A Comparative Study of Real Workload Traces and Synthetic Workload Models for Parallel Job Scheduling *

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Abstract. Two basic approaches are taken when modeling workloads in simulation-based performance evaluation of parallel job scheduling algorithms: (1) a carefully reconstructed trace from a real supercomputer can provide a very realistic job stream, or (2) a flexible synthetic model that attempts to capture the behavior of observed workloads can be devised. Both approaches require that accurate statistical observations be made and that the researcher be aware of the applicability of a given trace for his or her experimental goals.

In this paper, we compare a number of real workload traces and synthetic workload models currently used to evaluate job scheduling and allocation strategies. Our results indicate that the choice of workload model alone — real workload trace versus synthetic workload models — did not significantly affect the relative performance of the algorithms in this study (two scheduling algorithms and three static processor allocation algorithms). Almost all traces and models gave the same ranking of algorithms from best to worst. However, two specific workload characteristics were found to significantly affect algorithm performance: (a) proportion of power-of-two job sizes and (b) degree of correlation between job size and job runtime. When used in the experimental evaluation of resource management algorithms, workloads differing in these two characteristics may lead to discrepant conclusions.

1 Introduction

Simulation-based performance evaluation of parallel job scheduling strategies is traditionally carried out using a synthetic workload model to generate a stream of incoming jobs with associated job characteristics. Despite the acknowledged rigor of simulation testing using stochastically generated workloads, there has been a pressing need for more realistic performance evaluation to further validate algorithm performance. Recently, the use of massively parallel machines for high performance computing has grown rapidly, both in numbers and in the maturity of the user communities. Systems administrators at national labs and

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supercomputing center sites have collected large amounts of workload trace data and released them for use in the evaluation of new resource management algorithms. Thus, researchers in performance evaluation have at their disposal two valid methods for conducting simulations:

1. Use of **real workload traces** gathered from scientific production runs on real supercomputers and carefully reconstructed for use in simulation testing.
2. Use of **synthetic workload models** that use probability distributions to generate workload data. We refer to the earliest synthetic workload models as "naive" because they were based on little or no knowledge of real trace characteristics (due to the fact that real traces didn't exist). Recently, more realistic synthetic models have been developed in which the model and its parameters have been abstracted through careful analysis of real workload data from production machines.

Both approaches require that many assumptions and accurate statistical observations be made, and that the modeler understands well the profile of the targeted, real workload. Inaccurate assumptions or minor perturbations in any proposed model may yield a workload that provides a poor evaluation of scheduling strategies on the targeted system. Yet, there exists very little published literature that offers guidance to researchers concerning the use of real workload traces and synthetic workload models for experimentation with scheduling algorithms.

Our work aims to fill this void. Our goals are to determine the degree of influence of workload choice and workload characteristics on performance and, where possible, to isolate the causes of observed differences in performance results. We will begin to address issues such as those listed below and to propose some rules-of-thumb to help guide the use of these workload traces and models in simulation testing of scheduling algorithms.

- **Real workload traces versus synthetic workload models:** When should one use real traces and when should one use synthetic workloads? Do the results of simulation with these two types of workloads reinforce each other? If not, is it due to biases in the workload traces or inadequacies in the synthetic model?
- **Universality of workload traces:** Given a choice among real workload traces from different sites, how does one know which trace to use? If performance evaluation results are discrepant, how does one know which results are valid?
- **Sensitivity of scheduling algorithm performance to workload characteristics:** What specific workload characteristics might bias performance results?

The experiments reported in this paper compare many real workload traces and synthetic workload models, both analytically and through simulation, observing their effects on the performance evaluation of several classes of scheduling