Predicting Scientific Dataset Popularity Using dCache Logs

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ABSTRACT

The dCache installation is a storage management system that acts as a disk cache for high-energy physics (HEP) data. We present methods for forecasting the number of times a dataset stored on dCache will be accessed in the future. We developed a deep neural network that can predict the number of future dataset accesses with a high degree of accuracy, reporting a final normalized loss of 4.6e-8. We present a set of algorithms that can forecast future dataset accesses given an access sequence. Included in this set are two novel algorithms, Backup Predictor and Last N Successors, that outperform other file prediction algorithms. Findings suggest that it is possible to anticipate dataset popularity in advance, and therefore it is possible to move popular data into dCache ahead of time.

BACKGROUND INFO

dCache Background

- The ATLAS experiment produces substantial quantities of HEP data.
- dCache has connectivity to a separate high-performance storage system (HPSS), but accessing data stored in the dCache system is faster.
- **Therefore, it is best for frequently accessed data to be stored on dCache.**

MOTIVATION

Forecasting the number of dataset accesses in the future allows movement of popular datasets into the dCache in advance, which will substantially reduce average dataset access latency.

RESEARCH QUESTION

Is it possible to use historical dataset information to predict how many times a dataset will be accessed in the future?

METHODS

Deep Neural Network

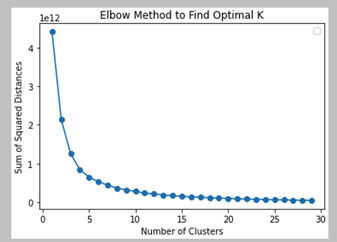
- 2 dense layers
- Tanh activation function
- ADAM optimizer
- 9 months of dCache accesses
- ~160,000 records, 5 features

Features

- Present accesses
- Number of files in dataset
- Dataset size
- Bytes read from dataset
- Dataset type (experiment data, log, simulation, etc.)

Clustering

- K-means clustering
- Present accesses vs. future accesses
- k=5, determined using elbow method



File Predictors

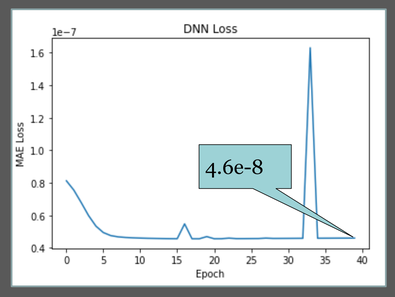
- Given a file access sequence, predicts future accesses

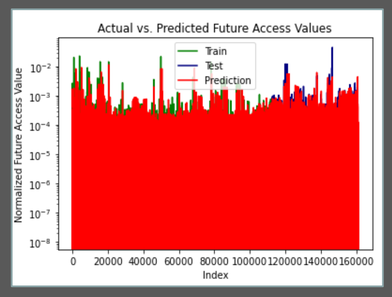
Algorithms

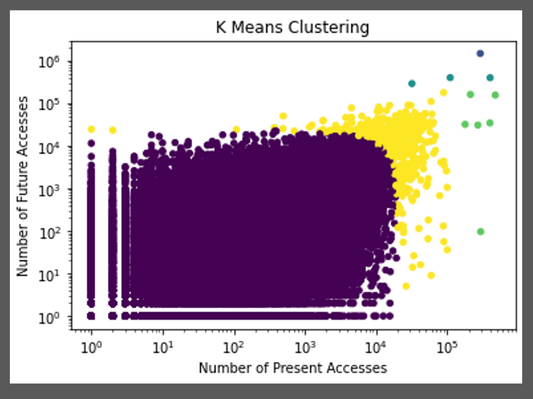
- First Successor (FS)
- Last Successor (LS)
- Last N Successors (LSN)
- Stable Successor (SS)
- First Stable Successor (FSS)
- Recent Popularity (RP)
- Predecessor Position (PP)
- Backup Predictor (BP)

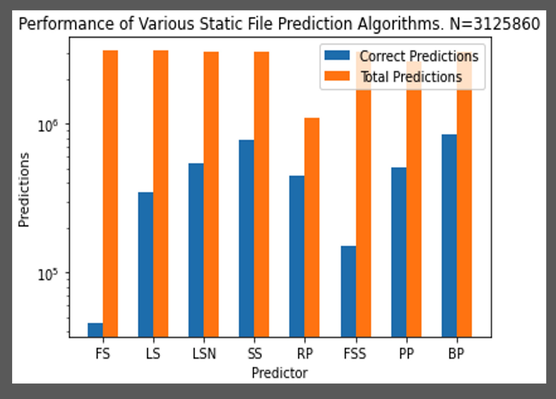
RESULTS

- On the right are plots of the MAE loss and predicted vs. actual future access values. The test and train data are shown in both plots.
- Below is the results of clustering with k=5. Note the size and diagonal placement of the groups.
- The bottom right plot shows the performance of the file prediction algorithms. BP and RP perform best.









CONCLUSION

- The deep neural network can accurately forecast how many times a dataset will be accessed the next day
- Clustering reveals that most datasets have fewer than 10000 future accesses, and those that have more than 10000 future accesses have many present accesses
- Backup Predictor using Recent Popularity and Last N Successors makes the highest raw number of correct predictions, at ~27.2%
- Recent Popularity gets ~40.08% of the predictions it makes correct
- Future work will refine the deep neural network and develop more accurate dynamic file prediction algorithms.

FURTHER READING

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