Development and evaluation of a Kubernetes cluster simulator based on Batsim

Presented by: Théo Larue
Supervised by: Olivier Richard & Michael Mercier

Université Grenoble Alpes

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Table of contents

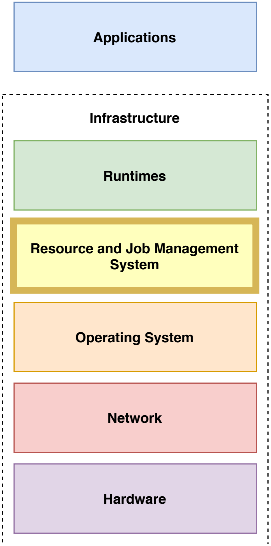
Introduction

Resource and Jobs Management System

The RJMS is at the core of the cluster.

Examples of RJMS

- OAR
- SLURM
- HadoopYARN
- Apache Mesos

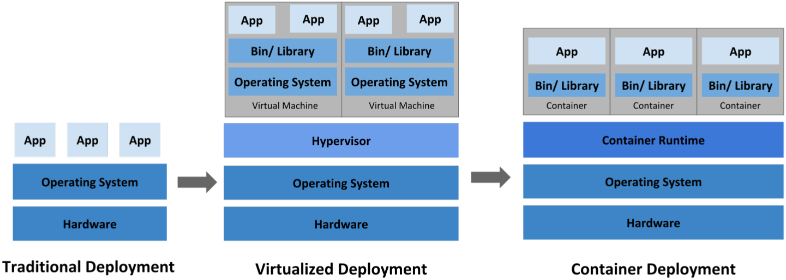


Kubernetes

Kubernetes in a nutshell

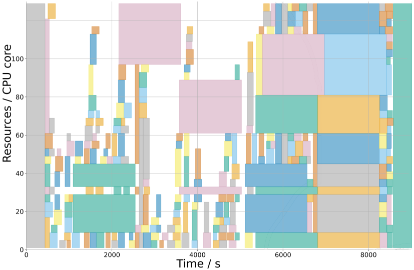
- Open source resource manager for containerized applications
- About 2M lines of code
- 2.8k contributors

kubernetes



source: https://kubernetes.io/docs/

A component of the RJMS: the scheduler



Scheduling is the act of allocating tasks to resources.

Numerous factors

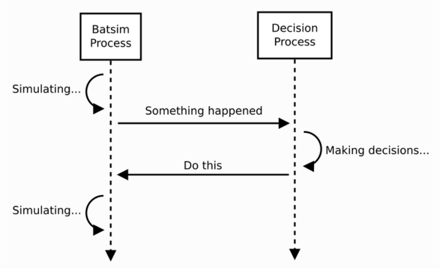
- Workloads
- Applications
- System size
- Network topology
- Energy consumption
- Scheduling policies

Complex implementations: Kubernetes default scheduler weighs **47k lines of code**.

Studying schedulers

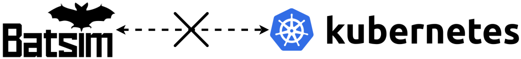
Different approaches

- Analytical study
- Real experiments
- Emulation
- **Simulation**



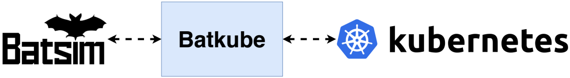
Batsim, an infrastructure simulator aimed at studying RJMS.

Contribution



- Event based
- Own protocol
- Dilated time

- Constant API requests
- Own protocol
- (Real) machine time



Batkube supports

- Any Go scheduler
- Any cluster size
- Resource requests
- Non parallel tasks

Literature review

Infrastructure simulators

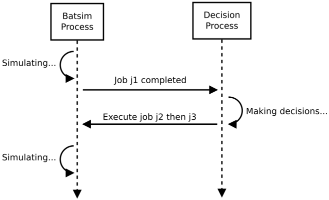
TODO or fix

Kubernetes cluster simulation

TODO: recap table of these two schedulers
k8s-cluster-simulator: open source, student project, delay jobs.
Schedulers provided via a Go interface.
joySim: closed-source, fully fledged kubernetes cluster simulator, service oriented (mock nodes).
TODO: recap kubernetes schedulers

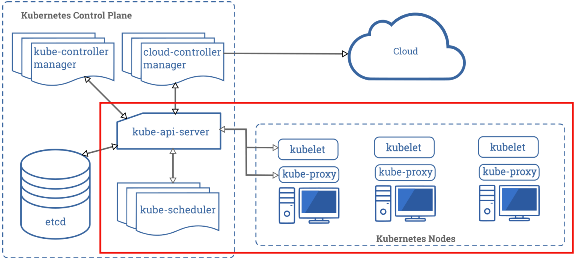
Integrating Kubernetes schedulers to Batsim

Different communication paradigms



source: https://batsim.readthedocs.io

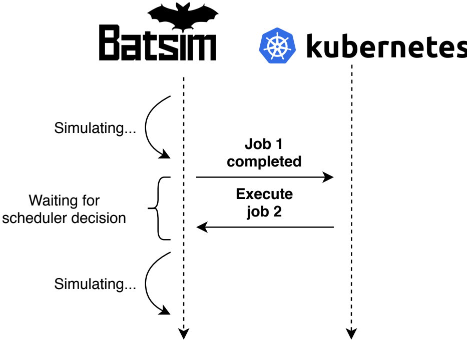
- Event based
- Simulation time



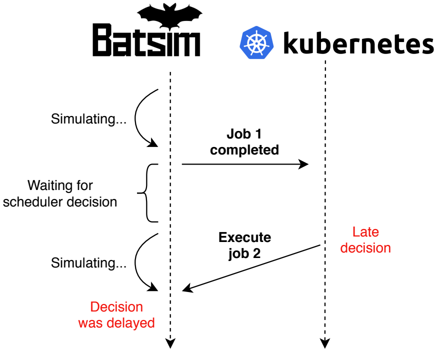
source: https://kubernetes.io/docs/concepts/overview/components/

- Central API
- Real time

Time synchronization



Scenario 1: correct synchronization



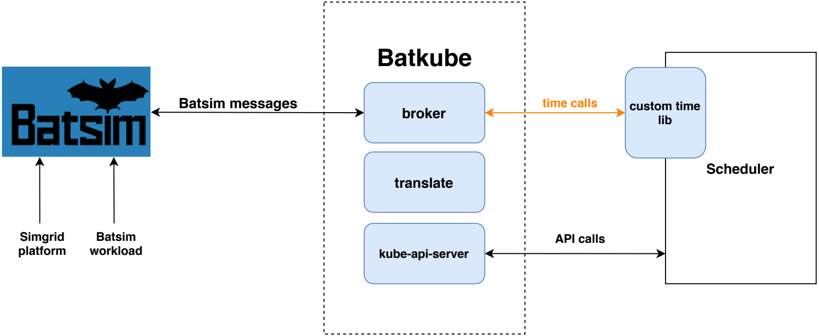
Scenario 2: delayed decision

Technical challenges

Challenges to tackle

1. Integration with Kubernetes
2. Scheduler time interception
3. Time synchronization

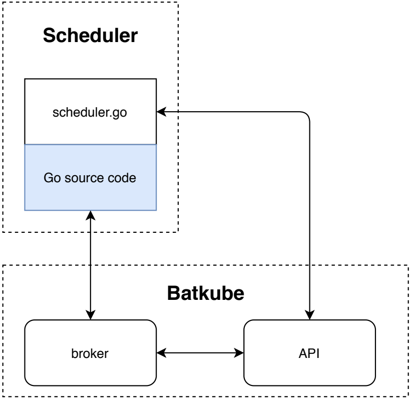
Architeture of Batkube



Global architecture of Batkube.

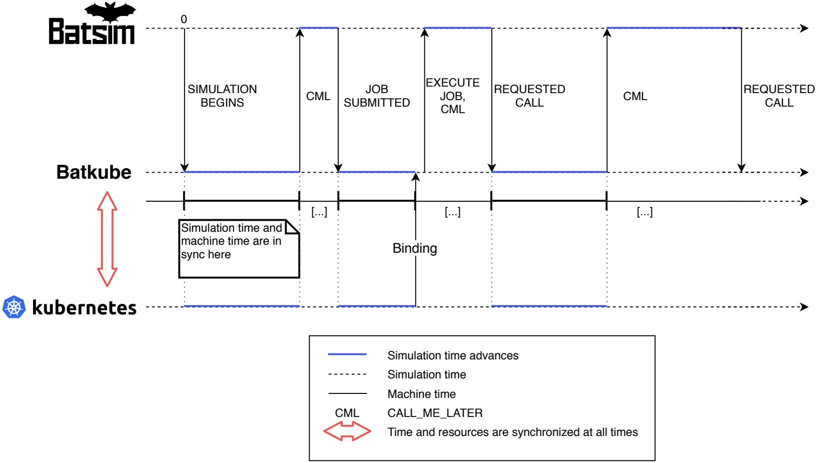
Time interception

TODO: explain code source manipulation with AST



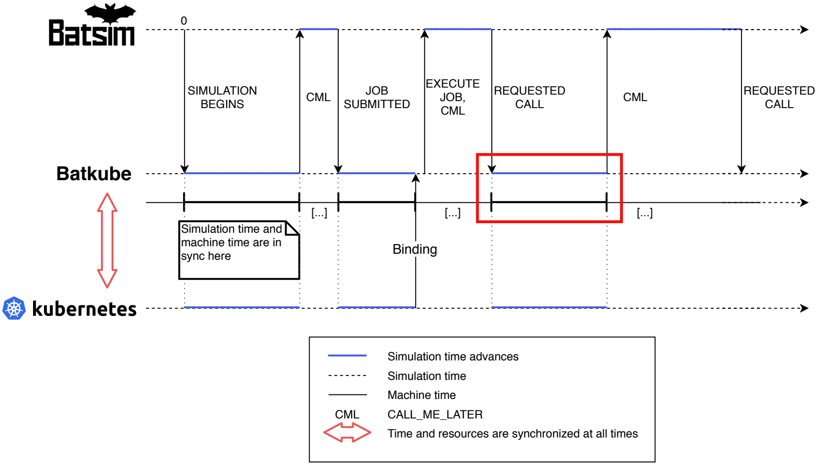
Schedulers are patched to redirect their time.

Time synchronization



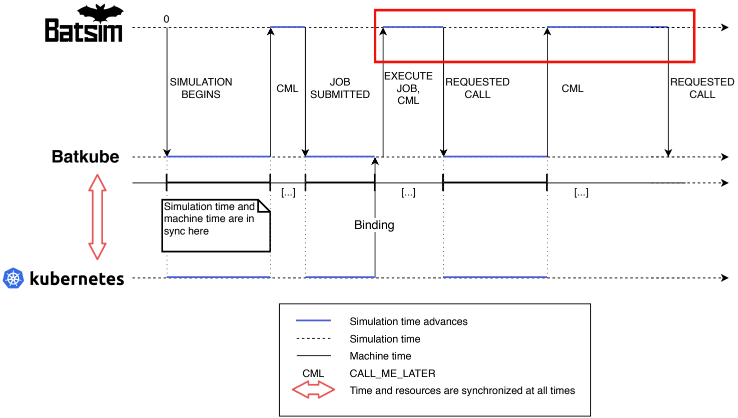
Time synchronization between Batsim and the scheduler

Parameters of the synchronization I



Timeout value

Parameters of the synchronization II



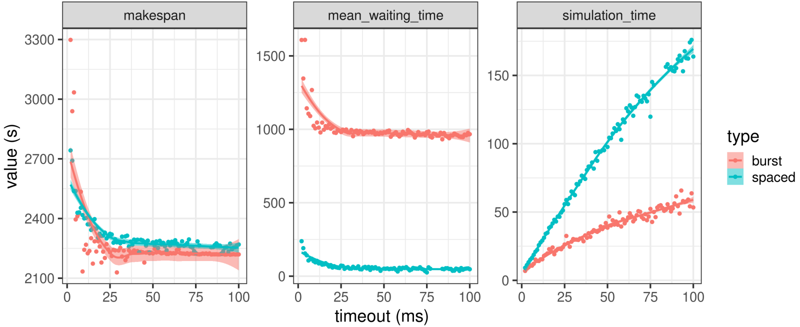
Simulation time step ∈ [`base-simulation-timestep`, `max-simulation-timestep`]

Study of the simulator

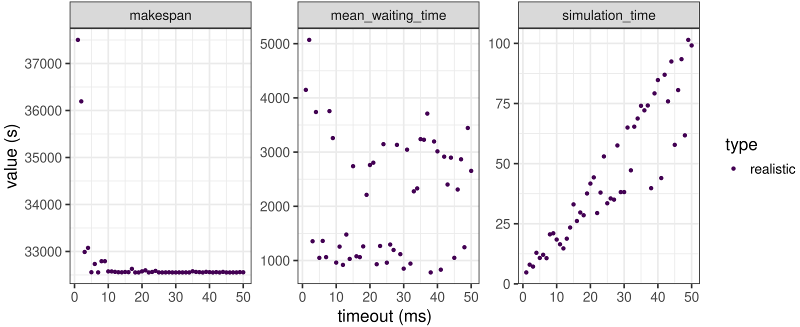
Experimental design

TODO: Scheduler used, platforms and workloads tested, what experiments (parameters, metrics studied, repetitions)

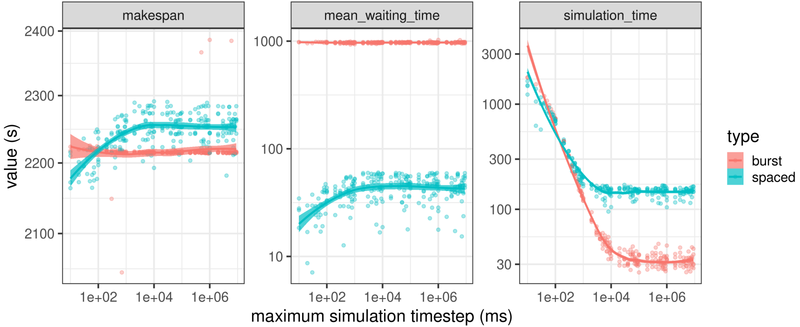
Timeout I


makespan
mean_waiting_time
simulation_time
value (s)
3300
3000
2700
2400
2100
1500
1000
500
0
150
100
50
0
0
25
50
75
100
timeout (ms)
type
burst
spaced

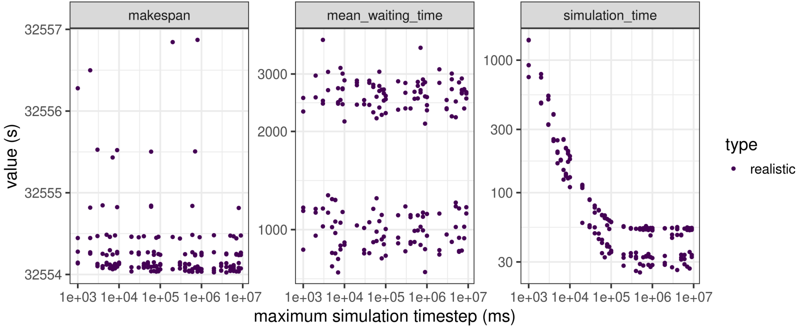
Timeout II


makespan
mean_waiting_time
simulation_time
value (s)
timeout (ms)
37000
36000
35000
34000
33000
5000
4000
3000
2000
1000
100
75
50
25
0
0 10 20 30 40 50
type
● realistic

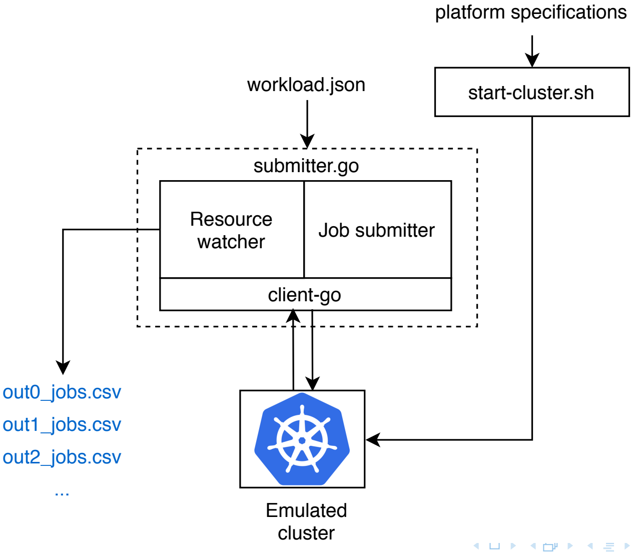
Maximum simulation timestep I



Maximum simulation timestep II



Experimentation on a real cluster



Deviation with reality

workload	**makespan**				**mean waiting time**			
	emulated		simulated		emulated		simulated	
	μ	σ	μ	σ	μ	σ	μ	σ
burst	2467	28.3	2215 (-252)	0.508	1077	10.6	970 (-107)	12.6
spaced	2468	5.14	2257 (-211)	16.9	146	1.67	48.1 (-97.9)	9.44
realistic	32556	-	32555 (-1)	1.30	2884	-	2020 (-864)	950

Conclusion

Deviation with reality: can be fixed with some work on the api. Need experiments to measur and quantify this deviation.
max timestep: studying max timestep alone is not enough, need to study it with backoff multiplier.
base time step: need an experiment on it. Too much importance was credited to max timestep, the base timestep might have importance.

Discussion and future work

Capabilities and limitations of Batkube

WIP

Capabilities

- Delay jobs
- Cpu and memory requests
- Can patch any kubernetes scheduler written in Go
- The api only supports the default scheduler

Limitations

- Memory hungry (in fact, the scheduler is memory hungry)
- Some problems with the scheduler
- Not scalable

Perspectives for future work

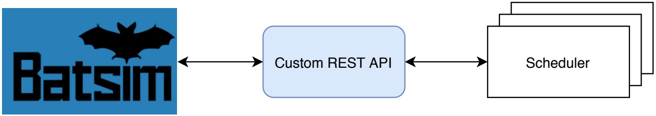
- parallel jobs
- storage
- more complete api: support for more schedulers but also tools (monitoring tools)

References I

Any questions?

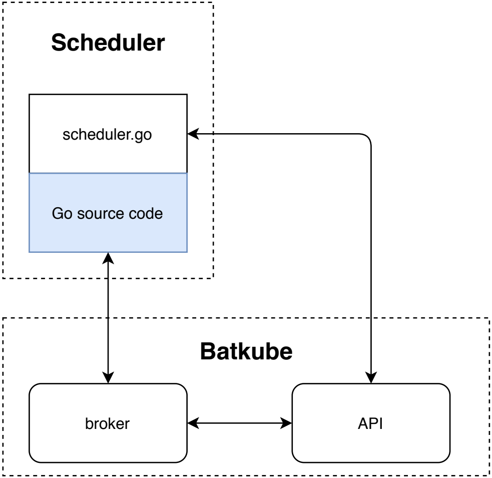
Thank you for your attention.
I am open to any questions.

Batkube integration with Kubernetes



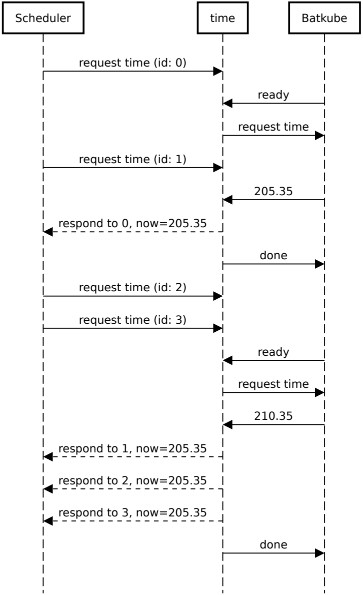
Reimplementation of a custom API.

Time interception



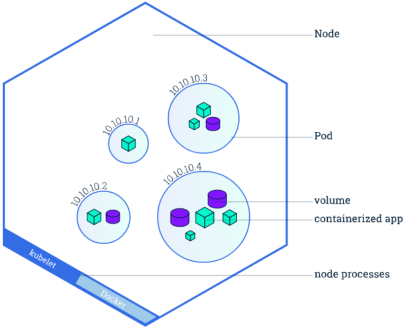
Schedulers are patched to redirect their time.

batsky-go



Exchanges between the scheduler, batsky-go ("time") and Batsim

Similar resources



source: `https://kubernetes.io/docs/tutorials/kubernetes-basics/explore/explore-intro/`

Translation between Kubernetes and Batsim

- A Pod = a job.
- A Node = a compute resource.