HPC Tools for Kokkos

Introduction to DOE Performance Portability Tutorial Day 2: Advanced Users

https://www.nersc.gov/users/training/past-training-events/2024/portability-series-kokkos-apr2024/

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Friday, April 26, 2023
9-9:10 AM PT

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Tools for Kokkos Programming

Kokkos Tools = A *set* of event-callback tool libraries, and the common infrastructure to support them

Manual

1. **Profile**:
   - TPL Vendor connectors, e.g., nvtx, roctx
   - Timer
   - Space-time-stack
   - Memory usage
2. **Debug:**
   - kernel logging
   - memory events

Automated

- **Auto-analyze:**
  - Test case generation
  - Performance insights
  - HPC System Monitoring
- **Auto-fix:**
  - fault-correction
  - auto-tuning

nvtx-connector: HPCToolkit (John Mellor-Crummey et al)

tau/apex (Kevin Huck, Sameer Shende et al)

→ Almost all tools use the Kokkos Tool interface hooking into Kokkos core (Kokkos_Profiling.hpp)

https://github.com/kokkos/kokkos-tools ← **Fork me!**

Kokkos Example Code for CPU+GPU

Needs: 1. Scientific Discovery 2. Engineering Innovation 3. service for Industry, AI/ML

~/stencil.cpp

```
#include <Kokkos_Core.hpp>
int main(int argc, char* argv[])
{
  Kokkos::initialize(argc, argv);
  Kokkos::View<double*> u(102), unew(102);
  Kokkos::View<double*>::HostMirror host_u = create_mirror_view(u);
  deep_copy(host_u, 1.0);
  int tstep = 0;
  while(tstep < 1000){
      Kokkos::Profiling::pushRegion("myCoolTimestepRegion");
      deep_copy(u, host_u);
      parallel_for(102, LAMBDA(int i){
        unew[i] = (u[i-1] + u[i] + u[i+1])/3.0;
      });
      deep_copy(host_u, unew);
      Kokkos::Profiling::popRegion("myCoolTimestepRegion");
      tstep++;
  }
  Kokkos::finalize();
}
```

Kokkos parallel computation *kernel*

Host-to-Device data transfer

Start Kokkos Tool

Stop Kokkos Tool

```
git clone github.com/kokkos/kokkos-tools; cd kokkos-tools; cmake .. -DCMAKE_INSTALL_PREFIX=${YOUR_KTO_INSTALL_DIR}/ ; cd-;
export KOKKOS_TOOLS_LIBS="${YOUR_KTO_INSTALL_DIR}/kp_kernel_logger.so;"; g++ stencil.cpp; ./stencil.out
```

Platform: supercomputer, cloud

Kokkos Tools: Available Set of Tools

Category	Available Kokkos Tools
Utilities	filter, sampler
Profiling	timer, space_time_stack, memory_usage, papi
Debugging	logger, memory_events
Tracing	systemtap, chrome-tracing, perfetto
Vendor Connectors	nvtx, roctx, vtune
Energy	variorium
Sophisticated Tools	caliper, apex, ldms

1. Developing a tool of Kokkos Tools requires implementing a small number of event callbacks corresponding to Kokkos user functions, e.g., parallel_for, Kokkos_initialize
2. Each tool operates independently, though any subset of Kokkos Tools can be built as one library.
3. The Kokkos Tools implementation facilitates low instrumentation overhead through capabilities such as its sampling and filtering utilities.

[1] David Boehme, Kevin Huck, Shravan Kale,, Vanessa Surjadidjaja, and Vivek Kale. **Performance Analysis and Auto-tuning Tools for Performance Portable Parallel Programs.** 2023 ACM/IEEE International Conference for High Performance Computing Networking, Storage, and Analysis. Denver, CO, USA. November 12-17, 2023.

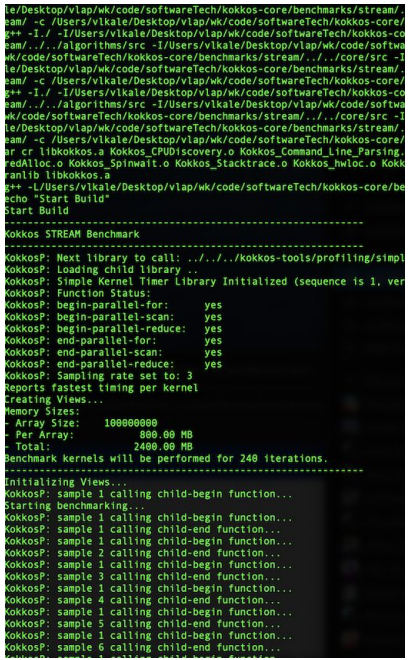
Agenda for the Session

1. 00-9:10 AM PT: Overview of tools for Kokkos including basic tools- Vivek Kale
2. 9:10-10AM PT: HPCToolkit for Kokkos applications - John Mellor-Crummey
3. 10:00 -10:30 AM PT: autotuning with Apex connector - Kevin Huck
4. 10:30 AM - 11:00 AM PT: all hands-on with
    - nvtx-connector
    - HPCToolkit
    - tau_exec and apex_exec - Kevin and Sameer
5. 11-12 PM PT: Build your own Kokkos tool - Daniel Arndt

Appendix

Aiding Kokkos Parallel Programming via Kokkos Tools Set

Sample Output



Quick Start

Setup

From source:

Install

```
git clone github.com/kokkos/kokkos-tools;
```

Build

→ Make

```
cd toolName; make;
```

→ CMake

```
mkdir build; cd build; cmake ..; make; make install;
```

Use

```
export KOKKOS_TOOLS_LIBS="toolName.so; toolName2.so;";
./myKokkosApp.exe
```

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