Understand Job Execution in Supercomputers

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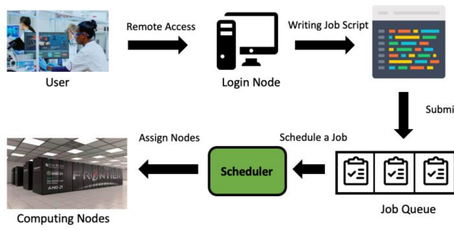
Introduction

High Performance Computing (HPC) is used for a wide range of objectives such as:

- Weather prediction
- Physical Simulations
- Quantum Computing

We can improve HPC efficiency by improving the scheduling of programs run by the HPC, referred to as *jobs*.



Objectives

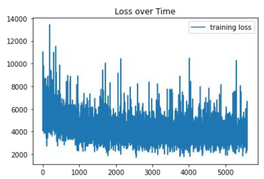
- One technique used to improve job scheduling is called *Backfilling.* It uses an estimate of job runtime to improve scheduling performance.
- Backfilling is typically based on a user-submitted runtime estimate known as the *request time*
- Could better job runtime prediction lead to better Backfilling?
- Is it possible to accurately predict job runtime?
- What level of job runtime prediction accuracy leads to the best performance?

Method

1. We implemented the method used in the paper “Improving backfilling by using machine learning to predict running times”
2. We used the *RLScheduler* program to simulate an HPC environment
3. We used the jobs actual *run time* as input to the backfiller, to simulate “perfect runtime prediction”
4. We ran several simulations using the actual runtime with varying amounts of noise to see where the best performance was achieved

ML Runtime Prediction

- The model uses l2-regularized polynomial regression
- Accuracy is measured in terms of *loss*, the lower the better



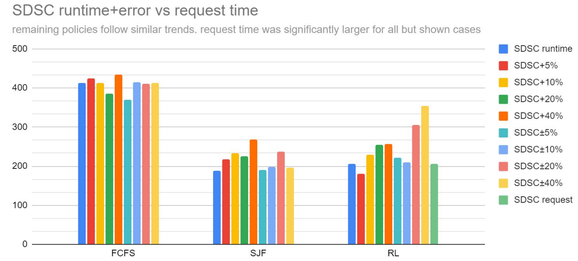
- We achieved similar results to the paper, and can now reasonably predict job runtime

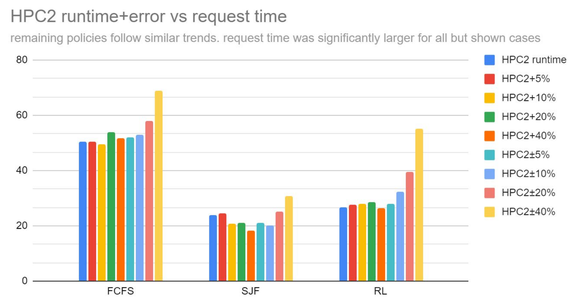
Prediction Method	Mean Average Error (MAE)	Mean E-Loss
AVE k2 (average of last 2 jobs runtime)	5217	10.2×10^{8}
E-Loss Learning (paper results)	6762	2.35×10^{5}
Our implementation	3825	8.36×10^{7}

Results

Contrary to what we expected, more accurate job runtime prediction does not lead to the best backfilling performance.

The best (lowest) performance was achieved multiple times by noisy prediction for both workloads





Conclusions

The data has shown that the best backfilling performance does not correspond to the most accurate job runtime prediction. This means that we must look for other methods to improve backfilling performance

We are now currently investigating the use of reinforcement learning to improve backfilling performance.

References

E. Gaussier, D. Glesser, V. Reis and D. Trystram, "Improving backfilling by using machine learning to predict running times," SC '15: Proceedings of the International Conference for High Performance Computing, Networking, Storage and Analysis, Austin, TX, USA, 2015, pp. 1-10, doi: 10.1145/2807591.2807646
Di Zhang, Dong Dai, Youbiao He, Forrest Sheng Bao, and Bing Xie. 2020. RLScheduler: an automated HPC batch job scheduler using reinforcement learning. In Proceedings of the International Conference for High Performance Computing, Networking, Storage and Analysis (SC '20). IEEE Press, Article 31, 1–15..