The CMS Heterogeneous Computing Revolution

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CPU trends

Price/performance evolution of installed CPU servers (CERN)

B. Panzer
Today

- High Level Trigger
  - readout of the whole detector with full granularity, based on the CMS software, running on 30,000 CPU cores
  - Maximum average latency is ~600ms with HT
- Offline reconstruction takes ~25s/evt at PU50
The CMS Trigger in Phase 2

- Level-1 Trigger output rate will increase to 750 kHz (7.5x)
- Pileup will increase by a factor 3x-4x
- The reconstruction of the new highly granular Calorimeter Endcap will contribute substantially to the required computing resources
- Missing an order of magnitude in computing performance
Heterogeneous Run3 HLT Farm

- We would like to exercise a Heterogeneous HLT farm well before Run4
- Targeted Pixel Tracks and Vertices, ECAL and HCAL recos
- What does CMS gain in the short term?
  - Better physics performance
  - Reconstruction able to run on Supercomputers
  - A new wave of physicists interested in reconstruction
Pixel Reco

Throughput

V100 - Riemann fit
V100 - broken line fit
T4 - Riemann fit
T4 - broken line fit

Dual Xeon Gold 6130
- 32 cores, 64 threads
- 32 cores, 32 threads

CMS Hcal Reconstruction CPU vs GPU

Upper Bound using Intel Xeon Gold 6148 2x16 cores

Configuration
- Nvidia V100 (1 CUDA Stream per CPU thread)
- Intel Xeon Gold 6148
Performance Portability

In the medium term, aiming at achieving performance portability with a single codebase

- native platforms:
  - standard C++ for traditional CPUs
  - CUDA and C++ for NVIDIA GPUs

- heterogeneous programming platforms
  - SYCL – better syntax, currently based on OpenCL

- C++ libraries
  - Alpaka / Cupla, Kokkos
GPU benchmarking with Patatrack

Representative applications from CMS are already part of the new HEP-score benchmarking suite for CPUs

- Generation/simulation, digitization, reconstruction
- Being extended to GPU-enabled applications
  - CMS Heterogeneous HLT a very suitable candidate
A first Docker image has been built, to run CMS Heterogeneous HLT in benchmarking mode (event throughput used as score)

- Currently very large (49 GB) but it will become much smaller once the software becomes available via CVMFS
- 5 GB of input data
- Usability to be improved
  - Configuration parameters currently hard-coded
  - Network connectivity still required
  - To be moved to public repository
- To be completed in the next weeks

This would allow vendors, industry and supercomputers to understand our heterogeneous reconstruction performance, provide better support, and contribute to improve our software
Enable our software to run on heterogeneous platforms is a game-changer:

• Run on HPC resources
• Better energy efficiency
• Improved physics reach