Bebida Improvements and Optimizations

REGALE Project

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[1] [2]

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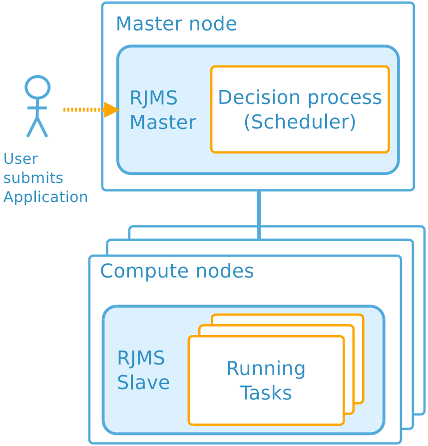
Resources and Jobs Management System (**RJMS**)

a.k.a. Batch scheduler

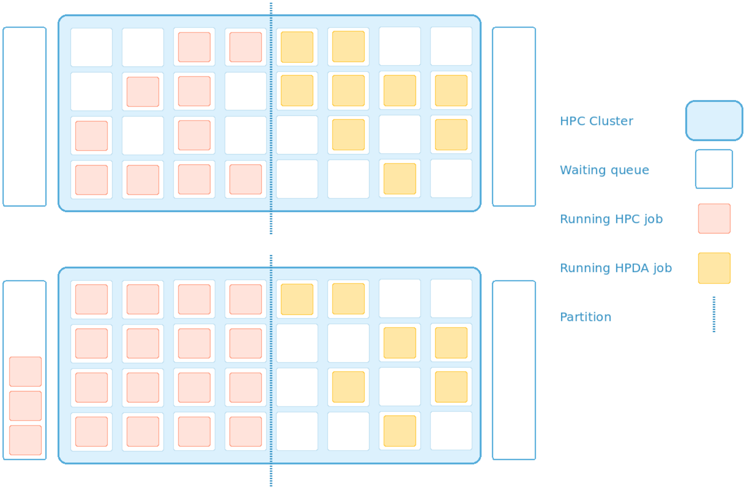
- Shares resources between users
- Resources are CPU, Memory, Network bandwidth, ...
- Conflicting objectives:
  - Minimize waiting time
  - Maximize jobs throughput
  - Maximize cluster utilization
- Examples:
  - HPC: SLURM, OAR, PBS, ...
  - Big Data and Cloud: Hadoop YARN, Kubernetes ...



RJMS are complex:
SLURM and YARN $\simeq$ 400k lines of code

What's happening today

Static partitioning



Static cluster partitioning:

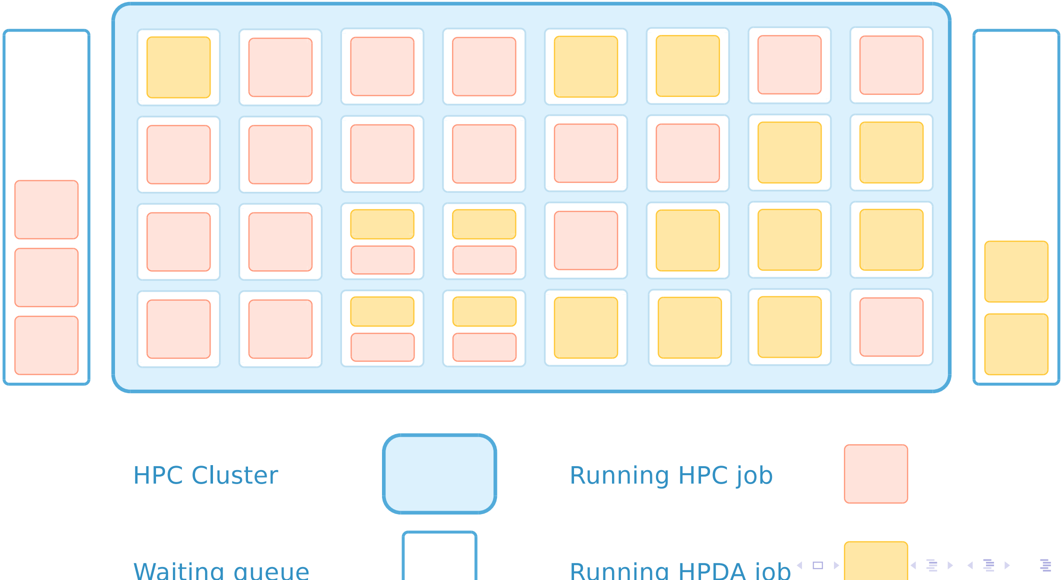
- Simple workload discrimination
- No node sharing

Leads to resources waste!

- When one queue is filling up
- Available nodes on the other partition are not used

What we want to achieve

Dynamic sharing

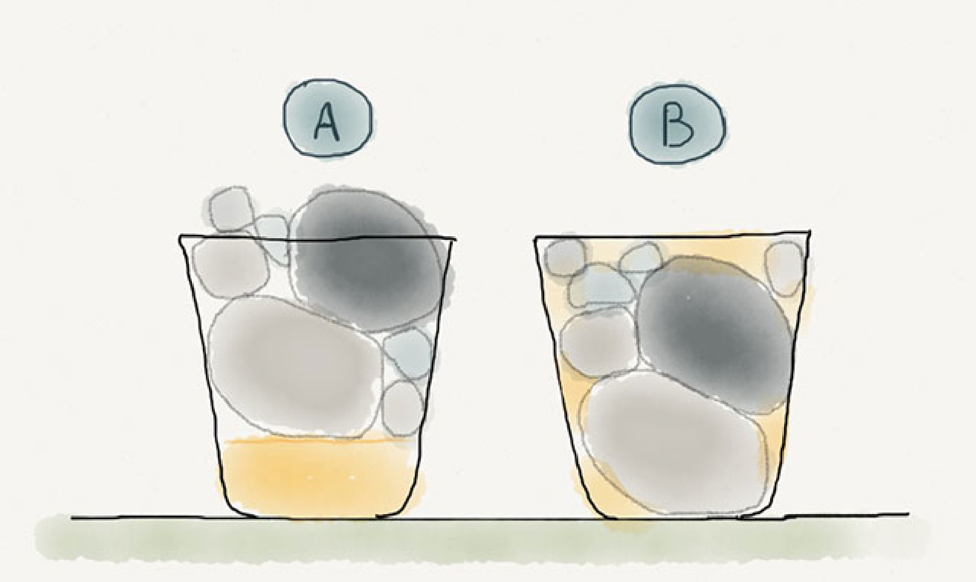


An analogy

Is the Jar Full?

A Scheduling Problem

Solutions



Big Data and HPC workload Collocation

At the Resource Management Level

Jar: HPC Hardware Cluster

- Resources (CPU cores)
- Time (seconds)

Stones: HPC Jobs

- Static resource allocation
- Static time allocation

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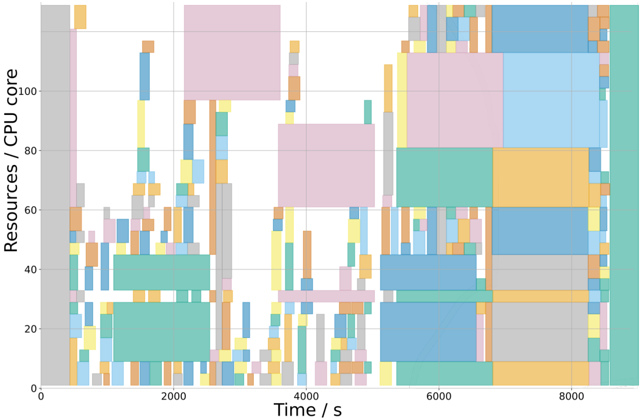
Sand: Big Data Applications

- Dynamic resource allocation
- Resilient to resource preemption



Existing Approaches for Collocation

Related Works

BigData in HPC job

- Setup/teardown at every job
- Need to import/export data

Two-level Scheduling

- Dynamically resources sharing negotiation
- Increase operational cost
- New API implementation required

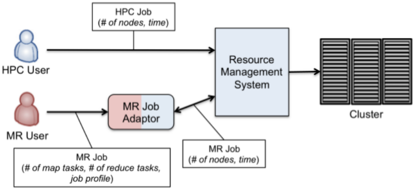
Examples: Mesos, Omega, Grid Engine

The major problem is complexity:
=> from 5k to 50k lines of code

RJMS adaptor

- HPC RJMS provides resources to Big Data
- Convert BigData resource requests
- Walltime problem

Examples: Neves et al. (Euro-Par 2012), Intel YARN adaptor



Keep it Simple

Requirements

We wants our solution to:

1. **Use existing tools unmodified** (RJMS + Applications)
2. **Work for any RJMS**
3. **Transparent for users**
4. **Minimal disturbance to HPC jobs** from Big Data applications
5. **Leverage Big Data dynamicity and resilience**

BeBiDa: Best effort Big Data on HPC cluster

Using HPC idle resources for Big Data analytics

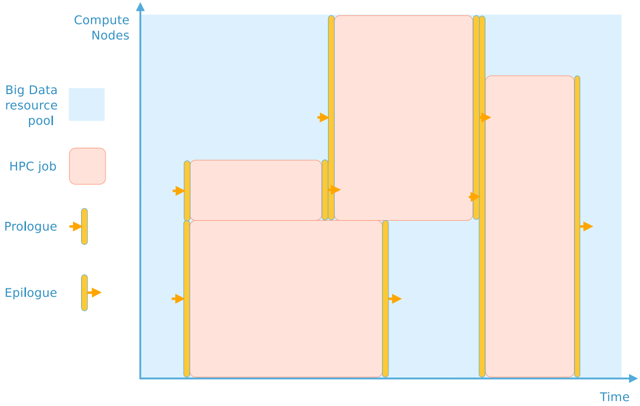
HPC: job's prolog/epilog (50 LoC)

BigData: resources {de}commission

1. *Initially:*
   Nodes are attached to the Big Data resource pool

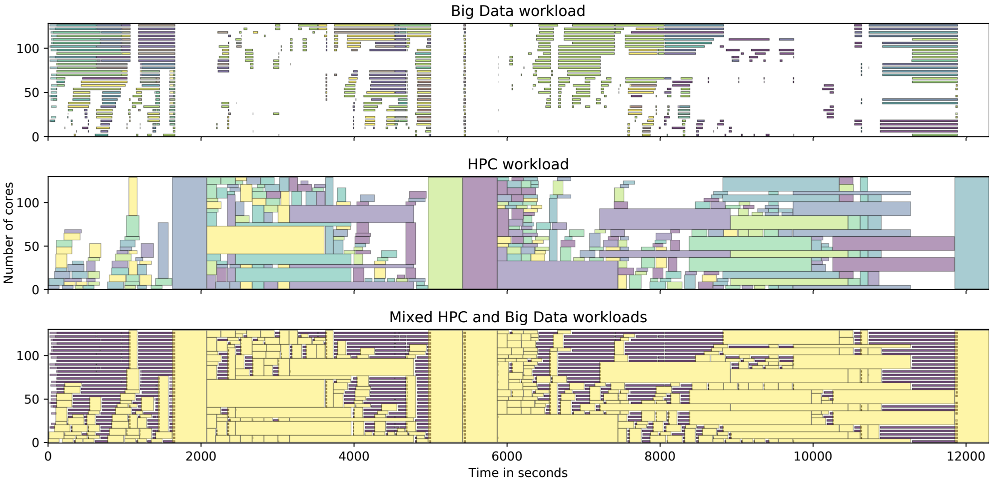
2. *When an HPC job starts:*
   Prologue decommissions the resources

3. *When an HPC job finishes:*
   Epilogue is giving resources back



BeBida Working Example

From 70% to 100% utilization



Resource Preemption Impact on Big Data

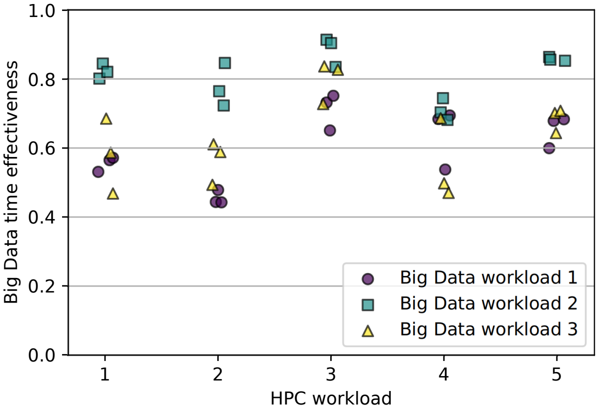
Measure effective computation time

Time Effectiveness

$$E = \frac{\textit{Useful computation time}}{\textit{Total computation time}}$$

Variability root causes:

- HPC workloads shape
- Big Data workload applications sensitivity
- Coincidence between "holes" and large applications
- System noise



Overhead on HPC Workloads

With and without BeBiDa

Mean Execution Time

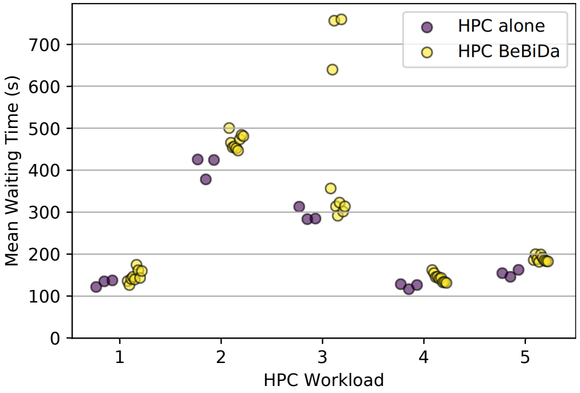
+6% on average with BeBiDa

Mean Waiting Time

- epilog/prolog: < 16s
- 26% (1min) to 1% (30min) of the jobs execution time
- +17% on average with BeBiDa

Variability root causes:

- Scheduling anomalies
- Network contentions
- DFS daemon



Key Characteristics

Advantages and Drawbacks

Performance impact

- HPC execution time +6% on average
- HPC waiting time +17% on average
- High variability in Big Data efficiency (68% on average)

BeBiDa main advantages

- Use any existing RJMSs without modification
- Transparent for users
- HPC workload has priority
- Only $\simeq$ 50 lines of code + configuration

  100 to 1000 times less code
- Increase the cluster utilization
- Uses resources that would be idle otherwise

Fully reproducible experiments and analysis:
`https://gitlab.inria.fr/mmercier/bebida/`

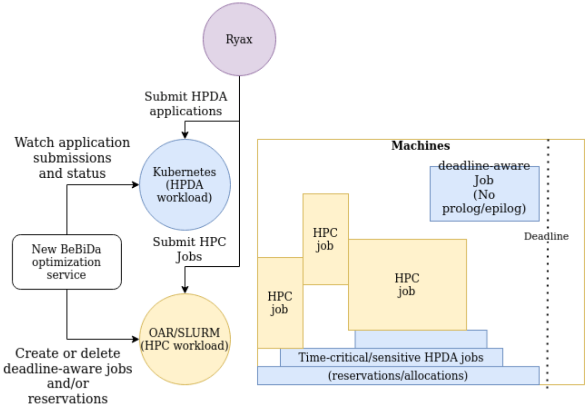
REGALE Use cases
and Optimizations

Spark Application for:

1. Hydrological flow analysis (Pilot 4)
2. Network security analysis (Pilot 3)

We want more guarantees:

- **Deadline aware** (1):
  Run before a user-defined deadline
- **Time critical** (2):
  Run as fast as possible



Bebida Optimization Service

Roadmap

- ☒ First implementation with simple heuristic (Ti'Punch):
  based on threshold on the number of pending job in the BDA queue, create HPC jobs that will stay in the BDA resource pool.
- ☒ support for K8s (BDA)
- ☒ support Slurm over SSH (HPC)
- ☒ Full testing environment
- ☒ Handle BDA app early termination (cancel HPC job if not used anymore)
- ☐ **Support for OAR (HPC)**
- ☐ Handle HPC job termination
- ☐ Improve heuristic using BDA app time and resource requirements

Hackathon Plan

Respond to

- Which version of OAR to use?
  => 2 or 3?
- How to create a container-based testbed for Bebida with OAR and K8s?
  => NXC or docker compose?
- What is the best way to implement the deadline?
  => Advanced reservation? Deadline aware jobs?
- What is the best way to implement the time-critical?
  => Priorities? Co-system? Walltime-less?
- How to connect to OAR?
  => REST API or SSH + commands?

Let's Hack ! B-)