BANA 7030 – Simulation Modelling

Final Project – Professor Yiwei Chen

DRUNKEN TACOS

@ucdrunkentacos at 200 West Mcmillan, Cincinnati

University of CINCINNATI

Declaration –
On my honor, I have neither given nor received unauthorized aid in completing this academic work.

Signed by
Komal Mahajan
M13231289

Chapter 1 - Project Executive Summary

Background and Objective

This study has been done to apply the learning of the coursework BANA 7030 – Simulation Modeling and to analyze the working model of a Mexican Cuisine Restaurant and Bar, **Drunken Tacos – The Nightlife Café,** in terms of resource utilization, different wait time experience by customers during their visit.

Here in America, we are affectionate with the tasty cuisine from our neighbor, Mexico. May be because of our mutual love for topping everything with cheese, lots of cheese. American and International students love the delectable Mexican dishes like Quesadillas, Burritos, Tacos, etc.



The purpose of my project is to simulate the working model of Drunken Tacos, flow of the customer and recommend options for improvement, if feasible. The objective behind this simulation study is to assess the following parameters:

1. How long each customer waits in queue and the total waiting time for each customer
2. Total Time customer stays in the restaurant from its arrival and exit
3. Factors influencing customer service time
4. Utilization of the different staff members
5. Using additional member and comparing with the model in place

Problem Statement

Drunken Tacos provides both dine-in and take away options. It is one of the most rated and crowded places near the university area and one of my favorites too. From Friday evening onwards, the weekend mode kicks in and this restaurant experiences a heavy footfall and long waiting lines. During rush hours around 6-9 PM, the average total time for the customers reaches up to 35-40 minutes. The staff there mentioned that many times, most of the customers leave due to long queues or waiting time.

Approach

Through this study, we will try to find how the current model in place can be improved to cater the requests of more customers. The data used in this analysis was collected during the rush hours on Saturday evening from 7 pm to 9 pm on the following aspects – customers arrival rate, dishes preparation time, beverages preparation time, service and packaging times.

Arena simulation software has been used to perform the simulation study of Drunken Tacos system. The input data was fitted and visualized using ***Arena – Input Analyzer tool***. The complete model was defined using two modules of Arena: flow chart and data modules and once the input data expression was linked

with the several entities, queues and resources, it was run for 2 hours. For better results, the simulation was replicated for 30 and 50 days, respectively. The results were almost same for both the replications. Based on the results the recommendation was made and the new simulation results were compared with the current model in place.

Model Assumptions

We considered the below assumptions to do the modeling of Drunken Tacos system in place:

- All resources are available throughout the working hours, no breaks
- Customers will give orders at the order counter and waits at the pickup counter
- The service time varies for different dishes
- If the customer leaves without ordering, then its time is not counted in the final metric of average waiting time of the customer in the system
- Customer exit means that the customer has received the order and the transaction is completed. Customer may or may not leave the restaurant.

Chapter 2 – Data Collection and Exploration

One of the pertinent process for simulating the model, is to get the specific data. Data was collected at Drunken Tacos for 2 hours on Saturday evening. The dataset contains information on customer arrival rate, order time, food preparation time, food-beverage combo preparation time, packing time.

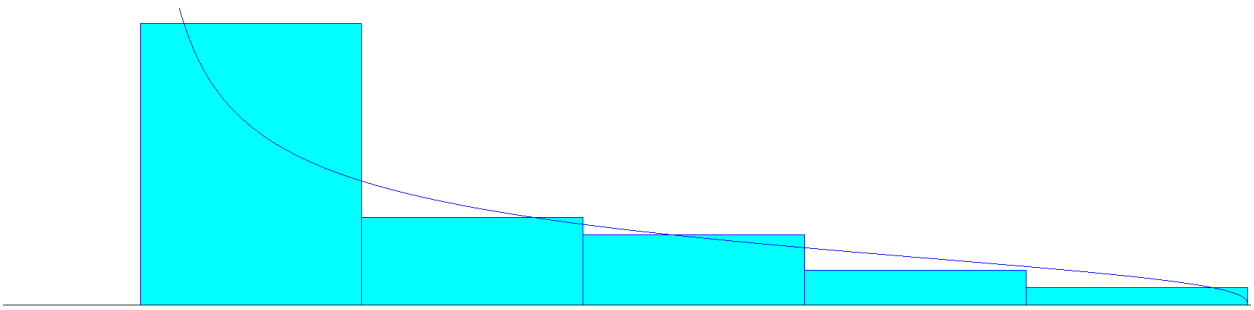
Below is a brief summary:

1. Drunken Tacos prepares only Mexican dishes in food. There are 2 cooking resources(chef) assigned solely for food preparation.
2. Drunken Tacos serves beverages (cocktails, beers, margaritas, and other drinks) as well and there is one bartender for this purpose.
3. There is one resource(cashier) at the order counter who takes the order and money from the customer, gives the confirmed order to the staff for preparation, picks up the order once prepared and gives it to the customer and thus completes the transaction with the customer.
4. It was found out from the Drunken Taco's staff, with their consent, that around 70% of the time customers order the combo of food and drinks and rest of the time they order only food.
5. It takes around 1 minute in serving on plate or packing to take away once the food is prepared.

Data Visualization and Fitting to find the distribution

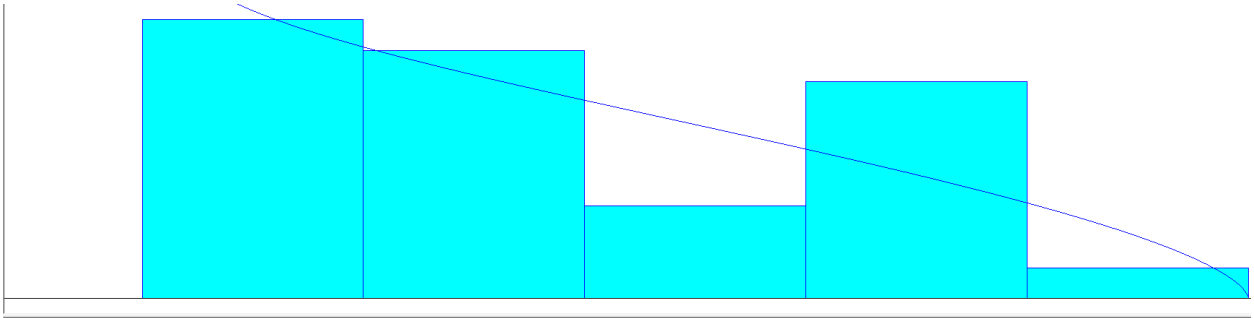
Input Analyser takes the data values in the file extension(.dst) and then chooses different different distributions to find the most appropriate fit. Below are the histograms and the distribution summaries of the fitted data of inter-arrival time of the customer, order time, food, and beverage preparation time.

Customer's Inter-Arrival Time Data Distribution



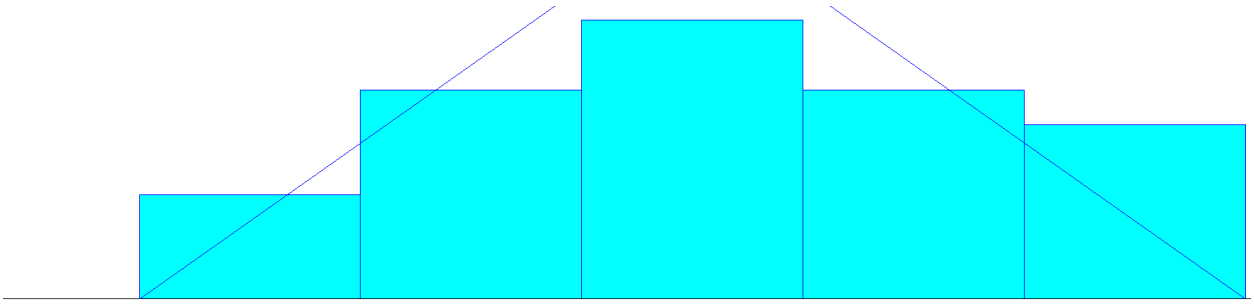
```
       Distribution Summary

Distribution:   Beta
Expression:     -0.001 + 8 * BETA(0.54, 1.38)
Square Error:   0.001802

Chi Square Test
  Number of intervals   = 3
  Degrees of freedom    = 0
  Test Statistic        = 0.311
  Corresponding p-value < 0.005

Kolmogorov-Smirnov Test
  Test Statistic        = 0.127
  Corresponding p-value > 0.15

       Data Summary

Number of Data Points   = 28
Min Data Value          = 0
Max Data Value          = 7.9
Sample Mean             = 2.02
Sample Std Dev          = 2.06

       Histogram Summary

Histogram Range         = -0.001 to 8
Number of Intervals     = 5
```

Customer's Order Time



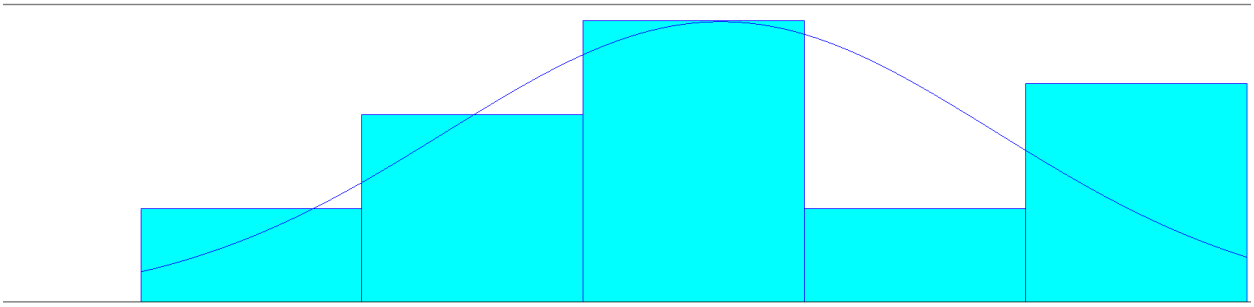
```
       Distribution Summary

Distribution:   Beta
Expression:     1 + 3.4 * BETA(0.908, 1.61)
Square Error:   0.022725

Chi Square Test
  Number of intervals   = 4
  Degrees of freedom    = 1
  Test Statistic        = 2.1
  Corresponding p-value = 0.165

Kolmogorov-Smirnov Test
  Test Statistic        = 0.131
  Corresponding p-value > 0.15

       Data Summary

Number of Data Points   = 28
Min Data Value          = 1.1
Max Data Value          = 4.1
Sample Mean             = 2.23
Sample Std Dev          = 0.871

       Histogram Summary

Histogram Range         = 1 to 4.4
Number of Intervals     = 5
```

Food Preparation Time



```
       Distribution Summary

Distribution:   Triangular
Expression:     TRIA(5.26, 7.13, 9)
Square Error:   0.017294

Chi Square Test
  Number of intervals   = 3
  Degrees of freedom    = 1
  Test Statistic        = 0.971
  Corresponding p-value = 0.351

Kolmogorov-Smirnov Test
  Test Statistic        = 0.205
  Corresponding p-value > 0.15

       Data Summary

Number of Data Points   = 28
Min Data Value          = 5.6
Max Data Value          = 9
Sample Mean             = 7.3
Sample Std Dev          = 0.994

       Histogram Summary

Histogram Range         = 5.26 to 9
Number of Intervals     = 5
```

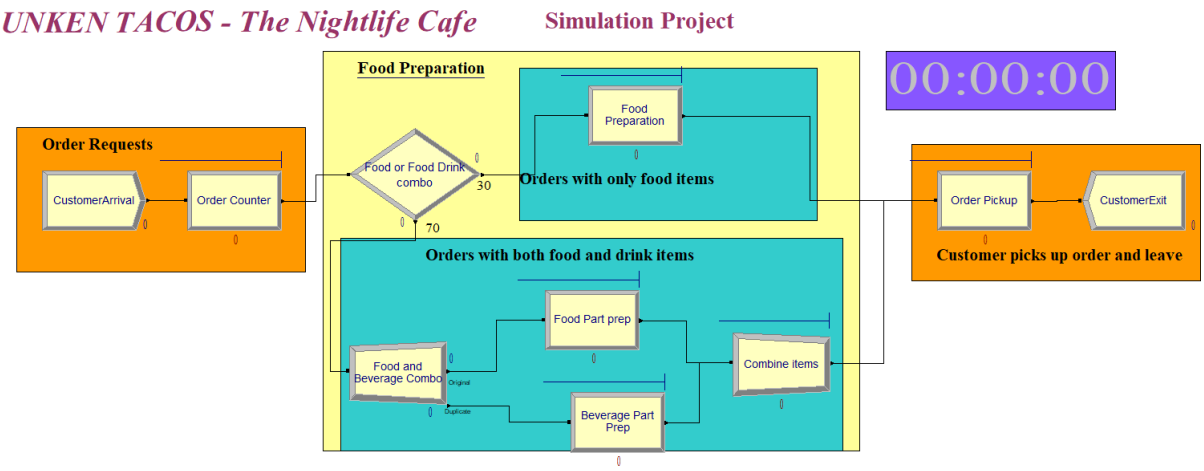
Beverage Prep Time



```
       Distribution Summary

Distribution:   Normal
Expression:     NORM(1.7, 0.682)
Square Error:   0.041114

Chi Square Test
  Number of intervals   = 3
  Degrees of freedom    = 0
  Test Statistic        = 2.31
  Corresponding p-value < 0.005

Kolmogorov-Smirnov Test
  Test Statistic        = 0.127
  Corresponding p-value > 0.15

       Data Summary

Number of Data Points   = 28
Min Data Value          = 0.5
Max Data Value          = 2.9
Sample Mean             = 1.7
Sample Std Dev          = 0.694

       Histogram Summary

Histogram Range         = 0.26 to 3
Number of Intervals     = 5
```

Chapter 3 – Model Simulation using ARENA

Drunken Tacos' system was simulated using the Flow chart Module and Data Module in Arena. The snapshot of the model that was created to simulate the real scenario:



Below is a brief description of the process:

1. Customer(Entity) arrives in the restaurant.
2. Customer waits in the Order queue(Queue1) to place the order.
3. The confirmed order starts getting prepared, or comes in order preparation queue, as per the choices(food only or combo). If it's a combo order then both the food and beverage part are prepared seperately and then order is combined.
4. Once the order is prepared, it gets packed and picked up by customer at Pickup counter.
5. Customer exits from the system.

Overview of Model parameters:

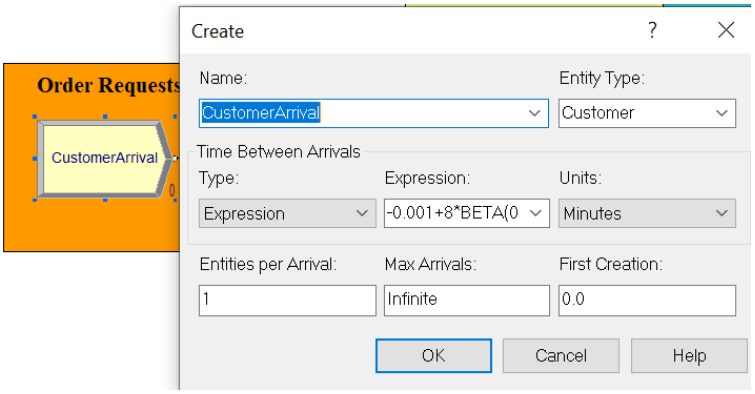
Number	Arena Parameters	Drunken Taco Parametsers	Type/Action
1	Entity	Customer	Actor
2	Resource 1	Cashier	Seize-Delay-Release
3	Resource 2	Chef	Seize-Delay-Release
4	Resource 3	Bartender	Seize-Delay-Release
5	Queue 1	Order Counter	FIFO
6	Queue 2	Food Preparation	FIFO
7	Queue 3	Combine items	FIFO
8	Queue 4	Food Part Preparation	FIFO
9	Queue 5	Beverage Part Preparation	FIFO
10	Queue 6	Pick up counter	FIFO

Model Building using Flow chart and Data Modules

Explanation of different modules(Basic Process) of Model and Logic used to build the model. All the expressions used are generated from the input analyzer distribution summary results:

Order Requests

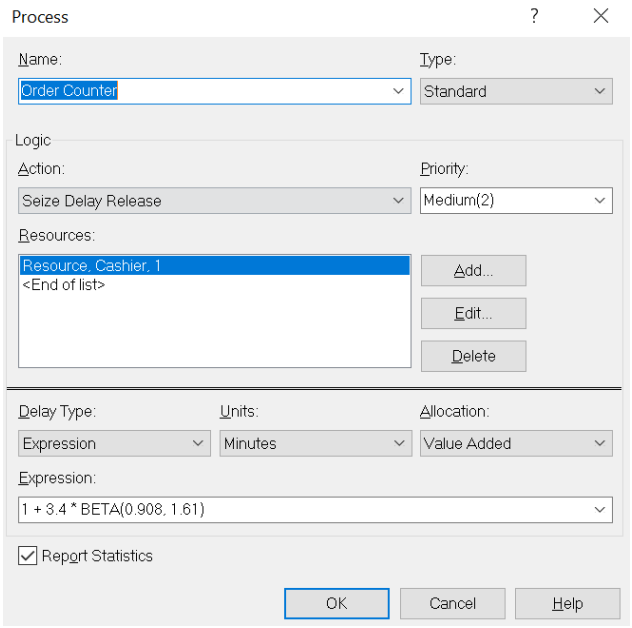
1. **CustomerArrival(Create)** – It records the arriving of the customers and their inter-arrival rate.



Create - Basic Process

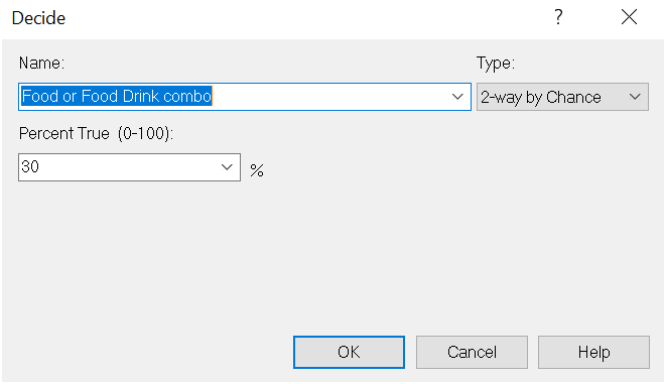
	Name	Entity Type	Type	Expression	Units	Entities per Arrival	Max Arrivals	First Creation
1	CustomerArrival	Customer	Expression	-0.001+8*BETA(0.54,1.38)	Minutes	1	Infinite	0.0

2. **Order Counter(Process)** – Customer wait in the order queue to place the order. There is a horizontal bar represnting the specific queues associated to the different processes in the above model snapshot.



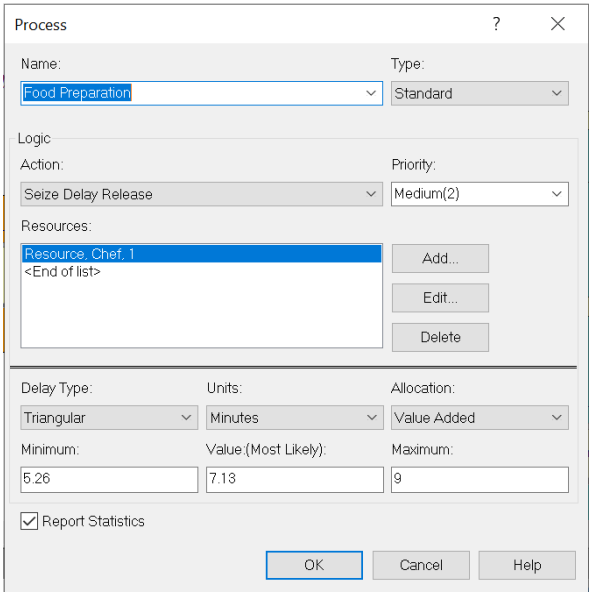
Food Preparation

3. **Decision Box(Decide)** – Once the order is confirmed, this module decides whether the order is for food only or combo of food and drinks both.

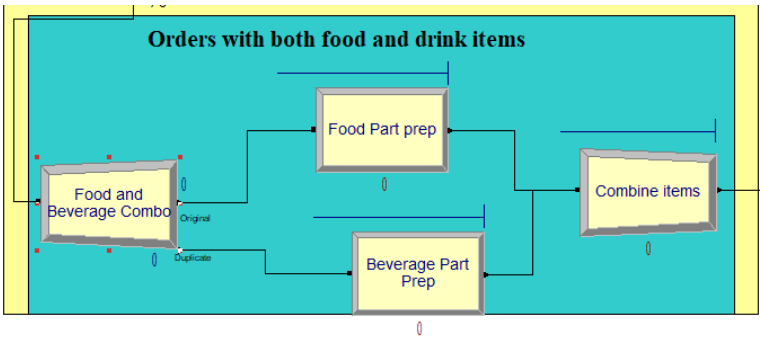


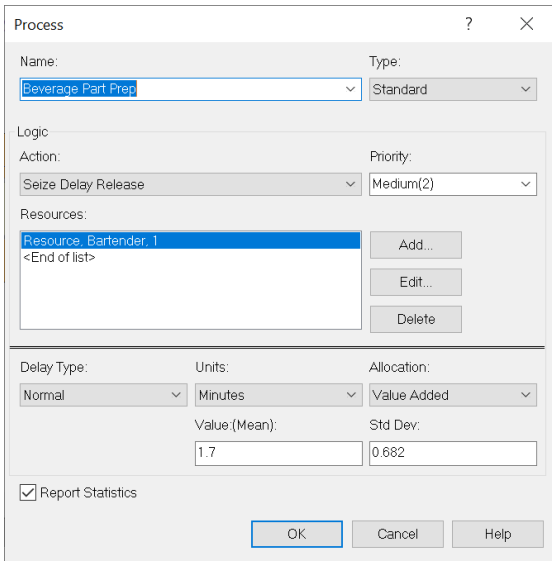
30% is representing the case for 'food only' orders.

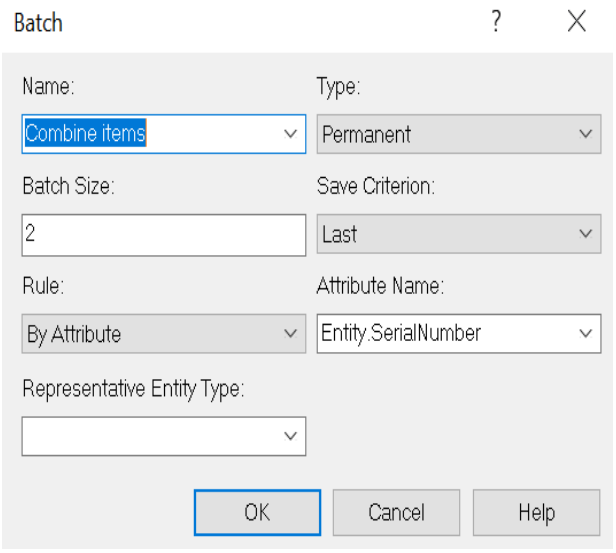
4. **Food Preparation(Process)** – The order for food only joins the 'food preparation' queue, trigerring the action to seize delay and release a chef who prepares this order. The delay type distribution here is food preparation expression generated by Input Analyzer.



5. **Food and Beverage Combo(Separate) and Combine(Batch)** – 70% of the orders contain both food items and drinks. For these case, food part of the order joins the 'food part prep' queue and the beverage part of the order joins the 'beverage part prep' queue. Both part triggers actions to to seize delay and release a chef and a bartender respectively who prepares their part of the orders. Once both the items are done, they are combined to form a single order for this they joins the 'combine items' queue.

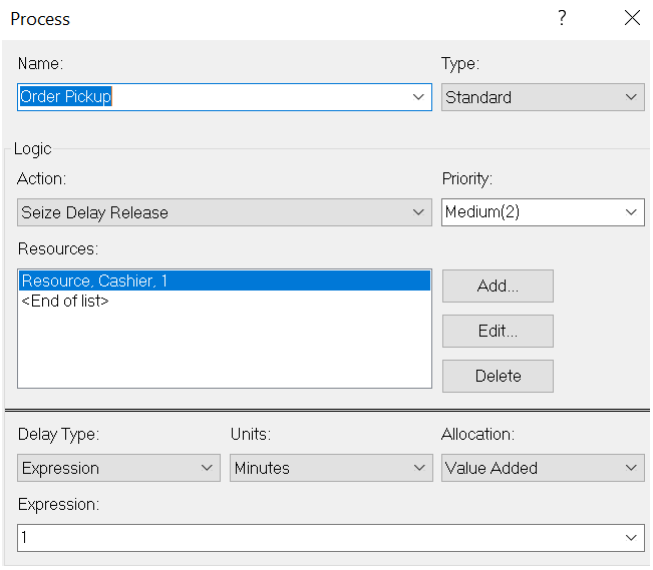




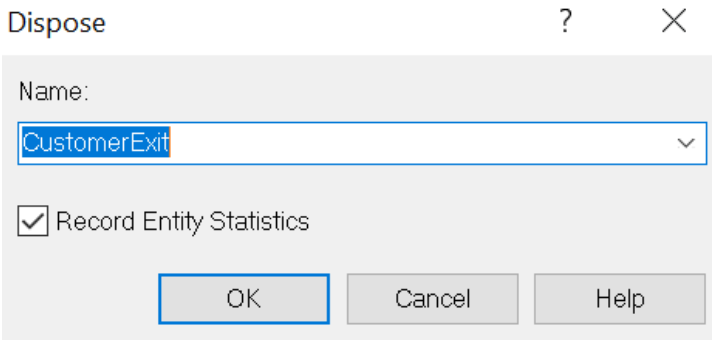


Customer picks up order and leave

6. **Order Pickup(Process)** – It takes 1 minute on an average in packing and serving the order by the resource(cashier) to hand it to the customer who are in the 'order pickup' queue waiting for the order.

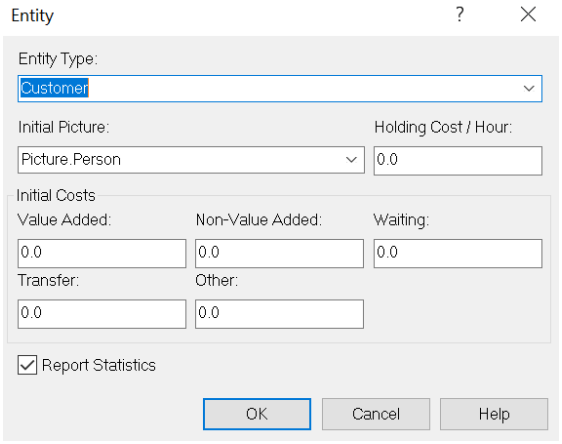


7. **CustomerExit(Dispose)** – We have used the dispose module to show that the customer leave the system once he/she gets their respective order.



Attributes of Data Modules

1. **Entity**



2. **Resources** – We have 1 cashier(order counter resource), 2 chef(cooking resource) and 1 bartender(beverage resource).

Resource - Basic Process

	Name	Type	Capacity	Busy / Hour	Idle / Hour	Per Use	StateSet Name	Failures	Report Statistics
1	Cashier	Fixed Capacity	1	0.0	0.0	0.0		0 rows	☑
2	Chef	Fixed Capacity	2	0.0	0.0	0.0		0 rows	☑
3	Bartender	Fixed Capacity	1	0.0	0.0	0.0		0 rows	☑

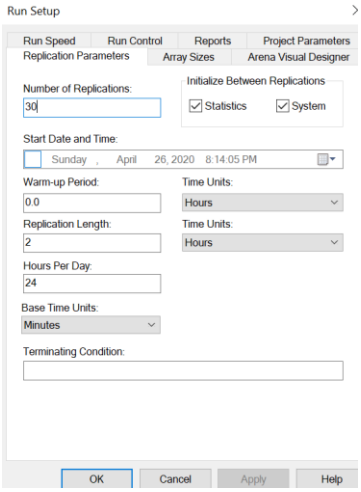
3. **Queues** – All queues cater request as First-In-First-Out(FIFO) order.

Queue - Basic Process

	Name	Type	Shared	Report Statistics
1	Order Counter.Queue	First In First Out	☐	☑
2	Food Preparation.Queue	First In First Out	☐	☑
3	Combine items.Queue	First In First Out	☐	☑
4	Food Part prep.Queue	First In First Out	☐	☑
5	Beverage Part Prep.Queue	First In First Out	☐	☑
6	Order Pickup.Queue	First In First Out	☐	☑

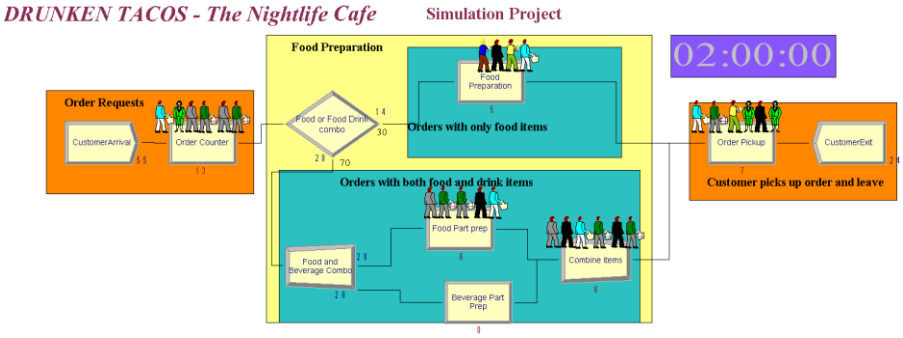
Chapter 4 – Results and Interpretation

Using Arena, we have run the simulation on our model by doing the setup as below. Here we have selected the number of replications to be 30 and replication length = 2 hours. The final analysis results output's base unit is chosen as minutes. There was not much difference in the results of 30 and 50 replications.



Result- The Arena software produces a well detailed and structured result report to interpret the result in terms of # of customers, wait time, resource utilization.

Our model, *Drunken Tacos – The Nightlife Café Simulation project,* that ran for 2 hours with 30 replications:



Replications: 30 Time Units: Minutes

Key Performance Indicators

System

	Average
Number Out	24

1. **Entity Time** – Overall average time customer stays in the system ~ 37 minutes.

   We should try to reduce this time so that customers service time can be less and customers don't have to wait for long in queues and to retain those customers who leave without ordering anything.

Total Time	Average	Half Width	Minimum Average	Maximum Average	Minimum Value	Maximum Value
Customer	37.4275	2.97	21.1371	55.7259	8.8637	88.4936

2. **Queue Time** – Arena gives specific details on the average waiting time in each of the queues and # of entities waiting for each queue. We can infer that the waiting time in each of the queues but beverage preparation is very high.

Queue

Time

Waiting Time	Average	Half Width	Minimum Average	Maximum Average	Minimum Value	Maximum Value
Beverage Part Prep.Queue	0.1129	0.03	0.00593618	0.3008	0.00	2.4376
Combine items.Queue	7.8134	0.63	5.2123	12.1877	0.00	36.8823
Food Part prep.Queue	10.9393	1.31	4.7887	19.9491	0.00	34.5647
Food Preparation.Queue	11.3810	1.28	5.6264	19.9904	0.00	34.3387
Order Counter.Queue	11.6238	1.65	3.6042	22.0139	0.00	42.1430
Order Pickup.Queue	13.1765	2.01	4.4631	27.5521	0.00	43.1981

Other

Number Waiting	Average	Half Width	Minimum Average	Maximum Average	Minimum Value	Maximum Value
Beverage Part Prep.Queue	0.02870376	0.01	0.00128617	0.07770079	0.00	2.0000
Combine items.Queue	3.6106	0.40	2.0223	7.0344	0.00	13.0000
Food Part prep.Queue	2.6915	0.39	0.9619	6.0034	0.00	11.0000
Food Preparation.Queue	1.1754	0.17	0.4689	2.0885	0.00	8.0000
Order Counter.Queue	5.2899	0.87	1.2915	10.4743	0.00	22.0000
Order Pickup.Queue	3.3662	0.48	1.1591	6.6291	0.00	13.0000

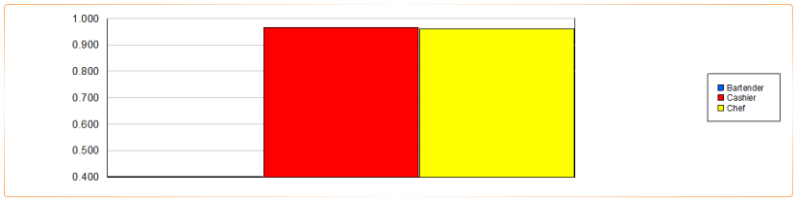
The average waiting time is the highest for order pickup queue, 13.2 minutes followed by order counter queue(11.6 minutes). The reason could be since both the counters are being handled by the same resource(cashier).

3. **Resource Utilization** – It can be seen that both the Cashier and 2 cooking resource are getting utilized almost 96%. Bartender is getting utilized for 40% only.

Usage

Instantaneous Utilization	Average	Half Width	Minimum Average	Maximum Average	Minimum Value	Maximum Value
Bartender	0.4023	0.02	0.3160	0.5327	0.00	1.0000
Cashier	0.9656	0.01	0.8888	1.0000	0.00	1.0000
Chef	0.9606	0.00	0.9239	0.9812	0.00	1.0000

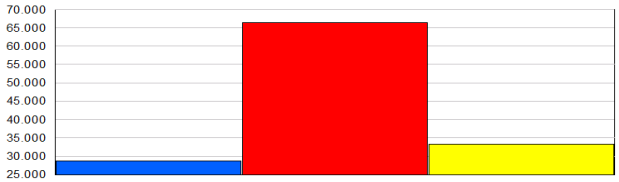
Number Busy	Average	Half Width	Minimum Average	Maximum Average	Minimum Value	Maximum Value
Bartender	0.4023	0.02	0.3160	0.5327	0.00	1.0000
Cashier	0.9656	0.01	0.8888	1.0000	0.00	1.0000
Chef	1.9213	0.01	1.8478	1.9624	0.00	2.0000



Resource

Usage

Total Number Seized	Average	Half Width	Minimum Average	Maximum Average
Bartender	28.7333	1.26	22.0000	36.0000
Cashier	66.4333	1.35	60.0000	73.0000
Chef	33.2667	0.28	32.0000	34.0000



Recommendations:

We can see from the above results that the number of customers coming into the restaurant is really high while the number of customer leaving the system after getting service is lesser. One of the kye reason we found could be the utilization of cashier resource at both order and pickup counter. Drunken Tacos restaurant's efficiency can be increased if we can appoint one more resource, server, who will perform the tasks at pickup counter. It will incur more cost but if the waiting time can get reduced, it will help in serving more customer orders and thus this can compensate for the additional cost of hiring one more resource.

Comparing the model with an extra resource to the current model in place:

We added one more resource, Server and linked it with the Pickup counter process and found the below results:

Resource - Basic Process

	Name	Type	Capacity	Busy / Hour	Idle / Hour	Per Use	StateSet Name	Failures	Report Statistics
1	Cashier	Fixed Capacity	1	0.0	0.0	0.0		0 rows	☑
2	Chef	Fixed Capacity	2	0.0	0.0	0.0		0 rows	☑
3	Bartender	Fixed Capacity	1	0.0	0.0	0.0		0 rows	☑
4	Server	Fixed Capacity	1	0.0	0.0	0.0		0 rows	☑

Drunken Tacos

Replications: 30 Time Units: Minutes

Key Performance Indicators

System

	Average
Number Out	31

Total Time	Average	Half Width	Minimum Average	Maximum Average	Minimum Value	Maximum Value
Customer	27.2128	2.19	15.8961	37.8758	8.1255	67.5507

Other

Number In	Average	Half Width	Minimum Average	Maximum Average
Customer	107.70	3.73	86.0000	127.00

Number Out	Average	Half Width	Minimum Average	Maximum Average
Customer	76.1667	1.79	67.0000	85.0000

Queue

Time

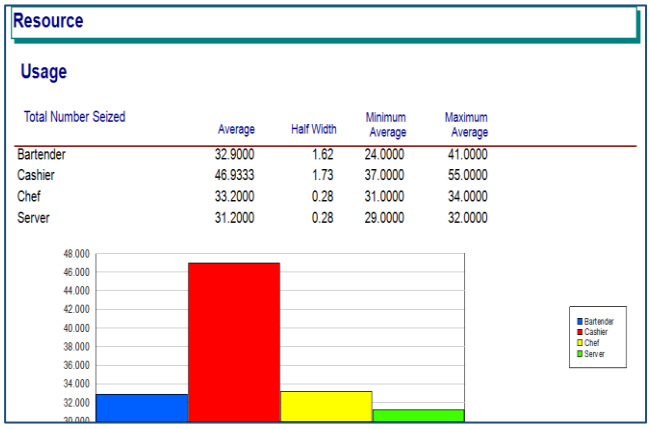
Waiting Time	Average	Half Width	Minimum Average	Maximum Average	Minimum Value	Maximum Value
Beverage Part Prep.Queue	0.1909	0.05	0.03691704	0.7396	0.00	4.0639
Combine items.Queue	9.0420	0.85	4.6671	13.2632	0.00	44.7512
Food Part prep.Queue	13.8405	1.84	4.2774	21.9004	0.00	42.7424
Food Preparation.Queue	14.1267	1.95	3.8419	24.2210	0.00	40.8285
Order Counter.Queue	5.7143	1.36	1.1282	15.2277	0.00	29.3832
Order Pickup.Queue	0.05291583	0.02	0.00	0.1702	0.00	0.9863

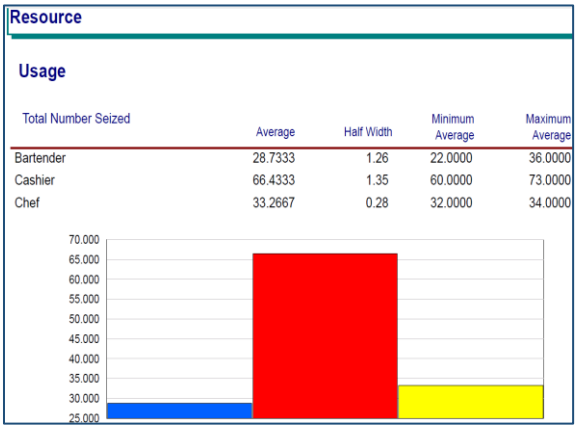
Other

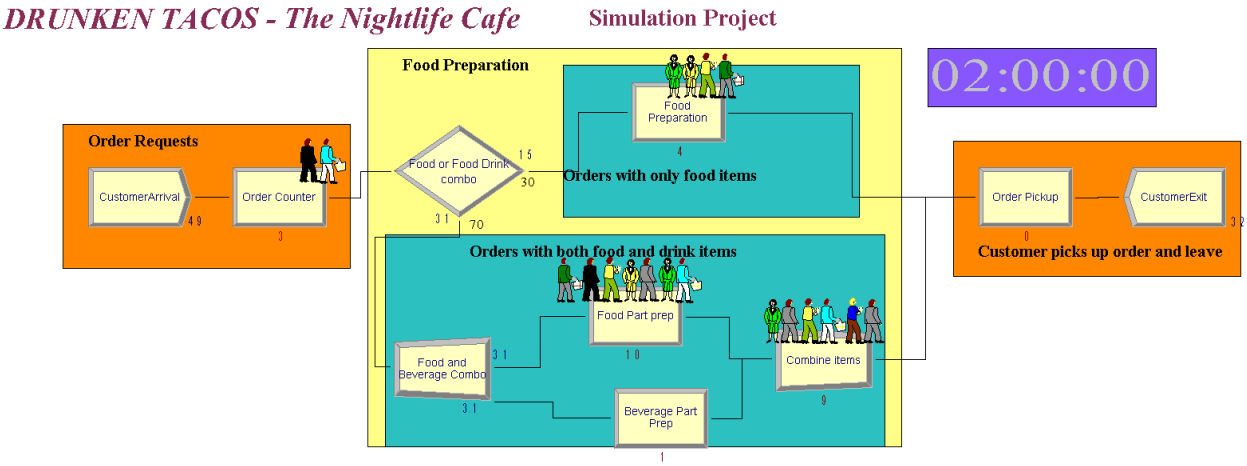
Number Waiting	Average	Half Width	Minimum Average	Maximum Average	Minimum Value	Maximum Value
Beverage Part Prep.Queue	0.05486307	0.02	0.00953690	0.2404	0.00	2.0000
Combine items.Queue	4.8808	0.59	1.7151	7.6585	0.00	17.0000
Food Part prep.Queue	3.9964	0.60	0.8742	6.7383	0.00	14.0000
Food Preparation.Queue	1.6195	0.32	0.3778	3.3711	0.00	8.0000
Order Counter.Queue	2.6501	0.70	0.3573	7.3602	0.00	15.0000
Order Pickup.Queue	0.01376072	0.00	0.00	0.04396663	0.00	1.0000

Scheduled Utilization	Average	Half Width	Minimum Average	Maximum Average
Bartender	0.4525	0.02	0.3042	0.5435
Cashier	0.8700	0.03	0.7241	1.0000
Chef	0.9582	0.01	0.8766	0.9812
Server	0.2589	0.00	0.2417	0.2667

Comparison of Total Number of customers served on average (Improved, Current Model)







Conclusion- We can see the following improvements with an additional resource, Server:

1. Overall Average time of the customer in the system is decreased to 27 mins (~reduction by 27%).
2. Having a different resource for taking the order and delivering the order has increased the number of customers being served. The new average of customer out is 31 from 24, an increase of 29% in serving more customers.

The both improvements are noticeable and worth of hiring an additional resource by Drunken Tacos to increase the efficiency of their current working model in place. As with this new model, they will be able to serve more customers' orders during the rush hours on weekends, and the profits from these customers may compensate for the extra cost being incurred because of the additional resource, server. With the lower waiting time, we can retain the customers who were leaving earlier due to long queues and hence might end up adding more revenues as well for Drunken Tacos.