Cache Compression in Two Dimensions

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INTRODUCTION

PROBLEM

cache densities and sizes have not kept up with increasing cache demands of applications

EXISTING SOLUTIONS

transparent, in-hardware cache compression

- *inter-block:* deduplicating identical blocks *across* the cache (e.g., [1])
- *intra-block:* compressing common patterns *within* each block (e.g., [2])

LIMITATIONS

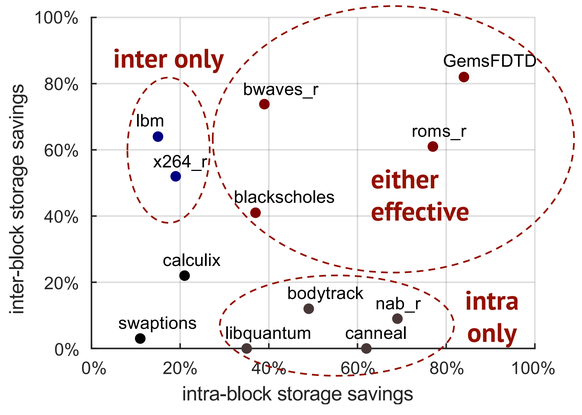
compression in only one dimension (either inter-block or intra-block)

[1] Pekhimenko et al. "Base-delta-immediate compression." PACT 2012.
[2] Tian et al. "Last-level Cache Deduplication." 2014.

OPPORTUNITIES

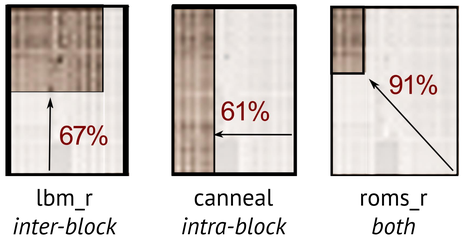
ACROSS WORKLOADS: CHOOSE INTER OR INTRA

many workloads are compressible using *only* inter-block or *only* intra-block methods:

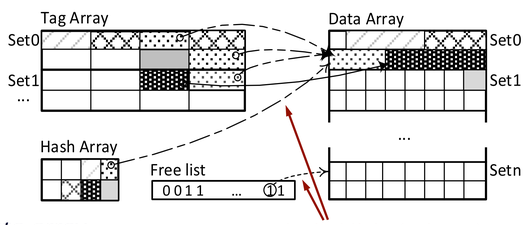


WITHIN WORKLOADS: NEED BOTH METHODS

many workloads compress best with *both*:



ARCHITECTURE: STORAGE STRUCTURES



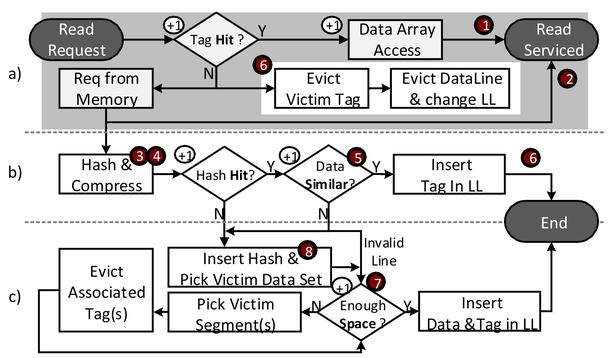
data array
- variable-sized blocks to allow compression
- evicts blocks with fewest duplicates

tag array
- 4× capacity vs standard to allow compression
- evicts least recently used tags

hash array
- helps detect duplicate blocks
- evicts least recently seen block hashes

ARCHITECTURE: OPERATION MECHANISM

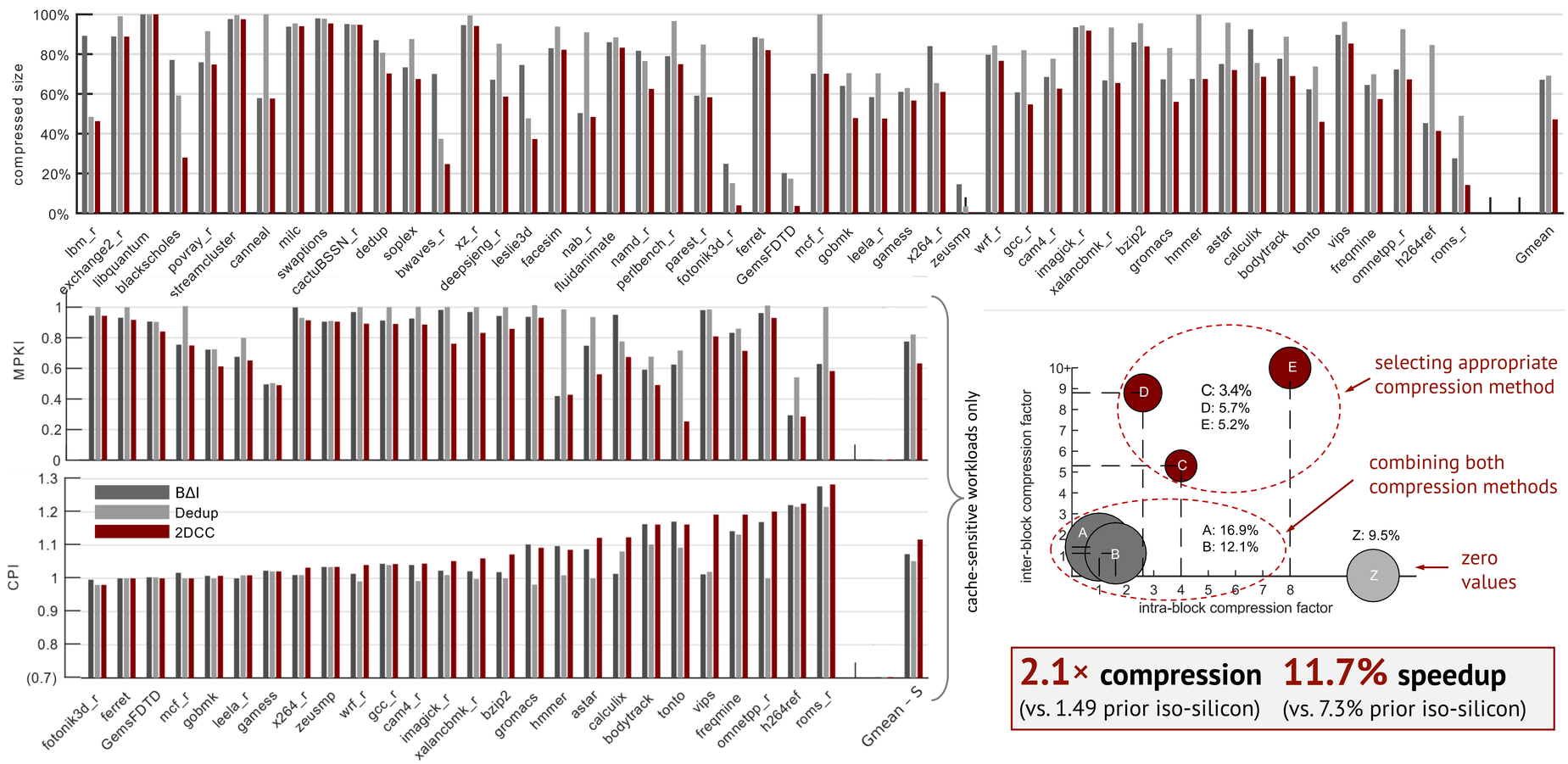
- **reads, evictions, and insertions:** the critical-path similar to a conventional cache
- **writes:** execute off the critical path, may change the compression factor (steps 3–8)
- deduplication / compression overheads are incurred off the critical path



on the critical path (shaded):
- **(1)** hit response
- **(2)** miss response

off the critical path:
- **(3)** hash calculation
- **(4)** block compression
- **(5)** duplicate block detection
- **(6)** tag entry insertion/replacement
- **(7)** data entry insertion/replacement
- **(8)** hash entry insertion (unique blocks)

RESULTS



2.1× compression (vs. 1.49 prior iso-silicon) **11.7% speedup** (vs. 7.3% prior iso-silicon)

a place of mind
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