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Towards an Energy-Aware Multi-objective Scheduling Policy for Server-based Edge-Cloud Continuum

Compas 2023

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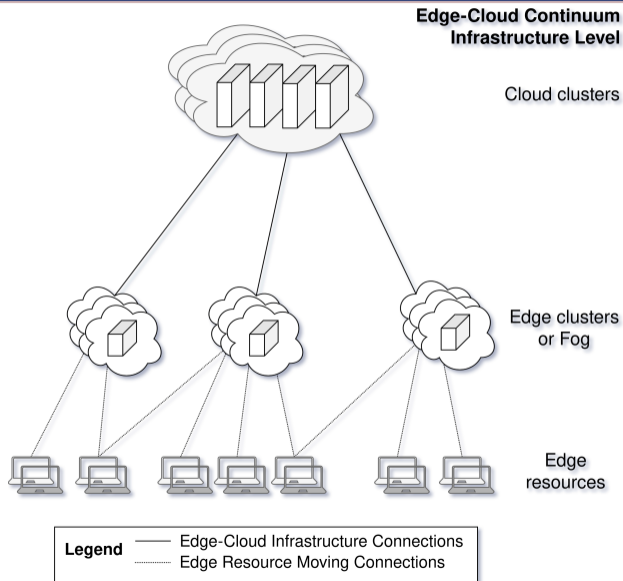
<https://andersonandrei.github.io/>

4-7 of July of 2023

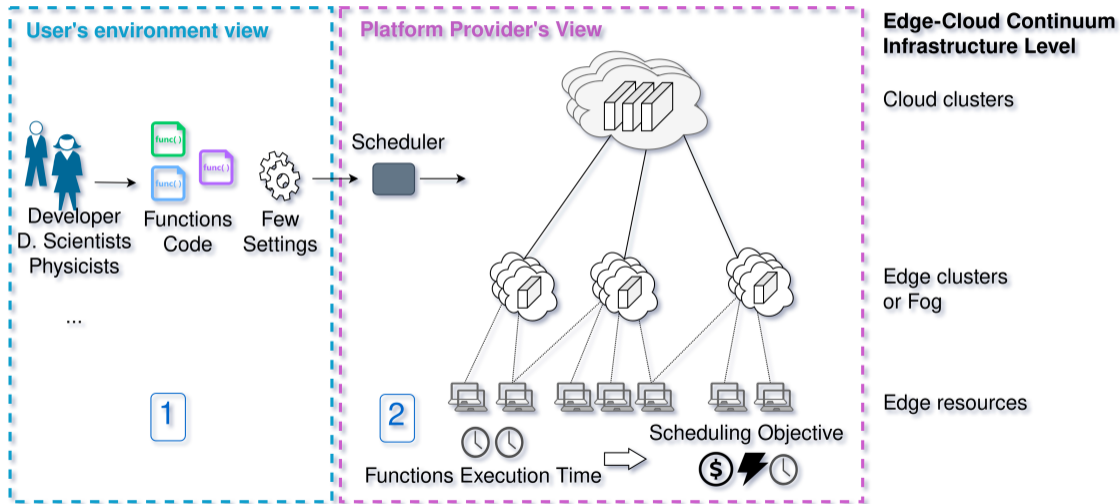


PHYSICS

The edge-cloud continuum



Serverless Computing and the Edge-Cloud Continuum



Towards a Multi-objective Scheduling Policy for Serverless-based Edge-Cloud Continuum

Towards a Multi-objective Scheduling Policy for Serverless-based Edge-Cloud Continuum

The 23rd IEEE/ACM International Symposium on Cluster, Cloud and Internet Computing
Bangalore, India — May 1-4, 2023

L. Angelelli¹, **Anderson Andrei Da Silva**^{1 2}, Y. Georgiou²,
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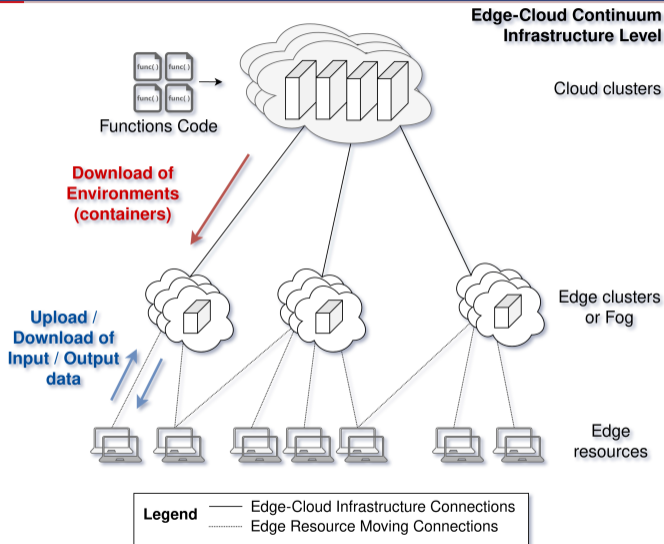
<https://gitlab.com/andersonandrei/foa-a-multi-objective-scheduling-policy-for-serverless>

Thanks to the Intelligence of the Multi-disciplinary Institute on Artificial Intelligence MIAI at Grenoble Alpes (ANR-19-P3IA-0003), to the European Union's Project H2020 PHYSICS (GA 101017047), and to the Grid'5000 testbed (<https://www.grid5000.fr>).

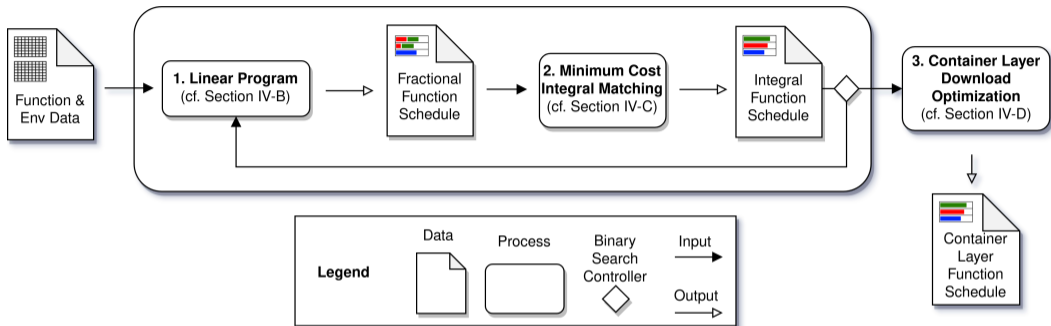


Reproducible
Artifacts

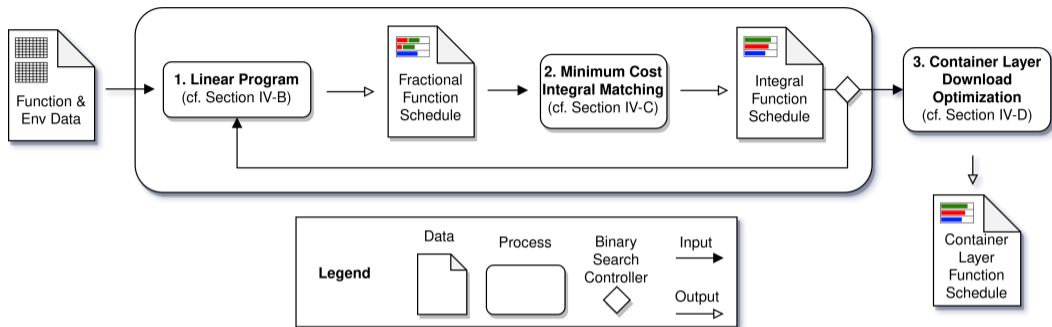
Motivation 1 and a multi-objective approach



FOA: Function Orchestration Algorithm



FOA: Function Orchestration Algorithm



Assumptions:

- 1) Functions and environments are independent and known in advance;
- 2) Their cost and processing time on each machine are known;
- 3) The dependency between functions and environments is known.

*The *Minimum Cost Integral Matching* phase uses the Dual-Approx. Algorithm of Shmoys and Tardos [D. B. Shmoys and E. Tardos, "An approximation algorithm for the generalized assignment problem," *Math. Program.*, vol. 62, no. 1-3, p.461-474, Feb. 1993].

Experimental Protocol

- Adaptation of the benchmark **FunctionBench** ¹,
- Deployment of **OpenWhisk** ² on **GRID5000** ³,
 - Measurement and calibration of results.
- Evaluation of scheduling policies FOA, K8S ImageLocality (baseline):
 - In a **simulated environment**,
 - On top of **Batsim/ Simgrid** [H.Casanova et.al, 2014].

¹ <https://github.com/kmu-bigdata/serverless-faas-workbench> ,

² <https://openwhisk.apache.org/>,

³ <https://www.grid5000.fr> .

Parameters	Values
Workload Size	200, 600, 1000
Platform Size	100, 300, 500
Heterogeneity Level	3, 5, 7
Scheduling Policies	FOA, <i>K8S ImageLocality</i>
Random Seeds	30

Table 1 Design of Experiments. Total of 1620 experiments.

Design of Experiments

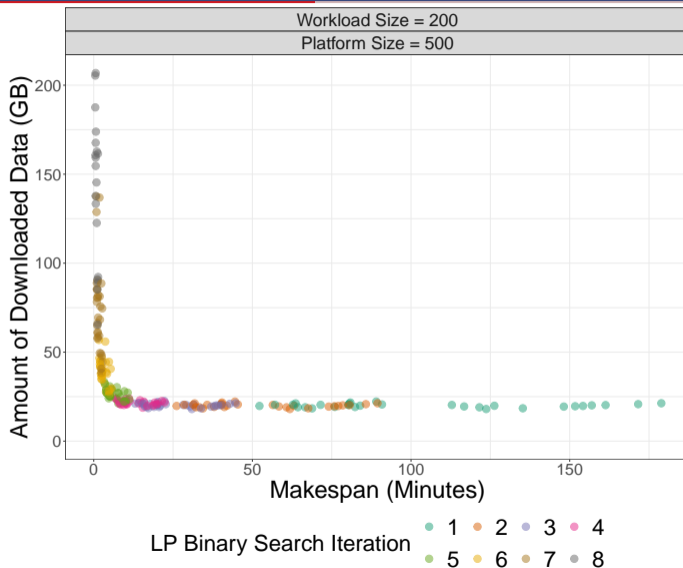
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Table 1 Design of Experiments. Total of 1620 experiments.

Function	Input Values	Unit
Chameleon	$2 \cdot 10^3$, $3 \cdot 10^3$	Matrix size
Float operation	$10 \cdot 10^7$, $20 \cdot 10^7$, $30 \cdot 10^7$	Operations
Image processing	60, 40	Image size in MB
Linpack	$5 \cdot 10^3$, $6 \cdot 10^3$	Matrix size
Matrix Multiplication	$3 \cdot 10^3$, $4 \cdot 10^3$	Matrix size
Model Training	50, 100	Dataset size
Pyaes	$3 \cdot 10^3$, $4 \cdot 10^3$, $5 \cdot 10^3$	Length of message
Video Processing	30, 50, 100	Video size in MB

Table 2: Functions adapted from FunctionBench.

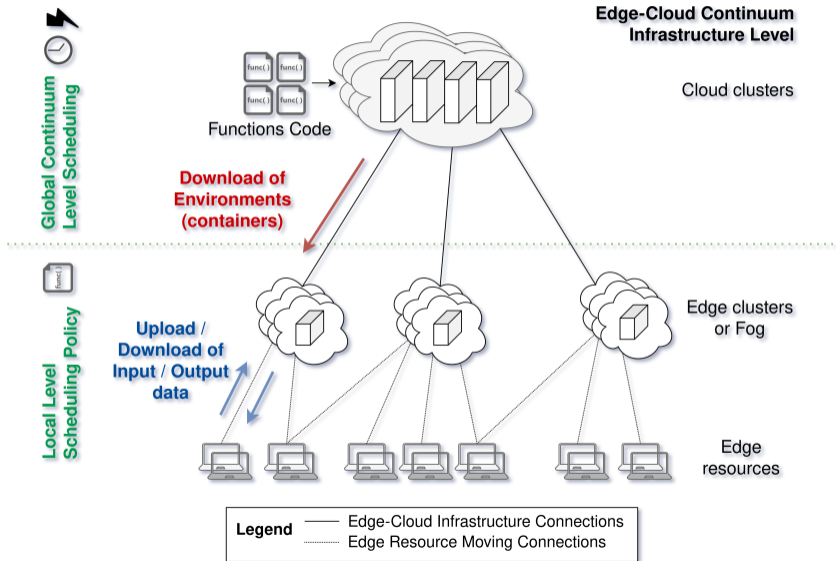
Experimental results: Linear program trade-off



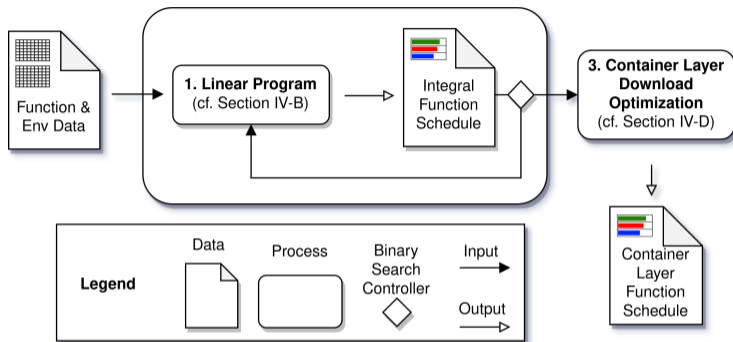
Conclusions - Part 1

- Cloud **greedy algorithms** may **not** profit from heterogeneity,
- FOA outperforms our baseline for both **data transfers** and **makespan** criteria, in addition to the **system utilization** by up to **two orders of magnitudes**,
- FOA minimizes **cold start delays** and **speed up** functions' **execution time**,
- However, FOA is very time-consuming.

Motivation 2 = Motivation 1 + Energy Consumption



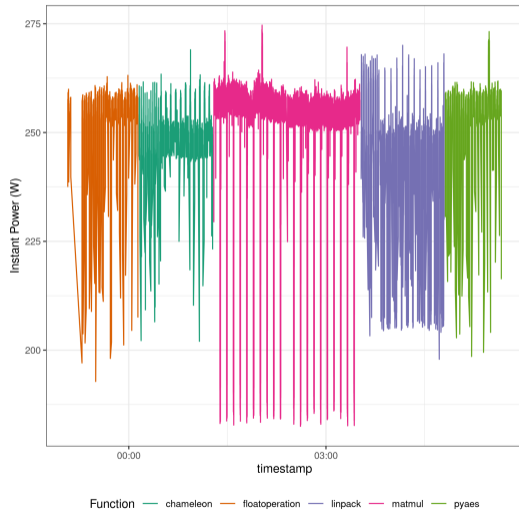
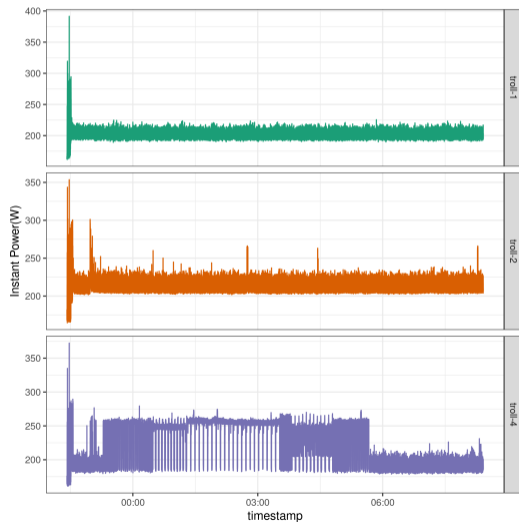
FOA-e: Function Orchestration Algorithm



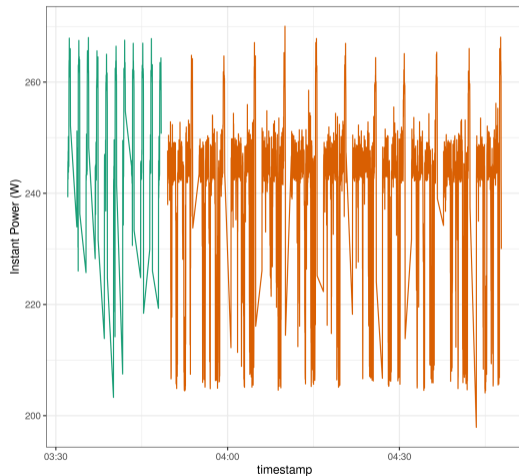
Assumptions:

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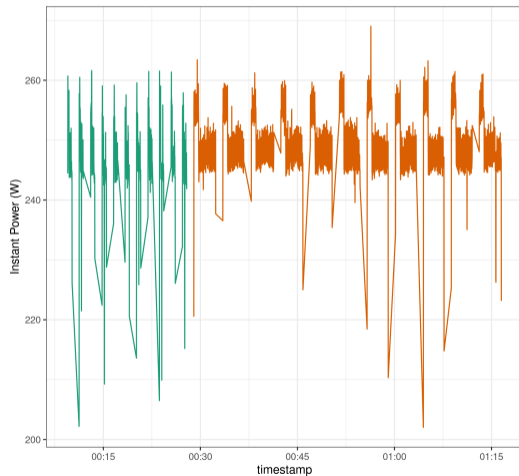
Energy Consumption on Serverless Platforms



Energy Consumption on Serverless Platforms

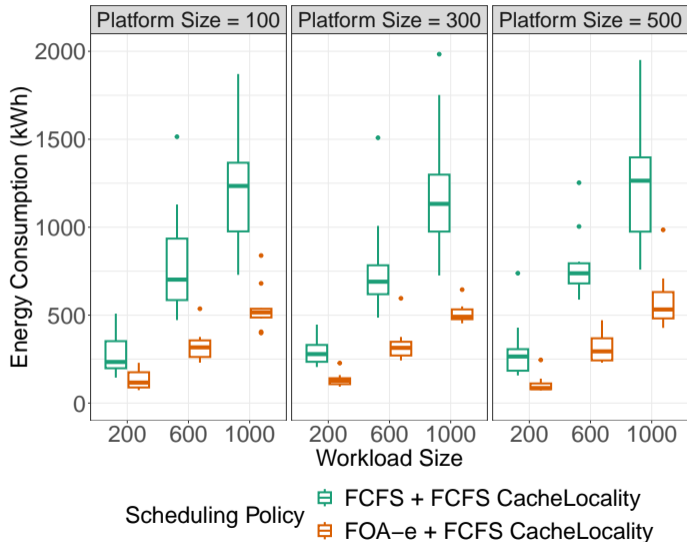


Function — linpack_5000 — linpack_6000



Function — chameleon_2000 — chameleon_4000

Experimental results: FOA-e Energy Consumption



Conclusions - Part 2

- Cloud **greedy algorithms** may **not** profit from heterogeneity,
- FOA-e outperforms our baseline for both **data transfers** and **energy consumption** criteria, in addition to the **system utilization**,
- FOA-e minimizes **cold start delays** and **speed up** functions' **execution time**,
- FOA-e has a scheduling time in order of seconds.

Conclusions - Part 2

- Cloud **greedy algorithms** may **not** profit from heterogeneity,
- FOA-e outperforms our baseline for both **data transfers** and **energy consumption** criteria, in addition to the **system utilization**,
- FOA-e minimizes **cold start delays** and **speed up** functions' **execution time**,
- FOA-e has a scheduling time in order of seconds.

Work in progress:

- We have implemented FOA-e to be executed in K8S,
- We have contributed to an Open-Source project called Kepler that measures the energy consumption of k8s components (containers, pods, nodes, etc).

- To improve FOA's **model** and try other linear programs' **solvers**,
- To study applications that can be modeled as **workflows** of serverless functions,
- To continue the investigations towards the reduction of energy consumption on serverless,
- To add both schedulers in the PHYSICS platforms,
- To include and use Kepler for a continuous measurement of the energy consumption,
- To perform experiments of k8s platforms to compare with the simulations and with default k8s scheduler.

Thank you for your attention! Any question?

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