Benchmarks & Best Results Targeting Superconducting Electronics

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Birds-of-a-Feather Meeting @ DAC'22
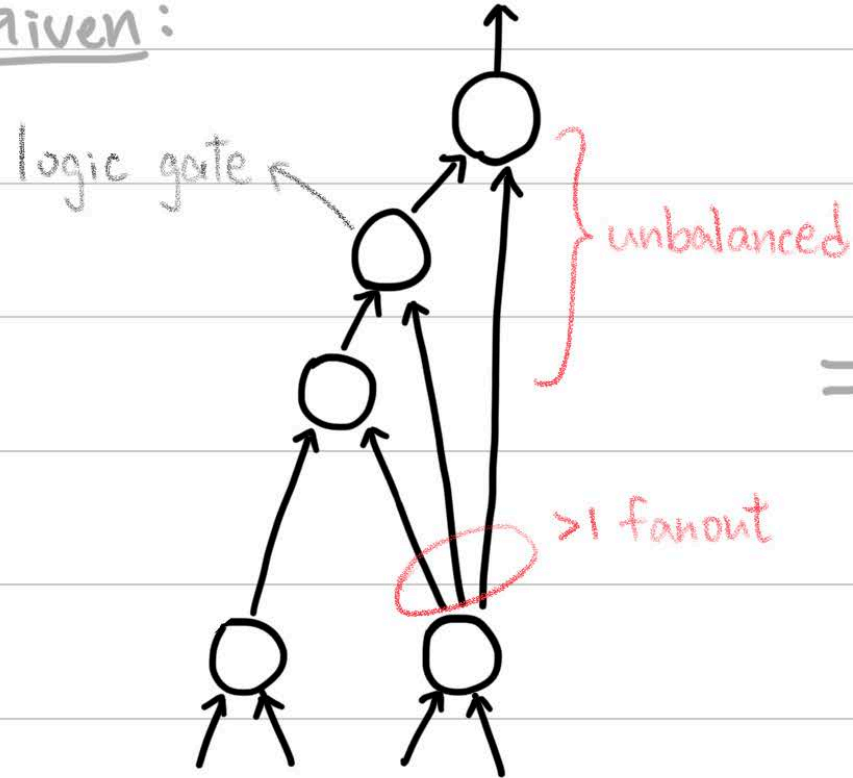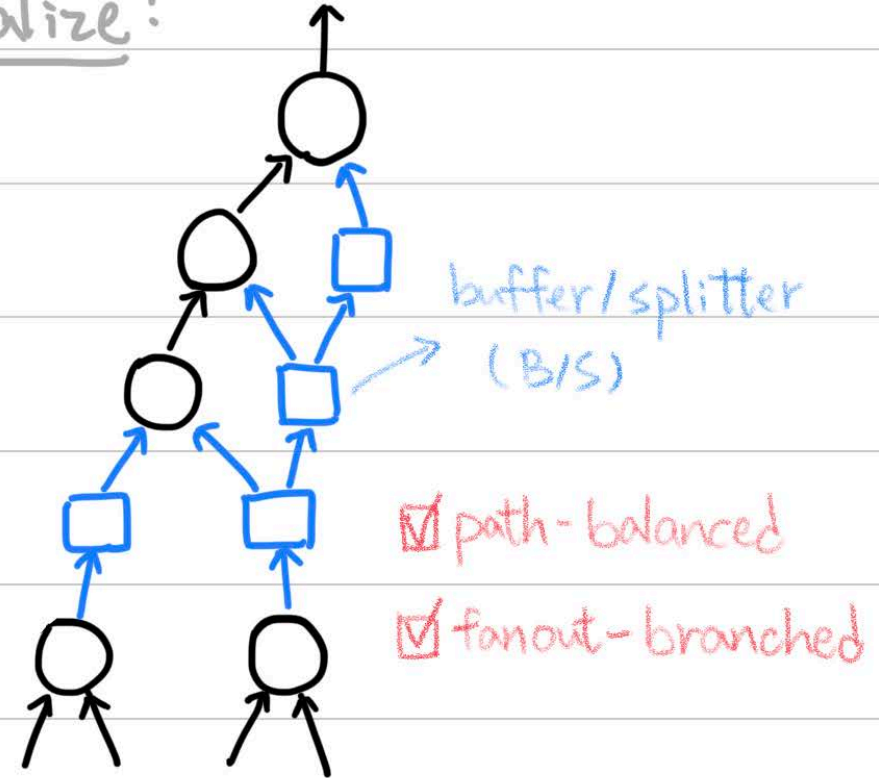
https://github.com/lsils/SCE-benchmarks

Adiabatic Quantum-Flux Parametron (AQFP)

- No
- Eve
- AQ
  - Pa
  - Fa
- Buf
- Tec ... EDA
  - Sp
  - W

Given:

logic gate

unbalanced

>1 fanout

Legalize:

buffer/splitter (B/S)

☑ path-balanced

☑ fanout-branched

[19] Naoki Takeuchi, Dan Ozawa, Yuki Yamanashi, and Nobuyuki Yoshikawa. An adiabatic quantum flux parametron as an ultra-low-power logic device. *Superconductor Science and Technology* 26, 3 (2013).

Problem #1: Assumptions matter

Table 3. Comparison of different technology assumptions.

		Branch PIs? Yes				Branch PIs? No	
		Balance PIs? Yes		Balance PIs? No		Balance PIs? No	
	Balance POs?	Yes	No	Yes	No	Yes	No
$s_b = 3$	$\sum \#B/S$	58135	41363	47213	35059	31544	22482
	$\sum d(N')$	1045	1045	1027	1040	1003	1004
$s_b = 4$	$\sum \#B/S$	55516	39043	45279	33392	29974	21518
	$\sum d(N')$	1012	1012	996	1005	977	977
$s_b = 8$	$\sum \#B/S$	53047	37120	44160	32635	29023	21237
	$\sum d(N')$	988	988	982	985	963	964

"Beyond local optimality of buffer and splitter insertion for AQFP circuits" (DAC 2022)

Problem #2: Benchmarks matter

- Which version of ISCAS'85 benchmark?

- How were MIGs mapped?

- Structural hashing?

Cleaned-up benchmarks & best results

- Benchmark suites
  - MCNC (used by [2,3,5,6])
  - ISCAS (used by [1,4,7])
- Best result types
  - Without logic restructuring (buffer insertion only)
  - Any optimization
- All possible assumptions
- PRs for new best results are welcomed!

https://github.com/lsils/SCE-benchmarks

[1] "A Buffer and Splitter Insertion Framework for Adiabatic Quantum-Flux-Parametron Superconducting Circuits" (ICCD 2019).
[2] "Algebraic and Boolean Optimization Methods for AQFP Superconducting Circuits" (ASP-DAC 2021).
[3] "Irredundant Buffer and Splitter Insertion and Scheduling-Based Optimization for AQFP Circuits" (IWLS 2021).
[4] "An Optimal Algorithm for Splitter and Buffer Insertion in Adiabatic Quantum-Flux-Parametron Circuits" (ICCAD 2021).
[5] "Optimizing Adiabatic Quantum-Flux-Parametron (AQFP) Circuits using an Exact Database" (NANOARCH 2021).
[6] "Majority-based Design Flow for AQFP Superconducting Family" (DATE 2022).
[7] "Beyond Local Optimality of Buffer and Splitter Insertion for AQFP Circuits" (DAC 2022).