

Transportation network modelling

Thomas Balstrøm
Department of Geosciences and
Natural Resource Management

tb@ign.ku.dk



Agenda

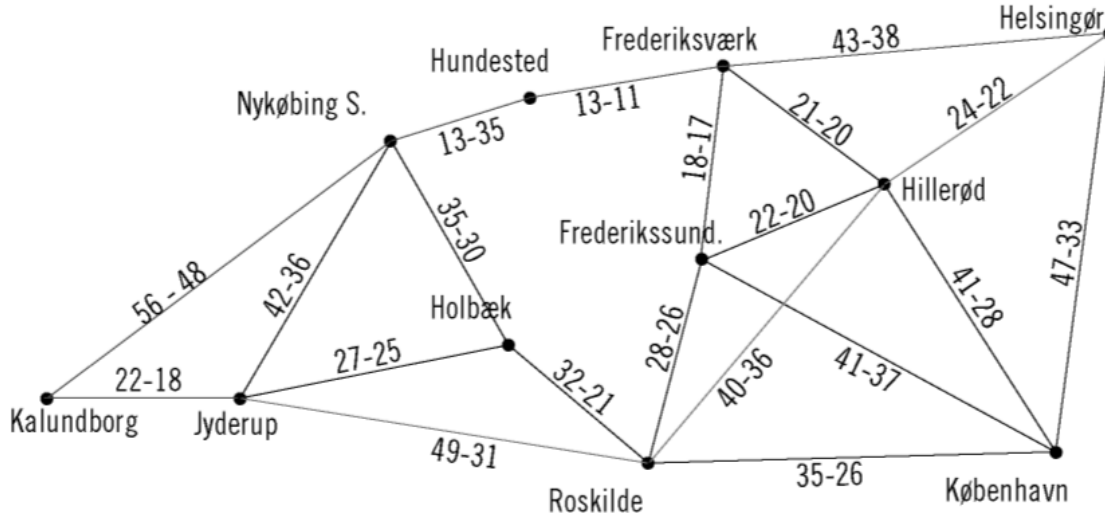
- What is a transportation network?
- Network algorithms
 - Shortest path and
 - Travelling Salesman's Problem
- Location - Allocation
- Service area
- Availability/Accessibility
- Network datamodel
- Network features
- Exercises



A transportation network is used to optimize searches relative to distances and travel time.

Travelling Salesman's Problem

Challenge: Visit a set of destinations once and return home having minimized the distance travelled.



First number = distance in km
Last number = travel time in minutes

Dijkstra's algorithm:

Start point = 0

All other points = ∞

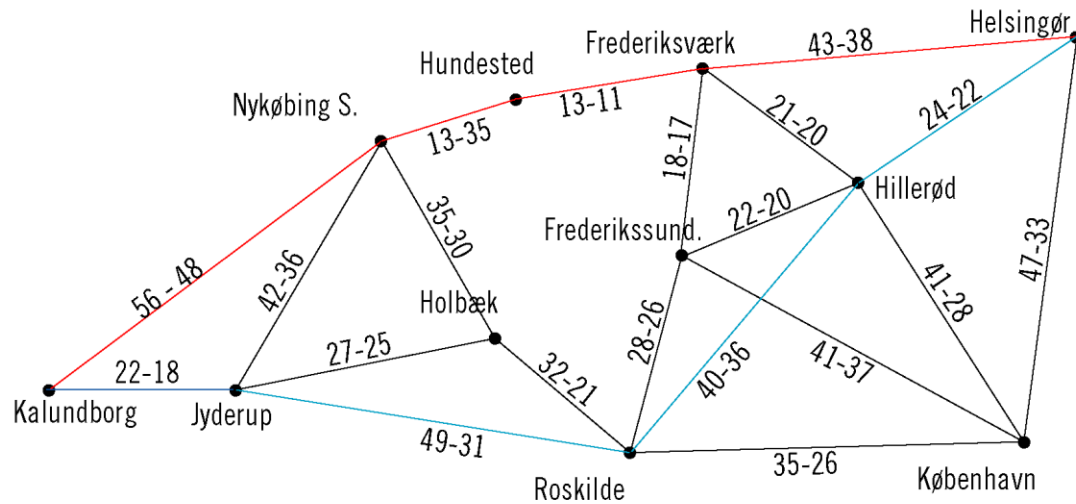
Start at 0 and determine distance to neighbors.

Sort the distances and select the point with the shortest distance to the lowest value and determine distance to neighbors from there.

Update accum. distances, select point with lowest value and continue.



Shortest / fastest route

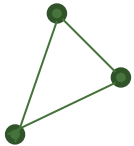


— Fastest route Kalundborg – Helsingør
 — Shortest route Kalundborg - Helsingør

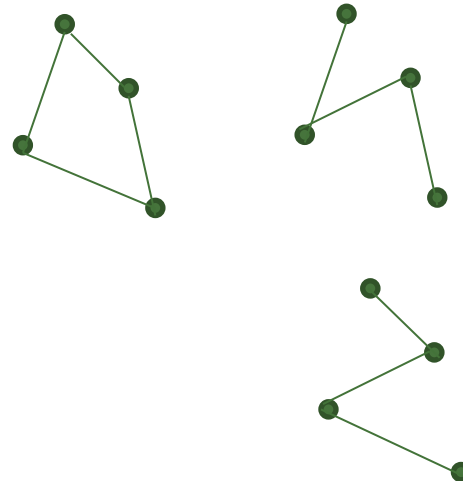
First number = distance in km
 Last number = travel time in minutes

Travelling Salesman's Problem

How many various combinations of path finding in between 3 cities: 1



How many various path finding combinations in between 4 cities: 3



Thus, the number of combinations of path finding is $(n-1)! / 2$

$$n = 3 \rightarrow (3-1)! / 2 \rightarrow 1$$

$$n = 4 \rightarrow (4-1)! / 2 \rightarrow 3$$

Travelling Salesman's Problem

How many various combinations of path finding in between 20 cities:

$$19 ! / 2 = 6,08 * 10^{16}$$

A fast home computer today can handle 10 Tflops (= 10^{12} floating point operations per second), the calculation will take

$$1,9 * 10^9 \text{ years}$$

Instead several heuristics are available:

1) random, 2) greedy, 3) 2-opt, 4) simulated annealing

[TSP video](#)

[Explanation: Simulated Annealing- The Travelling Salesman Problem \(fourmilab.ch\)](#)



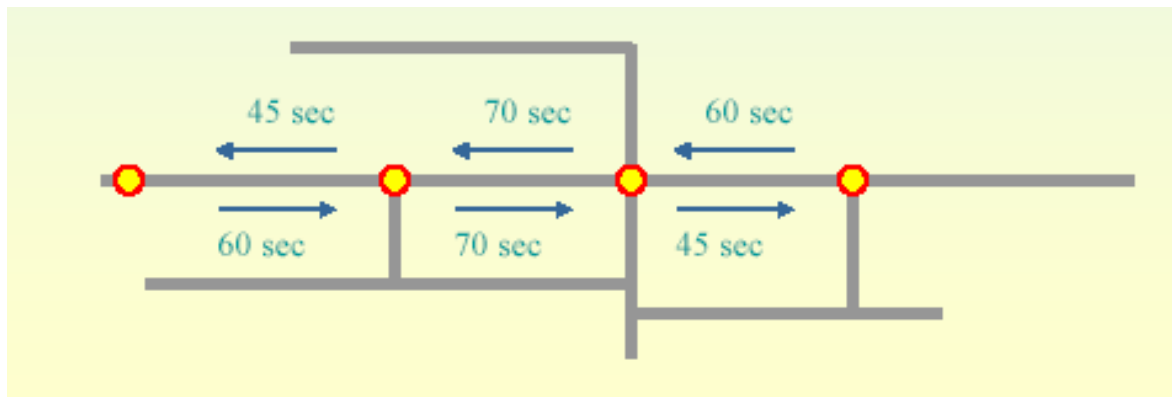
Network Dataset Features

- Cost attributes (distance vs. time costs)
- Historical traffic information
- Turn delays (turns that take a long time)
- Restriction attributes (one-way streets)
- Turn restrictions
- 'Global' turn delays (company prefers avoiding left turns)
- Directions (prohibiting)
- U-turns (prohibiting)
- Curb approach
- Barriers (construction, accidents)



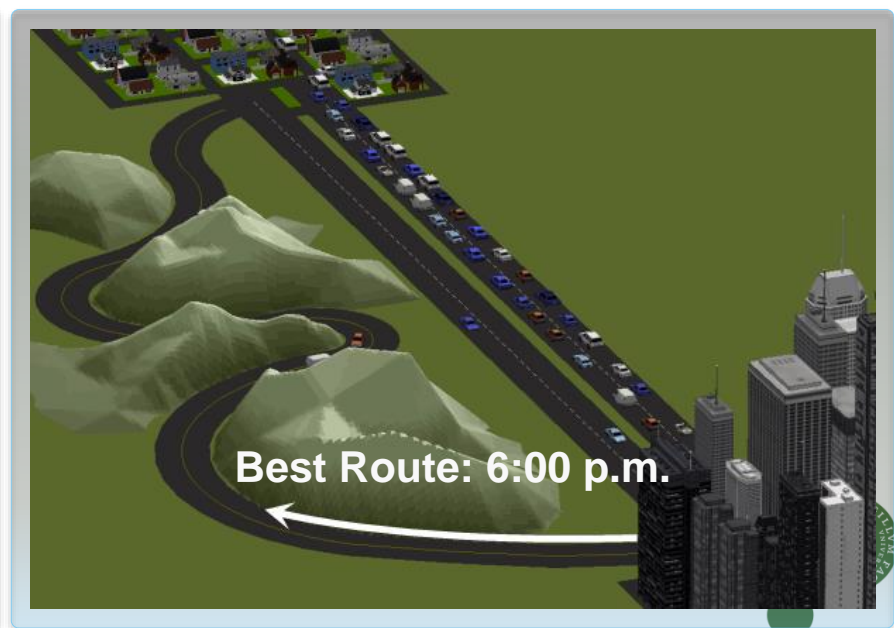
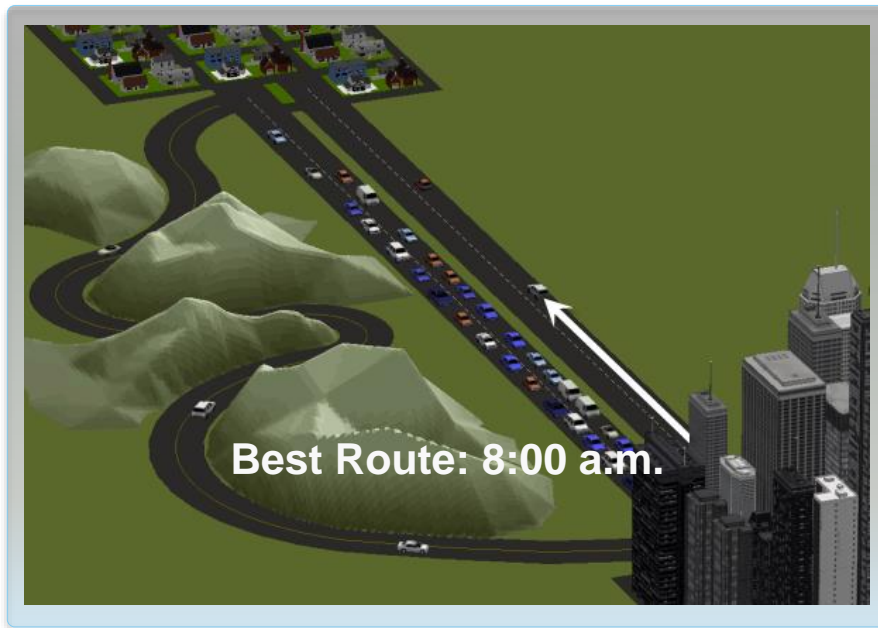
Cost of travel

- Properties
 - One-way street
 - Number of lanes in each direction
- Impedance
 - The costs by travelling through a network is usually expressed by travel distance or travel time
- The impedance is dependent on the direction of the travel

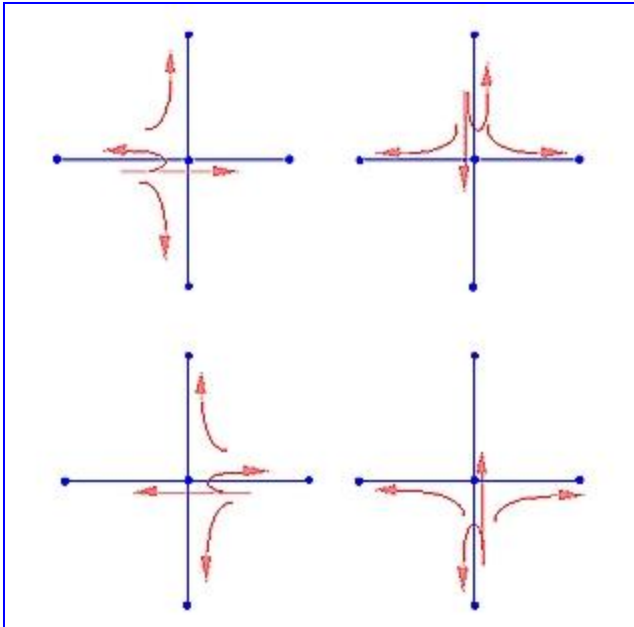


Cost Attributes

- Historical traffic
 - Find the best routes given expected traffic delays.
 - Get more accurate arrival times.



Turns



There exists 3 types of turns:

- Right turn
- Left turn
- U-turn

- Represent relationships for network connections
- Can influence the transport through a network (e.g. a right turn with oncoming traffic takes longer time than just driving straight ahead)
- Global Turn Delays
 - Global turns add a cost to every turn in the network.
 - Reduces the number of turn features you need to digitize.

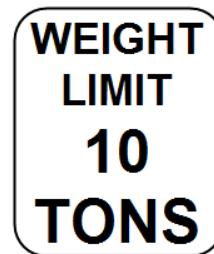
Restriction attributes

- Specify which edges, junctions, and turns that can't be traversed
 - One ways
 - Prohibited turns (no left turns, no U-turns)



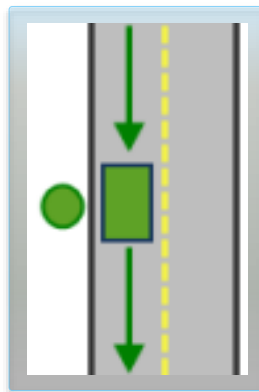
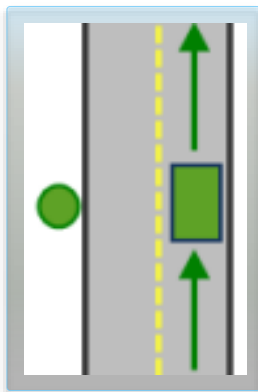
Restriction and Descriptor Attributes

- Restriction attributes can be derived from descriptor attributes and vehicle characteristics
 - Model height, weight, width limits



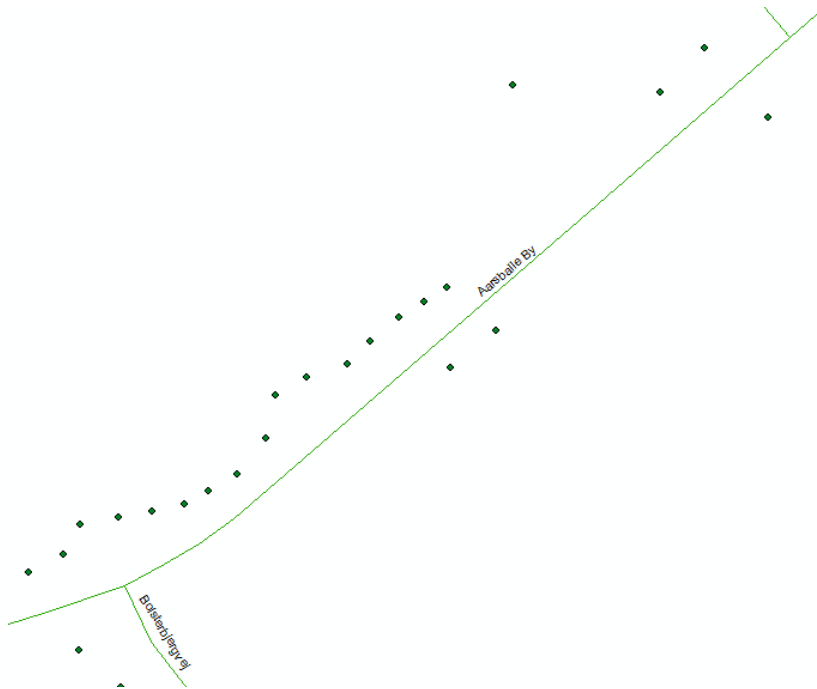
Curb Approach

- Curb approach ensures the vehicle arrives on and departs from a specific side of the road

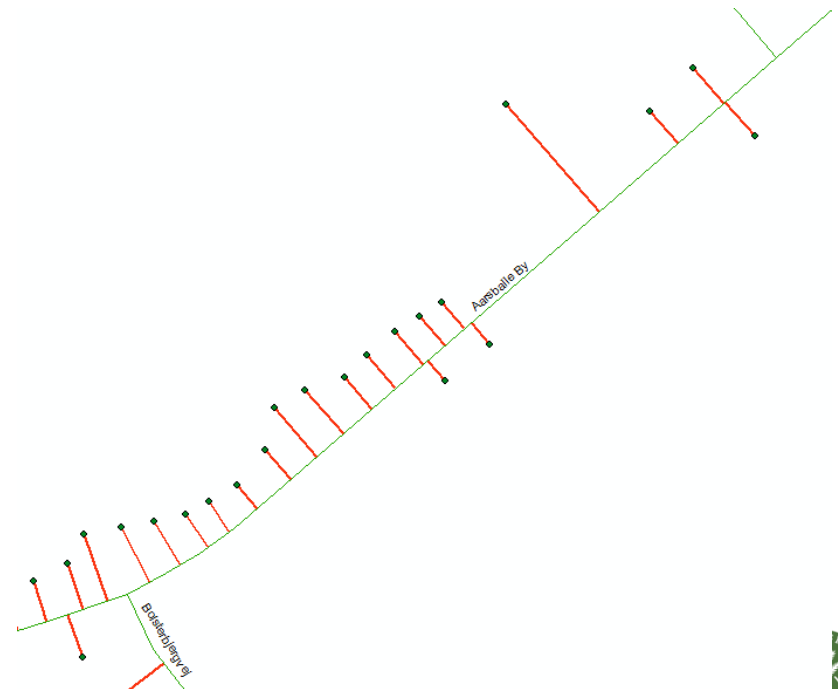


Connect address points to network

Addresses not connected to the network



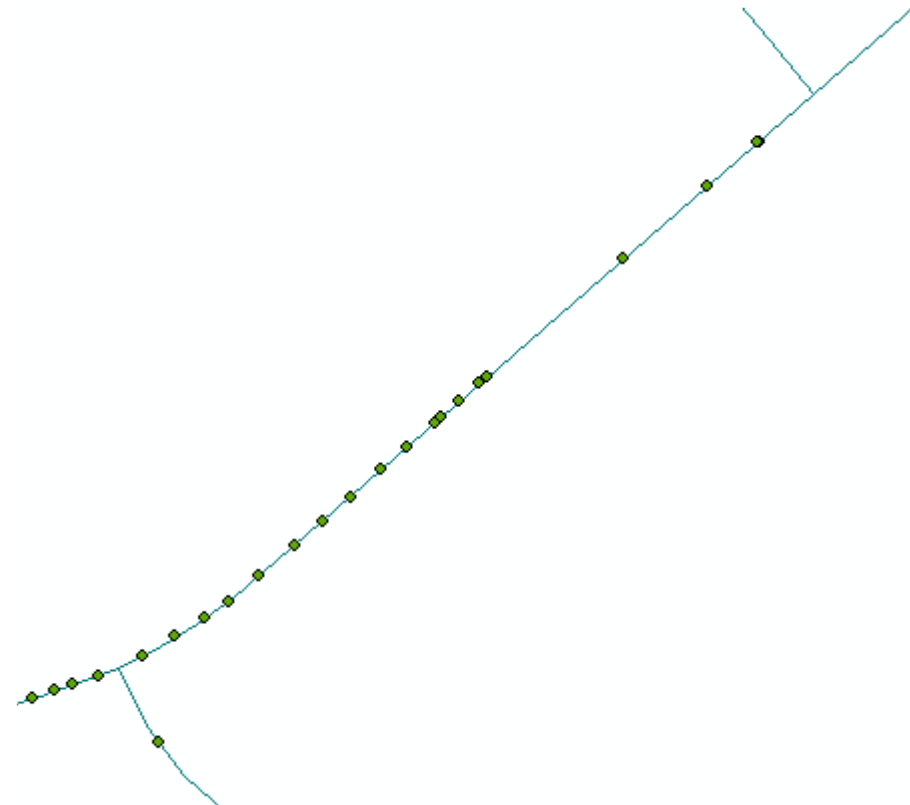
Addresses connected to the network by identifying the shortest distance from points to roads



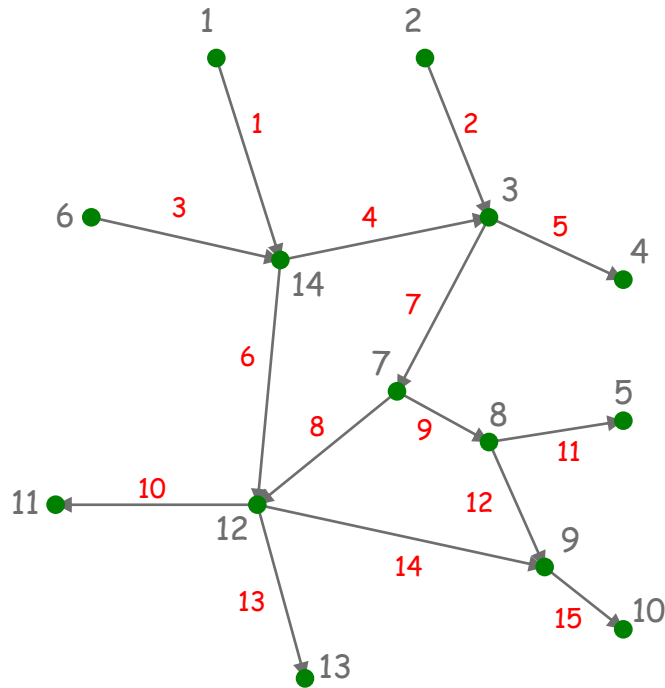
Connect address points to network

Alternatively snap the address' locations to nearest road edges

-> Use ArcGIS Snap tool



Network - datamodel



Network attribute table

LineID	FNODE	TNODE	Cost	ONE-WAY
1	1	14	90	B
2	2	3	85	B
3	6	14	110	B
4	14	3	75	FT

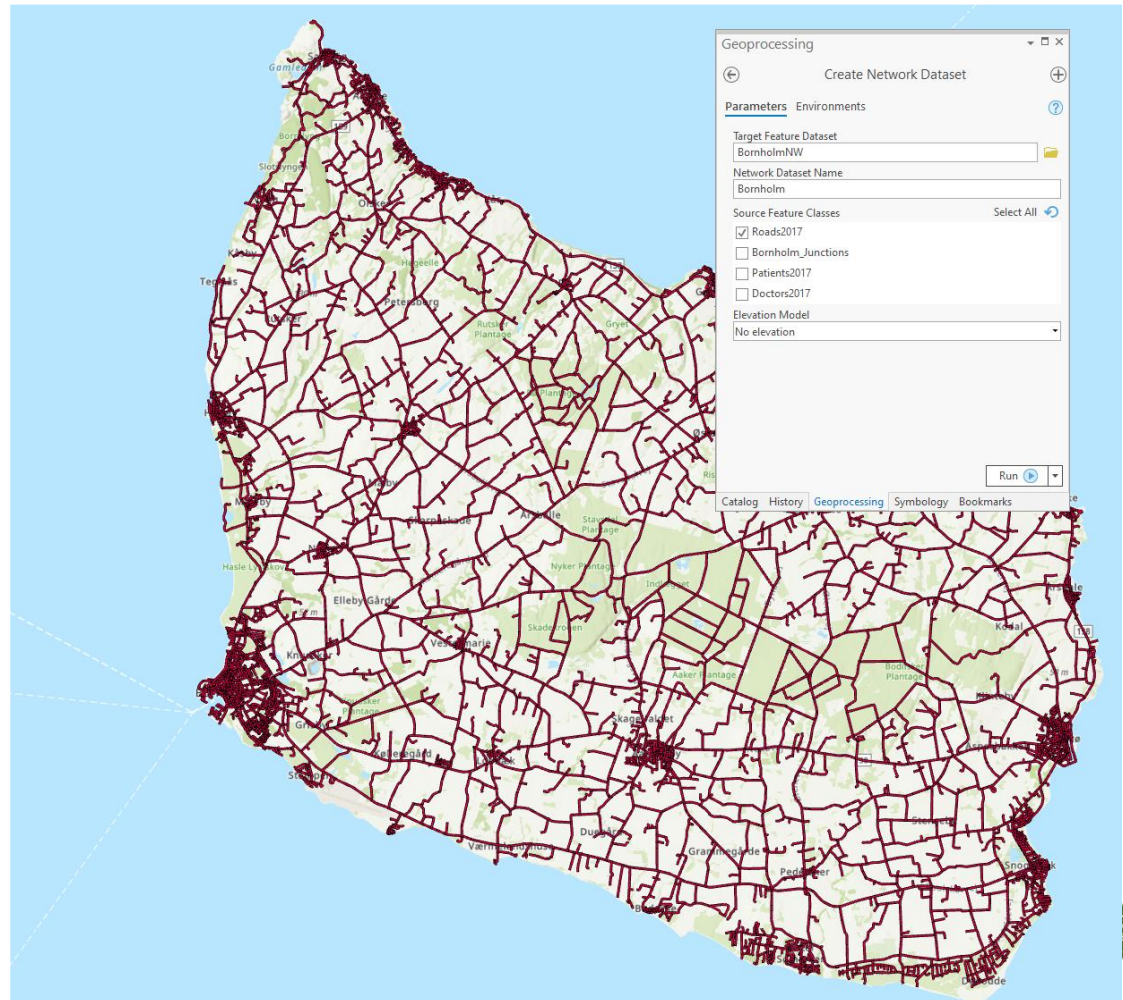
Turn table

Node	Arc1	Arc2	Cost
14	1	4	-1
7	7	8	23
9	14	15	34



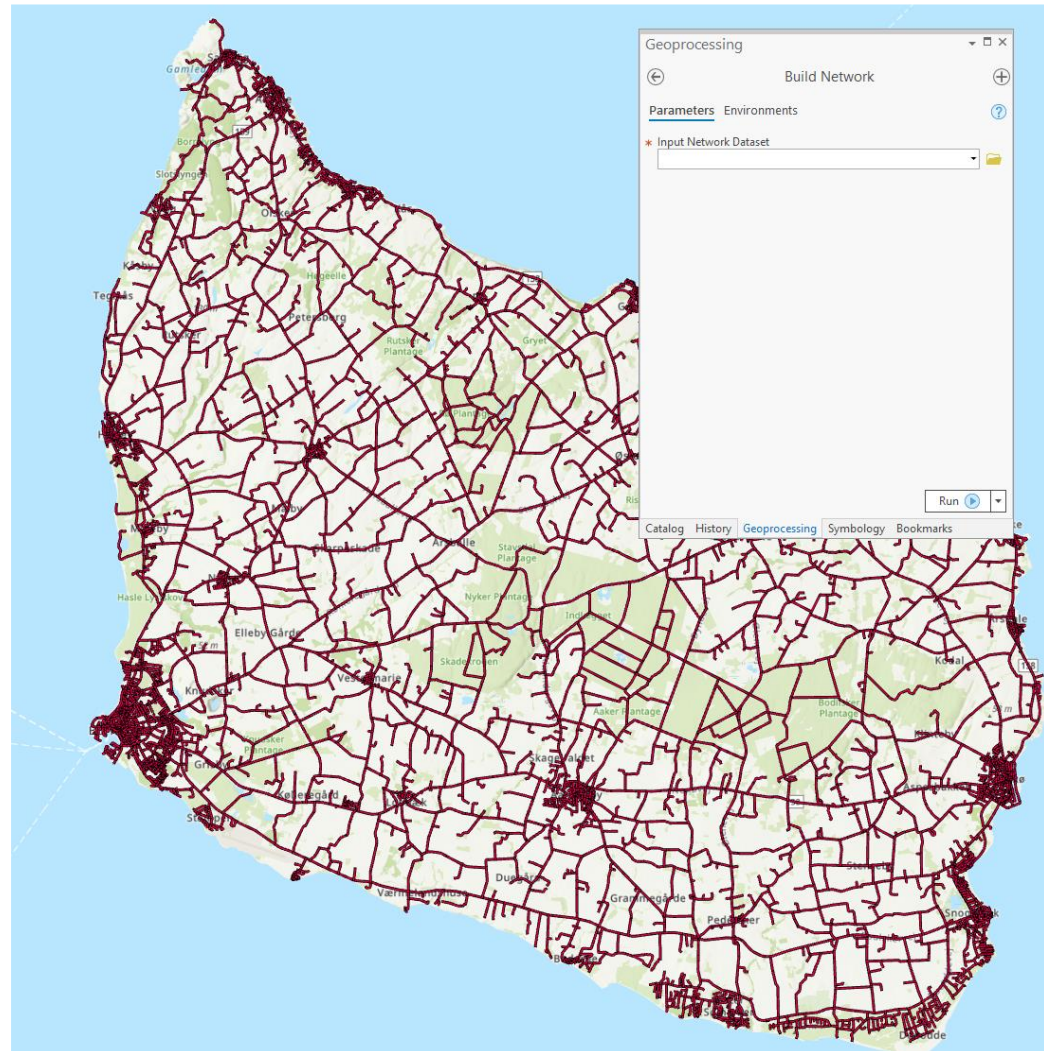
ArcGIS procedure: Create Network Dataset

Prepare the network's components and store them in a feature dataset

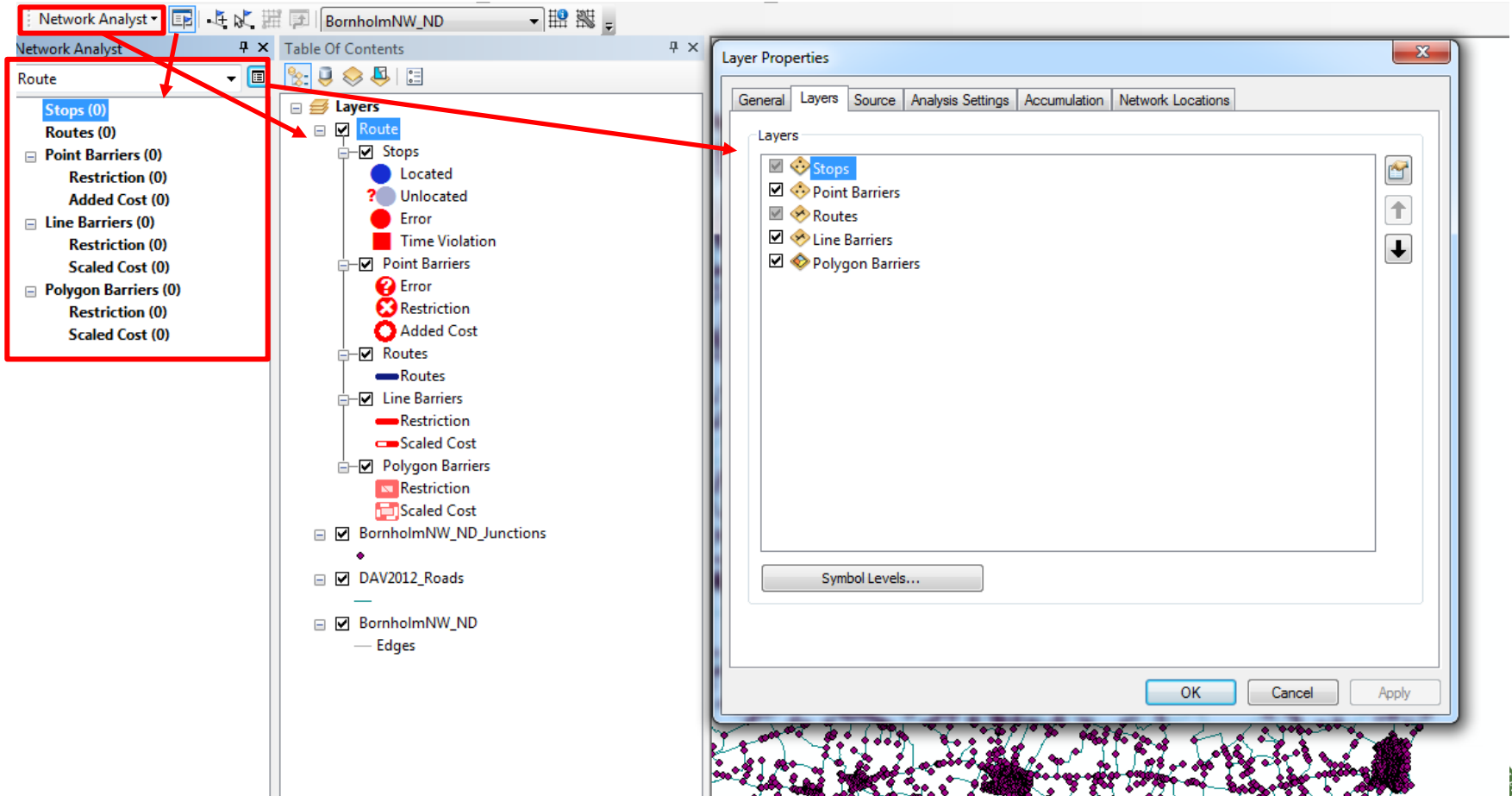


ArcGIS procedure: Build network

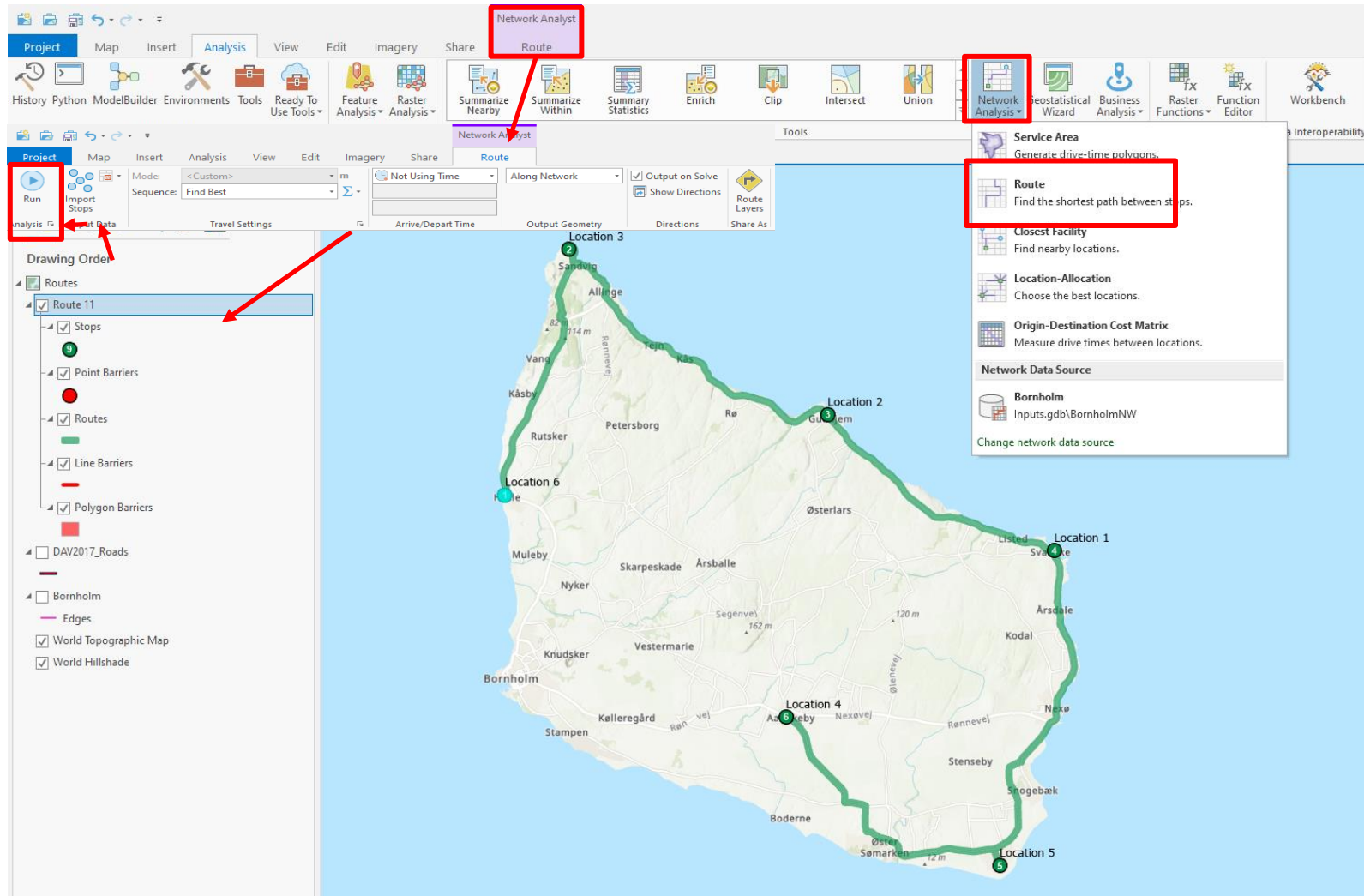
Build the network
from the feature
dataset's
components



ArcGIS procedure: Load stops

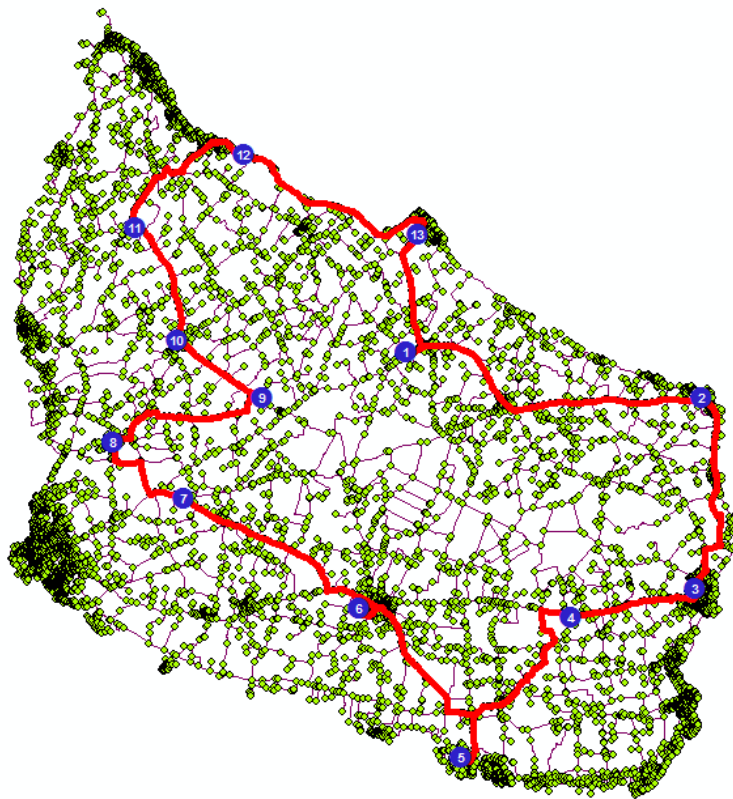


ArcGIS procedure: Line up the problem



Travelling Salesman's Problem

Driving directions



Directions (Route)		
[-] Route: Graphic Pick 13 - Graphic Pick 13		
	105 km	Map
1:	Start at Graphic Pick 13	Map
2:	Go southeast on Brommevej toward Skolevej	221 m Map
3:	Turn left on Stavsdalvej	468 m Map
4:	Continue on Nybrovej	3,2 km Map
5:	Continue on Godthåbsvej	1,7 km Map
6:	Continue on Svanekevej	5,3 km Map
7:	Continue on Østermarievej	2,4 km Map
8:	Continue on Storegade	385 m Map
9:	Bear right on Otto Holst Bakke	29 m Map
10:	Arrive at Graphic Pick 11, on the right	Map
11:	Depart Graphic Pick 11	
12:	Continue east on Otto Holst Bakke	56 m Map
13:	Bear right on Borberggade	41 m Map
14:	Turn right on Madvigsgade	40 m Map
15:	Continue on Svaneke Torv	58 m Map
16:	Continue on Postgade	51 m Map
17:	Turn right on Kirkebakken	113 m Map
18:	Turn left on Kirkepladsen	38 m Map
19:	Turn left to stay on Kirkepladsen	34 m Map
20:	Turn right on Sander Dichsgade and immediately turn left on Lille Plads	83 m Map
21:	Turn right on Lille Plads and immediately turn left on Hullebakke	71 m Map
22:	Continue on Søndergade	915 m Map
23:	Continue on Aarsdalevej	1,5 km Map
24:	Turn left on Strandvejen	596 m Map
25:	Continue on Gaden	547 m Map
26:	Turn left on Aarsdalevej	86 m Map
27:	Turn right on Sdr Aarsdalevej	2,6 km Map

Options...

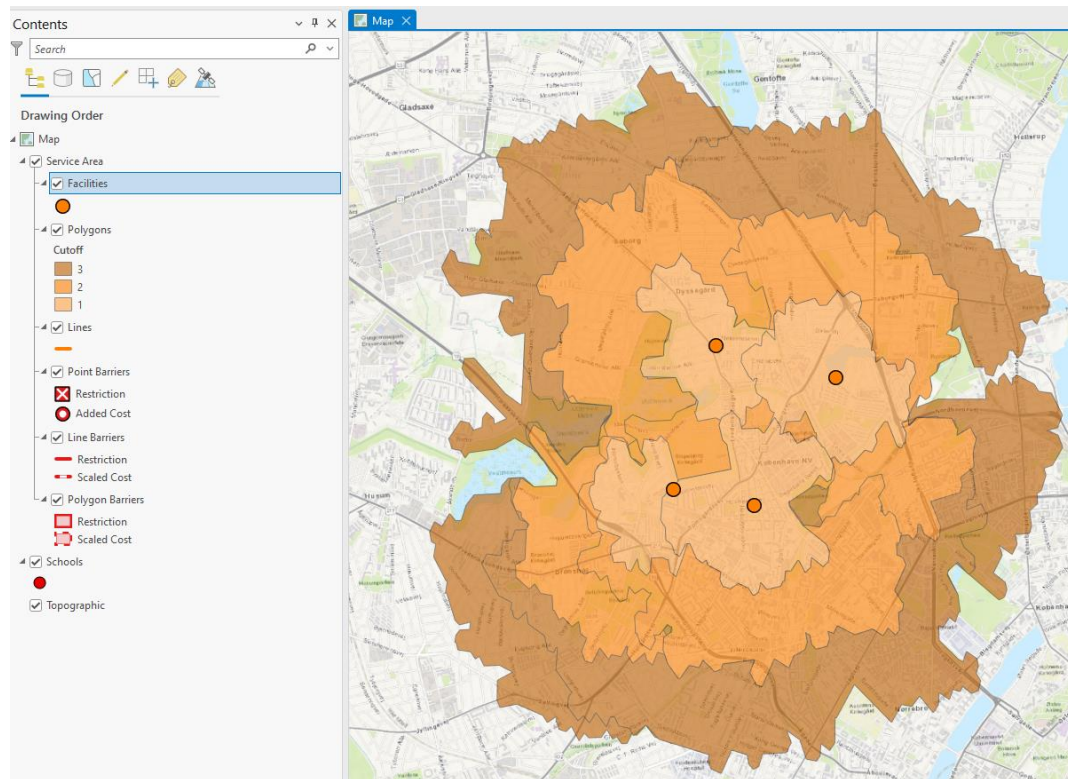
Print Preview...

Save As...

Print

Close

Service areas – school districts by travel time



Service areas:

Shows the areas within specific distances from one or more facilities.

Example: The service areas covered by 4 schools

Location - Allocation

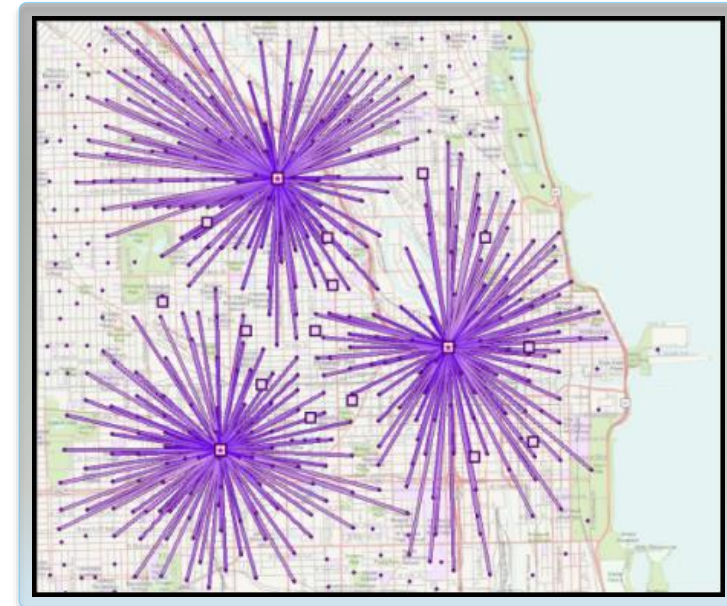
Which centres service a network?

Two criteria is applied in the allocation process:

Supply: The number of available resources in a centre.

Demand: The number of resources demanded in the nearby nodes.

Allocate works by allocating demand – usually to the nearest centre - until the demand corresponds to the supply of resources in the centre

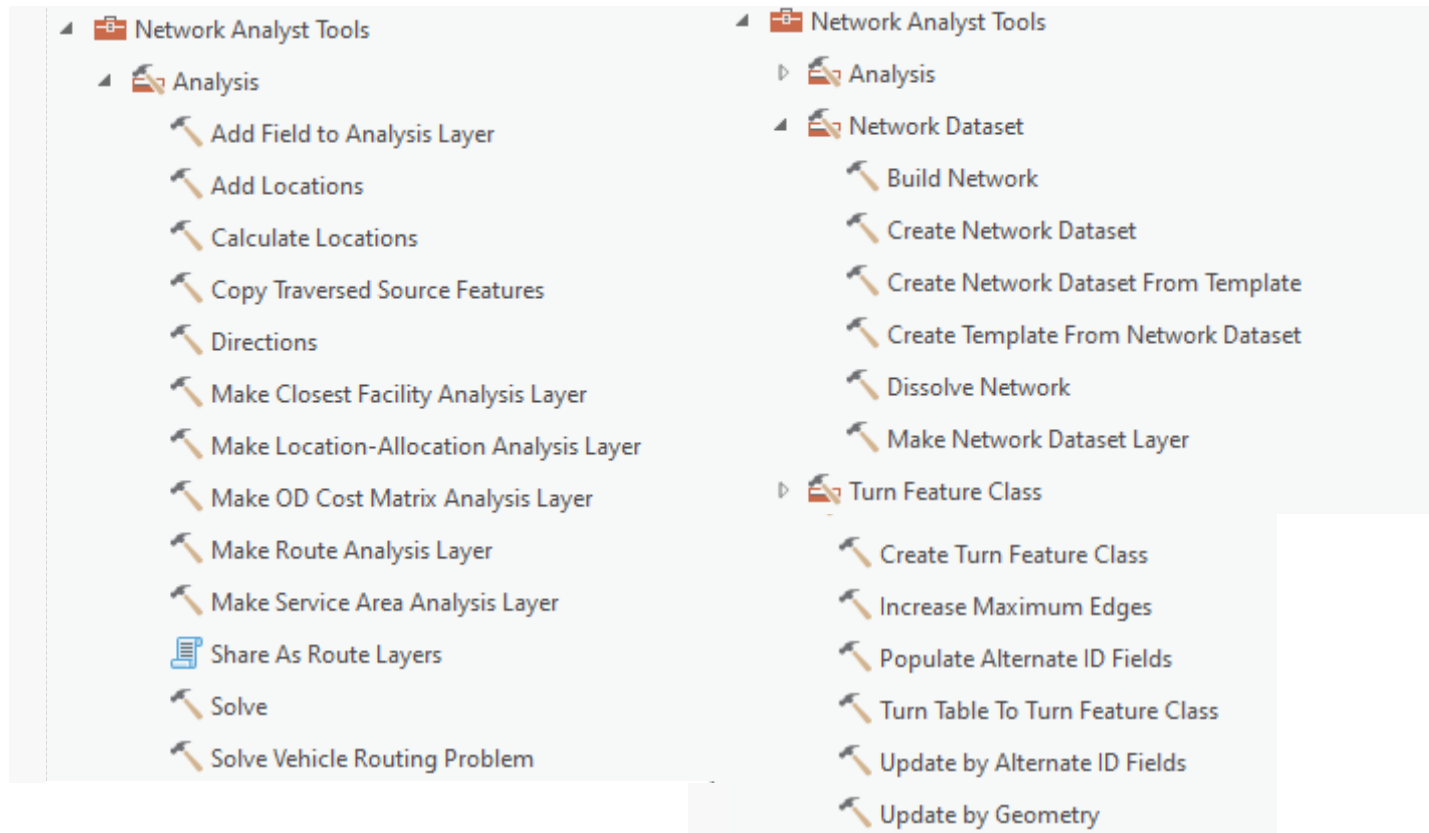


Example: A school (the centre) has a resource that is the available seats for pupils.

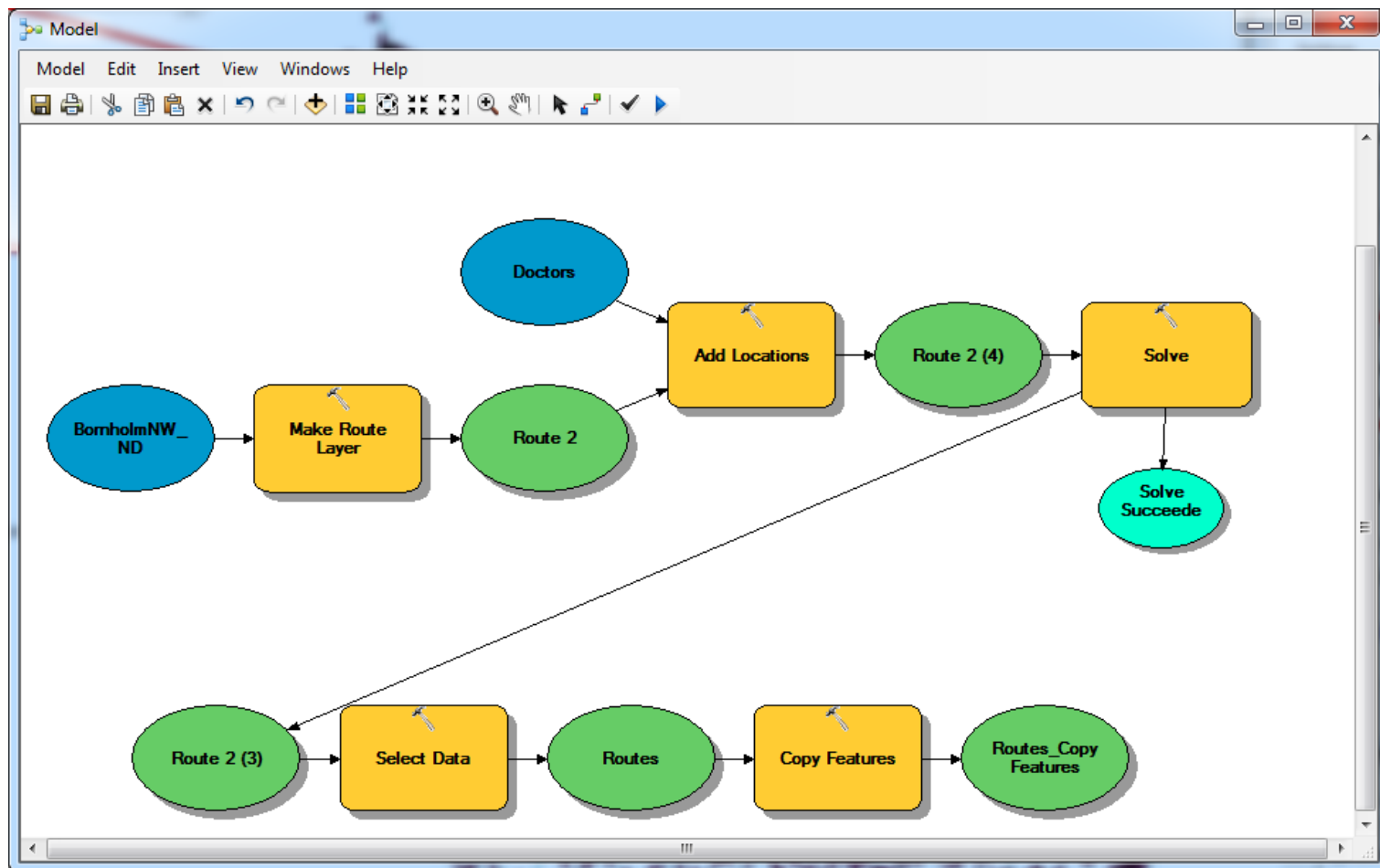
The number of pupils (nodes) makes up the demand.

Nodes are allocated to the schools via connections until the total number of pupils along all the connections is equal to the number of available seats.

ArcGIS geoprocessing environment for transportation networks



ArcGIS ModelBuilder workflow



ArcGIS – try more

Explore the Network Analyst Tutorial.

Search for **ArcGIS Pro network analyst tutorial:**

[Network Analyst tutorials—ArcGIS Pro | Documentation](#)

The screenshot shows the ArcGIS Pro web interface. The top navigation bar includes the Esri logo, links for Products, Solutions, Support & Services, News, and About, a search icon, and a Sign In button. Below this is a secondary navigation bar with links for Overview, Features, Resources, Free Trial, and a prominent Buy Now button. The main content area is titled 'Tutorial: Create routes' and includes a sub-header 'Available with Network Analyst license.' The tutorial text explains that routes represent the quickest or shortest path along roads to visit stops or point locations. A caution box states that using the tutorial with ArcGIS Online will consume credits. To the left is a sidebar with a list of tutorial topics, with 'Create routes' selected. To the right is a 'In this topic' section with links to various steps of the tutorial.

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Help / Analysis and geoprocessing / Network Analyst / Tutorials

Tutorial: Create routes

Available with Network Analyst license.

Routes represent the quickest or shortest path along roads to visit stops or point locations. They can be basic point-to-point routes visited in the order you specify or in the order that minimizes overall travel time or distance. A route is associated with a local network dataset or a network service hosted in ArcGIS Online or ArcGIS Enterprise. This tutorial first shows how to use a local network dataset and then shows how to use the online service.

Caution:
If you run the tutorial using ArcGIS Online, [credits](#) will be consumed.

Get the data

The data for this tutorial is available for download.

- 1 Go to the [data download page](#).
- 2 Click the **Download** button, and save the file locally.
- 3 Unzip the downloaded file.

In this topic

- [Get the data](#)
- [Create a map](#)
- [Add the tutorial data to the project](#)
- [Create the route layer](#)
- [Create stops](#)
- [Run the analysis](#)
- [Create a barrier](#)
- [Generate directions](#)
- [Route using ArcGIS Online](#)

Get started

Network datasets

Network analysis

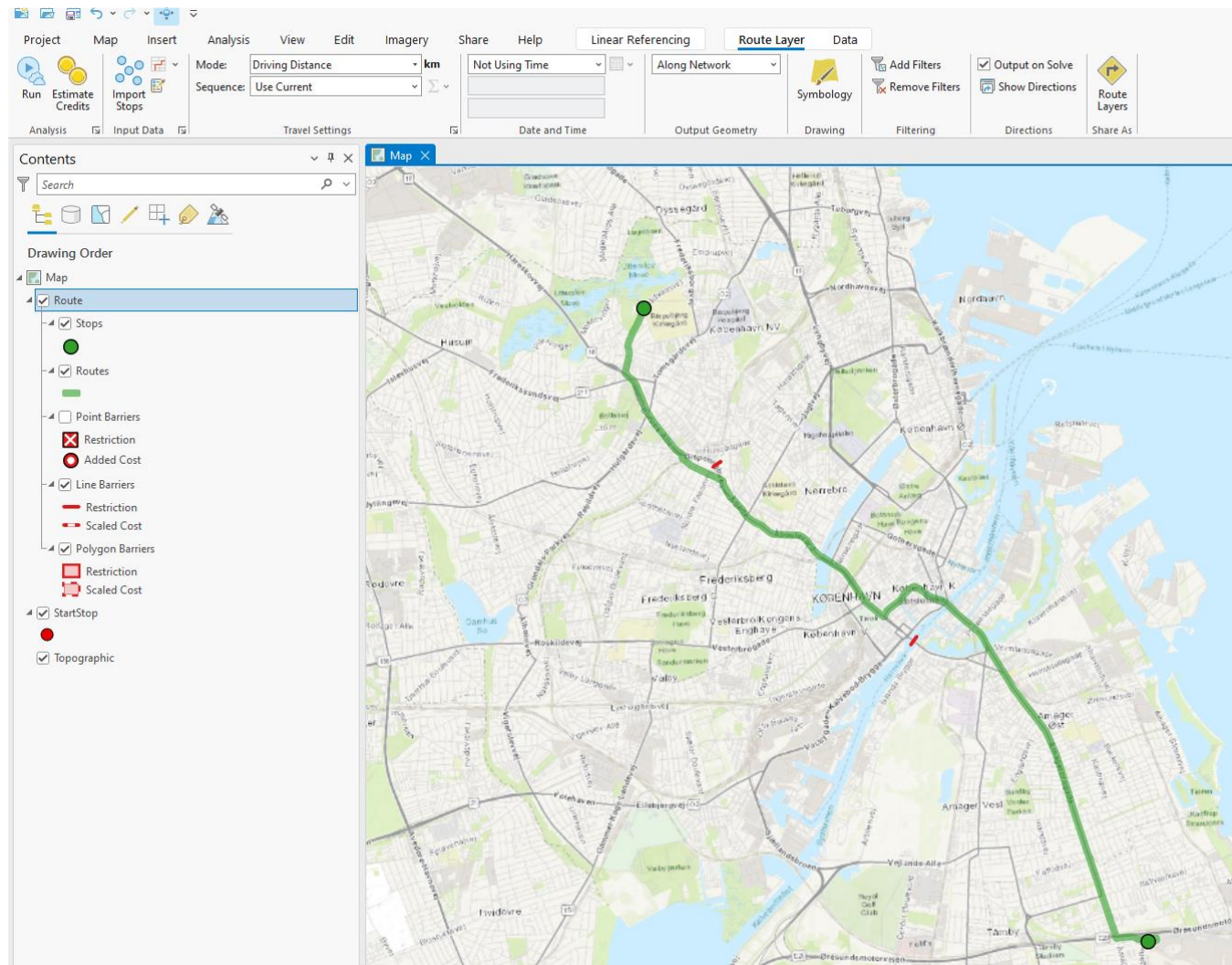
Routing Services

Tutorials

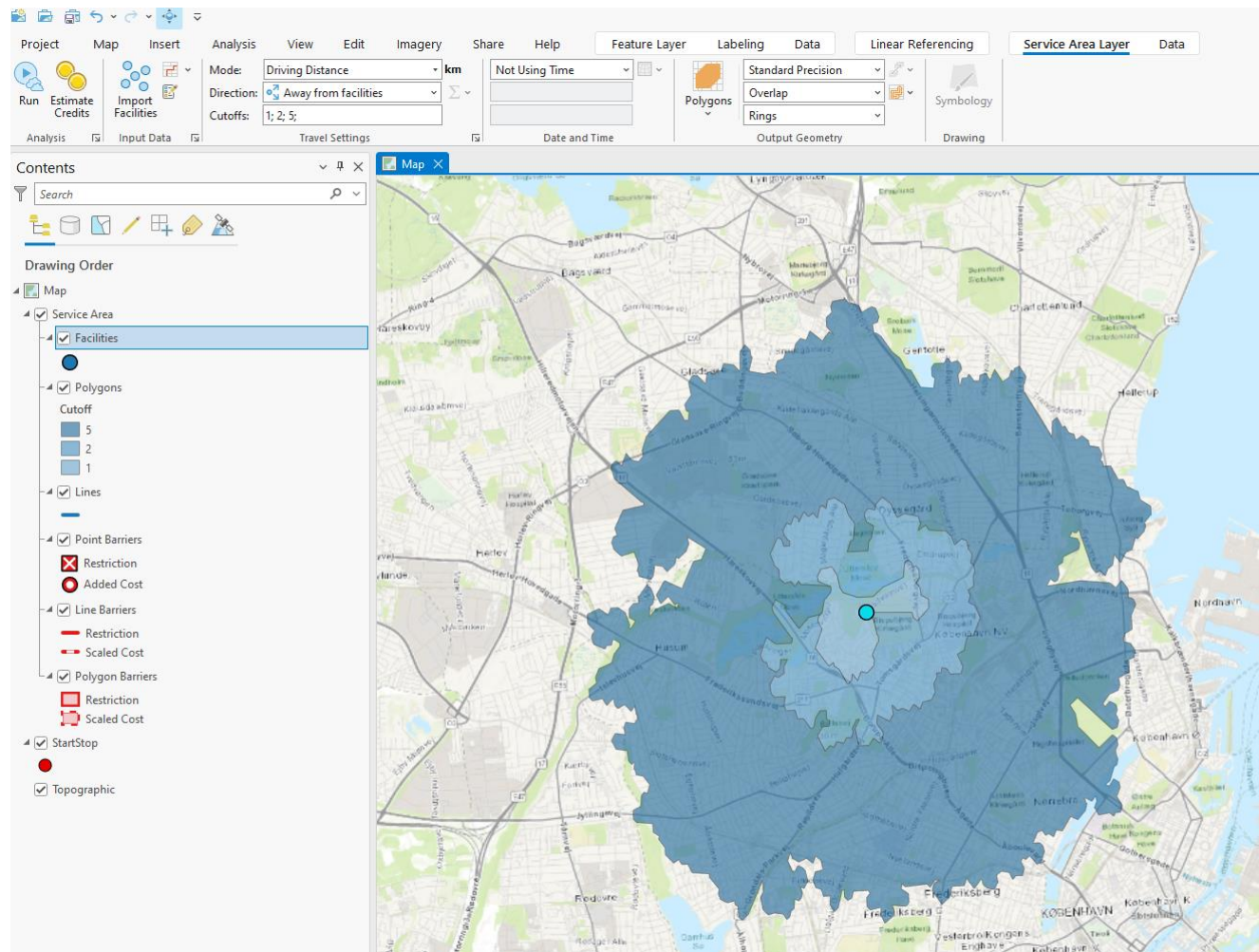
- Closest Facility
- Create a model for route analysis
- Create a network dataset
- Create and use a network dataset with public transit data
- Create routes**
- Create service areas
- Generate Origin Destination Cost Matrix
- Location Allocation



Network Analysis in ArcGIS Online – Find Routes



Network Analysis in ArcGIS Online – service areas



Online shortest path services right now – Google Maps

← → ↺ google.com/maps/dir/Støvns+Allé+43,+2400+København/Kastrups+flygplats,+Lufthavnsboulevarden,+Kastrup/@55.6474121,12.8329241,12z/data=!4m13!4m12!1m5!1m1!1

☰ ✕

○ Støvns Allé 43, 2400 København

○ København Lufthavn

⊕ Tilføj destination

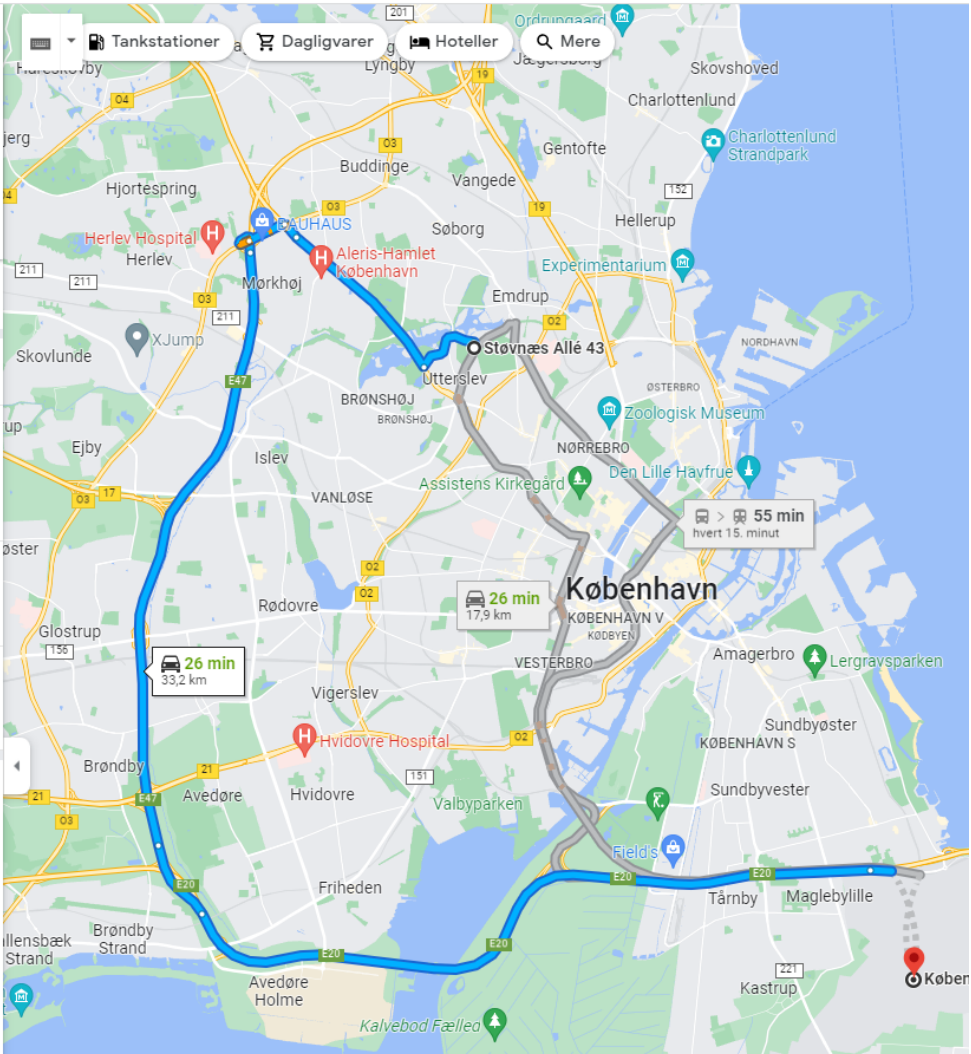
Tag af sted nu Valgmuligheder

Send rutevejledning til din telefon

via E47 og E20	26 min
Hurtigste rute, normal trafik	33,2 km
Detaljer	
via E20	26 min
	17,9 km
10.34-11.29	55 min
> 6A > 029	

Udforsk Københavns Lufthavn

Restoranter Hoteller Tankstationer Parkeringspladser Mere



Online shortest path services, rush hour prediction

Google Maps

