Efficient Memory Virtualization
Reducing Dimensionality of Nested Page Walks

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

TLB misses are very costly in virtual servers.
Cost

3.6x increase in overheads
## Cost

<table>
<thead>
<tr>
<th>memcached</th>
<th>4K</th>
<th>4K+4K</th>
<th>4K+2M</th>
<th>4K+1G</th>
</tr>
</thead>
<tbody>
<tr>
<td>Execution Time Overhead</td>
<td>%</td>
<td>%</td>
<td>%</td>
<td>%</td>
</tr>
<tr>
<td>Native</td>
<td>0%</td>
<td>5%</td>
<td>10%</td>
<td>15%</td>
</tr>
<tr>
<td>Virtual</td>
<td>10%</td>
<td>20%</td>
<td>25%</td>
<td>30%</td>
</tr>
</tbody>
</table>

- **3.6x increase in overheads**

## Problem

1. `gVA`
2. `2D`
3. `hPA`

- **Up to 24 memory accesses**
**Cost**

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<td>25%</td>
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<tr>
<td>30%</td>
</tr>
<tr>
<td>35%</td>
</tr>
<tr>
<td>40%</td>
</tr>
<tr>
<td>45%</td>
</tr>
</tbody>
</table>

- memcached

**Problem**

1. Up to 24 memory accesses
2. Direct Segments

**Opportunity**

3.6x increase in overheads

Up to 24 memory accesses

Direct Segments
Solution: Three Modes Extending Direct Segments

VMM Direct
2D → 1D
Solution: Three Modes Extending Direct Segments

VMM Direct
2D → 1D

Dual Direct
2D → 0D
Solution: Three Modes Extending Direct Segments

VMM Direct
2D → 1D

Dual Direct
2D → 0D

Guest Direct
2D → 1D
Solution: Three Modes Extending Direct Segments

- **VMM Direct**: 2D → 1D
- **Dual Direct**: 2D → 0D
- **Guest Direct**: 2D → 1D

Minimal Overheads:
- Native
- Virtual
- Modeled

Graph showing memory overheads for different modes:
- 4K
- 4K+4K
- VMM Direct
- Dual Direct
- Guest Direct

Graph illustrates execution time overheads with a bar chart indicating minimal overheads (~0%) for different scenarios.
Optimization

*Escape Filter*: Permanent “hard” memory faults
Optimization

*Escape Filter*: Permanent “hard” memory faults

Please come to our talk

**Today, Session: 2A, Main Auditorium**

**Efficient Memory Virtualization**

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