Team Number 06

Semester Project Report

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Semester Project Report

Project Overview:

The simulation model developed for Lion's Den Pizzeria aims to maximize worker numbers and facility layout to enhance both consumer and production flow. The ProModel software is used to perform the simulation, which contains protocols for both dine-in and take-out service. It includes interactions at the front desk and the processes involved in producing pizza and sandwiches. By accurately predicting these trends, the effort hopes to improve both operational efficiency and customer satisfaction.

Simulation Overview:

The simulation used random number generation and a queue server system with ProModel software to replicate the intricate workings of a busy restaurant. The three primary processes in the simulation are sandwich making, pizza making, and customer group arrival. Every step of the process, including the different rates at which client groups arrive and the specific procedures involved in meal preparation and delivery, was painstakingly modelled to replicate real-world operations.

General Recommendations:

- Staff Optimization: Adjust workforce levels to match client flow for more effective order preparation and handling during peak hours.

- Layout Reconfiguration: Rearrange the physical layout, particularly around the front counter and pickup areas, to facilitate faster service and smoother client movement.

- Process Streamlining: Continuously monitor and modify sandwich and pizza preparation procedures to reduce bottlenecks.

- Technological Improvement: Implement order tracking technologies to reduce mistakes and wait times at the front desk and pickup locations.

- Integration of Customer Input: Regularly gather and evaluate customer feedback, focusing on service, quality, and speed, to enhance the dining experience.

Recommendations related to our model design:

- Consider a tradeoff between resource/location capacities utilization and throughput. Similarly, there exists a correlation between table utilization and customer group wait time in the queue. If throughput is measured in terms of the total number of customers served is then there is a need to increase the number of tables. This results in decreasing utilization of tables, and vice versa.

- Instead of considering our model as non-terminating, if we consider the same as Terminating model, we can optimize the system accurately.

Experimentation and Analysis:

1. Run-time Parameters Experimentation

As this is a non-terminating model, we set up the run length as 12 hours and varied the number of replications to find the optimal throughput. In our model the throughput we focused on was the total number of Customer Group, Pizza and Sandwich exits. Upon analyzing the results, we realized that for 100 replications we obtained a steady throughput value.

Run Lengths (Hours)	# Replications	# Customer Groups		# Pizza		# Sandwich	
		95% CI	95% CI	95% CI	95% CI	95% CI	95% CI
		Low	High	Low	High	Low	High
12	10	270.46	280.14	377.57	382.43	252.67	270.73
12	25	273.17	281.47	379.11	382.41	254.94	271.94
12	50	262.13	279.59	362.92	385.8	248.97	267.91
12	75	266.64	278.71	368.81	383.91	253.8	267.64
12	100	264.82	277.06	366.11	382.51	251.94	265.46
12	150	268.18	276.52	370.97	381.92	255.29	264.96
12	200	269.82	276.21	373.12	381.35	256.57	264.67
12	300	271.07	275.55	374.92	380.56	258.17	264.09

2. Resources and Capacity experimentation

We experimented to find out if there is connection between the number of resources and the capacity of each location. Additionally, we intend to analyze how these impact on the results.

Initially we kept the resources (Front Host, Pizza Maker, and Sandwich Maker) to a minimum value and varied the constraints. The constraints were -increase in the business size, location capacities and table sizes.

(Frontdesk = 1, Pizza Maker = 1, Sandwich Maker =1)													
Constraints	**Base Model**			**Customer Group**		**Increase in Front Counter**		**Capacity variations**				**Table Size**	**Pizza-Sandwich (Oven/Warmer & Plating) Queue**
								MIN value	MAX Value	Mixed values			
Customer Groups	345			10%	25%								
Front Counter Capacity	4					1	10						
Pizza Assembly Station Capacity	3							1	30	3	30		
Pizza Oven Capacity	18							18	36	18	36		
Pizza Slicing Station Capacity	2							1	30	2	30		
Sandwich Assembly Station Capacity	3							1	30	30	3		
Sandwich Warmer Station Capacity	2							2	30	30	2		
Sandwich Plating Station Capacity	1							1	30	30	1		
2 Person Table	9											100	
4 Person Table	12											100	
6 Person Table	6											100	
Pizza-Sandwich (Oven/Warmer & Plating)	INFINITE												<10
Metrics	**Average**	**CI LL**	**CI UL**	**Average**	**Average**	**Average**	**Average**	**Average**	**Average**	**Average**	**Average**	**Average**	**Average**
Number of Customer Group Served	71.72	70.73	72.71	72.25	71.43	71.72	71.72	72	73.88	73.88	71.72	71.43	73.39
Number of Customers Served	283.32	280.51	286.13	285.7	282.65	283.32	283.32	285	287.4	287.4	283.32	282.65	287.4
Number of Pizzas made	98.23	97.72	98.74	99.12	97.51	98.23	98.23	98.6	98.39	98.39	98.23	97.51	98.28
Number of Sandwiches made	68.38	66.61	70.15	71.26	66.78	68.38	68.38	70.12	71.31	71.31	68.38	66.78	71.53
Utilization of 2 Person Table	18.62%	17.84	19.4	18.96	19.82%	18.62	18.62	18.82	22.96	22.96	18.62	19.82%	19.4
Utilization of 4 Person Table	13.10%	12.7	13.5	12.39	12.17%	13.1	13.1	13.69	11.67	11.67	13.1	12.17%	13.5
Utilization of 6 Person Table	12.83%	12.13	13.53	12.93	12.53%	12.83	12.83	12.5	11.32	11.32	12.83	12.53%	13.53
Waiting time to be seated	0.16	0.16	0.16	0.16	0.16	0.16	0.16	0.16	0.16	0.16	0.16	0.16	0.16

We observed a constant throughput irrespective of the constraint variations.

Later, we maximized the resources (Front Host, Pizza Maker, and Sandwich Maker) and varied the constraints.

(Frontdesk = 20, Pizza Maker = 30, Sandwich Maker =30)													
Constraints	**Base Model**			**Customer Group**		**Increase in Front Counter**		**Capacity variations**				**Table Size**	**Pizza-Sandwich (Oven/Warmer & Plating) Queue**
								MIN value	MAX Valu	Mixed values			
Customer Groups	345			10%	25%								
Front Counter Capacity	4					1	10						
Pizza Assembly Station Capacity	3							1	30	3	30		
Pizza Oven Capacity	18							18	36	18	36		
Pizza Slicing Station Capacity	2							1	30	2	30		
Sandwich Assembly Station Capacity	3							1	30	30	3		
Sandwich Warmer Station Capacity	2							2	30	30	2		
Sandwich Plating Station Capacity	1							1	30	30	1		
2 Person Table	9											100	
4 Person Table	12											100	
6 Person Table	6											100	
Pizza-Sandwich (Oven/Warmer & Platin	INFINITE												<10
Metrics	**Average**	**CI LL**	**CI UL**	**Average**	**Average**	**Average**	**Average**	**Average**	**Average**	**Average**	**Average**	**Average**	**Average**
Number of Customer Group Served	274.32	272.19	276.43	275.6	274.76	93.57	276	94.65	354.95	269.2	364.52	273.61	359.75
Number of Customers Served	1085.1	1079.4	1090.9	1090	1087.5	370.36	1091.8	372.82	1433.8	1095.34	1452.8	1083.12	1446.79
Number of Pizzas made	379.77	378.84	380.7	379.2	378.71	129.52	380.71	127.4	516.69	380.33	516.13	376.76	515.73
Number of Sandwiches made	260.03	255.78	264.28	266	262.33	87.97	263.01	92.8	356.96	262.87	354.2	261.78	353.49
Utilization of 2 Person Table	69.38%	67.86	70.91	69.55	68.98	23.94	69.98	24.46	92.81	84.19	89.64	6.24	91.38
Utilization of 4 Person Table	50.58%	49.78	51.38	50.98	51.16	17.33	50.97	17.38	64.82	42.33	69.97	6.08	66.88
Utilization of 6 Person Table	50.58%	49.25	51.91	51.08	50.35	17.24	51.33	16.8	61.85	41.39	65.91	3.06	65.06
Waiting time to be seated	1.74	1.36	2.12	1.69	1.84	0.16	1.72	0.17	21.18	9.92	10.85	0.16	13.85

We were able to notice changes in the throughput for different constraint variables. We observed significant improvements when Pizza and Sandwich making locations were increased. Additionally, when the Pizza and Sandwich oven queues' capacities were kept less than 10 instead of INFINITE, we noticed improved throughput.

From the above experimentation we concluded that there is a positive impact on total throughput when both Resources and Capacity of the locations were high. However, the utilization of the Resources and Capacities obtained were low in this case.

3. Hosts Count Experimentation from Simulation:

# No of Hosts Pizza Maker =6, Sandwich Maker=3	Utilization %	# Customer Groups		# Pizza		# Sandwich	
		95% CI Low	95% CI High	95% CI Low	95% CI High	95% CI Low	95% CI High
2	99.76	184.5	191.74	254.56	265.48	174.25	182.11
3	99.52	261.2	268.68	361.43	371.43	247.37	257.41
4	75.49	271.51	278.85	373.06	382.12	255.75	265.69
5	66.75	264.82	277.06	366.13	382.51	251.94	265.43

We considered a range of 2-5 number of hosts and analyzed the throughput. We could see constant throughput when 4/5 number of hosts were considered. However, in the case of 4 numbers of hosts we got higher utilization.

4. Pizza Maker Count Experimentation from Simulation:

No of Pizza makers	Utilization %	95% CI	95% CI	95% CI	95% CI	95% CI	95% CI
Hosts=4,Sandwich Maker =3		Low	High	Low	High	Low	High
2	99.01	145.43	148.37	199.73	200.71	139.13	145.15
3	99.73	217.73	220.79	299.29	300.51	206.73	213.03
4	90.77	262	269.88	360.36	370	249.39	260.95
5	74.84	264.82	277.06	366.11	382.51	251.94	265.46
6	62.49	271.51	278.85	373.06	382.12	255.75	265.69

By keeping Hosts and Sandwich makers constant, we varied the numbers of Pizza Makers from 2 to 6. We obtained steady throughput with optimal utilization for 5 numbers of Pizza Makers.

5. Sandwich Maker Count Experimentation from Simulation:

No of Sub makers Hosts=4,Pizza Maker = 5	Utilization %	95% CI Low	95% CI High	95% CI Low	95% CI High	95% CI Low	95% CI High
2	97.38	212.31	220.17	292.19	301.89	201.78	211.94
3	90.84	271.51	278.85	373.06	382.12	255.75	265.69
4	80.58	273.52	277.74	377.18	381.18	261.97	269.93
5	71.89	215.58	219.16	299.19	300.47	205.76	212.3

By keeping Hosts and Pizza makers constant, we varied the numbers of Sandwich Makers from 2 to 5. We obtained steady throughput with optimal utilization for 4 numbers of Sandwich Makers.

With Front desk personnel 4, Pizza Makers 5 and Sandwich Makers 3 we were able to achieve a similar throughput as in the case where the resources were maximum. In this way we were able to find out the optimal number of resources required in our case. Below table depicts the throughput for Front desk personnel 4, Pizza Makers 5 and Sandwich Makers 3 observed over various constraints.

Contraints	Base Model	Customer Group		Increase in Front Counter		Capacity variations				Table Size	Pizza-Sandwich (Oven/Warmer & Plating) Queue
						MIN value	MAX Value	Mixed values			
Customer Groups	345	10%	25%								
Front Counter Capacity	4			1	10						
Pizza Assembly Station Capacity	3					1	30	3	30		
Pizza Oven Capacity	18					18	36	18	36		
Pizza Slicing Station Capacity	2					1	30	2	30		
Sandwich Assembly Station Capacity	3					1	30	30	3		
Sandwich Warmer Station Capacity	2					2	30	30	2		
Sandwich Plating Station Capacity	1					1	30	30	1		
2 Person Table	9									100	
4 Person Table	12									100	
6 Person Table	6									100	
Pizza-Sandwich (Oven/Warmer & Plating) Queue	INFINITE										<10
(Frontdesk = 4, Pizza Maker = 5, Sandwich Maker =3)											
Metrics	Average	CI LL	CI UL	Average	Average	Average	Average	Average	Average	Average	Average	Average	Average
Number of Customer Group Served	270.94	264.88	277.06	275.18	274.74	94.97	275.29	94.43	315.98	270.74	316.6	275.29	316.64
Number of Customers Served	1075.8	1051.78	1099.82	1088.1	1089.36	378.08	1088.84	371.44	1254.24	1079.3	1258.54	1088.84	1252.86
Number of Pizzas made	374	366.23	382.51	377.59	379.74	130.97	379.31	127.27	435.08	379.59	437.61	379.33	433.5
Number of Sandwiches made	259	252.46	265.96	260.72	263.53	90.16	257.87	90.73	301.99	266.08	300.06	258.33	301.8
Utilization of 2 Person Table	68.86%	66.81	70.91	69.37	69.2	2.13	6.24	24.73	84.13	86.14	78.81	6.24	81.67
Utilization of 4 Person Table	49.74%	48.44	51.04	50.49	50.51	2.16	6.13	16.46	57.19	41.18	59.27	6.13	58.07
Utilization of 6 Person Table	50.21%	48.41	52.01	50.43	51.06	1.04	3.03	17.23	55.02	41.44	58.23	3.03	56.58
Waiting time to be seated	1.93 Min	1.59 Min	2.27 Min	2.14	1.99	0.16	0.16	0.16	6.79	11.53	4.54	0.16	5

We also worked on an alternative method of finding the optimal number of resources to be mathematically precise. In this method, we manually calculate the number of Pizzas and number of Sandwiches prepared every hour based on the type of customer orders as mentioned in the table below.

Number of Sandwiches and/or Pizzas per Group Order		
# Customers in Group	#Sandwiches	#Pizzas
2	2	0
	0	1
4	0	1
	0	2
	1	2
6	0	2
	2	2
8	2	2

Sandwich Makers Calculation:

No. of Sandwich Per Hour = 0.4*0.5*2+0.3*0.33*1+0.2*0.5*2+0.1*1*2 = 0.9

Process Step	Average Cycle Time (min)	Requires Sandwich Maker	Requires Sandwich Warmer
Gathers Sandwich Items	3-5 min	Yes	No
Preparation of Sandwich Plate	1-2 min	Yes	No

From the above table we determined the average time a Sandwich maker is required = 4+1.5 = 5.5 Minutes

Based the Customer Group size we determined the number of Sandwich Makers required:

1. Number of CG 50 = 50*0.9 = 45 Sandwiches
   Total time to make 45 sandwiches = 45*5.5 = 247.5 Minutes
   Total workers needed = 247.5/60 = 4.13 ~= 5 Sandwich Makers

2. Number of CG 10 = 10*0.9 = 9 Sandwiches
   Total time to make 9 sandwiches = 9*5.5 = 49.5 Minutes
   Total workers needed = 49.5/60 = 0.82 ~= 1 Sandwich Makers

3. Number of CG 30 = 30*0.9=27 Sandwiches
   Total time to make 27 sandwiches = 27*5.5 = 148.5 Minutes
   Total workers needed = 148.5/60 = 2.48 ~= 3 Sandwich Makers

4. Number of CG 25 = 25*0.9= 22.5 Sandwiches
   Total time to make 22.5 sandwiches = 22.5*5.5 = 123.75 Minutes
   Total workers needed = 123.75/60 = 2.06 ~= 3 Sandwich Makers

Pizza Makers Calculation:

No. of Pizza Per Hour:
=0.4*0.5*1+0.3*0.33*1+0.3*0.33*2+0.3*0.33*2+0.2*0.5*2+0.2*0.5*2+0.1*1*2
= 0.2+0.1+0.2+0.2+0.2+0.2+0.2
= 1.3

Process Step	Average Cycle Time (min)	Requires Pizza Maker	Requires Pizza Oven
Opens Dough	2-5 min	Yes	No
Adds Sauce & Items	1-3 min	Yes	No
Slices & Plates Pizza	1-2 min	Yes	No

From the above table we determined the average time a Pizza maker is required = 3.5+2+1.5= 7 Minutes

Based the Customer Group size we determined the number of Pizza Makers required:

1. Number of CG 50 = 50*1.3 = 65 Pizzas
   Total time to make 65 Pizzas = 65*7 = 455 Minutes
   Total workers needed = 455/60 = 7.58 ~= 8 Pizza Makers

2. Number of CG 10 = 10*1.3 = 13 Pizzas
   Total time to make 13 Pizzas = 13*7= 91 Minutes
   Total workers needed = 91/60 = 1.51 ~=2 Pizza Makers

3. Number of CG 30 = 30*1.3 = 39 Pizzas
   Total time to make 39 Pizzas = 39*7= 273 Minutes
   Total workers needed = 273/60 = 4.55 ~= 5 Pizza Makers

4. Number of CG 25 = 25*1.3 = 32.5 Pizzas
   Total time to make 32.5 Pizzas = 32.5*7 = 227.5 Minutes
   Total workers needed = 227.5/60 = 3.8 ~= 4 Pizza Makers

We consolidated the above findings in the below table.

		Total Time a Resources is needed to make a Sandwich and a Pizza						
	Sandwich	5.5			Pizza	7		
		Total number of Sandwiches and Pizzas per hour						
	Sandwich per hour	0.9			Pizza per hour	1.3		
Customer Group Sizes	**Total Sandwich per hour**	**Total time to make Sandwiches**	**Total workers needed**	**Rounding up**	**Total Pizza per hour**	**Total time to make Pizzas**	**Total workers needed**	**Rounding up**
50	45	247.5	4.125	5	65	455	7.583333333	8
10	9	49.5	0.825	1	13	91	1.516666667	2
30	27	148.5	2.475	3	39	273	4.55	5
25	22.5	123.75	2.0625	3	32.5	227.5	3.791666667	4
10% increase in Customer Group Size								
55	49.5	272.25	4.5375	5	71.5	500.5	8.341666667	9
11	9.9	54.45	0.9075	1	14.3	100.1	1.668333333	2
33	29.7	163.35	2.7225	3	42.9	300.3	5.005	6
27.5	24.75	136.125	2.26875	3	35.75	250.25	4.170833333	5
25% increase in Customer Group Size								
62.5	56.25	309.375	5.15625	6	81.25	568.75	9.479166667	10
12.5	11.25	61.875	1.03125	2	16.25	113.75	1.895833333	2
37.5	33.75	185.625	3.09375	4	48.75	341.25	5.6875	6
31.25	28.125	154.6875	2.578125	3	40.625	284.375	4.739583333	5

As we are not changing the number of resources based on the customer group occurrences in our model, we considered the average number of Pizza Makers and Sandwich makers required per day. On an average we need 3 Sandwich maker and 5 Pizza maker. In case of 10% or 25% increase in the business we need 4 Sandwich maker and 6 Pizza maker.

Front Counter Personnel Calculation:

From the model design we determined that the host spends on an average 7 minutes with each Customer Group. Based the Customer Group size we determined the number of Front Counter Hosts required:

1. Total time for 50 CG = 50* 7= 350 Minutes
   Hosts required = 350/60 = 5.83 ~= 6 Hosts

2. Total time for 10 CG = 10* 7= 70
   Hosts req = 70/60 = 1.1 ~= 2 Hosts

3. Total time for 30 CG = 30*7= 210
   Hosts req = 210/60 = 3.5 ~= 4 Hosts

4. Total time for 25 CG =25*7= 175
   Hosts req = 175/60=2.91~= 3 Hosts

We considered the average number of Front Counter Hosts required per day.

Total number of customers per day = 345
Total number of Customer Group per hour = 28.75
Total time = 7*28.75 = 201.25 min
Total number of Hosts required = 201.25 /60 = 3.35~= 4 Hosts

We consolidated the above calculation in the table below.

Host time per CG	7		
Customer Group Sizes	**Total time taken at Frontdesk**	**Total Host Required**	**Rounding up**
50	350	5.833333333	6
10	70	1.166666667	2
30	210	3.5	4
25	175	2.916666667	3
10% increase in Customer Group Size			
55	385	6.416666667	7
11	77	1.283333333	2
33	231	3.85	4
27.5	192.5	3.208333333	4
25% increase in Customer Group Size			
62.5	437.5	7.291666667	8
12.5	87.5	1.458333333	2
37.5	262.5	4.375	5
31.25	218.75	3.645833333	4

6. Optimal Tables size Experimentation:

In the next step we worked on determining the optimal number of tables to use in our model. To do that we first needed to eliminate the constraints that can affect us from finding the optimal number of tables. Therefore, we maximized the number of resources. As we had determined earlier, there is a correlation between resources and the capacity of Pizza/Sandwich locations. Hence, we also increased the capacity of Pizza/Sandwich locations to avoid these dependencies in finding the optimal number of tables.

Constraints	Capacity Variations					
Pizza Assembly Station Capacity	30	30	30	30	30	30
Pizza Oven Capacity	36	36	36	36	36	36
Pizza Slicing Station Capacity	30	30	30	30	30	30
Sandwich Assembly Station Capacity	30	30	30	30	30	30
Sandwich Warmer Station Capacity	30	30	30	30	30	30
Sandwich Plating Station Capacity	30	30	30	30	30	30
2 Person Table	100	50	15	12	11	10
4 Person Table	100	20	10	8	8	7
6 Person Table	100	20	10	6	4	3
Metric	**Percentages**					
Utilization of 2 Person Table	8.3	16.32	54.09	68.95	74.64	82.68
Utilization of 4 Person Table	6.4	32.16	65.16	80.22	80.37	88.24
Utilization of 6 Person Table	3.17	16.25	32.03	52.49	75.57	90.99

From the above table we found that we obtain maximum utilization with 10, 7, and 3 tables of capacity 2, 4 and 6 respectively. However, it is important to note that as we decrease the number of tables, the Customer Group wait time in the queue for tables increases.

We ran experiments to find out the optimal number of tables when the customer group size was increased by 10% and 25%.

Constraints	Capacity Variations					
Pizza Assembly Station Capacity	30	30	30	30	30	30
Pizza Oven Capacity	36	36	36	36	36	36
Pizza Slicing Station Capacity	30	30	30	30	30	30
Sandwich Assembly Station Capacity	30	30	30	30	30	30
Sandwich Warmer Station Capacity	30	30	30	30	30	30
Sandwich Plating Station Capacity	30	30	30	30	30	30
2 Person Table	100	50	15	12	11	10
4 Person Table	100	20	10	8	8	7
6 Person Table	100	20	10	6	4	3
10% Increase in CG						
Metric	**Percentages**					
Utilization of 2 Person Table	9.17	18.23	60.58	76.76	82.8	90.59
Utilization of 4 Person Table	7.03	34.95	70.93	86.19	86.11	92.25
Utilization of 6 Person Table	3.39	16.98	33.61	56.4	81.78	93.04
25% Increase in CG						
Metric	**Percentages**					
Utilization of 2 Person Table	10.62	21.36	71.36	87.05	92.77	95.24
Utilization of 4 Person Table	7.77	38.85	76.96	92.02	91.1	94.34
Utilization of 6 Person Table	3.78	18.58	37.5	62.48	87.38	94.28

From these experiments, we realized that 10, 7, and 3 tables of capacity 2, 4 and 6 respectively had maximum utilization. However, the wait time in the queue for the tables increased. There is a tradeoff between utilization of the tables and the wait time in queue for the table was the major take away from this experiment. As we intend to improve the throughput in terms of number of Customer Group exits, we decided to go with 12, 8 and 6 tables capacity 2, 4 and 6 respectively.

7. Optimal Capacity Experiment:

After finding the total resources and tables needed, we experimented with our model by varying the capacity of Front Counter, Pizza Stations, and Sandwich Stations, and noted down the results.

Front Counter Capacity Experimentation:

Front Counters	Customer Groups	Pizza	Sandwich	Utilization
3	265.46	370.09	254.29	99.95
4	273.79	379.55	259.87	83.11
5	274.2	378.12	261.78	78.61

The average time at the Front counter was expected to be 7 minutes. For Front counter size 4 we obtained maximum throughput in terms of the number of Customer group exits, Sandwich & Pizza order exits. And the utilization was also optimal. Hence, we considered the capacity of front counter to be equal to 4.

Pizza Station Capacity Experimentation:

Scenario1	Pizza Station Capacity	Customer Groups	Pizza	Sandwich
Pizza Assembly	5	273.79	379.55	259.87
Pizza Oven Queue	INFINITE			
Pizza Slicing Queue	INFINITE			
Pizza Slicing Station	3			
Scenario2	Pizza Station Capacity	Customer Groups	Pizza	Sandwich
Pizza Assembly	5	314.67	431.12	301.72
Pizza Oven Queue	4			
Pizza Slicing Queue	6			
Pizza Slicing Station	2			

In our initial model, the capacity of the Pizza queues was kept at Infinite capacity. In our experimentation we realized that we could obtain maximum throughput when these queues sizes were decreased. Above table shows the improved throughput when the queue sizes were decreased.

Sandwich Station Capacity Experimentation:

Scenario1	Sandwich Station Capacity	Customer Groups	Pizza	Sandwich
Sub Assembly	4	314.67	431.12	301.72
Sub Warmer Queue	INFINITE			
Sub Plating Queue	INFINITE			
Sub Plating Station	2			
Scenario2	Sandwich Station Capacity	Customer Groups	Pizza	Sandwich
Sub Assembly	4	313	432.01	298.98
Sub Warmer Queue	2			
Sub Plating Queue	2			
Sub Plating Station	3			

Similar to the Pizza queues, we had kept the Sandwich queue sizes as Infinite in our Initial model design. During experimentation we obtained maximum throughput when the sandwich queues were decreased.

Results and Conclusion:

Based on the experimentation outcomes, we updated the number of resources, location capacities and total number of tables. Below table depicts the changes in the throughput before and after our experimentation.

(Frontdesk = 4, Pizza Maker = 5, Sandwich Maker =3)						
Contraints	**Base Model**			**Optimized Model**		
Customer Groups	345			345		
Front Counter Capacity	4			4		
Pizza Assembly Station Capacity	3			5		
Pizza Oven Capacity	18			18		
Pizza Slicing Station Capacity	2			2		
Sandwich Assembly Station Capacity	3			4		
Sandwich Warmer Station Capacity	2			2		
Sandwich Plating Station Capacity	1			2		
2 Person Table	9			12		
4 Person Table	12			8		
6 Person Table	6			6		
Pizza-Sandwich (Oven/Warmer & Plating) Queue	INFINITE			<10		
Metrics	**Average**	**CI LL**	**CI UL**	**Average**	**CI LL**	**CI UL**
Number of Customer Group Served	270.94	264.88	277.06	313.12	310.53	315.71
Number of Customers Served	1075.8	1051.78	1099.82	1235.98	1223.72	1248.24
Number of Pizzas made	374	366.23	382.51	432	427.21	436.79
Number of Sandwiches made	259	252.46	265.96	298.69	294.49	302.89
Utilization of 2 Person Table	68.86%	66.81	70.91	62.34	61.29	63.39
Utilization of 4 Person Table	49.74%	48.44	51.04	83.92	82.63	85.21
Utilization of 6 Person Table	50.21%	48.41	52.01	55.25	53.82	56.68
Waiting time to be seated	1.93 Min	1.59 Min	2.27 Min	5.95 Min	5.19 Min	6.72 Min

We could clearly see an improvement in the total throughput of the model. We also determined the throughput when the business was increased by 10% and 25%. We created the table below to analyze the output.

(Frontdesk = 4, Pizza Maker = 5, Sandwich Maker =3)						
Contraints	**Optimized Model**			**Optimized Model**		
Customer Groups	10% Increase in Volume			25% Increase in Volume		
Front Counter Capacity	4			4		
Pizza Assembly Station Capacity	5			5		
Pizza Oven Capacity	18			18		
Pizza Slicing Station Capacity	2			2		
Sandwich Assembly Station Capacity	4			4		
Sandwich Warmer Station Capacity	2			2		
Sandwich Plating Station Capacity	2			2		
2 Person Table	12			12		
4 Person Table	8			8		
6 Person Table	6			6		
Pizza-Sandwich (Oven/Warmer & Plating) Queue	<10			<10		
Metrics	**Average**	**CI LL**	**CI UL**	**Average**	**CI LL**	**CI UL**
Number of Customer Group Served	339.15	337.51	340.79	350.55	347.67	355.62
Number of Customers Served	1331.62	1323.78	1339.82	1390.12	1388.23	1398.8
Number of Pizzas made	471.46	468.56	473.89	498.23	496.7	501.9
Number of Sandwiches made	329.12	325.61	332.63	352.17	347.65	355.12
Utilization of 2 Person Table	69.38%	68.25	70.5	69.78	68.61	70.95
Utilization of 4 Person Table	88.23%	87.33	89.14	88.77	87.95	89.59
Utilization of 6 Person Table	60.18%	58.76	61.6	62.49	60.91	64.08
Waiting time to be seated	9.11 Min	8.51 Min	10.22 Min	11.01 Min	9.12 Min	12.84 Min

From the above table we were able to conclude that our current model could handle a 10% and 25% increase in business.

Appendix:

Introduction:

We are developing a simulation model for Lion's den pizzeria for optimal facility layout and staffing plan. This model reflects both Customer and Production flow.
For the Customers, the model will reflect both Dine-in and Take-out services. For production flow this model will reflect the Front counter interactions, Sandwich making process and Pizza making process.
The model consists of 3 process flows. They are as follows,

1. Customer Group Arrival Process
2. Sandwich Making Process
3. Pizza Making Process

Process Map for Semester Project

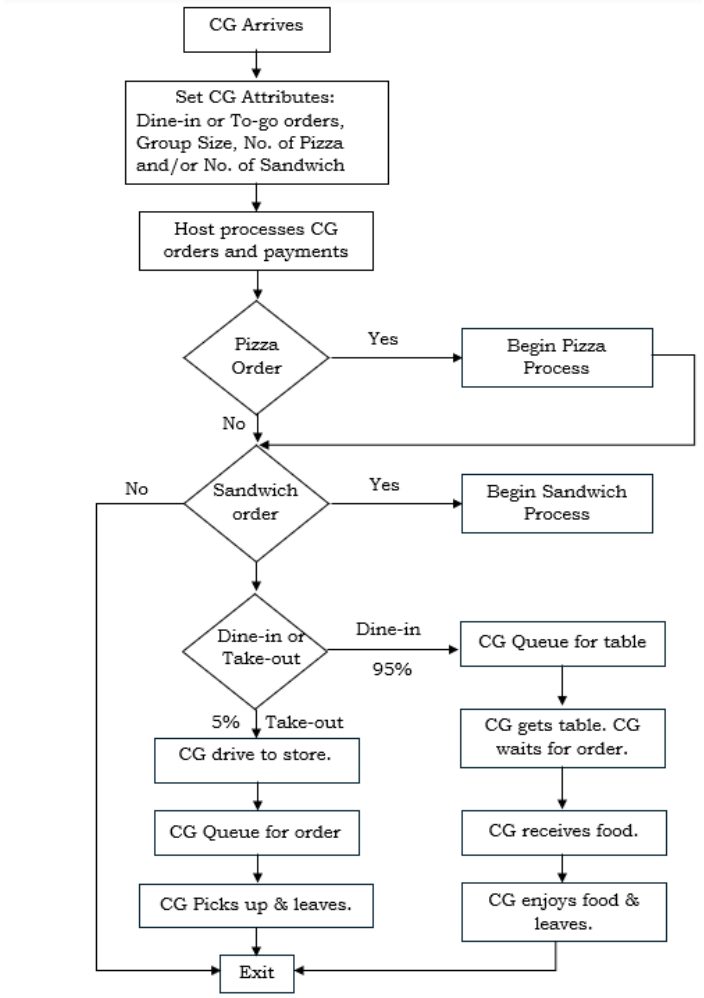

Figure 1: Customer Group Arrival Process Flow

Description:

Customer Group (CG) is the Entity in Customer Group Arrival Process. Arrival rate of the CG varies by the time of the day. When the CG arrives, we must assign attributes such as Dine-in or To-go orders, the CG size, type of order and number of Sandwich and/or number of Pizza. The Pizzeria Host or the front counter personnel greets the CG, processes their orders and payments. CG can order either Pizza or Sandwich or both. According to the CG order, the next processes begin. If the customer does not select either of these options, this process gets terminated. 95% of the Customers Dine-in, whereas 5% of the Customers place To-go orders. In case of Dine-in orders, CG must wait to be seated in the queue and then CG waits for their order. Once the Sandwich/Pizza is prepared it will be delivered to the Customer. CG enjoys their food and leaves. In case of Take-out orders, CG must drive to the Pizzeria. Note that the take-out orders preparations start 20 minutes before the CG arrives. Once CG arrives, they must wait in the queue for their order. Eventually, CG picks up their order and leaves.

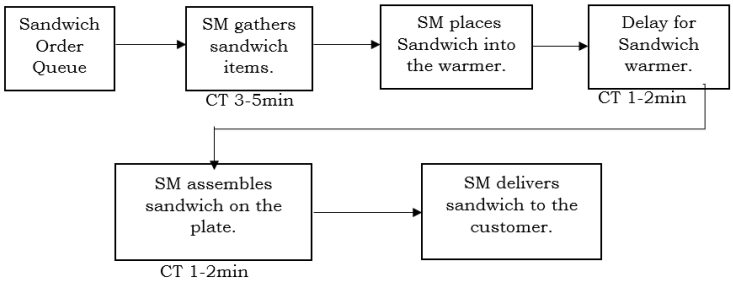

Figure 2: Sandwich Making Process Flow

Description

Sandwich order is the entity in the sandwich making process. When an order for the sandwich arrives, the sandwich maker will collect the ingredients required to make the sandwich and the cycle time for this process is three to five minutes. Once done the Sandwich maker places the sandwich in a sandwich warmer. The cycle time for the warmer to prepare the sandwich is one to two minutes. Once the sandwich gets ready, Sandwich maker will assemble the sandwich on the plate which requires one to two minutes, then the sandwich will be delivered to the customer.

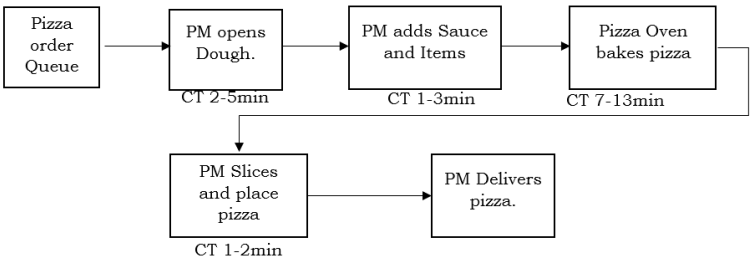

Figure 3: Pizza Making Process Flow

Description

Pizza Order in the Entity in Pizza-Making Process. When an order for the Pizza arrives, the Pizza Maker first starts to open the dough. Here the cycle time for this process is 2-5 minutes. Pizza Maker then adds the sauce and other ingredients to the dough. Cycle time in this process is 1-3 minutes. Next step in the process is to bake the pizza in a Pizza Oven. This process needs a cycle time of 7-13 minutes. Once the baking is completed, the Pizza Maker slices and places the pizza on to a plate, which requires a cycle time of 1-2 minutes. Finally, the pizza is ready to be served.

Critical Input data:

- Customer Group arrival varies by time of the day.
- From 11am-2pm 150 Customer groups arrive.
- From 2pm-5pm 30 Customer groups arrive.
- From 5pm-8pm 90 Customer groups arrive.
- From 8pm-11pm 75 Customer groups arrive.
- Lion' den Pizzeria operates for 12 hours from 11am to 11pm.
- 95% of the Customer Groups are Dine-in Customers and 5% of the Customer Groups are Take-out customers.
- 40% of the Customer Groups are of size 2, 30% of the Customer Groups are of size 4, 20% of the Customer Groups are of size 6 and 10% of the Customer Groups are of size 8.
- Customer Groups of size 2 can order:
    - 2 Sandwiches 50% of the time
    - 1 Pizza 50% of the time.
- Customer Groups of size 4 can order:
    - 1 Pizza 33.3% of the time.
    - 2 Pizza 33.3% of the time.
    - 2 Pizza and 2 Sandwiches 33.3% of the time
- Customer Groups of size 6 can order:
    - 2 Pizza 50% of the time.
    - 2 Pizza and 2 Sandwich 50% of the time.
- Customer Groups of size 8 can order 2 Pizza and 2 Sandwich.
- 30% of the Dine-in Customer Groups spend 20-30 minutes at a table.
- 50% of the Dine-in Customer Groups spend 30-50 minutes at a table.
- 20% of the Dine-in Customer Groups spend 50-90 minutes at a table.
- Entities require resources-Front counter personnel, Pizza Maker, and Sandwich Maker.