UCLA

Review of Layout Compaction Methods

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NanoCAD Group Meeting 11/12/09

Why Compaction?

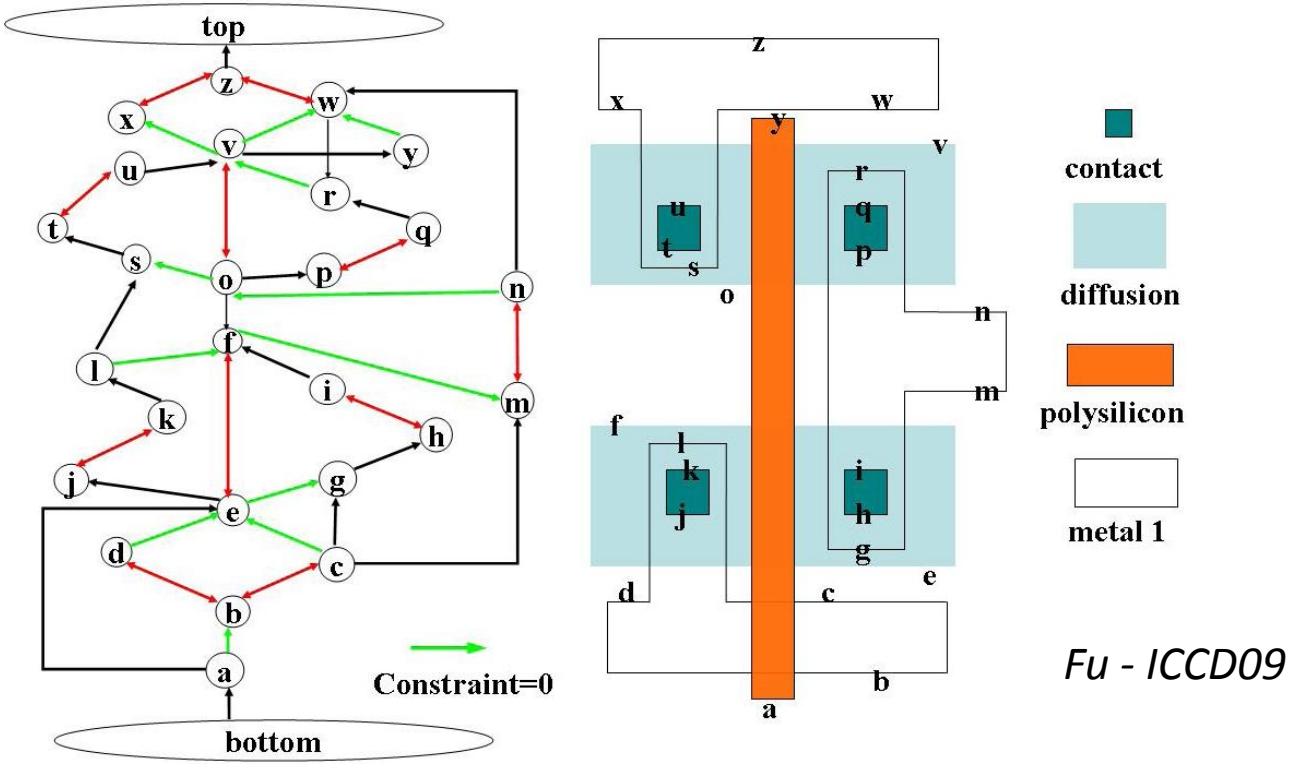
- Layout migration to a new technology process
  - Avoid redesigning the same layouts to fit a new tech or small changes in the process

- Layout legalization
  - Fix design rules violations
  - Fix layout for altPSM [Heng ISPD01]
  - Fix layout for double-patterning

How Compaction Works?

- Construct a constraint graph to represent the layout and all constraints
  - E.g., elements A and B needs to be 50nm apart → two nodes A and B with an edge constraint of 50nm
- Constraints represent DRs, layout style, alignment, recommended rules, etc…
- Solve the constraint graph while minimizing an objective
  - 2D compaction is NP-hard
  - Usually approximated to successive 1D compaction in X and Y directions
  - Objectives either area (wirelength) or minimum layout perturbation

Constraint Graph Construction



Fu - ICCD09

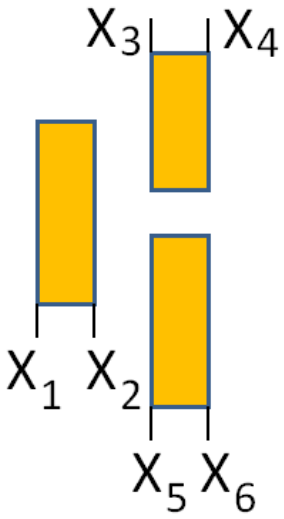
- Graph nodes typically represent layout edges
- Constraint generation between edges and their nearest neighbors only
  - Scanline-based algorithm

LP Formulation

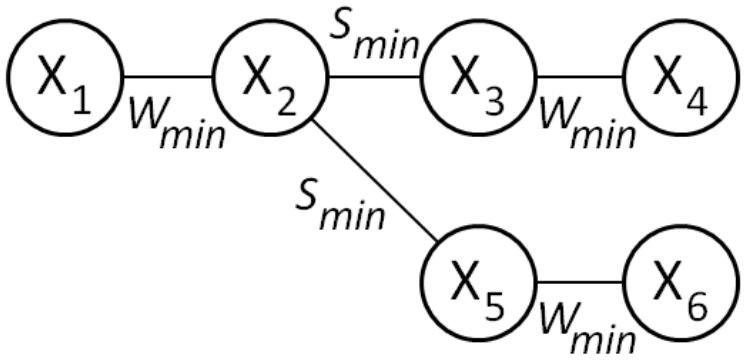
$$Minimize \quad \sum_i W_i |X_i - X_i^{init}|$$
$$Subject\ to: \quad X_j - X_i \geq d_{ij}, \forall A_{ij},$$

$$Minimize \quad \sum_i W_i (R_i - L_i)$$
$$Subject\ to: \quad X_j - X_i \geq d_{ij} \quad \forall A_{ij}$$
$$L_i \leq X_i, L_i \leq X_i^{init} \quad \forall i$$
$$R_i \geq X_i, R_i \geq X_i^{init} \quad \forall i$$

LAYOUT



CONSTRAINT GRAPH

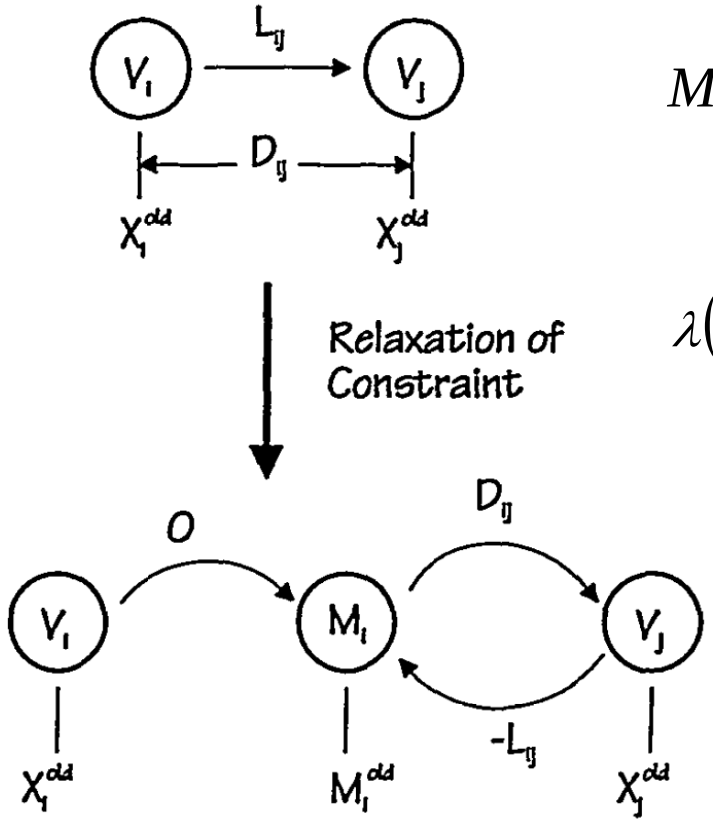


CONSTRAINTS

$$X_2 - X_1 \geq W_{\min}$$
$$X_3 - X_2 \geq S_{\min}$$
$$X_4 - X_3 \geq W_{\min}$$
$$X_5 - X_2 \geq S_{\min}$$
$$X_6 - X_5 \geq W_{\min}$$

Infeasible & Recommended Constraints

- New variable to relax the constraint and minimize it in the obj. function

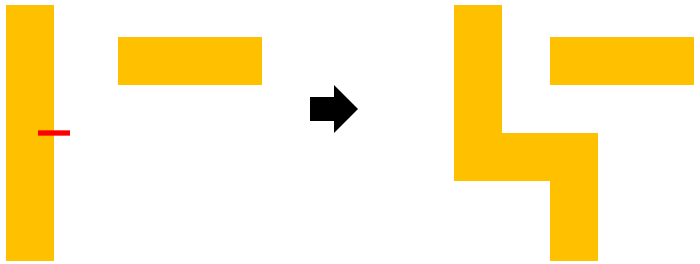


$$Minimize: \sum w_i \times (R_i - L_i) + \lambda \sum (M_i - X_j + L_{ij})$$

$\lambda(M_i - X_j + L_{ij})$ is minimum at $X_j - M_i = L_{ij}$

Other Methods

- Grouping of layout elements
- Defining jog points



- Area-based compaction
  - Objective function to minimize polygons area and min spacing
  - Can minimize wirelength
  - Might cause unwanted changes to the layout
- Other objectives
  - Critical-path centric, critical area, etc…