Evaluating Impact of Live Migration on Data Center Energy Saving

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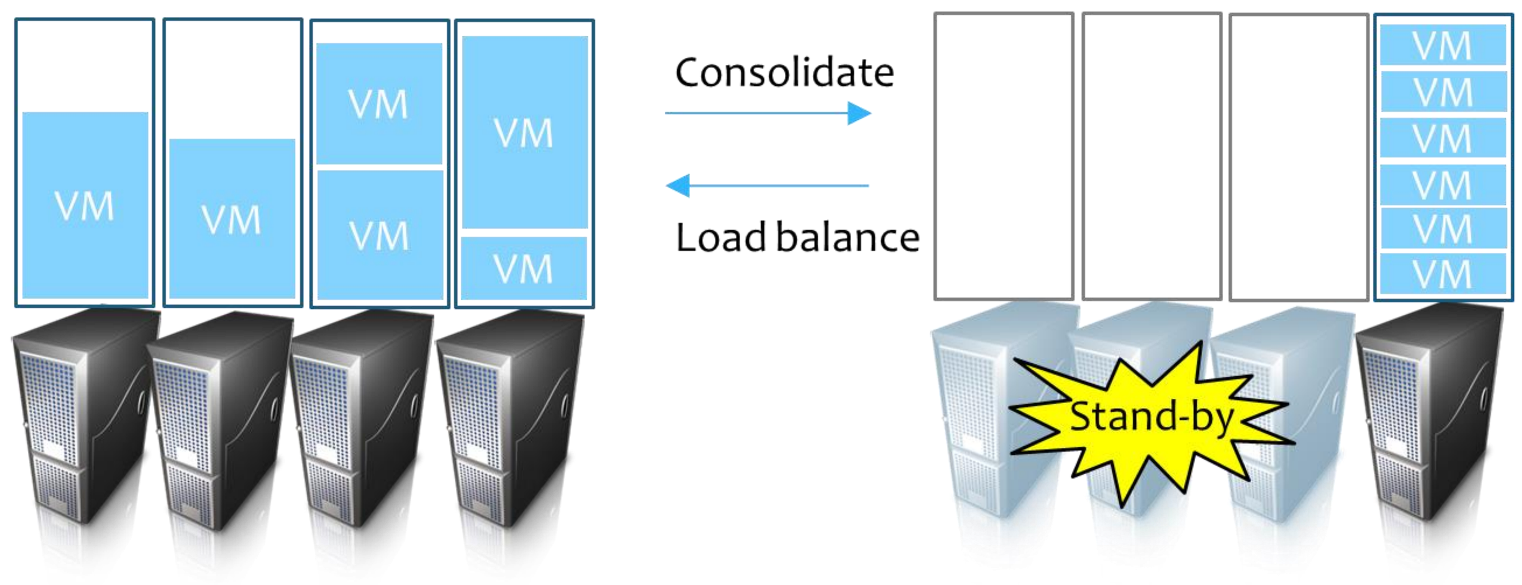
Background

Energy consumption of data centers is extremely huge
- Data centers consume 1.5% of the electricity in the US
- Data center energy grew 16%/year during 2000-2005

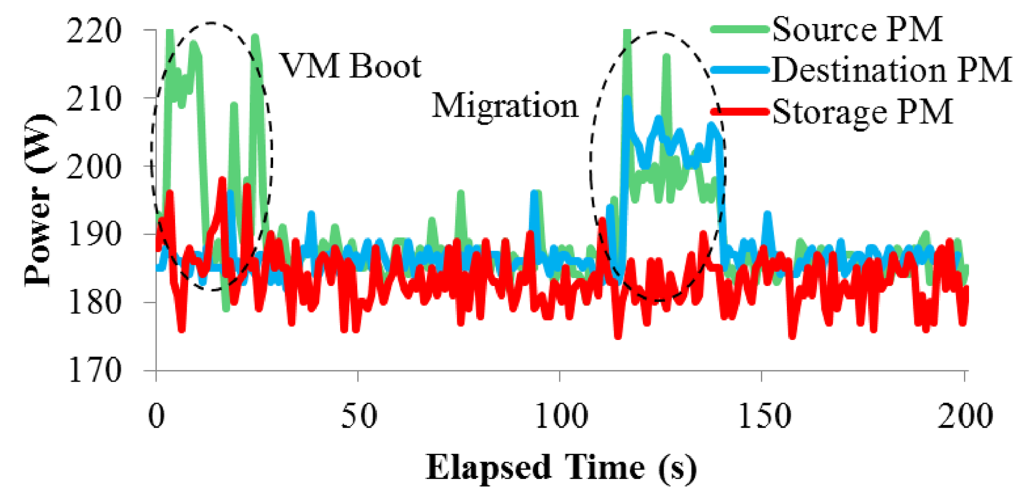
Dynamic VM consolidation (placement) for **energy saving**
- Idle VMs are consolidated to turn off space PMs
- E.g. consolidation using workload provisioning



Problem

Live Migration of Virtual Machines
- Move a VM among PMs with almost no interruption
- Essential for dynamic VM consolidation

Live migration itself has **energy overhead**
- Increased load of memory, CPU, network, bus

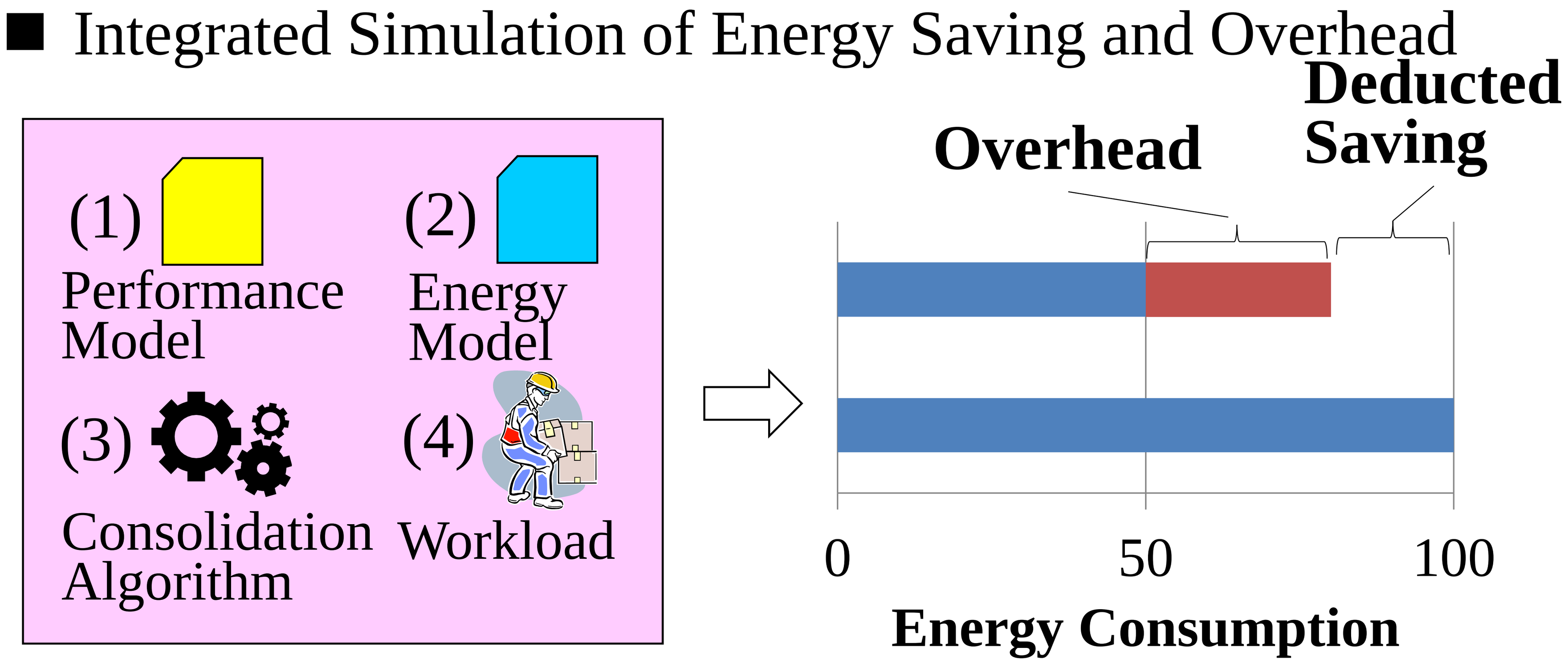


Unveiled tradeoff

Energy Saving ⟺ Energy Overhead

Approach

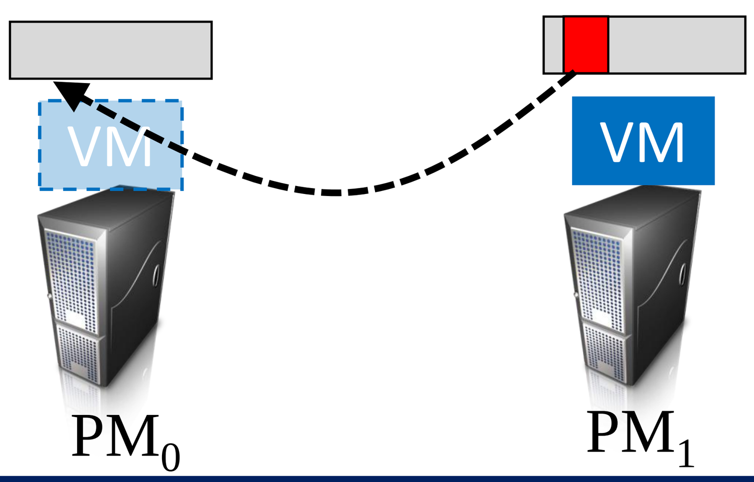
- Integrated Simulation of Energy Saving and Overhead



- Migration Mechanisms used for Simulation

1. Normal pre-copy
2. MiyakoDori - S. Akiyama *et al.*, in *IEEE CLOUD'12*

Memory images are kept in PMs on a migration to future reuse of the images when VMs migrate "back"



When a VM migrates back, only the updated region (red part) is transferred

- Performance Model of Live Migration

Workload (memory size/updates) + NW bandwidth → Total migration time, Amount of transferred memory

[Normal pre-copy]

Implemented in recent versions of SIMGRID

[MiyakoDori]

Migration history to simulate it (refer the paper)

- Energy Model of Live Migration

Amount of transferred memory → Energy overhead

[Normal pre-copy]

Energy overhead (E_{mig}) depends only on the amount of transferred memory (V_{mig}) - H. Liu *et al.*, in *HPDC'11*

$$E_{mig} = \alpha V_{mig} + \beta$$

[MiyakoDori]

Extra resource usage is negligible in terms of energy consumption → Use the model above as-is

Experimental Results

- Metrics

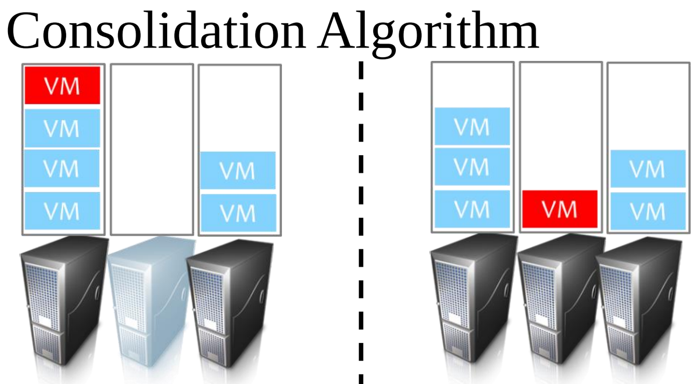
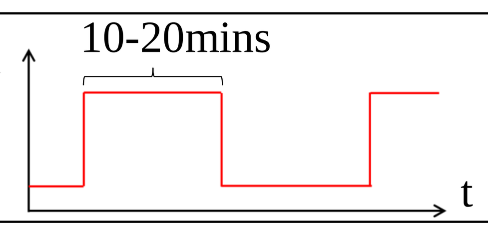
[Saved Energy Ratio (%)]

How much energy does consolidation actually save?

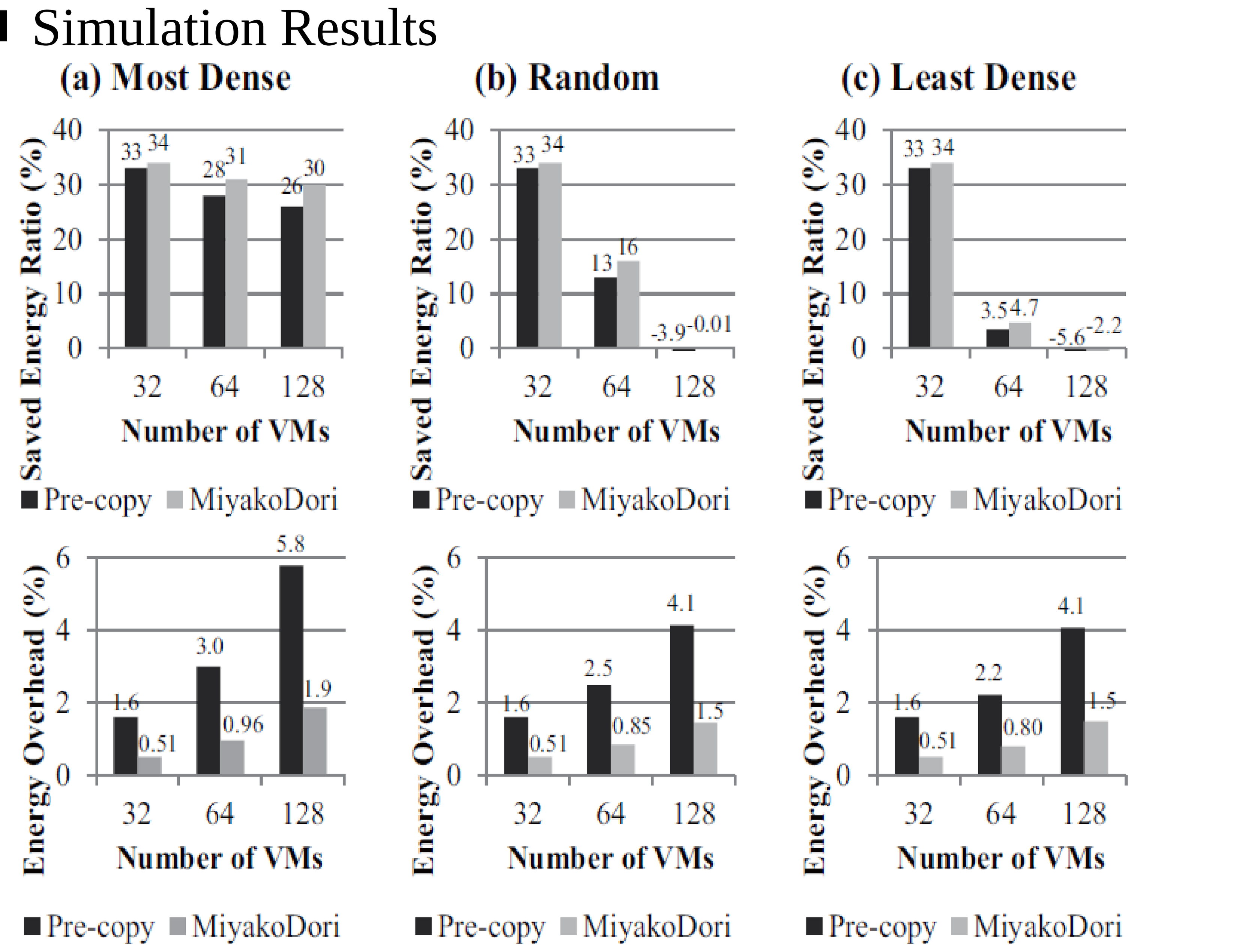
[Energy Overhead (%)]

How much portion of energy is lost for migration?

- Simulation Setting

Consolidation Algorithm 	1. An idle VM migrates to **the** warehouse server 2. A busy VM migrates to **a** high power server (most loaded one, least loaded one, random) 3. A PM sleeps when no VM is hosted on the PM
Workload 	4GB mem usage, 128MB hot stop (updated 2MB/s), 10-20 mins load/idle intervals for 12 hours
Number of Machines	{128 | 64 | 32} VMs on 32 PMs
Power of Active PM	185 + (235 − 185) × load/capacity [W]
Power of Sleeping PM	20 [W]

- Simulation Results



- Energy overhead of migration accounts for several percent
- Using acceleration (MiyakoDori) saves 4% of energy at most
- These values must be considered in energy/cost planning