STREAMLINING THE FOOD SUPPLY PROCESS AT SINGAPORE HOSPITAL VIA SIMULATION

Arun Kumar, Nanyang Technological University, 50 Nanyang Avenue, Singapore 639798
E-mail: makumar@ntu.edu.sg, Telephone: 65-6790-6181
Sung J. Shim, Seton Hall University, 400 South Orange Avenue, South Orange, NJ 07079
Email: shimsung@shu.edu, Telephone: 973-761-9236
Shitao Yang, Seton Hall University, 400 South Orange Avenue, South Orange, NJ 07079
Email: yangsh@shu.edu, Telephone: 973-761-9535

ABSTRACT

Using simulation, this study assesses the utilization of resources involved in the food supply process at Singapore Hospital and recommends the ways to improve the food supply process. The results would be helpful to those who consider improving the food supply process at hospitals and other similar processes.

INTRODUCTION

Managing the food supply process in hospitals is no easy task, as the logistics can be very complex with various departments involved. There are at least three departments that must interact harmoniously in the food supply process, including food storage, kitchen and transportation departments. These departments should coordinate with one another to ensure the smooth running of daily operations, as the operation of one department is dependent on the operations of the others. While the food supply process in hospitals has been rather managed based on experience, little research has been done on the ways to efficiently utilize the resources involved in the process. Using simulation, this study assesses the current process of food supply in Singapore Hospital and recommends ways to improve the utilization of resources involved in the process. Its scope is limited to the formulation and validation of simulation models and the evaluation of performance of the current system.

CASE STUDY

The Hospital's Materials Management Department (MMD) oversees the food supply process in the Hospital and manages the kitchen and tow trucks. The kitchen prepares the food for patients and tow trucks deliver the food to the five blocks where patients reside. There are six tow trucks, which transport the food as well as linens and other materials to the five blocks through the underground passageway. Each block consists of a different combination of surgical and medicinal wards.

The food supply process in the Hospital is as follows. First, patients order the food from the menus. Second, the orders are relayed to the MMD. Third, the MMD processes the orders and schedules the food delivery. Fourth, the kitchen prepares the food following the schedule. Fifth, the food prepared is placed in trolleys. Sixth, tow trucks transport food trolleys to the blocks. At the same time, the kitchen continues to prepare the food for other wards following the schedule.

Seventh, when tow trucks reach the blocks, lift attendants unload food trolleys from tow trucks and deliver the food to the respective wards. Eighth, tow trucks return to the kitchen once they finish delivering food trolleys to the blocks and they repeat the process until all food trolleys are delivered to the blocks.

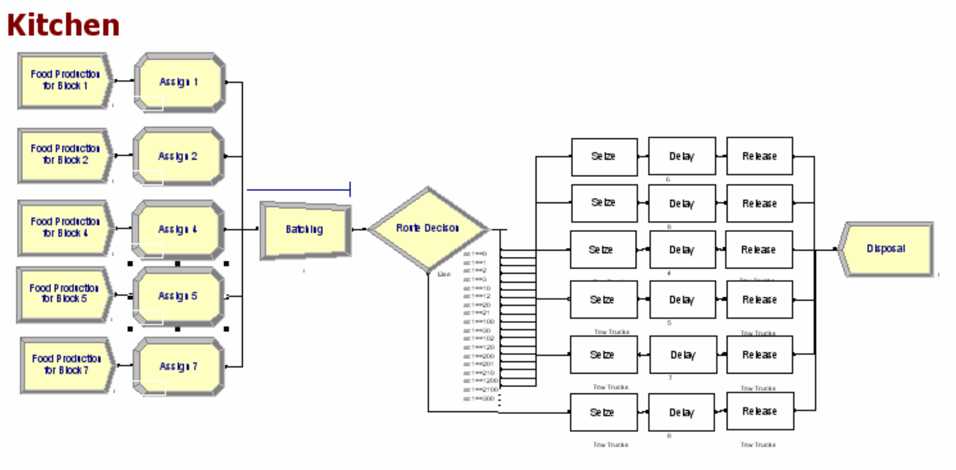
Each food trolley is attached with a tag that indicates the tow truck driver of which block the trolley is sent to. The first shift handles the breakfast and lunch orders, while the second shift handles the dinner orders. On each shift, six tow trucks are used on average to deliver food trolleys to the blocks. Each tow truck is capable of carrying up to three food trolleys per delivery. Each trolley contains the food for one entire ward. Each tow truck makes about three to four deliveries per shift. During the break between the two shifts, tow trucks also delivers cloth linens and other materials to the blocks using the same underground passageway. Tow trucks run at the maximum speed of 20 km/hour. With the maximum load, the speed of tow trucks reduces to 15 km/hour. The time taken by tow trucks to complete one delivery follows a triangular distribution based on varying traveling speeds. Tow truck drivers determine the shortest route of transporting the food. The time taken by lift attendants to unload food trolleys from tow trucks is negligible because food trolleys attached to tow trucks through a hook are quickly unloaded. Tow trucks do not need to stop and only need to slow down so that lift attendants can disconnect the hook and unload food trolleys.

Modeling the Food Supply Process

Due to the increasing number of patients admitted, the MMD is considering the ways to improve the food supply process, particularly the utilization of tow trucks used in the process. We used simulation to assess the utilization of tow trucks in the food supply process with historical data extracted from the scheduling database of the MMD for the month of November 2004. The data includes daily schedules of preparation of food trolleys by the kitchen as well as those of pickup and delivery of food trolleys by tow trucks, and details of which food trolley is delivered to which location by which tow truck. We used Arena simulation program. In Arena, the user can visualize operations with dynamic animation graphics and analyze how the system will perform in the 'as-is' process and under a myriad of possible 'to-be' alternatives. The simulation deals with only the breakfast shift, which is almost identical to the lunch and dinner shifts in terms of scheduling, quantity and types of food trolleys delivered.

Figure 1 shows the layout of the 'as-is' food supply process simulated in Arena. The process involves eight modules: Create, Assign, Batch, Decision, Seize, Delay, Release, and Dispose. The Create module creates the entities. An entity in simulation refers to any object or person that the simulation processes. In our simulation, entities represent food trolleys. The simulation involves five Creates, which are indicated as Food Production for Block 1, 2, 3, 4, and 5 in Figure 1, and each Create module is for one of the five blocks. The Assign module assigns a specific attribute value to entities so that they can be differentiated and carry out specific processes. The Batch module groups multiple entities into one batch. In our simulation, three entities are grouped into one batch, as each tow truck transports three food trolleys at a time. The Decision module decides which route of transport a particular batch of entities take. The Decision module sums up the total value of the prescribed values and determines which condition is satisfied. The Seize module seizes tow trucks for a particular batch of entities to take a particular route of transport. The Delay module simulates the transport process, and there are six Delays that represent the six different transport routes, respectively. The Release module frees up tow trucks to perform the next round of transport after they complete the transport that is at hand. There are six Seizes, six Delays and six Releases in the model. Finally, the Dispose module let batch of entities to exit the system.

Figure 1. Layout of the Completed Simulation Model



Tow trucks are the only resources used for transport of food trolley entities, and they perform Seize, Delay and Release functions as shown in Figure 1. Currently, six tow trucks are used to transport food trolleys to the various blocks. The MMD feels that the utilization of tow trucks is very low. While it is considered by the MMD to reduce the number of tow trucks to improve their utilization, it is important for tow truck drivers and tow trucks not to work overly. The arrivals of food trolleys are modeled using the schedule obtained from the MMD and the arrival cycle is over a one-day period. There is only one breakfast duty per day, the duration of the duty is almost identical, and the arrival cycle is set as one-day. The variable used in the simulation is the transportation time. The transportation time follows a triangular distribution with parameters as the minimum, most frequent and the maximum time for each transportation route. Table 1 summarizes the five different triangular distributions used by the different transportation routes.

Table 1. Triangular Distribution of Transportation Routes

Transportation Route	Time Taken		
	Minimum	Most Frequent	Maximum
1	5	6	7
2	7	8	9
3	3	4	5
4	7	8	9
5	8	9	10
6	10	11	12

Several assumptions were made in the simulation. First, the simulation is a good representation of the real food supply process. As mentioned earlier, the simulation scales down the number of duties from three to one. Second, the resources used are homogeneous. The time taken by different tow trucks on the same route differs insignificantly. Third, there is no increment or decrement in the number of resources used for the entire year. Fourth, there is no malingering among tow truck drivers, and so, the workload is evenly distributed among all tow truck drivers.

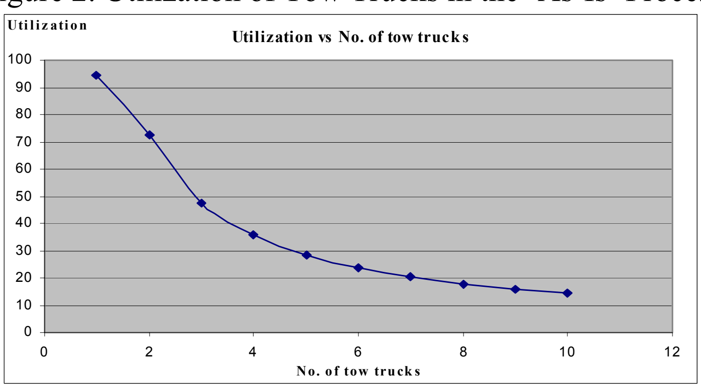
The current schedule of the food production is quite random, because the food for each block is produced at a different time. For example, the food for Block 4 is produced first at 6.50 am, and then, the kitchen produces the food for other blocks before producing the food for Block 4 again at 6.54 am. This means that at 6.50am, a tow truck has to transport two food trolleys to Block 4 and again at 6.54AM another tow truck has to transport a food trolley to Block 4. Thus, two tow trucks are used to make two deliveries instead of using one tow truck to make a single delivery. In a 'to-be' process, the schedule is rearranged so that all food for a given block is produced before moving on to produce the food for another block. The time taken to produce for all food trolleys remains the same as the 'as-is' process.

RESULTS AND DISCUSSION

The 'As-Is' Process

The number of replication to be used for all simulation models is set as 30. All simulation models were run for 1.25 hours per replication due to the time taken per duty being 1.25 hours. Figure 2 shows the average utilization of resources for all permutation of tow trucks. It is only 23.83% for a six tow-truck combination, which is low. This could be due to the irregularity of the schedule. In other words, there are times where tow trucks are very busy and there are times where tow trucks are idling. Thus, there is a need to even out these two periods to improve the efficiency of the system. Figure 3 shows the average waiting time for six tow trucks, which is 1.71 minutes. The objective is to maximize efficiency and so, there is a need to shorten this time.

Figure 2. Utilization of Tow Trucks in the 'As-Is' Process



The 'To-Be' Process

The models for the 'to-be' process were run for 1.25 hours per replication for 30 replications. The first 'to-be' model plays around with the number of resources and the second 'to-be' model modifies the schedule so that the food for a particular block is produced before producing the food for other blocks. As the number of tow trucks used decreases, the utilization of tow trucks increases. Figure 3 also reveals that increasing the number of tow trucks does not shorten the average waiting time. On the contrary, decreasing the number of tow trucks being used per duty shortens the average waiting time. The best result is found to be the combination of using two tow trucks per shift. The result for the first 'to-be' model is illustrated in Table 2.

Figure 3. Average Waiting Time of Tow Trucks in the 'As-Is' Process

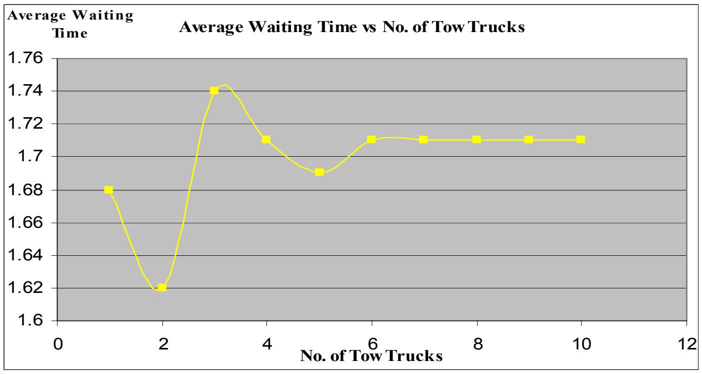


Table 2. Results from the First 'To-Be' Model

No. of Tow Trucks	Utilization (%)	Avg. Waiting Time (min)
1	94.431	1.68
2	72.402	1.62
3	47.314	1.74
4	35.751	1.71
5	28.601	1.69
6	23.834	1.71
7	20.429	1.71
8	17.876	1.71
9	15.889	1.71
10	14.301	1.71

In the second 'to-be' model, the schedule is first modified to produce the food for a particular block before producing the food for other blocks. The sequence of the blocks to receive the food is Block 1, followed by Block 2, Block 4, Block 5 and Block 7. The result of this model is summarized in Figures 4 and 5. For utilization of six tow trucks, the new schedule lowers the utilization but on the other hand, it shortens the average waiting time by 0.09 minutes.

Figure 4. Utilization of Tow Trucks in the 'To-Be' Process

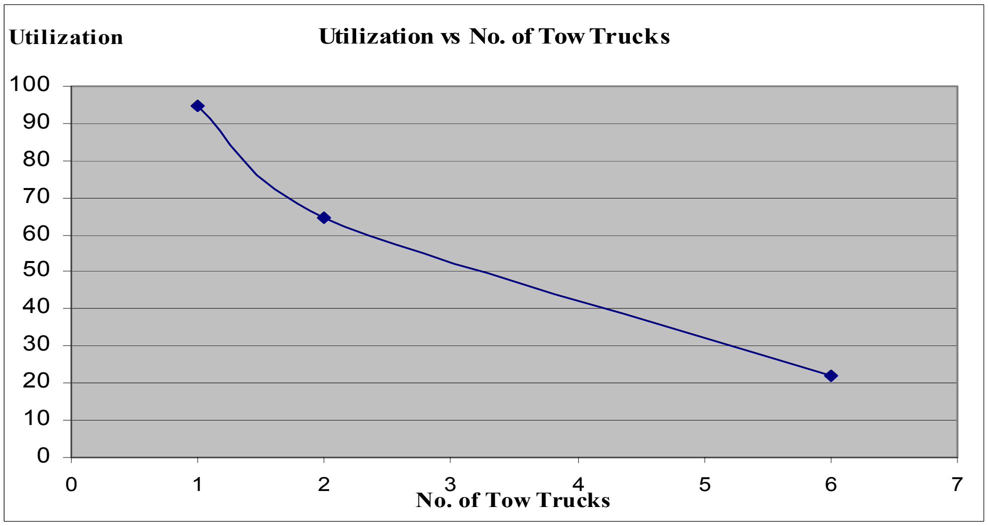
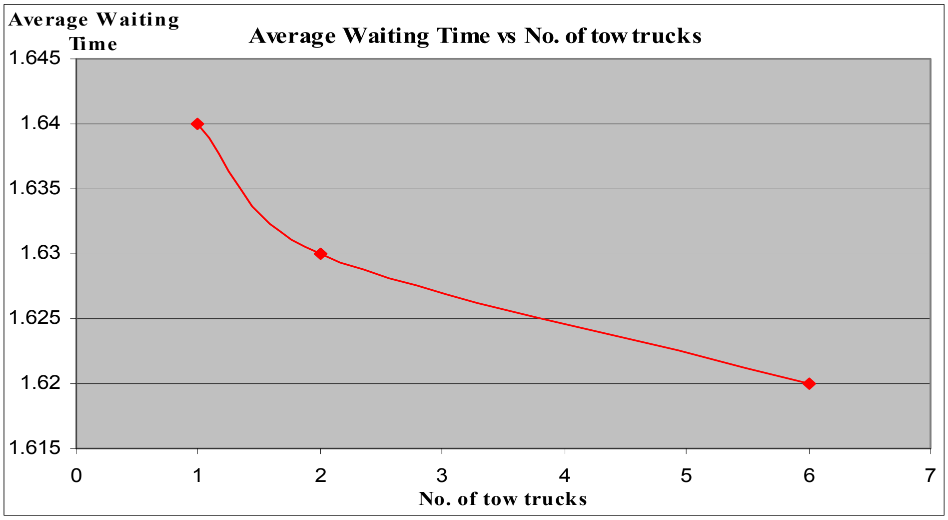


Figure 5. Average Waiting Time of Tow Trucks in the 'To-Be' Process



The model that would improve the efficiency and reduce wastage of resources should be selected as the most efficient model. Based on the results presented above, the most efficient model is the first 'to-be' model. It is found that for utilization of two tow trucks, the utilization level is 72.40% and has the shortest average waiting time among all the permutations of the number of tow trucks used. This arrangement increases the current utilization level of tow trucks by 48.57% and shortens the average waiting time by 0.09 minutes. Furthermore, it reduces the number of tow trucks used from six to two. Thus, there will be savings in terms of maintenance of tow trucks and freeing up of other tow trucks to be used for other duties.

If the number of tow trucks is reduced from six to two, it may mean that many tow truck drivers will either be transferred to another department which has shortage of manpower or will be asked to look for another job. Thus, tow truck drivers might not be happy with this change, as there is a reluctance to be readjusted to a new environment. Using two tow trucks will push up the utilization level to 72.41%, which implies that tow trucks drivers may have to over-work as they might not have sufficient rest between deliveries. Furthermore, tow truck drivers are all aged in their late forties; they might need a longer rest between deliveries.

CONCLUSION

This study attempted to assess the utilization of resources involved in the food supply process at Singapore Hospital. Using Arena simulation program, the food supply process was replicated virtually and alterations were made to the "as-is" simulation model to improve the overall efficiency of the system. The results of the simulation indicate that the utilization of tow trucks is low in the current system. We compared the results of the 'as-as' process with those of the "to-be" process in terms of the utilization of resources and the wait time. The results show that by reducing the number of tow trucks, the waiting time is shortened. The model that yielded the most efficient process was recommended to the MMD for implementation. It is also recommended that the data should be collected regularly and the review of the data should be done periodically for more accuracy. This needs to be done so that the simulation models can represent the process and the utilization of resources more accurately.