

# Efficient Memory Virtualization

## Reducing Dimensionality of Nested Page Walks

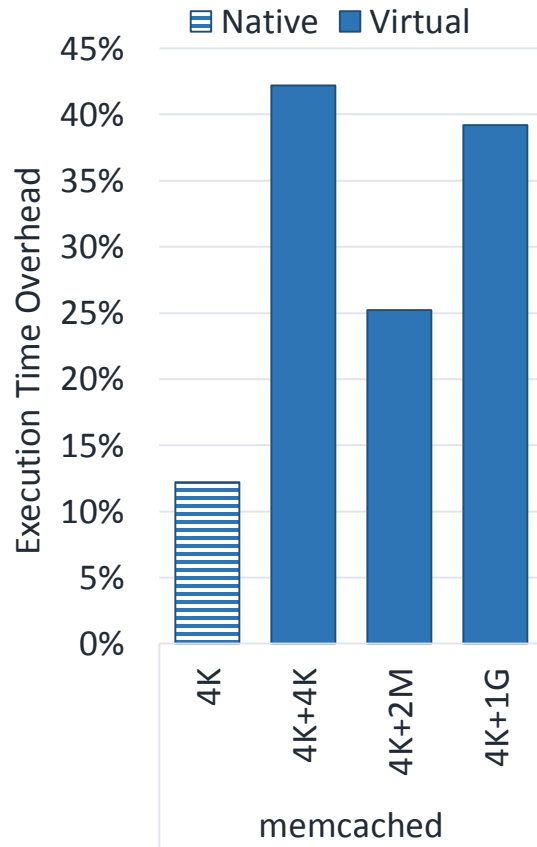
**Jayneel Gandhi**, Arkaprava Basu,  
Mark D. Hill, Michael M. Swift



*TLB misses are very costly in virtual servers.*

—Buell, et al. VMware Technical Journal 2013

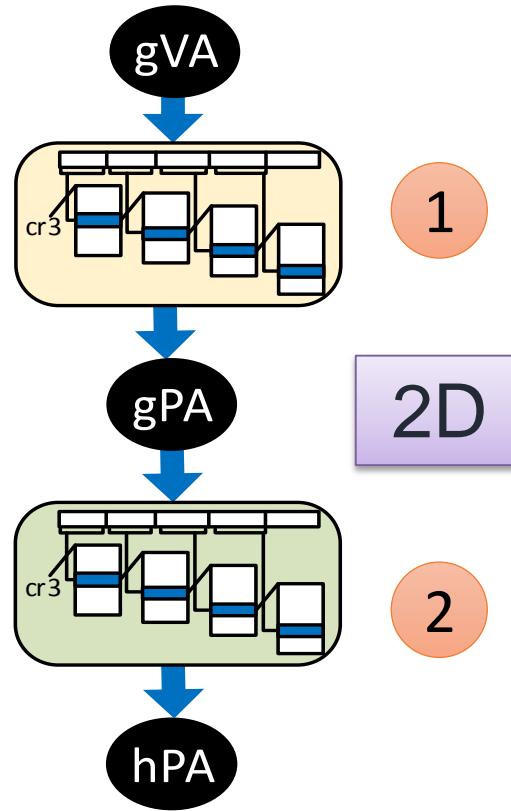
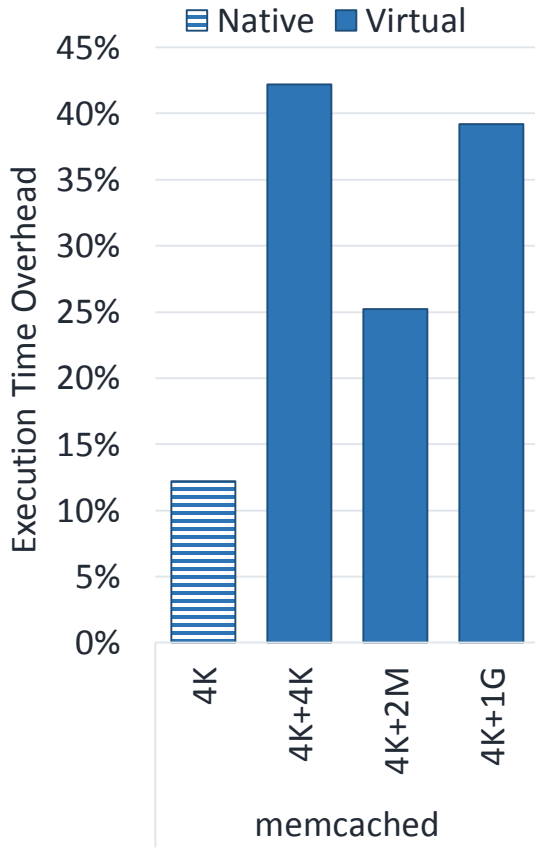
# Cost



3.6x increase in overheads

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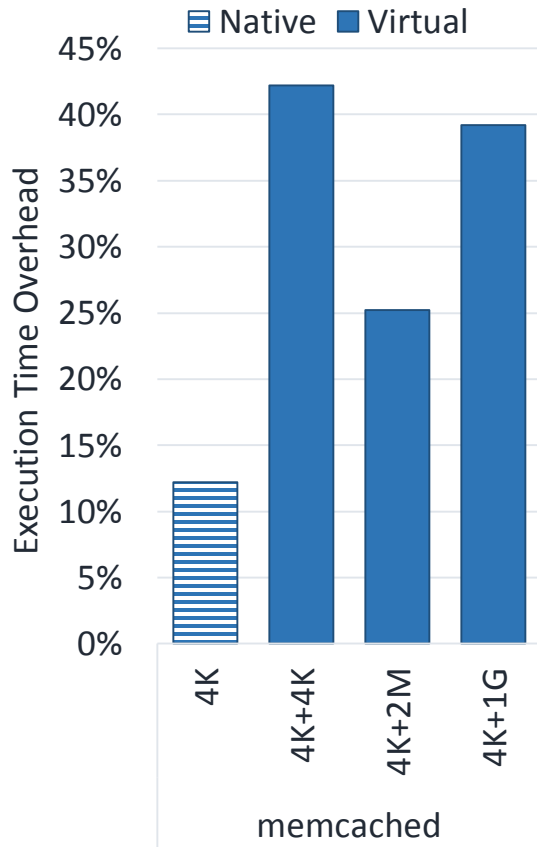
# Problem



3.6x increase in overheads

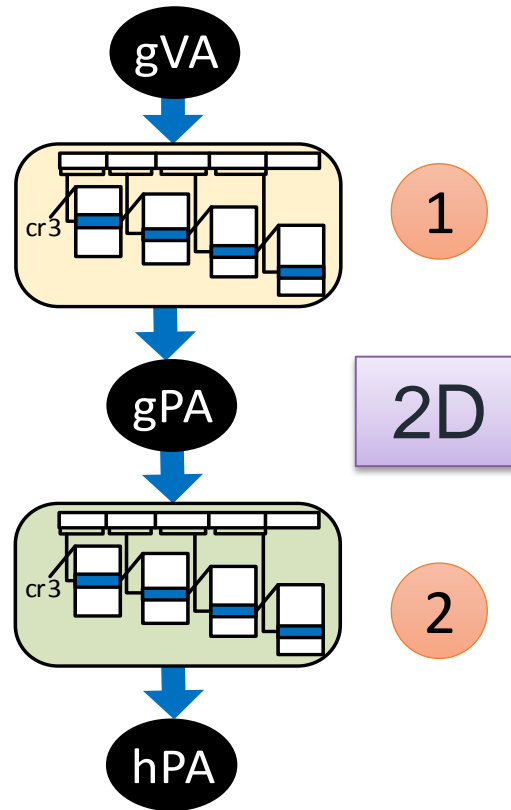
Up to 24 memory accesses

# Cost



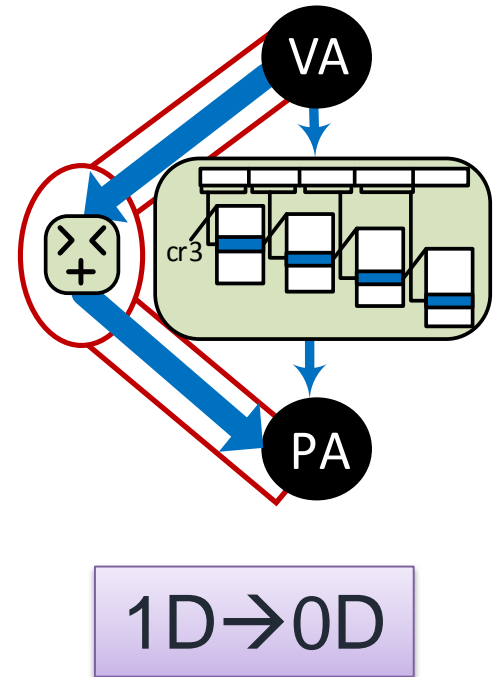
3.6x increase in overheads

# Problem



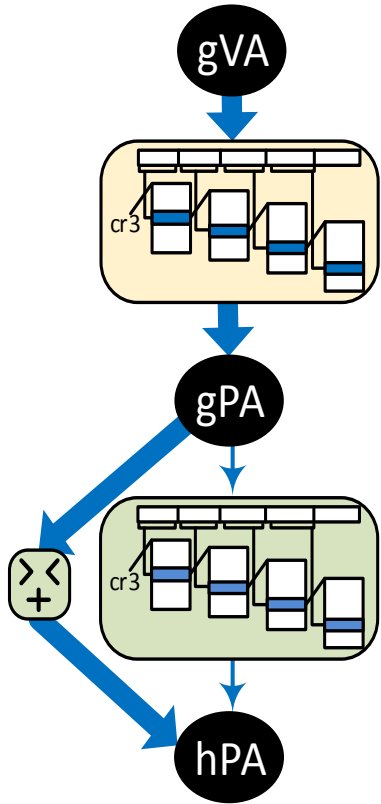
Up to 24 memory accesses

# Opportunity



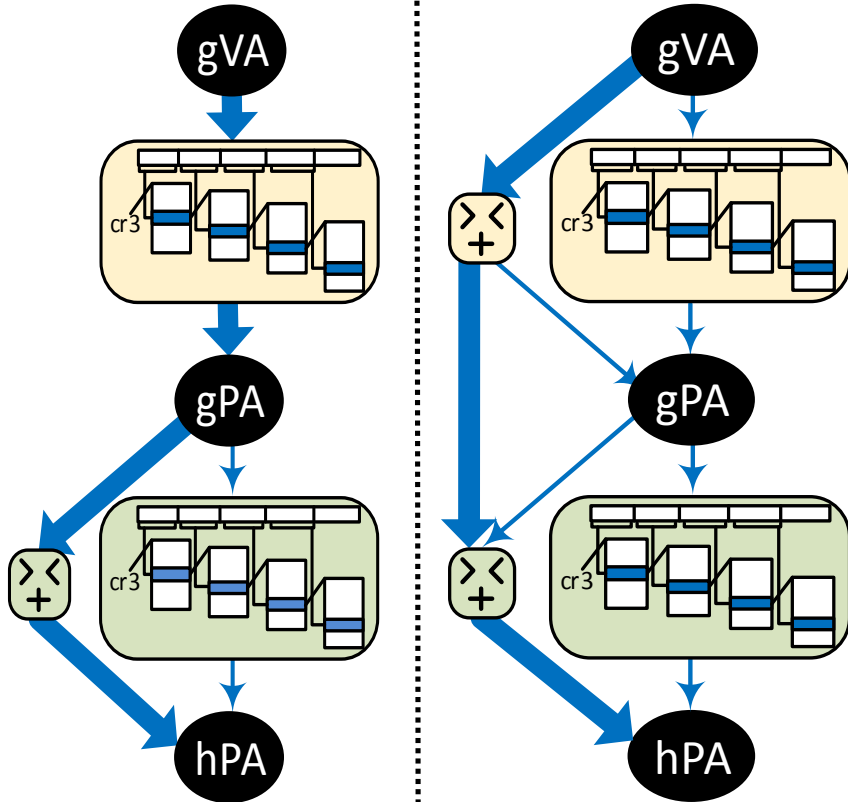
Direct Segments

# Solution: Three Modes Extending Direct Segments



VMM Direct  
2D → 1D

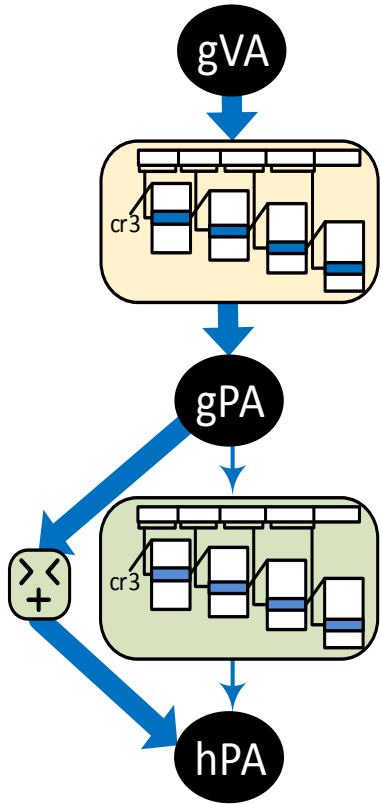
# Solution: Three Modes Extending Direct Segments



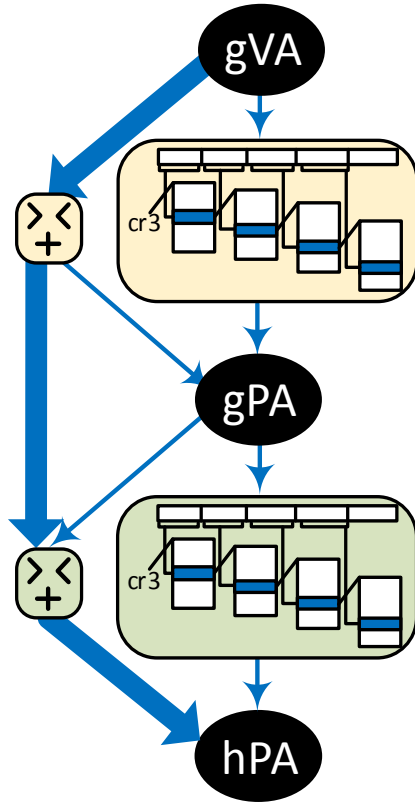
VMM Direct  
2D → 1D

Dual Direct  
2D → 0D

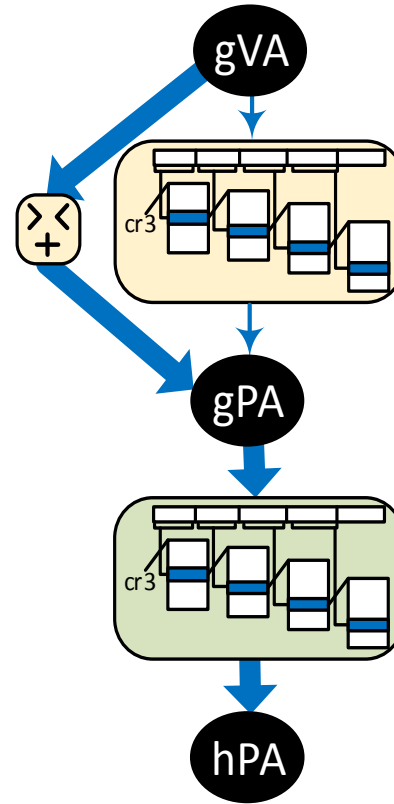
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VMM Direct  
2D → 1D

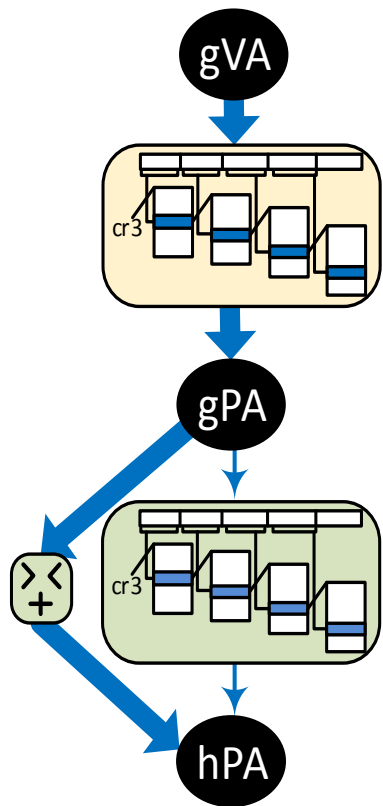


Dual Direct  
2D → 0D

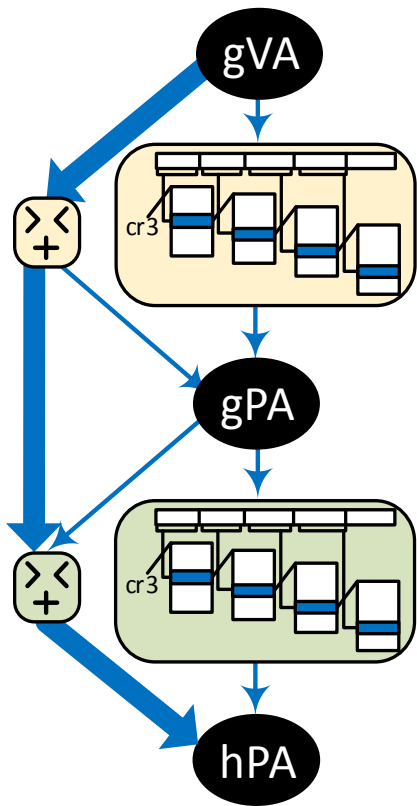


Guest Direct  
2D → 1D

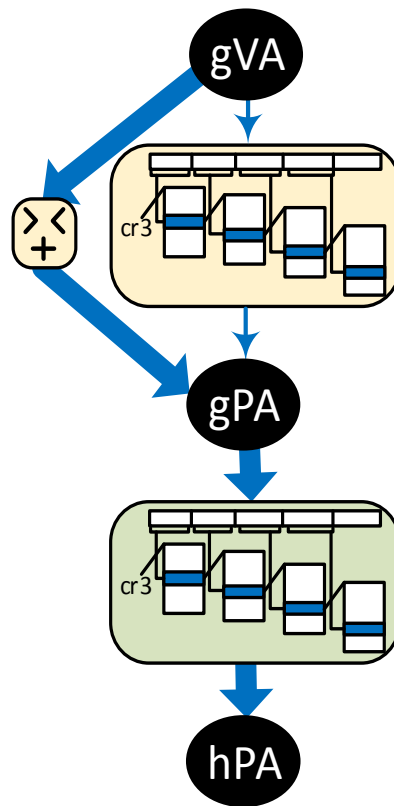
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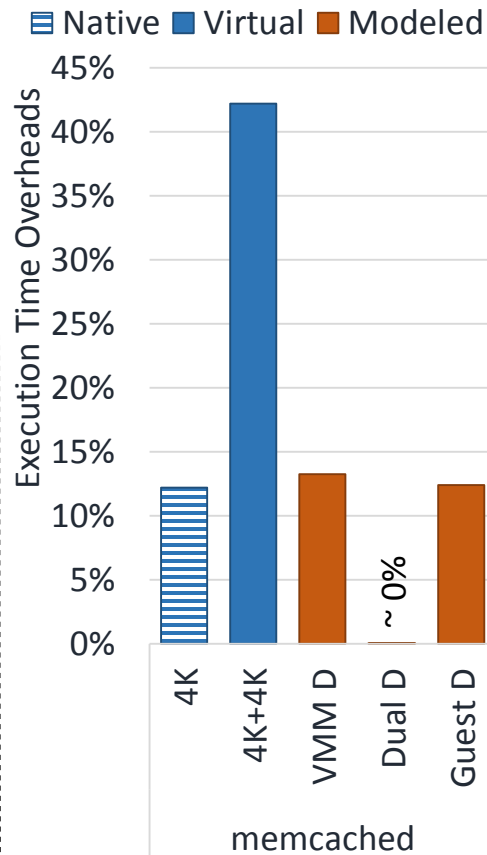
VMM Direct  
2D → 1D



Dual Direct  
2D → 0D



Guest Direct  
2D → 1D



Minimal  
Overheads



# Optimization

Escape Filter: Permanent “hard” memory faults

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Please come to our talk

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

**Efficient Memory Virtualization**  
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