A SIMULATION MODEL FOR A Fast Food Chain - Chik-Fil-A

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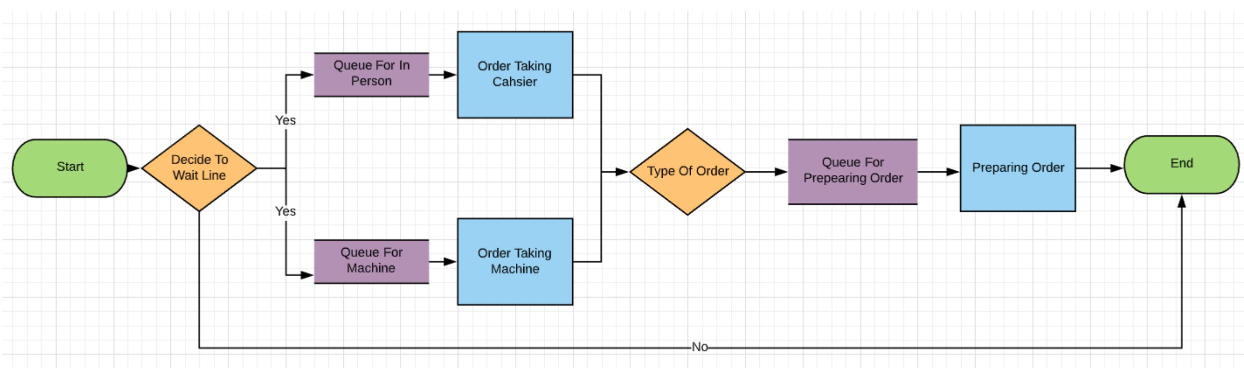
I. Executive Summary

The fast food industry has undergone several transformations and disruptions over the past few years. Different features like customizing your own meal, or online ordering have been implemented in many different fast food chains in order to give customers the optimal convenient experience for their visit. In an industry where convenience is a huge factor in keeping or growing market share, being able to optimize all resources and reduce the time it takes to get the food to the customer is key in staying ahead.

In our project, we wanted to simulate what a customer's experience at a typical fast food restaurant would be like to see what sort of constraints the fast food restaurant would face. The most important aspect for a fast food restaurant is keeping the customer satisfied. If the queue line is too long, the customer may choose not to begin queuing. If queue wait is too long, the customer could still choose to leave. Lastly, having a person or machine take the customer's order, and optimizing the number of cashiers needed is also something our model tries to answer. We tried to feasibly incorporate as many aspects as we can to the fast food experience so we can study a robust model. For our report, we used a typical Chik-Fil-A franchise that offers a billboard machine to take your order as a reference.

II. Conceptual Model



Our goal was to break down the flow process that a customer would go through, and the interactions they would have with Chik-Fil-A. We realized that we wanted to focus on the customer service side of the model rather than inventory and food preparation, although we did account for how quickly food would be prepared to the customer in the restaurant.

The chart above shows the process a customer encounters when he wants to order Chik-Fil-A. First their is a decision of whether to order from the cashier, a machine, or not buy Chik-Fil-A at all. Then, after ordering, they wait for the order to be prepared. Though this is a simplified model of the queueing process, we used it as a structure to expand on the variables we wanted to measure. In each queue along the way, there are variables of balking and reneging that change in likelihood along the way.

III. Model Implementation in Arena

1. Overview

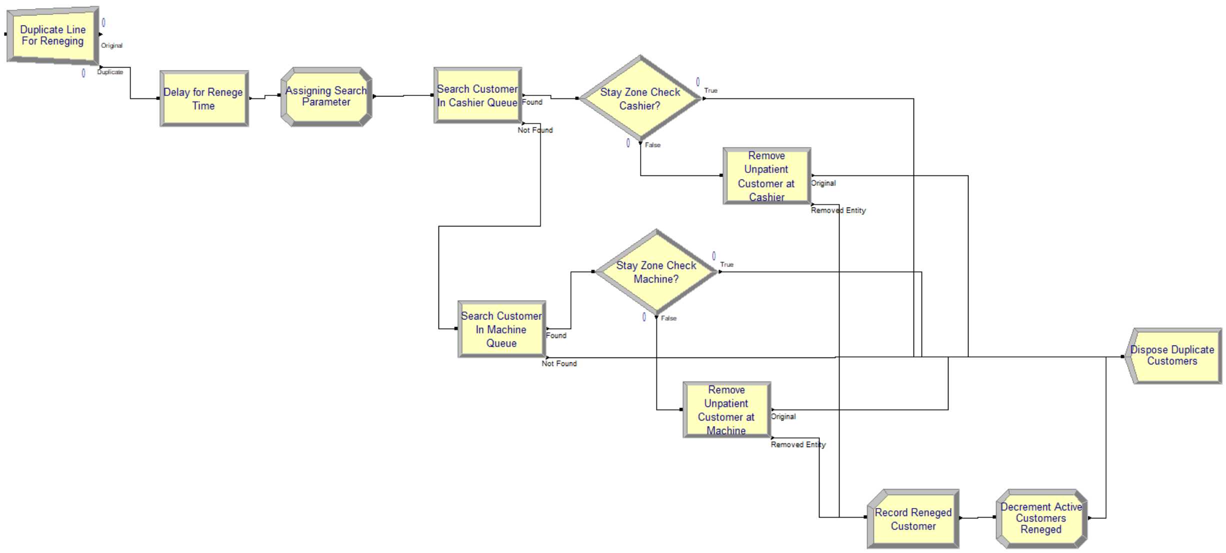
We have used various modules like: Create, Assign, Process, Decide, Separate, Record, Station, Route, Delay, Hold, Queue, Seize, Remove, Search and Dispose.
We also made use of various attributes, variables, schedules, set and expressions.

2.Logic flow

A. General Arrival

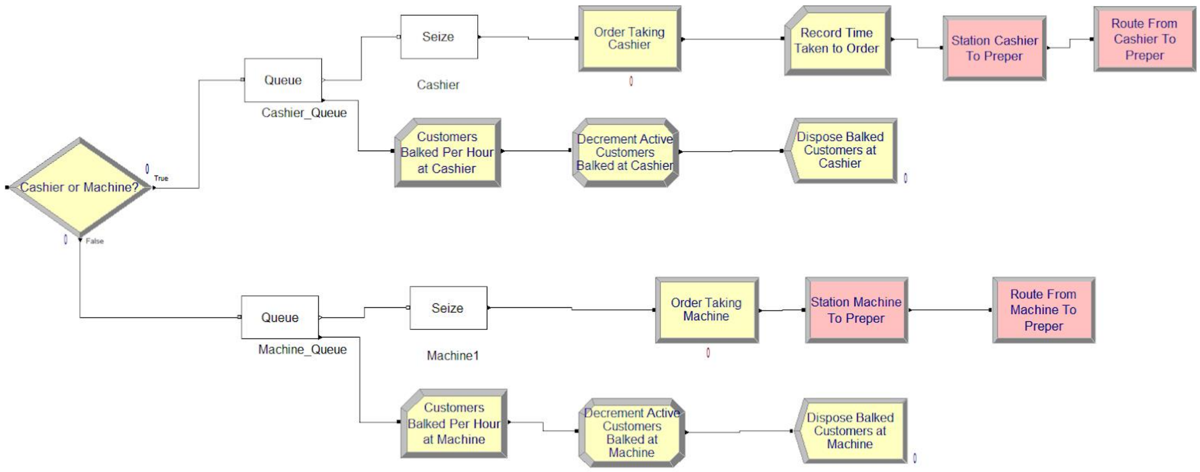
Customers arrive according to a schedule during the whole day and consideration for peak hours is also taken into account. The Arrived customers are recorded and assigned a value of what type of food they are going to order. A customer will select the queue he wants to wait in according to the number of people present in both the queues. We also assigned a few attributes like Reneging Time,Stay Zone and Max Queue Length to implement our Reneging and Balking logic.

B. Reneging Logic For Customers at Cashiers Queue and Machine Queue



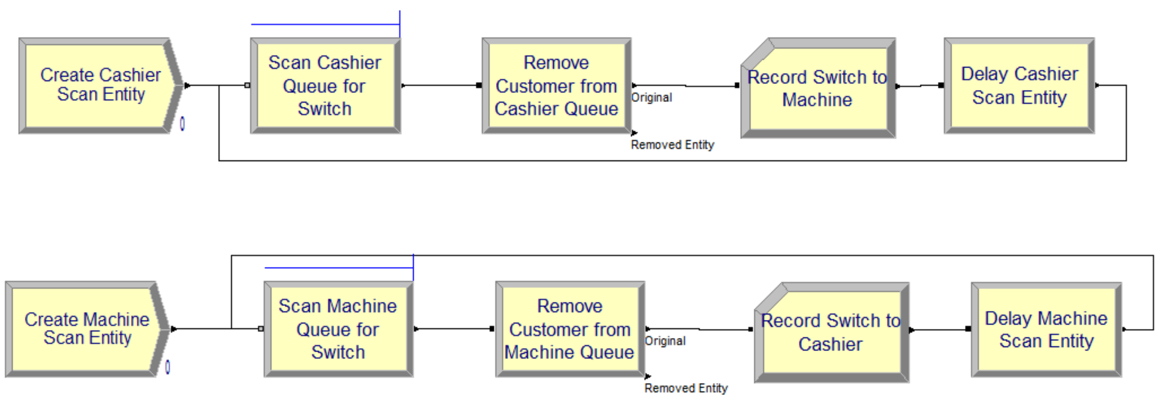
Once the customer has arrived at the chain, we create a duplicate of it for implementing our Reneging logic, we use the attributes and variables defined in the assign module. We first Delay the customer by some time and then search for him in the queue, when found, the customer is checked whether it is in the stay zone or not. Stay zone defines the number of people the customer is willing to wait for more before he gets serviced. If he is within the safe zone then the duplicated entity is disposed of, if not then the impatient customer is removed from the original line and then recorded to get a count of the total reneged customers.

C. Balking Logic



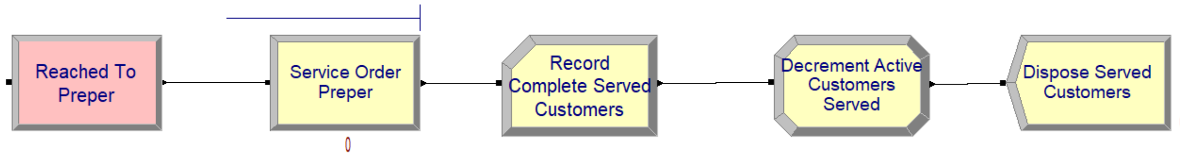
The Decision module makes sure that the customer joins the shortest queue. But before he gets in to wait in the queue, we check whether the customer will balk or not. During peak hours there are a number of people waiting in queue and each customer has a threshold of the number of people waiting ahead of him. If they are more than the value TRIA(2,3,4) then the customer leaves without getting in the queue at all. The Balked customer is recorded and the number of active customers is reduced by one and the entity is disposed of. If the customer waits in queue then the cashier/machine takes his order and time taken up till now is recorded to know much how average time it takes to just get your order processed. The Customer's order is then sent to the prepper via the Station and Route module.

D. Changing Queue Logic



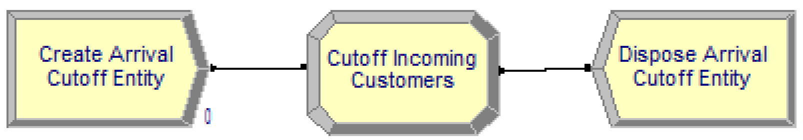
For a customer to place his order he can either choose the cashier queue or the machine queue. He can switch queues if the length of the other queue is shorter. For this we have devised the above logic. Since we have used Scan module for checking which length shorter, and for the condition to be executed we need inputs and hence we create dummy inputs at t=0, for both the cashier queue and machine queue. If the length at either of them is greater than the other then the customer leaves the longer queue and joins the shorter one, so we use the remove module to remove customer from the current queue. The removed customer directly joins the the other queue and the we record the number of switches and then delay the next scan by one minute.

E. Prepper's Logic



When order has been placed by the Customer, the order is then processed by the prepper, the first module is the Station module which brings the entity from both the cashier and machine queue to this point. It then processes the order. We record the number of serviced customers and decrease the Active Customers count by one, we do this because in our run setup the termination condition is that the number of active customers should be zero.

F. Cutoff Logic



Chick-fil-A closes at 8 pm and hence a cutoff logic is devised to 600 minutes i.e after 10 hours and that entity has a very high value which indirectly means that the system will be inactive until next morning or next simulation.

IV. Input Analysis

For the Input distribution we mainly relied on the domain knowledge as one of our team members worked at Stamp union so he knew what amount of customers can we expect at a typical hour and how many cashiers and food preppers we would need at a certain point. Moreover, we also had a conversation with the head of student stamp union Amilcar Hernandez to get better insight of the customers arriving and the type of orders we can accept and specific time in the day. We tried to make those estimations close to reality in order to test feasibility of our model. If we have real data available our model can adapt to that also and can have more reliable outputs.

	Value	Duration
1	10	1
2	20	1
3	50	1
4	80	1
5	60	1
6	40	1
7	20	1
8	10	1
9	5	1
10	5	1

Here we see that duration is 1 which is hourly and value shows the number of customers arriving in the stamp union at Chik-Fil-A at different times. We see more customers arrive at peak at 12-1 PM and 1-2 PM.

For Cashiers also we have created a Schedule to make it more realistic. Here in Stamp students are scheduled as cashiers and no student is available the whole day for which we have created a schedule to schedule different cashiers and different times according to their availability.

	Value	Duration
1	Period_Cashiers(1)	1
2	Period_Cashiers(2)	1
3	Period_Cashiers(3)	1
4	Period_Cashiers(4)	1
5	Period_Cashiers(5)	1
6	Period_Cashiers(6)	1
7	Period_Cashiers(7)	1
8	Period_Cashiers(8)	1
9	Period_Cashiers(9)	1
10	Period_Cashiers(10)	1
11	Period_Cashiers(11)	1

Model similarly has a schedule for preppers which is similar to that of Cashier. The only difference is that value is in form of 0 and 1 which tells us if that certain prepper is available at that time or not .

	Value	Duration
1	0	1
2	0	1
3	1	1
4	1	1
5	1	1
6	1	1
7	1	1
8	1	1
9	0	1
10	0	1
11	0	1

Output Measures

We measured and analyzed the following performance measures:

1. **Cashier Utilization:**
   a. This measures the scheduled utilization of the cashiers throughout the day.
   b. The higher the utilization of the cashiers, the better.

2. **Percent of Balked Customers:**
   a. The percentage of customers that arrive at the restaurant and leave immediately because of long queues at the cashiers and the machine.
   b. The lower the balked percentage, the better.

3. **Percent of Reneged Customers:**
   a. The percentage of customers that arrive at the restaurant, enter the cashier or machine queue and leave if their order is not taken within renege time.
   b. The lower the reneged percentage, the better.

4. **Total Percent of Customers Rejected:**
   a. This is the sum of percentage of balked and reneged customers
   b. The lower the total rejected percentage, the better.

5. **Average Waiting time at the Cashier Queue:**
   a. This is the average waiting time of customers in the cashier queue.
   b. The lower the average waiting time, the better.

6. **Preper Utilization:**
   a. Scheduled utilization of each of the 5 prepers.
   b. The higher the utilization of the prepers, the better.

7. **Average Waiting time at the Preper Queue:**
   a. This is the average waiting time of customers in the preper queue.
   b. The lower the average waiting time, the better.

8. **Machine Utilization:**
   a. Scheduled utilization of the machine.
   b. The higher the utilization of the machine, the better.

9. **Average Waiting time at the Machine Queue:**
   a. This is the average waiting time of customers in the machine queue.
   b. The lower the average waiting time, the better.

There would be a tradeoff between cashier utilization and the percentage of rejected customers. The company would tolerate <= 5% of rejected customers, to increase its cashier utilization.

Output Analysis

We considered 10 scenarios in PAN to find the optimal schedule of cashiers throughout the day. These scenarios explore the various tradeoffs between cashiers scheduled utilization and the percentage of rejected customers. Each scenario is run for 50 replications.

The optimal schedule of the cashiers is the scenario in which the cashiers utilization is the highest and the total percentage of customers rejected is less than or equal to 5%.
The arrival rate of customers is high from 12 PM to 3 PM. We explored various cashier schedules that have more cashiers during these peak hours.

In scenarios 1 through 5, the number of cashiers in 1 during the off peak hours and the number of cashiers in the peak hours is varied from 1 to 5. We observed that as the number of cashiers is increased, the cashier utilization falls from 72% to 56% and the total percentage of rejected customers falls from 34.8% from 2.8%.

In scenario 5, where we have 5 cashiers during the peak hours, we obtain the lowest total percentage of rejected customers, but the cashiers utilization is also the lowest. In scenarios 6 through 10, we tried various combinations of lower number of cashiers in the peak hours, such that the total percentage of rejected customers is around 5% and the cashiers utilization is maximized.

We observed that scenario 8, with the following schedule gives the highest cashiers utilization of 64.9% while keeping the total percentage of rejected customers under 5%. The total percentage of rejected customers is 4.6%.

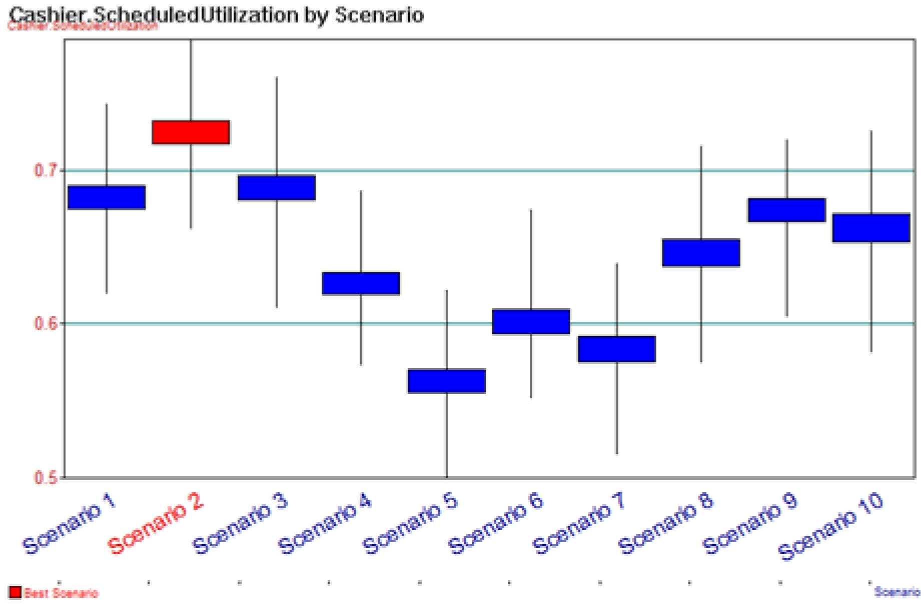
Schedule	**Number of Cashiers**
10 AM – 11 AM	1

11 AM – 12 PM	1
12 PM – 1 PM	4
1 PM – 2 PM	4
2 PM – 3 PM	4
3 PM – 4 PM	3
4 PM – 5 PM	1
5 PM – 6 PM	1
6 PM - 7 PM	1
7 PM – 8 PM	1
8 PM – until the last customer is served	1

Analysis Charts:

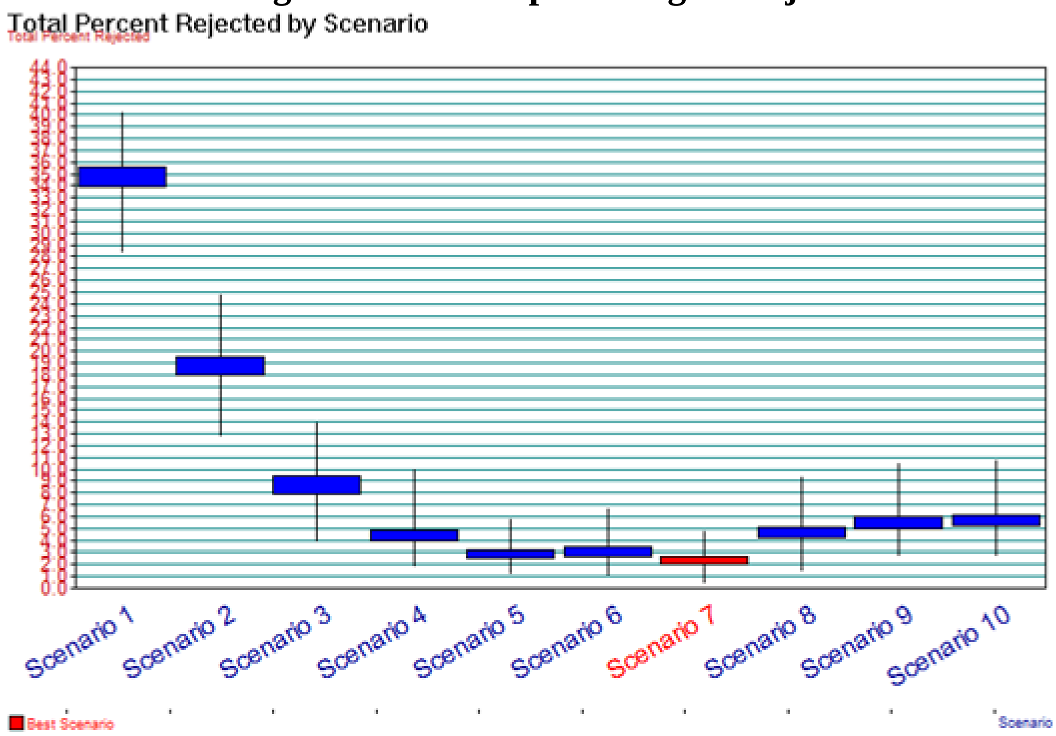
1. Scheduled Cashier utilization per scenario:

a. Scenario 2 gives the highest cashiers utilization of 72.8%.



2. Total percentage of rejected customers per scenario:

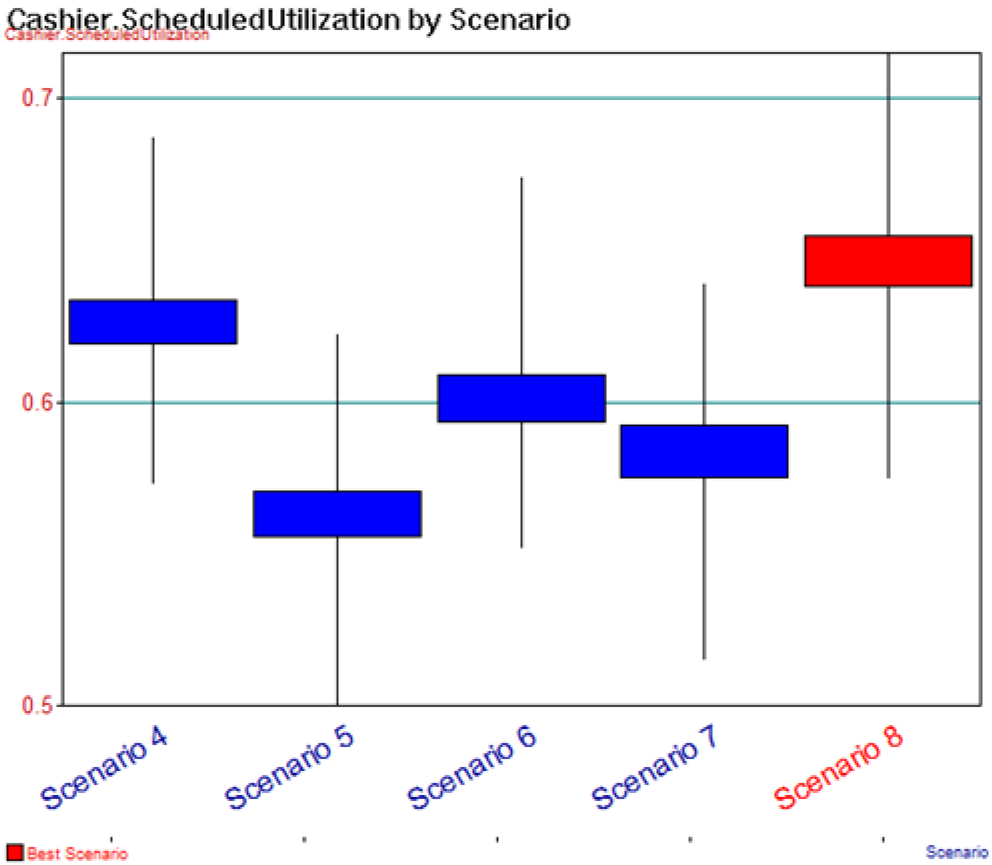
a. Scenario 7 gives the lowest percentage of rejected customers of 2.3%.



3. Scheduled Cashier utilization in scenarios with <=5% rejected customers:

a. Scenarios 4,5,6,7,8 have <=5% rejected customers

b. Scenario 8 has the highest cashiers utilization of 64.9%



CONCLUSION

The goal of our simulation project was to understand what would be the optimal way to manage our resources to keep the customers from balking or reneging. We conclude from the simulation results that the following cashiers schedule is optimal. This schedule maximizes the cashiers utilization while keeping the percentage of rejected customers to under 5%.

Schedule	Number of Cashiers
10 AM – 11 AM	1
11 AM – 12 PM	1

12 PM – 1 PM	4
1 PM – 2 PM	4
2 PM – 3 PM	4
3 PM – 4 PM	3
4 PM – 5 PM	1
5 PM – 6 PM	1
6 PM - 7 PM	1
7 PM – 8 PM	1
8 PM – until the last customer is served	1

Performance Metrics

Performance Metric	**Value**
Cashiers Scheduled Utilization	64.9 %
Total Percent of Rejected Customers	4.6%
Percent of Balked Customers	0.9%
Percent of Reneged Customers	3.7%
Average Cashier Queue Waiting Time	0.44 minutes

Preper 1 Scheduled Utilization	61.7%
Preper 2 Scheduled Utilization	48.5%
Preper 3 Scheduled Utilization	62.4%
Preper 4 Scheduled Utilization	82.3%
Preper 5 Scheduled Utilization	77.4%
Average Waiting time to receive Order	5.47 minutes
Machine Scheduled Utilization	22.5%
Average Machine Queue Waiting Time	1.33 minutes

Future Work

Future features could be simulated with a model to understand how we can improve customer satisfaction by reducing their wait time. For example, online ordering, especially during our quarantine where all restaurants are required to only serve take out and delivery, could be implemented. We could also examine different methods of payments and the most optimal way to reduce a customer's time with a machine or cashier via payment method. For example, cash would take a long time to do transactions, while a touchless Apple pay with the phone could be almost instant. Lastly, order analytics could be implemented to simulate an inventory and more in-depth food preparation model to further optimize existing resources and to rotate employees between prep and cashier.