GREENING THE CLOUD

The virtualization challenge

Dr. Paola Grosso

UNIVERSITEIT VAN AMSTERDAM

System and Network Engineering

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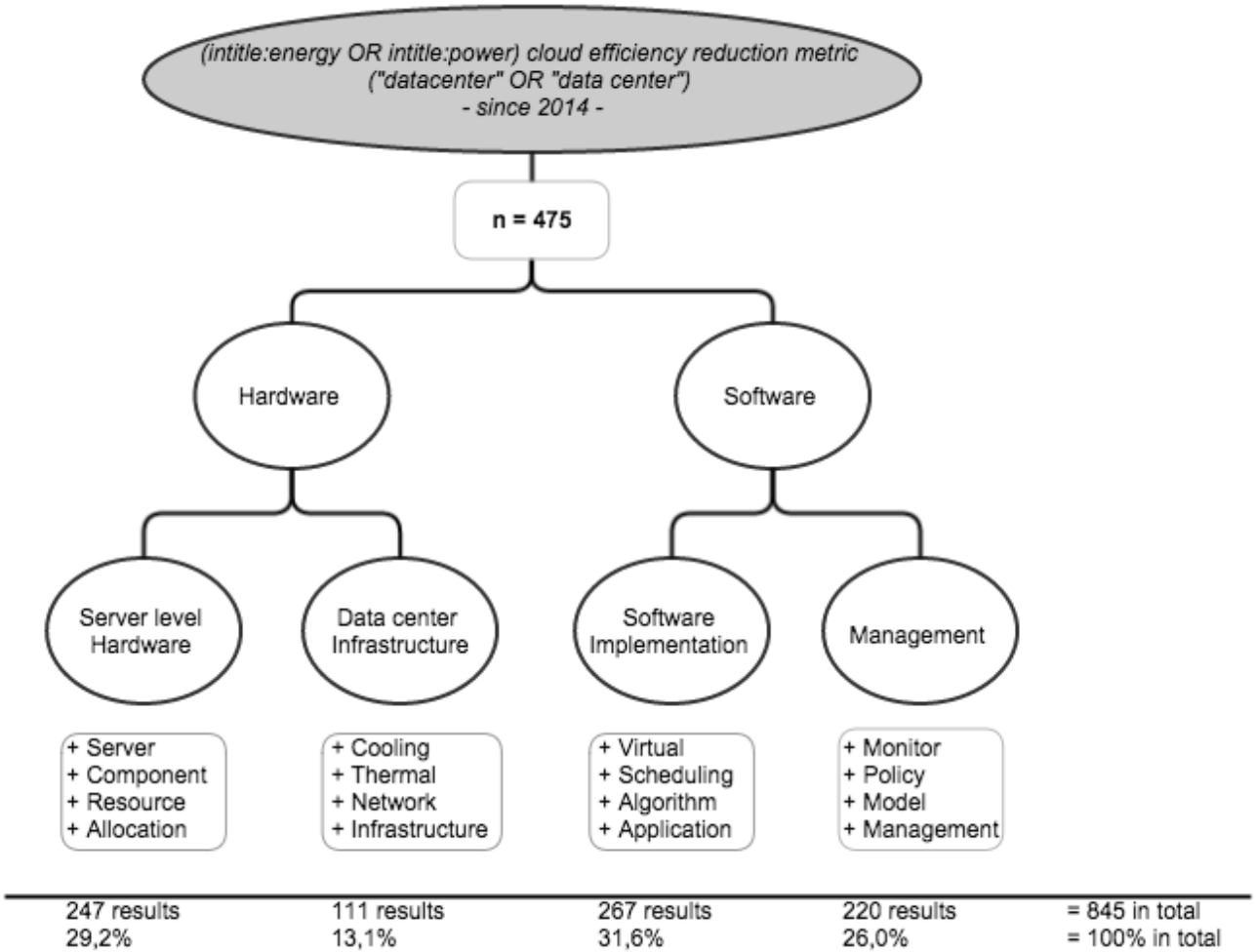
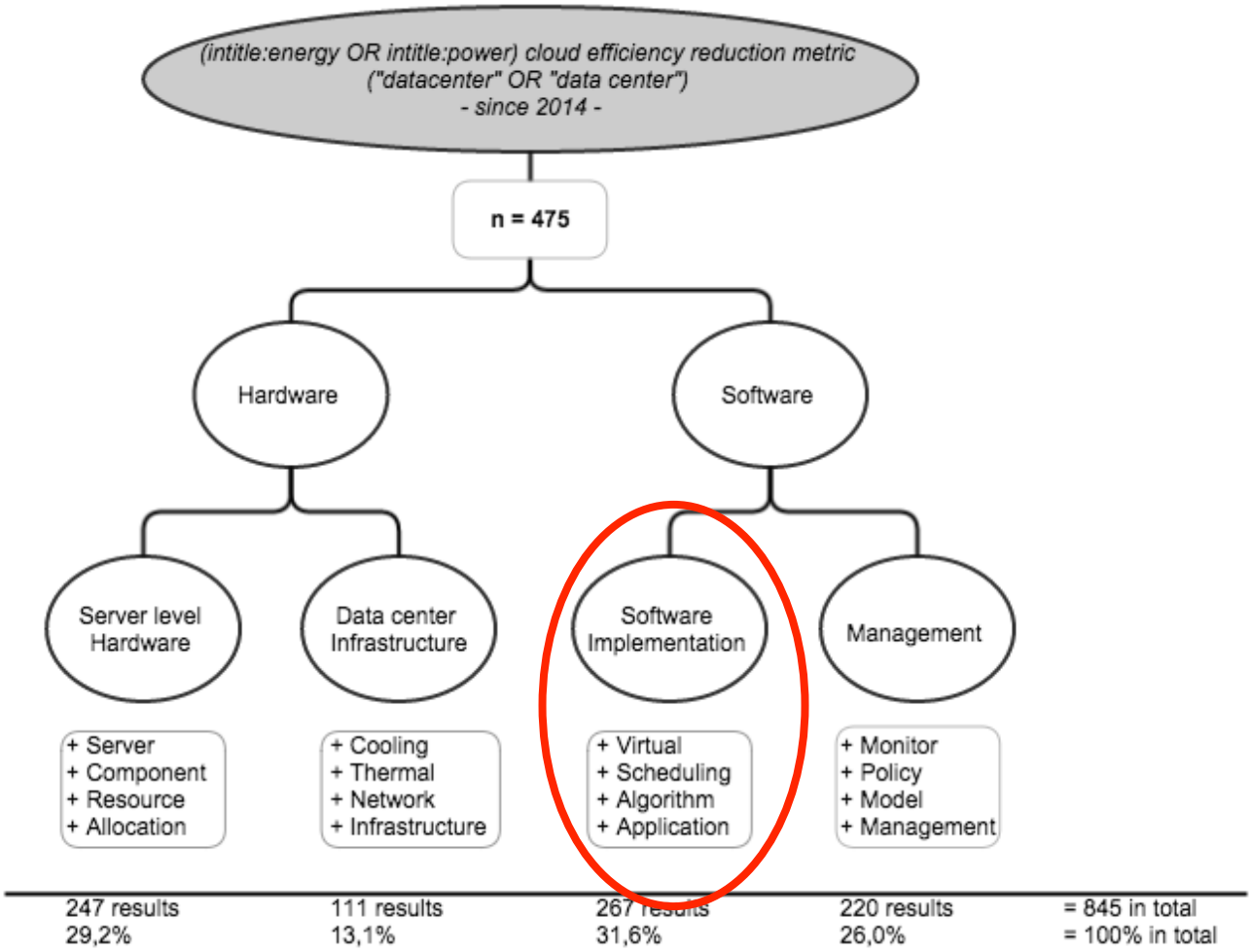
Focus of research

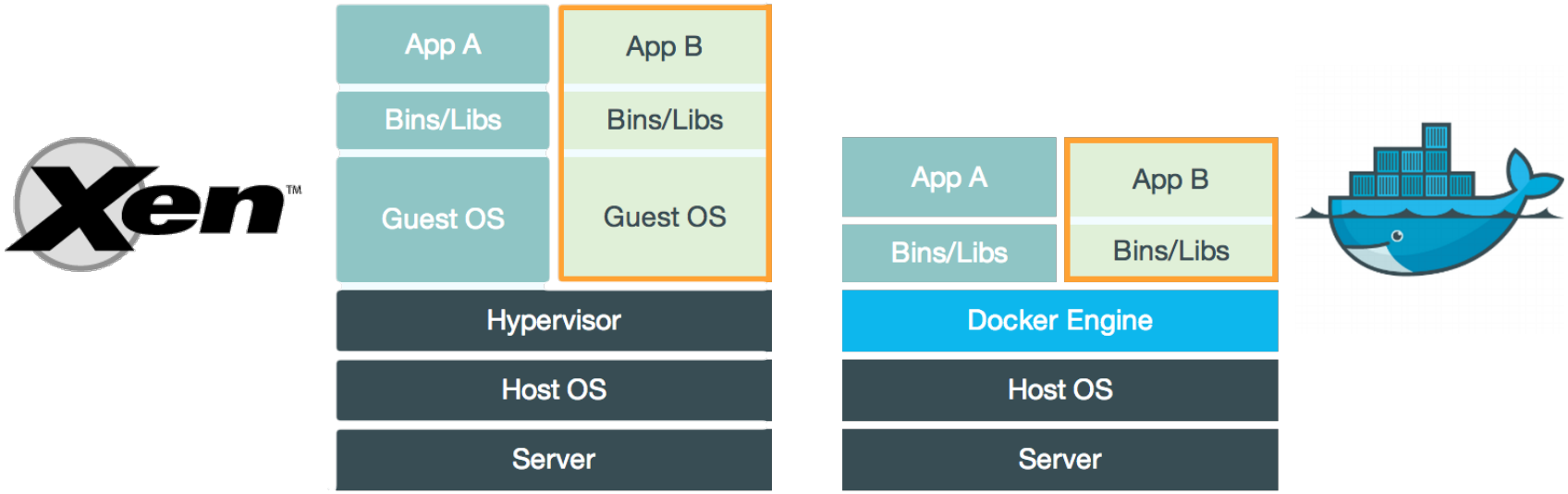


Focus of research



Hypervisors 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



The effect of virtualization on energy and power consumption is partially uncharted territory,

especially when it comes to comparing

hypervisors or **containers**

and their energy efficiency.

Any effort to create a greener cloud should take the efficiency of hypervisors into consideration.

Our focus

1. How do hypervisors and containers perform in terms of energy efficiency?

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

3. How do hypervisors and containers compare power-efficiency-wise for different virtualization ratios?

Hypervisors

1. **Energy estimation models**
   - Linear models estimate consumption when running hypervisors
   - Use of hardware counters versus OS-provided counters

2. **Energy efficiency methods regarding virtual machines**
   - Migration methods within data centers
     - Using pre-copy algorithms
   - Resource allocation methods
     - Resources on different sites based on heuristics
   - Frequency scaling methods

3. **Comparison between hypervisors**
   - Very hard to chose an 'optimal' hypervisor.

   Most (academic) research done on XEN and KVM.
   - Performance costs (lower performances) needs to be weighted against lower energy costs.

VMs vs. containers

Containers achieve generally better performance compared to traditional VMs

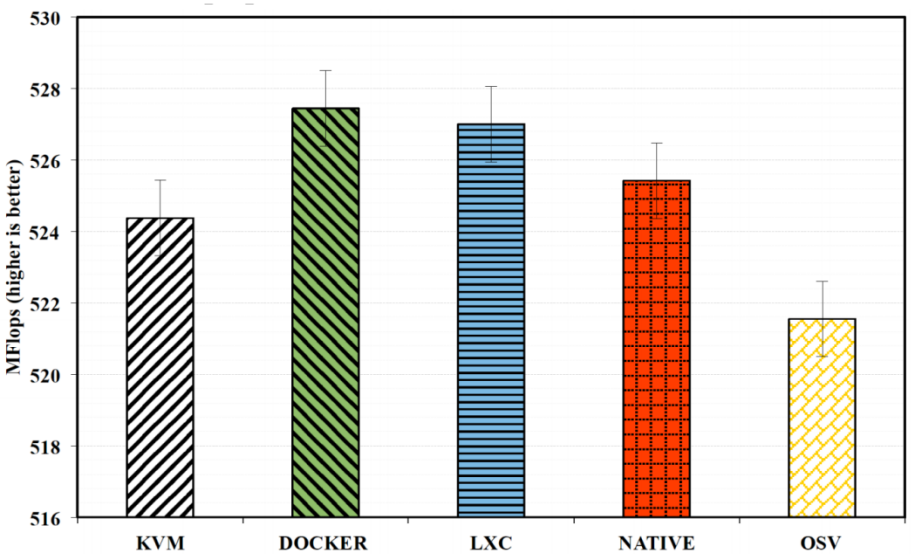


Figure 2: LINPACK CPU performance

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

The SEF lab

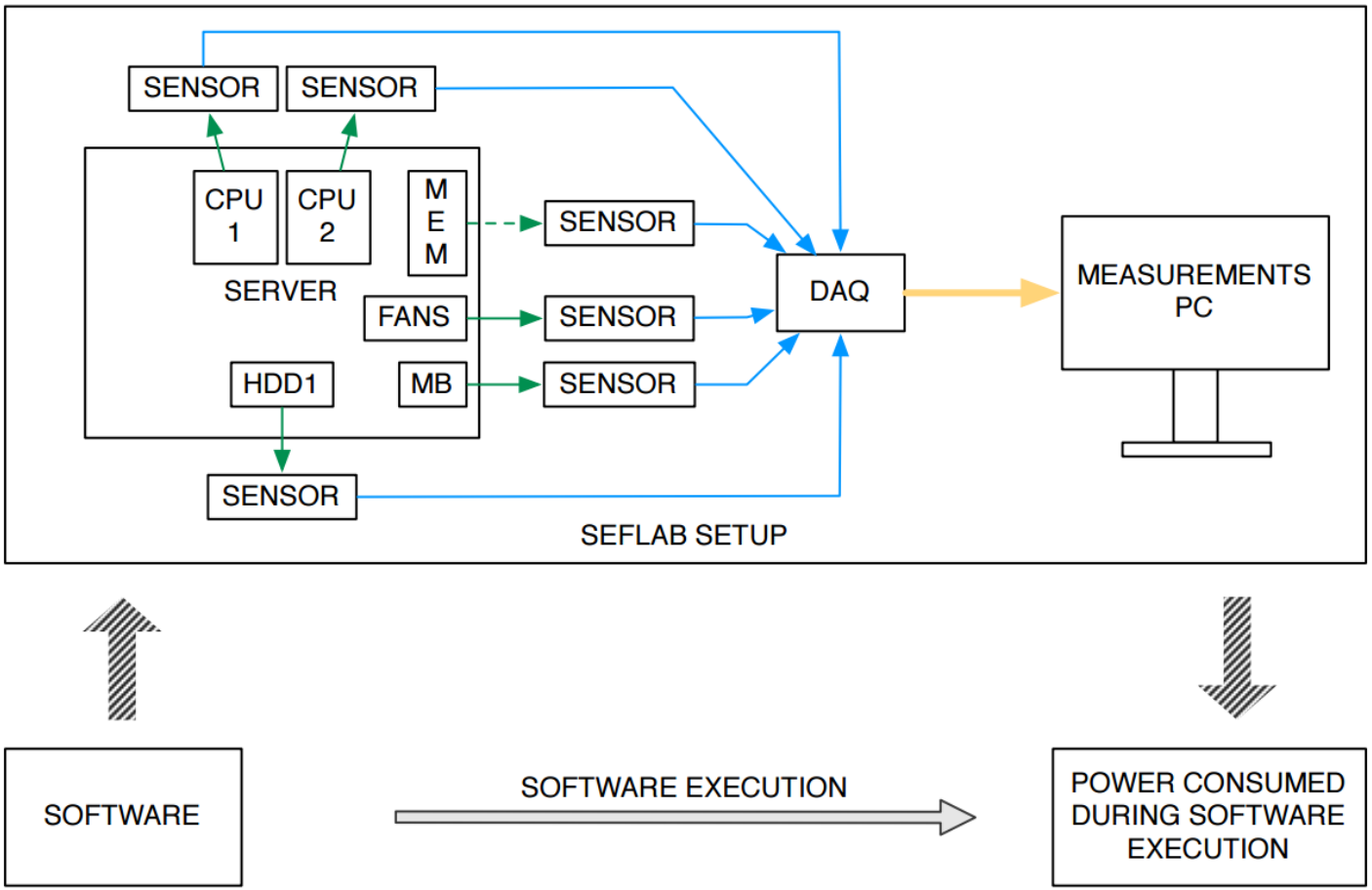


Figure 4: Power Measurement Setup

Benchmarks

Component	Benchmark	Used by	# virtual units tested	Metric
CPU	Linpack	Felter et al. [3] & Morabito et al. [2]	1	Performance
CPU	Sysbench CPU	Morabito [1]	8	Power
Memory	Sysbench MEM	Morabito [1]	8	Power
Disk	Bonnie++	Morabito et al. [2]	1	Performance
Disk	DD	Morabito et al. [2]	1	Performance

1) Roberto Morabito. Power consumption of virtualization technologies: an empirical investigation. arXiv preprint arXiv:1511.01232, 2015.

2) Roberto Morabito, Jimmy Kjallman, and Miika Komu. Hypervisors vs. lightweight virtualization: a performance comparison. In Cloud Engineering (IC2E), 2015 IEEE International Conference on, pages 386-393. IEEE,2015.

3) Wes Felter, Alexandre Ferreira, Ram Rajamony, and Juan Rubio. An updated performance comparison of virtual machines and linux containers. In Performance Analysis of Systems and Software (ISPASS), 2015 IEEE International Symposium On, pages 171-172. IEEE, 2015.

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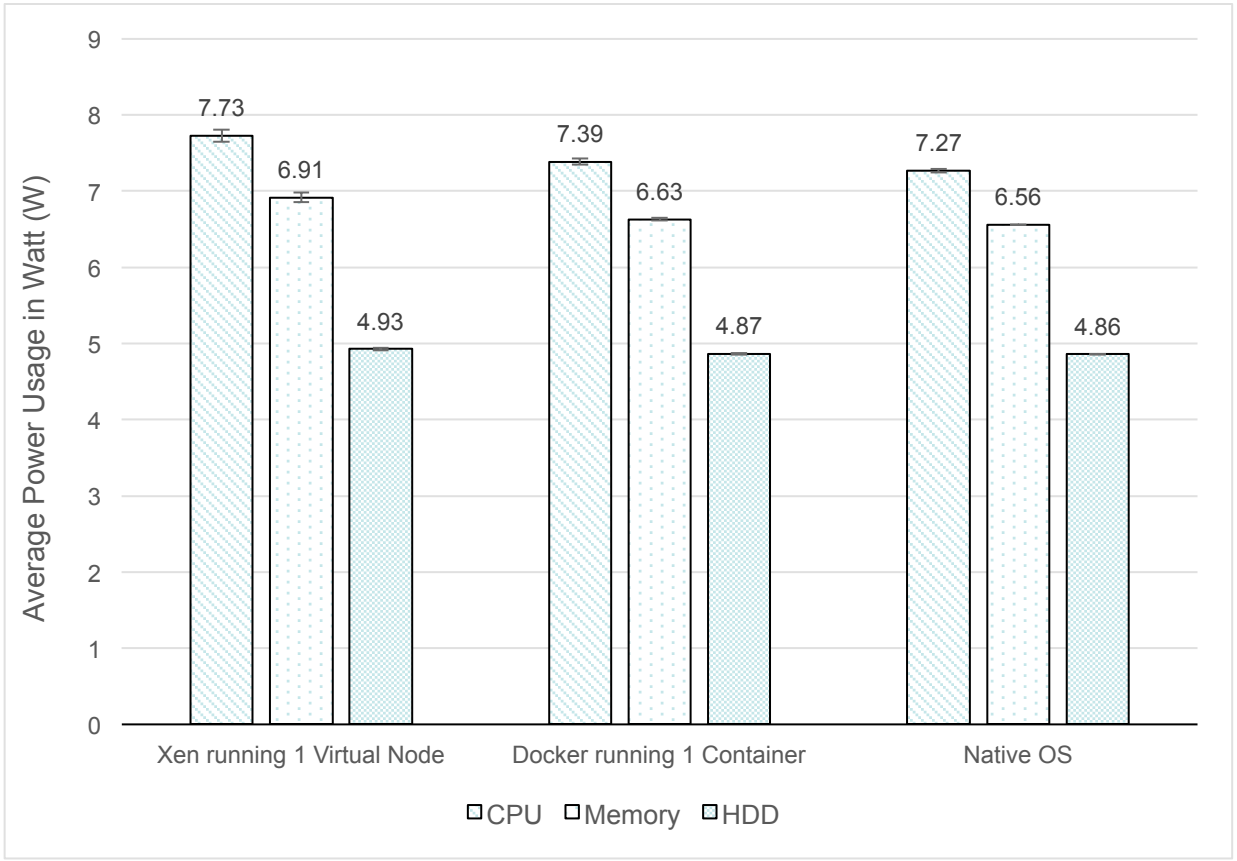
Idle power consumption



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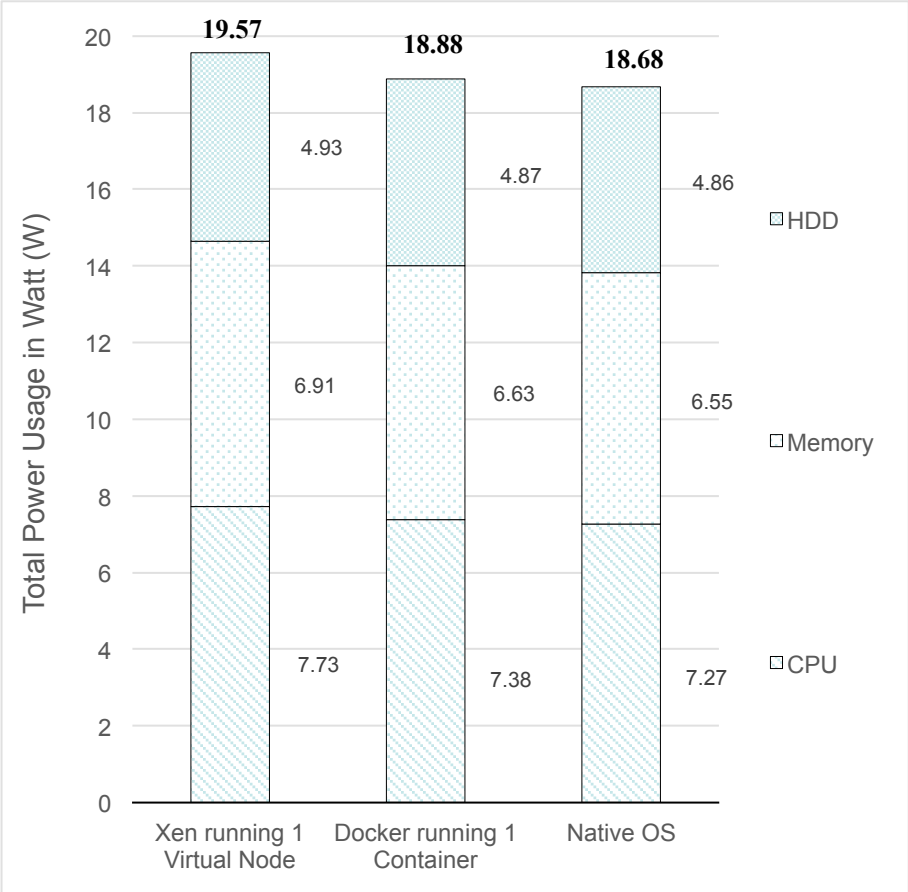
Total idle power consumption



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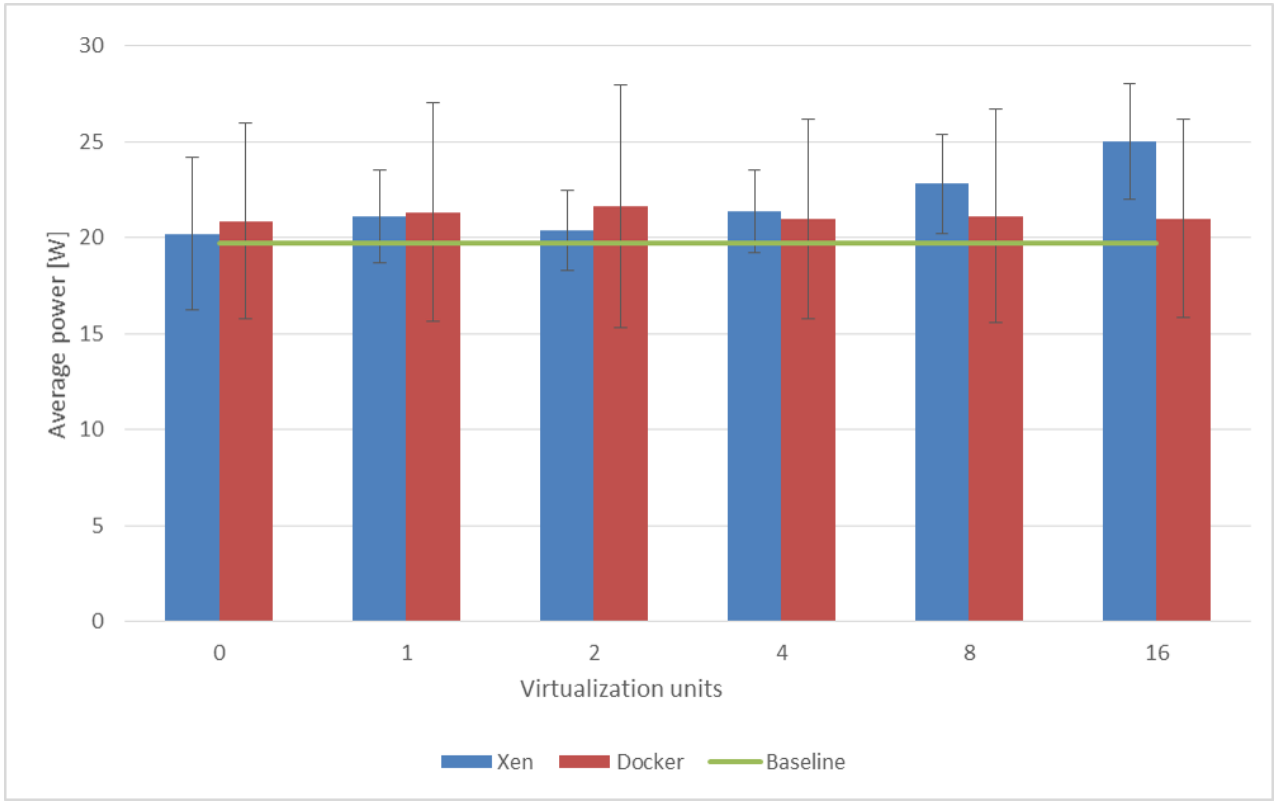
Total idle per virtualization units



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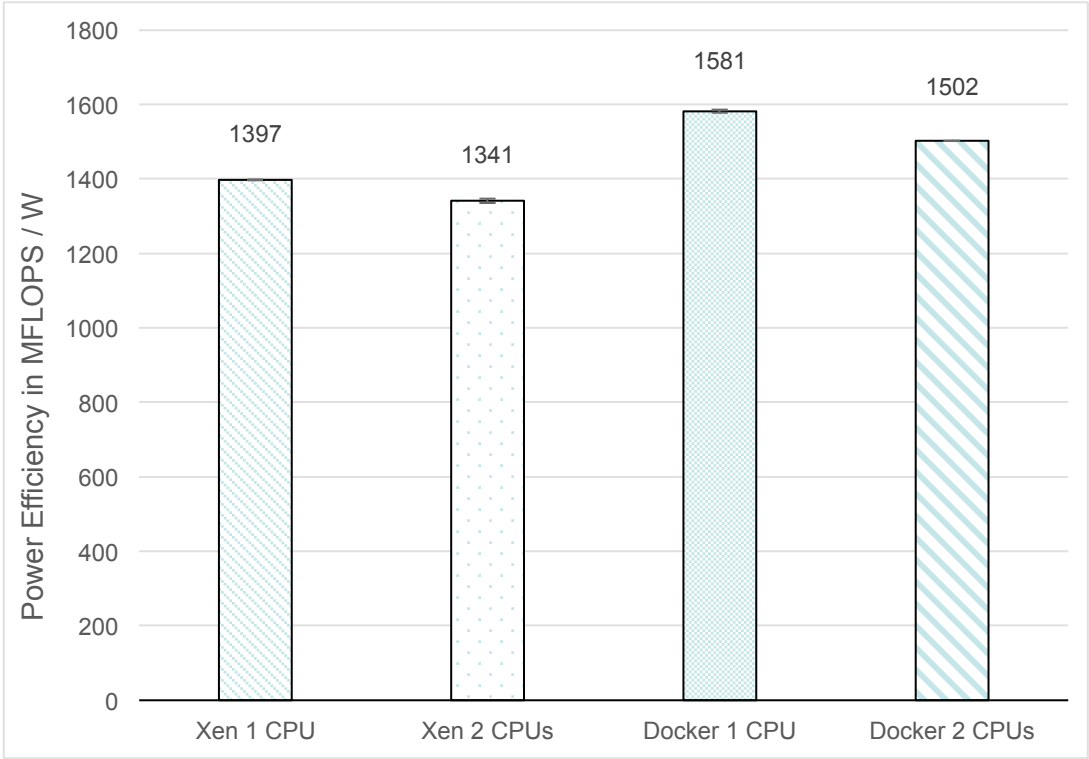
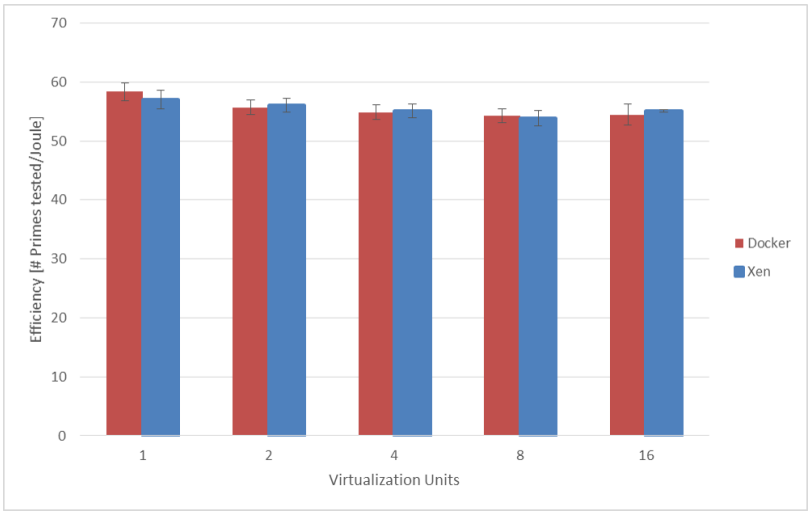
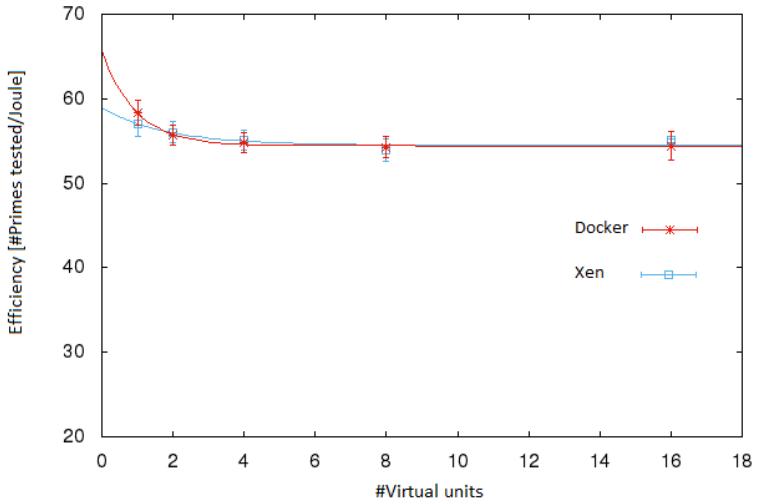
CPU: Power/energy efficiency

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



CPU: Energy efficiency per virtualization units





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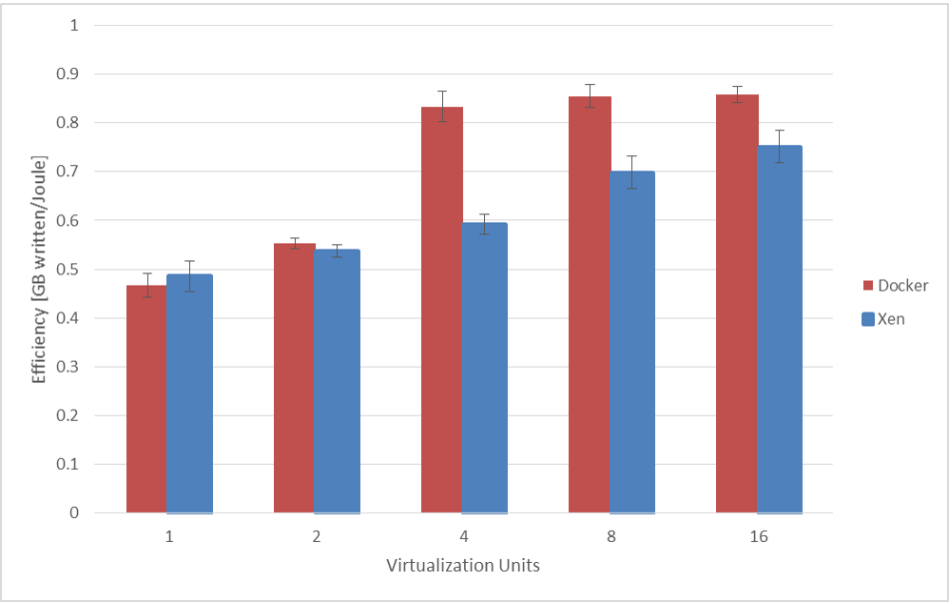
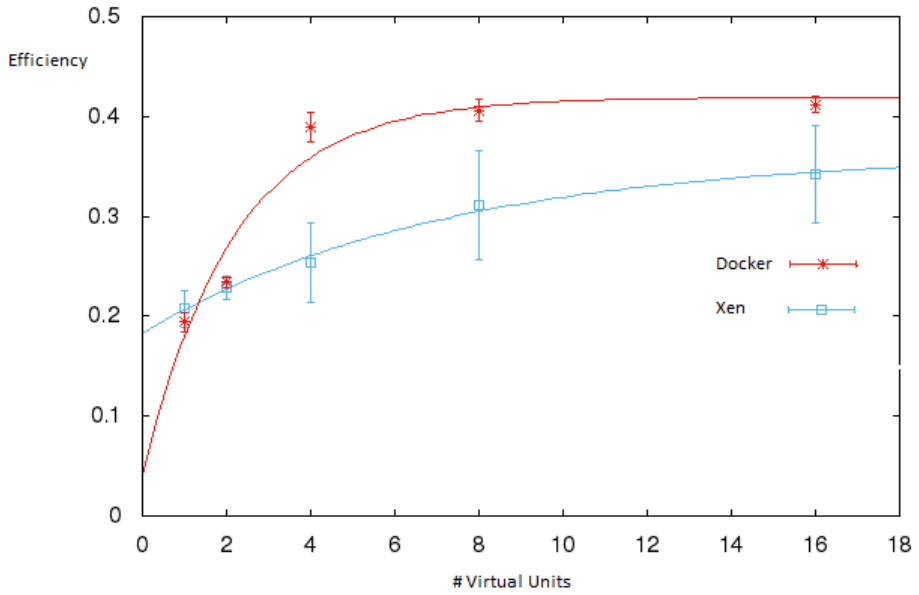
Memory: energy efficiency per virtualization units





4 docker containers achieve already the asymptotic behavior

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Results summary

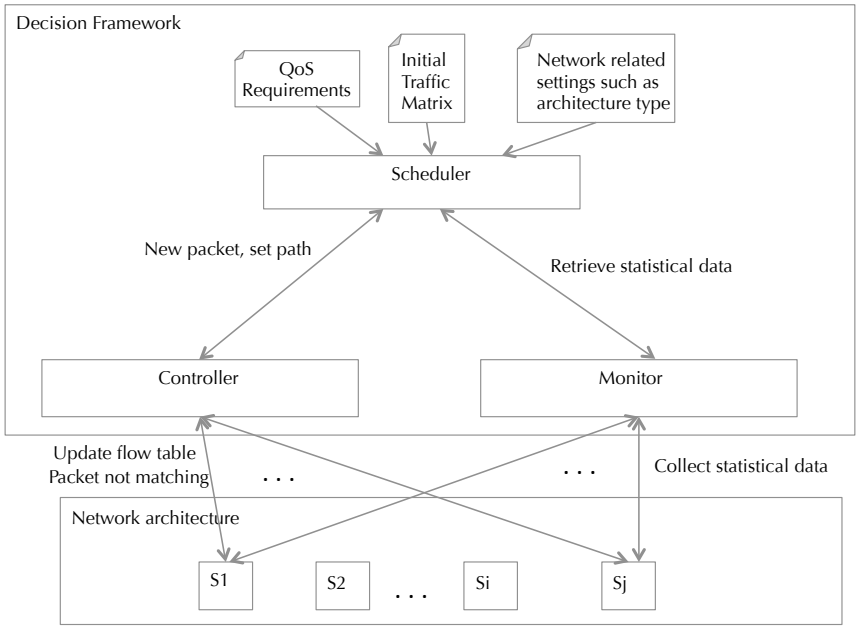
Component	Benchmark	PE Xen vs. Docker
CPU	Sysbench CPU	No sign. difference
Memory	Sysbench MEM write	Docker
Disk	DD read	Docker?
Disk	DD write	No sign. difference

Need simple benchmark to identify the basic behaviour

And now?

Still a number of open points:

- Investigate the energy footprint of the network component
- Performance evaluation of real life applications



Integrate this knowledge with the cloud orchestration platforms.

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Thanks!

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More information at:
https://ivi.fnwi.uva.nl/sne/projects/greening-the-cloud/