TEAM-12

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PROJECT PROCESS REPORT

Optimizing pizza making process and determining advertised time for different levels of service using ARENA

INTRODUCTION

Optimizing the production process is a mainstay to improving returns, increasing customer satisfaction, and reducing wastages. A common theme here is increasing the efficiency of the whole production process. We see an assembly line behind the scenes for almost every consumer product we use. Here we take the case of a locally owned pizzeria, which is run for the most part by students. We strive to implement whatever we have learnt in the course to improve the efficiency of the production process and improve key performance metrics like lead time using various simulation models. The delivery system of the pizzeria is also assessed by us so that we minimize the total delivery time by improving routing.

Pete's pizzeria is a pizza place which receives a large number of orders on a daily basis, and is situated within Purdue University's campus. With an increasing number of orders, the customers face a longer waiting time during peak hours, and we aim to reduce it by optimizing the production time as well as improve routing options so that the pizza is delivered as quickly as possible.

We aim to optimize the production process by eliminating any significant bottlenecks and improve the process flow by introducing operators or machinery wherever necessary. In this problem, the pizza goes through 4 different stations and there exists visible bottlenecks. The Pizza place wants to introduce a delivery system with only 1 delivery vehicle and varying vehicle capacity. We aim to determine advertising delivery time that Pizza place can use for marketing. Depending on various levels of service, we suggest vehicle capacity and advertised time for them to publicize.

PROBLEM DESCRIPTION

IMAGES OF THE CURRENT KITCHEN


Rotations
8 Pepperoni
8 Cheese
4 Garlic Cheese
4 Mushroom
4 Sausage
3-5 Meat Special
1-4 Veg Special
TURBOCHEF


2620
2620


Veggiez 12"
Cheezaburger 12"
1-4 Veg. Special

There exists bottlenecks in the production process which is apparent with the increased waiting time which leads to customer dissatisfaction.

For the production process there are 4 stations which are part of an assembly line. The initial stage which is the dough pressing station, takes an estimated 20 seconds to process. This causes a significant bottleneck as the number of dough which can be pressed at a given time is one, and also because it takes a predetermined set time (7 seconds, which is set by the press by default). Thus the flow of pressed dough to the next stage is restricted.

The making station is the most critical part of the assembly line because this station is where the variation in each kind of pizza originates. This depends on the number and types of toppings used on a specific pizza which leads to a difference in processing times. Rescheduling the orders in such a way that the processing time is minimum is of significance especially when taking into account the location of the customer. Based on the time advertised by the company, the orders are reorganized in such a way that they meet the set limit.

The next stage is the oven, where the pizzas are fed. This can also be priority based depending on the urgency of the order. After 3 minutes in the oven, the pizza is ready and moves to the next station.

At this station, the operator cuts the pizzas and packs them into the boxes and labels them accordingly. This is then sent to the front desk where another operator hands the customer their requested pizza.

A delivery system is also to be developed which utilizes one single vehicle to deliver all available pizzas.

SOLUTION APPROACHES

1. When we visited Pizzeria's kitchen, we observed that there were bottlenecks before the "Making" station. There were two operators working on the same Pizza. And when a pizza with high processing time arrives, the lead time of all the other types of pizzas which have lower processing times increases. So we have thought that if we divide the types of Pizzas into two groups depending on their processing times and then use the two operators to work on one pizzas of one group each, we might be able to reduce the average lead time of pizzas.
2. We make clusters of regions for the delivery system. The clusters are chosen based on demand. After identifying the clusters, they are prioritised based on the distance from the pizzeria. For selecting the orders for delivery after reaching the cluster, priority is given based on the value of (advertised time - (processing time+delivery time))
3. We try to find an optimal advertised time recognized by a service level of 98% identified by a minimum number of outliers for a varying vehicle capacity.

DATA COLLECTION

The “making” times for 4 types of pizzas are given below.

Pepperoni	Cheese	Sausage	Mushroom
10.06	1.98	2.63	2.49
9.85	1.99	5.01	2.5
9.99	1.99	0.99	2.52
9.99	1.98	5.34	2.52
10.23	2.02	7.39	2.48
9.91	1.99	4.66	2.52
9.94	2.02	4.6	2.51
10.04	2.02	3.67	2.52
10.04	2	2.07	2.49
10.19	1.97	6.88	2.49
10.17	1.99	3.7	2.48
9.81	1.98	4.65	2.5
9.96	1.98	4.28	2.52
10.02	2	0.59	2.49
10.07	1.99	0.35	2.51
9.93	2.01	5.21	2.51
10.03	2	-0.26	2.5
9.95	1.99	4.05	2.52
9.86	2.04	9.6	2.52
9.88	2.01	6.13	2.47
9.83	2	4.13	2.51
10.05	2.03	3.46	2.52
9.88	2	5.61	2.5
10.05	1.99	9.73	2.51
10.07	2.01	7.12	2.5
10.03	2.04	4.55	2.51
10.12	2	1.4	2.5
9.98	2.01	8.85	2.5
9.83	2.02	5.06	2.51
9.84	2.04	5.15	2.48
10.03	2.02	1.24	2.48
10.02	2.01	6.52	2.53
9.95	2	6.64	2.51
9.84	1.98	2.41	2.51
9.97	1.98	16.11	2.5
10.05	2.01	2.79	2.5
10.1	1.99	6.11	2.52
10.03	1.99	4.5	2.5
9.78	1.98	7.77	2.52
9.88	1.99	-0.41	2.51
10.1	2	6.26	2.5
9.72	2.02	3.54	2.51
9.88	2.02	1.64	2.5
10.17	2	-2.32	2.5
9.96	1.97	8.34	2.47
10.12	1.97	6.2	2.5

Processing time for dough presser and docker is the same for all the types of pizzas.

Processing times for dough presser and docker
0.29
0.29
0.29
0.29
0.29
0.29
0.27
0.29
0.27
0.29
0.28
0.25
0.28
0.28
0.29
0.27
0.29
0.28
0.27
0.29
0.28
0.3
0.27
0.27
0.29
0.27
0.27
0.26
0.29
0.27
0.28
0.3
0.28
0.29
0.27
0.3
0.28
0.3
0.28
0.28
0.26
0.3
0.29
0.3
0.28
0.29

Time in the oven is constant for each pizza which is 4 minutes
Cutting and Packing is also constant which is 2 minutes'

SIMULATION MODELING:

We have made a model of the Pete's Pizza food preparation process. It involves the following:

RESOURCES:

1). Dough Presser and docker: The presser flattens the dough for a constant time of 7 seconds and the docker is used to uniformly pierce the dough of pizza, to prevent over-rising or blistering and also to aerate the dough.

2). Oven: It uses a 2 row conveyor system which has an input of 20 pizzas at any given time, 10 in each row.

OPERATORS:

There are 4 different operators who work together in the kitchen to put out each pizza with the following tasks,

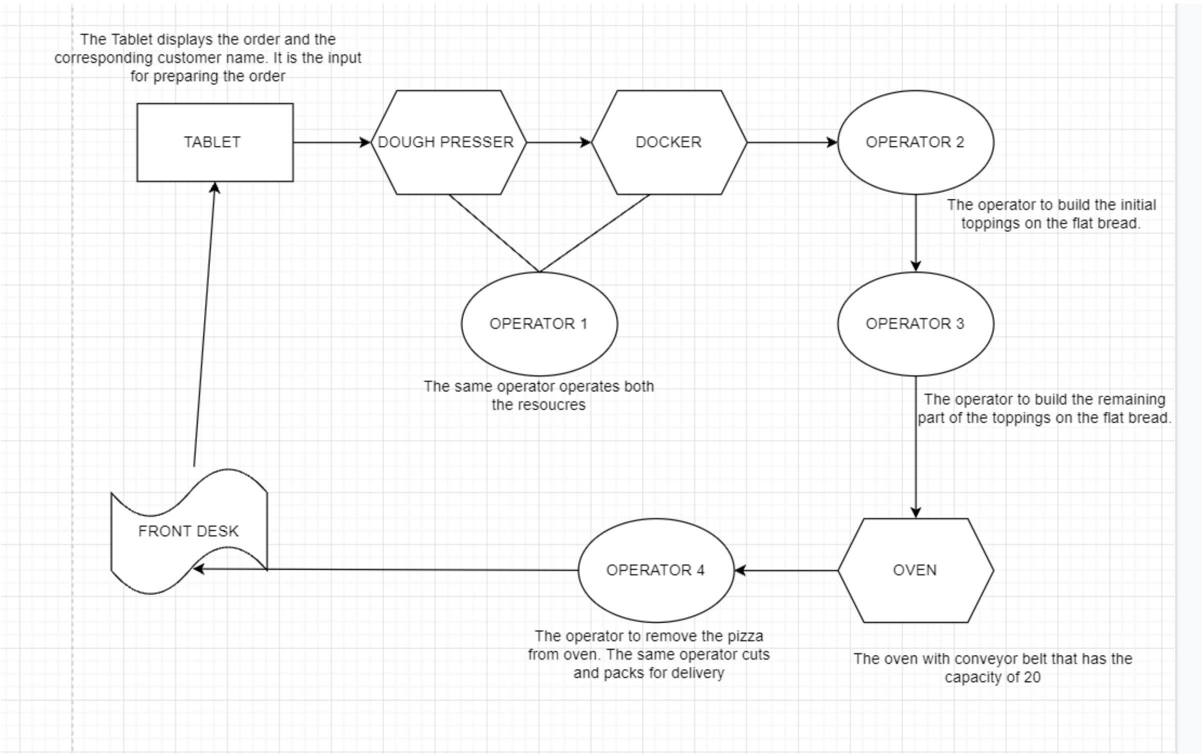
1). Operating the dough presser and docking the pizza.

2). Lay out initial toppings on the flattened dough.

3). To build the remaining toppings on the flattened dough.

4). Remove the pizza from the oven and to cut the pizza into slices of 8 and pack into boxes for delivery.

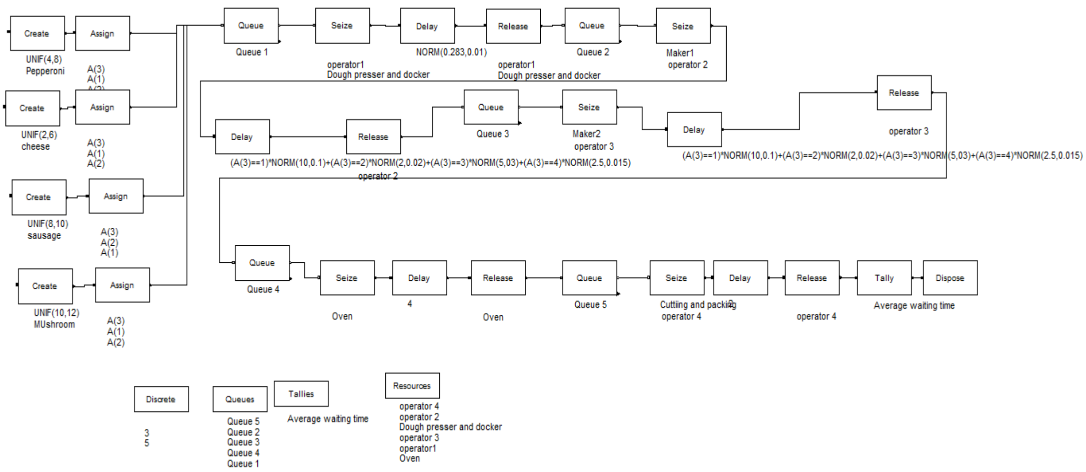
The current process is given below:



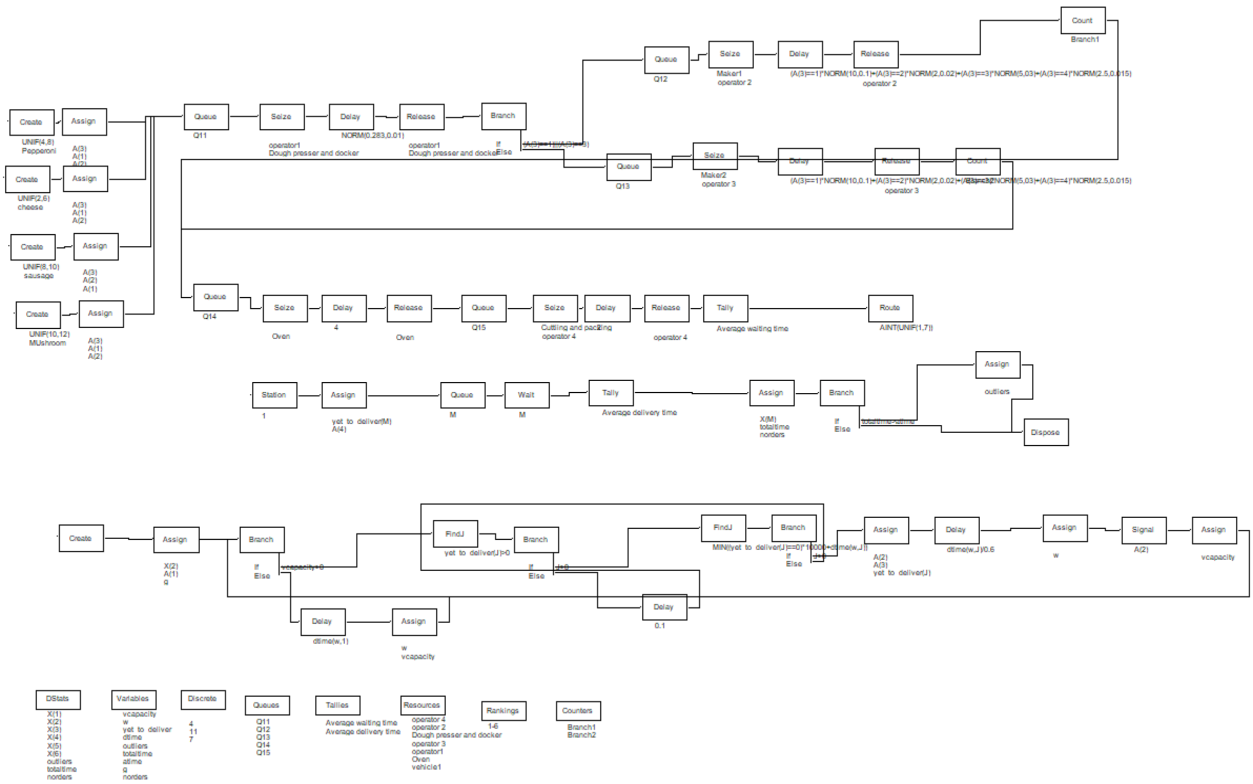
We configured the model into ARENA and varied the process flow to reduce the waiting time. The initial ARENA model is given below.

ARENA SIMULATION MODEL:

Current process without optimization and delivery system



Optimized process and recommended delivery system



The inhouse production system was improved by introducing two branches where each worker works on two separate pizza instead of working in sequence.

Assumptions:

1. *Equal probability of orders from all the clusters.*
2. *Uniformly distributed inter-arrival times for all pizzas.*

3. *For each cluster, the delivery point is the central point assuming the delivery time for all the orders in that cluster is negligible.*
4. *The speed of the car is assumed to be a constant value of 0.6 miles/ minute.*

We have followed the logic below to make the optimized model:

We have used two parallel models. One is for the flow of pizzas and another is for the flow of vehicle. For better understanding, we will call it "Flow of Pizzas" and "Flow of vehicle" in the report.

Flow of Pizzas

1. We used the CREATE block for incoming orders using data we collected from Pizzeria. We found inter-arrival times distribution for all the types of pizzas they make and used the data in the create block.

Pizza type	Inter-arrival times
Pepperoni	UNIF(3,5)
Cheese	UNIF(2,4)
Sausage	UNIF(8,10)
Mushroom	UNIF(10,12)

2. The attributes assigned in the ASSIGN block are as follows.

Attribute id	Attribute
A(1)	Time of order creation
A(3)	Type of pizza (1-Pepperoni, 2-Cheese, 3-Sausage, 4- Mushroom)
yet_to_deliver(M)	Number of pizzas to be delivered
A(4)	Time remaining with respect to advertised time (atime-TNOW+A(1))

3. After pressing and docker process, we used the first solution approach to optimize the "Making" process as the queue waiting time before making process was high.
4. It then goes in the oven and eventually in the cutting and packing process.
5. We use ROUTE and STATION to assign the clusters to the pizzas assuming an equal number of orders from all the clusters.
6. The pizzas will wait in the Queue till they get the signal from "Flow of vehicle" model. The signal will get activated when delivery is done to that particular cluster.
7. After that, we tally the total delivery time and put a BRANCH block for separating outliers based on the condition that the average delivery time is more than the advertised time.

8. The ranking of the each queue in the cluster is done in the ranking element as LVF(4), where attribute A(4) represents the time remaining with respect to advertised time.

S.No	Variable Name	Significance
1	vcapacity	Pizza carrying capacity of the vehicle
2	w	Current location of the vehicle
3	yet_to_deliver	Pizzas waiting to be delivered to each cluster
4	dtime	Distance
5	outliers	Number of deliveries where delivered time>advertised time
6	totaltime	Total time taken from receiving the order to its delivery
7	atime	Advertised time
8	g	Initialized value of vcapacity at 5
9	norders	Total deliveries

Flow of vehicle

1. We used the CREATE block to create 1 vehicle.
2. Then we used the FINDJ block to find if there are any pizzas to be delivered or not at the each cluster. In case there aren't any cluster with pizzas waiting to be delivered, J will be initialised to 0 and it will go through ELSE statement, it will DELAY for 0.1 mins and again go to FINDJ block to check again if there are pizzas waiting to be delivered.
3. When FINDJ is able to detect clusters with pizzas to be delivered,J will take a value greater than 0 and hence it will go to the FINDJ block.
4. The FINDJ block will iterate from 1-6 and find the clusters with pizzas to be delivered and the shortest distance cluster from the pizza stall is identified and J is initialised to that cluster(station) number.
5. The attribute A(2) will be assigned to J(the cluster that needs to be travelled) and the quantity to be delivered is assigned in A(3) and the pizzas to be delivered is reduced by that quantity(A(3)) as they will be removed from the queue in that particular cluster.
6. The vehicle will then travel to the closest cluster and the time taken is given by the delay block using 0.6 miles/minute.
7. Now w is assigned to J which will be the current location of the cluster.
8. The SIGNAL block with the signal code A(2) will be sent to the WAIT block to release from the corresponding cluster Queue and the release limit is equal to A(3).
9. Now the vehicle capacity defined in the variable capacity is reduced by A(3) and it goes back to the initial branch and the process repeats.
10.

Attribute id	Attribute
A(1)	Vehicle id
A(2)	The cluster to which the pizza needs to be delivered.
A(3)	The number of pizzas to be delivered in a particular cluster

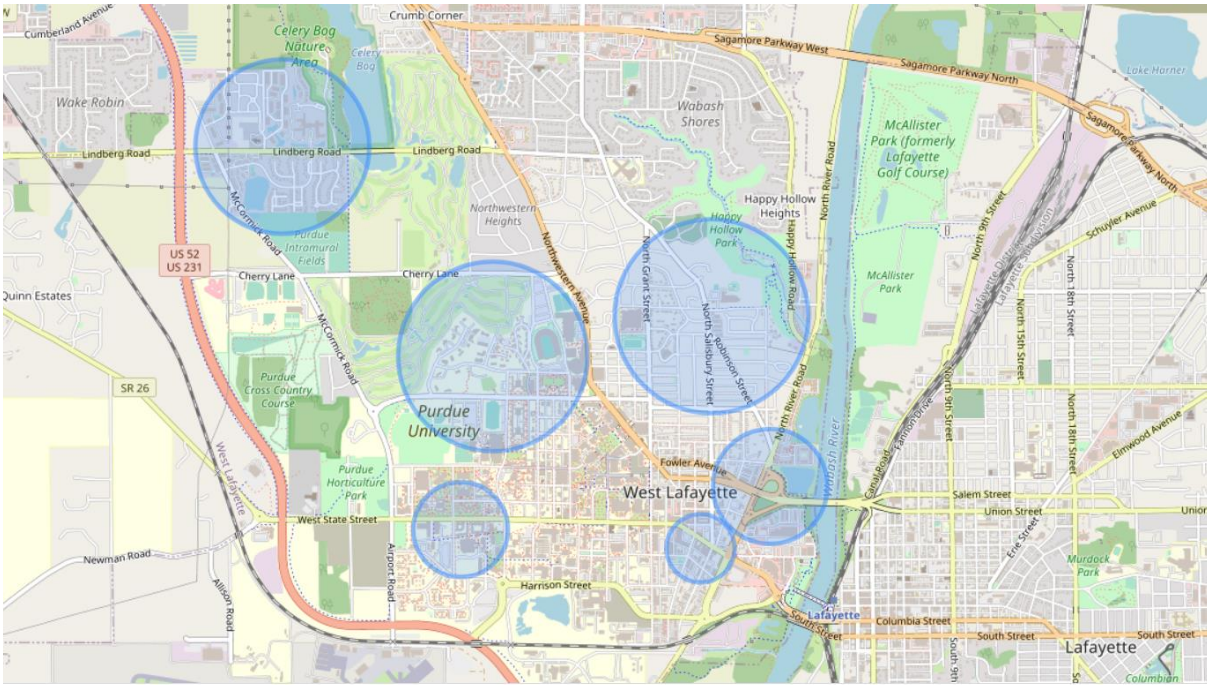
DESIGN OF EXPERIMENTS:

We are varying vehicle capacity and advertised time to find the best combination for the pizza stall. We will decide this based on the number of deliveries done with delivery time more than advertised time and we prefer lower number of pizzas in one delivery to improve the quality of pizza delivered.

We ran the model on the process analyzer and got the following results.

	Scenario Properties				Controls			Responses	
	S	Name	Program File	Reps	atime	vcapacity	Num Reps	outliers	norders
1		1	13 : final mod	7	65.0000	5.0000	7	0.286	467.000
2		1	13 : final mod	7	65.0000	4.0000	7	0.571	467.000
3		1	13 : final mod	7	65.0000	3.0000	7	2.000	467.000
4		1	13 : final mod	7	60.0000	5.0000	7	4.143	467.000
5		1	13 : final mod	7	60.0000	4.0000	7	4.429	467.000
6		1	13 : final mod	7	60.0000	3.0000	7	6.000	467.000
7		1	13 : final mod	7	65.0000	2.0000	7	7.714	467.000
8		1	13 : final mod	7	60.0000	2.0000	7	14.000	467.000
9		1	13 : final mod	7	55.0000	5.0000	7	15.000	467.000
10		1	13 : final mod	7	55.0000	4.0000	7	15.429	467.000
11		1	13 : final mod	7	55.0000	3.0000	7	20.143	467.000
12		1	13 : final mod	7	55.0000	2.0000	7	25.714	467.000
13		1	13 : final mod	7	50.0000	4.0000	7	40.286	467.000
14		1	13 : final mod	7	50.0000	5.0000	7	42.857	467.000
15		1	13 : final mod	7	50.0000	3.0000	7	45.286	467.000
16		1	13 : final mod	7	50.0000	2.0000	7	52.286	467.000
17		1	13 : final mod	7	45.0000	4.0000	7	79.143	467.000
18		1	13 : final mod	7	45.0000	5.0000	7	80.286	467.000
19		1	13 : final mod	7	45.0000	3.0000	7	81.143	467.000
20		1	13 : final mod	7	45.0000	2.0000	7	89.000	467.000
21		1	13 : final mod	7	40.0000	5.0000	7	101.429	467.000
22		1	13 : final mod	7	40.0000	4.0000	7	102.429	467.000
23		1	13 : final mod	7	40.0000	3.0000	7	102.429	467.000
24		1	13 : final mod	7	35.0000	5.0000	7	113.571	467.000
25		1	13 : final mod	7	40.0000	2.0000	7	113.571	467.000
26		1	13 : final mod	7	35.0000	4.0000	7	115.714	467.000
27		1	13 : final mod	7	35.0000	3.0000	7	116.143	467.000
28		1	13 : final mod	7	30.0000	5.0000	7	118.714	467.000
29		1	13 : final mod	7	30.0000	4.0000	7	122.286	467.000
30		1	13 : final mod	7	30.0000	3.0000	7	124.143	467.000
31		1	13 : final mod	7	35.0000	2.0000	7	126.286	467.000
32		1	13 : final mod	7	30.0000	2.0000	7	137.857	467.000
33		1	13 : final mod	7	65.0000	1.0000	7	140.714	467.000
34		1	13 : final mod	7	60.0000	1.0000	7	143.000	467.000
35		1	13 : final mod	7	55.0000	1.0000	7	153.571	467.000
36		1	13 : final mod	7	50.0000	1.0000	7	173.571	467.000
37		1	13 : final mod	7	45.0000	1.0000	7	200.429	467.000
38		1	13 : final mod	7	40.0000	1.0000	7	220.857	467.000
39		1	13 : final mod	7	35.0000	1.0000	7	230.000	467.000
41		1	13 : final mod	7	25.0000	1.0000	7	245.286	467.000

ANALYSIS:



Our aim is to optimise the process and routing so that the food is delivered within the advertised time. We will analyze the performance and conclude if there is any improvement in the model.

The current model output is:

	Scenario Properties				Control	Responses	
	S	Name	Program File	Reps	Num Reps	Average waiting time	number of orders
1		Current Model	13 : System s	7	7	33.417	285

The optimized model output is:

	Scenario Properties				Control	Responses	
	S	Name	Program File	Reps	Num Reps	Average waiting time	norders
1		Optimzed Model	3 : final model	7	7	18.677	467.000

We were able to reduce the average waiting time by 47.3% and increase the number of pizzas processed by 63.859%.

On an average one pizza costs 7 dollars. With the optimized model the pizza stall can sell 182 more pizzas resulting in $1274 of increase in revenue each week or an estimated $61,152 in revenue over a single year.

For >98% service level, we have the following scenarios:

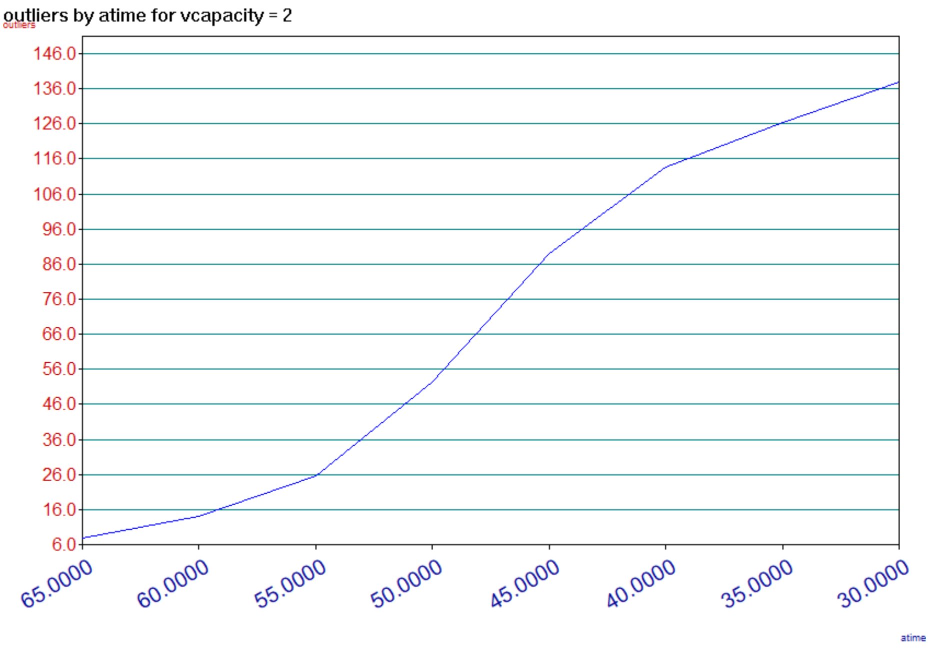
Service level= (norders- outliers)/norders
For all the scenarios in our model, norders = 467
For 98% service level, using the formula above we can have 9.34 outliers on an average. The following scenarios fulfil the condition.

Controls			Responses	
atime	vcapacity	Num Reps	outliers	norders
65.0000	5.0000	7	0.286	467.000
65.0000	4.0000	7	0.571	467.000
65.0000	3.0000	7	2.000	467.000
60.0000	5.0000	7	4.143	467.000
60.0000	4.0000	7	4.429	467.000
60.0000	3.0000	7	6.000	467.000
65.0000	2.0000	7	7.714	467.000

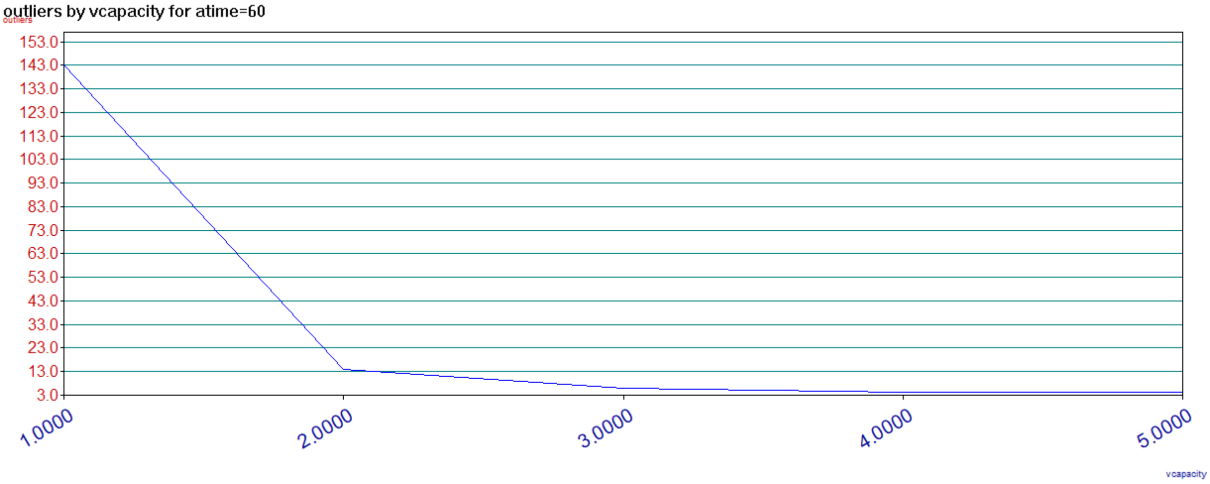
Our primary focus is advertised time. We want it to be as low as possible and increasing vehicle capaci Since we want the pizzas to be delivered hot, we want to keep vehicle capacity also to be as low as possible. We have two possible comparable good scenarios with 98% service level because the advertised time and vehicle capacity is less in these two scenarios.

60.0000	3.0000	7	6.000	467.000
65.0000	2.0000	7	7.714	467.000

Since both the options are good enough, we can suggest both these scenarios to the pizza stall owner.



From the above graph it is evident that the outliers increase with decreasing advertised time.



From the above graph it is evident that there are no significant changes in the outliers with increasing vehicle capacity except for the vehicle capacity of 1.

CONCLUSION AND DISCUSSION:

We can conclude that making a small change in the “making” process of pizza changes the “average waiting time” significantly. Dividing the pizzas according to “making” times resulted in an even distribution of workload and reduced bottlenecks before the making process. This in turn has resulted in an increase in revenue of approximately $61152 in an year. We can also conclude that changing the vehicle capacity does not decrease the outliers significantly except for the vehicle capacity of 1. So any vehicle capacity above 1 can be considered. With the scenarios above, they can achieve a maximum of 98.71% service level. This will help in determining the advertised time within which the pizzas would be delivered, increasing the reliability which in turn increases the reputation thereby improving the revenues in the future.

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