Energy-Aware VMs and Cloud Computing

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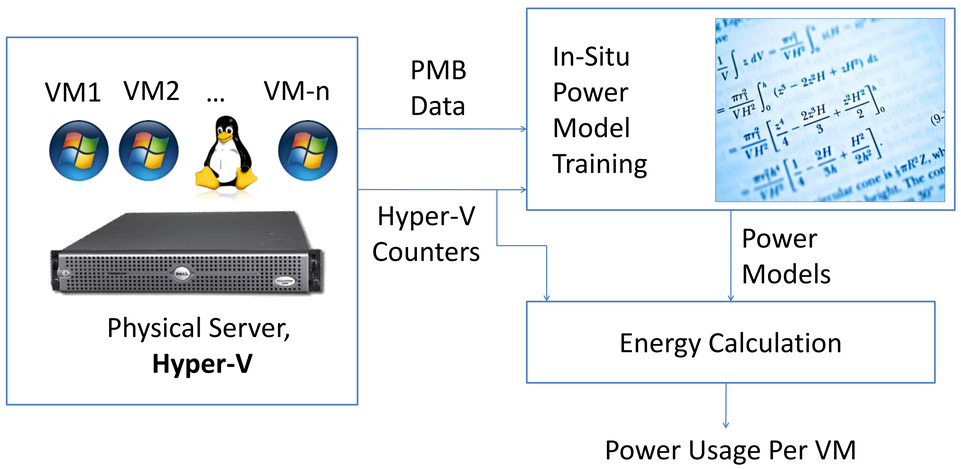
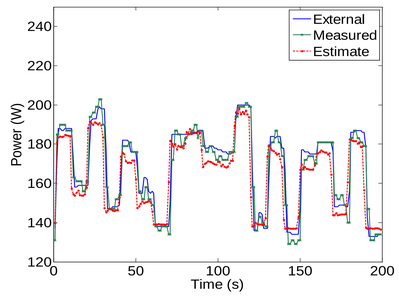
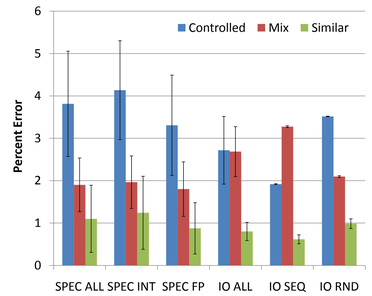
Measure VM Power

- Server power can be measured in hardware (available in new servers) but *cannot connect a power meter to a VM*
- Solution: model power in terms of resource usage
  - Hyper-V measures VM resource usage
  - Joulemeter automatically learns power model and converts resource usage into power

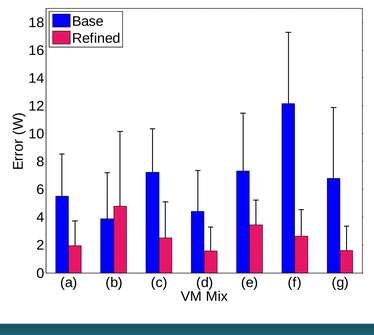


Accuracy





Mix	# VMs	Benchmarks
(a)	2	471.omnetpp, lometer
(b)	2	445.gobmk, 444.Namd
(c)	2	444.namd, lometer
(d)	2	453.povray, lometer
(e)	2	445.gobmk, 471.omnetpp
(f)	4	445.gobmk, 471.omnetpp, 453.povray, lometer
(g)	4	471.omnetpp, lometer, 444.namd, lometer



VM Metering Uses

- Power provisioning for VMs
- Energy visibility for cloud developer
- VM QoS control, migration control
- Accounting/chargeback for cloud and shared server scenarios
- Power capping and budgeting
- Monitor IT infrastructure power usage under actual load
- System Power Management

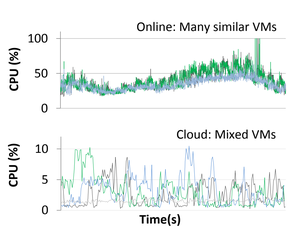
Power Provisioning

- Power capacity is expensive for data centers: so provision for actual power (instead of rated power)
- But if peak exceeds expected actual power:
  - Current: Throttle server (reduces performance)
  - With VMs: Cannot throttle server (may affect unknown VM performance)
- Solution: Measure and throttle individual VM power

Cost of UPS, Generators depends on power capacity more than usage

Experiments

- On production traces from MS datacenters
- Isolation savings of 14% to 26% (similar to physical server throttling)
- Additional savings due to virtualization:



Traces from production servers in Microsoft datacenters