Network analysis

How to build and exploit a network dataset

Expected learning outcomes

Knowledge:

- Understand what is network analysis in GIS
- Recognize the characteristics of a road dataset in order to be efficiently exploited in a network analysis context
- Define the different types of network analyses and their objectives

Skills:

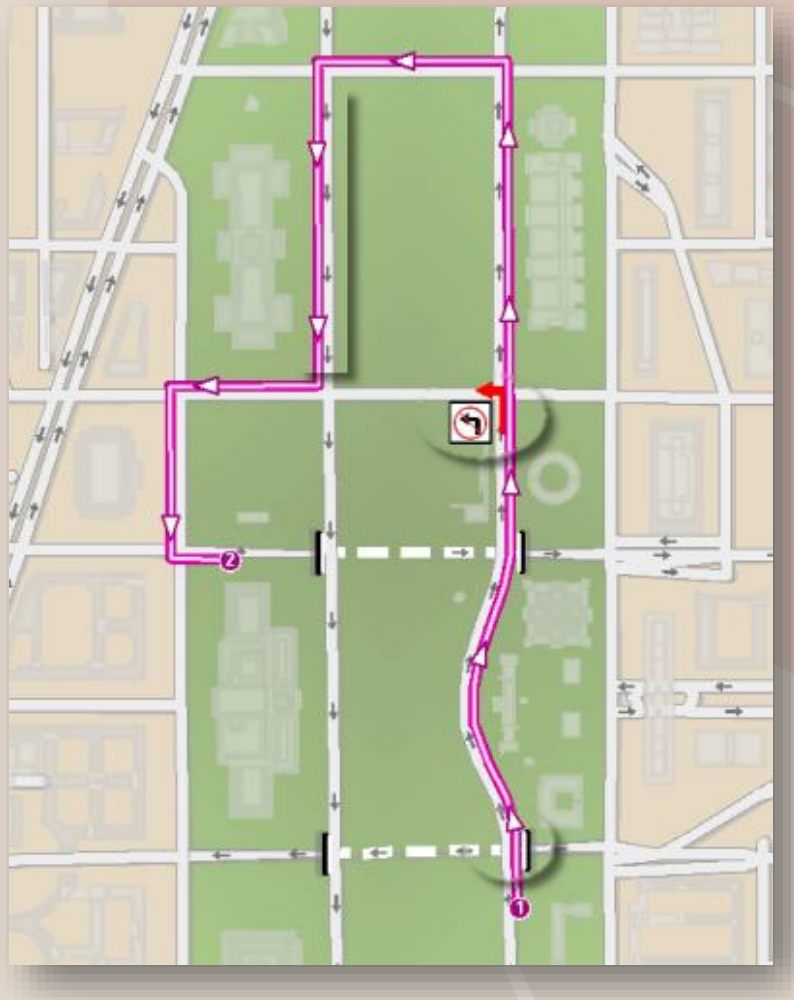
- Evaluate possible implementation alternatives and their consequences

Expertise:

- Design and implement an efficient and effective network analysis environment

Network dataset - definition

A **network dataset** is a data structure well suited to model transportation networks. It is created from **source features**, which can include simple features (**lines** and points) and **turns** (optional), and store the **connectivity** of the source features

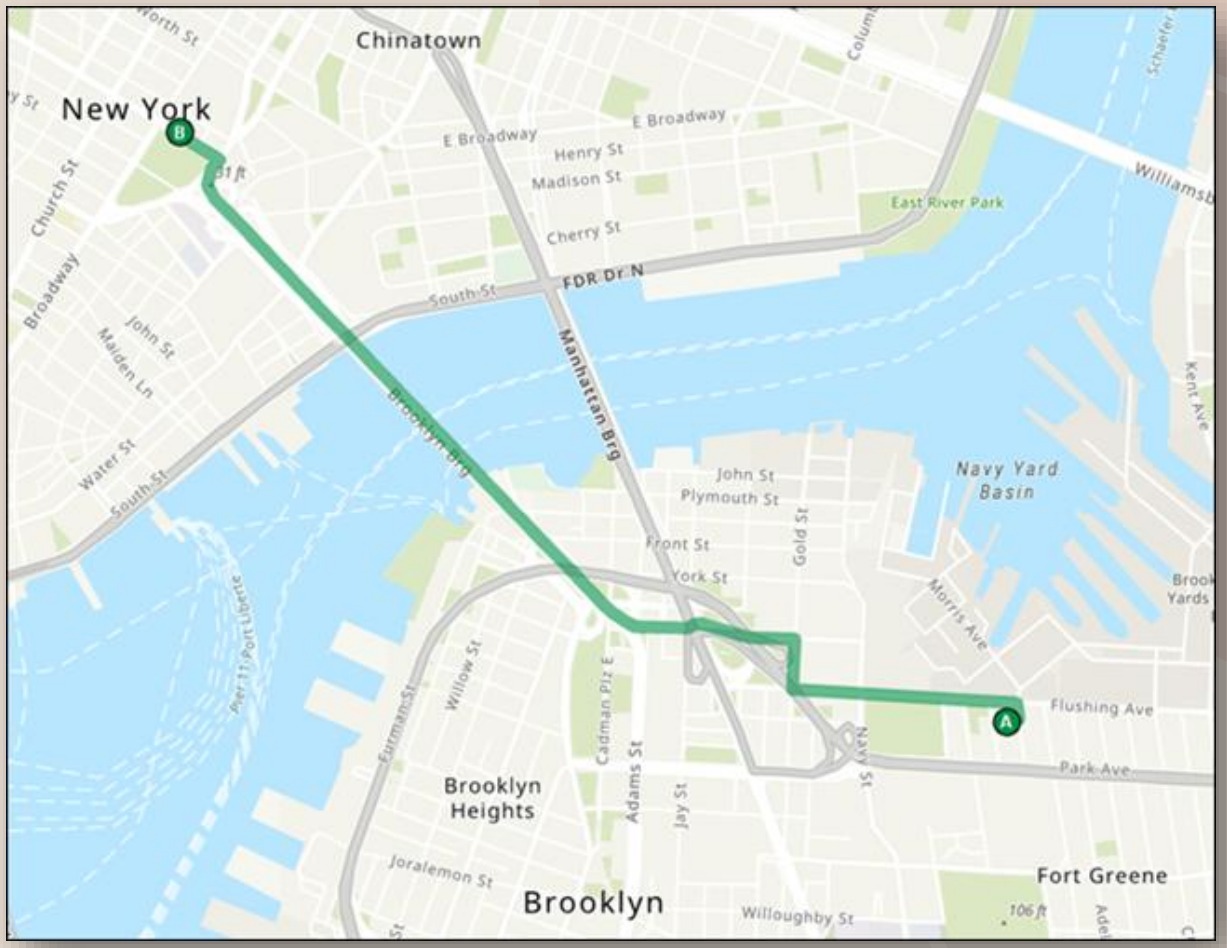


source: ESRI

Questions you can answer with a network dataset

What is the quickest way to get from point A to point B?

- The best route can be the **quickest**, **shortest**, **most scenic** route, etc. depending on the **impedance** chosen
- It's possible to generate directions with **turn-by-turn maps**



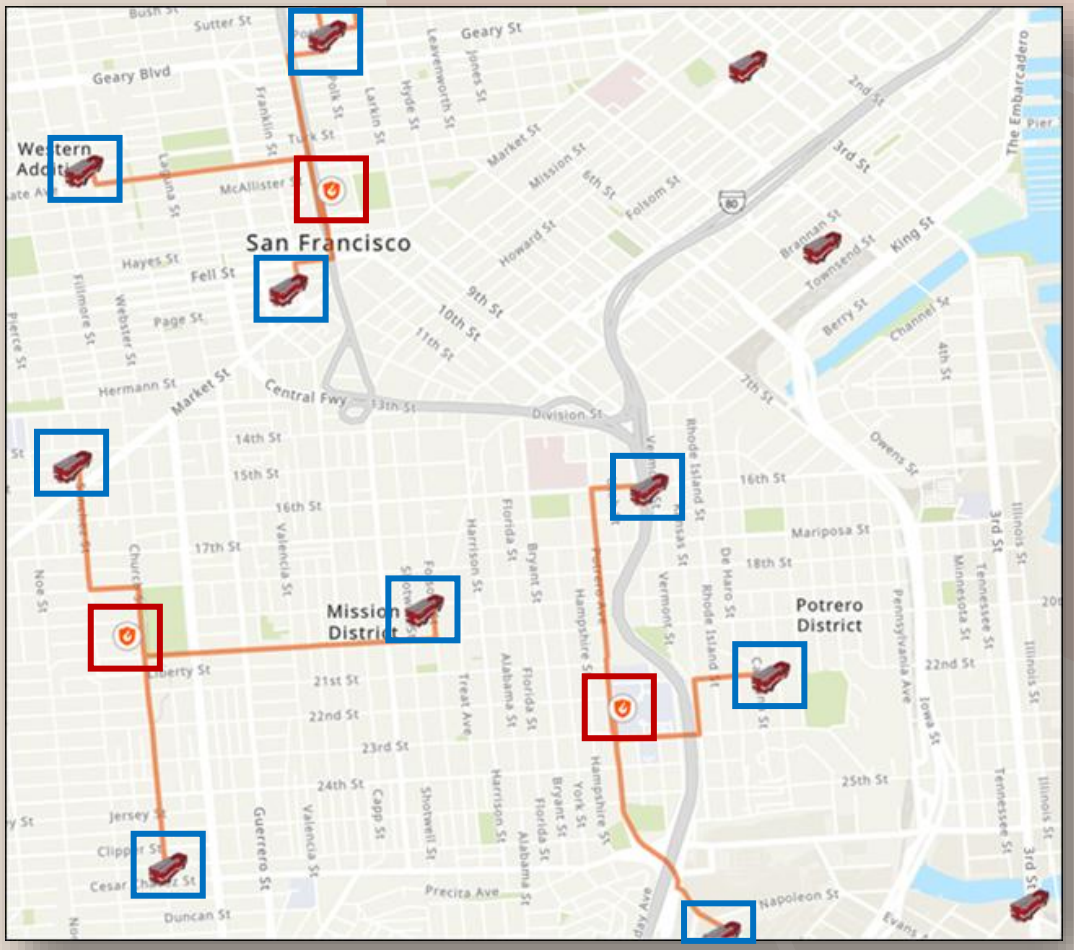
source: ESRI

Questions you can answer with a network dataset

What fire incidents can be reached within five minutes of fire stations?

Find **one or more facilities closest to an incident** based on travel time, distance, or other cost and outputs the **best route**, **chosen facility**, and **driving directions** between the incident and the facility

In this example, the solver finds the three closest fire stations that can respond to a fire incident within five minutes' drive time. Fire stations that are more than five minutes away are not included in the results



source: ESRI

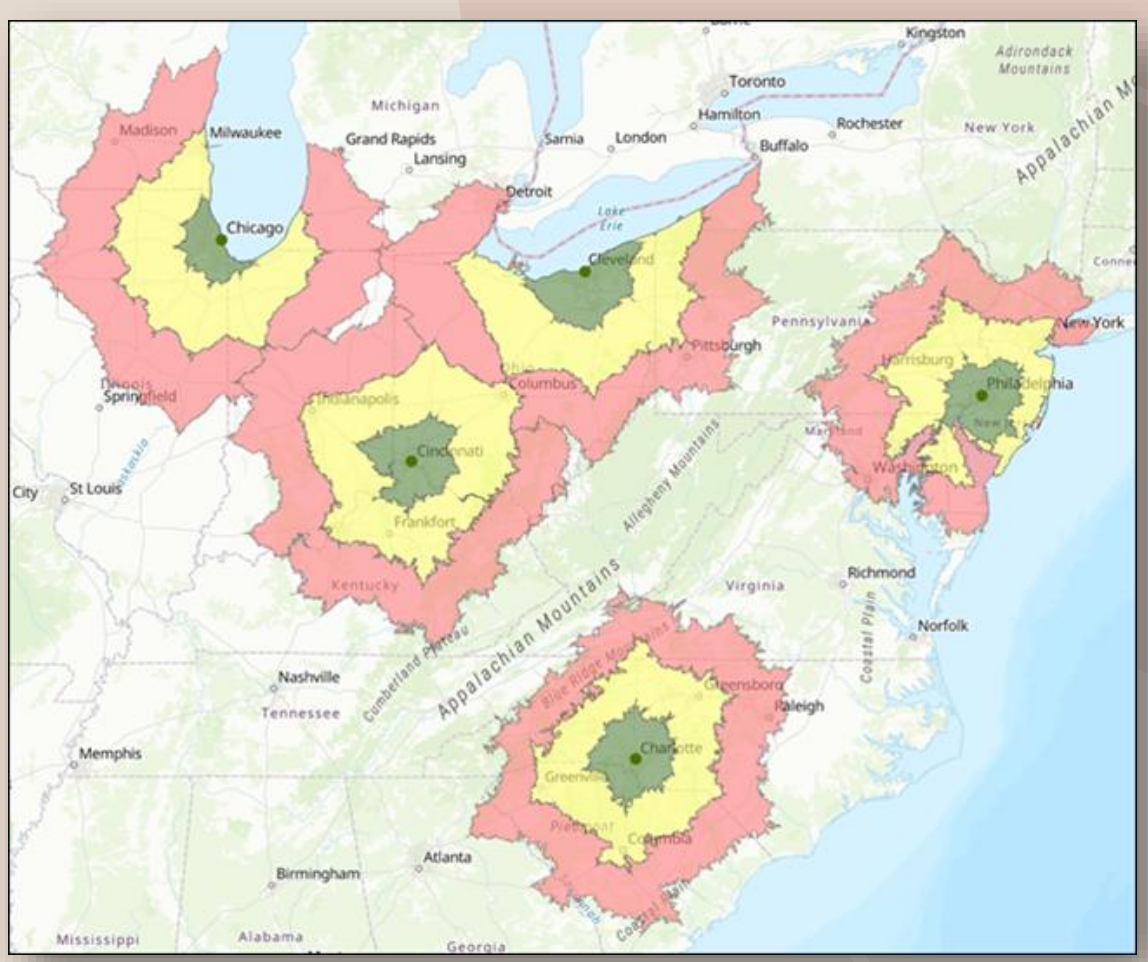
Questions you can answer with a network dataset

What market areas does the business cover?

The green points represent warehouses in various cities

The **polygons** represent warehouses' market areas, which are divided into three rings

The green polygons can be reached by trucks within **one hour**; yellow, within **two hours**; and red, within **three hours**



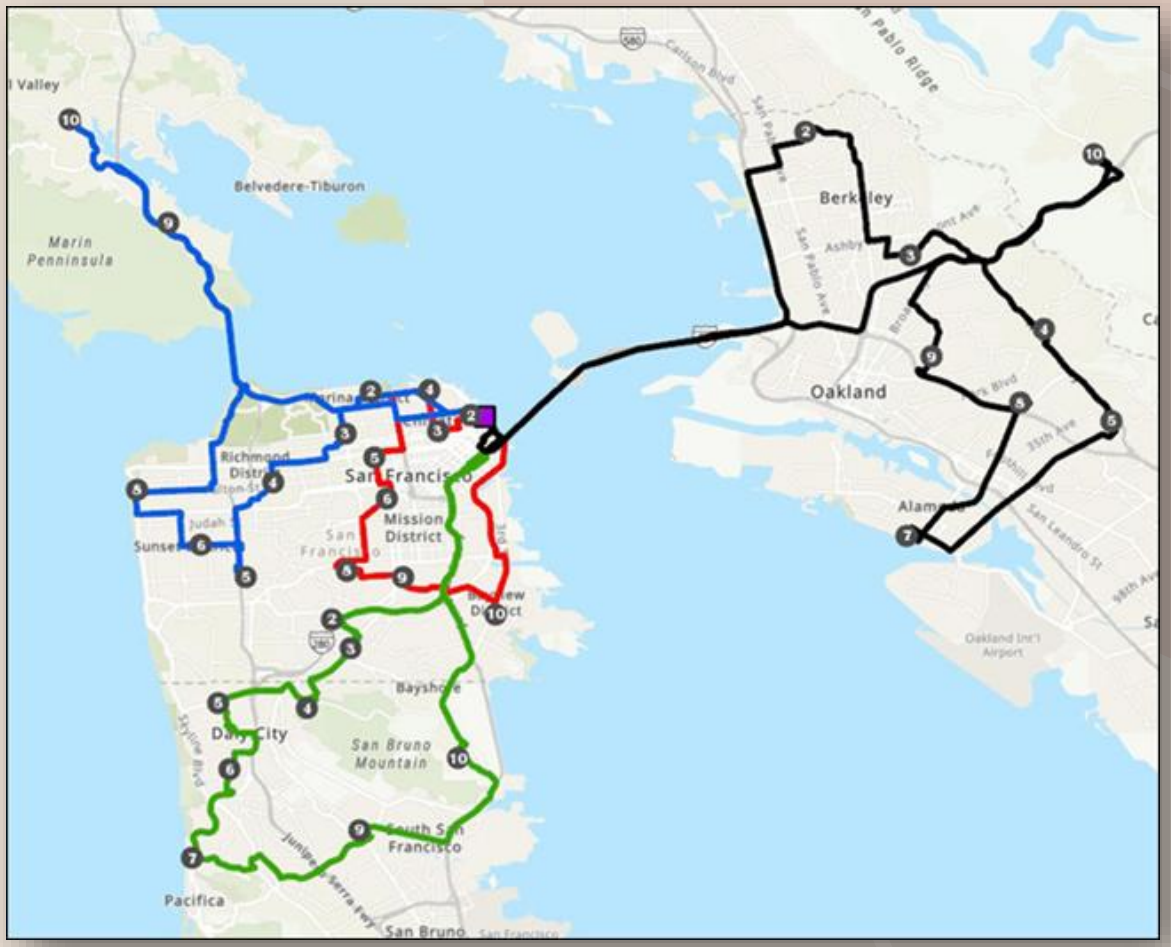
source: ESRI

Questions you can answer with a network dataset

How can we route our fleet of delivery vehicles to minimize overall transportation costs and improve customer service?

Food **delivery trucks** at a **distribution center** are **assigned grocery stores** and directions to the stores that **minimize transportation costs** (and related greenhouse gas emissions)

Vehicle capacities, lunch breaks, and maximum travel time (and others) constraints are included in the analysis



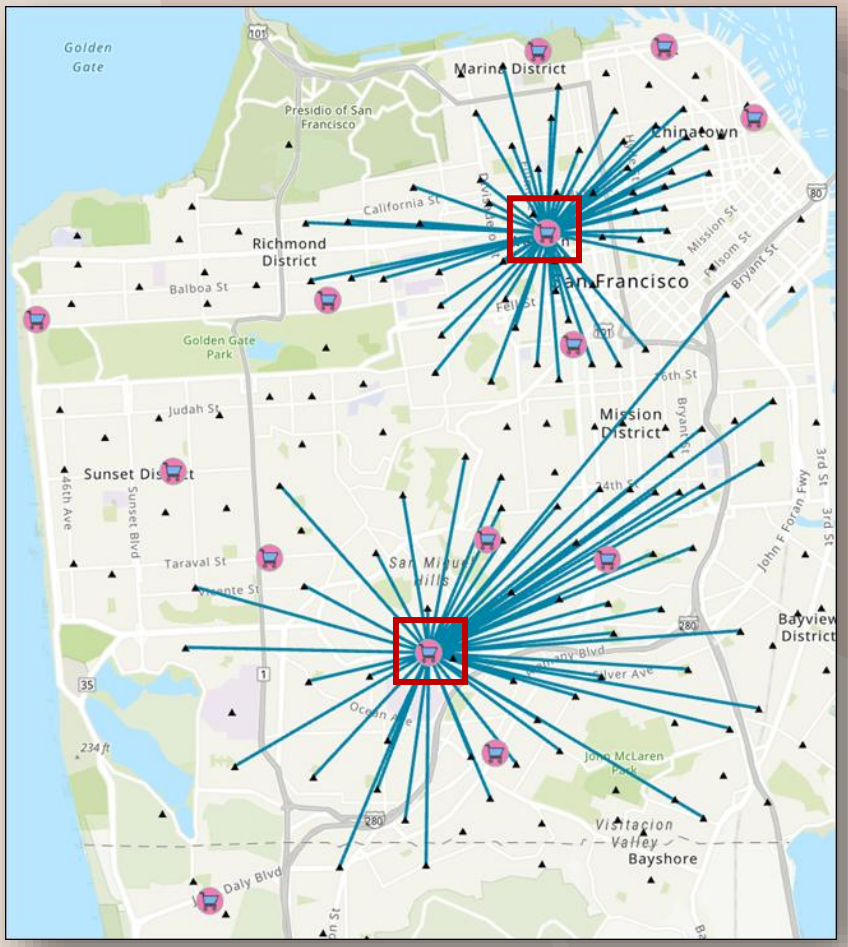
source: ESRI

Questions you can answer with a network dataset

Where should we open a new branch of our business to maximize market share?

Location-allocation can be used to **find the best locations** from a set of input location

In this example, the tool evaluated the **locations** that meet the business needs for the establishment of **new stores** and identified the locations that **capture the most demand** from the overall market area



source: ESRI

Questions you can answer with a network dataset

What are live or historical traffic conditions like, and how do they affect my network analysis results?

You can make use of **live or historical traffic conditions** so your analyses can account for changing traffic

source: ESRI

Questions you can answer with a network dataset

- *What is the nearest coffee shop from my current location?*
- *Which patrol cars can respond the quickest to the incidents?*
- *Our company needs to downsize - which stores should we close to maintain the most overall demand?*
- *…*

source: ESRI

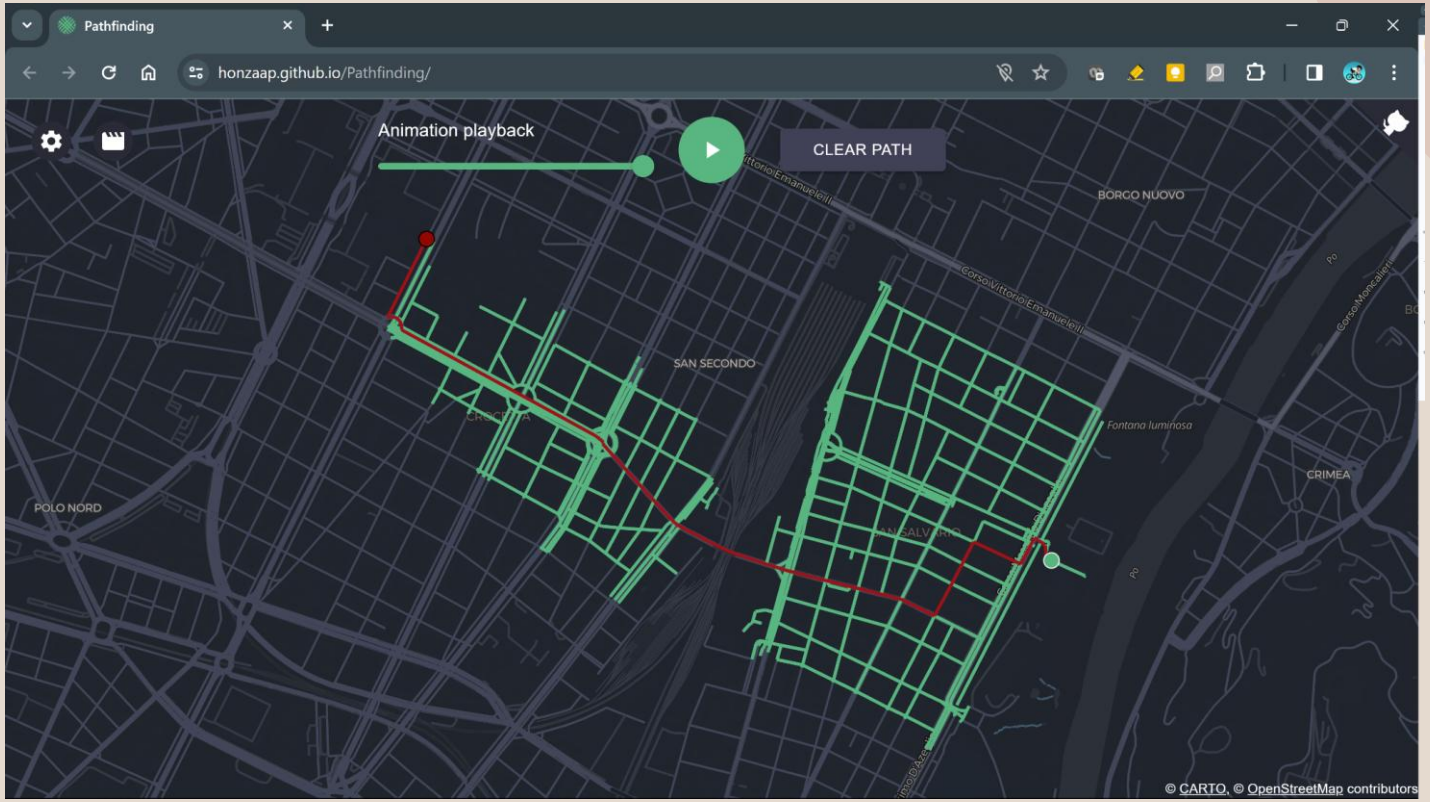
Questions you can answer with a network dataset

- *What is the nearest coffee shop from my current location?*
- *Which patrol cars can respond the quickest to the incidents?*
- *Our company needs to downsize - which stores should we close to maintain the most overall demand?*
- *…*
- *What is the best way to get from point A to point B for a pedestrian moving among different levels of a set of buildings (**indoor navigation**)?*

source: ESRI

How network analysis algorithms work?

This demonstrator can help in answering to the above question



Network dataset **elements** and **connectivity**

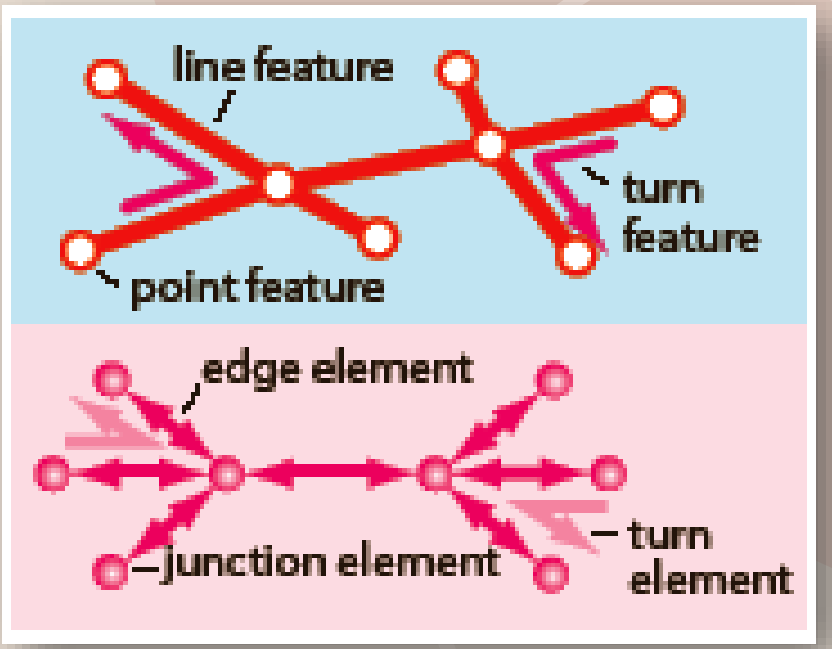
Steps required for creating a Network dataset

1. Identify the **source(s)** and the **role** they will play in the network, e.g. the layers acting as edge source and, optionally, as junction and turn source
2. Model **connectivity**:
   a) connectivity concept should be **designed before creating a network dataset**
   b) address special scenarios, such as **bridges and tunnels**
   c) an **elevation field model** can be used to enhance the connectivity of the network in a **3d scenario**
3. Define **attributes** and determine their values:
   a) identify the **costs/impedances** to be used during network analysis and determine their values from network sources and, possibly, from live traffic feeds
   b) determine the **restrictions** that will be used to control navigation over the network
   c) establish **hierarchy** (if required) for the edge elements in the network

Network dataset - Elements

Network dataset **elements** are:

- **Edges** - **connected line elements** (by means of junctions), they are the links over which agents travel
- **Junctions** - point elements that **connect edges and facilitate navigation** from one edge to another
- **Turns** (optional)- elements that store information that can **affect movement between two or more edges**

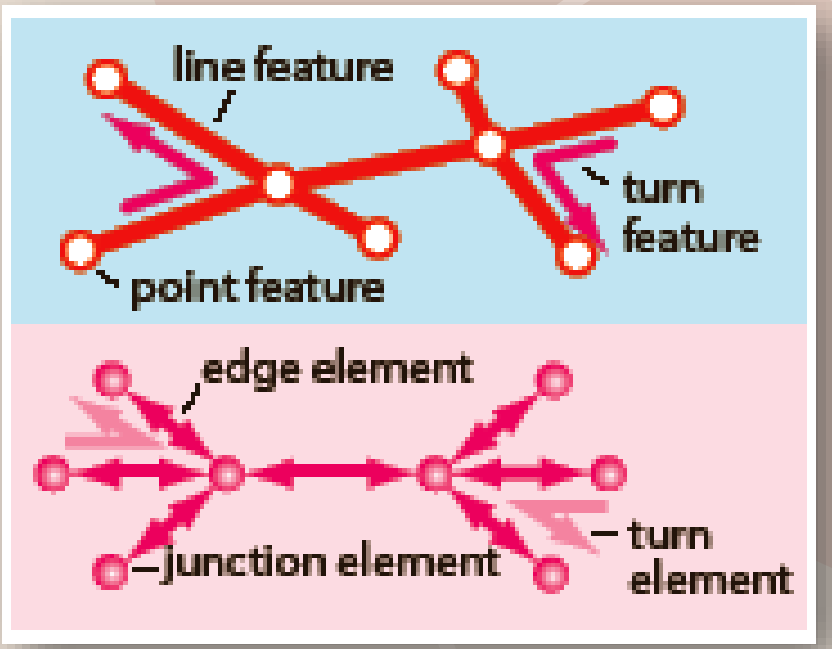


source: ESRI

Network dataset - Elements

Network dataset **sources** are:

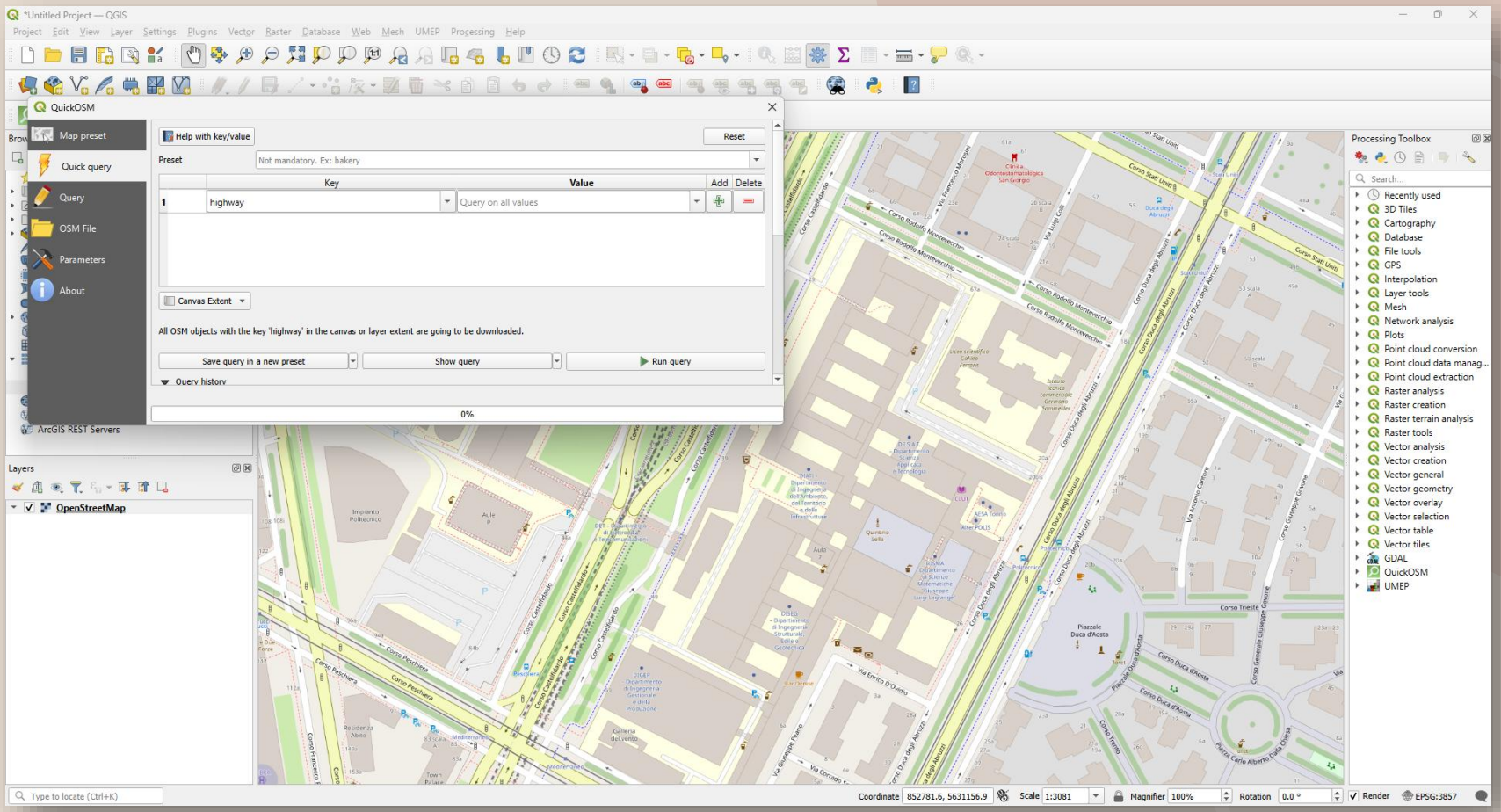
- **Edge feature sources** - **line** layer (i.e. a road network)
- **Junction feature sources** - **point** layer. A junction must exist at each end of an edge in a network dataset. System junction are automatically created based on the **connectivity model**
- **Turn feature sources** – a turn feature source explicitly models a subset of **possible transitions** between edge elements during navigation



source: ESRI

Identify the sources

You can exploit Overpass Turbo (or the QuickOSM plugin) to retrieve relevant OSM features



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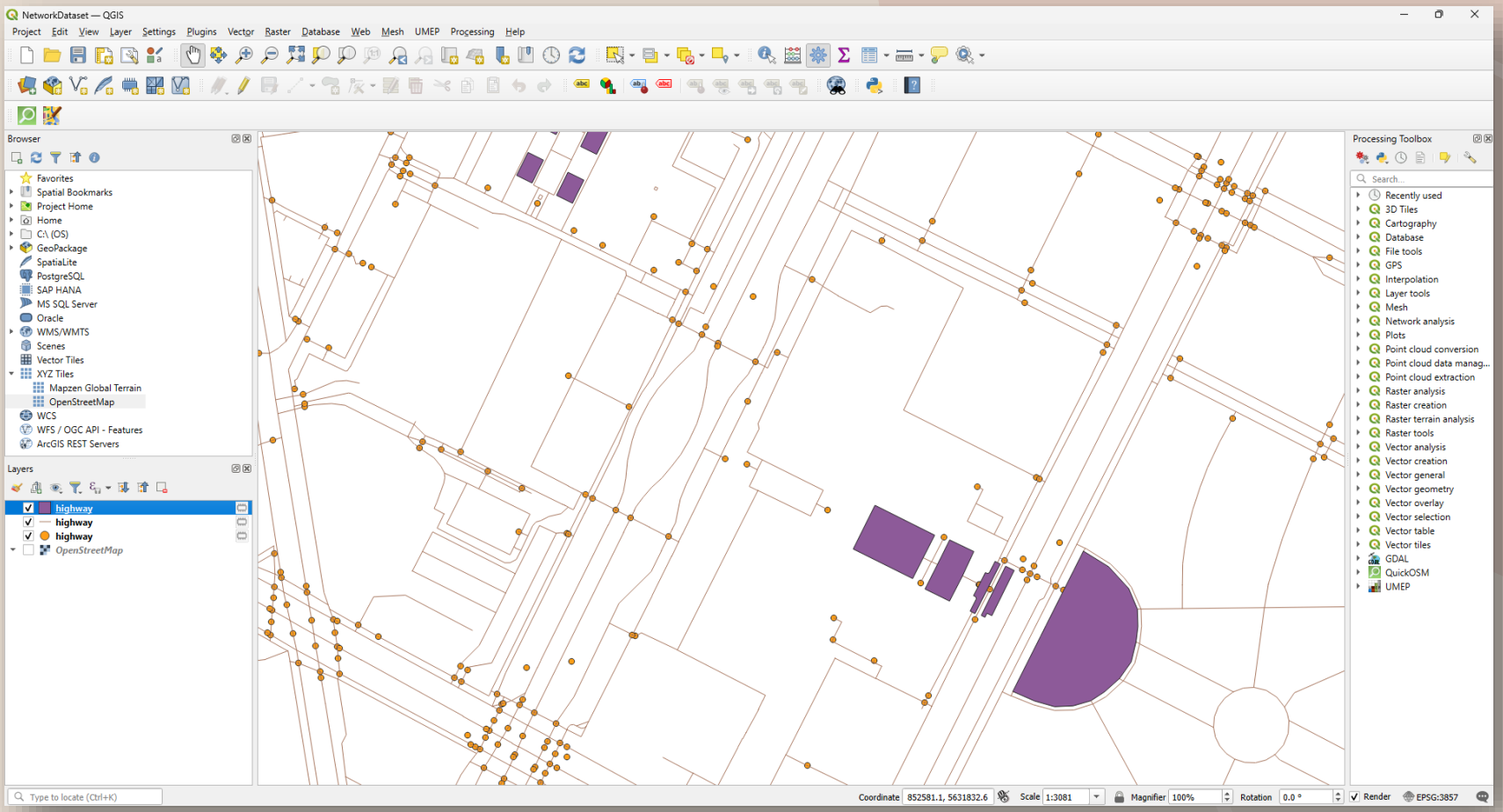

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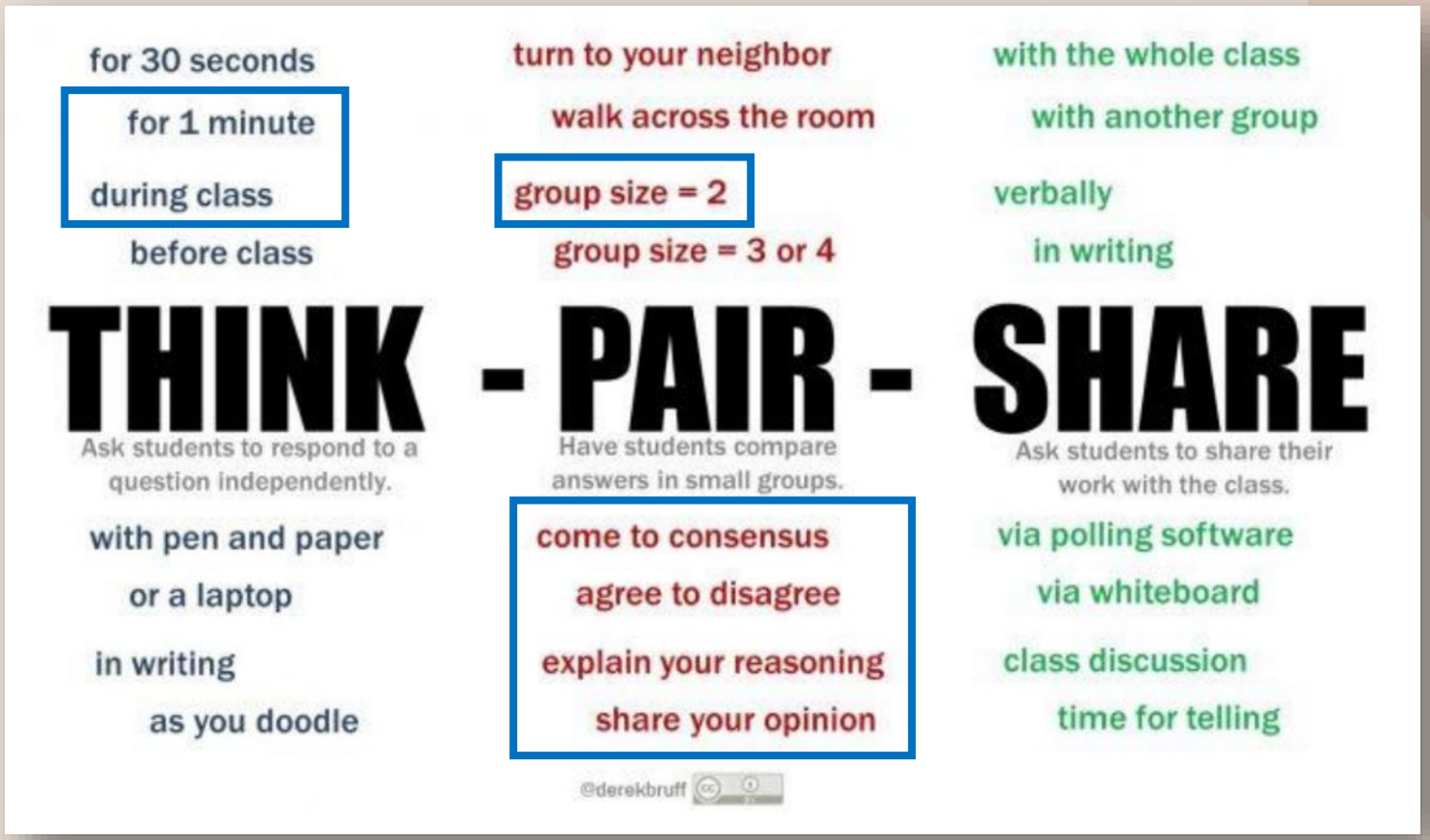

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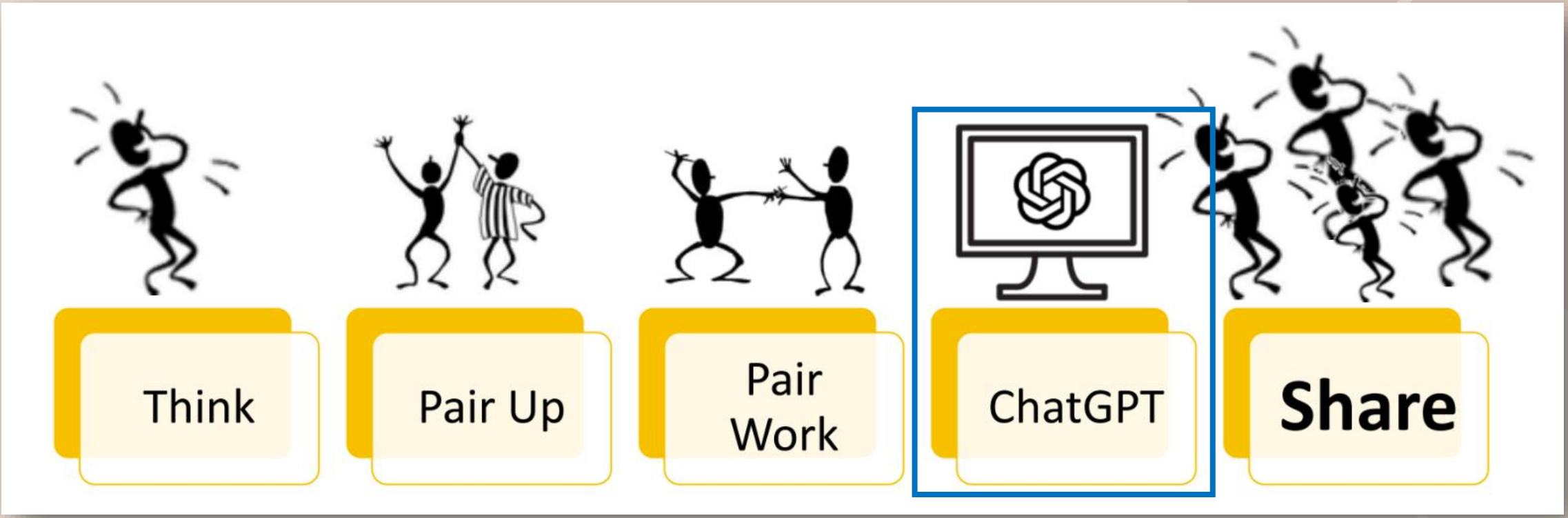
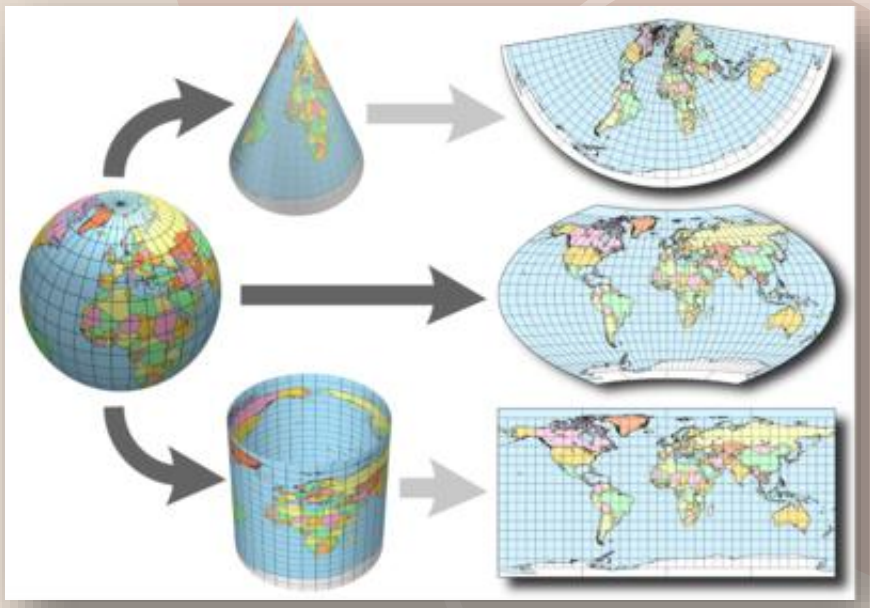


Are there data source alternatives to OSM?

https://polito.padlet.org/andreaajmar/mapping-polito-spaces-network-analysis-qq8hnftja7usxjpp

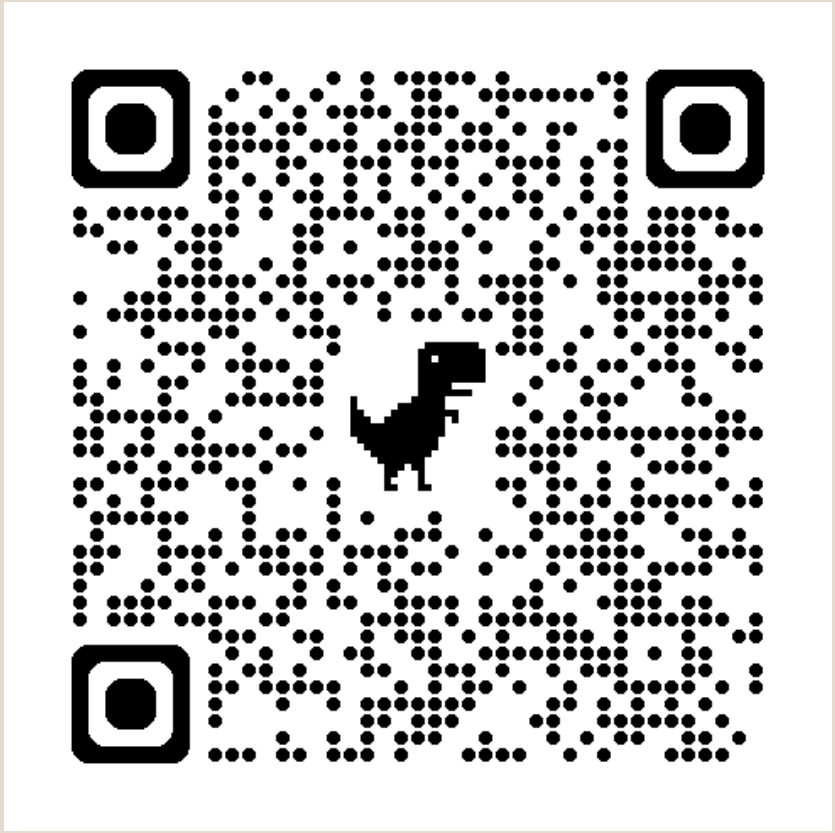
Convert to projected CRS

In a geographic CRS, calculating the actual physical distance between two points is difficult because the units are in degrees, not meters or feet, and the Earth is curved. This can result in inaccurate or distorted distance measurements when routing algorithms calculate paths



If you want to discover more, look here

Evaluate possible CRS conversion methods



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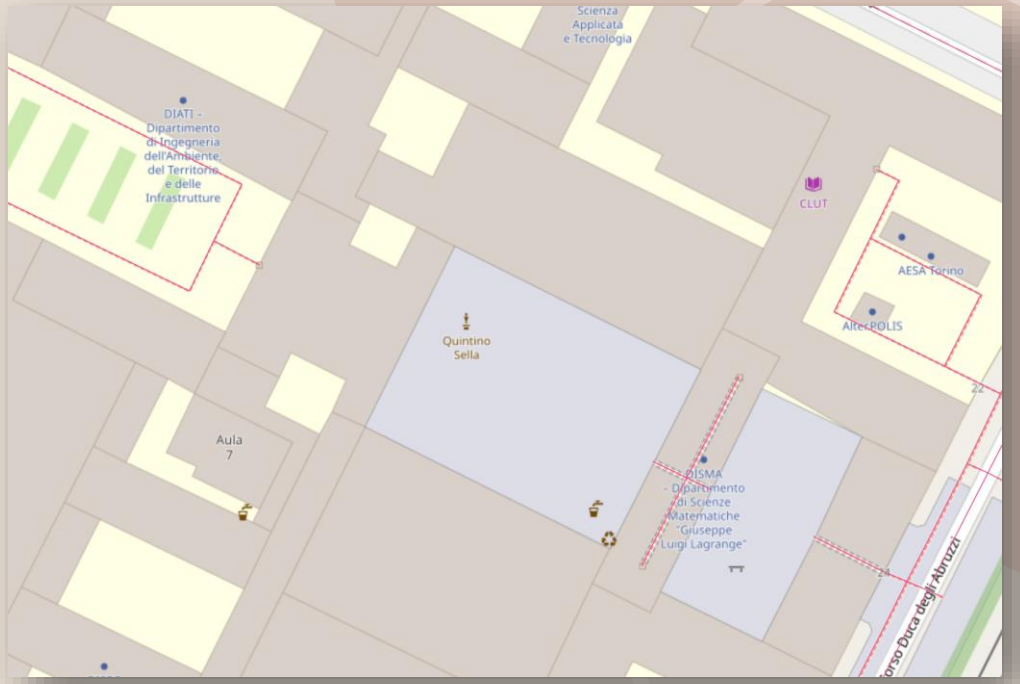
Import the source(s) into a PostGIS database

Within QGIS you just need to drag & drop an existing layer within an established PostgreSQL/PostGIS connection

But alternatives are possible…

Edit the source

You may have to complete **missing sections**

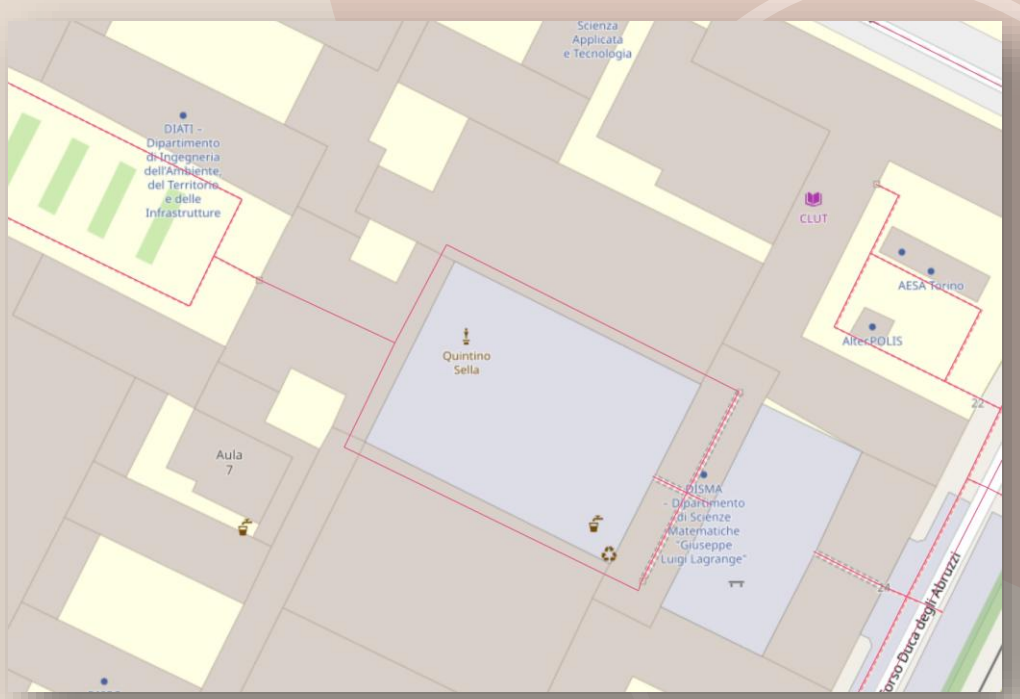


Edit the source

You may have to complete **missing sections**

In doing this:

- identify an appropriate and efficient method for retrieving new data (mapping party, tracing, GNSS tracks, etc.)



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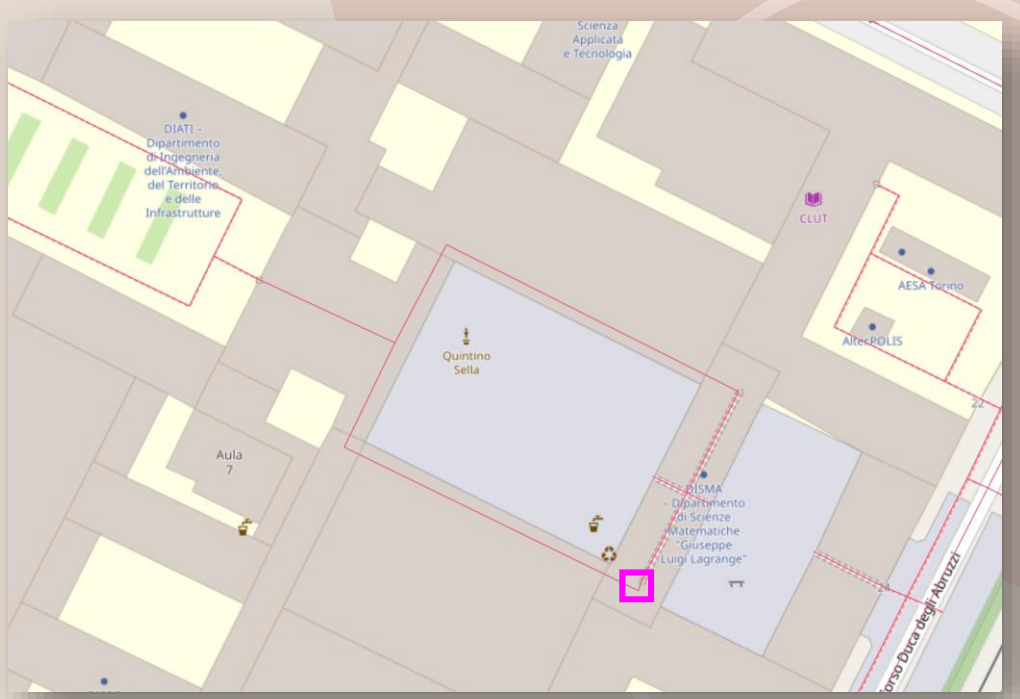
In doing this:

- identify an appropriate and efficient method for retrieving new data (mapping party, tracing, GNSS tracks, etc.)
- ensure connectivity by enabling snapping



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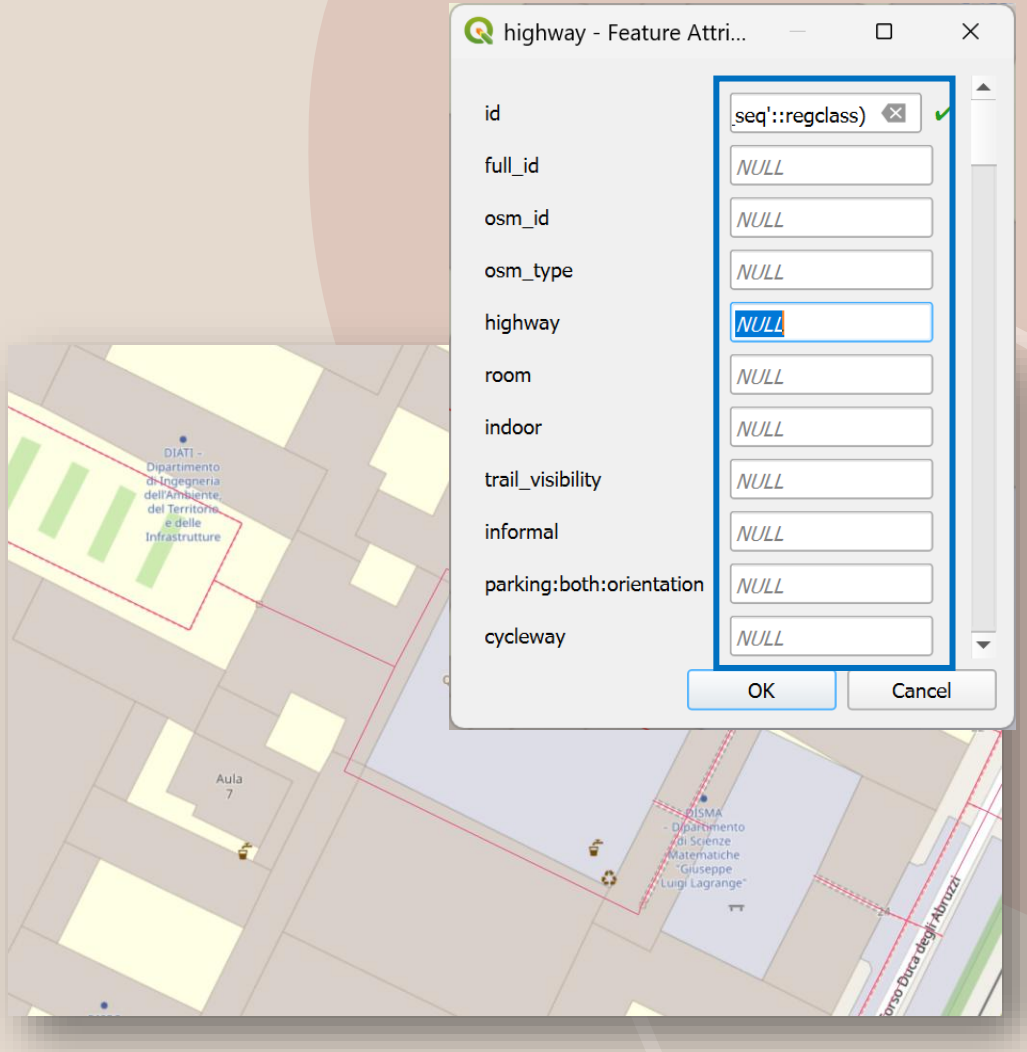
In doing this:

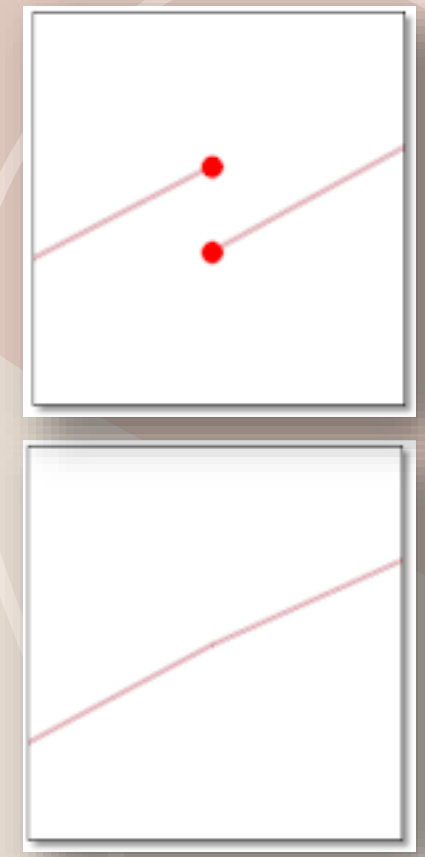
- identify an appropriate and efficient method for retrieving new data (mapping party, tracing, GNSS tracks, etc.)
- ensure connectivity by enabling snapping
- be ready to assign to each geometry the appropriate attributes



Check the connectivity

Connectivity ensures that there is a continuous path between the origin and destination points. Without connectivity, it would be impossible to find a valid route because there would be isolated segments or dead ends

For example, in a road network, if certain roads are not connected, you would be unable to travel between some locations, and routing algorithms would fail to identify a valid path between those locations

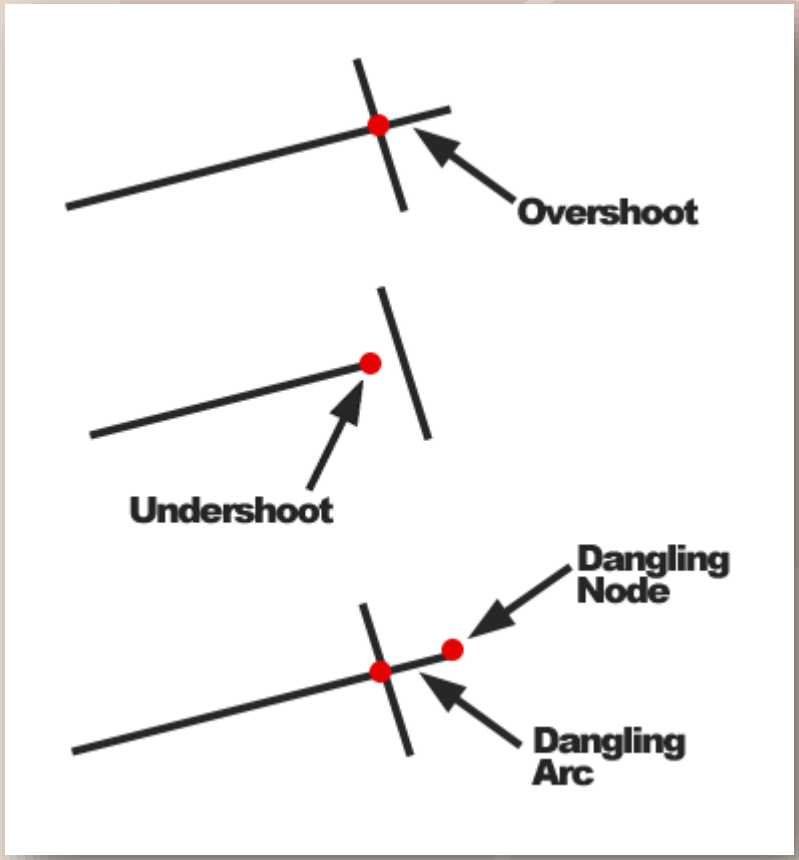


Check the connectivity

When the end vertex of a line does not snap to a point, line, or polygon resulting in a **dangle**

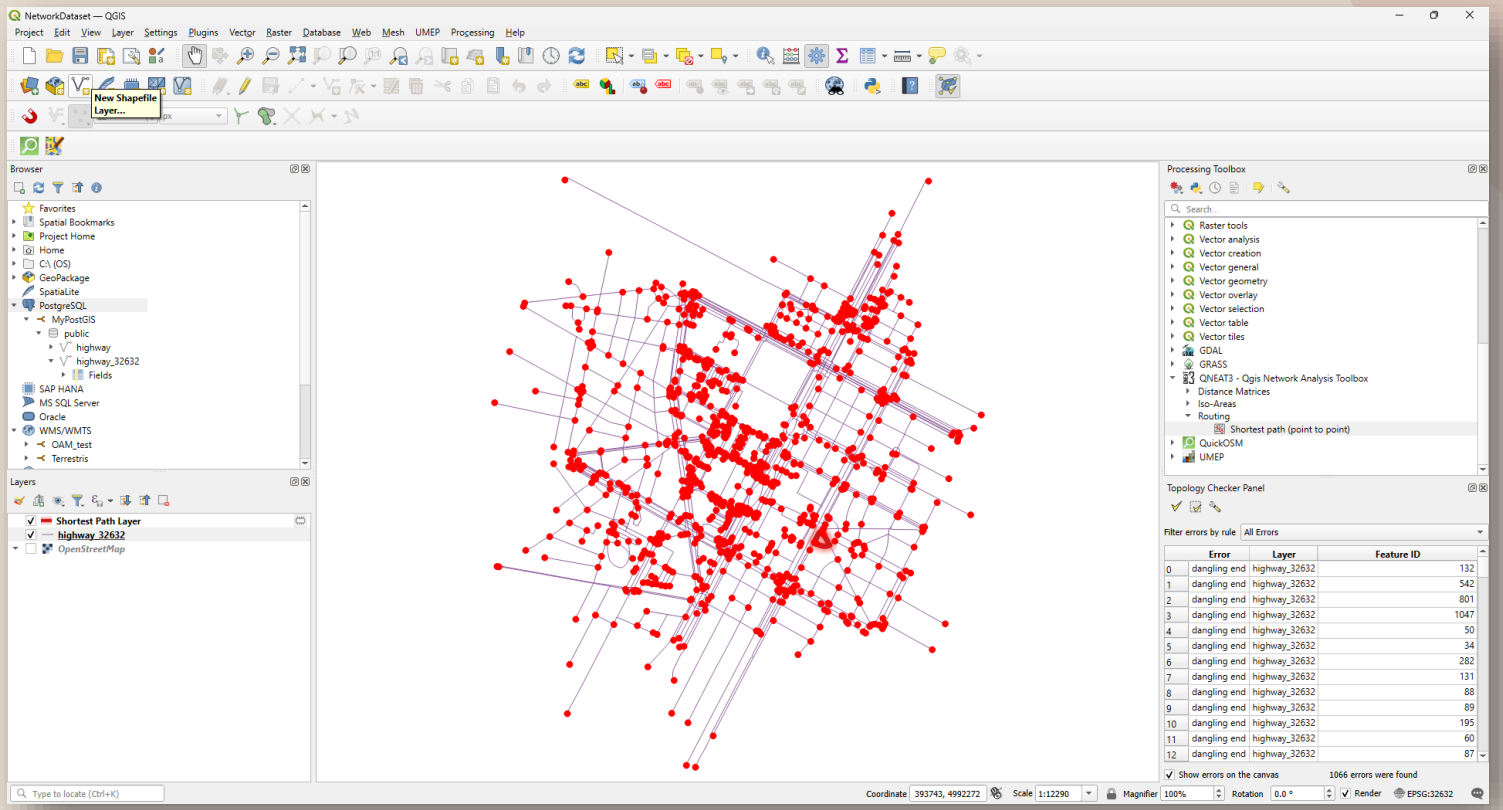
Overshoots occur when a line's endpoint does not snap to another feature resulting in a line extended too far

Undershoots occur when a line's endpoint does not snap to another feature resulting in a line too short



Check the connectivity

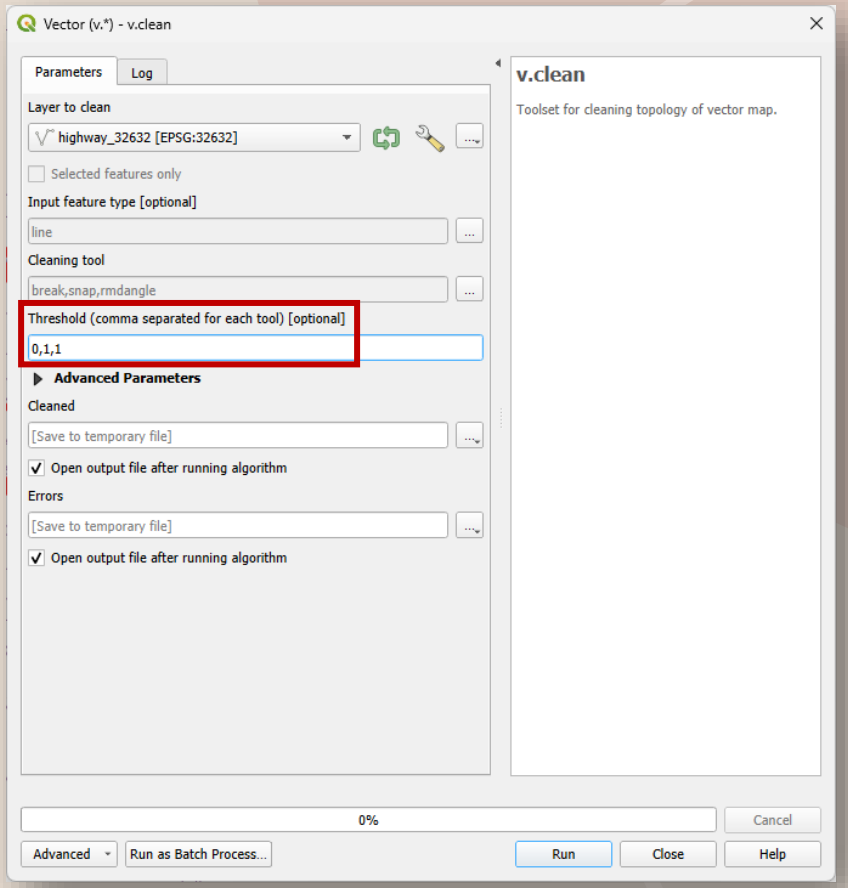
A possible solution for checking the topology is described here



Clean/correct the geometries

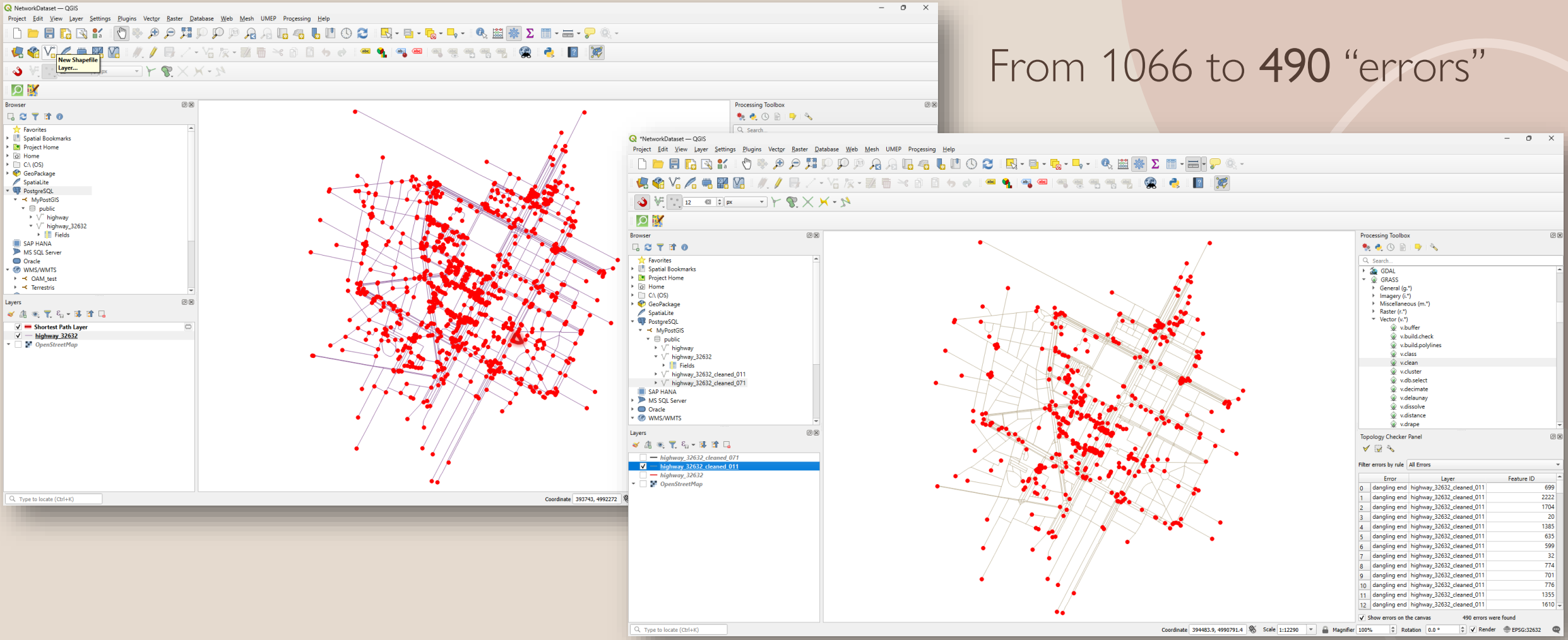
A possible solution for cleaning topology errors is described here

Smaller thresholds (e.g. 0,1,1) remove less errors but doesn't "destroy" original geometries



Clean/correct the geometries

From 1066 to **490** "errors"



Clean/correct the geometries

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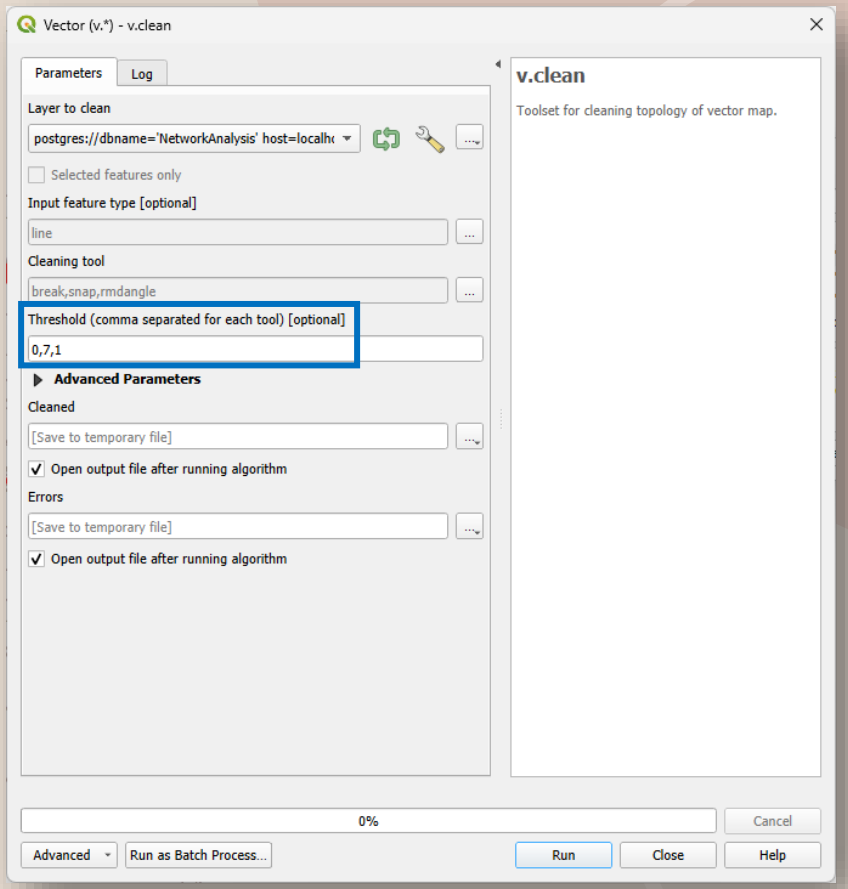
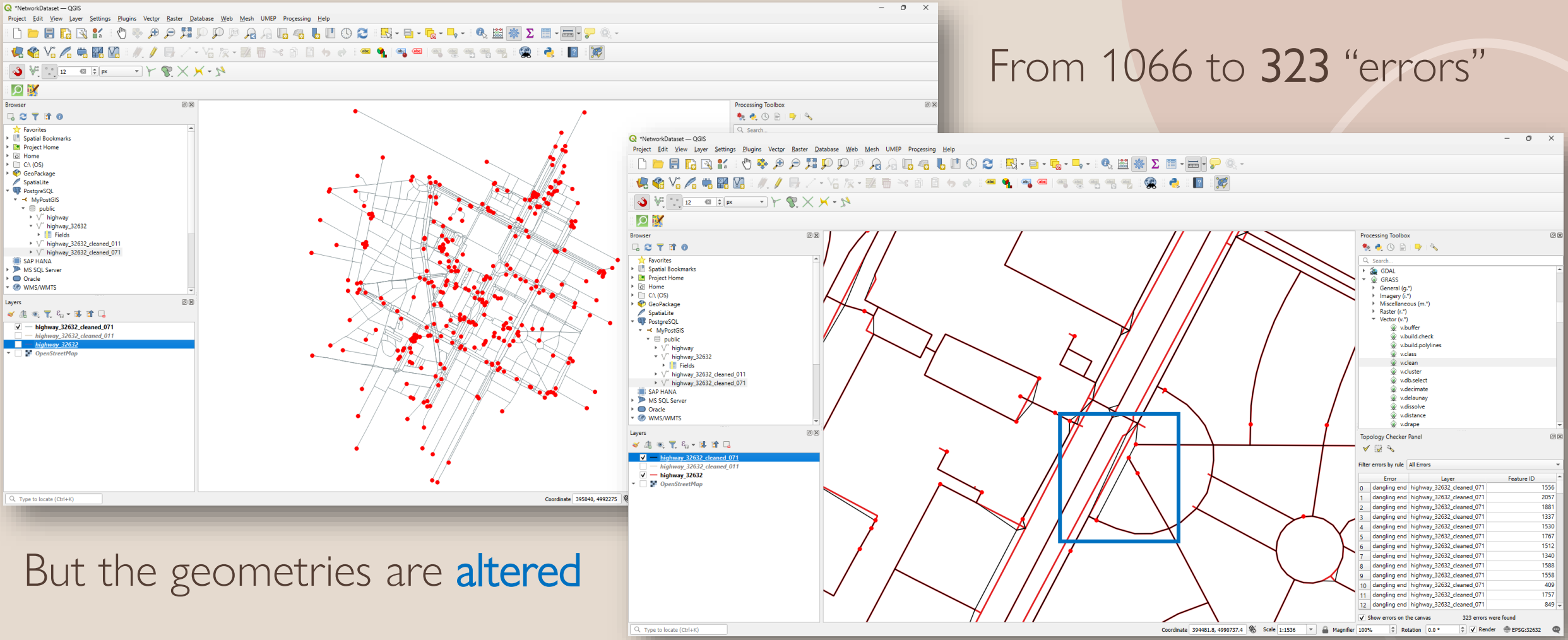
Larger thresholds (e.g. 0,7,1) remove more errors but significantly affect original geometries



Clean/correct the geometries

From 1066 to **323** "errors"

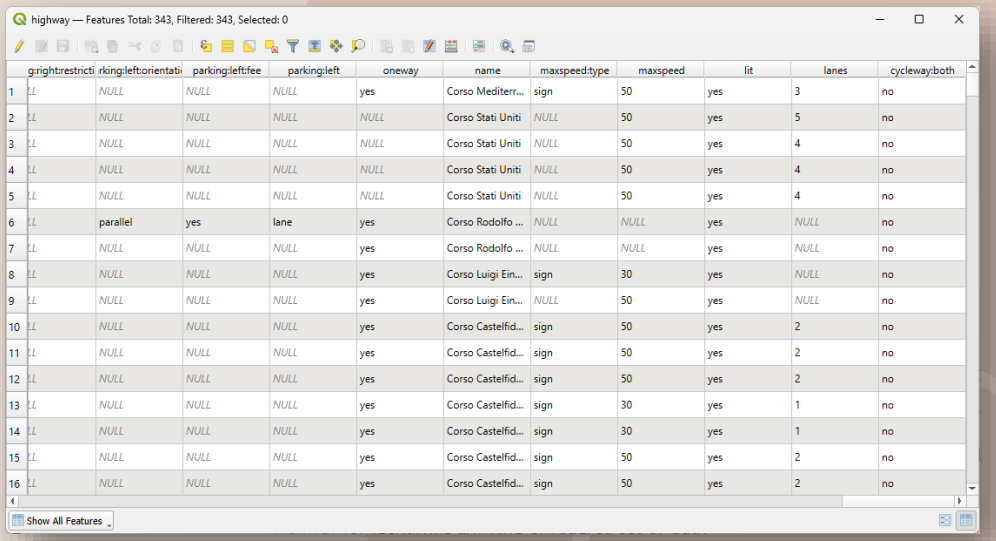


But the geometries are altered

Evaluate possible topology cleaning workflows

https://polito.padlet.org/andreaajmar/mapping-polito-spaces-network-analysis-qq8hnftja7usxjpp

Analyze the sources



	gright:restricti	rking:left:orientati	parking:left:fee	parking:left	oneway	name	maxspeed:type	maxspeed	lit	lanes	cycleway:both
1	NULL	NULL	NULL	NULL	yes	Corso Mediterr...	sign	50	yes	3	no
2	NULL	NULL	NULL	NULL	NULL	Corso Stati Uniti	NULL	50	yes	5	no
3	NULL	NULL	NULL	NULL	NULL	Corso Stati Uniti	NULL	50	yes	4	no
4	NULL	NULL	NULL	NULL	NULL	Corso Stati Uniti	NULL	50	yes	4	no
5	NULL	NULL	NULL	NULL	NULL	Corso Stati Uniti	NULL	50	yes	4	no
6	NULL	parallel	yes	lane	yes	Corso Rodolfo ...	NULL	NULL	yes	NULL	no
7	NULL	NULL	NULL	NULL	yes	Corso Rodolfo ...	NULL	NULL	yes	NULL	no
8	NULL	NULL	NULL	NULL	yes	Corso Luigi Ein...	sign	30	yes	NULL	no
9	NULL	NULL	NULL	NULL	yes	Corso Luigi Ein...	NULL	50	yes	NULL	no
10	NULL	NULL	NULL	NULL	yes	Corso Castelfid...	sign	50	yes	2	no
11	NULL	NULL	NULL	NULL	yes	Corso Castelfid...	sign	50	yes	2	no
12	NULL	NULL	NULL	NULL	yes	Corso Castelfid...	sign	50	yes	2	no
13	NULL	NULL	NULL	NULL	yes	Corso Castelfid...	sign	30	yes	1	no
14	NULL	NULL	NULL	NULL	yes	Corso Castelfid...	sign	30	yes	1	no
15	NULL	NULL	NULL	NULL	yes	Corso Castelfid...	sign	50	yes	2	no
16	NULL	NULL	NULL	NULL	yes	Corso Castelfid...	sign	50	yes	2	no

Have a look to the attributes and keep only the relevant ones. E.g.

- level for the 3D connectivity
- Impedance
  - maxspeed used on ways to define the maximum legal speed limit for general traffic on a particular road
- Restriction
  - wheelchair to mark places or ways that are suitable to be used with a wheelchair and a person with a disability
  - sidewalk to identify the part of a highway set aside for the exclusive use of pedestrians and sometimes cyclists too
  - oneway to indicate the access restriction on highways and other linear features for vehicles as appropriate
- Hierarchy
  - highway for identifying any kind of road, street or path

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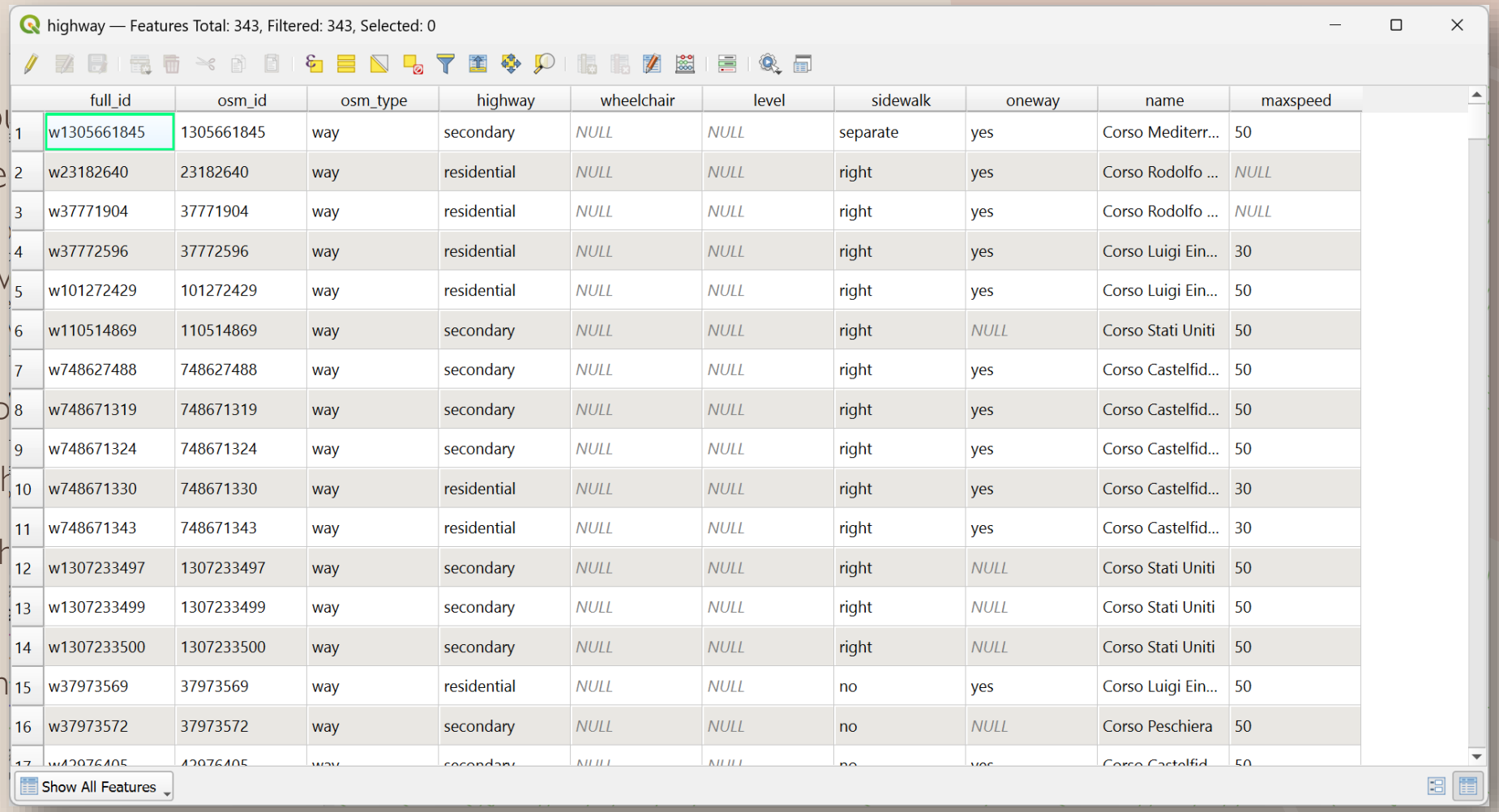
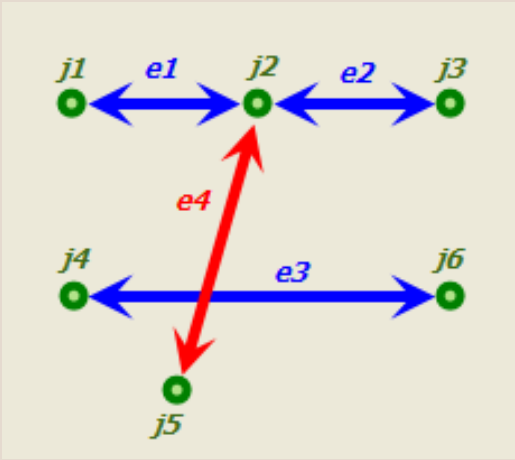
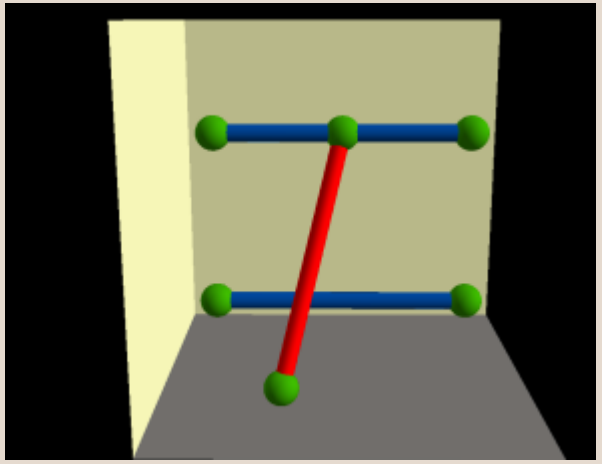


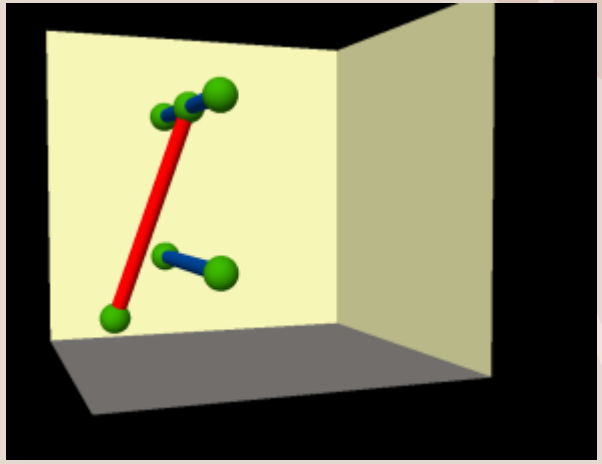
	full_id	osm_id	osm_type	highway	wheelchair	level	sidewalk	oneway	name	maxspeed
1	w1305661845	1305661845	way	secondary	NULL	NULL	separate	yes	Corso Mediterr...	50
2	w23182640	23182640	way	residential	NULL	NULL	right	yes	Corso Rodolfo ...	NULL
3	w37771904	37771904	way	residential	NULL	NULL	right	yes	Corso Rodolfo ...	NULL
4	w37772596	37772596	way	residential	NULL	NULL	right	yes	Corso Luigi Ein...	30
5	w101272429	101272429	way	residential	NULL	NULL	right	yes	Corso Luigi Ein...	50
6	w110514869	110514869	way	secondary	NULL	NULL	right	NULL	Corso Stati Uniti	50
7	w748627488	748627488	way	secondary	NULL	NULL	right	yes	Corso Castelfid...	50
8	w748671319	748671319	way	secondary	NULL	NULL	right	yes	Corso Castelfid...	50
9	w748671324	748671324	way	secondary	NULL	NULL	right	yes	Corso Castelfid...	50
10	w748671330	748671330	way	residential	NULL	NULL	right	yes	Corso Castelfid...	30
11	w748671343	748671343	way	residential	NULL	NULL	right	yes	Corso Castelfid...	30
12	w1307233497	1307233497	way	secondary	NULL	NULL	right	NULL	Corso Stati Uniti	50
13	w1307233499	1307233499	way	secondary	NULL	NULL	right	NULL	Corso Stati Uniti	50
14	w1307233500	1307233500	way	secondary	NULL	NULL	right	NULL	Corso Stati Uniti	50
15	w37973569	37973569	way	residential	NULL	NULL	no	yes	Corso Luigi Ein...	50
16	w37973572	37973572	way	secondary	NULL	NULL	no	NULL	Corso Peschiera	50

Model the connectivity

If you are interested in navigating through different levels, you must find a way to manage this situation







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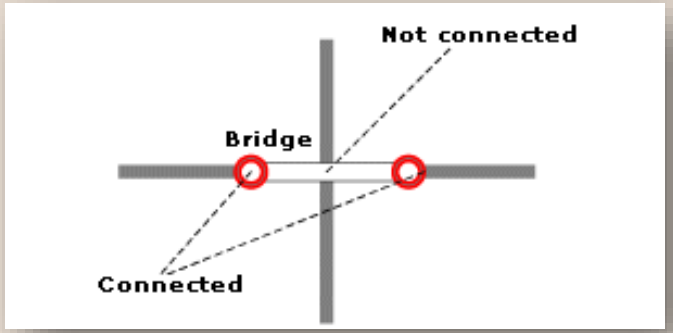
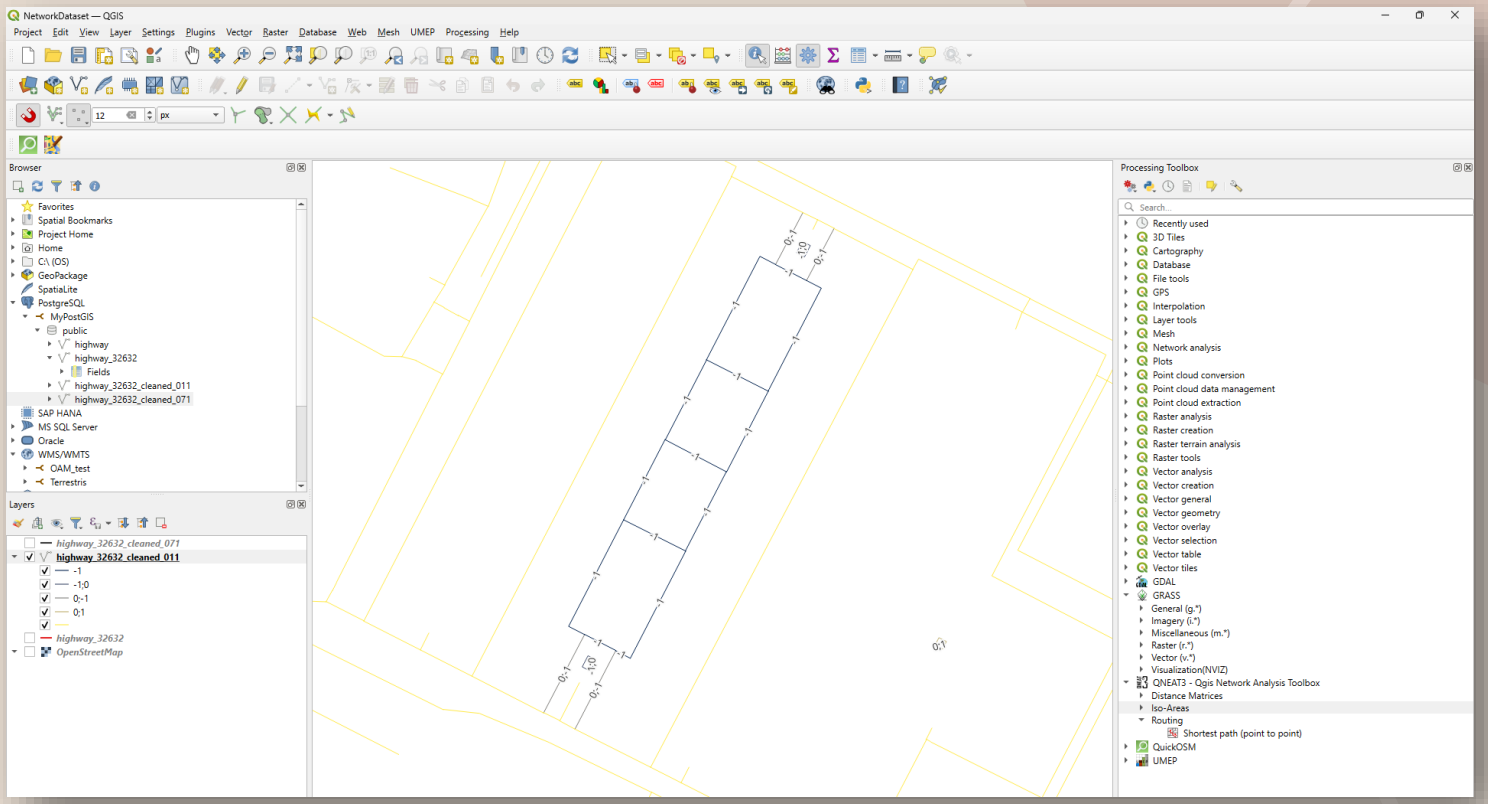


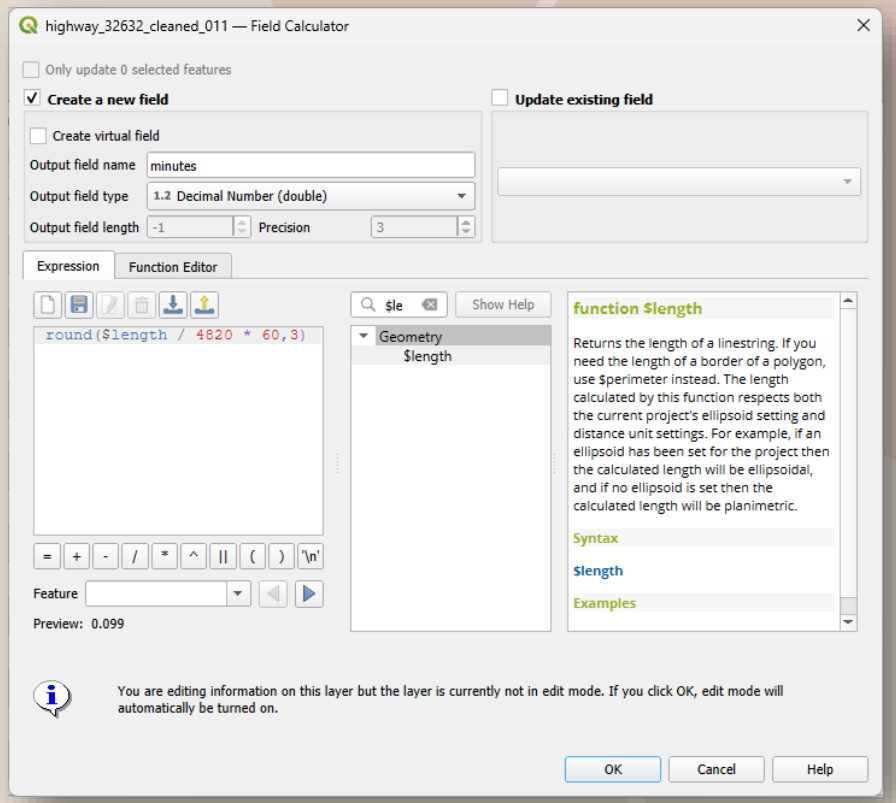


Impedances

You may be interested in performing a network analysis minimizing **time cost** (instead of distance)

Knowing the walking speed and edges' length, it's possible to derive the time needed to go through each single edge

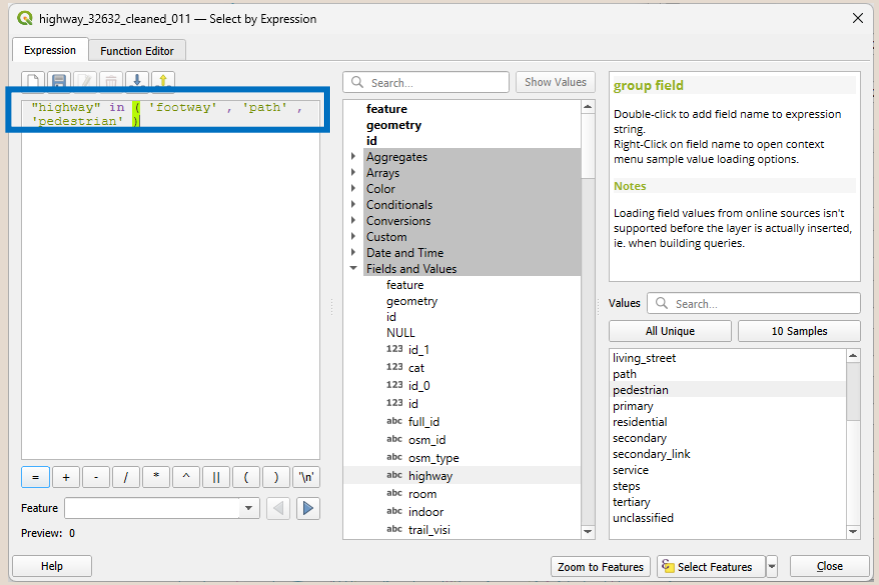
Age	Kilometers per hour (km/h)	Miles per hour (mph)
<30	4.82 km/h	3 mph
30–39	4.54 km/h	2.8 mph
40–49	4.54 km/h	2.8 mph
50–59	4.43 km/h	2.75 mph
>60	4.34 km/h	2.7 mph
>65	3.42 km/h	2.1 mph

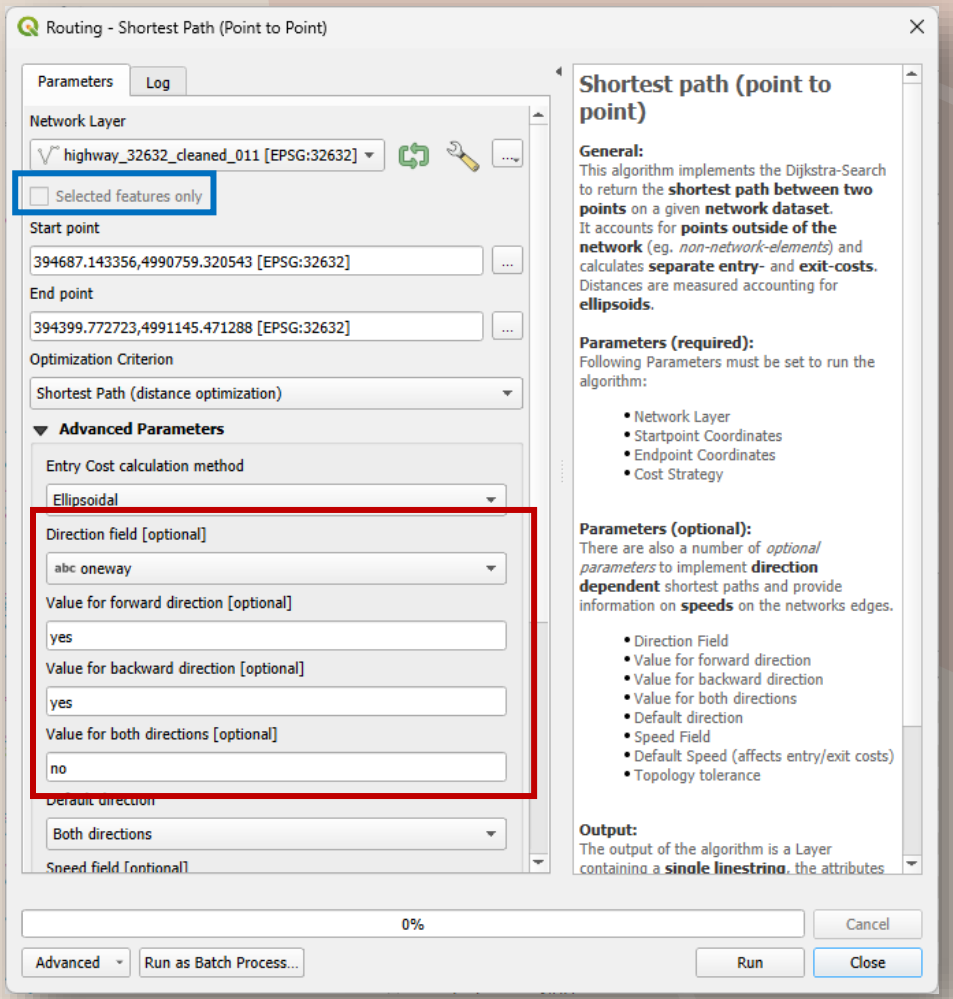


Restrictions

You may want to manage limitations, such as:

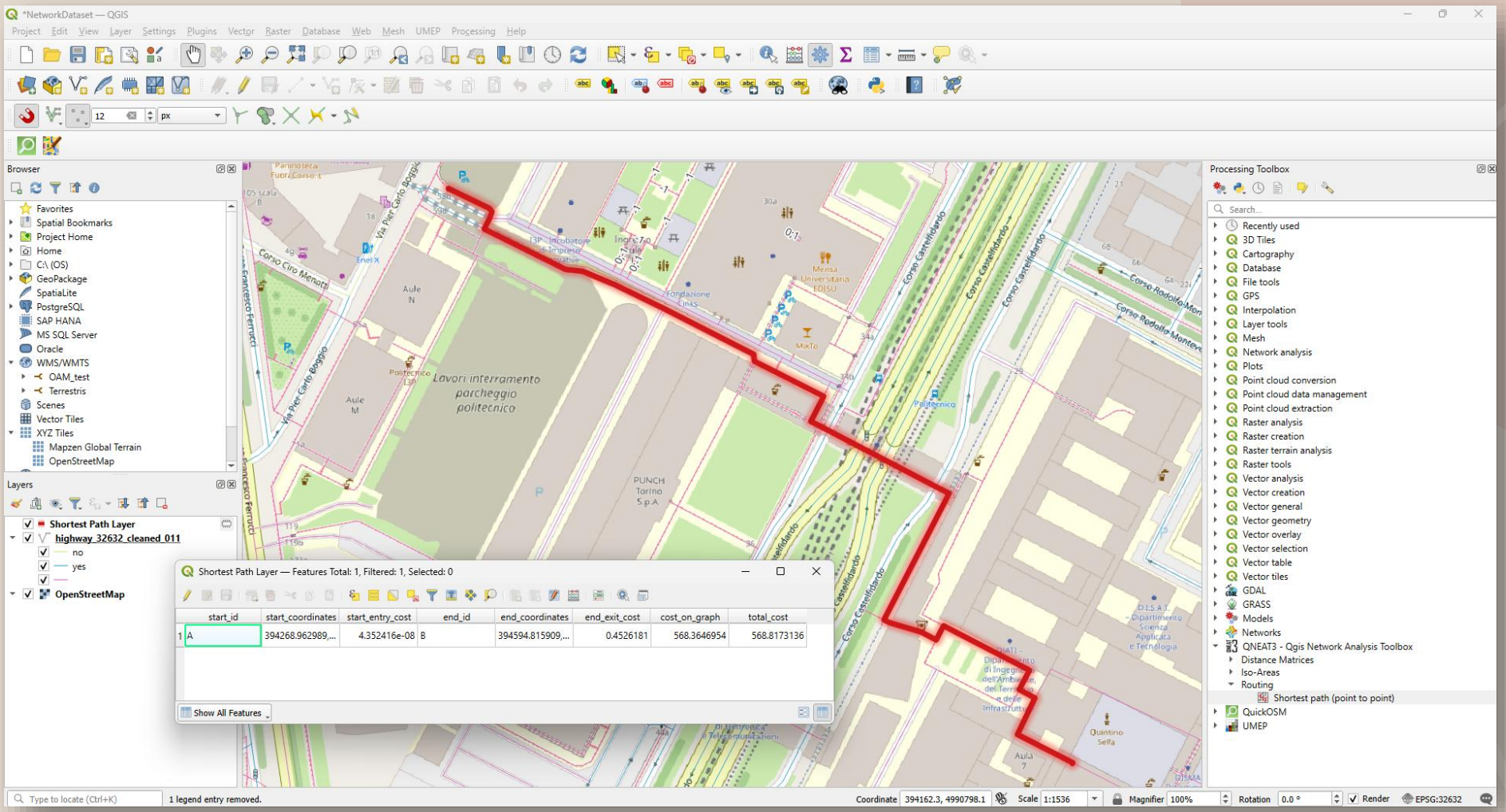
- one-ways
- pedestrian paths



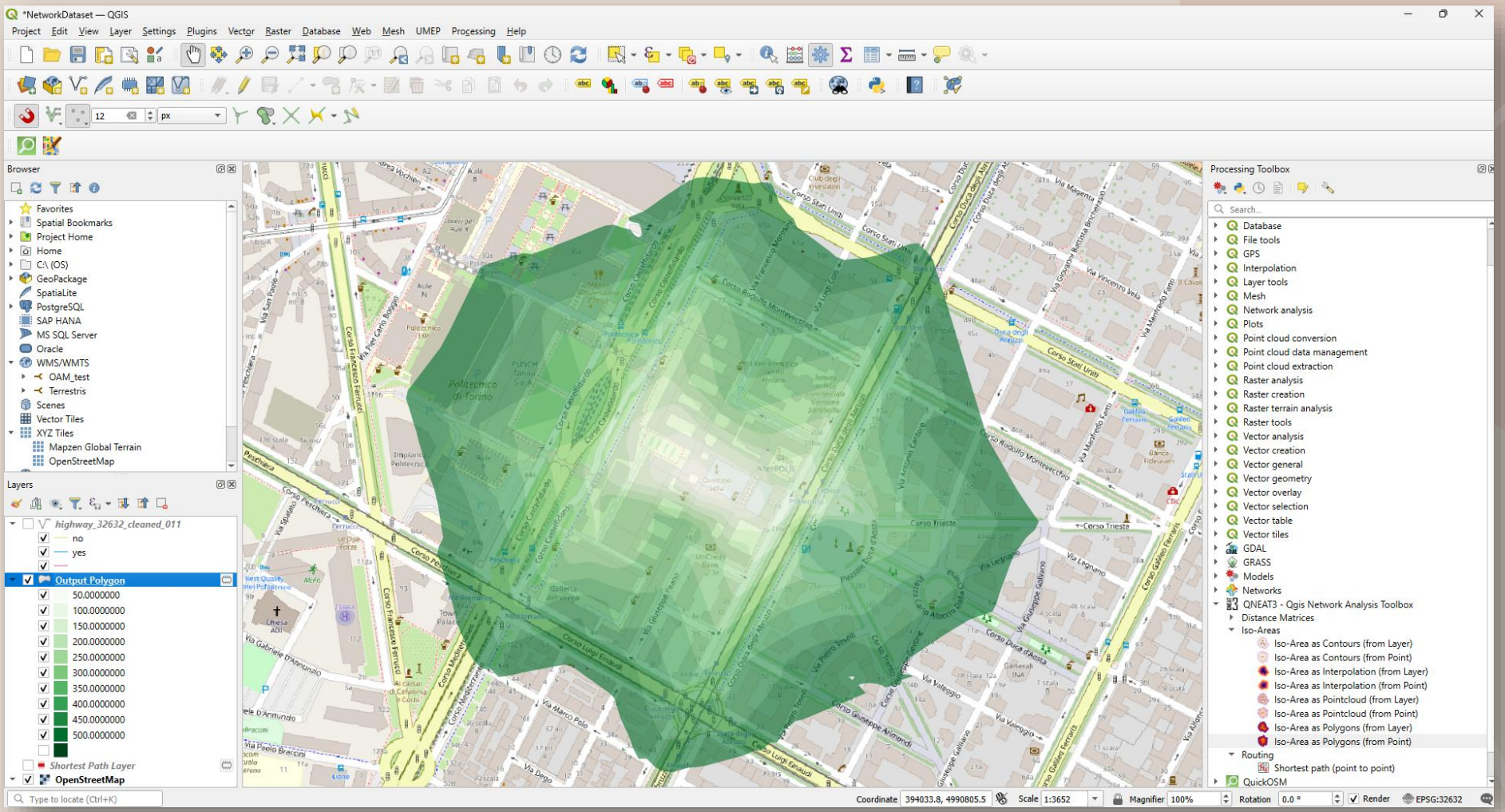


Network analysis

Routing


*NetworkDataset — QGIS
Browser
Layers
Processing Toolbox
Shortest Path Layer
highway_32632_cleaned_011
OpenStreetMap
Shortest Path Layer — Features Total: 1, Filtered: 1, Selected: 0
start_id | start_coordinates | start_entry_cost | end_id | end_coordinates | end_exit_cost | cost_on_graph | total_cost
A | 394268.962989,... | 4.352416e-08 | B | 394594.815909,... | 0.4526181 | 568.3646954 | 568.8173136
Lavori interramento parcheggio politecnico
1 legend entry removed.

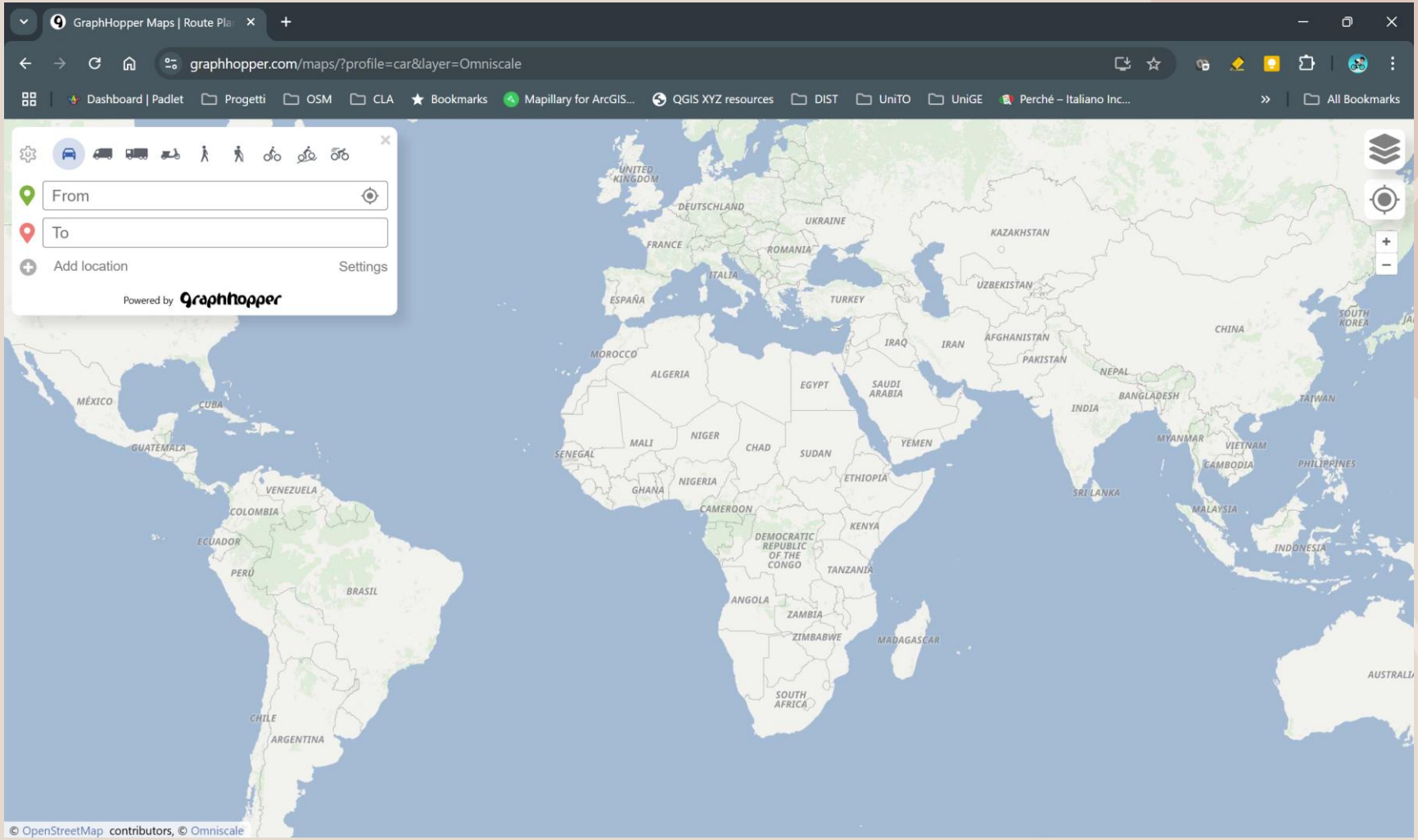
Iso-areas


*NetworkDataset — QGIS
Project Edit View Layer Settings Plugins Vector Raster Database Web Mesh UMEP Processing Help
Browser
Favorites
Spatial Bookmarks
Project Home
Home
C:\ (OS)
GeoPackage
SpatiaLite
PostgreSQL
SAP HANA
MS SQL Server
Oracle
WMS/WMTS
OAM_test
Terrestris
Scenes
Vector Tiles
XYZ Tiles
Mapzen Global Terrain
OpenStreetMap
Layers
highway_32632_cleaned_011
no
yes
Output Polygon
50.0000000
100.0000000
150.0000000
200.0000000
250.0000000
300.0000000
350.0000000
400.0000000
450.0000000
500.0000000
Shortest Path Layer
OpenStreetMap
Processing Toolbox
Search...
Database
File tools
GPS
Interpolation
Layer tools
Mesh
Network analysis
Plots
Point cloud conversion
Point cloud data management
Point cloud extraction
Raster analysis
Raster creation
Raster terrain analysis
Raster tools
Vector analysis
Vector creation
Vector general
Vector geometry
Vector overlay
Vector selection
Vector table
Vector tiles
GDAL
GRASS
Models
Networks
QNEAT3 - Qgis Network Analysis Toolbox
Distance Matrices
Iso-Areas
Iso-Area as Contours (from Layer)
Iso-Area as Contours (from Point)
Iso-Area as Interpolation (from Layer)
Iso-Area as Interpolation (from Point)
Iso-Area as Pointcloud (from Layer)
Iso-Area as Pointcloud (from Point)
Iso-Area as Polygons (from Layer)
Iso-Area as Polygons (from Point)
Routing
Shortest path (point to point)
QuickOSM
Coordinate 394033.8, 4990805.5
Scale 1:3652
Magnifier 100%
Rotation 0.0 °
Render
EPSG:32632

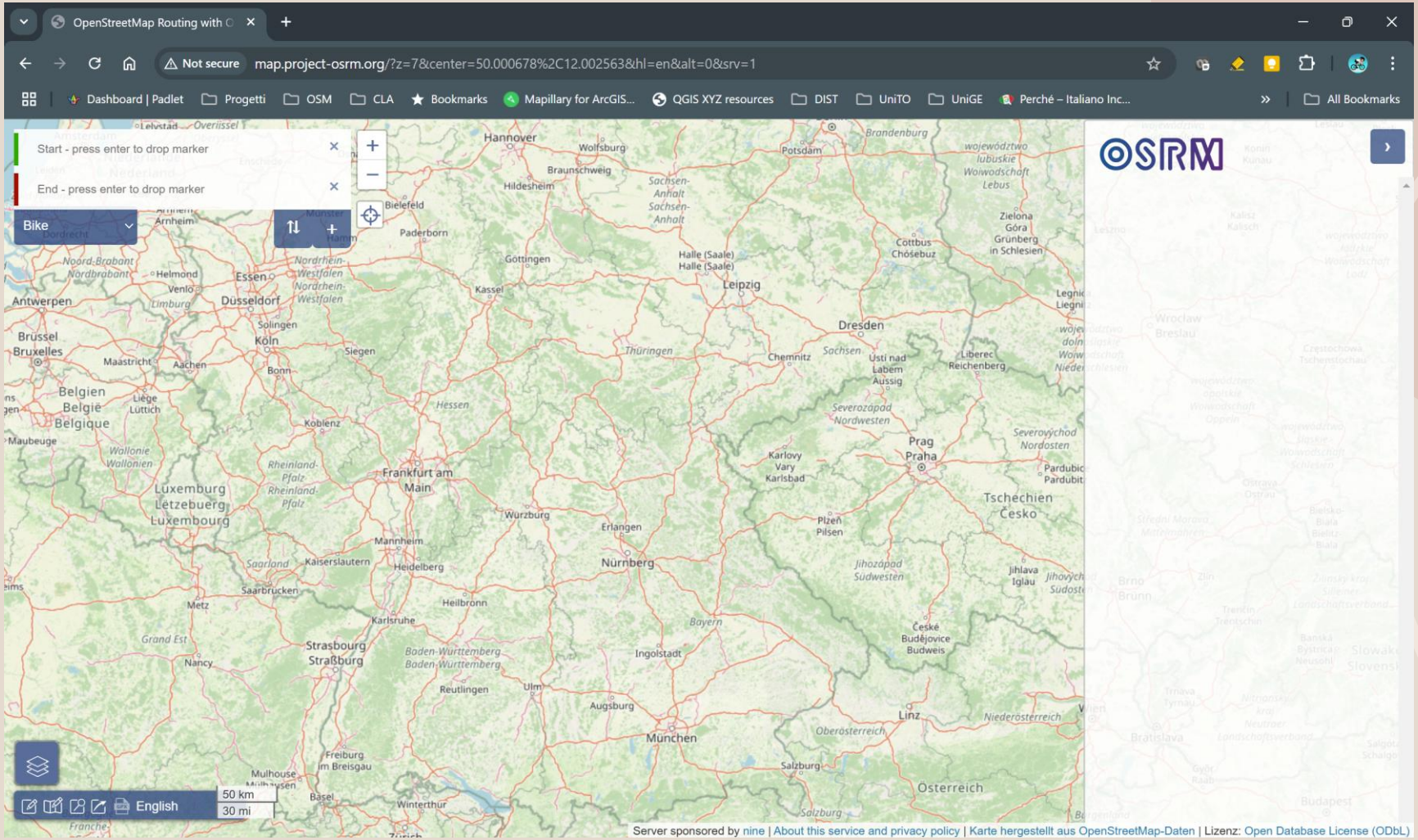
Evaluate alternatives in available routing algorithms

https://polito.padlet.org/andreaajmar/mapping-polito-spaces-network-analysis-qq8hnftja7usxjpp

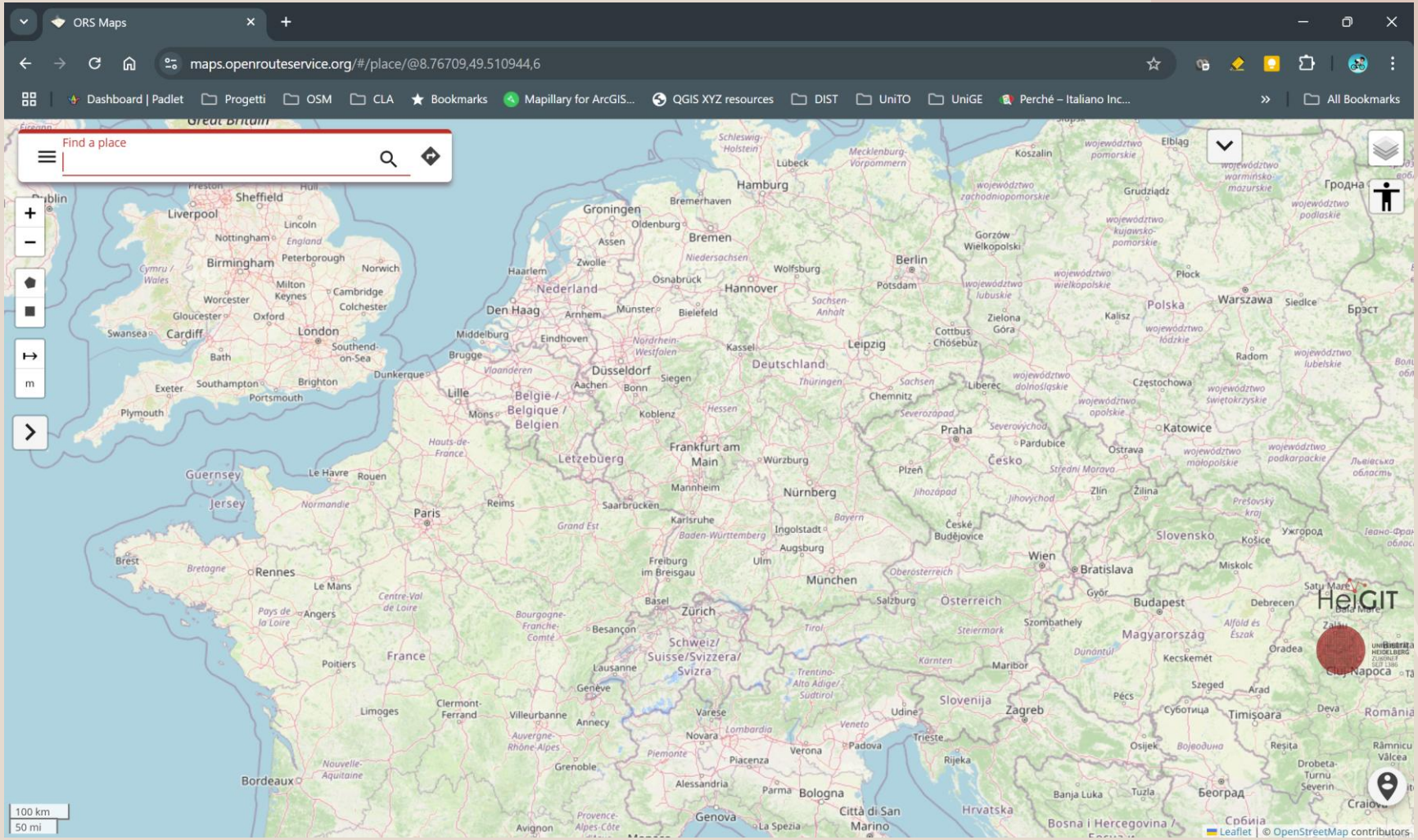
Existing applications



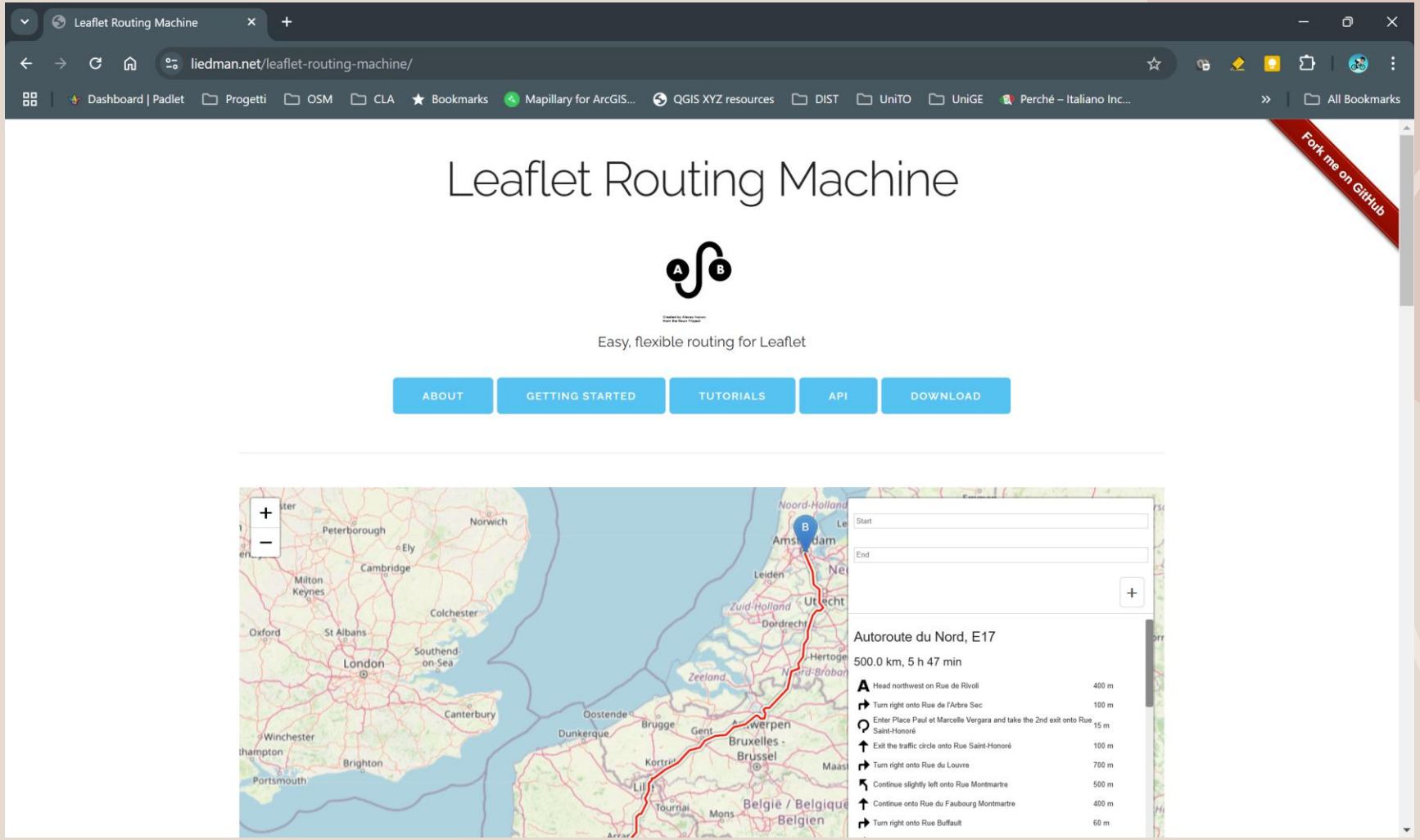
Existing applications



Existing applications



Existing applications



OSM resources

Routing

routing

Routing **- Other languages** Purge · Help

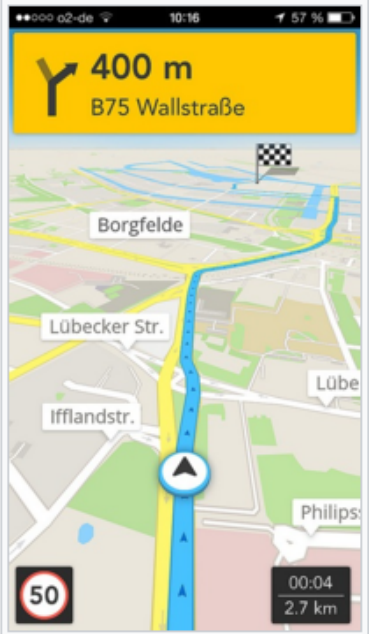
Deutsch **English** español français italiano русский پنجابی ਪੰਜਾਬੀ 한국어 中文 (简体) 日本語

Other languages...

Routing services (in some countries called *navigation* services) help people get from one place to another. OpenStreetMap data includes information for routing by many modes including car, foot, bicycle and horse. There are many offline, embedded and web-based routing services using OpenStreetMap data.

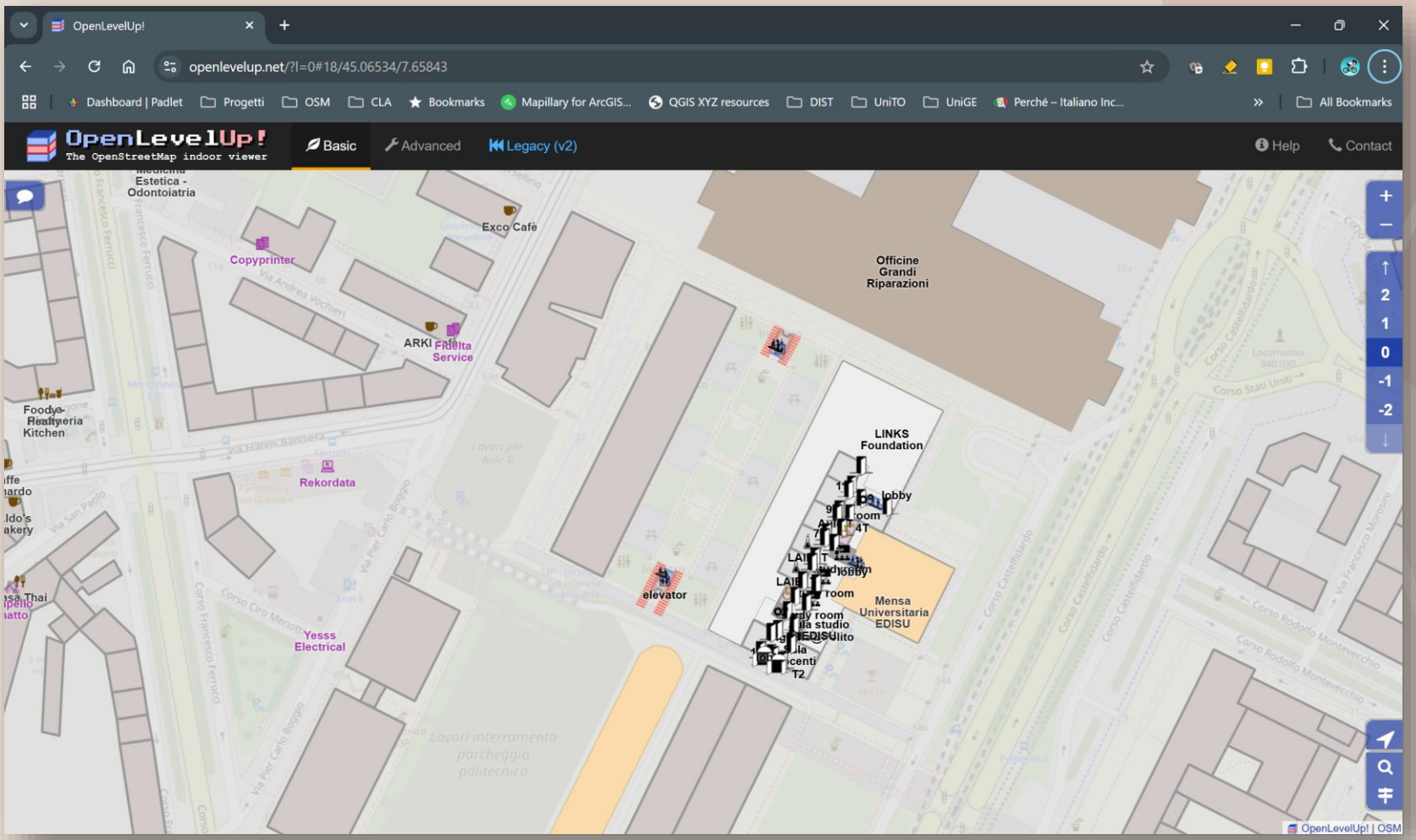
For developers this page provides advice on software available for creating new routing applications/deployments and details key OpenStreetMap data that can be used to create better routing engines. A number of mailing lists are also available.

Contents [hide]



Skobbler Navigation (online turn-by-turn navigation app for iOS).

OSM resources



A relevant event...

ArcGIS Indoors: La potenza del GIS all'interno delle tue strutture per la gestione degli spazi

Il **13 marzo** alle ore **11:00 Esri Italia**, in collaborazione con **RFI**, organizza un webinar dedicato ad **ArcGIS Indoors**.

ArcGIS Indoors permette all'organizzazione di creare un **sistema di informazioni geografico** *(GIS)* per ambienti interni e conferisce il potere del software di mappatura, identificazione strada e gestione dello spazio nelle mani degli utenti. Trasforma **CAD**, **BIM** e altre forme di dati di planimetrie in un sistema di record indoor, un unico luogo accessibile che può essere utilizzato per supportare la mappatura delle risorse, la sicurezza e la pianificazione di eventi attraverso l'orientamento, la gestione delle strutture e l'interazione con gli edifici.

Di seguito gli argomenti che verranno trattati durante il webinar
- ArcGIS Indoors
- ArcGIS Indoors Pro
- ArcGIS for AutoCAD
- Floor Plan Editor
- Caso d'uso RFI
- Questions & Answers

Il webinar sarà tenuto da ***Mariafrancesca Carrieri, Solutions Architect Esri Italia*** e ***Danilo Palermo, GIS Analyst RFI***.

Non perdere l'occasione, partecipa al webinar del 13 marzo.

I webinar di Esri Italia sono eventi gratuiti, previa iscrizione.