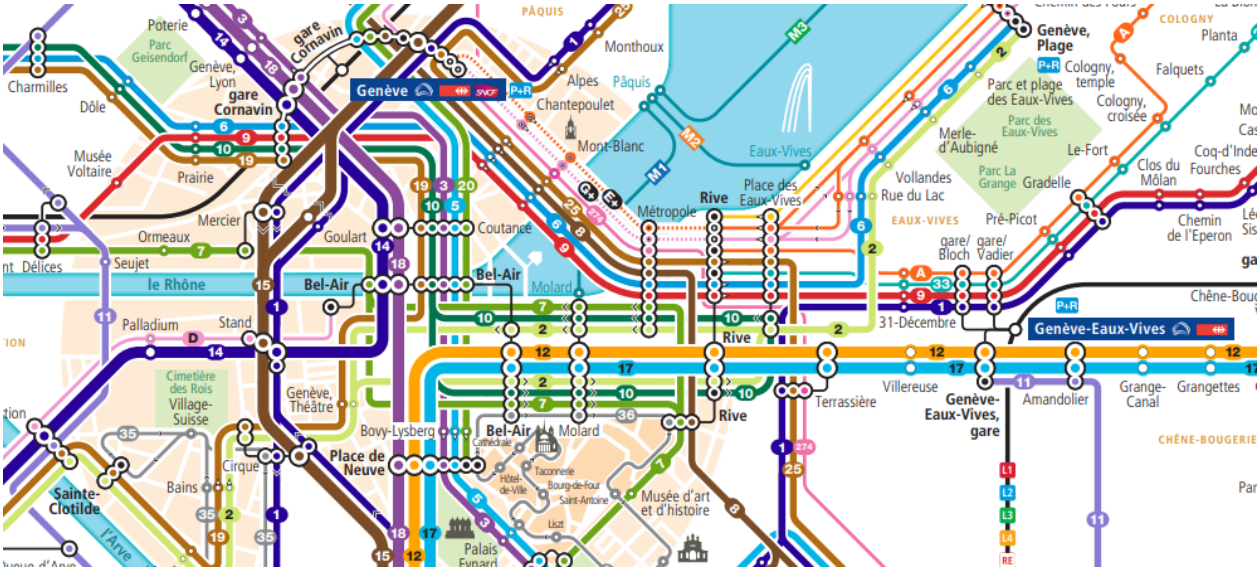
Assignment 1:

Network Structure Analysis



Important dates:

- Network selected by **Wednesday, 3rd May**
- Upload network indicators on BrightSpace by **Monday, 8th May**
- Submit written report by **Monday, 15th May**

For any questions concerning this assignment, please contact the responsible Teaching Assistant: Nejc Geržinič at n.gerzinic@tudelft.nl

Purpose:

To learn how to systematically analyse public transport networks and interpret network indicators for different network representations.

The case study involves representing a public transport network in different network representations in the form of graphs and analysing them. Through this, you will obtain various network indicators, discuss the network characteristics and evaluate how your chosen network performs with respect to other networks.

General instructions:

Each group, consisting of two students, should **choose a public transport system** that will be used as your case study. You should choose a public transport network from the list in Appendix A. Networks are assigned on the basis of first-come-first-served on BrightSpace**. Please enrol via the header "Groups", and not "Group Self Enrolment".**

Each group and the respective network are assigned to a category / thread. Other networks in your thread serve as your peer networks (see Step 5 below), against which you benchmark the performance of your own chosen network.

Guidelines:

Step 1: Select your preferred transport network to analyse

Select a network from the list of available networks.

Step 2: Construct your case study graph

Import the GTFS data and use the provided code to construct your network. Take note of the choices you make when constructing the network and explain your reasoning.

To help you with setting up the environment and importing the network, we provide a video tutorial.

Step 3: Generate and interpret network indicators

Investigate **global network indicators** for both L- space & P-space network representations and summarise them in table format:

- ***Number of nodes***
- ***Number of links***
- ***Diameter***
- ***Average shortest path (ASP)***
- ***Connectivity*** (gamma index)
- ***Meshedness*** (alpha index)

Investigate **local network indicators** for both L- space & P-space network representations:

- **Degree** centrality
- **Closeness** centrality
- **Betweenness** centrality (relative)

For each local network indicator, report:

- Average value, Standard deviation, Minimum, Maximum and Top 3 nodes (value and label)
- Plot a **histogram**
- Display the values in a **map**

Use the NetworkX python library to assist you in computing the necessary network indicators.

Barthelemy (2010) provides a highly useful summary of spatial network representation and related indicators.

Step 4: Analyse your network's circuity

Circuity (or detour) is defined as the ratio between the distance travelled over the network and the Eucledian distance. Findings suggest that circuity has an impact on travel behaviour, where routes with higher circuity are likely to have a lower share of public transport trips.

Calculate the average circuity for each node in your network. You may assume all destination nodes to be equally important and the shortest route between each node pair for the actually travelled distance. **Plot a histogram** for circuity and **display** the calculated values on the **map**.

Dixit et al. (2021) present an analysis of circuity for the Amsterdam public transport network and the related impacts from an equity perspective.

Step 5: Share and compare

On BrightSpace, each group is assigned to a thread of similar peer networks. Find your corresponding thread on the discussion page on BrightSpace and upload the indicators you obtained (from *Steps 3 and 4*) into the provided Google Sheets document. **You should do this by Monday, 8th May**!

Step 6: Discussion and report

Submit a concise report addressing carefully the following guidelines. The report should consist of the following chapters:

- **Introduction:**
  Describe the context and objectives of your assignment.
- **Methodology:**
  Outline the sequence of steps you undertook in performing your analysis.
- **Case study:**
  Introduce your selected network. Mention any assumptions you may have made when constructing the graph.
- **Results and discussion:**
  A. Report network indicators and centrality indicators for your network (*Step 3*)
  B. Explain what kind of information the different indicators convey in the different network representations (L-space and P-space).
  C. **Group member 1**:
  Discuss the network structure and centrality distribution in comparison to your peer networks (in the same thread).
  D. Report the results of the circuity analysis (*Step 4*)
  E. **Group member 2**:
  Discuss the results you obtained in (D). What trends do you observe in your network and the networks of your peers? Relate your findings and conclusions to those of Dixit et al. (2021)
  F. Reflect on the analysis you carried out (L-space, P-space and Circuity analysis). How have your modelling decisions impacted the results you obtained? In what way would the results be different if you made different modelling choices?

When submitting your report, attach also the network files (your *Network.csv* file).

Grading:

The grade of this assignment is based on the quality of the **content (Parts A-F)** and the **report** itself. The **report grade** is based on how the information and results are presented, structured, are they clearly readable, the use of scientific language etc. Two parts of the report (C and E) should be done by the two students **individually** (each student completes one of the two parts). Additionally, for the group choosing one of the 7 "Large networks", a 5% bonus is added to account for the extra work and complexity associated with analysing those networks. The final grade of each student is done as follows:

	Student 1	Student 2
Part A	10%	10%
Part B	20%	20%
Part C	20%	-
Part D	10%	10%
Part E	-	20%
Part F	20%	20%
Report grade	20%	20%
Large network bonus	5%	5%

Appendix A – List of public transport systems to choose from

In some cases the city may contain information on several modes. In the table below, the mode of interest is indicated. Additionally, 7 larger and more complex networks are also indicated.

Group number	City / Region	Mode of interest	Large network
1	Amsterdam	metro	
2	Athens	metro	
3	Atlanta	metro	
4	Berlin	metro	X
5	Brussels	metro	
6	Budapest	metro	
7	Buenos Aires	metro	
8	Chicago	metro	
9	Copenhagen	metro	
10	Hyderabad	metro	
11	Lille	metro	
12	Lisbon	metro	
13	London	metro	X
14	Lyon	metro	
15	Madrid	metro	X
16	Marseille	metro	
17	Milan	metro	
18	Montreal	metro	
19	Naples	metro	
20	New York	metro	X
21	Nuremberg	metro	
22	Oslo	metro	
23	Paris	metro	X
24	Philadelphia	metro	
25	Prague	metro	
26	Rotterdam	metro	
27	Santiago	metro	
28	Stockholm	metro	
29	Toronto	metro	
30	Valencia	metro	

31	Vancouver	metro	
32	Vienna	metro	
33	Washington	metro	
34	Berlin	S-bahn	
35	Bern	S-bahn	
36	Brussels	RER	
37	Copenhagen	S-tog	
38	Hannover	S-bahn	
39	Sydney	suburban trains	
40	Basel	tram	
41	Bremen	tram	
42	Freiburg	tram	
43	Gdansk	tram	
44	Helsinki	tram	X
45	Krakow	tram	
46	Mannheim	tram	
47	Montpellier	tram	
48	Oslo	tram	
49	Prague	tram	X
50	Strasbourg	tram	
51	Toronto	tram	
52	Zagreb	tram	
53	Zurich	tram	
54	Salzburg	trolleybus	