CNRS Interview: **Danilo Carastan dos Santos**

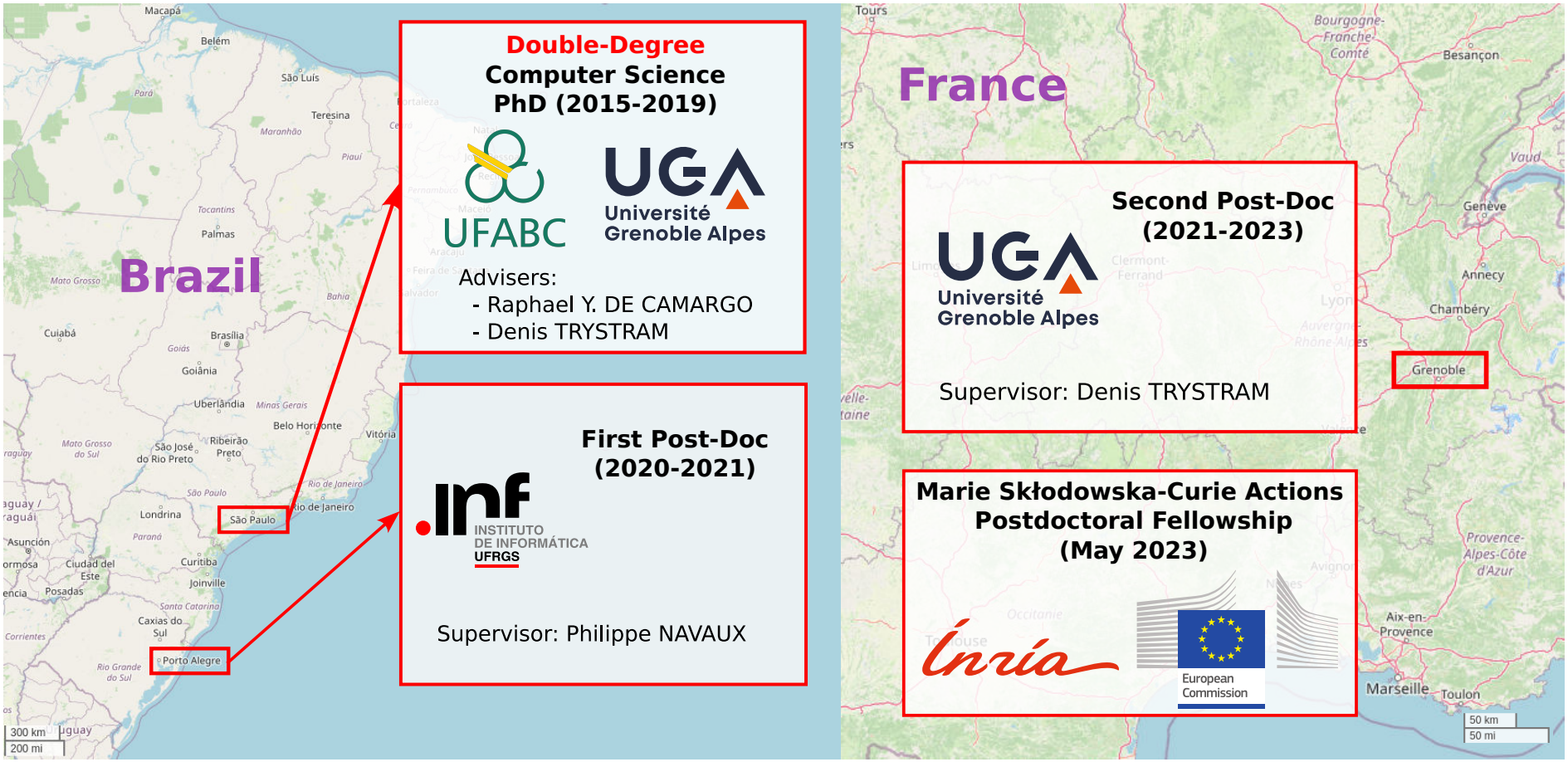
https://danilo-carastan-santos.github.io/

March 21, 2023

Outline and Keywords

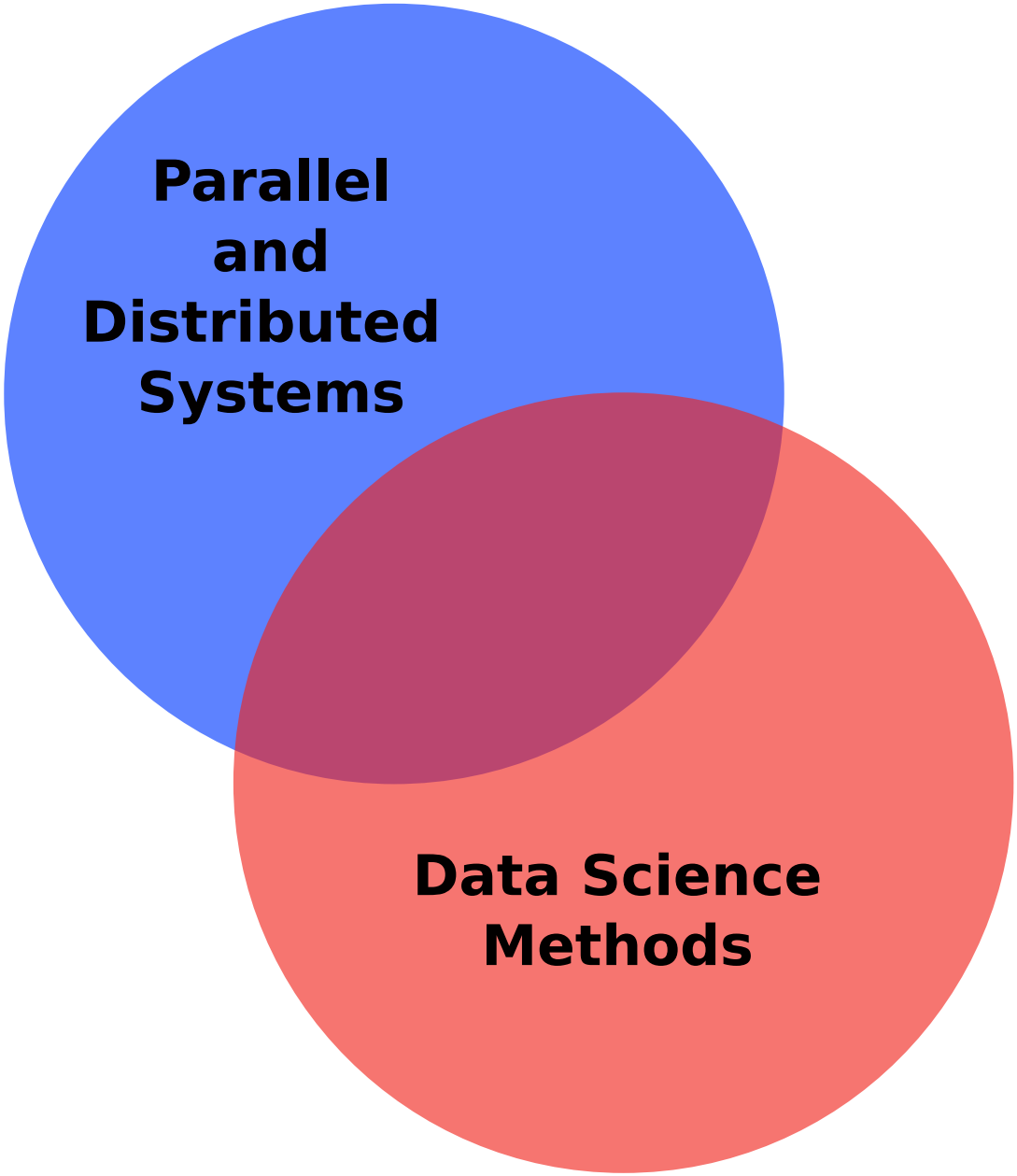
1. **Career path and research activity**
   - Distributed systems resource management
   - Data Science, Machine Learning and Experimental Analysis
   - Eco-responsible methods
2. Research project
   - Cloud/Fog/Edge Computing
   - Frugal, energy/CO2 emissions aware Edge Computing orchestration and simulation

Career Path

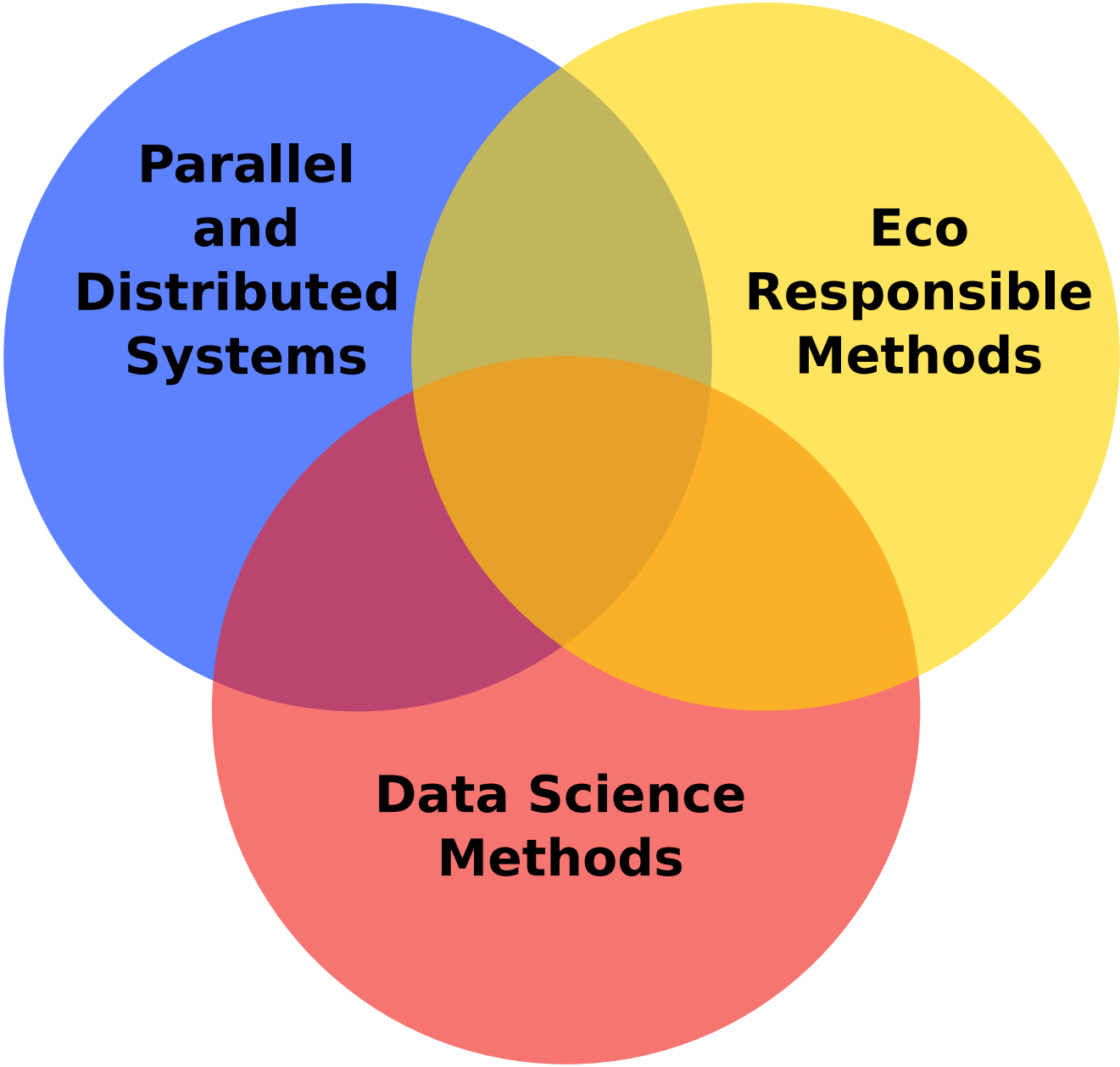


Map soruce: OpenStreetMap contributors.

Research Activity (2015-2021)



Research Activity (2022-present)



Some of my contributions to the disciplines

Parallel and Distributed Systems and Data Science/Machine Learning

- **Publication:** Danilo Carastan-Santos, and R. Y. de Camargo. SC (a.k.a. "SuperComputing") 2017 **(Core Rank A, Best Paper and Best Student Paper finalist)**
- **Publication:** Danilo Carastan Santos, R. Y. de Camargo, D. Trystram, S. Zrigui. CCGrid 2019, **Core Rank A, Best Paper Award)**
- **Publication:** V. S. Girelli, F. B. Moreira, M. S. Serpa, Danilo Carastan-Santos, and P. OA. Navaux. CCPE, 2021
- **Publication:** L. Rosa, Danilo Carastan-Santos, and A. Goldman. JSSPP 2023

Data Science and Eco-Responsible Methods

- **Invited Presentation:** with, K. Rzadca, L. Sousa and D. Trystram. Euro-Par 2022

Eco-Responsible Methods and Parallel and Distributed Systems

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- **Publication:** Danilo Carastan-Santos and T. H.T. Pham, CARLA 2022

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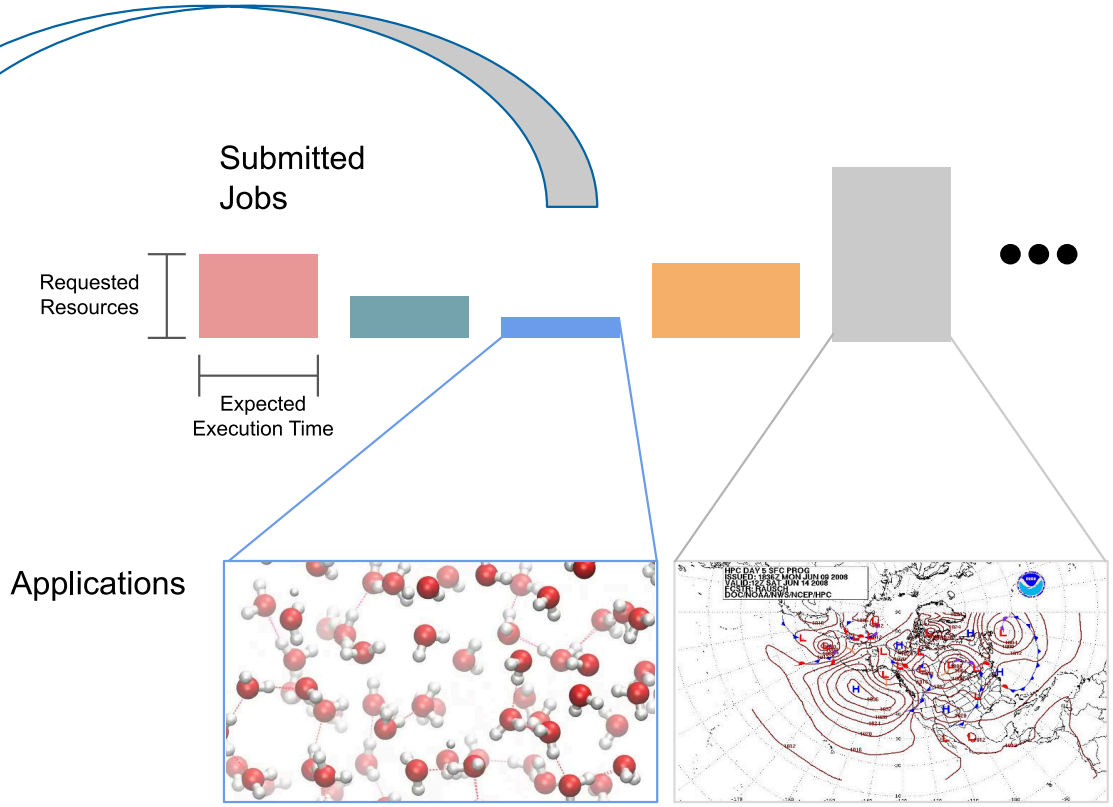
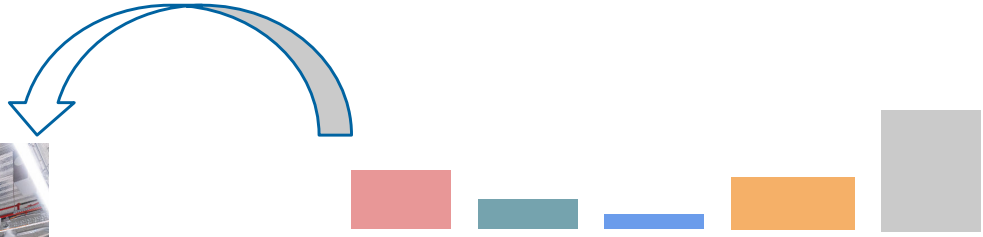
High-Performance Computing Resource Management



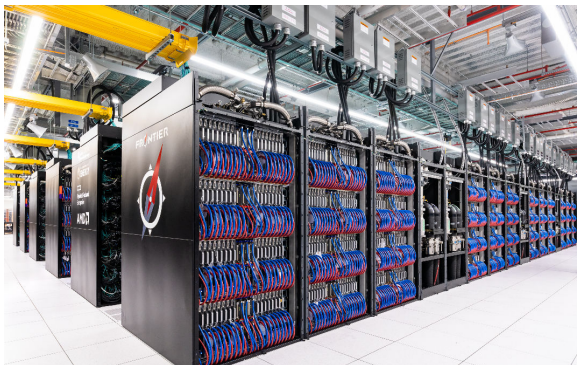
NP-Hard, difficult to be treated theoretically

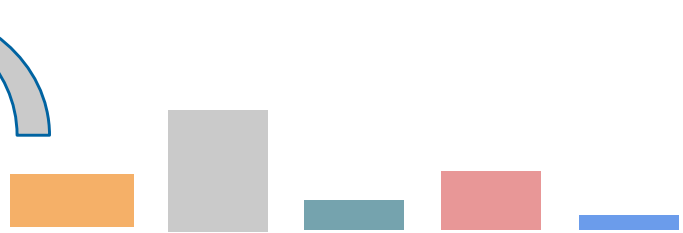
Figure source: Bleuse, R. (2017). Apprehending heterogeneity at (very) large scale (Doctoral dissertation).

Machine Learning to do better decision-making (reorder of applications)



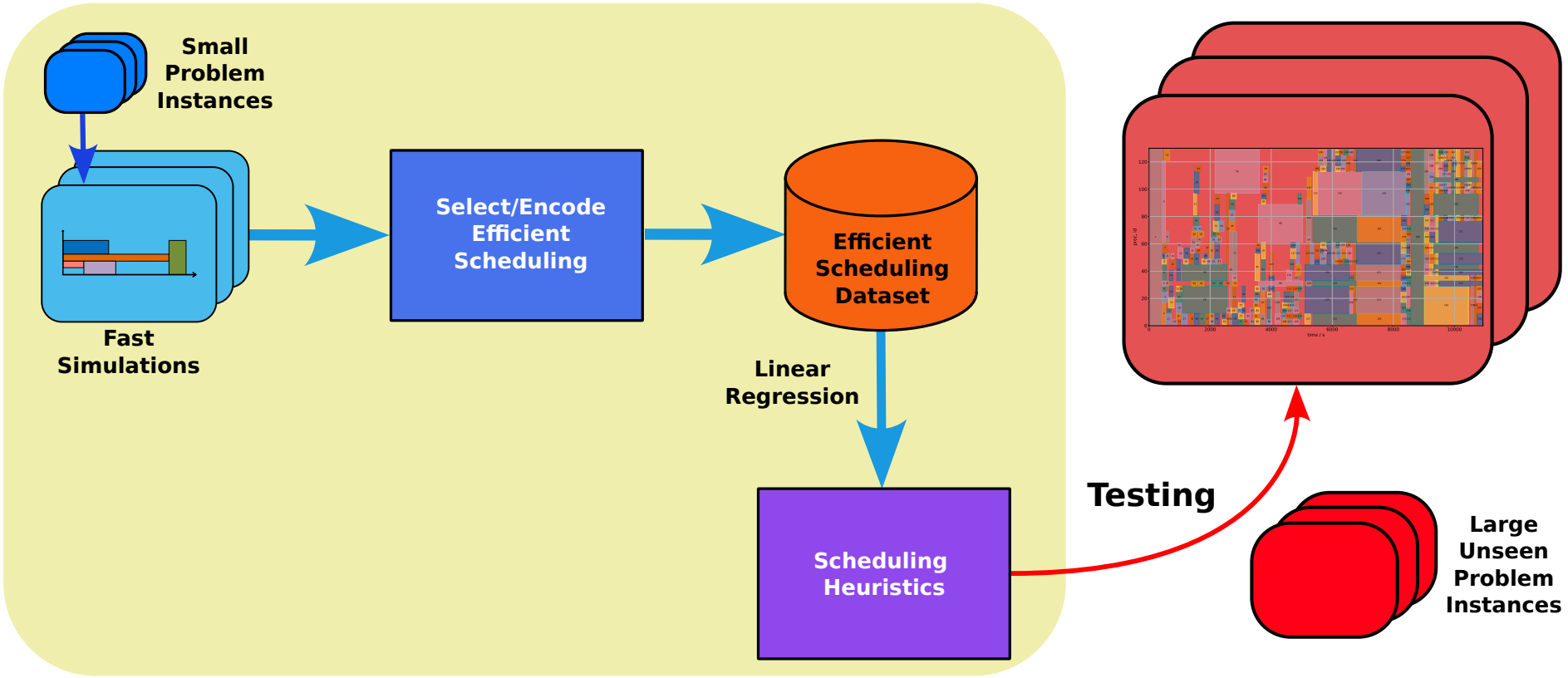
Or?





Machine Learning to do better decision-making[1] (reorder of applications)

Proposed method



[1] Danilo Carastan-Santos and Raphael Y. de Camargo. In: SC '17. 2017 **(Core Rank A, Best Paper and Best Student Paper award finalist)**.

Research activity highlights

Selected publications

1. **Danilo Carastan-Santos**, and R. Y. de Camargo. SC 17 (a.k.a. "SuperComputing"), 2017, **Core Rank A**
2. **Danilo Carastan Santos**, R. Y. de Camargo, Denis Trystram, Salah Zrigui. CCGrid, 2019, **Core Rank A**

Research supervision

- 7 students (Undergraduate and Masters)

Invited presentations

- 2nd Inria-DFKI European Summer School on AI (IDESSAI 2022)
- Euro-Par 2022. With, K. Rzadca, L. Sousa and D. Trystram.

Prizes and Awards

- **Marie Skłodowska-Curie Actions Postdoctoral Fellowship** 2023.
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- **Best PhD Thesis Award**, WSCAD 2020.
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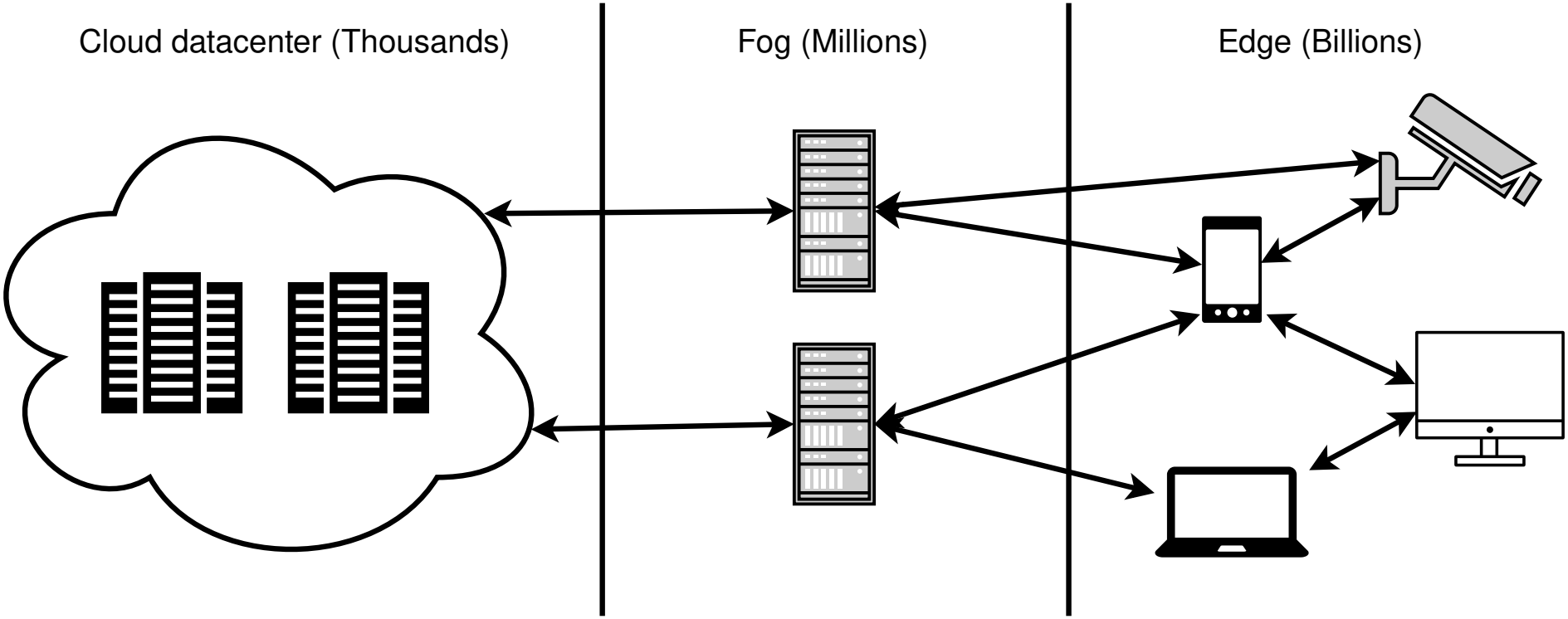
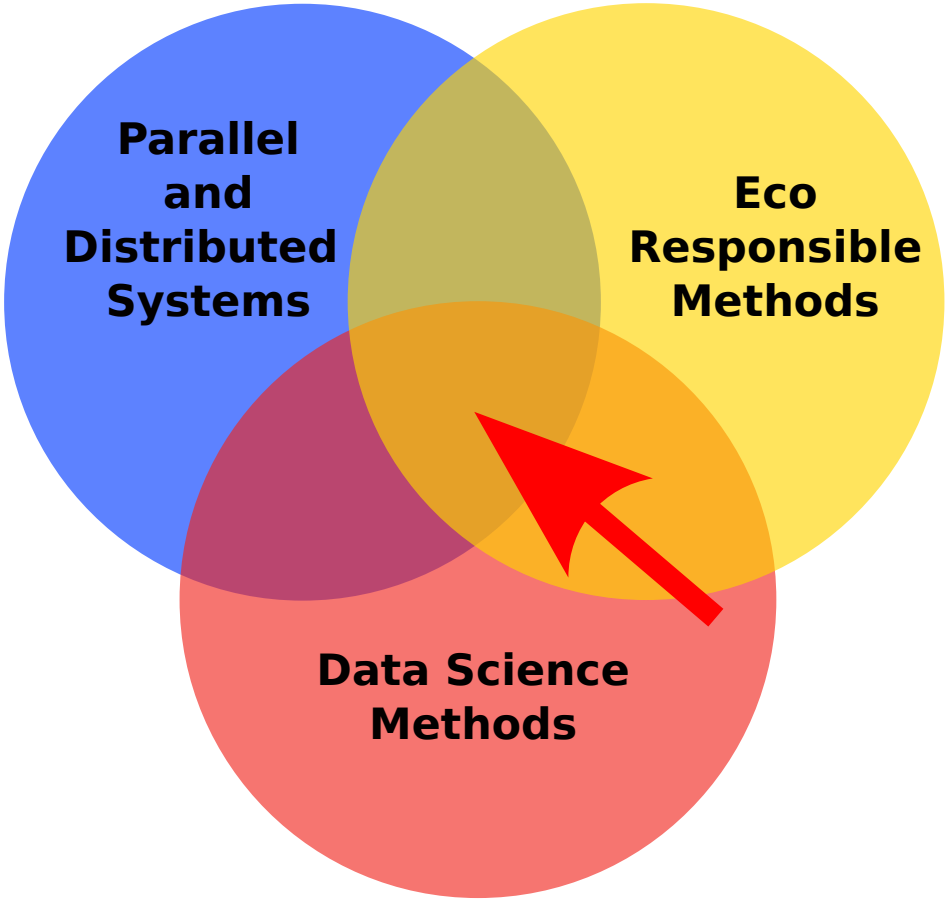
Research program's context

Evolution towards Cloud/Fog/Edge Continuum



- **Constraints:** processing power, communication, storage, energy mix
- **Geospatial, largely distributed nature**
- **Dynamic workloads:** e.g, Artificial Intelligence (Edge Intelligence)
- **Stochastic environment**

Research Objective



Objective: **Data Science, Machine Learning** to create frugal, **Eco-responsible** methods for managing and simulating **Edge Computing** and **Edge Intelligence**.

Research program's objectives

Objectives:

- **Axis 1:** Frugal, energy and CO2 emissions-aware Edge Intelligence orchestrators.
- **Axis 2:** Frugal and explainable models for Edge Computing network simulation.
- **Axis 3:** Energy, CO2 emissions-aware and dynamic infrastructure Edge Computing simulation.

Frugality of the methods

- High-level performance with fewer resources
- Easy to understand, efficient in practice
- Eco-responsible

Axis 1: Edge Computing/Intelligence orchestrators

Resource allocation, applications scheduling

Research question: Can we create efficient and frugal orchestrators?

- To minimize the energy consumption/CO2 emissions

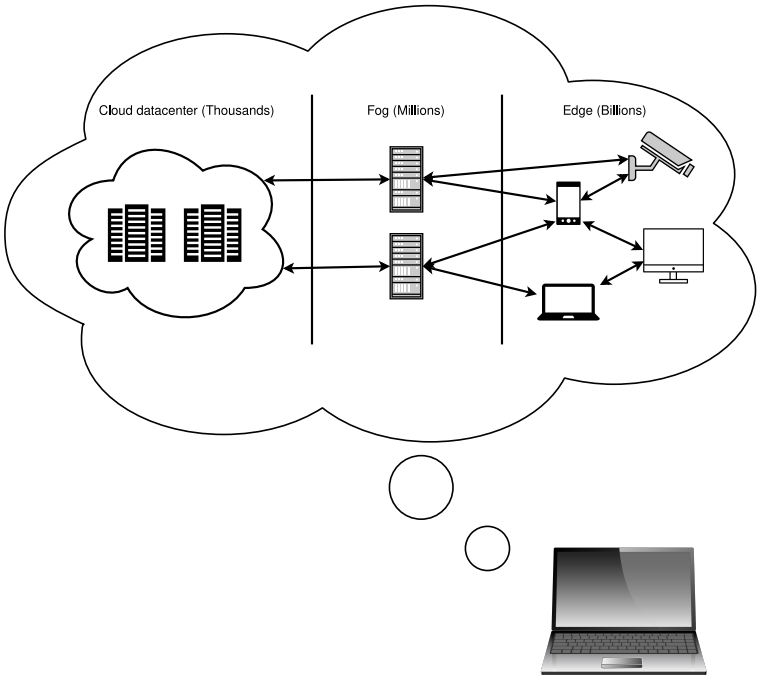
Method:

1. **Data Science:** Small-scale experiments/simulations → observations/hypothesis
2. **Machine Learning:** Small-scale experiments/simulations → dataset → supervised learning (linear regression, decision trees)

Collaborations:

- IRISA: Anne-Cécile Orgerie and Guillaume Pierre
- IRIT: Jean-Marc Pierson, Patricia Stolf, and Georges Da Costa

Axis 2 and 3: Edge Computing/Intelligence Simulation



- **Challenges**
  - Simulation speed
  - Simulation of Edge-specific characteristics
  - Energy/CO2 emissions simulation
- **Method**
  - Build upon SimGrid[2] to achieve large-scale Edge Computing simulation
    - Fast, scalable, validated, and well maintained

[2] (Henri Casanova et al. In: *JPDC* [2014])

Axis 2: Models for Edge Computing network simulation

Example: Wi-Fi channel throughput model[3] $T(x)$ in the function of concurrent flows x.

$$T(x) = \begin{cases} B_{max} & \text{if } x < thresh \\ ax + B_{max} & \text{if } x \geq thresh \end{cases}$$

Research questions

1. How to instantiate wireless models' parameters?

Method

1. **Data Science:** Small-scale experiments/simulations → observations/hypothesis
2. **Machine Learning:** Small-scale experiments/simulations → dataset → supervised learning

Collaborations:

- IRISA: Anne-Cécile Orgerie, Martin Quinson and François Lemercier
- IRIT: RMESS team

[3] Clément Courageux-Sudan et al. In: *MSWiM*. 2022.

Axis 3

Energy, CO2 emissions-aware and dynamic infrastructure Edge Computing simulation

- Edge Computing platforms are **highly dynamic**
  - Devices can move or shut down
  - Energy mix (e.g., solar panels)
- **Research question**
  - Simulate dynamic platforms?
  - Estimate the environmental impact (CO2 emissions) of the platform?
- **Method**
  - Model the Cloud/Fog/Edge continuum by dynamic graphs
  - Estimate CO2 emissions based on energy mix and life cycle analysis data

Collaborations:

- IRISA: Anne-Cécile Orgerie and Martin Quinson
- IRIT: Georges Da Costa and Millian Poquet

Frugal, energy and emissions aware, orchestration and simulation of Edge Computing and Edge Intelligence

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