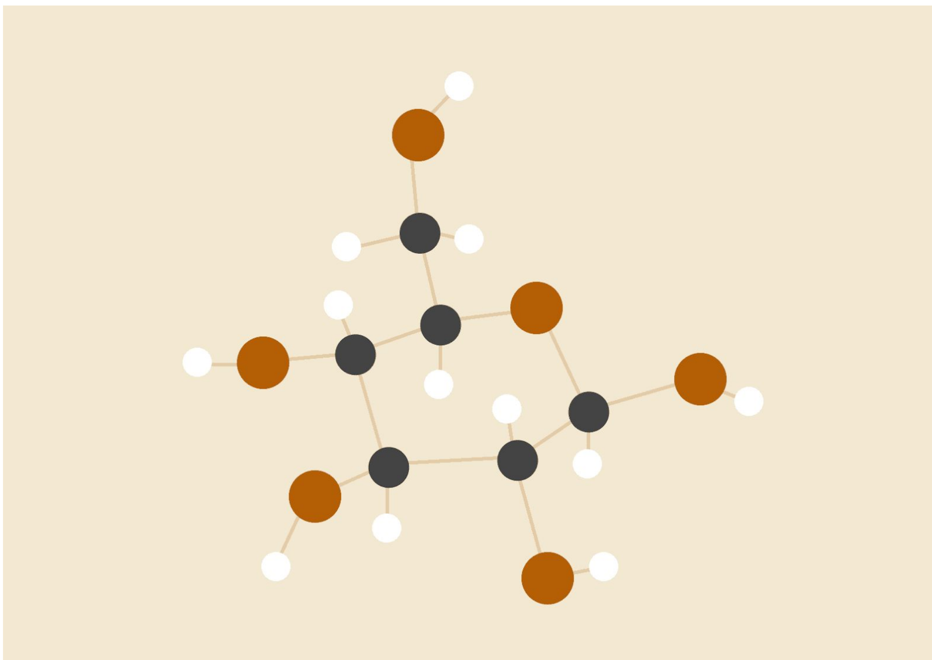
A SIMULATION MODEL FOR RESTAURANTS



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I. Executive Summary

Restaurants always play a crucial role in the real economy, even under the situation of COVID-19. However, food preparation procedures are quite different amongst different kinds of restaurants. Thus, when someone enters the industry, he/she should carefully consider material & human resource arrangement under the particular classification. How should I arrange staff in the peak hours? Would it be too long for my customers to wait under my reception capacity? Oftentimes, these answers should be given only after we consider real-life case-by-case input parameters.

In this project, we plan to build a model to simulate the operation of an American-style hot pot restaurant. It provides 3 kinds of dining choices: hot pot, sushi and dishes. Customers can choose either to dine in or take out for each of the dining choices. By modeling the process from customer arrival, queuing for tables, food preparation, eating procedure, payment to table cleaning, we try to analyse how long a customer would wait in each of the procedures and how should the restaurant owner arrange staffs to get a higher utilization rate, which would be provided on our simulation reports.

Our model has the input parameters from our real-life observation but can be flexibly adjusted to simulate other restaurants' operations. In this model though, we will use LaTao Hot Pot from Baltimore Avenue, College Park, MD as an example.

II. Conceptual Model

Since our simulation model is for restaurant operation, we take the following conditions into consideration: customer arrival with peak hours, queuing for different amounts of tables depending on party size, dining & payment choices which would determine the human & material resource usage, waiters with skill differences which would determine their service priority.

We directly assume customers arrive as parties. Upon arrival, they would first choose to dine in or take out.

If they choose to dine in, a small party would take 1 table and a big party would take 2. When there is no table available, the two kinds of parties will line in the same queue which applies the rule of “first come, first serve”. They have 3 dining choices: hot pot, sushi and dishes. For each of the dining choices, different cookers would prepare for the food. For different parties, there would also be cooking, dining and service time differences. After the party finishes eating, the table is still occupied for payment and cleaning.

For take out customers, they have the same dining choices but would only occupy cooking forces plus a server at payment. After paying, the customer party would leave the system.

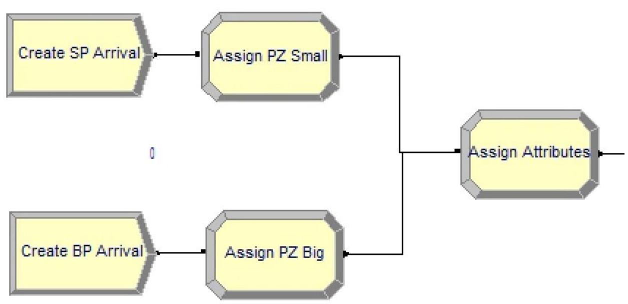
III. Model Implementation in Arena

1. Overview

There are 41 modules in total including 7 types, which are: Create, Dispose, Process, Decide, Assign, Record, and Hold. We also made use of Variable, Attribute, Schedule, Set, Resource, Statistics, and Expression.

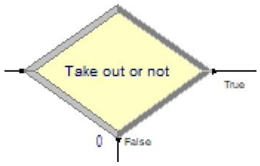
2. Logic Flow

1) Customers Arrival



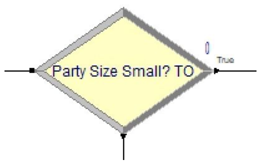
Customers arrive as two kinds of party sizes: small and big. The ‘Assign PZ Small’ module and ‘Assign PZ Big’ module assign Small party as Party Size =1 and Big party as Party Size =2. The customer arrival rate will be explained in the Input Analysis section. In this model, we have three kinds of customers based on what they choose to eat: Sushi; Hotpot; Dishes. The customer arrival schedule will be explained in the Input Analysis section. Probabilities for these three types are 40% for Sushi, 50% for Hotpot, and 10% for Dishes.

2) Choose Take out or Dine in



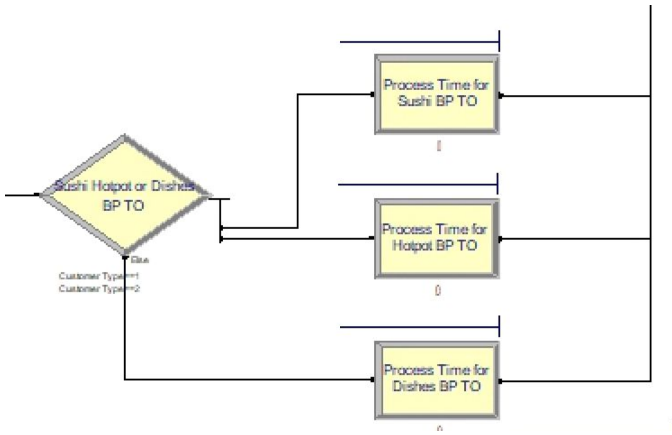
Customers may choose takeout or dine in after they arrive. The probability of choosing takeout is 10%.

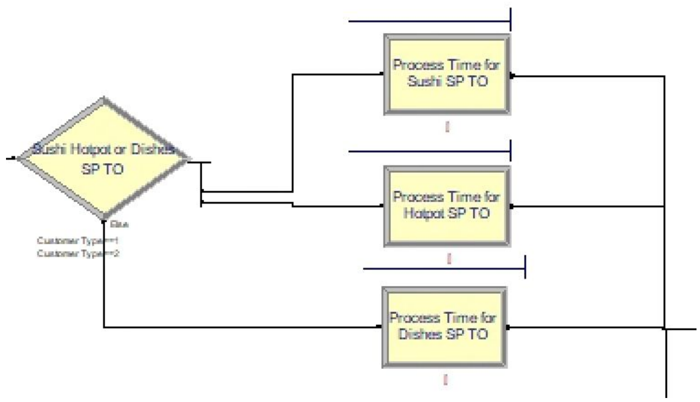
3) (Take out) Divide customers by party size



For customers who choose take out, we divide them again by party size.

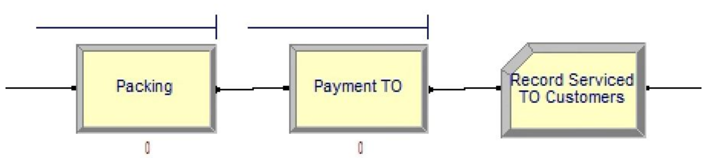
4) (Take out) Process food for two parties





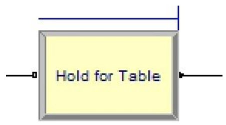
After customers are divided by party size, the restaurant starts to process food based on their need.

5) (Take out) Packing and Check-out



As all food is ready, waiters will start to pack the food. Before customers get food, they need to pay. Payment time is based on their payment method. The probability of choosing paying by card is 90%. The probability of choosing paying by cash is 10%. Serviced customers will be counted.

6) (Dine in) Wait for table

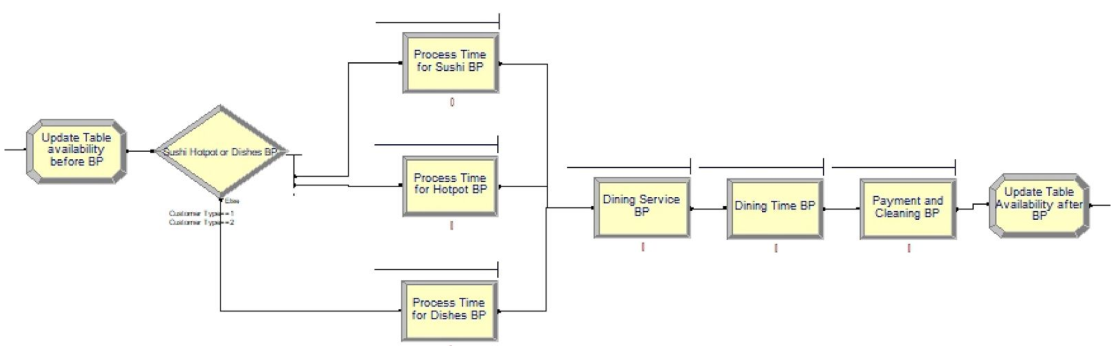


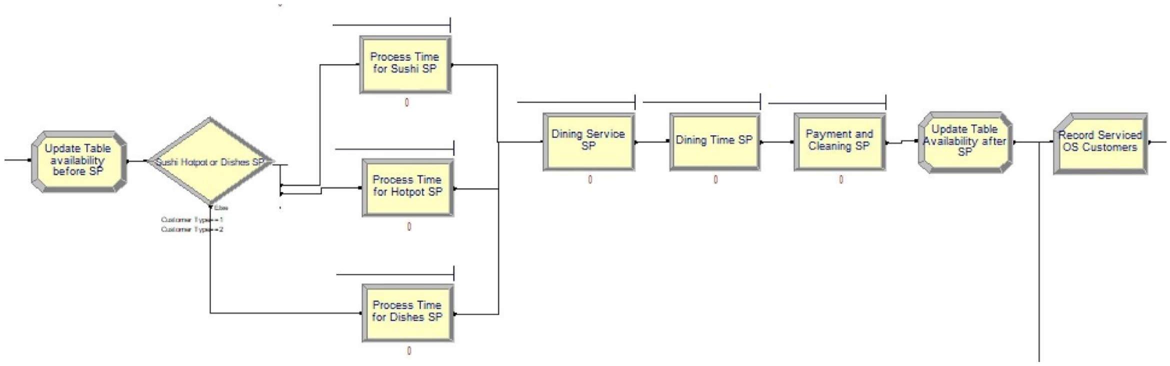
For customers who choose to dine in, they need to wait for tables, which is processed by the 'Hold for Table' module. Hold module type is 'Scan for Condition'. Only when the number of empty tables is larger than the number of eating tables, customers can go inside and sit.

7) (Dine in) Divide customers by party size

For customers who choose dine in , we divide them again by party size.

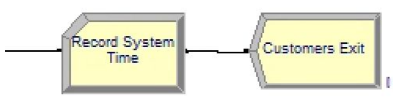
8) (Dine in) Update table, process food, service, dining, and check-out for two parties





The number of empty tables will be updated before and after customers leave. After customers are divided by party size, the restaurant starts to process food based on their need. Waiters will provide service during dining time. After customers check out, waiters will clean tables. We use a set module to schedule waiters. This will be explained in the Input Analysis section. Serviced customers will be counted.

9) Customers leave



Customers leave the restaurant.

IV. Input Analysis

The input data of this model can be categorized as Empirical Estimation. Since it is hard to find the exact data from restaurants, input parameters are estimated based on empirical experiences. The empirical estimation is based on our real life experience in LaTao Hot Pot. Estimation includes the process time of food, dining, and service. Details of each distribution can be found in the Appendix. Here we will get a close insight of the customer arrival schedule and waiter schedule.

1. Customer Arrival Schedule

Since we set this restaurant open for 13 hours a day, we set customers' arrival rate per hour as below. For peak hours, we add more customers correspondingly. Left is for Small party. Right is for Large party.

Durations

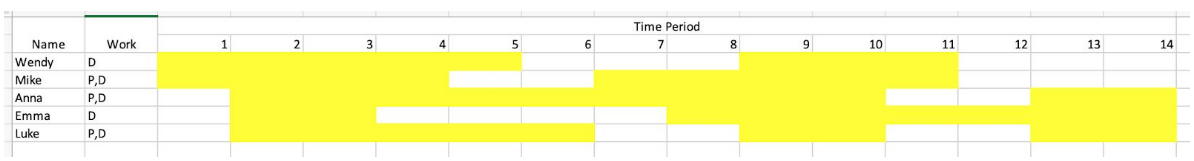
	Value	Duration
1	6	1
2	12	1
3	10	1
4	8	1
5	6	1
6	2	1
7	6	1
8	11	1
9	13	1
10	9	1
11	4	1
12	2	1
13	0	infinite

Durations

	Value	Duration
1	2	1
2	3	1
3	2	1
4	2	1
5	2	1
6	1	1
7	2	1
8	3	1
9	3	1
10	2	1
11	1	1
12	1	1
13	0	infinite

2. Waiter Schedule

We have 5 waiters in total. This table below is the waiters' working schedule, including skills they have. (yellow blocks are working periods) Also, for peak hours, we make all waiters work.



Each waiter has different skills, so we use ‘Pack’ and ‘Dining’, two set modules, to modify which waiter can provide what type of service. For example, for dining, we can call all 5 waiters. Selection rule is preferred order, which puts most skillful waiters at bottom. The set will check very first, and then check one by one. We save the attribute ‘Waiter Index’, so we know which waiter serves this service (in case of back office research) by number in the set module.

Packing:

Members

	Member Type	Resource Name
1	Single Element	Mike
2	Single Element	Anna
3	Single Element	Luke

Members

	Member Type	Resource Name
1	Single Element	Wendy
2	Single Element	Mike
3	Single Element	Emma
4	Single Element	Anna
5	Single Element	Luke

Dining:

V. Performance Analysis

1. Model Verification

In this part, we want to verify if the model runs as we expected.

(1) Model Input Implementation

At first, we separated our "Hold for Table" module for different party sizes. However, when there is only 1 table available, the model would assign the table to a small party rather than wait for 1 more table regardless of the big party's queuing priority. Thus we change the condition to an expression with an attribute, which directly improves the big party's waiting time.

Then, we adopted the suggestion to separate different party arrivals and add different food process time for different party sizes. This makes more sense since the big party would order more food and eat longer.

We also create skill sets for waiters. The 5 waiters with different skills are scheduled to work at different times, making the model more realistic. Since the set cannot be assigned as decimal numbers, we separate the dining process to eating time and service time, and add payment and cleaning procedure for dine in customers. Those actions would all occupy the tables.

(2) Glancing at Outputs

After setting the replication number to 10, the model generates a report that basically meets our expectations. The parameters we look at include average waiting time, average queue length, and utilization rate for each resource.

For the sample report, see the file attachment.

2. Model Performance

Overall, the model performs in a realistic pattern.

The table utilization rate is around 0.38, which can be explained by peak hours. Among all the cooks, the dish cook has the lowest utilization rate, this is because the dish is the least popular dining choice. And all the waiter’s utilization rate is less than 60%, they need time to rest.

As for the queue, waiting times are all in a reasonable range. We would explore different resource scenarios in our PAN analysis.

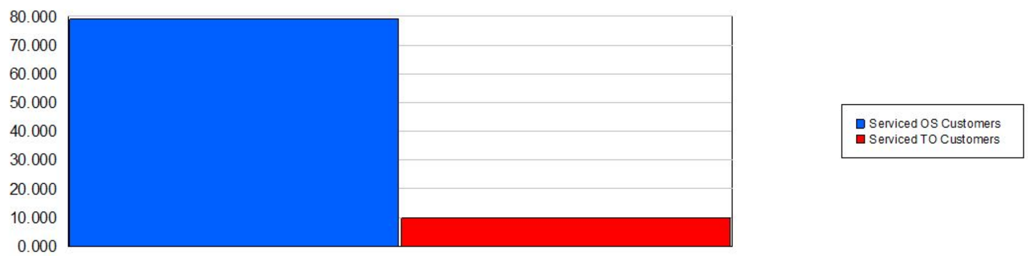
VI. Output Analysis

Tally

Interval	Average	Half Width	Minimum Average	Maximum Average	Minimum Value	Maximum Value
System Time	159.25	20.50	126.60	211.51	15.9011	405.32

Counter

Count	Average	Half Width	Minimum Average	Maximum Average
Serviced OS Customers	79.0000	5.72	62.0000	91.0000
Serviced TO Customers	9.8000	2.07	5.0000	14.0000



Output

Output	Average	Half Width	Minimum Average	Maximum Average
Serviced Customers Percentage	81.8213	9.84	61.5385	100.00

Our model can be generally applied to any hot pot restaurant. The output is based on ten replications. For each replication, the system runs 13 hours during the business hours from 11 am to 11:59 pm. The end of the operation of the system is determined by the conditions. The system will only stop if the time exceeds the business hours, and at the same time, there are no guests in the restaurant.

From the report, we can see that each process's queuing situation ranges from the average number of people waiting, to the average waiting time in minutes. For resources, the utilization rates of chefs and dining tables are also important indicators to measure the model's effectiveness.

Using the record modules, we recorded a few statistics that we thought were useful. For example, the total number of served take-out customers, the total number of served dine-in customers, and the average time when customers stay in the system. Using these data, we have calculated the proportion of customers who actually get the service. Raising this number is one of the goals that we use later to optimize the model.

Overall, all the results in the report look reasonable and realistic.

VII. Simulation Experiments

	Scenario Properties				Controls							Responses						
	S	Name	Program File	Reps	Assistant	Dish Cook	Hotpot Cook	Sushi Cook	Table	Anna	Empty Table	Hold for Table.Queue.NumberInQ	Hold for Table.Queue.Waiting	Table.Utilization	Serviced Customers Percentage	Dish Cook.Utilizati	Hotpot Cook.Utilizati	Sushi Cook.Utilizati
1		Scenario 1	5 : BUDT758	10	3.0000	1.0000	2.0000	2.0000	20.0000	1.0000	20.0000	7.588	57.250	0.433	86.091	0.144	0.603	0.529
2		Scenario 2	5 : BUDT758	10	4.0000	1.0000	2.0000	2.0000	20.0000	1.0000	20.0000	6.566	52.256	0.412	88.740	0.143	0.576	0.471
3		Scenario 3	7 : BUDT758	10	4.0000	1.0000	2.0000	2.0000	30.0000	1.0000	30.0000	1.748	15.279	0.275	92.935	0.182	0.610	0.475
4		Scenario 4	7 : BUDT758	10	4.0000	1.0000	2.0000	2.0000	25.0000	1.0000	25.0000	4.563	38.850	0.337	89.984	0.157	0.655	0.464
5		Scenario 5	5 : BUDT758	10	4.0000	1.0000	2.0000	2.0000	25.0000	2.0000	25.0000	4.563	38.850	0.337	89.984	0.157	0.655	0.464
6		Scenario 6	7 : BUDT758	10	4.0000	2.0000	2.0000	2.0000	25.0000	1.0000	25.0000	3.721	32.357	0.332	90.741	0.091	0.649	0.457
7		Scenario 7	7 : BUDT758	10	4.0000	3.0000	2.0000	2.0000	25.0000	1.0000	25.0000	3.771	32.944	0.333	90.741	0.062	0.646	0.460
8		Scenario 8	7 : BUDT758	10	4.0000	2.0000	3.0000	2.0000	25.0000	1.0000	25.0000	2.599	25.239	0.309	96.200	0.076	0.367	0.469
9		Scenario 9	7 : BUDT758	10	4.0000	2.0000	4.0000	2.0000	25.0000	1.0000	25.0000	2.768	25.528	0.297	95.976	0.080	0.270	0.440
10		Scenario 10	7 : BUDT758	10	4.0000	2.0000	3.0000	3.0000	25.0000	1.0000	25.0000	1.808	18.183	0.303	96.525	0.060	0.400	0.280
11		Scenario 11	7 : BUDT758	10	4.0000	2.0000	3.0000	4.0000	25.0000	1.0000	25.0000	1.321	13.626	0.278	98.217	0.072	0.351	0.188

When using Pan analysis, we created 11 possible scenarios. Our control variables include the number of cooks, the number of waiters, and the number of tables. In the output variables, we consider the utilization rates of various resources, the average waiting time of available tables before eating, the number of people in the queue, and the percentage of served customers. Scenario 1's input based on the estimated information, and the following are situations as comprising. According to the different goals of the restaurant, the optimal plan varies.

When we make adjustments on the controls, the result matches the common sense. When we add tables, chefs, and waiters, the average number of people in the queue will decrease, and the proportion of customers received will increase. Still, the utilization rate of resources will decrease. This is a trade-off and can only be weighed according to what you want to achieve.

To avoid low utilizations over resources to reduce the running cost, Senrio 4 is optimal. Overall, the utilization of tables and cooks are the highest at 0.337, 89.984, 0.157, 0.655, and 0.464. Dish cook always has a usage lower than 20%; the owner may consider replacing a cook who can handle two types of food, such as Sushi and Dish, or Hotpot and Dish. At the same time, 90% of customers are served—the changes needed to be done, adding one assistant and five more tables. If customer service quality and satisfaction are the most important for a certain period, add the resources til scenario 11. At that time, customers almost do not need to wait for a table, and 98% of them can get the meal.

VIII. System Improvement

Our model is not perfect, and there is still room for improvement.

First, improve the accuracy of input. Due to the COVID-19 epidemic situation, we were not able to obtain real-world data from actual restaurants. We can only rely on statistical knowledge to select potential distributions to simulate. If there is a real dataset storing arrival records, we can use @RISK software to fit the closest distribution, which will significantly improve the model accuracy.

Second, the arrangements of waiters as resources cannot be achieved. When assigning waiters, we used Set to create different schedules for individuals. Then we can ensure more people work for peak hours. However, in the Pan Analysis, we were not able to adjust everyone's schedule so that we may miss the optimal solution in this aspect.

IX. Conclusion

A simulation study is conducted in this project to provide hotpot restaurants owners with suggestions about human & material resource usage. This simulation model runs for 10 replications in one day. Our model tests possible situations in a hotpot restaurant. Waiting time is a large issue in this model. By optimizing different resource allocations, we build our model with the best scenario.

Overall, with this simulation model, hotpot restaurants owners can get an idea of how to arrange resources in an efficient way, which may improve profits and boost customer satisfaction.

X. Appendix-Input Parameters

Process Time	
Customer Type	DISC(0.4,1,0.9,2,1,3)
SP Food Process Time for Sushi	TRIA(8,18,25)
SP Food Process Time for Hotpot	TRIA(15,20,40)
SP Food Process Time for Dishes	TRIA(10,15,20)
BP Food Process Time for Sushi	TRIA(12,25,35)
BP Food Process Time for Hotpot	TRIA(20,35,50)
BP Food Process Time for Dishes	TRIA(15,20,25)
Packing	EXPO(5)
Dining Time Big Party for Sushi	TRIA(40,60,90)
Dining Time Big Party for Hotpot	TRIA(50,90,120)
Dining Time Big Party for Dishes	TRIA(15,25,40)
Dining Time Small Party for Sushi	TRIA(15,30,45)
Dining Time Small Party for Hotpot	TRIA(45,80,110)
Dining Time Small Party for Dishes	TRIA(10,15,30)

Service Time SP for Sushi	TRIA(2,5,8)
Service Time SP for Hotpot	TRIA(8,15,20)
Service Time SP for Dishes	TRIA(5,8,11)
Service Time BP for Sushi	TRIA(5,10,15)
Service Time BP for Hotpot	TRIA(12,20,28)
Service Time BP for Dishes	TRIA(8,11,14)
Cleaning Time for small party	EXPO(5)
Cleaning Time for big party	EXPO(8)
Payment Method	DISC(0.9,1,1,2)
Payment Time for card	EXPO(3)
Payment Time for cash	EXPO(8)