Improving Job Scheduling by using Machine Learning &

Yet an another SLURM simulator

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Improving Job Scheduling by using Machine Learning

Improving Backfilling by using Machine Learning to Predict Running Times

• By Eric Gaussier, David Glesser, Valentin Reis, Denis Trystram

• In proceedings of SuperComputing 2015
Improving Job Scheduling by using Machine Learning

• Machine Learning algorithms can learn odd patterns
• SLURM uses a backfilling algorithm
• the running time given by the user is used for scheduling, as the actual running time is not known
• The value used is very important

• better running time estimation => better performances

► Predict the running time to improve the scheduling
Improving Job Scheduling by using Machine Learning

• We select a Machine Learning algorithm that:
  
  • Use classic job parameters as input parameters
  • Work online (to adapt to new behaviors)
  • Use past knowledge of each user (as each user has its own behaviour)
  • Robust to noise (parameters are given by humans, jobs can segfault...)

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- We test 128 different algorithms on 6 logs (from the Feitelson Workload Archive) on the Pyss simulator

- A leave-one-out cross validation product give us the best algo that we called *E-Loss*:
  - Online linear regression model
  - Predict that a running time is more than the actual value cost more to the model
  - When we under estimate a running time, we add a fixed value (1min, 5min, 15 min, 30 min…)
  - When we backfill jobs we sort them by shortest first
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- Backfilling performances can be improved by changing running times
- More precise running times does not mean better performances
- Scheduling performances can be increased using basic Machine Learning algorithms
Improving Job Scheduling by using Machine Learning

Ongoing works

• Implement *E-Loss* in SLURM
• We need a simulator within SLURM to test it
  • Machine Learning algorithms perform best when they have a lot of data to learn from

• Instead of customizing the priority factors by hand, a Machine Learning can do it for you!
Improving Job Scheduling by using Machine Learning

&

Yet an another SLURM simulator
Yet an another SLURM simulator

- Previous work: run *sleeps* instead of actual jobs, multiple slurmd per physical node (to emulate bigger cluster than you have access to)

- Why not advancing in time when everybody sleeps?  
  ▶ Use simulation!
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Virtual Machines
+ perfect behaviour
- heavy and slow
+ No modifications to SLURM

Classic simulators
- no guarantee on the behaviour
+ extra light
- Modifications of SLURM
Introducing Simunix, an UNIX simulator

- We implement the "UNIX" API: pthreads, pthread_mutex, gettimeofday, sleep, send, recv…

- Use Simgrid framework

  ➤ We can run an unmodified slurm on a simulated cluster
Yet an another SLURM simulator

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Yet an another SLURM simulator

How to force a binary to use our libraries?
• Change how linking is done!

• The Linux linker load from the system and LD_PRELOAD the needed shared libraries
• It fills the GOT (Global Object Table) with the address of each functions of each libraries

• The compiler compile

  sleep(10);

  to

  GOT[“sleep@libc“](10);  

(Of course, it's not exactly like this, if you have more question RTFM of the ELF format)
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How to force a binary to use our libraries?
- Change how linking is done!

- At runtime, simunix rewrite the GOT
  - Of the selected binary/libraries
  - Not on the simunix library nor the Simgrid library!
  - Addresses in the GOT are replace by our own functions:

    ```
    GOT[“sleep@libc“] = &simunix_sleep;
    GOT[“time@libc“] = &simunix_time;
    ...
    ```
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Simgrid

• a framework to design simulators of distributed applications

• Supports:
  • advanced network models
  • energy consumption models
  • I/O models

• Actively developed
• Good practice: they (in)validate their simulator (they explicitly give the strengths and weaknesses of their models by testing them and compared them to real runs!)
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How this work?

• Then, each intercepted calls communicate to an independent maestro process
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Current works

• Optimize to simulate 1 year in a reasonable amount of time
• Support more Simgrid features:
  • run simulated apps not just a sleep (network contention…)
  • DVFS and energy
• Try out with other schedulers (every Linux software is compatible!)
Thanks