Preemptive Resource Management for Dynamically Arriving Tasks in an Oversubscribed Heterogeneous Computing System

Achievement: Designed and evaluated resource scheduling algorithms with support for preemption of serial tasks.

Significance and Impact: Designed and evaluated preemption-capable heuristics, which outperform Random and FCFS (first come first served) scheduling techniques. Also, the preemption-capable heuristics outperformed the previous utility-aware heuristics that did not incorporate preemption.

Research Details:
- Utility-based heuristics model the importance of a task completing in a given time interval
  - Performance of the system is measured using total utility earned by all tasks in an interval of time
  - Utility is the value (importance) of completing the task(s)
- Utility-based heuristics were extended to include preemption
  - Heuristics were compared with and without preemption
- Evaluate variety of scheduling algorithms
  - Preemption-based heuristics able to significantly increase utility earned
  - Preemption never result in worse performance for utility-based heuristics (at worst is equal)

Sponsor/Facility: Work was performed by ORNL and Colorado State University, sponsored by DoD.

PI and affiliation: Neena Imam (ORNL)

Team: G. Koenig, T. Naughton, N. Imam (ORNL); D. Machovec, S. Pasricha, A. Maciejewski, H.J. Siegel (Colorado State University); M. Wright, M. Hilton, R. Rambharos (DoD)

Figure 5. The percentage of maximum system utility earned by each of the heuristics for six different workloads where the percentage of tasks that can preempt and the percentage of tasks that can be preempted are varied over 0%, 20%, 40%, 60%, 80%, and 100%. The results are


Overview:
In this work, we designed resource management heuristics that assign serial tasks to the nodes of a heterogeneous high performance computing (HPC) system. The value of completing these tasks is modeled using monotonically decreasing utility functions that represent the time-varying importance of the task. The value of completing a task is equal to its utility function at the time of its completion. The overall performance of this system is measured using the total utility earned by all tasks during some interval of time. To maximize the performance of such a system where the preemption of tasks is possible, we have designed, analyzed, and compared a set of resource allocation heuristic techniques. We combined two
utility-aware heuristics with three different preemption techniques to create six preemption-capable heuristics. We also consider two utility-aware heuristics without preemption. We use simulation studies to evaluate this set of eight heuristics and compare them with a First Come First Served (FCFS) heuristic, which is often used in real systems, and random assignments. In general, our set of eight heuristics is able to significantly outperform the comparison heuristics, and the preemption-capable heuristics are able to significantly increase the utility earned compared to the heuristics that do not use preemption. We analyze the performance tradeoffs among the different preemption-capable heuristics under a variety of oversubscribed workload environments.