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Session 2C-2
Floorplanning

Constraint-Free Analog Placement with Topological Symmetry Structure

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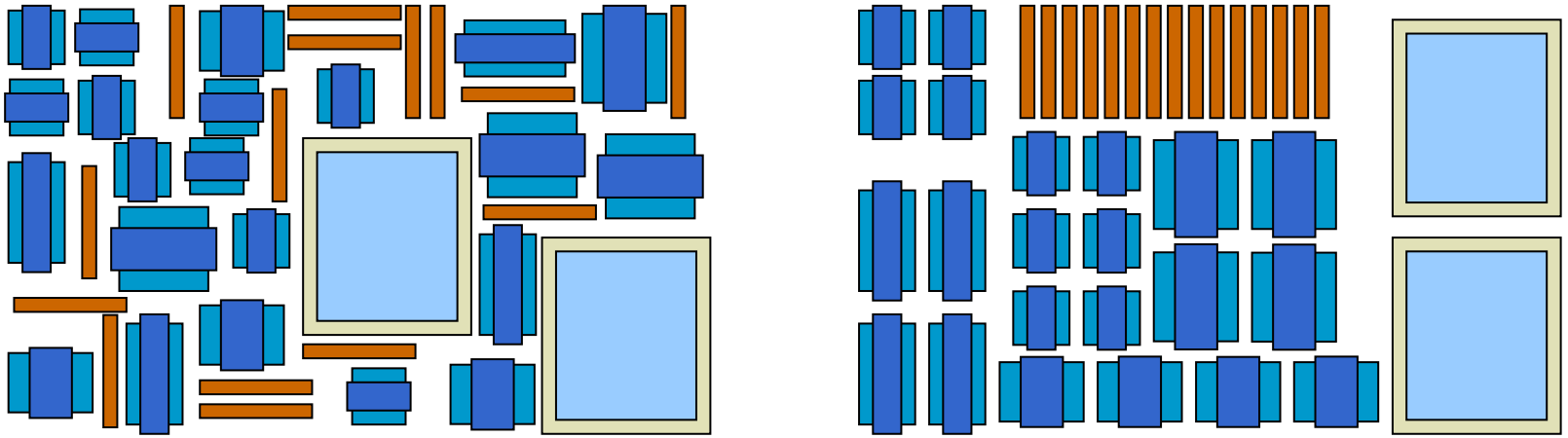
Outline

1. Analog Placement
2. Constraint-Free Analog Placement
3. Topological Symmetry Structure
4. Symmetry-Oriented Optimization
5. Experiments
6. Conclusion

Analog Placement(1)

Placement should be not just well packed, but also should include analog-specific features such as *regularity*.

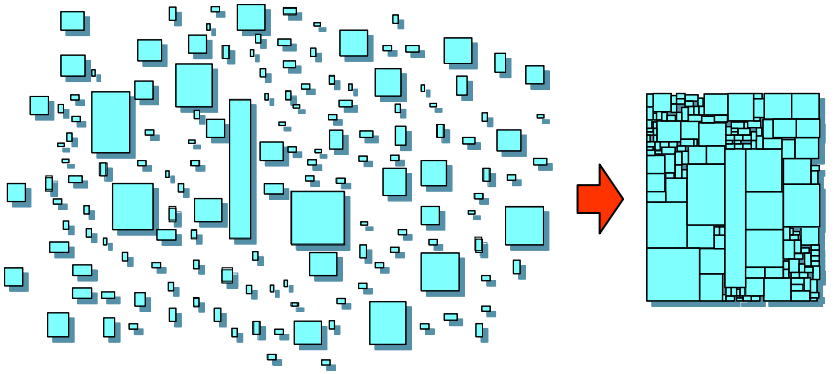


Which one is more preferable for analog circuits?

Typical analog placement has local regular structures
The regular structures serve high routability and suppression of variation on performances

Analog Placement(2)

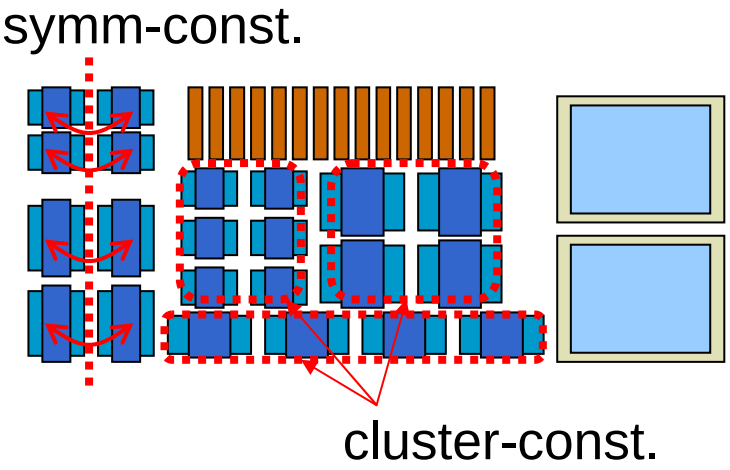
- **Rectangle Packing Approach**
  - Devices and blocks are regarded as rectangles
  - BSG, Sequence-Pair, O-tree, B*-tree, TCG-S can generate highly compacted placement



BUT, less regularity

- **Constraint-Driven Approach**
  - Symmetry/Cluster constraint

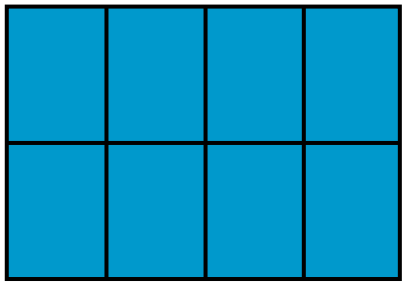
BUT, generation of constraint is still manual and time-consuming



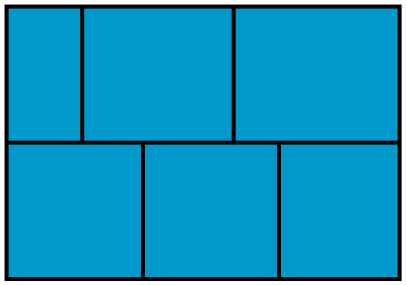
Automation of analog placement is immature

Structure of Placement

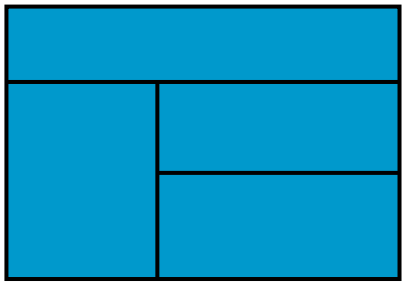
- Structures of placement can be classified into ***array, row, slice, room-base***, and ***object-base***.



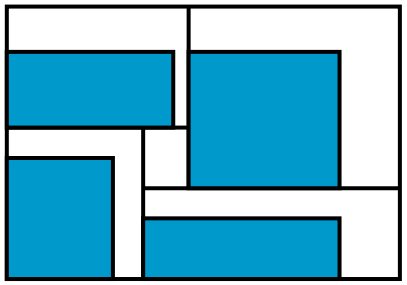
array



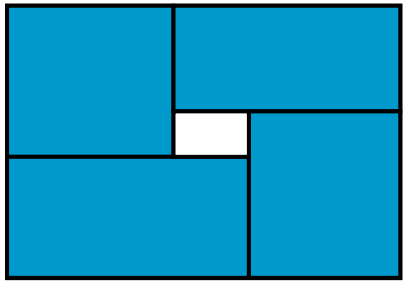
row



slice



room



object

- Strength of Structured Limitation:

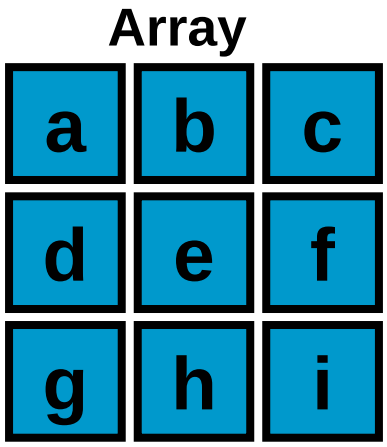
array>row>slice>room-base>object-base

- Freedom:

object-base >room-base>slice>row >array

Structure in terms of SP&SS

structure	*sequence-pair*	*single-sequence*



$$\Gamma_+ = \text{abcdefghi}$$

$$\Gamma_- = \text{ghidefabc}$$

$$SS = 789456123$$

[22] proposed method to extract subsequences from *SS* (or *SP*) corresponding to arrays or rows;

How to formulate symmetry structures?

[22]: Structued Placement with Topological Regularity Evaluation, ASPDAC 2007.

Constraint-free Placement with Symmetry Structure

- Concept
  - **Constraint-free**
  - **Naturally going** to a placement with global symmetry structure and many local regular structures such as arrays and rows.
- **OUR APPROACH**
  - **Formulating initial placement** that is topological symmetry.
  - **Evaluating the regularity&symmetricity** during optimization.
  - **Symmetry-Oriented** optimization.

Single-Sequence (SS)

Representation of **ONLY TOPOLOGICAL STRUCTURE** of Rectangle Placement **[20]**
(*SS* is standard representation of *SP.*)

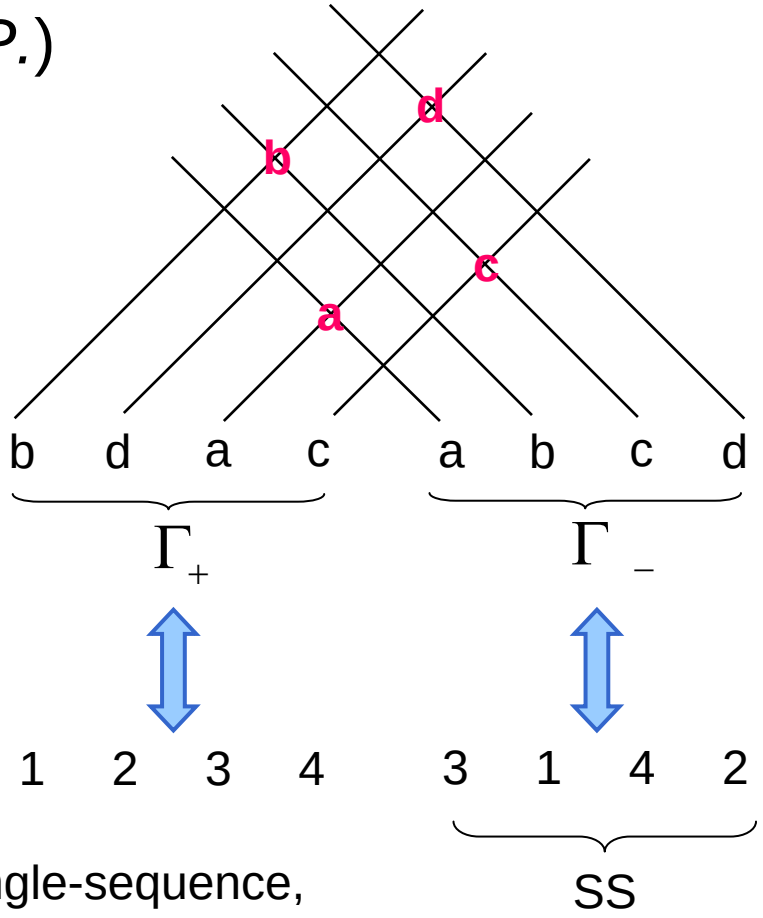
Example.

SP=(Γ_+, Γ_-)=(bdac; abcd),

SS=(3142).

k=3

$\Gamma_-(k)=c$, $\Gamma_+^{-1}(c)=4$, $SS_k=4$



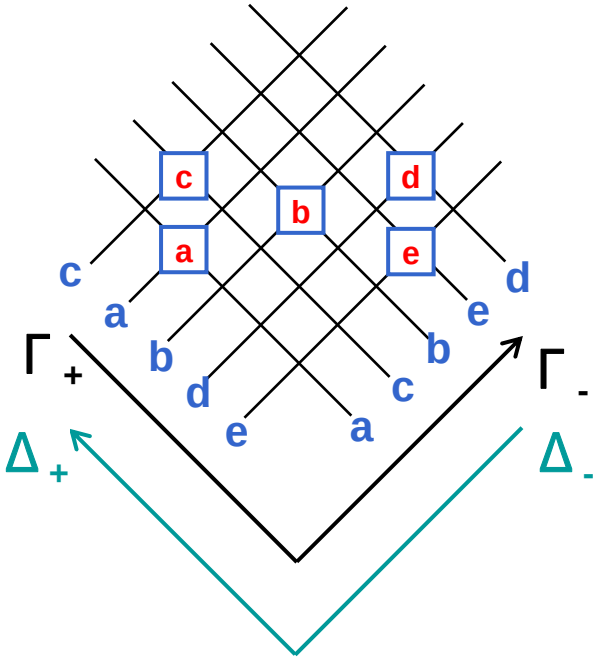
SS is Γ_- when Γ_+=(12…n)

[20]: Thoery of T-junction floorplans in terms of single-sequence, ISCAS 2004.

Definition of Topological Symmetry Structure

Let a sequence-pair be $SP=(\Gamma_+, \Gamma_-)$, and let the reverse sequences be Δ_+ and Δ_-, respectively.

- **LR-SP**: arrangement of blocks from the left-side to the right-side;
- **RL-SP**: arrangement of blocks from the right-side to the left-side.



LR-SP:(Γ_+, Γ_-)=(cabde,acbed)

RL-SP:(Δ_-, Δ_+)=(debca,edbac)

A sequence-pair has a ***horizontal symmetry topology,***

if *LR-SP* and *RL-SP* induce the same single-sequence:

$$\Gamma_+^{-1}(\Gamma_-(k)) = \Delta_-^{-1}(\Delta_+(k)) \ .$$

Example. k=1

$\Delta_+(k)=e \quad \Delta_-^{-1}(e)=\mathbf{2}$

$\Gamma_-(k)=a \quad \Gamma_+^{-1}(a)=\mathbf{2}$

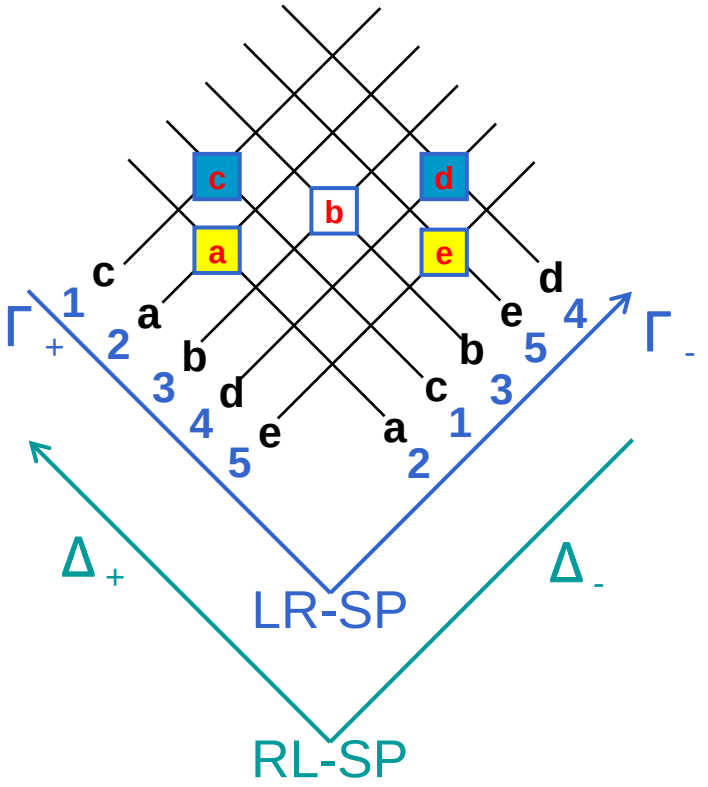
a and e form a symmetry pair.

k=3

$\Delta_+(k)=b \quad \Delta_-^{-1}(b)=\mathbf{3}$

$\Gamma_-(k)=b \quad \Gamma_+^{-1}(b)=\mathbf{3}$

b is a self-symmetry block.

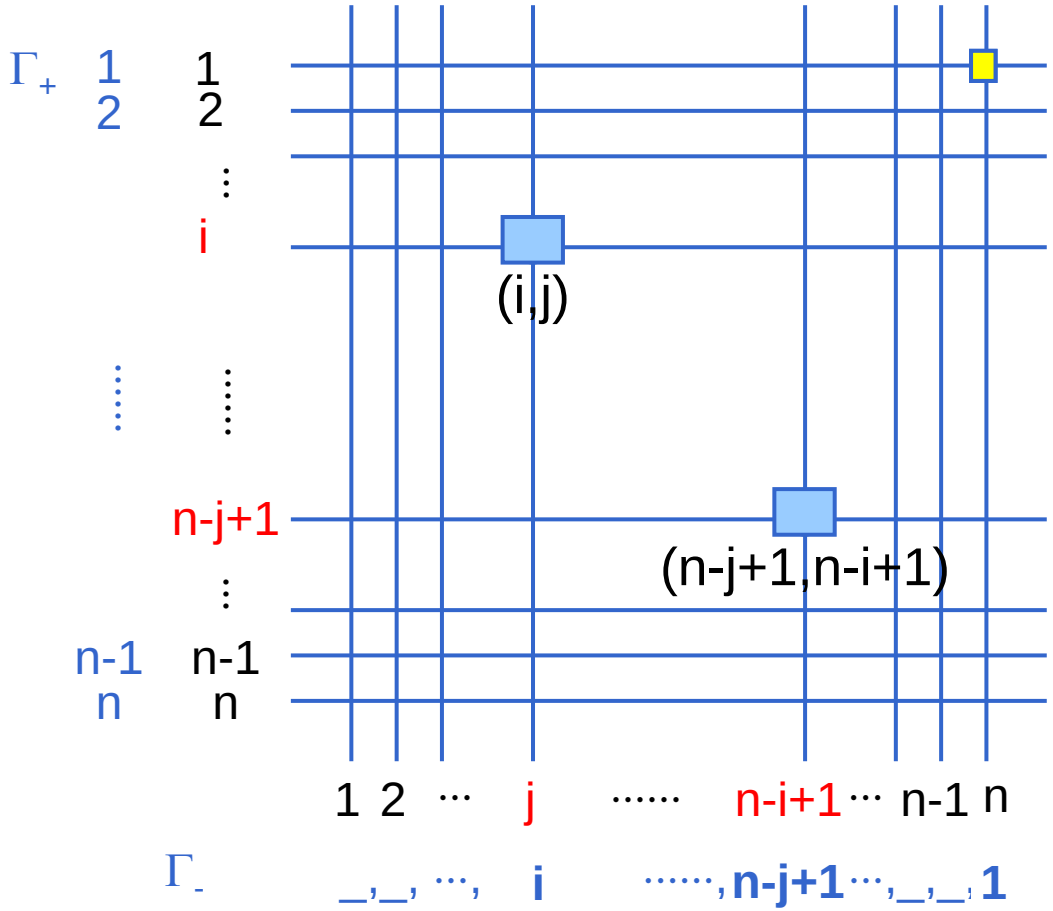


(Γ +, Γ -)=(cabde; acbed) =>SS(21354)

(Δ -, Δ +)=(debca; edbac)=>SS(21354)

Generation of Symmetry Structure

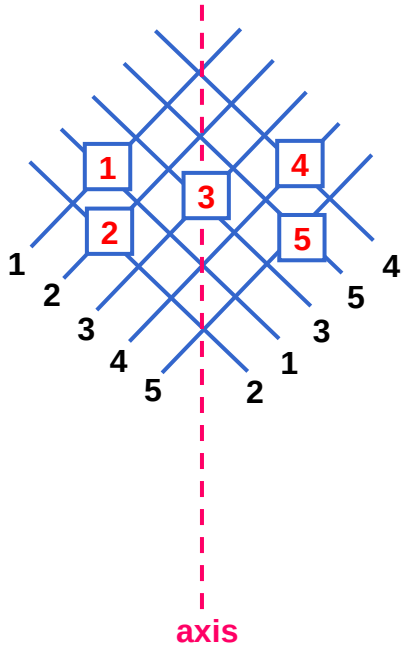
- Put a block into (i,j),then put another bolck into (n-j+1,n-i+1).



Generation of Symmetry Structure

TABLE 1 An example of single-sequence generation with a horizontal symmetry topology.

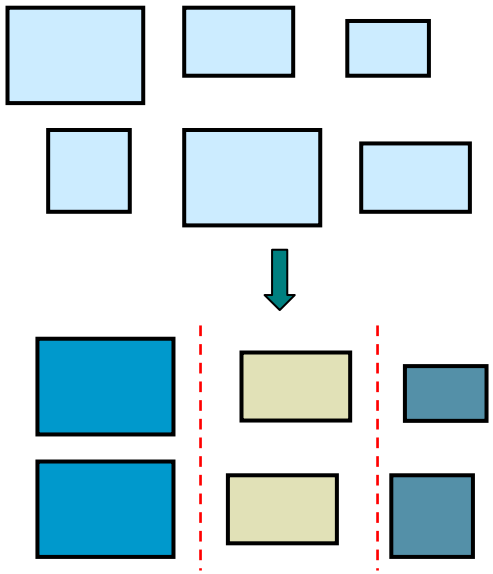
j	i	n-j+1	n-i+1	Γ (or SS)	check-list
initial				(_,_,_,_,_)	(1,2,3,4,5)
1	2	_	_	(2,_,_,_,_)	(1,3,4,5)
1	2	5	4	(2,_,_,5,_)	(1,3,4)
2	1	_	_	(2,1,_,5,_)	(3,4)
2	1	4	5	(2,1,_,5,4)	(3)
3	3	_	_	(2,1,3,5,4)	(_)



Symmetry-Oriented Optimization

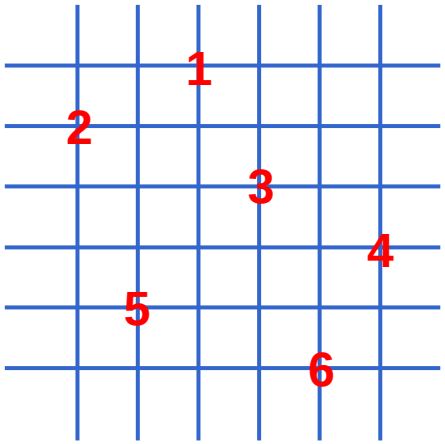
Generation of Initial Placement

•Blocks are classified according to size so that the partner is chosen from the same group.

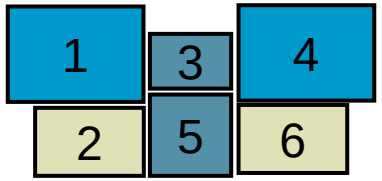


• Assign blocks to a single-sequence with an arbitrary horizontal symmetry topology.

SS=251364



Placement



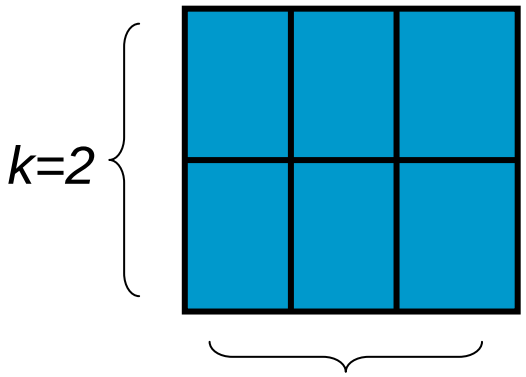
Evaluation of Topology

- SA is adopt as the optimization engine.
- Evaluate a placement by *topology* and *physical dimension.*

- ***Topological Structure Value[22]***

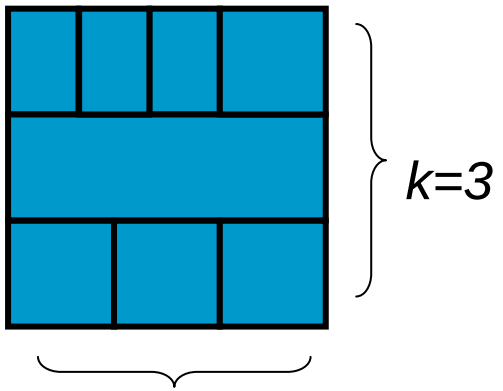
$$\sigma = \min(k, l) / \max(k, l)$$

An array



σ=*2 / 3*

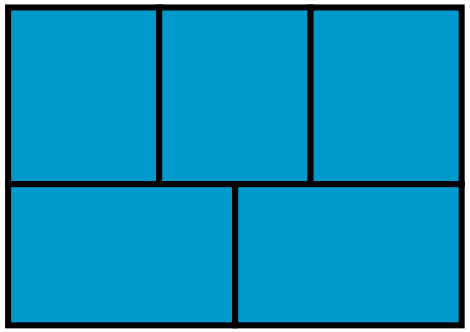
A multi-row



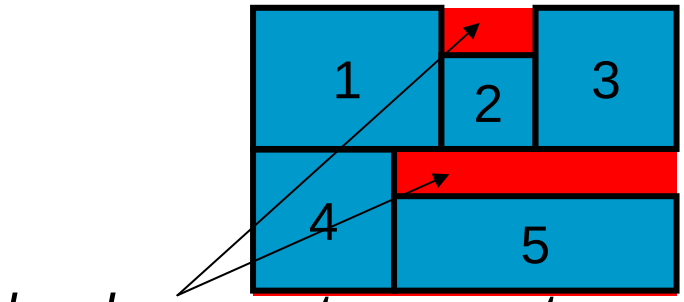
σ=*((4+1+3)/3) / 3*

Evaluation of Physical Dimension

- ***Local Compactness Cost[22]***

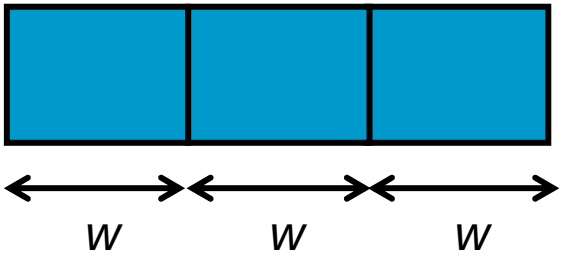


A ideal multi-row

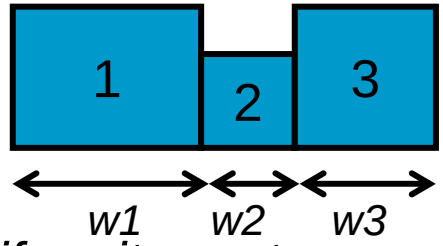


local compactness cost

- ***Local Uniformity Cost[22]***



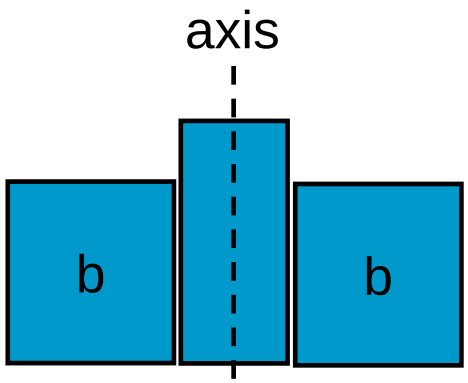
A ideal single row



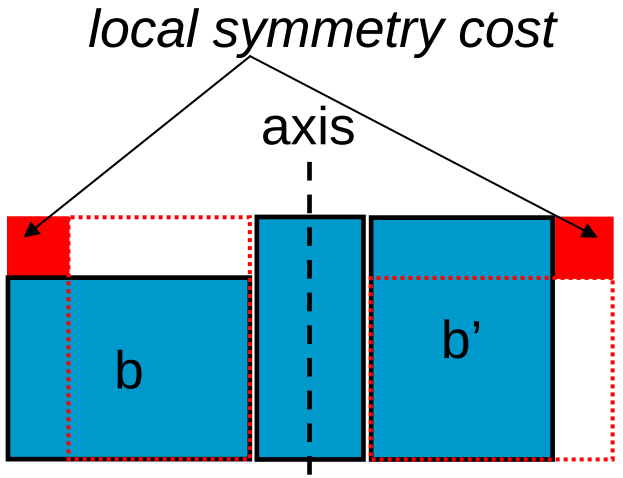
local uniformity cost =
max(w1,w2,w3)-min(w1,w2,w3)

Evaluation of Physical Dimension

- ***Local Symmetry Cost***

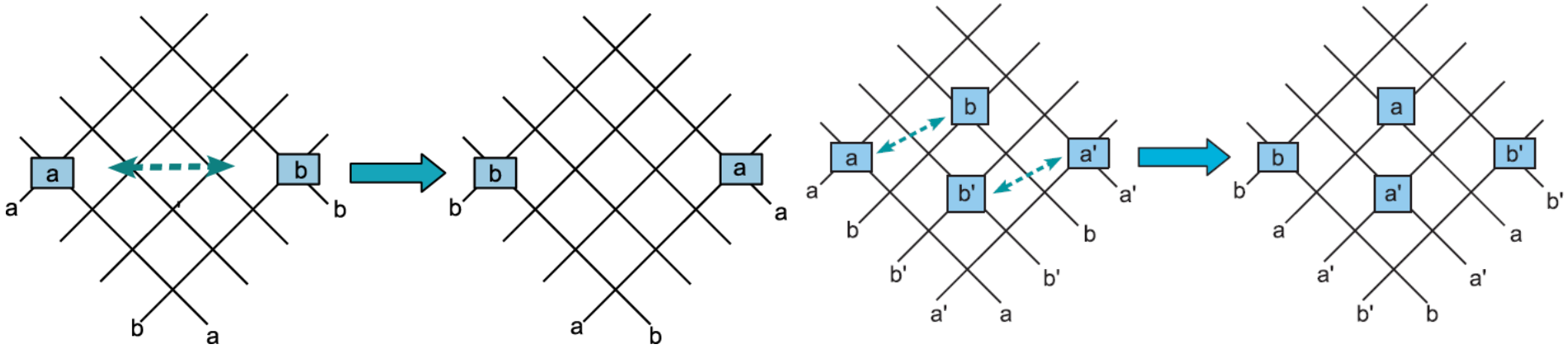


A ideal symmetry



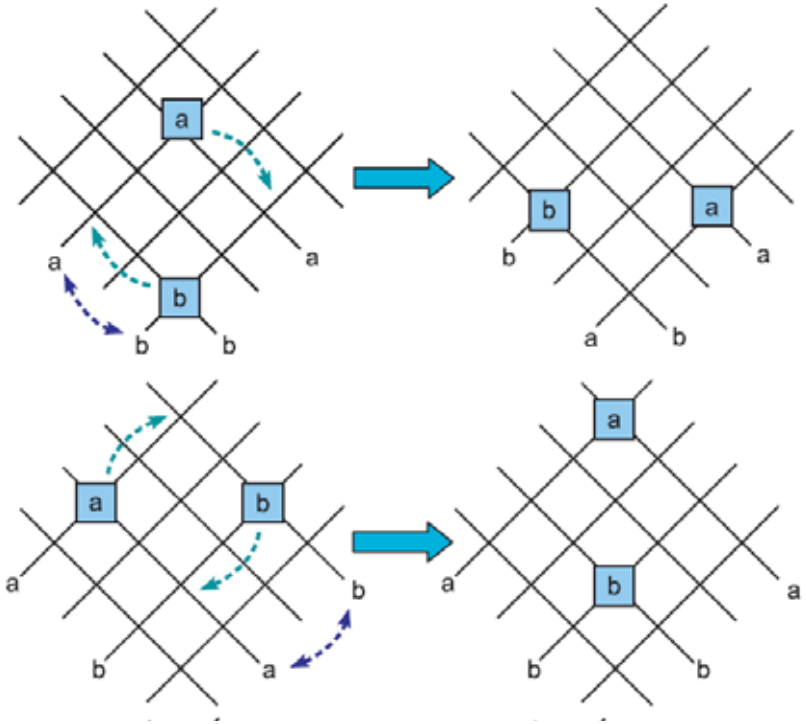
Moves Keeping Symmetry

- ***FullExchangeOfSymm***
  - If two blocks constitute a symmetry-pair, apply FullExchange.
  - Otherwise, apply FullExchange on them and on their corresponding symmetry partners.

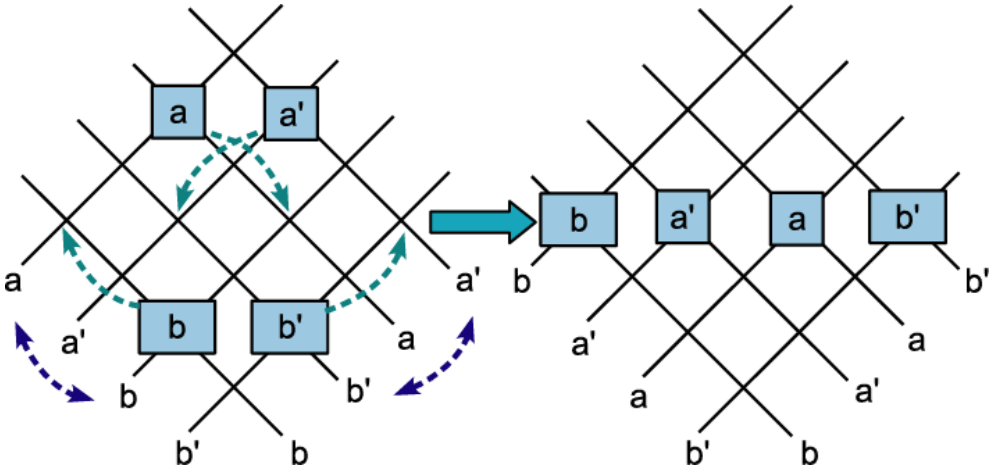


•*HalfExchangeOfSymm*

- If two blocks constitute a symmetry-pair or two self-symmetry blocks, apply HalfExchange.

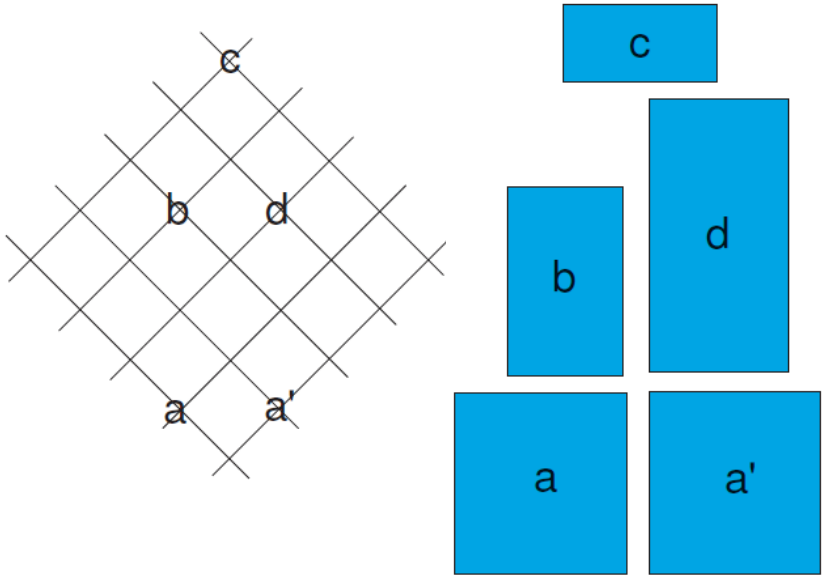


- Otherwise, apply both HalfExchange on their Γ_+ (or Γ_-) and HalfExchange on their symmetry partners' Γ_- (or Γ_+)..

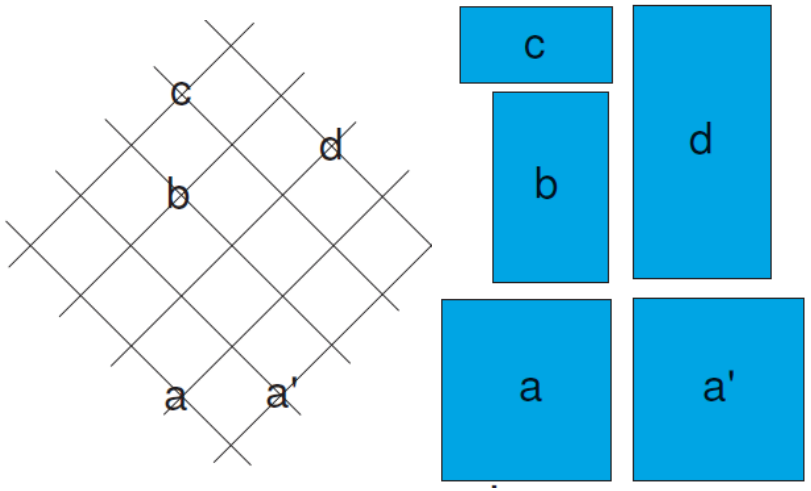


Physical Skewed Symmetry

- Complete topological symmetry structure might lead to a limitation.

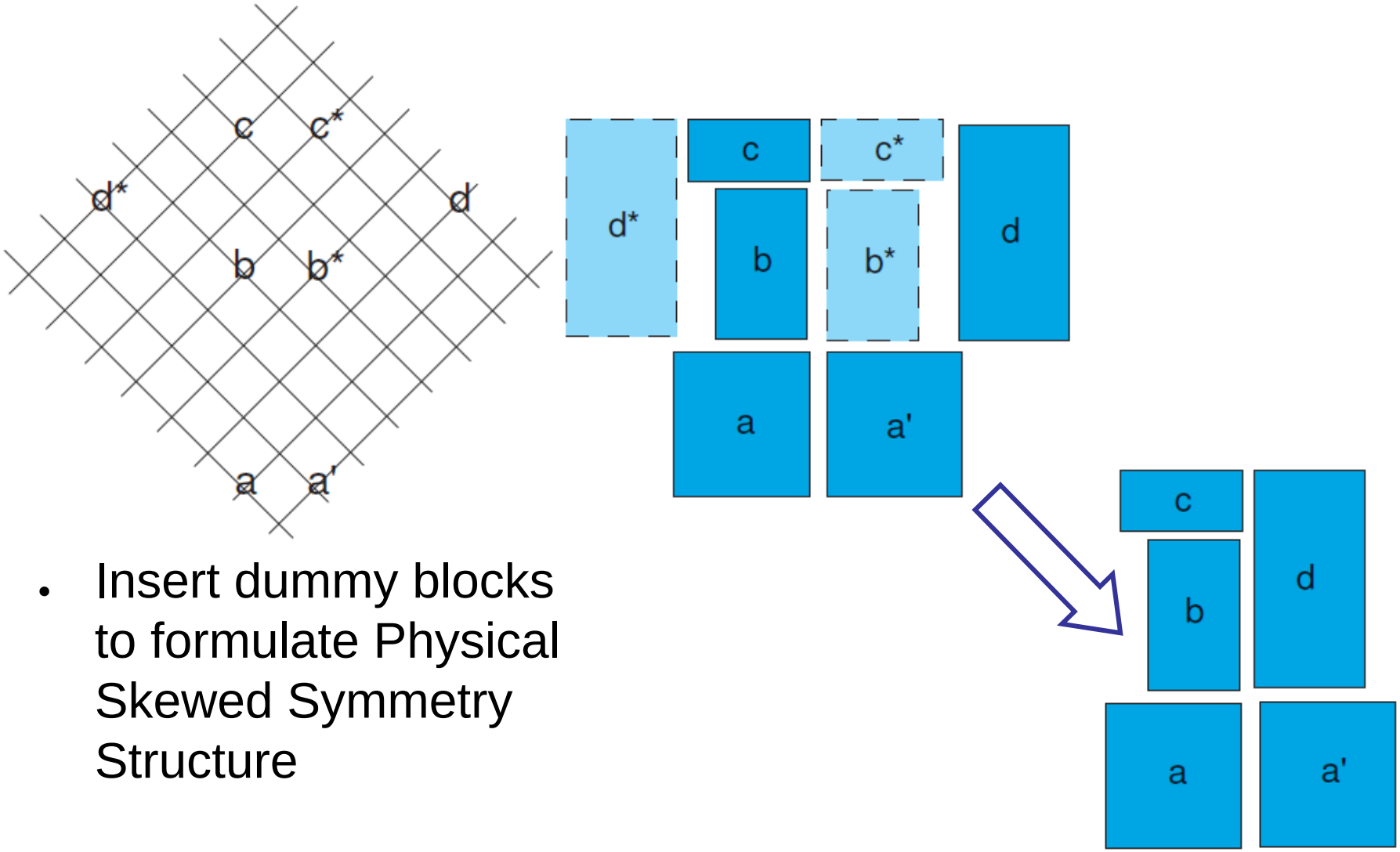


complete topolotical symmetry



non-complete topolotical symmetry

Dummy Blocks Insertion



- Insert dummy blocks to formulate Physical Skewed Symmetry Structure

Experiments(1)

Area*Wire Length V.S. Symmetry

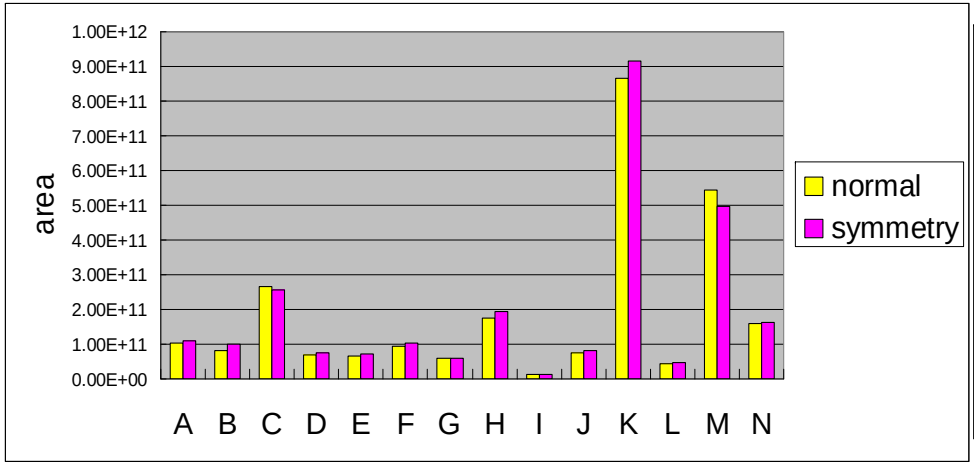
Numerical Data and Results

data	#blocks	#nets	normal	symm	(symm-normal)/symm	
			time(sec)	time(sec)	area(%)	wlen(%)
A	122	91	1,581	840	5.14	11.63
B	60	46	241	221	23.89	29.98
C	133	80	1,261	684	-2.89	-10.29
D	32	22	49	75	8.33	29.30
E	54	49	172	177	6.98	-8.01
F	90	58	700	497	10.48	1.10
G	64	49	263	258	3.28	14.58
H	66	29	632	534	11.70	-10.30
I	60	36	236	238	2.56	2.61
J	166	105	7,926	1,600	6.70	-18.82
K	55	91	376	449	5.85	-3.91
L	101	78	1,868	1,148	7.08	38.31
M	22	53	29	56	-8.57	20.46
N	60	44	463	352	2.43	-18.97
average:					5.93	5.55

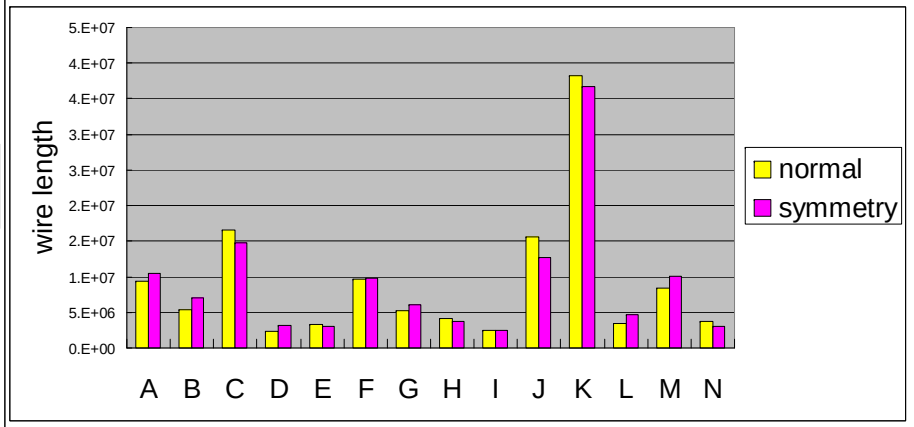
normal: normal placement
symm: our symmetry-oriented structured placement

Experiments(1)

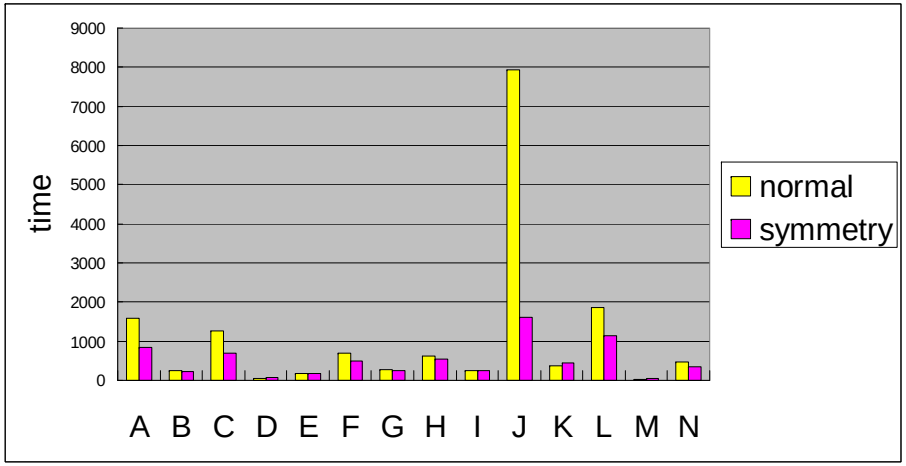
w.r.t. chip area



w.r.t. wire length



w.r.t. time



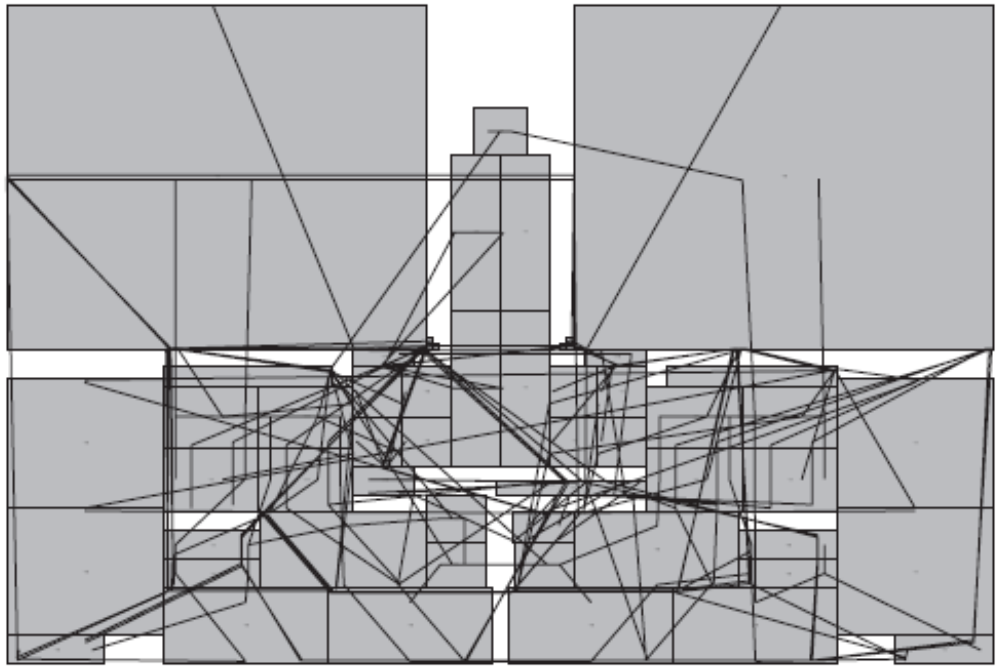
On average, the compromise on

- *area* is **5.93%,**
- wire length is **5.55%**

Experiments(1)

Area V.S. Symmetry on resultant placement

data K: normal



data K: symmetry

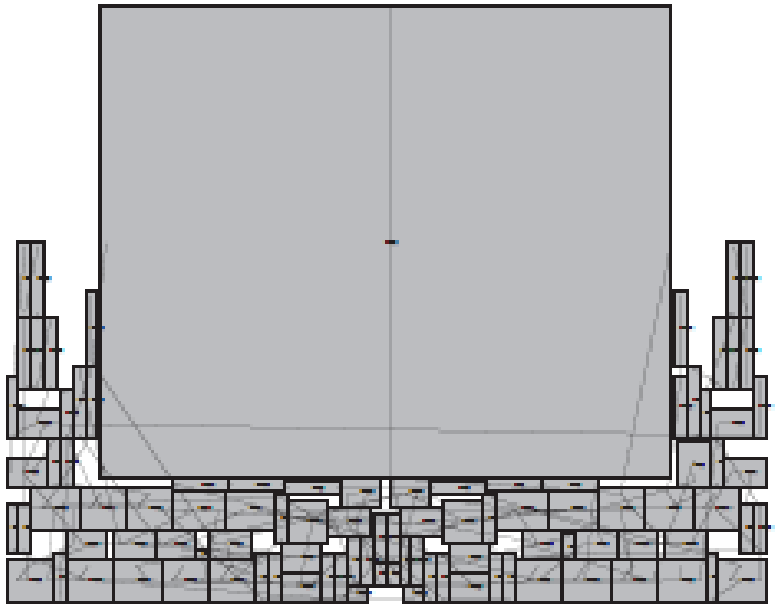
Experiments(2)

Numerical Results of analog block designs using Physical Skewed Symmetry Structure

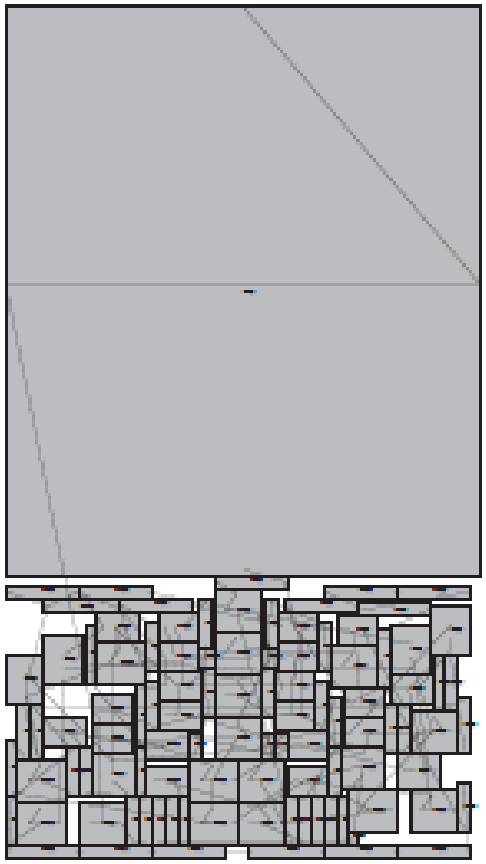
data	dummy 0%		dummy 10%		dummy 20%		dummy 30%		Best(0–30%)	
	area	wlen	area(%)	wlen(%)	area(%)	wlen(%)	area(%)	wlen(%)	area(%)	wlen(%)
A	100	100	91.2	111.7	102.3	106.6	98.6	113.3	91.2	100
B	100	100	91.1	75.7	91.2	83.2	85.5	81.7	85.0	75.7
C	100	100	124.9	104.7	125.5	98.4	114.2	99.8	100	98.4
D	100	100	96.9	130.4	98.3	103.9	96.4	83.3	96.4	83.3
E	100	100	109.0	97.3	99.2	108.5	98.6	108.7	98.6	97.3
F	100	100	89.3	103.3	95.9	96.6	94.4	96.4	89.3	96.4
G	100	100	99.8	98.5	100.8	95.4	102.5	106.7	99.8	95.4
H	100	100	112.5	84.4	100.8	85.4	99.4	91.8	99.4	84.4
I	100	100	84.2	80.6	90.3	82.6	96.5	76.0	84.2	76.0
J	100	100	102.2	107.3	98.6	73.2	99.6	94.7	98.6	73.2
K	100	100	98.2	93.2	129.5	153.9	96.2	105.3	96.2	93.2
L	100	100	89.8	81.4	90.6	85.3	89.2	75.9	89.2	75.9
M	100	100	106.1	113.9	104.6	63.9	100.2	73.2	100.0	63.9
N	100	100	94.0	141.3	98.7	118.5	101.7	109.4	94.0	100.0
average			99.2	101.7	101.9	96.8	98.0	94.0	94.4	86.6

Experiments(2)

The effectiveness of Physical Skewed Symmetry structure



data L: complete symmetry



data L: physical skewed symmetry

Conclusion

- Extend the **structured placement** for analog layouts focusing on symmetry
  - Constraint-free
  - Naturally going to a placement symmetrically.
- Our Symmetry Structured Placement:
  - Generate placement with symmetry topology
  - Symmetry-Oriented moves optimizes topology and keep the symmetry.
- Future Works:
  - Extraction and evaluation of **hierarchical regular structure**
  - Further **practical extension**

Acknowledgement

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- *Prof. Atsushi Iwata, Hiroshima University*
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Thanks for your attention!