Combinatorial Optimization Contest 2022:
Steiner tree in disguise

Combinatorial Optimization Team

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Steiner tree problem

- Classical $\mathcal{NP}$-hard problem
- Benchmark instances selected from `http://steinlib.zib.de/steinlib.php`
  - For many of them, optimality of the best-so-far solution has not been proved yet

Instances

- Diversity:
  - Instances with unit costs
  - Instances with non-unit costs
  - Polynomially solvable instances
  - Difficult instances
  - Special instances (grid graphs with rectangular holes)

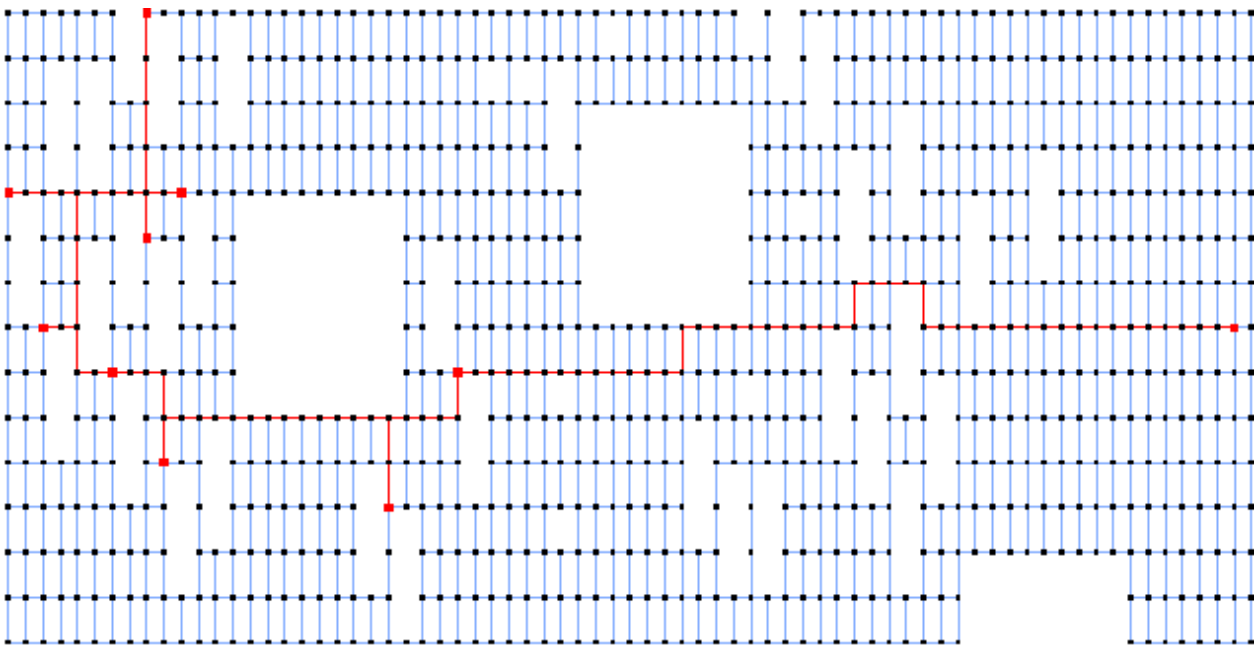


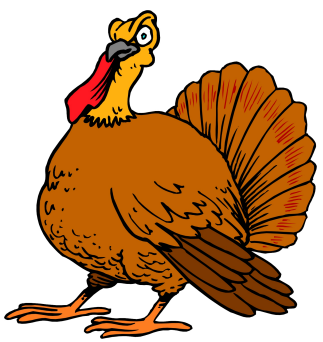
Figure: Example of a special instance of the Steiner tree problem

Reference solution

Several simple algorithms implemented to set some reasonable thresholds. One example:

1. Preprocess the graph (prune non-terminals of degree 1)
2. Find a minimum spanning tree
3. While time remains, greedily improve the current solution:
   - Try to remove some non-terminal vertex from the current spanning tree and find a new minimum spanning tree using the original graph without the removed vertex

Other strategies can be used too, e.g., splitting the tree (removing some non-terminal vertices) and trying to connect it again *somehow*.



State-of-the-art

Instance	**Complexity**	**State-of-the-art**	**Gramopav** 2019 winner	**Gap [%]**	**Nemecj38** 2022 winner	**Gap [%]**
bipa2p	??	35326	36674	3.8	38963	10.3
cc3-12u	??	185	190	2.7	196	6.0
cc7-3u	??	549	578	5.3	610	11.1
cc9-2p	??	17199	17671	2.7	18148	5.5
hc9p	NP?	30242	30823	1.9	32042	6.0
hc12u	??	2262	2351	3.9	2616	15.7
msm0709	LP	**884**	884	0.0	884	0.0
msm2152	PS	**1590**	1590	0.0	1595	0.3
msm4312	PS	**2016**	2016	0.0	2052	1.8
w23c23	NP?	**689**	701	1.7	770	11.8

Table: Comparison of the state-of-the art solutions and student's solutions

Note: LP (solvable by local preprocessing), PS (solvable by polynomial algorithms), NP (no polynomial algorithm is currently known), ?? (currently not known).