DSCI553 Foundations and Applications of Data Mining

Summer 2021

Assignment 2

Deadline: Jun 8th, 11:59 PM PST

1. Overview of the Assignment

In this assignment, you will implement the **SON** algorithm using the Apache Spark Framework. You will develop a program to find frequent itemsets in two datasets, one simulated dataset and one real-world dataset generated from Yelp dataset. The goal of this assignment is to apply the algorithms you have learned in class on large datasets more efficiently in a distributed environment.

2. Requirements

2.1 Programming Requirements

a. You must use Python to implement all tasks. You can only use standard python libraries (i.e., external libraries like NumPy or pandas are NOT allowed). There will be **10% bonus** for each task if you also submit a Scala implementation and both your Python and Scala implementations are correct.

b. You are required to only use Spark RDD in order to understand Spark operations more deeply. You will not get any point if you use Spark DataFrame or DataSet.

2.2 Programming Environment

Python 3.6, Scala 2.11.8, and Spark 2.3.0

We will use Vocareum to automatically run and grade your submission. We highly recommend that you first test your script on your local machine and then submit to Vocareum. You can also see section 6.6 to use the same amount of resource in your locas as the Vocarerum.

2.3 Write your own code

Do not share code with other students!!

For this assignment to be an effective learning experience, you must write your own code! We emphasize this point because you will be able to find Python implementations of some of the required functions on the web. Please do not look for or at any such code!

TAs will combine all the code we can find from the web (e.g., Github) as well as other students' code from this and this and other (previous) semesters for plagiarism detection. We will report all detected plagiarism.

2.4 What you need to turn in

a. Three Python scripts, named: (all lowercase): **task1.py, task2.py, preprocess.py**

b1. [OPTIONAL] two Scala scripts, named: (all lowercase)

task1.scala, task2.scala (No need to write preprocessing code in Scala)

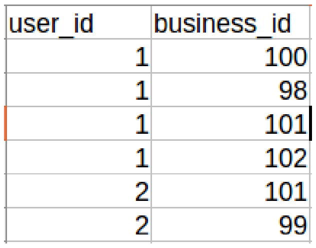
b2. [OPTIONAL] one jar package, named: **hw2.jar** (all lowercase)

Note. You don't need to include your output files for both tasks. We will grade on your code with our testing data (data will be in the same format).

3. Datasets

In this assignment, you will use one simulated dataset and one real-world dataset. In Task 1, you will build and test your program with a small simulated CSV file that has been provided to you.

For Task 2, you need to generate a subset using business.json and review.json from the Yelp dataset (https://drive.google.com/drive/folders/1-Y4H0vw2rRIjByDdGcsEuor9VagDyzin?usp=sharing) with the same structure as the simulated data. Figure 1 shows the file structure, the first column is user_id and the second column is business_id. In Task 2, you will test your code with this real-world data.



user_id	business_id
1	100
1	98
1	101
1	102
2	101
2	99

Figure 1: Input Data Format

3. 1 What you will find in your submission report on Vocareum for HW2.

We will only provide a submission report for small1.csv on Vocareum for Task 1. No submission report will be provided for Task 2. You are encouraged to use the command line to run the code for small2.csv as well as for Task 2 to get a sense of the running time.

4. Tasks

In this assignment, you will implement the **SON algorithm** to solve all tasks (Task 1 and 2) on top of Apache Spark Framework. You need to find **all the possible combinations of the frequent itemsets** in any given input file within the required time. You can refer to Chapter 6 from the Mining of Massive Datasets book and concentrate on section 6.4 – Limited-Pass Algorithms. (Hint: you can choose either A-Priori, MultiHash, or PCY algorithm to process each chunk of the data).

Task	Points (Scala bonus)
Task1- Case1	4.25pts (0.45pts)
Task1- Case2	4.25pts (0.4pts)
Task2-Case1	4.0pts (0.4pts)

4.1 Task 1: Simulated small data (8.5 pts)

There are two CSV files (small1.csv and small2.csv) provided on the Vocareum in your workspace. The small1.csv is just a sample file that you can use to debug your code. For Task1, **we will test your code on small2.csv for grading.**

In this task, you need to build two kinds of market-basket models.

Case 1 (4.25 pts):

You will calculate the combinations of **frequent businesses** (as singletons, pairs, triples, etc.) that are qualified as "frequent" given a support threshold. You need to create a basket for each user containing the business ids reviewed by this user. If a business was reviewed more than once by a reviewer, we consider this product was rated only once. More specifically, the business ids within each basket are unique. The generated baskets are similar to:

user1: [business11, business12, business13, ...]

user2: [business21, business22, business23, ...]

user3: [business31, business32, business33, ...]

Case 2 (4.25 pts):

You will calculate the combinations of **frequent users** (as singletons, pairs, triples, etc.) that are qualified as "frequent" given a support threshold. You need to create a basket for each business containing the user ids that commented on this business. Similar to case 1, the user ids within each basket are unique. The generated baskets are similar to:

business1: [user11, user12, user13, ...]

business2: [user21, user22, user23, ...]

business3: [user31, user32, user33, ...]

Input format:

1. Case number: **Integer** that specifies the case. **1 for Case 1 and 2 for Case 2**.

2. Support: **Integer** that defines the minimum count to qualify as a frequent itemset.

3. Input file path: This is the path to the input file including path, file name, and extension.

4. Output file path: This is the path to the output file including path, file name, and extension.

Output format:

1. Console output - Runtime: **the total execution time from loading the file till finishing writing the output file**

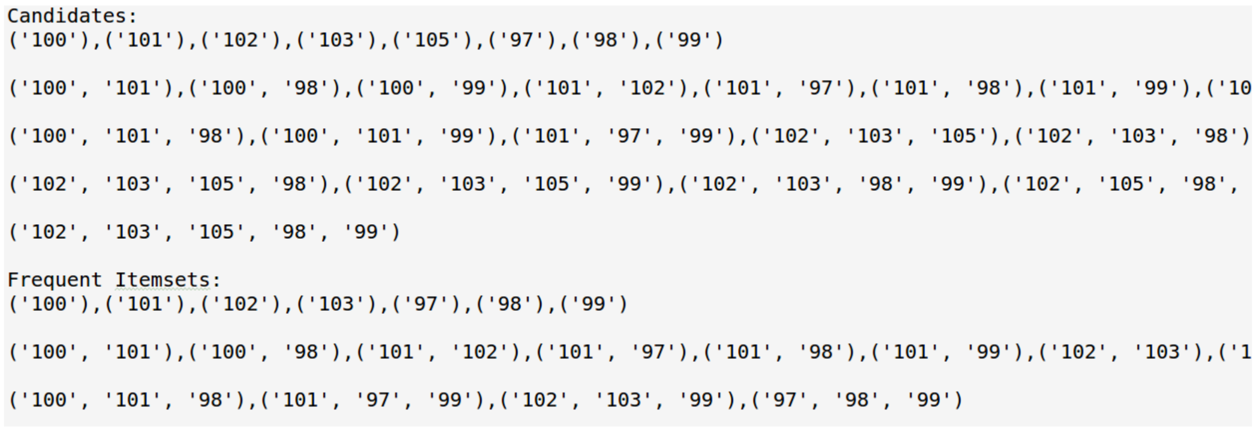
You need to **print the runtime in the console** with the "Duration" tag: "Duration: <time_in_seconds>", e.g., "Duration: 100.00"

2. Output file:

(1) Output-1

You should use “Candidates:” as the tag. For each line, you should output the candidates of frequent itemsets you find after the first pass of SON algorithm, followed by an empty line after each fequent-X itemset combination list. The printed itemsets must be sorted and arranged in **lexicographical** order. (Both user_id and business_id have the data type “string”.)

(2) Output-2
You should use “Frequent Itemsets:” as the tag. For each line, you should output the final frequent itemsets you found after finishing the SON algorithm. The format is the same as Output-1. The printed itemsets must be sorted and arranged in **lexicographical** order.
Here is an example of the output file:



```
Candidates:
('100'),('101'),('102'),('103'),('105'),('97'),('98'),('99')

('100', '101'),('100', '98'),('100', '99'),('101', '102'),('101', '97'),('101', '98'),('101', '99'),('10

('100', '101', '98'),('100', '101', '99'),('101', '97', '99'),('102', '103', '105'),('102', '103', '98')

('102', '103', '105', '98'),('102', '103', '105', '99'),('102', '103', '98', '99'),('102', '105', '98',

('102', '103', '105', '98', '99')

Frequent Itemsets:
('100'),('101'),('102'),('103'),('97'),('98'),('99')

('100', '101'),('100', '98'),('101', '102'),('101', '97'),('101', '98'),('101', '99'),('102', '103'),('1

('100', '101', '98'),('101', '97', '99'),('102', '103', '99'),('97', '98', '99')
```

Both the output-1 result and output-2 should be saved in ONE output result file.

Execution example:

Python: spark-submit task1.py <case number> <support> <input_file_path> <output_file_path>

Scala: spark-submit –class task1 hw2.jar <case number> <support> <input_file_path> <output_file_path>

4.2 Task 2: Real-world data set -Yelp data- (4.0 pts)

In task2, you will explore the Yelp dataset to find the frequent business sets (**only case 1**). You will jointly use the business.json and review.json to generate the input user-business CSV file yourselves.

(1) Data preprocessing

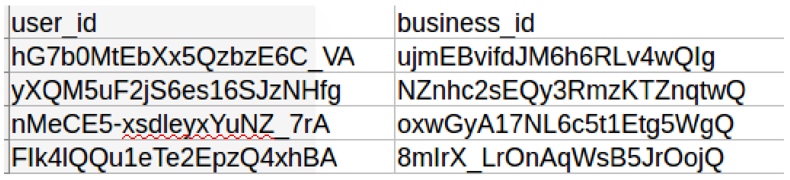
You need to generate a sample dataset from business.json and review.json that was the datasets we used for HW1 with the following steps:

1. The state of the business you need is Nevada, i.e., filtering ‘state’== ‘NV’.

2. Select “user_id” and “business_id” from review.json whose “business_id” is from Nevada. Each line in the CSV file would be “user_id1, business_id1”.

3. The header of CSV file should be “user_id,business_id”

You need to save the dataset in CSV format. Figure 3 shows an example of the output file



user_id	business_id
hG7b0MtEbXx5QzbzE6C_VA	ujmEBvifdJM6h6RLv4wQIg
yXQM5uF2jS6es16SJzNHfg	NZnhc2sEQy3RmzKTZnqtwQ
nMeCE5-xsdleyxYuNZ_7rA	oxwGyA17NL6c5t1Etg5WgQ
FIk4lQQu1eTe2EpzQ4xhBA	8mIrX_LrOnAqWsB5JrOojQ

Figure 2: user_business file

You need to submit the code for this data preprocessing step but the preprocessing code will NOT be graded for correctness. No need to submit the generated user-business file. You already have ub.csv file for you to run your test/task2.py in Vocareum.

(2) Apply SON algorithm

The requirements for task 2 are similar to task 1. However, you will test your implementation with the large dataset you just generated. For this purpose, you need to report the total execution time. For this execution time, we take into account also the time from reading the file till writing the results to the output file. You are asked to find the frequent business sets (**only case 1**) from the file you just generated. The following are the steps you need to do:

1. Reading the user_business CSV file in to RDD and then build the case 1 market-basket model;

2. Find out qualified users who reviewed more than *k* businesses. (*k* is the filter threshold);

3. Apply the SON algorithm code to the filtered market-basket model;

Input format:

1. Filter threshold: **Integer** that is used to filter out qualified users

2. Support: **Integer** that defines the minimum count to qualify as a frequent itemset.

3. Input file path: This is the path to the input file including path, file name, and extension.

4. Output file path: This is the path to the output file including path, file name, and extension.

Output format:

1. Runtime: **the total execution time from loading the file till finishing writing the output file**

You need to **print the runtime in the console** with the "Duration" tag, e.g., "Duration: 100".

2. Output file

The output file format is the same as task 1. Both the intermediate results and final results should be saved in ONE output result file.

Execution example:

Python: spark-submit task2.py <filter threshold> <support> <input_file_path> <output_file_path>

Scala: spark-submit –class task2 hw2.jar <filter threshold> <support> <input_file_path> <output_file_path>

5. Evaluation Metric

Task 1:

Input File	Case	Support	Runtime (sec)
small2.csv	1	4	<=200
small2.csv	2	9	<=200

Task 2:

Input File	Filter Threshold	Support	Runtime (sec)
user_business.csv	70	50	<=2,000

6. About Vocareum

1. The purpose of Vocareum is for you to test if your code can be executed properly on Vocareum and can produce output in the correct format. **We do not accept the regrading request if the submission cannot be run or generate correct output formats on Vocareum.**
2. You can use the provided datasets under the directory: asnlib/publicdata/ (for Vocareum terminal, the directory is $ASNLIB/publicdata/). So you do not need to upload the dataset to Vocareum.
3. You should upload the scripts under your workspace (under directory work/)
4. Once you click on "Submit", all your code is submitted, and the submission script is automatically run on Vocareum. You will receive a submission report after Vocareum finishes executing your scripts. The **submission report** should include the running time and score of each task for the Python implementation (see also Section 3.1). You can submit scripts on Vocareum as many times as you want. We will grade your last submission before the deadline.
5. You first test your scripts on your machine, and then on Vocareum terminal, and then submit to Vocareum if the testing both on your machine and Vocareum is successful. The submission script may not test all the aspects of your codes, so you **MUST** test your code in the Vocareum terminal as well as you might do for HW1.
6. You could add *--driver-memory 4g --executor-memory 4g* to your spark-submit command to limit its memory usage, in case your code could work properly in your local (with more resources) but would run into memory error. You can also use sc.setSystemProperty('spark.driver.memory', '4g') sc.setSystemProperty('spark.executor.memory', '4g') in your code.

7. Printing out too many outputs (printout) may crash the vocareum, so we recommend to use `sc.setLogLevel("OFF")` for your submission.
8. You can find a tutorial about Vocareum in the Week1 folder in D2L.

7. Grading Criteria

(% penalty = %penalty of possible points you get)

1. We do not have partial credits. For example, you will get **0** although your result covers 80% answer. **You will also get 0 if your outputs do not follow the format requirements (such as lexicographical order).** There will be no point if the total execution time exceeds the Section 6 evaluation metric.
2. You can use your free 5-day extension separately or together. You must submit a late-day request via https://forms.gle/syyUsyyTM684vf4K6. This form is recording the number of late days you use for each assignment. By default, we will not count the late days without your extension request. Please see the detail of late requests at Piazza. Also, you **are not able to use 5-day extension for the final HW (i.e., HW4)**.
3. There will be 20% penalty for the late submission within one week and no point after that. If you use your late days, there wouldn't be the 20% penalty.
4. There will be a 10% bonus for each task (i.e., 0.425pts, 0.425pts, and 0.4pts) if both your python Scala implementations are correct. **The Scala bonus will not be calculated if your Python results are not correct.** There is no partial point for Scala.
5. There will be no point if your programs cannot be executed on Vocareum Please start your assignment early! You can resubmit on Vocareum. We will grade your last submission.
6. There is no regrading. Once the grade is posted on D2L, we will only regrade your assignments if there is a grading error. No exceptions.
7. There will be no point if your submission falls into the following situations:
   a. The submission cannot be executed on Vocareum. Each task will be run five times and graded on the best run.
   b. The execution failure on Vocareum is because of script naming issues, output file format issues.
   c. The code works on your local but it does not properly on Vocareum.