
# Involving the users to mitigate the environmental impact of data centers

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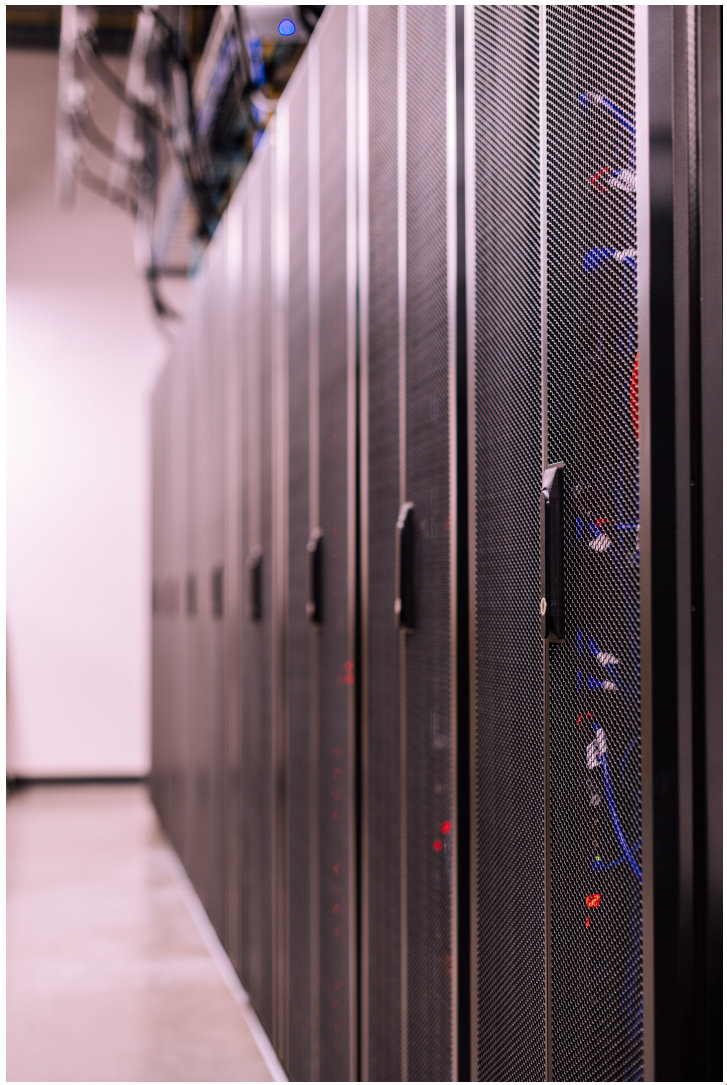
# Introduction

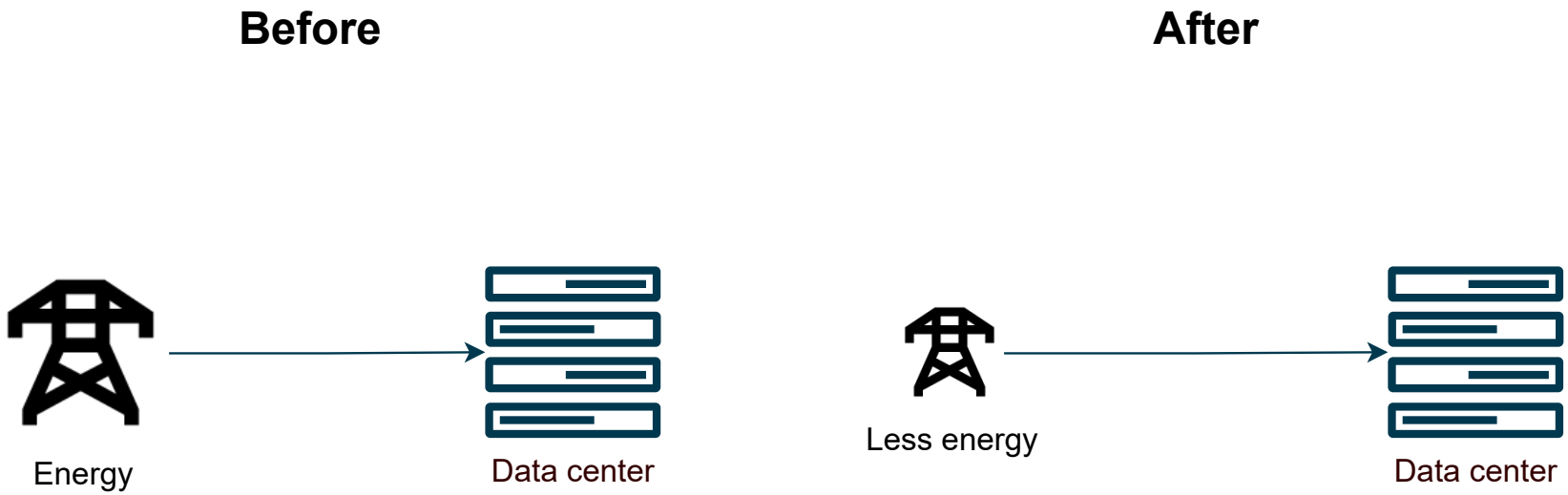
# Traditional techniques for footprint reduction in data centers

- **Energy efficiency** (virtualization, workload consolidation, DVFS...)
- **Use of renewable energies** (workload adaptation to power envelope, geographic load shifting, ...)
- **Data center environment** (cooling management, waste heat utilization, use of batteries)

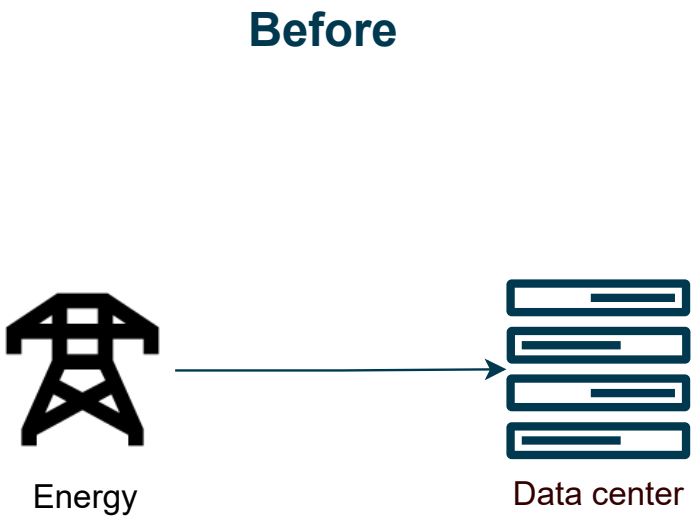


www.pexels.com

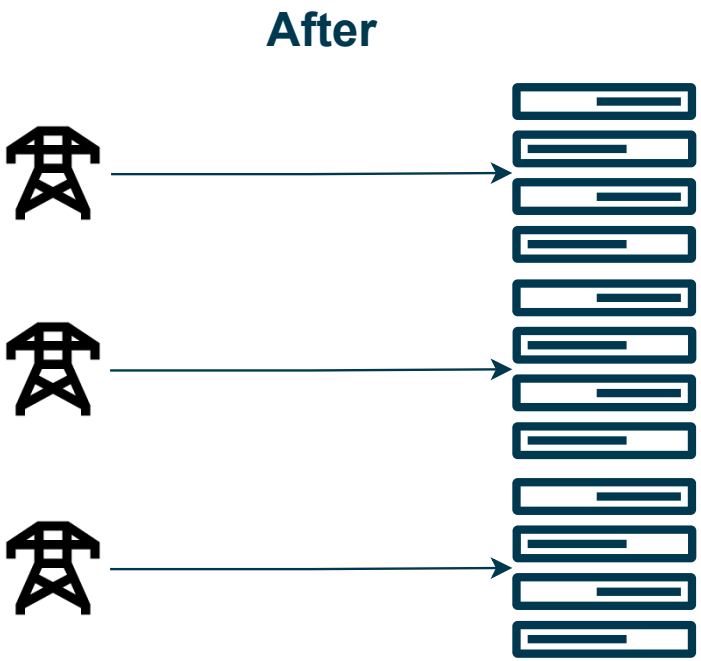
# Efficiency techniques



# Rebound effect?




Data center = 1
Energy = 2




Data center = 3
Energy = 3

# Sufficiency

- Efficiency is not enough: **sufficiency**

## Sufficiency policies (IPCC, 2022)

A set of measures and daily practices that **avoid demand** for energy, materials, land and water **while delivering human well-being** for all within planetary boundaries.

# Contents

**What would "sufficiency" mean for data centers?**
=> auto-regulate ourselves: raise awareness, empower and involve the user

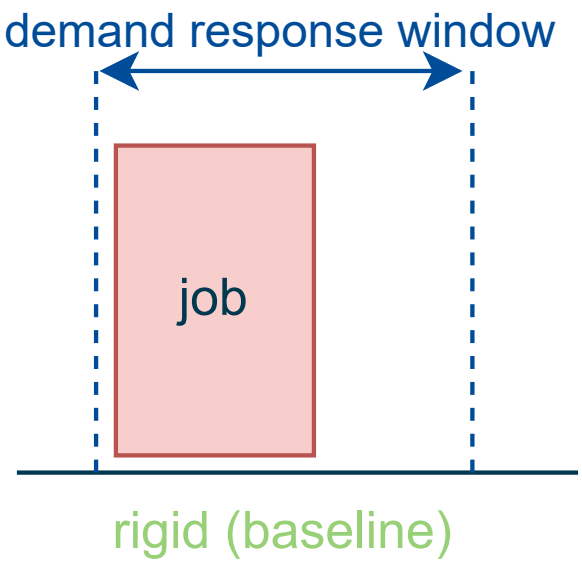
1. **simulation work:** understand how the user submission behavior affects the load in the data center
2. **case study:** digital sufficiency in flexible work

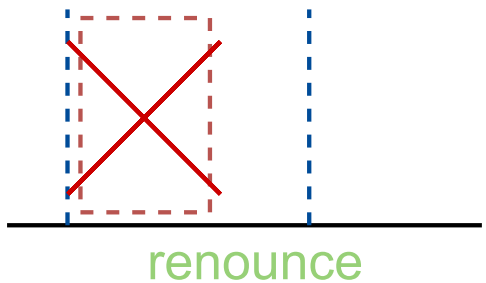

# Data center simulation

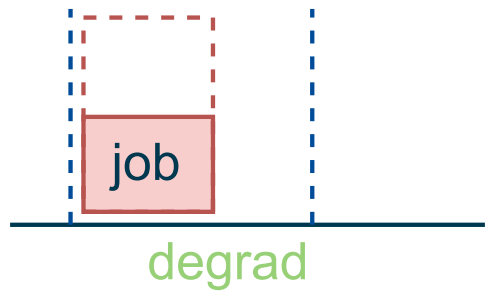
Understand how the user submission behavior affects the load in the data center

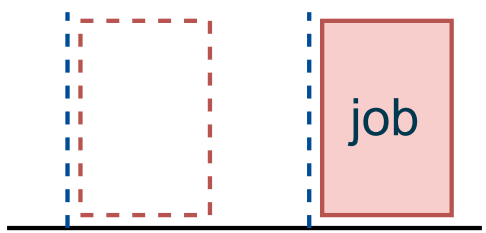
# Behaviors

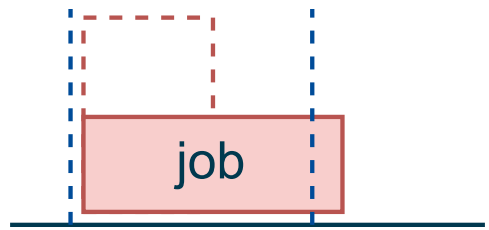
- Context: **demand response**
- Five behaviors studied:



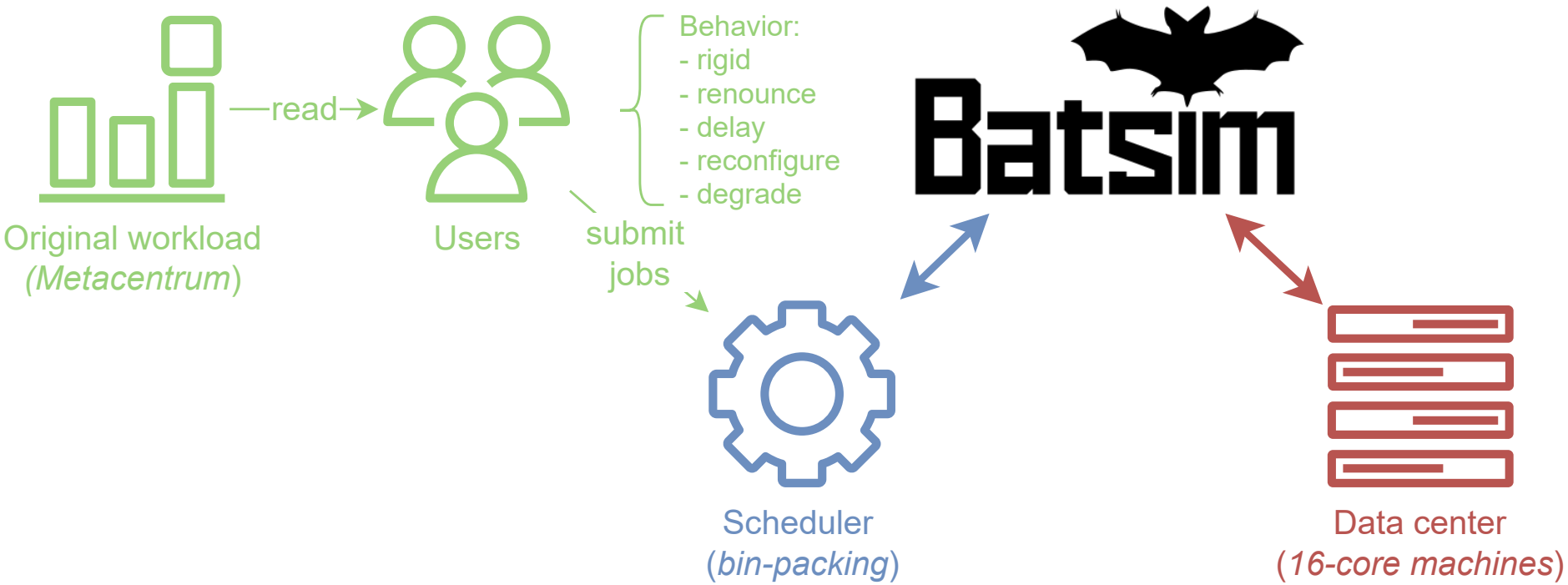



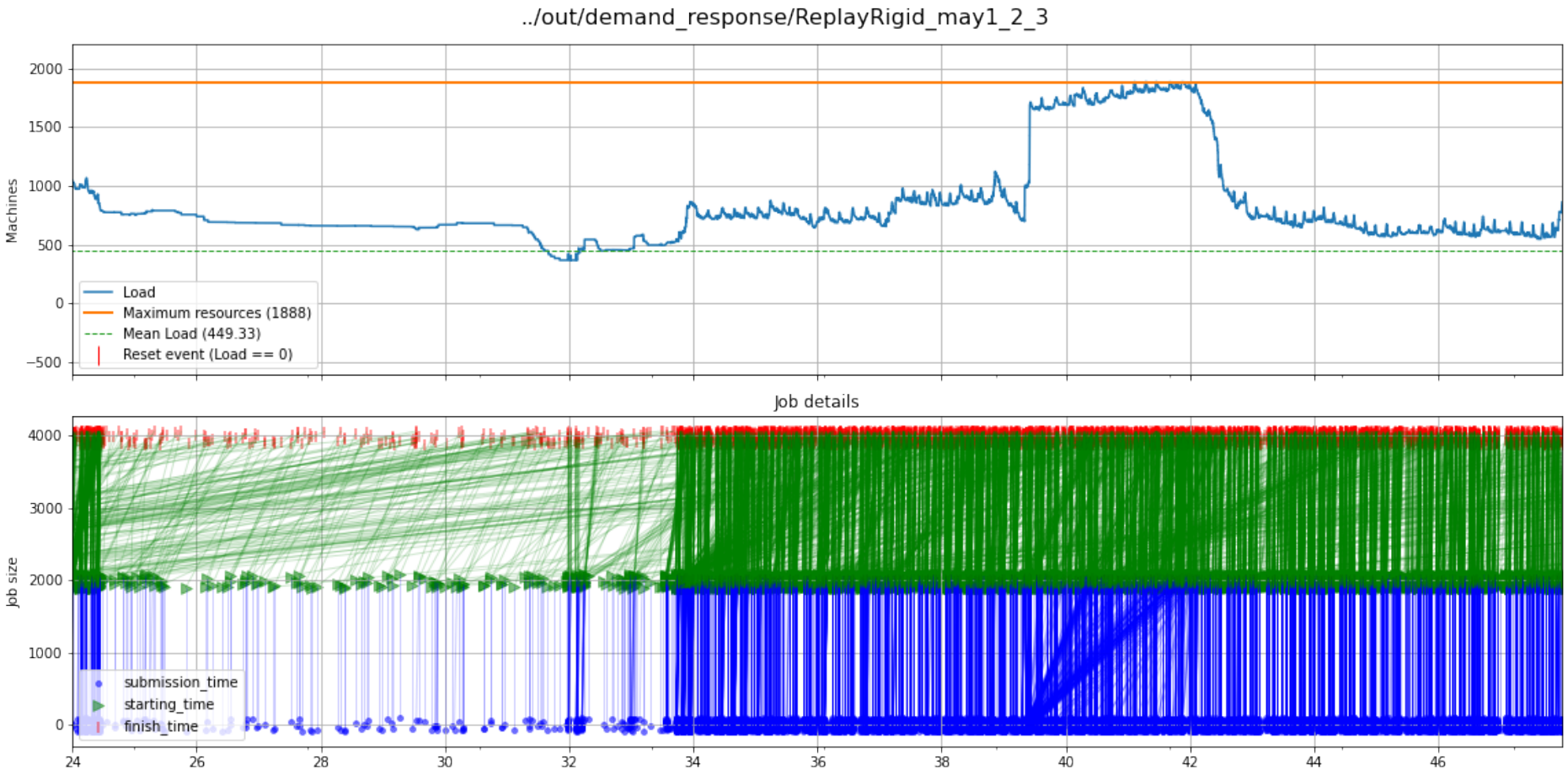



# The simulated system



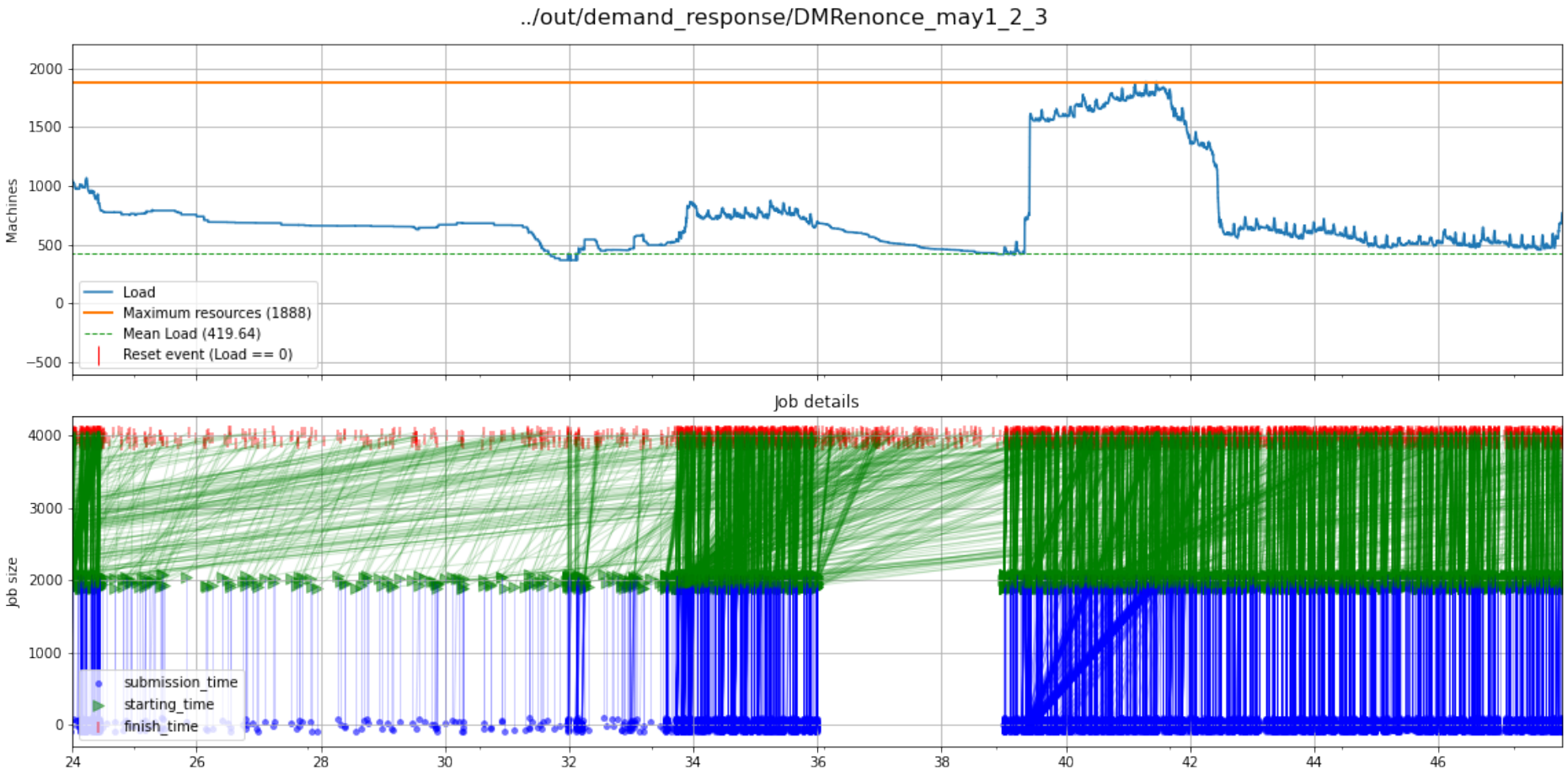
# Output

- Behavior during demand response window: **rigid**



# Output

- Behavior during demand response window: **renounce**

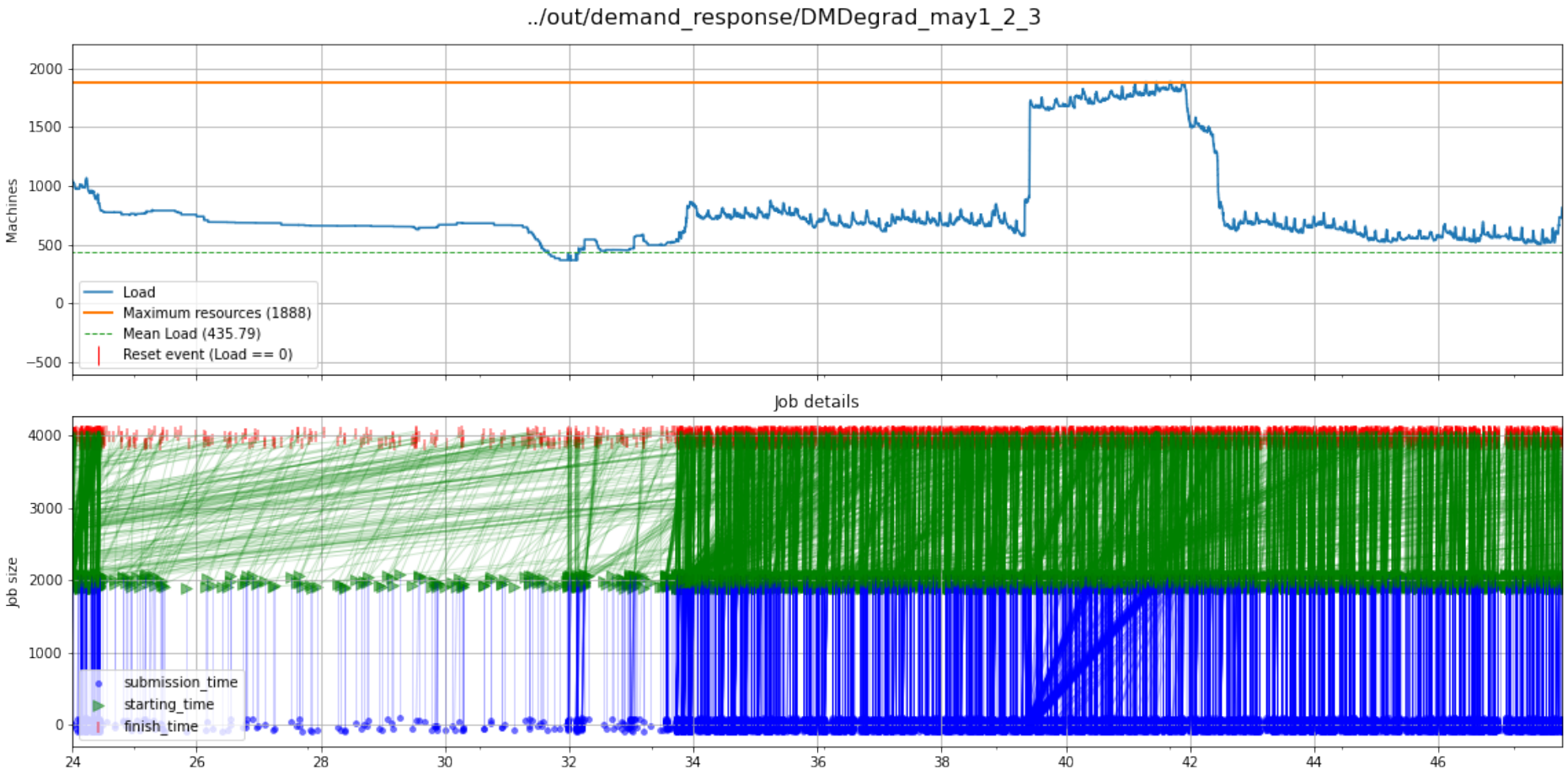


# Output

- Behavior during demand response window: **delay**

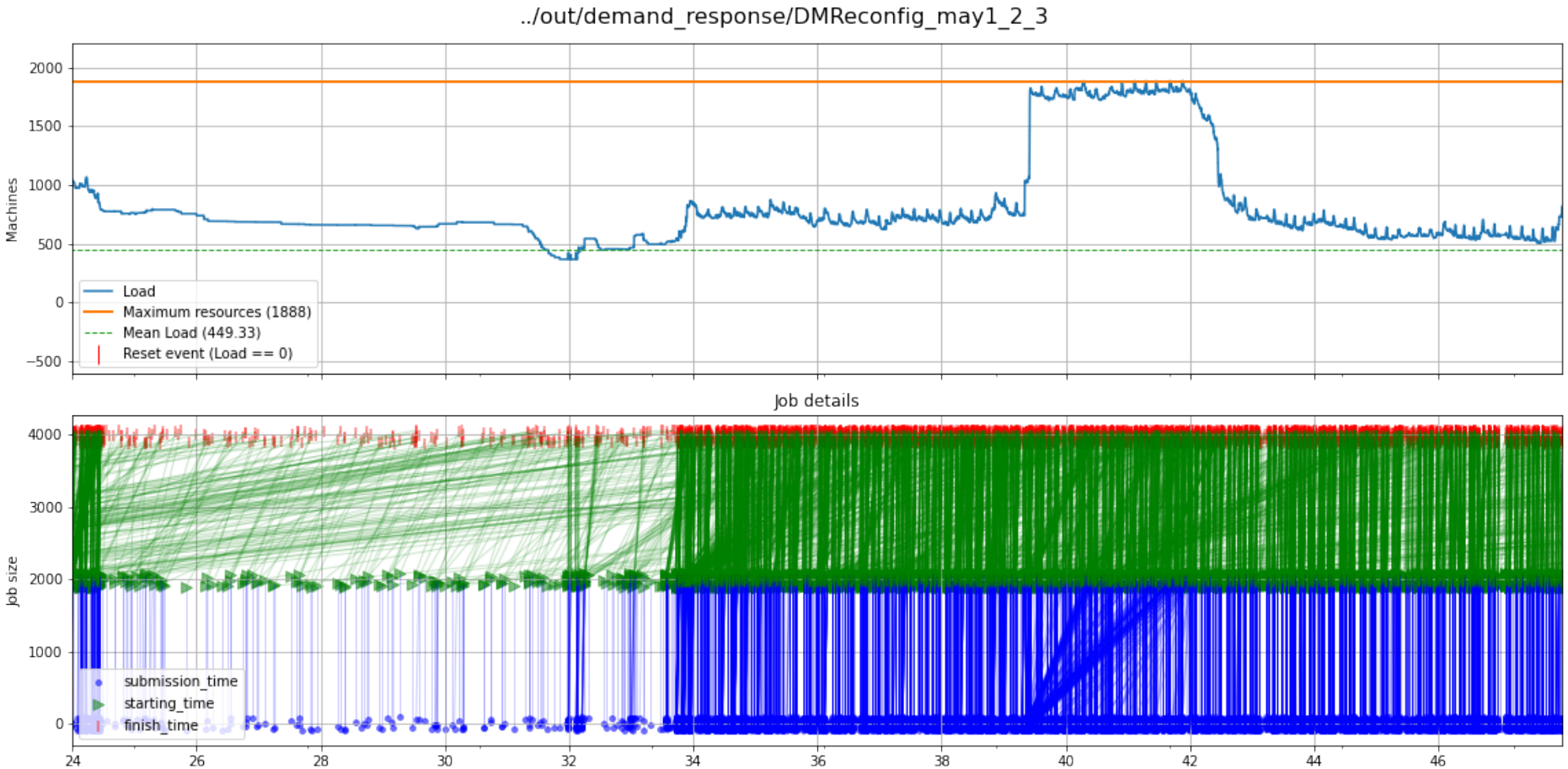
# Output

- Behavior during demand response window: **degrad**



# Output

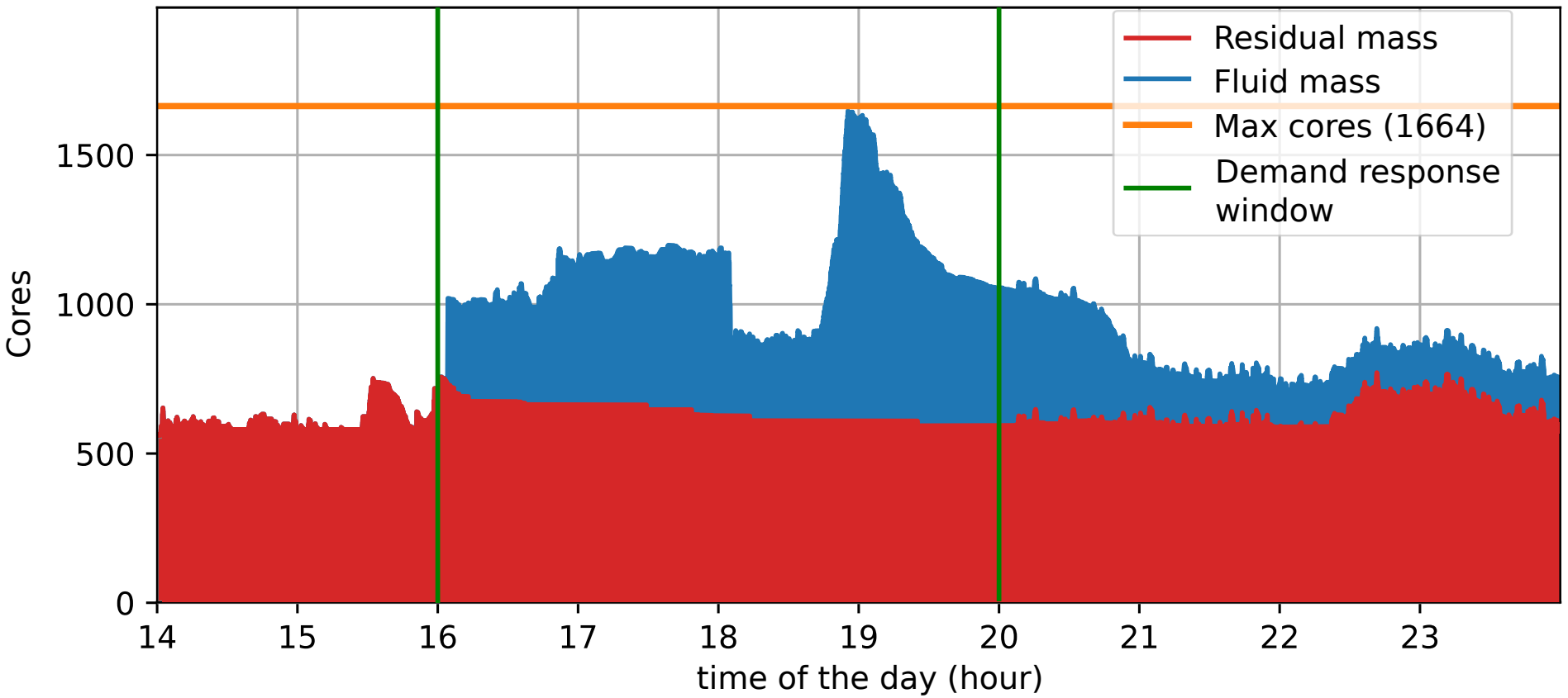
- Behavior during demand response window: **reconfig**




# Data center simulation

## Results

# Fluid and residual mass



# Results

- Pros and cons of each behavior:

| behavior | energy in | energy overall | sched. metrics | "acceptability" |
|---|---|---|---|---|
| **renounce** | 1st | 1st | 1st* | 4th |
| **delay** | 1st | 4th | 4th | 2nd |
| **degrad** | 3rd | 2nd | 2nd | 3rd |
| **reconfig** | 4th | 3rd | 3rd | 1st |

- All the details in the article[1]
- Open-source software and reproducible experiments: gitlab.irit.fr/sepia-pub/open-science/demand-response-user

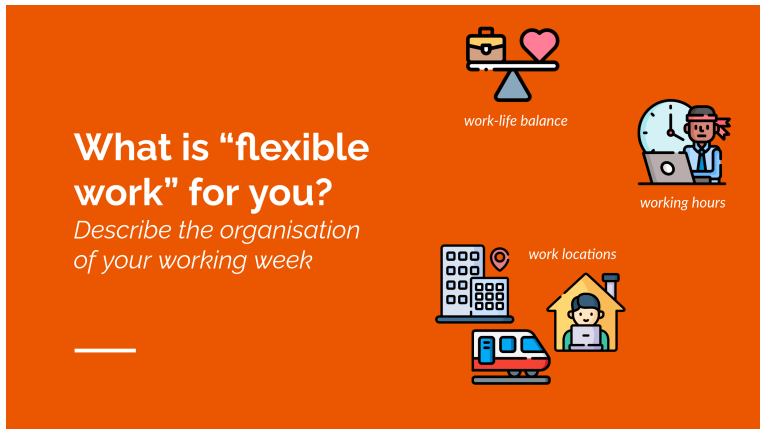
[1] M. Madon, G. Da Costa, and J.-M. Pierson, "*Characterization of Different User Behaviors for Demand Response in Data Centers*," in Euro-Par 2022, doi: 10.1007/978-3-031-12597-3_4

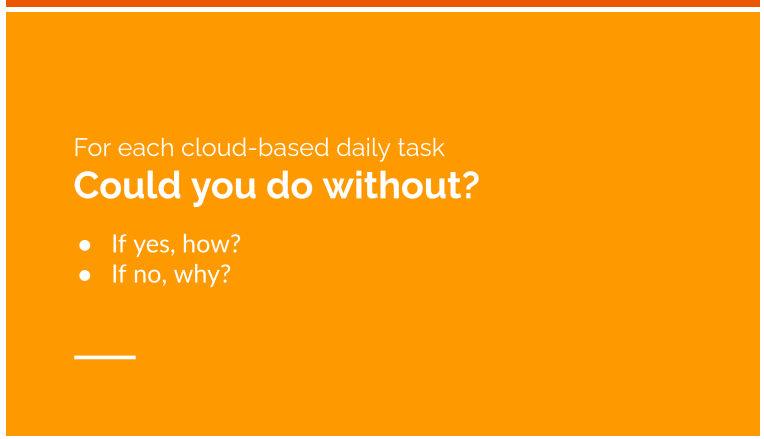

# Pilot study

## Digital Sufficiency in Flexible Work

# Digital Sufficiency in Flexible Work

- **Study goal:** Re-design the use of cloud services for flexible working towards sufficiency
- How much digital interventions are *necessary* and how much is *superfluous*?
- **Method:** Focus groups within companies



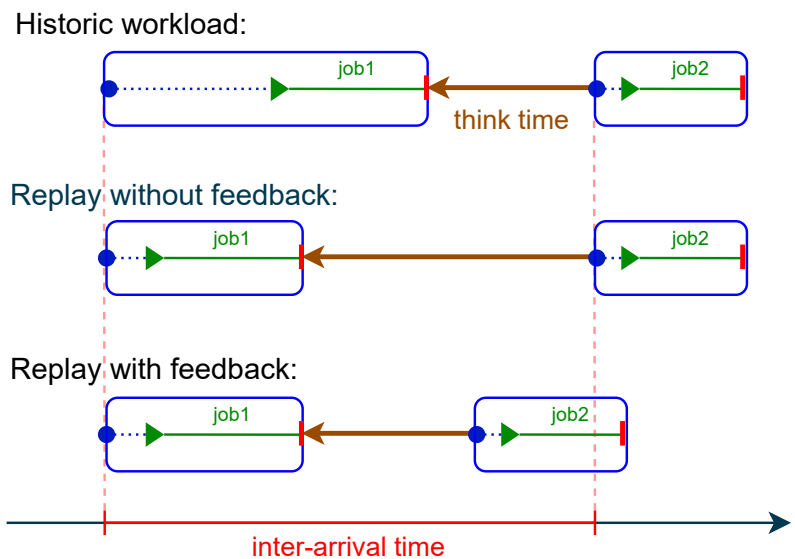




# Conclusion and research directions

# Future works

- Simulation work:
  - Home-made scheduler leveraging the user effort
  - Synergies with renewable energies
  - More realistic user submission patterns in simulations

**Replay with feedback: principle**




- Pilot study:
  - quantify the impact of the tactics towards sufficiency

# Conclusion

- Going beyond *efficiency*, investigating *sufficiency* in data centers
  - through **simulation** and **qualitative research** methods
- If interested, recent paper on Digital Sufficiency: Santarius et al. 2022[2]

- Please, do not hesitate to contact me :-)
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  - mael.madon@irit.fr

[2] T. Santarius et al., "*Digital sufficiency: conceptual considerations for ICTs on a finite planet*," Ann. Telecommun., May 2022, doi: 10.1007/s12243-022-00914-x