

Map-Reduce Algorithms

What Can Go Wrong?

Reducer Size and Replication Rate

Mapping Schemas

Matrix Multiplication

Mining of Massive Datasets

Leskovec, Rajaraman, and Ullman

Stanford University



Mappers and Reducers

- Map-Reduce job = Map function + Reduce function.
- Map Task = Map-function execution on a chunk of inputs.
- Reduce Task = Reduce-function execution on one or more key-(list of values) pairs.
- *Mapper* = application of the Map function to a single input.
- *Reducer* = application of the Reduce function to a single key-(list of values) pair.

Cost of Map-Reduce Jobs

- There are two principal costs:
 1. *Computation cost* of mappers, reducers, and system.
 - System cost is principally sorting key-value pairs by key and merging them at Reduce tasks.
 2. *Communication cost* shipping key-value pairs from mappers to reducers.
 - Assume Map tasks are executed where their input data resides, so no communication required.
 - Assume every key-value pair has to be moved.

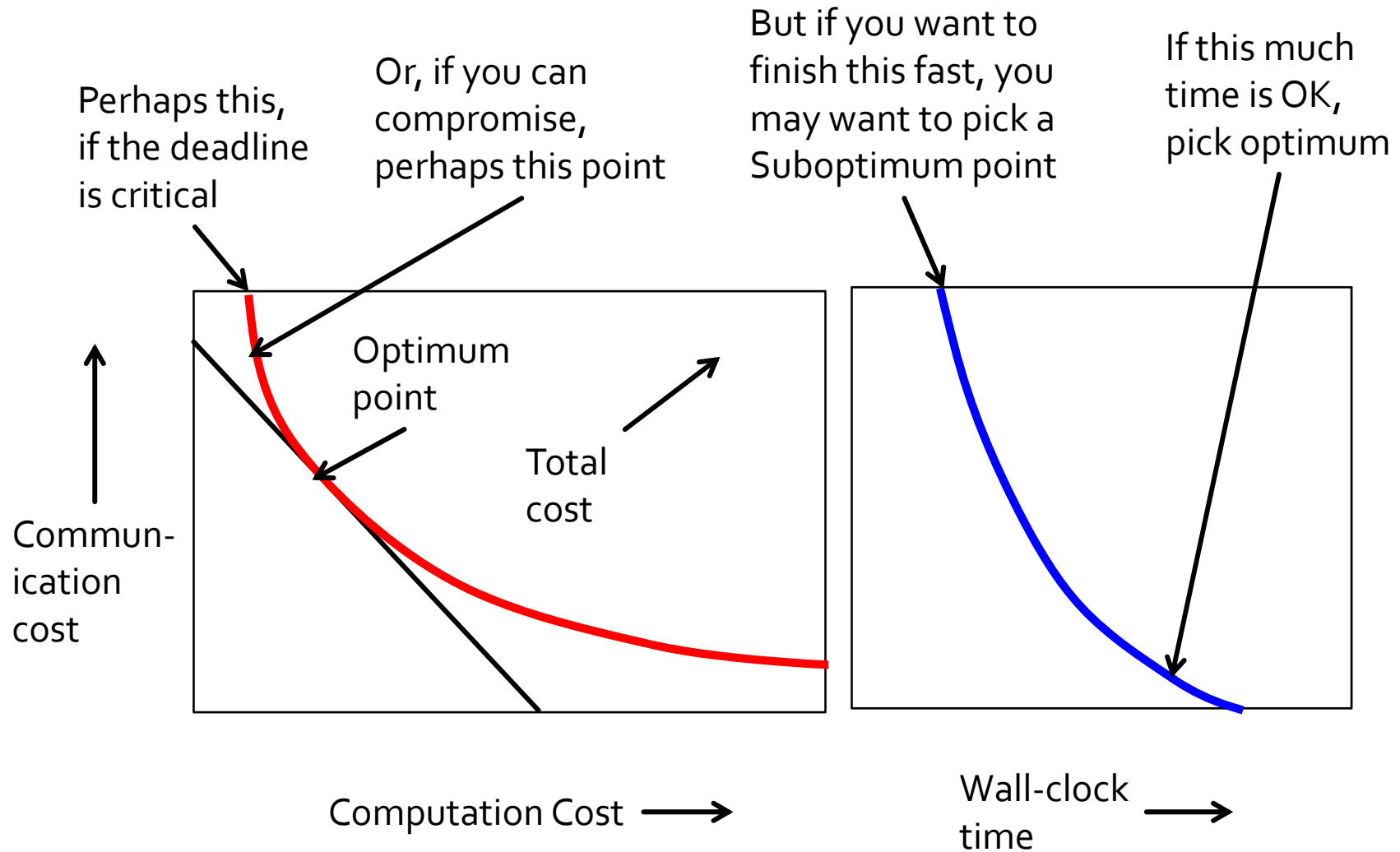
Cost of Map-Reduce Jobs – (2)

- Computation at the mappers is usually a small fraction of the communication cost and can be neglected.
- System cost of sorting is typically proportional to the communication cost.
- Communication cost often dominates computation cost.

Cost of Map-Reduce Jobs – (3)

- On a public cloud, you pay for computation and you also pay for communication.
 - Balancing the two is an important part of algorithm design.
- But you also want the job to finish fast, which requires a high degree of parallelism.
- Often, there is a second trade-off, with high parallelism pushing the communication higher than you would like for minimum cost.

A Picture of the Trade-Offs



Reducer Size – The Hidden Variable

- For some problems, the computation is the same no matter how you partition the problem.
- However, in many cases, the big issue is whether a reducer has too much input to operate in main memory.
 - To get reducers with small input size, you need a lot of communication.
 - Results in a step function of cost when communication gets too low.

A Common Case

