BASE-DELTA-IMMEDIATE COMPRESSION: PRACTICAL DATA COMPRESSION FOR ON-CHIP CACHES

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MOTIVATION & BACKGROUND

Significant redundancy in data:

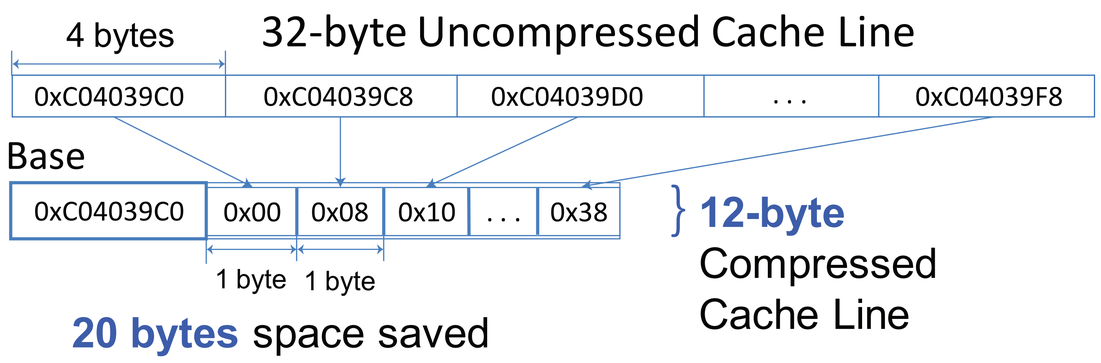
0x**00000000**	0x**0000000B**	0x**00000003**	0x**00000004**	…

Cache compression provides effect of a larger cache without making it physically larger

Key requirements:

- **Fast (low decompression latency)**
- **Simple (avoid complex hardware changes)**
- **Effective (good compression ratio)**

BASE+DELTA (B+Δ) ENCODING: KEY IDEA



BΔI IMPLEMENTATION

- **Decompressor design: vector addition (fast)**
- **Compressor design**
  - **Arithmetic (+/-) and comparisons**
- **BΔI cache organization**
  - **2X tags + compr. encoding**
  - **Data segmenting (e.g., 8-byte)**

KEY DATA PATTERNS

Zero Values: initialization, sparse matrices

0x00000000	0x00000000	0x00000000	0x00000000	…

Repeated Values: common initial values

0x*000000*FF	0x*000000*FF	0x*000000*FF	0x*000000*FF	…

Narrow Values: small values in a big data type

0x*00000000*	0x*0000000*B	0x*00000003*	0x*00000004*	…

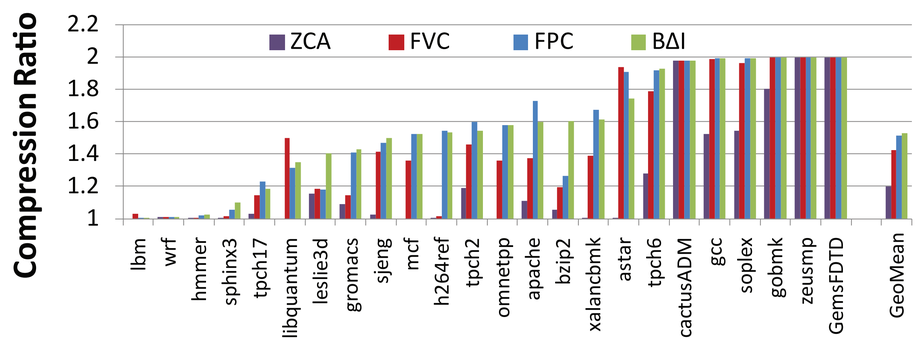
0x*C04039*C0	0x*C04039*C8	0x*C04039*D0	0x*C04039*D8	…

Low Dynamic Range

BASE-DELTA-IMMEDIATE COMPRESSION

- **Use multiple bases to increase compression coverage**
- **Pro: More cache lines can be compressed**
- **Cons: 1. Unclear how to find, 2. Higher overhead**
- **Empirically 2 bases is the best for our set of applications**
  1. **First base – first element in the cache lines (base+Δ)**
  2. **Second base – implicit base of 0 (immediate)**

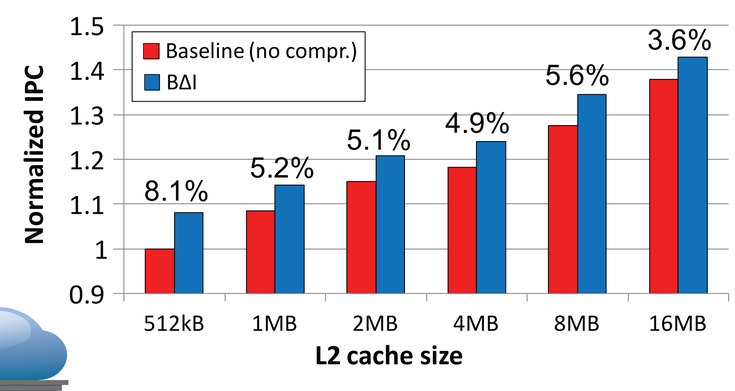
KEY RESULTS: COMPRESSION RATIO

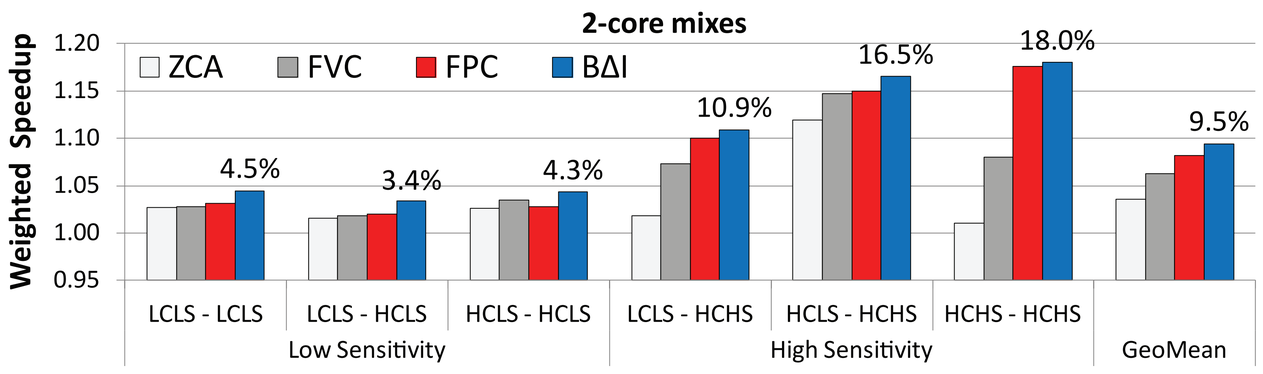


KEY RESULTS: PERFORMANCE

BΔI [4] performance over other mechanisms:

Cores	No Compression	ZCA[3]	FPC [1]	FVC [2]
1	5.1%	4.1%	2.1%	1.0%
2	9.5%	5.7%	3.1%	1.2%
4	11.2%	5.6%	3.2%	1.3%





[1] A. Alameldeen and D. Wood. Adaptive Cache Compression for High-Performance Processors, ISCA'04
[2] J. Yang et al., Frequent value compression in data caches. Micro'00
[3] J. Dusser et al., Zero-content augmented caches, ICS'09
[4] G. Pekhimenko et al., Base-Delta-Immediate Compression: Practical Data Compression for On-Chip Caches, PACT'12

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