WonderMarket
Section A – Internal Report

Kenton Lam

MATH3202 Assignment 1
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Abstract

We have been approached by WonderMarket to optimise their supply chain logistics. Given information about their costs and needs, we created and optimmised a model using Gurobi. This report describes the model and its solution.

Model Definition

WonderMarket operates a number of stores and distribution centres (DCs). Each week, each store requires some amount of goods (measured in truckloads) to be delivered from one or more of their distribution centres (DC).

After communication 4, we developed a detailed model to mathematically represent their objectives.

Sets

S set of stores (length 10).
D set of distribution centres (length 3).
U set of surge scenarios (comm 4, length 5).

Data

$\text{Cost}_{d,s}$ cost of moving one truckload of goods from DC d to store s (comm 1).
Demand_s number of truckloads required at store s per week normally (comm 1).
Capacity_d maximum capacity (truckloads) which can be send from d per week (comm 2).
Northside set of distribution centres on the north side (comm 3).
NorthsideMax maximum combined capacity of northside DCs (comm 3).
$\text{SurgeDemand}_{u,s}$ surge demand during scenario u at store s (comm 4).

Derived Data

To simplify later calculations, we derived some data from the data given above.

$\text{SurgeMultiplier}_{u,s}$ surge demand at store s during surge u, divided by regular demand at store s.

$$\text{SurgeMultiplier}_{u,s} = \text{SurgeDemand}_{u,s}/\text{Demand}_s$$

Variables

The following variables were used in the Gurobi model.

$Y_{d,s}$ truckloads to be sent from DC d to store s during normal demand.

Additionally, we had dummy variables which existed only in Python to make writing constraints easier. These were scalar multiplies of Y variables.

$X_{d,s,u}$ truckloads to be sent from DC d to store s during surge scenario u.
$$X_{d,s,u} = Y_{d,s} \cdot \text{SurgeMultiplier}_{u,s}$$

Objective

This minimises the total transport cost during normal demand.

$$\min \sum_{s \in S} \sum_{d \in D} \text{TotalCost}_{d,s} Y_{d,s}$$

Constraints

First, we have the constraint that all variables are non-negative.

$$Y_{d,s} \geq 0 \qquad\qquad \forall\, d \in D,\ s \in S.$$

We ensure the solution is valid for normal demand.

$$\sum_{d \in D} Y_{d,s} \geq \text{Demand}_{u,s} \qquad\qquad \forall\, s \in S$$

$$\sum_{s \in S} Y_{d,s} \leq \text{Capacity}_d \qquad\qquad \forall\, d \in D$$

$$\sum_{d \in \text{Northside}} \sum_{s \in S} Y_{d,s} \leq \text{NorthsideMax}$$

We ensure our assignments can scale up to each surge scenario while remaining feasible with the given constraints of DC capacity and northside capacity. For $u \in U$,

$$\sum_{d \in D} X_{d,s,u} \geq \text{SurgeDemand}_{u,s} \qquad\qquad \forall\, s \in S$$

$$\sum_{s \in S} X_{d,s,u} \leq \text{Capacity}_d \qquad\qquad \forall\, d \in D$$

$$\sum_{d \in \text{Northside}} \sum_{s \in S} X_{d,s,u} \leq \text{NorthsideMax}$$

Solution

Solving this linear model in Gurobi returns the following solution (obtained by dividing each Y variable by the store's normal demand).

Store	DC0	DC1	DC2
S0	0.00%	0.00%	100.00%
S1	100.00%	0.00%	0.00%
S2	100.00%	0.00%	0.00%
S3	0.00%	100.00%	0.00%
S4	58.82%	0.00%	41.18%
S5	0.00%	83.86%	16.14%
S6	0.00%	100.00%	0.00%
S7	0.00%	64.77%	35.23%
S8	0.00%	64.77%	35.23%
S9	100.00%	0.00%	0.00%

This would cost WonderMarket $199661.44 during regular demand.