INSE 691

Advanced Systems Modeling and Simulation

Project Report

Simulation of the Queensland Government Customer Care Call Centre

Submitted To:

Prof. Anjali Awasthi

Presentation Link:
https://www.youtube.com/watch?v=buGqIQ8zkhE

Submitted By:

Name	Student ID
Balkaran Singh Dhillon	40111539
Mohammed Faizan	40131626
Shadi Abu Arshid	40150932
Varinder Singh	40086602

Faculty of Engineering and Computer Science
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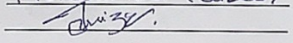
Course Number: INSE 691
Name: Mohammed Faizan
Signature: 
Instructor: Prof. ANJALI AWASTHI
I.D. # 40131626
Date: Aug 10, 2020

[1] Rules for reference citation can be found in "Form and Style" by Patrich MacDonagh and Jack Bordan, fourth edition, May, 2000, available at http://www.encs.concordia.ca/scs/Forms/Form&Style.pdf.
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Course Number: INSE 691
Name: Varinder Singh
Signature: Varinder Singh

Instructor: Prof. ANJALI AWASTHI
I.D. # 40086602
Date: Aug 10, 2020

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Course Number: INSE 691 Instructor: Prof. ANJALI AWASTHI
Name: Shadi Abu Anshid I.D. # 40150932
Signature: S.A Date: Aug, 10 2020

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Course Number: INSE 691 Instructor: Prof. ANJALI AWASTHI
Name: Balkaran Singh Dhillon I.D. # 40111539
Signature: Balkaran Date: Aug 12, 2020

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PROJECT CHARTER

Project Title:	Simulation of the Queensland Government Customer Care Call Centre		
Date of Authorization:	21/06/2020		
Project Start Date:	22/06/2020	Project End Date:	08/08/2020
Key Schedule:	● Complete Planning Phase of the Project by 25/06/2020. ● Complete Execution Phase of the Project by 25/07/2020. ● Complete Closing Phase of the Project by 05/08/2020.		
Project Objective:	The main objective of the project is to identify, understand, and suggest potential solutions through a model simulation to tackle the issue of time management at the customer call center in Australia		
Main Project Success Criteria:	The project meets time, budget, and appropriate quality constraints. Also, the project meets requirements, deliverables, objectives, and stakeholders' satisfaction.		
Approach:	● Make a skilled project team. ● Within one month, develop a clear role and responsibility breakdown structure, scope statement, and other documents required to complete the project. ● Identify all the tools required after the planning phase. ● Getting all work done in time and staying within time constraints. ● Hold weekly progress review meetings for the statue and risk occurring. ● Studying every aspect of government customer service center for continuous improvements.		

ROLES AND RESPONSIBILITIES

Name	Signature	Contact Information
Balkaran Singh Dhillon	Balkaran Singh Dhillon	Bsdhillon5767@gmail.com
Mohammed Faizan	Mohammed Faizan	reach2mdfaizan@gmail.com
Shadi Abu Arshid	Shadi Abu Arshid	shadi.abuarshid@outlook.com
Varinder Singh	Varinder Singh	varindersingh1995june@gmail.com

Comments:	"As the success of a company depends on its employees, I request everyone who is part of this team to please be heavily involved and make it a successful project".

KICK-OFF MEETING

Date: 22/06/2020

Meeting objective: The main matter is to comprehend the task target and explanation to colleagues to start the project in the correct manner**.**

Agenda:

- Introducing colleagues to the different services provided by the Queensland Government Customer Care Call Centre.
- Review of task-related records (Software Tools, and Project Charter).
- Explanation of working of various parts during execution, checking, and controlling of different stages.
- Discussion of undertaking prerequisites.
- Discussion of the model created.
- Discussion of a plan to come up with an alternative model.
- Assigning different topics to each team member.

S.NO.	ACTION ITEM	ASSIGNED TO	DATE
1	Introduction, Project Charter, Problem Statement, Objectives	Mohammed Faizan	25/06/2020
2	Literature Review, Data Collection	All members	02/07/2020
3	System Description, Conceptual Model	Shadi Abu Arshid, Balkaran Singh	15/07/2020
4	Discrete Event Simulation using Arena	Shadi Abu Arshid, Balkaran Singh, Mohammed Faizan	21/07/2020
5	Monte Carlo Simulation using Excel	Mohammed Faizan	28/07/2020
6	Use Case and Sequence Diagrams	Varinder Singh	02/08/2020
7	Conclusion	Varinder Singh	08/08/2020

Table1. Milestone List

INTRODUCTION

In today's world of competition and rivalries, in order for an organization to be successful, the service provided to be must be superior in both time and efficiency. The only way for an organization to reach success is through attaining maximum customer satisfaction by improving the quality of service throughout the organization. Thus, there is a need for model studies to identify and modify the factors that are directly responsible for customer satisfaction before and after being served. The organizations need to understand what a customer desires which can be done through a model replica of the service provided.

The main problem faced by an organization is the waiting time of a customer. These queuing problems could be a major concern and can lead to disruptive operations resulting in low-quality service. The wait time for the customer could be due to various circumstances that unfortunately leads to a customer spending more time in the queue even before being attended or served. There are many factors that lead to an increase in the service time and the total time spent in the queue by a customer such as time management issues, fewer resources, inexperienced employees, untrained staff, technological issues, insufficient service counters, organization issues, to mention a few. Thus, the acknowledgment and comprehension of customer requests and what the customer favors is the underlying stride for the change of the administration ability.

Objectives

- The objective of this project is to design a working simulation model of the Queensland Government Customer Care Call Centre located in Beaudesert, Australia.
- To design a conceptual model of the Customer Care Call Centre and perform discrete event simulation using Arena software.
- To perform Sensitivity Analysis using Monte Carlo Simulation in Microsoft Excel and determine the average waiting time and serve time of each customer.

Literature Review

Description

Smart Service Queensland provides customers with the primary contact destination to reach taxpayer-supported organizations across multiple transportation channels. Customers can access government and government data from 8:30 AM to 4:30 PM from Monday to Friday.

1. Locals in Australia can contact the Customer Care Call Centre through the phone number 13 QGOV (13 74 68). Callers can access their information and services without needing to know which agency looks after their enquiry.

2. People from outside Australia can contact the Customer Care Call Centre through the phone number +617 3405 0985 (+10 hours UTC). Callers can access their information and services without needing to know which agency looks after their enquiry.

Call Centre

Queenslanders can access government data and benefits, and share multiple conversations with just one call to the Queensland Contact Centre smart service. Experienced customer service advisors are ready to submit explicit administrations through the contact center for the benefit of the Queensland government. Queenslanders can travel from anywhere in Australia every day at the cost of a call to nearby Smart Service Queensland.

Queensland Government Service Centre (QGSC)

This system of taxpayer-backed organization counters is located in provincial, national, and remote networks across the country, and enables visual contact with customers in areas where access to network administration is restricted.

PROBLEM STATEMENT

Queensland is the second-largest state in Australia. There are three different levels of Government in Australia namely local, state, and federal, which provide different services to

people living in Queensland and maintain a happy community. The Queensland Government is responsible for providing various services like employment, business training, education, transport facilities, emergency, and other services. All of these services are handled with the help of a customer center called Beaudesert Customer Call Centre, located at Beaudesert, Queensland.

The purpose of the Beaudesert Customer Call Centre is to attend to the customer seeking various aforementioned services from the Queensland Government. This customer center is most frequently visited or contacted through phone calls. The Beaudesert Customer Call Centre operates from Monday to Friday from 8:30 AM to 4:30 PM every week. During the rush hours, there is a wait time for the services offered by the Government which causes disruptive services and long waiting queues for the customers. Thus there is a need to make the system more efficient by analyzing the dataset information collected, applying various strategies and simulation tools to come up with a new efficient model for faster and efficient services.

CONCEPTUAL MODEL

Process Map

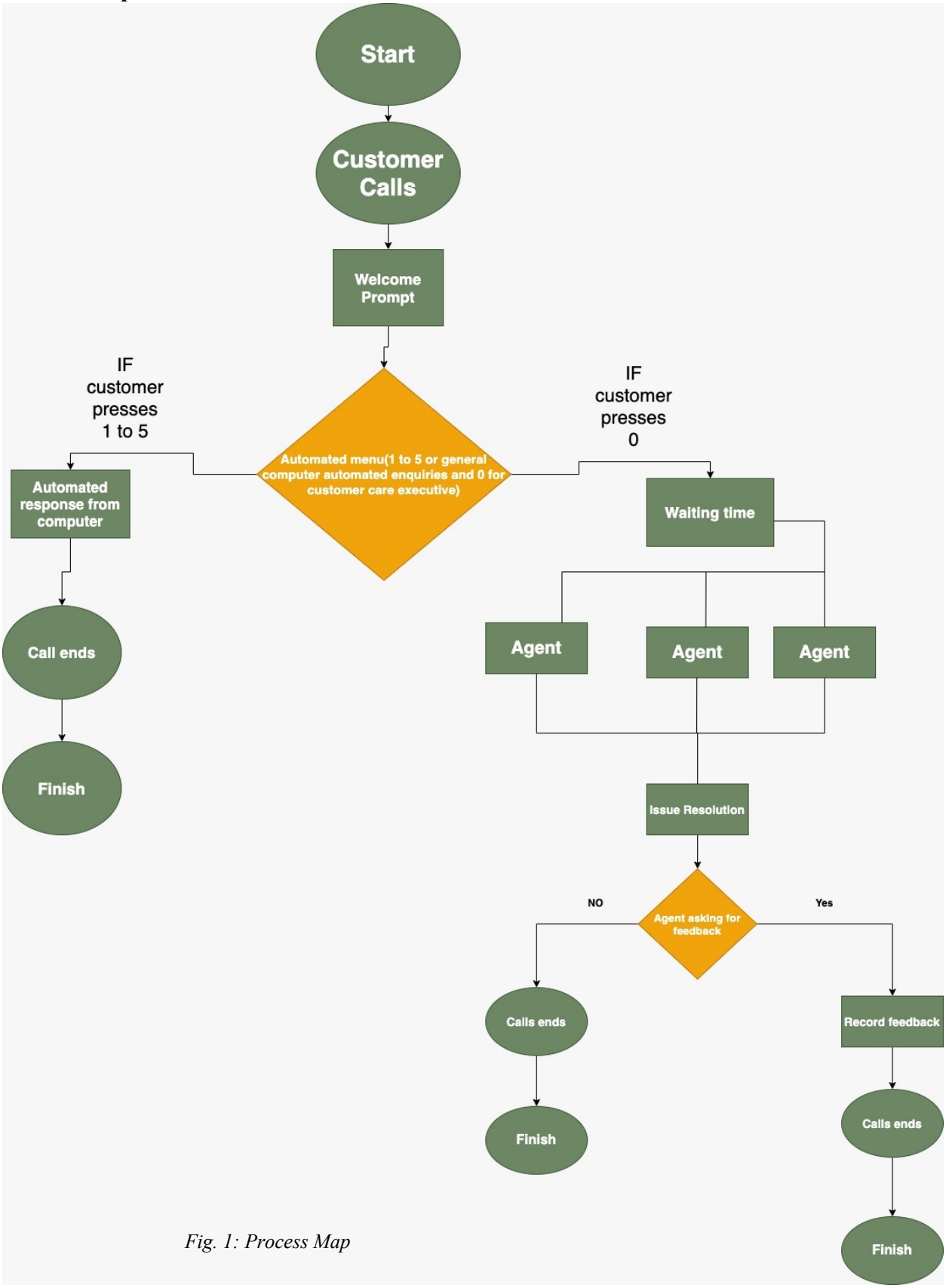


Fig. 1: Process Map

SYSTEM DESCRIPTION

1. Basic Model

Originally, Queensland service center has been assumed to have only one operator as a Call Centre agent that takes care of all customers' enquiries. It has been noticed that the Call Centre agent is always busy with calls at the Beaudesert Customer Care Call Centre. As it can be visualized in Figure5, the model begins with a customer call, followed by an Assign basic process which assigns Customer *x* to Time *t*. In other words, when a customer calls, the time the call is picked up by the answering machine is assigned to that customer, all of this happens within the system without the customer nor the operator noticing it. The reason behind such action is to keep a record of every call for every customer, whether it will be used for quality control purposes, or for feedback purposes that will be explained eventually. After that, the customer selects the suitable option from the menu narrated by the answering machine. Until the customer is connected with the customer service agent, two hidden processes are performed that are recording waiting time as well as asking a question whether the operator is available or not. In case the operator is not available for some reason, the customer will be driven back to the waiting terminal, the whole cycle is then repeated. As soon as the agent is available, all the customers that have been waiting, are transferred to form a queue for the operator. Obviously this will result in large waiting times for customers, fatigue for the operator that will both result in customer dissatisfaction. Within the system, a timer records the service time spent with each customer. Moreover, a feedback is added to the system where the customer is given a one question survey where they press 1 (Poorly Satisfied) to 5 (Highly Satisfied) for quality assurance purposes. Finally, after recording the customer's response to the survey, the call ends.

2. Alternative/Improved Model

After analyzing the existing system in terms of customers' numbers and their waiting time, an alternative model has been developed and tested. In fact, model improvement has been emphasized in the center of the previous model. Instead of one agent receiving calls from customers, three agents will be in place having equal chances of receiving calls from customers. After the customer chooses their desired option, a decision is there to distribute customers on the three agents. Each agent gets a chance of 33.33% of receiving a call, leaving it fair for all agents.

A question might rise of what-if all agents are unavailable? In fact, there will be a regulation implemented stating that at least one agent should be available at any time during working hours.

DISCRETE EVENT SIMULATION – ARENA Software

Purpose

Discrete Event Simulation technique best fits the proposed project idea of a governmental customer call center which is considered to be a meso or medium abstraction level. It has been chosen due to the fact that the system analyzed changes its status under discrete events with the aspect of the queuing system. Arena software has been used due to its flexibility in creating the models, rich generated reports after running the simulation, ability to input data and use it in the model simulation.

Model Components

- System: Customer Call Centre
- Entities: Customers
- Resources: Operator (1,2,3), Telephone line (1,2,3)
- Attributes: Arrival Time
- Event: Customer arrival/departure, Operators serving
- State Variables: Number of customers, Waiting Time, Service Time
- Problem: Long waiting time, Operator fatigue, Customers' dissatisfaction

Model Assumptions

The total number of customers called Queensland service center during the month of June 2010 is around 5000 customers. It was found that the number of customers follow normal distribution when plotted against time.

- The basic model has only one operator taking the queries of the customers, and the alternative model has 3 operators to serve the customers.
- Based on the historical data, and input modeling analysis done in the previous section, the number of customers is normally distributed with a mean of 314 seconds, and a standard deviation of 123 seconds.

Input Modeling

- **Goodness of Fit Test**

Chi-square test has been used to assess the goodness of fit of the obtained data as shown below. Four different random days have been picked when each of these days have exactly 150 customers contacting Queensland Government Customer Care Call Centre. We are assuming that Wait time in Seconds for the four days sample will be the same. To be able to generalize our result and the consistency of the wait time claim, 95% Confidence will be chosen to be analyzed.

H_0: $P_{day1} = P_{day2} = P_{day3} = P_{day4}$ H_1:

At least one $P_{day\ (n)} \neq P_{day\ (m)}$

The observed values are as follows:

Days	**1**	**2**	**3**	**4**
Number of Customers	150	150	150	150
Average Wait Seconds	389	386	402	396

Table 2: Random Sample

$E = \frac{\sum(389+386+402+396)}{4} = 393.25$

$\chi^2_{cal} = \frac{(Observed - Expected)^2}{Expected} = \frac{(389-393.25)^2}{392.25} + \frac{(386-393.25)^2}{392.25} + \frac{(402-393.25)^2}{392.25} + \frac{(396-393.25)^2}{392.25} = 0.045 + 0.134 + 0.195 + 0.019 = 0.393$

$\chi^2_{\alpha=0.05,\nu=2} = 5.99$

Since $\chi^2_{cal} = 0.393 \leq \chi^2_{\alpha=0.05,\nu=2} = 5.99$

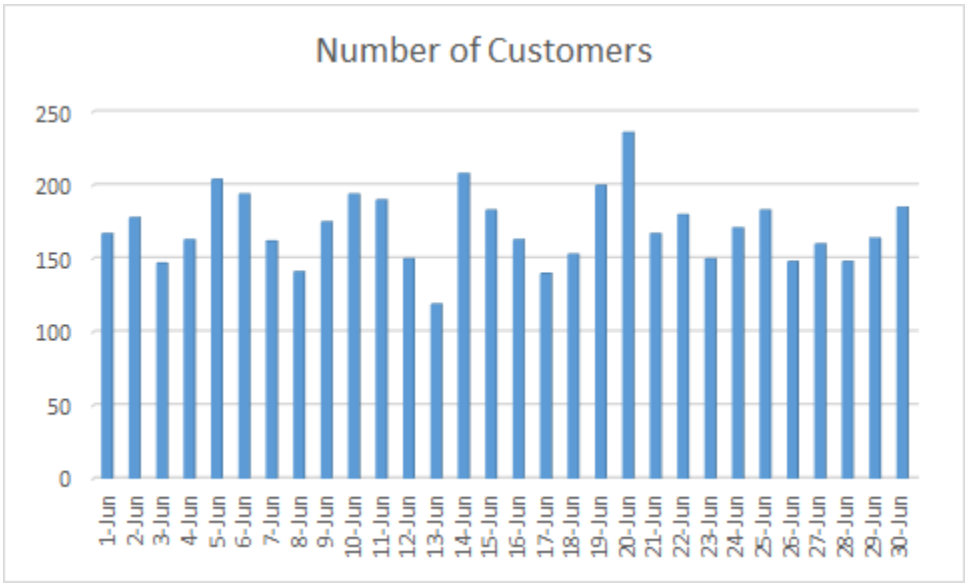
We can conclude that we fail to reject the null hypothesis H_0, thus; we are 95% confident that the average wait time is equal (393.25 seconds) when there are 150 customers any day at Queensland Governmental Customer Care Call Centre.

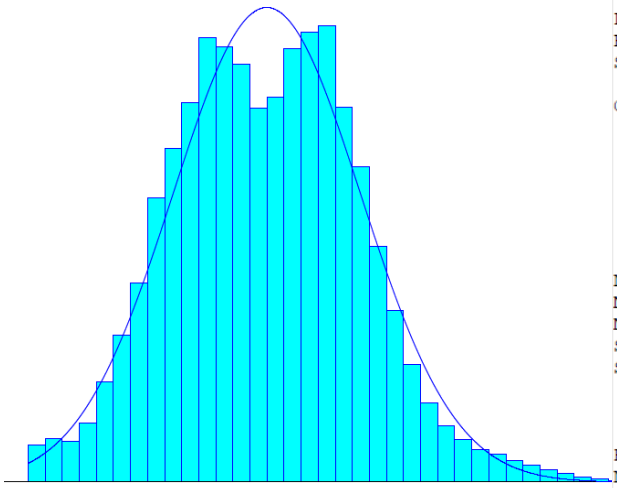
- **Data Analysis**

Three variables were used in this simulation modeling from a dataset obtained from Queensland Official Website. The variables are Number of Customers, Average Wait Seconds and Average Serve Seconds. In the figures below, bar-charts are used to better visualize each variable for the whole month of June.

Number of Customers:

The graphs below show that the obtained data of Number of Customers is Normally Distributed with a mean of 314 and a standard deviation of 123 with a minimum of 1 customer and a maximum of 897 customers as computed by Arena Software in the provided Distribution Summary.



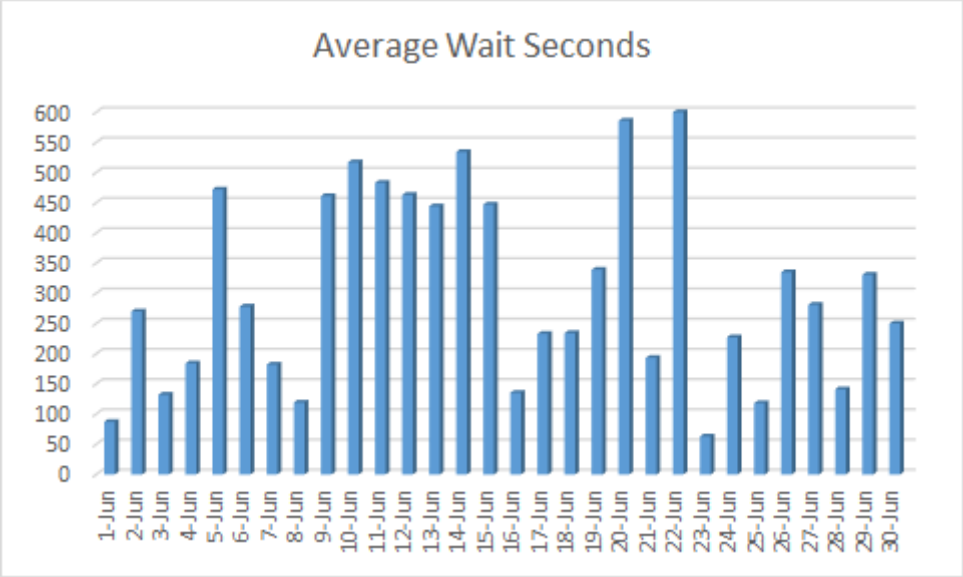


```
        Distribution Summary

Distribution:   Normal
Expression:     NORM(314, 123)
Square Error:   0.000910

Chi Square Test
  Number of intervals   = 35
  Degrees of freedom    = 32
  Test Statistic        = 2.56e+003
  Corresponding p-value < 0.005

        Data Summary

Number of Data Points   = 88521
Min Data Value          = 1
Max Data Value          = 897
Sample Mean             = 314
Sample Std Dev          = 123

        Histogram Summary

Histogram Range         = 0.999 to 897
Number of Intervals     = 40
```

Fig. 2: No. of Customers Graphs and Distribution Summary

Average Wait Seconds

The charts below show relatively large variation in Average Wait Seconds for customers to get served by a customer care agent representative. Similar to the Number of Customers, the data of Average Wait Seconds follow Normal Distribution with a mean of 450 and a standard deviation of 292 as shown in the Distribution Summary developed by Arena Software.



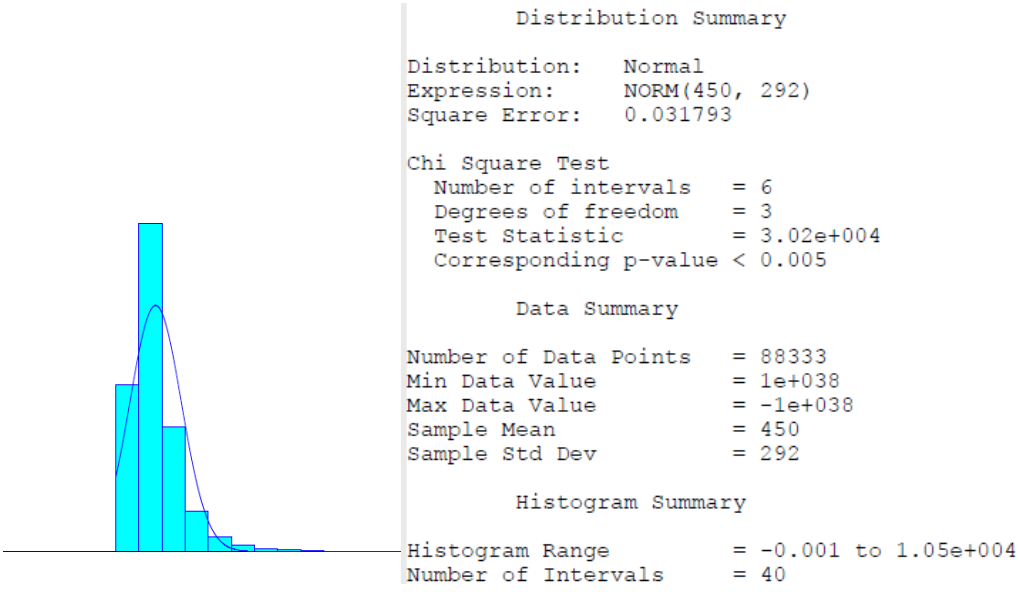
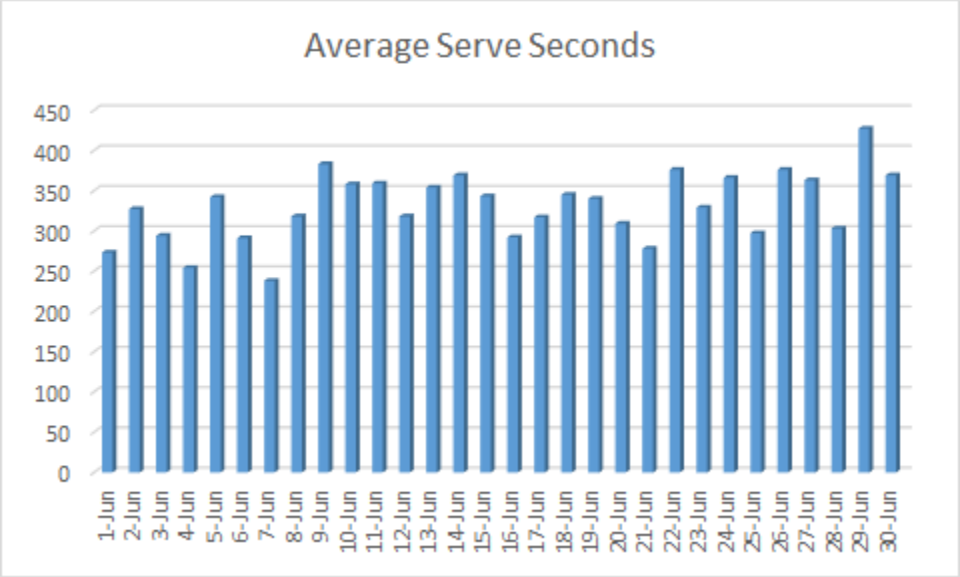
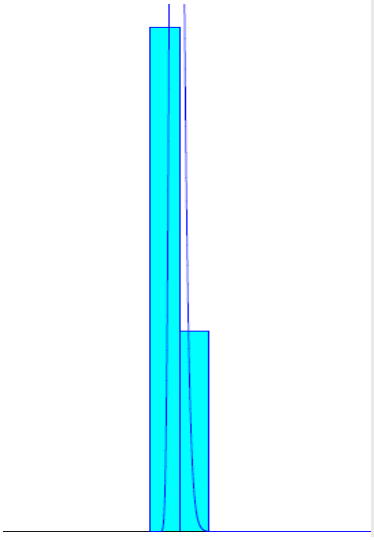


Fig. 3: Average Wait Seconds Graphs and Distribution Summary

Average Serve Seconds

From the graphs below, the variations of Average Serve Seconds can be visualized where the data follows a Lognormal distribution with a mean of 440 seconds and a standard deviation of 110 seconds as shown in the Distribution Summary developed by Arena Software.





```
        Distribution Summary

Distribution:   Lognormal
Expression:     -0.001 + LOGN(442, 88.8)
Square Error:   0.002388

Chi Square Test
  Number of intervals   = 2
  Degrees of freedom    = -1
  Test Statistic        = 816
  Corresponding p-value < 0.005

        Data Summary

Number of Data Points   = 88521
Min Data Value          = 0
Max Data Value          = 1.9e+004
Sample Mean             = 440
Sample Std Dev          = 110

        Histogram Summary

Histogram Range         = -0.001 to 1.9e+004
Number of Intervals     = 40
```

Fig. 4: Average Serve Seconds Graphs and Distribution Summary

Model Design

As explained earlier, the nature of the system is Discrete Event simulation that is due to the system's status change on discrete events. Due to the need of the queuing system of Queensland Service Center and the medium abstraction level, Arena Software has been chosen to model the Current (Basic) model and the Alternative one as shown below in Figure 5 and Figure 6.

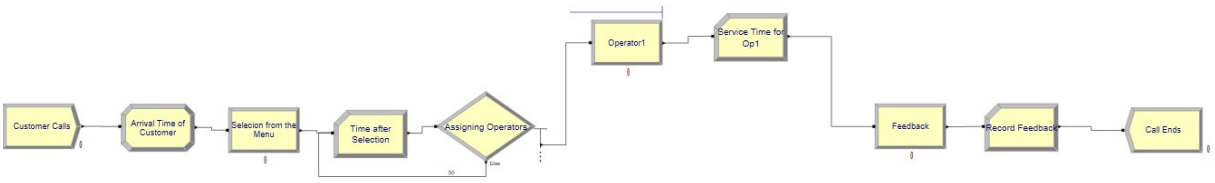


Fig. 5: Basic Arena Model

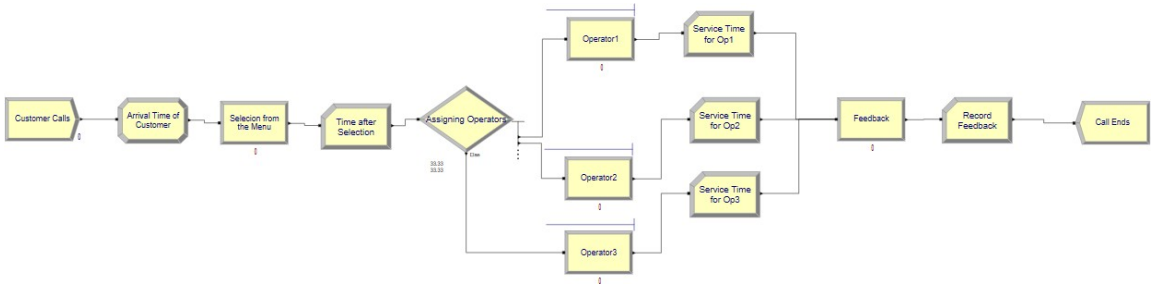


Fig. 6: Alternative Arena Model

Output Analysis

Basic:

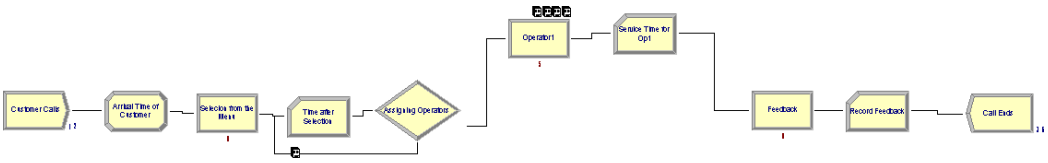


Fig. 7: Basic Arena Model Running

Category Overview:

Fig. 8: Number of Customers-Basic

By Queue:

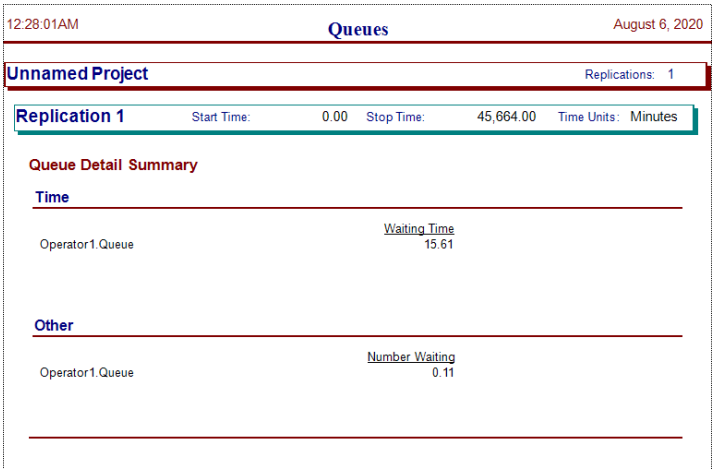


Fig. 9: Wait Time-Basic

By Resources:

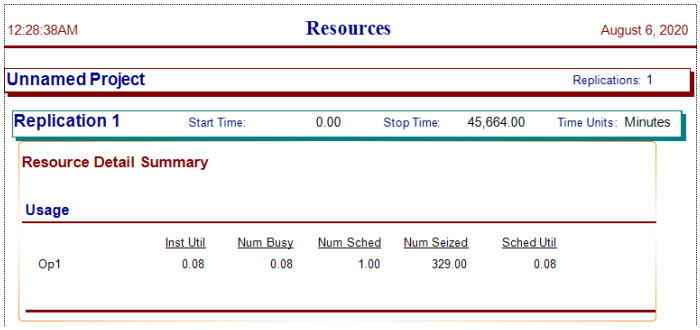
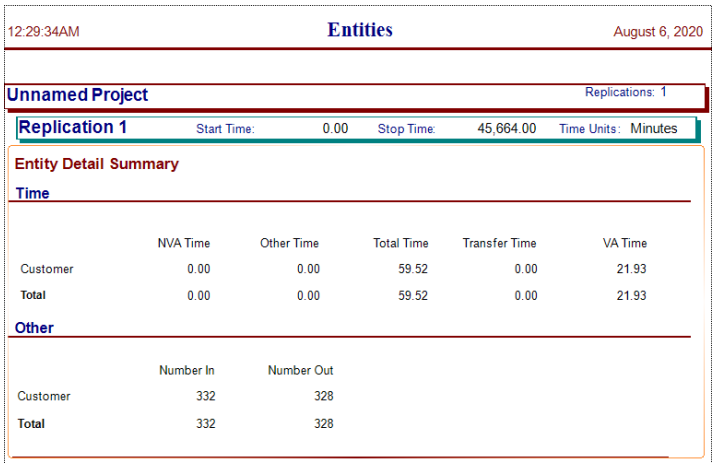


Fig. 10: Resource-Basic

By Entities:



12:29:34AM **Entities** August 6, 2020

Unnamed Project Replications: 1

Replication 1 Start Time: 0.00 Stop Time: 45,664.00 Time Units: Minutes

Entity Detail Summary

Time

	NVA Time	Other Time	Total Time	Transfer Time	VA Time
Customer	0.00	0.00	59.52	0.00	21.93
Total	0.00	0.00	59.52	0.00	21.93

Other

	Number In	Number Out
Customer	332	328
Total	332	328

Fig. 11: Entities-Basic

Alternative:

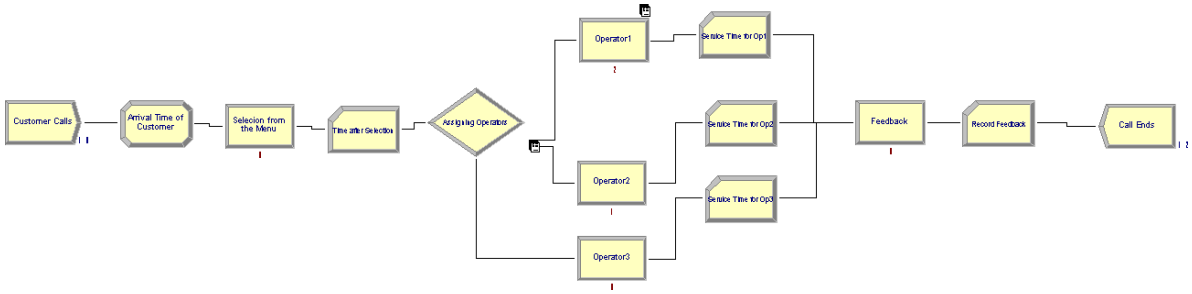
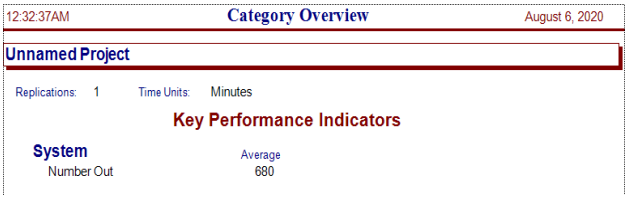


Fig. 12: Alternative Arena Model Running

Category Overview:



12:32:37AM **Category Overview** August 6, 2020

Unnamed Project

Replications: 1 Time Units: Minutes

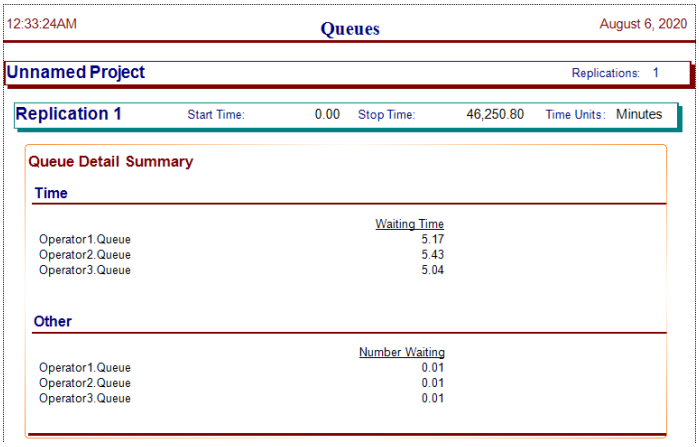
Key Performance Indicators

System

	Average
Number Out	680

Fig. 13: Number of Customers-Alternative

By Queue:



12:33:24AM **Queues** August 6, 2020

Unnamed Project Replications: 1

Replication 1 Start Time: 0.00 Stop Time: 46,250.80 Time Units: Minutes

Queue Detail Summary

Time

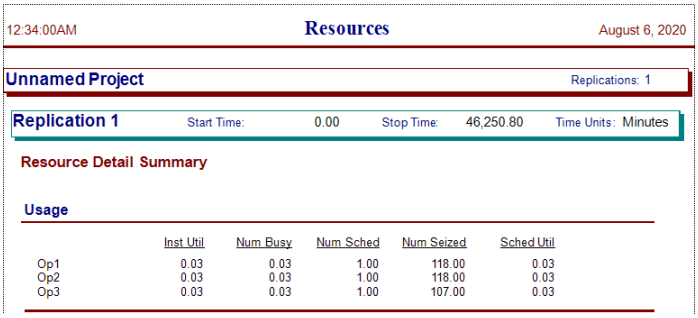
	Waiting Time
Operator1.Queue	5.17
Operator2.Queue	5.43
Operator3.Queue	5.04

Other

	Number Waiting
Operator1.Queue	0.01
Operator2.Queue	0.01
Operator3.Queue	0.01

Fig. 14: Wait Times-Alternative

By Resources



12:34:00AM **Resources** August 6, 2020

Unnamed Project Replications: 1

Replication 1 Start Time: 0.00 Stop Time: 46,250.80 Time Units: Minutes

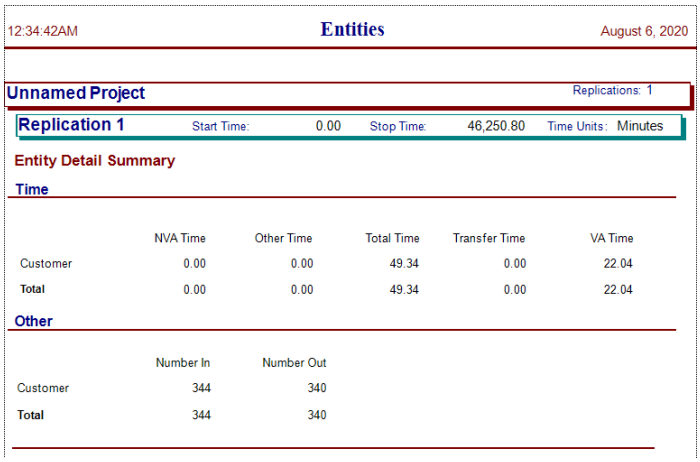
Resource Detail Summary

Usage

	Inst Util	Num Busy	Num Sched	Num Seized	Sched Util
Op1	0.03	0.03	1.00	118.00	0.03
Op2	0.03	0.03	1.00	118.00	0.03
Op3	0.03	0.03	1.00	107.00	0.03

Fig. 15: Resources-Alternative

By Entities



12:34:42AM **Entities** August 6, 2020

Unnamed Project Replications: 1

Replication 1 Start Time: 0.00 Stop Time: 46,250.80 Time Units: Minutes

Entity Detail Summary

Time

	NVA Time	Other Time	Total Time	Transfer Time	VA Time
Customer	0.00	0.00	49.34	0.00	22.04
Total	0.00	0.00	49.34	0.00	22.04

Other

	Number In	Number Out
Customer	344	340
Total	344	340

Fig. 16: Entities-Alternative

Model Verification

Verification is to build a model and implement it correctly along with good input. The following techniques have been followed in the Arena Simulation model.

- Programming and implementation of the conceptual model has been verified to be correctly working.
- Perform testing
    - Static testing: Inputs have walked through, their need of modeling was identified, as well as measuring the output parameter feasibility.
    - Dynamic testing: several parameters were included and removed to test the end results and sensitivity analysis of parameters that affects the performance of the model.

Model Validation

- Data validity*:* Data was obtained from Queensland's official governmental website which guarantees the accuracy of the data.
- The model has executed animation that reflects the actual system without any interruptions or freezing.
- Degenerate Tests: It was tested and noted the effect of having more operators with the customers waiting time. The two parameters are inversely proportional.
- Event Validity: Several events of occurrences of the simulation model are compared to those of the Customer Care Call Centre real system to determine for instance the wait time, and service time.
- Face Validity: A customer care call centre agent of a similar company in terms of operation has been contacted and his opinion was considered in modeling.
- Historical Data Validation: Based on the historical data, and input modeling analysis done in the previous section the number of customers were validated and it was observed that the data was normally distributed with a mean of 314 seconds and a standard deviation of 123 seconds.
- Internal Validity: Several replications have been performed as shown in the Appendix that show acceptable variations of waiting time.

- Traces: Simulation has been set to slow speed that allows visual observation of moving entities to ensure smooth and logical simulation. Several snapshots will be displayed in the Appendix.

MONTE CARLO SIMULATION- MS Excel

Purpose

Monte Carlo Simulation is a technique we have used to understand and identify the impact of uncertainty in our model. It is used to model the probability of different results in our model that cannot be easily predicted because of random variables. We have used this method to model uncertainty and it is considered as a methodical way of doing what-if analysis. It is a technique used to visualize the impact of risk and uncertainty in forecasting models.

The Monte Carlo Simulation is also used to estimate two metrics-

1. To calculate the customer's average waiting time before being served.
2. To calculate the customer's total stay time in the Customer Care Call Centre on Wednesday, 01-06-2020 between 8:30 AM to 4:30 PM.

Model Components

- System: Customer Call Centre
- Entities: 100 Customers
- Resources: Operators, Telephone
- Attributes: Arrival Time
- Event: Arrival/departure of customers, Operators serving
- State Variable: Number of customers, service time, wait time, arrival time
- Problem: Large amount of time spent by customers in the queue and system

Model Assumptions

The total number of customers who called the Customer Care Call Centre on one particular date which is 01/06/2010, is in the range of 1-178. So we do the simulation of customers calling the Customer Call Centre to analyze and estimate the waiting time of customers.

- The basic model has only one operator taking the queries of the customers, and the alternative model has 3 operators to serve the customers.
- Based on the historical data, and input modeling analysis done in the previous section the number of customers is normally distributed with a mean of 314 seconds and a standard deviation of 123 seconds.
- The Customer Care Call Centre believes that each customer takes 1 to 897 seconds to serve. In other words, the service time per customer is uniformly distributed between 1 and 897 seconds.

Input Modeling for Sensitivity Analysis

The sensitivity analysis investigates the stability of results by changing the modeling parameters. While conducting the Monte Carlo simulation for the model we will be considering some assumptions which will be the parameters for our Customer Care Call Centre model to measure the performance of our Customer Care Call Centre in terms of efficiency, resource utilization, and time provided to customers. With the help of Sensitivity Analysis, we were able to determine how the output is affected by making a change in one variable.

The below table describes the input parameters that have been used to model the system.

SNO.	INPUT NAME	DESCRIPTION
1	Customer #	This is the number of customers calling the Customer Care Call Centre on the date 01/06/2010 (100 customers for testing).
2	Rand	This contains a RAND() function where we generate evenly distributed random numbers.
3	Inter Arrival Time	It is the time between two customer arrivals. This will allow us to generate the arrival time. It is random and is calculated as: Syntax- NORM.INV(probability,mean,standard_dev) Model- NORM.INV(Rand,314,123)
4	Arrival Time	This is the time where the customer first calls the Customer Care Call Centre. Arrival Time for the first customer = Inter Arrival Time.

		Arrival Time for next customers = Arrival Time of previous customer + Inter Arrival Time of current customer
5	Service Start Time	It is the time where the customer starts to be served by the operators. It is random. Service Start Time for the first customer = Arrival Time Service Start Time for next customers = MAX(Arrival Time, Service End Time of previous customer)
6	Service End Time	It is the time where the customer finishes being served by the operators. Service End Time = Service Start Time + Service Time
7	Service Time	This is the total time taken to serve the customer. It is random. Service Time = (Min + Rand * (Max - Min)) Where, Min and Max are related to Service Time Distribution.
8	Operators	It represents the number of call centre employees available to serve the customers.
9	Wait Time	This is the time where the customer has been waiting on the line or queue. Wait Time = Service Start Time - Arrival Time
10	Total Time	It represents the total time spent by the customer at the Customer Care Call Centre. Total Time = Service End Time - Arrival Time
11	Inter Arrival Time Distribution	The Inter Arrival Time between the customers is normally distributed with a mean of 314 seconds and a standard deviation of 123 seconds.
12	Service Time Distribution	The service time per customer is uniformly distributed between 1 and 897 seconds.

Table3: Input Modeling of Overall System

Model Design for Sensitivity Analysis

Customer #	Rand	Inter Arrival time	Arrival Time	Service Start Time	Operators	Rand	Service Time	Service End Time	Wait time	Total time
1	0.0756	137.48	137.48	137.48	1	0.4203	377.61	515.10	0	377.61
2	0.1944	208.00	345.49	515.10	1	0.5164	463.68	978.78	170	633.29
3	0.1335	177.50	522.98	978.78	1	0.6628	594.90	1573.68	456	1050.70
4	0.0512	113.07	636.05	1573.68	1	0.8524	764.72	2338.40	938	1702.36
5	0.9588	527.68	1163.73	2338.40	1	0.3215	289.05	2627.45	1175	1463.72
6	0.5949	343.54	1507.27	2627.45	1	0.4483	402.64	3030.10	1120	1522.83
7	0.8349	433.78	1941.05	3030.10	1	0.3372	303.14	3333.24	1089	1392.19
8	0.2792	242.02	2183.06	3333.24	1	0.572	513.49	3846.72	1150	1663.66
9	0.2112	215.31	2398.37	3846.72	1	0.3776	339.37	4186.10	1448	1787.72
10	0.2801	242.34	2640.72	4186.10	1	0.8238	739.13	4925.23	1545	2284.51
11	0.7493	396.69	3037.41	4925.23	1	0.5641	506.40	5431.64	1888	2394.23
12	0.3722	273.91	3311.31	5431.64	1	0.0462	42.38	5474.01	2120	2162.70
13	0.8742	455.04	3766.35	5474.01	1	0.2562	230.56	5704.58	1708	1938.22
14	0.1728	197.99	3964.34	5704.58	1	0.2819	253.60	5958.18	1740	1993.83
15	0.0283	79.44	4043.78	5958.18	1	0.8603	771.84	6730.02	1914	2686.24
16	0.4727	305.58	4349.36	6730.02	1	0.607	544.91	7274.93	2381	2925.57
17	0.3337	261.13	4610.50	7274.93	1	0.0885	80.33	7355.26	2664	2744.77
18	0.2703	238.72	4849.22	7355.26	1	0.3716	333.97	7689.23	2506	2840.02
19	0.762	401.68	5250.89	7689.23	1	0.3282	295.04	7984.28	2438	2733.38
20	0.988	591.79	5842.68	7984.28	1	0.6328	568.02	8552.29	2142	2709.61
21	0.7655	403.08	403.08	403.08	1	0.1173	106.11	509.19	0	106.11
22	0.8143	423.96	827.04	827.04	1	0.3125	280.96	1108.00	0	280.96
23	0.7412	393.59	1220.64	1220.64	1	0.5916	531.05	1751.69	0	531.05

Arrival Time Distribution	
Mean	Stddev
314	123

Service Time Distribution	
Min	1
Max	897
	Seconds

Average Wait Time	2902.267822
Average Total Time	2542.234859

Fig. 17: Sensitivity Analysis Design for one simulation run - Basic

Customer #	Rand	Inter Arrival time	Arrival Time	Service Start Time	Operators	Rand	Service Time	Service End Time	Wait time	Total time
1	0.6345	356.28	356.28	28	3	0.9299	834.19	1190.47	0	834.19
2	0.5963	343.97	700.25	1190.47	2	0.666	597.76	1788.23	490	1087.98
3	0.4503	298.64	998.89	1788.23	3	0.9537	855.53	2643.76	789	1644.87
4	0.2193	218.72	1217.61	2643.76	2	0.6479	581.55	3225.31	1426	2007.70
5	0.4225	289.95	1507.56	3225.31	2	0.826	741.07	3966.38	1718	2458.82
6	0.2097	214.66	1722.22	3966.38	3	0.7233	649.07	4615.45	2244	2893.23
7	0.2386	226.58	1948.80	4615.45	2	0.9993	896.37	5511.82	2667	3563.03
8	0.4721	305.40	2254.20	5511.82	3	0.1116	101.03	5612.85	3258	3358.65
9	0.5852	340.48	2594.68	5612.85	1	0.1483	133.86	5746.71	3018	3152.02
10	0.8782	457.42	3052.10	5746.71	3	0.2328	209.62	5956.33	2695	2904.22
11	0.1724	197.79	3249.90	5956.33	3	0.9885	886.66	6842.99	2706	3593.09
12	0.9403	505.51	3755.41	6842.99	1	0.8888	797.41	7640.40	3088	3884.98
13	0.2718	239.30	3994.72	7640.40	1	0.2154	193.96	7834.36	3646	3839.64
14	0.8767	456.51	4451.22	7834.36	1	0.3384	304.20	8138.55	3383	3687.33
15	0.138	179.99	4631.21	8138.55	2	0.1299	117.35	8255.91	3507	3624.69
16	0.6163	350.37	4981.58	8255.91	1	0.9469	849.45	9105.36	3274	4123.78
17	0.0799	141.07	5122.65	9105.36	1	0.7823	701.97	9807.32	3983	4684.67
18	0.5879	341.31	5463.96	9807.32	2	0.1153	104.27	9911.59	4343	4447.63

Arrival Time Distribution	
Mean	Stddev
314	123

Service Time Distribution	
Min	1
Max	897
	Seconds

Average Wait Time	1048.9905
Average Total Time	649.13418

Fig. 18: Sensitivity Analysis Design for one simulation run of Alternative

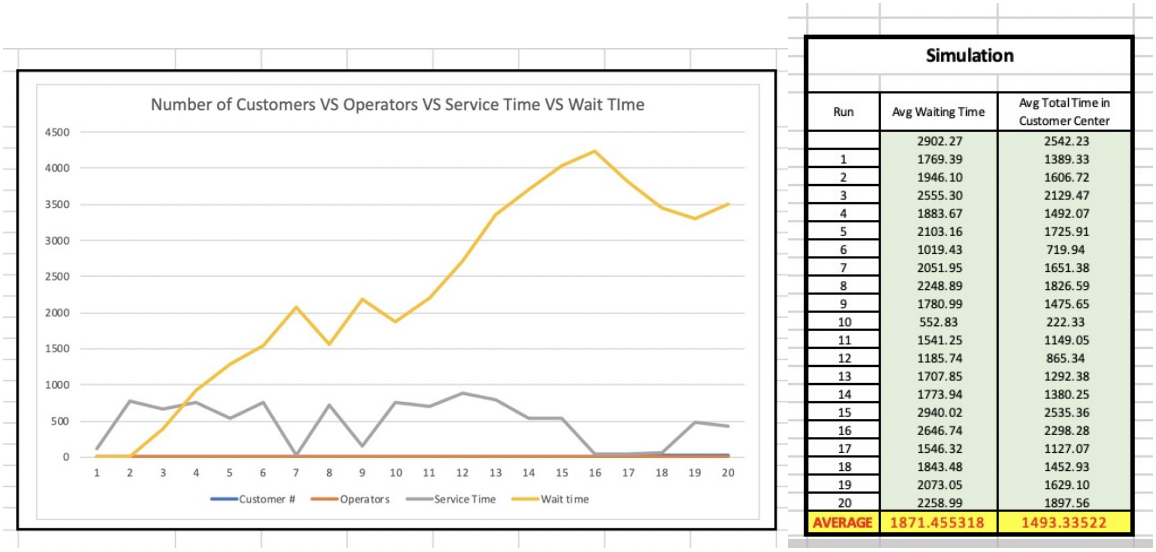
The number of customers arriving in the Customer Care Call Centre is generated in a sequence in order to properly identify the serve and wait time for each customer. The number of operators for the basic model is assumed to be only 1, and for the alternate model the number of operators is created with “RANDBETWEEN” function in excel in the range of (1, 3). The service time and wait time depends on number operators that are present with respect to the number of customers arriving in the queue and accordingly the service time and waiting will be varying.

Output Analysis for Sensitivity Analysis

The table below describes the output parameters that have been used to model the system.

SNO.	OUTPUT NAME	DESCRIPTION
1	Run	It represents 20 runs of simulation.
2	Average Waiting Time	This is the average of the Wait Time of that specific run.
3	Average Total Time in Customer Centre	This is the average of the Total Time of that specific run.
4	Average	This shows the average of every simulation run.

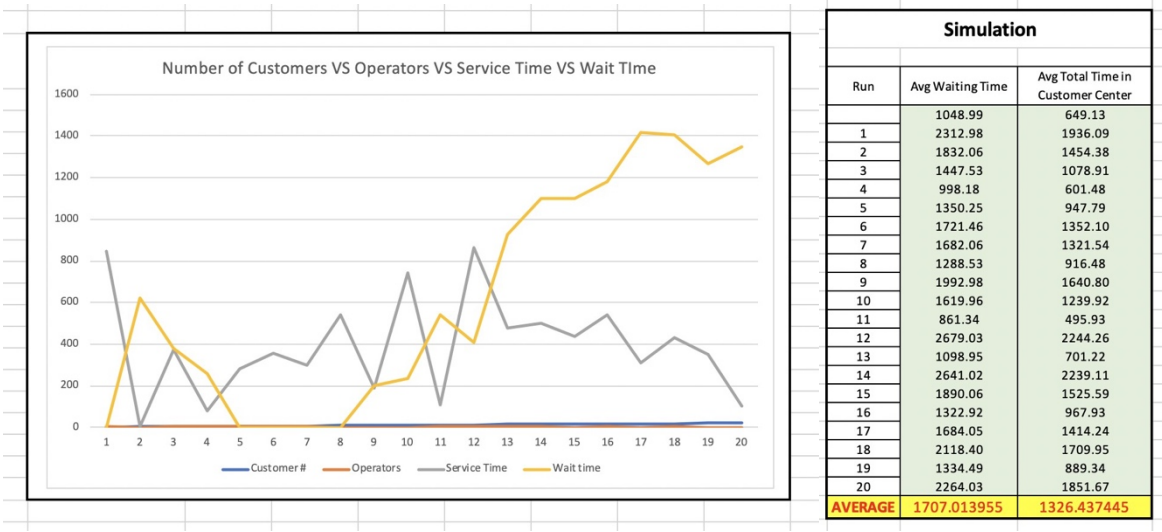
Table 4: Output Modeling of Overall System



Simulation

Run	Avg Waiting Time	Avg Total Time in Customer Center
	2902.27	2542.23
1	1769.39	1389.33
2	1946.10	1606.72
3	2555.30	2129.47
4	1883.67	1492.07
5	2103.16	1725.91
6	1019.43	719.94
7	2051.95	1651.38
8	2248.89	1826.59
9	1780.99	1475.65
10	552.83	222.33
11	1541.25	1149.05
12	1185.74	865.34
13	1707.85	1292.38
14	1773.94	1380.25
15	2940.02	2535.36
16	2646.74	2298.28
17	1546.32	1127.07
18	1843.48	1452.93
19	2073.05	1629.10
20	2258.99	1897.56
AVERAGE	1871.455318	1493.33522

Fig. 19: Sensitivity Model Output of Basic Model



Simulation

Run	Avg Waiting Time	Avg Total Time in Customer Center
	1048.99	649.13
1	2312.98	1936.09
2	1832.06	1454.38
3	1447.53	1078.91
4	998.18	601.48
5	1350.25	947.79
6	1721.46	1352.10
7	1682.06	1321.54
8	1288.53	916.48
9	1992.98	1640.80
10	1619.96	1239.92
11	861.34	495.93
12	2679.03	2244.26
13	1098.95	701.22
14	2641.02	2239.11
15	1890.06	1525.59
16	1322.92	967.93
17	1684.05	1414.24
18	2118.40	1709.95
19	1334.49	889.34
20	2264.03	1851.67
AVERAGE	1707.013955	1326.437445

Fig. 20: Sensitivity Model Output of Alternative Model

From the obtained output it can be observed that as the number of operators decrease the service time would increase and in turn the wait time would increase as well. As shown in the figure, 20 simulation runs or replications were recorded using the What-if analysis (data table) for the model and the best simulation run gave the Average Wait Time as 1049 seconds and the Average Total Time spent on the call by the customers was 650 seconds. Overall, it must follow that as the number of customers is less and staff is high, wait time must be low and vice versa.

Model Verification

Here, we compare the MS Excel simulated model against the concept model that was formed. We checked if each segment of the model is working properly or not. Each step of the model is checked for errors and similarly all the steps till the end are checked and verified before moving to the next step.

- Static testing- we did the static testing by walking through all the input models selected, we identified their need for the model, and analyzed the output parameter feasibility.
- Dynamic testing- several parameters were included and removed to test the end results and sensitivity analysis of parameters that affects the performance of the model.

Model Validation

This was done to check the accuracy of our computer-based model in comparison to the real model. The replication was run 20 times in comparison to the one particular day of a real-life system. The output difference of these systems comes out to be acceptable enough to consider it as an appropriate symbol.

- Degenerate Tests: The degeneracy of the model's behavior is tested by selection of the waiting time of the customers increase as the number of operators serving the customer decreases.

- Comparison of results of both the basic model simulation and the alternate model simulation was recorded and compared which clearly showed the alternate model had better performance.
- Event Validity: Several events of occurrences of the simulation model are compared to those of the Customer Care Call Centre real system to determine for instance the inter arrival time, service start and end time, and many other formulations.
- Historical Data Validation: Based on the historical data, and input modeling analysis done in the previous section the number of customers were validated and it was observed that the data was normally distributed with a mean of 314 seconds and a standard deviation of 123 seconds, and also the service time per customer was uniformly distributed between 1 and 897 seconds. This data was used to build the model.
- Internal Validity: In order to do the internal validation, we first simulated only one replication of the model and recorded the results. Later 20 more replications were done to verify and have an overall average of the replications.
- Multistage Validity: This was done by first developing the model's assumption by visiting and examining the Customer Care Call Centre website. Secondly, we validated the correctness of the assumptions through input modeling. Finally, the input and output parameters were compared with the real system such as the arrival time and serve time variables.
- Parameter Variability - Sensitivity Analysis: This technique was used to change the values of the number of operators serving the customers (1 to 3). We were able to determine the effect upon the model's behavior or output by increasing and decreasing the operators for the Customer Care Call Centre.

CLASS DIAGRAM

Class Diagram is a static diagram which describes the attributes and the operations of the class.

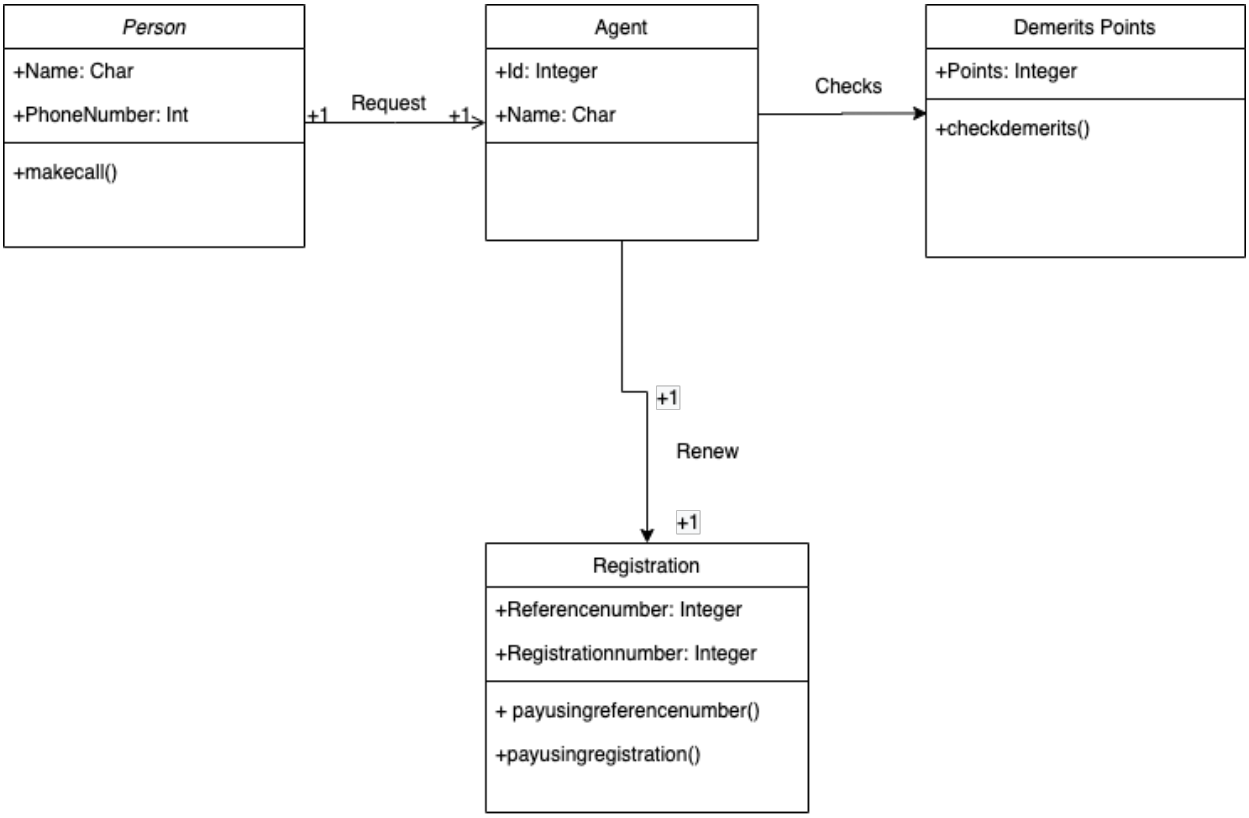


Fig. 21: Class Diagram

The above Class diagram shows the four classes Person, Agent, Demerits Points and Registration. In the Person class Name and the PhoneNumber are the attribute and makecall is a member function.

The client calls the Queensland government service number with the makecall function. The agent receives the call and asks for the client's name and phone number. After verifying the details, the agent will help the client with the information about the demerits points on their driver's license or they can help them with the payment of the car registration.

USE CASE DIAGRAM

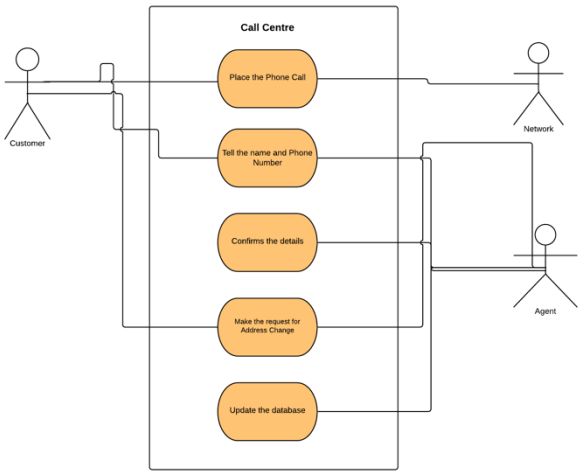


Fig. 22: Use Case Diagram

UML SEQUENCE DIAGRAM

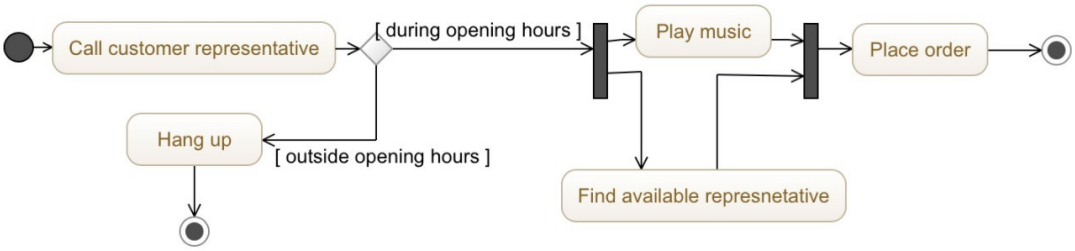


Fig. 23: UML Diagram

The above Sequence diagram shows a scenario of the client making a call to an agent to avail the services of the Queensland government. At first, the client makes the call, and then it is checked whether he/she is calling during office hours if no then the call is hung up and if yes then music is played, and it finds the available representative and connects the call. After connecting the call, the client can ask for any information.

FUTURE SCOPE

Government offices are feeling the pressure to offer a superior support quality with a less holding up time administration to the clients. The future of client assistance needs another model of operational excellence. With time the trend has been changed and the government is taking this quality aspect into consideration. The Government is working on improving the technology and they are also hiring more people for the future projects just to improve the service and quality. The

government of Queensland right now provides a range of services through its agencies call centers and by using different simulation models they can increase the count of services in future. The future of customer service excellence depends upon five things which are customer centricity, outcome-first design, data-driven decision making and workflow, automation-focus, and ecosystem-based. In the future the government needs to focus on these five issues to achieve a better rating in the customer service industry.

CONCLUSION

The project was started to increase customer satisfaction by reducing the waiting time for the customer availing the services of the Queensland government call centre. In a basic Arena simulation model, which has only one operator had an average wait time of 15.61 minutes spent by a customer which is a lot thus increases the waiting time of the customer to talk to an agent. This problem is solved by implementing the Alternative Arena model which has three operators to handle the customer calls and reduces the average wait time by 10.4 minutes. Also, from the Monte Carlo simulation, it can be observed that by adding more operators in the system reduces the average waiting time of the customer by 31 minutes.

CONTRIBUTION LIST

STUDENT ID	NAME	RESPONSIBILITY
40111539	Balkaran Singh Dhillon	Literature Review, Process Mapping, Discrete Event Simulation using Arena, Future Scope
40131626	Mohammed Faizan	Introduction, Project Charter, Kick-off, Problem Statement, Objectives, Discrete Event Simulation using Arena, Monte Carlo Simulation using MS Excel
40150932	Shadi Abu Arshid	System Description, Goodness of Fit test, Data Analysis, Discrete Event Simulation using Arena, References & Appendix
40086602	Varinder Singh	Data Collection, Use Case diagram, Sequence diagram, UML diagram, Process Mapping, Conclusion

Table 6: Contribution Table

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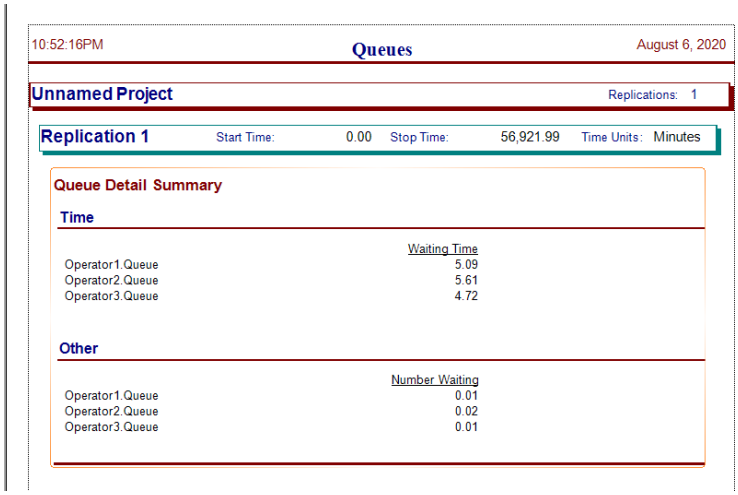
APPENDIX

- Replications screenshots



10:52:16PM — Queues — August 6, 2020

Unnamed Project — Replications: 1

Replication 1 — Start Time: 0.00 — Stop Time: 56,921.99 — Time Units: Minutes

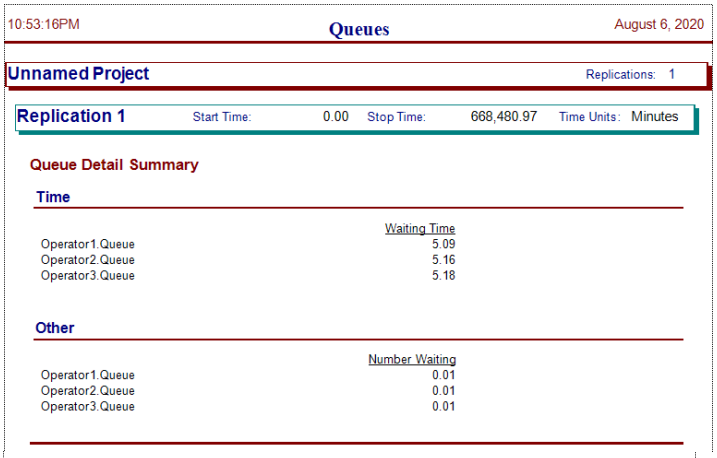
Queue Detail Summary

Time

	Waiting Time
Operator1.Queue	5.09
Operator2.Queue	5.61
Operator3.Queue	4.72

Other

	Number Waiting
Operator1.Queue	0.01
Operator2.Queue	0.02
Operator3.Queue	0.01



10:53:16PM — Queues — August 6, 2020

Unnamed Project — Replications: 1

Replication 1 — Start Time: 0.00 — Stop Time: 668,480.97 — Time Units: Minutes

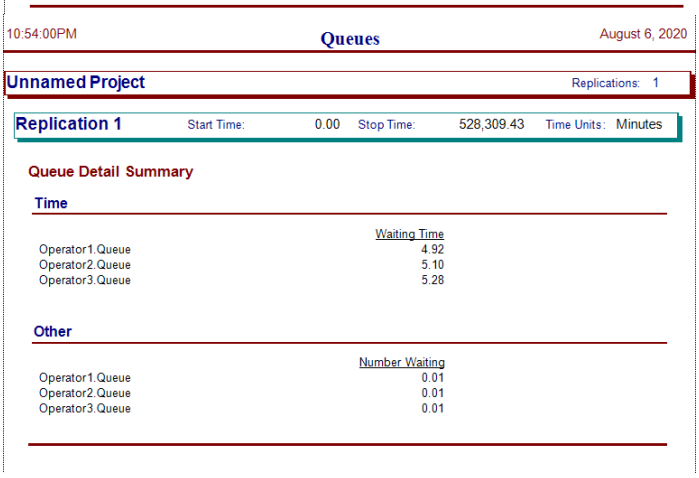
Queue Detail Summary

Time

	Waiting Time
Operator1.Queue	5.09
Operator2.Queue	5.16
Operator3.Queue	5.18

Other

	Number Waiting
Operator1.Queue	0.01
Operator2.Queue	0.01
Operator3.Queue	0.01



10:54:00PM — Queues — August 6, 2020

Unnamed Project — Replications: 1

Replication 1 — Start Time: 0.00 — Stop Time: 528,309.43 — Time Units: Minutes

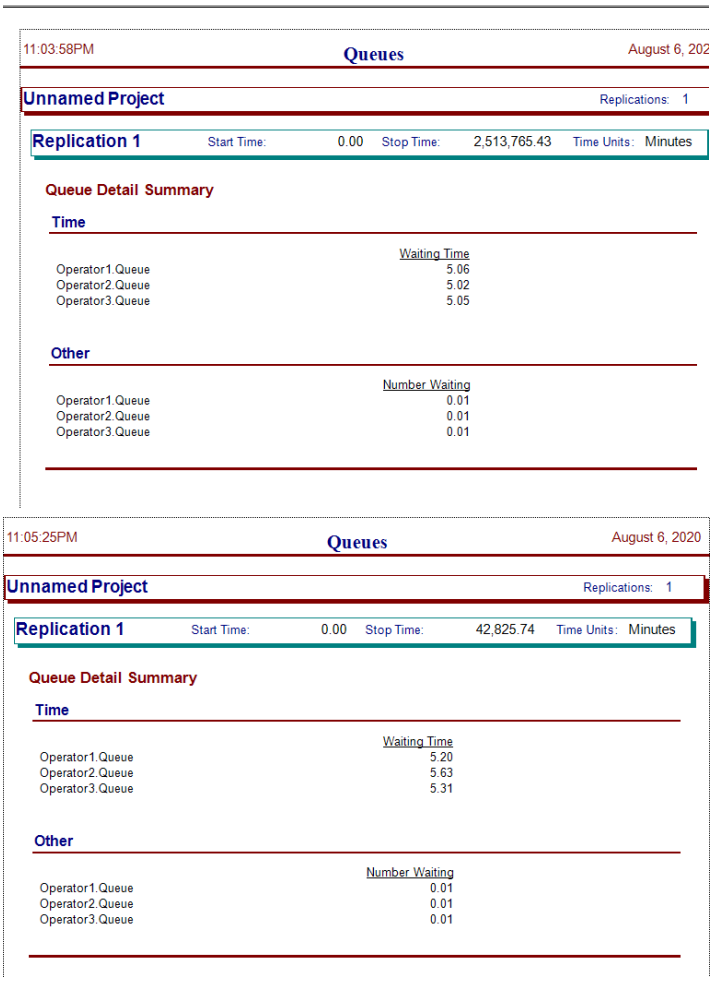
Queue Detail Summary

Time

	Waiting Time
Operator1.Queue	4.92
Operator2.Queue	5.10
Operator3.Queue	5.28

Other

	Number Waiting
Operator1.Queue	0.01
Operator2.Queue	0.01
Operator3.Queue	0.01



11:03:58PM **Queues** August 6, 202

Unnamed Project Replications: 1

Replication 1 Start Time: 0.00 Stop Time: 2,513,765.43 Time Units: Minutes

Queue Detail Summary

Time

	Waiting Time
Operator1.Queue	5.06
Operator2.Queue	5.02
Operator3.Queue	5.05

Other

	Number Waiting
Operator1.Queue	0.01
Operator2.Queue	0.01
Operator3.Queue	0.01

11:05:25PM **Queues** August 6, 2020

Unnamed Project Replications: 1

Replication 1 Start Time: 0.00 Stop Time: 42,825.74 Time Units: Minutes

Queue Detail Summary

Time

	Waiting Time
Operator1.Queue	5.20
Operator2.Queue	5.63
Operator3.Queue	5.31

Other

	Number Waiting
Operator1.Queue	0.01
Operator2.Queue	0.01
Operator3.Queue	0.01

Fig. 24: Arena Replications for Queues

- Traces

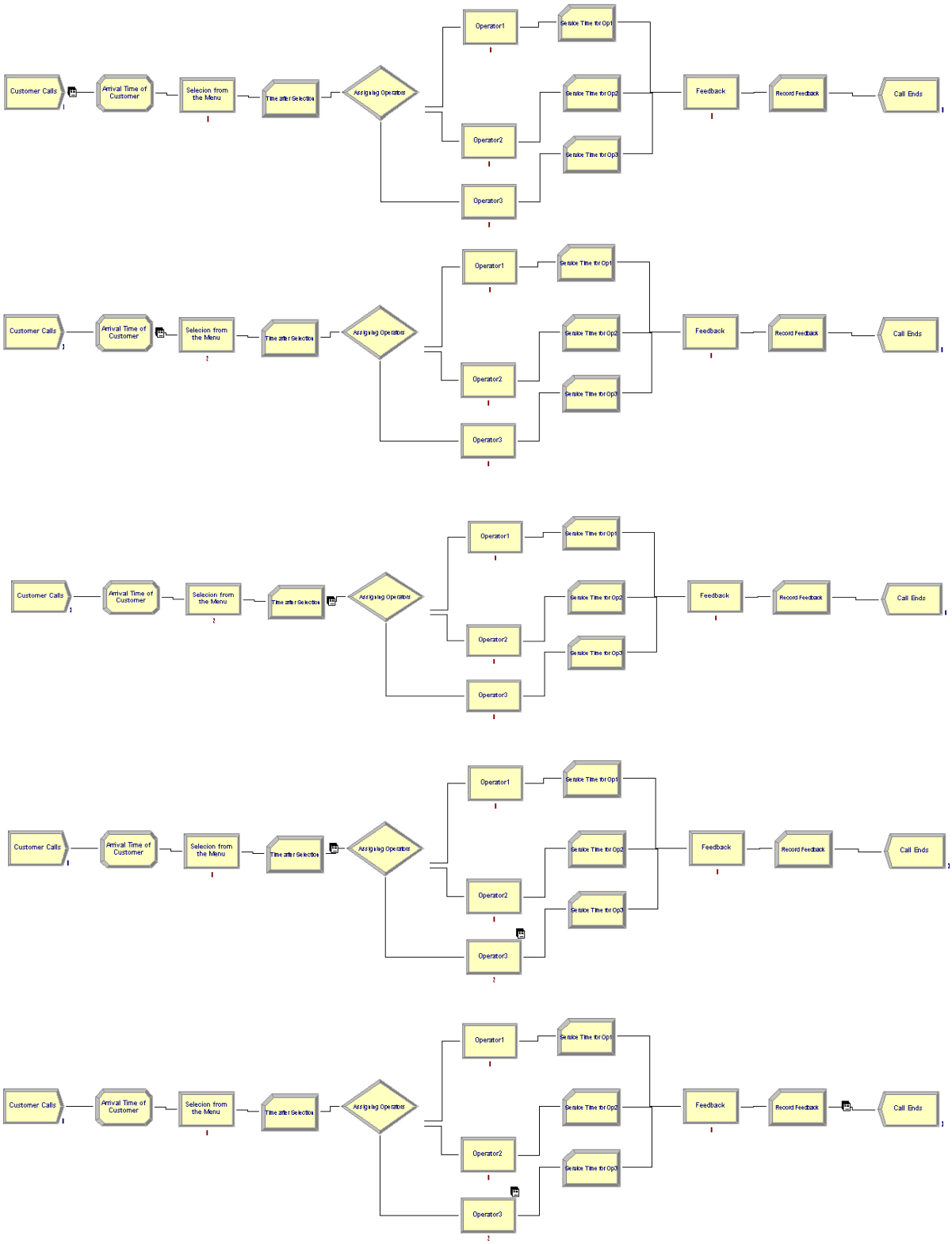


Fig. 25: Arena Alternative Model Tracing

- Monte Carlo Replications

Simulation		
Run	Avg Waiting Time	Avg Total Time in Customer Center
	2458.36	1947.31
1	1691.24	1279.02
2	1129.93	754.58
3	1623.18	1214.34
4	3058.91	2549.53
5	1131.33	719.75
6	2850.67	2320.99
7	1475.21	1031.71
8	2277.75	1767.37
9	1503.21	1109.44
10	3612.34	3009.52
11	1626.95	1197.56
12	2650.27	2176.86
13	3231.63	2670.56
14	1287.76	929.13
15	1976.93	1491.22
16	1564.56	1143.83
17	3014.00	2434.56
18	1227.94	868.31
19	1068.40	678.90
20	1591.97	1176.51
AVERAGE	1979.70897	1526.184806

Simulation		
Run	Avg Waiting Time	Avg Total Time in Customer Center
	514.95	211.84
1	1290.82	921.13
2	2082.46	1660.47
3	1921.79	1497.29
4	1396.05	987.56
5	662.63	337.86
6	1117.06	689.23
7	1762.32	1328.72
8	1575.54	1145.53
9	1998.22	1601.01
10	2565.80	2082.49
11	2294.02	1789.79
12	1093.09	724.41
13	1851.57	1351.80
14	1423.08	1013.80
15	935.26	558.35
16	1802.28	1385.21
17	1754.80	1308.27
18	2258.77	1752.13
19	1923.19	1487.24
20	1474.19	1074.57
AVERAGE	1659.14855	1234.843697

Simulation		
Run	Avg Waiting Time	Avg Total Time in Customer Center
	1388.00	959.99
1	1836.14	1402.93
2	2237.75	1696.17
3	2016.32	1576.82
4	2729.34	2227.62
5	2129.49	1566.13
6	1588.59	1073.37
7	2827.48	2317.15
8	2553.02	2003.63
9	2078.60	1649.42
10	769.46	368.52
11	1448.94	965.30
12	1103.05	726.62
13	1200.15	748.35
14	1556.34	1190.63
15	1576.45	1166.12
16	1327.22	883.79
17	1383.79	961.09
18	809.01	404.28
19	3500.62	2980.05
20	1249.11	892.87
AVERAGE	1796.04427	1340.04385

Fig. 26: Excel Monte Carlo Replications