Power Efficiency of Hypervisor and Container-based Virtualization

University of Amsterdam
MSc. System & Network Engineering
Research Project II

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02-02-2016

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Significance

- **Growing consumption** of **cloud services**

  Cisco claims: "by **2019, more than 86 percent** of **all workload** will be **processed by cloud data centers**"

- More **awareness** on **power consumption**
- **Container-based** virtualization is an **emerging technology**

  Docker became very popular in a relative short time

Related Work (1)

- Van der Poll [2015]
  - **Power consumption** of two open-source **hypervisors, KVM and Xen**
  - **KVM** as a **more green solution** than **Xen**.
- IBM research division [2014]
  - **Performance** comparison of virtual nodes ran by a hypervisor versus Linux containers
  - **Docker** had **equal** or **faster** performance compared to **KVM**
- Ericsson research division [2015] [1]

Empirical Investigation of **power consumption** of **virtualization platforms**

- **Compared number of VMs and Containers**
- Power impact of CPU, memory and HDD
- Used a Power Measurement Device
- Results: virtualization platforms behave similarly in idle state and in CPU/Memory stress test

Figure 1: Power Measurement Device

Image source: http://media.bestofmicro.com/green-power-cpu-performance,E-o-228600-13.jpg

Related Work (2)

- Ericsson research division [2015] [2]
  - **Performance** comparison between traditional hypervisors and Linux containers
  - **Containers** achieve generally **better performance** compared to **traditional VMs**

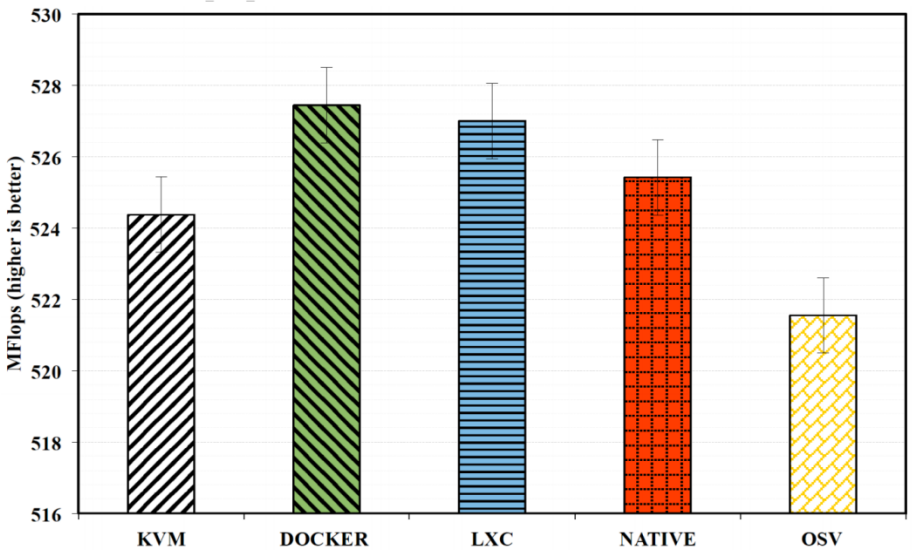


Figure 2: LINPACK CPU performance

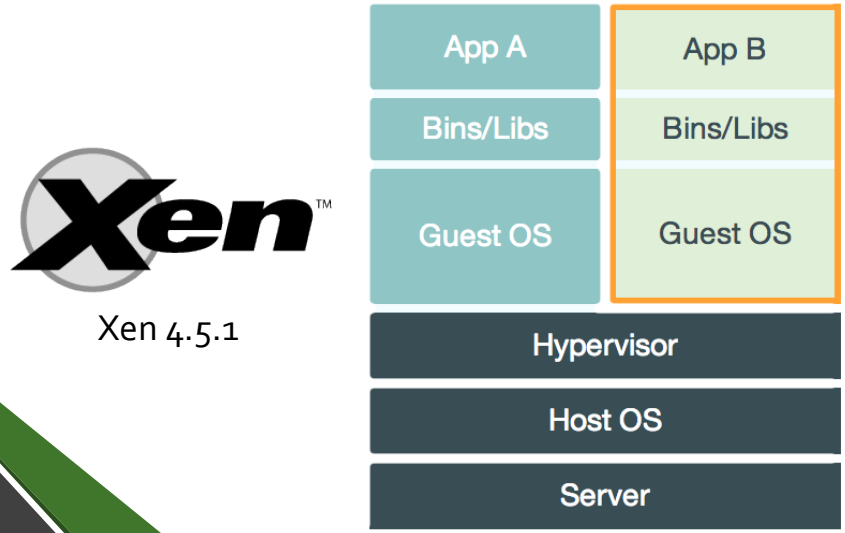
Source: Ericsson, Hypervisors vs. Lightweight Virtualization: a Performance Comparison [2015]

Research Question (1)

Is there a **difference** in **power efficiency** under a **traditional hypervisor-based virtualization** versus **Linux containers**?

VMs and Containers

- Container virtualization is a **lightweight** alternative to hypervisor-based virtualization
- Container runs on top of the **same shared host OS kernel**
  - While VMs install a full Guest OS
- Containers **do not isolate** resources **as well as hypervisors**



Xen 4.5.1

Docker 1.9.1

Figure 3: Image source: http://gordonsun-blog.s3.amazonaws.com/wp-content/uploads/2015/05/docker-containers-vs-vms.png

Approach

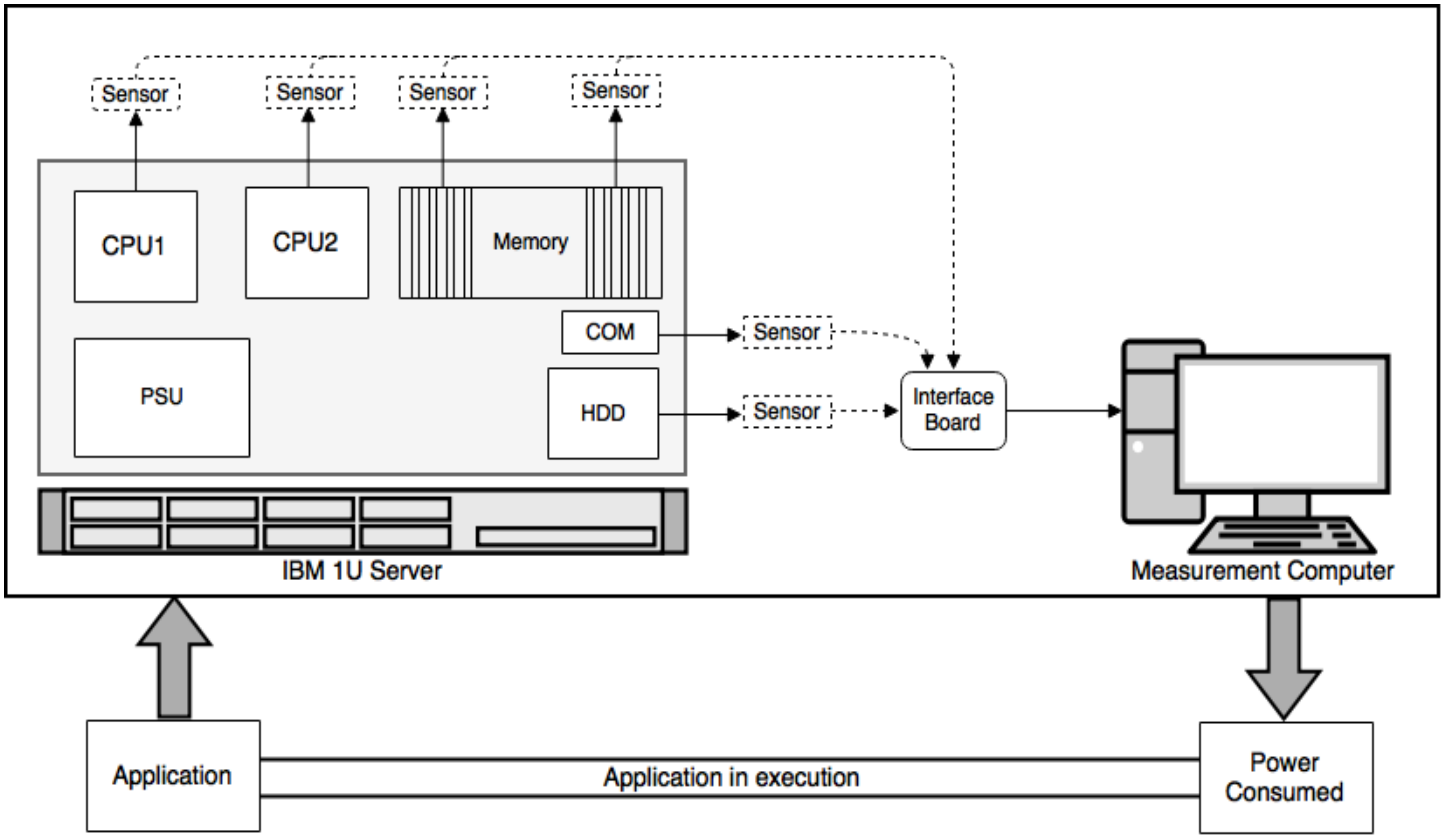


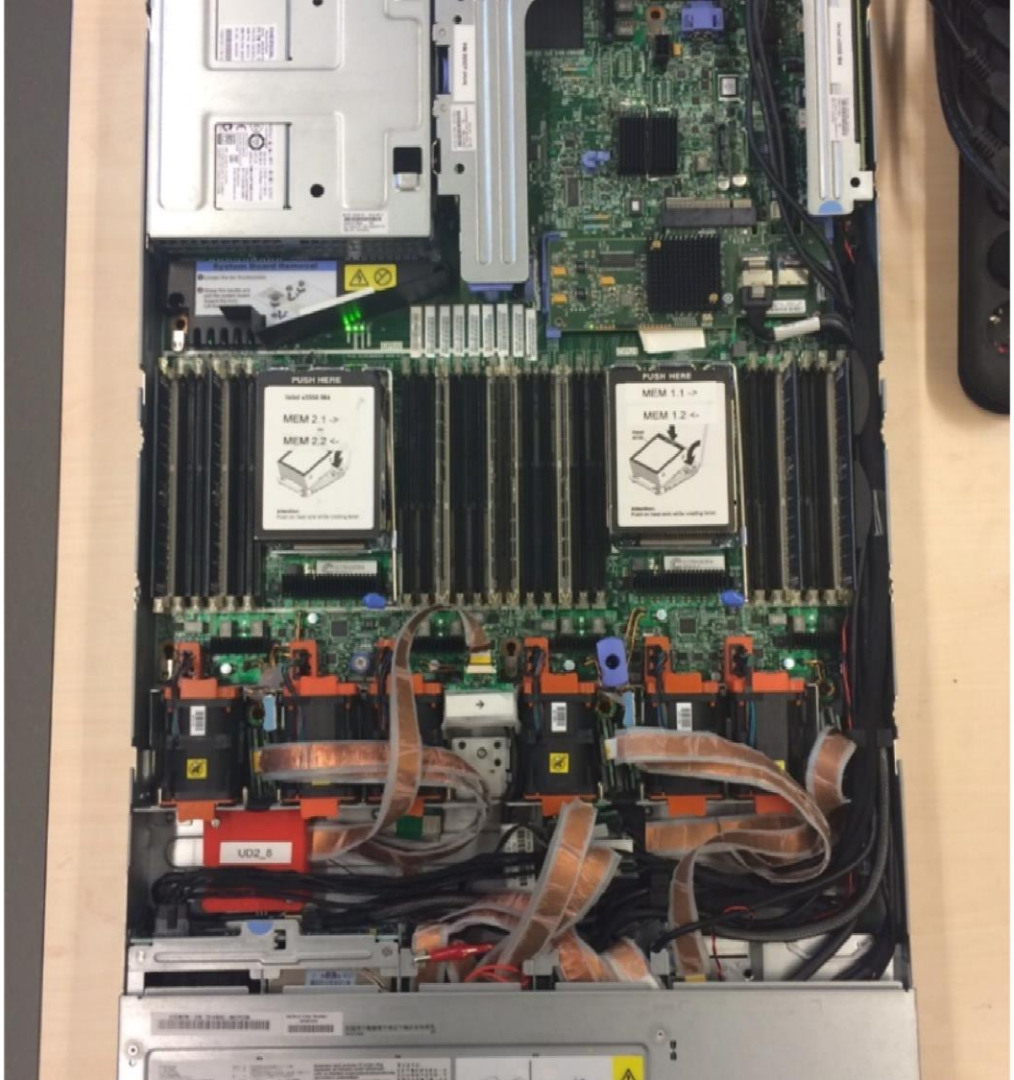
Figure 4: Power Measurement Setup

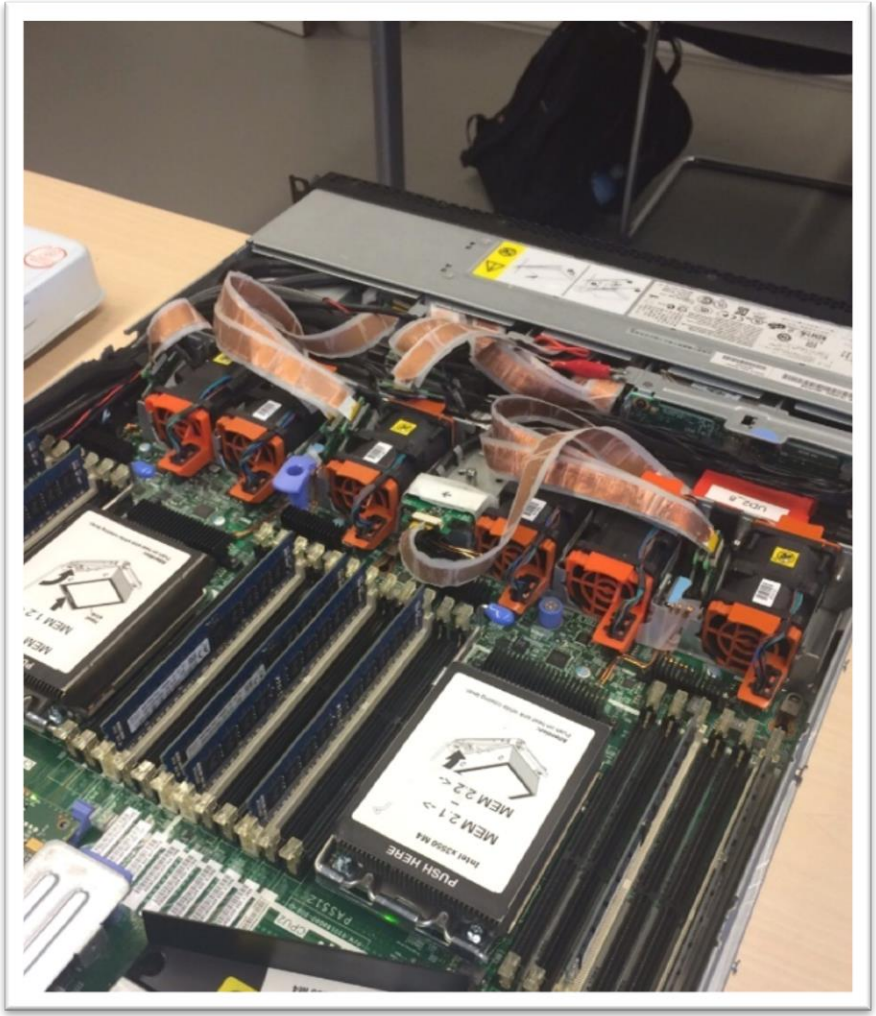
Measurement Setup

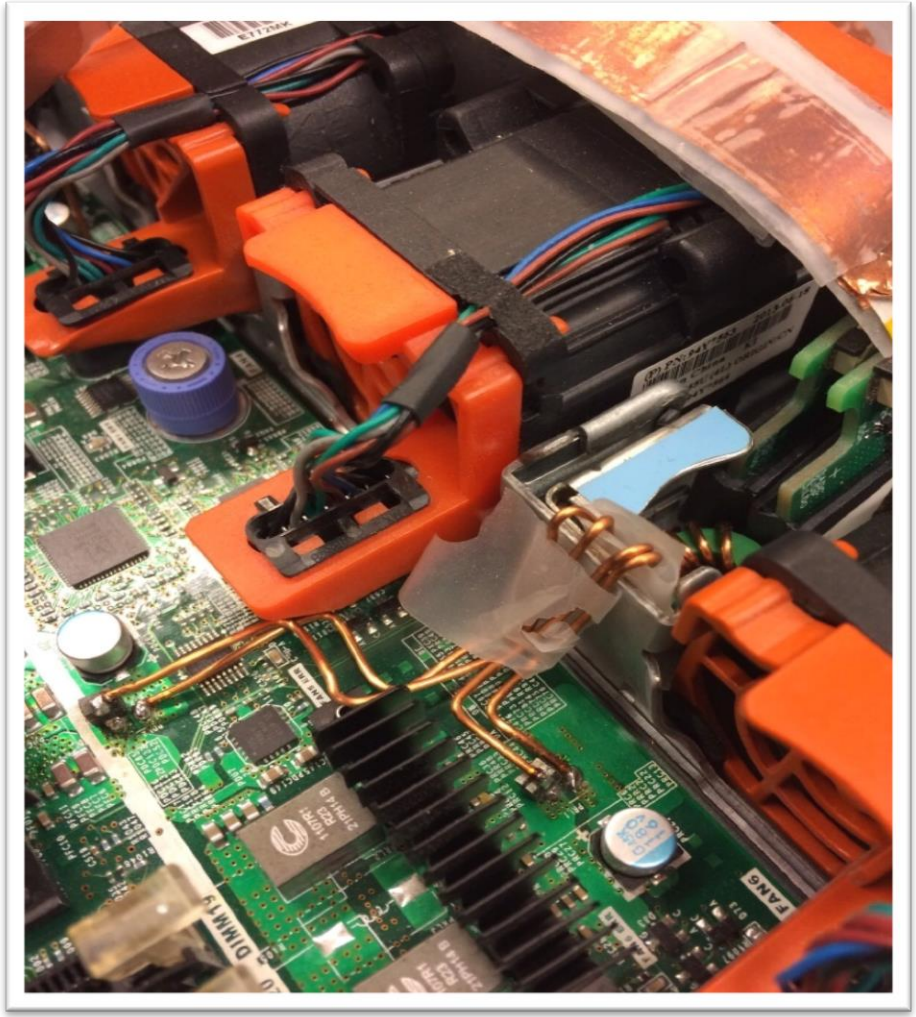
	System Information
Model	IBM System x3550 M4 7914B3G Server (Firmware version 1.9)
Motherboard	IBM 00D3449
Power Supply	IBM Emerson 550W (80+ Platinum Certification)
Processors	2x Intel Xeon E5-2609 v2 @ 2.50 GHz, 8 cores, 6.4 GT/s, 25 MB Cache
Memory	64 GiB (8 GiB x 8 Slots) Hynix DDR3 PC3 1333MHz 14900R, 13-12-B1
HDD	HP 146 GB 2.5-inch SCSI SAS, 3.0 GB/sec, 10,000 RPM

Table 1: IBM 1U Server Specifications

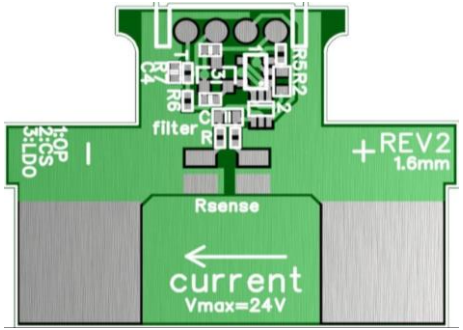
Running Ubuntu 15.10 x64


PUSH HERE
MEM 2.1 ->
MEM 2.2 <-
PUSH HERE
MEM 1.1 ->
MEM 1.2 <-
UD2_8

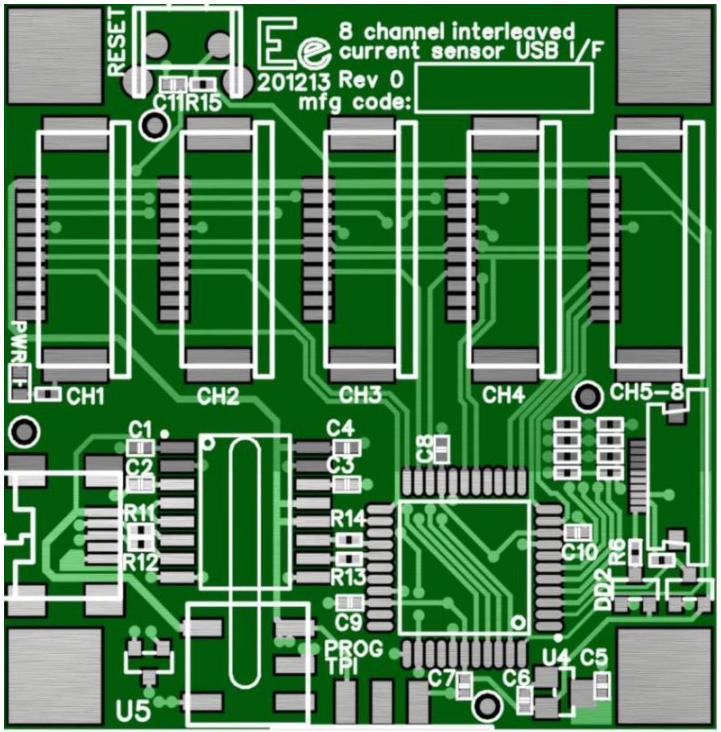

MEM 2 1 ->
MEM 2 2 <-
PUSH HERE


FAN6
DIMM 1 9

Measurement Sensors



(1)
Power Usage Sensor



(2)
Data Acquisition Interface Board

Image source: eurocircuits.com blueprints

Measurement results

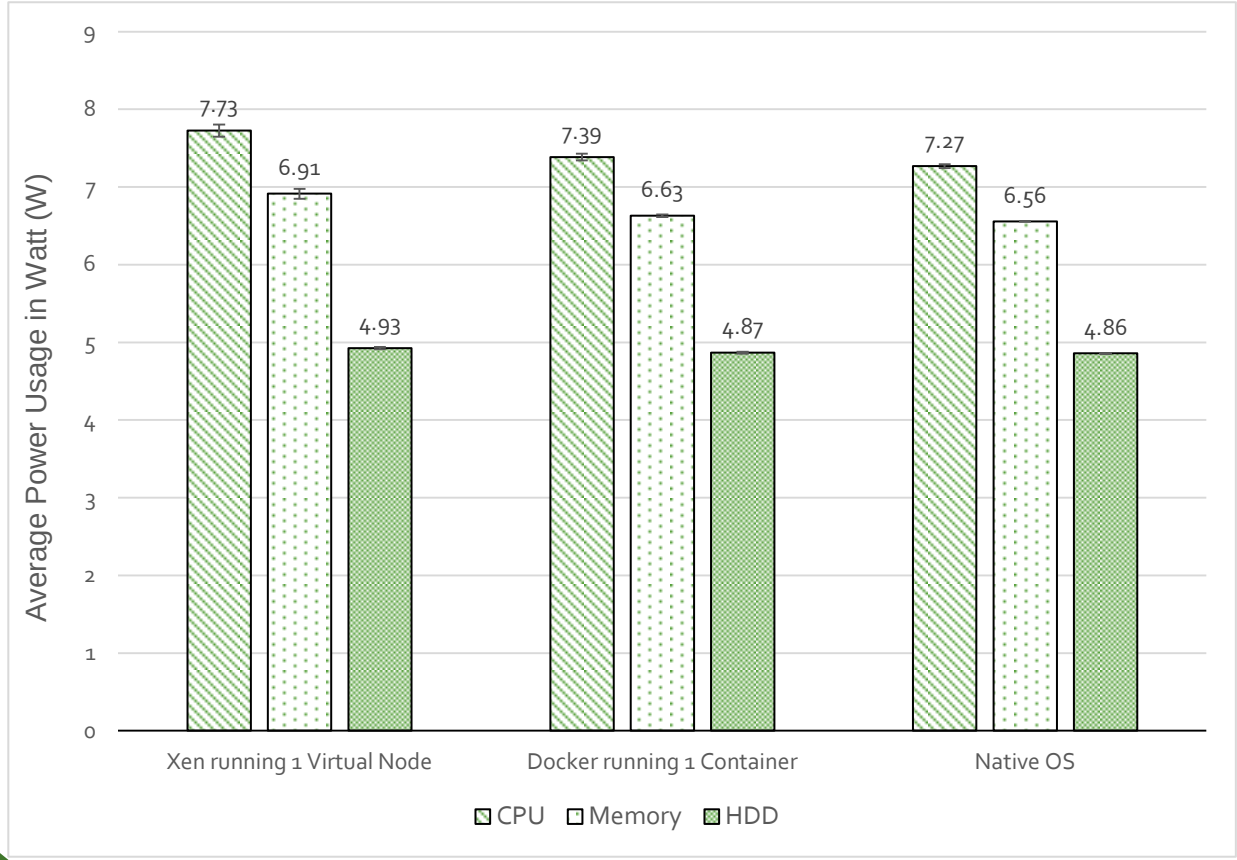
Synthetics Applications

Dominant Hardware Component	Benchmark Application
Processors	Intel Optimized LINPACK
Memory	sysbench
HDD	Bonnie++

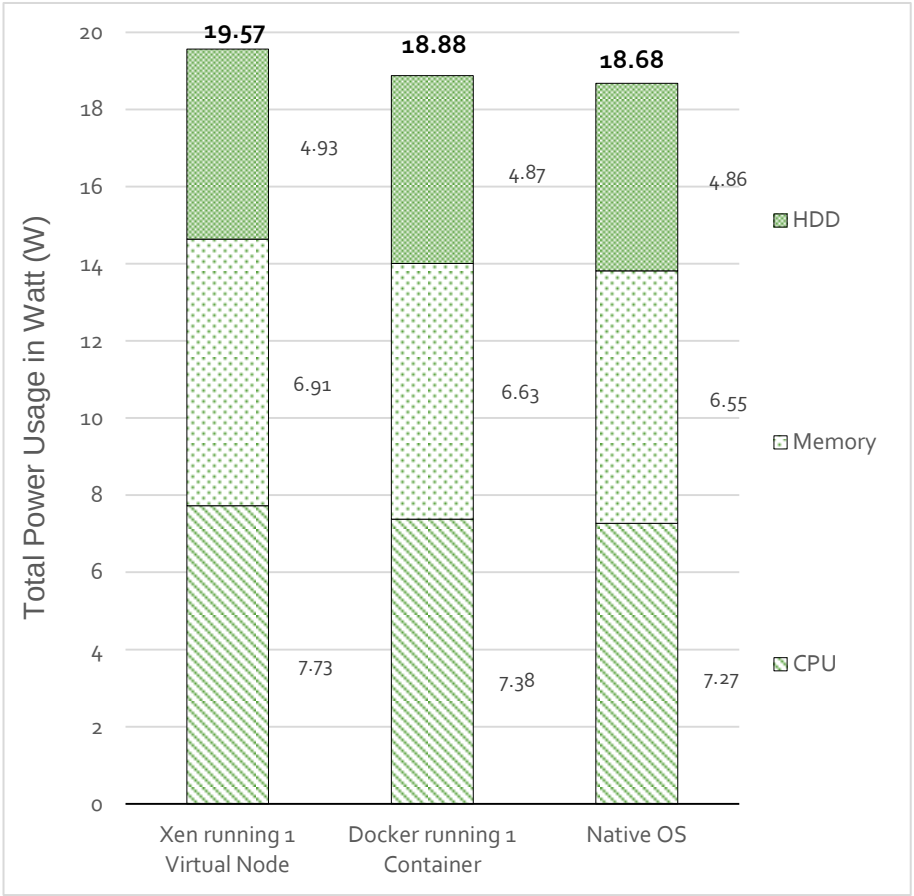
Table 2: Dominant components and their synthetics benchmark applications

But first, IDLE is measured as a baseline

IDLE Power consumption (1)



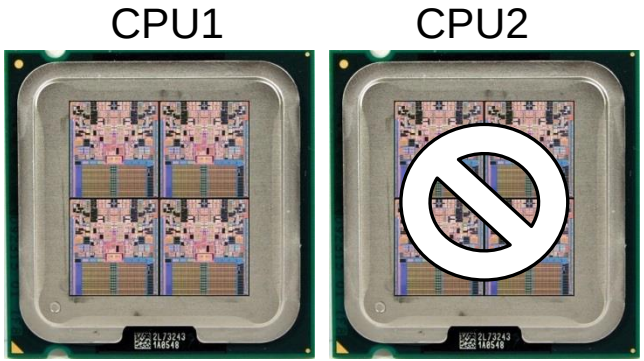
Total IDLE Power consumption (2)



CPUs and Cores

Experiment 1:

4 cores on CPU1



Experiment 2:

2 cores both CPU1 and CPU2

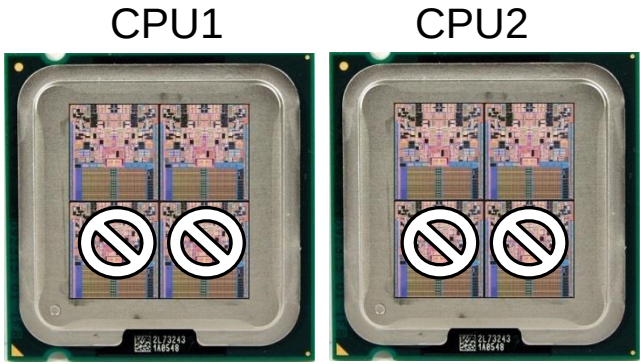
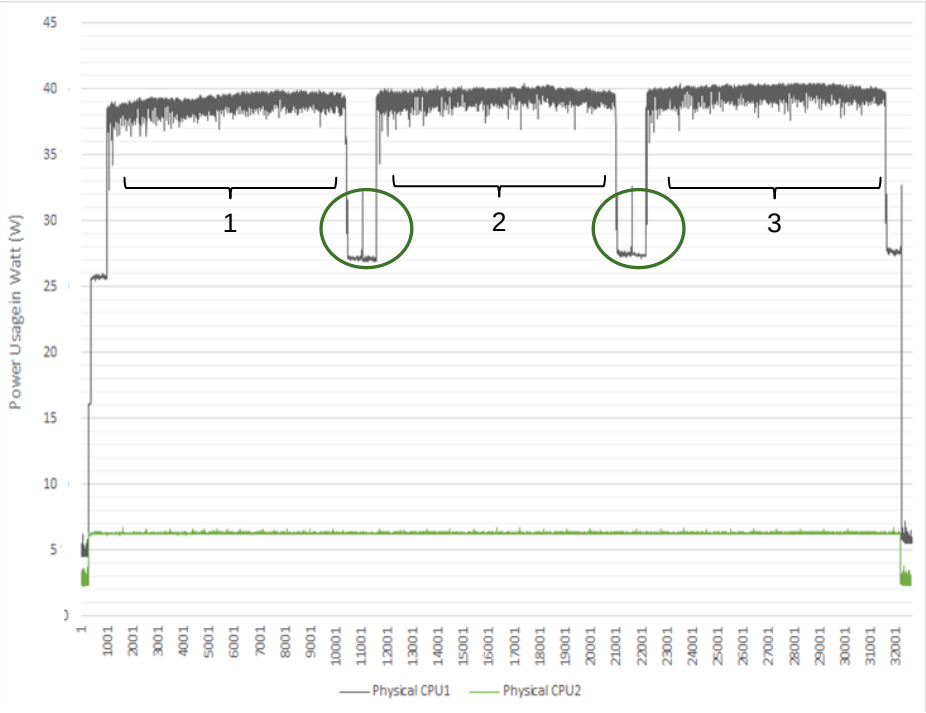
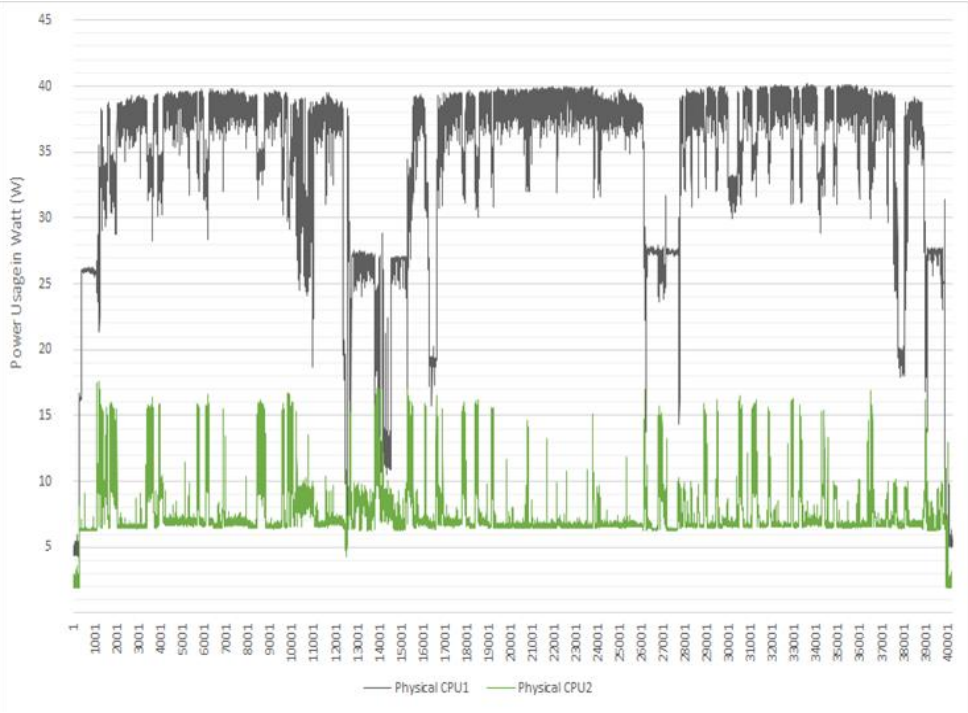


Image source: http://img.tomshardware.com/us/2007/10/29/hitting_4ghz_with_air_cooling/intel_penryn_45_nm_octo_core.jpg

Power Consumption during **LINPACK** on **Docker (1)** and **Xen (2)**

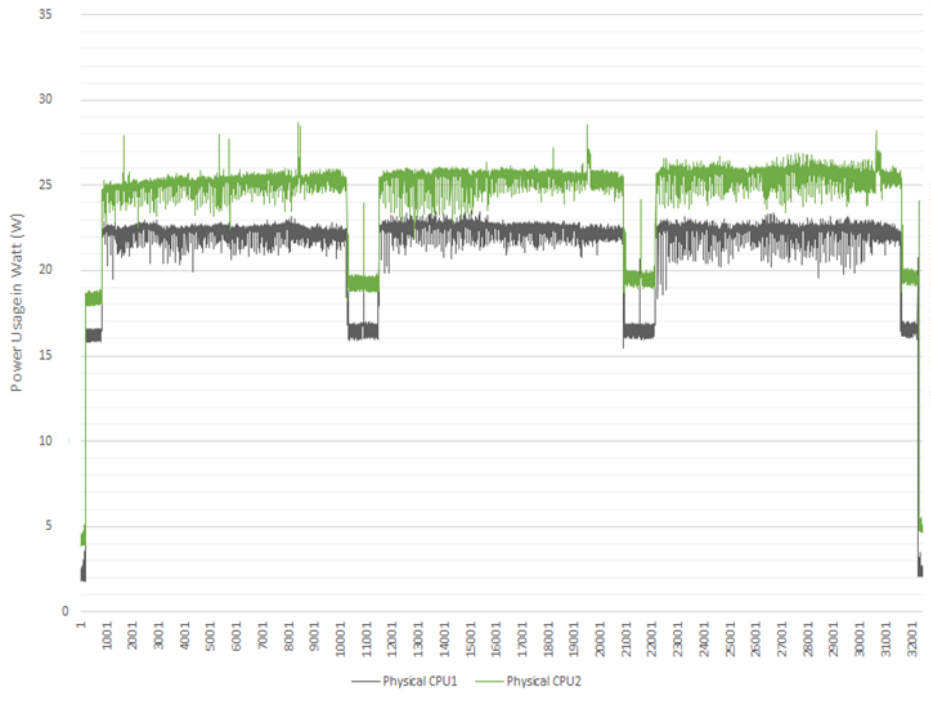


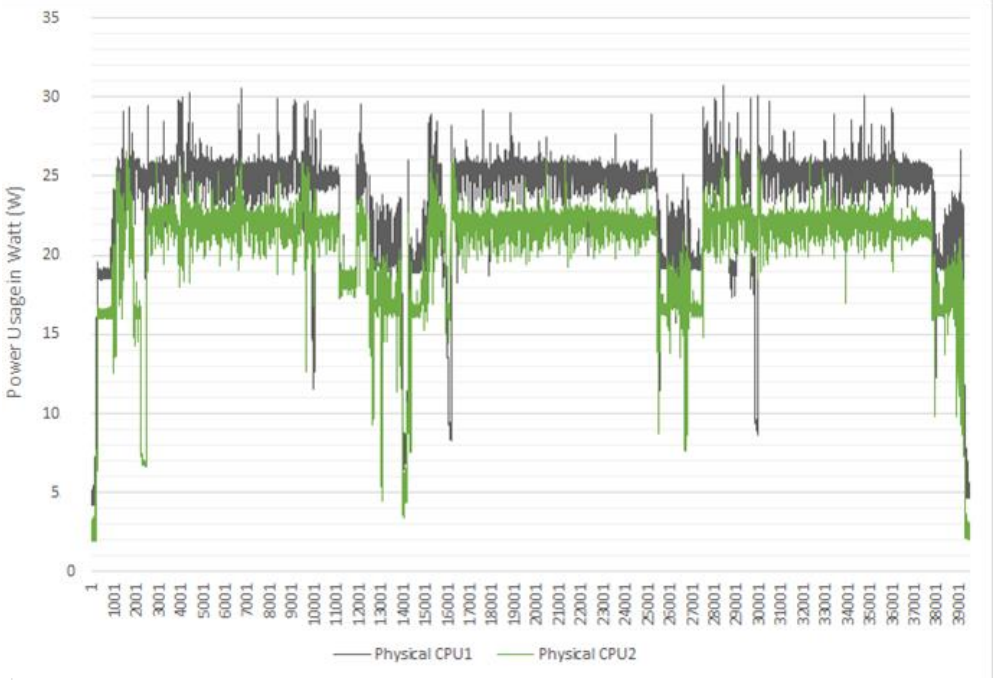


(1) **Docker**: All **4 cores** used on **physical CPU1**

(2) **Xen**: All **4 cores** used on **physical CPU1**

Power Consumption during **LINPACK** on **Docker (1)** and **Xen (2)**

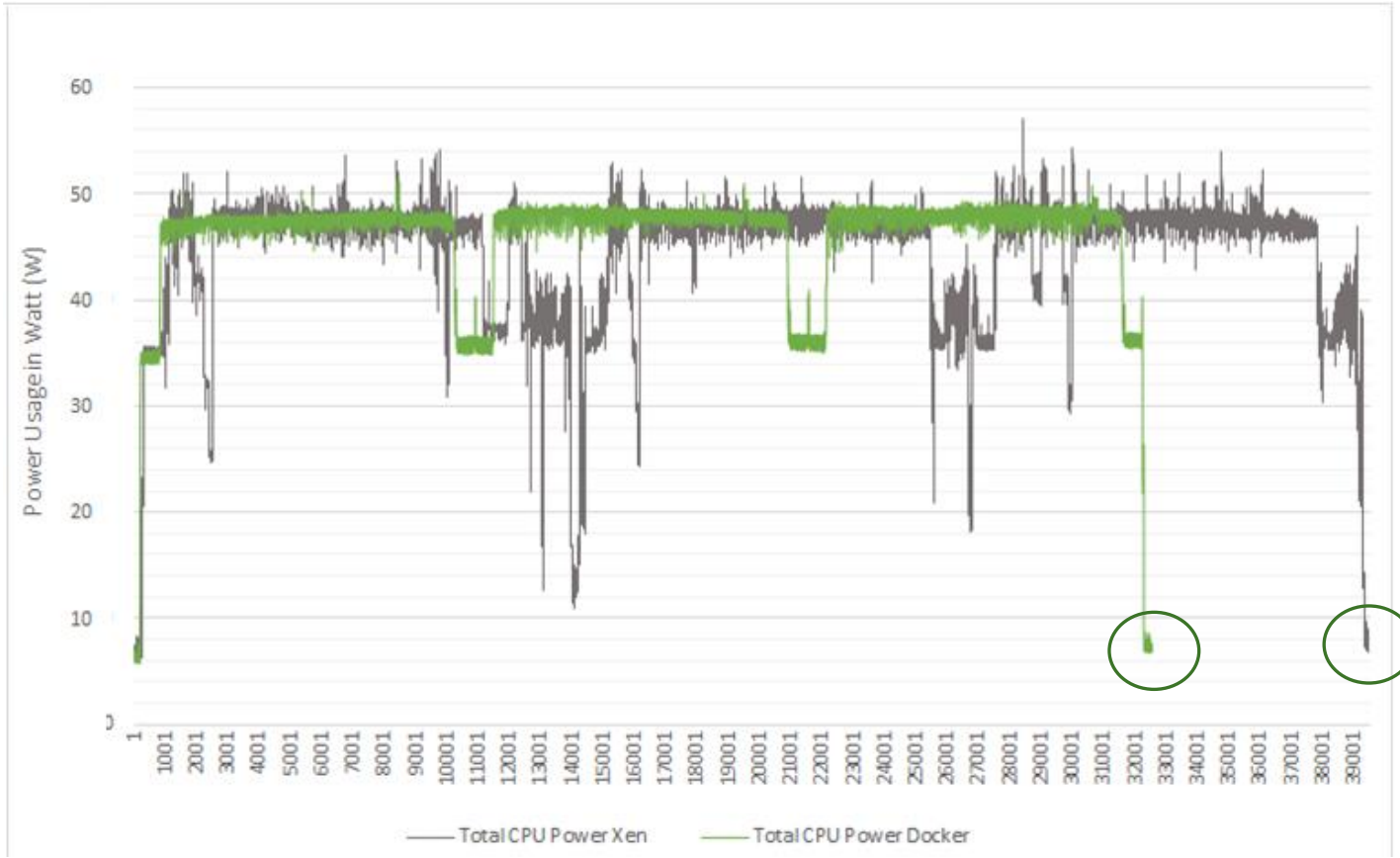




(1) **Docker**: **2 cores** used of each **CPU1 and CPU2**

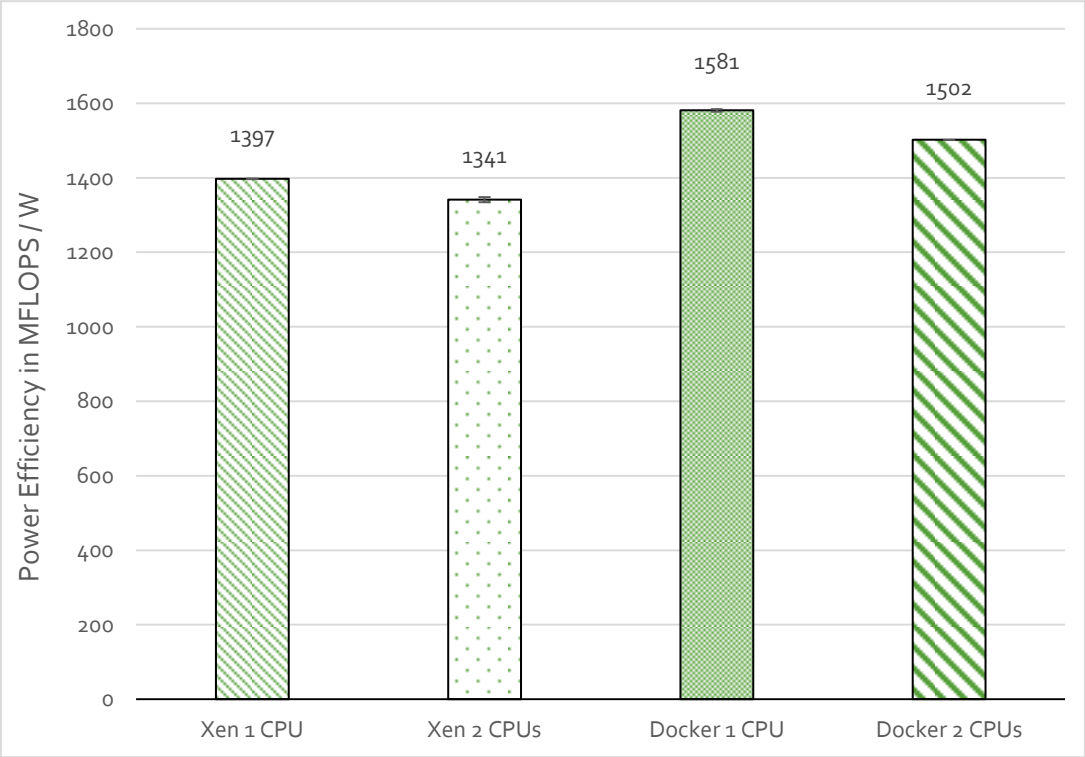
(2) **Xen**: **2 cores** used of each **CPU1 and CPU2**

Total Power consumption of **LINPACK** CPU **Docker** and **Xen**

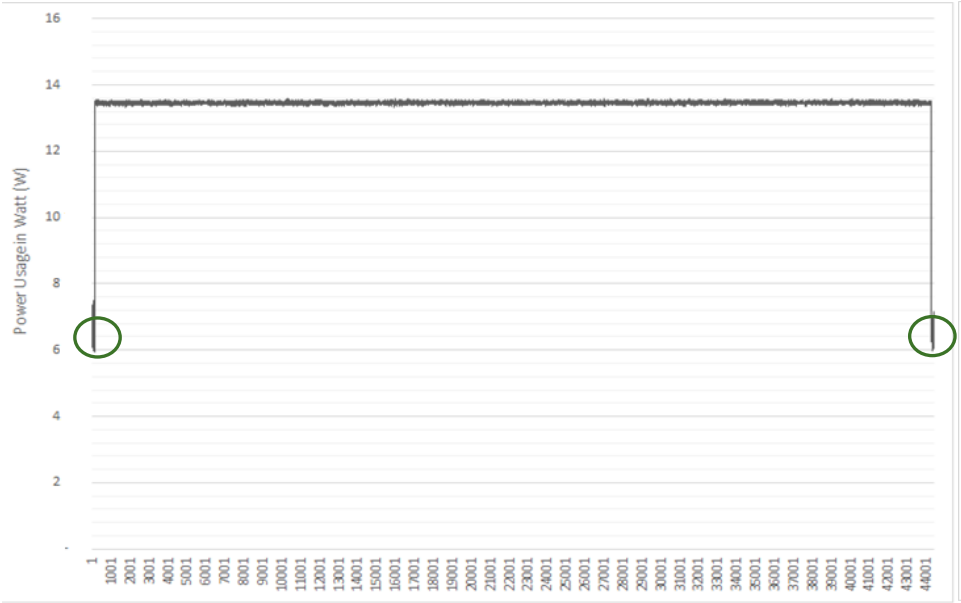


Energy efficiency during **LINPACK** (CPU intensive)

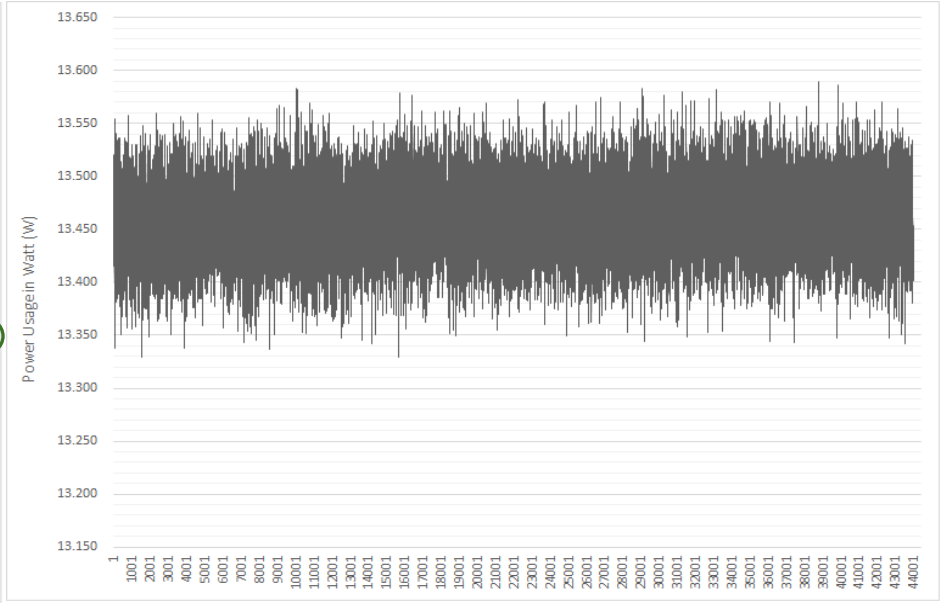
$$Power\ Efficiency = \frac{Average\ Compute\ Performance}{Average\ Power}$$



Power Consumption during **sysbench** 350GiB memory transfer

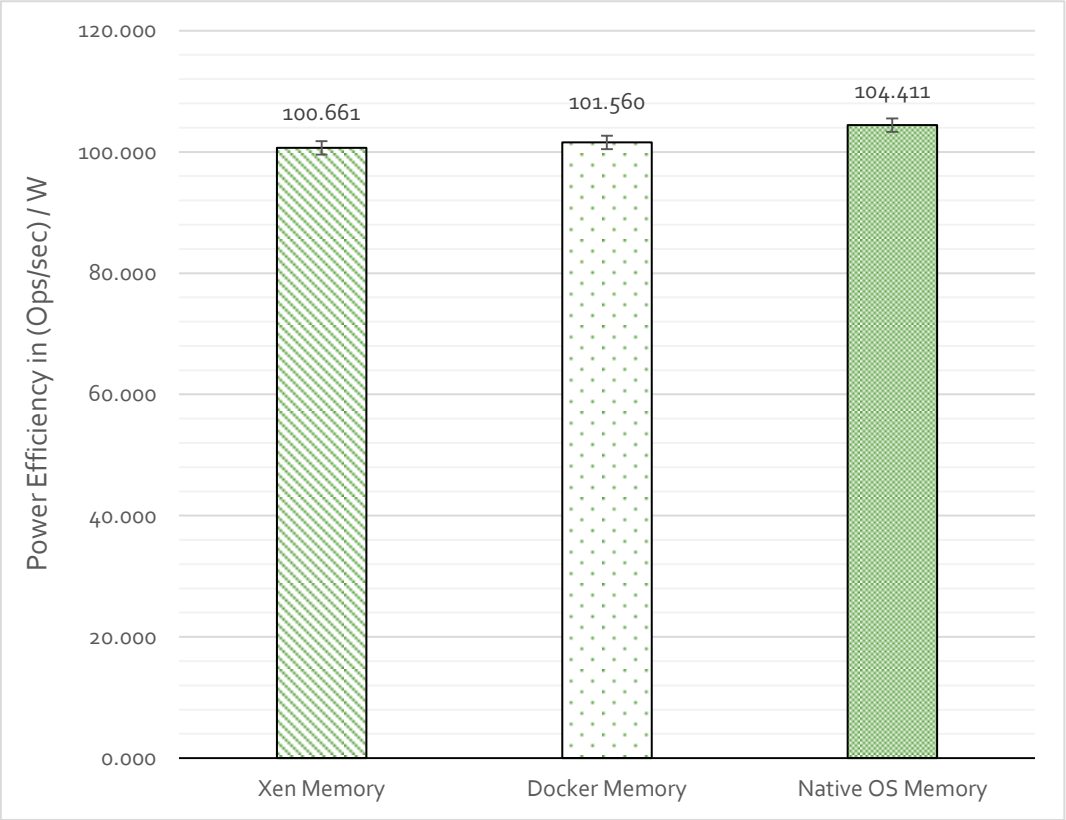


Power Usage of all memory banks (1)

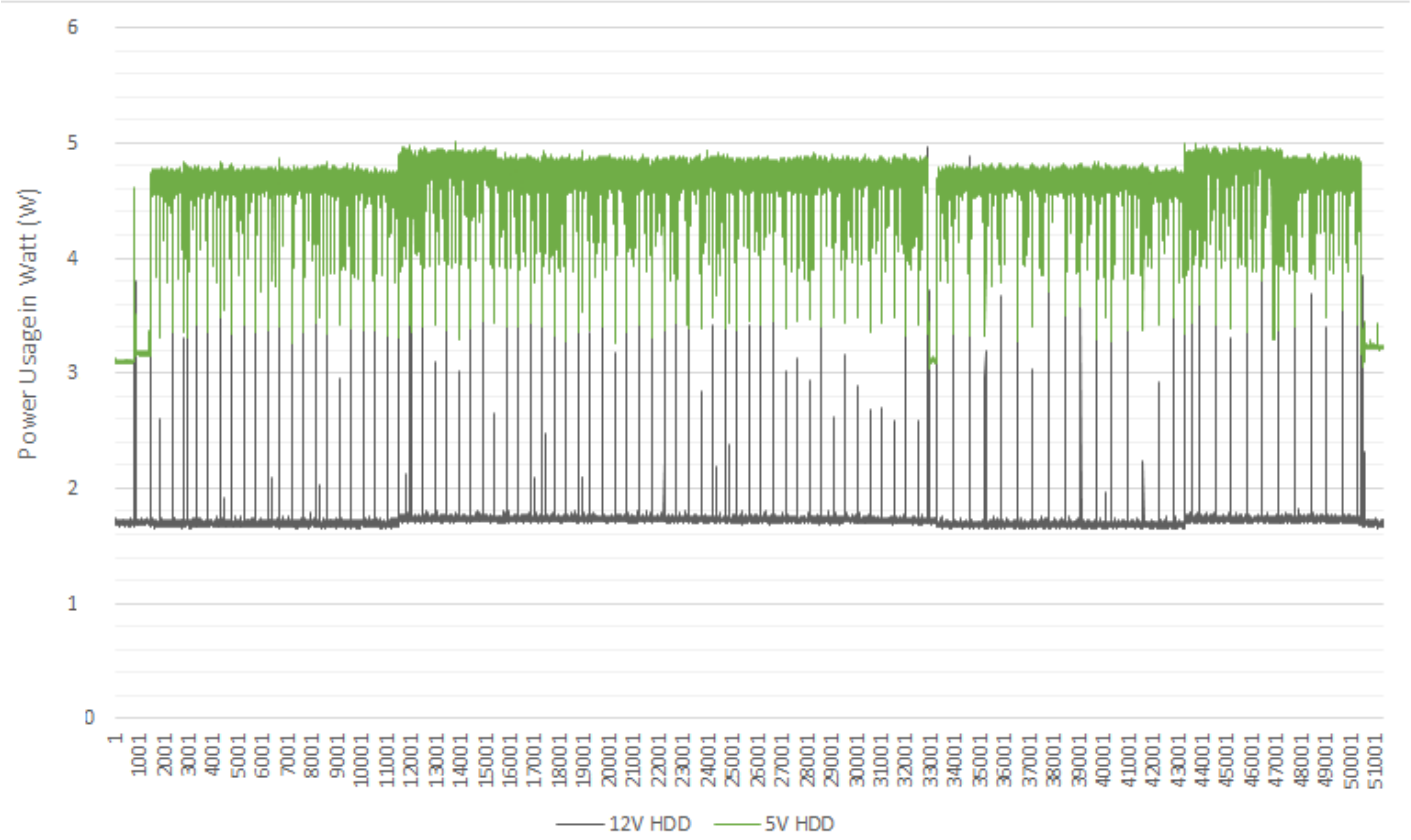


Power Usage of all memory banks (2)

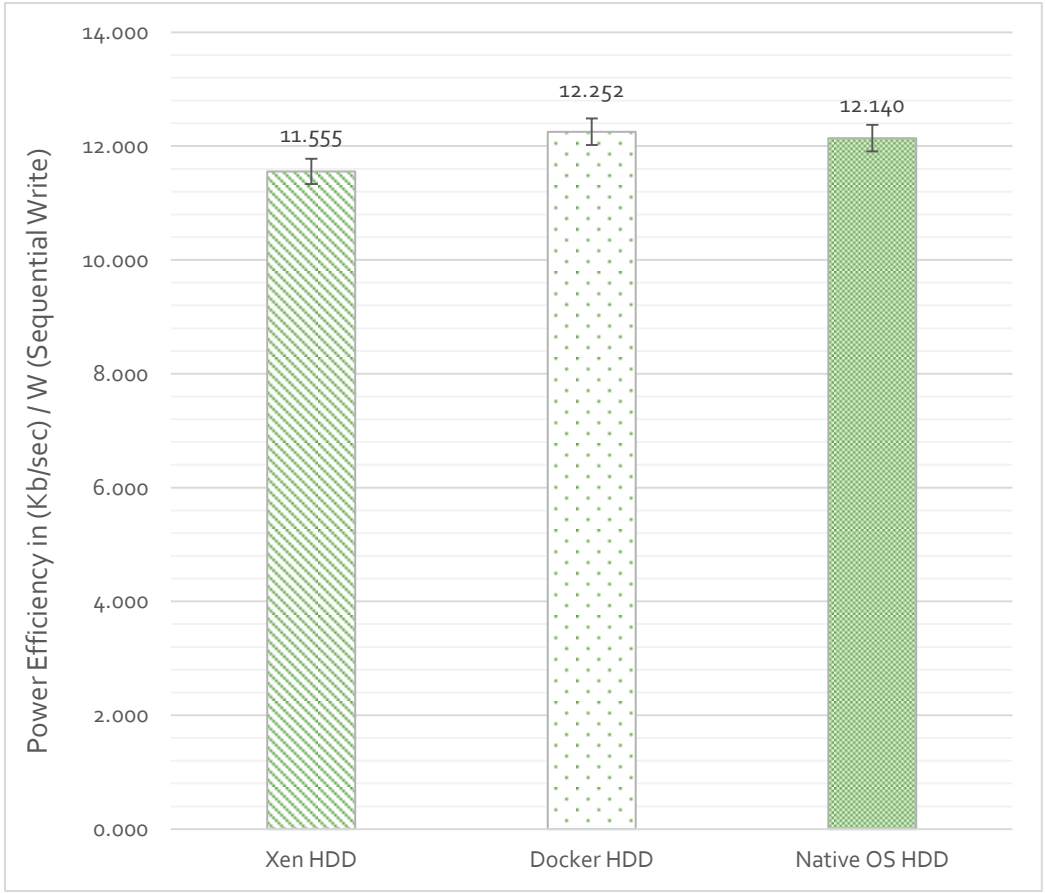
Total Power efficiency during a **sysbench** 350GiB memory transfer



Power Consumption during **Bonnie++** (25GiB)



Total Power efficiency during **Bonnie++** 25GiB (Sequential Writes in Kb/sec)



Conclusion

Research question:

Is there a difference in power efficiency under a traditional hypervisor-based virtualization versus Linux containers?

Performance results match with the Ericsson research

Power Efficiency results:

CPU:

Docker is more efficient in terms of power

Memory, HDD (Writes) and IDLE:

Docker is more efficient but almost negligible

Future Work

- Benchmark **multiple virtual nodes and containers**
- Investigate the **energy footprint** of the **network** component
- Test other applications

  Performance evaluation of **real life applications**
- Futher investigation of **other platforms** such as **LXC, KVM and VMware**
- Investigate **energy impact** of **(Xen) Paravirtualization**

Thanks for your attention