

Simulation of Real-Time Scheduling Algorithms with Cache Effects

Maxime Chéramy, Pierre-Emmanuel Hladik, Anne-Marie Déplanche,
Silvano Dal Zilio

WATERS, 7th July 2015

1. Introduction

- Problem Definition
- Evaluation of scheduling algorithms
- SimSo

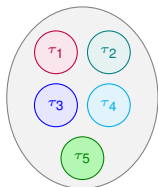
2. Simulating cache effects

- Cache effects
- Modeling the caches
- Integration in SimSo

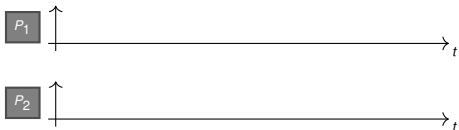
3. Example of experiment

4. Conclusion

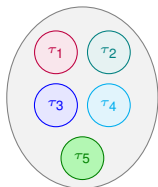
Problem Definition



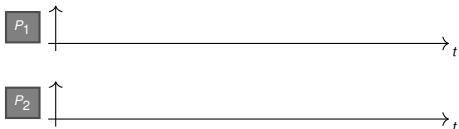
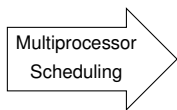
Independent and
periodic tasks



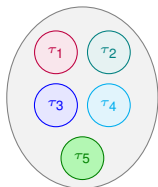
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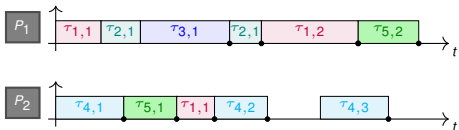
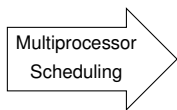
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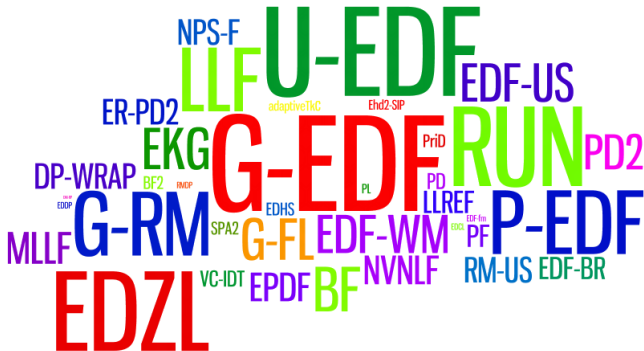
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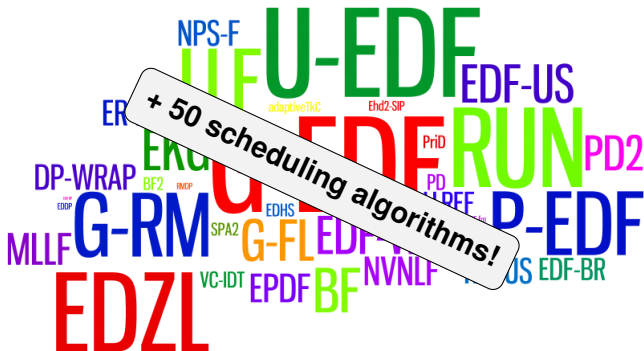
Independent and
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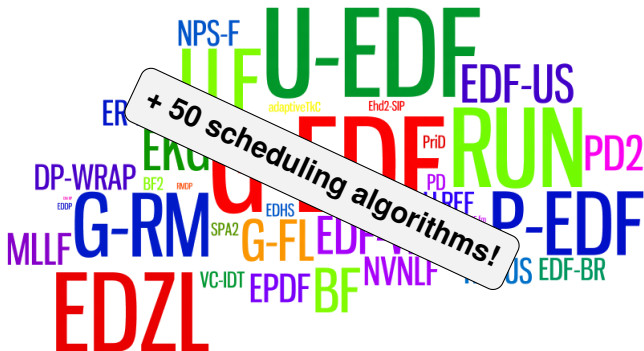
Many Real-Time Multiprocessor Scheduling Algorithms



Many Real-Time Multiprocessor Scheduling Algorithms



Many Real-Time Multiprocessor Scheduling Algorithms



Objective

To evaluate their behavior and performance.

Several Approaches

Theoretical analysis

Good way to prove schedulability, **but** hard to take into consideration some aspects

Empirical studies on real systems

Realistic **but** require a significant amount of time and skills to handle the tools

Simulations

Easy to use and very flexible **but** less accurate than a real system

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SimSo : A Simulator to Evaluate Scheduling Algorithms

The logo for SimSo, consisting of the text "SimSo" with a small superscript "1" to the right, enclosed in a rounded rectangular box.

- ▶ Simulator dedicated to the study of new scheduling algorithms.

¹SimSo: A Simulation Tool to Evaluate Real-Time Multiprocessor Scheduling Algorithms, WATERS 2014.

SimSo : A Simulator to Evaluate Scheduling Algorithms

SimSo¹

- ▶ Simulator dedicated to the study of new scheduling algorithms.
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- ▶ More than 25 scheduling algorithms are available.
- ▶ Open Source : <http://projects.laas.fr/simso/>

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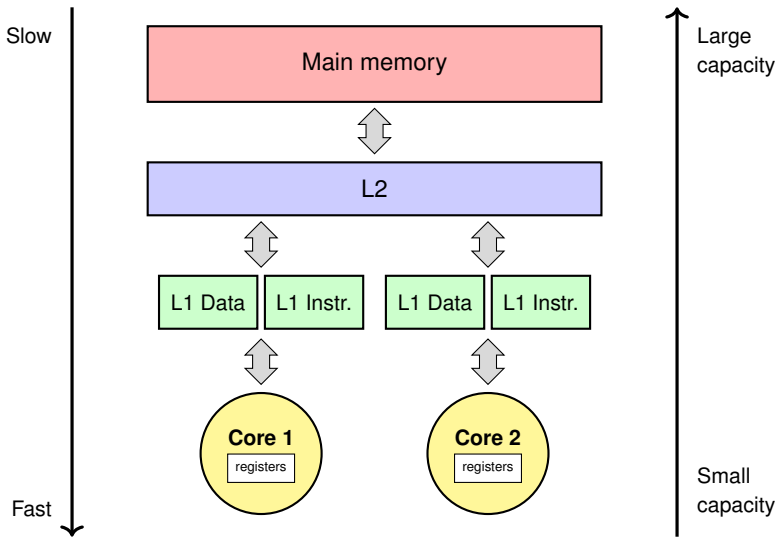
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Memory hierarchy

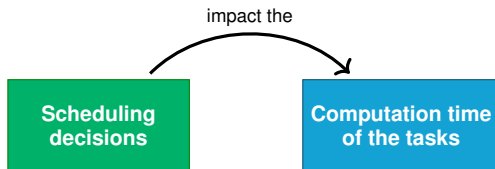


Operational Aspects

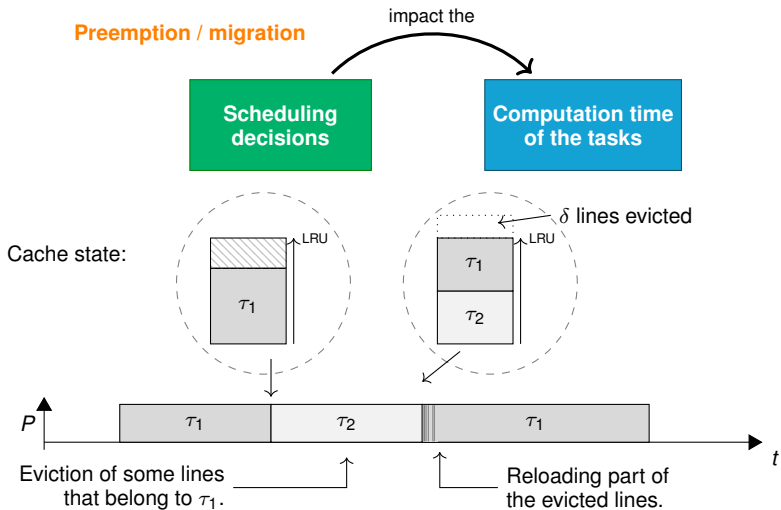
**Scheduling
decisions**

**Computation time
of the tasks**

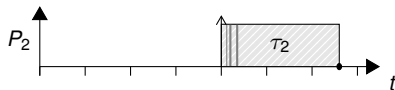
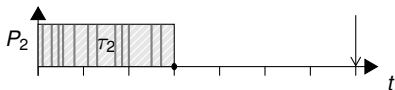
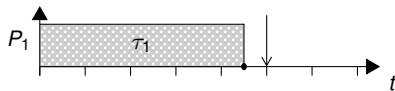
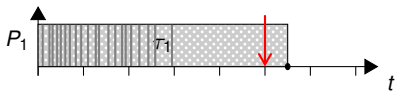
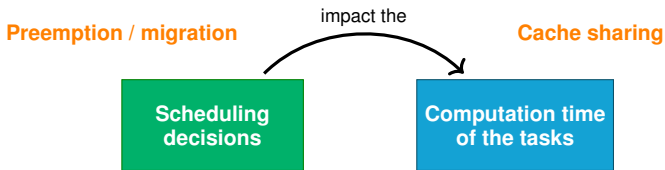
Operational Aspects



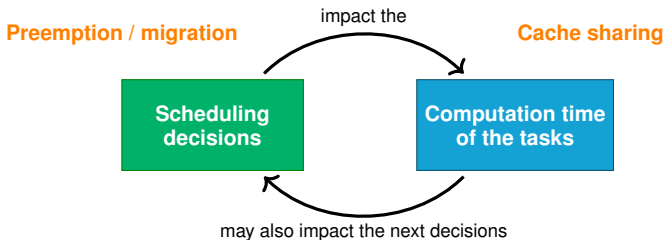
Operational Aspects



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Approach

Estimation of the computation time of the jobs
while taking into consideration the caches

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Simulation at an
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- Use of statistical models
- Behaviors found on real systems

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~~Simulate the exact behavior
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Study the scheduling algorithms
with cache-related phenomena

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Estimation of the computation time of the jobs
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~~Accurate simulation
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Simulation at an
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- Use of statistical models
- Behaviors found on real systems

~~Simulate the exact behavior
of a system~~

Study the scheduling algorithms
with cache-related phenomena

- Get general trends

Selected models

After the study of various statistical cache models, we've selected:

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Cache sharing

FOA model (*Frequency Of Access*), because of:

- ▶ its good accuracy
- ▶ its simplicity
- ▶ its low calculating complexity

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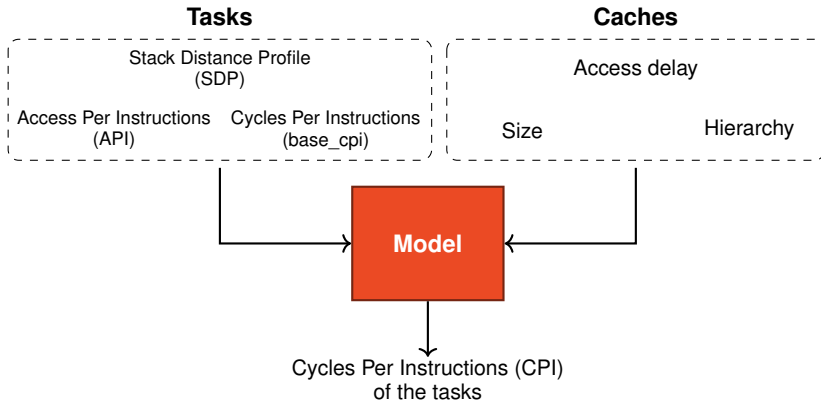
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- ▶ its simplicity
- ▶ its low calculating complexity

Preemptions and migrations delays

Our experiments show that it highly depends on the task (preempted and preempting), its duration and the moment the preemption occurs

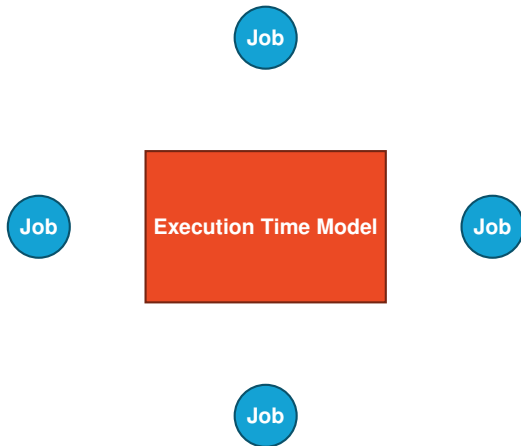
→ Use of fixed temporal penalties, specific for each task

Inputs / Outputs

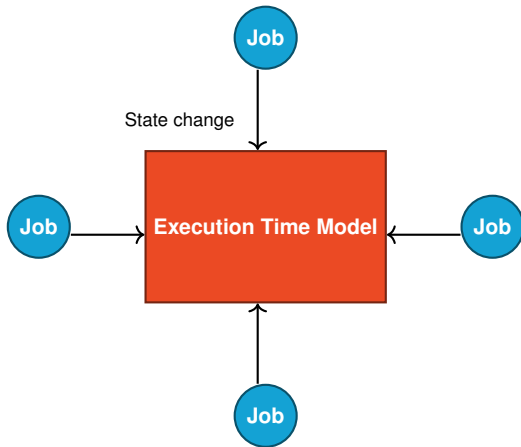


$\text{Duration} / \text{CPI} = \text{number of executed instructions for a given time interval}$

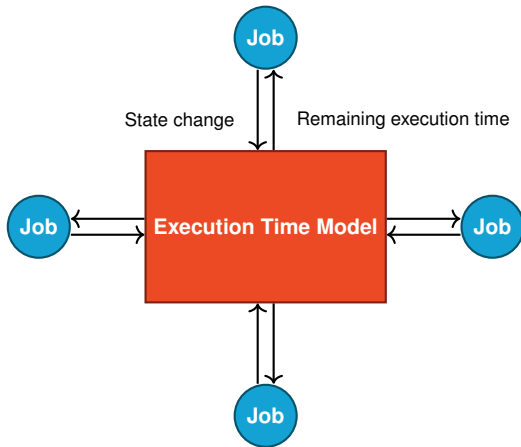
Execution Time Model (ETM)



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Cache effects on system with P-EDF scheduling

Cache effects on system with P-EDF scheduling

Objective

Evaluate the impact on the system load of:

- ▶ the choice of the first activate dates of the tasks
- ▶ the allocation of the tasks on the processors

Studied system

Compress

T : 20
C : 5
I : 46 771 323
API : 0.28

Patricia

T : 30
C : 8
I : 204 293 931
API : 0.34

CNT

T : 10
C : 3
I : 143 775 036
API : 0.08

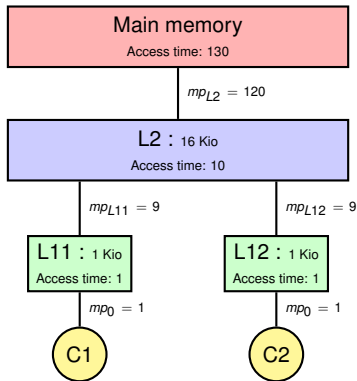
Dijkstra-L

T : 40
C : 9
I : 188 603 755
API : 0.30

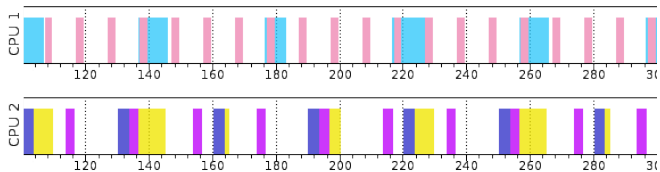
MatMult

T : 30
C : 10
I : 47 922 711
API : 0.37

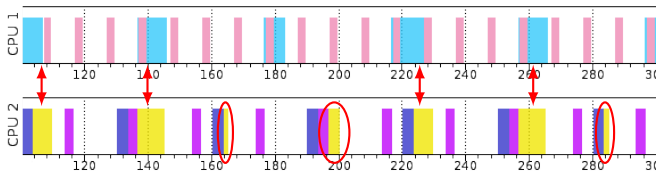
T : Period
C : WCET
I : Instructions
API : Access / Instructions



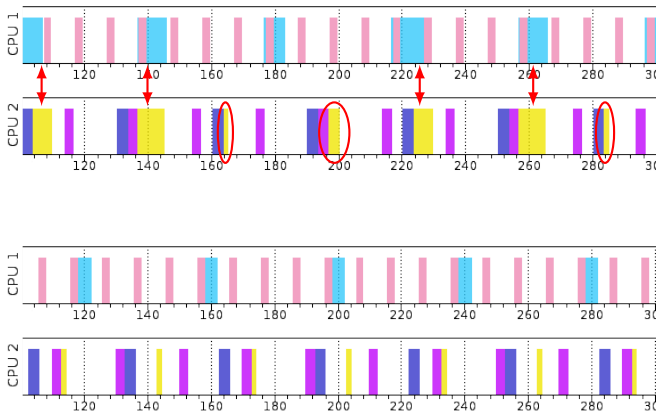
Variation of the first activation dates



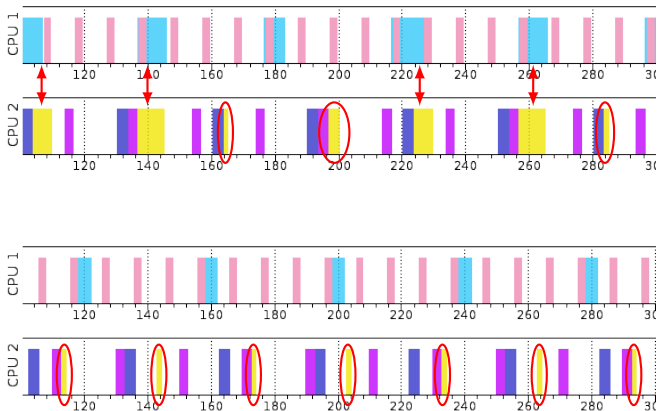
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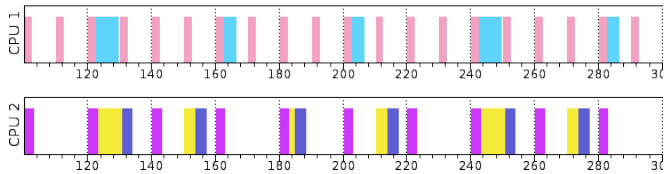
Variation of the first activation dates



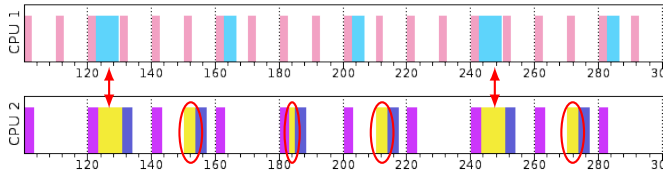
Variation of the first activation dates



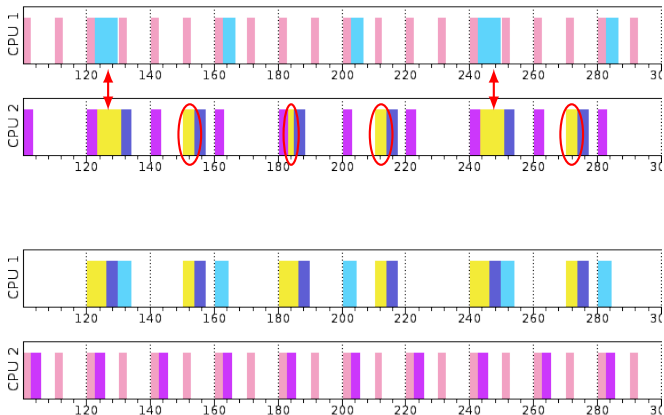
Allocation of the tasks on the processors



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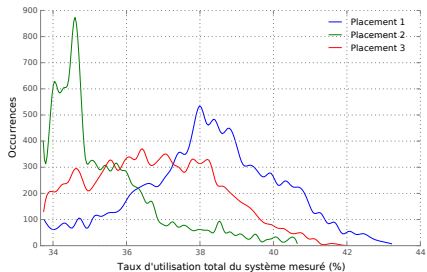
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Results

For each line:

- Variation of the activation dates for 10 000 simulations



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- ▶ SimSo: real-time scheduling simulator
- ▶ Allow to control the way the computation time of the jobs are simulated
- ▶ Integration of statistical cache models in the simulation
- ▶ Open new evaluation possibilities

Thank you for your attention. Any questions?