Chapter 5
Model Verification and Model Validation

After complete model creation in previous chapter, this chapter is to test whether the created model operate as expectation and validate for the actual condition. This chapter consisted of 2 main parts: model verification and model validation.

5.1 Model Verification

According to W. David Kelton, Randall P. Sadowski, and Doborah A. Sadowski (1998, pp. 444), "verification is the task of ensuring that the model behaves as you intended". Using the inputs with constant is a way to verify the model because it's convenient to check the simulation result.

Assume that there are 360 customers per hour (thus, interarrival rate is 10 second per customer), 90% of them use only IVR service. The IVR service time is 100 seconds, transfer time is 20 seconds, and agent service time is 150 seconds. Moreover, there are 50 customers that contact the agents directly. The result of simulation is shown below:

ARENA Simulation Results
Pa - License #9400000

Summary for Replication 1 of 1

Project: Call Center Anal — Run execution date : 4/ 1/2001
Analyst: — Model revision date: 4/ 1/2001

Replication ended at time : 3600.0

TALLY VARIABLES

Identifier	Average	Half Width	Minimum	Maximum	Observations
Transfer Time	20.000	(Insuf)	20.000	20.000	35
Agent Time	150.00	(Insuf)	150.00	150.00	82
IVR Ports_Q Queue Time	.00000	.00000	.00000	.00000	360
IVR Time	100.00	(Insuf)	100.00	100.00	315
Agent Number_Q Queue T	.00000	(Insuf)	.00000	.00000	85

DISCRETE-CHANGE VARIABLES

Identifier	Average	Half Width	Minimum	Maximum	Final Value
# in IVR Ports_Q	.00000	(Insuf)	.00000	.00000	.00000
IVR Ports Available	60.000	(Insuf)	60.000	60.000	60.000
Agent Number Available	15.000	(Insuf)	15.000	15.000	15.000
Agent Number Busy	4.1822	(Insuf)	.00000	8.0000	4.0000
IVR Ports Busy	9.0972	.27784	.00000	11.000	10.000
# in Agent Number_Q	.00000	(Insuf)	.00000	.00000	.00000
Telephone Lines Busy	10.541	(Corr)	.00000	14.000	11.000
Telephone Lines Availa	70.000	(Insuf)	70.000	70.000	70.000

COUNTERS

Identifier	Count	Limit
Lines Success	360	Infinite
Internal Line	50	Infinite
Lines Busy	0	Infinite

Simulation run time: 0.00 minutes.
Simulation run complete.

The result of simulation is the same as expect: there are 360 customers that can enter the system, 50 customers that contact the agent directly, and 35 customers that transfer to the agent through IVR. The IVR service time is 100 seconds, Transfer time is 20 seconds, and Agent service time is 150 seconds.

Another way to verify the model is to use the trace functioned to track the behavior of each entity. The part of result of verification by using trace function is shown below:

```
SIMAN System Trace Beginning at Time: 0.0

Seq#  Label            Block    System Status Change
----  ---------------- -------- ------------------------------------------

Time: 0.0  Entity: 2
    1 60$              CREATE
                                Next creation scheduled at time 32400.0
    2 67$              TRACE
-Entity Created
    3 61$              ASSIGN
                                PERIOD set to 0.0
    4 66$              ASSIGN
                                Entity 2 picture changed to 0
    5 0$               TRACE
-Making assignments
    6 68$              ASSIGN
                                PERIOD set to 1.0
                                PER PERIOD BUSY set to 0.0
                                BUSY PER PERIOD set to 0.0
                                PER PERIOD SUCCESS set to 0.0
                                SUCCESS PER PERIOD set to 0.0
    7 1$               TRACE
-Choosing from 2 options
    8 69$              BRANCH
                                Selecting at most 1 of 2 branches
                                IF: Entity 2 sent to 2$
    9 2$               TRACE
-Delaying for time 3600
   10 70$              DELAY
                                Delayed by 3600.0 until time 3600.0
Time: 1e-006.0  Entity: 3
   13 72$              CREATE
                                CALL IN set to 1e-006.0
                                Next creation scheduled at time 10.0
   14 79$              TRACE
-Entity Created
   15 76$              ASSIGN
                                Entity 3 picture changed to DEFAULT
   16 4$               QUEUE
                                Entity 3 sent to next block
   17 80$              SEIZE
                                Seized 1 unit(s) of resource TELEPHONE LINES
   18 85$              ASSIGN
                                J set to 0
   19 82$              DELAY
                                Delayed by 0.0 until time 1e-006.0
                                Entity transferred to block 6$
   21 6$               TRACE
-Updating counter Lines Success
   22 86$              COUNT
                                Counter LINES SUCCESS incremented by 1 to 1
   23 8$               TRACE
-Making assignments
   24 88$              ASSIGN
                                SUCCESS PER PERIOD set to 1.0
   25 11$              QUEUE
                                QUEUETIME set to 1e-006.0
                                Entity 3 sent to next block
   26 89$              SEIZE
                                Seized 1 unit(s) of resource IVR PORTS
   27 94$              ASSIGN
                                J set to 0
   28 90$              TALLY
                                Tally IVR_Q QUEUE TIME recorded 0.0
   29 15$              TRACE
-Making assignments
   30 95$              ASSIGN
                                CALL START set to 1e-006.0
   31 16$              TRACE
```

5.2 Model Validation

According to Averill M. Law and W. David Kelton (2000, pp.279), "the most definitive test of simulation model's validity is to establish that its output data closely resemble the output data that would be expected from the actual (proposed) system". If the two sets of data (from simulation, and actual system) compare closely, then the model of the existing system is considering valid.

The generated output data from simulation in this case is saved in data file format (.dat file). There are 3 methods, One-Sample T Test, Independent-Samples T Test, and Kruskal-Wallis H test, used for testing these two sets of data.

According to SPSS help file, the One-Sample T Test procedure tests whether the mean of a single variable differs from a specified constant. This test assumes that the data are normally distributed; however, this test is fairly robust to departures from normality.

According to SPSS help file, the Independent-Samples T Test procedure compares means for two groups of cases. Ideally, for this test, the subjects should be randomly assigned to two groups, so that any difference in response is due to the treatment (or lack of treatment) and not to other factors.

According to SPSS help file, the Kruskal-Wallis H test are available to determine if several independent samples come from the same population. The Kruskal-Wallis H test, an extension of the Mann-Whitney U test, is the nonparametric analog of one-way analysis of variance and detects differences in distribution location.

These tests are applied with 3 simulation outputs: IVR service time, Transfer time, and Agent Service Time.

The chosen day for validation is 9 January 2001 at 9:00 AM to 10:00 AM. Assume that there are about 1800 calls and 50 executive customers trying to enter the call center system in this period. The result of simulation is shown below:

ARENA Simulation Results
Pa - License #9400000

Summary for Replication 1 of 10

Project: Call Center Anal — Run execution date : 4/ 4/2001
Analyst: — Model revision date: 4/ 4/2001

Replication ended at time : 3600.0

TALLY VARIABLES

Identifier	Average	Half Width	Minimum	Maximum	Observations
Transfer Time	87.896	(Insuf)	16.147	647.94	141
Agent Time	230.65	(Insuf)	11.489	2094.0	155
IVR Ports_Q Queue Time	1.4380	1.5874	.00000	28.409	1401
IVR Time	142.73	5.6293	8.2505	499.49	1219
Agent Number_Q Queue T	131.18	(Insuf)	.00000	517.90	169

DISCRETE-CHANGE VARIABLES

Identifier	Average	Half Width	Minimum	Maximum	Final Value

# in IVR Ports_Q	.55963	(Corr)	.00000	8.0000	.00000
IVR Ports Available	60.000	(Insuf)	60.000	60.000	60.000
Agent Number Available	15.000	(Insuf)	15.000	15.000	15.000
Agent Number Busy	14.145	(Insuf)	.00000	15.000	15.000
IVR Ports Busy	52.938	(Corr)	.00000	60.000	41.000
# in Agent Number_Q	8.4876	(Insuf)	.00000	34.000	33.000
Telephone Lines Busy	68.799	(Corr)	.00000	70.000	70.000
Telephone Lines Availa	70.000	(Insuf)	70.000	70.000	70.000

COUNTERS

Identifier	Count	Limit
Lines Success	1401	Infinite
Internal Line	61	Infinite
Lines Busy	2557	Infinite

Beginning replication 2 of 10

ARENA Simulation Results
Pa - License #9400000

Summary for Replication 2 of 10

Project: Call Center Anal
Analyst:

Run execution date : 4/ 4/2001
Model revision date: 4/ 4/2001

Replication ended at time : 3600.0

TALLY VARIABLES

Identifier	Average	Half Width	Minimum	Maximum	Observations
Transfer Time	95.689	(Insuf)	16.063	397.03	153
Agent Time	196.97	(Insuf)	11.017	1718.3	181
IVR Ports_Q Queue Time	1.7489	(Corr)	.00000	28.050	1540
IVR Time	138.27	6.8969	8.1422	498.25	1341
Agent Number_Q Queue T	76.642	(Insuf)	.00000	340.79	193

DISCRETE-CHANGE VARIABLES

Identifier	Average	Half Width	Minimum	Maximum	Final Value
# in IVR Ports_Q	.74815	(Corr)	.00000	8.0000	.00000
IVR Ports Available	60.000	(Insuf)	60.000	60.000	60.000
Agent Number Available	15.000	(Insuf)	15.000	15.000	15.000
Agent Number Busy	13.884	(Insuf)	.00000	15.000	15.000
IVR Ports Busy	56.759	(Corr)	.00000	60.000	46.000
# in Agent Number_Q	5.2824	(Insuf)	.00000	28.000	27.000
Telephone Lines Busy	68.842	(Corr)	.00000	70.000	70.000
Telephone Lines Availa	70.000	(Insuf)	70.000	70.000	70.000

COUNTERS

Identifier	Count	Limit
Lines Success	1540	Infinite
Internal Line	67	Infinite
Lines Busy	2549	Infinite

Beginning replication 3 of 10

ARENA Simulation Results
Pa - License #9400000

Summary for Replication 3 of 10

Project: Call Center Anal
Analyst:

Run execution date : 4/ 4/2001
Model revision date: 4/ 4/2001

Replication ended at time : 3600.0

TALLY VARIABLES

Identifier	Average	Half Width	Minimum	Maximum	Observations

Transfer Time	81.413	(Insuf)	16.010	382.07	149
Agent Time	234.40	(Insuf)	7.1560	2321.5	159
IVR Ports_Q Queue Time	1.2794	1.2242	.00000	30.450	1361
IVR Time	143.02	6.5068	9.1838	522.38	1176
Agent Number_Q Queue T	192.15	(Insuf)	.00000	671.86	173

DISCRETE-CHANGE VARIABLES

Identifier	Average	Half Width	Minimum	Maximum	Final Value
# in IVR Ports_Q	.48371	(Corr)	.00000	9.0000	.00000
IVR Ports Available	60.000	(Insuf)	60.000	60.000	60.000
Agent Number Available	15.000	(Insuf)	15.000	15.000	15.000
Agent Number Busy	14.474	(Insuf)	.00000	15.000	15.000
IVR Ports Busy	51.022	(Corr)	.00000	60.000	36.000
# in Agent Number_Q	12.434	(Corr)	.00000	38.000	36.000
Telephone Lines Busy	68.873	(Corr)	.00000	70.000	70.000
Telephone Lines Availa	70.000	(Insuf)	70.000	70.000	70.000

COUNTERS

Identifier	Count	Limit
Lines Success	1361	Infinite
Internal Line	60	Infinite
Lines Busy	2617	Infinite

Beginning replication 4 of 10

ARENA Simulation Results
Pa - License #9400000

Summary for Replication 4 of 10

Project: Call Center Anal
Analyst:

Run execution date : 4/ 4/2001
Model revision date: 4/ 4/2001

Replication ended at time : 3600.0

TALLY VARIABLES

Identifier	Average	Half Width	Minimum	Maximum	Observations
Transfer Time	89.570	(Insuf)	16.134	267.44	159
Agent Time	174.31	(Insuf)	8.6431	2285.1	188
IVR Ports_Q Queue Time	1.5560	(Corr)	.00000	26.475	1329
IVR Time	144.47	(Corr)	6.7165	576.18	1120
Agent Number_Q Queue T	203.67	(Insuf)	.00000	503.26	201

DISCRETE-CHANGE VARIABLES

Identifier	Average	Half Width	Minimum	Maximum	Final Value
# in IVR Ports_Q	.57444	(Corr)	.00000	9.0000	.00000
IVR Ports Available	60.000	(Insuf)	60.000	60.000	60.000
Agent Number Available	15.000	(Insuf)	15.000	15.000	15.000
Agent Number Busy	14.103	(Insuf)	.00000	15.000	15.000
IVR Ports Busy	50.086	(Corr)	.00000	60.000	50.000
# in Agent Number_Q	12.602	(Insuf)	.00000	25.000	21.000
Telephone Lines Busy	68.855	(Corr)	.00000	70.000	70.000
Telephone Lines Availa	70.000	(Insuf)	70.000	70.000	70.000

COUNTERS

Identifier	Count	Limit
Lines Success	1329	Infinite
Internal Line	63	Infinite
Lines Busy	2581	Infinite

Beginning replication 5 of 10

ARENA Simulation Results
Pa - License #9400000

Summary for Replication 5 of 10

Project: Call Center Anal
Analyst:

Run execution date : 4/ 4/2001
Model revision date: 4/ 4/2001

Replication ended at time : 3600.0

TALLY VARIABLES

Identifier	Average	Half Width	Minimum	Maximum	Observations
Transfer Time	80.478	(Insuf)	16.196	259.31	151
Agent Time	217.83	(Insuf)	11.092	2687.6	167
IVR Ports_Q Queue Time	1.0526	(Corr)	.00000	27.557	1379
IVR Time	142.85	5.7337	7.6318	580.18	1186
Agent Number_Q Queue T	229.22	(Insuf)	.00000	589.67	180

DISCRETE-CHANGE VARIABLES

Identifier	Average	Half Width	Minimum	Maximum	Final Value
# in IVR Ports_Q	.40322	(Corr)	.00000	9.0000	.00000
IVR Ports Available	60.000	(Insuf)	60.000	60.000	60.000
Agent Number Available	15.000	(Insuf)	15.000	15.000	15.000
Agent Number Busy	14.151	(Insuf)	.00000	15.000	15.000
IVR Ports Busy	51.416	(Corr)	.00000	60.000	42.000
# in Agent Number_Q	13.902	(Insuf)	.00000	35.000	33.000
Telephone Lines Busy	68.844	(Corr)	.00000	70.000	70.000
Telephone Lines Availa	70.000	(Insuf)	70.000	70.000	70.000

COUNTERS

Identifier	Count	Limit
Lines Success	1379	Infinite
Internal Line	62	Infinite
Lines Busy	2574	Infinite

Beginning replication 6 of 10

ARENA Simulation Results
Pa - License #9400000

Summary for Replication 6 of 10

Project: Call Center Anal
Analyst:

Run execution date : 4/ 4/2001
Model revision date: 4/ 4/2001

Replication ended at time : 3600.0

TALLY VARIABLES

Identifier	Average	Half Width	Minimum	Maximum	Observations
Transfer Time	88.551	(Insuf)	16.244	560.66	135
Agent Time	209.28	(Insuf)	8.5841	2911.3	155
IVR Ports_Q Queue Time	2.9709	(Corr)	.00000	44.530	1497
IVR Time	140.86	4.7660	11.078	534.10	1310
Agent Number_Q Queue T	100.07	(Insuf)	.00000	383.71	167

DISCRETE-CHANGE VARIABLES

Identifier	Average	Half Width	Minimum	Maximum	Final Value
# in IVR Ports_Q	1.2354	(Corr)	.00000	10.000	.00000
IVR Ports Available	60.000	(Insuf)	60.000	60.000	60.000
Agent Number Available	15.000	(Insuf)	15.000	15.000	15.000
Agent Number Busy	12.533	(Insuf)	.00000	15.000	15.000
IVR Ports Busy	56.042	(Corr)	.00000	60.000	52.000
# in Agent Number_Q	5.0537	(Insuf)	.00000	22.000	14.000
Telephone Lines Busy	68.966	(Corr)	.00000	70.000	70.000
Telephone Lines Availa	70.000	(Insuf)	70.000	70.000	70.000

COUNTERS

Identifier	Count	Limit
Lines Success	1497	Infinite
Internal Line	46	Infinite
Lines Busy	2510	Infinite

Beginning replication 7 of 10

ARENA Simulation Results

Pa - License #9400000

Summary for Replication 7 of 10

Project: Call Center Anal
Analyst:

Run execution date : 4/ 4/2001
Model revision date: 4/ 4/2001

Replication ended at time : 3600.0

TALLY VARIABLES

Identifier	Average	Half Width	Minimum	Maximum	Observations
Transfer Time	78.435	(Insuf)	16.033	315.10	156
Agent Time	184.10	(Insuf)	6.6258	1754.7	190
IVR Ports_Q Queue Time	2.9792	1.9225	.00000	34.191	1520
IVR Time	141.14	5.0965	8.3797	508.23	1312
Agent Number_Q Queue T	82.210	(Insuf)	.00000	303.77	202

DISCRETE-CHANGE VARIABLES

Identifier	Average	Half Width	Minimum	Maximum	Final Value
# in IVR Ports_Q	1.2579	(Corr)	.00000	8.0000	.00000
IVR Ports Available	60.000	(Insuf)	60.000	60.000	60.000
Agent Number Available	15.000	(Insuf)	15.000	15.000	15.000
Agent Number Busy	13.964	(Insuf)	.00000	15.000	15.000
IVR Ports Busy	56.131	(Corr)	.00000	60.000	52.000
# in Agent Number_Q	4.8430	(Insuf)	.00000	22.000	11.000
Telephone Lines Busy	68.812	(Corr)	.00000	70.000	69.000
Telephone Lines Availa	70.000	(Insuf)	70.000	70.000	70.000

COUNTERS

Identifier	Count	Limit
Lines Success	1520	Infinite
Internal Line	57	Infinite
Lines Busy	2477	Infinite

Beginning replication 8 of 10

ARENA Simulation Results
Pa - License #9400000

Summary for Replication 8 of 10

Project: Call Center Anal
Analyst:

Run execution date : 4/ 4/2001
Model revision date: 4/ 4/2001

Replication ended at time : 3600.0

TALLY VARIABLES

Identifier	Average	Half Width	Minimum	Maximum	Observations
Transfer Time	86.608	(Insuf)	16.284	389.41	154
Agent Time	240.85	(Insuf)	8.6396	2054.7	166
IVR Ports_Q Queue Time	1.8257	(Corr)	.00000	25.478	1325
IVR Time	140.81	6.3430	7.3155	516.46	1126
Agent Number_Q Queue T	215.38	(Insuf)	.00000	505.77	178

DISCRETE-CHANGE VARIABLES

Identifier	Average	Half Width	Minimum	Maximum	Final Value
# in IVR Ports_Q	.67196	(Corr)	.00000	9.0000	.00000
IVR Ports Available	60.000	(Insuf)	60.000	60.000	60.000
Agent Number Available	15.000	(Insuf)	15.000	15.000	15.000
Agent Number Busy	14.187	(Insuf)	.00000	15.000	15.000
IVR Ports Busy	49.070	(Corr)	.00000	60.000	45.000
# in Agent Number_Q	12.177	(Insuf)	.00000	29.000	21.000
Telephone Lines Busy	69.013	(Corr)	.00000	70.000	70.000
Telephone Lines Availa	70.000	(Insuf)	70.000	70.000	70.000

COUNTERS

Identifier	Count	Limit
Lines Success	1325	Infinite
Internal Line	45	Infinite
Lines Busy	2790	Infinite

Beginning replication 9 of 10

ARENA Simulation Results
Pa - License #9400000

Summary for Replication 9 of 10

Project: Call Center Anal
Analyst:

Run execution date : 4/ 4/2001
Model revision date: 4/ 4/2001

Replication ended at time : 3600.0

TALLY VARIABLES

Identifier	Average	Half Width	Minimum	Maximum	Observations
Transfer Time	89.489	(Insuf)	16.817	353.47	150
Agent Time	190.54	(Insuf)	9.8317	2062.6	194
IVR Ports_Q Queue Time	.45382	.80529	.00000	32.100	1360
IVR Time	140.86	(Corr)	7.8590	573.37	1156
Agent Number_Q Queue T	229.82	(Insuf)	.00000	513.55	205

DISCRETE-CHANGE VARIABLES

Identifier	Average	Half Width	Minimum	Maximum	Final Value
# in IVR Ports_Q	.17144	(Insuf)	.00000	8.0000	.00000
IVR Ports Available	60.000	(Insuf)	60.000	60.000	60.000
Agent Number Available	15.000	(Insuf)	15.000	15.000	15.000
Agent Number Busy	14.538	(Insuf)	.00000	15.000	15.000
IVR Ports Busy	50.718	(Corr)	.00000	60.000	54.000
# in Agent Number_Q	13.725	(Corr)	.00000	30.000	16.000
Telephone Lines Busy	68.899	(Corr)	.00000	70.000	70.000
Telephone Lines Availa	70.000	(Insuf)	70.000	70.000	70.000

COUNTERS

Identifier	Count	Limit
Lines Success	1360	Infinite
Internal Line	71	Infinite
Lines Busy	2627	Infinite

Beginning replication 10 of 10

ARENA Simulation Results
Pa - License #9400000

Summary for Replication 10 of 10

Project: Call Center Anal
Analyst:

Run execution date : 4/ 4/2001
Model revision date: 4/ 4/2001

Replication ended at time : 3600.0

TALLY VARIABLES

Identifier	Average	Half Width	Minimum	Maximum	Observations
Transfer Time	89.838	(Insuf)	16.164	339.41	134
Agent Time	269.10	(Insuf)	8.9122	1988.3	144
IVR Ports_Q Queue Time	1.6955	(Corr)	.00000	30.513	1221
IVR Time	145.73	(Corr)	8.7522	585.20	1054
Agent Number_Q Queue T	345.69	(Insuf)	.00000	1083.7	159

DISCRETE-CHANGE VARIABLES

Identifier	Average	Half Width	Minimum	Maximum	Final Value

```
# in IVR Ports_Q          .57508     (Corr)     .00000     9.0000     .00000
IVR Ports Available       60.000     (Insuf)    60.000     60.000     60.000
Agent Number Available    15.000     (Insuf)    15.000     15.000     15.000
Agent Number Busy         14.013     (Insuf)    .00000     15.000     15.000
IVR Ports Busy            47.047     (Corr)     .00000     60.000     33.000
# in Agent Number_Q       20.953     (Insuf)    .00000     49.000     39.000
Telephone Lines Busy      68.952     (Corr)     .00000     70.000     70.000
Telephone Lines Availa    70.000     (Insuf)    70.000     70.000     70.000

                                  COUNTERS

Identifier                                    Count    Limit
-------------------------------------------------------------

Lines Success                                  1221    Infinite
Internal Line                                    64    Infinite
Lines Busy                                     2803    Infinite

Simulation run time: 0.82 minutes.
Simulation run complete.
```

First, the IVR service time is tested. The result is shown below:

One-Sample Statistics

	N	Mean	Std. Deviation	Std. Error Mean
DATE9	1293	142.3983	87.2071	2.4252

One-Sample Test

	Test Value = 141.86					
					95% Confidence Interval of the Difference	
	t	df	Sig. (2-tailed)	Mean Difference	Lower	Upper
DATE9	.222	1292	.824	.5383	-4.2195	5.2961

Figure 5-1: One-Sample T Test for IVR service time at 9 January 9:00 to 10:00

Group Statistics

	DATE	N	Mean	Std. Deviation	Std. Error Mean
SERVICET	0	12009	141.8583	80.0078	.7301
	9	1293	142.3983	87.2071	2.4252

Independent Samples Test

		Levene's Test for Equality of Variances		t-test for Equality of Means						
									95% Confidence Interval of the Difference	
		F	Sig.	t	df	Sig. (2-tailed)	Mean Difference	Std. Error Difference	Lower	Upper
SERVICET	Equal variances assumed	4.697	.030	-.229	13300	.819	-.5400	2.3630	-5.1719	4.0919
	Equal variances not assumed			-.213	1535.432	.831	-.5400	2.5327	-5.5080	4.4280

Figure 5-2: Independent-Samples T Test for IVR service time at 9 January 9:00 to 10:00

Ranks

	DATE	N	Mean Rank
SERVICET	0	12009	6658.55
	9	1293	6583.86
	Total	13302	

Test Statistics[a,b]

	SERVICET
Chi-Square	.442
df	1
Asymp. Sig.	.506

a. Kruskal Wallis Test

b. Grouping Variable: DATE

Figure 5-3: Kruskal-Wallis H test for IVR Service Time at 9 January 9:00 to 10:00

Second, the transfer time is tested. The result is shown below:

One-Sample Statistics

	N	Mean	Std. Deviation	Std. Error Mean
DATE9	159	89.2013	73.3088	5.8138

One-Sample Test

	Test Value = 86.2					
	t	df	Sig. (2-tailed)	Mean Difference	95% Confidence Interval of the Difference	
					Lower	Upper
DATE9	.516	158	.606	3.0013	-8.4815	14.4840

Figure 5-4: One-Sample T Test for Transfer Time at 9 January 9:00 to 10:00

Group Statistics

	DATE	N	Mean	Std. Deviation	Std. Error Mean
SERVICET	0	1491	86.2164	70.1262	1.8161
	9	159	89.2013	73.3088	5.8138

Independent Samples Test

		Levene's Test for Equality of Variances		t-test for Equality of Means						
									95% Confidence Interval of the Difference	
		F	Sig.	t	df	Sig. (2-tailed)	Mean Difference	Std. Error Difference	Lower	Upper
SERVICET	Equal variances assumed	.973	.324	-.508	1648	.612	-2.9849	5.8764	-14.5108	8.5411
	Equal variances not assumed			-.490	190.148	.625	-2.9849	6.0908	-14.9991	9.0294

Figure 5-5: Independent-Samples T Test for Transfer Time at 9 January 9:00 to 10:00

Ranks

	DATE	N	Mean Rank
SERVICET	0	1491	823.81
	9	159	841.39
	Total	1650	

Test Statistics[a,b]

	SERVICET
Chi-Square	.196
df	1
Asymp. Sig.	.658

a. Kruskal Wallis Test

b. Grouping Variable: DATE

Figure 5-6: Kruskal-Wallis H test for Transfer Time at 9 January 9:00 to 10:00

And, the result of agent transfer time testing is illustrated below:

One-Sample Statistics

	N	Mean	Std. Deviation	Std. Error Mean
DATE9	216	207.74	288.78	19.65

One-Sample Test

	Test Value = 211.35					
					95% Confidence Interval of the Difference	
	t	df	Sig. (2-tailed)	Mean Difference	Lower	Upper
DATE9	-.184	215	.854	-3.61	-42.34	35.12

Figure 5-7: One-Sample T Test for Agent Service Time at 9 January 9:00 to 10:00

Group Statistics

	DATE	N	Mean	Std. Deviation	Std. Error Mean
SERVICET	0	1708	211.3248	312.3733	7.5584
	9	215	208.2977	289.3394	19.7328

Independent Samples Test

		Levene's Test for Equality of Variances		t-test for Equality of Means						
									95% Confidence Interval of the Difference	
		F	Sig.	t	df	Sig. (2-tailed)	Mean Difference	Std. Error Difference	Lower	Upper
SERVICET	Equal variances assumed	2.137	.144	.135	1921	.893	3.0271	22.4252	-40.9533	47.0074
	Equal variances not assumed			.143	280.645	.886	3.0271	21.1308	-38.5680	44.6221

Figure 5-8: Independent-Samples T Test for Agent Service Time at 9 January 9:00 to 10:00

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COUNTERS

Identifier	Count	Limit
Lines Success	1494	Infinite
Lines Busy	360	Infinite

OUTPUTS

Identifier	Value
Avg IVR Q Time	1.1777
Avg Agent Q Time	73.805
Busy Lines	360.00
Success Lines	1494.0
IVR Utilize	.83333
Telephone Utilize	.98571
Agent Utilize	1.0000
Success Percent	80.582

Beginning replication 2 of 10

ARENA Simulation Results
Pa - License #9400000

Summary for Replication 2 of 10

Project: Call Center Anal
Analyst:

Run execution date : 4/20/2001
Model revision date: 4/20/2001

Replication ended at time : 3600.0

TALLY VARIABLES

Identifier	Average	Half Width	Minimum	Maximum	Observations
Transfer Time	136.11	(Insuf)	18.043	674.64	146
Agent_Q Queue Time	339.22	(Insuf)	.00000	622.83	168
Agent Time	260.03	(Insuf)	16.198	2131.8	158
IVR Time	129.46	4.9305	7.6460	429.15	1084
IVR_Q Queue Time	.21365	(Corr)	.00000	13.965	1270

DISCRETE-CHANGE VARIABLES

Identifier	Average	Half Width	Minimum	Maximum	Final Value
IVR Ports Available	60.000	(Insuf)	60.000	60.000	60.000
Agent Number Available	15.000	(Insuf)	15.000	15.000	15.000
# in Agent_Q	17.447	(Insuf)	.00000	28.000	27.000
Agent Number Busy	14.299	(Insuf)	.00000	15.000	15.000
IVR Ports Busy	45.438	(Corr)	.00000	60.000	40.000
IVR Utilization	.75731	(Corr)	.00000	1.0000	.66667
Telephone Utilization	.94960	(Corr)	.00000	1.0000	.97143
Agent Utilization	.95332	(Insuf)	.00000	1.0000	1.0000
Telephone Lines Busy	66.472	(Corr)	.00000	70.000	68.000
# in IVR_Q	.07537	(Insuf)	.00000	4.0000	.00000
Telephone Lines Availa	70.000	(Insuf)	70.000	70.000	70.000

COUNTERS

Identifier	Count	Limit
Lines Success	1270	Infinite
Lines Busy	532	Infinite

OUTPUTS

Identifier	Value
Avg IVR Q Time	.21365
Avg Agent Q Time	339.22
Busy Lines	532.00
Success Lines	1270.0
IVR Utilize	.66667
Telephone Utilize	.97143
Agent Utilize	1.0000
Success Percent	70.477

Beginning replication 3 of 10

ARENA Simulation Results
Pa - License #9400000

Summary for Replication 3 of 10

Project: Call Center Anal
Analyst:

Run execution date : 4/20/2001
Model revision date: 4/20/2001

Replication ended at time : 3600.0

TALLY VARIABLES

Identifier	Average	Half Width	Minimum	Maximum	Observations
Transfer Time	158.88	(Insuf)	18.685	818.77	159
Agent_Q Queue Time	77.713	(Insuf)	.00000	342.65	192
Agent Time	182.91	(Insuf)	14.623	1455.2	180
IVR Time	126.49	4.2162	11.709	484.88	1254
IVR_Q Queue Time	.60776	.59042	.00000	26.555	1464

DISCRETE-CHANGE VARIABLES

Identifier	Average	Half Width	Minimum	Maximum	Final Value
IVR Ports Available	60.000	(Insuf)	60.000	60.000	60.000
Agent Number Available	15.000	(Insuf)	15.000	15.000	15.000
# in Agent_Q	4.4870	(Insuf)	.00000	16.000	13.000
Agent Number Busy	12.595	(Insuf)	.00000	15.000	15.000
IVR Ports Busy	52.335	(Corr)	.00000	60.000	51.000
IVR Utilization	.87226	(Corr)	.00000	1.0000	.85000
Telephone Utilization	.92120	(Corr)	.00000	1.0000	.95714
Agent Utilization	.83971	(Insuf)	.00000	1.0000	1.0000
Telephone Lines Busy	64.484	(Corr)	.00000	70.000	67.000
# in IVR_Q	.24716	(Insuf)	.00000	8.0000	.00000
Telephone Lines Availa	70.000	(Insuf)	70.000	70.000	70.000

COUNTERS

Identifier	Count	Limit
Lines Success	1464	Infinite
Lines Busy	332	Infinite

OUTPUTS

Identifier	Value
Avg IVR Q Time	.60776
Avg Agent Q Time	77.713
Busy Lines	332.00
Success Lines	1464.0
IVR Utilize	.85000
Telephone Utilize	.95714
Agent Utilize	1.0000
Success Percent	81.514

Beginning replication 4 of 10

ARENA Simulation Results
Pa - License #9400000

Summary for Replication 4 of 10

Project: Call Center Anal
Analyst:

Run execution date : 4/20/2001
Model revision date: 4/20/2001

Replication ended at time : 3600.0

TALLY VARIABLES

Identifier	Average	Half Width	Minimum	Maximum	Observations
Transfer Time	155.96	(Insuf)	17.855	782.43	143
Agent_Q Queue Time	172.26	(Insuf)	.00000	543.97	180
Agent Time	221.50	(Insuf)	18.003	1704.9	170
IVR Time	132.05	5.4338	16.521	519.24	1211
IVR_Q Queue Time	1.2566	(Corr)	.00000	21.698	1403

DISCRETE-CHANGE VARIABLES

Identifier	Average	Half Width	Minimum	Maximum	Final Value

IVR Ports Available	60.000	(Insuf)	60.000	60.000	60.000
Agent Number Available	15.000	(Insuf)	15.000	15.000	15.000
# in Agent_Q	9.5556	(Insuf)	.00000	26.000	16.000
Agent Number Busy	13.522	(Insuf)	.00000	15.000	15.000
IVR Ports Busy	51.568	(Corr)	.00000	60.000	49.000
IVR Utilization	.85947	(Corr)	.00000	1.0000	.81667
Telephone Utilization	.94161	(Corr)	.00000	1.0000	1.0000
Agent Utilization	.90148	(Insuf)	.00000	1.0000	1.0000
Telephone Lines Busy	65.912	(Corr)	.00000	70.000	70.000
# in IVR_Q	.48975	(Corr)	.00000	7.0000	.00000
Telephone Lines Availa	70.000	(Insuf)	70.000	70.000	70.000

COUNTERS

Identifier	Count	Limit
Lines Success	1403	Infinite
Lines Busy	422	Infinite

OUTPUTS

Identifier	Value
Avg IVR Q Time	1.2566
Avg Agent Q Time	172.26
Busy Lines	422.00
Success Lines	1403.0
IVR Utilize	.81667
Telephone Utilize	1.0000
Agent Utilize	1.0000
Success Percent	76.876

Beginning replication 5 of 10

ARENA Simulation Results
Pa - License #9400000

Summary for Replication 5 of 10

Project: Call Center Anal
Analyst:

Run execution date : 4/20/2001
Model revision date: 4/20/2001

Replication ended at time : 3600.0

TALLY VARIABLES

Identifier	Average	Half Width	Minimum	Maximum	Observations
Transfer Time	151.23	(Insuf)	17.195	690.56	124
Agent_Q Queue Time	231.06	(Insuf)	.00000	544.28	162
Agent Time	238.61	(Insuf)	15.449	1700.3	149
IVR Time	126.53	5.5933	5.9380	520.97	1215
IVR_Q Queue Time	.40208	(Corr)	.00000	19.501	1388

DISCRETE-CHANGE VARIABLES

Identifier	Average	Half Width	Minimum	Maximum	Final Value
IVR Ports Available	60.000	(Insuf)	60.000	60.000	60.000
Agent Number Available	15.000	(Insuf)	15.000	15.000	15.000
# in Agent_Q	10.815	(Insuf)	.00000	25.000	15.000
Agent Number Busy	13.701	(Insuf)	.00000	15.000	15.000
IVR Ports Busy	49.024	(Corr)	.00000	60.000	49.000
IVR Utilization	.81707	(Corr)	.00000	1.0000	.81667
Telephone Utilization	.93058	(Corr)	.00000	1.0000	.97143
Agent Utilization	.91347	(Insuf)	.00000	1.0000	1.0000
Telephone Lines Busy	65.140	(Corr)	.00000	70.000	68.000
# in IVR_Q	.15502	(Insuf)	.00000	7.0000	.00000
Telephone Lines Availa	70.000	(Insuf)	70.000	70.000	70.000

COUNTERS

Identifier	Count	Limit
Lines Success	1388	Infinite
Lines Busy	407	Infinite

OUTPUTS

Identifier	Value

Avg IVR Q Time	.40208
Avg Agent Q Time	231.06
Busy Lines	407.00
Success Lines	1388.0
IVR Utilize	.81667
Telephone Utilize	.97143
Agent Utilize	1.0000
Success Percent	77.325

Beginning replication 6 of 10

ARENA Simulation Results
Pa - License #9400000

Summary for Replication 6 of 10

Project: Call Center Anal — Run execution date : 4/20/2001
Analyst: — Model revision date: 4/20/2001

Replication ended at time : 3600.0

TALLY VARIABLES

Identifier	Average	Half Width	Minimum	Maximum	Observations
Transfer Time	135.49	(Insuf)	18.438	603.02	137
Agent_Q Queue Time	69.965	(Insuf)	.00000	280.02	191
Agent Time	194.66	(Insuf)	16.970	1146.0	178
IVR Time	127.79	5.7137	7.5423	616.47	1297
IVR_Q Queue Time	.76780	.77775	.00000	33.160	1482

DISCRETE-CHANGE VARIABLES

Identifier	Average	Half Width	Minimum	Maximum	Final Value
IVR Ports Available	60.000	(Insuf)	60.000	60.000	60.000
Agent Number Available	15.000	(Insuf)	15.000	15.000	15.000
# in Agent_Q	4.1158	(Insuf)	.00000	16.000	13.000
Agent Number Busy	13.437	(Insuf)	.00000	15.000	15.000
IVR Ports Busy	52.635	(Corr)	.00000	60.000	48.000
IVR Utilization	.87726	(Corr)	.00000	1.0000	.80000
Telephone Utilization	.89644	(Corr)	.00000	1.0000	.95714
Agent Utilization	.89586	(Insuf)	.00000	1.0000	1.0000
Telephone Lines Busy	62.750	(Corr)	.00000	70.000	67.000
# in IVR_Q	.31608	(Corr)	.00000	8.0000	.00000
Telephone Lines Availa	70.000	(Insuf)	70.000	70.000	70.000

COUNTERS

Identifier	Count	Limit
Lines Success	1482	Infinite
Lines Busy	241	Infinite

OUTPUTS

Identifier	Value
Avg IVR Q Time	.76780
Avg Agent Q Time	69.965
Busy Lines	241.00
Success Lines	1482.0
IVR Utilize	.80000
Telephone Utilize	.95714
Agent Utilize	1.0000
Success Percent	86.012

Beginning replication 7 of 10

ARENA Simulation Results
Pa - License #9400000

Summary for Replication 7 of 10

Project: Call Center Anal — Run execution date : 4/20/2001
Analyst: — Model revision date: 4/20/2001

Replication ended at time : 3600.0

TALLY VARIABLES

Identifier	Average	Half Width	Minimum	Maximum	Observations

Transfer Time	153.92	(Insuf)	20.967	649.78	141
Agent_Q Queue Time	58.752	(Insuf)	.00000	305.91	175
Agent Time	204.84	(Insuf)	13.432	1322.0	162
IVR Time	128.59	4.6236	11.064	519.16	1297
IVR_Q Queue Time	1.3417	1.1614	.00000	28.821	1486

DISCRETE-CHANGE VARIABLES

Identifier	Average	Half Width	Minimum	Maximum	Final Value
IVR Ports Available	60.000	(Insuf)	60.000	60.000	60.000
Agent Number Available	15.000	(Insuf)	15.000	15.000	15.000
# in Agent_Q	3.2982	(Insuf)	.00000	16.000	13.000
Agent Number Busy	12.904	(Insuf)	.00000	15.000	15.000
IVR Ports Busy	53.910	(Corr)	.00000	60.000	48.000
IVR Utilization	.89852	(Corr)	.00000	1.0000	.80000
Telephone Utilization	.93686	(Corr)	.00000	1.0000	.98571
Agent Utilization	.86029	(Insuf)	.00000	1.0000	1.0000
Telephone Lines Busy	65.580	(Corr)	.00000	70.000	69.000
# in IVR_Q	.55386	(Corr)	.00000	10.000	.00000
Telephone Lines Availa	70.000	(Insuf)	70.000	70.000	70.000

COUNTERS

Identifier	Count	Limit
Lines Success	1486	Infinite
Lines Busy	375	Infinite

OUTPUTS

Identifier	Value
Avg IVR Q Time	1.3417
Avg Agent Q Time	58.752
Busy Lines	375.00
Success Lines	1486.0
IVR Utilize	.80000
Telephone Utilize	.98571
Agent Utilize	1.0000
Success Percent	79.849

Beginning replication 8 of 10

ARENA Simulation Results
Pa - License #9400000

Summary for Replication 8 of 10

Project: Call Center Anal
Analyst:

Run execution date : 4/20/2001
Model revision date: 4/20/2001

Replication ended at time : 3600.0

TALLY VARIABLES

Identifier	Average	Half Width	Minimum	Maximum	Observations
Transfer Time	133.21	(Insuf)	17.499	619.26	125
Agent_Q Queue Time	167.03	(Insuf)	.00000	466.59	177
Agent Time	235.17	(Insuf)	14.241	2173.8	165
IVR Time	128.88	(Corr)	10.205	431.79	1266
IVR_Q Queue Time	.59318	(Corr)	.00000	28.000	1444

DISCRETE-CHANGE VARIABLES

Identifier	Average	Half Width	Minimum	Maximum	Final Value
IVR Ports Available	60.000	(Insuf)	60.000	60.000	60.000
Agent Number Available	15.000	(Insuf)	15.000	15.000	15.000
# in Agent_Q	8.2422	(Insuf)	.00000	24.000	4.0000
Agent Number Busy	13.182	(Insuf)	.00000	15.000	15.000
IVR Ports Busy	51.368	(Corr)	.00000	60.000	53.000
IVR Utilization	.85614	(Corr)	.00000	1.0000	.88333
Telephone Utilization	.92322	(Corr)	.00000	1.0000	.91429
Agent Utilization	.87884	(Insuf)	.00000	1.0000	1.0000
Telephone Lines Busy	64.625	(Corr)	.00000	70.000	64.000
# in IVR_Q	.23793	(Insuf)	.00000	8.0000	.00000
Telephone Lines Availa	70.000	(Insuf)	70.000	70.000	70.000

COUNTERS

Identifier	Count	Limit
Lines Success	1444	Infinite
Lines Busy	320	Infinite

OUTPUTS

Identifier	Value
Avg IVR Q Time	.59318
Avg Agent Q Time	167.03
Busy Lines	320.00
Success Lines	1444.0
IVR Utilize	.88333
Telephone Utilize	.91429
Agent Utilize	1.0000
Success Percent	81.859

Beginning replication 9 of 10

ARENA Simulation Results
Pa - License #9400000

Summary for Replication 9 of 10

Project: Call Center Anal
Analyst:

Run execution date : 4/20/2001
Model revision date: 4/20/2001

Replication ended at time : 3600.0

TALLY VARIABLES

Identifier	Average	Half Width	Minimum	Maximum	Observations
Transfer Time	138.58	(Insuf)	19.009	718.60	161
Agent_Q Queue Time	114.40	(Insuf)	.00000	461.45	206
Agent Time	200.17	(Insuf)	13.369	1187.8	195
IVR Time	125.43	(Corr)	6.4085	497.00	1267
IVR_Q Queue Time	.71990	(Corr)	.00000	16.908	1472

DISCRETE-CHANGE VARIABLES

Identifier	Average	Half Width	Minimum	Maximum	Final Value
IVR Ports Available	60.000	(Insuf)	60.000	60.000	60.000
Agent Number Available	15.000	(Insuf)	15.000	15.000	15.000
# in Agent_Q	7.0789	(Corr)	.00000	22.000	16.000
Agent Number Busy	13.832	(Insuf)	.00000	15.000	15.000
IVR Ports Busy	51.381	(Corr)	.00000	60.000	44.000
IVR Utilization	.85635	(Corr)	.00000	1.0000	.73333
Telephone Utilization	.93555	(Corr)	.00000	1.0000	.91429
Agent Utilization	.92217	(Insuf)	.00000	1.0000	1.0000
Telephone Lines Busy	65.488	(Corr)	.00000	70.000	64.000
# in IVR_Q	.29436	(Corr)	.00000	7.0000	.00000
Telephone Lines Availa	70.000	(Insuf)	70.000	70.000	70.000

COUNTERS

Identifier	Count	Limit
Lines Success	1472	Infinite
Lines Busy	315	Infinite

OUTPUTS

Identifier	Value
Avg IVR Q Time	.71990
Avg Agent Q Time	114.40
Busy Lines	315.00
Success Lines	1472.0
IVR Utilize	.73333
Telephone Utilize	.91429
Agent Utilize	1.0000
Success Percent	82.372

Beginning replication 10 of 10

ARENA Simulation Results

Pa - License #9400000

Summary for Replication 10 of 10

Project: Call Center Anal
Analyst:

Run execution date : 4/20/2001
Model revision date: 4/20/2001

Replication ended at time : 3600.0

TALLY VARIABLES

Identifier	Average	Half Width	Minimum	Maximum	Observations
Transfer Time	129.77	(Insuf)	17.315	559.28	145
Agent_Q Queue Time	237.90	(Insuf)	.00000	574.25	169
Agent Time	253.09	(Insuf)	12.599	1673.7	156
IVR Time	127.20	5.7828	10.828	506.26	1165
IVR_Q Queue Time	.01070	.02243	.00000	6.8456	1348

DISCRETE-CHANGE VARIABLES

Identifier	Average	Half Width	Minimum	Maximum	Final Value
IVR Ports Available	60.000	(Insuf)	60.000	60.000	60.000
Agent Number Available	15.000	(Insuf)	15.000	15.000	15.000
# in Agent_Q	13.037	(Insuf)	.00000	33.000	28.000
Agent Number Busy	14.247	(Insuf)	.00000	15.000	15.000
IVR Ports Busy	47.008	(Corr)	.00000	60.000	38.000
IVR Utilization	.78347	(Corr)	.00000	1.0000	.63333
Telephone Utilization	.93194	(Corr)	.00000	1.0000	.97143
Agent Utilization	.94984	(Insuf)	.00000	1.0000	1.0000
Telephone Lines Busy	65.236	(Corr)	.00000	70.000	68.000
# in IVR_Q	.00401	(Insuf)	.00000	2.0000	.00000
Telephone Lines Availa	70.000	(Insuf)	70.000	70.000	70.000

COUNTERS

Identifier	Count	Limit
Lines Success	1348	Infinite
Lines Busy	403	Infinite

OUTPUTS

Identifier	Value
Avg IVR Q Time	.01070
Avg Agent Q Time	237.90
Busy Lines	403.00
Success Lines	1348.0
IVR Utilize	.63333
Telephone Utilize	.97143
Agent Utilize	1.0000
Success Percent	76.984

ARENA Simulation Results
Pa - License #9400000

Output Summary for 10 Replications

Project: Call Center Anal
Analyst:

Run execution date : 4/20/2001
Model revision date: 4/20/2001

OUTPUTS

Identifier	Average	Half-width	Minimum	Maximum	# Replications
Avg IVR Q Time	.70912	.29768	.01070	1.3417	10
Avg Agent Q Time	154.21	62.308	58.752	339.22	10
Busy Lines	370.70	52.472	241.00	532.00	10
Success Lines	1425.1	48.769	1270.0	1494.0	10
IVR Utilize	.78333	.05397	.63333	.88333	10
Telephone Utilize	.96286	.01926	.91429	1.0000	10
Agent Utilize	1.0000	.00000	1.0000	1.0000	10
Success Percent	79.385	2.8337	70.477	86.012	10

Simulation run time: 0.40 minutes.
Simulation run complete.

First, the IVR service time is tested. The result is shown below:

One-Sample Statistics

	N	Mean	Std. Deviation	Std. Error Mean
DATE5	1326	128.88	80.70	2.22

One-Sample Test

	Test Value = 128.14					
	t	df	Sig. (2-tailed)	Mean Difference	95% Confidence Interval of the Difference	
					Lower	Upper
DATE5	.336	1325	.737	.74	-3.60	5.09

Figure 5-10: One-Sample T Test for IVR service time at 5 January 11:00 to 12:00

Ranks

	DATE	N	Mean Rank
SERVICET	0	12374	6854.71
	5	1325	6803.85
	Total	13699	

Test Statistics[a,b]

	SERVICET
Chi-Square	.198
df	1
Asymp. Sig.	.656

a. Kruskal Wallis Test

b. Grouping Variable: DATE

Figure 5-11: Kruskal-Wallis H test for IVR Service Time at 5 January 11:00 to 12:00

Group Statistics

	DATE	N	Mean	Std. Deviation	Std. Error Mean
SERVICET	0	12374	128.1436	73.5015	.6608
	5	1325	128.8717	80.7310	2.2178

Independent Samples Test

		Levene's Test for Equality of Variances		t-test for Equality of Means						
									95% Confidence Interval of the Difference	
		F	Sig.	t	df	Sig. (2-tailed)	Mean Difference	Std. Error Difference	Lower	Upper
SERVICET	Equal variances assumed	.210	.646	-.339	13697	.734	-.7281	2.1457	-4.9339	3.4778
	Equal variances not assumed			-.315	1568.146	.753	-.7281	2.3142	-5.2673	3.8111

Figure 5-12: Independent-Samples T Test for IVR Service Time at 5 January 11:00 to 12:00

Second, the transfer time is tested. The result is shown below:

One-Sample Statistics

	N	Mean	Std. Deviation	Std. Error Mean
DATE5	161	147.2298	122.1679	9.6282

One-Sample Test

	Test Value = 143.8					
	t	df	Sig. (2-tailed)	Mean Difference	95% Confidence Interval of the Difference	
					Lower	Upper
DATE5	.356	160	.722	3.4298	-15.5849	22.4445

Figure 5-13: One-Sample T Test for transfer time at 5 January 11:00 to 12:00

Ranks

	DATE	N	Mean Rank
SERVICET	0	1407	780.24
	5	161	821.76
	Total	1568	

Test Statistics[a,b]

	SERVICET
Chi-Square	1.215
df	1
Asymp. Sig.	.270

a. Kruskal Wallis Test

b. Grouping Variable: DATE

Figure 5-14: Kruskal-Wallis H test for transfer time at 5 January 11:00 to 12:00

Group Statistics

	DATE	N	Mean	Std. Deviation	Std. Error Mean
SERVICET	0	1407	143.8230	126.1985	3.3644
	5	161	147.2298	122.1679	9.6282

Independent Samples Test

		Levene's Test for Equality of Variances		t-test for Equality of Means						
									95% Confidence Interval of the Difference	
		F	Sig.	t	df	Sig. (2-tailed)	Mean Difference	Std. Error Difference	Lower	Upper
SERVICET	Equal variances assumed	.227	.634	-.326	1566	.745	-3.4068	10.4657	-23.9351	17.1215
	Equal variances not assumed			-.334	201.117	.739	-3.4068	10.1991	-23.5176	16.7040

Figure 5-15: Independent-Samples T Test for transfer time at 5 January 11:00 to 12:00

And, the result of agent transfer time testing is illustrated below:

One-Sample Statistics

	N	Mean	Std. Deviation	Std. Error Mean
DATE5	214	216.51	361.46	24.71

One-Sample Test

	Test Value = 221.6					
					95% Confidence Interval of the Difference	
	t	df	Sig. (2-tailed)	Mean Difference	Lower	Upper
DATE5	-.206	213	.837	-5.09	-53.80	43.61

Figure 5-16: One-Sample T Test for agent service time at 5 January 11:00 to 12:00

Ranks

	DATE	N	Mean Rank
SERVICET	0	1663	936.00
	5	214	962.29
	Total	1877	

Test Statistics[a,b]

	SERVICET
Chi-Square	.446
df	1
Asymp. Sig.	.504

a. Kruskal Wallis Test

b. Grouping Variable: DATE

Figure 5-17: Kruskal-Wallis H test for agent service time at 5 January 11:00 to 12:00

Group Statistics

	DATE	N	Mean	Std. Deviation	Std. Error Mean
SERVICET	0	1663	221.6141	268.5168	6.5845
	5	214	216.5093	361.4597	24.7089

Independent Samples Test

		Levene's Test for Equality of Variances		t-test for Equality of Means						
									95% Confidence Interval of the Difference	
		F	Sig	t	df	Sig. (2-tailed)	Mean Difference	Std. Error Difference	Lower	Upper
SERVICET	Equal variances assumed	1.092	.296	.250	1875	.802	5.1048	20.3804	-34.8658	45.0754
	Equal variances not assumed			.200	244.168	.842	5.1048	25.5712	-45.2634	55.4730

Figure 5-18: Independent-Samples T Test for agent service time at 5 January 11:00 to 12:00

From these figure, we may conclude that this model is valid with the existing system because the outputs of the simulation (IVR service time, transfer time, and agent service time) is not differ from the existing system.

5.3 Model Verification for Agent Model

We suppose that there are 360 ordinary customers and 50 executive customers in the system. The agent service time is 150 seconds. The result of simulation is shown below:

ARENA Simulation Results
Pa - License #9400000

Summary for Replication 1 of 1

Project: Call Center Anal
Analyst:

Run execution date : 4/ 6/2001
Model revision date: 4/ 6/2001

Replication ended at time : 3600.0

TALLY VARIABLES

Identifier	Average	Half Width	Minimum	Maximum	Observations
Agent Time	150.00	(Corr)	150.00	150.00	393
Agent_Q Queue Time	.00000	.00000	.00000	.00000	410

DISCRETE-CHANGE VARIABLES

Identifier	Average	Half Width	Minimum	Maximum	Final Value
Agent Number Available	25.000	(Insuf)	25.000	25.000	25.000
# in Agent_Q	.00000	(Insuf)	.00000	.00000	.00000
Agent Number Busy	21.658	(Corr)	.00000	23.000	21.000

COUNTERS

Identifier	Count	Limit
Customer	360	Infinite
Exec Customer	50	Infinite

Simulation run time: 0.00 minutes.
Simulation run complete.

The result from simulation is the same as expectation so we may conclude that the simulation model generates the output as intend.

Like the previous model, another way to verify is using the trace function. The part of the result when using the trace function is shown below:

SIMAN System Trace Beginning at Time: 0.0

Seq#	Label	Block	System Status Change
Time: 0.0 Entity: 2			
1	27$	CREATE	Next creation scheduled at time 32400.0
2	34$	TRACE	

```
-Entity Created
    3 28$               ASSIGN
                                    PERIOD set to 0.0
    4 33$               ASSIGN
                                    Entity 2 picture changed to 0
    5 0$                TRACE
-Making assignments
    6 35$               ASSIGN
                                    PERIOD set to 1.0
                                    PER PERIOD BUSY set to 0.0
                                    BUSY PER PERIOD set to 0.0
                                    PER PERIOD SUCCESS set to 0.0
                                    SUCCESS PER PERIOD set to 0.0
    7 1$                TRACE
-Choosing from 2 options
    8 36$               BRANCH
                                    Selecting at most 1 of 2 branches
                                    IF: Entity 2 sent to 2$
    9 2$                TRACE
-Delaying for time 3600
   10 37$               DELAY
                                    Delayed by 3600.0 until time 3600.0
Time: 0.0  Entity: 4
   32 60$               CREATE
                                    Next creation scheduled at time 72.0
Time: 1e-006.0  Entity: 3
   13 39$               CREATE
                                    CALL IN set to 1e-006.0
                                    Next creation scheduled at time 10.0
   14 46$               TRACE
-Entity Created
   15 43$               ASSIGN
                                    Entity 3 picture changed to DEFAULT
   16 4$                QUEUE
                                    QUEUETIME set to 1e-006.0
                                    Entity 3 sent to next block
   17 47$               SEIZE
                                    Seized 1 unit(s) of resource AGENT NUMBER
   18 52$               ASSIGN
                                    J set to 0
   19 48$               TALLY
                                    Tally AGENT_Q QUEUE TIME recorded 0.0
   20 7$                TRACE
-Making assignments
   21 53$               ASSIGN
                                    CALL AGENT set to 1e-006.0
   22 6$                TRACE
-Delaying for time 150
   23 54$               DELAY
                                    Delayed by 150.0 until time 150.0
Time: 10.0  Entity: 4
   13 39$               CREATE
                                    CALL IN set to 10.0
                                    Next creation scheduled at time 20.0
   14 46$               TRACE
-Entity Created
   15 43$               ASSIGN
                                    Entity 4 picture changed to DEFAULT
   16 4$                QUEUE
                                    QUEUETIME set to 10.0
                                    Entity 4 sent to next block
   17 47$               SEIZE
                                    Seized 1 unit(s) of resource AGENT NUMBER
   18 52$               ASSIGN
                                    J set to 0
   19 48$               TALLY
                                    Tally AGENT_Q QUEUE TIME recorded 0.0
   20 7$                TRACE
-Making assignments
   21 53$               ASSIGN
                                    CALL AGENT set to 10.0
   22 6$                TRACE
-Delaying for time 150
   23 54$               DELAY
                                    Delayed by 150.0 until time 160.0
Time: 20.0  Entity: 7
   13 39$               CREATE
                                    CALL IN set to 20.0
                                    Next creation scheduled at time 30.0
   14 46$               TRACE
-Entity Created
   15 43$               ASSIGN
                                    Entity 7 picture changed to DEFAULT
   16 4$                QUEUE
                                    QUEUETIME set to 20.0
                                    Entity 7 sent to next block
   17 47$               SEIZE
```

```
                                    Seized 1 unit(s) of resource AGENT NUMBER
   18 52$              ASSIGN
                                    J set to 0
   19 48$              TALLY
                                    Tally AGENT_Q QUEUE TIME recorded 0.0
   20 7$               TRACE
-Making assignments
   21 53$              ASSIGN
                                    CALL AGENT set to 20.0
   22 6$               TRACE
-Delaying for time 150
   23 54$              DELAY
                                    Delayed by 150.0 until time 170.0
Time: 30.0  Entity: 8
   13 39$              CREATE
                                    CALL IN set to 30.0
                                    Next creation scheduled at time 40.0
   14 46$              TRACE
-Entity Created
   15 43$              ASSIGN
                                    Entity 8 picture changed to DEFAULT
   16 4$               QUEUE
                                    QUEUETIME set to 30.0
                                    Entity 8 sent to next block
   17 47$              SEIZE
                                    Seized 1 unit(s) of resource AGENT NUMBER
   18 52$              ASSIGN
                                    J set to 0
   19 48$              TALLY
                                    Tally AGENT_Q QUEUE TIME recorded 0.0
   20 7$               TRACE
-Making assignments
   21 53$              ASSIGN
                                    CALL AGENT set to 30.0
   22 6$               TRACE
-Delaying for time 150
   23 54$              DELAY
                                    Delayed by 150.0 until time 180.0
Time: 40.0  Entity: 9
   13 39$              CREATE
                                    CALL IN set to 40.0
                                    Next creation scheduled at time 50.0
   14 46$              TRACE
-Entity Created
   15 43$              ASSIGN
                                    Entity 9 picture changed to DEFAULT
   16 4$               QUEUE
                                    QUEUETIME set to 40.0
                                    Entity 9 sent to next block
   17 47$              SEIZE
                                    Seized 1 unit(s) of resource AGENT NUMBER
   18 52$              ASSIGN
                                    J set to 0
   19 48$              TALLY
                                    Tally AGENT_Q QUEUE TIME recorded 0.0
   20 7$               TRACE
-Making assignments
   21 53$              ASSIGN
                                    CALL AGENT set to 40.0
   22 6$               TRACE
-Delaying for time 150
   23 54$              DELAY
                                    Delayed by 150.0 until time 190.0
Time: 50.0  Entity: 10
   13 39$              CREATE
                                    CALL IN set to 50.0
                                    Next creation scheduled at time 60.0
   14 46$              TRACE
-Entity Created
   15 43$              ASSIGN
                                    Entity 10 picture changed to DEFAULT
   16 4$               QUEUE
                                    QUEUETIME set to 50.0
                                    Entity 10 sent to next block
   17 47$              SEIZE
                                    Seized 1 unit(s) of resource AGENT NUMBER
   18 52$              ASSIGN
                                    J set to 0
   19 48$              TALLY
                                    Tally AGENT_Q QUEUE TIME recorded 0.0
   20 7$               TRACE
-Making assignments
   21 53$              ASSIGN
                                    CALL AGENT set to 50.0
   22 6$               TRACE
-Delaying for time 150
   23 54$              DELAY
```

```
                                                    Delayed by 150.0 until time 200.0
Time: 60.0  Entity: 11
   13 39$               CREATE
                                                    CALL IN set to 60.0
                                                    Next creation scheduled at time 70.0
   14 46$               TRACE
-Entity Created
   15 43$               ASSIGN
                                                    Entity 11 picture changed to DEFAULT
   16 4$                QUEUE
                                                    QUEUETIME set to 60.0
                                                    Entity 11 sent to next block
   17 47$               SEIZE
                                                    Seized 1 unit(s) of resource AGENT NUMBER
   18 52$               ASSIGN
                                                    J set to 0
   19 48$               TALLY
                                                    Tally AGENT_Q QUEUE TIME recorded 0.0
   20 7$                TRACE
-Making assignments
   21 53$               ASSIGN
                                                    CALL AGENT set to 60.0
   22 6$                TRACE
-Delaying for time 150
   23 54$               DELAY
                                                    Delayed by 150.0 until time 210.0
Time: 70.0  Entity: 12
   13 39$               CREATE
                                                    CALL IN set to 70.0
                                                    Next creation scheduled at time 80.0
   14 46$               TRACE
-Entity Created
   15 43$               ASSIGN
                                                    Entity 12 picture changed to DEFAULT
   16 4$                QUEUE
                                                    QUEUETIME set to 70.0
                                                    Entity 12 sent to next block
   17 47$               SEIZE
                                                    Seized 1 unit(s) of resource AGENT NUMBER
   18 52$               ASSIGN
                                                    J set to 0
   19 48$               TALLY
                                                    Tally AGENT_Q QUEUE TIME recorded 0.0
   20 7$                TRACE
-Making assignments
   21 53$               ASSIGN
                                                    CALL AGENT set to 70.0
   22 6$                TRACE
-Delaying for time 150
   23 54$               DELAY
                                                    Delayed by 150.0 until time 220.0
Time: 72.0  Entity: 6
   32 60$               CREATE
                                                    Next creation scheduled at time 144.0
Time: 80.0  Entity: 13
   13 39$               CREATE
                                                    CALL IN set to 80.0
                                                    Next creation scheduled at time 90.0
   14 46$               TRACE
-Entity Created
   15 43$               ASSIGN
                                                    Entity 13 picture changed to DEFAULT
   16 4$                QUEUE
                                                    QUEUETIME set to 80.0
                                                    Entity 13 sent to next block
   17 47$               SEIZE
                                                    Seized 1 unit(s) of resource AGENT NUMBER
   18 52$               ASSIGN
                                                    J set to 0
   19 48$               TALLY
                                                    Tally AGENT_Q QUEUE TIME recorded 0.0
   20 7$                TRACE
-Making assignments
   21 53$               ASSIGN
                                                    CALL AGENT set to 80.0
   22 6$                TRACE
-Delaying for time 150
   23 54$               DELAY
                                                    Delayed by 150.0 until time 230.0
Time: 90.0  Entity: 6
   13 39$               CREATE
                                                    CALL IN set to 90.0
                                                    Next creation scheduled at time 100.0
   14 46$               TRACE
-Entity Created
   15 43$               ASSIGN
                                                    Entity 6 picture changed to DEFAULT
```

```
   16 4$                QUEUE
                                    QUEUETIME set to 90.0
                                    Entity 6 sent to next block
   17 47$               SEIZE
                                    Seized 1 unit(s) of resource AGENT NUMBER
   18 52$               ASSIGN
                                    J set to 0
   19 48$               TALLY
                                    Tally AGENT_Q QUEUE TIME recorded 0.0
   20 7$                TRACE
-Making assignments
   21 53$               ASSIGN
                                    CALL AGENT set to 90.0
   22 6$                TRACE
-Delaying for time 150
   23 54$               DELAY
                                    Delayed by 150.0 until time 240.0
Time: 100.0  Entity: 15
   13 39$               CREATE
                                    CALL IN set to 100.0
                                    Next creation scheduled at time 110.0
   14 46$               TRACE
-Entity Created
   15 43$               ASSIGN
                                    Entity 15 picture changed to DEFAULT
   16 4$                QUEUE
                                    QUEUETIME set to 100.0
                                    Entity 15 sent to next block
   17 47$               SEIZE
                                    Seized 1 unit(s) of resource AGENT NUMBER
   18 52$               ASSIGN
                                    J set to 0
   19 48$               TALLY
                                    Tally AGENT_Q QUEUE TIME recorded 0.0
   20 7$                TRACE
-Making assignments
   21 53$               ASSIGN
                                    CALL AGENT set to 100.0
   22 6$                TRACE
-Delaying for time 150
   23 54$               DELAY
                                    Delayed by 150.0 until time 250.0
Time: 110.0  Entity: 16
   13 39$               CREATE
                                    CALL IN set to 110.0
                                    Next creation scheduled at time 120.0
   14 46$               TRACE
-Entity Created
   15 43$               ASSIGN
                                    Entity 16 picture changed to DEFAULT
   16 4$                QUEUE
                                    QUEUETIME set to 110.0
                                    Entity 16 sent to next block
   17 47$               SEIZE
                                    Seized 1 unit(s) of resource AGENT NUMBER
   18 52$               ASSIGN
                                    J set to 0
   19 48$               TALLY
                                    Tally AGENT_Q QUEUE TIME recorded 0.0
   20 7$                TRACE
-Making assignments
   21 53$               ASSIGN
                                    CALL AGENT set to 110.0
   22 6$                TRACE
-Delaying for time 150
   23 54$               DELAY
                                    Delayed by 150.0 until time 260.0
Time: 120.0  Entity: 17
```

5.4 Model Validation for Agent Model

The chosen day for validation is 11 January 2001 at 9:00 AM to 10:00 AM. Assume that there are about 150 calls and 50 executive customers trying to enter the call center system in this period. The result of simulation is shown below:

```
ARENA Simulation Results
Pa - License #9400000

Summary for Replication 1 of 20
```

Project: Call Center Anal
Analyst:

Run execution date : 4/ 6/2001
Model revision date: 4/ 6/2001

Replication ended at time : 3600.0

TALLY VARIABLES

Identifier	Average	Half Width	Minimum	Maximum	Observations
Agent_Q Queue Time	.00000	(Insuf)	.00000	.00000	197
Agent Time	207.87	(Insuf)	6.1244	1244.1	187

DISCRETE-CHANGE VARIABLES

Identifier	Average	Half Width	Minimum	Maximum	Final Value
# in IVR Ports_Q	.00000	(Insuf)	.00000	.00000	.00000
IVR Ports Available	90.000	(Insuf)	90.000	90.000	90.000
Agent Number Available	25.000	(Insuf)	25.000	25.000	25.000
# in Agent_Q	.00000	(Insuf)	.00000	.00000	.00000
Agent Number Busy	13.635	(Corr)	.00000	22.000	12.000
IVR Ports Busy	.00000	(Insuf)	.00000	.00000	.00000
Telephone Lines Busy	.00000	(Insuf)	.00000	.00000	.00000
Telephone Lines Availa	100.00	(Insuf)	100.00	100.00	100.00

COUNTERS

Identifier	Count	Limit
Customer	153	Infinite
Exec Customer	44	Infinite

Beginning replication 2 of 20

ARENA Simulation Results
Pa - License #9400000

Summary for Replication 2 of 20

Project: Call Center Anal
Analyst:

Run execution date : 4/ 6/2001
Model revision date: 4/ 6/2001

Replication ended at time : 3600.0

TALLY VARIABLES

Identifier	Average	Half Width	Minimum	Maximum	Observations
Agent_Q Queue Time	.00000	(Insuf)	.00000	.00000	199
Agent Time	193.30	(Insuf)	5.8187	890.88	187

DISCRETE-CHANGE VARIABLES

Identifier	Average	Half Width	Minimum	Maximum	Final Value
# in IVR Ports_Q	.00000	(Insuf)	.00000	.00000	.00000
IVR Ports Available	90.000	(Insuf)	90.000	90.000	90.000
Agent Number Available	25.000	(Insuf)	25.000	25.000	25.000
# in Agent_Q	.00000	(Insuf)	.00000	.00000	.00000
Agent Number Busy	13.290	(Corr)	.00000	23.000	13.000
IVR Ports Busy	.00000	(Insuf)	.00000	.00000	.00000
Telephone Lines Busy	.00000	(Insuf)	.00000	.00000	.00000
Telephone Lines Availa	100.00	(Insuf)	100.00	100.00	100.00

COUNTERS

Identifier	Count	Limit
Customer	147	Infinite
Exec Customer	52	Infinite

Beginning replication 3 of 20

ARENA Simulation Results
Pa - License #9400000

Summary for Replication 3 of 20

Project: Call Center Anal
Analyst:

Run execution date : 4/ 6/2001
Model revision date: 4/ 6/2001

Replication ended at time : 3600.0

TALLY VARIABLES

Identifier	Average	Half Width	Minimum	Maximum	Observations
Agent_Q Queue Time	.21160	(Insuf)	.00000	25.093	204
Agent Time	196.30	(Insuf)	9.6900	903.74	194

DISCRETE-CHANGE VARIABLES

Identifier	Average	Half Width	Minimum	Maximum	Final Value
# in IVR Ports_Q	.00000	(Insuf)	.00000	.00000	.00000
IVR Ports Available	90.000	(Insuf)	90.000	90.000	90.000
Agent Number Available	25.000	(Insuf)	25.000	25.000	25.000
# in Agent_Q	.01199	(Insuf)	.00000	2.0000	.00000
Agent Number Busy	13.506	(Corr)	.00000	25.000	13.000
IVR Ports Busy	.00000	(Insuf)	.00000	.00000	.00000
Telephone Lines Busy	.00000	(Insuf)	.00000	.00000	.00000
Telephone Lines Availa	100.00	(Insuf)	100.00	100.00	100.00

COUNTERS

Identifier	Count	Limit
Customer	162	Infinite
Exec Customer	42	Infinite

Beginning replication 4 of 20

ARENA Simulation Results
Pa - License #9400000

Summary for Replication 4 of 20

Project: Call Center Anal
Analyst:

Run execution date : 4/ 6/2001
Model revision date: 4/ 6/2001

Replication ended at time : 3600.0

TALLY VARIABLES

Identifier	Average	Half Width	Minimum	Maximum	Observations
Agent_Q Queue Time	.00000	(Insuf)	.00000	.00000	208
Agent Time	205.36	(Insuf)	5.5945	1443.8	196

DISCRETE-CHANGE VARIABLES

Identifier	Average	Half Width	Minimum	Maximum	Final Value
# in IVR Ports_Q	.00000	(Insuf)	.00000	.00000	.00000
IVR Ports Available	90.000	(Insuf)	90.000	90.000	90.000
Agent Number Available	25.000	(Insuf)	25.000	25.000	25.000
# in Agent_Q	.00000	(Insuf)	.00000	.00000	.00000
Agent Number Busy	15.290	(Corr)	.00000	25.000	18.000
IVR Ports Busy	.00000	(Insuf)	.00000	.00000	.00000
Telephone Lines Busy	.00000	(Insuf)	.00000	.00000	.00000
Telephone Lines Availa	100.00	(Insuf)	100.00	100.00	100.00

COUNTERS

Identifier	Count	Limit
Customer	154	Infinite
Exec Customer	54	Infinite

Beginning replication 5 of 20

ARENA Simulation Results
Pa - License #9400000

Summary for Replication 5 of 20

Project: Call Center Anal
Analyst:

Run execution date : 4/ 6/2001
Model revision date: 4/ 6/2001

Replication ended at time : 3600.0

TALLY VARIABLES

Identifier	Average	Half Width	Minimum	Maximum	Observations
Agent_Q Queue Time	.00000	(Insuf)	.00000	.00000	206
Agent Time	224.15	(Insuf)	5.4712	1528.4	192

DISCRETE-CHANGE VARIABLES

Identifier	Average	Half Width	Minimum	Maximum	Final Value
# in IVR Ports_Q	.00000	(Insuf)	.00000	.00000	.00000
IVR Ports Available	90.000	(Insuf)	90.000	90.000	90.000
Agent Number Available	25.000	(Insuf)	25.000	25.000	25.000
# in Agent_Q	.00000	(Insuf)	.00000	.00000	.00000
Agent Number Busy	15.171	(Corr)	.00000	25.000	14.000
IVR Ports Busy	.00000	(Insuf)	.00000	.00000	.00000
Telephone Lines Busy	.00000	(Insuf)	.00000	.00000	.00000
Telephone Lines Availa	100.00	(Insuf)	100.00	100.00	100.00

COUNTERS

Identifier	Count	Limit
Customer	155	Infinite
Exec Customer	51	Infinite

Beginning replication 6 of 20

ARENA Simulation Results
Pa - License #9400000

Summary for Replication 6 of 20

Project: Call Center Anal — Run execution date : 4/ 6/2001
Analyst: — Model revision date: 4/ 6/2001

Replication ended at time : 3600.0

TALLY VARIABLES

Identifier	Average	Half Width	Minimum	Maximum	Observations
Agent_Q Queue Time	.00000	(Insuf)	.00000	.00000	179
Agent Time	204.26	(Insuf)	7.0980	1068.1	170

DISCRETE-CHANGE VARIABLES

Identifier	Average	Half Width	Minimum	Maximum	Final Value
# in IVR Ports_Q	.00000	(Insuf)	.00000	.00000	.00000
IVR Ports Available	90.000	(Insuf)	90.000	90.000	90.000
Agent Number Available	25.000	(Insuf)	25.000	25.000	25.000
# in Agent_Q	.00000	(Insuf)	.00000	.00000	.00000
Agent Number Busy	12.374	(Corr)	.00000	20.000	9.0000
IVR Ports Busy	.00000	(Insuf)	.00000	.00000	.00000
Telephone Lines Busy	.00000	(Insuf)	.00000	.00000	.00000
Telephone Lines Availa	100.00	(Insuf)	100.00	100.00	100.00

COUNTERS

Identifier	Count	Limit
Customer	133	Infinite
Exec Customer	46	Infinite

Beginning replication 7 of 20

ARENA Simulation Results
Pa - License #9400000

Summary for Replication 7 of 20

Project: Call Center Anal — Run execution date : 4/ 6/2001
Analyst: — Model revision date: 4/ 6/2001

Replication ended at time : 3600.0

TALLY VARIABLES

Identifier	Average	Half Width	Minimum	Maximum	Observations

Agent_Q Queue Time	.00000	(Insuf)	.00000	.00000	182
Agent Time	260.42	(Insuf)	5.1434	1449.8	176

DISCRETE-CHANGE VARIABLES

Identifier	Average	Half Width	Minimum	Maximum	Final Value
# in IVR Ports_Q	.00000	(Insuf)	.00000	.00000	.00000
IVR Ports Available	90.000	(Insuf)	90.000	90.000	90.000
Agent Number Available	25.000	(Insuf)	25.000	25.000	25.000
# in Agent_Q	.00000	(Insuf)	.00000	.00000	.00000
Agent Number Busy	15.180	(Corr)	.00000	25.000	7.0000
IVR Ports Busy	.00000	(Insuf)	.00000	.00000	.00000
Telephone Lines Busy	.00000	(Insuf)	.00000	.00000	.00000
Telephone Lines Availa	100.00	(Insuf)	100.00	100.00	100.00

COUNTERS

Identifier	Count	Limit
Customer	148	Infinite
Exec Customer	34	Infinite

Beginning replication 8 of 20

ARENA Simulation Results
Pa - License #9400000

Summary for Replication 8 of 20

Project: Call Center Anal
Analyst:

Run execution date : 4/ 6/2001
Model revision date: 4/ 6/2001

Replication ended at time : 3600.0

TALLY VARIABLES

Identifier	Average	Half Width	Minimum	Maximum	Observations
Agent_Q Queue Time	.00000	(Insuf)	.00000	.00000	196
Agent Time	192.94	(Insuf)	5.5191	1025.0	186

DISCRETE-CHANGE VARIABLES

Identifier	Average	Half Width	Minimum	Maximum	Final Value
# in IVR Ports_Q	.00000	(Insuf)	.00000	.00000	.00000
IVR Ports Available	90.000	(Insuf)	90.000	90.000	90.000
Agent Number Available	25.000	(Insuf)	25.000	25.000	25.000
# in Agent_Q	.00000	(Insuf)	.00000	.00000	.00000
Agent Number Busy	12.802	(Corr)	.00000	21.000	15.000
IVR Ports Busy	.00000	(Insuf)	.00000	.00000	.00000
Telephone Lines Busy	.00000	(Insuf)	.00000	.00000	.00000
Telephone Lines Availa	100.00	(Insuf)	100.00	100.00	100.00

COUNTERS

Identifier	Count	Limit
Customer	144	Infinite
Exec Customer	52	Infinite

Beginning replication 9 of 20

ARENA Simulation Results
Pa - License #9400000

Summary for Replication 9 of 20

Project: Call Center Anal
Analyst:

Run execution date : 4/ 6/2001
Model revision date: 4/ 6/2001

Replication ended at time : 3600.0

TALLY VARIABLES

Identifier	Average	Half Width	Minimum	Maximum	Observations
Agent_Q Queue Time	.15972	(Insuf)	.00000	17.590	208
Agent Time	215.88	(Insuf)	7.7529	845.34	194

DISCRETE-CHANGE VARIABLES

Identifier	Average	Half Width	Minimum	Maximum	Final Value
# in IVR Ports_Q	.00000	(Insuf)	.00000	.00000	.00000
IVR Ports Available	90.000	(Insuf)	90.000	90.000	90.000
Agent Number Available	25.000	(Insuf)	25.000	25.000	25.000
# in Agent_Q	.00923	(Insuf)	.00000	1.0000	.00000
Agent Number Busy	15.202	(Corr)	.00000	25.000	14.000
IVR Ports Busy	.00000	(Insuf)	.00000	.00000	.00000
Telephone Lines Busy	.00000	(Insuf)	.00000	.00000	.00000
Telephone Lines Availa	100.00	(Insuf)	100.00	100.00	100.00

COUNTERS

Identifier	Count	Limit
Customer	155	Infinite
Exec Customer	53	Infinite

Beginning replication 10 of 20

ARENA Simulation Results
Pa - License #9400000

Summary for Replication 10 of 20

Project: Call Center Anal
Analyst:

Run execution date : 4/ 6/2001
Model revision date: 4/ 6/2001

Replication ended at time : 3600.0

TALLY VARIABLES

Identifier	Average	Half Width	Minimum	Maximum	Observations
Agent_Q Queue Time	.00000	(Insuf)	.00000	.00000	184
Agent Time	217.44	(Insuf)	6.6243	901.49	179

DISCRETE-CHANGE VARIABLES

Identifier	Average	Half Width	Minimum	Maximum	Final Value
# in IVR Ports_Q	.00000	(Insuf)	.00000	.00000	.00000
IVR Ports Available	90.000	(Insuf)	90.000	90.000	90.000
Agent Number Available	25.000	(Insuf)	25.000	25.000	25.000
# in Agent_Q	.00000	(Insuf)	.00000	.00000	.00000
Agent Number Busy	13.362	(Corr)	.00000	23.000	5.0000
IVR Ports Busy	.00000	(Insuf)	.00000	.00000	.00000
Telephone Lines Busy	.00000	(Insuf)	.00000	.00000	.00000
Telephone Lines Availa	100.00	(Insuf)	100.00	100.00	100.00

COUNTERS

Identifier	Count	Limit
Customer	145	Infinite
Exec Customer	39	Infinite

Beginning replication 11 of 20

ARENA Simulation Results
Pa - License #9400000

Summary for Replication 11 of 20

Project: Call Center Anal
Analyst:

Run execution date : 4/ 6/2001
Model revision date: 4/ 6/2001

Replication ended at time : 3600.0

TALLY VARIABLES

Identifier	Average	Half Width	Minimum	Maximum	Observations
Agent_Q Queue Time	.00000	(Insuf)	.00000	.00000	219
Agent Time	198.19	(Insuf)	6.1930	1200.0	205

DISCRETE-CHANGE VARIABLES

Identifier	Average	Half Width	Minimum	Maximum	Final Value
# in IVR Ports_Q	.00000	(Insuf)	.00000	.00000	.00000
IVR Ports Available	90.000	(Insuf)	90.000	90.000	90.000
Agent Number Available	25.000	(Insuf)	25.000	25.000	25.000
# in Agent_Q	.00000	(Insuf)	.00000	.00000	.00000
Agent Number Busy	14.545	(Corr)	.00000	25.000	18.000
IVR Ports Busy	.00000	(Insuf)	.00000	.00000	.00000
Telephone Lines Busy	.00000	(Insuf)	.00000	.00000	.00000
Telephone Lines Availa	100.00	(Insuf)	100.00	100.00	100.00

COUNTERS

Identifier	Count	Limit
Customer	147	Infinite
Exec Customer	72	Infinite

Beginning replication 12 of 20

ARENA Simulation Results
Pa - License #9400000

Summary for Replication 12 of 20

Project: Call Center Anal
Analyst:

Run execution date : 4/ 6/2001
Model revision date: 4/ 6/2001

Replication ended at time : 3600.0

TALLY VARIABLES

Identifier	Average	Half Width	Minimum	Maximum	Observations
Agent_Q Queue Time	.09129	(Insuf)	.00000	12.261	201
Agent Time	202.73	(Insuf)	8.8204	988.85	188

DISCRETE-CHANGE VARIABLES

Identifier	Average	Half Width	Minimum	Maximum	Final Value
# in IVR Ports_Q	.00000	(Insuf)	.00000	.00000	.00000
IVR Ports Available	90.000	(Insuf)	90.000	90.000	90.000
Agent Number Available	25.000	(Insuf)	25.000	25.000	25.000
# in Agent_Q	.00510	(Insuf)	.00000	1.0000	.00000
Agent Number Busy	13.458	(Corr)	.00000	25.000	15.000
IVR Ports Busy	.00000	(Insuf)	.00000	.00000	.00000
Telephone Lines Busy	.00000	(Insuf)	.00000	.00000	.00000
Telephone Lines Availa	100.00	(Insuf)	100.00	100.00	100.00

COUNTERS

Identifier	Count	Limit
Customer	143	Infinite
Exec Customer	58	Infinite

Beginning replication 13 of 20

ARENA Simulation Results
Pa - License #9400000

Summary for Replication 13 of 20

Project: Call Center Anal
Analyst:

Run execution date : 4/ 6/2001
Model revision date: 4/ 6/2001

Replication ended at time : 3600.0

TALLY VARIABLES

Identifier	Average	Half Width	Minimum	Maximum	Observations
Agent_Q Queue Time	.00000	(Insuf)	.00000	.00000	203
Agent Time	201.86	(Insuf)	7.6412	803.66	192

DISCRETE-CHANGE VARIABLES

Identifier	Average	Half Width	Minimum	Maximum	Final Value

# in IVR Ports_Q	.00000	(Insuf)	.00000	.00000	.00000
IVR Ports Available	90.000	(Insuf)	90.000	90.000	90.000
Agent Number Available	25.000	(Insuf)	25.000	25.000	25.000
# in Agent_Q	.00000	(Insuf)	.00000	.00000	.00000
Agent Number Busy	13.705	(Corr)	.00000	22.000	13.000
IVR Ports Busy	.00000	(Insuf)	.00000	.00000	.00000
Telephone Lines Busy	.00000	(Insuf)	.00000	.00000	.00000
Telephone Lines Availa	100.00	(Insuf)	100.00	100.00	100.00

COUNTERS

Identifier	Count	Limit
Customer	148	Infinite
Exec Customer	55	Infinite

Beginning replication 14 of 20

ARENA Simulation Results
Pa - License #9400000

Summary for Replication 14 of 20

Project: Call Center Anal
Analyst:

Run execution date : 4/ 6/2001
Model revision date: 4/ 6/2001

Replication ended at time : 3600.0

TALLY VARIABLES

Identifier	Average	Half Width	Minimum	Maximum	Observations
Agent_Q Queue Time	1.0020	(Insuf)	.00000	34.946	204
Agent Time	210.60	(Insuf)	6.4941	1012.9	187

DISCRETE-CHANGE VARIABLES

Identifier	Average	Half Width	Minimum	Maximum	Final Value
# in IVR Ports_Q	.00000	(Insuf)	.00000	.00000	.00000
IVR Ports Available	90.000	(Insuf)	90.000	90.000	90.000
Agent Number Available	25.000	(Insuf)	25.000	25.000	25.000
# in Agent_Q	.05678	(Insuf)	.00000	4.0000	.00000
Agent Number Busy	14.118	(Corr)	.00000	25.000	23.000
IVR Ports Busy	.00000	(Insuf)	.00000	.00000	.00000
Telephone Lines Busy	.00000	(Insuf)	.00000	.00000	.00000
Telephone Lines Availa	100.00	(Insuf)	100.00	100.00	100.00

COUNTERS

Identifier	Count	Limit
Customer	160	Infinite
Exec Customer	44	Infinite

Beginning replication 15 of 20

ARENA Simulation Results
Pa - License #9400000

Summary for Replication 15 of 20

Project: Call Center Anal
Analyst:

Run execution date : 4/ 6/2001
Model revision date: 4/ 6/2001

Replication ended at time : 3600.0

TALLY VARIABLES

Identifier	Average	Half Width	Minimum	Maximum	Observations
Agent_Q Queue Time	.00000	(Insuf)	.00000	.00000	181
Agent Time	194.30	(Insuf)	9.3524	991.65	172

DISCRETE-CHANGE VARIABLES

Identifier	Average	Half Width	Minimum	Maximum	Final Value
# in IVR Ports_Q	.00000	(Insuf)	.00000	.00000	.00000
IVR Ports Available	90.000	(Insuf)	90.000	90.000	90.000
Agent Number Available	25.000	(Insuf)	25.000	25.000	25.000

# in Agent_Q	.00000	(Insuf)	.00000	.00000	.00000
Agent Number Busy	11.932	(Corr)	.00000	22.000	10.000
IVR Ports Busy	.00000	(Insuf)	.00000	.00000	.00000
Telephone Lines Busy	.00000	(Insuf)	.00000	.00000	.00000
Telephone Lines Availa	100.00	(Insuf)	100.00	100.00	100.00

COUNTERS

Identifier	Count	Limit
Customer	135	Infinite
Exec Customer	46	Infinite

Beginning replication 16 of 20

ARENA Simulation Results
Pa - License #9400000

Summary for Replication 16 of 20

Project: Call Center Anal
Analyst:

Run execution date : 4/ 6/2001
Model revision date: 4/ 6/2001

Replication ended at time : 3600.0

TALLY VARIABLES

Identifier	Average	Half Width	Minimum	Maximum	Observations
Agent_Q Queue Time	.00000	(Insuf)	.00000	.00000	172
Agent Time	175.20	(Insuf)	6.3785	993.58	156

DISCRETE-CHANGE VARIABLES

Identifier	Average	Half Width	Minimum	Maximum	Final Value
# in IVR Ports_Q	.00000	(Insuf)	.00000	.00000	.00000
IVR Ports Available	90.000	(Insuf)	90.000	90.000	90.000
Agent Number Available	25.000	(Insuf)	25.000	25.000	25.000
# in Agent_Q	.00000	(Insuf)	.00000	.00000	.00000
Agent Number Busy	10.984	(Corr)	.00000	22.000	20.000
IVR Ports Busy	.00000	(Insuf)	.00000	.00000	.00000
Telephone Lines Busy	.00000	(Insuf)	.00000	.00000	.00000
Telephone Lines Availa	100.00	(Insuf)	100.00	100.00	100.00

COUNTERS

Identifier	Count	Limit
Customer	130	Infinite
Exec Customer	42	Infinite

Beginning replication 17 of 20

ARENA Simulation Results
Pa - License #9400000

Summary for Replication 17 of 20

Project: Call Center Anal
Analyst:

Run execution date : 4/ 6/2001
Model revision date: 4/ 6/2001

Replication ended at time : 3600.0

TALLY VARIABLES

Identifier	Average	Half Width	Minimum	Maximum	Observations
Agent_Q Queue Time	.00000	(Insuf)	.00000	.00000	207
Agent Time	193.85	(Insuf)	5.7082	1255.0	196

DISCRETE-CHANGE VARIABLES

Identifier	Average	Half Width	Minimum	Maximum	Final Value
# in IVR Ports_Q	.00000	(Insuf)	.00000	.00000	.00000
IVR Ports Available	90.000	(Insuf)	90.000	90.000	90.000
Agent Number Available	25.000	(Insuf)	25.000	25.000	25.000
# in Agent_Q	.00000	(Insuf)	.00000	.00000	.00000
Agent Number Busy	13.464	(Corr)	.00000	22.000	17.000
IVR Ports Busy	.00000	(Insuf)	.00000	.00000	.00000

Telephone Lines Busy	.00000	(Insuf)	.00000	.00000	.00000
Telephone Lines Availa	100.00	(Insuf)	100.00	100.00	100.00

COUNTERS

Identifier	Count	Limit
Customer	153	Infinite
Exec Customer	54	Infinite

Beginning replication 18 of 20

ARENA Simulation Results
Pa - License #9400000

Summary for Replication 18 of 20

Project: Call Center Anal — Run execution date : 4/ 6/2001
Analyst: — Model revision date: 4/ 6/2001

Replication ended at time : 3600.0

TALLY VARIABLES

Identifier	Average	Half Width	Minimum	Maximum	Observations
Agent_Q Queue Time	.16910	(Insuf)	.00000	17.865	216
Agent Time	197.03	(Insuf)	6.0974	1949.5	207

DISCRETE-CHANGE VARIABLES

Identifier	Average	Half Width	Minimum	Maximum	Final Value
# in IVR Ports_Q	.00000	(Insuf)	.00000	.00000	.00000
IVR Ports Available	90.000	(Insuf)	90.000	90.000	90.000
Agent Number Available	25.000	(Insuf)	25.000	25.000	25.000
# in Agent_Q	.01015	(Insuf)	.00000	2.0000	.00000
Agent Number Busy	14.564	(Corr)	.00000	25.000	10.000
IVR Ports Busy	.00000	(Insuf)	.00000	.00000	.00000
Telephone Lines Busy	.00000	(Insuf)	.00000	.00000	.00000
Telephone Lines Availa	100.00	(Insuf)	100.00	100.00	100.00

COUNTERS

Identifier	Count	Limit
Customer	163	Infinite
Exec Customer	53	Infinite

Beginning replication 19 of 20

ARENA Simulation Results
Pa - License #9400000

Summary for Replication 19 of 20

Project: Call Center Anal — Run execution date : 4/ 6/2001
Analyst: — Model revision date: 4/ 6/2001

Replication ended at time : 3600.0

TALLY VARIABLES

Identifier	Average	Half Width	Minimum	Maximum	Observations
Agent_Q Queue Time	.06480	(Insuf)	.00000	8.1309	211
Agent Time	221.61	(Insuf)	5.9317	1232.7	205

DISCRETE-CHANGE VARIABLES

Identifier	Average	Half Width	Minimum	Maximum	Final Value
# in IVR Ports_Q	.00000	(Insuf)	.00000	.00000	.00000
IVR Ports Available	90.000	(Insuf)	90.000	90.000	90.000
Agent Number Available	25.000	(Insuf)	25.000	25.000	25.000
# in Agent_Q	.00380	(Insuf)	.00000	1.0000	.00000
Agent Number Busy	15.567	(Corr)	.00000	25.000	12.000
IVR Ports Busy	.00000	(Insuf)	.00000	.00000	.00000
Telephone Lines Busy	.00000	(Insuf)	.00000	.00000	.00000
Telephone Lines Availa	100.00	(Insuf)	100.00	100.00	100.00

```
                              COUNTERS

                Identifier                 Count    Limit

                Customer                     156    Infinite
                Exec Customer                 55    Infinite

Beginning replication 20 of 20

                        ARENA Simulation Results
                          Pa - License #9400000

                     Summary for Replication 20 of 20

Project:  Call Center Anal                    Run execution date :   4/ 6/2001
Analyst:                                      Model revision date:   4/ 6/2001

Replication ended at time      : 3600.0

                             TALLY VARIABLES

Identifier              Average    Half Width  Minimum     Maximum    Observations

Agent_Q Queue Time      .00000     (Insuf)     .00000      .00000          189
Agent Time              203.42     (Insuf)     5.9735      1355.2          174

                          DISCRETE-CHANGE VARIABLES

Identifier              Average    Half Width  Minimum     Maximum    Final Value

# in IVR Ports_Q        .00000     (Insuf)     .00000      .00000      .00000
IVR Ports Available     90.000     (Insuf)     90.000      90.000      90.000
Agent Number Available  25.000     (Insuf)     25.000      25.000      25.000
# in Agent_Q            .00000     (Insuf)     .00000      .00000      .00000
Agent Number Busy       13.009     (Corr)      .00000      22.000      15.000
IVR Ports Busy          .00000     (Insuf)     .00000      .00000      .00000
Telephone Lines Busy    .00000     (Insuf)     .00000      .00000      .00000
Telephone Lines Availa  100.00     (Insuf)     100.00      100.00      100.00

                              COUNTERS

                Identifier                 Count    Limit

                Customer                     139    Infinite
                Exec Customer                 50    Infinite

Simulation run time: 0.38 minutes.
Simulation run complete.
```

The agent service time is tested, and the result is shown below:

One-Sample Statistics

	N	Mean	Std. Deviation	Std. Error Mean
DATE10	211	217.71	234.36	16.13

One-Sample Test

	Test Value = 206					
					95% Confidence Interval of the Difference	
	t	df	Sig. (2-tailed)	Mean Difference	Lower	Upper
DATE10	.726	210	.469	11.71	-20.10	43.51

Figure 5-19: One-Sample T Test for Agent Service Time at 10 January 9:00 to 10:00

Group Statistics

	DATE	N	Mean	Std. Deviation	Std. Error Mean
SERVICET	0	3743	205.9555	198.5223	3.2449
	10	211	217.7062	234.3638	16.1343

Independent Samples Test

		Levene's Test for Equality of Variances		t-test for Equality of Means						
									95% Confidence Interval of the Difference	
		F	Sig.	t	df	Sig. (2-tailed)	Mean Difference	Std. Error Difference	Lower	Upper
SERVICET	Equal variances assumed	1.418	.234	-.828	3952	.408	-11.7506	14.1929	-39.5768	16.0755
	Equal variances not assumed			-.714	227.311	.476	-11.7506	16.4573	-44.1791	20.6778

Figure 5-20: Independent-Samples T Test for Agent Service Time at 10 January 9:00 to 10:00

Ranks

	DATE	N	Mean Rank
SERVICET	0	3743	1975.32
	10	211	2016.17
	Total	3954	

Test Statistics[a,b]

	SERVICET
Chi-Square	.256
df	1
Asymp. Sig.	.613

a. Kruskal Wallis Test

b. Grouping Variable: DATE

Figure 5-21: Kruskal-Wallis test for Agent Service Time at 10 January 9:00 to 10:00

Note: These results are generated from 20 replications of simulation

From these figure, we may conclude that this model is valid with the existing system because the outputs of the simulation (agent service time) is not differ from the existing system.

However, to ensure that the model is valid, it is suitable to compare the result of the model with actual data on another day. The chosen day is 18 January from 14:00 to 15:00.

The result of simulation is shown below:

```
                    ARENA Simulation Results
                    Pa - License #9400000

                Summary for Replication 1 of 20

Project:  Call Center Anal                  Run execution date :   4/21/2001
Analyst:                                    Model revision date:   4/21/2001

Replication ended at time      : 3600.0

                          TALLY VARIABLES

Identifier                Average   Half Width  Minimum    Maximum   Observations
-------------------------------------------------------------------------------

Agent_Q Queue Time        64.933      (Corr)     .00000     207.36        352
Agent Time                198.43      29.359     12.034     1151.2        335

                      DISCRETE-CHANGE VARIABLES

Identifier                Average   Half Width  Minimum    Maximum   Final Value
-------------------------------------------------------------------------------

Agent Number Available    25.000      (Insuf)    25.000     25.000      25.000
# in Agent_Q              6.6445      (Corr)     .00000     24.000      17.000
Agent Number Busy         23.101      (Corr)     .00000     25.000      25.000
# in Agent Number_Q       .00000      (Insuf)    .00000     .00000      .00000
Agent Utilization         .92406      (Insuf)    .00000     1.0000      1.0000

                             OUTPUTS

                  Identifier                        Value
                  ----------                        -----
```

Agent Queue Time	64.933
Agent Utilize	.92406

Beginning replication 2 of 20

ARENA Simulation Results
Pa - License #9400000

Summary for Replication 2 of 20

Project: Call Center Anal
Analyst:

Run execution date : 4/21/2001
Model revision date: 4/21/2001

Replication ended at time : 3600.0

TALLY VARIABLES

Identifier	Average	Half Width	Minimum	Maximum	Observations
Agent_Q Queue Time	26.210	(Corr)	.00000	113.50	344
Agent Time	190.56	21.864	11.344	876.34	325

DISCRETE-CHANGE VARIABLES

Identifier	Average	Half Width	Minimum	Maximum	Final Value
Agent Number Available	25.000	(Insuf)	25.000	25.000	25.000
# in Agent_Q	2.8039	(Corr)	.00000	15.000	15.000
Agent Number Busy	22.380	(Corr)	.00000	25.000	25.000
# in Agent Number_Q	.00000	(Insuf)	.00000	.00000	.00000
Agent Utilization	.89523	(Insuf)	.00000	1.0000	1.0000

OUTPUTS

Identifier	Value
Agent Queue Time	26.210
Agent Utilize	.89523

Beginning replication 3 of 20

ARENA Simulation Results
Pa - License #9400000

Summary for Replication 3 of 20

Project: Call Center Anal
Analyst:

Run execution date : 4/21/2001
Model revision date: 4/21/2001

Replication ended at time : 3600.0

TALLY VARIABLES

Identifier	Average	Half Width	Minimum	Maximum	Observations
Agent_Q Queue Time	299.16	(Corr)	.00000	541.78	330
Agent Time	220.37	(Insuf)	11.433	1556.3	310

DISCRETE-CHANGE VARIABLES

Identifier	Average	Half Width	Minimum	Maximum	Final Value
Agent Number Available	25.000	(Insuf)	25.000	25.000	25.000
# in Agent_Q	29.457	(Corr)	.00000	54.000	37.000
Agent Number Busy	23.811	(Corr)	.00000	25.000	25.000
# in Agent Number_Q	.00000	(Insuf)	.00000	.00000	.00000
Agent Utilization	.95247	(Insuf)	.00000	1.0000	1.0000

OUTPUTS

Identifier	Value
Agent Queue Time	299.16
Agent Utilize	.95247

Beginning replication 4 of 20

ARENA Simulation Results
Pa - License #9400000

Summary for Replication 4 of 20

Project: Call Center Anal
Analyst:

Run execution date : 4/21/2001
Model revision date: 4/21/2001

Replication ended at time : 3600.0

TALLY VARIABLES

Identifier	Average	Half Width	Minimum	Maximum	Observations
Agent_Q Queue Time	68.020	(Insuf)	.00000	308.04	312
Agent Time	228.75	(Insuf)	12.733	1424.2	289

DISCRETE-CHANGE VARIABLES

Identifier	Average	Half Width	Minimum	Maximum	Final Value
Agent Number Available	25.000	(Insuf)	25.000	25.000	25.000
# in Agent_Q	6.2393	(Corr)	.00000	29.000	13.000
Agent Number Busy	22.938	(Corr)	.00000	25.000	25.000
# in Agent Number_Q	.00000	(Insuf)	.00000	.00000	.00000
Agent Utilization	.91755	(Insuf)	.00000	1.0000	1.0000

OUTPUTS

Identifier	Value
Agent Queue Time	68.020
Agent Utilize	.91755

Beginning replication 5 of 20

ARENA Simulation Results
Pa - License #9400000

Summary for Replication 5 of 20

Project: Call Center Anal
Analyst:

Run execution date : 4/21/2001
Model revision date: 4/21/2001

Replication ended at time : 3600.0

TALLY VARIABLES

Identifier	Average	Half Width	Minimum	Maximum	Observations
Agent_Q Queue Time	27.323	(Corr)	.00000	153.82	349
Agent Time	192.82	19.877	11.477	1035.8	329

DISCRETE-CHANGE VARIABLES

Identifier	Average	Half Width	Minimum	Maximum	Final Value
Agent Number Available	25.000	(Insuf)	25.000	25.000	25.000
# in Agent_Q	2.8309	(Corr)	.00000	12.000	12.000
Agent Number Busy	22.923	(Corr)	.00000	25.000	25.000
# in Agent Number_Q	.00000	(Insuf)	.00000	.00000	.00000
Agent Utilization	.91692	(Insuf)	.00000	1.0000	1.0000

OUTPUTS

Identifier	Value
Agent Queue Time	27.323
Agent Utilize	.91692

Beginning replication 6 of 20

ARENA Simulation Results
Pa - License #9400000

Summary for Replication 6 of 20

Project: Call Center Anal
Analyst:

Run execution date : 4/21/2001
Model revision date: 4/21/2001

Replication ended at time : 3600.0

TALLY VARIABLES

Identifier	Average	Half Width	Minimum	Maximum	Observations

Agent_Q Queue Time	13.000	(Corr)	.00000	105.82	336
Agent Time	192.29	(Insuf)	11.014	1023.2	312

DISCRETE-CHANGE VARIABLES

Identifier	Average	Half Width	Minimum	Maximum	Final Value
Agent Number Available	25.000	(Insuf)	25.000	25.000	25.000
# in Agent_Q	1.2816	(Insuf)	.00000	11.000	6.0000
Agent Number Busy	22.046	(Corr)	.00000	25.000	25.000
# in Agent Number_Q	.00000	(Insuf)	.00000	.00000	.00000
Agent Utilization	.88185	(Corr)	.00000	1.0000	1.0000

OUTPUTS

Identifier	Value
Agent Queue Time	13.000
Agent Utilize	.88185

Beginning replication 7 of 20

ARENA Simulation Results
Pa - License #9400000

Summary for Replication 7 of 20

Project: Call Center Anal — Run execution date : 4/21/2001
Analyst: — Model revision date: 4/21/2001

Replication ended at time : 3600.0

TALLY VARIABLES

Identifier	Average	Half Width	Minimum	Maximum	Observations
Agent_Q Queue Time	140.26	(Corr)	.00000	470.33	346
Agent Time	205.48	24.287	11.219	1110.6	323

DISCRETE-CHANGE VARIABLES

Identifier	Average	Half Width	Minimum	Maximum	Final Value
Agent Number Available	25.000	(Insuf)	25.000	25.000	25.000
# in Agent_Q	16.047	(Corr)	.00000	46.000	44.000
Agent Number Busy	23.831	(Corr)	.00000	25.000	25.000
# in Agent Number_Q	.00000	(Insuf)	.00000	.00000	.00000
Agent Utilization	.95325	(Insuf)	.00000	1.0000	1.0000

OUTPUTS

Identifier	Value
Agent Queue Time	140.26
Agent Utilize	.95325

Beginning replication 8 of 20

ARENA Simulation Results
Pa - License #9400000

Summary for Replication 8 of 20

Project: Call Center Anal — Run execution date : 4/21/2001
Analyst: — Model revision date: 4/21/2001

Replication ended at time : 3600.0

TALLY VARIABLES

Identifier	Average	Half Width	Minimum	Maximum	Observations
Agent_Q Queue Time	115.28	(Corr)	.00000	347.32	358
Agent Time	191.60	24.447	12.374	1194.3	339

DISCRETE-CHANGE VARIABLES

Identifier	Average	Half Width	Minimum	Maximum	Final Value

Agent Number Available	25.000	(Insuf)	25.000	25.000	25.000
# in Agent_Q	13.069	(Corr)	.00000	40.000	36.000
Agent Number Busy	23.454	(Corr)	.00000	25.000	25.000
# in Agent Number_Q	.00000	(Insuf)	.00000	.00000	.00000
Agent Utilization	.93817	(Insuf)	.00000	1.0000	1.0000

OUTPUTS

Identifier	Value
Agent Queue Time	115.28
Agent Utilize	.93817

Beginning replication 9 of 20

ARENA Simulation Results
Pa - License #9400000

Summary for Replication 9 of 20

Project: Call Center Anal
Analyst:

Run execution date : 4/21/2001
Model revision date: 4/21/2001

Replication ended at time : 3600.0

TALLY VARIABLES

Identifier	Average	Half Width	Minimum	Maximum	Observations
Agent_Q Queue Time	51.506	(Corr)	.00000	179.49	322
Agent Time	196.73	(Insuf)	12.268	998.06	301

DISCRETE-CHANGE VARIABLES

Identifier	Average	Half Width	Minimum	Maximum	Final Value
Agent Number Available	25.000	(Insuf)	25.000	25.000	25.000
# in Agent_Q	4.7091	(Corr)	.00000	20.000	8.0000
Agent Number Busy	21.817	(Corr)	.00000	25.000	25.000
# in Agent Number_Q	.00000	(Insuf)	.00000	.00000	.00000
Agent Utilization	.87269	(Insuf)	.00000	1.0000	1.0000

OUTPUTS

Identifier	Value
Agent Queue Time	51.506
Agent Utilize	.87269

Beginning replication 10 of 20

ARENA Simulation Results
Pa - License #9400000

Summary for Replication 10 of 20

Project: Call Center Anal
Analyst:

Run execution date : 4/21/2001
Model revision date: 4/21/2001

Replication ended at time : 3600.0

TALLY VARIABLES

Identifier	Average	Half Width	Minimum	Maximum	Observations
Agent_Q Queue Time	81.240	(Corr)	.00000	307.63	360
Agent Time	184.15	24.480	11.651	879.10	339

DISCRETE-CHANGE VARIABLES

Identifier	Average	Half Width	Minimum	Maximum	Final Value
Agent Number Available	25.000	(Insuf)	25.000	25.000	25.000
# in Agent_Q	10.020	(Corr)	.00000	44.000	42.000
Agent Number Busy	23.128	(Corr)	.00000	25.000	25.000
# in Agent Number_Q	.00000	(Insuf)	.00000	.00000	.00000
Agent Utilization	.92515	(Insuf)	.00000	1.0000	1.0000

OUTPUTS

Identifier	Value
Agent Queue Time	81.240
Agent Utilize	.92515

Beginning replication 11 of 20

ARENA Simulation Results
Pa - License #9400000

Summary for Replication 11 of 20

Project: Call Center Anal
Analyst:
Run execution date : 4/21/2001
Model revision date: 4/21/2001

Replication ended at time : 3600.0

TALLY VARIABLES

Identifier	Average	Half Width	Minimum	Maximum	Observations
Agent_Q Queue Time	39.781	(Corr)	.00000	177.93	341
Agent Time	196.26	19.474	11.857	937.18	325

DISCRETE-CHANGE VARIABLES

Identifier	Average	Half Width	Minimum	Maximum	Final Value
Agent Number Available	25.000	(Insuf)	25.000	25.000	25.000
# in Agent_Q	3.7681	(Corr)	.00000	16.000	.00000
Agent Number Busy	22.309	(Corr)	.00000	25.000	20.000
# in Agent Number_Q	.00000	(Insuf)	.00000	.00000	.00000
Agent Utilization	.89239	(Insuf)	.00000	1.0000	.80000

OUTPUTS

Identifier	Value
Agent Queue Time	39.781
Agent Utilize	.89239

Beginning replication 12 of 20

ARENA Simulation Results
Pa - License #9400000

Summary for Replication 12 of 20

Project: Call Center Anal
Analyst:
Run execution date : 4/21/2001
Model revision date: 4/21/2001

Replication ended at time : 3600.0

TALLY VARIABLES

Identifier	Average	Half Width	Minimum	Maximum	Observations
Agent_Q Queue Time	43.564	(Corr)	.00000	184.78	328
Agent Time	199.26	(Insuf)	11.108	1253.5	306

DISCRETE-CHANGE VARIABLES

Identifier	Average	Half Width	Minimum	Maximum	Final Value
Agent Number Available	25.000	(Insuf)	25.000	25.000	25.000
# in Agent_Q	3.9766	(Corr)	.00000	17.000	2.0000
Agent Number Busy	22.190	(Corr)	.00000	25.000	25.000
# in Agent Number_Q	.00000	(Insuf)	.00000	.00000	.00000
Agent Utilization	.88764	(Insuf)	.00000	1.0000	1.0000

OUTPUTS

Identifier	Value
Agent Queue Time	43.564
Agent Utilize	.88764

Beginning replication 13 of 20

ARENA Simulation Results

Pa - License #9400000

Summary for Replication 13 of 20

Project: Call Center Anal
Analyst:

Run execution date : 4/21/2001
Model revision date: 4/21/2001

Replication ended at time : 3600.0

TALLY VARIABLES

Identifier	Average	Half Width	Minimum	Maximum	Observations
Agent_Q Queue Time	22.565	11.034	.00000	135.88	363
Agent Time	186.08	21.344	11.160	1051.5	343

DISCRETE-CHANGE VARIABLES

Identifier	Average	Half Width	Minimum	Maximum	Final Value
Agent Number Available	25.000	(Insuf)	25.000	25.000	25.000
# in Agent_Q	2.3200	(Corr)	.00000	16.000	7.0000
Agent Number Busy	22.904	(Corr)	.00000	25.000	25.000
# in Agent Number_Q	.00000	(Insuf)	.00000	.00000	.00000
Agent Utilization	.91617	(Insuf)	.00000	1.0000	1.0000

OUTPUTS

Identifier	Value
Agent Queue Time	22.565
Agent Utilize	.91617

Beginning replication 14 of 20

ARENA Simulation Results
Pa - License #9400000

Summary for Replication 14 of 20

Project: Call Center Anal
Analyst:

Run execution date : 4/21/2001
Model revision date: 4/21/2001

Replication ended at time : 3600.0

TALLY VARIABLES

Identifier	Average	Half Width	Minimum	Maximum	Observations
Agent_Q Queue Time	142.36	(Corr)	.00000	498.20	365
Agent Time	194.95	25.381	11.156	1192.1	343

DISCRETE-CHANGE VARIABLES

Identifier	Average	Half Width	Minimum	Maximum	Final Value
Agent Number Available	25.000	(Insuf)	25.000	25.000	25.000
# in Agent_Q	17.295	(Corr)	.00000	52.000	47.000
Agent Number Busy	23.856	(Corr)	.00000	25.000	25.000
# in Agent Number_Q	.00000	(Insuf)	.00000	.00000	.00000
Agent Utilization	.95428	(Insuf)	.00000	1.0000	1.0000

OUTPUTS

Identifier	Value
Agent Queue Time	142.36
Agent Utilize	.95428

Beginning replication 15 of 20

ARENA Simulation Results
Pa - License #9400000

Summary for Replication 15 of 20

Project: Call Center Anal
Analyst:

Run execution date : 4/21/2001
Model revision date: 4/21/2001

Replication ended at time : 3600.0

TALLY VARIABLES

Identifier	Average	Half Width	Minimum	Maximum	Observations
Agent_Q Queue Time	18.693	(Corr)	.00000	91.507	332
Agent Time	196.10	(Insuf)	11.310	1093.2	310

DISCRETE-CHANGE VARIABLES

Identifier	Average	Half Width	Minimum	Maximum	Final Value
Agent Number Available	25.000	(Insuf)	25.000	25.000	25.000
# in Agent_Q	1.7394	(Insuf)	.00000	12.000	3.0000
Agent Number Busy	21.702	(Corr)	.00000	25.000	25.000
# in Agent Number_Q	.00000	(Insuf)	.00000	.00000	.00000
Agent Utilization	.86810	(Corr)	.00000	1.0000	1.0000

OUTPUTS

Identifier	Value
Agent Queue Time	18.693
Agent Utilize	.86810

Beginning replication 16 of 20

ARENA Simulation Results
Pa - License #9400000

Summary for Replication 16 of 20

Project: Call Center Anal
Analyst:

Run execution date : 4/21/2001
Model revision date: 4/21/2001

Replication ended at time : 3600.0

TALLY VARIABLES

Identifier	Average	Half Width	Minimum	Maximum	Observations
Agent_Q Queue Time	4.1893	2.7548	.00000	56.343	336
Agent Time	186.40	(Insuf)	11.231	1010.6	317

DISCRETE-CHANGE VARIABLES

Identifier	Average	Half Width	Minimum	Maximum	Final Value
Agent Number Available	25.000	(Insuf)	25.000	25.000	25.000
# in Agent_Q	.39101	(Insuf)	.00000	6.0000	.00000
Agent Number Busy	21.267	(Corr)	.00000	25.000	22.000
# in Agent Number_Q	.00000	(Insuf)	.00000	.00000	.00000
Agent Utilization	.85071	(Corr)	.00000	1.0000	.88000

OUTPUTS

Identifier	Value
Agent Queue Time	4.1893
Agent Utilize	.85071

Beginning replication 17 of 20

ARENA Simulation Results
Pa - License #9400000

Summary for Replication 17 of 20

Project: Call Center Anal
Analyst:

Run execution date : 4/21/2001
Model revision date: 4/21/2001

Replication ended at time : 3600.0

TALLY VARIABLES

Identifier	Average	Half Width	Minimum	Maximum	Observations
Agent_Q Queue Time	59.116	(Corr)	.00000	240.27	347
Agent Time	191.45	21.614	11.876	1421.6	327

DISCRETE-CHANGE VARIABLES

Identifier	Average	Half Width	Minimum	Maximum	Final Value
Agent Number Available	25.000	(Insuf)	25.000	25.000	25.000
# in Agent_Q	6.0761	(Corr)	.00000	21.000	14.000
Agent Number Busy	22.897	(Corr)	.00000	25.000	25.000
# in Agent Number_Q	.00000	(Insuf)	.00000	.00000	.00000
Agent Utilization	.91590	(Insuf)	.00000	1.0000	1.0000

OUTPUTS

Identifier	Value
Agent Queue Time	59.116
Agent Utilize	.91590

Beginning replication 18 of 20

ARENA Simulation Results
Pa - License #9400000

Summary for Replication 18 of 20

Project: Call Center Anal
Analyst:

Run execution date : 4/21/2001
Model revision date: 4/21/2001

Replication ended at time : 3600.0

TALLY VARIABLES

Identifier	Average	Half Width	Minimum	Maximum	Observations
Agent_Q Queue Time	14.269	(Corr)	.00000	114.74	339
Agent Time	178.44	20.071	11.493	1231.8	320

DISCRETE-CHANGE VARIABLES

Identifier	Average	Half Width	Minimum	Maximum	Final Value
Agent Number Available	25.000	(Insuf)	25.000	25.000	25.000
# in Agent_Q	1.3444	(Insuf)	.00000	13.000	1.0000
Agent Number Busy	20.705	(Corr)	.00000	25.000	25.000
# in Agent Number_Q	.00000	(Insuf)	.00000	.00000	.00000
Agent Utilization	.82822	(Corr)	.00000	1.0000	1.0000

OUTPUTS

Identifier	Value
Agent Queue Time	14.269
Agent Utilize	.82822

Beginning replication 19 of 20

ARENA Simulation Results
Pa - License #9400000

Summary for Replication 19 of 20

Project: Call Center Anal
Analyst:

Run execution date : 4/21/2001
Model revision date: 4/21/2001

Replication ended at time : 3600.0

TALLY VARIABLES

Identifier	Average	Half Width	Minimum	Maximum	Observations
Agent_Q Queue Time	16.615	(Corr)	.00000	95.156	340
Agent Time	187.39	(Insuf)	12.115	1536.8	318

DISCRETE-CHANGE VARIABLES

Identifier	Average	Half Width	Minimum	Maximum	Final Value
Agent Number Available	25.000	(Insuf)	25.000	25.000	25.000
# in Agent_Q	1.7034	(Corr)	.00000	13.000	12.000
Agent Number Busy	21.615	(Corr)	.00000	25.000	25.000
# in Agent Number_Q	.00000	(Insuf)	.00000	.00000	.00000
Agent Utilization	.86462	(Corr)	.00000	1.0000	1.0000

OUTPUTS

Identifier	Value
Agent Queue Time	16.615
Agent Utilize	.86462

Beginning replication 20 of 20

ARENA Simulation Results
Pa - License #9400000

Summary for Replication 20 of 20

Project: Call Center Anal — Run execution date : 4/21/2001
Analyst: — Model revision date: 4/21/2001

Replication ended at time : 3600.0

TALLY VARIABLES

Identifier	Average	Half Width	Minimum	Maximum	Observations
Agent_Q Queue Time	184.99	(Corr)	.00000	445.75	356
Agent Time	202.10	28.158	11.796	1467.1	335

DISCRETE-CHANGE VARIABLES

Identifier	Average	Half Width	Minimum	Maximum	Final Value
Agent Number Available	25.000	(Insuf)	25.000	25.000	25.000
# in Agent_Q	18.327	(Corr)	.00000	43.000	6.0000
Agent Number Busy	23.931	(Corr)	.00000	25.000	25.000
# in Agent Number_Q	.00000	(Insuf)	.00000	.00000	.00000
Agent Utilization	.95726	(Insuf)	.00000	1.0000	1.0000

OUTPUTS

Identifier	Value
Agent Queue Time	184.99
Agent Utilize	.95726

ARENA Simulation Results
Pa - License #9400000

Output Summary for 20 Replications

Project: Call Center Anal — Run execution date : 4/21/2001
Analyst: — Model revision date: 4/21/2001

OUTPUTS

Identifier	Average	Half-width	Minimum	Maximum	# Replications
Agent Queue Time	71.654	34.290	4.1893	299.16	20
Agent Utilize	.90563	.01733	.82822	.95726	20

Simulation run time: 0.27 minutes.
Simulation run complete.

The agent service time is tested, and the result is shown below:

One-Sample Statistics

	N	Mean	Std. Deviation	Std. Error Mean
DATE18	268	206.50	233.30	14.25

One-Sample Test

	Test Value = 195.72					
					95% Confidence Interval of the Difference	
	t	df	Sig. (2-tailed)	Mean Difference	Lower	Upper
DATE18	.757	267	.450	10.78	-17.28	38.84

Figure 5-22: One-Sample T Test for Agent Service Time, 18 January 14:00 to 15:00

Ranks

	DATE	N	Mean Rank
SERVICET	0	6446	3358.03
	18	268	3343.32
	Total	6714	

Test Statistics[a,b]

	SERVICET
Chi-Square	.015
df	1
Asymp. Sig.	.903

a. Kruskal Wallis Test

b. Grouping Variable: DATE

Figure 5-23: Kruskal-Wallis test for Agent Service Time at 18 January 14:00 to 15:00

Group Statistics

	DATE	N	Mean	Std. Deviation	Std. Error Mean
SERVICET	0	6446	195.7167	182.7510	2.2762
	18	268	206.5037	233.3022	14.2512

Independent Samples Test

		Levene's Test for Equality of Variances		t-test for Equality of Means						
									95% Confidence Interval of the Difference	
		F	Sig.	t	df	Sig. (2-tailed)	Mean Difference	Std. Error Difference	Lower	Upper
SERVICET	Equal variances assumed	3.639	.056	-.935	6712	.350	-10.7871	11.5348	-33.3990	11.8248
	Equal variances not assumed			-.747	280.789	.455	-10.7871	14.4318	-39.1954	17.6213

Figure 5-24: Independent-Samples T Test for Agent Service Time at 18 January 14:00 to 15:00

From these figure, we may conclude that this model is valid with the existing system because the outputs of the simulation (agent service time) is not differ from the existing system.