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Raphaël Bleuse, Éric Rutten

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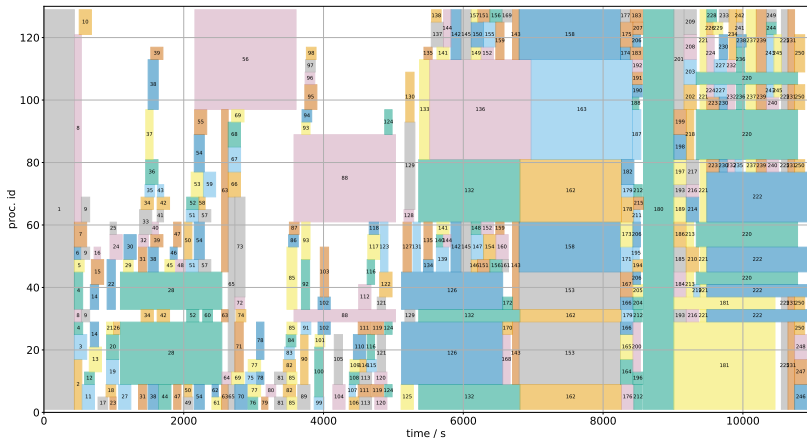
# Composition of Scheduling and Control Theory Techniques

Raphaël BLEUSE, Éric RUTTEN

Univ. Grenoble Alpes, Inria, CNRS, Grenoble INP, LIG, France

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## Scheduling (~ Resource Allocation)



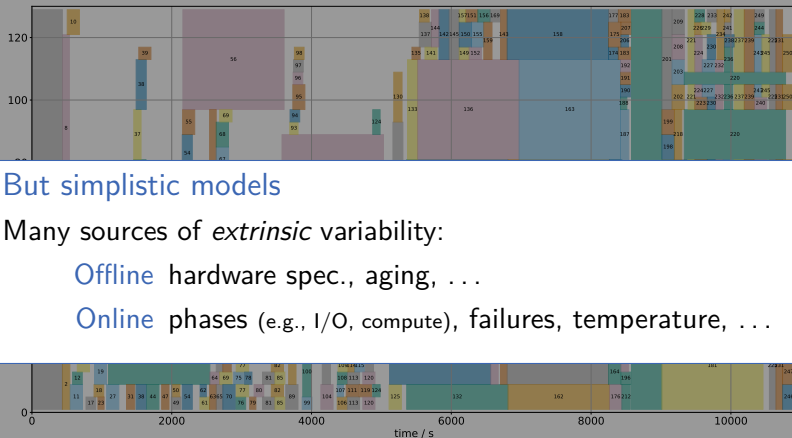
platform

tasks/jobs

objective

⇒ where? &amp; when?

## Scheduling (~ Resource Allocation)



But simplistic models

Many sources of *extrinsic* variability:

Offline hardware spec., aging, ...

Online phases (e.g., I/O, compute), failures, temperature, ...

platform

tasks/jobs

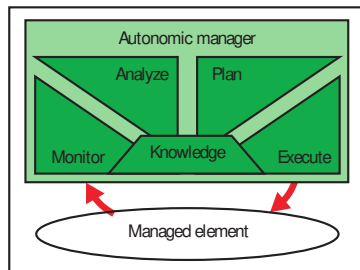
objective

⇒ where? & when?

# Feedback loops (*à la* Control Theory)

## Autonomic Computing (Kephart et al. 2003)

- 1 monitor system state
- 2 choose (online) parameters
- 3 repeat



## Control Theory

### Challenges

- stability, accuracy, explainability
- transient vs. steady-state behavior

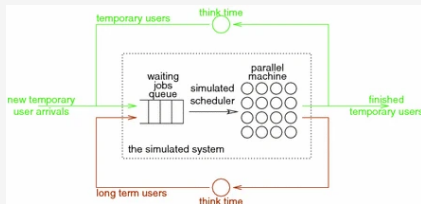
### Gains

- simpler models
- adapt to actual behavior

# Unexploited loops

Most scheduling approaches rely on an *unrealist* open-loop model. They struggle/fail for example:

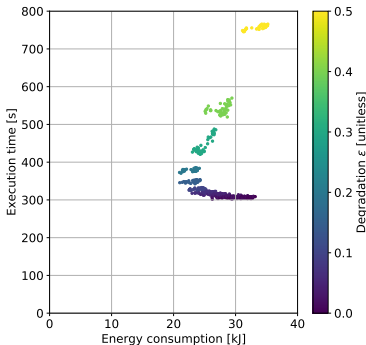
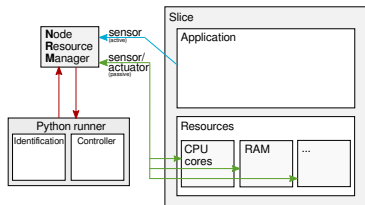
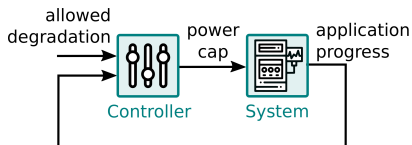
- congestion
- user behavior (Feitelson 2016)



Classic workarounds: “cyclic” scheduling, more variables (increases models’ complexity), . . .

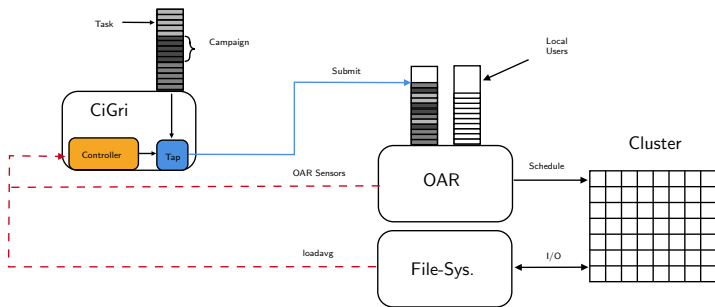
Existing usages/compositions: RAPL  $\times$  NRM

(Cerf et al. 2021; Hawila et al. 2022), ongoing collab. ANL/Inria

**Objective** Reducing energy consumption while sustaining performance**Approach** Dynamic power regulation using Control Theory

## Existing usages/compositions: Cigri

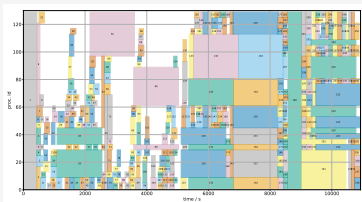
(Guilloteau et al. 2022)

**Objective** Minimize wasted resources (idle node, killed BE jobs)**Constraint** No (low?) impact on local users

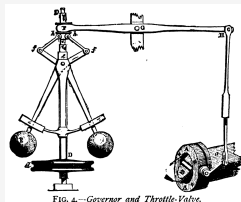


# Potential combinations

Scheduling × Control Theory

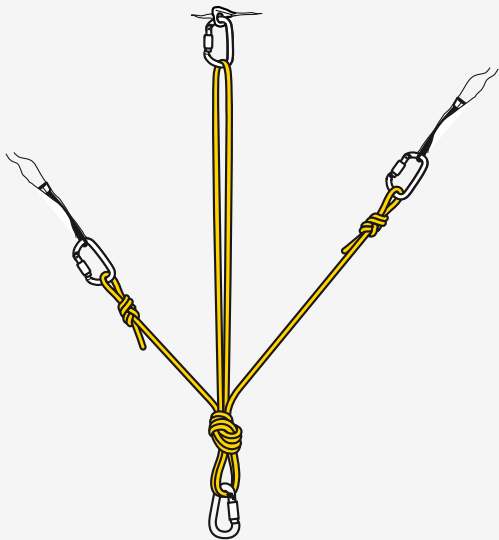


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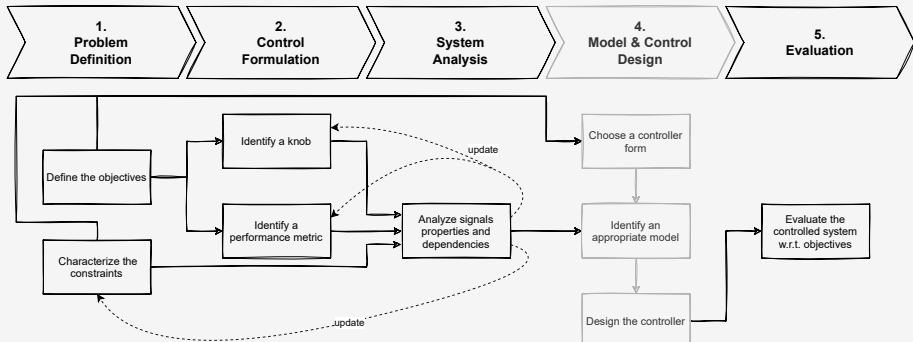
## Open questions / Directions to explore

- what are the interesting properties to enforce?
- how to structure the loops?
- what to measure? what to control?
- what is the dynamic at play?



Backup slides

# Control Theory Methodology



# References I

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