Principles of Spatial Analysis

WEEK 08: Accessibility Analysis

UCL

This week

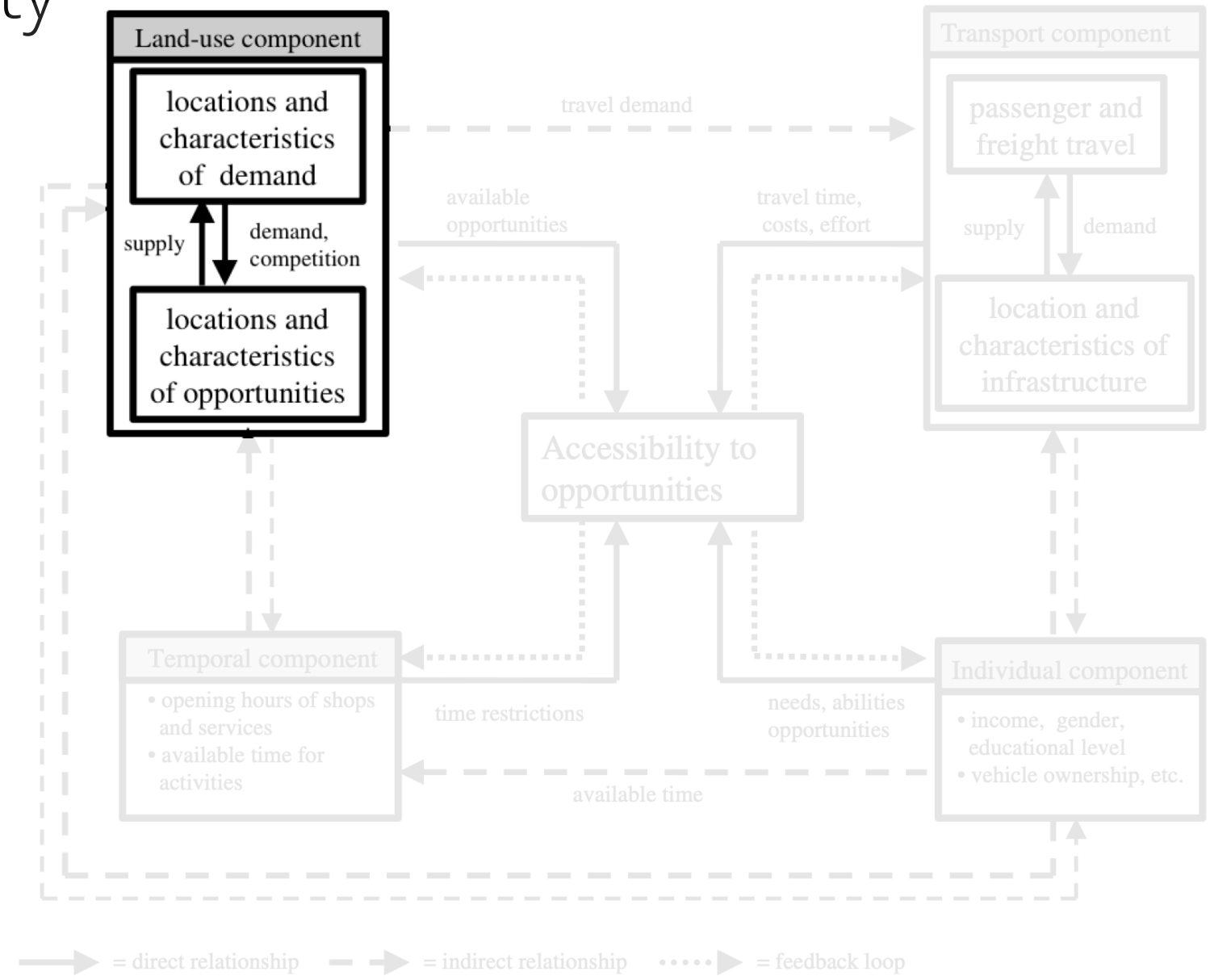
- Transport network and accessibility analysis.
- Spatial network structure.
- Dijkstra’s shortest path algorithm.
- An example of transport network and accessibility analysis.

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



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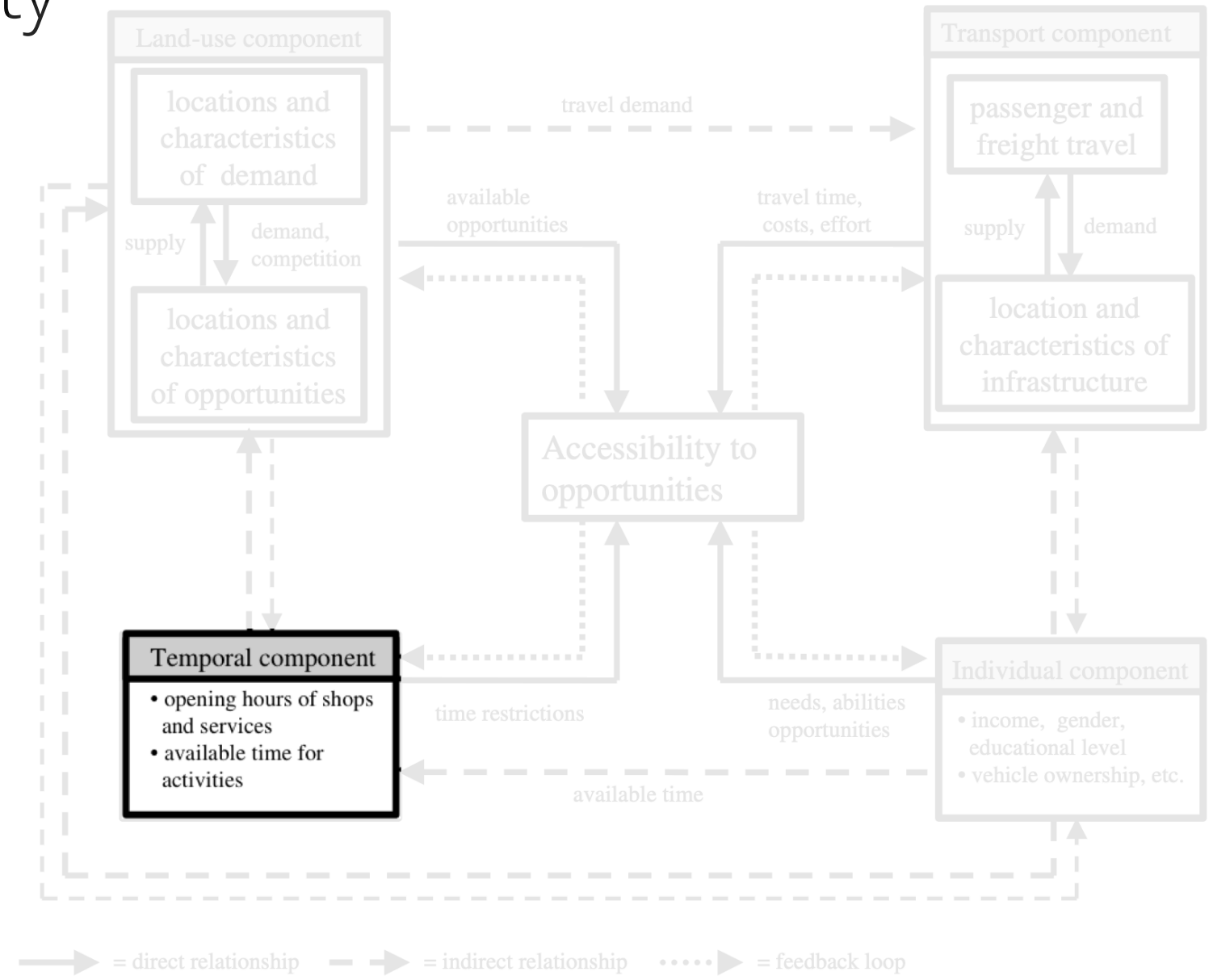

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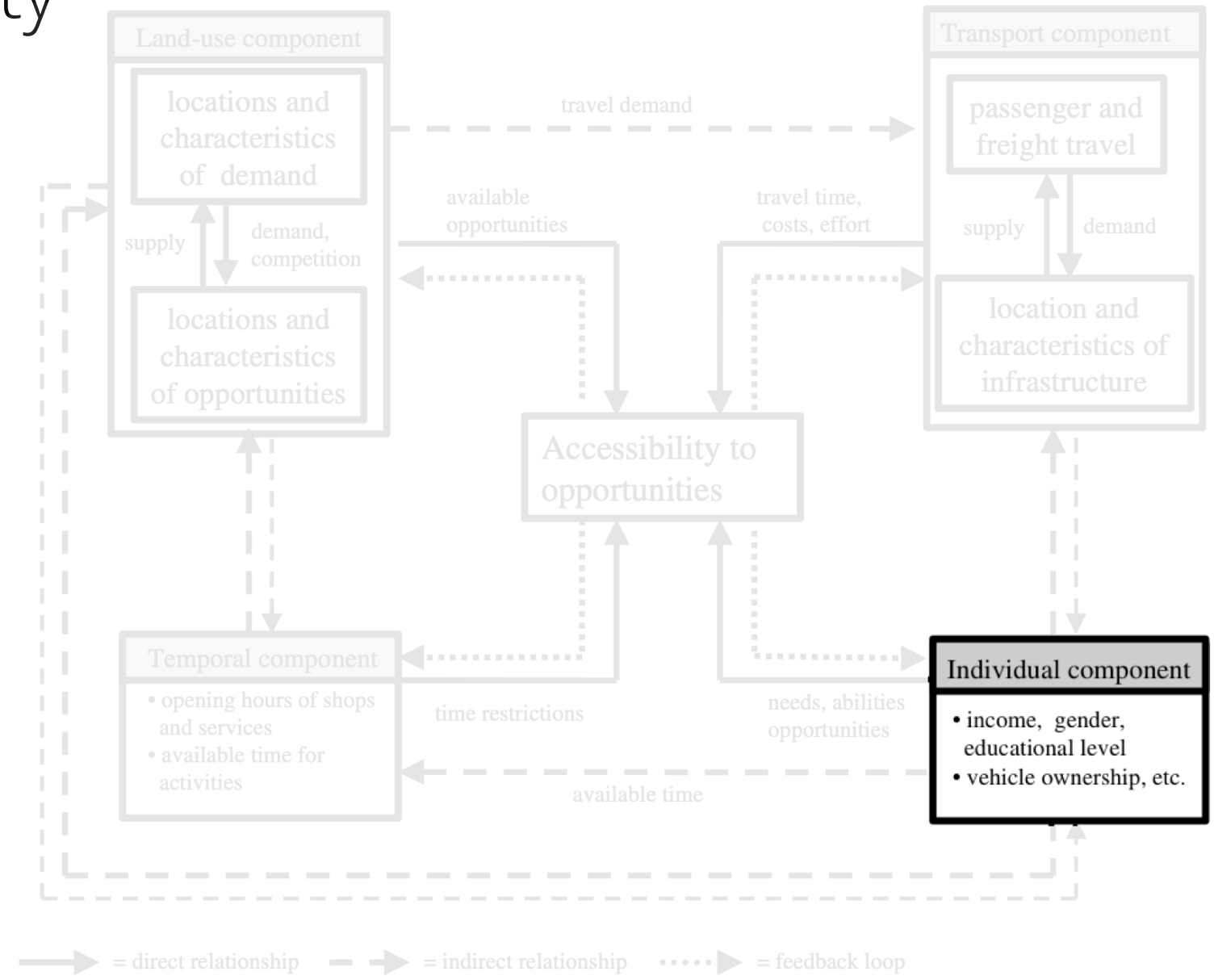

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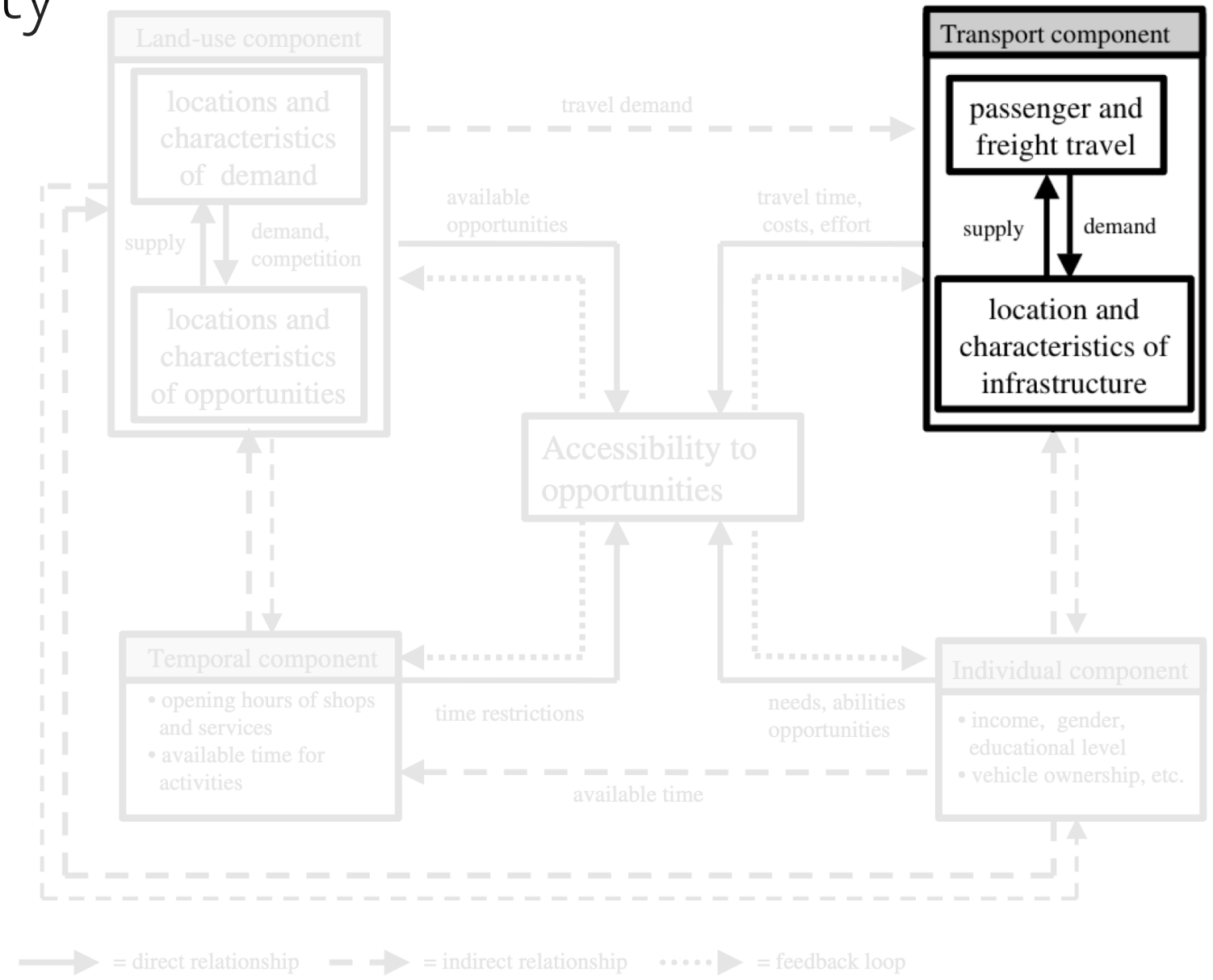

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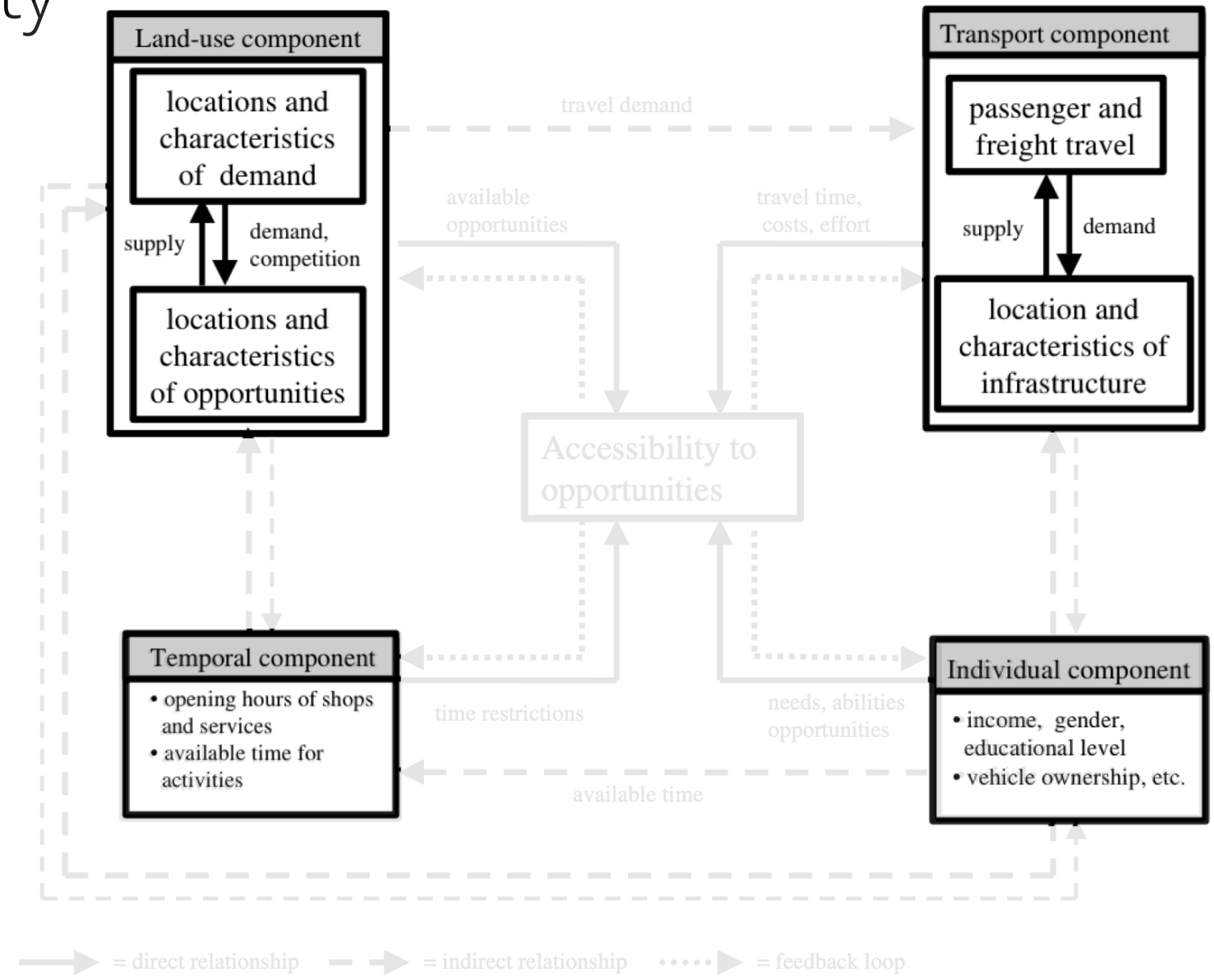

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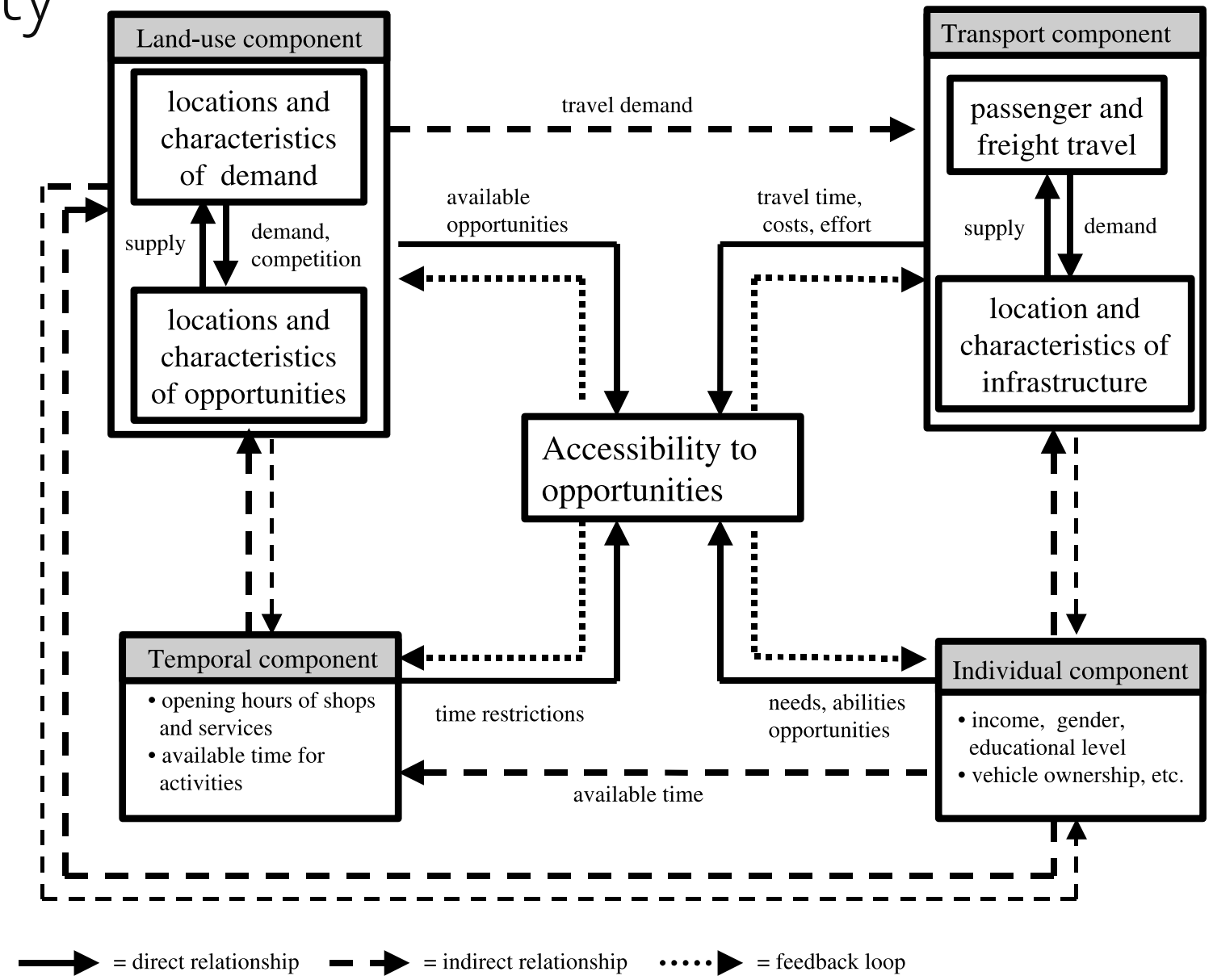
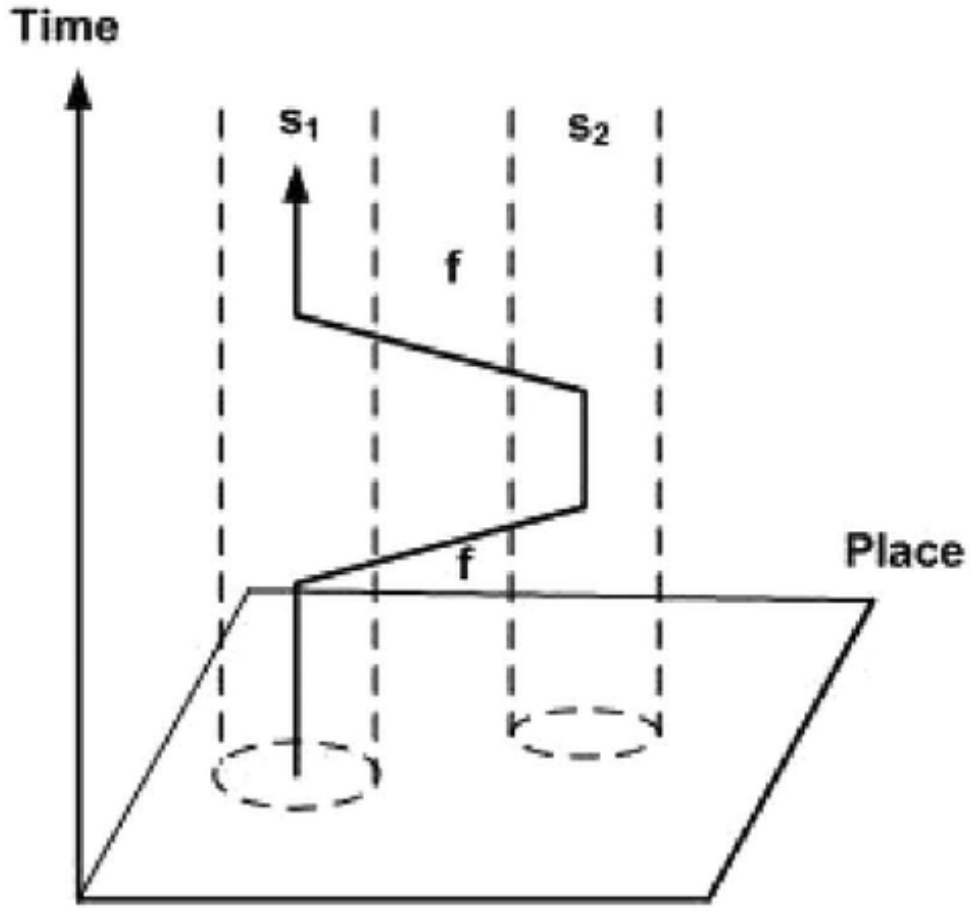


Geurs and Van Wee 2004

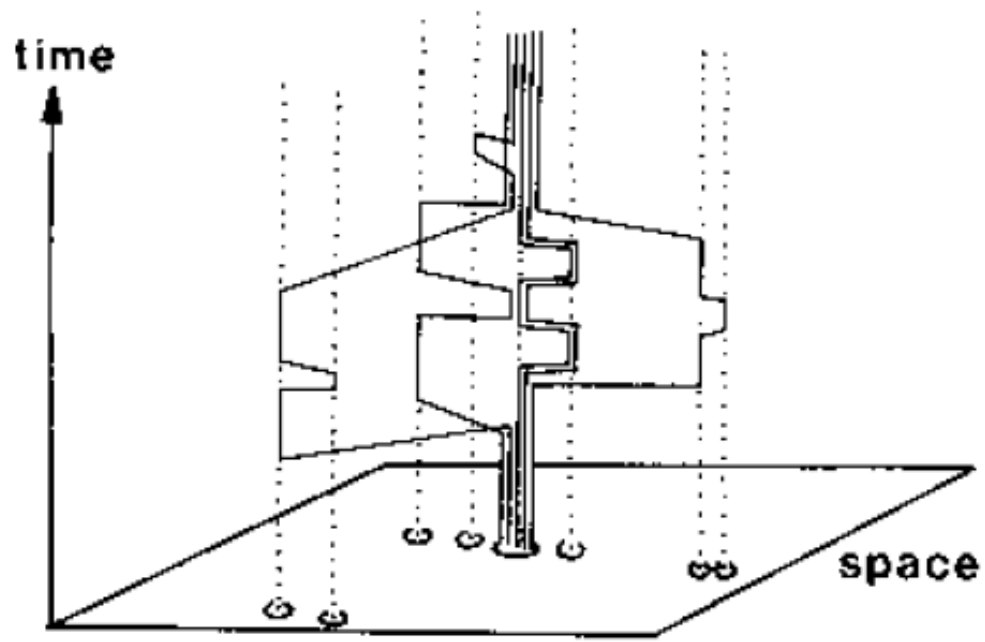
Time geography

- Proposed by Torsten Hägerstrand in the 1970s.
- Time geography describes the life of an individual as a continuous path through time and space, constituted by movements through space and activities localised in space.
- All activities are governed by three constraints: physiological constraints, capability constraints, and coupling constraints.
- These constraints can mitigate but also reinforce one another's impacts on activity participation and travel behaviour.
- When people meet their individual space-time paths form a bundle.

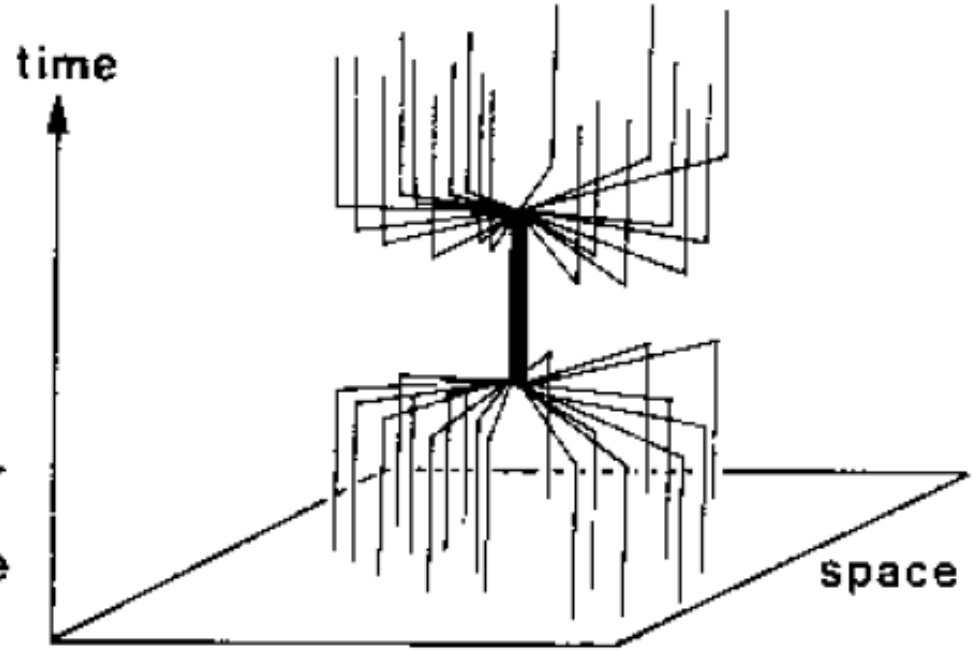
Time geography



Time geography



Household
”bundle”



School
”bundle”

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?

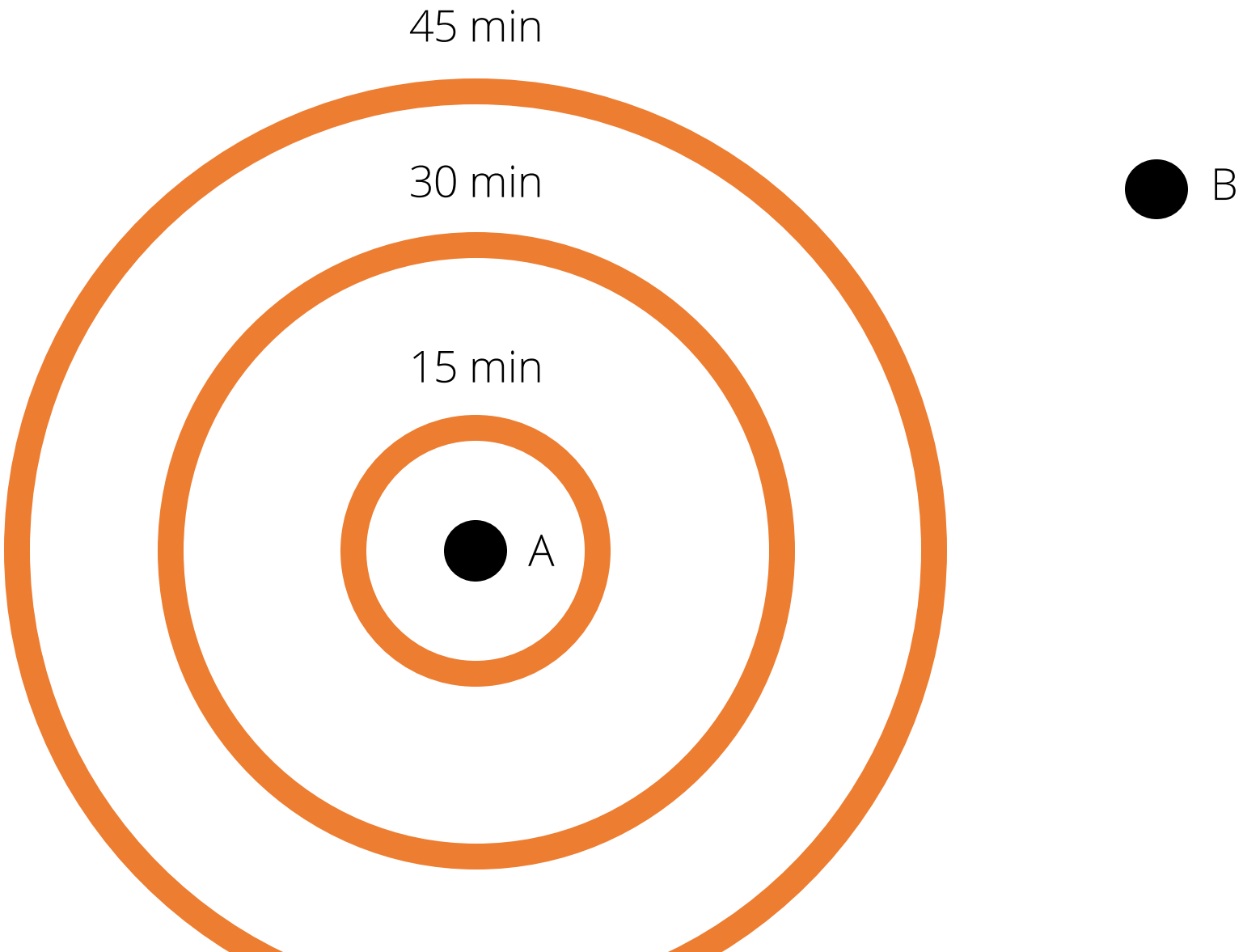
Accessibility

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

- A set of origins (e.g. set of fast-food outlets).
- A set of destinations (e.g. set of schools in an area).
- Some form of a digital spatial network to connect origins and destinations.

Accessibility

Accessibility



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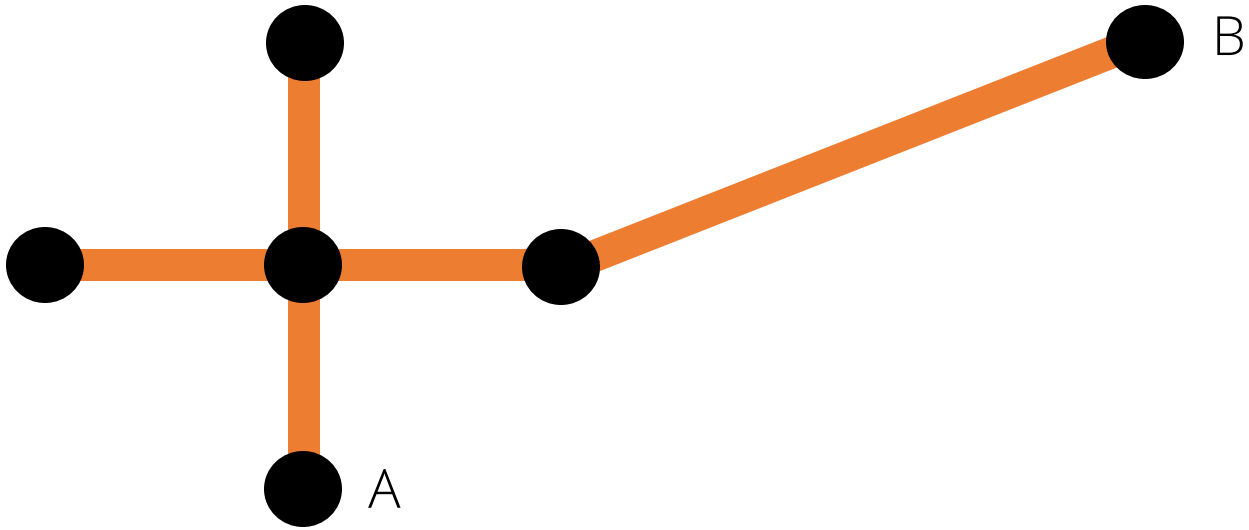


Spatial network

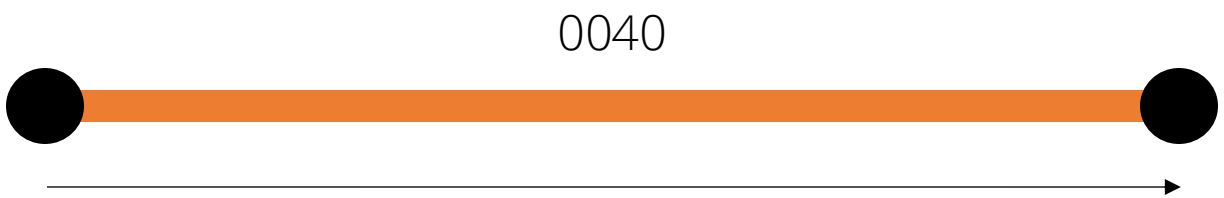
- A spatial network is an organised system or collection of nodes and edges embedded in geographic space.
- Nodes can be a representation of physical objects in geographical space,
  and edges show what connections are formed between the objects.
- Examples of networks: street configuration, transportation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

Spatial network structure

Characteristics of a polyline vector in a GIS data model:

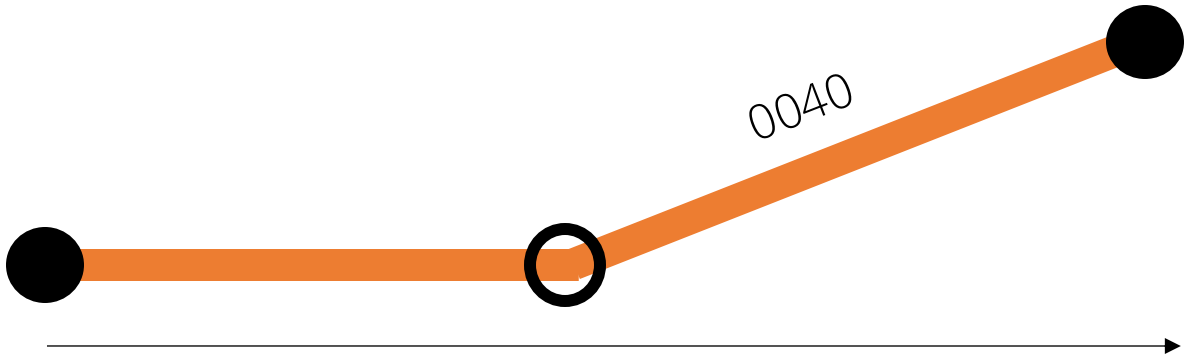
- Series of XY locations (coordinates) that form a line.
- Has a direction (importance when it comes to roads, rivers, etc.).
- Can be connected to other polyline vectors to form a network.
- Geometry consists of 2 nodes and can have one or more vertices.

Spatial network structure



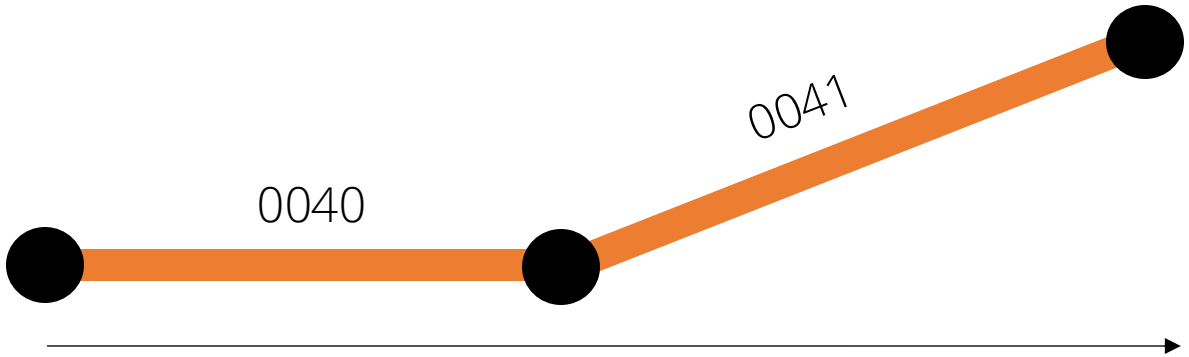
FeatureID	Type	Length
0040	Bicycle lane	1,500

Spatial network structure



FeatureID	Type	Length
0040	Bicycle lane	1,650

Spatial network structure

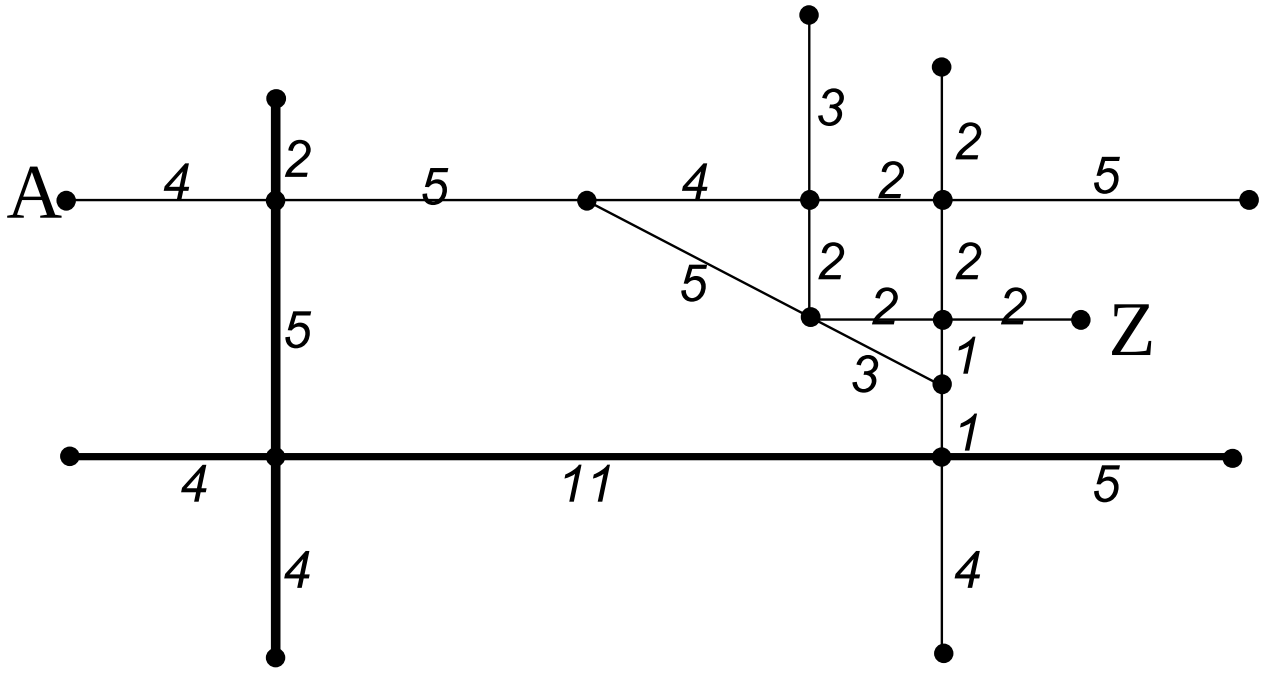


FeatureID	Type	Length
0040	Bicycle lane	600
0041	Bicycle lane	1,050

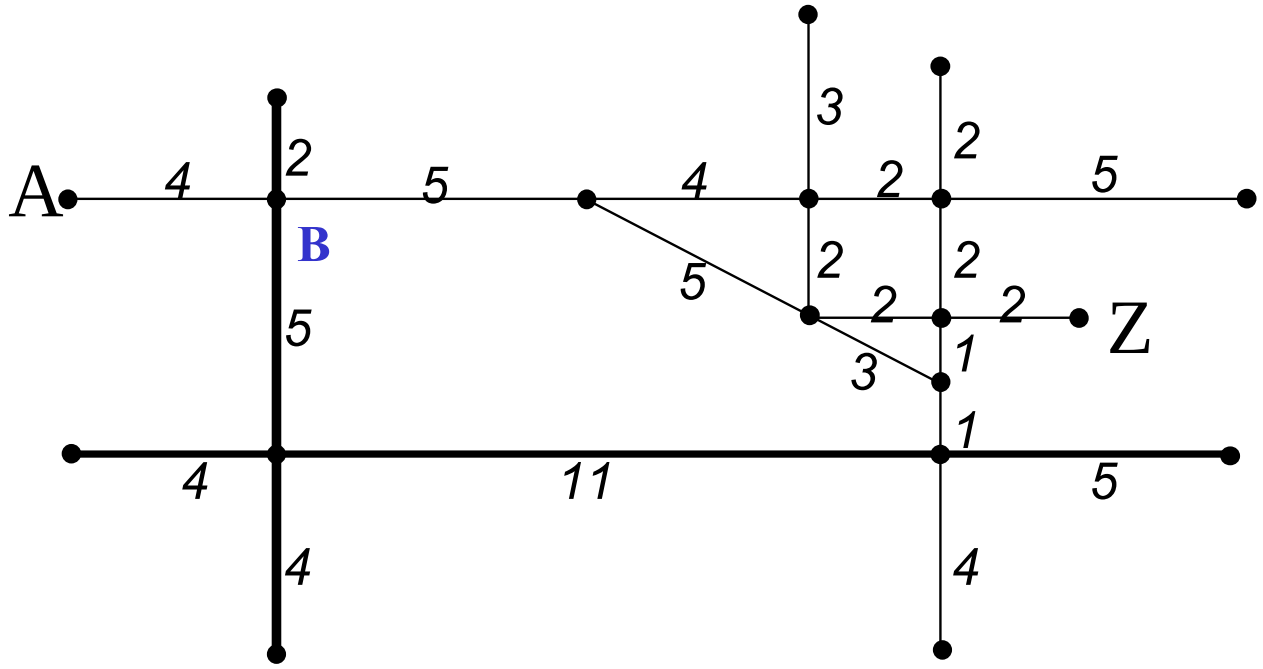
Dijkstra’s shortest path algorithm

- Shortest path
- Quickest path
- Cheapest path

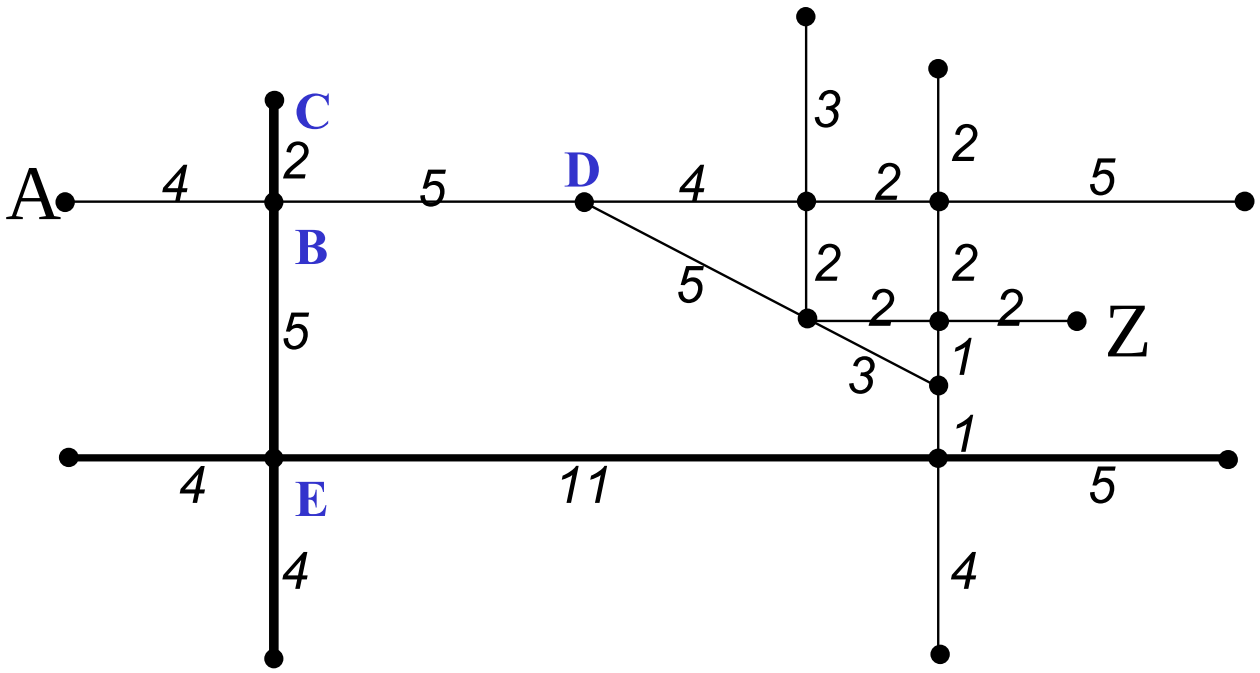
Dijkstra’s shortest path algorithm



Dijkstra's shortest path algorithm



Dijkstra’s shortest path algorithm

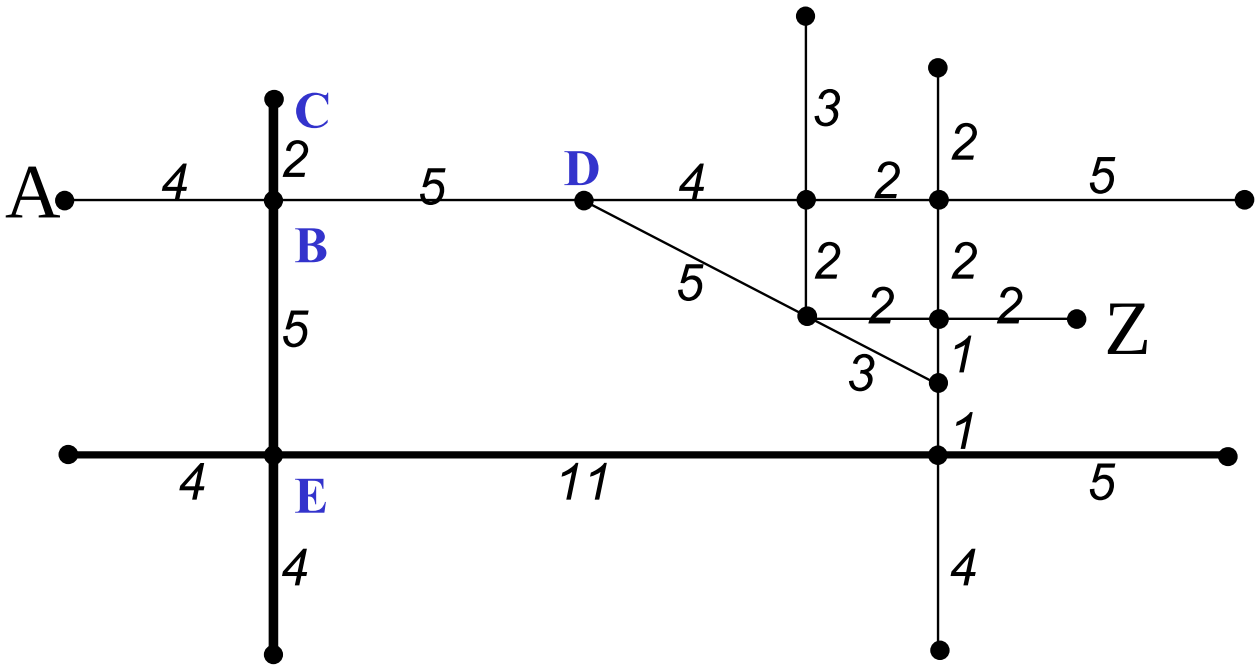


…

ABC	6
ABD	9
ABE	9

B – AB 4

Dijkstra’s shortest path algorithm



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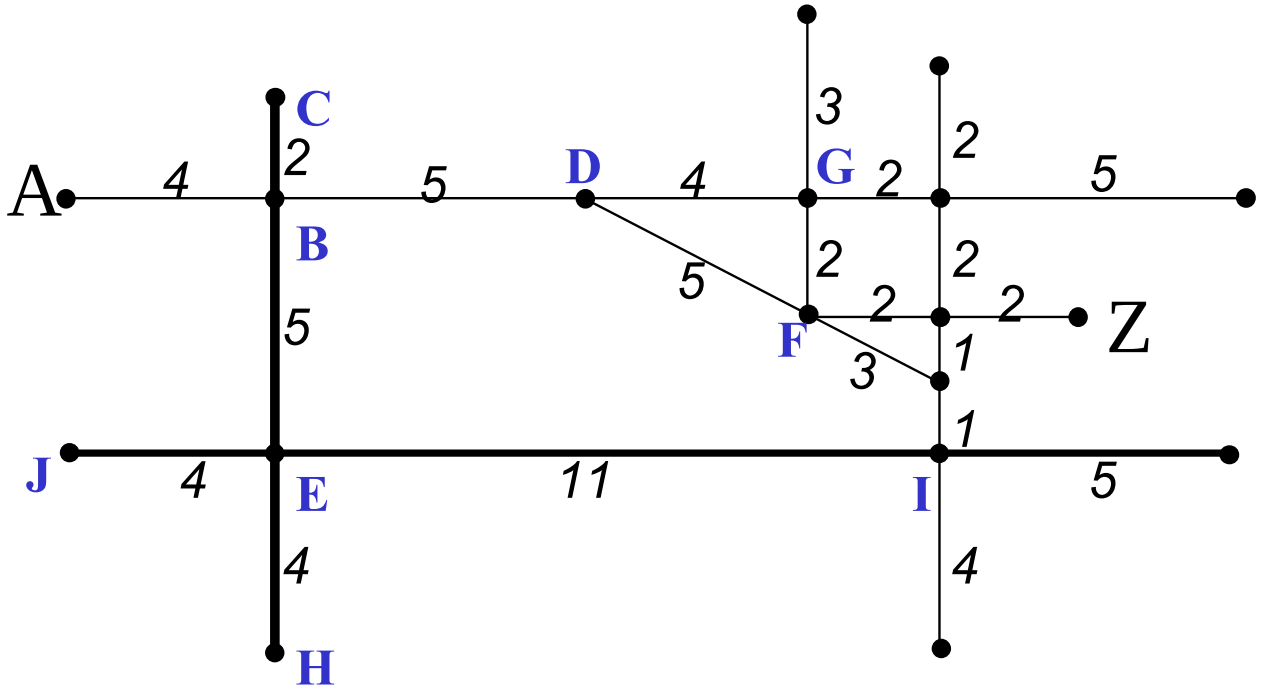
ABD	9
ABE	9

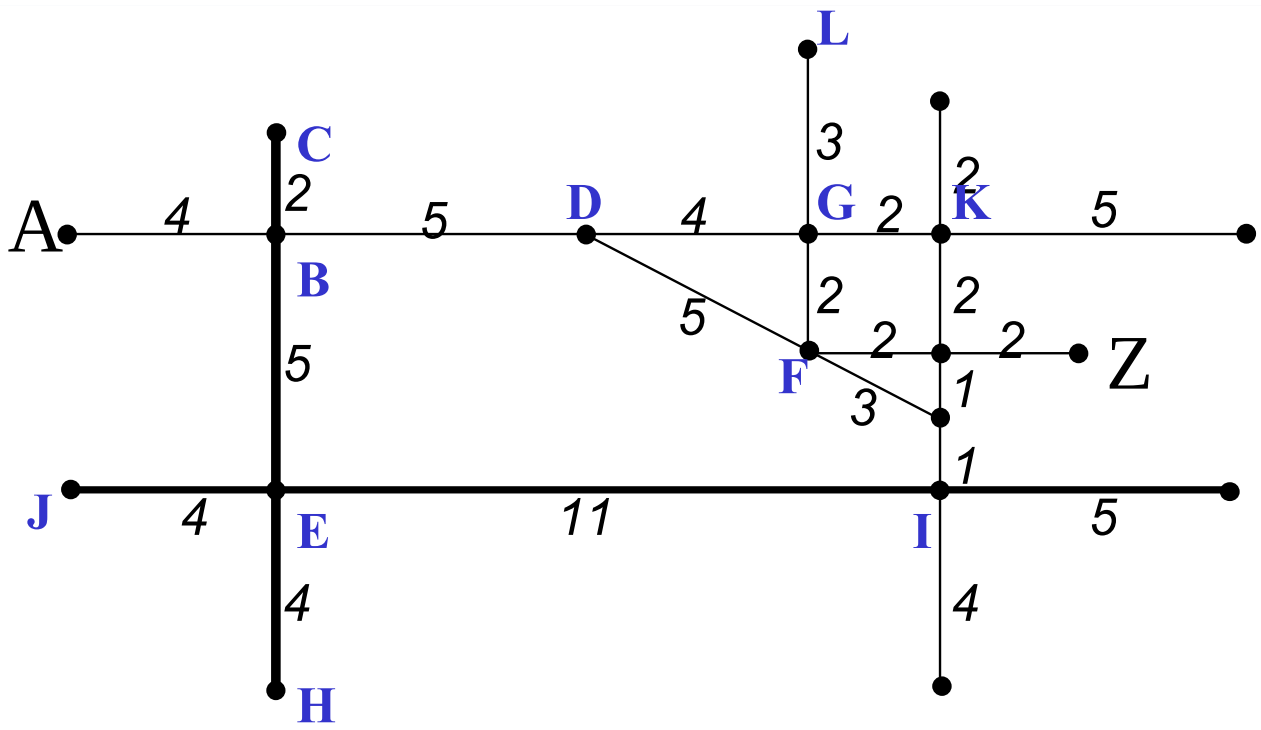
B – AB	4
C – ABC	6

Dijkstra's shortest path algorithm



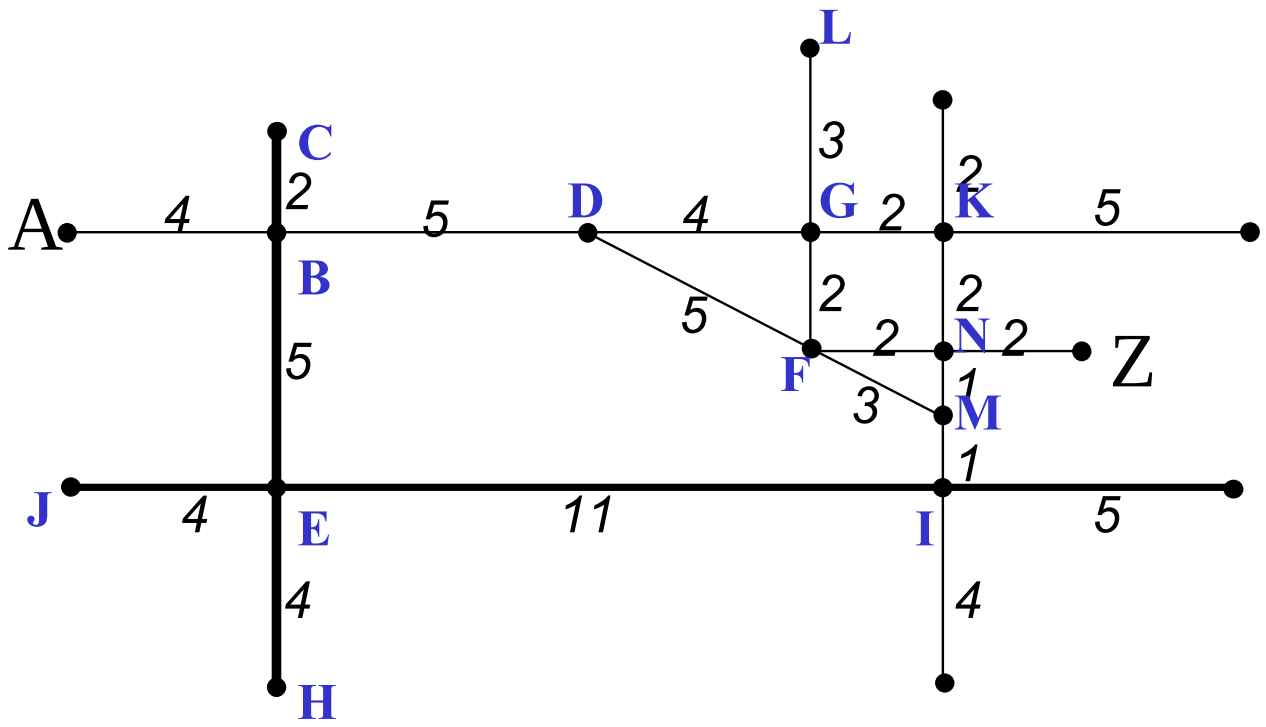
...	
ABDG	13
ABEJ	13
ABEH	13
ABDF	14
ABEI	20
B – AB	4
C – ABC	6
D – ABD	9
E – ABE	9

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

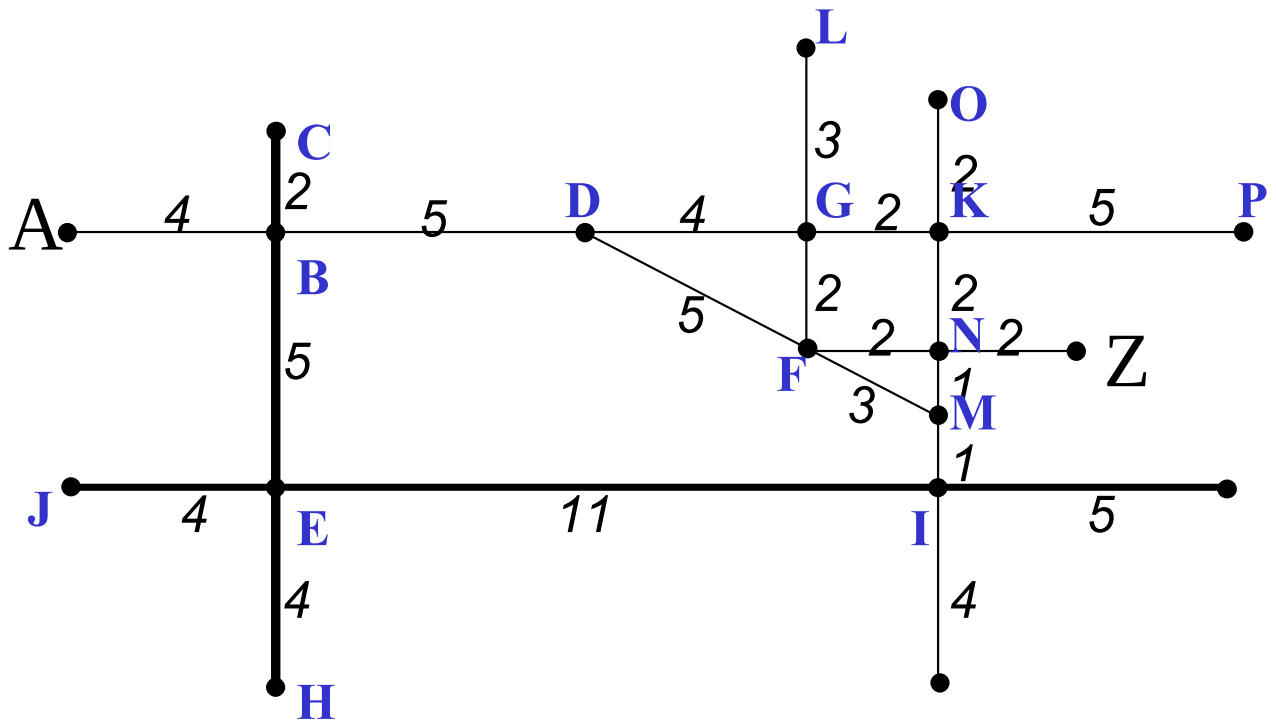
Dijkstra’s shortest path algorithm



…	
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

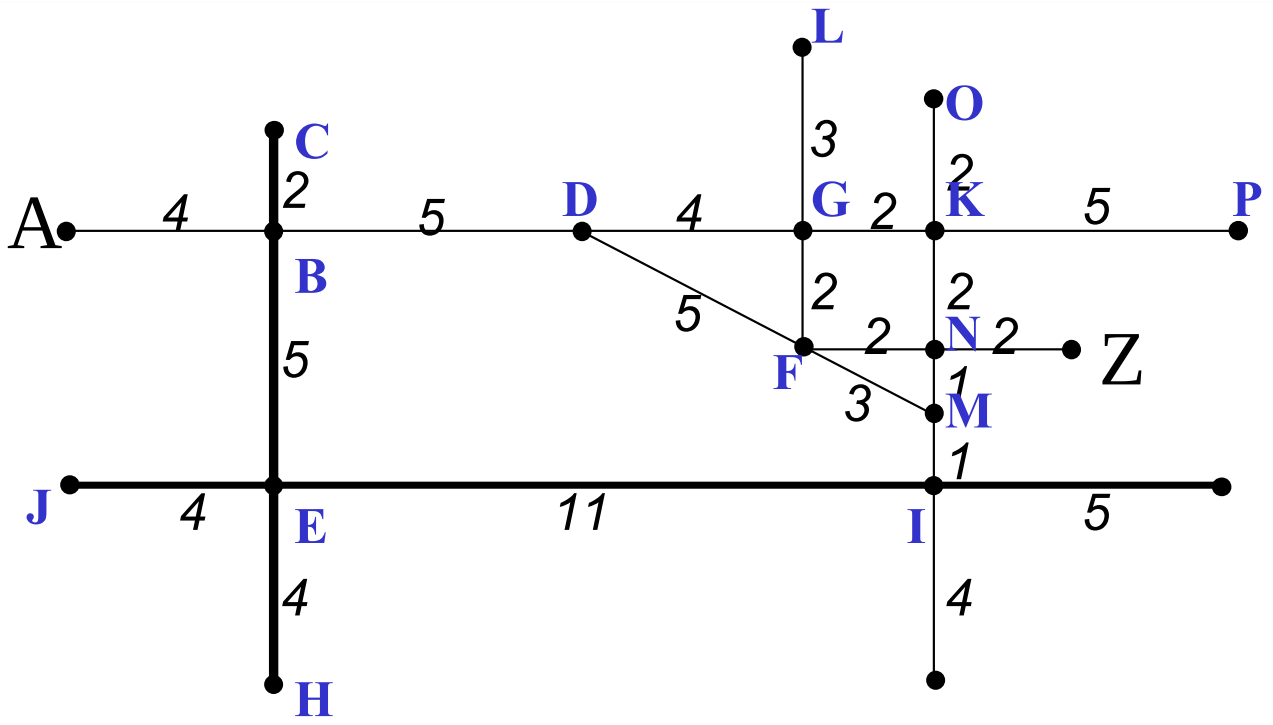


…

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

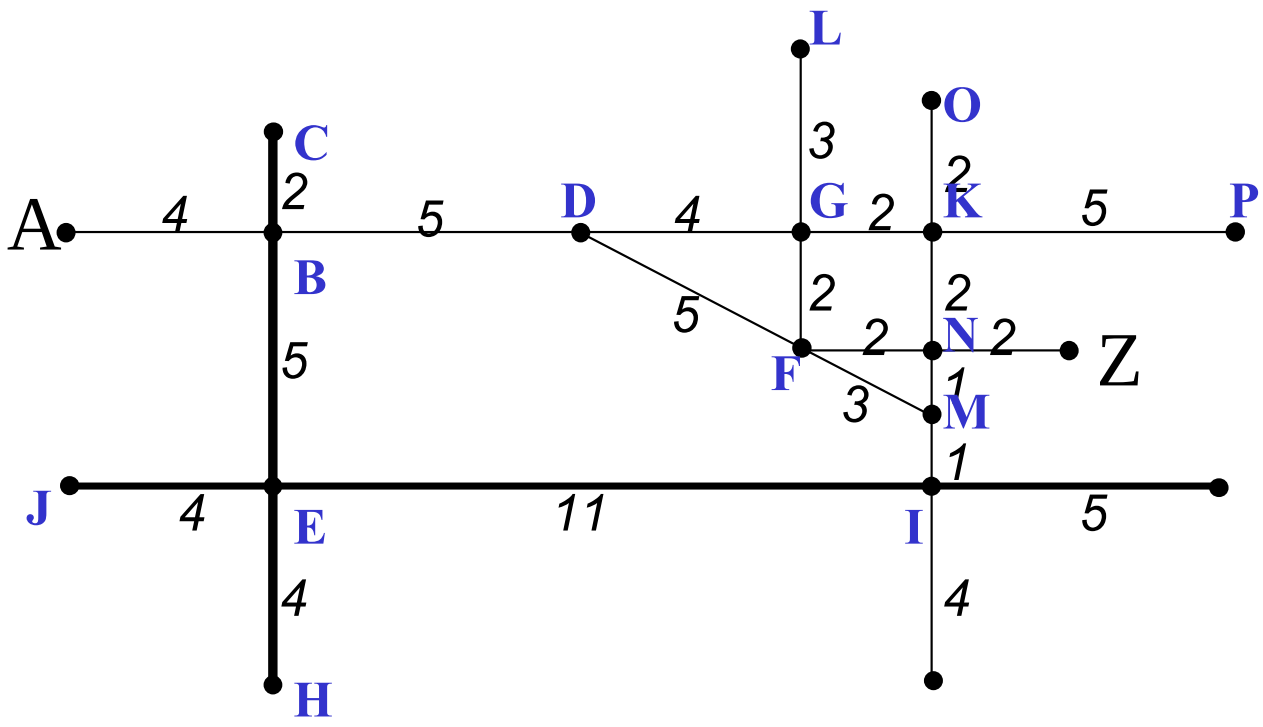


...

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

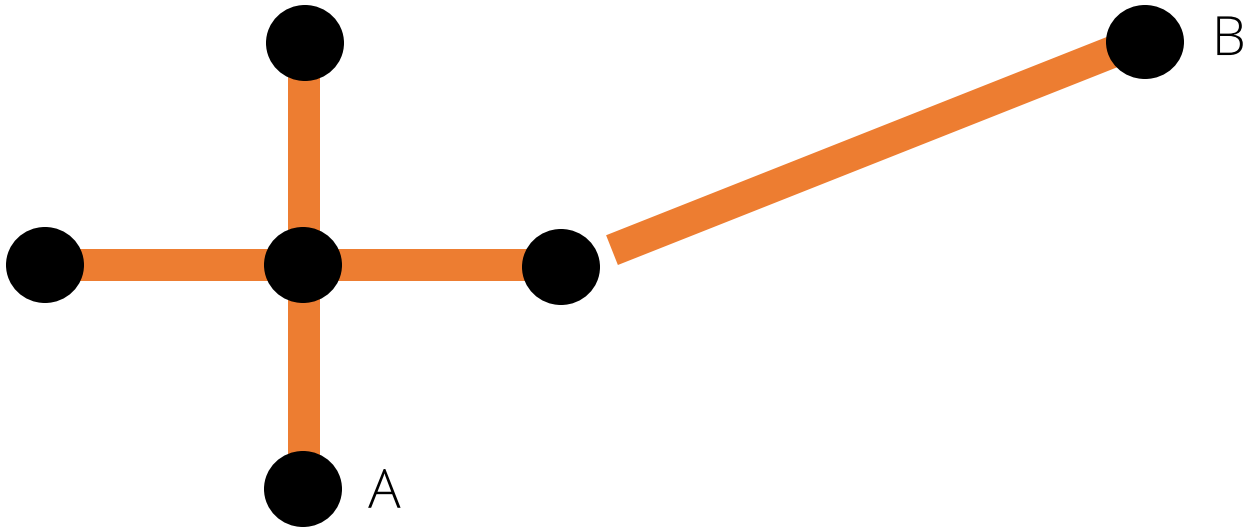
... with Dijkstra's algorithm we need

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

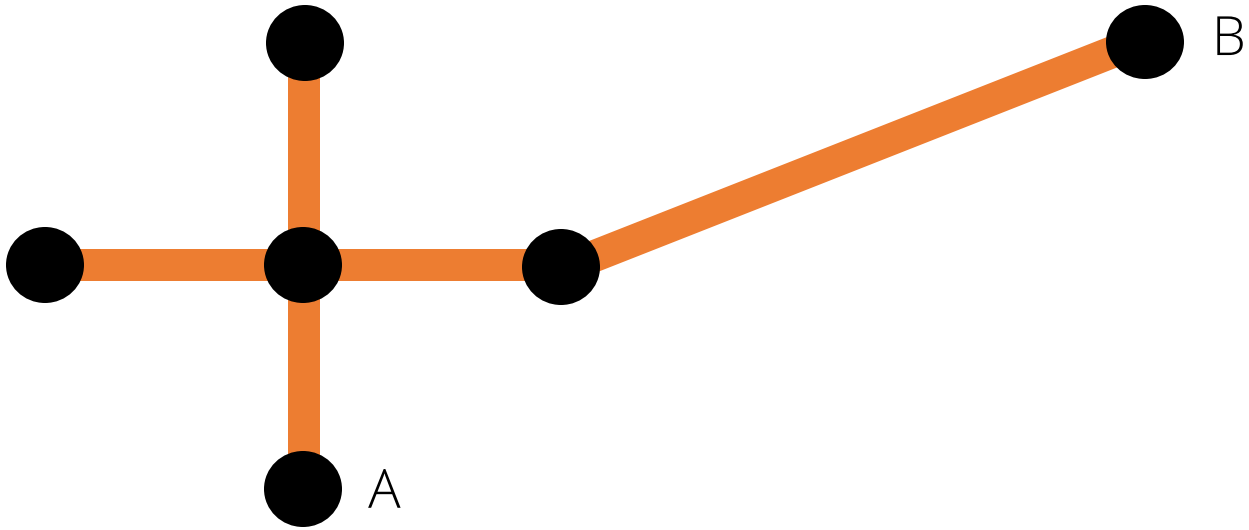
To consider

- 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?

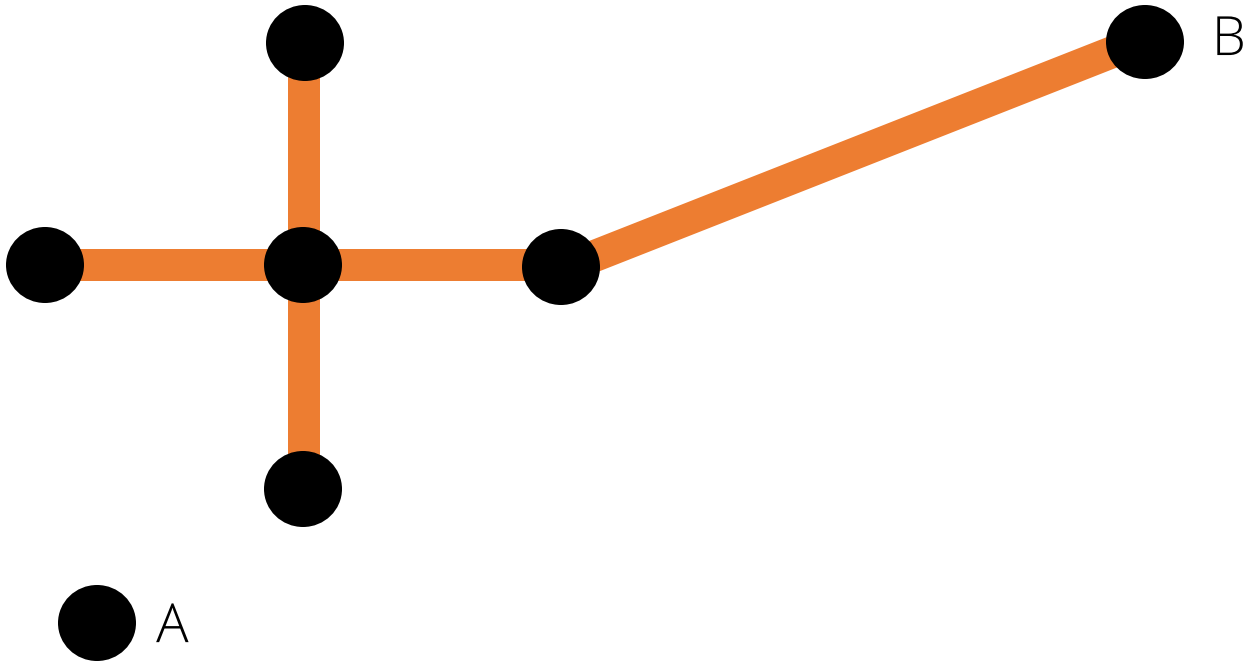
Connectivity



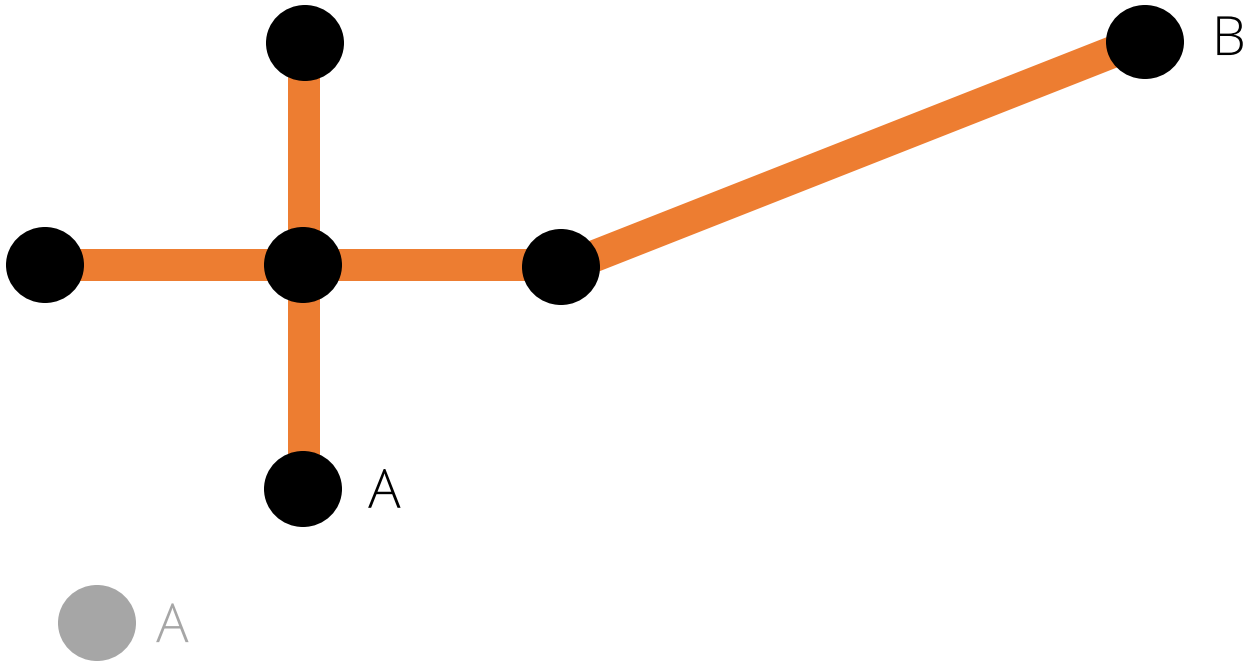
Connectivity



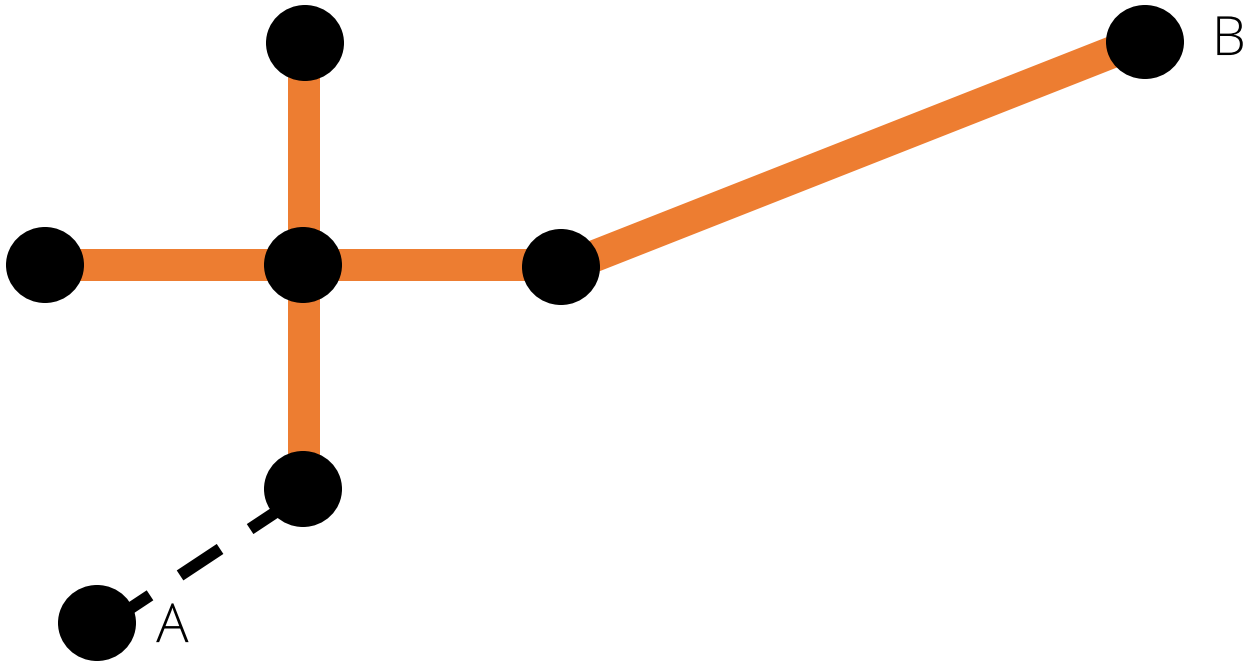
Connectivity



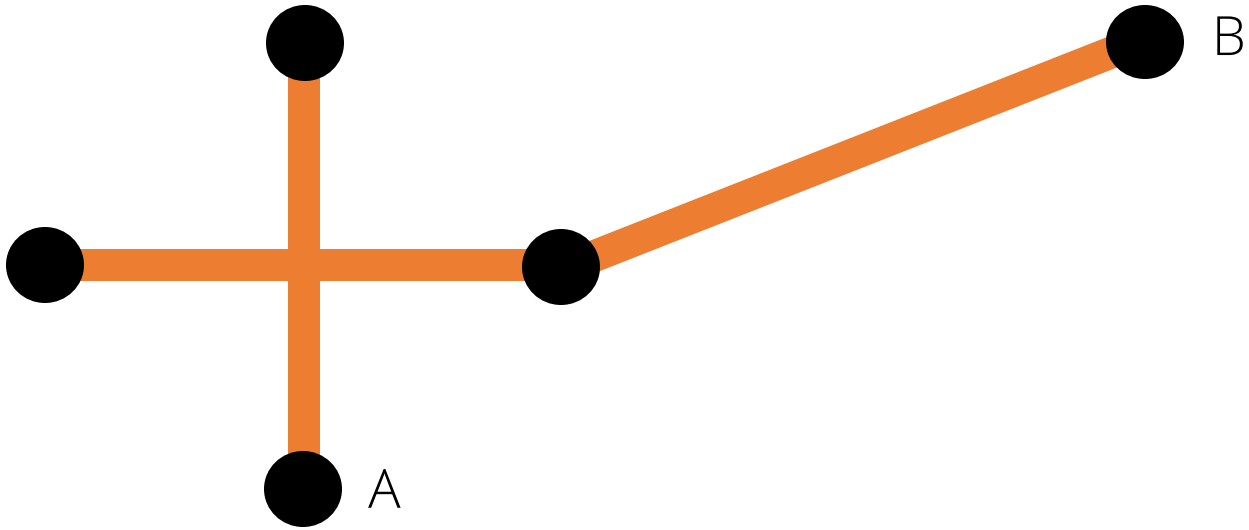
Connectivity



Connectivity



Topology



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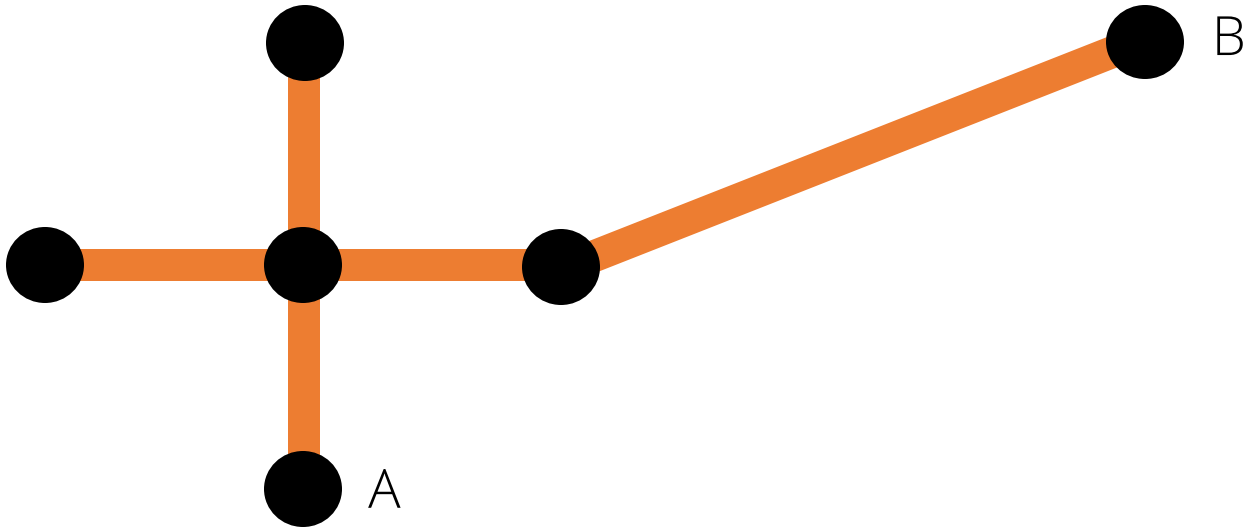
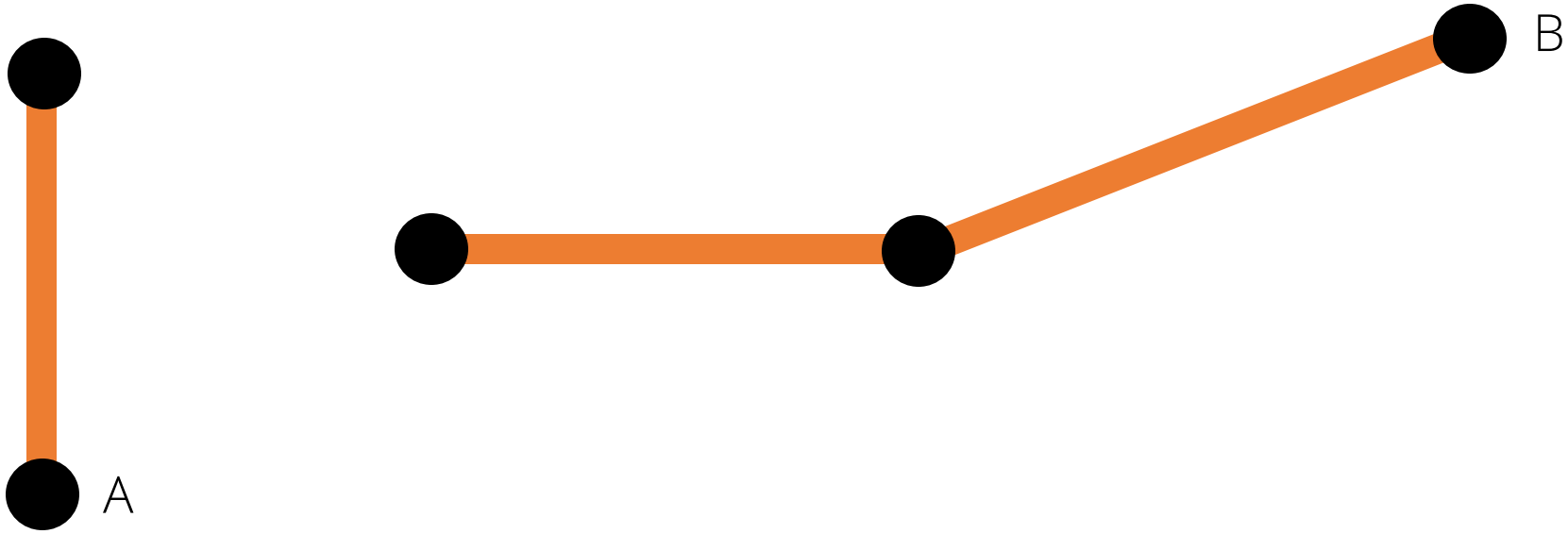
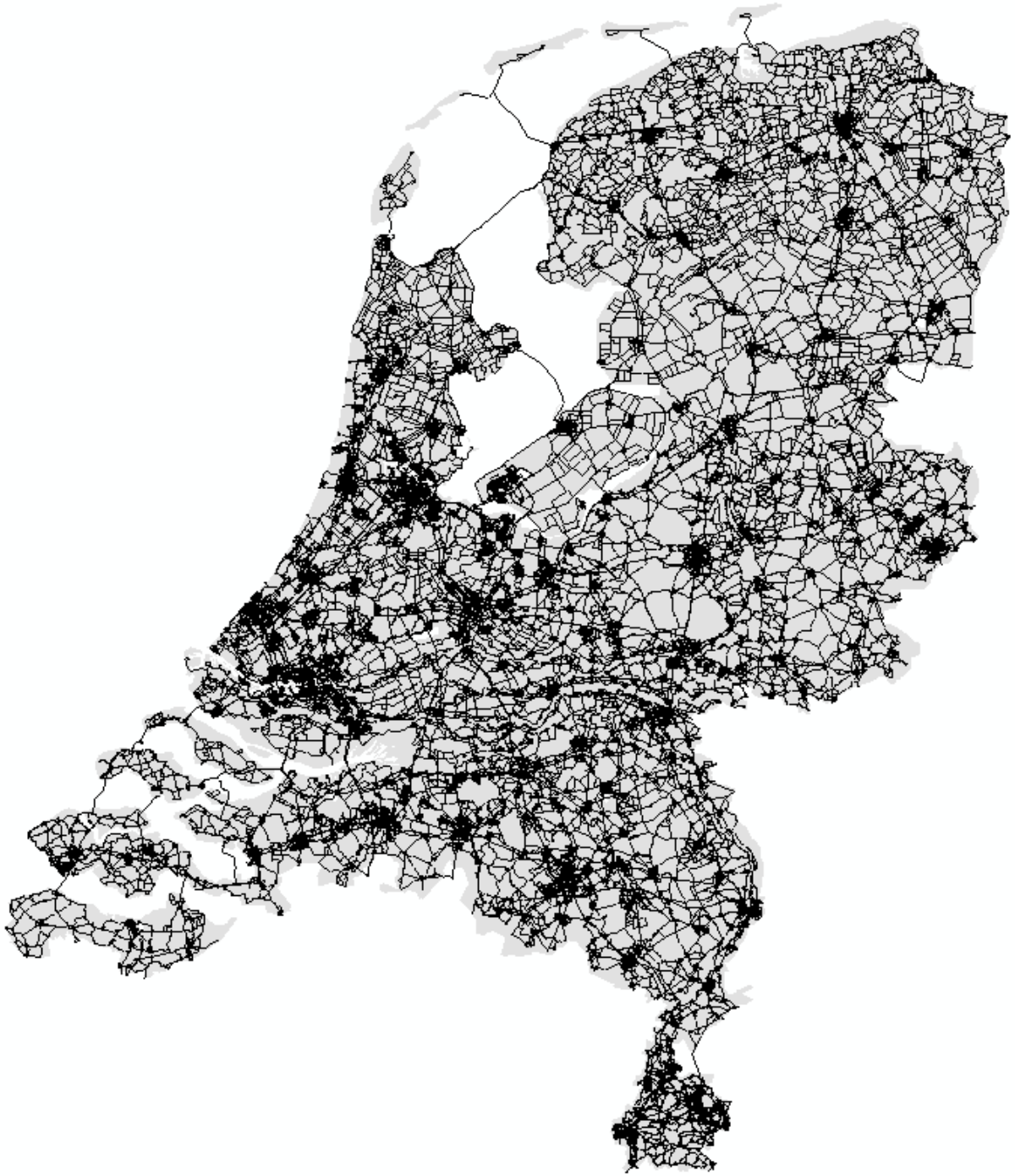


Topology



Coverage



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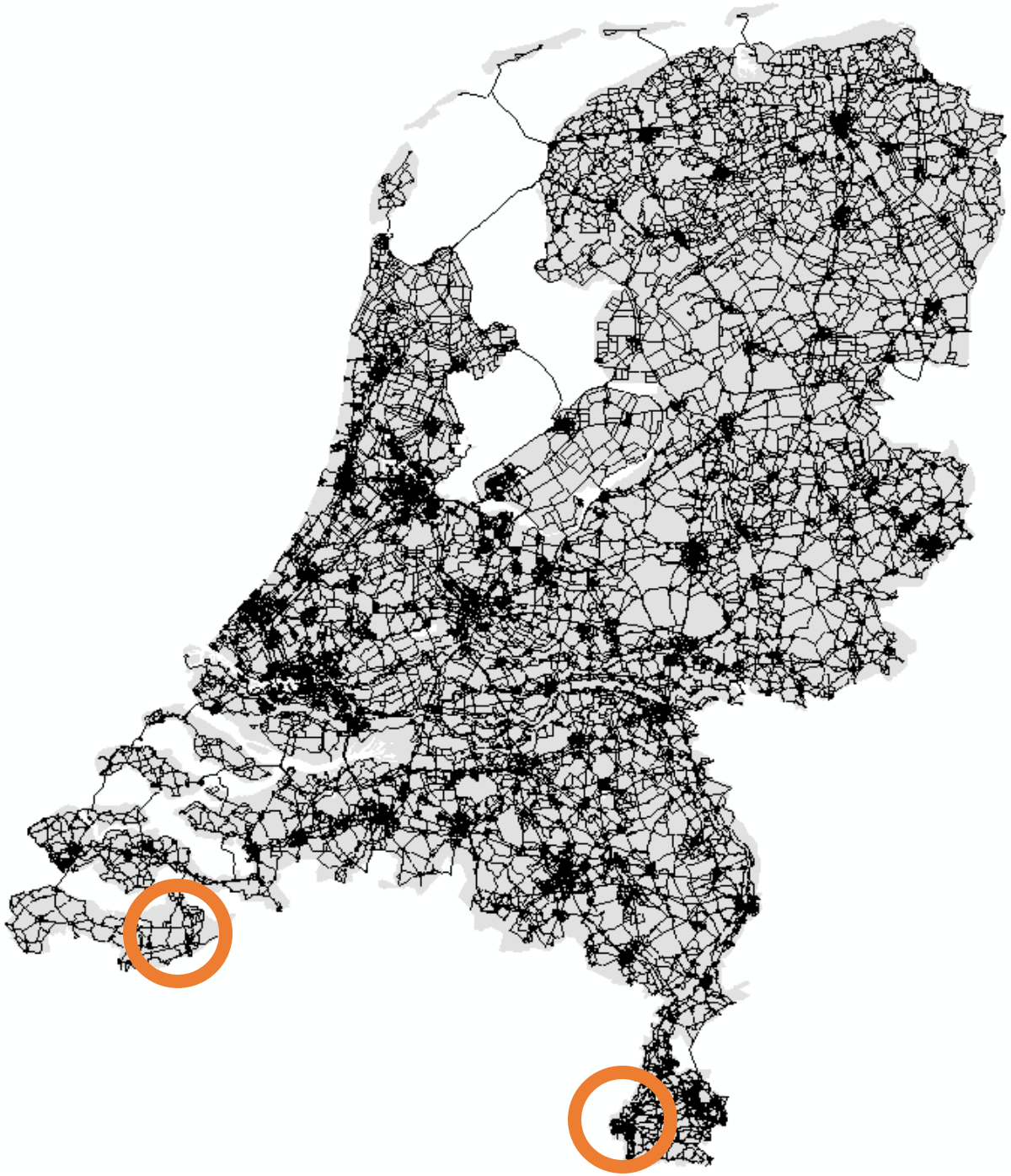

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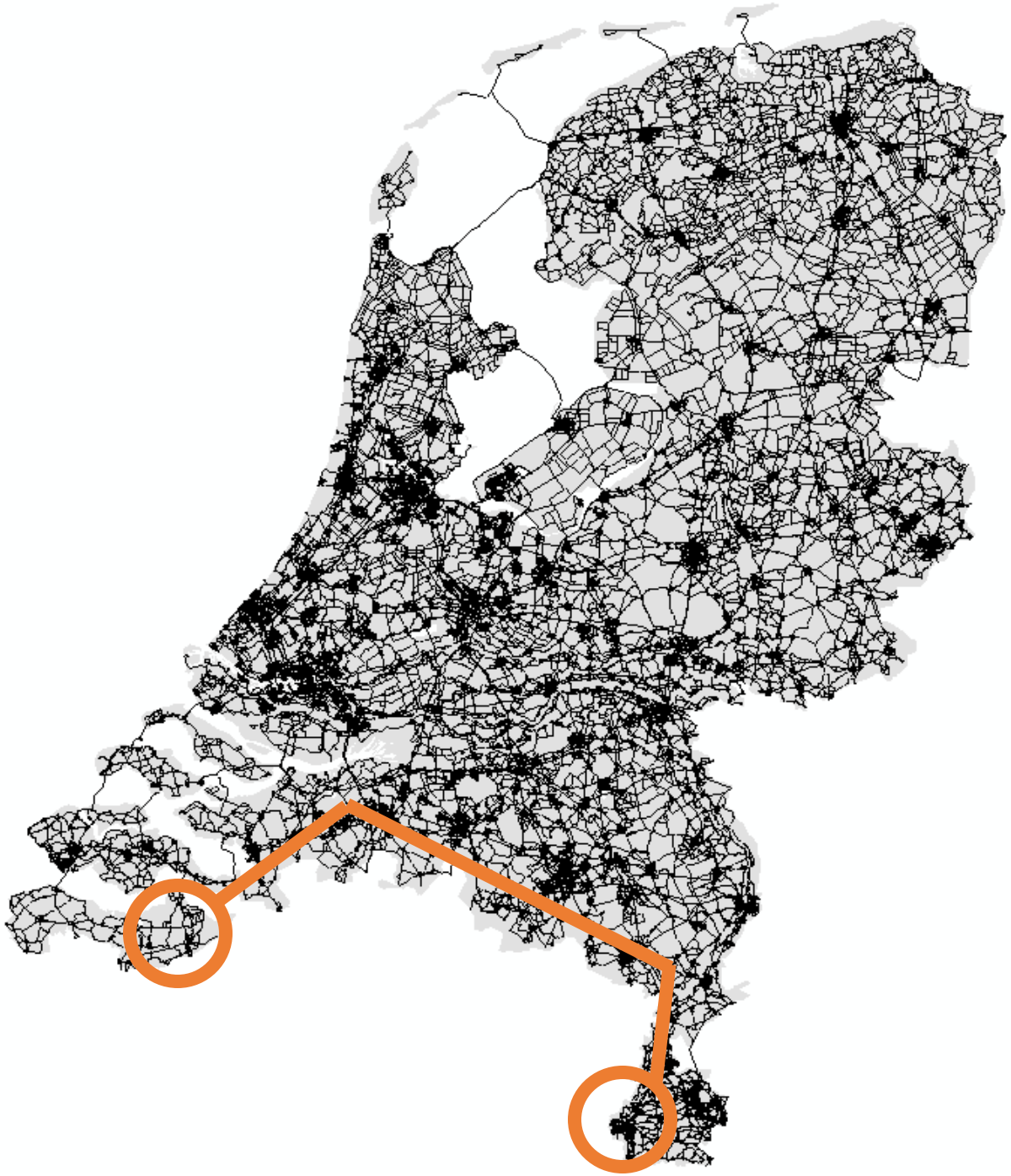

Coverage

Accessibility

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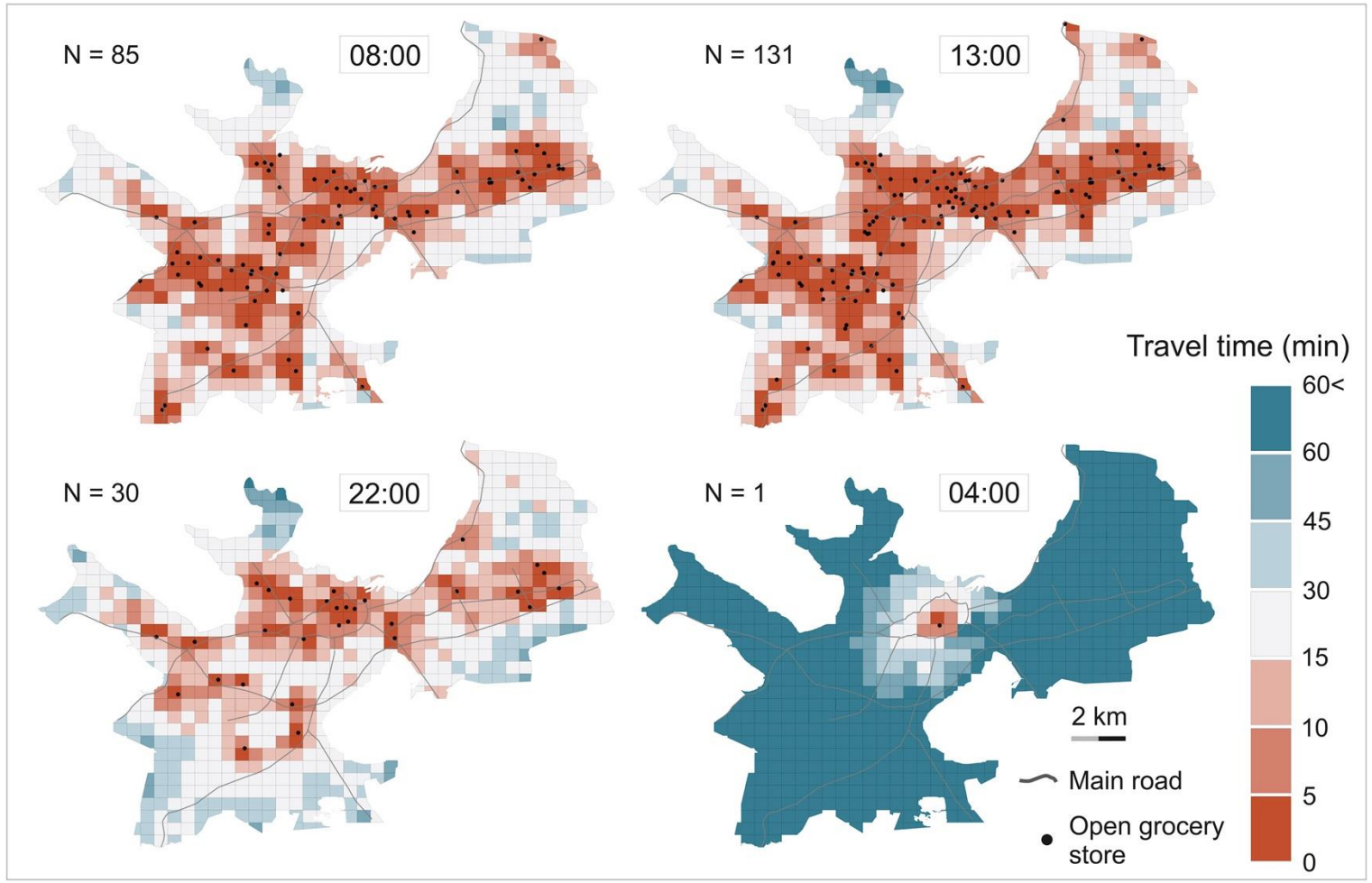
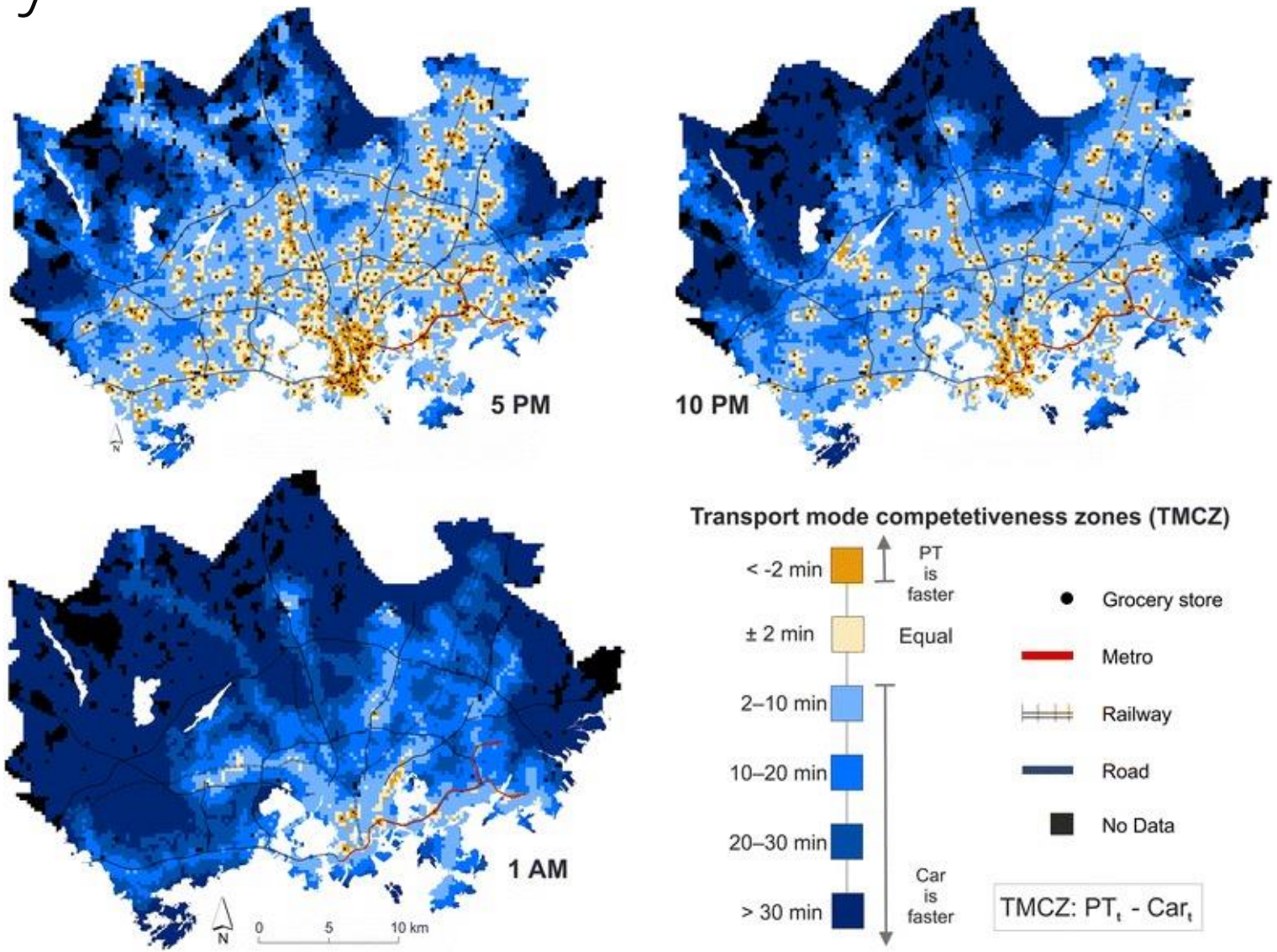


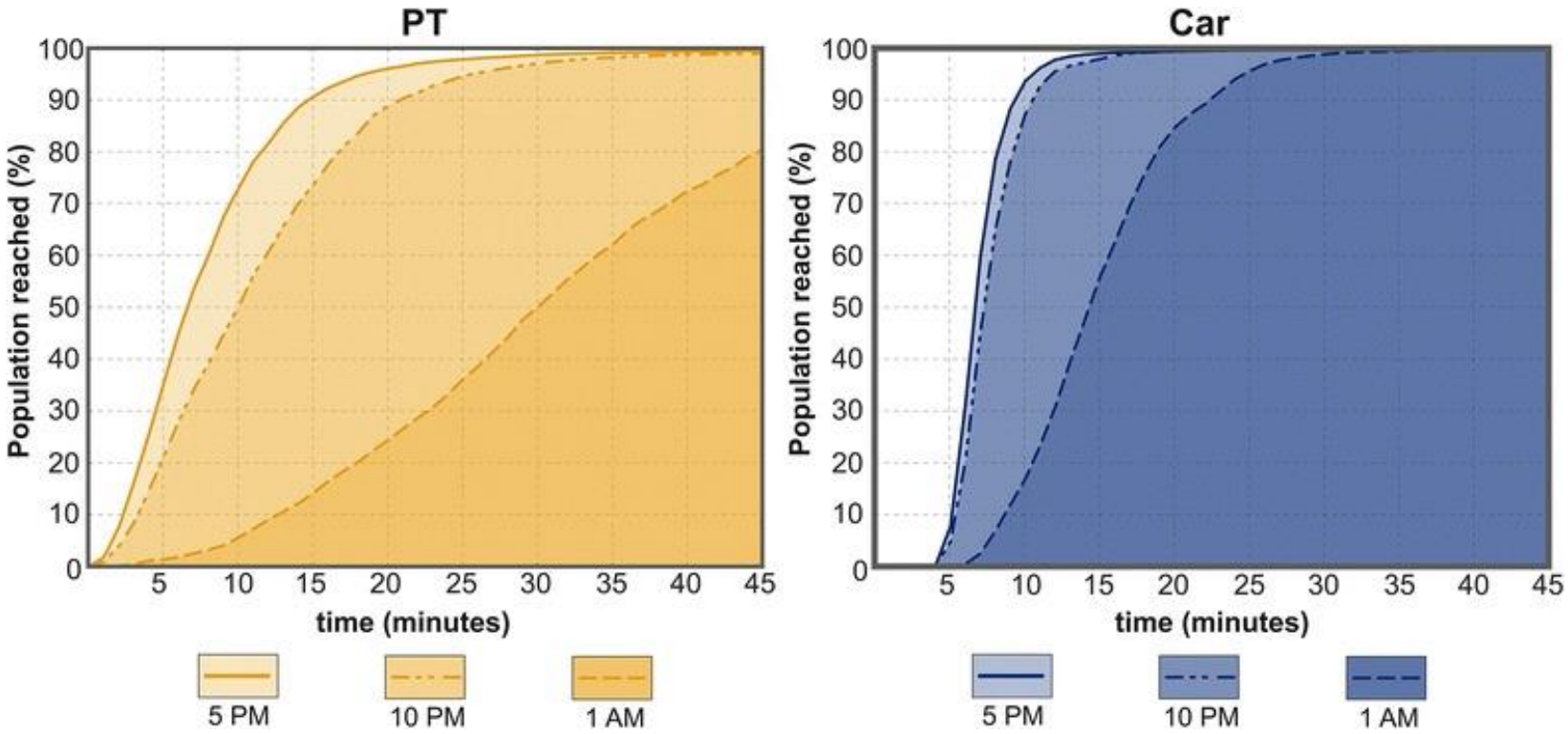
Järv *et al.* 2018

Accessibility



Tenkanen *et al.* 2016

Accessibility



Tenkanen *et al.* 2016

Conclusion

- Pretty much talked about modelling accessibility scenarios using transport network analysis. Accessibility needs to be operationalised – accessibility in terms of what?
- 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.
- Lots of open-source tools available: dodgr, R^5 (r5r, r5py), stplanr.

Questions

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