Project 1-IPPUDO Restaurant-CS150

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1.Introduction

The aim of this project is to find a seating arrangement for the restaurant Ippudo which maximizes profits(number of people) while minimizing the maximum wait time for customers. While performing the experiments, I made the assumptions that as soon as a group leaves, another group is immediately seated. Also, the arrival of new groups is random and normally distributed depending on the group being small or large. The eating time (which includes eating, ordering and paying) is also normally distributed depending on the size of the group. The formula used for calculating an estimate of the waiting times is also assumed to maximize profit i.e. minimize number of people left over in the waiting queue while maximizing number of people seated. Basing my hypothesis on experimentally tested data, I believe that the best seating arrangement is when there are multiple tables at which smaller groups can sit(1-4) as compared to extremely large groups(7-8) (which should have a type of seating all to themselves). The estimated waiting time should also be calculated such that near the end of closing time, the estimate is more accurate and if a difference cannot be avoided, should be an over estimate of the actual waiting time so as to prevent losses due to compensation.

2. Approach

There are four main classes in this experiment. The first one is the *WaitingList* class. This class essentially creates a Linked list which acts as a queue for a restaurant. The reason a linked list is chosen is that elements can be easily added and removed from any slot. It is also easy to go through the items in the list one at a time. The next class is the *Group* class. This class creates a group object each with a set of fields. The class also contains get and set methods to change

those object fields and retrieve them. The third class is the *Table* class. This class is used for the creation of all the tables in the restaurant experiment. It creates an array list which acts as a table. An Array list is used as it is easy to replace objects and index elements with a smaller complexity than other type of lists. This class basically holds the customers who arrive and essentially acts as a normal restaurant table. The final class is the *ExperimentController* class. This class is the main class which runs the experiment. It also contains the algorithm for seating arrangement as well as the addition and removal of groups to and from the queue and the tables. This class is fundamentally the system of the restaurants seating.

3.Methods

The experiment was run with 5 different seating arrangements. Each arrangement was also run 5 times and an average obtained for the maximum time a group had to wait, the number of people who were seated compared to the number of people who had to wait in the queue and finally the profit (number of people) of that seating arrangement per day. Each seating arrangement was tested in the same way with one formula for generating estimated wait times. The parameters used in this experiment were as followed:

Parameter	**Value**
S_EATING_TIME	2700
L_EATING_TIME	3600
S_ARRIVAL_TIME	20
L_ARRIVAL_TIME	30
S_EATING_STAN_DEV	600
L_EATING_STAN_DEV	900
S_ARRIVAL_STAN_DEV	10
L_ARRIVAL_STAN_DEV	15

Each of these parameters represent a value utilized each time a group arrives. These values have been chosen by a consensus amongst several people who believe that these values represent the average times of arrival and eating a group may take depending on its size. Small groups are from 1-4 people whereas large groups are from 5-8 people. Also, if anyone who is left in the queue does not get seated will be compensated by the equivalent of 4 meals. The calculation of the estimate time is reasonable enough to produce results which can be assumed to be profit maximizing. When testing for an optimal formula, data was obtained which sat the exact amount that was queued but the profit would be a maximum of 600 people. Without turning people away, over 9000 people may be added to the queue with only 1000 being seated this resulting in a loss instead of a profit. Other estimation formulas were tested which produced too little profit. Thus, the formula chosen was experimentally obtained and is thought to be optimal.

4.Data and Analysis

After running the experiment, data was obtained and calculated to conclude which of the seating arrangements maximizes profits. The following seating arrangements were used (along with values of maximum wait time, people seated, people in queue and profit generated).

Seating Arrangement	Seating	Data
1		
2		
3		

1

People in group	First Preference	Second Preference
1	Bar	
2	Bar	Round
3	Round	Four
4	Four	
5	Eight	Round
6	Eight	
7	Eight	
8	Eight	

Column1	Column4
Average Max Wait Time	20378
Average People Seated	925.8
Average Queued	977.8
Average Profit	717.8

2

People in group	First Preference	Second Preference
1	Bar	Round
2	Bar	Round
3	Round	Four
4	Four	
5	Round	Eight
6	Round	Eight
7	Eight	
8	Eight	

Average Max Wait Time	16305.2
Average People Seated	968.4
Average Queued	1004
Average Profit	826

3

People in group	First Preference	Second Preference
1	Bar	Round
2	Bar	Round
3	Round	Four
4	Four	
5	Round	
6	Round	
7	Eight	
8	Eight	

Average Max Wait Time	19898.8
Average People Seated	970.4
Average Queued	1016.4
Average Profit	786.4

<table>
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<td>4</td>
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<table>
<tr><th>People in group</th><th>First Preference</th><th>Second Preference</th></tr>
<tr><td>1</td><td>Round</td><td></td></tr>
<tr><td>2</td><td>Bar</td><td></td></tr>
<tr><td>3</td><td>Round</td><td></td></tr>
<tr><td>4</td><td>Four</td><td></td></tr>
<tr><td>5</td><td>Round</td><td></td></tr>
<tr><td>6</td><td>Round</td><td>Eight</td></tr>
<tr><td>7</td><td>Eight</td><td></td></tr>
<tr><td>8</td><td>Eight</td><td></td></tr>
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<td>
Average Max Wait Time 15760.6
Average People Seated 951
Average Queued 989.4
Average Profit 797.4
</td>
</tr>
<tr>
<td>5</td>
<td>
<table>
<tr><th>People in group</th><th>First Preference</th><th>Second Preference</th></tr>
<tr><td>1</td><td>Round</td><td>Bar</td></tr>
<tr><td>2</td><td>Bar</td><td></td></tr>
<tr><td>3</td><td>Round</td><td>Four</td></tr>
<tr><td>4</td><td>Four</td><td></td></tr>
<tr><td>5</td><td>Round</td><td></td></tr>
<tr><td>6</td><td>Round</td><td></td></tr>
<tr><td>7</td><td>Eight</td><td></td></tr>
<tr><td>8</td><td>Eight</td><td></td></tr>
</table>
</td>
<td>
Average Max Wait Time 23696.8
Average People Seated 924.6
Average Queued 966.4
Average Profit 757.4
</td>
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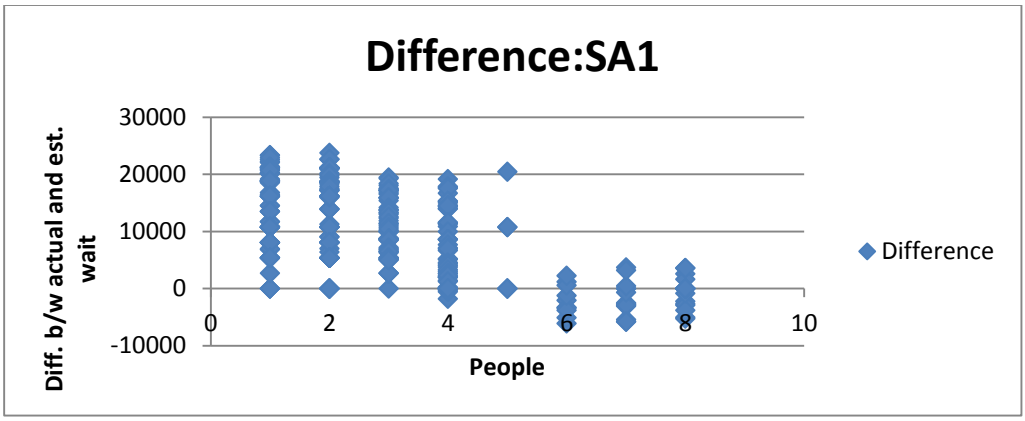
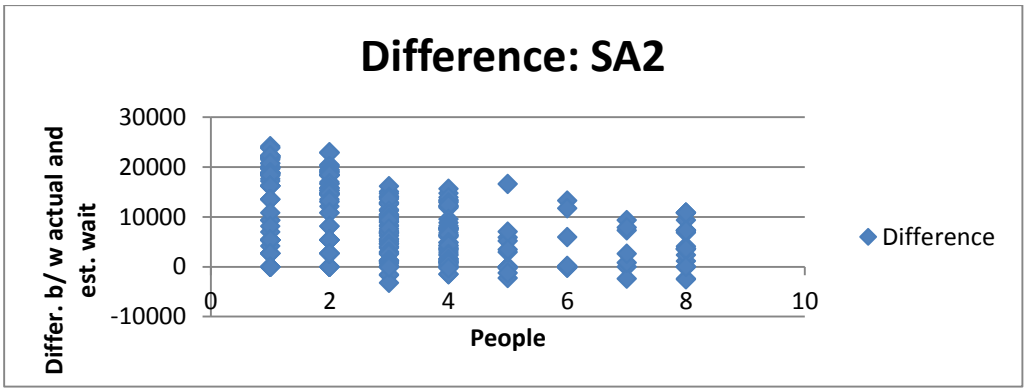
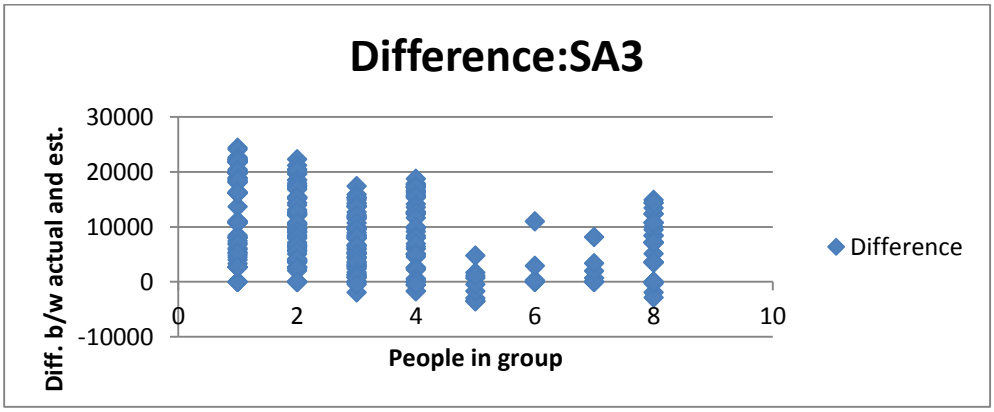
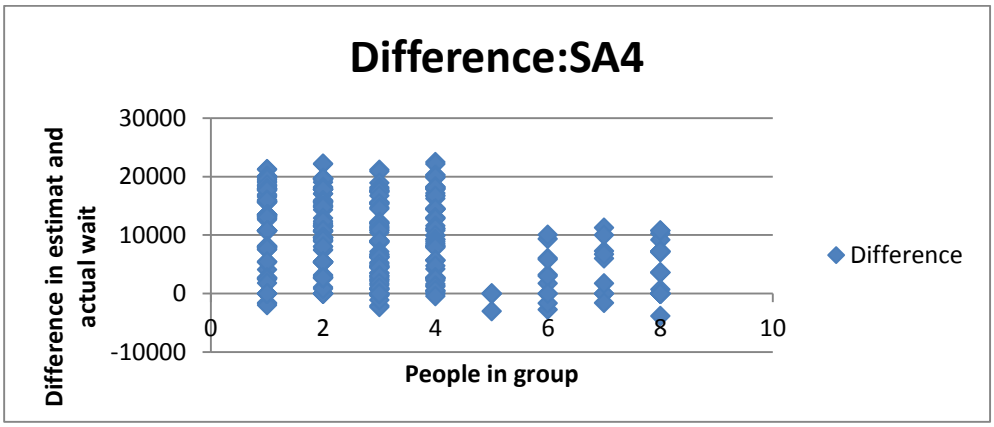
</table>

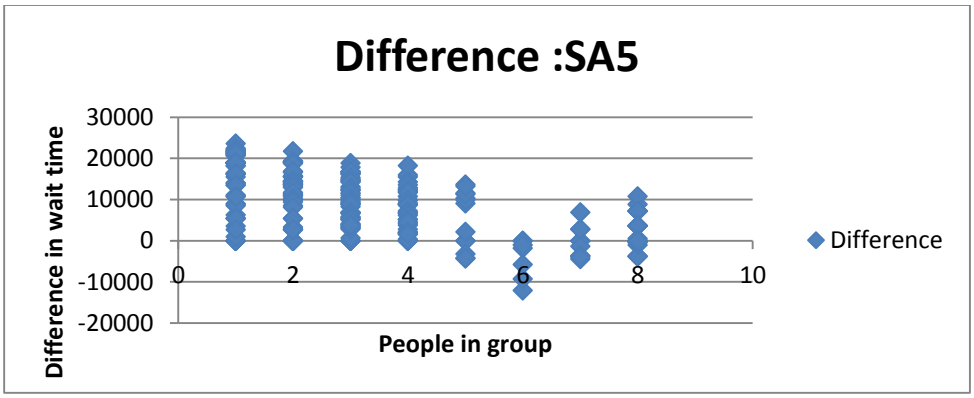
Using the data above, its shown that although most seating arrangements range from low to high 700s in profits, seating arrangement 2 is the only one with a profit above 800 i.e. 826 (in terms of people). For each seating strategy, the longest average wait time is also calculated(average of five runs for that arrangement). The longest wait time was obtained with a seating strategy 5 , of 23696.8 seconds while the lowest waiting time was achieved by seating arrangement 4 of 15760.6 seconds. Based on the data, customers may be turned away or not after a certain time depending on the size of the group as well as the number of tables available. The data below shows the difference between estimation and the actual wait times for one runs of each seating arrangement tests.


Difference:SA1
Diff. b/w actual and est. wait
30000
20000
10000
0
-10000
0
2
4
6
8
10
People
Difference

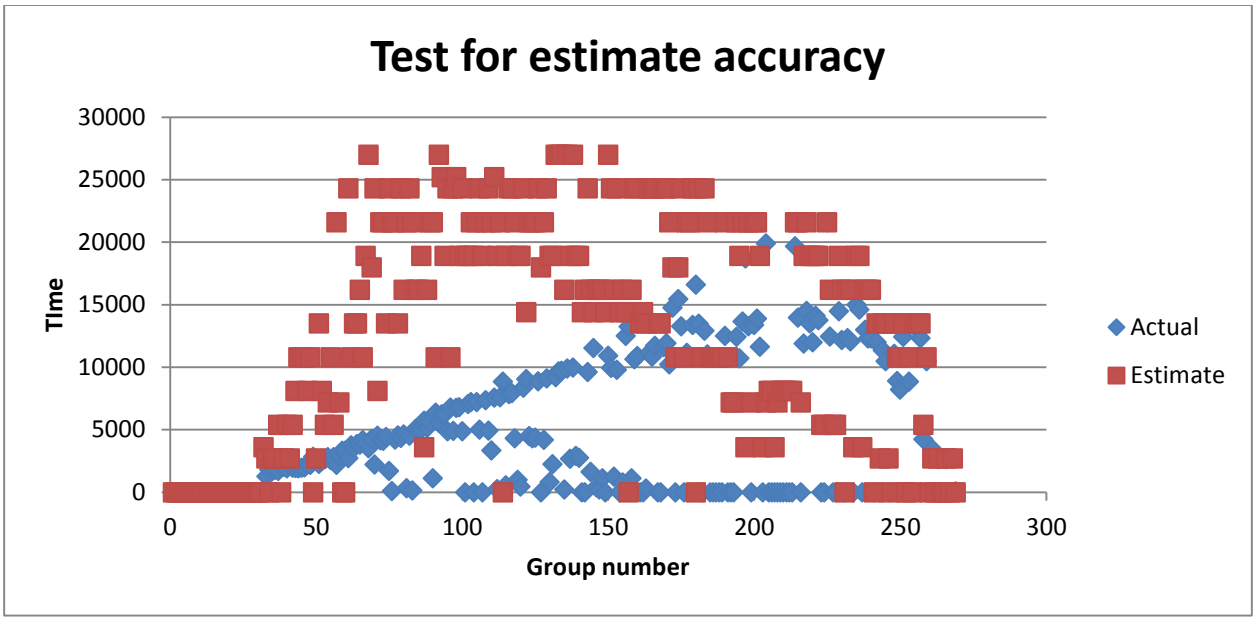

Difference: SA2
Differ. b/ w actual and est. wait
30000
20000
10000
0
-10000
0
2
4
6
8
10
People
Difference


Difference:SA3
Diff. b/w actual and est.
30000
20000
10000
0
-10000
0
2
4
6
8
10
People in group
Difference


Difference:SA4
Difference in estimat and actual wait
30000
20000
10000
0
-10000
0
2
4
6
8
10
People in group
Difference



As shown by the graphs above, the estimation is almost always greater than the actual wait time. This is to make sure that there aren't too many people in the waiting queue when the restaurant closes which would thus result in losses. The difference in the estimates and the actual wait times also vary depending on the size of the group. Its observed that groups of size 1-4 have the greatest difference in the estimated and actual wait times(mostly the estimate is greater ranging from an overestimation of 0-20000 seconds) whereas for groups of 5-8, the range of difference is smaller for all types of seating arrangements used in this experiment. As seen above, the estimate is not as good as could be expected in the sense that it gives large differences between actual time and calculated time for waiting. But, in terms of maximizing profits, it is an optimal estimate as those who probably would have been seated are seated regardless of the estimate they are given. Also, from the tests run, the estimate is actually more accurate during the last few hours of the restaurants working hours. Although some groups may be given large overestimates of waiting time if they arrive in the middle or at the beginning of working hours, others which arrive close to the end , when they are most likely to be turned away, are given reasonable estimates. This can be seen in the random data collected from a run of the seating arrangement 5.



As can be seen above, as the last groups are added, the estimate and the actual wait times are more likely to be close to equal. Based on the data collected, groups defined as large(5-8 people) should be turned away if the estimated wait time calculated will allow them to sit only after 2 am. Smaller groups (1-4 people), as the estimated wait times can be significantly greater than the actual wait times, should be turned away if the estimated wait time is greater than 15000 seconds. This is based on the point between the highest levels of difference for large groups(approx. 10000 seconds) and small groups(approx. 20000 seconds) as well as from analyzing the data of obtained for each seating arrangement. Also, this makes sure that the worst case scenario for a small group is to wait exactly 15000 seconds (but as that is highly unlikely given the size of overestimations), it is a reasonably optimal value.

5.Conclusion

Based on the data collected and the seating arrangements tested, the best results(maximum revenue and minimize waiting time) occurs when each group has multiple options and preferences for seating. For groups of 7-8, the tables of 8 should be reserved but each other

group level should be able to sit at multiple tables. The bar table is to be used for groups 1-3 while the round table should be limited to groups of 4-6. The tables which seat 4 should be reserved for groups of 3-4 where groups of 4 are given a preference if they have arrived first. There is also no formula for accurately calculating the wait times but as each person queued but not served is given a compensation of 4 meals, it is preferred to overestimate the waiting time for a group. Thus, although this experiment does not initially give accurate wait times(it does not matter at that stage as even by the estimate, the group will be seated before closing), it does accurately predict the wait times for groups which might've or might not have been turned away otherwise thus maximizing profit and minimizing actual wait times.

6.References

- Liew, Chun. "Project 1-CS 150-Lafayette College." Web. 1 Mar. 2015. <https://moodle.lafayette.edu/pluginfile.php/154315/mod_resource/content/3/p1.pdf>.
- "You're Welcome to Wait in the Bar." - *Restaurants Food Math*. Web. 26 Feb. 2015. <http://ask.metafilter.com/145297/Youre-welcome-to-wait-in-the-bar>.
- Liew, Chun. "Report Guideline." Web. 1 Mar. 2015. <https://moodle.lafayette.edu/pluginfile.php/151579/mod_resource/content/1/writeup-guidelines.pdf>.