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LSDS
Large-Scale Data & Systems Group

MapReduce: Simplified Data Processing on Large Clusters

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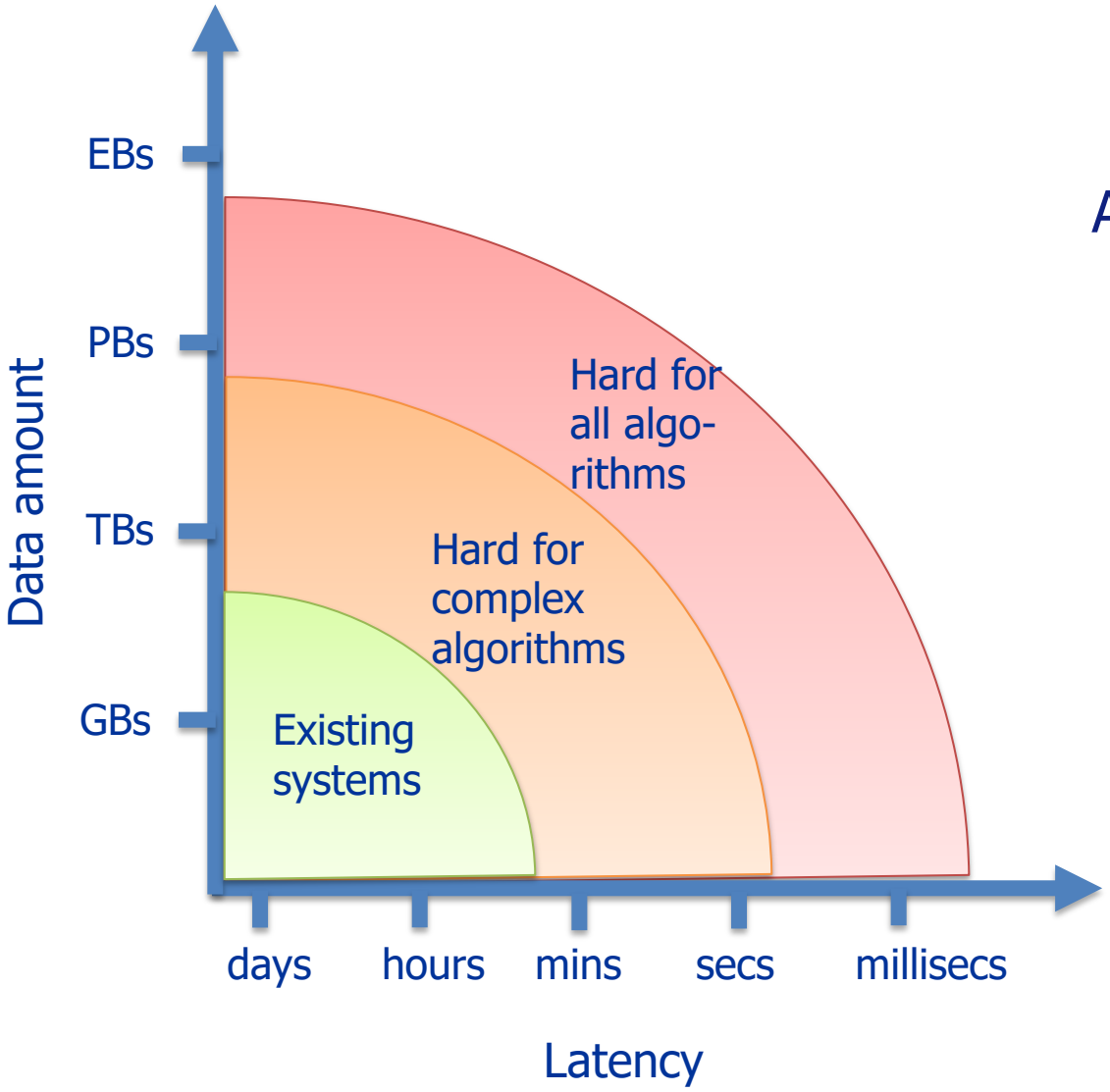
Design Space: Big Data Processing



Volume and Velocity

Algorithmic complexity

- Arbitrary data transformation
- Iterative algorithms
- Large state as part of computation

MapReduce Overview

Mainstream "Big Data" analytics framework

- E.g. PageRank (web search indexing)
- Made popular by Google in 2004
- Open source version (Hadoop) by Yahoo/Apache

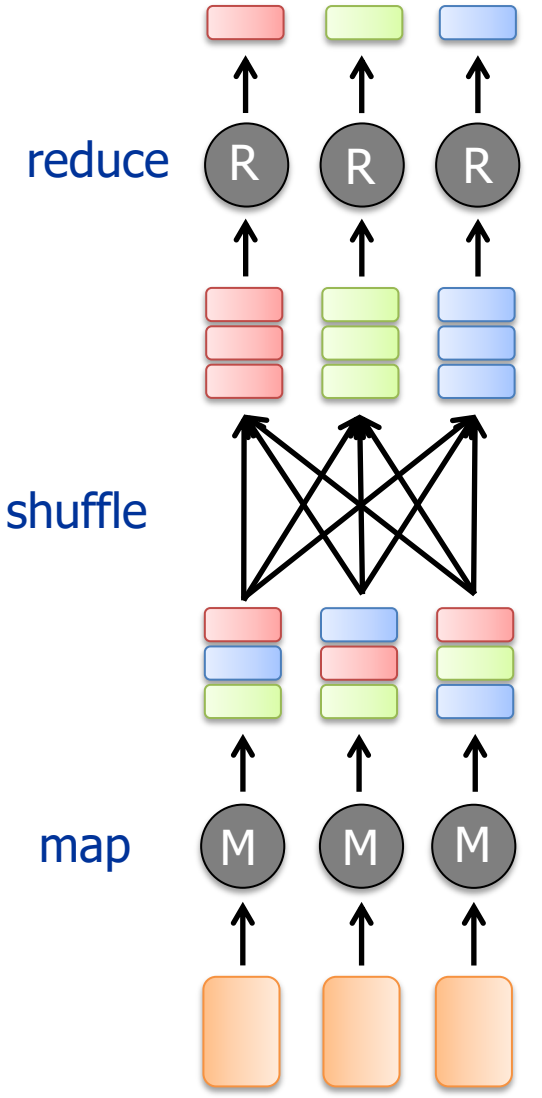
Sanjay Ghemawat | Jeff Dean

Benefits:

- Simple programming model
- Transparent parallelisation
- Fault-tolerant processing

$2 billion market revenue (2013)

MapReduce: Distributed Dataflow



Data model: (key, value) pairs

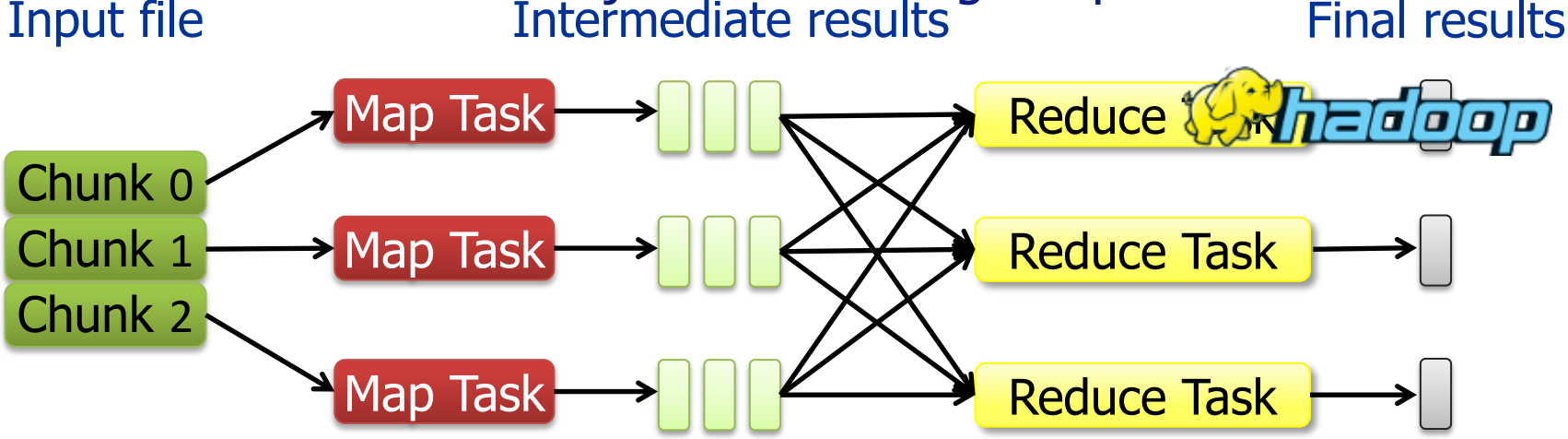
Two processing functions:

map(k_1,v_1) → list(k_2,v_2)

reduce(k_2, list(v_2)) → list (v_3)

Example: Wordcount

Consider a Word Count job for counting unique words…



Map: Processes input data and generates (key, value) pairs

- e.g. {(cat, 5), (dog, 7), (elephant, 9)}

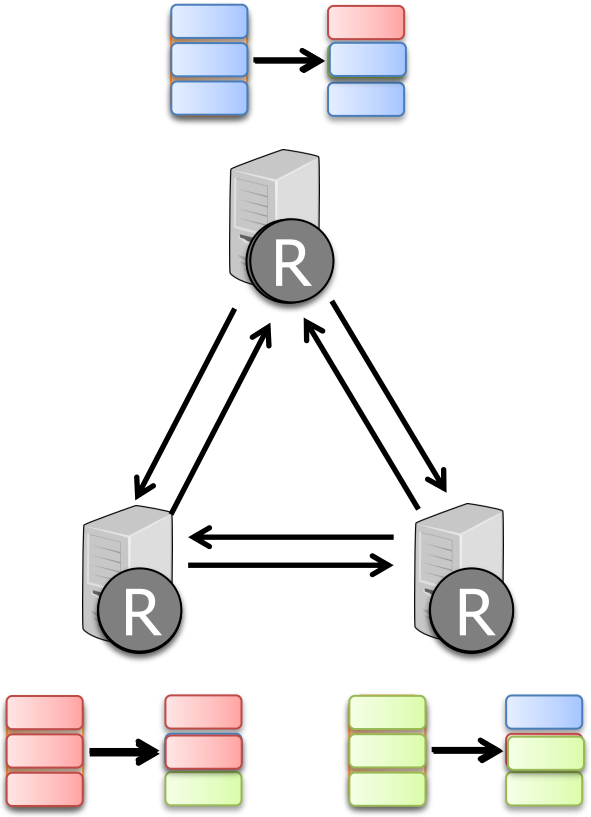
Shuffle: Distributes intermediate pairs to reduce tasks

- e.g. all words starting with 'A' to reducer 1, those with 'B' to reducer 2

Reduce: Aggregates all values associated to each key

- e.g. sum all values for word "cat", all values for word "dog"

MapReduce Execution Model



Map/reduce tasks scheduled across cluster nodes

- Locality-aware scheduler

Intermediate results persisted to local disks

- Final results of MapReduce job stored in GFS

Failure Recovery

1. Task failure: restart task
   - Map tasks fetch data from GFS
   - Reduce tasks fetch intermediate results from local disks

2. Node failure: restart tasks on new node
   - Need to re-run all tasks because intermediate results are lost

Speculative Execution

MapReduce jobs dominated by slowest task

Speculative execution:

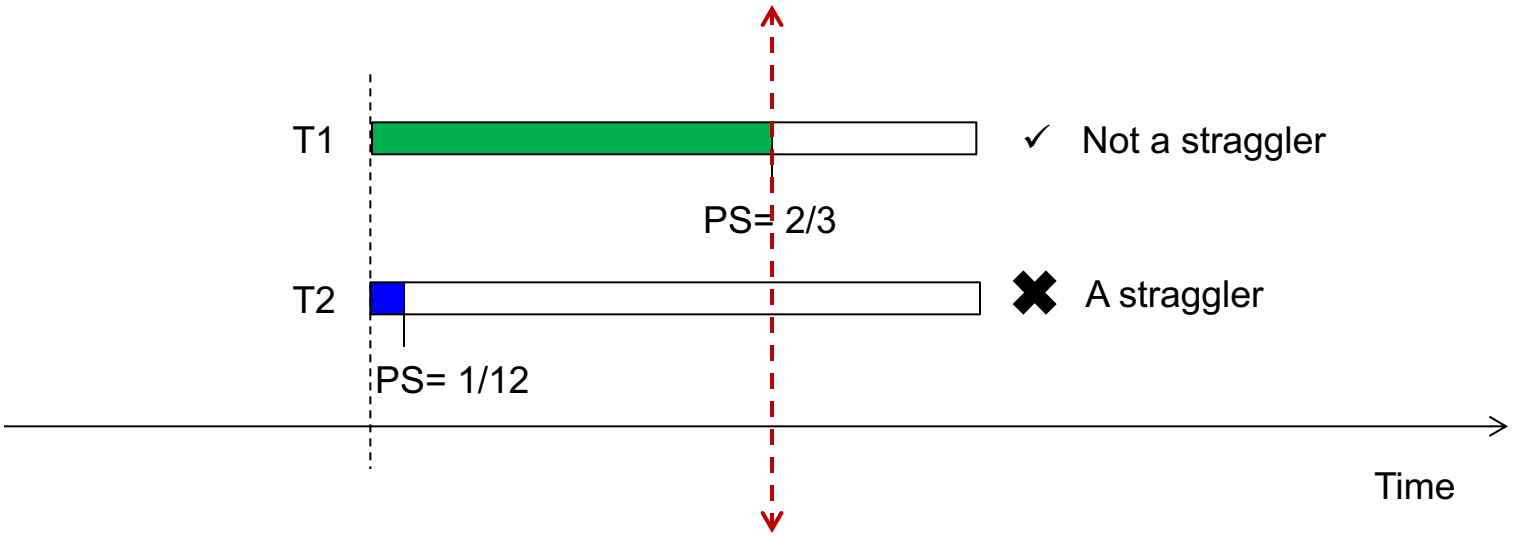
MapReduce attempts to locate slow tasks (stragglers) and run redundant (speculative) tasks

- Hope that speculative tasks finish before stragglers
- Only one copy of straggler allowed to be speculated

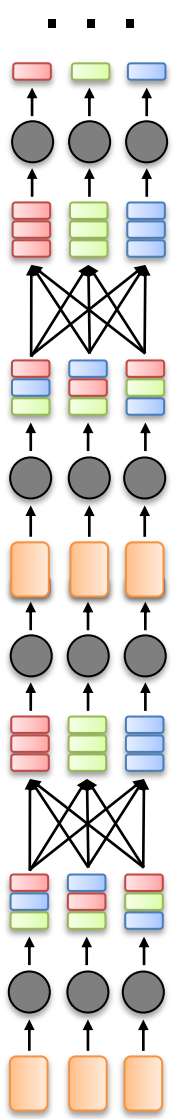
Locating Stragglers

How does Hadoop locate stragglers?

- Hadoop monitors each task progress using progress score between 0 and 1
- If task's progress score less than (average – 0.2) + task ran for at least 1 minute ➔ mark as straggler



Support for Iteration



Iteration useful for many algorithms

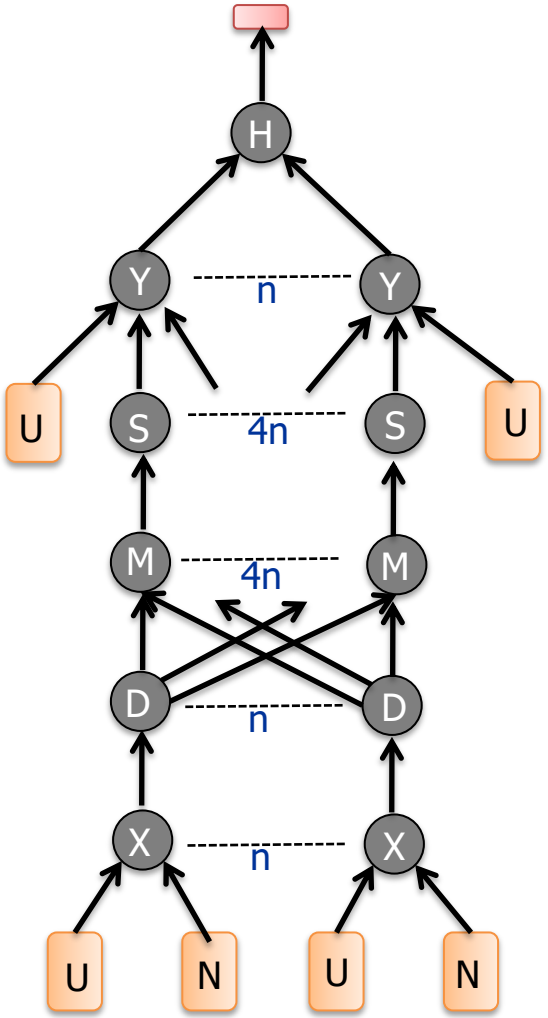
- Machine learning/data mining algorithm (pagerank, k-means, logistic regression, …)

Loop unrolling: multiple MapReduce jobs

Challenge:

- Materialisation of intermediate results becomes expensive

Dryad: Dataflows as DAGs



Arbitrary functions as tasks

- Eg Joins, group by etc

Dataflow graph → directed acyclic graph

Same model as Spark...

SkyServer query:
3-way join to find gravitational lensing in astronomy data