alpaka Parallel Programming - Online Tutorial

Lecture 00 – Getting Started with alpaka

Lesson 02: Portable Heterogeneous Parallel Programming



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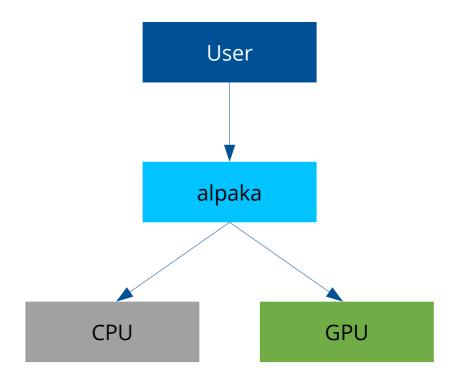






alpaka enables portability!

- Idea: Write algorithms once...
 - ... independently of target architecture
 - ... independently of available programming models
- Decision on target platform made during compilation
 - Choosing another platform just requires another compilation pass
- alpaka defines an abstract programming model
- alpaka utilizes C++14 to support many architectures
 - CUDA, HIP, OpenMP, TBB, ...





alpaka enables full utilization of heterogeneous systems!

Algorithms are generally independent of chosen target architecture

```
auto const taskCpu = alpaka::kernel::createTaskKernel<AccCpu>(workDivCpu, kernel, ...);
auto const taskGpu = alpaka::kernel::createTaskKernel<AccGpu>(workDivGpu, kernel, ...);
```

Optimization for specific architecture is still possible

```
template <typename TAcc>
                                                                // general case
void someComputationIntensiveFunction(TAcc const & acc) { ... };
template <>
                                                                // specialization for AccGpu
void someComputationIntensiveFunction<AccGpu>(AccGpu const & acc) { ... };
```



How parallelism is achieved, Part I: The grid, a digital frontier

- alpaka is ideal for data-parallel algorithms
 - → execute the same algorithm on different data elements
- alpaka kernel: sequence of commands forming the algorithm on a per-element level
- alpaka **thread:** execution of a kernel for a single data element
- threads are executed in parallel and are independent of each other
- alpaka grid: n-dimensional grid of all threads executing a specific kernel
 - each thread is assigned a unique index on the grid
 - threads on the grid are able to communicate through high-latency **global memory**

Grid		
Thread (0,0)	Thread (1,0)	
Thread (0,1)	Thread (1,1)	
Thread (0,2)	Thread (1,2)	
Thread (0,3)	Thread (1,3)	



How parallelism is achieved, Part II: Blocks on the grid

- Grids are divided into independent blocks of equal size
- Each thread is assigned to exactly one block
- Each thread is assigned an unique index on the block
- All threads inside a block are executed in parallel
- All threads inside a single block can be synchronized → no synchronization on the grid level!
- All threads inside a block can communicate through low-latency shared memory

Grid	
Block (0, 0)	Block (1, 0)
Thread (0,0)	Thread (0,0)
Thread (0,1)	Thread (0,1)
Thread (0,0)	Thread (0,0)
Thread (0,1)	Thread (0,1)
Block (0, 1)	Block (1, 1)



Summary

- alpaka is ideal for data-parallel algorithms
- Algorithms are written per data element (kernel)
- data parallelism achieved through a hierarchy of independent threads and blocks on a grid
- All threads can communicate through high-latency global memory
- Threads inside a block can be synchronized
- Threads inside a block can communicate through low-latency shared memory



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