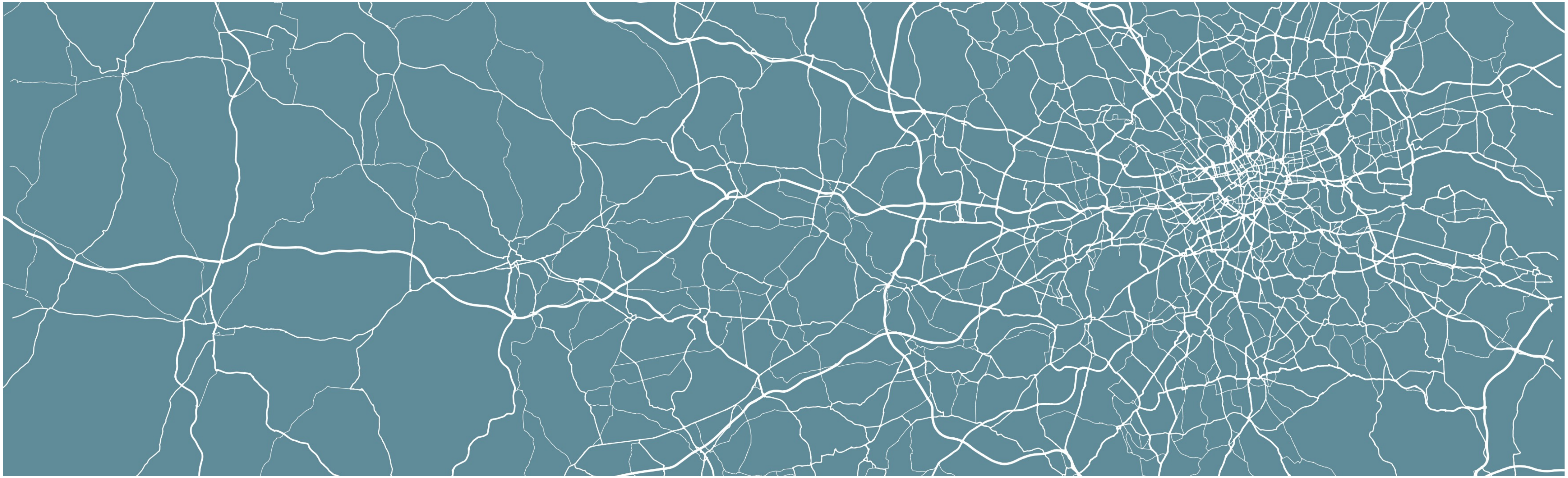
Geocomputation

Transport Network Analysis



Where are we at?

Part I: Foundational Concepts

W1	Geocomputation: An Introduction	
W2	GIScience and GIS software	QGIS
W3	Cartography and Visualisation	QGIS
W4	Programming for Data Analysis	R
W5	Programming for Spatial Analysis	R

Where are we at?

Part II: Core Spatial Analysis

W6	Geometric Operations and Spatial Queries	R
W7	Spatial Autocorrelation	
W8	Point pattern analysis	

Part III: Advanced Spatial Analysis

W9	Rasters, Zonal Statistics and Interpolation	R
W10	**Transport Network Analysis**	

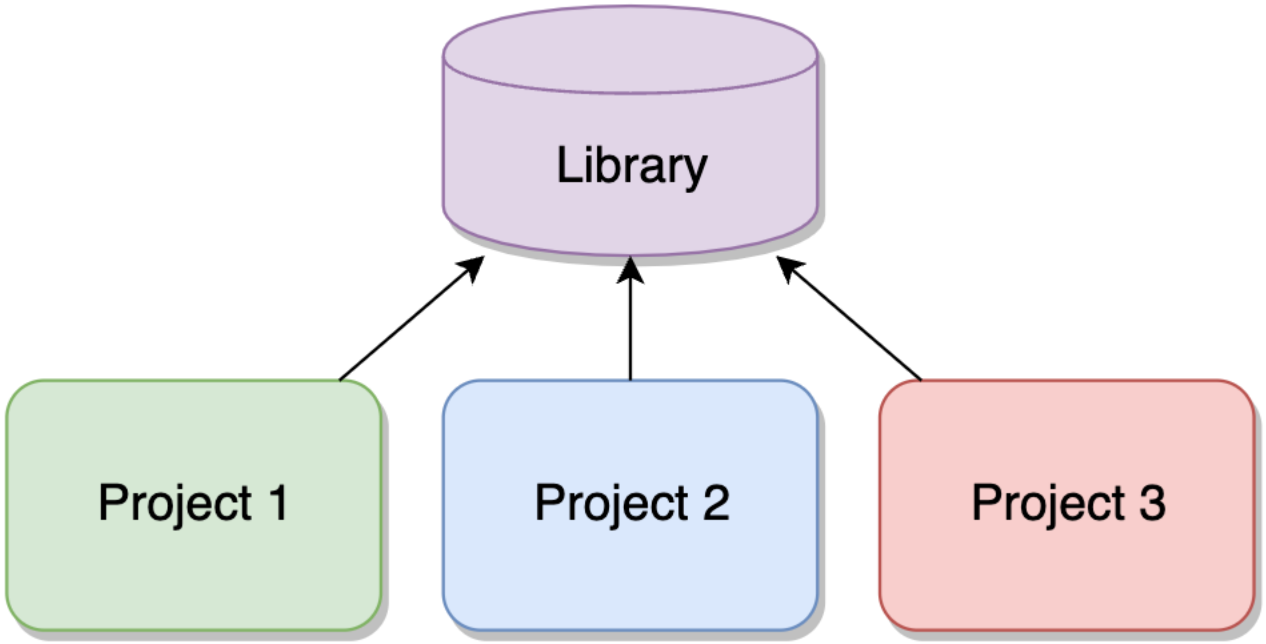
This week

- A brief note on package management
- Spatial interaction: transport network and accessibility analysis
- Spatial network structure
- Dijkstra’s shortest path algorithm
- Examples: transport network and accessibility analysis
- Brief module recap

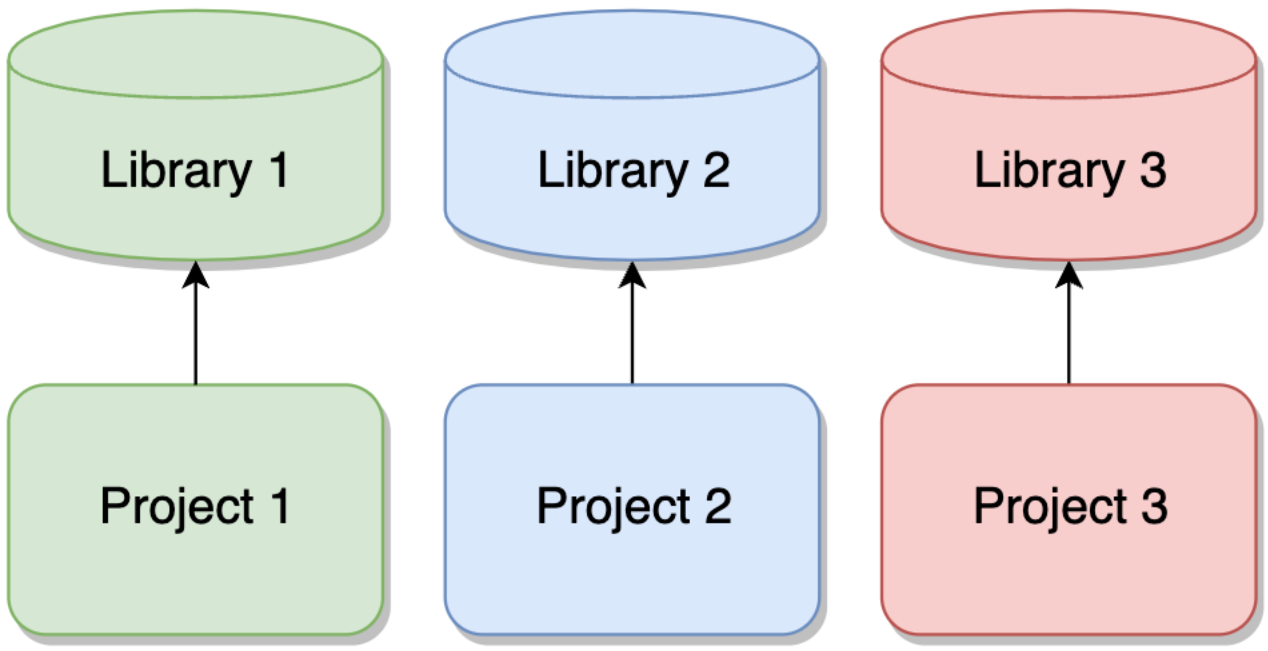
Package management

- Package management is the process of handling the many and varied dependencies and artifacts for your servers, applications, and developers.
- Toolkit used to manage project-local libraries.
- Combination with version management through Git.

Package management



Package management

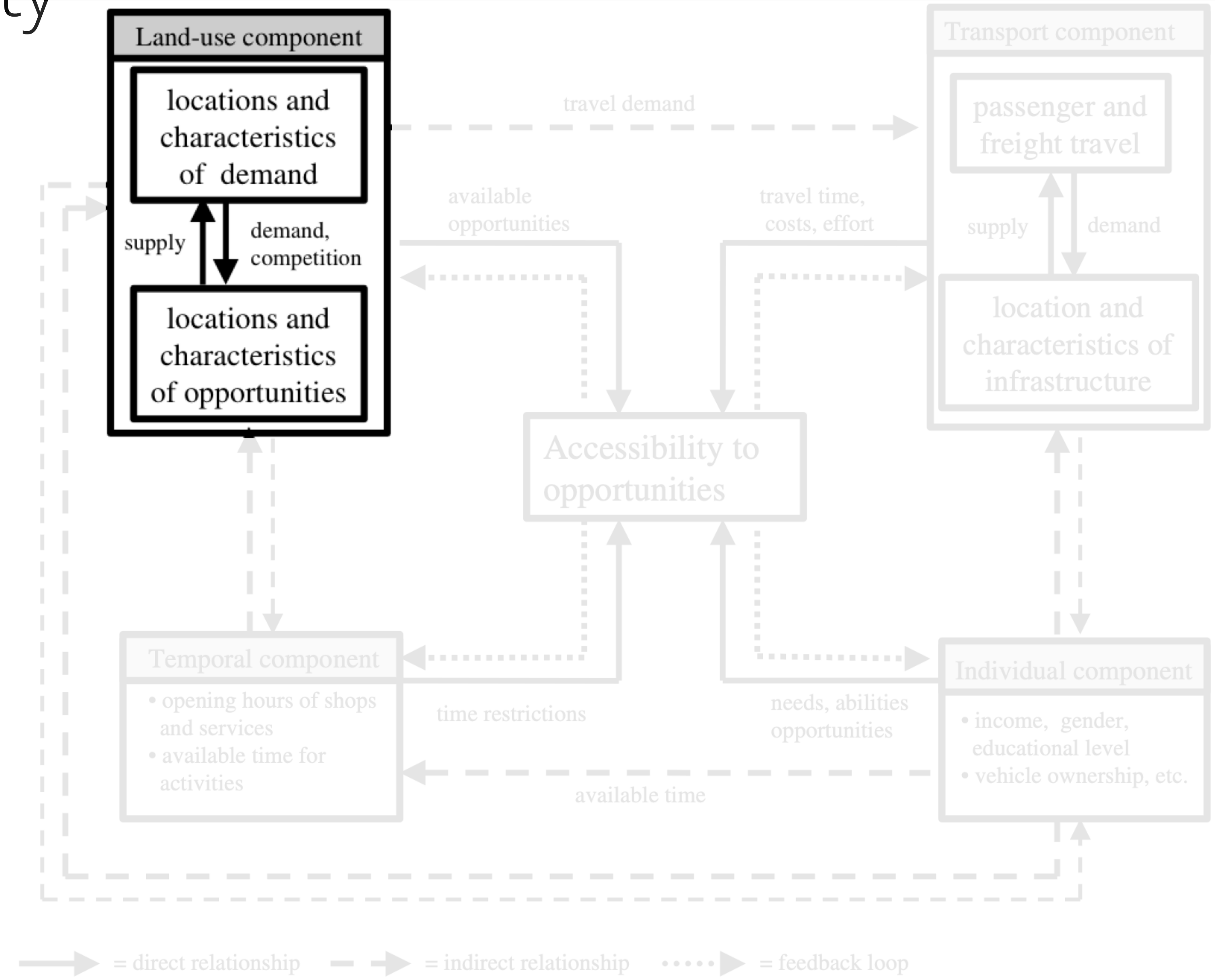


Spatial interaction

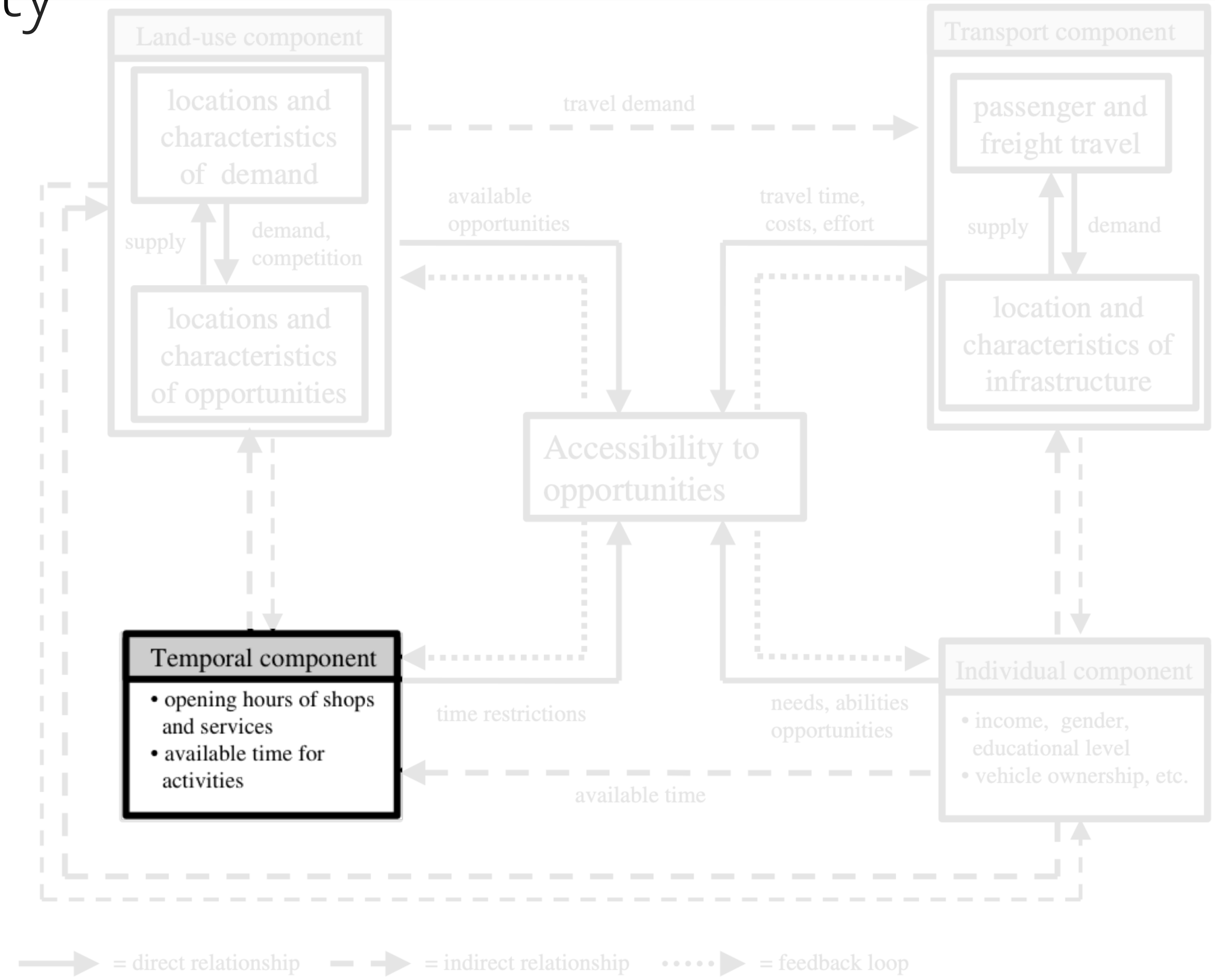
- We have mostly dealt with static events: events that happen at a particular point in time and space.
- Spatial interaction is concerned with the idea that there are relations between different locations (e.g. measured in people or goods travelling).

Spatial interaction

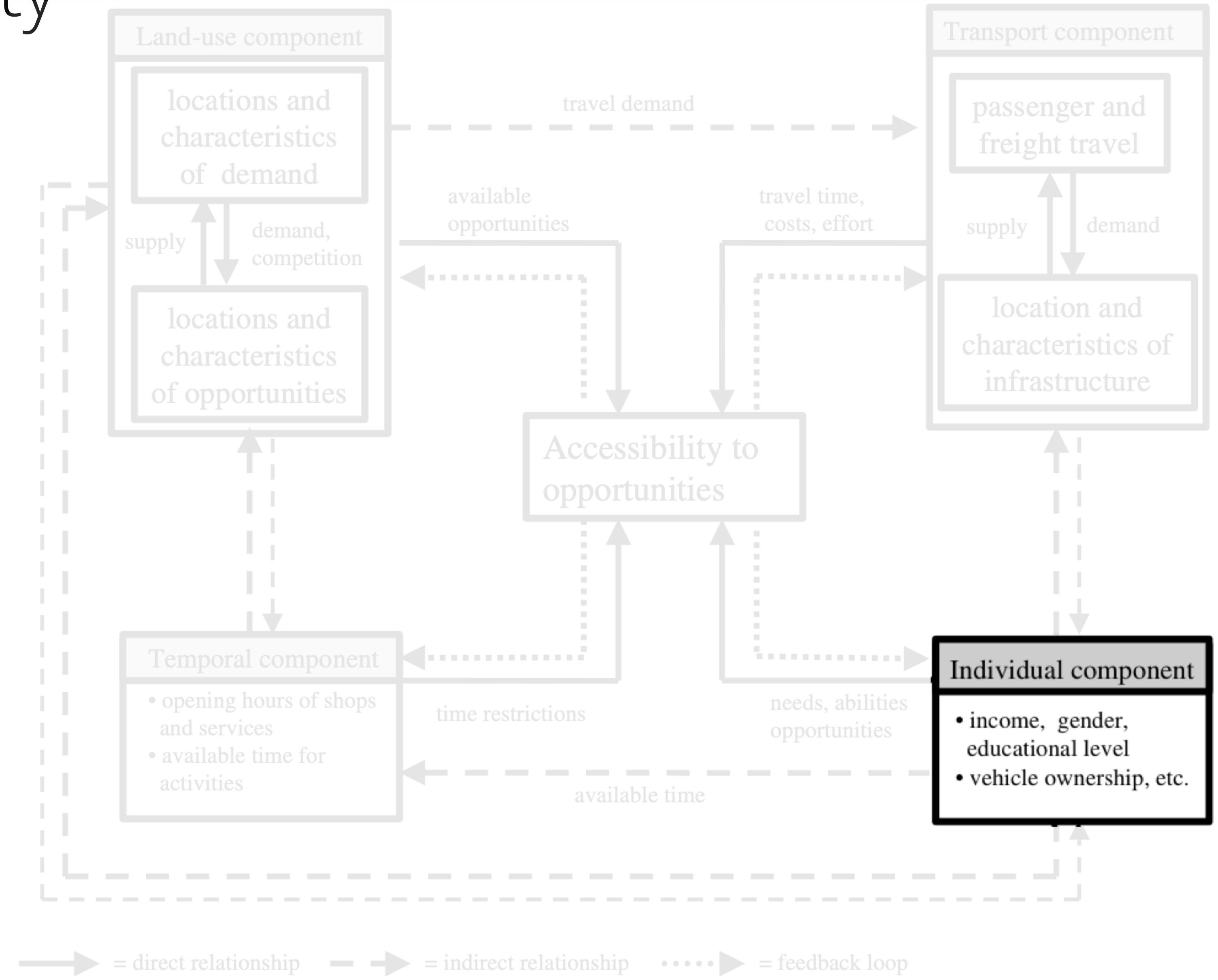
Accessibility



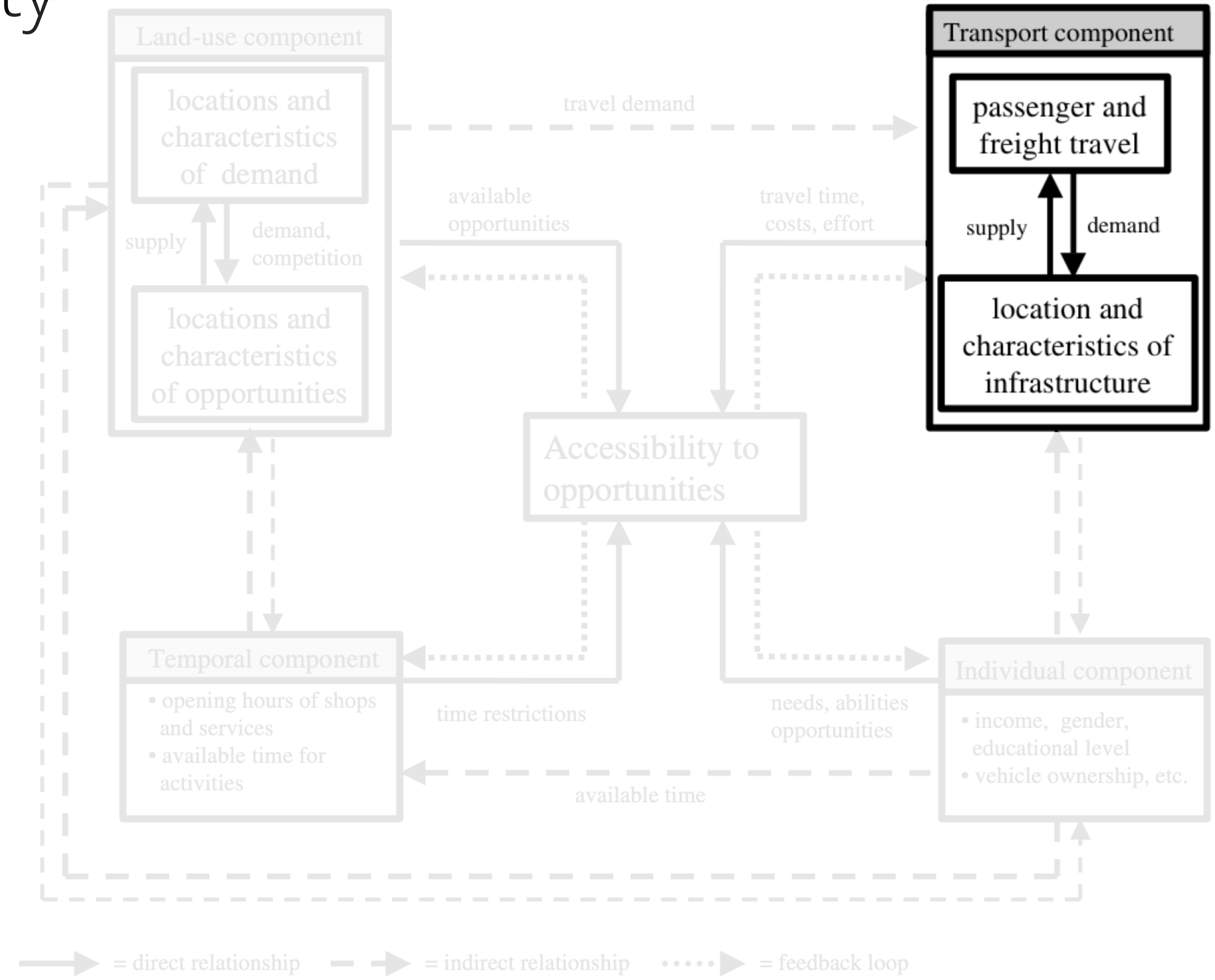
Accessibility



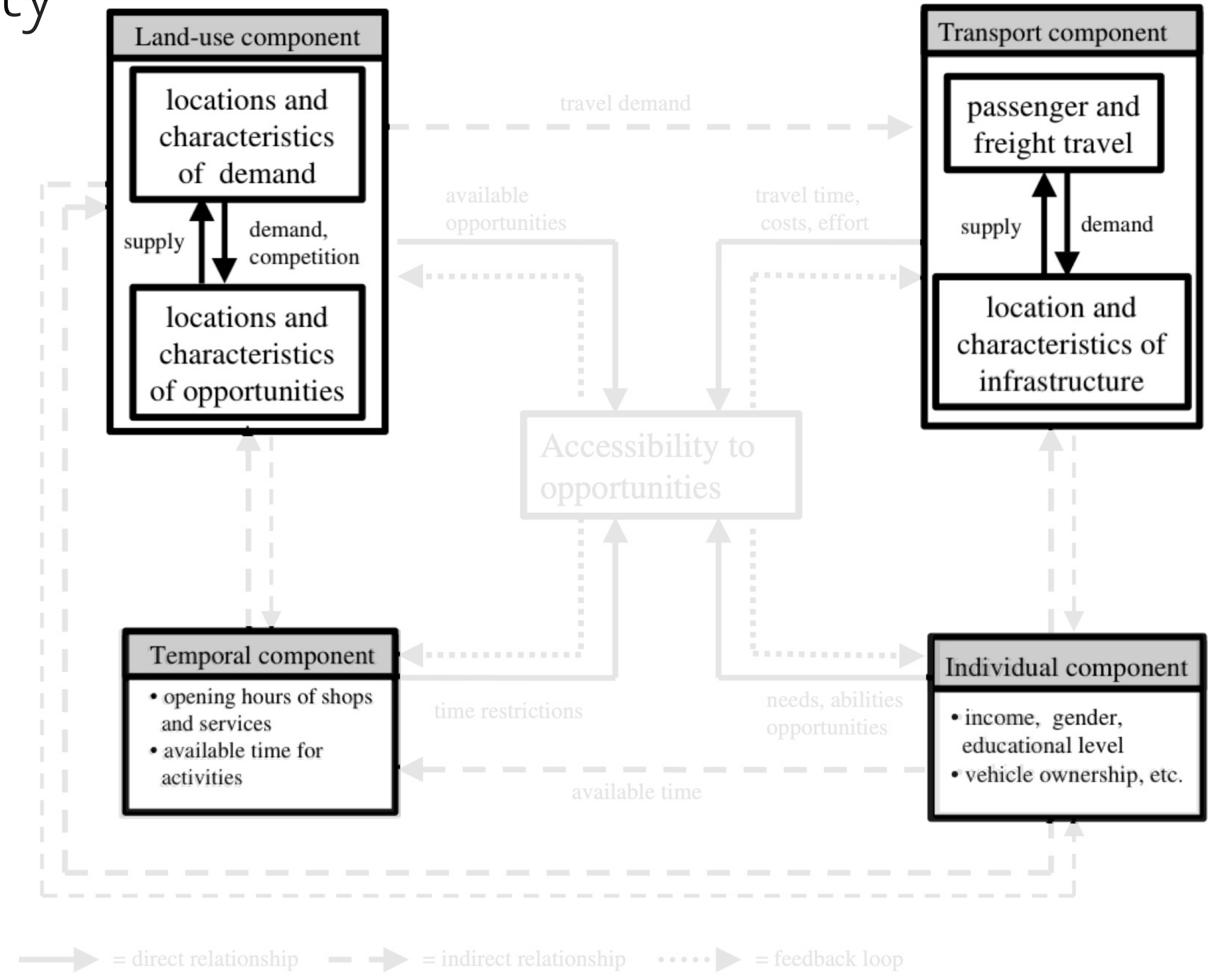
Accessibility



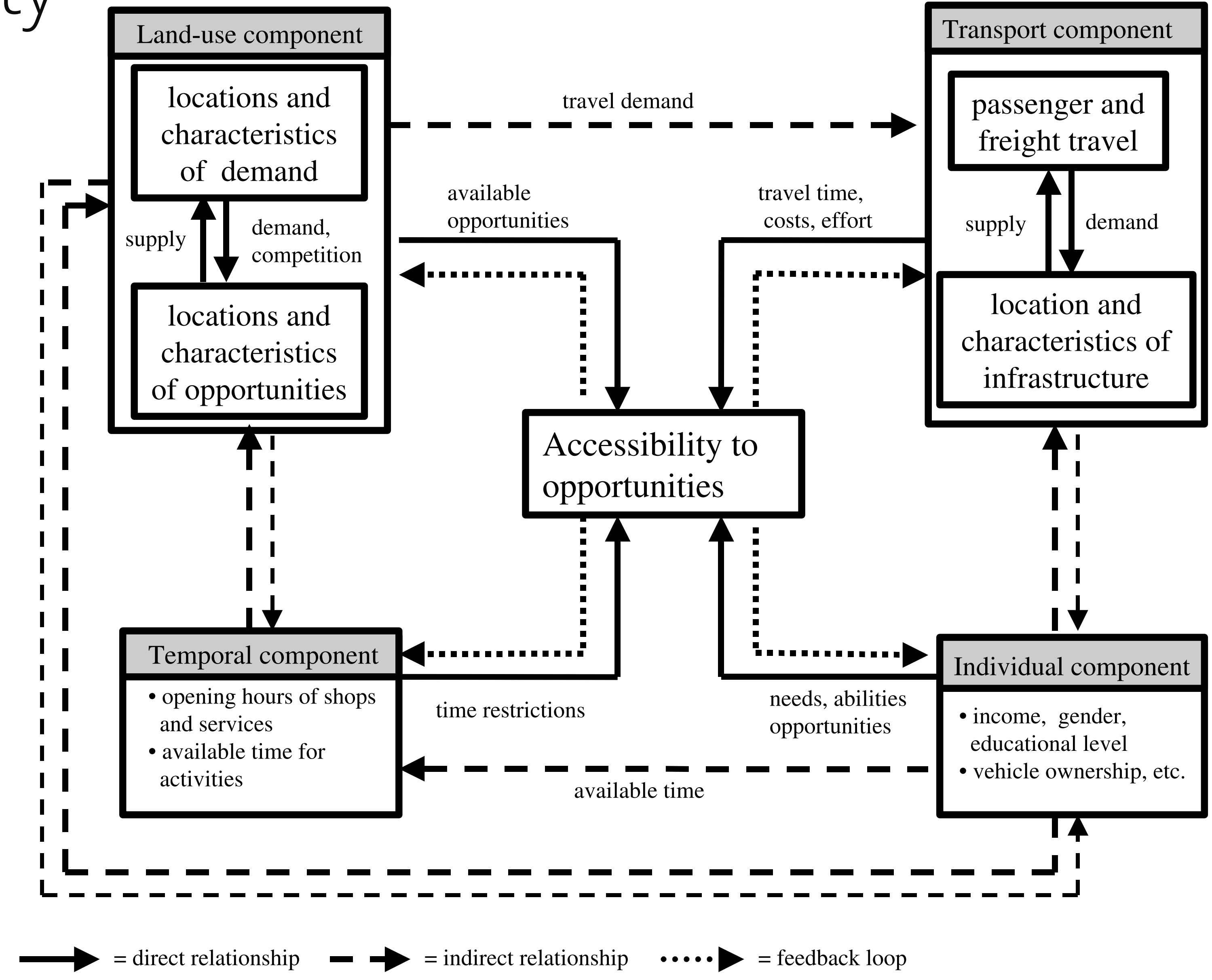
Accessibility



Accessibility



Accessibility



Geurs and Van Wee 2004

Accessibility

Typical questions where accessibility analysis comes in:

- How many jobs / shops / people can I reach within 15 / 30 / 45 / 60 minutes of travel?
- How long do I need to travel to reach N jobs / shops / people?
- How does accessibility differ spatially?
- How does accessibility differ temporally?

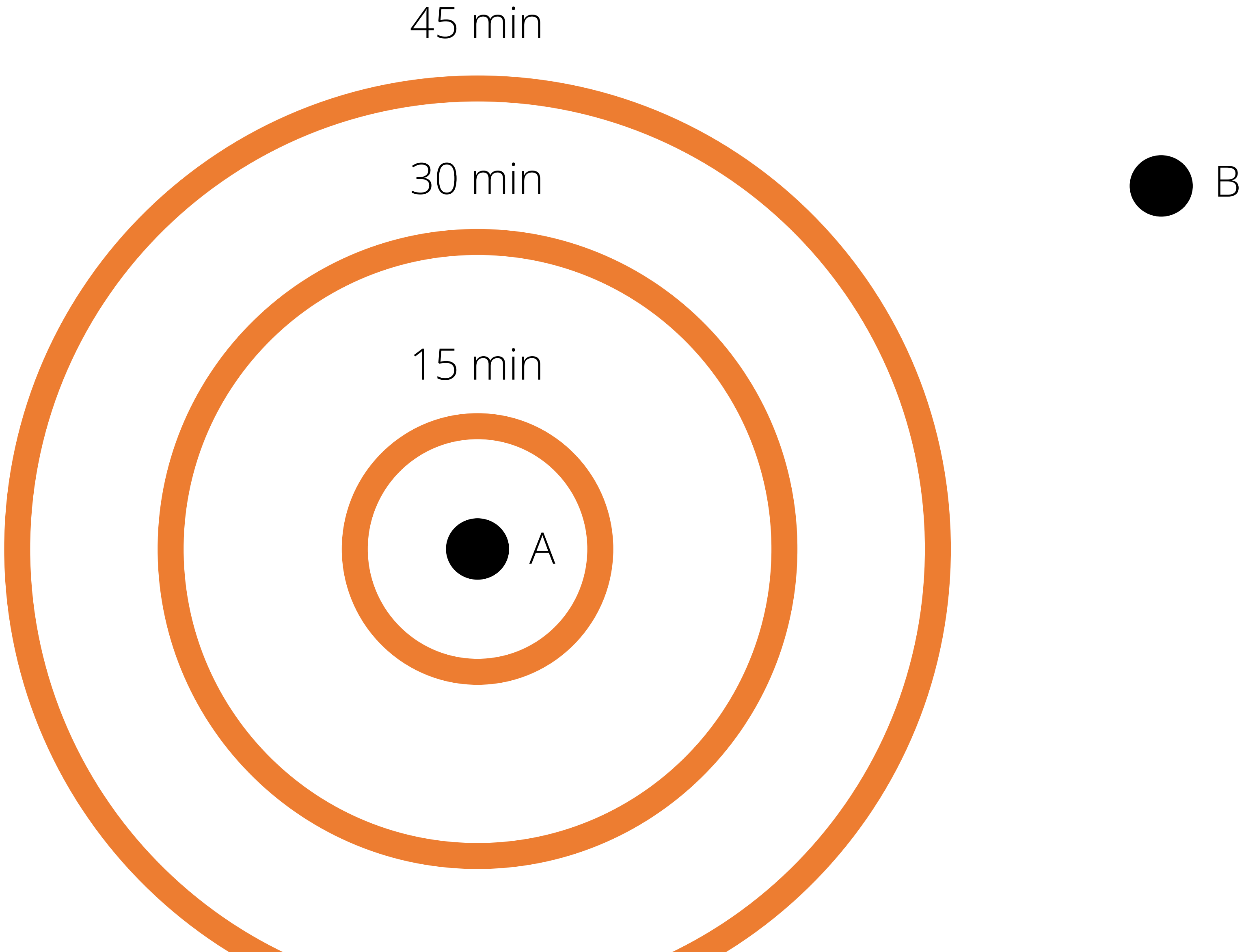
Accessibility

To quantitatively measure accessibility in a GIS we need at least:

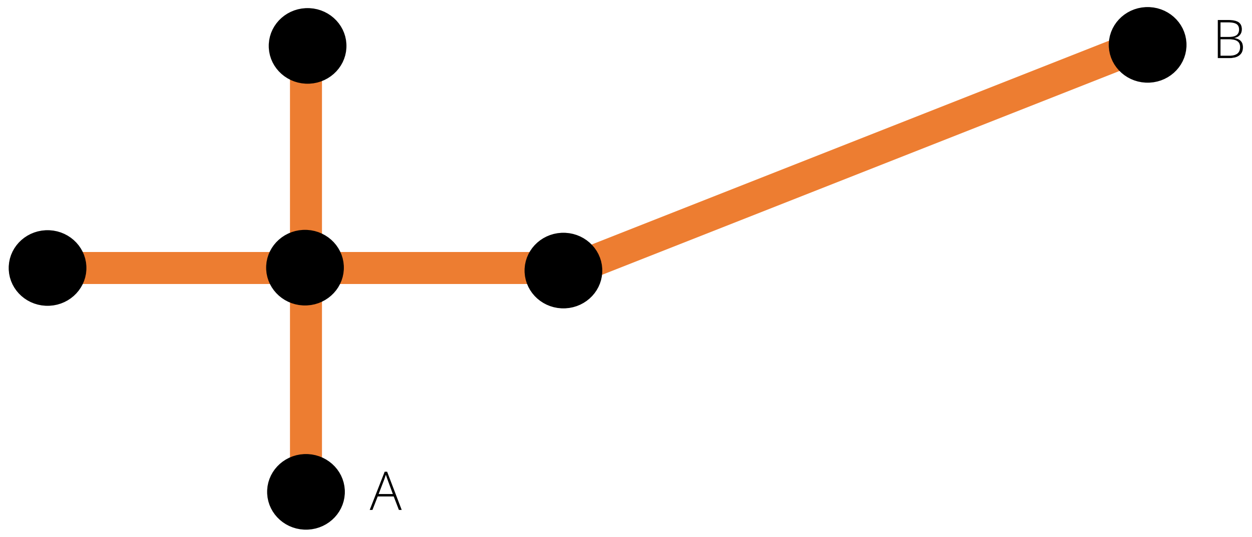
- A set of origins (e.g. set of fastfood outlets) [point vectors]
- A set of destinations (e.g. set of schools in an area) [point vector]
- Some form of a digital spatial network to connect origins and destinations [polyline vector]

Accessibility

Accessibility



Accessibility



Spatial network

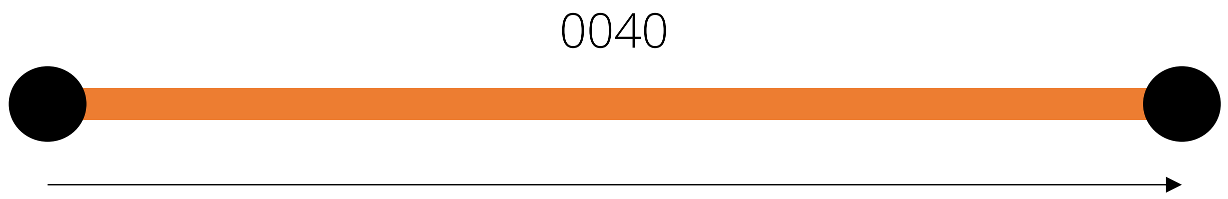
- A spatial network is an organised system or collection of nodes and edges embedded in geographic space.
- Nodes can be a representation of physical objects in geographical space, and edges show what connections are formed between the objects.
- Examples of networks: street configuration, transportation and shipping routes, river basins, telecommunication lines, etc.

Spatial network structure

Characteristics of a polyline vector in a GIS data model:

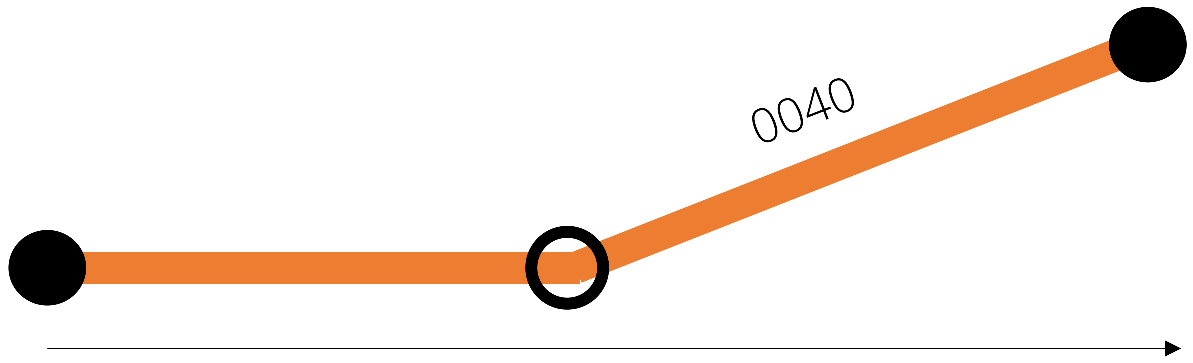
- Series of XY locations (coordinates) that form a line
- Has no area
- Has a length
- Has a direction (importance when it comes to roads, rivers, etc.)
- Can be connected to other polyline vectors to form a network
- Geometry consists of 2 nodes (start node and end node) and can have one or more vertices
- Used for: features without an area but with a length

Spatial network structure



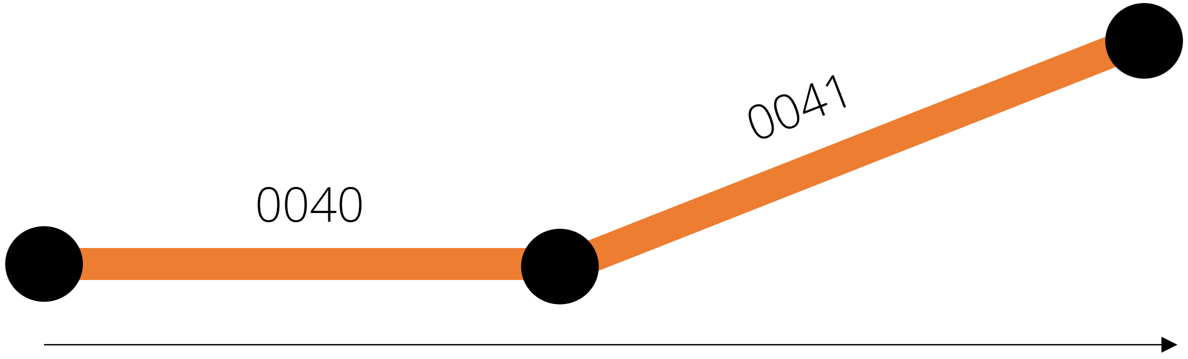
FeatureID	Type	Length
0040	Bicycle lane	1,500

Spatial network structure



FeatureID	Type	Length
0040	Bicycle lane	1,650

Spatial network structure

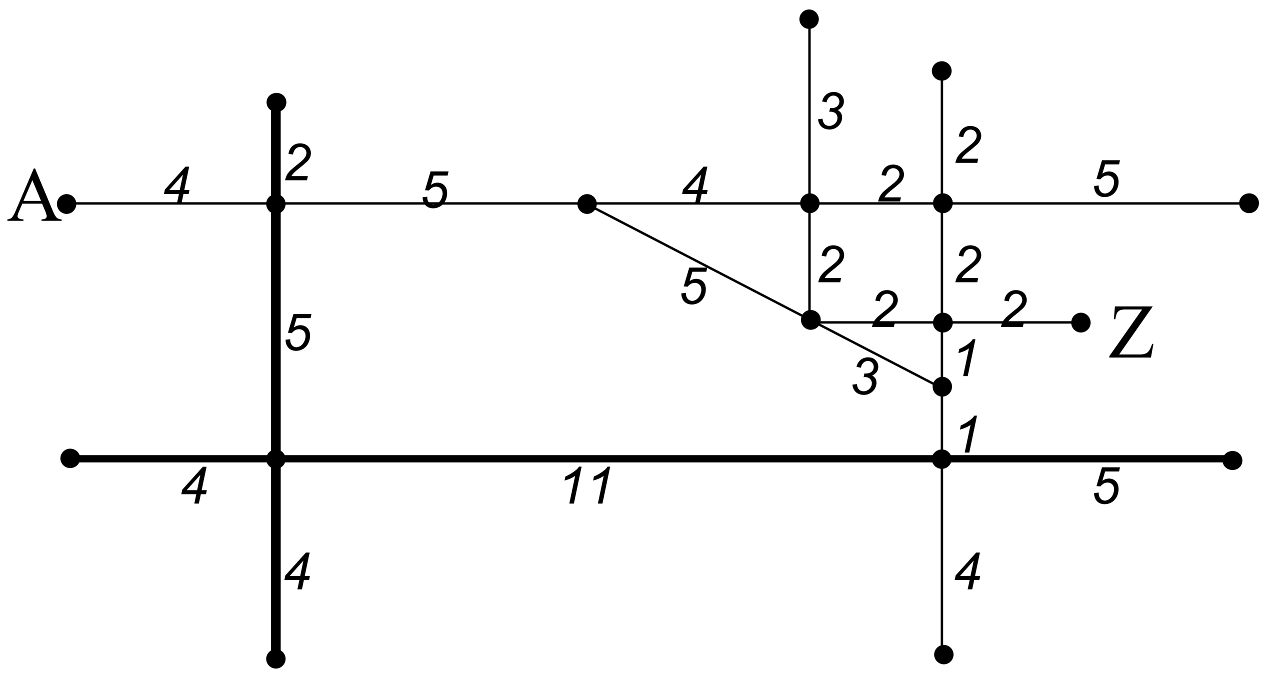


FeatureID	Type	Length
0040	Bicycle lane	600
0041	Bicycle lane	1,050

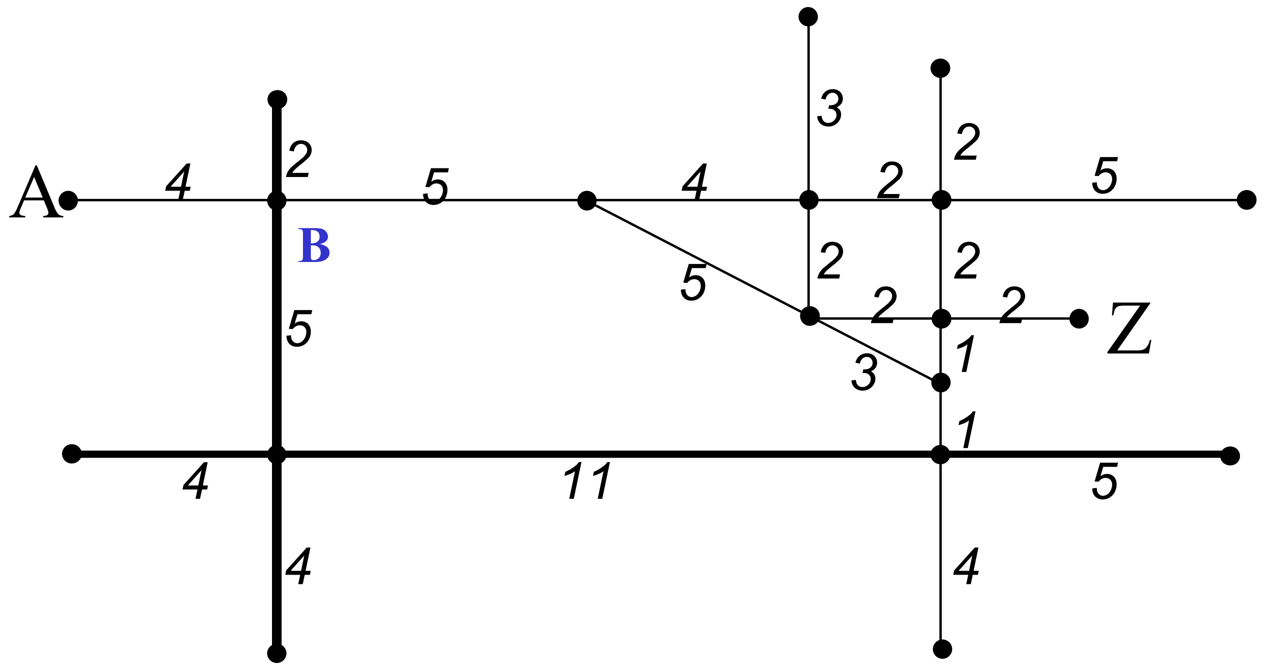
Dijkstra’s shortest path algorithm

- Shortest path
- Quickest path
- Cheapest path

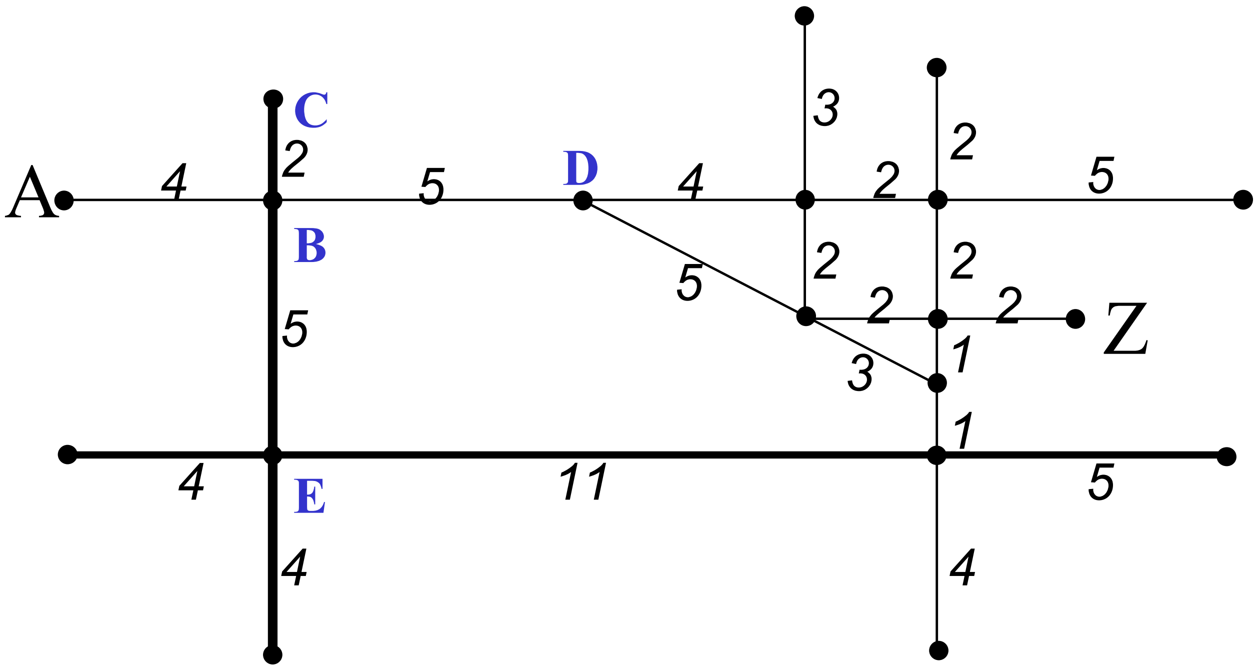
Dijkstra’s shortest path algorithm



Dijkstra's shortest path algorithm

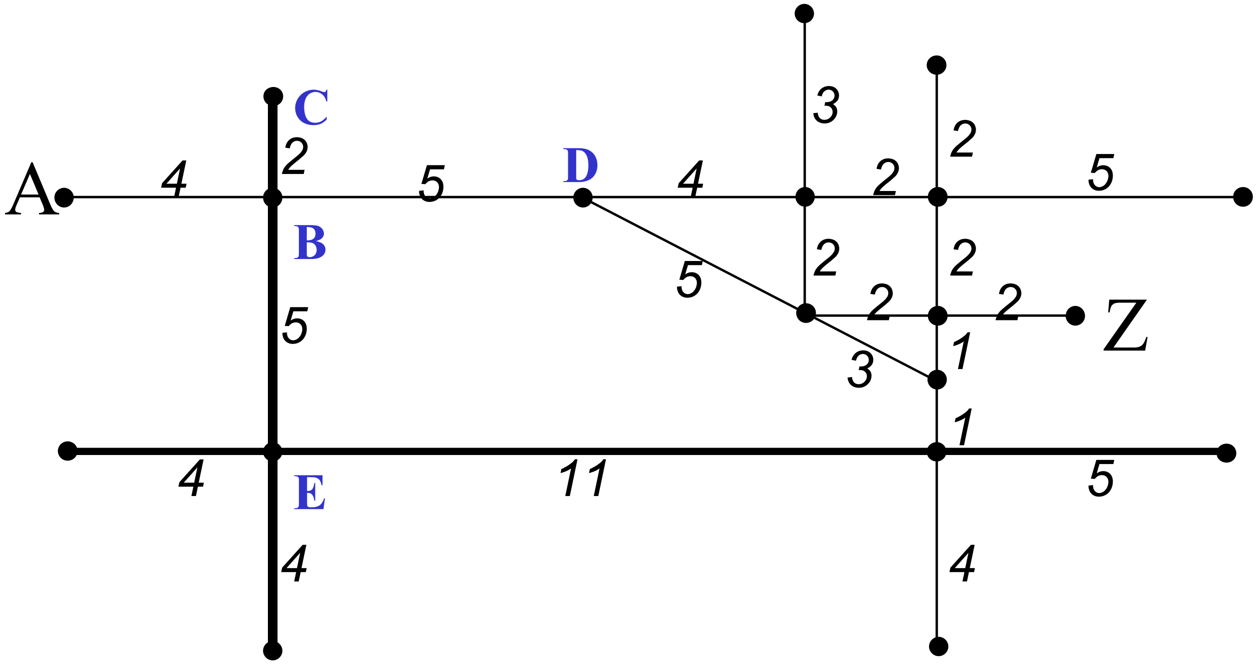


Dijkstra's shortest path algorithm



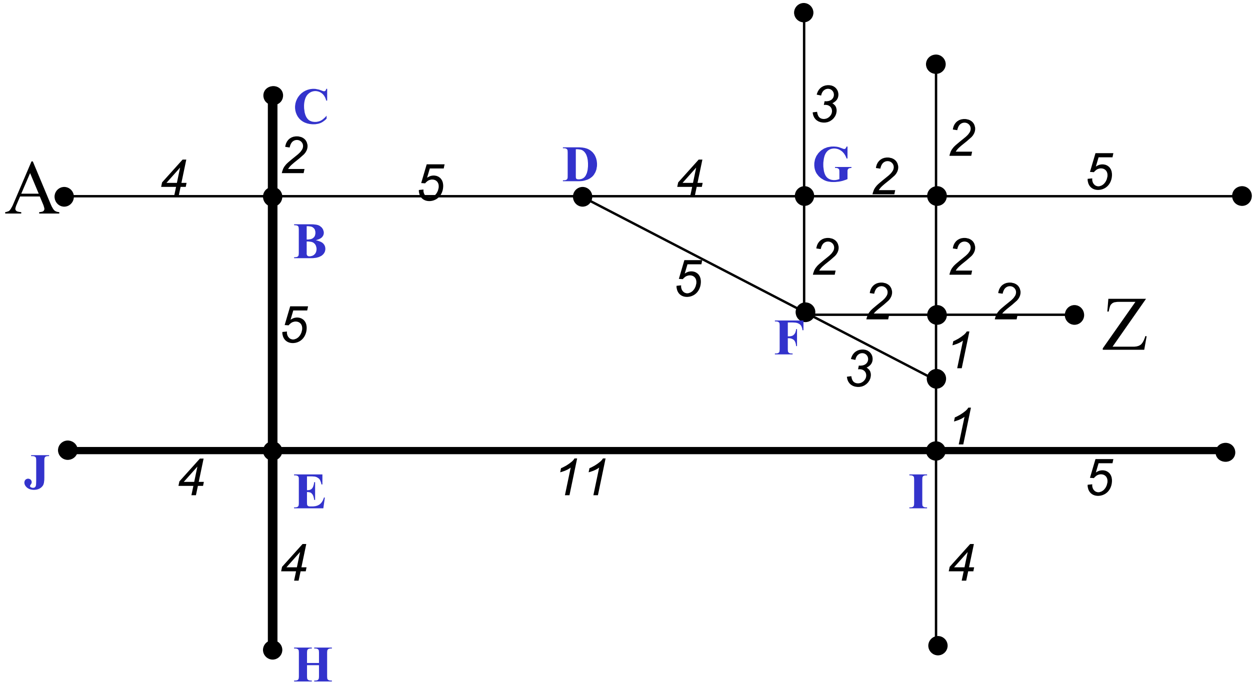
…	
ABC	6
ABD	9
ABE	9
B – AB	4

Dijkstra’s shortest path algorithm



…	
ABD	9
ABE	9
B – AB	4
C – ABC	6

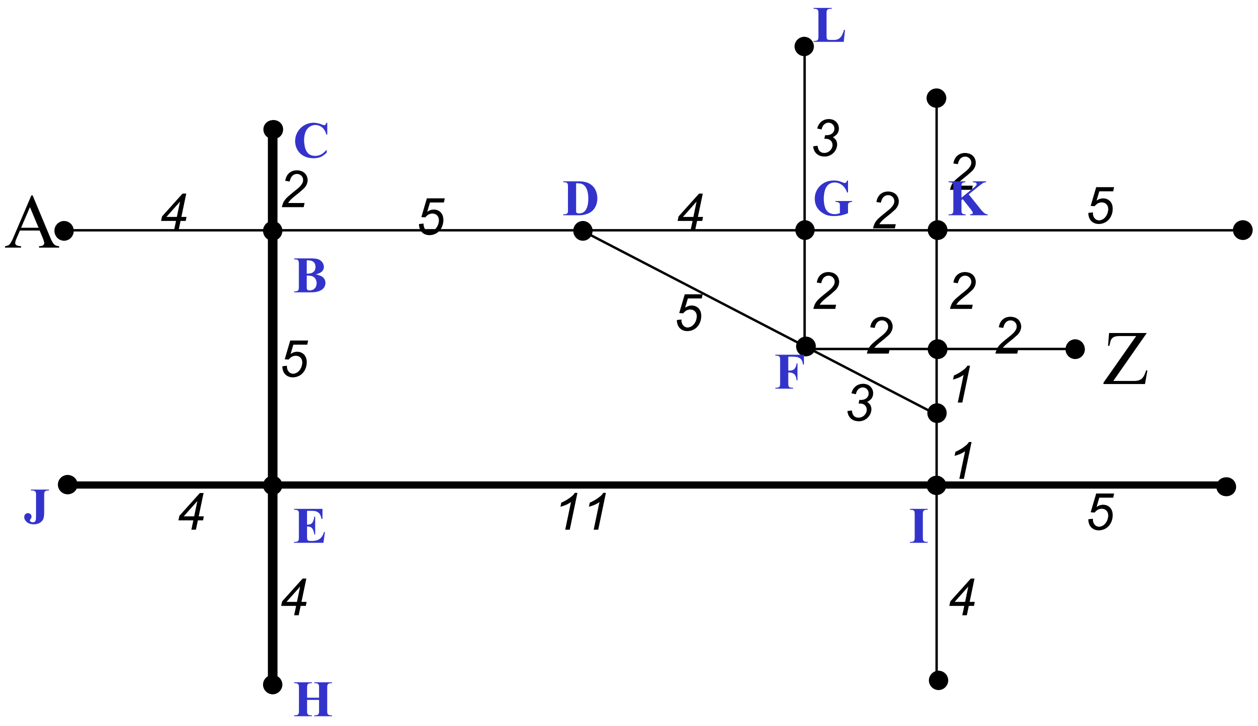
Dijkstra’s shortest path algorithm



…	
ABDG	13
ABEJ	13
ABEH	13
ABDF	14
ABEI	20

B – AB	4
C – ABC	6
D – ABD	9
E – ABE	9

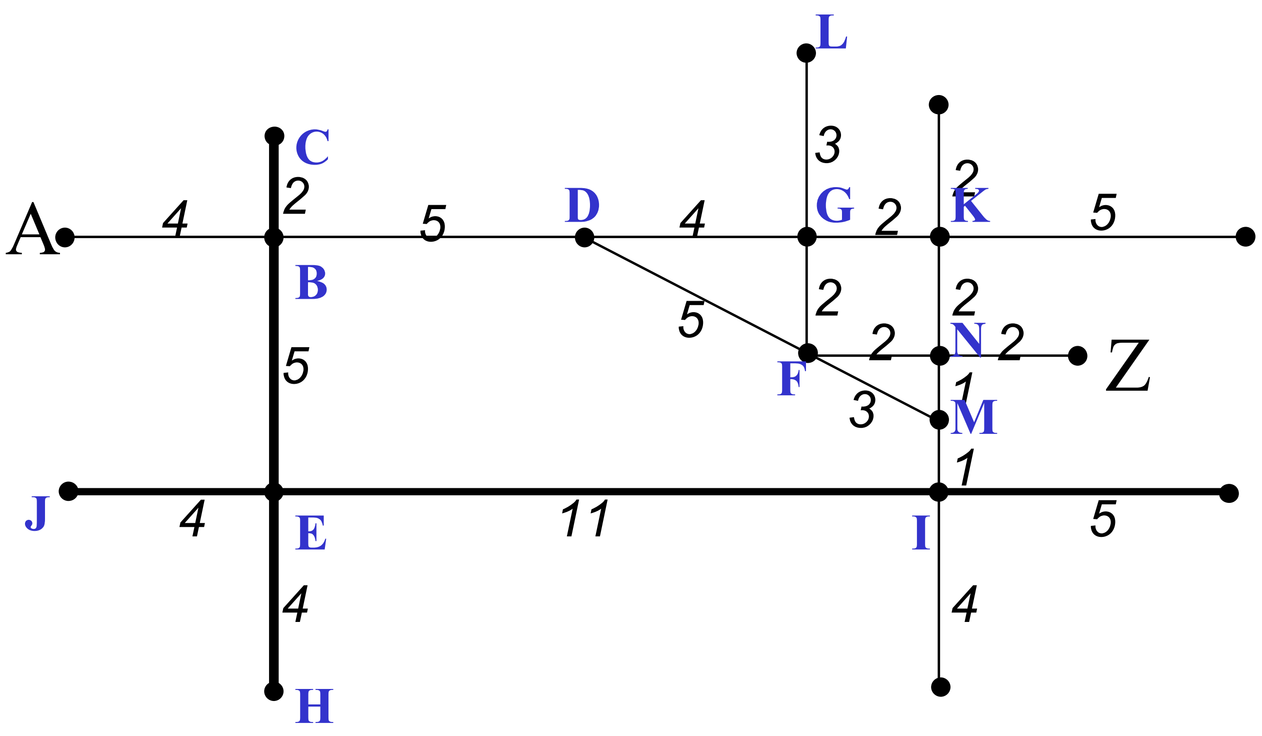
Dijkstra’s shortest path algorithm



…	
ABDF	14
ABDGK	15
ABDGF	15
ABDGL	16
ABEI	20

B – AB	4
C – ABC	6
D – ABD	9
E – ABE	9
G – ABDG	13
H – ABEH	13
J – ABEJ	13

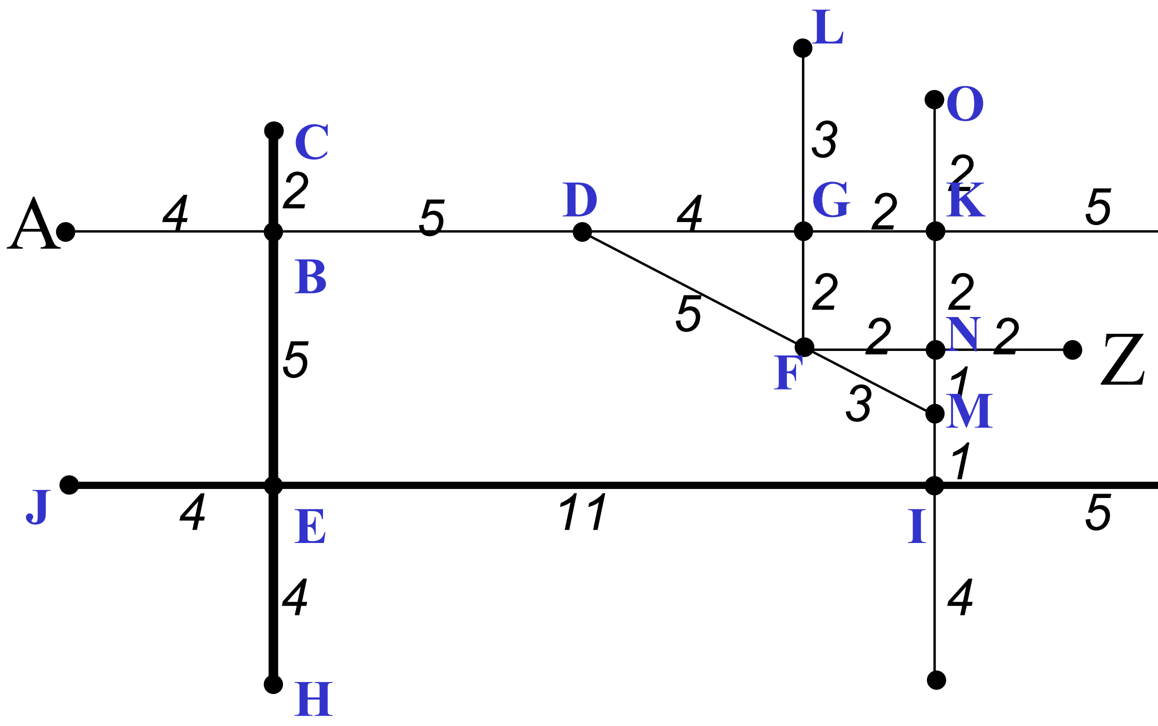
Dijkstra's shortest path algorithm



…	
ABDGK	15
ABDGL	16
ABDFN	16
ABDFM	17
ABEI	20

B – AB	4
C – ABC	6
D – ABD	9
E – ABE	9
G – ABDG	13
H – ABEH	13
J – ABEJ	13
F – ABDF	14

Dijkstra’s shortest path algorithm

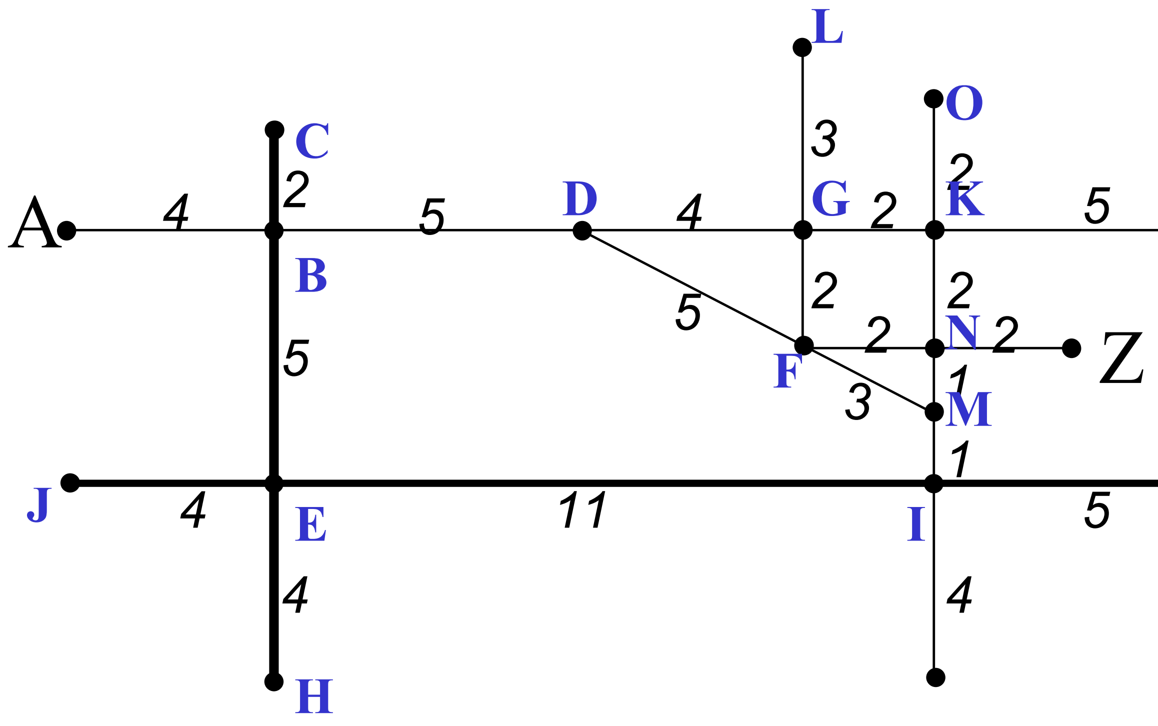


…

ABDGL	16
ABDFN	16
ABDFM	17
ABDGKO	17
ABDGKN	17
ABDGKP	20
ABEI	20

B – AB	4
C – ABC	6
D – ABD	9
E – ABE	9
G – ABDG	13
H – ABEH	13
J – ABEJ	13
F – ABDF	14
K – ABDGK	15

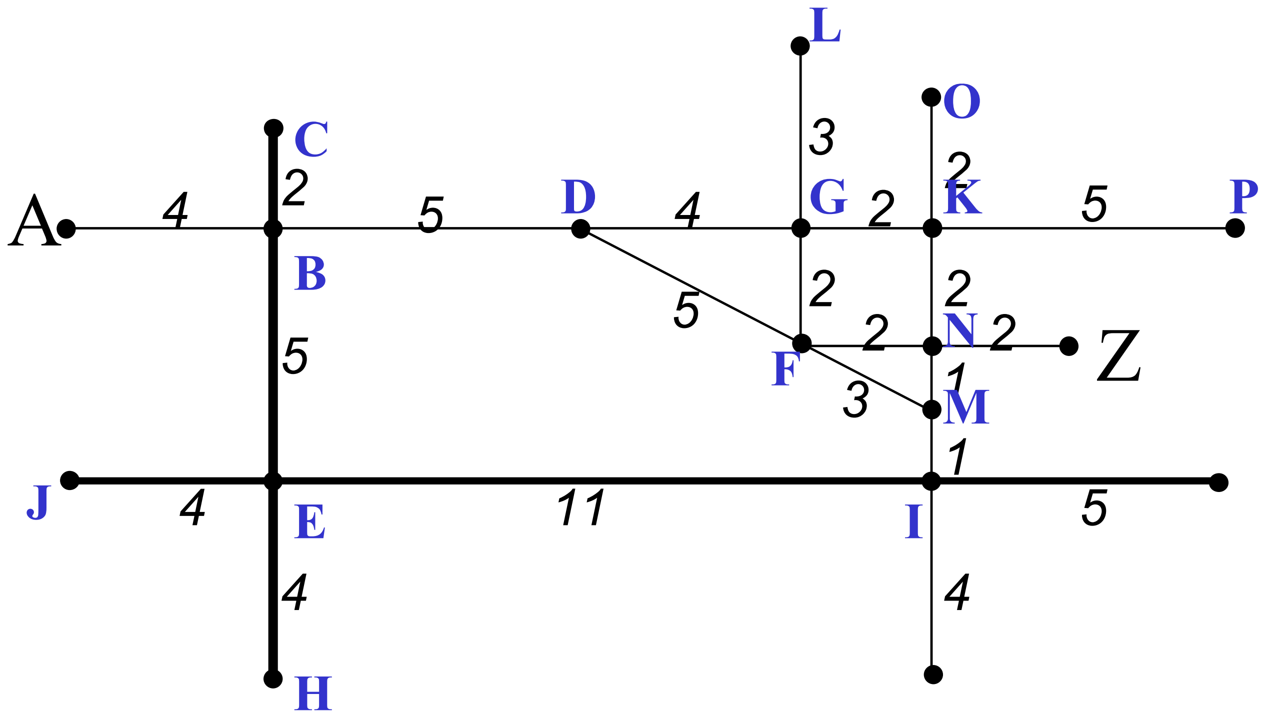
Dijkstra's shortest path algorithm



…	
ABDFNM	17
ABDGKO	17
ABDFNZ	18
ABDGKP	20
ABEI	20

B – AB	4
C – ABC	6
D – ABD	9
E – ABE	9
G – ABDG	13
H – ABEH	13
J – ABEJ	13
F – ABDF	14
K – ABDGK	15
L – ABDGL	16
N – ABDFN	16

Dijkstra's shortest path algorithm



...

ABDFNZ	18
ABDFMN	18
ABDFMI	18

B – AB	4
C – ABC	6
D – ABD	9
E – ABE	9
G – ABDG	13
H – ABEH	13
J – ABEJ	13
F – ABDF	14
K – ABDGK	15
L – ABDGL	16
N – ABDFN	16
M – ABDFM	17
O – ABDGKO	17

To measure accessibility

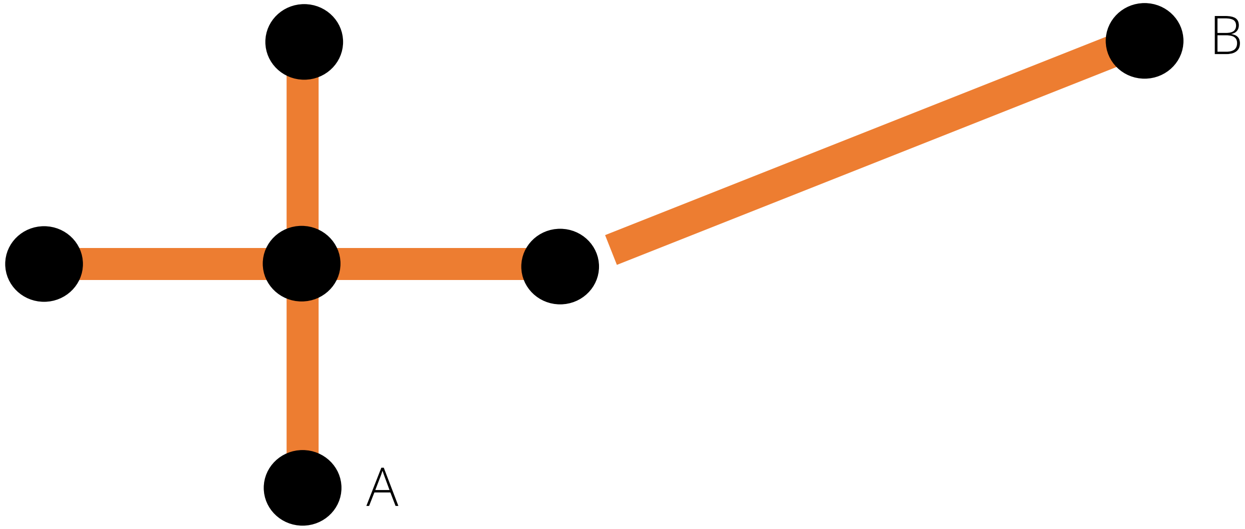
… with Dijkstra’s algorithm we need

- A set of origins (e.g. set of fastfood outlets) [point vectors]
- A set of destinations (e.g. set of schools in an area) [point vector]
- Some form of a digital spatial network to connect origins and destinations [polyline vector]
- Impedance values per mode of transport / costs for each network segment
- If available: access indicators to construct a weighted graph

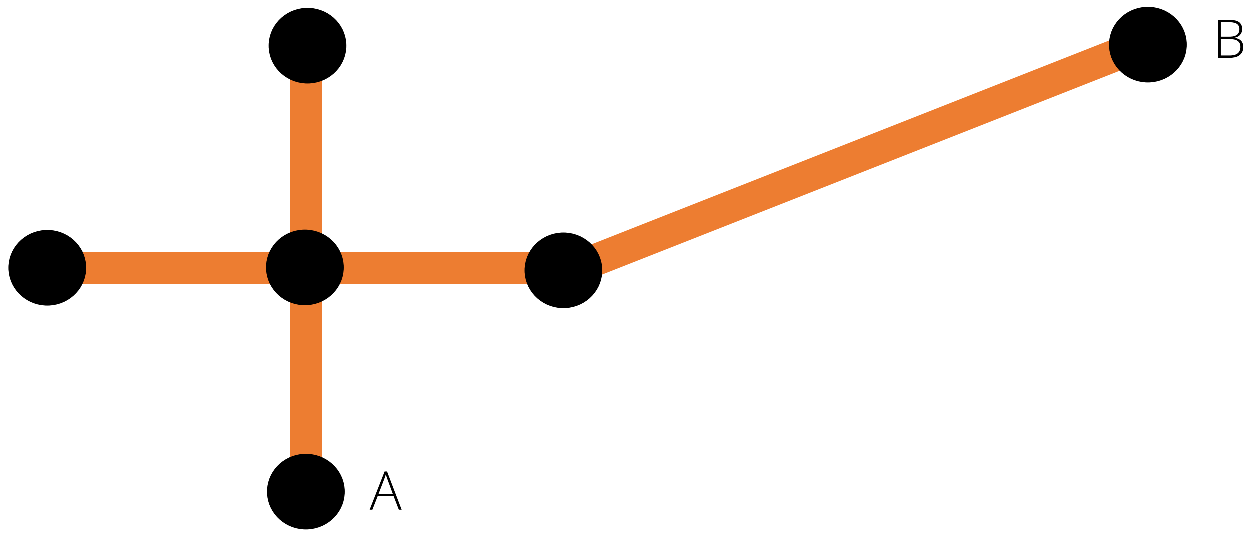
To consider

- Completeness – are all areas covered?
- Attributes – are they correct?
- Connectivity – are all network segments that should be connected, connected?
- Topology – are all network segments connected the way they should be?
- Coverage – is the full network covered?

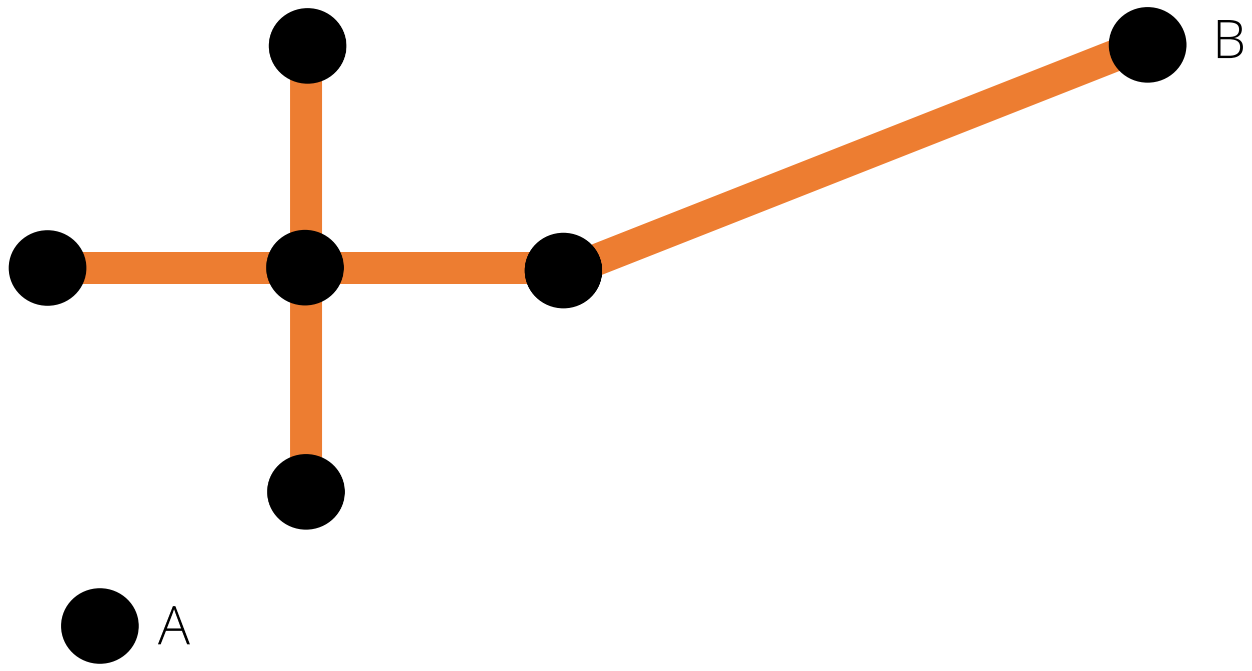
Connectivity



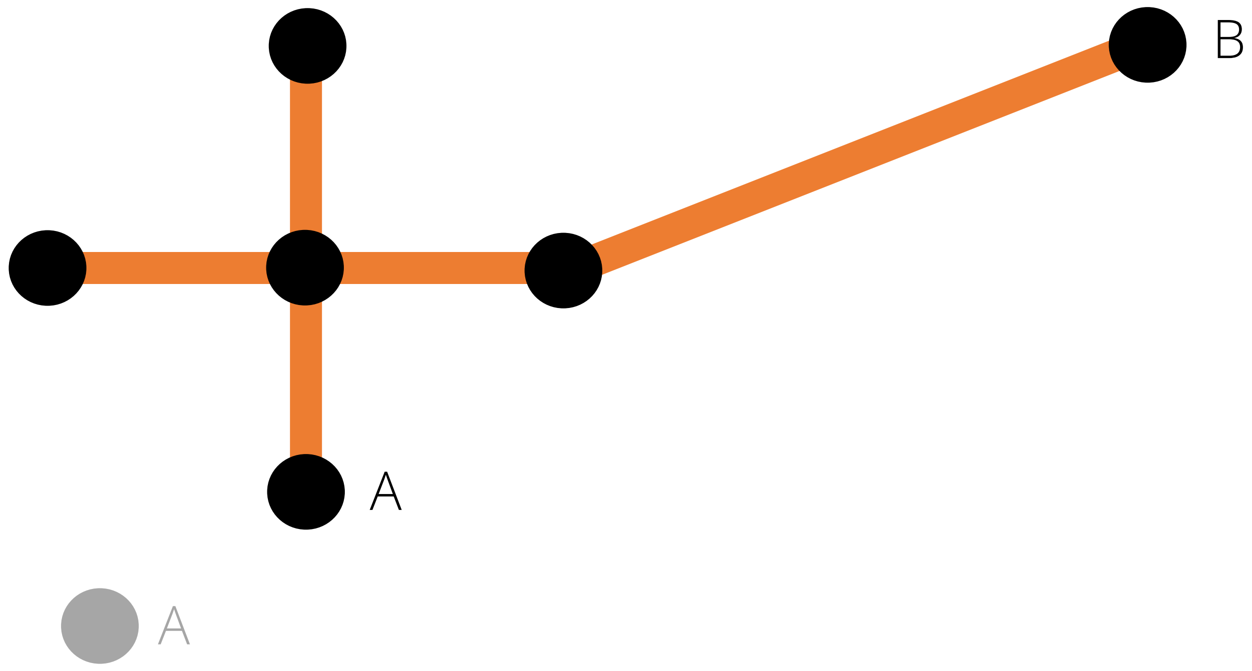
Connectivity



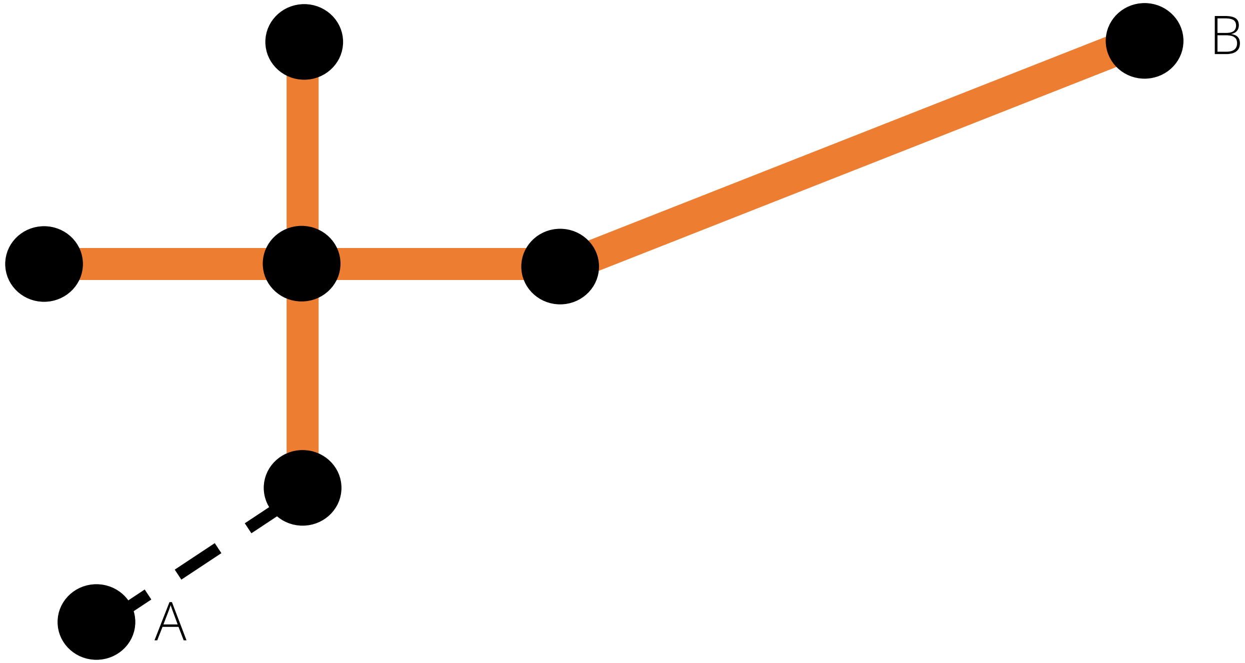
Connectivity



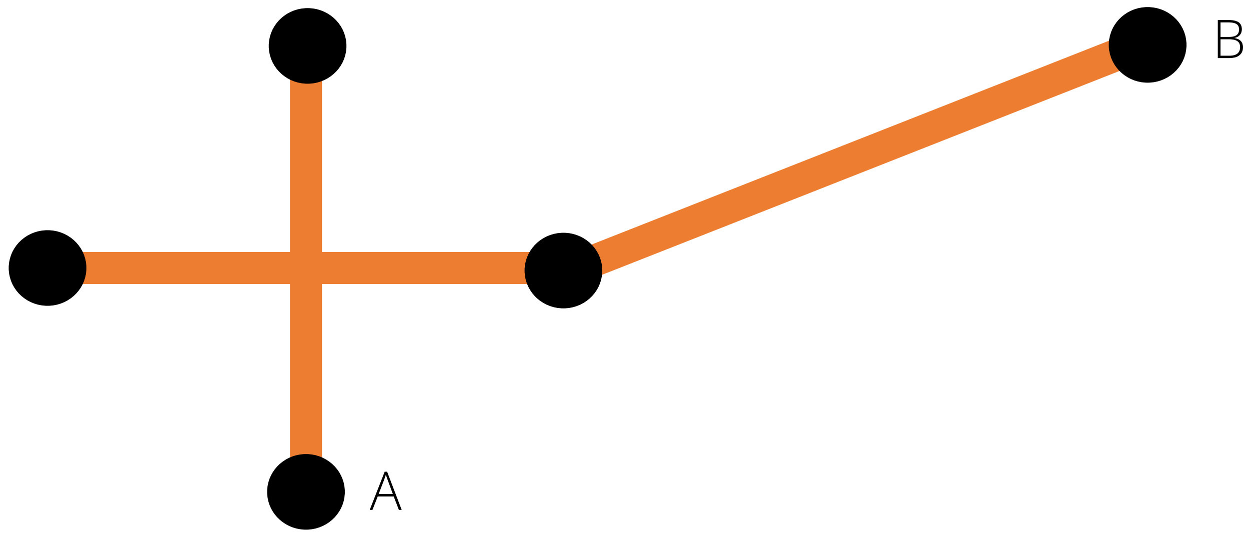
Connectivity



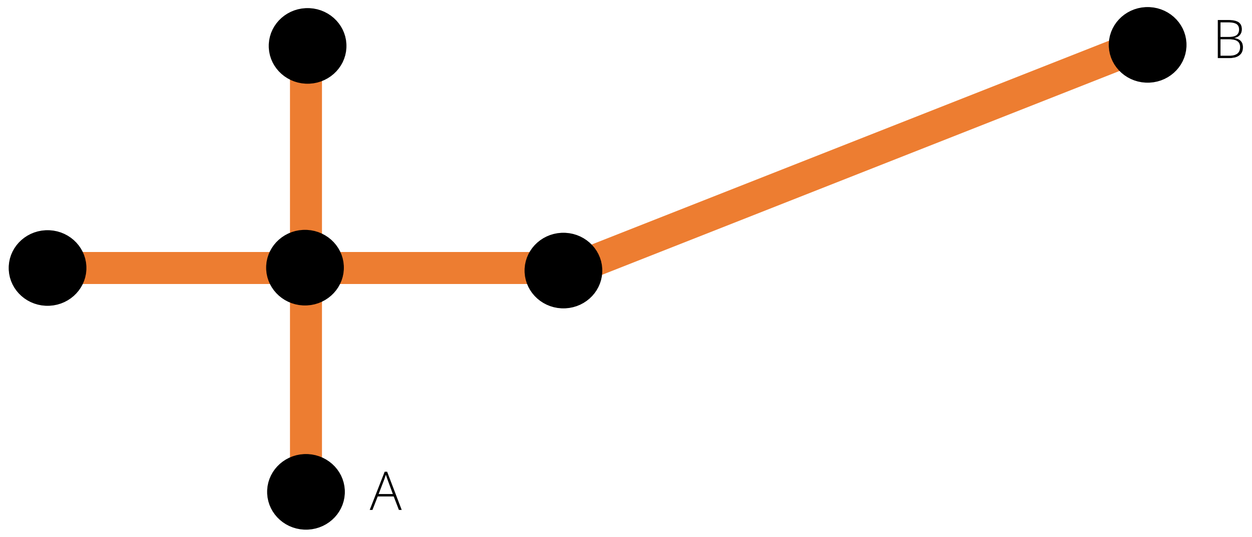
Connectivity



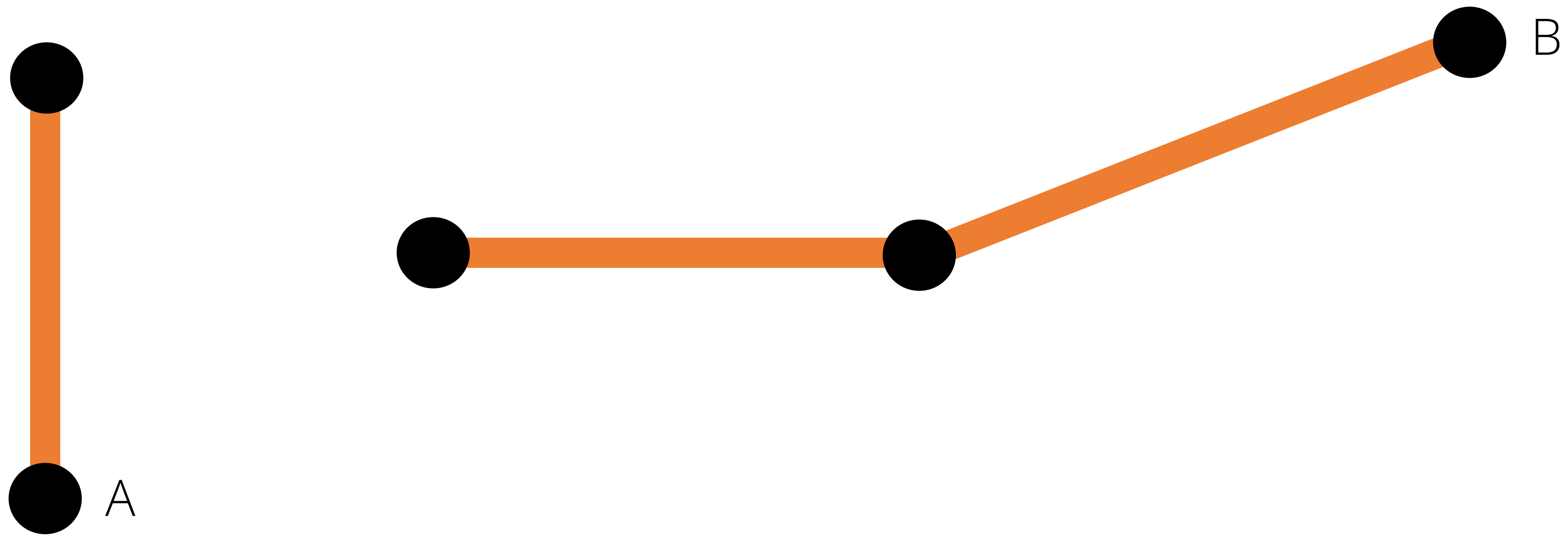
Topology



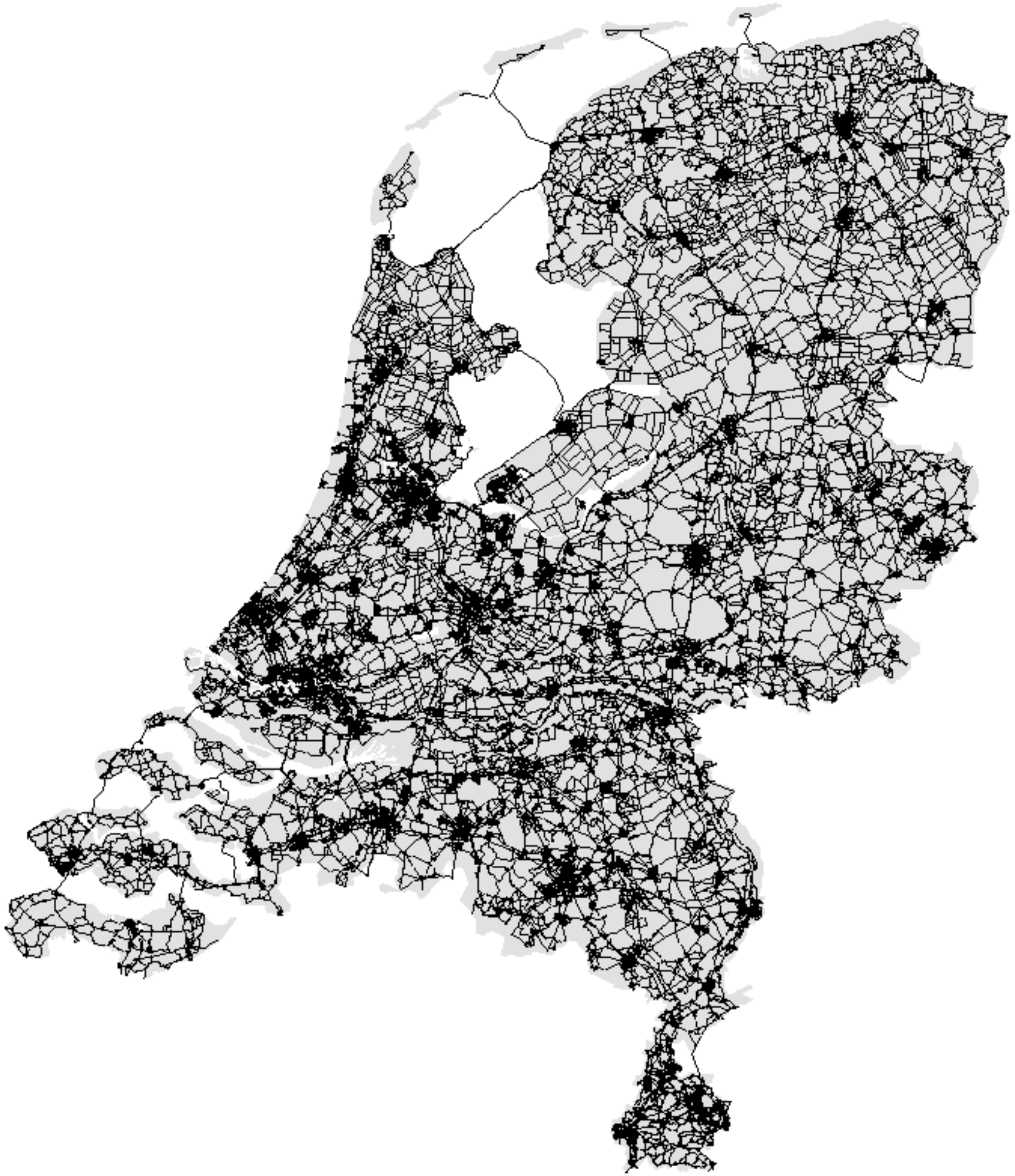
Topology



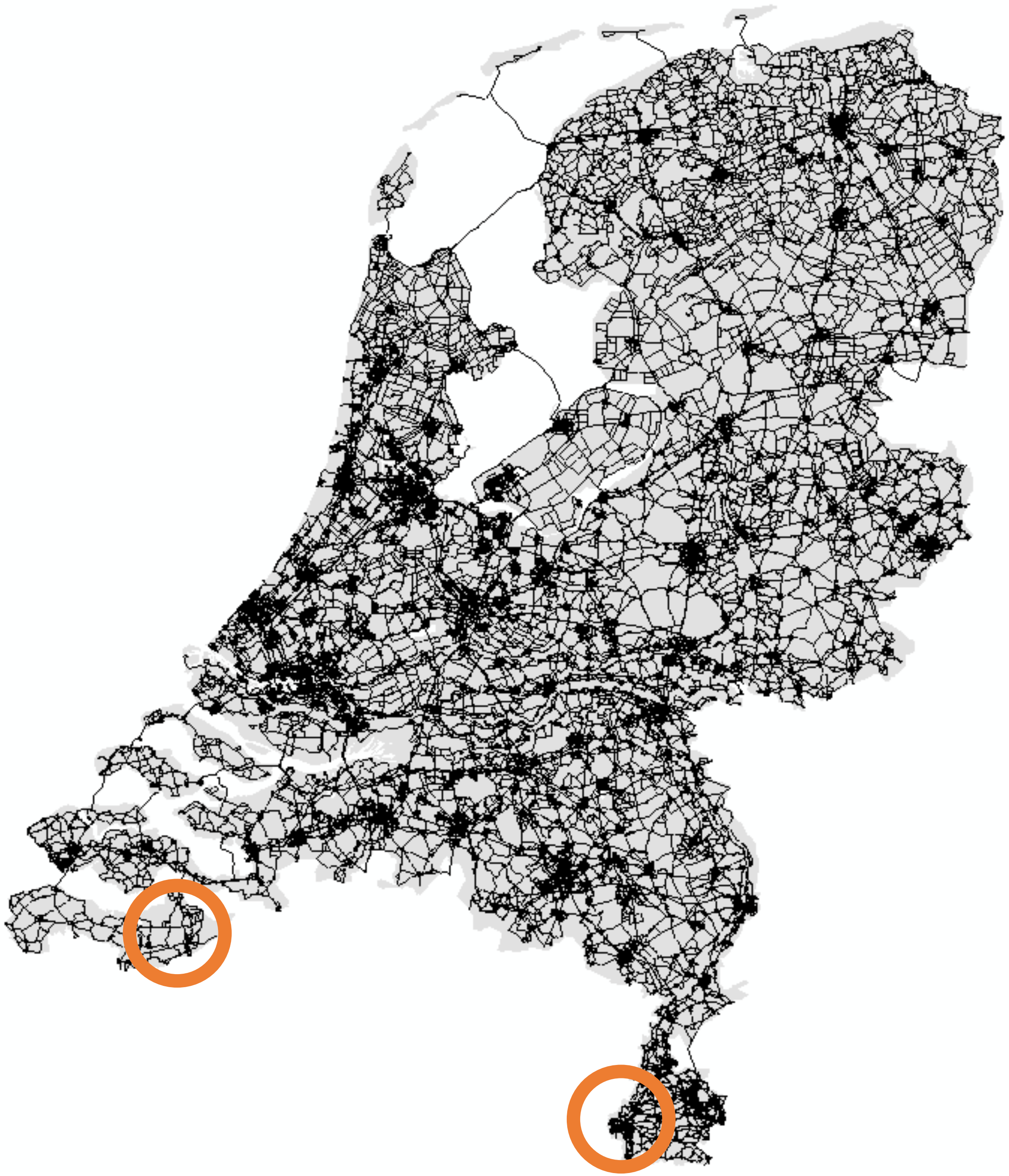
Topology



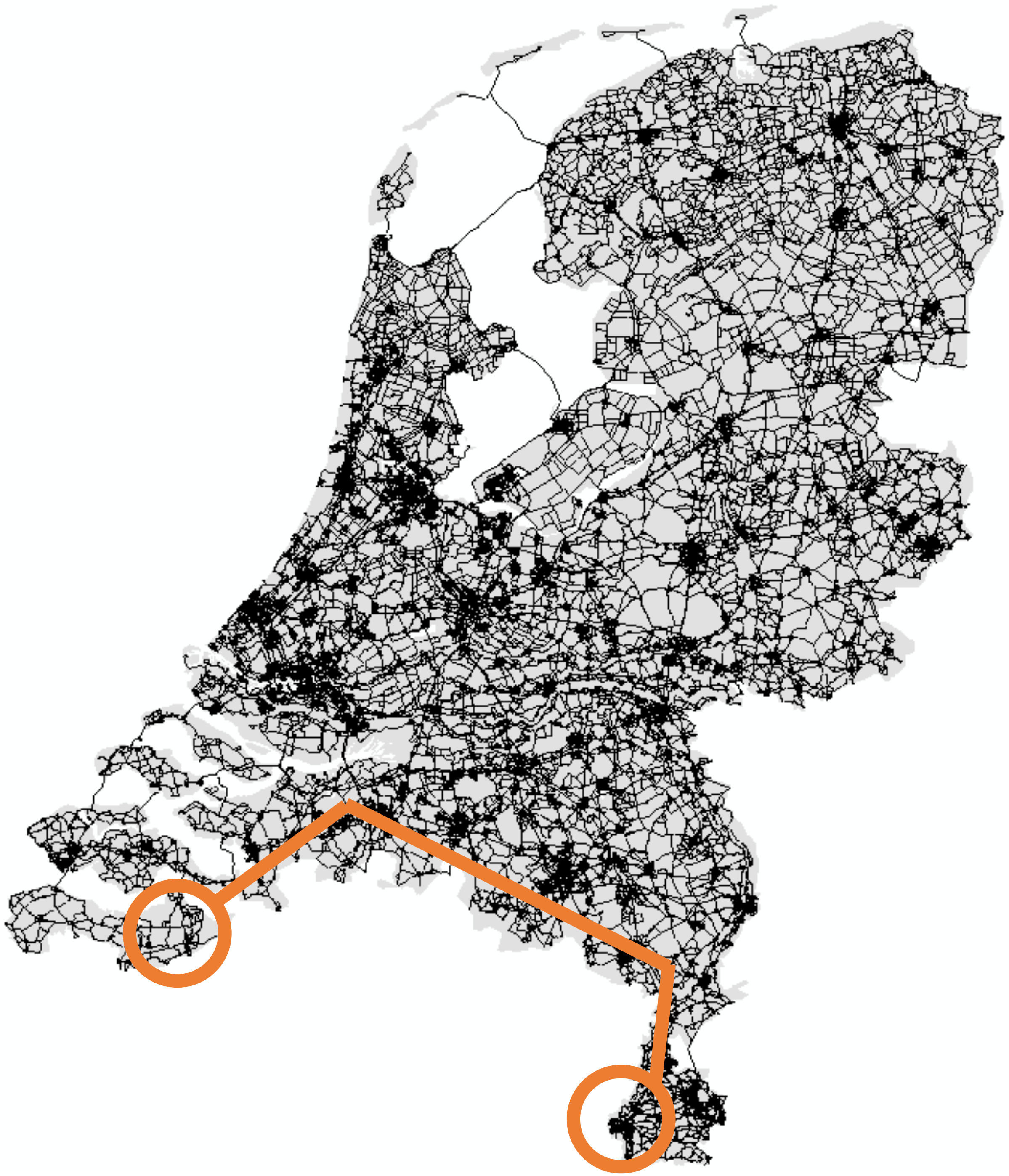
Coverage



Coverage



Coverage



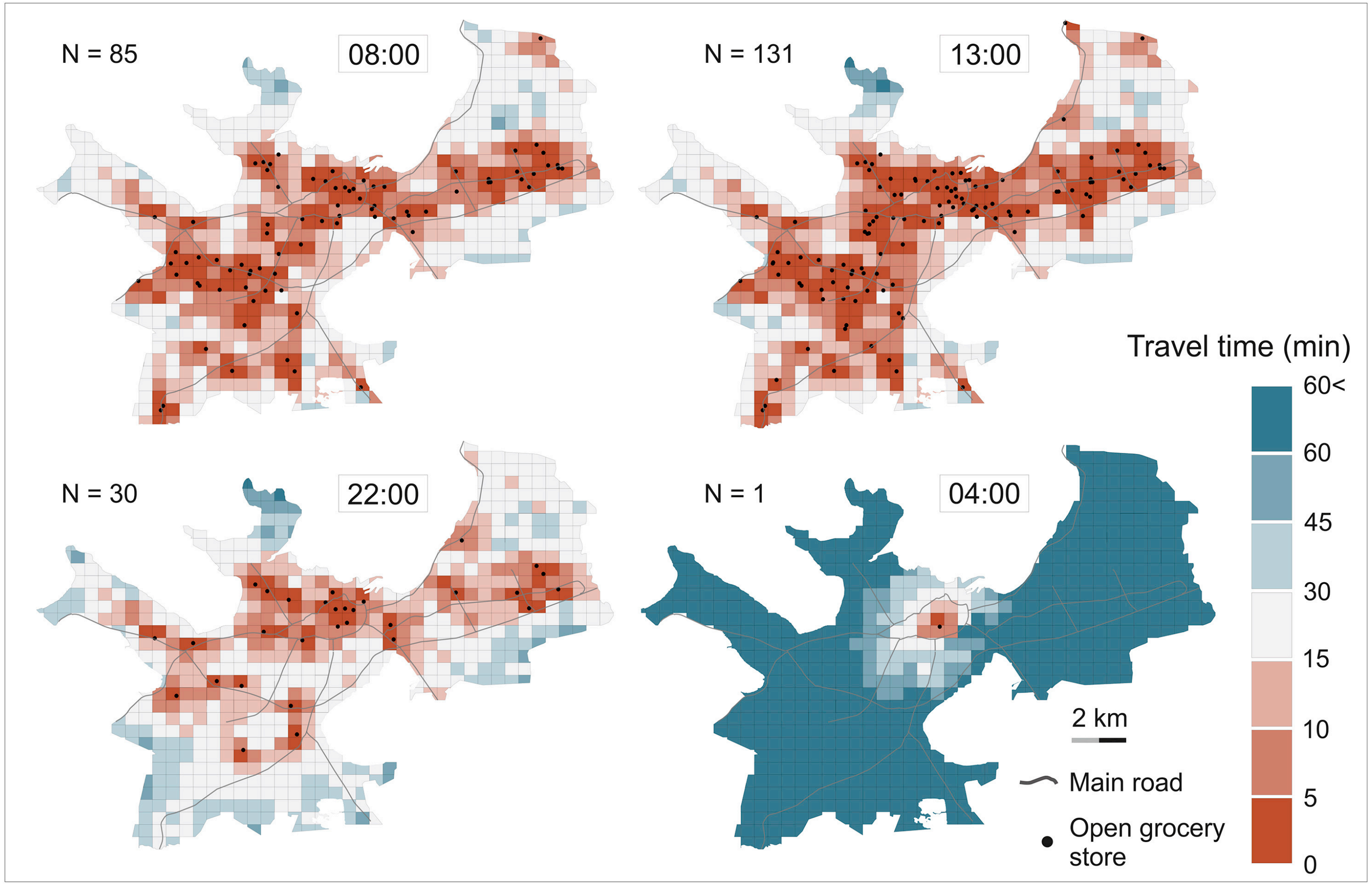
Coverage

Accessibility

Typical questions where accessibility analysis comes in:

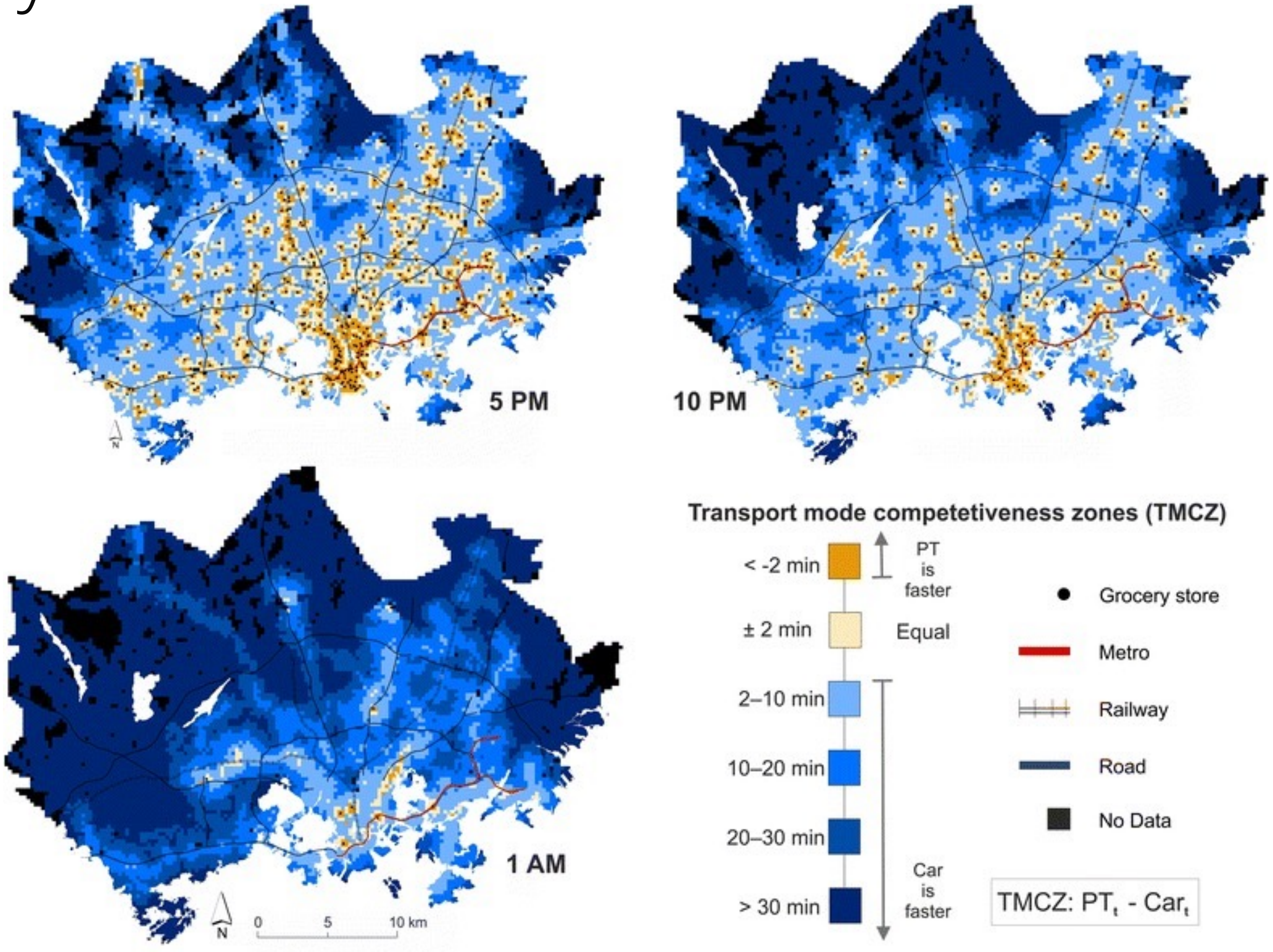
- How many jobs / shops / people can I reach within 15 / 30 / 45 / 60 minutes of travel?
- How long do I need to travel to reach N jobs / shops / people?
- How does accessibility differ spatially?
- How does accessibility differ temporally?

Accessibility



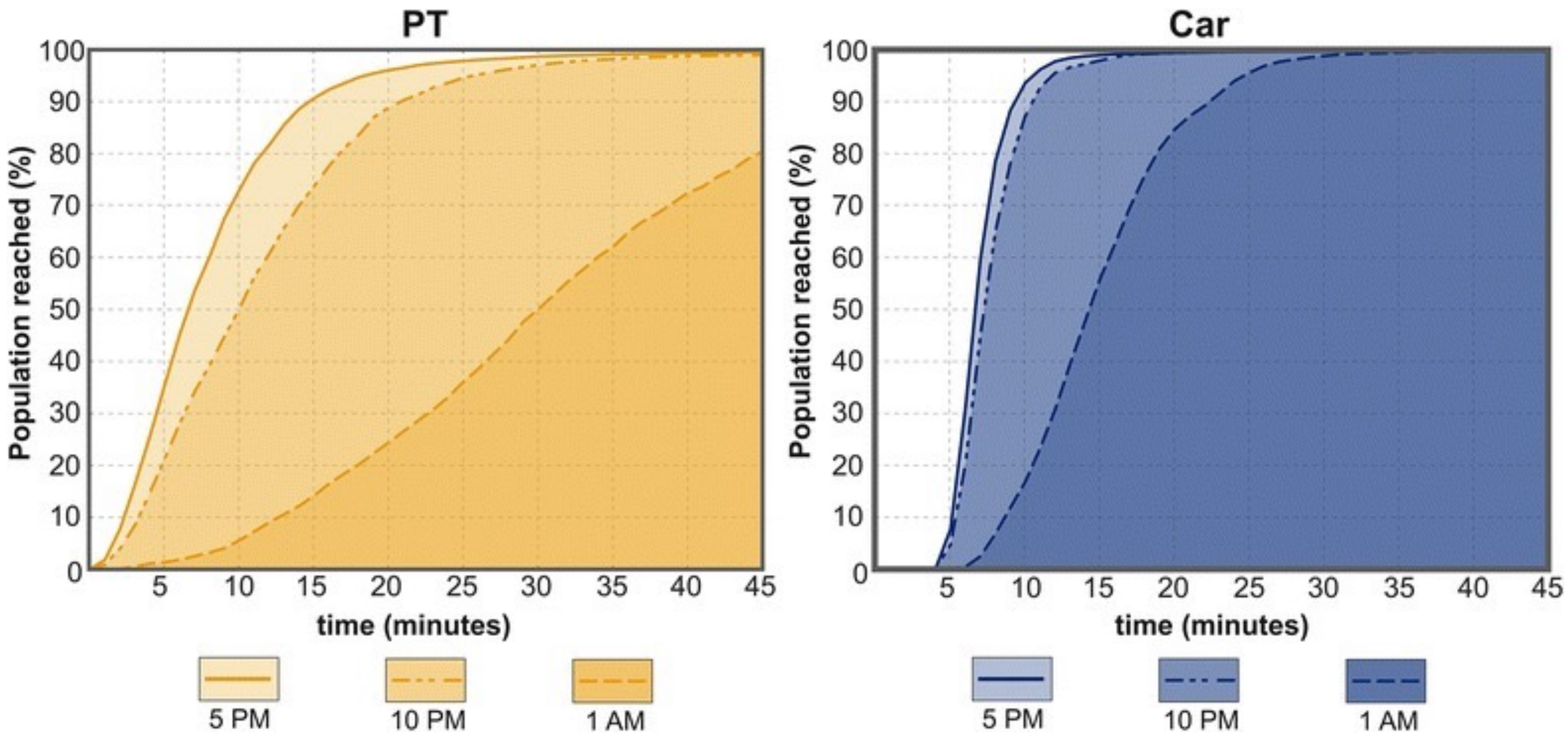
Järv *et al.* 2018

Accessibility



Tenkanen *et al.* 2016

Accessibility



Tenkanen *et al.* 2016

Conclusion

- Pretty much talked about modelling accessibility using transport network analysis.
- Need at least some origins, some destinations, some form of network.
- Shortest path between origins and destinations is typically calculated using Dijkstra's Algorithm.
- Network properties are important – especially connectivity, but coverage can make a big difference.
- There is much more: including all types of network centrality measures.

Everything we covered

Everything we covered Pt. 1

1) Geocomputation as a GIS 2.0: working with geographic data in a computational way, focusing on code, reproducibility and modularity.
2) GIS data models; raster versus vector and when to use.
3) Decisions involved when creating maps and visualisations – together with how to position a map (i.e. Coordinate Reference Systems and Projections).
4) A brief introduction to the principles of R and its usefulness for data analysis.
5) Usage of R in the context of spatial analysis, including the idea of tidy data and the grammar of graphics.

Everything we covered Pt. 2

1) Spatial operations using spatial properties and relationships – the core of spatial analysis
2) The First Law of Geography in action: measuring spatial autocorrelation.
3) Summarising point data through various methods, including a deep dive into Kernel Density Estimation.
4) Raster analysis and associated methods, spatial data interpolation through Inverse Distance Weighting and Kriging.
5) Transport Network Analysis: modelling accessibility using a digital transport network.

Geocomputation Extra Help Session

- Friday March 24 from 14h00-16h00 in North-West Wing 3.04.
- Bring your own laptop.
- Not mandatory.

Geocomputation Extra Help Session

- Monday April 3 from 12h00-14h00 in North-West Wing 1.16.
- Bring your own laptop.
- Not mandatory.

Geocomputation Exam Q&A Session

- Friday April 28 from 11h00-12h00 in Bentham House LG17 Lecture Theatre B.
- Not mandatory.

Questions

Justin van Dijk

j.t.vandijk@ucl.ac.uk

Thank you

Justin van Dijk

j.t.vandijk@ucl.ac.uk