Porting of GEOPM to IBM Power8 with NVLink microarchitecture

Vadim Elisseev[1] Miloš Puzović[2]

[1]IBM Research

[2]Hartree Centre

BoF: PowerAPI, GEOPM and Redfish: Open Interfaces for Power/Energy Measurement and Control

Motivation

Energy Aware Scheduling (EAS)

The performance of future large-scale HPC and data-centric systems will be constrained by power costs

- **Optimizing performance under power constraints**
  - Reduce power consumption of idle nodes
  - Reduce power consumption of active nodes

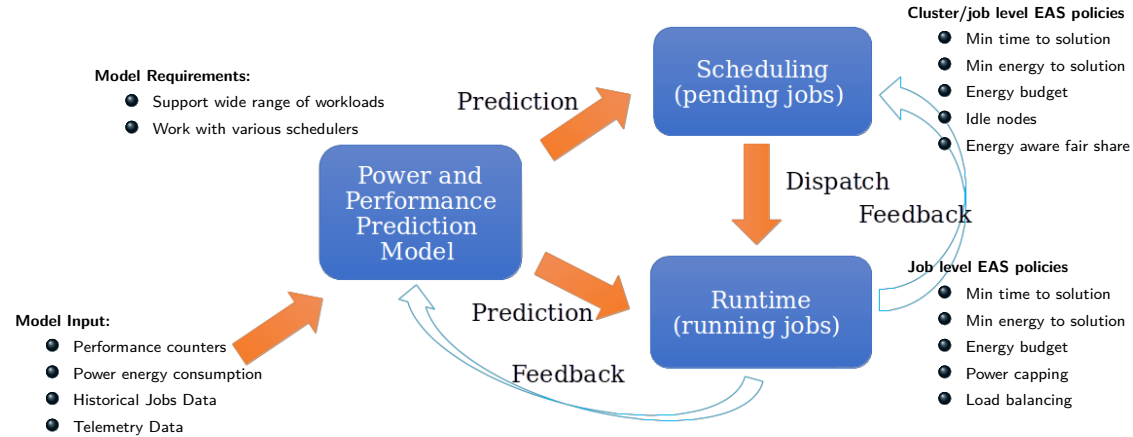
$E(t) = \int_0^t P(x)\,dx$ 

Reduce and Control Energy
Reduce Power
Reduce Time
Reduce Power and Time
Deal with Power Variations

EAS Policies
Minimize Time to Solution
Minimize Power to Solution
Power Capping
Energy Budget

Motivation

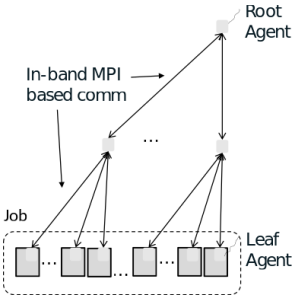
Implementing EAS



Why **G**lobal **E**xtensible **O**pen **P**ower **M**anager?

- **Common goals with our work on EAS:**
  1. unlock more performance in power-limited systems
  2. accelerate innovation in power management
  3. enable researches to focus effort on algorithms
  4. drive codesign of power and performance management features in new processors

- **Current functionality aligns with our aims too:**
  - Framework easily pluggable to the existing data-center and HPC schedulers
  - Scaling challenge for future exascale machines addressed successfully via tree-hierarchical design and hierarchical policies
  - Leverage application-awareness and learning to recognise patterns to optimise decisions
  - Comprehend and mitigate dynamic load imbalances
  - Extensibility provided via plugins



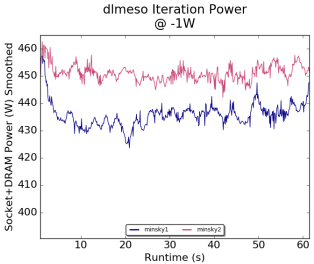
Progress of the port to date

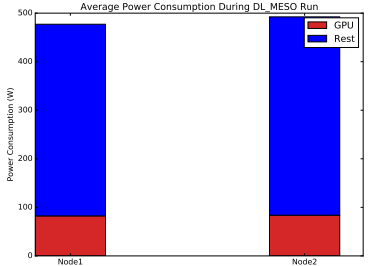
- Port of GEOPM *observation* part on IBM Power[1] with **five** new classes:
  - `OCCPlatform` extends `Platform` to describe RAPL-like observers and controllers on Power
  - `NVLMPlatform` extends `Platform` to describe RAPL-like observers and controllers on GPU
  - `Power8NVLinkPlatformImp` extends `PlatformImp` to implement sampling and management by referring work to following two classes and aggregating results from them:
    - ◇ `PowerPlatformImp` extends `PlatformImp` for information from CPUs
    - ◇ `PascalPlatformImp` extends `PlatformImp` for information from GPUs
- To collect power and performance data we are using:
  - on CPU:
    - ◇ `libpfm4` library for performance counters
    - ◇ sensor data from `/sys/devices/system/cpu/occ_sensors` for power consumption
  - on GPU NVIDIA Management Library (NVML), a C-based API for monitoring and managing
- Port of the GEOPM framework to IBM Power8 with NVLink builds on:
  - IBM C/C++ and FORTRAN Compiler and IBM Spectrum MPI
  - GNU toolchain and OpenMPI 2.1.2

[1] Power8 dual-socket CPU + Nvidia Pascal P100 GPU with high-speed embedded, proprietary and private NVLink interface

Example results

- Setup:
  - 2× nodes - dual-socket 160 *threaded* cores IBM Power 8 CPU, 4× Nvidia Pascal P100 GPUs and 512GB RAM
  - GCC version 4.8.5 and OpenMPI version 2.1.1
  - Workload: DL_MESO - *mesoscale simulation package*, within Top 3 of all workloads (32.73% share) @ Hartree
  - Plot (left): "`geopmplotter -vp combined_power -smooth 15 .`" (`bgeltz-plotter-runtime` branch)





- Further exploration:
  - understand where discrepancies in power across nodes are coming
  - scale the running from 2 nodes to 30+ nodes
  - run the GPU-optimised version of DL_MESO

The future immediate work

- Remove workarounds where we are using `#defines` to separate between x86 and Power:
  - in `Controller.cpp` `plugin_desc.platform` only knows of RAPL platform
  - avoid using `cpuid.h` to figure out target (non-existent for Power)
  - more generic implementation of CRC32 (do not rely on x86 instructions)
  - `is_updated()` to find out whether *fresh* performance/power data is available relies on RAPL
- Implement *management* part of the GEOPM framework on Power microarchitecture
  - this is already on-going work,
  - the most difficult part is being able to do DVFS-like modifications in user mode
- Integration with:
  - High Performance Computing batch scheduler such as LSF, and
  - manager of containerized applications such as Mesos and/or Kubernetes.
- Use these extensions to GEOPM to identify imbalance in applications ran on Hartree machines and optimise them for a certain objective function:
  - Widely used applications such as `CodeSaturne` and `DL_MESO`
  - Demonstrate speed up and energy savings