Aalto-yliopisto
Perustieteiden
korkeakoulu

Symmetric optimum requirement graphs for grids (topic presentation)

Inka Hirvinen

07.03.2024

Advisor: *Philine Schiewe*

Supervisor: *Philine Schiewe*

Systeemianalyysin
laboratorio

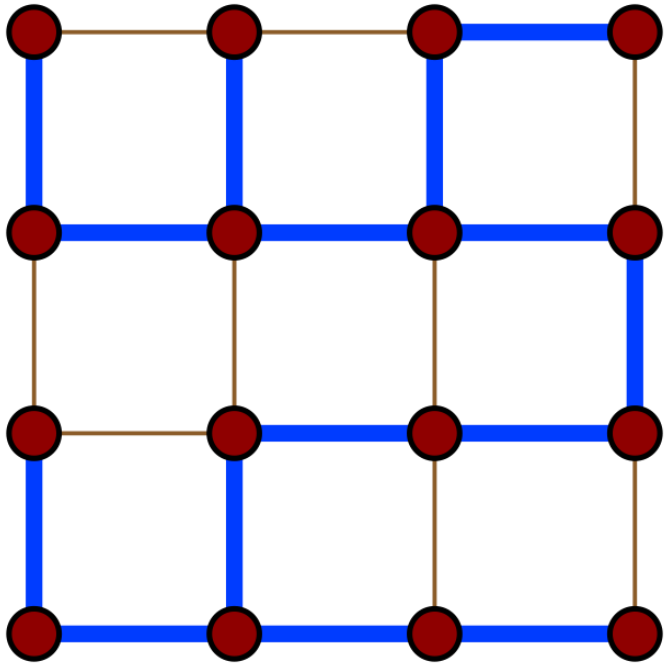
Table of Contents

LinTim

- LinTim is a software toolbox for solving various public transportation planning steps
  - Line planning
  - Passenger assignment
  - Timetabling
- The model will be implemented in LinTim

Generalized optimum requirement graph

- Spanning graphs
- Routing costs
  - sum of all shortest paths weighted by the demands



D. Eppstein, 2007, “4x4 grid spanning tree”, Wikimedia Commons, https://commons.wikimedia.org/wiki/File:4x4_grid_spanning_tree.svg?uselang=en#Licensing (Accessed 27.2.2024)

Generalized optimum requirement graph

- The problem is to find a spanning subgraph H of a given weighted graph G, which minimizes the routing costs of all spanning subgraphs that have building costs at most K
  - Both demand and cost can take on arbitrary non-negative values

IP formulation (GORG)

$$\min \sum_{s<t\in V} \sum_{uv\in E} a_{u,v} c(uv)(y_{uv}^{st} + y_{vu}^{st})$$

$$s.t. \sum_{e\in E} c(e)x_e \leq K$$

$$\sum_{w\in V:wu\in E} (y_{wu}^{st} + y_{uw}^{st}) -$$

$$\sum_{w\in V:uw\in E} (y_{uw}^{st} + y_{wu}^{st}) = \begin{cases} -1; & u = s \\ 1; & u = t \\ 0; & else \end{cases} \quad s < t\epsilon V, u\epsilon V$$

$$y_{uv}^{st} \leq x_{uv} \quad s < t \in V, uv \in E$$

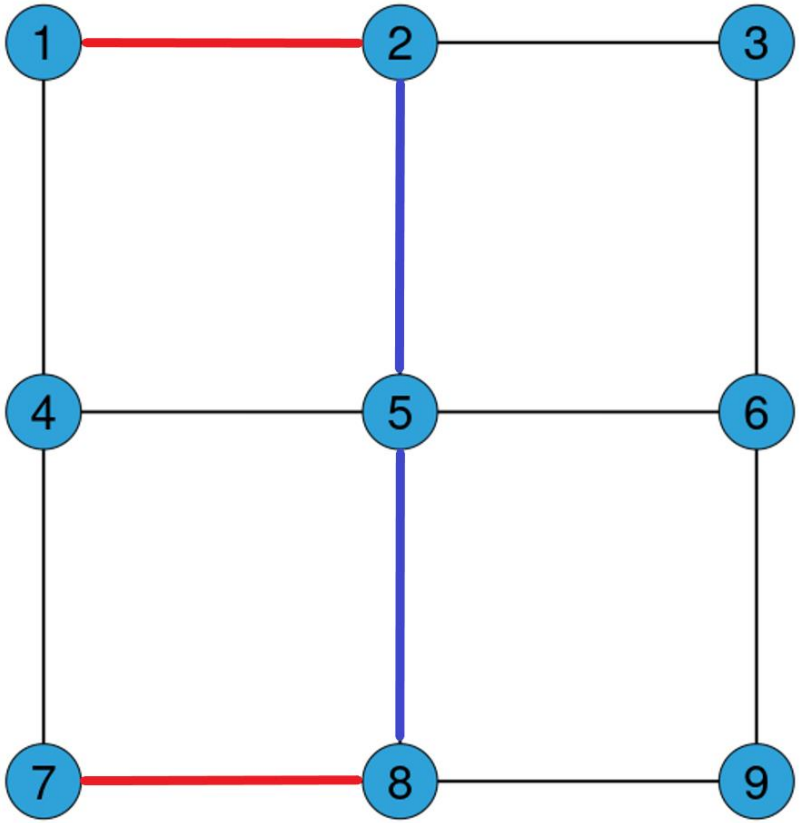
$$y_{vu}^{st} \leq x_{uv} \quad s < t \in V, uv \in E$$

$$x_e \epsilon \{0,1\} \quad e\epsilon E$$

$$y_{uv}^{st}, y_{vu}^{st} \epsilon \{0,1\} \quad s < t\epsilon V, uv\epsilon E$$

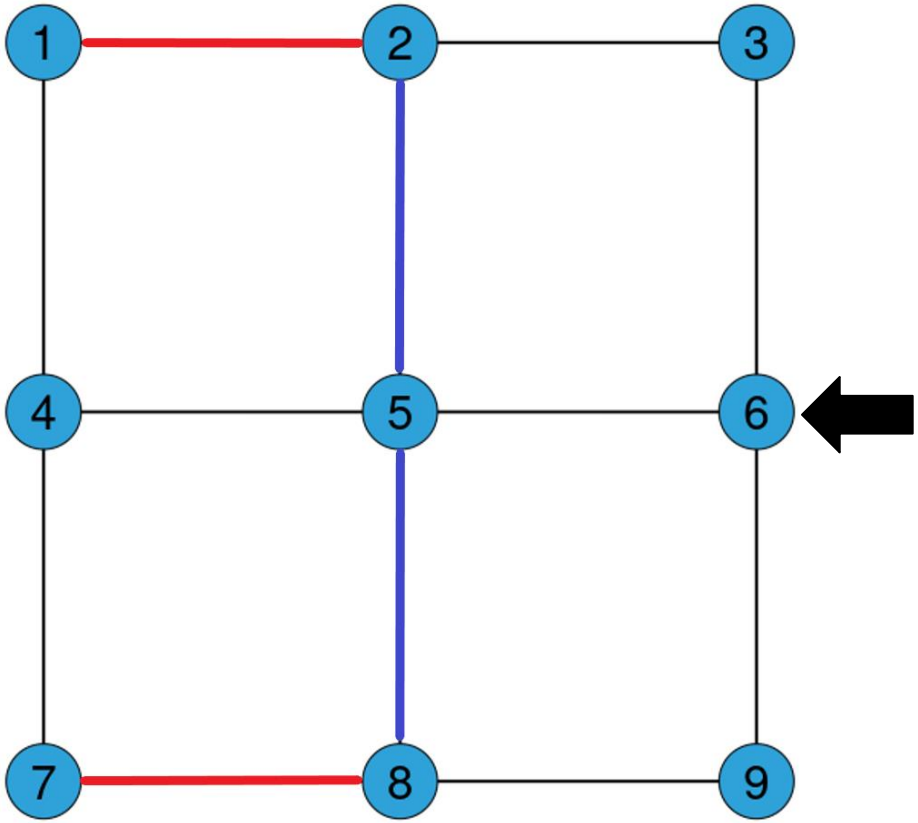
Symmetric optimum requirement graph

- The LinTim implementation will be focusing on 3x3 grids for now
- The objective is to find a symmetric spanning subgraph for the grid graph



Symmetric optimum requirement graph

- Horizontal symmetry on the 3x3 grid graph:



Implementation

- Model will be implemented in LinTim
  - LinTim Python functionality
  - Solver: Gurobi
- Computational experiments:
  - Testing the effect of the value of K on the solution

Schedule

- Building the LinTim implementation 2/2024-3/2024
- Presenting thesis subject 3/2024
- Writing thesis 3/2024-4/2024
- Thesis ready 4/2024

References and Literature

- Heinrich, I., Herrala, O., Schiewe, P., Terho T., (2023). Using Light Spanning Graphs for Passenger Assignment in Public Transport. In 23rd Symposium on Algorithmic Approaches for Transportation Modelling, Optimization, and Systems (ATMOS 2023). Open Access Series in Informatics (OASIcs), Volume 115, pp. 2:1-2:16, Schloss Dagstuhl - Leibniz-Zentrum für Informatik
- LinTim: https://lintim.net/