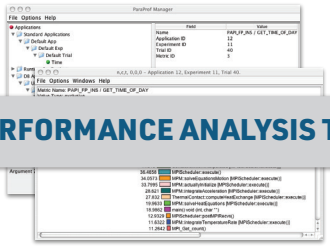
INNOVATIVE COMPUTING LABORATORY

PAPI

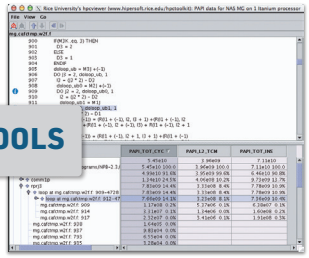
PAPI (Performance Application Programming Interface) provides a consistent interface (and methodology) for hardware performance counters, found across a compute system: i. e., CPUs, GPUs, on- and off-chip memory, interconnects, I/O system, file system, energy/power, etc. PAPI enables software engineers to see, in near real time, the relationship between **software performance** and **hardware events** across the **entire** compute system. FIND OUT MORE AT **http://icl.utk.edu/papi**

PERFORMANCE ANALYSIS TOOLS

Vampir



TAU



HPCView

MORE

HPCToolkit

Open|SpeedShop

PaRSEC

PerfSuite

Scalasca

SCORE-P

STANDARD FEATURES

Standardized Performance Metrics

Easy Access to Platform-Specific Metrics

Multiplexed Event Measurement

Dispatch on Overflow

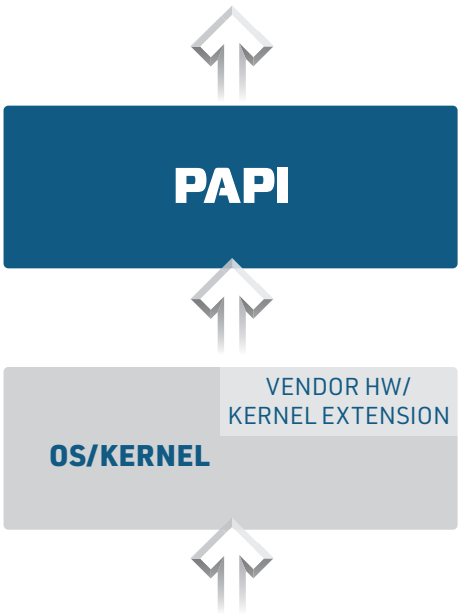
Overflow & Profiling on Multiple Simultaneous Events

Bindings for C, Fortran and Matlab

User Definable Metrics derived from Platform-Specific Metrics

Support for Virtual Computing Environments

Performance counter monitoring at task granularity for dataflow runtime PaRSEC



SUPPORTED ARCHITECTURES

AMD X86

ARM
Cortex A7, A8, A9, A15, X-Gene (ARM64), Raspberry Pi

CRAY
Gemini and Aries interconnects | RAPL power

IBM
Blue Gene Series, Q: 5D-Torus, I/O system, EMON power on BG/Q | Power Series

Infiniband

Intel
Nehalem, Westmere, Sandy Bridge, Ivy Bridge, Haswell, Haswell-EP, Broadwell, Skylake(-X), Kaby Lake, Knights Corner, Knights Landing | RAPL; power capping, Power on Xeon Phi

Lustre

NVIDIA
Tesla, Kepler, NVML | CUDA support for multiple GPUs, PC Sampling

Virtual Environment VMWare, KVM

FutureGrid provided resources for testing and development of PAPI-V

R&D100 WINNER

ICL INNOVATIVE COMPUTING LABORATORY

THE UNIVERSITY OF TENNESSEE KNOXVILLE

IN COLLABORATION WITH THE UNIVERSITY OF MAINE

WITH SUPPORT FROM AMD CRAY THE SUPERCOMPUTER COMPANY IBM intel NVIDIA

U.S. Department of Defense

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CITR CENTER FOR INFORMATION TECHNOLOGY RESEARCH

INNOVATIVE COMPUTING LABORATORY

EXA-PAPI

EXTENDING PAPI FOR ECP APPLICATIONS

PAPI provides tool designers and application engineers with a consistent interface and methodology for the use of low-level performance counter hardware found across the entire compute system (i.e. CPUs, GPUs, on/off-chip memory, interconnects, I/O system, energy/power, etc.). PAPI enables users to see, in near real time, the relationships between software performance and hardware events across the entire compute system.

Exa-PAPI builds on the latest PAPI project and we will extend it with:

- Performance counter monitoring capabilities for new and advanced ECP hardware, and also software technologies;
- Fine-grained power management support;
- Integration capabilities for exascale paradigms, such as task-based runtime systems that support dataflow programming models;
- "Software-defined Events" that originate from the ECP software stack and are currently treated as black boxes (i.e., communication libraries, math libraries, task-based runtime systems, etc.).

The objective is to enable monitoring of both types of performance events—hardware- and software-related events—in a uniform way, through one consistent PAPI interface. That implies, 3rd-party tools and application developers have to handle only a single hook to PAPI in order to access all hardware performance counters in a system, including the new software-defined events.

PUBLICATIONS

Haidar, A., H. Jagode, A. YarKhan, P. Vaccaro, S. Tomov, and J. Dongarra, **"Power-aware Computing: Measurement, Control, and Performance Analysis for Intel Xeon Phi"**, *2017 IEEE High Performance Extreme Computing Conference (HPEC'17)*, Best Paper Finalist, Waltham, MA, IEEE, September 2017.

Haidar, A., H. Jagode, P. Vaccaro, S. Tomov, and J. Dongarra, **"Investigating Power Capping toward Energy-Efficient Scientific Applications"**, *Concurrency and Computation: Practice and Experience (CCPE): Special Issue on Power-Aware Computing 2017*, Submitted.

EXASCALE COMPUTING PROJECT

Exa-PAPI is part of ICL's involvment in the Exascale Computing Project (ECP). The ECP was established with the goals of maximizing the benefits of high-performance computing (HPC) for the United States and accelerating the development of a capable exascale computing ecosystem. Exascale refers to computing systems at least 50 times faster than the nation's most powerful supercomputers in use today.

FIND OUT MORE AT **https://exascaleproject.org**

FIND OUT MORE AT **http://icl.utk.edu/exa-papi**

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U.S. DEPARTMENT OF ENERGY | Office of Science

ECP

NNSA National Nuclear Security Administration

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