Concepts and Models of Parallel and Data-centric Programming

MapReduce – Hadoop Ecosystem

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Outline

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2. Shared Memory
3. GPU Programming
4. Bulk-Synchronous Parallelism
5. Message Passing
6. Distributed Shared Memory
7. Parallel Algorithms
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9. **MapReduce**
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a. MapReduce Programming Model
b. Parallelizing MapReduce
c. Hadoop Ecosystem
d. Hadoop Distributed File System
e. Yet Another Resource Negotiator
f. Comparison to Other Approaches
g. MapReduce Design Patterns

MapReduce Implementations

- MapReduce programming model generic, different implementations
- Two different implementations of MapReduce in Hadoop
  - “Classic” MapReduce (MapReduce 1) till including Hadoop 0.20
  - YARN (MapReduce 2) from Hadoop 2.0 onwards
- Further implementations
  - MapReduce-MPI (based on Message Passing Interface)
  - Disco (core written in Erlang, user code in Python)
  - Phoenix (shared memory implementation of MapReduce)
  - Bashreduce (MapReduce in a bash script)
  - …
- Covered here: Hadoop implementation

Word Count Example in Hadoop

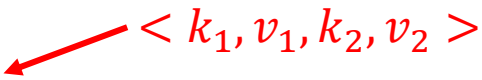
- Map function and Reduce function wrapped in separate classes
- Reminder:
  - $Map(k_1, v_1) \rightarrow list(k_2, v_2)$
  - $Reduce\big(k_2, list(v_2)\big) \rightarrow list(k_3, v_3)$
- Two base classes
  - $\mathrm{Mapper}< k_1, v_1, k_2, v_2 >$: Implementation of Map function
  - $\mathrm{Reducer}< k_2, v_2, k_3, v_3 >$: Implementation of Reduce function
- Application configuration set in Job object

Word Count Example in Hadoop (1)

$$Map(k_1, v_1) \rightarrow list(k_2, v_2)$$

Mapper for Word Count in Hadoop:

```
1  public class WordCountMapper
2          extends Mapper<Object, Text, Text, IntWritable> {
3      private final static IntWritable one = new IntWritable(1);
4      private Text word = new Text();
5
6      public void map(Object key, Text value, Context context)
7              throws IOException, InterruptedException {
8          StringTokenizer itr = new StringTokenizer(
9                                          value.toString());
10
11         while (itr.hasMoreTokens()) {
12             word.set(itr.nextToken());
13             context.write(word, one);
14         }
15     }
16 }
```



Word Count Example in Hadoop (2)

$$Reduce\big(k_2, list(v_2)\big) \rightarrow list(k_3, v_3)$$

Reducer for Word Count in Hadoop:

$< k_2, v_2, k_3, v_3 >$

```
1  public class WordCountReducer
2          extends Reducer<Text,IntWritable,Text,IntWritable> {
3      private IntWritable result = new IntWritable();
4
5      public void reduce(Text key, Iterable<IntWritable> values,
6                         Context context)
7             throws IOException, InterruptedException {
8          int sum = 0;
9          for (IntWritable val : values) {
10             sum += val.get();
11         }
12         result.set(sum);
13         context.write(key, result);
14     }
15 }
```

Sum Reduction

Emit(key, sum)

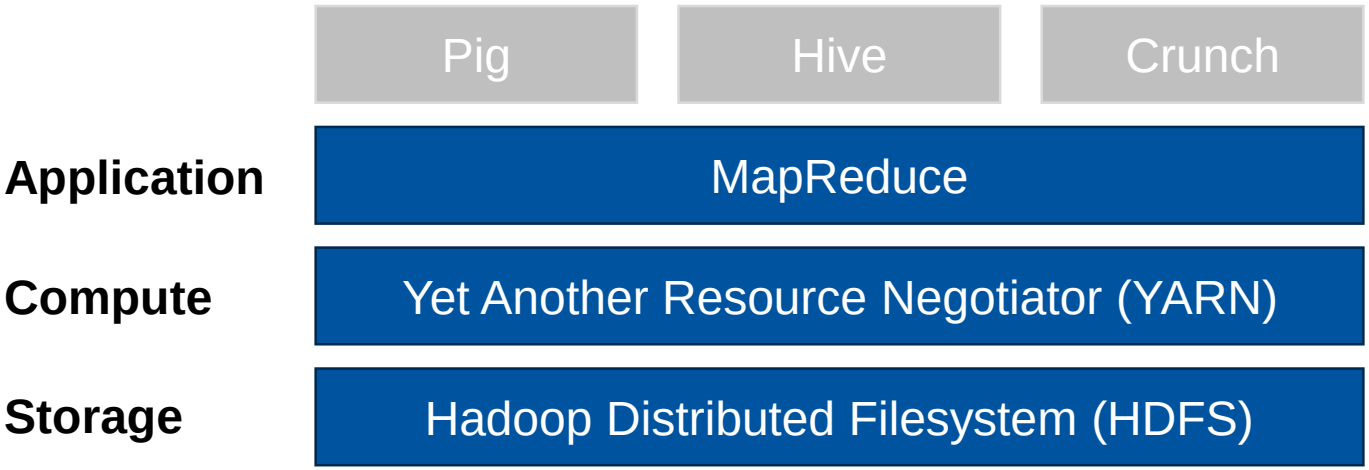
Word Count Example in Hadoop (3)

Job configuration and submission:

```
1  public class WordCount {
2    public static void main(String[] args) throws Exception {
3      Configuration conf = new Configuration();
4      Job job = Job.getInstance(conf, "word count");
5      job.setJarByClass(WordCount.class);
6
7      job.setMapperClass(WordCountMapper.class);
8      job.setReducerClass(WordCountReducer.class);
9
10     job.setOutputKeyClass(Text.class);
11     job.setOutputValueClass(IntWritable.class);
12
13     FileInputFormat.addInputPath(job, new Path(args[0]));
14     FileOutputFormat.setOutputPath(job, new Path(args[1]));
15
16     System.exit(job.waitForCompletion(true) ? 0 : 1);
17   }
18 }
```

Hadoop Ecosystem

- Hadoop: Framework for scalable distributed computing
- Consists of three main components (and extensions)



- Many extensions running on top of these components
  - Pig: High-level language abstraction for MapReduce
  - Hive: Data warehouse system on top of MapReduce, SQL like queries
  - Crunch: Define pipelines of user-defined functions based on MapReduce