Text Retrieval and Search Engines

Web Search: Web Indexing

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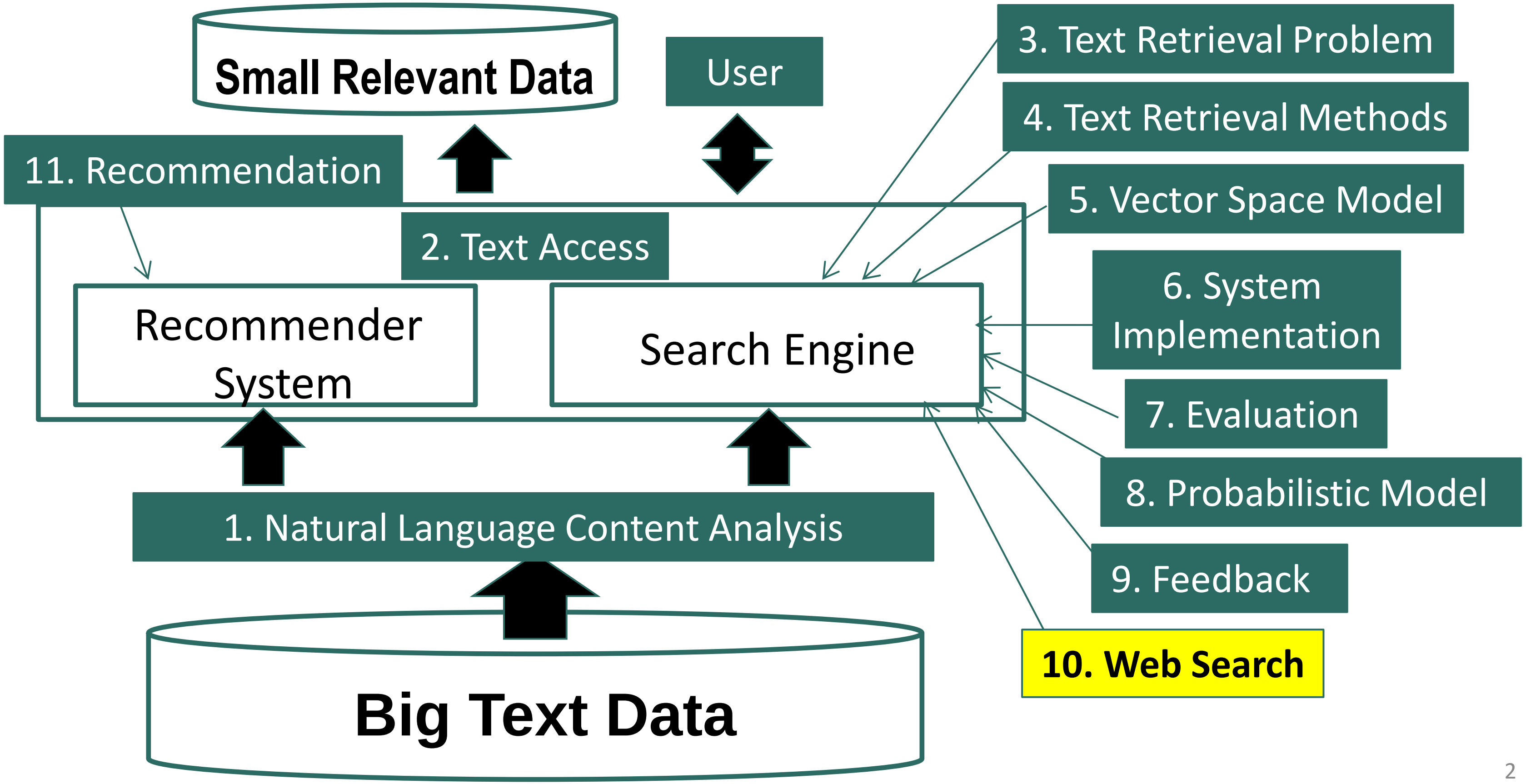
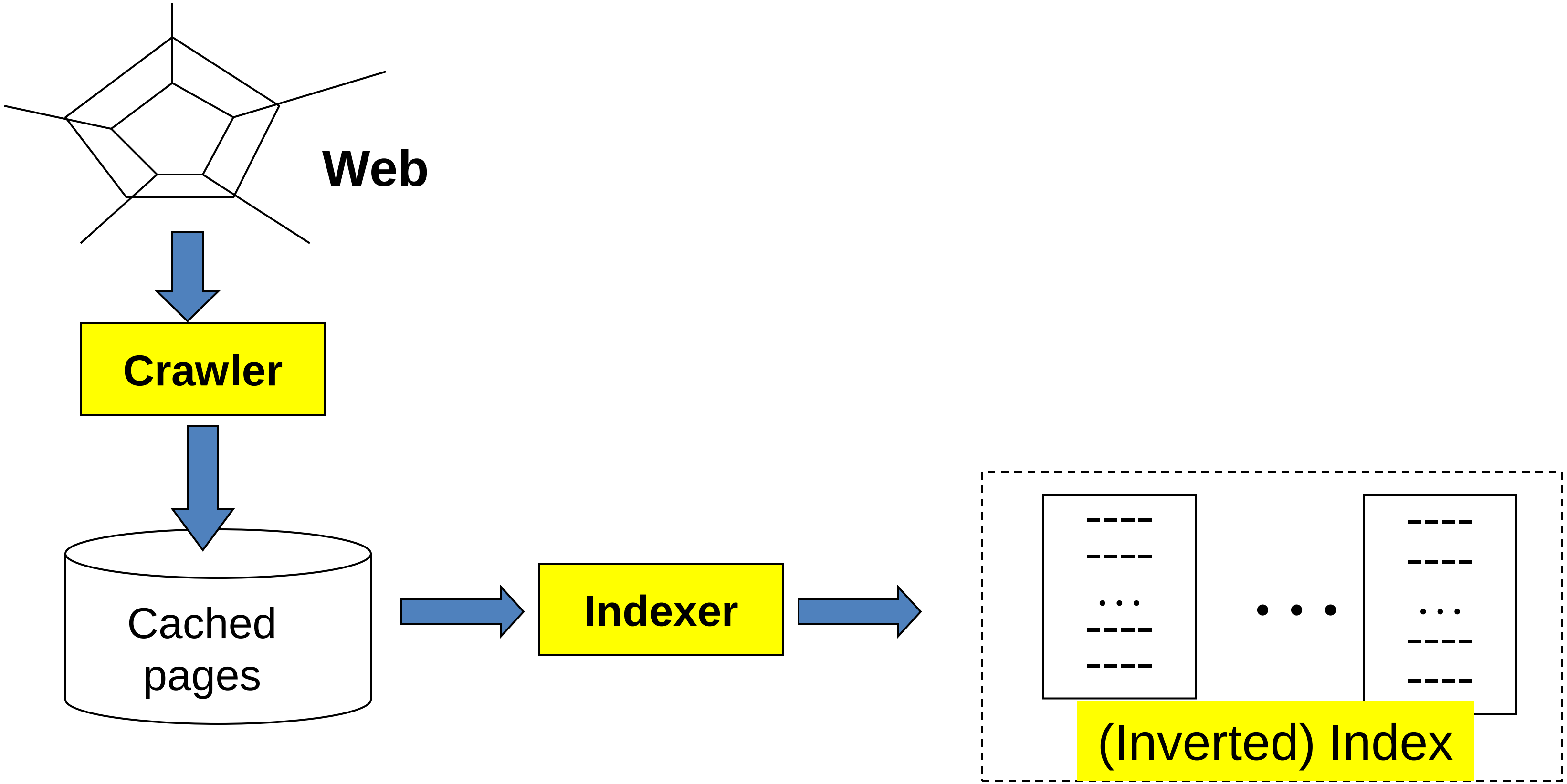
Web Search: Web Indexing



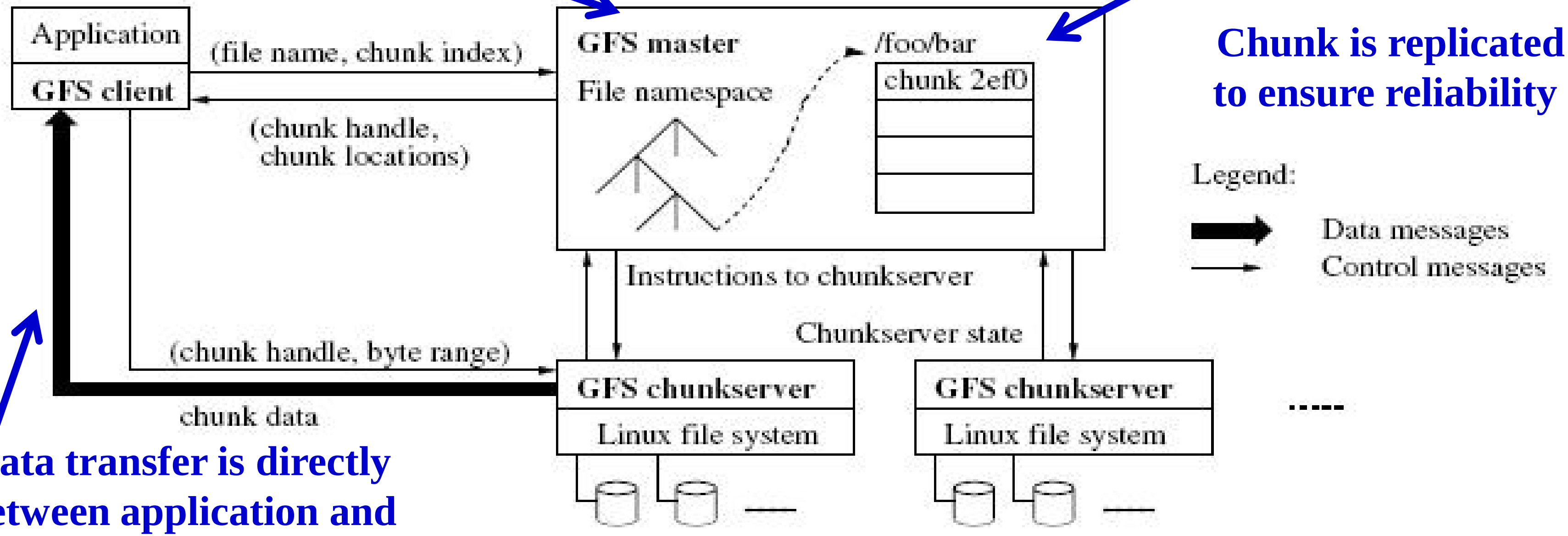
Basic Search Engine Technologies



Overview of Web Indexing

- Standard IR techniques are the basis, but insufficient
  - Scalability
  - Efficiency
- Google’s contributions:
  - Google File System (GFS): distributed file system
  - MapReduce: Software framework for parallel computation
  - Hadoop: Open source implementation of MapReduce

GFS Architecture



Simple centralized management

Fixed chunk size (64 MB)

Chunk is replicated to ensure reliability

Data transfer is directly between application and chunk servers

Figure 1: GFS Architecture

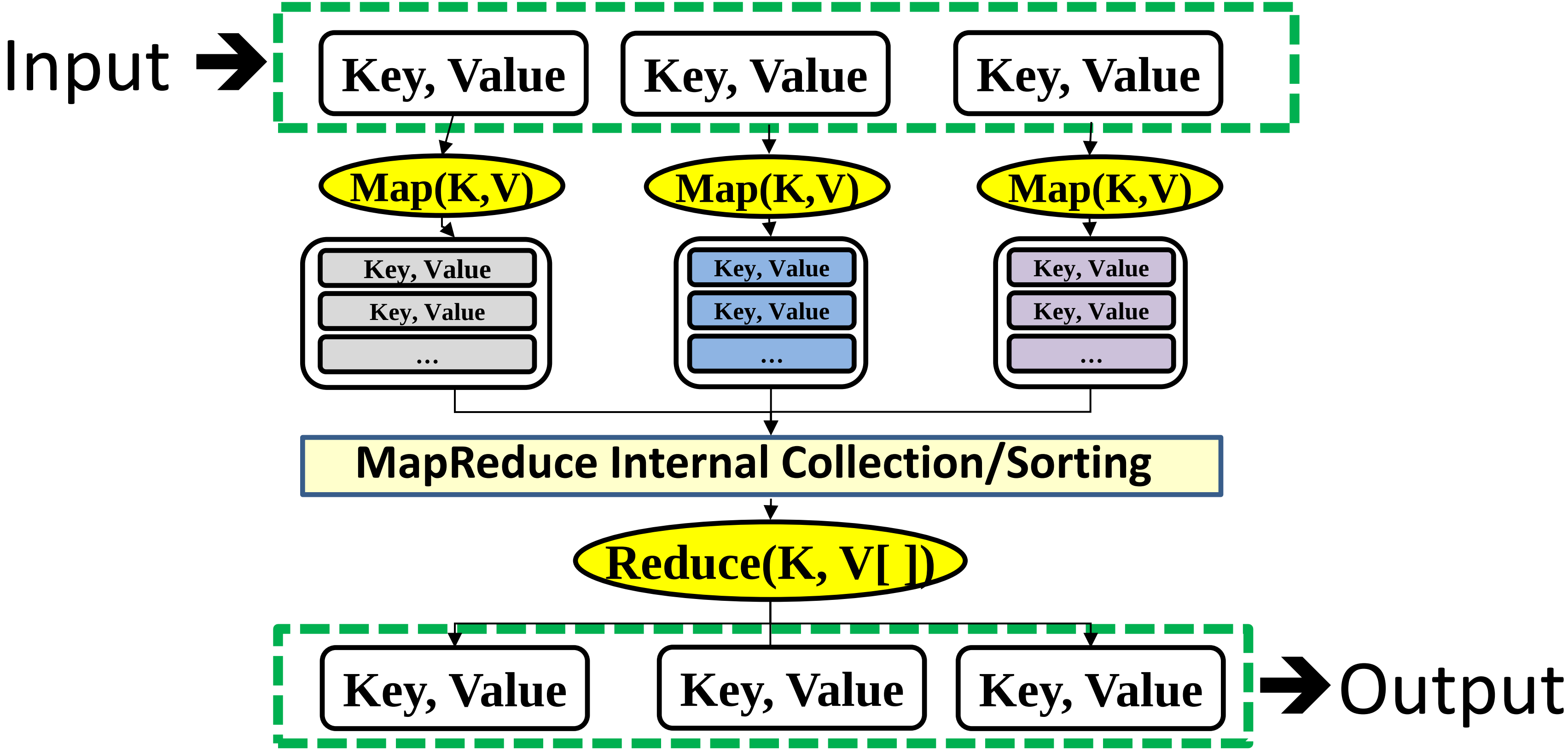
GHEMAWAT, S., GOBIOFF, H., AND LEUNG, S.-T. The google file system. In SOSP ’03: Proceedings of the nineteenth ACM symposium on Operating systems principles (New York, NY, USA, 2003), ACM, pp. 29–43.

http://static.googleusercontent.com/media/research.google.com/en/us/archive/gfs-sosp2003.pdf

MapReduce: A Framework for Parallel Programming

- Minimize effort of programmer for simple parallel processing tasks
- Features
    - Hide many low-level details (network, storage)
    - Built-in fault tolerance
    - Automatic load balancing

MapReduce: Computation Pipeline

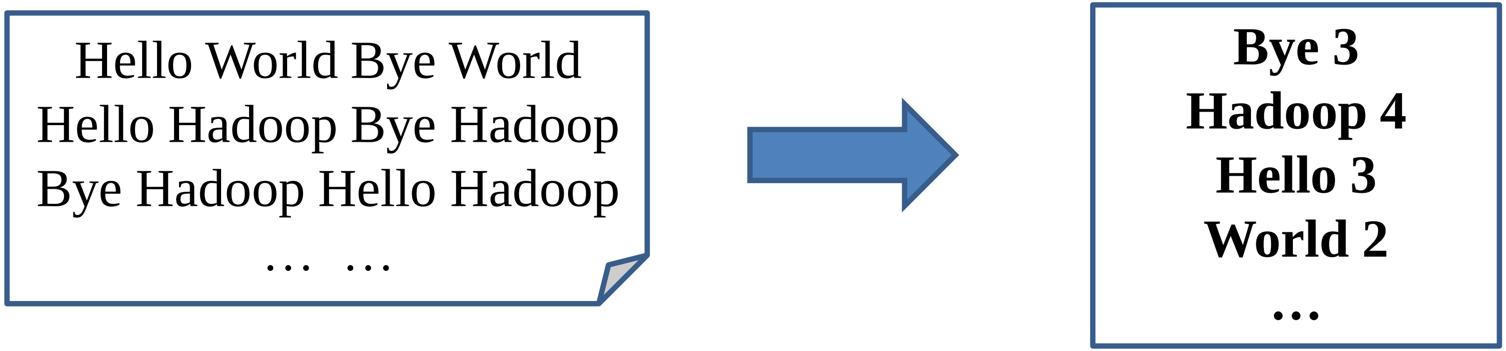


Slide adapted from Alexander Behm & Ajey Shah’s presentation (http://www.slideshare.net/gothicane/behm-shah-pagerank)

Word Counting

Input: Text Data

**Output:
Count of each word**



Hello World Bye World
Hello Hadoop Bye Hadoop
Bye Hadoop Hello Hadoop
… …

**Bye 3
Hadoop 4
Hello 3
World 2
…**

How can we do this within the MapReduce framework?

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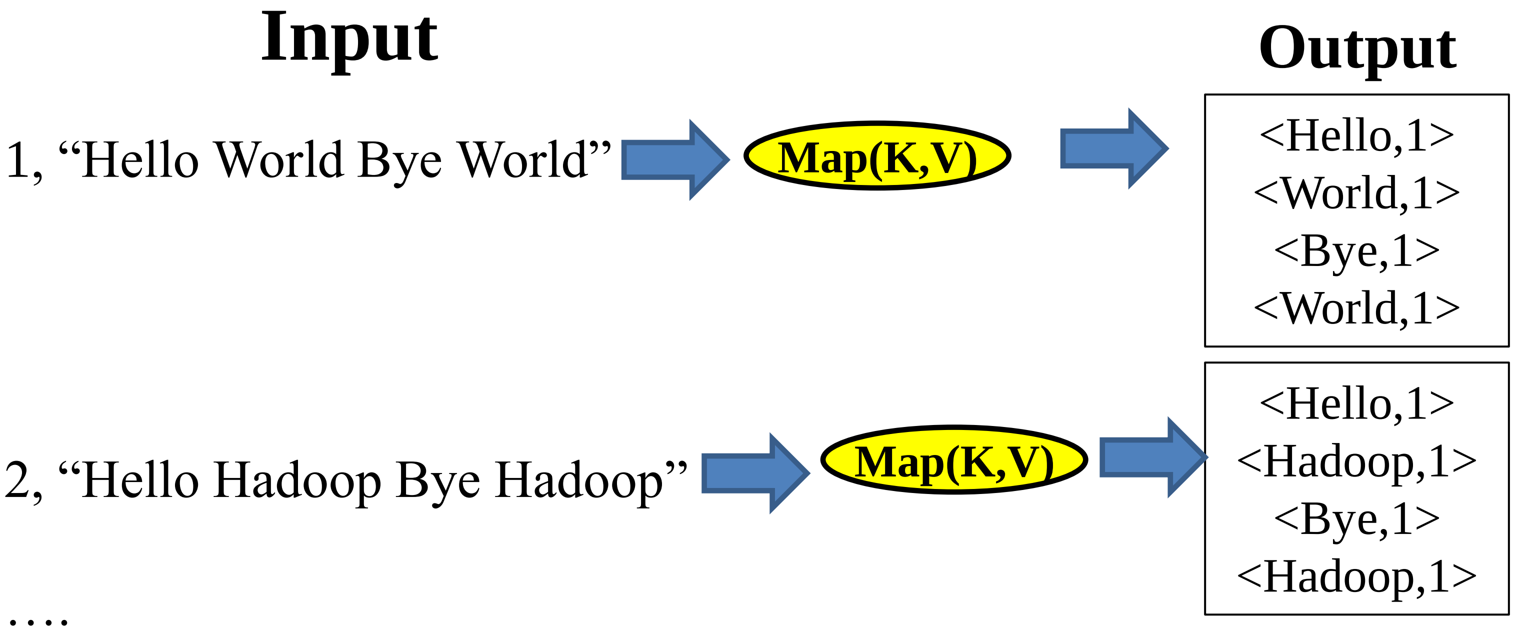
Word Counting: Map Function



Input

1, “Hello World Bye World”

Output

<Hello,1>
<World,1>
<Bye,1>
<World,1>

2, “Hello Hadoop Bye Hadoop”

<Hello,1>
<Hadoop,1>
<Bye,1>
<Hadoop,1>

….

Map(K, V)
{ For each word w in V, Collect(w, 1);}

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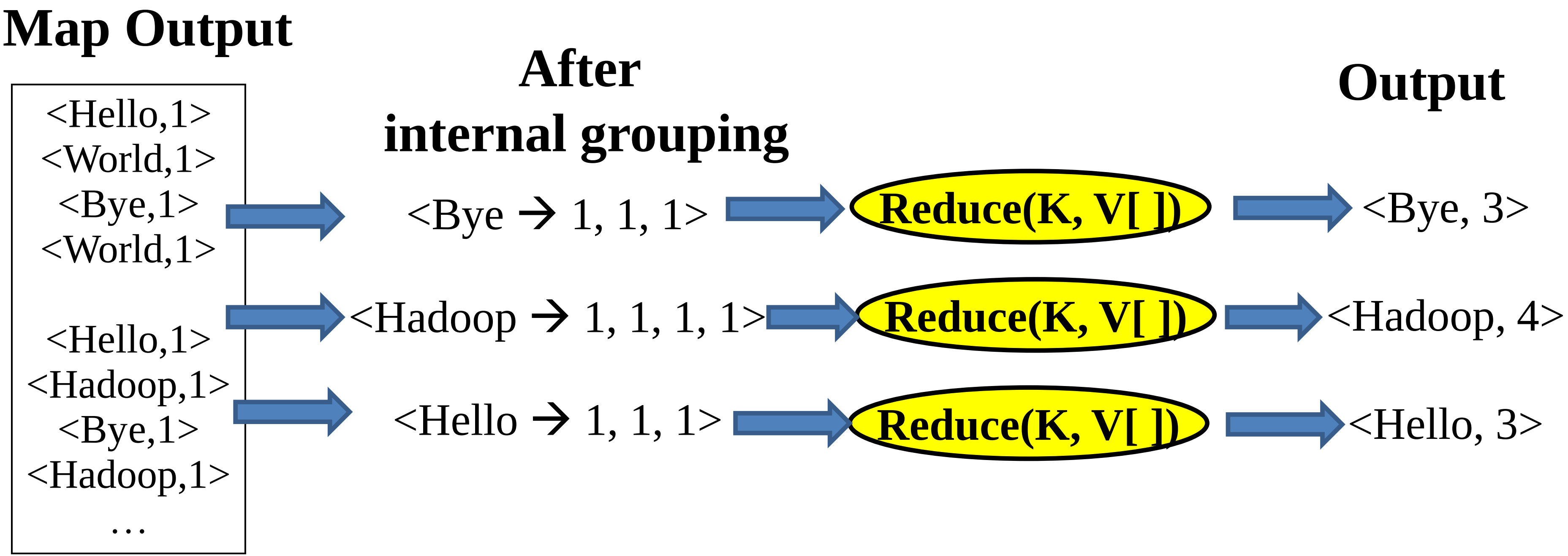
Word Counting: Reduce Function



Map Output

<Hello,1>
<World,1>
<Bye,1>
<World,1>

<Hello,1>
<Hadoop,1>
<Bye,1>
<Hadoop,1>
…

After internal grouping

<Bye → 1, 1, 1>
<Hadoop → 1, 1, 1, 1>
<Hello → 1, 1, 1>

Reduce(K, V[ ])
Reduce(K, V[ ])
Reduce(K, V[ ])

Output

<Bye, 3>
<Hadoop, 4>
<Hello, 3>

```
Reduce(K, V[ ])
{  Int count = 0;  For each v in V,  count += v;   Collect(K, count); }
```

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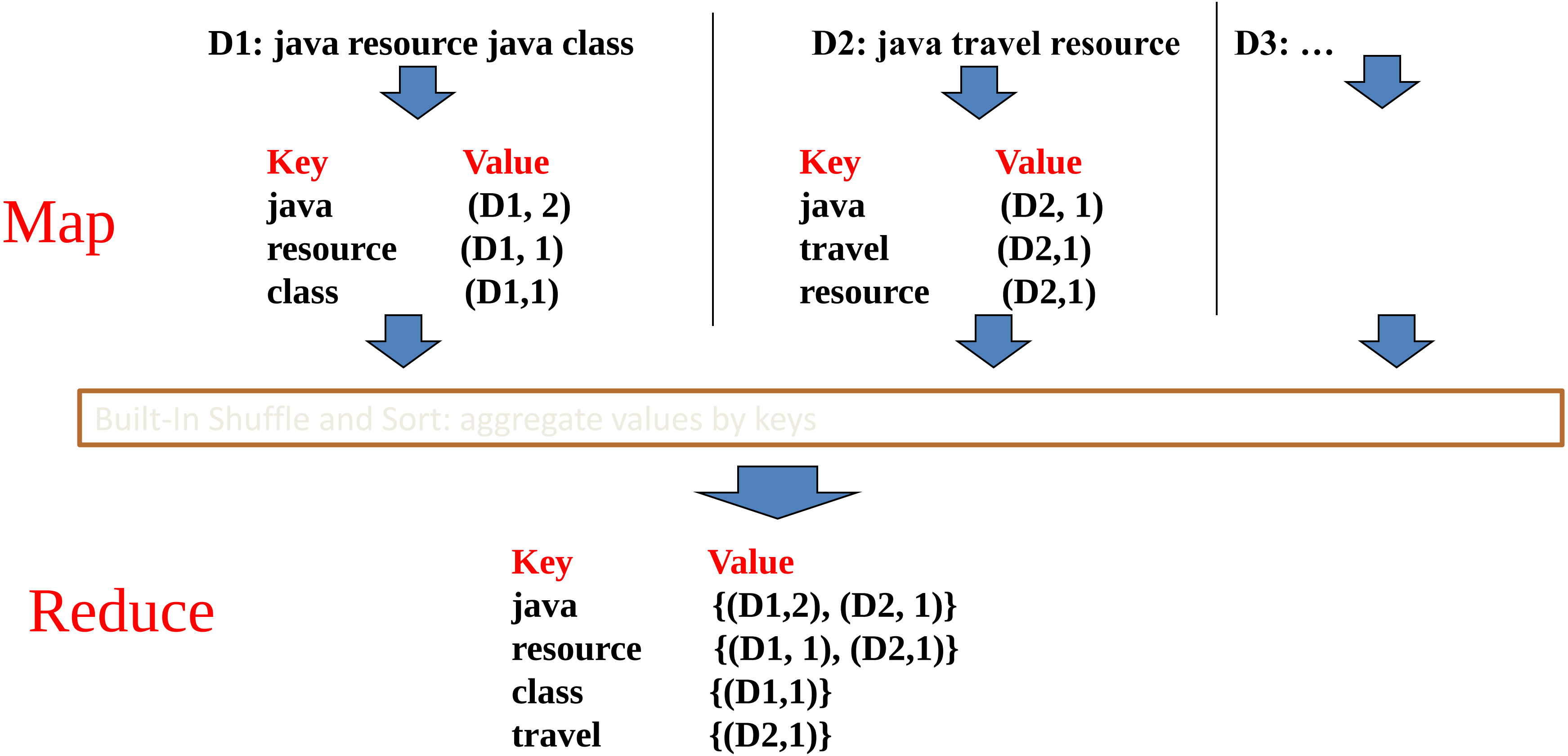
Inverted Indexing with MapReduce



Map

D1: java resource java class

Key	Value
java	(D1, 2)
resource	(D1, 1)
class	(D1,1)

D2: java travel resource

Key	Value
java	(D2, 1)
travel	(D2,1)
resource	(D2,1)

D3: …

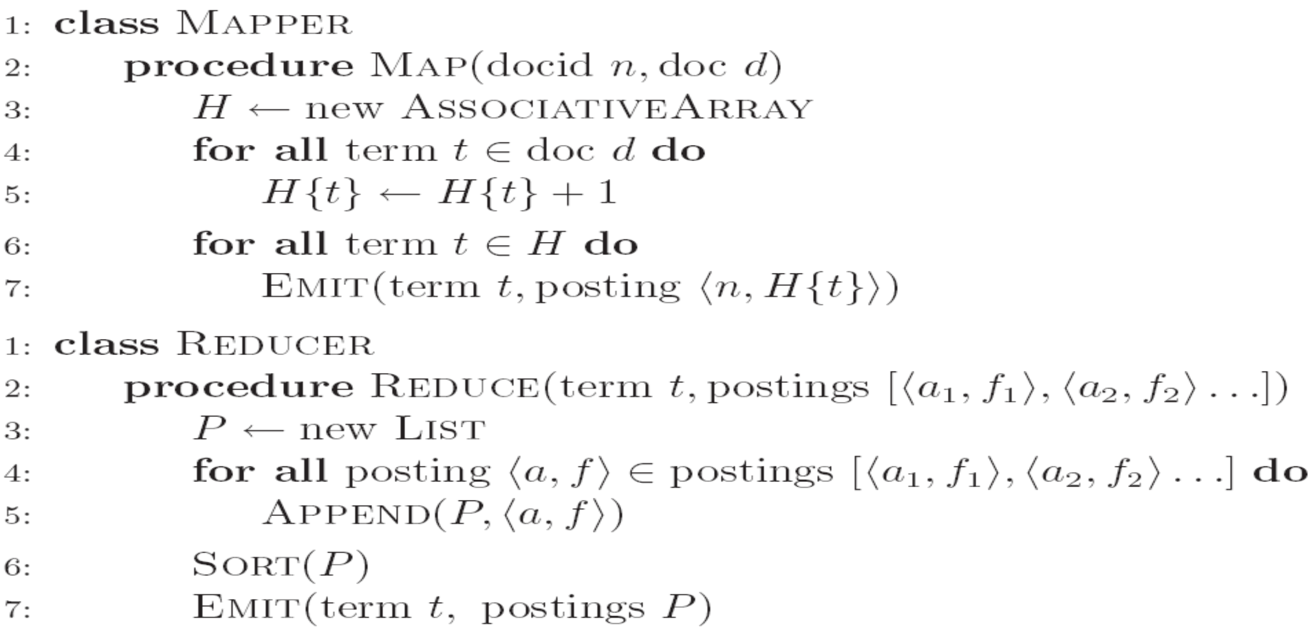
Built-In Shuffle and Sort: aggregate values by keys

Reduce

Key	Value
java	{(D1,2), (D2, 1)}
resource	{(D1, 1), (D2,1)}
class	{(D1,1)}
travel	{(D2,1)}
…	

Slide adapted from Jimmy Lin’s presentation

Inverted Indexing: Pseudo-Code



```
class Mapper
    procedure Map(docid $n$, doc $d$)
        $H \leftarrow$ new AssociativeArray
        for all term $t \in$ doc $d$ do
            $H\{t\} \leftarrow H\{t\} + 1$
        for all term $t \in H$ do
            Emit(term $t$, posting $\langle n, H\{t\}\rangle$)

class Reducer
    procedure Reduce(term $t$, postings $[\langle a_1, f_1\rangle, \langle a_2, f_2\rangle \ldots]$)
        $P \leftarrow$ new List
        for all posting $\langle a, f\rangle \in$ postings $[\langle a_1, f_1\rangle, \langle a_2, f_2\rangle \ldots]$ do
            Append($P, \langle a, f\rangle$)
        Sort($P$)
        Emit(term $t$, postings $P$)
```

Slide adapted from Jimmy Lin’s presentation

Summary

- Web scale indexing requires
  - Storing the index on multiple machines (GFS)
  - Creating the index in parallel (MapReduce)
- Both GFS and MapReduce are general infrastructures