A Count-Based Scheme for Fault Detection in Memory Arrays

Lorena Ndreu, Yiannakis Sazeides, Bushra Ahsan, Isidoros Sideris

Sachin Idgunji, Emre Ozer

cs04ln1@cs.ucy.ac.cy

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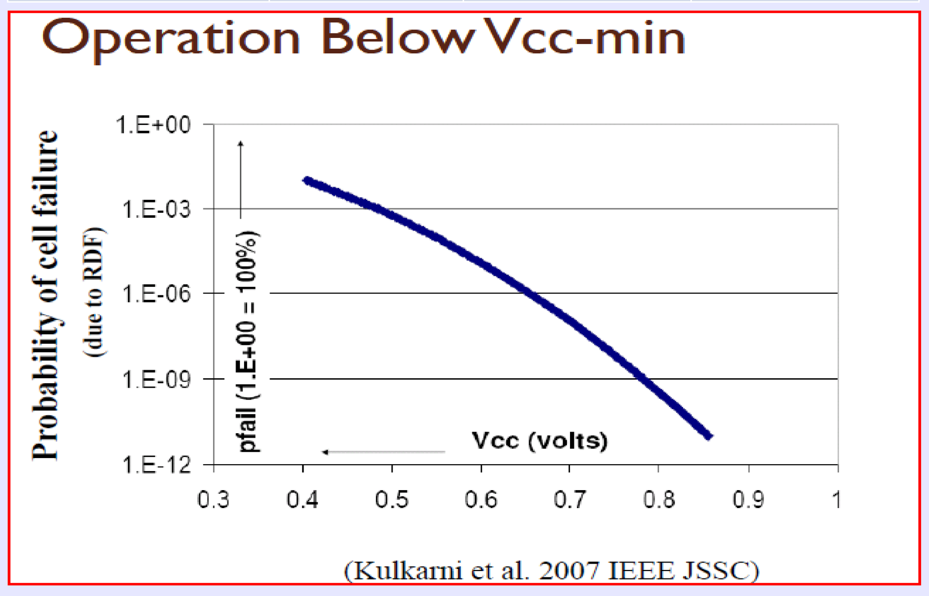
www.cs.ucy.ac.cy/carch/xi

CBFD: Motivation

- Technology scaling keeps increasing device density
- Power, energy, reliability increasingly intertwined
- Pfail for all circuits due to parametric, latent and wear-out grows faster than area scaling
- More protection leads to extra area and energy consumption
  - Stronger ECC codes, Increase spares, Larger margins/cells
- Need cost effective solutions for SRAM reliability

Technology	Inverter	Latch	SRAM
45	~0	~0	6.1e-13
32	~0	1.8e-44	7.3e-09
22	~0	5.5e-18	1.5e-06
16	2.4e-58	5.4e-10	5.5e-05
12	1.2e-39	3.6e-07	2.6e-04

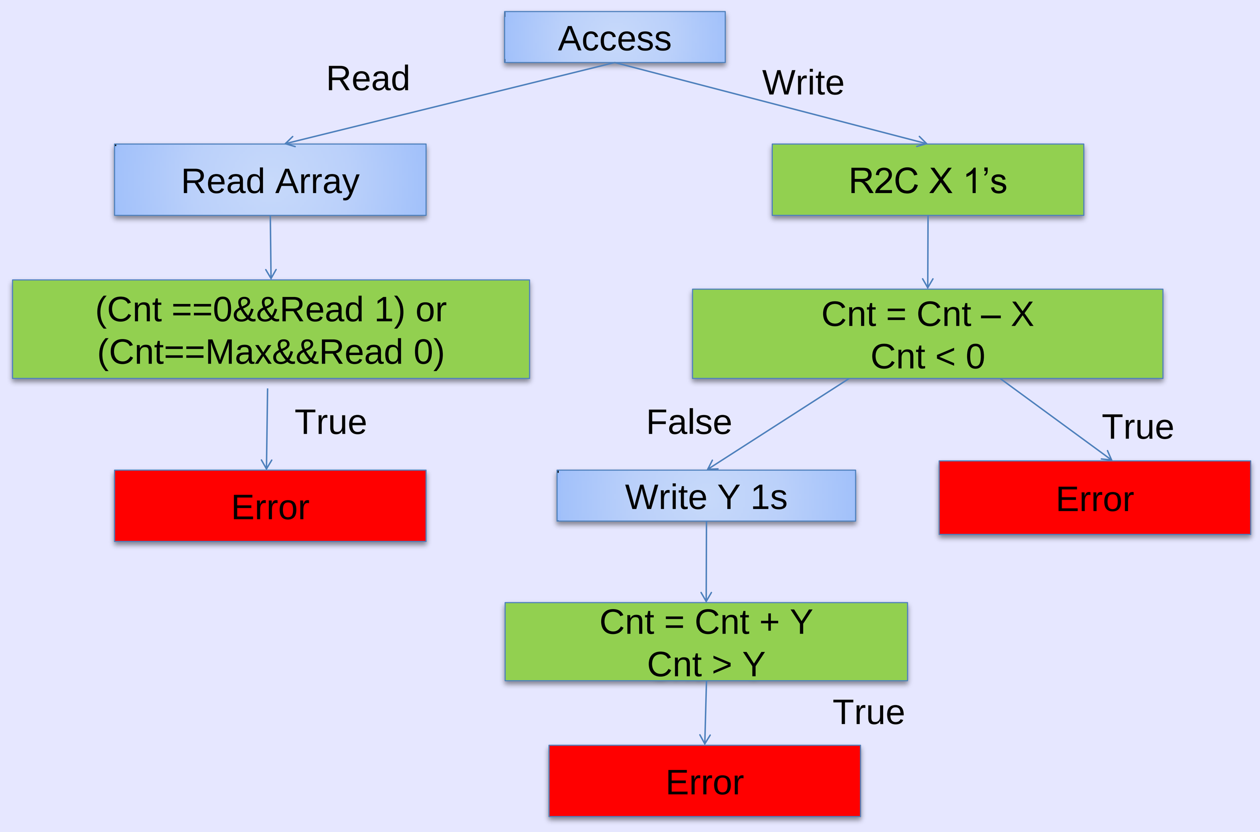


CBFD: Contribution

- Count-Based Fault Detection Scheme
- Low area cost (log2(n)+1 vs n/8)
- Captures fault not captured by per entry parity
- Delay detection, with lower cost
- Detect soft and hard errors both in array cells and peripheral logic

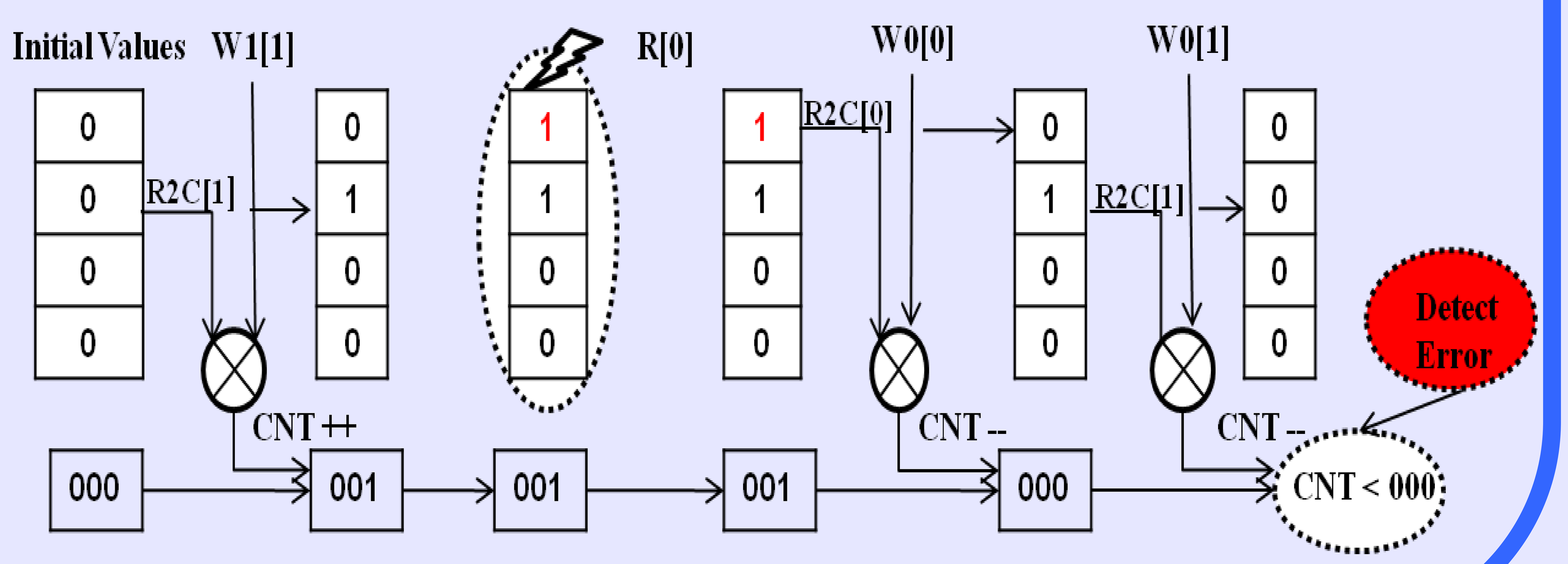
CBFD: Counter Based Fault Detection Method

- Use a counter to track number of 1s in an array
- Counter size: log2(NB)+1, N is # of entries, B is bits/entry
- At initialization number of 1s in the array stored in the counter
- Maintain Read-Write Invariance



CBFD: Overheads & Fault Detection Latency

- Overheads
  - Area for Counter(s)
  - Energy of updating counters
  - Performance/Energy implication of Read2Counts
- Fault Detection Latency: Use Sweeping to bound Latency



Example with one counter to track number of 1s in an array

CBFD: Applications

- CBFD + Partitioning + Sweeping
  - Low cost+ reasonable coverage symptom detector
  - Combine with check-pointing to provide recovery
  - Sweeping may be not needed for prediction arrays
- CBFD Error Detection: Soft & Hard Errors, Cells and Peripheral Logic
- For low-cost error detection: stand-alone
- For high coverage: combination with Parity and ECC
- Power savings: Prevent precharging bitlines that all their cells store the same value

	Byte Parity Coverage	Byte Parity Cost	CBFD Coverage	CBFD Cost
within a word	Odd	n/8	Odd+Even Unbal.	$\log_2(n)+1$
bursts of d bits	interleaving	n/8	interleaving+ partitioning	$d(\log_2(n/d)+1)$
random across words	High	n/8	needs partitions	$P(\log_2(n/P)+1)$

CBFD: Comparison to Parity

Conclusions & Future Work

- Keep track of the number of 1s in the array of size N by a counter of size 1+log2(N) bits
- Relies on Read-Write Invariance
- CBFD + Sweeping + Checkpointing: low cost detection and recovery
- Applications: Testing, Power savings, Reliability
- Future directions
  - 2D CBFD
  - Detailed Evaluation
  - Byte parity and ECC checks only on writes + Sweeping + Checkpointing (LBFD: Lazy Based Fault Detection)

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