Student Guide for CS4225/CS5425 Coding Assignment

1 Overview

Getting your hands dirty is always an effective way of learning big data systems. It can be a tough and challenging process, but it will also be a fruitful experience. Let's start from here.

In this student guide, we present the setup that you need to do before Assignments 1 and 2. To minimize the difficulty in installing and configuring Hadoop / Spark under different local environments, we recommend skipping Step 1 and only using the SoC cluster to test your code, as it has Hadoop and Spark already installed for you.

- Step 1 (Optional): You may try to set up a local environment for Hadoop and Spark. This step is not necessary for assignments, in which we will use the SoC cluster as a unified environment.
- Step 2: Test and build your programs in SoC cluster. **We will grade your submission in this environment.** The environment here is similar to cloud environments on public providers. To write your code, you can either edit directly on the clusters using a text editor like vim (https://en.wikipedia.org/wiki/Vim_(text_editor)), or write your code locally using an IDE like IntelliJ IDEA (or other IDE / text editor of your choice), then transfer the files to the cluster for testing using scp (see section 5.2 of this guide or https://linuxize.com/post/how-to-use-scp-command-to-securely-transfer-files/), or a file transfer software like WinSCP / Cyberduck. This involves the following sub-steps.
    - Step 2.1: Login to SoC Clusters. If you do not have an SoC account, you need to create one. See more details in Section 3 of this guide.
    - Step 2.2: Configure the environments for Hadoop and Spark.
    - Step 2.3: You should be able to run simple programs on Hadoop and Spark. Cheers!

2 Local Environment Setup (Optional)

In case you prefer to test your code locally or for the benefit of future projects, we provide guidelines to help you setup debug environments locally. We recommend IntelliJ IDEA 2020.1 as IDE, on which this section is based. For this assignment, this section is optional and only for reference, as you can also choose to debug and test solely on the cluster. You can also choose other IDEs based on your preference.

To do this, follow the guides in subsection 2.1-2.3 based on your operating system.

2.1 Windows 10

a) Install Java 11

Please follow this tutorial to install Java 11 on Windows

https://java.tutorials24x7.com/blog/how-to-install-java-11-on-windows. You should also ensure all the environmental variables of Java are set properly (as the tutorial).

b) Install Hadoop

Download Hadoop 3.3.0 from https://archive.apache.org/dist/hadoop/common/hadoop-3.3.0/ Unzip to a directory, e.g. `C:\\Program Files\hadoop-3.3.0`. You do not need to run the installer.

However, this package does not contain some windows native required components. Download these components from https://github.com/kontext-tech/winutils, then unzip and copy the whole directory `hadoop-3.3.0/bin` to your installation path of Hadoop , e.g. `C:\\Program Files\hadoop-3.3.0`. When conflict happens, choose to replace all conflict files Also, copy `hadoop-3.3.0/bin/hadoop.dll` to `C:\Windows\System32`.

c) Configure environment variables for Hadoop

Open file explorer (by Press `Ctrl+E`). Right click "`This PC`", choose

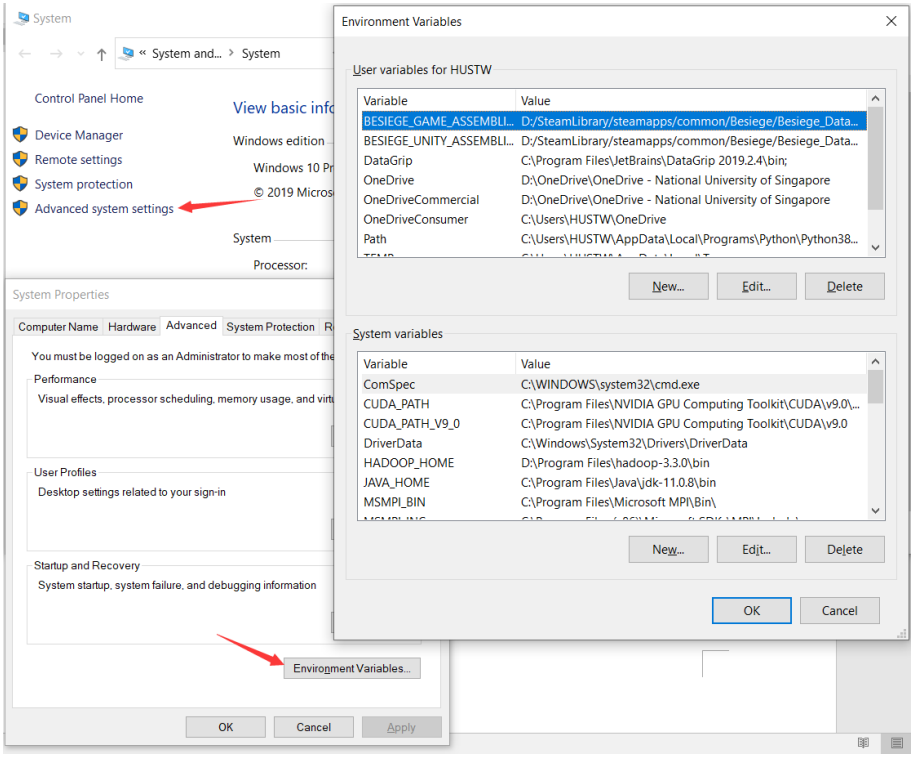
"properties". In the popup window, click "Advanced System Settings", then click "Environment Variables". In "system variables", create 2 new system variables by "New…".

```
HADOOP_HOME          D:\Program Files\hadoop-3.3.0 <Your Path>
HADOOP_BIN_PATH      %HADOOP_HOME%\bin
```

HADOOP_BIN_PATH	%HADOOP_HOME%\bin
HADOOP_HOME	D:\Program Files\hadoop-3.3.0

In User variables, edit "PATH" variable by adding %HADOOP_HOME%\bin and %HADOOP_HOME%\sbin.

Click "OK", "OK", "OK" to save the changes. It should take effect immediately.

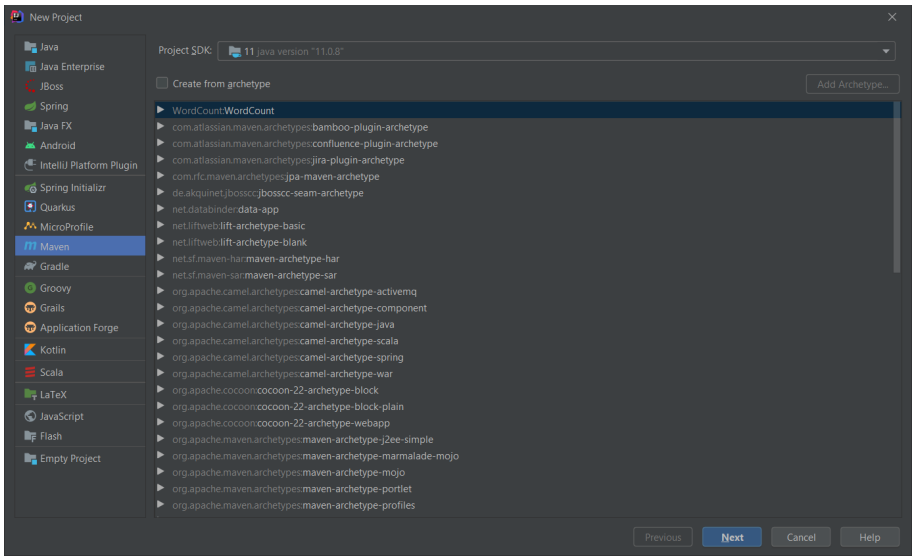


d) Install IntelliJ IDEA

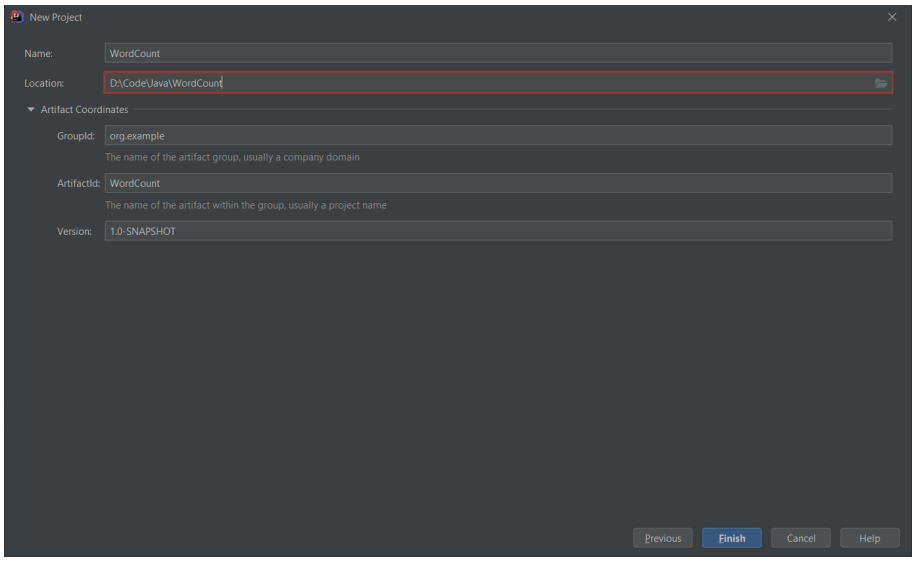
Download latest IntelliJ IDEA from https://www.jetbrains.com/idea/download/#section=windows and install it.

e) Configure IDEA with Hadoop

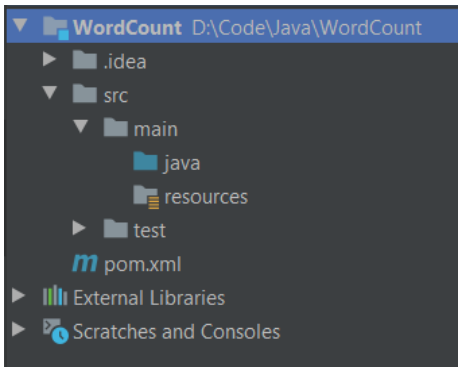
Create Maven project by "File → New → Project → Maven".



Then, click "`Next`", enter project `WordCount`. Click "Artifact Coordinates", enter information like the below figure.



Click `Finish` to create the project. Your project structure should look like this.

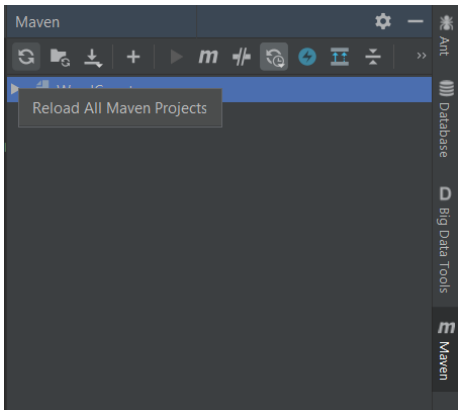


To prevent an error, add the following lines to `pom.xml`.

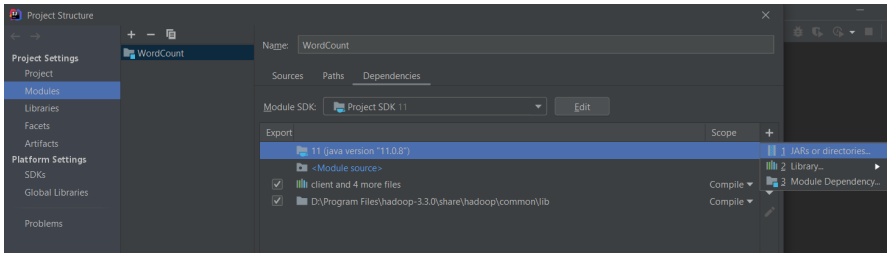
```
<properties>
```

```
    <maven.compiler.source>1.8</maven.compiler.source>
    <maven.compiler.target>1.8</maven.compiler.target>
</properties>
```

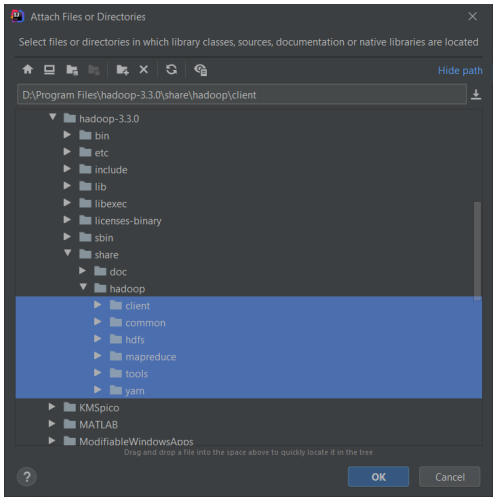
Then reload all maven projects

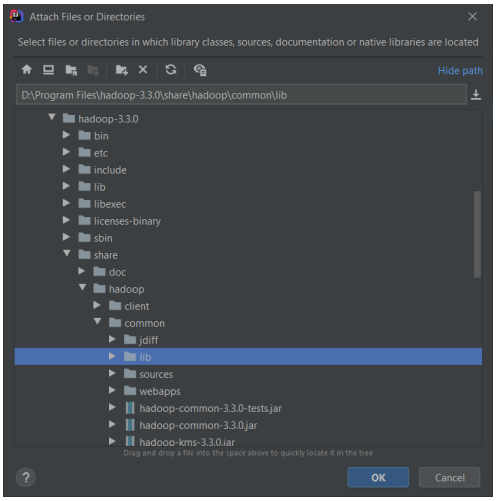


Then add Hadoop dependencies by `File → Project Structure → Modules → Dependencies`. Click "`+ → JARS or directories`"

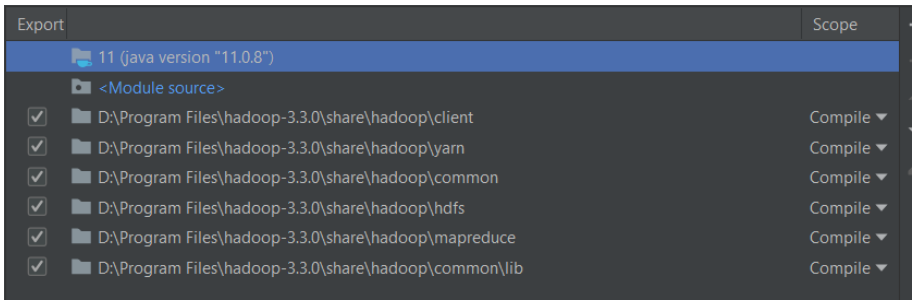


Add the following directories as dependencies.

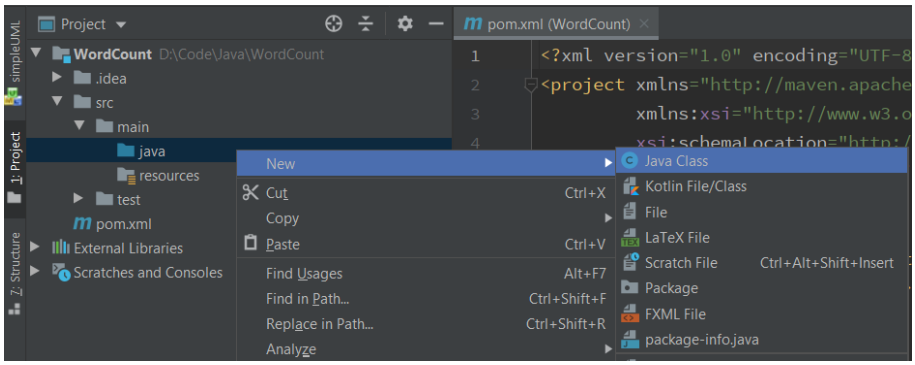




After that, the dependencies should look like this. Then click "`OK`".



Create a java class file `WordCount.java` like below



Download `assign0_hadoop_test` from Luminus or from the cluster (see subsection 5.2). Find example codes `WordCount.java` in the package. Copy the content of `WordCount.java` in that file. Then create a directory `input` and two text files in the directory `file0.txt` and `file1.txt`. Their contents are as below.

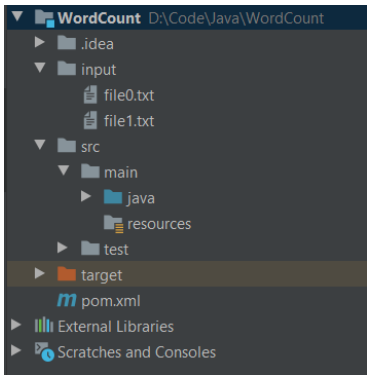
(input/file0.txt)

```
Hello World Bye World
```

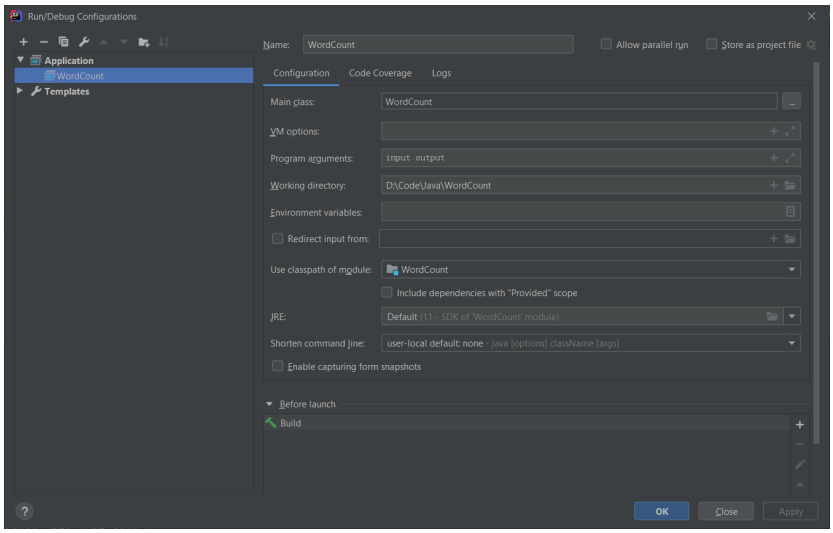
(input/file1.txt)

```
Hello Hadoop Goodbye Hadoop
```

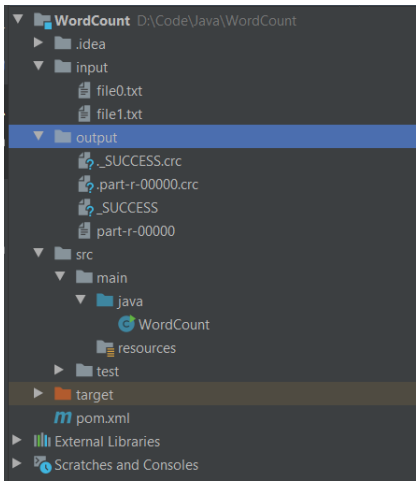
The directory structure should look like this now.



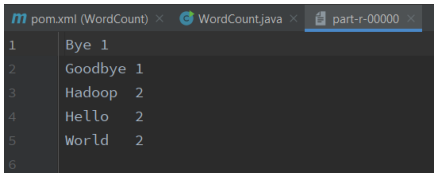
Then click "Add configurations" on right top. In the popup window, click "`+ → Application`". Configure as below.



Then click `OK`. Click the green triangular button "`run`" to run the program. After it finishes, the project structure will contain a new folder `output`.



`output/part-r-00000` contains the result of word count.



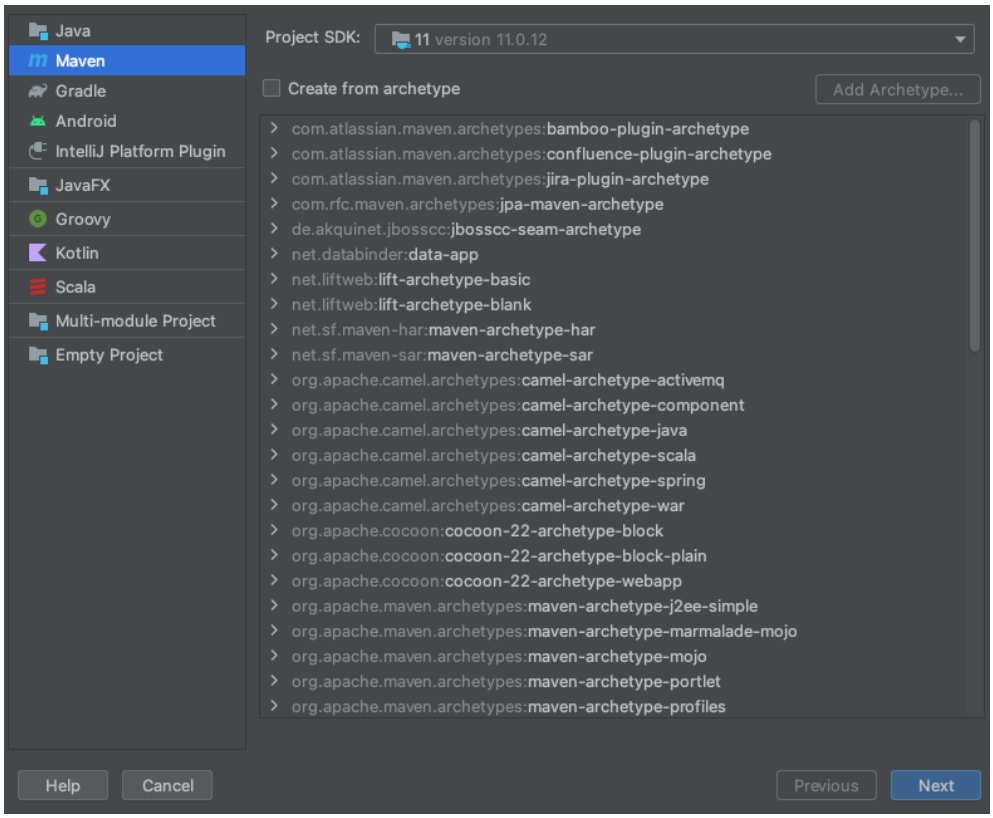
You can also click to debug button to debug your program. IntelliJ IDEA is a very powerful IDE. Enjoy exploring.

f) Install Spark

Download Spark 3.0.0 from https://archive.apache.org/dist/spark/spark-3.0.0. Select spark-3.0.0.tgz, download it, and extract it with 7zip or other decompression software to your installation path of Spark, e.g. C:\\Program Files\spark-3.0.0.

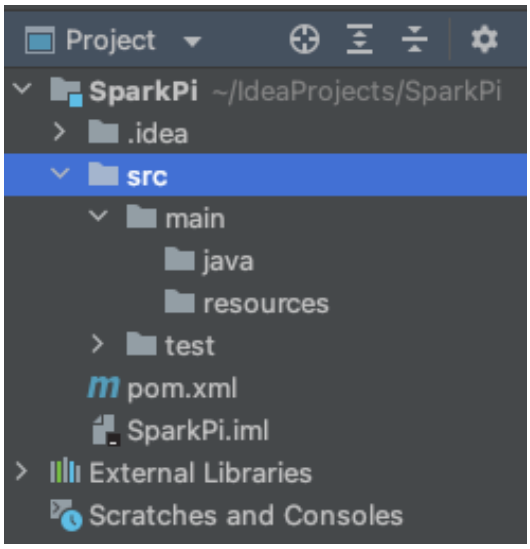
g) Configure IDEA with Spark

Create Maven project by "`File → New → Project → Maven`".



Then, click "`Next`", name the project `SparkPi` and click Next.

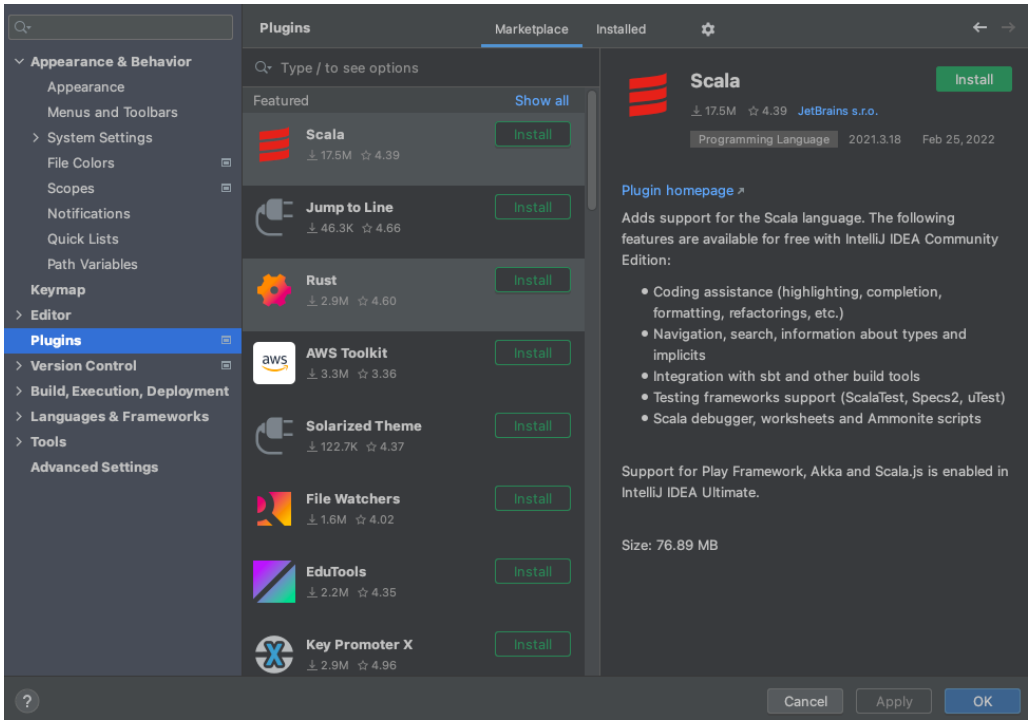
Then click Finish to create the project. Your project structure should look like this:



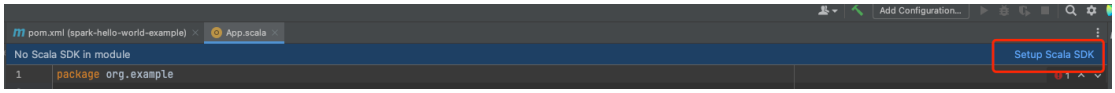
Now we need to install scala plugin. Navigate to File > Settings

Select the Plugins option from the left panel. This brings you Feature panel.

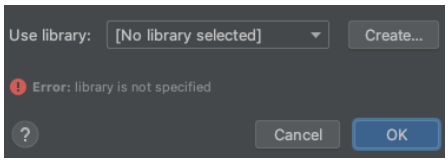
Click on Install to install the Scala plugin.



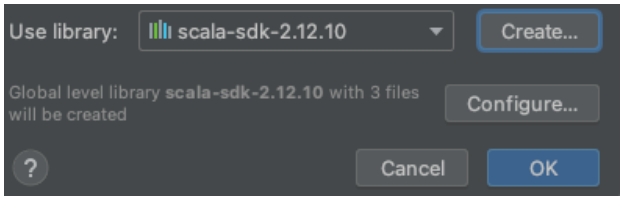
After that, IntelliJ will prompt you as shown below to Setup Scala SDK (You may need to restart the IntelliJ).



Select Setup Scala SDK, it prompts you the below window, select the create option.

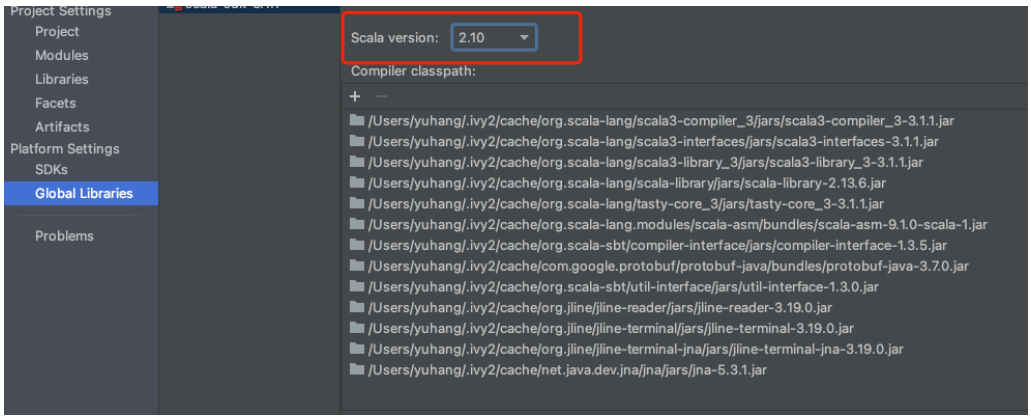


From the next window select the Download option and choose the Scala version 2.12.10. You should see the following window and click OK.

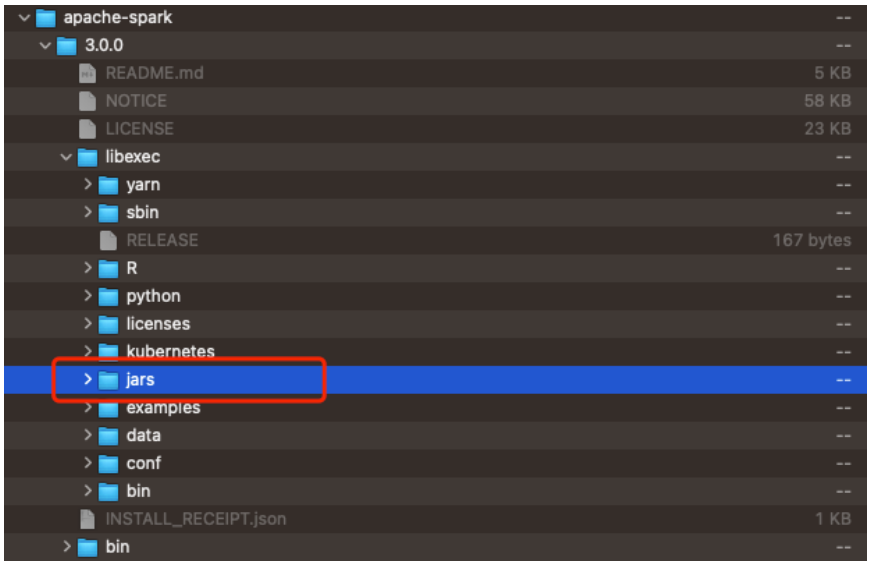


You can also choose the scala version by "`File → Project Structure →`

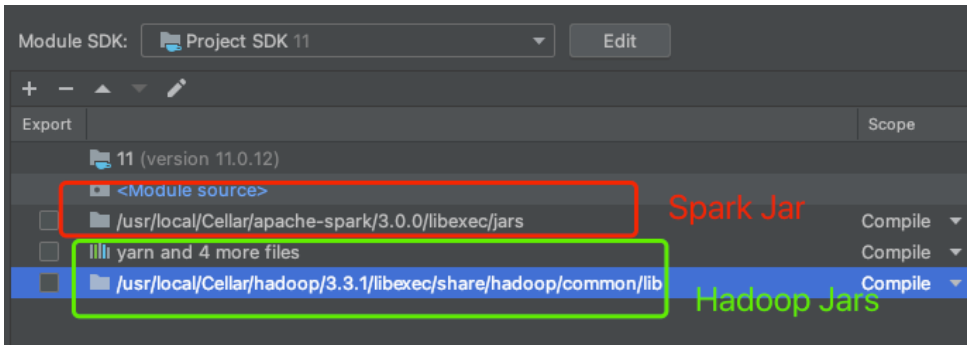
`Global Libraries`".



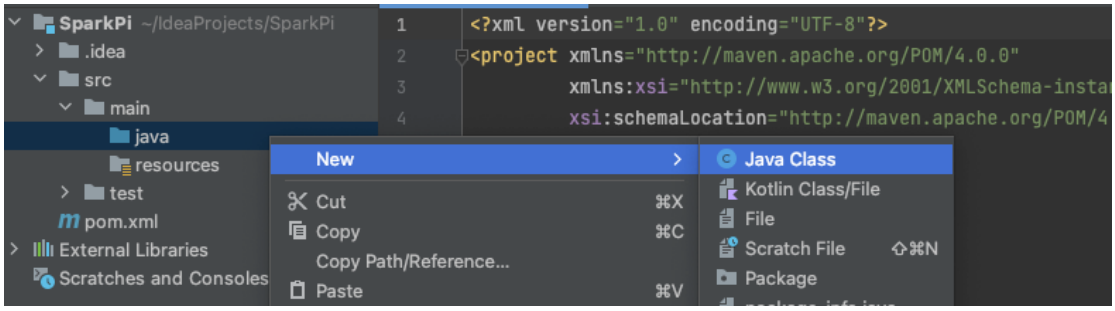
Then add Spark dependencies by `File → Project Structure → Modules → Dependencies`. Click "`+ → JARS or directories`". Then add the following directory as dependency.



Then add same Hadoop dependencies as Section 2.1.e). You should put Spark dependency ahead of Hadoop dependencies. You may also import dependencies graphframes or spark-xml for your assignment2, you need to import them after the Hadoop dependencies.



Create a java class file `SparkPi.java` like below

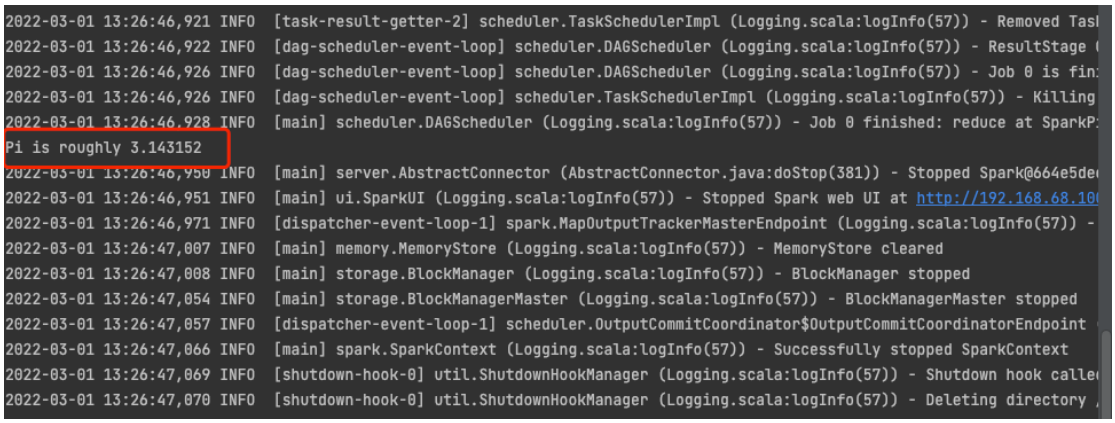


Then paste the following code into the java file.

```
import org.apache.spark.SparkConf;
import org.apache.spark.api.java.JavaRDD;
import org.apache.spark.api.java.JavaSparkContext;
import org.apache.spark.api.java.function.Function;
import org.apache.spark.api.java.function.Function2;

import java.util.ArrayList;
import java.util.List;

/**
 * Computes an approximation to pi
 * Usage: JavaSparkPi [slices]
 * https://github.com/apache/spark/blob/master/pom.xml
 */
public final class SparkPi {

    static boolean runOnCluster = false;

    public static void main(String[] args) throws Exception {
        SparkConf sparkConf = new SparkConf().setAppName("SparkPi");
        int slices = 0;
        JavaSparkContext jsc = null;
        if (!runOnCluster) {
```

```
            sparkConf.setMaster("local[2]");
            sparkConf
                    .setJars(new String[] { "target/eduonix_spark-deploy.jar" });
            slices = 10;
            jsc = new JavaSparkContext(sparkConf);
        } else {
            slices = (args.length == 1) ? Integer.parseInt(args[0]) : 2;
            jsc = new JavaSparkContext(sparkConf);
        }

        int n = 100000 * slices;
        List<Integer> l = new ArrayList<Integer>(n);
        for (int i = 0; i < n; i++) {
            l.add(i);
        }

        JavaRDD<Integer> dataSet = jsc.parallelize(l, slices);

        int count = dataSet.map(new Function<Integer, Integer>() {
            @Override
            public Integer call(Integer integer) {
                double x = Math.random() * 2 - 1;
                double y = Math.random() * 2 - 1;
                return (x * x + y * y < 1) ? 1 : 0;
            }
        }).reduce(new Function2<Integer, Integer, Integer>() {
            @Override
            public Integer call(Integer integer, Integer integer2) {
                return integer + integer2;
            }
        });

        System.out.println("Pi is roughly " + 4.0 * count / n);

        jsc.stop();
    }
}
```

Then you can build and run your project, it should output an estimation value of Pi.



2.2 Linux

a) Install Java 11

There are a lot of tutorials about installing Java 11, you can choose one based on your Linux distribution.

- Ubuntu: http://ubuntuhandbook.org/index.php/2018/11/how-to-install-oracle-java-11-in-ubuntu-18-04-18-10/
- CentOS: https://linuxhint.com/install_oracle_jdk11_centos7/
- Arch Linux: https://wiki.archlinux.org/index.php/Java
- Fedora: https://www.tecmint.com/install-java-in-fedora/

After installation, check your java version by following command

```
$ java -version
openjdk version "11" 2018-09-25
OpenJDK Runtime Environment 18.9 (build 11+28)
OpenJDK 64-Bit Server VM 18.9 (build 11+28, mixed mode)
```

You should ensure the JDK version is 11. The implementation could be either OpenJDK or Oracle JDK. Meanwhile, remember the path where your install java, e.g. `/usr/lib/java`. Add an environmental variable `JAVA_HOME` by

```
$ echo 'export JAVA_HOME=/usr/lib/java' >> ~/.bash_profile
$ source ~/.bash_profile
```

You can check if successful by

```
$ echo $JAVA_HOME
/usr/lib/java
```

Note: Do not simply copy the commands. You need to check your installation path first.

b) Install Hadoop

Download Hadoop 3.3.0

```
$ wget https://archive.apache.org/dist/hadoop/common/hadoop-3.3.0/hadoop-3.3.0.tar.gz
$ tar xzvf hadoop-3.3.0.tar.gz
```

Configure java path for Hadoop: recall the path where you install java in a), e.g. `/usr/lib/java`. Edit `hadoop-3.3.0/etc/hadoop/hadoop-env.sh`. Find `export JAVA_HOME=`, and change this line to `export JAVA_HOME=/usr/bin/java`.

Note: Do not simply copy the commands. You need to check your installation path first.

c) Install Spark

Download Spark 3.0.0

```
$ wget https://archive.apache.org/dist/spark/spark-3.0.0/spark-3.0.0-bin-hadoop3.2.tgz
$ tar xvf spark-*
```

d) Install IntelliJ IDEA

Download latest IntelliJ IDEA from (Ultimate is free for NUS students, Community is enough for this module)

https://www.jetbrains.com/idea/download/#section=linux

Unzip the file

```
$ tar xzvf ideaIC-2020.2.tar.gz
```

run IDEA by

```
$ cd ideaIC-2020.2
$ bin/idea.sh
```

e) Configure IDEA with Hadoop and Spark

This part is exactly the same as that on Windows 10. Please refer to that subsection.

2.3 MacOS

a) Install Java 11

Follow the guide of Linux in section 2.2 a).

b) Install Hadoop

You can install via brew. Simply run

```
brew install Hadoop
```

Make sure your installed version is `3.3.0`. You can also install as the Linux guide in section 2.2 b).

Configure java path for Hadoop, recall the path where you install java in a), e.g. `/usr/lib/java`. Edit `<hadoop-installation-path>/etc/hadoop/hadoop-env.sh`. Find `export JAVA_HOME=`, change this line to `export JAVA_HOME=<Java-installation-path>`.

Note: Do not simply copy the commands. You need to check your installation path first.

c) Install Spark

You can install via brew. Simply run

```
brew install apache-spark
```

Make sure your installed version is `3.0.0`. You can also install as the Linux guide in section 2.2 c).

Add the following environment variables to your .bash_profile or .zshrc:

```
export SPARK_HOME=/usr/local/Cellar/apache-spark/3.0.0/libexec
export PATH="$SPARK_HOME/bin/:$PATH"
```

spark Note: Do not simply copy the commands. You need to check your Spark path first.

d) Install IntelliJ IDEA

Download latest IntelliJ IDEA from (Ultimate is free for NUS students, Community is enough for this module)

https://www.jetbrains.com/idea/download/#section=mac

e) Configure IntelliJ IDEA

This part is exactly the same as that on Windows 10

f) Configure IDEA with Hadoop and Spark

Please refer to that subsection.

3 Login to SoC Clusters

This is required for all students who take this module since all the assignments will be run, submitted and graded on SoC clusters.

3.1 Create SoC account

All the students from SoC and students who take SoC modules can register a SoC account. Registration and enabling clusters are done on **'mySoC'**. For more details, please refer to the following link: https://dochub.comp.nus.edu.sg/cf/guides/compute-cluster/enable-disable-access .

3.2 Report SoC account

Please email Sixu Hu(e0409758@u.nus.edu) or Yuhang Chen(e0546081@u.nus.edu) if you cannot access the SoC Cluster. No report is required if your account is created before/on that date.

3.3 Login to SoC Cluster

If you are connecting to SoC network, you can connect to `xcnd<20-59>.comp.nus.edu.sg` directly via ssh. We have divided all student into 4 different cluster, each cluster can only access its own 10 nodes. For example, if you are in cluster 1, you can only access xcnd20-xcnd29, you can find your cluster number using the follow google sheet link: https://docs.google.com/spreadsheets/d/1CYQq56ymiV6N1k7MgBA4ezwS9QjVDmrutc2N3lAFZ0A/edit#gid=0 . For load balancing purposes, try to choose one of these nodes randomly, or one that is less occupied.

Take studentA's xcnd26 account as an example.

```
$ ssh studentA@xcnd26.comp.nus.edu.sg
```

You have two ways to connect to SoC cluster: through a jump server or through NUS VPN. The second approach is only applicable for Windows and Mac users. For Linux users, please connect via jump server.

a) Jump Server Solution

Suppose your soc ID is "studentA", open a terminal, type

```
$ ssh studentA@sunfire.comp.nus.edu.sg
```

and return. Then input your soc account password, and then you should successfully

connect to the jump server.

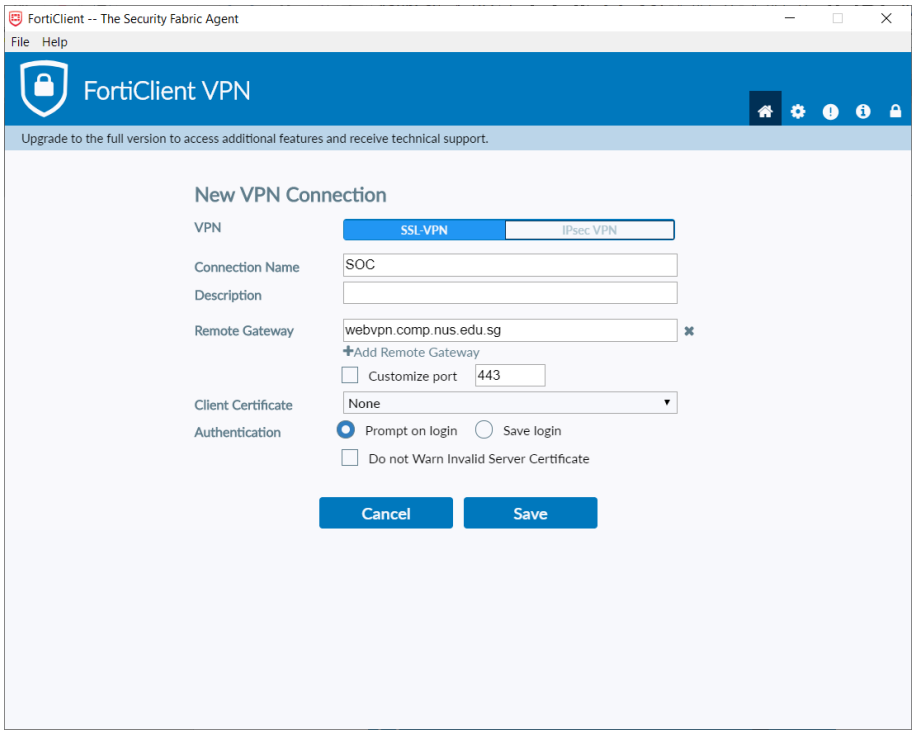
```
λ ssh zhaomin@sunfire.comp.nus.edu.sg
Password:
Last login: Tue Jul 28 14:37:50 2020 from sunfire-r.comp.
Last login: Tue Jul 28 14:37:50 2020 from sunfire-r.comp.
_________________________ANNOUNCEMENTS(common)_____________________________

DR3 & DR4: book at https://aces.nus.edu.sg/fbs/

Paying Your Print Quota: 24x7 @SoC Self Service Station.

Printing w/o banner: [psts/pstsb/pstsc/psc008/psc011]-nb

Printer: cptsc printer is down till further notice.

Due to COVID-19, all SoC MRs and DRs are closed temporarily.
_____________________________________________________________________________
Sun Microsystems Inc.   SunOS 5.10      Generic January 2005
You have 529 New mail(s) in your Inbox.
Last login on sunfire0.comp.nus.edu.sg at Tuesday, July 28, 2020 02:37:50 PM SGT
zhaomin@sunfire0:~[55]$
```

Then type `ssh xcnd26` (or any server xcnd26-29) on sunfire and return, then type your SoC account password. You will connect to one machine in SoC clusters.

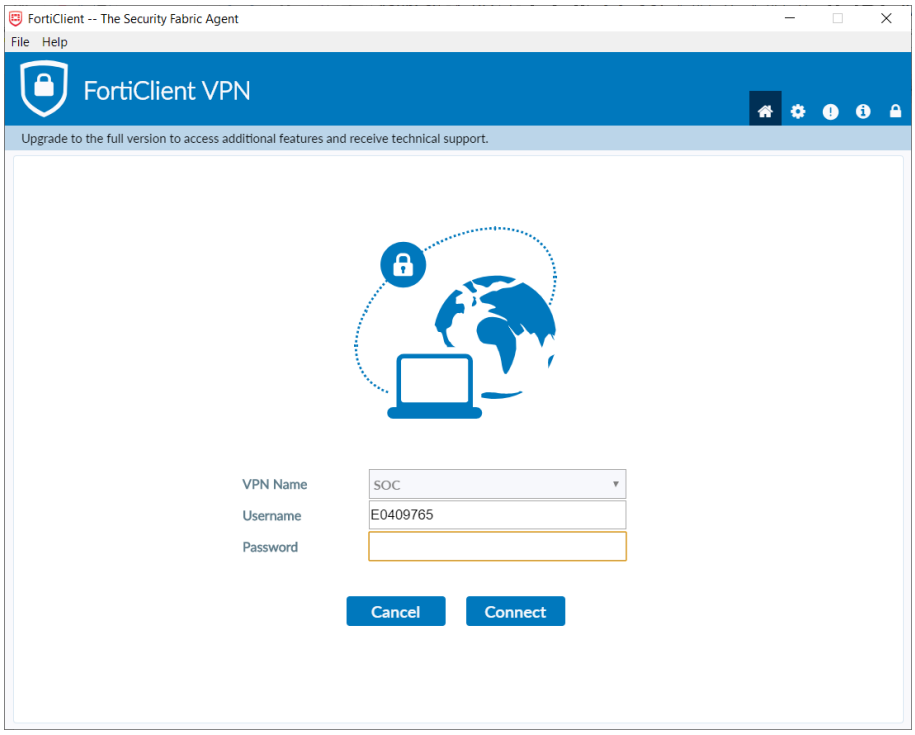
```
zhaomin@xcnd0's password:
Last login: Wed Aug  5 14:03:50 2020 from 192.168.26.35
_____________________________Important_Message_____________________________

CRYPTOCURRENCY MINING, PASSWORD CRACKING, NETWORK SCANNING prohibited.

NO BACKUP for homedirs. Please do OWN BACKUP. User homedir quota 500G.

LIST of hardware <https://dochub.comp.nus.edu.sg/cf/guides/compute-cluster/hardware>

USE /temp local-to-node storage for faster computation! Remember to SAVE your results!

Reserved till 15 Aug 2020: xgpd1

Reserved till 15 Aug 2020: xgpf8-9, xgpf11

Reserved till 31 Aug 2020: xgpe4, xgpf4

Reserved till 31 Aug 2020: xgpc1, xgpc4, xgpf5-6

Reserved till 31 Aug 2020: xgpc5-7

Reserved till 15 Nov 2020: cgpa0-3

Reserved till 5 Dec 2020: xgpe10-11 (CS4246/CS5446)

Offline: xcnb15, xgpa0, xgpb2

-----------------------------------------------------------------------------
zhaomin@xcnd0:~$
```

b) NUS VPN Solution

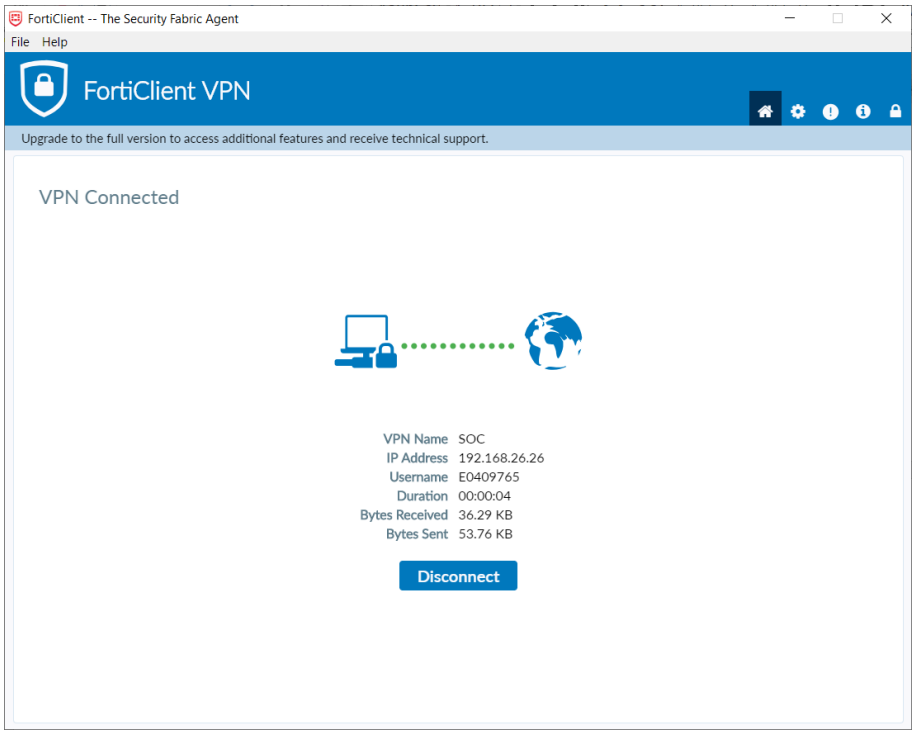
For Windows and Mac users, please download FortiClient VPN from the following link: https://webvpn.comp.nus.edu.sg/sslvpn/portal.html#/ . Then install and run FortiClient VPN on your laptop. After launching FortiClient, you should observe



Fill in the information as above, then click "Save", you should see



Choose "VPN Name" as "SOC", fill in your NUSNET ID and password, click "connect". After a few seconds, you should see the following information, which indicates successful connection.



After successfully connecting, suppose your soc account id is "studentA", open terminal and type `ssh studentA@xcnd0.comp.nus.edu.sg`. Then type your soc account password, then you will connect to one machine in SoC clusters.

```
zhaomin@xcnd0's password:
Last login: Wed Aug  5 14:03:50 2020 from 192.168.26.35
_____________________________Important_Message_____________________________

CRYPTOCURRENCY MINING, PASSWORD CRACKING, NETWORK SCANNING prohibited.

NO BACKUP for homedirs. Please do OWN BACKUP. User homedir quota 500G.

LIST of hardware <https://dochub.comp.nus.edu.sg/cf/guides/compute-cluster/hardware>

USE /temp local-to-node storage for faster computation! Remember to SAVE your results!

Reserved till 15 Aug 2020: xgpd1

Reserved till 15 Aug 2020: xgpf8-9, xgpf11

Reserved till 31 Aug 2020: xgpe4, xgpf4

Reserved till 31 Aug 2020: xgpc1, xgpc4, xgpf5-6

Reserved till 31 Aug 2020: xgpc5-7

Reserved till 15 Nov 2020: cgpa0-3

Reserved till 5 Dec 2020: xgpe10-11 (CS4246/CS5446)

Offline: xcnb15, xgpa0, xgpb2

------------------------------------------------------------------------------
zhaomin@xcnd0:~$
```

4 Configure Hadoop and Spark

Hadoop and spark have been already installed on the clusters. All you need to do is to run it. All the following procedures are done on clusters, e.g. `xcnd26`.

4.1 Modify Environmental Variables

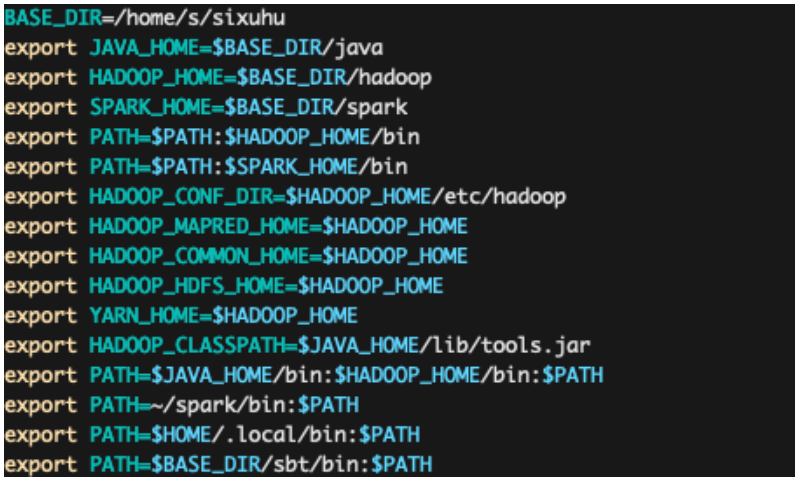
First open ~/.bash_profile by vim

```
$ vim ~/.bash_profile
```

Press `i` on keyboard to enter insert mode. Copy the following contents and paste at the end of the file. (Important: make sure you enter insert mode before pasting; otherwise, some characters will be missing when you paste).

```
BASE_DIR=/home/s/sixuhu
export JAVA_HOME=$BASE_DIR/java
export HADOOP_HOME=$BASE_DIR/hadoop
export SPARK_HOME=$BASE_DIR/spark
export PATH=$PATH:$HADOOP_HOME/bin
export PATH=$PATH:$SPARK_HOME/bin
export HADOOP_CONF_DIR=$HADOOP_HOME/etc/hadoop
export HADOOP_MAPRED_HOME=$HADOOP_HOME
export HADOOP_COMMON_HOME=$HADOOP_HOME
export HADOOP_HDFS_HOME=$HADOOP_HOME
export YARN_HOME=$HADOOP_HOME
export HADOOP_CLASSPATH=$JAVA_HOME/lib/tools.jar
export PATH=$JAVA_HOME/bin:$HADOOP_HOME/bin:$PATH
export PATH=~/spark/bin:$PATH
export PATH=$HOME/.local/bin:$PATH
export PATH=$BASE_DIR/sbt/bin:$PATH
```

You should see as follows.



Then press "ESC" on keyboard to exit insert mode. Type :wq and return to save and exit vim. For more Vim comments, please see https://www.fprintf.net/vimCheatSheet.html. After saved, run the following command in terminal.

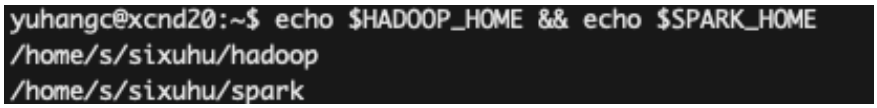
```
$ source ~/.bash_profile
```

4.2 Check Environmental Variables

To check if the environmental variables are correctly set, simply run the following command.

```
$ echo $HADOOP_HOME && echo $SPARK_HOME
```

If you get the following results, that means your configuration is successful.



5 Test Configuration

5.1 Test Spark

To test the availability of spark, simply run an example program of spark by

```
spark-submit --deploy-mode client --class
org.apache.spark.examples.SparkPi
$SPARK_HOME/examples/jars/spark-examples_2.12-3.0.0.jar
```

This program will estimate the value of π. After some calculation (few seconds to a minute), it should output the similar results to the following one.

```
(Many other outputs)
Pi is roughly 3.1350556752783763
2020-08-04 20:55:12,042 INFO server.AbstractConnector: Stopped
Spark@31f0ddb1{HTTP/1.1,[http/1.1]}{0.0.0.0:4040}
2020-08-04 20:55:12,049 INFO ui.SparkUI: Stopped Spark web UI
at http://xcnd0.comp.nus.edu.sg:4040 2020-08-04 20:55:12,055
INFO cluster.YarnClientSchedulerBackend: Interrupting monitor
thread
2020-08-04 20:55:12,083 INFO
cluster.YarnClientSchedulerBackend: Shutting down all
executors
2020-08-04 20:55:12,084 INFO
cluster.YarnSchedulerBackend$YarnDriverEndpoint: Asking each
executor to shut down
2020-08-04 20:55:12,091 INFO
cluster.YarnClientSchedulerBackend: YARN client scheduler
backend Stopped
2020-08-04 20:55:12,108 INFO
spark.MapOutputTrackerMasterEndpoint:
MapOutputTrackerMasterEndpoint stopped!
2020-08-04 20:55:12,135 INFO memory.MemoryStore: MemoryStore
cleared
2020-08-04 20:55:12,135 INFO storage.BlockManager:
BlockManager stopped
2020-08-04 20:55:12,145 INFO storage.BlockManagerMaster:
BlockManagerMaster stopped
2020-08-04 20:55:12,149 INFO
scheduler.OutputCommitCoordinator$OutputCommitCoordinatorEndpo
int: OutputCommitCoordinator stopped!
2020-08-04 20:55:12,212 INFO spark.SparkContext: Successfully
stopped SparkContext
2020-08-04 20:55:12,219 INFO util.ShutdownHookManager:
Shutdown hook called
```

```
2020-08-04 20:55:12,221 INFO util.ShutdownHookManager:
Deleting directory /tmp/spark-1dc8df74-cc87-465d-b4fd-
3ff6f54b00ef
2020-08-04 20:55:12,226 INFO util.ShutdownHookManager:
Deleting directory /tmp/spark-4fbed1cb-afe1-431f-b9d4-
94279a6266b9
```

5.2 Test Hadoop and Submission

In this subsection, we will go through the procedure of "a mock test" using assignment 0 (a simple test program, whose code is already fully written) for a real assignment, including downloading files, writing codes, running program and submitting. All the operations in this subsection are performed on the clusters.

a) Download Assignment Files

All required packages will be stored in `/home/y/yuhangc` on SoC clusters. You can download these files by simply copying them to your home directory. Type the following command in terminal and return.

```
$ cp -r /home/y/yuhangc/assign0_hadoop_test ~
```

Then you should find a new folder `assign0_hadoop_test` in your home directory.

Simply check by

```
$ ls assign0_hadoop_test
```

```
WordCount$IntSumReducer.class  WordCount$TokenizerMapper.class  WordCount.class  WordCount.j
ava  answer.txt  compile_run  file01.txt  file02.txt  readme  submit  wc.jar  wordcount
```

Alternatively, if you want to first write your codes locally, you can download assignment files from LumiNUS and upload to the server after you finished. The upload can be done by `scp`. With your (e.g. stuA's) NUS VPN connected, enter the folder which contains the directory you want to upload, and run this command on your own laptop

```
$ scp -r assign0_hadoop_test stuA@xcnd26.comp.nus.edu.sg:~
```

After finishing copying, you will find a new folder `assign0_hadoop_test` under your home directory on `xcnd26`. If you are using Linux and cannot connect to `xcnd26`, you can upload your submission to `sunfire` first and then upload to `xcnd26` by `scp`. To learn more about `scp`, please refer to: https://haydenjames.io/linux-securely-copy-files-using-scp/.

b) Write your code

For assignment 0, the code in `WordCount.java` is already written for you.

c) Compile and Run Your Codes

Enter that folder and call the scripts to automatically compile and run

```
$ cd ~/assign0_hadoop_test
$ ./compile_run
```

The script will compile and run `WordCount.java`, which counts the words in file01.txt and file02.txt. After a short calculation, you will see the following result.

```
Job finished. Print results.
Bye     1
Goodbye 1
Hadoop  2
Hello   2
World   2
Test passed.
```

The script will automatically compare your result to the answer. If the output is "Test Passed", that means your result is correct on the given dataset. Otherwise, it means that your result is incorrect and you need to double check your codes.

d) Submit

Once you have successfully tested using assignment 0, you can start on assignment 2. Similar to assignment 0, you can copy the files by

```
$ cp -r /home/y/yuhangc/assign2 ~
```

Then write your code in `FindPath.java` , and similar to assignment 0, use the `compile_run` to test your codes.

Once you have finished the assignment, you can submit your codes into the folder AssignmentSubmission/Assignment2 in Luminus. Do remember you can only modify and submit the file `FindPath.java`.

You are allowed to submit multiple times before the due date; your last submission will be graded. After due time, the submission folder will be locked and no more submission will be accepted.

Although Hadoop has load balancing itself, you are still recommended to choose a machine with less CPU consumption; i.e. replace xcnd26 with xcnd27, xcnd28 or xcnd29. You can check CPU and memory consumption by `htop`. In case you face issues with the clusters for some reason (e.g. if the clusters go down or becomes

excessively slow near the deadline), please email the TAs who will try to handle it (or extend the deadline if necessary).

6 Java OpenStreetMap Editor (Optional)

Java OpenStreetMap (JOSM) is an extensible editor for OpenStreetMap (OSM), you can use it to load the OSM files in assignment2.

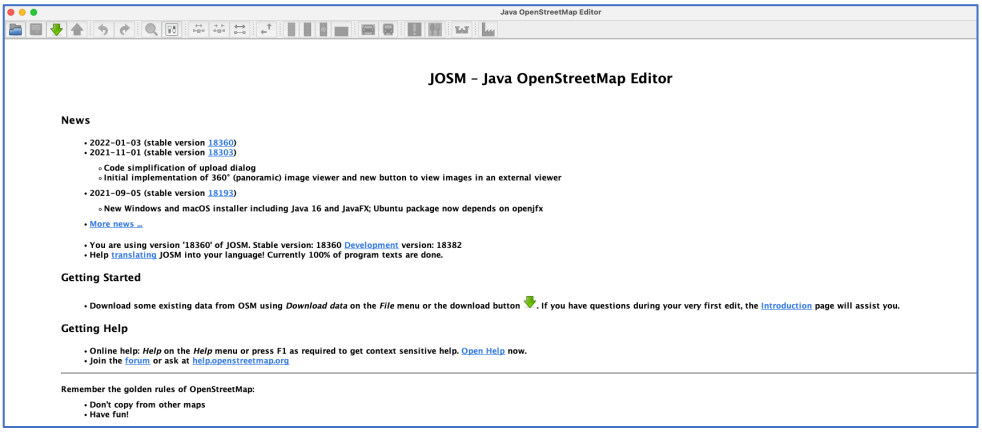
6.1 Download

Please refer to https://josm.openstreetmap.de/ to download and install the JOSM package based on your operating system.

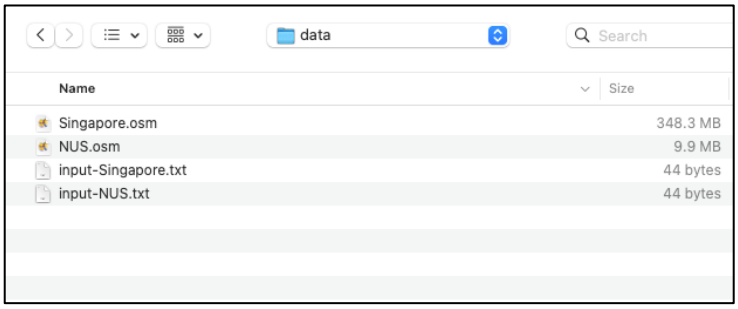
6.2 JOSM Basic Operations

a) Load OSM file

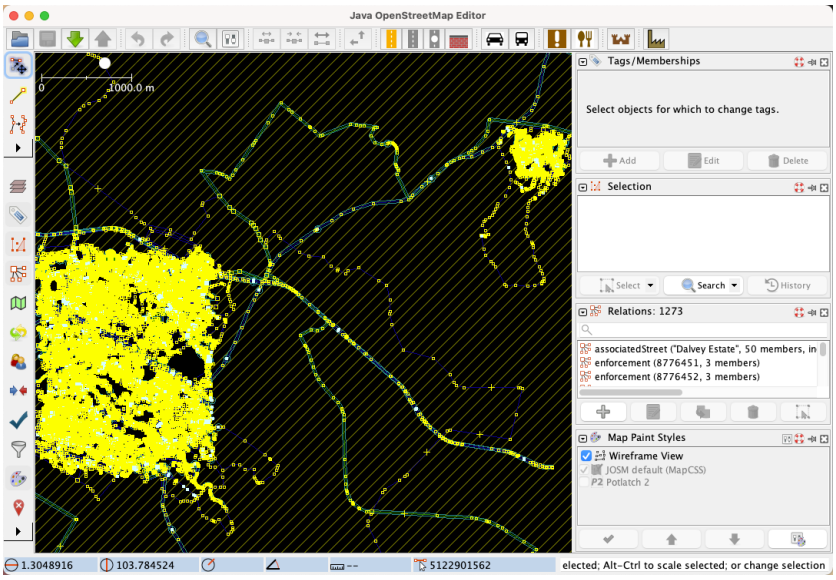
After you successfully install and launch the JOSM editor, you should observe



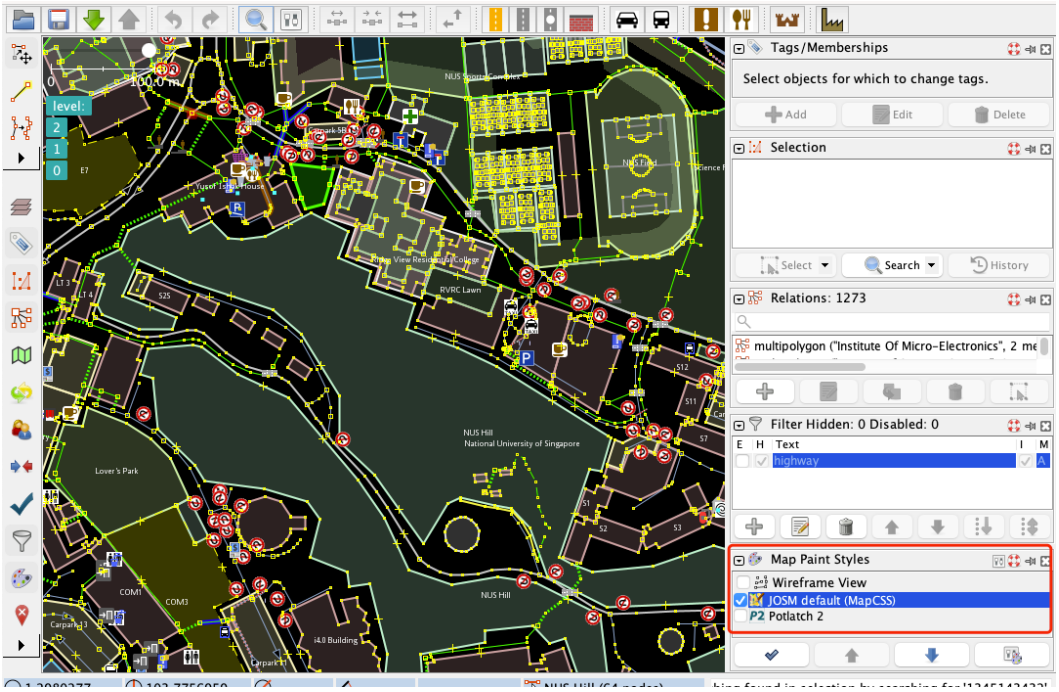
Then you can click `File → Open` to load an OSM file, for assignment2, you only need to use the file 'NUS.osm'.



If you successfully load the NUS roadmap, you should observe the map similar to:



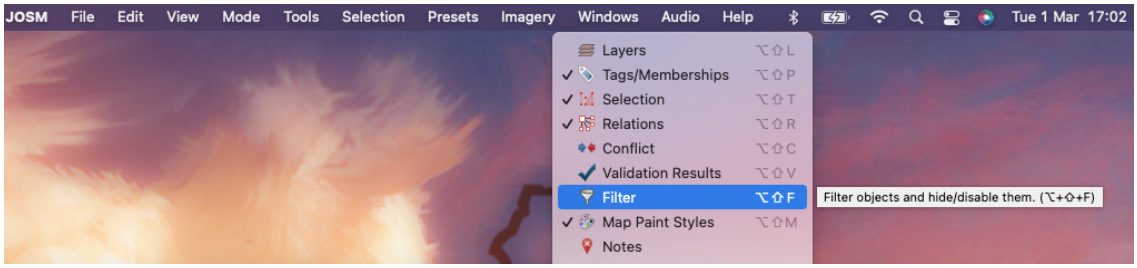
You can change the map paint styles for a better view.



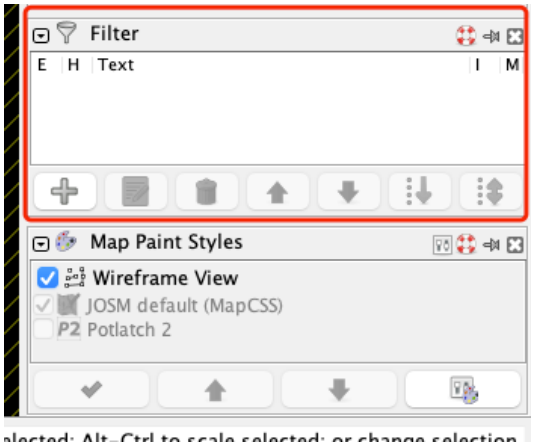
b) Filter and search in the map

For assignment2, we only care about the way with a highway tag, we can use the filter function to find those roads.

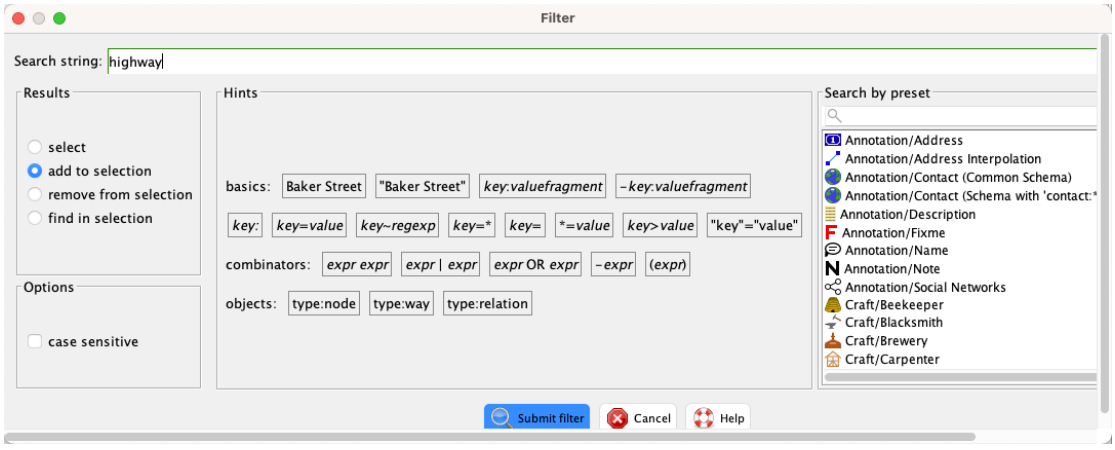
You can open the Filter window by clicking the `Windows → Filter`



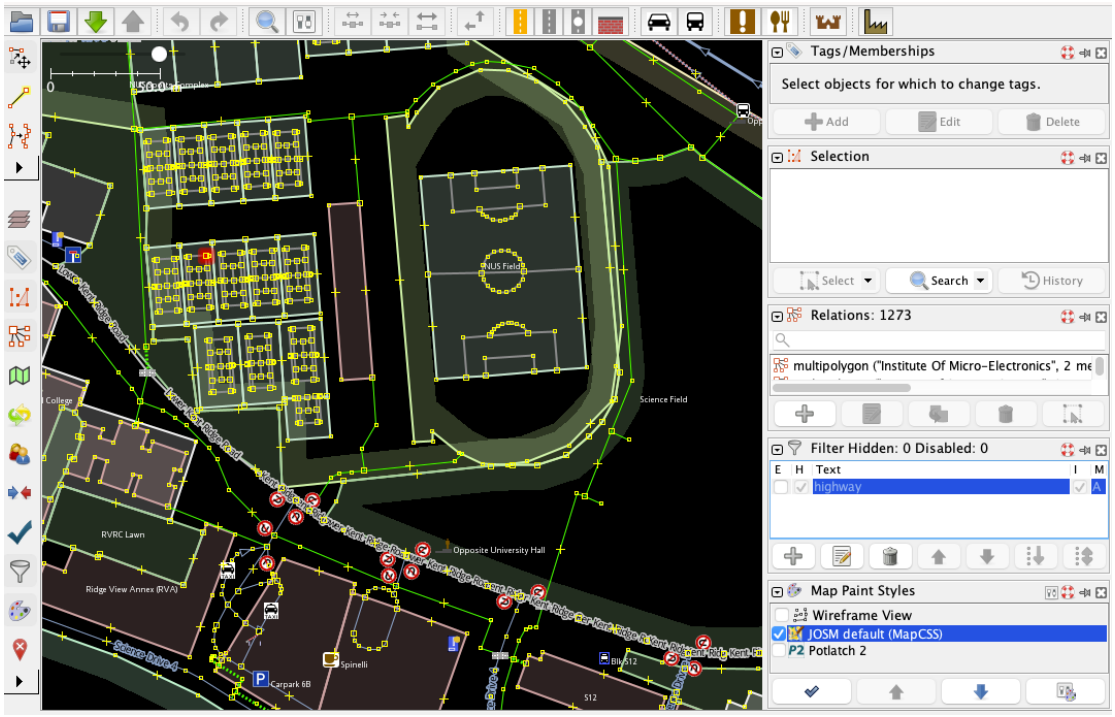
After that, you should be able to see the Filter window on the right side of the JOSM editor.



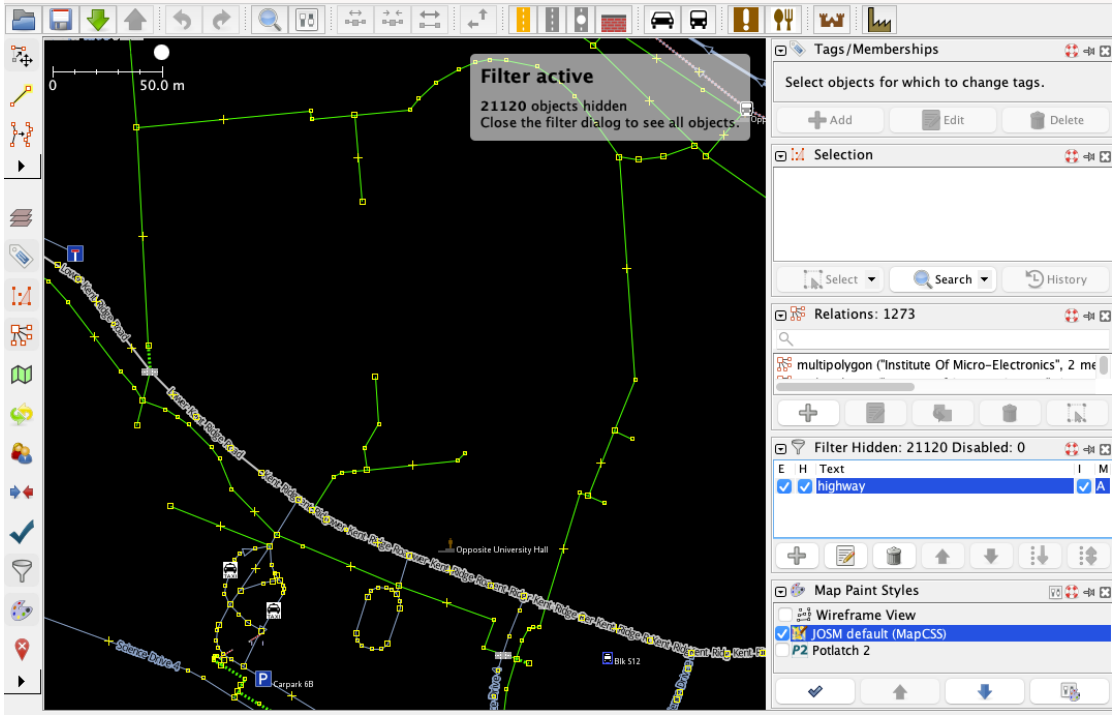
Then you can click the `'+'` symbol to add the filter string highway, then click the `Submit filter.`



After that, you should click all the check box in the filter window to only show the roads with highway tag.

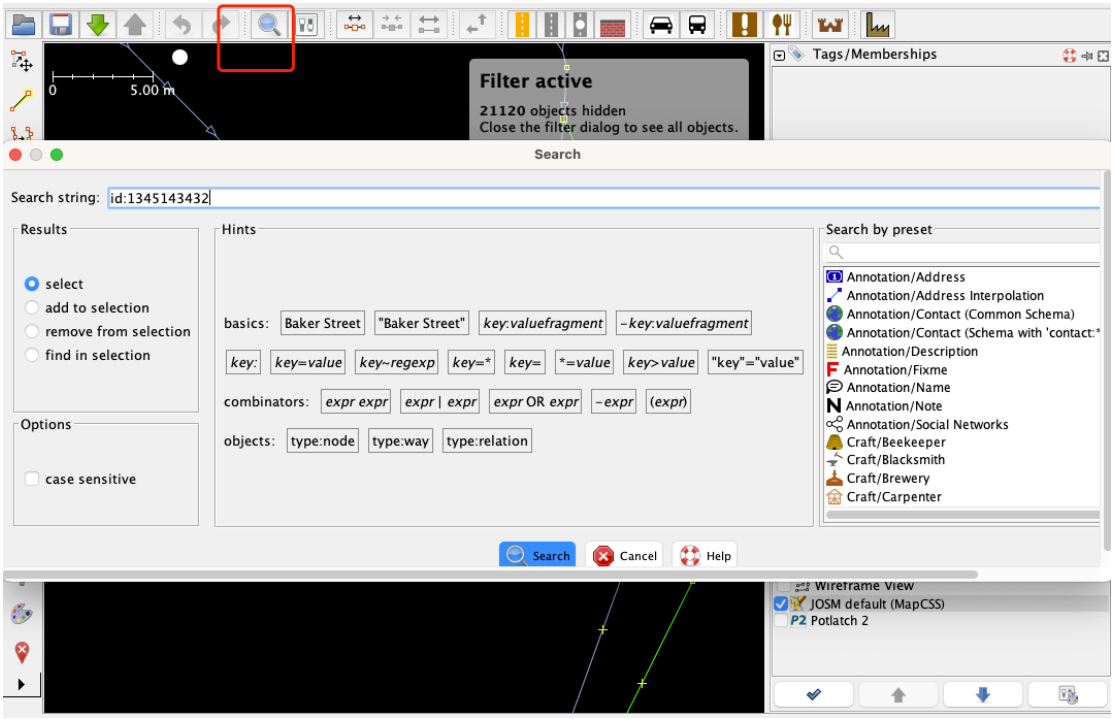


Playground before filtering

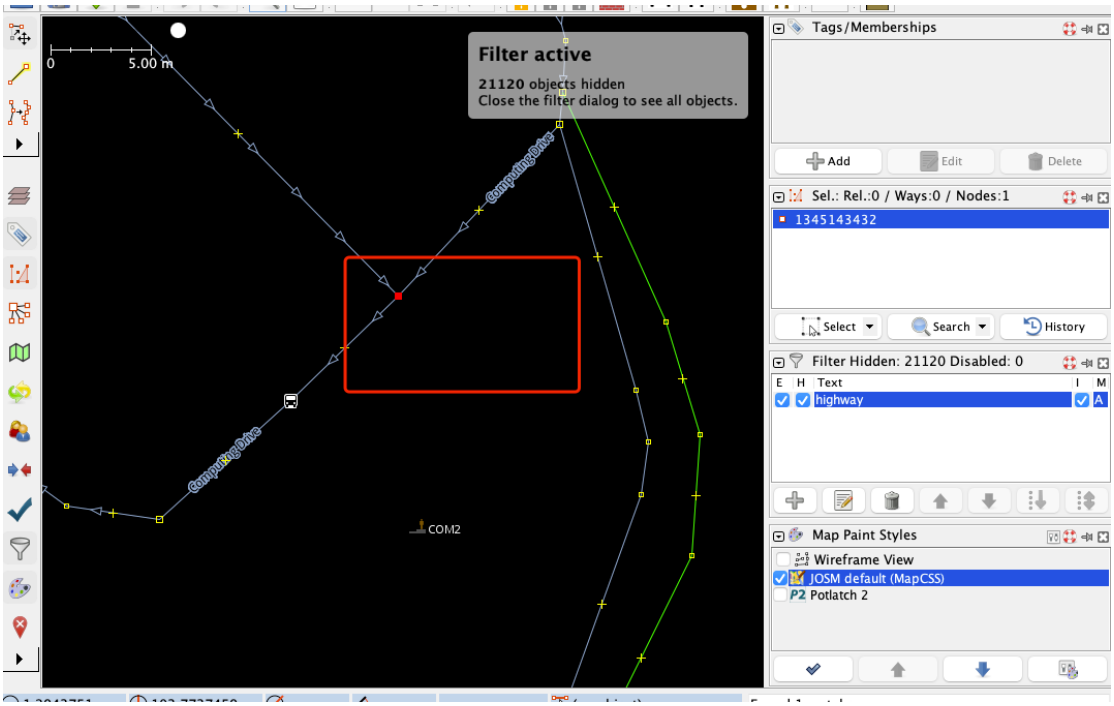


Playground after filtering

You can also search for a certain node using its id by clicking the search button (as shown in the red box), then input '`id:<node_id>`' in the search string.



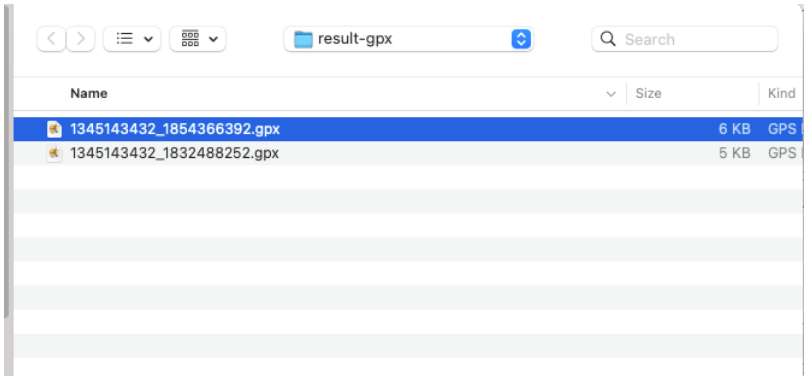
After clicking search, the corresponding node will be highlighted in the map.



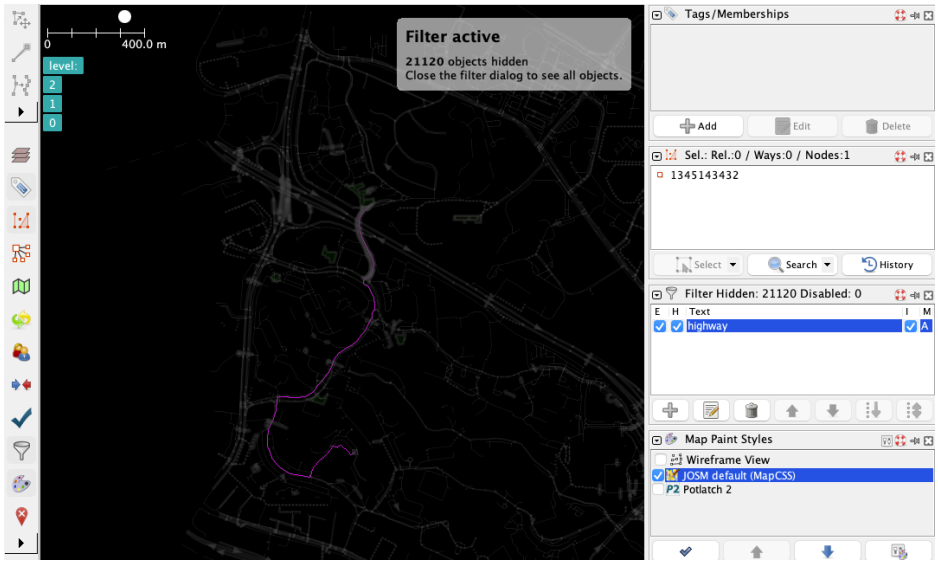
c) Load gpx file

Our osmutils dijkstra command (please refer to the assignment2 slides) support to find and output a psedo-path between two nodes in GPS exchange format, you can also load this file using JSOM.

You can click `File → Open` to load an GPX file



After loading the file, you can see this path is highlighted in the map.



You can refer to https://josm.openstreetmap.de/wiki/Introduction for more details.

7 Q&A and Contact

If you have any questions, you are encouraged to submit them to the forum in LumiNUS. Otherwise, please contact Mr. Sixu Hu, e0409758@u.nus.edu or Mr. Yuhang Chen, e0546081@u.nus.edu. Please note that, we may anonymize your question, and post the question as well as the answer to the forum (for sharing).

For your reference: we have included some frequent Q&A from previous semesters. You can use it as reference (but note it may contain outdated information).

Q: Failed to ssh to xcnd44: Connection closed by (IP)

Reason: SoC clusters is not enabled by default. Solution: Enable SoC clusters at mySoC

Q: -bash: ./compile_run: Permission Denied

Reason: You need to grant execute permission to compile_run. Solution: Grant execute permission by chmod +x compile_run

Q: Fine on local machine, "ArrayIndexOutOfBoundsException" or "NullPointerException", or other unexpected output on clusters

Reason: One possible reason is that static class variables are used in Hadoop, which will not be shared across machines. Solution: Avoid using static variables.

Q: Fine on local machine, got "Wrong Answer" or "FileNotFoundException: stopwords.txt"

Reason: Load stopwords.txt directly from the system. This works fine on local machine since there is no HDFS. But on clusters, files in HDFS cannot be loaded in this way. Solution: Load stopwords.txt by Java HDFS API (see the compile_run script given in the assignment package)

Q: Fine on local machine, got "ClassNotFoundException for 'Pair'" on clusters

Reason: Not known yet. Solution: Use another alternative data structure instead of Pair. Or, implement a custom Pair yourself.

Q: I got a warning "xxx". But my code is runnable and produces the correct output (Test Passed). Why?

Reason: N/A

Solution: Submit and move on to the next task.