Prof. Dr. Rüdiger Ehlers Francisco Palau, M.Sc.

Applied Computational Engines 2018 – Assignment Sheet 6

Due: **Monday, 28th May 2018, 7:30am**, 7:30 am

Please indicate your **name** and **email address**. You can work in **groups** of up to **three** students. Only one submission per group is necessary. However, in the tutorials every group member must be able to present the solutions to each problem solved by your group.

Please submit your solutions either

- by e-mail to `fpalau@uni-bremen.de` **and** `rehlers@uni-bremen.de`, or
- on paper in **letter box 52** (Francisco Palau-Romero) on floor 6 of the MZH building.

Note that you will need 50% of the points on all exercise sheets in order to take the "Fachgespräch" OR the oral exam. We may ask you to present your solutions in the tutorial, especially if you work in a group. We aim for asking everyone taking part in the course to present at least twice during the course of the semester.

Sorting networks (25 pts.)

Does the sorting network in Figure 1 sort all six-tuples with values from the domain {**false**, **true**} correctly?

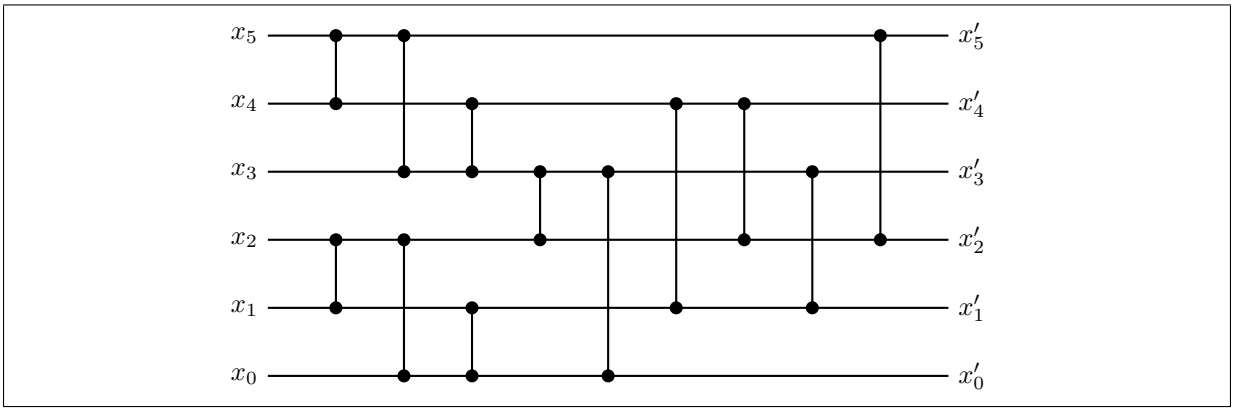

Figure 1: A sorting network.

Describe informally how you construct a SAT formula that checks this and build such a SAT instance. You can do so either by hand, or write a small program to generate the SAT instance.

Pseudo-boolean constraint solving (25 pts.)

Model the following problem as a pseudo-boolean constraint system, and solve it using a pseudo-boolean constraint solving tool.

We need to build an energy transportation network that delivers clean renewable energy from the north of the country depicted in Figure 2 to the south. For this purpose, all the cities marked in Figure 2 need to be connected by a network (a *spanning tree*) of electricity lines. Every possible connection between two cities is marked in the figure with its corresponding cost. **Derive a selection of connections that minimizes the cost of the overall network**.

Due to political constraints, it is not possible to build more than 3 connections in any of the country's states on the map except for one of them. Which one of the states is the "relaxed one" should be the choice of the constraint solver. Connections that span more than one state count for all of them. For the state in the south east of the country (that is colored differently), due to political constraints, it is only possible to build 2 connections in the state, so that this state cannot be the "relaxed one".

Important Note: A subgraph of a graph is a spanning tree if and only if for all *cuts* through the graph, at least one of the edges in the cut is part of the subgraph, and no edge can be removed from the subgraph without losing this property. A list of cuts through the graph in Figure 2 can be obtained from `http://motesy.cs.uni-bremen.de/ace2018s/data/`. Without using this list of cuts, the problem is quite difficult to solve. Also note that there is no need for programming in this exercise – instead, the "search and replace" function of your text editor may be helpful.

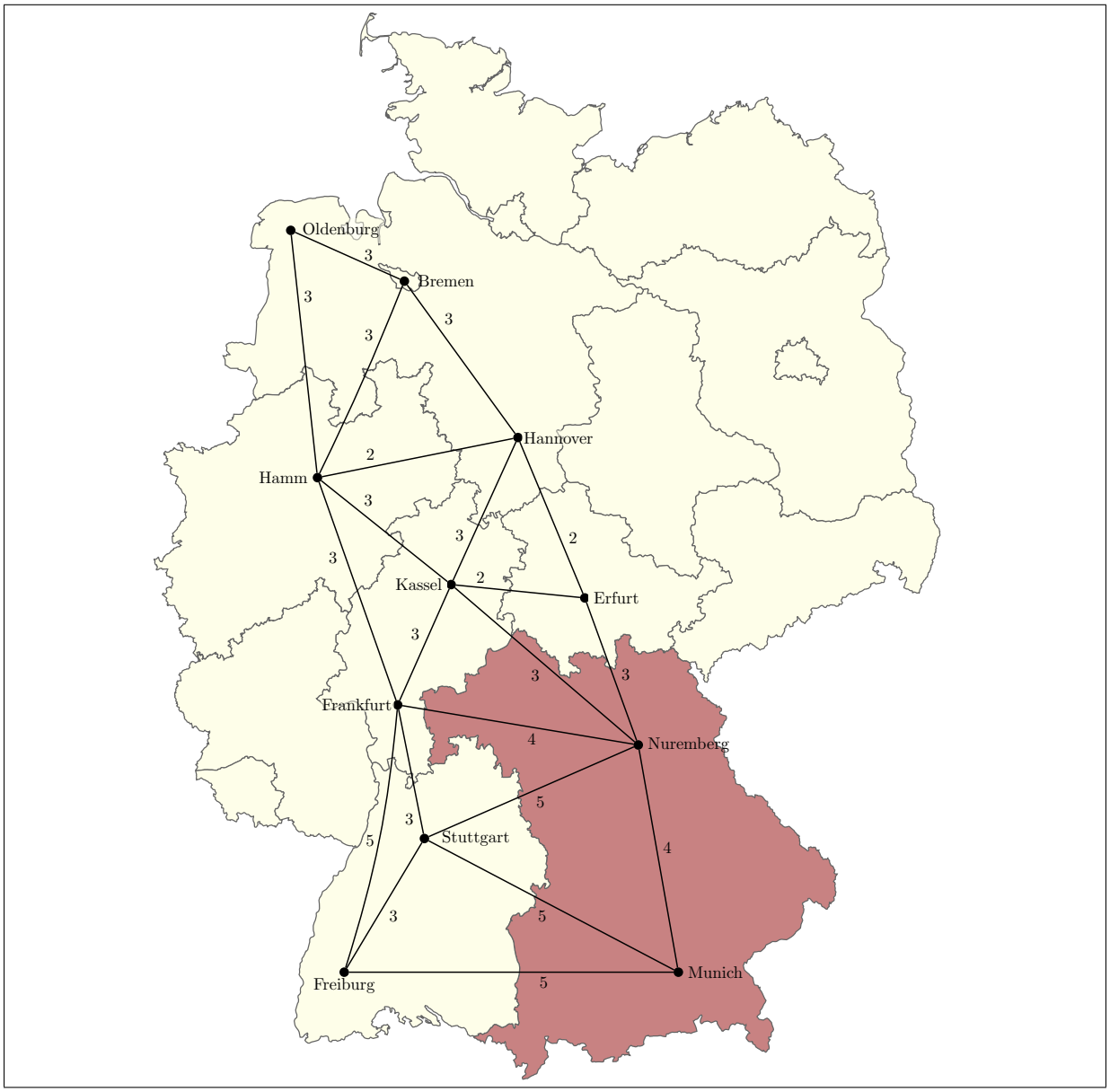

Figure 2: Map of a country and the possible energy lines among the ones to be built. Based on a map by Wikimedia Commons user TUBS, licensed under CC by-sa/3.0. Source map obtained from `https://de.wikipedia.org/wiki/Datei:Locator_map_Bavaria_in_Germany.svg`