CROW

A Low-Cost Substrate for Improving DRAM Performance, Energy Efficiency, and Reliability

Hasan Hassan

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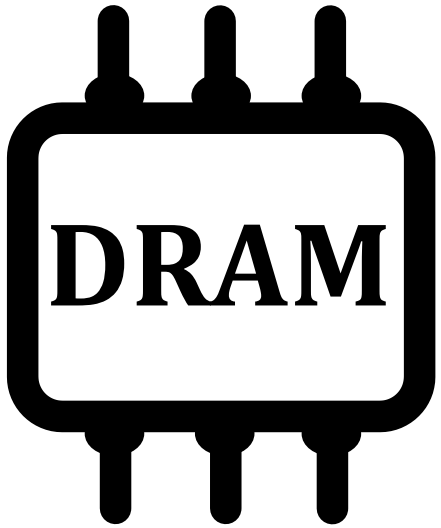
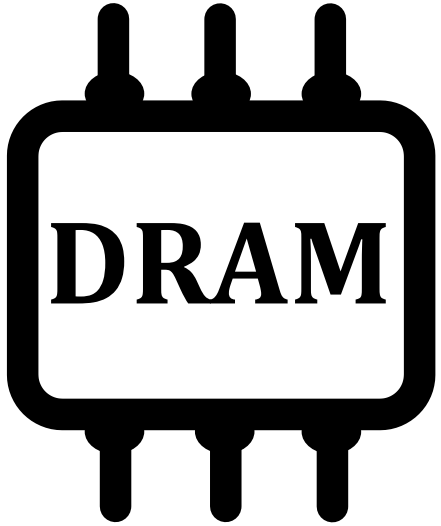
Challenges of DRAM Scaling



Challenges of DRAM Scaling

1 access latency



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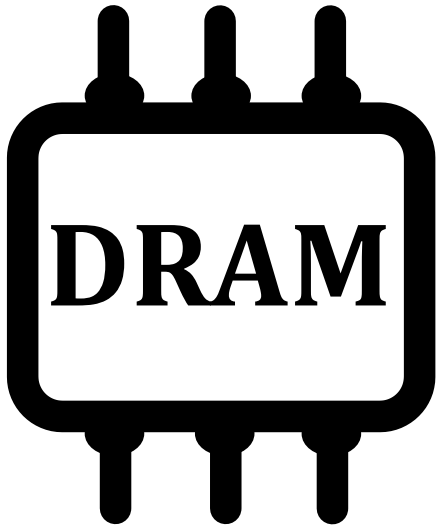

1. access latency

2. refresh overhead

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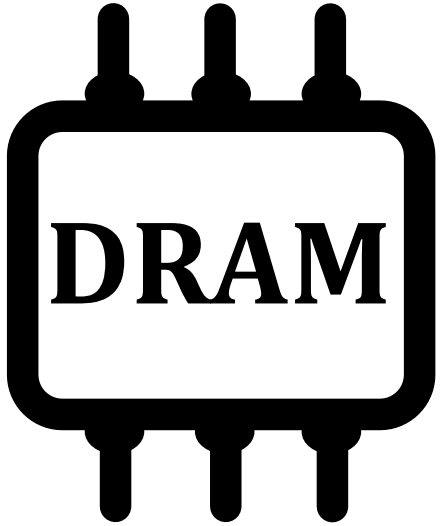
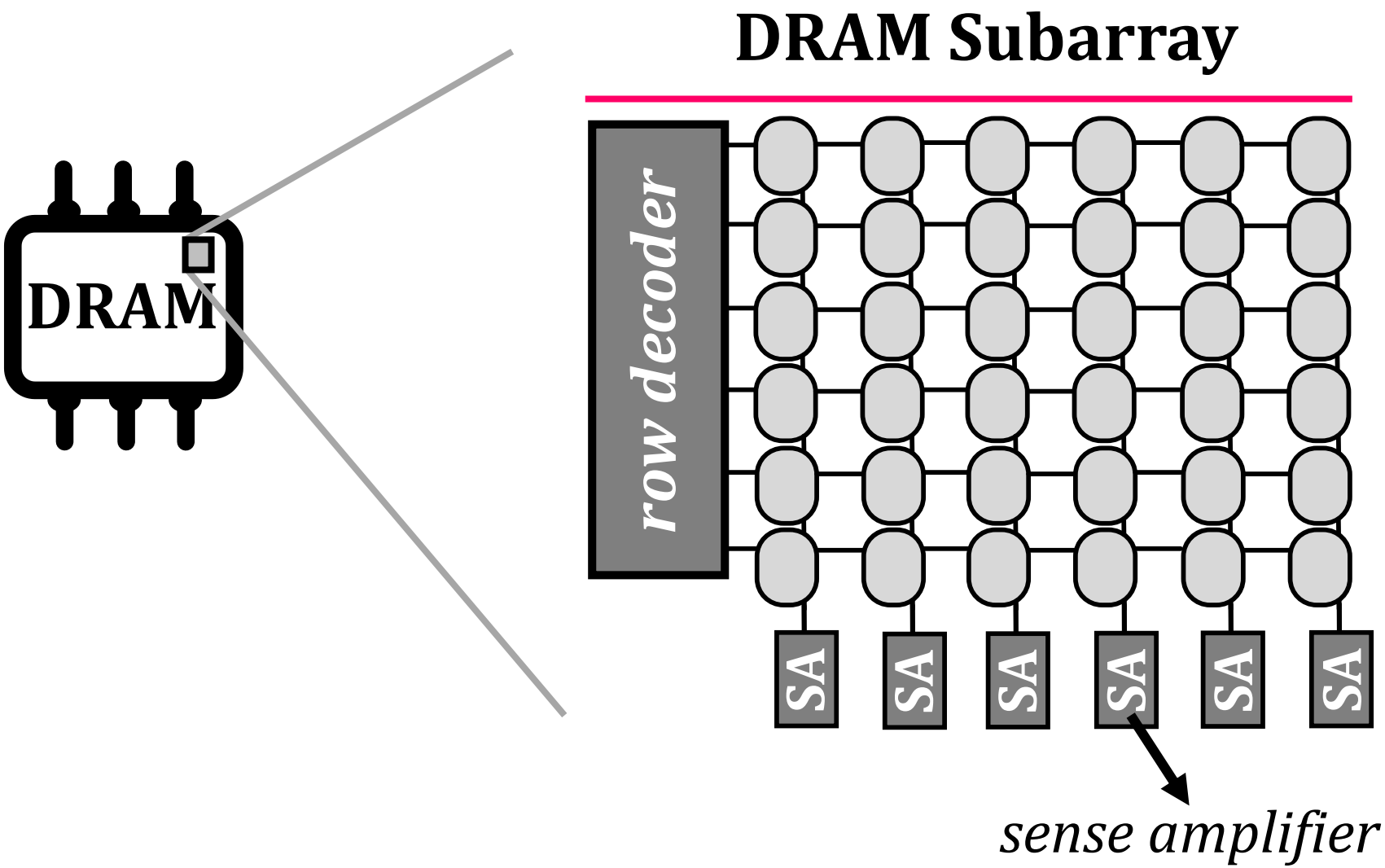


1. access latency
2. refresh overhead
3. exposure to vulnerabilities

Conventional DRAM

Conventional DRAM



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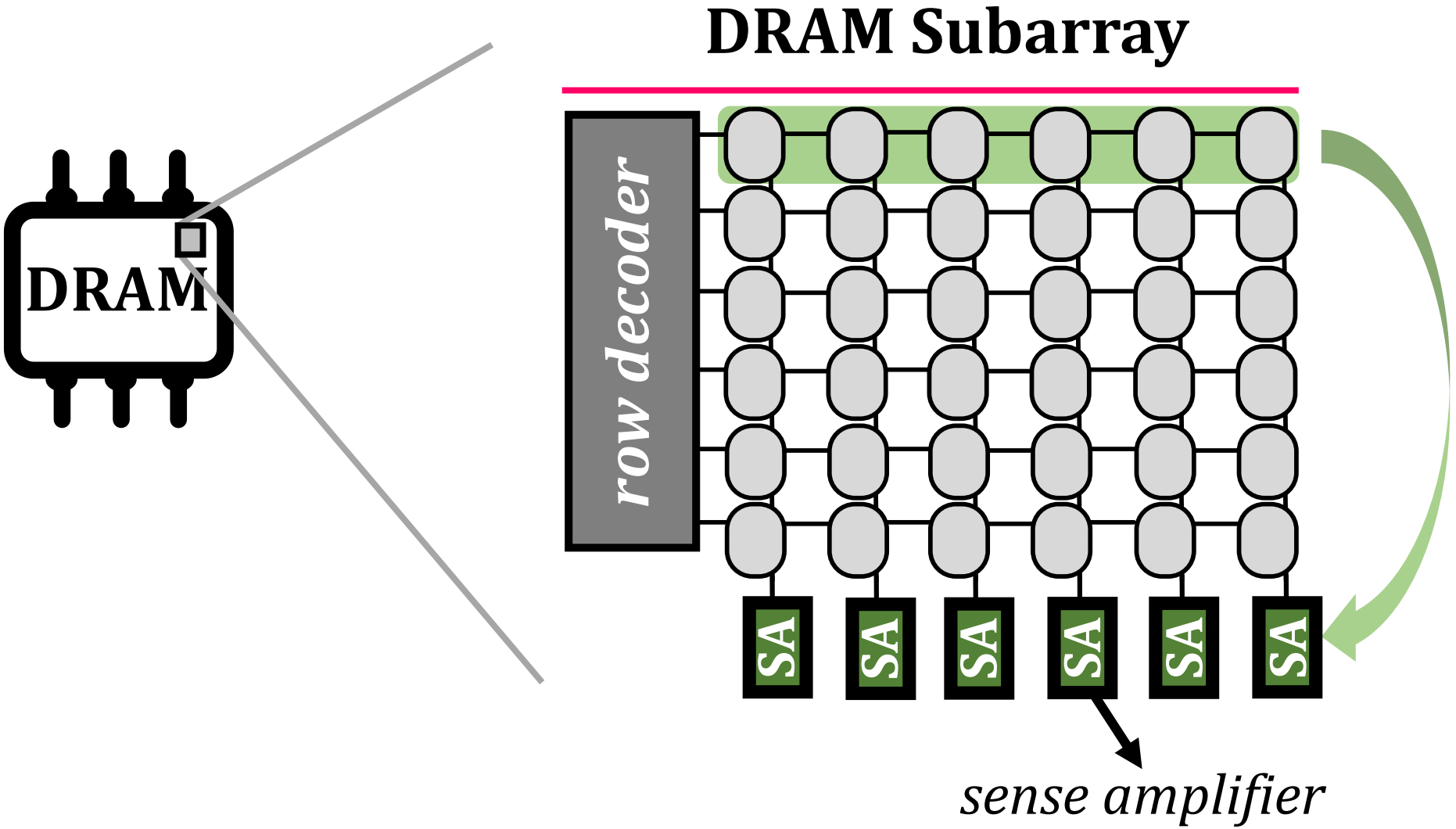
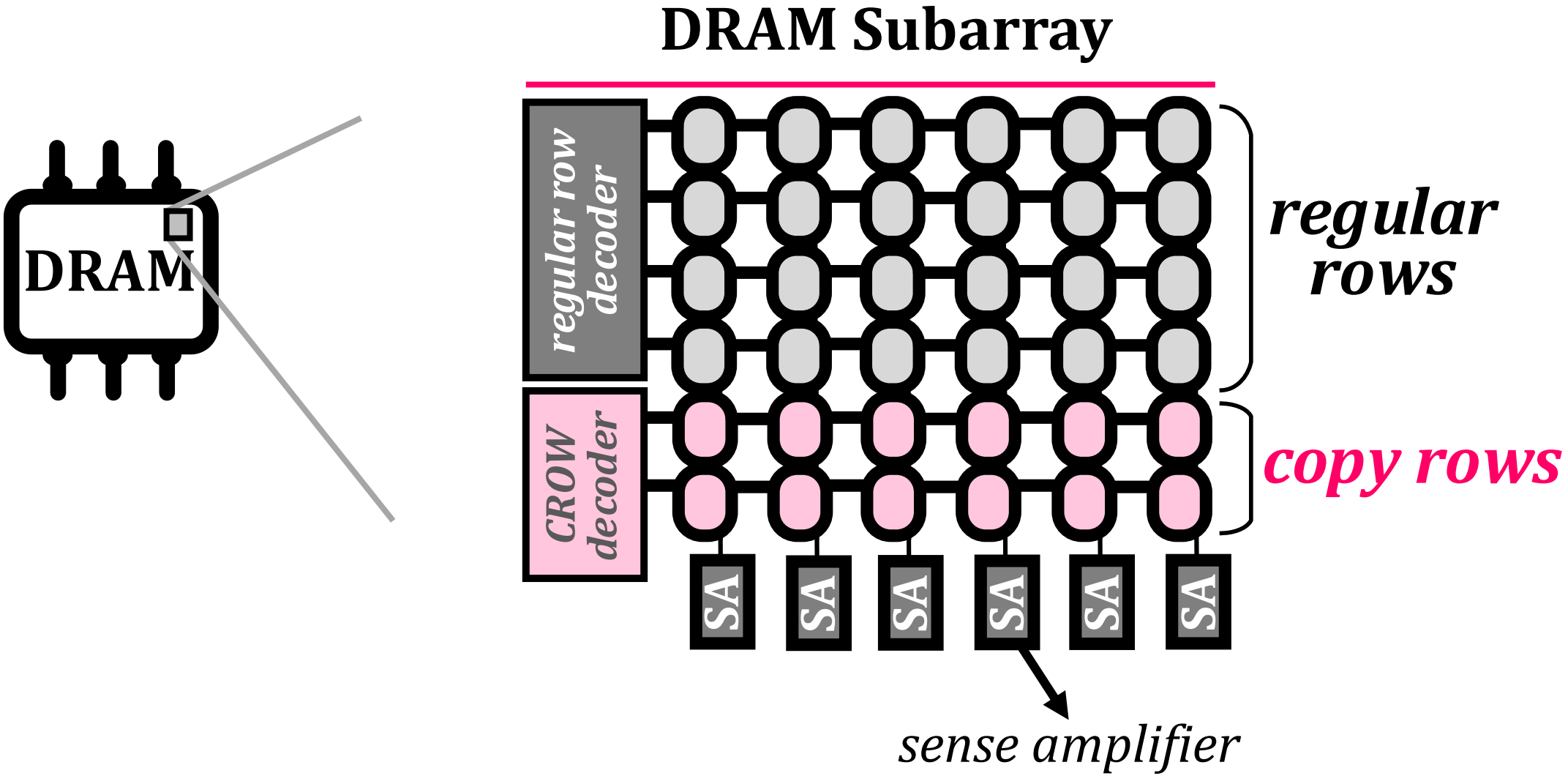


Copy Row DRAM (CROW)



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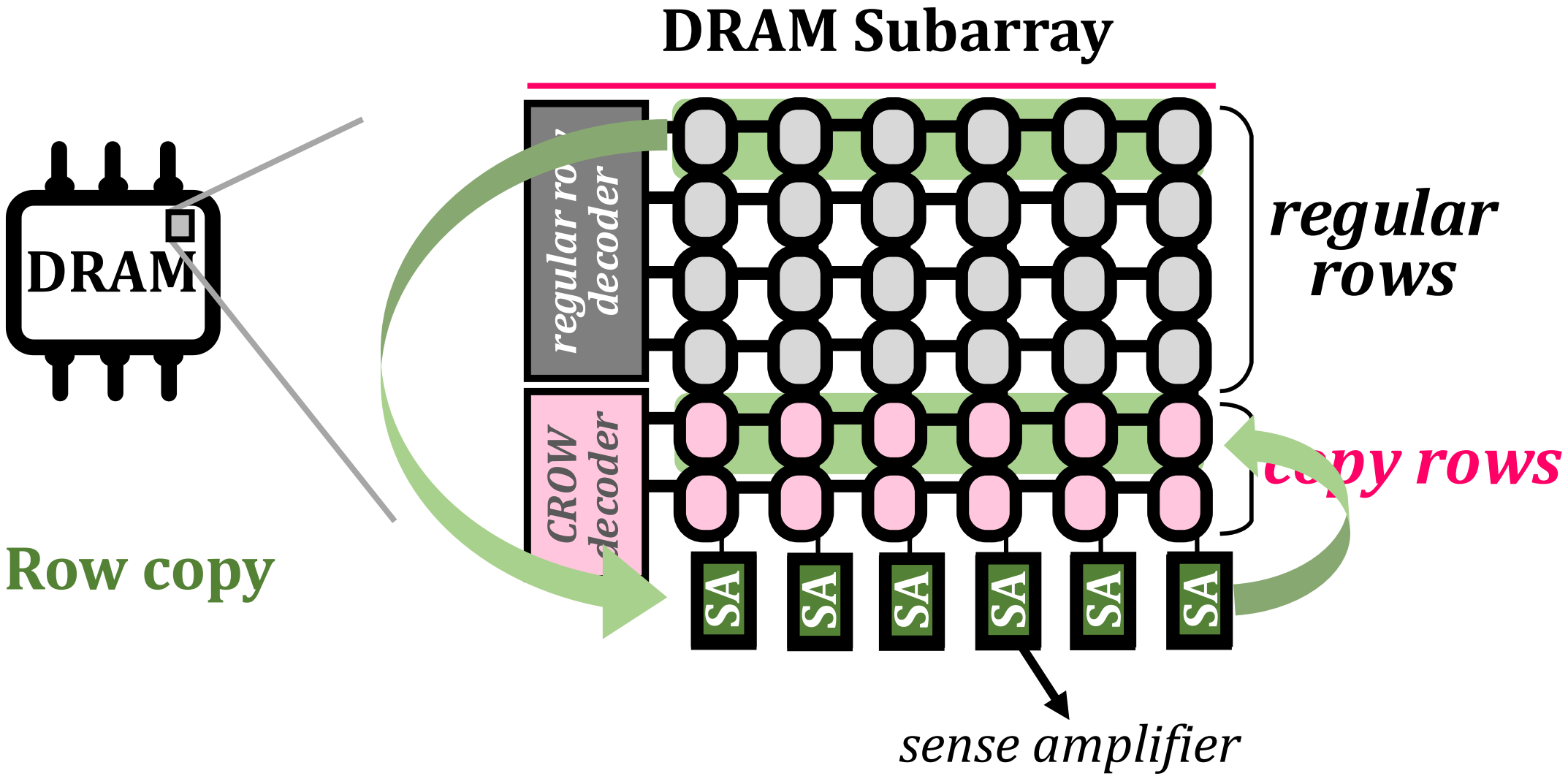

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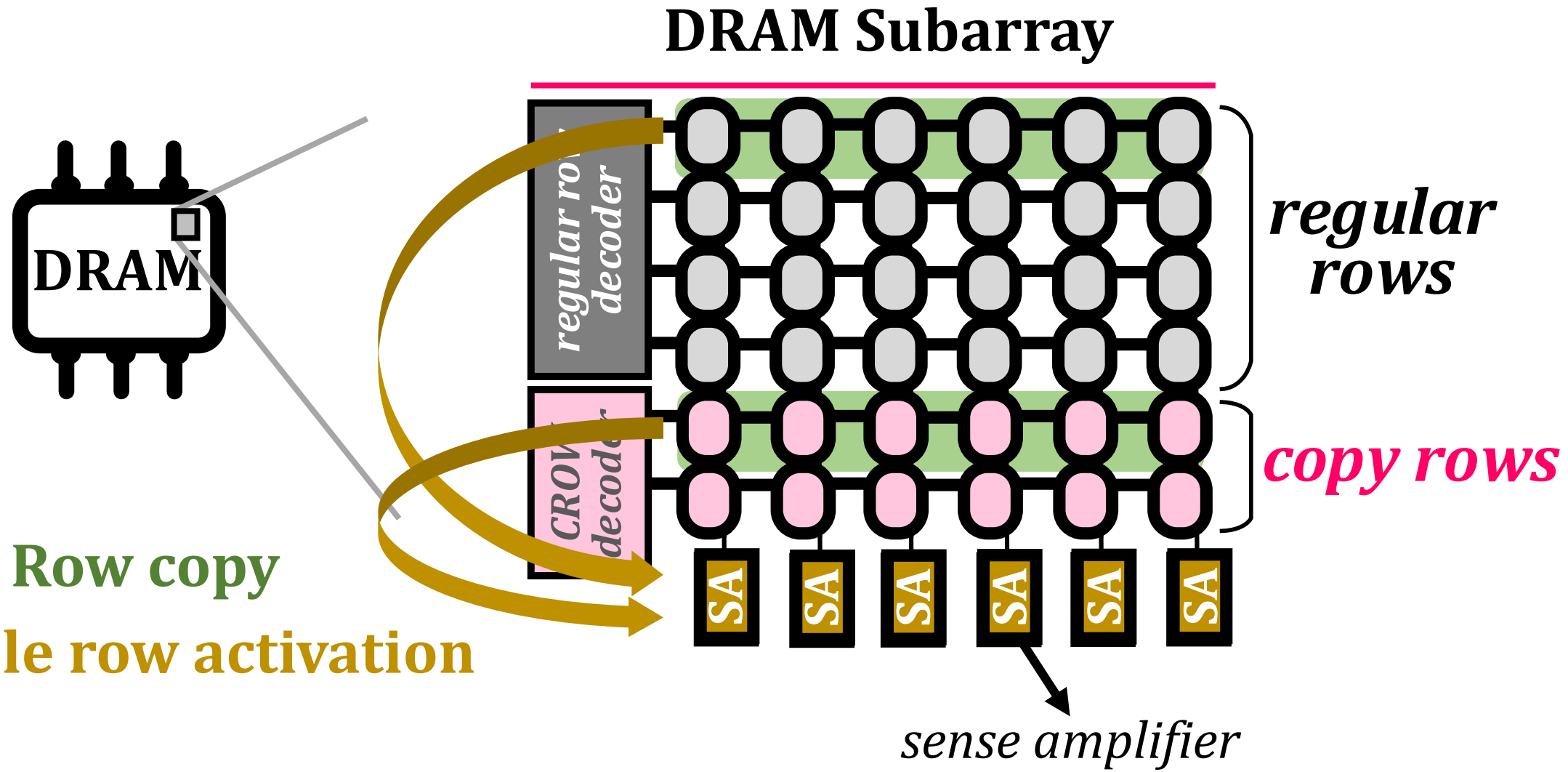

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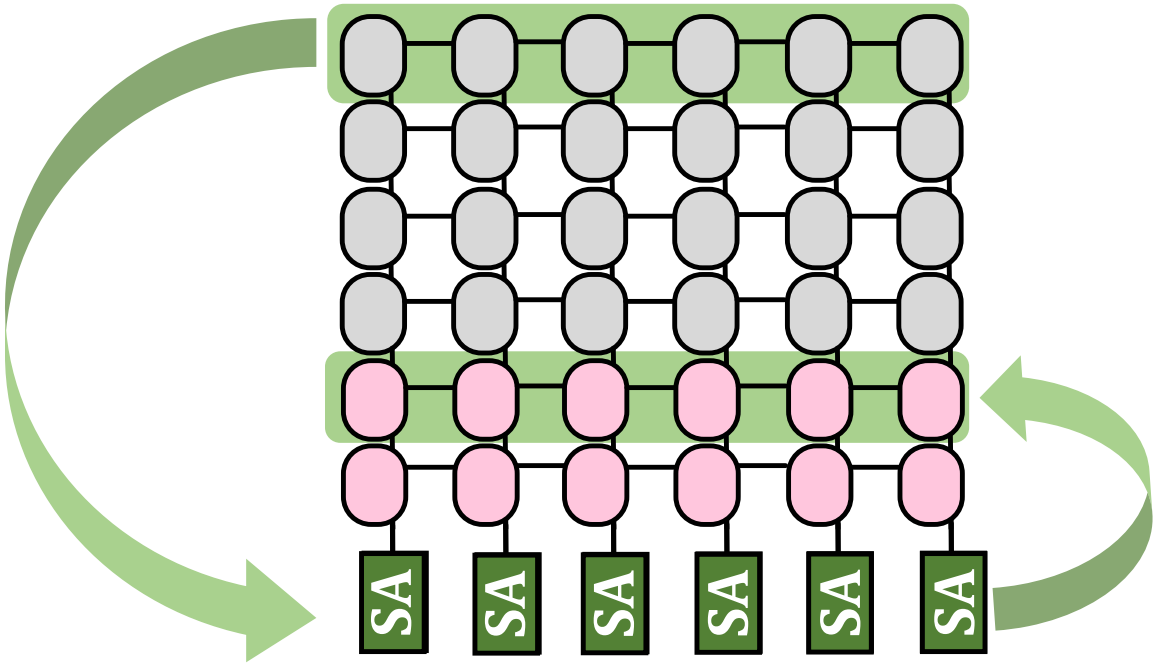

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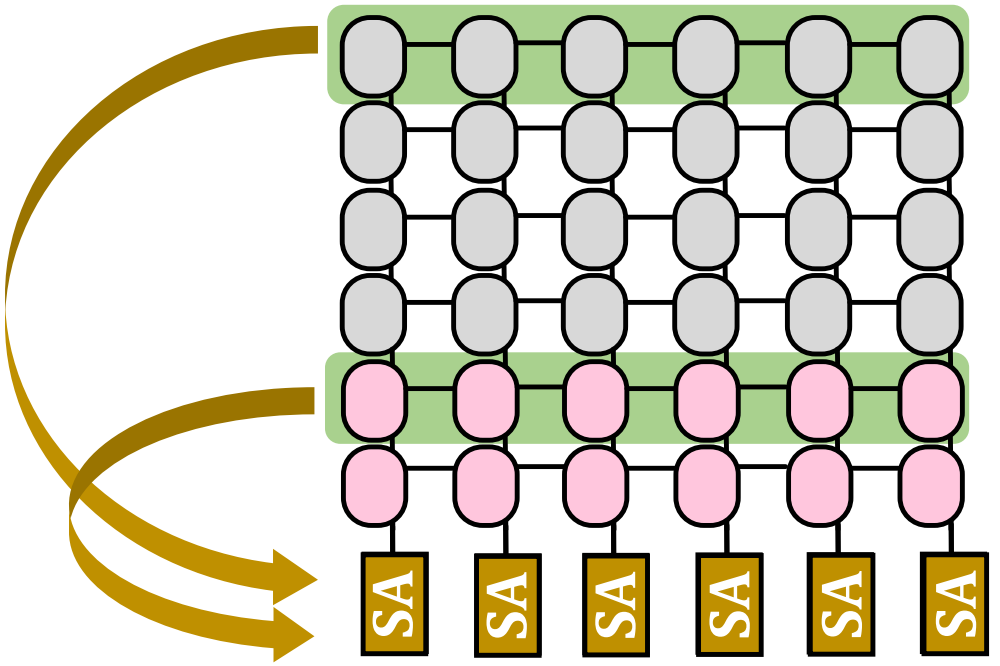

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- **CROW-ref**
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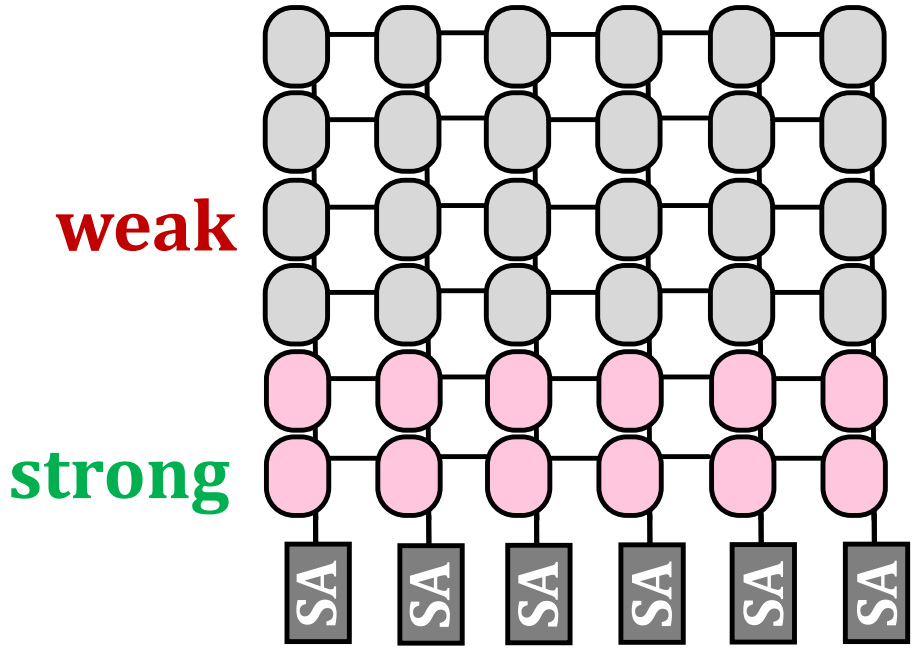

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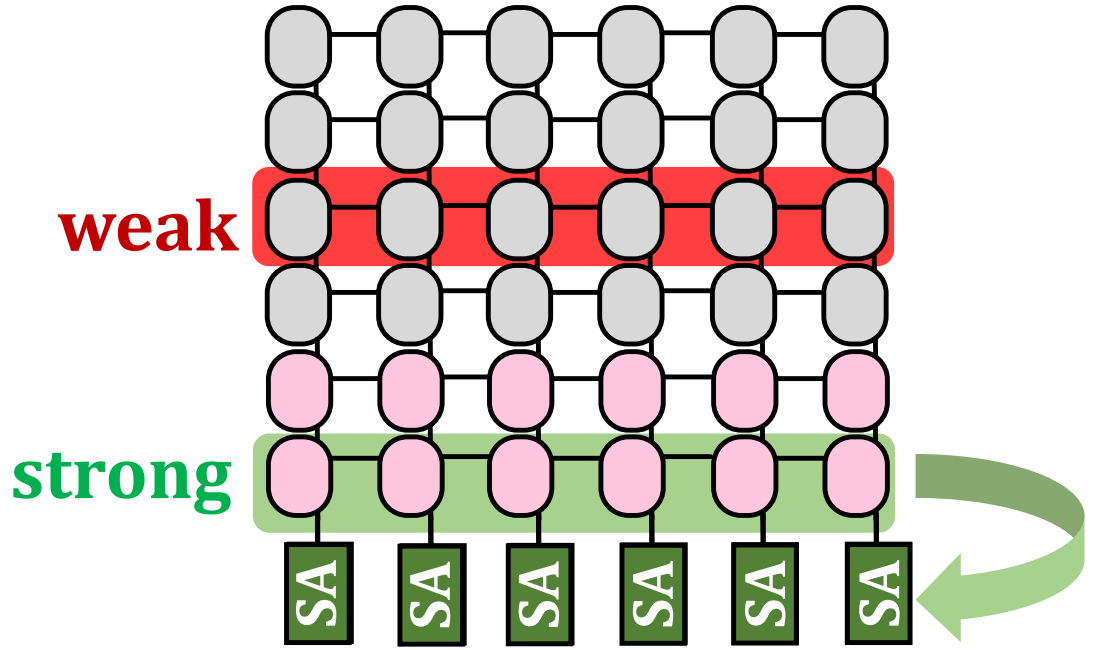

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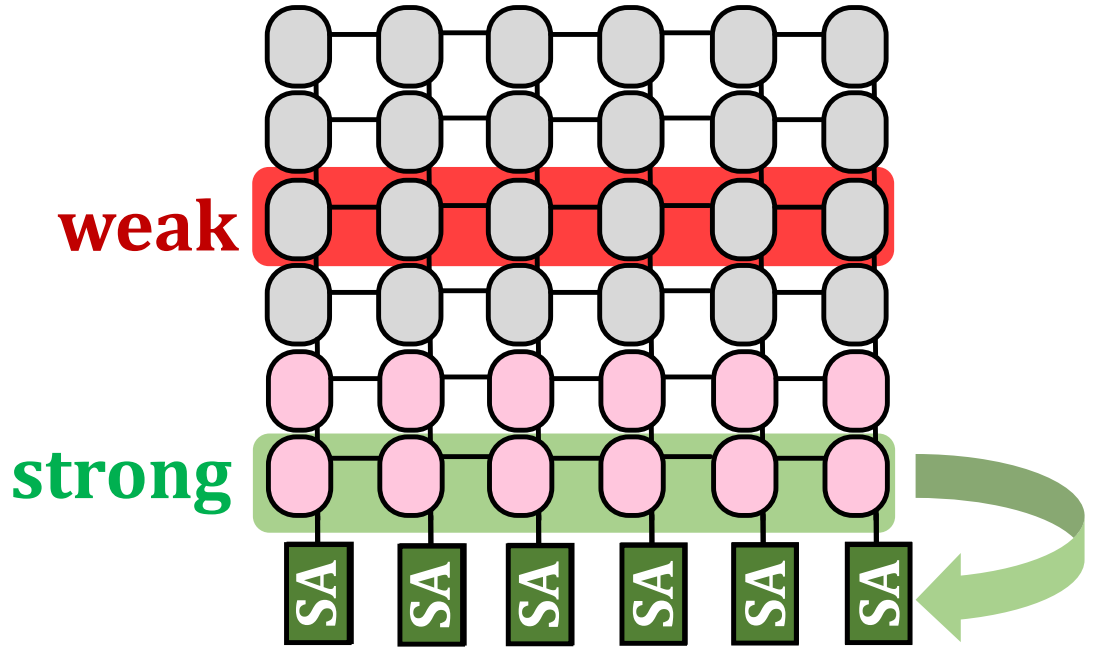

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  - ✓ reduces DRAM *refresh overhead*

- A mechanism for protecting against *RowHammer*

Key Results

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CROW-cache + CROW-ref

- 20% speedup
- 22% less DRAM energy

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Hardware Overhead

- 0.5% DRAM chip area
- 1.6% DRAM capacity
- 11.3 KiB memory controller storage

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