ETH Zürich

SAFARI

Bit-Exact ECC Recovery (BEER):

Determining DRAM On-Die ECC Functions by Exploiting DRAM Data Retention Characteristics

Minesh Patel, Jeremie S. Kim

Taha Shahroodi, Hasan Hassan, Onur Mutlu

MICRO 2020 (Session 2C – Memory)

Aggregate failure rates?

Minimum viable operating timings?

Temperature dependence?

'Weak' cell locations?

What are the DRAM chip's **reliability characteristics?**

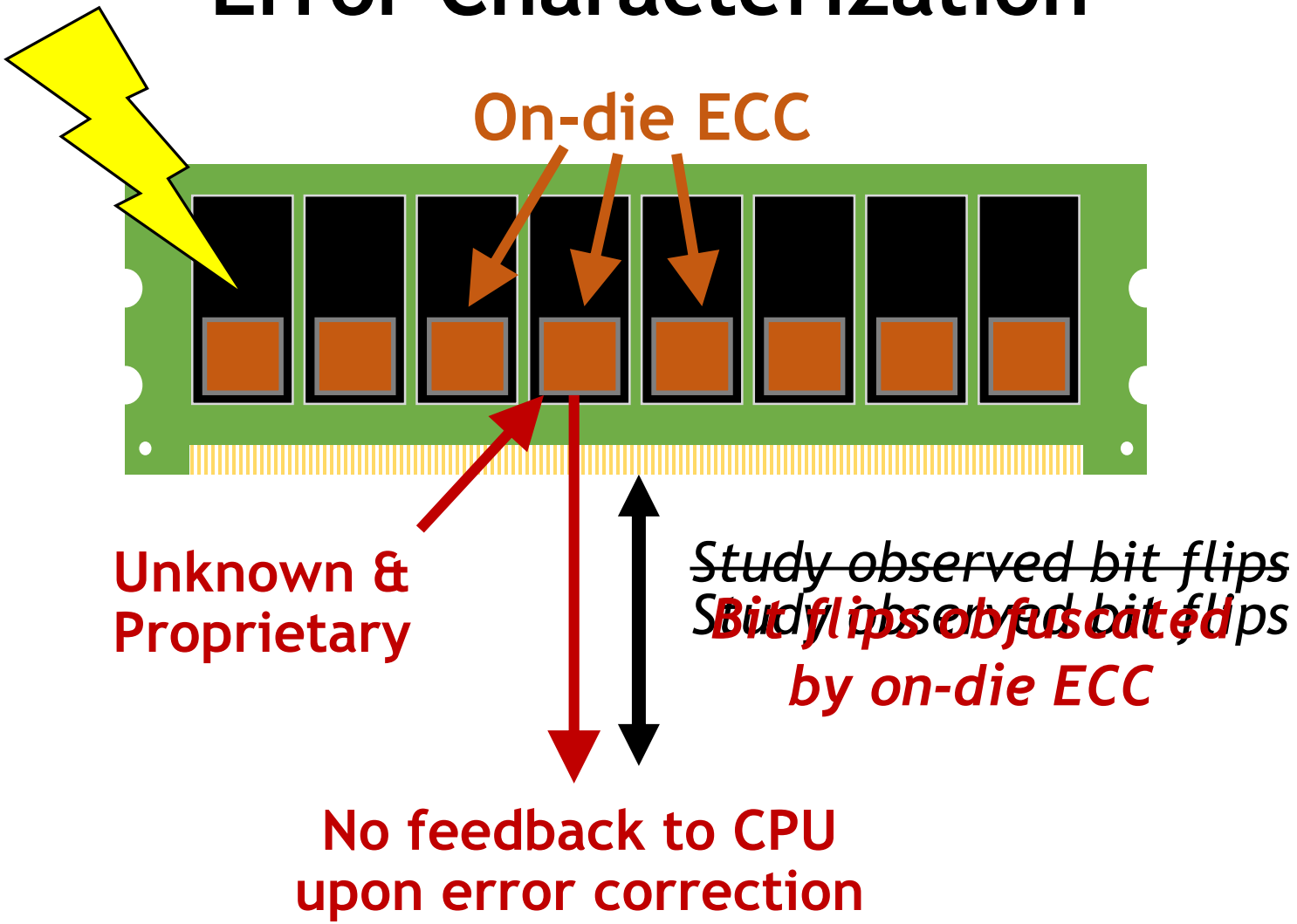
Inter-chip variation?

Statistical error distributions?

Third-party DRAM consumer

- System Designer
- Test/Validation Engineer
- Research Scientist

DRAM Testing and Error Characterization

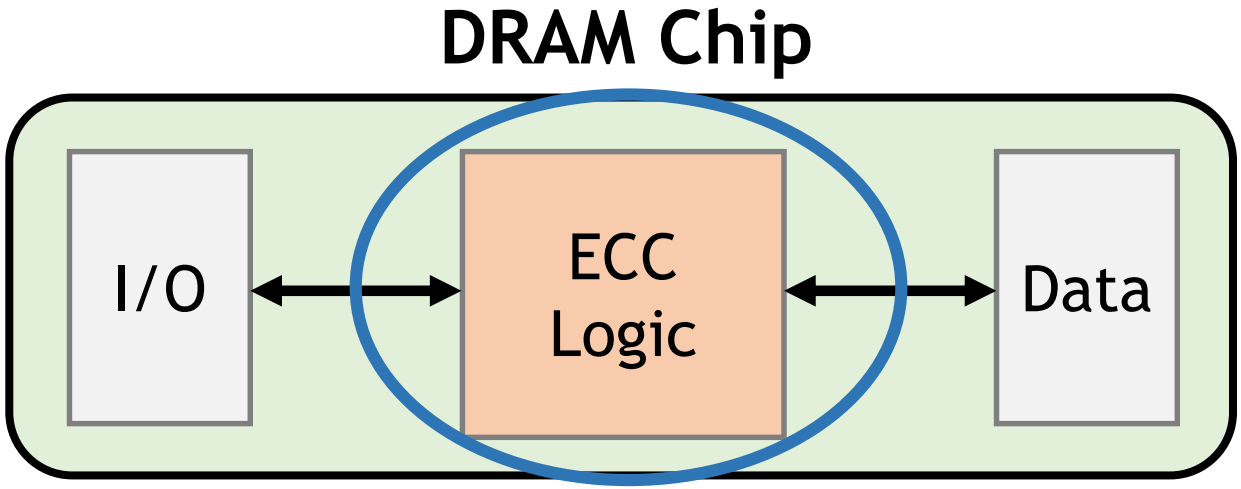


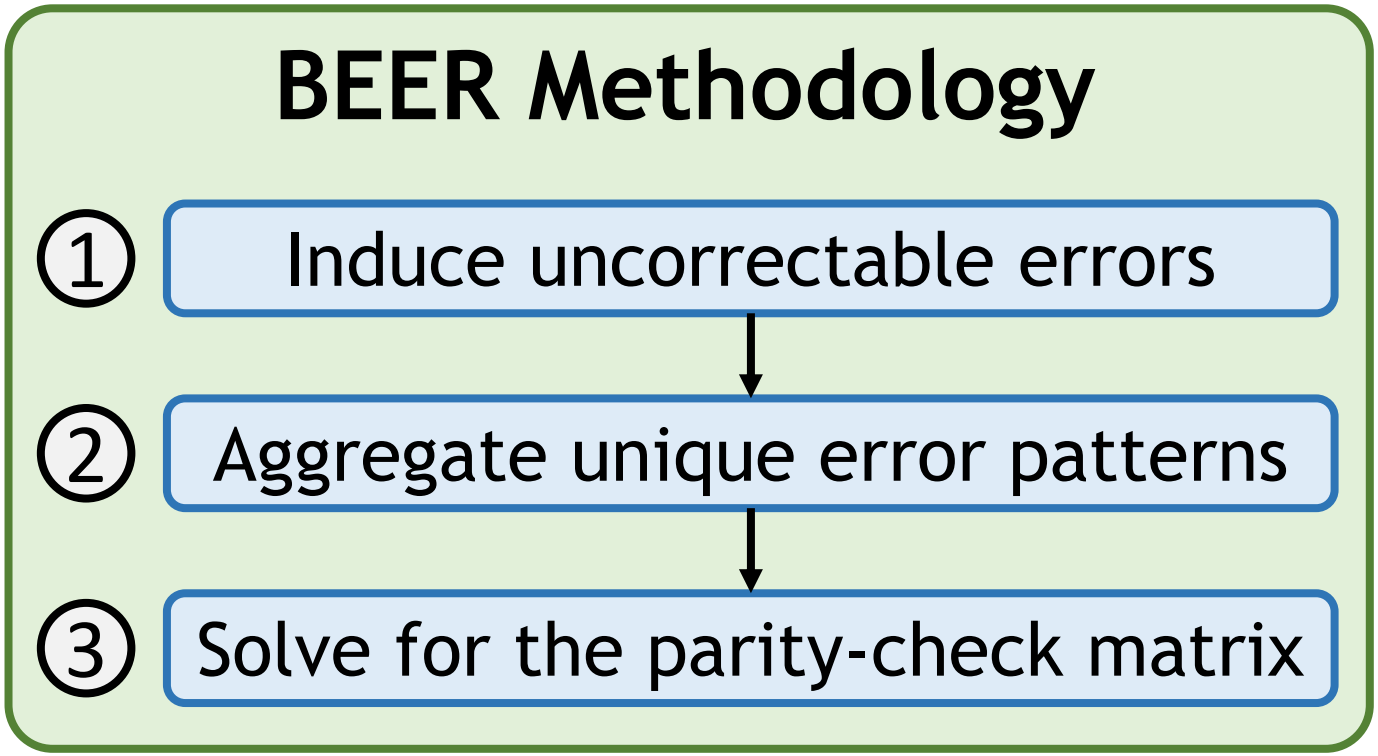
On-die ECC complicates **third-party DRAM testing**

Overcoming Challenges of On-Die ECC

Our goal:

Determine **exactly how** on-die ECC obfuscates errors (i.e., its parity-check matrix)





BEER requires no special hardware or knowledge

https://github.com/CMU-SAFARI/BEER

Experimental demonstration

80 LPDDR4 DRAM chips

(3 major manufacturers)

Two-Part Evaluation

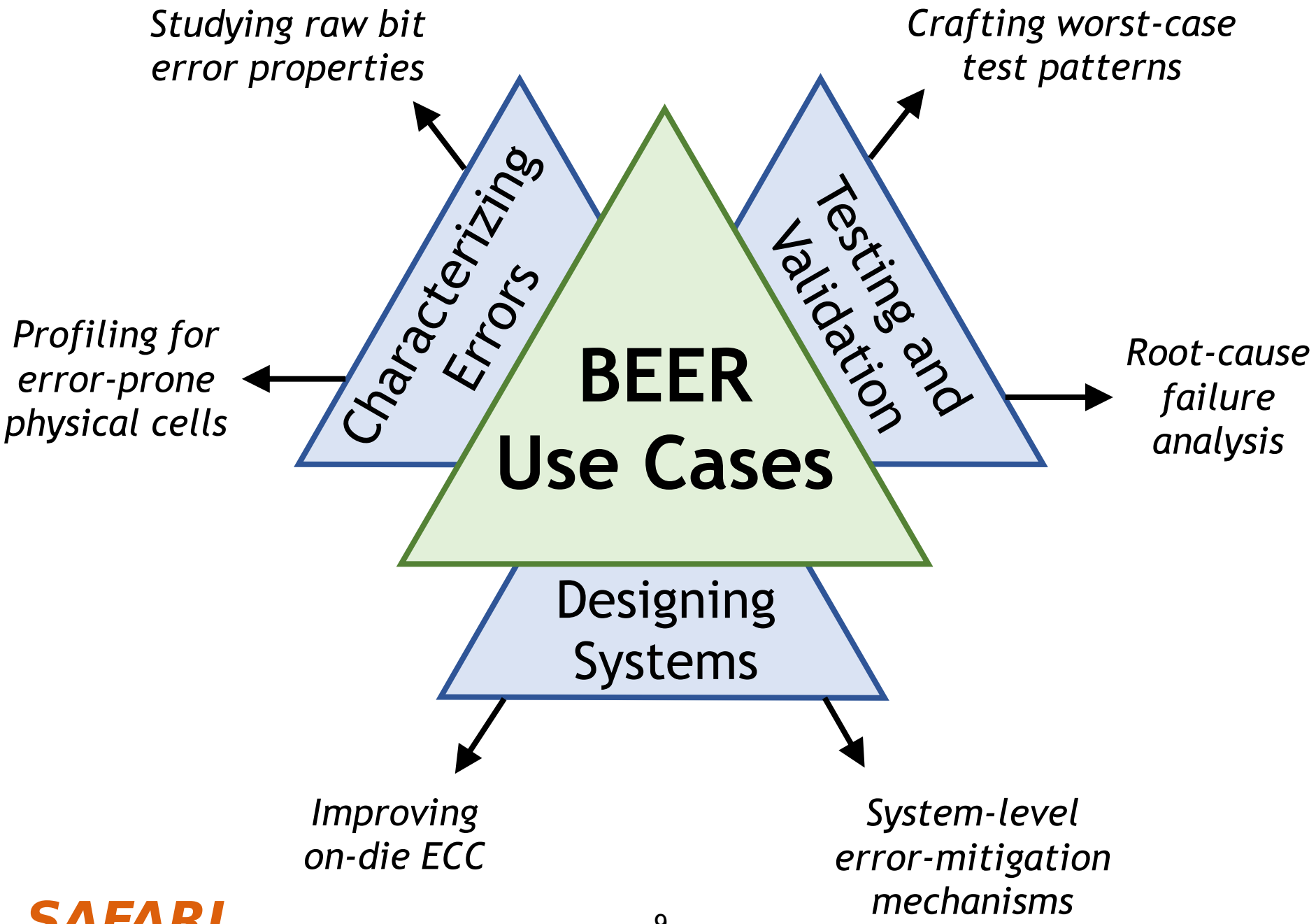
Simulated correctness and practicality

Over 100,000 representative ECC codes of varying word lengths (4 – 247 bits)

1. Different manufacturers appear to use **different** parity-check matrices
2. Chips of the same model appear to use **identical** parity-check matrices

Two-Part Evaluation

1. BEER works for **all** simulated test cases
2. BEER is **practical** in both runtime and memory usage


Studying raw bit error properties
Crafting worst-case test patterns
Characterizing Errors
Testing and Validation
Profiling for error-prone physical cells
BEER Use Cases
Root-cause failure analysis
Designing Systems
Improving on-die ECC
System-level error-mitigation mechanisms

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