Apache Spark + GraphFrames + GraphX

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INTRODUCTION

GraphFrame mainly provides the following built-in algorithms:

Triangle count

PageRank

Shortest Path

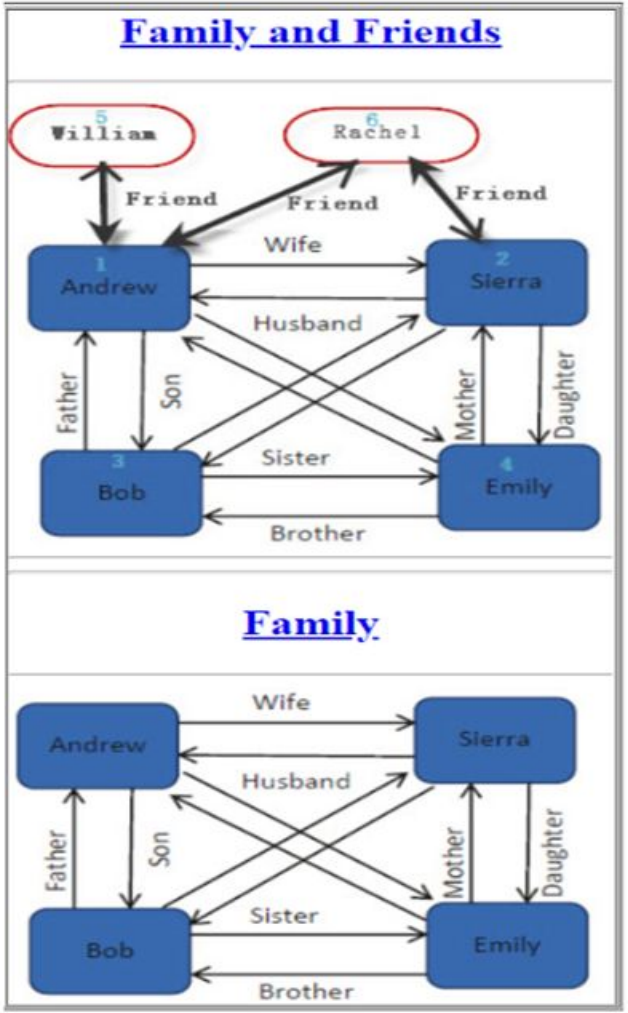
GraphFrames vs. GraphX

	GraphFrames	GraphX
Core APIs	Scala, Java, Python	Scala, Java, Python
Programming Abstraction	DataFrames	RDDs
Use Cases	Algorithms, Queries, Motif Finding	Algorithms
Vertex/edge attributes	Any number of DataFrame columns	Any type
Return Types	GraphFrames/DataFrames	Graph

DESIGN

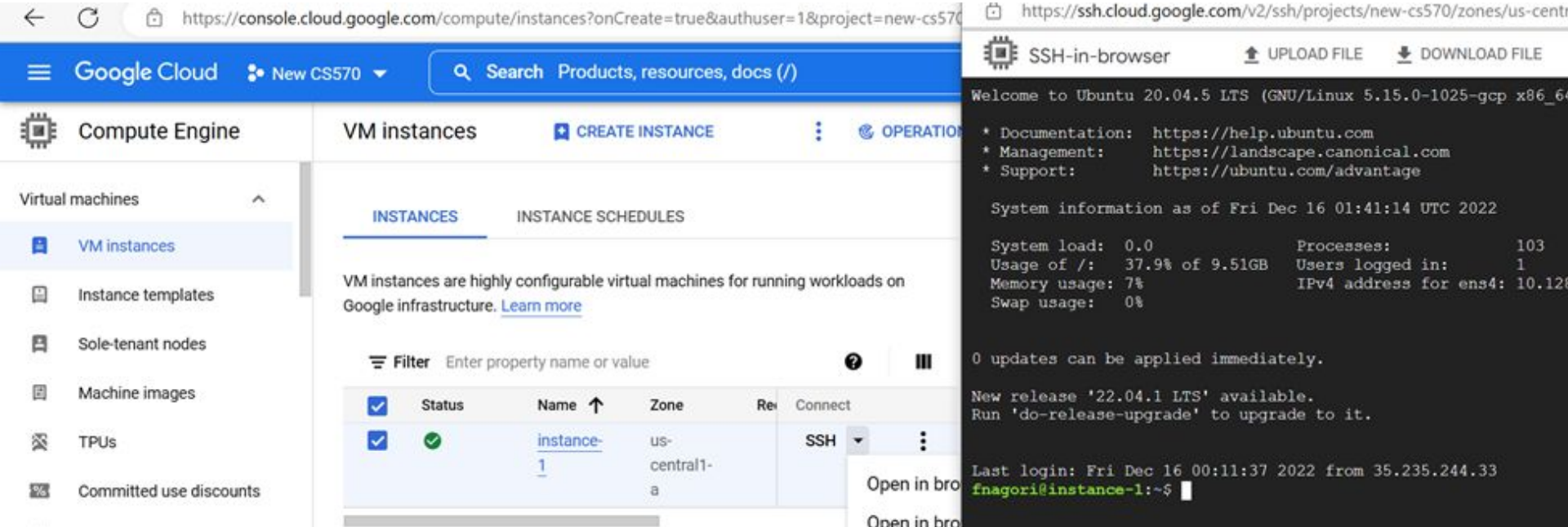
Family and Friend information:

- Here source and destination are user ids to relationship column show the relationship between them.



IMPLEMENTATION

1. Create GCP project and compute engine vm instance



2.Install pyspark and java 11

```
fnagori@instance-1:~$ wget https://archive.apache.org/dist/spark/spark-3.1.3/spark-3.1.3-bin-hadoop2.7.tgz
--2022-12-16 00:14:39--  https://archive.apache.org/dist/spark/spark-3.1.3/spark-3.1.3-bin-hadoop2.7.tgz
Resolving archive.apache.org (archive.apache.org)... 138.201.131.134, 2a01:4f8:172:2ec5::2
Connecting to archive.apache.org (archive.apache.org)|138.201.131.134|:443... connected.
HTTP request sent, awaiting response... 200 OK
Length: 227452039 (217M) [application/x-gzip]
Saving to: 'spark-3.1.3-bin-hadoop2.7.tgz'

spark-3.1.3-bin-ha 100%[==========>] 216.92M  16.9MB/s    in 14s

2022-12-16 00:14:54 (15.5 MB/s) - 'spark-3.1.3-bin-hadoop2.7.tgz' saved [227452039/227452039]

fnagori@instance-1:~$ tar -xvf spark-3.1.3-bin-hadoop2.7.tgz
spark-3.1.3-bin-hadoop2.7/
spark-3.1.3-bin-hadoop2.7/bin/
spark-3.1.3-bin-hadoop2.7/bin/pyspark.cmd
spark-3.1.3-bin-hadoop2.7/bin/spark-submit
spark-3.1.3-bin-hadoop2.7/bin/spark-submit.cmd
spark-3.1.3-bin-hadoop2.7/bin/spark-class2.cmd
spark-3.1.3-bin-hadoop2.7/bin/spark-shell2.cmd
spark-3.1.3-bin-hadoop2.7/bin/pyspark2.cmd
spark-3.1.3-bin-hadoop2.7/bin/docker-image-tool.sh
```

3. SET THE ENVIRONMENT VARIABLE IN .bashrc
4. source .bashrc

```
  elif [ -f /etc/bash_completion ]; then
    . /etc/bash_completion
  fi
fi
export SPARK_HOME=/home/fnagori/spark
export PATH=$SPARKK_HOME/bin:$PATH
export PATH=$SPARK_HOME/sbin:$PATH
export JAVA_HOME=/usr/lib/jvm/java-11-openjdk-amd64
~
~
~
```

5. Verify the pyspark

```
fnagori@instance-1:~$ source .bashrc
fnagori@instance-1:~$ pyspark
Python 3.8.10 (default, Nov 14 2022, 12:59:47)
[GCC 9.4.0] on linux
Type "help", "copyright", "credits" or "license" for more information.
WARNING: An illegal reflective access operation has occurred
WARNING: Illegal reflective access by org.apache.spark.unsafe.Platform (file:/home/fnagori/spark-3.1.3-bin-hadoop2.7/jars/spark-unsafe_2.12-3.1.3.jar) to const
ructor java.nio.DirectByteBuffer(long,int)
WARNING: Please consider reporting this to the maintainers of org.apache.spark.unsafe.Platform
WARNING: Use --illegal-access=warn to enable warnings of further illegal reflective access operations
WARNING: All illegal access operations will be denied in a future release
22/12/16 00:43:54 WARN NativeCodeLoader: Unable to load native-hadoop library for your platform... using builtin-java classes where applicable
Using Spark's default log4j profile: org/apache/spark/log4j-defaults.properties
Setting default log level to "WARN".
To adjust logging level use sc.setLogLevel(newLevel). For SparkR, use setLogLevel(newLevel).
Welcome to
      ____              __
     / __/__  ___ _____/ /__
    _\ \/ _ \/ _ `/ __/  '_/
   /__ / .__/\_,_/_/ /_/\_\   version 3.1.3
      /_/

Using Python version 3.8.10 (default, Nov 14 2022 12:59:47)
Spark context Web UI available at http://instance-1.us-central1-a.c.new-cs570.internal:4040
Spark context available as 'sc' (master = local[*], app id = local-1671151437630).
SparkSession available as 'spark'.
>>>
```

- Prepare input data files

```
$ mkdir in
$ cd in
$ vi person.csv
$ vi relationship.csv
$ cat person.csv
$ cat relationship.csv
```

person.csv

id	Name	Age
1	Andrew	45
2	Sierra	43
3	Bob	12
4	Emily	10
5	William	35
6	Rachel	32

relation.csv

src	dst	relation
1	2	Husband
1	3	Father
1	4	Father
1	5	Friend
1	6	Friend
2	1	Wife
2	3	Mother
2	4	Mother
2	6	Friend
3	1	Son
3	2	Son
4	1	Daughter
4	2	Daughter
5	1	Friend
6	1	Friend
6	2	Friend

```
fnagori@instance-1:~$ mkdir in
fnagori@instance-1:~$ cd in
fnagori@instance-1:~/in$ vi person.csv
fnagori@instance-1:~/in$ vi relationship.csv
fnagori@instance-1:~/in$ vi pyspark_graphX.py
fnagori@instance-1:~/in$
```

6. Prepare script file- pyspark-graphX.py

```
# Import PySpark
import pyspark
from pyspark.sql import SparkSession

#Create SparkSession
spark =
SparkSession.builder.master("local[1]").appName("pysparkGraphX").getOrCreate()

from graphframes import *

# Recipe 9-1. Create GraphFrames
#     person dataframe : id, Name, age
personsDf = spark.read.csv('in/person.csv',header=True, inferSchema=True)

# Create a "persons" SQL table from personsDF DataFrame
personsDf.createOrReplaceTempView("persons")
spark.sql("select * from persons").show()

# relationship dataframe : src, dst, relation
relationshipDf = spark.read.csv('in/relationship.csv',header=True, inferSchema=True)
relationshipDf.createOrReplaceTempView("relationship")
spark.sql("select * from relationship").show()

# - Create a GraphFrame from both person and relationship dataframes
#     >>> graph
#     GraphFrame(v:[id: int, Name: string ... 1 more field], e:[src:
#     int, dst: int ... 1 more field])
# - A GraphFrame that contains v and e.
#   + The v represents vertices and e represents edges.
graph = GraphFrame(personsDf, relationshipDf)

# - Degrees represent the number of edges that are connected to a vertex.
#   + GraphFrame supports inDegrees and outDegrees.
#     - inDegrees give you the number of incoming links to a vertex.
#     - outDegrees give the number of outgoing edges from a node.
```

```
# - Find all the edges connected to Andrew.
graph.degrees.filter("id = 1").show()

# Find the number of incoming links to Andrew
graph.inDegrees.filter("id = 1").show()

# Find the number of links coming out from Andrew using the outDegrees
graph.outDegrees.filter("id = 1").show()

# Recipe 9-2. Apply Triangle Counting in a GraphFrame
# - Find how many triangle relationships the vertex is participating in
personsTriangleCountDf = graph.triangleCount()
personsTriangleCountDf.show()

# Create a "personsTriangleCount" SQL table from the
# personsTriangleCountDf DataFrame
personsTriangleCountDf.createOrReplaceTempView("personsTriangleCount")

# Create a "personsMaxTriangleCount" SQL table from the
# maxCountDf DataFrame
maxCountDf = spark.sql("select max(count) as max_count from personsTriangleCount")
maxCountDf.createOrReplaceTempView("personsMaxTriangleCount")

spark.sql("select * from personsTriangleCount P JOIN (select * from
personsMaxTriangleCount) M ON (M.max_count = P.count) ").show()

# Recipe 9-3. Apply a PageRank Algorithm
pageRank = graph.pageRank(resetProbability=0.20, maxIter=10)
pageRank.vertices.printSchema()

pageRank.vertices.orderBy("pagerank",ascending=False).show()

pageRank.edges.orderBy("weight",ascending=False).show()

# Recipe 9-4. Apply the Breadth First Algorithm
graph.bfs(fromExpr = "Name='Bob'",toExpr = "Name='William'").show()

graph.bfs(fromExpr = "age < 20", toExpr = "name = 'Rachel'").show()
graph.bfs(fromExpr = "age < 20", toExpr = "name = 'Rachel'", edgeFilter = "relation !=
'Son'").show()
```

Pip3 install numpy

```
fnagori@instance-1:~/in$ pip3 install numpy
Collecting numpy
  Downloading numpy-1.23.5-cp38-cp38-manylinux_2_17_x86_64.manylinux2014_x86_64.whl (17.1 MB)
     |████████████████████████████████| 17.1 MB 4.8 MB/s
Installing collected packages: numpy
  WARNING: The scripts f2py, f2py3 and f2py3.8 are installed in '/home/fnagori/.local/bin' which is not on PATH.
  Consider adding this directory to PATH or, if you prefer to suppress this warning, use --no-warn-script-location.
Successfully installed numpy-1.23.5
fnagori@instance-1:~/in$
```

5. Submit the job

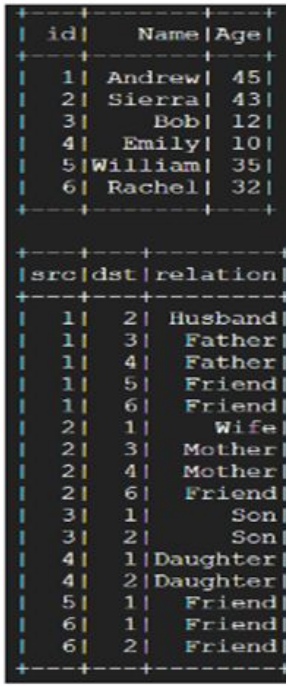
$ spark-submit --packages graphframes:graphframes:0.8.2-spark3.1-s_2.12 pyspark_graphX.py

Note: graphframes versions available at: https://spark-packages.org/package/graphframes/graphframes

```
fnagori@instance-1:~$ spark-submit --packages graphframes:graphframes:0.8.2-spark3.1-s_2.12 pyspark_graphX.py
WARNING: An illegal reflective access operation has occurred
WARNING: Illegal reflective access by org.apache.spark.unsafe.Platform (file:/home/fnagori/spark-3.1.3-bin-hadoop2.7/jars/spark-unsafe_2.12-3.1.3.jar) to const
ructor java.nio.DirectByteBuffer(long,int)
WARNING: Please consider reporting this to the maintainers of org.apache.spark.unsafe.Platform
WARNING: Use --illegal-access=warn to enable warnings of further illegal reflective access operations
WARNING: All illegal access operations will be denied in a future release
:: loading settings :: url = jar:file:/home/fnagori/spark-3.1.3-bin-hadoop2.7/jars/ivy-2.4.0.jar!/org/apache/ivy/core/settings/ivysettings.xml
Ivy Default Cache set to: /home/fnagori/.ivy2/cache
The jars for the packages stored in: /home/fnagori/.ivy2/jars
graphframes#graphframes added as a dependency
:: resolving dependencies :: org.apache.spark#spark-submit-parent-460dfc75-7f5c-4919-83f8-e4813f157c2c;1.0
        confs: [default]
        found graphframes#graphframes;0.8.2-spark3.1-s_2.12 in spark-packages
        found org.slf4j#slf4j-api;1.7.16 in central
:: resolution report :: resolve 330ms :: artifacts dl 8ms
        :: modules in use:
        graphframes#graphframes;0.8.2-spark3.1-s_2.12 from spark-packages in [default]
        org.slf4j#slf4j-api;1.7.16 from central in [default]
        ---------------------------------------------------------------------
        |                  |            modules            ||   artifacts   |
        |       conf       | number| search|dwnlded|evicted|| number|dwnlded|
        ---------------------------------------------------------------------
        |      default     |   2   |   0   |   0   |   0   ||   2   |   0   |
        ---------------------------------------------------------------------
:: retrieving :: org.apache.spark#spark-submit-parent-460dfc75-7f5c-4919-83f8-e4813f157c2c
        confs: [default]
        0 artifacts copied, 2 already retrieved (0kB/8ms)
22/12/16 01:15:55 WARN NativeCodeLoader: Unable to load native-hadoop library for your platform... using builtin-java classes where applicable
Using Spark's default log4j profile: org/apache/spark/log4j-defaults.properties
22/12/16 01:15:56 INFO SparkContext: Running Spark version 3.1.3
22/12/16 01:15:56 INFO ResourceUtils: ==============================================================
22/12/16 01:15:56 INFO ResourceUtils: No custom resources configured for spark.driver.
22/12/16 01:15:56 INFO ResourceUtils: ==============================================================
22/12/16 01:15:56 INFO SparkContext: Submitted application: pysparkGraphX
22/12/16 01:15:56 INFO ResourceProfile: Default ResourceProfile created, executor resources: Map(cores -> name: cores, amount: 1, script: , vendor: , memory ->
 name: memory, amount: 1024, script: , vendor: , offHeap -> name: offHeap, amount: 0, script: , vendor: ), task resources: Map(cpus -> name: cpus, amount: 1.0)
```

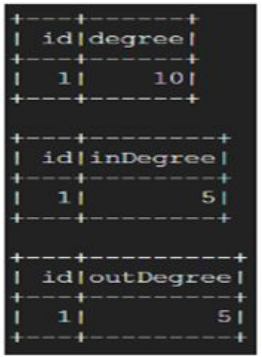
Result:

GraphFrame:

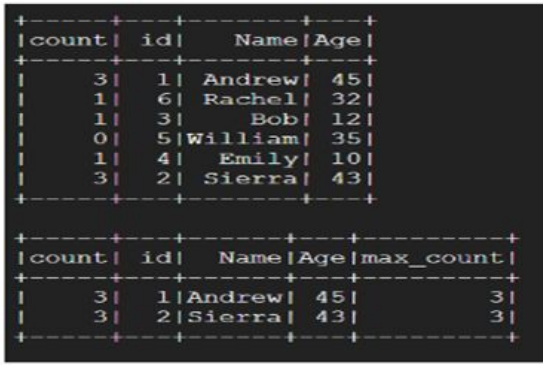


```
+---+-------+---+
| id|   Name|Age|
+---+-------+---+
|  1| Andrew| 45|
|  2| Sierra| 43|
|  3|    Bob| 12|
|  4|  Emily| 10|
|  5|William| 35|
|  6| Rachel| 32|
+---+-------+---+

+---+---+--------+
|src|dst|relation|
+---+---+--------+
|  1|  2| Husband|
|  1|  3|  Father|
|  1|  4|  Father|
|  1|  5|  Friend|
|  1|  6|  Friend|
|  2|  1|    Wife|
|  2|  3|  Mother|
|  2|  4|  Mother|
|  2|  6|  Friend|
|  3|  1|     Son|
|  3|  2|     Son|
|  4|  1|Daughter|
|  4|  2|Daughter|
|  5|  1|  Friend|
|  6|  1|  Friend|
|  6|  2|  Friend|
+---+---+--------+
```

TriangleCount:

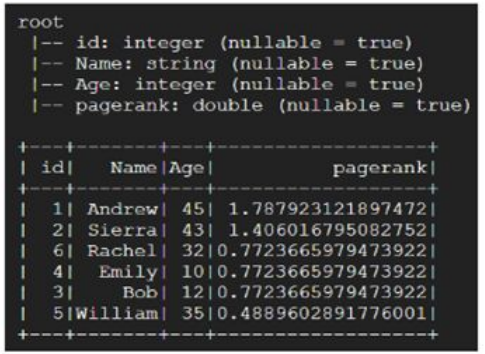


```
+---+------+
| id|degree|
+---+------+
|  1|    10|
+---+------+

+---+--------+
| id|inDegree|
+---+--------+
|  1|       5|
+---+--------+

+---+---------+
| id|outDegree|
+---+---------+
|  1|        5|
+---+---------+
```

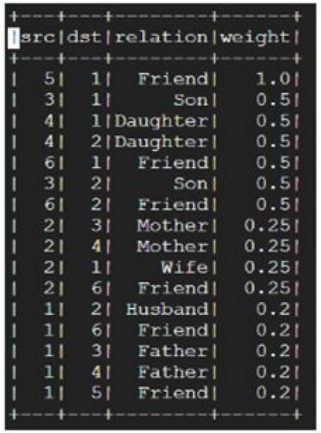


```
+-----+---+-------+---+
|count| id|   Name|Age|
+-----+---+-------+---+
|    3|  1| Andrew| 45|
|    1|  6| Rachel| 32|
|    1|  3|    Bob| 12|
|    0|  5|William| 35|
|    1|  4|  Emily| 10|
|    3|  2| Sierra| 43|
+-----+---+-------+---+

+-----+---+------+---+---------+
|count| id|  Name|Age|max_count|
+-----+---+------+---+---------+
|    3|  1|Andrew| 45|        3|
|    3|  2|Sierra| 43|        3|
+-----+---+------+---+---------+
```

PageRank:



```
root
 |-- id: integer (nullable = true)
 |-- Name: string (nullable = true)
 |-- Age: integer (nullable = true)
 |-- pagerank: double (nullable = true)

+---+-------+---+------------------+
| id|   Name|Age|          pagerank|
+---+-------+---+------------------+
|  1| Andrew| 45| 1.787923121897472|
|  2| Sierra| 43| 1.406016795082752|
|  6| Rachel| 32|0.7723665979473922|
|  4|  Emily| 10|0.7723665979473922|
|  3|    Bob| 12|0.7723665979473922|
|  5|William| 35|0.4889602891776001|
+---+-------+---+------------------+
```

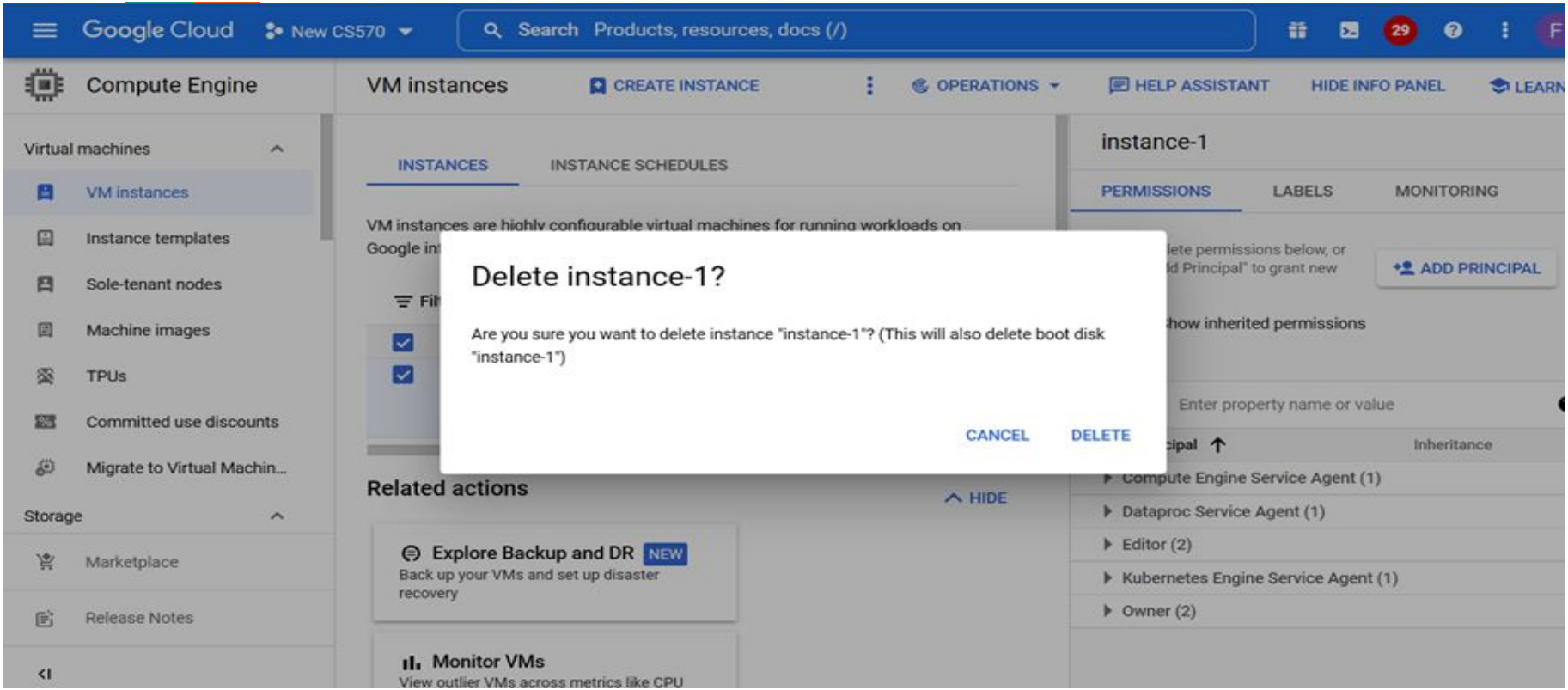


```
+---+---+--------+------+
|src|dst|relation|weight|
+---+---+--------+------+
|  5|  1|  Friend|   1.0|
|  3|  1|     Son|   0.5|
|  4|  1|Daughter|   0.5|
|  4|  2|Daughter|   0.5|
|  6|  1|  Friend|   0.5|
|  3|  2|     Son|   0.5|
|  6|  2|  Friend|   0.5|
|  2|  3|  Mother|  0.25|
|  2|  4|  Mother|  0.25|
|  2|  1|    Wife|  0.25|
|  2|  6|  Friend|  0.25|
|  1|  2| Husband|   0.2|
|  1|  6|  Friend|   0.2|
|  1|  3|  Father|   0.2|
|  1|  4|  Father|   0.2|
|  1|  5|  Friend|   0.2|
+---+---+--------+------+
```

BFS:

```
+------------+-----------+---------------+--------------+----------------+
|        from|         e0|             v1|            e1|              to|
+------------+-----------+---------------+--------------+----------------+
|{3, Bob, 12}|{3, 1, Son}|{1, Andrew, 45}|{1, 5, Friend}|{5, William, 35}|
+------------+-----------+---------------+--------------+----------------+

+-------------+----------------+--------------+-------------+---------------+
|         from|              e0|            v1|           e1|             to|
+-------------+----------------+--------------+-------------+---------------+
|{4, Emily, 10}|{4, 1, Daughter}|{1, Andrew, 45}|{1, 6, Friend}|{6, Rachel, 32}|
|  {3, Bob, 12}|     {3, 1, Son}|{1, Andrew, 45}|{1, 6, Friend}|{6, Rachel, 32}|
|{4, Emily, 10}|{4, 2, Daughter}|{2, Sierra, 43}|{2, 6, Friend}|{6, Rachel, 32}|
|  {3, Bob, 12}|     {3, 2, Son}|{2, Sierra, 43}|{2, 6, Friend}|{6, Rachel, 32}|
+-------------+----------------+--------------+-------------+---------------+

+-------------+----------------+--------------+-------------+---------------+
|         from|              e0|            v1|           e1|             to|
+-------------+----------------+--------------+-------------+---------------+
|{4, Emily, 10}|{4, 1, Daughter}|{1, Andrew, 45}|{1, 6, Friend}|{6, Rachel, 32}|
|{4, Emily, 10}|{4, 2, Daughter}|{2, Sierra, 43}|{2, 6, Friend}|{6, Rachel, 32}|
+-------------+----------------+--------------+-------------+---------------+
```

DELETE THE INSTANCE:



Conclusion:

The Spark GraphFrame is a powerful abstraction for processing large graphs using distributed computing. It provides a plethora of common graph algorithms including label propagation and PageRank. Further, it provides the foundations for implementing complex graph algorithms, including a robust implementation of the Pregel paradigm for graph processing.

REFERENCE:

https://spark-packages.org/package/graphframes/graphframes
https://towardsdatascience.com/graphframes-in-jupyter-a-practical-guide-9b3b346cebc5#:~:text=The%20functionality%20of%20GraphFrames%20and,browsing%20through%20the%20API%20documentation.

https://hc.labnet.sfbu.edu/~henry/sfbu/course/pyspark_sql_recipes/graphframes/slide/graphx.html