



Josh Handelman
Samyam Lamichhane
Andy Lee
Erik Lee
Sasha Malik
Sarthak Malla
Aibar Talip

“Ride the Wave of Efficiency”



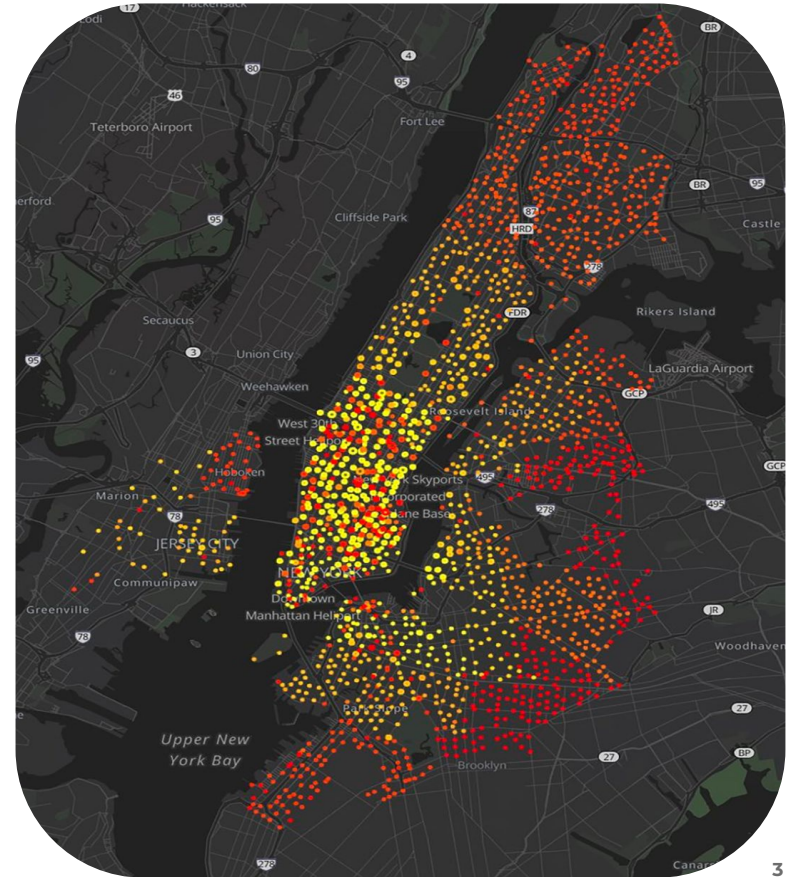
Problem

- New York City's subways are **outdated** and **inefficient**, increased carbon emissions from private vehicles
- **Unequal access** to public transportation
- **Reliability Issues:** Frequent disruptions have eroded public confidence in the MTA

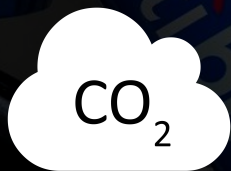


Solution

- **Optimize** placement of Citi Bike stations.
- Implementing **real-time** route optimization for green buses based on demand and delay prediction with quantum optimization algorithms.
- Delay **prediction** done at each subway station using our ML model



CITI BIKE BENEFITS



Reduces CO₂
emissions of
average
person by **67%**



**50% of daily
trips** are less
than 2 miles
(3.2 km)



AVOIDED
2,808,087.0
pounds of CO₂
in June 2023



REAL-TIME BUS SERVICE



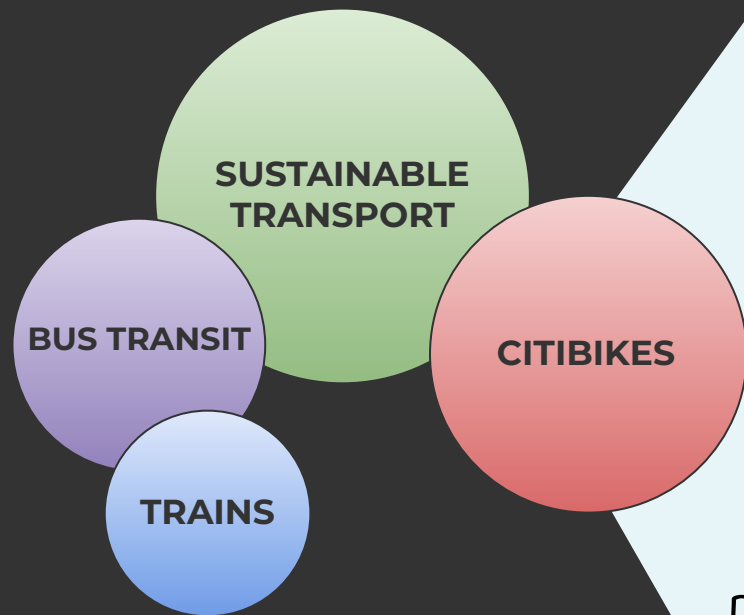
Reduce empty buses for **efficiency**, add new buses when **necessary**



Decrease average waiting times by up to 3 **minutes**

Mode of Transport	CO2 per mile (g)
Combustion Car	366.4
Bus	161.6
EV	144
Walking	89.6
Conventional Bike	28
ebike	23.68

Implementation



Station placement:
NP-hard

Delay prediction

Hack stack

IBM Q



NISQ, quantum-inspired algorithms and quantum annealing for optimization

Advanced machine learning



Qiskit



PyTorch

Quantum Optimization

Hamiltonians used in calculations:

$$H_{(0)} = A \sum_{(ij) \in E} w_{ij}(1 - x_i)(1 - x_j)$$

$$H_{(1)} = \sum_{i \in \mathcal{V}} c_i x_i$$

$$H_{(2)} = B \left(\sum_{i \in \mathcal{V}} x_i - s \right)^2$$

$$H_P = H_{(0)} + H_{(1)} + H_{(2)}$$

Cost function:

$$c_i = C f_i + D g_i + E h_i$$

Betweenness Centrality equation:

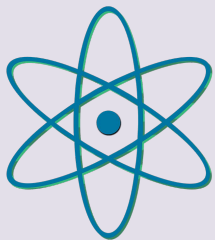
$$C_e^B = \sum_{s \neq t \in \mathcal{V}} \frac{\sigma_{s,t}(e)}{\sigma_{s,t}}$$



Cost-efficient station placement



Comparisons of energy consumption



WHY QUANTUM?



Classical Methods

Slow to solve
nondeterministic
polynomial time
problems



Quantum Algorithms:

Quantum Unconstrained
Binary Optimization

Quantum Approximate
Optimization Algorithm



Hamiltonians

Used to quantify the
energy costs



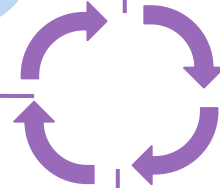
Variational Quantum Eigensolver

Calculates expected
values using a hybrid of
classical and quantum
computing

1



2



4

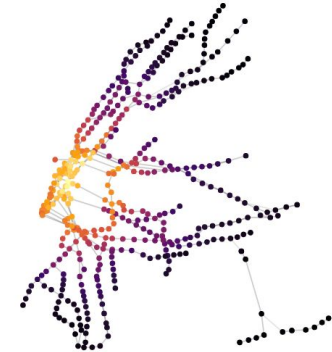


Comparing betweenness and reach centralities

Brighter nodes are more central

Betweenness

Reach

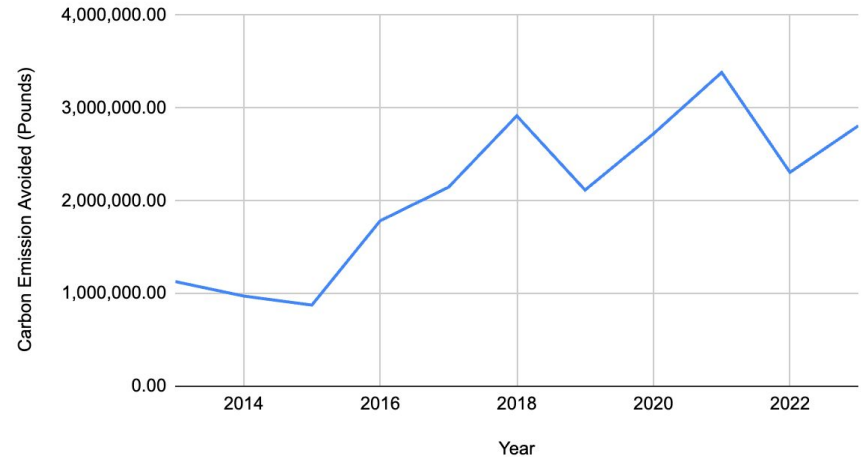


3

CitiBike Metrics

- There were 3,444,063 trips on Citi Bike while avoiding **2,808,087** pounds of carbon emissions (June 2023 Citibike Data)
- Average **0.813** pounds of carbon per trip per bike in 2023

Carbon Emission Avoided (Pounds) vs. Year



Bus Optimization Metrics

- **25% of bus riders** are concerned about bus wait times
- Our model will solve energy waste from “bunching” by providing **real-time demand-based service**
- Real-time service will **reduce** bus delays

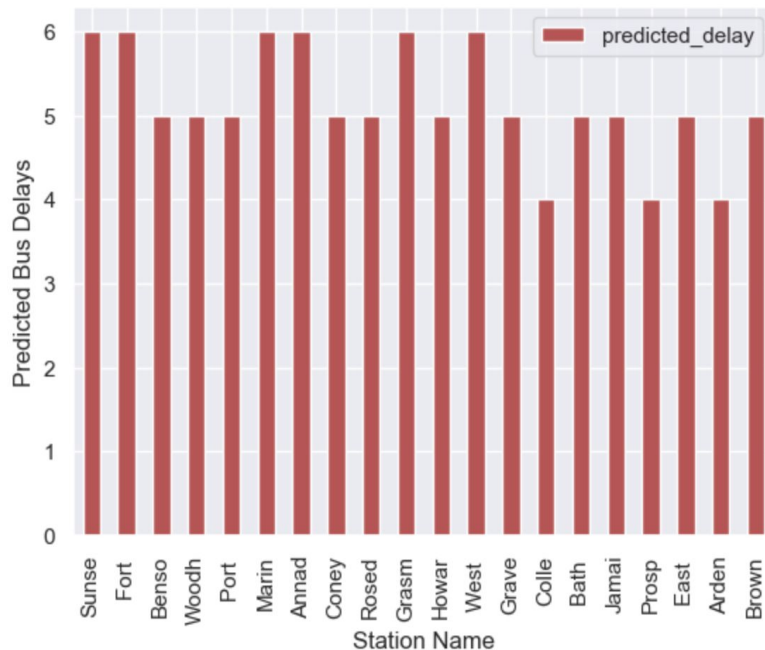
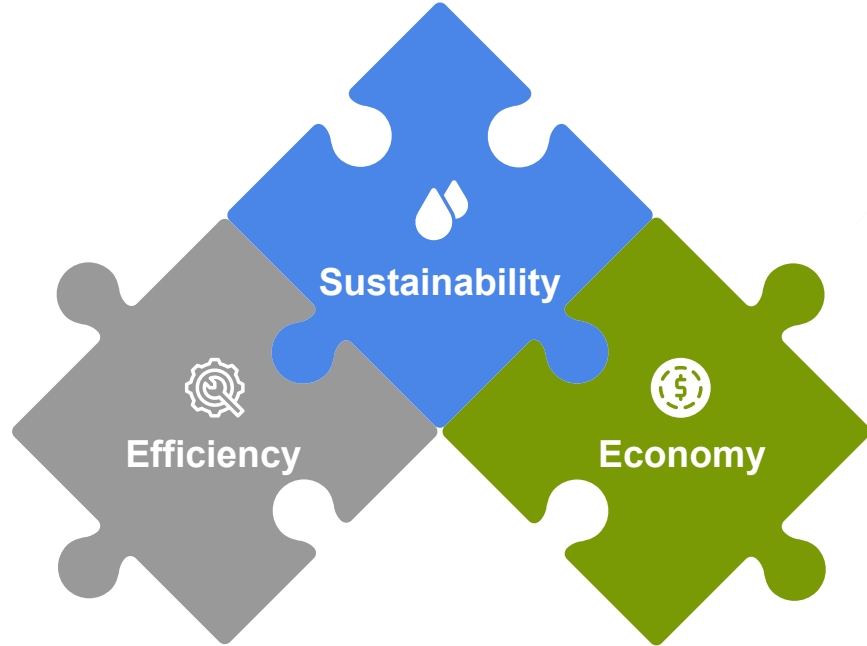


Figure 1: Predicted bus delays per day based on our model

Impact

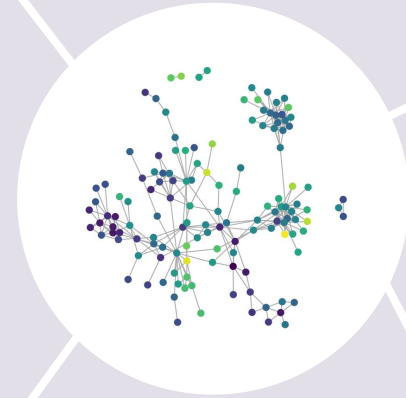


Scalability

**Adaptable to
transportation
networks**



**Industry
standard
compatible**



**Cost
efficient for
city budget**

**Open Source
Python Package
Qommuter**

Our Enthusiastic Research Team...



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