WAREHOUSE OPERATION OPTIMIZATION-SIMULATION MODEL

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ABSTRACT

This paper presents a warehouse optimization model based on a simulation software. The warehouse in study belongs to a leading logistics company in Vietnam and it aimed to increase order fulfilment productivity by 50% without further space expansion. The research team conducted onsite observation over three-month period. Current practice included random storage practice and lacking optimized picking route per order or multiple ones had been employed, hence resulting in low productivity in order fulfilment. Picking sequence was not optimized for minimum traveling and picking time. Picking process took up to 70% of total processing time of an order. Using a self-customized warehouse operation simulation called Anylogic, the team suggested several optimal picking sequences and batch picking for immediate improvement to the order picking process. For the long run, zone picking, hot-pick area, and pick sequencing are also recommended.

Keywords: Warehouse Optimization, Warehouse management, Simulation, Picking optimization, Order fulfilment, Anylogic

1. INTRODUCTION

Order picking is one of the major activities in warehouse operation management which accounts for more than 50% of warehousing costs. Its operation is highly labor-intensive requiring a massive amount of human manual tasks since inefficiency directly link to additional costs. Warehouse and its function in the supply chain used to be underestimated as cost centres and rarely adding value (Faber, De Koster & Smidts, 2013). However, with the growth of ecommerce and the rapid increase in customer demand, the role of warehouse has become more important. According to Richards (2017), supply chain with the seven core responsibilities of ensuring the right products, right quantity, right customers, right place, right time, right condition and right price, has witnessed a great contribution of warehouse management in fulfilling these criteria.

Precisely conducting the warehouse's product picking and dispatching process directly affect the right product in the right quantity of the supply chain (Richards, 2017). At the same time, correctly labelling the products and load onto the correct vehicle with sufficient time to meet the delivery deadline will live up to the requirements of delivering to the right customer at the right place and right time. The warehouse operation also should to ensure the products leave the warehouse clean and damage free. In order to deliver at the right price, we require a cost-efficient operation that provides value for money (Richards, 2017).

Common warehouse activities include moving items, allocating items, picking and storage. To ensure these activities run smoothly, good warehouse management is necessary. Inventory accuracy, inventory storage and location, space utilization and warehouse layout, redundant processes and picking optimization are the most common challenges for any warehouse operation. Due to the importance of warehouse management on the whole supply chain, it is essential for managers to consider these aspects to optimize the who operation.

In this paper, we present the outcome of a final-year student project in which optimization of order picking and other aspects of warehouse operation were conducted. With inadequate technology and specialized pallet handlings support for a 12,000 ft2 warehouse, unproductive picking performance and poor productivity are resulted from random picking sequence from the staff. Furthermore, infrastructure and poor warehouse safety practices such as lighting and over-stacking respectively are also considered as major challenges for operation efficiency. The main objective of this project is to increase productivity of fulfilment warehouse, since the current order fulfilment, warehouse layout and others were not optimized. Through onsite observation and simulation software, various scenarios of picking sequencing and storage method have been evaluated to provide most feasible techniques.

2. WAREHOUSE OPERATIONS ASSESSMENT & ANALYSIS

2.1 Company background

X Logistics provides integrated logistics solutions, including transportation, warehouse, fulfillment and delivery services for its internal operation and external customers. X Logistics also possesses truck network across all 63 provinces and fulfillment services in three major hubs (Hanoi, Danang, HCMC). Even though, serving the internal operation of the group is the primary objective, X Logistics has earned several strategic customers in various industries such as F&B chain (The Coffee House), and fashion retailers (Juno, HNOSS). Providing efficient and cost-effective warehousing services has been recognized as a critical strategic aspect of the company. Gaining other customers who are the leading retailers in their fields proves the strategic and untapped potential revenue stream. This makes X Logistics become an interesting yet challenging case for study team to investigate its warehouse operation as part of the strategic plan.

2.2 Order Picking Practice

The team conducted on-site assessment to investigate various aspects of the warehouse. The following identified observations are considered to be critical in both short run and long run performance of the warehouse, which are addressed in the later sections.

2.2.1 Lack of standardized picking route

Figure 1 shows the picking sequence of two typical orders. The blue line indicates the pallet area while the orange line indicates the rack area. The sequence is not optimized for minimum traveling and picking time. Instead, the pickers moved back and forth between and pallets and racking areas. This figure proves that even though there is a picking sequence recommended by a mobile device, pickers still manually choose the route, and this lack of standardization makes the picking flow slow and unmanageable.

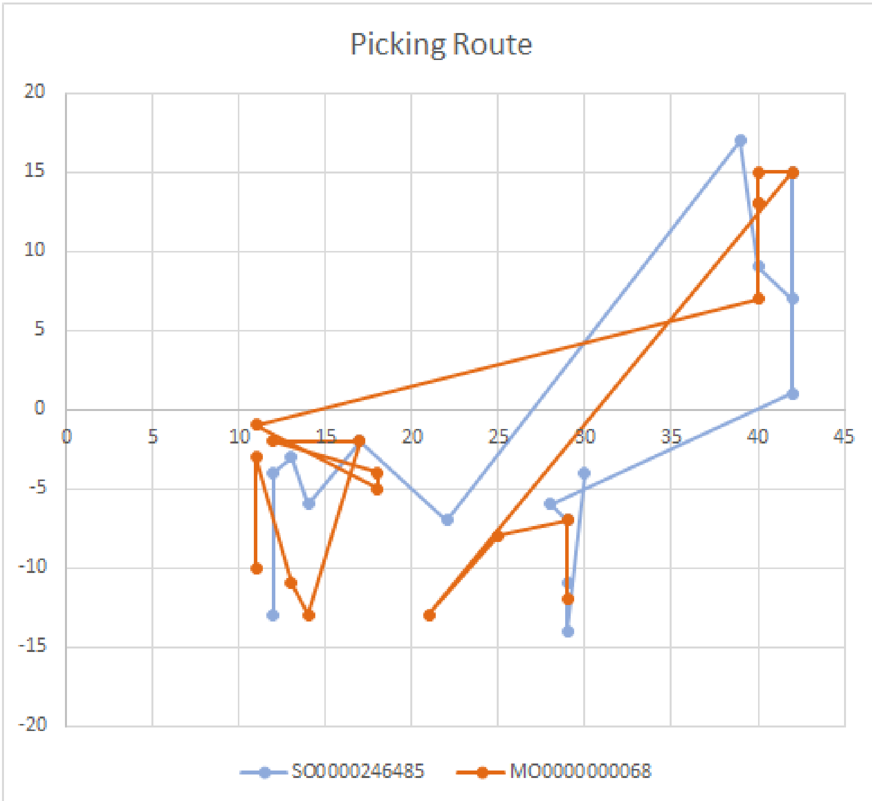

Figure 1: Illustrated picking routes

2.2.2 Random storage

The warehouse seems to be using random storage method. As shown in Figure 2, darker cells indicating storage locations with more frequent visits and spread out substantially. This method exposes too many issues including unoptimized travel time and managerial challenges. One reason for this is to utilize space and vehicles as well as equipment that assist space utilization measures

Ro	-18	-17	-16	-15	-14	-13	-12	-11	-10	-9	-8	-7	-6	-5	-4	-3	-2	-1	1	3	5	7	9	11	13	15	17	19	21
1					57	53	36	41	108	3	69	38	35	12		80	46	94	602	96	45		258	185	110	167	114	103	
2							2	55			5			2		89	34	59	236	114	123	91	92	24	61	257	115	74	
3					29	34	177	5	103										347	184	170	268	169	209	235	208	182	139	
4							3		2	4	3		1					6	80	158	176	210	179	79	35	104	110	201	
5					112	4	89	33	24	16	275	311	19	65	158	240	48	440	172	188	46	99	27	68	131	127	64	60	
6					5	12	184	28	164	115	53	97	218	82	97	33	93	214	182	119	77	133	96	57	190	100	113	47	
7					101	103	203	67	114	35	30	81	195	10	164	31	109	43	131	134	53	16	58	115	103	79	99	4	
8					98	5	17	213	75	80	36	29	34	33	42	173	58	14	36	97	100	141	156	178	154	268	200	163	
9						10	11	44	33	35	18	123	44	18	27	19	17	324	111	141	149	181	220	159	155	129	43	26	
10						9	28	27	78	13	89	44		9			6		325	251	140	198	134	113	79	71	43	68	
11							1	171	58	20	17	58	25	5	44	56	4	78	281	149	153	98	131	88	65	83	117	16	
12					301	382	170	100	25		1	51	13	28	35	53	25	19	246	108	84	110	113	187	121	139	130	49	
13					39	78	95	47	47	99	1	60	100			28	1	29	207	222	263	65	85	44	103	193	19	65	
14					100	82	8		58	74	81	13	56	30	10	8	10	16	159	77	152	213	170	115	120	133	152	164	
15					10	26				47	53	3		23	118	53	24	23	231	225	113	120	2	72	24	23	59	83	
16									62	3	19	11	11	5	54	66	24	50	122	122	33	94	134	85	80	217	64	64	
17						15	16	74		3	62		11	46	20	14	122		129	76	225	68	70	49	40	48	32	25	
18										37		4	11	57	92	68		48	8	21	73	40	80	113	125	97	87	75	
19					22		124	49							8		16	7	44	68	50	29	17	5	2	120	131	37	
20					21	3	8	23	73	26	24	6	22	69	86		3	1	149	114	102	178	94	87	15	16	24	26	
21					25	78	48	4		12	36		2	13	12	8	25		209	115	157	148	104	92	97	77	111	63	
22									40	27	42	29	29		24	23		87	180	168	64	137	57	37	79	113	58	96	
23							19	19		17	59	58	79		61	49			76	66	22	48	53	44	43	26	9	2	
24					31	1		4					14	29	87	58	37		186	177	128	82	140	139	45	105	65	43	
25					19		1			41	87	4	8		5	38	134		114	99	145	146	202	234	101	50	26	69	
26					24	37		103	23				8			2		10	100	68	83	191	63	38	70	23	9	39	
27							20	28	35	4			6	80	5				89	82	69	30	132	124	85	102	58	46	
28					89	30	8						4		1	10		4	389	353	311	289	264	273	258	194	240	164	
29					15		73	37	132	180	68	168	130	108	27		21	106	406	319	367	281	273	250	144	206	262	159	
30								17		1			9	24	25	48	84	35	257	50	32	147	479	386	120	47	66	194	
31		170	65	148	105	70	50	41	124	196	115	125	85	30	175	80	125	45	381	239	219	263	290	240	180	189	280	285	112
32		105		75	205	181		94	15			85	130		95	110	125	80	119	52	41	121	86	56	95	72	153	132	12
33		105	110		65	90	40	80	134	135	121	125	145	121	125	145			102	147	69	43	19	74	26	46	95	43	23
34															25		105	30	137	141	93	128	176	145	130	152	173	129	
35				87	50	105	190	230	135	70	71	68	125	69	73	70	1	85	1								1		
36															75	45		150	305	395	814	199	93	110	22	44			
37				151	55	75		45	30	70	95	40	205	100	123	60	118	127	109	45	60	56	48	29	24	23	10	7	
38			10	46	5	15	103	90	51											51	27	69	61	52	44	57	57	81	
39		120	100	135	60	35	45	85	15	35	80	30	30	80	355	65	385	40	226	64	119	96	226	65	12	24	146	37	
40		80		105		140		85	45	55	70	50		79	291	65	53	85	149	152	41	87	107	20	173	122	177	80	4
41					90	105	100	65		170	117		95	80	35	285	118	162	47	82	17	6	86	11	23		25	147	86
42			10		250	100	30	20	7		130	77	75			300		5	97	34	55	109	67	66		112	82	108	107
43		140	85						25	85	475	294	119	50	76	25	85												
44		125	220	12	55	85				150	232		5	55	20	170	40	65											
45		115	160		115	146	105	155	125	170	115	75	55	25	172	330		175											
46			70	180	99	240	125	30		55	68	132	246	70	200	140	30												
47		52	37	9				73	60	81	96	8			74	51	11	110											
48		1		70		1		4						33	5		50												

Figure 2: Random storage (Reproduced from company data)

3. STUDY METHOD

Process modelling was employed to determine which could be the most optimal order picking and warehouse space utilisation for the warehouse. Among various modelling methods, simulation is suitable for complicated system that it is impossible or too complex to develop an analytical model (Borella, 2019). Simulation models are usually applied to:

- Model complex system interactions or system uncertainty
- Systematically experiment with new system designs or decision rules
- Experiment without disrupting real operations
- Analyze, describe, and visualize interactions, outcomes, and sensitivities

Simulation modelling proves to be appropriate for this order picking problem due to the complex interactions between the warehouse's objects (e.g. pickers, orders, vehicle and rack system), referred to as agents in this paper, and high uncertainty of the impact of any changes made to the real system that analytical modelling deems to be overly complicated. For example, it is nearly impossible to develop a mathematical formula that calculates cycle time of an order with a decent level of accuracy.

A simulation model was developed to capture the order picking system of the fulfilment warehouse and measure the system performance. The model's aim is to evaluate different picking models which would be selected for subsequent implementation. Once the model proves to accurately represent the real operation for the intended purpose at an accepted level, a set of initiatives impacting order picking performance are then tested by the simulation.

In preparation for the model development, the following datasets were provided by the company:

- Warehouse layout and floor plan of data requirement
- Inventory by stock locations of data requirement
- Inventory throughput by SKU for four-month period
- Data of outbound activities includes orders information, client, time of creation, time of picking, pick location, picker ID, and picking list from the same period
- Data of rack system: size, number of locations, addresses of data requirement

The developed model was built in AnyLogic 8 because it offers flexible modelling capabilities including multi-method modelling that meet the project needs at no cost. In addition, AnyLogic has a rich library of tutorials and examples that can be freely used.

4. EXPERIMENT RESULTS

Due to the limit of the paper length, only selected simulation experiment results are presented here. For the first initiative, scenario 5 results in the most favourable result as it increases picking capacity by about 12% and reduces travel distance per order by 10%. Scenario 5 applies cross aisle setting for racks area and packing area setting for pallet areas (see Table 1 and Figure 3).

Table 1: Experiment result 1

Experiment	Travel distance (m/picker)	Average moving speed (mps)	Pickers utilization (%)	Average queuing time (min)	Picking capacity (orders/h)	Travel distance per order
Base scenario	100%	100%	100%	100%	100%	100%
Scenario 1	93%	99%	97%	93%	108%	92%
Scenario 2	95%	99%	96%	104%	107%	87%
Scenario 3	91%	99%	95%	104%	108%	85%
Scenario 4	95%	100%	97%	94%	107%	97%
Scenario 5	92%	97%	93%	87%	112%	90%

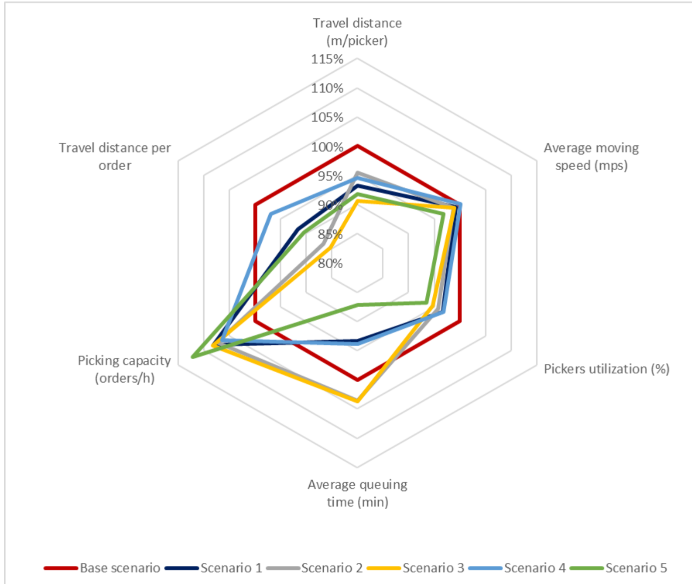

Figure 3: Experiment Result 1

Regarding the orders batching initiative, scenario 3 outperforms the others as it leads to 34% improvement in picking capacity and a 37% reduction in travel distance per order (see Table 2 and Figure 4). In this case, the impact on order queuing time is not evaluated as the time would increase when the batch size increases, but it is still controlled by the max queuing time mechanism.

Table 2: Experiment result 2

Experiment	Travel distance (m/picker)	Average moving speed (mps)	Pickers utilization (%)	Picking capacity (orders/h)	Travel distance per order
Base scenario	100%	100%	100%	100%	100%
Scenario 1	70%	102%	85%	127%	67%
Scenario 2	62%	99%	98%	131%	58%
Scenario 3	68%	98%	88%	134%	63%
Scenario 4	62%	98%	115%	125%	58%

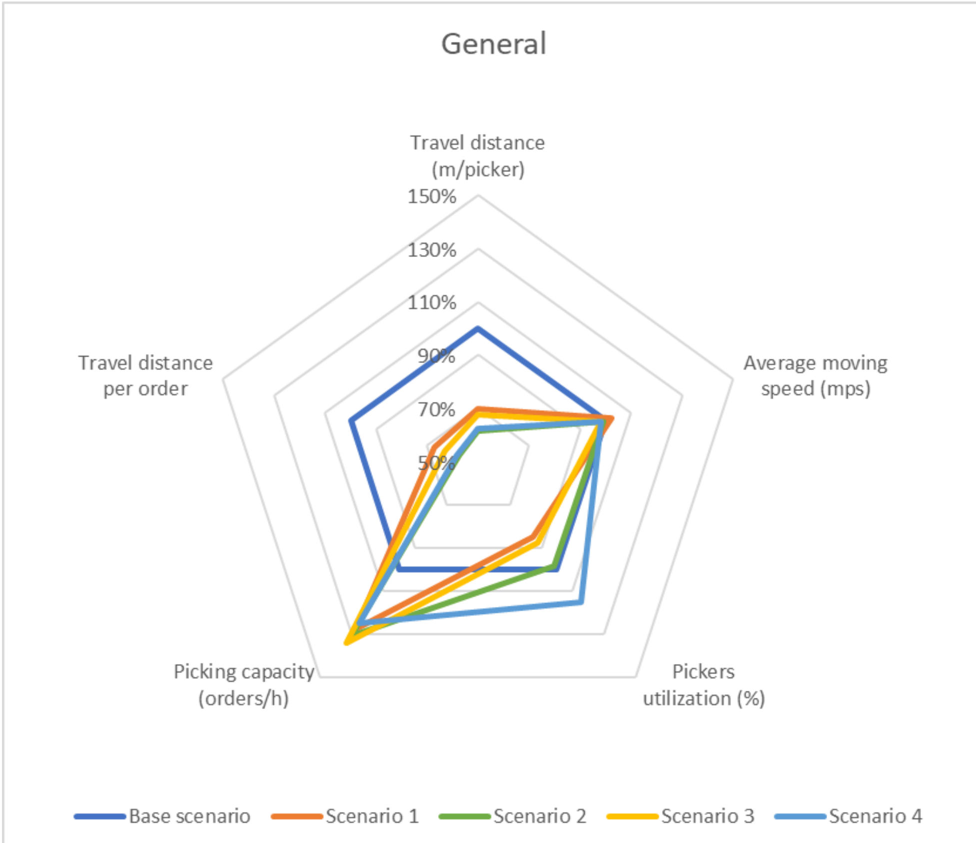

Figure 4: Experiment Result 2

Figure 5 and Figure 6 present overall simulation results of different models on various aspects of warehouse operation including travel distance, average moving speed, picker utilisation, picking capacity and travel distance per order.

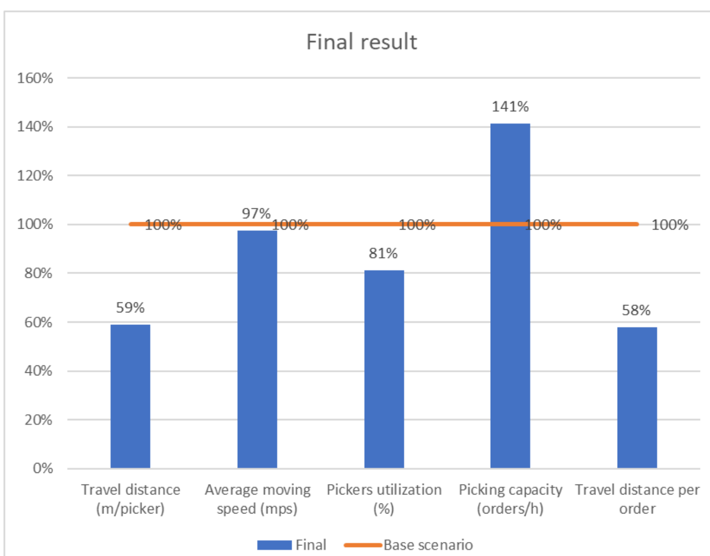

Figure 5: Warehouse Operation Model Impact

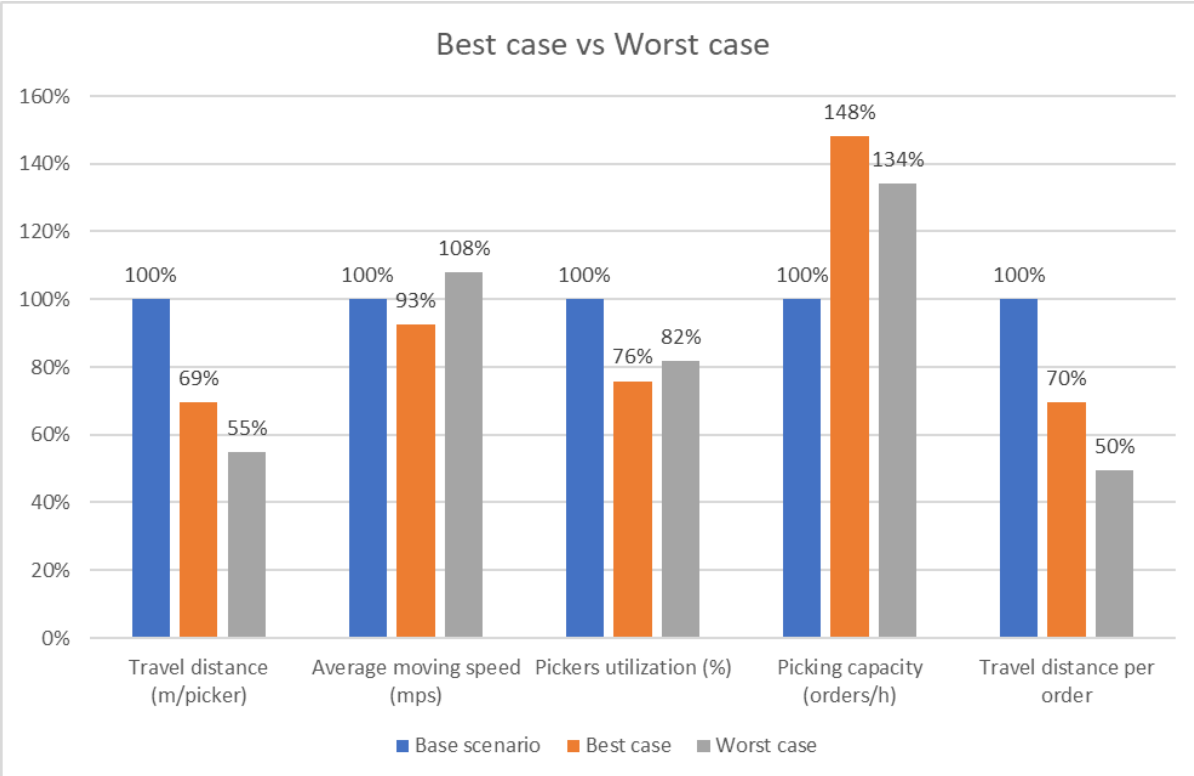

Figure 6: Best Case vs Worst Case

5. CONCLUSION

This study presents a simulation approach to identify optimal picking routes and storage space to increase productivity of a warehouse facility. Due to current limitations of warehouse capacity, solutions are divided into short term and long term.

In the short run, in order to select the most optimal model, reallocation and batch single-item orders are chosen to be tested in different scenarios since the approaches require little investments on automotive tools or equipment and minimal system support. By combining the two most optimal approach of selected initiatives (setting for racks area and packing area setting for pallet areas and following the batching rule either batch size reach 20 items or 10 minutes max time window), the final scenario results in an improvement of 41% in capacity and reduces the travel distance per order to 58%. In the best case, capacity can increase up to 48% from the base scenario. The given above short-term solutions might not be the best solutions to encounter the picking inefficiency issue due to the limitations on project time, resources and system support.

Therefore, further improvements on the facility capacity in the long run is a must to respond to constantly increasing demand. Proposed approaches including zone picking, hot-pick area, and pick sequencing are given when it comes to future solution selection stage. Each of the initiative has its own pros and cons. Zone picking can encounter picking productivity; however, zoning requires layout redesign, item re-allocation, and system support to function, while the costs associated with re-stock activity is the main consideration of hot-pick area approach. Pick sequencing may acquire computationally heuristic intelligence to function efficiently.

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