

## Programming Exercise 1

**Exercise P.1.** Implement the DIJKSTRA-STEINER Algorithm for rectilinear Steiner trees on the Hanan grid.

Your program will be started with a single argument that specifies an instance file. Such an instance file will be in the following format:

$n$
$x_1 \quad y_1$
$x_2 \quad y_2$
$\vdots \quad \vdots$
$x_n \quad y_n$

where all the numbers are space-separated non-negative integers. Each line encodes a terminal at position  $t_i := (x_i, y_i)$ . Assume  $c(v, w) = \ell_1(v, w)$  which will not be encoded explicitly. Your task is to find a shortest rectilinear Steiner tree in the Hanan grid on the terminals.

If the input is valid, your program must compute the length of a shortest Steiner tree and print this value to the standard output.

The program should achieve the proven theoretical running time up to the running time of the heap. You do not have to implement a Fibonacci heap; you may use simpler heap structures instead (providing  $\mathcal{O}(\log n)$  heap operations e.g. as available in the standard library). Your implementation has to use some future costs, e.g. the bounding box to the remaining terminals. You should expect test instances of up to 20 terminals, in which case sets of terminals are most efficiently stored in `std::bitset`'s.

The program must be written in C or C++ and must compile and run on Linux. You are allowed to use any any ISO C or C++ standard including C++20. You can use any tool available in the standard library. Your program must compile with either Clang (any version  $\geq 3.4.2$ ) or Gcc (version  $\geq 4.8.3$ ) with `-Wall -Wextra -Wpedantic -Werror` and cannot link to any external library except the standard library.

To achieve the maximum score, your program must not leak any memory and must be well documented. Bonus points will be rewarded for beautiful implementations and effective speedup techniques.

You can find test instances and a starting point for your program including a parser at:

<https://gitlab.com/ChipDesignProgramming/dijkstra-steiner>

(24 + 8\* points)

**Deadline:** May 6, before the lecture. The websites for lecture and exercises can be found at:

[https://www.or.uni-bonn.de/lectures/ss25/chipss25\\_ex.html](https://www.or.uni-bonn.de/lectures/ss25/chipss25_ex.html)

In case of any questions feel free to contact me at [heinz@dm.uni-bonn.de](mailto:heinz@dm.uni-bonn.de).