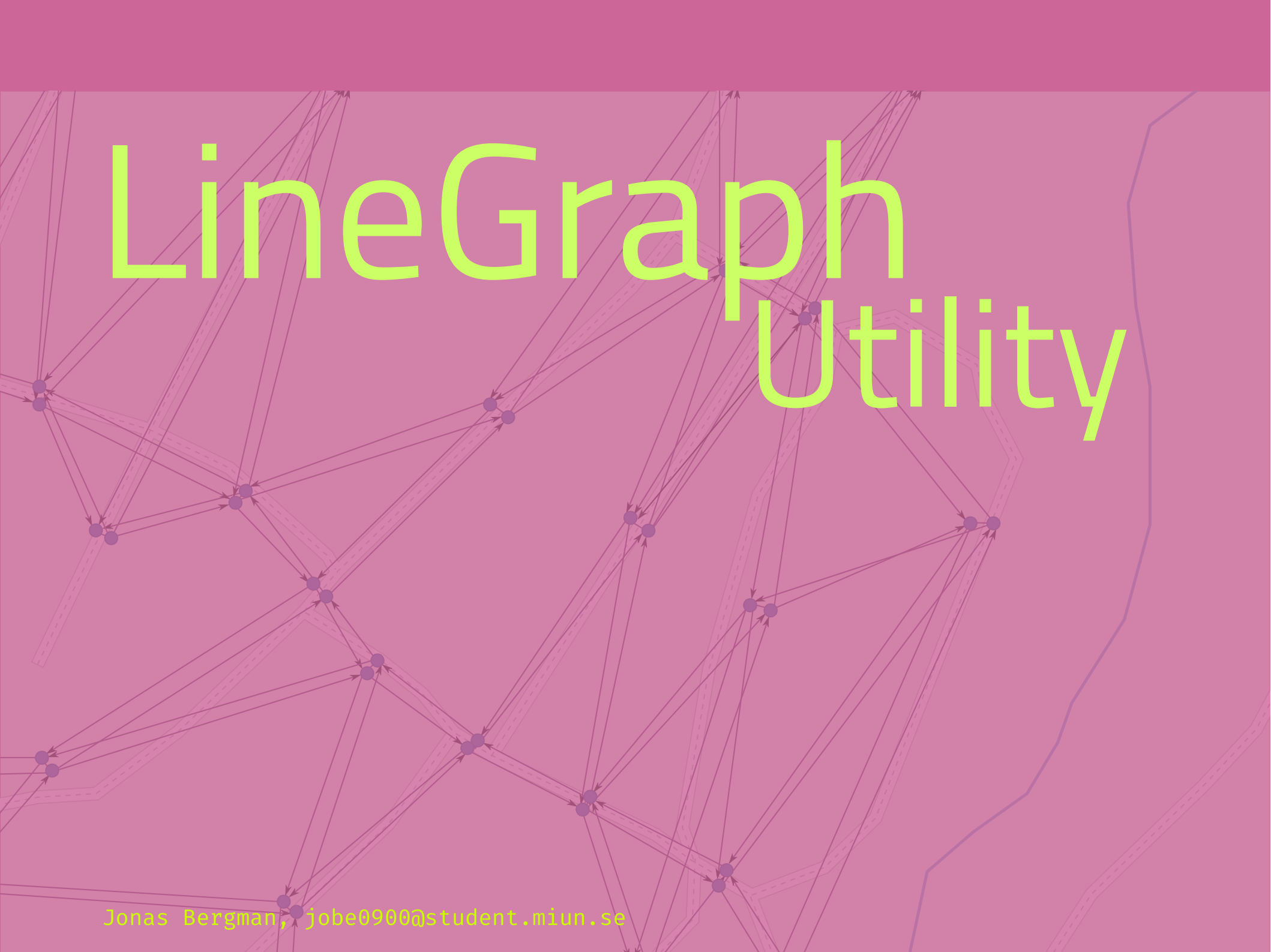
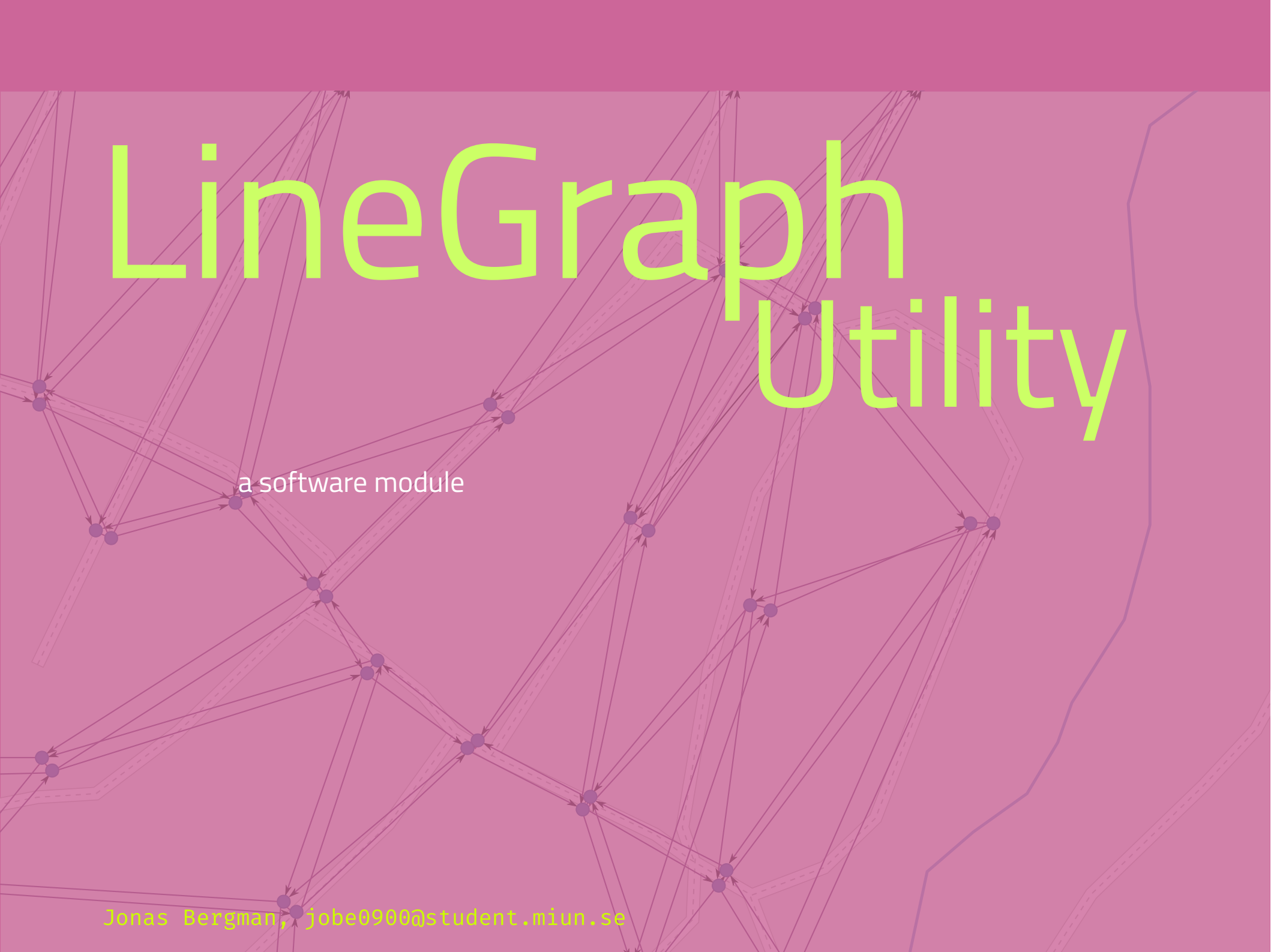


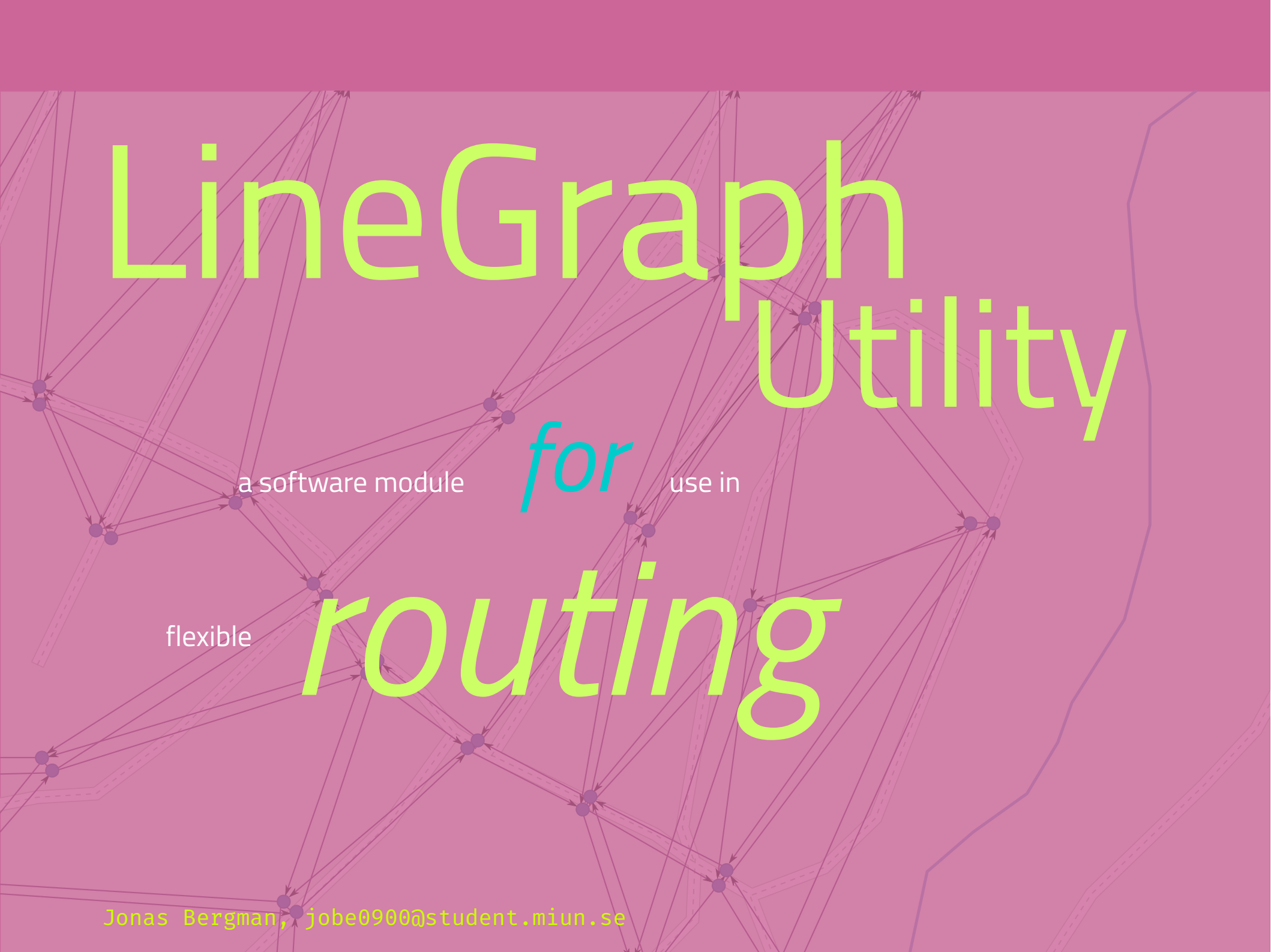
# LineGraph Utility

The background of the slide features a light purple map of a road network. Overlaid on this map is a complex graph structure. The graph consists of numerous small, dark purple circular nodes. These nodes are interconnected by a dense web of thin, dark purple lines representing edges. Some of these edges are directed, as indicated by small arrowheads. The graph appears to be a utility or network model, possibly representing a transportation or communication system, with nodes located at various points along the road network.

# LineGraph Utility

The background of the slide features a complex directed graph. It consists of numerous small, dark purple circular nodes connected by thin, light purple lines. Some of these lines have arrowheads, indicating the direction of the edges. The graph is overlaid on a faint, light purple map of a city, with the graph's structure following the general layout of the city's streets and landmarks.

a software module

A complex network diagram with numerous nodes and directed edges, overlaid on a light purple background. The nodes are represented by small dark purple circles, and the edges are thin lines with arrowheads. The network is dense and interconnected, with some nodes having multiple incoming and outgoing connections. The overall style is technical and abstract, suggesting a network or graph structure.

# LineGraph Utility

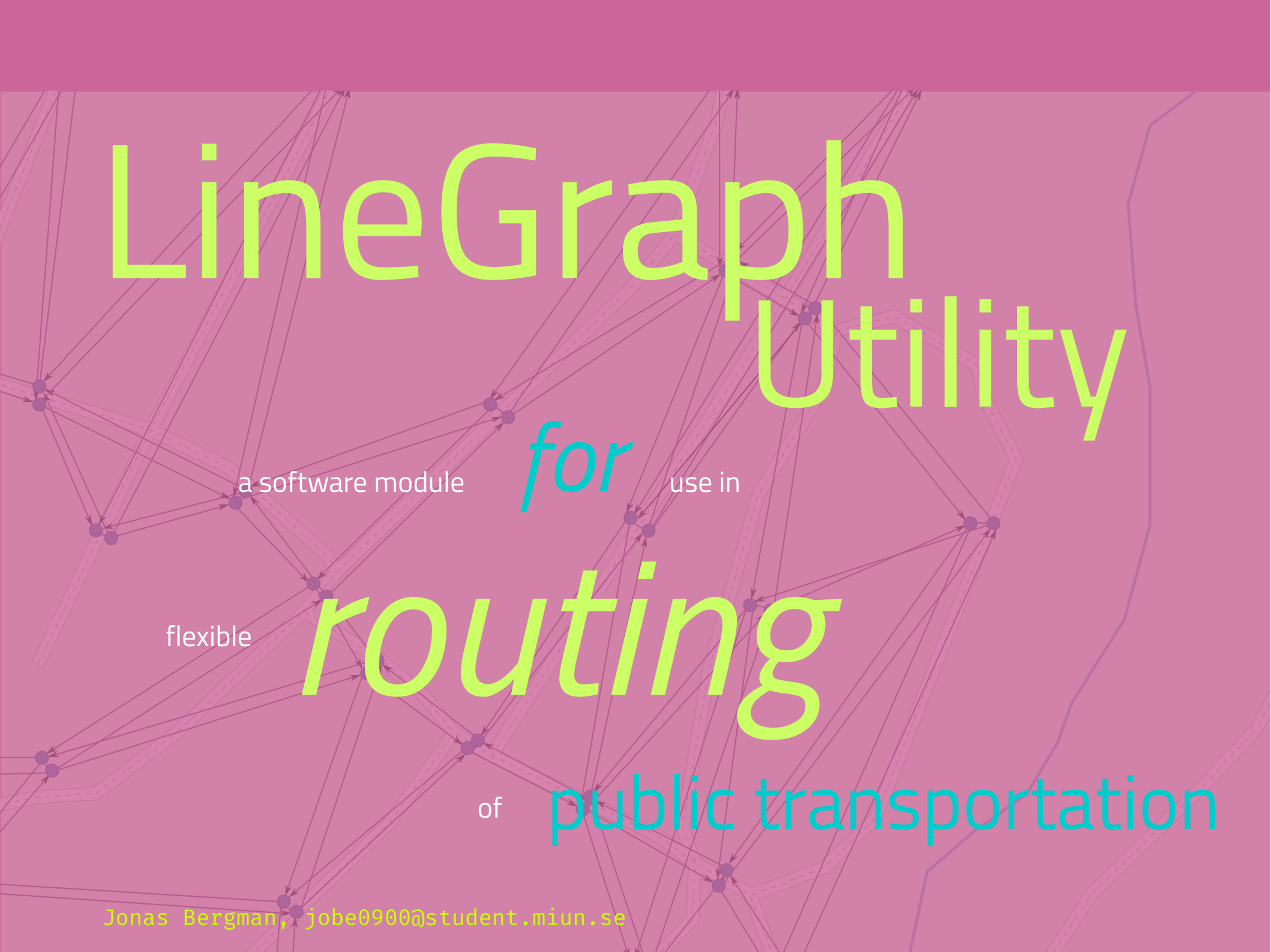
a software module

*for*

use in

flexible

# *routing*



# LineGraph Utility *for* *routing* of public transportation

a software module use in  
flexible

# requirements



in: *map* data

in: *map* data

out: *line graph*

1 load *map* data



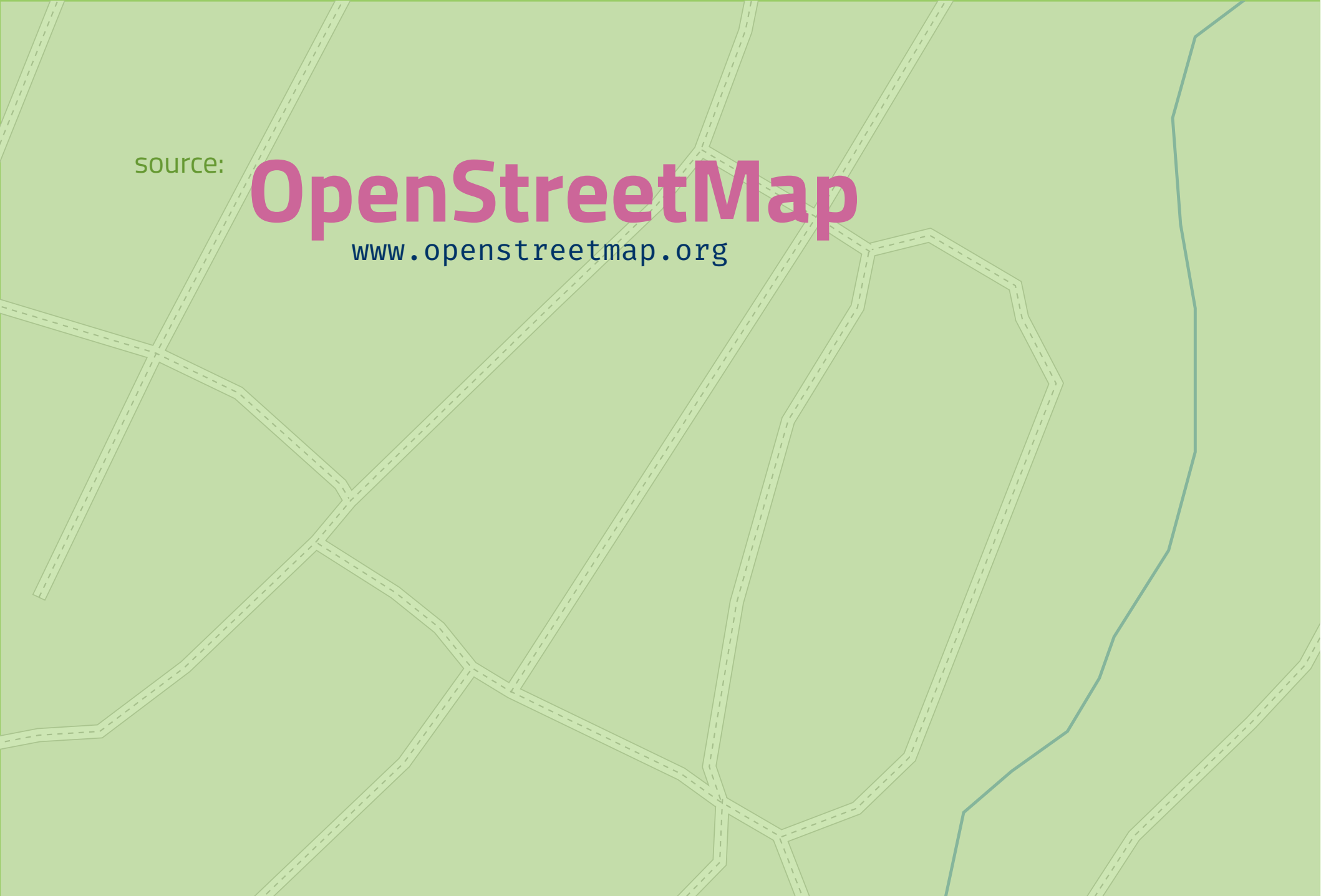
# 1. map



## 1. map

source:

**OpenStreetMap**  
[www.openstreetmap.org](http://www.openstreetmap.org)



## 1. map

source:

**OpenStreetMap**  
[www.openstreetmap.org](http://www.openstreetmap.org)

store:

**PostGIS**  
[www.postgis.net](http://www.postgis.net)

# 1. map

source:

# OpenStreetMap

[www.openstreetmap.org](http://www.openstreetmap.org)

store:

# PostGIS

*PostgreSQL + spatial data extension*

[www.postgis.net](http://www.postgis.net)

# 1. map

source:

# OpenStreetMap

[www.openstreetmap.org](http://www.openstreetmap.org)

load:

```
$ osm2pgsql
```

store:

# PostGIS

[www.postgis.net](http://www.postgis.net)

*PostgreSQL + spatial data extension*

# 1. map

source:

# OpenStreetMap

[www.openstreetmap.org](http://www.openstreetmap.org)

load:

```
$ osm2pgsql -U user -d map_db -s -k mapdata.osm
```

store:

# PostGIS

[www.postgis.net](http://www.postgis.net)

*PostgreSQL + spatial data extension*

1 load *map* data

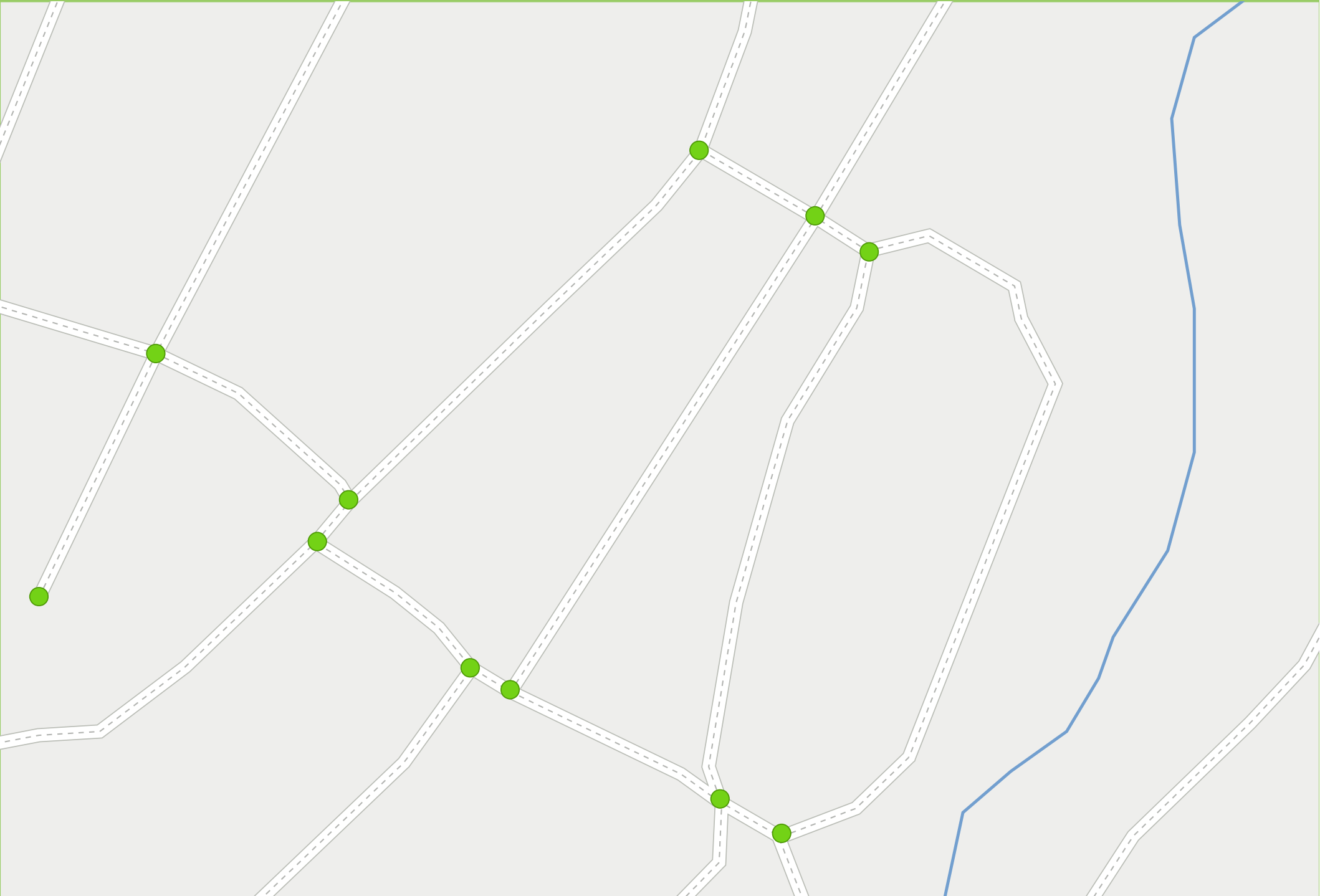
2 build *topology*

## 2. topology





## 2. topology



## 2. topology



## 2. topology



## 2. topology



## 2. topology



## 2. topology

tool:

postgis\_topology



1 load *map* data

2 build *topology*

3 apply *restrictions*

### 3. restrictions







### 3. restrictions

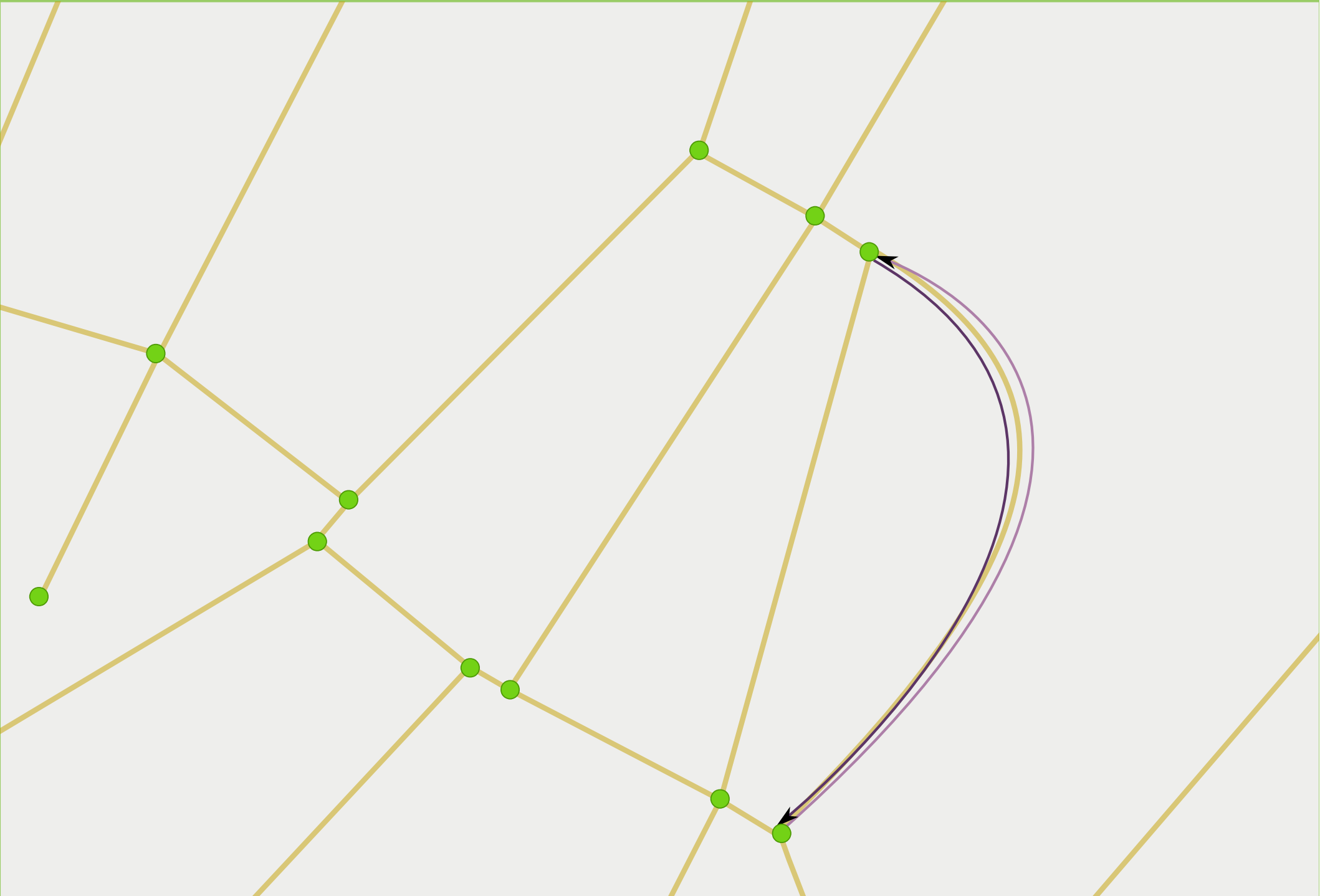


### 3. restrictions (directed graph)





### 3. restrictions (directed graph)



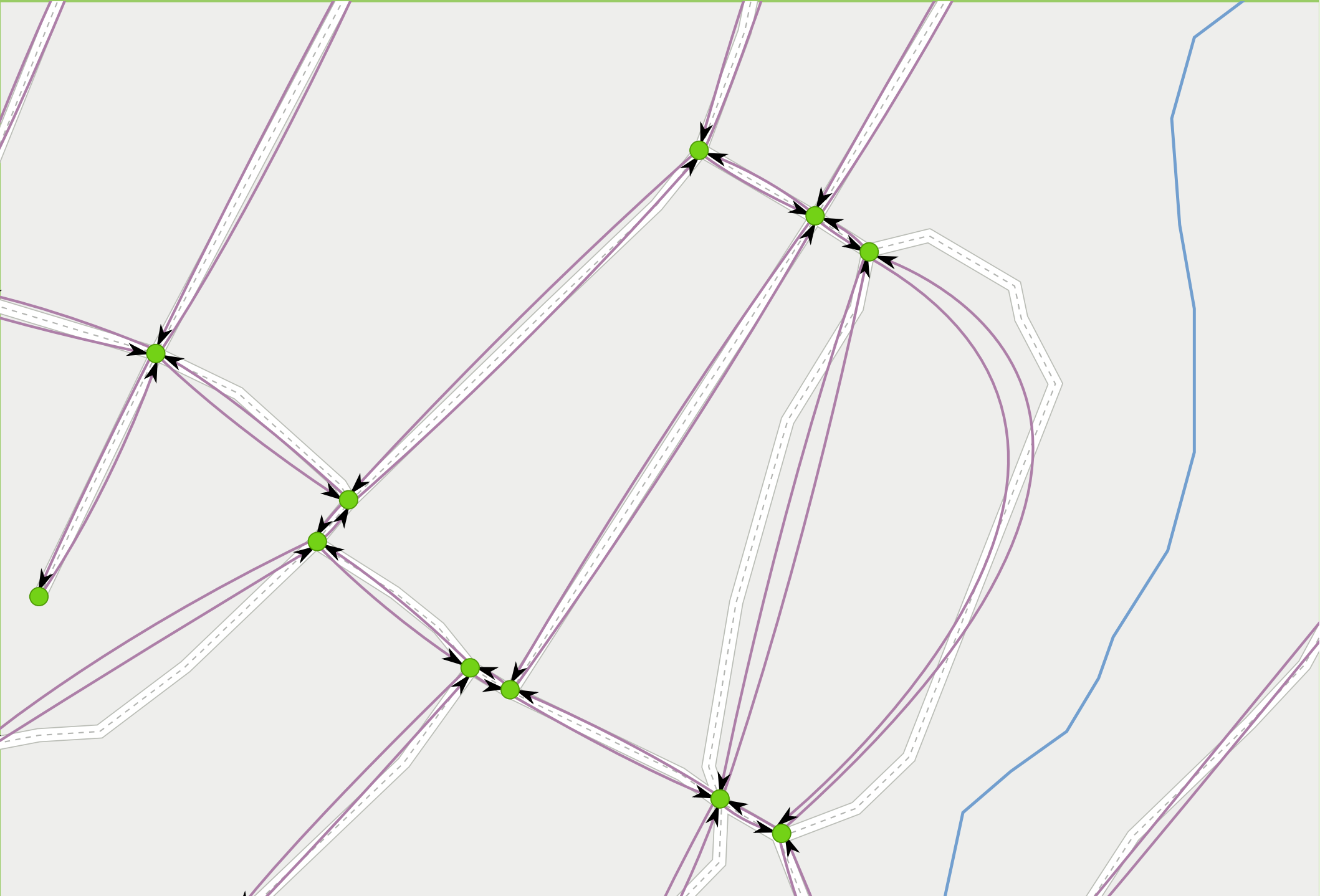
### 3. restrictions (directed graph)



### 3. restrictions (directed graph)



### 3. restrictions (directed graph)

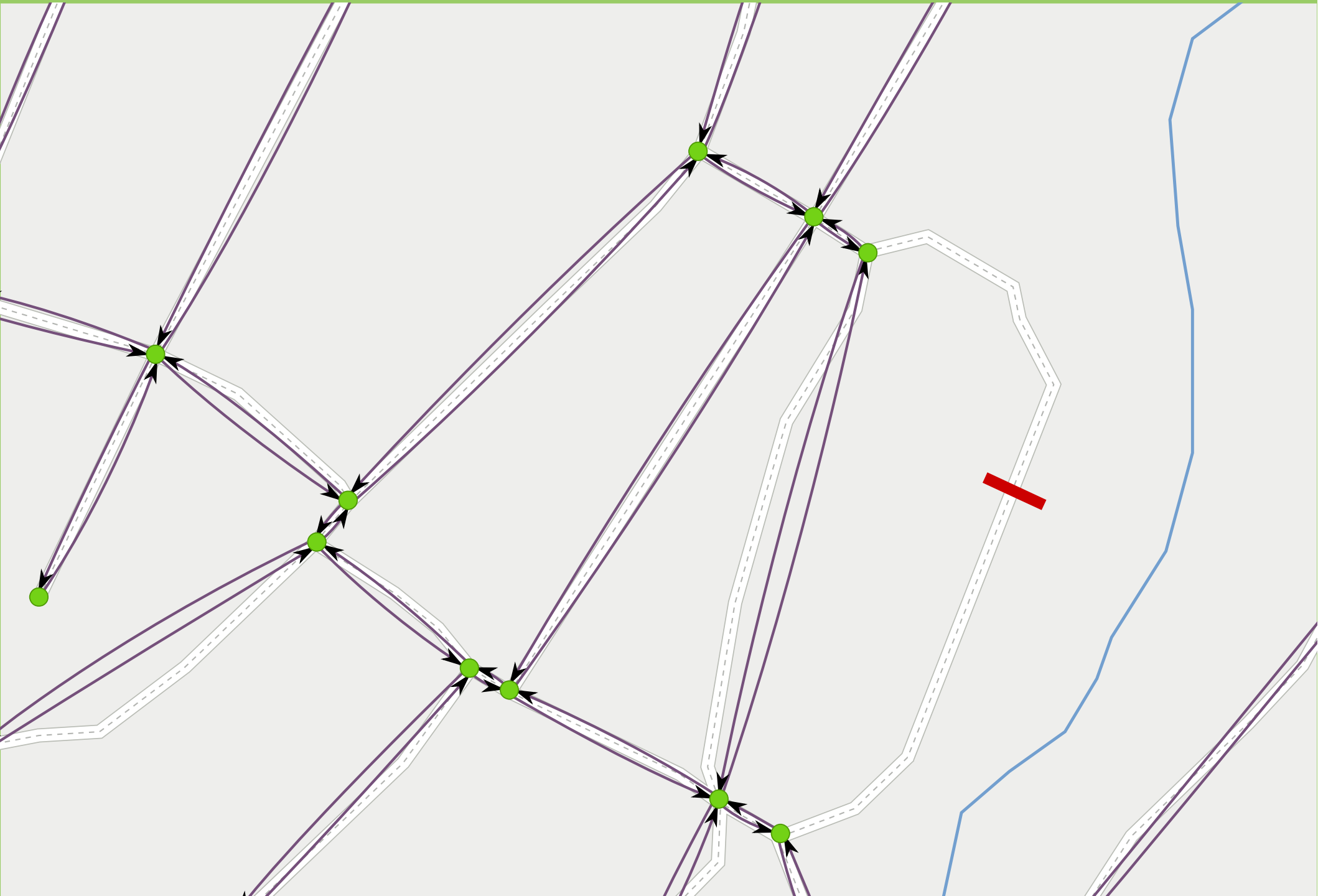




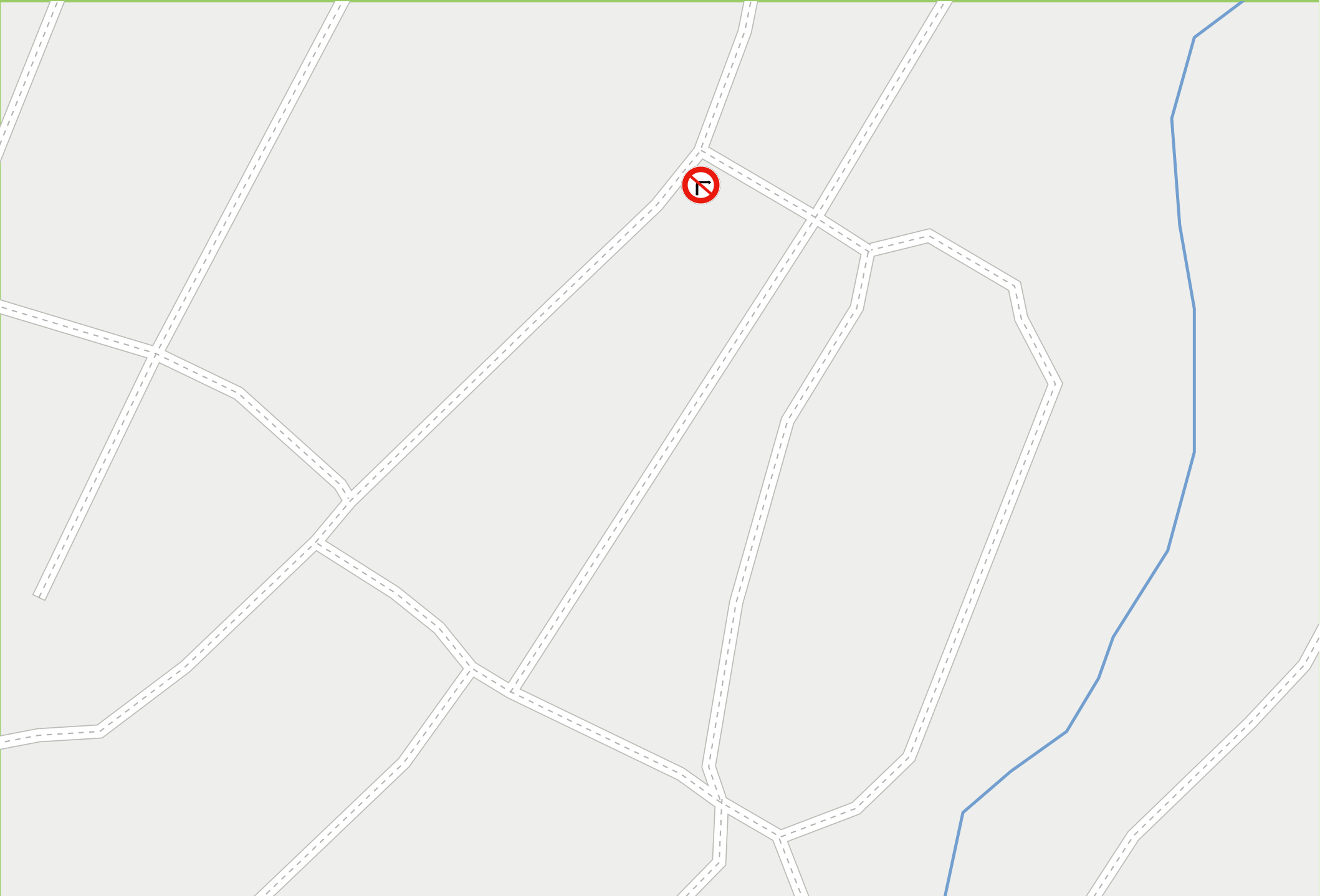
### 3. restrictions



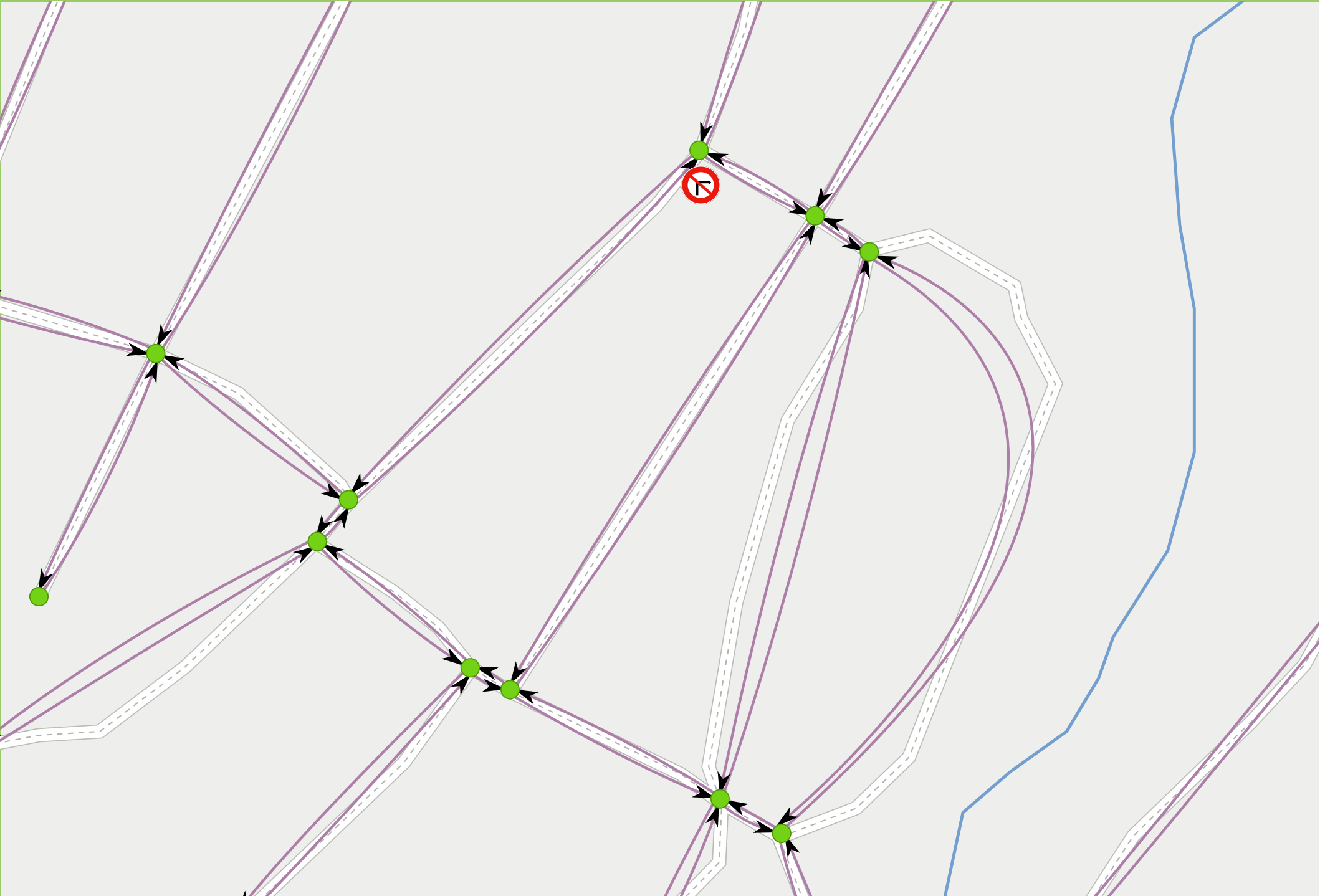
### 3. restrictions



### 3. restrictions



### 3. restrictions



1 load *map* data

2 build *topology*

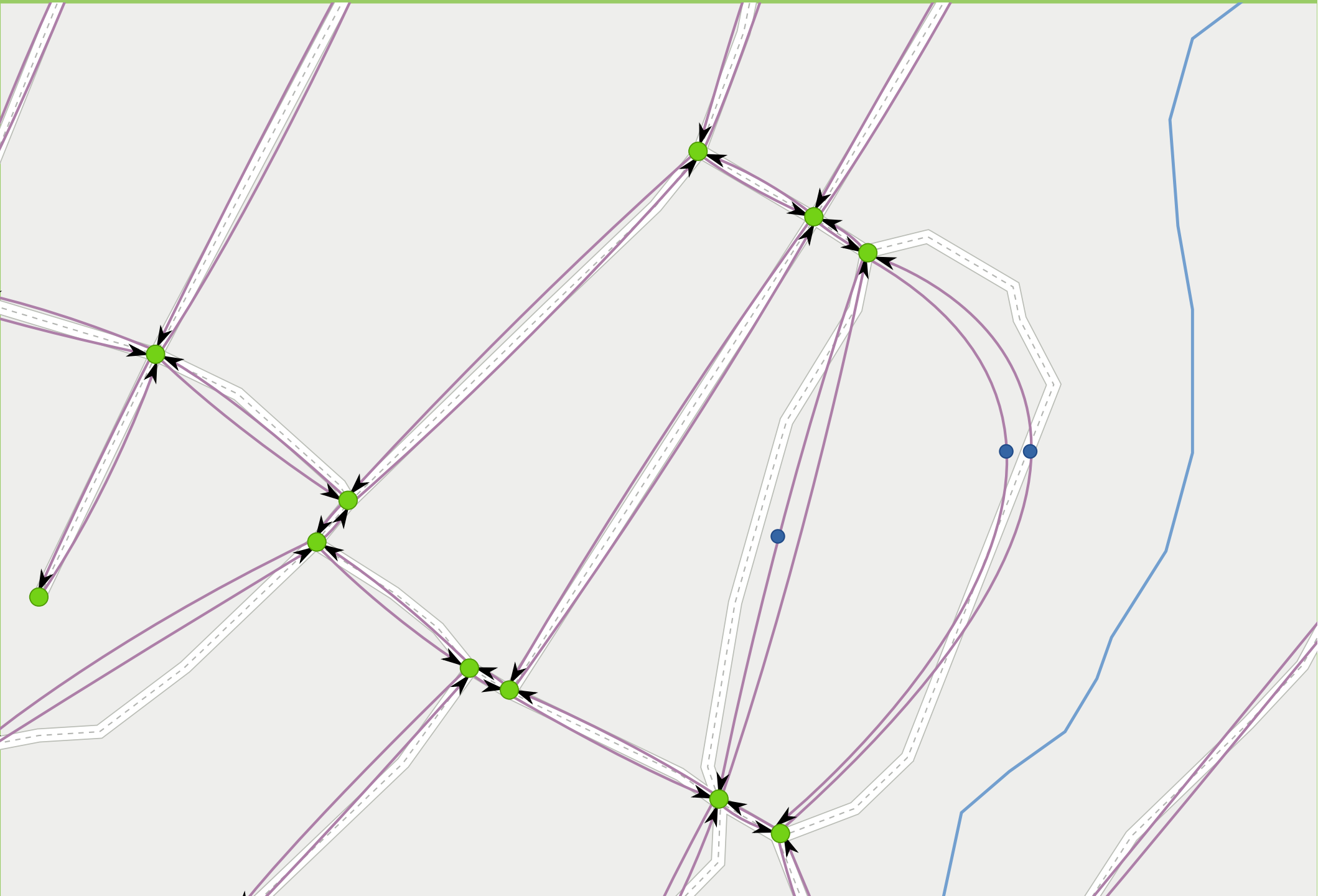
3 apply *restrictions*

4 build *line graph*



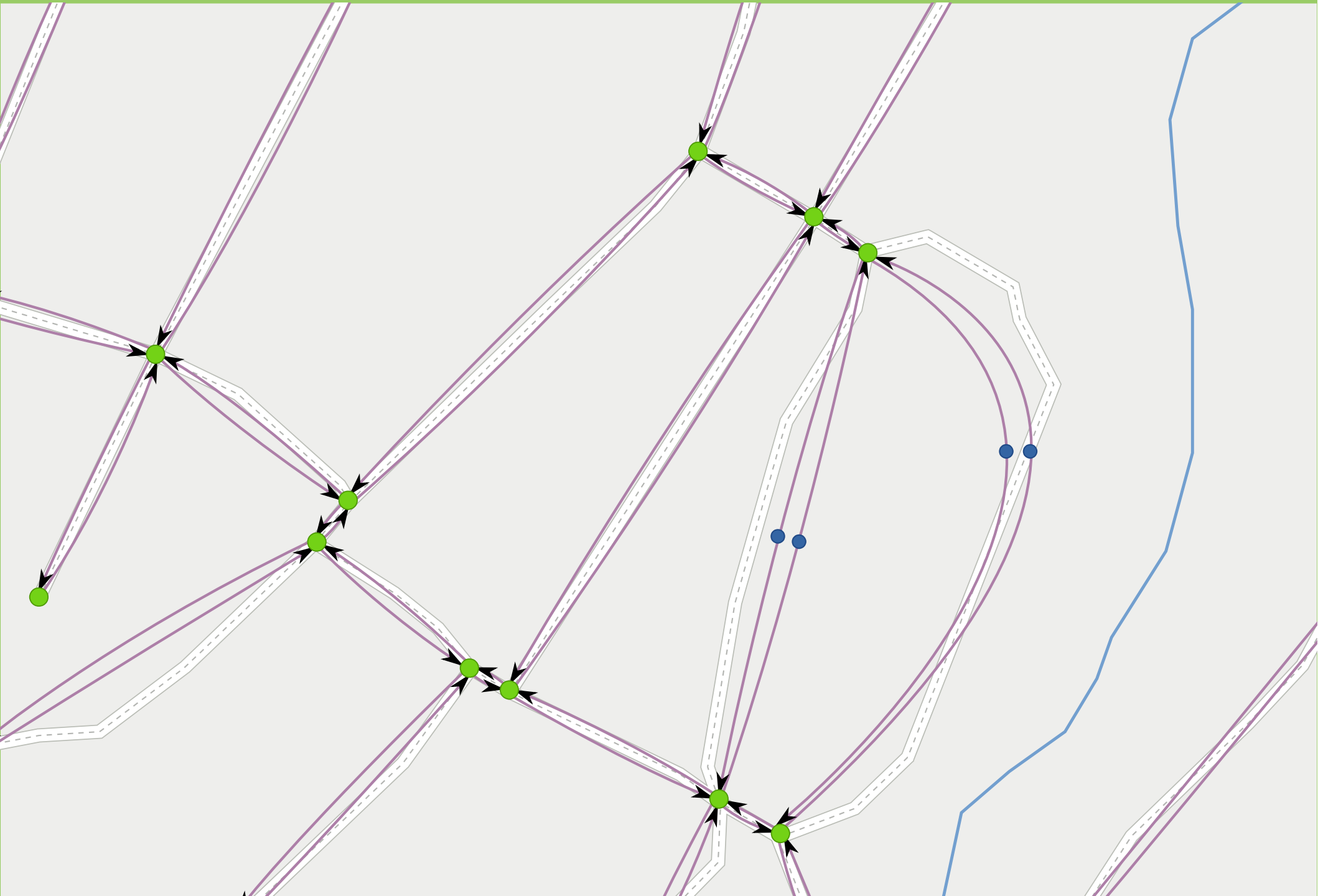


## 4. line graph

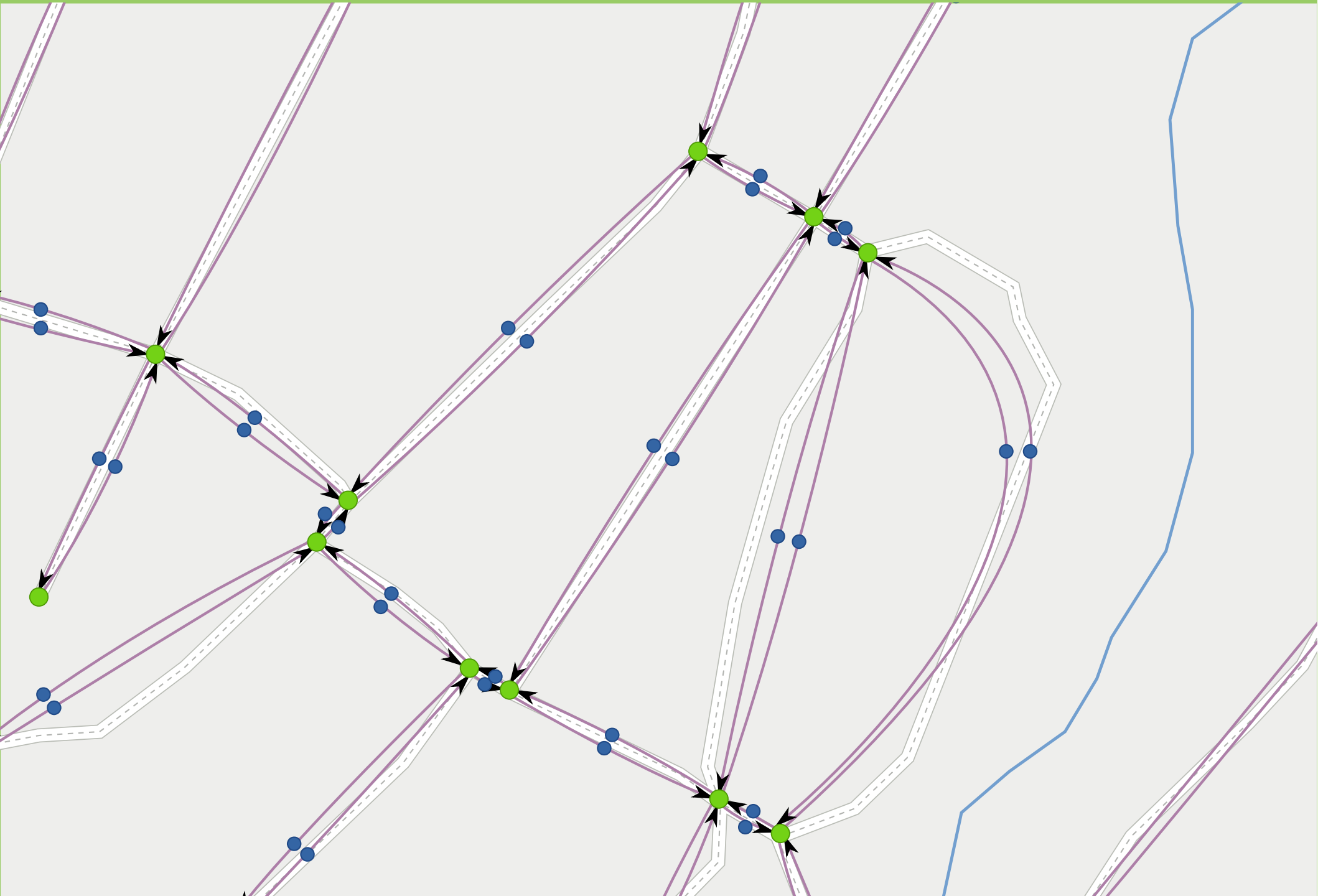




## 4. line graph

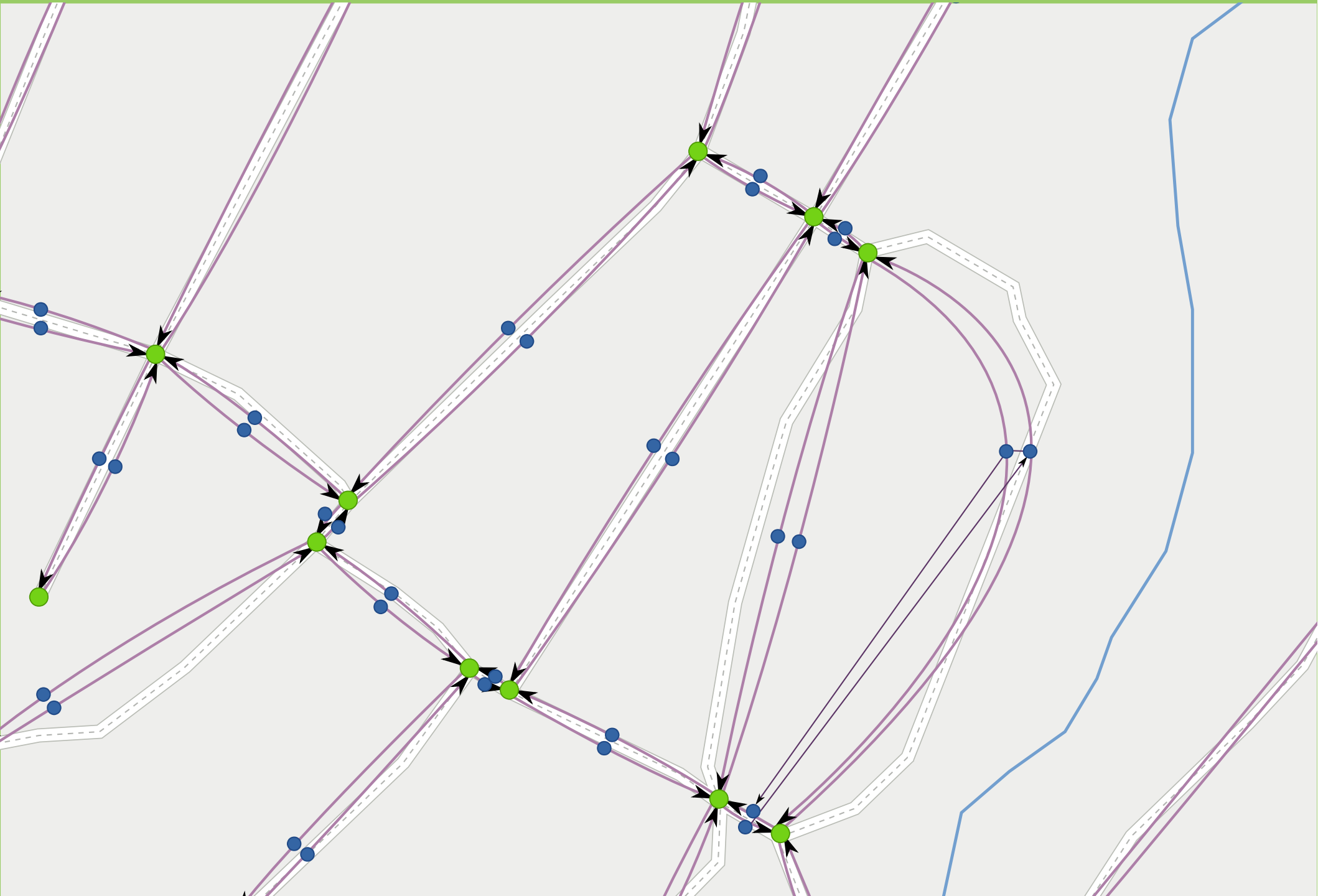


## 4. line graph

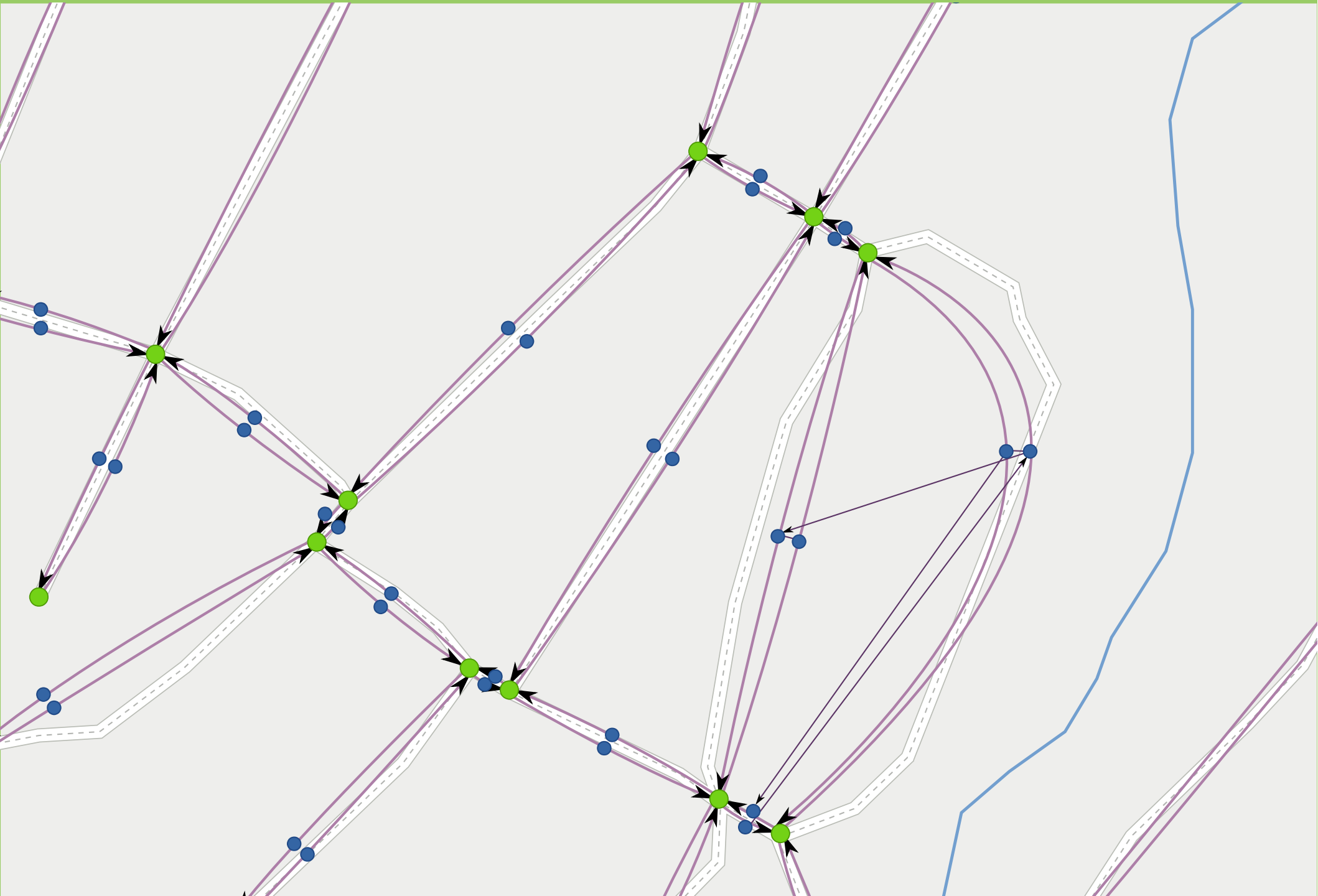




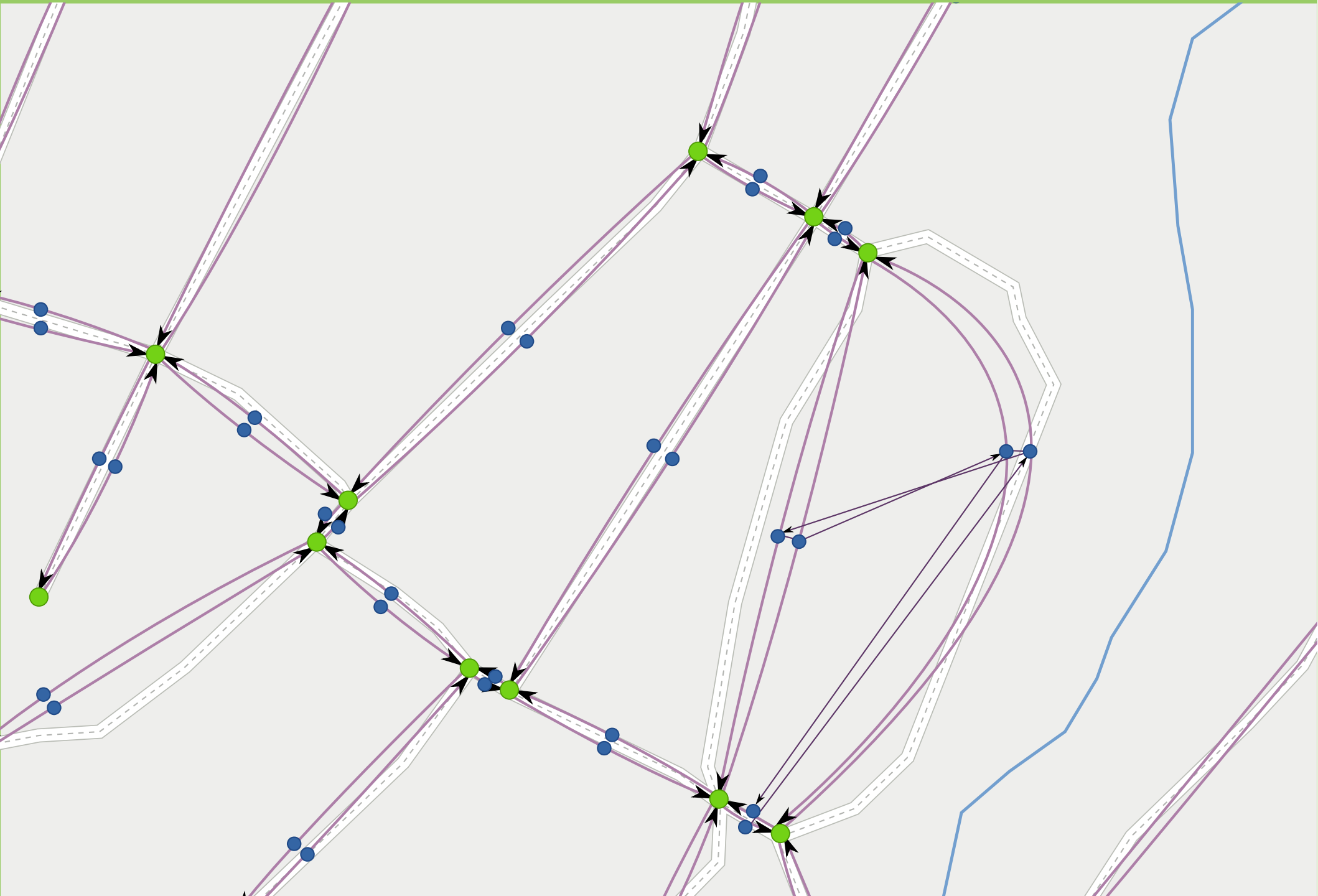
## 4. line graph



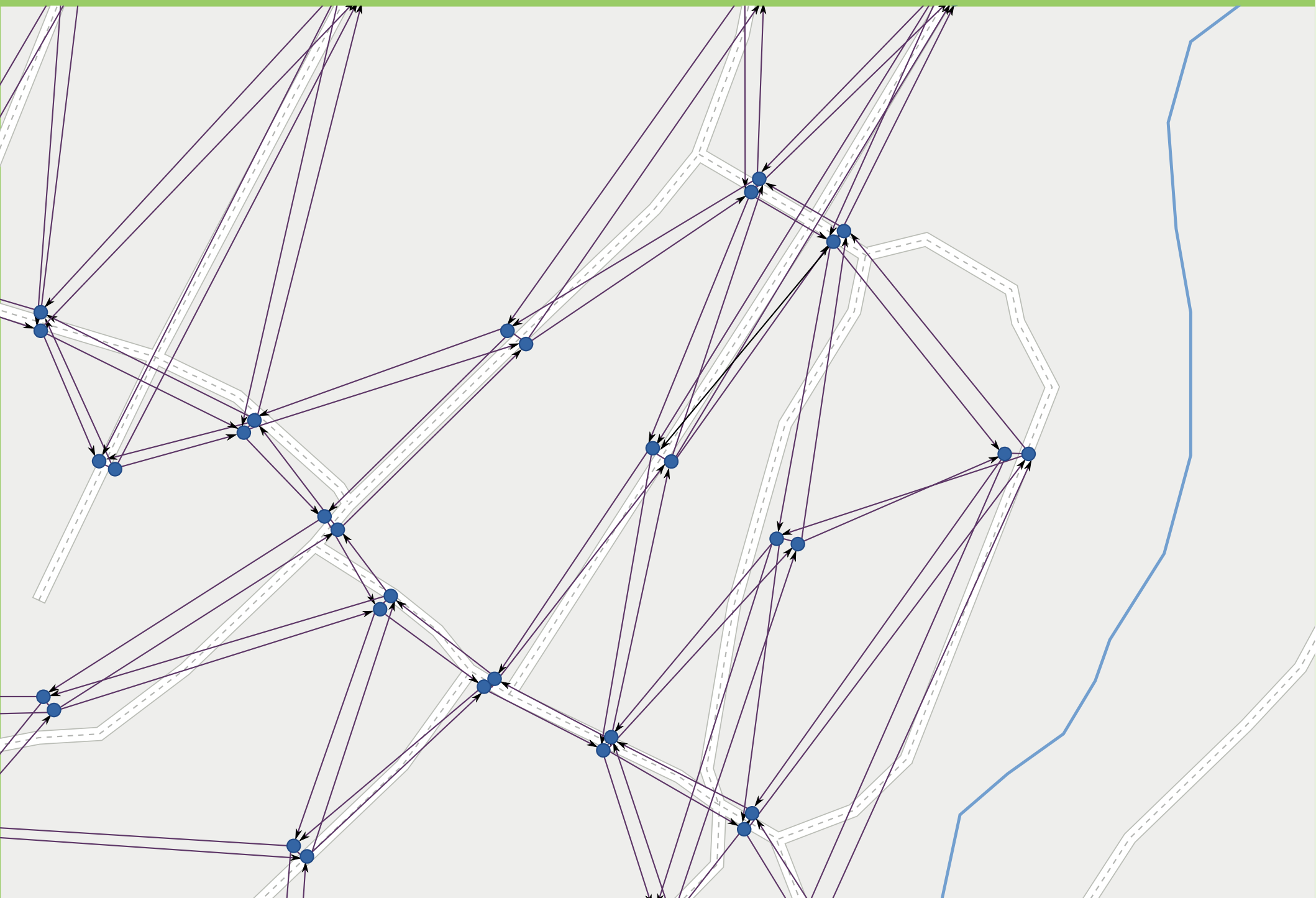
## 4. line graph



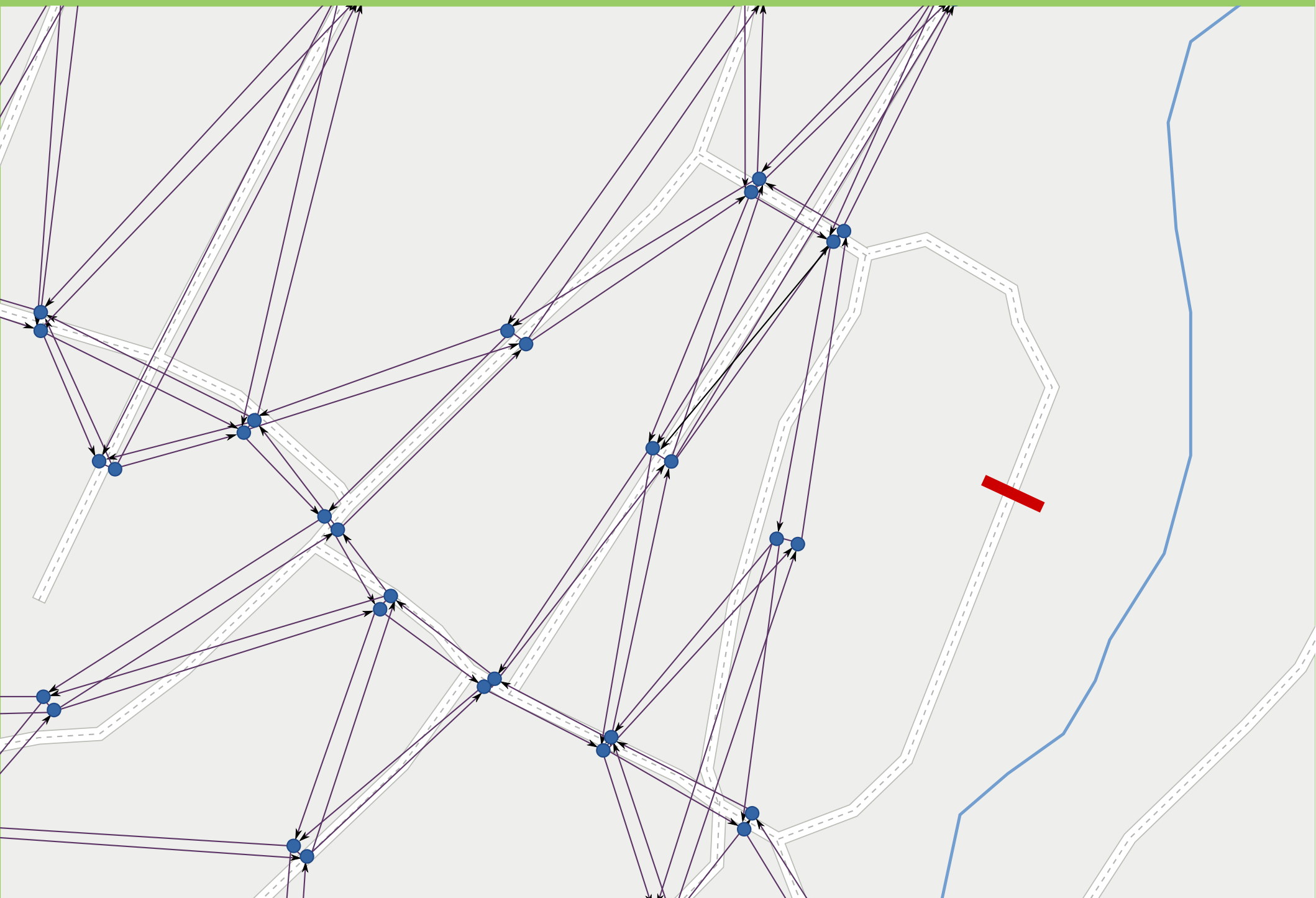
## 4. line graph



## 4. line graph

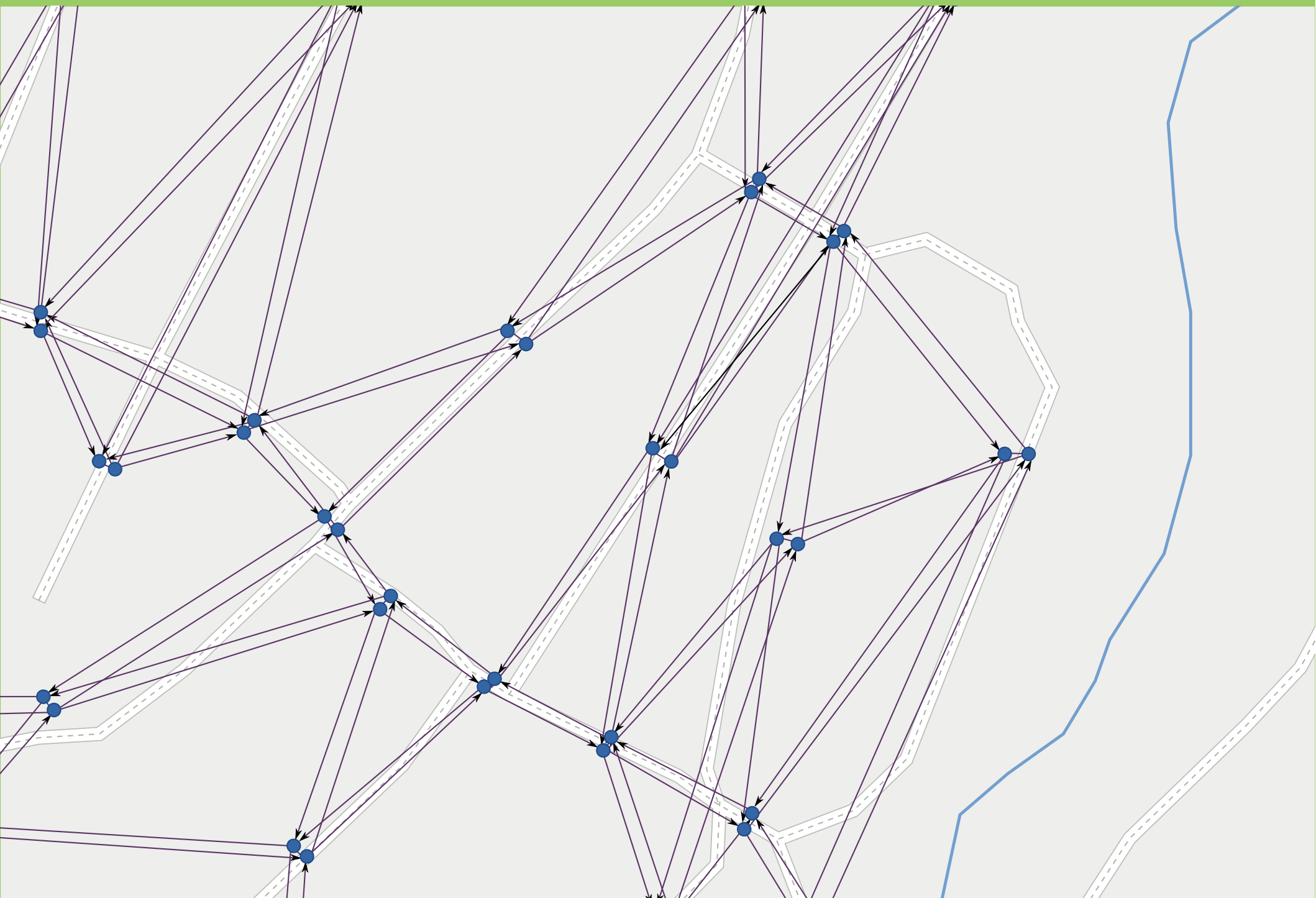


## 4. line graph

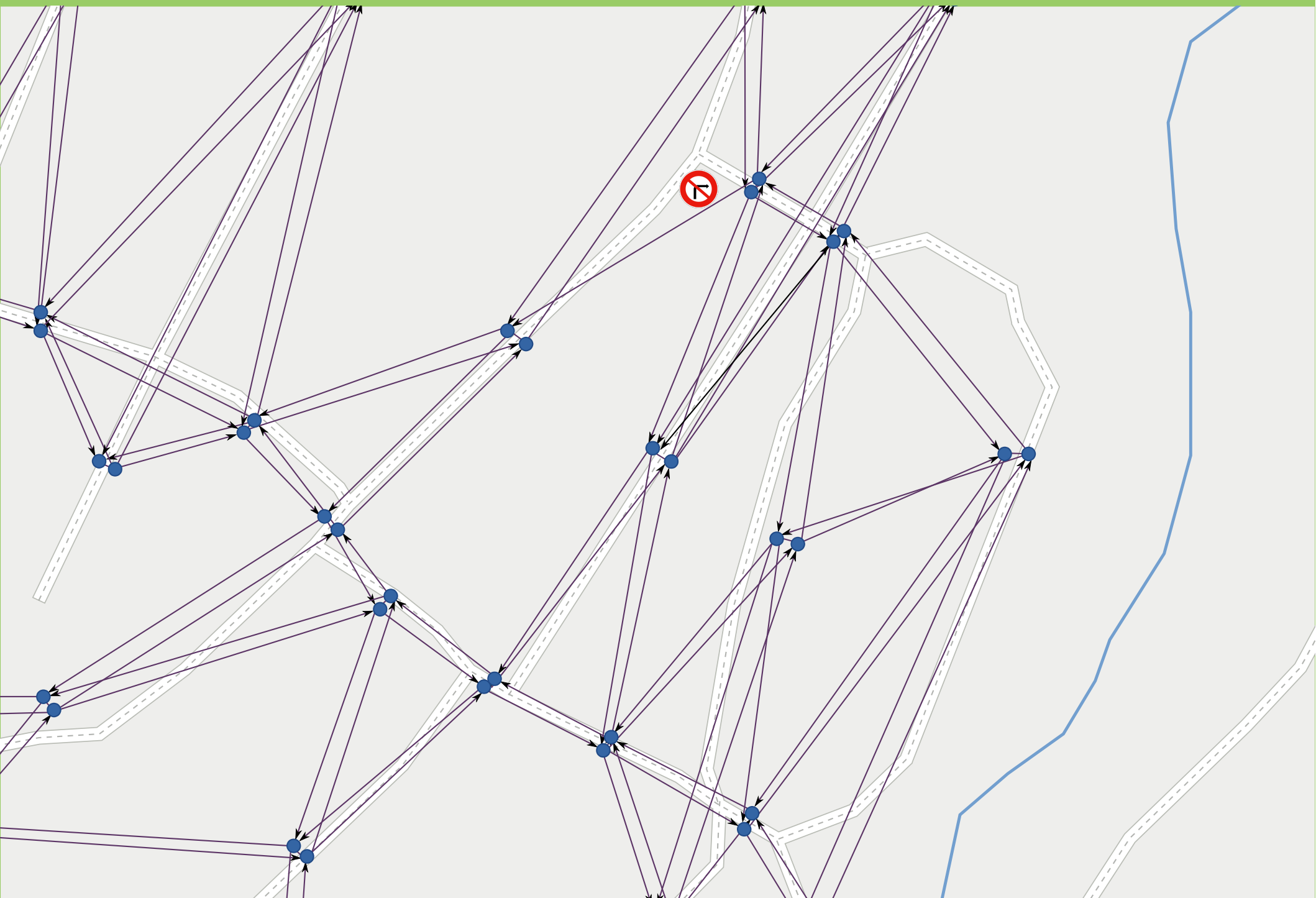




## 4. line graph



## 4. line graph



## 4. line graph

tool:

# Boost graph library

```
typedef boost::adjacency_list  
    < boost::listS, boost::vecS, boost::directedS,  
      LineGraphNode, LineGraphLine >  
    LineGraphType;
```



remarks

preliminary

# preliminary

load *map* data

preliminary

load *map* data

build *topology*

preliminary

load *map* data

build *topology*

on demand



preliminary

load *map* data

build *topology*

on demand

apply *restrictions*

preliminary

load *map* data

build *topology*

on demand

apply *restrictions*

build *line graph*

configurable

configurable

*json*

file  
for

*settings*

configurable

*json*

file  
for

*settings*

database

# configurable

*json*

file  
for

*settings*

database, vehicle properties

# configurable

***json***

file  
for

***settings***

database, vehicle properties,  
road speeds

# configurable

*json*

file  
for

*settings*

database, vehicle properties,  
road speeds, surfaces



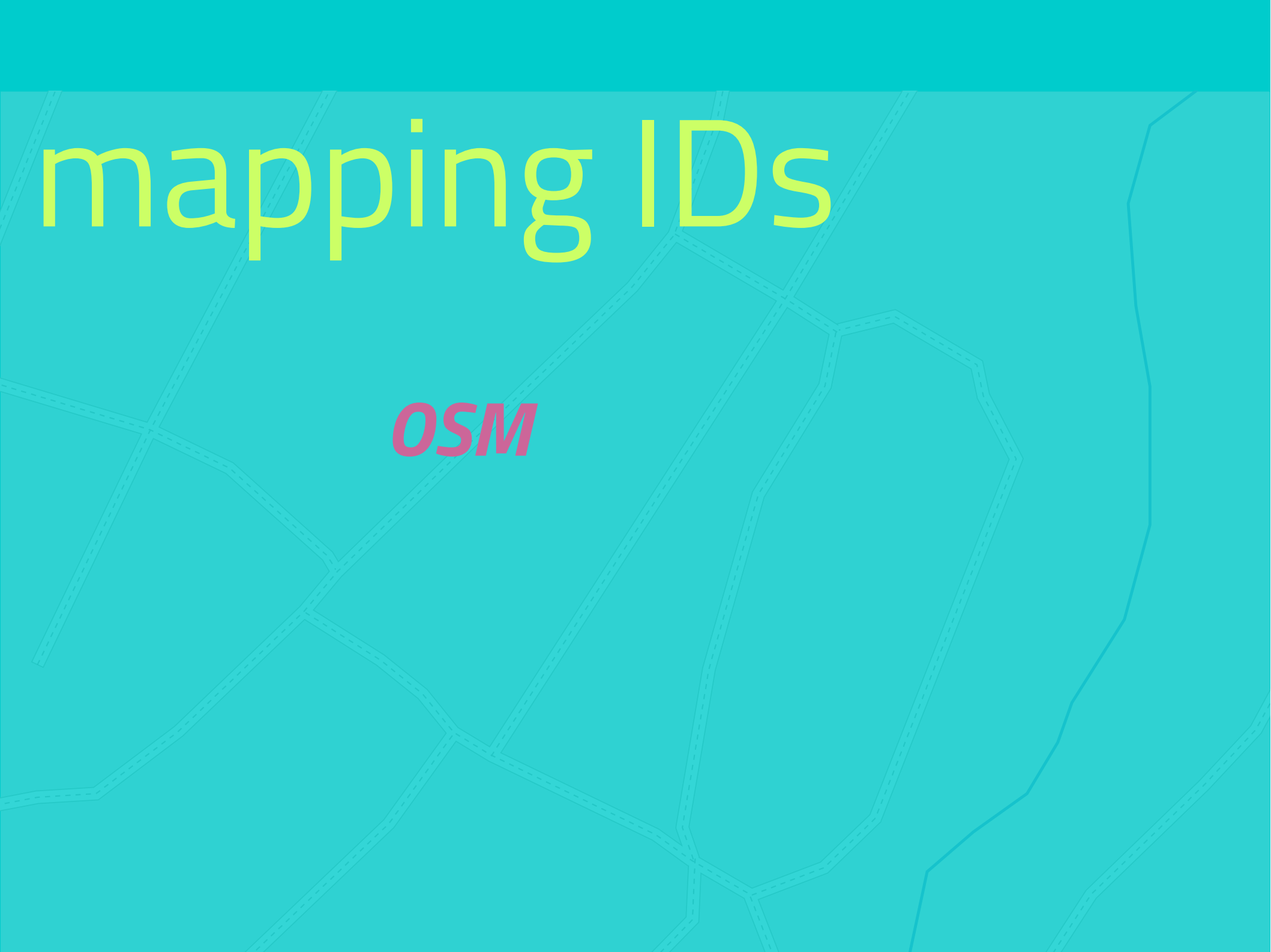
# configurable

*json*

file  
for

*settings*

database, vehicle properties,  
road speeds, surfaces,  
restrictions and costs, ...



# mapping IDs

*OSM*

# mapping IDs



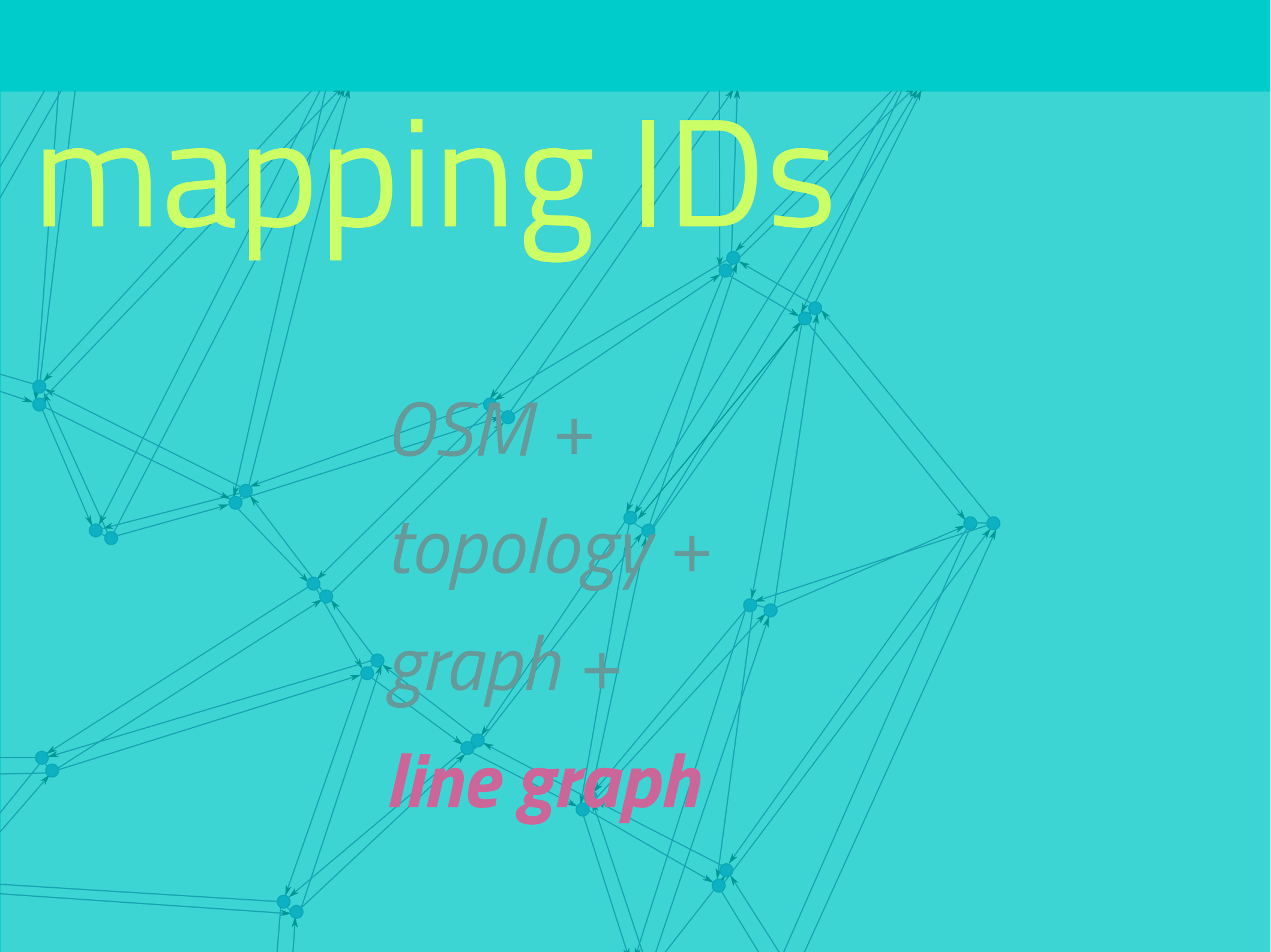
*OSM +*

***topology***

# mapping IDs

*OSM +  
topology +  
graph*

A network graph is overlaid on the teal background. It consists of approximately 12 green circular nodes connected by thin blue lines representing edges. The connections form a complex web, with some nodes having multiple incoming or outgoing edges, suggesting a directed or weighted graph structure. The edges are thin and light blue, contrasting with the darker teal background.



# mapping IDs

*OSM +*

*topology +*

*graph +*

*line graph*

# restrictions

Values:

*yes*

# restrictions

Values:

yes,

*no*

# restrictions

Values:

yes, no,

*permissive*



# restrictions

Values:

yes, no, permissive,

*designated*

# restrictions

Values:

yes, no, permissive, designated,

*private*

# restrictions

Values:

yes, no, permissive, designated, private,

*discouraged*

# restrictions

Values:

yes, no, permissive, designated, private, discouraged,

*delivery*

# restrictions

Values:

yes, no, permissive, designated, private, discouraged, delivery,

*customers*...

# restrictions

## values:

yes, no, permissive, designated, private, discouraged, delivery, customers ...

## routing:

one-way (explicit / implicit), lanes ...

# restrictions

## values:

yes, no, permissive, designated, private, discouraged, delivery, customers ...

## routing:

one-way (explicit / implicit), lanes ...

## transportation mode:

*all*

# restrictions

## values:

yes, no, permissive, designated, private, discouraged, delivery, customers ...

## routing:

one-way (explicit / implicit), lanes ...

## transportation mode:

all,

*foot*



# restrictions

## values:

yes, no, permissive, designated, private, discouraged, delivery, customers ...

## routing:

one-way (explicit / implicit), lanes ...

## transportation mode:

all, foot,

*vehicle*

# restrictions

## values:

yes, no, permissive, designated, private, discouraged, delivery, customers ...

## routing:

one-way (explicit / implicit), lanes ...

## transportation mode:

all, foot, vehicle,

***bicycle***

# restrictions

## values:

yes, no, permissive, designated, private, discouraged, delivery, customers ...

## routing:

one-way (explicit / implicit), lanes ...

## transportation mode:

all, foot, vehicle, bicycle,

***motor\_vehicle***

# restrictions

## values:

yes, no, permissive, designated, private, discouraged, delivery, customers ...

## routing:

one-way (explicit / implicit), lanes ...

## transportation mode:

all, foot, vehicle, bicycle, motor\_vehicle,

***motorcycle***

# restrictions

## values:

yes, no, permissive, designated, private, discouraged, delivery, customers ...

## routing:

one-way (explicit / implicit), lanes ...

## transportation mode:

all, foot, vehicle, bicycle, motor\_vehicle, motorcycle,

*motorcar*

# restrictions

## values:

yes, no, permissive, designated, private, discouraged, delivery, customers ...

## routing:

one-way (explicit / implicit), lanes ...

## transportation mode:

all, foot, vehicle, bicycle, motor\_vehicle, motorcycle, motorcar,

*goods*

# restrictions

## values:

yes, no, permissive, designated, private, discouraged, delivery, customers ...

## routing:

one-way (explicit / implicit), lanes ...

## transportation mode:

all, foot, vehicle, bicycle, motor\_vehicle, motorcycle, motorcar, goods,

*hgv*

# restrictions

## values:

yes, no, permissive, designated, private, discouraged, delivery, customers ...

## routing:

one-way (explicit / implicit), lanes ...

## transportation mode:

all, foot, vehicle, bicycle, motor\_vehicle, motorcycle, motorcar, goods, hgv ...

## by use:

*psv*



# restrictions

## values:

yes, no, permissive, designated, private, discouraged, delivery, customers ...

## routing:

one-way (explicit / implicit), lanes ...

## transportation mode:

all, foot, vehicle, bicycle, motor\_vehicle, motorcycle, motorcar, goods, hgv ...

## by use:

psv,

*car\_sharing*

# restrictions

## values:

yes, no, permissive, designated, private, discouraged, delivery, customers ...

## routing:

one-way (explicit / implicit), lanes ...

## transportation mode:

all, foot, vehicle, bicycle, motor\_vehicle, motorcycle, motorcar, goods, hgv ...

## by use:

psv, car\_sharing,

*emergency*

# restrictions

## values:

yes, no, permissive, designated, private, discouraged, delivery, customers ...

## routing:

one-way (explicit / implicit), lanes ...

## transportation mode:

all, foot, vehicle, bicycle, motor\_vehicle, motorcycle, motorcar, goods, hgv ...

## by use:

psv, car\_sharing, emergency,

***hazmat***

# restrictions

## values:

yes, no, permissive, designated, private, discouraged, delivery, customers ...

## routing:

one-way (explicit / implicit), lanes ...

## transportation mode:

all, foot, vehicle, bicycle, motor\_vehicle, motorcycle, motorcar, goods, hgv ...

## by use:

psv, car\_sharing, emergency, hazmat,

*disabled*

# restrictions

## values:

yes, no, permissive, designated, private, discouraged, delivery, customers ...

## routing:

one-way (explicit / implicit), lanes ...

## transportation mode:

all, foot, vehicle, bicycle, motor\_vehicle, motorcycle, motorcar, goods, hgv ...

## by use:

psv, car\_sharing, emergency, hazmat, disabled ...

# restrictions

## values:

yes, no, permissive, designated, private, discouraged, delivery, customers ...

## routing:

one-way (explicit / implicit), lanes ...

## transportation mode:

all, foot, vehicle, bicycle, motor\_vehicle, motorcycle, motorcar, goods, hgv ...

## by use:

psv, car\_sharing, emergency, hazmat, disabled ...

## dimensions:

max height, weight, width ...

# *conditional* restrictions



# *conditional* restrictions



Photo (cropped): Achadwick. ©CC-SA 2.0

[http://wiki.openstreetmap.org/wiki/File:UK\\_motor\\_restriction\\_sign\\_with\\_exceptions.jpg](http://wiki.openstreetmap.org/wiki/File:UK_motor_restriction_sign_with_exceptions.jpg)

motor\_vehicle=no

motor\_vehicle:conditional=yes @ (18:30-07:30)

psv=yes



# *conditional* restrictions

```
maxspeed=none  
maxspeed:conditional=  
    120 @ (06:00-20:00);  
    100 @ (22:00-06:00)
```

# *turning* restrictions

Relation:

# *turning* restrictions

Relation:

*from*

# *turning* restrictions

Relation:

from  $\rightarrow$  *via*

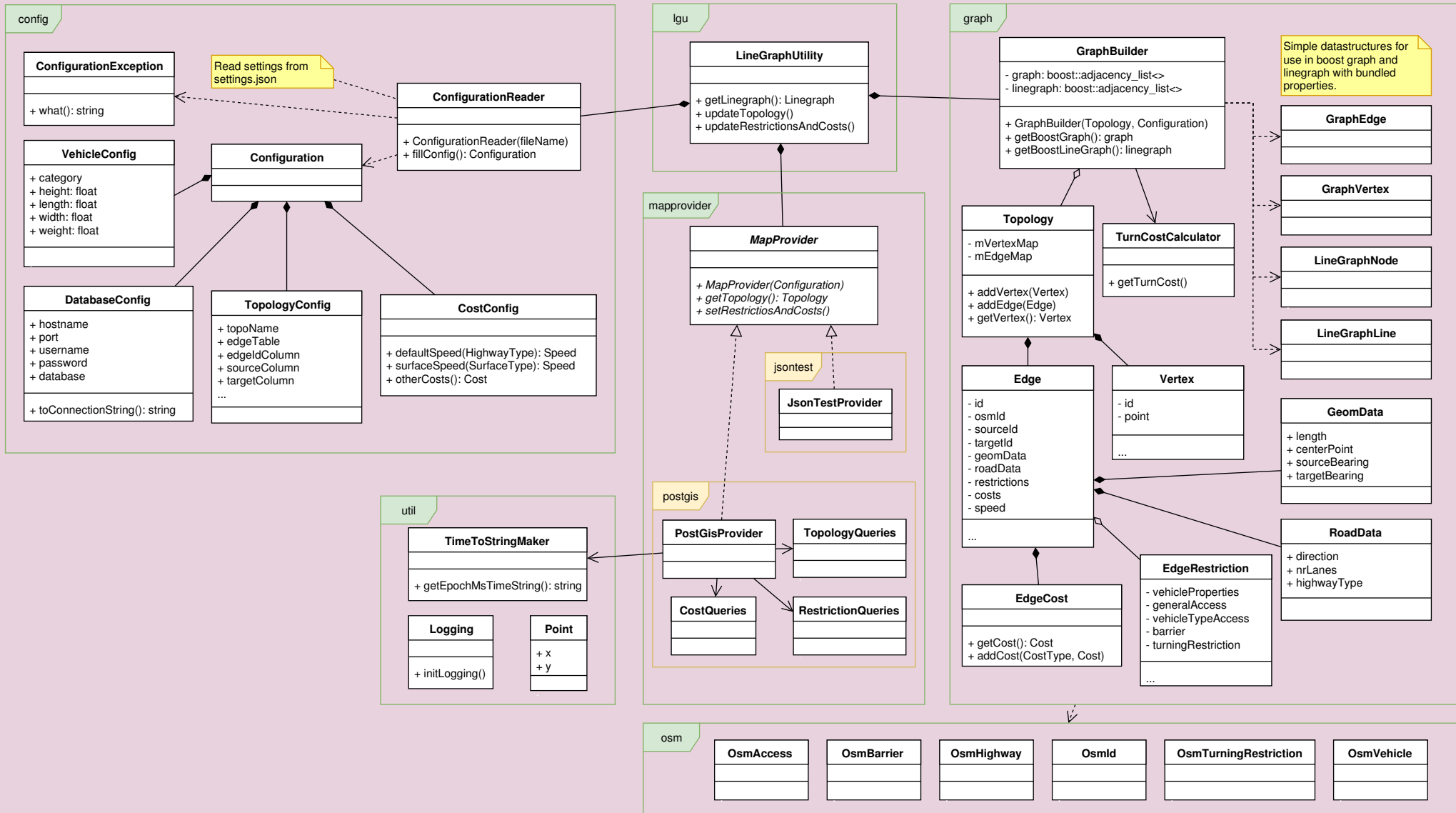
# *turning* restrictions

Relation:

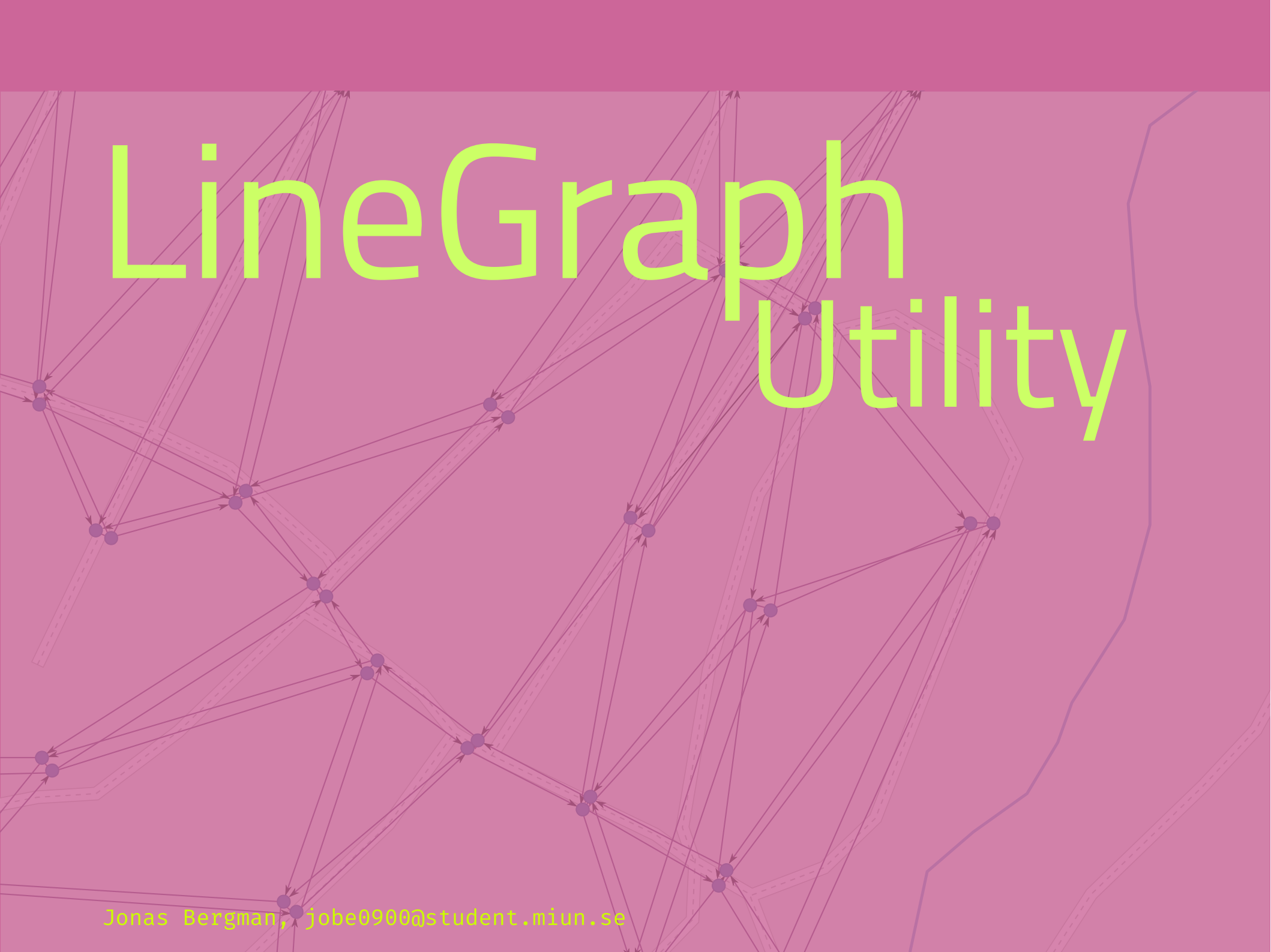
from  $\rightarrow$  via  $\rightarrow$  *to*

# solution

## class diagram



# LineGraph Utility

The background of the slide features a light purple map of a road network. Overlaid on this map is a complex graph structure. The graph consists of numerous small, dark purple circular nodes. These nodes are interconnected by a web of thin, dark purple lines representing edges. The nodes are positioned at various points along the road network, often at intersections or along straight segments. The edges connect these nodes in a way that suggests a flow or relationship between different parts of the network. The overall aesthetic is technical and data-oriented.