RSPlace: Rotation Sensing Macro Placement via Bidirectional Tree Expansion

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Overview

Motivation: Existing placers ignore the orientation of macros, resulting in the state space constrained to 2-D coordinates and greatly restricting the exploration opportunities.
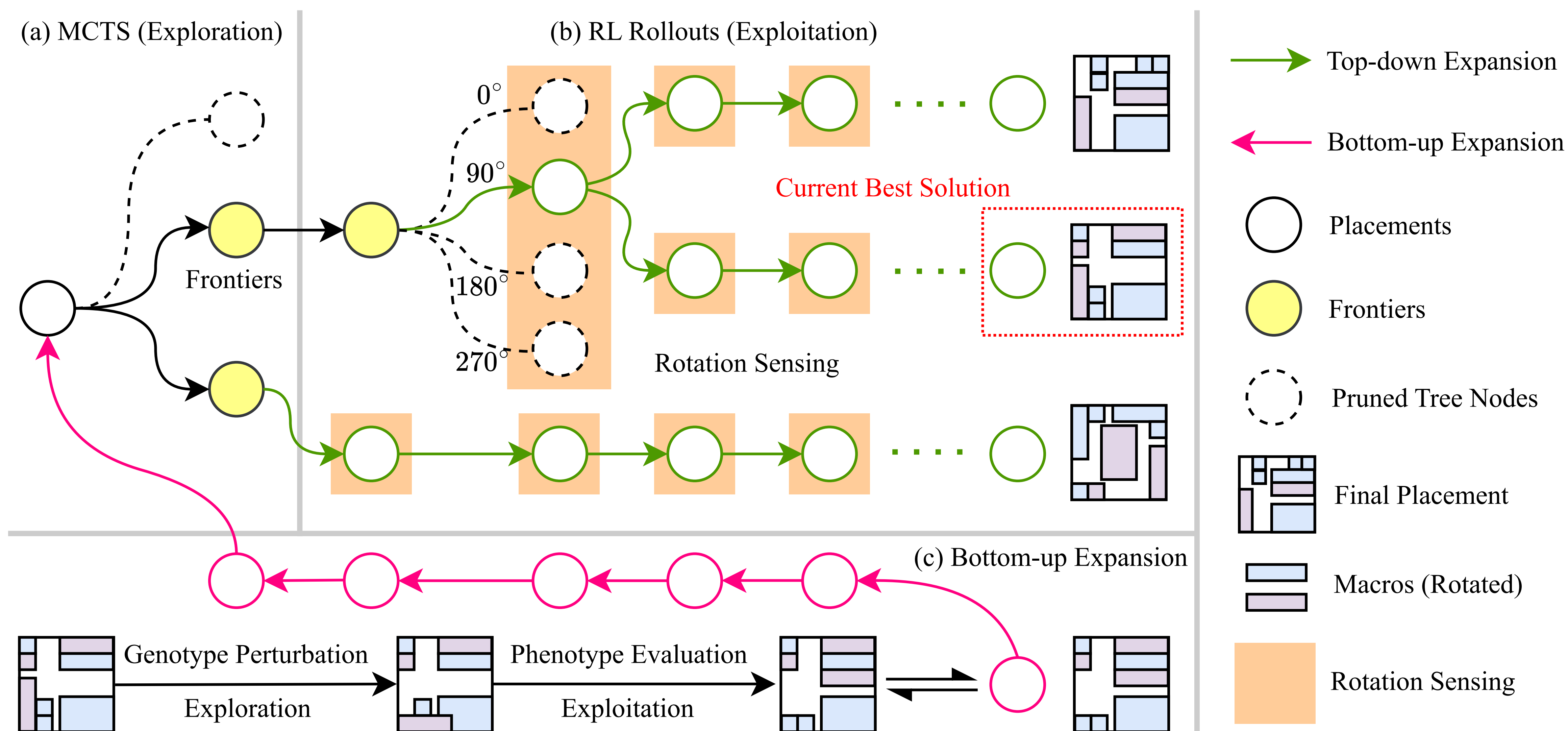
Solution: We propose a novel macro placement method, RSPlace, which guides the bidirectional expansion of the global search tree to offer the RL agent more exploration opportunities, incorporating rotation into the RL-based macro placement solution for the first time.
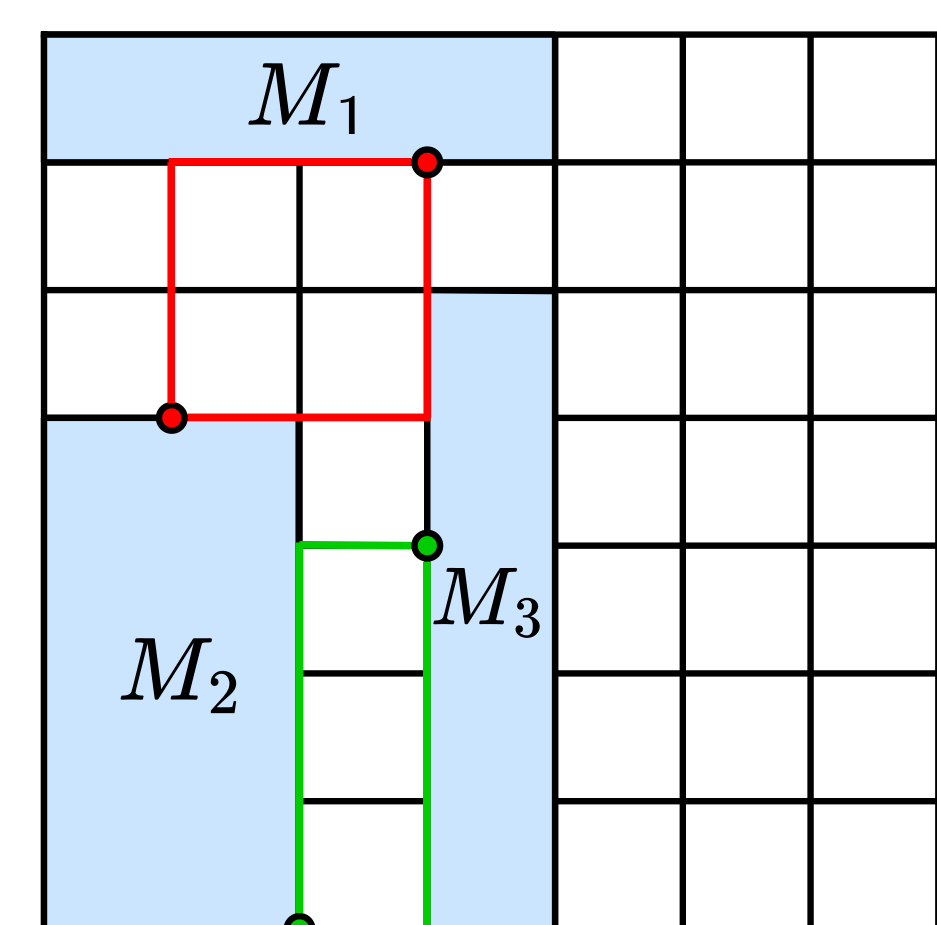
Key Contributions:

- **The New Dimension.** We incorporate rotation sensing and placement perturbations into the expansion process of the global search tree to select the optimal rotation angle, integrating the macro orientation into the RL-based macro placement problem.
- **Comprehensive Analysis.** The potential positive impacts of rotation on macro placement are comprehensively analyzed, including generating more feasible positions and fewer HPWL increments.
- **Outstanding Performance.** Extensive experiments demonstrate that our approach achieves better performance compared to existing work, even outperforming the recent state-of-the-art method.
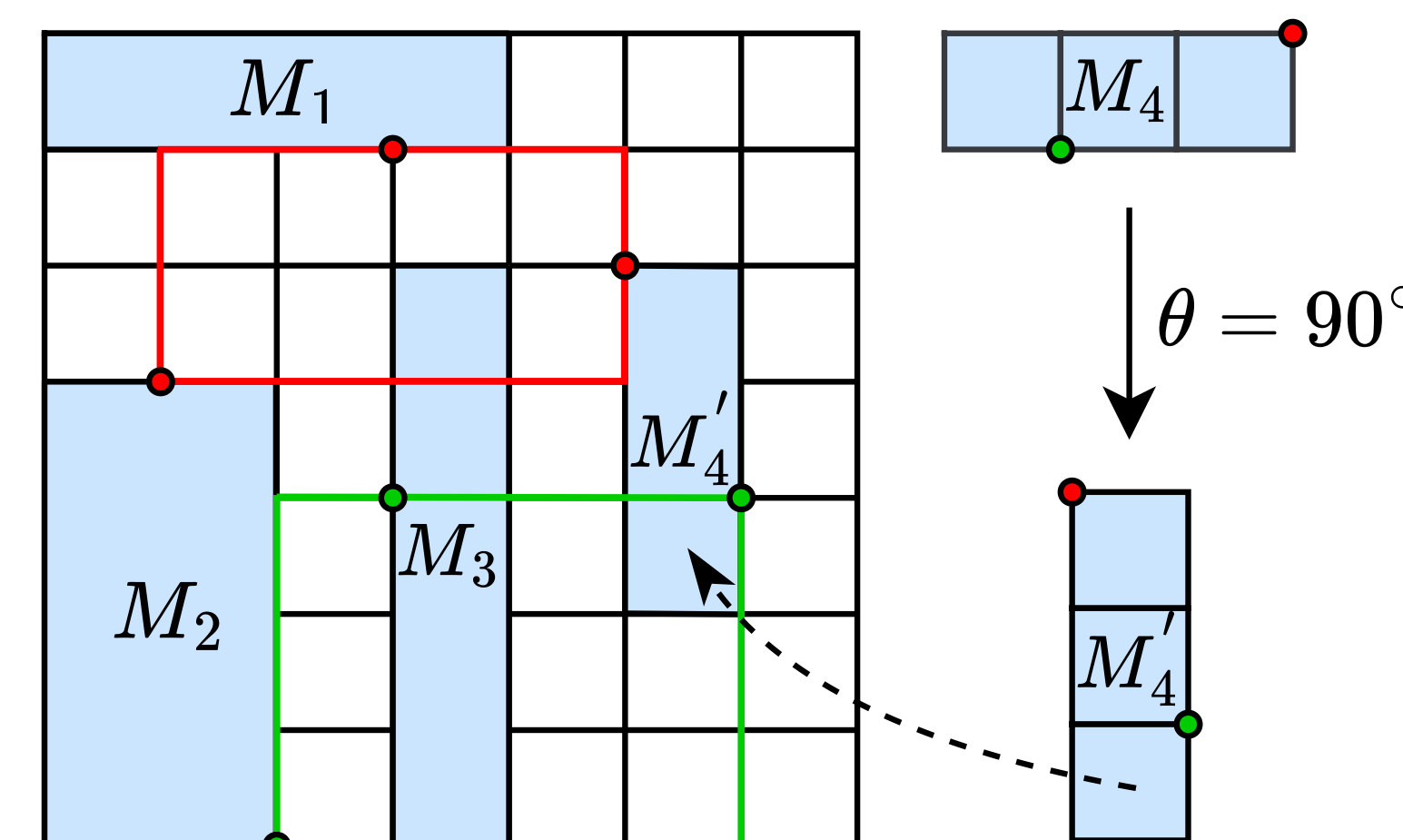
Method

RSPlace Framework:

(a) MCTS (Exploration)

(b) RL Rollouts (Exploitation)

Current Best Solution

Rotation Sensing

(c) Bottom-up Expansion

Genotype Perturbation — Phenotype Evaluation

Exploration — Exploitation

→ Top-down Expansion

← Bottom-up Expansion

○ Placements

● Frontiers

⬭ Pruned Tree Nodes

▦ Final Placement

▭ Macros (Rotated)

▮ Rotation Sensing

Orientation Benefits:

(a) Placement Example

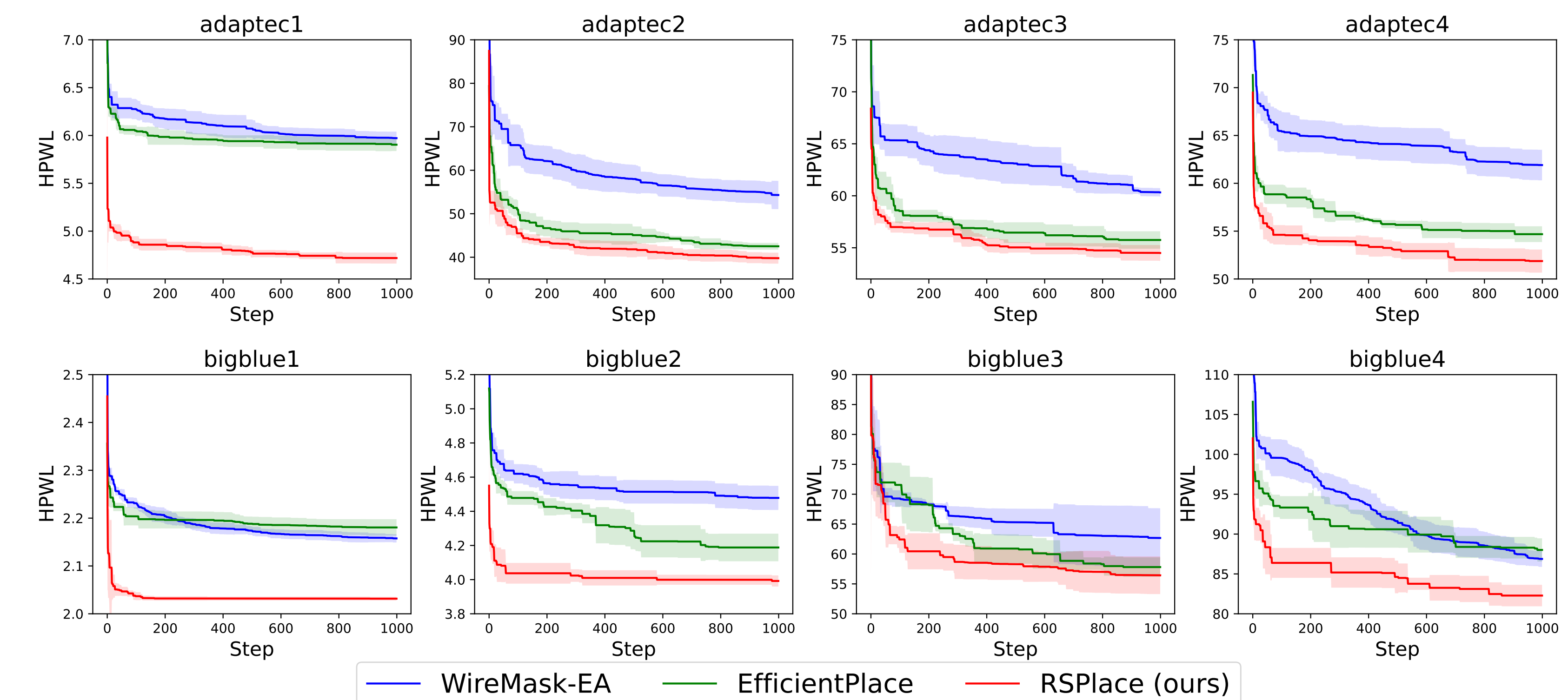(b) Masks for $\theta = 0°$

(c) Masks for $\theta = 90°$

(d) Calculation of HPWL

$\theta = 90°$
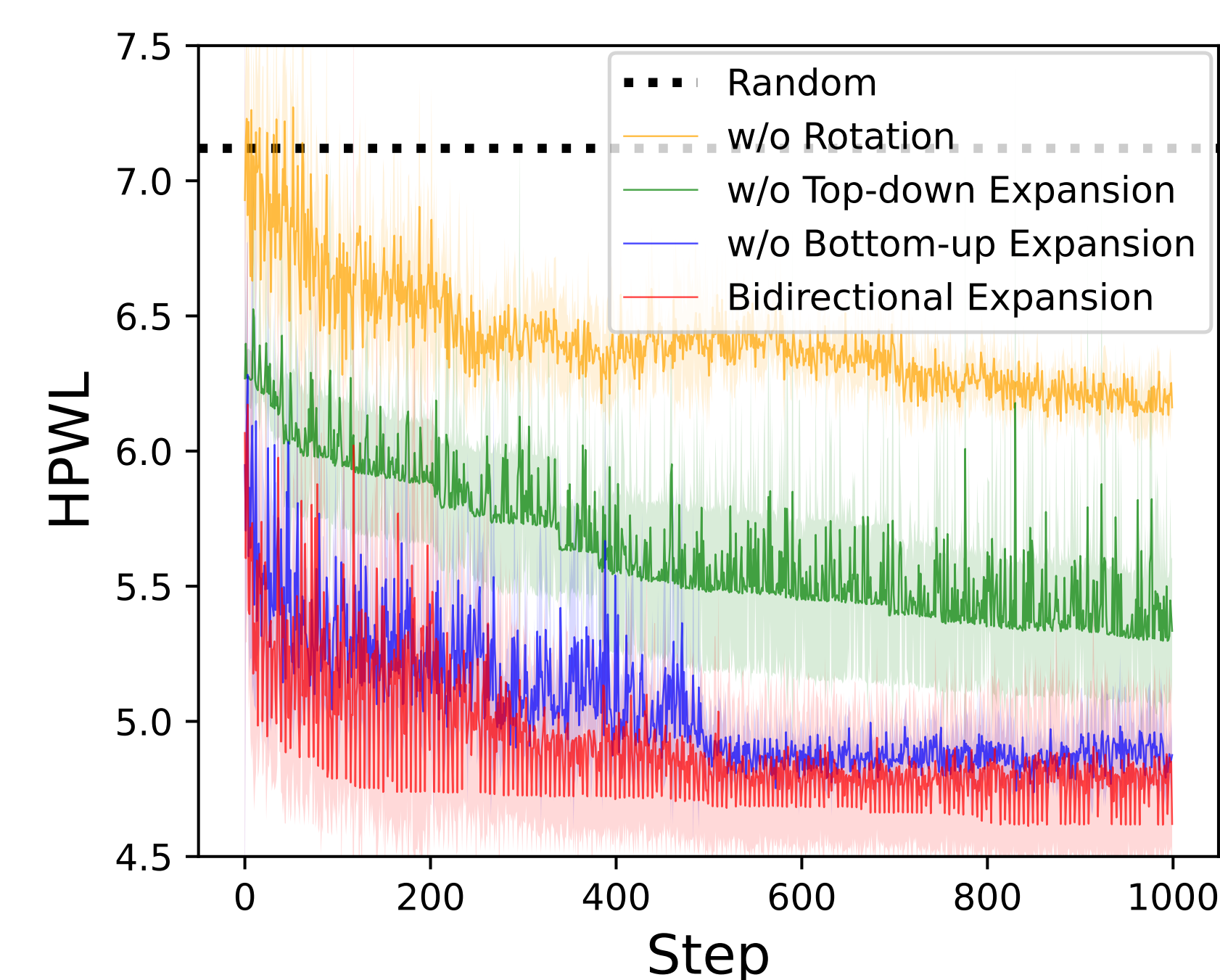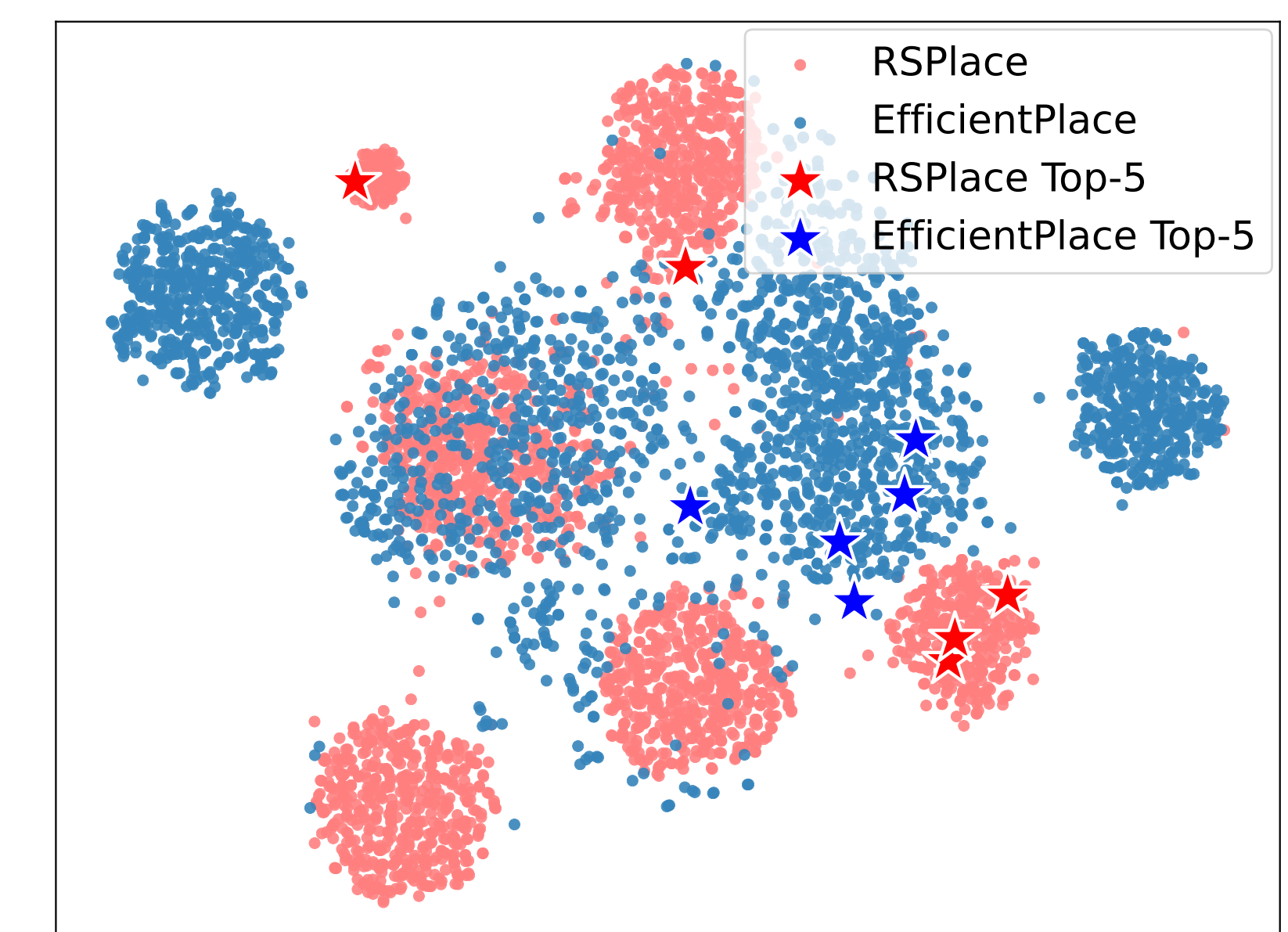
Experiment

Main Results: The following figure shows the HPWL results of our method and related baselines. RSPlace attains the lowest HPWL in all circuit benchmarks.
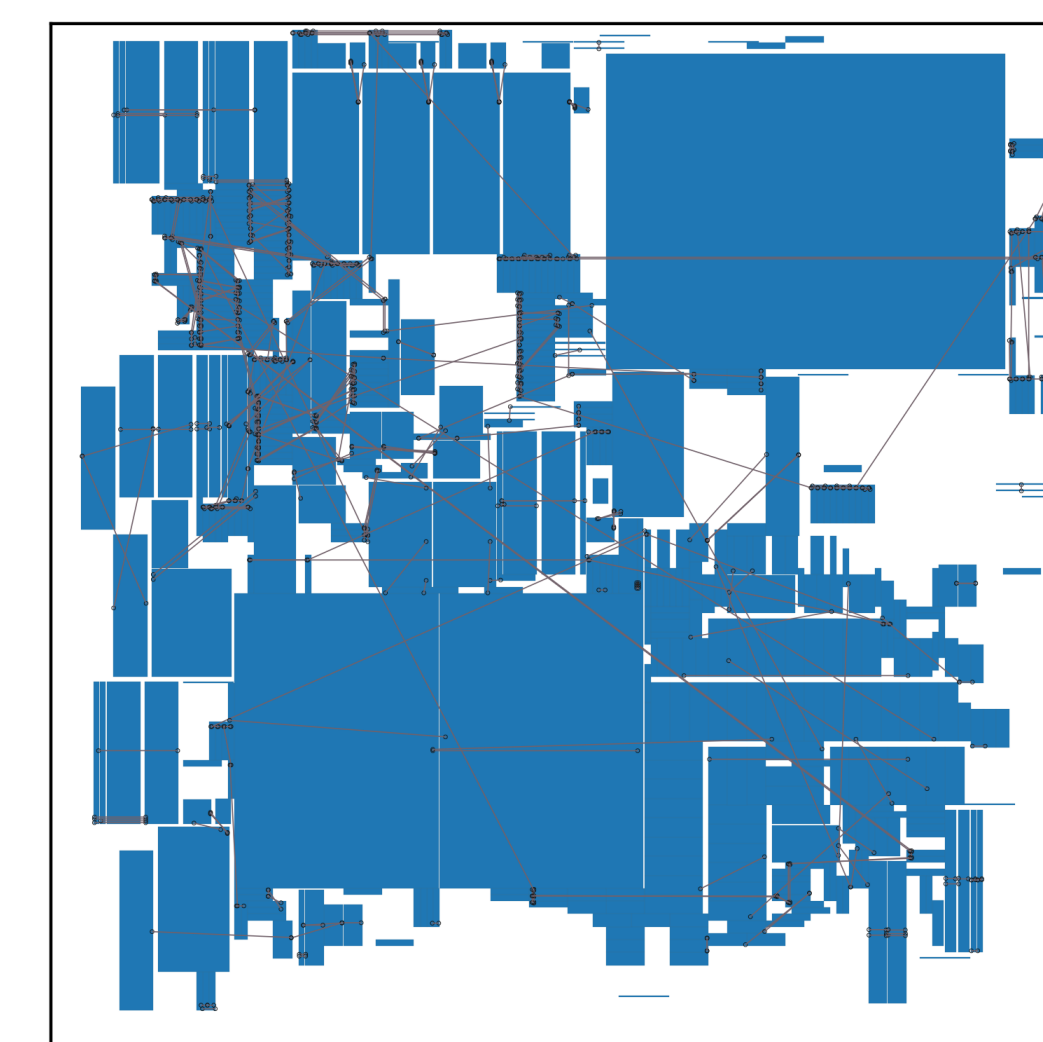

— WireMask-EA — EfficientPlace — RSPlace (ours)

Ablation Study:

- ···· Random
- w/o Rotation
- w/o Top-down Expansion
- w/o Bottom-up Expansion
- Bidirectional Expansion

Trajectory Exploration:

- RSPlace
- EfficientPlace
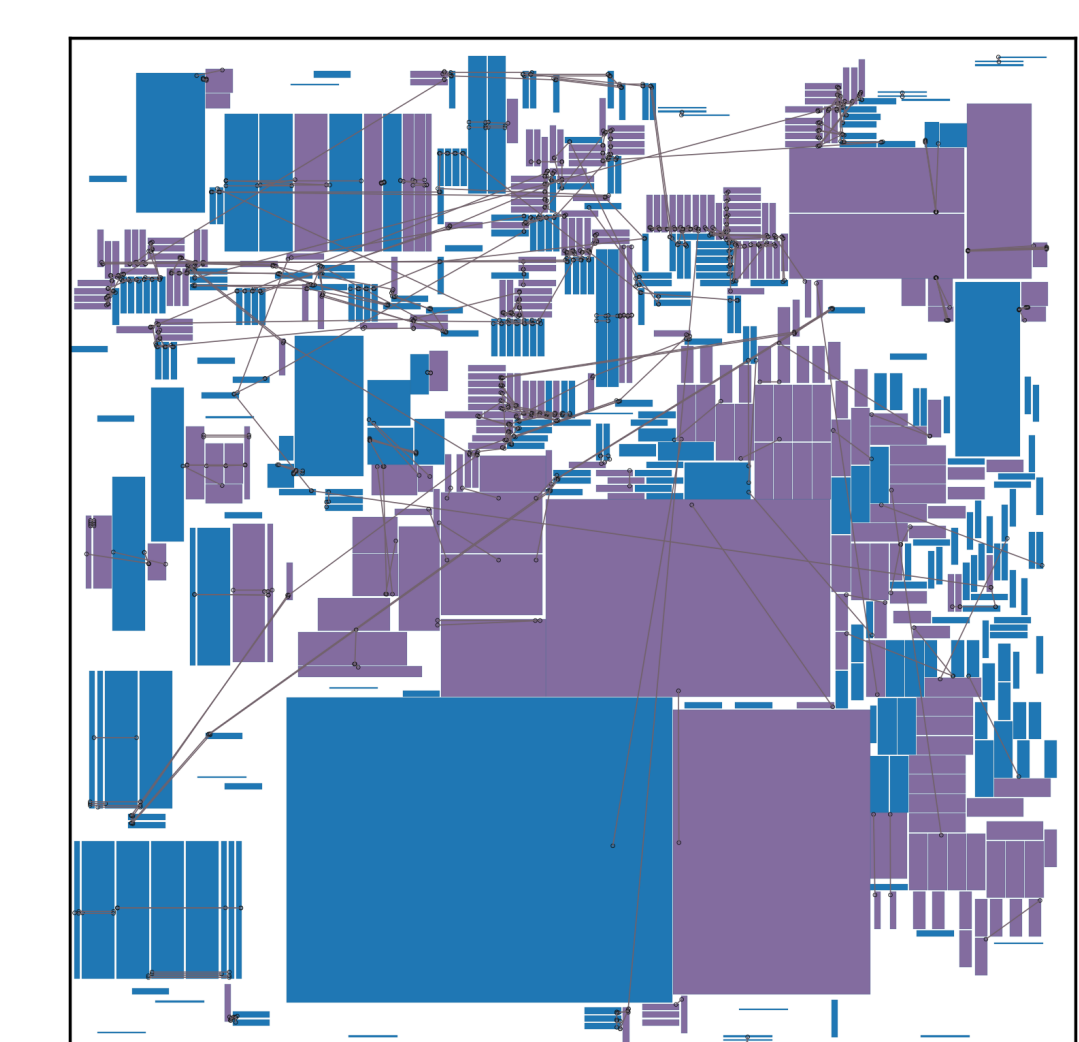- ★ RSPlace Top-5
- ★ EfficientPlace Top-5

Visualization: Visualization of macro placement result. The macros are visualized by blue or purple rectangles, where purple rectangles mean that macros have been rotated. The smaller the value of HPWL, the better.

(a) WireMask-EA
HPWL = 55.32×10^5
Overlap = 0%
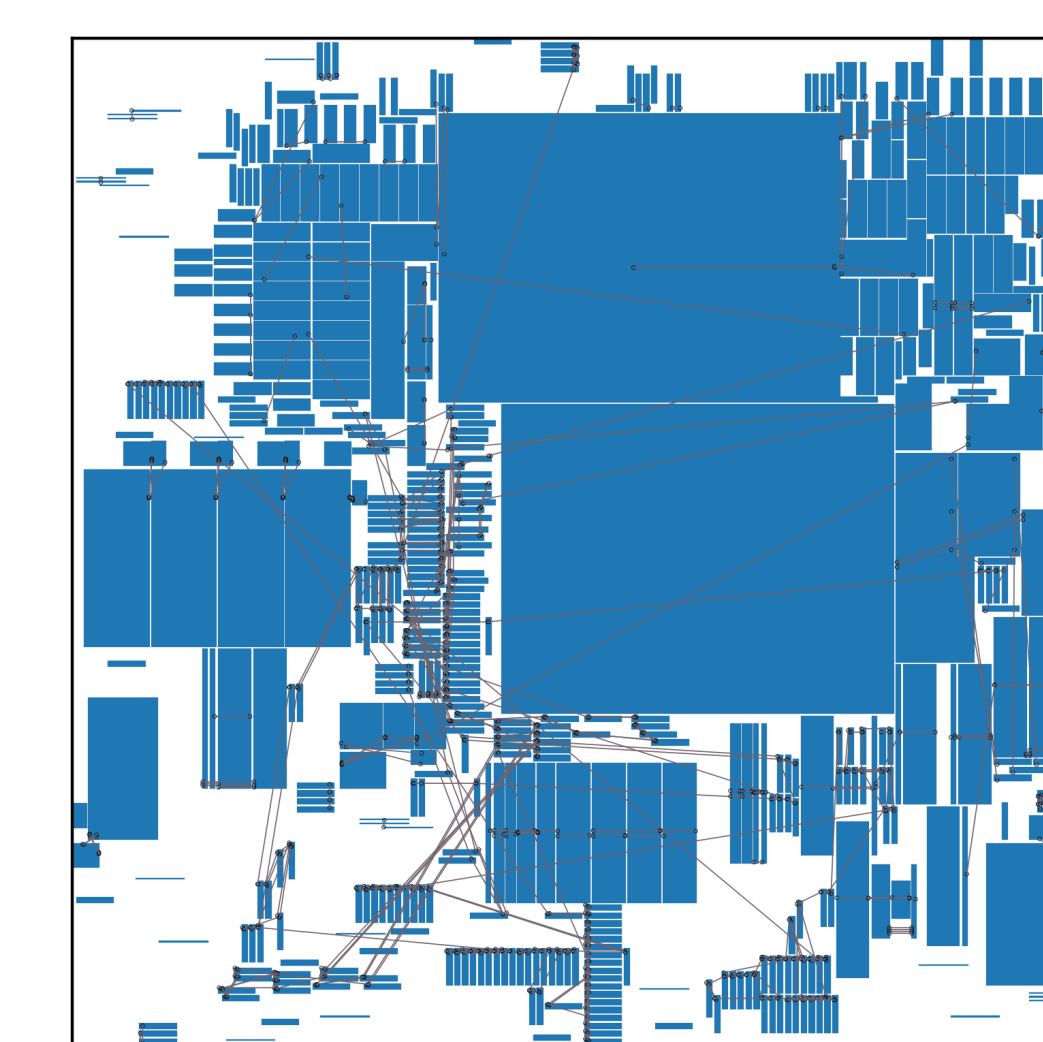
(b) EfficientPlace
HPWL = 43.35×10^5
Overlap = 0%

(c) RSPlace
HPWL = 38.00×10^5
Overlap = 0%