**15-440 Map Reduce**

**Tyler Healy – Justin Greet**

**System Administration**

**Starting the Map Reduce System**

Our Map Reduce package contains many Java files that work together to allow problems following the Map-Reduce paradigm to be run in parallel across multiple systems. However, in order for a machine to be a participant in the computation of one of these problems, it must have the package installed on a machine. The package can be installed by copying the files of the package into a directory on the participating system.

Once the package is installed, a system can be prepared for participation by doing the following:

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**Reference Manual**

**An Example**

**Colorcount**

Before we get into the specific interfaces that need implemented, let us walkthrough an example of a program that successfully completes a Map-Reduce job.

The idea of Colorcount is to take an image and count the number of pixels of each color: black, blue, aqua, purple, red, green, yellow, and white. The mappers will map the pixels to colors, and the reducers will combine the results to count the number of pixels of each color.

Take a moment to examine the code contained in the following three files include with the Map-Reduce package:

* ColorcountMap.java
* ColorcountReduce.java
* ColorcountConfig.java

The ColorcountMap class implements the Mapper interface, and defines the map behavior for a given input key and value. Here, the input key is a long, which is not used in our calculation, and the input value is a pixel, or set of three bytes. The map function examines the pixel and determines what color that pixel is closest to. That result is then collected.

The ColorcountReduce class implements the Reducer interface, and defines the reduce (and combine) behavior for a given intermediate key and a set of associated values. Here, the intermediate key is the name of the color, and the associated values are an array containing Integers that represent the number of occurrences. The reduce function takes a key and sums together all the associated values into one final Integer value. That result is then collected.

Lastly, the ColorcountConfig class, which implements the Configuration interface, provides all the necessary information for the job to run. You will have to change result of getMapperClassPath, getCombinerClassPath, and getReducerClassPath to the location of the .class files for each of these classes, but an example of how the String should be formatted is included.

Once the Configuration file is correctly adjusted for the system you are running on, you can change individual details of the job, such as the job name and the number of workers and reducers. The values of getMasterLocation and getWorkerLocations also need to be adjusted to include hosts on your system that will be running the Map-Reduce program. More information about setting the values of these two methods is given below in “Configuration.” Lastly, you will need to set the location of the input image for this job, as well as the desired output location. This is done in the getFileInputPath and getFileOutputPath respectively.

Details such as getInputFormat, getRecordLength, getOutputKeyClass and getOutputValueClass are set to work with this job and should not be adjusted for Colorcount.

Once the ColorcountConfig.java file is correctly adjusted for your system and has been compiled, it is ready to be passed to a Map-Reduce system to complete a job. This can be done by entering the following command in the shell of a system running the Map-Reduce program (more information for how to prepare a system to accept a job is given in System Administration):

*start /path/to/config/file.class*

The system then attempts to run your job by dividing map work amongst the workers (provided by the Configuration file). The mappers, each with a distinct subset of the input data, complete the map (and combine in the case of Colorcount) operations on the input data. This data is passed to the master worker (provided by the Configuration file), which concatenates the data together and partitions it into subsets to be given to the reducers. The reducers then run the reduce operation on its data and outputs it to file as specified in the Configuration file. There will be one output file for each reducer, and each one will contain a subset of the final results of your job.

As an example, try using this image:

<http://2.bp.blogspot.com/-EZHl3fasivY/TWa-Sh8dGdI/AAAAAAAAACY/SjWdzc-25fA/s1600/yankees+win2.jpg>

The output produced by Map-Reduce should be as follows:

<aqua,128303>

<black,204852>

<blue,119589>

<green,59>

<purple,1277>

<red,32086>

<white,244100>

<yellow,18534>

**User Interfaces**

**Configuration**

The Configuration file contains all the necessary information for the Map-Reduce package to complete a job.

A user can create a configuration file by implementing the Configuration interface included in the Map-Reduce package, as well as all the functions required by the interface. A description of each function is given below.

*getJobName()*

Defines the name of the job. Used in monitoring the jobs currently running.

*getMapperClassPath()*

Defines the full path of the .class file containing the Map class as defined by the user. This class must implement the Mapper interface. This should be given as a String.

*getCombinerClassPath()*

Defines the full path of the .class file containing the Combiner class as defined by the user. This class must implement the Reducer interface. This should be given as a String. If the job does not have a combiner, *null* should be returned.

*getReducerClassPath()*

Defines the full path of the .class file containing the Reduce class as defined by the user. This class must implement the Reducer interface. This should be given as a String.

*getMasterLocation()*

Defines the machine (host and port) the will be declared the master node. The master is responsible for splitting the input, distributing work to the mappers, partitioning the intermediate outputs, and distributing work to the reducers. This method should return a String given in the following format:

*“hostname:port”*

*getWorkerLocations()*

Defines the machines (host and ports) that are available to do work (either mapping or reducing). Each one of these machines may be assigned to do mapping or reducing work during the job. For each host, two ports must be provided. One is for obtaining work from the master, while the other is used to let the master know that it is alive. It is important to note that if the machine is not running the Map-Reduce application configured to the proper host, it will not be available to do work. More information on preparing a system to do work is given in the “System Administration” manual. This method should return a String given in the following format:

*“hostname:port:port”*

*getFileInputPath()*

Defines the file that contains the raw input to the Map-Reduce job. This should be given as a String representing the full path of the location of the file.

*getFileOutputPath()*

Defines the file to which the Map-Reduce job will write the output. This should be given as a String representing the full path of the location of the file. If the file does not exist, it will be created. If it does exists, it will be overwritten.

*getNumOfMappers()*

Defines the number of map workers (and thus the number of input splits) for the Map-Reduce job. This method should return an int.

*getNumOfReducers()*

Defines the number of reduce workers (and thus the number of partitions of the intermediate output) for the Map-Reduce job. This method should return an int.

*getInputFormat()*

Defines the class of the InputFormat that is used in this job. The InputFormat describes the input, the types of the input keys and values, and the methods to read the input. More information this interface is given below.

*getOutputKeyClass()*

Defines the Class of the keys that will be given as output. This method should return a Class. Our Map-Reduce package allows for the following Output keys:

* String

*getOutputValueClass()*

Defines the Class of the values that will be given as output. This method should return a Class. Our Map-Reduce package allows for the following Output keys:

* String
* Integer

*getRecordLength()*

Defines the length of the record. This method should return an int that is greater than the length of the longest record that could be a result of the Map-Reduce job.

**Mapper and Reducer**

A Map-Reduce program must implement these two interfaces: Mapper and Reducer. These form the core of the Map-Reduce job to be completed.

**Mapper**

The mapper takes a set of input key/value pairs and produces a set of intermediate key/value pairs.

The number of mappers to be used for a given job is defined in the configuration file. The input is split amongst the mappers, and each mapper takes a partition of the input and calls the map function on each input record.

The map reduce takes the following inputs:

* Input key
* Input value
* OutputCollecter

The outputs of the map operation are collected in the provided OutputCollecter, which is explained later.

If applicable, the intermediate outputs are passed through a combiner. More information about a combiner is given later.

The intermediate outputs are written to a file. The Output Path, as set in the configuration file, determines where the results are written. The locations of these files are then passed to the master worker, which concatenates the results together to be reduced.

**Reducer**

The reducer takes the intermediate key/value pairs as produced by the mappers, and combines them into the final result of the Map-Reduce job. This is done by grouping all values with equal keys together, and running the reduce method on the key and its associated set of values.

The number of reducers to be used for a given job is defined in the configuration file. The intermediate key/value pairs are split amongst the reducers by hashing the keys into regions. The reducer then collects the data to be reduced, collects all values with equal keys together, and calls the reduce method on each key and its associated set of values.

The reduce method takes the following inputs:

* Intermediate key
* Set of Intermediate values
* Output Collecter

The outputs of the map operation are collected in the provided OutputCollecter, which is explained later.

The intermediate outputs are written to a file. The Output Path, as set in the configuration file, determines where the results are written.

**Job Input**

**InputFormat440**

The InputFormat describes the input that is being given to the Map-Reduce job. The InputFormat verifies the input, splits into into logical InputSplit instances, and provides the RecordReader implementation that turns the raw input into actual data that can be mapped.

The following InputFormat implementations are include with out Map-Reduce package:

* TextInputFormat440
* ImageInputFormat440

**InputSplit440**

The InputSplit represents the data that an individual mapper is to read and map. The InputSplit is a logical split. This means the result sent to a mapper is not the data itself, but directions on which data to read from the input file.

The following InputSplit implementations are included with our Map-Reduce package:

* TextSplit440
* ImageSplit440

**RecordReader440**

The RecordReader takes an InputSplit and converts the raw input data into key/value pairs (records) that can be used by the mapper. It converts the logical split of data into actual records that the map method can be called on.

The following RecordReader implementations are included with our Map-Reduce package:

* LineRecordReader440
* WordRecrdReader440
* ImageRecordReader440

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**Design Report**