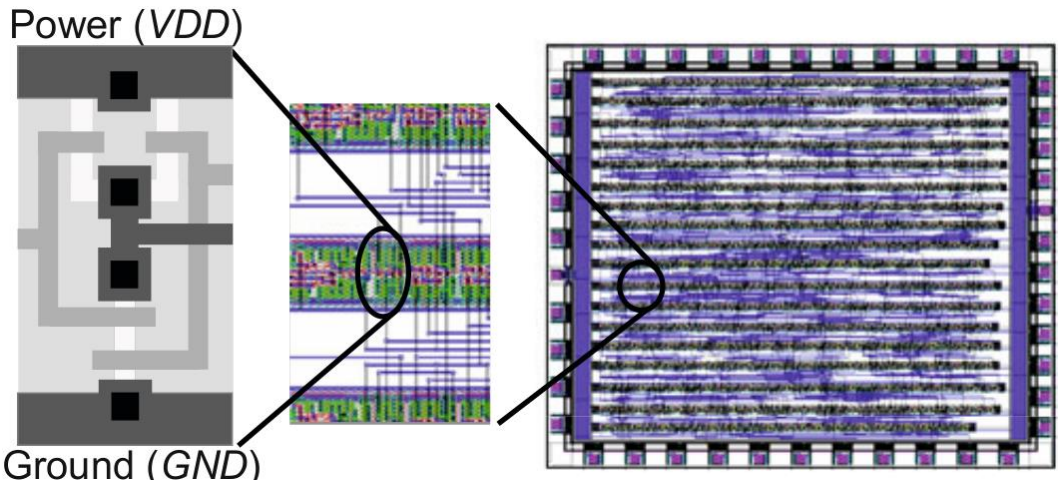
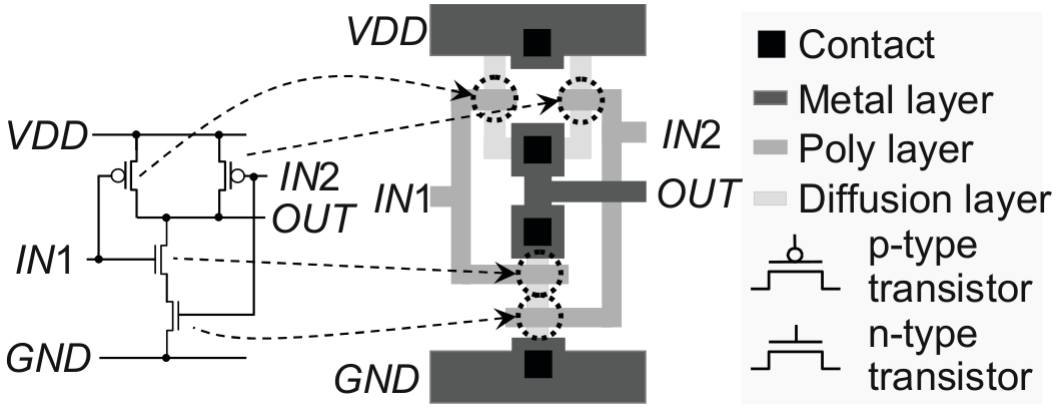
Automated 3D Integration

Research progress

What is in an IC?





2D is struggling and reforming

CMOS scaling

5nm in 2020, but at what cost?

ITRS restructed themselves to find alternatives

2D Future is manyfold

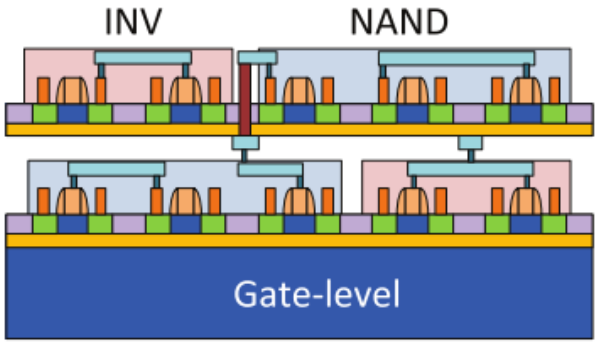
Keep scaling CMOS beyond its limits

3D integration

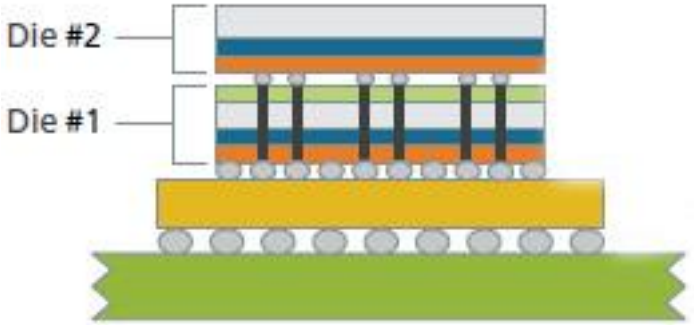
Quantum computing

3D wafer processing

Sequential: Monolithic

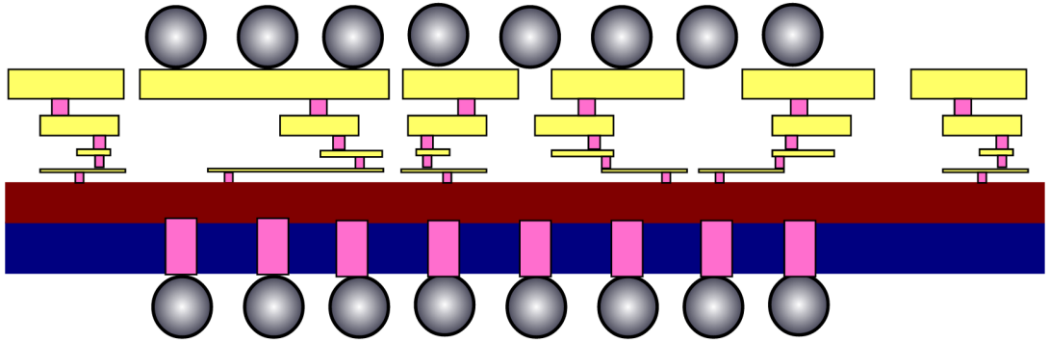


Parallel: Stacking



3D Stacking techniques

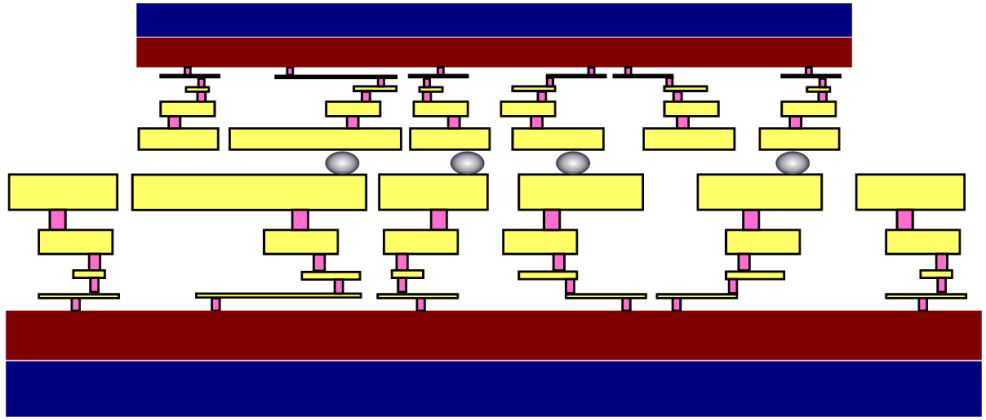
TSV, µ-bumps

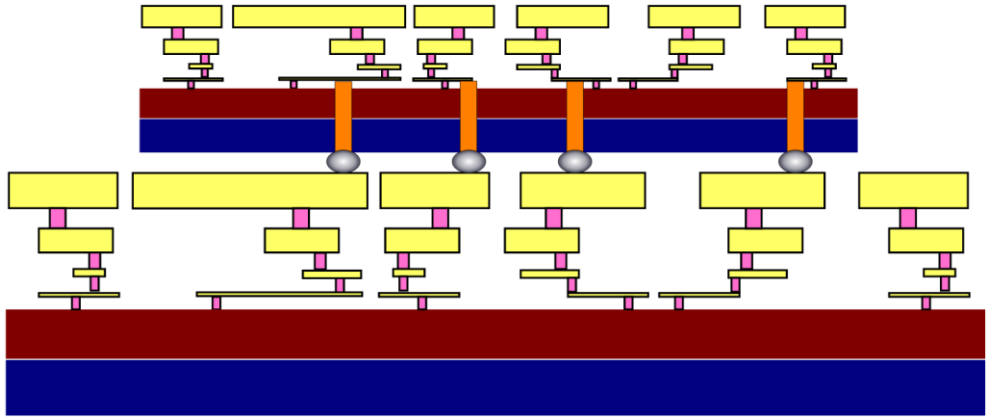


3D Stacking techniques

TSV, µ-bumps

F2F, F2B



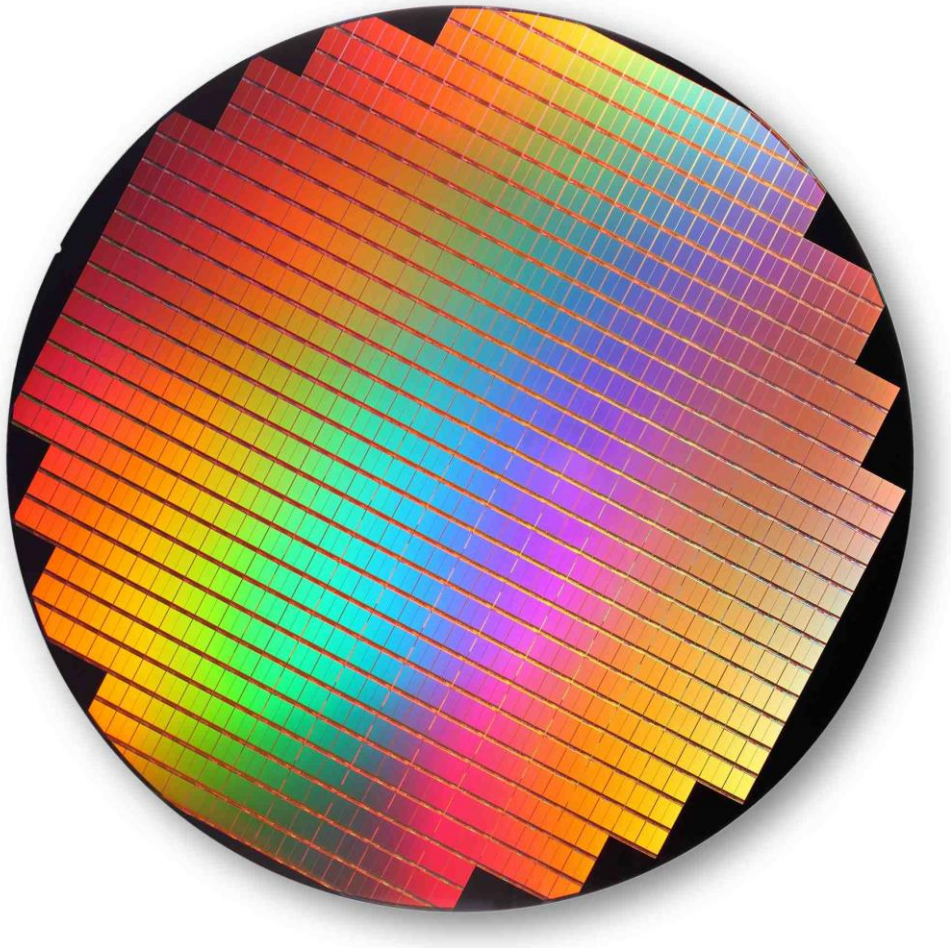


3D Stacking techniques

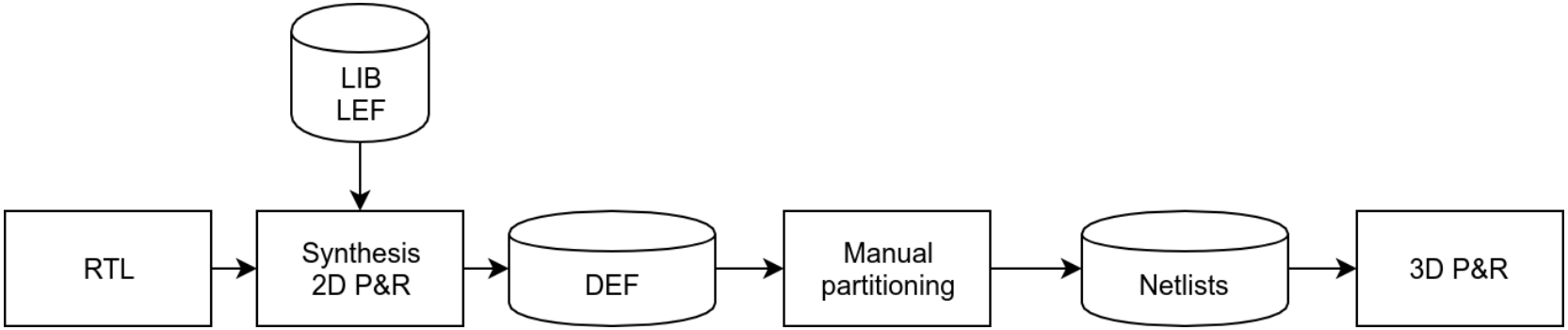
TSV, µ-bumps

F2F, F2B

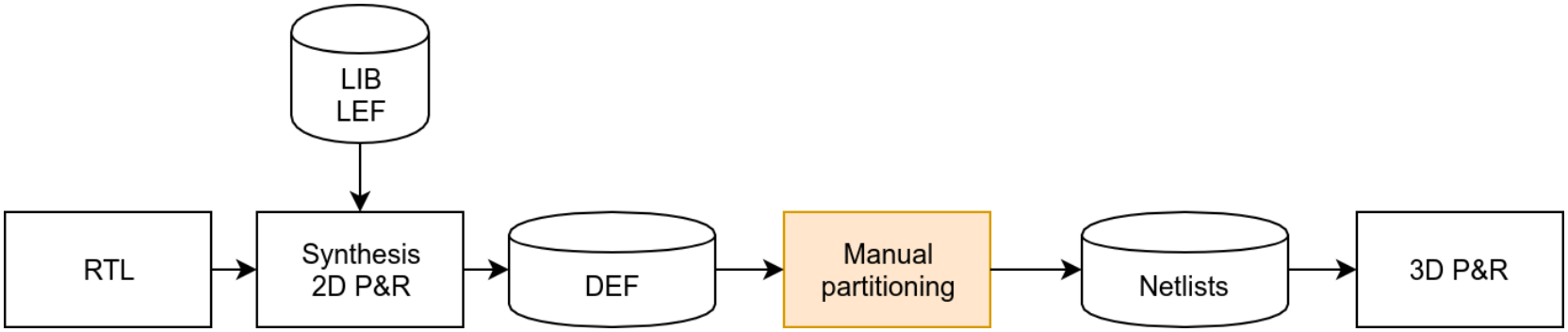
W2W, D2W, D2D



3D Flow


LIB
LEF
RTL
Synthesis
2D P&R
DEF
Manual
partitioning
Netlists
3D P&R

3D Flow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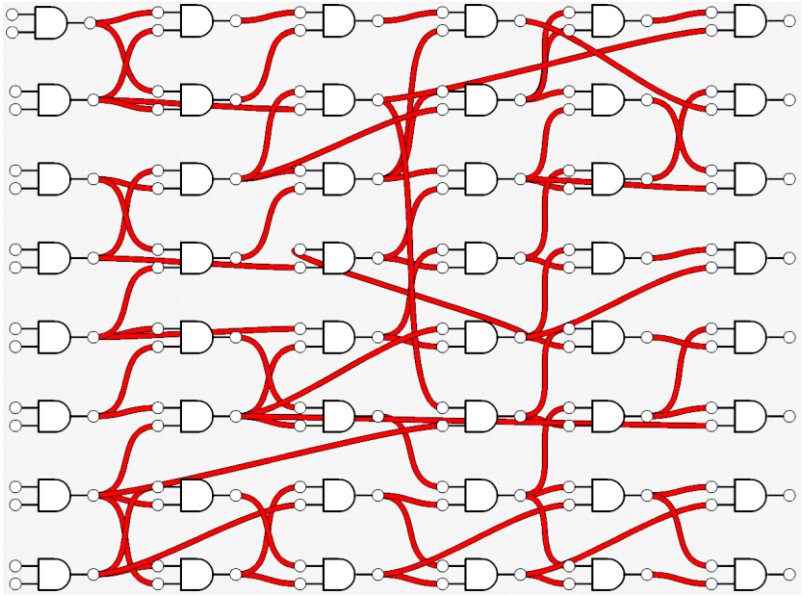
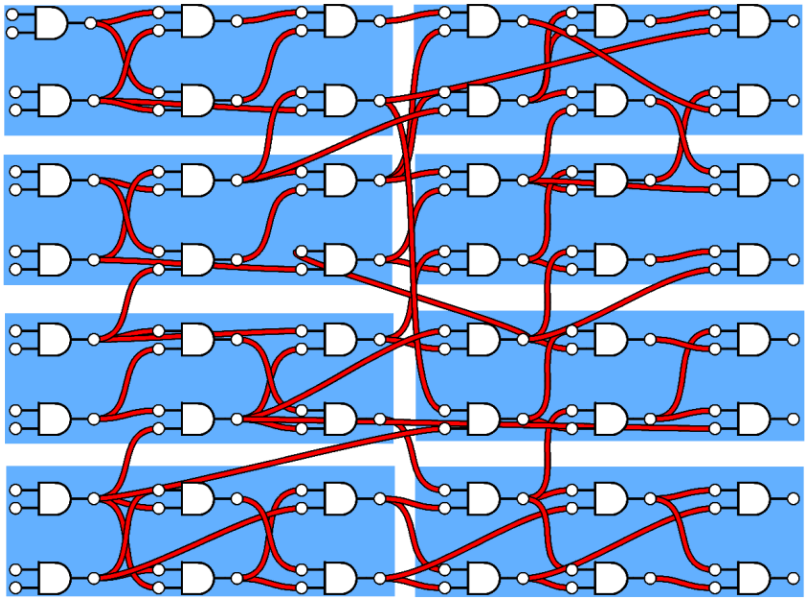
The problem

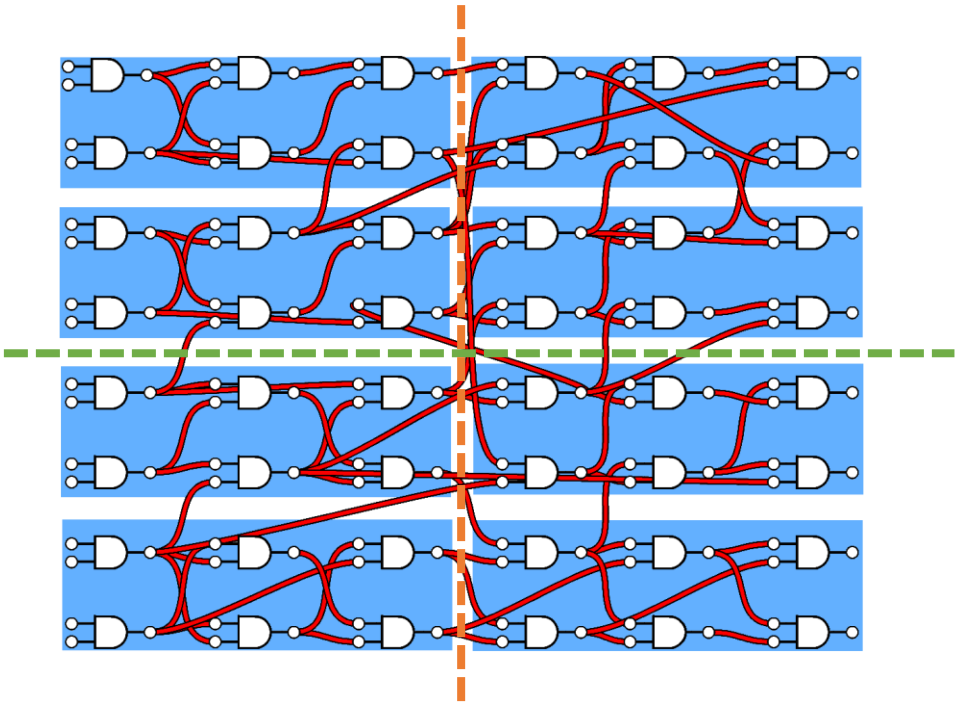


The problem



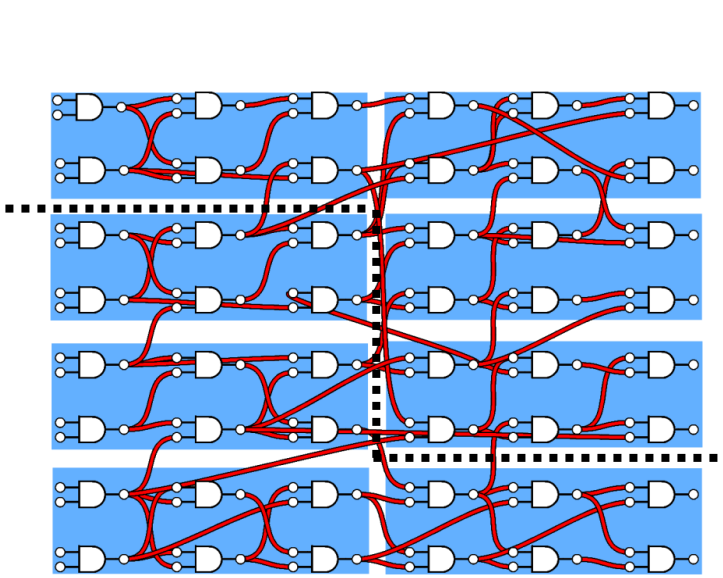
- How do we cluster?

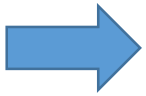
The problem

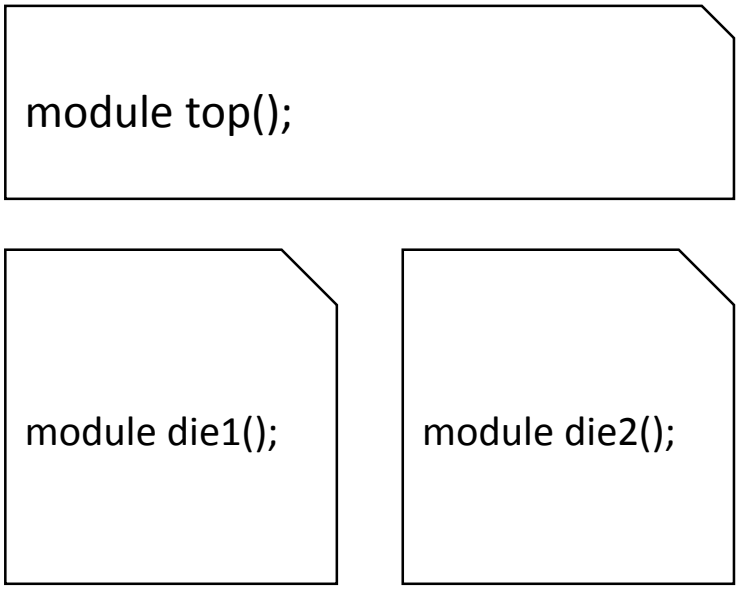


- How do we cluster?
- How do we partition?

The problem

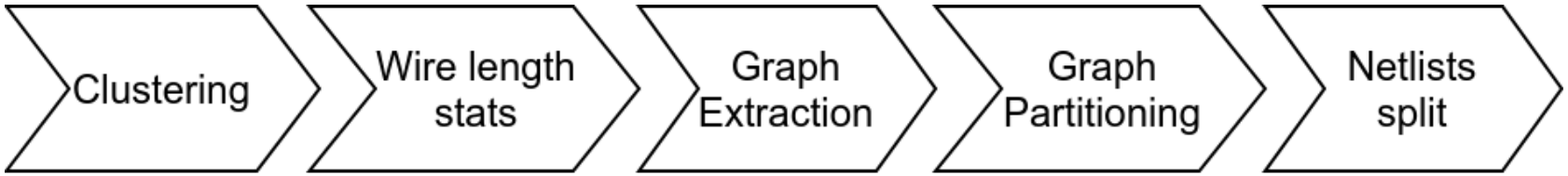




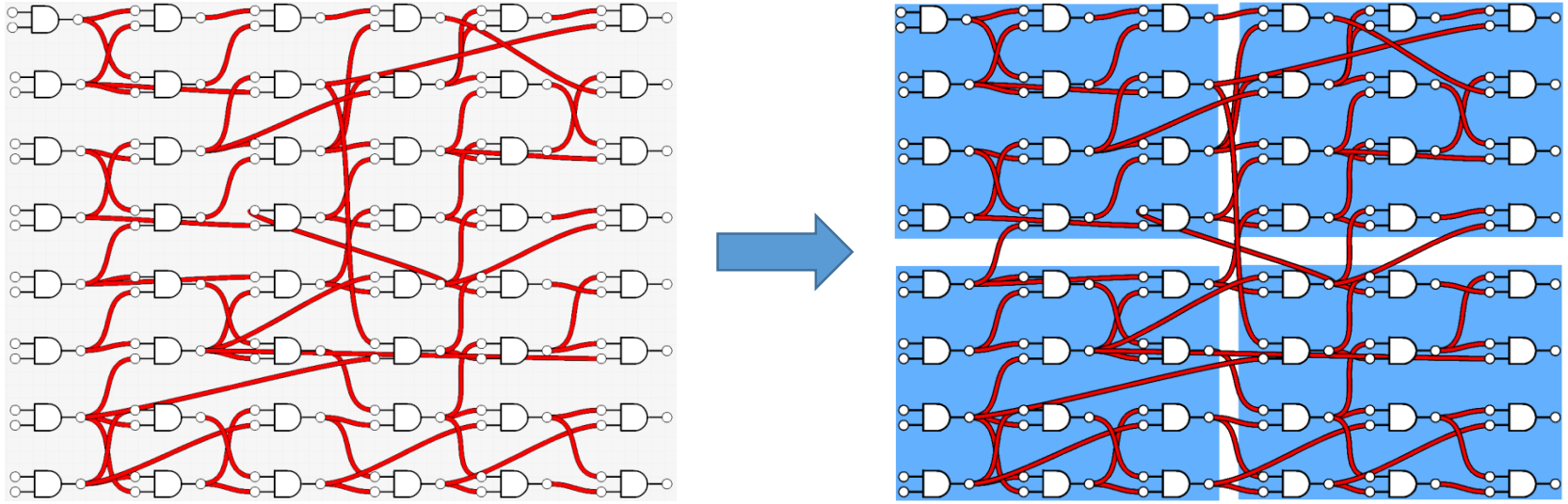


- How do we cluster?
- How do we partition?
- How do we generate the netlists?

Automate the partitioning



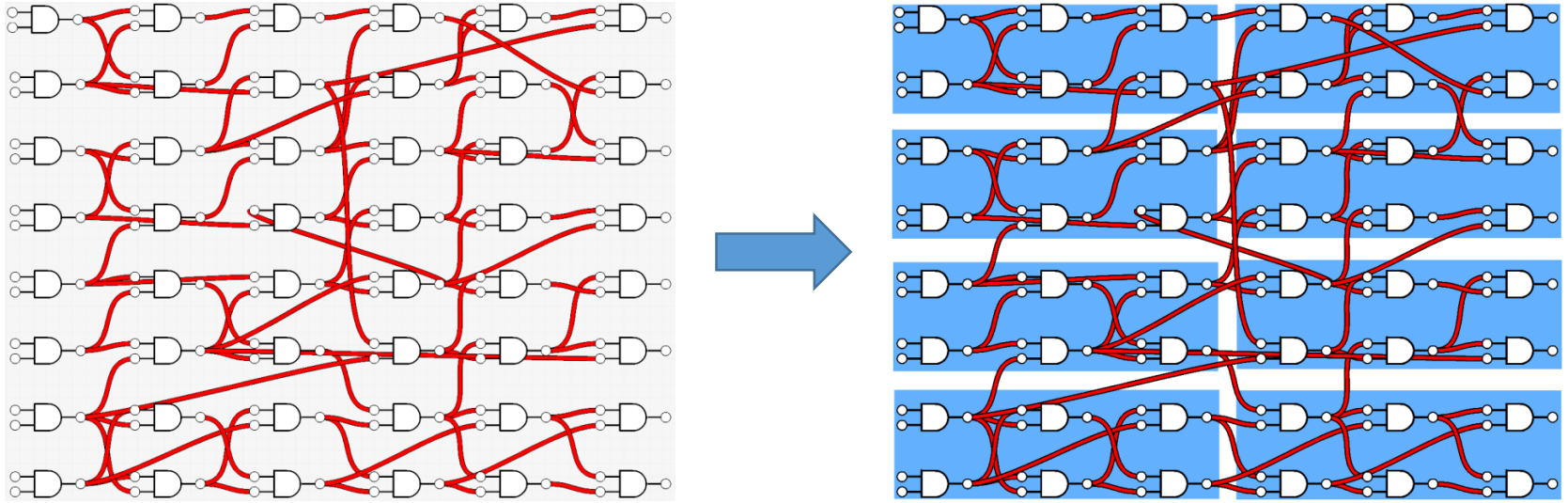
Choose the right clustering



Inter-cluster connectivity: 13 nets

Intra-cluster connectivity: 27 nets

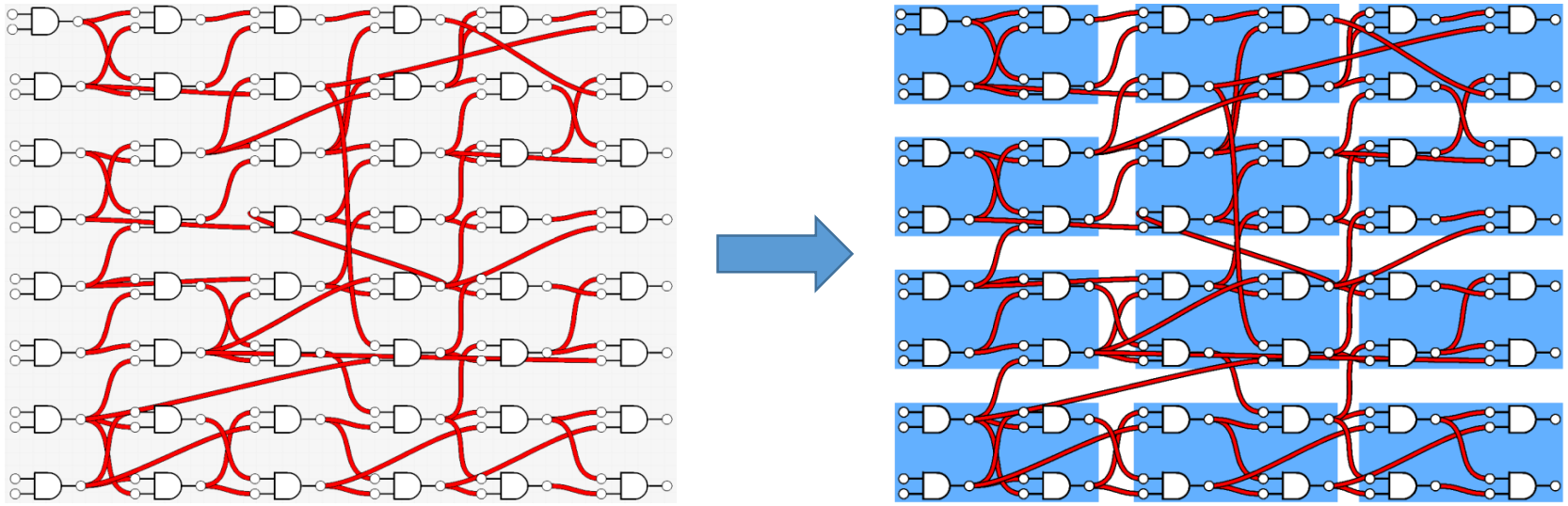
Clustering



Inter-cluster connectivity: 18 nets

Intra-cluster connectivity: 22 nets

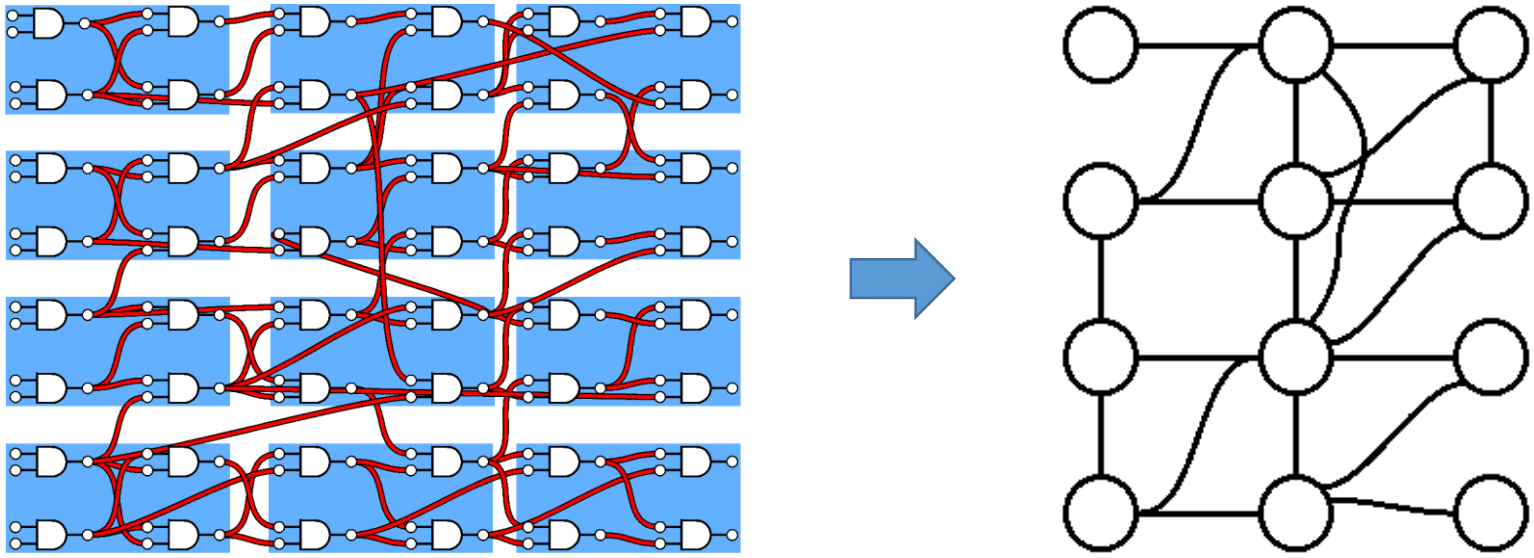
Clustering



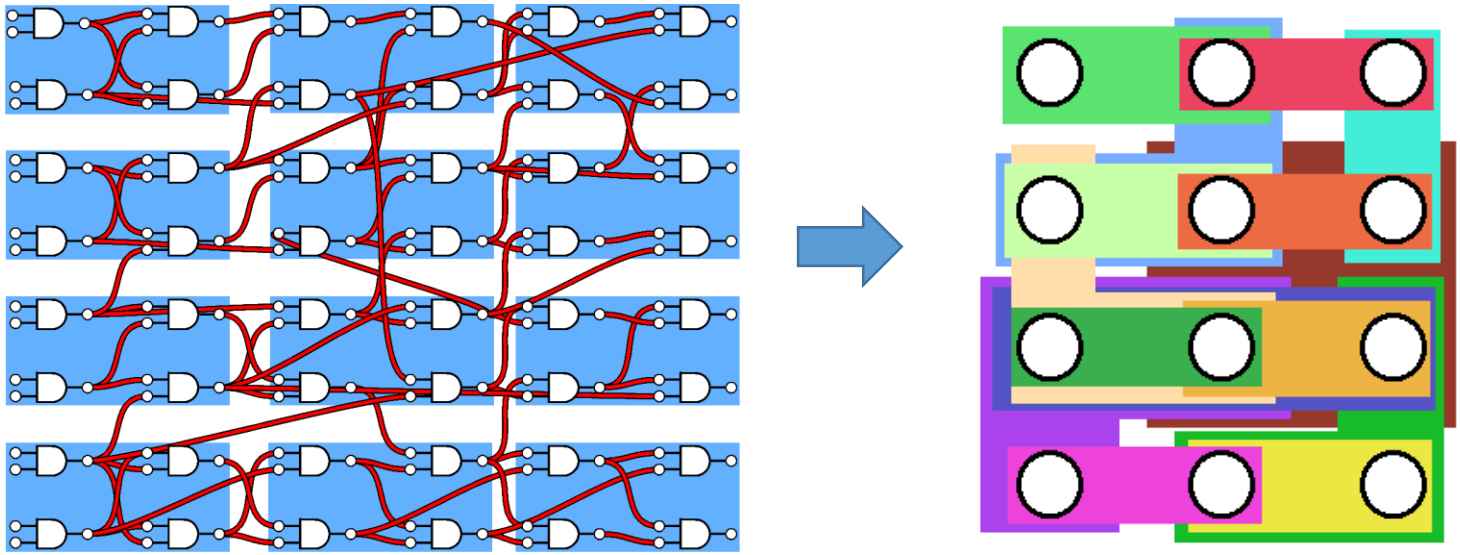
Inter-cluster connectivity: 27 nets

Intra-cluster connectivity: 13 nets

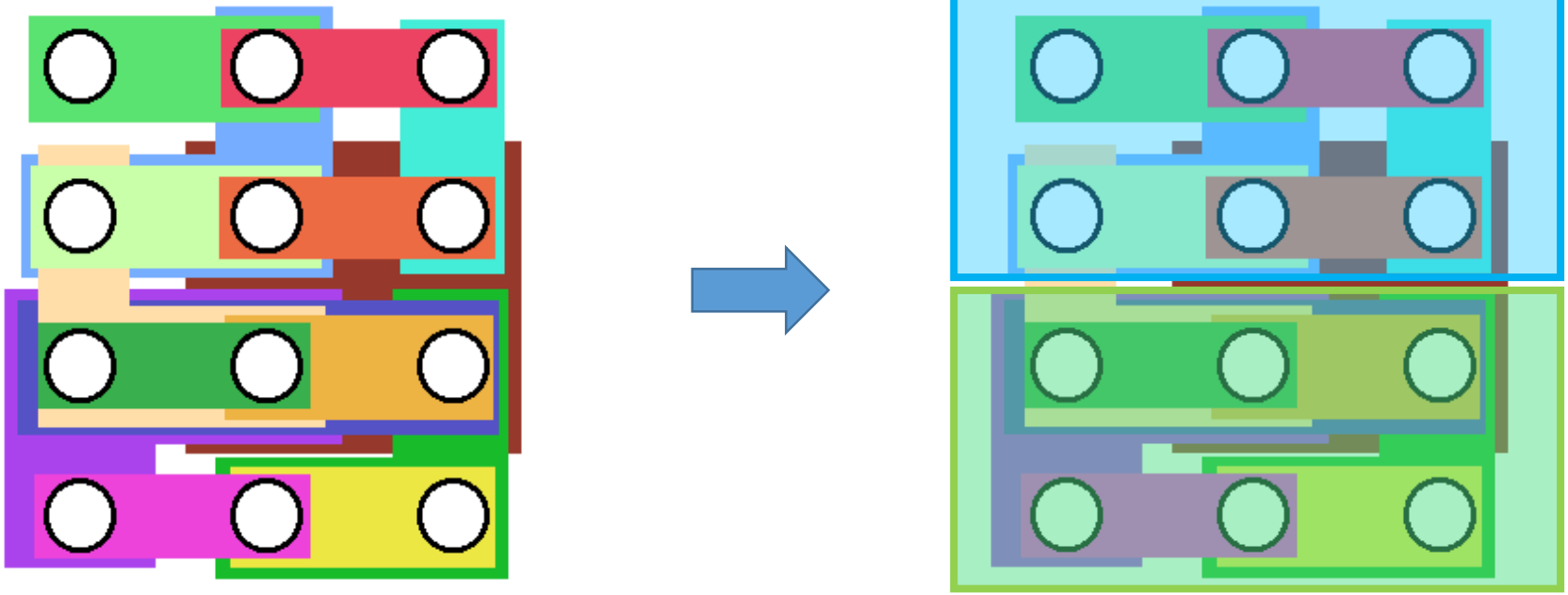
Graph extraction



Hypergraph extraction

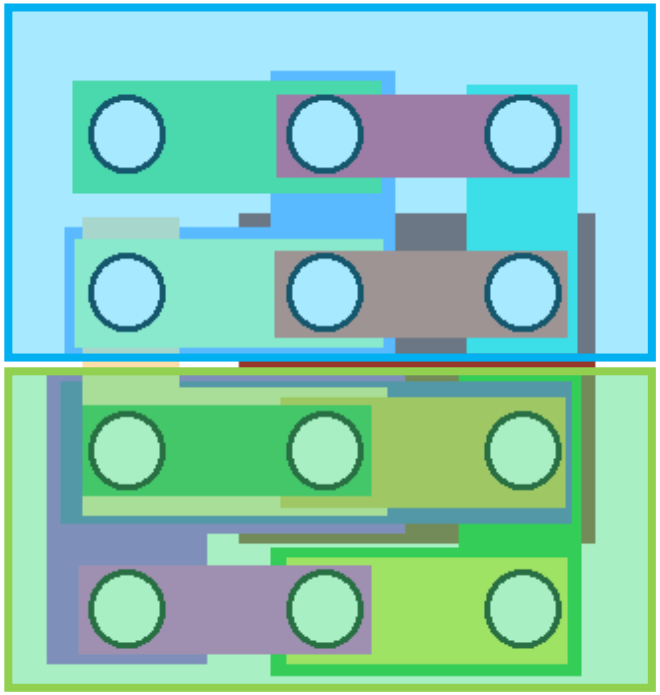


Partitioning



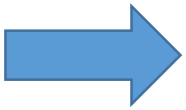
Split the netlist

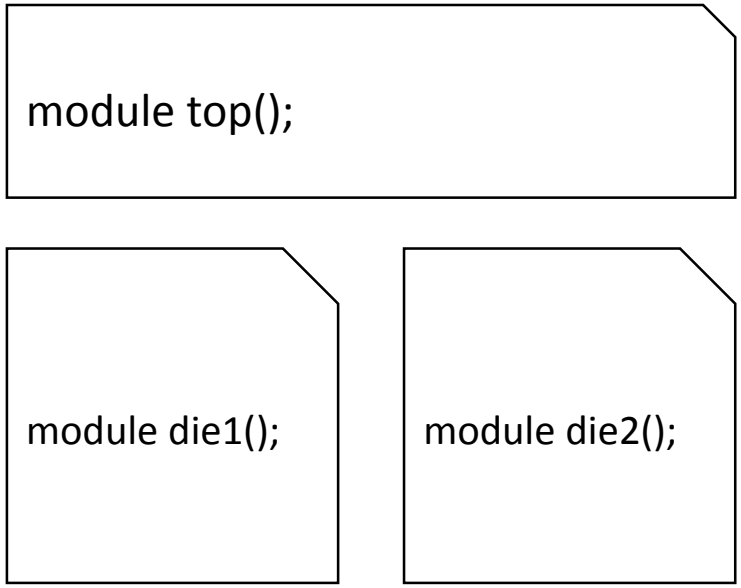
Die 1



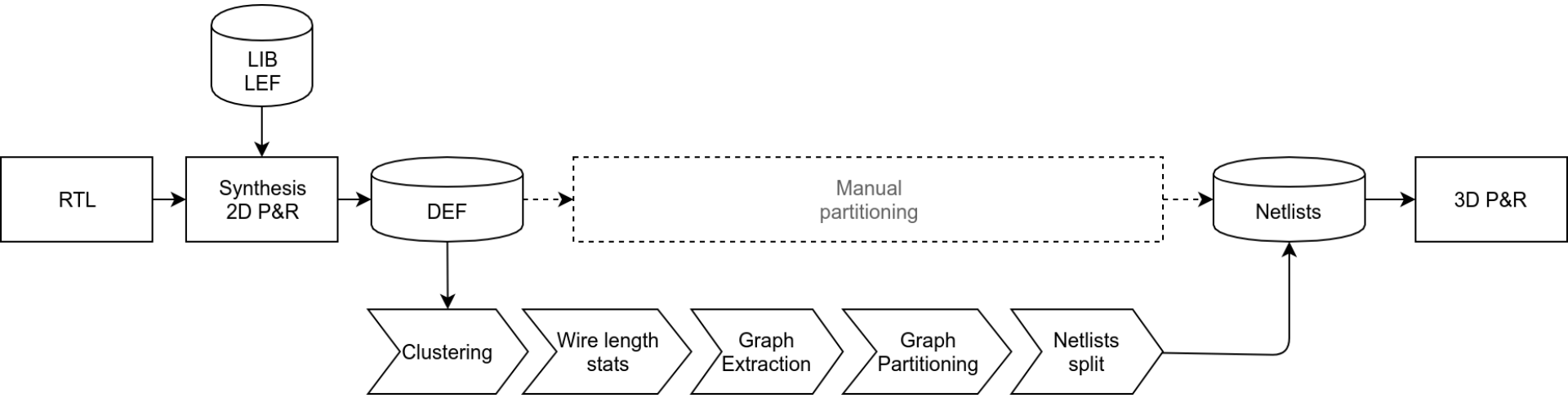
Die 2

?





New 3D flow


LIB
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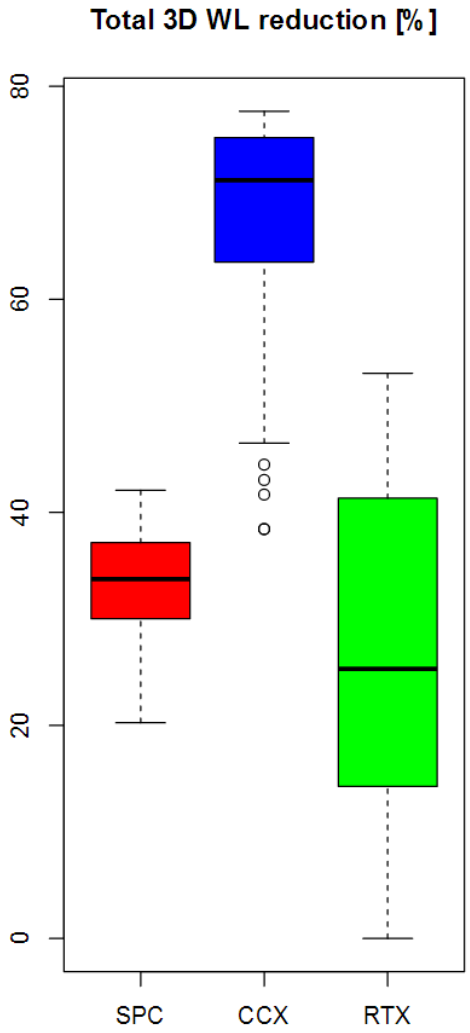
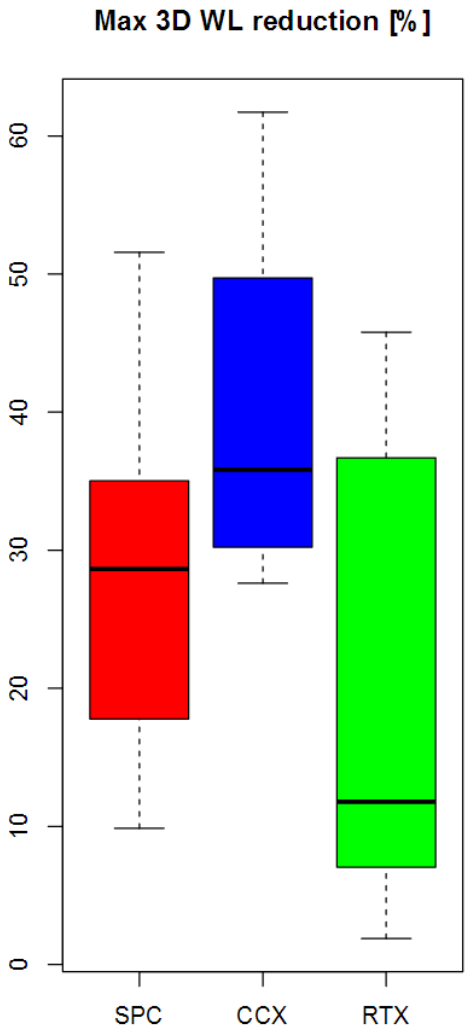
Wire length
stats
Graph
Extraction
Graph
Partitioning
Netlists
split

Up to 77% save in 3D wire length

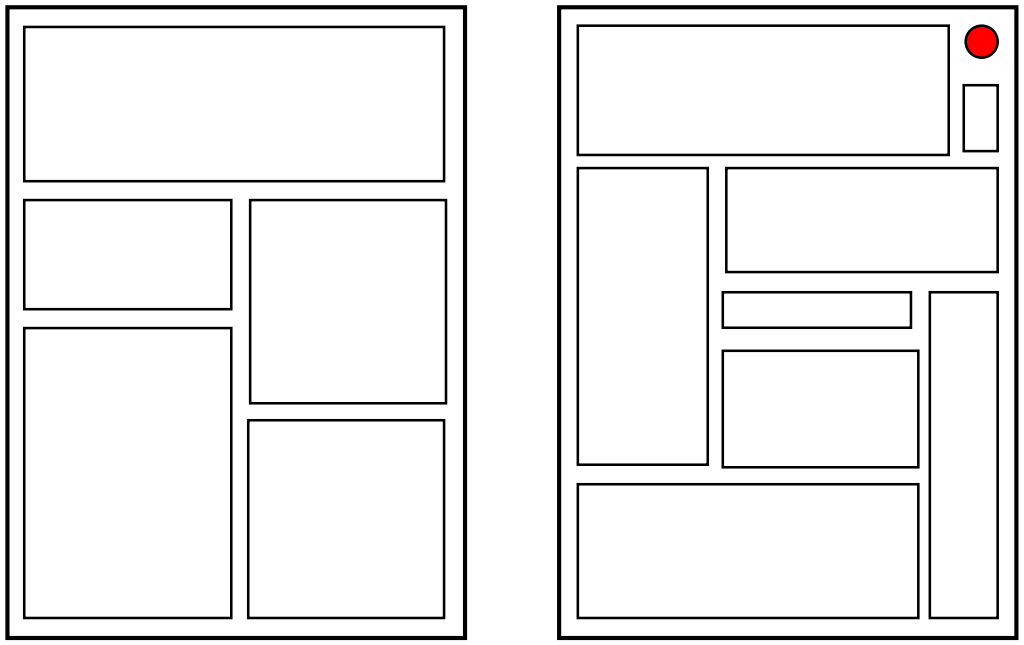


Up to 61% in critical path reduction



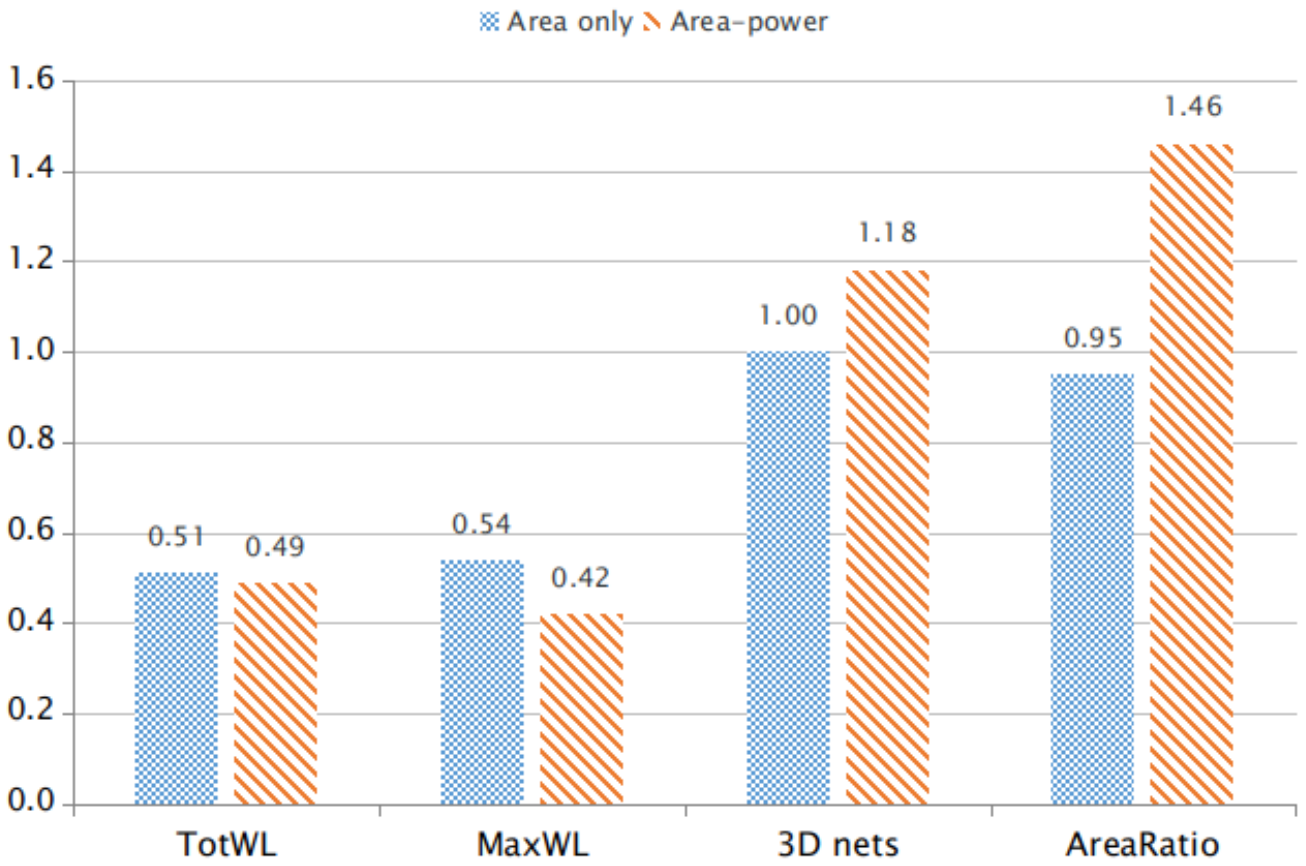
Asymmetric partitioning

How to trick the partitioner

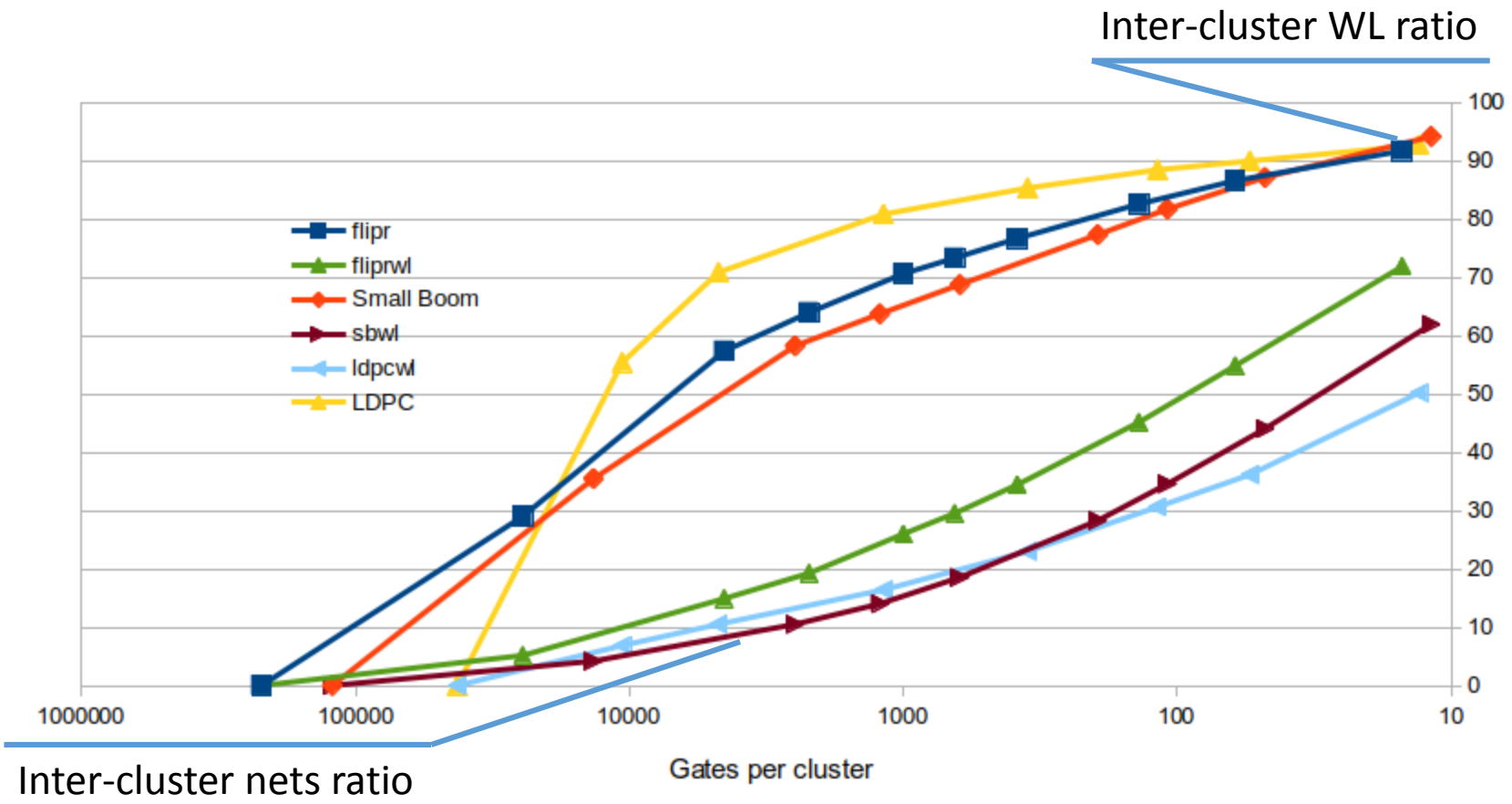


Dummy node with no area impact, but high power

Unwanted area disbalance



Clustering grain: Target 1000 gates



Smaller clusters

Next steps

Test other clustering methods

Netlist split

Various software improvements

Publication plan

Optimal cluster size for 3D integration

Clustering methods review: what is the best, should it be taken lightly?

Long term

Clustering and partitioning methods collection

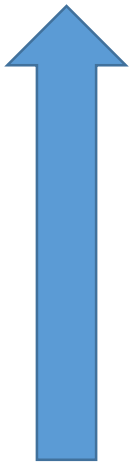
Cadence integration is risky, → alternative?

Netlist partitioning, how to publish?

3D integration comparison: monolithic vs stacking

Probabilité

Impact



	Faible	Moyenne	Elevée
Intolérable		Perte de licence	
Préoccupant	Perte du partenariat avec IMEC	Sujet obsolète	Outils libres inadéquats
Négligeable		Article refusé	