Simulating Great Clips Operations

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MS-BA Fall 2017
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Introduction

This project is done as a final project for the course BANA 7030- Simulation Modeling where the aim is to understand the basis of Simulation concepts using "Arena" software. The purpose of the project is to prepare a working simulation of Great Clips Salon at 213 Calhoun St, Cincinnati. The model in Arena provides an output for many statistical values like total number of customers served in a interval of time, time spent in the queues before being serviced, maximum service times, resource allocation and utilization levels etc. The input data for the model consists of inter-arrival times of the customers, the service times at each station and the shopping times which was collected at the peak hours of student visits at Kroger's store. The model was also run for 100 replications to analyze the results, changes were made to the existing model and tested and based on the results suggestions are made to improve the efficiency of the store.

Overview

Great Clips is a hair salon franchise with over 4,100 locations across the United States and Canada. It is headquartered in Minneapolis, Minnesota. In 2016, it had system-wide sales of $1.23 billion. Over 30,000 stylists are employed by Great Clips salons and the company is known for no-appointment, no-frills salons that provide customers with affordable haircuts. Lean investment and operating costs of franchises have enabled Great Clips to provide low-priced services and has led to ten-year growth for the company.

The operating hours for the shop is as follows:
Monday – Saturday: 9 A.M to 9 P.M
Sunday: 12 P.M to 6 P.M

Great Clips provides the list of services with corresponding costs.

1. Hair Trim: cost $15 per haircut.
2. Beard Trim: cost $5 each time.
3. Shampoo: cost $5 each time.
4. Conditioning: cost $15 each time.
5. Overall Styling: $55 each time.

The salon employees five employees James, Cherish, Sarah, Stevin and Mariah (also manages the salon). All the employees work in different 6 Hrs. schedule except for Mariah who works for 12 Hrs. everyday. All the employees get one half hour lunch break at different times of the day.
Each of the employee can provide one or more of the services which also help in determining cost of the employee. The description of the services provided by each of them is described in the table 1.1. where each row describes the services offered by each employee.

Table 1.1: Description of the services provided by different employees

Employee/service	Haircut	Beard Trim	Shampoo	Conditioning	Full Style
Mariah	Yes	Yes	Yes	Yes	Yes
James	Yes	Yes	No	No	Yes
Cherish	Yes	No	Yes	Yes	No
Sarah	Yes	No	Yes	Yes	Yes
Steve	Yes	Yes	No	No	No

Problem statement and assumptions

Problem Statement: The project aims to simulate the working of Great Clips and try to reduce the cost required to run the shop by hiring proper number of resources of each type where type defines the number of services a resource can provide. The simulation will also look at very critical factor of waiting time in queue. In salons, lot of people leave when they have to wait a lot for any service. Also, if a customer feels that he or she will have to wait a lot for the turn they would prefer another salon in the future. So, large waiting time can lead to loss of customers which is very detrimental for business. The simulation will aim to test multiple scenarios where scenarios differ in terms of number of resources employed. Simulation using arena will help in identifying statistically better scenario among the tested ones which reduce waiting times but significantly compromising on profits.

Assumptions: The simulation has been carried keeping some of the assumptions which define the scope of applicability. The existing system at Great Clips has been modeled to the best possible extent and there are some variations due to unscheduled or unforeseen circumstances and natural variations.
The assumptions in the simulation project are as follows:

1. We assume that a customer can take only one of the following services:
    a. Hair Trim
    b. Beard Trim
    c. Shampoo
    d. Conditioning
    e. Full Styling

    If a customer wants to go for another service, then the customer will be treated as new one.

2. Both walk in and online customers have equal priority and attended by resources on first come first serve bases.
3. We assume that customers do not have any preference for any specific employee and once any customer registers then (s)he does not leave.
4. We simulate the model for weekend only i.e. Saturday when all types of customer arrive and none of the resources have holiday.
5. The decision module and each process timing data has been taken from observation.

6. Due to restrictions during data collection, the hourly cost of resources has been assumed to be as follows:
    a. Manager Mariah: 14 dollars per hour. Is manager and handles both registration and other services
    b. James: 10 dollars per hour and can only do Hair and beard trimming
    c. Cherry: 11 dollars per hour and can-do hair trimming, shampoo and conditioning.
    d. Sarah: 12 dollars per hour and can do all the tasks.
    e. Steven: 10 dollars per hour and works on demand. We would be trying to create scenarios by adding Steven type of resource which is initially assumed to be one.

We also assume that to service each customer 1.5 dollars are spent as operational cost

7. The process timings of each service also include the billing time. So, no separate billing process has been created.
8. The customer arrival times and various service times observed remain similar over all the simulated replications as actual arrival times vary each day.
9. The data follows the input distribution: Input distribution has been derived by analyzing the time intervals of customers for arrival times and servicing times. These distributions are a rough estimate and it is assumed the data follows these distributions approximately.

Data Collection

The outlet was visited twice on Saturday for the data collection. Permission was taken from the staff and the inter-arrival time of the customers was recorded. Data pertaining to salary of the salon stylists were not shared due to restrictions. The Manager did share the ratio in which hourly salary has been distributed among different types of employees. Inter arrival time of customers and processing time for each of the five services were observed and noted in person for 4 Hrs. on two different weekends.

System Description

The *Figure 1.1 System Flow Diagram* on the next page represents the overall movement of customers and working of Great Clips. It consists of 4 major components namely customer arrival, customer registration, decision about which service to choose and the final service itself. Each of the steps have been explained below.

Step 1: Both walk in and online check in customers arrive into system. Customers coming after online check in don't leave even if the queue is long while walk in customers have 0.15 probability to leave because of large waiting time in queue.

Step 2: Customers register themselves at the registration desk by providing details such as Name, address and contact number.

Step 3: Customers select the service they want to take and go on to sit the respective queue.

Step 4: Based on the service selected in previous step, customers are assigned the first available resource. Once the process is completed, customers pay the bill and exit from the system.

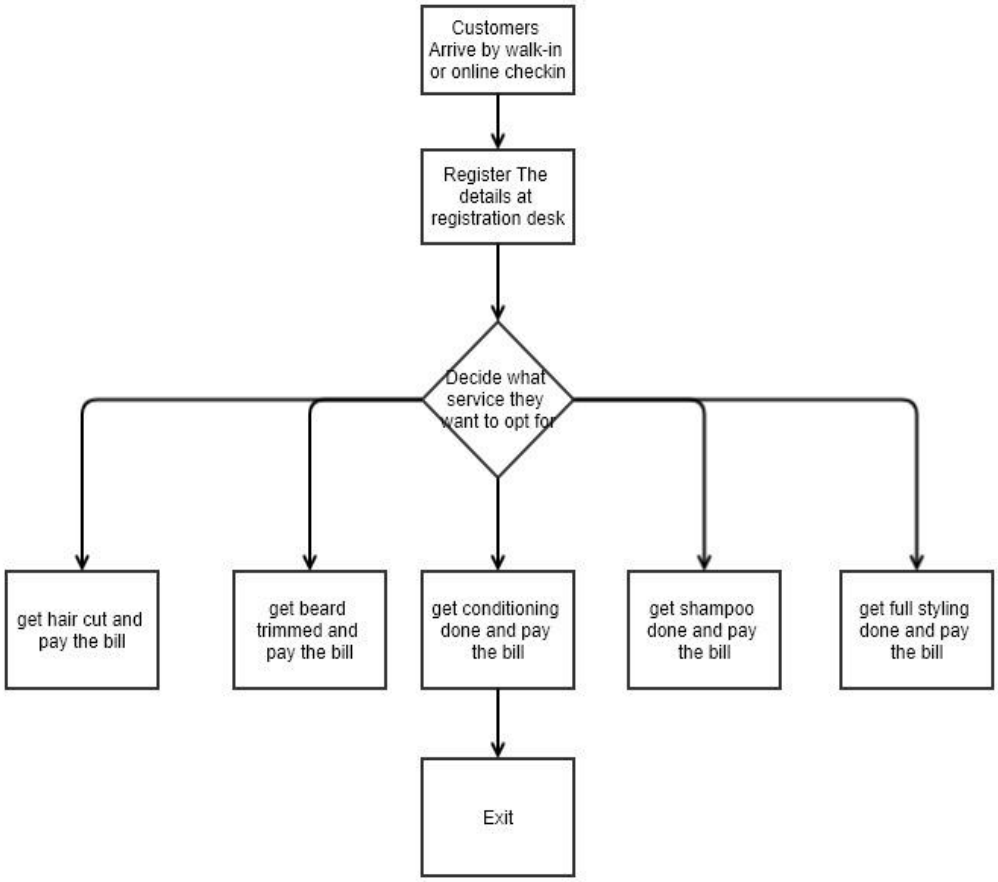


FIGURE 1.1 System Flow Diagram

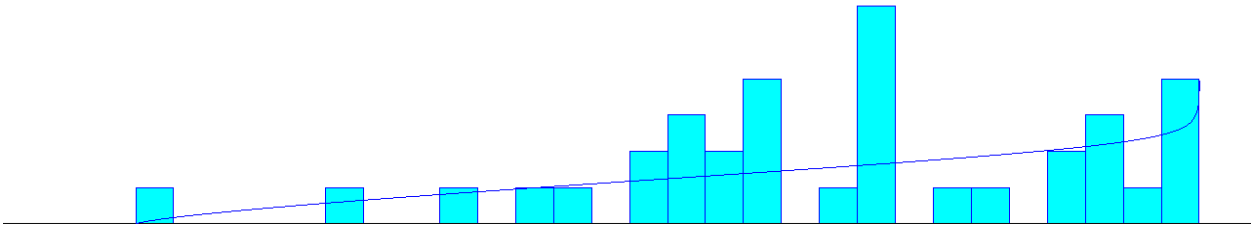
The above figure describes the working of Great clips through movement of customers.

Data Fitting

The Arena model takes the input data for customer arrival rate and for service times to run and analyze through different modules in the model. Arena accepts the data in the form of a distribution which will be best fitted for the raw data for different blocks in the model. The raw data of inter-arrival times and service times for all the resources are fitted into a distribution which is fed into Arena. Rockwell's Input Analyzer was used in this project to determine the distributions of the various interarrival times and service times. The data was loaded in the form of a text file with raw data which was then fit to a suitable distribution. Please find below the distribution of the inter-arrival times and service times at various points of the model.

Walk in customer arrival data

The inter arrival time for walk in customer follows beta distribution with equation -0.5 + 28 * BETA(1.72, 0.922). All the values are in minutes. The below *Figure 1.2 Walk in customer inter-arrival time* shows the histogram and output summary of input analyzer.

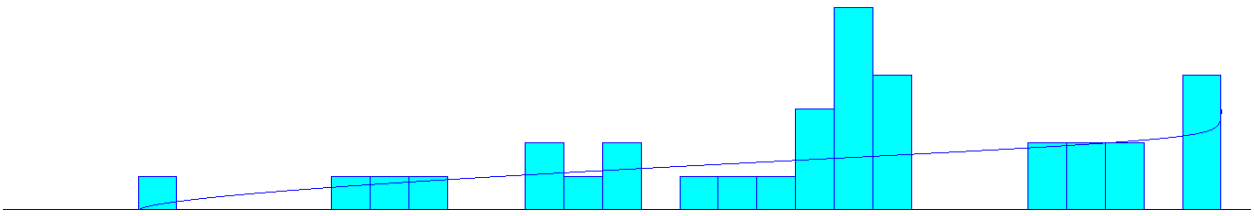


```
Distribution:   Beta
Expression:     -0.5 + 28 * BETA(1.72, 0.922)
Square Error:   0.040396

Chi Square Test
  Number of intervals   = 6
  Degrees of freedom    = 3
  Test Statistic        = 3.84
  Corresponding p-value = 0.288

       Data Summary

Number of Data Points   = 35
Min Data Value          = 0
Max Data Value          = 27
Sample Mean             = 17.9
Sample Std Dev          = 6.59

       Histogram Summary

Histogram Range         = -0.5 to 27.5
Number of Intervals     = 28
```

FIGURE 1.2 Walk in customer inter-arrival time

Online check-in customer arrival data

The inter arrival time for online check-in customer follows beta distribution with equation -0.5 + 28 * BETA(1.61, 0.951). All the values are in minutes. The below *Figure 1.3 Online check-in customer inter-arrival time* shows the histogram and output summary of input analyzer.

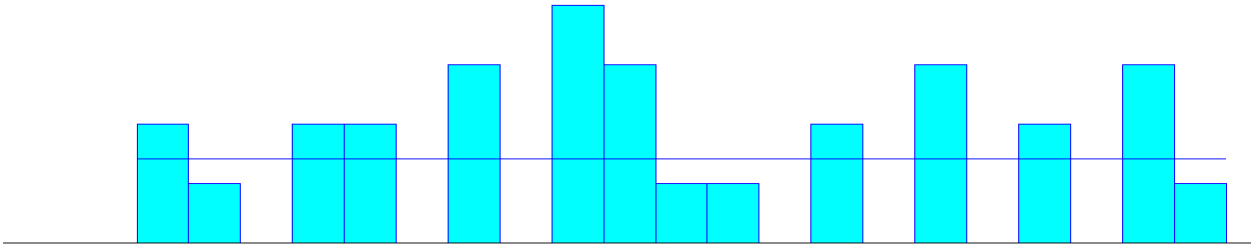


```
       Distribution Summary

Distribution:   Beta
Expression:     -0.5 + 28 * BETA(1.61, 0.951)
Square Error:   0.041919

Chi Square Test
  Number of intervals   = 6
  Degrees of freedom    = 3
  Test Statistic        = 2.7
  Corresponding p-value = 0.452

       Data Summary

Number of Data Points   = 35
Min Data Value          = 0
Max Data Value          = 27
Sample Mean             = 17.3
Sample Std Dev          = 6.79

       Histogram Summary

Histogram Range         = -0.5 to 27.5
Number of Intervals     = 28
```

FIGURE 1.3 Online check-in customer inter-arrival time

Registration Time

The registration time for customers at registration desk follows uniform distribution with equation UNIF(9.5, 30.5). All the values are in seconds. The below *Figure 1.4 Registration time* shows the histogram and output summary of input analyzer.

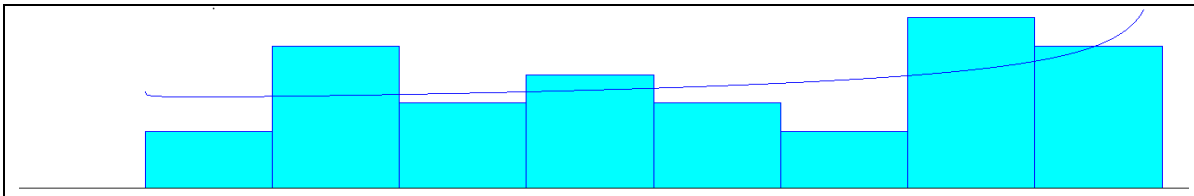


```
       Distribution Summary

Distribution:   Uniform
Expression:     UNIF(9.5, 30.5)
Square Error:   0.036825

Chi Square Test
  Number of intervals   = 5
  Degrees of freedom    = 4
  Test Statistic        = 2.43
  Corresponding p-value = 0.662

       Data Summary

Number of Data Points   = 30
Min Data Value          = 10
Max Data Value          = 30
Sample Mean             = 19.8
Sample Std Dev          = 6.02
```

FIGURE 1.4 Registration time

Haircut Time

The haircut time for customer follows beta distribution with equation 17.5 + 8 * BETA(0.99, 0.824). The values are in minutes. The below *Figure 1.5 Haircut time* shows the histogram and output summary of input analyzer.

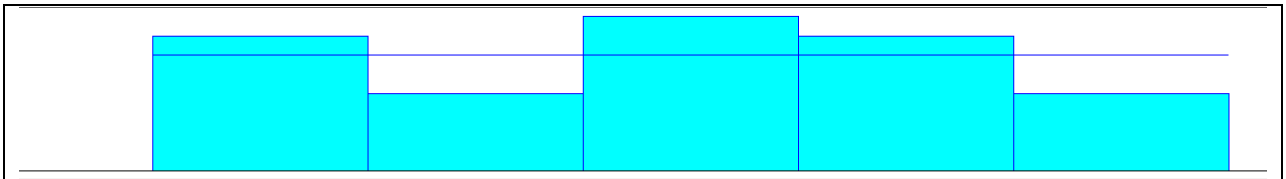


```
       Distribution Summary

Distribution:   Beta
Expression:     17.5 + 8 * BETA(0.99, 0.824)
Square Error:   0.013503

Chi Square Test
  Number of intervals   = 4
  Degrees of freedom    = 1
  Test Statistic        = 1.02
  Corresponding p-value = 0.337

       Data Summary

Number of Data Points   = 30
Min Data Value          = 18
Max Data Value          = 25
Sample Mean             = 21.9
Sample Std Dev          = 2.37

       Histogram Summary

Histogram Range         = 17.5 to 25.5
Number of Intervals     = 8
```

FIGURE 1.5 Haircut time

Beard Trim Time

The beard trim time for customer follows uniform distribution with equation UNIF(7.37, 11). The values are in minutes. The below *Figure 1.6 Beard trim time* shows the histogram and output summary of input analyzer.

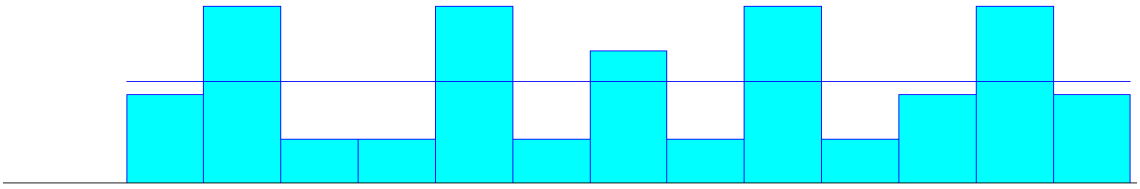


```
       Distribution Summary

Distribution:   Uniform
Expression:     UNIF(7.37, 11)
Square Error:   0.015556

Chi Square Test
  Number of intervals   = 5
  Degrees of freedom    = 4
  Test Statistic        = 2.33
  Corresponding p-value = 0.678

Kolmogorov-Smirnov Test
  Test Statistic        = 0.133
  Corresponding p-value > 0.15

       Data Summary

Number of Data Points   = 30
Min Data Value          = 7.7
Max Data Value          = 11
Sample Mean             = 9.2
Sample Std Dev          = 1.04

       Histogram Summary

Histogram Range         = 7.37 to 11
Number of Intervals     = 5
```

FIGURE 1.6 Beard trim time

Conditioning Time

The conditioning time for customer follows uniform distribution with equation UNIF(23.5,36.5). The values are in minutes. The below *Figure 1.7 Conditioning time* shows the histogram and output summary of input analyzer.

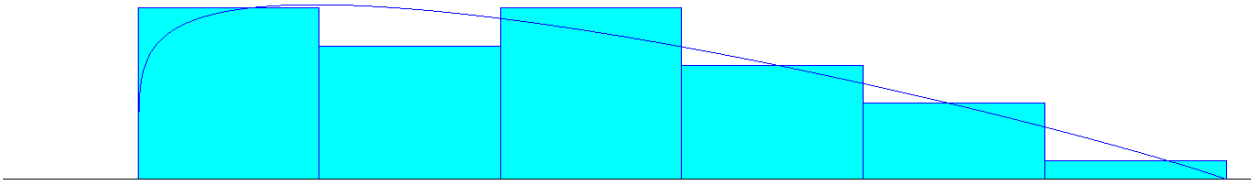


```
       Distribution Summary

Distribution:   Uniform
Expression:     UNIF(23.5, 36.5)
Square Error:   0.023077

Chi Square Test
  Number of intervals   = 4
  Degrees of freedom    = 3
  Test Statistic        = 0.298
  Corresponding p-value > 0.75

       Data Summary

Number of Data Points   = 30
Min Data Value          = 24
Max Data Value          = 36
Sample Mean             = 30.1
Sample Std Dev          = 3.91

       Histogram Summary

Histogram Range         = 23.5 to 36.5
Number of Intervals     = 13
```

FIGURE 1.7 Conditioning time

Shampoo Time

The shampoo time for customer follows beta distribution with equation 3.5 + 6 * BETA(1.18, 1.93). The values are in minutes. The below *Figure 1.8 Shampoo time* shows the histogram and output summary of input analyzer.

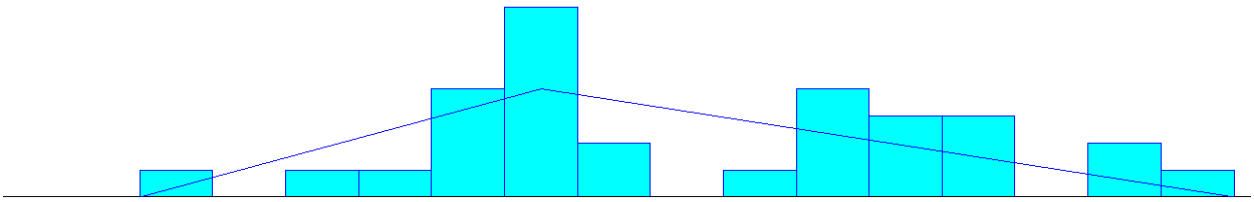


```
       Distribution Summary

Distribution:   Beta
Expression:     3.5 + 6 * BETA(1.18, 1.93)
Square Error:   0.004435

Chi Square Test
  Number of intervals   = 5
  Degrees of freedom    = 2
  Test Statistic        = 0.675
  Corresponding p-value = 0.719

       Data Summary

Number of Data Points   = 36
Min Data Value          = 4
Max Data Value          = 9
Sample Mean             = 5.78
Sample Std Dev          = 1.44

       Histogram Summary

Histogram Range         = 3.5 to 9.5
Number of Intervals     = 6
```

FIGURE 1.8 Shampoo time

Styling Time

The styling time for customer follows triangular distribution with equation TRIA(17.5, 23, 32.5). The values are in minutes. The below *Figure 1.9 Styling time* shows the histogram and output summary of input analyzer.



```
       Distribution Summary

Distribution:   Triangular
Expression:     TRIA(17.5, 23, 32.5)
Square Error:   0.045042

Chi Square Test
  Number of intervals   = 5
  Degrees of freedom    = 3
  Test Statistic        = 11.2
  Corresponding p-value = 0.0113

       Data Summary

Number of Data Points   = 30
Min Data Value          = 18
Max Data Value          = 32
Sample Mean             = 25.2
Sample Std Dev          = 3.56

       Histogram Summary

Histogram Range         = 17.5 to 32.5
Number of Intervals     = 15
```

FIGURE 1.9 Styling time

Model in Arena

The Great Clips salon was divided into different components to prepare a model in Arena. Various modules have been used such as Record, Create, Counter, Assign, Process, Decision, Dispose. The procedure has been split into steps according to the flow diagram mentioned above. The different steps are:

1. Walk in and online customers enters the salon
2. Customers wait in registration queue
3. Customer registers at the registration counter
4. Customer decides which service it wants to take
5. Customer joins the respective process queue
6. Customer receives the service and pays the bill
7. Customer leaves the store

There is also one decision module to check for the service that the customer wants to take. Assign and Record modules are used to assign the entity type and record the total number of customers getting serviced. There are 5 counters used to count the individual number of customers processed in each process module. There is a queue for each of registration, haircut, beard trim, conditioning, shampoo and styling. There are five resources who can provide all the services. The model records statistics such as total wait time of customers, total expenditure for salon, total revenue and profit for the day.
Based on above information, following model in figure 1.10 is designed in ARENA software.

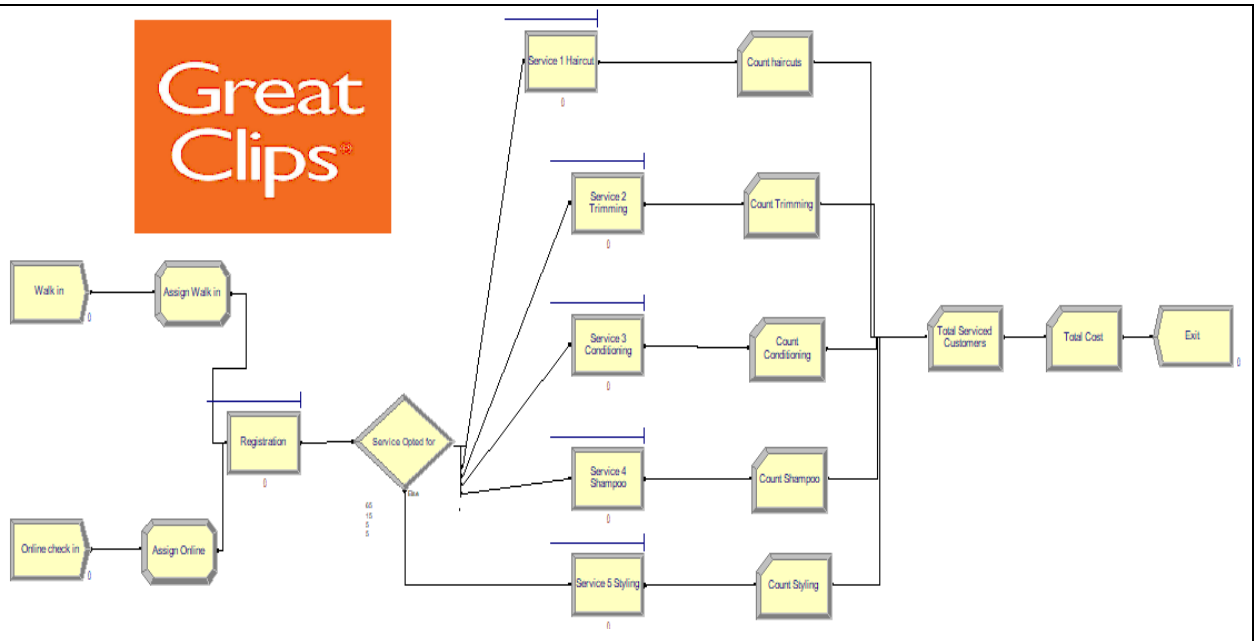


FIGURE 1.10: ARENA MODEL FOR GREAT CLIPS

The description of each of the major components is as follows:

Customer Arrival

Two Create modules each for walk in and online registered customers are used to model the Customers entering the salon whose dialog box and the entry parameters are shown below in figure 1.11. The expressions have been obtained from input analyzer.

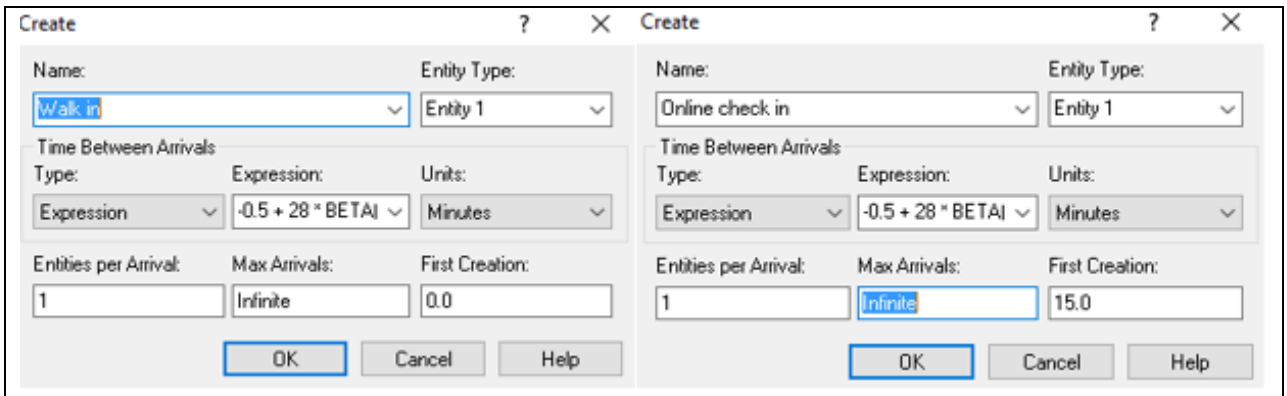


FIGURE: 1.11: Create modules for walk in and online customers

The model has two assign blocks to assign the entity the type to define whether it is walk-in customer or online registered customer. The dialog boxes of assign blocks have been shown below in figure 1.12.

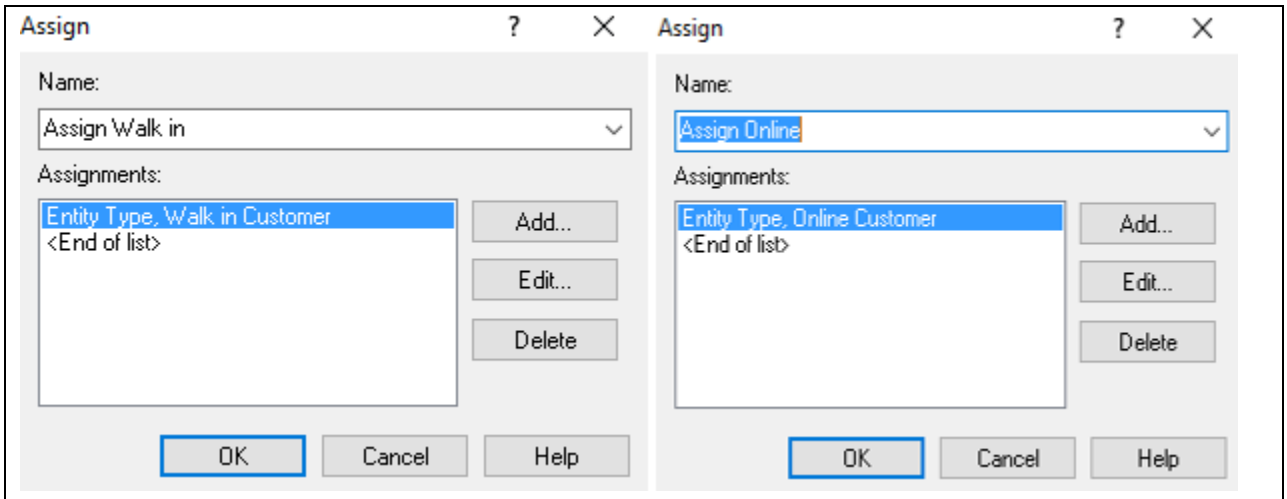


FIGURE 1.12: Assign modules for walk in and online customers

Registration Desk

Customers then proceed to the registration desk where they register by providing details such as name, address and contact details. A seize, delay and release process block is used with the input expression defined through input analyzer. The resource for this process has been allocated through registration set module which defines resources who can perform this service. The dialog has been shown below in figure 1.13.

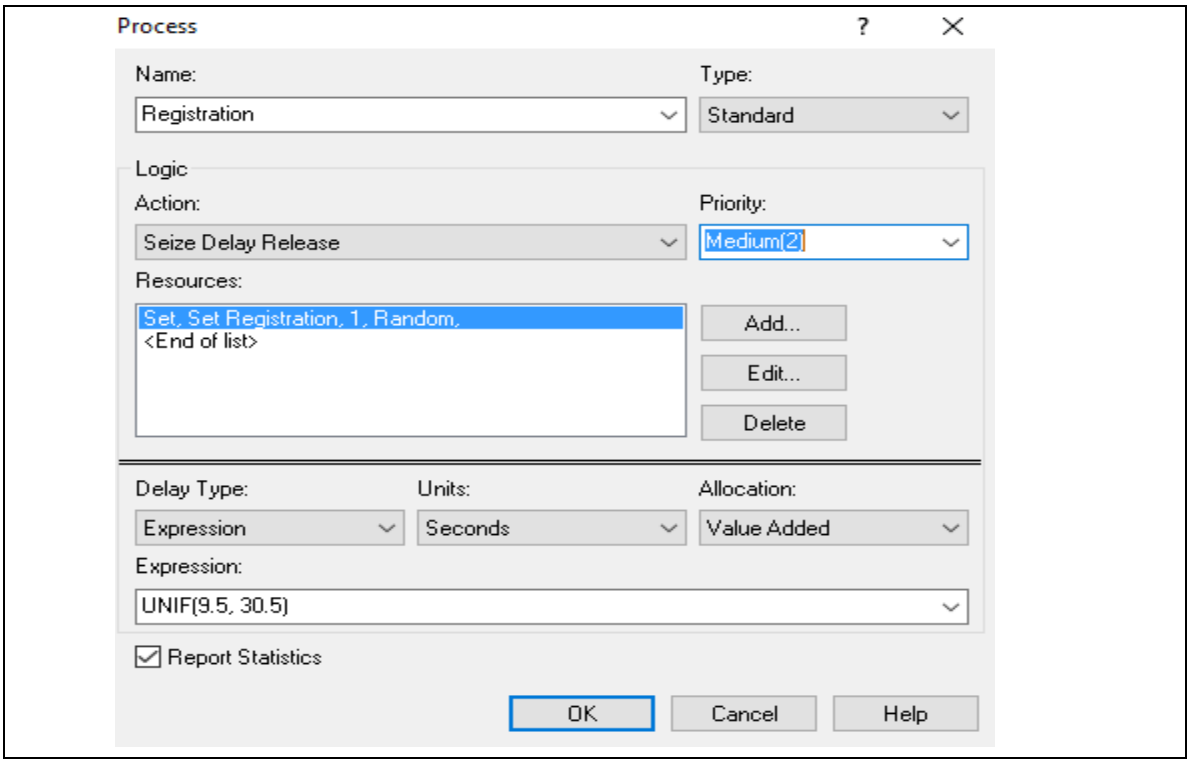


FIGURE 1.13: Registration desk process block

Service Decision Module

A n-way decide module block is used which defines customers deciding on the service which they want to take. Based on the data obtained from the manager at Great Clips, inputs are given in the form of probabilities. The probability of customer choosing each of the services is as follows:

Haircut: 0.90 **Beard trim**: 0.02 **Shampoo**: 0.02 **Conditioning**: 0.01 **Styling:** 0.05

The dialog box of the service decision box is shown in below figure 1.14.

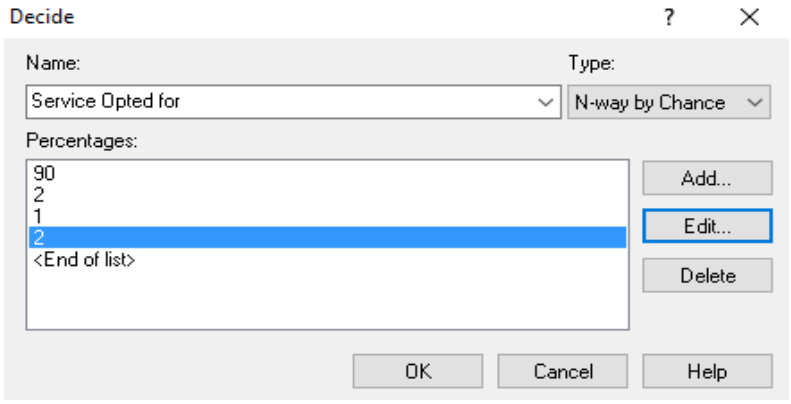


FIGURE 1.14: Service Decision Box

Haircut Process Block

Customers who decide to go for haircut proceed to the haircut queue where they wait for their turn. Once a resource is available, the customer will acquire that resource and release it once the haircut is done. A seize, delay and release process block is used with the input expression defined through input analyzer. The resource for this process has been allocated through haircut set module which defines resources who can perform haircut. The dialog box has been shown below in figure 1.15.

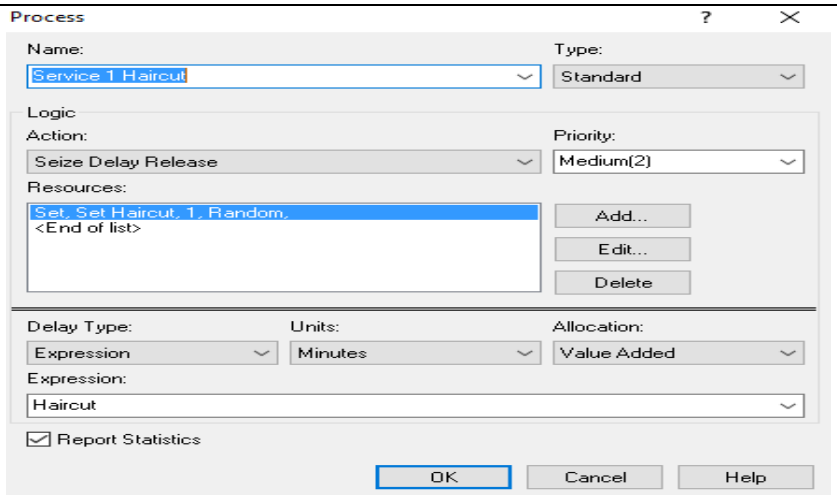


FIGURE 1.15: Haircut Process Block

Beard Trim Process Block

Customers who decide to go for beard trim proceed to the beard trim queue where they wait for their turn. Once a resource is available, customer will acquire that resource and release it once the service is done. A seize, delay and release process block is used with the input expression defined through input analyzer. The resource for this process has been allocated through beard trim set module which defines resources who can perform beard trim. The dialog box has been shown below in figure 1.16.

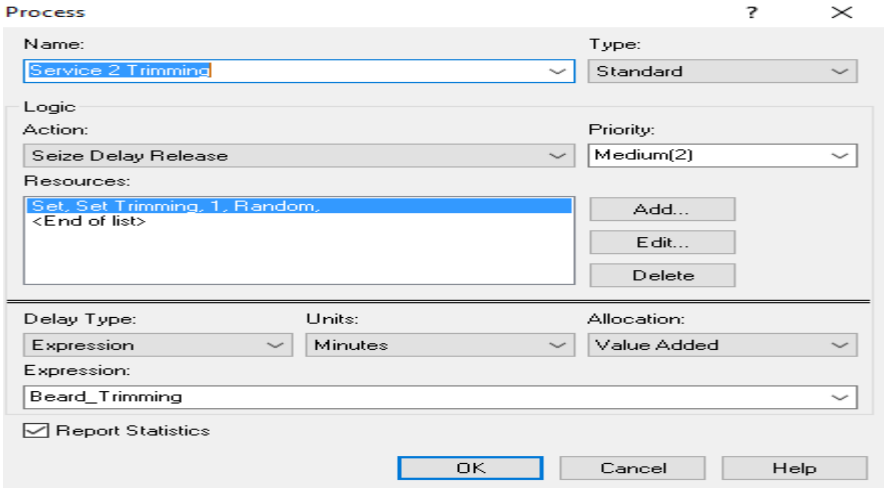


FIGURE 1.16: Beard Trim Process

Shampoo Process Block

Customers who decide to go for shampoo proceed to the shampoo queue where they wait for their turn. Once a resource is available, the customer will acquire that resource and release it once the service is done. A seize, delay and release process block is used with the input expression defined through input analyzer. The resource for this process has been allocated through shampoo set module which defines resources who can perform shampoo. The dialog box has been shown below in figure 1.17.

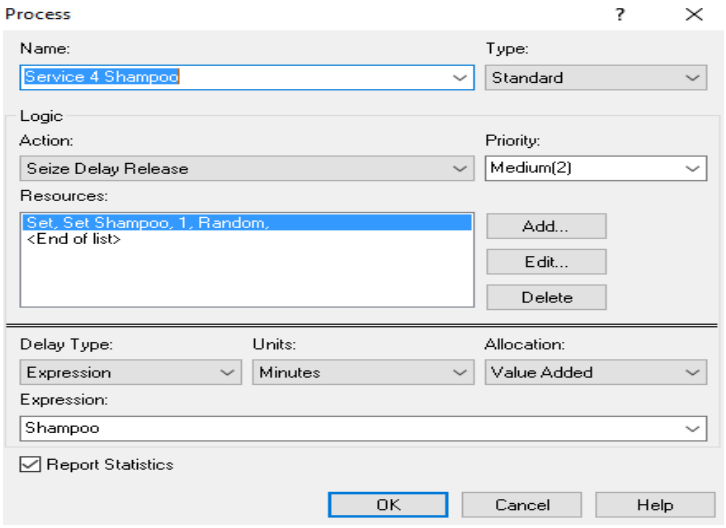


FIGURE 1.17 Shampoo Process Block

Conditioning Process Block

Customers who decide to go for conditioning then proceed to the conditioning queue where they wait for their turn. Once a resource is available, the customer will acquire that resource and release it once the service is done. A seize, delay and release process block is used with the input expression defined through input analyzer. The resource has been allocated through conditioning set module which defines resources who can perform conditioning. The dialog box has been shown below in figure 1.18.

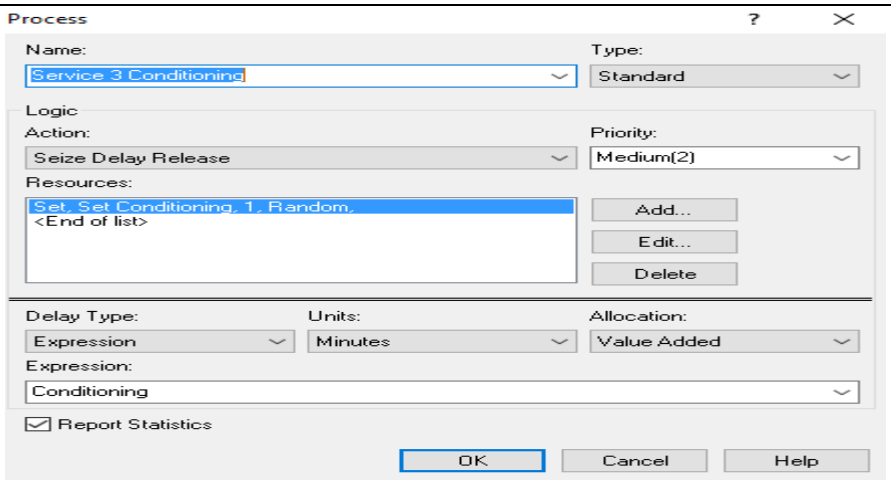


FIGURE 1.18: Conditioning Process

Styling Process Block

Customers who decide to go for styling then proceed to the styling queue where they wait for their turn. Once a resource is available, the customer will acquire that resource and release it once the styling is done. A seize, delay and release process block is used with the input expression defined through input analyzer. The resource for this process has been allocated through styling set module which defines resources who can perform styling. The dialog has been shown below in figure 1.19.

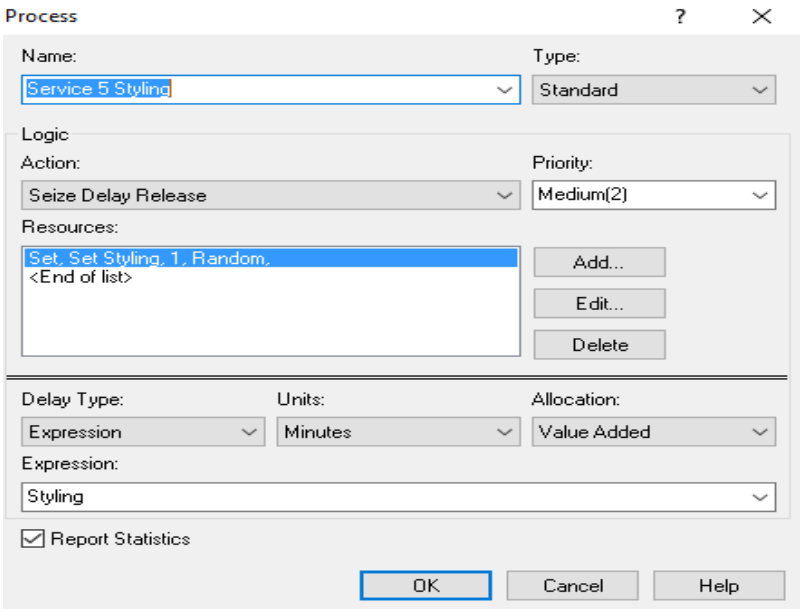


FIGURE 1.19: Styling Process

Record Blocks

A total of 7 record blocks have been used in the model to store number of people being processed by each of 5 process blocks, total people serviced and the total cost. Record blocks can be divided into two groups as follows

Process out value count Records

5 Record modules have been used to count and record the number of customers coming out of haircut, beard trim, shampoo, conditioning and styling process blocks respectively. The dialog boxes of each of these 5 record modules have been shown below in Figure 1.20.

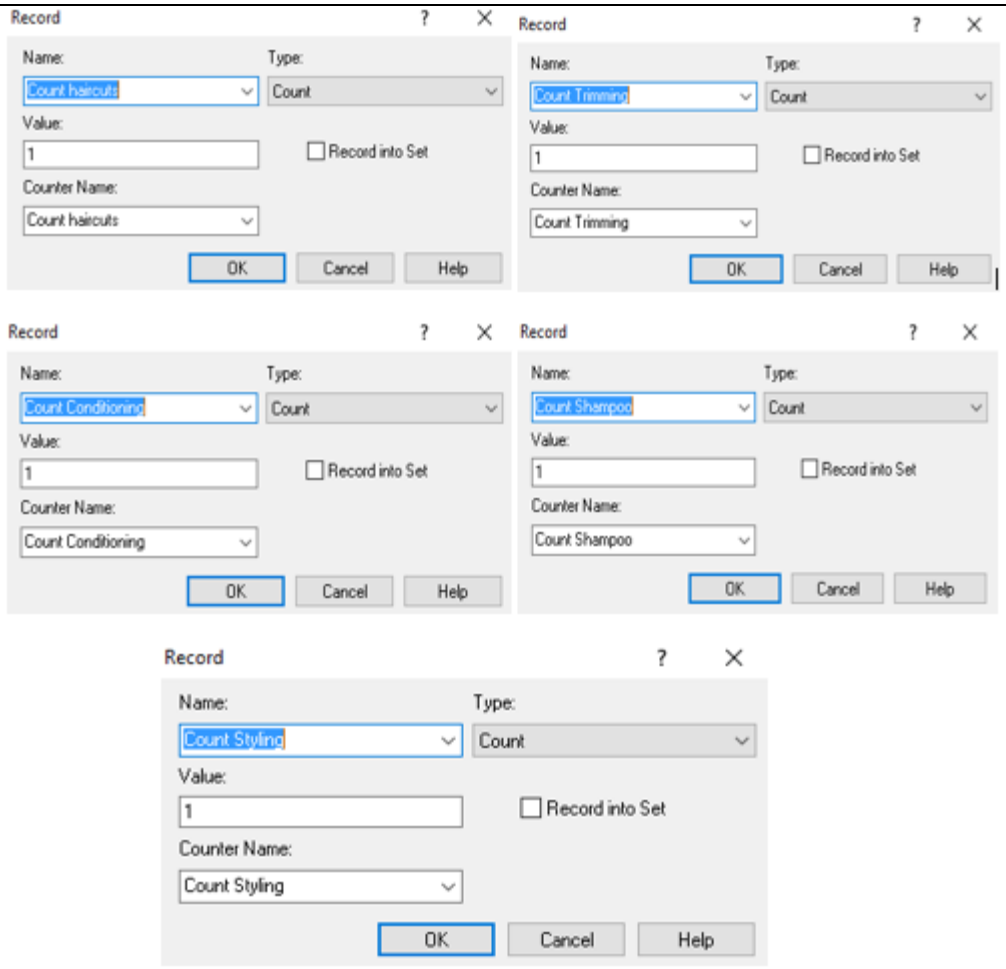


FIGURE 1.20: Record modules for processes

Record modules to store cost and total customers

There are 2 record blocks to store the sum of total customer serviced and to store the total cost or expenditure for the whole day. These blocks have been created so that we can have these values displayed in the final report as total number of customers serviced and expenditure are important figures to track. The dialog box of both the record blocks is shown in figure 1.21.

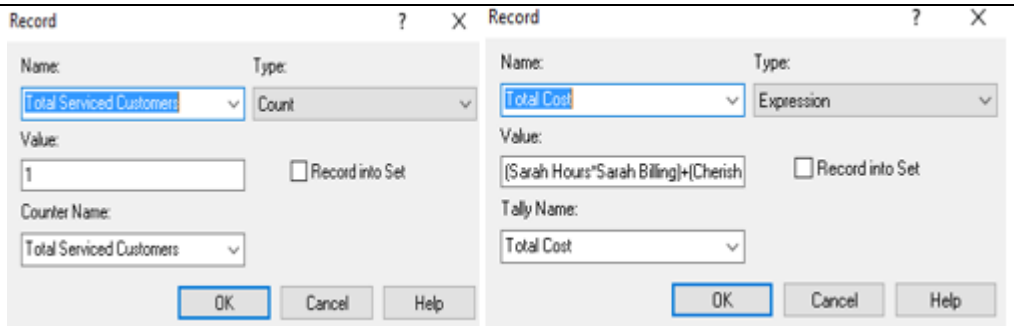


FIGURE 1.21: Record module for cost and total customers served

Customers Exit Block

After customers are done with the services and pay their bills, they exit from the salon. This is shown in the arena model using a dispose block known as Exit. The figure 1.22 below shows the dialog box of the dispose module.

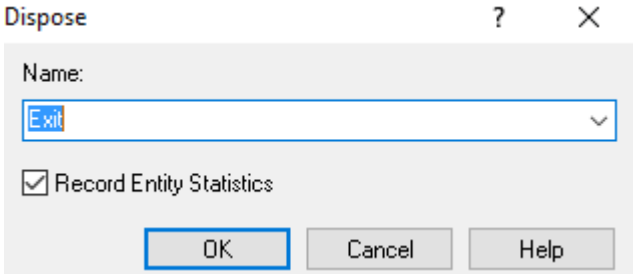


FIGURE 1.22: Customers Exit dispose block

Queues in the model

There are 6 queues present in the model for registration, haircut, beard trim, conditioning, shampoo and styling respectively. The snapshot of the queue system is shown below in figure 1.23.

Queue - Basic Process

	Name	Type	Shared	Report Statistics
1	Service 1 Haircut.Queue	First In First Out	☐	☑
2	Service 2 Trimming.Queue	First In First Out	☐	☑
3	Service 3 Conditioning.Queue	First In First Out	☐	☑
4	Service 4 Shampoo.Queue	First In First Out	☐	☑
5	Service 5 Styling.Queue	First In First Out	☐	☑
6	Registration.Queue	First In First Out	☐	☑

FIGURE 1.23: Queues in model

Resources used in model

As enquired from the manager Mariah at Great Clips, there are 4 permanent employees James, Sarah, Cherish and herself. Each employee can do all the services but have different speeds of completing the services which defines their hourly wages. We have one extra resource "*Extra Stylist*" which we would using in our model to check for better scenarios or alternative solutions. The below figure 1.24 shows the Resource snapshot used in arena model.

Resource - Basic Process

	Name	Type	Schedule Name	Schedule Rule	Busy / Hour	Idle / Hour	Per Use	StateSet Name	Failures	Report Statistics
1	Mariah	Based on Schedule	Schedule Mariah	Ignore	0.0	0.0	0.0		0 rows	☑
2	James	Based on Schedule	Schedule James	Ignore	0.0	0.0	0.0		0 rows	☑
3	Cherish	Based on Schedule	Schedule Cherish	Ignore	0.0	0.0	0.0		0 rows	☑
4	Sarah	Based on Schedule	Schedule Sarah	Ignore	0.0	0.0	0.0		0 rows	☑
5	Extra stylist	Based on Schedule	Extra Stylist	Ignore	0.0	0.0	0.0		0 rows	☑

FIGURE 1.24: Resources in model

Schedules used in the model

Each of the resource work on specific schedule for a total of 6 hours a day except for Mariah who works for whole day from morning 9 a.m. to 10 a.m. as she is the manager of the shop. Every resource gets a half hour break for lunch. The snapshot of the schedule system is shown below in figure 1.25.

Schedule - Basic Process

	Name	Type	Time Units	Scale Factor	Durations
1	Schedule James	Capacity	Halfhours	1.0	4 rows
2	Schedule Mariah	Capacity	Halfhours	1.0	5 rows
3	Schedule Cherish	Capacity	Halfhours	1.0	5 rows
4	Schedule Sarah	Capacity	Halfhours	1.0	4 rows
5	Extra Stylist Schedule1	Capacity	Halfhours	1.0	2 rows

FIGURE 1.25: Schedules used in model

Simulation parameter setup

We use the Run Set-up to run for 100 replications simulating to consider all the variabilities associated with the model and each replication with 12 hours of operation. Figure 1.26 depicts the snapshot of the Run Set up option.

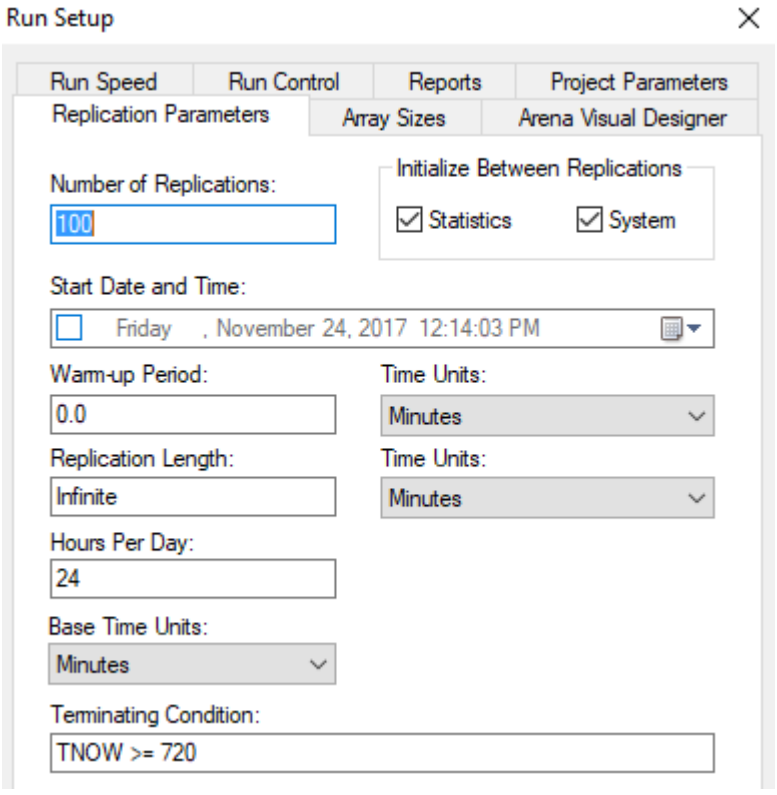
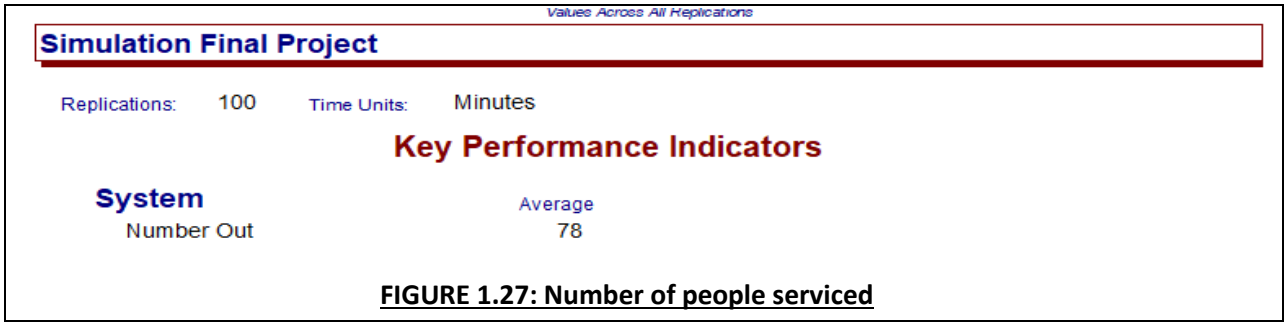


FIGURE 1.26: Run setup option

Results and Interpretations

The Arena software produces detailed results post running of the model. These results are grouped by Entity, Queue, Resource and User Defined which are the default settings. There are also additional reports like process reports which can be generated based on needs. The number of Entities out / number of customers' out is a default first key performance indicator in the category overview report. For this model, the number of customers out of a salon in a simulation of 12 hours for 100 replications on Saturday is 78. The snapshot of the result from simulation is shown below in figure 1.27.



Values Across All Replications

Simulation Final Project

Replications: 100 Time Units: Minutes

Key Performance Indicators

System	Average
Number Out	78

FIGURE 1.27: Number of people serviced

ENTITY OUTPUTS

Entity/ Customer is defined by two parameters, the number of customers (entering, out and in the system) and by the time taken by the customer (queue and total times). Arena gives a very detailed output with the mean, half width or confidence intervals, maximum and minimum for the various times that are observed in the model simulation. In the Great Clips Salon model, the major output needed was the total time spent by each type of customer in the system.

TIME OUTPUTS FOR ENTITY

VA Time	Average	Half Width	Minimum Average	Maximum Average	Minimum Value	Maximum Value
Online Customer	21.7375	0.11	20.3919	23.2202	3.8031	36.333
Walk in Customer	21.7748	0.12	20.1558	23.1094	3.9690	36.578

NVA Time	Average	Half Width	Minimum Average	Maximum Average	Minimum Value	Maximum Value
Online Customer	0.00	0.00	0.00	0.00	0.00	0.0
Walk in Customer	0.00	0.00	0.00	0.00	0.00	0.0

Wait Time	Average	Half Width	Minimum Average	Maximum Average	Minimum Value	Maximum Value
Online Customer	22.0534	2.33	3.5292	67.7934	0.00	109.1
Walk in Customer	21.2648	2.27	3.8815	71.9781	0.00	113.0

Transfer Time	Average	Half Width	Minimum Average	Maximum Average	Minimum Value	Maximum Value
Online Customer	0.00	0.00	0.00	0.00	0.00	0.0
Walk in Customer	0.00	0.00	0.00	0.00	0.00	0.0

Other Time	Average	Half Width	Minimum Average	Maximum Average	Minimum Value	Maximum Value
Online Customer	0.00	0.00	0.00	0.00	0.00	0.0
Walk in Customer	0.00	0.00	0.00	0.00	0.00	0.0

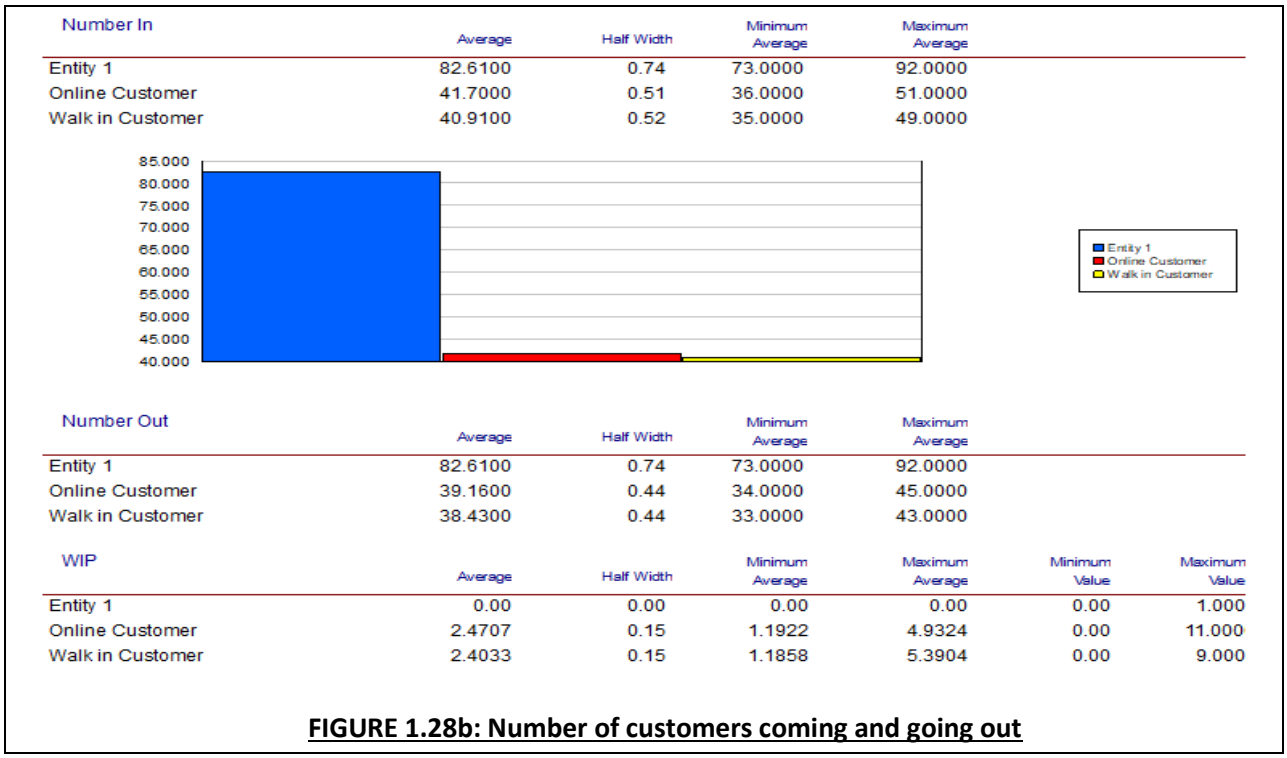
Total Time	Average	Half Width	Minimum Average	Maximum Average	Minimum Value	Maximum Value
Online Customer	43.7909	2.36	24.5913	89.9732	4.9293	133.1
Walk in Customer	43.0396	2.30	25.7112	94.5340	3.9814	134.7

FIGURE 1.28a: Time related outputs for customers

We find from above figure 1.28a that on an average a walk-in customer spends about 43.03 minutes in the salon with a half width of +/- 2.30 minutes while an online customer spends about 43.79 minutes in the salon with a half width of +/- 2.36 minutes. The average service time (value added time) for the walk-in customer is nearly 21.77 minutes with an average wait time of about 22.26 minutes. The average service time (value added time) for the online check in customer is nearly 21.73 minutes with an average wait time of about 22.05 minutes.

Number IN and Number OUT

The snapshot attached in figure 1.28b shows the number of people coming into the salon and number of people going out. Total entities coming in are 82 and going out are 78.



Number In

	Average	Half Width	Minimum Average	Maximum Average
Entity 1	82.6100	0.74	73.0000	92.0000
Online Customer	41.7000	0.51	36.0000	51.0000
Walk in Customer	40.9100	0.52	35.0000	49.0000

Number Out

	Average	Half Width	Minimum Average	Maximum Average
Entity 1	82.6100	0.74	73.0000	92.0000
Online Customer	39.1600	0.44	34.0000	45.0000
Walk in Customer	38.4300	0.44	33.0000	43.0000

WIP

	Average	Half Width	Minimum Average	Maximum Average	Minimum Value	Maximum Value
Entity 1	0.00	0.00	0.00	0.00	0.00	1.000
Online Customer	2.4707	0.15	1.1922	4.9324	0.00	11.000
Walk in Customer	2.4033	0.15	1.1858	5.3904	0.00	9.000

FIGURE 1.28b: Number of customers coming and going out

QUEUE OUTPUTS

Arena results also provide information about the average waiting time in queues and average number of patients in different queues at a time. For the current simulation, the figure 1.29 shows the snapshot of the results corresponding to queue.

Queue

Time

Waiting Time	Average	Half Width	Minimum Average	Maximum Average	Minimum Value	Maximum Value
Registration.Queue	12.6646	1.19	2.7083	36.0685	0.00	104.2
Service 1 Haircut.Queue	9.0642	1.10	1.0958	34.2690	0.00	108.7
Service 2 Trimming.Queue	8.0955	2.15	0.00	56.0119	0.00	67.630
Service 3 Conditioning.Queue	4.5600	2.25	0.00	82.2820	0.00	82.282
Service 4 Shampoo.Queue	6.0507	1.70	0.00	41.2704	0.00	64.547
Service 5 Styling.Queue	9.1646	1.84	0.00	58.5080	0.00	80.228

Other

Number Waiting	Average	Half Width	Minimum Average	Maximum Average	Minimum Value	Maximum Value
Registration.Queue	1.4720	0.15	0.2821	4.5086	0.00	14.000
Service 1 Haircut.Queue	0.9311	0.12	0.0944	3.5219	0.00	11.000
Service 2 Trimming.Queue	0.02216269	0.01	0.00	0.1344	0.00	2.000
Service 3 Conditioning.Queue	0.00847742	0.00	0.00	0.1277	0.00	1.000
Service 4 Shampoo.Queue	0.01632191	0.00	0.00	0.1146	0.00	2.000
Service 5 Styling.Queue	0.05544877	0.01	0.00	0.2977	0.00	2.000

FIGURE 1.29: Results for waiting time and average number of customers in queue

The waiting time in **registration queue is in seconds** while **rest of the waiting times are in minutes**. The aim of simulating the alternate scenarios will be to reduce the waiting times of customers in these queues.

RESOURCE OUTPUTS

Resource Utilization is a very important parameter which will determine whether the resources have been utilized to their highest potential or not. The Scheduled utilization is the most important factor or parameter of consideration. The below Figure 1.30 shows the arena output for scheduled utilization of resources.

Scheduled Utilization	Average	Half Width	Minimum Average	Maximum Average
Cherish	0.9955	0.01	0.8555	1.1221
Extra stylist	0.00	0.00	0.00	0.00
James	1.0028	0.01	0.8270	1.0830
Mariah	0.9867	0.01	0.8807	1.0589
Sarah	0.9561	0.01	0.7800	1.0655

FIGURE 1.30: Resource utilization

We can see that all the resources have been utilized to almost their full potential.

*Note***: Resource utilization of extra stylist is 0 because in base scenario there are only four employees i.e. Mariah, Cherish, Sarah and James.

USER SPECIFIED OUTPUTS

Arena software facilitates the user by allowing them to generate their own values or outputs which they want to check after simulation completes. All these outputs get stored together under user specified category in the final report that is generated by the software. For our model, we look at the number of people taking each service, total serviced customers, total wait time, total expenditure, total revenue and total profits. The below figure 1.31 and 1.32 show the arena output for user defined parameters.

User Specified

Tally

Expression	Average	Half Width	Minimum Average	Maximum Average	Minimum Value	Maximum Value
Total Cost	392.94	0.43	386.50	397.75	335.50	460.0

Counter

Count	Average	Half Width	Minimum Average	Maximum Average
Count Conditioning	0.7600	0.18	0.00	4.0000
Count haircuts	69.6400	0.75	60.0000	77.0000
Count Shampoo	1.3300	0.24	0.00	7.0000
Count Styling	4.1900	0.38	0.00	9.0000
Count Trimming	1.6700	0.24	0.00	5.0000
Total Serviced Customers	77.5900	0.57	69.0000	84.0000

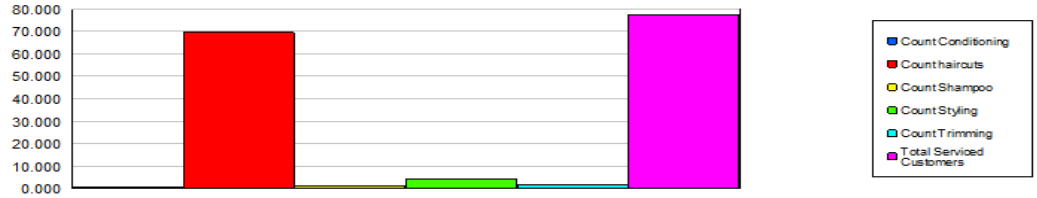


FIGURE 1.31: Count of customers taking each service and total cost

Output	Average	Half Width	Minimum Average	Maximum Average
Total Expenditure	450.39	0.86	437.50	460.00
Total Profit	781.43	16.95	588.00	1027.00
Total Revenue	1231.81	17.26	1033.00	1481.00
Total wait time	6.2679	0.80	0.4726	18.9018

FIGURE: 1.32: Output Stats from base model

We can see that for base model the average output parameters are as follows:

Total Expenditure: $450.39
Total Revenue: $1231.81
Total Profits: $781.43
Total Wait time: 6.2679 minutes per person

In the coming section of alternate scenarios, we would be using PAN to try out different number of extra resources and infer which scenario leads to improvement in above output statistics.

Alternate Scenarios and Improvements

We saw in base model that the scheduled utilization of the resources were very high with that of James being >1.0. We try to run different scenarios by adding one resource each time and work upon improving the output parameters discussed in previous steps. For scenario comparison, we would be using Arena PAN (Process Output Analyzer) to compare scenarios.

Conditions to be tested or to achieved

1. **Profits:** Profits should be at least $600 a day.
2. **Wait time:** Customers average waiting time should be less than 5 minutes
3. **Scheduled utilization:** The scheduled utilization of the resources should not be less than 0.5 and more than 1.0

Control Variables

The control variable will the number of extra resources Great Clips Should Hire. This value is represented by the variable Extra Stylist 1.

Response Variables

Three are three response variables.

1. The average waiting of any customer. We aim to make it below 5 minutes.
2. The total profits for the day. Profits should be more than $600
3. The scheduled utilization of the resources should be more than 0.50 but less than 1.00.

Scenarios to be tested

Scenario 1: Base Scenario

No extra resource is hired. This is the base model which we are trying to improve.

Scenario 2: 1 Extra Stylist hired

1 extra stylist is hired who can provide all the services and who will be working in last six hours of the day.

Scenario 3:

Two extra stylists are hired who can provide all the services and who will be working in last six hours of the day.

Scenario 4:

Three extra stylists are hired who can provide all the services and who will be working in last six hours of the day.

Process Analyzer(PAN) to compare scenarios

The below figure shows 1.33 shows the output of the PAN for all the scenarios.

	Scenario Properties				Control	Responses							
	S	Name	Program File	Reps	Extra Stylist1	Total Serviced	Total Profit	Total wait time	Cherish.ScheduledUtilization	Extra stylist.ScheduledUtiliz	James.ScheduledUtilization	Mariah.ScheduledUtilizatio	Sarah.ScheduledUtilization
1		Base: No extra Resource	16 : Barber s	100	0.0000	78	781.425	6.268	0.996	0.000	1.003	0.987	0.956
2		One extra Resource	16 : Barber s	100	1.0000	80	738.425	3.475	0.801	0.736	0.937	0.824	0.723
3		Two extra Resource	16 : Barber s	100	2.0000	80	629.775	3.053	0.692	0.557	0.884	0.685	0.605
4		Three extra Resource	16 : Barber s	100	3.0000	81	525.545	2.726	0.645	0.429	0.846	0.629	0.593

FIGURE 1.33: PAN Output

We can see from the above output that for each of the scenarios 2, 3 and 4 the total average waiting time is less than 5 mins. We have one extra customer served in scenario 4 when there are 3 extra resources added. This reduces the profits by 100 dollars as compared to scenario 2. Also, the resource utilization values have become too low in scenario 4.

Scenarios 2 and 3 are almost similar in terms of total waiting time and scheduled utilization but in case of scenario 2 we have extra profit of 109 dollars for same number of customers served.

To further analyze the models, we look at the boxplots of the two key response variables i.e. Total profits and average total waiting time for the scenarios. The below figures 1.34 shows the graphs.

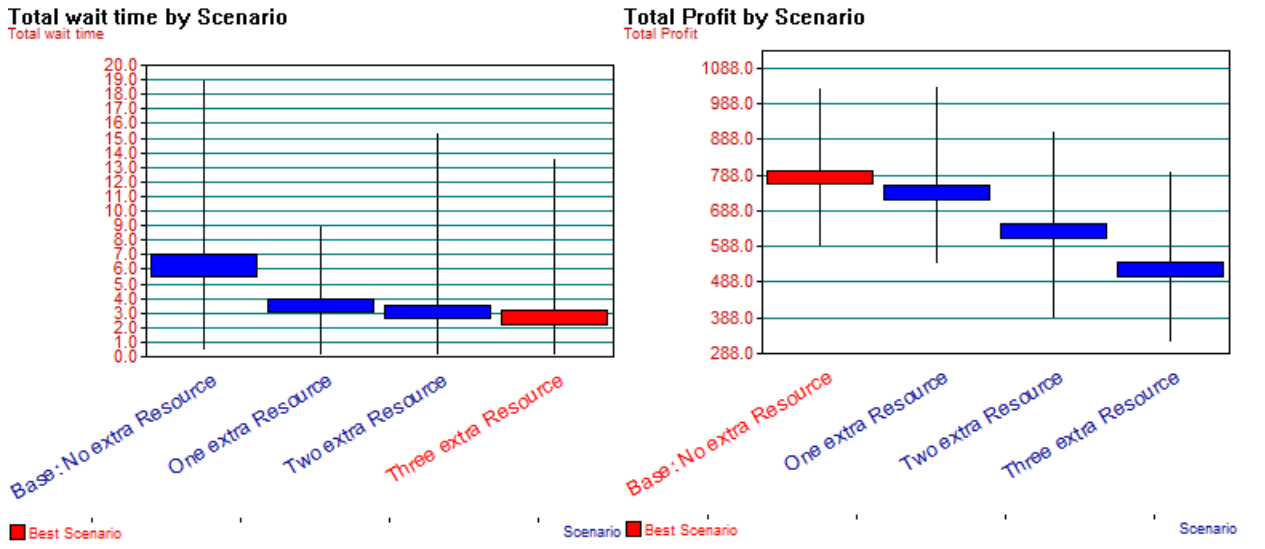


FIGURE 1.34: Boxplots of Total Profit and Total wait time

By looking at the above graphs we can infer that, total wait time reduces once a new resource is hired and does increase substantially on hiring many new resources. On, hiring one extra resource the profit decreases by $50 (remains higher than 700) but once we hire more resources the decrease in profits is higher without any substantial decrease in waiting times.

We can clearly infer from the above graphs that Scenario 2: One Extra Stylist is better ones amongst the tested scenarios.

We can also have a look at the scheduled utilization values for all the resources across scenarios in figure 1.35 shown below.

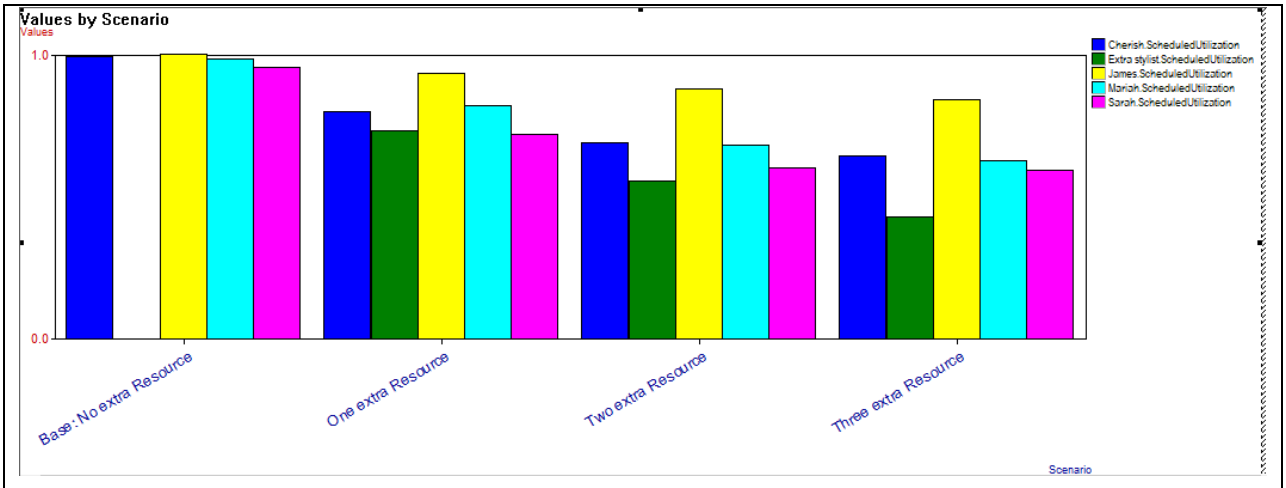


FIGURE 1.35: Scheduled utilization of resources

In above bar plot, we can see in scenario 1 where we have not extra resource, the utilization value is very and it is more than 1.0 for James. While in scenarios 2,3 and 4 utilization has gradually decreased.

Issue with scenario 4 where we have 3 extra resources is that the utilization value has become less than .50 for extra resource which is not good.

After analyzing the above three graphs, we can conclude that amongst the given scenarios, scenario 2 is better as it has high profit over $700 with waiting time way less than 4 minutes. So, Great clips should hire 1 extra resource who can perform all the services and works in the last 6 Hrs. of the day. After scenario 2, scenario 3 is better but scenarios 1 and 4 are not good because they have large wait time and small profits respectively.

Conclusions and Recommendations

Recommendation

After looking at the results of Process Analyzer, we can conclude that by adding just 1 extra stylist who can all the service, the total wait time gets reduced from 6.28minutes to 3.45 minutes with a slight decrease of $50 in profits. Also, by adding one extra resource the scheduled utilization of the resources is in the optimum range of 0.70 to 1.0.

The comparison of output values of the base model and recommended model is summarized in the following table 1.2.

TABLE 1.2: Comparison of outputs between Base and Recommended Model

Parameter	Base Model	Recommended model
Difference in models	no extra resource	one extra resource
Total Wait time	6.268 minutes	3.475 mins
Total Expenditure	$450.39	$550.41
Total Revenue	$1,231.81	$1,288.83
Total Profits	$781.43	$738.43
Cherish Schedule utilization	0.996	0.881
James Scheduled utilization	1.003	0.937
Mariah Scheduled utilization	0.987	0.824
Sarah Scheduled utilization	0.956	0.723
Extra Stylist Scheduled utilization	0	0.736
Haircut wait time	8.9 mins	4.81 mins
Beard Trim wait time	6.6 mins	4.89 mins
Shampoo wait time	6.8 mins	2.11 mins
Styling wait time	11.98 mins	6.70 mins
Conditioning wait time	3.18 mins	2.31 mins
Total Customers Served	78	80

Conclusion

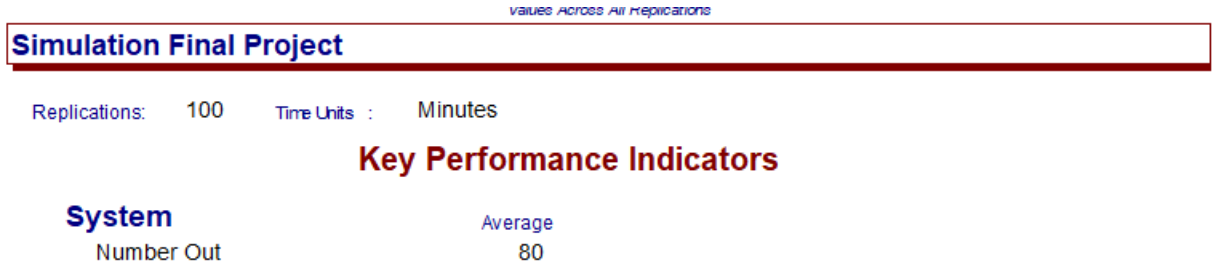
The Great Clips Salon was modelled using Arena Simulation Software to suggest the better ways to reduce the queueing times and average waiting time for the customer to receive the services at the salon. Different pieces of software were used to design the inputs and analyze the outputs provided by Arena like input analyzer which fit the distribution of the data and process analyzer which helped in analysis of the outputs and graph plotting. By probing into the outputs provided by Arena, we observed that the total waiting time in the queue was larger than 7 minutes and scheduled utilization values very high (more than 1.0 for one resource) in Base model. We implemented 4 different scenarios in Process Analyzer for understanding the effects of changes on employing more resources at peak time. We found through the Process Analyzer results that adding more resources will not only decrease both the total average waiting time and resource utilization but also decrease the overall profits. We also find the statistical significance of our better scenarios by inferring from the outputs and charts in process analyzer. We thus conclude that by adding just 1 extra resource, we can reduce the waiting time significantly and serve more customers without reducing profits by significant amount. There could be many other modifications possible which can be made to the model to get better results and this is just one of the better solutions or recommendations taking into consideration our assumptions to build the model.

References

1. Simulation with Arena- 6th Edition- David Kelton W., Randall P. Sadowski, Nancy B. Zupick, Rockwell Automation
2. Data- Great Clips, 213 Calhoun St, Cincinnati, Ohio
3. Logo- Trademark of Great Clips
4. https://www.greatclips.com

Appendix

In the appendix of the report, output snapshots of recommended model have been attached.



VA Time	Average	Half Width	Minimum Average	Maximum Average	Minimum Value	Maximum Value
Online Customer	21.8460	0.13	20.3657	23.1481	3.7666	36.380
Walk in Customer	21.8671	0.13	20.4137	23.4424	3.9655	36.987

NVA Time	Average	Half Width	Minimum Average	Maximum Average	Minimum Value	Maximum Value
Online Customer	0.00	0.00	0.00	0.00	0.00	0.0
Walk in Customer	0.00	0.00	0.00	0.00	0.00	0.0

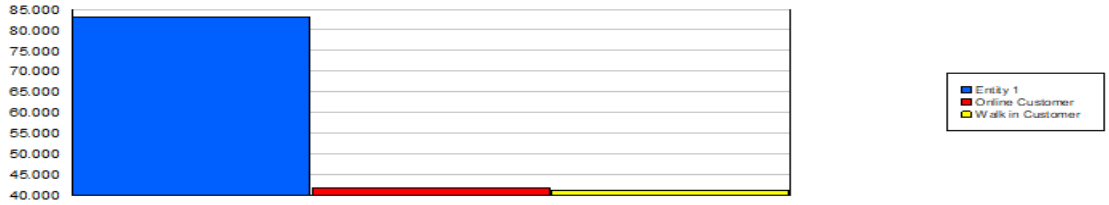
Wait Time	Average	Half Width	Minimum Average	Maximum Average	Minimum Value	Maximum Value
Online Customer	12.1895	1.14	0.9647	26.4224	0.00	87.578
Walk in Customer	11.8781	1.14	1.5453	28.5664	0.00	88.462

Transfer Time	Average	Half Width	Minimum Average	Maximum Average	Minimum Value	Maximum Value
Online Customer	0.00	0.00	0.00	0.00	0.00	0.0
Walk in Customer	0.00	0.00	0.00	0.00	0.00	0.0

Other Time	Average	Half Width	Minimum Average	Maximum Average	Minimum Value	Maximum Value
Online Customer	0.00	0.00	0.00	0.00	0.00	0.0
Walk in Customer	0.00	0.00	0.00	0.00	0.00	0.0

Total Time	Average	Half Width	Minimum Average	Maximum Average	Minimum Value	Maximum Value
Online Customer	34.0355	1.18	22.5190	48.5972	3.7666	110.1
Walk in Customer	33.7452	1.16	23.5161	51.0150	3.9814	108.1

Number In	Average	Half Width	Minimum Average	Maximum Average
Entity 1	82.9900	0.75	72.0000	94.0000
Online Customer	41.7700	0.54	35.0000	49.0000
Walk in Customer	41.2200	0.47	36.0000	49.0000



Number Out	Average	Half Width	Minimum Average	Maximum Average
Entity 1	82.9900	0.75	72.0000	94.0000
Online Customer	40.3300	0.53	34.0000	47.0000
Walk in Customer	39.9400	0.46	35.0000	46.0000

WIP	Average	Half Width	Minimum Average	Maximum Average	Minimum Value	Maximum Value
Entity 1	0.00	0.00	0.00	0.00	0.00	1.000
Online Customer	1.9420	0.08	1.0852	3.1591	0.00	10.000
Walk in Customer	1.9025	0.08	1.2066	3.1001	0.00	8.000

Queue

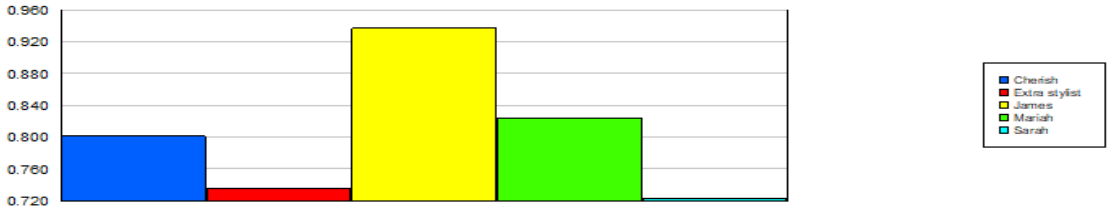
Time

Waiting Time	Average	Half Width	Minimum Average	Maximum Average	Minimum Value	Maximum Value
Registration.Queue	6.8327	0.59	0.9251	15.1645	0.00	76.157
Service 1 Haircut.Queue	4.8170	0.54	0.00	11.6502	0.00	76.100
Service 2 Trimming.Queue	4.8964	1.56	0.00	25.4891	0.00	57.625
Service 3 Conditioning.Queue	2.3117	1.13	0.00	27.2819	0.00	44.913
Service 4 Shampoo.Queue	2.1165	1.04	0.00	26.2730	0.00	43.000
Service 5 Styling.Queue	6.7081	1.22	0.00	28.9058	0.00	62.500

Other

Number Waiting	Average	Half Width	Minimum Average	Maximum Average	Minimum Value	Maximum Value
Registration.Queue	0.7958	0.07	0.0925	1.9603	0.00	11.000
Service 1 Haircut.Queue	0.5001	0.06	0.00	1.2945	0.00	10.000
Service 2 Trimming.Queue	0.01315158	0.00	0.00	0.1591	0.00	2.000
Service 3 Conditioning.Queue	0.00452356	0.00	0.00	0.06237910	0.00	1.000
Service 4 Shampoo.Queue	0.00625262	0.00	0.00	0.07875139	0.00	2.000
Service 5 Styling.Queue	0.04800401	0.01	0.00	0.1941	0.00	2.000

Scheduled Utilization	Average	Half Width	Minimum Average	Maximum Average
Cherish	0.8011	0.02	0.5787	0.9600
Extra stylist	0.7360	0.01	0.5236	0.8724
James	0.9367	0.01	0.7644	1.0560
Mariah	0.8245	0.01	0.7125	0.9410
Sarah	0.7227	0.01	0.5391	0.8744

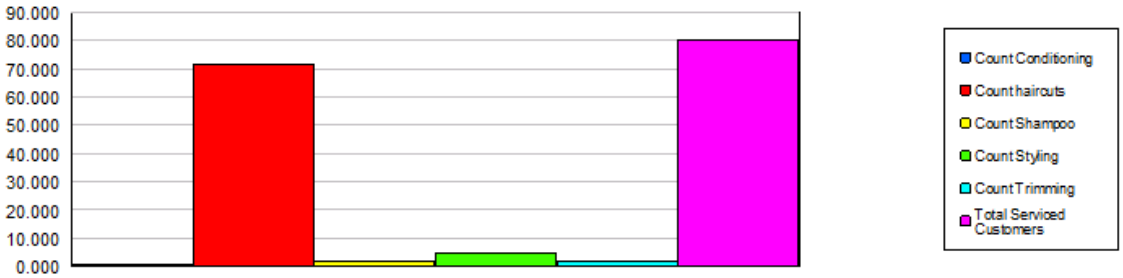


Total Number Seized	Average	Half Width	Minimum Average	Maximum Average
Cherish	25.6900	0.91	16.0000	37.0000
Extra stylist	33.1000	0.77	25.0000	42.0000
James	32.5200	1.00	20.0000	46.0000
Mariah	51.4500	1.21	41.0000	71.0000
Sarah	22.8800	0.53	17.0000	29.0000

Expression	Average	Half Width	Minimum Average	Maximum Average	Minimum Value	Maximum Value
Total Cost	490.95	0.56	482.50	498.25	431.50	565.0

Counter

Count	Average	Half Width	Minimum Average	Maximum Average
Count Conditioning	0.7900	0.15	0.00	3.0000
Count haircuts	71.6200	0.85	61.0000	81.0000
Count Shampoo	1.5700	0.26	0.00	5.0000
Count Styling	4.7000	0.42	0.00	10.0000
Count Trimming	1.5900	0.24	0.00	5.0000
Total Serviced Customers	80.2700	0.75	69.0000	90.0000



Output

Output	Average	Half Width	Minimum Average	Maximum Average
Total Expenditure	550.41	1.12	533.50	565.00
Total Profit	738.43	20.87	538.50	1034.50
Total Revenue	1288.83	21.48	1084.00	1598.00
Total wait time	3.4750	0.45	0.1571	8.9062