Map-Reduce

Computational Model Examples

Mining of Massive Datasets
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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 applications
  - 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

Word Count (2)

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

- Case 2 captures the essence of MapReduce
  - Great thing is that it is naturally parallelizable

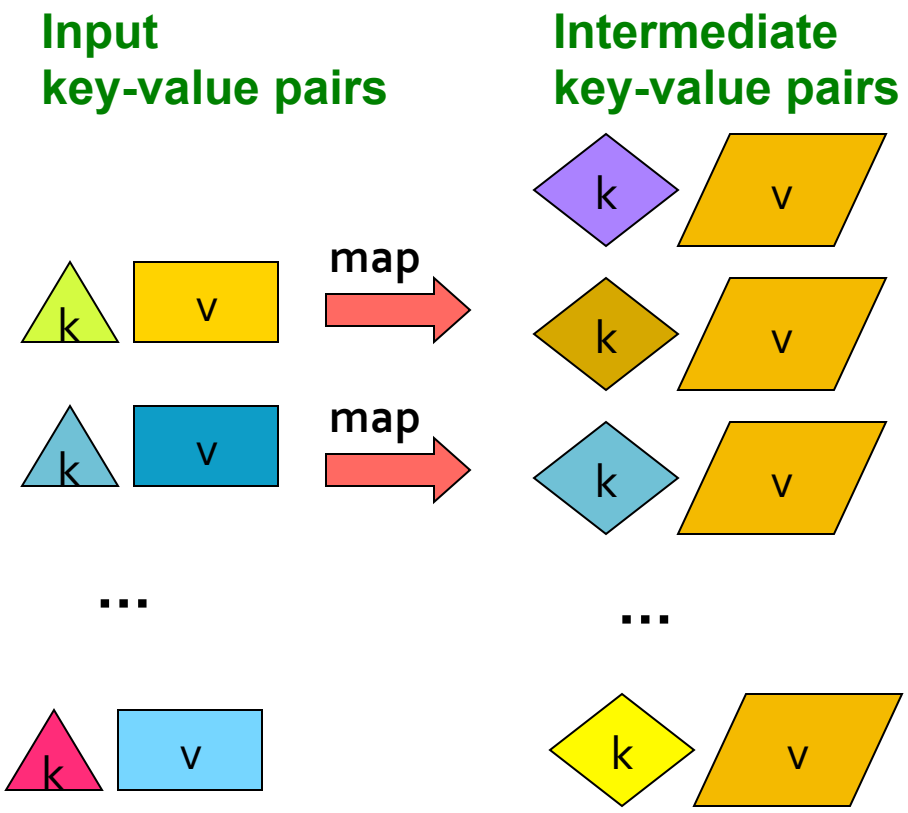
MapReduce: Overview

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

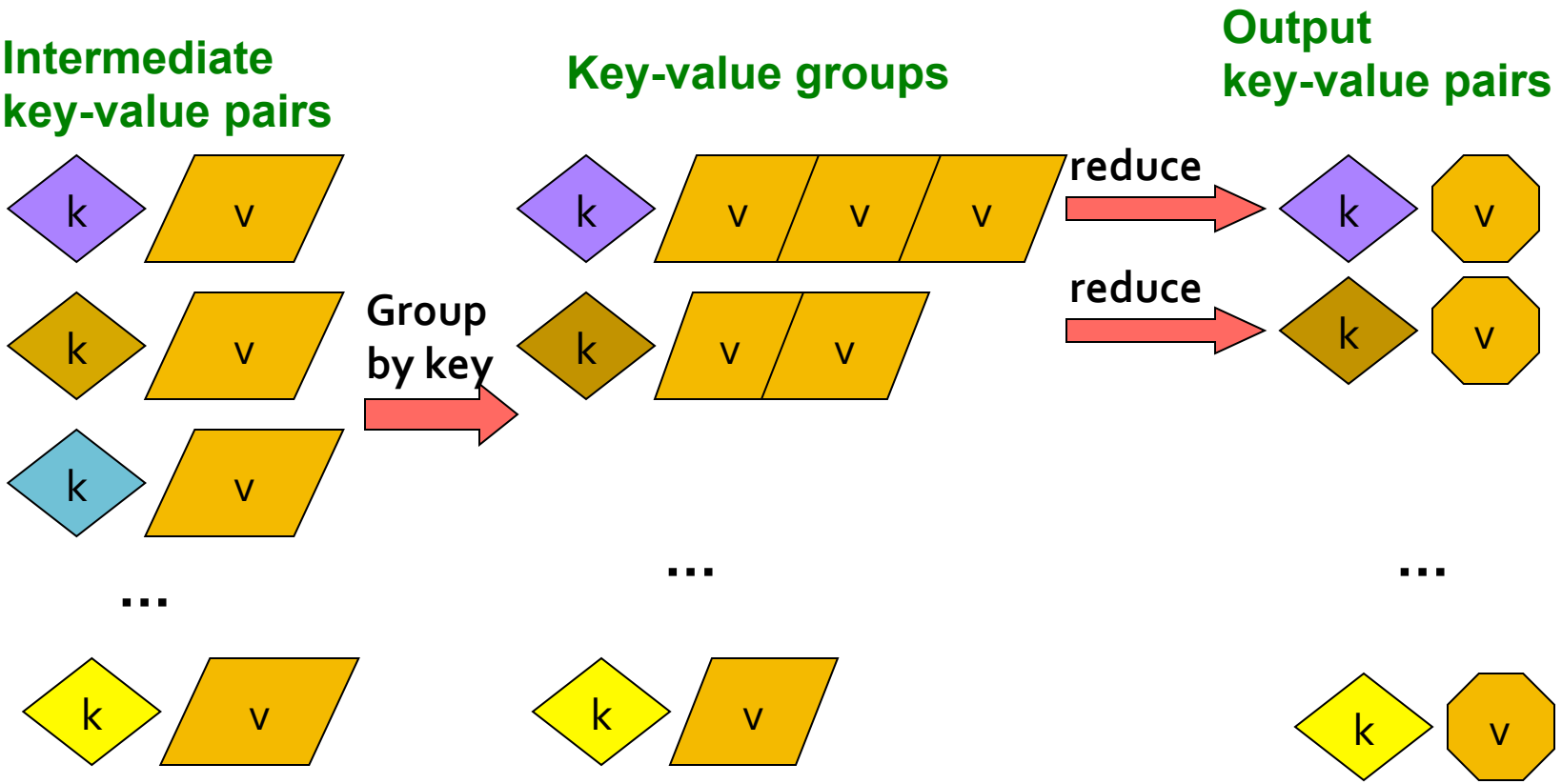
- **Map**
  - Scan input file record-at-a-time
  - Extract something you care about from each record (keys)
- **Group by key**
  - Sort and Shuffle
- **Reduce**
  - Aggregate, summarize, filter or transform
  - Write the result

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

MapReduce: The Map Step



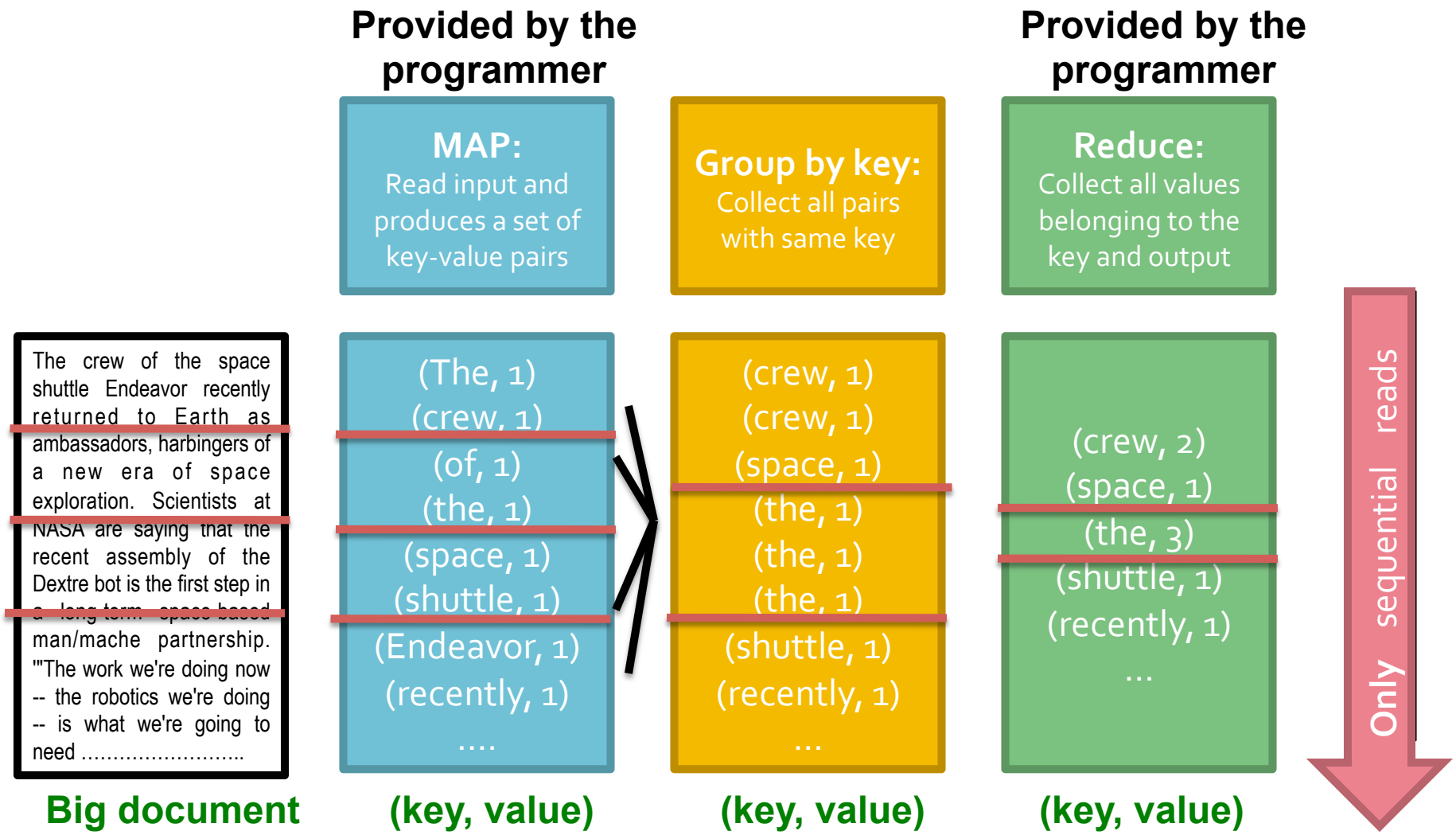
MapReduce: The Reduce Step



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



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)
```

Example: Host size

- Suppose we have a large web corpus with a metadata file formatted as follows:
  - Each record of the form: (URL, size, date, …)
- 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
- Map
  - Extract (5-word sequence, count) from document
- Reduce
  - Combine the counts