Hadoop 程序编写

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2.1   示例程序运行

2.1.1   示例代码`WordCount.java`

```java
package org.myorg;

import java.io.IOException;
import java.util.*;

import org.apache.hadoop.fs.Path;
import org.apache.hadoop.conf.*;
import org.apache.hadoop.io.*;
import org.apache.hadoop.mapred.*;
import org.apache.hadoop.util.*;

public class WordCount {

    public static class Map extends MapReduceBase implements Mapper<LongWritable,
Text, Text, IntWritable> {
        private final static IntWritable one = new IntWritable(1);
        private Text word = new Text();

        public void map(LongWritable key, Text value,
OutputCollector<Text, IntWritable> output, Reporter reporter) throws IOException {
            String line = value.toString();
            StringTokenizer tokenizer = new StringTokenizer(line);
            while (tokenizer.hasMoreTokens()) {
              word.set(tokenizer.nextToken());
              output.collect(word, one);
            }
        }
    }

    public static class Reduce extends MapReduceBase implements Reducer<Text, IntWritable,
Text, IntWritable> {
        public void reduce(Text key, Iterator<IntWritable> values,
```

```
    OutputCollector<Text, IntWritable> output, Reporter reporter) throws IOException {
      int sum = 0;
      while (values.hasNext()) {
        sum += values.next().get();
      }
      output.collect(key, new IntWritable(sum));
    }
  }

  public static void main(String[] args) throws Exception {
    JobConf conf = new JobConf(WordCount.class);
    conf.setJobName("wordcount");

    conf.setOutputKeyClass(Text.class);
    conf.setOutputValueClass(IntWritable.class);

    conf.setMapperClass(Map.class);
    conf.setCombinerClass(Reduce.class);
    conf.setReducerClass(Reduce.class);

    conf.setInputFormat(TextInputFormat.class);
    conf.setOutputFormat(TextOutputFormat.class);

    FileInputFormat.setInputPaths(conf, new Path(args[0]));
    FileOutputFormat.setOutputPath(conf, new Path(args[1]));

    JobClient.runJob(conf);
  }
}
```

2.1.2 编译 Java 程序代码

检查环境变量CLASSPATH是否设置为 CDH4 对应的位置：

```
$ echo $CLASSPATH
/opt/cloudera/parcels/CDH/lib/hadoop/*:/opt/cloudera/parcels/CDH/lib/hadoop/client-0.20/*:
```

编译代码：

```
$ mkdir wordcount_classes
```

```
$ javac -d wordcount_classes WordCount.java
```

生成 Jar 包：

```
$ jar -cvf wordcount.jar -C wordcount_classes/ .
```

2.1.3 准备数据

随便抓取一些文本数据作为 WordCount 程序的输入。输入数据需要从本地复制到 HDFS 中。

```
$ mkdir input
$ curl http://www.sjtu.edu.cn > input/file01.txt
$ curl http://net.sjtu.edu.cn > input/file02.txt
$ hdfs dfs -mkdir /user/jianwen/wordcount
$ hdfs dfs -copyFromLocal input /user/jianwen/wordcount/input
$ hdfs dfs -ls /user/jianwen/wordcount/input
Found 2 items
-rw-r--r--   3 jianwen hadoop       74758 2013-11-21 14:35 /user/jianwen/wordcount/input/file01.txt
-rw-r--r--   3 jianwen hadoop       33553 2013-11-21 14:35 /user/jianwen/wordcount/input/file02.txt
```

2.1.4 运行作业

使用 hadoop 命令提交作业，在参数中指定 jar 包、Java 主类、输入文件夹、输出文件夹。

```
$ hadoop jar wordcount.jar org.myorg.WordCount \
/user/jianwen/wordcount/input /user/jianwen/wordcount/output
```

运行很快就能完成，在运行过程中显示的作业信息如下：

```
13/11/21 14:38:41 WARN mapred.JobClient: Use GenericOptionsParser for parsing the arguments. Appli
13/11/21 14:38:41 INFO mapred.FileInputFormat: Total input paths to process : 2
13/11/21 14:38:41 INFO mapred.JobClient: Running job: job_201311150128_0050
13/11/21 14:38:42 INFO mapred.JobClient:  map 0% reduce 0%
13/11/21 14:38:48 INFO mapred.JobClient:  map 100% reduce 0%
13/11/21 14:38:53 INFO mapred.JobClient:  map 100% reduce 41%
```

```
13/11/21 14:38:54 INFO mapred.JobClient:  map 100% reduce 100%
13/11/21 14:38:55 INFO mapred.JobClient: Job complete: job_201311150128_0050
13/11/21 14:38:55 INFO mapred.JobClient: Counters: 33
13/11/21 14:38:55 INFO mapred.JobClient:    File System Counters
13/11/21 14:38:55 INFO mapred.JobClient:      FILE: Number of bytes read=56585
13/11/21 14:38:55 INFO mapred.JobClient:      FILE: Number of bytes written=25028678
13/11/21 14:38:55 INFO mapred.JobClient:      FILE: Number of read operations=0
13/11/21 14:38:55 INFO mapred.JobClient:      FILE: Number of large read operations=0
13/11/21 14:38:55 INFO mapred.JobClient:      FILE: Number of write operations=0
13/11/21 14:38:55 INFO mapred.JobClient:      HDFS: Number of bytes read=120091
13/11/21 14:38:55 INFO mapred.JobClient:      HDFS: Number of bytes written=51565
13/11/21 14:38:55 INFO mapred.JobClient:      HDFS: Number of read operations=150
13/11/21 14:38:55 INFO mapred.JobClient:      HDFS: Number of large read operations=0
13/11/21 14:38:55 INFO mapred.JobClient:      HDFS: Number of write operations=288
13/11/21 14:38:55 INFO mapred.JobClient:    Job Counters
13/11/21 14:38:55 INFO mapred.JobClient:      Launched map tasks=3
13/11/21 14:38:55 INFO mapred.JobClient:      Launched reduce tasks=144
13/11/21 14:38:55 INFO mapred.JobClient:      Data-local map tasks=3
13/11/21 14:38:55 INFO mapred.JobClient:      Total time spent by all maps in occupied slots (ms)=9
13/11/21 14:38:55 INFO mapred.JobClient:      Total time spent by all reduces in occupied slots (ms
13/11/21 14:38:55 INFO mapred.JobClient:      Total time spent by all maps waiting after reserving
13/11/21 14:38:55 INFO mapred.JobClient:      Total time spent by all reduces waiting after reservi
13/11/21 14:38:55 INFO mapred.JobClient:    Map-Reduce Framework
13/11/21 14:38:55 INFO mapred.JobClient:      Map input records=1468
13/11/21 14:38:55 INFO mapred.JobClient:      Map output records=5378
13/11/21 14:38:55 INFO mapred.JobClient:      Map output bytes=121396
13/11/21 14:38:55 INFO mapred.JobClient:      Input split bytes=399
13/11/21 14:38:55 INFO mapred.JobClient:      Combine input records=5378
13/11/21 14:38:55 INFO mapred.JobClient:      Combine output records=1891
13/11/21 14:38:55 INFO mapred.JobClient:      Reduce input groups=1587
13/11/21 14:38:55 INFO mapred.JobClient:      Reduce shuffle bytes=69083
13/11/21 14:38:55 INFO mapred.JobClient:      Reduce input records=1891
13/11/21 14:38:55 INFO mapred.JobClient:      Reduce output records=1587
13/11/21 14:38:55 INFO mapred.JobClient:      Spilled Records=3782
13/11/21 14:38:55 INFO mapred.JobClient:      CPU time spent (ms)=196290
13/11/21 14:38:55 INFO mapred.JobClient:      Physical memory (bytes) snapshot=42758049792
13/11/21 14:38:55 INFO mapred.JobClient:      Virtual memory (bytes) snapshot=238107385856
13/11/21 14:38:55 INFO mapred.JobClient:      Total committed heap usage (bytes)=146269863936
13/11/21 14:38:55 INFO mapred.JobClient:    org.apache.hadoop.mapreduce.lib.input.FileInputFormatCo
13/11/21 14:38:55 INFO mapred.JobClient:      BYTES_READ=108311
```

可以在 HDFS 上直接查看运行结果，当然还也可以把结果复制到本地。

```
$ hdfs dfs -ls /user/jianwen/wordcount/output
Found 146 items
-rw-r--r--   3 jianwen hadoop              0 2013-11-21 14:38 /user/jianwen/wordcount/output/_SUCCESS
drwxr-xr-x   - jianwen hadoop              0 2013-11-21 14:38 /user/jianwen/wordcount/output/_logs
-rw-r--r--   3 jianwen hadoop            505 2013-11-21 14:38 /user/jianwen/wordcount/output/part-0000
-rw-r--r--   3 jianwen hadoop            236 2013-11-21 14:38 /user/jianwen/wordcount/output/part-0000
-rw-r--r--   3 jianwen hadoop            255 2013-11-21 14:38 /user/jianwen/wordcount/output/part-0000
...


$ hdfs dfs -cat /user/jianwen/wordcount/output/part-00001


$ hdfs dfs -copyToLocal hdfs dfs -cat /user/jianwen/wordcount/output ./wordcount-output
```

2.2 程序模块说明

使用 Java 开发 Hadoop 应用程序，使用的主要的类包括：

- Input and Output
- Mapper
- Reducer
- Partitioner
- Reporter
- OutputCollector

除此以外，Hadoop 还包含一个辅助工具包`lib`，提供作业管理、数据分割、数据合并等辅助功能。

2.3 初步优化建议

3 使用 Python 编写 Hadoop MapReduce 程序

4 使用 C++ 编写 Hadoop MapRedducech 程序

5 TODO

- 在命令行，而不是代码中指定这些参数：作业名、并行 Mapper/Reducer 数量；
- Java Makefile http://geosoft.no/development/javamake.html

6 参考资料

- Cloudera Hadoop Tutorial http://www.cloudera.com/content/cloudera-content/cloudera-docs/HadoopTutorial/CDH4/Hadoop-Tutorial.html
- Apache Hadoop Commands Guide http://hadoop.apache.org/docs/r1.2.1/commands_manual.html
- Java Doc: Package `org.apache.hadoop.mapred.lib` http://hadoop.apache.org/docs/current/api/org/apache/hadoop/mapred/lib/package-summary.html