Chip Design
Summer term 2010

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Exercises 2

1) Let N be a finite set of pins, and let $\mathcal{S}(p)$ be a set of axis-parallel rectangles for each $p \in N$. We want to compute the bounding box net length of N. To this end, we look for an axis-parallel rectangle R with minimum perimeter such that for every $p \in N$ there is a $S \in \mathcal{S}(p)$ with $R \cap S \neq \emptyset$. Let $n := \sum_{p \in N} |\mathcal{S}(p)|$.
Show that such a rectangle can be computed in $O(n^3)$ time.
(Hint: Enumerate possible coordinates for the lower left corner of R.)

(4 points)

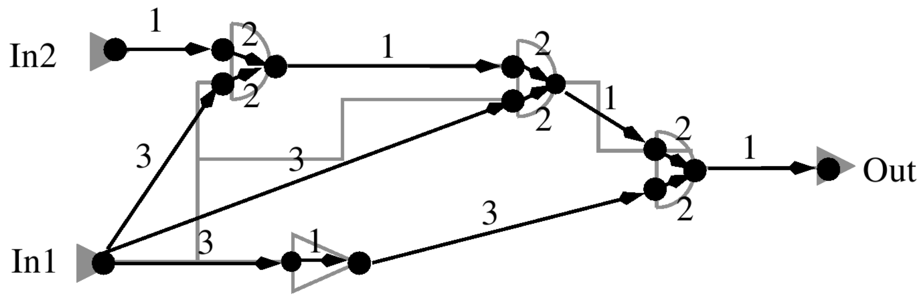
2) Given a netlist with placement and routing. For a net N let $\mathcal{S}(N)$ be the set of all shapes corresponding to the wiring edges of the connection for N.
The routing has to satisfy the following minimum distance rule for a given constant $c \in \mathbb{R}_{>0}$: For any two nets N_1, N_2, $N_1 \neq N_2$ and any pair of shapes $S = [x_1, x_2] \times [y_1, y_2] \times \{z\} \in \mathcal{S}(N_1)$ and $S' = [x'_1, x'_2] \times [y'_1, y'_2] \times \{z'\} \in \mathcal{S}(N_2)$ with $z = z'$:

$$\max\{x'_1 - x_2, x_1 - x'_2, y'_1 - y_2, y_1 - y'_2\} \geq c. \tag{1}$$

Formulate an $O(n \log n + k)$-time algorithm that computes all pairs of shapes that violate the minimum distance rule. (k denotes the number of pairs of shapes not satisfying (1), including pairs where both shapes are in the connection for the same net.)

(4 points)

3) Consider the following piece of combinatorial logic and its timing graph:



The edge labels specify the delay over the timing graph edge. We do not distinguish between rising and falling signals and do not consider slew. Maximum (late mode) and minimum (early mode) delays are equal. Assume that all the arrival times for the latest and earliest signal at the primary inputs 'In1' and 'In2' are 0 and the required arrival times at the primary output 'Out' are 10 (early mode) and 12 (late mode).

a) What are the earliest and latest arrival times of a signal at the primary output pin 'Out' ?

b) Compute the early and late slack at each pin.

(4 points)

4) Let a set of signals $\Sigma(p)$ be given for each logical source, inducing $\Sigma(q) = \bigcup_{e=(p,q)\in\delta^-(q)}\{\vartheta_e(\sigma) : \sigma \in \Sigma(p)\}$ for all other vertices q. Let required arrival times be given for each logical sink, propagated backwards as defined in the lecture. Let p be a pin which is not a logical sink and q a pin which is not a logical source. Let $\eta \in \{\text{early}, \text{late}\}$. Prove that

$$\begin{aligned} slack^\eta(p) &\geq \min\{slack^\eta(q) : (p,q) \in \delta^+(p)\} \quad \text{and} \\ slack^\eta(q) &\geq \min\{slack^\eta(p) : (p,q) \in \delta^-(q)\}. \end{aligned}$$

(4 points)

Deadline: April 27 before the lecture (12.15 pm).