Performance Application Programming Interface (PAPI) provides a consistent interface (and methodology) for hardware performance counters found across a compute system: i.e., CPUs, GPUs, on- and off-chip memory, interconnects, I/O system, file system, and energy/power. PAPI enables software engineers to see, in near real time, the relationship between software performance and hardware events across the entire compute system.
Extending PAPI for ECP Applications

The Exa-PAPI project is developing new performance counter monitoring capabilities as well as power management support for novel and advanced ECP hardware, and software technologies. Exa-PAPI builds upon classic-PAPI functionality and strengthens its path to exascale with a standard interface and methodology for using low-level performance counters in CPUs, GPUs, on/off-chip memory, interconnects, and the I/O system, including energy/power management.

In addition to providing hardware counter-based information, a standardizing layer for monitoring software-defined events (SDE) is being incorporated that exposes the internal behavior of runtime systems and libraries, such as communication and math libraries, to the applications. As a result, the notion of performance events is broadened from strictly hardware-related events to include software-based information. Enabling monitoring of both hardware and software events provides more flexibility to scientific application developers when capturing performance information.

Key Challenges

Widely deployed and widely used, PAPI has established itself as fundamental software infrastructure in every application domain where improving performance can be mission critical.

However, processor and system designs have been experiencing radical changes. Systems now combine multi-core CPUs and accelerators, shared and distributed memory, PCI-express and other interconnects, and power efficiency is emerging as a primary design constraint. These changes pose new challenges and bring new opportunities to PAPI. At the same time, the ever-increasing importance of communication and synchronization costs in parallel applications, as well as the emergence of task-based programming paradigms, pose challenges to the development of performance-critical applications and create a need for standardizing performance events that originate from various ECP software layers.

Solution Strategy

The Exa-PAPI team is preparing PAPI support to stand up to the challenges posed by exascale systems by:

- widening its applicability and providing robust support for exascale hardware resources;
- supporting finer-grain measurement and control of power, thus offering software developers a basic building block for dynamic application optimization under power constraints;
- extending PAPI to support software-defined events; and
- applying semantic analysis to hardware counters so that the application developer can better make sense of the ever-growing list of raw hardware performance events that can be measured during execution.

In summary, the team is channeling the monitoring capabilities of hardware counters, power usage, software-defined events into a robust PAPI software package.

Recent Publications

Barry, D., Danalis, A., Jagode, H.
Effortless Monitoring of Arithmetic Intensity with PAPI’s Counter Analysis Toolkit

Jagode, H., A. Danalis, H. Anzt, J. Dongarra
PAPI Software-Defined Events for in-Depth Performance Analysis

Software-defined Events through PAPI
24th International Workshop on High-Level Parallel Programming Models and Supportive Environments (HIPS), in conjunction with 33rd IEEE International Parallel & Distributed Processing Symposium (IPDPS), May 20-24, 2019, Rio de Janeiro, Brazil, pp. 1-10, 2019.