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Research Article

Distribution Center Logistics Optimization Based on Simulation

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Abstract: Considering of the complexity of work flow in distribution center, system simulation has become an important tool for its design. Reasonable simulation goal, proper system modeling and correct simulation executing procedure is the precondition for reliable result. Taking a typical DC as an example, which purchases goods from many suppliers, stores them in its warehouse and delivers to their customers according to order, this study developed a simulation model with Flexsim software and then experimented with the model to observe the effect different scenarios may have on the behavior of the model. Based on the simulation statistical report data of model entities, the operation scheme, including the can be optimized with the goal of having the highest profit and the fittest inventory scale. The result illustrate that the highest profit is triple more than the lowest.

Keywords: Distribution center, operation scheme, optimizing, simulating

INTRODUCTION

Distribution Center (DC) is a modern circulation facility, which undertakes cargo distribution and delivery and realizes sales and supply service. Different from the traditional storage facilities, DC has become chain enterprise's center of business flow, material flow and information flow and also the key establishment to maintain the chain enterprise running normally.

From the point of view of simulation, DC can be seen as a discrete-event system. It changes state at discrete points in time as a result of specific events. Common states of a DC might be classified as idle, busy, blocked or down etc. and some examples of events would be the arrival of customer orders, product movement and machine breakdowns. The items being processed in a DC system are often physical products, but they might also be customers, studywork, drawings, tasks, phone calls, electronic messages, etc. These items proceed through a series of processing, queuing and transportation steps in what is termed a process flow. Each step of the process may require one or more resources such as a machine, a conveyor, an operator, a vehicle or a tool of some sort. Some of these resources are stationary and some are mobile, some resources are dedicated to a specific task and others must be shared across multiple tasks.

Discrete event simulation optimization is a problem of significant interest to practitioners interested in extracting useful information about an actual or yet to be designed system that can be modeled using discrete event simulation. It provides a structured approach to determine optimal input parameter values, where optimal is measured by a function of output variables associated with a simulation model. There are many good literatures in this field. Swisher *et al*. (2000) presented a brief survey of the literature on discrete-event simulation optimization since 1988. An approach for generating scenarios of sea port container terminals was introduced that was used as input data for simulation models and the results can support solving optimization problems in container terminal logistics such as berth planning and crane scheduling (Sönke, 2004). Zhou *et al*. (2010) proposed an approach to model and analyzes production logistics system with eM-Plant. The production logistics system's equipment's utilization, working efficiency, production capacity statistics can be analyzed effectively. Bartolacci *et al*. (2012) pointed out there still are areas that remain to be explored that will allow it to achieve an even larger and more successful role in the management of companies. The application of simulating technology in logistics distribution, facility layout and supply chain management refer to Wu *et al.* (2011), Huang *et al*. (2012) and Griffis *et al*. (2012).

Flexsim is a powerful analysis tool that helps engineers and planners make intelligent decisions in the design and operation of a system. With Flexsim, users can build a 3-dimensional computer model of a real-life system, then study that system in either a shorter time frame or for less cost than with the actual system.

As a "what-if" analysis tool, Flexsim provides quantitative feedback on a number of proposed solutions to help users quickly narrow in on the optimum solution. With Flexsim's realistic graphical animation and extensive performance reports, users can identify problems and evaluate alternative solutions in a short amount of time. By using Flexsim to model a system before it is built, or to test operating policies before they are actually implemented, many of the

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pitfalls that are often encountered in the startup of a new system will be avoided. Improvements that previously took users months or years of trial-and-error experimentation to achieve can now be attained in a matter of days and hours using Flexsim.

Based on above-mentioned characteristic, Ma *et al*. (2011) analyzed the eficiency of two different picking strategy of DC by Flexsim simulation. The relationship among the picking time, vehicles number, number of goods items and picking efficiency under two types of picking strategies were compared. The simulation results provide a decision support of optimizing of distribution center picking work. Based on Flexsim simulation, the production logistics system with better production efficiency can be analyzed before it goes into production. By simulating, the bottlenecks of production logistics system was found out and provided suggestion for improvement. As a result, the utilization of resources and equipment is improved and the production plans was carried out smoothly (Peng, 2011). There are many other good Flexsim application cases for simulating logistics system of DC and production line based on event-driven (Nordgren, 2003; Xu and Xiong, 2007; Si-qintana *et al*., 2008). Under Flexsim environment, all the possible running results of DC model can be simulated by setting different parameters for model elements and its execution process can be displayed dynamically.

Taking a typical DC as an example, which purchases goods from three suppliers and delivers to three customers, this study developed a model with Flexsim software and optimized its distribution scheme by simulating with the goal of having the highest profit.

PROBLEM DESCRIPTION

Basic information of the DC:

- **Suppliers:** There are three suppliers in the model. It is supposed that they begin to produce if the product inventory in DC is below 10 and stop producing when above 20, that supplier 1 and supplier 2 distribute products at a rate as 4 piece per hour and the time for supplying one product obeys uniform distribution U (3, 6).
- **Delivery of DC:** The DC stops delivering products when manufactures' inventory is above 10, respectively. The start-to-delivering point of every manufacture is different; it is 2 for manufacture 1, 3 for manufacture 2 and 4 manufacture 3 and the inventory cost in DC is 1 Yuan/100 h.
- **Cost and profit of DC**: The cost for purchasing is 3 Yuan/piece; the price of supplying is 5 Yuan/piece
- **Manufactures:** There are three manufactures that produce continuously. The time that every manufacture cost for each product is different. It is 6 hours for manufacture 1. For manufacture 2 and 3, the .producing time obey uniform distribution U (3, 9) and U (2, 8), respectively.

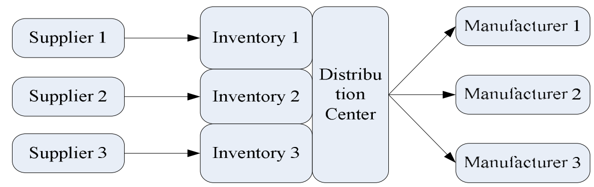

Fig. 1: Concept model of the DC

Concept model: According to the DC description above, the concept model can be abstracted as Fig. 1.

All the system elements concerned in Fig. 1 can be modeled using Flexsim software and all elements' properties also can be set obeying its running rules mentioned in section I.

MODEL CONSTRUCTION

Model element: According to the DC system information and the concept model, the Flexsim elements needed for DC model and its corresponding relationship with System elements is shown in Table 1. Flexsim objects simulate different types of resources in the simulation. An example is the Queue object, which acts as a storage or buffer area.

The Queue can represent a line of people, a queue of idle processes on a CPU, a storage area on the floor of a factory, or a queue of waiting calls at a customer service center. Another example of a Flexsim object is the Processor object, which simulates a delay or processing time. This object can represent a machine in a factory, a bank teller servicing a customer, a mail employee sorting packages etc.

The item type is a label that is placed on the flowitem that could represent a barcode number, product

Table 1: Model elements and corresponding relationship with system elements

Model elements	System elements	Description
Flowitem	Product	
Source	Product generator	The rate that the source produces product should faster than the one DC delivers to manufacture
Processor	Supplier	The processing rate of three suppliers is different and should be set according to the DC basic data
Rack	Distribution center	Three racks is corresponding to three suppliers
Queue	Manufacture inventory	The ordering condition is different and is set according to the DC basic data
Processor	Manufacturer	The machining rate of three manufacturing is different and is set according to the DC basic data
Sink	Product collector	The arrival place the final product reach

Table 2: Main parameters' settings of model objects

Model objects	Basic parameter	Trigger setting
Source (1,2,3)	Interarrival time: By expression Expression: 1	Exittrigger: set color Color: color yellow (for 1), colorbule (for 2), colored (for 3) Object: item
Supplier (1,2,3)	Process time: By expression Expression: 4 (for 1 and 2) Statistical distribution: uniform (2, 6, 1) (for 3)	
Rack (1,2,3)	2 rows × 6 rays × 10 levels	Entrytrigger: Close and open ports Condition:20 Action: close input object exittrigger: close and open ports Condition:10 Action: open input object
Inventory (1,2,3)	Maximum content:15; Flow: Pull from any port return duniform (1,3)	Entrytrigger: Close and open ports Condition:10 Action: close input object exittrigger : close and open ports Condition: 2(for 1), 3(for 2), 4(for 3) Action: open input object
Processor (1,2,3)	Process time : By expression expression: 6 (for 1); Uniform distribution: uniform (3, 9, 1) (for 2); uniform (2, 8, 1) (for 3)	

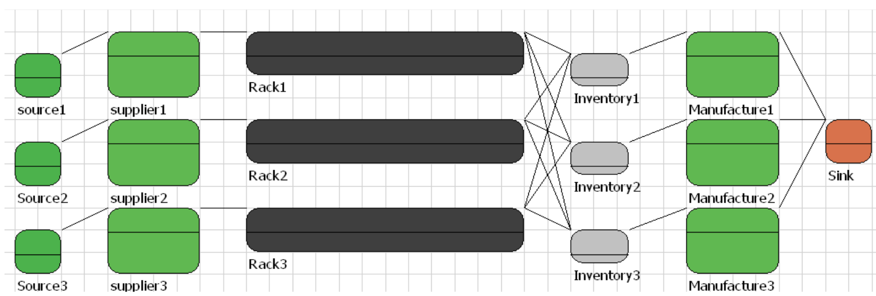

Fig. 2: Flexsim model of DC

type, or part number. Flexsim is set up to use the item type as a reference in routing flowitems.

Model construction: Under Flexsim environment, create three Sources, six Processors, three Racks, three Queues and a Sink in the model by dragging corresponding objects from the Library into the Model View. Name and place them as shown in Fig. 2. Connection between objects is also shown as below.

Model parameter setting: According to the DC system information and the concept model, the Flexsim elements needed for DC model and its corresponding relationship with System element.

In order to make the model behave as specified in the model description, the properties of the different objects should be changed in their own properties window, through which data and logic are added to the model. The settings of model objects' main parameters are as shown in Table 2.

Simulating procedure: All elements in model handle flowitems in a certain way. They "receive" flowitems through their input ports; do something to those flowitems, then "release" the flowitems to the following element through their output ports. Taking manufacture 1 as example, it receives exactly one flowitem, processes it, then releases it and waits until the flowitem has left before receiving the next flowitem. Although model elements receive and release flowitems at different times, the processes of receiving and releasing the flowitem are the same. Each goes through a certain set of steps for each flowitem that it receives and releases. Some of these steps are automatically handled and some allow modeler to define the way flowitems are received and released. All of these modeler-defined inputs can be edited in the "Flow" tab of an object's Properties window.

The steps that the model goes through for each flowitem that it receives and subsequently releases are shown as Fig. 3.

MODEL RUNNING

Simulating procedure: In order to collect and analyse the running data of DC during one year, the Simulation

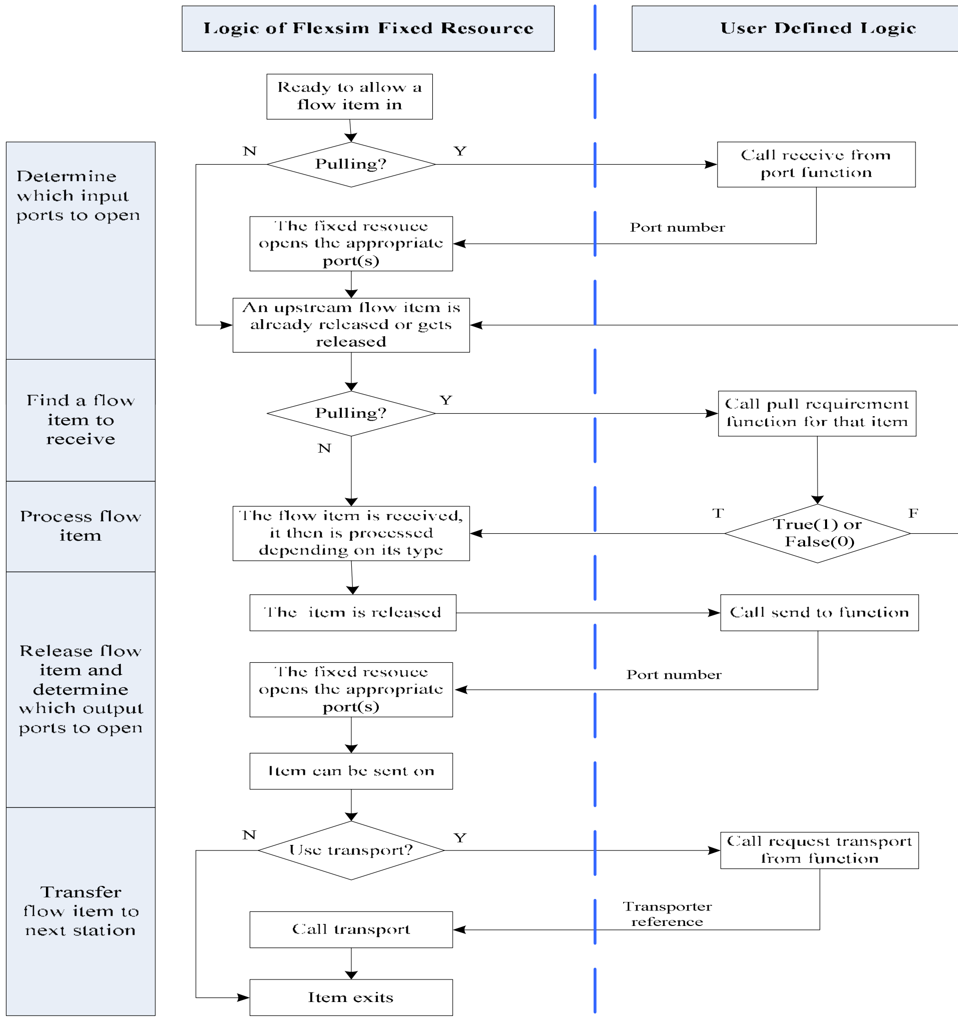

Fig. 3: Simulating procedure of DC model

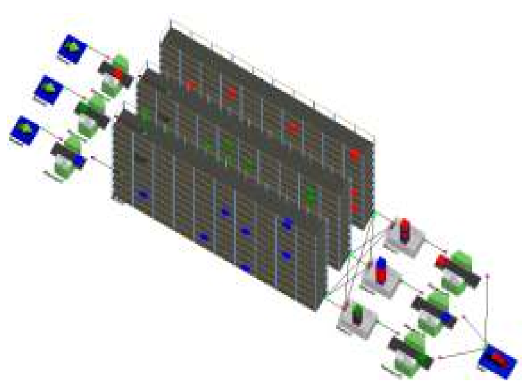
Fig. 4: Running diagram of DC model

Run parameters, Stop Time, is set at 8760 (i.e., 24h/day*365 days/year = 8760).

The influence analysis of DC inventory strategy on the profit can be studied under different settings about Rack. The maximum inventory level and reorder point can be modified in Rack trigger: OnEntry and OnExit.

This study considers five conditions as follows, (maximum inventory level, reorder point):

Condition 1: (20,10)
Condition 2: (30,5)
Condition 3: (50,10)
Condition 4: (10,3)
Condition 5: (100,20)

The running process of the model is shown as Fig. 4.

LITERATURE REVIEW

By simulating the DC model under different conditions, the running results were listed in Table 3.

From Table 3, we can find: the DC profit varies from 2839.1 to 8679.4 under condition 1 to 4 and also the profit increases with the decrease in maximum inventory level. Under condition 5, the profit becomes minus quantity because the too many average inventory. So the DC inventory strategy and warehouse scale can be decided according to the condition 4.

Table 3: Simulation results under different conditions

Statistic Item		Inventory_max	Reorder	Content_avg	Output	Profit
DCRack1	1	20	10	12.45	1729	2367.3
	2	30	5	14.4	1701	2292.6
	3	50	10	27.4	1712	1023.7
	4	10	3	4.68	1697	2984
	5	100	20	53.75	1697	-1314.5
DCRack2	1	20	10	13.47	1640	2100
	2	30	5	15.42	1637	1923.2
	3	50	10	26.97	1653	943.4
	4	10	3	5.43	1697	2918.3
	5	100	20	55.28	1689	-1464.5
DCRack3	1	20	10	12.66	1671	2232.9
	2	30	5	14.34	1724	2191.8
	3	50	10	28.06	1665	871.9
	4	10	3	5.81	1643	2777
	5	100	20	55.01	1679	-1460.8

CONCLUSION

The modelling procedure of a DC system with Flexsim software was introduced in this study, including the construction of the DC concept model, the transformation from the concept model elements to the Flexsim model elements, the setting of the model parameters, the simulation running flow and the model simulating under different conditions. The simulating results can provide helpful information for the decision-making in DC inventory strategy and warehouse scale.

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