Practical considerations over routing algorithms

Agata Migalska

DevBreak‘19
Château du Vivier, 13-14.06.2019

About me

- ~12 years in software engineering
- Co-founder of a startup
  in optimization and automation
  in architecture and real estate
- PhD in Computer Science
  in statistical image processing
- Currently working as a Data Engineer

@onomatopeia6

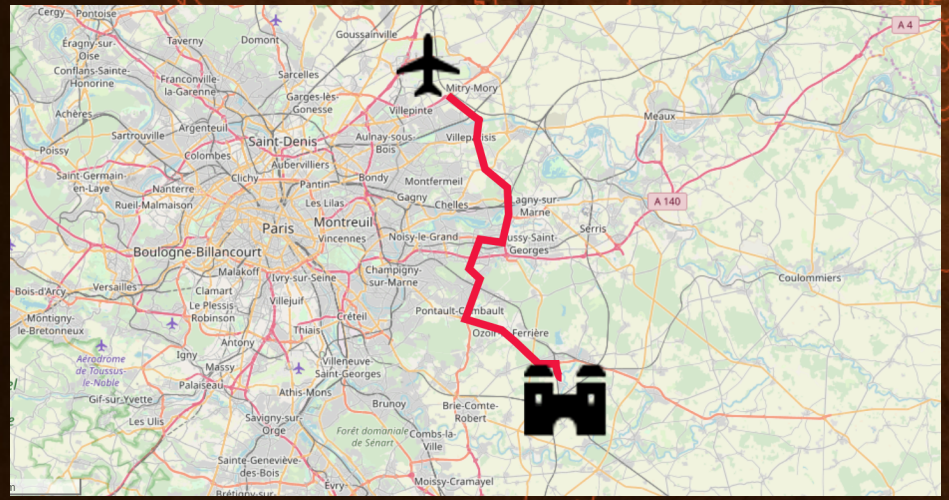
https://github.com/onomatopeia/devbreak19

Geospatial Data

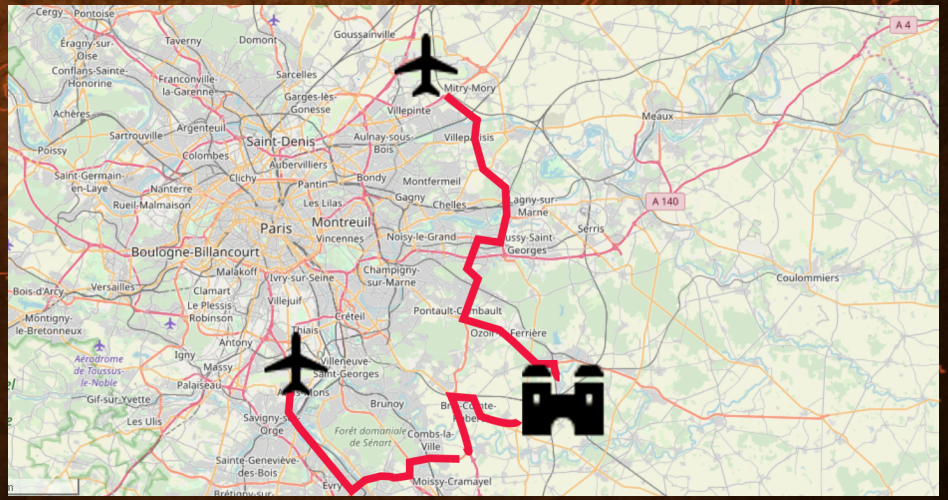
- Applications
  - Commuting
  - Travels planning
  - Leisure planning
  - Property / location valuation
- Incentives
  - Multitude of applications
  - Data availability
  - Computational power at hand

Typical Use Cases

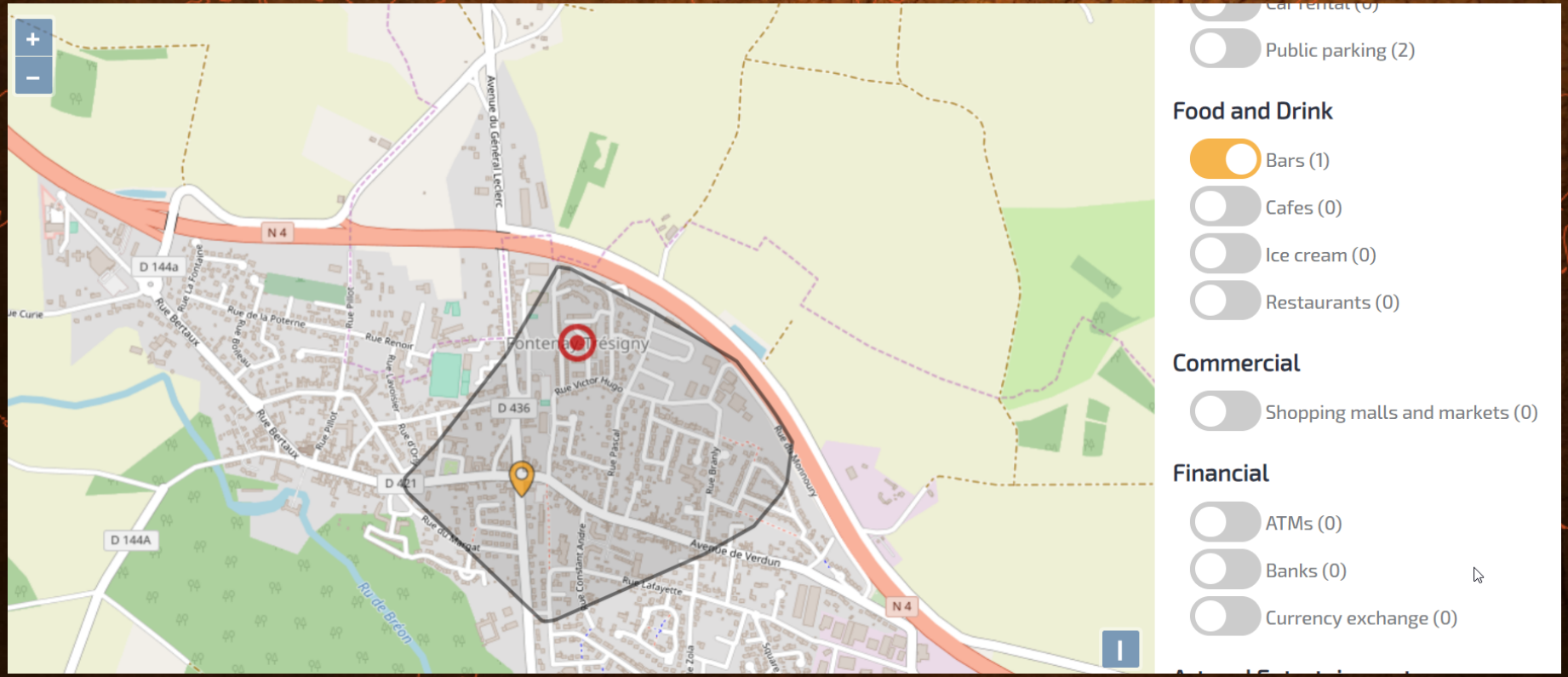
- Finding the route to the CDG Airport (destination) from the Château du Vivier (source)



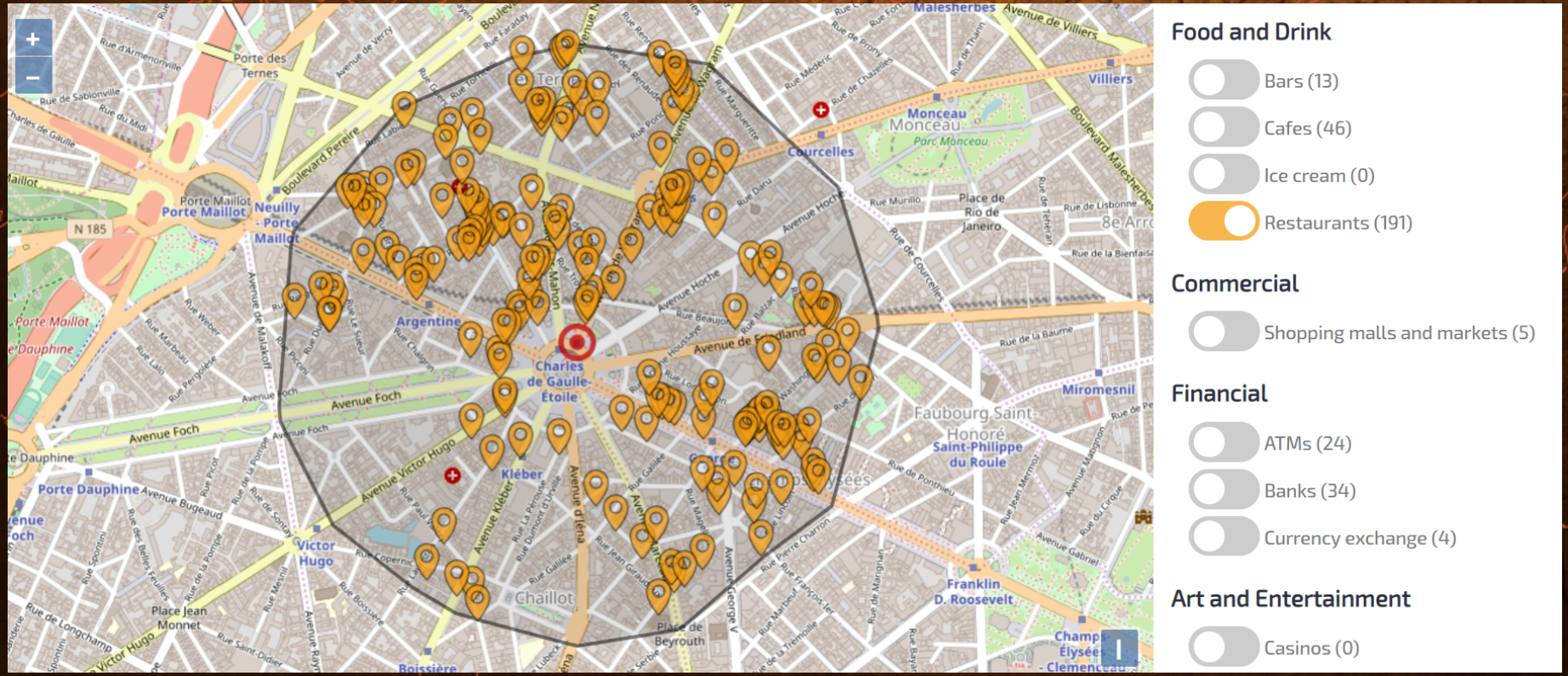
- Finding the closest airport (multiple destinations) to the Château du Vivier (source)



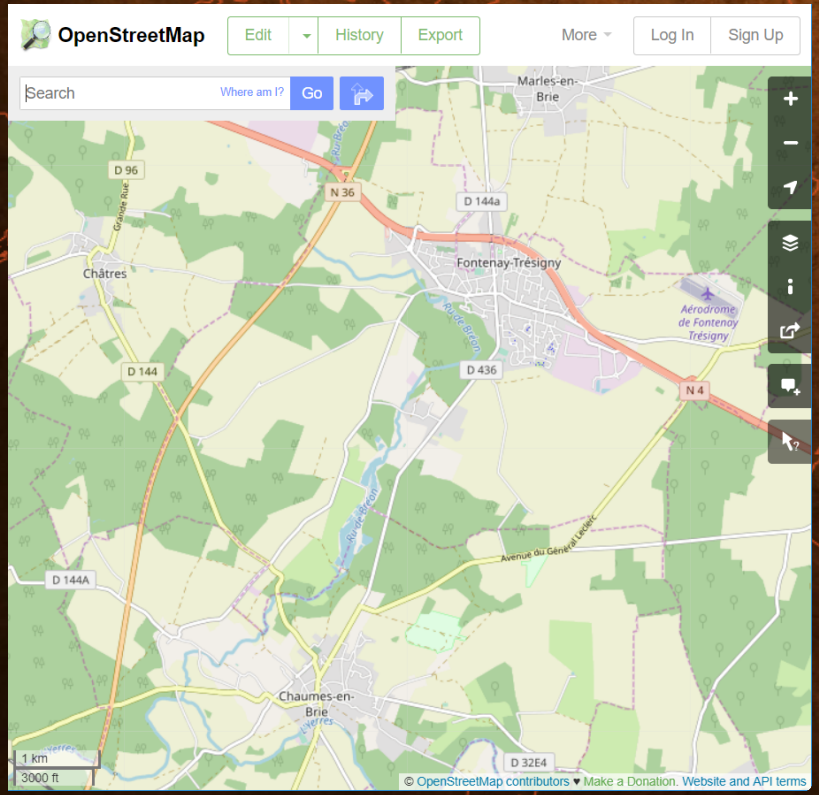
My use case – from 1 bar ...



… to 191 restaurants



OpenStreetMap.org



- Collaborative project to create a free editable map of the world
- Over two million registered users
- Favourably compared with proprietary datasources (Zielstra 2012)

Nodes, Ways and Relations

Node

- Shop, bus stop, mountain peak

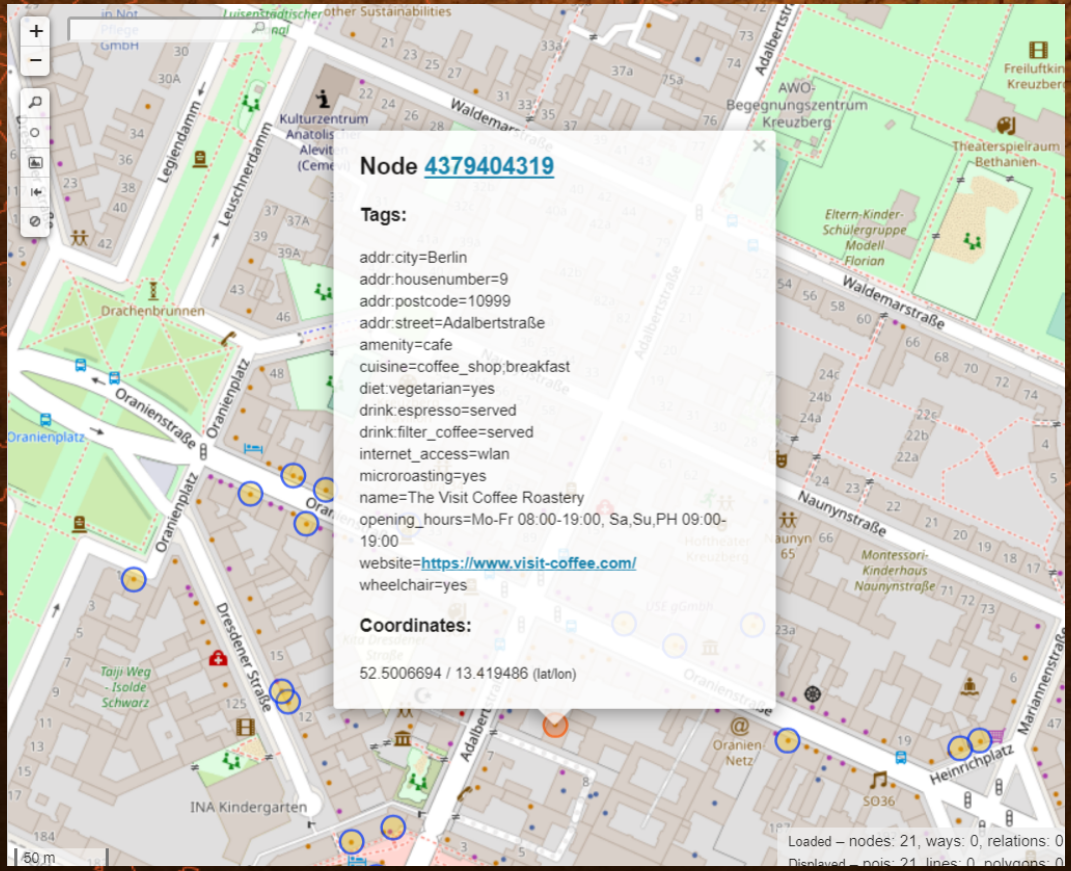
Way

- Footpath
- Roundabout
- Building outline

Relation

- University campus
- Bus route

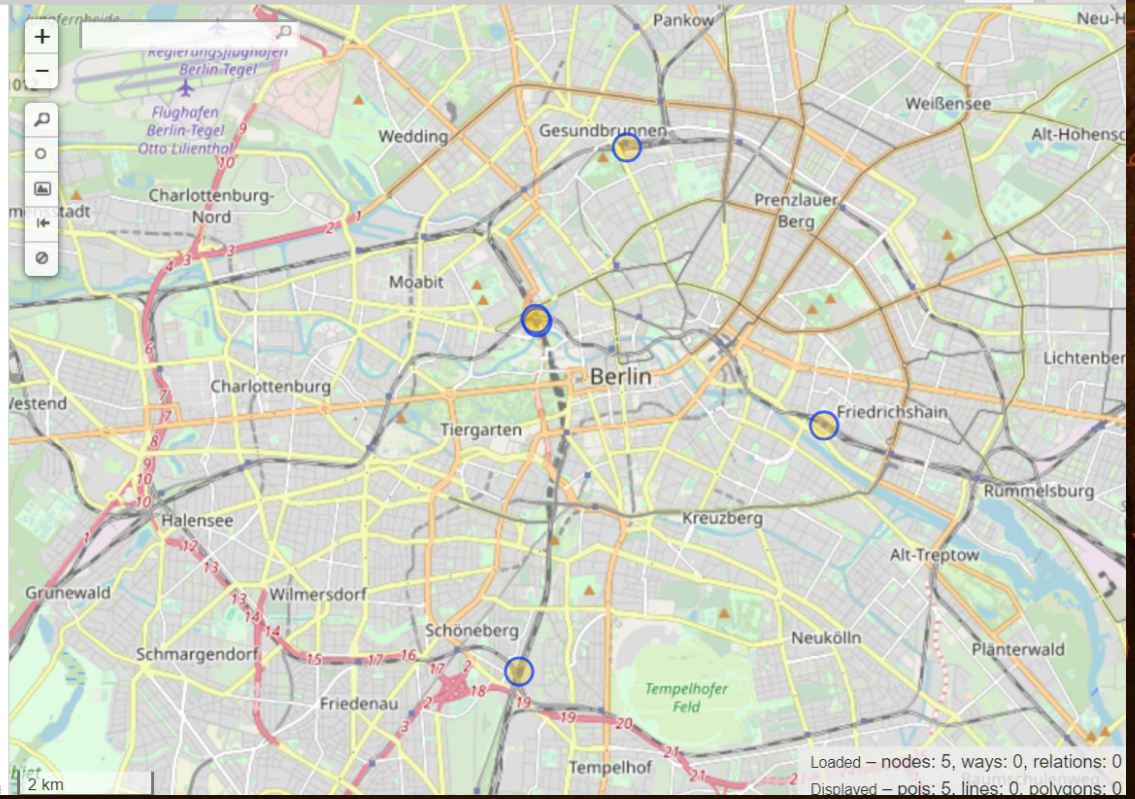
Nodes


Node 4379404319
Tags:
addr:city=Berlin
addr:housenumber=9
addr:postcode=10999
addr:street=Adalbertstraße
amenity=cafe
cuisine=coffee_shop;breakfast
diet:vegetarian=yes
drink:espresso=served
drink:filter_coffee=served
internet_access=wlan
microroasting=yes
name=The Visit Coffee Roastery
opening_hours=Mo-Fr 08:00-19:00, Sa,Su,PH 09:00-19:00
website=https://www.visit-coffee.com/
wheelchair=yes
Coordinates:
52.5006694 / 13.419486 (lat/lon)
Oranienstraße
Oranienplatz
Waldemarstraße
Naunynstraße
Dresdener Straße
Adalbertstraße
Heinrichplatz
Drachenbrunnen
INA Kindergarten
Montessori-Kinderhaus Naunynstraße
Eltern-Kinder-Schülergruppe Modell Florian
AWO Begegnungszentrum Kreuzberg
Loaded – nodes: 21, ways: 0, relations: 0
50 m

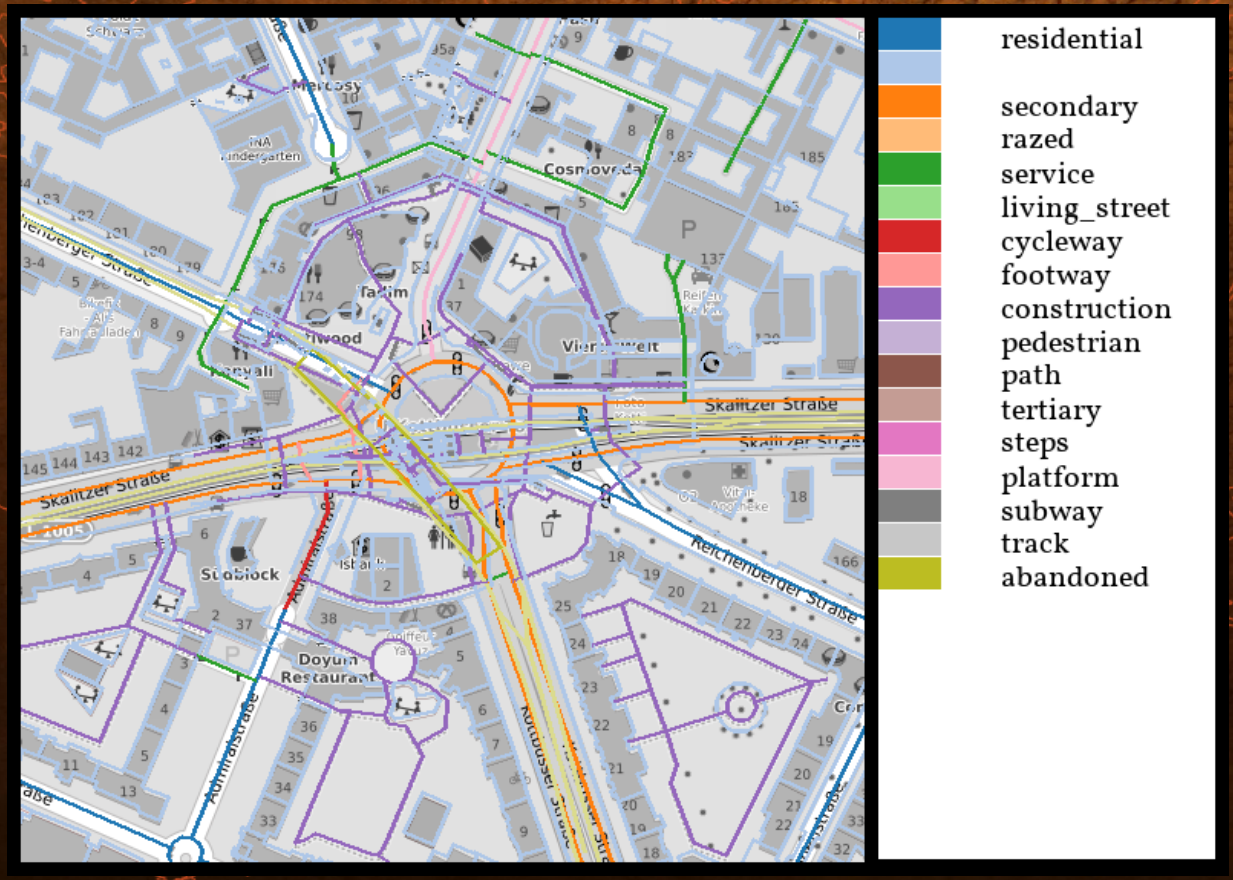
Nodes

Run | Share | Export | Wizard | Save | Load | Logout | Settings | Help | overpass turbo | Map | Data

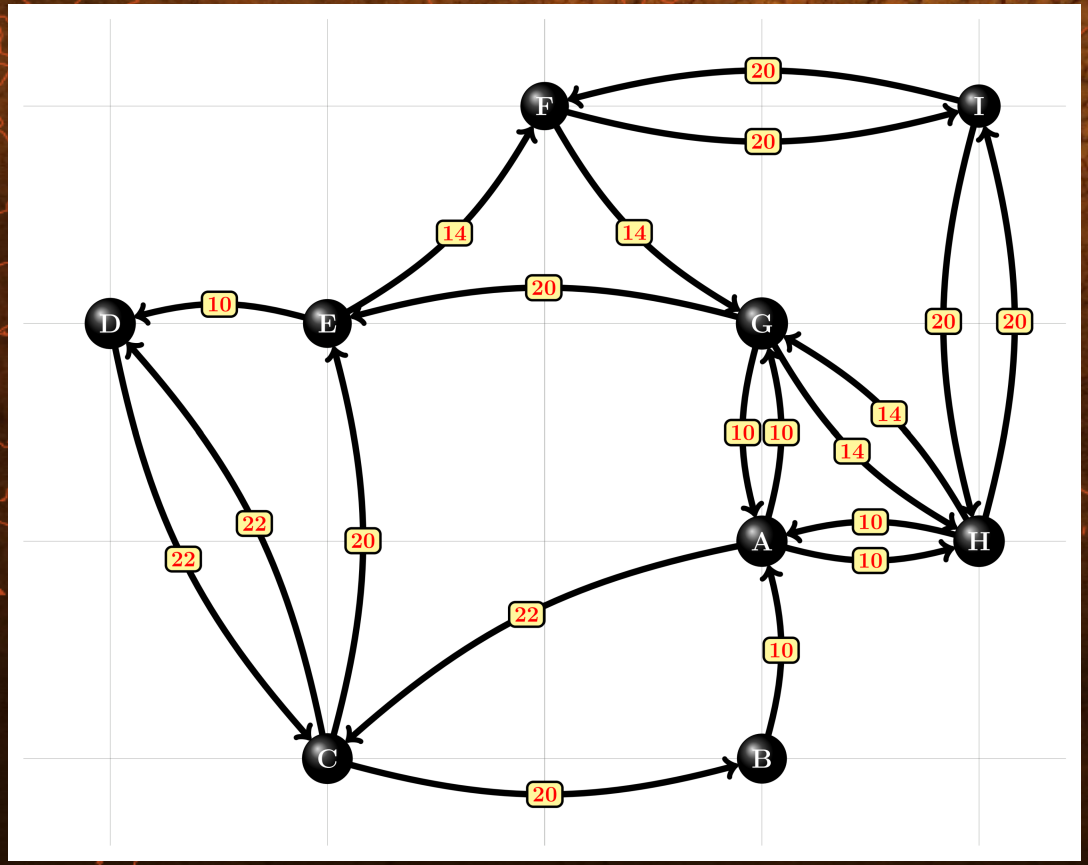
```
(((node[railway=station][public_transport=station]
[name]({{bbox}});
   - node[railway=station][name][station=subway]
({{bbox}}););
  - node[railway=station][name][subway=yes]({{bbox}});
);
 - node[railway=station][name][station=light_rail]
({{bbox}}); )->.a;

(node[railway=station][name]
[!"railway:station_category"]({{bbox}});
node[railway=station][name]
["railway:station_category"=1]({{bbox}});)->.b;

node.a.b;
out;
```



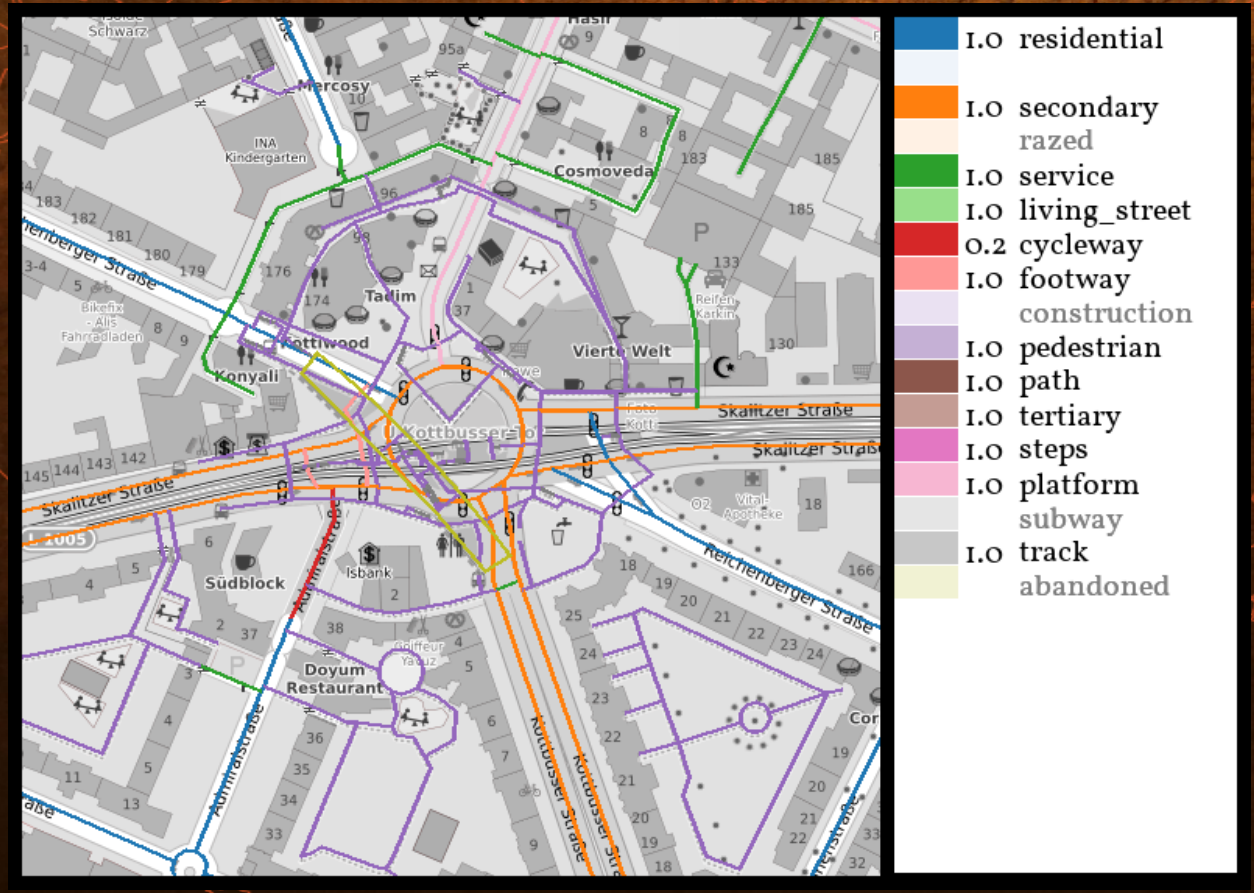
Ways


residential
secondary
razed
service
living_street
cycleway
footway
construction
pedestrian
path
tertiary
steps
platform
subway
track
abandoned
Skalitzer Straße
Admiralstraße
Reichenberger Straße
Doyum Restaurant

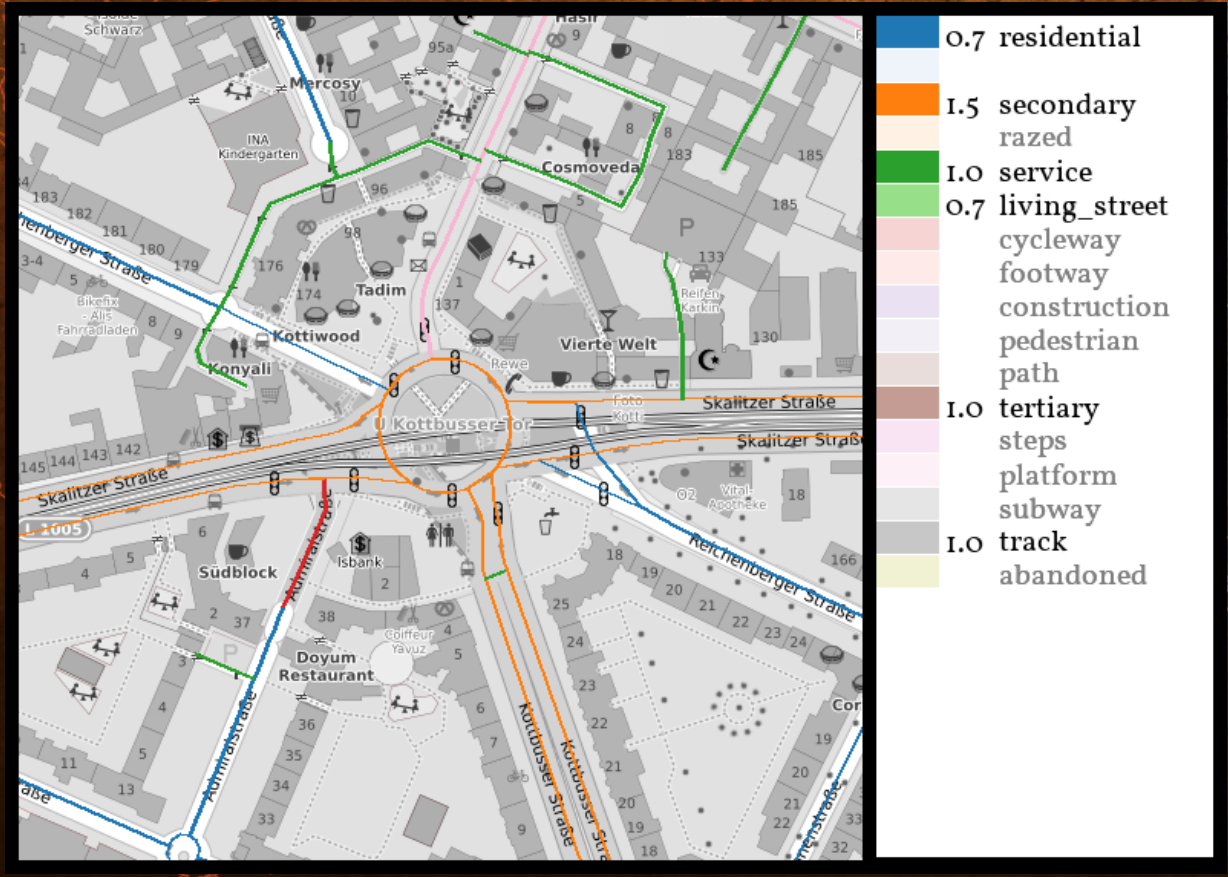
Routing Graph



Walking


Mercosy
INA Kindergarten
Cosmoveda
Tadim
Kottiwood
Konyali
Vierte Welt
Kottbusser Tor
Skalitzer Straße
Reichenberger Straße
Südblock
Isbank
Admiralstraße
Doyum Restaurant
Kottbusser Straße
1.0 residential
1.0 secondary
razed
1.0 service
1.0 living_street
0.2 cycleway
1.0 footway
construction
1.0 pedestrian
1.0 path
1.0 tertiary
1.0 steps
1.0 platform
subway
1.0 track
abandoned

Car


0.7 residential
1.5 secondary
razed
1.0 service
0.7 living_street
cycleway
footway
construction
pedestrian
path
1.0 tertiary
steps
platform
subway
1.0 track
abandoned
Kottbusser Tor
Skalitzer Straße
Reichenberger Straße
Admiralstraße
Kottbusser Straße
Südblock
Doyum Restaurant
Kottiwood
Konyali
Tadim
Cosmoveda
Vierte Welt
Mercosy
Isbank
Rewe

Routing Algorithms

“Dijkstra algorithm would never be used for pathfinding. Using A is a no-brainer [if you can come up with a decent heuristic].”*

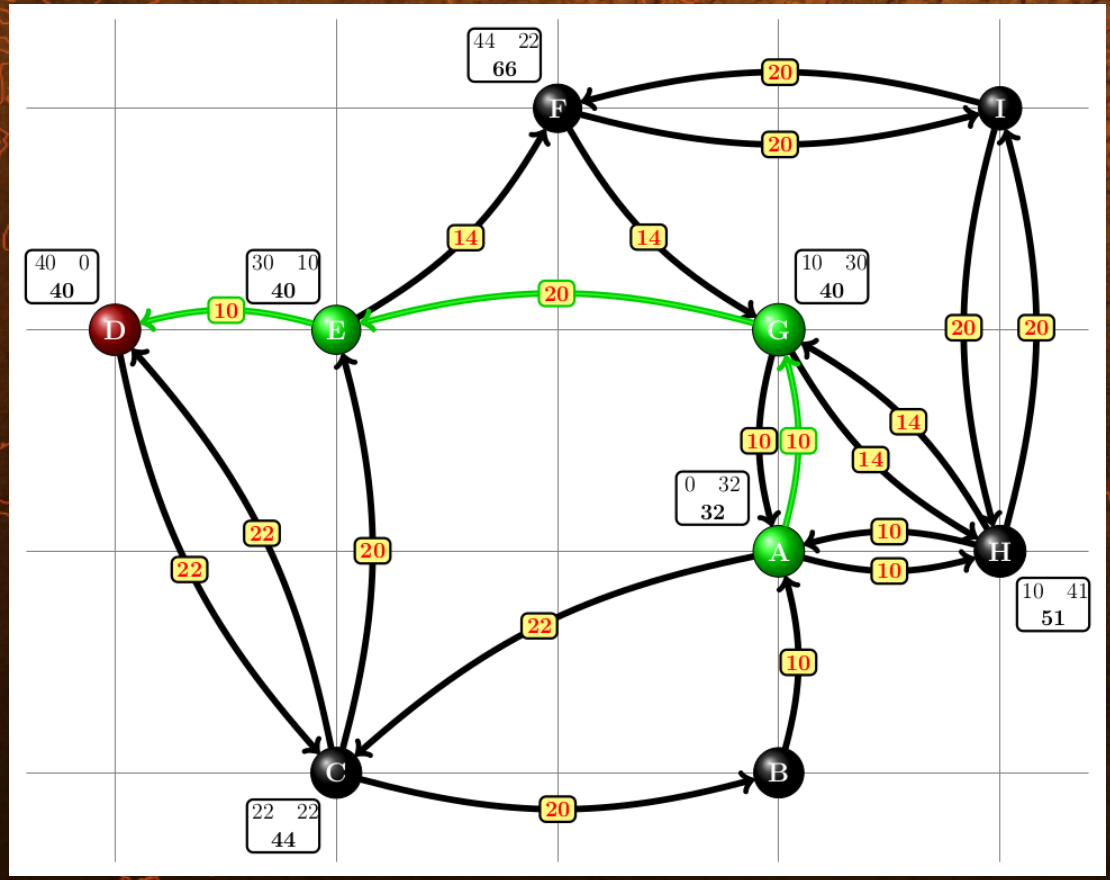
Source: https://stackoverflow.com/a/1332561

But is it always true?

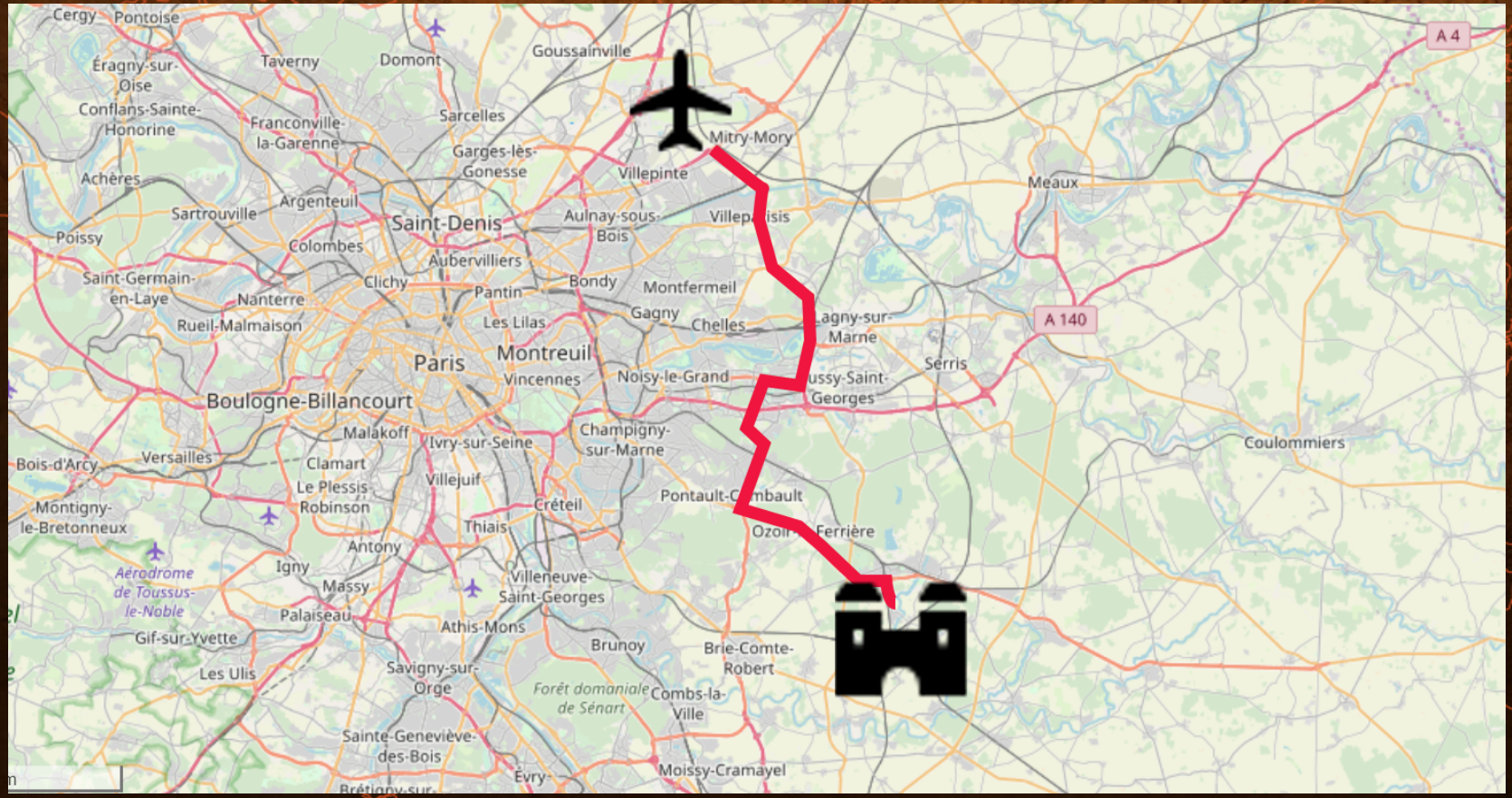
A*

- Worst case performance O(|E|)
  - |E| - number of edges in a graph
- An informed search algorithm: aims to find a path to the given goal node having the smallest cost (least distance travelled, shortest time, etc.)

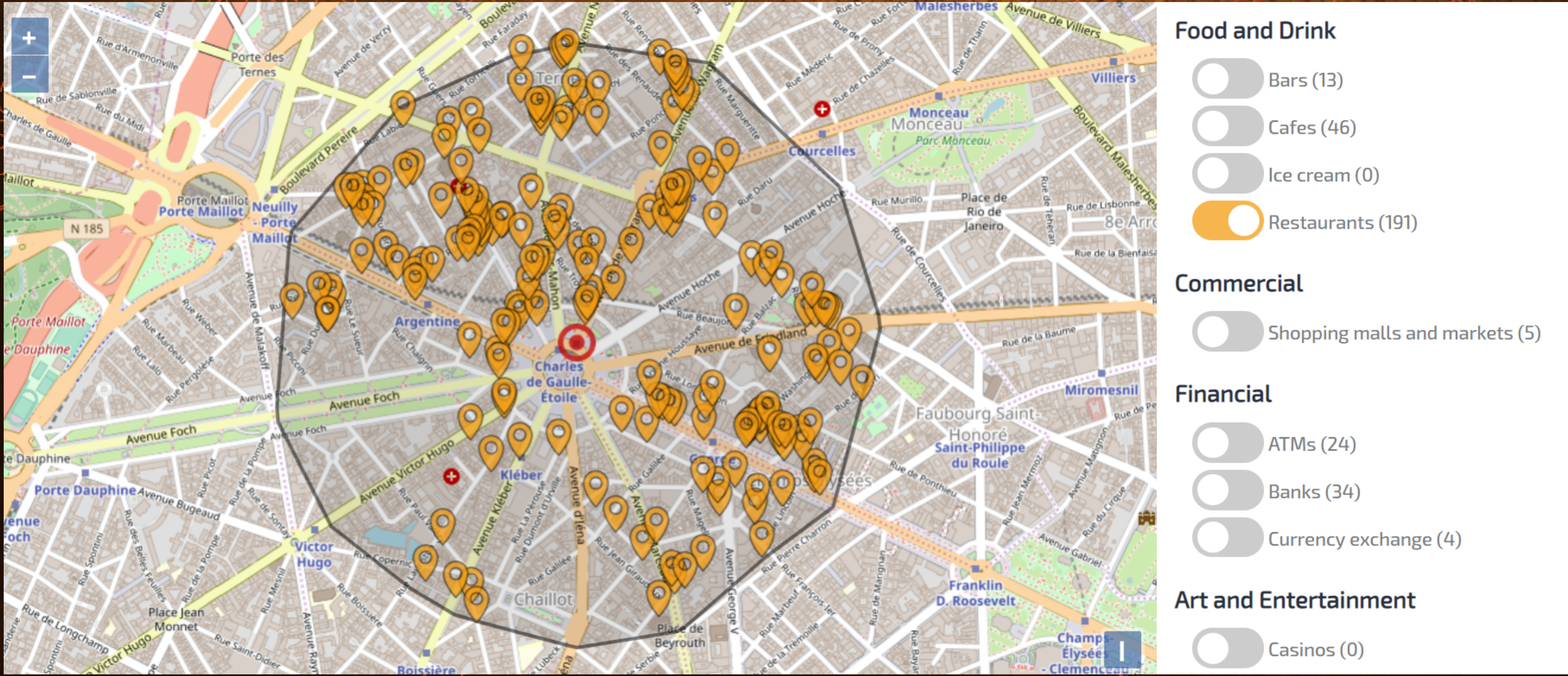
How does A* work?



The problem A* solves



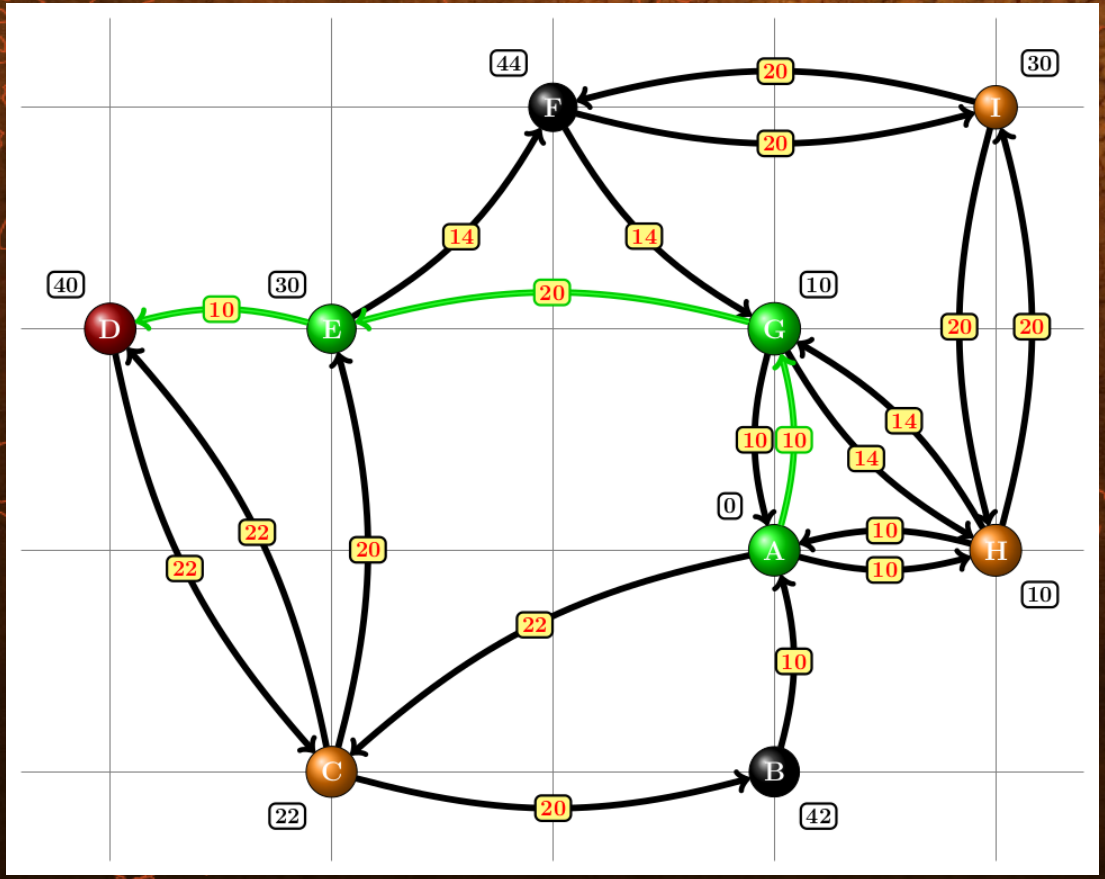
But what if there are 191 restaurants?



Dijkstra's

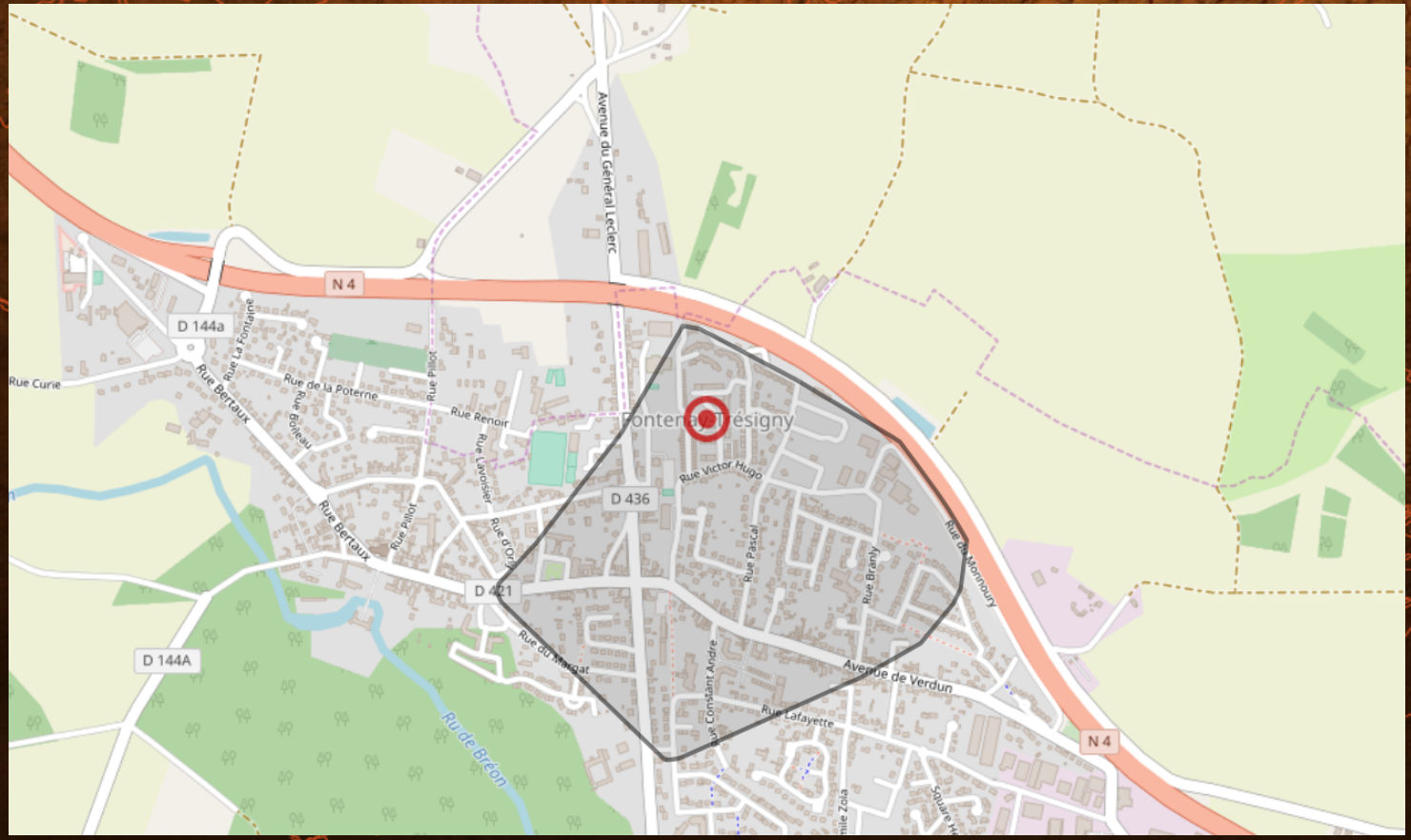
- Worst case performance – O(|E|+|V| log |V|)
  - |E| is the number of edges
  - |V| - the number of vertices

How does Dijkstra's work?

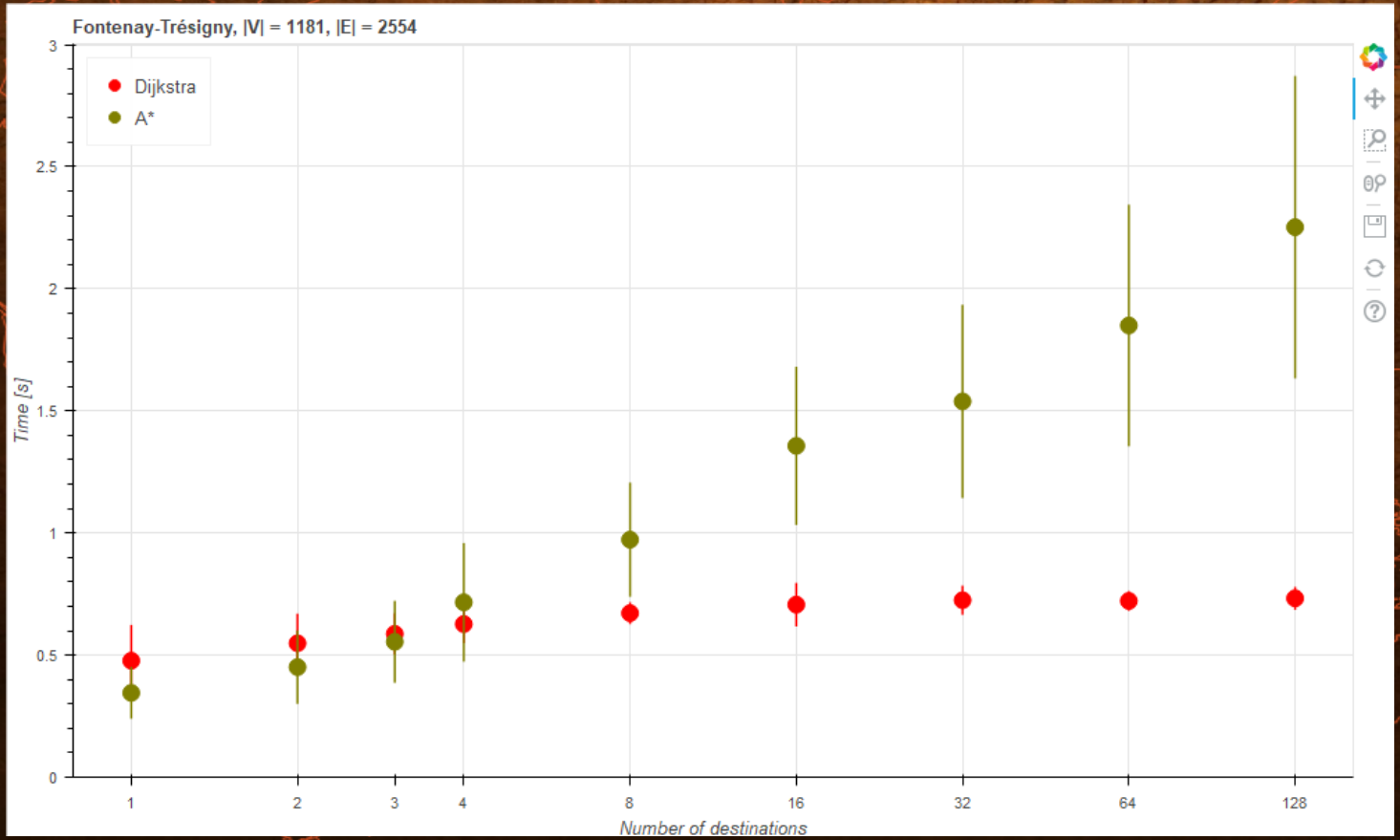



How shall I choose?

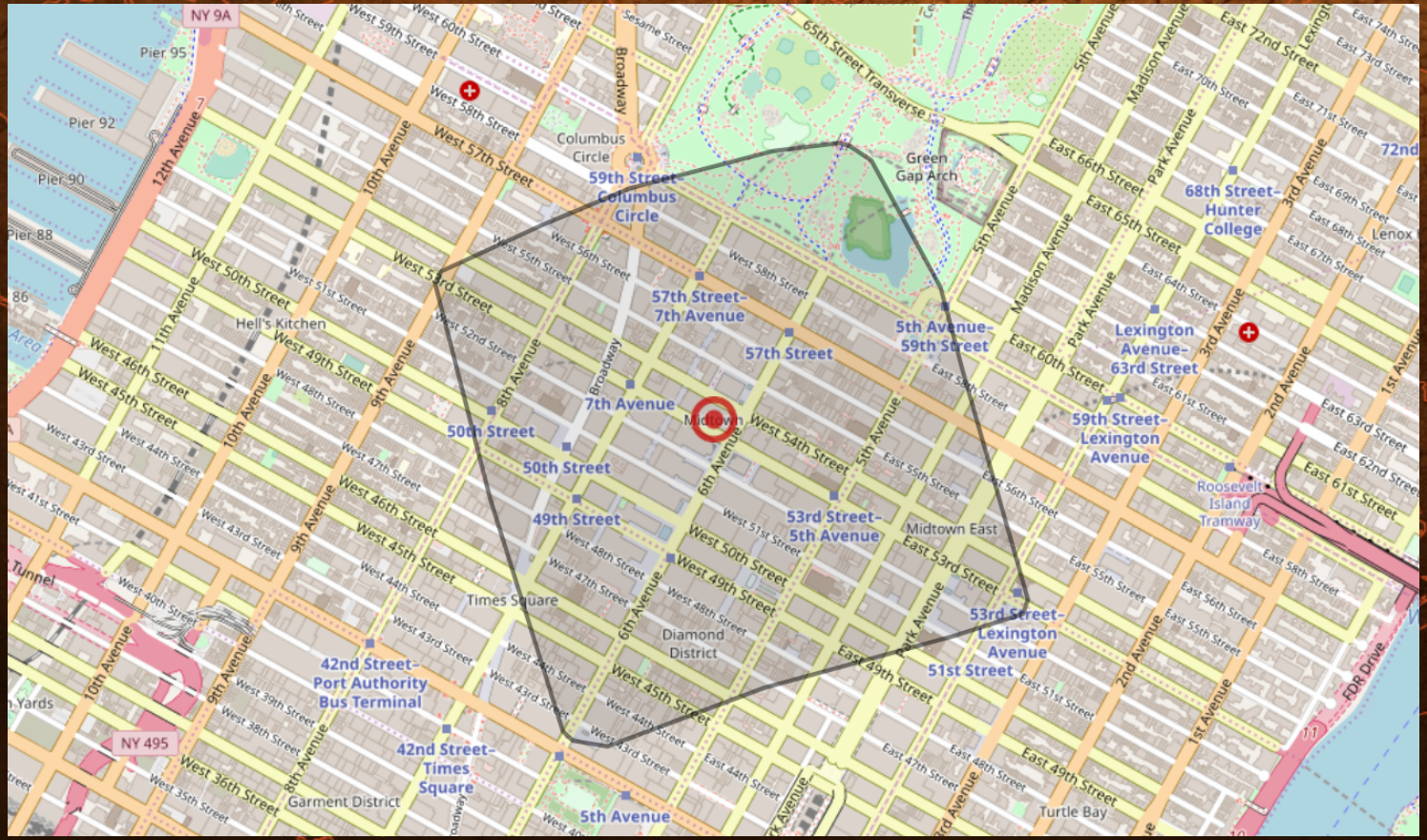
Fontenay-Trésigny



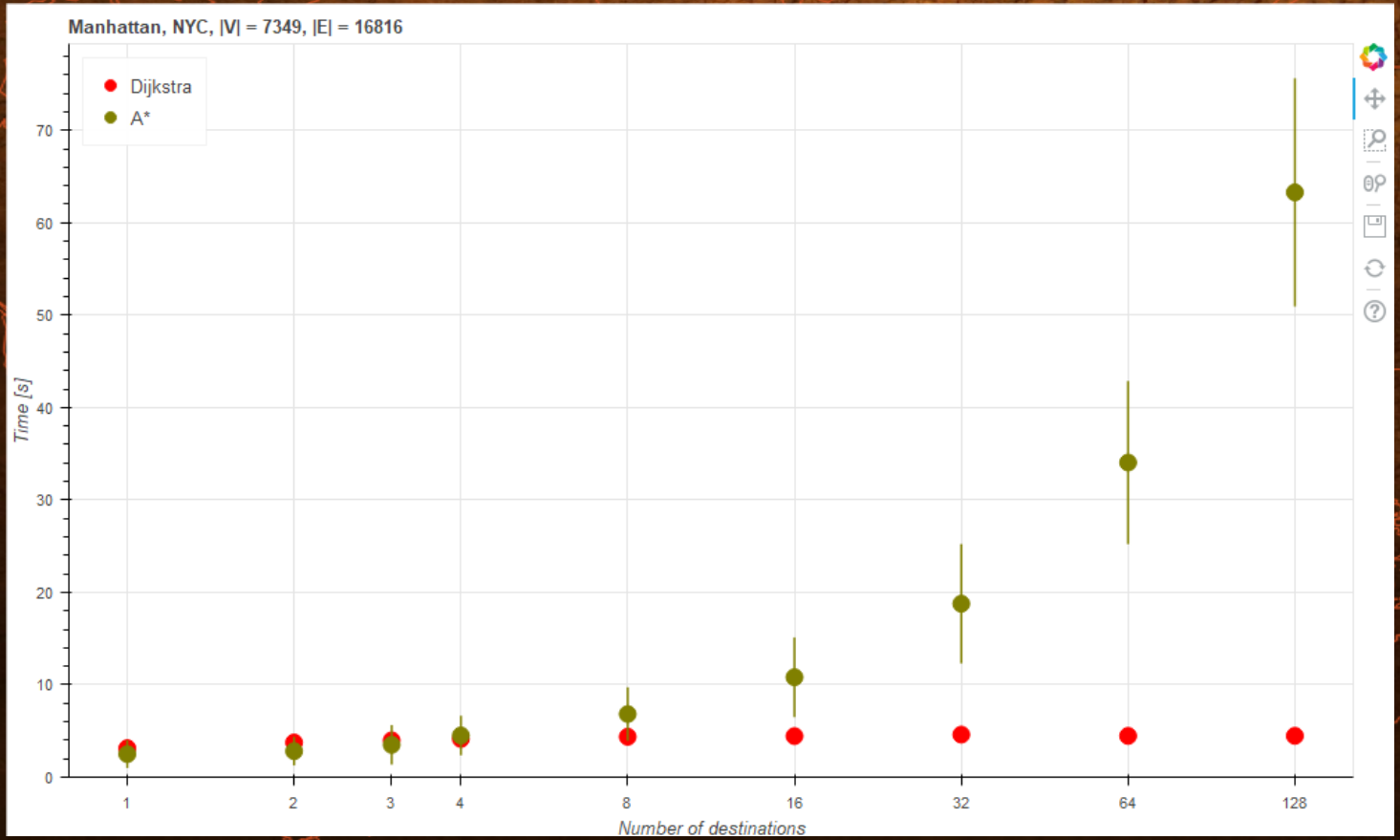
Fontenay-Trésigny



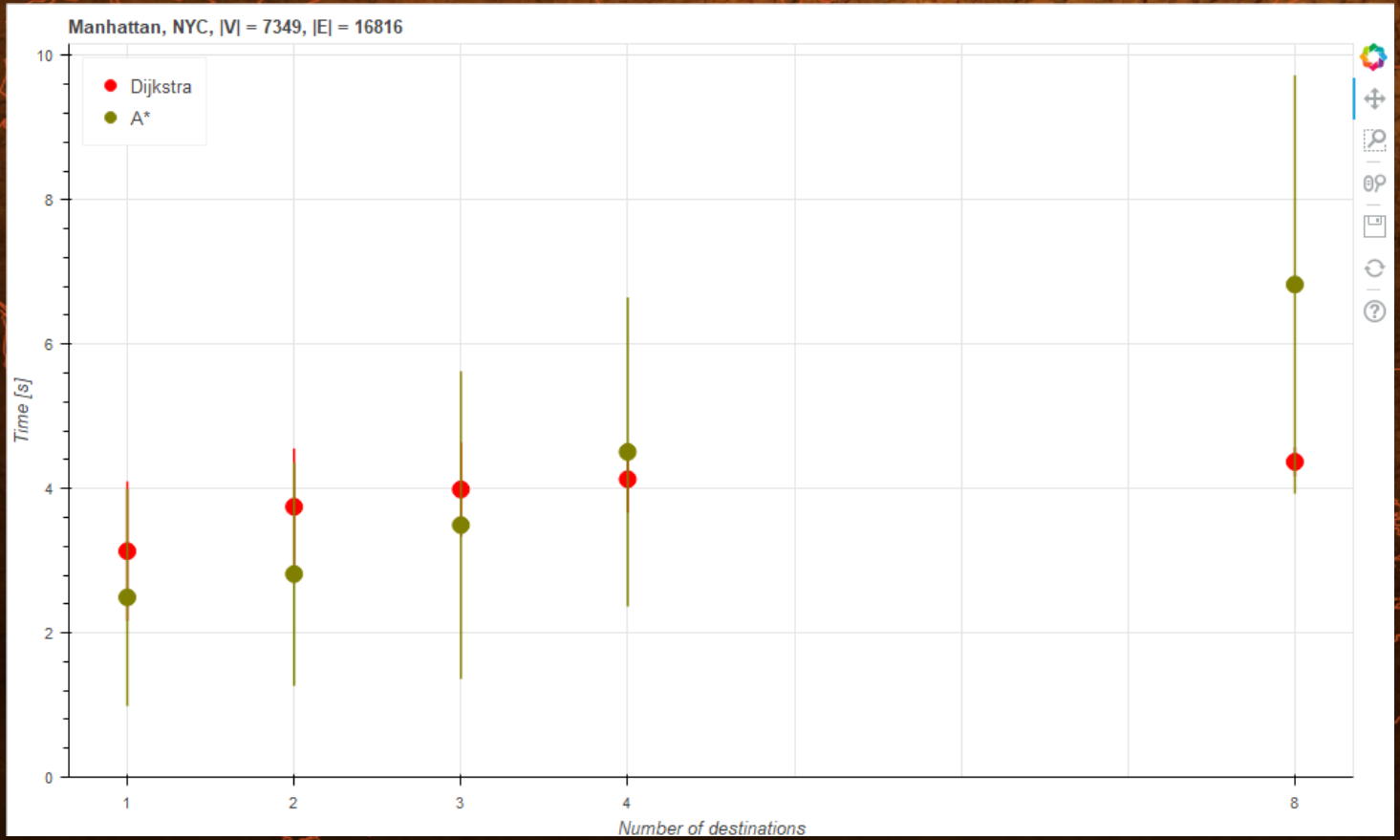
Manhattan, NYC



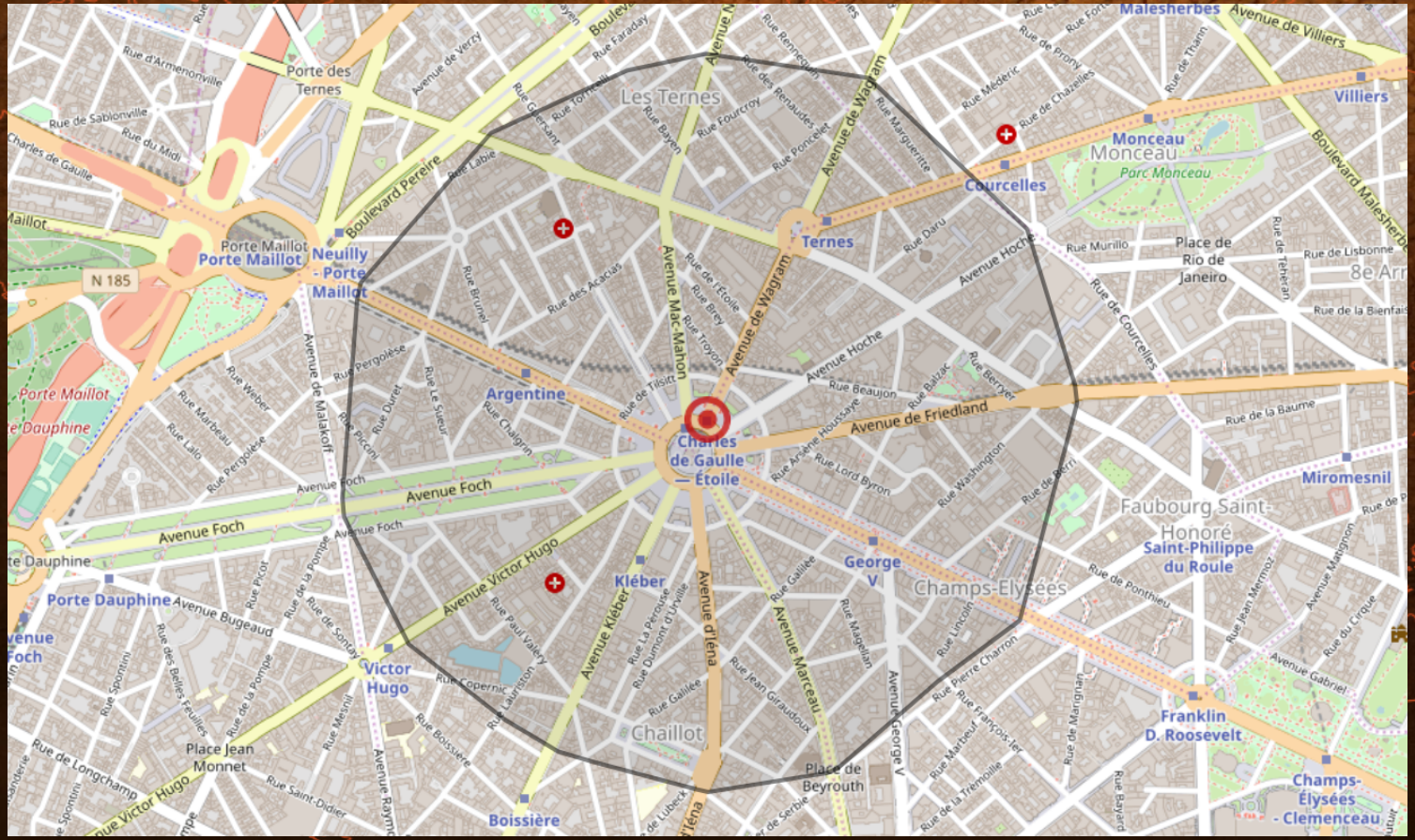
Manhattan, NYC



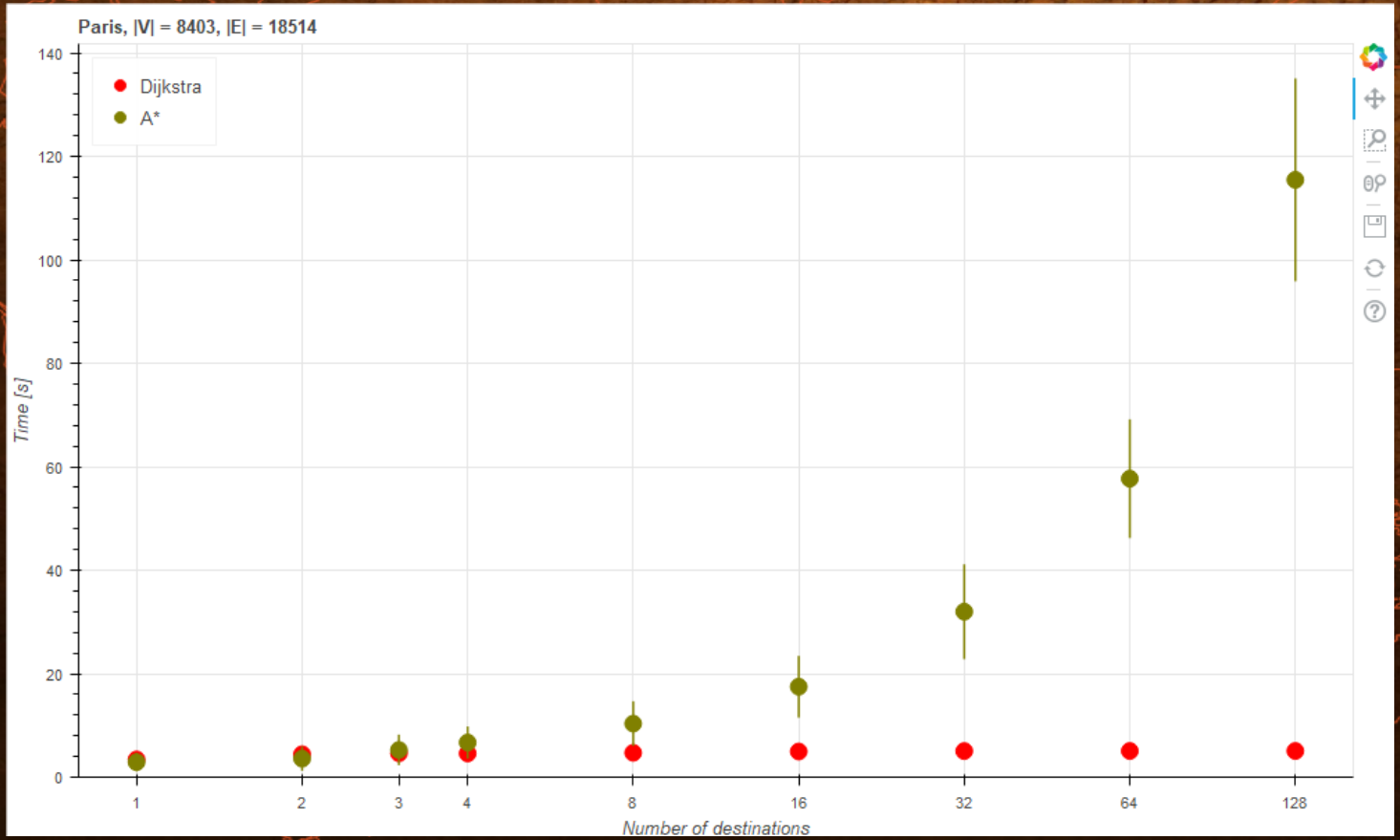
Manhattan, NYC



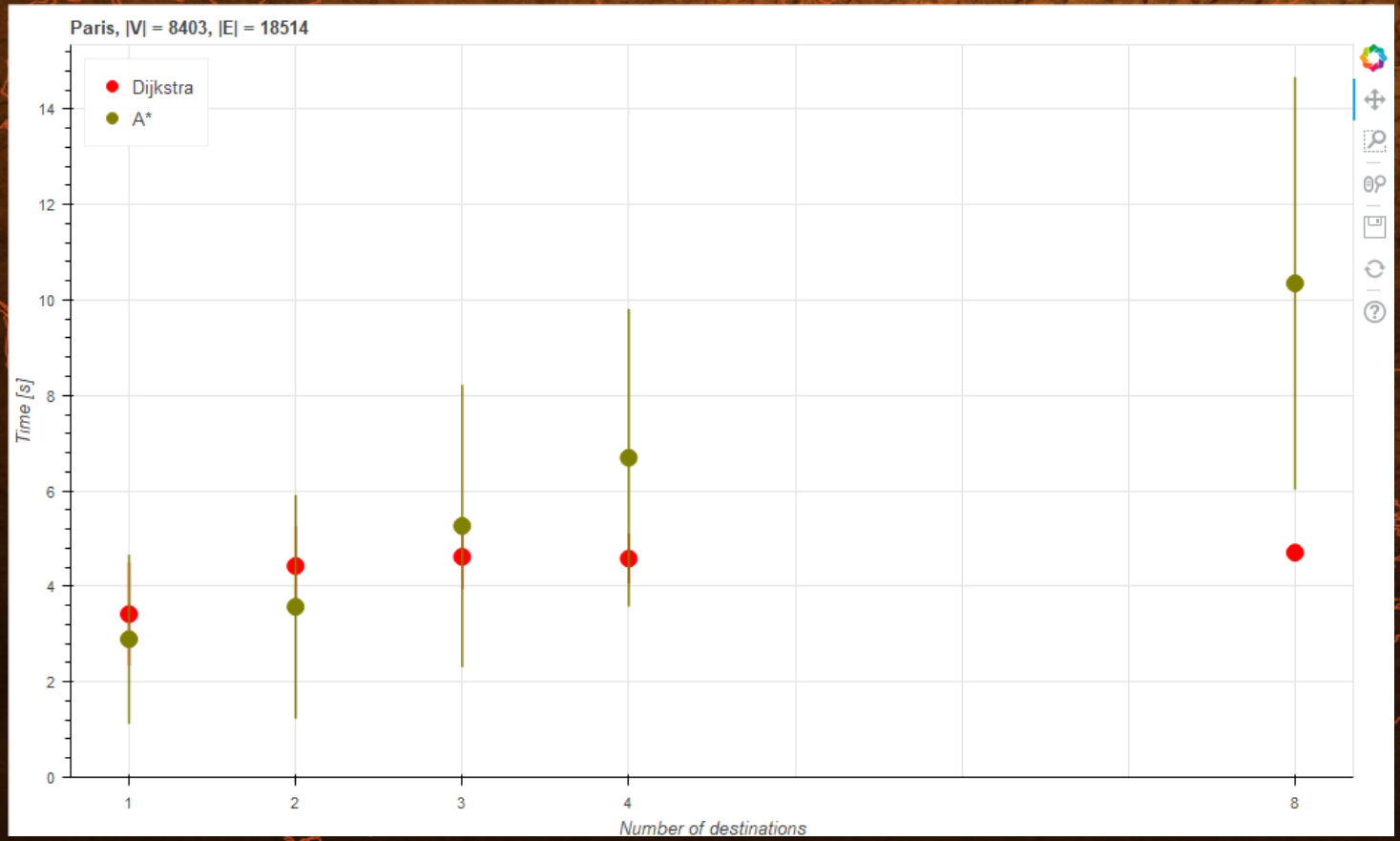
Paris

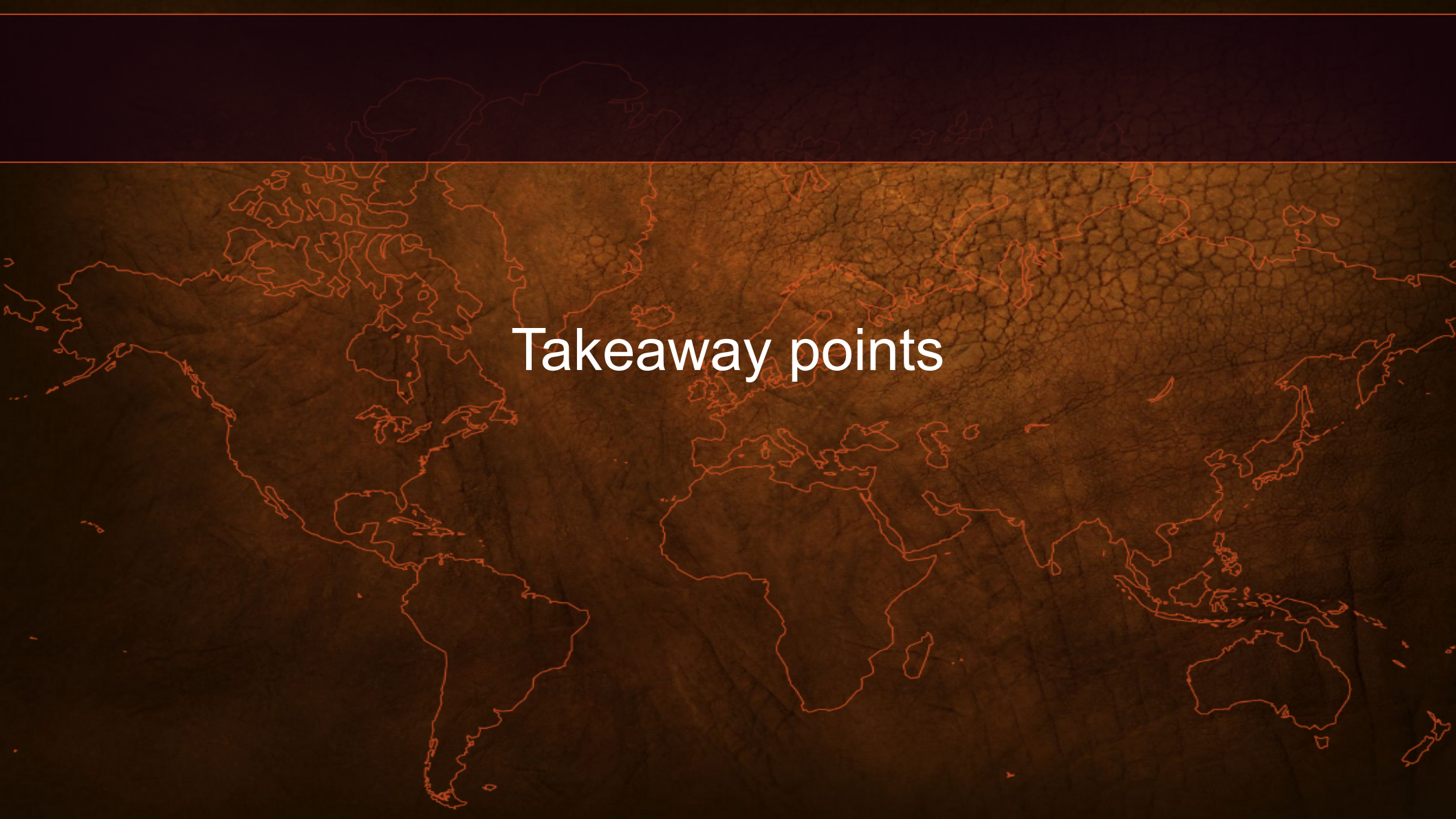

Porte des Ternes
Les Ternes
Malesherbes
Avenue de Villiers
Villiers
Monceau
Parc Monceau
Courcelles
Boulevard Pereire
Porte Maillot
Neuilly - Porte Maillot
N 185
Ternes
Place de Rio de Janeiro
Avenue Mac-Mahon
Avenue de Wagram
Avenue Hoche
Argentine
Charles de Gaulle — Étoile
Avenue de Friedland
Avenue Foch
Avenue Victor Hugo
Porte Dauphine
Kléber
George V
Champs-Élysées
Faubourg Saint-Honoré
Saint-Philippe du Roule
Miromesnil
Victor Hugo
Avenue Kleber
Avenue d'Iéna
Avenue Marceau
Chaillot
Franklin D. Roosevelt
Champs-Élysées - Clemenceau
Place Jean Monnet
Boissière
Place de Beyrouth

Paris

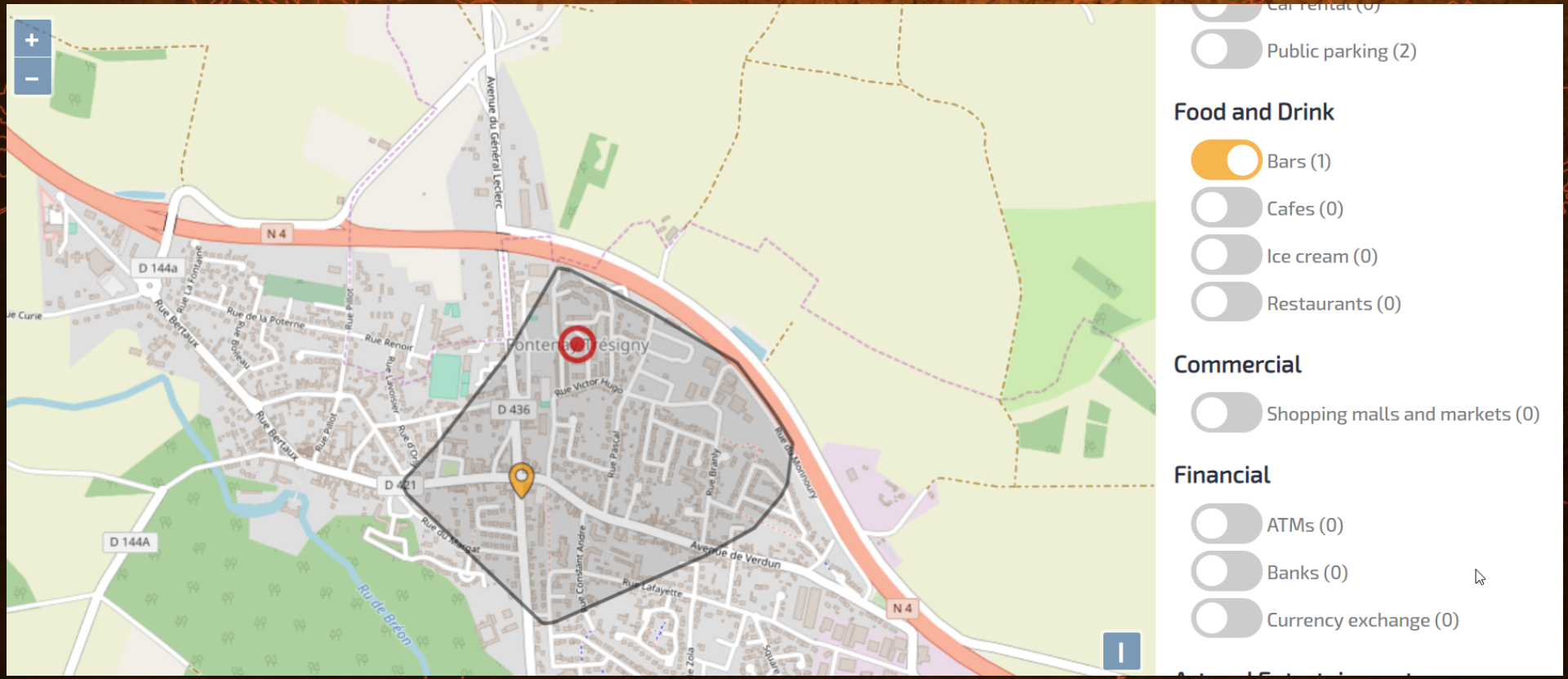

Paris, |V| = 8403, |E| = 18514
Dijkstra
A*
Time [s]
0
20
40
60
80
100
120
140
1
2
3
4
8
16
32
64
128
Number of destinations

Paris

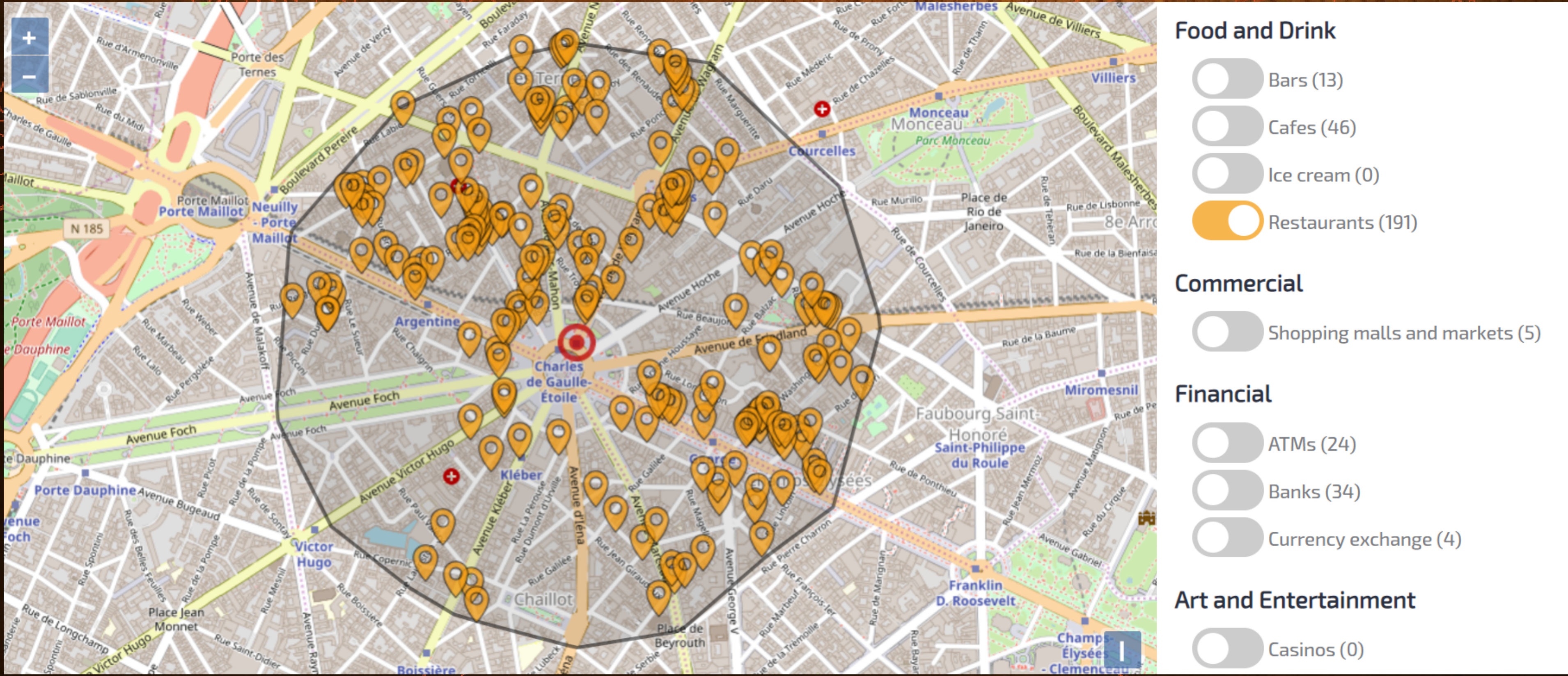

Paris, |V| = 8403, |E| = 18514
Dijkstra
A*
Time [s]
0
2
4
6
8
10
12
14
1
2
3
4
8
Number of destinations


Takeaway points

Use A* for few destinations



Use Dijkstra‘s for more



Resources & Credits

- OpenStreetMap.org
- Wiki.OpenStreetMap.org
- Overpass-turbo.eu
- OpenRouteService.org (isochrones)


Thank you