Auto-Tuning OmpSs-OpenCL Kernels across GPU Machines

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Auto-Tune - Motivation

- GPUs have become focal point in todays HPC.
- GPUs architectural upgrades are quite predominant with every generation release.
- With every release, Performance Portability across these machines is desired.
- Lack of tools hinder this smooth portability, hence burdening the programmer.
- We address this issue with an Auto-Tune Tool focusing on modifying OpenCL kernel execution configuration based on GPU characteristics.

OmpSs-OpenCL Programming Model

- OpenCL support for OmpSs model using annotations for parallel regions(Directive based).
- Task based model with an asynchronous execution model following a sequential style of programming supporting Heterogeneous devices(both OpenCL CPU and GPU).
- Comprises of Mercurium compiler and Nanos runtime which maintains data dependency and implements the asynchronous execution of tasks.

OmpSs-OpenCL Example

1. #pragma omp target device (clgpu) ndrange(1,size,256) copy
2. #pragma omp task input ([size]b, [size]c) output ([size]a)
3. void triad_task(double *, double *, double *, int size);
4. int main(int argc, char** argv)
   copy_task(x,y,z); triad_task(a,b,c,scalar,size);
5. #pragma omp taskwait

OmpSs-OpenCL Kernel/Task

- _kernel void triad_task (_global double *, _global double *, _global double *, _global double *, _global double *, _global double *, _global double *, _global double *);
- int j=get_global_id(0);
- a[j] = b[j]+scalar*c[j];

Auto-Tune Model

- Auto-tuning framework
- Optimization Space
- Configure OpenCL Kernel Parameters
- Configure OpenCL Kernel Configuration & Compilation Log
- User-Specific Kernel Configuration & Compilation Log
- Global Default Local Workgroup Size Register Count
- Best Auto-Tuned Execution Configuration for OpenCL Application Kernel
- Test Run (OpenCL Kernel)
- Execution Log

Key-features Tuned

- Work-Group sizes are tuned in such a manner that the kernel fits the local Memory, Register Count and Hardware Threads specific to the GPU.
- An optimization Space is created consisting of all possible kernel configuration for a single GPU.
- The set is executed to find the best mapping of the threads (work-group size) onto the GPU cores.
- The kernel characteristics and the device features are obtained using OpenCL API calls and kernel compilation log.
- This Auto-Tune Tool fits perfectly for OmpSs-OpenCL Task-based programming model.

Analysis

- We investigated the tool with 3 different benchmarks with 3 different GPUs.
- We focused on Matmul and histogram using local memory and register-based matmul benchmarks for our analysis.

Results-Matmul

![Figure 2: Tesla M2090](image)

![Figure 3: NVS 3100M](image)

![Figure 4: GT 630M](image)

Results-Histogram

![Figure 5: Tesla M2090](image)

![Figure 6: NVS 3100M](image)

![Figure 7: GT 630M](image)

Conclusion

- Auto-tune Tool addresses one aspect in OpenCL performance portability across GPU machines.
- The investigation with OmpSs-OpenCL delivered a performance increase of 5% for 64 blocked matmul tasks across 3 GPUs.
- In GPU1 & GPU3 user configuration fails to give the best performance and tuning helps in providing 10% & 6% gain. Whereas in GPU2, when user specification is optimal and tuning becomes an overhead of 3%.

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