Optimized Fuel Supply Chain Management

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About the Client

Coextrix Technologies is an innovative information technology and services firm providing offshore software development, product engineering, analytics, infrastructure and consulting services since 2009. The company is located in the technology hub of Bangalore, India. Nationwide first mile procurement and last mile delivery for oil and gas distribution is a strong service offering by Coextrix.

Motivation

Supply chain optimization is a big challenge in fuel distribution logistics management which requires timely fulfillment of orders while keeping costs low. In the United States, fuel gets pumped from refineries to terminals through pipelines hosted by several vendors. Different fuel station operators pick fuel up from these terminals in fuel-trucks and transport to their respective truck-stops. Large aggregators operate with inventory in the scale of millions of dollars daily for ensuring ample fuel at their stations to meet public demand. Until recently, these large operators focused on ensuring the supplies rather than saving on logistics cost or looking for cheaper vendors at the terminals. Consequently, an efficient route planning and decision support system was envisaged.

Problem

Large fuel station owners have several options across the country at fuel terminals. The options can be in the form of contracts with specific vendors wherein, a fixed fuel lift is promised at a relatively cheaper rate than market norm. Also, terminal vendors quickly want to empty their existing fuel at a "throw-away" price when fresh supplies from refineries are expected. Based on the cost of fuel on any given day for multiple vendors at terminals spread across the breadth of the country, the decision support system needs to identify cheapest yet feasible routes to fulfill fuel demands at the truck-stops which are also spread throughout the country. At **Gyan Data**, we helped formulate the loosely defined requirements as an optimization problem with demand and supply constraints and cost based objective.

The complexity increased when including limited number of service hours available for trucks for the truck-stops besides uncertainty in driver show-up and weather patterns for planning logistics. The fuel prices also fluctuated and the problem needed to be solved multiple times for trip-scheduling of trucks. With several demand and supply options, the total number of variables rose to millions and went out of reach of standard solvers for getting the global optimum solution. Thus, a tighter formulation was required.

Solution

The decision variables for the optimization were the number of trips between any given demand and supply point. This translates into an Integer Program (IP), i.e., a linear optimization problem with integer variables. Besides, several variables could be removed from the problem based on practical insights and heuristics in order to have a tighter formulation. With a mix of data science skills, we supported our client to extract information from the data-bases on cost and transportation matrix to formulate the mathematical optimization problem.

At **Gyan Data**, we formulated the problem mathematically in a python environment through the PuLP [1] package and also in the Julia programming language using JuMP [2]. These were powerful and yet free alternatives to commercial high-cost AMPL or GAMS programs.

We explored a variety of Mixed Integer Programming (MIP) solvers in the commercial domain (Gurobi [3], CPLEX [4]) and also in the free & open-source domain (CBC [5] and packages from the COIN-OR [6] pool). Larger problems were solved on commercial packages after data obfuscation on the NEOS Software-as-a-Service platform [7, 8, 9]. In all instances, the naive formulations invariably gave a tough time even for the best performing Gurobi solver. We identified drastic reduction in solver times for large problems through smarter heuristics while keeping to the free and open source solver CBC although we could not achieve global optimum for a small set of cases.

As the problem continued to include extensive practical insights in the form of constraints or modified objectives, we realized that Gurobi scored over all other solvers in terms of delivering quick and global minimum solutions. Our proof-of-concept code incorporated the complexity of field experience of the experts to an extent that it could be immediately deployed at scale. The end-client could clearly see the huge cost savings compared to their existing practices.

References

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