Cloud Services in Practice

Documents, Services and Data on the Web

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Case Study: Amazon Web Services

- Amazon Web Services (AWS – aws.amazon.com) provide a wide range of services, including:
  - Infrastructure as a service:
    - EC2: purchase of virtual machines of different capabilities, with different operating systems, and for different periods.
    - S3: purchase of storage that is accessed through a simple file system style interface.
  - Platform as a service:
    - EMR (Elastic Map Reduce): the ability to run scalable applications written using the map reduce programming model over EC2 and S3 infrastructure.
- Using EMR involves storing some data in S3, and then creating a map reduce job that runs on some EC2 machines.

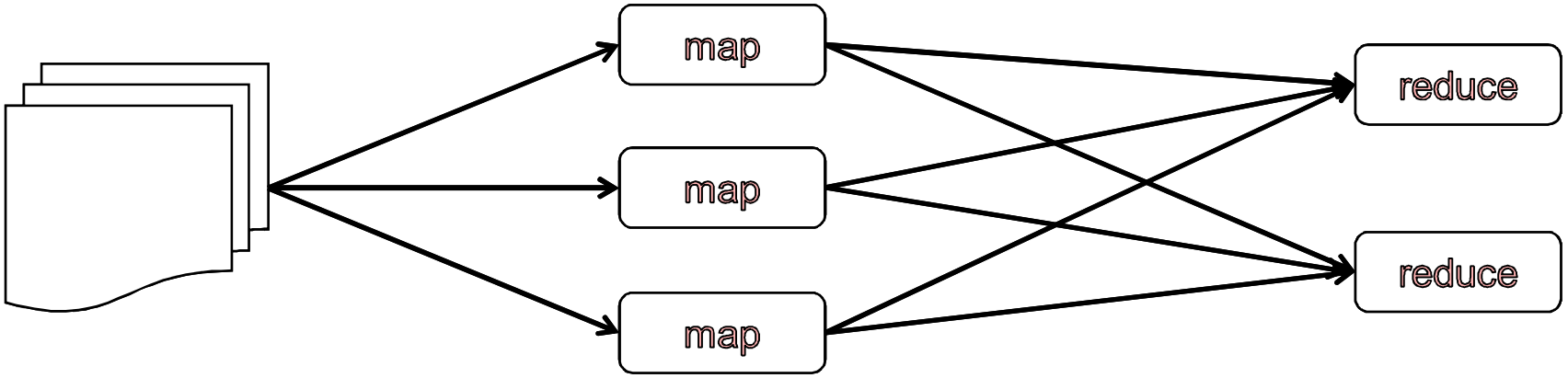
Map Reduce

- *Map Reduce* is a scalable programming model, originally developed by Google for tasks such as index building.
- In Map Reduce:
  - applications are developed using two simple, functional operations (*map* and *reduce*);
  - the infrastructure supports the running of Map Reduce applications in parallel on potentially huge data sets on potentially numerous commodity machines.
- *Hadoop* is a widely used open source implementation of map reduce (hadoop.apache.org).

Word Count Example

- The standard map reduce example program counts the number of occurrences of each word in a document (although this is in some ways a toy task, it is relevant to web indexing).

Word Count at Runtime



the reduce operation, given the id of a document and the document, emits a collection of key-value pairs
...

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a document and the document,

...

(the, 1)
(reduce, 1)
(the, 1)
...

(the, 1)
(document, 1)
...

...

(the, [1,1,1])
(reduce,[1]))
...

(of, [1,1])
(pairs,[1]))
...

(the, 3)
(reduce, 1)
...

(of, 2)
(pairs, 1)
...

Word Count Map

- Recall the description of map:
  - map(key_1, $value_1$) -> [(key_2,$value_2$)]
  - map, given a key key_1 and a value $value_1$, generates a collection of key-value pairs (key_2,$value_2$).
- In WordCount:
  - key_1 is the identifier of the document (not used).
  - $value_1$ is the document (or part of the document).
  - key_2 is a word from the document.
  - $value_2$ is an occurrence count for key_2.

Map Pseudo-Code

- The map operation, given the id of a document and the document, emits a collection of key-value pairs, where the key is a word in the document and the value is a (partial) count of the number of occurrences of the word in the document.

```
map(documentId key1, document value1) {
    for each term t in value1 do
        emit(term t, count 1)
}
```

Word Count Reduce

- Recall the description of reduce:
  - reduce(key_2,[$value_2$]) -> [(key_3, $value_3$)]
  - reduce, given a key key_2 output by map, and a collection of all the values $value_2$ associated with that key, returns a new collection of key-value pairs.
- In WordCount:
  - key_2 is a term from the document processed by map.
  - $value_2$ is a (partial) count of occurrences of key_2 from map.
  - key_3 is the same as key_2.
  - $value_3$ is the total occurrence count for key_3.

Reduce Pseudo-Code

- The reduce operation, given a term and a list of partial counts of the term from map, emits a collection of key-value pairs, where the key is the term and the value is the sum of the partial counts.

```
reduce(term key2, list of count value2) {
    sum = 0
    for each count in value2 do
        sum = sum + count;
    emit(term key2, count sum)
}
```

Why like this…

- The basic idea is that, without modifying your code (partial truth), a map reduce program can run with very high levels of parallelism over huge files.
- Normally to write a parallel application you need to worry about data partitioning, scheduling, load balancing, …
- The classic web scale example: given data from a web crawl, build an index for use by a search engine.

How to Run it on the Cloud?

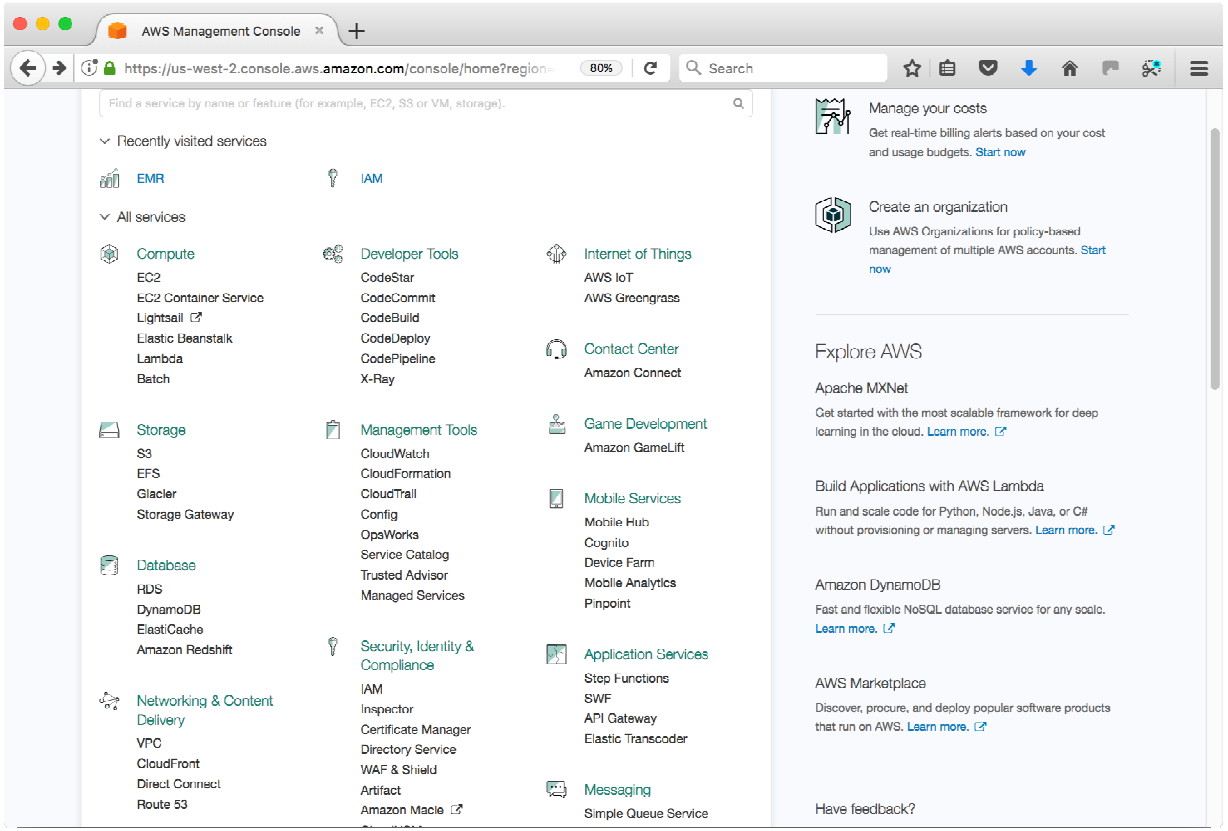
- You can run a Word Count example on the cloud using Amazon Web Services (AWS).
- Note that the AWS web interface changes on an ongoing basis, so some of the screen shots may not exactly match what you see.
- The basic idea:
  - You can upload a text file of your choice to a cloud data store (S3).
  - You can run an existing WordCount map/reduce program using a (small) dynamically provisioned cluster (EMR).
  - You can look at the results of the WordCount run that will also be stored in S3.

Prerequisite

- First, log into the AWS management console.
- This should have been done by the time you need to move on to the next step…

AWS Management Console

- The Management Console provides access to a comprehensive list of services.



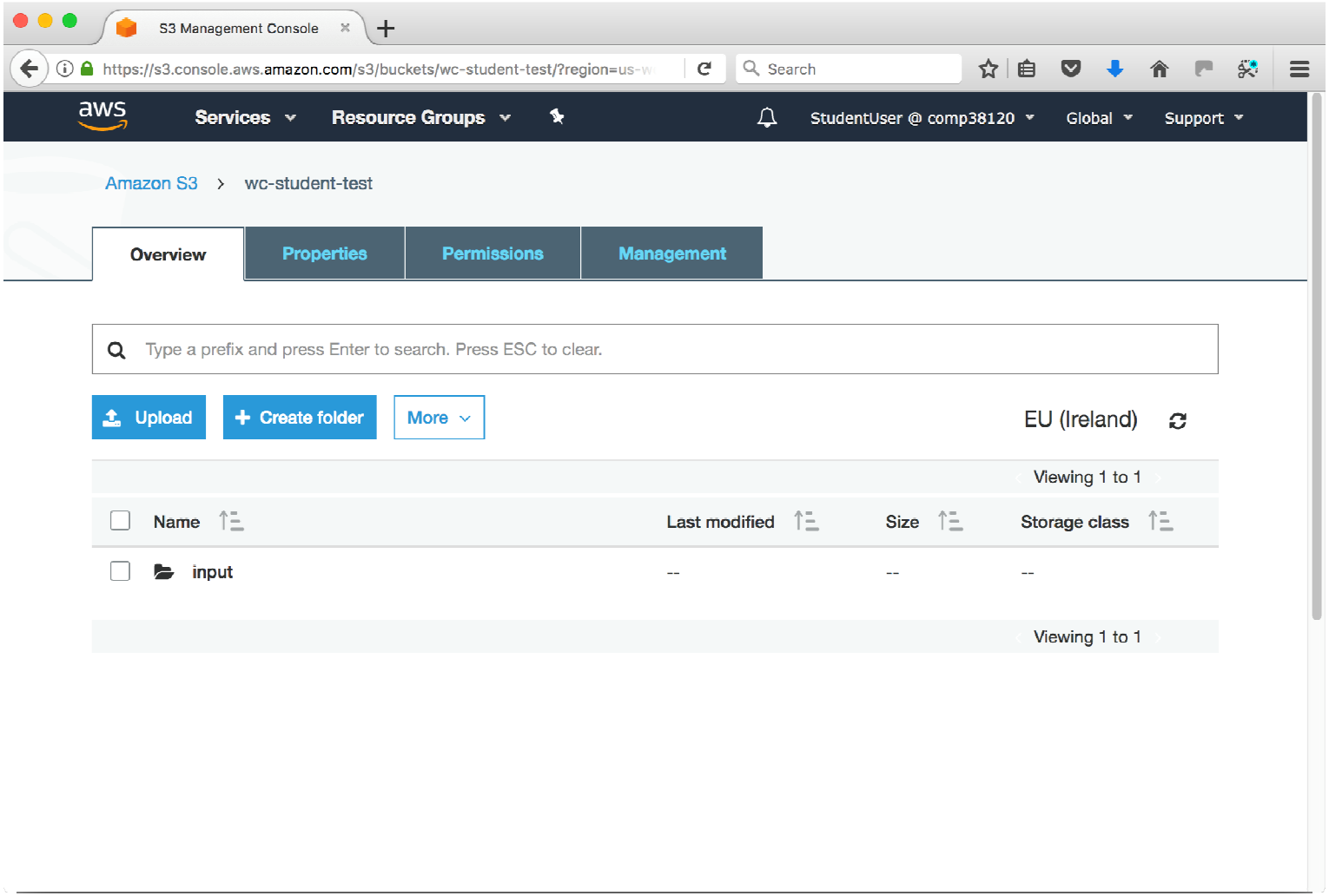
Amazon S3 Storage

- S3 provides a hierarchical file structure, which will be used for:
  - The input to a map/reduce program.
  - The JAR that contains the WordCount.
  - The output from the execution of the program.
  - Logging information.
- For this activity:
  - Buckets are essentially folders.
  - You can create a bucket in S3, where you can store the JAR you will use, for example:
    - s3://uom38120wordcount/WordCount.jar

Prepare S3 For Your Run

- Move to the S3 Service.
  - Services -> S3.
- Create another bucket:
  - Action: *+CreateBucket*.
  - Give it a distinctive name.
    - The one in the slides is called *wc-student-test*.
  - Take the default properties for the bucket.
- Create a folder called *input* in your group bucket.
  - Change into your bucket by clicking on it.
  - Action: *+CreateFolder*.

Your New Bucket and Folder

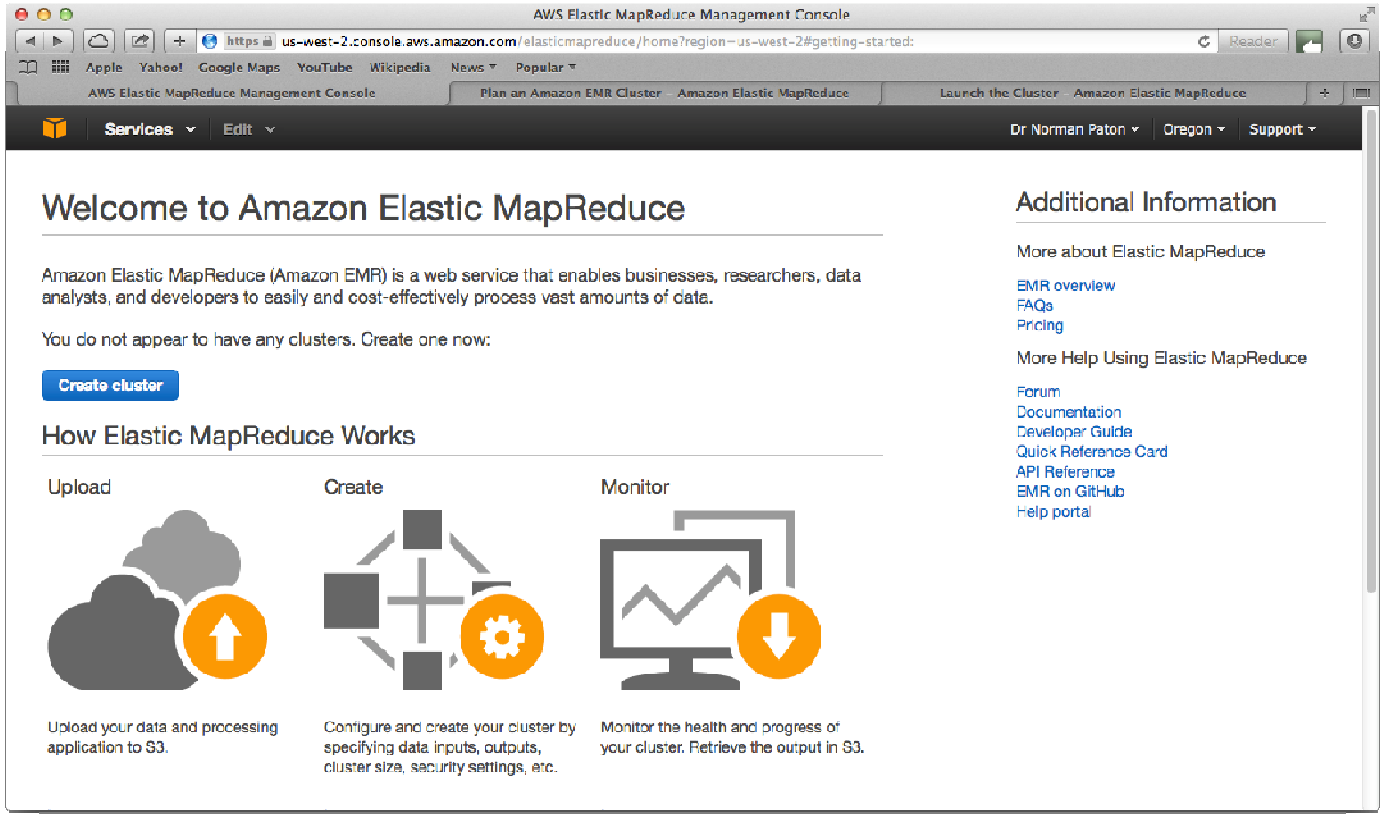


Upload your Data

- Change into your *input* folder by clicking on it.
- Upload a text file (neither tiny nor huge) of your choice:
  - Action: *Upload*.
- Just accept the default properties for the uploaded file.

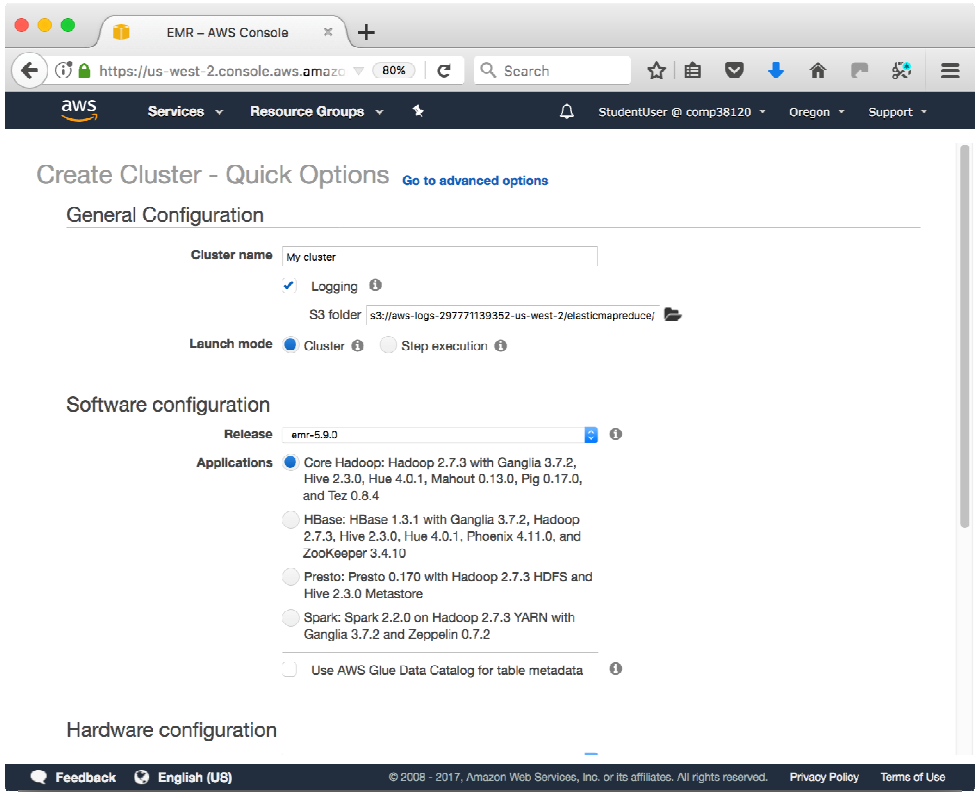
Run Map Reduce Program

- Move to the Elastic Map Reduce (EMR) service:
  - Services -> Elastic Map Reduce.



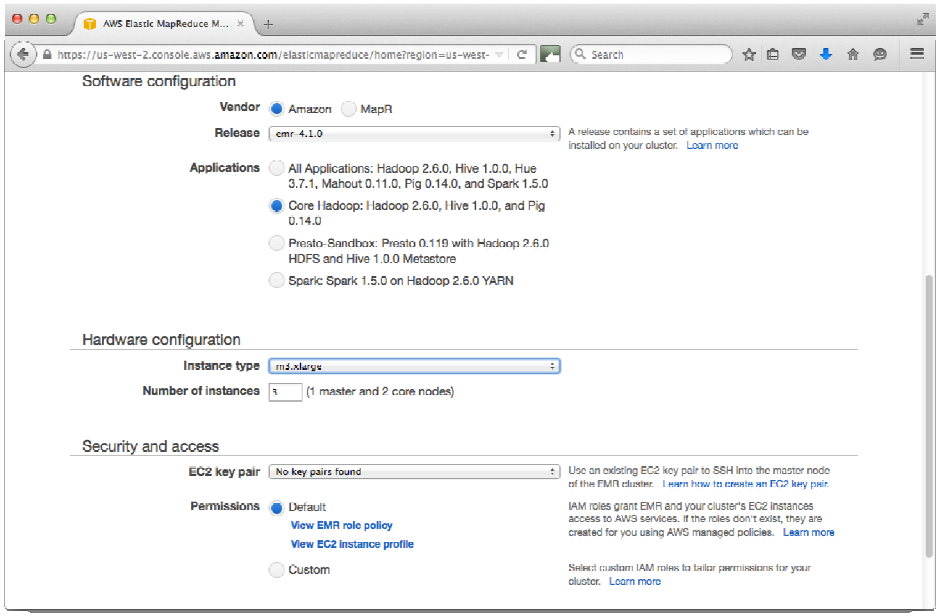
Create a cluster for your job

- Click on Create Cluster.
- Use defaults unless otherwise specified.
- Define The Cluster:
  - Give it some form of distinctive name.
  - Define the log file in your bucket. Mine is: s3://*wc-student-test*/log/
  - This does not have to already exist.



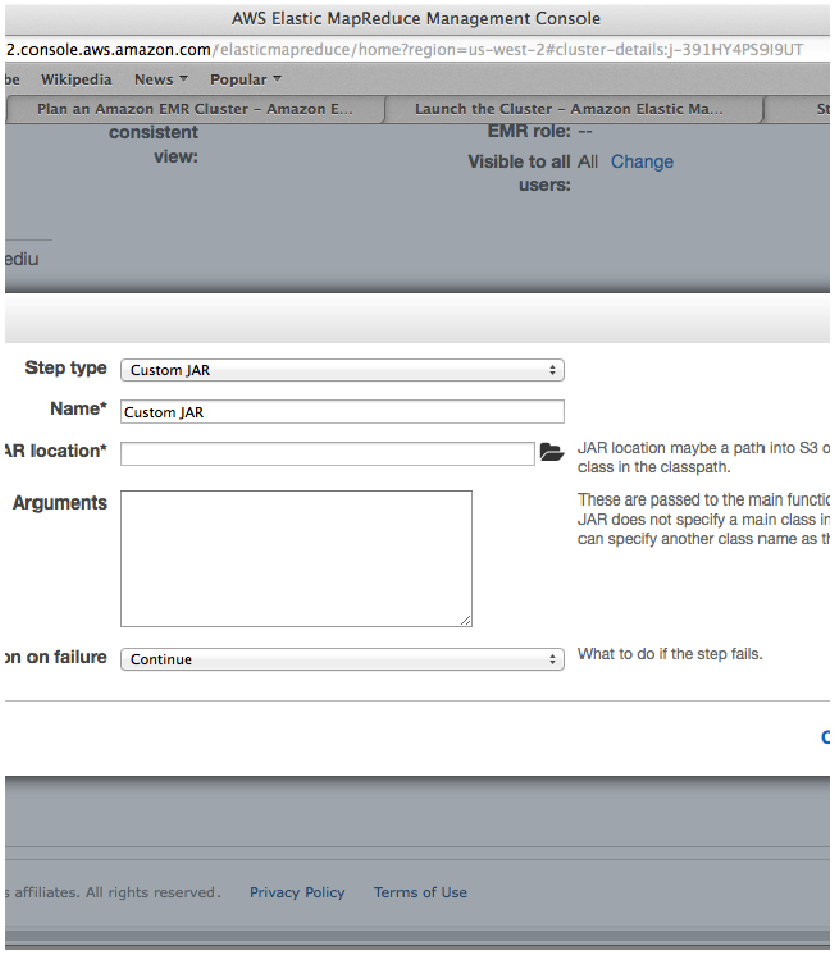
Specify Parameters

- Software configuration:
  - Amazon.
  - Emr-5.19.0.
- Applications:
  - Core Hadoop 2.8.5.
- Hardware configuration:
  - You will get access to 3 (virtual) machines, 1 master and 2 workers.
  - Choose m4.large for them the configuration.
- Finally, Create cluster.



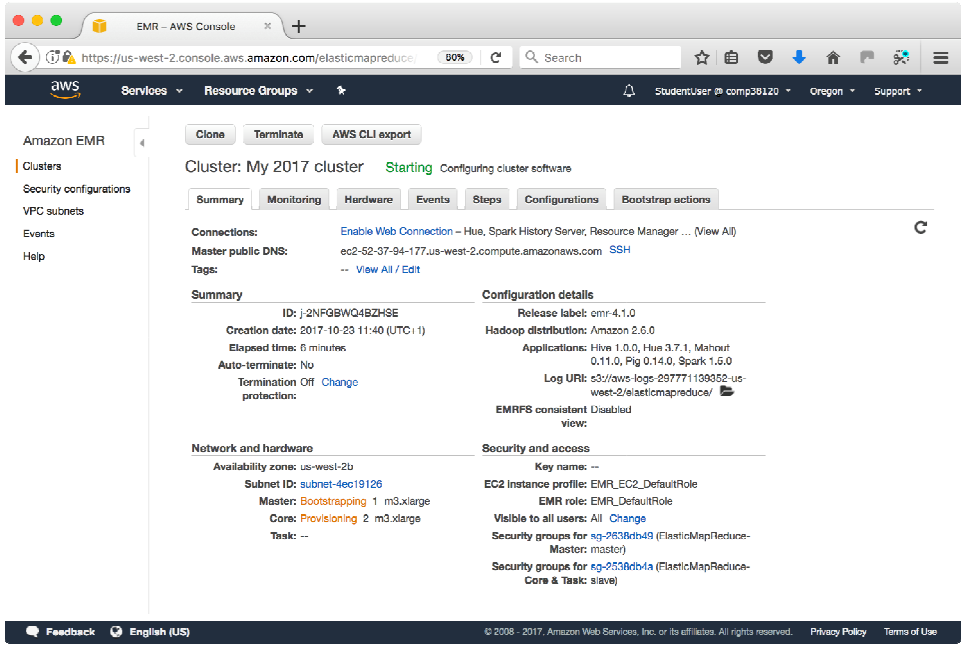
Add a Step

- Select Steps -> *Add Step*.
- Step type:
  - Custom JAR.
- Name:
  - Something distinctive
- JAR Location:
  - s3://uom38120wordcount/WordCount_2.jar
- Arguments: Your space-separated input and not-yet-existing output; mine are:
  - s3://*wc-student-test*/input
  - s3://*wc-student-test*/output
- Action on failure: continue



Running the Job

- This page should auto-update (but refresh at top right to hurry it along).
- Expand Steps to see the details. Your job flow should transition through:
  - Pending, Starting, Running, ... Completed.
- … but on the other hand may cut to Failed at any point, in which case try the log files.
- At the end, please

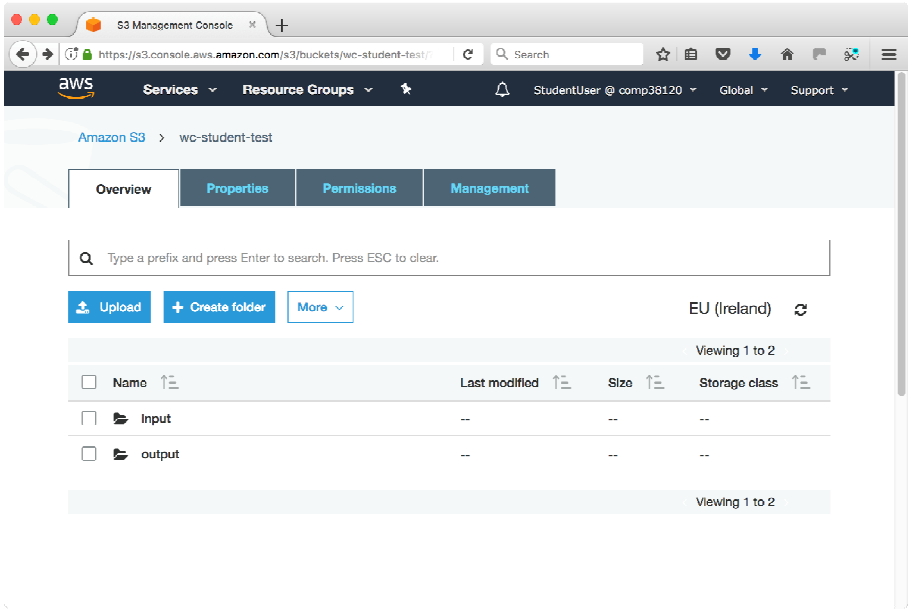


It can take some time to provision a cluster (several minutes).

If your run fails for some reason, you can always add another Step without needing to run the cluster again.

Viewing the Results

- To see the results, go to S3:
  - Services -> S3.
- In your output folder there will be a different result file for each reduce job.
- View results by:
  - Selecting the file.
  - Actions -> Download.



More Information

- The WordCount run here is from the following book, somewhat simplified to act on text files:
  - Donald Miner, Adam Shook, MapReduce Design Patterns, O'Reilly Media, 2012.

- The user/developer guides for S3 and EMR (huge) are at:
  - http://aws.amazon.com/documentation/s3/
  - http://aws.amazon.com/documentation/elasticmapreduce/

Later you will…

- Learn more about application development using map reduce, including:
  - Hadoop – the infrastructure, its properties.
  - Map reduce – application design and patterns.
- Apply map reduce in labs to search applications in the web of documents and the web of data.
- Although you will not run hadoop on a cloud for your project, you have now seen what is involved in doing so.