Page Overlays: A New Framework for Fine-grained Memory Management

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1. High Redundancy
2. High Latency
3. High Bandwidth Consumption
4. High Energy Consumption

Fine-grained Memory Management
- Higher Performance (e.g., more efficient copy-on-write)
- More efficient capacity management (avoid internal fragmentation, deduplication)
- Fine-grained data protection (simpler programs)
- Fine-grained metadata management (better security, efficient software debugging)

The Copy-on-Write Technique
- Virtual Page 1 (4KB) → Physical Page 1 (4KB)
- Virtual Page 2 (4KB) → Physical Page 2 (4KB)

The Page Overlay Framework
- The overlay contains only a subset of cache lines from the virtual page
- Access Semantics: Only cache lines not present in the overlay are accessed from the physical page
- Overlay maintains the newer version of a subset of cache lines from the virtual page

Implementation Overview
- Overlay Mapping Table (OMT) (maintained by memory controller)
- Additional Memory (MBs)
- Cycles per Instruction

Applications for Page Overlays
- Sparse data structure representation
- Virtualizing speculation
- Memory checkpointing
- Fine-grained metadata management

Cloud Computing – Multiple Virtual Machines
- Fine-grained deduplication
  - increased memory capacity (difference engine – OSDI’08)
- Flexible superpage management
  - get benefits of copy-on-write & TLB miss reduction