Power prediction with probabilistic topic modeling for HPC

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Abstract

Recently, HPC power prediction by machine learning using input job information has been studied. However, it requires time-consuming tuning of entry weights, because the each entry differently contributes to the power prediction.
In this paper, we propose a new two-step prediction scheme which contains “Topic model” and “Probabilistic model“.
Without manual tuning of “weights” of entries, we successfully demonstrated the power prediction of K computer system with an average relative error of 18 %.

1. Introduction

- Towards the exascale supercomputer to be implemented in 2023, power saving operation is getting increasingly significant to reduce its operation cost.
- Power Capping, which controls system power not to exceed a preset power level, is known as a method for power saving operation. One form of adapting the power capping is a power-aware job scheduling method that predicts power of a job before its execution and controls the job execution order based on the predicted value.

Technique for predicting job power from job information can contribute to energy saving

- Power prediction techniques by machine learning using the entries in the submitted scripts, have been proposed.[1] This approach **requires manual tuning of “weight” for each entry,** in order to make more effective entries contribute more to prediction. “Weights”, however, could be different for each site.
- For example, site A has higher weights for user and group, while site B has a higher weight for job name in Fig.1.

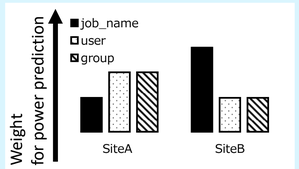


Fig. 1. Conceptual diagram of weight for power prediction at each site

Challenge: Adaptive scheme to find optimal weights for each site

[1] Andrea Borghesi, Andrea Bartolini, Michele Lombardi, Michela Milano, Luca Benini, **Scheduling-based Power Capping in High Performance Computing Systems**, Sustainable Computing: Informatics and Systems 19, May 2018

2. Proposal

Tuning-less power prediction model by automatic weight calculation and feedback

- New two-step scheme using “Topic model” and “Probabilistic model” enables prediction with both wide acceptance of entries and high accuracy by proper weighting (Fig.2).
  - 1st step: “Topic model” is trained from the past job information. In the prediction phase, it selects 10 candidates from the past based on the similarity to the target job.
  - 2nd step: “Probabilistic model” is trained by the combination of entries and power of past jobs. “Probabilistic model” selects most similar past job out of 10 candidates and uses its power as prediction.

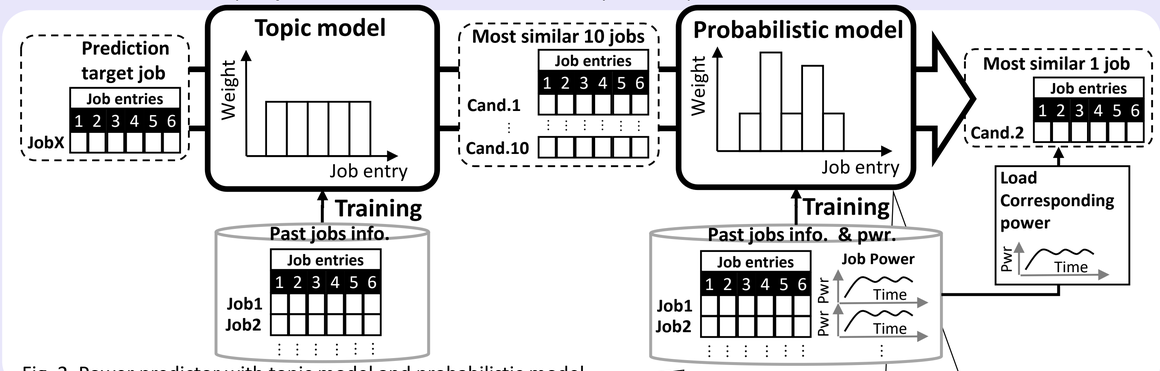


Fig. 2. Power predictor with topic model and probabilistic model

Training

- Calculate “weights” for each entry based on the effectiveness for the probability of success (Fig.3)
  - Training for “Probabilistic model” is executed by supervised learning. “Weight” for each entry is determined by the following procedure.

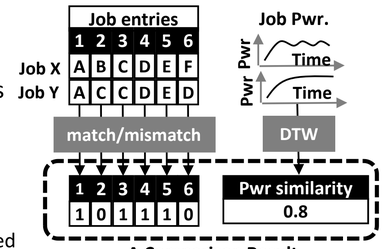
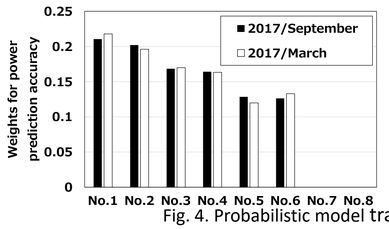


Fig. 3. Probabilistic model training

i. Compare each entry between job X and job Y if it is matched or not.
ii. Compare time-series power between job X and job Y by using Dynamic Time Warping (DTW) method and score the probability of success based on their similarity.
iii. Based on the results of I and II, “probabilistic model” calculate “weight” for each entry.

- “Weights” of entries on the K computer (Fig.4)
  - Six out of eight job entries used were relevant for power prediction accuracy.
  - “Probabilistic model” succeeded to extract more effective entries.
    e.g. Though both “Number of request node (No.2)” and “Queue (No.6)” represent the size of job, No2. should contribute more as it has more detail information. As a result of “Probabilistic model”, we confirmed No.2 gets higher weight than No.6 (Fig.4) .



Number	job entry
No.1	request duration
No.2	number of request node
No.3	user
No.4	group
No.5	job name
No.6	queue
No.7	submission time
No.8	job id

Fig. 4. Probabilistic model training result on the K computer

Confirm that the weight is calculated by the proposed algorithm

Prediction

- Based on the probability of success calculated by “Probabilistic model”, 10 candidates selected by “Topic model” are re-ranked (Fig.5). Then, the first ranked time-series power is selected as a prediction for the target job

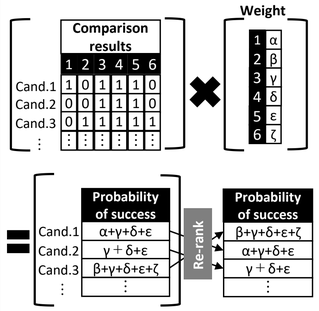


Fig5. Probabilistic model prediction

3. Evaluation

- Accuracy of two-step scheme is better by 3.1% in comparison with one-step, “Topic model” only, scheme. We achieved an average relative error of 18% (Tab.2, Fig.6).
- Test Conditions
  - Evaluated data is time-series power of all jobs from July to Sep, 2017 on the K computer.
  - Training is conducted using past 3-month data with 15-minute interval.

Tab1. Compute Server Spec. for evaluation

CPU	Intel(R) Xeon(R) CPU E5-2680 v4 @ 2.40GHz 2sockets, 14 core/socket
Memory	2400 RDIMM 128GB
Disk	SAS 12Gbps, 10krpm
GPU	None

Tab. 2. Precision comparison

	July	August	September	Total
only topic model Relative Error(%)	17.8	22.0	23.6	**21.1**
two-step model Relative Error(%)	16.1	17.9	20.1	**18.0**

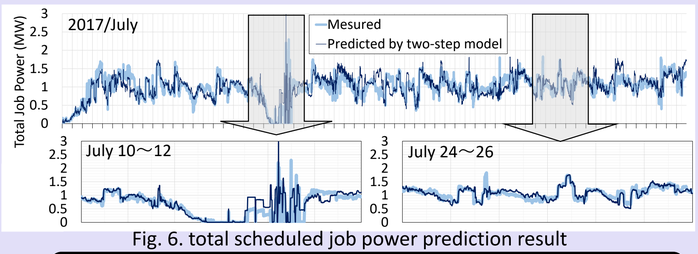


Fig. 6. total scheduled job power prediction result

Adaptation of weight contributes to improvement of prediction accuracy

- Analysis of prediction results for each job
  - We analyzed the results with two criteria, power height and elapsed time (Fig.7).
  - Only when both criteria fail, the failure ratio is decreased by adopting the two-step scheme.

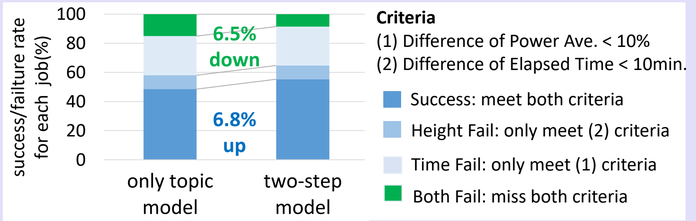


Fig. 7. prediction result for each job

4. Conclusion & Future Work

- We implemented a novel power prediction model that enables prediction with both wide acceptances of entries and high accuracy by proper weighting. Accuracy of two-step scheme is better by 3.1% in comparison with one-step, “Topic model” only, scheme. **System operators can predict power with high accuracy by simply introducing the two-step.**
- Future work
  - Develop technologies for further improvement of time-series prediction.
  - Study another application that the theory of “Probabilistic model” will be applicable.