Course: Telecommunication Network Design
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Studies: Electronics and Telecommunications
Speciality: Networks and Services
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Draft of the lecture

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1 Linear Programming

1.1 Basics of linear programming

1. Standard form, matrix form, solution space. Standard form:
   - MAX:
     - $z = \sum_{j=1,2,\ldots,n} c_j x_j$
   - S.t. (subject to):
     - $\sum_{j=1,2,\ldots,n} a_{ij} x_j = b_i \quad i = 1, 2, \ldots, m;$
     - $x_j \geq 0 \quad j = 1, 2, \ldots, n;$
     - $x_j \in \mathbb{R} \quad j = 1, 2, \ldots, n.$

   and its matrix form:
   - MAX:
     - $z = \mathbf{c}\mathbf{x}^T$ (transposition is usually not emphasised, especially when it is obvious from the context; therefore, typically it is written as: $z = \mathbf{c}\mathbf{x}$).
   - S.t.:
     - $\mathbf{A}\mathbf{x}^T = \mathbf{b}^T$ ($\mathbf{A}\mathbf{x} = \mathbf{b}$);
     - $\mathbf{x}^T \geq \mathbf{0}^T$ ($\mathbf{x} \geq \mathbf{0}$).

   and the compact notation: $z = \max\{\mathbf{c}\mathbf{x} : \mathbf{A}\mathbf{x} = \mathbf{b} \wedge \mathbf{x} \geq \mathbf{0}\}$.
2. Basic solution method: simplex method (Dantzig), extreme point, simplex, basis matrix, basis solution, feasible basis solution, properties of the optimal solution (a number of non-zero optimal variables).

1.2 Exercises

- An optimization task is given as below:
  - goal function: $\min z = 2x_1 + 2x_2$
  - constraints:
    - $x_1 \leq 5$
    - $x_2 \leq 5$
    - $Ax_1 + Bx_2 \leq C$

  Find such A, B, and C ($A, B, C \in \mathbb{R} \setminus \{0\}$), so that this task is infeasible.

1.3 Reading

1.3.1 Contents of the lecture

Problems described in this lecture are generally dealt with in the following position:

- Michał Pióro and Deepankar Medhi. *Routing, Flow and Capacity Design in Communication and Computer Networks*. Morgan Kaufmann Publishers—Elsevier, San Francisco, CA, 2004: appendix C.3.

1.3.2 Auxiliary references

- Michał Pióro and Deepankar Medhi. *Routing, Flow and Capacity Design in Communication and Computer Networks*. Morgan Kaufmann Publishers—Elsevier, San Francisco, CA, 2004: basic network design problems.
- Poompat Saengudomlert. *Optimization for Communications and Networks*. CRC Press/Science Publishers, Boca Raton, FL, 2012: overview of various optimization problems relevant to communications/computer networks.