732A54 - Big Data Analytics

BDA1 Spark Exercises

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Question 1:

- What are the lowest and highest temperatures measured each year for the period 1950-2014. Provide the lists sorted in the descending order with respect to the maximum temperature. In this exercise you will use the `temperature-readings.csv` file.
- Non-parallelized program in Python to find the maximum temperatures for each year without using Spark. In this case you will run the program using: `python script.py`

Code (Non-parallelized):

```
#!/usr/bin/env python2
# -*- coding: utf-8 -*-
"""
Created on Sun Dec 11 21:27:34 2016

@author: ashraf
"""
import time, argparse

parser = argparse.ArgumentParser(description='MinMaxTempExtractor')
parser.add_argument('-o', '--output', help='Output file', default='out_temp.csv')
requiredNamed = parser.add_argument_group('Required arguments')
requiredNamed.add_argument('-t', '--time', help='Time interval in years ex. 2005:2010',
                           required=True)
requiredNamed.add_argument('-i', '--input', help='Input file', required=True)
args = parser.parse_args()
iFile = args.input
oFile = args.output
years =  args.time.split(":")
fromYear = int(years[0])
toYear = int(years[1])

start = time.time()
print('Running Python MinMaxTempExtractor:\nFrom %s To %s\nInput file: %s\nOutput file: %s'
      % (fromYear, toYear, iFile, oFile))
temp_dict = dict()
with open(iFile) as f:
    for l in f:
        line = l.split(";")
        year = int(line[1].split("-")[0])
        if year >= fromYear and year <= toYear:
            temp = temp_dict.get(year)
            station = line[0];
```

```
            curr_temp = float(line[3]);
            if not temp:
                #1st list for min temp and 2nd list for max temp
                temp_dict[year] = [[station, curr_temp], [station, curr_temp]]
            else:
                min = float(temp[0][1])
                max = float(temp[1][1])
                if curr_temp < min:
                    temp[0][0] = station
                    temp[0][1] = curr_temp
                if curr_temp > max:
                    temp[1][0] = station
                    temp[1][1] = curr_temp
#close the file after reading the lines.
f.close()

#sort temperatures descending by max temp
sorted_temp = temp_dict.items()
sorted_temp.sort(key=lambda x: x[1][1][1], reverse=True)

#write the output to file.
with open(oFile,'wb+') as f:
    for i in sorted_temp:
        #python will convert \n to os.linesep
        f.write('%s,%s,%s,%s,%s\n' % (i[0], i[1][0][0], i[1][0][1], i[1][1][0],
                                      i[1][1][1]))
#close the file after writting the lines.
f.close()
end = time.time()
print('Done in %s seconds' % (end - start))
```

Code (Spark):

```
#!/usr/bin/env python2
# -*- coding: utf-8 -*-
"""
Created on Mon Dec 12 17:06:24 2016

@author: ashraf
"""
from pyspark import SparkContext

iFile = 'data/temperature-readings.csv'
oFile = 'data/min_max_temperature'
fromYear = 1950
toYear = 2014

sc = SparkContext(appName="MinMaxTempExtractorSparkJob")

lines = sc.textFile(iFile)
```

```
lines = lines.map(lambda a: a.split(";"))

lines = lines.filter(lambda x: int(x[1][0:4]) >= 1950 and int(x[1][0:4]) <= 2014)

temperatures = lines.map(lambda x: (x[1][0:4], (x[0], float(x[3]))))

################## Custom MIN/MAX Function ############################

min = (lambda x, y: x if x[1] < y[1] else y)
max = (lambda x, y: x if x[1] > y[1] else y)

minTemperatures = temperatures.reduceByKey(min)

maxTemperatures = temperatures.reduceByKey(max)

minMaxTemp = minMaxTemp = minTemperatures.union(maxTemperatures). \
reduceByKey(lambda x,y: (x[0],x[1],y[0],y[1]))

sortedMinMaxTemp = minMaxTemp.sortBy(ascending=False, keyfunc=lambda a: a[1][3])

sortedMinMaxTempCsv = sortedMinMaxTemp.map(lambda a: '%s,%s,%s,%s,%s' \
% (a[0], a[1][0], a[1][1], a[1][2], a[1][3]))

sortedMinMaxTempCsv.coalesce(1).saveAsTextFile(oFile)
```

The lowest and highest temperatures:

```
year,station,min,station,max
1975,157860,-37.0,86200,36.1
1992,179960,-36.1,63600,35.4
1994,179960,-40.5,117160,34.7
2010,191910,-41.7,75250,34.4
2014,192840,-42.5,96560,34.4
1989,166870,-38.2,63050,33.9
1982,113410,-42.2,94050,33.8
1968,179950,-42.0,137100,33.7
1966,179950,-49.4,151640,33.5
1983,191900,-38.2,98210,33.3
```

- It's clearly appears that the Spark parallel version (1.5 min) takes much less time than the serial one (5 min) as this the main benefits of multiprocessing environment.

Question 2:

- Count the number of readings for each month in the period of 1950-2014 which are higher than 10 degrees. Repeat the exercise, this time taking only distinct readings from each station. That is, if a station reported a reading above 10 degrees in some month, then it appears only once in the count for that month.

Code:

```
#!/usr/bin/env python2
# -*- coding: utf-8 -*-
"""
Created on Mon Dec 12 17:06:24 2016

@author: ashraf
"""
from pyspark import SparkContext

iFile = 'data/temperature-readings.csv'
oFile = 'data/over_ten_mth_temp_counts'
oFile2 = 'data/over_ten_temp_distinct_counts'
fromYear = 1950
toYear = 2014
target_temp = 10

sc = SparkContext(appName="TempCounterSparkJob")

lines = sc.textFile(iFile)

lines = lines.map(lambda a: a.split(";"))

observations = lines.filter(lambda observation:
                            (int(observation[1][:4]) >= fromYear and
                             int(observation[1][:4]) <= toYear)) \
                    .cache()

"""
Q2a. Year-month, number
"""
temperatures = observations.map(lambda observation:
                                (observation[1][:7], (float(observation[3]), 1))) \
                           .filter(lambda (month, (temp, count)): temp > target_temp)

reading_counts = temperatures.reduceByKey(lambda (temp1, count1), (temp2, count2):
                                          (temp1, count1 + count2)) \
                             .map(lambda (month, (temp, count)):(month, count))

reading_counts.repartition(1).saveAsTextFile(oFile)

"""
Q2b. Year-month, distinct number
"""
station_temperatures = observations.map(lambda observation:
                                       (observation[1][:7],
                                        (observation[0], float(observation[3])))) \
                                   .filter(lambda (month, (station, temp)):
                                           temp > target_temp)

year_station = station_temperatures.map(lambda (month, (station, temp)):
                                       (month, (station, 1))).distinct()
```

```
reading_counts = year_station.reduceByKey(lambda (station1, count1), (station2, count2):
                                                (station1, count1 + count2)) \
                                    .map(lambda (month, (station, count)): (month, count))

reading_counts.repartition(1).saveAsTextFile(oFile2)
```

Count of the readings above 10 degrees for each month:

```
print reading_counts.take(10)
[(u'1967-07', 53813),
(u'1974-07', 66277),
(u'2003-05', 48264),
(u'1978-03', 306),
(u'1981-10', 9882),
(u'1983-09', 38692),
(u'1987-05', 17191),
(u'1979-04', 1684),
(u'2009-07', 133008),
(u'1986-11', 1198)]
```

Distinct count of the readings above 10 degrees for each month:

```
print reading_counts.take(10)
[(u'1997-04', 190),
(u'1974-07', 362),
(u'2003-05', 321),
(u'1981-10', 325),
(u'1983-09', 332),
(u'1987-05', 320),
(u'1979-04', 227),
(u'2009-07', 312),
(u'1986-11', 138),
(u'1966-08', 359)]
```

Question 3:

- Find the average monthly temperature for each available station in Sweden. Your result should include average temperature for each station for each month in the period of 1960-2014. Bear in mind that not every station has the readings for each month in this timeframe.

Code:

```
#!/usr/bin/env python2
# -*- coding: utf-8 -*-
"""
```

```
Created on Mon Dec 12 17:06:24 2016

@author: ashraf
"""
from pyspark import SparkContext

iFile = 'data/temperature-readings.csv'
oFile = 'data/station_avg_mth_temp'
fromYear = 1960
toYear = 2014

sc = SparkContext(appName="AvgTempSparkJob")

lines = sc.textFile(iFile)

lines = lines.map(lambda a: a.split(";"))

observations = observations.filter(lambda observation:
                                   (int(observation[1][:4]) >= fromYear and
                                    int(observation[1][:4]) <= toYear))

stationDailyTemps = observations.map(lambda observation:
                                              ((observation[1], observation[0]),
                                               (float(observation[3]),
                                                float(observation[3]))))

stationDailyMinMaxTemps = stationDailyTemps.reduceByKey(lambda
                                                        (mintemp1, maxtemp1),
                                                        (mintemp2, maxtemp2):
                                                        (min(mintemp1, mintemp2),
                                                        max(maxtemp1, maxtemp2)))

stationMonthlyAvgTemps = stationDailyMinMaxTemps.map(lambda ((day, station),
                                                             (mintemp, maxtemp)):
                                                        ((day[:7], station),
                                                         (sum((mintemp, maxtemp)), 2))) \
                                                .reduceByKey(lambda (temp1, count1),
                                                             (temp2, count2):
                                                             (temp1 + temp2,
                                                              count1 + count2)) \
                                                .map(lambda ((month, station),
                                                             (temp, count)):
                                                             ((month, station),
                                                             temp / float(count)))

stationMonthlyAvgTemps.repartition(1).saveAsTextFile(oFile)
```

Station average monthly temperature:

```
print stationMonthlyAvgTemps.take(10)
[((u'2001-01', u'63280'), 0.0032258064516128633),
((u'1969-03', u'83620'), -4.780645161290321),
```

```
((u'1978-09', u'156730'), 5.5566666666666675),
((u'1991-11', u'106500'), -0.051666666666666645),
((u'1995-06', u'112080'), 12.001666666666669),
((u'1998-05', u'172770'), 5.282258064516128),
((u'2003-06', u'177930'), 8.711666666666668),
((u'1976-10', u'89240'), 6.138709677419355),
((u'2001-02', u'159770'), -14.35),
((u'1963-07', u'53560'), 17.738709677419358)]
```

Question 4:

- Provide a list of stations with their associated maximum measured temperatures and maximum measured daily precipitation. Show only those stations where the maximum temperature is between 25 and 30 degrees and maximum daily precipitation is between 100 mm and 200 mm.

Code:

```
#!/usr/bin/env python2
# -*- coding: utf-8 -*-
"""
Created on Mon Dec 12 17:06:24 2016

@author: ashraf
"""
from pyspark import SparkContext

iFile = 'data/temperature-readings.csv'
iFile2 = 'data/precipitation-readings.csv'
oFile = 'data/max_temperature_precipitation'

sc = SparkContext(appName="MaxTempPrecExtractorSparkJob")

######### Max Temperatures #########
temperatures = sc.textFile(iFile)
temperatures = temperatures.map(lambda a: a.split(";"))
temperatures = temperatures.map(lambda x: (x[0], float(x[3])))
maxTemperatures = temperatures.reduceByKey(max)
maxTemperatures = maxTemperatures.filter(lambda a: a[1] > 25 and a[1] < 30)

######### Max Precipitations #########
precipitations = sc.textFile(iFile2)
precipitations = precipitations.map(lambda a: a.split(";"))
precipitations = precipitations.map(lambda x: (x[0]+','+x[1], float(x[3])))
maxPrecipitations = precipitations.reduceByKey(lambda v1, v2: v1+v2)
maxPrecipitations = maxPrecipitations.filter(lambda a: a[1] >= 100 and a[1] <= 200) \
.map(lambda x: (x[0].split(",")[0], x[1])).reduceByKey(max)

######### Merged Max Temperatures/Precipitations #########
maxTempPrec = maxTemperatures.leftOuterJoin(maxPrecipitations)
```

```
maxTempPrecCsv = maxTempPrec.map(lambda a: '%s,%s,%s' % (a[0], a[1][0], a[1][1]))

maxTempPrec.coalesce(1).saveAsTextFile(oFile)
```

stations maximum measured daily temperatures/precipitation:

```
station,maxTemp,maxPrec
128510,29.5,None
192830,29.5,None
84660,27.6,None
139110,29.0,None
161670,25.7,None
166940,27.9,None
77180,29.3,None
180740,29.0,None
72340,29.8,None
147560,29.9,None
```

Question 5:

- Calculate the average monthly precipitation for the Östergotland region (list of stations is provided in the separate file). In order to do this, you will first need to calculate the total monthly precipitation for each station before calculating the monthly average (by averaging over stations).

Code:

```
#!/usr/bin/env python2
# -*- coding: utf-8 -*-
"""
Created on Mon Dec 12 17:06:24 2016

@author: ashraf
"""
from pyspark import SparkContext

iFile = 'data/stations-Ostergotland.csv'
iFile2 = 'data/precipitation-readings.csv'
oFile = 'data/OstergotlandAveMonthlyPrec'

sc = SparkContext(appName="OstergotlandAvgMonthlyPrecSparkJob")

ostergotlandStations = sc.textFile(iFile)

ostergotlandStations = ostergotlandStations.map(lambda line: line.split(";")) \
.map(lambda x: int(x[0])).distinct().collect()

isOstergotlandStation = (lambda s: s in ostergotlandStations)
```

```
precipitations = sc.textFile(iFile2)

daily_precipitations = precipitations.map(lambda line: line.split(";")) \
.filter(lambda x: isOstergotlandStation(int(x[0])))

daily_precipitations = daily_precipitations.map(lambda x: (x[0]+','+x[1], float(x[3]))). \
reduceByKey(lambda a, b: a + b)

monthly_precipitations = daily_precipitations. \
map(lambda x:(x[0].split("-")[0]+','+x[0].split("-")[1], (x[1], 1)))

monthly_precipitations = monthly_precipitations. \
reduceByKey(lambda v1, v2: (v1[0] + v2[0], v1[1] + v2[1]))

monthly_precipitations = monthly_precipitations.map(lambda x: (x[0], x[1][0] / x[1][1]))

monthly_precipitations_csv = monthly_precipitations.map(lambda a: '%s,%s' % (a[0], a[1]))

monthly_precipitations_csv.coalesce(1).saveAsTextFile(oFile)
```

Östergotland average monthly precipitation:

```
station,year,month,avgPrec
85460,1996,04,0.506666666667
75520,2004,12,0.648387096774
85050,2015,02,0.757142857143
86420,2014,07,0.133333333333
75520,1997,05,1.26129032258
75520,2006,12,0.887096774194
75520,2008,01,1.20967741935
75520,2008,06,0.816666666667
85460,2013,03,0.109677419355
87140,2000,06,1.68666666667
```

Question 6:

- Compare the average monthly temperature (find the difference) in the period 1950-2014 for all stations in Östergotland with long-term monthly averages in the period of 1950-1980.

spark_ostergot_avg_temp_diff_extractor.py:

```
#!/usr/bin/env python2
# -*- coding: utf-8 -*-
"""
Created on Mon Dec 12 17:06:24 2016

@author: ashraf
"""
```

```
from pyspark import SparkContext

iFile = 'data/stations-Ostergotland.csv'
iFile2 = 'data/temperature-readings.csv'
oFile = 'data/OstergotlandAvgMonthlyDiffTemp'
fromYear = 1960
toYear = 2014

sc = SparkContext(appName="OstergotlandAvgMonthlyTempDiffSparkJob")

ostergotlandStations = sc.textFile(iFile)

ostergotlandStations = ostergotlandStations.map(lambda line: line.split(";")). \
                                            map(lambda x: int(x[0])).distinct().collect()

isOstergotlandStation = (lambda s: s in ostergotlandStations)

temperatures = sc.textFile(iFile2).map(lambda line: line.split(";")). \
                                   filter(lambda x: isOstergotlandStation(int(x[0]))
                                          and int(x[1][0:4]) >= fromYear and int(x[1][0:4]) <= toYear)

monthlyAvgTemps = temperatures.map(lambda obs:
                                           ((obs[1], int(obs[0])),
                                                  (float(obs[3]), float(obs[3])))) \
                                            .reduceByKey(lambda (mint1, maxt1),
                                                                (mint2, maxt2):
                                                                (min(mint1, mint2),
                                                                 max(maxt1, maxt2))) \
                                            .map(lambda ((day, station), (mint, maxt)):
                                                 (day[:7], (mint + maxt, 2))) \
                                            .reduceByKey(lambda (temp1, count1),
                                                                (temp2, count2):
                                                                (temp1 + temp2,
                                                                 count1 + count2)) \
                                            .map(lambda (month, (temp, count)):
                                                        (month, temp / float(count)))

monthlyLongtermAvgTemps = monthlyAvgTemps.filter(lambda (month, temp):
                                                        int(month[:4]) <= 1980) \
                                           .map(lambda (month, temp):
                                                (month[-2:], (temp, 1))) \
                                           .reduceByKey(lambda (temp1, count1),
                                                               (temp2, count2):
                                                               (temp1 + temp2,
                                                                count1 + count2)) \
                                           .map(lambda (month, (temp, count)):
                                                       (month, temp / float(count)))

month_temp = {month: temp for month, temp in monthlyLongtermAvgTemps.collect()}

monthlyAvgTemps = monthlyAvgTemps.map(lambda (month, temp):
                                          (month, abs(temp) - abs(month_temp[month[-2:]]))) \
                                 .sortBy(ascending=True, keyfunc=lambda (month, temp): month)
```

```
monthlyAvgTempsCsv = monthlyAvgTemps.map(lambda a: '%s,%s,%s' %
                                         (a[0].split('-')[0], a[0].split('-')[1], a[1]))

monthlyAvgTempsCsv.repartition(1).saveAsTextFile(oFile)
```

Östergotland average monthly temperature compared with long-term monthly averages:

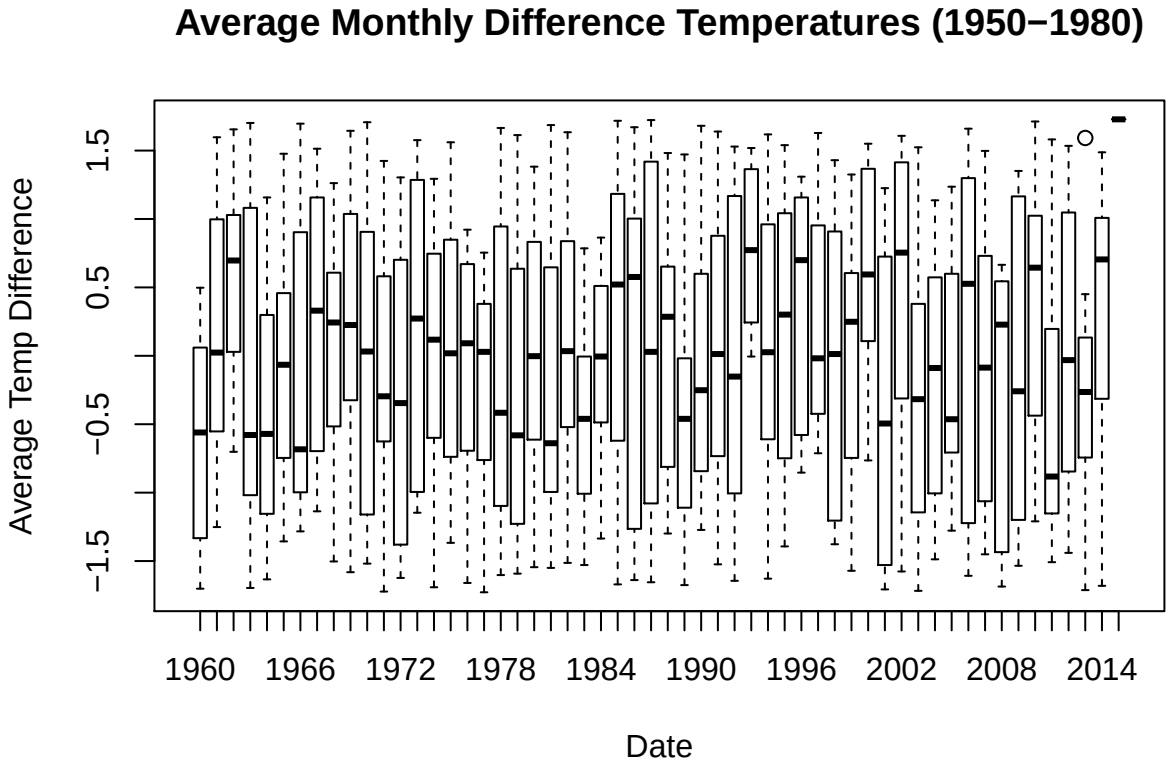
```
print monthlyAvgTempsCsv.take(10)
[u'1960,01,0.761463766648',
u'1960,02,1.5272002457',
u'1960,03,0.192050448272',
u'1960,04,-0.642024384346',
u'1960,05,0.157772987381',
u'1960,06,-0.237311108204',
u'1960,07,-1.28047382725',
u'1960,08,-0.985763468482',
u'1960,09,0.00674101691958',
u'1960,10,-1.34710218737']
```

plot:

```
avgDiffTemp <- read.csv(file = 'OstergotlandAvgMonthlyDiffTemp.csv',
                        header = FALSE, sep = ',', dec = '.')
colnames(avgDiffTemp) <- c('year', 'month', 'tempDiff')
head(avgDiffTemp)
```

```
##   year month        tempDiff NA
## 1 year month        tempDiff NA
## 2 1960    01  0.761463766648 NA
## 3 1960    02    1.5272002457 NA
## 4 1960    03  0.192050448272 NA
## 5 1960    04 -0.642024384346 NA
## 6 1960    05  0.157772987381 NA
```

```
plot(x = avgDiffTemp$year, y = scale(as.numeric(avgDiffTemp$tempDiff)),
     main = 'Average Monthly Difference Temperatures (1950-1980)',
     xlab = 'Date', ylab = 'Average Temp Difference')
```


Average Monthly Difference Temperatures (1950−1980)
Average Temp Difference
1.5
0.5
−0.5
−1.5
1960
1966
1972
1978
1984
1990
1996
2002
2008
2014
Date