

# Timing Driven Placement

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## Timing Driven Placement

- ▶ The timing-driven placement seeks to optimize the circuit delay when placing the design.
- ▶ The approaches of the timing-driven placement is as follows:
  - ▶ Net-Based Approaches
  - ▶ Path-Based Approaches
  - ▶ Compound Approaches



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## Net-Based Approaches

- ▶ Net-based Approaches optimize the delay by converting the results of the timing analysis into weights and length constraints for the critical nets.
- ▶ Incremental STA and Zero-slack Assignment is some methods that are usually used in conjunction with the net-based approaches

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## Path-Based Approaches

- ▶ Path-based Approaches target the individual critical paths and ensure that each path meets the timing constraints.
- ▶ Path-based Approaches achieve better solutions than net-based approaches, but are impractical for a big number of paths.
- ▶ Techniques like partitioning and Lagrangian relaxation can help solving the approach, and even with improved quality.

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## Compound Approaches

- ▶ Compound approaches seek to combine the scalability of net-based approaches and accuracy of path-based approaches.

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## Force Directed Timing Driven Placement [2]

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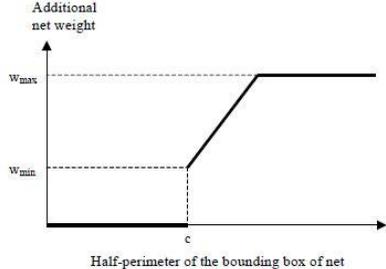
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- ▶ The force-directed placement Algorithm which is used on this paper is the one from [3]:
  - ▶  $C * \vec{p} + \vec{d} + \vec{e} = 0$
- ▶ The main point of the paper [2] is the net-based technique that is introduced, which adds weights on the array  $C$  on the coordinates of the critical components.

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## Net Weights

- ▶ Weight is only added to the critical nets, nets that are in the critical path or one of the critical paths.
- ▶ The weight is bound by two values  $w_{min}$  and  $w_{max}$ , shown to the following graph. The weight is also broken into  $w_x$  and  $w_y$ .
- ▶ Even if the net is not critical after some iterations, the weight stays on the array to prevent the cells to move to their initial positions.



The graph plots 'Additional net weight' on the vertical axis against 'Half-perimeter of the bounding box of net' on the horizontal axis. The weight is zero for half-perimeters less than a critical value 'c'. At 'c', the weight begins to rise linearly, reaching a maximum value  $w_{max}$ . For half-perimeters greater than 'c', the weight remains constant at  $w_{max}$ . A minimum weight  $w_{min}$  is also indicated on the vertical axis, which is zero in this specific graph.

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## Net Model

- ▶ The nets are presented with the Star Model. Thus the nets are divided into sub nets and each subnet's net takes a portion of the weight, depending on its position.



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## Main Algorithm

```

procedure timing-driven force-directed placement
  begin
    create a graph vertex for every movable cell
    for all nets {
       $k$  = number of cells connected to the net
      define an additional vertex for the center of the net
      create  $k$  edges, one from each cell to the center vertex
      assign a weight of 1 to all edges
    }

    while (placement is not spread out) {
      for (fixed number of iterations) {
        for (all net constraints) {
          if (net not meeting constraint) {
            distribute additional weight to bounding cells on this net
          }
        }
        calculate spreading forces to form  $e$  vector
        construct the  $C$  matrix and the  $d$  vector
        solve for the new placement of cells
      }
      run the timing analysis engine on the current placement
      use heuristics to constrain critical nets
    }
  end

```

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## Distribute Net Weights

- ▶ Extract the critical paths from the report of the timing analysis.

- ▶ Break each path to its nets.

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## Distribute Net Weights

- ▶ Find the star point of each net and distribute the weight of the net for each cell on each coordinate.

$$wx_1 = wx \cdot \frac{(x_c - x_1)}{(x_6 - x_1)}$$

$$wx_2 = wx_3 = wx_4 = wx_5 = 0$$

$$wx_6 = wx \cdot \frac{(x_6 - x_c)}{(x_6 - x_1)}$$

$$wy_1 = wy_3 = wy_4 = wy_6 = 0$$

$$wy_2 = wy \cdot \frac{(y_2 - y_c)}{(y_2 - y_5)}$$

$$wy_5 = wy \cdot \frac{(y_c - y_5)}{(y_2 - y_5)}$$

$$wx_1 = wx \cdot \frac{(x_c - x_1)}{(x_6 - x_1)}$$

$$wx_2 = wx_3 = wx_4 = wx_5 = 0$$

$$wx_6 = wx \cdot \frac{(x_6 - x_c)}{(x_6 - x_1)}$$

$$wy_1 = wy_3 = wy_4 = wy_6 = 0$$

$$wy_2 = wy \cdot \frac{(y_2 - y_c)}{(y_2 - y_5)}$$

$$wy_5 = wy \cdot \frac{(y_c - y_5)}{(y_2 - y_5)}$$

- ▶ The portion of the weight on each net of bounding box is given based on its position compared to the star point.

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- ▶ When the weights are finally distributed, run for a fixed number of iteration the Placement Algorithm.
- ▶ After the placement, run the timing analysis and extract the critical paths.
- ▶ Repeat this process until the placement is spread out enough.



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## References



1. Markov, Igor L., Jin Hu, and Myung-Chul Kim. "Progress and challenges in VLSI placement research." *Proceedings of the IEEE* 103.11 (2015): 1985-2003.
2. Rajagopal, Karthik, et al. "Timing driven force directed placement with physical net constraints." *Proceedings of the 2003 international symposium on Physical design*. ACM, 2003.
3. H. Eisenmann and F. M. Johannes, "Generic Global Placement and Floorplanning", ACM/IEEE DAC, 1998.



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