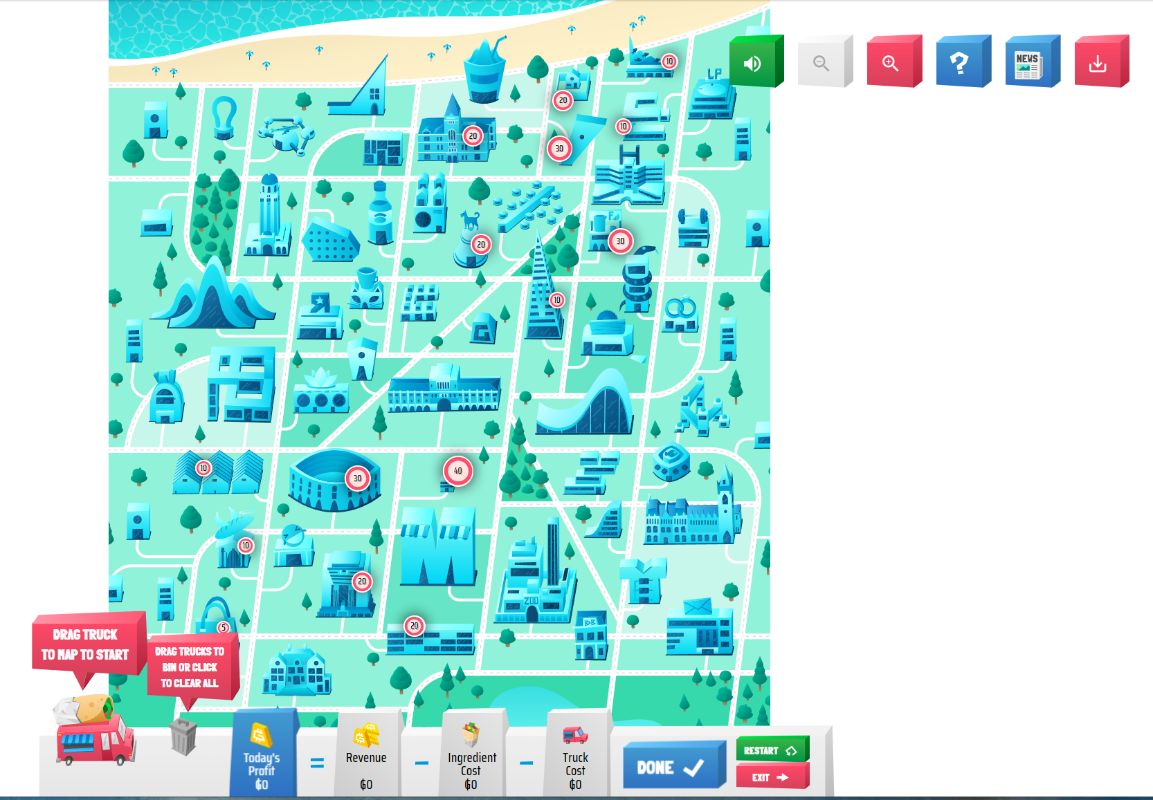
**Assignment 2**

Due: By midnight on Thursday, November 28th, via Canvas. Have one person from each group submit one Cohort\_Group#\_HW2.docx and one Cohort\_Group#\_HW2.ipynb (e.g., BA1\_Group3\_HW2.docx and BA1\_Group3\_HW2.ipynb) file to the Assignments area of Canvas. Indicate the full names and student numbers of your team members at the top of the Word document and Jupyter notebook. The Word document should be this document, with your answers to the questions below. The Jupyter notebook should provide any of the analyses needed to support your answers and discussions. Where appropriate, reference the part of your Jupyter notebook that helps you answer any of the questions below (or provide screen shots where helpful).

**Burrito Optimization Game**

All of the questions on this assignment relate to the Burrito Optimization game, which we will play/played in class. If you go to Round 1, Day 1, of regular play mode and click on the download box in the upper-right corner (see Figure 1 below), you will obtain four .csv files. These provide data, which are used on the back-end when Gurobi solves the model and displays the optimal solution. This is just for your information; for this problem, **don’t download your own files; instead, use the ones I have provided**. These are files that I downloaded when I loaded the game on my end (which may be different than what you get if you download them; i.e. we don’t always see the same version of Round 1, Day 1 when playing regular mode).

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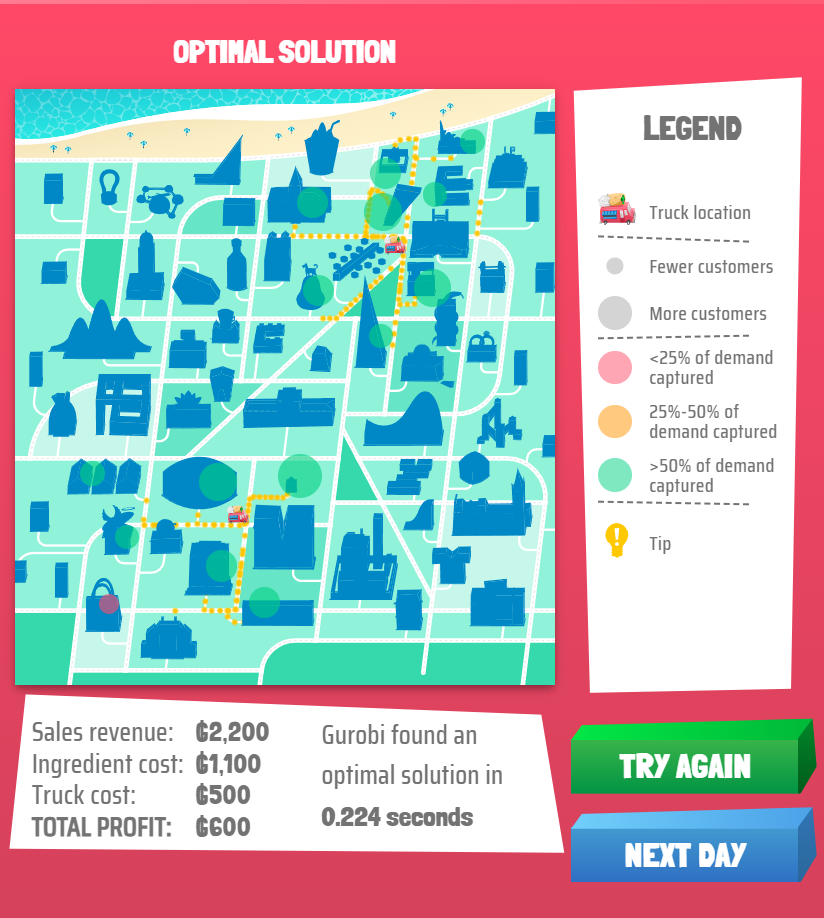
**Figure 1**

The information contained in these files is summarized as follows:

* problem\_data.csv: gives the cost and revenue parameters for the day
* demand\_node\_data.csv: gives the x,y coordinates of the buildings and their total demand
* truck\_node\_data.csv: gives the x,y coordinates of all the possible locations where you can place the trucks
* demand\_truck\_data.csv: gives the distances between each building and each possible truck location, along with the scaled demand. The scaled demand shown are the values of the “” terms from the integer programming (IP) formulation in the middle of [this page](https://www.gurobi.com/burrito-optimization-game-guide/) on the Gurobi website (see sections on “The IP: Notation” and “The IP: Formulation”).

**Q1.** Although most of this course (and BAMS 506) has focused on “prescriptive analytics”, this part is about “predictive analytics.” Estimate a function, f(*d*), which provides a good fit for predicting the fraction of total demand that will travel a distance of *d* for a burrito. In other words, this question asks you to estimate a function to predict the parameters as a function of the distance between a building “i” and a truck “j”. Justify your answer.

**Q2.** Using the information contained in the files provided, set up and solve the optimization problem in Gurobi (you can use the formulation given at the same Gurobi link provided above). Check that you get the same solution shown in Figure 2, which is what Gurobi produced after I clicked on “Done” on Day 1, Round 1 of the game (which was based on the files I downloaded and provided).

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**Figure 2**

The following questions relate to the formulation given in “The IP: Formulation” section of the same Gurobi link above. Recall that the game (and formulation) assumes that trucks have unlimited capacity.

**Q3.** The formulation they provide has this constraint:

True or False: as long as building “i” has positive (> 0) demand, the optimal solution will actually make this a binding constraint. In other words, the optimal solution will be such that:

Explain your reasoning.

**Q4.** The formulation they provide indicates that the variables must be binary. Is this necessary? Specifically, consider the following T/F question:

True or False: if we let the variables be continuous, with each and non-negative, then the optimal solution will automatically be such that the optimal are binary. Explain your reasoning.

**Q5.** Suppose that instead of using decision variables as done on the Gurobi site, someone wanted to formulate the problem using decision variables to represent the *quantity of demand to assign from building “i” to truck “j”.* For example, if a building “i” has a demand of 50 people who want burritos, then an optimal solution might set , meaning assign all of the demand at building “i” to go to the nearest truck “j” (this would then get scaled by to get the number of people that actually walk the distance between their building and that closest truck). Provide an algebraic formulation for the optimization problem that uses this approach for creating the allocation decisions (keeping the same binary variables they use to indicate truck placement decisions at each possible truck location j).

**Q6.** Suppose that from one day to the next, the only thing that changes is that the ingredient cost per burrito increases. All other model parameters (e.g., revenue, demand from each building, etc.) remain the same between the two days. (Note, this is what happens between Days 2 and 3 in the game, but this question is meant to be more general and not specific to just those day’s parameters.)

1. Can you say how the *optimal profit* on the second day will compare to the optimal profit on the first day? Explain.
2. Can you say how the *optimal* *number of trucks* placed on the second day will compare to the optimal number of trucks placed on the first day? Explain.

**Q7.** The Burrito Optimization Game assumes that trucks have unlimited capacity. This question asks you to think about trucks with limited capacity.

Suppose now that each truck has a capacity to serve at most 75 burritos in a day, and at most one truck can be placed at each location. Assume there is a central planner, who assigns the demand at the different buildings to the trucks. For example, if one building has a demand of 40, the central planner can tell 30 of them to go to one truck and the other 10 to go to another truck. Assume the number of people that actually make the walk to those assigned trucks still scales according to the fraction . (Note this also means that the planner might assign more than a total of 75 people from different buildings to go to a specific truck if the scaled-down number who actually would walk to that truck is 75).

1. Provide an algebraic formulation for this new version of the problem.
2. Use Gurobi to solve your new formulation, using the same Round 1, Day 1 data you used to solve Q2. Compare the results and provide managerial insights.

Now assume that more than one truck can park at the same location (assume there is space for any number of trucks to park there).

1. Update your algebraic formulation, solve it, and compare your results to part b.
2. More generally, consider comparing the solution of a day solved with either Assumption 1 or Assumption 2:

Assumption 1: the original assumption of unlimited truck capacity

Assumption 2: the assumption that each truck has a capacity of C, and we can locate multiple trucks at the same location

Which one(s) of the choices in the bracket make the following statement true?

“The number of trucks placed in the optimal solution under Assumption 2 can be [**more than, less than, the same as**] the number of trucks placed in the optimal solution under Assumption 1.”

Explain your reasoning.