Project Report

System Simulation @ Burger King

EGRM 6617

System Simulation

Spring 2017

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0. Team & Group Name Identification

Team Name: Simulation Rockers.

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1. Executive Summary

Burger King is one of the fastest growing fast food chain in the USA. Burger King is an American global chain of hamburger fast food restaurants. Headquartered in the unincorporated area of Miami-Dade County, Florida, the company was founded in 1953 as InstaBurger King, a Jacksonville, Florida-based restaurant chain. The growth then become exponential in coming years. With growth comes are much difficult responsibilities of customer satisfaction. There starts coming of the complains regarding the servicing times and waiting time.

In the project, we tried to understand these problems at a local Burger King. With the help of Arena Simulation software, we tried to analyze and study the system for reducing the wait time and servicing time. With the help of ARENA, we simulated the actual working of system at burger king, then for validation With the help of PAN, we come up with different scenarios. That helped to come up with solution at the end.

2. Introduction of Project focus area

During first team meeting, with the help of brainstorming and initial discussion all agreed to do system simulation project in the field of service industry. So, we tried to search around for the location of business of such kind.

Project focus area: Fast Food restaurant- Burger King

Location: 644 Campbell Avenue, West Haven CT- 06516

Type of system: Service based system. The location seems to be busy so, we thought of using system simulation methods to analyses the working and running of the system and give recommendations.

3. Problem statement

The first problem what we have seen there is long queue and more waiting time. The restaurant seems to be busy most of the time. The downtown street of West Haven and crossing with many residency around it makes it busier.

During our research over there we noticed that there are less number of employee working during the busy time of the day-Lunch Time. Due to these is usually a queue of 2-3 customer. There is two cashier machine but only one was used always when we were taking the data, making long wait time during lunch time.

The motivation came for choosing this topic for project is our own experience during the visits over there. The restaurant seems to be busy during day time and at night on weekends. Usually during our visits, we all have seen that there is always waiting time in queue. So, it gave us thought to check and make a real-time simulation model for the store and give recommendations.

We are using Arena 15.0 simulation software for our project.

4. System Analysis

4.1 Graphical Representation of the system

There is fixed layout of the store. The store has two entrance and there is sitting of almost 70 customers. The store also has Drive-Thru. The store has shift based working system of the employee. The drive-thru employee are just focused on giving service to the drive-thru and some employee gives service to instore. There is just one cashier for instore activities.

The store has accessibility for disabled also.

The following simple layout of the store shows basic parts and system of it.

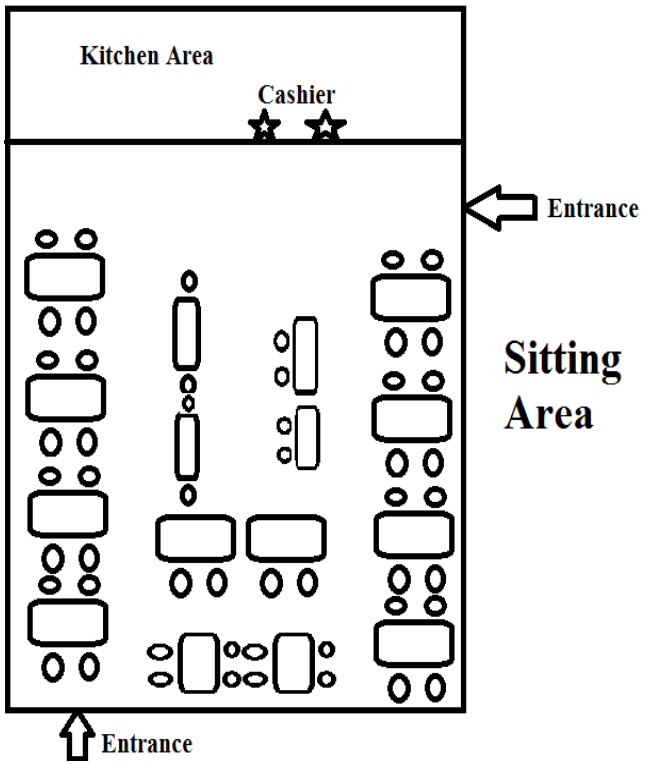


Figure 1: Graphical layout of system

4.2 Objective of the system

The main objective of the system is proper utilization of resource which we think is not properly used. The objective is based on our observation that only one cashier is used when the store is on the pick time of business. The resource such are wasted and same time making conjections in the system. So, we got the objective that we must give the result regarding proper utilization of resource and making waiting time less. There were only six Employee working with one cashier. The store was designed such that only some Employees is allocated the drive-thru and some are given the in-store order.

4.3 Elements of the system

The elements of the system are; customers, cashier, employees, grill machine, fryer, coke machine, tables, frozen freezer, raw materials required for making burger, and others. The elements are mostly obtained locally. Like the main customers are the local people from West Haven, any very little from the from interstate. The use of grill machine is used to make sandwich for them and frozen is used to store the frozen products. Fryer are used to make fries and all.

Simply it could include:

- Employees
- Customers
- Machines
- Raw materials such as; Bun, Frozen products, vegetables etc.

4.4 Type of system

The type of system that could best describe the system is **Dynamic/Discrete/Stochastic/Open system**

Following are the reasons for these type of system

- Dynamic: It is because the system is affected by change in time. Time is the factor that is analyzed.
- Discrete: Because the arrival of customers is one by one and not continuous as a line. Also, the arrival is countable so these is discrete type.
- Stochastic: It is because the arrival of eutomer is in random way.
- Open system: The system can be affected by any other things from outside so it is open in nature.

4.5 Variables of the system

The variable is the generally time dependent. The variance noted in the variable is of importance in the simulation. In study of the store we have considered # of customers serviced during the noting of time. Also, interarrival time and service time are also variable as they are influenced by order and time of the day. Waiting and queue time are also of importance.

4.6 Parameters of the system

Parameters are # of employee working during particular time of the day, sitting capacity of the store, # of cashier working, data collection time is also parameter in the system. Some are controllable parameter and some are uncontrollable parameter.

4.7 Feedback or causal relations (Relationships)

The relationships in the system are space based and time based. As the machine and type of products are having space based relationship. There is also a dependent relationship between fryer and frozen. As the frozen machine and fryer are adjacent steps from fries and frozen foods. The same is with grill and frozen.

4.8 System performance metrics

- Minimum/Maximum/Average length of queue,
- Minimum/Maximum/Average waiting time for the customers/service time,
- Minimum/Maximum/Average utilization (resource schedule) with efficiency of workers which are the major performance metrics

4.9 Constants of the system

Anything that can't be changed over time is constants in the system. The layout of the system is one of constant parameter in the system. The positions of the machine and time of operation of the store.

4.10 Constraints of the system

Constraints of the system are one that is having restriction for further use then allotted. Example number of employee in the shifts, number of workers can work, supply, maximum number of customers allowed in the store by city, capacities of the machines.

4.11 Environment around the system

The environment around the store is very dynamic in the sense that there is always moment of cars, buses, people and more. There is bus stand near by which also makes it busier place. And there is exit for interstate that also impact the business of the store.

4.12 Subsystems

No subsystems are presents.

5 Input Data Collection and Analysis

Data for the simulation were collected from the location directly with the help of team mates. The strategy for collection of data was to take the help of stopwatch and visually noting the timings of the customer as they pass the point where the timing was to be taken. The timings were noted on the sheet made specially made to take time.The data were collected for following days and time

- **Wednesday - Afternoon and Evening**
- **Saturday – Afternoon and Evening**

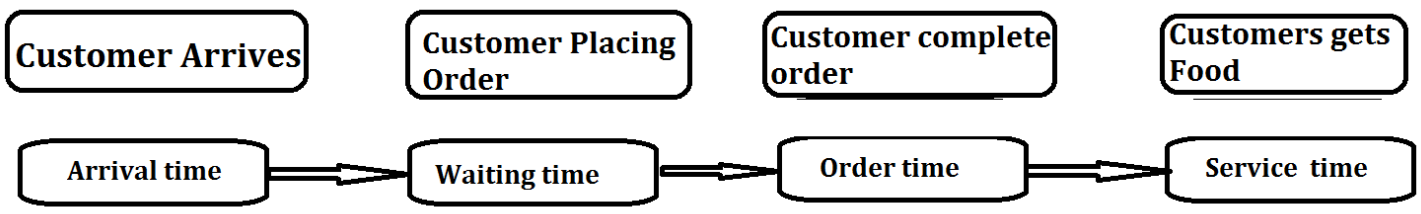


Figure 2: Points of timing that were taken

The data were taken then the timings were placed in Excel file for further help in analysis. The timings were taken with following rule.

- **Interarrival Time:** The time difference between the arrival of customers. The time depends on the rate of arrival.
- **Waiting Time:** The time difference between the customers' arrival and the time he starts to place his/her order. These will give the waiting time in the queue.
- **Order Time:** The time difference between the customer placing and finishing the order. These times can help in analysis the complexity of placing the order if the customer is new/old.
- **Service Time:** The time difference between the customer finishing his/her order and getting food. The time will help in analysis the service timing and its effects.

5.1 Initial Raw Data

The following is the data from Wednesday-Afternoon and Evening

Wednesday(Afternoon) Time: 12:40 PM Date: 03/01/2017

Customer Number	Arrival Time	Queuing Time	Ordering Time	Service Time	Raw Data in seconds: Interarrival Time	Waiting Time	Ordering Tiime	Service Time
1	0:00:15	0:00:26	0:02:00	0:09:39	15	11	94	459
2	0:02:09	0:02:15	0:04:30	0:07:26	114	06	135	176
3	0:08:50	0:09:00	0:09:50	0:12:40	401	10	50	170
4	0:09:30	0:09:52	0:10:52	0:14:25	40	22	60	213
5	0:12:09	0:12:14	0:12:55	0:15:41	159	05	41	166
6	0:15:50	0:15:52	0:17:10	0:20:19	221	02	78	189
7	0:16:55	0:17:20	0:17:55	0:20:34	65	25	35	159
8	0:18:09	0:18:17	0:19:35	0:20:51	74	08	78	76
9	0:18:35	0:19:40	0:20:20	0:22:10	26	65	40	110
10	0:20:30	0:20:35	0:21:15	0:23:38	115	05	40	143
11	0:22:35	0:23:05	0:23:50	0:26:10	125	30	45	140
12	0:23:50	0:24:54	0:25:15	0:28:50	75	64	21	215
13	0:24:00	0:25:33	0:26:45	0:31:55	10	93	72	310
14	0:25:03	0:26:58	0:27:40	0:28:20	63	115	42	40
15	0:29:30	0:29:45	0:30:45	0:32:45	267	15	60	120
16	0:30:59	0:31:33	0:32:50	0:34:45	89	34	77	115
17	0:31:30	0:34:00	0:34:31	0:36:21	31	150	31	110
18	0:31:50	0:34:40	0:35:20	0:38:30	20	170	40	190
19	0:33:45	0:35:25	0:36:50	0:42:50	115	100	85	360
20	0:34:50	0:36:53	0:37:10	0:37:30	65	123	17	20
21	0:35:38	0:37:14	0:39:00	0:42:24	48	96	106	204
22	0:38:48	0:39:10	0:40:20	0:43:50	190	22	70	210
23	0:39:07	0:40:25	0:43:07	0:44:15	19	78	162	68
24	0:39:20	0:43:20	0:44:13	0:46:45	13	240	53	152
25	0:40:40	0:44:13	0:44:40	0:49:35	80	213	27	295
26	0:44:30	0:45:20	0:46:20	0:49:29	230	50	60	189
27	0:47:00	0:47:09	0:47:30	0:49:35	150	09	21	125
28	0:47:15	0:47:35	0:48:31	0:51:15	15	20	56	164
29	0:47:32	0:51:18	0:52:35	0:55:12	17	226	77	157
30	0:48:37	0:52:54	0:54:06	0:55:48	65	257	72	102
31	0:49:00	0:54:11	0:54:59	0:56:15	23	311	48	76
32	0:51:36	0:55:00	0:56:10	1:00:10	156	204	70	240
33	0:51:42	0:57:13	0:57:53	1:01:09	06	331	40	196
34	0:53:00	0:59:15	1:00:06	1:01:58	78	375	51	112
35	0:54:42	1:00:25	1:01:49	1:02:29	102	343	84	40
36	0:54:50	1:01:52	1:02:35	1:06:14	08	422	43	219
37	0:56:10	1:02:38	1:03:53	1:07:34	80	388	75	221
38	0:56:30	1:03:56	1:04:27	1:09:17	20	446	31	290
39	0:58:00	1:04:30	1:06:50	1:09:32	90	390	140	162
40	1:02:08	1:06:58	1:09:41	1:12:00	248	290	163	139
41	1:02:15	1:08:44	1:09:00	1:11:00	07	389	16	120
42	1:04:38	1:09:42	1:10:15	1:13:30	143	304	33	195
43	1:05:14	1:10:28	1:11:28	1:17:05	36	314	60	337
44	1:05:20	1:11:38	1:12:19	1:15:00	06	378	41	161
45	1:06:50	1:12:20	1:13:03	1:17:30	90	330	43	267

Mean	89	166	62	176
Standard Deviation	84	149	35	88
UCL	300	537	149	395
LCL	-122	-205	-26	-43

Wednesday(Evening) Time: 08:00 PM Date: 03/01/2017

Customer Number	Arrival Time	Queuing Time	Order Time	Service Time	Raw Data in seconds: Interarrival Time	Waiting Time	Ordering time	Service Time
1	0:00:43	0:00:48	0:01:56	0:04:16	43	05	68	140
2	0:03:01	0:03:06	0:03:45	0:06:35	138	05	39	170
3	0:10:00	0:10:05	0:11:15	0:13:11	419	05	70	116
4	0:13:43	0:13:46	0:14:32	0:15:22	223	03	46	50
5	0:15:12	0:15:15	0:15:45	0:16:07	89	03	30	22
6	0:22:59	0:23:05	0:23:52	0:25:00	467	06	47	68
7	0:23:09	0:23:59	0:24:19	0:27:27	10	50	20	188
8	0:24:15	0:25:42	0:26:54	0:29:39	66	87	72	165
9	0:25:15	0:26:09	0:26:54	0:29:39	60	54	45	165
10	0:26:14	0:27:35	0:28:49	0:32:40	59	81	74	231
11	0:30:35	0:30:58	0:31:29	0:33:00	261	23	31	91
12	0:35:50	0:35:55	0:36:12	0:37:10	315	05	17	58
13	0:35:59	0:36:16	0:36:38	0:38:07	09	17	22	89
14	0:36:15	0:36:40	0:37:44	0:38:45	16	25	64	61
15	0:43:20	0:43:22	0:44:50	0:47:30	425	02	88	160
16	0:44:50	0:44:52	0:45:50	0:48:30	90	02	58	160
17	0:44:52	0:45:56	0:46:35	0:49:35	02	64	39	180
18	0:45:13	0:46:39	0:47:35	0:50:59	21	86	56	204
19	0:46:35	0:47:39	0:49:38	0:53:13	82	64	119	215
20	0:47:10	0:49:42	0:50:51	0:55:30	35	152	69	279
21	0:52:14	0:52:15	0:52:50	0:56:31	304	01	35	221
22	0:54:20	0:54:25	0:55:29	0:57:26	126	05	64	117
23	0:59:08	0:59:10	1:01:15	1:02:39	288	02	125	84
24	1:01:54	1:01:56	1:02:48	1:03:39	166	02	52	51
25	1:02:00	1:02:58	1:03:45	1:05:29	06	58	47	104
26	1:04:31	1:04:33	1:05:30	1:07:53	151	02	57	143
27	1:08:11	1:08:14	1:08:42	1:10:37	220	03	28	115
28	1:08:13	1:08:47	1:09:12	1:09:25	02	34	25	13
29	1:12:36	1:12:38	1:13:49	1:15:39	263	02	71	110
30	1:15:14	1:15:16	1:16:05	1:17:10	158	02	49	65
31	1:16:39	1:16:42	1:17:19	1:19:18	85	03	37	119
32	1:18:27	1:18:29	1:19:10	1:20:49	108	02	41	99
33	1:19:49	1:19:54	1:21:07	1:23:16	82	05	73	129
34	1:19:49	1:21:10	1:22:21	1:25:10	00	81	71	169
35	1:24:11	1:24:13	1:25:07	1:26:49	262	02	54	102
36	1:24:12	1:25:10	1:26:20	1:28:17	01	58	70	117
37	1:25:11	1:26:20	1:27:10	1:29:50	59	69	50	160
38	1:27:10	1:27:11	1:28:07	1:30:59	119	01	56	172
39	1:28:34	1:28:36	1:29:10	1:31:10	84	02	34	120
40	1:31:10	1:31:11	1:31:55	1:32:39	156	01	44	44
41	1:33:10	1:33:12	1:34:10	1:36:02	120	02	58	112
42	1:35:11	1:35:12	1:36:12	1:38:10	121	01	60	118
43	1:35:12	1:36:15	1:37:10	1:39:11	01	63	55	121
44	1:35:14	1:37:18	1:38:10	1:40:19	02	124	52	129
45	1:37:10	1:38:18	1:38:53	1:42:10	116	68	35	197

Mean	130	30	54	128
Standard Deviation	123	38	22	58
UCL	436	125	109	272
LCL	-177	-66	-02	-17

The following is the data from Saturday-Afternoon

Saturday(Afternoon) Time: 1:00 PM Date: 03/04/2017						Raw Data in seconds			
Customer Number	Arrival Time	Queuing Time	Order Time	Service Time		Interarrival Time	Waiting Time	Ordering Time	Service Time
1	0:00:18	0:00:25	0:02:05	0:07:48		18	07	100	343
2	0:00:37	0:02:15	0:02:57	0:07:50		19	98	42	293
3	0:01:50	0:03:06	0:04:32	0:10:56		73	76	86	384
4	0:04:26	0:05:10	0:05:59	0:12:19		156	44	49	380
5	0:06:17	0:08:29	0:09:04	0:13:56		111	132	35	292
6	0:07:12	0:09:11	0:10:05	0:16:56		55	119	54	411
7	0:09:27	0:10:12	0:11:31	0:18:35		135	45	79	424
8	0:10:08	0:14:12	0:15:09	0:15:55		41	244	57	46
9	0:13:58	0:15:16	0:16:07	0:17:11		230	78	51	64
10	0:17:49	0:17:52	0:18:38	0:26:56		231	03	46	498
11	0:18:13	0:18:40	0:19:48	0:21:28		24	27	68	100
12	0:19:46	0:20:25	0:21:56	0:23:05		93	39	91	69
13	0:24:10	0:24:30	0:25:49	0:28:55		264	20	79	186
14	0:25:28	0:26:35	0:27:18	0:29:14		78	67	43	116
15	0:27:16	0:27:52	0:28:17	0:31:01		108	36	25	164
16	0:30:14	0:31:04	0:32:35	0:35:24		178	50	91	169
17	0:31:06	0:32:43	0:33:05	0:37:03		52	97	22	238
18	0:32:20	0:33:10	0:34:03	0:38:10		74	50	53	247
19	0:37:29	0:37:35	0:38:28	0:38:54		309	06	53	26
20	0:37:46	0:38:33	0:39:09	0:44:00		17	47	36	291
21	0:40:27	0:40:46	0:41:28	0:44:34		161	19	42	186
22	0:40:35	0:41:39	0:42:28	0:44:42		08	64	49	134
23	0:42:20	0:44:54	0:45:30	0:47:25		105	154	36	115
24	0:43:11	0:45:35	0:46:11	0:47:10		51	144	36	59
25	0:44:18	0:46:14	0:47:59	0:50:29		67	116	105	150
26	0:45:59	0:48:09	0:48:53	0:51:30		101	130	44	157
27	0:49:33	0:50:50	0:51:35	0:53:38		214	77	45	123
28	0:51:30	0:52:16	0:53:24	0:56:11		117	46	68	167
29	0:51:35	0:53:28	0:54:15	0:56:46		05	113	47	151
30	0:51:57	0:54:22	0:54:50	0:56:59		22	145	28	129
31	0:53:32	0:54:54	0:55:38	0:58:26		95	82	44	168
32	0:54:35	0:55:50	0:56:30	0:58:45		63	75	40	135
33	0:54:40	0:56:48	0:57:55	1:01:03		05	128	67	188
34	0:57:01	0:57:58	0:58:50	1:03:10		141	57	52	260
35	0:59:32	1:00:25	1:01:29	1:03:50		151	53	64	141
36	1:01:18	1:01:50	1:03:25	1:05:18		106	32	95	113
37	1:03:00	1:04:09	1:05:42	1:06:13		102	69	93	31
38	1:03:46	1:05:55	1:06:50	1:09:09		46	129	55	139
39	1:06:23	1:06:59	1:08:26	1:10:11		157	36	87	105
40	1:07:41	1:08:32	1:09:18	1:11:21		78	51	46	123
41	1:07:48	1:09:42	1:09:54	1:12:45		07	114	12	171
42	1:08:37	1:09:59	1:10:26	1:14:38		49	82	27	252
43	1:09:22	1:11:26	1:11:45	1:15:26		45	124	19	221
44	1:13:58	1:14:05	1:14:58	1:16:53		276	07	53	115
45	1:14:10	1:15:04	1:16:10	1:18:19		12	54	66	129
					Mean	99	75	55	187
					Std Dev	78	49	23	110
					UCL	295	199	113	462
					LCL	-97	-48	-03	-89

Saturday(Evening) Time: 1:00 PM Date: 03/04/2017						Raw Data in seconds			
Customer Number	Arrival Time	Queuing Time	Order Time	Service Time		Interarrival Time	Waiting Time	Ordering Time	Service Time
1	0:00:23	0:00:58	0:02:14	0:04:17		23	35	76	123
2	0:01:15	0:02:23	0:03:36	0:05:31		52	68	73	115
3	0:01:23	0:03:49	0:04:38	0:06:26		08	146	49	108
4	0:01:56	0:04:53	0:05:58	0:06:51		33	177	65	53
5	0:02:48	0:06:43	0:07:52	0:09:28		52	235	69	96
6	0:05:14	0:07:58	0:08:46	0:11:29		146	164	48	163
7	0:06:23	0:08:50	0:10:41	0:14:15		69	147	111	214
8	0:06:44	0:10:55	0:12:35	0:14:56		21	251	100	141
9	0:07:12	0:12:42	0:13:53	0:16:09		28	330	71	136
10	0:09:11	0:13:58	0:14:37	0:15:44		119	287	39	67
11	0:12:39	0:14:48	0:15:59	0:17:12		208	129	71	73
12	0:15:48	0:16:53	0:17:38	0:19:54		189	65	45	136
13	0:16:55	0:17:49	0:19:27	0:22:17		67	54	98	170
14	0:19:45	0:19:56	0:21:01	0:22:53		170	11	65	112
15	0:21:16	0:21:48	0:22:22	0:25:51		91	32	34	209
16	0:24:12	0:24:20	0:25:39	0:27:32		176	08	79	113
17	0:25:23	0:25:45	0:27:55	0:30:11		71	22	130	136
18	0:28:19	0:28:54	0:29:48	0:32:25		176	35	54	157
19	0:28:54	0:30:00	0:32:21	0:33:58		35	66	141	97
20	0:30:22	0:32:29	0:33:49	0:36:51		88	127	80	182
21	0:32:16	0:33:53	0:35:42	0:38:12		114	97	109	150
22	0:35:19	0:35:58	0:37:21	0:39:43		183	39	83	142
23	0:36:20	0:37:59	0:38:46	0:42:54		61	99	47	248
24	0:37:48	0:40:18	0:41:12	0:44:19		88	150	54	187
25	0:39:26	0:41:20	0:42:56	0:44:53		98	114	96	117
26	0:43:51	0:44:19	0:45:57	0:48:28		265	28	98	151
27	0:44:12	0:46:58	0:48:14	0:51:23		21	166	76	189
28	0:44:24	0:48:19	0:49:10	0:51:57		12	235	51	167
29	0:45:52	0:49:16	0:50:17	0:53:25		88	204	61	188
30	0:45:55	0:50:23	0:51:17	0:53:49		03	268	54	152
31	0:49:56	0:51:53	0:52:44	0:55:21		241	117	51	157
32	0:50:41	0:52:48	0:54:15	0:56:07		45	127	87	112
33	0:50:52	0:54:28	0:55:49	0:58:28		11	216	81	159
34	0:51:31	0:55:56	0:57:12	0:59:56		39	265	76	164
35	0:53:24	0:57:17	0:59:18	1:02:19		113	233	121	181
36	0:56:45	0:59:24	1:00:47	1:03:41		201	159	83	174
37	0:58:21	1:00:52	1:02:32	1:04:55		96	151	100	143
38	0:58:51	1:02:47	1:03:39	1:06:24		30	236	52	165
39	0:59:44	1:03:45	1:04:58	1:06:55		53	241	73	117
40	1:00:13	1:05:03	1:05:46	1:08:12		29	290	43	146
41	1:00:39	1:05:52	1:06:33	1:08:39		26	313	41	126
42	1:00:55	1:06:40	1:07:29	1:09:47		16	345	49	138
43	1:03:26	1:07:34	1:08:54	1:11:15		151	248	80	141
44	1:04:52	1:08:58	1:09:51	1:11:28		86	246	53	97
45	1:06:49	1:09:57	1:10:36	1:12:19		117	188	39	103
					Mean	89	159	72	143
					Std Dev	69	95	26	39
					UCL	261	397	136	241
					LCL	-83	-78	08	44

The red and yellow marks are the outliers in the data.

5.2 Data after removing outliers

The outliers were found with the help of rule of thumb. It is used to find the UCL and LCL so that the outliers can be found from the data. The UCL/LCL can be found with the help of $Mean \pm 2.5\ standard\ deviation$.

Following are the data after removing the outliers

Wednesday(Afternoon)

After Removal of Outliers

Interarrival Time	Waiting Time	Ordering Tiime	Service Time
15	11	94	176
114	06	135	170
40	10	50	213
159	22	60	166
221	05	41	189
65	02	78	159
74	25	35	76
26	08	78	110
115	65	40	143
125	05	40	140
75	30	45	215
10	64	21	310
63	93	72	40
267	115	42	120
89	15	60	115
31	34	77	110
20	150	31	190
115	170	40	360
65	100	85	20
48	123	17	204
190	96	106	210
19	22	70	68
13	78	53	152
80	240	27	295
230	213	60	189
150	50	21	125
15	09	56	164
17	20	77	157
65	226	72	102
23	257	48	76
156	311	70	240
06	204	40	196
78	331	51	112
102	375	84	40
08	343	43	219
80	422	75	221
20	388	31	290
90	446	140	162
248	390	16	139
07	290	33	120
143	389	60	195
36	304	41	337
06	314	43	161
90	378		267
	330		

Wednesday(Evening)

After Removal of Outliers

Interarrival Time	Waiting Time	Ordering time	Service Time
43	05	68	140
138	05	39	170
419	05	70	116
223	03	46	50
89	03	30	22
10	06	47	68
66	50	20	188
60	87	72	165
59	54	45	165
261	81	74	231
315	23	31	91
09	05	17	58
16	17	22	89
425	25	64	61
90	02	88	160
02	02	58	160
21	64	39	180
82	86	56	204
35	64	69	215
304	01	35	221
126	05	64	117
288	02	52	84
166	02	47	51
06	58	57	104
151	02	28	143
220	03	25	115
02	34	71	13
263	02	49	110
158	02	37	65
85	03	41	119
108	02	73	99
82	05	71	129
00	81	54	169
262	02	70	102
01	58	50	117
59	69	56	160
119	01	34	172
84	02	44	120
156	01	58	44
120	02	60	112
121	01	55	118
01	63	52	121
02	124	35	129
116	68		197

Saturday(Afternoon)			
After Removal of Outliers			
Interarrival Time	Waiting Time	Ordering Time	Service Time
18	07	100	343
19	98	42	293
73	76	86	384
156	44	49	380
111	132	35	292
55	119	54	411
135	45	79	424
41	78	57	46
230	03	51	64
231	27	46	100
24	39	68	69
93	20	91	186
264	67	79	116
78	36	43	164
108	50	25	169
178	97	91	238
52	50	22	247
74	06	53	26
17	47	53	291
161	19	36	186
08	64	42	134
105	154	49	115
51	144	36	59
67	116	36	150
101	130	105	157
214	77	44	123
117	46	45	167
05	113	68	151
22	145	47	129
95	82	28	168
63	75	44	135
05	128	40	188
141	57	67	260
151	53	52	141
106	32	64	113
102	69	95	31
46	129	93	139
157	36	55	105
78	51	87	123
07	114	46	171
49	82	12	252
45	124	27	221
276	07	19	115
12	54	53	129
		66	

Saturday(Evening)			
After Removal of Outliers			
Interarrival Time	Waiting Time	Ordering Time	Service Time
23	35	76	123
52	68	73	115
08	146	49	108
33	177	65	53
52	235	69	96
146	164	48	163
69	147	111	214
21	251	100	141
28	330	71	136
119	287	39	67
208	129	71	73
189	65	45	136
67	54	98	170
170	11	65	112
91	32	34	209
176	08	79	113
71	22	130	136
176	35	54	157
35	66	80	97
88	127	109	182
114	97	83	150
183	39	47	142
61	99	54	187
88	150	96	117
98	114	98	151
21	28	76	189
12	166	51	167
88	235	61	188
03	204	54	152
241	268	51	157
45	117	87	112
11	127	81	159
39	216	76	164
113	265	121	181
201	233	83	174
96	159	100	143
30	151	52	165
53	236	73	117
29	241	43	146
26	290	41	126
16	313	49	138
151	345	80	141
86	248	53	97
117	246	39	103
	188		

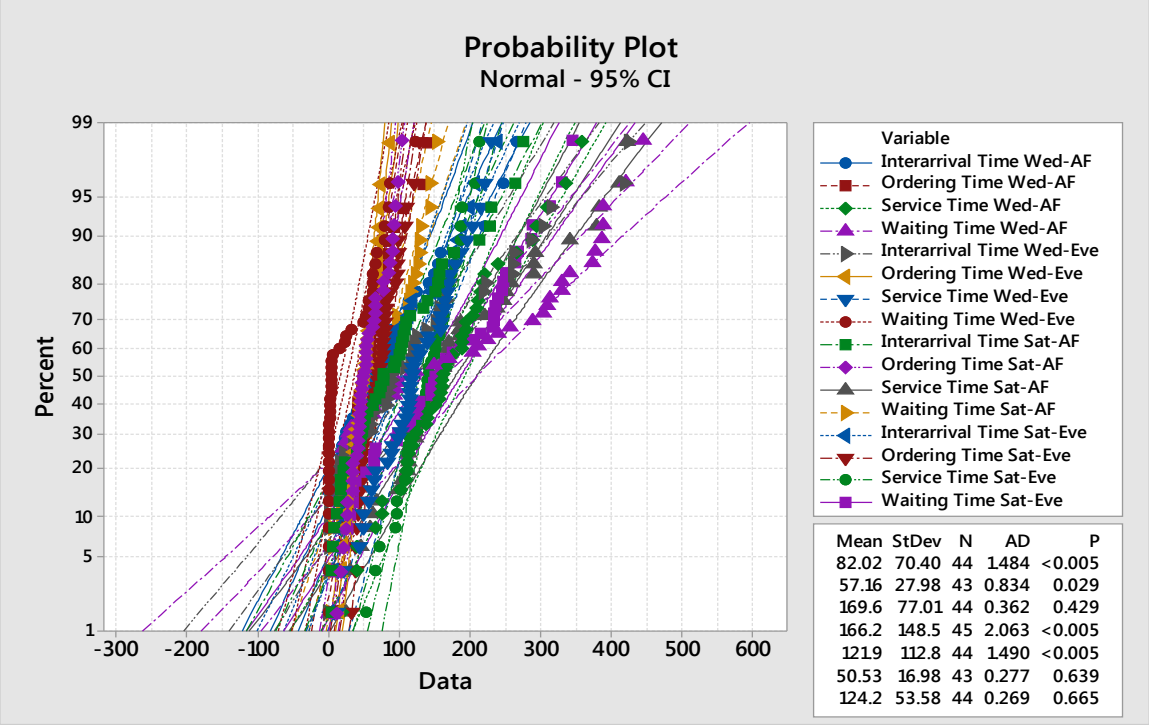


Figure 3: Normality Plot for All the timings

Here it can be seen that some data are following normal distribution and some are not following normal distribution.

Descriptive Statistics:

Variable	Mean	SE Mean	StDev	Sum of Squares	Minimum	Q1	Median	Q3	Maximum
Interarrival Time Wed-AF	82.0	10.6	70.4	509145.0	6.0	20.0	69.5	115.0	267.0
Ordering Time Wed-AF	57.16	4.27	27.98	173388.00	16.00	40.00	51.00	75.00	140.00
Service Time Wed-AF	169.6	11.6	77.0	1520849.0	20.0	116.3	163.0	212.3	360.0
Waiting Time Wed-AF	166.2	22.1	148.5	2213381.0	2.0	22.0	115.0	312.5	446.0
Interarrival Time Wed-Ev	121.9	17.0	112.8	1200403.0	0.0	24.5	89.5	164.0	425.0
Ordering Time Wed-Eve	50.53	2.59	16.98	121927.00	17.00	37.00	52.00	64.00	88.00
Service Time Wed-Eve	124.18	8.08	53.58	801954.00	13.00	89.50	118.50	165.00	231.00
Waiting Time Wed-Eve	26.82	5.06	33.54	80022.00	1.00	2.00	5.00	58.00	124.00
Interarrival Time Sat-AF	94.1	10.9	72.2	613965.0	5.0	42.0	78.0	139.5	276.0
Ordering Time Sat-AF	55.11	3.45	23.11	160176.00	12.00	41.00	51.00	68.00	105.00
Service Time Sat-AF	179.7	15.2	100.6	1855605.0	26.0	115.3	154.0	244.8	424.0
Waiting Time Sat-AF	71.41	6.42	42.61	302436.00	3.00	40.25	65.50	113.75	154.00
Interarrival Time Sat-Ev	85.09	9.64	63.97	494564.00	3.00	29.25	70.00	118.50	241.00
Ordering Time Sat-Eve	70.80	3.57	23.68	244647.00	34.00	51.00	71.00	83.00	130.00
Service Time Sat-Eve	140.16	5.46	36.22	920757.00	53.00	113.50	141.50	164.75	214.00
Waiting Time Sat-Eve	159.2	14.2	95.1	1538216.0	8.0	67.0	151.0	238.5	345.0

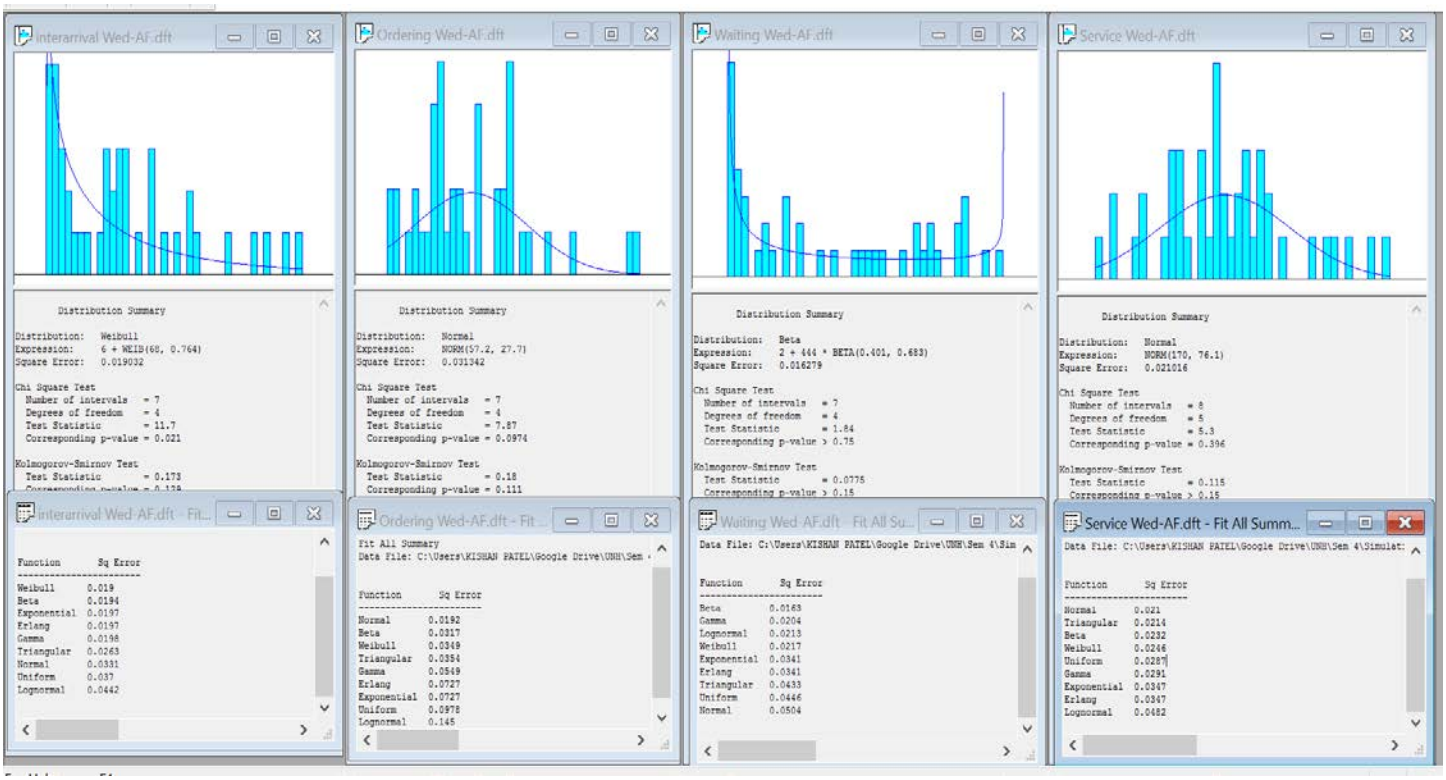
Above is the display for descriptive timing for all the timing taken. The data gives very good explanations for working of system. All the data here are in seconds. The interarrival time for is weekday in afternoon is less that because it was lunch time, it's almost 1:30 mins. And during these times only the service time is more in comparison with evening on weekdays.

The important thing to note is waiting for week day afternoon and weekend evening is almost same. It is due to lunch time on weekday and busy on weekend is due to all being free at that time. It about 2:30 mins.The service time is almost same for all the days and time. The service time is almost of 3 mins.

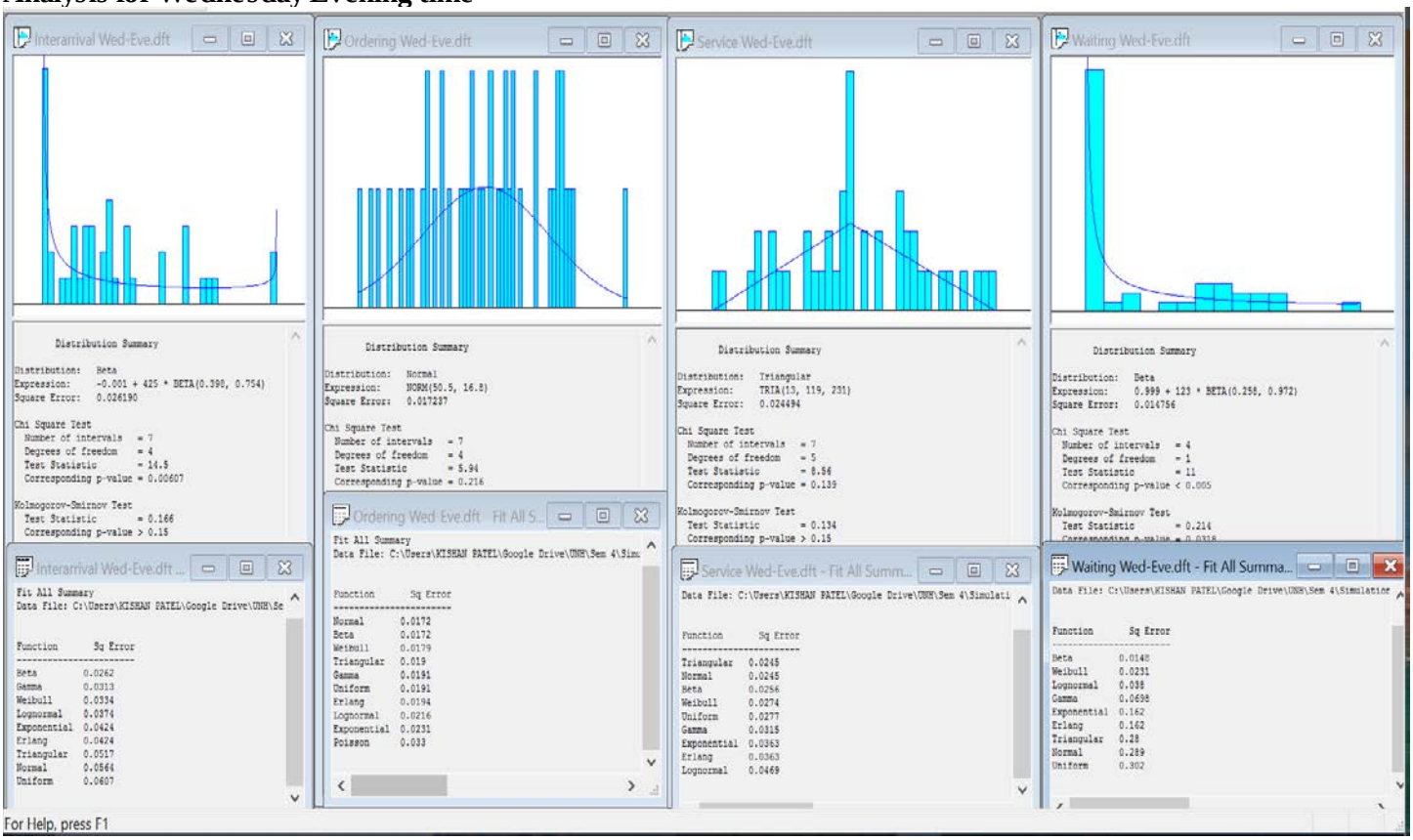
So it came out that on an average 7:30-8 mins for all the stuffs before you starts eating.

5.3 Input analysis

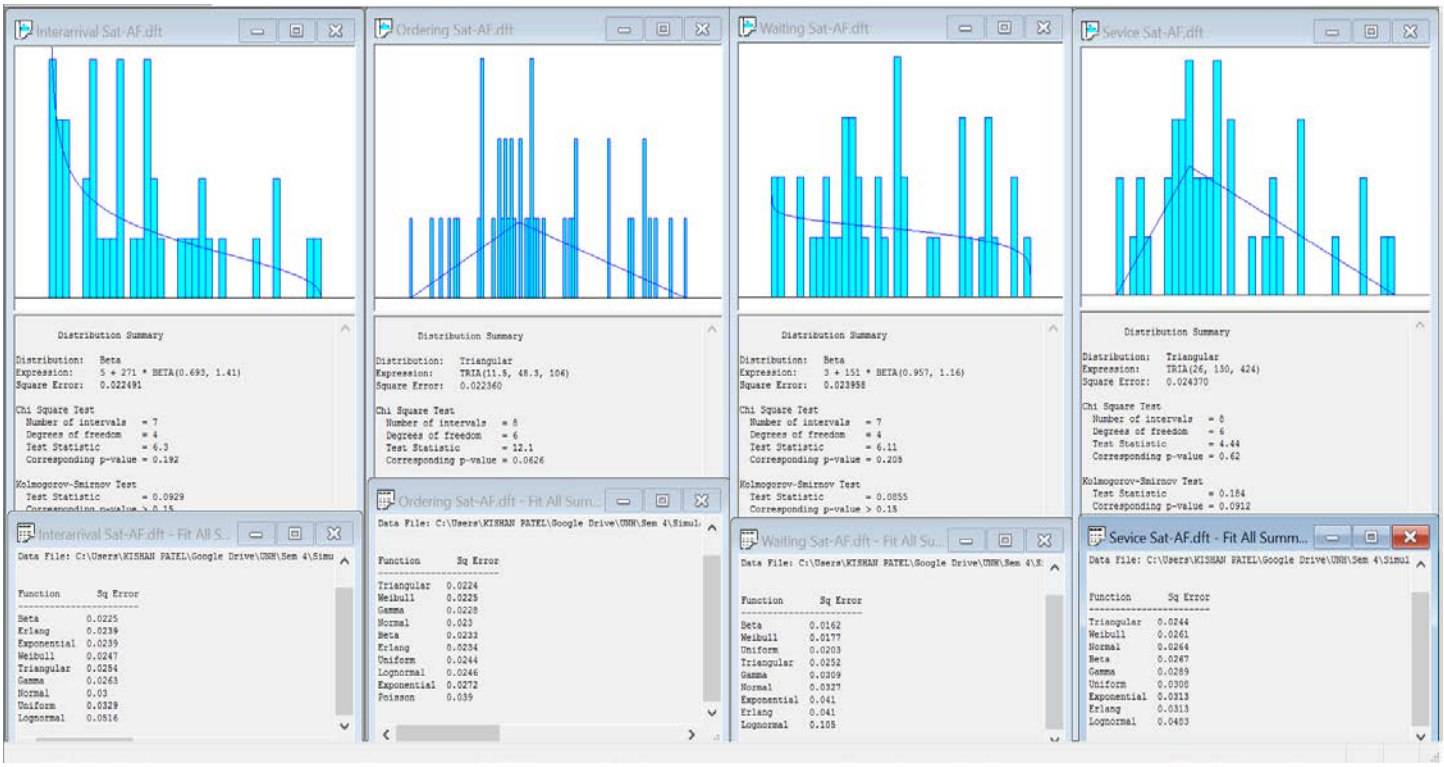
Analysis for Wednesday afternoon time



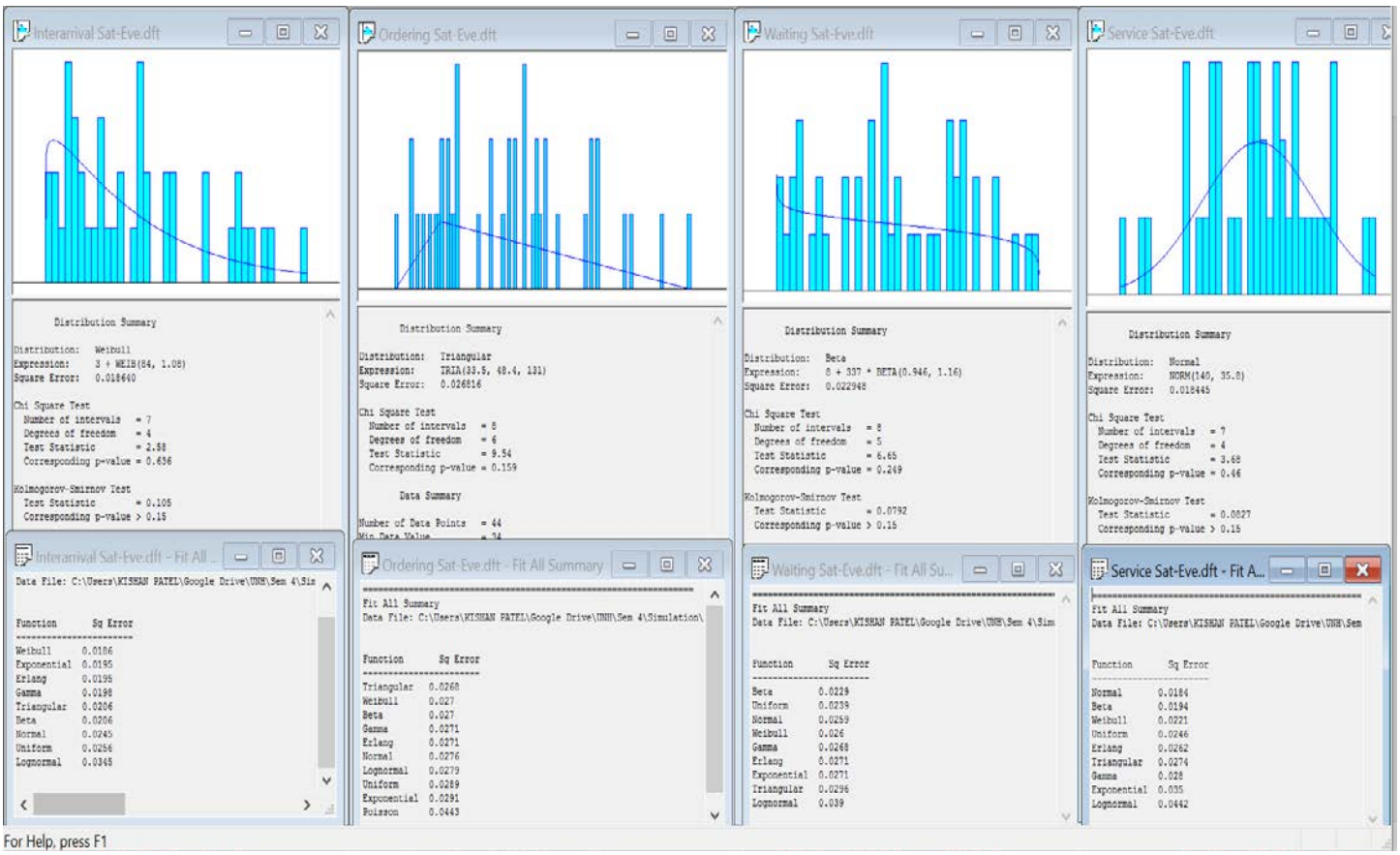
Analysis for Wednesday Evening time



Analysis for Saturday afternoon time



Analysis for Saturday Evening time



The following table show the distribution details

Day		Time	Timing Taken	Type of distribution	Distributiion Details
Wednesday		Afternoon	Interarrival Time	Weibull	6+WEIB(68, 0.764)
			Ordering Time	Normal	NORM(57.2,27.7)
			Waiting Time	Beta	2+444*BETA(0.40+0.683)
			Service Time	Normal	NORM(170,76.1)
		Evening	Interarrival Time	Beta	-0.001+425*BETA(0.398,0.754)
			Ordering Time	Normal	NORM(50.5,16.8)
			Waiting Time	Triangular	TRIA(13,119,231)
			Service Time	Beta	.999+123*BETA(0.258,0.972)

Day		Time	Timing Taken	Type of distribution	Distributiion Details
Saturday		Afternoon	Interarrival Time	Beta	5+271BETA(0.693,1.41)
			Ordering Time	Triangular	TRIA(11.5,48.3,106)
			Waiting Time	Beta	3+151*BETA(0.957,1.16)
			Service Time	Triangular	TRIA(26,130,424)
		Evening	Interarrival Time	Weibull	3+WEIB(84,1.08)
			Ordering Time	Triangular	TRAI(33.5,48.4,131)
			Waiting Time	Beta	8+337*BETA(0.946,1.16)
			Service Time	Normal	NORM(140,35.8)

6 Conceptual Simulation Model

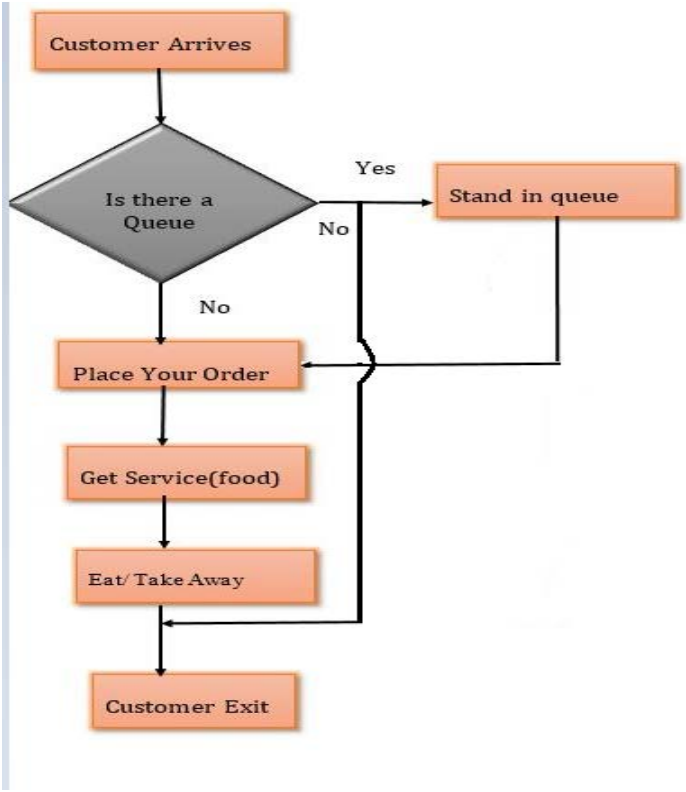
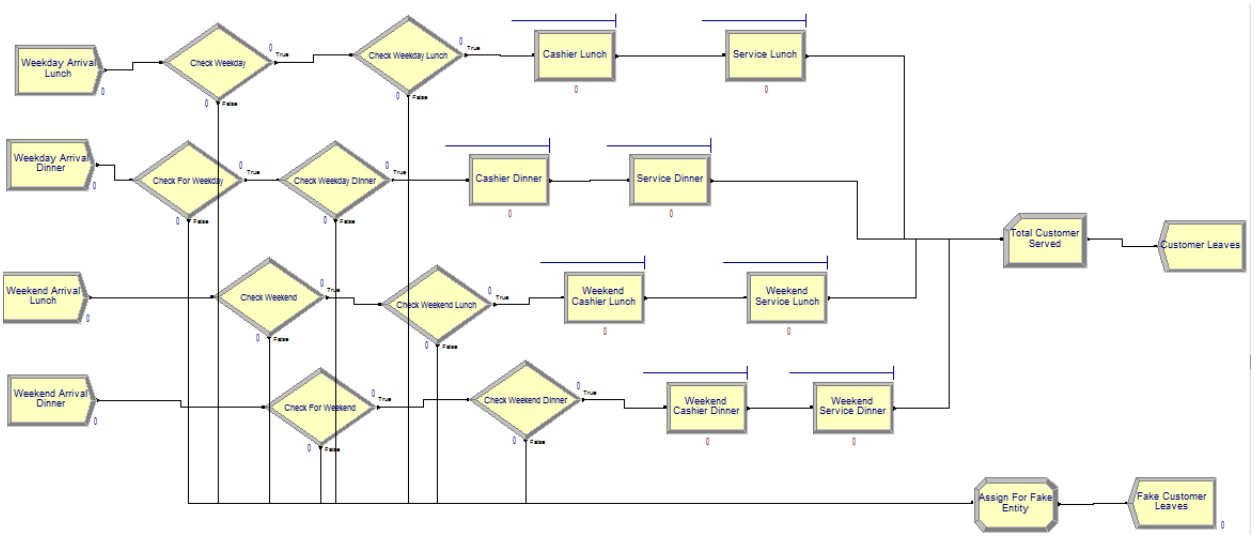


Figure 2: Flow Chart for the System

7 ARENA Simulation Model

The following is the overview model for simulation with the help of Arena for Burger King system analysis. The model shows that it is having multiple arrival for different days and for different times. The model has different run parameters. The model then has Decide Module for checking the condition for different times and different types of days in week like weekday and weekend.



As can be seen that after Decide Module there are two Process Modules. These modules are for Ordering and Service Times for the systems. And as the data were taken for different days and different times they are made for individual types of days. The module is made with the expression that we got from Input Analyzer and the expression are kept in a table in 4.3 Section of Input Analysis.

As can be seen that the model is having four Create Modules, eight Decide Modules and eight Process Modules. With these there is module created for fake entity. The Assign Module is created for counting the fake entities that would be generated during the running of simulation. The model will be explained in following section.

7.1 Resources and Entities

There are two Entity in the model. One is Customer and Other is Fake Entity. The Customer is Entity made for Customer Arrival and Fake Entity is one that is not matching with the Decision Modules.

The Resource is a set of four as there are four Employees that are working. And it is assumed that the pay of all the employees are $10/hrs.

Resource - Basic Process

	Name	Type	Capacity	Busy / Hour	Idle / Hour	Per Use	StateSet Name	Failures	Report Statistics
1	Cashier1	Fixed Capacity	1	10	10	0.0		0 rows	☑
2	Kishan	Fixed Capacity	1	10	10	0.0		0 rows	☑
3	Abdul	Fixed Capacity	1	10	10	0.0		0 rows	☑
4	Sai	Fixed Capacity	1	10	10	0.0		0 rows	☑
5	Nath	Fixed Capacity	1	10	10	0.0		0 rows	☑

7.2 Creation of different expression for different Modules.

Expression Table

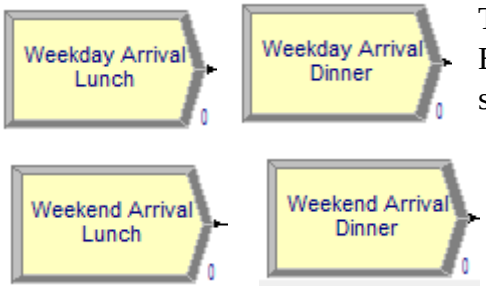
Expression Name	Time	Timing Taken	Type of distribution	Distributiion Details
Weekday Lunch	Afternoon	Interarrival Time	Weibull	6+WEIB(68, 0.764)
Weekday Cashier Lunch		Ordering Time	Normal	NORM(57.2,27.7)
Weekday Service Lunch		Service Time	Normal	NORM(170,76.1)
Weekday Dinner	Everning	Interarrival Time	Beta	-0.001+425*BETA(0.398,0.754)
Weekday Cashier Dinner		Ordering Time	Normal	NORM(50.5,16.8)
WeekDay Service Dinner		Service Time	Beta	.999+123*BETA(0.258,0.972)
Weekend Lunch	Afternoon	Interarrival Time	Beta	5+271BETA(0.693,1.41)
Weekend Cashier Lunch1		Ordering Time	Triangular	TRIA(11.5,48.3,106)
Weekend Service Dinner		Service Time	Triangular	TRIA(26,130,424)
Weekend Dinner	Everning	Interarrival Time	Weibull	3+WEIB(84,1.08)
Weekend Cashier Dinner 1		Ordering Time	Triangular	TRAI(33.5,48.4,131)
Weekend Service Dinner 1		Service Time	Normal	NORM(140,35.8)

Expression - Advanced Process

	Name	Comment	Rows	Columns	Data Type	File Name	Expression Values
1	Weekday Lunch				Native		1 rows
2	Weekday Dinner				Native		1 rows
3	Weekend Lunch				Native		1 rows
4	Weekend Dinner				Native		1 rows
5	Weekday Cashier Lunch				Native		1 rows
6	Weekday Cashier Dinner				Native		1 rows
7	Weekend Cashier Lunch1				Native		1 rows
8	Weekend Cashier Dinner1				Native		1 rows
9	Weekday Service Lunch				Native		1 rows
10	Weekday Service Dinner				Native		1 rows
11	Weekend Service Lunch1				Native		1 rows
12	Weekend Service Dinner1				Native		1 rows

The expression followed would be the one that is explained in Section 4.3 of Input Analysis.

7.3 Create Modules for different Interarrivals



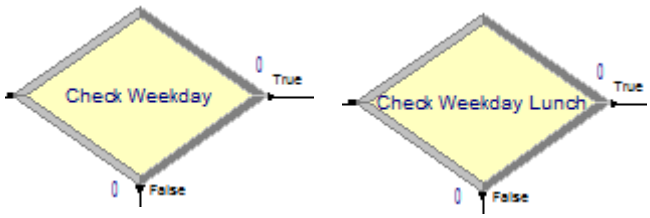
These are the Create Modules created for Interarrival of the Customer Entity. The Unites for all the modules are in Seconds as can be seen in the screenshot below with the Expression they are following according to Expressioon Table.

Create - Basic Process

	Name	Entity Type	Type	Expression	Units	Entities per Arrival	Max Arrivals	First Creation
1	Weekday Arrival Lunch	Customer	Expression	Weekday Lunch	Seconds	1	Infinite	0.0
2	Weekday Arrival Dinner	Customer	Expression	Weekday Dinner	Seconds	1	Infinite	21601
3	Weekend Arrival Lunch	Customer	Expression	Weekend Lunch	Seconds	1	INFINITE	0.0
4	Weekend Arrival Dinner	Customer	Expression	Weekend Dinner	Seconds	1	Infinite	21601

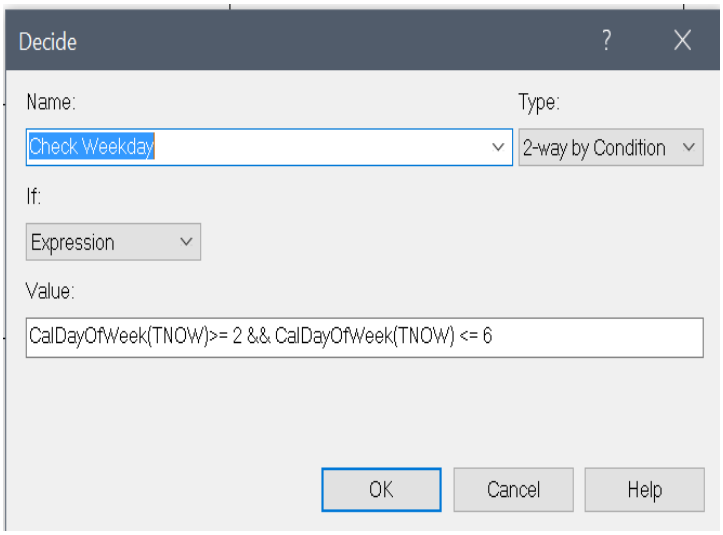
7.4 Decide Modules

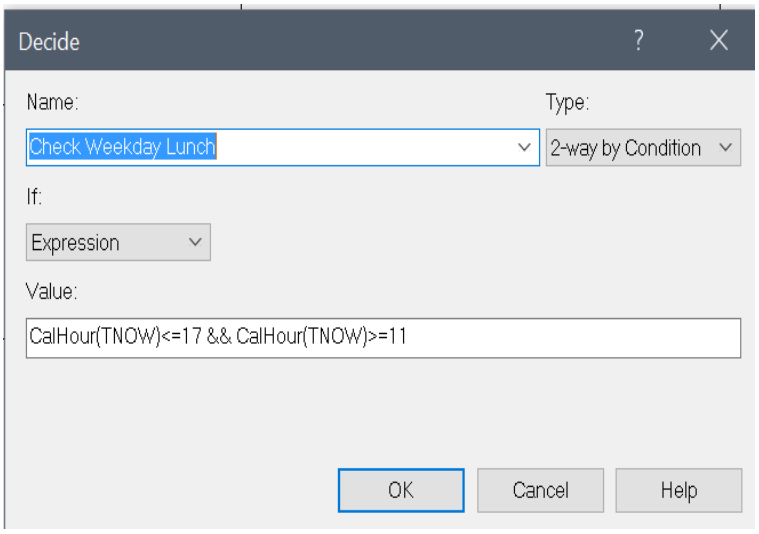
The Decide Module are used to check the condition for weekday/weekend and Lunch/Dinner. The condition are made to filter the entities and let the right entity pass the condition according to the time and type of day.

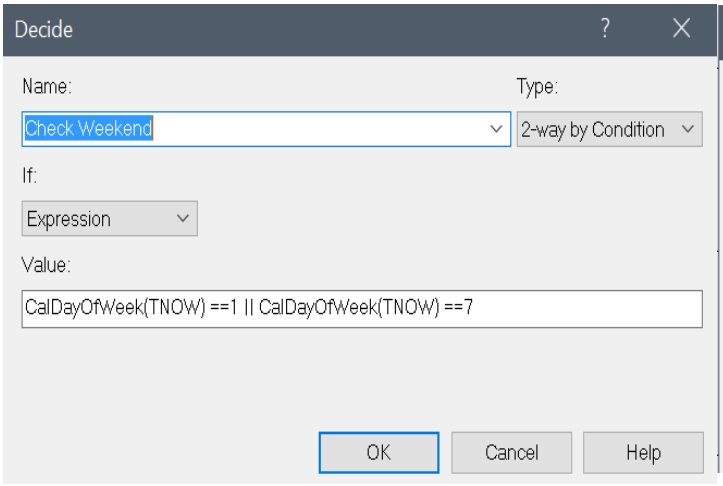


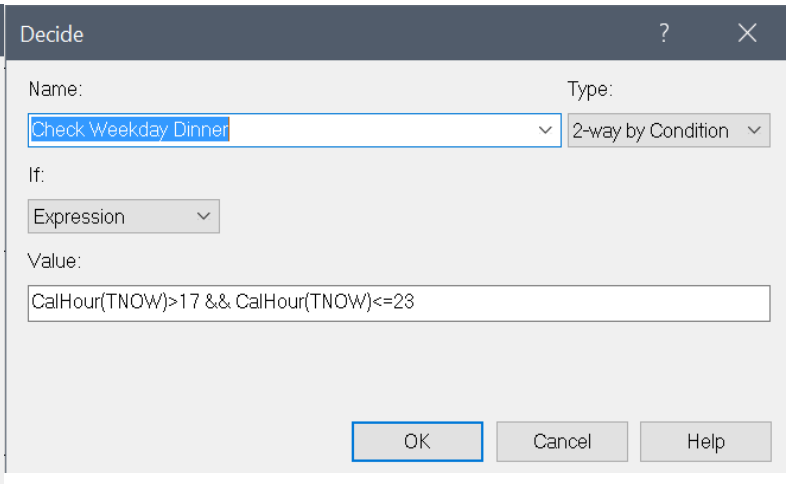
The Check Condition for Lunch/Dinner is done with the help of CalHour(Tnow) function. In the function 0 is 12 is midnight and it is in 24 hr system. So it will return a integer from 0-23 according to TNOW. The Lunch time is 11 AM to 5 PM daily and Dinner is from 5PM to 11 PM is considered.

The check condition for Weekday/Weekend are done using CalDayOfWeek function in Arena. In this function 1 is considered as Sunday and as follows the rest days.









Decide - Basic Process

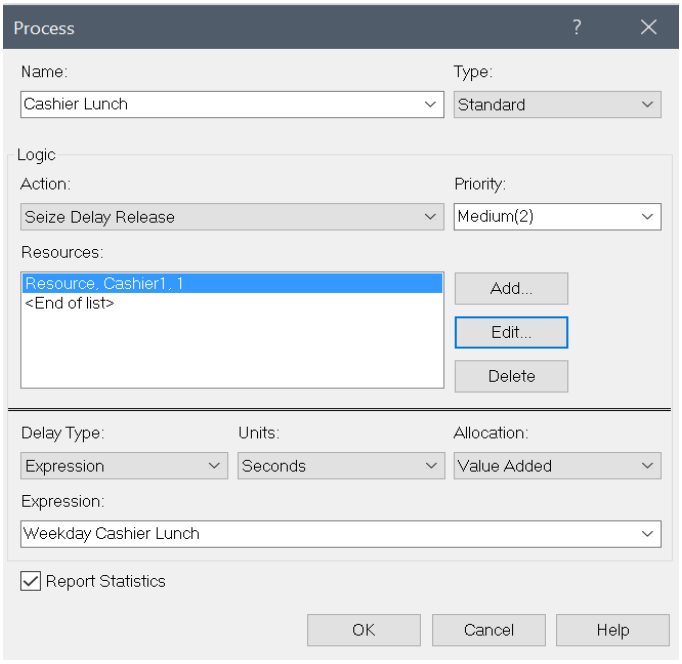
	Name	Type	If	Value
1	Check Weekday	2-way by Condition	Expression	CalDayOfWeek(TNOW)>= 2 && CalDayOfWeek(TNOW) <= 6
2	Check Weekday Lunch	2-way by Condition	Expression	CalHour(TNOW)<=17 && CalHour(TNOW)>=11
3	Check For Weekday	2-way by Condition	Expression	CalDayOfWeek(TNOW)>= 2 && CalDayOfWeek(TNOW) <= 6
4	Check Weekday Dinner	2-way by Condition	Expression	CalHour(TNOW)>17 && CalHour(TNOW)<=23
5	Check Weekend	2-way by Condition	Expression	CalDayOfWeek(TNOW) ==1 || CalDayOfWeek(TNOW) ==7
6	Check Weekend Lunch	2-way by Condition	Expression	CalHour(TNOW)<=17 && CalHour(TNOW)>=11
7	Check For Weekend	2-way by Condition	Expression	CalDayOfWeek(TNOW) ==1 || CalDayOfWeek(TNOW) ==7
8	Check Weekend Dinner	2-way by Condition	Expression	CalHour(TNOW)>17 && CalHour(TNOW)<=23

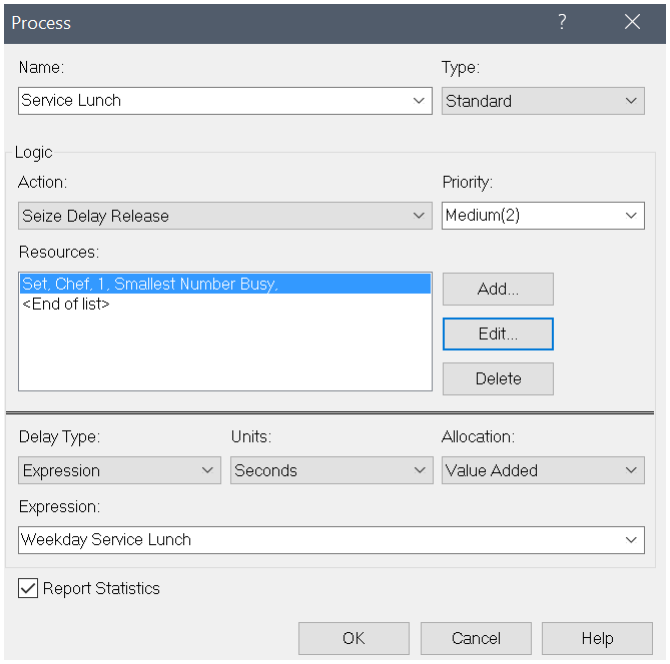
The all the Decide Module table is shown above with the condition it is following and the Value of that condition.

7.5 Process Modules

The process module is for ordering and service. The Ordering Process has the expression of arrival according to the expression generated from the input analyzer. Same is the case for the Service Process Modules. There are eight order and service module. The Ordering is for Cashier Process and Servicing is for Servicing Process. In Cashier Process the resource used is Cashier1 and for Service Process the Resource used is Set of 4 employees.

Below shows example for Weekday Lunch. Same would be case for different arrivals.





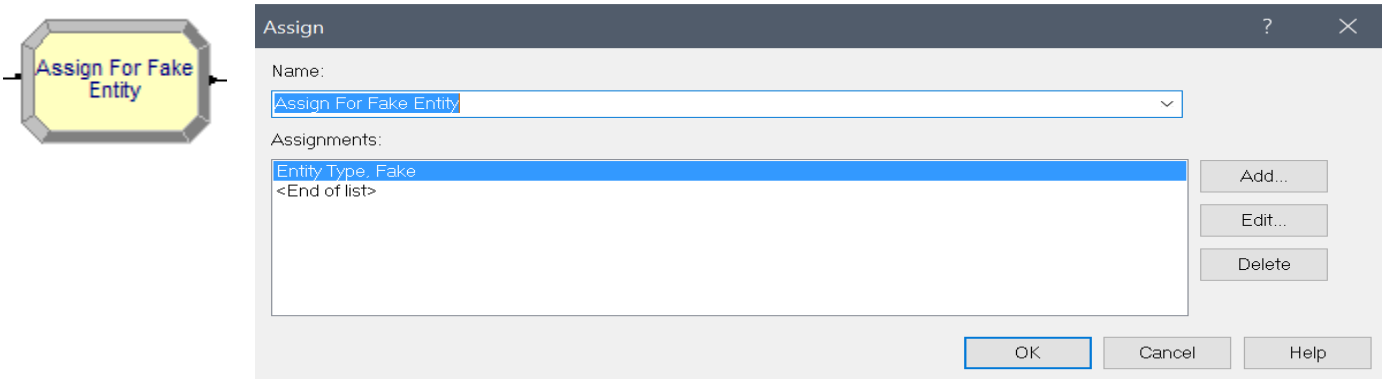
Below table shows the other process and the condition they are following. The resouces they are using the arrival entities are accoring to the specified expression.

Process - Basic Process

	Name	Type	Action	Priority	Resources	Delay Type	Units	Allocation	Expression	Report Statistics
1	Cashier Lunch	Standard	Seize Delay Release	Medium(2)	1 rows	Expression	Seconds	Value Added	Weekday Cashier Lunch	☑
2	Service Lunch	Standard	Seize Delay Release	Medium(2)	1 rows	Expression	Seconds	Value Added	Weekday Service Lunch	☑
3	Cashier Dinner	Standard	Seize Delay Release	Medium(2)	1 rows	Expression	Seconds	Value Added	Weekday Cashier Dinner	☑
4	Service Dinner	Standard	Seize Delay Release	Medium(2)	1 rows	Expression	Seconds	Value Added	Weekday Service Dinner	☑
5	Weekend Cashier Lunch	Standard	Seize Delay Release	Medium(2)	1 rows	Expression	Seconds	Value Added	Weekend Cashier Lunch1	☑
6	Weekend Service Lunch	Standard	Seize Delay Release	Medium(2)	1 rows	Expression	Seconds	Value Added	Weekend Service Lunch1	☑
7	Weekend Cashier Dinner	Standard	Seize Delay Release	Medium(2)	1 rows	Expression	Seconds	Value Added	Weekend Cashier Dinner1	☑
8	Weekend Service Dinner	Standard	Seize Delay Release	Medium(2)	1 rows	Expression	Seconds	Value Added	Weekend Service Dinner1	☑

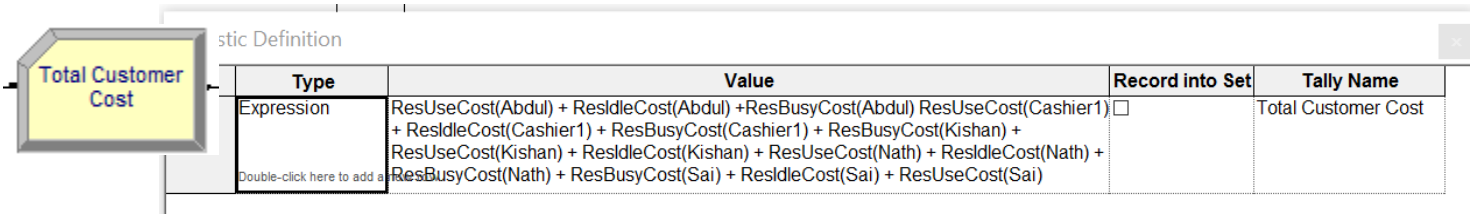
7.6 Assign Modules

The Assign Module is used because to check and count the Fake entity.



7.7 Record Module

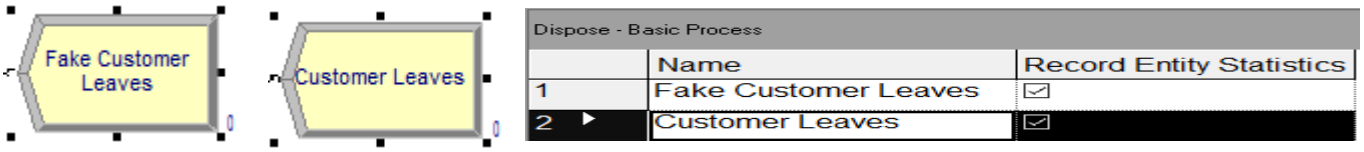
The record module is used for recording the customer out at the same time calculating the cost of the serving the customers.



The expression is according to the usage/idle/busy condition of the employees.

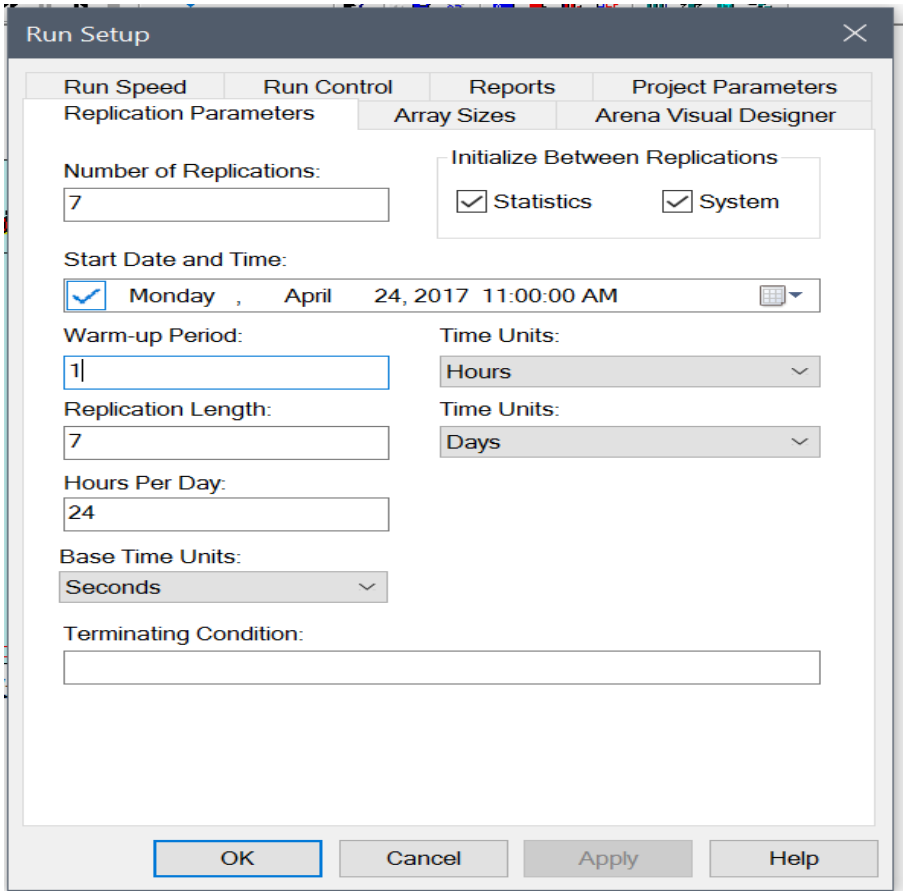
7.8 Dispose Module

The dispose module is used for disposing the entity be it Fake or Customer Entity.

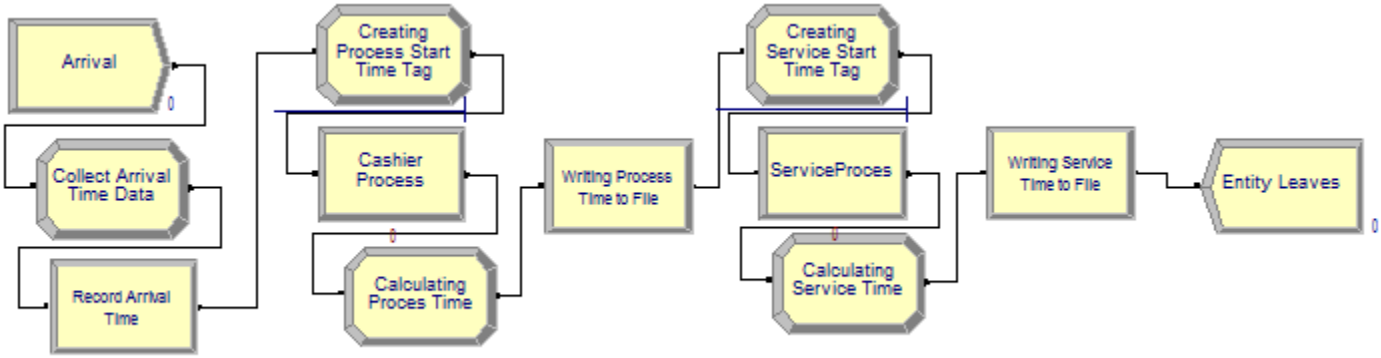


7.9 Run Parameters

- Number of Replication: 7
- Warm Up time: 1 Hour
- Replication Length: 7 Days
- Hours Per Day: 24 Hours
- Base time Units: Seconds



8 Model Validation.



For validating our model, we used Read/Write Module to extract the model data from actual running of simulation model. The process is using assign module for attributing the process start time and same way at the end again with the help of assign module storing the TNOW in that assign module subtracting the TNOW from previous assign Module. The value is then stored in the Read/Write Module.

All the data that are generated are stored in a notepad and with that data and the actual data that we collected are kept in Minitab for validation. Our data did not follow the normal distribution so we tried to validate on the parameter of comparison of Median as base. The test is done according to Kruskal-Wallis Test.

The screenshot below show that the model is validating as the p-value is grater then 0.05 for all the three timings.

Kruskal-Wallis Test: Interarrival Time versus Group Id Arrival

```
Kruskal-Wallis Test on Interarrival Time

Group Id
Arrival      N  Median  Ave Rank      Z
0           44   69.50     160.7   0.98
1          253   40.08     147.0  -0.98
Overall    297             149.0

H = 0.95  DF = 1  P = 0.329
H = 0.95  DF = 1  P = 0.329  (adjusted for ties)
```

Kruskal-Wallis Test: Cashier Time versus Group Id Cashier

```
Kruskal-Wallis Test on Cashier Time

Group Id
Cashier      N  Median  Ave Rank      Z
0           43  151.00      64.0  -7.01
1          253  137.17     162.9   7.01
Overall    296             148.5

H = 49.09  DF = 1  P = 0.067
H = 49.09  DF = 1  P = 0.067  (adjusted for ties)
```

Kruskal-Wallis Test: Service Time versus Group Id Service

```
Kruskal-Wallis Test on Service Time

Group Id
Service      N  Median  Ave Rank      Z
0           44   163.0     142.1  -0.50
1          251   175.8     149.0   0.50
Overall    295             148.0

H = 0.25  DF = 1  P = 0.617
H = 0.25  DF = 1  P = 0.617  (adjusted for ties)
```

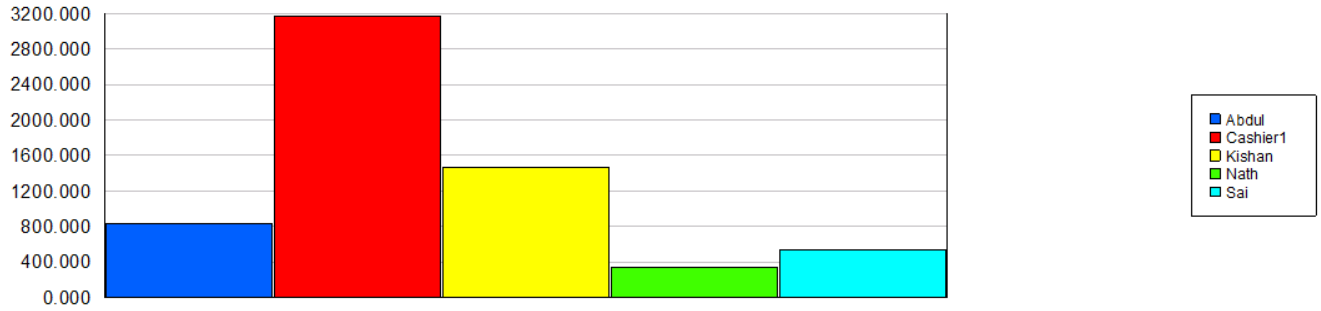
9 Initial Performance Analysis (Base model)

From the initial report of the model it seems that the problem that was there in real world seems to be still there. The analysis shows that the Cashier is the most utilized resource. The problem observed is due to just one Cashier the problem of Waiting time is continuing. At the same time the less employee is making service queue bigger.

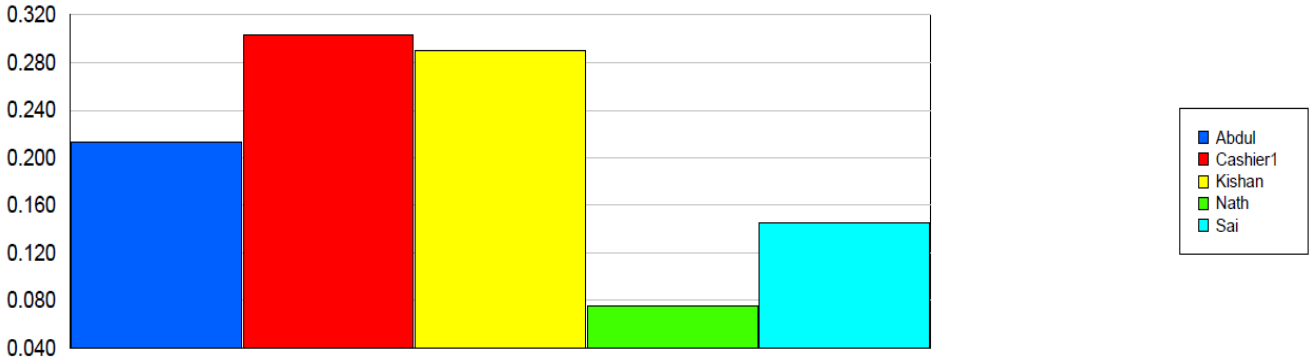
Below shows some of the initial Report.

Usage

Total Number Seized	Average	Half Width	Minimum Average	Maximum Average
Abdul	832.57	15.92	812.00	859.00
Cashier1	3170.57	47.10	3126.00	3268.00
Kishan	1462.14	21.25	1426.00	1498.00
Nath	335.29	15.47	315.00	364.00
Sai	540.57	22.55	506.00	583.00



Scheduled Utilization	Average	Half Width	Minimum Average	Maximum Average
Abdul	0.2136	0.00	0.2106	0.2196
Cashier1	0.3035	0.00	0.3005	0.3076
Kishan	0.2903	0.00	0.2855	0.2927
Nath	0.07577547	0.00	0.07177598	0.08205265
Sai	0.1452	0.01	0.1369	0.1562



10 Test of the Scenarios with Process Analyzer (PAN), Output Analysis (OA) and OptQuest

10.1 Process Analyzer (PAN)

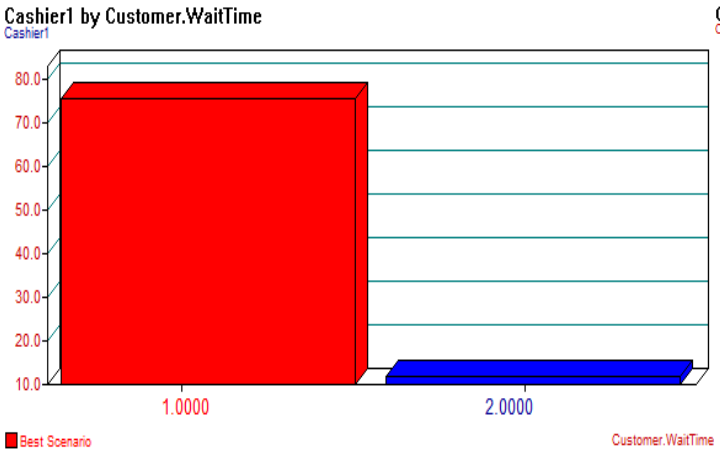
With the help PAN we generated different scenarios on the bases of problem observed in the initial report. We tried to make scenarios by increasing the employees, replications, and cost. The control for the PAN were all the resources and number of Reps. And the Response that we wanted to study of the customer wait time and the cost of increasing the employees. The utilization of the employees was also an important response to study.

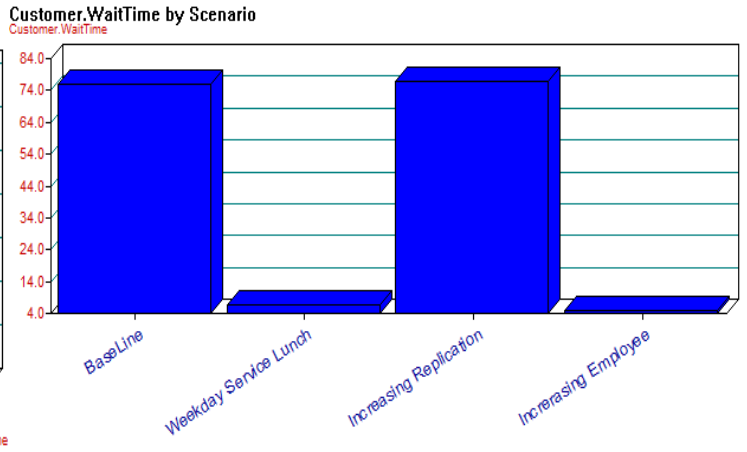
Below shows different scenarios with different control and the response is generated according to it.

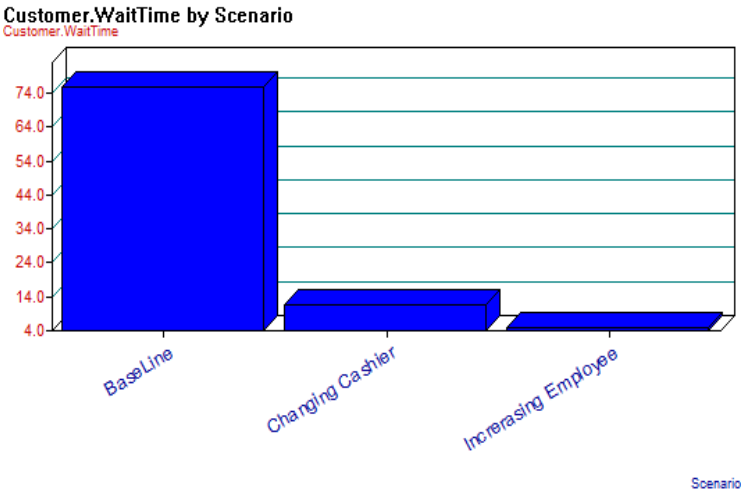
	Scenario Properties				Controls						Res					
	S	Name	Program File	Reps	Abdul	Cashier1	Kishan	Nath	Sai	Num Reps	System.NumberOut	Customer.WaitTime	Total Customer	Cashier1.Utilization	Kishan.Utilization	Cashier Dinner.Queu
1		BaseLine	3 : burgerkin	7	1.0000	1.0000	1.0000	1.0000	1.0000	7	23932.714	75.766	2061450	0.304	0.290	20.829
2		Weekday Service	3 : burgerkin	7	1.0000	2.0000	2.0000	1.0000	1.0000	7	24073.143	6.590	2079544	0.152	0.153	2.049
3		Increasing Replicati	3 : burgerkin	40	1.0000	1.0000	1.0000	1.0000	1.0000	40	24045.950	77.019	2059005	0.306	0.292	20.598
4		Incrersing Employ	3 : burgerkin	7	2.0000	2.0000	2.0000	2.0000	2.0000	7	24056.714	4.866	4643276	0.153	0.149	1.893
5		Changing Cashier	3 : burgerkin	7	1.0000	2.0000	1.0000	1.0000	1.0000	7	24024.429	11.720	2050939	0.152	0.275	2.152
6		Removing Employe	3 : burgerkin	7	0.0000	1.0000	0.0000	1.0000	1.0000	7	24066.714	686.931	0	0.307	0.000	19.753
7		Removing Least Uti	3 : burgerkin	7	1.0000	1.0000	1.0000	0.0000	1.0000	7	24047.143	101.665	1990141	0.308	0.311	19.775
8		Increasing Most Uti	3 : burgerkin	7	2.0000	1.0000	1.0000	1.0000	1.0000	7	24058.143	86.183	4567293	0.304	0.286	19.738
9		Checking for Utiliza	3 : burgerkin	7	0.0000	1.0000	0.0000	1.0000	1.0000	7	24066.714	686.931	0	0.307	0.000	19.753
10		Cost	3 : burgerkin	7	2.0000	2.0000	2.0000	1.0000	1.0000	7	24052.857	5.283	4636395	0.154	0.151	1.874

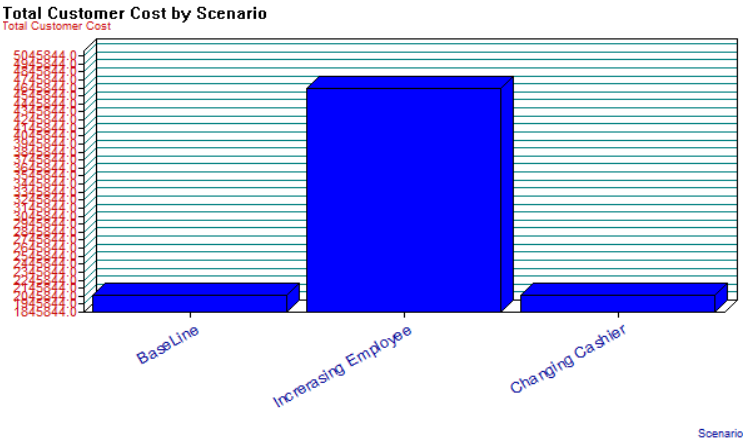
Responses												
System.NumberOut	Customer.WaitTime	Total Customer	Cashier1.Utilization	Kishan.Utilization	Cashier Dinner.Queu	Cashier Lunch.Queue	Service Lunch.Queue	System.Total Cost	Abdul.Utilization	Kishan.Utilization	Sai.Utilization	Cashier1.BusyCost
23932.714	75.766	2061450	0.304	0.290	20.829	87.600	3.204	8400.000	0.214	0.290	0.145	509.910
24073.143	6.590	2079544	0.152	0.153	2.049	6.950	3.515	11760.000	0.199	0.153	0.138	510.635
24045.950	77.019	2059005	0.306	0.292	20.598	93.026	3.662	8400.000	0.216	0.292	0.146	513.410
24056.714	4.866	4643276	0.153	0.149	1.893	6.895	0.023	16800.000	0.105	0.149	0.071	513.818
24024.429	11.720	2050939	0.152	0.275	2.152	7.034	12.792	10080.000	0.207	0.275	0.148	509.270
24066.714	686.931	0	0.307	0.000	19.753	96.605	958.516	5040.000	0.000	0.000	0.386	516.029
24047.143	101.665	1990141	0.308	0.311	19.775	100.027	31.915	6720.000	0.244	0.311	0.183	517.699
24058.143	86.183	4567293	0.304	0.286	19.738	95.136	0.469	10080.000	0.116	0.286	0.141	511.215
24066.714	686.931	0	0.307	0.000	19.753	96.605	958.516	5040.000	0.000	0.000	0.386	516.029
24052.857	5.283	4636395	0.154	0.151	1.874	7.089	0.619	13440.000	0.107	0.151	0.140	517.739

Graphical Analysis of the scenarios.





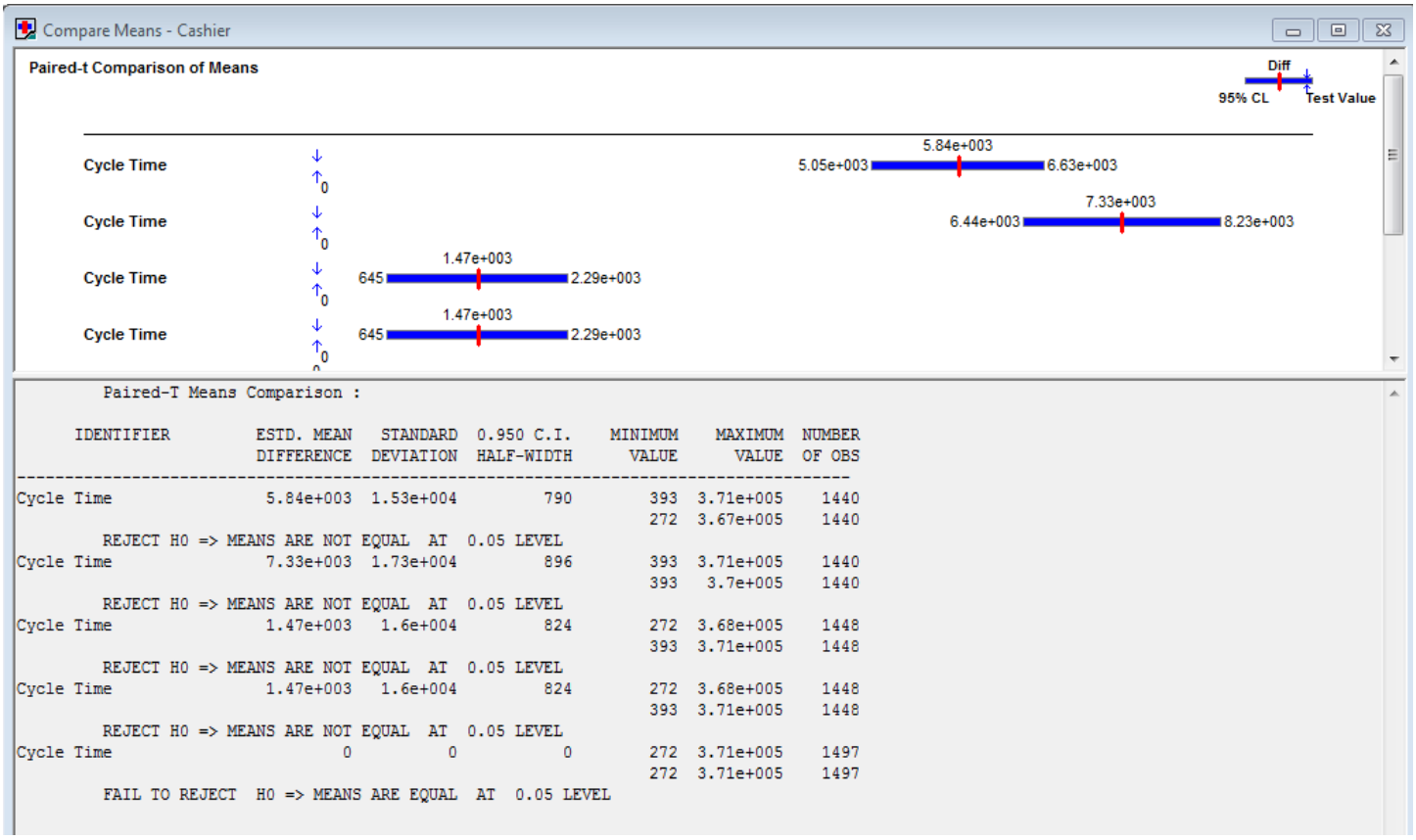




10.2 Output Analysis (OA)

From the output analyzer, we compared the base model and with different cycle time scenarios and we find out that there is a significant difference between all four different scenarios. So, we concluded that our model is verified and satisfied customer requirement of less ordering and service time.

The screenshot below shows the same.



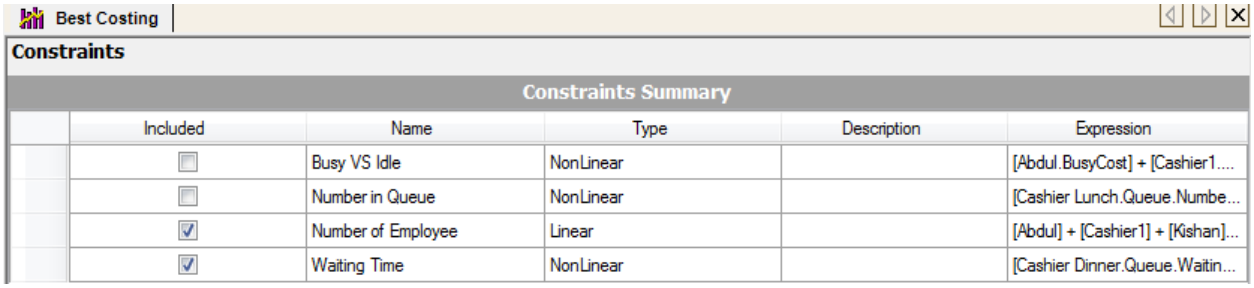

```
        Paired-T Means Comparison :

     IDENTIFIER         ESTD. MEAN   STANDARD  0.950 C.I.    MINIMUM    MAXIMUM  NUMBER
                        DIFFERENCE  DEVIATION  HALF-WIDTH      VALUE      VALUE  OF OBS
-------------------------------------------------------------------------------------
Cycle Time               5.84e+003  1.53e+004         790        393  3.71e+005    1440
                                                               272  3.67e+005    1440
        REJECT H0 => MEANS ARE NOT EQUAL  AT  0.05 LEVEL
Cycle Time               7.33e+003  1.73e+004         896        393  3.71e+005    1440
                                                               393   3.7e+005    1440
        REJECT H0 => MEANS ARE NOT EQUAL  AT  0.05 LEVEL
Cycle Time               1.47e+003   1.6e+004         824        272  3.68e+005    1448
                                                               393  3.71e+005    1448
        REJECT H0 => MEANS ARE NOT EQUAL  AT  0.05 LEVEL
Cycle Time               1.47e+003   1.6e+004         824        272  3.68e+005    1448
                                                               393  3.71e+005    1448
        REJECT H0 => MEANS ARE NOT EQUAL  AT  0.05 LEVEL
Cycle Time                       0          0           0        272  3.71e+005    1497
                                                               272  3.71e+005    1497
        FAIL TO REJECT  H0 => MEANS ARE EQUAL  AT  0.05 LEVEL
```

10.3 OptQuest

For OptQuest we tried to study the problem what was observed in initial report and that found in PAN. The cost was of major importance and waiting time. For the problem, we defined different constraints, controls, objectives. The screenshot below tries to explain all.

- **Constraints.**



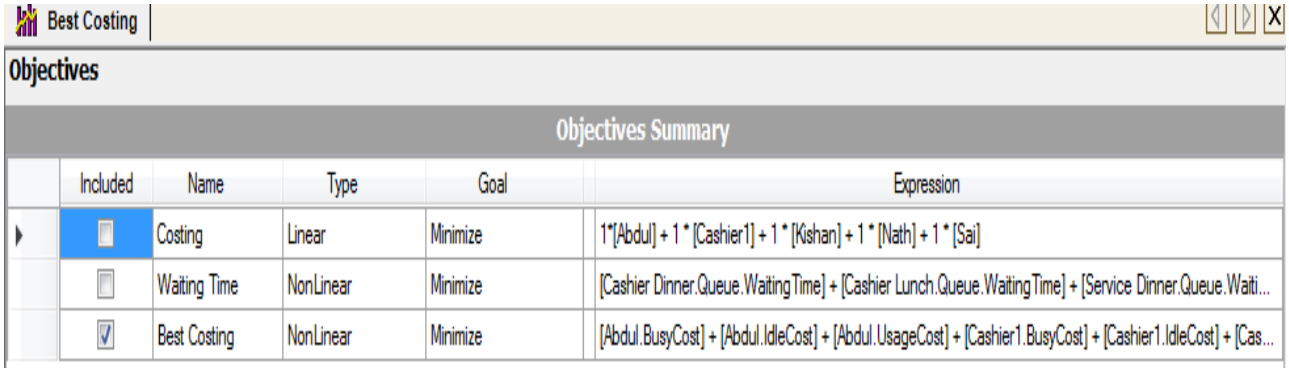
Best Costing

Constraints

Constraints Summary

Included	Name	Type	Description	Expression
☐	Busy VS Idle	NonLinear		[Abdul.BusyCost] + [Cashier1....
☐	Number in Queue	NonLinear		[Cashier Lunch.Queue.Numbe...
☑	Number of Employee	Linear		[Abdul] + [Cashier1] + [Kishan]...
☑	Waiting Time	NonLinear		[Cashier Dinner.Queue.Waitin...

- **Different Objective**



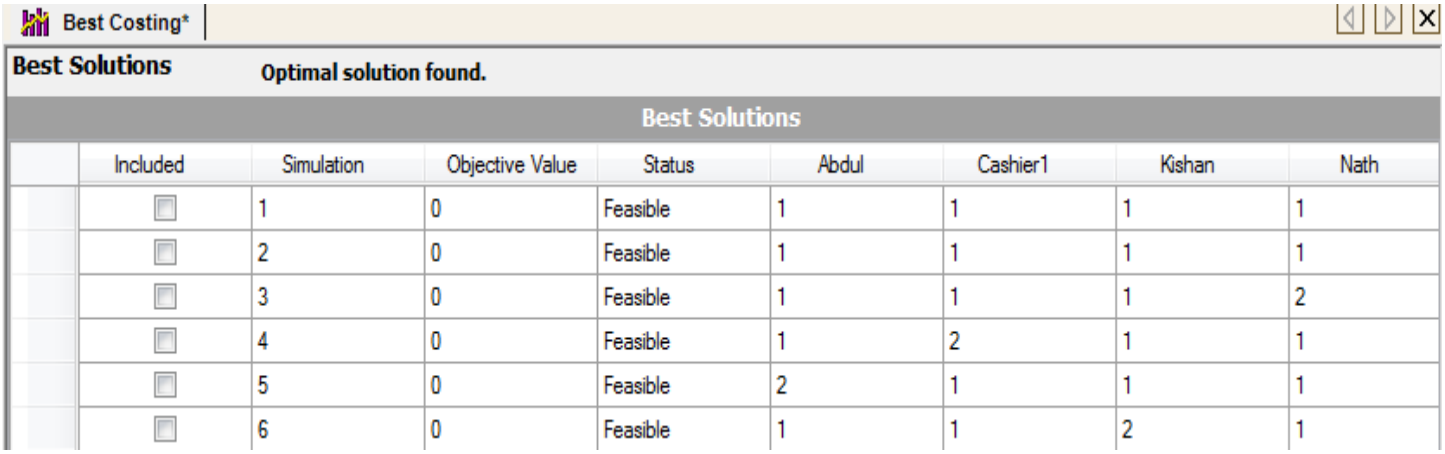
Best Costing

Objectives

Objectives Summary

Included	Name	Type	Goal	Expression
☐	Costing	Linear	Minimize	1*[Abdul] + 1 * [Cashier1] + 1 * [Kishan] + 1 * [Nath] + 1 * [Sai]
☐	Waiting Time	NonLinear	Minimize	[Cashier Dinner.Queue.WaitingTime] + [Cashier Lunch.Queue.WaitingTime] + [Service Dinner.Queue.Waiti...
☑	Best Costing	NonLinear	Minimize	[Abdul.BusyCost] + [Abdul.IdleCost] + [Abdul.UsageCost] + [Cashier1.BusyCost] + [Cashier1.IdleCost] + [Cas...

- **Result for Best Costing Objective**



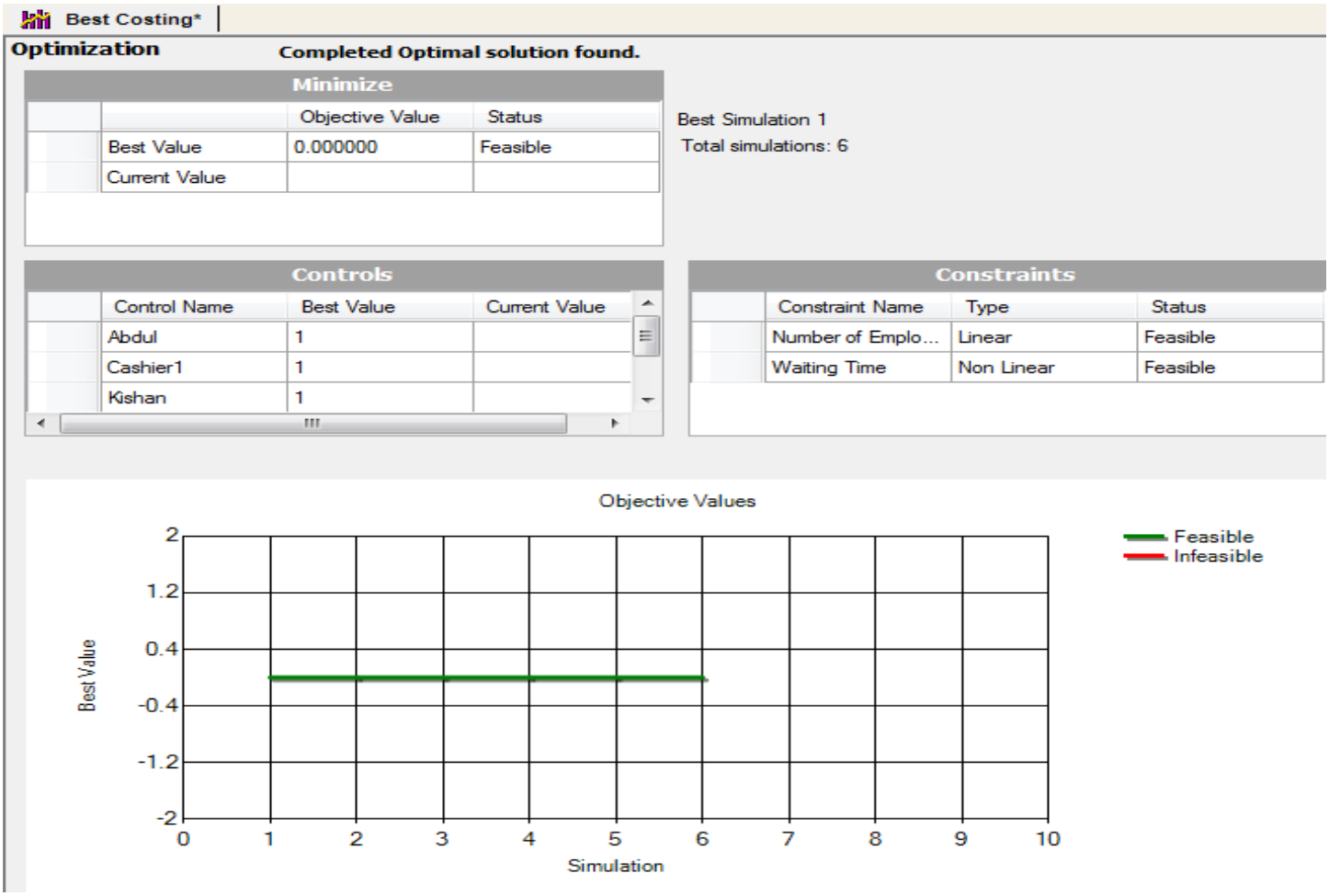
Best Costing*

Best Solutions — Optimal solution found.

Best Solutions

Included	Simulation	Objective Value	Status	Abdul	Cashier1	Kishan	Nath
☐	1	0	Feasible	1	1	1	1
☐	2	0	Feasible	1	1	1	1
☐	3	0	Feasible	1	1	1	2
☐	4	0	Feasible	1	2	1	1
☐	5	0	Feasible	2	1	1	1
☐	6	0	Feasible	1	1	2	1

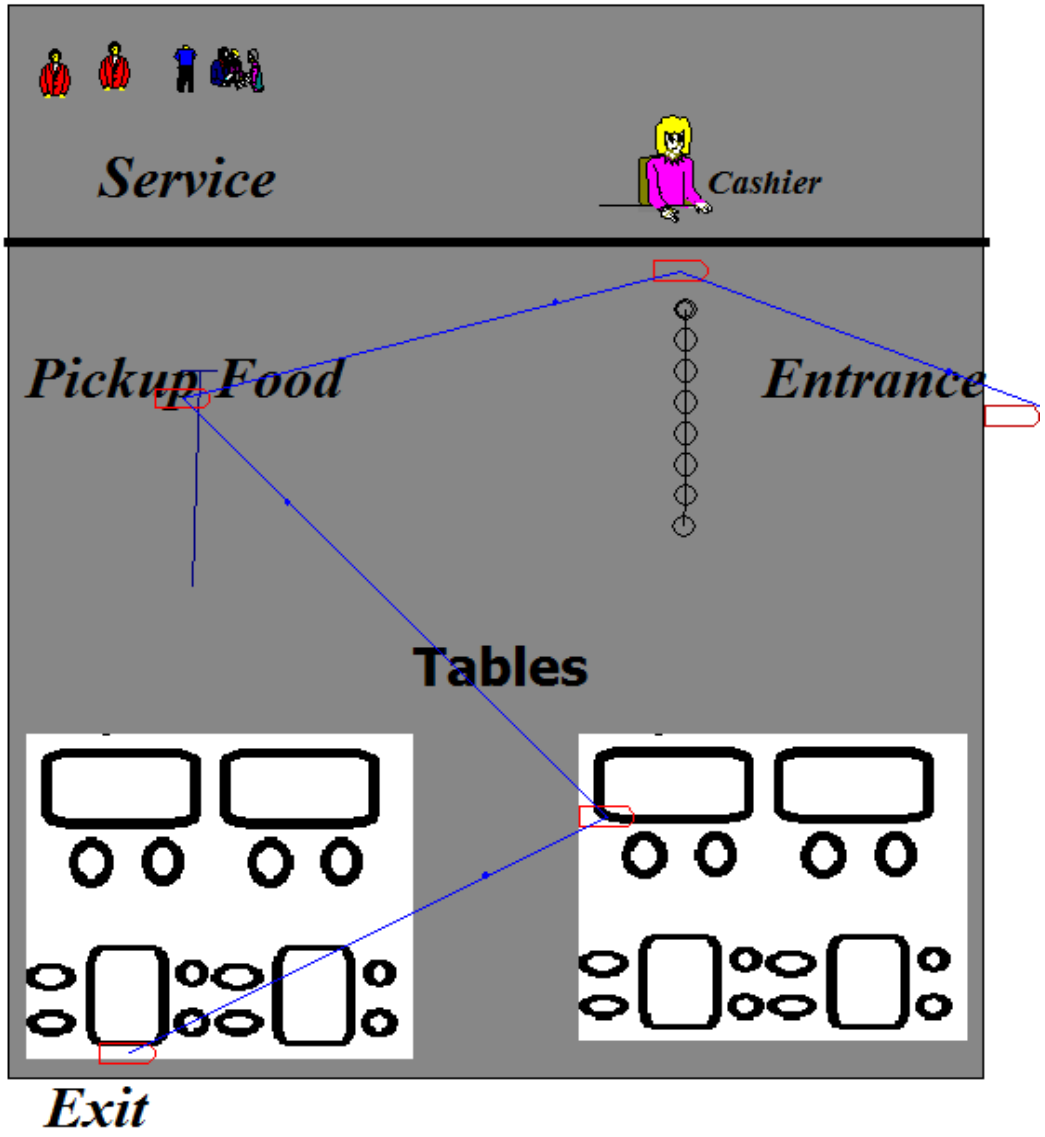
- **Optimization of Best Costing objective**



11 Proposed Performance Improvement Scenarios

As Per all the Process Analysis (PAN) that is done for the scenarios we came up with best case scenario that the store should increase one more cashier to reduce the wait time at low cost rather than increasing the service employee. The utilization should be increased with more productive working. For customer satisfaction, we need to reduce the wait time and ordering time. We also suggest to use Kaizen methods to decrease the wait and ordering time.

12 2 D Animation



13 Conclusions

- With the help of all analysis we came up with the conclusion that the queue in the system is mostly due to difference in interarrival time and servicing time. The interarrival time is almost half of the service time. These is making the working of system complicated
- By doing these the service time and customer service will improve
  From the above analysis, we came to know that the system working is little complicated due to only one cashier working. The complication can be reduced if there is more number of employees and cashier for instore ordering.
- Here we saw that the arrival time of the customer is less than the service time. These is the reason that makes the queue in the store. We would conclude by give recommendation that the store should increase the employment so as decrease the servicing time. It's almost double for all time except for Wednesday evening time.