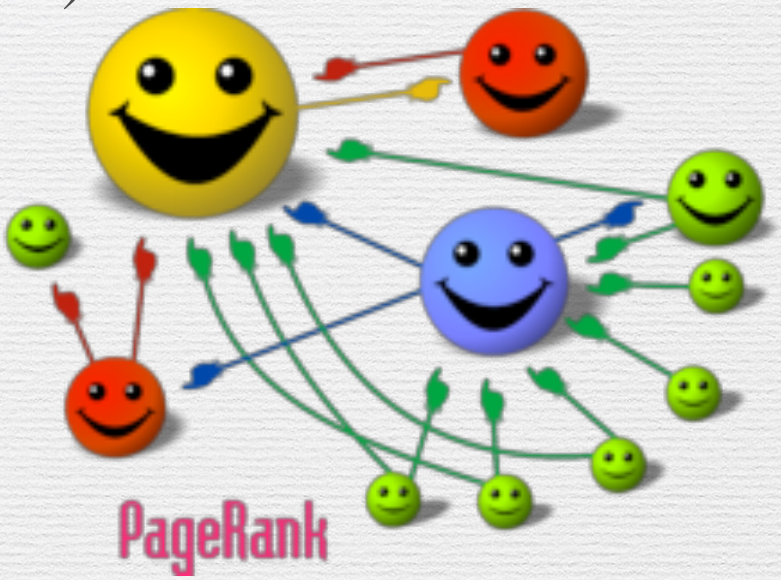
MapReduce

1997

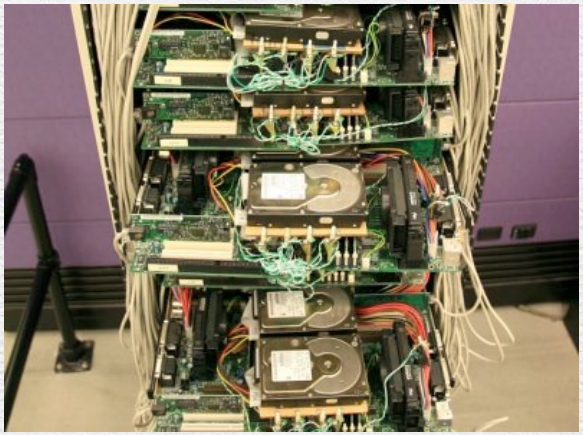
Data	Webpages (URLs)
Problem	Find URLs
Idea: Algorithm	PageRank



Larry Page and Sergey Brin

2003

Data	Webpages (URLs)
Problem	Find Webpage
Idea: Algorithm	PageRank
System	MapReduce



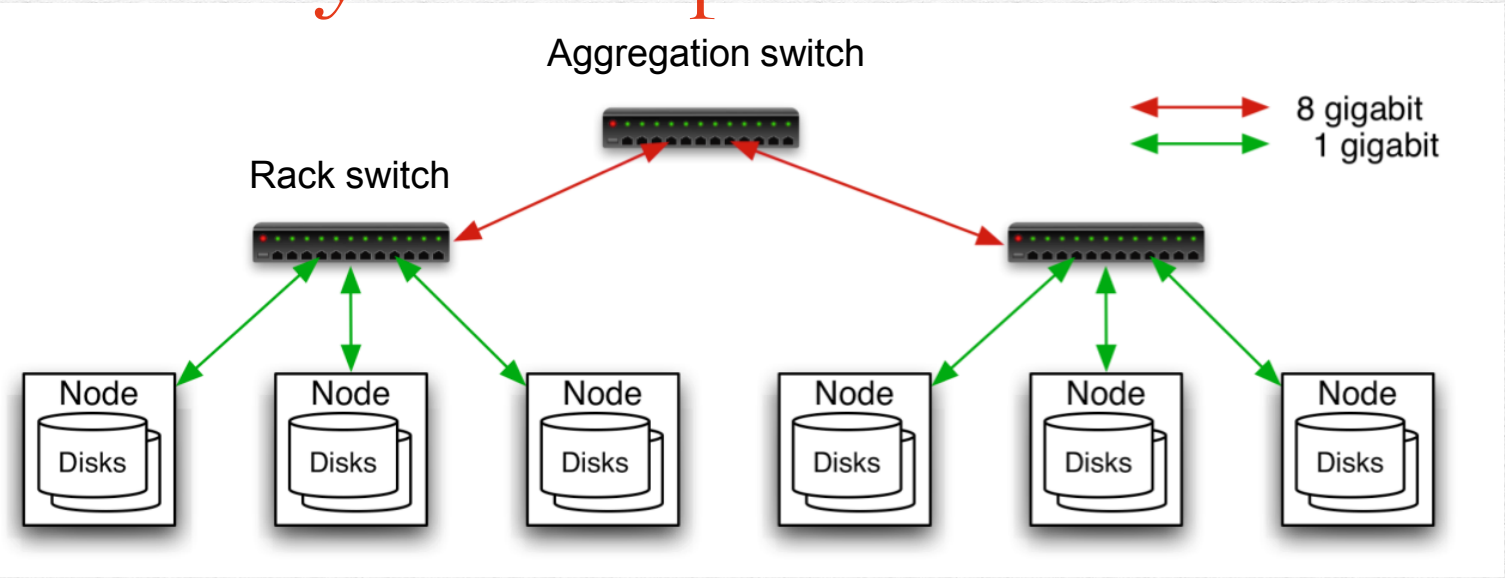
Google

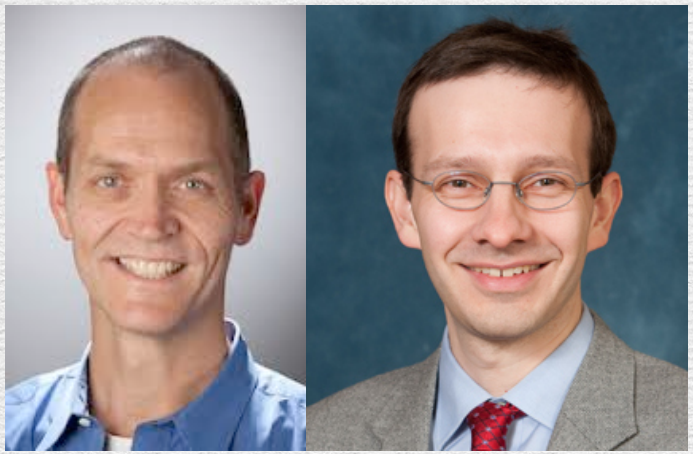
Sanjay Ghemawat and Jeffrey Dean

System

2005

MapReduce System + Open source





Doug Cutting and Mike Cafarella

now used by Yahoo
Facebook Amazon

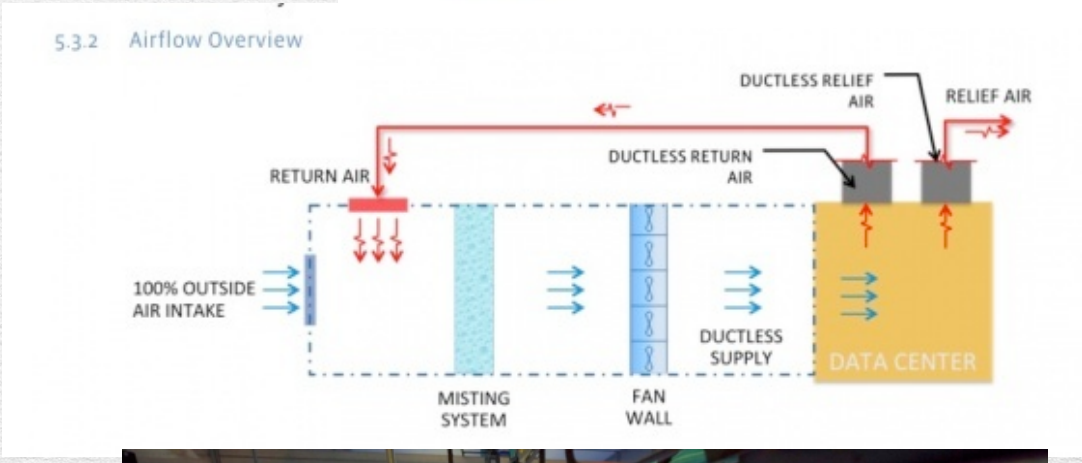
Hardware

2011

Data Center Design + Open source

https://www.youtube.com/watch?v=_r97qdyQtIk

OPEN Compute Project



facebook

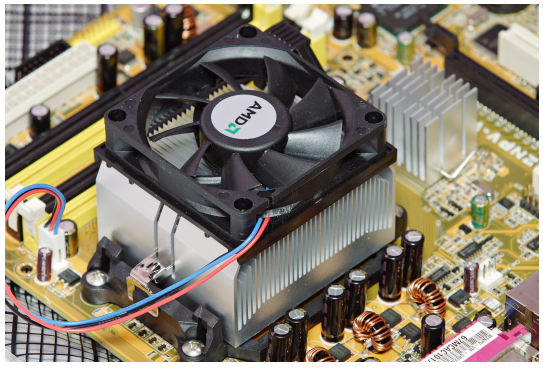
data center cooling system storage power plant

Programming: **MapReduce**, Spark …

Programming: Python, Java, …

laptop

fan



hard drive

power cord

MapReduce

- MapReduce
  - Framework for parallel computing
  - Programmers get simple API
  - Don't have to worry about handling
    - parallelization
    - data distribution
    - load balancing
    - fault tolerance

- Allows one to process huge amounts of data (terabytes and petabytes) on thousands of processors

Mappers

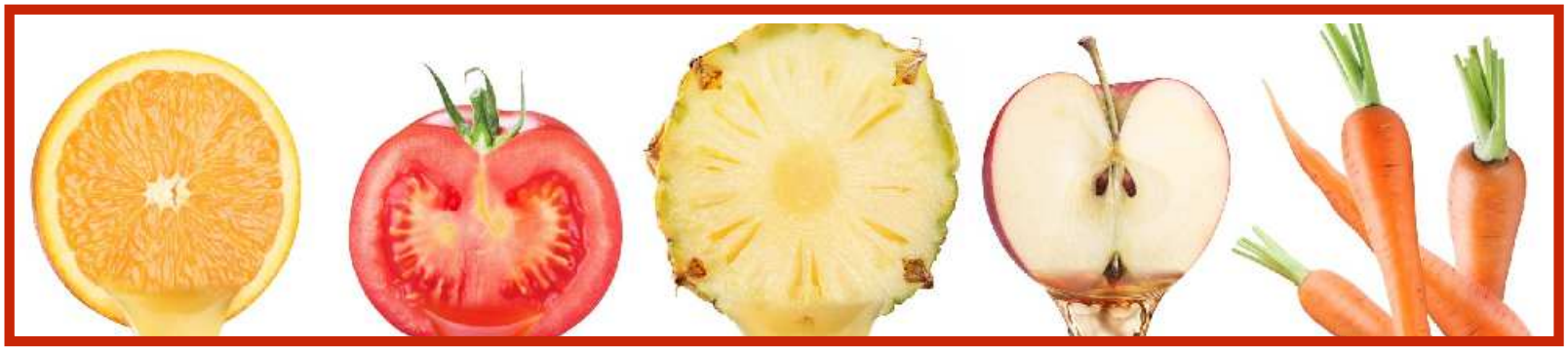
Input:

one data record

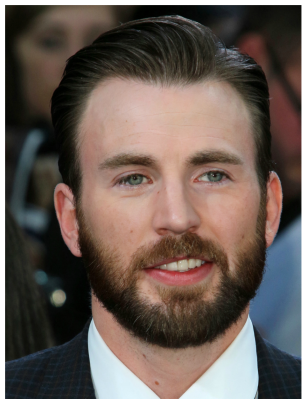
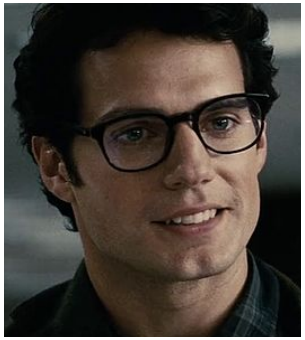
Output:

one/more results

Reducer

Input:	a list of data records 
Output: one/more results	

Mappers

Input: one data record					
Output: one/more results					

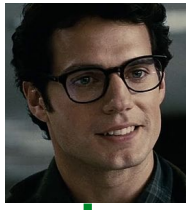
Reducer

Input:

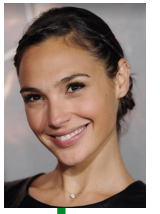
a collection of data records

Output:

one (or multiple) result(s)



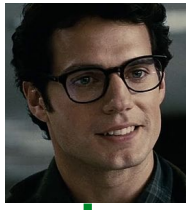

map
map
map
map
map
map



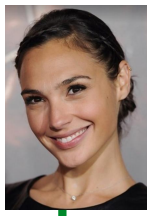





reduce
reduce





map

map

map

map

map

map



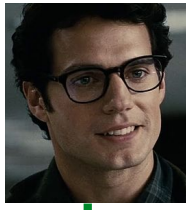



reduce

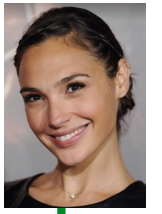
reduce

4

2




map
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map

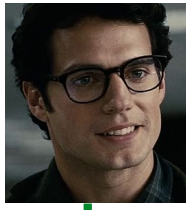




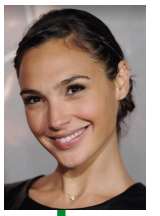


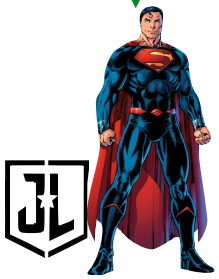

reduce
reduce
















map
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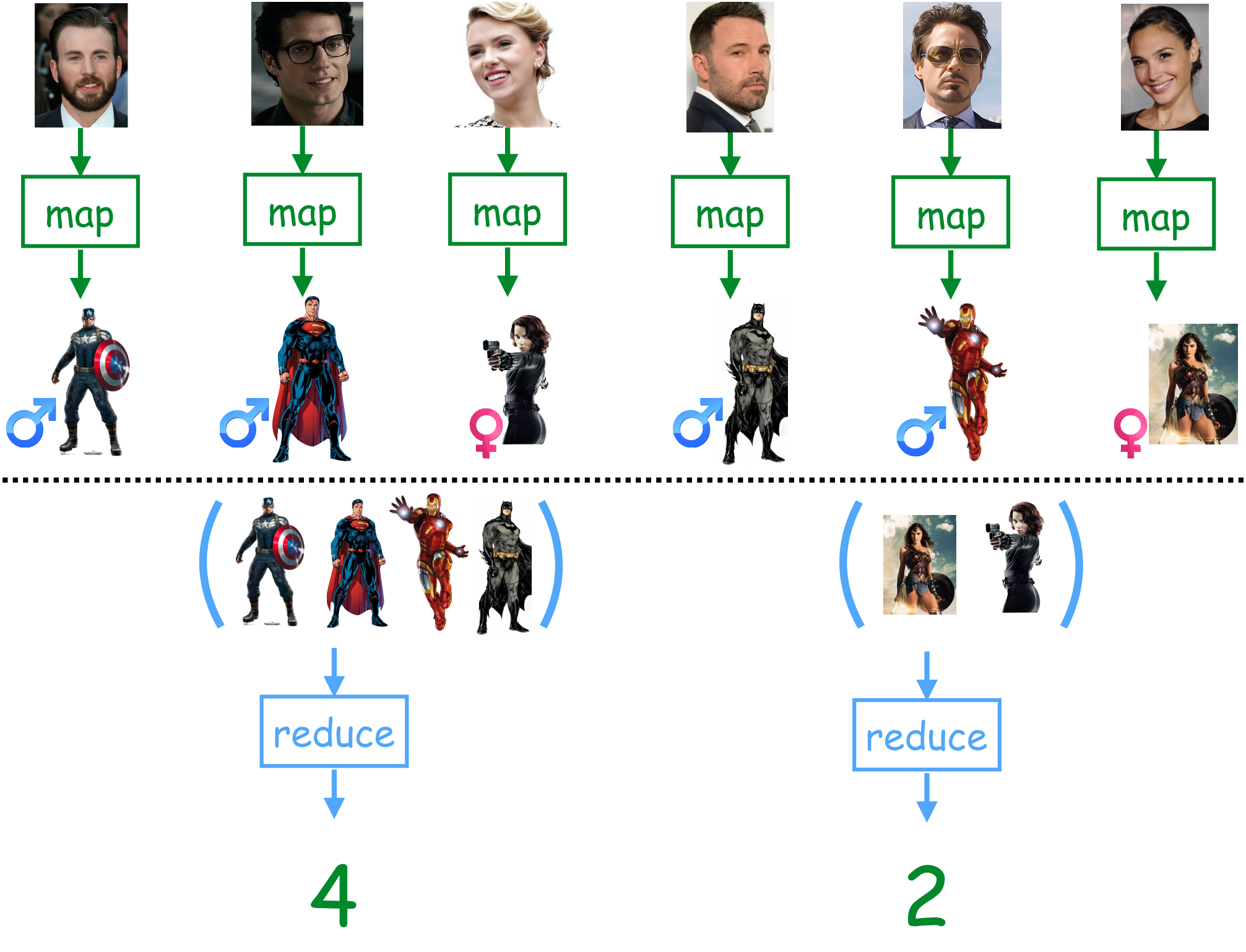
reduce
reduce


map
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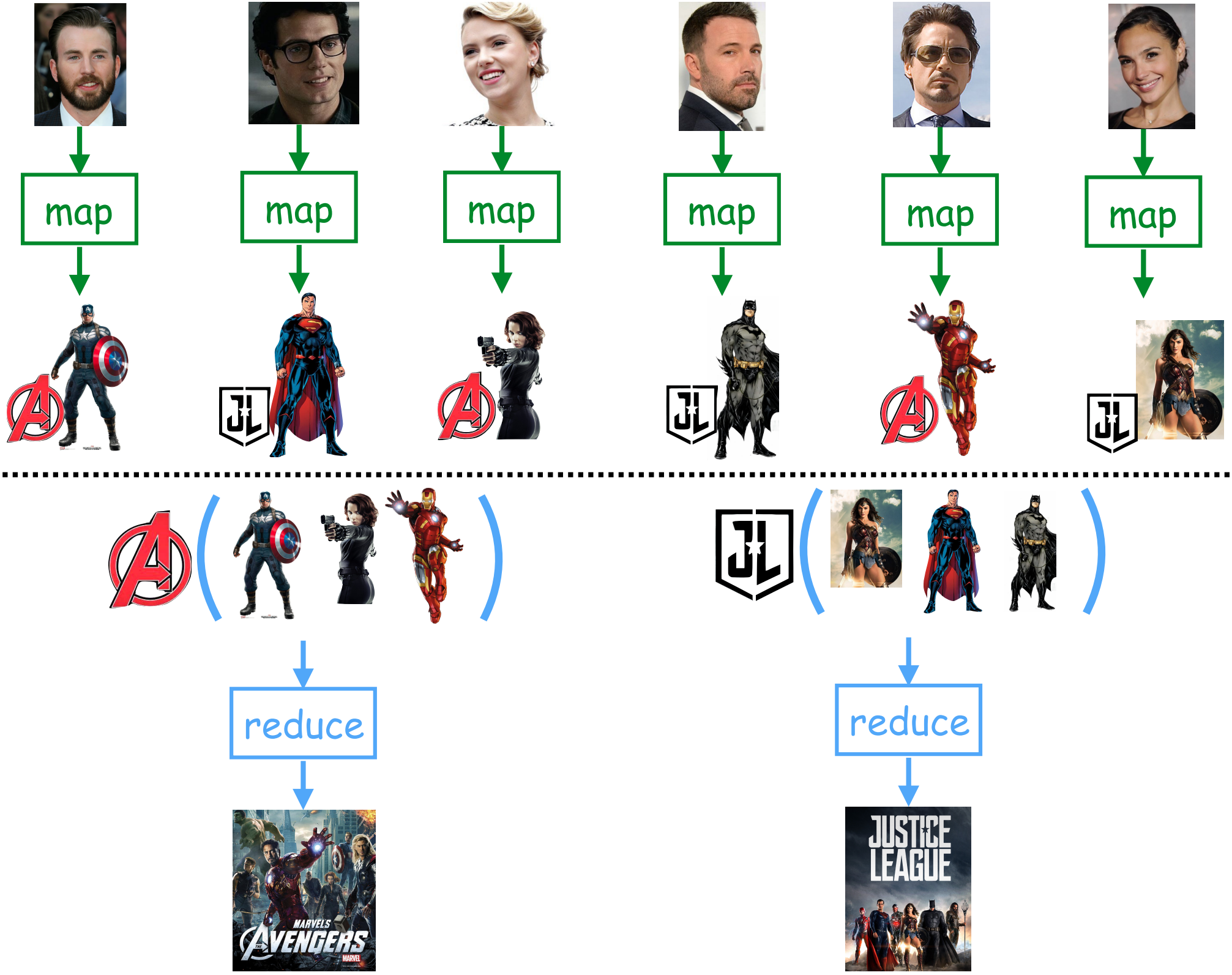
2


map
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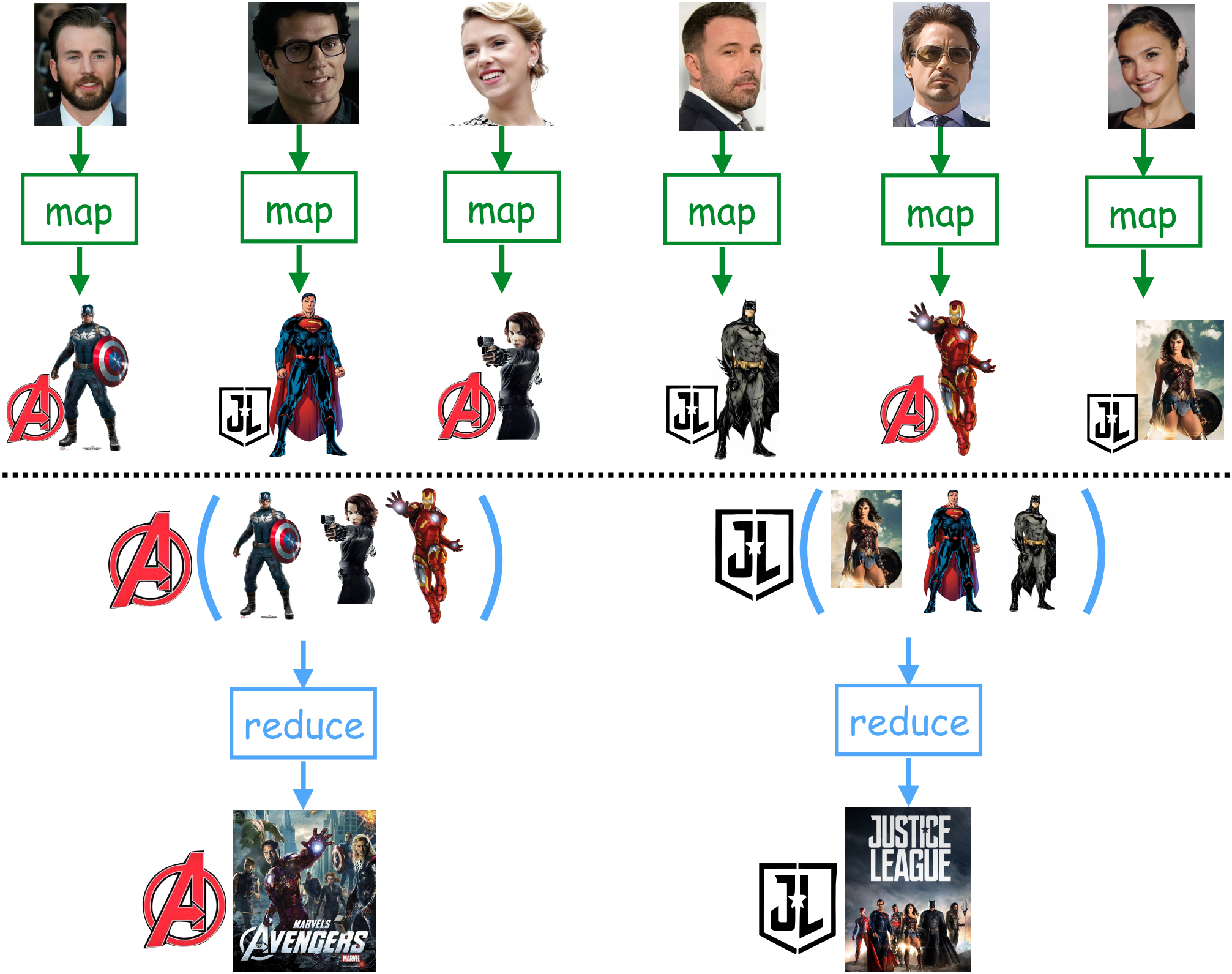
map
map
reduce
reduce
MARVELS
AVENGERS
JUSTICE
LEAGUE


map
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reduce
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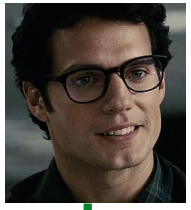
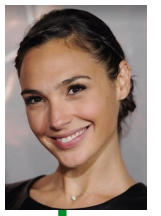
MARVELS
AVENGERS
JUSTICE
LEAGUE





map map map map map map

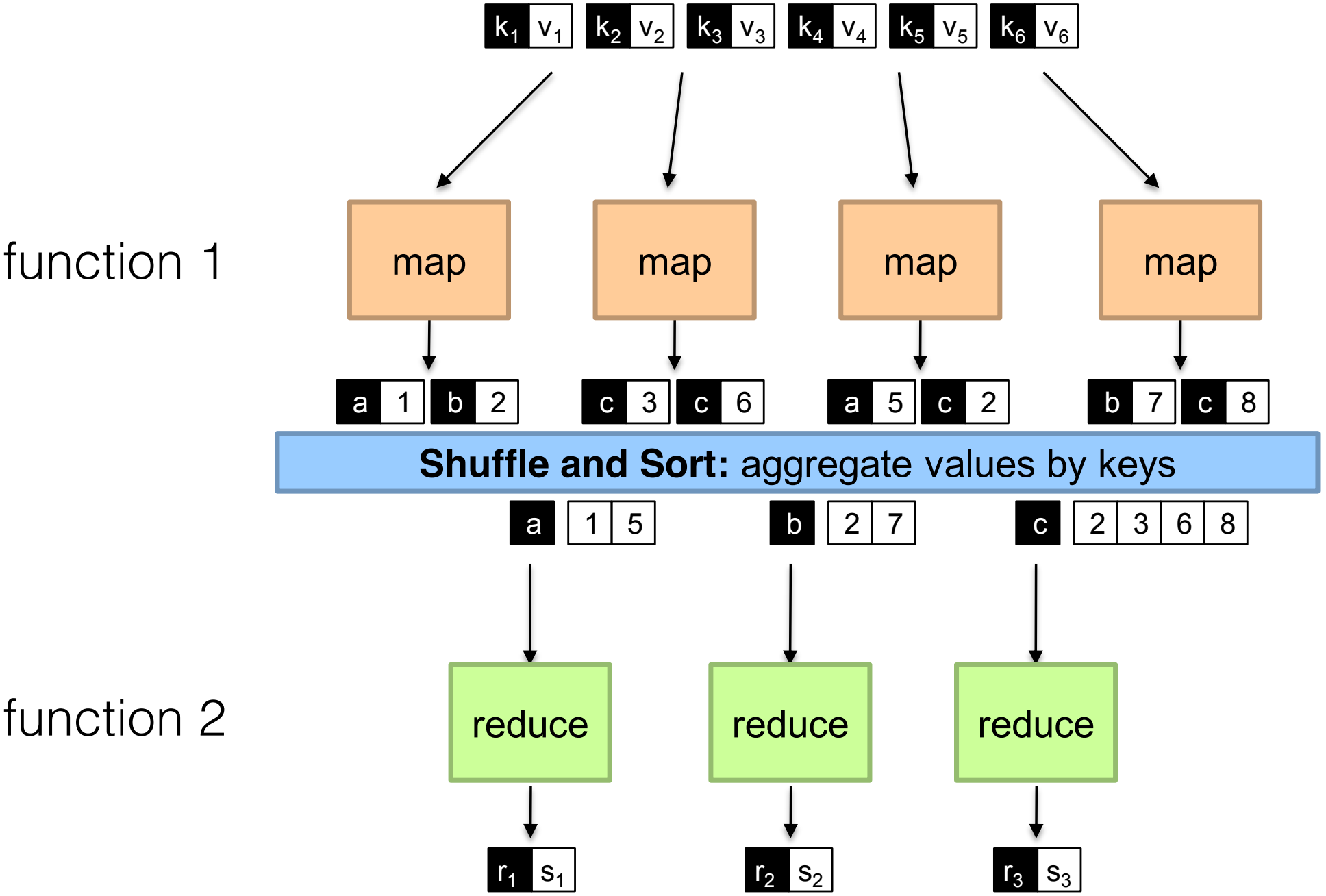






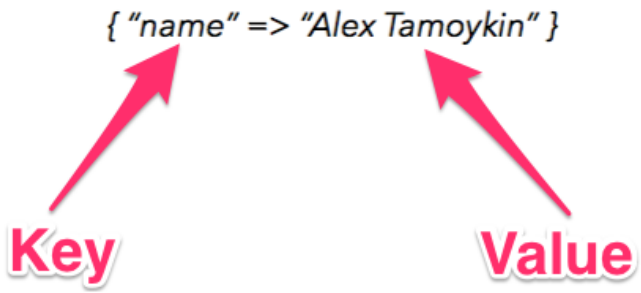
reduce reduce

♂4 ♀2


k1 v1
k2 v2
k3 v3
k4 v4
k5 v5
k6 v6
function 1
map
map
map
map
a 1
b 2
c 3
c 6
a 5
c 2
b 7
c 8
Shuffle and Sort: aggregate values by keys
a 1 5
b 2 7
c 2 3 6 8
function 2
reduce
reduce
reduce
r1 s1
r2 s2
r3 s3

Key- Value Pairs

- Mappers and Reducers are users' code (provided functions)
- Just need to obey the Key-Value pairs interface
- **Mappers:**
  - Consume <key, value> pairs
  - Produce <key, value> pairs
- **Reducers:**
  - Consume <key, <list of values>>
  - Produce <key, value>
- **Shuffling and Sorting:**
  - Hidden phase between mappers and reducers
  - Groups all similar keys from all mappers, sorts and passes them to a certain reducer in the form of <key, <list of values>>



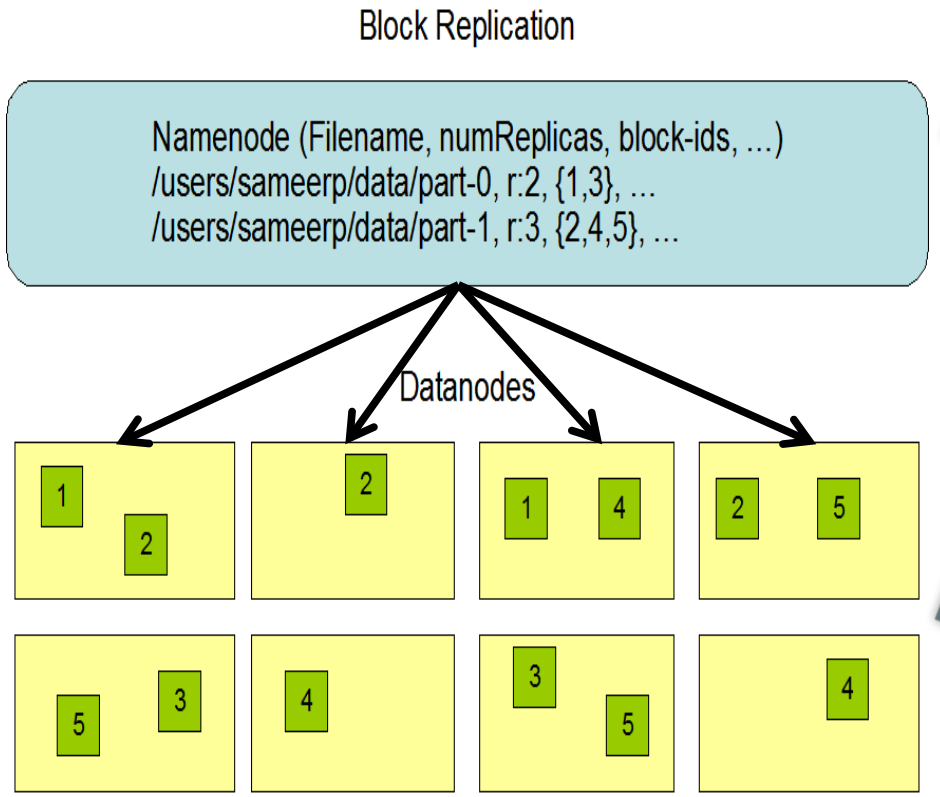
Game

The four French playing card suits used primarily in the English speaking world: spades (♠), hearts (♥), diamonds (♦) and clubs (♣).

Main Properties of HDFS

- ***Large:*** A HDFS instance may consist of thousands of server machines, each storing part of the file system's data
- ***Replication:*** Each data block is replicated many times (default is 3)
- ***Failure:*** Failure is the norm rather than exception
- ***Fault Tolerance:*** Detection of faults and quick, automatic recovery from them is a core architectural goal of HDFS
  - Namenode is consistently checking Datanodes

Hadoop Distributed File System (HDFS)



Centralized namenode

- Maintains metadata info about files

File *F*

Blocks (64 MB)

Many datanode (1000s)

- Store the actual data
- Files are divided into blocks
- Each block is replicated *N* times (Default = 3)

MRjob package

pythonhosted.org/mrjob/guides/quickstart.html

mrjob v0.4.2 documentation

Home » Guides

← Why mrjob? | Concepts →

Table Of Contents

Need help?

Join the mailing list by visiting the Google group page or sending an email to mrjob+subscribe@googlegroups.com.

type to search

Fundamentals

Installation

Install with `pip`:

```
pip install mrjob
```

or from a git clone of the source code:

```
python setup.py test && python setup.py install
```

Writing your first job

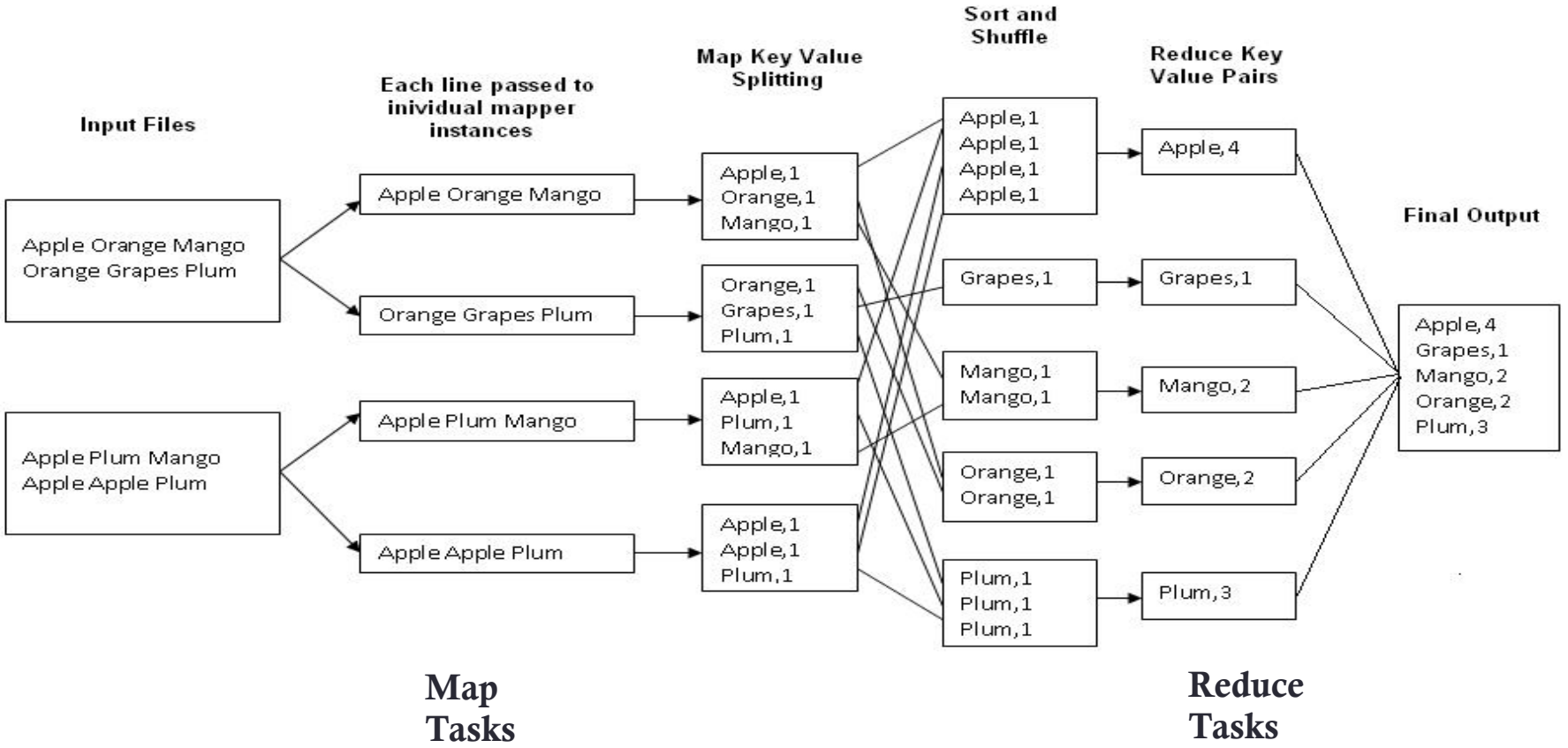
Open a file called `word_count.py` and type this into it:

```
from mrjob.job import MRJob


class MRWordFrequencyCount(MRJob):

    def mapper(self, _, line):
        yield "chars", len(line)
        yield "words", len(line.split())
        yield "lines", 1

    def reducer(self, key, values):
        yield key, sum(values)
```

http://pythonhosted.org/mrjob/guides/quickstart.html

Example 1: Word Count

- **Job: Count the occurrences of each word in a data set**



The Famous Word Count Example

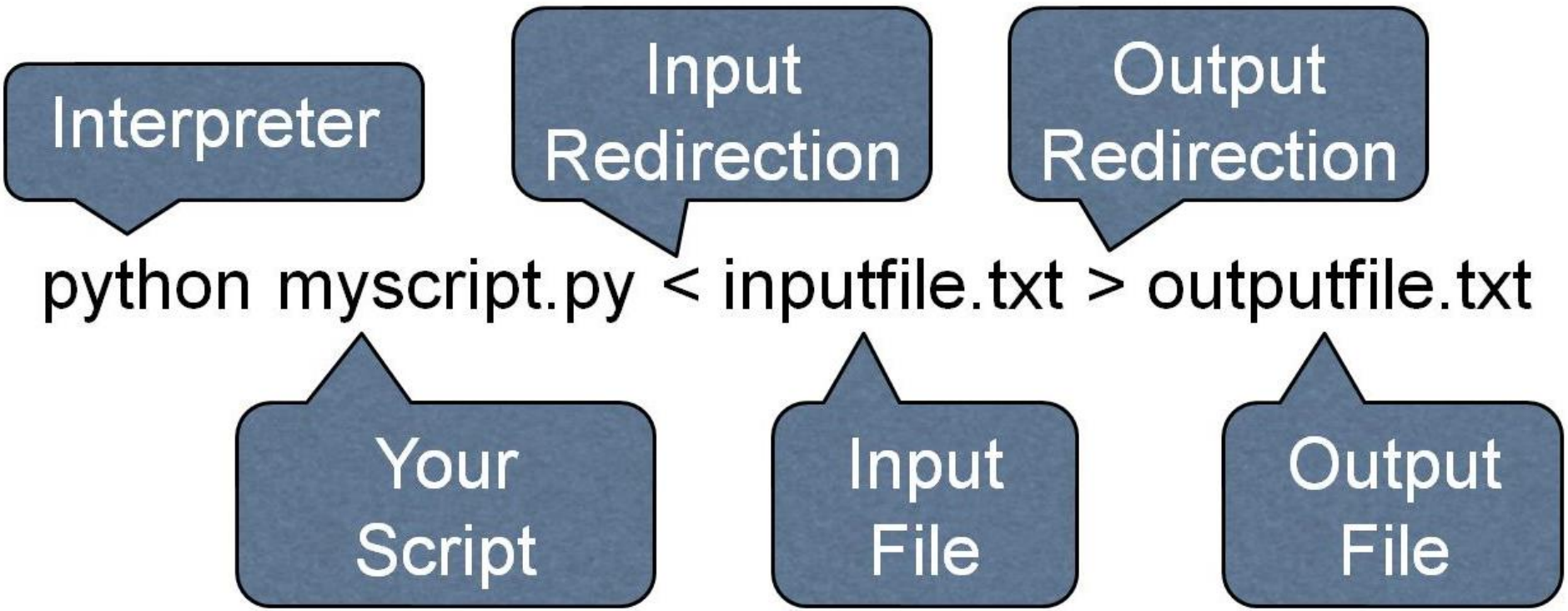
```
from mrjob.job import MRJob

class mrWordCount(MRJob):

    def mapper(self,key,line):
        for word in line.split(' '):
            yield word.lower(),1

    def reducer(self, word, occurrences):
        yield word, sum(occurrences)

if __name__ == '__main__':
    mrWordCount.run()
```

Example Input Data

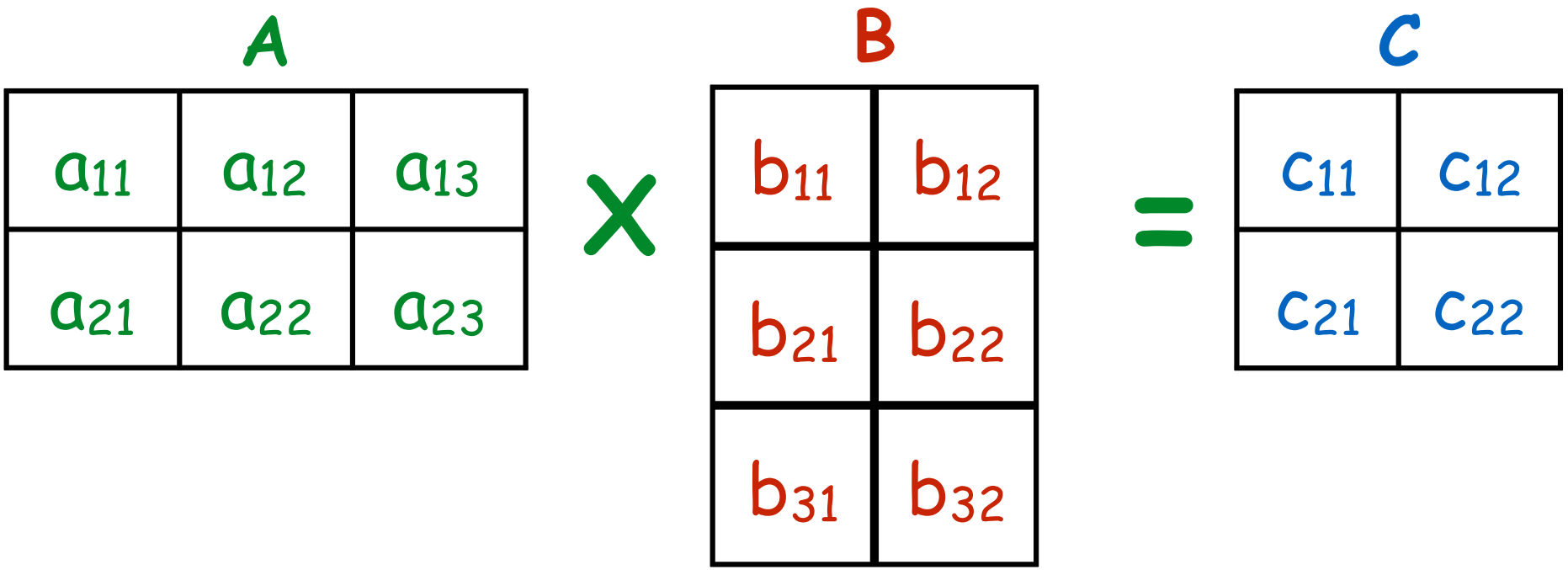
Hamlet

Shakespeare

Launching the Job

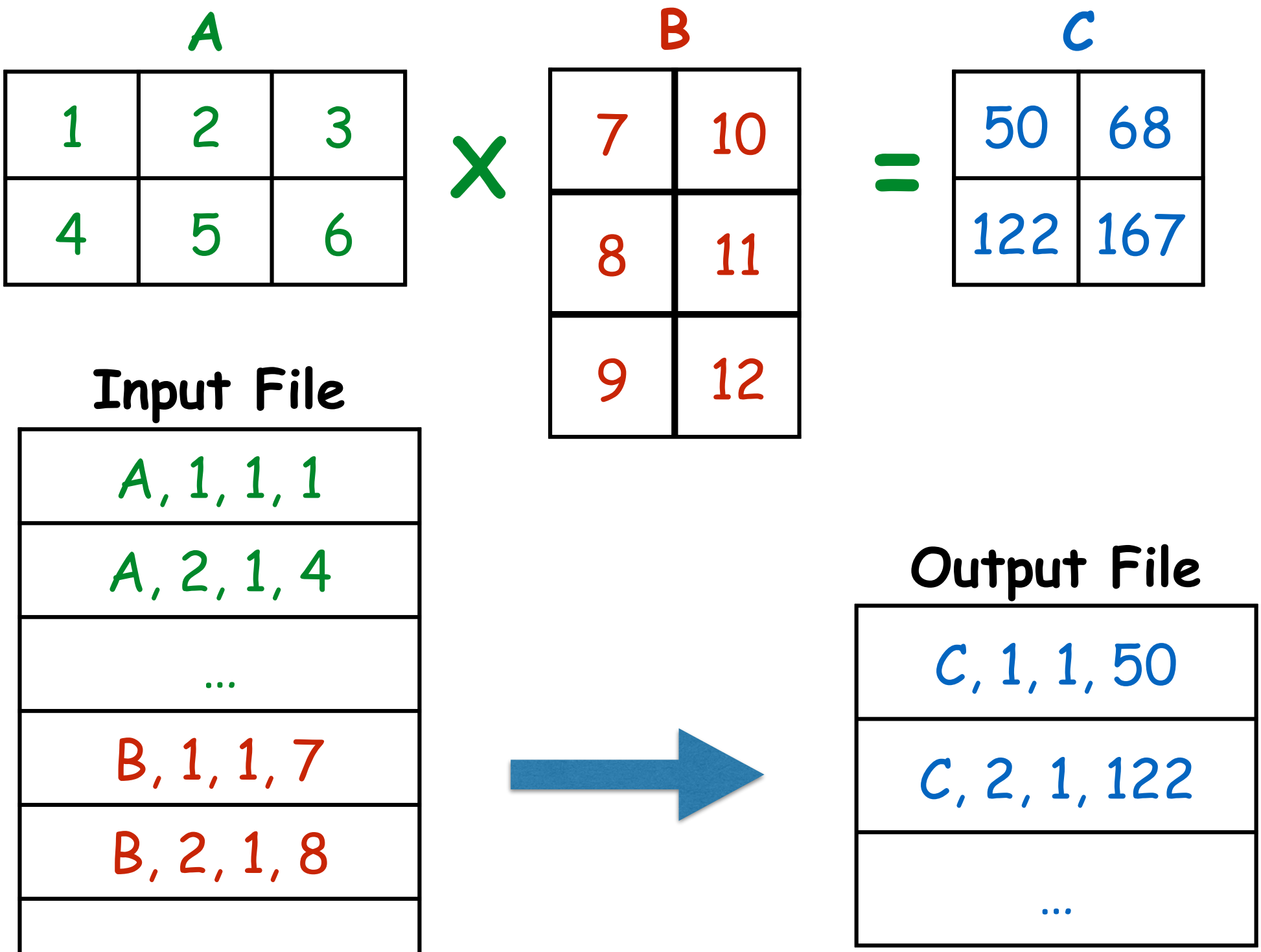


Matrix Multiplication



$$c_{11} = a_{11} \times b_{11} + a_{12} \times b_{21} + a_{13} \times b_{31}$$

$$c_{ij} = a_{i1} \times b_{1j} + a_{i2} \times b_{2j} + a_{i3} \times b_{3j}$$


A
1 2 3
4 5 6
X
B
7 10
8 11
9 12
=
C
50 68
122 167
Input File
A, 1, 1, 1
A, 2, 1, 4
...
B, 1, 1, 7
B, 2, 1, 8
...
Output File
C, 1, 1, 50
C, 2, 1, 122
...

Mapper

Input:

one element of an input matrix

A, 1, 1, 1	A, 2, 1, 4	B, 1, 1, 7	B, 2, 2, 11
A[1,1]	A[2,1]	B[1,1]	B[2,2]
1 2 3 4 5 6	1 2 3 4 5 6	7 10 8 11 9 12	7 10 8 11 9 12

Output:

(C[1,1], A[1,1])	(C[2,1], A[2,1])	(C[1,1], B[1,1])	(C[1,2], B[2,2])
(C[1,2], A[1,1])	(C[2,2], A[2,1])	(C[2,1], B[1,1])	(C[2,2], B[2,2])
key, value	key, value	key, value	key, value

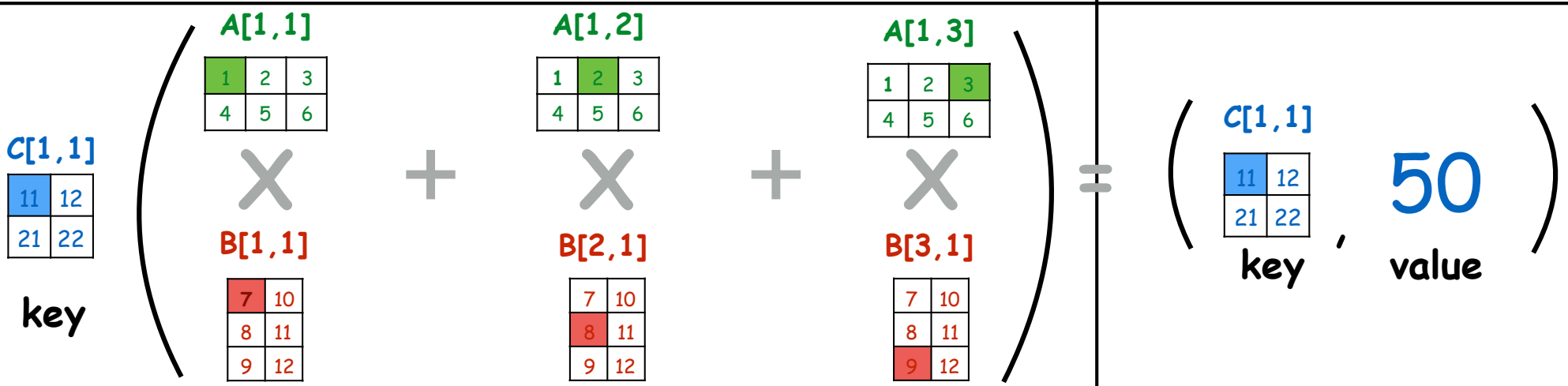
Reducer

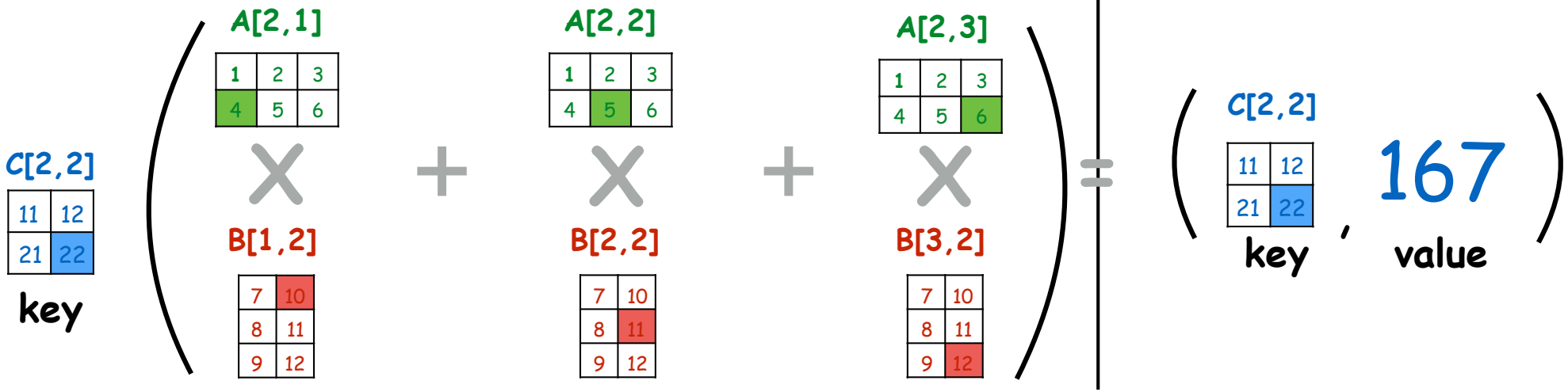
Input:

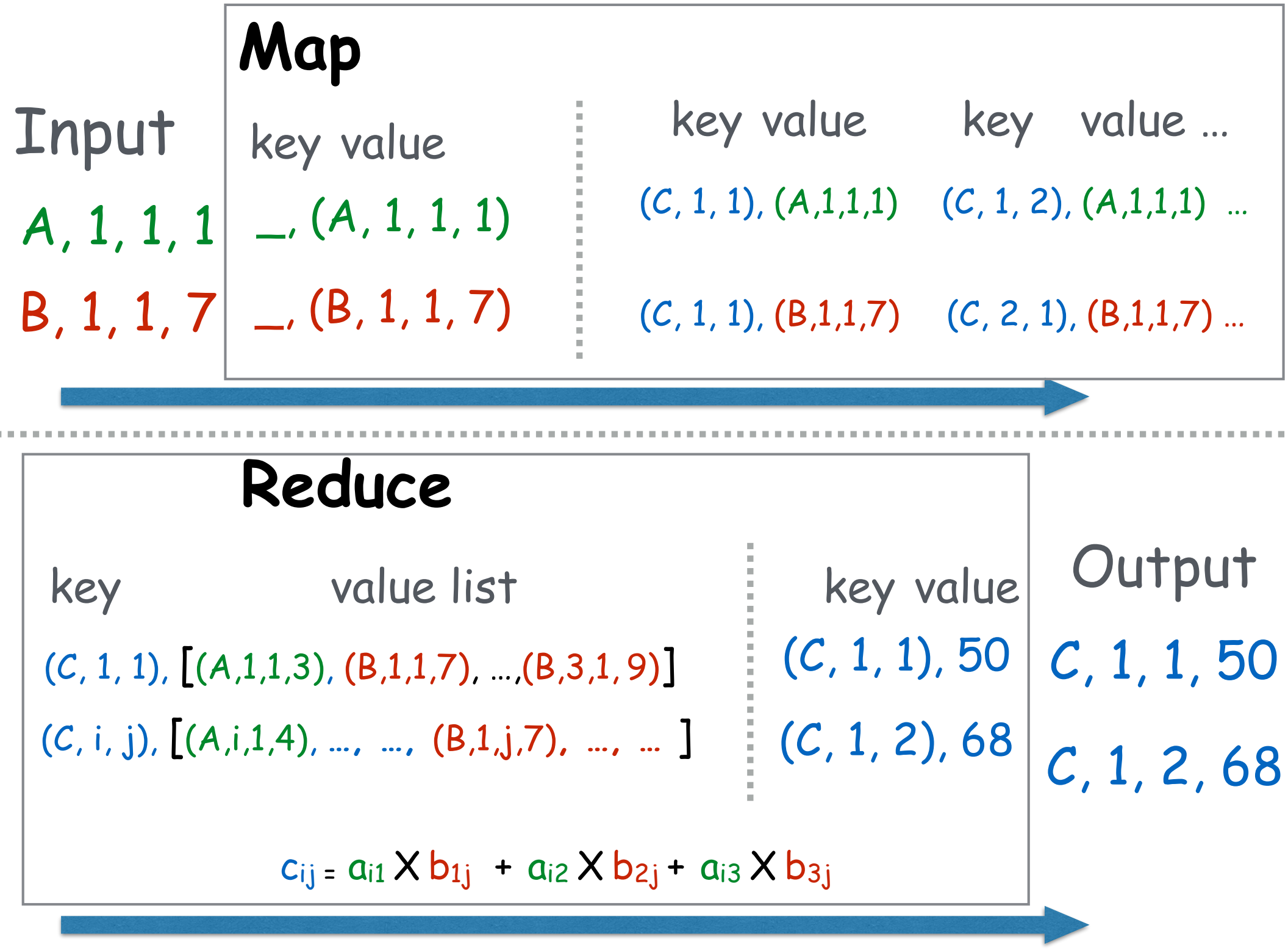
a collection of data records

Output:

one element of matrix C






Map
Input
key value
A, 1, 1, 1
_, (A, 1, 1, 1)
B, 1, 1, 7
_, (B, 1, 1, 7)
key value
key value ...
(C, 1, 1), (A,1,1,1)
(C, 1, 2), (A,1,1,1) ...
(C, 1, 1), (B,1,1,7)
(C, 2, 1), (B,1,1,7) ...
Reduce
key
value list
(C, 1, 1), [(A,1,1,3), (B,1,1,7), ...,(B,3,1, 9)]
(C, i, j), [(A,i,1,4), ..., ..., (B,1,j,7), ..., ...]
key value
(C, 1, 1), 50
(C, 1, 2), 68
Output
C, 1, 1, 50
C, 1, 2, 68
$c_{ij} = a_{i1} \times b_{1j} + a_{i2} \times b_{2j} + a_{i3} \times b_{3j}$