Proceedings of the 2009 Winter Simulation Conference
M. D. Rossetti, R. R. Hill, B. Johansson, A. Dunkin and R. G. Ingalls, eds.

SIMULATION IN RETAIL: A CASE STUDY FOR PROCESS IMPROVEMENT IN THE RECEIVING AREA

Marissa A. Vallette
Prajwal Khadgi
Reinaldo Moraga
Ehsan Asoudegi
Omar Ghrayeb

Department of Industrial and Systems Engineering
590 Garden Road, Engineering Building Room 230
Northern Illinois University
DeKalb, IL 60115, USA

ABSTRACT

Simulation tools allow its users to computationally model real-life systems in order to determine their best future outcome. One real-life system that can benefit from simulation is that of the retail industry. This paper describes how simulation can be an effective tool for this type of industry, especially for process improvement projects. In addition, a small case study is presented to demonstrate the use of simulation for a large retailer which needs to improve its unloading and receiving processes. Among the future ideas for research, this paper shows that less obvious methods for process improvement, such as tracking customer loyalty, can be analyzed using simulation to determine which route a retailer should take in order to please its customers. Other topics on this subject are suggested at the conclusion of this paper.

1 INTRODUCTION

Due to the current state of the economy, consumers are now watching their money more than ever. In times like these, normal retail customers are probably not spending as much money as they normally would or they are altogether not making the extra shopping trip. However, there is certainly a lot of room to improve processes in retail companies and, therefore, to make substantial progress; simulation techniques can help retailers improve the performance of their operations.

Simulation techniques are capable of mimicking large and complex systems. Even with extremely large amounts of inputs and variables, simulation models do not take long to retrieve findings. This paper discusses articles and journal papers that have used simulation to lead to valuable insights about a retailer and how its operations are run. What makes simulation so powerful is that a retailer can use it for multiple purposes, not to simply figure out how it can lower its prices or increase store profits. The analysis of a simulation model can allow a retailer to schedule its manpower, to control its inventory, to correctly place marketing in the store, and to run its operations more efficiently in addition to many other possible outcomes.

In short, simulation is an excellent method for a business to not only look at how its business is currently being run, but also to find opportunities for process improvement or to help fine-tune conclusions within process improvement projects. Most methods that practitioners use for process improvement tend to be mathematically simple and often do not take variability into consideration. This is why simulation can be an effective tool for managers to monitor and improve their daily operations. This paper is about creating a small simulation model based on information given by an important retail chain, which was embarked in a major process improvement project, and finding a way to improve the current operations. By using simulation, the authors are able to explore multiple scenarios for the retailer and recommend an option that would improve its current state. Even though this recommendation might not necessarily be optimal, it is a way for the authors to provide the retailer valuable insights of its current operations and what could potentially happen if the retailer were to select an alternative method to conduct its operations.

Section 2 talks about different simulation inputs for retailers and elaborates by giving some detailed examples of simulation models and papers already published in journals and conference proceedings, Section 3 provides a case study conducted by the authors for using simulation in process improvement, and Section 4 makes some concluding remarks and suggests further work.

2 LITERATURE REVIEW

The important concept of simulation is that it is an attractive tool for any industry. It allows a business "the ability to consider alternative scenarios, or [to consider] 'what might have been'" (Houston 2006). What enables this is the ability to experiment with certain variables, constraints, entities, queues, and other decision-making parts of the model (Stallinger 2000). Stallinger continues by arguing that simulation modeling not only allows the company to understand the current business situation but also helps to understand and learn the "complexities of dynamic behavior" (Stallinger 2000), thus, gaining insights to process improvement.

In the world of retail, management cannot possibly control everything. The number of customers purchasing items, the fraction of items that will be unaccounted for at the end of the day, the number of workers who will call off sick, the total revenue for the day, and many other uncontrollable factors need to be considered. Simulation is able to relieve the practitioner of some unpredictability without a sophisticated mathematical model. The following are a few components of retail that engineers consider when creating a simulation model and real-life examples of these operations factors put to use. All of these uses are for the purpose of process improvement. Without the use of simulation in these examples, insights of the company would not be easily and readily available and management would have to find other ways to improve their operations without the convenient tool of simulation.

2.1 Inventory and Replenishment

Where there is a retailer, there is inventory. The main purpose of a retailer is to sell a product or a service. There are many uncontrollable situations with inventory: theft, order lead times, inventory on hand, defective items, etc. Inventory is probably the most popular research topic when it comes to retailing because it is the main purpose of retailing. For example, Signorile (2002), Fleisch and Tellcamp (2005), Leonard and Cronan (2002), and Nair and Closs (2006) all did research on inventory control and replenishment strategies in retailer supply chains. Another study was done by Ayanso et al. (2006) which was based on shopping online and inventory rationing.

Al-Zubaidi and Tyler (2004) studied how to properly replenish seasonal clothing. In their study, they applied an approach called Quick Response (QR) which conveys a business strategy that reacts to customer demand. What this implies is that this strategy works well with suppliers whose goods have sold well.

The objective of this study was to simulate a range of responsive behaviors in the clothing supply chain based on customer behaviors and responses. The simulation model was divided into two QR strategies: fixed quantity re-ordering and fixed interval re-ordering. The results of the simulation found that by increasing the order quantity, the number of lost sales was reduced during the particular season. Also, by adopting the fixed interval re-ordering approach, the lowest level of lost sales could be obtained. These results are intuitive; if a particular item of clothing is very popular, it is better to have more on hand rather than too few. Otherwise, the store might have to backorder large quantities which in turn leads to loss-of-goodwill. Another scenario that Al-Zubaidi and Tyler (2004) explored was a customer leaving the store to purchase that particular item elsewhere and perhaps at a cheaper price. If the store adopts a policy where the re-ordering is done at intervals, this will allow the company to know how much inventory is in stock and will allow the bookkeeping mess to be kept to a minimum. If the company does not know when stock will be coming into the store, it will be hard to prepare for its arrival, thus creating problems.

As mentioned above, inventory and replenishment are the main focus of any retailer. Because there are multiple ways in which a company can order its inventory, the company can benefit from using simulation to model different re-ordering scenarios to figure out which one works best to improve the company's overall operations.

2.2 Staff Scheduling

One area that management has some control over is the number of workers that are scheduled each day. As mentioned above, management, however, cannot control how many workers call off sick but through the use of simulation, management can at least plan for the number of sales staff that they know will need to be on hand in order to help achieve the sales forecasts.

Kabak et al. (2008) conducted a simulation study which adopted the logic of Lam, Vandenbosch, and Pearce (1998) and their model. Kabak et al. (2008) elaborated on this model by proposing a two-stage model. The first stage used a sales response model to specify hourly staff requirements while the second part of the model used integer optimization to find an optimal number of staff to the daily shifts. The study was applied to a Turkish apparel chain store which had three different types of stores: central business district stores, neighborhood business district stores, and shopping mall stores.

First, Kabak et al. (2008) forecasted sales revenue based on pre-existing data such as store traffic, time period, the number of all available staff and others. For example, categorization was used to determine customer arrivals. In order to create the sales response model, the approach to calculating the amount of salespeople was calculated in a different manner. Lam, Vandenbosch, and Pearce (1998) calculated this number by arguing that salespeople should be added to the schedule as long as their contribution to being in the store added to the profit of the store. However, Kabak et al. (2008) executed a different approach: the number of staff that maximized net gross profit was used. This meant that the number of staff and the overall sales of the store were positively related.

Kabak et al. (2008) continued to elaborate on other meaningful inputs such as customer purchasing behaviors in relation to how long customers spent in the store as well as how they reacted to discounts. Simulation was used because it provided Kabak et al. (2008) with results that were used to validate the sales response function as well as to revise the model if needed.

The final results of this simulation found that maximum weekly profit occurred at what is called a "percentage of increment" level (Kabak et al. 2008). This is a value that maximized weekly profit and in this case, it maximized the profit for each store type used in the Turkish apparel chain store. Even though there were different kinds of stores, each store type, central business district, neighborhood business district and shopping mall, all benefitted from this "percentage of increment" (Kabak et al. 2008).

What makes the research of Kabak et al. (2008) so important is that it maximized the efficiency of scheduling while at the same time maximizing profit. The Turkish apparel chain store can profit from this study because now, management knows how to schedule their staff without having to worry about who they are scheduling and for what hours and whether or not they will help the chain realize their sales goals. No matter what the case, the chain will be making money. The schedule showed the number of required staff for that day. Therefore, management could take into account how many people would need to be scheduled just in case one or two called off sick.

When scheduling staff, a lot of variables need to be addressed such as the availability of staff, the hours of the store, and the sales goals that need to be met during store hours. If the store's ultimate goal is to make more money, then this efficient scheduling process as presented by Kabak et al. (2008) should be more than enough to help get the store realizing more profits. Also, by having a complete staff schedule, managers will be able to determine the flow of their customers, and potential sales, based upon how many and where each staff member is located.

2.3 Competition and Cooperation

Managers do not have control over the pricing of their products. This information comes from higher management and perhaps even the CEO. Sometimes these prices affect the shopping habits of customers which give competitors an advantage. They know what one store is doing and it is either working, which implies creating customer satisfaction, or it is not working, implying that customers are leaving unhappily and shopping elsewhere. Everyone wants to get the best price on a product or service. In fact, some customers will go out of their way in order to get the best price possible. This is particularly true in the current day now that the economy is in a recession and customers are now more money conscience than ever.

This topic is discussed by Xie and Chen (2004). In their paper, Xie and Chen adopted an agent-based simulation in order to study the competition between price-setting retailers. Their model consisted of a single product supply chain with multiple competing retailers who needed to make decisions based upon pricing and quantity. In their paper, Xie and Chen (2004) described a set of chronological events. Ultimately what happened, and should have happened, is that retailers satisfied customer demands based upon their own policies during a certain time period. Once this period was over, they evaluated the performance of their current policies.

In addition to these events, Xie and Chen (2004) took into account customer behavior and retailer behavior. To make matters simple, it was assumed that customers only wanted one unit of product. As for retailer behavior, it was assumed that there was little information known about the retailer's environment such as the policies of their respective competition. This eliminated perfect rationality which is commonly found in game models (Xie and Chen 2004). Finally, supplier's behavior was also monitored. This was not as complex as the other two behaviors but it still was relevant.

Five experiments were completed by changing the numbers of retailers in the environment. Increasing the number of retailers implied a much more intense competition among these retailers. Wholesale price was constant, the number of customers was a Poisson random number, two different prices for products were given, and retailer order quality was assumed.

What helped Xie and Chen (2004) come to their results was the fact that they divided their results into two sections: convergence and insights. To summarize quickly, the results of the experiments demonstrated that the system approached Nash equilibrium in steady states. This implied that the retailer had no incentive to change his or her policies. While this is quite interesting, it is probably much easier to look at the insights of the results. As the number of retailers in the environment increased, overall pricing decreased which meant that customers benefitted from the competition. Also, when there was much more competition, implying more retailers, the war against lowering prices was not as fierce as it might have first seemed. Retailers were "simple-minded" as Xie and Chen (2004) described, meaning that these retailers preferred a higher profit and would not change their policies in order to beat other retailers in the war on pricing. Because retailer competition implied overall lower prices, this implied two things: (1) this reduced retailers' total profit, and (2) this increased customer demand which increased total profit.

In a similar study, Xie and Chen (2005) explored retailer cooperation. Two experiments were designed that incorporated a certain number of retailers and whether or not they cooperated with one another. More specifically, experiment group one contained two experiments simply with two retailers and the only difference between the two experiments was whether or not these two retailers cooperated with one another. The second experiment group contained multiple retailers and some possible combinations of cooperation among them. Xie and Chen (2005) defined retailer cooperation as the cooperation among the partners on the same supply chain level. After running the two sets of experiments, some interesting conclusions were drawn. From the first experiment group, it was found that cooperation raised retail prices. Because of this, customers would not demand as much which therefore decreased the total profits realized by each retailer. Thus, suppliers would not want to reinforce cooperation between retailers. From the second experiment group, it was concluded that cooperation was more beneficial to the competitors. This was due to the fact that more profit was gained when cooperation was involved.

Competition and cooperation are two very important factors in retail. They can lead to conclusions about the decisions made in the store and how they can affect the other stores in the same industry. These two factors are hard to quantify and if better tools are used to predict them, such as simulation, then retailers will be able to use them to their advantage by analyzing and applying them to their business.

2.4 Relationships

People are an uncontrollable force. Retailers have no idea how many customers are going to walk through their stores everyday and lower management has no idea what demands higher management will put upon them. Relationships between the staff are incredibly important as well as relationships between the store and the manufacturers. Both of these relationships allow engineers to better understand the mentality of the people working in the real-life system. These relationships are the foundation of the store; they help determine what is accepted and what is not and how to maintain the balance between what can be done and what could potentially be done.

Ou-Yang and Shieh (1999) developed a Petri-net simulation model to demonstrate the hierarchy of a shop floor. What they found, by computing resources for the main shop floor controller, is that there still indirectly existed a loose "master/slave" relation, as they coined it, between central and cell controllers (Ou-Yang and Shieh 2008). This implied that even though managers and associates worked together, and the working environment that is created by management is somewhat friendly, there was still some tension in the workplace. Furthermore, company information was only given to certain people. This supports the argument that simulation can be used to study the lack of company knowledge of those in lower-level positions and how their responses either contribute to or harm the future success of the company.

Another stressful relationship, as mentioned above, is between the store and its outsourced facility. Kumar and Arbi (2008) conducted a case study on two major factors, cost and delivery time, that determined the success of US retailers and how these two factors could be used to help guide the retailer to the appropriate course for outsourcing. The case study included the analysis of four major entities: the customer, parent facility, outsourced facility, and logistical services provided to the company. The apparel retailer had to be located in the United States and had the option of outsourcing overseas. Monte Carlo simulation was used to determine cost distributions for various supply chain levels, and ultimately, how these different cost distributions would effect apparel delivery time. Kumar and Arbi (2008) concluded two major points: (1) the responsiveness of the outsourced facility was strongly dependent on the capabilities of the logistics supplier, and (2) cost savings existed even if the company needed to outsource overseas. In addition, Kumar and Arbi (2008) made two inferences from their case study. The first was that the total monetary savings could be drastic if a company decided to outsource. However, the option of outsourcing had to be used with caution. Outsourcing is recommended for large seasonal orders, not to meet short-term demands. The second inference was that the total lead-time for the US apparel producer could improve assuming that "certain controllable factors (such as, order processing) could be made as efficient as possible" (Kumar and Arbi 2008). However, what Kumar and Arbi ultimately concluded was that "true synergies of outsourcing [which are]…logistics, IT systems, long-term relationships, and the use of simulation" can help determine the true cost savings and time savings of outsourcing (Kumar and Arbi 2008).

2.5 Literature Review Summary

As seen in the above literature review, there are many extensive articles on simulation in process improvement. Even though these articles do not always implicitly state that simulation has improved the overall operations of the particular problem being studied, the resolved issues or conclusions made from any type of simulation model can be argued that they helped with process improvement. Inventory and replenishment strategies, which are the main aspect of a retailer's operations, help the retailer determine how to better help their customers by knowing exactly how much inventory is in the store at all times and when to expect the next shipment and what it will contain. Scheduling helps managers understand the flow of their staff and where to expect customers to be asking questions or picking up certain items. Competition and cooperation help better a company as well as the other companies in the same industry. If one type of way of doing business works for one retailer, it should hopefully work for the other retailers. Finally, relationships are essential to the success of a retailer. Whether it's the relationship between a sales associate and a manager, or the company and the outsourced facility, both help determine how a business is run and what effects, financial and timely, they have on the customer.

There are other aspects of process improvement that should be explored in future research. Only a few are mentioned at the end of this paper. Because there are so many papers and so many more options for improvement, simulation will help retailers in all sectors to improve their operations. Therefore, there is much more room for growth in this small area for applications of simulation.

3 CASE STUDY

Simulation can be used in the retail sector to observe a system via computer model to help improve a retailer's operations by evaluating the effects of various decision variables. Some sub-systems within a retail operation are the receiving process of new merchandise, replenishment of merchandise, inventory control, placement of an order, and customer experience. In this paper, the authors have developed a simulation model of a section of a retail operation, specifically, truck receiving and apparel preparation area for a retail company. The simulation model was built using ARENA software. By running this model and evaluating various scenarios and observing the effects of changing variables, such as the size of the truck load, and the number of workers deployed, the authors provided important insights to the process improvement team which contributed to the decision-making processes within the retail management system and subsequently to the overall process improvement in retail operations.

3.1 Problem Description

A large retail chain has its inventory delivered to one of its stores via truck. The process improvement team estimated that each truck can carry between 800 and 1600 cartons. After the truck arrives at the retailer's facility, it is driven up to an unloading area where cartons are unloaded by an unloading worker. At the unloading dock, this worker unloads all the cartons and places them on a conveyor belt. As the cartons travel along the conveyor, there are additional workers who sort each carton based on its contents and places it in one of ten pallets in the receiving area. By using statistical sampling, it was determined that each pallet can hold 20 to 30 cartons. Once the pallet is full, the pallet is moved by one of the workers to its respective location. For example, all electronics will be moved to the electronics preparation area. For the purposes of this study, the authors focused on pallets 1 and 3 which contain men's and women's apparel. With these two pallets, once one is full, one of the receiving area workers will remove the pallet and bring it to the apparel preparation area. In this area, the items of clothing are removed from the cartons, organized, and placed on the inventory rack. This process is done before the actual replenishment, where the floor associates will take these apparel racks onto the floor and replenish necessary apparel as required. Furthermore, for the apparel that is more expensive, it is tagged with sensors to ensure safety of the merchandise. Once all the apparel has been prepared, it is then moved from the apparel preparation area to the sales floor which is outside the boundaries of the model. At the same time, the pallet that has been used is then moved back to the receiving area by a receiving area worker and placed back in its respective location where cartons can resume being placed on it.

The process improvement team was interested in estimating the number of workers required for different levels of carton load. Therefore, the purpose of this simulation model was to determine a few factors: increase total worker utilization by finding the minimum number of workers at each area, decreasing the total unloading time for all cartons using 800, 1200, and 1600 carton scenarios, and increasing the total number of cartons unloaded from the truck by reducing unloading time. The different sizes of the truck load were determined according to the retail manager. According to the manager at the store, the size of the truck varied depending on the season, day of the week, order quantity, and other factors. A minimum of 800 cartons was assumed as a low load case and a maximum of 1600 cartons was assumed as a high load case. Thus, 800, 1200 and 1600 carton trucks were selected for this case study as low, medium and high load scenarios. As mentioned earlier, simulation is a tool that can help retailers make better management decisions by evaluating different scenarios beforehand. This will greatly help in the process improvement of retail operations because scenarios can be evaluated by taking into account variability observed from the operations. Even though the results of this case study might not necessarily be an optimal solution, it will guide the retailer in the right direction as to how many workers to hire, how many cartons are expected to be unloaded, and the expected time it will take to unload those cartons.

3.2 Simulation

The model is divided into two parts: the unloading and receiving area and the apparel preparation area. As mentioned above, the unloading and receiving area is where the cartons are unloaded from the truck, placed on the conveyor, sorted by contents, and moved to the apparel preparation area or another area outside the boundaries of the model. The creation of the cartons was done by using a Submodel as seen in Figure 1. In the Submodel, a "Create" module was made to generate ten entities (cartons) which would keep track of the total number of cartons in the system and an "Assign" module would give an attribute to each carton as to how many of what type of carton were entering the unloading area such as men's apparel, electronics, etc. The Submodel was programmed to stop generating cartons once the total number of cartons equaled the total number of cartons in the truck. Once a carton was created and counted, it would move to the main model where it was unloaded from the truck and placed on the conveyor. The contents of the carton would be determined, given by Skid, and then routed to the correct pallet. Each carton had to go through a "Block" block and an "Unblock" block. These two blocks were used in case a pallet was already being occupied, such as in the apparel preparation area, and the carton could not immediately go to the pallet. Once a pallet was full, it would be moved to its appropriate location, thus, leaving the unloading and receiving area. Figure 2 shows the top half of the unloading/receiving area.

The second part of the model is the apparel preparation area. This is where the men's and women's apparel pallets are brought once they have left the unloading and receiving area. Once the pallet arrives, cartons are taken out one-by-one. Their contents are removed from the carton, sorted, and placed on a rack. Also, some of the inventory is tagged with sensors. Simultaneously, the emptied cartons are disposed once all contents have been removed from the carton. This process continues on until all the cartons have had their contents processed and all cartons are removed from the pallet. The pallet is then returned to the unloading and receiving area by a worker and the process of sorting the unloaded cartons into the pallet starts over. A portion of the apparel preparation area is shown in Figure 3.

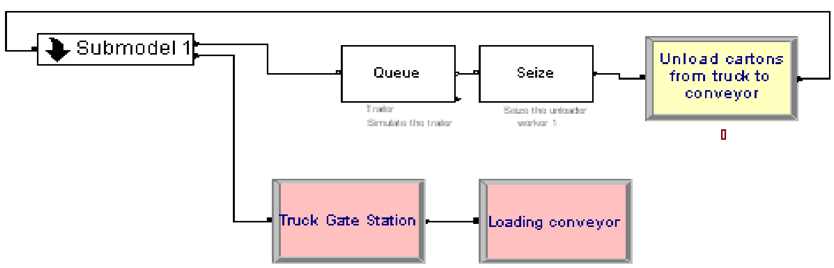

Figure 1: Submodel

Prior research had been done at the retailer making information about processing times, number of workers, number of cartons, and other numerical figures readily available. The distribution for all the process times were evaluated in Input Analyzer according to data collected by some of the authors in a previous study. Some of the processes did not have enough data to formulate the actual distribution. For this reason, a triangular distribution that contained the average standard times, the minimum allowed, and the maximum allowed value was used. This was good representation of the process distribution in cases where a lot of data was not available. The total number of workers in the receiving area was variable according to the manager's decision as well as the truck load at the time of unloading. A variable, called "cartonMax", was assigned to produce the number of cartons on the truck. Three types of workers, as resources, were also generated in the unloading and receiving area. The first resource, "worker1", worked inside the truck unloading the cartons onto the conveyor. There was initially one of these workers. The other two resources, "worker2" and "worker3", were located near the pallets and were responsible to sort the cartons from the conveyor onto the pallets as well as transfer pallets to the stockrooms. "Worker2" and "worker3" had variable capacities. This variable capacity was used to simulate different quantities of workers using only two resources, as sets, instead of using separate resources. By doing so, it was easier to change the capacity of the workers to represent changing number of workers in different scenarios later in Process Analyzer.

After setting up the model for an initial scenario, the terminating condition of the model was determined and entered into the simulation model. The goal was to capture the total time taken to unload all the cartons from the truck. Therefore, the terminating condition was given when the variable "CartonsUnloaded" equaled the variable "cartonMax", which meant that the model would stop when all the cartons in the truck had been unloaded onto the pallets.

The variable "UnloadingRate" was defined as (cartonMax / UnloadingTime), where the variable "UnloadingTime" was equal to (total simulation time / 3600). By doing this, it was easier to observe the unloading time and unloading rate in terms of hours.

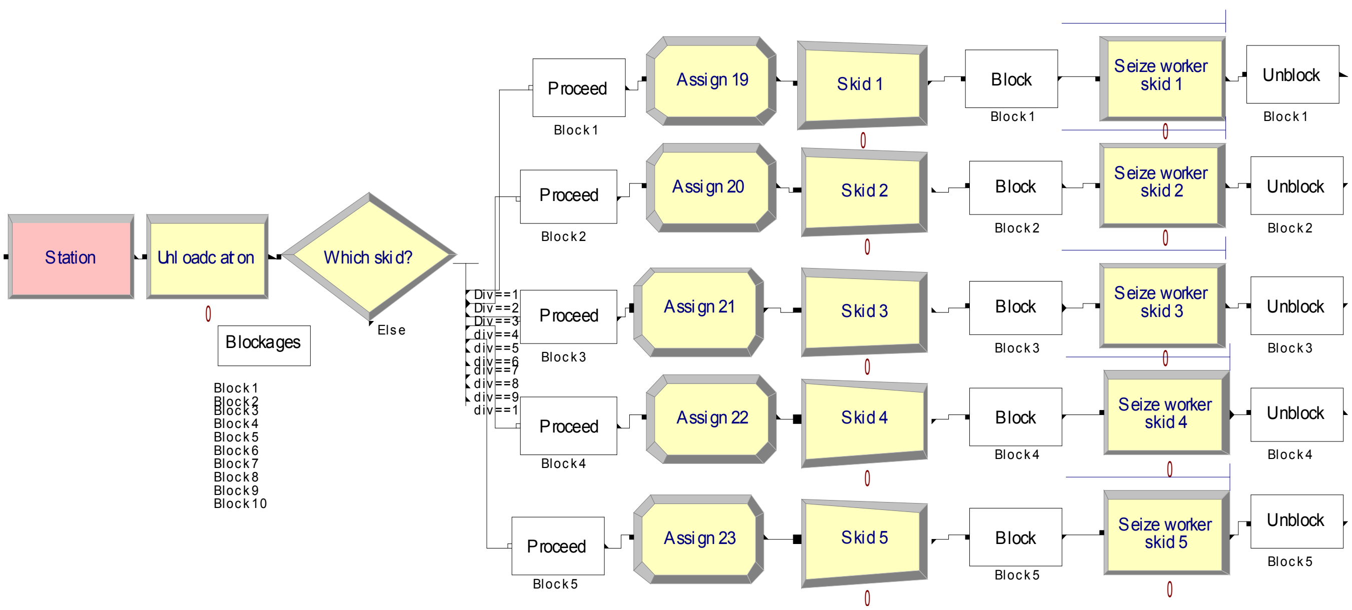

Figure 2: Unloading/receiving area of the retail store

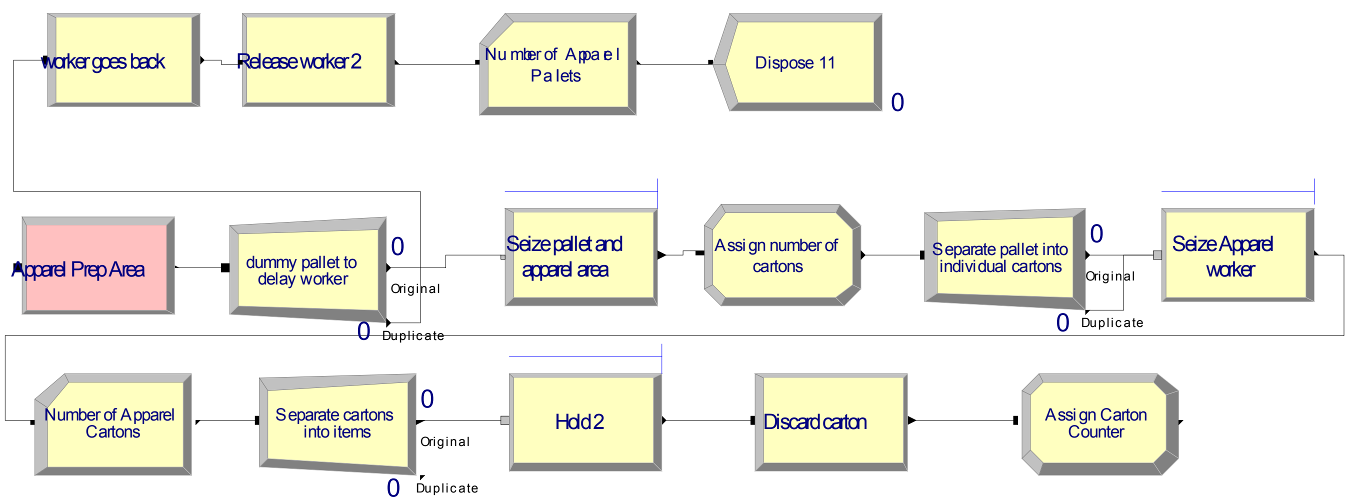

Figure 3: Apparel preparation area

The variable for "UnloadingRate" was used to validate the simulation model. Ten preliminary replications were run in order to calculate the number of replications needed. The number of cartons unloaded per hour observed directly from the system was 290 cartons. After running the model for the initial ten replications, an average unloading rate of 268 cartons per hour was observed. This value is within 7.5% of the actual standard unloading rate of 290 cartons per hour. This showed that the simulation model was behaving close to the actual system.

Once the model was validated, the number of replications had to be calculated. Based on the calculations of mean, standard deviation, and half-width given by Output Analyzer, the number of replications required was calculated as shown below. Figure 4 shows the 95% confidence interval on the mean unloading rate. The correct number of replications was calculated as

$$h = t_{n-1}\frac{s}{\sqrt{n}}.$$

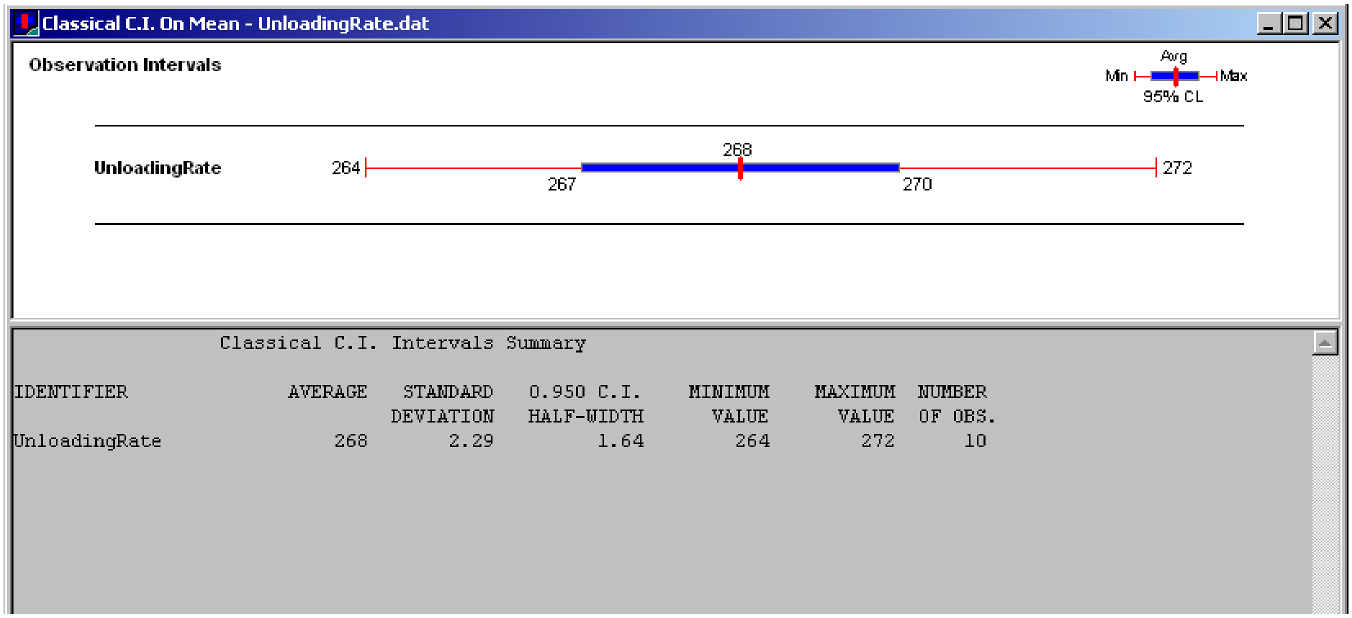

Figure 4: Confidence interval analysis

From the confidence interval analysis in Output Analyzer, as shown in Figure 4, the half width (h) = 1.64 and the standard deviation (s) = 2.29. In order to calculate a confidence interval of 95%, the t-table value gave t_{n-1} = 2.262 which was given for α = 0.025. Hence, the number of replications required was calculated as

$$
\begin{aligned}
n &= t_{n-1}^2 \frac{s^2}{h^2} \\
&= 2.262^2 \frac{2.29^2}{1.64^2} \\
&= 9.97 \\
&\approx 10.
\end{aligned}
$$

3.3 Results

After the total number of replications required was calculated, scenarios for improvement could be complied and run through Process Analyzer. The control variables were the number of cartons in the truck and the number of workers in the unloading and receiving area. The total number of cartons was chosen among 800, 1200, and 1600 cartons. The number of workers used varied between three and seven, with one worker solely dedicated inside the truck for unloading. “UnloadingRate”, “UnloadingTime”, and worker utilizations were selected as the responses.

Figure 5 shows the scenarios and their respective results. After running all scenarios, the responses for “UnloadingRate”, “UnloadingTime”, and the worker utilizations were observed. For an 800 carton load, the total unloading time reduced from 3 hours to 1.5 hours by adding an extra worker inside the truck and also slightly increasing the number of sorting workers. For the 800 cartons load, which were Scenarios 1, 2, and 3, the best case was Scenario 2, to have three workers sorting and two workers unloading, since the unloading time is 1.58 hours and the worker utilization was also almost always 95%.

For the 1200 and 1600 carton load, there were similar results. The unloading time decreased and the unloading rate increased drastically by adding an extra worker inside the truck for unloading. It is seen that about four workers working in sorting and two workers inside the truck produced a better unloading rate as well as almost 75% worker utilization.

Scenario Properties				Controls				Responses				
S	Name	Program File	Reps	worker 2	worker 3	worker 1	cartonMax	worker 2.Utilization	worker 3.Utilization	worker 1.Utilization	UnloadingRate	UnloadingTime
	Scenario 1	10 : RetailSimulation.p	10	1	1	1	800	0.762	0.766	0.986	266.342	3.004
	Scenario 2	10 : RetailSimulation.p	10	1	2	2	800	0.952	0.955	0.909	505.380	1.583
	Scenario 3	10 : RetailSimulation.p	10	2	2	2	800	0.750	0.733	0.955	526.861	1.519
	Scenario 4	10 : RetailSimulation.p	10	1	2	1	1200	0.557	0.492	0.990	266.357	4.506
	Scenario 5	10 : RetailSimulation.p	10	2	2	2	1200	0.763	0.747	0.971	532.110	2.256
	Scenario 6	10 : RetailSimulation.p	10	3	2	2	1200	0.592	0.634	0.972	530.875	2.261
	Scenario 7	10 : RetailSimulation.p	10	2	2	1	1600	0.386	0.391	0.995	266.269	6.009
	Scenario 8	10 : RetailSimulation.p	10	3	2	2	1600	0.599	0.644	0.983	532.469	3.005
	Scenario 9	10 : RetailSimulation.p	10	3	3	2	1600	0.506	0.516	0.978	532.694	3.004

Figure 5: Scenarios and results from Process Analyzer

3.4 Analysis

As seen from the results above, the addition of an extra worker inside the truck greatly increased the unloading rate. However, the addition of too many workers in the sorting section did not greatly contribute to the unloading rate but only decreased the worker utilization. This meant that too many workers caused more idle time while the unloading time remained the same. For specific days or seasons, workers can be scheduled by utilizing a simulation model and observing the effects of various parameters. In this particular study, Scenarios 2, 5, and 8 would be suggested to the retailer considering that they achieved the main objectives of reducing unloading time, thus increasing the unloading rate, and increasing worker utilization by having the smallest amount of workers possible.

By completing this simulation model and running Process Analyzer, the authors do not intend to solve for an optimal solution for this particular case study. However, as mentioned earlier, this case study is to demonstrate that simulation is a powerful tool which may be used to analyze different operational conditions and make useful decisions for those businesses that choose to use it. The different scenarios studied in the above experiment only represent a small number of possibilities, and many more cases can exist depending on the season, day, time, etc. The number of cartons also varied from truck to truck and hence, separate scenarios and cases should be run in the future by the retailer. This study can provide a good tool to effectively schedule labor as well as organize the work load, thus improving overall operations.

Retail managers can utilize this kind of study and its results in improving current processes to achieve higher efficiency and overall throughput in their operations. The model that has been studied in this paper represents a small portion of the entire retail chain, and there is a great possibility of using similar kinds of simulation techniques in various other sectors of the retail system for process improvement and better decision-making.

4 CONCLUSION AND FURTHER WORK

Throughout, the paper has shown that simulation modeling is an important tool to consider when a process improvement project takes place. The case study discussed shows that a small but focused simulation model can provide enormous insights for the team in charge of performing process improvement. The reason why simulation is an ideal tool is because it can incorporate variability which allows the users to see the results of the potential possibilities without implementing the changes in real-life until an optimal decision can be made. With this, simulation can be applied to any real-life system. This can be hospitals, department stores, classrooms, and airports. No matter the size of the system, simulation is able to take on the defining characteristics of each system and provide reports based on entities, resources, queues, and user-specified inputs. Simulation allows the business to change anything possible without costing the company money; it allows the implementation of new ideas without implementing them in the real-world. Some of the possible changes include inventory and replenishment, scheduling, quality improvements, and business relationships.

Engineers should not ignore the hot topics in simulation today such as healthcare. However, it is the duty of an industrial engineer to make a product, process, or service more efficient. With this comes the experience of shopping. Engineers, through simulation, can make shopping a little bit easier for everyone, even for those who do not enjoy it.

Because a retailer has so many different places to consider when simulating, there are many areas for potential improvement. Even though these areas were not specifically included in the case study above, they are still important factors to those retailers who find them to be a main part of their operations and they should be included in future simulation models.

Baydar (2002) suggests that simulating all customer loyalty cards can become quite expensive. Even though sorting through each customer's shopping behaviors can lead to larger store profits, it is also time-consuming. A simulation model could be created on the sorting process which would reduce the retailer's original cost of sorting them manually. In addition, retailers would be well on their way to improving customer satisfaction and store profits by using individualized shopping.

There is always room for potential in this area considering that customer satisfaction and store profits should always be two main goals in retailing. In addition, this would help process improvement by improving the flow of customer traffic considering that return customers might not necessarily shop in the same manner as those who are shopping in the store for the first time.

Similarly to modeling customer loyalty, another area for process improvement is modeling human behavior. There is no way to know how a customer is going to react in any given situation. This is just what human nature is. It might be impossible to figure out how to model human behavior in retailing when each retailer sells multiple products everyday. The same customers do not come into the store everyday. Simulation might be able to help in this area by creating multiple experiments based on human behaviors. Perhaps certain behaviors are demonstrated when presented with different products. By figuring out certain human behaviors in the store, the retailer would have a better idea as to what to expect from customers. This would help improve the store's way of approaching customers by knowing potential problem spots ahead of time.

Management should keep track of how efficient their staff is in each department. For example, in the apparel sector, sales staff should make sure that they know all about the products being sold in the store: what sizes and colors they come in, how well they fit, what prices they are fixed at, etc. Cashiers should be able to complete all kinds of transactions as well as complete returns no matter how difficult. Inventory staff should know how to properly process incoming inventory and how it should be prepared to be put on display. If this is used as an input in simulation, it might possibly show light on why other aspects of the store such as why customers wait for so long at the cash register, why certain items are unaccounted for, why certain items are better sellers than others, etc. If management knows the efficiency of the staff, this could potentially lead to a reduction in delay times in all areas of the store.

Different stores use different means of technology. Simulation can look at the way staff and managers are using what is available to them and determining whether or not the current practices of the business are contributing to their profit. Simulation can also imitate staff and management using other software packages or simply using different methods in order to see if changing what they do makes a difference. Sometimes it takes a particular business a longer amount of time to understand newly implemented technology. This leads to the retailer focusing more on the technology rather than the customers. If this is true, then customers will be waiting longer for someone to help them which therefore will lead to longer time spent in the store.

Forecasting demand is one of the most unpredictable elements in retail, especially the apparel sector. Since popular fashion can change on a day-to-day basis, businesses would benefit from using simulation to predict what customers are buying and in what quantities. Even though predicting customer demand may never be an exact science, simulation would at the very least provide a business with customer habits and perhaps be able to include environmental factors such as current market trends and economic status of shoppers. If the retailer knew exactly what was in the store at what time and when new orders are arriving, the retailer can not only improve customer satisfaction, but also their operations because they are more aware of what they have.

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AUTHOR BIOGRAPHIES

MARISSA A. VALLETTE is a graduate student at Northern Illinois University in DeKalb, Illinois. She is currently pursuing a Master of Science degree in Industrial and Systems Engineering. Ms. Vallette obtained her Bachelor of Arts degree in mathematics and Spanish from Lawrence University in Appleton, Wisconsin, in 2008. Her current research interests are operations research, production planning and control, and lean manufacturing. At Northern Illinois, she is the Educational Director for the university's chapter of the Institute of Industrial Engineers as well as a member of the university's chapters of the Society of Women Engineers and Alpha Pi Mu. She can be contacted at <marissa.vallette@gmail.com>.

PRAJWAL KHADGI is a graduate student at Northern Illinois University in DeKalb, Illinois, pursuing his Master of Science degree in Industrial and Systems Engineering. He completed his Bachelor of Science degree in Mechanical Engineering from the Institute of Engineering in Pulchowk, Nepal. His research interests include simulation and modeling techniques, operations research, and product and process design and he has been involved in research projects involving process improvements in the retail sector. Mr. Khadgi is a member of the university's chapter of Alpha Pi Mu. He can be contacted at <k_prajwal@hotmail.com>.

DR. REINALDO MORAGA is an assistant professor in the Department of Industrial Engineering at the Northern Illinois University. He received two Bachelor of Science degrees in Wood Engineering in 1988 and Industrial Engineering in 1993 from Universidad del Bio, in Chile, and has both a Master of Science and a Ph.D. in Industrial Engineering from the University of Central Florida. His research interests are simulation, operations research, disaster operations management, and supply chain management. He can be contacted at <moraga@ceet.niu.edu>.

DR. EHSAN ASOUDEGI is an assistant professor of Industrial and Systems Engineering at Northern Illinois University. He received his Master of Science degree in Industrial and Operations Engineering from the University of Michigan and his Ph.D. in Industrial Engineering from West Virginia University. He has been involved in teaching, research, and consulting in the areas of human factors, industrial ergonomics, work measurement and time studies, design of experiment, and quality control. Companies and agencies he has worked with include Connxal, EMD, MMM, FAA, and the Department of Education. He can be contacted at <asoudegi@ceet.niu.edu>.

DR. OMAR GHRAYEB joined the Northern Illinois University College of Engineering and Engineering Technology in 2001 and currently serves as the Department Chair and an associate professor in the Department of Industrial and Systems Engineering. He holds a Master of Science and a Ph.D. in Industrial Engineering from New Mexico State University. Dr. Ghrayeb's research interests include production system design and optimization, scheduling heuristics, facilities layout and design, applied operations research and supply chain management. His publications have appeared in journals such as *IJPR*, *SME Journal of Manufacturing Systems,* and *International Journal of Industrial Engineering*. Dr. Ghrayeb can be contacted at <ghrayeb@ceet.niu.edu>.