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Integration of logistics system design and logistics system analysis models

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Outline

1. Overview
2. Problem description
3. Performed analysis
4. Conclusion and next steps

Scenario

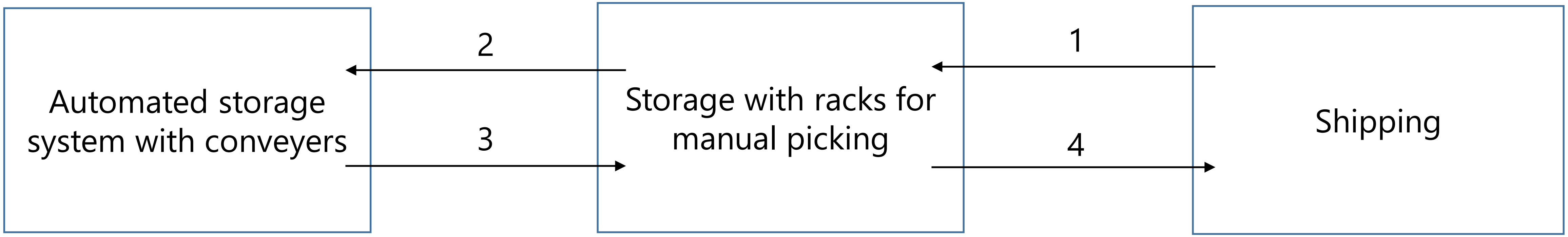
Combining an automated storage system with conventional storage in an order assembly process.

The conventional storage is zoned into two distinct areas.

Orders are assembled in a batch pick and pack process, where the order picker visits the three zones (two manual and one automated)

The challenge is to estimate system performance for various design alternatives for the automated system.

Overview



Three different zones

Could be visited in any order. For the sake of argument, assume the automated zone is the second one visited.

Picker assembles a three layer pallet

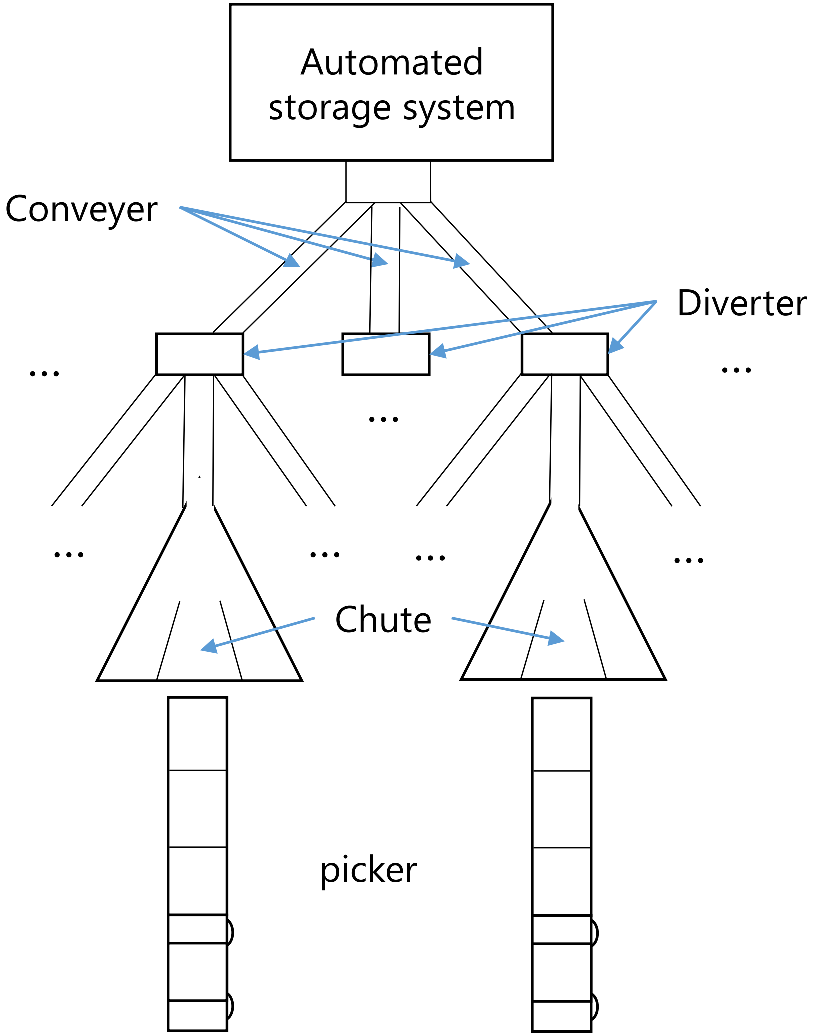
For the sake of argument, assume the orders are assembled on pallets, in layers by zone, in a batch of three pallets (orders).

Problem Description: Automated System

Goods from the automated system are routed to chutes by order, and the three orders in a pick batch are routed to adjacent chutes.

Key design issues:

- How many sets of chutes?
- How much capacity in each chute?
- How to sequence retrievals from the storage system?



Problem description: Operation

Possible scenarios for a picker on arriving at automated storage system

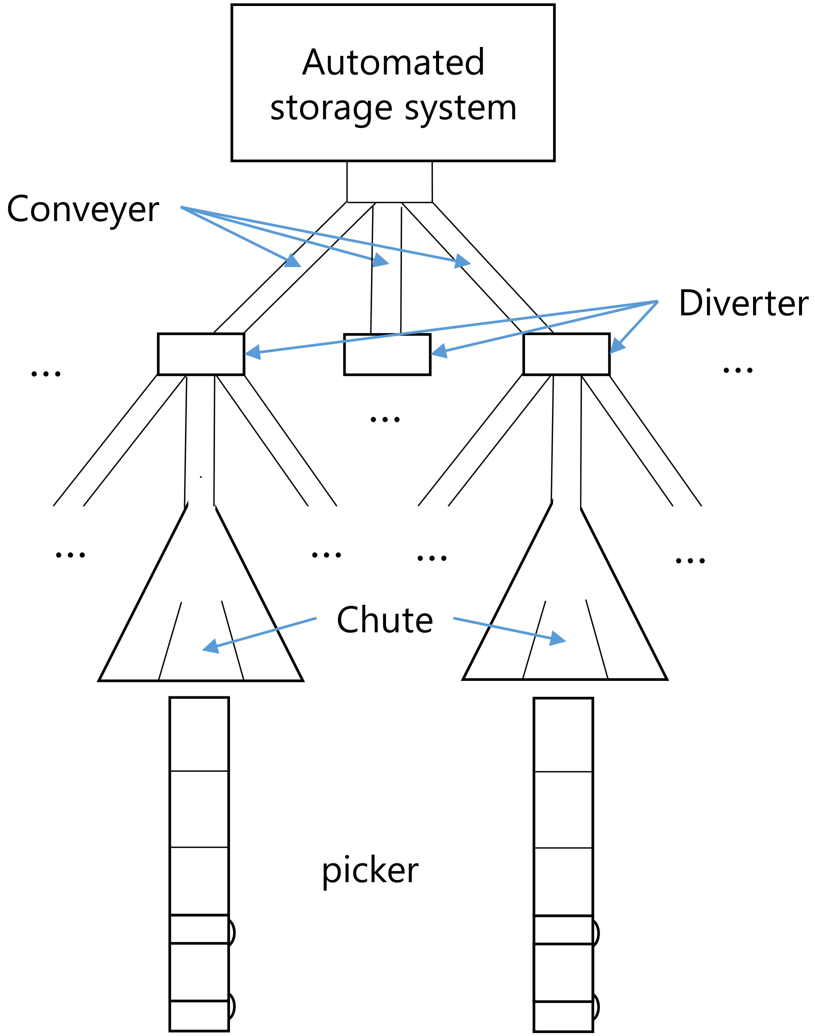
1. picker arrives, picks second layer and leaves to pick the third layer at manual storage

OR

2. picker arrives, all chutes are occupied by other pickers and picker has to wait until a chute becomes free so that the automated storage system can send out cases

OR

3. picker arrives at a free chute but has to wait, because the automated storage system hasn‘t send out any cases yet

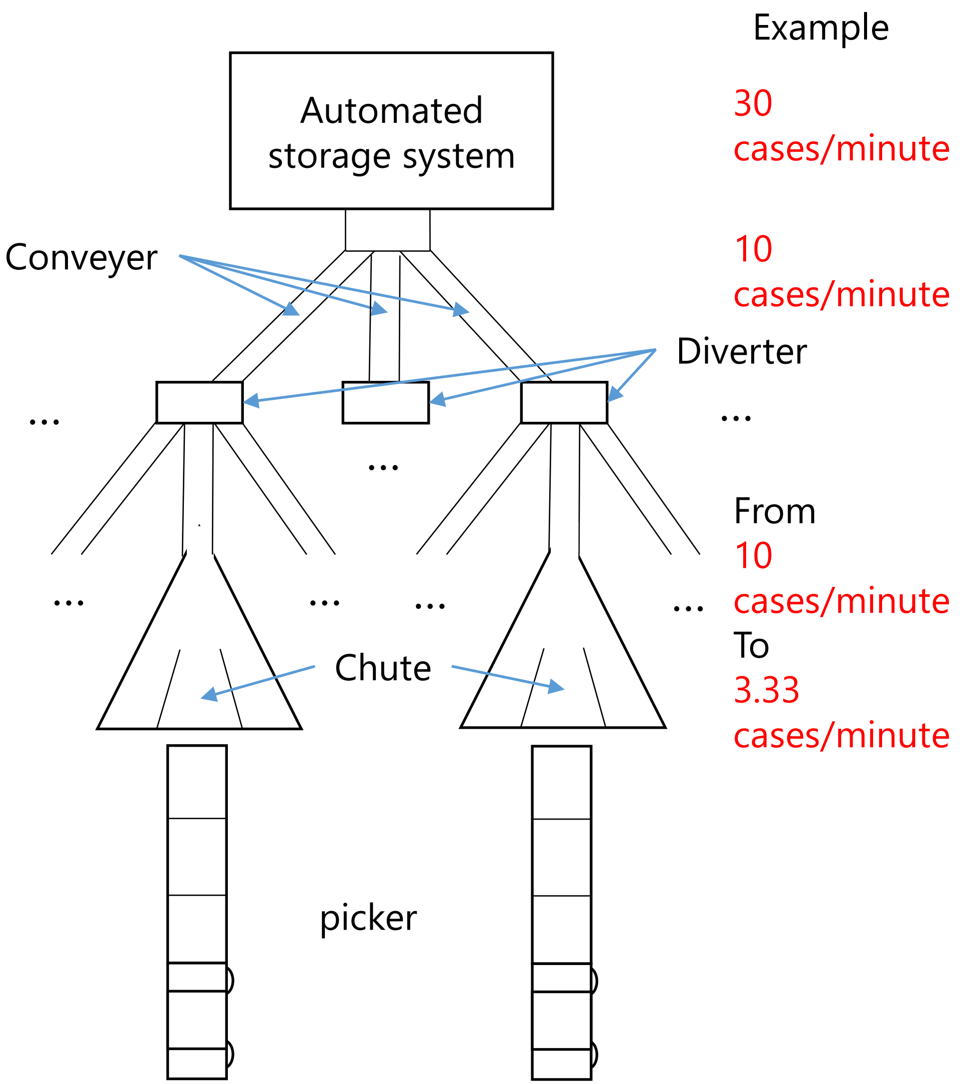


Problem description

Details of automated storage system

- Automated storage system starts sending out new cases when a picker scans the last case at a chute
- Automated storage system has an average output rate per minute
- Conveyers can handle an average output rate of cases which is determined by average output rate per case of automated storage system divided by the number of conveyers
- Diverters can keep up with average output rate of the conveyers
- The time it takes to fill up a chute depends on how many chutes are going to be filled at the moment within one diverter

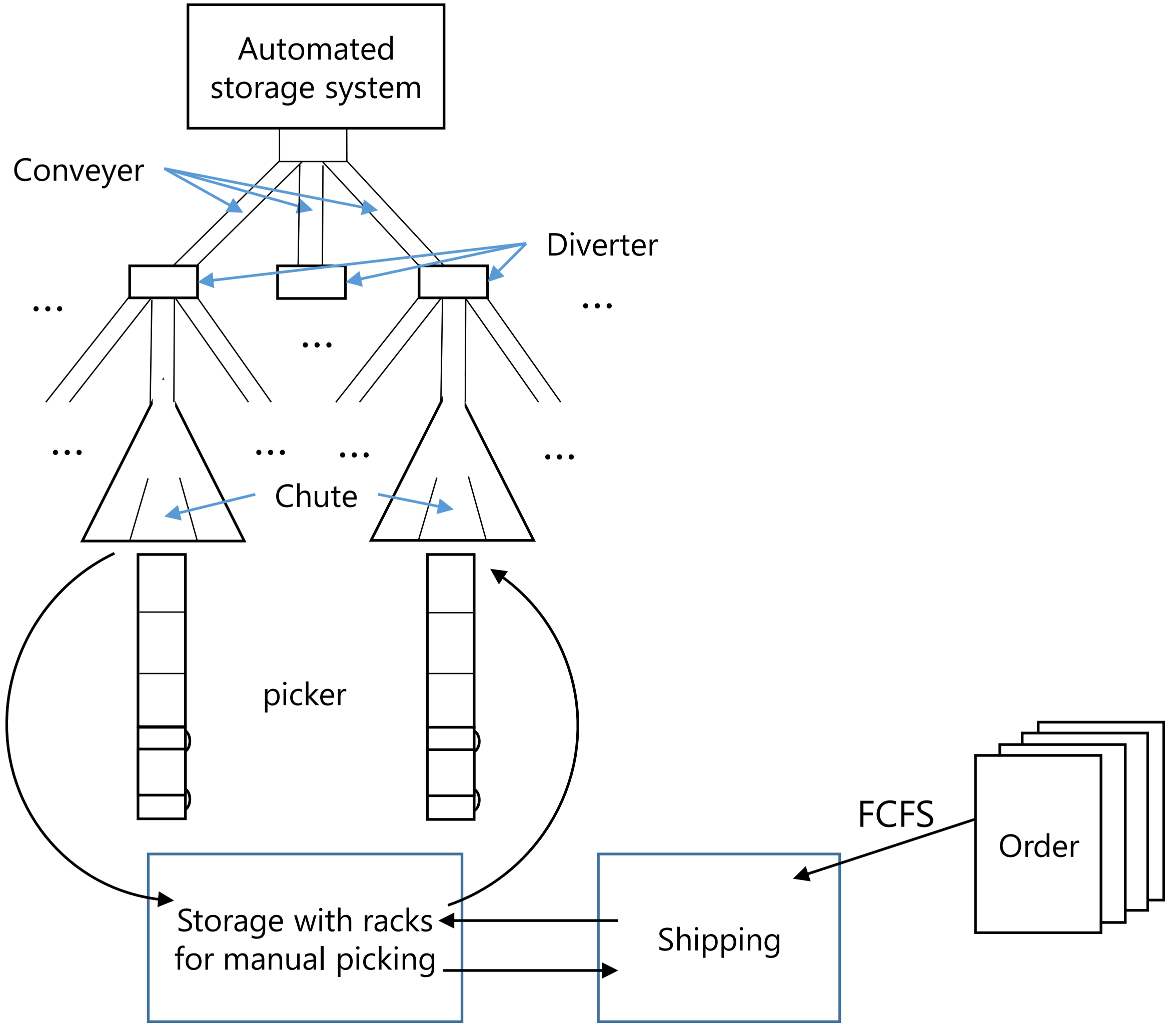
➢ Let's take a look at an example



Performed analysis

General assumptions

- Travel times between zones are deterministic
- Picking time at each zone is constant
- Pickers cannot overtake each other
- Order sequence is determined externally (FCFS)
- Given number of conveyors and chutes and number of pickers and removal rate are investigated



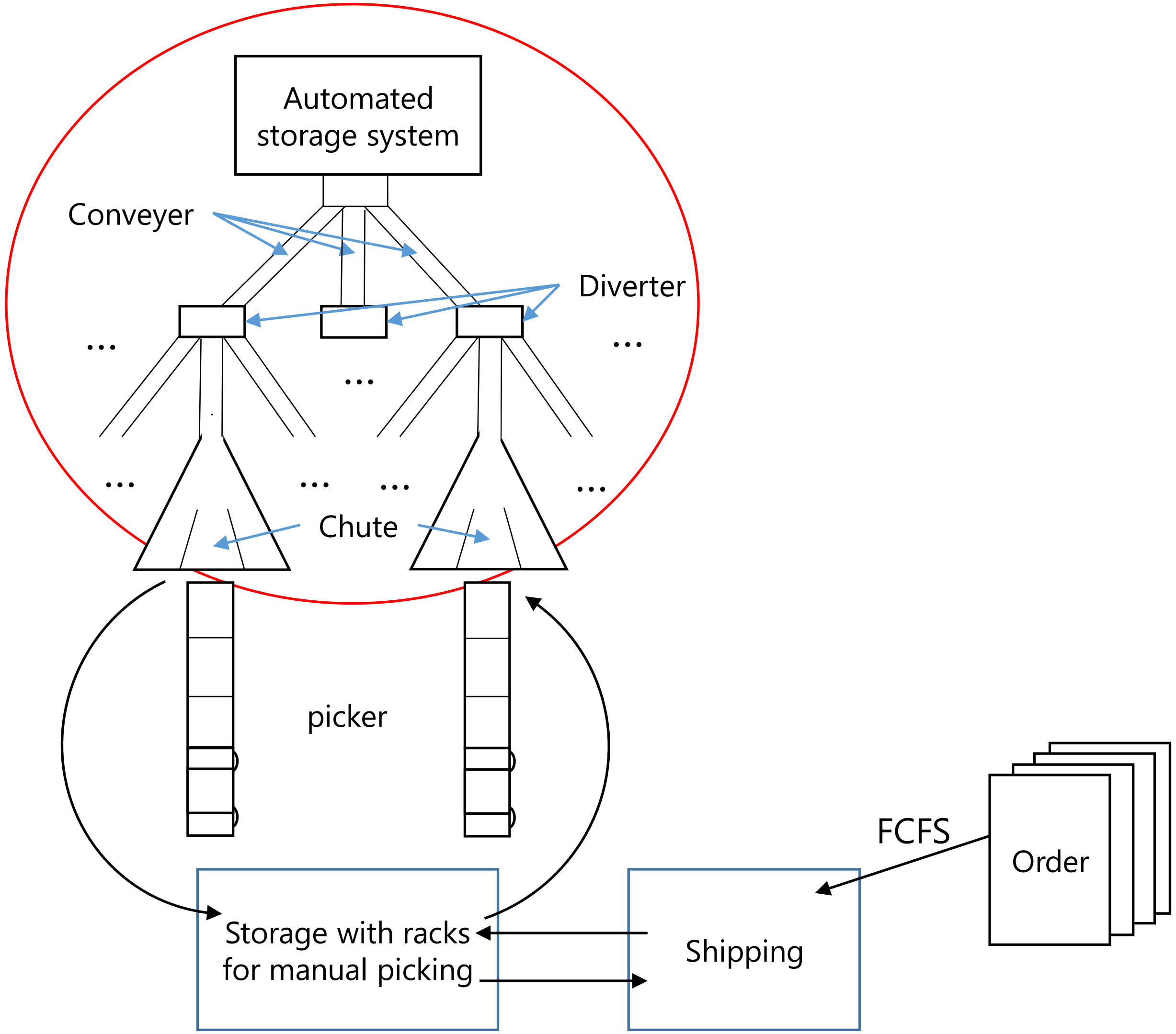
Performed analysis

1. Automated storage system is never the bottleneck

Items are always ready at chute when picker arrives

Performed analysis

- Determine the probability of being blocked at chute
- Find the expected blocking time for each picker
- Determine interference loss in the removal rate depending on the number of pickers



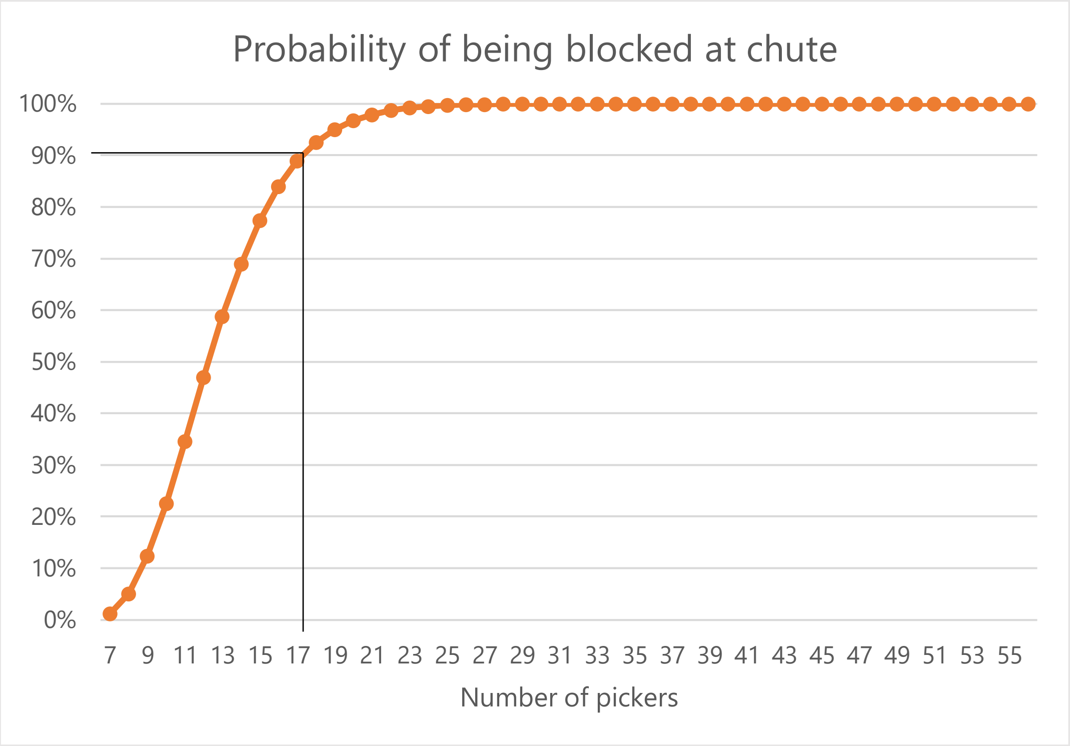
1. Automated storage system is never the bottleneck Example with 2 conveyers and 6 chutes (1/2)

$$\sum_{k=No.\,of\ chutes+1}^{n=No.\,of\ selectors} \binom{n}{k-(No.\,of\ chutes+1)} * P(being\ at\ chute)^{n-(k-(No.\,of\ chutes+1))} * P(being\ not\ at\ chute)^{k-(No.\,of\ chutes+1)}$$

with

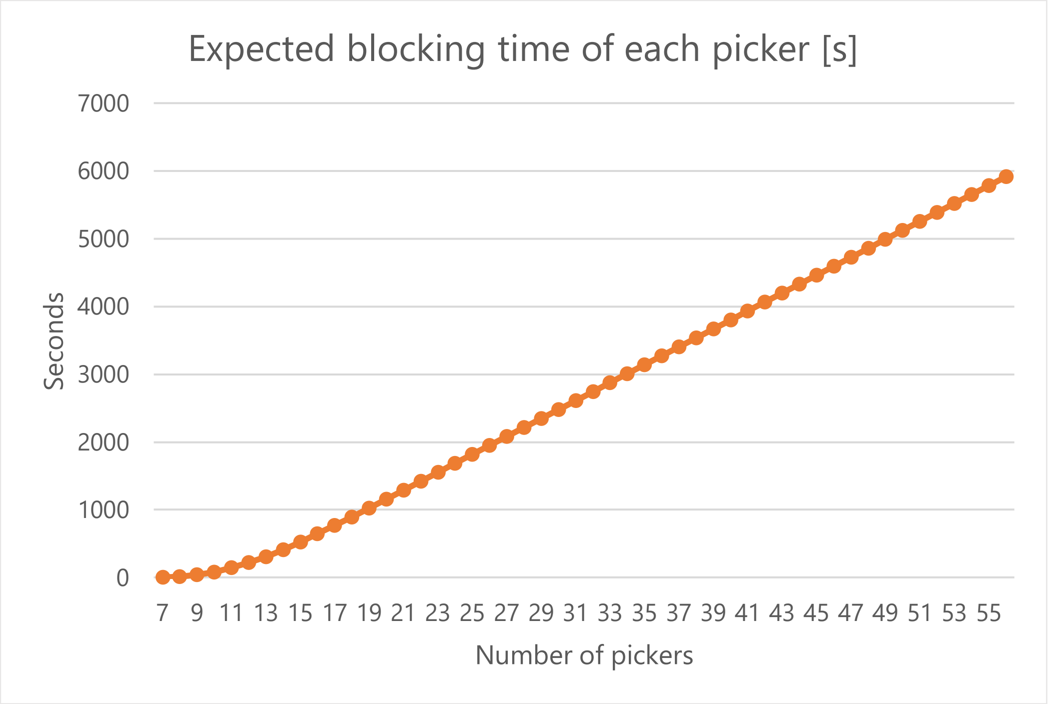
$$\binom{n}{k-(No.\,of\ chutes+1)} = \frac{n!}{(k-(No.\,of\ chutes+1))!\,(n-(k-(No.\,of\ chutes+1)))!}$$

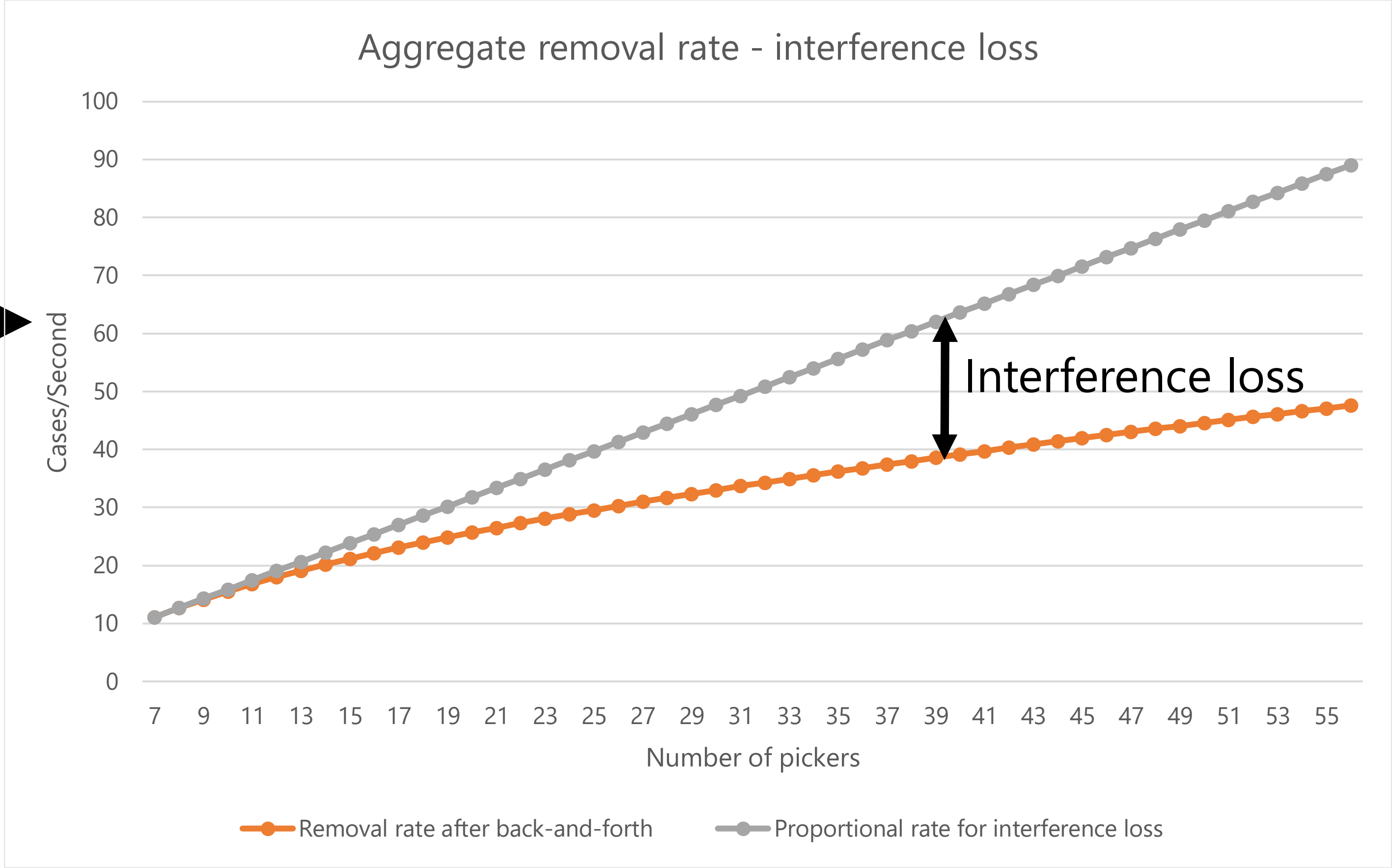
	A	B	C	D	E	F
1	**Time parameters**				**Resource parameter**	
2	Travel in Store 1	100	[s]		No. of Chutes	6
3	Time to pick Layer 1	20	[s/case]		No. of Triples	7
4	Travel from Store 1 to Chute	20	[s]		Cases per 1st Layer	25
5	Blocked time	0	[s]		Cases per 2nd Layer	75
6	Time to remove cases (2nd Layer)	20	[s/case]		Cases per 3rd Layer	25
7	Travel from Chute to Store 1	20	[s]		Maximum No. Of Triples	56
8	Travel in Store 1	100	[s]			
9	Time to pick Layer 3	20	[s/case]			
10	Travel from Store 1 to Shipping	20	[s]			
11	Time in Shipping	50	[s]			
12	Travel from Shipping to Store 1	20	[s]			



1. Automated storage system is never the bottleneck Example with 2 conveyers and 6 chutes (2/2)

Probability of being blocked at chute





Removal rate converges as No. of pickers increases

- ➢ After a certain number of pickers additional pickers do not improve the performance

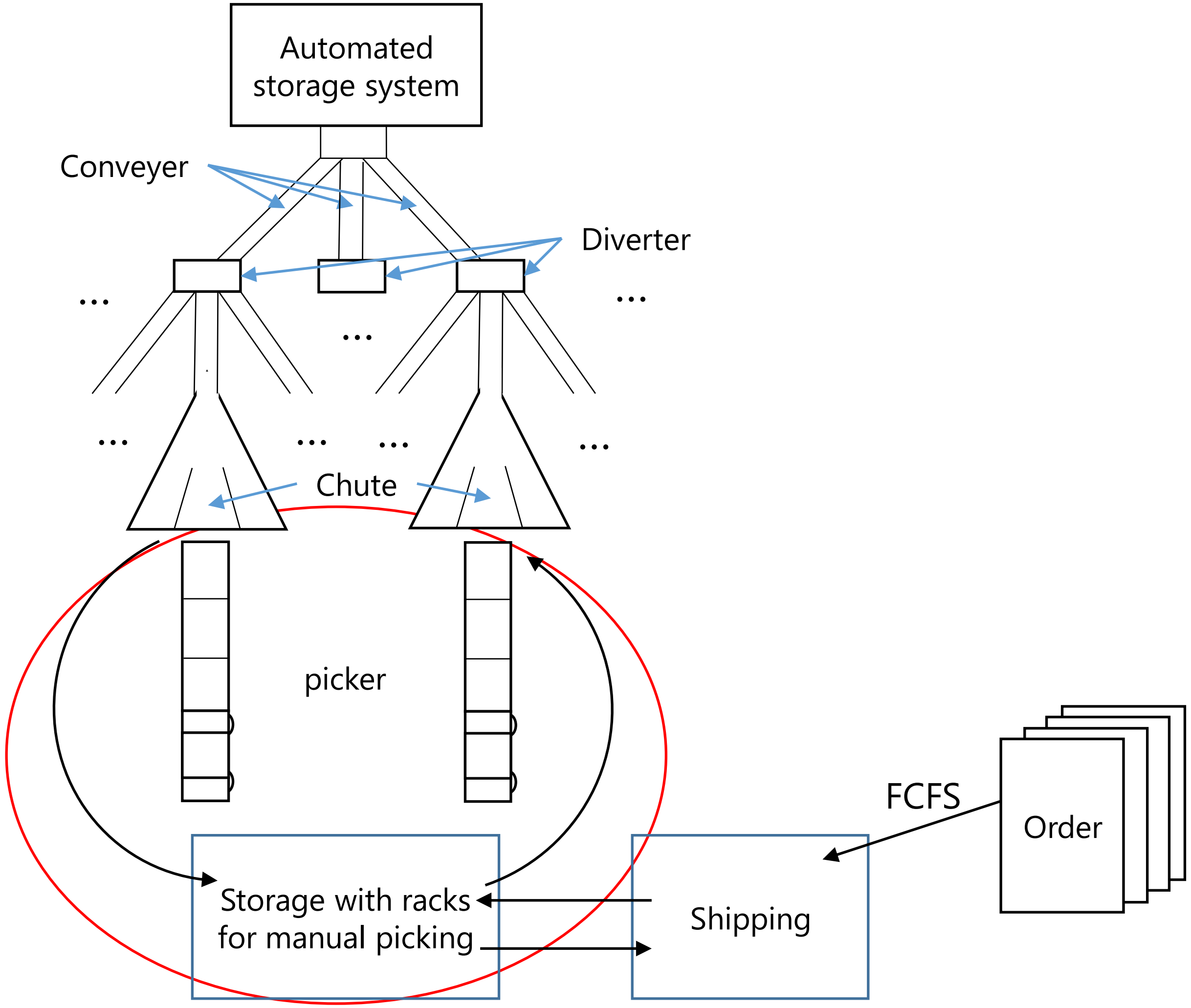
Performed analysis

2. pickers are never the bottleneck

pickers arrive back-to-back when a picker leaves a chute

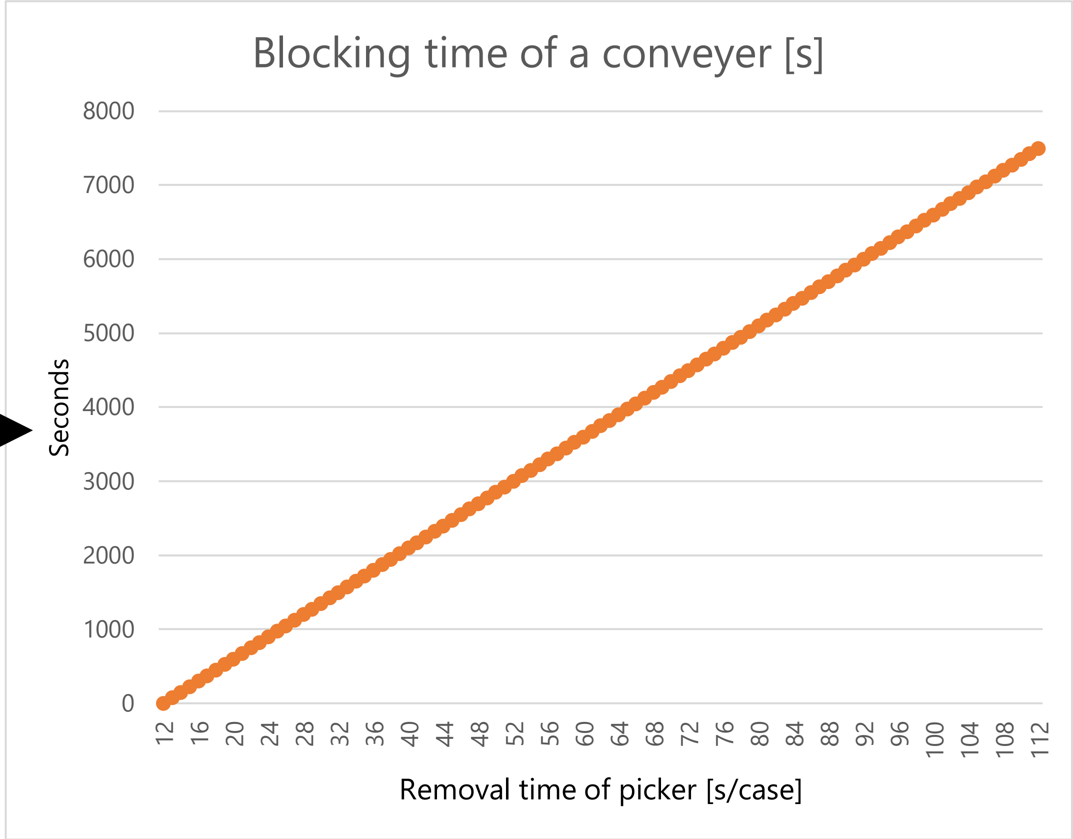
Performed analysis

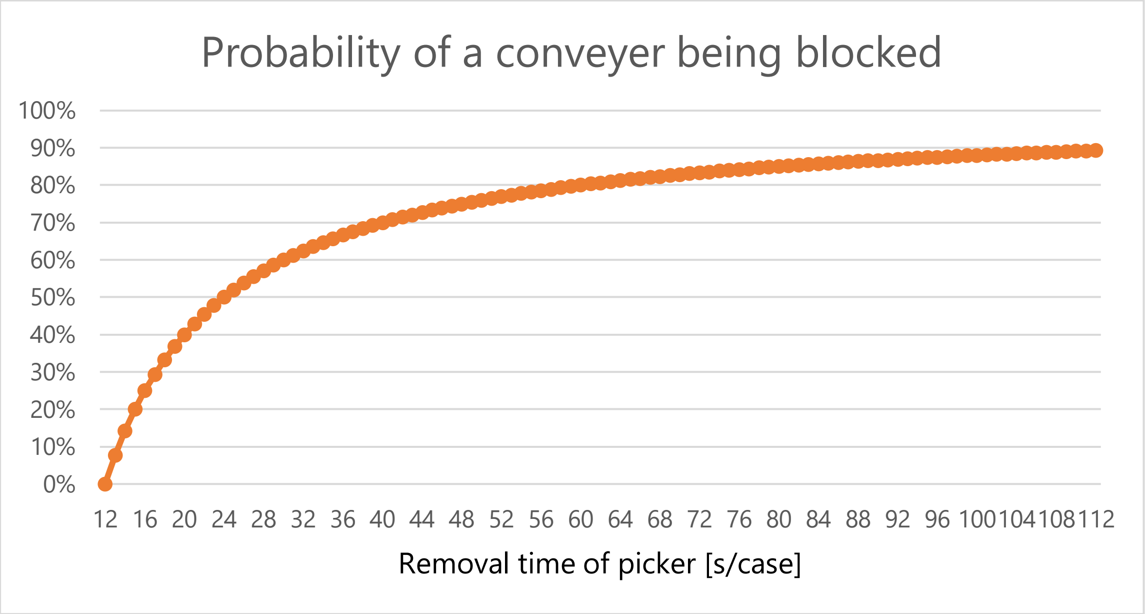
- Determine the probability of a conveyer being blocked
- Find the expected blocking time of a conveyer
- Performe the same computation for the automated storage system



2. pickers are never the bottleneck
Example with 2 conveyers and 6 chutes (1/2)

	A	B	C	D	E	F
1	**Time parameters**				**Resource parameter**	
2	Removal rate per case (2nd Layer)	20	[s/case]		Cases per 2nd Layer	75
3	Starting Removal rate per case (2nd Layer)	15	[s/case]			
4	Time needed to complete picking at Store 2	1500	[s]			
5						
6	Output rate of automated storage system	30	[cases/min]			
7	Output rate for each of the 2 conveyer	15	[cases/min]			
8	Time needed to fullfill three chutes	900	[s]			
9						
10	Probability of conveyer being idle	40,00%				
11	Probability of being busy	60,00%				





- The longer the removal time of picker the higher the probability of a conveyer being blocked
- Same occurs to blocking time of a conveyer

2. pickers are never the bottleneck
Example with 2 conveyers and 6 chutes (2/2)

	A	B	C	D	E	F
1	**Time parameters**				**Resource parameter**	
2	Removal rate per case (2nd Layer)	20	[s/case]		Cases per 2nd Layer	75
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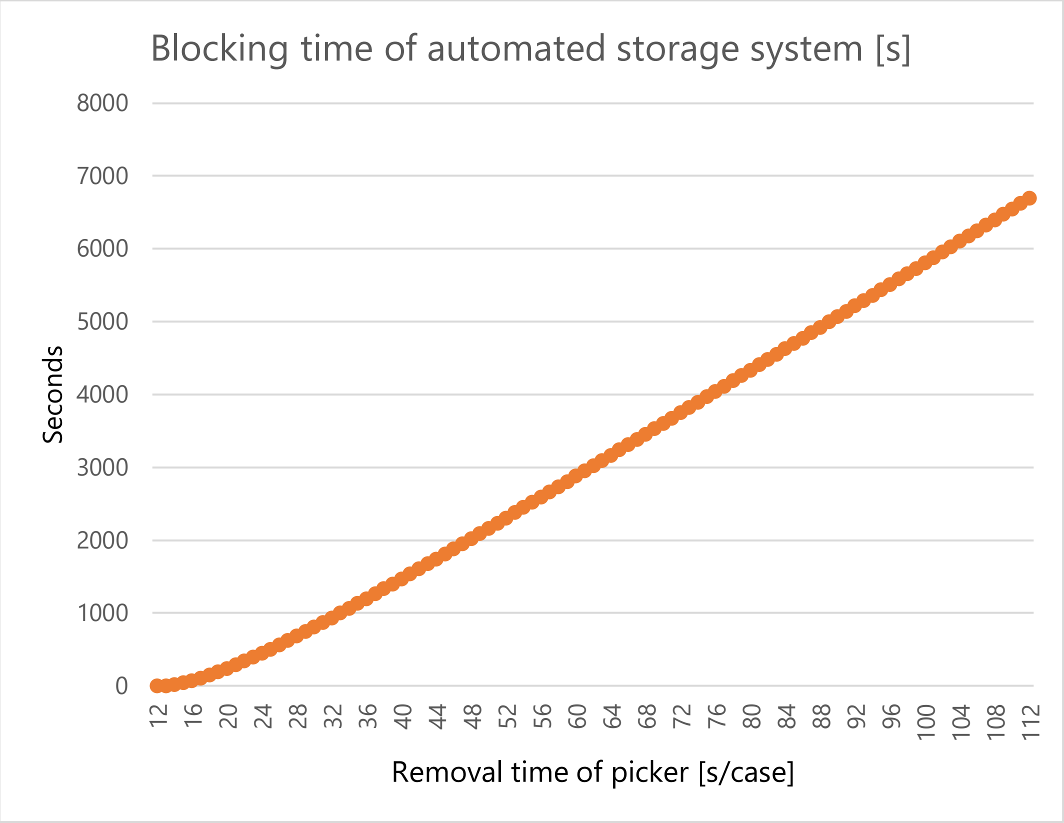
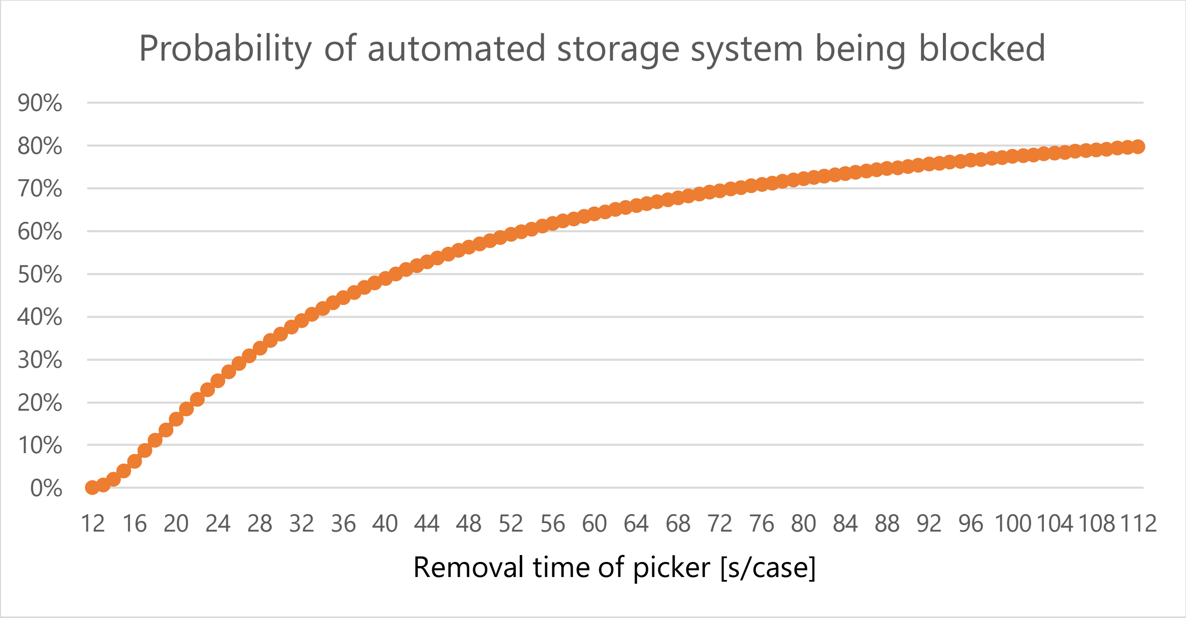




- The longer the removal time of picker the higher the probability of automated storage system being blocked
- Same occurs to blocking time of automated storage system

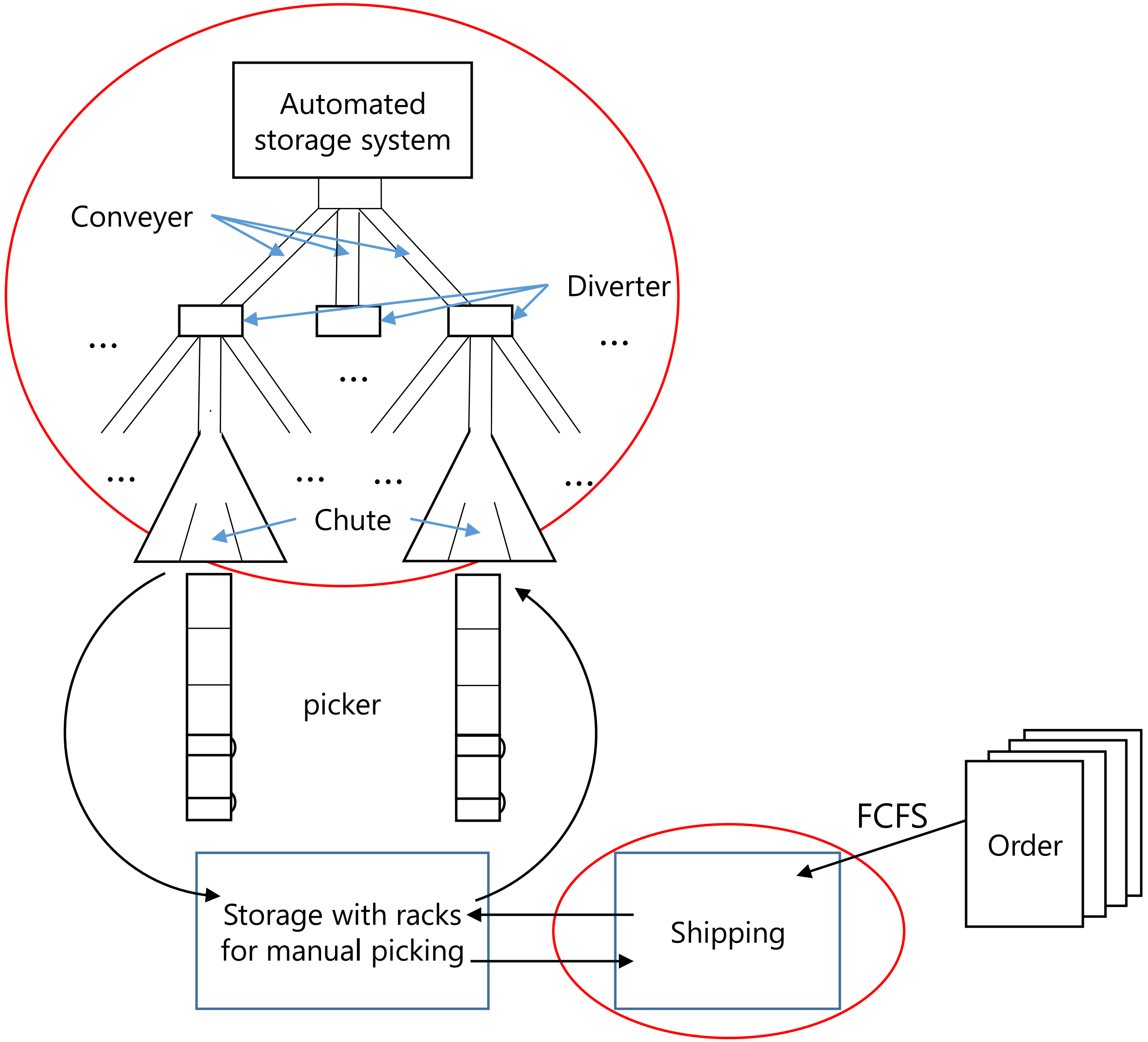
3. Combining both analysis

3. Combining both analysis

Cases are shipped as fast as the automated storage system sends them out

Performed analysis

Given a certain number of pickers, compute the removal rate, which equals the output rate of automated storage system and shipping rate



3. Combining both analysis
Example with 2 conveyers and 6 chutes (1/2)

	A	B	C	D	E	F
1	**Time parameters**				**Resource parameter**	
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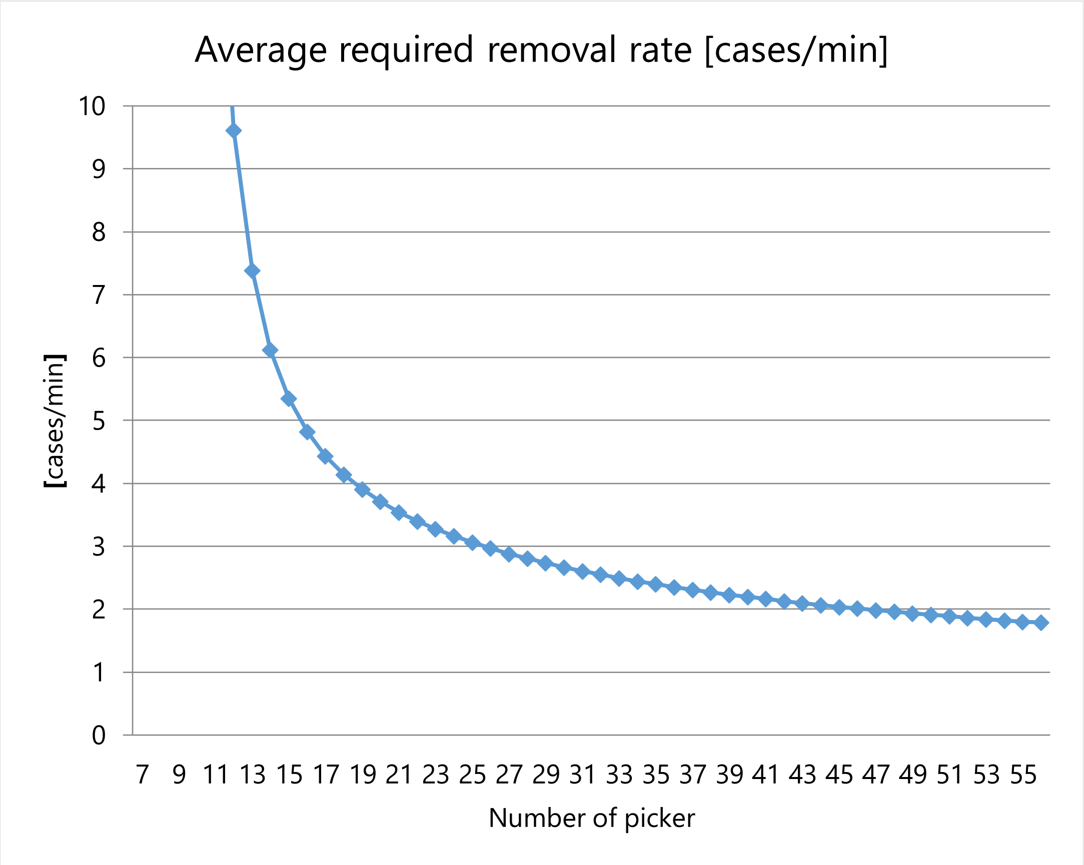
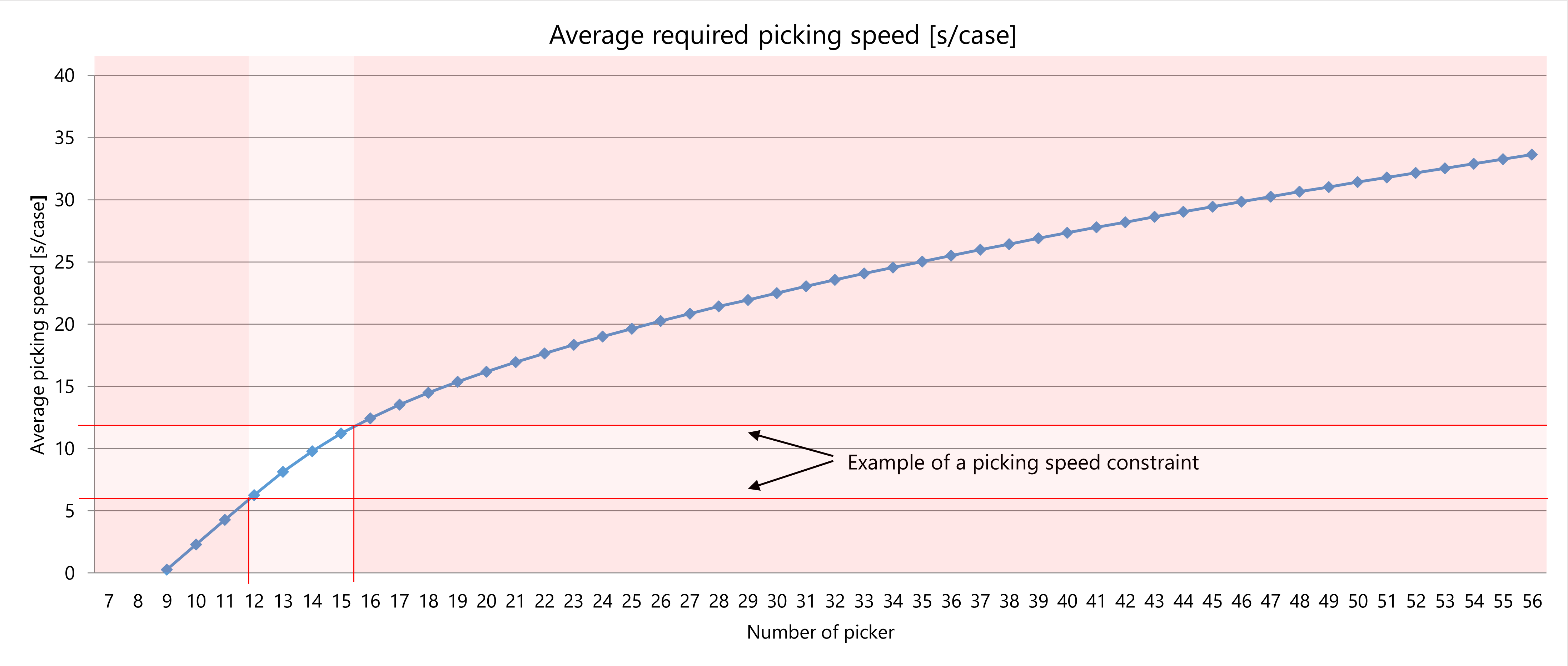
8	Travel in Store 1	100	[s]			
9	Time to pick Layer 3	20	[s/case]			
10	Travel from Store 1 to Shipping	20	[s]			
11	Time in Shipping	50	[s]			
12	Travel from Shipping to Store 1	20	[s]			
13						
14	Probability of Being at Chute	0,5849263	0			
15	Probability of not Being at Chute	0,4150737				
16						
17	Output rate of automated storage system	30	[cases/min]			
18	Output rate for each of the 2 conveyer	15	[cases/min]			
19	Time needed to fullfill three chutes	900	[s]			



Automated storage output rate = shipping rate

The fewer pickers the faster the required removal rate of pickers must be

3. Combining both analysis
Example with 2 conveyers and 6 chutes (2/2)



There will be constraints on the picking rate, which narrows the possible combination down

Conclusion and next steps

Summary

With relatively easy computations

- Needed/required resources for specific outcomes can be determined
- Bottleneck problems can be detected and solved
- Targets and incentives for workers can be set

➢ Decrease costs and save money

These are ***optimistic*** estimates!

Next steps

- Simulation runs with randomness should verify obtained deterministic results
- Costs should be linked to resources to determine best warehouse design

Thank you

Questions?

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