ECE297 OP2

CD41: ORAL PRESENTATION 2

April 30, 2024

Prepared by

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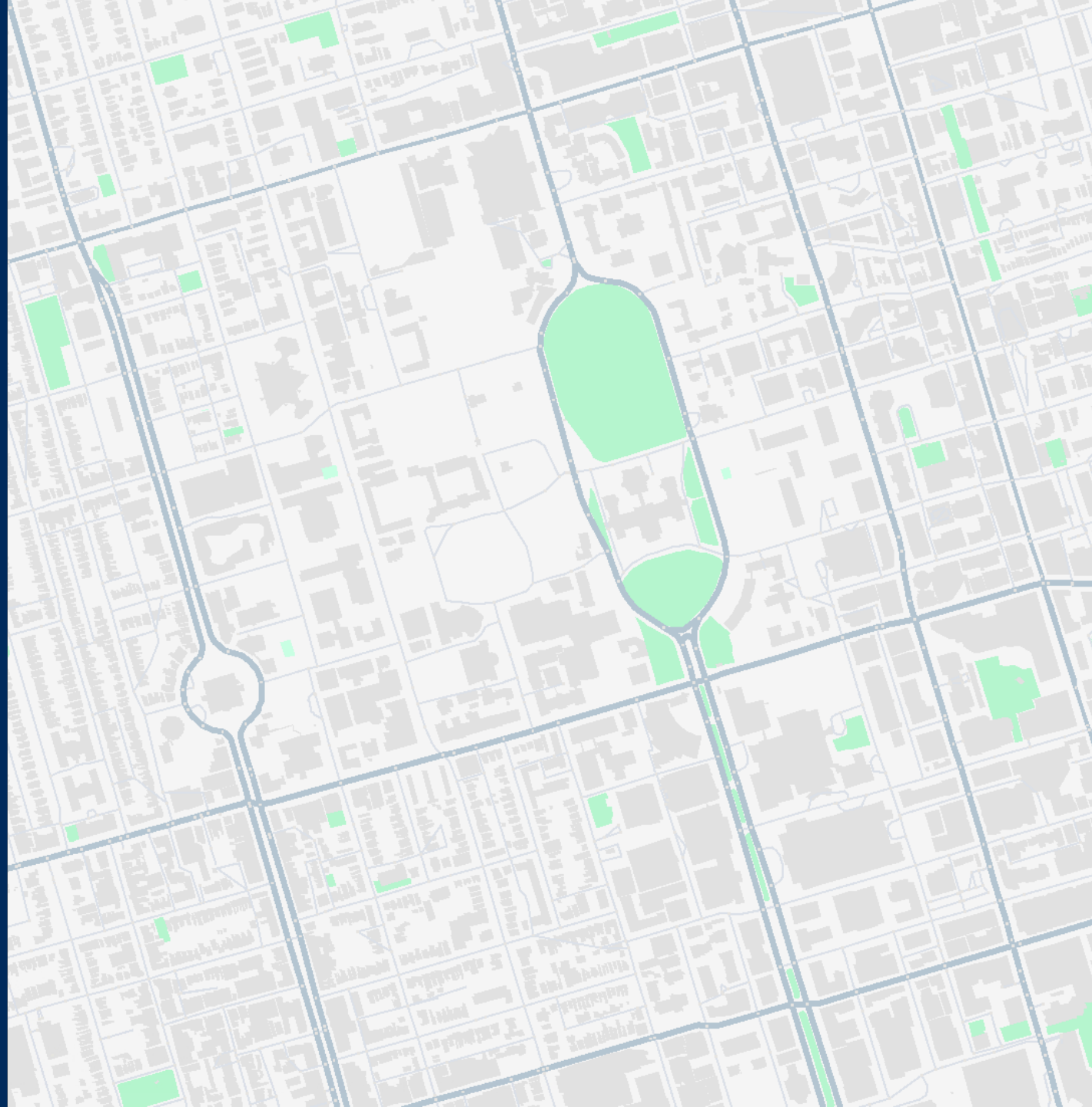
and Johnny Meng



[1]

Over 3 Million Canadians Live in Poverty

Struggling to access basic needs

Lack of transportation to get to food banks

Embarrassed to go to a food bank

Food Banks

Limited Volunteers

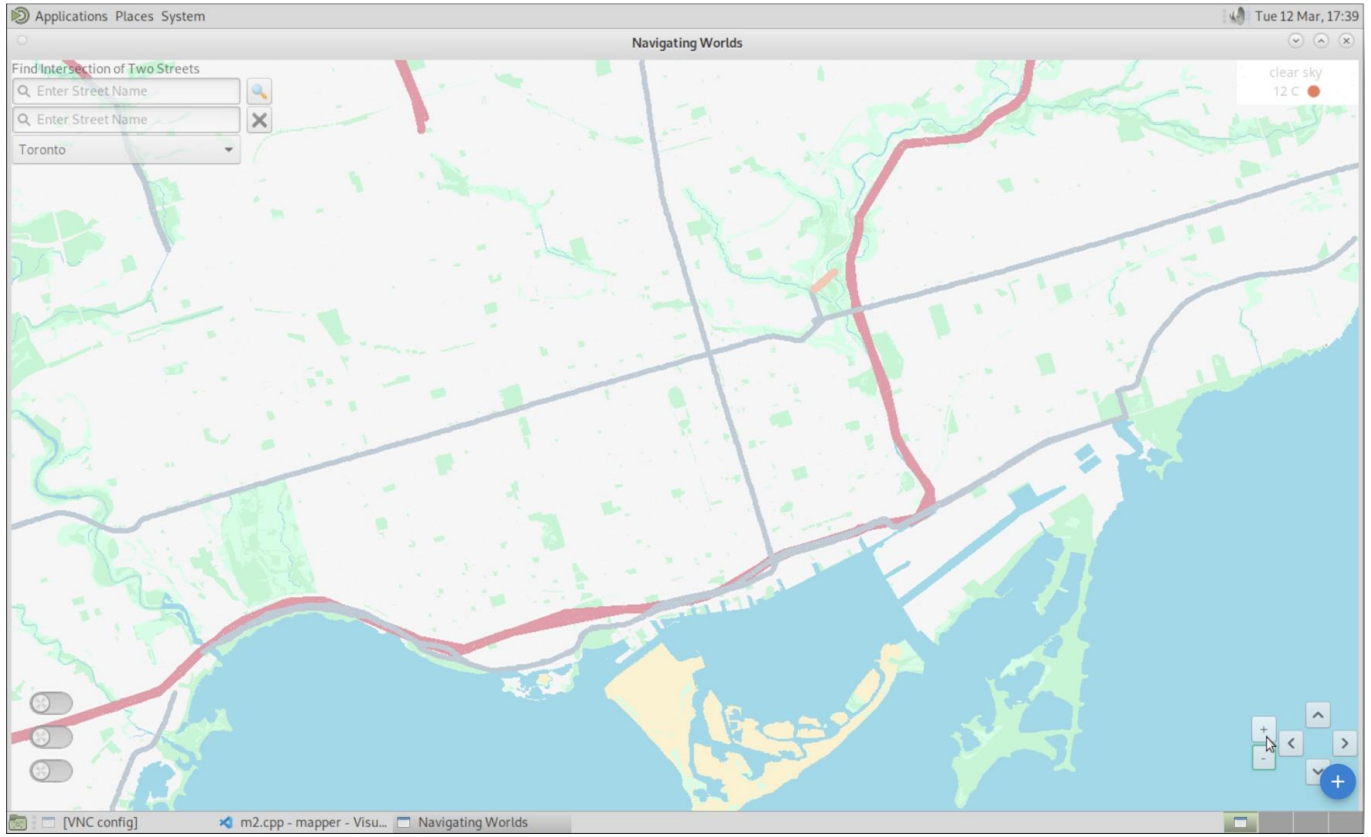
No efficient way of collecting or distributing donations

https://www.ctvnews.ca/politics/statcan-says-3-2-million-living-in-poverty-including-566-000-children-1.4824546

Our Map: "Harbour Hope"

Fast routes to collect + distribute donations simultaneously

Maximizing Efficiency



Families get food at their doorstep

Lack of transportation no longer a barrier

"Our GIS Offers An All-In-One Platform For Food Banks to Efficiently Distribute and Collect Donations"

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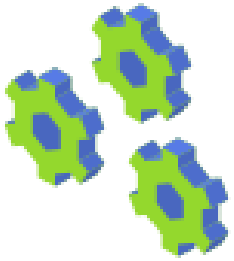
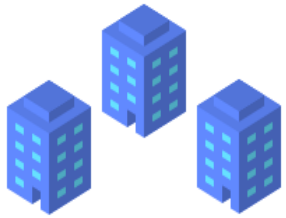


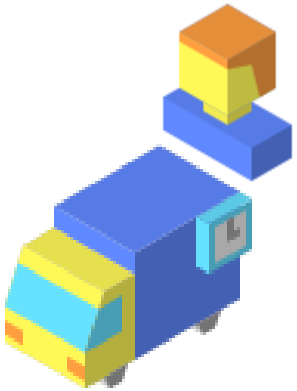
4) Permutations



5) Multithreading

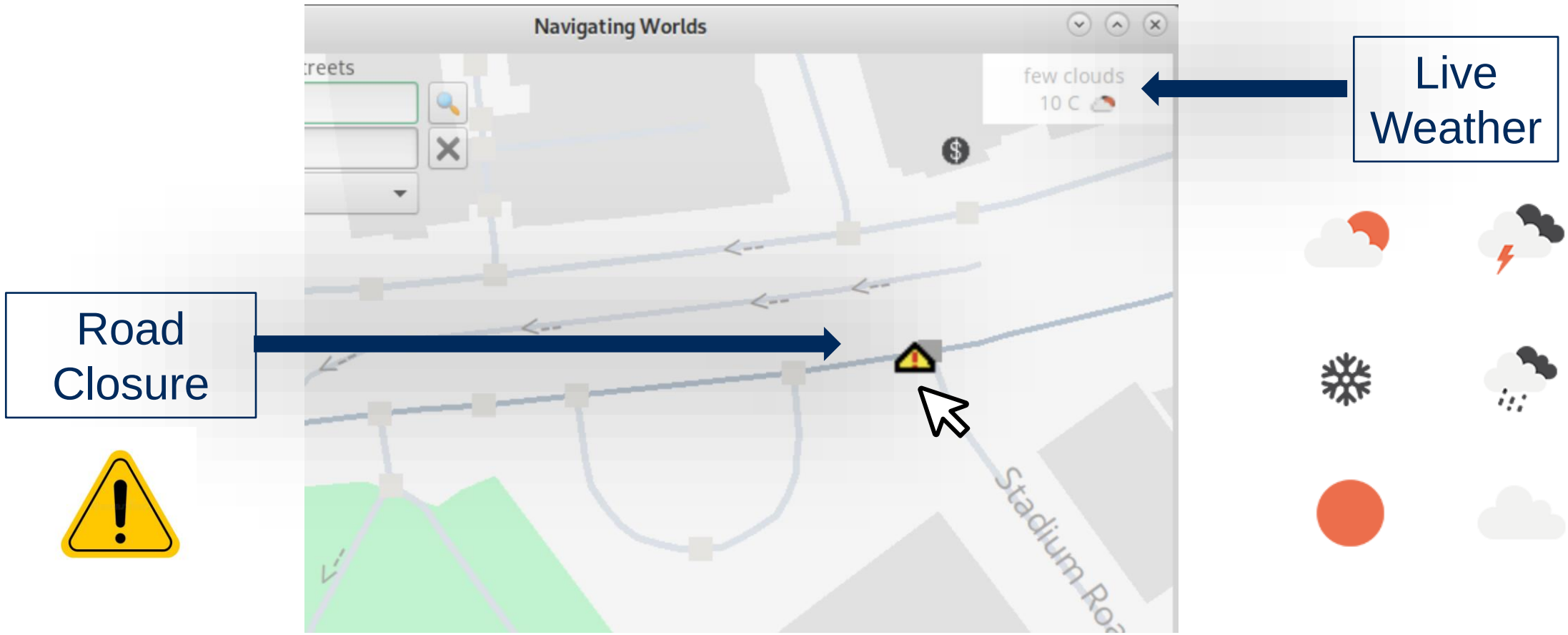
6) Pitch

Road Closure



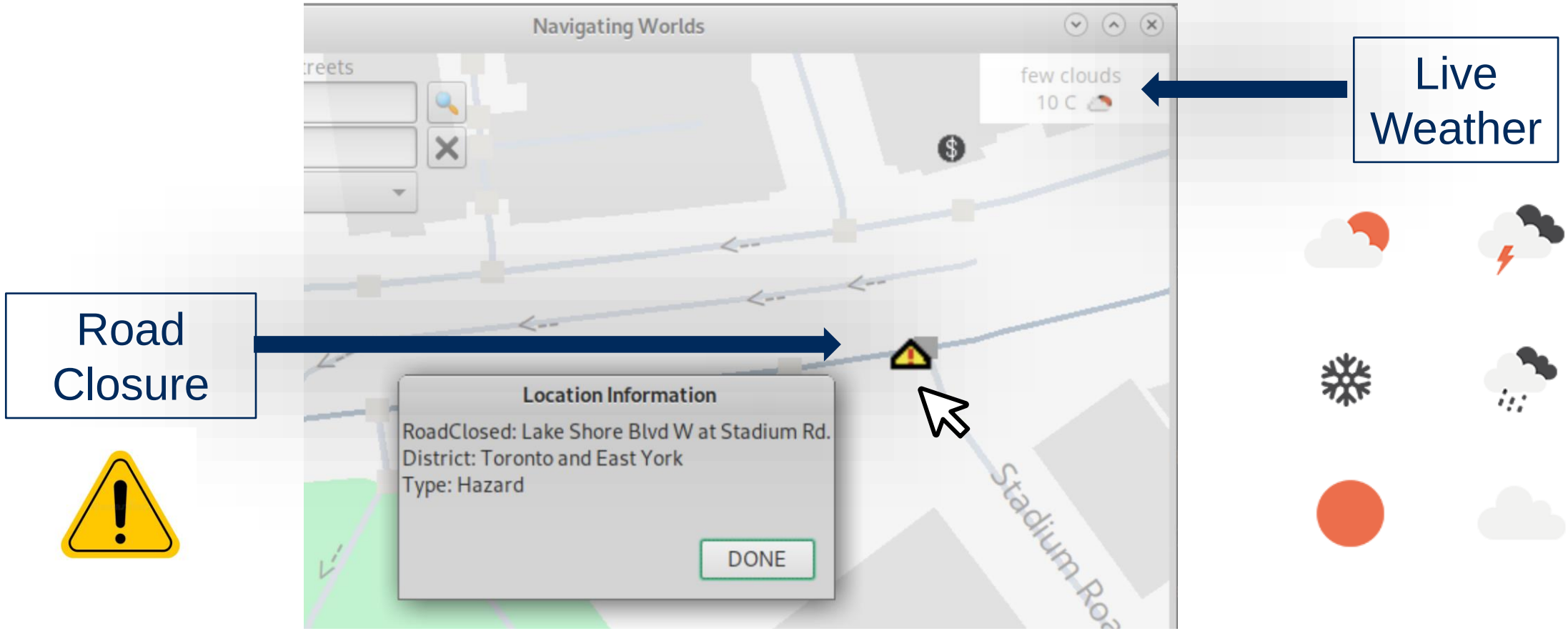
Live Weather

Intuitive Icons Cleary Communicate Live Data



[2]

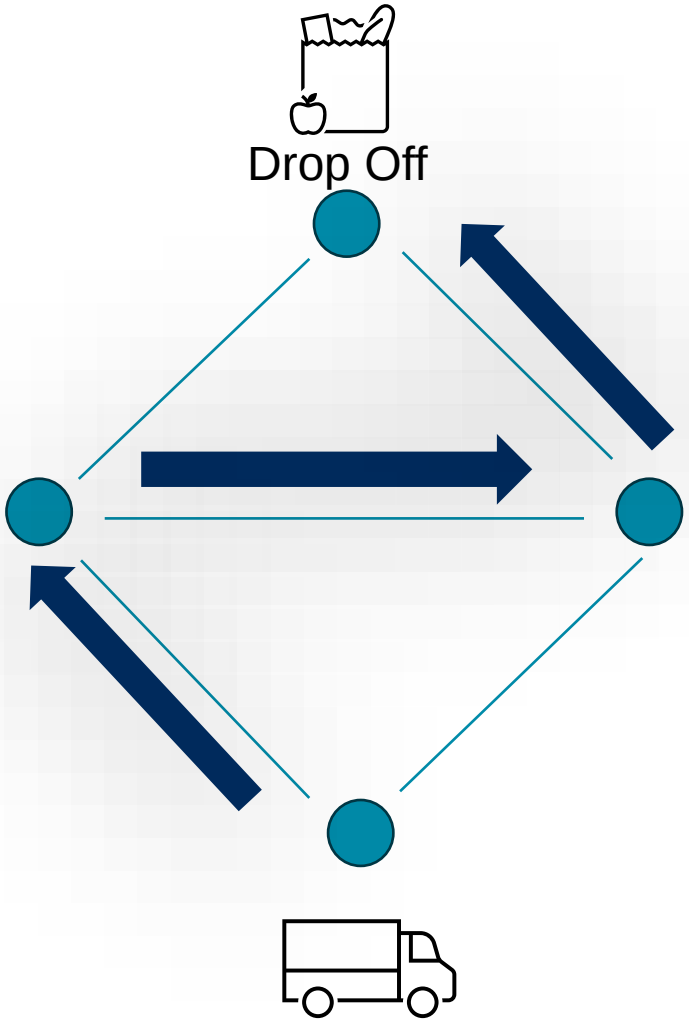
Intuitive Icons Cleary Communicate Live Data



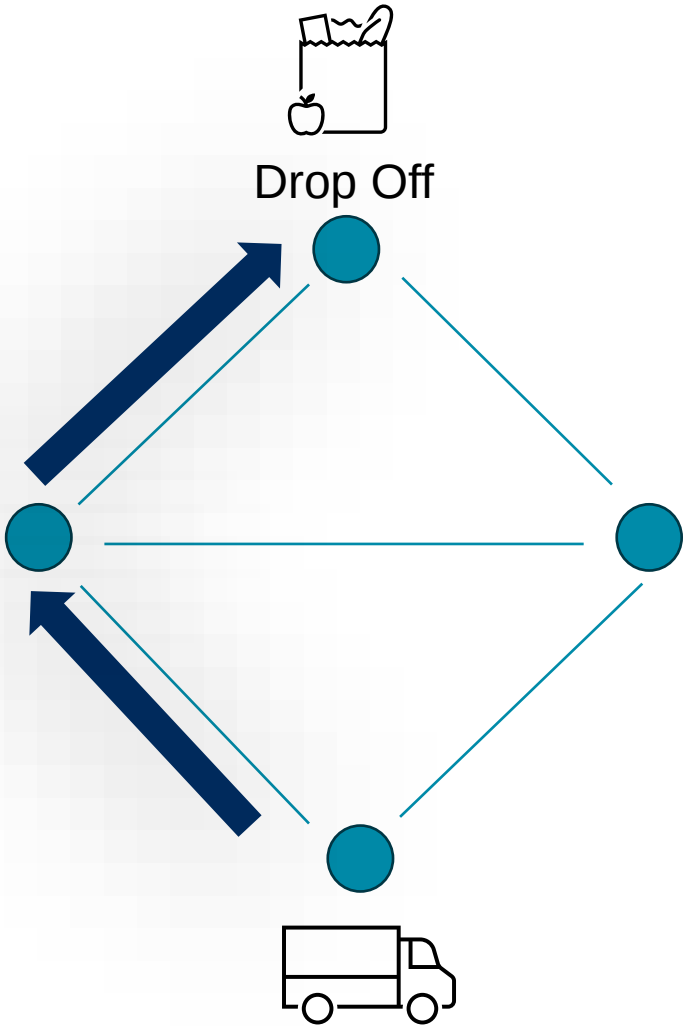
Research show that icons improve usability by reducing confusion and clearly communicating functionality

https://www.toptal.com/designers/ui/icon-usability-and-design

Best path to Destination?



7 mins



4 mins

Dijkstra's Algorithm Leads to Optimal Solution

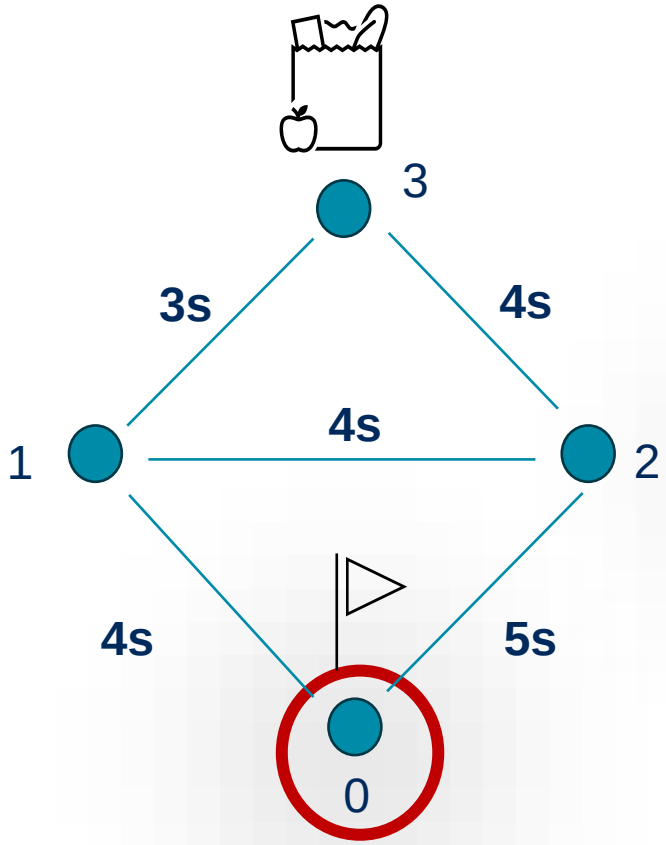
Priority Queue

Select the node that takes least time to reach

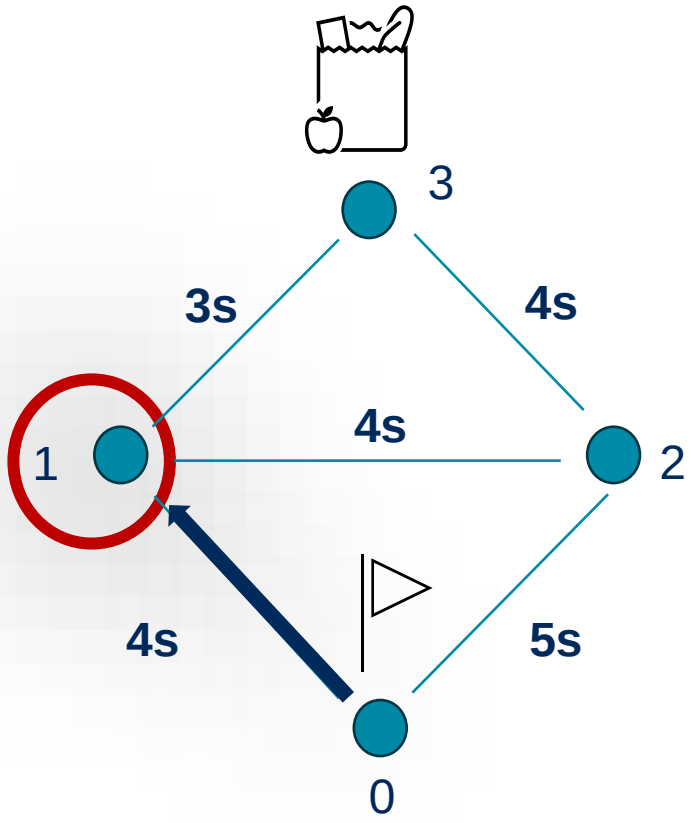
Our Priority Queue

Node 7 6 secs	Node 9 8 secs	Node 10 11 secs

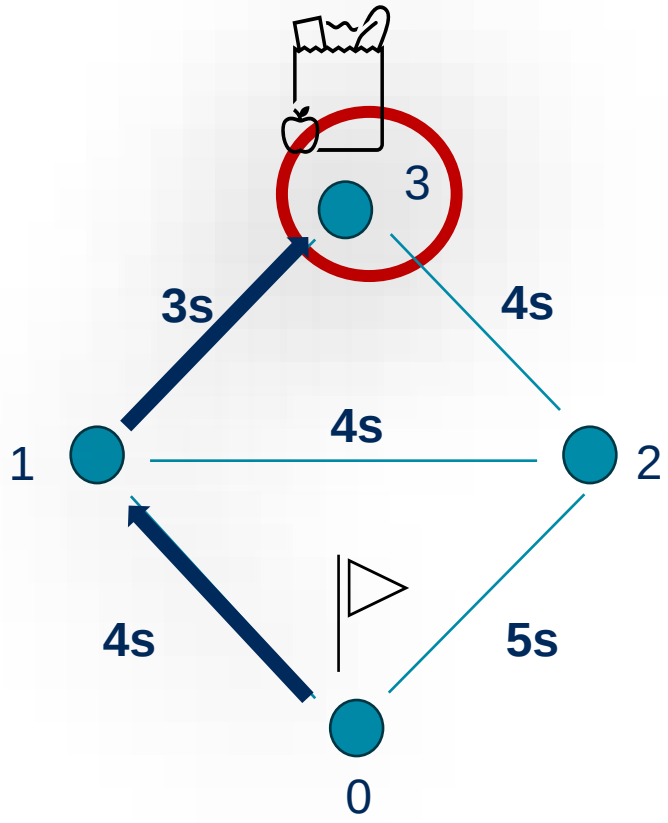
Dijkstra's Algorithm Leads to Optimal Solution



{(1,4s),(2,5s)}



{(3,7s),(2,8s)}

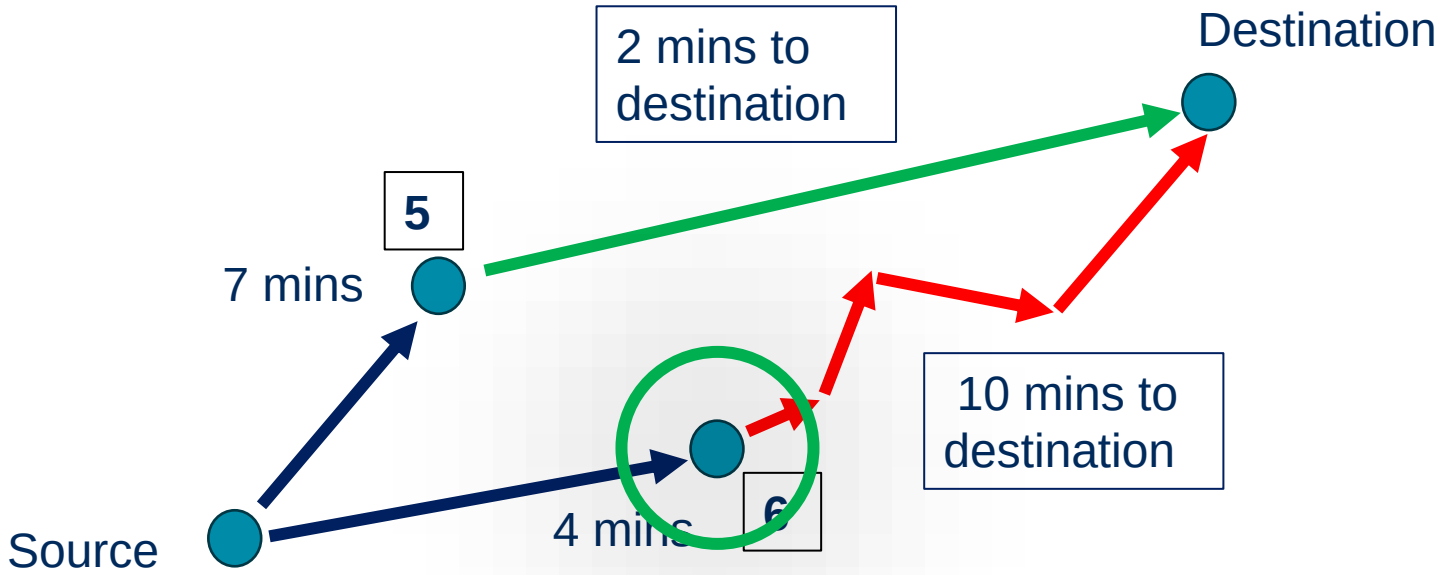


Destination!
Stop looking!

A* Heuristic Leads to Faster Travel path

Sorts Priority Queue based on Total Path Cost

= Cost to Reach Current Node + Estimated Cost to Reach Destination



Total Cost

Node 5 = 9 mins (7 + 2)

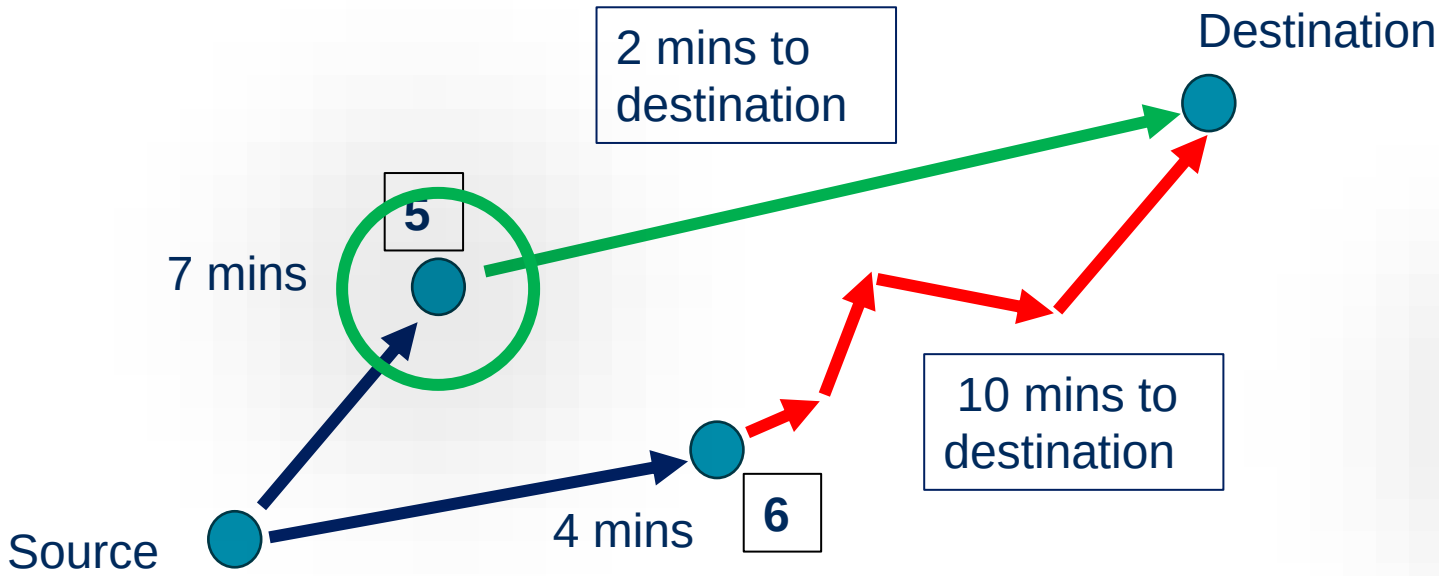
Node 6 = 14 mins (4 + 10)

{(5,5 mins), (6, 4 mins)}

A* Heuristic Leads to Faster Travel path

Sorts Priority Queue based on Total Path Cost

= Cost to Reach Current Node + Estimated Cost to Reach Destination



Total Cost

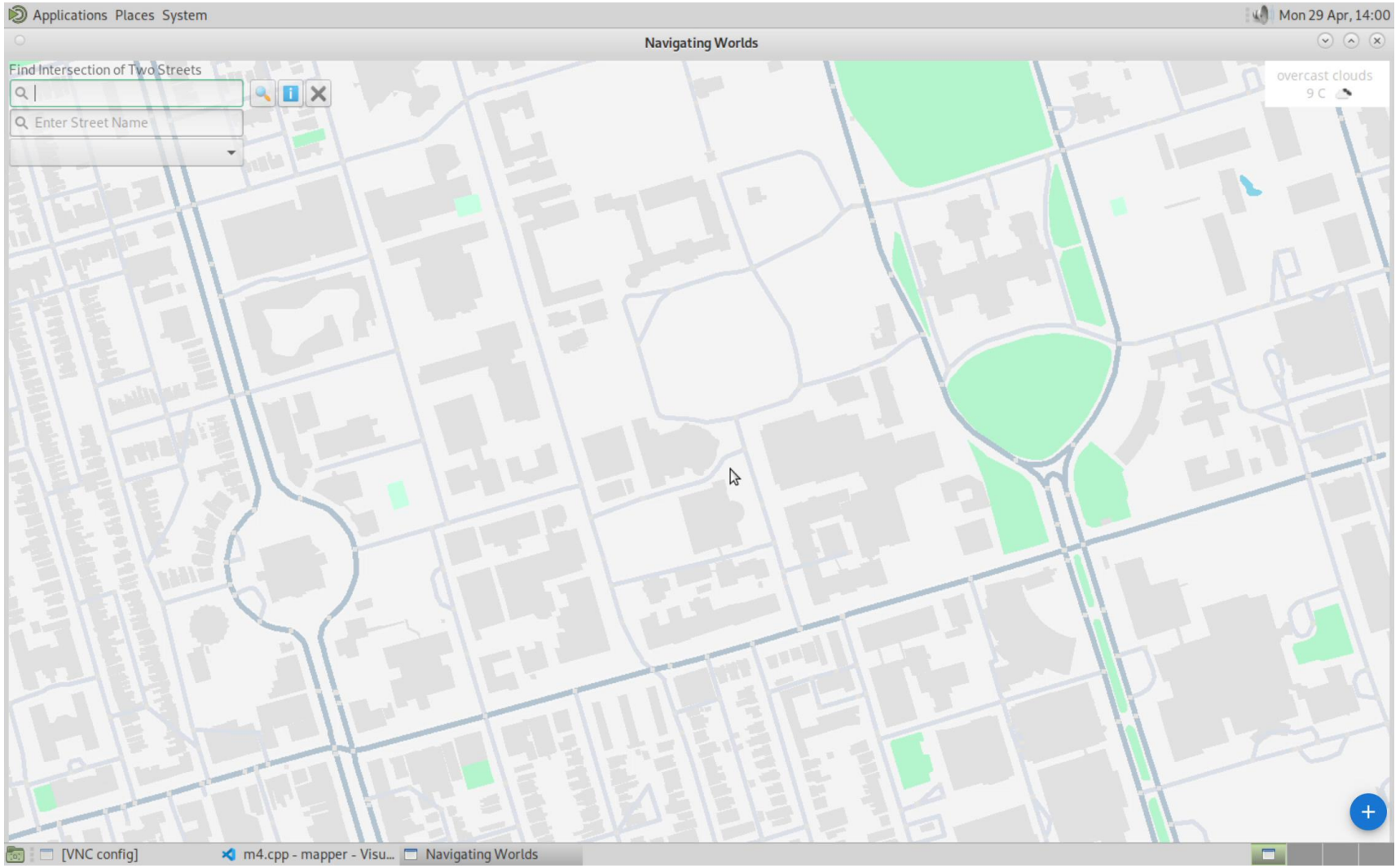
Node 5 = 9 mins (7 + 2)

Node 6 = 14 mins (4 + 10)

Priority Queue will Choose Node 5

{(5,5 mins) (6, 4 mins)}

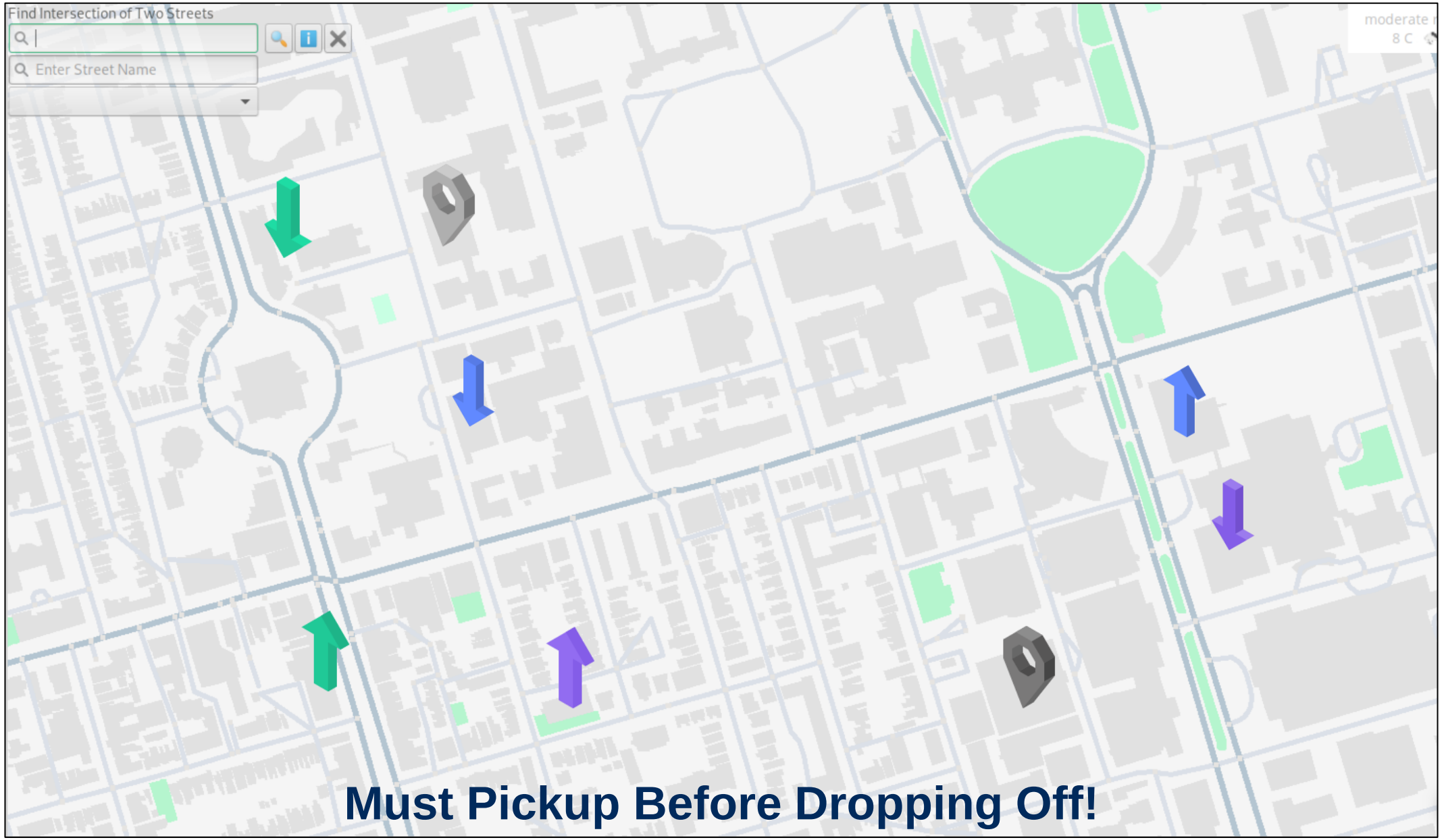
A* Algorithm Demo



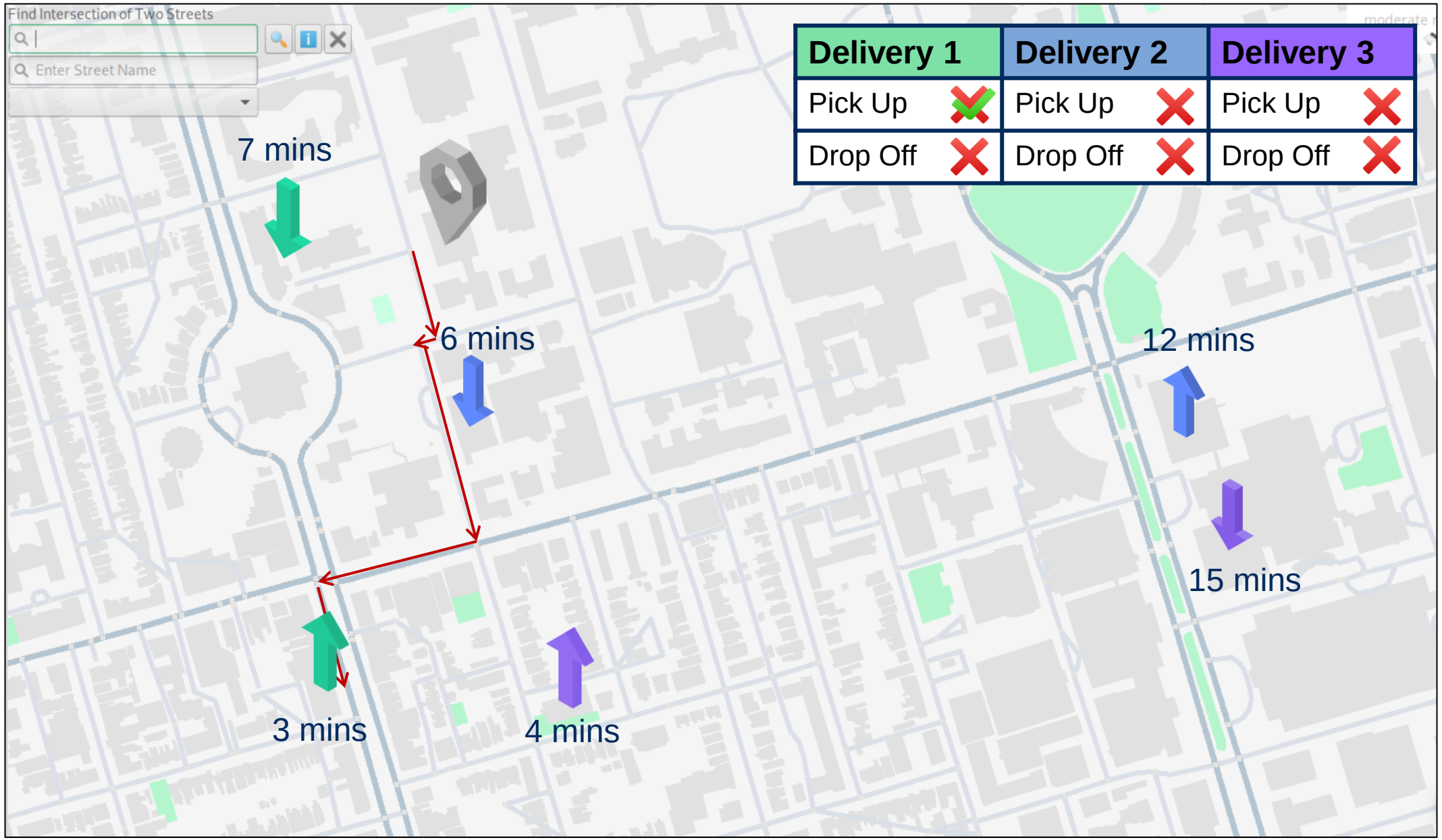
✓ Fastest Path

✓ Response time = 0.1 seconds

What are Key Elements of the Travelling Couriersman

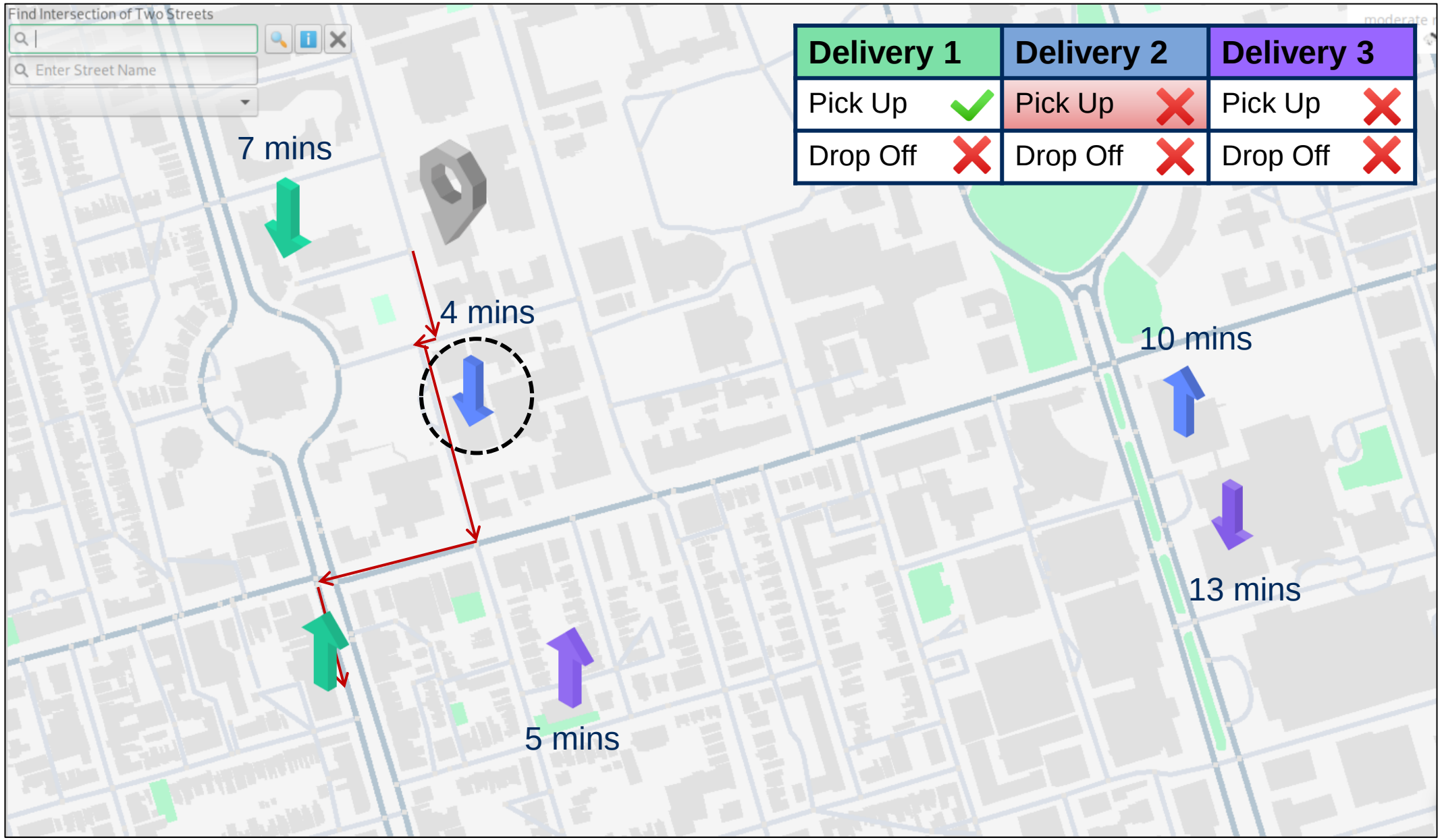


Retrieving our First Pickup



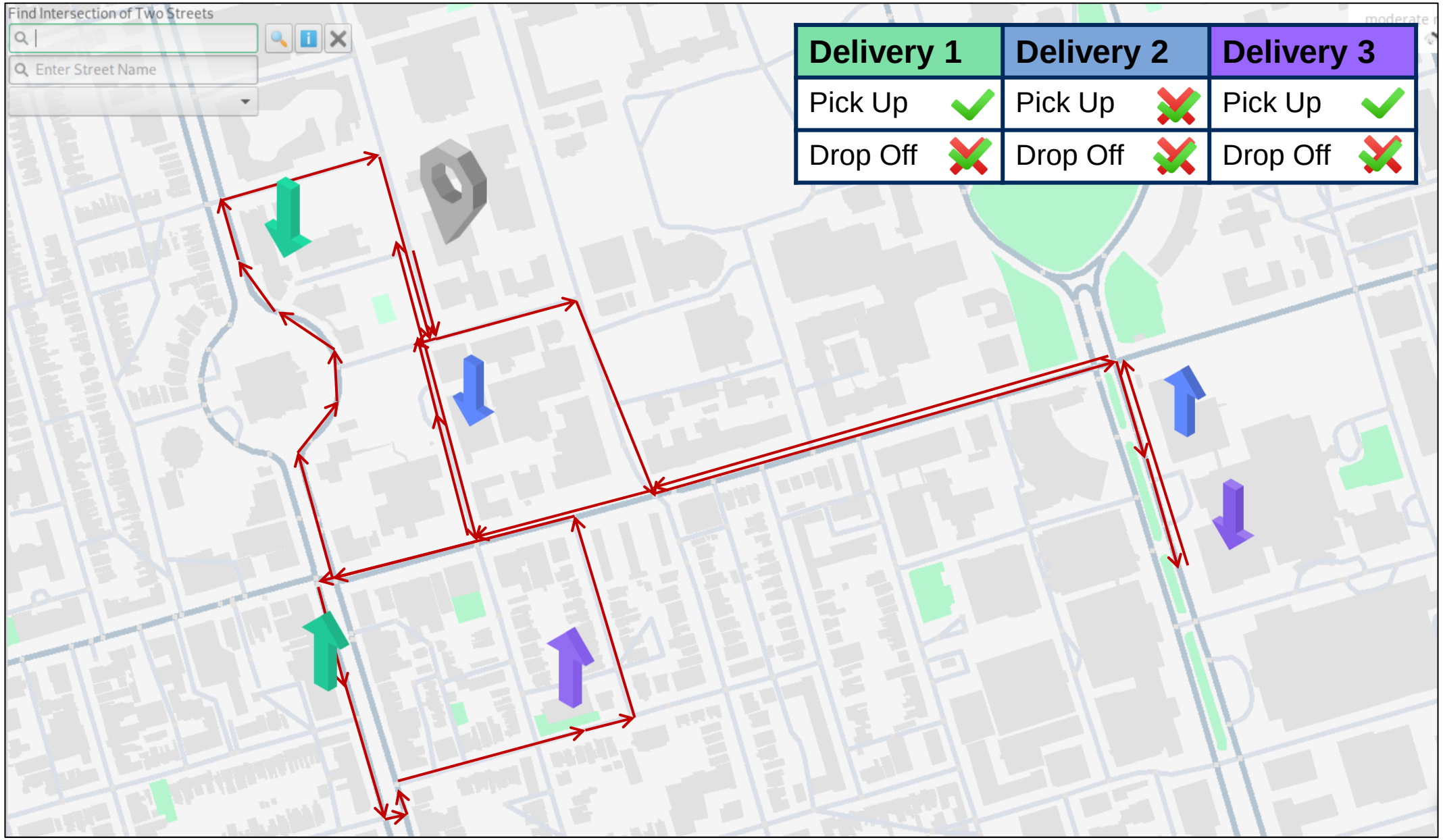
Delivery 1	Delivery 2	Delivery 3
Pick Up ✓	Pick Up ✗	Pick Up ✗
Drop Off ✗	Drop Off ✗	Drop Off ✗

Delivery 2 Is Technically the Next Best, But is Not a Legal Solution

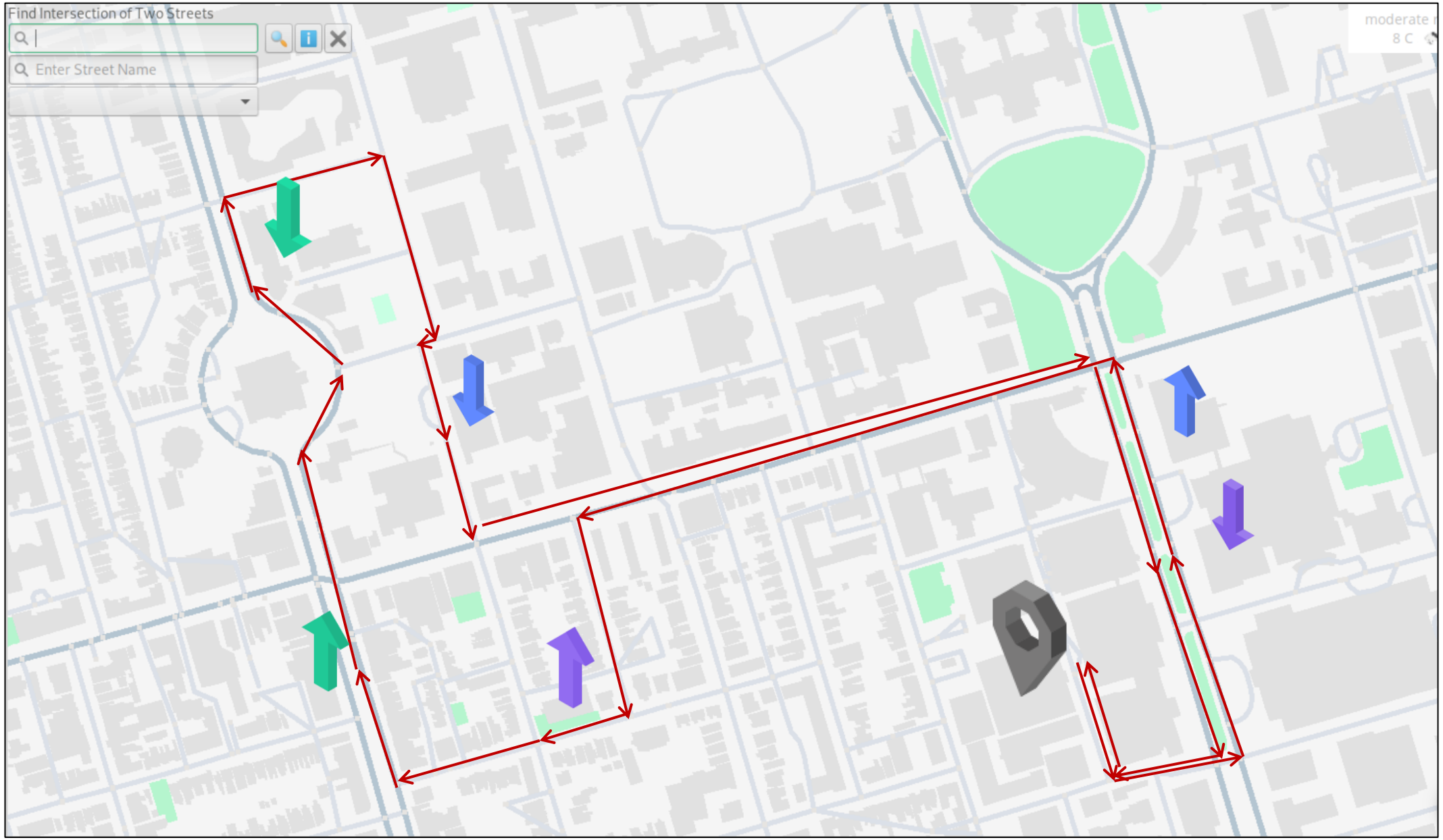


Delivery 1	Delivery 2	Delivery 3
Pick Up ✓	Pick Up ✗	Pick Up ✗
Drop Off ✗	Drop Off ✗	Drop Off ✗

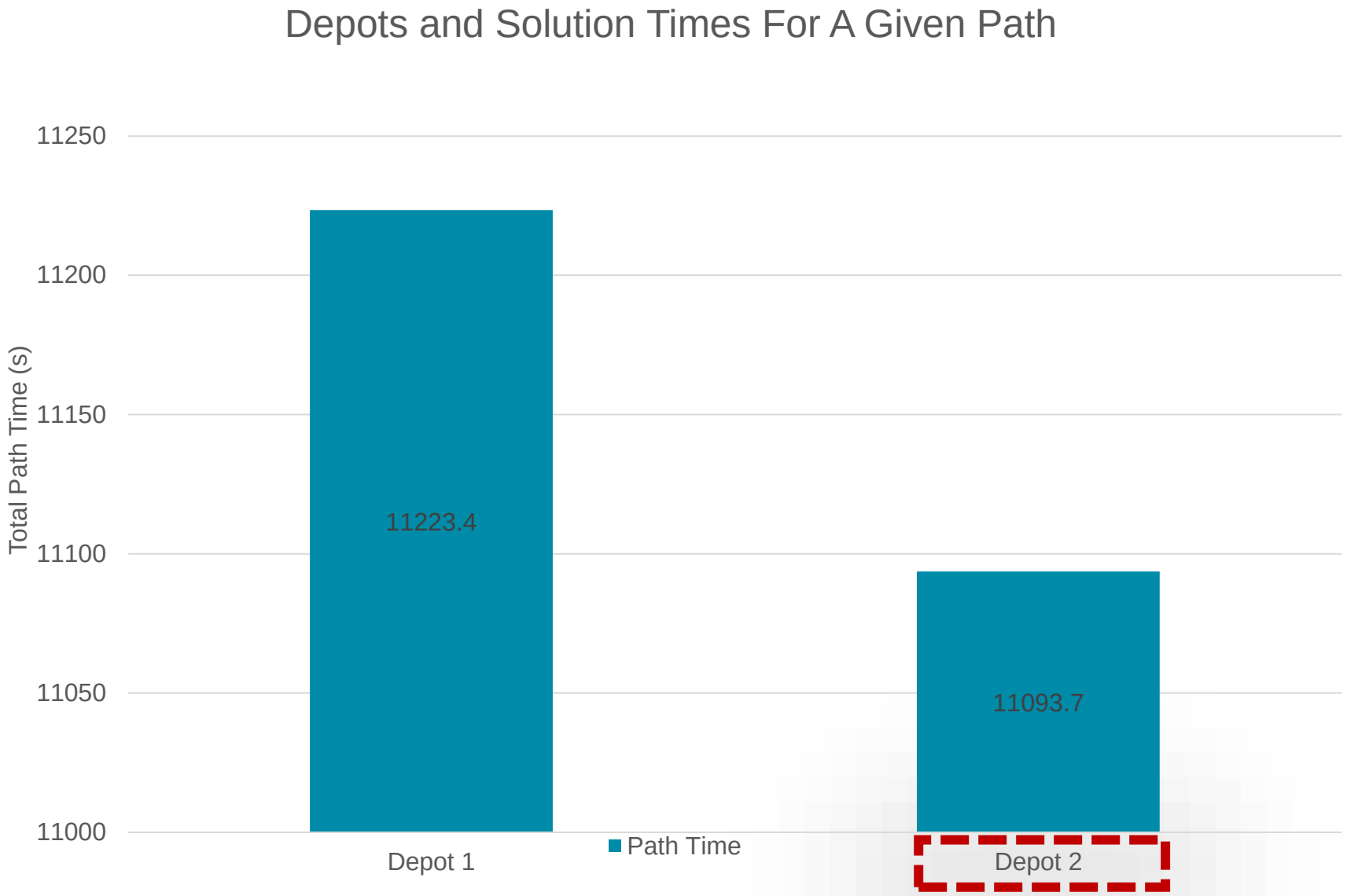
The Greedy Algorithm Makes Choices Based only Immediate Best Options



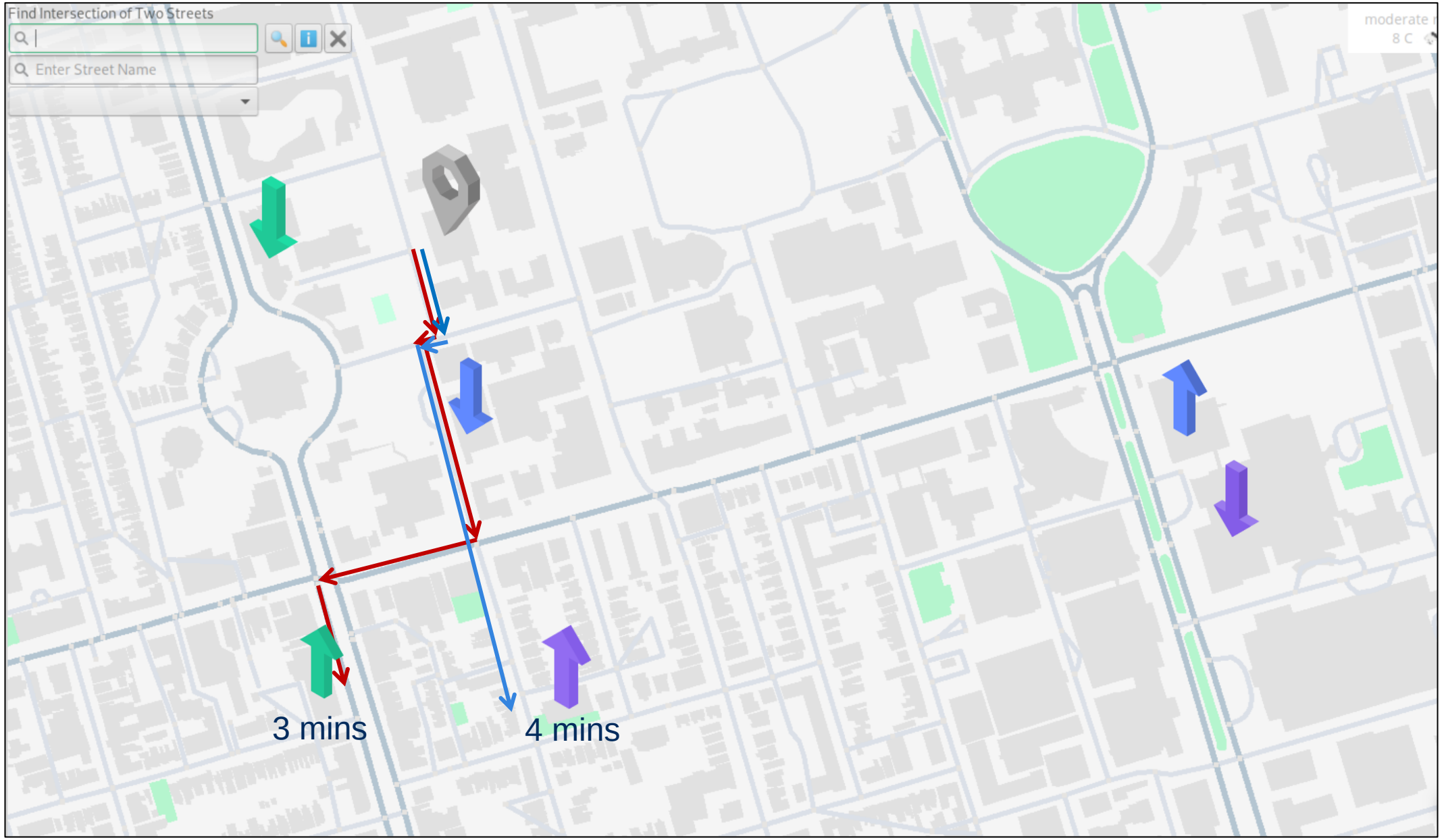
Selecting a Different Depot Could Provide a Faster Result



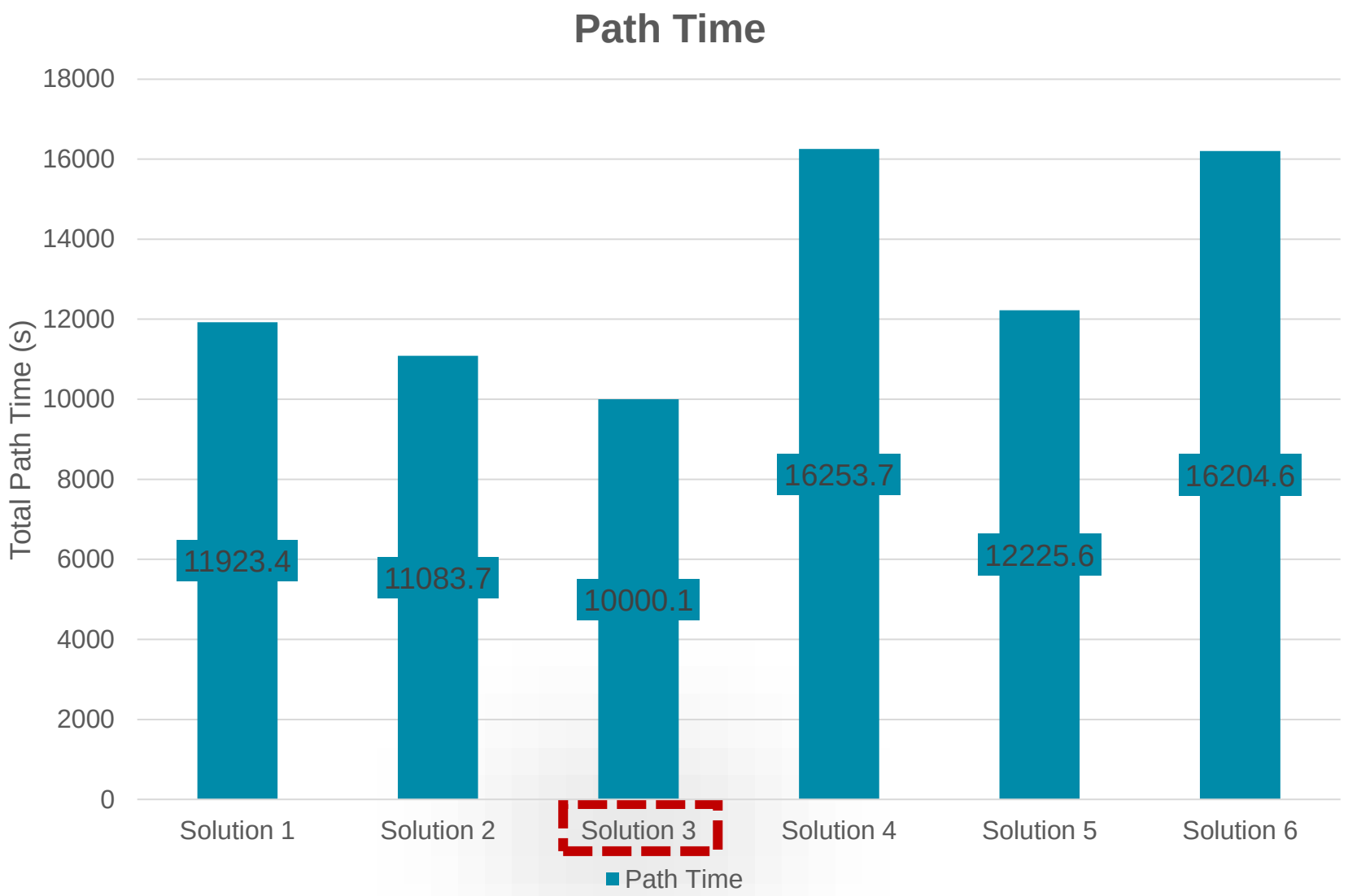
MultiStart: We Create Multiple Solutions and Select the Best One



We Don’t Always Select the Best Option To Vary Our Solutions



Repeating the Algorithm Provides Various Different Solutions



Greedy Solution is Not the Most Optimal

Makes locally optimal choices without accounting for the future → Does not always provide best solution

We want to give food bank volunteers the most optimal path → Solution? → Permutations (small changes may lead to better path)

https://www.freecodecamp.org/news/greedy-algorithms/

Local Permutations Decrease Path Time

1) Chose two random intersections in path

2) Swap them with adjacent intersection

Local Permutations Decrease Path Time

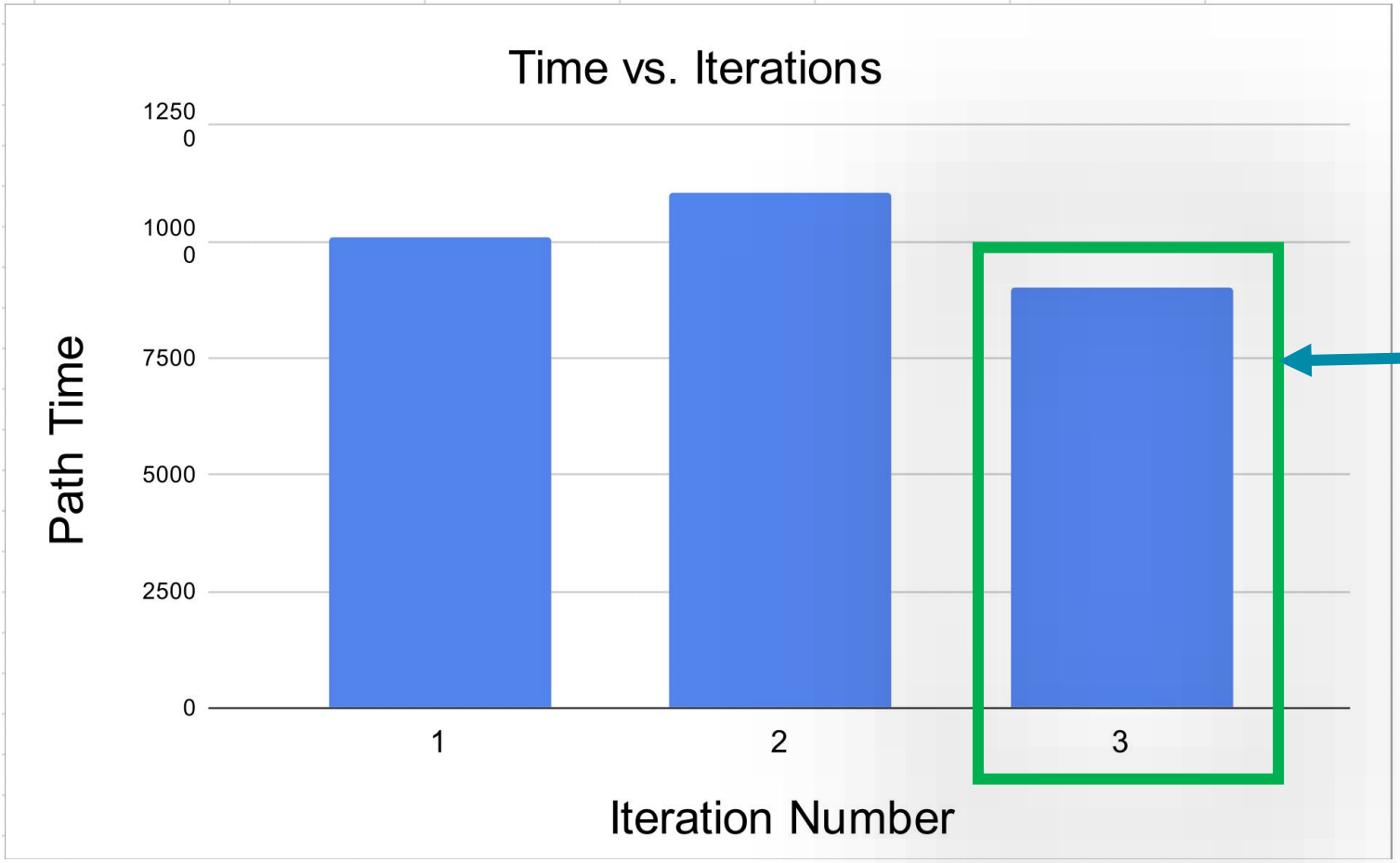
1) Chose two random intersections in path

2) Swap them with adjacent intersection

3) If travel time decreased + legal, update solution

4) Repeat..

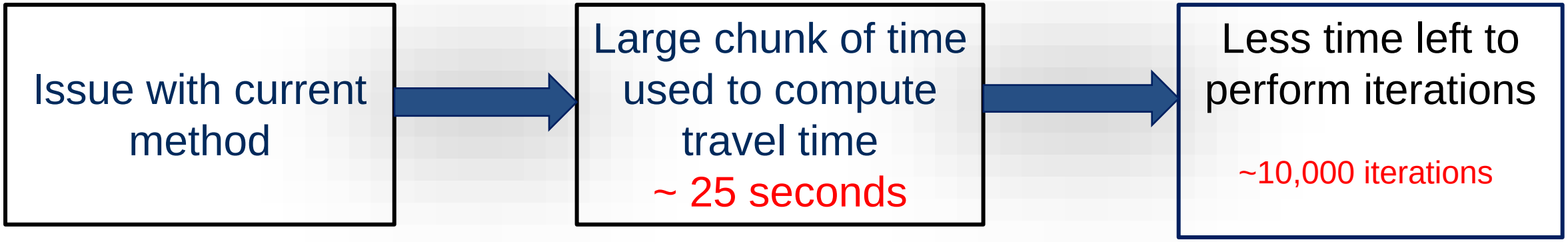
Local Permutations Decrease Path Time



Found faster and legal path, update solution!

Research Shows Continuous Iterations Lead to Improvements

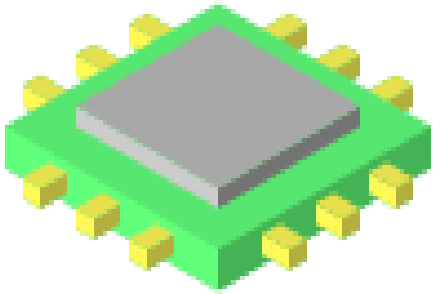
- Time = 50 seconds
- Goal: Do as many iterations as possible in 50 seconds
- End optimization just before time limit



https://typeset.io/papers/perspectives-on-iteration-in-design-and-development-37ziu8hhri

Modern CPUs Have Multiple Cores

- This allows programs to execute multiple “instructions” at a time on different cores



https://www.geeksforgeeks.org/multithreading-in-cpp/

Modern CPUs Have Multiple Cores

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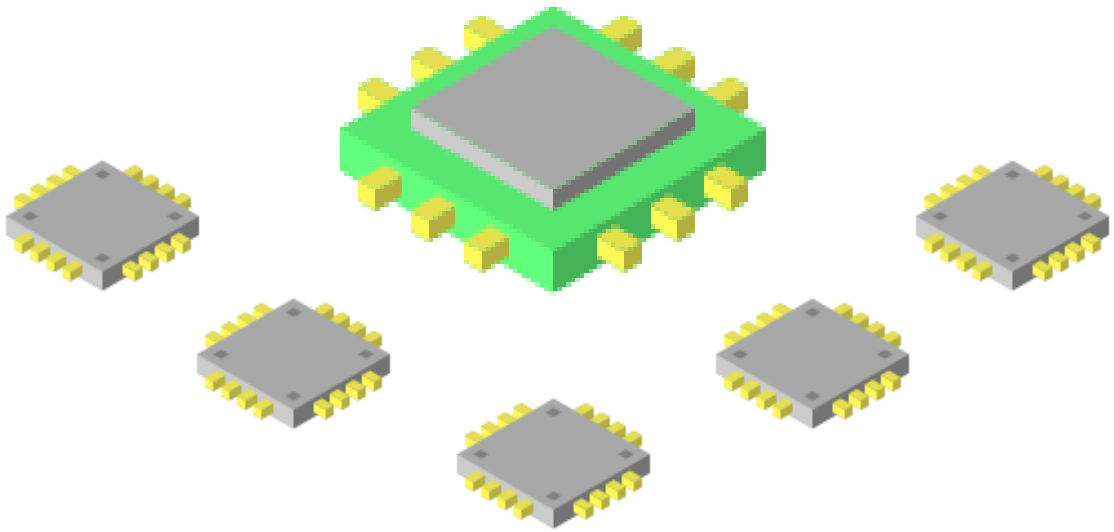
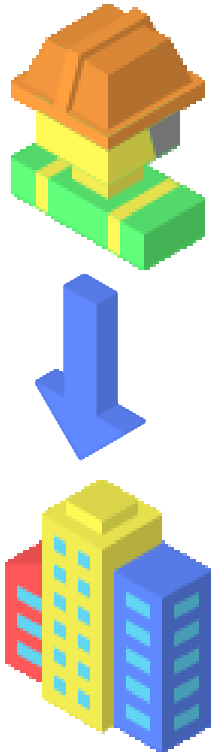


https://www.geeksforgeeks.org/multithreading-in-cpp/

CPU Cores Execute Code Serially

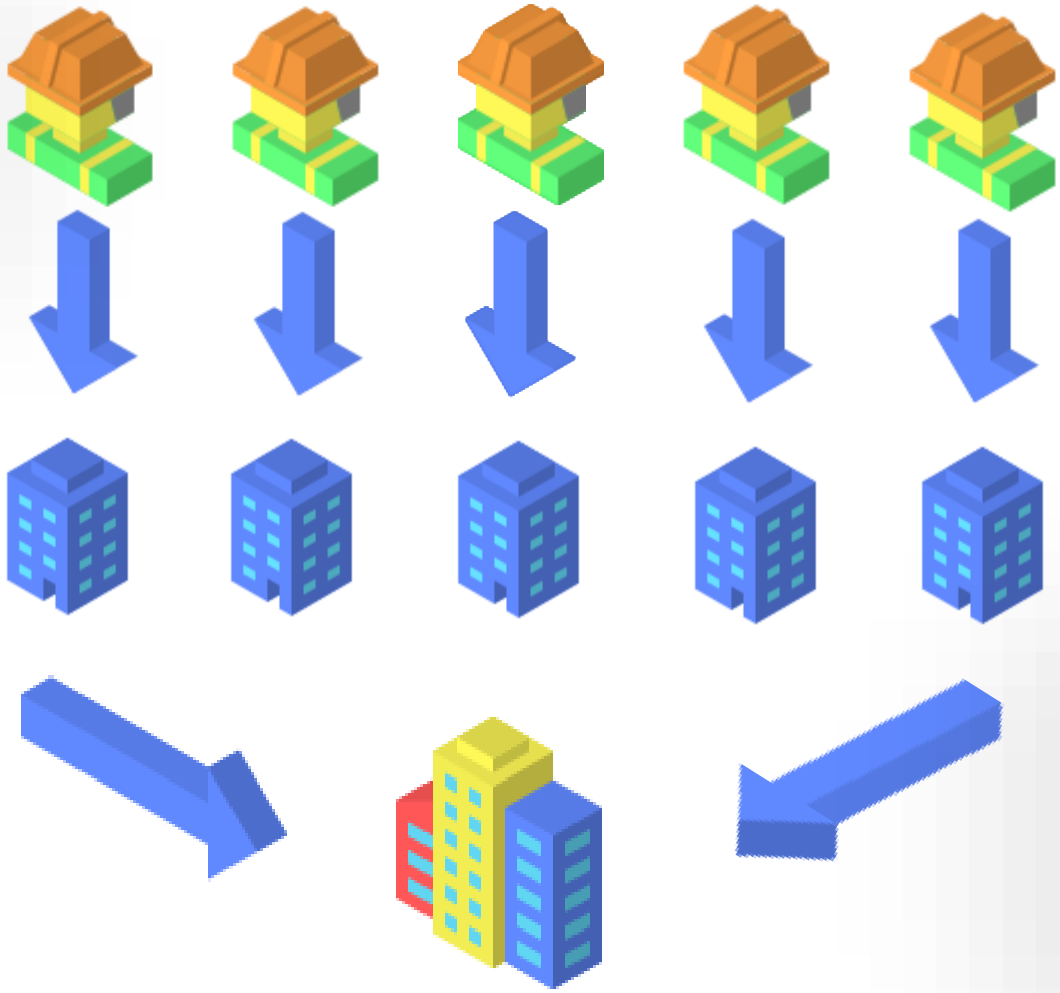
- Single threaded programs can only execute 1 instruction at a time



Computing In Parallel Performs The Same Calculation On Multiple Cores

- Multiple cores can split up work between them

Each “core” does the same “small” task

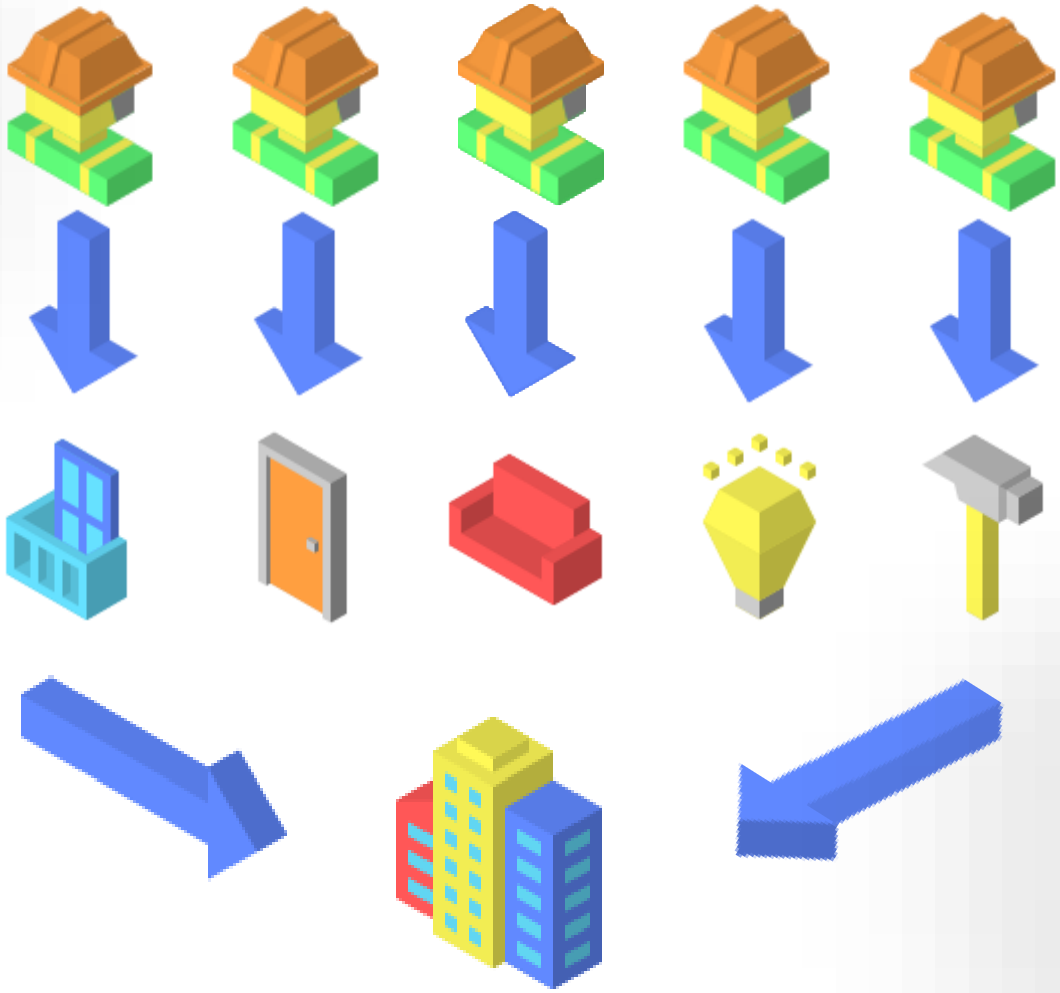


Tasks combine to complete the bigger goal

Concurrent Compute Assigns Each Core A Different Task

- Concurrency execute different instructions on multiple cores

"Cores" each do different, unique tasks



Unique tasks combine to complete the bigger goal

Multi-Threading Reduced Overall Compute Time by ~10x

- Found exact time between intersections using Multi-Dijkstra's
- Used thread pool to concurrently generated new tours with different parameters

Time Matrix Without Multithreading

~25 seconds

Swap Iterations Without Multithreading

~10,000 Iterations

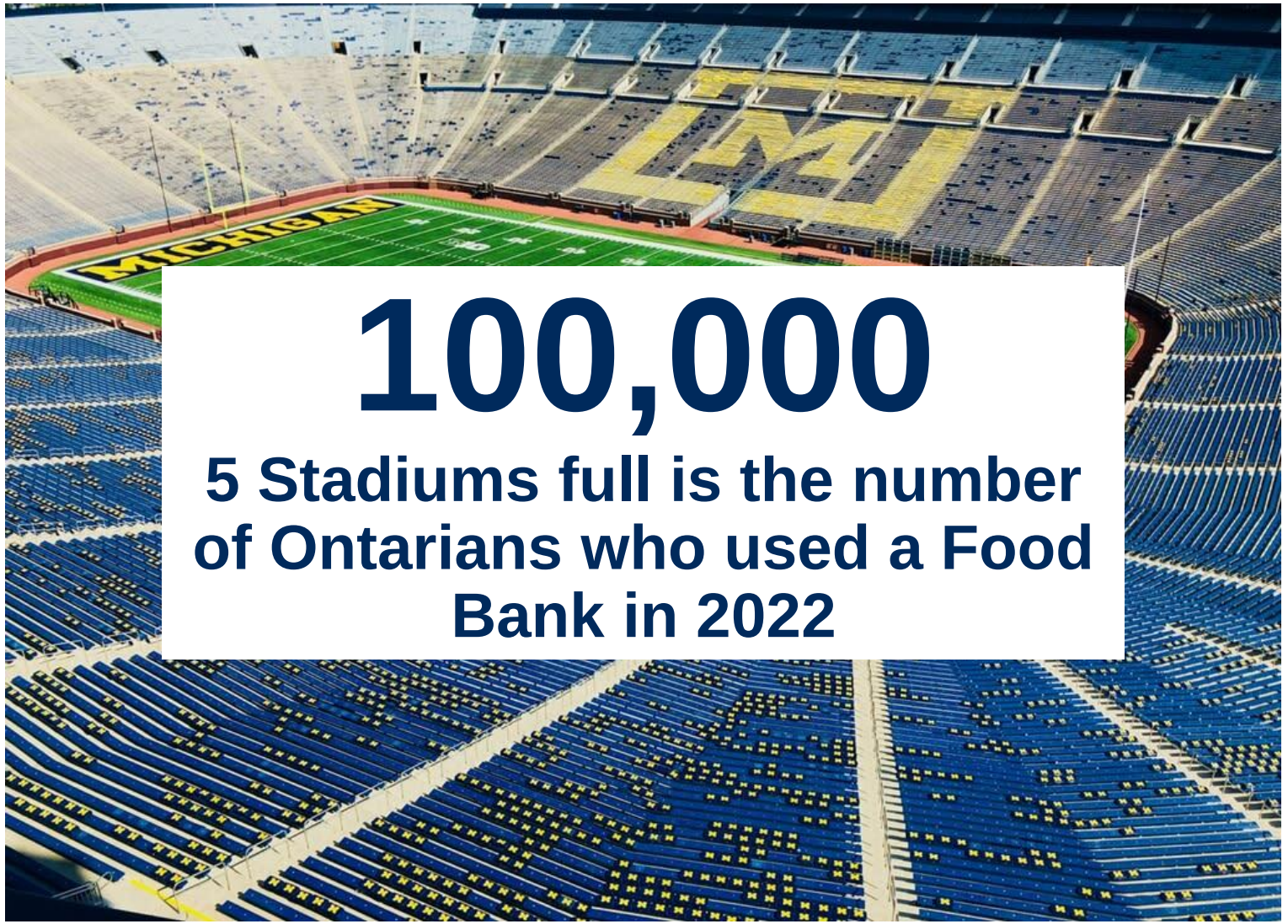
Time Matrix With Multithreading

~2.5 seconds

Swap Iterations Without Multithreading

~85,000 Iterations

How Many People Can Fit in This Stadium?



https://feedontario.ca/wp-content/uploads/2022/11/Hunger-Report-2022-Final.pdf

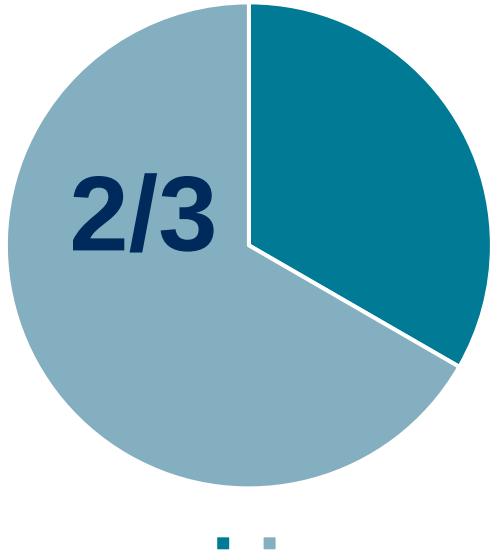
[6]

Post Pandemic Food Bank Usage Has Almost Doubled

200,000
In 2020

x2

450,000
In 2022

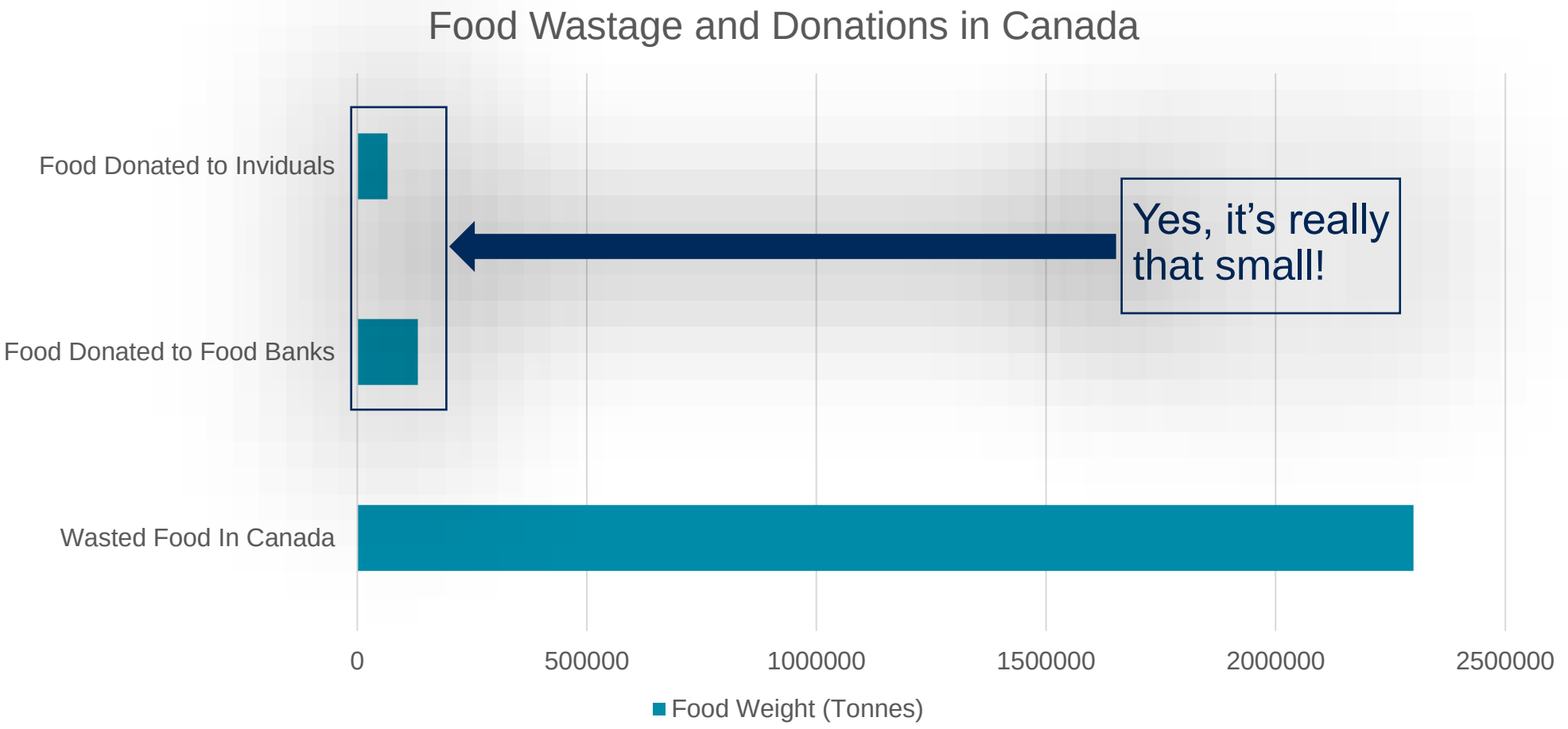


Felt Number of Donations of gone down post pandemic

https://feedontario.ca/wp-content/uploads/2022/11/Hunger-Report-2022-Final.pdf

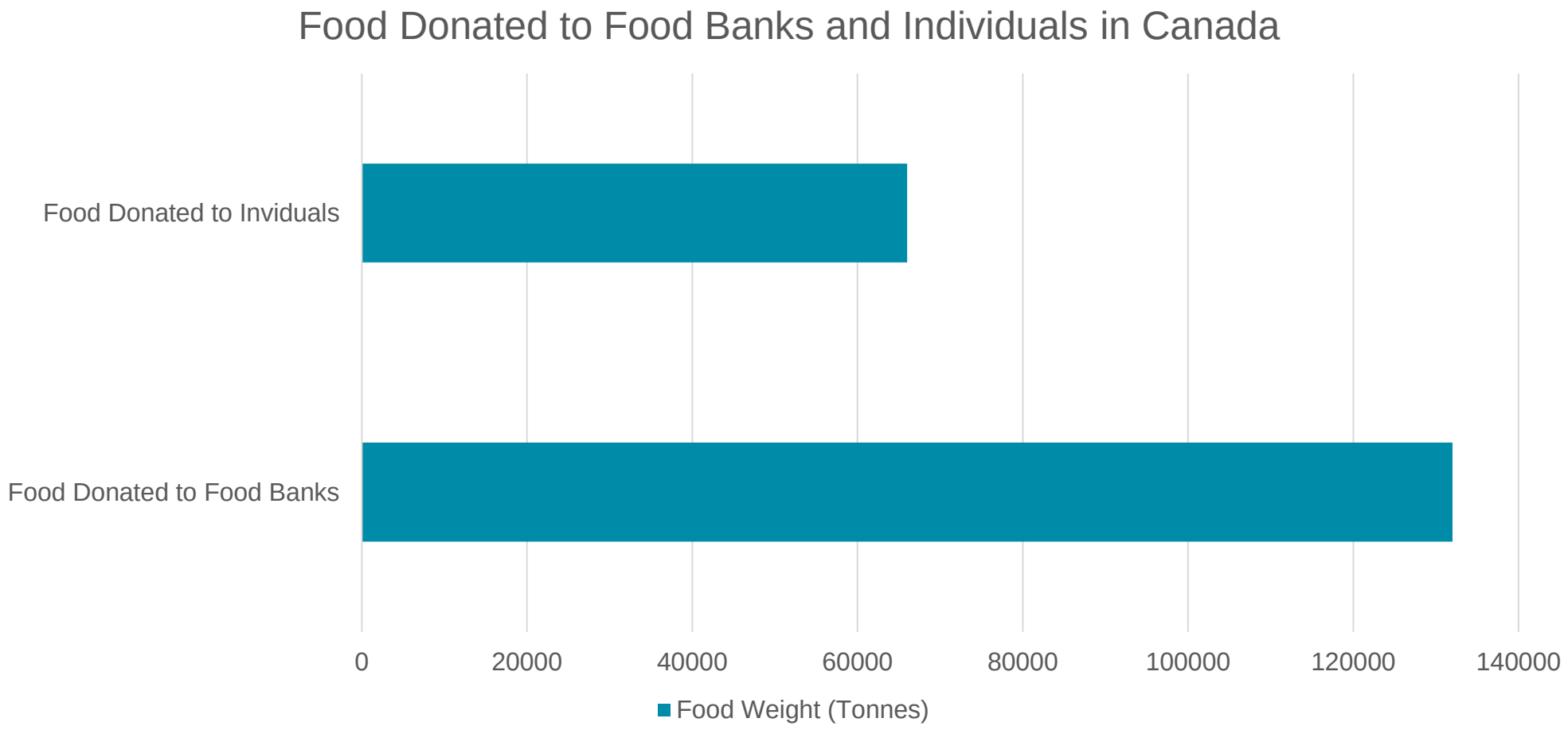
The Weight of ~19.5 CN Towers Worth of Edible Food is Wasted Canada Every Year

[7,8]



https://madeinca.ca/food-waste-canada-statistics/#:~:text=How%20much%20food%20is%20wasted,average%20household%20in%20a%20year.
https://www.secondharvest.ca/

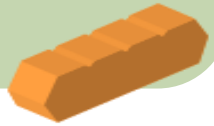
Only Half of the Donated Food Gets to Those That Need It



https://nationalpost.com/opinion/buying-canned-goods-to-donate-to-food-banks-is-inefficient-and-misguided-donate-money-instead#:~:text=According%20to%20U.S.%20data%20up,off%20a%20donor%20for%20life.

Goal: Provide Food Banks with an Efficient managing system for Retrieving and Sending Donations

User requests donation pickup based on locational needs

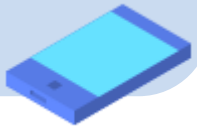


Driver picks up donations (along with other user donations)

Driver drops off donation at the selected food bank

Goal: Provide Food Banks with an Efficient managing system for Retrieving and Sending Donations

User requests Items from Food Banks



Driver picks up from Food Bank (along with other user donations)

Driver drops off donation at requested location

[11,12,13]

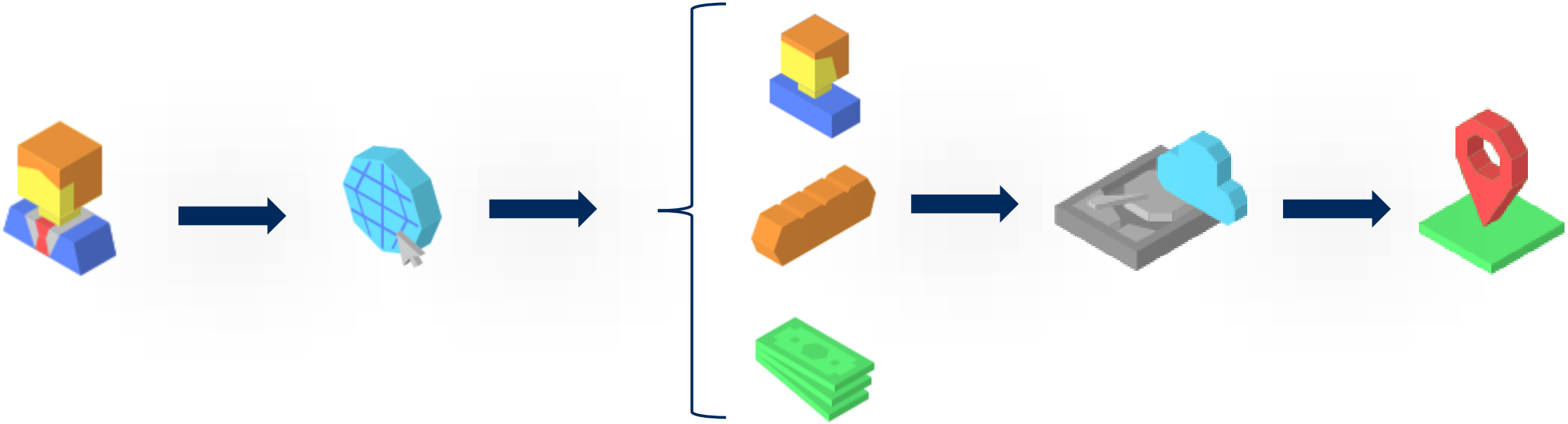
How do Current Food Banks Manage their Donations?

	HarbourHope	FareShare (UK)	Food Banks Canada	FeedingAmerica (USA)
Delivery to Food Banks	✓	✓	✗	✗
Pickup from Food Banks	✓	✓	✗	✗
Online Ordering / Pickup System	✓	✓	✗	✗
Works with any food bank	✓	✗	✗	✗
Live Updates on what food stock	✓	✗	✗	✗

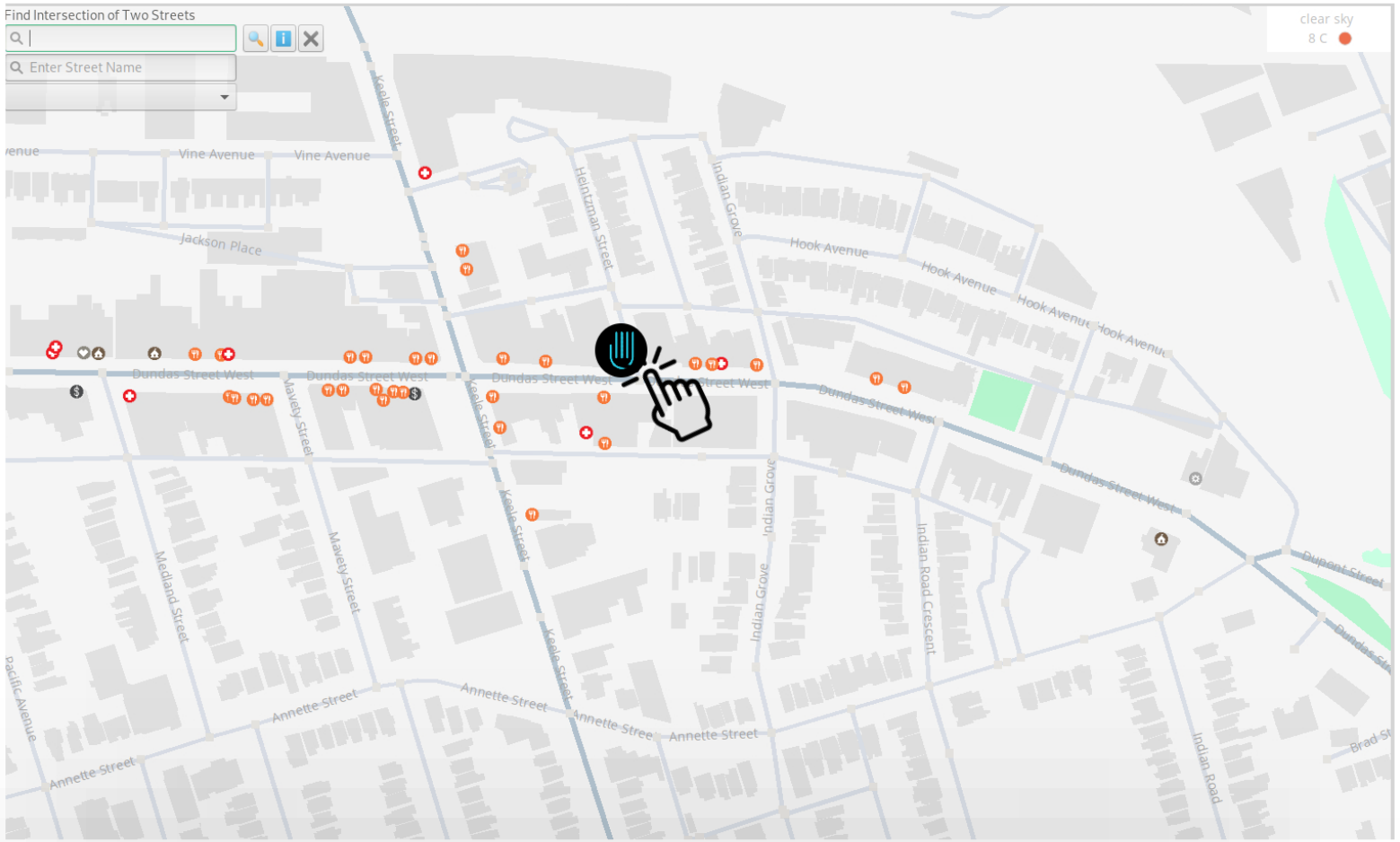
https://www.sciencedirect.com/science/article/pii/S0925527323001585 https://foodbankscanada.ca/how-you-can-help/ https://www.feedingamerica.org/find-your-local-foodbank

A React Website Will be Created for Food Banks to Manage Deliveries

- Website will be created using React, used to track deliveries and manage inventory
- Data will be stored in SQL database which updates front end GIS app



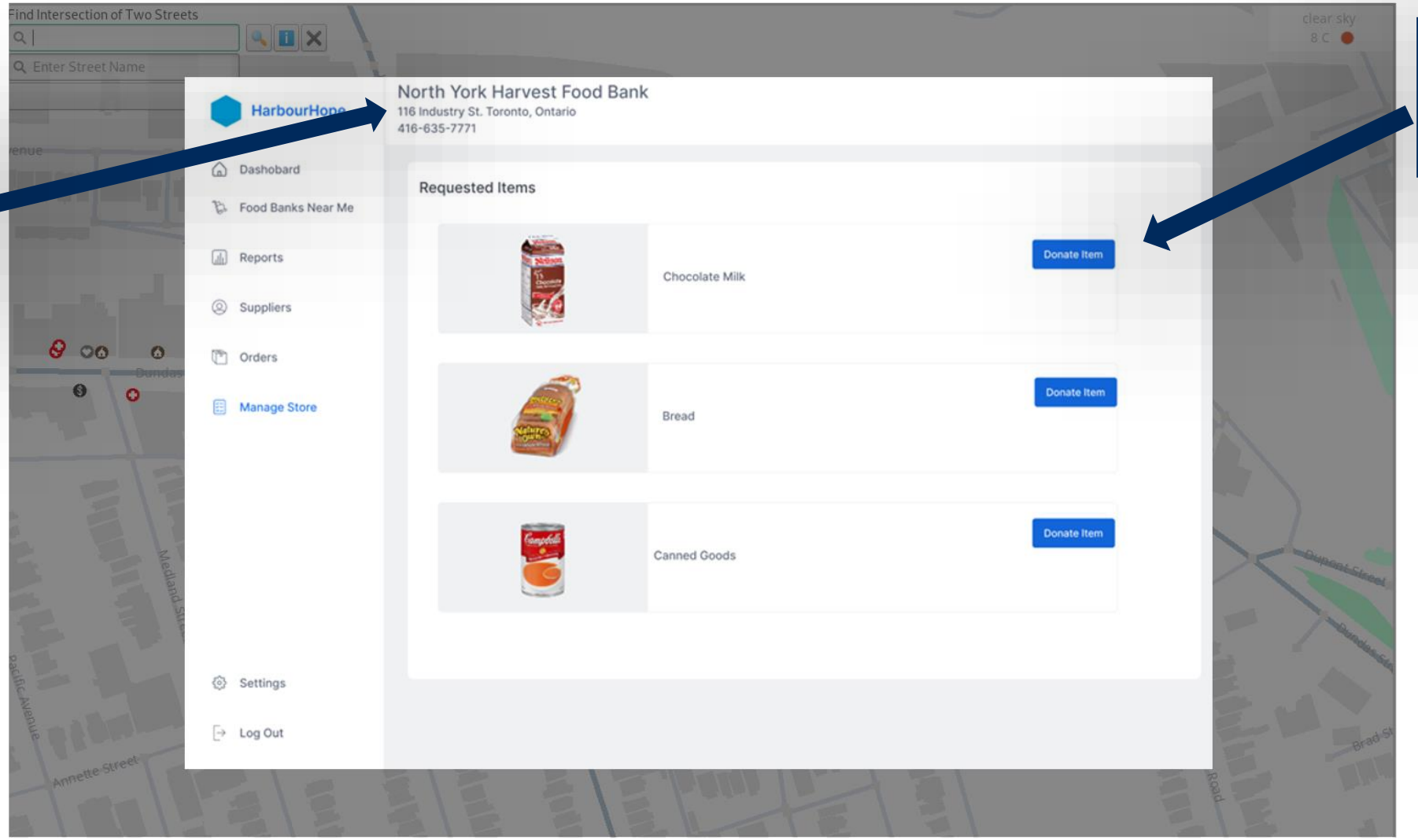
HarbourHope Clearly Displays the Location of Food Banks



Clicking on a food bank shows additional info

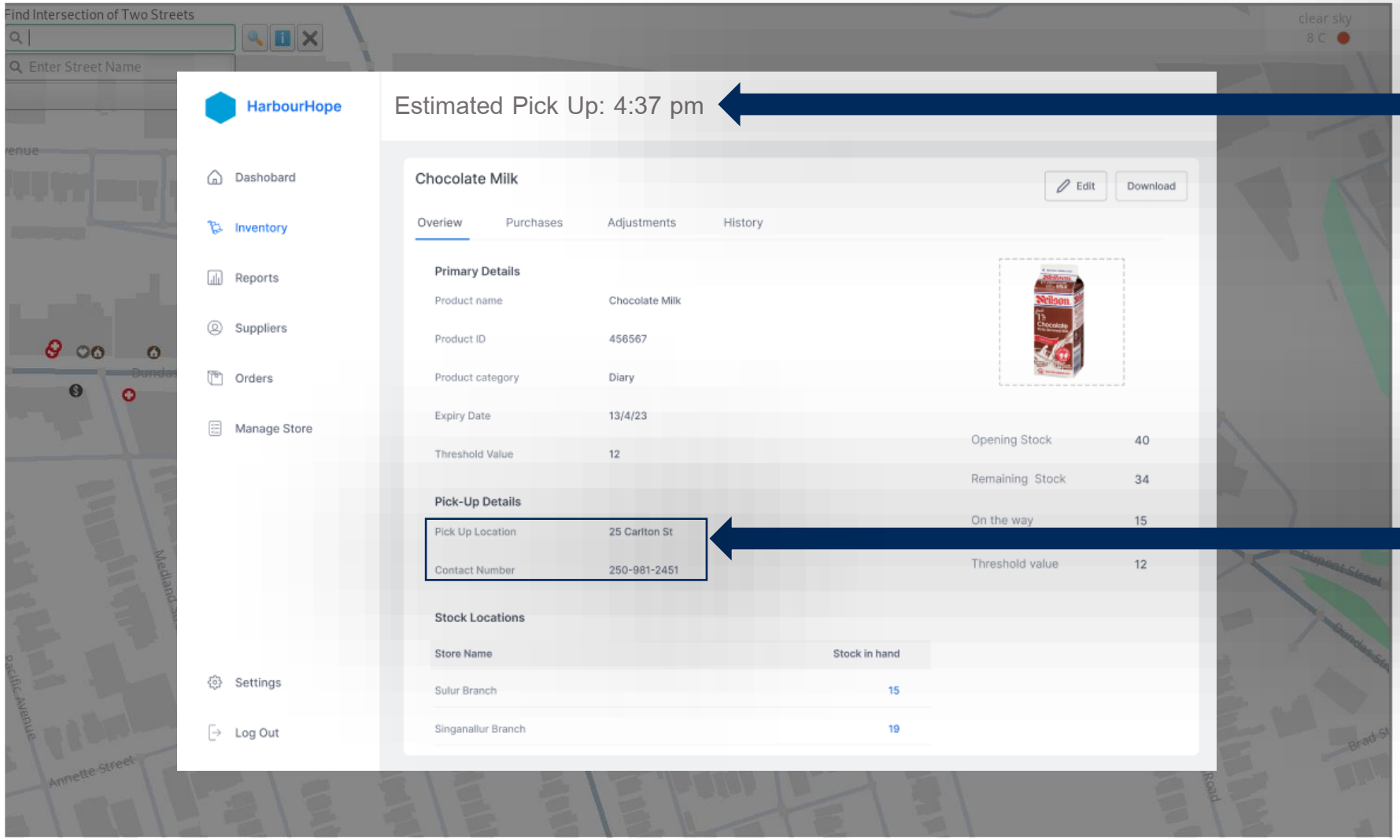
Clicking On A Food Bank Shows What Products They Need

Food bank info shown at the top



Clicking on Donate will show a new prompt

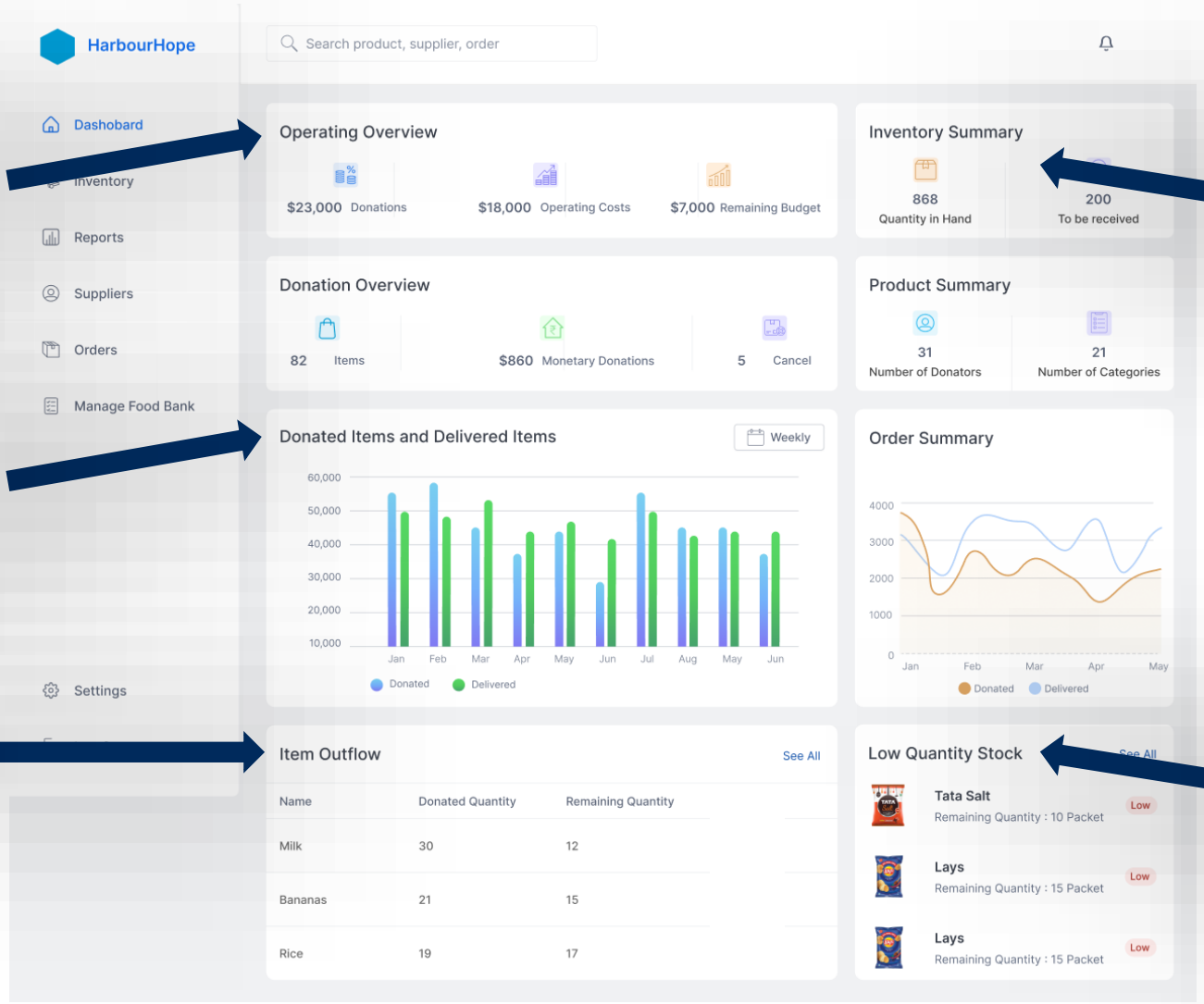
Donators Can Enter Their Address and Contact Number For Pick Up



Estimated Pick Up Time Shown

User can enter pick up address

Food Bank Dashboard Shows Vital Operating Information



Monthly Operating Expenses

Donation History

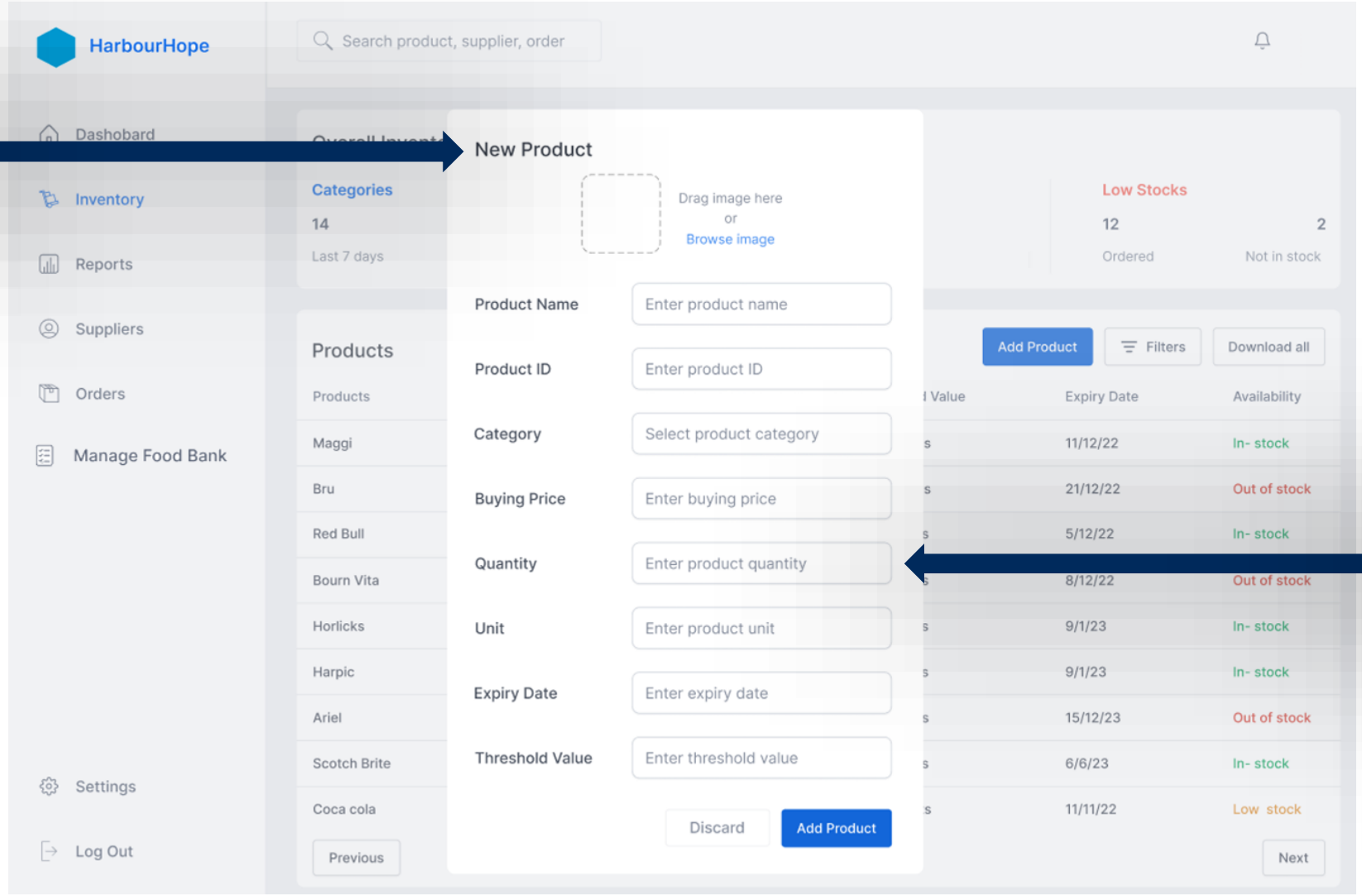
Most Recently Donated Items

Inventory Summary

Low Stock Items

Food Banks Can Enter What Products They Need

Request New Donations



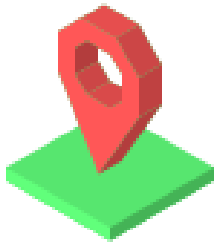
Request # of Items

Food Banks Can Track Delivery Status

https://project-osrm.org/

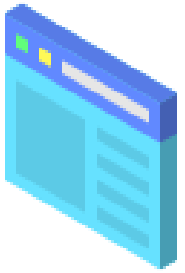
HarbourHope Connects an Easy-to-Use GIS Application to the Internet to Increase Food Bank Efficiency [13]

- General UI, live data reporting, and shortest path finding functionality make HarbourHope efficient.
- Food bank management platform and cloud storage provide convenient methods to donate.
- Offers an easy, at home donation process



Intuitive GIS

+



Online Management Platform

= HarbourHope

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CPU CORES EXECUTE CODE SERIALLY

- Single threaded programs can only execute 1 instruction at a time