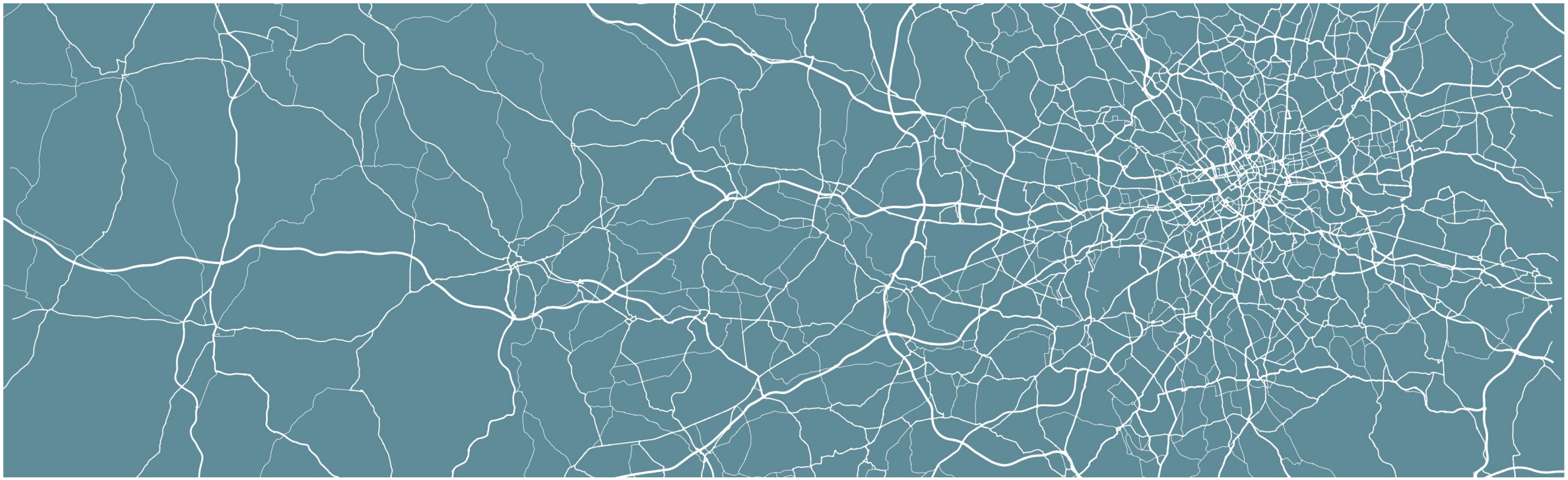
Geocomputation

W10 – Transport Network Analysis



UCL

Where are we at?

Part I: Foundational Concepts

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

Where are we at?

Part II: Core Spatial Analysis

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

] R

Part III: Advanced Spatial Analysis

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

] R

This week

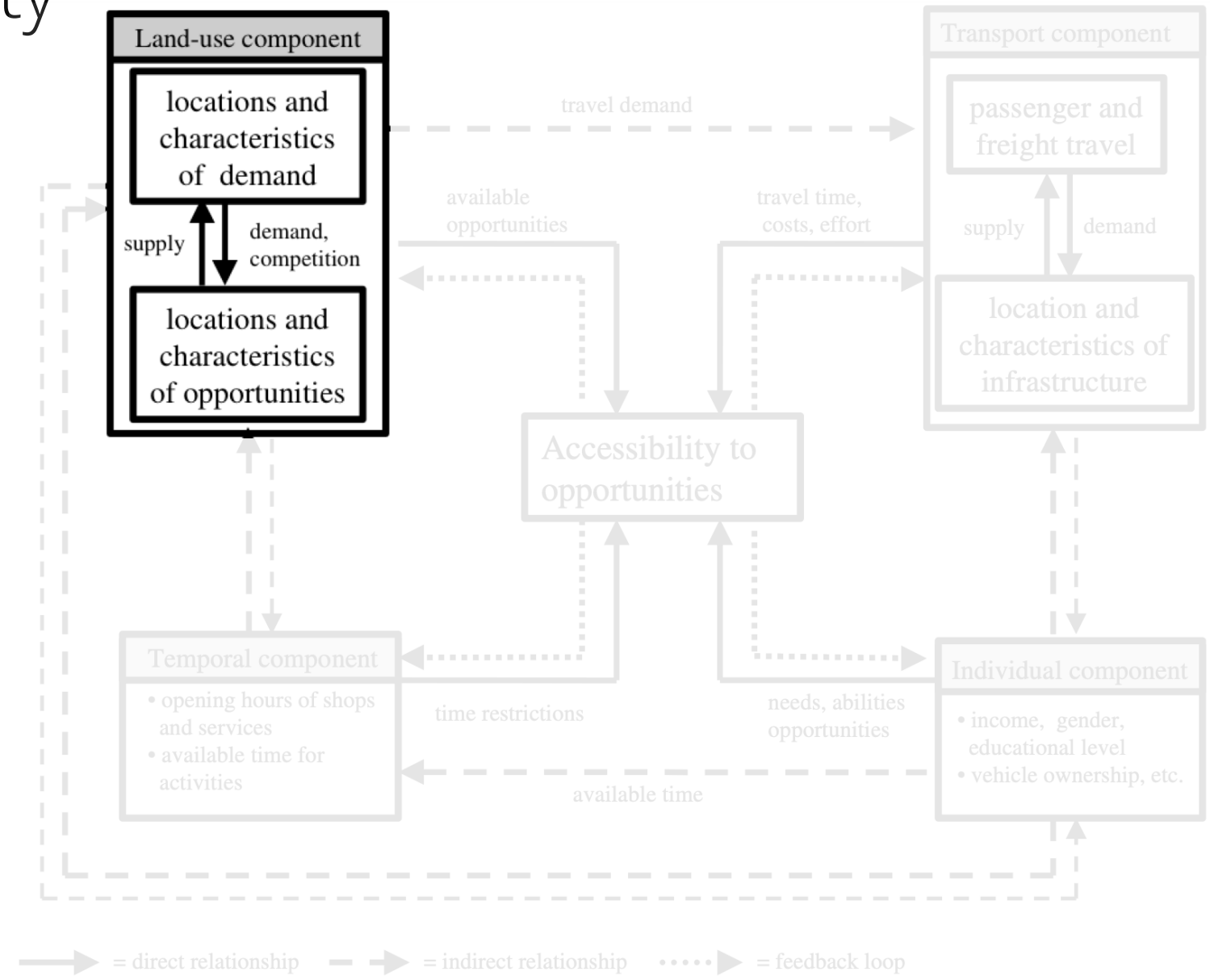
- Transport network and accessibility analysis
- Spatial network structure
- Dijkstra’s shortest path algorithm
- An example of transport network and accessibility analysis
- Brief module recap
- Some pointers for the exam

Spatial interaction

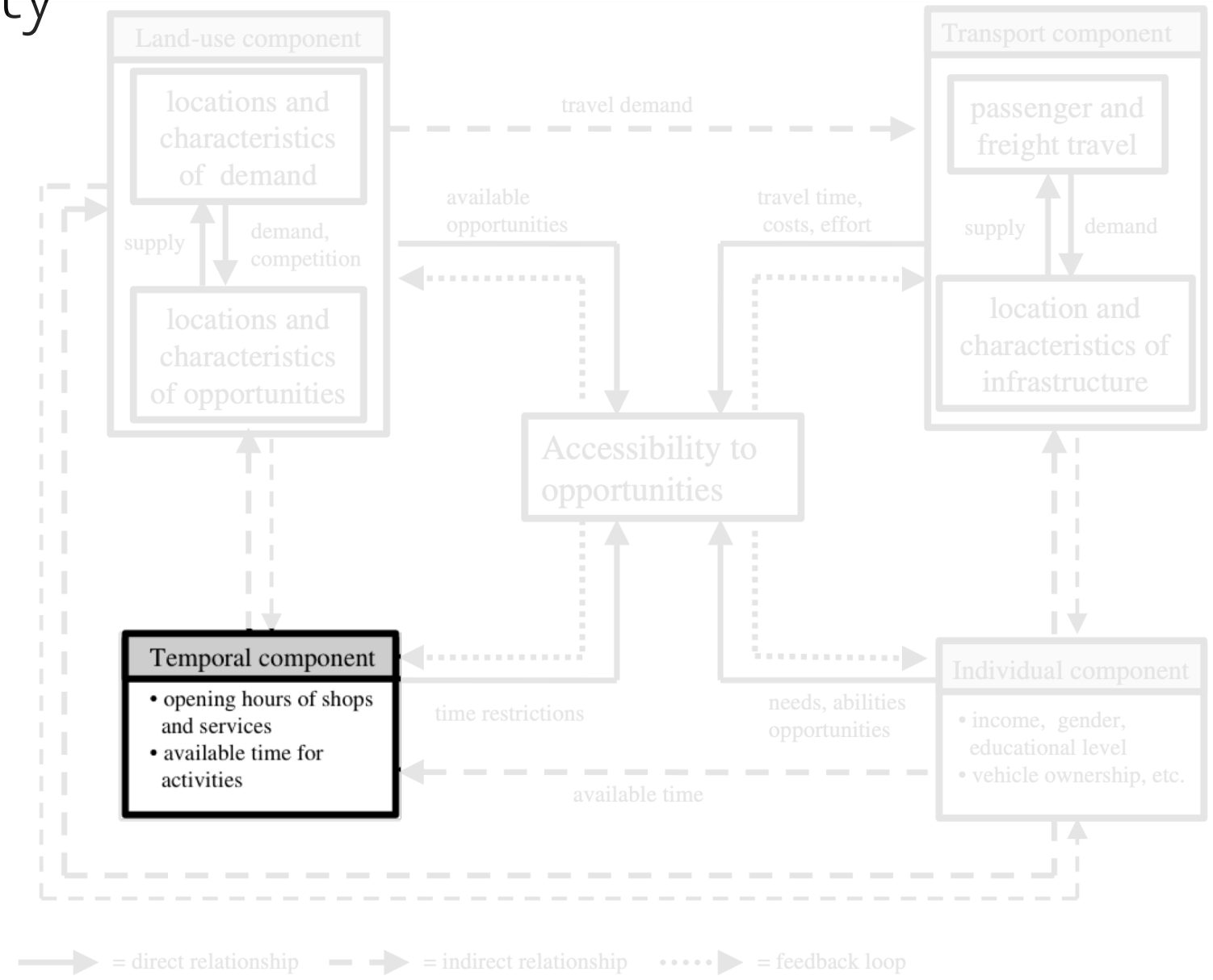
- We have mostly dealt with static events: events that happen at a particular point in time and space.
- Spatial interaction is concerned with the idea that there are relations between different locations (e.g. measured in people or goods travelling).

Spatial interaction

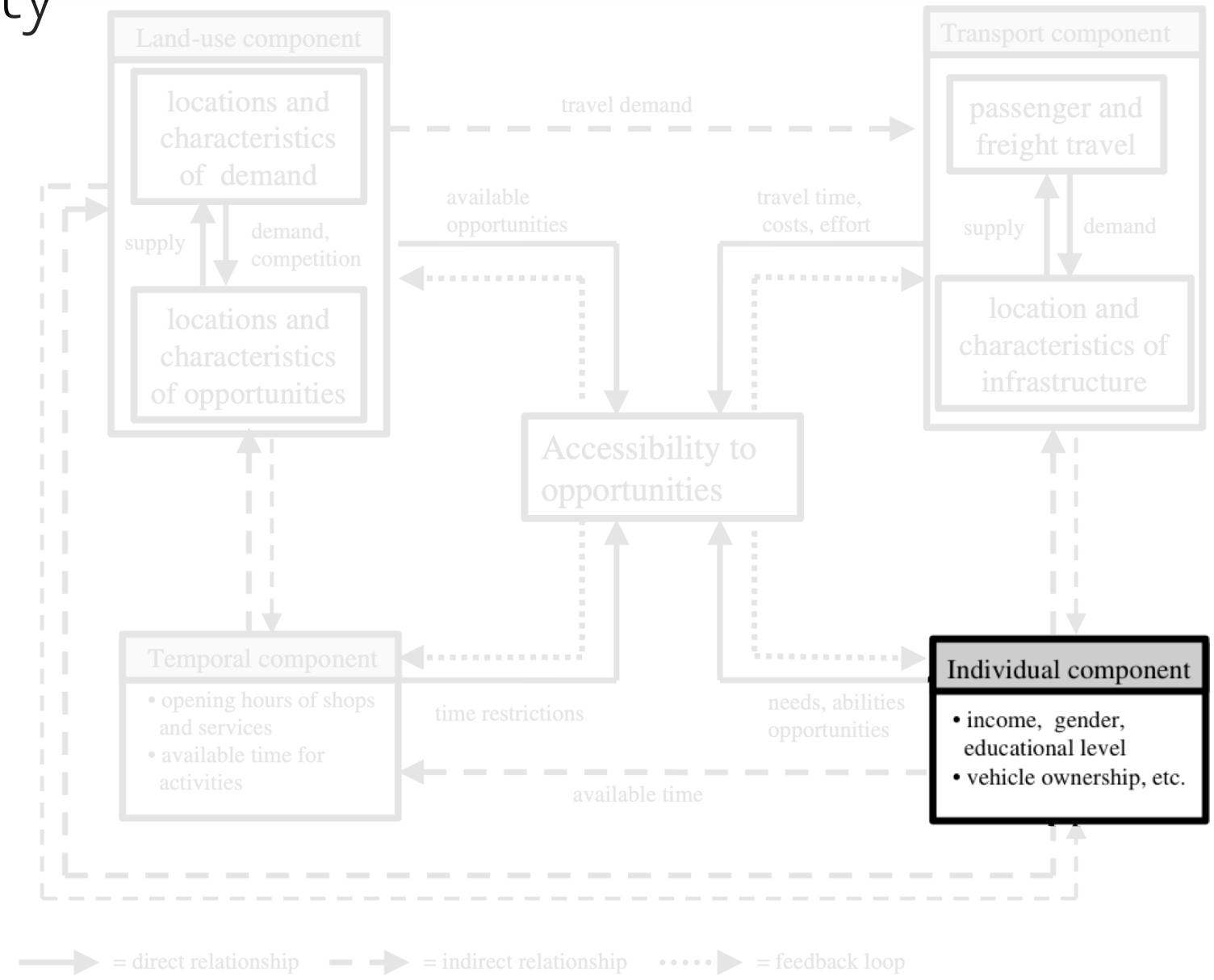
Accessibility



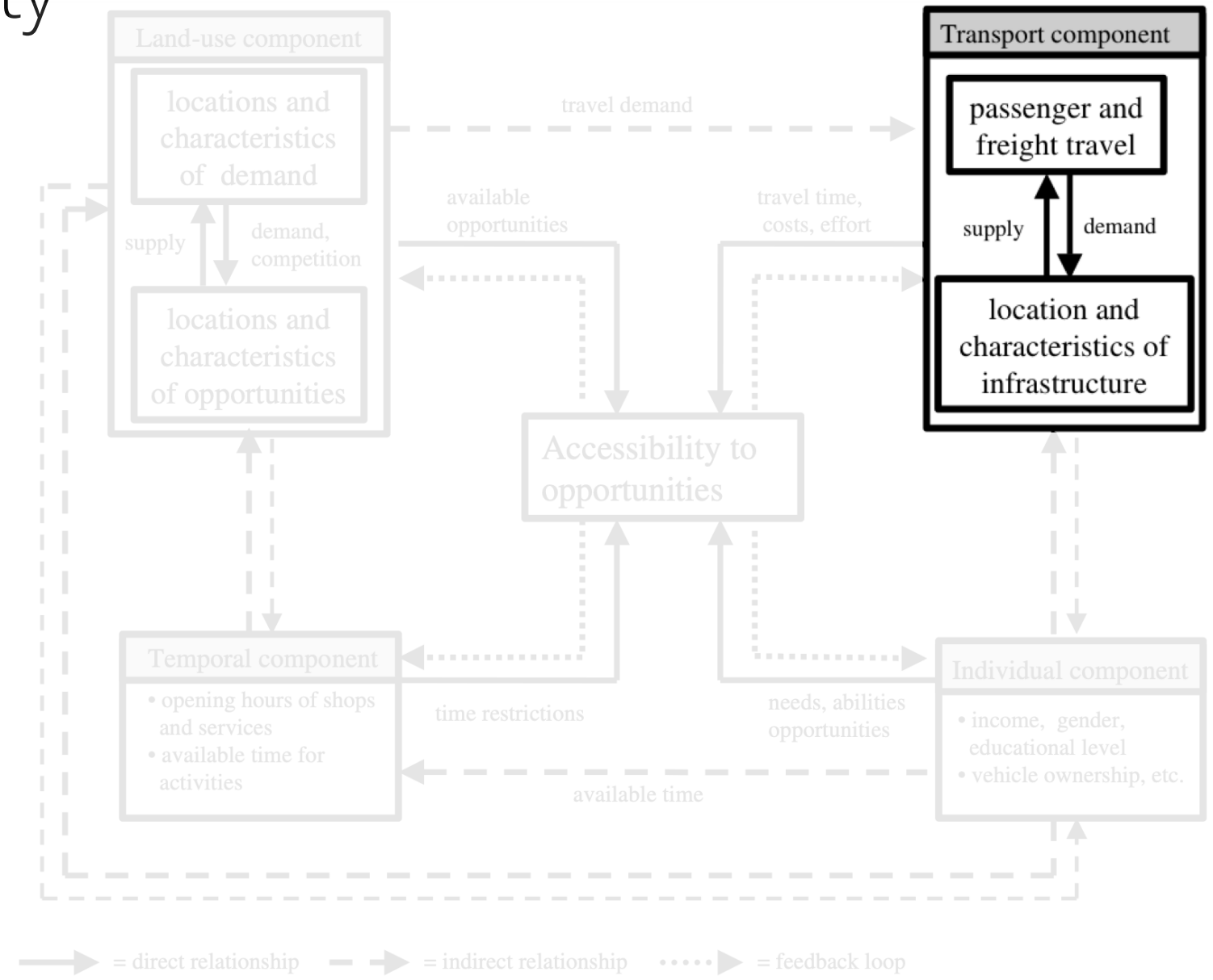
Accessibility



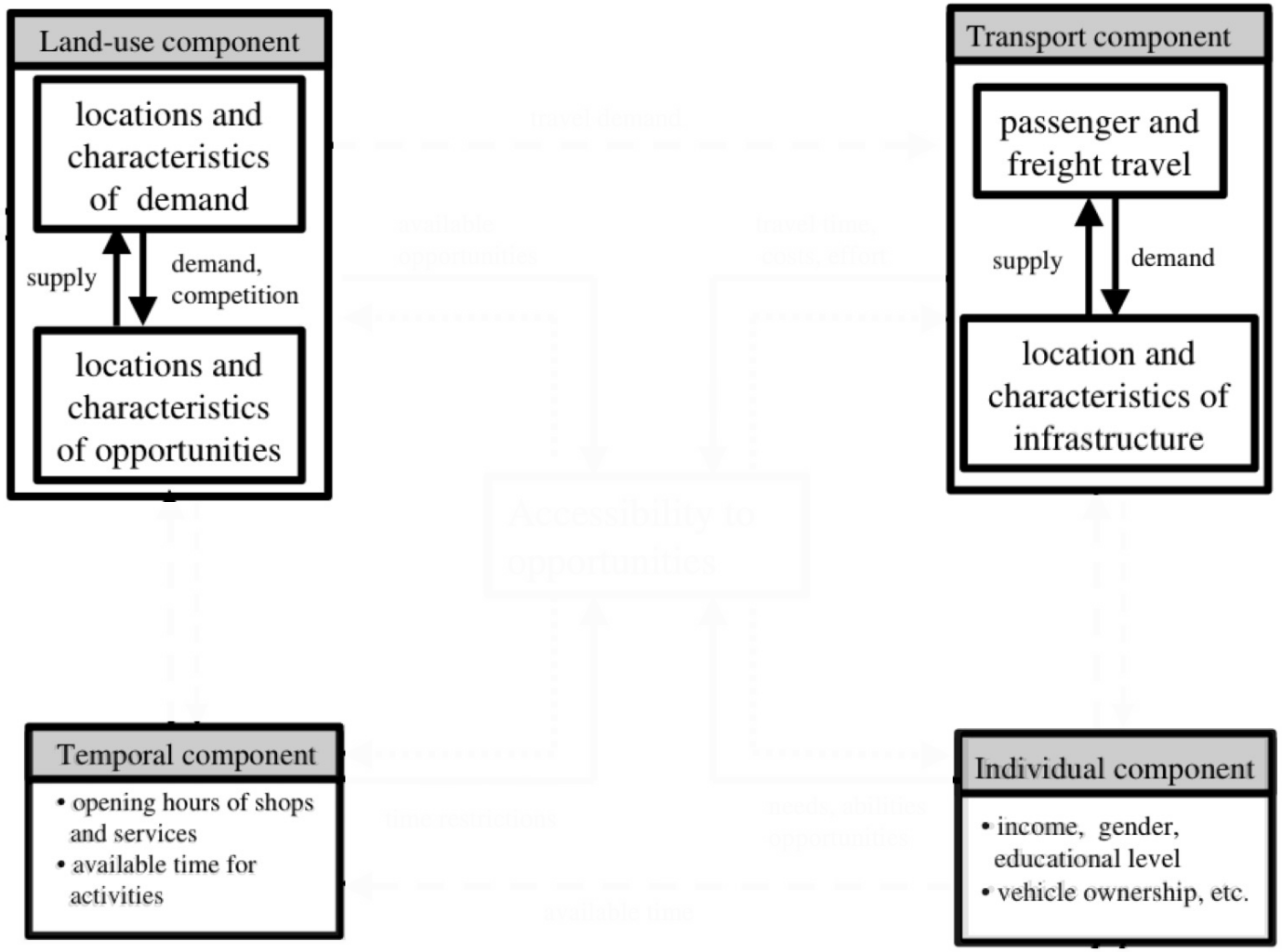
Accessibility



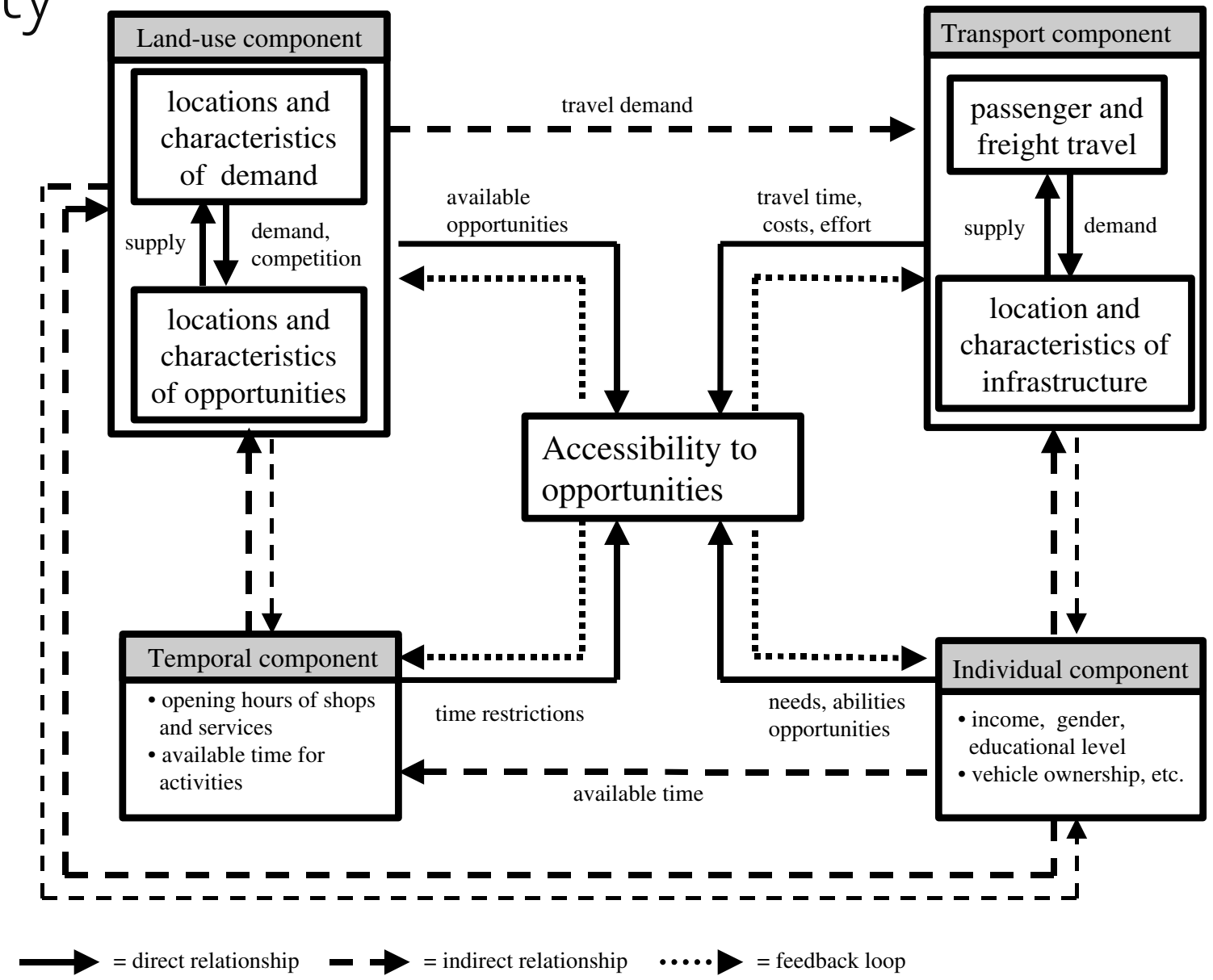
Accessibility



Accessibility



Accessibility

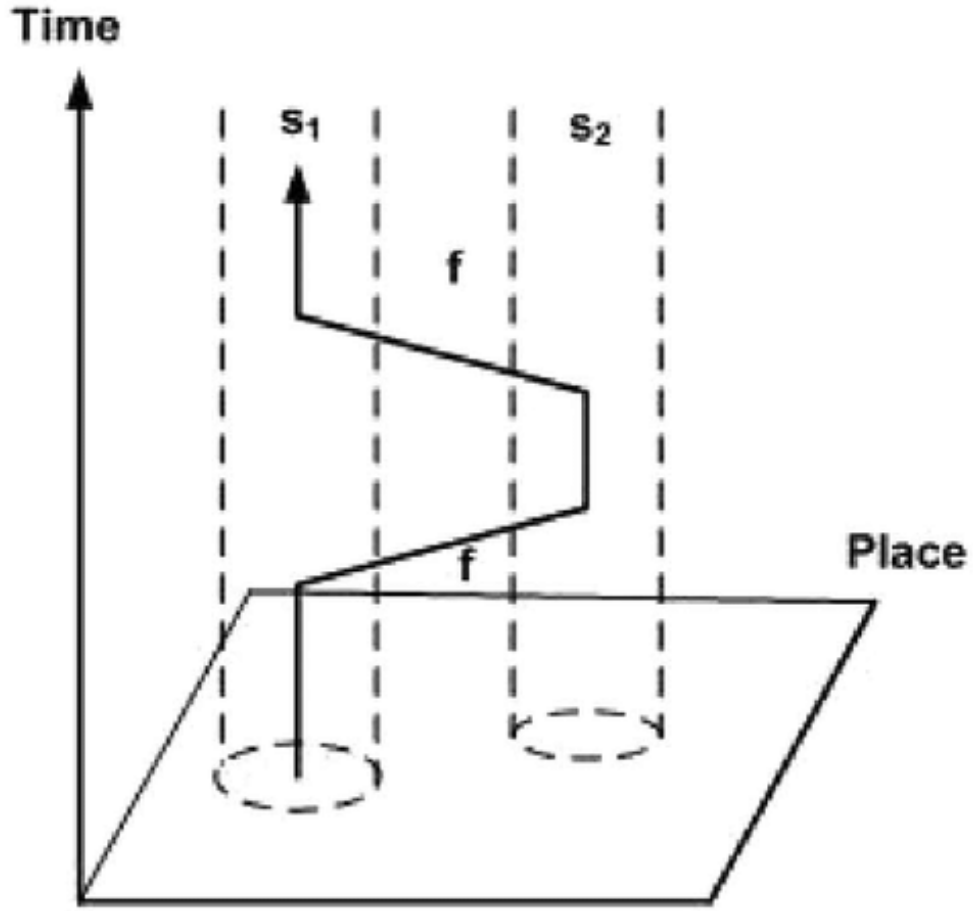


Geurs and Van Wee 2004

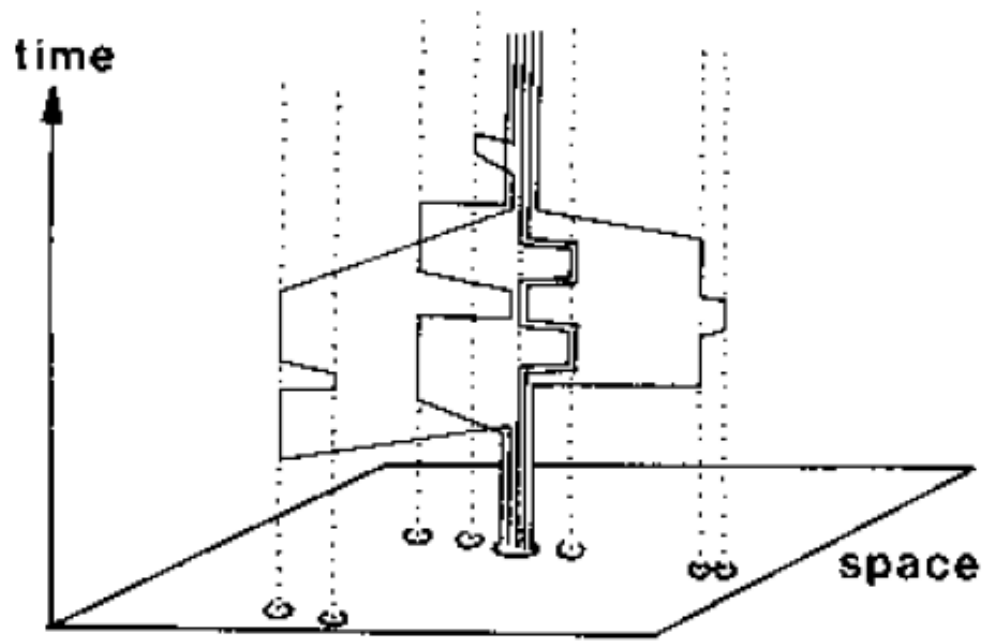
Time geography

- 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.

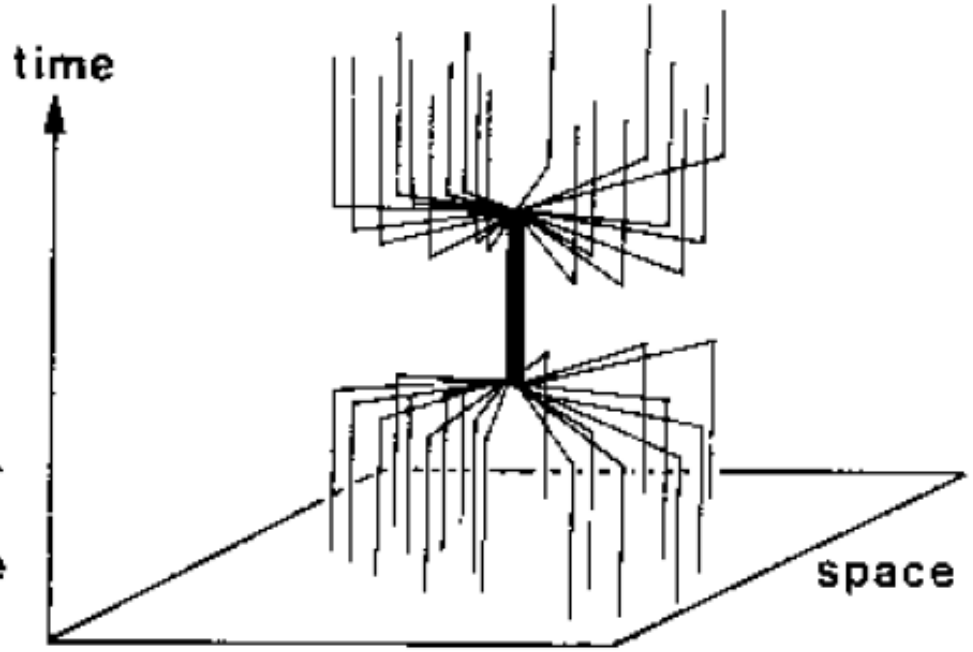
Time geography



Time geography



Household
”bundle”



School
”bundle”

Accessibility

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]

Spatial network

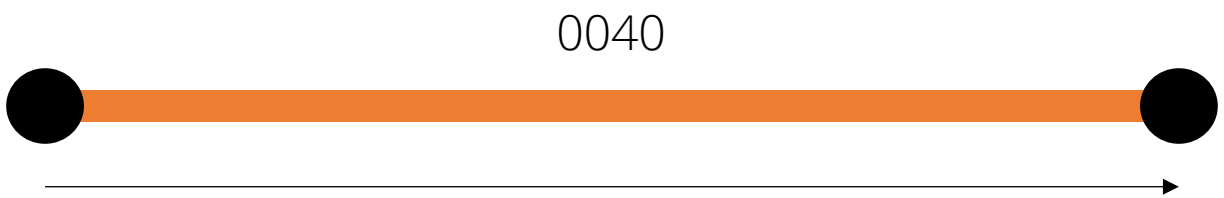
- A spatial network is an organised system or collection of nodes and edges embedded in geographic space.
- Nodes can be a representation of physical objects in geographical space,
  and edges show what connections are formed between the objects.
- Examples of networks: street configuration, transportation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

Spatial network structure

Characteristics of a polyline vector in a GIS data model:

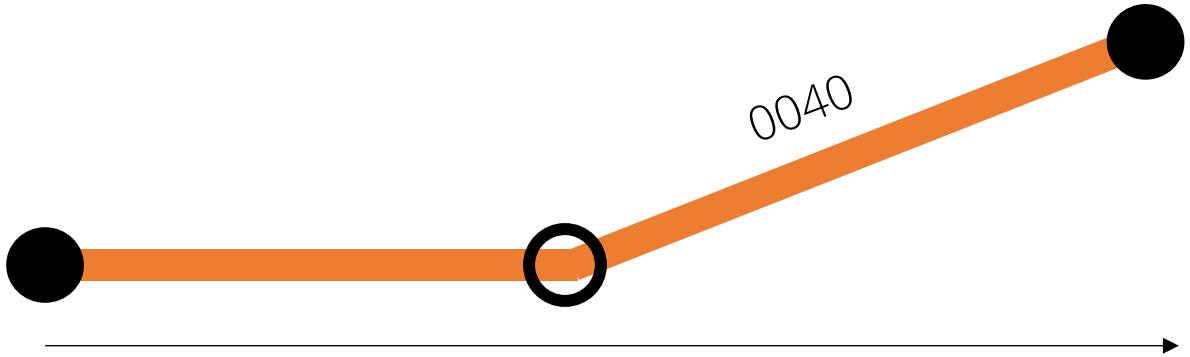
- Series of XY locations (coordinates) that form a line
- Has no area
- Has a length
- Has a direction (importance when it comes to roads, rivers, etc.)
- Can be connected to other polyline vectors to form a network
- Geometry consists of 2 nodes (start node and end node) and can have one or more vertices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

Spatial network structure



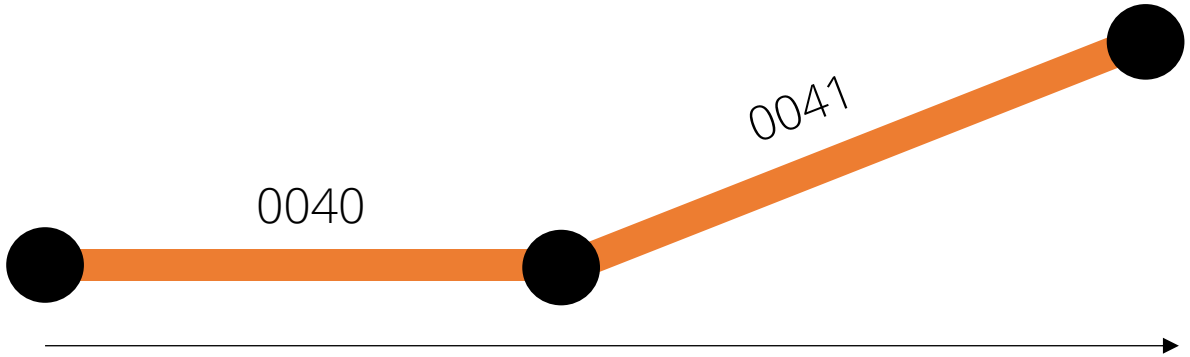
FeatureID	Type	Length
0040	Bicycle lane	1,500

Spatial network structure



FeatureID	Type	Length
0040	Bicycle lane	1,650

Spatial network structure

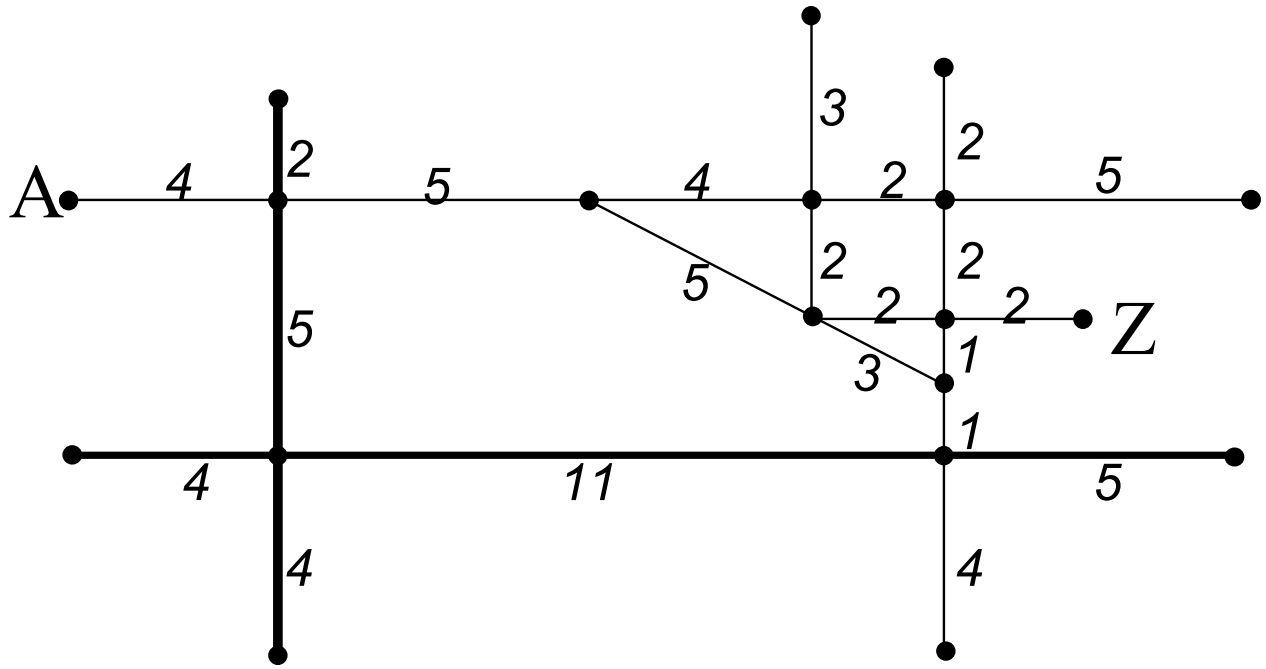


FeatureID	Type	Length
0040	Bicycle lane	600
0041	Bicycle lane	1,050

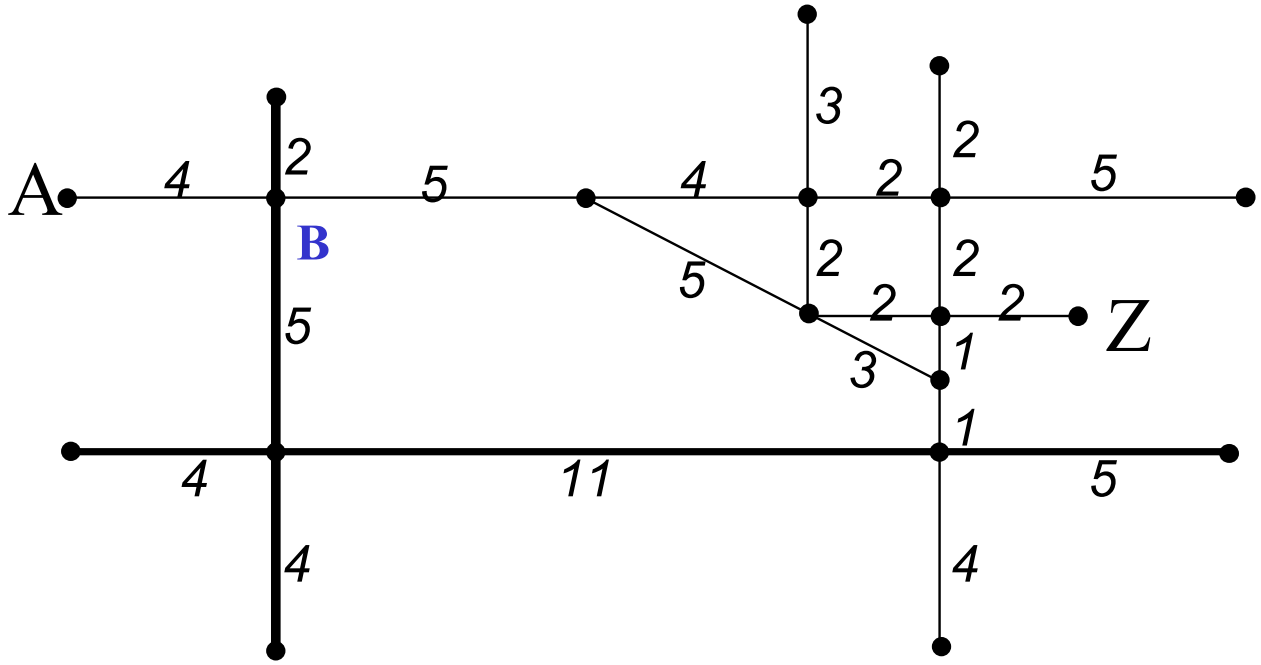
Dijkstra’s shortest path algorithm

- Shortest path
- Quickest path
- Cheapest path

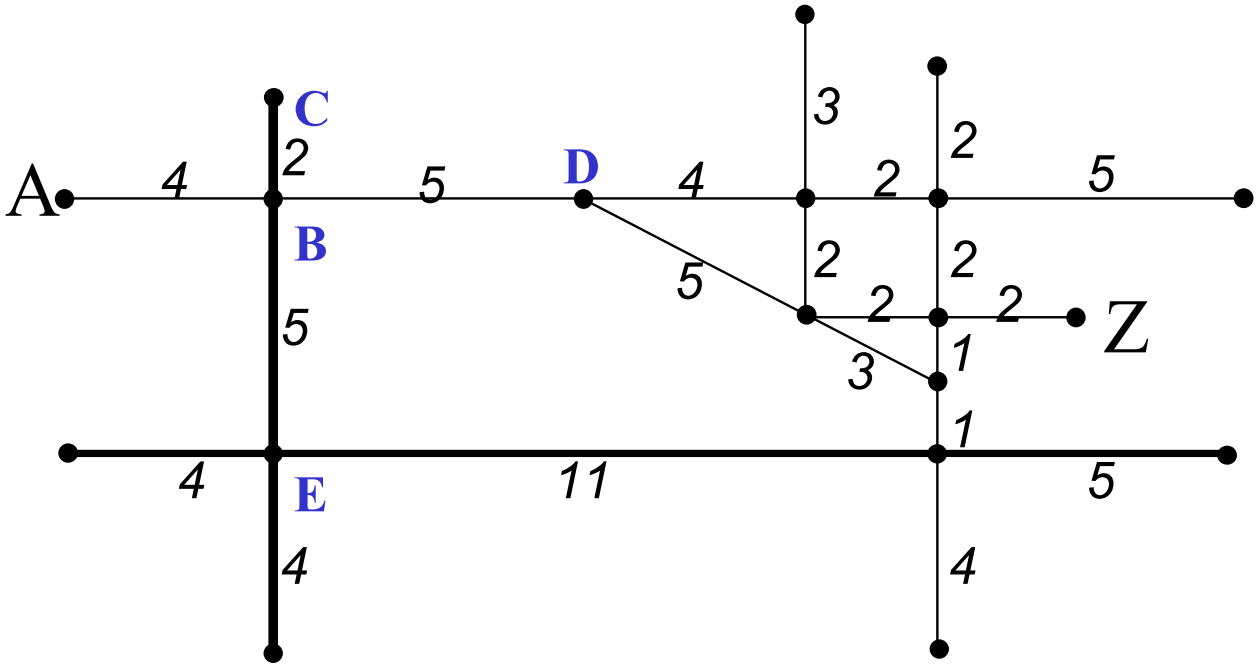
Dijkstra’s shortest path algorithm



Dijkstra's shortest path algorithm



Dijkstra’s shortest path algorithm

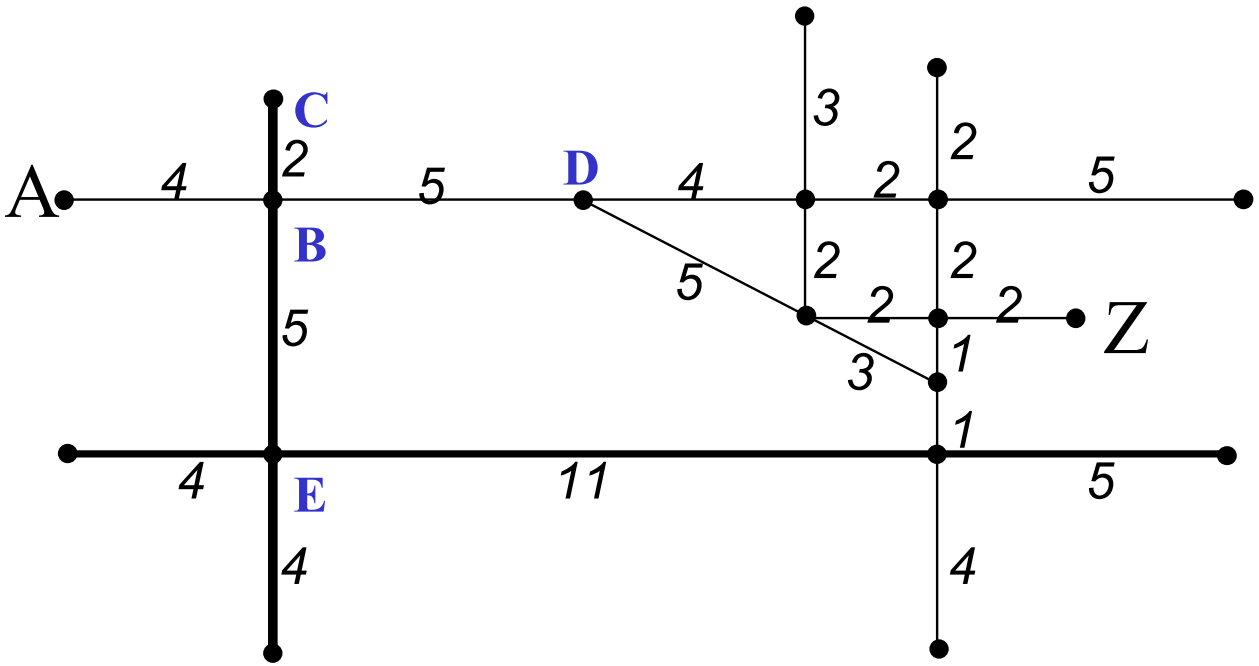


…

ABC	6
ABD	9
ABE	9

B – AB	4

Dijkstra’s shortest path algorithm

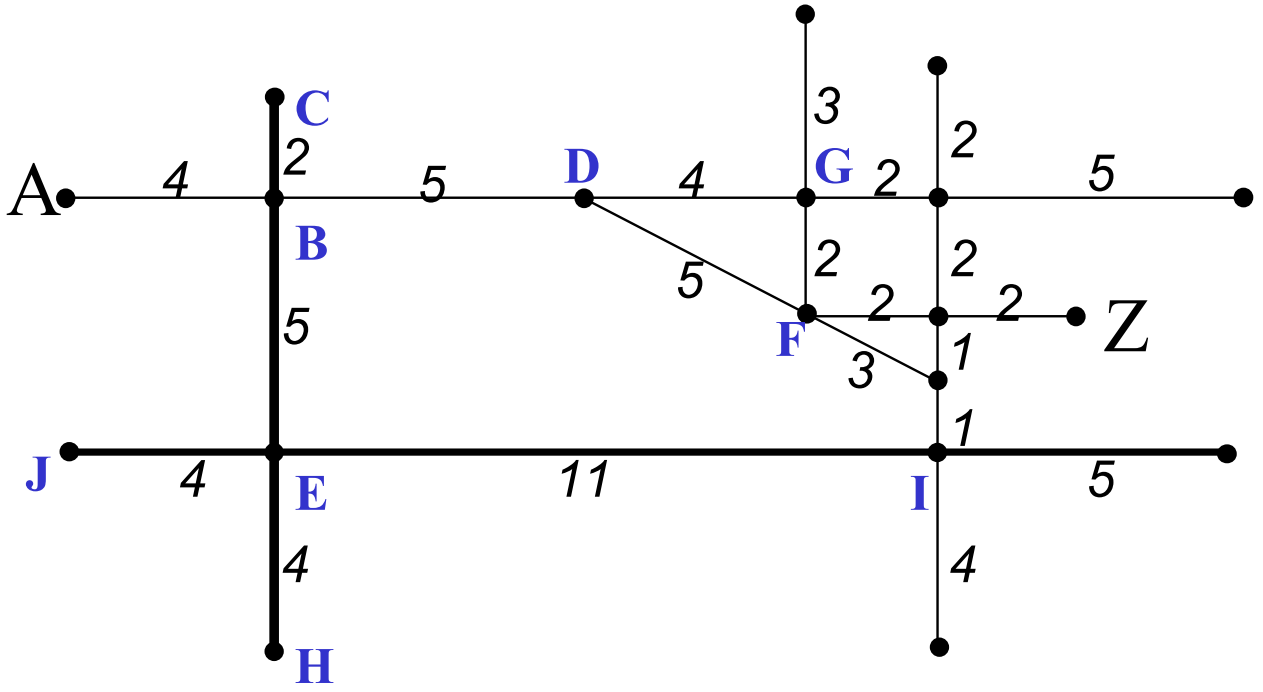


…

ABD	9
ABE	9

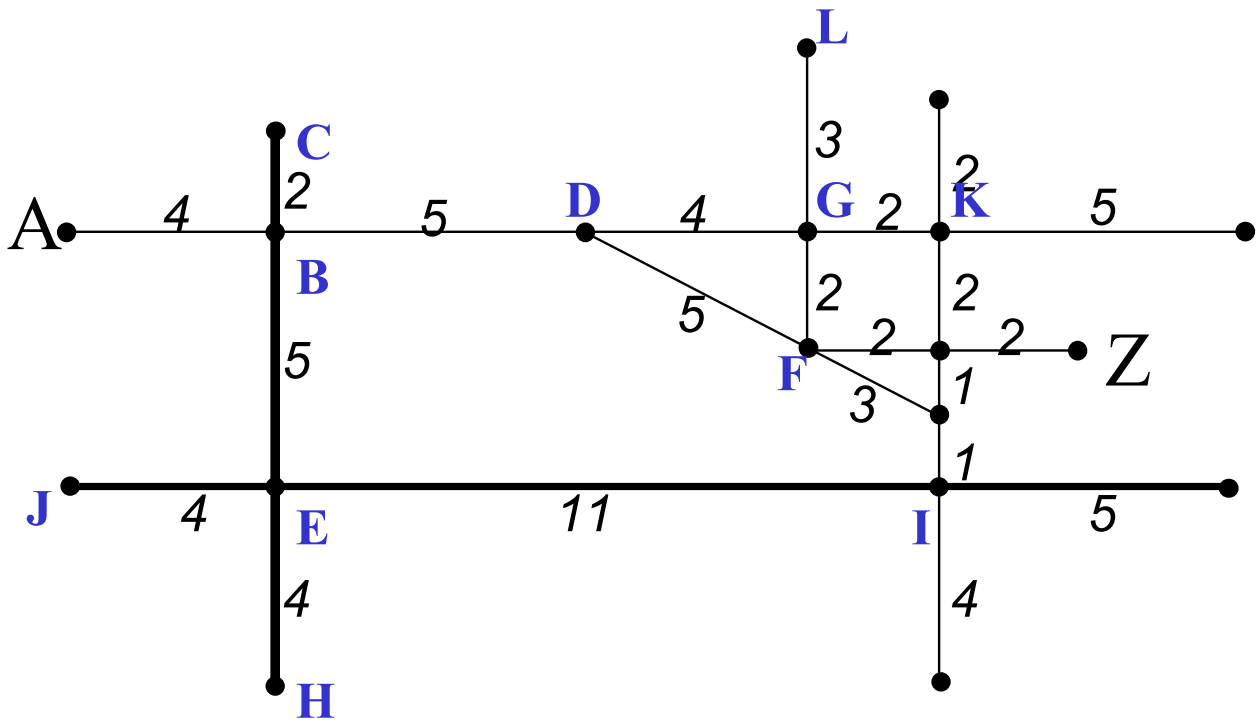
B – AB	4
C – ABC	6

Dijkstra's shortest path algorithm



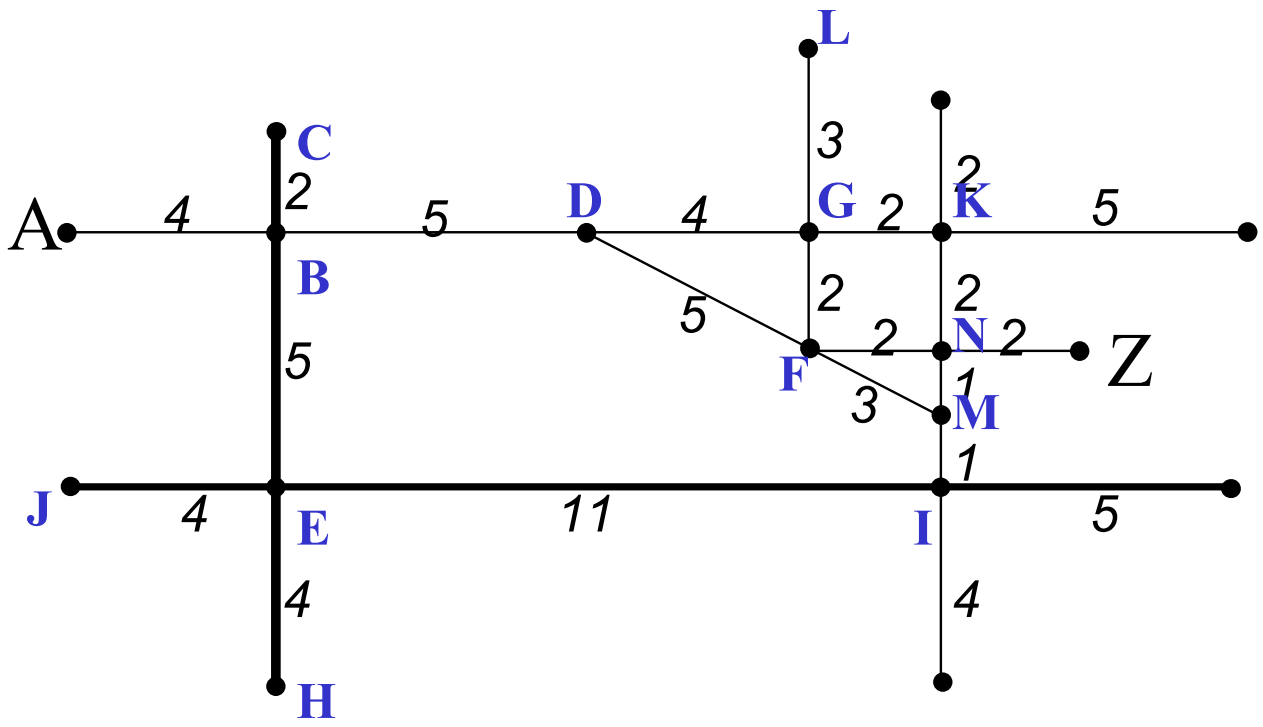
...	
ABDG	13
ABEJ	13
ABEH	13
ABDF	14
ABEI	20
B – AB	4
C – ABC	6
D – ABD	9
E – ABE	9

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

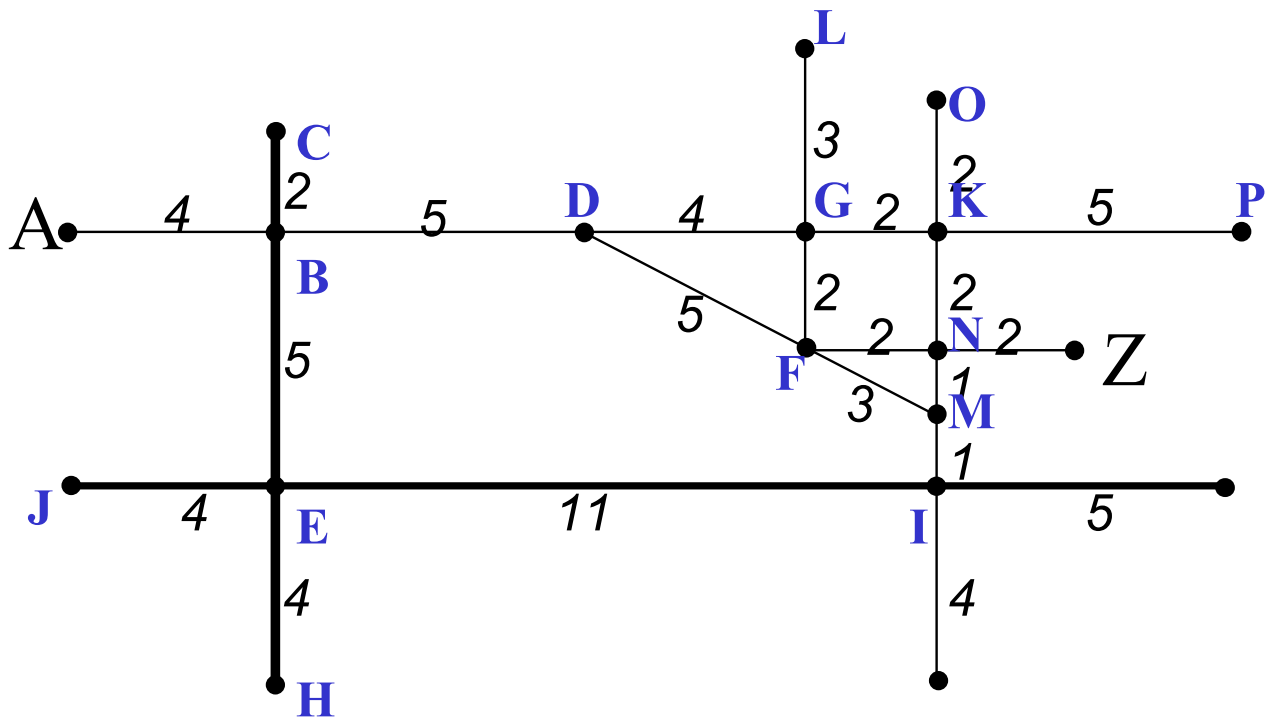


...

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

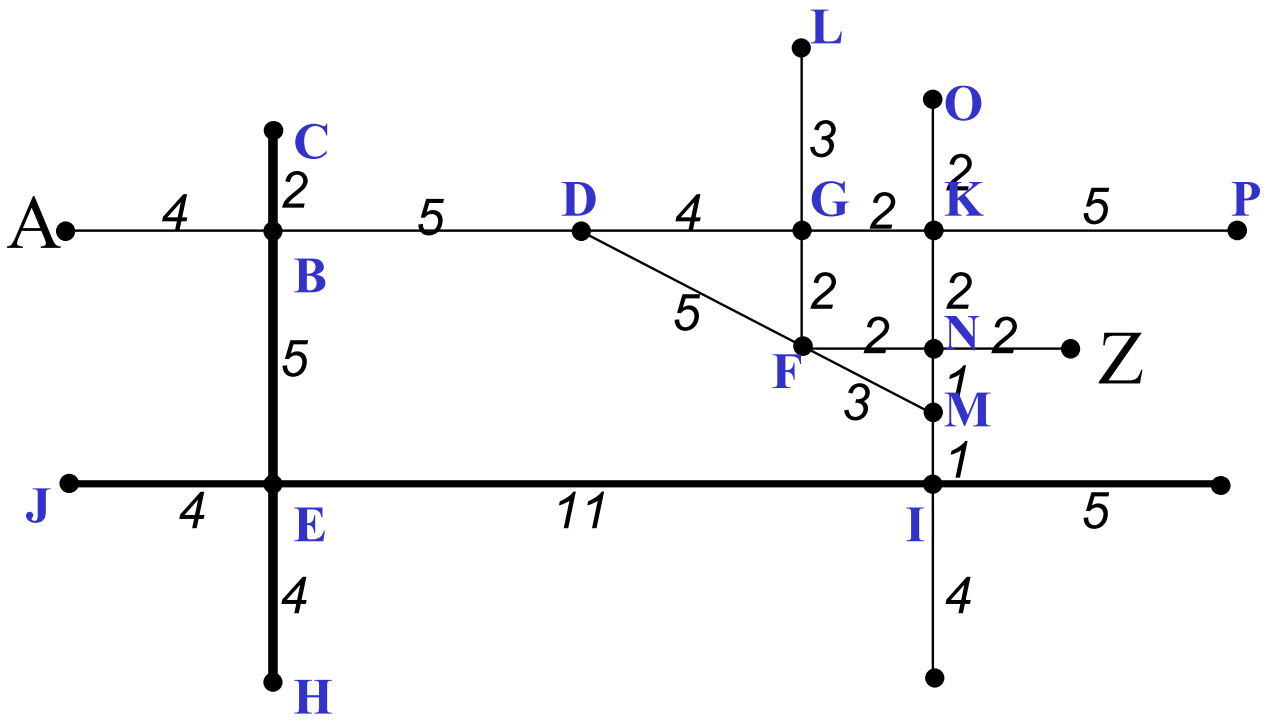
Dijkstra’s shortest path algorithm



…	
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

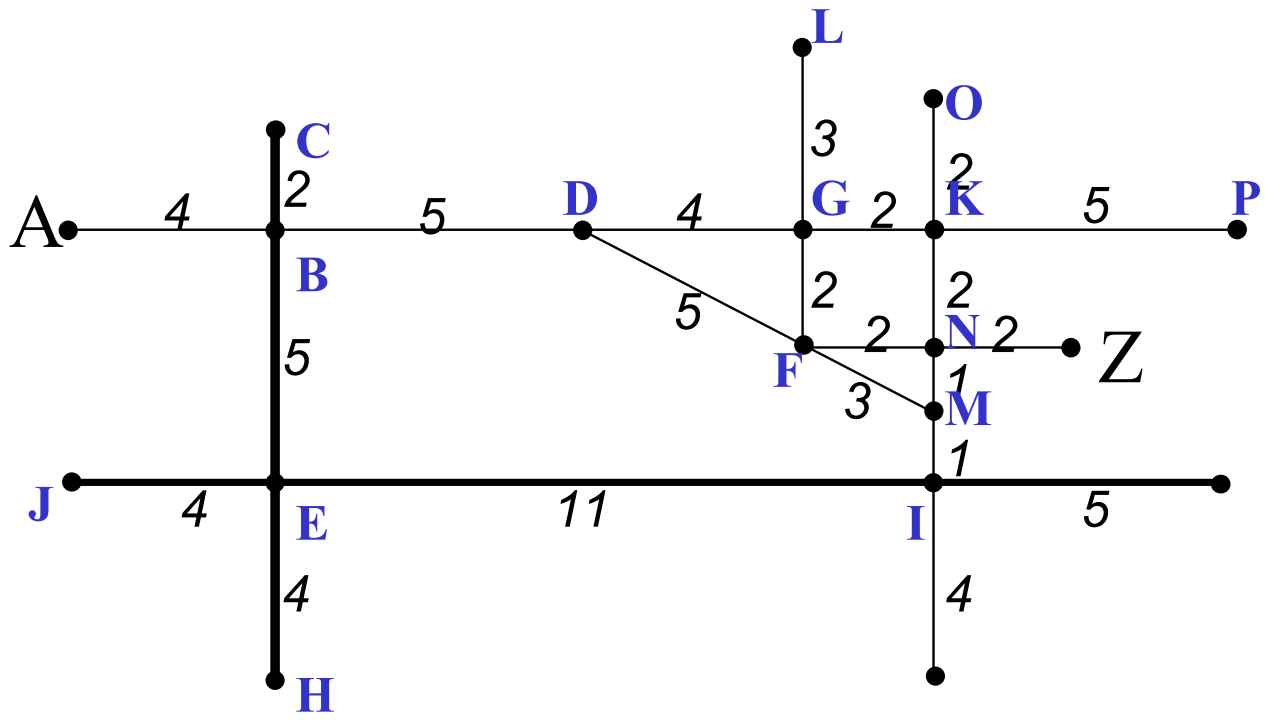


...

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

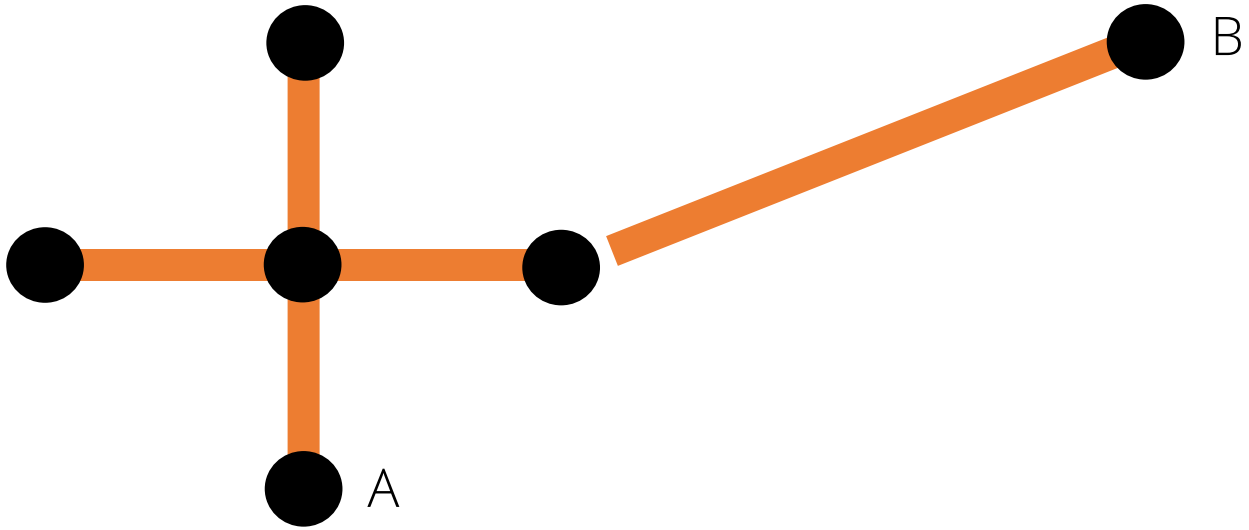
… with Dijkstra's algorithm we need

- 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

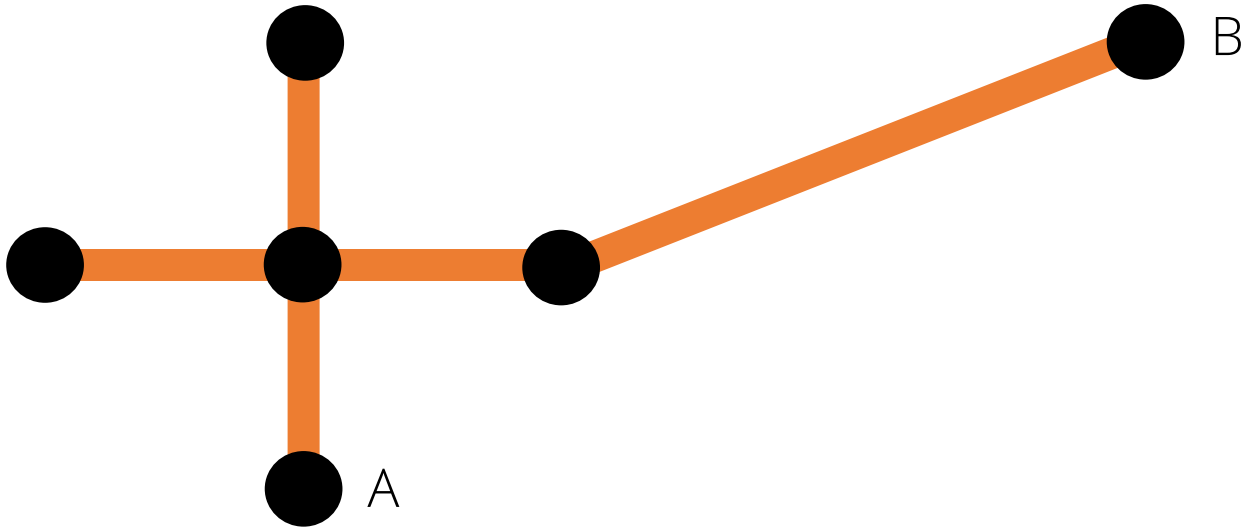
To consider

- 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?

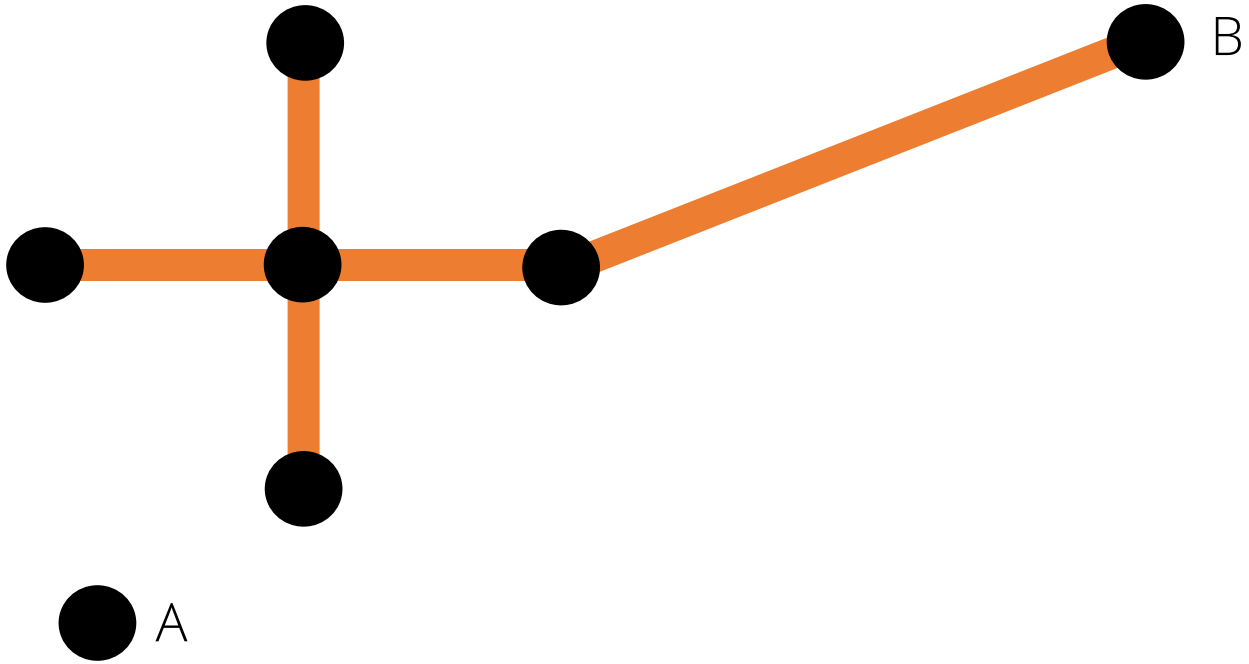
Connectivity



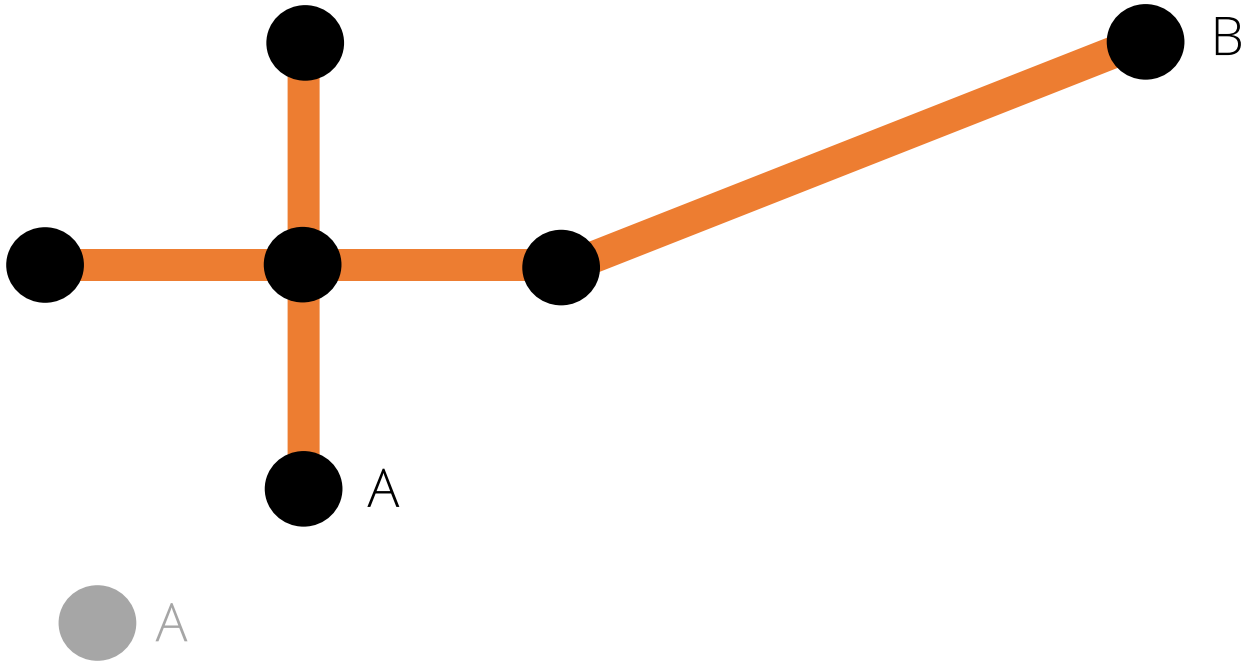
Connectivity



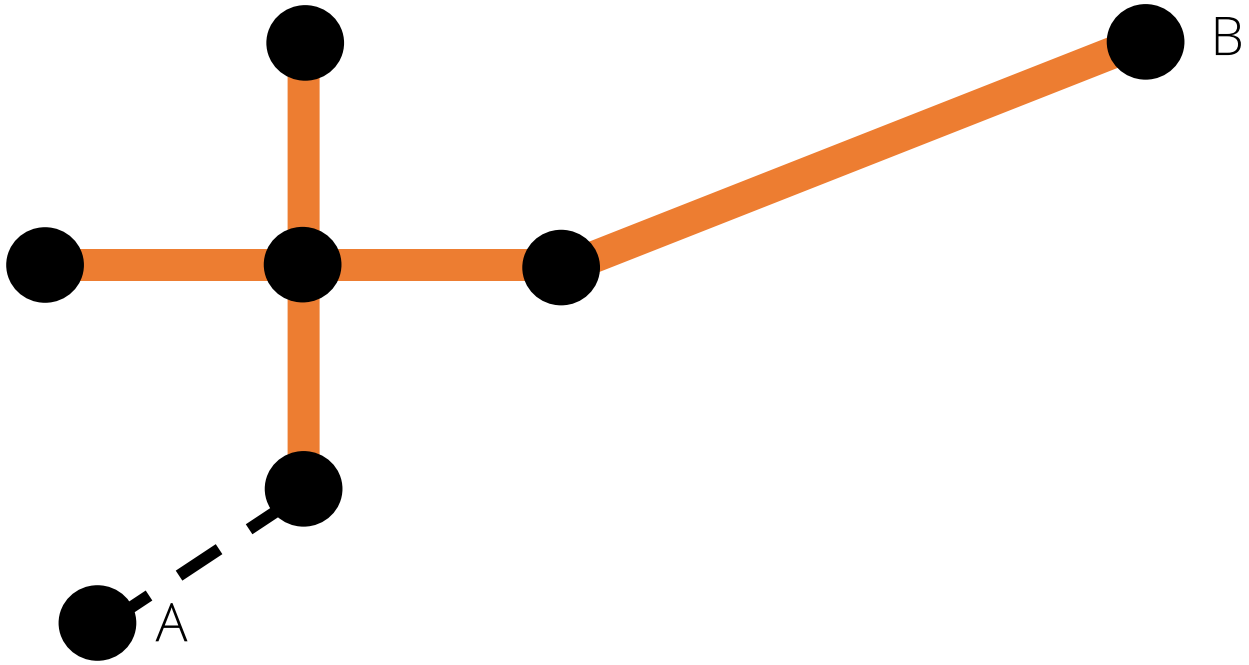
Connectivity



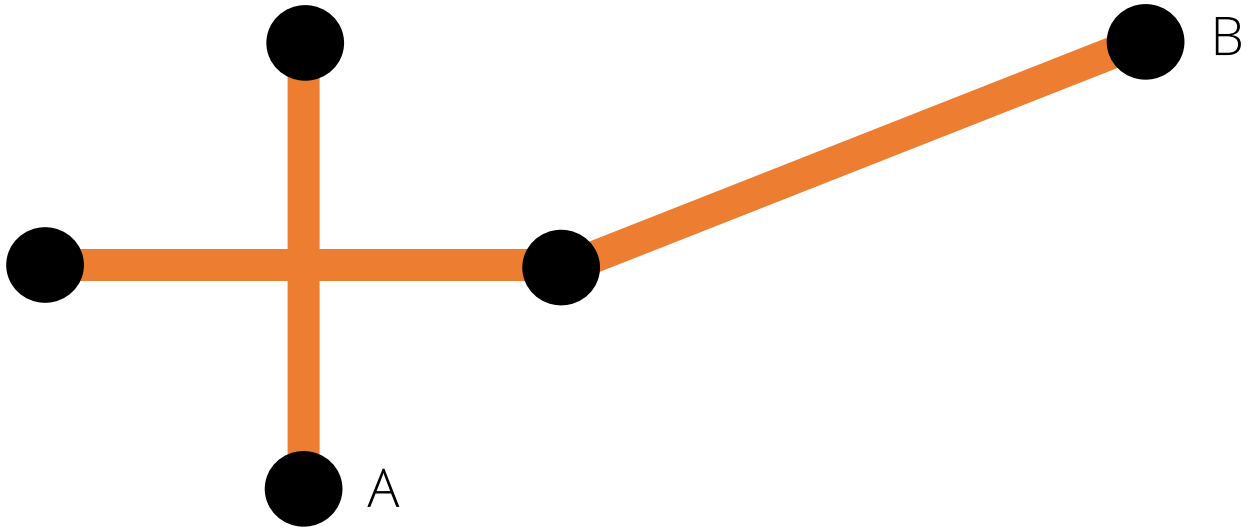
Connectivity



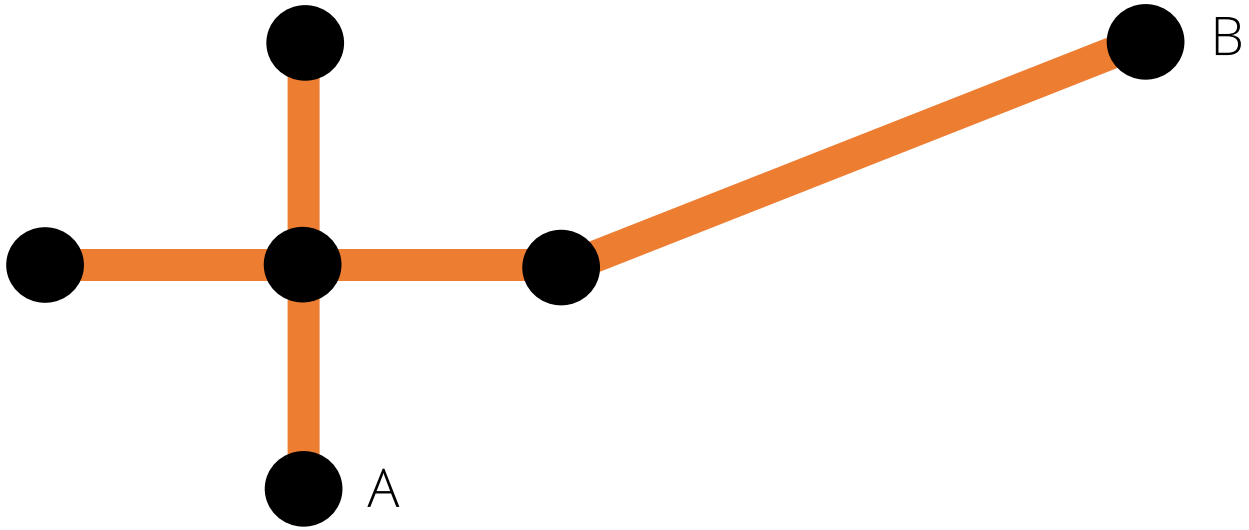
Connectivity



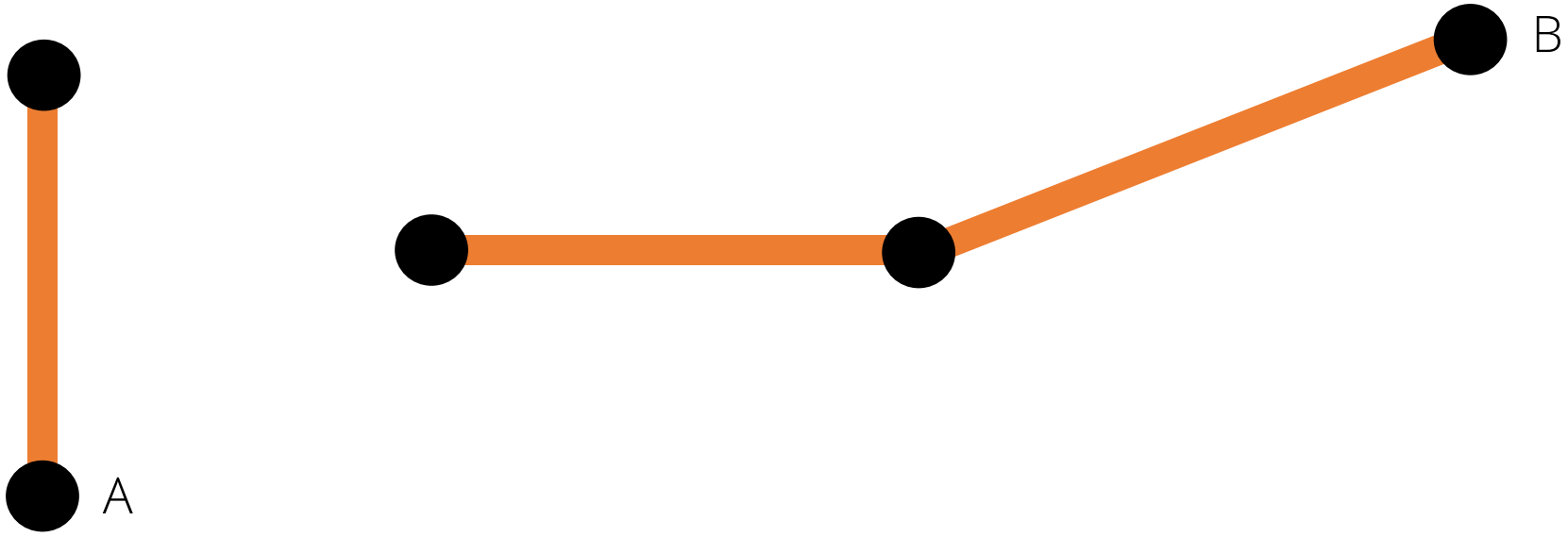
Topology



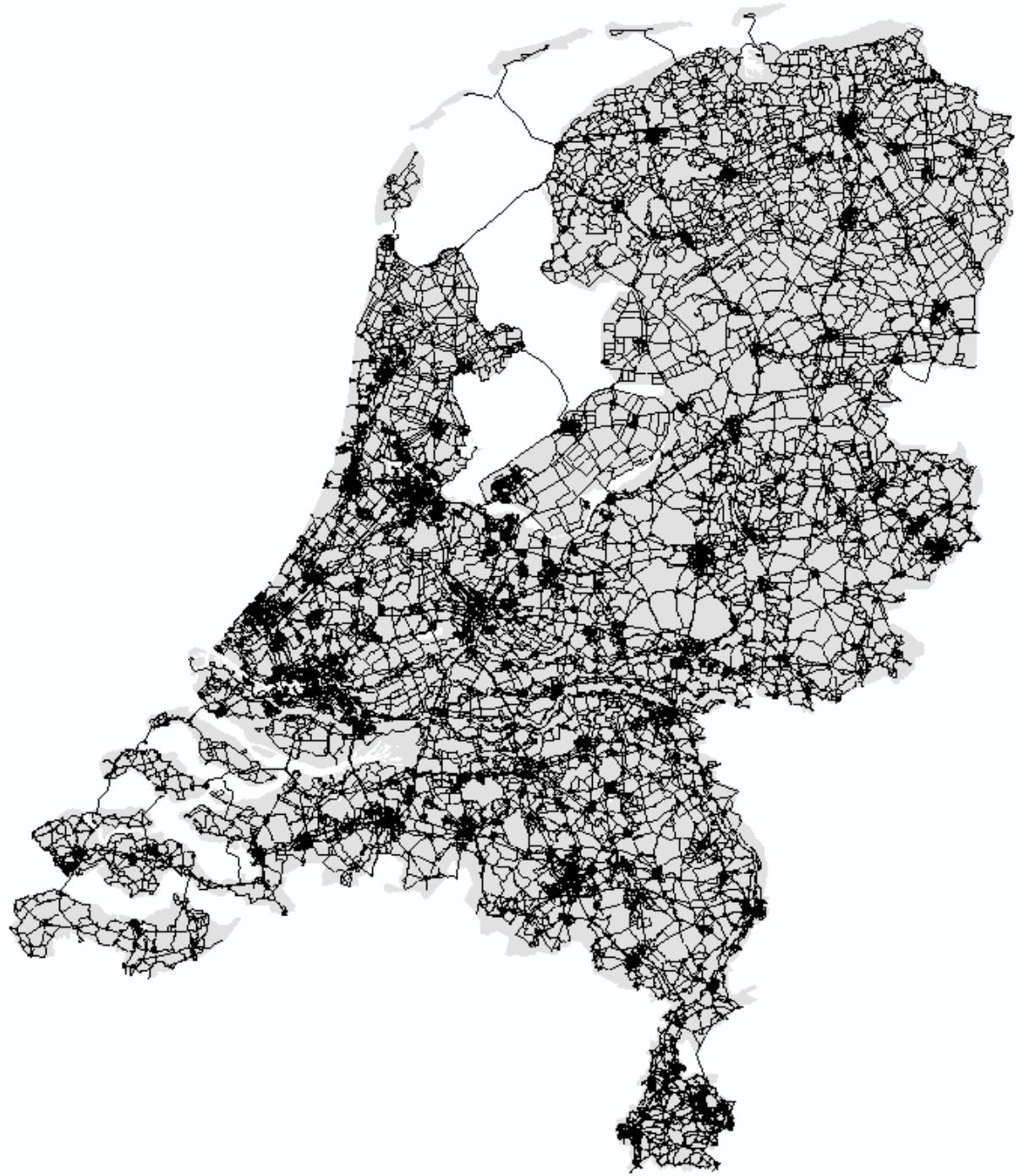
Topology



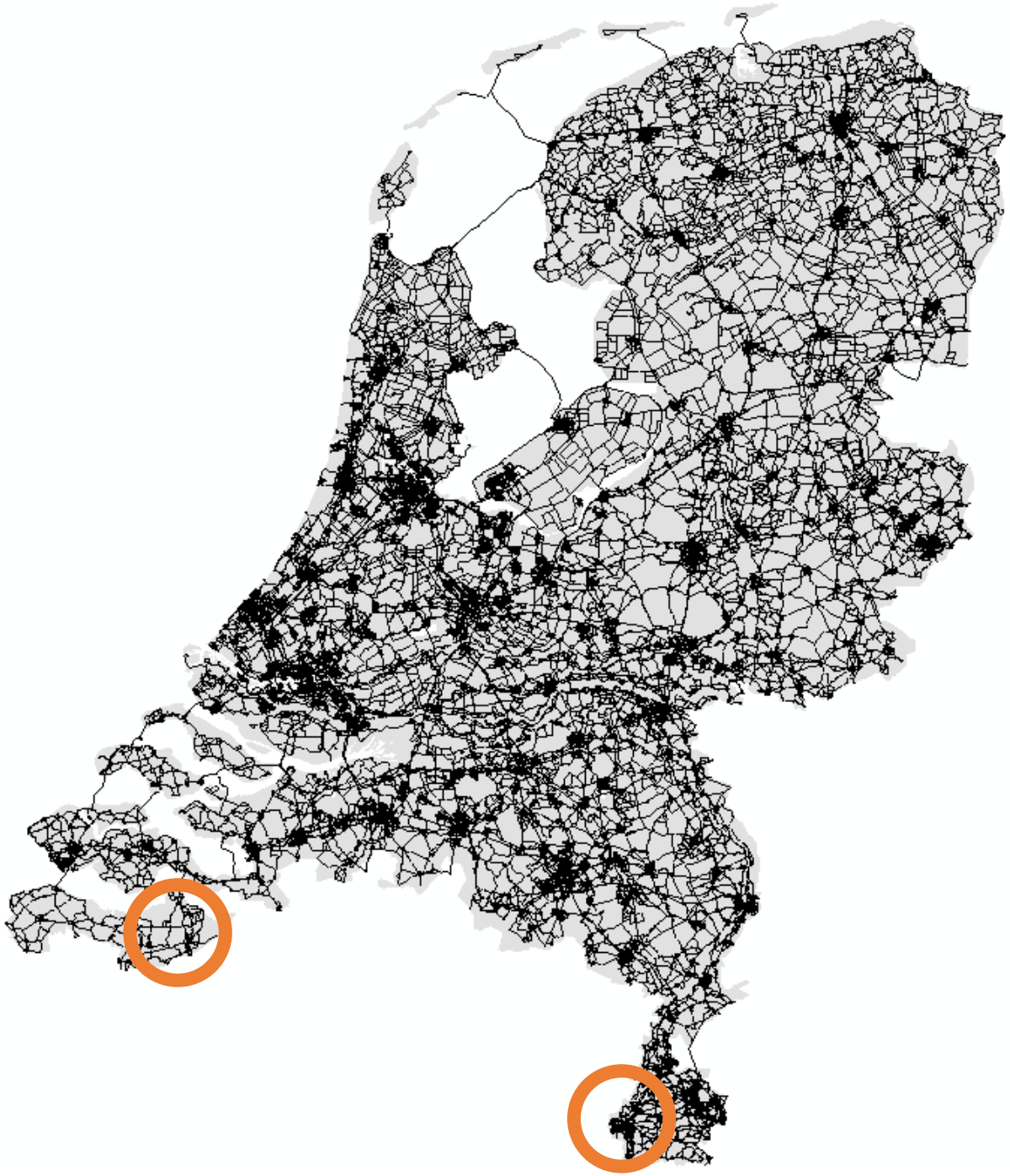
Topology



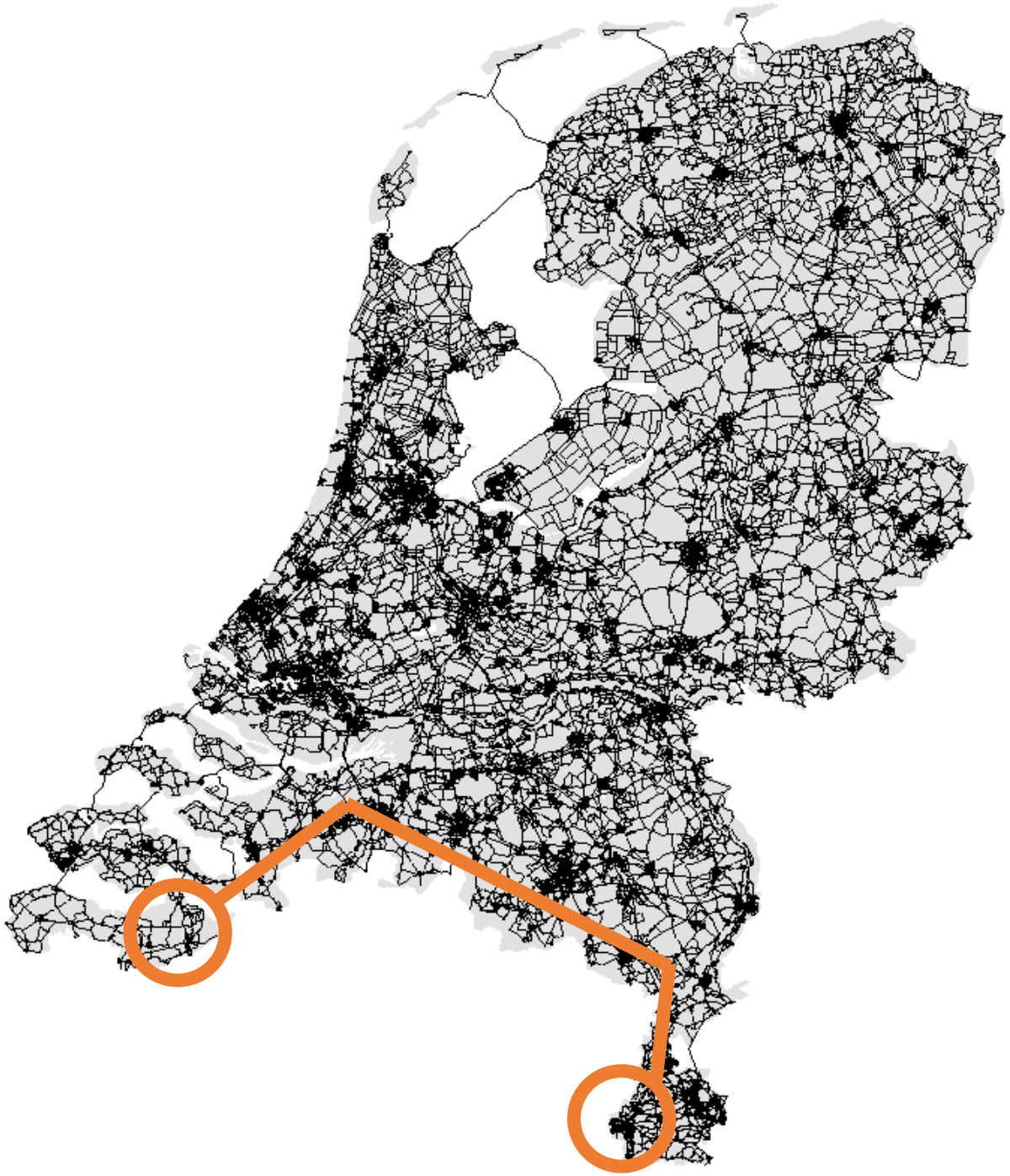
Coverage



Coverage



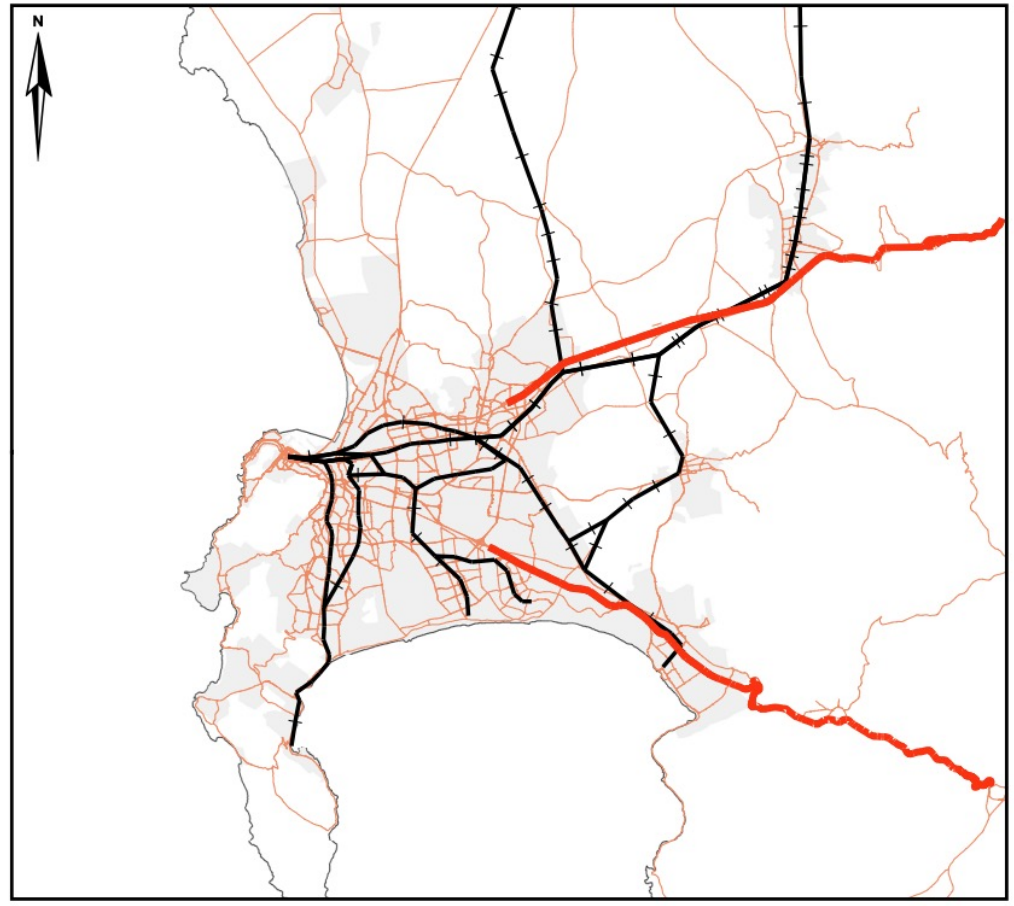
Coverage

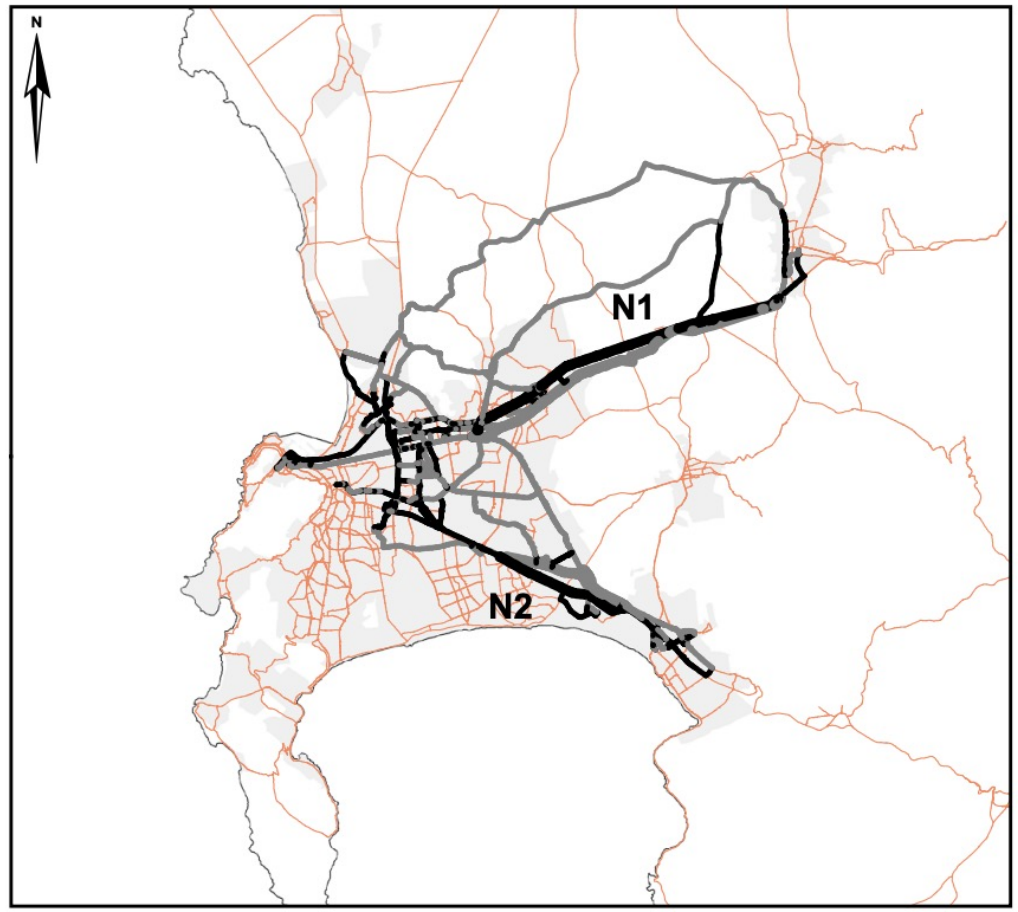


Coverage

Accessibility in Cape Town

- Equity effects of a proposed toll charge on the traffic diversions and geographical accessibility of work locations in Cape Town, South Africa.
- High dependency on road transport, largely inherited from the racial and spatial segregation of the apartheid regime.
- Hypothesis: a toll in this region will take a proportionally greater amount from those on lower incomes.


N
Roads to be tolled
Train lines
Main roads
Transport Zones
0 5 10 20 Kilometers



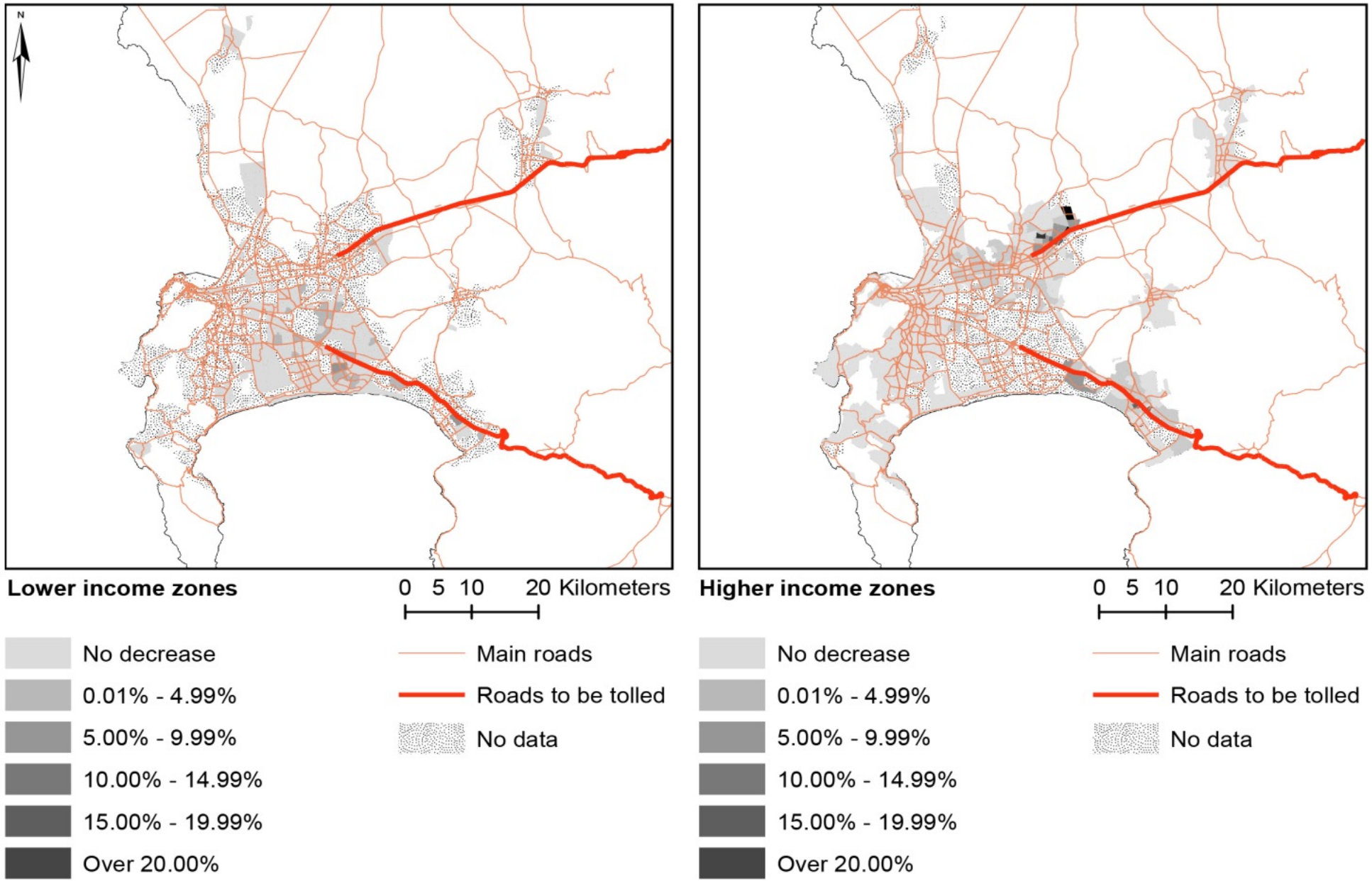
Decrease in flows

- 1 - 1000
- 1001 - 2000
- More than 2000
- Main roads
- Transport Zones

Increase in flows

- 1 - 1000
- 1001 - 2000
- More than 2000

0 5 10 20 Kilometers


N
Lower income zones
0 5 10 20 Kilometers
No decrease
0.01% - 4.99%
5.00% - 9.99%
10.00% - 14.99%
15.00% - 19.99%
Over 20.00%
Main roads
Roads to be tolled
No data
Higher income zones
0 5 10 20 Kilometers
No decrease
0.01% - 4.99%
5.00% - 9.99%
10.00% - 14.99%
15.00% - 19.99%
Over 20.00%
Main roads
Roads to be tolled
No data

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.

Some pointers for the exam

Exam format

- 2-hour timed exam on Thursday 26 May 2022 at 10h00
- 2 essays (no word limit), aim to spend one hour on each
- 6 questions to choose from a range of topics covered by the lectures across the term
- Some references are expected, but do not go overboard

Exam general guidance

Departmental instruction

“Any essay-based answer should demonstrate the ability to construct a clear argument, and build a coherent answer providing evidence to make each point, drawing on readings and case studies as appropriate.”

Strategy

“First 10 minutes planning your response. Then you’d likely spend the next 40 minutes writing out that response. Then you might spend the final 10 minutes reading through your piece to check for clarity.”

Exam general guidance

- Demonstrate the ability to construct a clear argument: make sure you have an Introduction, Analysis/Discussion and Conclusion.
- Build a coherent answer: think about the logic of your answer, ‘build’ the argument from point to point.
- Provide evidence drawing on readings and case studies: use the book chapters and articles in the reading list to substantiate your points; you might use books as your “technical reference” whilst articles for case studies can be used to illustrate your points.

Exam essay structure

- Introduction
- Prioritise your analysis points (2 – 4)
  - Make your point as clear as possible, use a single sentence
  - Example with some references
- Conclusion is used to summarise your argument

Exam marking criteria

Marking Criteria for Exams, Term 3, 2021-2022[1]

	Inadequate	Adequate	Fair	Good	Excellent	Outstanding	Exceptional
	1-19: 5 inadequate 1-5 20-29: 4 inadequate 1-5 30-39: 3 inadequate 1-5	40-49: Majority of 1-5 Adequate or higher	50-59: Majority 1-5 Fair or higher	60-69: Majority 1-5 Good or higher	70-79: Majority 1-5 Excellent or higher	80-89: Majority 1-5 Outstanding or higher	90+: Majority 1-5 Exceptional
1. Response to the task set	Either no argument or argument is inept & irrelevant. Conclusions absent or irrelevant.	An indirect response to the task set, with gesture towards a relevant argument & conclusions.	A reasonable response with a limited sense of argument & partial conclusions.	A sound response with a reasonable argument & straightforward, logical conclusions.	A distinctive response with a clear argument & sensible conclusions; evidence of nuance.	Impressive response with nuanced argument, presenting significant & nuanced insights.	Exceptional response with very sophisticated argument ending in subtle conclusions.
2. Grasp of relevant issues	General misunderstanding of issues discussed.	Rudimentary, inter-mittent grasp of issues with confusions.	Reasonable grasp of issues & their broader implications.	Sound understanding, with insights into broader implications.	Thorough grasp w/ some sophisticated insights.	Striking grasp of complexities & significance of issues.	Exceptional grasp of complexities & issues' significance.
3. Reflection, thought, & conceptual framework	Erroneous or un-conceptual analysis. Poor understanding of basics of the taught materials.	Analysis relies on partial reproduction of taught materials. Some concepts absent or wrongly used.	Reasonable reproduction of taught materials. Rudimentary use of concepts.	Evidence of student's own analysis. Concepts effectively defined & used systematically.	Innovative analysis. Concepts deftly defined & used with some theoretical context.	Impressive thought, insights & analysis. Concepts deftly defined & used w/ strong context.	Engaged w/ cutting edge. Sophisticated conceptual framework used in context.
4. Knowledge of literature & empirical topic	No evidence of, or largely inaccurate use of, conceptual literature & empirical material.	Rudimentary knowledge of required reading & empirical aspects of topic, with inaccuracies.	Limited knowledge of required reading & empirical aspects of the topic, with inaccuracies.	Sound knowledge of required reading & empirical aspects, with occasional inaccuracies.	Thorough knowledge of relevant reading & empirical aspects of the topic.	Impressive knowledge of relevant literature & empirical aspects of the topic.	Comprehensive knowledge of relevant literature & empirical aspects of the topic.
5. Evidence to support claims	No effective use of evidence to support any claims made.	Evidence rarely or ineffectively used to support claims.	A few claims warranted by evidence.	The essay's most crucial claims are supported by relevant evidence.	The essay's claims are mostly supported by appropriate evidence.	The essay's claims are warranted by apt, accurate evidence.	Claims are warranted by accurate, up-to-date & detailed evidence.
6. Structure & planning	Structure not discernible; minimal progression. (-3)	Structure discernible, but frequently absent. (-2)	Structure is apparent; frequent digression. (-1)	Conventional structure w/ rare digressions. (0)	Logical, coherent structure. (1)	Outstanding structure adds to overall effect. (2)	Exceptional structure crucial to argument. (3)
7.Writing style[2]	Style is consistently unclear. Inappropriate word choices. (-3)	Style & word choice lacks fluency & argument is only clear in parts. (-2)	Style generally clear but errors in use of jargon, grammar & spelling. (-1)	Style largely clear & fluent. Use of jargon is generally accurate. (0)	Style consistently clear & fluent with accurate use of terms. (1)	Style is elegant & precise with accurate use of jargon. (2)	Sophisticated style w/ impeccable spelling, grammar & jargon. (3)

Exam further help

- Departmental Exam Guidance (see Moodle assessment tab)
- Departmental Exam Practice (see Moodle announcement)
- Past Exam Papers (e.g. 2019, 2021) to get an idea of the type of questions to expect

Computer tutorial

- Today: transport network analysis and measuring accessibility in Portsmouth.
- Carefully read the instructions although there *may* be small deviations in the syntax.
- Assignment: no need to hand-in but if you want to leave before the end of the computer tutorial you should be able to show your results.

Geocomputation Help Session

- Thursday from 14h00-15h00 in Foster Court 215.
- Bring your own laptop.

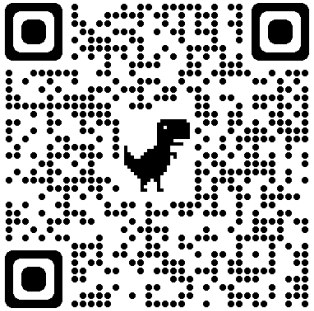
Geocomputation Extra Help Session

- Monday April 11 from 14h00-16h00
- Torrington Place 113.
- Not mandatory.

Questions

Justin van Dijk

j.t.vandijk@ucl.ac.uk



Thank you

Justin van Dijk

j.t.vandijk@ucl.ac.uk