Chip Design
Summer term 2009

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# Exercises 3

1. Prove that following decision problem is either solvable in polynomial time or *NP*-complete. Given a placement instance without blockages where all circuits have height 1 and the chip area has height 2, is there a legal placement (rotation is allowed)? [2 points]

2. Given rectangles $C_1, \dots, C_n$ with widths $w_1, \dots, w_n$ and heights $h_1, \dots, h_n$, formulate an integer linear program that checks wether they can be packed (without overlaps) within a rectangle $[x_{\min}, x_{\max}] \times [y_{\min}, y_{\max}]$ allowing rotation by multiples of 90°. [4 points]

3. Assume there is an oracle which returns a placement of minimum total netlength (possibly with overlaps) for any input netlist $(\mathcal{C}', P', \gamma', \mathcal{N}')$ containing only two-terminal nets in $O(T(|\mathcal{N}'|) + |\mathcal{C}'|)$ time.

   Show that such an oracle can be used to find a placement (possibly with overlaps) minimizing the bounding box netlength of a general netlist $(\mathcal{C}, P, \gamma, \mathcal{N})$ in $O(T(|P|) + |\mathcal{C}|)$ time. [6 points]

4. Given an instance of the Standard Placement Problem that contains only a single circuit ($|\mathcal{C}| = 1$). Develop an algorithm for minimizing the weighted bounding box netlength. Try to achieve a smallest possible running time in terms of $|\mathcal{N}|$ and $|P|$. [4 points]

5. Given a finite set $V \subset \mathbb{R}^2$ of points in the plane, show that

   (a) the clique length defined as

   $$\text{CLIQUE}(V) := \frac{1}{|V| - 1} \sum_{(x,y),(x',y') \in V} (|x - x'| + |y - y'|)$$

   can be computed in $O(|V| \log |V|)$ time, [2 points]

   (b) the star length defined as

   $$\text{STAR}(V) := \min_{(x',y') \in \mathbb{R}} \sum_{(x,y) \in V} (|x - x'| + |y - y'|)$$

   can be computed in $O(|V| \log |V|)$ time. [2 points]

The deadline for submitting solutions is May 7 before the lecture (12:15).