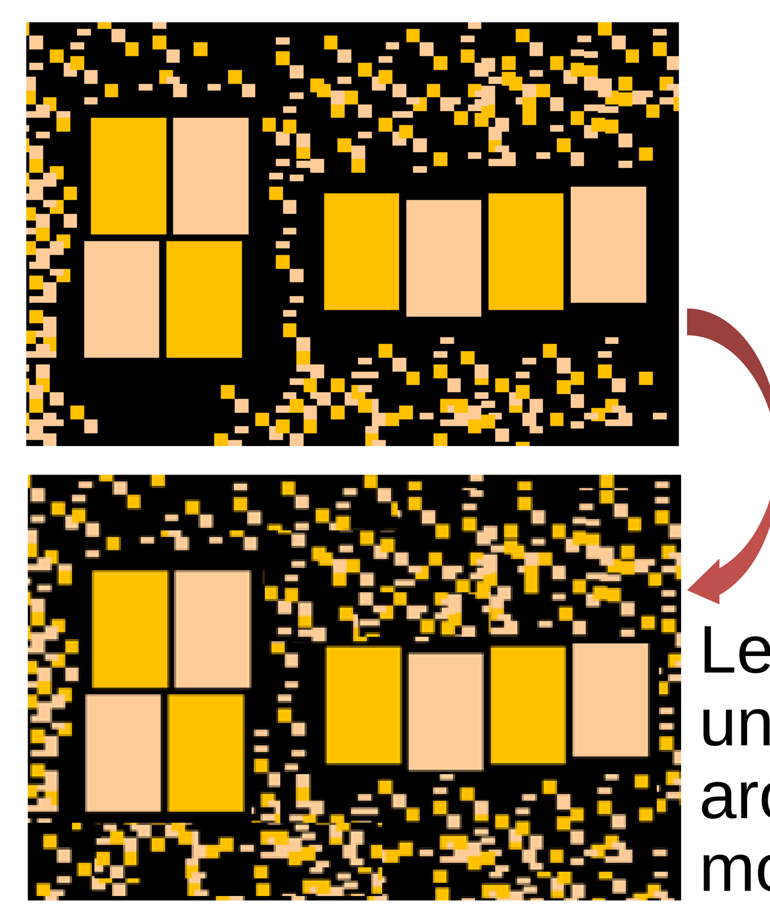
Global Placement Exploiting Standard Cell Merging Constraint for Effective Semi-Custom Design Optimization

1. Introduction

- Semi-custom sub-module designs enable great control over placement and based on understanding of dataflow, signal toggle, and power budget.
- Integration of these design into top-level design is challenging: fixed position and don't touch attribute constraints often degrade PPA.
- We propose **cell merging constraint** through **user-defined templates** to maintain design integrity while optimizing global placement objectives.

2. Challenges in calculation of merged sub-modules

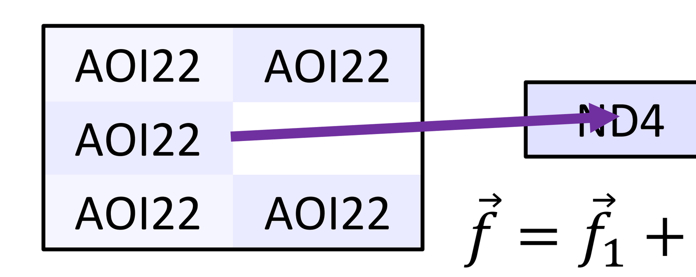
I: Excessive cell area
Calculate density of custom sub-modules by scaling them appropriately.



Less of unused area around sub-modules

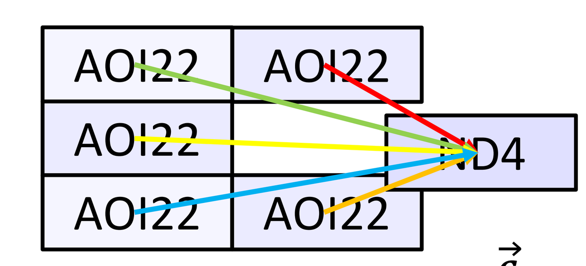
II: Irregularly shaped sub-modules
Sum up the density gradient force vectors of standard cells within the submodule.

scalar sum



$$\vec{f} = \vec{f}_1 + \vec{f}_2 + \vec{f}_3 + \vec{f}_4$$
$$= \vec{k}_1 A_1 + \vec{k}_2 A_2 + \vec{k}_3 A_3 + \vec{k}_4 A_4$$

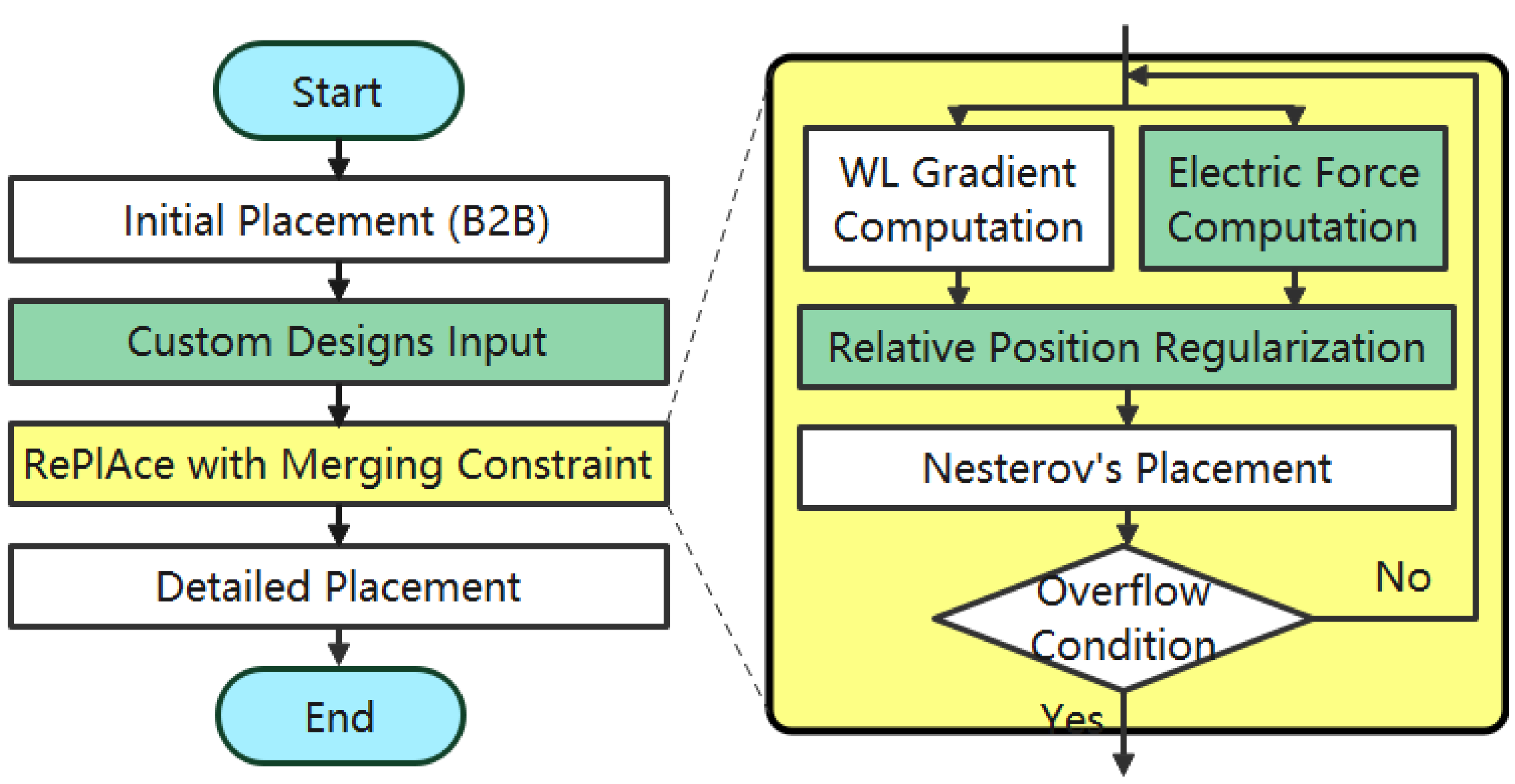
vector sum



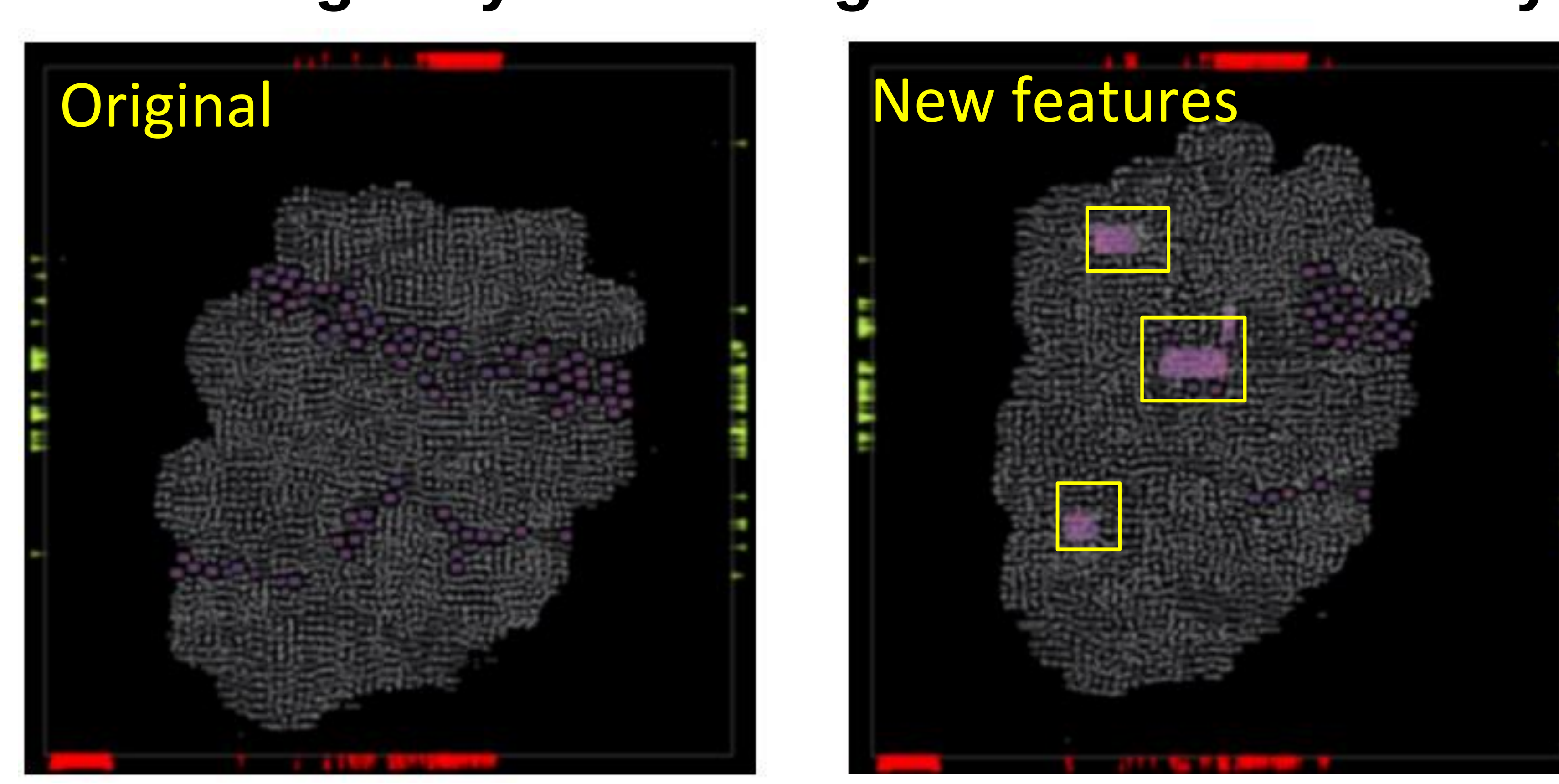
$$\vec{f} = \vec{k}(A_1 + A_2 + A_3 + A_4)$$

3. Implementation and results

- Work is implemented using OpenROAD-RePlAce
- Electric force is computed using vector sum
- Relative position regularization is applied



- The semi-customized registers are grouped into three sets
- Each set **maintaining its original design without any additional white space**
- The constraint has **minimal impact on the overall wire length**, while effectively improving **the local wire length by increasing the local cell density**



4. Summary

- **We merge cells** according to **user-defined templates**, while **maintaining their relative positions** throughout the entire placement process.
- This approach does not compromise the optimization of global placement objectives.
- This constraint results in minimal impact on overall wire length, but improves local wire length and density.
- As future work, we plan to add analysis methods to provide suggestions for customized consolidation templates.

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