빅데이터 분석 및 응용

L02: MapReduce Programming Model

Summer 2020

Kookmin University

In this lecture

- MapReduce Programming Model

Programming Model: MapReduce

Warm-up task:

- We have a huge text document
- Count the number of times each distinct word appears in the file
- Sample application:
  - Analyze web server logs to find popular URLs
  - Term statistics for search

Task: Word Count

Case 1:

- File too large for memory, but all <word, count> pairs fit in memory

Case 2:

- Even the <word, count> pairs don't fit in memory
  - `words(doc.txt) | sort | uniq -c`
    - where `words` takes a file and outputs the words in it, one per a line
      (e.g., `cat doc.txt | tr -s '[:punct:][:space:]' '\n'`)
- Case 2 captures the essence of MapReduce
  - Great thing is that it is naturally parallelizable

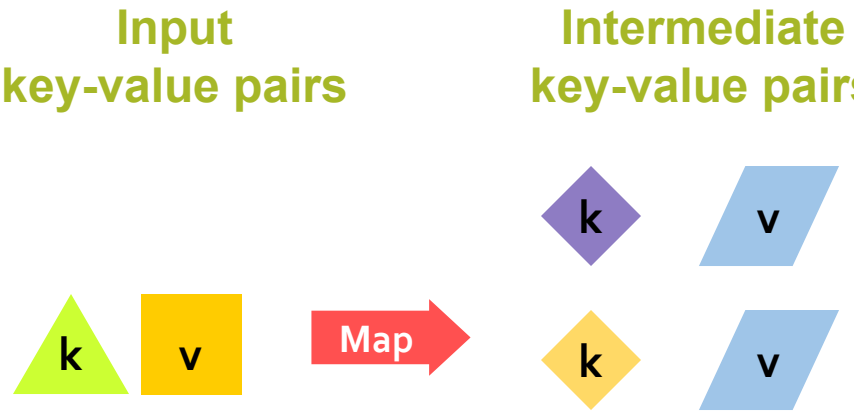
MapReduce: Overview

```
words(doc.txt) | sort | uniq -c
```

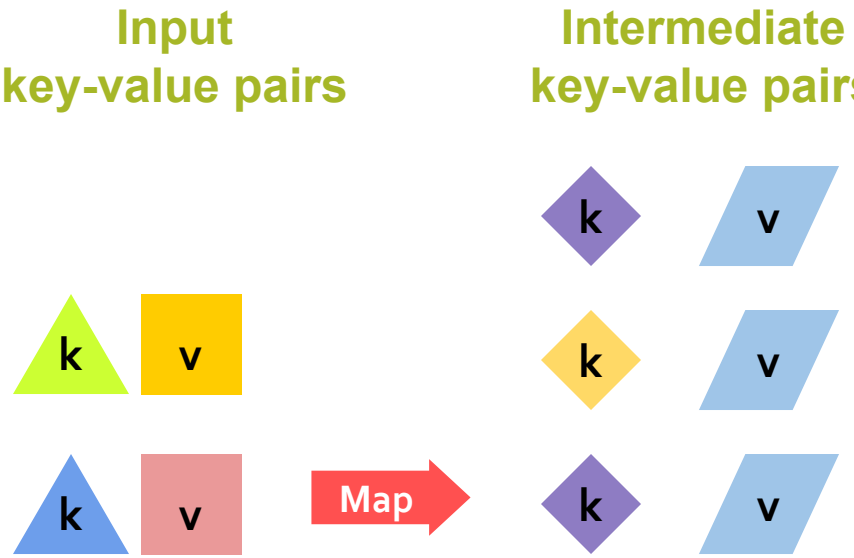
- **Map**
  - Scan input file record-at-a-time
  - Extract something you care about from each record (keys)
- **Group by key**
  - Sort and Shuffle
- **Reduce**
  - Aggregate, summarize, filter or transform
  - Write the result

Outline stays the same, **Map** and **Reduce** change to fit the problem

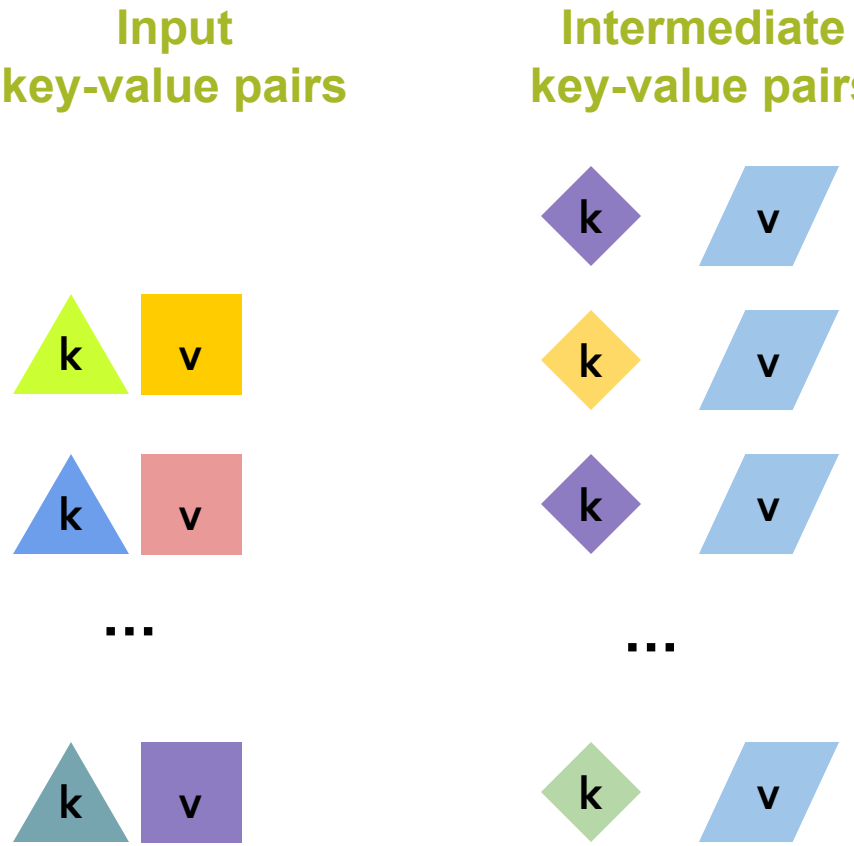
MapReduce: The Map Step



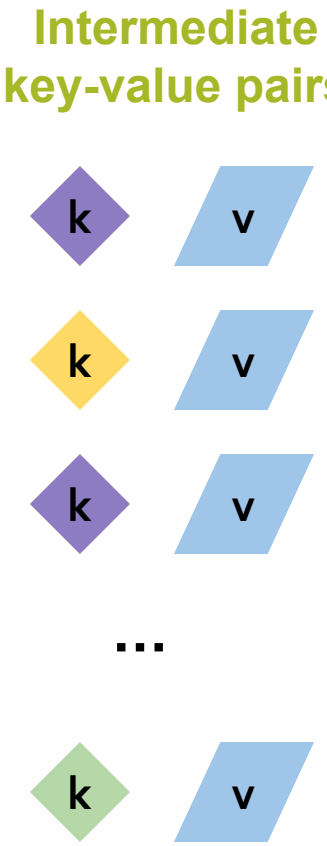
MapReduce: The Map Step



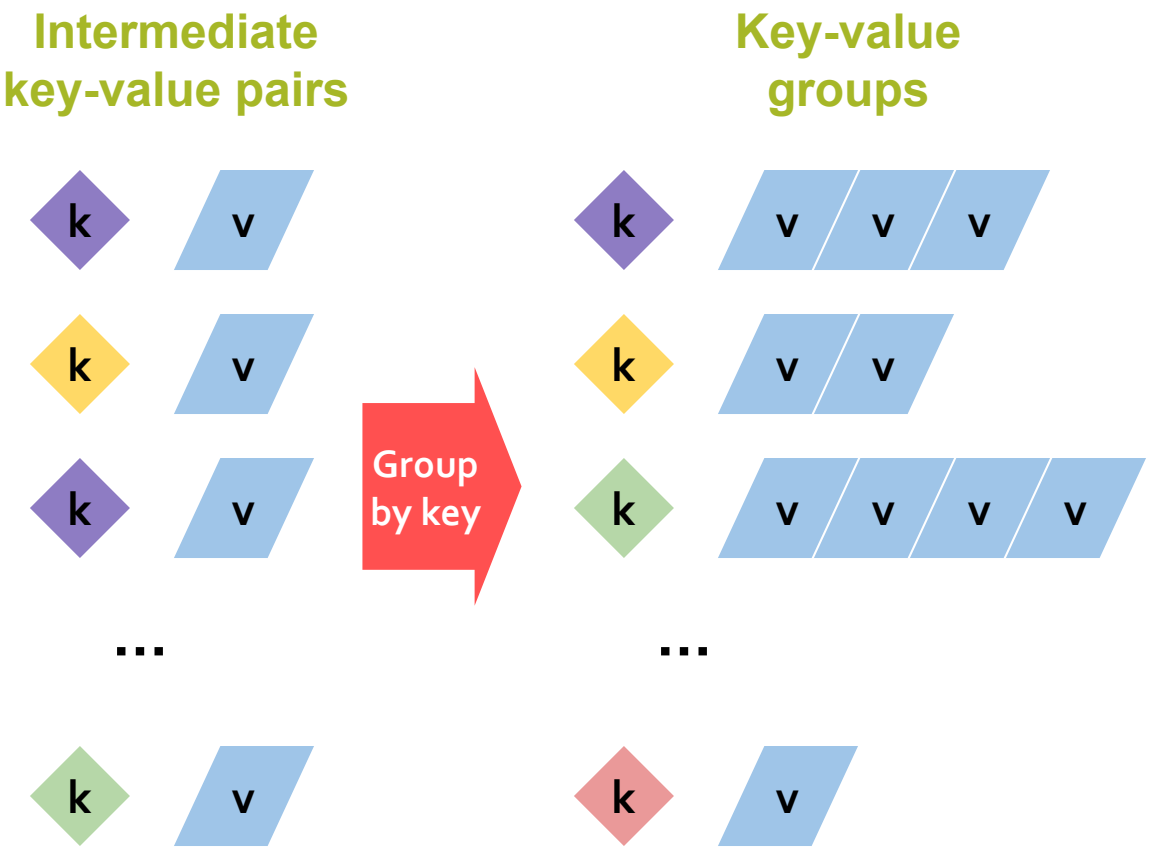
MapReduce: The Map Step



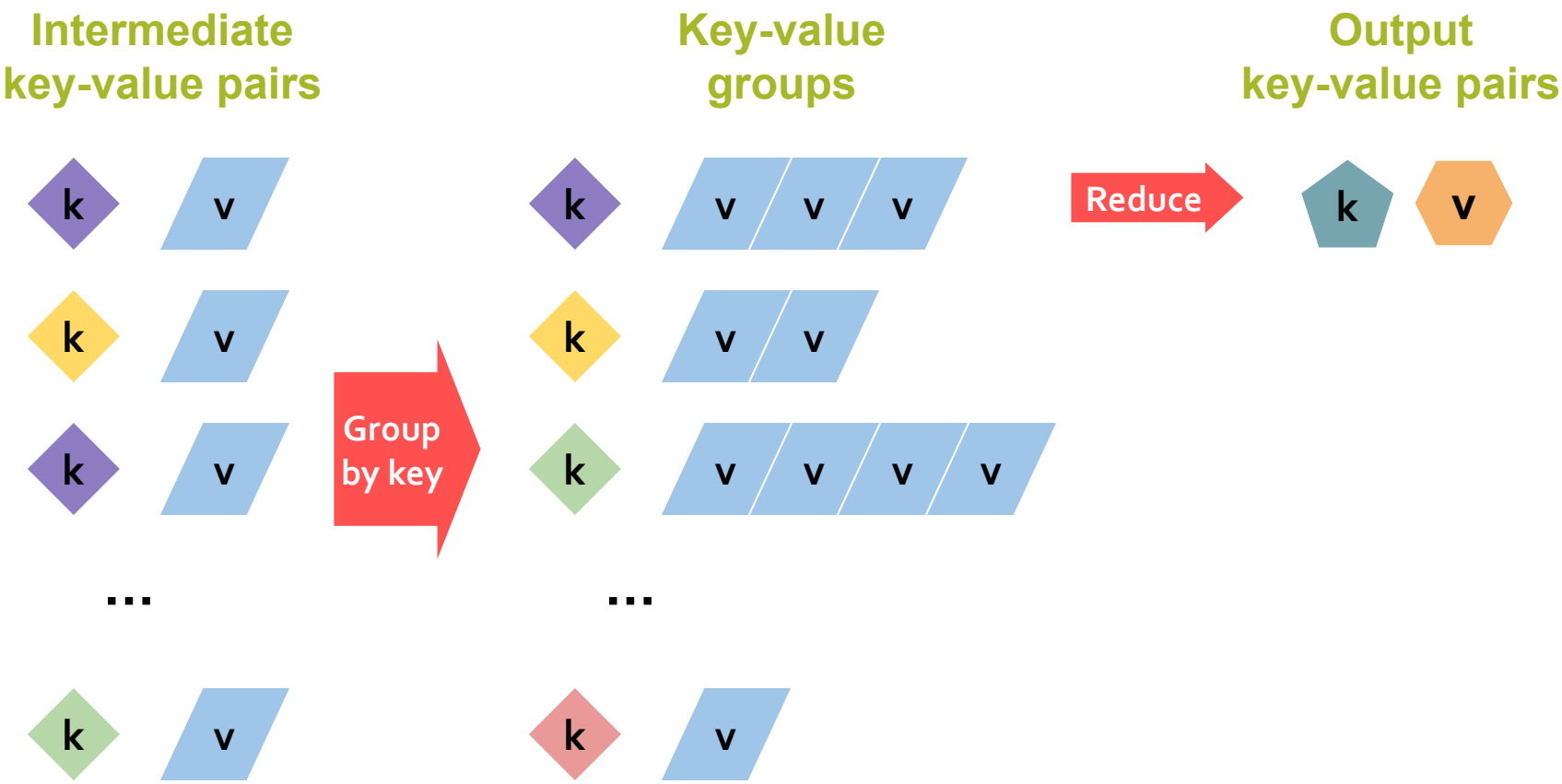
MapReduce: The Reduce Step



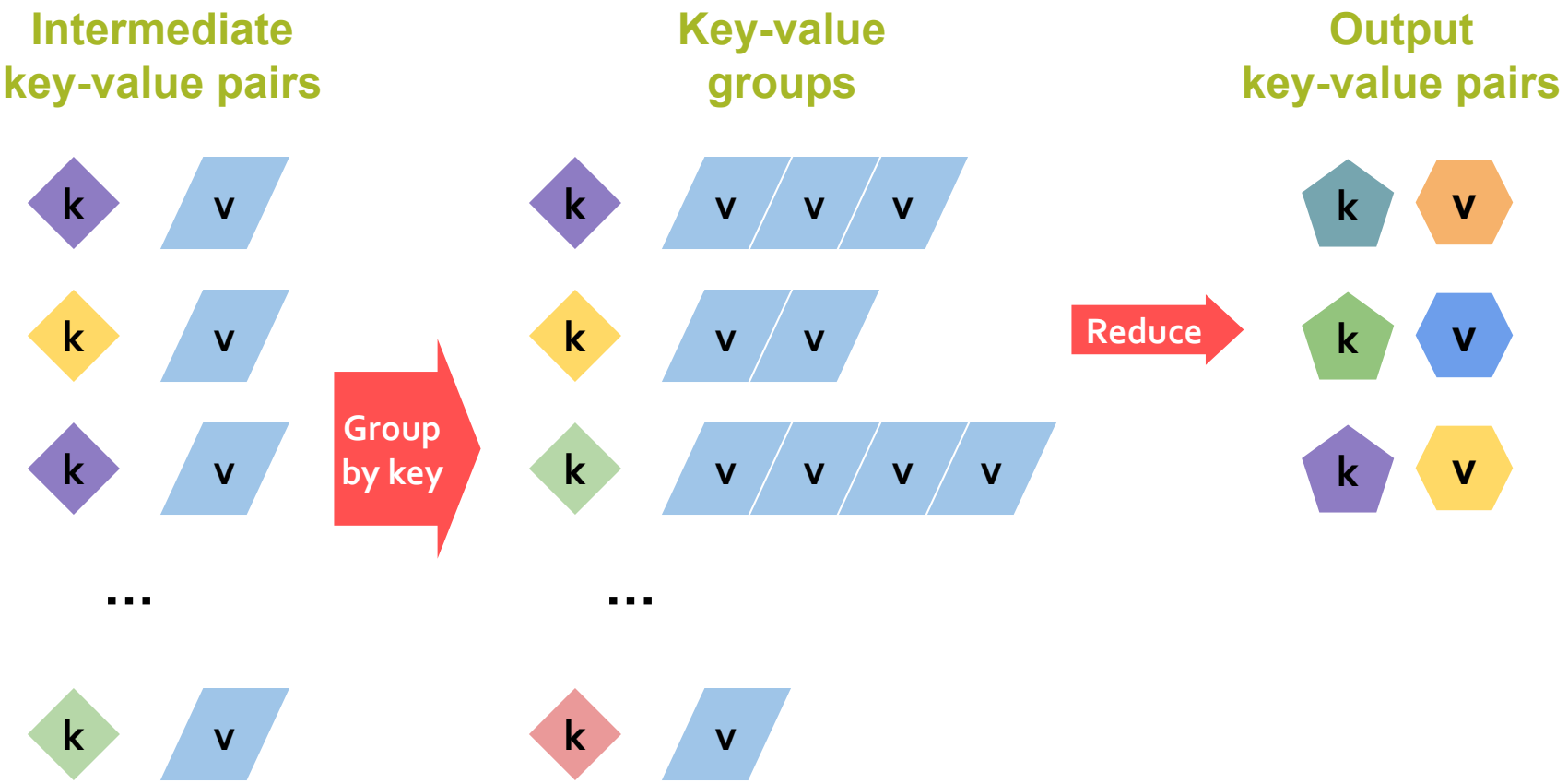
MapReduce: The Reduce Step



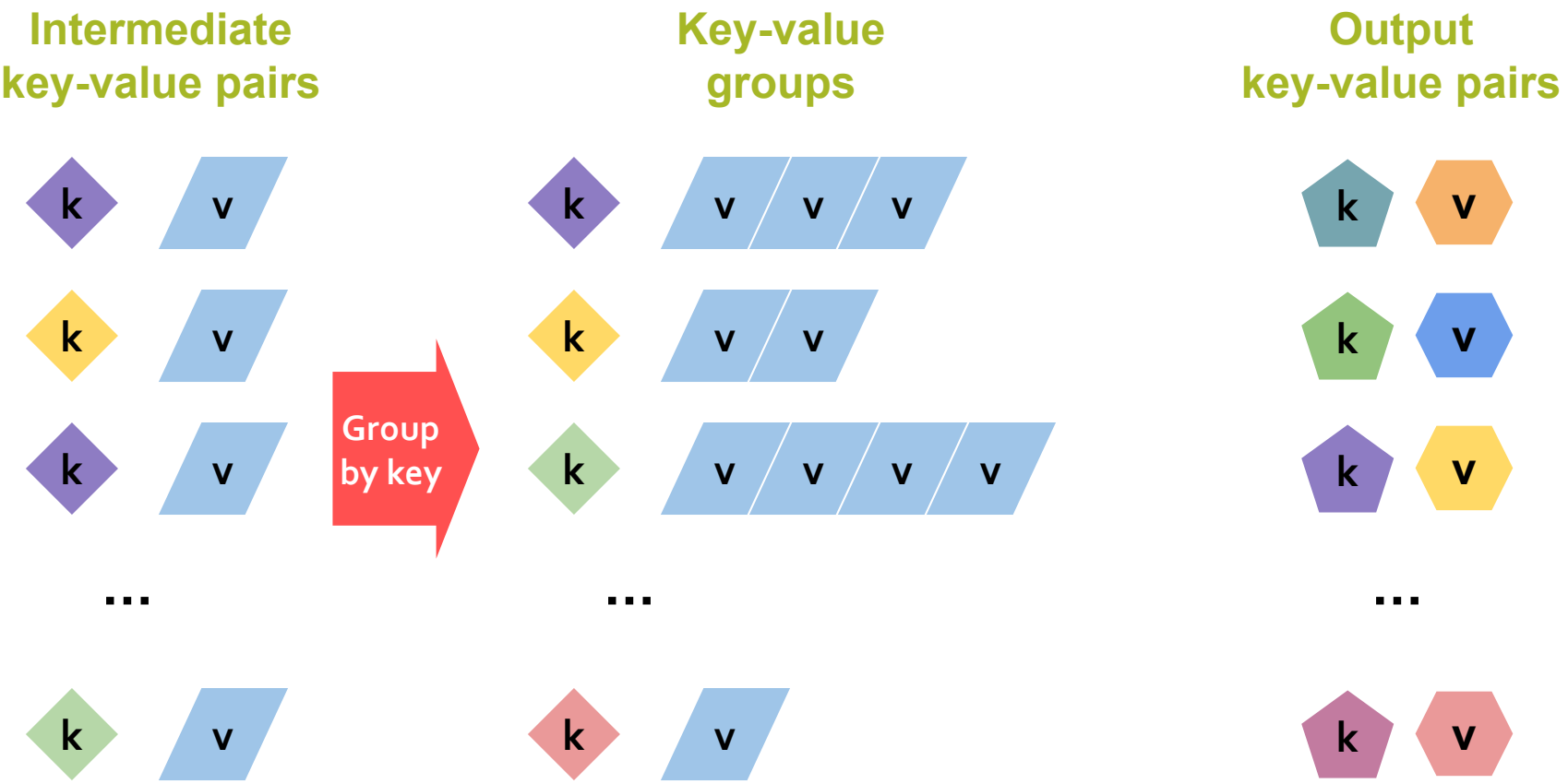
MapReduce: The Reduce Step



MapReduce: The Reduce Step



MapReduce: The Reduce Step



More formally…

- **Input:** a set of key-value pairs
- Programmer specifies two methods:
  - **Map(k, v)** → <k', v'>*
    - Takes a key-value pair and outputs a set of key-value pairs
    - There is one Map call for every *(k,v)* pair
  - **Reduce(k', <v'>*)** → <k', v''>*
    - **All values *v'* with same key *k'* are reduced together**
    - There is one Reduce function call per unique key *k'*

MapReduce: Word Counting

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/mache partnership. '"The work we're doing now -- the robotics we're doing -- is what we're going to need ……..

Big document

MapReduce: Word Counting

Provided by the programmer

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

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Big document

(the, 1)
(crew, 1)
…
(of , 1)
(a, 1)
…
(man, 1)
(mache, 1)
….

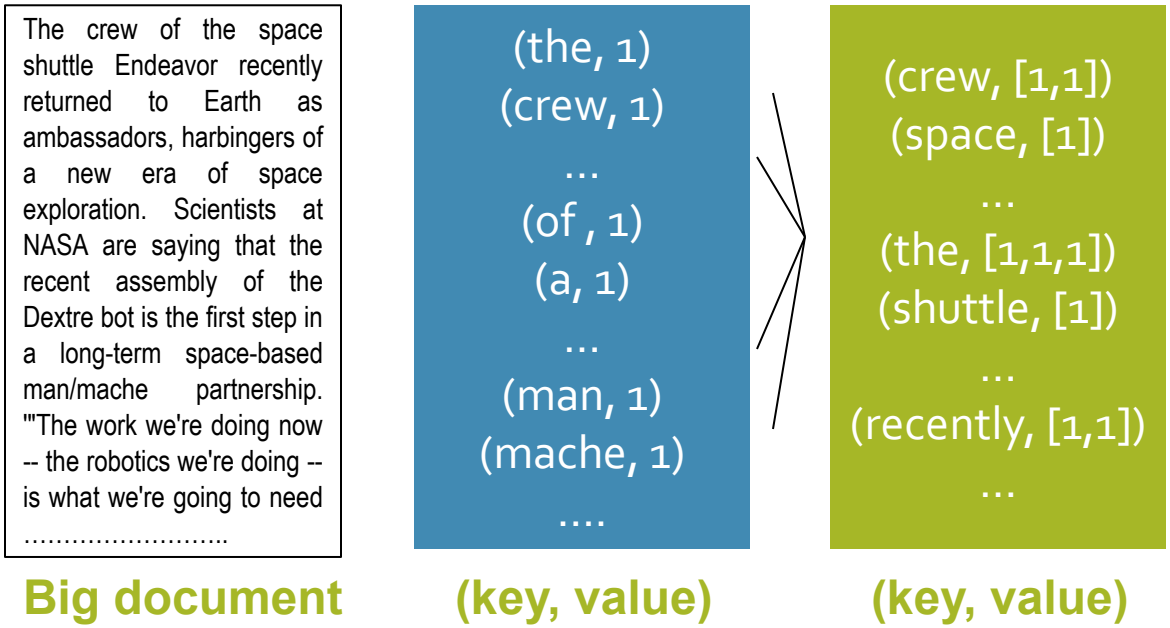
(key, value)

MapReduce: Word Counting

Provided by the programmer

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

Group by key:
Collect all pairs with same key



MapReduce: Word Counting

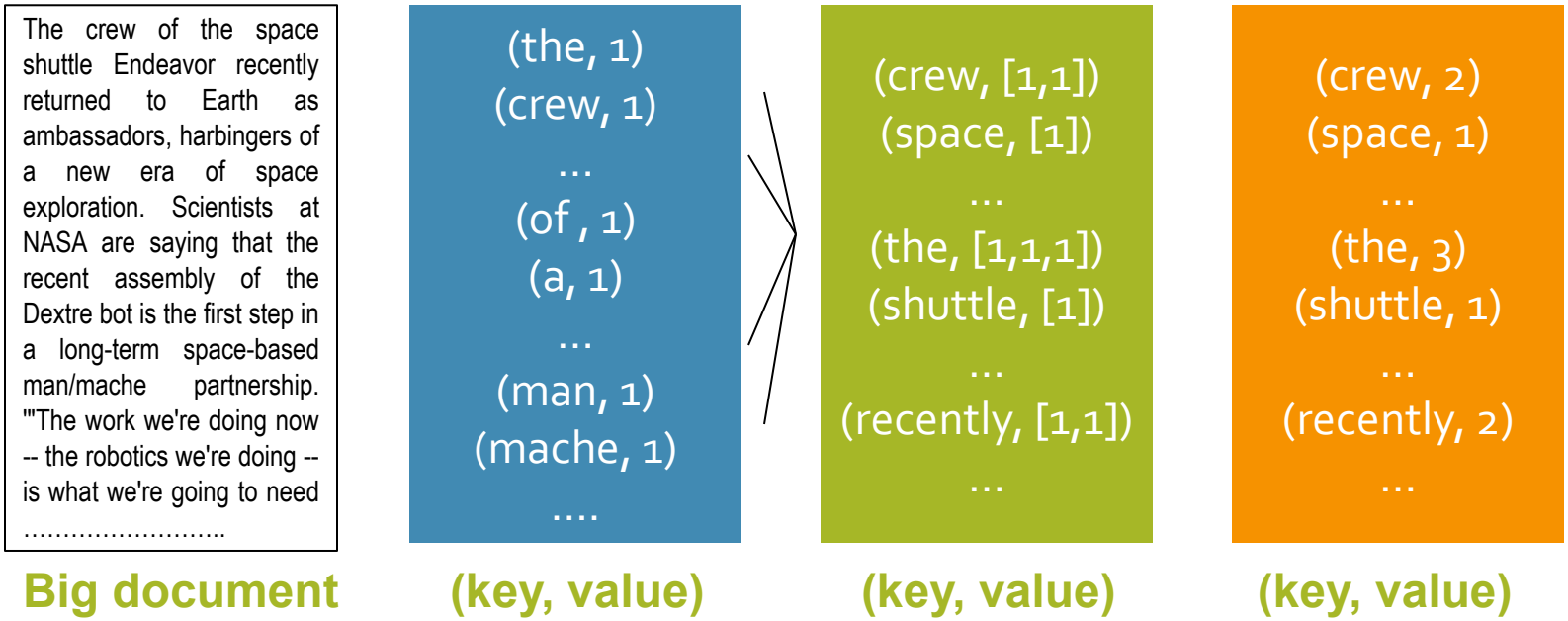
Provided by the programmer

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

Group by key:
Collect all pairs with same key

Provided by the programmer

Reduce:
Collect all values belonging to the key and output



Big document | **(key, value)** | **(key, value)** | **(key, value)**

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

Example: Host size

- Suppose we have a large web corpus with a metadata file formatted as follows:
  - Each record of the form: (URL, size, data, …)
- For each host, find the total number of bytes

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- Suppose we have a large web corpus with a metadata file formatted as follows:
  - Each record of the form: (URL, size, data, …)
- For each host, find the total number of bytes

- **Map**
  - For each record, output (hostname(URL), size)
- **Reduce**
  - Sum the sizes for each host

Example: Language Model

- Count number of times each 5-word sequence occurs in a large corpus of documents (5-gram)

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- Count number of times each 5-word sequence occurs in a large corpus of documents (5-gram)

- **Map**
  - Extract (5-word sequence, count) from document

- **Reduce**
  - Combine the counts

Questions?