Wrong Way: Successes, Failures, and Lessons Learned from Using the “Wrong” Programming Approach for Summit

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Mid-2020 DOE Landscape

• Department of Energy (DOE) computing centers exhibit variety
  – Accelerators vs. no accelerators
    • Variety of accelerator vendors
    • Variety in CPU/GPU ratios, connectivity
  – Interconnect type, topology, capabilities
  – On-node NVM vs. near-node NVM vs. no NVM

• DOE Centers epitomize need for **Performance, Portability, and Productivity**
The DOE Landscape: OLCF

- Oak Ridge Leadership Computing Facility (OLCF) currently fields Summit
  - Each node contains six NVIDIA V100 GPUs and two POWER9 CPUs

- OLCF will soon deploy Frontier
  - Each node will contain four AMD Radeon Instinct GPUs and one AMD EPYC CPU

- 90%+ of OLCF systems’ computational capability comes from GPUs
  - Other systems have/will have similar characteristics
  - I will focus on GPUs in this talk
“Right Way” vs. “Wrong Way”

• GPU type suggests “right” or “natural” approach
  – Summit:
    • CUDA
    • OpenACC
    • OpenMP offload
  – Frontier
    • HIP
    • OpenMP offload
  – Also portability libraries (e.g., Kokkos, RAJA) with these backends

• Sometimes fun to consider what is possible, especially when it is “natural” on some other interesting system(s)
  – Open source options
  – Functionality rather than performance

• Definitely NOT a criticism about vendor(s) choices!
OLCF: Some Possible “Wrong Ways”

• What “wrong ways” are theoretically possible on Summit?
  – OpenCL
  – HIP
  – SYCL
  – DPC++

• And on Frontier?
  – OpenCL
  – SYCL
  – DPC++
Summit: OpenCL

- OpenCL: Khronos standard, C-based, very mature – and might even be performance portable

- CUDA installation includes some OpenCL-related files
  - Installable Client Driver (ICD) with config file
  - OpenCL loader library (libOpenCL.so) – but it is for X86_64
  - No OpenCL headers
  - To reiterate: I am not criticizing NVIDIA for not supporting OpenCL on POWER9

- Two possible “wrong ways”
  - For both: Download Khronos headers, build Khronos ICD loader library
  - Option 1: use NVIDIA ICD
    - Platform/device queries and data transfer OK, can’t do OpenCL JIT compile
  - Option 2: use Portable Computing Language (POCL) open source OpenCL implementation
Summit: HIP

- Heterogeneous-compute Interface for Portability (HIP)
- Not really a “wrong way” on Summit
  - HIP designed as portability layer with AMD ROCm and NVIDIA CUDA backends
- OLCF provides a module for HIP but not (yet) any of the hip* libraries
  - HIP can be installed by user as header-only library
  - HIP libraries can be built for CUDA backend and installed by user

Producing and Compiling HIP Code

- Hipify-* tools help convert CUDA code (kernels and API calls) to HIP
- Hipcc compiler driver invokes correct underlying compiler to compile for target GPU, with GPU-specific HIP headers

Performance (II)

- Average of normalized HIP performance was 99.8% with data transfer costs, 99.9% w/out

Note axis range (0.9 to 1.05)
Summit: SYCL

- SYCL: Khronos standard, C++-based, OpenCL’s spiritual successor

- Some options for this “wrong way”:
  - hipSYCL: a SYCL 1.2 implementation built on HIP
    - CUDA for GPU, OpenMP for CPU
    - Have demonstrated this running on Summit with simple examples, e.g., matrix $aX + Y$
  - Tried using CodePlay’s Community Edition to compile kernels to PTX code on spare x86_64 system, transferring to Summit, and using them via POCL – not successful
DPC++

• Intel’s oneAPI C++-based programming approach
  – Several useful extensions to SYCL 1.2 (some appearing in SYCL 2020)

• A “wrong way” for Summit:
  – Intel LLVM staging repository includes DPC++ compiler sources
  – Found small number of build problems, e.g., reliance on CPUID instruction that isn’t supported on POWER9

• Others have reported some success in working around for other non-x86_64 platforms, so may be possible soon on Summit
Frontier: OpenCL, SYCL, and DPC++

- Have less experience trying these “wrong way” approaches on pre-Frontier systems so far

- AMD has traditionally supported OpenCL
  - But SPIR/SPIR-V support varies by product line - not supported on MI25/MI60
  - Options: POCL, “manual” conversion of SPIR-V to AMDGCN

- SYCL and DPC++
  - CodePlay’s community edition
    - Earlier versions had some undocumented support for AMDGCN, missing from more recent versions
  - Intel LLVM repository
    - CPUID not an issue here
    - Still reliant on SPIR-V tools/translator to convert to AMDGCN?
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Summary

• Thanks to open source projects, it can be quite interesting to explore the “wrong way” options for programming GPUs on systems like OLCF’s Summit
  – Actively exploring OpenCL, HIP, SYCL/DPC++
  – Starting to explore approaches for Frontier

• There can be a cost in terms of
  – Stability
  – Standards compliance
  – Performance
  – Support

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