

COSC-254 Data Mining

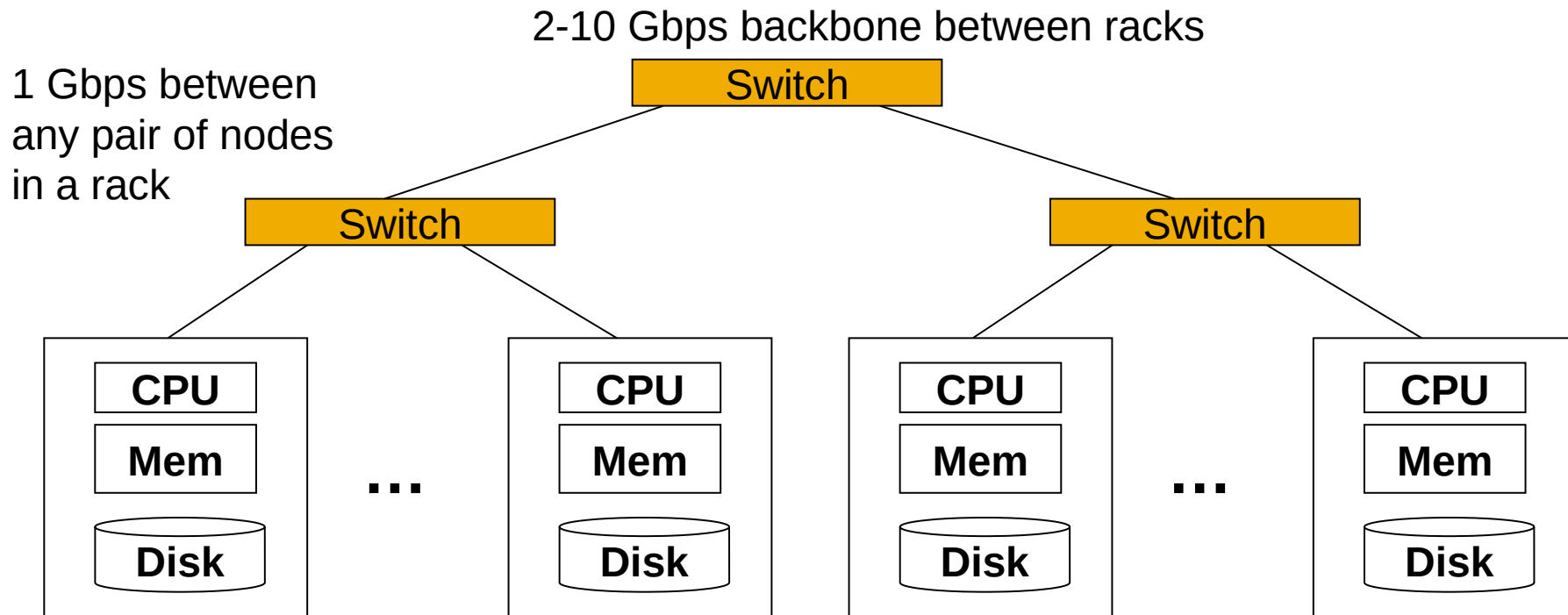
Lec 02: MapReduce & Hadoop

Motivation: Google Example

- 20+ billion web pages x 20KB = 400+ TB
- 1 computer reads 30-35 MB/sec from disk
- ~4 months to read the web
- ~1,000 hard drives to store the web

- Much more time to **do something useful with the data!**

Cluster Architecture



Each rack contains 16-64 nodes

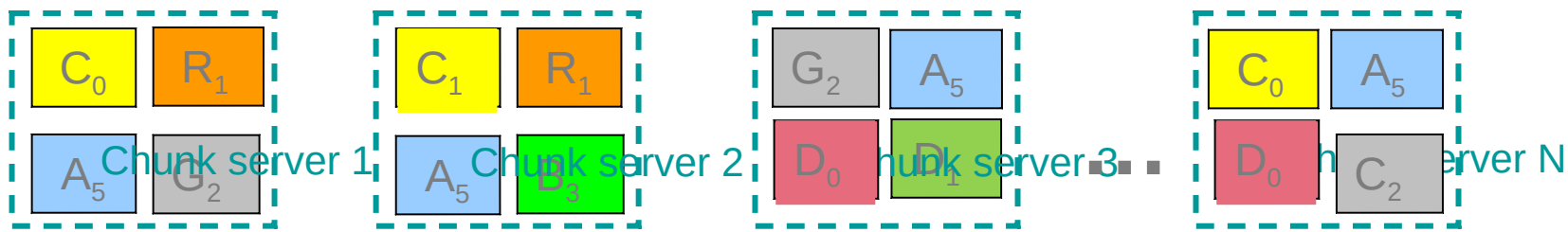
In 2011 it was gestimated that Google had 1M machines, <http://bit.ly/Shh0RO>



Machines fail

- **Machines fail:**
- One server may stay up 3 years (1,000 days)
- If you have 1,000 servers, expect to loose 1/day
- People estimated Google had ~1M machines in 2011
 - 1,000 machines fail every day!

Distributed File System

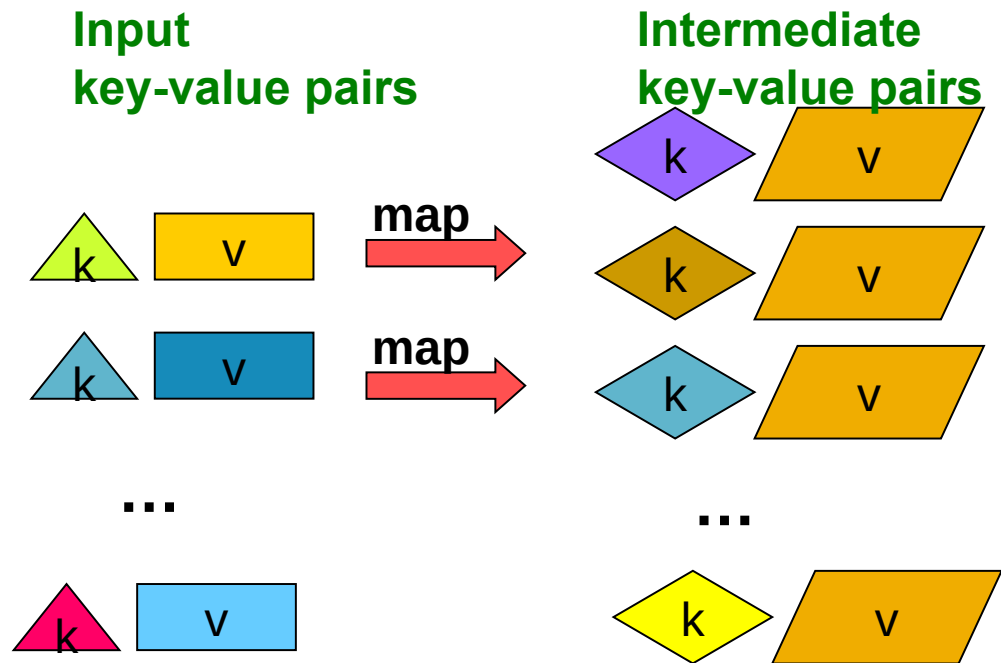


- Master node (Name Node in Hadoop): keeps metadata

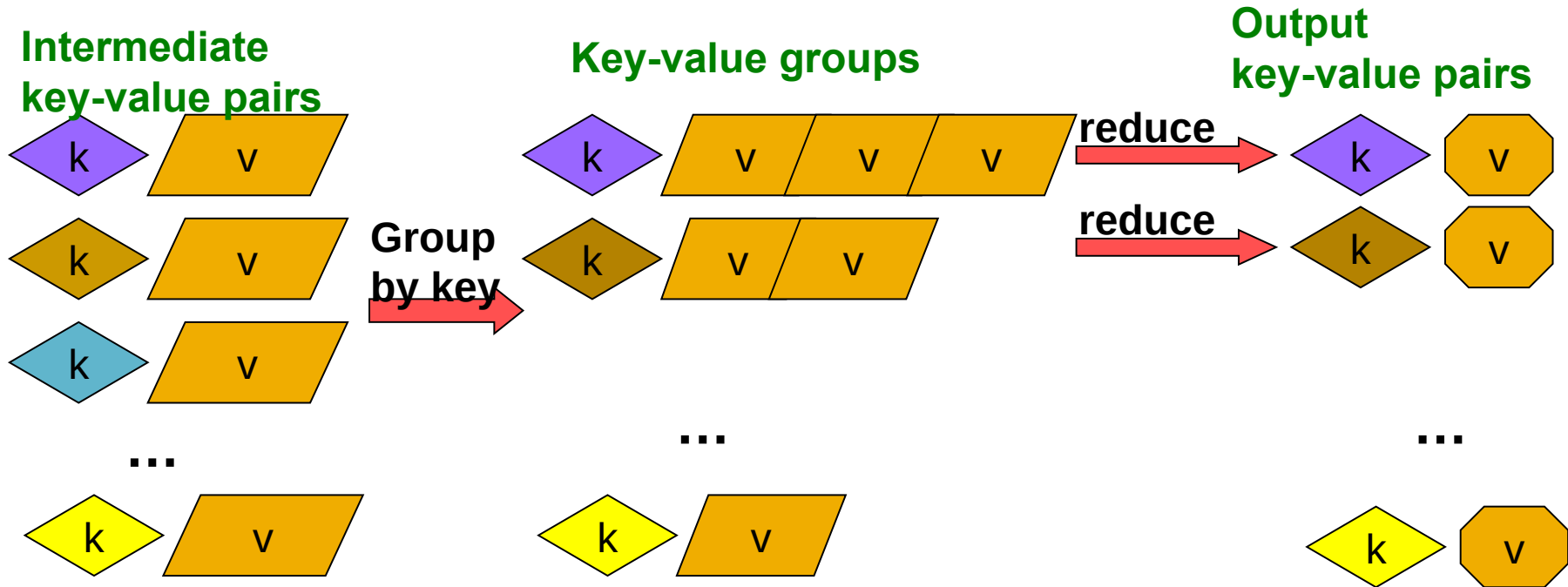
MapReduce: Overview

- Sequentially read units of data
- **Map:** for each unit, **extract** some “thing” you care about
- **Group by key:** **Sort** the things and **Shuffle**
- **Reduce:** **Aggregate**, filter, transform all the “equal” things
- Write the result

MapReduce: The Map Step



MapReduce: The Reduce Step



MR/Hadoop: Word Counting

Provided by the programmer

MAP:

Read input and produces a set of key-value pairs

(the, 1)
(crew, 1)

(of, 1)

(the, 1)

(space, 1)

(shuttle, 1)

(Endeavor, 1)

(recently, 1)

(key, value)

Group by key:
Collect all pairs with same key

(crew, 1)
(crew, 1)

(space, 1)

(the, 1)

(the, 1)

(the, 1)

(shuttle, 1)

(recently, 1)

(key, value)

Provided by the programmer

Reduce:

Collect all values belonging to the key and output

(crew, 2)

(space, 1)

(the, 3)

(shuttle, 1)

(recently, 1)

...

(key, value)

The crew of the space shuttle Endeavor recently returned to Earth as ambassadors, harbingers of a new era of space exploration. Scientists at NASA are saying that the recent assembly of the Dextre bot is the first step in a long-term space-based man/machine partnership. "The work we're doing now -- the robotics we're doing -- is what we're going to need....."

Big document

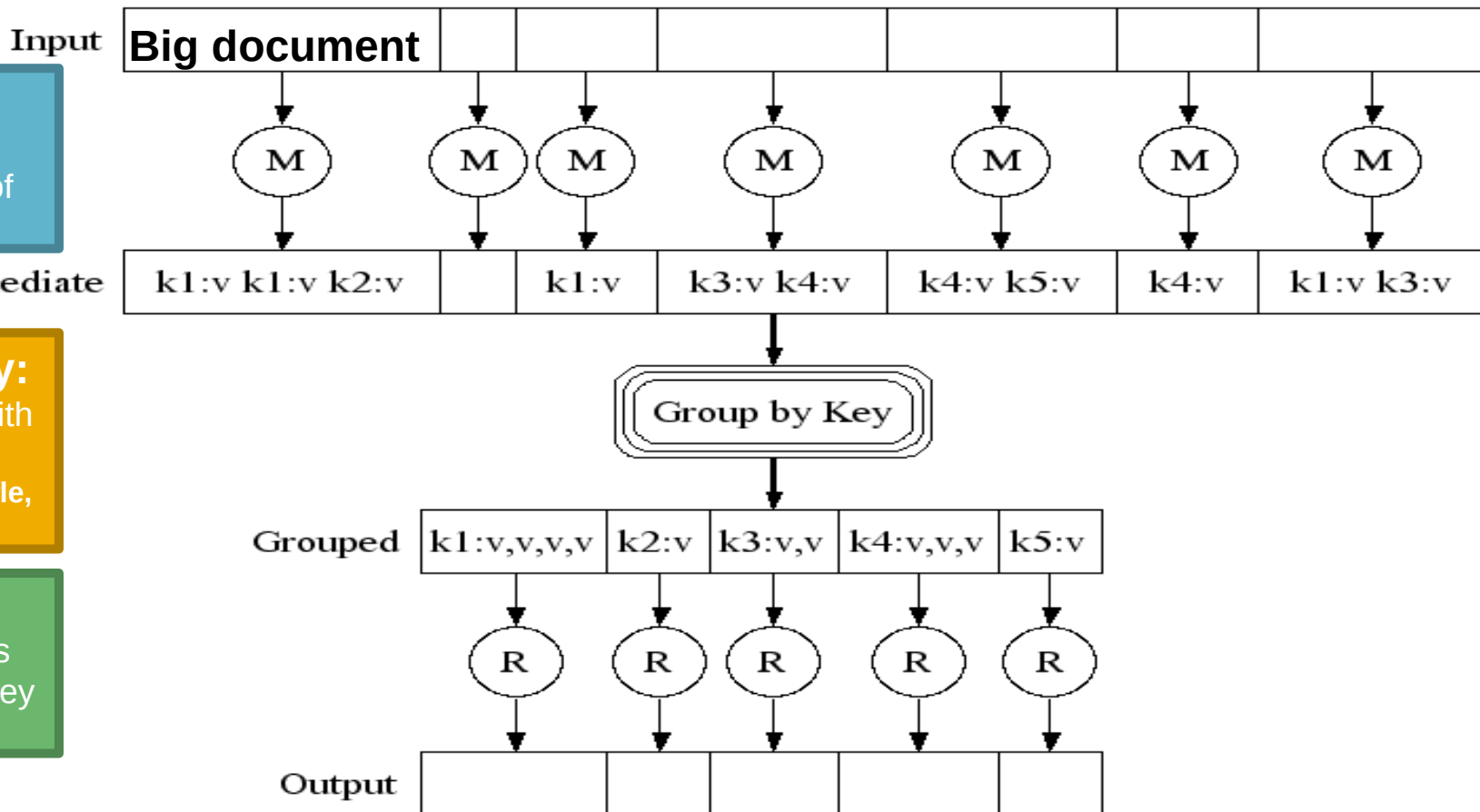
Only sequential reads

Map-Reduce: A diagram

MAP:
Read input and produces a set of key-value pairs

Group by key:
Collect all pairs with same key
(Hash merge, Shuffle, Sort, Partition)

Reduce:
Collect all values belonging to the key and output



What is the **muddiest point** about Hadoop/MR?

Go to <http://bit.ly/DM19M204> and tell us!

Hadoop: Environment

Hadoop environment takes care of:

- Partitioning the input data
- Scheduling the execution across a set of machines
- Performing the **group by key** step
- Handling machine failures
- Managing required inter-machine communication

Word Count Using MapReduce

map(key, value) :

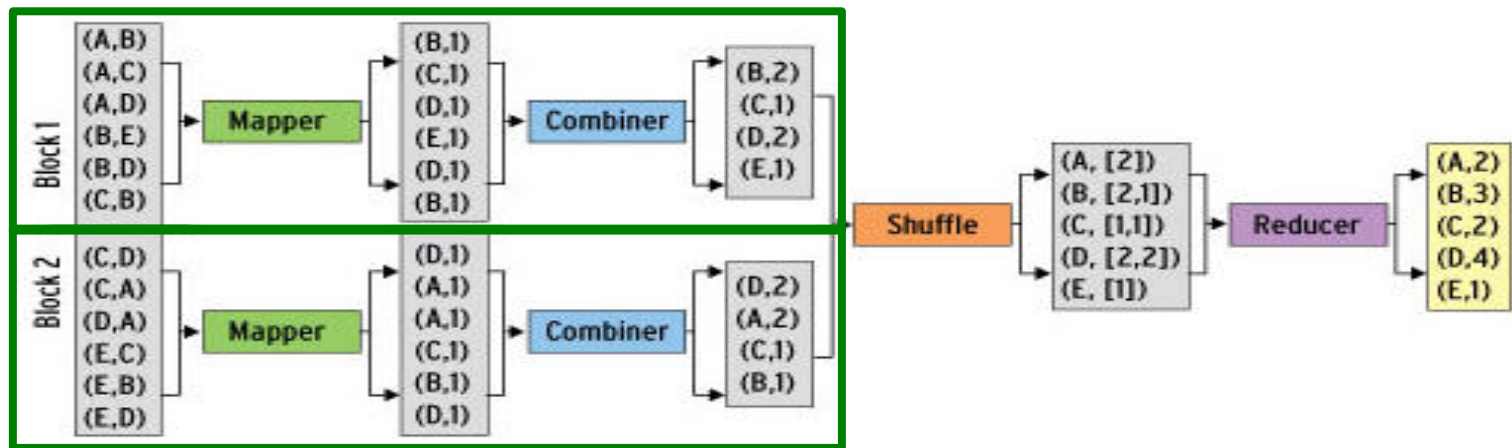
```
// key: document name; value: text of the document
  for each word w in value:
    emit(w, 1)
```

reduce(key, values) :

```
// key: a word; value: an iterator over counts
  result = 0
  for each count v in values:
    result += v
  emit(key, result)
```

Refinement: Combiners

- Back to our word counting example:
 - Combiner combines the values of all keys of a single mapper (single machine):



- Much less data needs to be copied and shuffled!