ISYE6501: Homework 12

2025-04-08

Question 18.1

Describe analytics models and data that could be used to make good recommendations to the power company. Here are some questions to consider:

• The bottom-line question is which shutoffs should be done each month, given the capacity constraints. One consideration is that some of the capacity – the workers' time – is taken up by travel, so maybe the shutoffs can be scheduled in a way that increases the number of them that can be done.

• Not every shutoff is equal. Some shutoffs shouldn't be done at all, because if the power is left on, those people are likely to pay the bill eventually. How can you identify which shutoffs should or shouldn't be done? And among the ones to shut off, how should they be prioritized?

You can use the {given, use, to} format to guide the discussions: Given {data}, use {model} to {result}.

A power company is facing a recurring operational challenge: many customers who are capable of paying their electricity bills choose not to, and the company wants to identify and shut off service to only those customers who are unlikely to ever pay. However, this process is constrained by limited operational capacity, shutoffs must be completed manually by field workers who travel to each location, which takes time and limits the number of shutoffs that can be performed each month. The core goal, is to determine which shutoffs should be prioritized each month in a way that maximizes the recovery of unrecoverable losses, while staying within these operational constraints.

To address this, we can break the problem into three main analytical components: prediction, prioritization, and optimization. First, we can use a classification model such as logistic regression, decision trees, or random forest to predict the likelihood that a customer will never pay their outstanding balance. This model would be trained using historical data such as payment history, billing amounts, past shutoff warnings, and reconnection records. The output of this model would be a risk score for each customer, representing the probability that their account is uncollectible.

Next, we can develop a prioritization model that uses this probability, along with the customer's outstanding balance and their historical behavior when facing shutoff threats (whether they typically pay once warned), to compute a shutoff score. This score could be calculated using a formula like: Shutoff Score = (Probability of Non-Payment) $\times$ (Outstanding Amount) $\times$ (Behavioral Weight). The resulting score ranks customers based on the expected financial loss if no action is taken, enabling the company to focus on those whose unpaid bills pose the greatest financial risk.

Once we have a ranked list of shutoff candidates, we then address the logistical constraint by applying an optimization model. Specifically, we can frame this as a Vehicle Routing Problem (VRP) or an Integer Linear Programming (ILP) problem, where the goal is to determine the most efficient routes and schedules for field workers. These models take into account the location of each shutoff site, estimated travel times between them, and the available labor hours each day. The output is an optimized schedule that allows the company to complete the most high-priority shutoffs within its operational limits.

Throughout this process, the output of each model becomes the input for the next: the classification model feeds into the prioritization model, and the prioritization results are used in the route optimization model.

The final output is a monthly shutoff plan that targets the right customers, maximizes financial recovery, and stays within resource constraints.

To further improve accuracy and fairness, additional data could be incorporated, such as customer service call logs (which may indicate intent to pay), extreme weather data (to avoid shutoffs during hazardous conditions), flags for customers receiving government or charitable aid, real-time traffic data, and detailed worker availability.

In summary, given data on customer behavior, billing history, and location, we can use predictive modeling, prioritization scoring, and optimization algorithms to recommend which shutoffs should be executed each month. This approach enables the power company to act more strategically and ethically, recovering more revenue while respecting both logistical limits and customer circumstances.