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Optimization for Non-Mathematicians

Sheet 12

Exercise 27: Maximum flow

On a coast a new wind power plant is planned. We have to check whether the existing power supply system is able to transport power peaks up to 1600 kW to the consumers and electricity storages or whether the power supply system has to be extended. Let the system be given by a graph (Figure 1) with several sinks (e.g., consumers and storages). Each edge in the graph has an upper bound for the capacity it can transport.

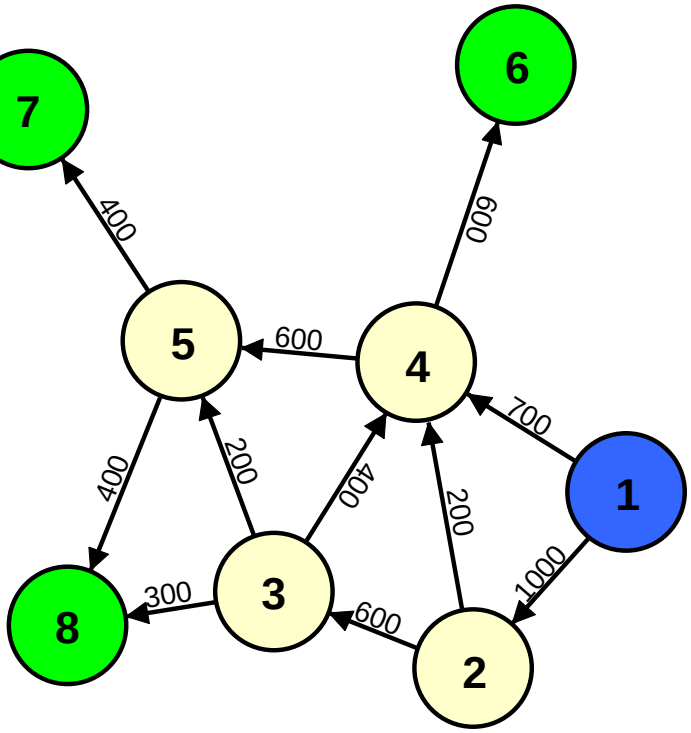

Figure 1: Graph of the power supply system: node 1 is the wind power plant and nodes 6, 7 and 8 represent the sinks. The edge labels are the upper bounds for the capacities in kW.

(a) How can we extend the graph by additional edges, such that the node balances in all nodes (i.e. sources and sinks) are fulfilled? What is the optimization problem?

(b) Solve the problem with MATLAB using `linprog`. Details about the power supply system can be found in the file `data_power_network.m` on the homepage.

(c) If the maximal flow can not transport 1600 kW: which edges are to be extended (i.e., the upper bound of corresponding edge is increased)?

Exercise 28: Bipartite matching problem

Within a support program 15 students applied for internships in 5 different companies.

- All candidates are assumed to be equally eligible. The allocation should be done in such a way that the average satisfaction of the applicants is as high as possible.
- The applicants were able to state their first, second and third choices. Let the satisfaction for a accepted first choice be 1.0, for a second choice 0.8 and for a third choice 0.6.

(a) Which graph can be used for this problem? What is the mathematical optimization problem?

(b) Solve the problem with MATLAB using `linprog`. Details about the choice of the applicants und the available places can be found in the file `data_internship.m` on the homepage.

(c) How can the problem be modified if each company i offers a certain number of internships p_i instead of only one?

(d) How does the problem change if some of the applicants have been guaranteed an internship (e.g., due to excellent qualification)?

Exercise 29: Study planning

A company plans an in-house study on the usability of a medical device. For this purpose 60 employees are asked to participate in a 30-minute study, if possible. There are 60 time slots available for the study and only one employee can participate in the study per time slot. Each employee has an individual schedule and is available for certain time slots only. This is encoded in a 60×60 matrix P with

$$P_{ij} = \begin{cases} 1, & \text{the employee } i \text{ is available for the time slot } j. \\ 0, & \text{the employee } i \text{ is not available for the time slot } j. \end{cases}$$

The company seeks a plan for the study that assigns as many employees as possible to the time slots.

(a) Which graph can be used for this problem? What is the mathematical optimization problem?

(b) Solve the problem with MATLAB using `linprog`. The matrix P with the availabilities of the employees can be found in `P.mat` on our homepage.

(c) How could the problem be modified if two employees could take the study at the same time.