Reducing Memory Virtualization Overheads in Virtualized Datacenters

Jayneel Gandhi, Arkaprava Basu, Michael M. Swift, Mark D. Hill

1. Problem
Hardware Virtualized MMUs have high overheads
We show that that the increase in translation lookaside buffer (TLB) miss-handling costs due to the hardware-assisted memory management unit (MMU) is the largest contributor to the performance gap between native and virtual servers.

2. Why is a TLB miss costlier?

3. Solution
Segmentation to bypass paging
- Extend Direct Segments for virtualization
- Direct Segment at VMM, guest or both levels
- Three modes with different tradeoffs

4. Modes

5. Tradeoffs

6. Optimizations
- Guest physical memory fragmentation: Self-ballooning
  - Balloon-out fragmented memory and provide to VMM
  - VMM hot-adds new contiguous guest physical memory
- Host physical memory fragmentation: Compaction
  - Remap fragmented pages to create contiguous physical memory
- Permanent “hard” memory faults: Escape filter
  - Escape filter stores few pages with permanent “hard” faults
  - Escape filter checked in parallel with VMM segment register
  - If found in escape filter, get alternate translation through paging

7. Overheads + Results
Near- or better-than-native performance