Coordinated and Efficient Huge Page Management with Ingens

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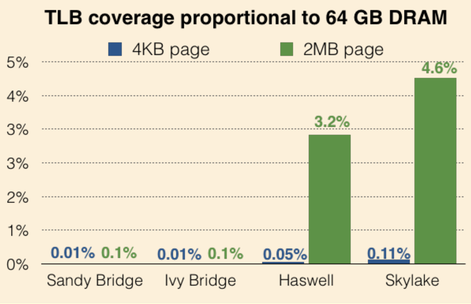
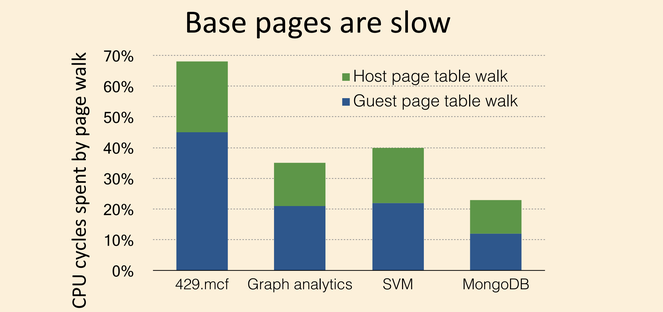
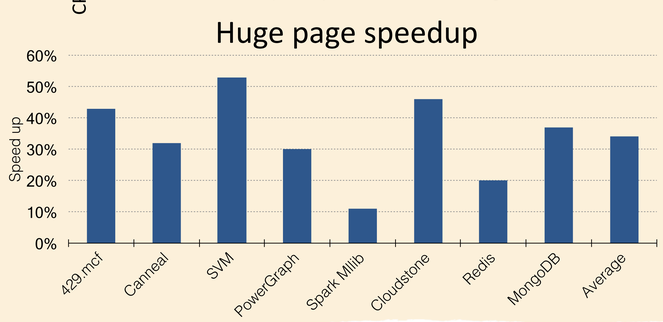
Huge pages reduce address translation cost

Modern applications
- Large memory footprint
- Low memory locality

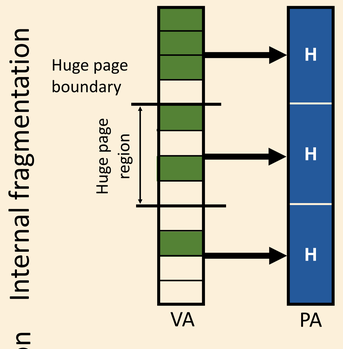
Huge page TLB coverage increasing
- Huge pages now useful







Pathologies in current huge page management

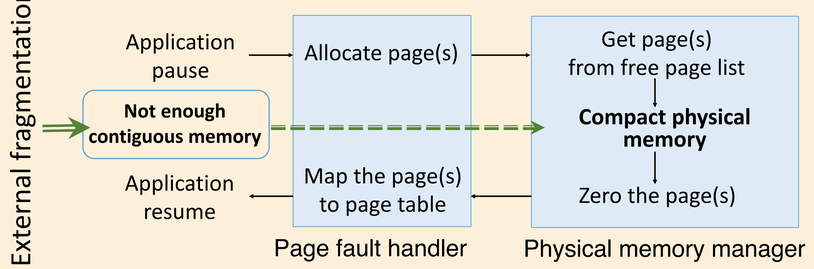


Memory bloating

- Huge pages increase fragmentation
- Fragmentation happens fast in any size of physical memory

Physical memory use

	Using huge page	Using only base page
Redis	20.7GB (1.69x)	12.2GB
MongoDB	12.4GB (1.23x)	10.1GB



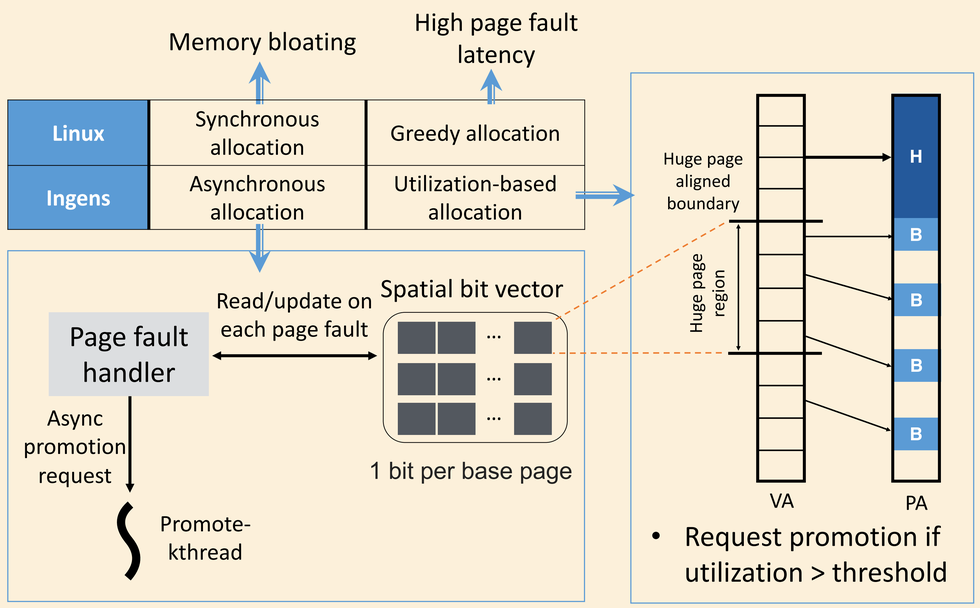
High huge page fault latency

4KB page	3.6 us
2MB page	378 us

Linux synchronously compacts memory
- Further increases latency

Ingens: Asynchronous and utilization-based huge page promotion

Ingens design



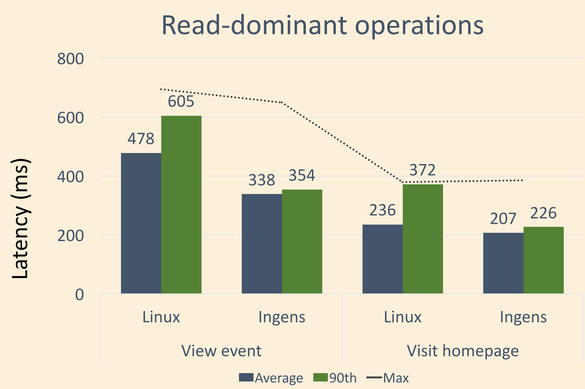
- Request promotion if utilization > threshold

Evaluation

CloudStone WEB 2.0 Benchmark

Throughput (req/s)

Linux	Ingens
922.3	1091.9 (+18%)



Eliminates Redis memory bloating

Linux (base only)	Linux (huge)	Ingens
12.2 GB	20.7 GB	12.3 GB

GET latency (ms)

	Throughput	90th lat.	99.9th lat.
Linux (base only)	19.0K	4	109
Linux (huge)	21.7K	3	8
Ingens	20.9K	3	64

Negligible overhead
- 2% in the worst case