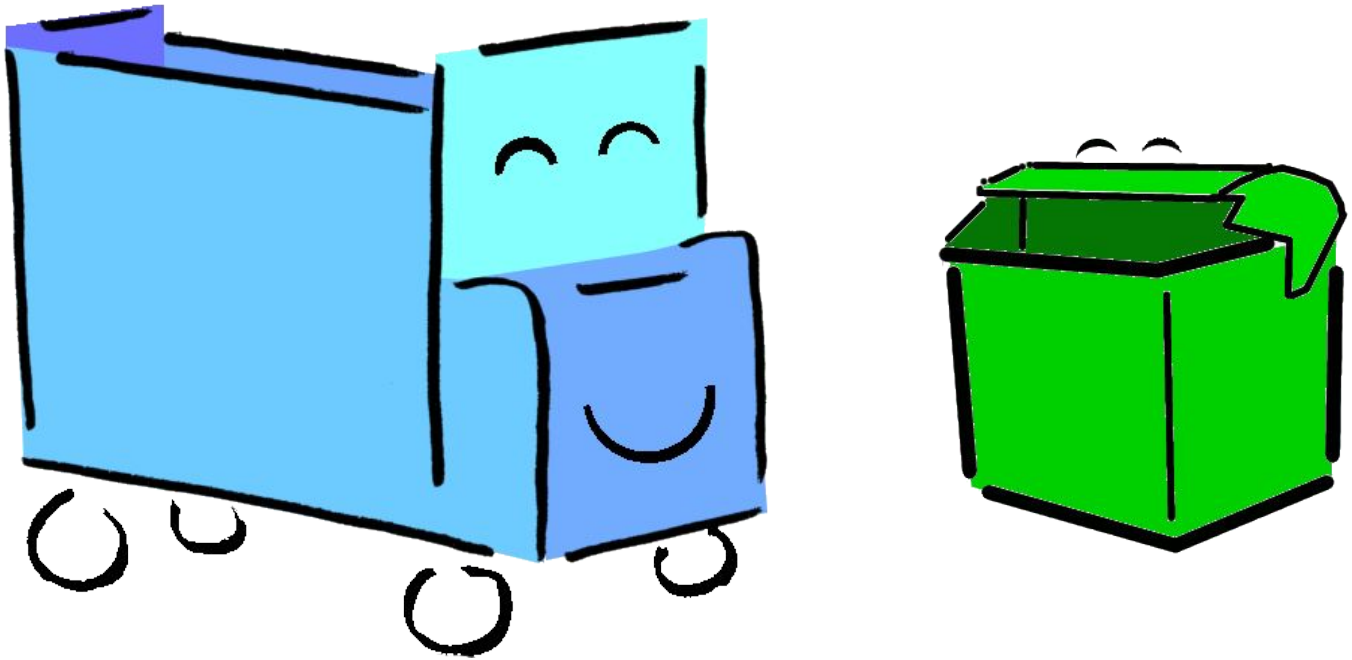


Garbage Collection with FOSS4G

Vicky Vergara / Daniel Kastl

This Old Earth

"This old earth
Needs our help
To stay fresh and clean and green
With a pick it up; pitch it in; and throw it in the can--
This old earth needs a helping hand!"

www.canteach.ca

Celia Virginia Vergara Castillo

- Economist, Computer Scientist
- Work in Georepublic
- pgRouting developer
- Living in Mexico
- Known as Vicky

Please, enjoy FOSS4G Bonn!!!

The Problem

Sustainable City → Waste output → Garbage Collection

Using FOSS4G tools

Montevideo City

Backend Developers

Vicky Vergara

Steve Woodbridge

pgRouting developers

Sustainable City

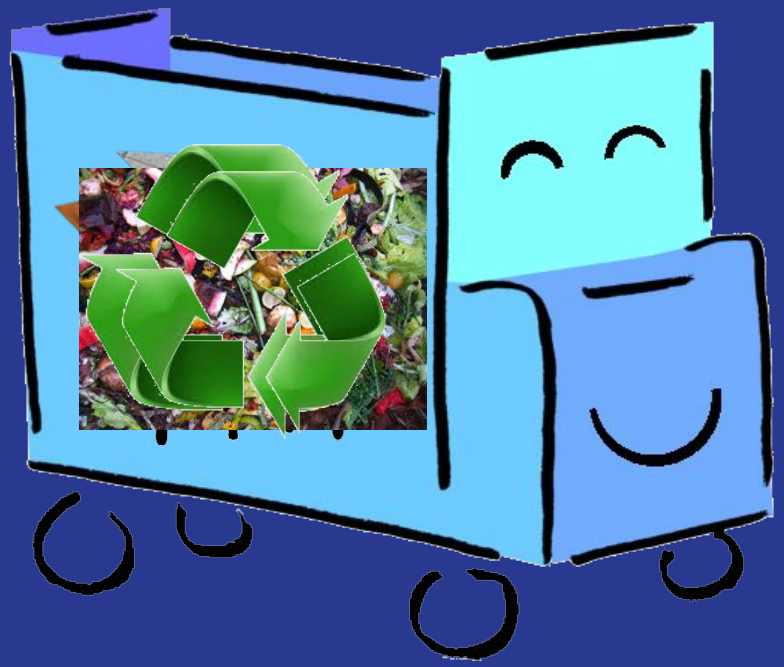
Consideration of environmental impact

Minimization of

- Required inputs of energy
- Waste output
- Pollution

Waste Output

- Household waste
- Industry waste
- Dry waste
- Wet waste (organic)
- Recyclable waste



Garbage Collection

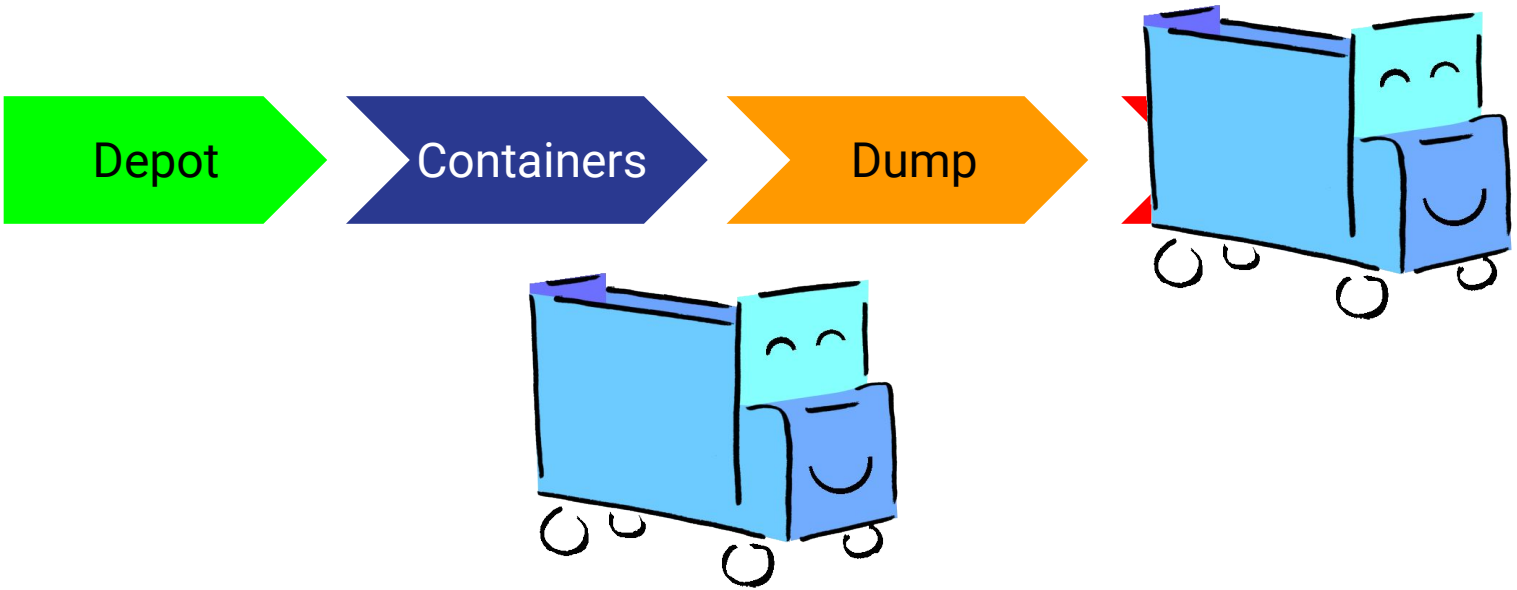
VRP

Vehicle

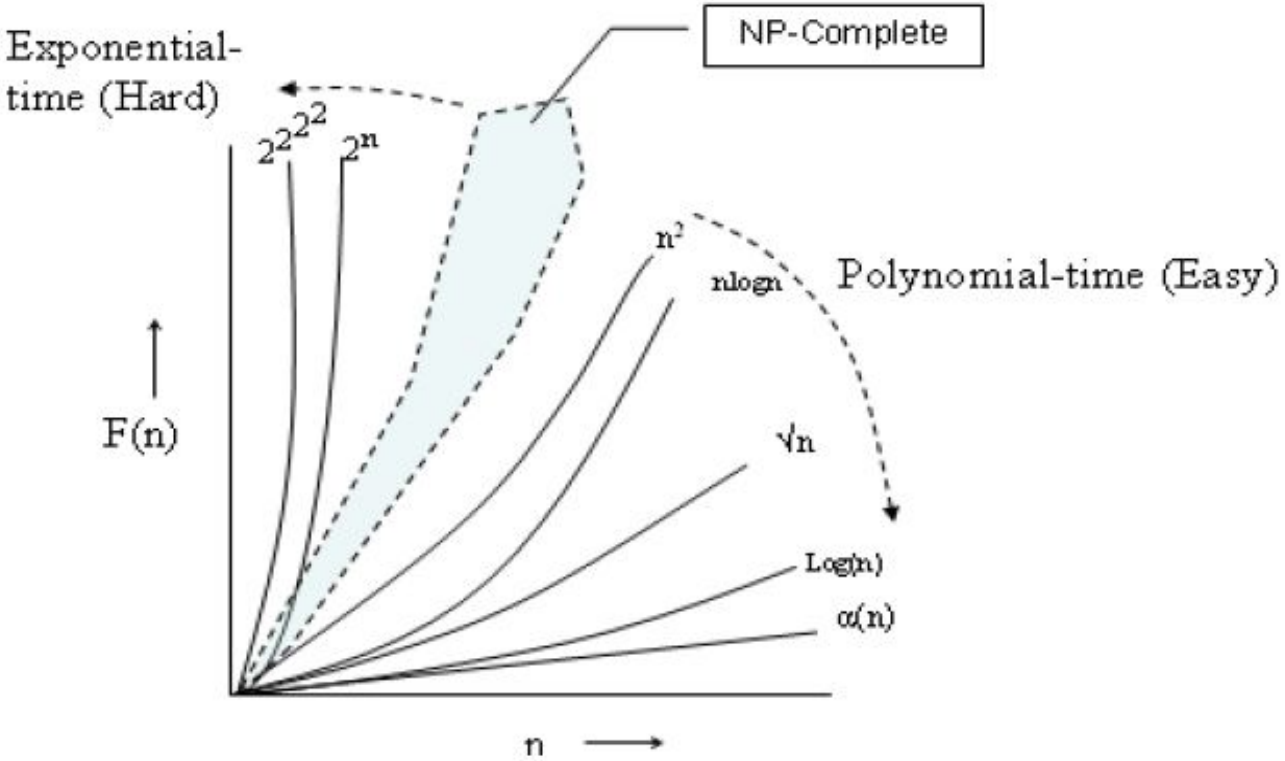
Routing

Problem

VRP simple Truck’s trip



NP Problem:


NP-Complete
Exponential-time (Hard)
$2^{2^{2^2}}$
2^n
n^2
nlogn
Polynomial-time (Easy)
F(n)
$\sqrt{n}$
Log(n)
α(n)
n

VRP: variants

CVRP

C = capacity

The vehicles have limited carrying capacity.

VRPMT

M = Multiple T = trips

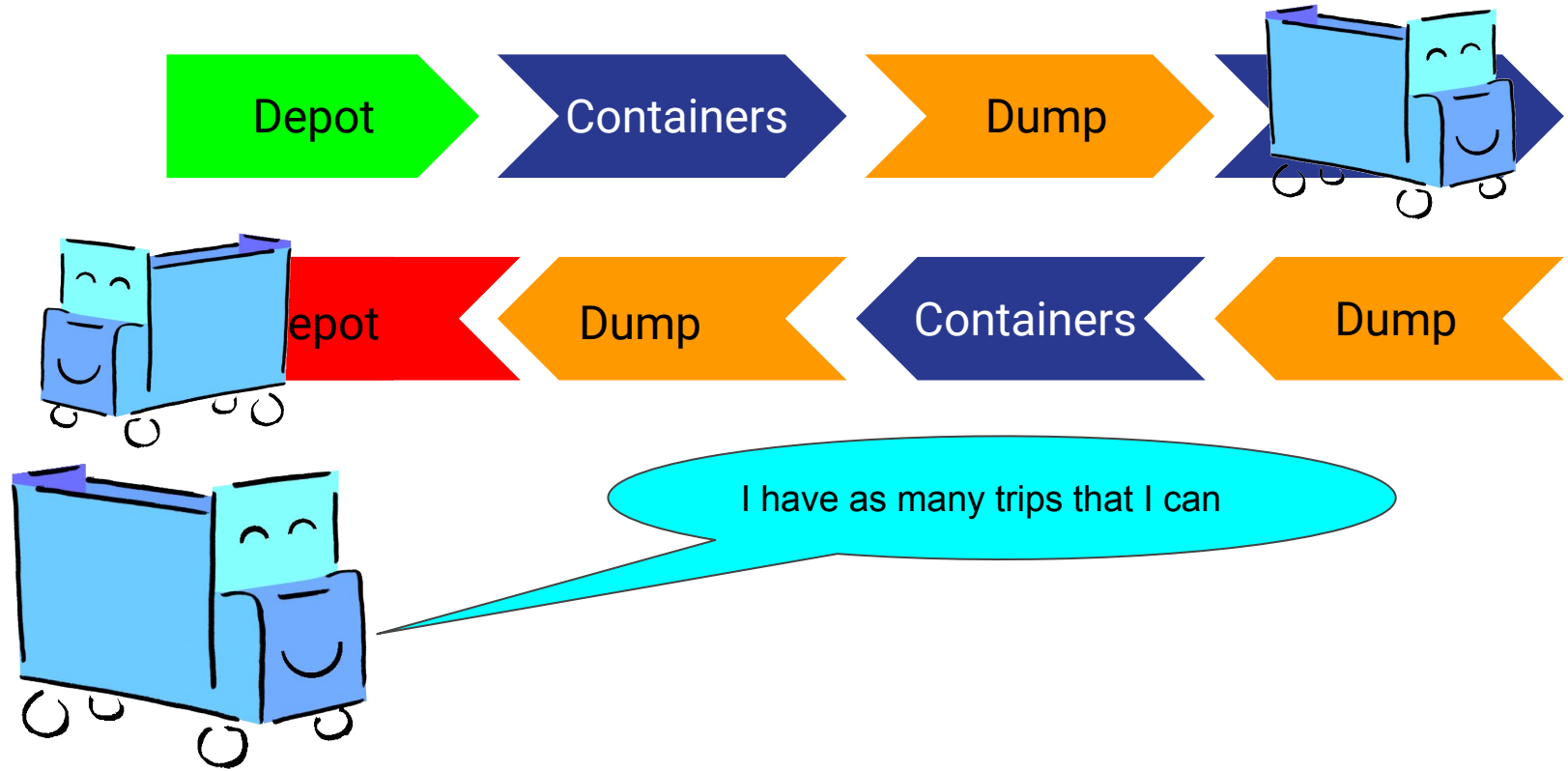
The vehicles can do more than one route.

VRPTW

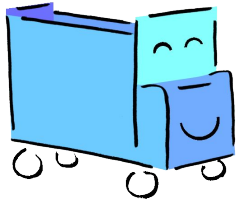
T = time W = windows

The locations have time windows within which visits must be made.

Garbage Collection Truck Trip



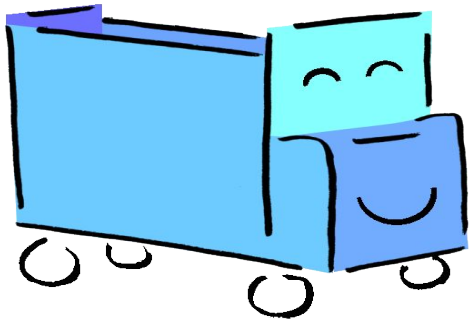
Truck with different capacity



Depot → Containers → Dump

Dump → Containers

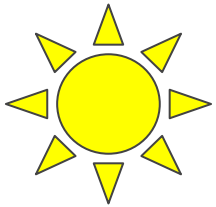
Containers → Dump → Depot

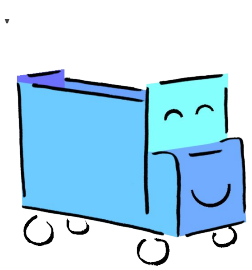


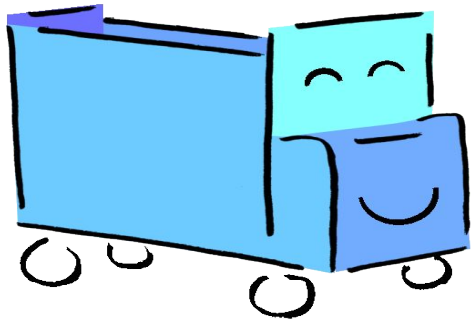
Depot → Containers → Dump

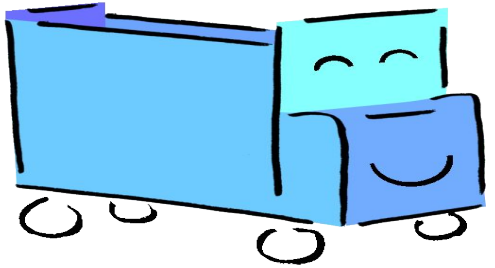
Depot → Dump → Containers

Truck Drivers With Different Schedules









VRP variants on Garbage collection

Is a CVRP ?

YES!!!

The vehicles have limited carrying capacity.

Is a VRPMT?

YES!!!

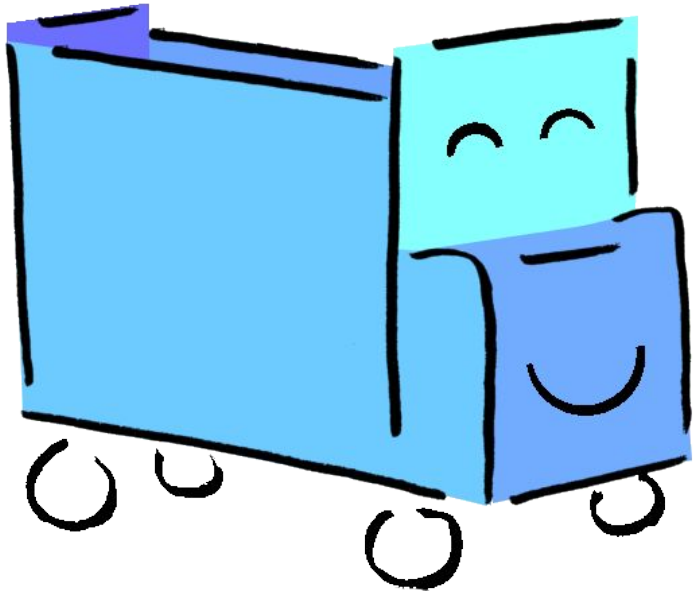
The vehicles can do more than one route.

VRPTW

YES!!!

The locations have time windows within visits must be made.

CVRPTWMT

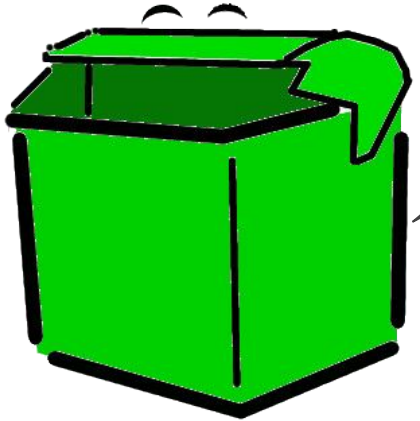


Garbage Collection:

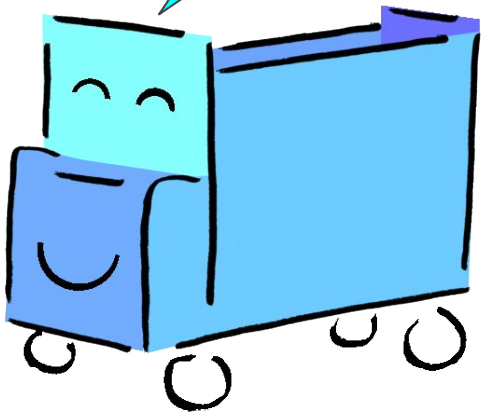
Is a Capacitated Vehicle Routing Problem with Time Windows and Multiple Trips

More Restrictions

I am in a street market



I am on the right side of the street



Can not make U turns

I pick up from the left side.

More Restrictions

Municipalities

A truck that picks from one municipality, can not pick from another. Exception: trucks that pick up hospitals biomedical waste.

Waste - Truck relationship

For some types of waste there are special types of trucks

Container - Truck relationship

For some types of containers there are special types of trucks

More Restrictions

Access Restriction

A truck can not access areas within a certain times.

Speed Limit

The average speed limit can change depending on the time of the day.

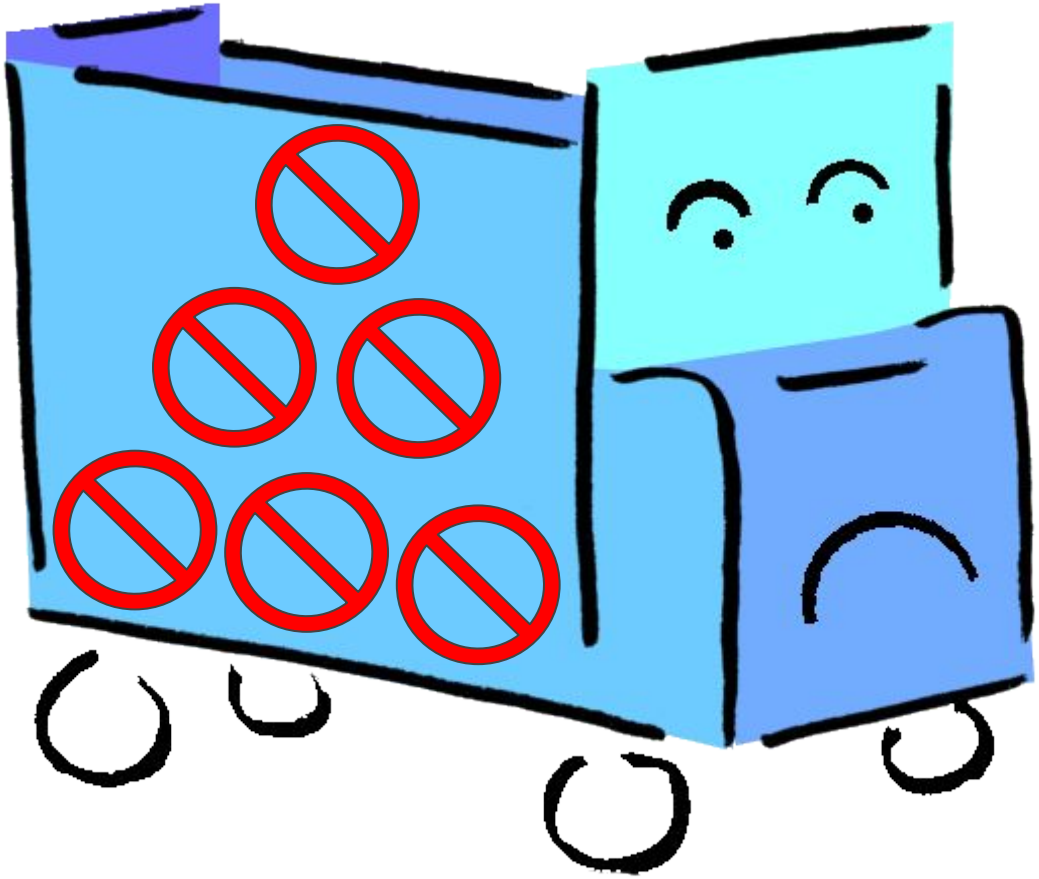
Turns restrictions

A truck can not make a U turn.

Restrictions classification

- Global restrictions:
  - Containers within Municipalities
  - Trucks for Municipalities
  - Containers across Municipalities
    - Medical waste

- Detailed restrictions:
  - Capacity
  - Right/left side pickup
  - Speed



Approach

FRONTEND

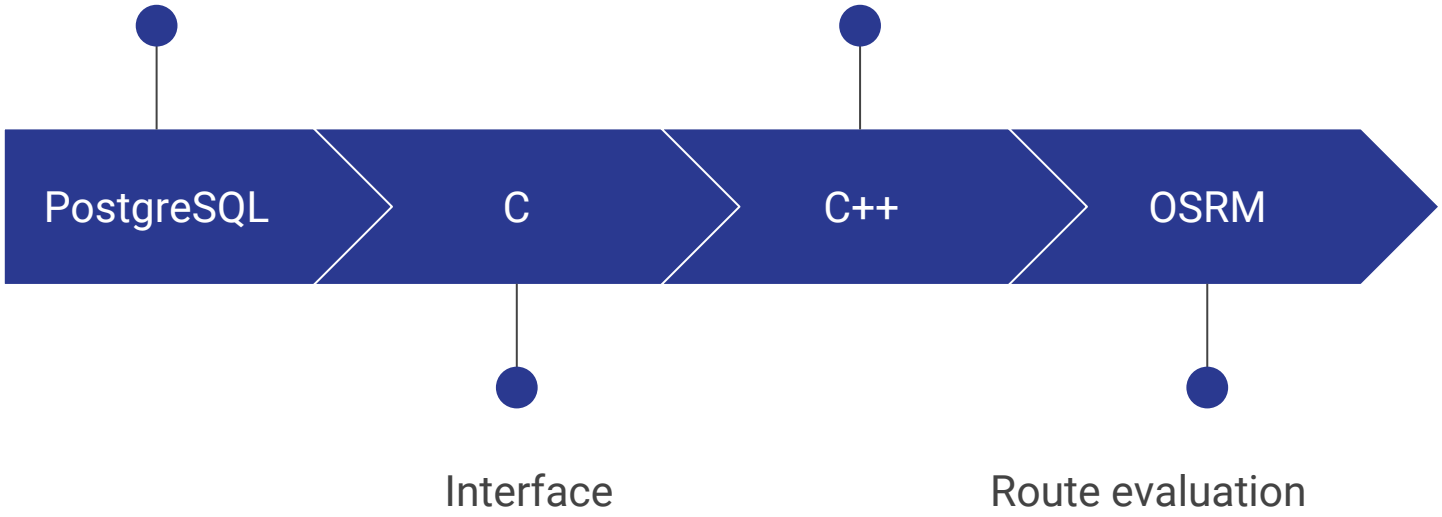
- OSM: Map
- Be able to:
  - Select Containers
  - Select Trucks
  - Select Depot and Dump sites
- Query the Database
- Display results:
  - Route on a map
  - Projected timings
- Global Restrictions handling

Note: The front end is not the focus of this presentation

BACKEND

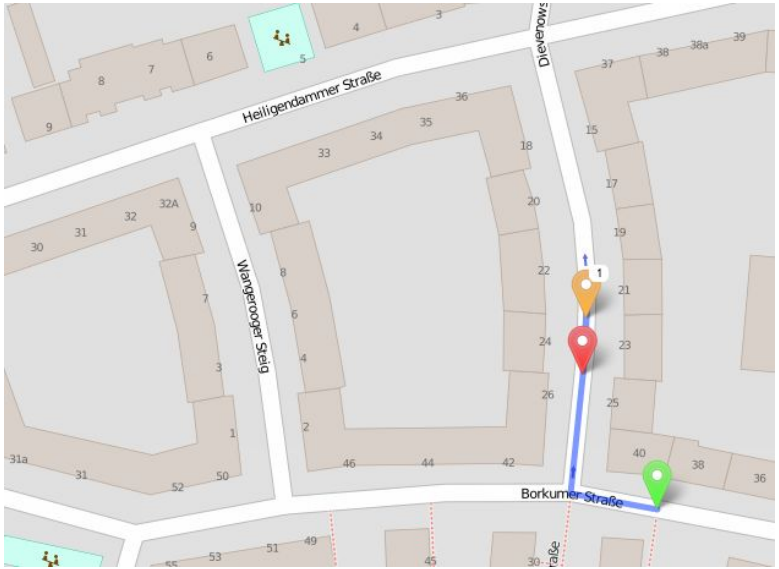
- Trucks
- Containers
- Locations

- Initial Solution
- Tabu Search
- Detail restriction handling



OSRM

- Version 0.3.3
- Instead of calling using web api:
  - a C++ interface class
  - Increased performance
- Difficult to maintain a travel time matrix.
  - Strange loops
  - Strange routes



Almost ... Tabu Search

- Shake operation is done by having
  - 7 different initial solutions.
- Optimize
  - Trip ordering
  - Minimize cost

```
...
case 1:
      insertBestPairInCleanTrip(trip);
      insertBigSubPathAtBegin(trip);
      break;
...
```

The Cost Function

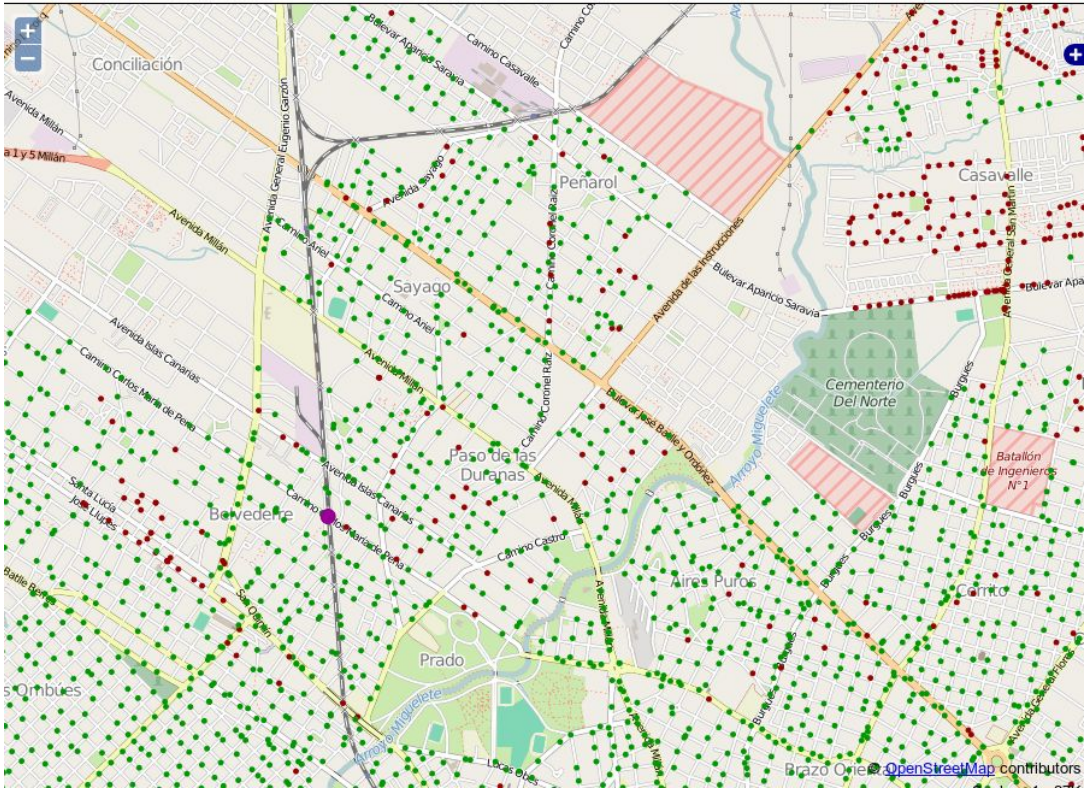
- Integrate theory with reality
  - Deep mathematical analysis
  - Reflect the analysis within the code

```
 //estimated:
  // forcedWaitTime > 0: truck finishes duties before the shift ends
  // forcedWaitTime < 0: truck finishes duties after the shift ends
  // For this problem: serviceE == 0
  // From the point of view of the truck the endingSite closes at end of
shift
  // therefore the expected value is positive otherwise a time violation
exists
  // at the ending site
  forcedWaitTime = endTime - (arrivalEclosesLast(C)  +  serviceE());
```

Code snippet taken from:
https://github.com/woodbri/vehicle-routing-problems/blob/montevideo-release-v4/src/trash-prob/trashWithMovingDumps/solverTrash/costvehicle.cpp#L104

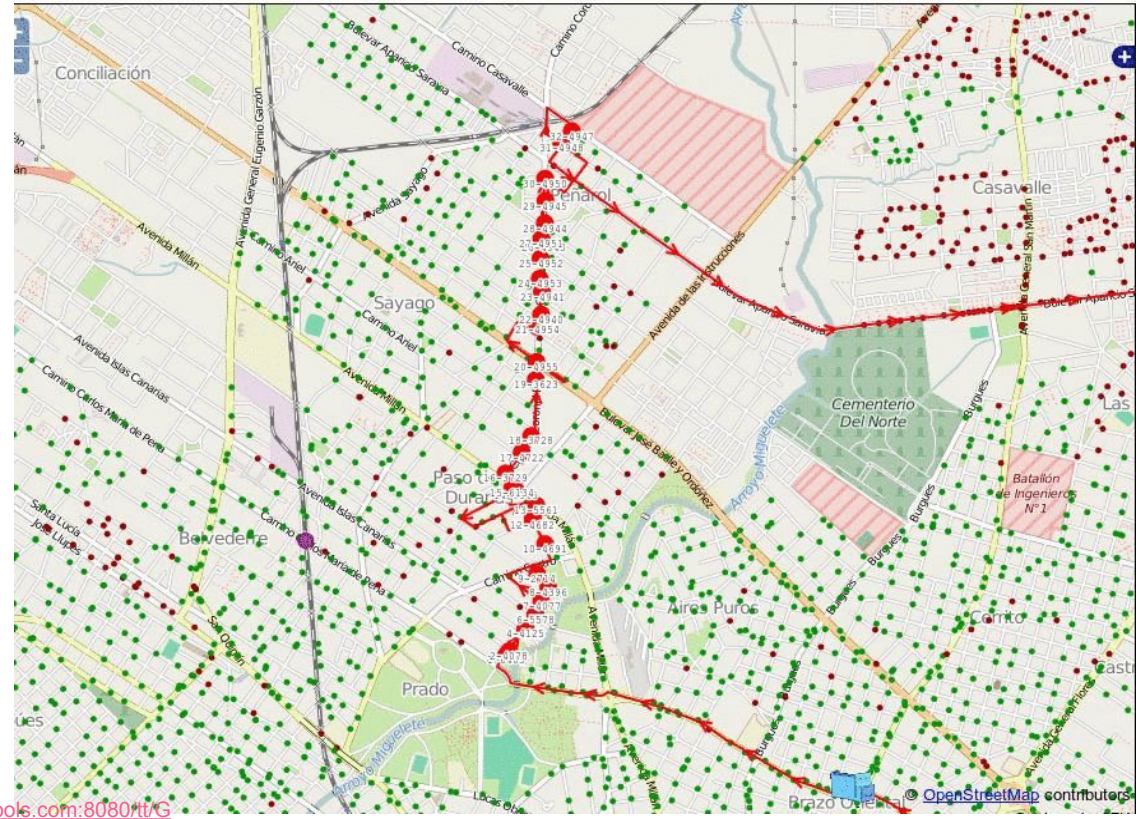
A preview

Containers



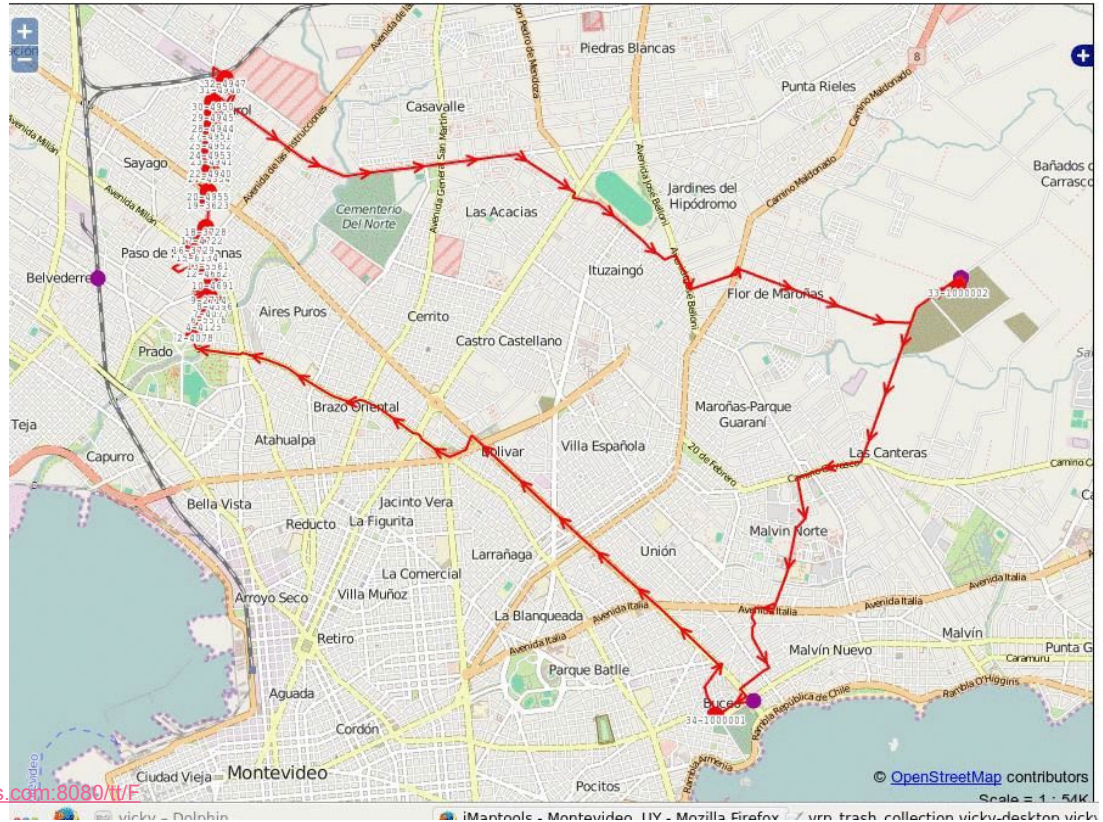
Conciliación
Avenida Millán
Avenida General Eugenio Garzón
Bulevar Aparicio Saravia
Camino Casavalle
Peñarol
Casavalle
Avenida Sayago
Camino Ariel
Sayago
Avenida de las Instrucciones
Bulevar Aparicio Saravia
Avenida Islas Canarias
Camino Carlos María de Pena
Cementerio Del Norte
Arroyo Miguelete
Paso de las Duranas
Bulevar José Batlle y Ordóñez
Batallón de Ingenieros N°1
Santa Lucía
José Llupes
Belvedere
Camino Castro
Aires Puros
Cerrito
Prado
Arroyo Miguelete
Locas Obes
Brazo Oriental
© OpenStreetMap contributors

insertBestPairInCleanTrip



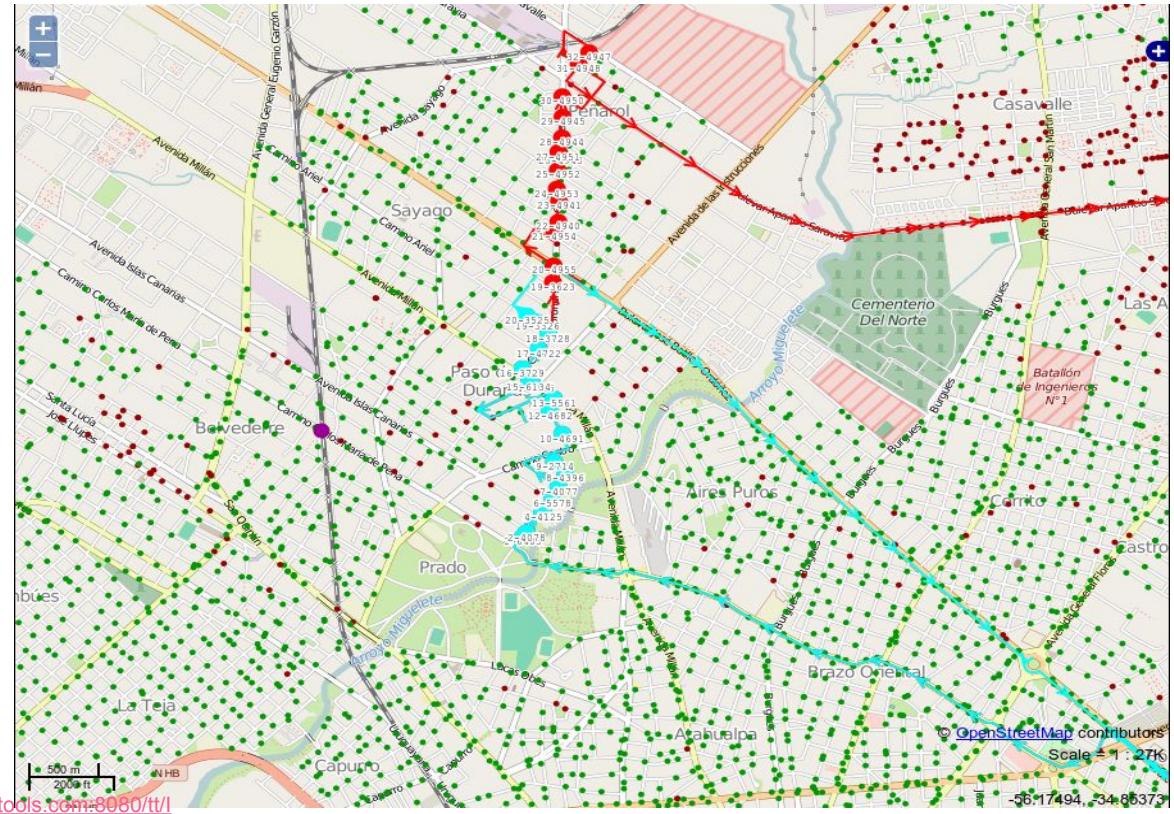
Link to animation: http://imaptools.com:8080/tt/G

The complete Route



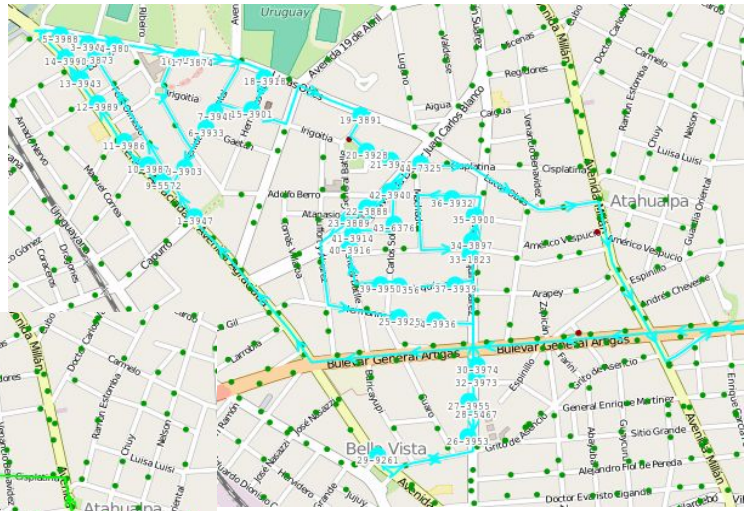
Link to animation:http://imaptools.com:8080/tt/F

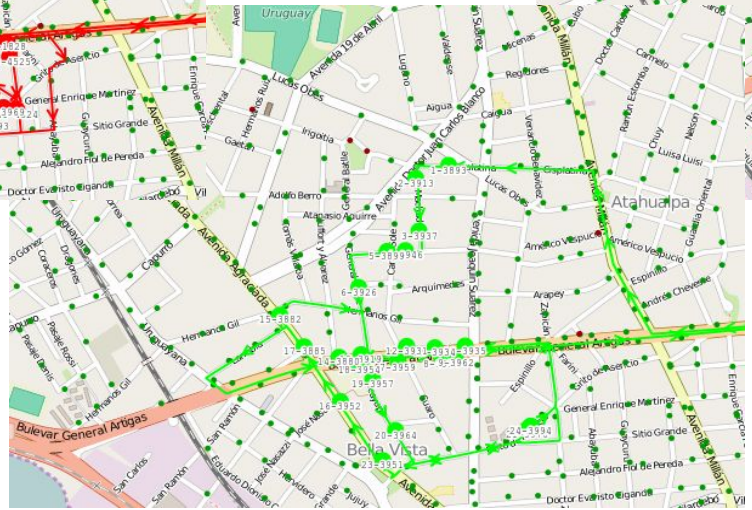
insertBigSubPathAtBegin



Link to animation:http://imaptools.com:8080/tt/l

Truck With 3 Trips





V1 [45.75 min.], npts: 46

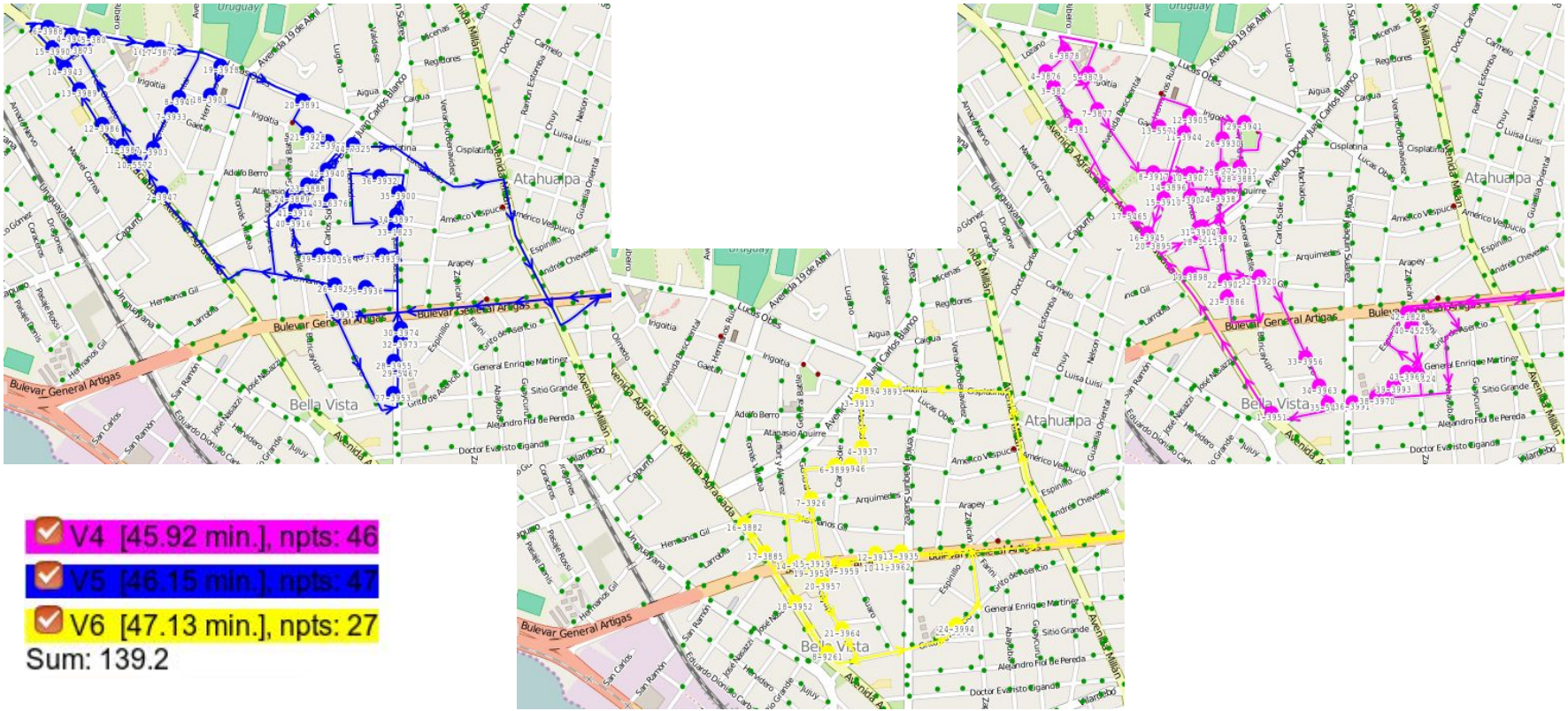
V2 [49.08 min.], npts: 47

V3 [50.33 min.], npts: 27

Sum: 145.16

Link to animation: http://imaptools.com:8080/tt/J

Optimized Truck With 3 Trips



Link to animation:http://imaptools.com:8080/tt/J

What’s next

Code

- Many ideas were coded and discarded.
  - There is a lot of unused code.
- Upgrade to be used with OSRM 5.3
  - Under development
- Migrate the code to C++14
  - Originaly coded with C++98
  - Currently OSRM use C++14
- Improve the function library
- Develop an open Frontend

Side effects

Incorporated some ideas into pgRouting

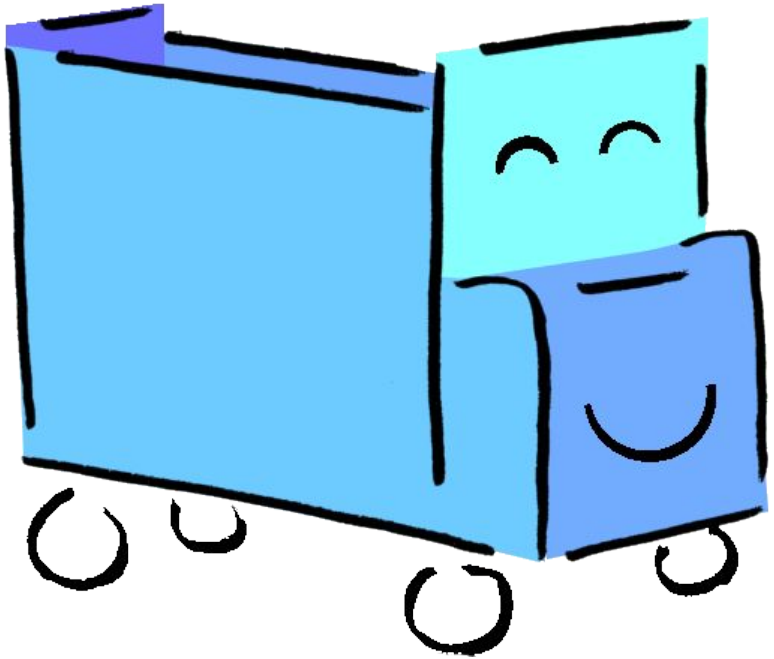
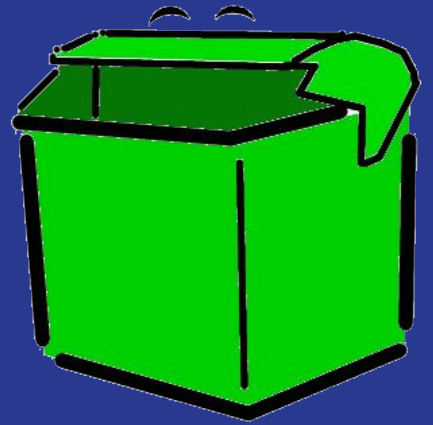
- With Points family of functions
  - Pass in front and visit concepts
  - Left /right driving sides
  - http://docs.pgrouting.org/2.2/en/src/withPoints/doc/withPoints.html#withpoints

Lessons learned

- OSM data
  - Evaluation with OSRM
    - Own storage
  - PostgreSQL (one place have it all)
    - Storage for front end
    - Storage of the problems data
    - Evaluation can be done with other tools like pgRouting

Theory

- NP problems.
- Exponential growth on time execution
- High level abstraction
  - Not many restrictions
- Euclidean approximations
  - Not good for real problems.

Reality

- They are NP problems
- User wants small execution times
- User has many restrictions
  - Restrictions might change between users
- Implied restrictions on a city graph.