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A Real-World Example for Student Learning: BTSU Cafeteria Simulation

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Abstract

Simulation is a powerful tool both for teaching students about simulation techniques as well as providing deeper understanding of some courses contents such as networking, operating systems, operational research, just to name a few. Simulation is a well-known technique for evaluation of what-if scenarios for decision making in industry, defense, finance, and many others.

Teaching simulation techniques may require creativity in assigning problems to students. Real word examples often excite students and motivate them focusing on their learning objectives. Further, it challenges them to develop models to reflect the reality. Clear examples can teach students how to collect data, develop base model, improve it to advanced models, analyze the obtained results, and think about usability of their simulation results. These learning outcomes can clearly demonstrate valuable educational objectives.

This paper, presents an example where a group of students were assigned to develop a simulation model for the BGSU Students Union (BTSU) Cafeteria. Managing a university cafeteria often exhibits challenges for the food services located in the cafeteria. One challenge regards waiting times. This study was focused on reducing the average waiting time of the diners in the queues, while increasing overall efficiency of the food services.

The popularity of each food station, measured in number diners visiting that food-station, was first observed. Then the arrival rate of the customers and the number of workers were recorded. Based on the collected data, several scenarios were developed to assess the system. The simulation result suggests that adding food-servers to the top 3 most visited food stations can dramatically reduce the overall waiting time. In addition, offering special deals, could further improve the result.

1. Introduction

One of the challenges teaching a simulation course regards example models students are assigned to develop. Albeit simple and generic models can teach students the basics, the usability of what they learned comes often from real world examples. Samples include simulation of a local traffic, student health center, or student cafeteria. This paper reflects experiments conducted by a group of students, in a simulation technique course, who had six weeks to complete their term project on modeling and simulation of the student cafeteria, called the Nest, an acronym for Falcon Nest.

To accomplish their goal, students focused on reducing average time visitors spent in the system. They first measured and analyzed the popularity (i.e. visiting rate in time unit) of each food station, the arrival rate of the customers, and the number of workers in each station. An important objective for the students was how they could change the simulation model to come up with a working solution to the overcrowding faced during the peak rush hours of the food service. Consequently, students focused on a working solution suggesting that adding food-runners to the top 3 most crowded food stations could significantly improve the overall serving time. In addition, their simulation results suggest that special deals and offers could improve the overall performance.

Accessibility of Falcon's Nest gave the model developers a great jump start to their project study. Further, students found a Subject Matter Expert (SME), the director of the food service, who provided certain statistical information about different parts of the cafeteria. To make sure they are developing the right model, they researched the literature and collected several examples of simulations where similar restaurants and cafeterias were studied. These studies delivered to our students the verification and validation of their own model as well as comparing their results. This paper describes the efforts of these students and how they conducted their project.

As part of their achievement, student reported that the Falcon's Nest simulation could help BGSU in reducing diners' time in the Nest, as well as increasing overall efficiency of the food service. In addition, the obtained model could also serve future student projects for the Falcon's Nest. Current study suggests that new simulation models could easily be added to the existing models to make the new ones become more realistic and thus to obtain better results. For example, additional what-if scenarios, human-based decisions, or more accurate serving times, are potential extensions.

The rest of this paper is organized as follow: Section 2 presents related works. Section 3 describes the simulation problem. Section 4 describes the simulation project from students' perspective. Section 5 overviews the simulation models, while Section 6 provides results and analysis of this study. Section 7 gives concluding remarks.

2. Related Work

Reviewing the literature and finding work of others was great help for the group. The review gave students the confidence they needed how to pursue their simulation study to go through its various phases. Students found a useful case by looking at the Fox Hole cafeteria simulation [1]. The model which was created by a group of engineering students at Washington University directed our students how they could design their conceptual model. From the Fox Hole model, the group learned multiple issues to make their model become accurate. Examples include the distribution of customer arrivals, the decision making of the customers in terms of where they choose their food, the popularity of each food station, and how long each station in the cafeteria would take to process a costumer. The study encouraged our students how to pursue and complete their work.

Another study was conducted by Texas A&M University simulating a fast-food restaurant [2]. This study helped our students to enforce a standard for their model. The final model of current work resembles with the Texas A&M study, advocating solutions how to reduce the customer waiting times during the rush-hours. Simulation models were developed by adding more workers, adding more space for the workers in their respective stations, and by applying these suggestions during the core hours [3]. The decision making implemented in [2] was more complex than the current study. However, the implementations in [2] served our students how to continue the developing work presented in this paper. After analyzing how to implement entities and decision making, students continued to identify how to decrease the queueing time of the customers. The

NFSMI simulation studies and analysis reported in [4] helped further to focus on the next step. This study suggested hiring an additional worker at each food station to serve as a "food-runner", a person at a station, can cut the queue time by over 56% [4].

A solution for a busy restaurant through a case study was given by Ahsan et al [5] using queueing theory to reduce customer wait time. The arrivals rate were nearly the same rate as being served. Another study of a fast-food restaurant [6] showed how to model the service time. In this study, the authors argued that more employees would be an ideal solution. However, they suggested moving employees from less crowded stations to busier services would be more cost efficient [6].

Benefiting from these studies, our students decided to adapt their model to match that of the Fox Hole as well as the NSFMI. As a result, the current simulation model of Falcon's Nest resembles with those reported in [1] [4] [6].

3. Simulating the Falcon's Nest Cafeteria

This project was focused on finding realistic solutions for the Nest cafeteria in order to increase the efficiency and decrease the average time of the customer spent in the system.

3.1. Overview of the Nest System

The Nest is students' cafeteria at BGSU which functions as an important part of the University's food service. This cafeteria serves thousands of students every weekdays and weekends. During the rush-hours of lunch and dinner, this place gets really busy and congested with long queues contributing to long waiting times. From the simulation perspective, the Nest model consists of five main components: Costumers, Servers, Locations, Queues, and Cashiers.

3.2. Using ProModel

To achieve the simulation objectives ProModel was used. This tool was chosen for multiple reasons, one of which was the availability, and the second one regards the course which used this tool and trained students during the course. In addition, the tool can simulate discrete-event systems and has large number of library models, as well as statistical analysis, and desired output results with animations.

3.3. Problems Encounter Developing the Simulation Model

The main problem faced was lack of statistics and accurate information not being available in timely manner to complete the study. Other barriers include project time limit and lack of deeper familiarity of ProModel. These problems mainly affected the developing timeframe. Next issue faced was the complexity of manipulating logics in ProModel for decision making purposes.

3.4. Available Solutions

Based on the primary analysis two potential solutions were possible to solve the simulation problem: (1) to increase the number of employee (food servers); (2) to increase the popularity of other locations (food providers) which have a lower waiting time. In addition, there were three approaches to reach the goals: either to ask the SME to provide all sensitive data and statistics information they had about the cafeteria; or to make a very detailed and time consuming observation over the actual model through longer observation periods in the Nest. A third approach was a combination of the two abovenamed methods. The latter approach was adapted due to time limit, as well as not all information could be released from the SME due to its sensitivity.

4. Project Description and Methods

4.1. Overall Project's Overview

We simulated the BTSU Falcon's Nest on BGSU's campus. We reviewed the literatures to investigate what has been done, and which study would provide us with models similar to what we were after. Researching the literature, we were able to develop a model that focused on delivering a solution to the problem of overcrowding of the Falcon's Nest during lunch and dinner hours. With the Falcon's Nest being in our access for direct observation, it was easy to make our model directly represent the system that BGSU currently has. In terms of finding a solution to the overcrowding problem, we used literature and researched how other universities were handling this issue. In particular, how BGSU would be able to decrease the queuing time, resulting in less stress for the popular food stations by using idle time of those less populated stations.

4.2. Methods

The time frame of the term project was six weeks and thus a concern. Several work were done in parallel; gathering data from the Nest by observation, talking to SME, research and read the related works, last but not least develop the base model. Decisions needed to be made on number of issues such as key parameters of the simulation, what to focus as the result of the simulation, how to make input-output analysis of the model, the data, and how to validate and verify the models.

To acquire the data, the SME was contacted. While he was reserved to supply all needed data, he was able to furnish sufficient information to make the model reliable. Information that we were not able to secure was the shift schedule of the workers at each food station / checkout, percentages for popularity of each food station, and the processing times at each food station. These pieces of data were not recorded by our SME, and thus we had to rely on our personal observations to get the processing times for each station. Nevertheless, the SME provided some statistics for the popularity of each station by their respective names ordered from most popular to least popular. As mentioned earlier, we also added our own observation to make sure that the obtained model would be as close to real one by visiting to the Nest multiple times. The only concerns making the results slightly unreliable was the fact that not having info on the schedules shift of the personnel.

After applying all numbers into the model and testing the base model several times for accuracy, we decided to perform additional testing by some case studies. In order to make the queueing times shorter, we decided on two solutions to test: adding an extra worker at more populated food stations (Panda Express, Steak Escape, and Chickendipity) to act as a food-runner, who is a person that makes sure there is no down-time when food starts to run out.

The second solution was based on changing the popularity factor of each food station to spread it more evenly. The reason were based on observations on certain lines were most crowded during the peak hours of service and thus leading to longer queue times. If the customers were more evenly distributed to the less populated food stations, then the overall average queue times of customers should decrease. This solution would also make use of the idle time of workers from the least popular food stations. The popularity factor could be controlled by e.g. offering special deals at other food stations, adding new items to the menu of other food stations, etc.

4.3. Project Limitation and Strengths

The project encountered several limitations, such as time, detailed statistics, implementation of logical human decisions, and the area of the cafeteria that the model represents. Time was a major limitation as it proved to be difficult to keep up with the project schedule due in 6 weeks. Detailed statistics became an issue since the head manager of the Falcon's Nest, was concerned that some released information might harm BGSU. Consequently, we limited the simulation scope to what we could deliver in 6-weeks' time period. We succeed doing so by delivering a reliable simulation model with four scenarios: a base model, an improved model, an advanced one, and the final model. The next section will describe the details of the models.

5. Simulation Models

Four phases were used to develop the needed models: base, intermediate, advanced, and final models. In the following subsection, the details of these models will be described.

5.1. Base Model

The base model had very basic setup as shown in Figure 1. The objective was focused only to test one station where the costumers arrived to the station, to get their food, and then move to the checkout station with queues connecting each station. This model gave the needed start point and statistics to advance to the next model.

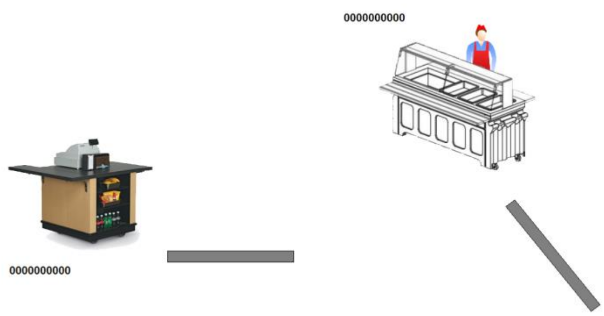

Figure 1: The Base-Model for the Falcon-Nest Cafeteria

5.2. Intermediate Model

To improve from the base model to the intermediate one, all food stations were added according to the falcons Nest (Figure 2) along with the logics for entities to move through the system. For this model, no separate queue was implemented but rather making sure all entities were moving through the system correctly.

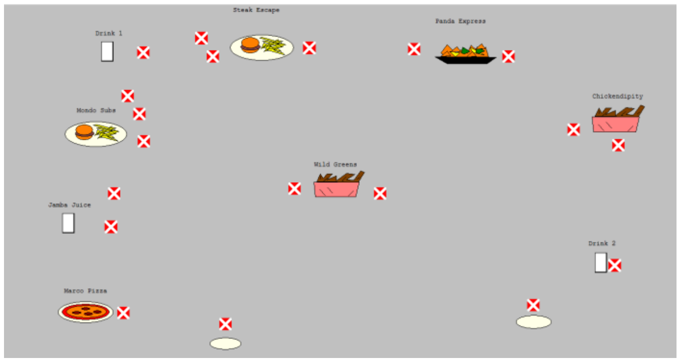

Figure 2: The intermediate model improved from the base model

5.3. Advanced Model

The advanced model (Figure 3) included all of the queues of the system. This model targeted obtaining realistic output statistics by simulating several scenarios. To generate realistic results, model relied on the data received from the subject matter expert.

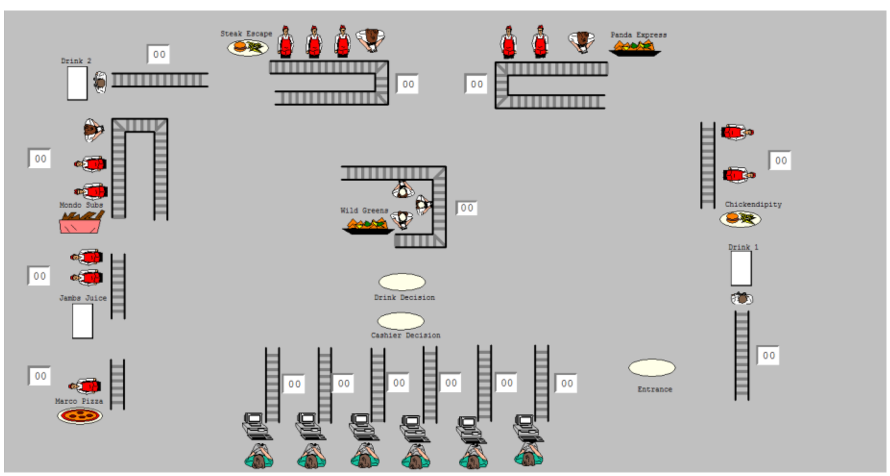

Figure 3: The Advanced Model improved from the intermediate one

5.4. Final Model

After developing three scenarios, obtaining good confidence, making sure being on the right track, we moved towards developing the final model as shown in Figure 4. It was implemented using a time schedule to simulate the rush hour traffic, as well as the normal operating hours. In addition, graphics were added to make the model more appealing.

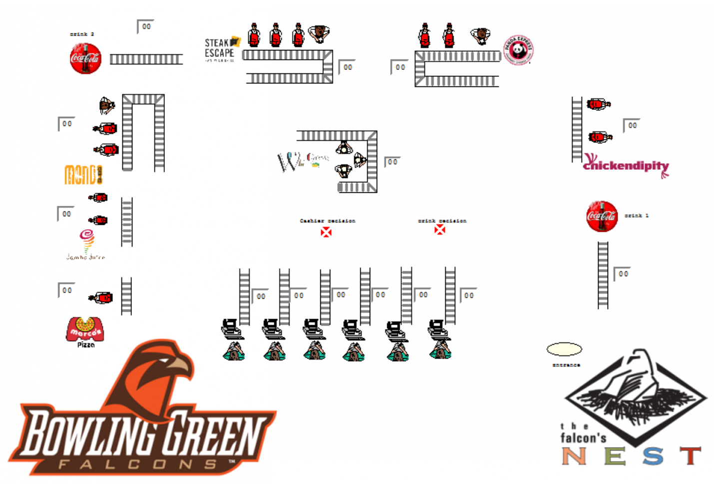

Figure 4: Final simulation model for the Falcone Nest Cafeteria

6. Results and Analysis

In this simulation, we first aimed to find an ideal solution for the Falcon's Nest that could demonstrate how to reduce waiting time in the system by simply changing the parameters. However, it turned out that such scenario would need more implementation time. Instead, we focused on two things that BGSU could do: (1) implementing a method to make other food stations more attractive; (2) adding additional workers to each of the top three food stations as a food runner. Test-cases were developed for each solution to support solving the issues. Following decisions were adapted: removing 5% of Panda Express's popularity and 2% of Steak Escapes popularity; check which station would benefit the 7% distribution. To support the simulation, test cases (shown in Table 1) were used to determine if our popularity solution would work. The statistics in Table 1 were provided by the SME which reflects the data measurements compiled by other groups.

Table 1: Solution 1; Percent of Popularity for each food-station for each scenario

	Panda Express	Steak Escape	Chickendipity	Marco's Pizza	Mondo	Jamba Juice	Wild Greens
Baseline	25%	16%	15%	9%	14%	11%	10%
Case 1	20%	14%	17%	14%	14%	11%	10%
Case 2	20%	14%	15%	16%	14%	11%	10%
Case 3	20%	14%	22%	9%	14%	11%	10%
Case 4	20%	14%	18%	13%	14%	11%	10%
Case 5	20%	14%	16%	15%	14%	11%	10%

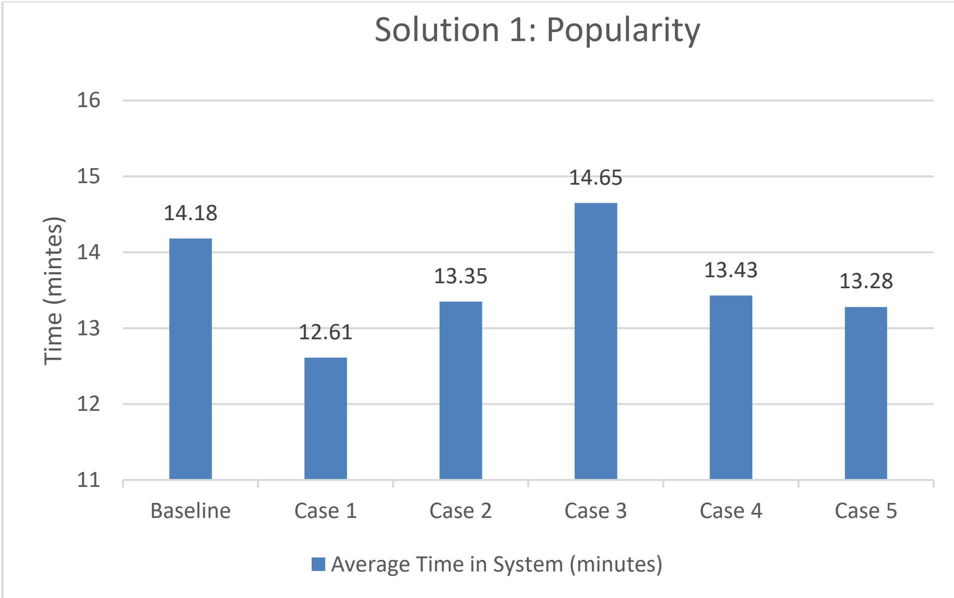

Figure 5: Solution 1 demonstrating reduction of Average Time in the system

The result of simulation is sown in Figure 5, which demonstrates a reduction in the average time in the system comparing with the baseline, for most cases except Case 3. Further, this figure suggests an 11.1% decrease in average time spent in the Falcon's Nest by customers.

The next method chosen to improve the waiting time was adding food runners to the top 3 most populated food stations in the Nest. This method was simulated and tested with 4 scenarios, and was compared with the baseline. Table 2 shows the changes in the number of workers, and was confirmed by the SME.

Table 2: Solution 2; Number of workers to change by different cases for food-stations

	Panda Express	Steak Escape	Chickendipity	Marco's Pizza	Mondo	Jamba Juice	Wild Greens
Baseline	3	4	3	1	3	2	3
Case 1	4	4	3	1	3	2	3
Case 2	3	5	3	1	3	2	3
Case 3	3	4	4	1	3	2	3
Case 4	4	5	4	1	3	2	3

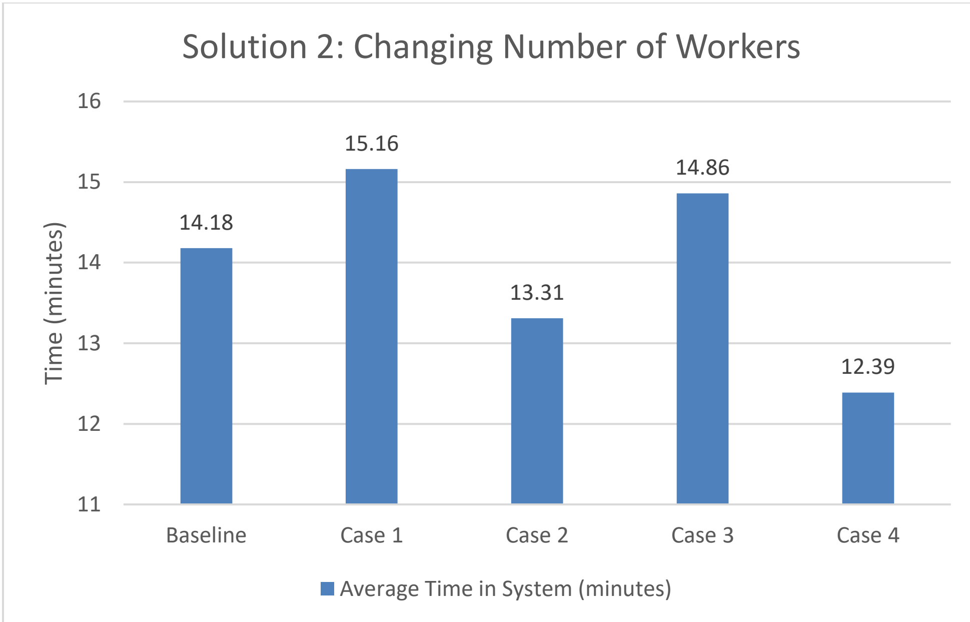

Figure 6: Solution 2 results, advocating one additional worker at each food station

As was expected, by adding a food-runner to each station the average time of the customers would decrease. However, certain station would benefit the most. Figure 6 shows the result of this simulation. If case 4 were to be implemented by the Nest, there would be a 12.6% reduction in time spent by customers which is significant. However, if the Nest would select to add only 1 food runner to for 1 food station, then adding the food runner to Steak Escape would have yield only to 6.1% decrease in average time spent in the system by customers. While we anticipated that both of the solutions could work, we have not simulated the cost performance relationship, and left for the future studies. Current studies, however, provides multiple opportunities for future students to improve the models as well as to further advance the solution.

7. Concluding Remarks

This paper presented an example of real-world simulation case study conducted by a group of students as a term project in a simulation technique course shared by senior undergraduate students as well as graduate students. An important result of this case study demonstrates how deeply these students were engaged in their learning objectives of the course. In a short period of 6 weeks, they conducted a complete case study including: observation, gathering data, analyzing the problem at hand, developing models, confirm with the subject matter expert, documenting, and delivering the results. Albeit, the obtained models are simple solutions to a known problems in the Nest, they have been designed such that any successor students could continue the work and be able to add features which were left from this study.

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