Power and Energy Footprint of OpenMP Programs Using OpenMP Runtime API

Abstract

Power and energy have become dominant aspects of hardware and software design in the High Performance Computing (HPC). Recently, the Department of Defense (DOD) has put a constraint that applications and architectures need to attain 75 GFLOPS/Watt in order to support the future missions. This requires a significant research effort towards power and energy optimization. OpenMP programming model is an integral part of HPC. Comprehensive analysis of OpenMP programs for power and execution performance is an active research area. Work has been done to characterize OpenMP programs with respect to power performance at kernel level. However, no work has been done at the OpenMP event level. OpenMP Runtime API (ORA), proposed by the OpenMP standard committee, allow a performance tool to collect information at the OpenMP event level. In this paper, we present a comprehensive analysis of the OpenMP programs using ORA for power and execution performance. Using hardware counters in the Intel SandyBridge x86-64 and Running Average Power Limit (RAPL) energy sensors, we measure power and energy characteristics of OpenMP benchmarks. Our results show that the best execution performance does not always give the best energy usage. We also find out that the waiting time at the barriers and in queue are the main factors for high power consumption for a given OpenMP program. Our results also show that there are unique patterns at the fine level that can be used by the dynamic power management system to enhance the power performance. Our results show substantial variation in energy usage depending upon the runtime environment.