

# Equation-driven Stochastic Multi-objective algorithm for circuit sizing and Hierarchical Synthesis

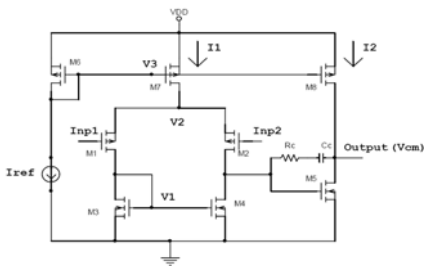
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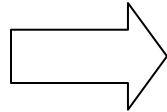
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# Equation-driven Stochastic Multi-objective Algorithm (SMOOA)

## Circuit



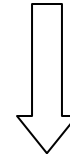
*designer*



## Simple first-order equations

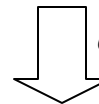
$$gain = \frac{gm1 * gm5}{(gds4 + gds1) * (gds5 + gds8)}$$

*designer/automatic*



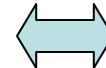
Knowledge for  
SMOOA

*automatic*



Circuit-tuned  
SMOOA

SPICE



### Features

- Uses designer knowledge
- Gives much more accurate optimization with no added computational cost
- Requires only approximate equations.
- Doesn't need SPICE-accurate equations, models.
- Little/No manual work to derive knowledge.
- SPICE accurate

### Comparison

#### **Geometric Programming**

- Needs accurate equations
- SPICE correctness not assured
- Equations constrained to posynomial form

#### **Simulation-based approach:**

- Slow and not circuit-specific
- Fails to exploit available equation-knowledge

**Accuracy:** 38% of circuits optimized by zero-knowledge SMOOA worse than knowledge-based SMOOA for opamp.

**Speed:** Given 10 times more CPU time, zero-knowledge SMOOA is still worse than knowledge-based SMOOA!

**How much better:** A designer-picked circuit optimized by knowledge-based SMOOA had slightly better gain, double unity gain frequency, half the area and one-third the power as compared to zero-knowledge SMOOA.

# Detailed Comparison results

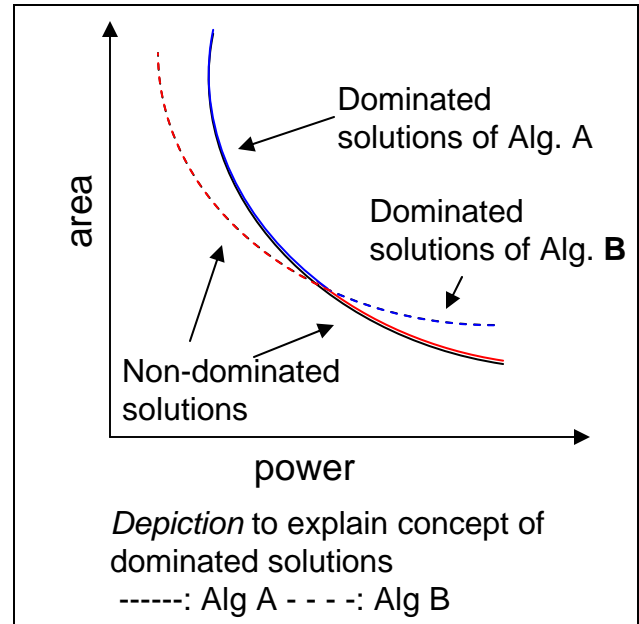
## 0-knowledge SMOOA (0k) and Knowledge-based SMOOA (kb)

### Dominated Statistics (DS)

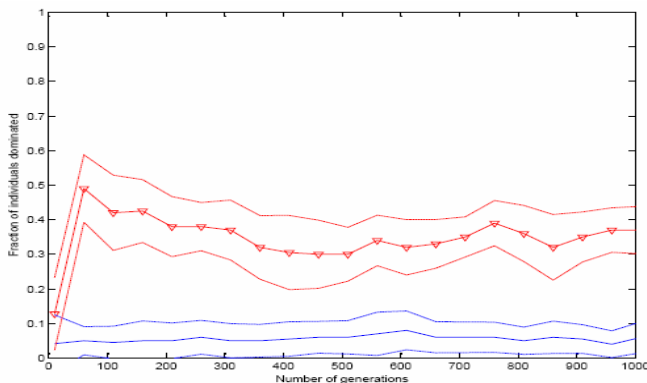
- Metric to compare results of two SMOOA
- $DS_{a,b}$  is the fraction of optimized solutions of algorithm a worse than (dominated by) that of algorithm b.
- Higher  $DS_{a,b} \rightarrow$  worse algorithm a.

### Comparison

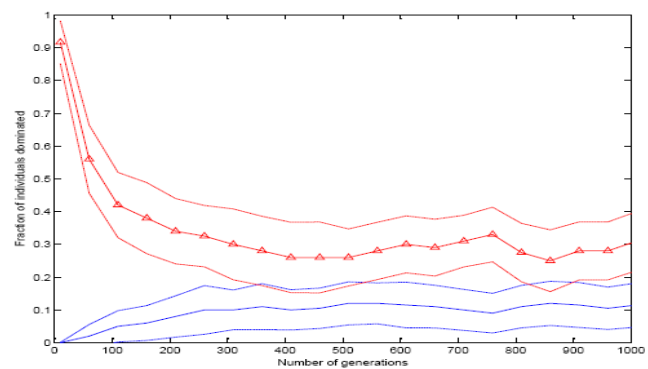
Simple opamp (0.18u TSMC) optimization for gain, unity-gain frequency, power and area.



Curves show DS of 0k, kb and vice-versa against number of iterations in algorithm; **Red**:  $DS_{0k,kb}$ ; **Blue**:  $DS_{kb,0k}$  (dotted line shows standard deviation over 10 runs).



Less than 10% sols. of kb are dominated, while 35%-40% of those of 0K are.



kb's solutions at iter. 100 are compared with that of 0k at different number of iterations. Kb's solutions at iter. 100 are much better than those of 0kb even at 1000<sup>th</sup> iter!

### How much better?:

**An example for perspective:** A designer-picked circuit optimized by knowledge-based SMOOA had slightly better gain, double unity gain frequency, half the area and one-third the power as compared to zero-knowledge SMOOA.