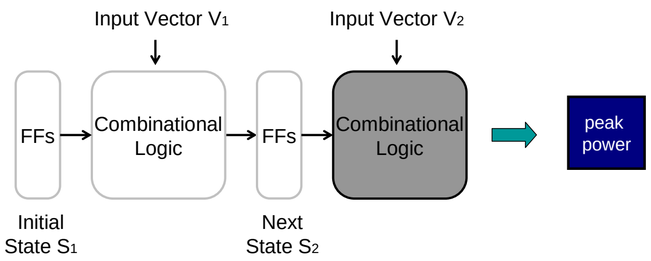
CO-based Peak Power Estimation in VLSI Circ

Introduction

- Power dissipation is controlled by a three-tuple (S_1, V_1, V_2)



Problem Formulation

- T : Cycle time
- V_{dd} : Supply voltage
- C_{out} : Gate output capacitance

- Power - $P = \frac{1}{2} \cdot I_{dd} V_{dd} \cdot 4 = \frac{1}{2} \cdot \frac{Q}{T} V_{dd} \cdot 4 = \frac{1}{2} \frac{C_{out} V_{dd}^2}{T} \cdot 4$

Problem Formulation

- Consider a circuit with *m* internal nodes.
- If only the contribution of the charging and discharging is considered

$$P = \frac{V_{dd}^2}{2 \cdot T} \sum_{i=1}^{m} C_i D_i$$

- V_{dd} : Supply voltage
- C_i : Gate output capacitance at node *i*
- D_i : Number of rising or falling transitions at node *i*

Problem Formulation

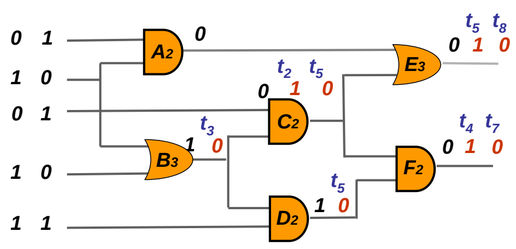
- Transition density (TD) per node could be expressed as the following equation

$$TD = \frac{\sum_{i=1}^{m} C_i D_i}{NC}$$

- *NC* : Number of capacitance node (# gate input)
- The power consumption is proportional to the TD
- For simplicity, the assumption is made that the output capacitance is equal to the number of fanouts

Initial Solution Construction

- To construct a better solution with high TD, 10,000 random pairs (V_1, V_2) are applied to the circuits

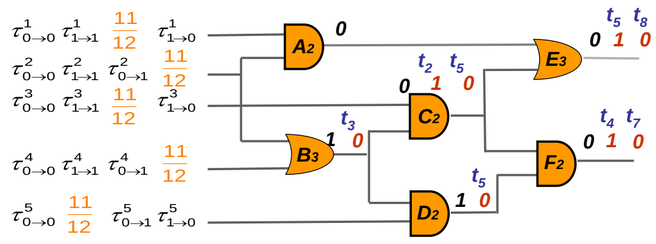


For (01011) → (10101)

$$TD = \frac{1\times2 + 2\times2 + 1\times1 + 2\times1 + 2\times1}{12} = \frac{11}{12}$$

Pheromone Update

For (01011) → (10101), TD = $\frac{11}{12}$

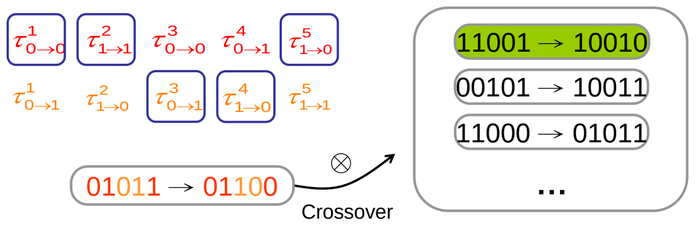


Pheromone Update

- Pheromone evaporation
  - Pheromone on the input will evaporate with the rate ***k*** ($0 < \boldsymbol{k} \leqq 1$)
  - The parameter ***k*** is used to avoid unlimited accumulation of the pheromone trails
  - Forget inappropriate decisions previously taken
  - *k* – too large : Previously good decisions may be eliminated
    - too small : Rapid convergence to a suboptimal solution

Local Search

- Crossover

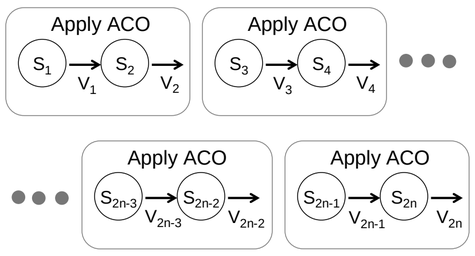


01011 → 01100 ⊗ 11001 → 10010 ➡ 01001 → 01110

Updating the pheromone

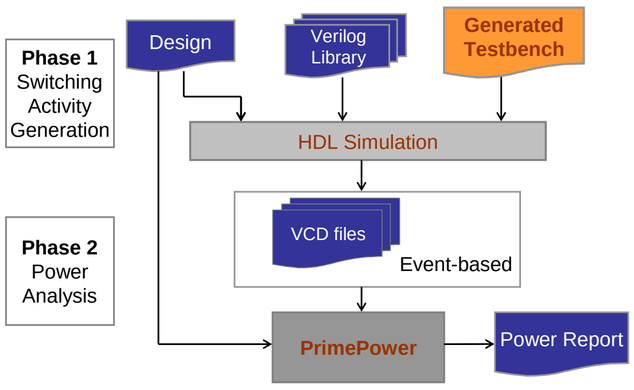
Sequential Circuits

- S_1 is the reset state, and all states in the path is valid



Power Calculation

- Power calculation with PrimePower



Experimental Results

ISCAS85 – TSMC under 0.18um

Circuit	PI	NG	NC	RAN_{18}	ACO_{18}	$\frac{ACO_{18}}{RAN_{18}}$	Time (Sec.)
c432	36	204	343	10.9	22.3	2.05	22.2
c499	41	276	440	10.48	17.9	1.71	55.4
c880	60	470	755	37.2	71.7	1.93	47.2
c1355	41	620	1096	27.9	29.45	1.06	34.8
c1908	33	939	1523	15.27	18.47	1.21	60.4
c2670	234	1567	2216	114.8	241	2.1	241.5
c3540	**50**	**1742**	**2961**	**65.1**	**237.1**	**3.65**	**141.1**
c5315	178	2609	4509	131.4	172.3	1.31	429.3
c6288	32	2481	4832	204.6	233.4	1.14	2814.3
c7552	207	3828	6252	240.8	338.8	1.41	1787.4

Average 1.76

Experimental Results

ISCAS89 – TSMC under 0.18um

Circuit	PI	NG	NC	FFs	RAN_{18}	ACO_{18}	$\frac{ACO_{18}}{RAN_{18}}$	Time (Sec.)
s344	9	101	295	15	9.46	11.95	1.26	58.2
s386	7	118	359	6	2.97	2.97	1.0	33.6
s1196	14	388	1045	18	23.4	39.72	1.7	124.2
s1423	17	490	1300	74	13.29	18.47	1.39	133.2
s1488	8	550	1410	6	17.18	25.73	1.5	321
s1494	8	558	1416	6	25.24	36.12	1.43	334.8
s5378	35	1004	4584	179	16.23	49.26	3.04	319.8
s9234	36	2027	8396	211	17.19	26.25	1.53	901.3
s13207	31	2573	12593	669	28.62	32.12	1.12	1399.8
s35932	35	12204	30282	1728	56.73	73.49	1.3	2764.2
s38584	12	11448	34498	1452	45.1	89.9	1.99	2779.8

Average 1.52