Efficient Resource Management for Cloud Computing Environments

Andrew J. Younge, Gregor von Laszewski, Lizhe Wang
Pervasive Technology Institute
Indianan University
Bloomington, IN USA

Sonia Lopez-Alarcon, Warren Carithers
Rochester Institute of Technology
Rochester, NY USA

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Outline

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- Green Cloud Framework
- VM Scheduling & Management
- Power Consumption Analysis
- Conclusion and Future Work

Introduction

- Cloud becomes popular, the dependence on power also increases. In 2005, the data centers consume 1.2% of the U.S. total electricity usage. And it's projected to double every 5 years.

- There is a need to create an efficient Cloud computing system that minimizing its energy footprint.

- In this paper a new framework is presented that provides efficient green enhancements within a scalable Cloud computing architecture.

Related Research (1/3)

- Cloud
  - Scalable
  - Quality of Service (QoS)
  - Specialized Environment
  - Cost Effective
  - Simplified Interface

Related Research (2/3)

- Green Computing
  - Supercomputer power-saving features

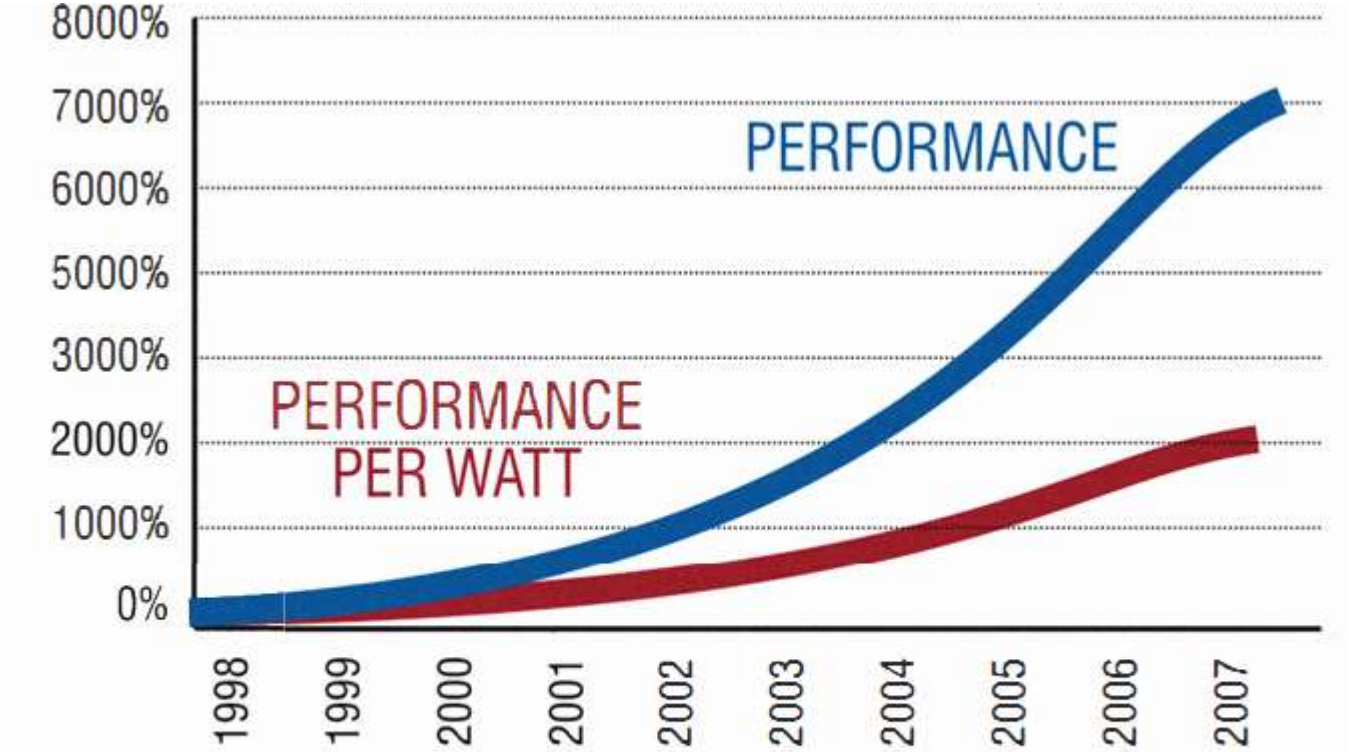


Fig. 2. Performance increases much faster than performance per watt of energy consumed [20]

Related Research (3/3)

- Green Computing
  - Dynamic Voltage and Frequency Scaling (DVFS)
    - Originally used in portable and laptop systems
    - Now migrated to chipsets: Intel SpeedStep, AMD PowerNow!

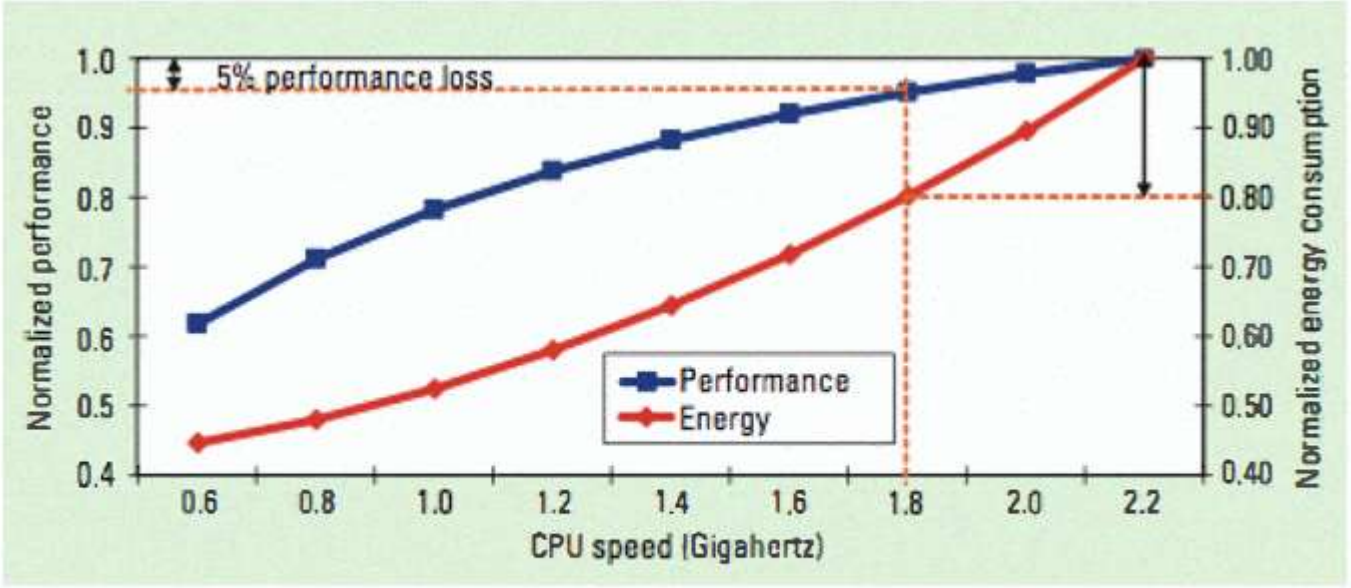
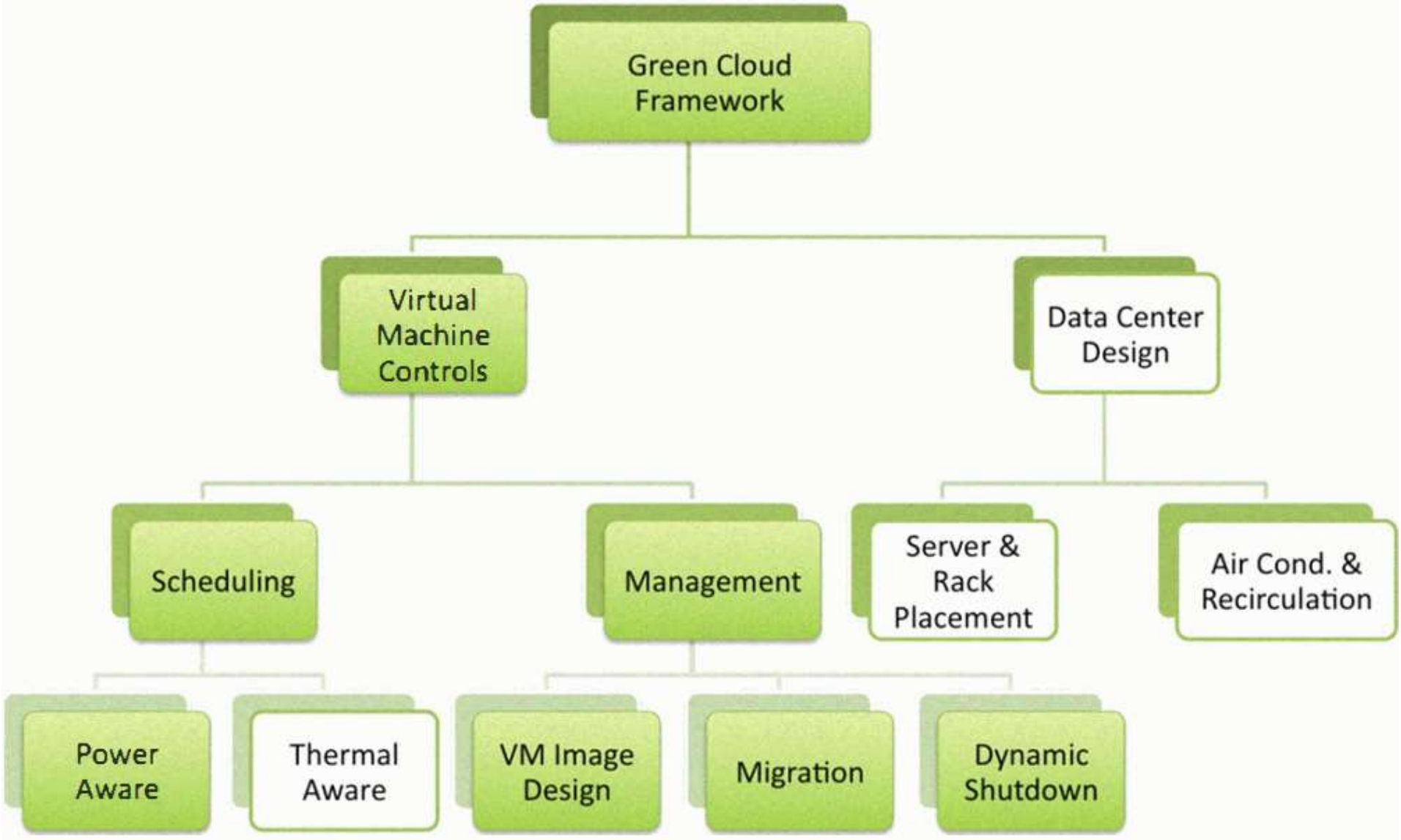


Fig. 3. Possible energy to performance trade-off . Here you can see a 18% reduction in frequency contributes to only a 5% performance loss. [28]

Green Cloud Framework (1/2)

- We present a novel Green computing framework that is applied to the Cloud in order to meet the goal of reducing power consumption.
  - VM scheduling
  - VM image management
  - Advanced data center design

Green Cloud Framework (2/2)



VM Scheduling & Management (1/5)

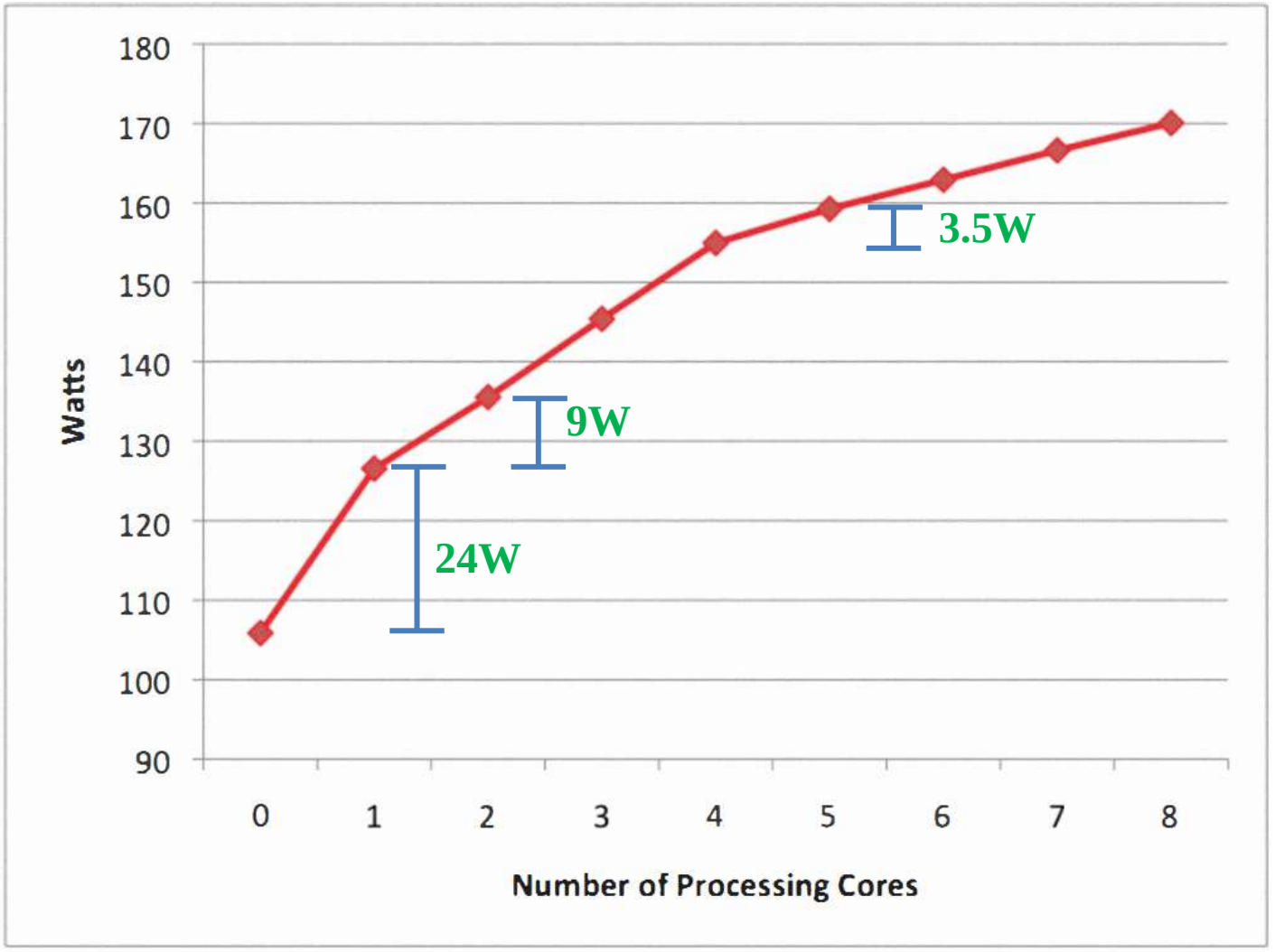


Fig. 5. Power consumption curve of an Intel Core i7 920 CPU

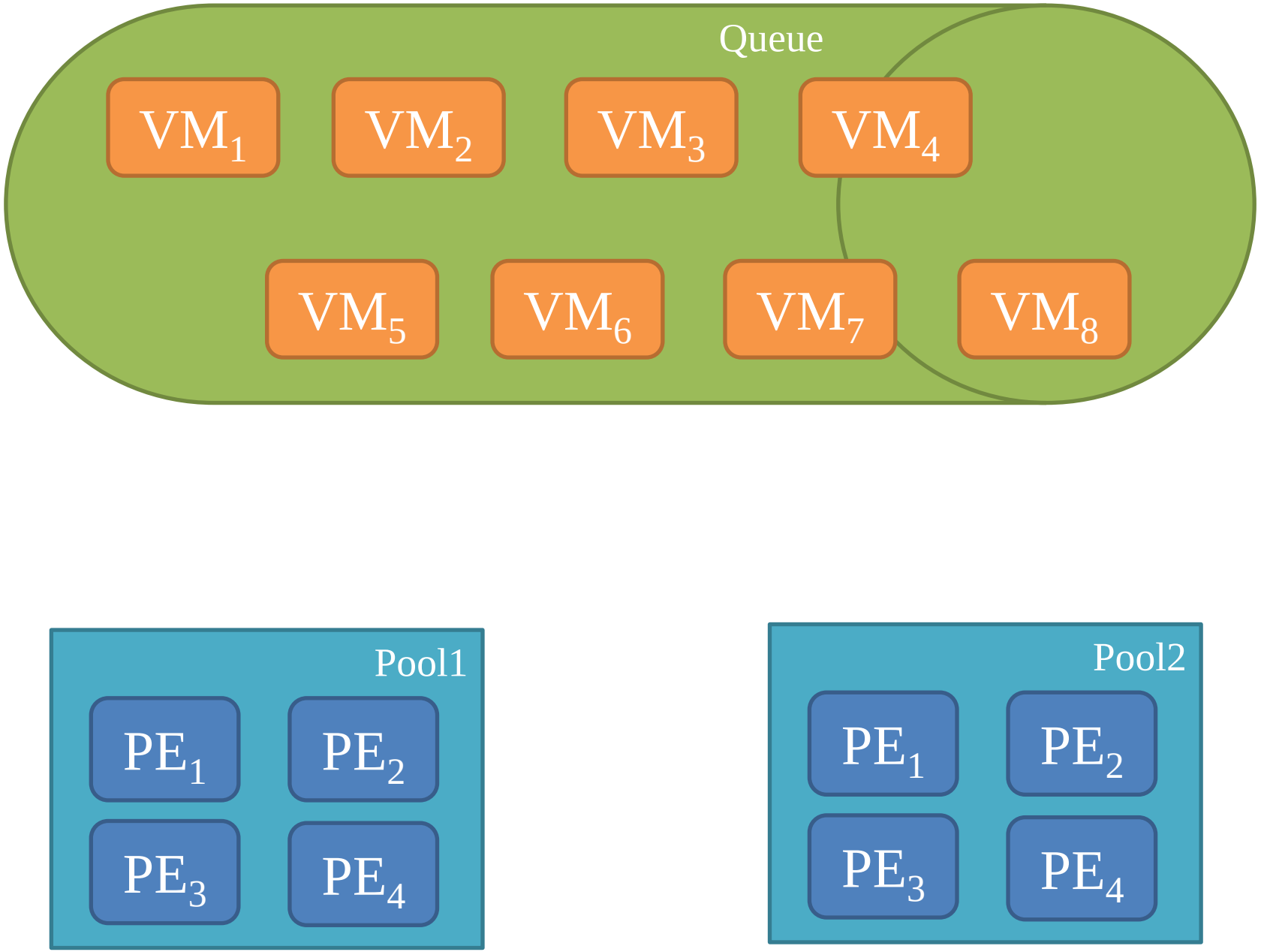
VM Scheduling & Management (2/5)

- Scheduling algorithm

Algorithm 1 Power based scheduling of VMs

```
FOR i = 1 TO i ≤ |pool| DO
  pe_i = num cores in pool_i
END FOR

WHILE (true)
  FOR i = 1 TO i ≤ |queue| DO
    vm = queue_i
      FOR j = 1 TO j ≤ |pool| DO
        IF pe_j ≥ 1 THEN
        IF check capacity vm on pe_j THEN
          schedule vm on pe_j
          pe_j − 1
        END IF
      END IF
    END FOR
  END FOR
  wait for interval t
END WHILE
```


Queue
VM1
VM2
VM3
VM4
VM5
VM6
VM7
VM8
Pool1
PE1
PE2
PE3
PE4
Pool2
PE1
PE2
PE3
PE4

VM Scheduling & Management (3/5)

- VM Management
  - Idle physical machines in a Cloud can be dynamically shutdown and restarted to conserve energy during low load situations.
  - Live migration can be applied to Green computing in order to shift VMs from low load to medium load machines when needed.
  - Low load servers can be shutdown when all VMs have migrated away.

VM Scheduling & Management (4/5)

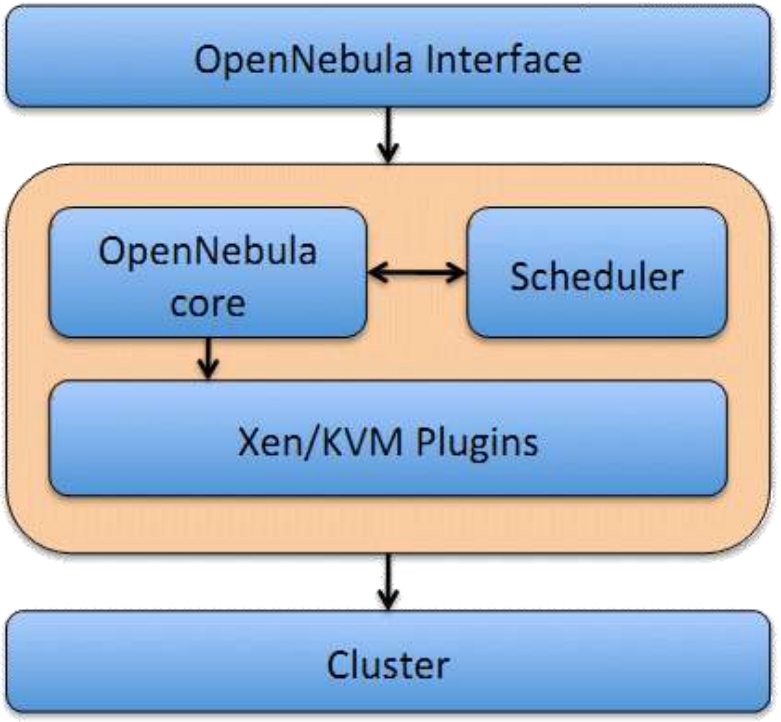
- Service oriented virtual machine image
  - Full OS VMs are scheduled often to carry out specific tasks. The images contain much more than they need.
    - Support a wide variety of hardware & software
    - But each VM is typically designed for a specific task
  - A hypervisor provides the same virtualized hardware to each VM.
    - We want the OS within the VM to act only as a light wrapper which supports a few specific but refined tasks or services, not an entire desktop suite.
  - We concentrate on two areas: VM images and boot time.

VM Scheduling & Management (5/5)

- Service oriented virtual machine image
  - Customizing the VM environment
    - Remove the kernel modules which are not needed.
    - Remove the daemons and applications which are not needed.
  - Reducing the boot time
    - bootchart: Profiles where boot-up system inefficiencies occur and to allow for optimization of the boot sequence.
    - readahead: Profiles the system startup sequence and use prefetching to load files into memory before they are requested.

Power Consumption Analysis (1/4)

- Scheduling Analysis
  - OpenNebula
    - Customized scheduler component
  - 4 machines
    - CPU: Intel Core i7 920 2.6GHz
    - RAM: 12GB RAM
  - Schedule 8 VMs



Power Consumption Analysis (2/4)

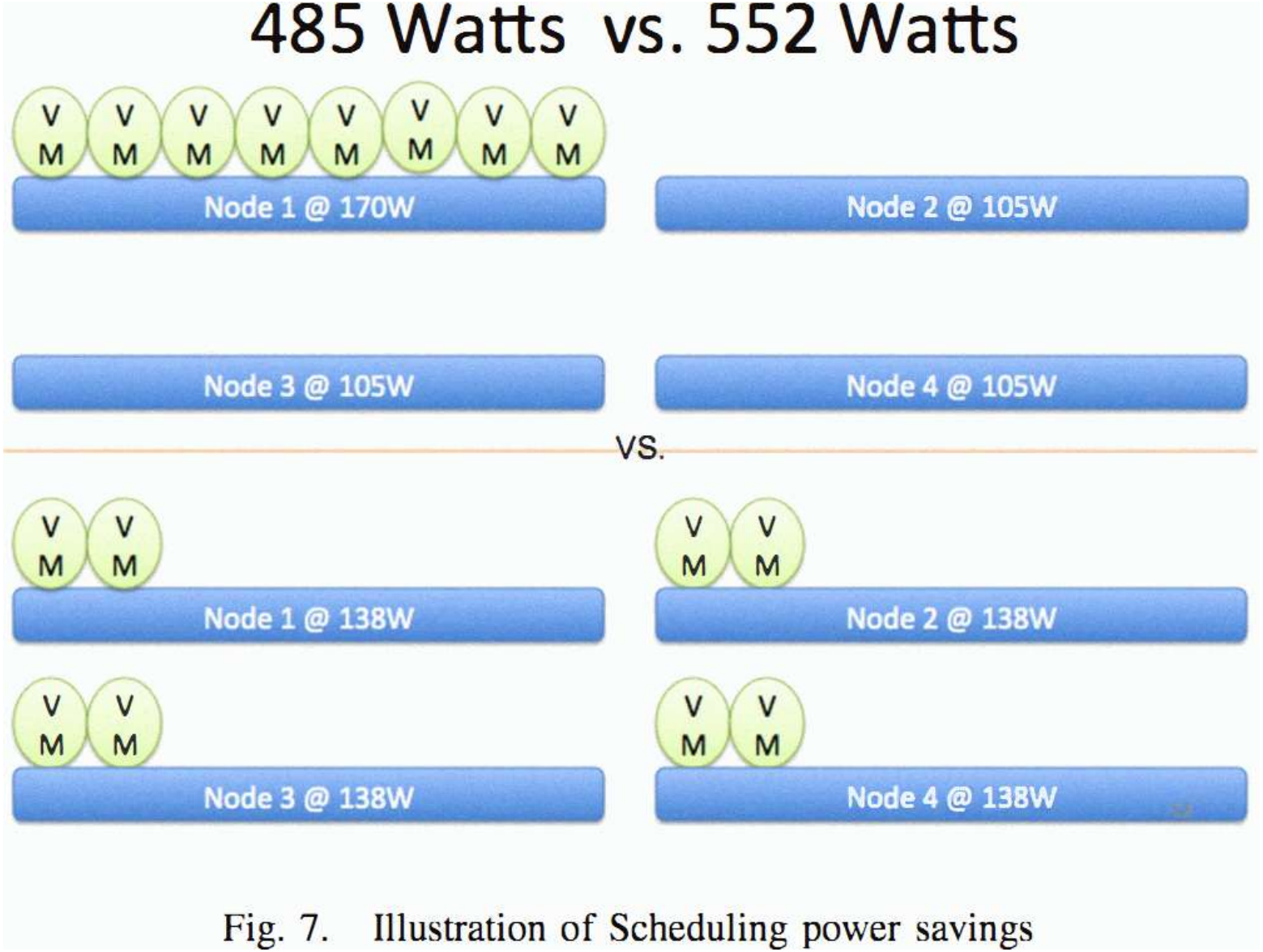
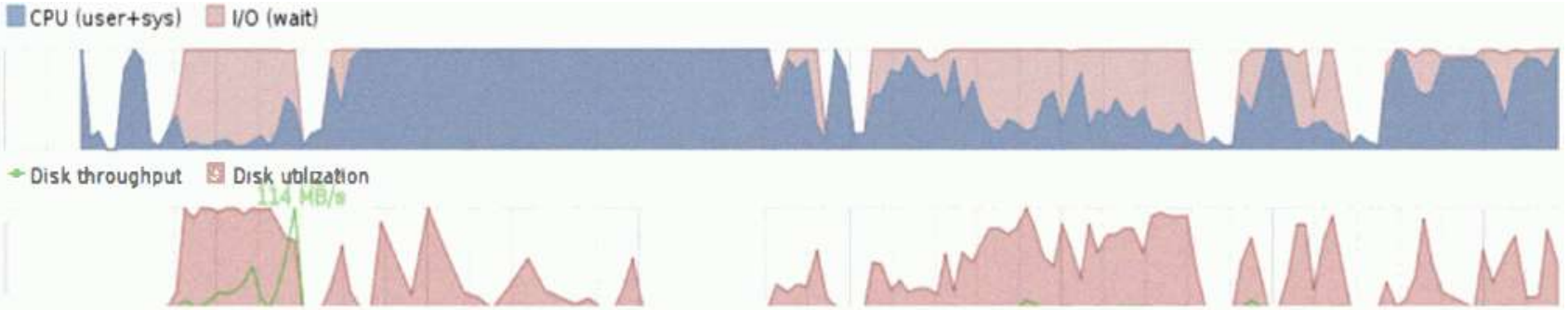


Fig. 7. Illustration of Scheduling power savings

Power Consumption Analysis (3/4)

- VM image Analysis
  - Top-down approach: Based on Ubuntu 9.04 Jaunty, removing all unnecessary packages.
  - Number of kernel modules were removed from the 2.6.28-11 kernel to speed up the init and modprobe processes.
- Test boot time
  - Basic Ubuntu 9.04 vs. Custom VM image
  - VMware server
    - CPU: Intel Core2 Duo 2.5GHz
    - RAM: 4GB

Power Consumption Analysis (4/4)



38s

Fig. 8. Bootup chart of the default Ubuntu Linux VM image

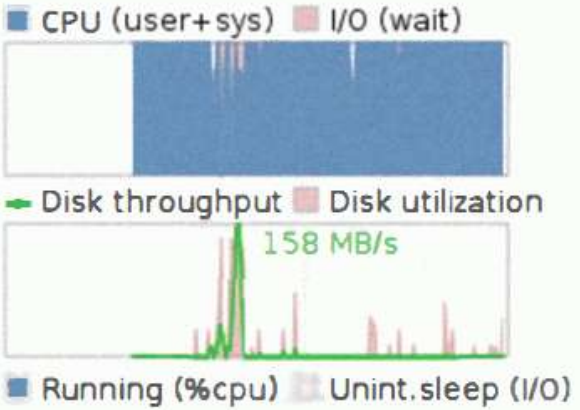


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Fig. 9. Bootup chart of Minimal Linux VM image

Conclusion and Future Work

- In this paper we have presented a novel Green Cloud framework for improving system efficiency. We have found new ways to save vast amounts of energy while minimally impacting performance.

- Future opportunities could explore a scheduling system that is both power-aware and thermal-aware to maximum energy savings.

- We believe Green computing will be one of the fundamental components of the next generation of Cloud computing.