CS 378 – Big Data Programming

Lecture 2

Map-Reduce

MapReduce

- Large data sets are not new
- What characterizes a problem suitable for MR?
  - Most or all of the data is processed
    - But viewed in small increments
    - For the most part, map and reduce tasks are stateless
  - Write once, read multiple times
    - Data Warehouse has this intended usage (write once)
  - Unstructured data vs. structured/normalized
- Data pipelines are common
  - Chain of MR jobs, with intermediate results

MapReduce

Table 1-1, Hadoop – The Definitive Guide

	Traditional RDBMS	MapReduce
Data Size	Gigabytes	Petabytes
Access	Interactive and batch	Batch
Updates	Read and write many times	Write once, read many
Transactions	ACID	None
Structure	Schema-on-write	Schema-on-read
Integrity	High	Low
Scaling	Nonlinear	Linear

MapReduce

- Tom White, in *Hadoop: The Definitive Guide*

- "*MapReduce works well on unstructured or semistructured data because it is designed to interpret the data at processing time. In other words, the input keys and values for MapReduce are not intrinsic properties of the data, but they are chosen by the persona analyzing the data*."

MapReduce

- When writing a MapReduce program …
  - You don't know the size of the data
  - You don't know the extent of the parallelism

- MapReduce tries to collocate the code and the data on a compute node
  - Parallelize the I/O
  - Make the I/O local (versus across network)

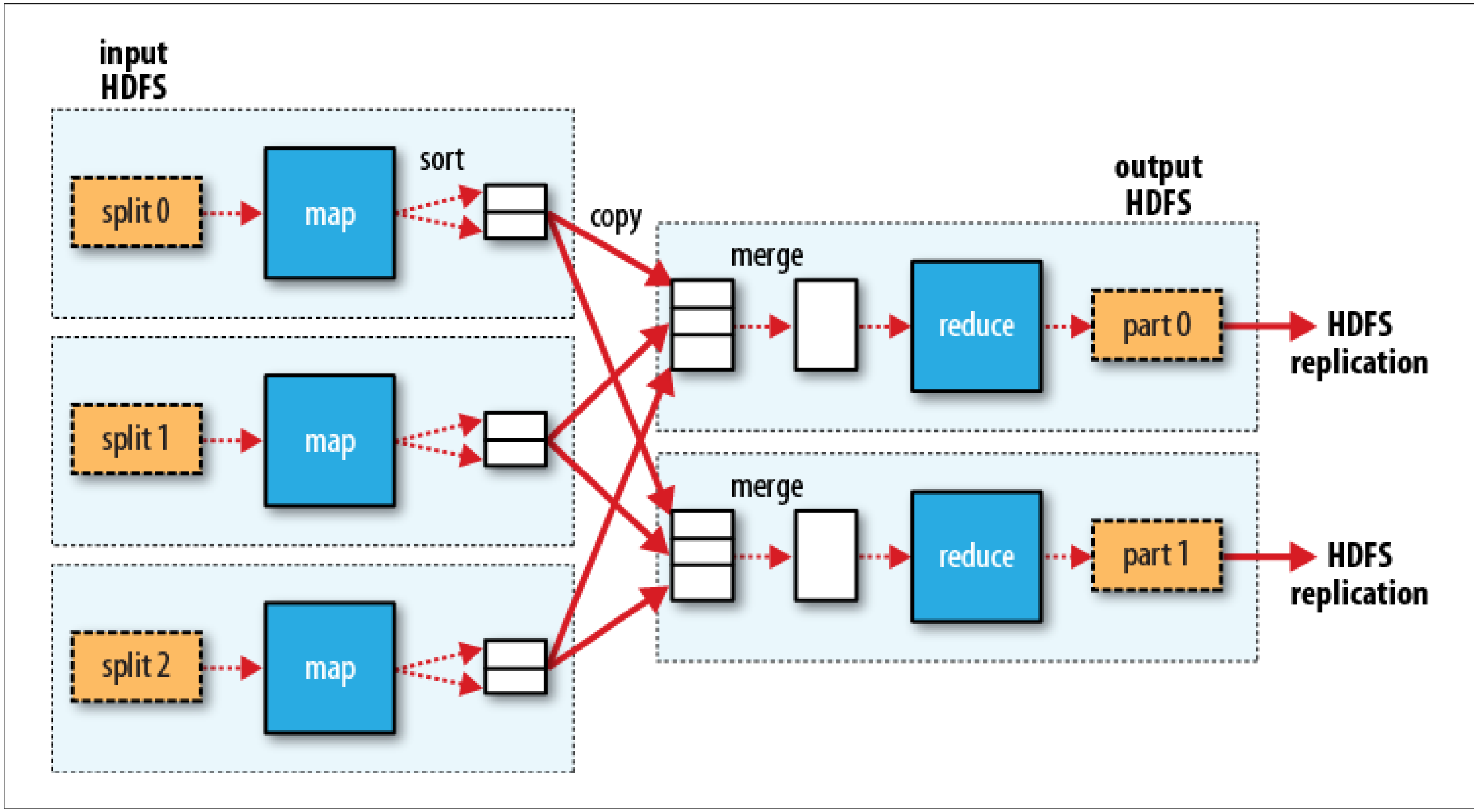
MapReduce

- As the name implies, for each problem we'll write
  - Map method/function
  - Reduce method/function
- Terms from functional programming

- Map
  - Apply a function to each input, output the result
  - May generate multiple "outputs"
- Reduce
  - Given a list of inputs, compute some output value

MapReduce in Hadoop

Figure 2.4, Hadoop - The Definitive Guide



Map Function

- Map input is a stream of key/value pairs
  - Web logs: Server name (key), log entry (value)
  - Sensor reading: sensor ID (key), sensed values (value)
  - Document ID (key), contents (value)

- Map function processes each input pair in turn

- For each input pair, the map function can (but isn't required to) emit one or more key/value pairs
  - Key/value pair(s) derived from the input key/value pair
  - Does not need to be the same key or value data type

Reduce Function

- Reduce input is a stream of key/value-list pairs
  - These are the key value pairs emitted by the map function grouped by key
- Reduce function processes each input pair in turn
- For each input pair, the reduce function can (but isn't required to) emit one or more key/value pairs
  - Key value pair derived from the input key/value-list pair
  - Does not need to be the same key or value data type

WordCount Example

- For an input text file of arbitrary size, or
- Multiple text files of arbitrary size, or
- An arbitrary number of documents

- Count the occurrences of all the words that appear in the input.
- Output:
  - word1, count
  - word2, count
  - …

WordCount Example - Map

- Map input is a stream of key/value pairs
  - File position in bytes (key), line of text (value)

- Map function processes each input pair in turn
  - Extract each word from the line of text input
  - Emits a key/value pair for each word: *<the-word, 1>*

- For each input pair, the map function emits multiple key/value pairs
  - Key is a text string (the word), value is a number

WordCount Example - Reduce

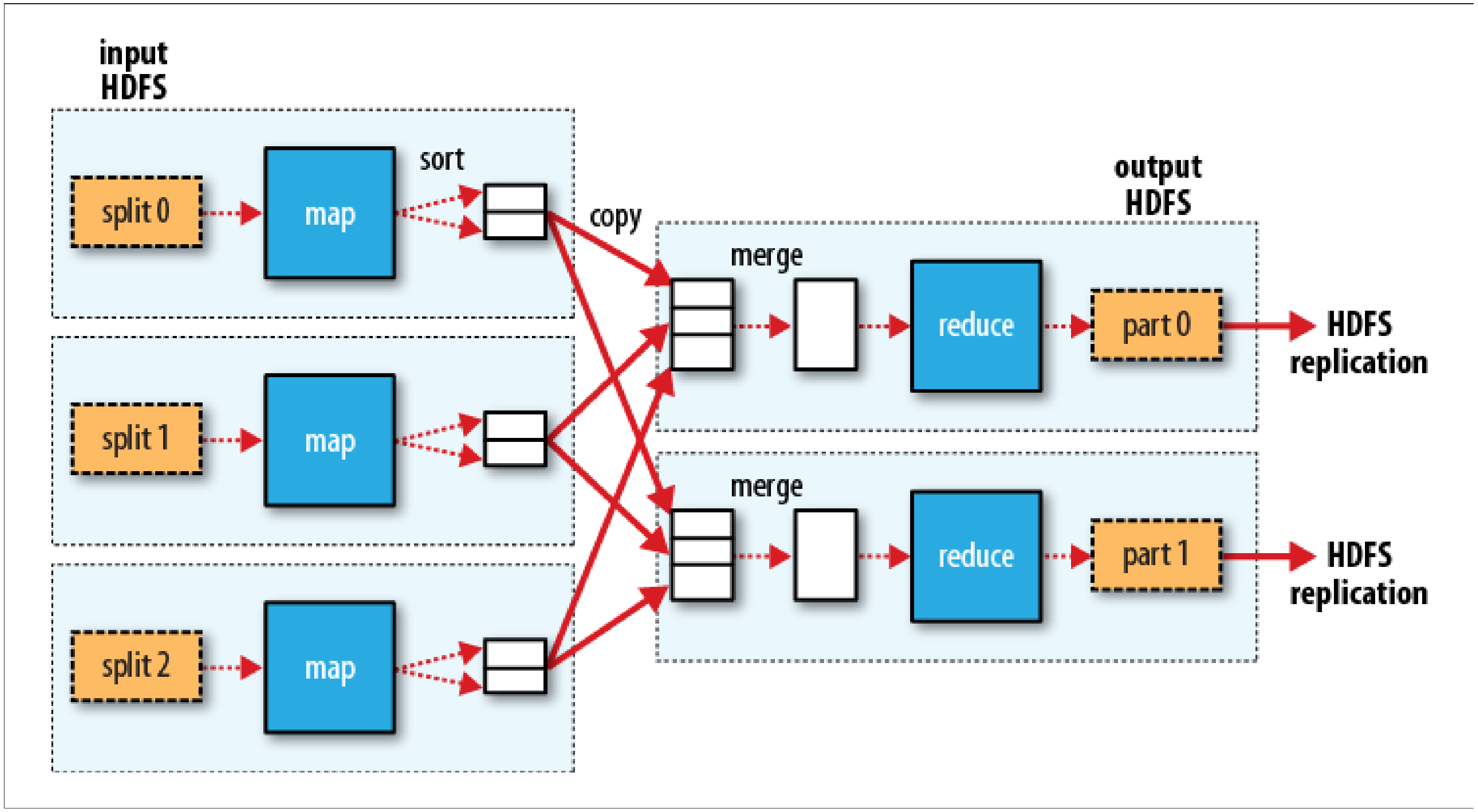
- Reduce input is a stream of key/value-list pairs
  - These are the key value pairs emitted by the map function
  - Key is a text string (the word), value is a list of some number of the value “1”
  - Hadoop has grouped data together by key

- Reduce function processes each input pair in turn
  - Sums the values in the value-list

- For each input pair, the reduce function emits a key/value pair
  - Key is a text string (the word), value is total count for that word

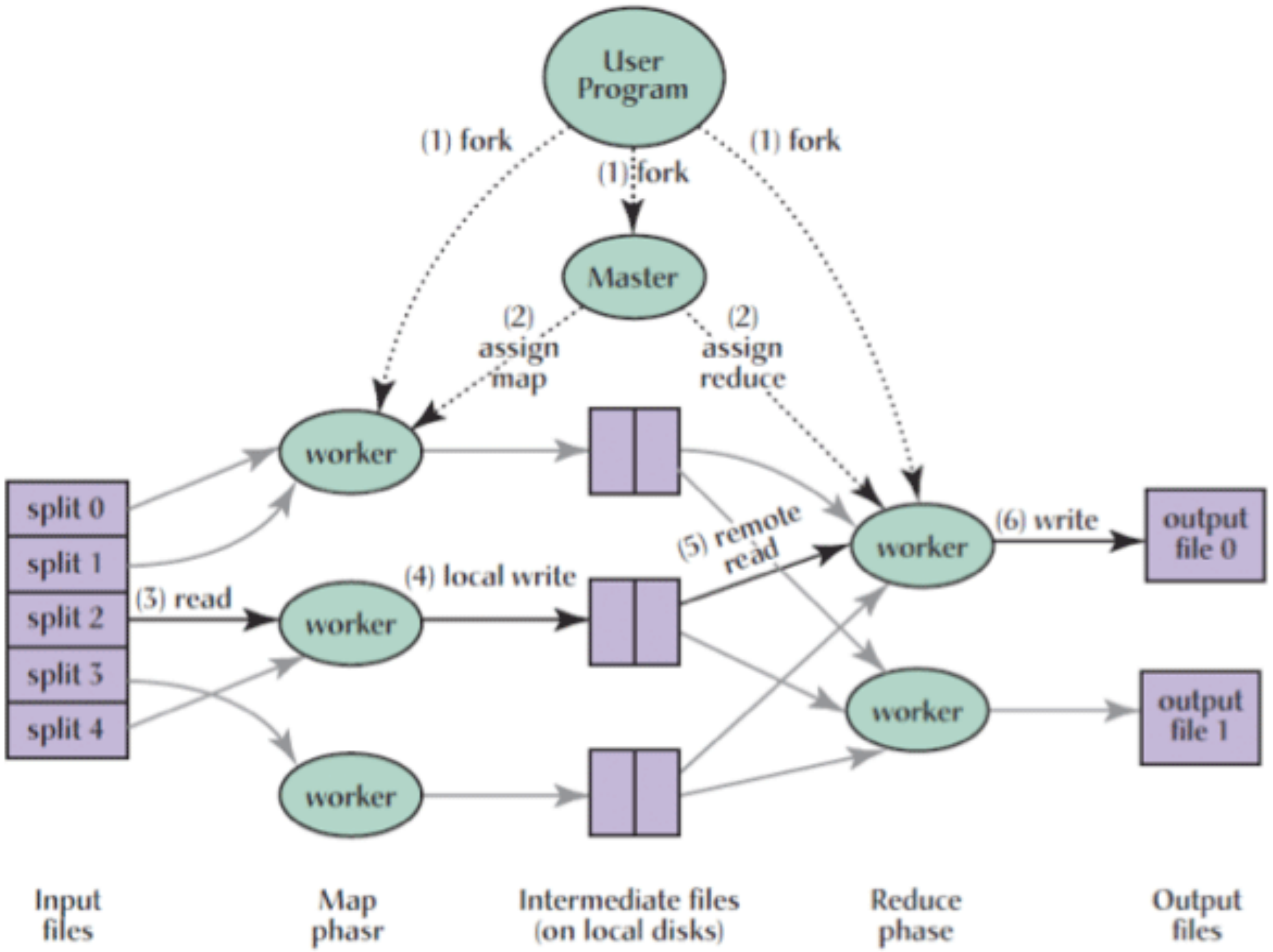
MapReduce in Hadoop

Figure 2.4, Hadoop - The Definitive Guide



MapReduce

(from cubrid.org)



Java and Maven Review

- Directory structure expected by maven (supported in IDEs):
  - Project directory (example name: bdp)
  - Source code directory: bdp/src/main/java
  - The Java package structure appears in the "java" directory
  - Ex: bdp/src/main/java/com/refactorlabs/cs378/assign1
  - A class defined in the com.refactorlabs.cs378.assign1 package placed here
  - Ex: bdp/src/main/java/com/refactorlabs/cs378/assign1/WordCount.java

- Easy setup - Create your project directory
  - Place pom.xml in this directory
  - Place WordCount.java as shown above
  - Import the maven pom.xml into your IDE.

Assignment Artifacts

- For each assignment, there will be one or more artifacts to submit:
  - Java code
    - Source files in one directory (for easy inspection)
    - Source files in `src/main/java/`… structure (use “tar”)
  - Build info: `pom.xml` file used for maven
    - An initial `pom.xml` file will be provided, and we’ll expand this during the semester
  - Program outputs
    - Extracted from HDFS

- Artifacts required for each assignment will be listed.

Assignment 1

- Build a JAR file
- Upload to AWS S3
- Create a cluster using Elastic MapReduce (EMR)
- Run your map-reduce job on EMR cluster
- Download the output
- Artifacts to submit
  - zip or tar of all source files in one (flat) directory
  - tar of project (will include pom.xml and source files)
  - Output