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Modeling Sampling Strategy Optimization by Machine Learning Based Analysis

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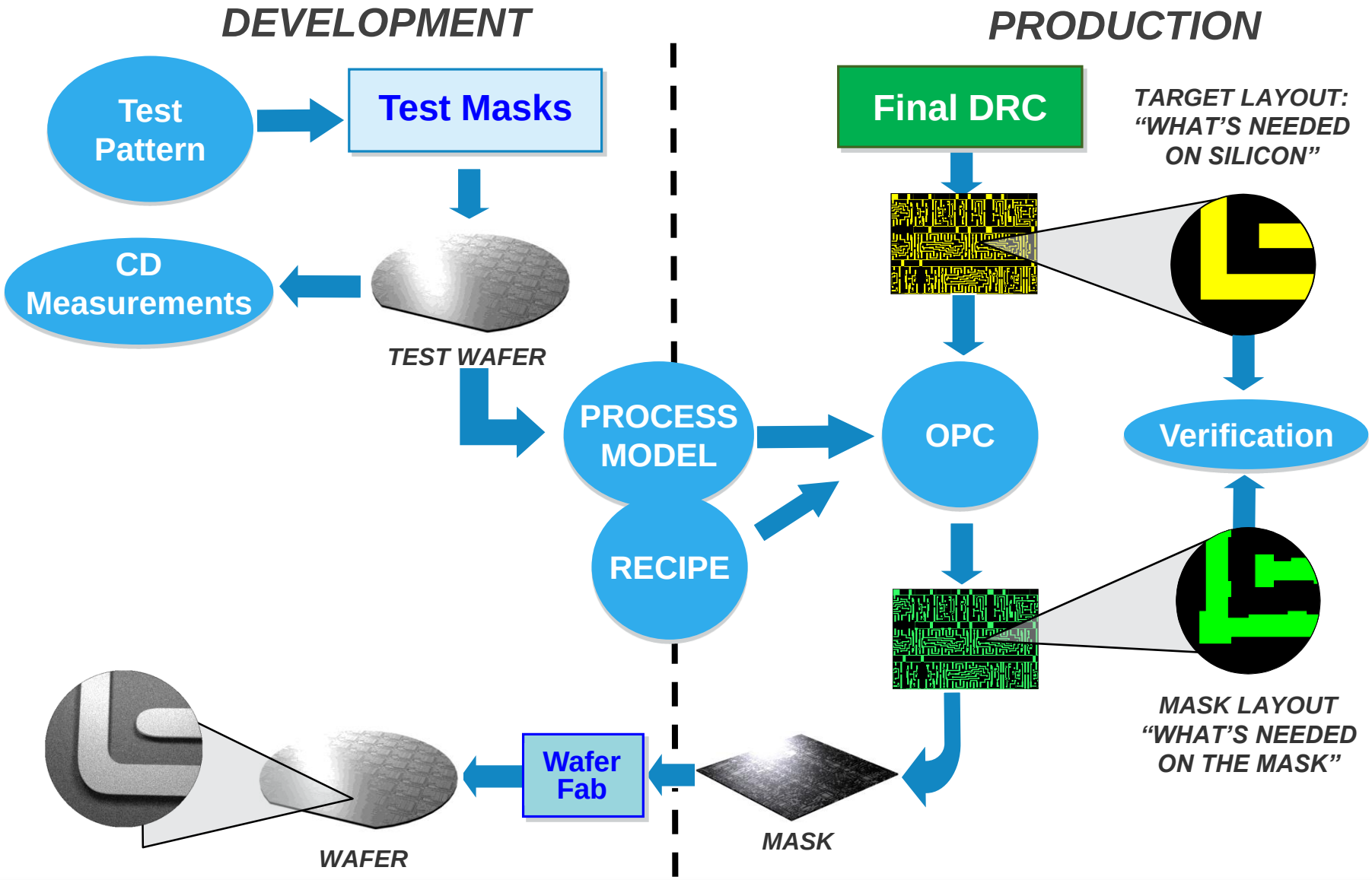
OPC modeling Manager, HFC

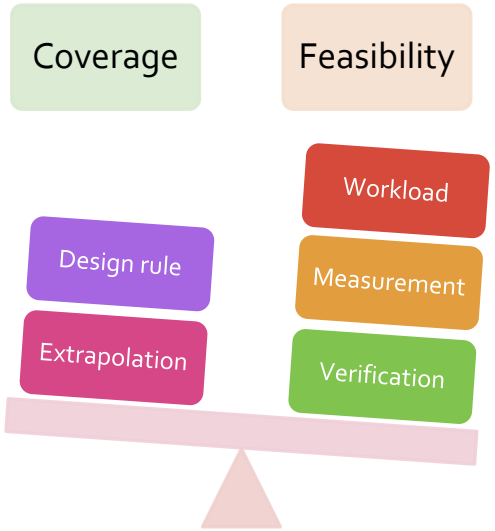
Model based OPC development flow



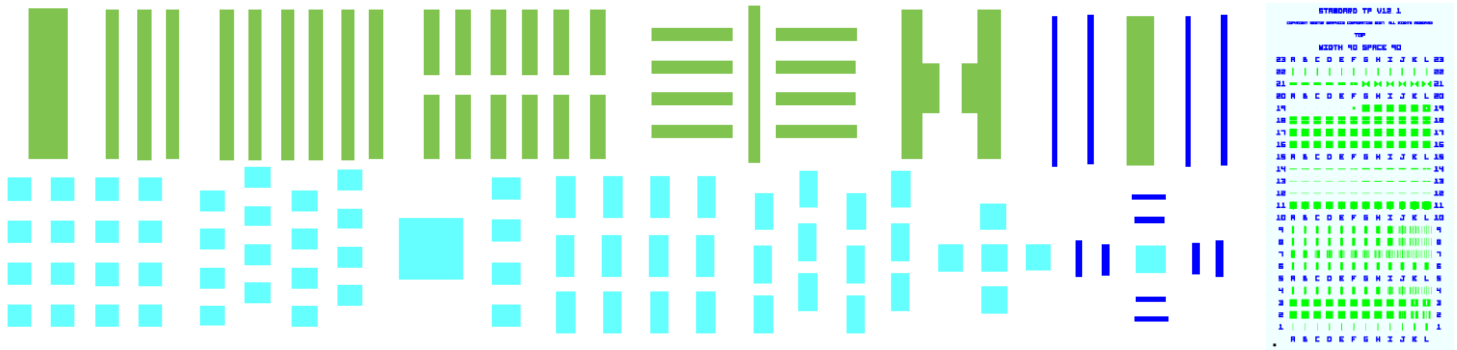
Model sampling is important

With node going to smaller, resist effects become more and more pronouncing, to pursue higher precision for smaller target

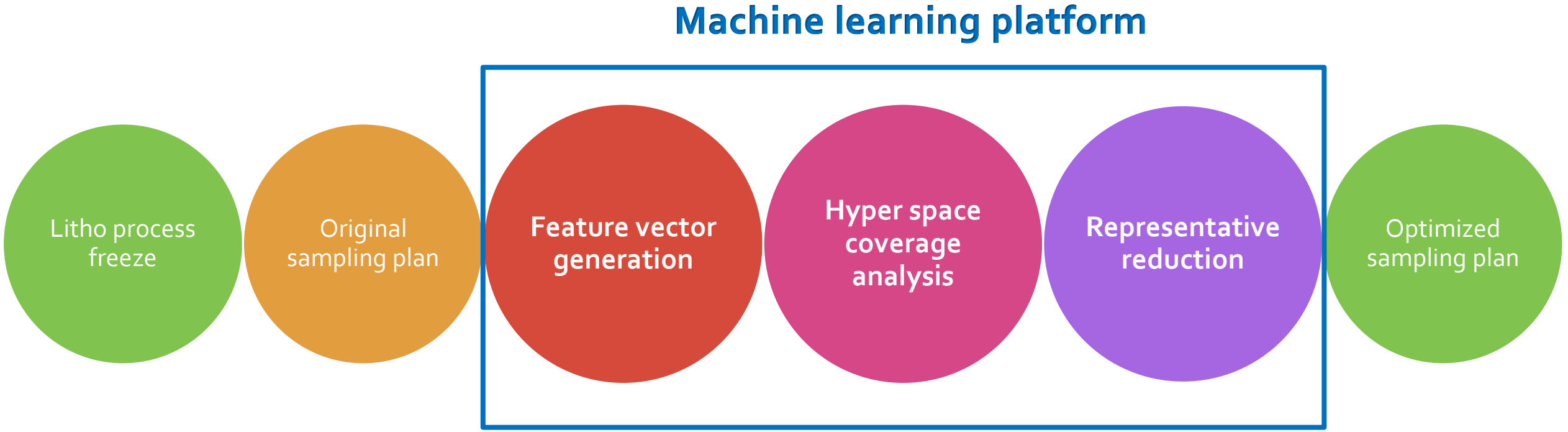
TP coverage becomes ever more important with higher accuracy and robustness requirements for OPC models



Traditional TP patterns

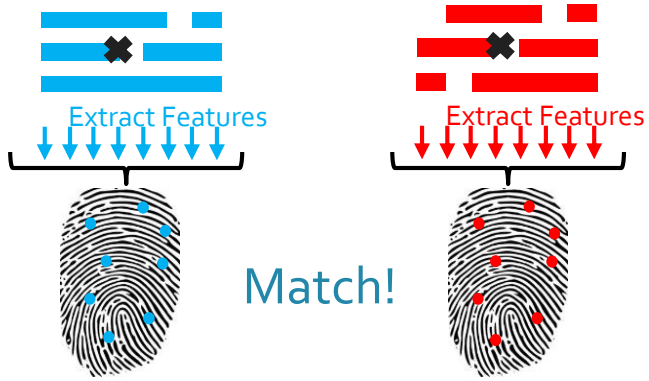


Model sampling strategy optimization



Feature vector generation

- Feature vectors are used to "fingerprint" a layout
- More than 100 feature vectors are used to describe a sample



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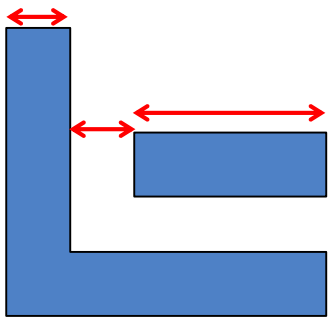
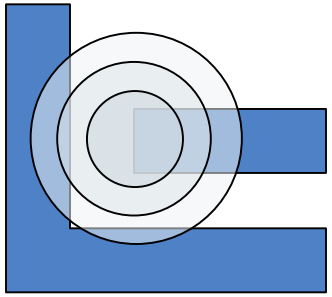
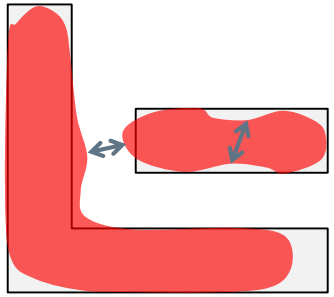


Layout
Dimension



Pattern
Density



Contour
Dimensions

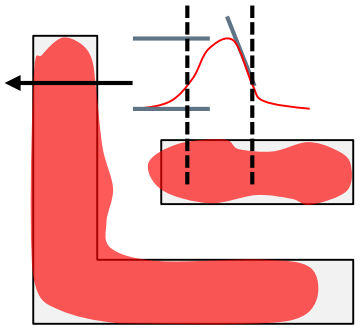
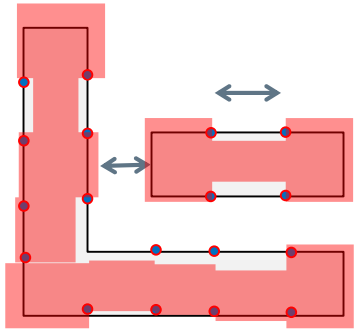
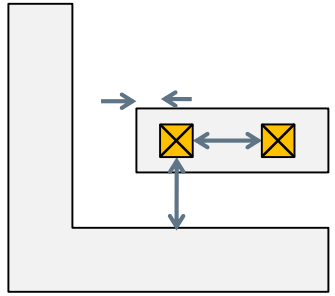


Image (Intensity)
Measurements



OPC Mask
Measurements



User-defined
Features, etc.

Hyper-space coverage analysis

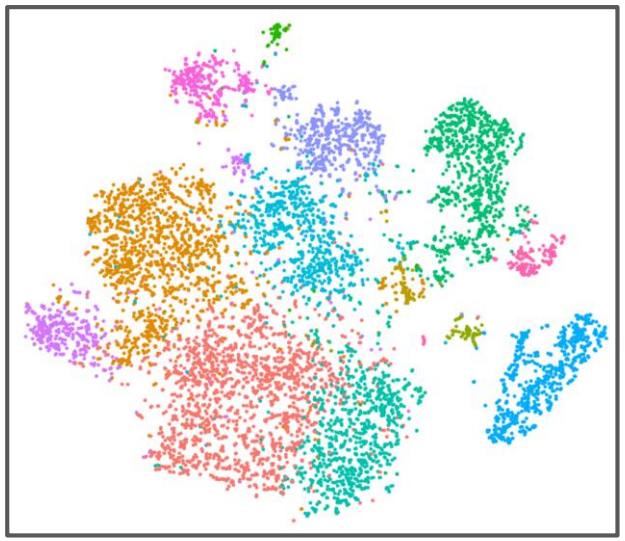
Basic idea for clustering [a]

–Clusters are dense regions in the data space, separated by regions of lower object density

–A cluster is defined as a maximal set of density-connected points

Feature vectors

Clusters

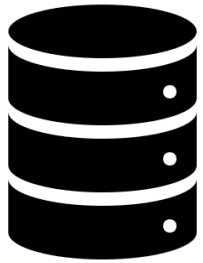


Visualized 2-dimension plot

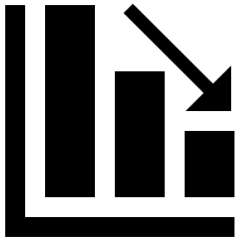
[a] K. Naqshbandi, T. Gedeon and U. A. Abdulla, "Automatic clustering of eye gaze data for machine learning," in IEEE International Conference on Systems, Man, and Cybernetics (SMC), Oct. 2016.

Representative reduction

Clusters

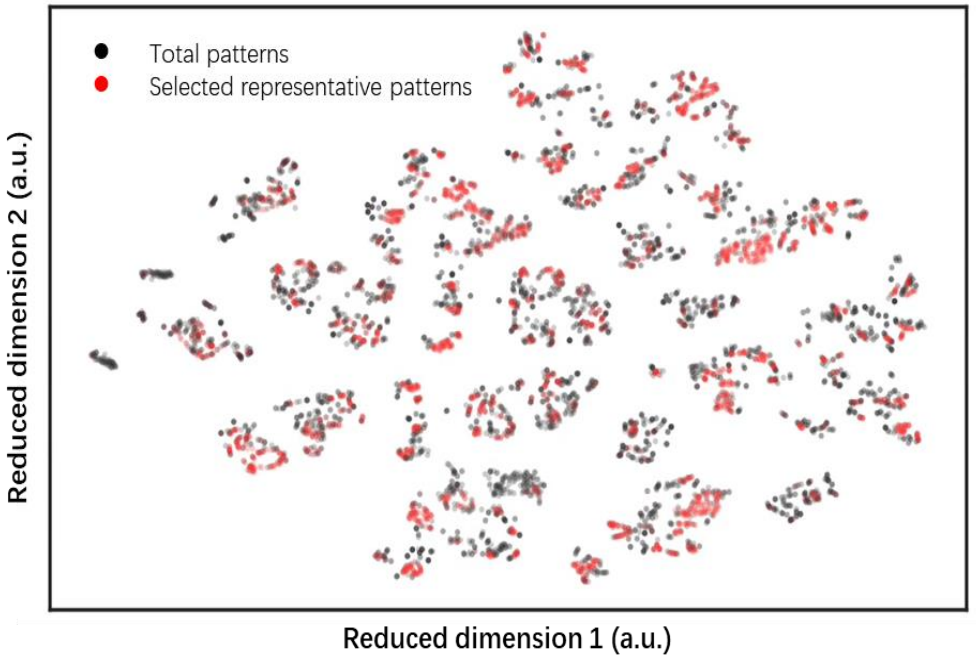


Ranking scores and selecting



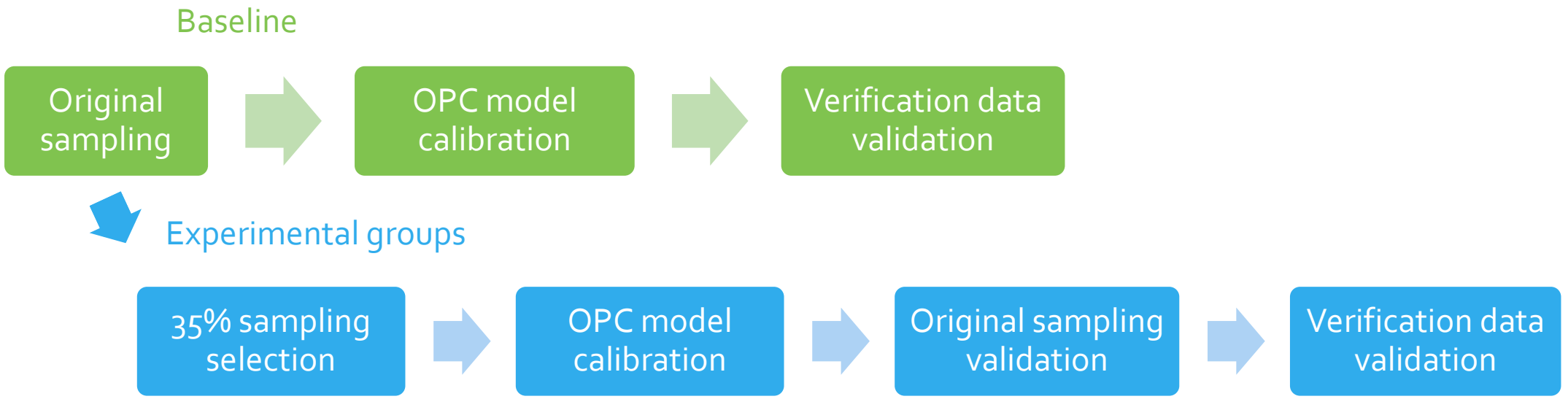
I. Scores tell how well the data represents its cluster.
II. Apply some linear transform on the scores for each cluster to make the top representative data more striking.
III. Top specified ranking data are selected as representative samples in whole data set.

2-dimension projection of hyperspace plot



Experiment design

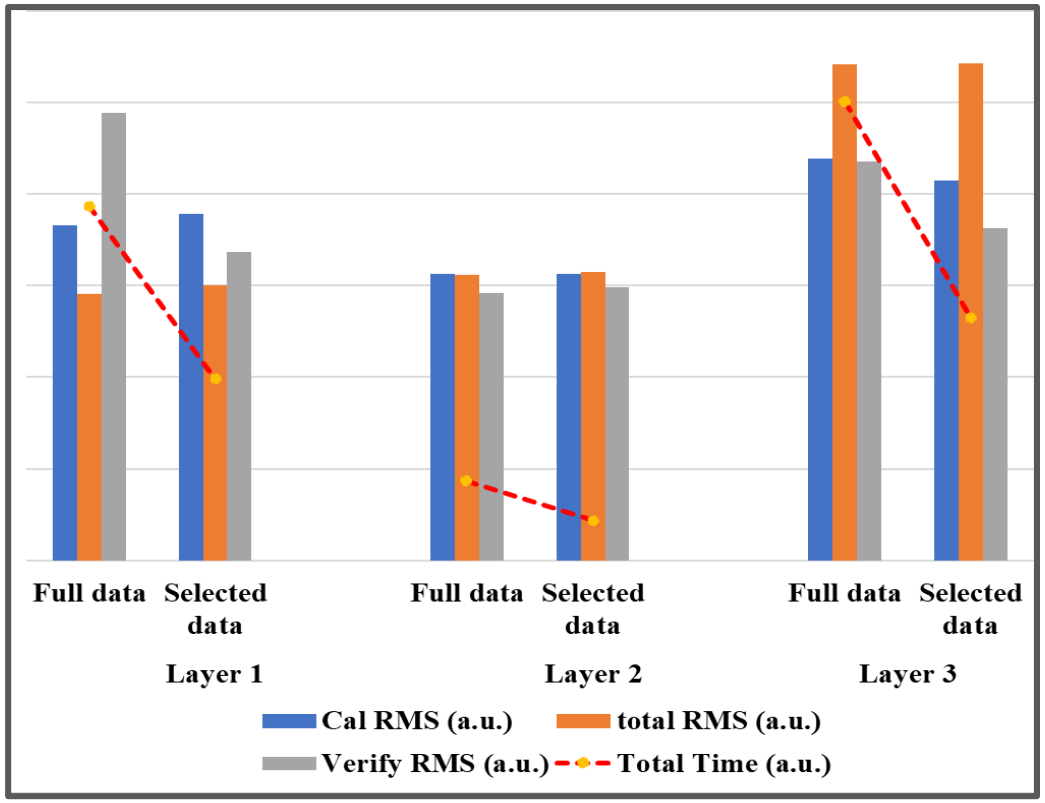
Experimented on three layers from advanced node device.



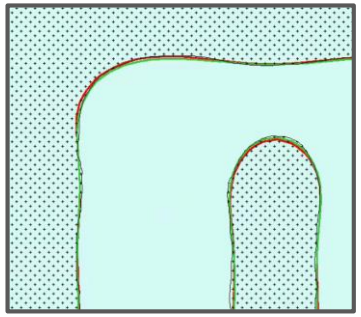
Experiment results

- Comparable OPC model quality.
- Comparable full data RMS and verification RMS for models built from 35% selected samples.
- Model tuning time is decreased by 50%.

OPC model building results from three layers on advanced node device



Comparable fitting



SEM contour

Simulation contours from:

Model built from full samples
Model built from 35% samples

Summary and future work

- The proposed methodology is proved to improve OPC model tuning cycle without sacrificing model accuracy and robustness.
- In the future, we will:
  - Apply to different layers & different nodes in model building process.
  - Find application in improving model coverage and robustness.

Acknowledgement

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Thank you !