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Memory-Aware Scheduling
Of Tasks Sharing Data On Multiple GPUs

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Motivation: Extract peak performance from GPUs

- Scientific application uses a huge quantity of data
- GPUs can calculate quickly but their memory are limited
- The PCI bus becomes a bottleneck when large amounts of data need to be loaded

Figures 1

To get peak performance we need to minimize the number of access to the main memory

Frameworks and objectives

- Independent tasks sharing data
- Same size data
- Multiple GPUs with limited memory

Figures 2

A novel strategy: Data-Aware Reactive Task Scheduling (DARTS)

Using (hyper-)graph partitioning: hMETIS

- Hypergraph ⇒ Represents a data being shared by multiple tasks
- hMETIS produces subsets of task that maximize the amount of edges (data shares) inside each subset
- We add dynamic reordering and task stealing to improve performance

Figures 3

Experimental evaluations on independent tasksset

- Tesla V100 GPUs with a 12000 MB/s PCI bandwidth
- GPU memory limited to 500 MB to better distinguish the performance even on small datasets
- 10 runs per experiment (deviation < 2%)

Figures 4

Experimental evaluations on independent tasksset

Algorithms from the state of the art

- Using (hyper-)graph partitioning: hMETIS
- hMETIS suffers from a conflict between prefetches and evictions
- DMDAR suffers from a large scheduling cost
- Even without memory limitation, DARTS outperforms DMDAR

Figures 5

A novel strategy: Data-Aware Reactive Task Scheduling (DARTS)

DMDAR

- Process tasks in the order in which it receives them ⇒ our baseline
- EAGER

Figures 6

Experimental evaluations with dependencies

- Limiting data movement is crucial to extract the most out of GPUs
- DARTS achieves better performances once the memory is a constraint (after the red dotted line) for EAGER, hMETIS and DARTS

Figures 7

DARTS nicely overlaps communications and computations

- DARTS can be used with a reduced complexity (DARTS+OPTI) by stopping the search for the optimal data earlier.
- Even without memory limitation, DARTS outperforms DMDAR

Figures 8

Summary and conclusion

- High-performance computing applications, like weather and climate forecasting, have an increasing demand in computer power
- GPUs have a large computation power but have a limited memory. This, coupled with the share of a single PCI express bus by multiple GPUs induce a large amount of data transfers which reduces performance ⇒ Limiting data movement is crucial to extract the most out of GPUs
- We provide a new algorithm (DARTS) and a new eviction policy (LUF) focused on data locality
- DARTS+LUF achieves good performance because it
- Limits data transfers thanks to the finding of an optimal data and an adapted eviction policy
- Overlaps communication and computations by distributing transfers over time
- Can be used with a reduced complexity
- Can deal with priorities
- Areas for improvement:
  - Manage multiple MPI nodes
  - Use other out-of-core applications (DARTS is not specific to GPUs)

Figures 9