

DOPPELGÄNGER: A CACHE FOR APPROXIMATE COMPUTING

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CONTRIBUTIONS

- We recognize **approximate similarity** in data values; two data blocks are approximately similar if replacing one with the other still yields acceptable application output. We characterize the amount of approximately similar data that exists in the last-level cache.
- We propose **Doppelgänger**, a novel cache architecture that identifies approximately similar cache blocks and associates them with a single data array entry. We evaluate the Doppelgänger cache, demonstrating $1.55\times$, $2.55\times$ and $1.41\times$ reductions in LLC area, dynamic energy and leakage energy ($1.36\times$, $1.19\times$ and $1.28\times$ for total on-chip cache hierarchy) with low application error and only a 2.3% increase in runtime.

APPROXIMATE SIMILARITY

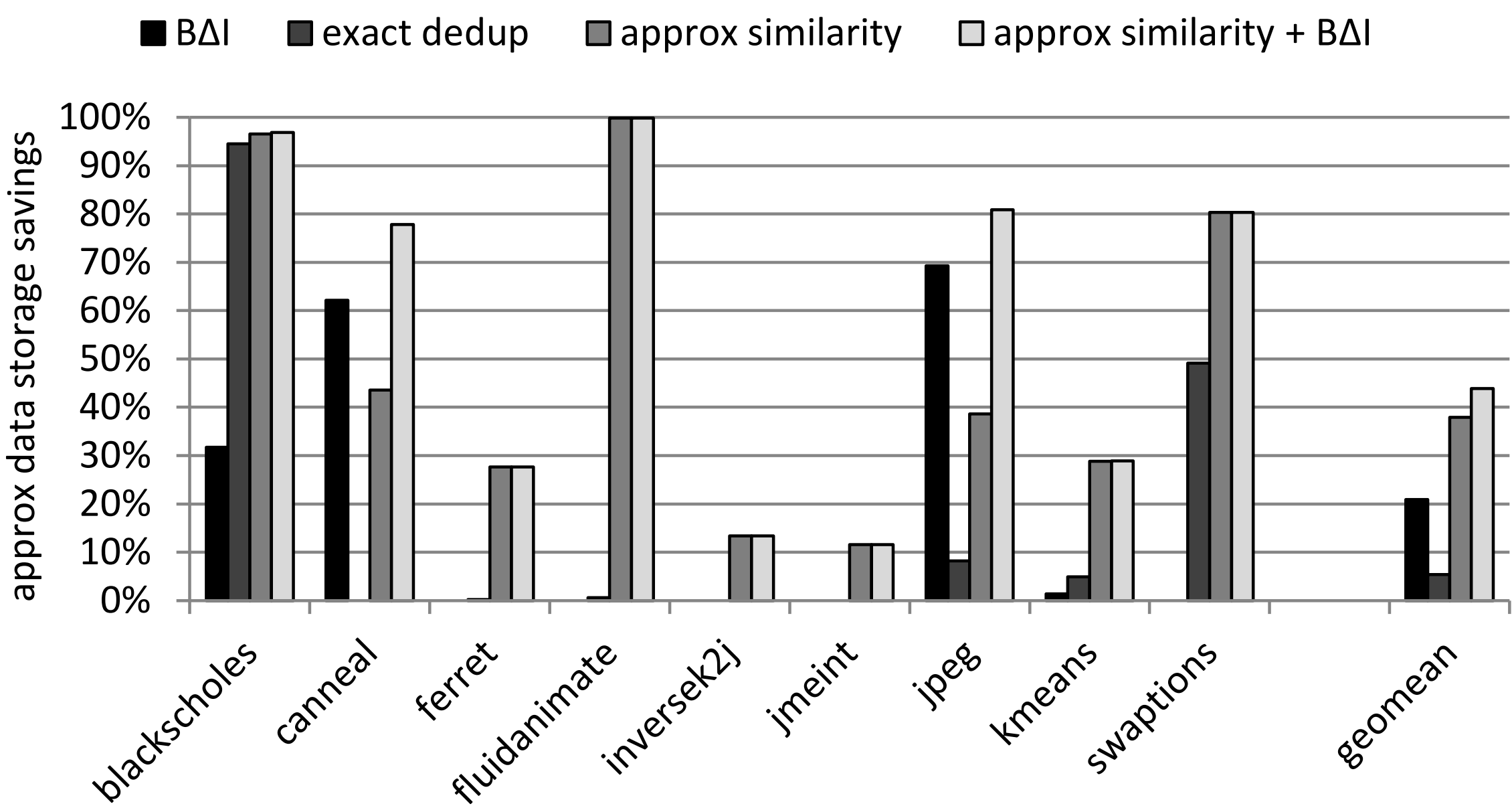


Example of approximate similarity in an image. Many pixel values are similar. Boxes indicate regions of data in the example.
Source: wikipedia.

	R	G	B	R	G	B
1	92	131	183	91	132	186
2	90	131	185	93	133	184
3	35	31	29	43	38	37

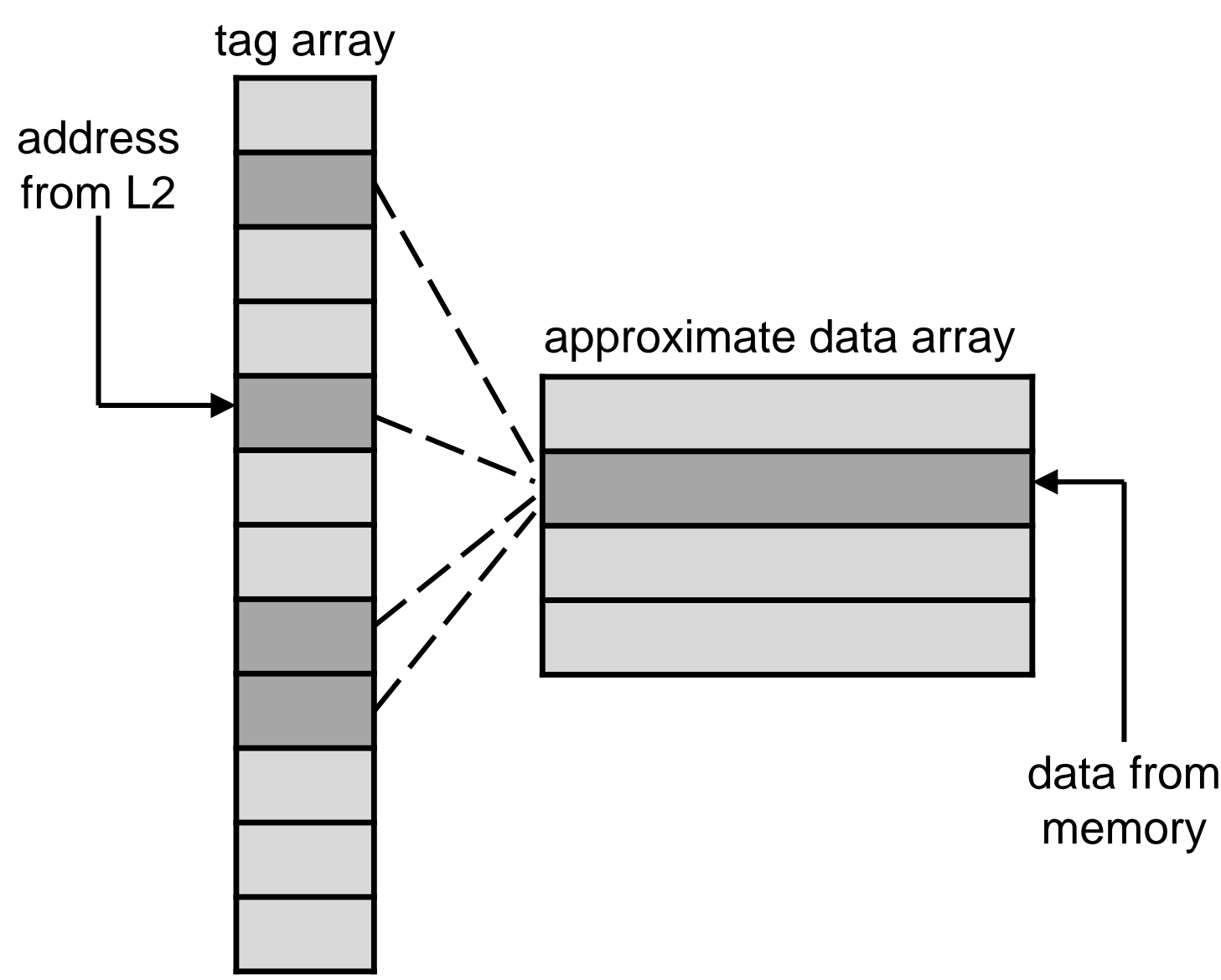
RGB pixel values in cache blocks corresponding to boxes in image (assuming each cache block holds two pixels).

APPROXIMATE SIMILARITY STORAGE



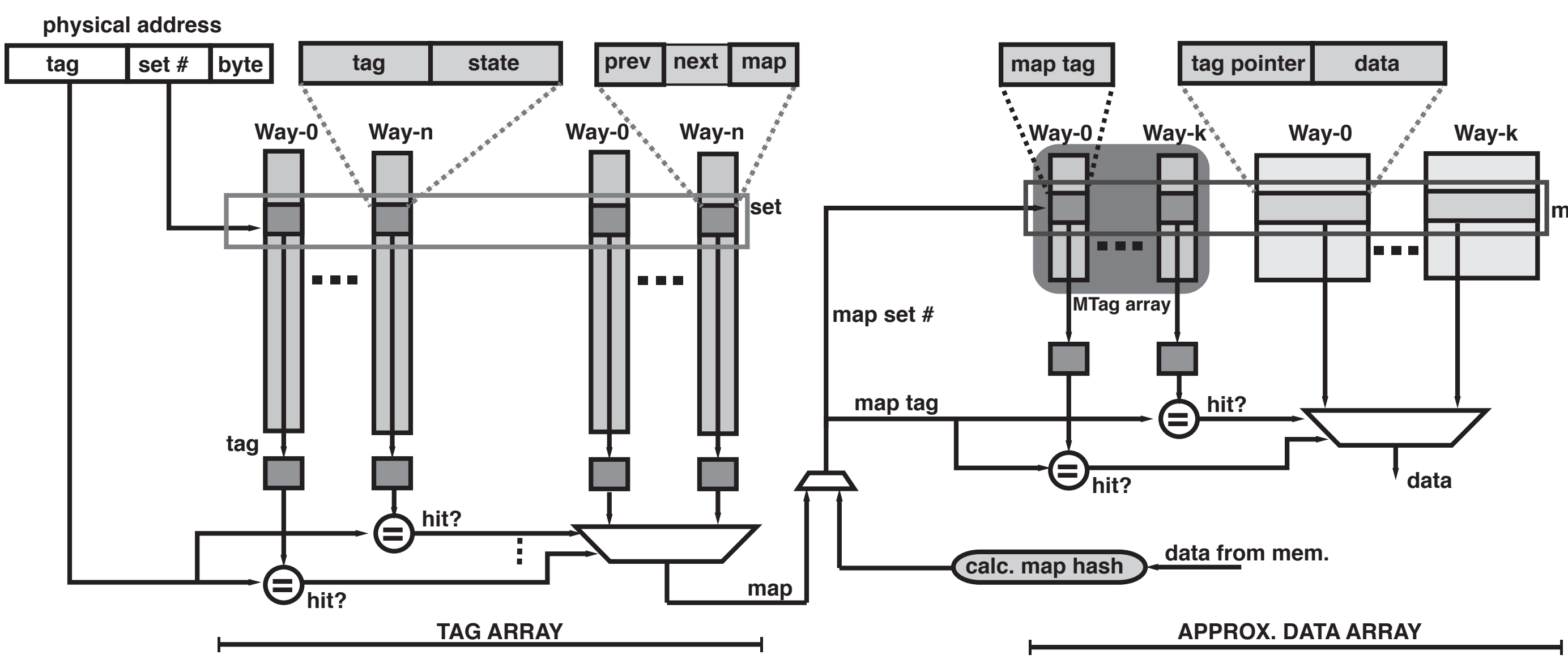
Cache storage savings due to approximate similarity. Comparing against BAI compression and exact deduplication.

DOPPELGÄNGER CACHE OVERVIEW

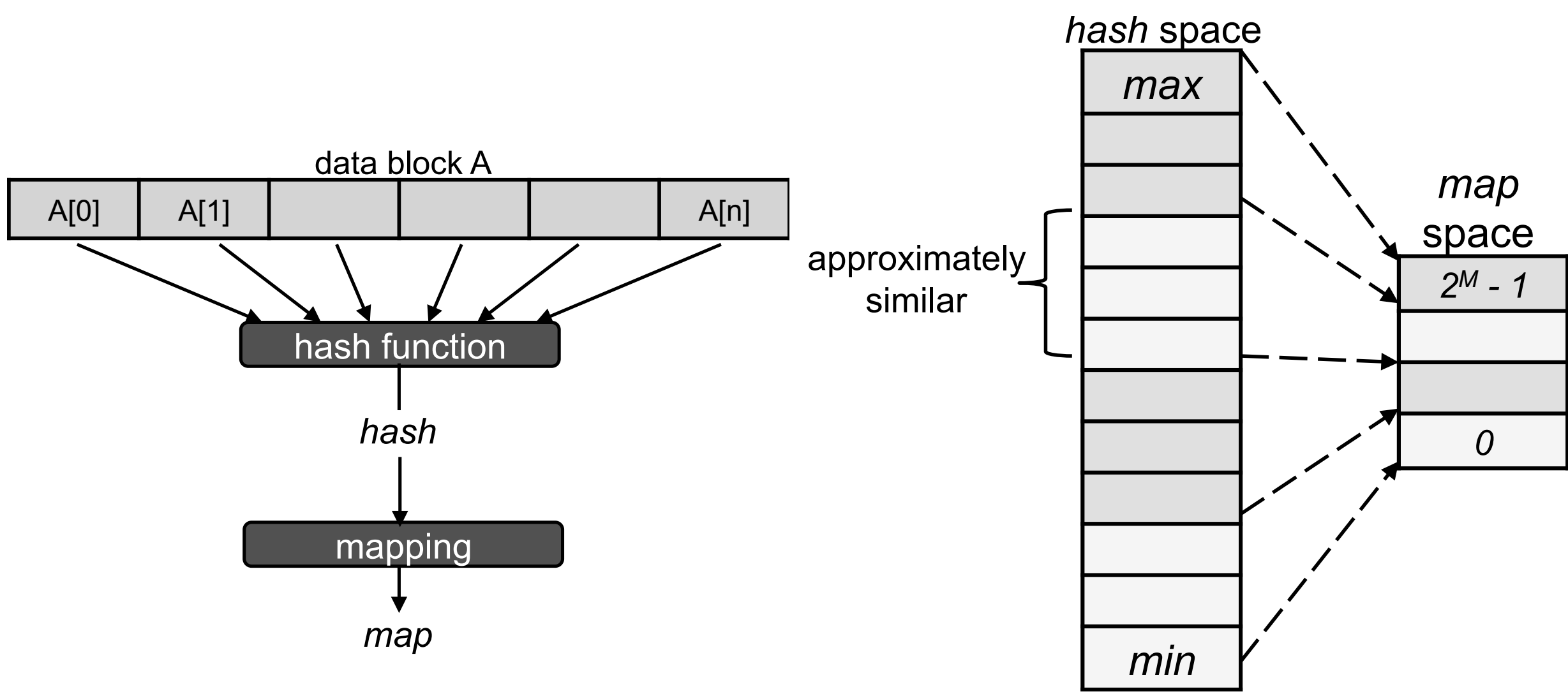


In the Doppelgänger cache, tags of approximately similar blocks are associated with the same data entry.

DOPPELGÄNGER CACHE ARCHITECTURE

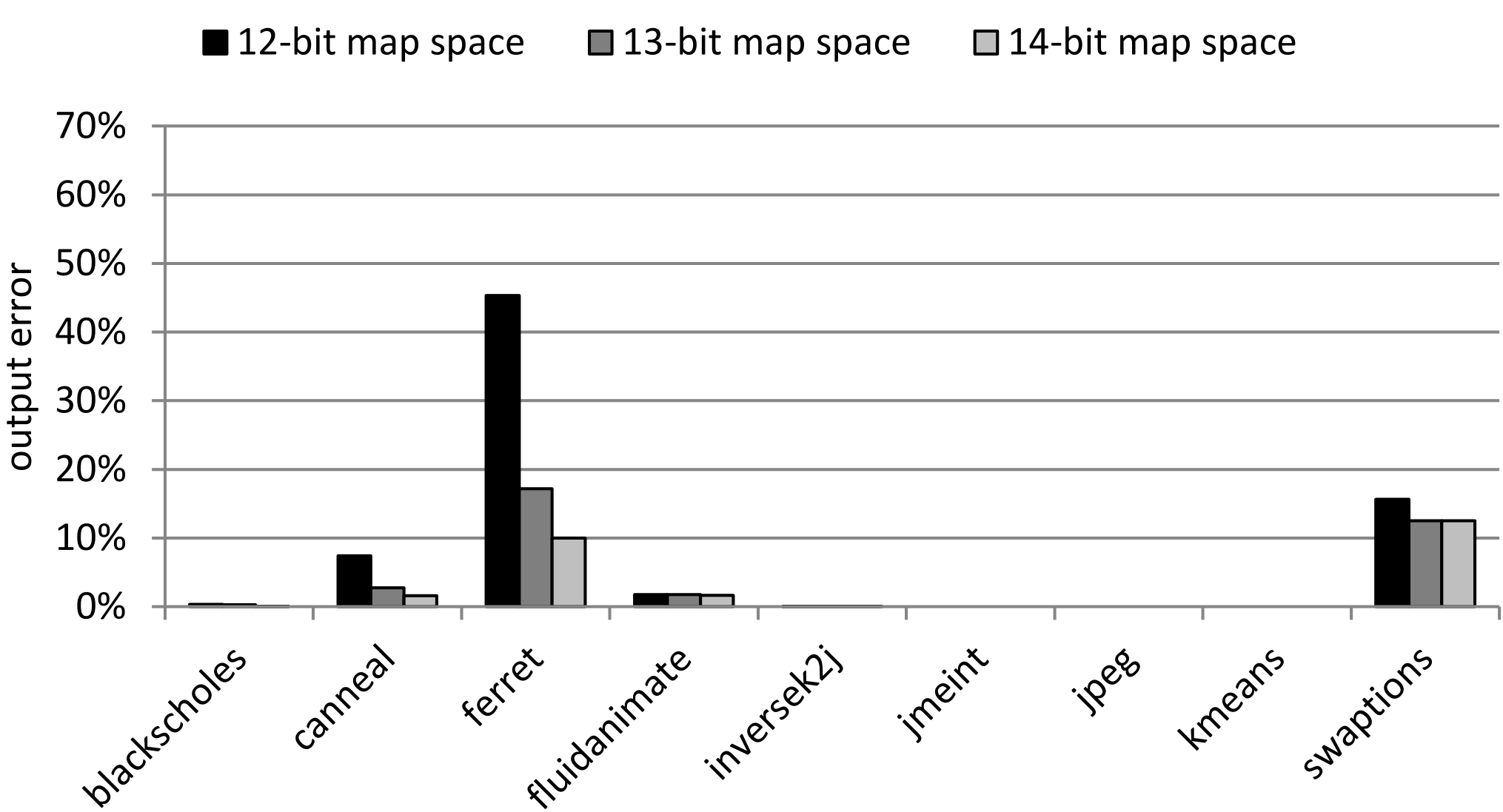


DOPPELGÄNGER SIMILARITY MAPPING



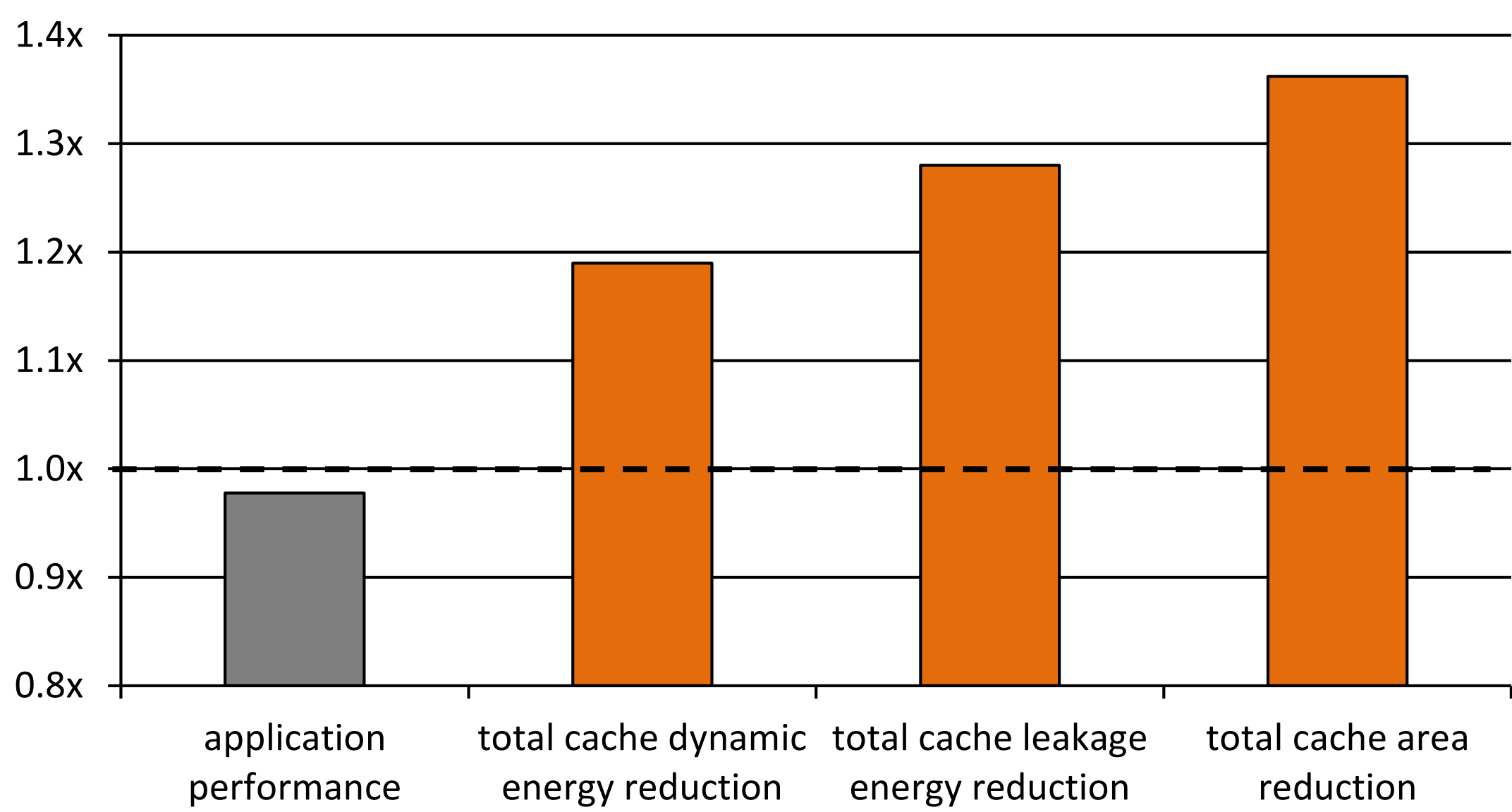
Overview of Doppelgänger similarity mapping (left), which consists of a hash function and mapping (right).

EVALUATION - OUTPUT ERROR



Application output error with Doppelgänger while varying size of similarity map space.

EVALUATION



Average performance, energy and area of Doppelgänger relative to baseline precise last-level cache.