



Enabling Consolidation and Scaling Down to Provide Power Management for Cloud Computing

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Background - Power Management in Virtualized Environment



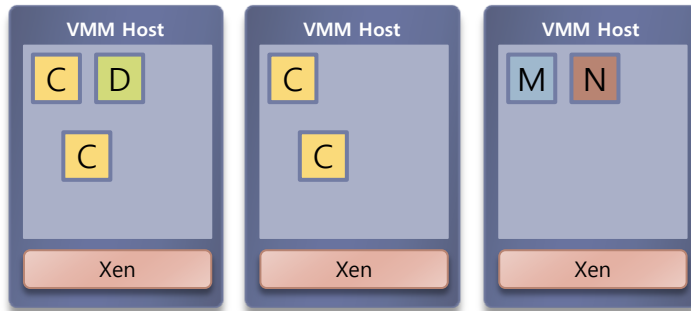
- ▶ **Virtualization techniques for VM scheduling**
 - ▶ VM consolidation
 - ▶ VM live migration
- ▶ **Goal of VM scheduling**
 - ▶ To maximize utilization performance
- ▶ **Require power management for green computing**
 - ▶ Power management (dynamic cluster scaling – scaling down)
 - ▶ Introduce additional trade-offs



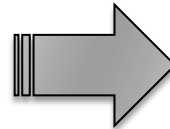
Consolidation & Power Management



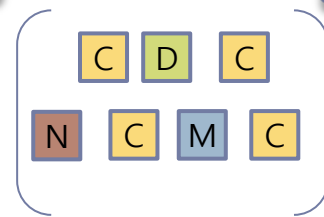
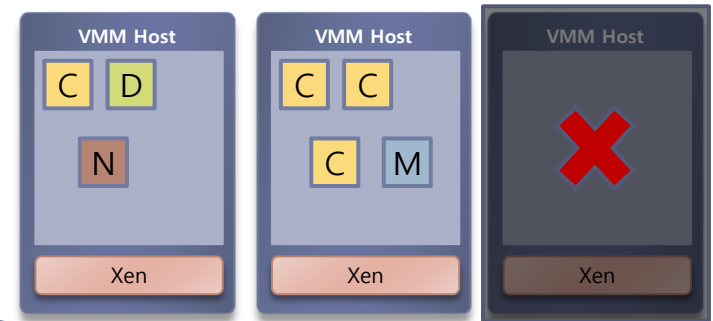
Configuration A



VM Placement



Configuration B



Power,
System Constraints...?

Performance...?





Require Various Studies ...

- ▶ To better design a VM scheduler in terms of power and performance
 - ▶ VM placement algorithm
- ▶ Examining various aspects of VM consolidation
 - ▶ The effects of VM co-location
 - ▶ The cache effects
 - ▶ The effects of CPU thermal throttling
 - ▶ ...



Experimental Settings – The Effects of VM Co-location



- ▶ A study on the impact of performance interference

Benchmarks	General Characteristics (CpuMemDskNet)	Remarks
gobmk	C	SPECcpu2006
mcf	CM	SPECcpu2006
postmarkLrg	D	
netperf	N	
bzip2	Cm	SPECcpu2006
tpc	cmn	
cg	cn	NPB
mg	cmn	NPB
copy	d	Lightweight I/O
postmarkSm	d	Lightweight I/O

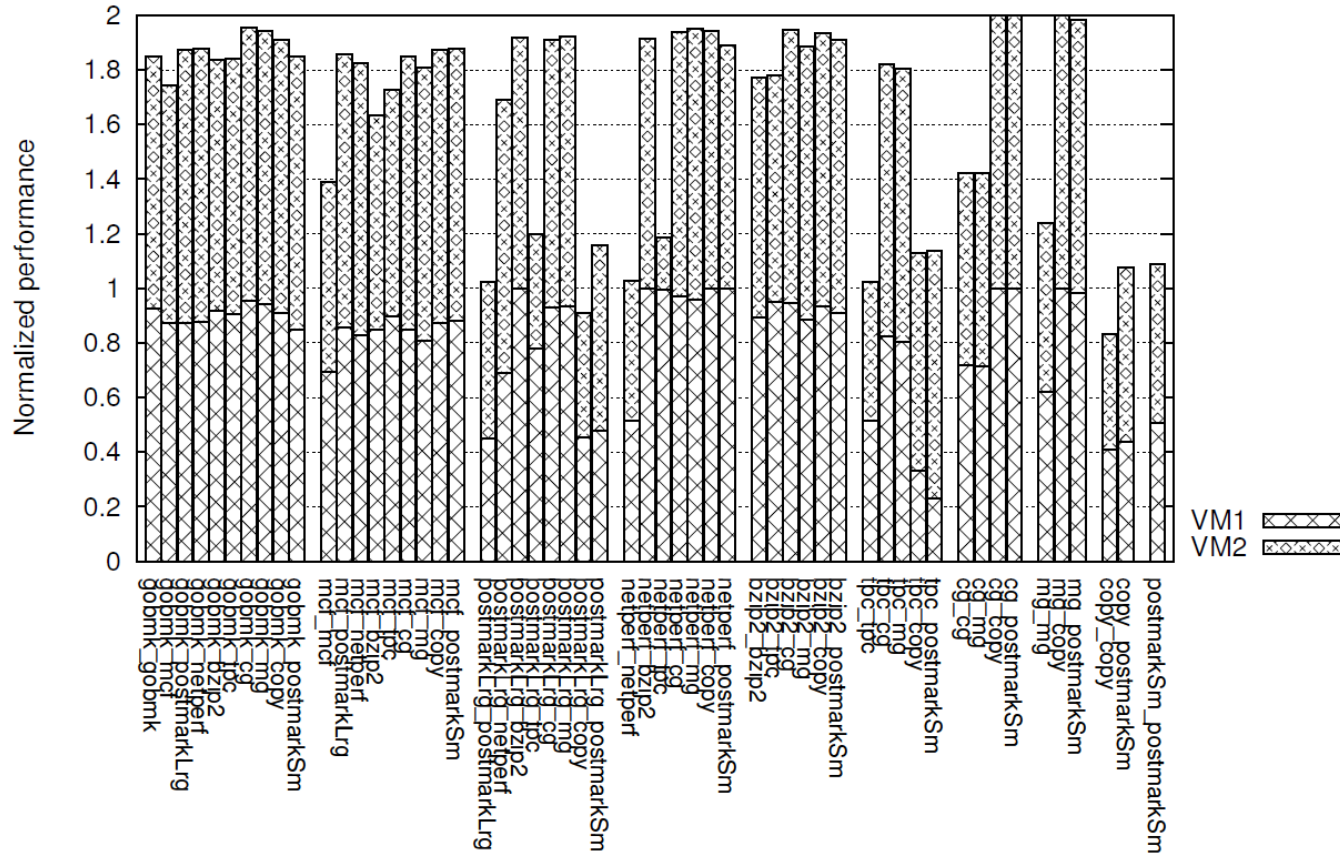
Intensive Workloads

Various Mixed Workloads

Physical Machine

- Quad-core 2.83Ghz, 8GB RAM
- Xen 3.3 Installed
- Each VM
 - 1 VCPU, 2GB MEM, 20GB image

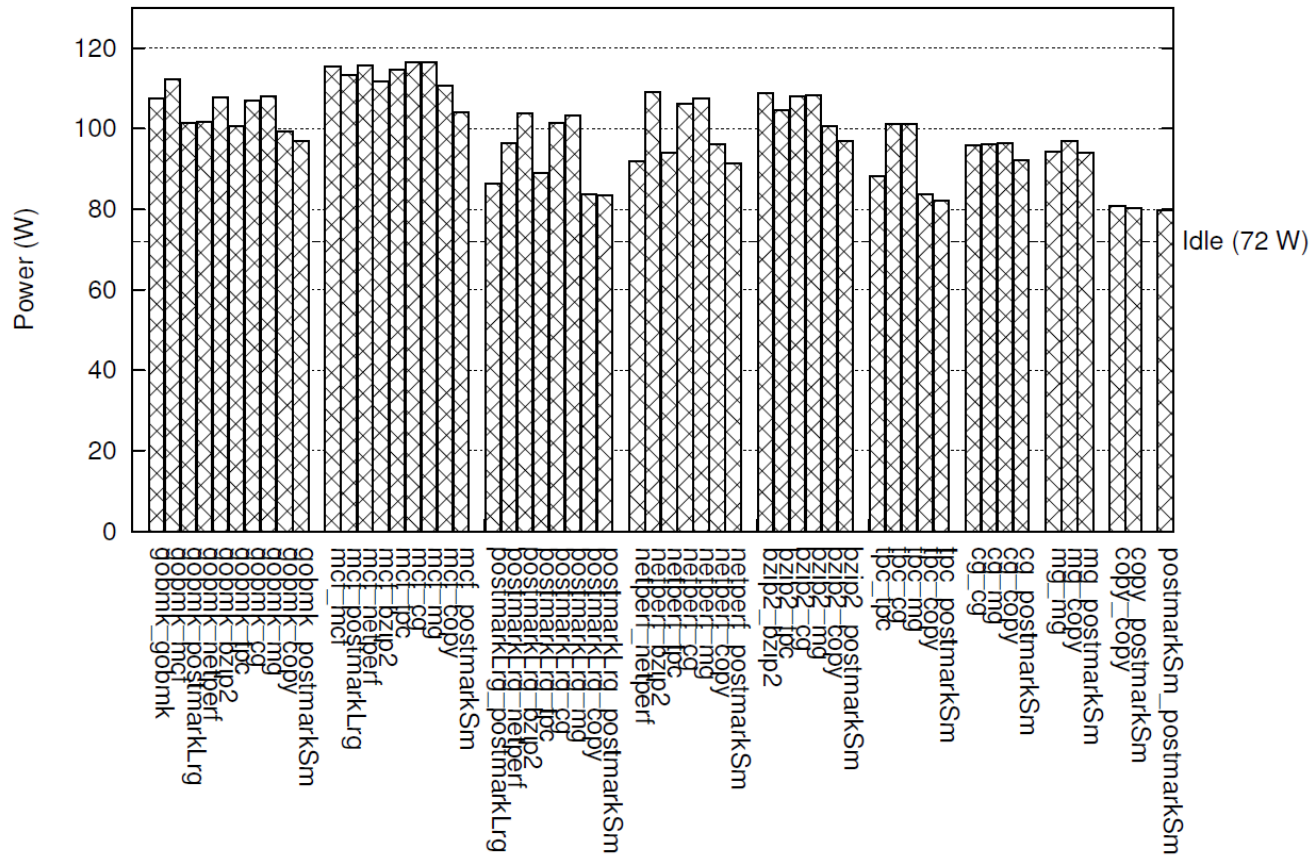
The Effects of VM Co-location – Performance Interference



- **Workload-aware VM placement:** consider workload characteristics during consolidation



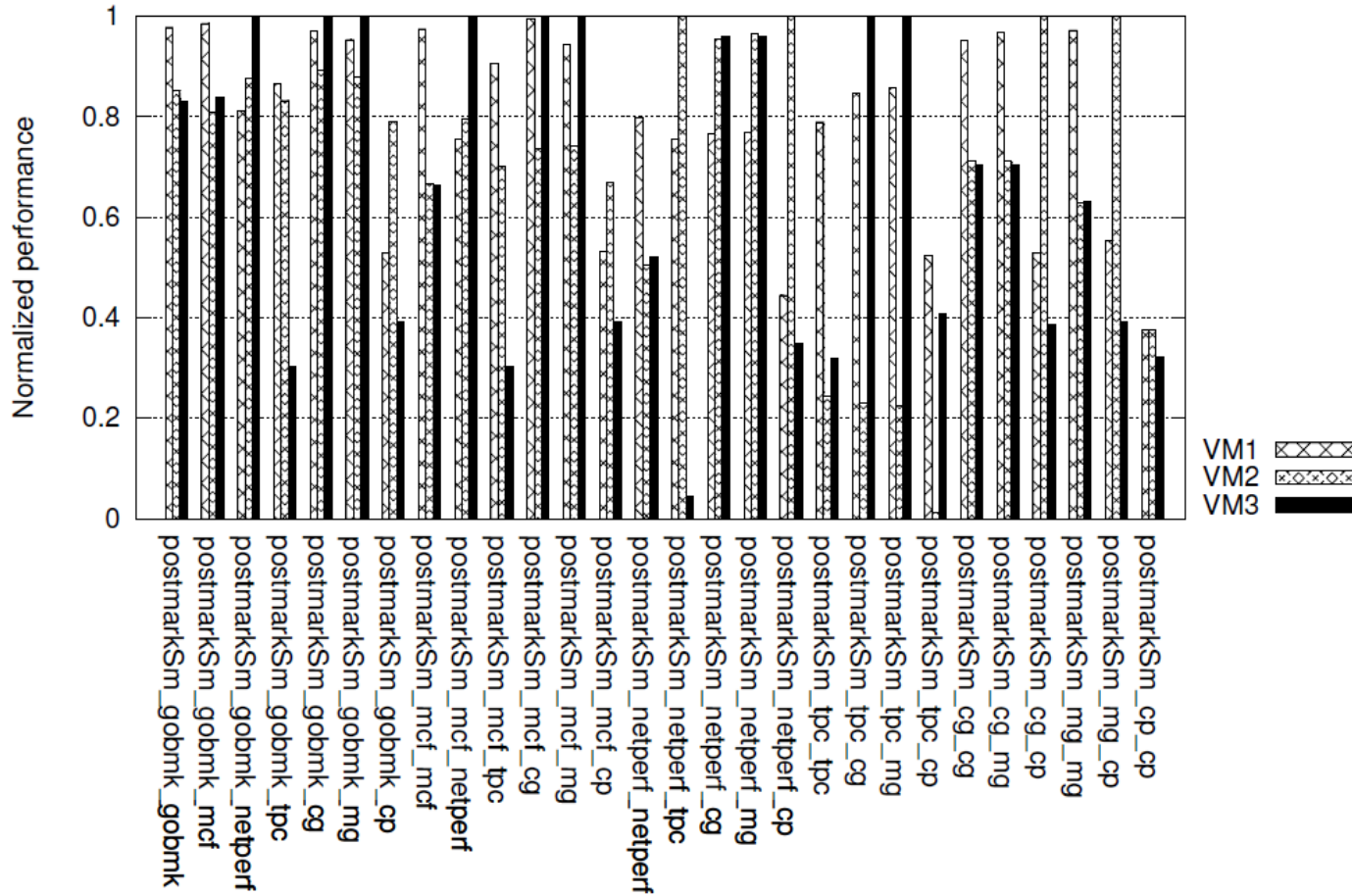
The Effects of VM Co-location – Power Consumption



- **Insight:** CPU and memory-intensive applications tend to consume more power



The Effects of VM Co-location – Three Mixes





Cache Effects

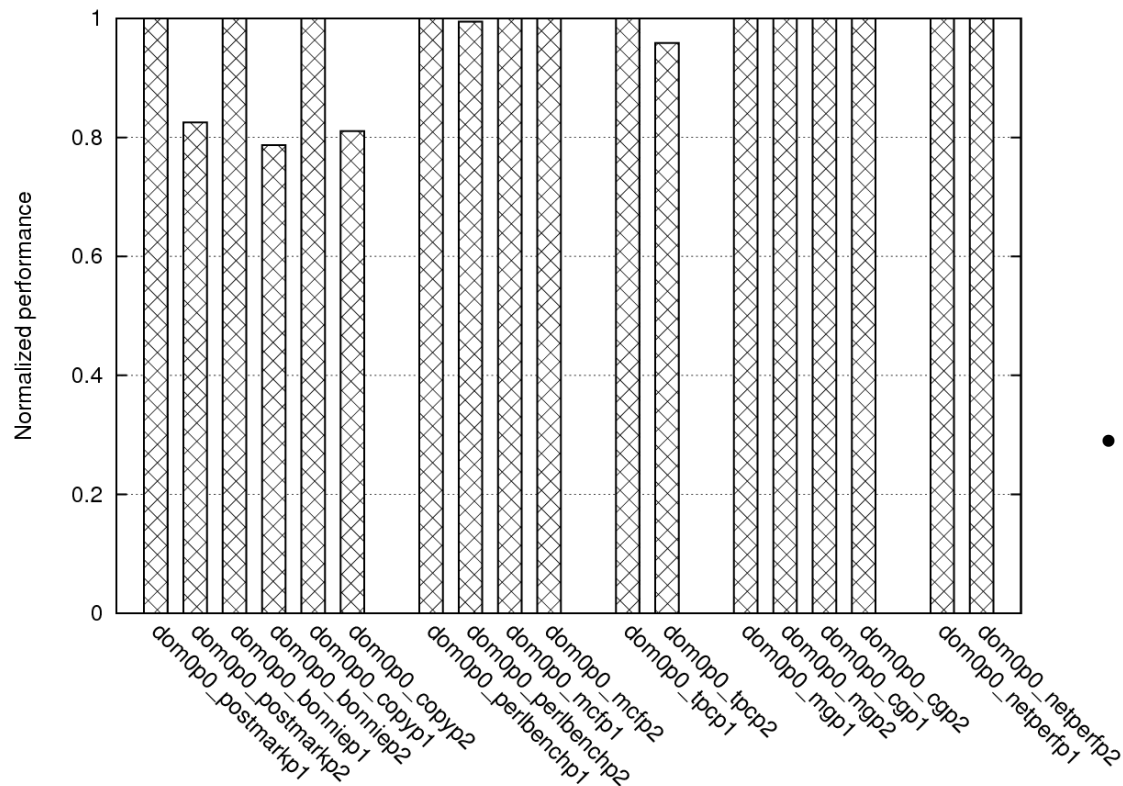


Table 2.3: CPU pinning configuration on Xen

CPU ID	0	1	2	3
	dom0	benchmark		
	dom0		benchmark	
	dom0		benchmark	benchmark
	dom0	benchmark	benchmark	

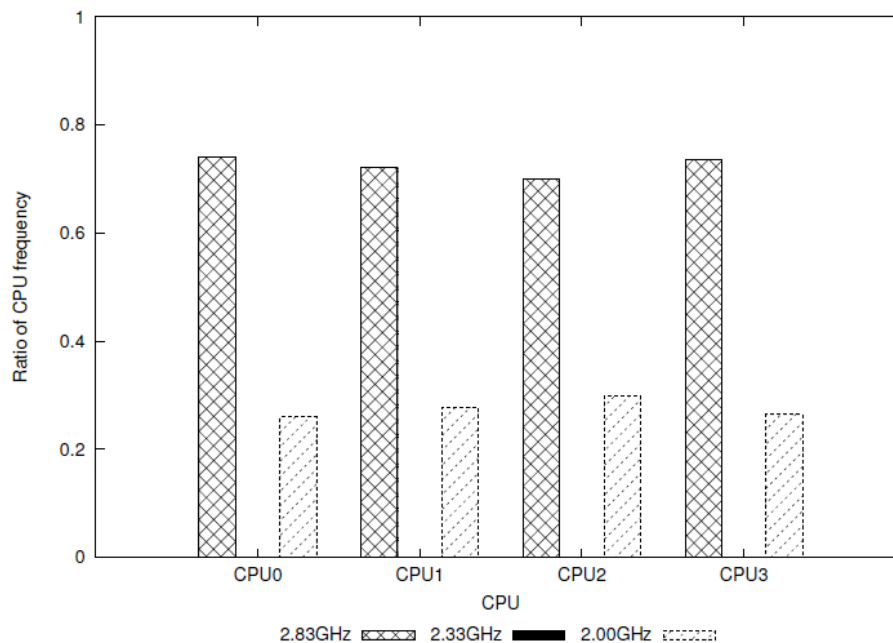
- Quad Processor Q9950
- two independent, but shared 12MB of L2 cache (2x6MB)

- **Insight:** the disk intensive workload shows better performance when pinning together with domain 0
- **Cache-aware VM placement:** pinning VMs (domain U) by L2 cache, but also pinning domain U with domain 0



Thermal Effects

- ▶ Running CPU-intensive applications at the maximum frequency



- **Insight:** Due to CPU thermal throttling, the frequency of the cores does not constantly remain at 2.83GHz to avoid overheating
- **Thermal-aware VM placement:** mixing different types of workload rather than consolidate only CPU-intensive application



Conclusion

- ▶ Examined various aspects of VM consolidation
 - ▶ To design a better-aware VM scheduler (VM placement)
- ▶ Still there are more opportunity for better scheduling
 - ▶ Workload-aware VM placement
 - ▶ Consider workload characteristics during consolidation
 - ▶ Cache-aware VM placement
 - ▶ Pinning domain U with domain 0 for I/O intensive workload
 - ▶ Thermal-aware VM placement
 - ▶ Consolidate different types of workload instead of CPU-intensive applications only





Thank you

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