September 2024

Recent works on Scheduling Algorithms, Libraries and Tools for all (SALT4all)

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Agenda

1. About me
2. Research motivation
3. Work: SDR on homogeneous resources
4. Work: FL on heterogeneous resources
5. Closing remarks

1. About me

Some previous or ongoing research topics of interest

Topology-aware, distributed, or energy-aware dynamic load balancing; Topology, thread, and data mapping; GPU reliability under radiation; Parallel algorithms and application parallelization …

Some work (but not research) topics of interest

Diversity and inclusion; Safety; Scientific communication; Reviewing; Reproducibility ...

2. Research motivation

Research: scheduling* as a means of providing performance

* “a mechanism or policy used to efficiently and effectively manage the access to and use of a resource by its various consumers”

Main research objectives

To propose efficient and effective scheduling algorithms

(to solve issues coming from parallelism and complexity)

To provide scheduling software that is readily available for use

(to make sure these innovations are accessible for those who need them)

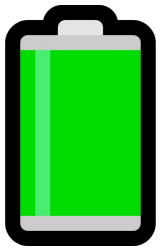
2. Research motivation

Challenges for scheduling algorithms

Scalability: more parallelism (in hardware and software) means more options and data to consider

Heterogeneity: more variety means harder decisions

Locality: more diverse distances means more waiting



Energy: new objectives and constraints mean different decisions have to be made

2. Research motivation

Challenges for scheduling software

Integration: complex software, usually integrated to its system of use, hard to reuse and migrate

Workloads: difficulty to measure and compare scheduling algorithms, lack of standards and best practices

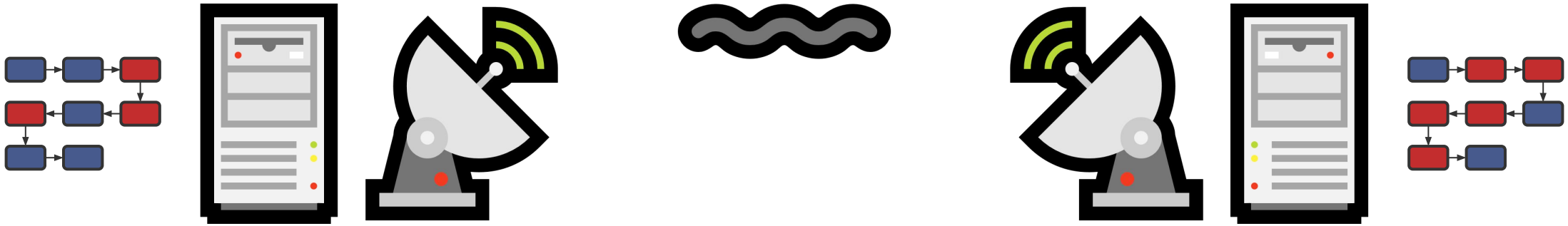
3. Work: SDR on homogeneous resources

Context: Software-Defined Radio

Implementing digital communication standards in software

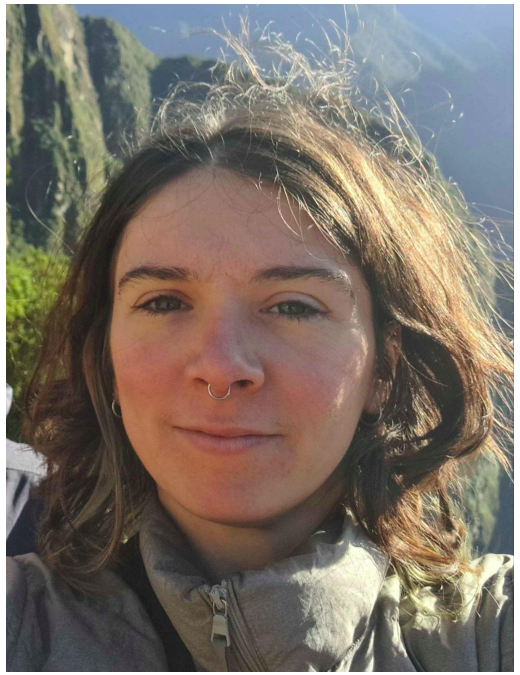
More flexible, easier to maintain, cheaper

Running on servers connected to antennas, satellites, etc



3. Work: SDR on homogeneous resources

Problem: performance and resource utilization in software

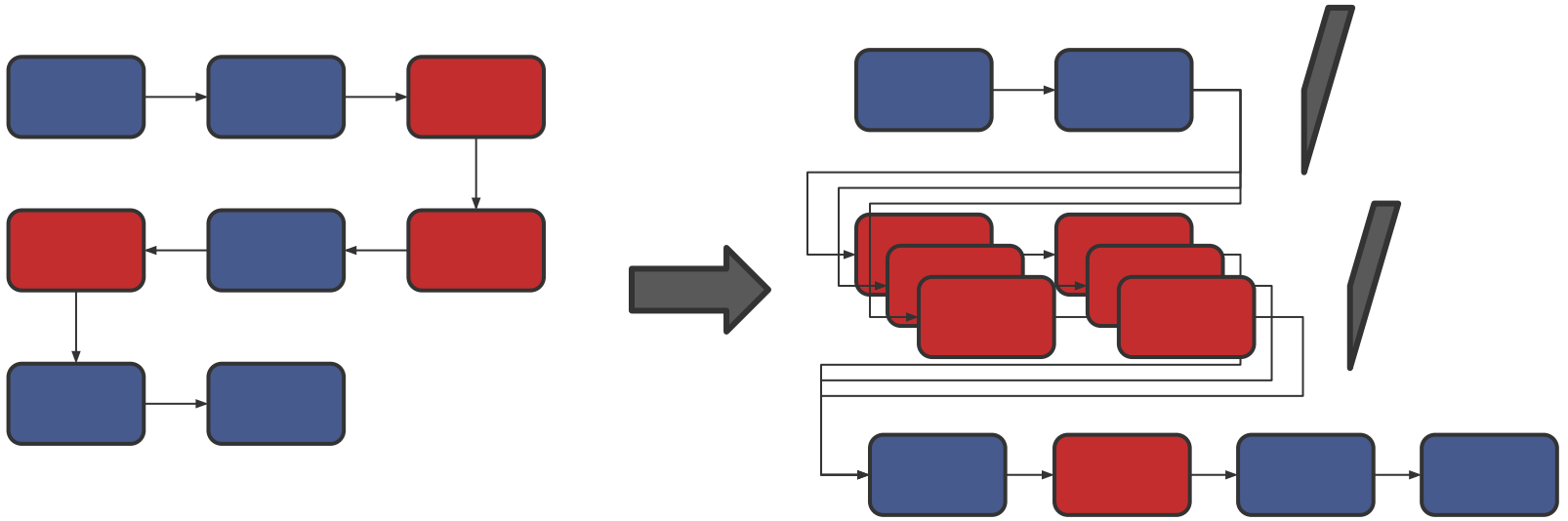


Diane Orhan's PhD

Task chain with **stateful** and **stateless** tasks

Use pipelining and replication to improve throughput

Solution: **OTAC** -> greedy algorithm + binary search



\+ 10 cores

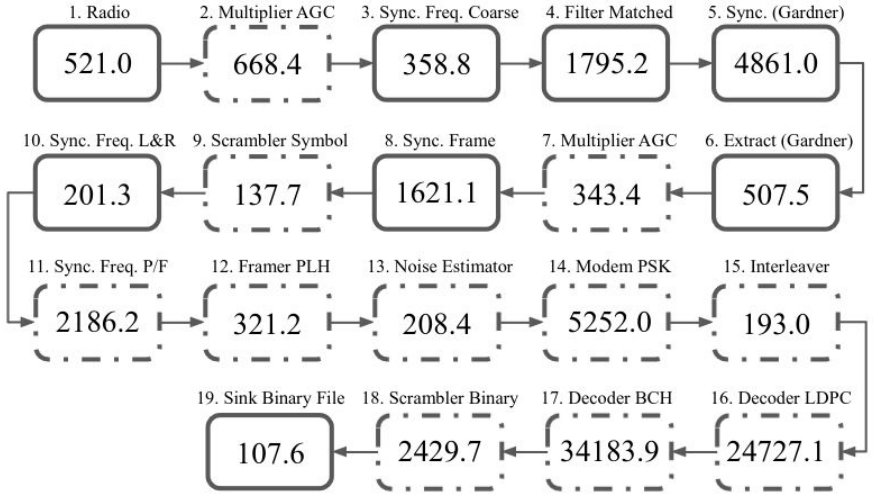
using 5 cores

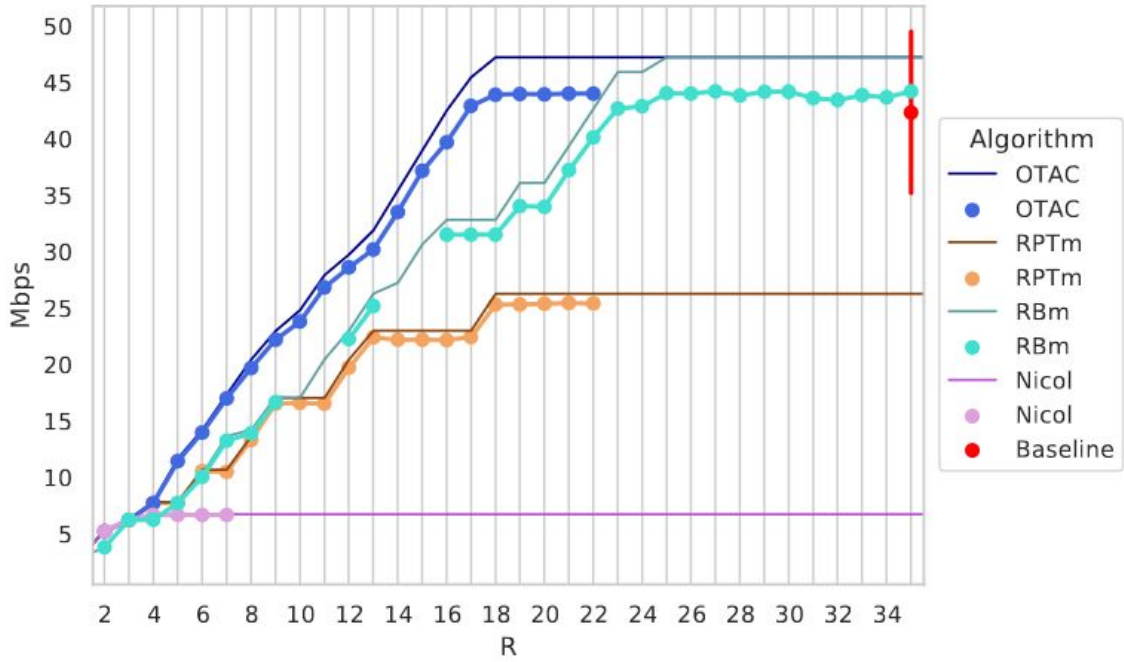
3. Work: SDR on homogeneous resources

Submitted 2024: optimal schedule with minimal resources

Optimal Scheduling Algorithms for Software-Defined Radio Pipelined and Replicated Task Chains on Multicore Architectures

Diane Orhan[1,a,*], Laércio Lima Pilla[1,a], Denis Barthou[1,b], Adrien Cassagne[1,c], Olivier Aumage[1,a], Romain Tajan[1,d], Christophe Jégo[1,d], Camille Leroux[1,d]





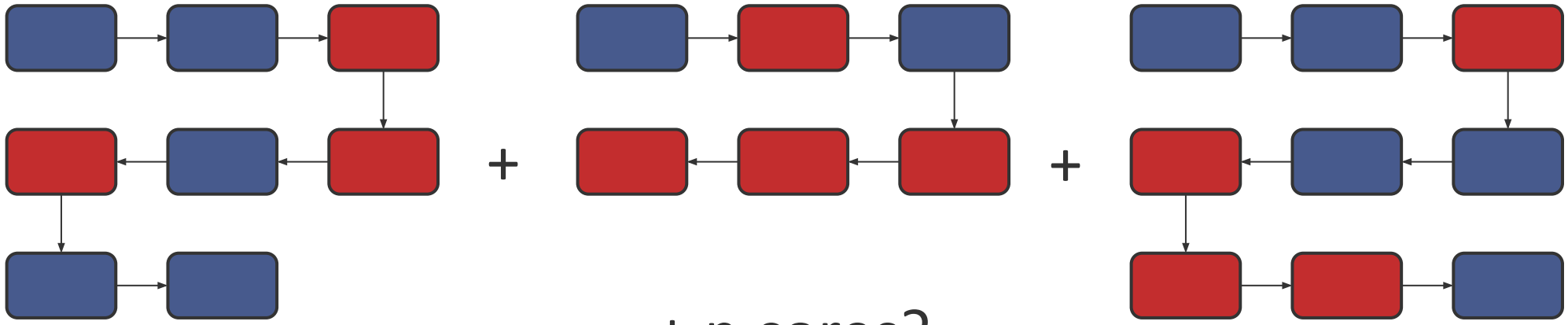
https://hal.science/hal-04228117

Implemented in AFF3CT

3. Work: SDR on homogeneous resources

Next steps: OTAC for more problems

- **Multiple chains** in the same resources
- More complex graphs
- Two kinds of resources
- New applications

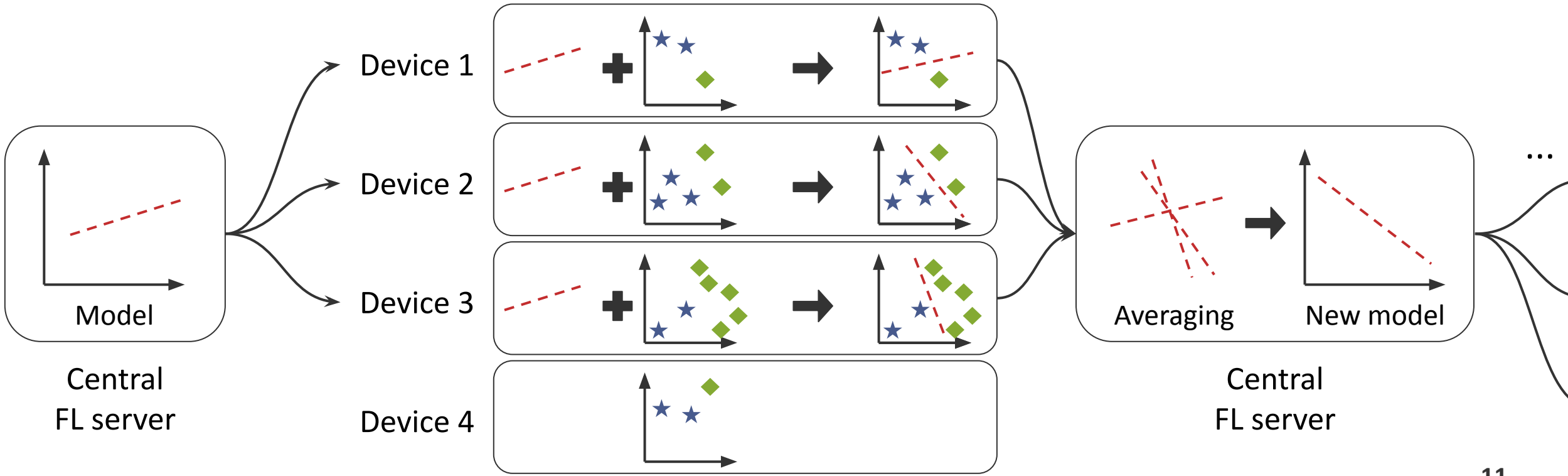


4. Work: FL on heterogeneous resources

Context: Federated Learning

Distributed learning + local data is never shared

Data parallelism in ML vocabulary



4. Work: FL on heterogeneous resources

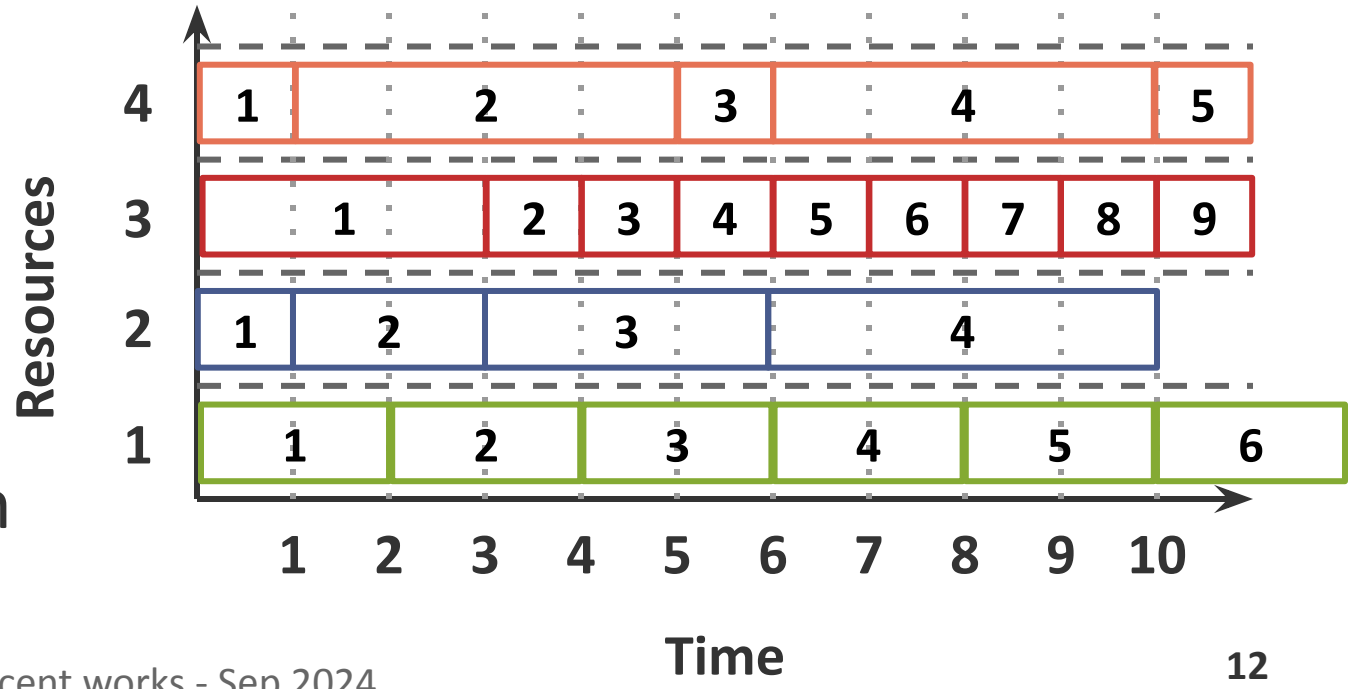
IPDPS 2021: Problem: time optimization

Optimal Task Assignment for Heterogeneous Federated Learning Devices

Laercio Lima Pilla

https://hal.science/hal-02954040

- Minimize training round duration (single round)
- Control the amount of work on each device
- Assuming increasing costs
- Optimal solution with time in O(n + T log n)



4. Work: FL on heterogeneous resources

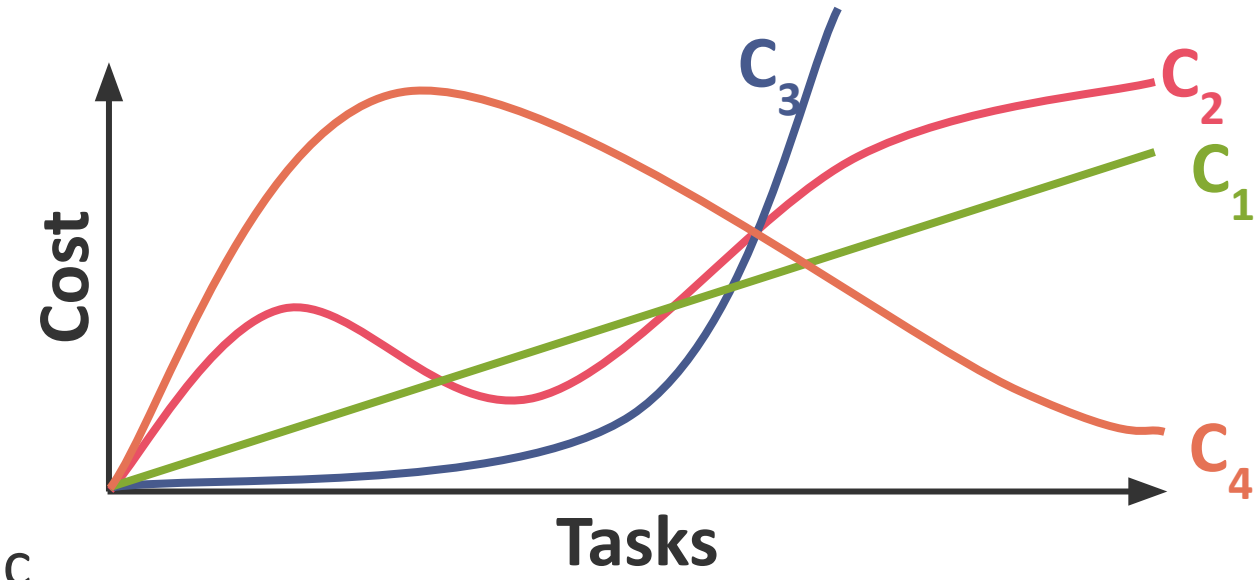
TPDS 2023: Problem: energy consumption / emissions

Scheduling Algorithms for Federated Learning With Minimal Energy Consumption

Laércio Lima Pilla

https://hal.science/hal-03775491

- Minimize total [energy] cost
- Control the amount of work on each device
- Optimal solution with time in $O(T^2n)$
  - ***Multiple-Choice Minimum-Cost Maximum Knapsack Packing Problem - $(MC)^2MKP$***
- Faster solutions for cases with specific marginal cost behaviors

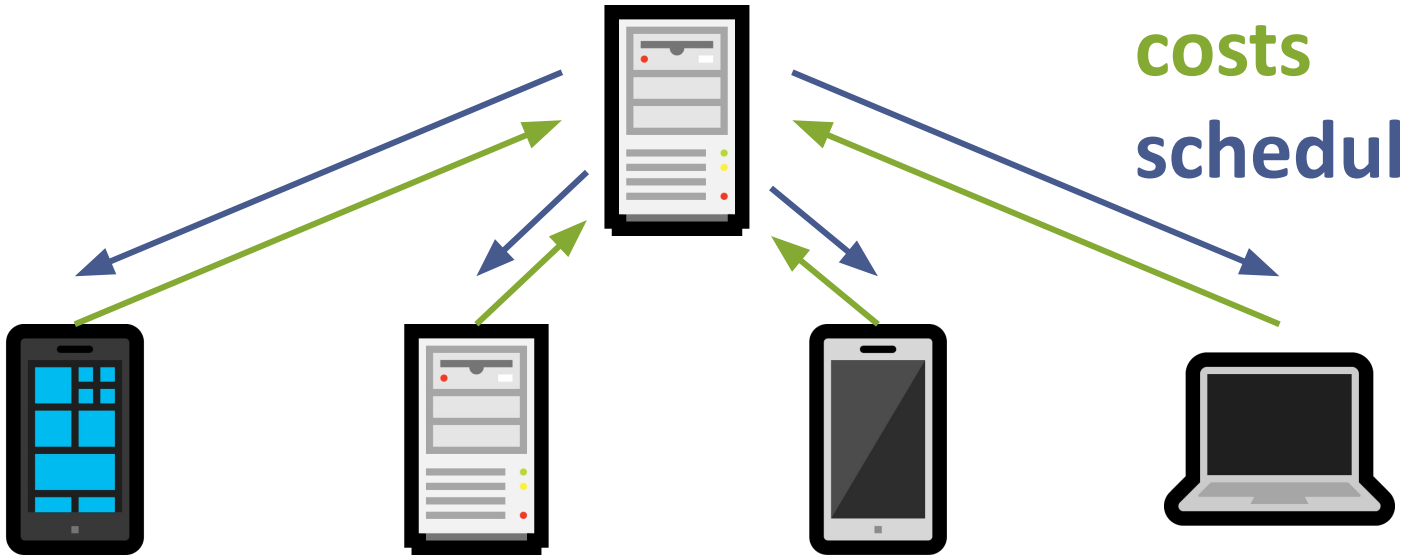


4. Work: FL on heterogeneous resources

Problem: optimize for time and energy (and others?)

Alan Lira Nunes' PhD

Obtain profiling information from clients
Define optimization objective
Compute and apply schedule
Make decisions for next training round



4. Work: FL on heterogeneous resources

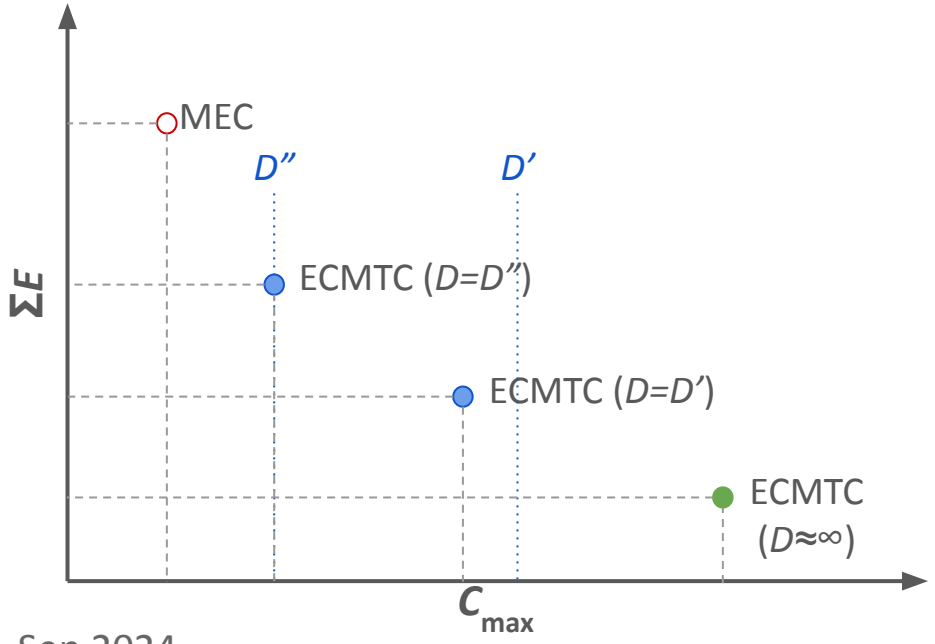
SBAC-PAD 2024 (accepted): time and energy optimization

Optimal Time and Energy-Aware Client Selection Algorithms for Federated Learning on Heterogeneous Resources

Alan L. Nunes[1,2], Cristina Boeres[1], Lúcia M. A. Drummond[1], Laércio L. Pilla[2]

- Lexical optimization
  - MEC - time first, energy second
  - ECMTC - energy first, time second, with a deadline
- Always in the Pareto front
- Implemented in Flower

https://hal.science/hal-04690494



4. Work: FL on heterogeneous resources

Next steps: improvements to the framework

- Different objectives
  - Scalarized (weighted sum)
  - Include accuracy
- Focus on the whole training process
  - Not just a single round
- Add new options to the scheduling framework
  - Heuristics
  - Affect other aspects than work distribution

5. Closing remarks

Motivation: ever-increasing difficulty to make a proper (optimized) use of computing systems

Research: scheduling algorithms and scheduling software

Opportunities for collaboration: see previous slides, or just talk to me

September 2024

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