PRIONN: Predicting Runtime and IO using Neural Networks

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Next generation HPC schedulers rely on information about job resource usage to improve machine utilization [1].

### Resource Prediction Challenges

- Accurate Resource Usage Knowledge → Better Scheduling
- Traditional job script analysis (i.e., learning from parsed features of job scripts) represents each job with a limited number of features
- Jobs look the same from the perspective of parsed features

Small differences between two job scripts often create large differences in resource usage. Important additional information present in job scripts (highlighted in red) cannot be parsed with traditional methods.

#### Image-Like Job Scripts

- We expand the representation of a job beyond parsed features:
  - **Entire job script text**
  - The text in each job script is mapped to an image-like representation
  - We use the Word2Vec algorithm to transform each character in a job script to a vector (i.e., pixel)
  - A 2D Convolutional Neural Network (CNN) analyzes entire job scripts
  - CNNs automatically detect and learn features in unparsed text

We use entire job scripts as input to deep learning models for predicting runtime and IO of HPC jobs. The text is automatically mapped to an image-like representation.

### Runtime and IO Prediction Workflow for IO-Aware Scheduling

1. Users submit job scripts to the scheduler
2. User-submitted job scripts are mapped to a 2D CNN's like representation
3. A 2D-CNN predicts per-job runtime and IO from image-like representation
4. Flux system simulator simulates execution of all queued jobs and calculates future system IO based on per-job runtime and IO predictions
5. IO-aware scheduler schedules jobs and avoid IO contention

#### Forecasting System IO Contention

- We evaluate PRIONN’s ability to predict per-job runtime and IO usage with 300,000 jobs run on Cab at LLNL during 2016
- We measure the relative accuracy of predictions to the true resource usage for each job
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  \text{Relative Accuracy} (%) = 100 \times \left(1 - \frac{|\text{pred} - \text{true}|}{\max(\text{pred, true})}\right)
  \]
- We use the Flux system simulator to simulate job execution with PRIONN’s per-job runtime and IO predictions. From this, we obtain a forecast of future IO, including future IO bursts (i.e., high IO activity representing potential for IO contention)
- IO burst predictions enable the scheduler to avoid IO contention

#### References:


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