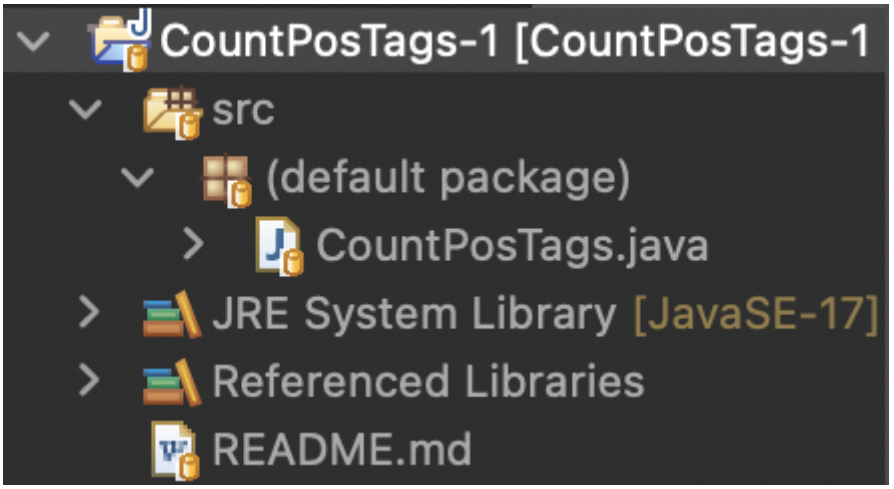
Assignment 2

Solution 1

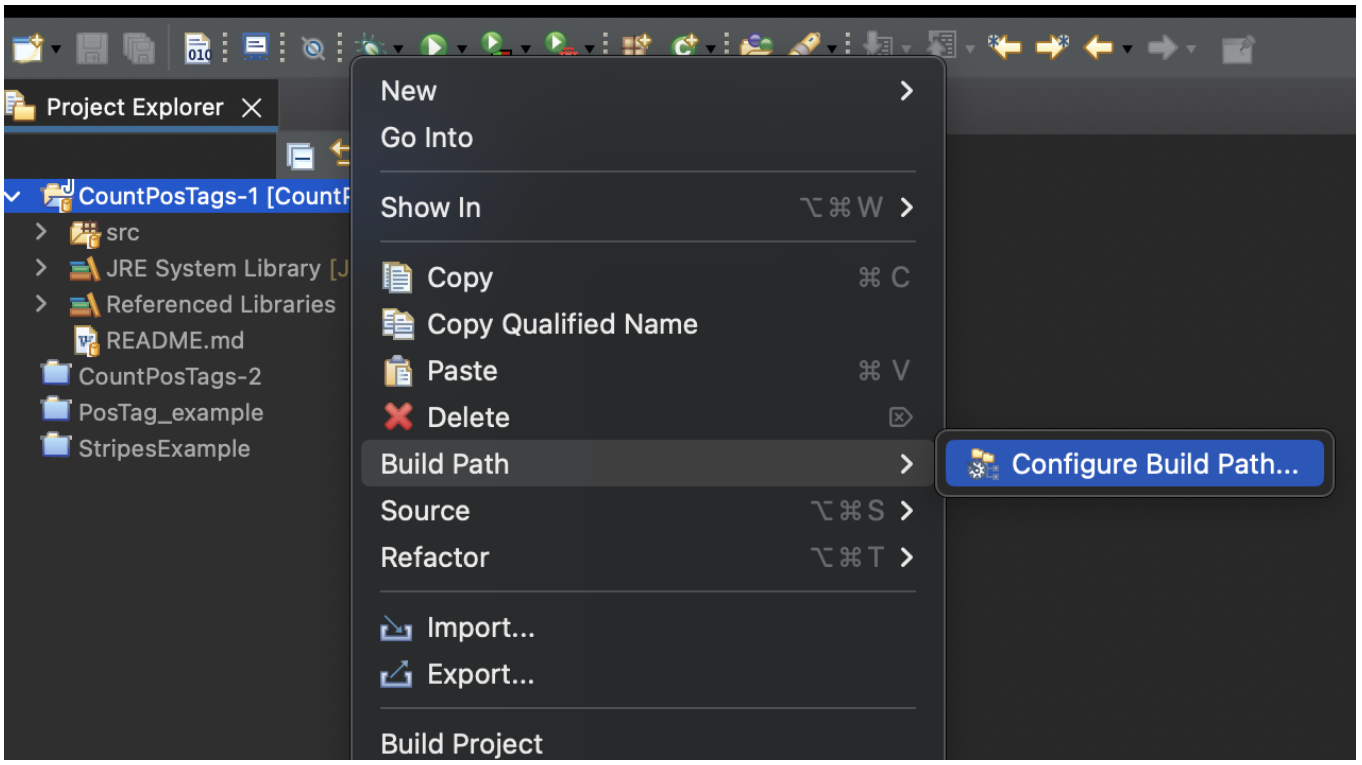
Solution for 1.1

How to Run the code:

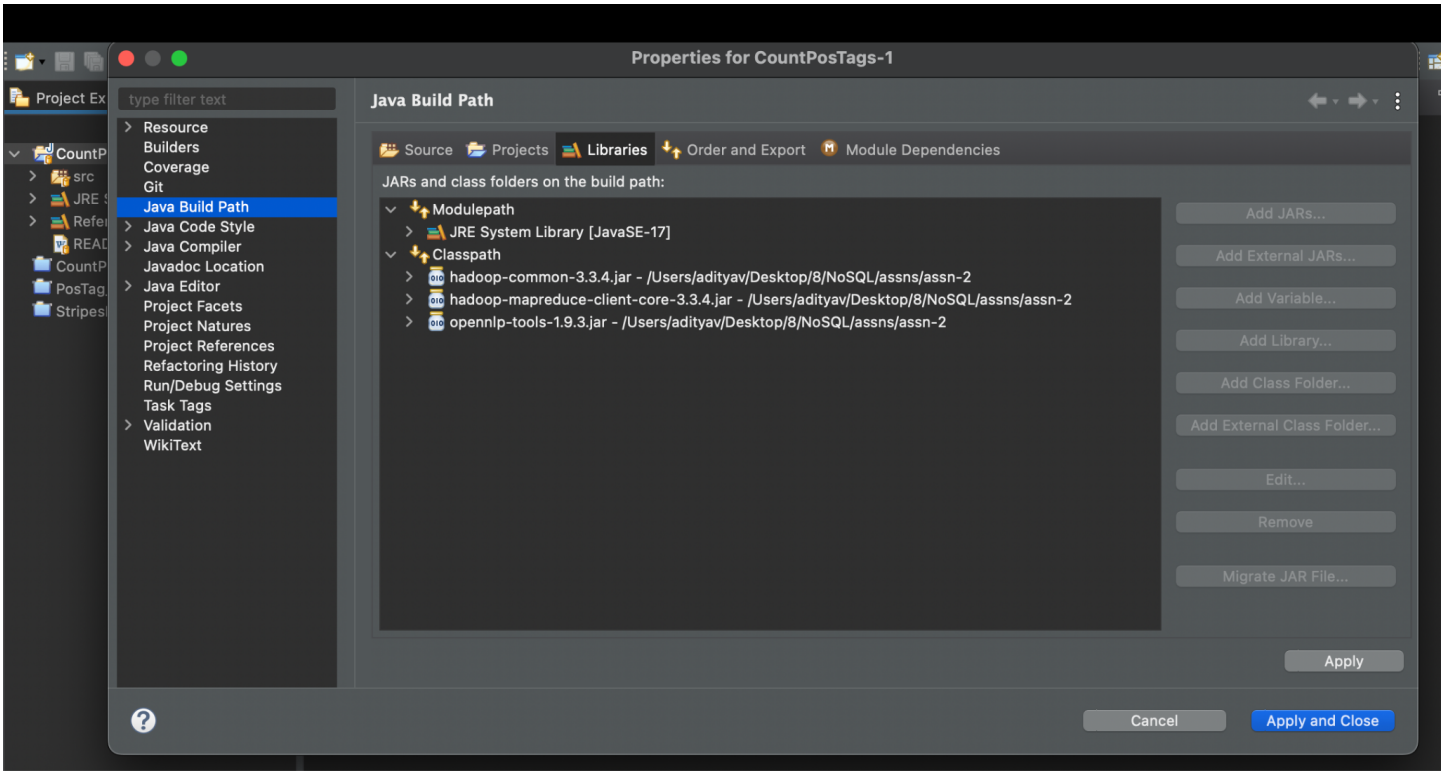
Open the project in eclipse with the file system in folder CountPosTags-1. Directory Structure will be something like below:



Right click on the project file structure and add external jar files to the project.



Select ‘Java Build Path’ from the right window. Click on the ‘Classpath’ and add all the jar files from ‘JARS’ folder.

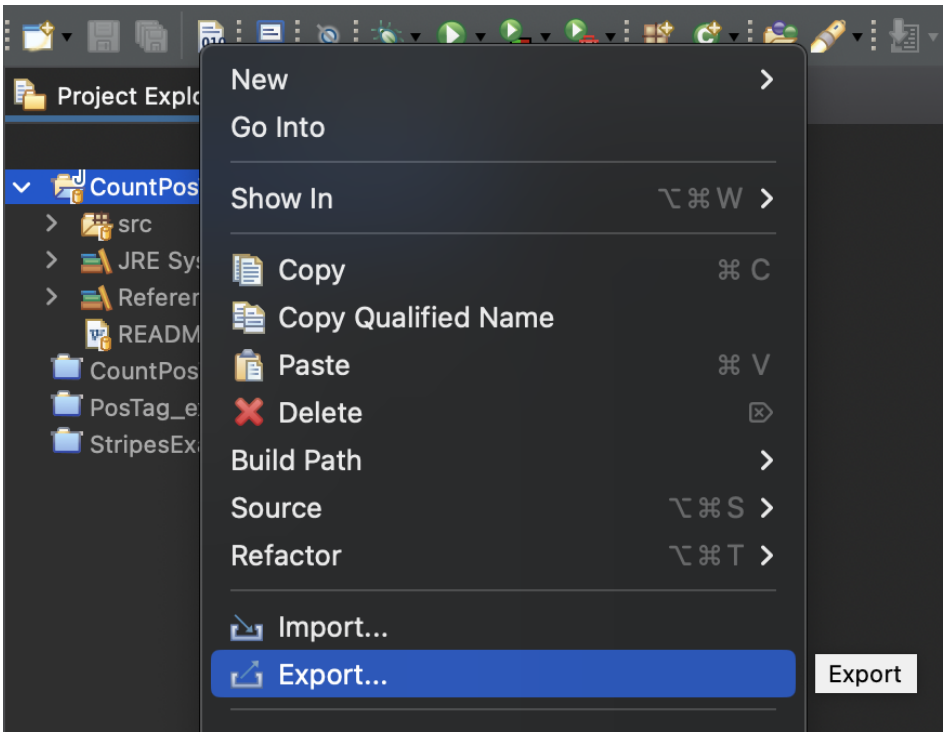


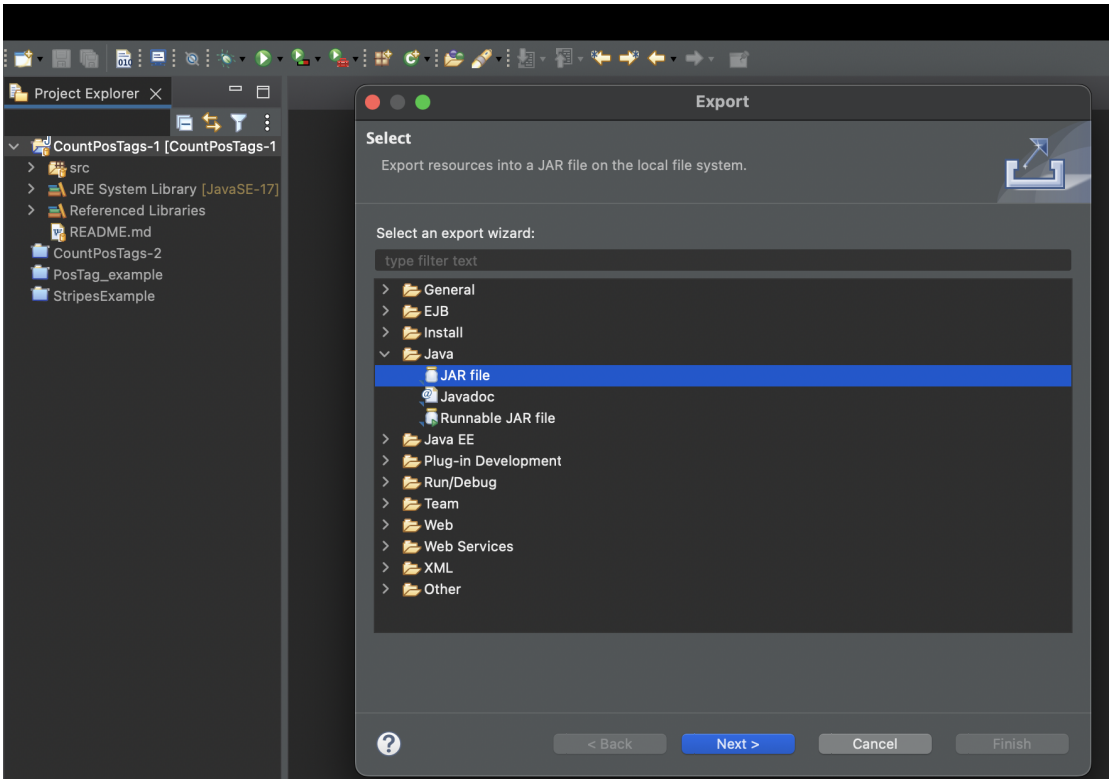
Make sure that **HADOOP_HOME** and **HADOOP_CLASSPATH.** On terminal this should return something like the following:

```
$ echo  ${HADOOP_HOME}
/opt/homebrew/Cellar/hadoop/3.3.4/libexec
```

```
echo ${HADOOP_CLASSPATH}
/Users/adityav/Desktop/8/NoSQL/assns/assn-2/*
```

Now export the project in the form of a ‘jar’ file.


Project Explo
CountPos
src
JRE Sy
Referer
READM
CountPos
PosTag_e
StripesEx
New
Go Into
Show In ⌥⌘W
Copy ⌘C
Copy Qualified Name
Paste ⌘V
Delete
Build Path
Source ⌥⌘S
Refactor ⌥⌘T
Import...
Export...
Export


Project Explorer
CountPosTags-1 [CountPosTags-1
src
JRE System Library [JavaSE-17]
Referenced Libraries
README.md
CountPosTags-2
PosTag_example
StripesExample
Export
Select
Export resources into a JAR file on the local file system.
Select an export wizard:
type filter text
General
EJB
Install
Java
JAR file
Javadoc
Runnable JAR file
Java EE
Plug-in Development
Run/Debug
Team
Web
Web Services
XML
Other
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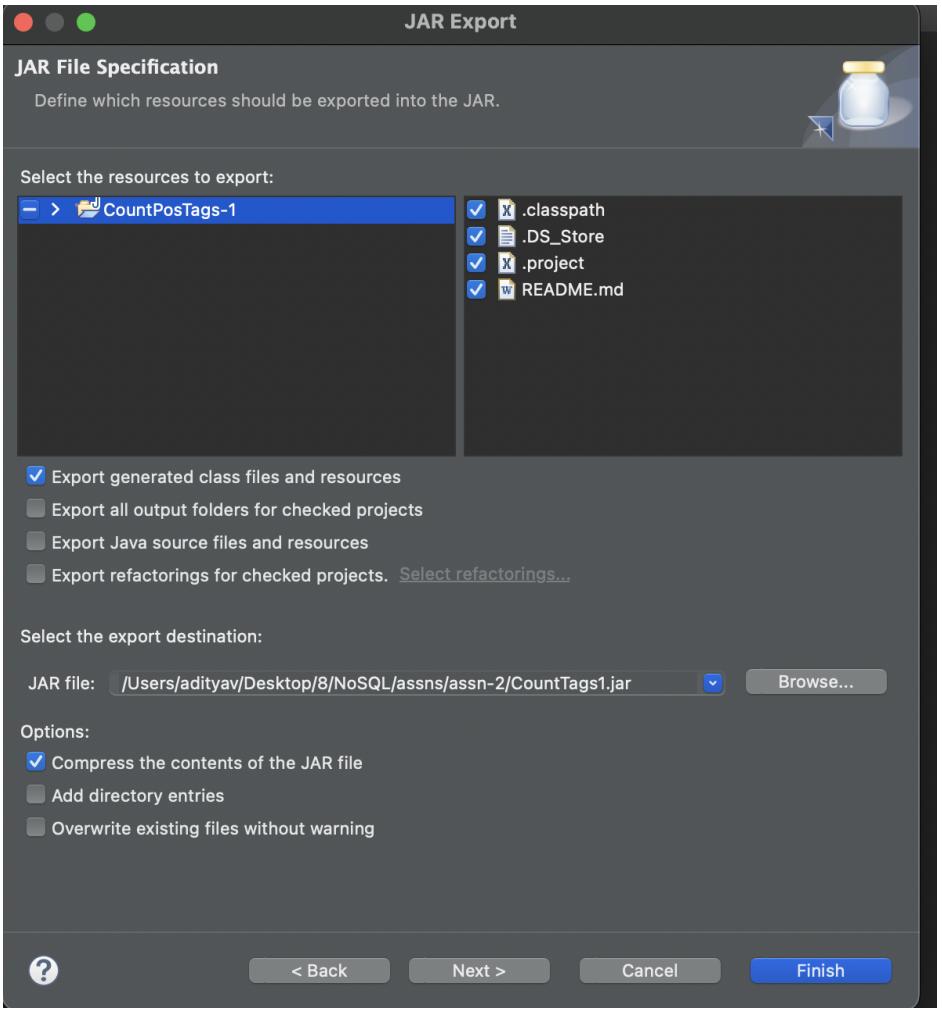
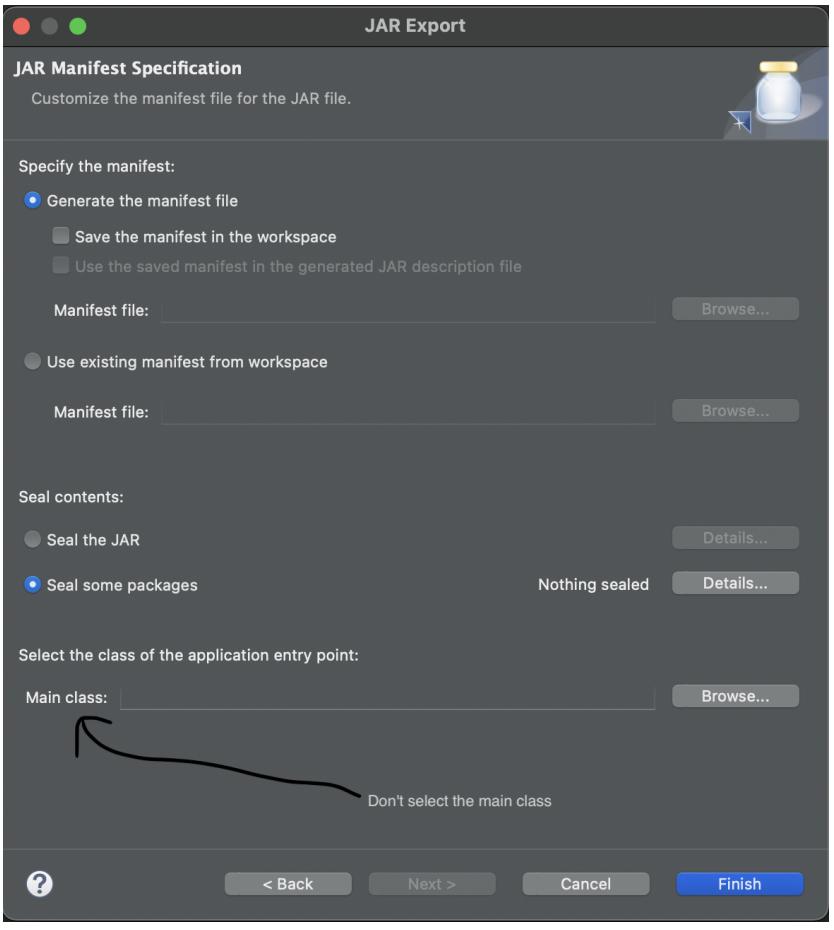


Don’t save the ‘main class’, leave it empty.



Now move to the folder where you exported the jar file, and run the following command.

```
$ hadoop jar <jar-file> <main-class-name> <folder-containing-input> <output-directory>
```

The output can be found in the file **part-r-00000** (in the output folder)

Code Explanation:

We have the following code in the main function:

```
70    public static void main(String[] args) throws Exception {
71
72        Configuration conf = new Configuration();
73        Job job = Job.getInstance(conf, "countTags_using_pairs_algo");
74
75        job.setMapperClass(TokenizerMapper.class); //.class is a special syntax in Java that retrieves the Class obj
76        job.setCombinerClass(IntSumReducer.class); // enable to use 'local aggregation'
77        job.setReducerClass(IntSumReducer.class);
78
79        job.setOutputKeyClass(Text.class);
80        job.setOutputValueClass(IntWritable.class);
81
82        FileInputFormat.addInputPath(job, new Path(args[0]));
83        FileOutputFormat.setOutputPath(job, new Path(args[1]));
84
85
86 //       In Hadoop MapReduce, the waitForCompletion() method is used to submit the job
87 //       to the Hadoop cluster and wait for it to complete. The argument true passed to
88 //       the waitForCompletion() method specifies that the driver program should block
89 //       until the job completes.
90        long startTime = System.currentTimeMillis();
91        boolean output = job.waitForCompletion(true);
92        long endTime = System.currentTimeMillis();
93        // Calculate the elapsed time for each job
94        long elapsedTime = endTime - startTime;
95        // Print the elapsed time for each job
96        System.out.println("Elapsed time for job: " + elapsedTime + " ms");
97        System.exit(output ? 0 : 1);
98
99    }
```

Instances of configuration and jobs are created, and the corresponding mapper, combiner and reducer classes are specified. The time elapse for job execution is calculated.

MAPPER CLASS

```
//  This line creates an instance of the POSModel class, which represents a
//  pre-trained model for part-of-speech tagging. The model is loaded from a
//  file on the local file system.
    private static POSModel model = new POSModelLoader().load(new File("/Users/adityav/Desktop/8/NoSQL/assns/assn-2/open

    // Object: input key type
    // Text: input value type
    // Text: output key type
    // IntWritable: output value type
    public static class TokenizerMapper extends Mapper<Object, Text, Text, IntWritable> {

//      This line creates an instance of the POSTaggerME class, which is used to
//      perform part-of-speech tagging on a given input sentence. The tagger is
//      initialized with the pre-trained model.
        POSTaggerME tagger = new POSTaggerME(model);

        private final static IntWritable one = new IntWritable(1);
        private Text objKey = new Text();

        @Override
        public void map(Object key, Text value, Context context) throws IOException, InterruptedException {
            String line = value.toString();
            String[] tokens = line.split("[^\\w']+"); // extract words

            String[] tags = tagger.tag(tokens);
            for (String posTag : tags) {
                objKey.set(posTag+","+posTag); // a Text object is created using the set() method

                context.write(objKey, one); // IntWritable object representing the count is used as the output value.
            }
        }
    }
```

The mapper class contains a **POSTagger** model for tagging. Following are the input and output classes:

1. Input key class: Object
2. Input value class: Text
3. Output key class: Text
4. Output value class: IntWritable

The map function tokenizes the given input, computes the corresponding tags using the **POSTagger** model and stores it in a tags array. The tags array is then iterated through and a write operation is performed where the key is assigned as **“<tag>,<tag>”** and the value is assigned as a byte stream one.

REDUCER CLASS

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

        @Override
        public void reduce(Text key, Iterable<IntWritable> values, Context context)
                throws IOException, InterruptedException {
            int sum = 0;
            for (IntWritable val : values) {
                sum += val.get();
            }
            result.set(sum);

            context.write(key, result);
        }

    }
```

The mapper class contains a **POSTagger** model for tagging. Following are the input and output classes:
1. Input key class: Text
2. Input value class: IntWritable
3. Output key class: Text
4. Output value class: IntWritable

The reducer iterates through a list of integer values corresponding to each POS tag, computes the sum and performs a write operation where the key is assigned as **“<tag>,<tag>”** and the value is the corresponding sum.

Solution for 1.2

The steps for running the code are similar to solution 1.1.

Code Explanation:

```
    public static void main(String[] args) throws Exception {
//      System.out.println("Hello");

        Configuration conf = new Configuration();
        Job job = Job.getInstance(conf, "countTags_using_stripes_algo");

        job.setMapperClass(TokenizerMapper.class); //.class is a special syntax in Java that retrieves the Class obj
        job.setReducerClass(IntSumReducer.class);


        /* Following 2 lines correspond to the output key, value classes of MAPPER */
        job.setOutputKeyClass(Text.class);
        job.setOutputValueClass(MapWritable.class);

        FileInputFormat.addInputPath(job, new Path(args[0]));
        FileOutputFormat.setOutputPath(job, new Path(args[1]));


//      In Hadoop MapReduce, the waitForCompletion() method is used to submit the job
//      to the Hadoop cluster and wait for it to complete. The argument true passed to
//      the waitForCompletion() method specifies that the driver program should block
//      until the job completes.
        long startTime = System.currentTimeMillis();
        boolean output = job.waitForCompletion(true);
        long endTime = System.currentTimeMillis();
        // Calculate the elapsed time for each job
        long elapsedTime = endTime - startTime;
        // Print the elapsed time for each job
        System.out.println("Elapsed time for job: " + elapsedTime + " ms");
        System.exit(output ? 0 : 1);
    }
```

Instances of configuration and jobs are created, and the corresponding mapper, combiner and reducer classes are specified. The time elapse for job execution is calculated.

MAPPER CLASS

```java
    // IntWritable: output value type
    public static class TokenizerMapper extends Mapper<Object, Text, Text, MapWritable> {

        private MapWritable row = new MapWritable();
        private Text rowKey = new Text();

//      This line creates an instance of the POSTaggerME class, which is used to
//      perform part-of-speech tagging on a given input sentence. The tagger is
//      initialized with the pre-trained model.
        POSTaggerME tagger = new POSTaggerME(model);


        @Override
        public void map(Object key, Text value, Context context) throws IOException, InterruptedException {
            String line = value.toString();
            String[] tokens = line.split("[^\\w']+"); // extract words
            String[] tags = tagger.tag(tokens);

            HashMap<String, ArrayList<String>> tagTokenMap = new HashMap<String, ArrayList<String>>();
            for(int i=0; i<tokens.length; i++) {
                String posTag = tags[i];
                String token = tokens[i];

                if (!tagTokenMap.containsKey(posTag)) {
                    tagTokenMap.put(posTag, new ArrayList<String>());
                    tagTokenMap.get(posTag).add(token);
                }

                else {
                    tagTokenMap.get(posTag).add(token);
                }
            }


            for (Map.Entry<String, ArrayList<String>> entry : tagTokenMap.entrySet()) {
                String tag = entry.getKey(); // get the key
                ArrayList<String> toks = entry.getValue(); // get the values

                row.clear();

                for (String tok : toks) {
                    Text tokKey = new Text(tok);
                    if (row.containsKey(tokKey)) {
                        IntWritable count = (IntWritable) row.get(tokKey);
                        count.set(count.get() + 1);
                    } else {
                        row.put(tokKey, new IntWritable(1));
                    }
                }

                rowKey.set(tag);
                System.out.println("Hello World!");
                context.write(rowKey, row);
            }
        }
    }
```

The mapper class contains a **POSTagger** model for tagging. Following are the input and output classes:
1. Input key class: Object
2. Input value class: Text
3. Output key class: Text
4. Output value class: MapWritable

The map function tokenizes the given input, computes the corresponding tags using the **POSTagger** model and stores it in a tags array. The tags array is then iterated through and a hashmap is created where key is the tag and the value is the list of words with the corresponding POS tag.

Then using this hashmap we iteratively create a MapWritable row with row key as the tag value and it contains pair <word,count> i.e. pair of word and the corresponding count of how many times that word is occurring as that POS tag, and a write operation is performed on this row.

REDUCER CLASS

```
88
89      public static class IntSumReducer extends Reducer<Text, MapWritable, Text, IntWritable> {
90
91          @Override
92          public void reduce(Text key, Iterable<MapWritable> values, Context context)
93                  throws IOException, InterruptedException {
94
95              int sum = 0;
96              for (MapWritable val : values) {
97                  for (Map.Entry<Writable, Writable> entry : val.entrySet()) {
98                      IntWritable count = (IntWritable) entry.getValue();
99                      sum += count.get();
100                 }
101             }
102
103             IntWritable total = new IntWritable(sum);
104             context.write(key, total);
105
106         }
107
108     }
```

The mapper class contains a **POSTagger** model for tagging. Following are the input and output classes:
1. Input key class: Text
2. Input value class: MapWritable
3. Output key class: Text
4. Output value class: IntWritable

The reduce function iterates through the list of rows corresponding to each key(tag) and sums up the counts of each word to get a count of the current tag. Then a write operation is performed with key as tag and value as the computed sum.

Comparison of execution programs using pairs and stripes algorithm:

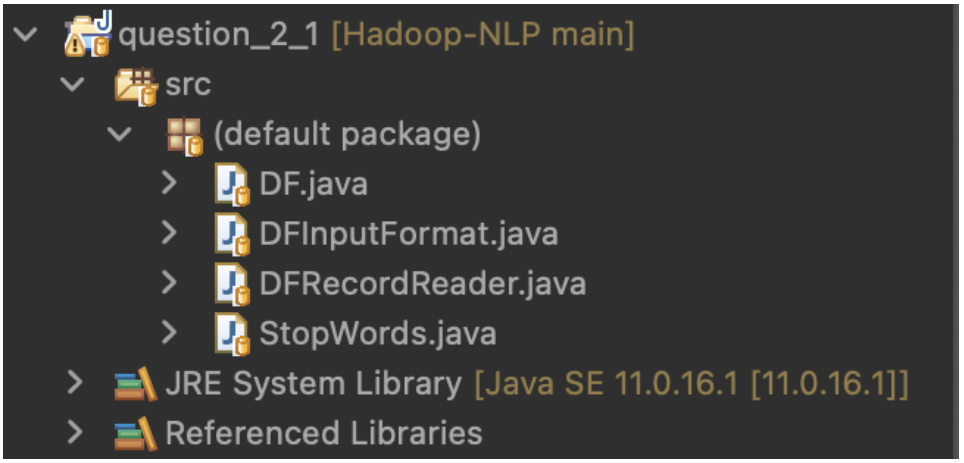
a. Using pairs algorithm without combiner takes **5581 ms**
b. Using pairs algorithm with combiner takes **4799 ms**
c. Using stripes algorithm takes **4564 ms**

Solution 2

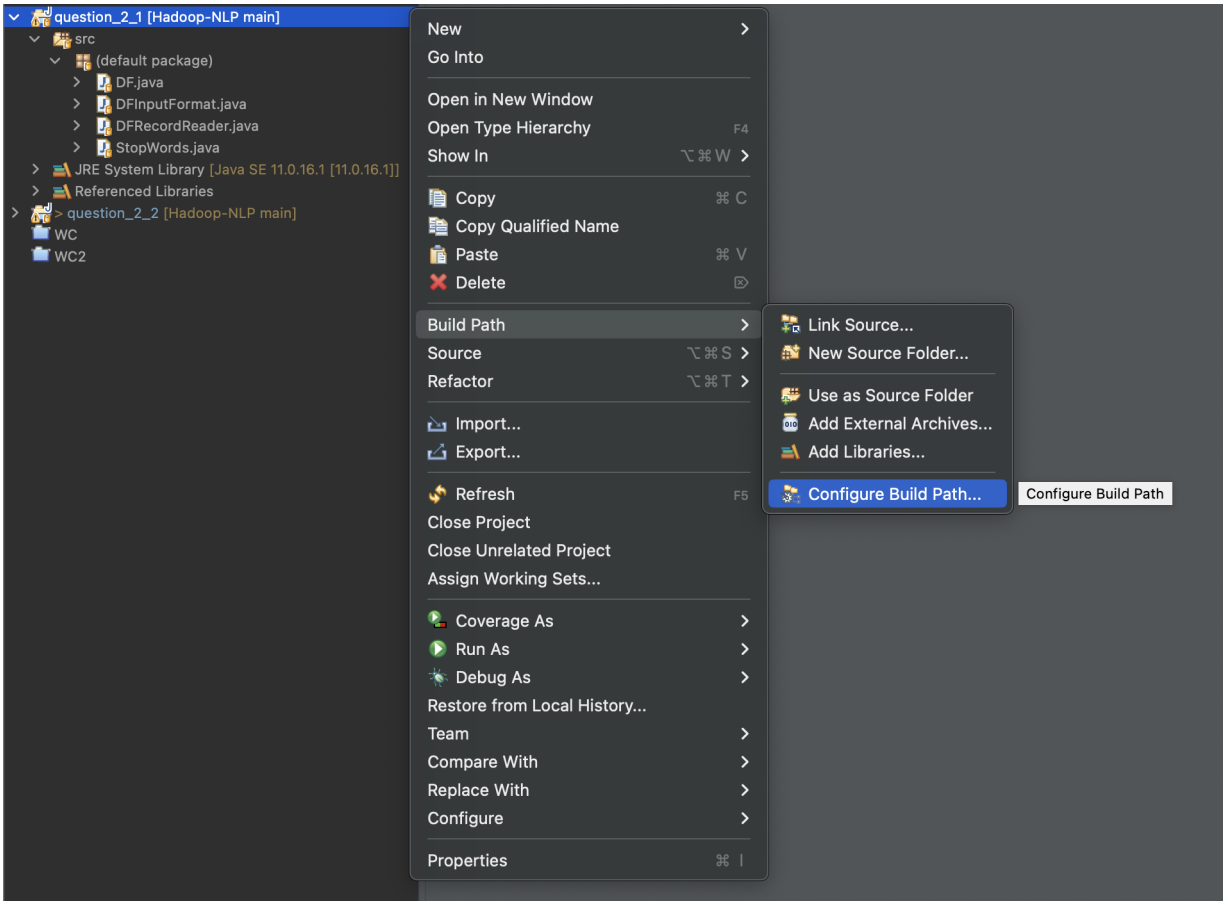
Solution for 2.1

How to Run the code:

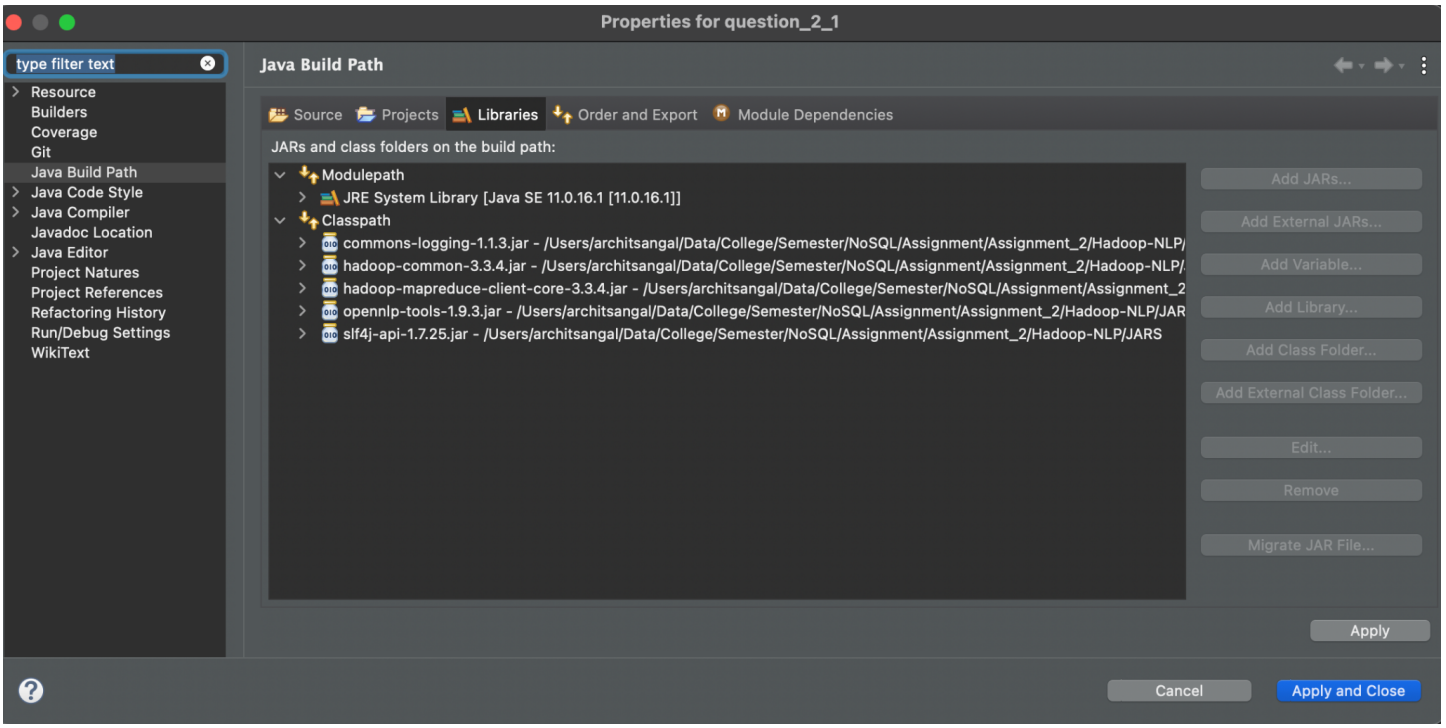
Open the project in eclipse with the file system in folder 2.1. Directory Structure will be something like below:



Right click on the project file structure and add external jar files to the project.



Select ‘Java Build Path’ from the right window. Click on the ‘Classpath’ and add all the jar files from ‘JARS’ folder.

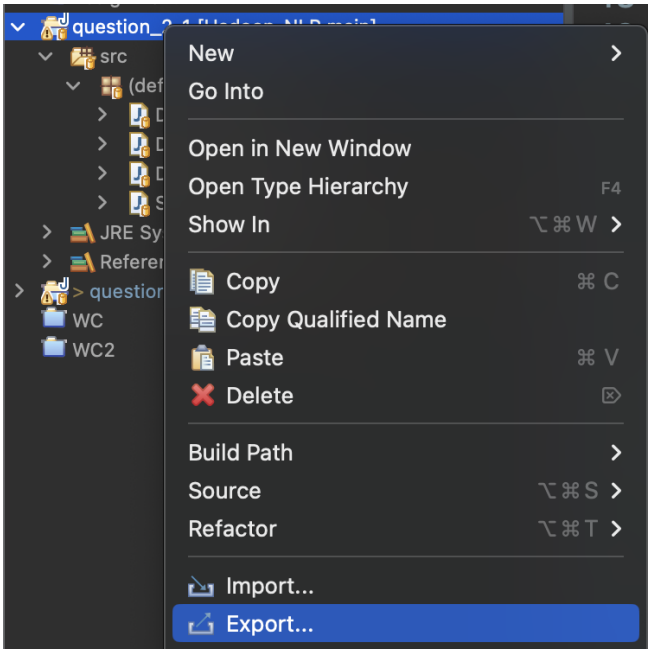


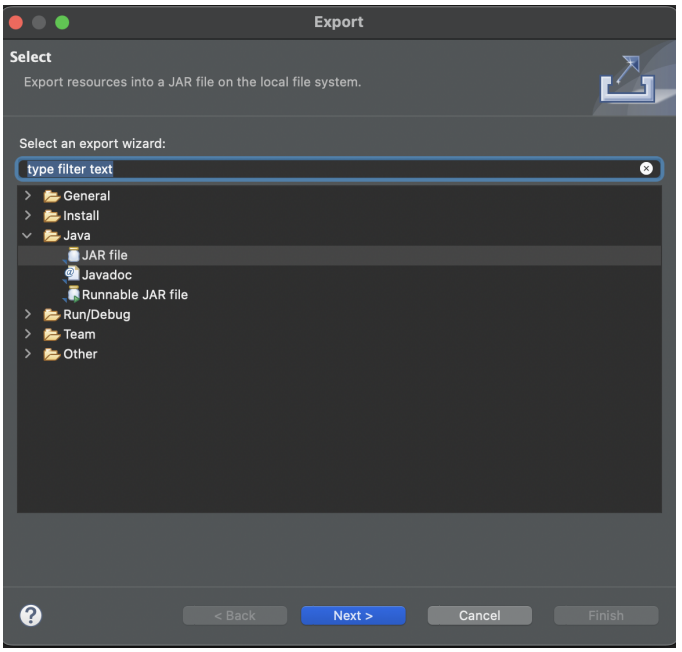
Make sure that **HADOOP_HOME** and **HADOOP_CLASSPATH.** On terminal this should return something like the following:

```
$ echo  ${HADOOP_HOME}
/opt/homebrew/Cellar/hadoop/3.3.4/libexec
```

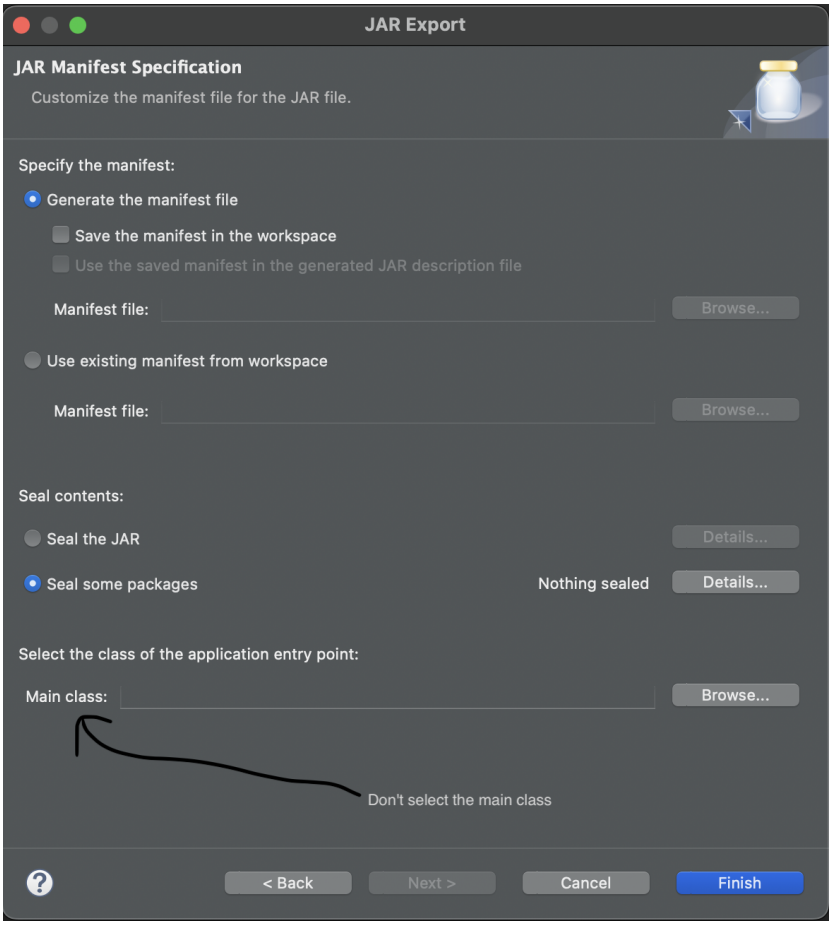
```
echo ${HADOOP_CLASSPATH}
/Users/architsangal/Data/College/Semester/NoSQL/Assignment/Assignment_2/Hadoop-NLP/JARS
/*
```

Now export the project in form of a ‘jar’ file. Save it to a folder called ‘TarFiles’.





Don’t save the ‘main class’, leave it empty.



Now move to the 'TarFiles' folder, and run the following command. Note that the output folder should not be there. It will be created in run time.

```
$ hadoop jar temp.jar DF ./../Wikipedia-articles/full/ ./output/full
```

The output can be found in the file **part-r-00000 (**at location 'TarFiles/output/full'**)**.

Code Explanation:

We have the following code in the main function:

```
public static void main(String[] args) throws Exception {

    Configuration conf = new Configuration();
    Job job = Job.getInstance(conf, "df");

    job.setMapperClass(TokenizerMapper.class);
    // job.setCombinerClass(IntSumReducer.class); // enable to use 'local
    // aggregation'
    job.setReducerClass(IntSumReducer.class);

    job.setInputFormatClass(DFInputFormat.class);
    // job.setInputFormatClass(DFInputFormat.class);

    job.setOutputKeyClass(Text.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);
}
```

Instances of configuration and jobs are created. As we are reading the entire document, and it must not get divided we need to use some custom class. They are the following:

```
@Override
protected boolean isSplitable(JobContext context, Path file) {
    return false;
}

@Override
public RecordReader<IntWritable, Text> createRecordReader(
        InputSplit split, TaskAttemptContext context) throws IOException,
        InterruptedException {
    DFRecordReader reader = new DFRecordReader();
    reader.initialize(split, context);
    return reader;
}
```

Notice isSplitable() returns false. And we return the CustomRecordReader.

Take the document as Text and store the words in the set after stemming them. And remove the unnecessary words like number, empty string, stop words, etc. pass the stemmed words in form of a (key,value) i.e. (word,1)

```
@Override
public void map(Object key, Text value, Context context) throws IOException, InterruptedException {
    String line = value.toString();
    String[] tokens = line.split("[^\\w']+");

    PorterStemmer steammer = new PorterStemmer();
    for (int i = 0; i < tokens.length; i++)
        tokens[i] = steammer.stem(tokens[i]).toString();

    StopWords st = new StopWords();
    HashSet<String> words = st.words;

    HashSet<String> set = new HashSet<>();

    for (String token : tokens) {
        if (!(set.contains(token) || words.contains(token.toLowerCase()) || token.equals(""))) {
            set.add(token);
            word.set(token);
            context.write(word, one); // context is like the output
        }
    }
}
```

Below is the reducer that sums the value with the same key.

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

    @Override
    public void reduce(Text key, Iterable<IntWritable> values, Context context)
            throws IOException, InterruptedException {
        int sum = 0;
        for (IntWritable val : values) {
            sum += val.get();
        }
        result.set(sum);
        context.write(key, result);
    }
}
```

Solution for 2.2

How to Run the code:

Steps remain the same, just the hadoop commands need to be modified, which is the following for test files:

```
$ hadoop jar temp_2.jar TFIDF ./../Wikipedia-articles/test/ ./output/secondtest/
./../TarFiles/output/secondtest/part-r-00000  ./output/secondsectest
```

There should be no folder in output directory with names: **secondtest** and **secondsectest**.

Run the following command for running it on the entire set.

```
$ hadoop jar temp_2.jar TFIDF ./../Wikipedia-articles/full/ ./output/secondfull/
./../TarFiles/output/secondfull/part-r-00000  ./output/secondsecfull
```

Code Explanation:

We have the following code in the main function:

```
public static void main(String[] args) throws Exception
{
    Configuration conf = new Configuration();

    Job job0 = Job.getInstance(conf, "MR TF");

    job0.addCacheFile(new URI("/Users/architsangal/Data/College/Semester/NoSQL/Assignment/Assignment_2/Hadoop-NLP/TarFiles/output/full/part-r-00000"));

    job0.setInputFormatClass(DFInputFormat.class);

    job0.setMapperClass(MapTF.class);
    job0.setReducerClass(ReduceTF.class);

    job0.setOutputKeyClass(Text.class);
    job0.setOutputValueClass(MapWritable.class);

    job0.setOutputFormatClass(TextOutputFormat.class);

    FileInputFormat.setInputPaths(job0, new Path(args[0]));
    FileOutputFormat.setOutputPath(job0, new Path(args[1]));

    ////////////////////
    Configuration conf1 = new Configuration();
    Job job1 = Job.getInstance(conf1, "Stripes");

    job1.addCacheFile(new URI("/Users/architsangal/Data/College/Semester/NoSQL/Assignment/Assignment_2/Hadoop-NLP/TarFiles/output/full/part-r-00000"));

    job1.setMapperClass(Map.class);
    job1.setReducerClass(Reduce.class);

    job1.setOutputKeyClass(Text.class);
    job1.setOutputValueClass(Text.class);

    FileInputFormat.setInputPaths(job1, new Path(args[2]));
    FileOutputFormat.setOutputPath(job1, new Path(args[3]));

    ////////////////////

    if(job0.waitForCompletion(true))
        System.exit(job1.waitForCompletion(true) ? 0 : 1);


}
```

So we have two jobs here:

1. For finding TF
2. For finding the Score using DF (imported from the previous part 2.1 i.e. **TarFiles/output/full/part-r-00000**) and TF.

The 2 jobs need to be cascaded in nature. Hence, we have that last if condition.

2.2.1 Finding TF

We have a class Top which stores the top DF words using setup() of the mapper class of the TF. It takes the cached files and takes the input. It does some preprocessing on the data and choose top 100 words.

```java
@Override
public void setup(Context context) throws IOException, InterruptedException
{
    if(Top.initialized)
    {
        return;
    }
    // Load DF values from the cached file into a main-memory data structure
    URI[] cacheFiles = context.getCacheFiles();
    if (cacheFiles != null && cacheFiles.length > 0) {
        try
        {
            HashMap<Integer,ArrayList<String>> map = new HashMap<Integer,ArrayList<String>>();
            PriorityQueue<Integer> pq = new PriorityQueue<>(Collections.reverseOrder());

            BufferedReader bufferedReader = new BufferedReader(new FileReader(cacheFiles[0].toString()));
            String line;
            while ((line = bufferedReader.readLine()) != null)
            {
                String[] words = line.trim().split("\t");
                String val = words[0];
                int DF = Integer.parseInt(words[1]);
                pq.add(DF);
                if(map.containsKey(DF))
                    map.get(DF).add(val);
                else
                {
                    map.put(DF, new ArrayList<String>());
                    map.get(DF).add(val);
                }

                  System.out.println(val + " " + DF);
            }

            Top obj = new Top();

            bufferedReader.close();

            int count = 0;
            ArrayList<String> answer = new ArrayList<String>();
            ArrayList<Integer> df = new ArrayList<Integer>();
            while(count<=100)
            {
                int DF = pq.remove();
                try
                {
                    Integer.parseInt(map.get(DF).get(0));
                }
                catch(Exception e)
                {
                    answer.add(map.get(DF).get(0));
                    System.out.print("\"" + map.get(DF).get(0) + "\",");
                    df.add(DF);
                    Top.newtop(map.get(DF).get(0));
                    Top.newfreq(DF);
                    count++;
                }
                map.get(DF).remove(0);
            }

            System.out.println();
            for(int DF : df)
            {
                System.out.print(DF + ",");
            }
        } catch (Exception e) {
            System.out.println("Error while reading cache : " + e.toString());
            System.exit(1);
        }
    }
}
```

Below is the code of the map function.It takes the words of the document (here also we use the custom class for taking the entire document as input). Takes the words from the document and stems it compare it to DF. If the word is there in top DF then put it in a map which act like a stripes.

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

        String line = value.toString();
        String[] tokens = line.split("[^\\w']+");

        PorterStemmer steammer = new PorterStemmer();
        for (int i = 0; i < tokens.length; i++)
            tokens[i] = steammer.stem(tokens[i]).toString();
        int[] freq = new int[100];
        Top obj = new Top();
        String[] top = obj.top;
        for(String token : tokens)
        {
            for(int i=0;i<100;i++)
            {
                if(token.equals(top[i]))
                {
                    freq[i]++;
                }
            }
        }

        MapWritable map = new MapWritable();
        for(int i=0;i<100;i++)
        {
            map.put(new Text(top[i]),new LongWritable(freq[i]));
        }

        context.write(new Text(key.toString()), map);
    }
}
```

Just store the key and value as output.

```
 public static class ReduceTF extends Reducer<Text, MapWritable, Text, Text>
 {

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

         for (MapWritable value : values)
         {
             for(MapWritable.Entry<Writable, Writable> e : value.entrySet())
             {
                 System.out.println(key.toString());
                 context.write(new Text(key.toString()+"\t"+e.getKey().toString()),new Text(e.getValue().toString()));
             }

         }
     }
 }
```

The above was a map reduce for finding the TF. Now we have a map reduce for finding the score. Each line of the output of the previous line is a key,value pair for us in the mapper. Mapper does some preprocessing and passes the key and value to a reducer.

```
public static class Map extends Mapper<Object, Text, Text, Text>
{
    @Override
    public void map(Object key, Text value, Context context) throws IOException, InterruptedException
    {

        String line = value.toString();
        String[] tokens = line.split("\t",-1);

        context.write(new Text(tokens[0]+"\t"+tokens[1]), new Text(tokens[2]));
    }
}
```

Reducer calculates the score using the TF and DF already cached or passed from map. And store the final output.

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