Power Consumption of Virtual Machine Live Migration in Clouds

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Introduction

- What Is Virtualization Technology?
  - Virtualization technology increases efficiency in data center by enabling servers to run multiple operating systems and applications.
- Virtualization Technology has been employed increasingly widely in modern data centers in order to improve its energy efficiency.
- The capability of virtual machine (VM) migration brings multiple benefits for such as resources (CPU, memory, et al.) distribution, energy aware consolidation.
- But, the migration of virtual machines itself brings extra power consumption.
- A better understanding of its effect on system power consumption is very important

Virtualization

- Data centers start to employ server virtualization strategies for resource sharing to reduce hardware and operating costs.
- Few Virtualization Technologies are Xen, VMware, and Microsoft Virtual Servers
- The advantage of employing virtualization technology is the ability to flexibly remap physical resources to virtual servers.
- This paper focuses on the evaluation on power cost of “live” or “hot” migration, which allows migrating an OS as it continues to run.
  - (+) The possibility to migrate an virtual machine with near-zero downtime.

Contribution

- 1st, they give a practical experimental approach to evaluate the power consumption of VM migration.
- 2nd, they quantify the power cost of VM migration both for the original physical server that starts the migration and the destination physical server that accepts the transfer.
- The results ST, the power influence of migration to the original server decreases when the CPU usage of the migrated VM increases, but to the destination server, the influence is stable.
- The time cost of migration is not impacted by the CPU usage of VM.

Related Work

- Zhao & Figueiredo and William Voorsluys et al. specifically deal with VM migration.
- Zhao & Figueiredo, analyzed performance degradation when migrating CPU and memory intensive workloads as well as migrating multiple VMs at the time; however such study employs a pure stop-and-copy migration approach rather live migration.
- William Voorsluys et al, evaluated the performance cost of virtual machine live migration in clouds, and shows that in most case, migration overhead is acceptable but cannot be disregarded, especially in systems where service availability and responsiveness are governed by strict Service Level Agreements (SLAs),
- However their study did not consider power consumption.

Related Work

- Shekhar Srikantaiah et al. studied the the energy performance trade-offs for consolidation of applications, but without quantifying the impact of VM live migration.
- Takayuki Imada et al. study investigates power and QoS performance characteristics of virtual servers with virtual machine technology. They found that the live migration scheme can be applied with slight QoS performance degradation and slight increased power consumption.
- But this study is based on a single benchmark workload, without given a quantified study on the virtual machine power impact and they only study the original server, without considering the migration as a system.

Background

- Power Management in Data Center
- Live Migration

Power Management in Data Center

- Power management in data centers has become a critical issue in most countries.
- Many efforts have been made to improve the energy efficiency of data center, such as
  - Network Power Management,
  - Chip-Multiprocessing (CMP) energy efficiency,
  - Power Capping,
  - Storage Power Management solutions etc.

Virtualization Technique

- Enables multiple OS environments to coexist on the same physical computer, in strong isolation with each other.
- It offers the possibility of consolidation of applications in cloud computing environments which presents a opportunity for energy optimization.
- Consolidation is used to dynamically reduce the number of nodes used within a running cluster by liberating nodes that are not needed by the current phase of the computation.
  - (-) The failure to fulfill the Service Level Agreement (SLA), extra power consumption within the procedure of migration.

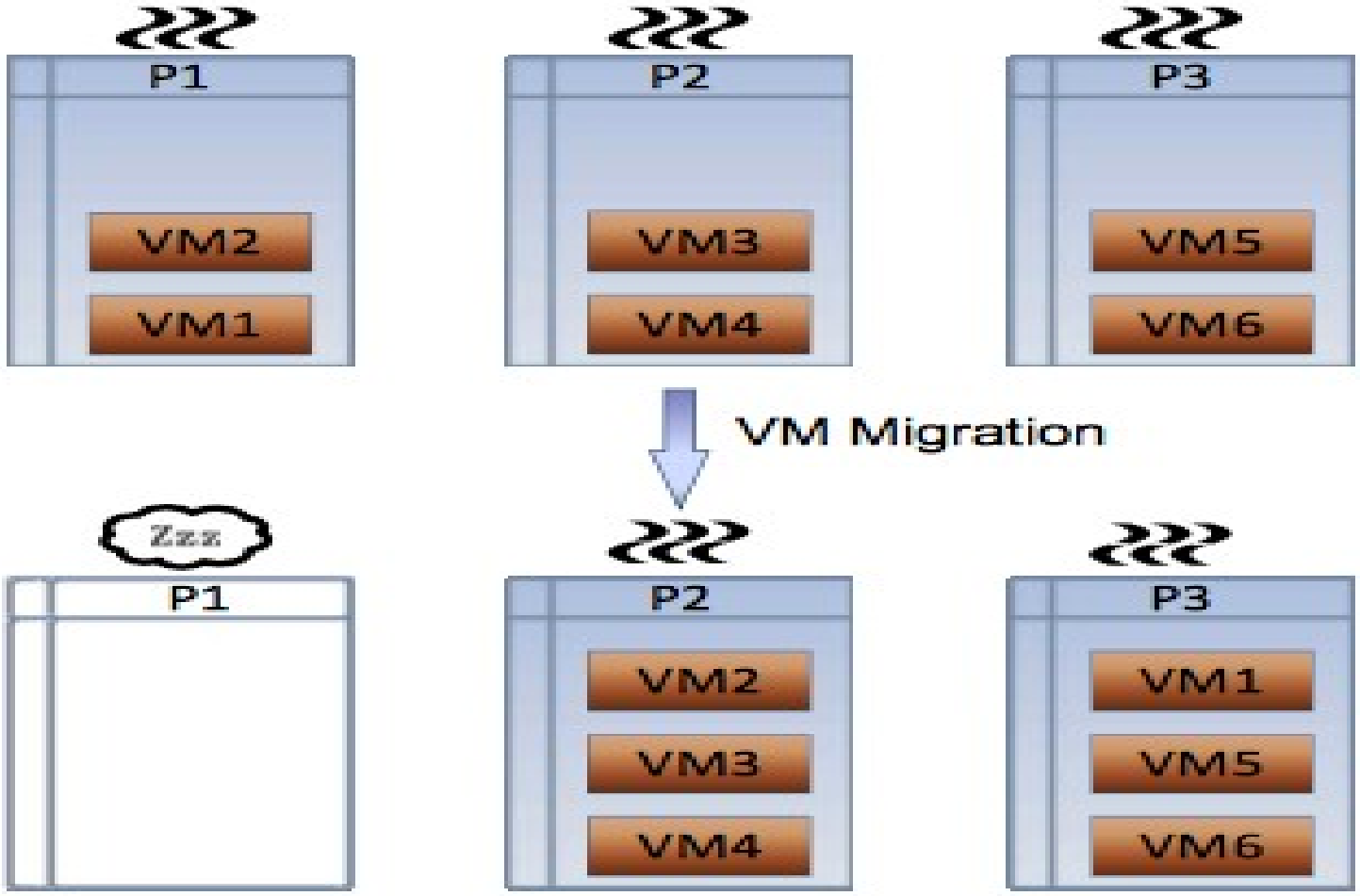


Fig. 1. Resource Consolidation in Cluster. It consists of 6 VMs (VM1-VM6) running on three physical servers (P1-P3). with the VM migration technology. VM1 and VM2 is consolidated on P2 and P3 respectively. And P1 is turned off, so the power consumption of the cluster is reduced.

Virtual machine migration:

- Virtual machine migration:
- Used to transfer a VM across physical servers.
- To achieve better energy efficiency of data centers.
- It can be classified into two categories:

1. Regular Migration
2. Live Migration

Virtual machine migration:

- VM Migration
  - Regular Migration
    - It moves a VM from one host to another by pausing the originally used server, copying its memory contents, and then resuming it on the destination.

Great Potential

  - Live Migration
    - It performs the same logical functionality but without the need to pause the server domain for the transition.
    - (+) Efficiently manage workload consolidation,
    - (+) Improve the total data center power efficiency.

EXPERIMENTS AND RESULTS

- Their goal is to achieve a better understanding of power influence of live migration.
- - Two aspects that mainly dedicate to power cost of server which are:

1. CPU utilization percentage
2. Processor frequency

EXPERIMENTS AND RESULTS

- They designed two preliminary experiments:

1. The first one is to verify that the server power cost can be represented .
2. The second is to get power consumption of server in each processor frequency, then evaluated the power consumption caused by live migration.

Experimental Setup

- *Experimental Setup*
- **- *They* used three physical servers:**

1. One server is for VM hosting and operates one or two Vms.
2. The other one which is used to accepted the VM transferred by the originator.
3. All nodes shares an NFS (Network File System) mounted storage device.

- **- Each node is equipped with Intel(R) Core(TM)2 DuoCPU E8400 and 3 Gigabytes memory.**
- **- The servers are connected through a Gigabit Ethernet switch.**
- **- An iPDU power meter is adopted to monitor the real-time power consumption of physical machines.**

1. Power-related parameters monitored by the power meter for a machine include Current, Voltage, Power and Kilowatt hour.
2. The parameters are collected every 2 seconds.

Experimental Setup

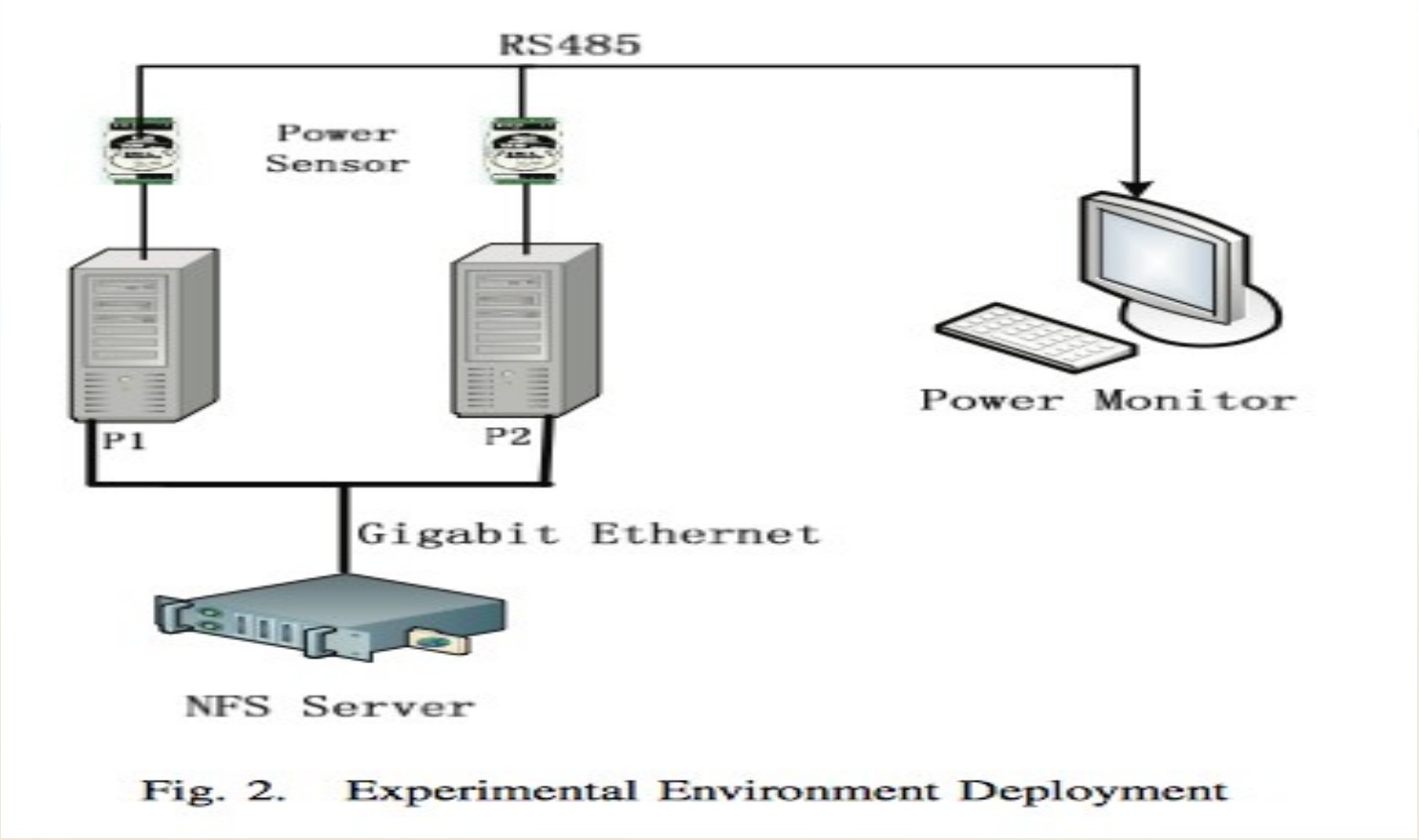


Fig. 2. Experimental Environment Deployment

Preliminary experiment

- - *P*ower consumption can be expressed as percentage of the peak power across the data center.
- - The power consumption of the physical server is approximately linear model of the server utilization. -
- - Their experiment indicate that power consumption is mainly determined by CPU usage.
- - They design a computational workload which runs in the virtual server to control its CPU utilization percentage.
- - So, they verify that the power consumption increase almost linearly with CPU utilization

Preliminary experiment

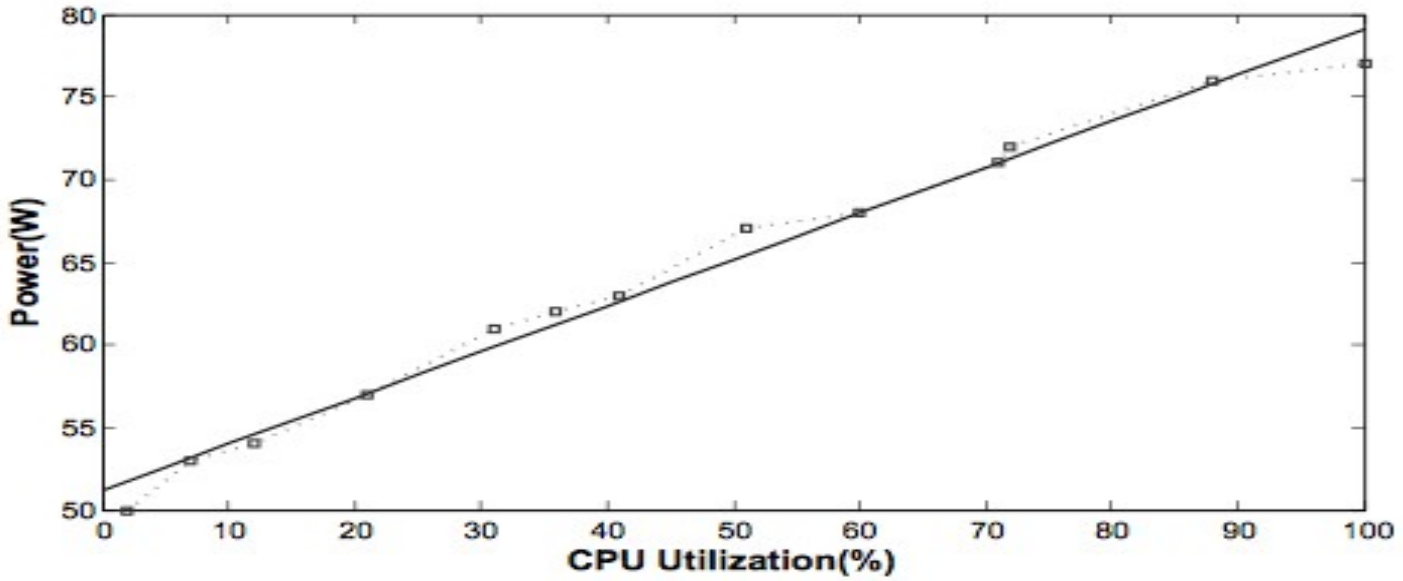


Fig. 3. Power Consumption v.s. Utilization. The actual power consumption on each CPU utilization is nearly equal to the model we set up.

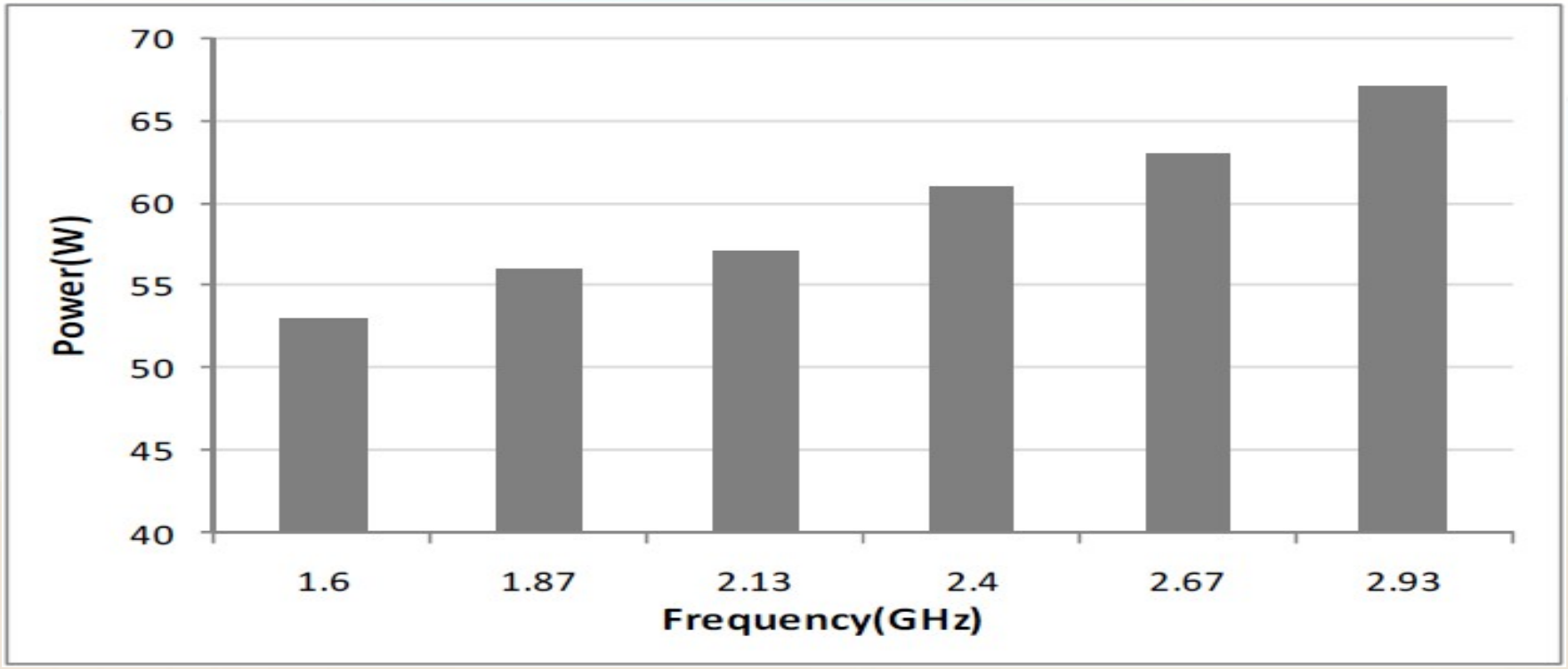
Preliminary experiment

- According to their results, the power consumption of server can be represented as follows:
- $P = 0.2782 * Util + 51.2765$
- where P is the power consumption of our physical server,
- and *Util* is the CPU utilization.

Configuration of CPU Frequency

- Powersave
- Userspace
- Ondemand
- And more...

Configuration of CPU Frequency



power consumption can be reduced by configuring CPU frequency

Power Consumption of Live migration

- *Power Consumption of Live migration*

  -Power used by the original physical server.

  -The power used by the destination server.

- the cost is caused by the increase of resources:

  -CPU(s).

  -Storage resources.

  -I/O resources (NetWork).

Power Consumption of Live migration

- designed a computational workload which can change the CPU utilization of virtual server.

- WHY?
- - To explore the power consumption of live migration according

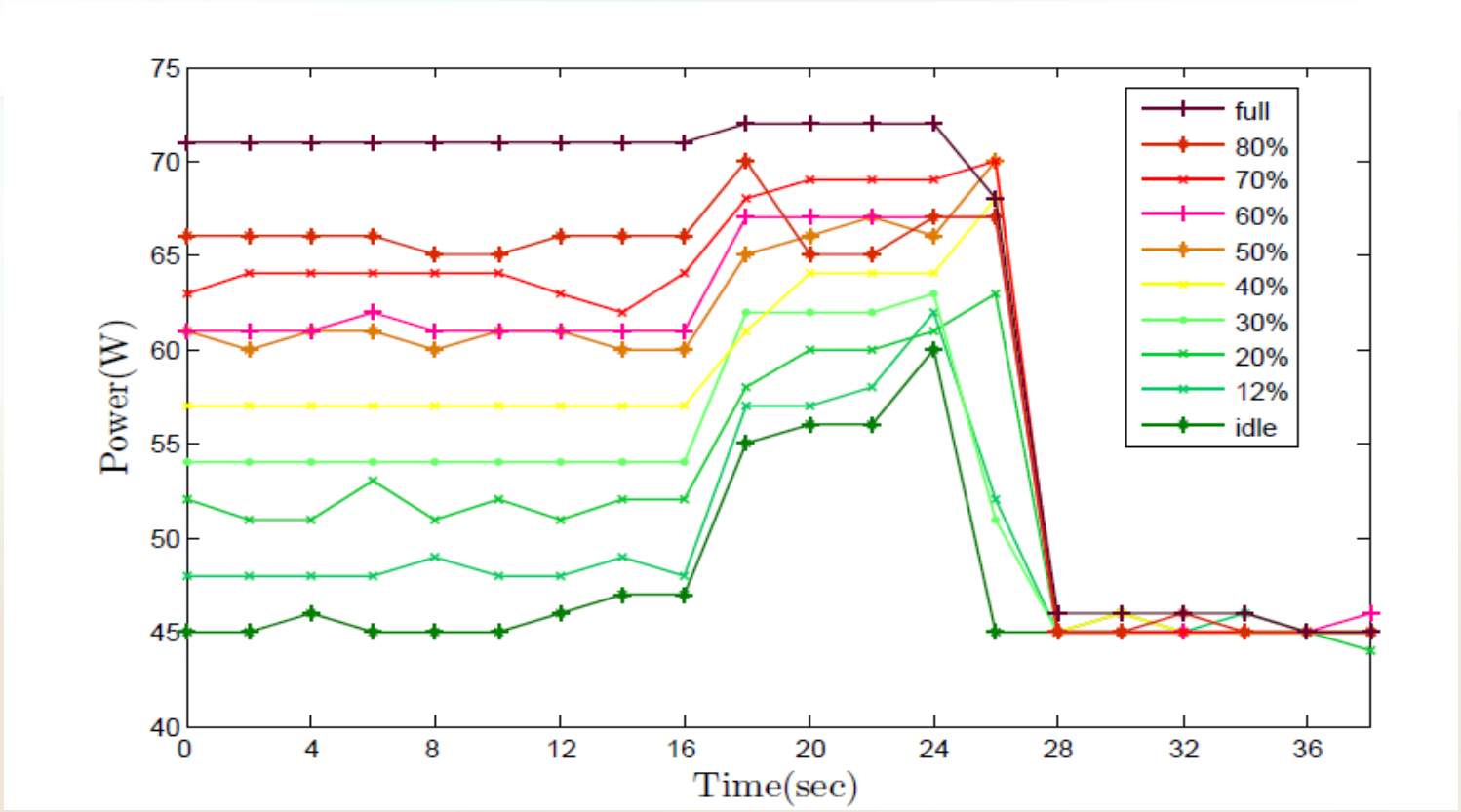
  to the CPU utilization

Power Consumption of Live migration

- Observed facts :

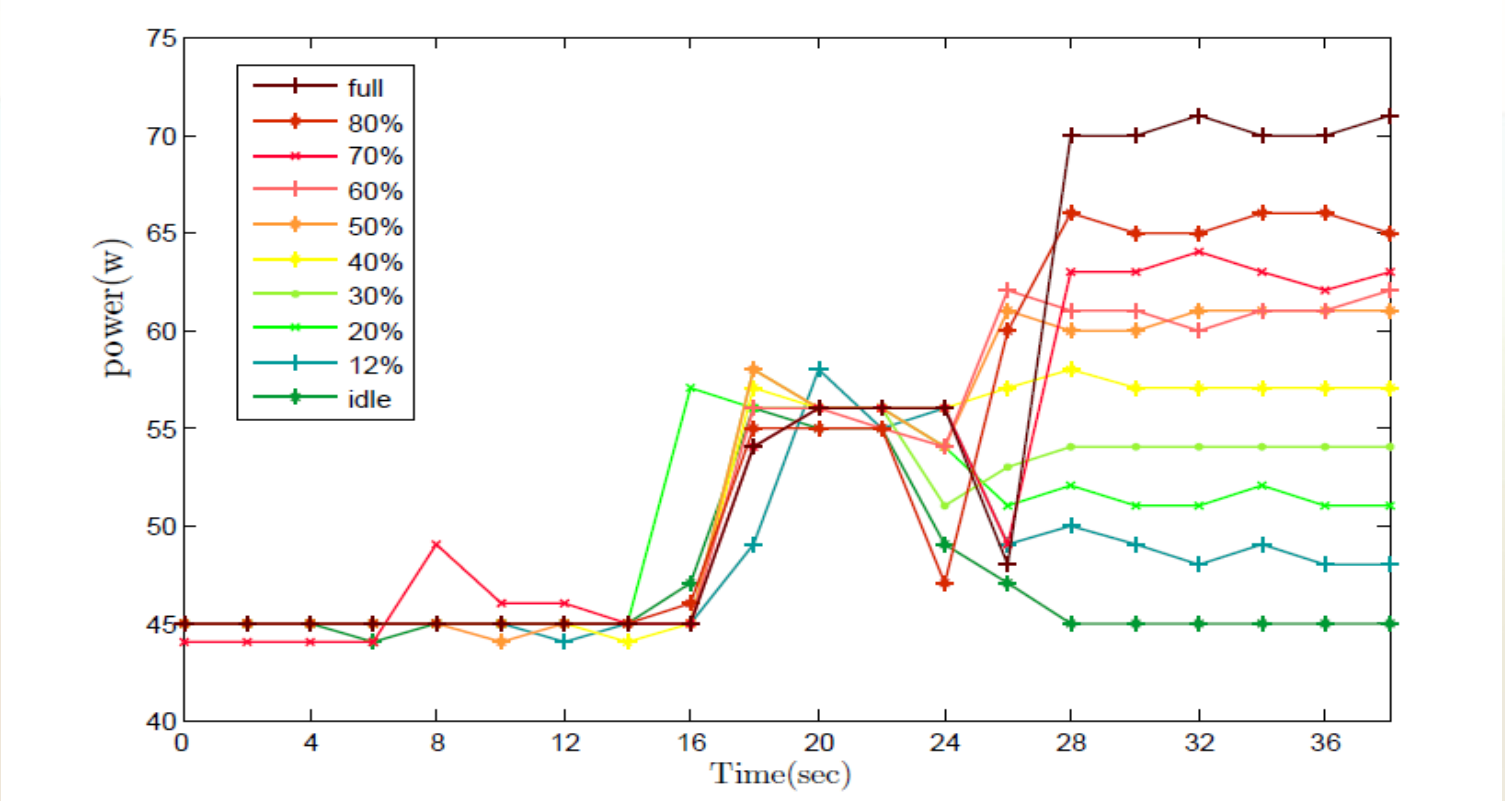
1. The power influence of migration on the original server goes down with the increase of CPU usage of the migrated VM, but for the destination server, the influence is stable.
2. The time cost of migration is not impacted by the CPU usage of VM.

Power Consumption of Live migration (Original Server)



The power consumption of migration decreases from 10Watt to 1Watt when the CPU utilization rises from idle to full(The time cost is 7).

Power Consumption of Live migration (Destination Server)



Time cost and power consumption is almost the same(7 seconds, 10 Watts).

Conclusion

- VM migration is key to realize VM-based resource reservation and power reduction.
- This paper quantifies the cost of live migration for both source and destination physical servers.
- For the original server :

  Increasing VM CPU usage decreasing power consumption.
- For the *destination* server :

  No impact happens.
- Time cost doesn’t change with changing VM CPU utilization.

FUTURE WORK

- “The ongoing investigation is focus on generalizing this paper’s results and evaluating the migration cost.”

- “Our study would aid researchers and practitioners currently evaluating the application of VM migration for consolidation strategy in clouds.”

Questions