82.97	0.09	189.54	0.10	389.03	0.12
	Within	54.49	0.25	126.74	0.23	239.38	0.31
	Across	60.46	0.10	136.15	0.14	243.03	0.15
	Middle	75.77	0.07	177.49	0.10	348.08	0.09
Medium	Random	205.26	0.05	424.15	0.06	937.82	0.10
	Within	104.51	0.14	263.82	0.18	582.44	0.19
	Across	127.36	0.08	288.82	0.09	577.10	0.11
	Middle	97.95	0.07	228.69	0.09	526.67	0.11
Large	Random	389.62	0.05	791.18	0.06	1890.3	0.10
	Within	174.23	0.13	409.67	0.12	882.54	0.18
	Across	237.03	0.10	548.10	0.07	1154.1	0.09
	Middle	179.03	0.07	419.31	0.14	994.79	0.18

Conclusions and further research

- *Assisted order picking leads to significant improvements in makespan (and other statistics).*
- Well suited for e-commerce companies that deliver same-day
- Possible extensions
  - *Zoning*
  - *Stochastic order arrivals*

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