Carnegie Mellon University
Tepper School of Business

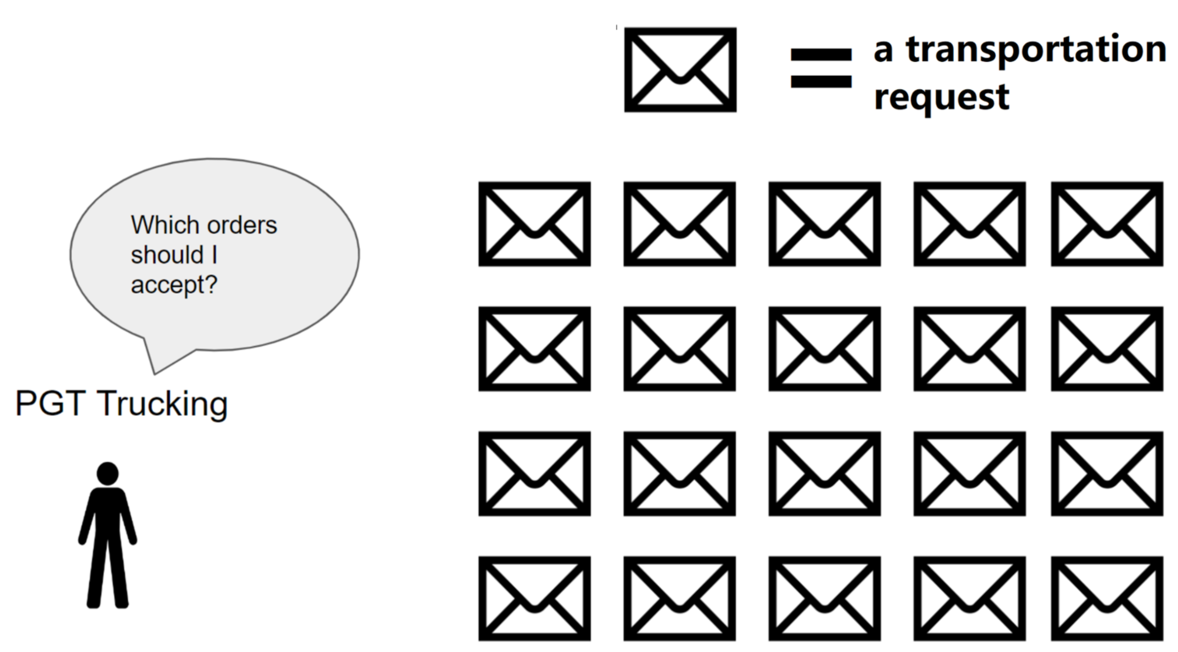
PGT Trucking Order Selection Project

MS in Business Analytics Capstone Project

Amr Farahat (advisor)
Jiarui Wang
Jiadi Zhang
Peter Pan
Sanjit Sokhi
Zhiyu Pan

ABSTRACT

PGT Trucking faces a high surplus of demand. It receives far more order requests for hauling services than it could satisfy. Therefore, PGT requires an automated algorithm that helps it selectively accept the optimal combination of order requests that not only produce high revenue but do not conflict with each other geographically or timely.

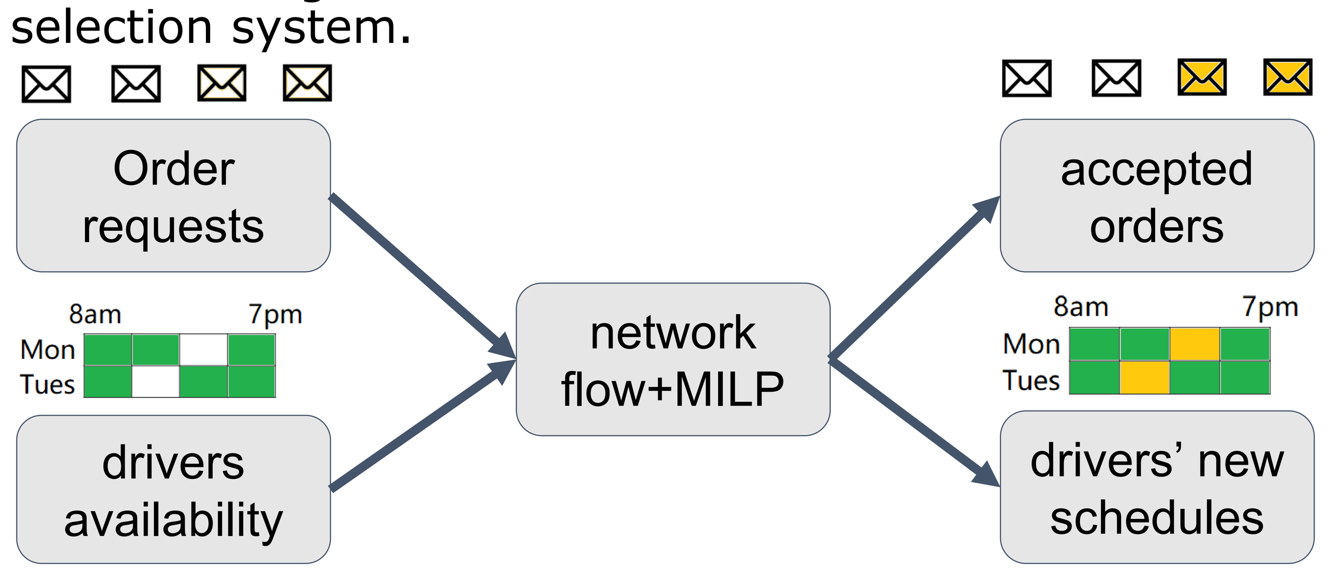


INTRODUCTION

In this project, we explored the possibility of using network flow and Mixed Integer Linear Programming (MILP) to find the optimal order-to-driver matchup from the order request pool. By the end of this project, our result shows that MILP can not only able to help PGT selectively accept order requests that result in higher total revenue, but support the selection of every chosen order with an underlying order-completion schedule that is feasible.

After creating the MILP models in Python through Gurobi, we conducted order-selection simulations on a small sample of drivers and a small sample of historical order requests that PGT used to assign those drivers their jobs.

The result shows that the MILP model can select order sets with higher total revenue than PGT's current order selection system.



METHODS AND MATERIALS

Algorithm design:
Network flow[1] and Mixed Integer Linear Programming[2](MILP) are deployed to find the optimal request-to-driver match up.
Objective function: $\Sigma\ job_i * revenue_i$
Nodes: job(order) requests, drivers' home locations
Decision variables:

- Purple Out: the action of arriving and finishing a job after a driver is deployed from his/her home location
- Purple In: the action of arriving home after a driver finishes a job.
- Green Arc: the action of transitioning and finishing a job after a driver completes a job.

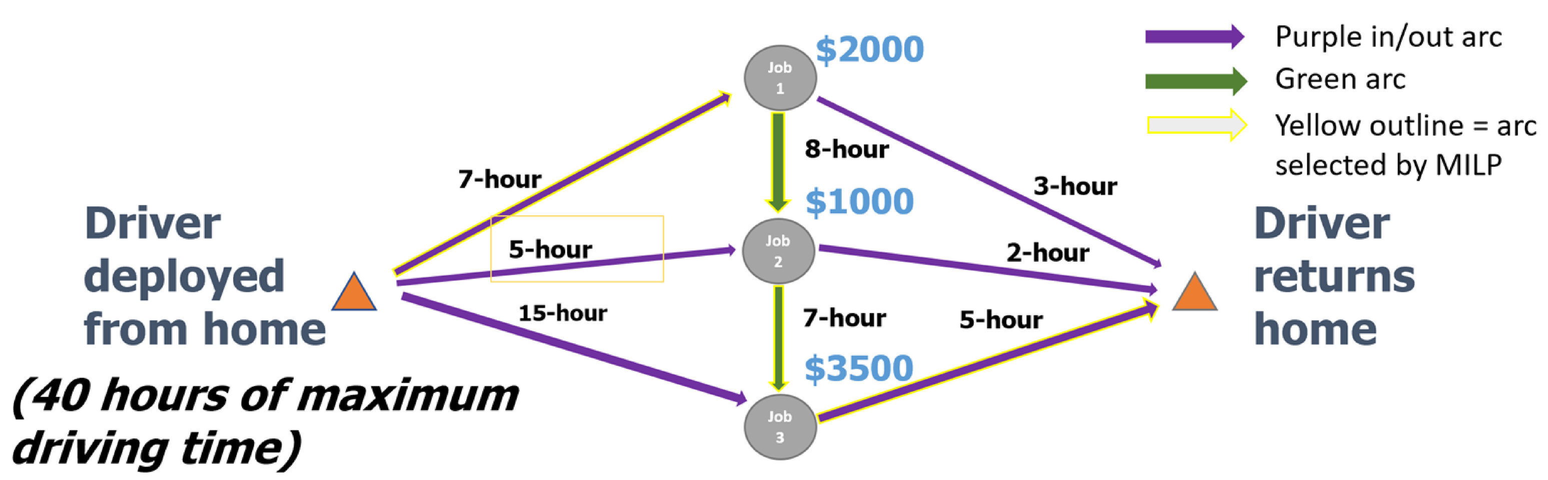
Constraints: $\sum_{o,d} x_{*,o,d} \leq 1\ \forall (o,d) \in allarcs$

$$\sum_k x_{d,k,j} = \sum_i x_{d,j,i}\ \forall d \in drivers, j \in nodes$$

$$\sum_{i,k} x_{i,k,j} = y_j\ \forall j \in jobs$$

$$\sum_{ch \in driver} flowarcs_{ch} \cdot x_{ch} \leq 70$$

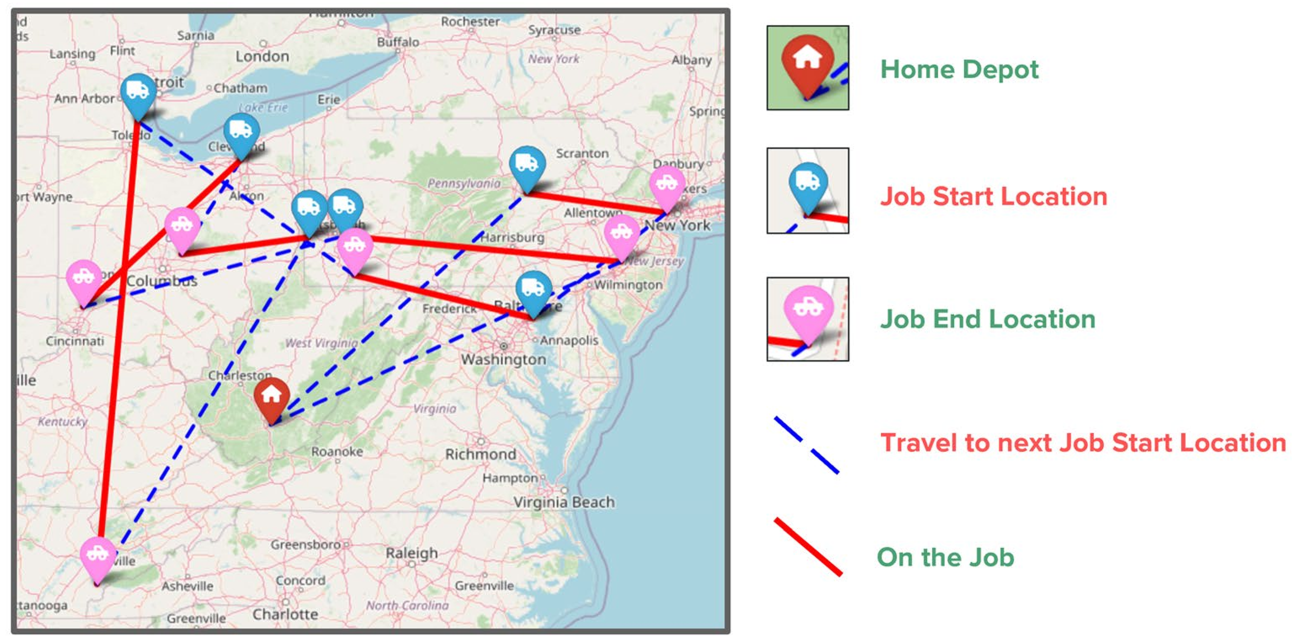
$$\sum_{o \in drivers} x_{o,*,t} \leq 1\ \forall t \in terminals$$



RESULTS

Simulations show that MILP can significantly increase PGT's trucking revenue by selecting closely located and high-revenue requests and fitting them into feasible schedules for the drivers.
Higher generated revenue:
5 simulations with an average of 284 order requests and 40 drivers show that the MILP model is able to help PGT select order requests with a total revenue that is on average 16% higher than that from PGT's order selection system.
Save drivers' time:
The model is also able to help drivers arrange orders that happen close to them geographically and allow drivers to complete more orders in a given week than did PGT's current order selection system.

Example route for one driver (made through Folium[3]):



DISCUSSION

Business application: In the real business setting, the company would first accumulate order requests for a certain period of time and then conduct MILP upon the accumulated order requests and all the drivers.
Computational cost: One potential drawback of this order selection method is the amount of computational cost required to conduct order selection upon thousands of order requests (including both unaccepted orders and accepted requests) and hundreds of drivers. One method to alleviate this drawback is to split one global optimization into several regional optimizations.
Further improvements: the capacity of the model to select order combinations with higher total revenue can still be improved by 1) relaxing the time window at which each job needs to be completed and 2) improving the estimation of drivers' traveling speeds.

CONCLUSIONS

MILP has shown promising results in optimizing the selection of orders, the allocation of orders among drivers, and the total revenue for PGT. Introducing more techniques such as relaxing the time windows of the orders can further improve the model's ability to maximize revenue. The model's scalability also shows that it can handle a larger number of orders than what is simulated, making it a valuable tool for PGT to optimize the order selection process. Overall, MILP is demonstrated to be a reliable and efficient potential solution for PGT to streamline its delivery services.

CONTACT

Jiadi Zhang — jiadiz@andrew.cmu.edu
Vincent(Zhiyu) Pan — zhiyup@andrew.cmu.edu
CMU ft-MsBA

REFERENCES

1.https://www.gurobi.com/documentation/9.5/quickstart_windows/cs_netflow_py_example.html
2.https://www.gurobi.com/resources/mixed-integer-programming-mip-a-primer-on-the-basics/
3.https://pypi.org/project/folium/