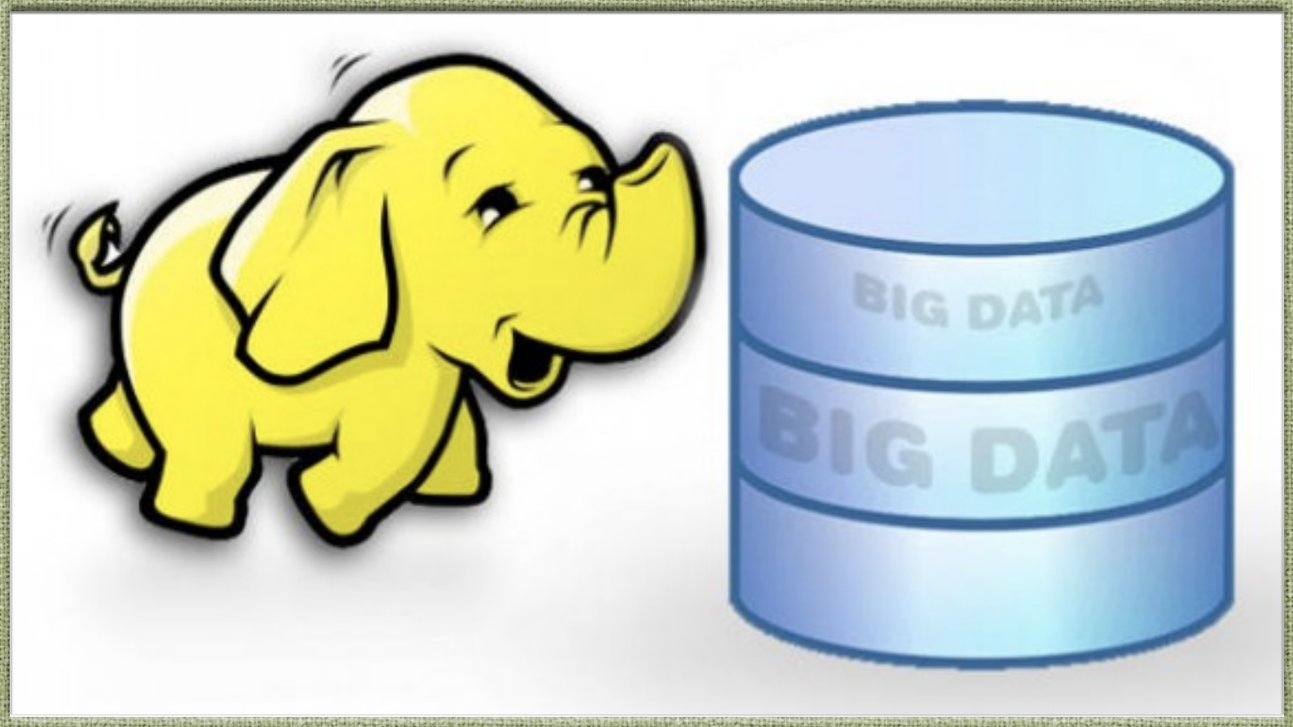
MapReduce

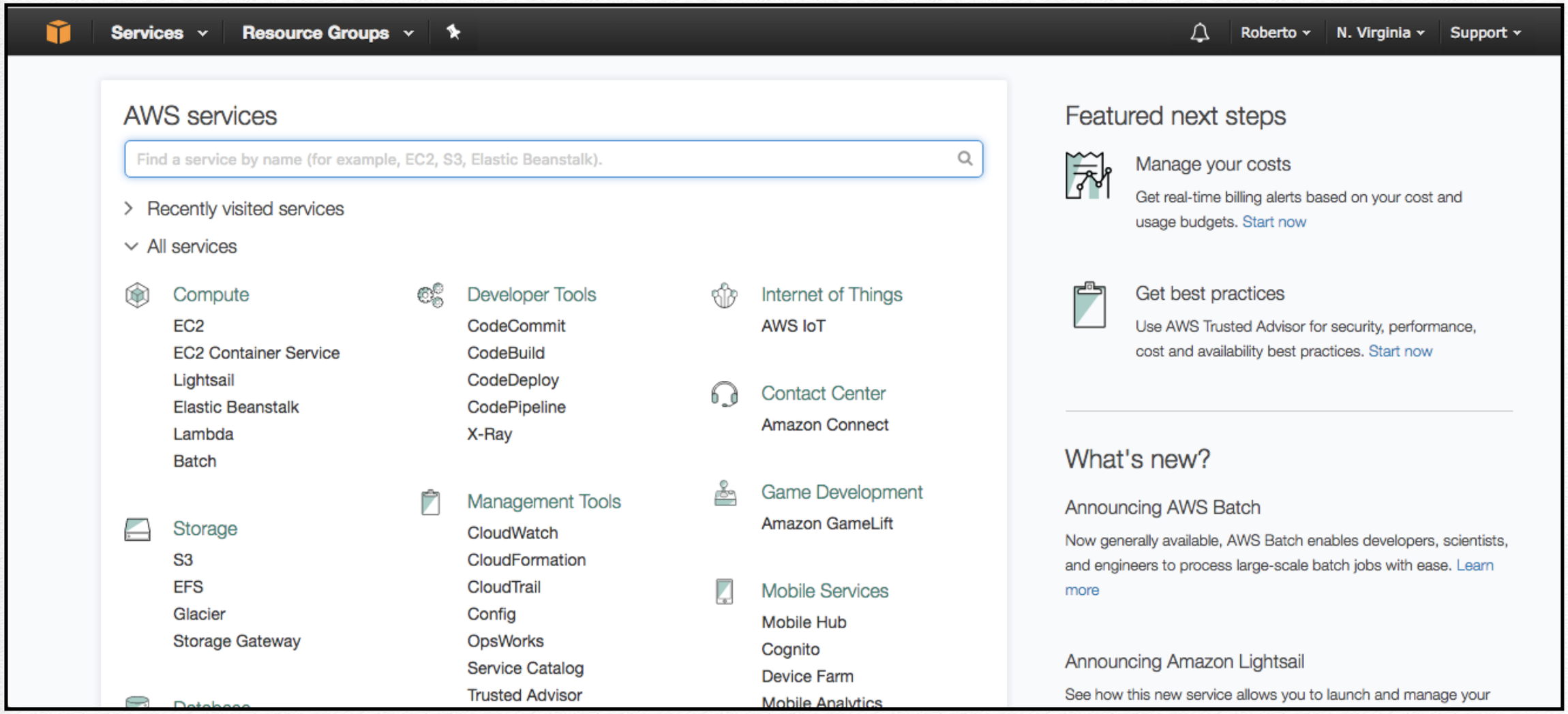


Hadoop 3.X more examples

Big Data - 01/04/2020

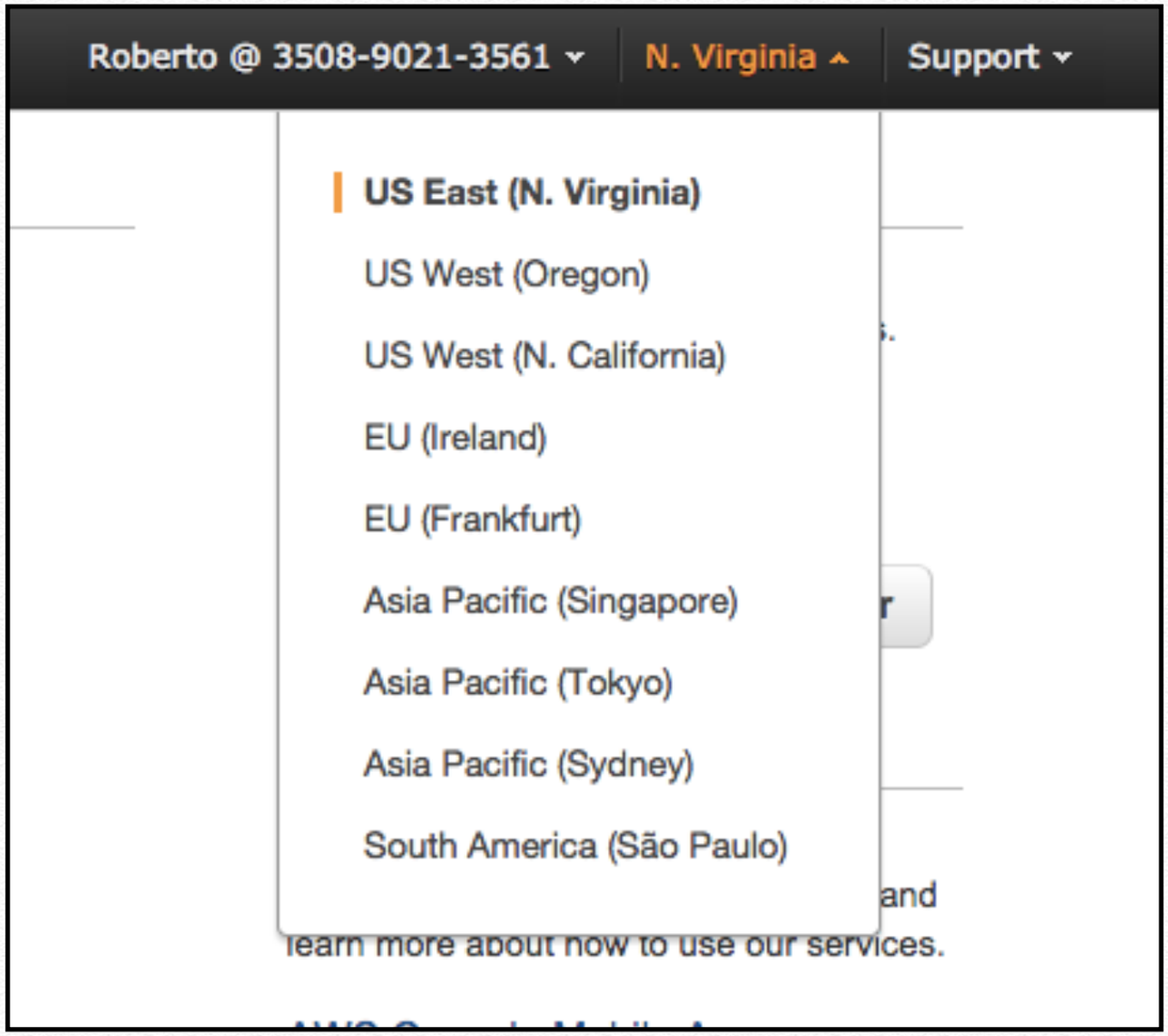
Hadoop 3 on AMAZON

Hadoop 3 on AMAZON



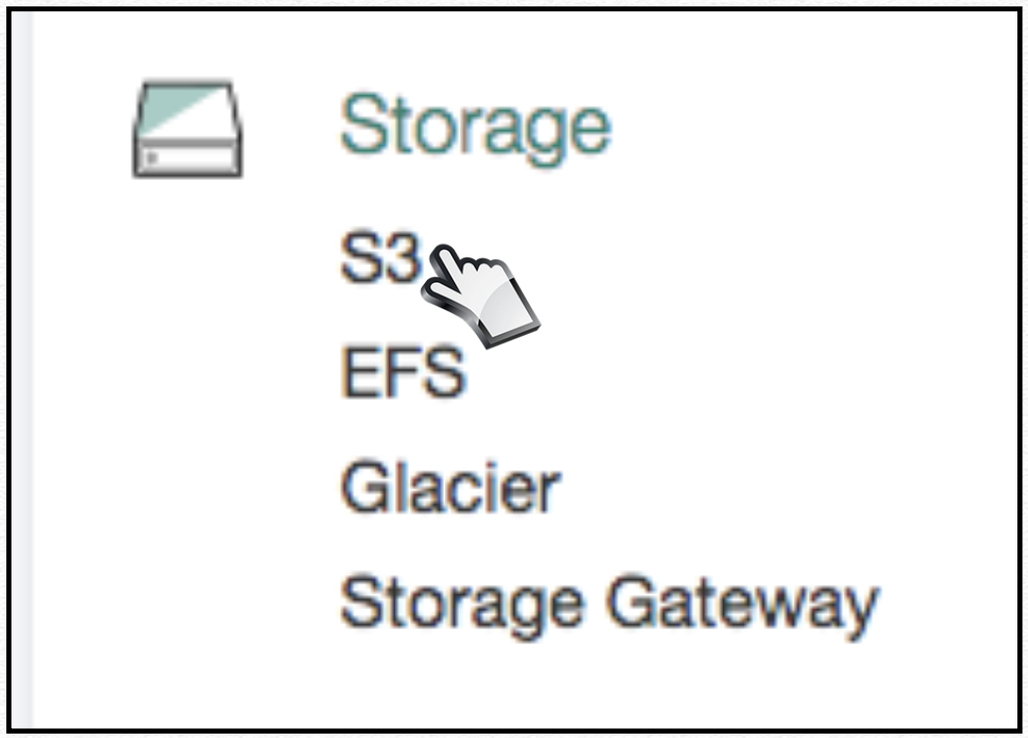
Hadoop 3 on AMAZON

Regions



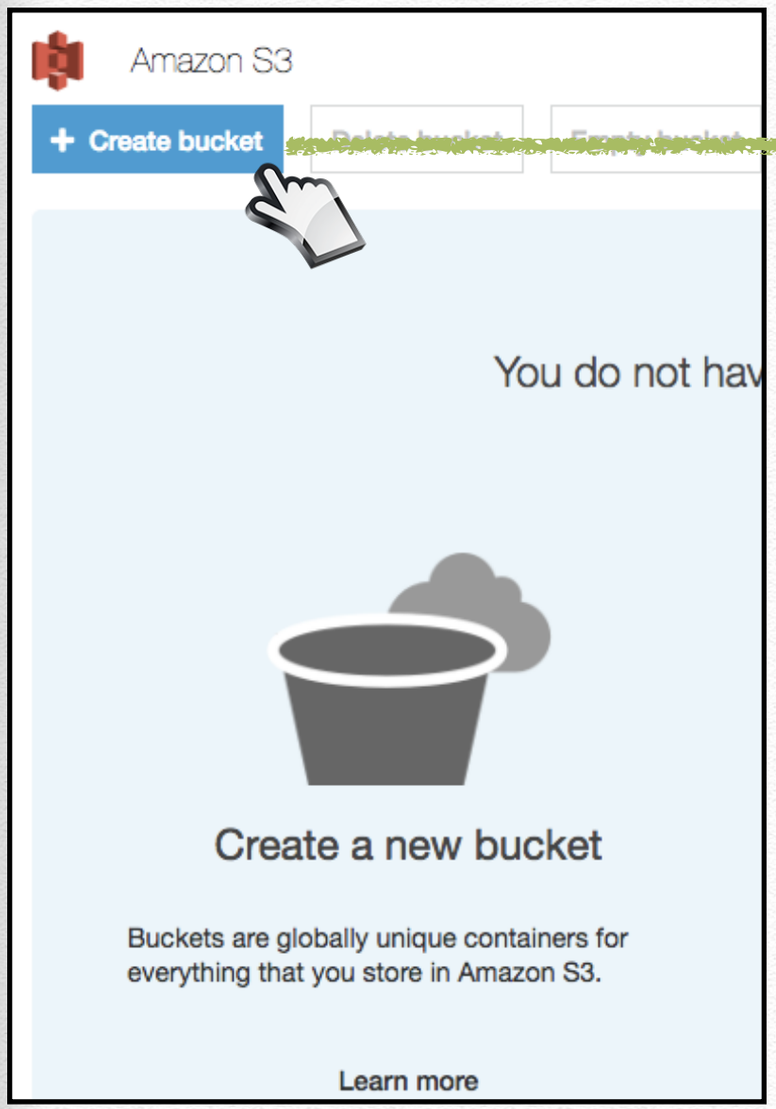
Hadoop 3 on AMAZON

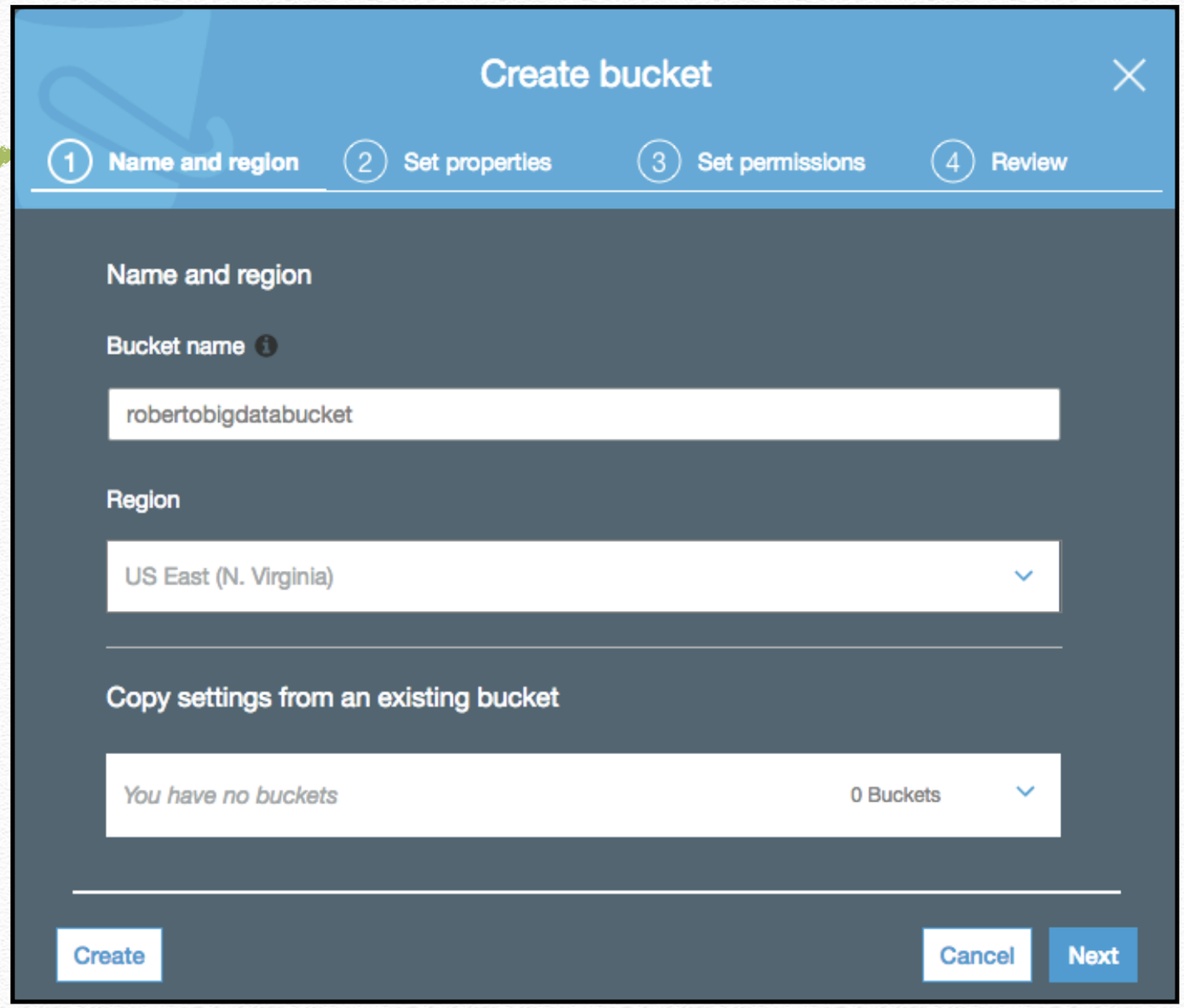
S3 and buckets



Hadoop 3 on AMAZON

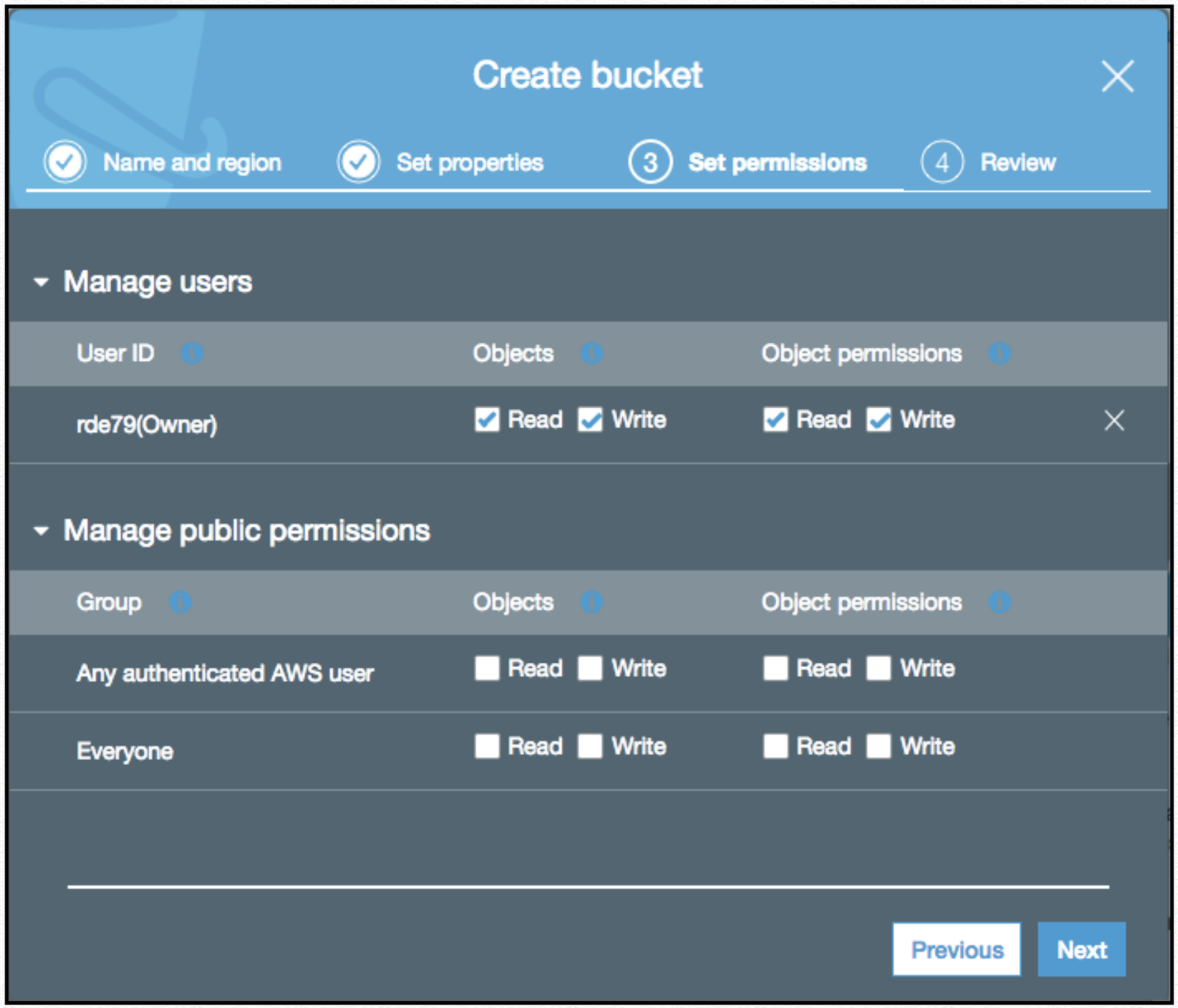
S3 and buckets





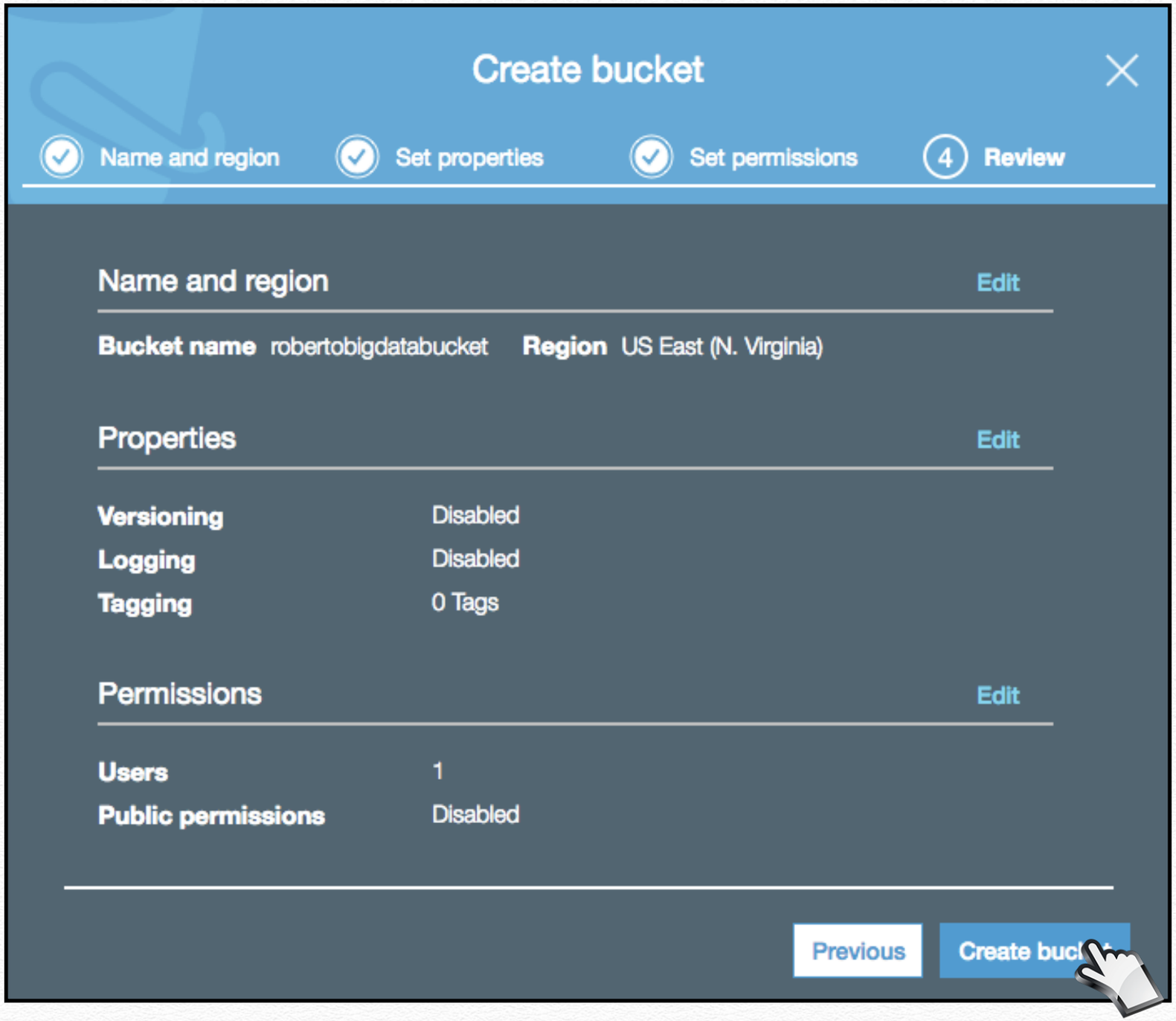
Hadoop 3 on AMAZON

S3 and buckets



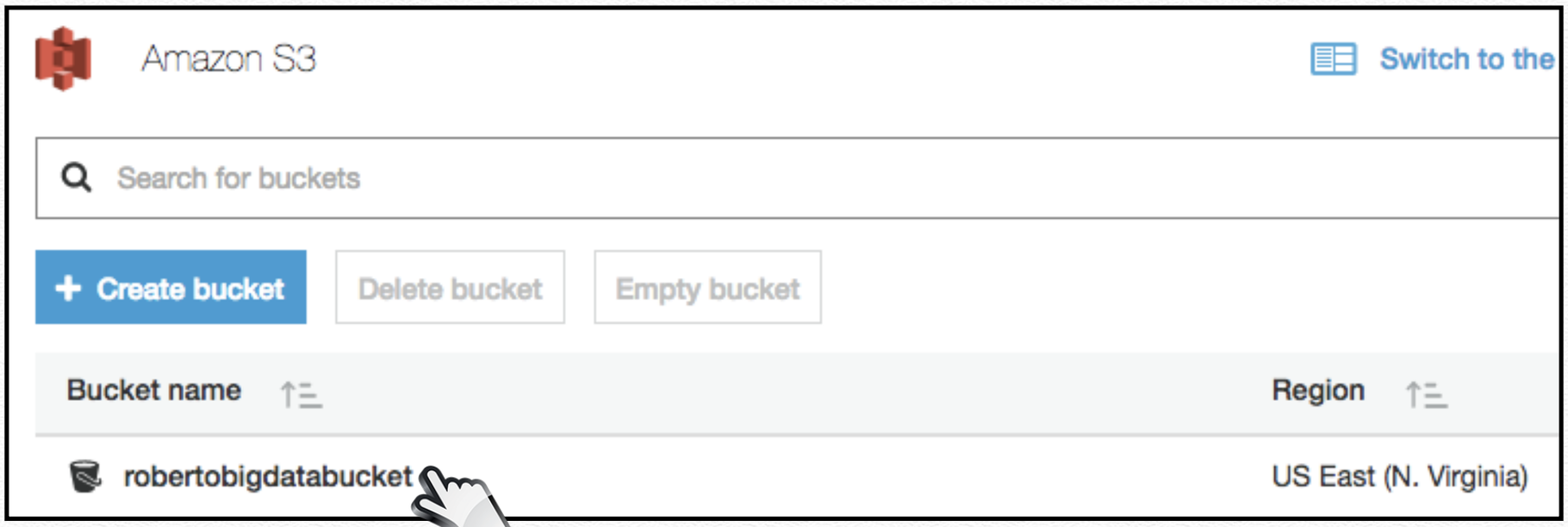
Hadoop 3 on AMAZON

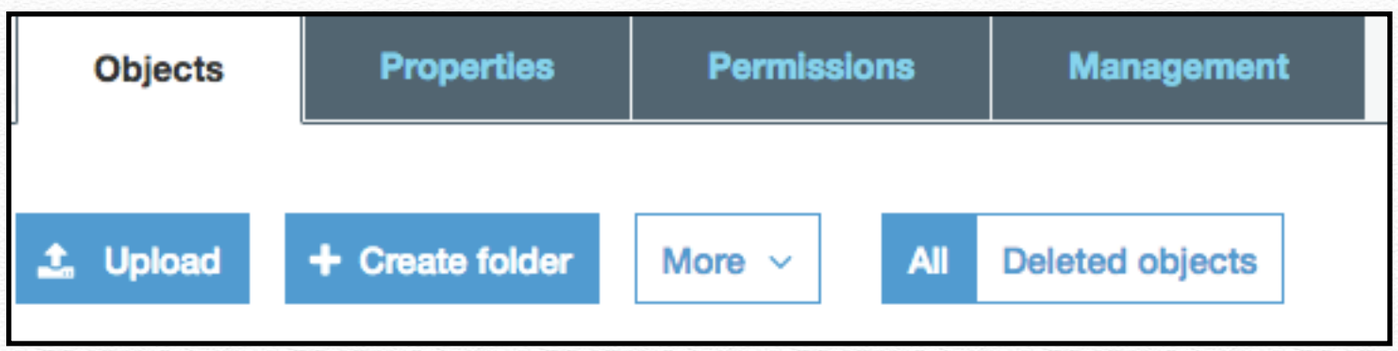
S3 and buckets



Hadoop 3 on AMAZON

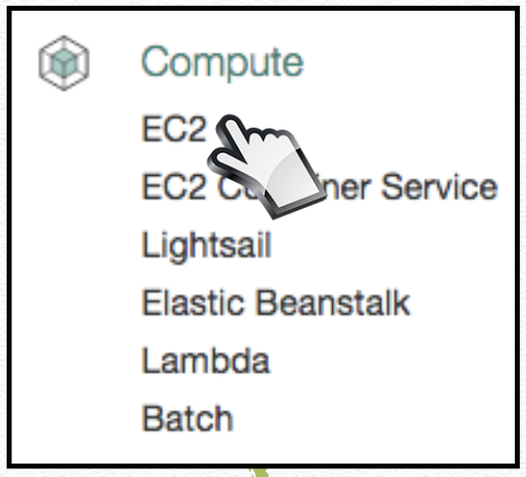
S3 and buckets

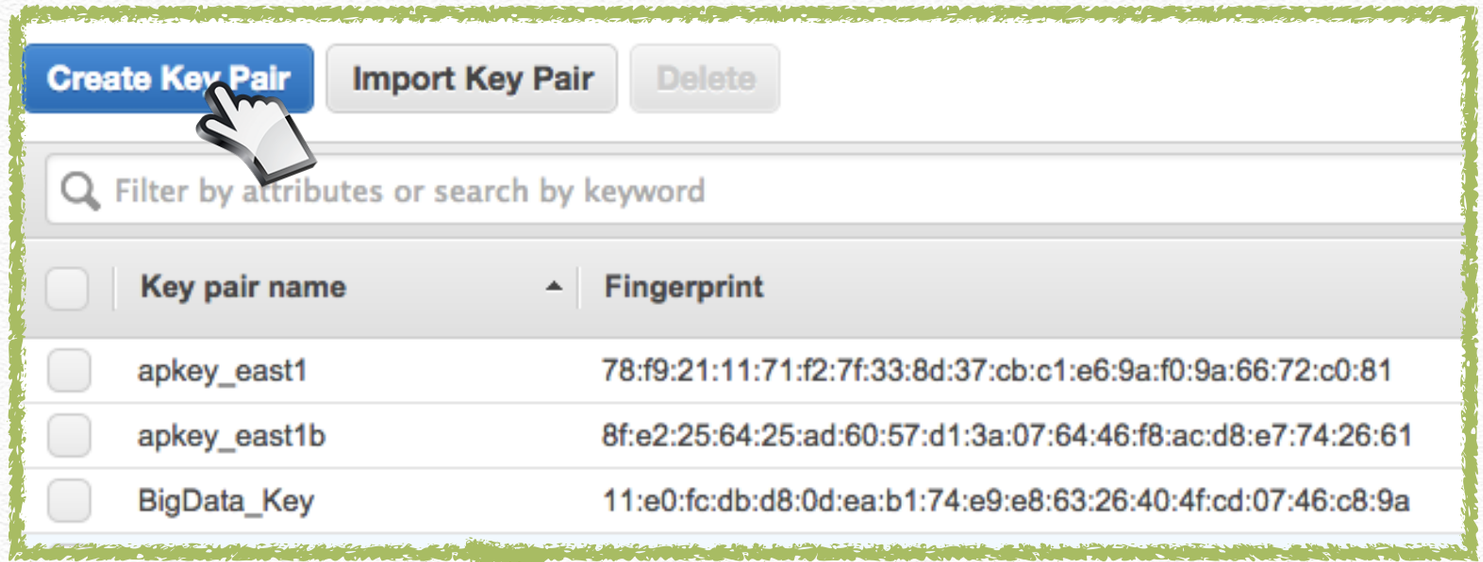


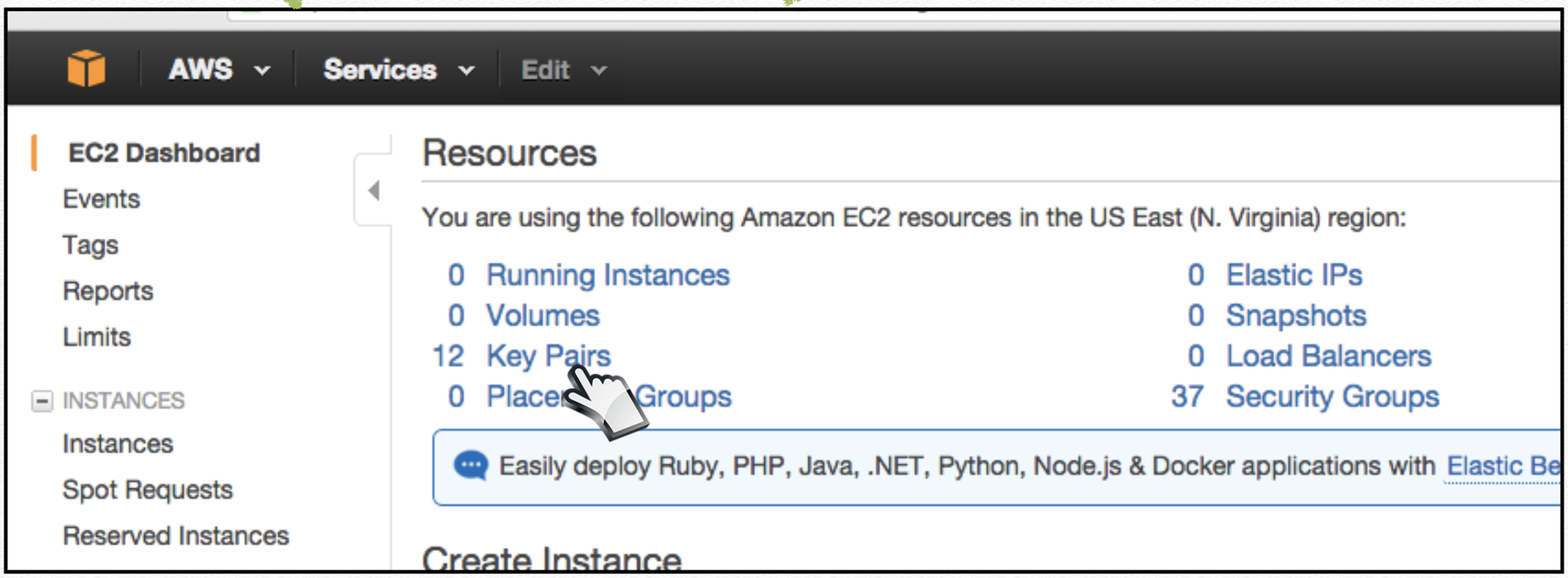


Hadoop 3 on AMAZON

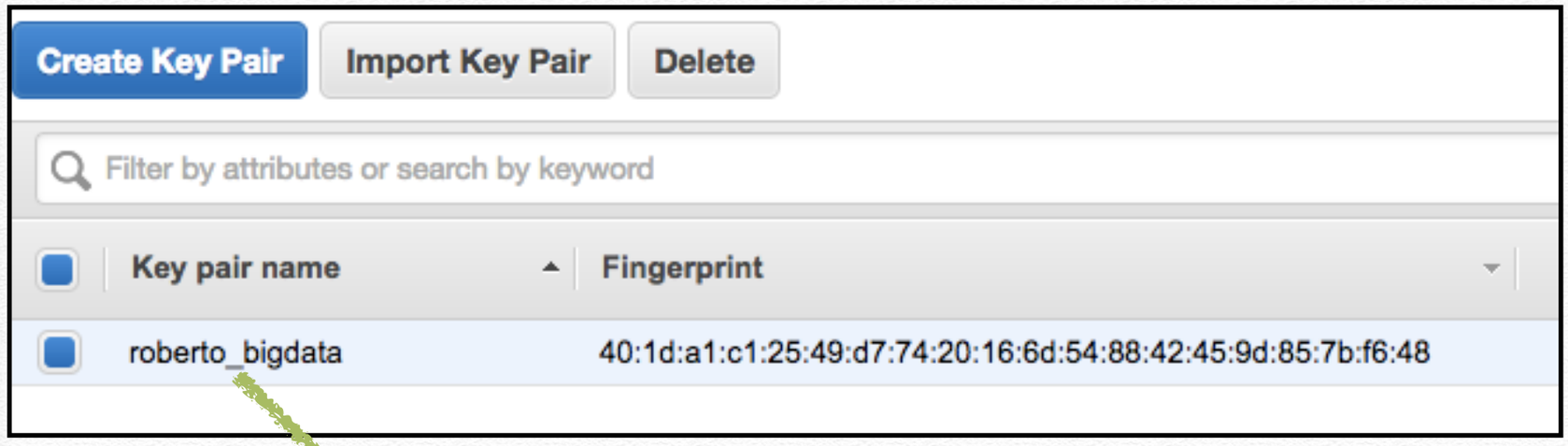
EC2 virtual servers







Hadoop 3 on AMAZON



file .pem


```
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Wltx8fAuMRtoR5ojqp3wo1ZUNzp+0saPPVQ7n6CBWjj3TbzU5w6bR4Ul2kiPomt40rEx
-----END RSA PRIVATE KEY-----
```
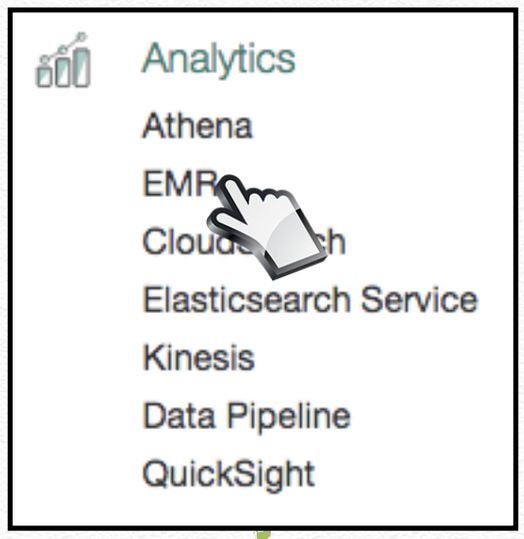
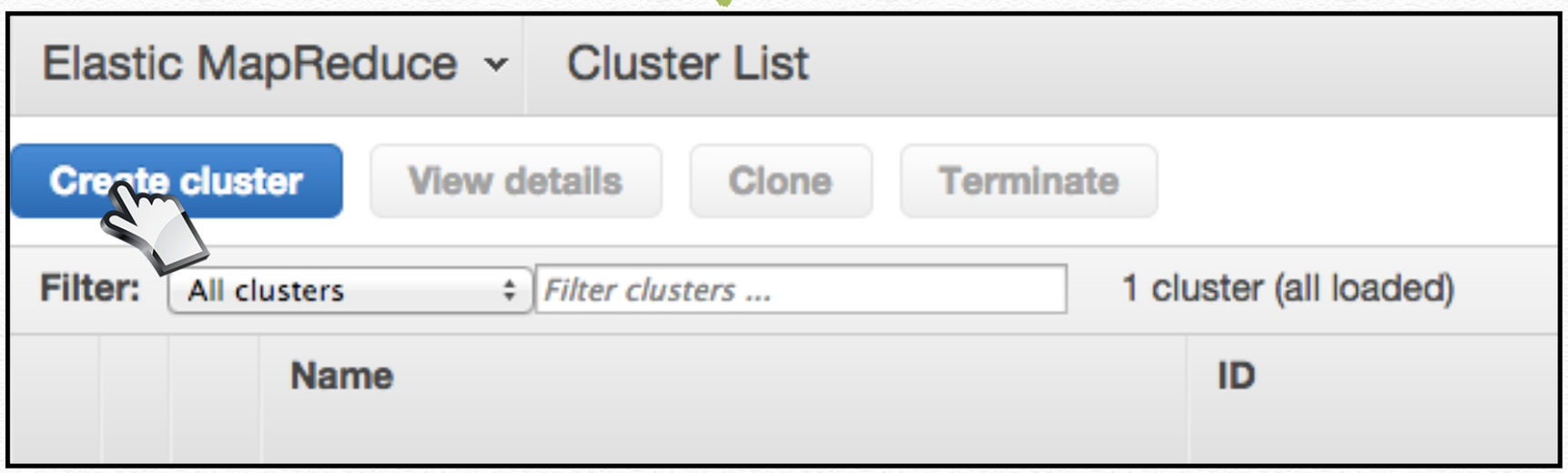

Hadoop 3 on AMAZON

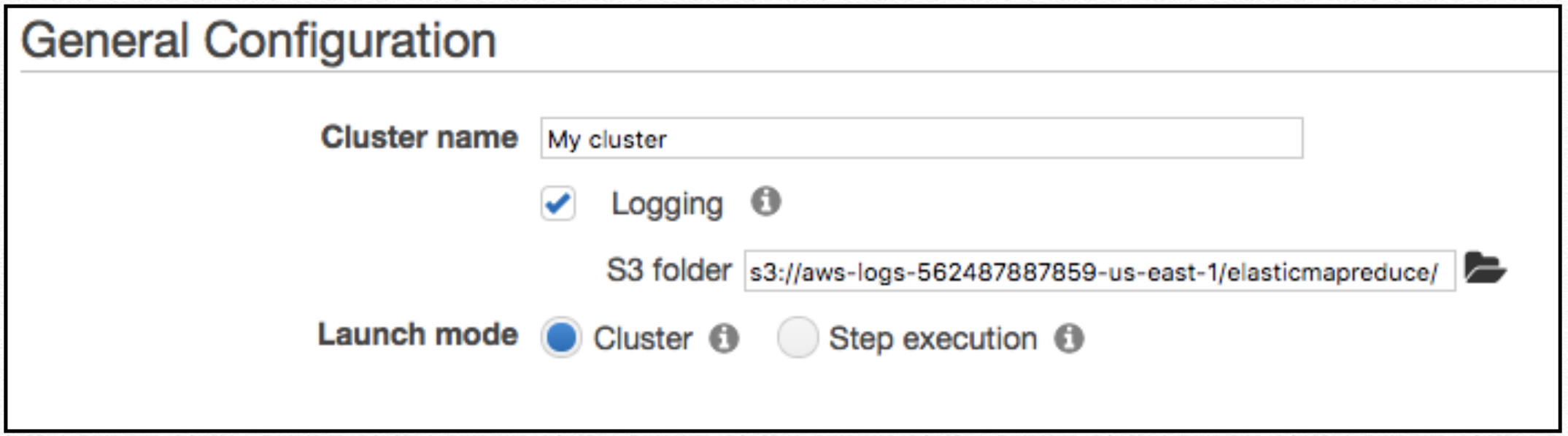
Elastic Map Reduce





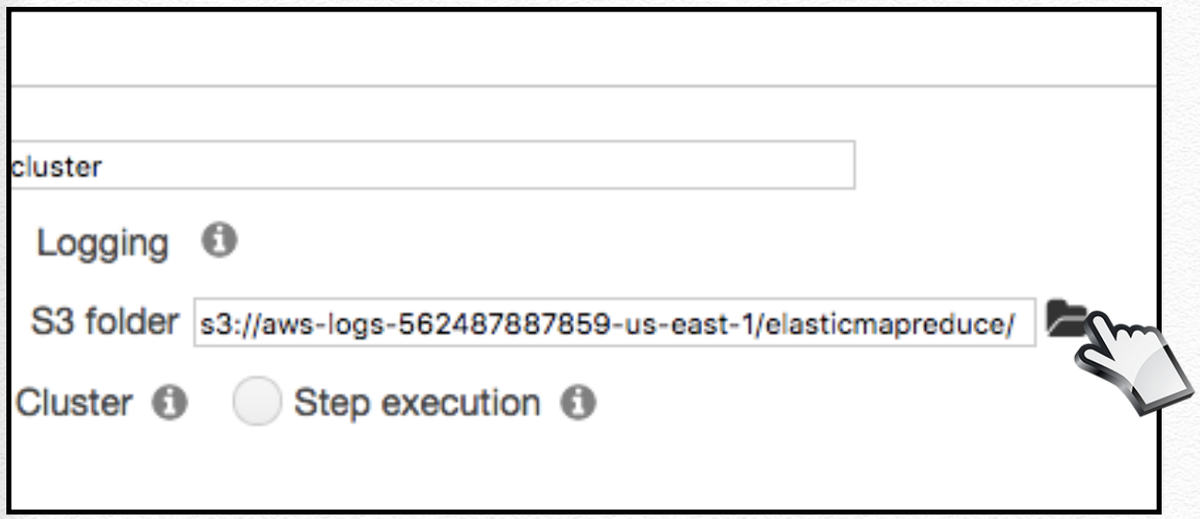
Hadoop 3 on AMAZON

EMR cluster



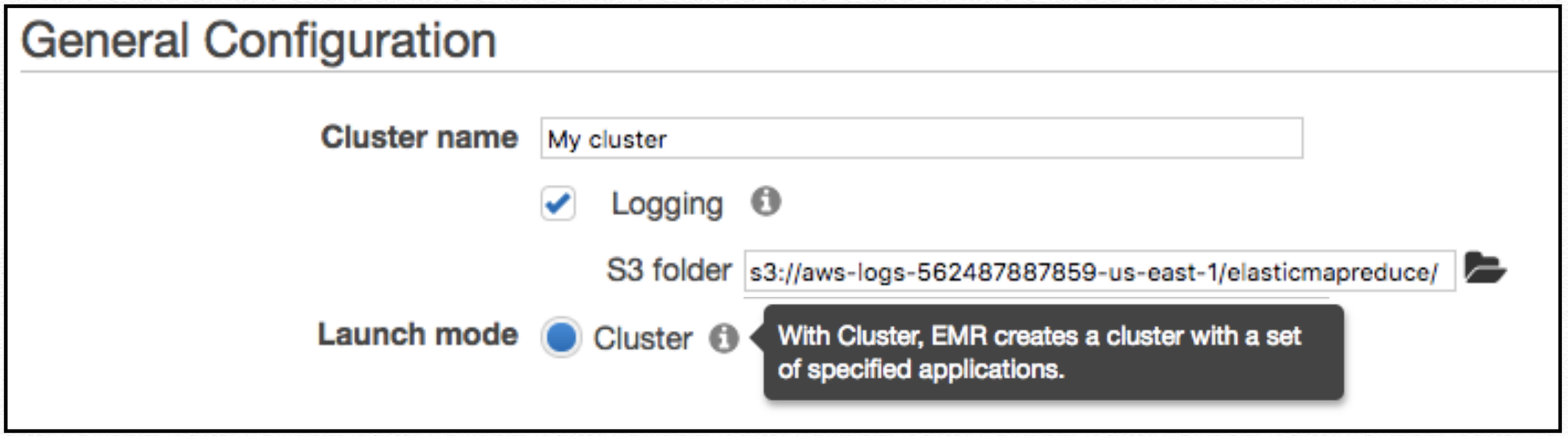
Hadoop 3 on AMAZON

EMR cluster



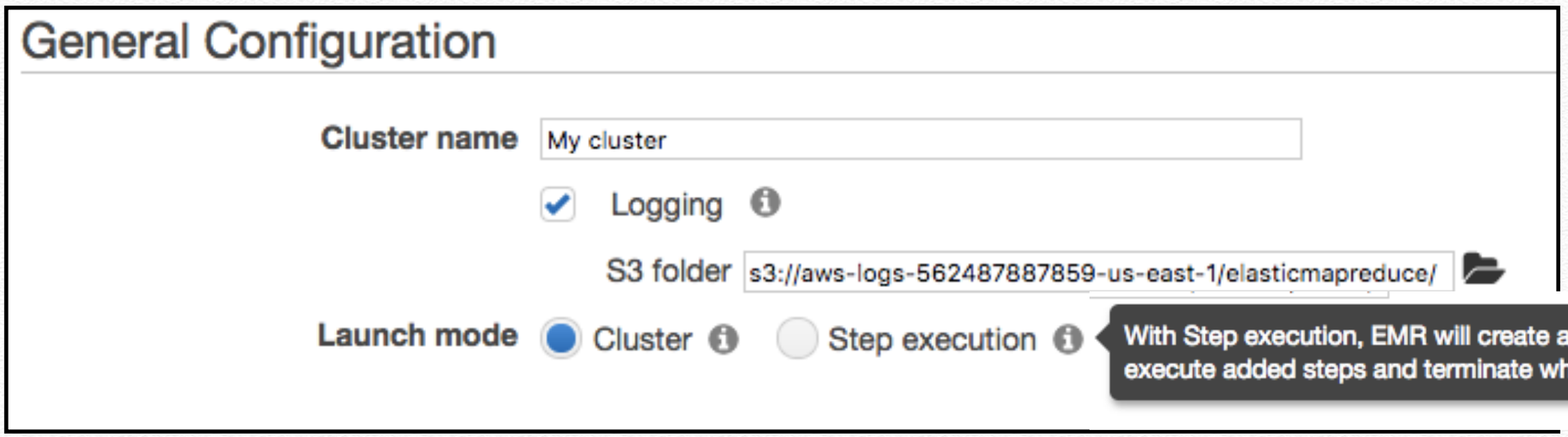
Hadoop 3 on AMAZON

EMR cluster



Hadoop 3 on AMAZON

EMR cluster



Hadoop 3 on AMAZON

EMR cluster

Software configuration

Vendor (●) Amazon ( ) MapR

Release emr-5.4.0 ⓘ

Applications

(●) Core Hadoop: Hadoop 2.7.3 with Ganglia 3.7.2, Hive 2.1.1, Hue 3.11.0, Mahout 0.12.2, Pig 0.16.0, and Tez 0.8.4

( ) HBase: HBase 1.3.0 with Ganglia 3.7.2, Hadoop 2.7.3, Hive 2.1.1, Hue 3.11.0, Phoenix 4.9.0, and ZooKeeper 3.4.9

( ) Presto: Presto 0.166 with Hadoop 2.7.3 HDFS and Hive 2.1.1 Metastore

( ) Spark: Spark 2.1.0 on Hadoop 2.7.3 YARN with Ganglia 3.7.2 and Zeppelin 0.7.0

Hadoop 3 on AMAZON

EMR cluster

Software configuration

Vendor Amazon MapR

Release MapR - M3 - 4.0.2

Applications All applications: Hadoop 2.4.0, Hive 0.13.1, and Pig 0.12.0

http://doc.mapr.com/display/MapR/MapR+Overview

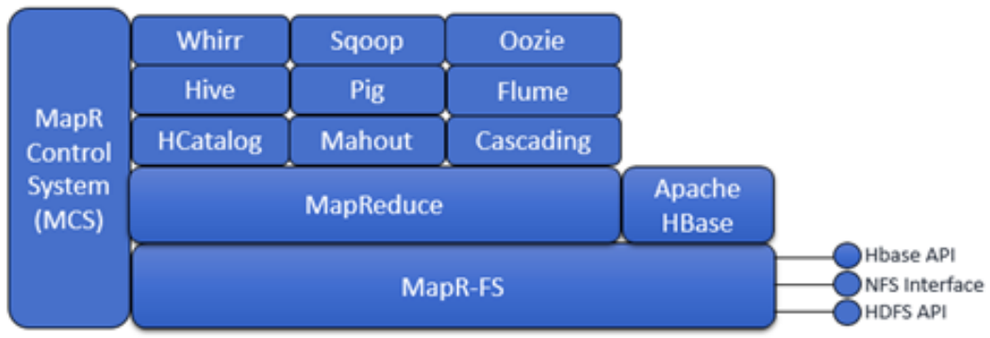
MapR 5.0 Documentation / Home

Tools

MapR Overview

MapR is a complete enterprise-grade distribution for Apache Hadoop. The MapR Distribution for Apache Hadoop has been engineered to improve Hadoop's reliability, performance, and ease of use. The MapR distribution provides a full Hadoop stack that includes the MapR File System (MapR-FS), MapReduce, a complete Hadoop ecosystem, and the MapR Control System user interface. You can use MapR with Apache Hadoop, HDFS, and MapReduce APIs.

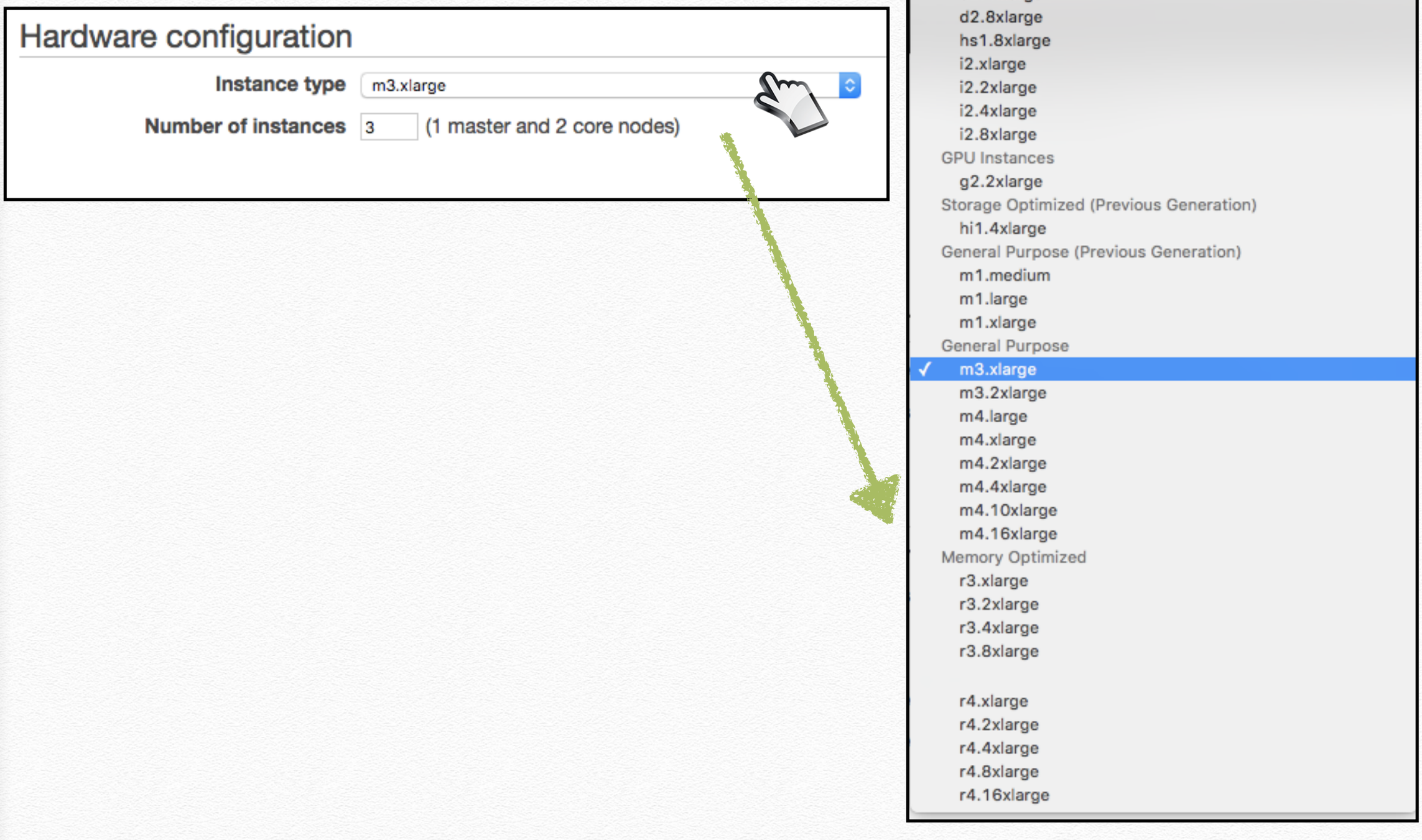
The following image displays a high-level view of the MapR Distribution for Apache Hadoop:



The MapR distribution provides several unique features that address common concerns with Apache Hadoop:

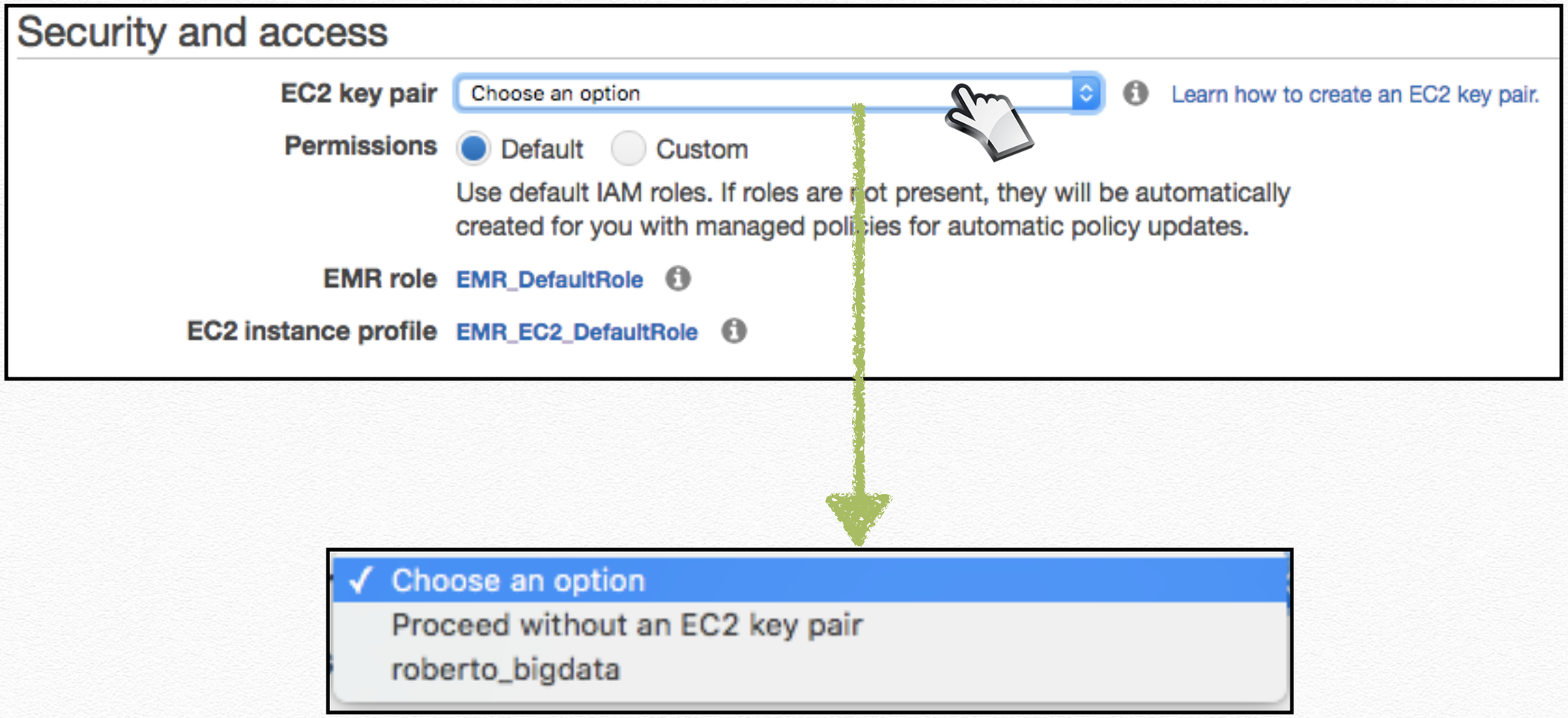
Hadoop 3 on AMAZON

EMR cluster



Hadoop 3 on AMAZON

EMR cluster



Hadoop 3 on AMAZON

EMR cluster

Cluster: My cluster Starting Configuring cluster software

Connections: Enable Web Connection – Hue, Ganglia, Resource Manager … (View All)
Master public DNS: ec2-54-159-62-237.compute-1.amazonaws.com SSH
Tags: -- View All / Edit

Summary

ID: j-47LWBSL8AKPS
Creation date: 2017-04-04 11:55 (UTC+2)
Elapsed time: 2 minutes
Auto-terminate: No
Termination protection: Off Change

Configuration Details

Release label: emr-5.4.0
Hadoop distribution: Amazon 2.7.3
Applications: Ganglia 3.7.2, Hive 2.1.1, Hue 3.11.0, Mahout 0.12.2, Pig 0.16.0, Tez 0.8.4
Log URI: s3://robertobigdatabucket/
EMRFS consistent view: Disabled

Network and Hardware

Availability zone: us-east-1c
Subnet ID: --
Master: Bootstrapping 1 m3.xlarge
Core: Provisioning 2 m3.xlarge
Task: --

Security and Access

Key name: roberto_bigdata
EC2 instance profile: EMR_EC2_DefaultRole
EMR role: EMR_DefaultRole
Visible to all users: All Change
Security groups for Master: sg-98da73f3 (ElasticMapReduce-master)

https://youtu.be/Z1je94H_jSg

- Web video to **configure** AWS cluster

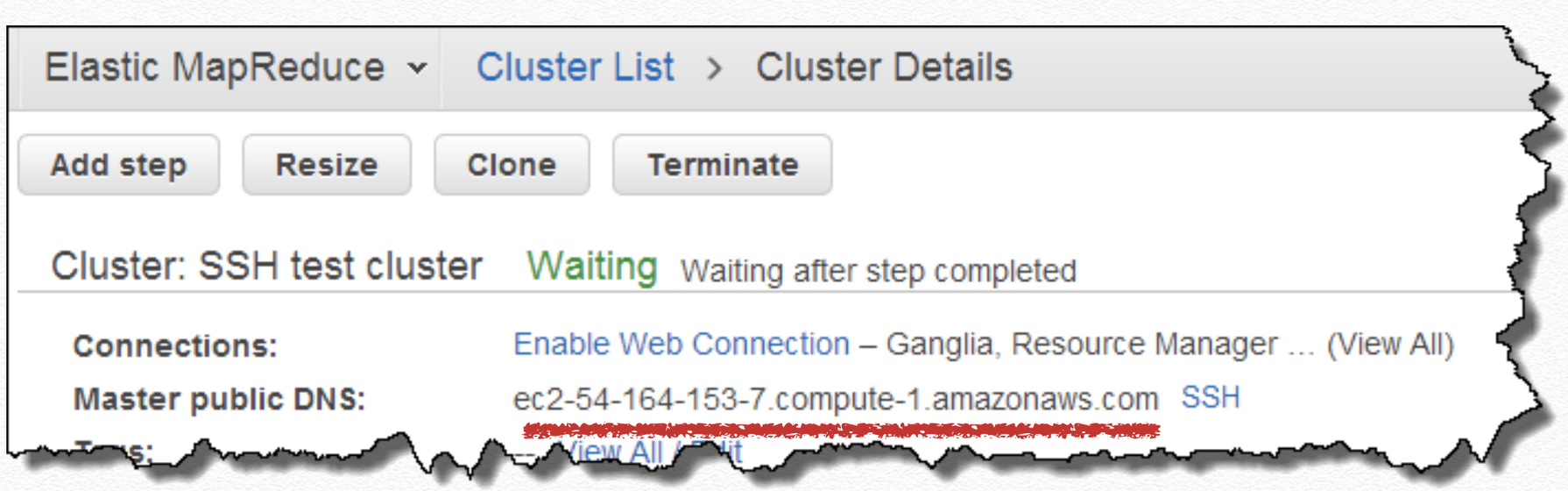
Hadoop 3 Running on AWS

- **Authorization** of the . pem file

```
$:~ chmod 400 roberto_bigdata.pem
```

- **Upload files (data and your personal jars)** on hadoop of EMR cluster:

```
$:~ scp -i <file .pem> <file> hadoop@<DNS_EMR_CLUSTER>:~
```




```
$:~ scp -i roberto_bigdata.pem ./example_data/words.txt
    hadoop@ec2-54-164-153-7.compute-1.amazonaws.com:~
```

```
$:~ scp -i roberto_bigdata.pem ./jar/Ex1-1.jar
    hadoop@ec2-54-164-153-7.compute-1.amazonaws.com:~
```

Hadoop 3 Running on AWS

- **Connection to** hadoop of EMR cluster:

```
$:~ ssh hadoop@<DNS_EMR_CLUSTER> -i <file .pem>
```

```
$:~ ssh hadoop@ec2-54-164-153-7.compute-1.amazonaws.com
    -i roberto_bigdata.pem
```

- Then you can execute MR jobs as in your local machine

Hadoop 3 Running on AWS

- **Execution** hadoop of EMR cluster:

```
[hadoop@ip-172-31-45-32 ~]$ ls
 Ex1-1.jar words.txt

[hadoop@ip-172-31-45-32 ~]$ hdfs dfs -mkdir /input
[hadoop@ip-172-31-45-32 ~]$ hdfs dfs -mkdir /output


[hadoop@ip-172-31-45-32 ~]$ hadoop jar Ex1-1.jar wordcount/WordCount
                                    /input/words.txt /output/results_words
```

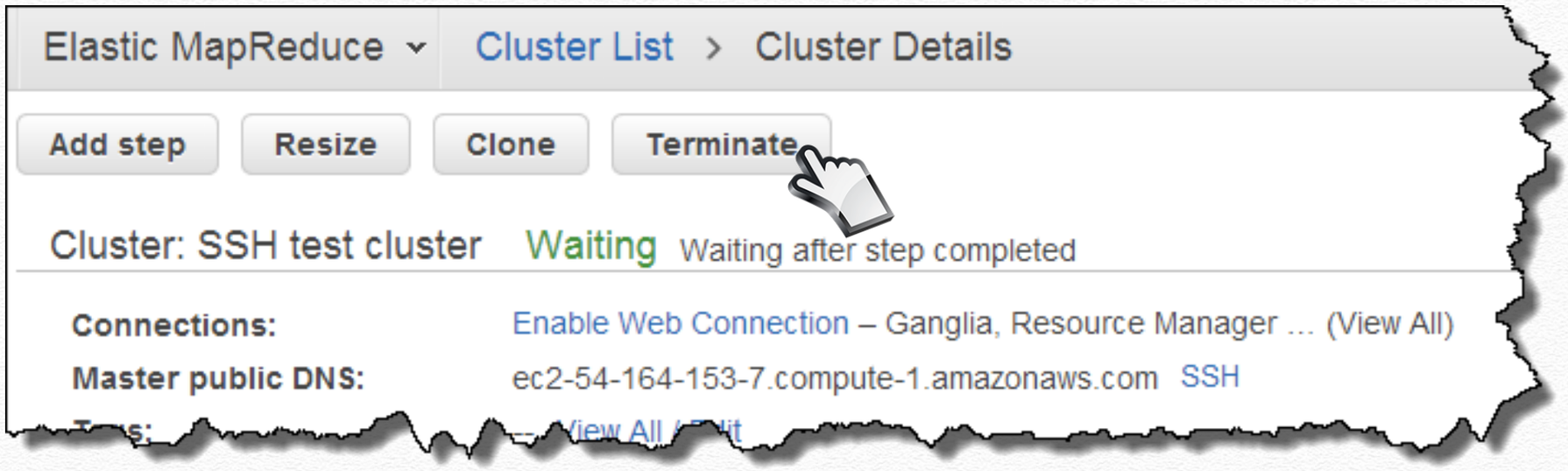
Hadoop 3 Running on AWS

- **View** hadoop execution results of EMR cluster:

```
[hadoop@ip-172-31-45-32 ~]$ hdfs dfs -ls /output/results_words

/output/results_words/_SUCCESS
/output/results_words/part-r-00000
/output/results_words/part-r-00001
/output/results_words/part-r-00002


[hadoop@ip-172-31-45-32 ~]$ hdfs dfs -cat /output/results_words/part-r-00000

panca 2
otto 1
```

Hadoop 3 Running on AWS

- Finally **TERMINATE** your cluster



https://youtu.be/JZD7MjlzwCQ

- Web video to **execute** a **Java** MapReduce job on AWS Cluster

View Web Interfaces Hosted on Amazon EMR Clusters

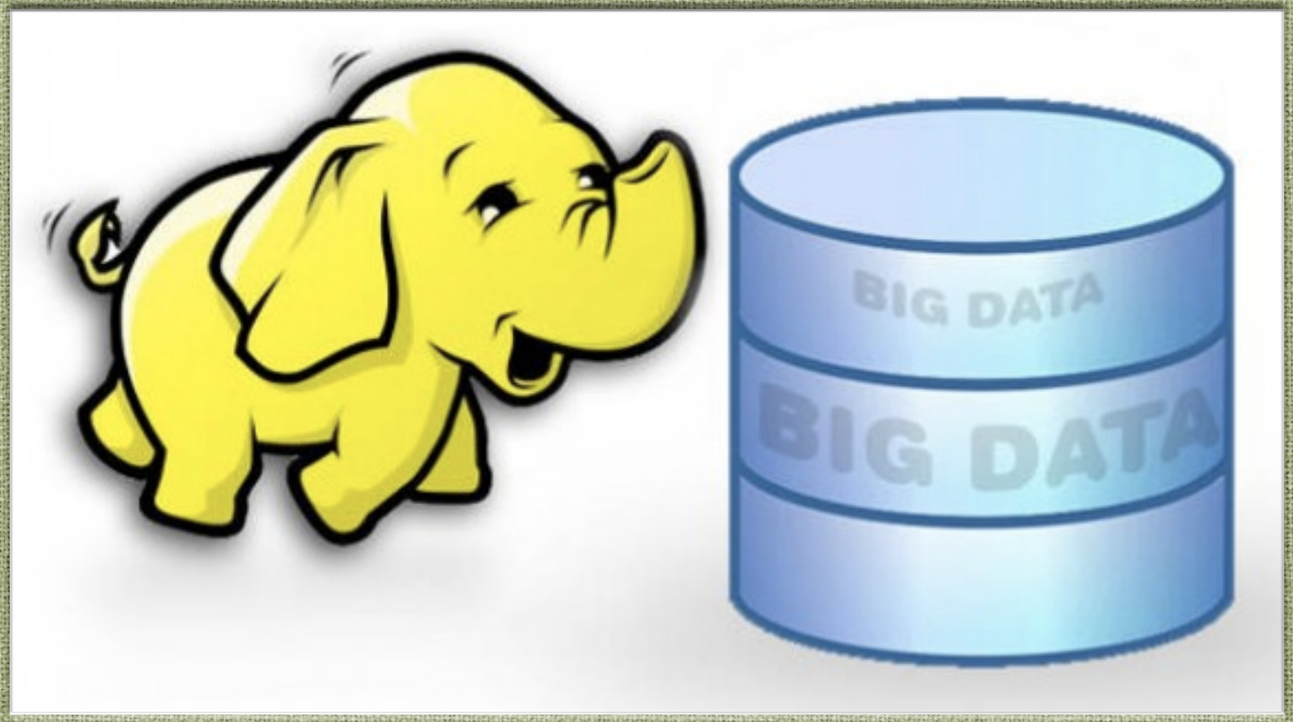
- To access **web interfaces**, you must edit the **security groups** associated with master and core instances so that they have an inbound rule that allows SSH traffic (port 22) from trusted clients, such as your computer's IP address.

- For more information about modifying security group rules, see Adding Rules to a Security Group in the *Amazon EC2 User Guide for Linux Instances*.

View Web Interfaces Hosted on Amazon EMR Clusters

Name of interface	URI
Ganglia	http://*master-public-dns-name*/ganglia/
Hadoop HDFS NameNode	https://*master-public-dns-name*:50470/
Hadoop HDFS DataNode	https://*coretask-public-dns-name*:50475/
HBase	http://*master-public-dns-name*:16010/
Hue	http://*master-public-dns-name*:8888/
JupyterHub	https://*master-public-dns-name*:9443/
Livy	http://*master-public-dns-name*:8998/
Spark HistoryServer	http://*master-public-dns-name*:18080/
Tez	http://*master-public-dns-name*:8080/tez-ui
YARN NodeManager	http://*coretask-public-dns-name*:8042/
YARN ResourceManager	http://*master-public-dns-name*:8088/
Zeppelin	http://*master-public-dns-name*:8890/

MapReduce



Let's start with some examples!

Example: LastFM Listeners per Track

Consider the following log file

```
UserId|TrackId|Shared|Radio|Skip
111115|222|0|1|0
111113|225|1|0|0
111117|223|0|1|1
111115|225|1|0|0
```

- Number of unique listeners
- Number of times the track was shared with others
- Number of times the track was listened to on the radio
- Number of times the track was listened to in total
- Number of times the track was skipped on the radio

taken from XYZ.com that is an online music website where users listen to various tracks

Example: LastFM Listeners per Track

Write a MapReduce code to find out unique listeners per track

```
111115|222|0|1|0
111113|225|1|0|0
111117|223|0|1|1
111115|225|1|0|0
```

```
222   1
223   1
225   2
```

Example: LastFM Listeners per Track

To make it simple to remember the data sequence, let's create a constants class as shown below

```
public class LastFMConstants {

    public static final int USER_ID = 0;
    public static final int TRACK_ID = 1;
    public static final int IS_SHARED = 2;
    public static final int RADIO = 3;
    public static final int IS_SKIPPED = 4;

}
```

Example: LastFM Listeners per Track

lets create the mapper class which would emit intermediate

key value pairs as (TrackId, UserId) as shown below

```
public static class UniqueListenersMapper extends
Mapper< Object , Text, IntWritable, IntWritable > {
        IntWritable trackId = new IntWritable();
        IntWritable userId = new IntWritable();

public void map(Object key, Text value,
    Mapper< Object , Text, IntWritable, IntWritable > .Context context)
        throws IOException, InterruptedException {

    String[] parts = value.toString().split("[|]");
    trackId.set(Integer.parseInt(parts[LastFMConstants.TRACK_ID]));
    userId.set(Integer.parseInt(parts[LastFMConstants.USER_ID]));
        if (parts.length == 5) {
        context.write(trackId, userId);
    } else {
        // add counter for invalid records
        context.getCounter(COUNTERS.INVALID_RECORD_COUNT).increment(1L);
    }
    }
}
```

Example: LastFM Listeners per Track

You would have also noticed that we are using a counter here named **INVALID_RECORD_COUNT**, to count if there are any invalid records which are not coming the expected format. Remember, if we don't do this then in case of invalid records, our program might fail.

Example: LastFM Listeners per Track

let's write a Reducer class to aggregate the results.

```
public static class UniqueListenersReducer extends
    Reducer< IntWritable , IntWritable, IntWritable, IntWritable> {
    public void reduce(IntWritable trackId, Iterable< IntWritable > userIds,
      Reducer< IntWritable , IntWritable, IntWritable, IntWritable>.Context
context) throws IOException, InterruptedException {

        Set< Integer > userIdSet = new HashSet< Integer >();
        for (IntWritable userId : userIds) {
        userIdSet.add(userId.get());
        }
        IntWritable size = new IntWritable(userIdSet.size());
        context.write(trackId, size);

    }
}
```

Example: LastFM Listeners per Track

Now we can take look at the Driver class

```
public static void main(String[] args) throws Exception {
        Configuration conf = new Configuration();
        if (args.length != 2) {
            System.err.println("Usage: uniquelisteners < in > < out >");
            System.exit(2);
        }
        Job job = new Job(conf, "Unique listeners per track");
        job.setJarByClass(UniqueListeners.class);
        job.setMapperClass(UniqueListenersMapper.class);
        job.setReducerClass(UniqueListenersReducer.class);
        job.setOutputKeyClass(IntWritable.class);
        job.setOutputValueClass(IntWritable.class);
        FileInputFormat.addInputPath(job, new Path(args[0]));
        FileOutputFormat.setOutputPath(job, new Path(args[1]));
        System.exit(job.waitForCompletion(true) ? 0 : 1);
        org.apache.hadoop.mapreduce.Counters counters = job.getCounters();
        System.out.println("No. of Invalid Records :"
                + counters.findCounter(COUNTERS.INVALID_RECORD_COUNT)
                        .getValue());
}
```

Example: Call Data Record (CDR) Analytics

Consider the following log file

```
FromPhoneNumber|ToPhoneNumber|CallStartTime|CallEndTime|STDFlag
9665128505|8983006310|2015-03-01 09:08:10|2015-03-01 10:12:15|1
9665128505|8983006310|2015-03-01 07:08:10|2015-03-01 08:12:15|0
9665128505|8983006310|2015-03-01 09:08:10|2015-03-01 09:12:15|1
9665128505|8983006310|2015-03-01 09:08:10|2015-03-01 10:12:15|0
9665128506|8983006310|2015-03-01 09:08:10|2015-03-01 10:12:15|1
9665128507|8983006310|2015-03-01 09:08:10|2015-03-01 10:12:15|1
```

taken a Telecom company keeping records for its subscribers in specific format.

Example: Call Data Record (CDR) Analytics

- Now we have to write a map reduce code to find out all phone numbers who are making more than 60 mins of STD calls.
- Here if STD Flag is 1 that means it was as STD Call. STD is call which is made outside of your state or long distance calls.
- By identifying such subscribers, telecom company wants to offer them STD(Long Distance) Pack which would efficient for them instead spending more money without that package.

FromPhoneNumber	duration
9665128505	68
9665128506	64
9665128507	64

Example: Call Data Record (CDR) Analytics

To make it simple to remember the data sequence, let's create a constants class as shown below

```
public class CDRConstants {

    public static int fromPhoneNumber = 0;
    public static int toPhoneNumber = 1;
    public static int callStartTime = 2;
    public static int callEndTime = 3;
    public static int STDFlag = 4;

}
```

Example: Call Data Record (CDR) Analytics

lets create the mapper class which would emit intermediate key value pairs as (FromPhoneNumber, Duration), here we would also need to use our Java skills to calculate duration (CallEndTime - CallStartTime). We are also making some manipulations to get duration in minutes

```
public static class TokenizerMapper extends
            Mapper< Object , Text, Text, LongWritable> {

        Text phoneNumber = new Text();
        LongWritable durationInMinutes = new LongWritable();

        public void map(Object key, Text value,
                Mapper< Object , Text, Text, LongWritable>.Context context)
                throws IOException, InterruptedException {
            String[] parts = value.toString().split("[|]");
            if (parts[CDRConstants.STDFlag].equalsIgnoreCase("1")) {

                phoneNumber.set(parts[CDRConstants.fromPhoneNumber]);
                String callEndTime = parts[CDRConstants.callEndTime];
                String callStartTime = parts[CDRConstants.callStartTime];
                long duration = toMillis(callEndTime) - toMillis(callStartTime);
                durationInMinutes.set(duration / (1000 * 60));
                context.write(phoneNumber, durationInMinutes);
            }
        }

        private long toMillis(String date) { …. }
    }
```

Example: Call Data Record (CDR) Analytics

lets create the mapper class which would emit intermediate key value pairs as (FromPhoneNumber, Duration), here we would also need to use our Java skills to calculate duration (CallEndTime - CallStartTime). We are also making some manipulations to get duration in minutes

```
public static class TokenizerMapper extends
            Mapper< Object , Text, Text, LongWritable> {

      …
    …
    private long toMillis(String date) {

          SimpleDateFormat format = new SimpleDateFormat(
                  "yyyy-MM-dd HH:mm:ss");
          Date dateFrm = null;
          try {
              dateFrm = format.parse(date);

          } catch (ParseException e) {

              e.printStackTrace();
          }
          return dateFrm.getTime();
      }
  }
```

Example: Call Data Record (CDR) Analytics

Now that we have already done majority of things in Mapper Class itself, here a reduce would be a simple Sum Reducer. Here is how the code would look like

```
public static class SumReducer extends
            Reducer< Text , LongWritable, Text, LongWritable> {
        private LongWritable result = new LongWritable();

        public void reduce(Text key, Iterable< LongWritable> values,
                Reducer< Text , LongWritable, Text, LongWritable>.Context context)
                throws IOException, InterruptedException {
            long sum = 0;
            for (LongWritable val : values) {
                sum += val.get();
            }
            this.result.set(sum);
            if (sum >= 60) {
                context.write(key, this.result);
            }

        }
    }
```

Example: topN

We want to find the top-20 used words of a text file.

Input Data:

The text of the book "Flatland" By E. Abbott.

The Project Gutenberg EBook of Flatland: A Romance of Many Dimensions (Illustrated), by Edwin A. Abbot
This eBook is for the use of anyone anywhere at no cost and with almost no restrictions whatsoever. You may copy it, give it away or re-use it under the terms of the Project Gutenberg License included with this eBook or online at www.gutenberg.net
Title: Flatland: A Romance of Many Dimensions (Illustrated)
Author: Edwin A. Abbot
Release Date: March 10, 2008 [EBook #201]
Language: English
**** START OF THIS PROJECT GUTENBERG EBOOK FLATLAND ****

Example: topN

- Now we have to write a map reduce code to find out the top-20 used word.

word	occurrences
the	2286
of	1634
and	1098
to	1088
a	936
i	735
in	713
that	499
is	429
you	419
my	334
it	330
as	322
by	317
not	317
or	299
but	279
. . .	

Example: topN

lets create the mapper class which would emit intermediate key value pairs as (word, 1).

```
public static class TopNMapper extends Mapper<Object, Text, Text, IntWritable> {

        private final static IntWritable one = new IntWritable(1);
        private Text word = new Text();
        private String tokens = "[_|$#<>\\^=\\[\\]\\*/\\\\,;,.\\-:()?!\"']";

        @Override
        public void map(Object key, Text value, Context context) throws
                                IOException, InterruptedException {
            String cleanLine =
                        value.toString().toLowerCase().replaceAll(tokens, " ");
            StringTokenizer itr = new StringTokenizer(cleanLine);
            while (itr.hasMoreTokens()) {
                word.set(itr.nextToken().trim());
                context.write(word, one);
            }
        }
    }
```

Example: topN

lets create the reducer that retrieves every word and puts it into a Map: if the word already exists in the map, increments its value, otherwise sets it to 1.

```
public static class TopNReducer extends Reducer<Text, IntWritable, Text, IntWritable> {

        private Map<Text, IntWritable> countMap = new HashMap<Text, IntWritable>();

        @Override
        public void reduce(Text key, Iterable<IntWritable> values, Context context) throws
                                        IOException, InterruptedException {

            // computes the number of occurrences of a single word
            int sum = 0;
            for (IntWritable val : values) {
                sum += val.get();
            }

            countMap.put(new Text(key), new IntWritable(sum));
        }

        @Override
        protected void cleanup(Context context) throws IOException, InterruptedException {
            …
        }
}
```

Example: topN

lets create the reducer that retrieves every word and puts it into a Map: if the word already exists in the map, increments its value, otherwise sets it to 1.

```
@Override
protected void cleanup(Context context) throws IOException, InterruptedException {

    Map<Text, IntWritable> sortedMap = sortByValues(countMap);

    int counter = 0;
    for (Text key : sortedMap.keySet()) {
        if (counter++ == 20) {
            break;
        }
        context.write(key, sortedMap.get(key));
    }
}
```

Example: Mean

We want to find the mean max temperature for every month.

Input Data:

```
DDMMYYYY, MIN, MAX

01012000, -4.0, 5.0

02012000, -5.0, 5.1

03012000, -5.0, 7.7

...

29122013,  3.0, 9.0

30122013,  0.0, 9.8

31122013,  0.0, 9.0
```

Example: Mean

- Now we have to write a map reduce code to find out the mean max temperature for every month.

MMYYYY	AVG
022012	7.230769230769231
022013	7.2
022010	7.851851851851852
022011	9.785714285714286
032013	10.741935483870968
032010	13.133333333333333
032012	18.548387096774192
032011	13.741935483870968
. . .	

Example: Mean

lets create the mapper class which would emit intermediate key value pairs as (month, list of max temperatures).

```
 public static class MeanMapper extends Mapper<Object, Text, Text, SumCount> {

        private final int DATE = 0;
        private final int MIN = 1;
        private final int MAX = 2;

        private Map<Text, List<Double>> maxMap = new HashMap<Text, List<Double>>();

        @Override
        public void map(Object key, Text value, Context context)
                                    throws IOException, InterruptedException {

            // gets the fields of the CSV line
            String[] values = value.toString().split((","));

            // defensive check
            if (values.length != 3) {
                return;
            }

            // gets date and max temperature
            String date = values[DATE];
            Text month = new Text(date.substring(2));
            Double max = Double.parseDouble(values[MAX]);
```

Example: Mean

lets create the mapper class which would emit intermediate key value pairs as (month, list of max temperatures).

```
            // if not present, put this month into the map
            if (!maxMap.containsKey(month)) {
                maxMap.put(month, new ArrayList<Double>());
            }

            // adds the max temperature for this day to the list of temperatures
            maxMap.get(month).add(max);
        }


    @Override
     protected void cleanup(Context context) throws IOException, InterruptedException {

      --- // code

      }


     }
```

Example: Mean

Let's create **SumCount** that is a ***utility wrapper*** around two values for computing the **mean of a dataset**.

The two values are:

* the ***sum*** of the values
* the ***number of values*** summed

so that ***dividing*** the **first** by the **second** will give us the **mean**.

Example: Mean

Let's create **SumCount** that is a ***utility wrapper*** around two values for computing the **mean of a dataset**.

```
public class SumCount implements WritableComparable<SumCount> {

        DoubleWritable sum;
        IntWritable count;

       public SumCount() {
         set(new DoubleWritable(0), new IntWritable(0));
       }

        --- // code

        public void addSumCount(SumCount sumCount) {
                set(new DoubleWritable(this.sum.get() + sumCount.getSum().get()),
                    new IntWritable(this.count.get() + sumCount.getCount().get()));
            }

        --- // code

}
```

Example: Mean

lets create the mapper class which would emit intermediate key value pairs as (month, SumCount).

```
    @Override
    protected void cleanup(Context context) throws IOException, InterruptedException {

            // loops over the months collected in the map() method
            for (Text month: maxMap.keySet()) {

                List<Double> temperatures = maxMap.get(month);

                // computes the sum of the max temperatures for this month
                Double sum = 0d;
                for (Double max: temperatures) {
                    sum += max;
                }

                // emits the month as the key and a SumCount as the value
                context.write(month, new SumCount(sum, temperatures.size()));
            }
```

Example: Mean

lets create the reducer class which would emit key value pairs as (month, avg max temperatures).

```
public static class MeanReducer extends Reducer<Text, SumCount, Text, DoubleWritable> {

        private Map<Text, SumCount> sumCountMap = new HashMap<Text, SumCount>();

        @Override
        public void reduce(Text key, Iterable<SumCount> values, Context context)
                                    throws IOException, InterruptedException {

            SumCount totalSumCount = new SumCount();

            for (SumCount sumCount : values) {

                // sums all of them
                totalSumCount.addSumCount(sumCount);
            }

            // puts the resulting SumCount into a map
            sumCountMap.put(new Text(key), totalSumCount);
        }

    @Override
    protected void cleanup(Context context) throws IOException, InterruptedException {

      --- // code

      }

}
```

Example: Mean

lets create the reducer class which would emit key value pairs as (month, mean).

```
@Override
protected void cleanup(Context context) throws IOException, InterruptedException {

        // loops over the months collected in the reduce() method
        for (Text month: sumCountMap.keySet()) {

            double sum = sumCountMap.get(month).getSum().get();
            int count = sumCountMap.get(month).getCount().get();

            // emits the month and the mean of the max temperatures for the month
            context.write(month, new DoubleWritable(sum/count));
        }
    }
```

MapReduce

Hadoop 3.X more examples

Big Data - 01/04/2020