Clifton Market Superstore Simulation Project

ARENA SOFTWARE

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PROJECT CHARTER

1.1 INTRODUCTION

Clifton Market is a local grocery store in Cincinnati's Clifton neighborhood. It was incorporated as a co-op in the State of Ohio in January 2014. It has primarily raised capital through crowd-funding by Clifton residents. Clifton Market offers a variety of fresh produce, perishable items, groceries and selected beverages. It has a food counter of assorted items for customers to choose from. The store operates from 7am-11pm everyday (16 hours).

This project is aimed at creating a virtual representation of Clifton Market Superstore by using Arena software. Arena is a simulation software that allows users to create complex process modules guided by different statistical parameters to arrive at quantifiable and measurable values. Through the usage of this tool, users can compare several different real scenarios based on different constraints in a virtual environment to arrive at an optimal implementation plan for optimizing a system.

1.2 PROBLEM STATEMENT

Clifton Market Superstore has seen an increase in number of customers steadily since its inception based on interaction with one of its representative. It is thronged by residents and University of Cincinnati's students for their day-to-day purchase. Growing popularity has led to longer queues at the check-out counter resulting in an increase in waiting time for customers. The store aims to reduce these wait times and avoid the accompanied increase length of non-value-added time spent at the store by customers.

1.3 GOAL STATEMENT

- A simulation of real time environment at the superstore which would lead to quantifying the metrics of existing system thereby identifying the root cause of the problem.
- Generating a set of alternative scenarios and evaluating each of these alternatives with the existing As-Is process would help in arriving at an optimized system that would be beneficial to both customers and the superstore's owners.
- Assessing the metrics of final selected model to measure improvement.

1.4 SCOPE & PROCESS BOUNDARIES

- In Scope- All the customer interactions occurring inside store boundaries.
- Process Boundaries- Entering the store until exit after payment.

1.5 ASSUMPTIONS

The virtual model created in this project is replicating Clifton Markets' system to the best extent. However, this model does take into consideration some assumptions for real-world scenarios that are hard to apply in such as:

- All workers are operating without any breaks.
- There is no hardware or software malfunction.
- The store does not run out of food supplies.
- All workers irrespective of their type have same hourly pay-grade.
- Consumers do not spend time interacting with store workers during their interactions.
- The store stops serving customers at its exact predetermined time every day.

2 MEASURE PHASE

2.1 DATA COLLECTION

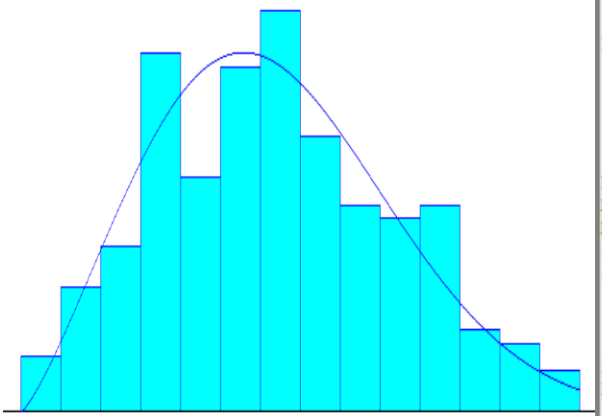
Data for different stages in the Clifton Market was collected through observations. Data was collected for interarrival times for two types of customers (grocery purchasing customers and customers who came to consume in-store food), food selection time, billing time and item packaging time.

Arena has an input analyzer module that helps in identifying the appropriate distribution for the relevant process. The data collected through observation was loaded into a text file and fed into the input analyzer. The input analyzer converts fits the data into suitable distribution.

Fit all option was selected to arrive at the best-case distribution that would have the least error. Examining the results of K-S and Chi-square statistical test, we can see that corresponding p-values are greater than 0.1. Hence, there is a fair degree of confidence that theatrical distribution would give us a good representation of data.

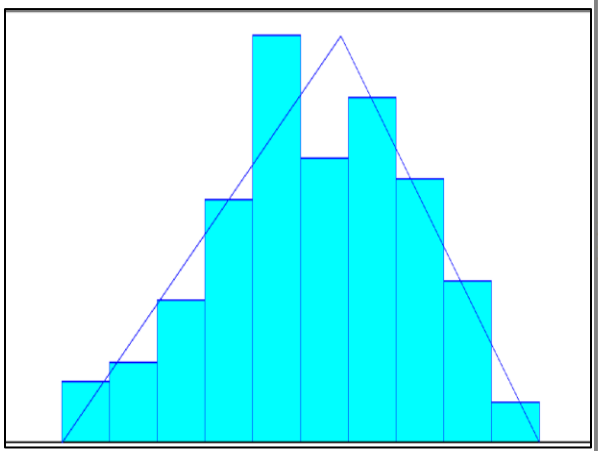
Below are the distributions of interarrival times of customers and service times of different processes:

Interarrival time for regular grocery purchasing customer



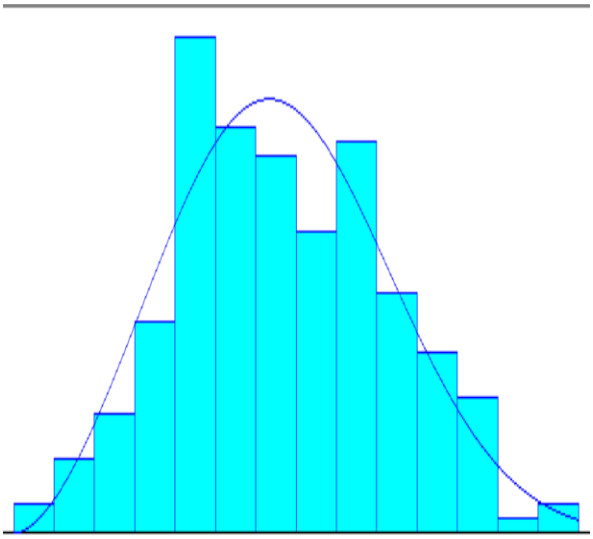
```
        Distribution Summary

Distribution:    Weibull
Expression:      2 + WEIB(4.11, 2.27)
Square Error:    0.003955

Chi Square Test
  Number of intervals    = 10
  Degrees of freedom     = 7
  Test Statistic         = 9.83
  Corresponding p-value  = 0.21

Kolmogorov-Smirnov Test
  Test Statistic         = 0.0457
  Corresponding p-value  > 0.15

        Data Summary

Number of Data Points    = 200
Min Data Value           = 2.45
Max Data Value           = 9.99
Sample Mean              = 5.64
Sample Std Dev           = 1.71

        Histogram Summary

Histogram Range          = 2 to 10
Number of Intervals      = 14
```

Interarrival time for in-store food consuming customer



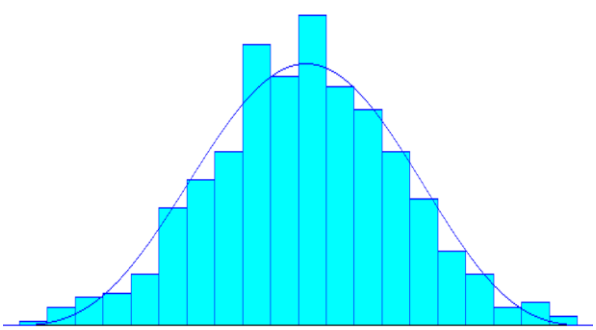
```
        Distribution Summary

Distribution:    Triangular
Expression:      TRIA(15, 31.9, 44)
Square Error:    0.005059

Chi Square Test
  Number of intervals    = 6
  Degrees of freedom     = 4
  Test Statistic         = 2.86
  Corresponding p-value  = 0.587

Kolmogorov-Smirnov Test
  Test Statistic         = 0.0606
  Corresponding p-value  > 0.15

        Data Summary

Number of Data Points    = 100
Min Data Value           = 15.2
Max Data Value           = 43.1
Sample Mean              = 30.3
Sample Std Dev           = 6.29

        Histogram Summary

Histogram Range          = 15 to 44
Number of Intervals      = 10
```

Grocery Purchase time



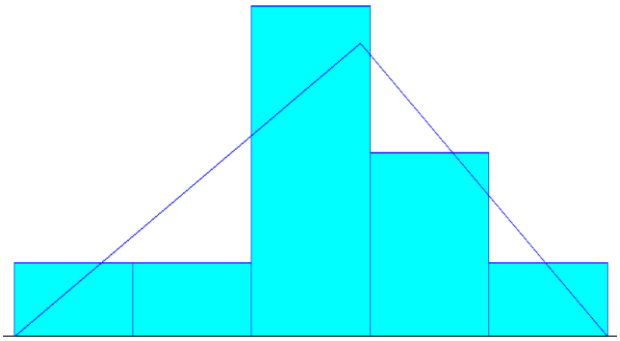
```
        Distribution Summary

Distribution:   Weibull
Expression:     22 + WEIB(8.57, 2.72)
Square Error:   0.004931

Chi Square Test
  Number of intervals   = 10
  Degrees of freedom    = 7
  Test Statistic        = 7.69
  Corresponding p-value = 0.375

Kolmogorov-Smirnov Test
  Test Statistic        = 0.0378
  Corresponding p-value > 0.15

        Data Summary

Number of Data Points   = 200
Min Data Value          = 22.4
Max Data Value          = 37.5
Sample Mean             = 29.6
Sample Std Dev          = 3.04
```

Grocery items scan and payment



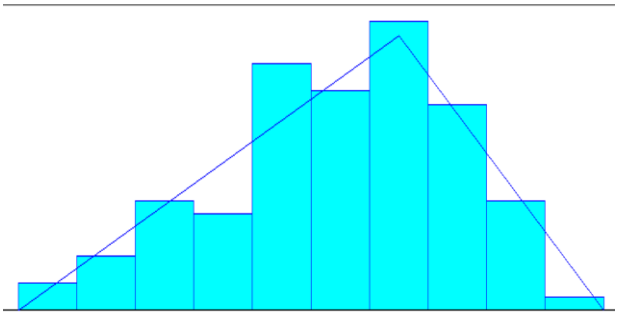
```
        Distribution Summary

Distribution:   Beta
Expression:     3.31 + 3.27 * BETA(4.95, 4.76)
Square Error:   0.001440

Chi Square Test
  Number of intervals   = 14
  Degrees of freedom    = 11
  Test Statistic        = 9.13
  Corresponding p-value = 0.61

Kolmogorov-Smirnov Test
  Test Statistic        = 0.03
  Corresponding p-value > 0.15

        Data Summary

Number of Data Points   = 500
Min Data Value          = 3.59
Max Data Value          = 6.3
Sample Mean             = 4.98
Sample Std Dev          = 0.5

        Histogram Summary

Histogram Range         = 3.31 to 6.58
Number of Intervals     = 22
```

Food item selection



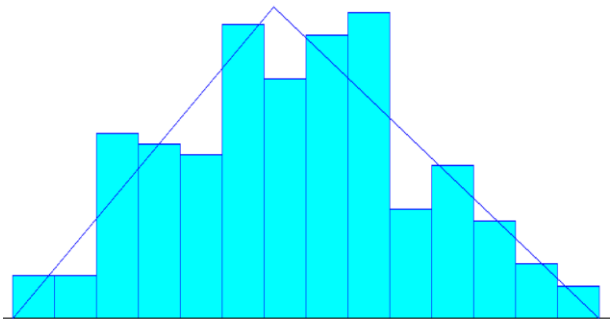
```
        Distribution Summary

Distribution:    Triangular
Expression:      TRIA(2, 2.71, 3.21)
Square Error:    0.025346

Chi Square Test
  Number of intervals    = 3
  Degrees of freedom     = 1
  Test Statistic         = 1.25
  Corresponding p-value  = 0.271

Kolmogorov-Smirnov Test
  Test Statistic         = 0.0952
  Corresponding p-value  > 0.15

        Data Summary

Number of Data Points    = 20
Min Data Value           = 2.08
Max Data Value           = 3.1
Sample Mean              = 2.64
Sample Std Dev           = 0.267

        Histogram Summary

Histogram Range          = 2 to 3.21
Number of Intervals      = 5
```

Food item payment



```
        Distribution Summary

Distribution:    Triangular
Expression:      TRIA(1, 2.02, 2.57)
Square Error:    0.004169

Chi Square Test
  Number of intervals    = 7
  Degrees of freedom     = 5
  Test Statistic         = 3.4
  Corresponding p-value  = 0.642

Kolmogorov-Smirnov Test
  Test Statistic         = 0.0532
  Corresponding p-value  > 0.15

        Data Summary

Number of Data Points    = 100
Min Data Value           = 1.07
Max Data Value           = 2.43
Sample Mean              = 1.85
Sample Std Dev           = 0.312
```

Item packing



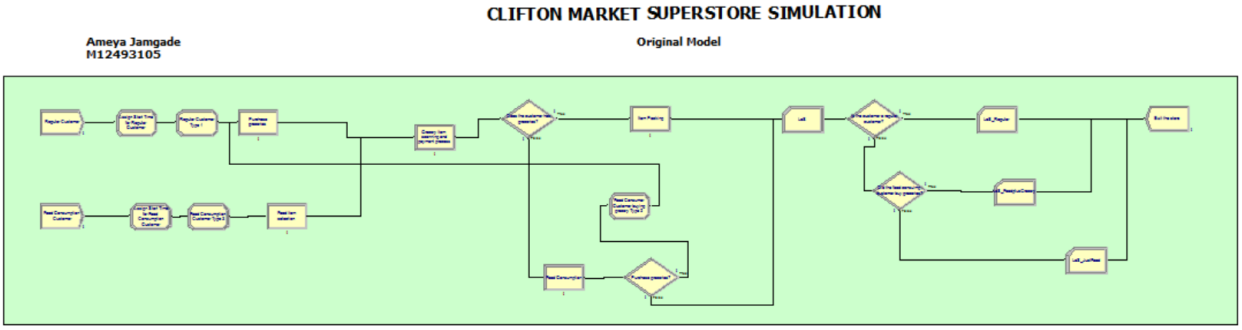
```
        Distribution Summary

Distribution:   Triangular
Expression:     TRIA(1, 1.89, 3)
Square Error:   0.005404

Chi Square Test
  Number of intervals   = 10
  Degrees of freedom    = 8
  Test Statistic        = 9.55
  Corresponding p-value = 0.308

Kolmogorov-Smirnov Test
  Test Statistic        = 0.0498
  Corresponding p-value > 0.15

        Data Summary

Number of Data Points   = 200
Min Data Value          = 1.07
Max Data Value          = 2.89
Sample Mean             = 1.96
Sample Std Dev          = 0.422
```

2.2 EXISTING PROCESS (As-Is)

The Clifton Market has two types of customers arriving at its store:

1. Grocery purchasing (Regular) customers- These customers are only involved in purchasing groceries at the store.
2. Food consuming customers- Clifton Market has a food counter such as salads, appetizers etc. These customers purchase food items, consume the food while sitting at the restaurant styled seating area. These customers sometimes do purchase grocery items as well.

Below is the existing model of Clifton Market.



The procedure for the Clifton Market process is given below:

1. Regular Customer arrival- Create module is used to model the arrival of Grocery purchasing (Regular) customers. An assign module is used to record the time of arrival of these customers. This will be used to calculate the length of stay of these customers.

2. Food Consuming Customer arrival- Create module is used to model the arrival of food consuming customers. These customers arrive at a much slower frequency that regular customers (TRIA(15, 31.9, 44) minutes). An assign module is used to record the time of arrival of these customers. This will be used to calculate the length of stay of these customers.

3. Assignment for each customer type- An assign module is placed after the arrivals to categorize the different customers into different customer types.

4. Purchase groceries- Regular grocery purchasing customers shop through different aisles of the superstore and select items. A process module with a delay action was used to model the shopping process of Regular customers.

5. Food item selection- The food consuming customers go through the item selection process at the food counter in the store. A process module with a delay action was used to model this process. There was hardly any queue at this step because these types of customers arrive very infrequently.

6. Grocery item scanning and payment process- Both grocery purchasers or food consuming customers arrive here for payment. This process involves scanning of grocery items or scanning of food items for consumption depending on the type of customer arrive. Then the payment of those items occurs. Since food items are usually few in numbers than grocery items, it takes different time for the staff to process each customer. It takes far more time to scan items for grocery purchasers than for food consuming customers. This difference in times has been incorporated in this module. 4 staff work at this payment counter in parallel.

7. Item packaging decision- The grocery items need scanning whereas food items don't. This has been modeled using a decision module.

8. Item Packing- The packing of grocery items into paper or plastic bags is done by the 2 'Item Packing Staff' working in parallel.

9. Food consumption- The food consuming customer after item scanning and payment proceeds towards the restaurant styled seating section. He/She consumes the purchased food item at the seating area.

10. Decision of customer to purchase groceries after eating- After eating, the food consuming customers frequently decides to purchase groceries (2/3rd of time). This has been modeled into the system through a decision module. This customer then proceeds towards the aisle, selects items and then goes through the entire payment process but this time as a grocery purchasing customer.

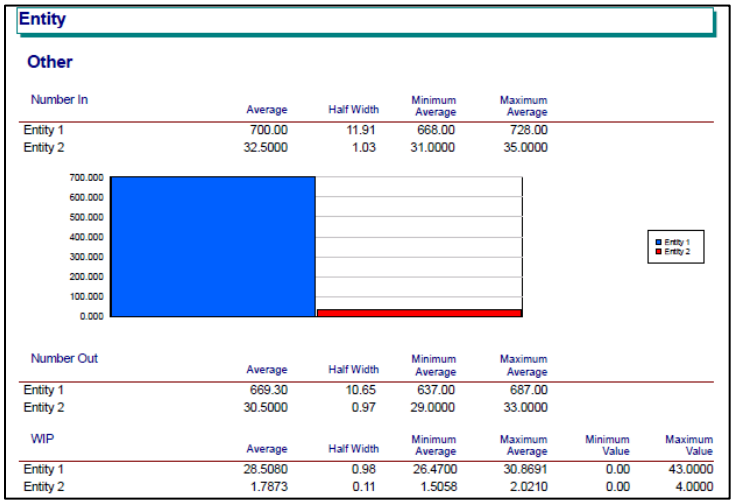
    For calculation of length of stay metrics, we have essentially 4 different values.
    1. Length of stay of all customers
    2. Length of stay of only grocery purchasing (Regular) customers
    3. Length of stay for customers who just purchase and consume food items at the store
    4. Length of stay for customers who purchase food items, consume them and then purchase groceries

3 ANALYZE PHASE

3.1 RESULTS OF EXISTING PROCESS (As-Is)

By Entity

The original model was executed for 16 hours (7am-11pm) for 10 replications. The Clifton Market store has about 732 customers of different types arriving in this 16 hour time slot. At any point in time there are ~30 customers in the store. It can also be seen that the regular customer spends 40 minutes on average in the store whereas the food consuming customer spends 54 minutes in the store.



Entity

Other

Number In	Average	Half Width	Minimum Average	Maximum Average
Entity 1	700.00	11.91	668.00	728.00
Entity 2	32.5000	1.03	31.0000	35.0000

Number Out	Average	Half Width	Minimum Average	Maximum Average
Entity 1	669.30	10.65	637.00	687.00
Entity 2	30.5000	0.97	29.0000	33.0000

WIP	Average	Half Width	Minimum Average	Maximum Average	Minimum Value	Maximum Value
Entity 1	28.5080	0.98	26.4700	30.8691	0.00	43.0000
Entity 2	1.7873	0.11	1.5058	2.0210	0.00	4.0000

By Queue

The average waiting time at the Item Scanning and Payment process is 3.1474 minutes. The average waiting time at the Item Packing step is 0.2314 mins which is low and thus a good sign. Average customers waiting in Payment stage and Packing stage are 4.4079 and 0.1668 respectively.

Queue

Time

Waiting Time	Average	Half Width	Minimum Average	Maximum Average	Minimum Value	Maximum Value
Grocery item scanning and payment process.Queue	3.1474	0.83	1.7522	5.4526	0.00	17.7704
Item Packing.Queue	0.2314	0.02	0.1954	0.2638	0.00	2.5138

Other

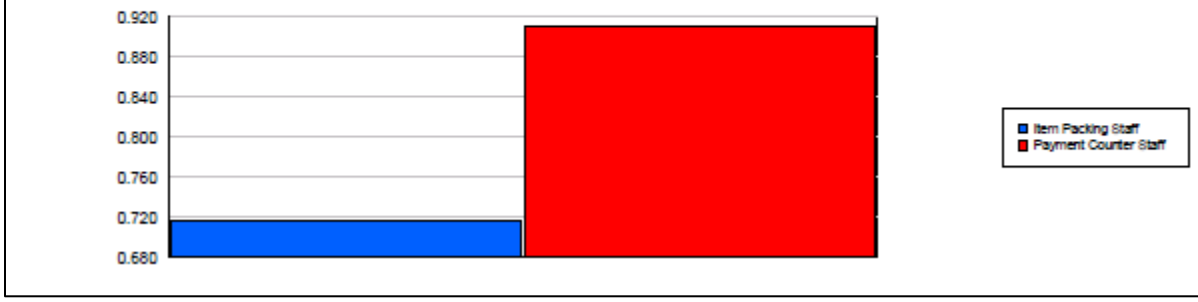
Number Waiting	Average	Half Width	Minimum Average	Maximum Average	Minimum Value	Maximum Value
Grocery item scanning and payment process.Queue	2.4079	0.66	1.3113	4.2201	0.00	16.0000
Item Packing.Queue	0.1668	0.01	0.1335	0.1940	0.00	3.0000

From the above results the aim is to decrease the waiting times at the 'Item Scan and Payment stage' and reduce number of people waiting at this stage.

By Resource

Utilization of resources would help in identifying if any staff is being overworked and is that clogging the system. We can see that despite having a staff of 4, the payment counter personnel have a high utilization of 91.16%. The item packing staff has a decent utilization of 71.60%.

Scheduled Utilization	Average	Half Width	Minimum Average	Maximum Average
Item Packing Staff	0.7160	0.01	0.6792	0.7385
Payment Counter Staff	0.9116	0.01	0.8708	0.9373



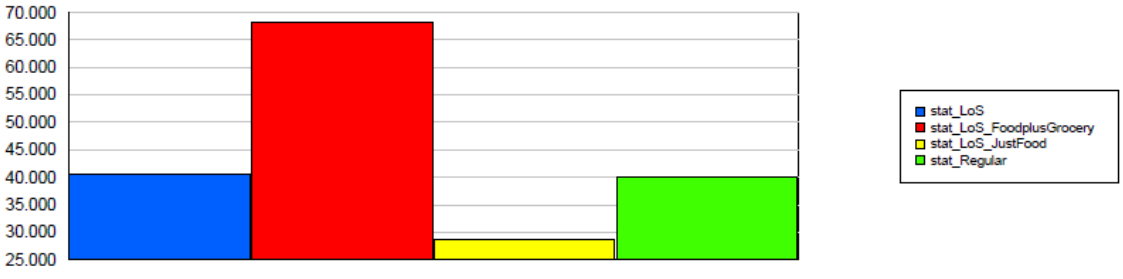
By Length of Stay

For calculation of length of stay metrics, we have essentially 4 different values.

5. Length of stay of all customers = 40.5 minutes

6. Length of stay of only grocery purchasing (Regular) customers= 39.9 minutes
7. Length of stay for customers who just purchase and consume food items at the store = 28.6 minutes
8. Length of stay for customers who purchase food items, consume them and then purchase groceries = 68.2 minutes

Output	Average	Half Width	Minimum Average	Maximum Average
stat_LoS	40.5589	0.85	39.2205	42.9479
stat_LoS_FoodplusGrocery	68.2034	2.24	64.4694	74.8050
stat_LoS_JustFood	28.6432	1.71	24.8915	31.1674
stat_Regular	39.9413	0.81	38.7126	42.3525



3.2 RESULTS INTERPRETATION EXISTING PROCESS (As-Is)

The 'Item Scan and Payment counter' has a high utilization rate. It also has a high waiting time. There is much scope for improvement at this stage.

The 'Item Packing' counter has a very small value of waiting time and has a decent resource utilization rate. Considering real world irregularities, this step doesn't need much improvement.

4 IMPROVE PHASE

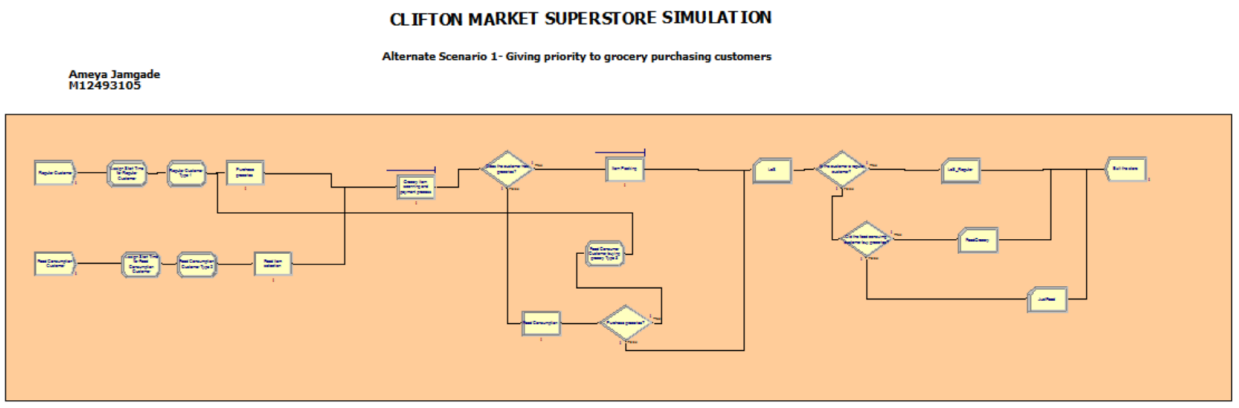
There were 2 alternate scenarios considered to improve the existing model of Clifton Market superstore.

4.1 ALTERNATE SCENARIO- 1

In this scenario, regular customers were given priority in the 'Item Scan and Payment' step over the food consuming customer. This was done because the regular customer would usually be more valuable to the store than a food consuming customer. Also, the food consuming customer would traditionally be not in a hurry and hence wouldn't mind if other type of customer is given a preference.

The regular customer would be placed ahead of the food consuming customer in the queue at 'Item Scan and Payment' stage. However, no regular customer would ever kick out or preempt the ongoing process if a food consuming customer is being serviced.

4.1.1 MODEL OF ALTERNATE SCENARIO-1



4.1.2 RESULTS OF ALTERNATE SCENAIO-1

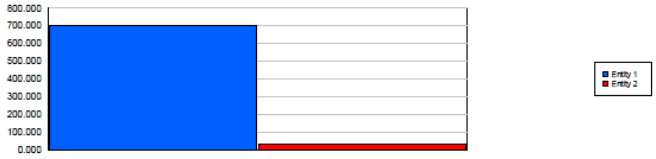
By Entity

The original model was executed for 16 hours (7am-11pm) for 10 replications. The Clifton Market store has about 732 customers of different types arriving in this 16 hour time slot. At any point in time there are ~29 customers in the store.

Entity

Other

Number In	Average	Half Width	Minimum Average	Maximum Average
Entity 1	700.40	8.68	692.00	728.00
Entity 2	32.2000	1.00	30.0000	34.0000



Number Out	Average	Half Width	Minimum Average	Maximum Average
Entity 1	671.50	6.75	662.00	692.00
Entity 2	29.3000	0.90	27.0000	31.0000

WIP	Average	Half Width	Minimum Average	Maximum Average	Minimum Value	Maximum Value
Entity 1	27.8659	0.54	27.1141	29.2055	0.00	40.0000
Entity 2	2.6843	0.59	1.9715	4.7571	0.00	12.0000

By Queue

The average waiting time at the Item Scanning and Payment process is 3.50 minutes. The average waiting time at the Item Packing step is 0.22 mins which is low and thus a good sign. Average customers waiting in Payment stage and Packing stage are 2.72 and 0.1653 respectively.

Queue

Time

Waiting Time	Average	Half Width	Minimum Average	Maximum Average	Minimum Value	Maximum Value
Grocery item scanning and payment process.Queue	3.5068	1.04	2.2026	7.0965	0.00	216.07
Item Packing.Queue	0.2292	0.01	0.2113	0.2623	0.00	2.5343

Other

Number Waiting	Average	Half Width	Minimum Average	Maximum Average	Minimum Value	Maximum Value
Grocery item scanning and payment process.Queue	2.7202	0.83	1.6497	5.4787	0.00	20.0000
Item Packing.Queue	0.1653	0.01	0.1519	0.1888	0.00	3.0000

By Resource

Utilization of resources would help in identifying if any staff is being overworked and is that clogging the system. We can see that despite having a staff of 4, the payment counter personnel have a high utilization of 91.7%. The item packing staff has a decent utilization of 71.97%.

Scheduled Utilization	Average	Half Width	Minimum Average	Maximum Average
Item Packing Staff	0.7197	0.01	0.7070	0.7404
Payment Counter Staff	0.9170	0.01	0.9040	0.9346

By Length of Stay

For calculation of length of stay metrics, we have essentially 4 different values.

9. Length of stay of all customers = 40.82 minutes
10. Length of stay of only grocery purchasing (Regular) customers= 38.99 minutes
11. Length of stay for customers who just purchase and consume food items at the store = 47.03 minutes
12. Length of stay for customers who purchase food items, consume them and then purchase groceries = 101.89 minutes

Interval	Average	Half Width	Minimum Average	Maximum Average	Minimum Value	Maximum Value
FoodGrocery	101.89	23.84	75.8879	186.41	44.9017	443.79
JustFood	47.0313	9.86	32.4902	75.9100	10.2047	177.75
LoS	40.8266	1.06	39.4897	44.5605	10.2047	443.79
LoS_Regular	38.9974	0.35	38.3418	40.0590	29.8240	53.4915

4.1.2 CONCLUSION OF ALTERNATE SCENAIO-1

From above results, it can be seen that length of stay for both regular customers and food consuming customers has increased drastically. Also, the wait times at 'Item Scan and Payment' counter which was needed to be increased hasn't and this was the main goal. Hence this alternate scenario in no way improves the existing system.

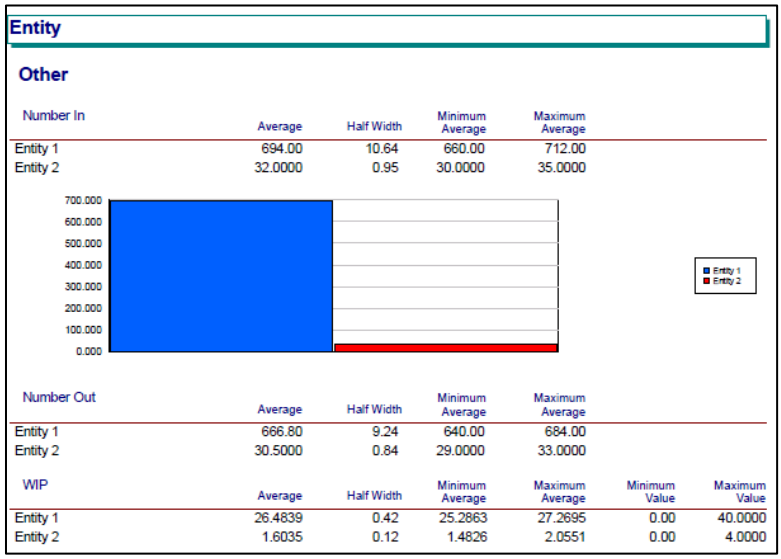
4.2 ALTERNATE SCENARIO- 2

In this scenario, 'Item Scan and Payment' counter staff was increased by 1. Since the 'Item Scan and Payment' counter staff also has a high utilization rate and a high waiting time, this would be the most logical step.

4.1.2 RESULTS OF ALTERNATE SCENAIO-2

By Entity

The original model was executed for 16 hours (7am-11pm) for 10 replications. The Clifton Market store has about 726 customers of different types arriving in this 16 hour time slot. At any point in time there are ~27 customers in the store.



Entity

Other

Number In	Average	Half Width	Minimum Average	Maximum Average
Entity 1	694.00	10.64	660.00	712.00
Entity 2	32.0000	0.95	30.0000	35.0000

Number Out	Average	Half Width	Minimum Average	Maximum Average
Entity 1	666.80	9.24	640.00	684.00
Entity 2	30.5000	0.84	29.0000	33.0000

WIP	Average	Half Width	Minimum Average	Maximum Average	Minimum Value	Maximum Value
Entity 1	26.4839	0.42	25.2863	27.2695	0.00	40.0000
Entity 2	1.6035	0.12	1.4826	2.0551	0.00	4.0000

By Queue

The average waiting time at the Item Scanning and Payment process is 0.3943 minutes. The average waiting time at the Item Packing step is 0.43 mins which is low and thus a good sign. Average customers waiting in Payment stage and Packing stage are 0.2981 and 0.3119 respectively.

Queue

Time

Waiting Time	Average	Half Width	Minimum Average	Maximum Average	Minimum Value	Maximum Value
Grocery item scanning and payment process.Queue	0.3943	0.06	0.2923	0.4994	0.00	6.1680
Item Packing.Queue	0.4346	0.04	0.3270	0.4908	0.00	3.7986

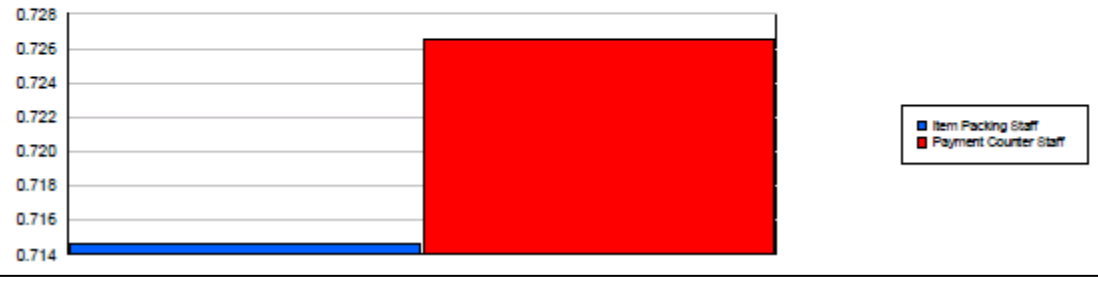
Other

Number Waiting	Average	Half Width	Minimum Average	Maximum Average	Minimum Value	Maximum Value
Grocery item scanning and payment process.Queue	0.2981	0.05	0.2162	0.3883	0.00	6.0000
Item Packing.Queue	0.3119	0.03	0.2302	0.3645	0.00	4.0000

By Resource

Utilization of resources would help in identifying if any staff is being overworked and is that clogging the system. We can see that having a staff of 5, the payment counter personnel have a utilization of 71.46%. The item packing staff has a decent utilization of 72.66%.

Scheduled Utilization	Average	Half Width	Minimum Average	Maximum Average
Item Packing Staff	0.7146	0.01	0.6847	0.7434
Payment Counter Staff	0.7266	0.01	0.7029	0.7508



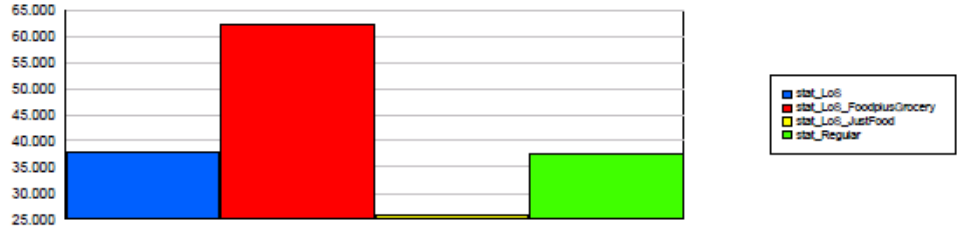
By Length of Stay

For calculation of length of stay metrics, we have essentially 4 different values.

13. Length of stay of all customers = 37.86 minutes
14. Length of stay of only grocery purchasing (Regular) customers= 37.35 minutes

15. Length of stay for customers who just purchase and consume food items at the store = 25.85 minutes
16. Length of stay for customers who purchase food items, consume them and then purchase groceries = 62.28 minutes

Output	Average	Half Width	Minimum Average	Maximum Average
stat_LoS	37.8684	0.23	37.2769	38.5456
stat_LoS_FoodplusGrocery	62.2868	0.99	59.5297	64.0825
stat_LoS_JustFood	25.8584	1.30	23.6529	28.3428
stat_Regular	37.3533	0.14	36.9290	37.6216



4.1.2 OUTPUT ANALYZER FOR SCENAIO-2

To check authenticity of these results it is necessary to analyze the output statistically. This can be done using the output analyzer.

Ho: Means of length of stay metrics are same for both models

Ha: Means of length of stay metrics are not same for both models

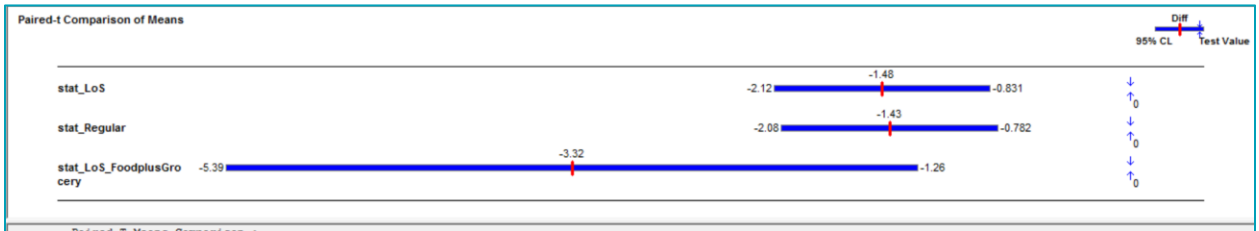
Ho: Means of length of stay metrics are same for regular customers in both models

Ha: Means of length of stay metrics are not same for regular customers in both models

Ho: Means of length of stay metrics are same for customers buying food and grocery in both models

Ha: Means of length of stay metrics are not same for customers buying food and grocery in both models

We reject all the Ho for all the responses. There is difference in the means of length of stay by customers for As-Is model and Scenrio-2 model.



Paired-T Means Comparison :

IDENTIFIER	ESTD. MEAN DIFFERENCE	STANDARD DEVIATION	0.950 C.I. HALF-WIDTH	MINIMUM VALUE	MAXIMUM VALUE	NUMBER OF OBS
stat_LoS	-1.48	0.902	0.645	37.3	38.5	10
				38.4	40.9	10
REJECT H0 => MEANS ARE NOT EQUAL AT 0.05 LEVEL						
stat_Regular	-1.43	0.905	0.648	36.9	37.6	10
				38	40.4	10
REJECT H0 => MEANS ARE NOT EQUAL AT 0.05 LEVEL						
stat_LoS_FoodplusGro cery	-3.32	2.88	2.06	59.5	64.1	10
				62.6	70.7	10
REJECT H0 => MEANS ARE NOT EQUAL AT 0.05 LEVEL						

4.1.3 CONCLUSION OF ALTERNATE SCENAIO-2

- From above results, length of stay for both regular customers and food consuming customers has decreased drastically
- The wait times at 'Item Scan and Payment' counter which was needed to be decreased has decreased significantly from 3.5 minutes to just 0.3943 minutes.
- The utilization of 'Item Scan and Payment' has decreased from 91% to 72%

Hence this alternate scenario improves the existing system.

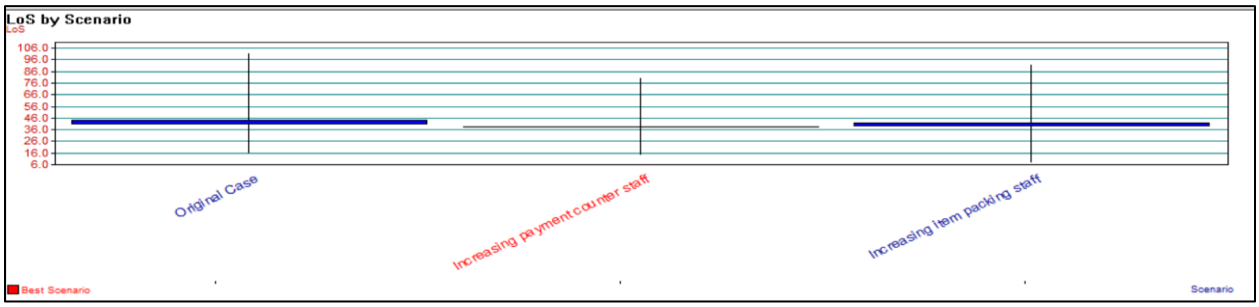
4.1.4 COMPARISON USING ARENA PROCESS ANALYZER

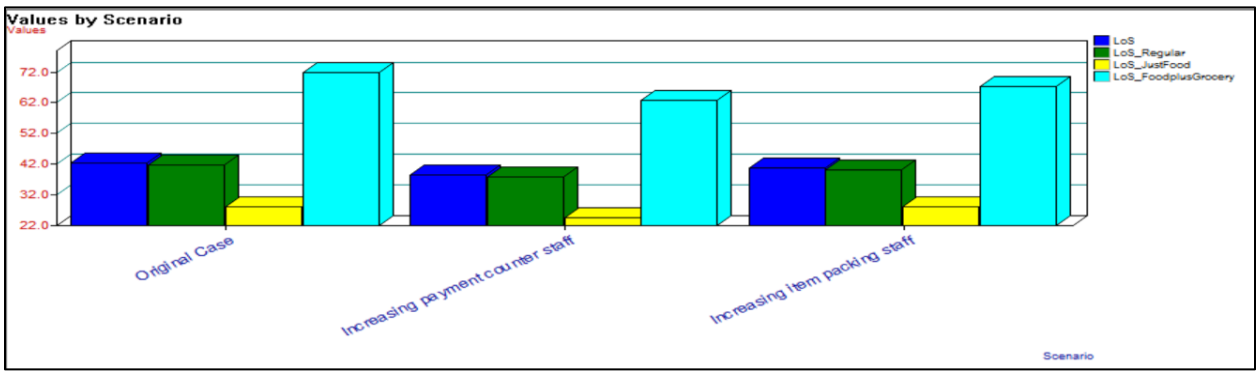
Below are the outputs of process analyzer of comparison of original case and scenario 2 of increasing counter staff by 1. In addition to these 2, a third scenario where there is an increase in 'Item packing staff' was also included.

	Scenario Properties				Controls		Responses					
	S	Name	Program File	Reps	Item Packing Staff	Payment Counter Staff	LoS	LoS_Regular	LoS_JustFood	LoS_FoodplusGrocery	Grocery item scanning and	Payment Counter
1		Original Case	1 : Original M	10	2.0000	4.0000	42.417	41.762	28.265	71.839	4.540	0.923
2		Increasing payment counter staff	1 : Original M	10	2.0000	5.0000	38.406	37.874	24.511	62.897	0.469	0.733
3		Increasing item packing staff	1 : Original M	10	3.0000	4.0000	40.656	40.093	28.208	67.335	3.149	0.906

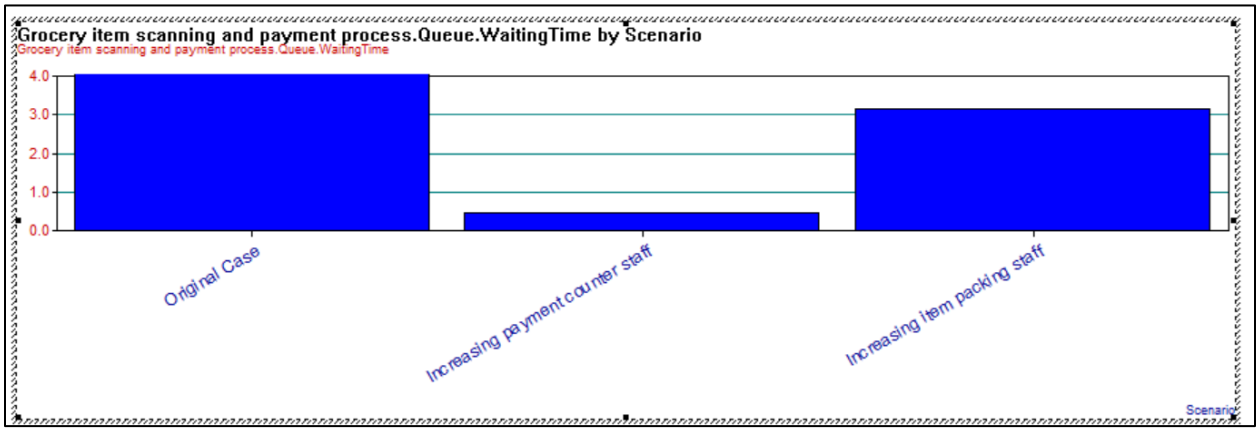
Double-click here to add a new scenario.

The box and whiskers plot of Length of Stay for all customers and bar chart for Length of Stay for all customers is depicted below. It can be seen that the best-case scenario is 'Increasing the Payment Counter Staff by 1'

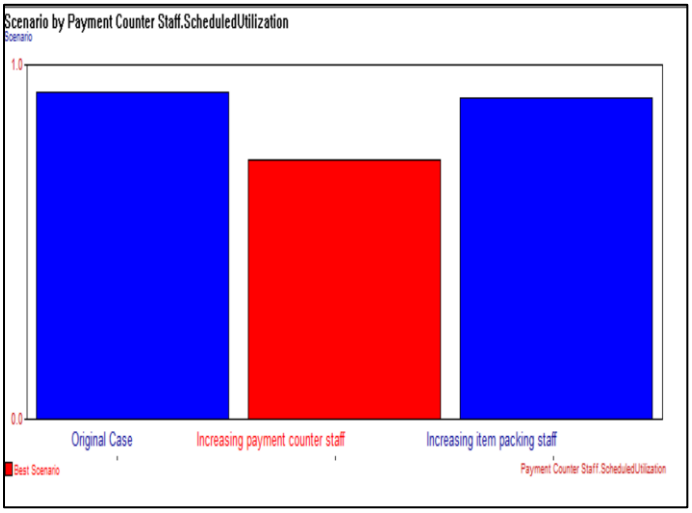




Waiting time of all 3 cases is shown below. Increasing the 'Increasing the Payment Counter Staff by 1' reduces the waiting time of the payment counter queue.



Scheduled utilization of all 3 cases is shown below



5 CONCLUSION

Simulation of real time environment at the Clifton Market superstore was performed using Arena simulation software. This helped in quantifying the metrics of existing system thereby identifying the root cause of the problem. The main issue was the high utilization of staff performing the item scanning and payment process. Different scenarios were considered and modelled to improve the metrics of the existing system and evaluated based on predefined metrics. It was observed that the waiting time of queues and scheduled utilization of the staff can be reduced by increasing the staff personnel by 1.

6 REFERENCES

- Clifton Market, Cliton, Cincinnati, Ohio USA
- Simulation with Arena by Kelton, Sadowski, Zupick