Accuracy Analysis of Power Sensors in Compute Servers Using a High Precision Power Analyzer

Manuel Pitz, Niklas Eiling, Felix Wege, Iris Köster, Stefan Lankes, Antonello Monti {manuel.pitz, niklas.eiling, fwege, ikoester, slankes, amonti}@eonerc.rwth-aachen.de
Institute for Automation of Complex Power Systems - RWTH Aachen University

Abstract

As power densities increase and energy prices become more relevant for operational costs, the demand for analysis, optimization and evaluation of the energy efficiency of computing systems grows. An indispensable tool for evaluating energy efficiency are power measurements. Today, CPUs, GPUs and platform management controllers have power sensors that allow evaluating energy consumption. However, these sensors have limited time resolution and reading them introduces computational load leading to distorted data. In this poster, we use a dedicated, calibrated power monitoring device to determine the accuracy of integrated power sensors of a typical server platform. We show that the use of the integrated power sensors alone is not sufficient to characterize the energy consumption of a computing system under varying loads. We find that not all measurement methodologies show an accurate picture of the energy consumption of the entire system, which can lead to deriving false conclusions.

Related work

For the profiling of the power use of computing systems usually one of three data sources are used [1]:

1. Device-sensors measure the power of individual components. They are embedded into some computing devices, e.g., GPUs and CPUs. Accuracy and sample rate vary, and reading these sensors may incur significant additional computational load [2, 3].
2. Platform-sensors measure the overall power use of the system including all devices. Accuracy and sample rate of these sensors are often limited.
3. An external power monitoring device measures the system power between device and wall outlet. This guarantees that the measurement cannot influence the recorded data. Most power monitoring devices are designed for monitoring overall energy consumption or safety critical changes of the power grid. Examples for devices used in literature are the Schneider PM800 or Power Distribution Units [1, 4].

In this poster we employ the external power monitoring methodology using a high precision, high sampling rate commercial Precision Power Analyzer (PPA) to analyze the accuracy of device- and platform-sensors under varying computational loads.

Measurement Setup

- Dell R7525 Server (2xAMD EPYC 7313 CPUs, NVIDIA Tesla P4, P40, T4 and A100, 1.5 TB RAM, OS 8.6
- Two-way redundant power supplies connected to the PPA, a ZES Zimmer LMG671 with a L60-CH-B type measurement cards.

Sensor capabilities:

- CPU sensor: “zenpower3” [6] driver (maximum sample rate of 70us)
- GPU sensor: “nvml” [7] library (max sample rate of 10Hz (Tesla T4 and A100) or 100Hz (Tesla P4 and P40)
- Platform-sensor: Dell iDRAC srvadmin [8] tool (maximum sample rate of one per minute)
- PPA (sample rate of up to 50 samples per second and an accuracy of 0.07%)

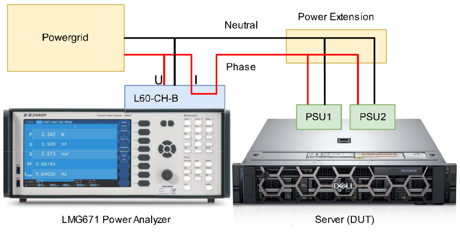

Figure 1: Schema of measurement setup

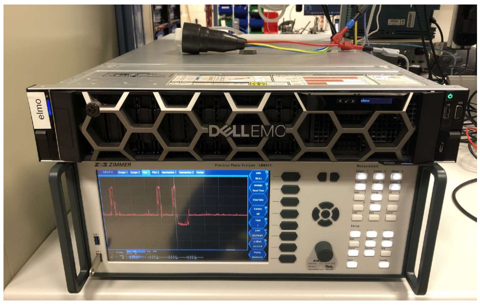

Figure 2: Measurement setup with GPU Server (top) and Precision Power Analyzer (bottom)

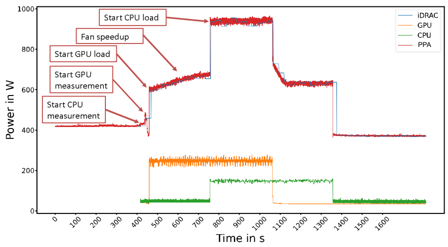

Figure 3: The figure shows the CPU sensor in green, the GPU sensor in orange, the system-sensor in blue and the PPA data in red. We use the tool "stress" to load the CPU 64 workers for CPU, memory and I/O load, and "gpu-burn" [5] to load the A100 GPU.

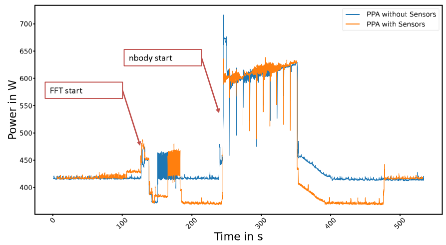

Figure 5: The figure shows two applications (FFT and nbody problem) executed consecutively. Reading the sensors leads to widely different power measurements at the power monitoring device compared to an execution without device-sensor readings.

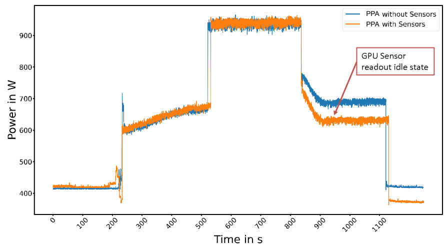

Figure 4: Using the same load as in Figure 3, we compare the measurements of using only PPA to when also sampling the device- and platform-sensors. The figure shows that sampling sensors has an impact on the power use of the entire system.

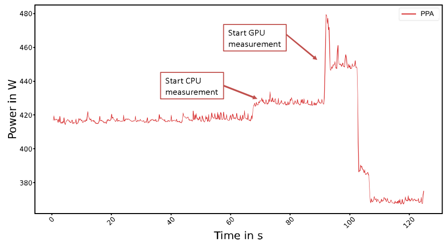

Figure 6: The figure shows the impact of the CPU and GPU sensor readings on an idle system measured with the PPA.

Discussion

Figure 3 shows that the platform-sensor measurements are consistent with the PPA measurements. However, the lower sampling rate of the platform-sensor leads to an error in the acquisition time of up to one minute. Due to a higher sampling rate this error is not present for device-sensor measurements. Furthermore, the figure shows that the device-sensors do not capture the entire power load generated by applying a computational load to CPU and/or GPU. Before loading the system, the system is idling. However, the start of reading the power sensors of the GPU and the CPU can be clearly seen. After starting to read the GPU-sensor, Figure 5 shows a reduction in power use. This is due to GPU clock throttling, when the reading of the GPU-sensor starts. This shows that measuring power can have non-obvious, unintended side-effects. This poster shows the importance of measurement parameters when analyzing the power use of computing systems. The device-sensors themselves can increase the power use and platform-sensors offer only low sample rates that may hide important power load changes. Furthermore, the data shows a discrepancy between the power reported by the CPU sensors and the actual power increase, when the CPU experiences varying computational load. Only a combination of device sensors and high-quality external power monitoring devices offer an accurate and holistic view of the power use of a computing system. An analysis of sensor accuracy and sampling rate is indispensable for building useful measurement setups and developing energy aware applications in the HPC context.

[1] Fahad M, Shahid A, Manumachu RR, Lastovetsky A. A Comparative Study of Methods for Measurement of Energy of Computing. Energies. 2019; 12(11):2204. https://doi.org/10.3390/en12112204
[2] Yehia Arafa, Ammar ElWazir, Abdelrahman ElKanishy, Youssef Aly, Ayatelrahman Elsayed, Abdel-Hameed Badawy, Gopinath Chennupati, Stephan Eidenbenz, and Nandakishore Santhi. 2020. Verified instruction-level energy consumption measurement for NVIDIA GPUs. In Proceedings of the 17th ACM International Conference on Computing Frontiers (CF '20). Association for Computing Machinery, New York, NY, USA, 60–70. https://doi.org/10.1145/3387902.3392613
[3] Robert A. Bridges, Neena Imam, and Tiffany M. Mintz. 2016. Understanding GPU Power: A Survey of Profiling, Modeling, and Simulation Methods. ACM Comput. Surv. 49, 3, Article 41 (September 2017), 27 pages. https://doi.org/10.1145/2962131
[4] Fahad M, Shahid A, Manumachu RR and Lastovetsky A, "Accurate Energy Modelling of Hybrid Parallel Applications on Modern Heterogeneous Computing Platforms Using System-Level Measurements," in IEEE Access, vol. 8, pp. 93793-93829, 2020, doi: 10.1109/ACCESS.2020.2994953.
[5] https://github.com/wilicc/gpu-burn; [6] https://git.exozy.me/a/zenpower3; [7] https://developer.nvidia.com/nvidia-management-library-nvml;
[8] https://linux.dell.com/repo/hardware/latest/

RWTH Aachen University | E.ON Energy Research Center
Institute for Automation of Complex Power Systems
Mathieustraße 10 | 52074 Aachen | Germany
www.acs.eonerc.rwth-aachen.de
+49 (0)241 80-49700 | +49 (0)241 80-49709

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