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Modeling and Simulation of Community Group Buying Warehousing and Distribution Center Based on Flexsim

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Abstract: With the continuous increase in the demand for small quantities, diverse varieties, and high-efficiency goods distribution, there is a growing customer need for short-cycle products. In this context, leveraging Flexsim software platform, this paper models the warehousing and distribution center for community group-buying goods. The modeling encompasses key operational aspects such as product supply, storage, picking and grouping, as well as loading and unloading, and distribution. Through simulation, the results are analyzed and optimized, yielding the optimal layout scheme for the community group-buying warehousing and distribution center model.

Keywords: Community Group Buying, Short-Cycle Products, Warehousing Center, Goods Distribution.

1. Research Background

With the development of information and self-media technology, logistics warehousing and distribution centers have gradually become a hot topic of great concern in both the logistics industry and academia. However, a notable deficiency is the lack of research on logistics aspects of community group-buying warehousing and distribution. The community group-buying warehousing and distribution center involves the large-scale procurement, stocking, and storage based on orders from group-buying users and forecasts of sales. Subsequently, it ensures timely delivery to group-buying customers at specified times in logistics facilities. Against this background, this paper focuses on the research of community group-buying e-commerce, primarily in the domain of short-cycle products, implementing group buying to communities, and systematically studying the service capabilities of distribution centers. Helio et al. [1] proposed a mixed-integer programming (MIP) for agricultural supply chain fresh food delivery. Wang and Yang [2] researched fresh food delivery routes, fresh product distribution, and methods for allocating resources. Wang and Geng [3] discussed the planning and simulation optimization of the cold chain logistics system in fresh agricultural product distribution centers. Xing [4] used Flexsim software to analyze the operational processes of aviation cold chain logistics distribution centers. Wang Haiyan and Sun Tao [5] analyzed the subsystem of cold chain disassembly and processing. This paper primarily analyzes existing group-buying models, employing the Flexsim simulation tool to discover imbalances in physical resource utilization through simulation data analysis. It proposes improved optimization solutions for transportation tools to enhance equipment utilization efficiency.

2. Process Analysis

The entire operation process of community group-buying, as depicted in Figure 1, begins internally within the community group-buying enterprise. Goods transported by suppliers are unloaded and transported to the supply area. Subsequently, the processed and inspected goods proceed through a processing inspection station. Items passing inspection are then directed to the packaging and storage area. Different categories of goods are allocated to various storage spaces. The goods are then grouped and packaged for group-purchase promotions. Following this, the assembled products enter the sales area, awaiting either direct sales or distribution. From the perspective of community group-buying for customers, the process starts with reviewing orders to ascertain inventory availability to fulfill customer orders. Subsequently, there's sorting and preparing of goods, followed by outbound goods inspection. Finally, there's the distribution of goods, which includes either offline pickup or doorstep delivery, as shown in Figure 1.

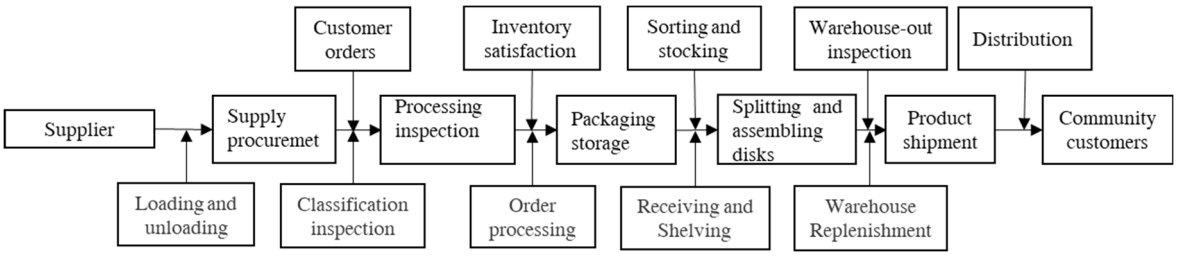


Figure 1. Flowchart of Community Group-Buying Model

3. Modeling Process

The overall engineering of the community group-buying warehousing supply and distribution system is divided into the commodity supply area, the commodity processing and inspection area, the commodity packaging and storage area, the commodity sorting and grouping area, and the commodity shipping area. This model takes six different categories of daily necessities (A, B, C, D, E, F) as an example, including short-term daily goods, food, fresh fruits and vegetables, etc.

The model layout involves three suppliers. Supplier 1 sends two types of products, A and B, to the group-buying distribution center. 40% of the products are type A, and 60% are type B. The arrival time follows a normal distribution with a mean of 25 and a standard deviation of 30. Supplier 2 sends two types of products, C and D, to the distribution center, with an equal distribution ratio, and the arrival time follows a discrete uniform distribution between 20 and 30. Supplier 3 sends two types of products, E and F, to the distribution center. 40% of the products are type E, and 60% are type F. The arrival time follows an exponential distribution Exp (0.0, 10.0). The processing station can handle up to 6 types of products simultaneously, and they are transported to the inspection and processing area by three forklifts.

Due to the community group-buying scenario, the model involves many short-term daily goods, food, and some perishable products. As these products have a short shelf life and are prone to damage, the model includes an inspection stage before entering the warehouse. According to the data, it is assumed that 4% of the products are damaged or spoiled during inspection and cannot be stocked. A processor is set up to recycle and reprocess these products or handle them as waste. Some products undergo sorting, processing, and packaging, followed by handover by two operators.

After processing, due to the special nature of group-buying products, some items cannot be stored together. To efficiently use warehouse equipment, the model categorizes group-buying products and packs six products into one pallet. They are then sorted into six warehouses (designed as six shelves in this document). The packaged products are transported to the goods warehouse by a conveyor belt, waiting for community user orders, and sent to the conveyor line for product sorting and promotional combination. Subsequently, the elevator places the palletized goods into the corresponding warehouse for products on the respective floors. The goods area consists of six high-level shelves, each with 10 floors and 10 columns.

Based on the group-buying product combination table, the model designs six group-buying product promotion combinations. The outbound grouping list process is carried out, and the goods are taken from the corresponding inventory of the elevator to the product sorting area. Machine equipment automatically sorts the products, and then, according to the group-buying product combination table (such as Table 1) and the order arrival timetable (such as Table 2), grouping is performed. The quantity of orders arriving is set at 6, and the grouping speed is 2s per pallet.

Table 1. Group Purchase Product Combination

	Order Combination 1	Order Combination 2	Order Combination 3	Order Combination 4	Order Combination 5	Order Combination 6
Product 1	4	4	4	4	4	4
Product 2	4	5	6	5	3	3
Product 3	5	5	4	4	6	6
Product 4	5	4	3	5	3	6
Product 5	6	4	5	4	3	5
Product 6	6	6	4	5	6	5

Table 2. Order Arrival Schedule

	The Arrival Time	Project Name	Project Type	Quantity
Order 1	0	A	1	2
Order 2	1500	B	2	1
Order 3	1800	C	3	3
Order 4	2550	D	4	4
Order 5	3000	E	5	2
Order 6	3600	F	6	3

After the sorting of the goods is completed, the sorting conveyor belt will, according to the order information, respectively place the items in the shipping storage area. Finally, the transportation vehicle will deliver them to the sales area for offline sales, as well as for offline pickup of goods ordered online or for home delivery. The minimum dwell time for various goods follows a uniform distribution with parameters (30, 50). The overall simulation model of the system is illustrated in Figure 2.

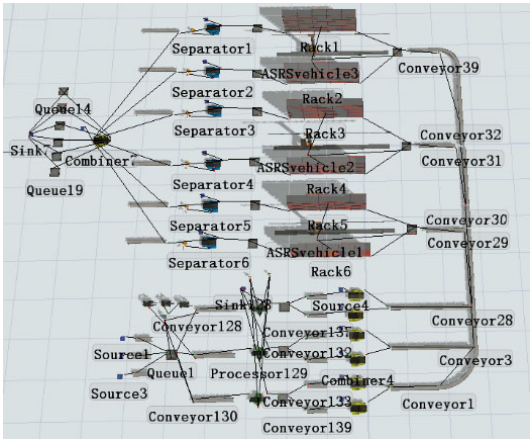


Figure 2. Simulation diagram of the overall system model

4. Simulation Results Analysis and Optimization

Through running the model, data collection was conducted on the usage of operators, forklifts, robotic arms, stackers, and other handling tools. Corresponding state diagrams were obtained, and the simulation results provide intuitive and comprehensive information.

The state pie chart for two operators, as shown in Figure 3, reveals that the utilization rate of one operator is 79.74%. Additionally, one operator remains idle consistently, indicating that only one operator is sufficient for this inspection area.

The state pie chart for three forklifts, as depicted in Figure 4, indicates that one forklift remains idle consistently. Consequently, only two forklifts are needed for the goods supply area.

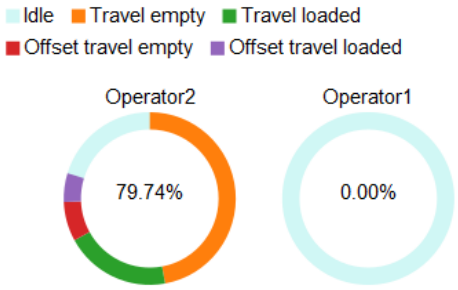


Figure 3. Pie Chart of Operator States

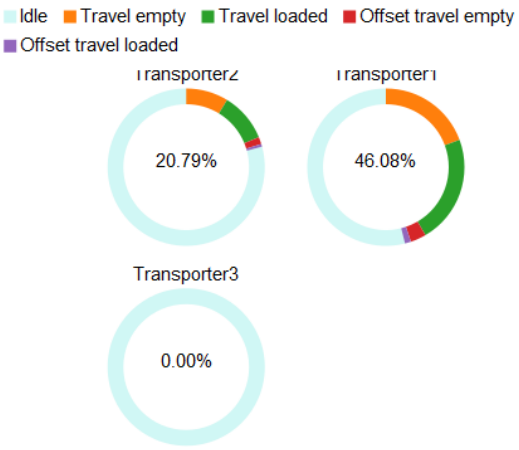


Figure 4. Pie Chart of Three Forklifts

The pie chart illustrating the working status of six robotic arms is shown in Figure 5. From the chart, it can be observed that the utilization rate of all six robotic arms is 4.4%, which is not high. Therefore, it is recommended to establish a robotic arm station in this specific area for improved efficiency.

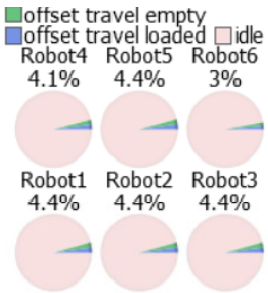


Figure 5. The pie chart depicts the working status of six robotic arms.

The pie chart depicting the operational status of two synthesizers can be found in Figure 6. The utilization rates for the packing area and the palletizing area's synthesizers are 56.7% and 58.8% respectively, which are relatively appropriate. Therefore, no modifications are needed for the synthesizers.

The pie chart displaying the operational status of three processors is shown in Figure 7. As there is a longer waiting time in the inspection area, it is advisable to increase the processing time. The processing time should be adjusted from "2" to "5".

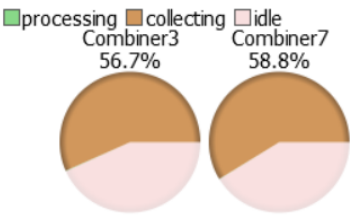


Figure 6. Pie Chart of the Operating Status of Two Synthesizers

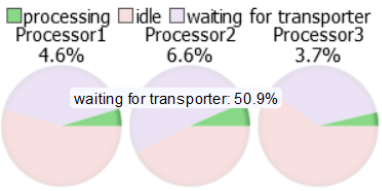


Figure 7. Pie Chart of the Operating Status of Three Processors

The pie chart illustrating the operational status of two decomposers can be found in Figure 8. From the chart, it is evident that there is a significant congestion and idleness issue with the processors. In this situation, it is recommended to reduce the synthesis time of the synthesizers and increase the decomposition time of the decomposers.

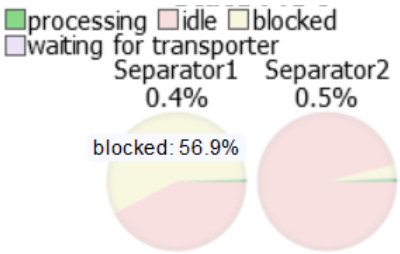


Figure 8. Pie chart depicting the operational states of the two decomposers

Through the optimization of model analysis, the operational efficiency of the model entity has significantly improved, with a noticeable enhancement in the efficiency of the three processors. When only one operator is used, there is also an improvement in the operator's efficiency. Among them, the robotic arm shows the most significant improvement in efficiency, and the efficiency of the three stackers has also increased. Optimizing by removing one forklift has led to improved efficiency in the remaining two forklifts. This is illustrated in Figures 9, 10, 11, and 12 below.

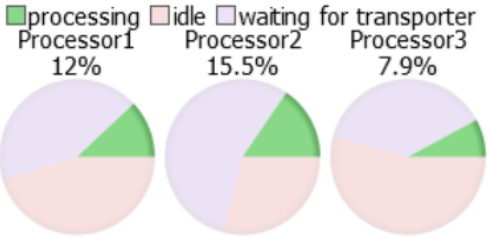


Figure 9. Pie Chart of the Operating Status of Three Processors

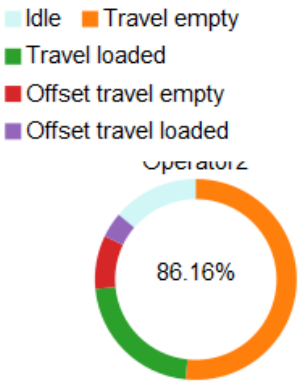


Figure 10. Operator Work Status Chart

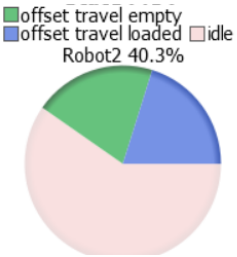


Figure 11. Chart of the Operating Status of the Robotic Arm

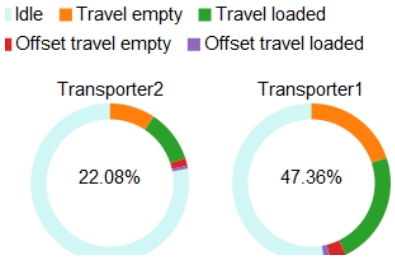


Figure 12. Chart of the Operating Status of Two Forklifts

5. Conclusion

This paper focuses on the design and research of community group buying, analyzing the existing group buying model to enhance the overall performance of the community group buying system as the optimization goal. The Flexsim simulation tool is employed, and the simulation model is analyzed, distinguishing functional areas as follows: product supply area, product processing and inspection area, product packaging and storage area, product sorting and grouping area, and product shipping area. Through the analysis of simulation data, it was found that the utilization of entities is unbalanced. An improved optimization plan for transportation vehicles is proposed. Comparative analysis of data demonstrates the feasibility of the optimized model, achieving the optimization of equipment utilization efficiency. The paper utilizes the system simulation method to model, analyze, and optimize the warehouse operation system.

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