

# A STUDY OF SERVICE WAIT TIME AND ITS IMPROVEMENT IN ACAFETERIA USING DISCRETE EVENT SIMULATION

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## Abstract

*Service wait time is a key performance indicator in the food service industry. A real-case scenario of a cafeteria situated on a college campus is studied for service time. During the lunch hours, there is always a large queue that impacts serviceability. This study identifies the stations and events where the wait time increase and suggests with a solution.*

*A discrete event simulation (DES) model is developed with the information and factors gathered based on observation. The simulation model suggests the places and time periods where the service bottleneck occurs, shows the queues dispersion, and helps in coming up with cost effective solution. Three instants have been simulated for reducing wait time without affecting serviceability: addition of resources, stations which facilitate easy dispersion, and effective planning on the preparation charts. The supply and demand information for an influx is also studied to help optimize planning the cafeteria operations.*

**Keywords:** Discrete event simulation, service time, bottleneck, queue.

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## 1. INTRODUCTION

A cafeteria is a type of food service where there normally is little waiting staff for table services. As cafeterias require few employees, they are often found within a larger institution, catering to the clientele of the institution. Cafeteria customers are either charged a flat rate for admission (as in a buffet) or pay at the check-out for the item selected.

### 1.1 Literature Review

Several important factors like taste, cleanliness, restaurant layout, and settings determine the popularity of a restaurant. These factors, when well managed, are able to attract a plenty of customers. However, a factor needs to be considered especially when a restaurant has already succeeded in attracting customers. This factor is the customers queuing or wait time [1]. Customers may view wait time negatively as a result customers may leave the line or not return [2].

Wait time also affects serviceability and customer satisfaction, Lee and Lambert [3] used a simulation model to identify whether wait time could be managed effectively to improve customer satisfaction in a cafeteria. They concluded that a simulation model is an effective tool to evaluate the levels of wait time for each service station, to examine average wait time, and to estimate the impact of operational changes. They further argued that understanding the relationships between wait time, satisfaction, and service quality is a strong foundation for effective wait time management.

Several studies have been done on the queue theory. Researchers have used queuing theory to model the restaurant operations, to reduce cycle time, as well as to increase throughput and efficiency [4]. They used both analytical and simulation to model, study, and validate queue. Mathias and Erwin [5] built a model of real-case scenario of a restaurant using an analytical method and validated the data using Little's theorem to show queue theory satisfies the model when tested with a real-case scenario. The Little's theorem [6] describes the relationship between throughput rate (i.e. arrival and service rate), cycle time, and work in process (i.e. number of customers/jobs in the system). This relationship has been shown to be valid for a wide class of queuing models and estimate the performance change when the system is modified [7].

Several simulation tools are used for building restaurant models like Quick Service Restaurant Simulation (QSR) module [8], Restaurant Modeling Studio (RMS) [9], and discrete event simulation (DES), such as Monte Carlo Simulation [10]. Discrete-event system simulation is the modeling of systems in which the state variable changes only at a discrete set of points in time. The simulation models are analyzed by numerical methods. The main advantage of using DES techniques is that an analysis can be performed to indicate where the processes are being delayed and "what if" questions can be answered, particularly for a new system proposal [11].

Chou and Liu [12] built a DES model to reduce the wait time in a fast-food restaurant. They concluded that no significant evidence indicates that a one line queuing system is better than multi-line queuing system. During the busiest hours the customer wait time increases dramatically, the

simulation results show that adding a server can reduce the customer wait time considerably. An economic analysis presented by Qamar Iqbal, Lawrence E. Whitman & Don Malzahn [13] suggested that the improvement made by adding server should be justified economically as adding a server requires investment. The break-even point decreases with increase in the number of customer.

Modeling fast food restaurant on campus to reduce service time also was developed by Curin, Vosko, Chang and Tsimhoni [14]. Another study of queuing system of a busy restaurant was conducted and a facilitate queuing system was proposed by Ahsan, Islam and Alam [1], used a simulation study to improve the service time at a fast food restaurant on campus.

All the literatures give a clear picture of the problem occurring in the food service industries and the importance and relationship between customer wait time, queue, and serviceability and suggest solutions to solve the problem and improve throughput and efficiency: like to add the server to reduce the queue wait time and improves customer satisfaction. These literatures are good reference for our study, as it focus on identifying the bottle neck and suggest a solution to improve the queue wait time without affecting the serviceability.

## 1.2 Motivation and Objectives

Our study builds and studies a campus cafeteria model. The cafeteria offers varieties of food items and has separate stations for each type of food, such as separate stations for vegan and vegetarian. The peak hour for the cafeteria is

lunch time, or 11:00 am to 2:00 pm. We also observe when the waiting queue is very long, students may skip their meals due to their schedules.

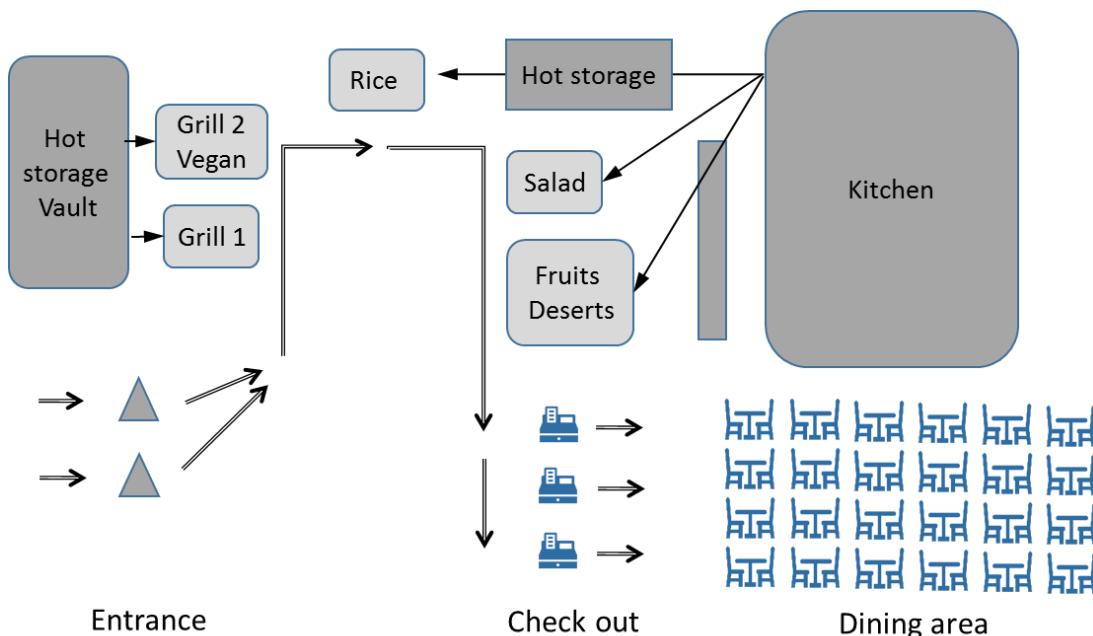
For such a study, knowledge about wait lines is an important part of operations and a valuable tool for the operations management. It is noticed that in the cafeteria for about every 12 min in queue one customer leaves the line, which results in economic losses. Analysis of queues in terms of waiting-line length, average wait time, queue performance, and other factors gives an overall understanding of cafeteria food stations, and maintenance activities. This understanding helps in improving and optimizing the operations which are feasible economically resulting in good serviceability and customer satisfaction.

Performing a DES model can create a preparation chart for managers and chefs with a clear idea of how much food is required each hour according to the arrival of customers. The preparation planning will fulfill the demand to minimize the wait time of customers due of lack of food and reduce food wastage. This will also help the cafeteria serve fresh food every hour.

## 2. METHODOLOGY

### 2.1 Cafeteria Layout

The cafeteria consists of entry for check in, five food stations, one checking out billing counter, a dining area, as shown in Figure 2.1. The entry point is used to keep a count on the number of students entering the cafeteria and inform the manager and chefs about the student flow.



**Fig 2.1: Schematic layout of the cafeteria**

In the cafeteria, the five food stations are Grill1 (meat grills), Grill2(vegan food), Rice bar, Salad bar, and Fruits and Desert. The most of customers in the cafeteria are campus students. A huge dining area provides for them to eat there.

The check-in point of the cafeteria requests customers to show their ID cards. After taking their food, they pay for their plates at the Billing Counter.

## 2.2 Data Collection

The data were collected by observing the cafeteria for two weeks in order to properly understand and present the cafeteria performance during peak hours. The data collection serves as the foundation for build the restaurant model with Simul8 software. The parameters of the modeling include arrival times, time in queue, time in a particular station, time for preparation, time for storage, capacity of the queue, customer leaving rate, customers demand, and employee workability.

The factors for queuing is identified based on arrival time and service time distribution, the arrival timing is observed and considered after allocating through charts as input for the model. The arrival rates are considered linear and not changing more than 5% as the customers are the campus

students. The 5% fluctuation may happen as sometime students are absent or may bring their friends with them. The service time fits under processes assumed in an exponential pattern.

The number of people entering cafeteria is given in Figure 2.2a. The cumulative trend quickly goes up an hour before noon and keep the trend for about two hours. The cafeteria should be ready for the busy hours. The DES modeling can be used to simulate of the arrangement would work or make it come down. The stream lining the crowd and arriving at the point where the manager could make a decision having peers to move and connect to move and connect to keep the queue without surging to very high number is a sequential goal of any plan. Figure 2.2b shows the serving time for each station.

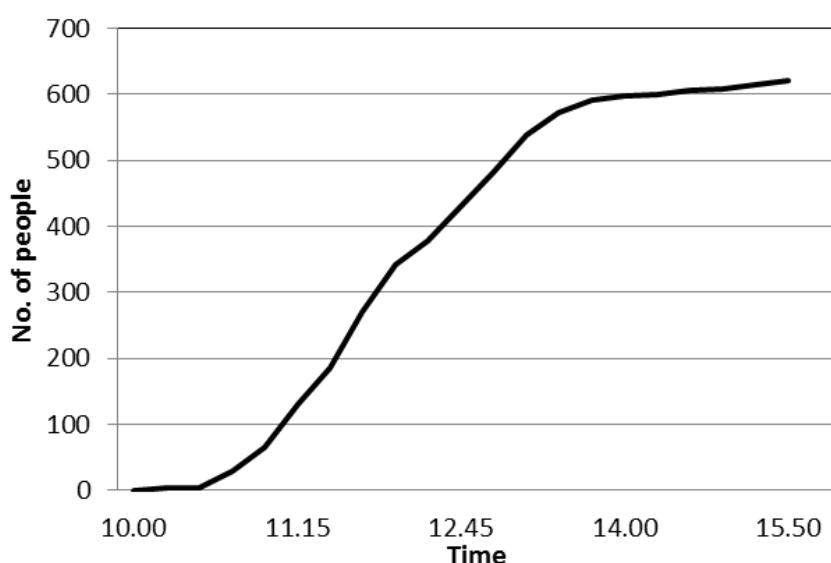


Fig 2.2 a: Number of people entering the cafeteria

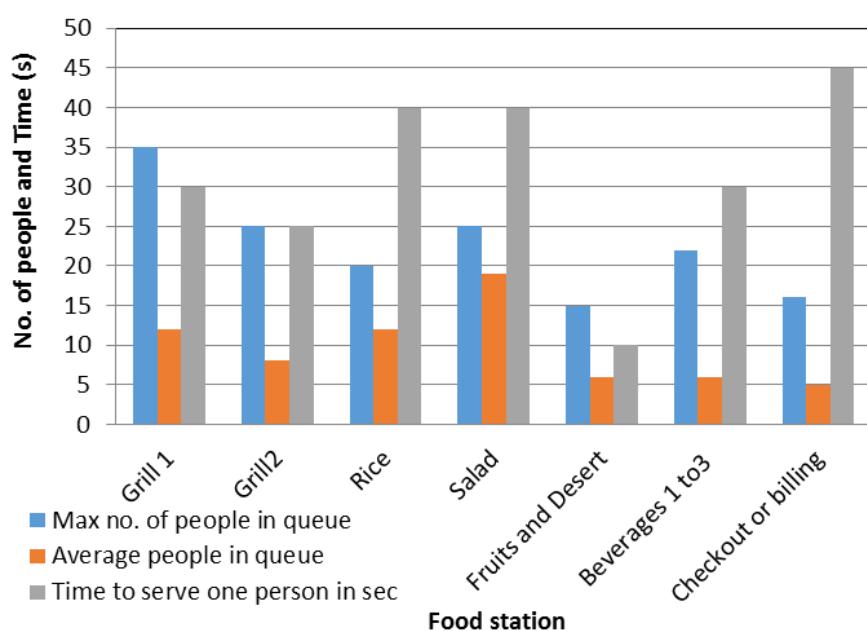


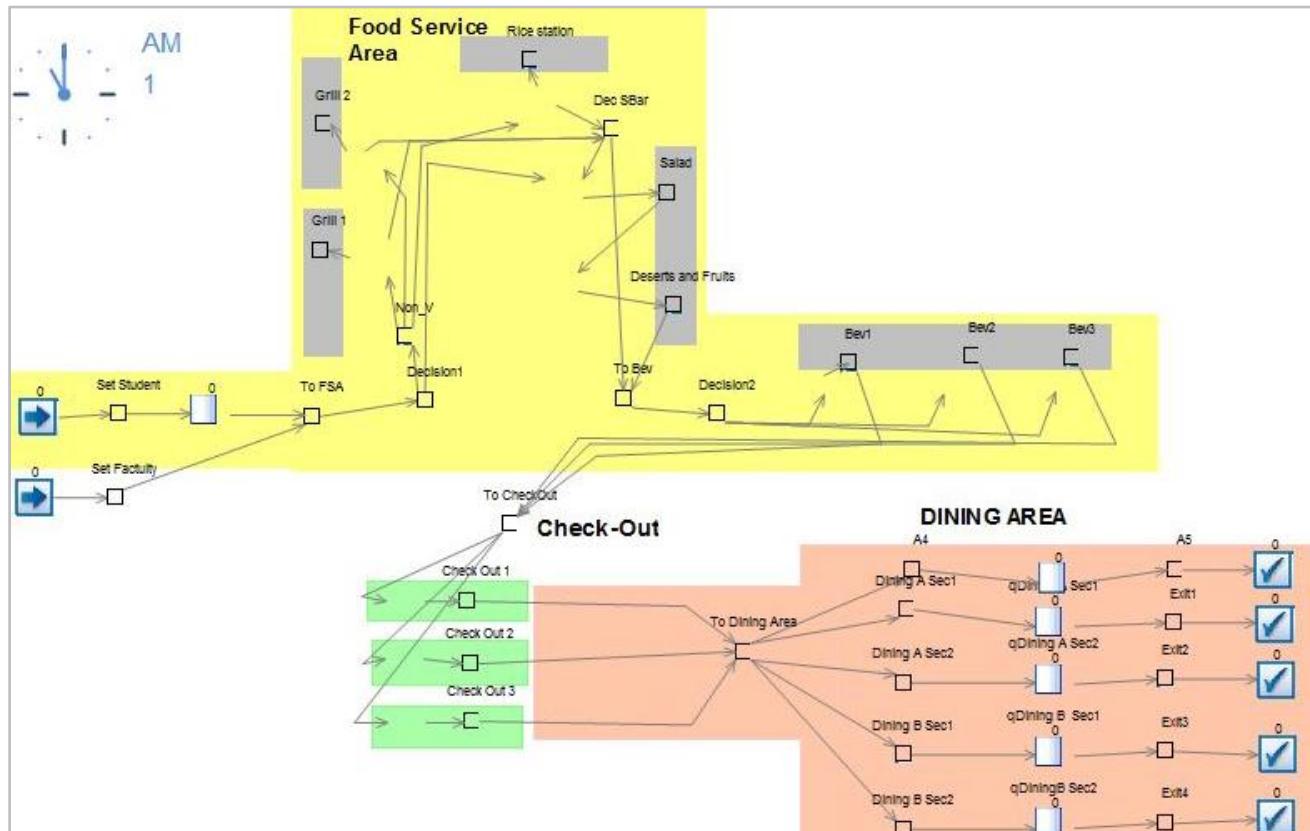
Fig 2.2b: Customer wait time in each station

Showed in Figure 2.2b, the queue sizes sometimes exceed to typically 30 persons in most stations due to indefinite arrival of customers for a short time. Sometimes, students come in a group of 10 or 15 in a short time which leads to a long queue formation. The bottleneck occurred at few stations needs to be considered for more detailed analysis.

### 2.3 Modeling

The cafeteria DES model is developed using Simul8 software. The model is showed in Figure 2.3, which consists

of an entry gate, four stations (Grill1&2, Rice, and Salad). One person serves the foods in each station. The Fruits and Desert station are pre-arranged in plates that are ready to take, for fast dispersal. The beverage station has three fountain machines and there are three billing counters at the end with one person per counter.



**Fig 2.3:** Cafeteria model and typical flow paths in Simul8

### Model Elements

The DES model of cafeteria has model elements, or system components, are created, like system events such as starting with customer-arrival and customer-departure. The events of server-begins-service can be part of the logic of the arrival, fast arrival, and departure events. The events that might be directly influencing the system, such as slowing down, namely number-of-customers-in-the-queue and server-status, busy or idle. The structural components of model of this study include:

- 1) Model entities: customers and their arrival rates and timing other attributes like repetition
  - a. Stations, flow path, Entry and Exit.
- 2) Model activities: Flow rules, Supplying to vault or service area, serving customer in counter and at billing area.
- 3) Model resources: Serving personnel at counter and cashier

4) Queue: waiting lines at food station and at billing.

### Considerations and Assumptions

There are a few assumptions are considered to avoid complex simulation. The cafeteria modeled here operates during peak hours of 11 am to 2 pm. The mode is assumed as first in first out (FIFO), or the person who comes first is served first and he/she goes out first. About 45 % of customers return for refill. All employees considered in this model have work efficiencies (difference less than 20%) and change over time included is six seconds. The queue jockeying or reneging and the moving time between stations are not considered in the model as the time to move between stations is rare.

With the data collected from the cafeteria food wastage and the relation between the wastage and wait time has been observed in real time. The assumptions such as limited cross

over between the lines while queueing, refilling trips are limited to two for 95% of the crowd and the reminder has > 2 refilling attempts.

### Simulation

The cafeteria is modeled and simulated twice; the first is the base model (current scenario) and the second with the improvement by regulation of queue with a higher service rate (Figure 3.1a). The rate is increased as more customers can be served at an instant (usually four).

Warm up time for the model was set 200 hours before and run several times for error checking before results collection.

The arrival rate from simulation are checked with the real time counters and average how many pan (1 pan= 18 plates) of food required to serve customers an hour.

Figure 2.4 shows the customer arrival from simulation data is comparatively agreed to the actual data with a small aberration. This inherently helps understand the cafeteria operation from a result stand point that despite of a minor variation the running model can whether or not induce variation in the queue lengths and most importantly that possibility of handling. As this eventually brings down the service based performance of the cafeteria.

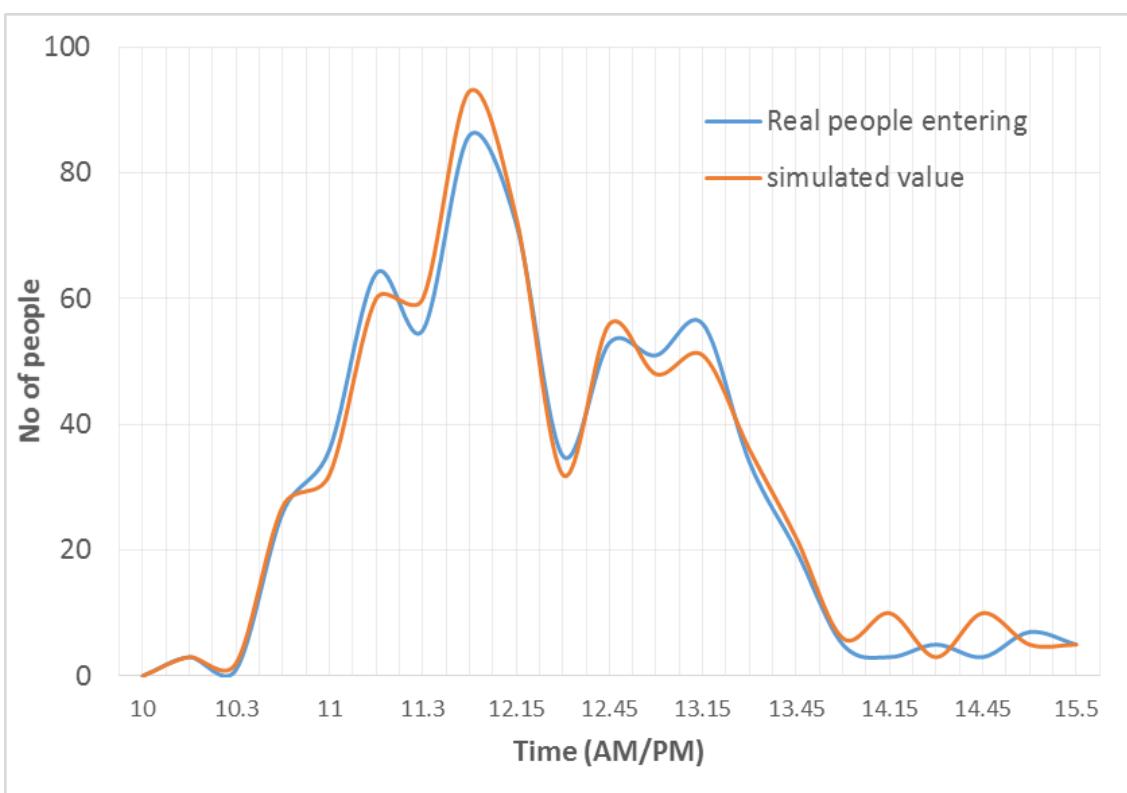
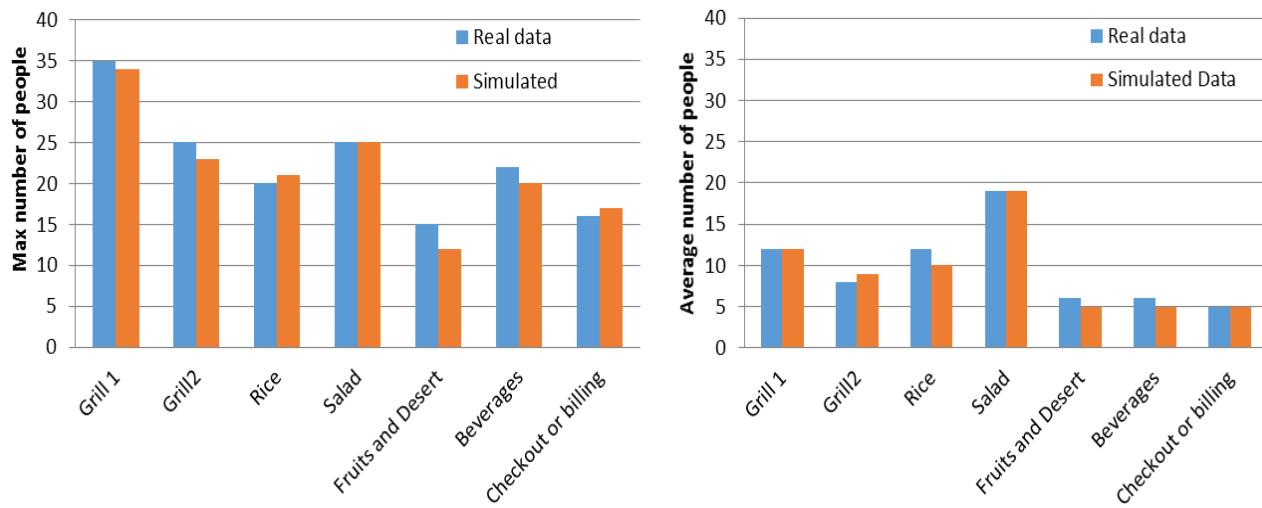
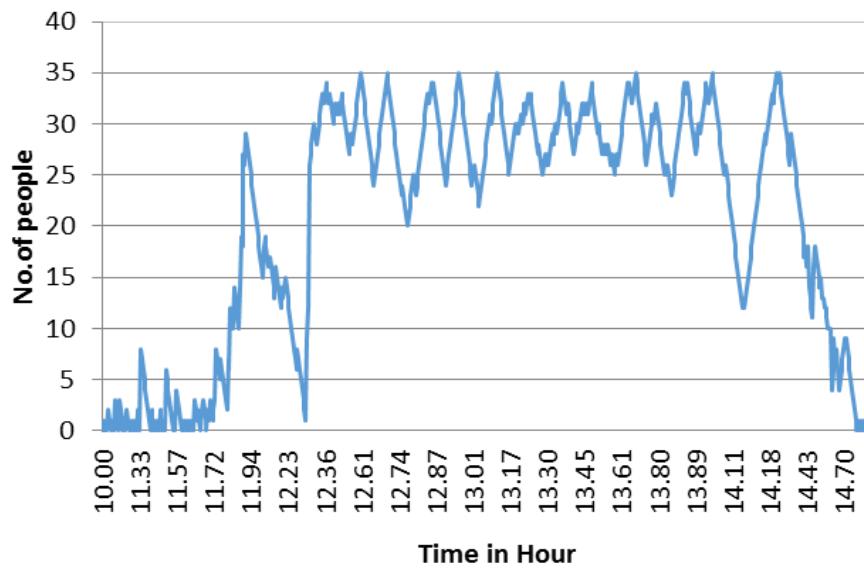
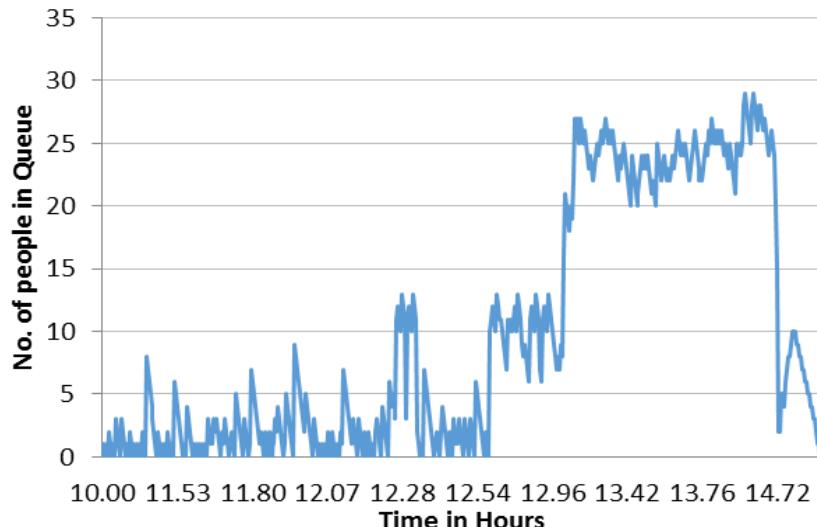


Fig 2.4: Customer arrival trend for actual and simulated data

### 3. RESULTS AND DISCUSSION

The Figure 3.1a clearly shows that both the values of the simulated data and actual data are approximately the same. In the existing setup, service bottlenecks occur at two places: Grill1, Salad station. Figures 3.1b and 3.1c show that at the both stations there is a huge queue from 11.30 am to 2pm. To reduce the wait time at these stations, they have been created into two counters instead of one and adding extra serve person each station according to the requirement as show in Table 3.1. These changes are updated in the model and simulated to get new results.

**Fig 3.1a:** comparison of actual and simulated values (base and improved)**Fig 3.1b:** Queue in Grill station 1**Fig 3.1c:** Queue in Salad station

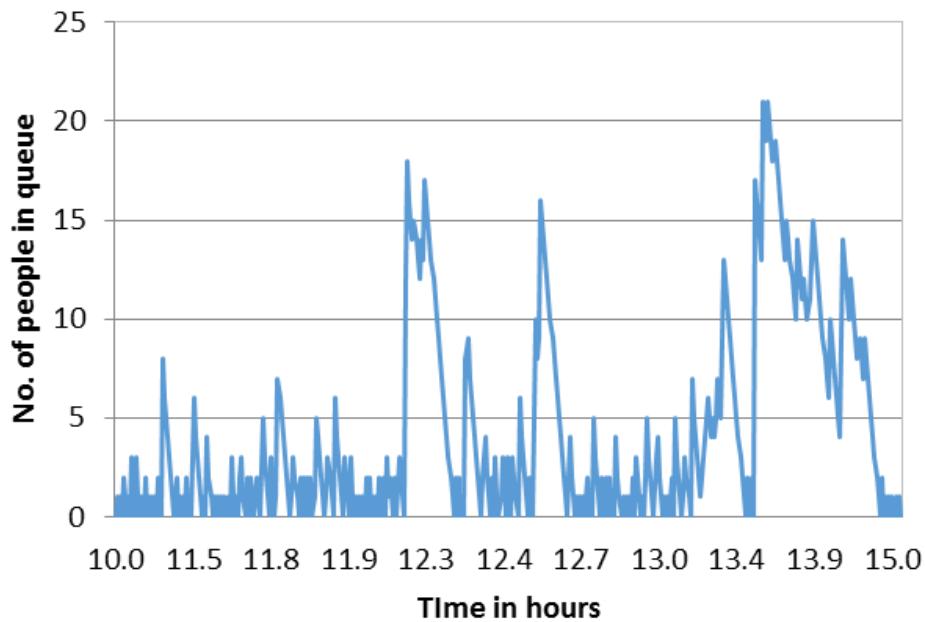
**Table 3.1:** Serve people required at each station

Stations	Service Person Required
Grill 1	1 @ 11:00 2 @ 11:30 to 2:00
Grill2	1 @ 11:00 2 @ 11:30 to 12:30
Rice	2 only from 11:30 to 2:00
Salad	3 for all time
Fruits and Desert	2 for getting the serving ready
Checkout	One extra person apart from three check out at @12:00

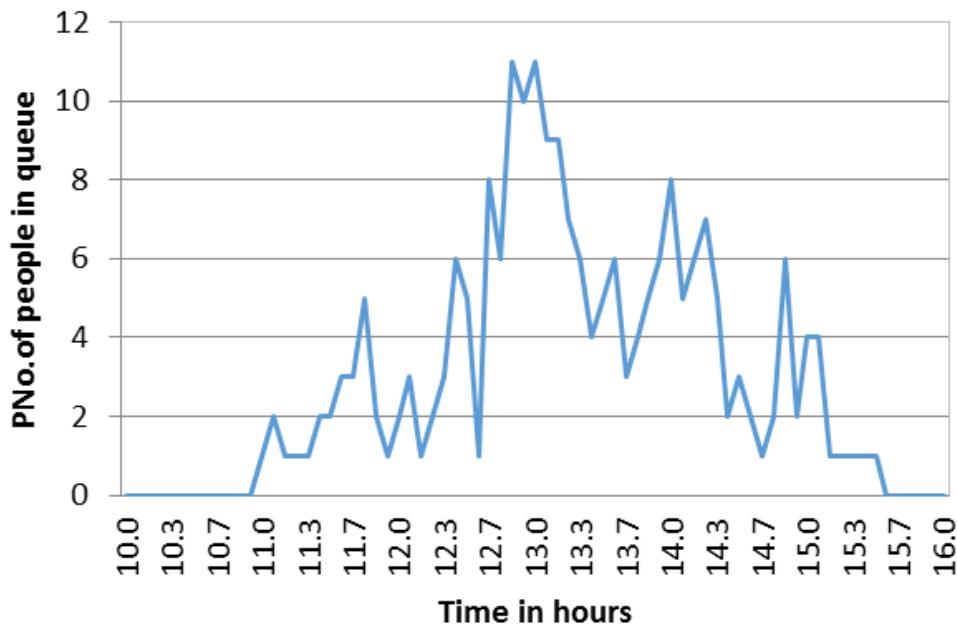
The Salad filling rates varies from person to person in prior and for the returning crowd while refilling. Hence it was decided that the salad should be ready filled with

appropriate grams of lettuce, spinach etc., with prescribed daily nutrition levels (excluding nuts and dressing). This is done by three persons in salad station to serve in a faster pace while initial hour (11 am to 1 pm). Still the upcoming crowd is high during the hours from 1 pm to 2 pm. So shifting one more person into the salad station would be only remedy to bring down the crowd than an expensive extension of the existing salad bar.

The following observation was made from the model after adding resources for the existing setup. Grill station 1: The Figure 3.2 shows a clear picture of the grill station after the improvement has implemented. The maximum number of people in queue is reduced to 23 from 35 (Figure 3.1a) and the average reduced to 2.32 from 9.8. The peak of 23 people in queue occurs around 1:30 pm to 2:30 pm due to indefinite arrival of students.

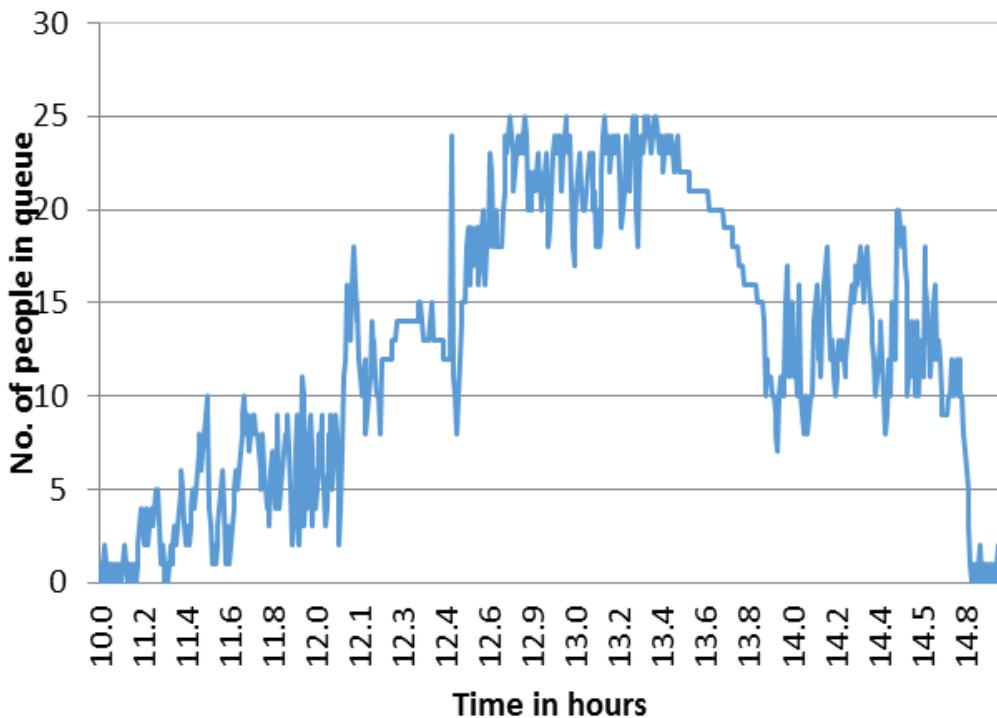
**Fig 3.2:** Grill station 1 with one service person

Checking out counter: The queue in the billing counter is reduced from 17 max and 5 average (Figure 3.1a) to 11 max and 1 average (Figure 3.3). The only time the maximum queue length goes to 11 is around 12 pm for a few minutes and once the fourth counter is opened the queue reduces and with average of one.

**Fig 3.3:** Queue at checking out counter

Salad station (Figure 3.4): There is always a huge queue in the salad bar even with 3 serving people and 2 counters the maximum people in the queue is still 25 but the average has decreased to 9.61 from 17. The salad station is common for

both vegan and other consumers. The serving rate per student can be minimized from 40 sec to 15 sec by fast serving personnel as discussed related to Figure 3.1c.

**Fig 3.4:** Queue in Salad station

Rice station: Figure 3.5 of rice station looks like the grill station and the queue is reduced from 21 max– 17 avg. to 18 max–2 avg. The queue starts building around 12pm and the arrival of students is not in linear during that time. Students

arrive in group of 10 to 15 at one stretch that leads to a queue formation and increase wait time.

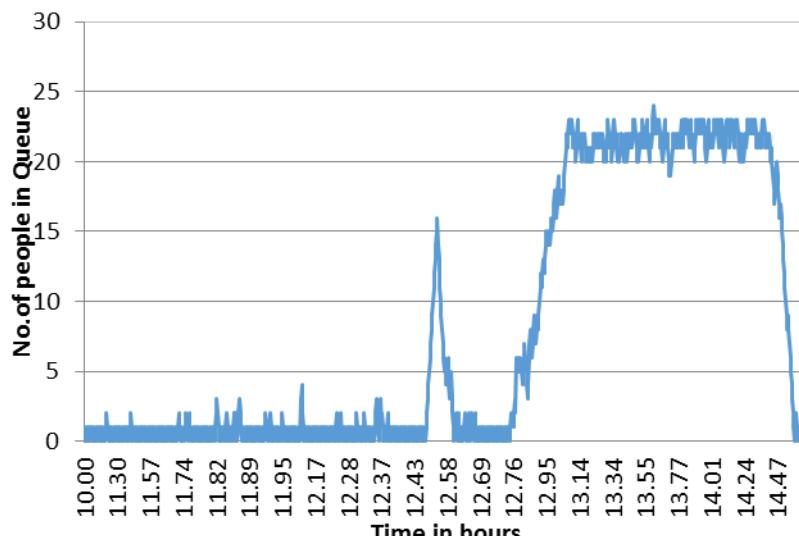
**Fig 3.5:** Queue in rice station

Table 3.2 compares overall reduction in time and queue size, which is about reduced average 10 – 12 minutes wait time to close to 25 % for customers during the peak serving hours. The two service persons added in all stations for the first

three hours may increase the operating cost of about \$80, but improve the serviceability with a subtle reduction in wastage of food and energy cost for getting the food ready, which is discussed below.

**Table 3.2:** Result comparison

Stations	Max no. of people in queue		Processing time for percentage of people	
	Before	After	Before	After
<b>Grill Area</b>	<b>35</b>	<b>18</b>	<b>32% &lt; 6 sec</b>	<b>52% &lt; 6 sec</b>
<b>Rice</b>	<b>17</b>	<b>17</b>	<b>35% &lt; 8 sec</b>	<b>75% in &lt; 8 sec</b>
<b>Salad</b>	<b>25</b>	<b>23</b>	<b>56% &lt; 4 sec</b>	<b>92% in &lt; 3 sec</b>
<b>Beverages</b>	<b>18</b>	<b>8 – 9</b>	<b>35 % - 45 % &lt; 35sec</b>	<b>41% &lt; 20 sec</b>
<b>Checkout</b>	<b>17</b>	<b>11</b>	<b>5 % &lt; 2 min</b>	<b>10% &lt; 1 min</b>

### Wastage and Wait time

Data was collected for calculating the food wastage from 450 to 500 plates for three consecutive days in two different weeks. It was observed that when the wait time overall is greater than 6 minutes average wastage of food is 50 to 75 grams, when the wait time is greater than 8 min wastages is 120 grams, but when it increases to more than 12 minutes the wastage also increase to 300 grams. From the observation, it is clear that the wait time increases the wastage

### Knowing an estimate of Food Required at Counters

Looking at the arrival rate from the simulation, a data table like one shown in Table 3.4 can be created for the chefs to estimate an idea of quantity required for each station with a specific time. This helps fresh food to be served every hour, thus reducing food wastage, wait time due to lack of food, and improve cooking and preparation plans. That also helps to reduce the unwanted pressure to meet the demand due to sudden arrival and while circumstances such as to plan while absenteeism of any employee.

**Table 3.3:** Required amount of food every hour

Time	Station	Individual units	Required pans
at 11:30 am	Grill 1	120	8.5
	Grill 2	100	5.5
	Rice	100	5
at 12:00 pm	Grill 1	89	5
	Grill 2	70	4
	Rice	120	7
at 12:30 pm	Grill 1	57	3

	<b>Grill 2</b>	<b>71</b>	<b>3</b>
	<b>Rice</b>	<b>110</b>	<b>~ 7</b>
<b>at 1:00 pm</b>	<b>Grill 1</b>	<b>45</b>	<b>2.5</b>
	<b>Grill 2</b>	<b>48</b>	<b>3</b>
	<b>Rice</b>	<b>85</b>	<b>4.72</b>
<b>at 1:30 pm</b>	<b>Grill 1</b>	<b>46</b>	<b>3</b>
	<b>Grill 2</b>	<b>79</b>	<b>4.5</b>
	<b>Rice</b>	<b>65</b>	<b>3.6</b>
<b>at 2:00 pm</b>	<b>Grill 1</b>	<b>54</b>	<b>3</b>
	<b>Grill 2</b>	<b>103</b>	<b>6</b>
	<b>Rice</b>	<b>85</b>	<b>4.72</b>

#### 4. CONCLUSION

The cafeteria has regular and large influx of customers with different arrival rates. The results of DES modeling and analysis with existing scenario gives a clear understanding of how cafeteria functions and helps in identifying the operational bottlenecks occurring in serving stations. These results also indicate how the overall time reduction in each station. The queue size can also be planned by altering the operational time in each station and help make a line balancing scenario for distributing the crowd among stations.

After allocating resources in required time 12 pm to 2 pm for salad, rice, grill stations, a second DES model is conducted to simulate for reduced queuing time in all serving stations whereas there is less difference in queuing lengths after the change. Queuing time reduced based on this improvements deciding in adding/removing an extra person in each station according to any specific upcoming requirement and customer revisiting patterns to the station can be found. Overall reduction in time and queue size has reduced the average 10 – 12 minutes wait time to close to 25 % for customers during the peak serving hours. This enhances the serviceability of restaurant and helps for capacity management.

Simulation trials also make a data table as an opportunity for manager and chefs to make advance plans to stream line the process and consider for serving extra incoming customers. The simulation on the improved scenario helps the consideration in wastage reduction and satisfaction mapping on the customer end and on preparatory end as well.

The future work of this study could include more accurate modeling of cafeteria with considerations of working efficiency of employees and different occasions, such as seat availability. An interactive model could also be built to show instant serviceability rates of cafeteria opening more grounds for improvement.

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