MapReduce on GPUs

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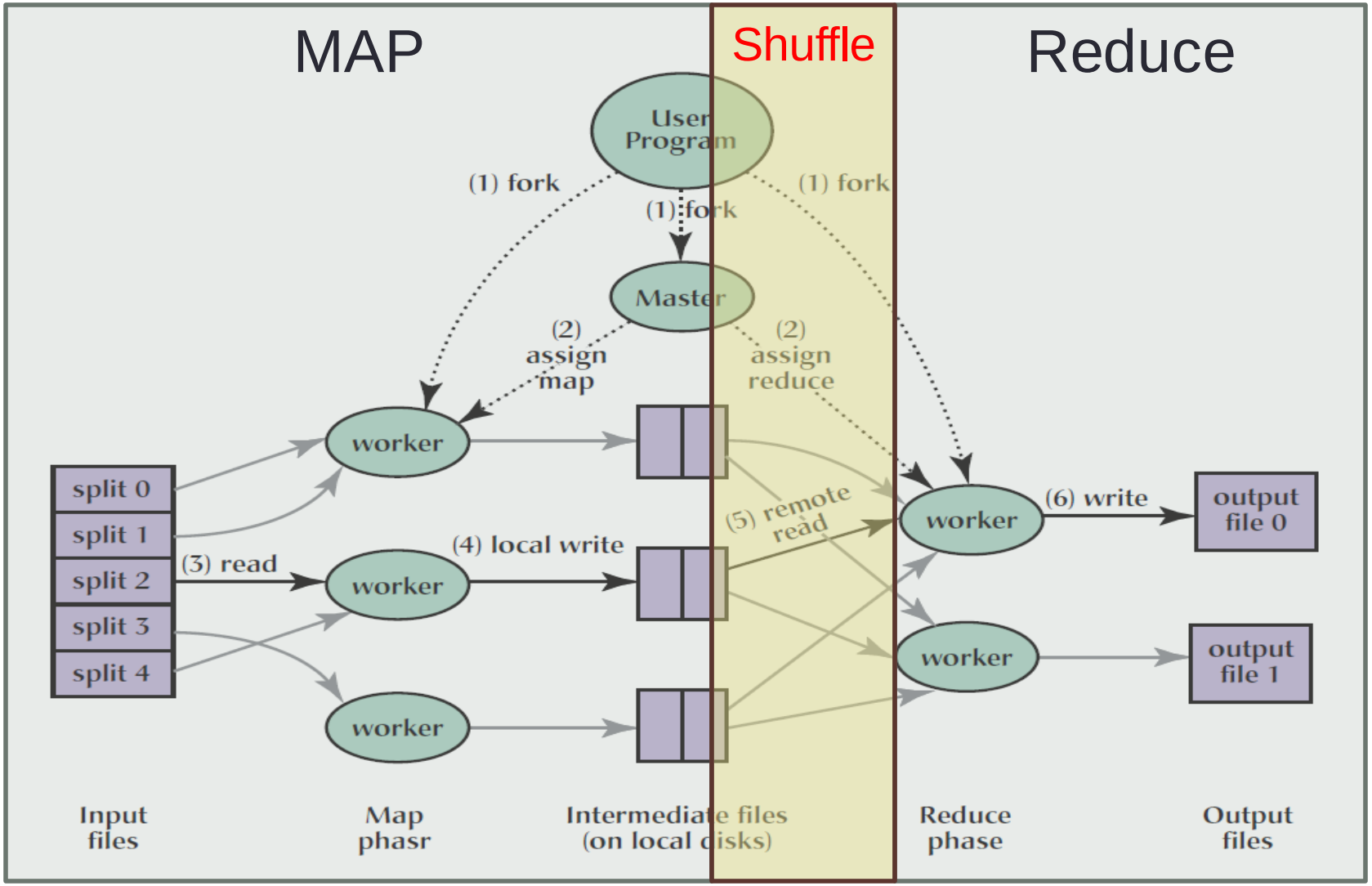
MapReduce


MAP
Shuffle
Reduce
User Program
(1) fork
(1) fork
(1) fork
Master
(2) assign map
(2) assign reduce
worker
worker
worker
worker
worker
split 0
split 1
split 2
split 3
split 4
(3) read
(4) local write
(5) remote read
(6) write
output file 0
output file 1
Input files
Map phasr
Intermediate files (on local disks)
Reduce phase
Output files

Hadoop

- Open-source MapReduce framework from Apache, written in Java
- Used by Yahoo!, Facebook, Ebay, Hulu, IBM, LinkedIn, Spotify, Twitter etc.
- Primary usage – Data mining/machine learning algorithms on large datasets

Motivation

- *Map* phase of MapReduce programming model is extremely parallel
- *Combine*, the local reduce stage, is partially parallel
- On average more than 60% of the execution time is spent in (Map + Combine)
- GPU memory bandwidth > 10 * CPU memory bandwidth

Question :

Can we run the Map and Combine phases of MapReduce on an extremely parallel machine, like a GPU?

Related Work

- Phoenix – MapReduce for multi-cores

- Mars – MapReduce on a single node GPU
  - Pros – Performs GPU specific optimizations
  - Cons – Restricted to a single node system

- GPMR – MapReduce for GPU cluster with CUDA + MPI
  - Pros – Displays MapReduce Scalability in a GPU cluster
  - Cons – CUDA + MPI impose a productivity challenge

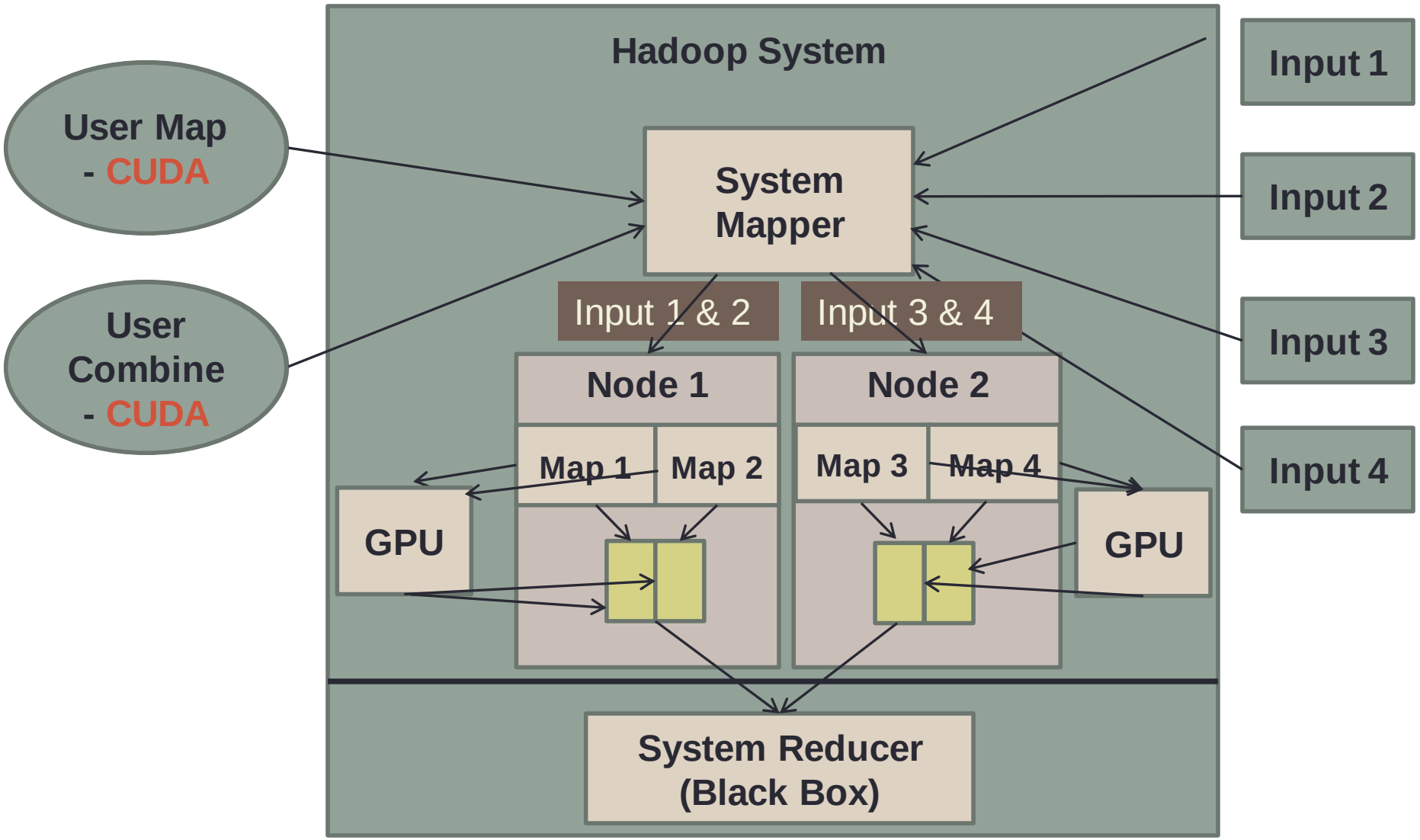
Challenges & Scope of the Project

- Programming Language
- Avoiding divergence on GPUs
- Combiner Implementation – exploiting partial parallelism

Scope :

- Run on single machine → Evaluate effectiveness of GPUs
- Use hand-written *CUDA* Map + Combine code
- Compare CPU vs. GPU Hadoop performance on different data sizes.

System Design



CUDA Implementation

Mapper:

- Input is split, every GPU thread works on same sized input
- Input is in text format → Inherent intra-thread diversion
- Map output sorting – Strings represented as a hash function

Combiner:

- One thread per Streaming Multiprocessor

Evaluation

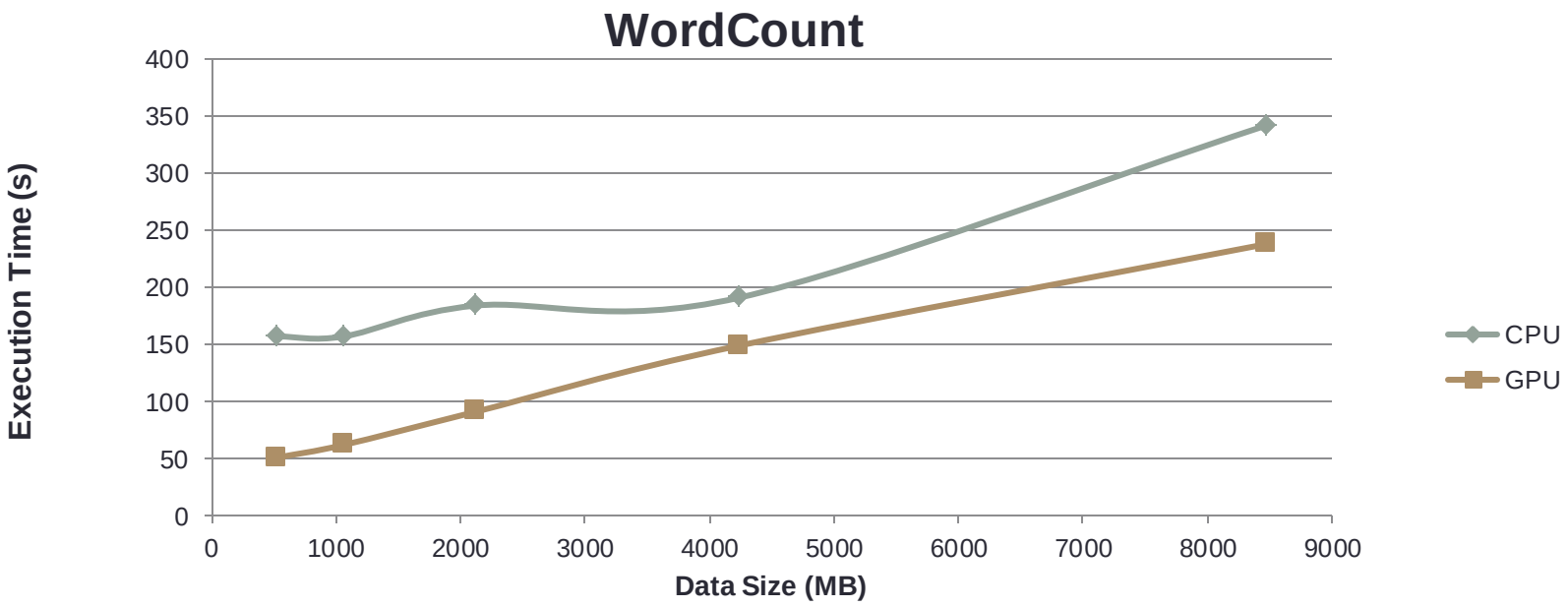
Setup

- CPU – AMD Opteron 6282 – 16 cores, 2.6 GHz
- GPU – Tesla M2090 – 16 SMs

Benchmarks

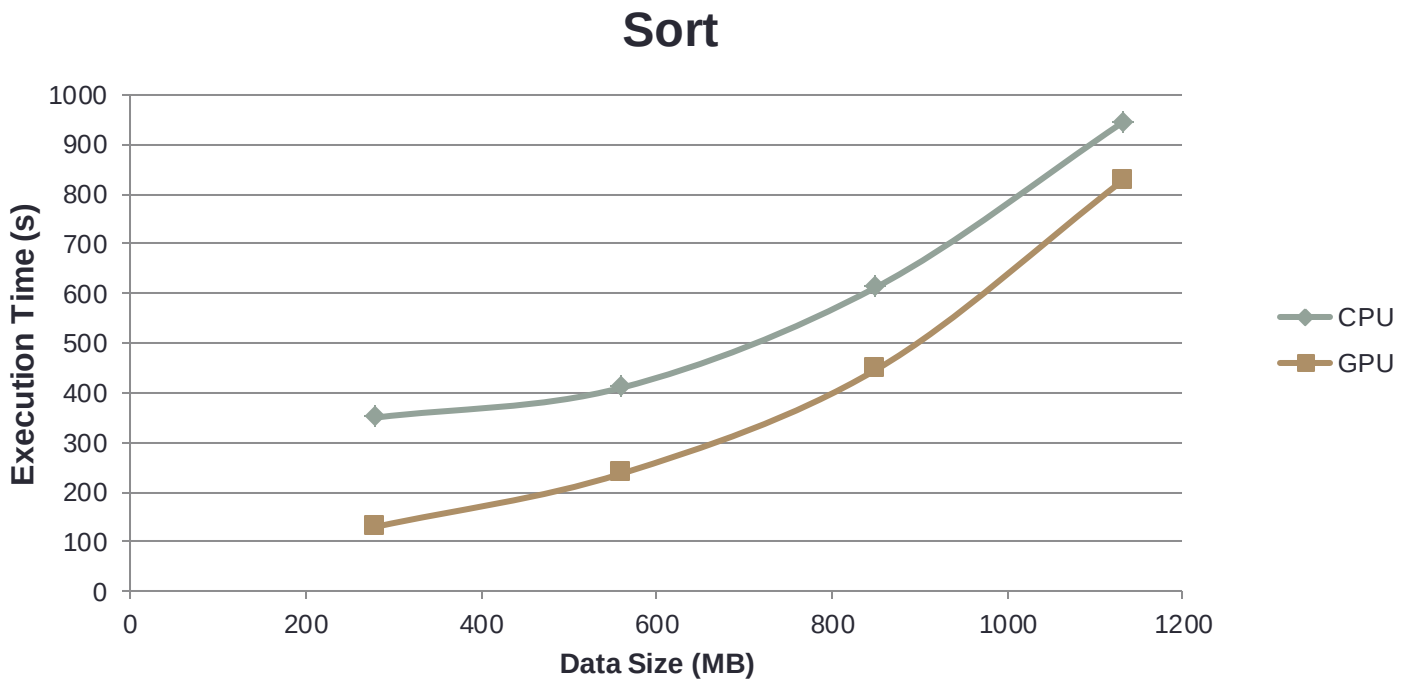
- WordCount – Data size up to 8GB
- Sort – Data size up to 1GB

Evaluation - WordCount



- File Size – 250 MB
- At 4 GB data, all CPU cores are engaged
- Combiner reduces the intermediate data

Evaluation – Sort



- Sort does not have a combiner → Huge intermediate data
- CPU parallelism is restricted by I/O
- Most of the time is consumed by reducer

Future Work

- Multiple Map tasks run in a serialized manner on the GPU
  → Combine them into a single, bigger Map task

- Hadoop scheduling in CPU + GPU environment

References

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Thank You!