An Experimental Study on the Energy-Saving Potential of IaaS-PaaS Co-Design

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Roadmap

1. Motivation
2. Potential of IaaS-PaaS co-design
3. Experimental study
4. Conclusions and future work

Roadmap

1. Motivation
    - Growing concern about energy-consumptions in data centers
    - Cloud computing is a green technology?
2. Potential of IaaS-PaaS co-design
3. Experimental study
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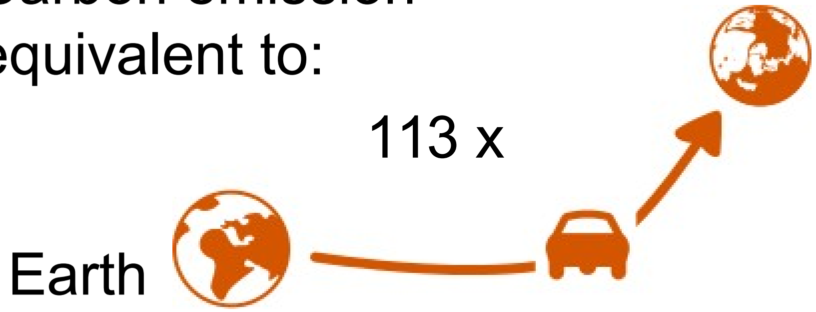
Growing concern about energy-consumption in data centers

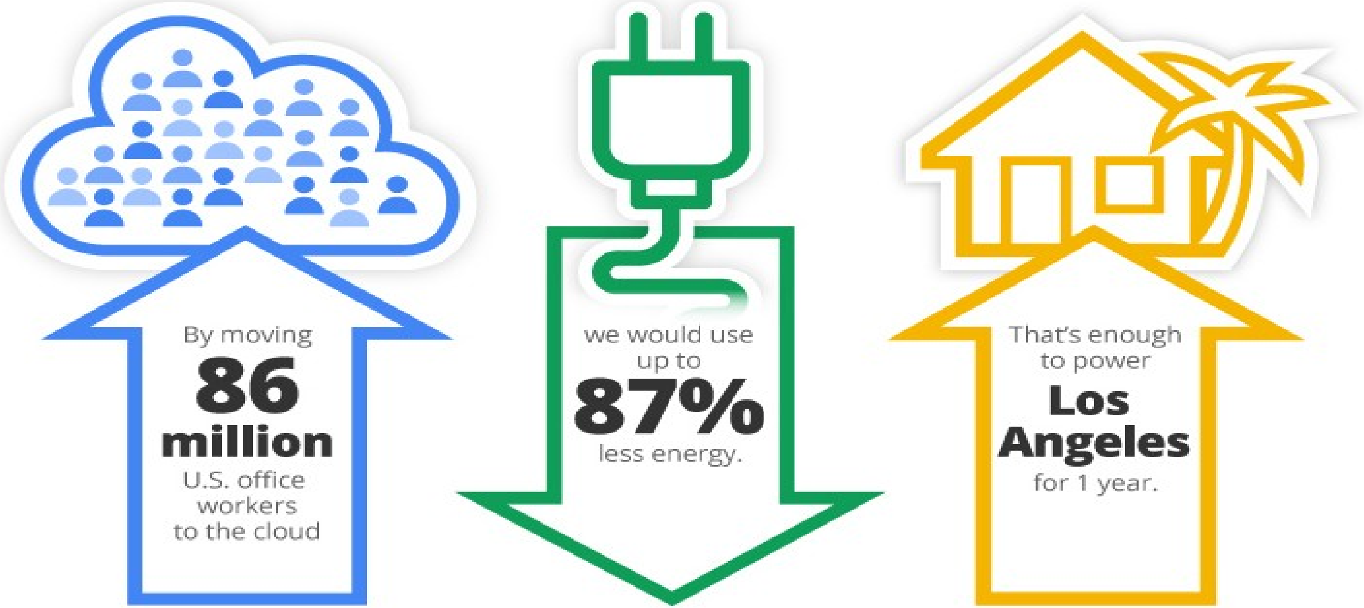
US. data centers = 2xNYC households

Google consumes <1% of electricity used by data centers worldwide

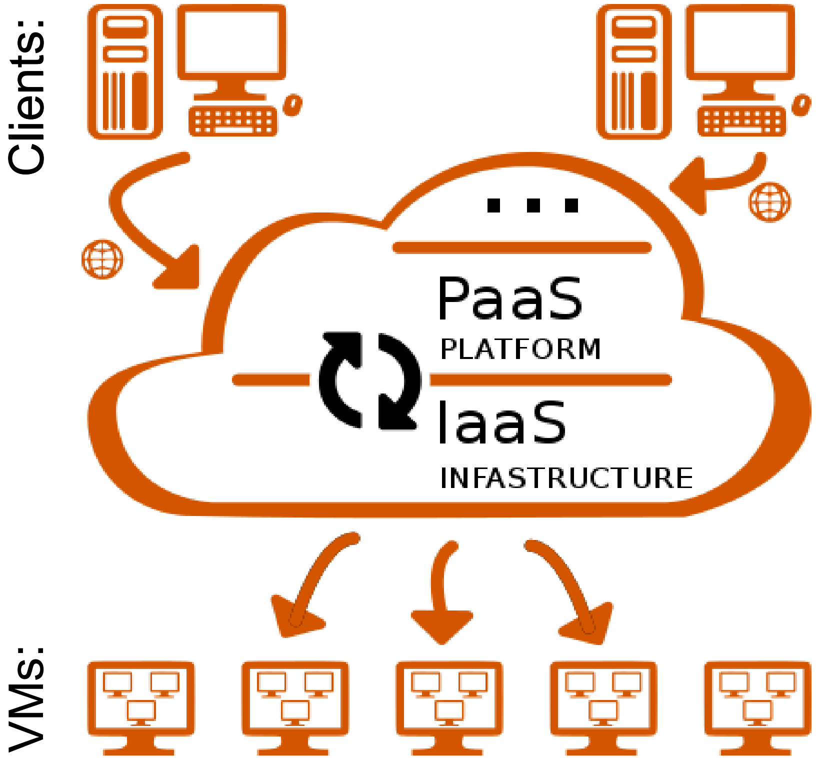
- Carbon emission equivalent to:



Is Cloud Computing a Green Technology?

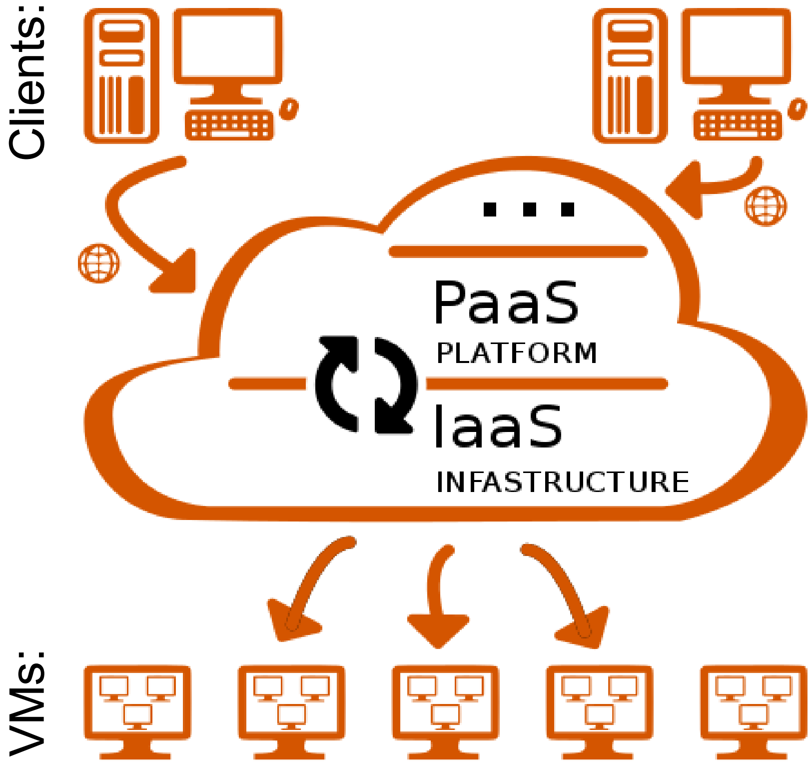


Cloud computing



- The cloud has several layers:
  - **Platform** layer facilitates deployment of applications
    - => consuming cloud infrastructure
  - **Infrastructure** layer handles the platform virtualization environment
- We target services which require (at least) platform + infrastructure

Related work



IaaS:

- scheduling and consolidation combined with turn off idle servers
- dynamic voltage frequency scaling

Overall energy of the Cloud:

- Better utilization of available energy:
  - moving services or scheduling jobs to increase renewable energy

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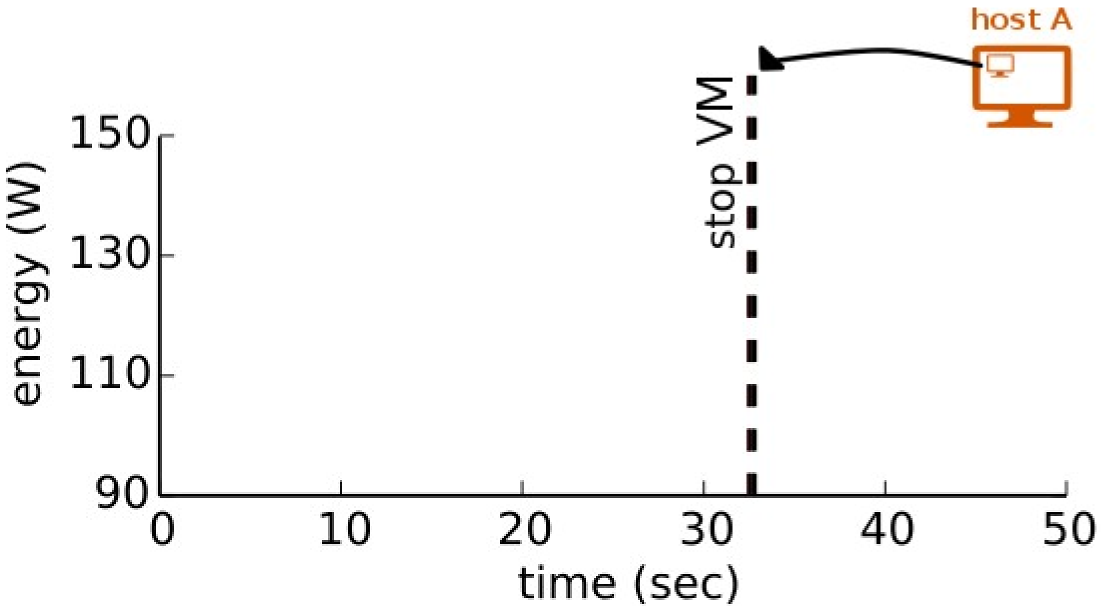
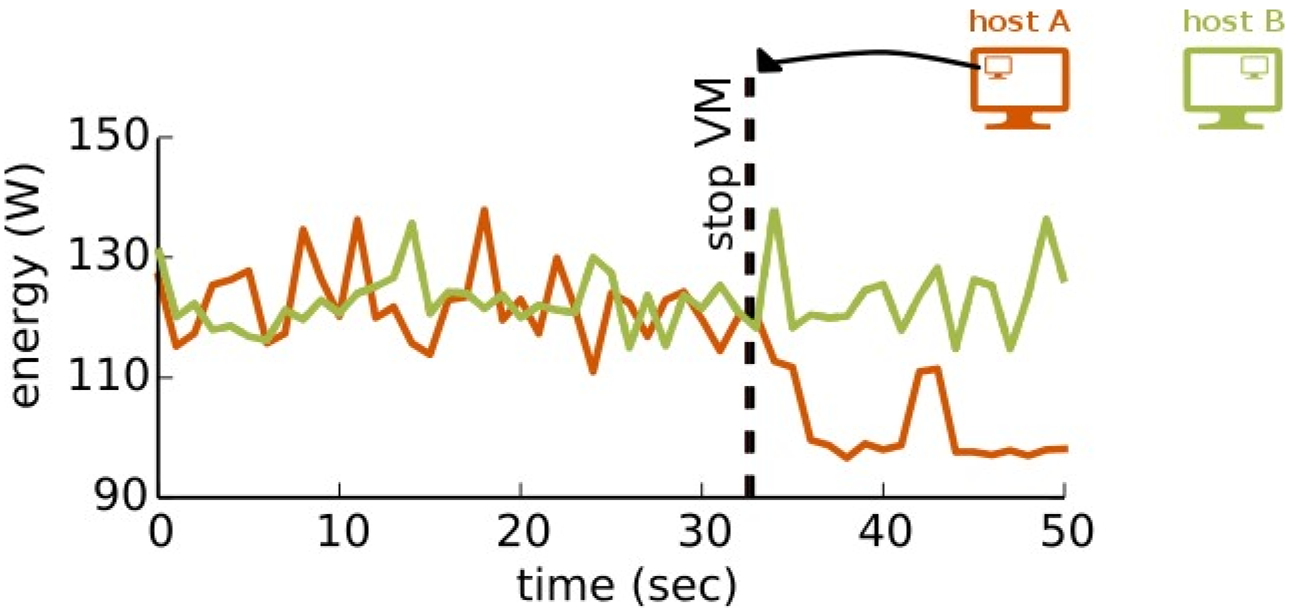
Counter-productive case



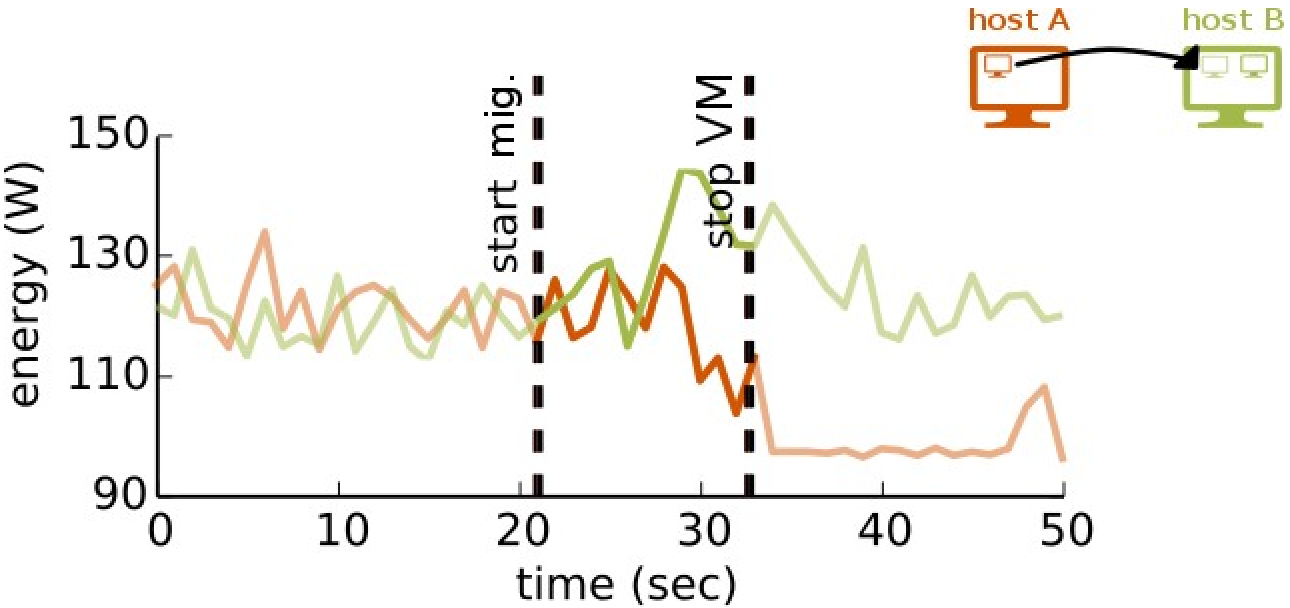
Counter-productive case

- Stopping VMs depends on load (PaaS)

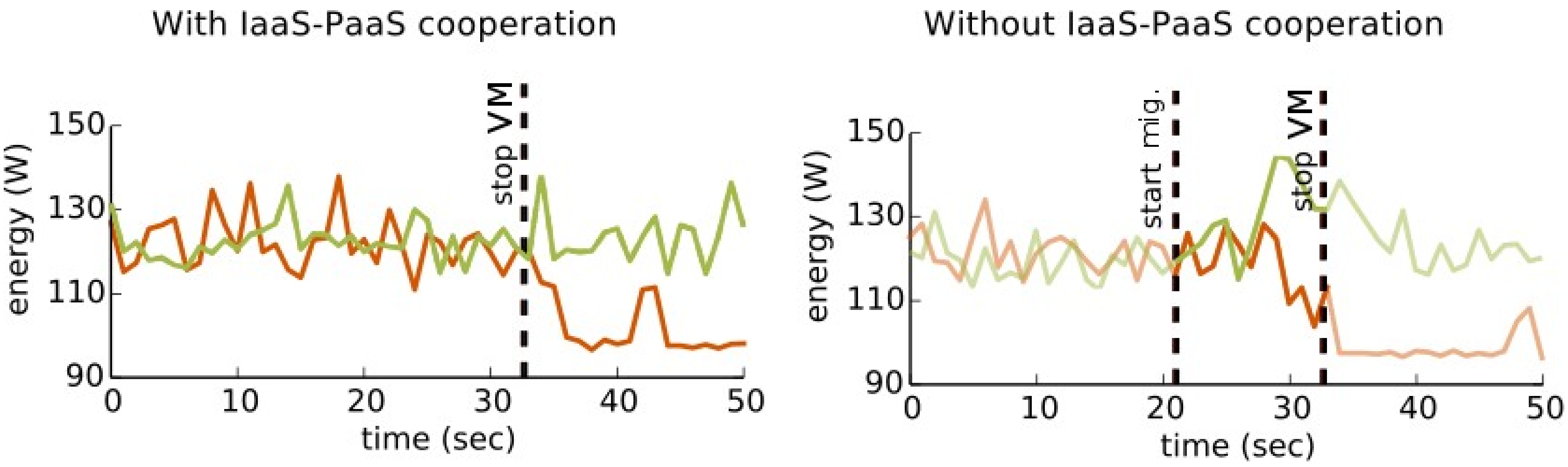


Counter-productive case

- IaaS has decided VM migration



Counter-productive case



Migration wastes 65.58J

Energy-saving potential in IaaS-PaaS co-desing

- IaaS-PaaS co-desing:
  - Layers exchange information
  - Layers coordinate their actions
- We focus on VM management operations
- We demonstrate the potential by an experimental study

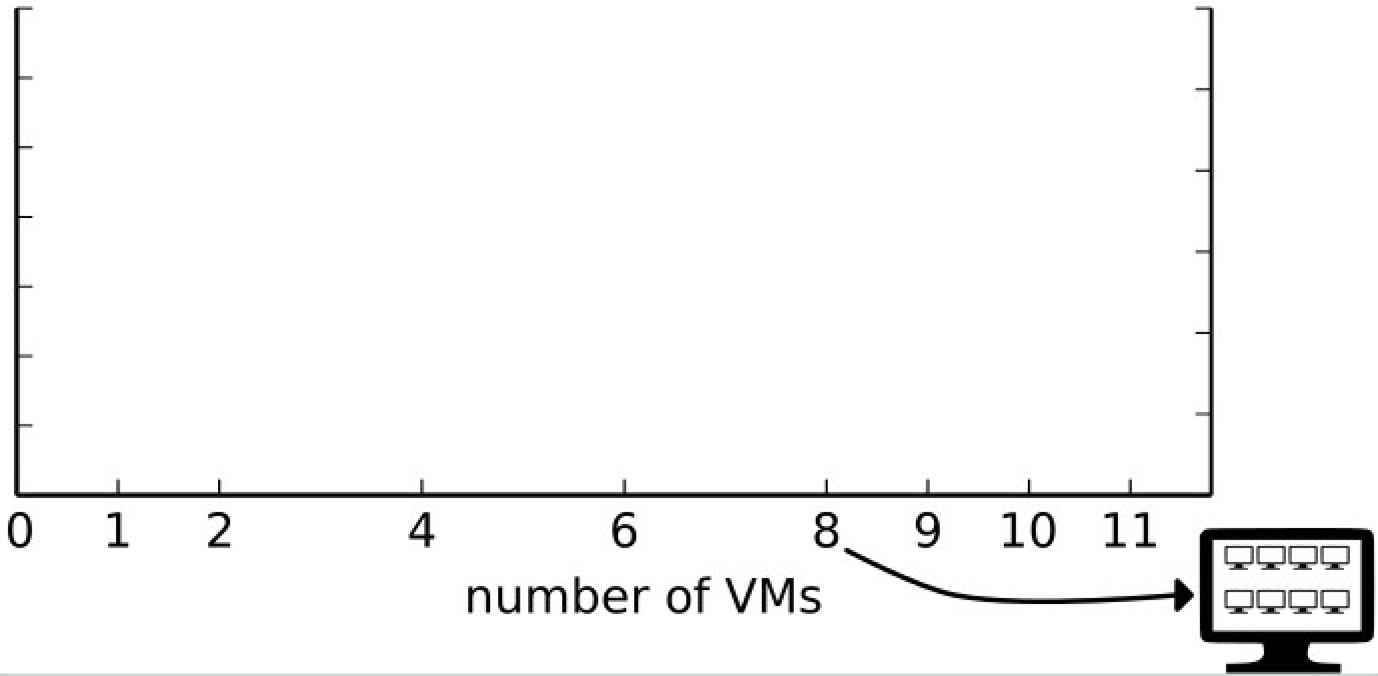
Roadmap

1. Motivation
2. Potential of IaaS-PaaS co-design
3. Experimental study
   - Stationary scenario
   - VM start-up
   - VM migration
4. Conclusions and future work

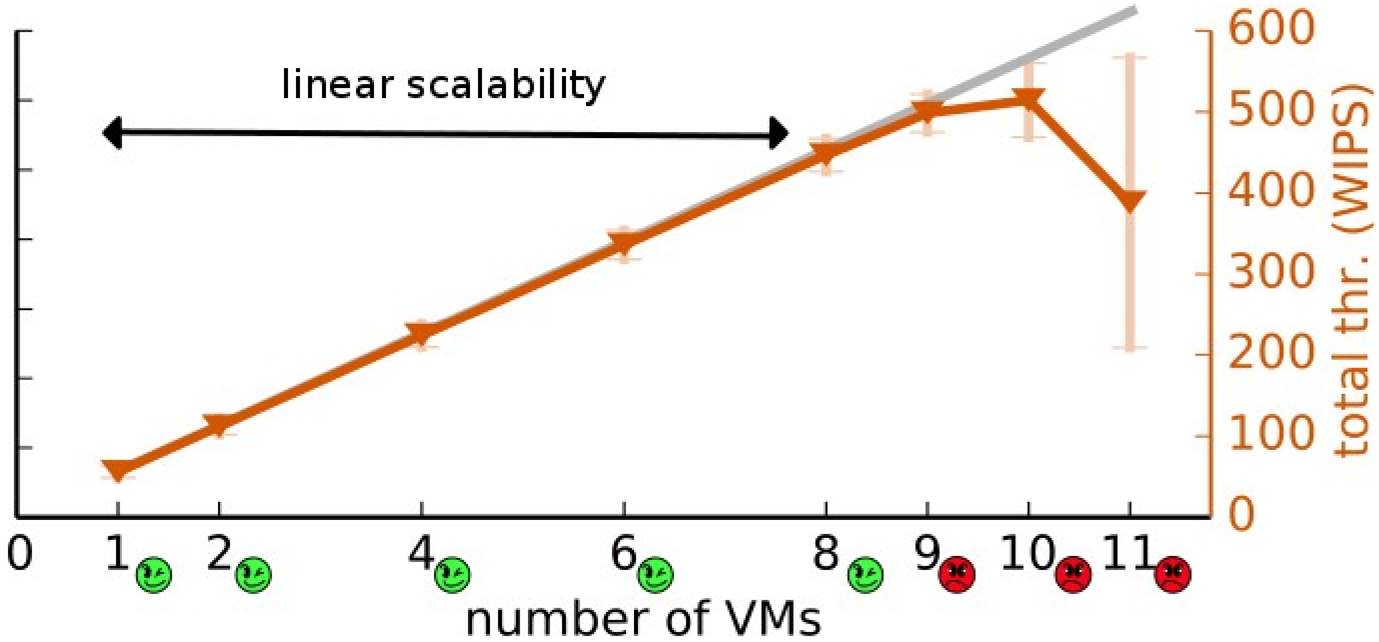
Experimental setup

- Grid'5000 test-bed (taurus)
  - 12-cores Xeon E5-2630@2.3GHz
- (IaaS) Openstack
- (PaaS) MySQL+Apache
- TPC-W benchmark
- Metrics:
  - power (W)
  - thoughput (WIPS=Web Interaction Per Second)

Stationary scenario: experiment setup

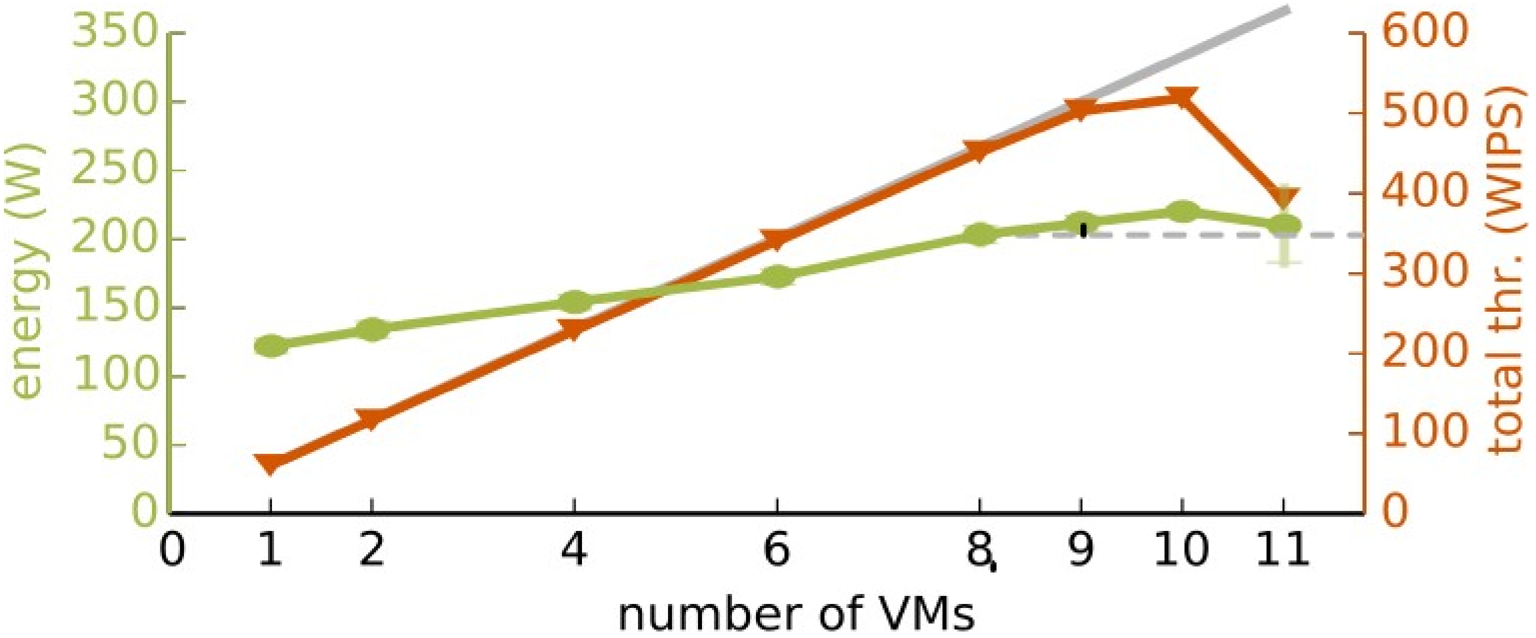


Stationary scenario: throughput results



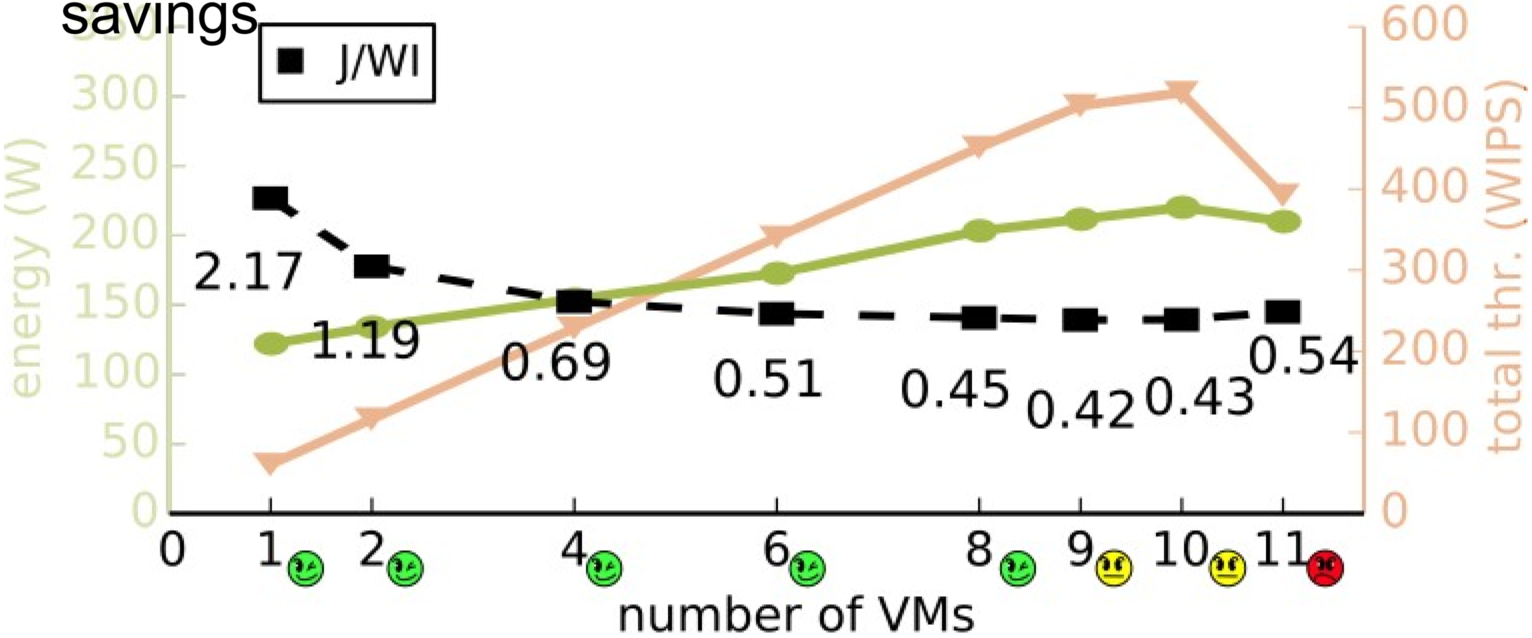
Stationary scenario: throughput results

- Small energy overhead, small throughput degradation



Stationary scenario: throughput / energy

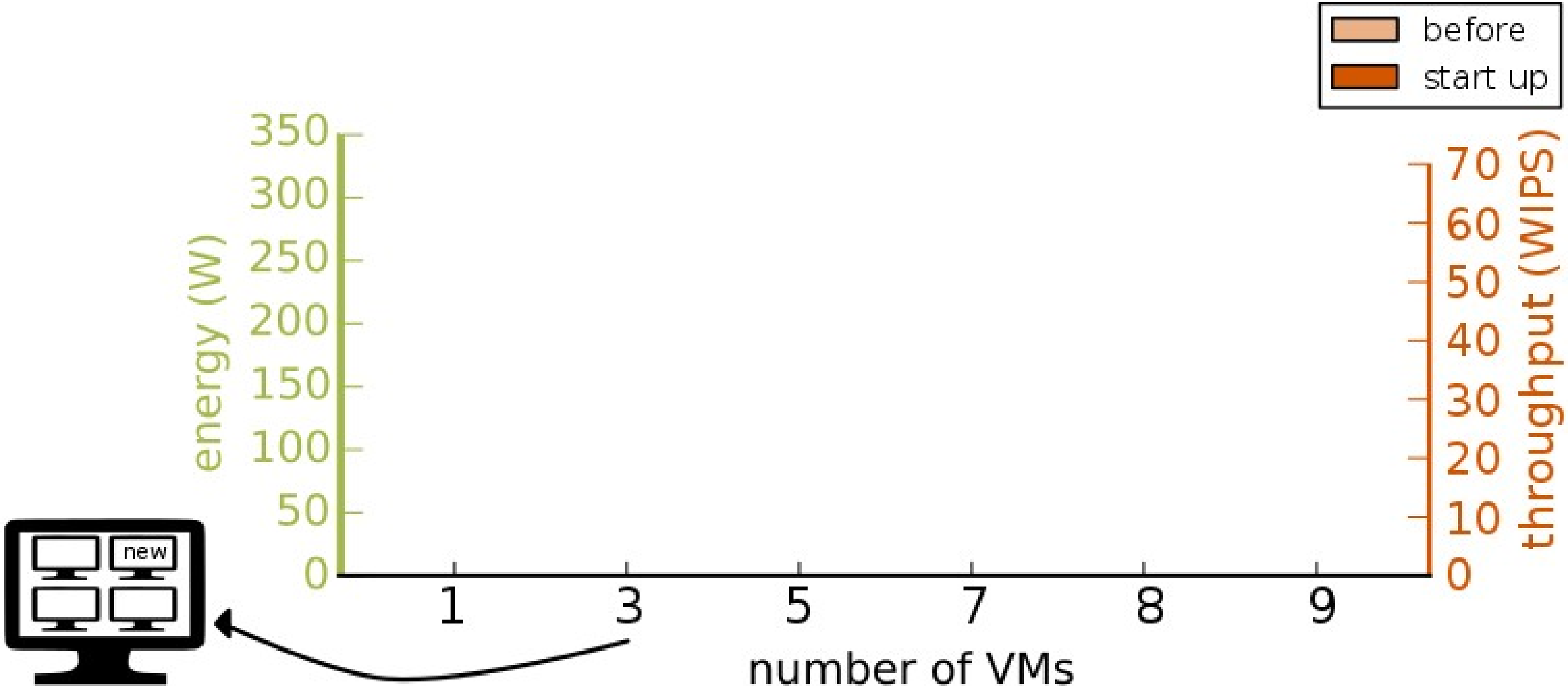
- A small degradation in throughput can generate energy savings



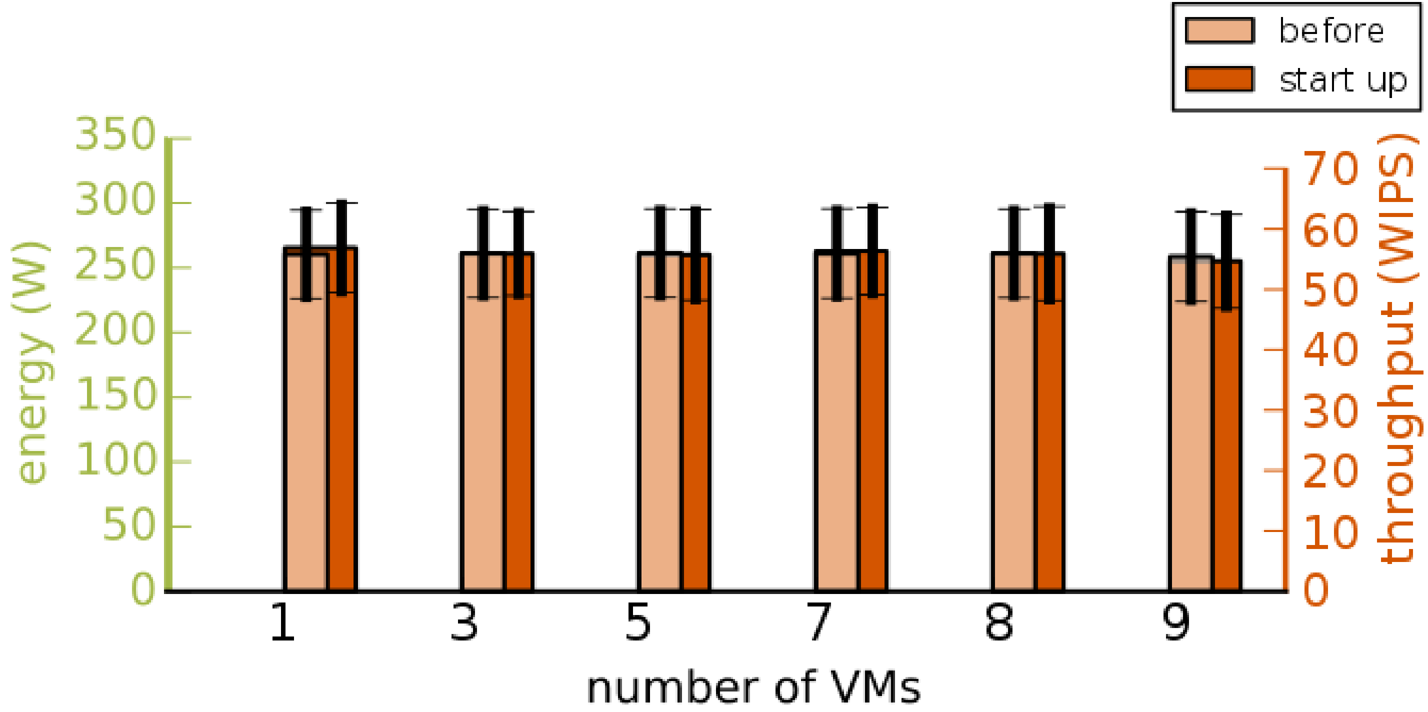
Stationary scenario: conclusion

- An energy-efficient system should determine VM placement
- IaaS-PaaS cooperation is required because:
  - IaaS layer allocates VMs
  - PaaS layer can decide the allowed throughput degradation

VM start-up: experiment setup

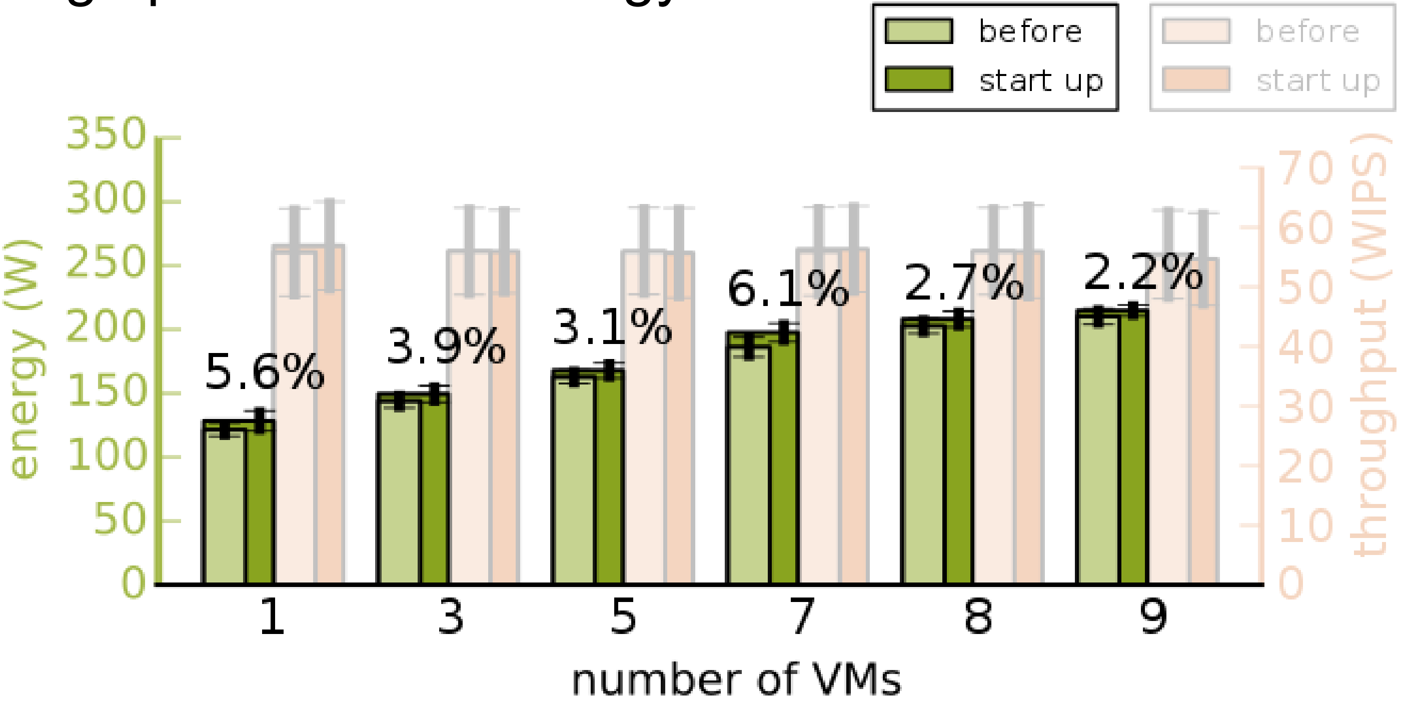


VM start-up : throughput results



VM start-up : energy results

- Starting up a VM is not energy-neutral

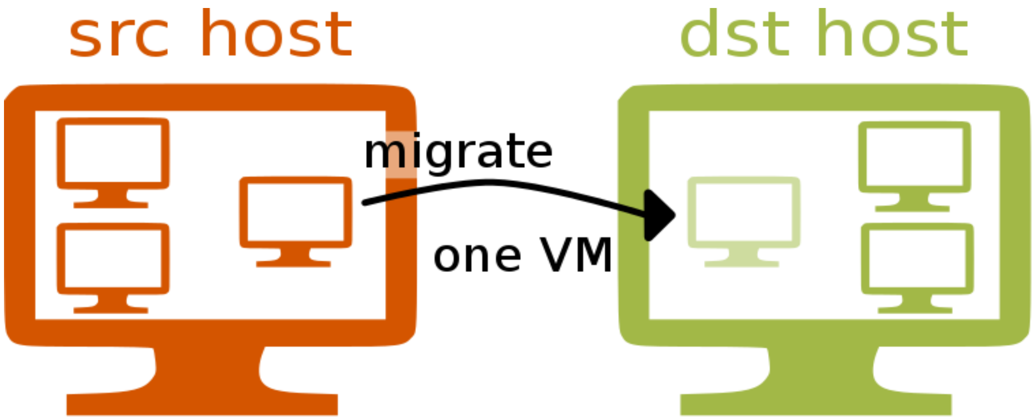


VM startup: conclusion

- An energy-efficient system should guarantee a minimum lifetime after creation
- IaaS-PaaS cooperation is required because:
  - IaaS layer starts VMs
  - PaaS layer is able to predict VM lifetime from workload

VM migration

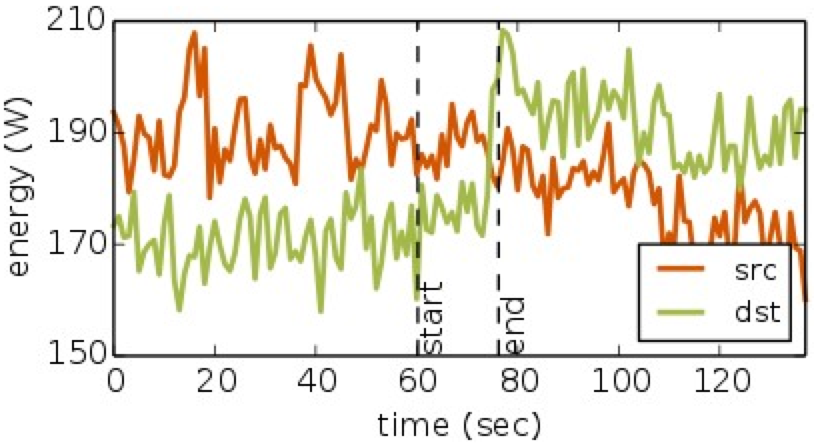
- Energy-consumption / throughput can fluctuate in both hosts
- Thoughput is specially impacted in migrated VM



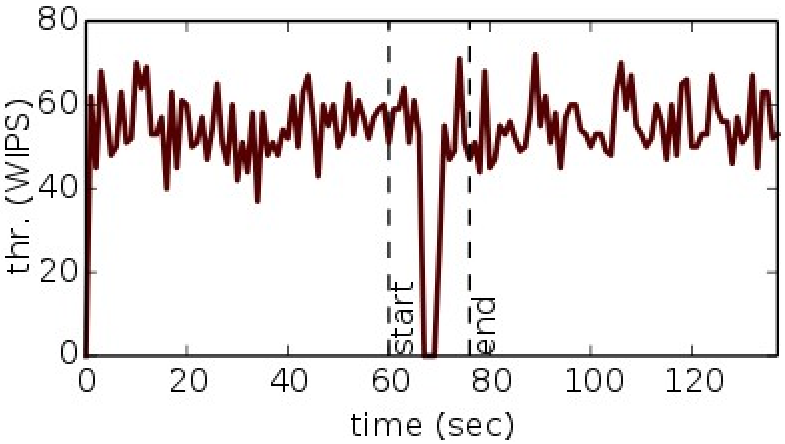
- Both hosts have the same number of non-migrated VMs

VM migration: an example

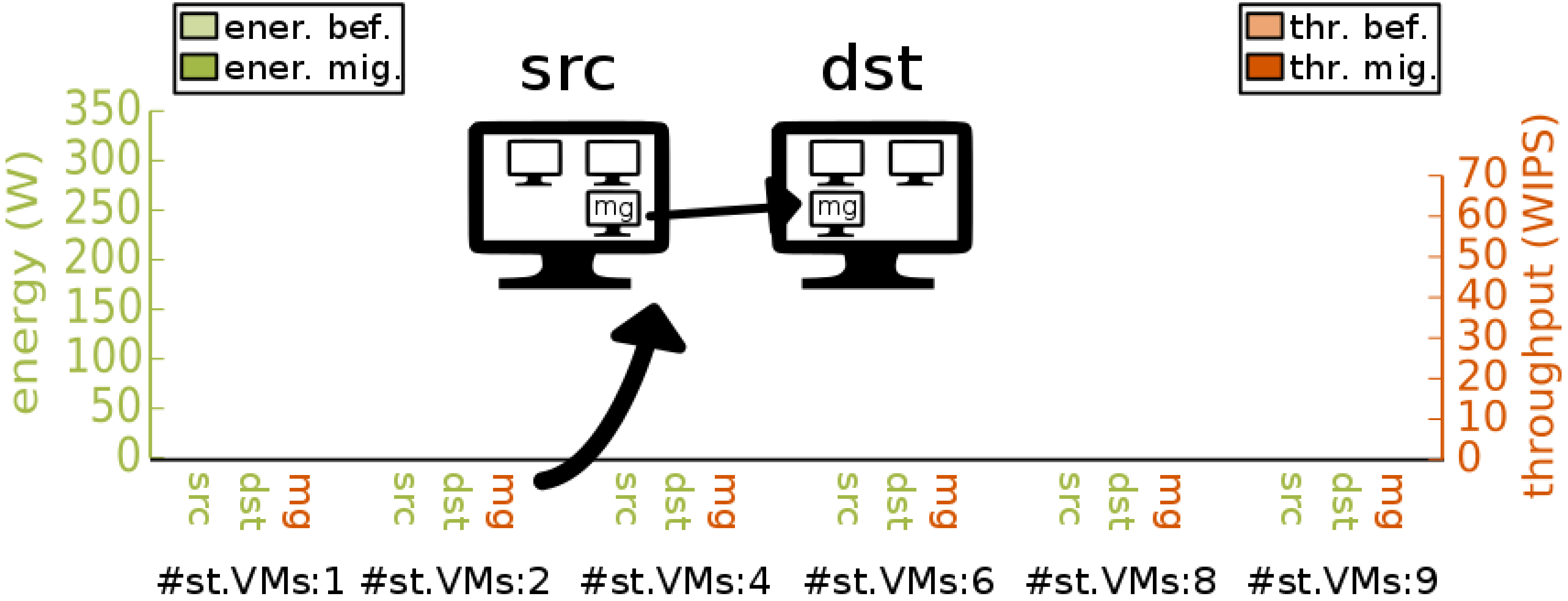
Energy in both hosts:



Throughput of migrated VM:

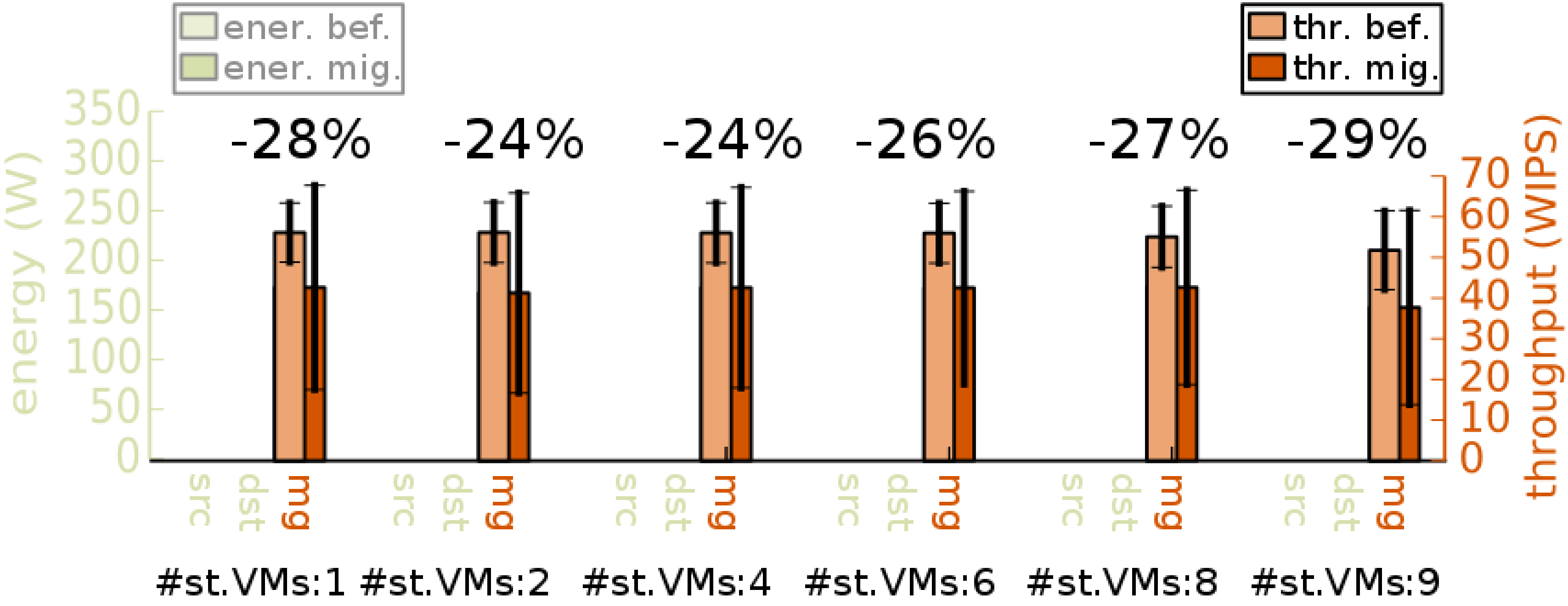


VM migration: experiment setup

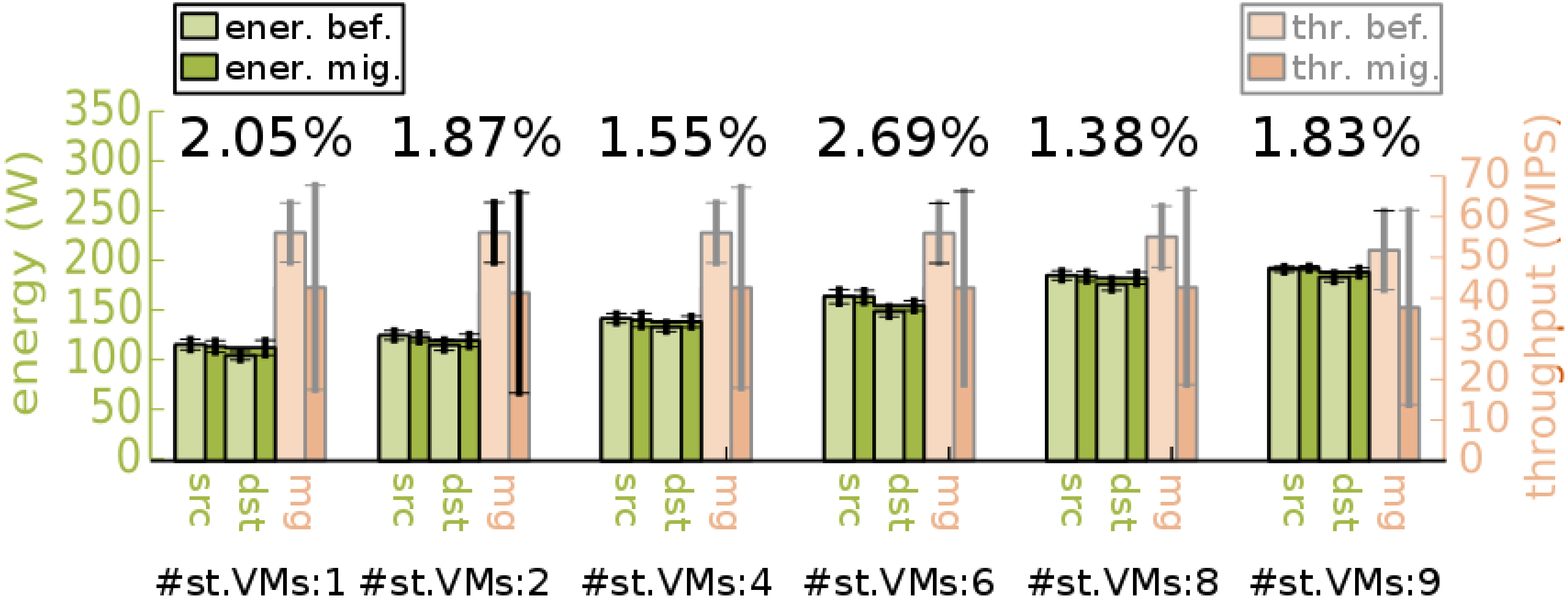


st. = static = non-migrated

VM migration: throughput results



VM migration: energy results



VM migration: conclusion

- An energy-efficient system should consider throughput degradation
- IaaS-PaaS cooperation is required because:
  - IaaS layer migrates VMs
  - PaaS layer can determine when a throughput degradation is less important

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Conclusion and future work

- Experiments has shown the potential of co-design to save energy:
  - Avoiding counter-productive actions
    - E.g. guaranteeing a lifetime after VM startup
  - Coordinating choices by information exchanges
    - E.g. deciding VMs placement

- Design an energy/performace-aware IaaS-PaaS API