On the Impact of Energy-saving Strategies in Opportunistic Grids

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Outline

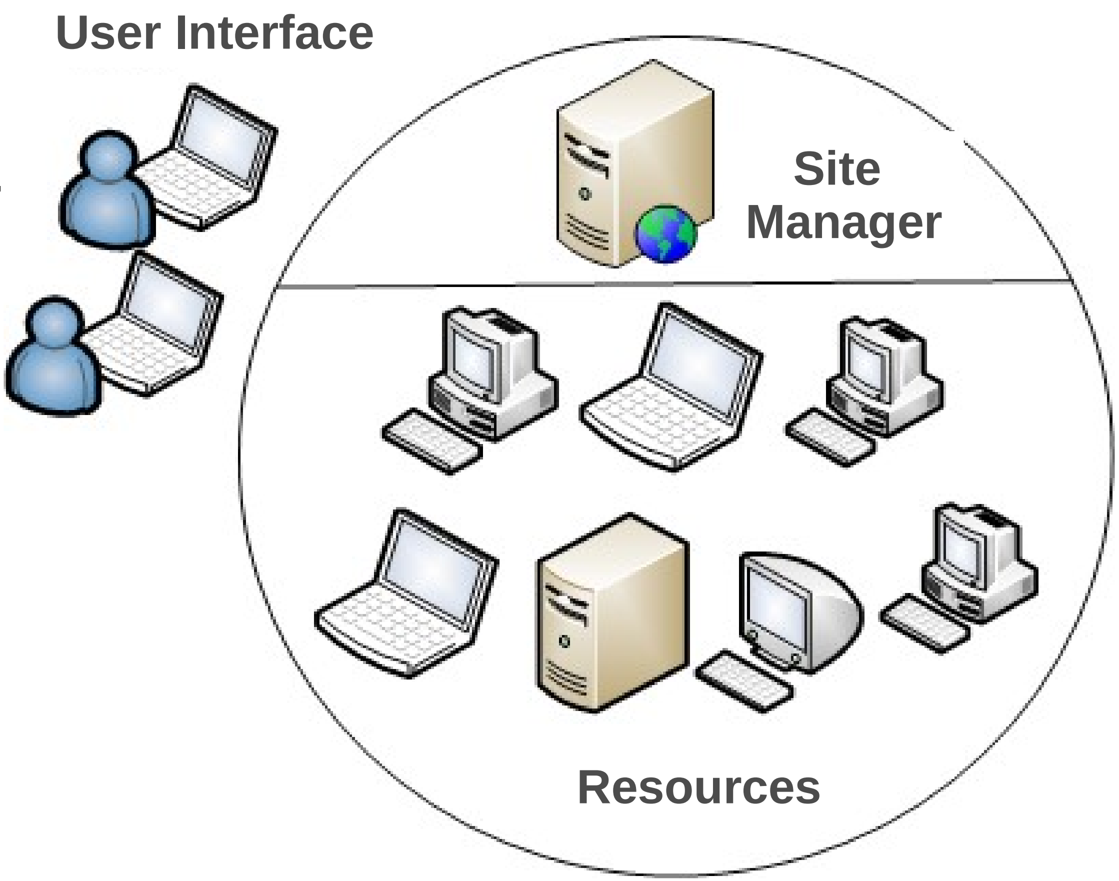
- Introduction
  - Context
  - Problem Statement
- Related work
- Energy Saving in Opportunistic Grids
- Evaluation
- Results
- Conclusions

Opportunistic Grids

Harvest the idle computing cycles

Suitable for the execution Bag-of-Tasks applications

Grid components



Resources and demand for resources

Resources differ on their processing power and **energy consumption**

– Energy-aware Scheduling Strategies

During bursts of resource demand, many grid resources are required, **but at other times they remain idle for long periods**

– Sleeping Strategies

Problem Statement

What the impact that energy-saving strategies have on energy-saving and job makespan in opportunistic grids?

Related Work

Energy-saving strategies in computers

- Better design of hardware and software
- Pinheiro et al. (2003), Irani et al. (2003), Augostine et al. (2004)

Energy-aware scheduling and Sleeping strategies in grids or clusters

- Energy saving and its associated impact on job's deadline in infrastructures with resources reservation
- Garg and Buyya(2009), Kim(2007), Sharma and Aggarwal (2009), Orgerie et al. (2008), Lammie et al. (2009)

Idle, Standby, and Hibernate States

Idle

- The machine is powered on, and it is waiting a new instruction

Standby

- The memory is kept powered on and other components are powered off (e.g.: CPU, Disk)

Hibernate

- The memory status is saved on the disk, and then the memory and other components are powered off

Both Standby and Hibernate allow to wake up the machine by LAN interface (wake-on-LAN)

Idle, Standby, and Hibernate States

Decreasing Power Consumption →

Idle Standby Hibernate

Increase Latency to wake-up →

Strategies to save energy in Opportunistic Grids

Two ways to save energy

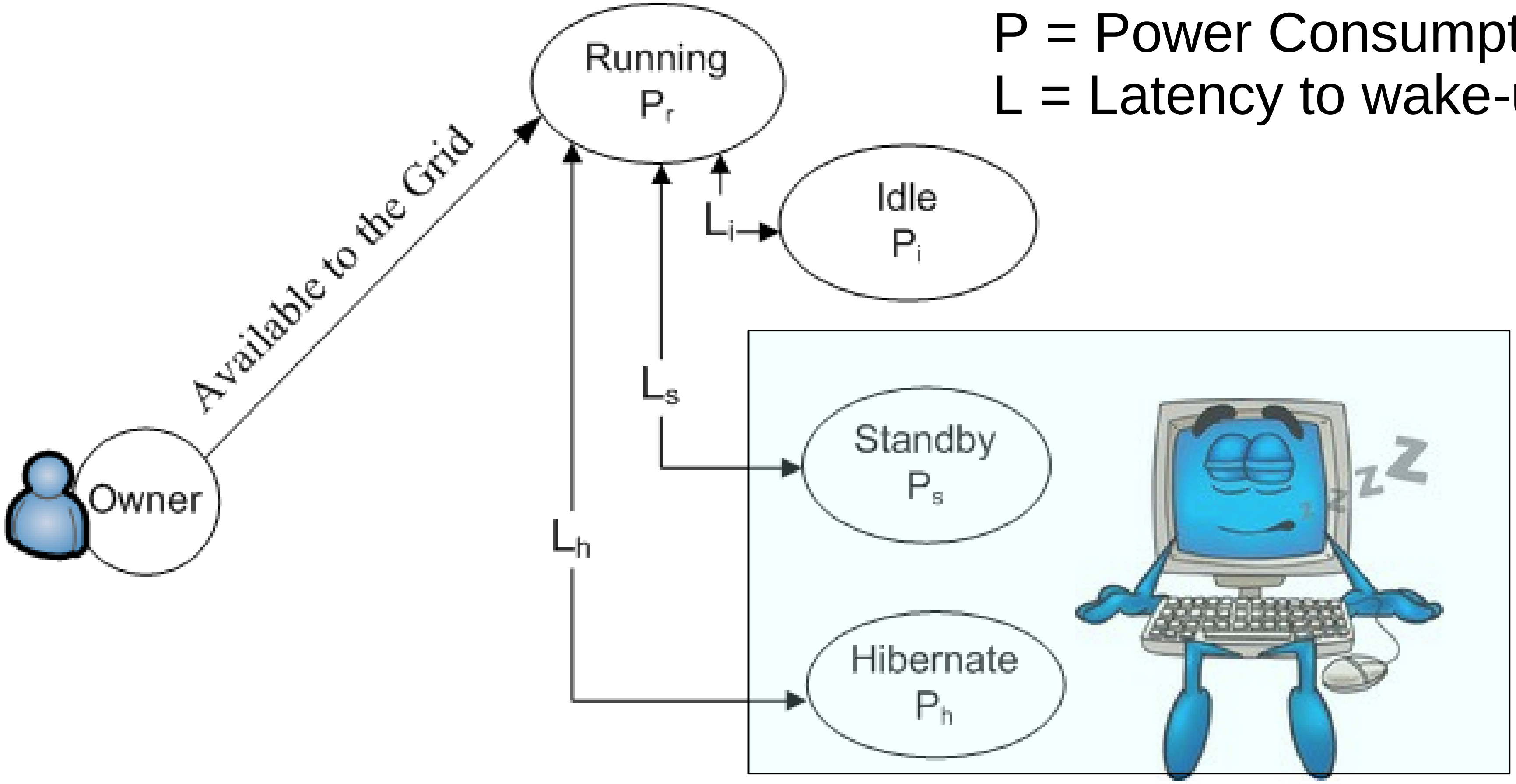
Sleeping strategies save energy at resources idle times

- Advanced Configuration and Power Interface (ACPI)

Energy-aware scheduling strategies save energy on resources allocation

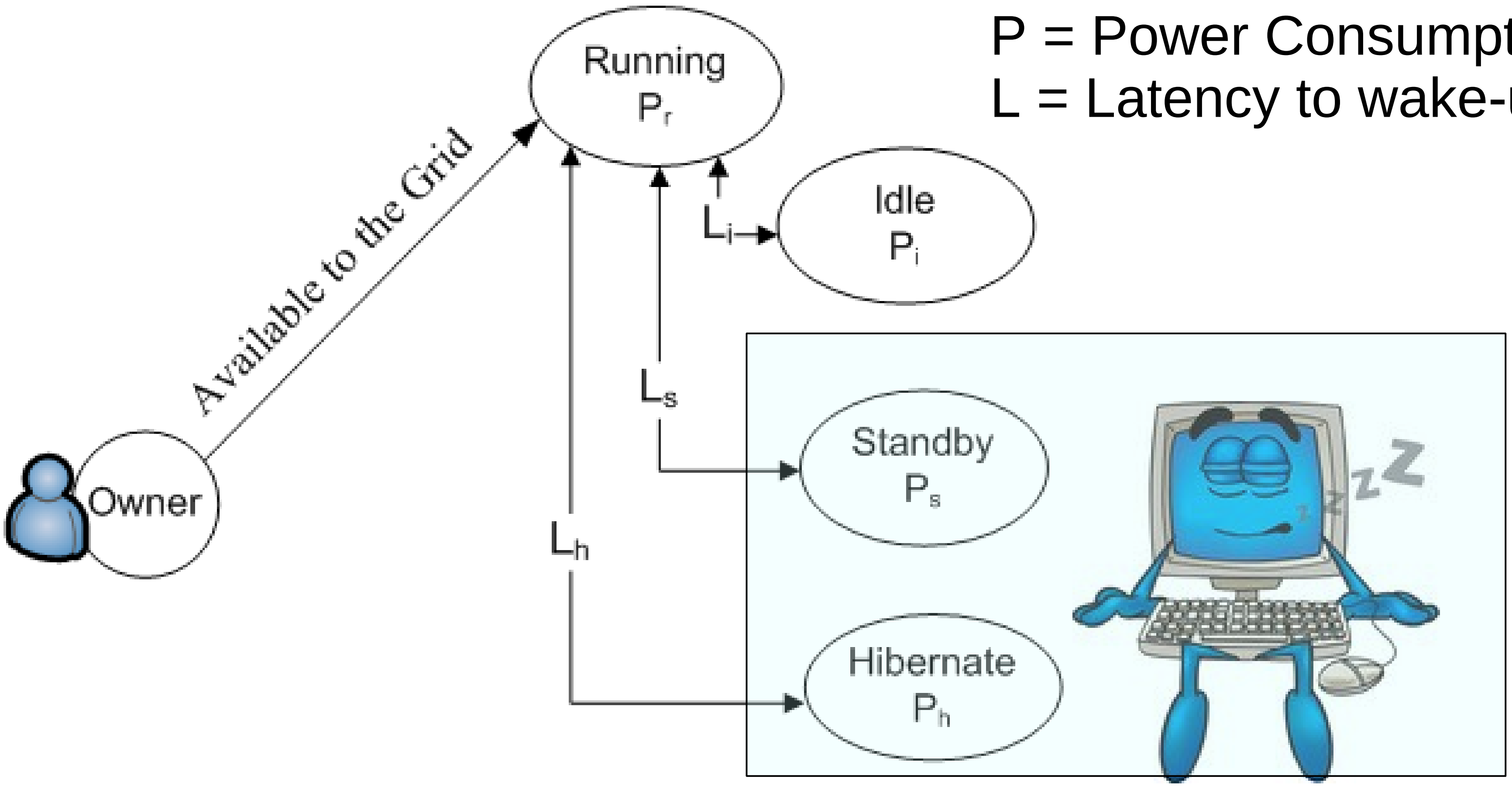
- how to choose which machine should be woken up, if several options are available
- how to decide which tasks to schedule to the available machines

Sleeping Strategies



P = Power Consumption
L = Latency to wake-up

Sleeping Strategies



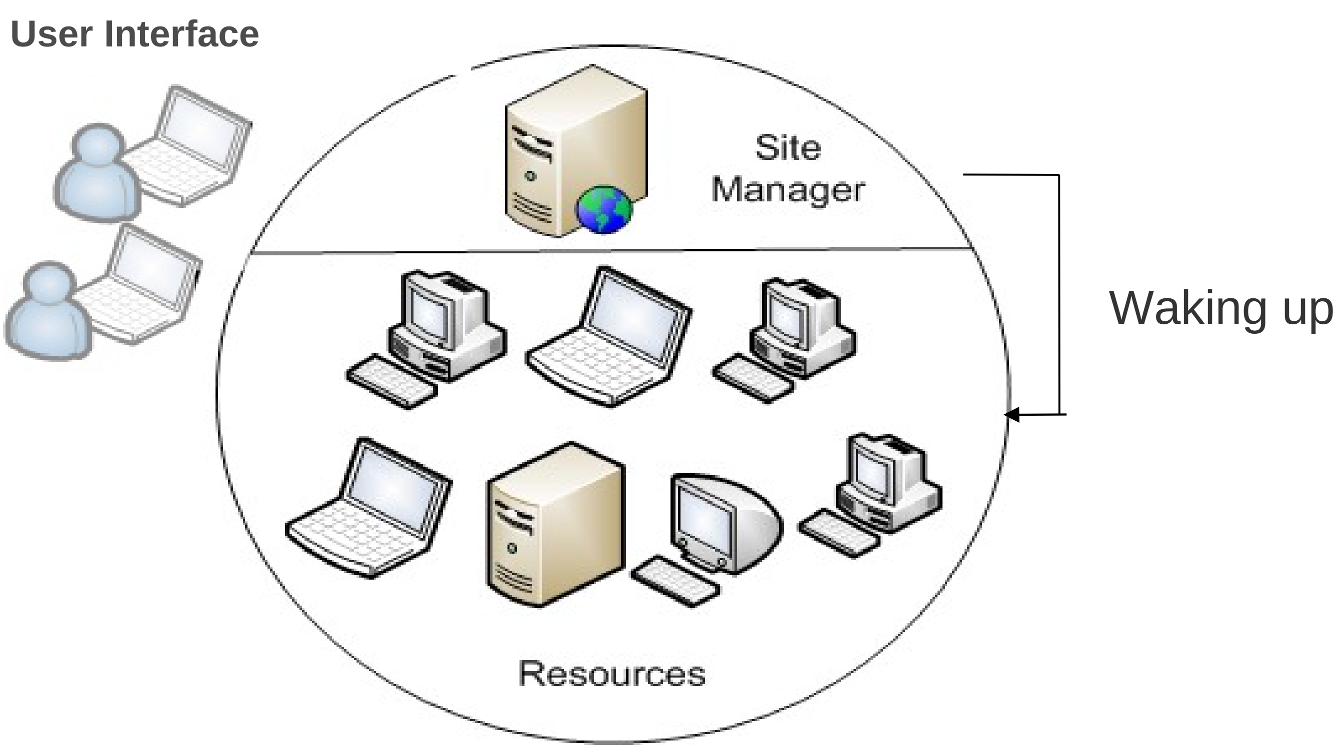
P = Power Consumption
L = Latency to wake-up

$P_h < P_s < P_i$ e $L_h > L_s > L_i$

Sleeping strategies can **provide energy savings**, but can **increase job makespan**

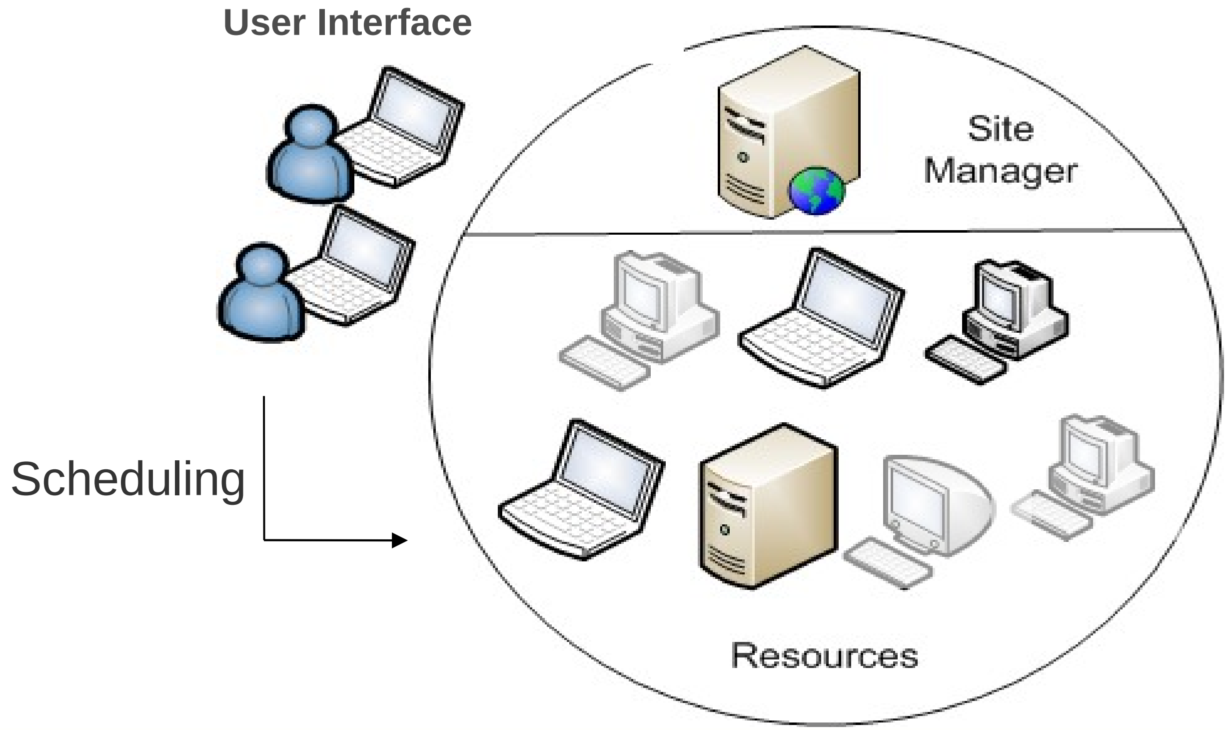
Wake-up Strategies

- Most Recently Sleeping (MRS)
- Energy Aware (EA)



Scheduling Strategies

- First Come First Served (FCFS)
- Fastest Processor to Largest Task (FPLT)
- Most Energy-Efficient First (MEEF)
- Most Energy-Efficient to Largest Task (MEELT)



Evaluation

Recalling the problem statement...

What is the purpose of this experiment?

- The purpose is **to analyze the impact that the proposed** sleeping, waking up, and scheduling **strategies have on energy-saving and job makespan** in Opportunistic Grid

Metrics

Job makespan (M_j): $M_j = c_j - s_j$

where s_j is the job submission time and c_j the latest time of completion of any of its tasks

Job slowdown (S_j): $S_j = \frac{m_j^A}{m_j^B}$

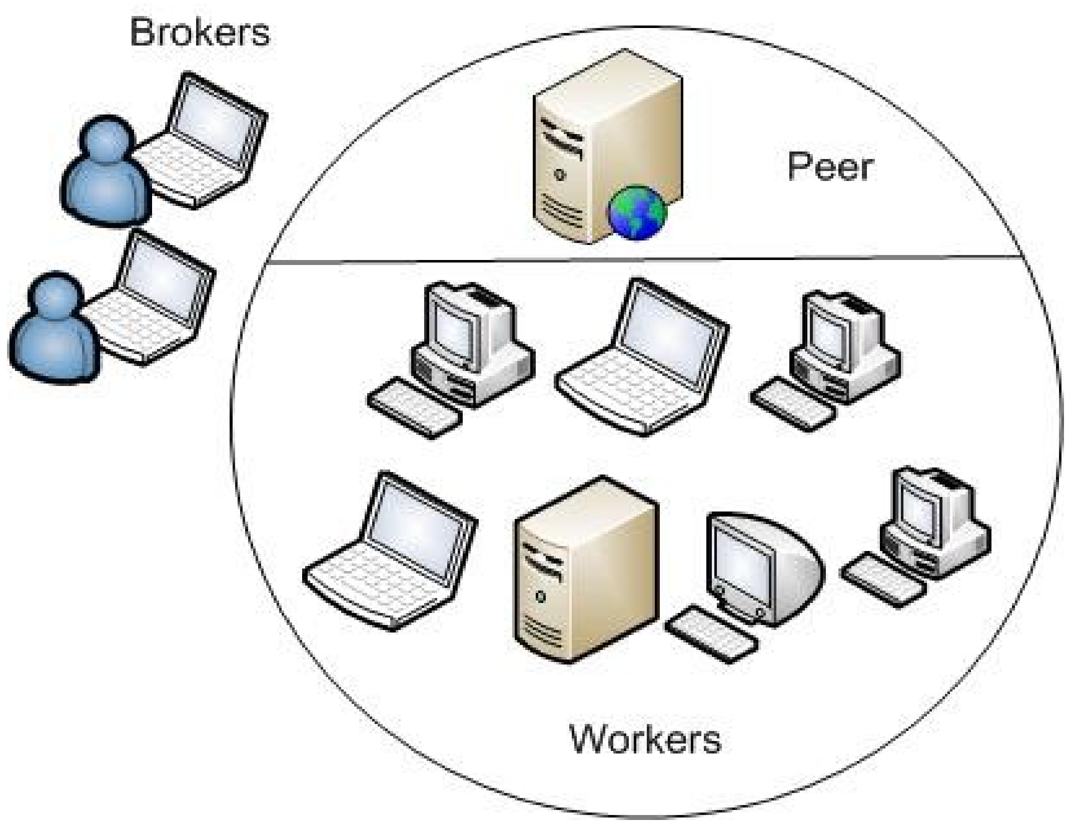
where *A* and *B* are site configuration

Energy Saving: $\xi_A = \frac{E_A - E_B}{E_B} * 100$

where *E* is the energy consumed by all machines of the site

Grid Simulator

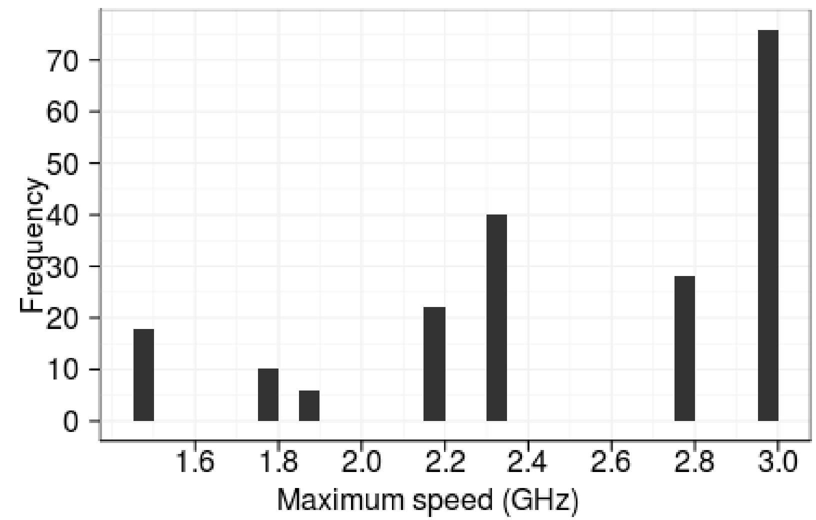
Simulator based on OurGrid P2P opportunistic Grid

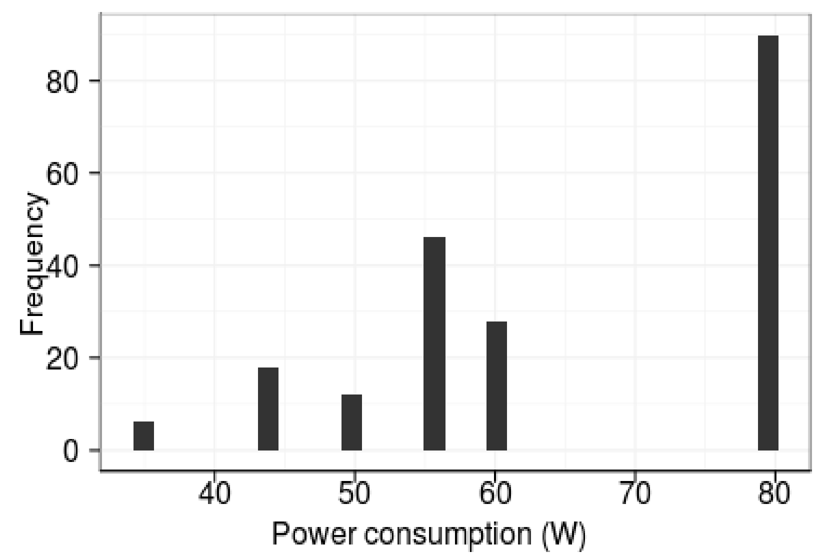


Experimental Configuration

Resources

- Up to 360 machines
- Power consumption based on TDP
- Variations in the machines availability (Kondo et al., 2007)





Bag-of-task applications

- Tasks CPU-Bound
- 11 months of OurGrid trace
- Synthetic Workload (Iosup et al., 2008)

Results

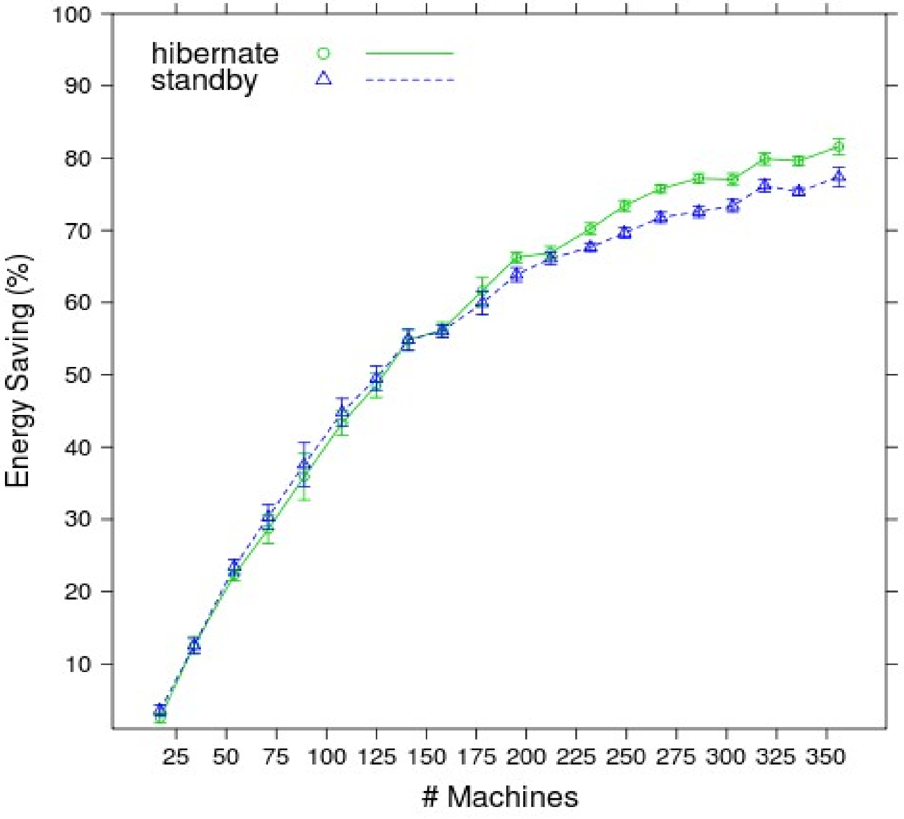
Sleeping Strategies

Grid Configuration

- Sleeping: *
- Scheduling: FCFS
- Wake-up: EA

Results

- Sleeping strategies can provide substantial energy savings
- Hibernate provides greater energy saving than standby when the number of resources provisioned grows



Relative error bars for a confidence level of 95%

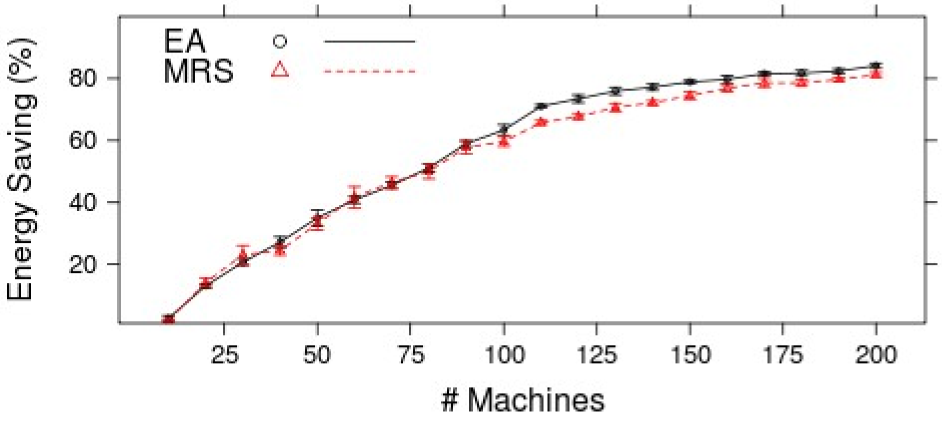
Wake-up Strategies

Grid Configuration

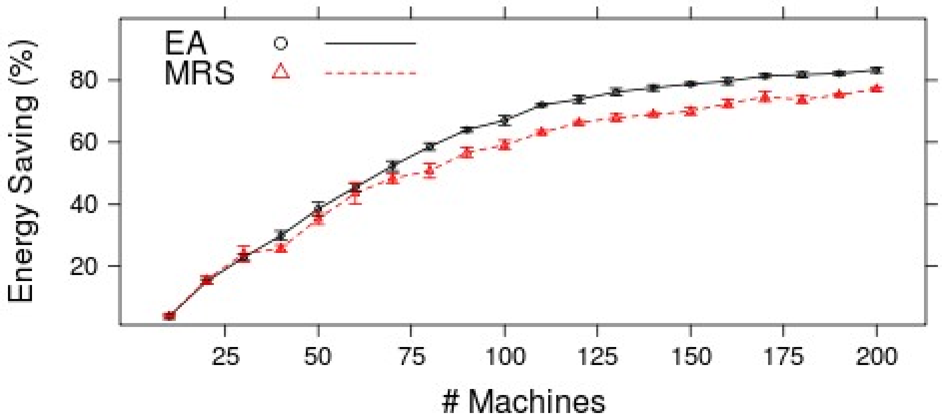
- Sleeping: *
- Scheduling: FCFS
- Wake-up: *

Results

- EA performers better than MRS when the number of resources provisioned grows



Hibernate



Standby

Relative error bars for a confidence level of 95%

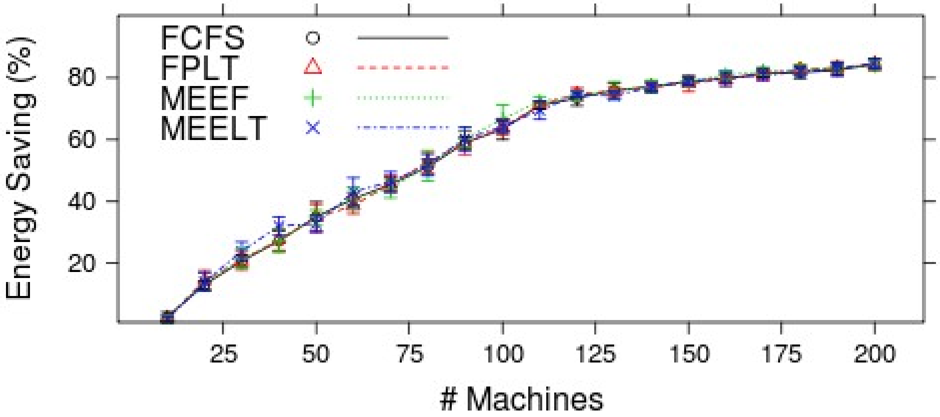
Scheduling Strategies

Grid Configuration

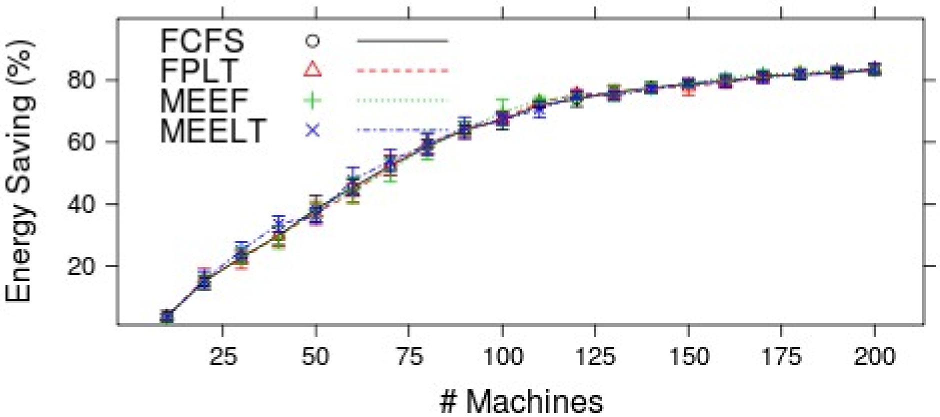
- Sleeping: *
- Scheduling: *
- Wake-up: EA

Results

- They have not shown significant difference when compared with each other



Hibernate



Standby

Relative error bars for a confidence level of 95%

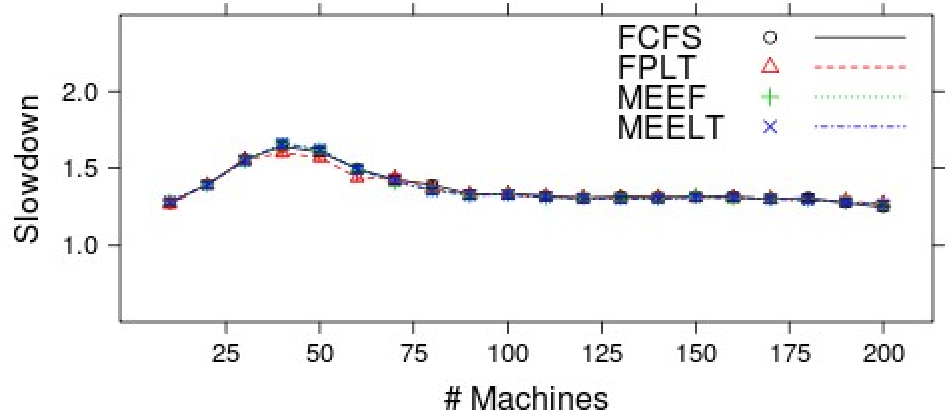
Slowdown

Grid Configuration

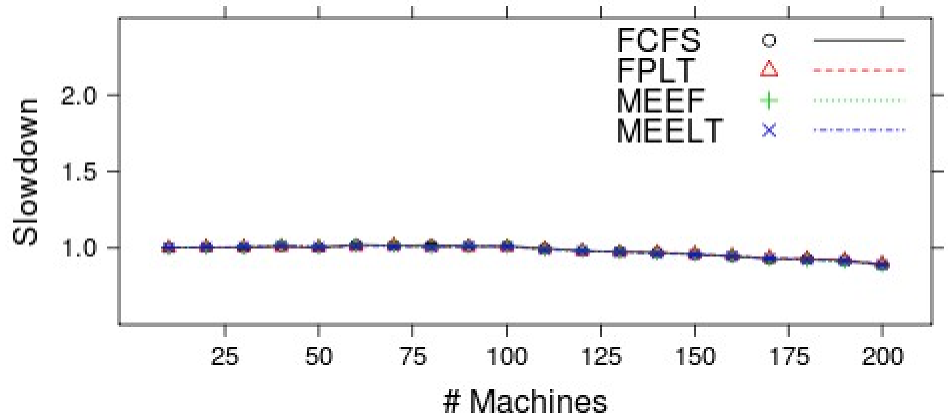
- Sleeping: *
- Scheduling: *
- Wake-up: EA

Results

- Wake-up and scheduling strategies have not impacted significantly on slowdown
- Hibernate has presented greater slowdown than standby in all scenarios



Hibernate



Standby

Relative error bars for a confidence level of 95%

Conclusions

Analyze different strategies considering several aspects of the grid

Most of the energy savings comes from the sleeping strategies

Energy saving surpass 80% in a scenario when the contention for resources in the grid was low

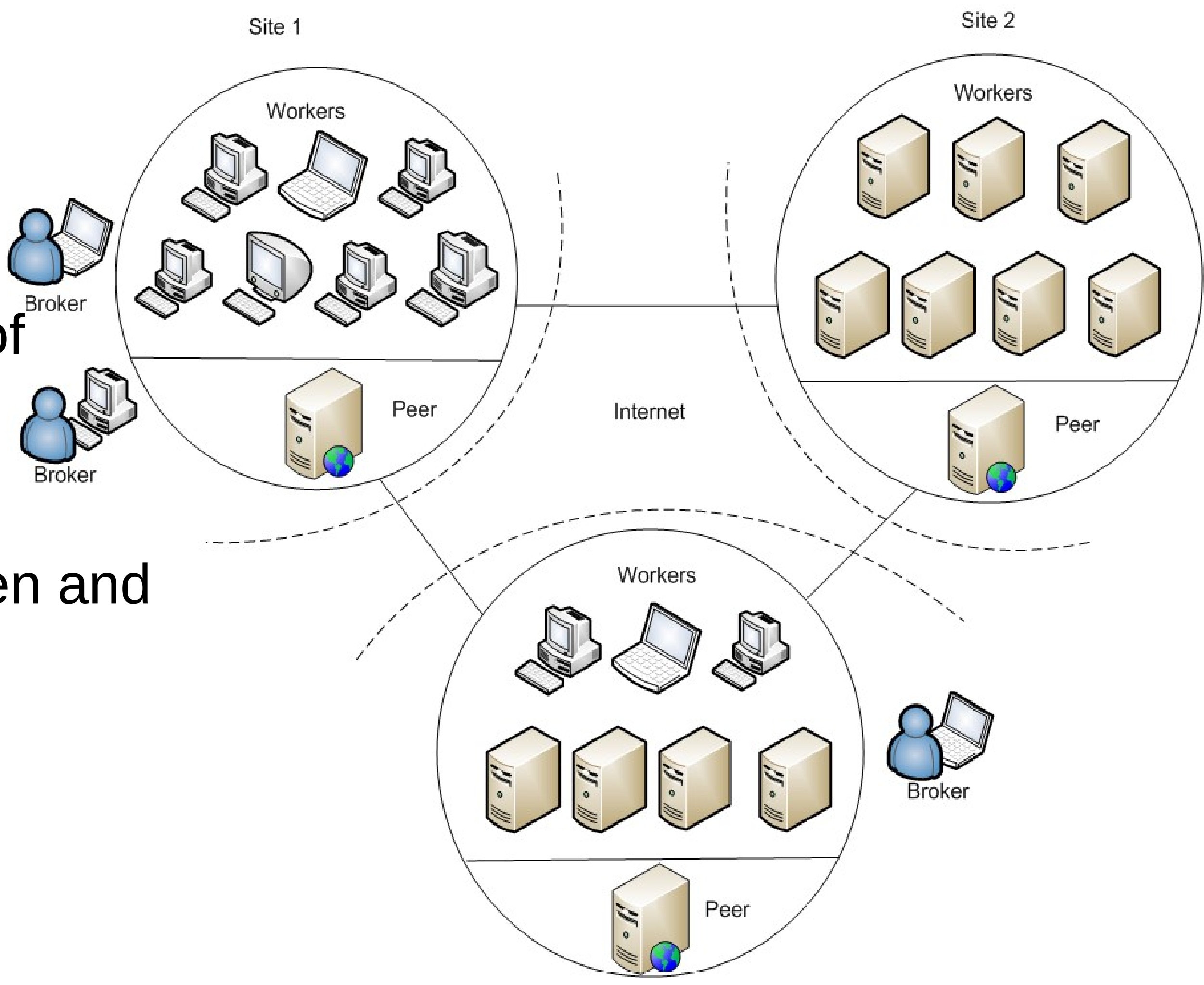
Limited impact on the makespan of the applications

Future Work

P2P Opportunistic Grid

Sensitivity analysis of power consumption and latency of sleeping states

New strategies to decide when and which machines can go to sleeping state over time



Thank you!

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The idle times are small,
The task waits the machine finish
going to sleep and wake-up

From 75 to 200. The idle times are high
The task waits, only the machine wake-up

There are not idle times, then
Sleeping Strategy is not used