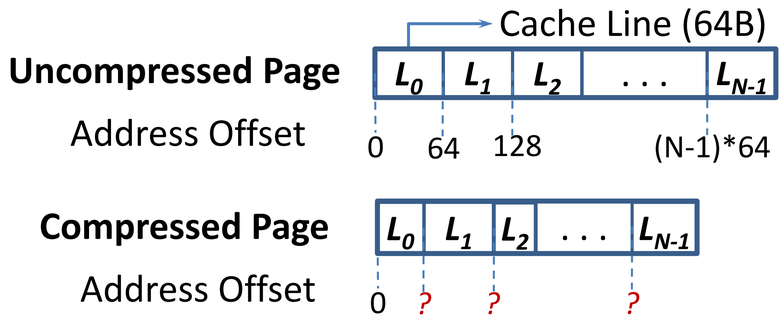
Linearly Compressed Pages: A Low Complexity, Low Latency Main Memory Compression Framework

Summary

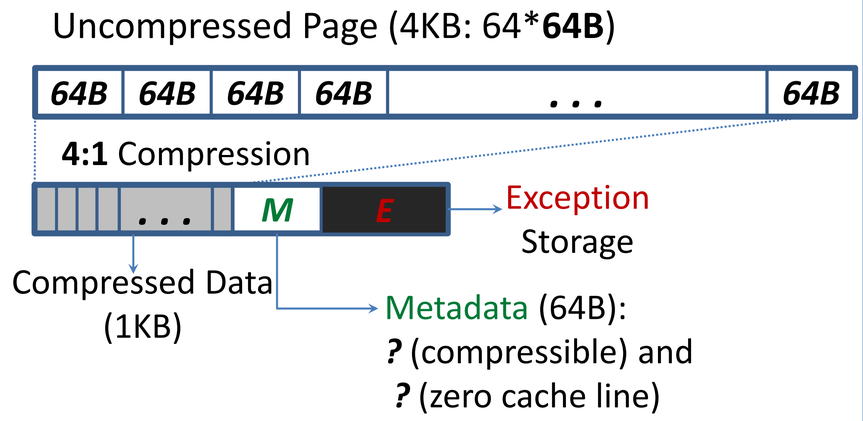
- Main memory is a limited shared resource
- **Observation**: Significant data redundancy
- **Idea**: Compress data in main memory
- **Problem**: How to avoid latency increase?
- **Solution**: Linearly Compressed Pages (LCP): fixed-size cache line granularity compression
  1. Increases capacity (**62%** on average)
  2. Decreases bandwidth consumption (**24%**)
  3. Improves overall performance (**13.9%**)
  4. Decreases memory energy consumption (**9.5%**)

Challenge in Memory Compression



Challenge: Address Computation

Linearly Compressed Pages (LCP)

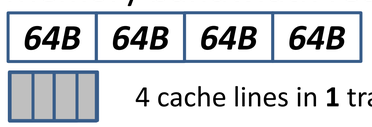


LCP Overview

- Page Table entry extension
  compression type, size, and extended physical base address
- Operating System management support
  4 memory pools (512B, 1KB, 2KB, 4KB)
- Handling page overflows
- Hardware support
- Compression algorithms:
  Base-Delta-Immediate (**BDI**) and
  Frequent Pattern Compression (**FPC**)

LCP Optimizations

- Metadata cache
  Avoids additional requests to metadata
- Memory bandwidth reduction



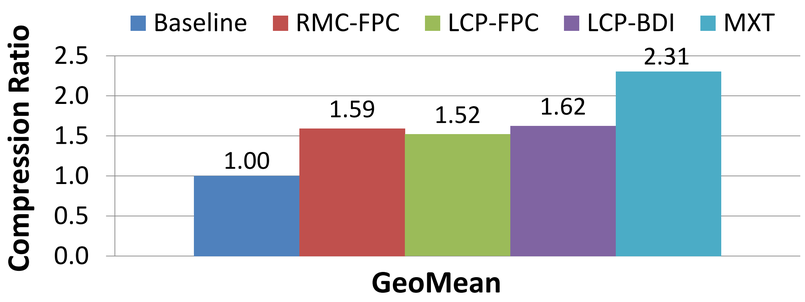
- Zero pages and zero cache lines
  Handled separately in TLB (1-bit) and metadata (1-bit per line)

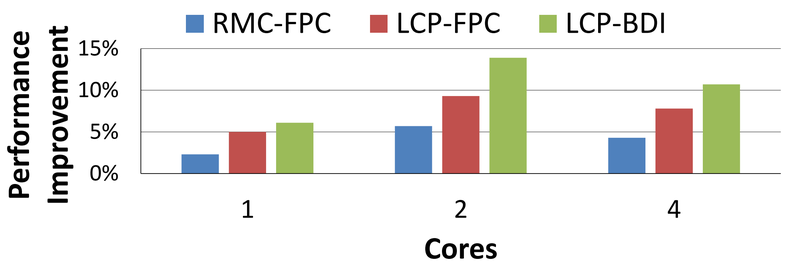
Methodology

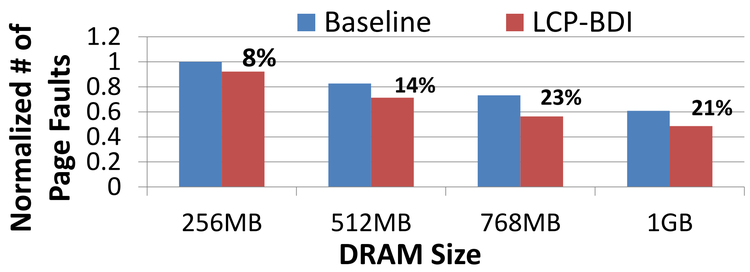
Evaluated designs

No.	Label	Description
1	Baseline	Baseline (no compression)
2	RMC-FPC	Main memory compression using RMC and FPC
3	LCP-FPC	LCP framework with FPC
4	LCP-BDI	LCP framework with BDI
5	MXT	IBM MXT design

Key Results: Compression Ratio, Performance, Page Faults







SPEC2006, databases, web workloads, L2 2MB cache

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