

# Efficiently Energetic Acceleration EEA-Aware For Scientific Applications of Large-Scale On Heterogeneous Architectures

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**Abstract—** Heterogeneous parallel programming has two main problems on large computation systems: the first one is the increase of power consumption on supercomputers in proportion to the amount of computational resources used to obtain high performance, the second one is the underuse these resources by scientific applications with improper distribution of tasks. Select the optimal computational resources and make a good mapping of task granularity is the fundamental challenge for build the next generation of Exascale Systems. This research proposes an integrated energy-aware scheme called efficiently energetic acceleration (EEA) for large-scale scientific applications running on heterogeneous architectures. The EEA scheme uses statistical techniques to get GPU power levels to create a GPU power cost function and obtains the computational resource set that maximizes energy efficiency for a provided workload. The programmer or load balancing framework can use the computational resources obtained to schedule the map parallel task granularity in static time.

**Keywords—** Energy Efficiency, Power Capping, Energy Aware; Exascale computing

## I. INTRODUCTION (HEADING 1)

The evaluation of performance and power consumption is a main step in design of applications for large computation systems, such as supercomputers and clusters with nodes that have manycores and multi-GPUs. Researchers must design several experiments for workload characterization to observing the architectural implications of different parameters combinations such as problem size, number of cores per GPU or accelerator, number MPI ranks and observe the resulting clock frequency, memory usage, bandwidth and power consumption, which are factors that determine the performance and energy efficiency of their workload implementation. A key observation from the study of DARPA (Technology Challenges in Achieving Exascale Systems)[1] is that may be easier to solve the power problem associated with base computation than it will be to reduce the problem of transporting data from one site to another on the same chip, between closely coupled chips in a common package or between different racks on opposite sides of a large machine room, or storing data in the aggregate memory hierarchy. Therefore this research designed an integrated scheme called Energy Efficient Acceleration (AEE) as shows in the Figure 1, in which can be used by load balancing frameworks (eg.

StarPU, OmpSs) for mapping tasks on the computational resources; then it uses a monitor called enerGyPU and enerGyPhi for capturing metrics of performance and power consumption in order to characterize the application and computing architecture; finally the prediction system uses the scheme AEE to predict the combination of computational resources that maximize energy efficiency of applications running on heterogeneous architectures CPU-GPU type.

## II. EEA-AWARE STRUCTURE

### A. General Structure

This poster proposes an integrated energy-aware scheme called Efficiently Energetic Acceleration (EEA) for scientific applications on large-scale on heterogeneous architectures like a Figure 1. . The EEA structure has a workflow of three steps as shown in Figure 2.

### B. Data capture in runtime

In the first step, the data is captured in runtime and executed the enerGyPU or enerGPhi monitor tool in parallel with the scientific application using different combinations of computational resources, applying the power capping technique for nodes with multi-GPU.

### C. Data visualization and statistics characterization

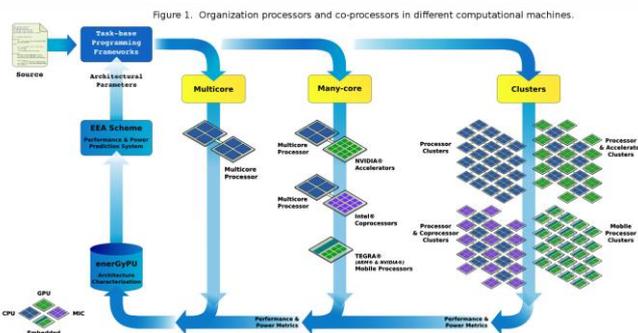
In the second step, the data visualization and statistics characterization used a separate level of enerGyPU and enerGPhi monitor tool for analysis the key factors by results of each experiment in terms of energy efficiency and estimated the power levels. A deep description of monitor structure and utilization is present by García John et al. in [2], [3].

### D. Model prediction system

Finally using the data collected by monitors cost functions are build and model prediction system running for obtaining the optimal computational resources in a static time to mapping parallel task granularity of scientific applications on heterogeneous architectures.

### III. EXPERIMENTAL PROCEDURES AND RESULTS

At the first level the global parameters have chosen the workload and computational architecture according to the combination of resources that will be used. The experimental procedures were executed with a set of tests of HPL code variants using different workload and architectural parameters on Cluster nodes GUANE. The experimental procedures were chosen following the fractional factorial design principle proposed by Raj Jain [4]. The source code may be download from our repository locate on stable version on <http://forge.sc3.uis.edu.co/redmine/projects/eea-uis> and testing version on <https://github.com/jagh/enerGyPU>



### IV. CONCLUSIONS

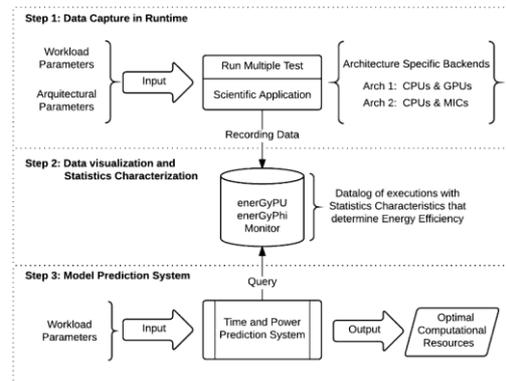
Each computational problem need a characterization to get the best resource distribution on each specific workload, this process required a huge time to tuning the best resource distribution, special when need improve the energy use. This research found that use that using huge number of task with relative few data size offer an efficient energetic acceleration scheme to solve linear equations on heterogeneous architecture with GPU capable cards. enerGyPu and enerGyPhi were develop to help the characterization process (capture, analyzing and visualization) across of several experiments with different resource distributions and so determine the control factor that offer the best energetic efficiency without change the applications with instrumentation process.

Additionally, we develop the EEA scheme to choose the computational resource needed by a specific workload on runtime and then use a workload manager that could implements this metrics (like StartPU or OmpSs) and apply power capping reducing the energy consumption and improve the performance of solution.

With this work we show that need improve the current metrics using for the traditional workload manager and jobs

schedules to incorporate new energy-aware metrics like energy-to solutions o performance per watt, because it's the key factor to building exascale architectures.

This Research demonstrate that using a huge number of task with a small data size, it allow obtain an energetic efficient acceleration when processed linear equation systems on nodes with heterogeneous architecture CPU-GPU type



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