Restaurant design

Introduction

You are the owner of a restaurant, and, given the customer arrival, you have to choose the table arrangement and the seating policy to have a successful business.

The decisions that you have to make are:

- The table arrangement, i.e. number and type of tables.
- The seating policy, i.e. the rules that you apply to allocate customers to tables.

The aim of the "Simulation Project" is to develop a discrete event simulation that represents the system and to evaluate the performance of two solutions of table arrangement and seating policy.

During the "Optimization Project", the discrete event simulation is expanded, and the optimal solution in term of table arrangement and seating policy is identified by an optimization algorithm.

Develop the discrete event simulation with a modular structure. It should be possible to modify the various components, such as the customer arrival rate, table configuration and seating policy, during the "Optimization Project".

Project description

The arrangement of the tables is made at the beginning of the opening time, and it cannot be modified after. The restaurant has space for up to 400 seats, independently from the table arrangement. The size of tables can vary. The available table sizes are for 2 customers, 3 customers, 4 customers and 5 customers. You can choose the number of tables for each size, such that the constraint in terms of number of seats is satisfied.

The customers arrive in groups with an arrival rate defined by c. Groups start arriving at 19:00, and no group arrives after 22:00. The group size is defined by g, and the dinner duration is defined by d. After a group leaves, the table is immediately available for the next customers. The bill per person is proportional to the time of the dinner. People that stay longer order more courses and consequently spend more. The bill per person is defined by b.

All the customers waiting in a queue are served even after 22:00. A group as a whole has to sit together at the same table. You cannot split a group into different tables, and tables cannot be joined together to accommodate larger groups. More than one groups can sit together at the same table, but in that case, the duration and bill decrease.

Customers waiting in the queue for a long period of time may decide to go to another restaurant. Every five minutes, a group of customers chooses if waiting for other five minutes, or leaving the queue. The probability that a group leaves the queues is the following.

Waiting time	no waiting time	< 5 minutes	5 – 10 minutes	10-20 minutes	> 20 minutes
Probability of leaving	0.0	0.1	0.3	0.4	0.5

The manager estimates that the restaurant incurs the cost of 10 euro cents per minute per seat (empty or taken) during the operating time. The operating time starts at 19:00 and ends when the last customer leaves the restaurant.

We assume the following distribution for the variables:

- Customer arrivals are non-homogeneous and change among group sizes. They described in the following arrival rates [groups/hour]:

Group size	19:00-20:00	20:00-21:00	21:00-22:00
1	1	8	3
2	2	14	20
3	3	11	15
4	4	9	13
5	5	7	14

- The duration of the dinner *d* is minimum 40 minutes, plus an unknown time following an exponential distribution with a mean of 20 minutes. However, after 2 hours, the group is always requested to leave.
- The bill per person *b* can be calculated by multiplying a customer-specific consumption rate, defined by *r*, and the dinner duration *d*. The customer-specific consumption rate *r* is uniformly distributed between 0.5 €/minute and 1.2 €/minute.
- When a group sit together with another group at the same table, the duration *d* decreases to *d*0.5*. Moreover, the consumption rate *r* also decreases to *r*0.8*.

Simulation

For the simulation project, you are requested to:

- Develop a discrete event simulation to represent the described project.
- Define the indexes used to quantify the success of the restaurant
  - Remember that extreme cases are important; evaluate other indexes in addition to the mean.
  - Report the mean square error of your estimation using bootstrapping when necessary.
  - Use variance reduction techniques to reduce the computational time.
- Decide the seating policy for your restaurant, i.e. the rules that you apply to assign groups to tables. For example, you could decide to have different queues for different group sizes, and to assign groups only at tables accommodating the exact size.

- Evaluate the success of the restaurant with two different table arrangements:
  - 40 tables for 5 customers
  - 50 tables for 2 customers and 20 tables for 5 customers
  - (or any other scenarios that show your simulation performance well)
- Make any necessary assumptions.

Optimization

There are plans for a major renovation, after which the restaurant will be able to accommodate up to 400 seats. The owner is interested in knowing the best configuration of the seats as well the capacity of the restaurant. We disregard renovation costs and our only interest is the maximization of the daily revenue.

For the optimization project, you are requested to:

- Identify the decision variables of the problem.
- Define the objective function
- Design an optimization algorithm and apply it to solve the problem. The value of the objective function is evaluated by discrete event simulation.
- Like in the simulation project, the objective function can reflect various policies of the decision maker: whether they want to optimize over the average, best, worst, or certain percentile of the objective function distribution. Decide what your position is and justify it, or present results for several alternatives.
- Compare the result of your algorithm with the seating policies described in the simulation project.
- For the best configuration that you have found, use your creativity and design a new seating policy that would lead to a lower cost solution.