Graph Analysis with Flight Data!
Toronto Apache Spark Meetup

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November 30th 2016

World of
Watson
2016

Big thanks to David Taieb (IBM)
for the original analysis!

IBM

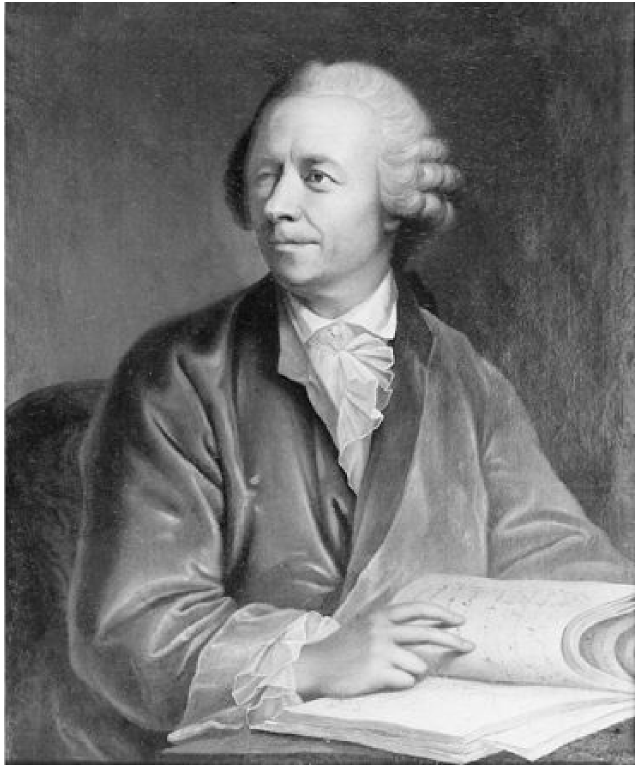
Objectives

By the end of this session, you should be able to:

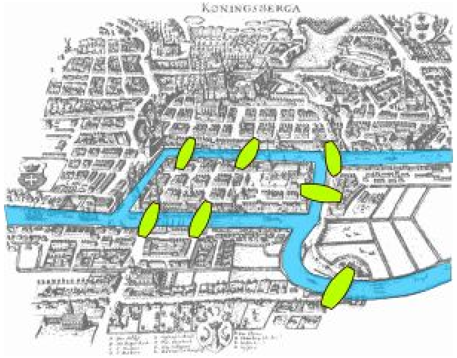
- Have basic knowledge of Graphs, Graph Databases and associated use cases
- Understand Graph processing with Apache Spark GraphX
- Use GraphFrames in a Python Notebook to perform basic Graph parallel computation on airports and flights data

Graphs

A bit of History



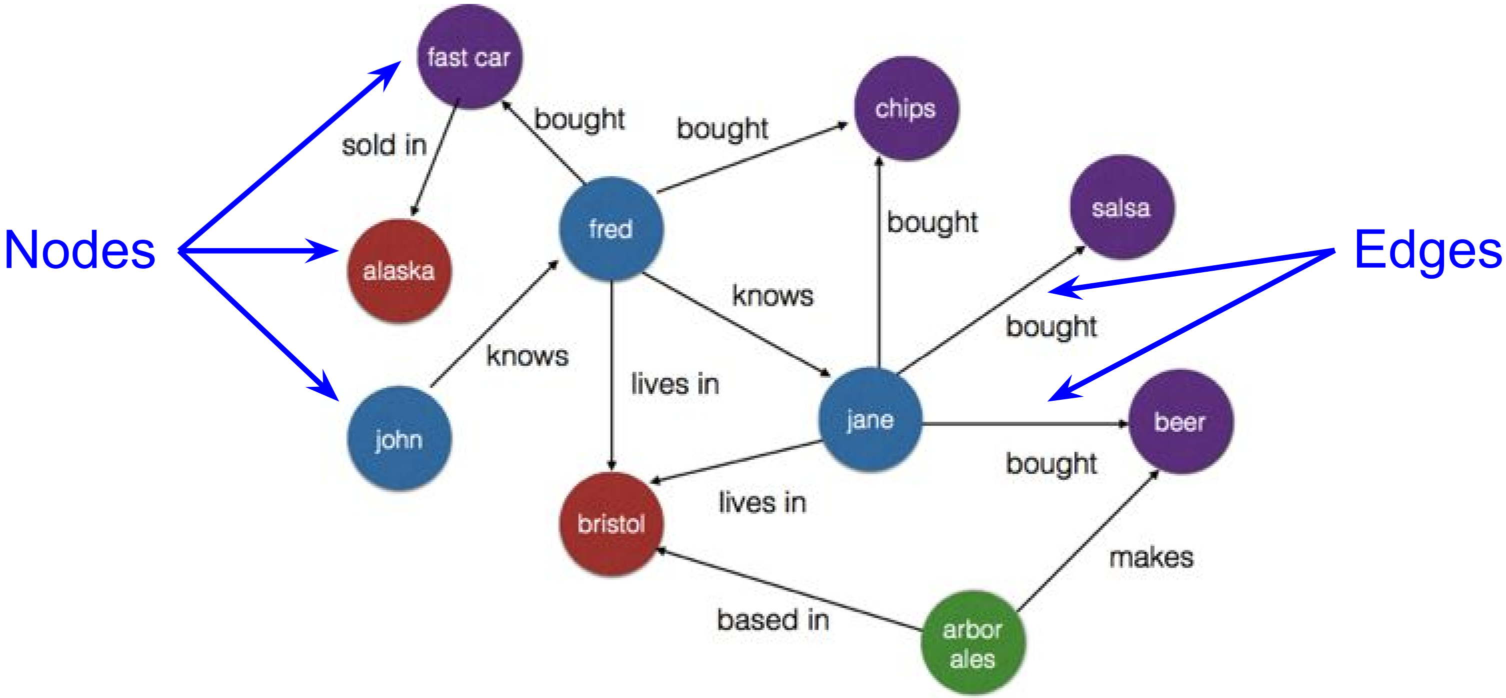
Graph Theory finds its roots from a paper written in 1736 by Leonard Euler on the Seven Bridges of Königsberg urban problem



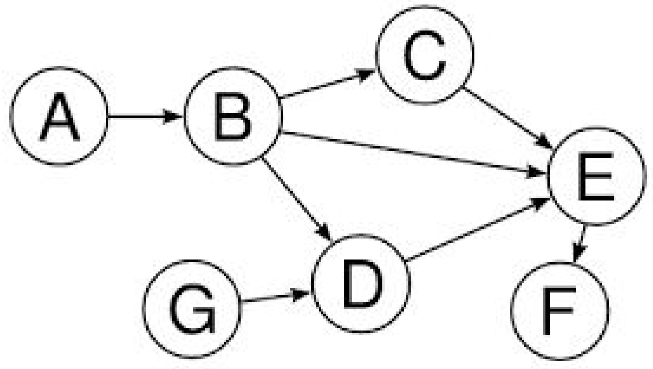
https://en.wikipedia.org/wiki/Graph_theory
https://en.wikipedia.org/wiki/Seven_Bridges_of_K%C3%B6nigsberg

Graphs

A graph is a representation of a set of nodes (vertices) where some pairs of nodes are connected by edges.



Types of graphs



Directed Acyclic Graph

- **Directed graphs**

  A graph where the edges have a direction associated with them. An example of directed graph is a Twitter follower. User Bob can follow user Carol without implying that the reciprocal relationship is true

- **Regular graphs**

  Graphs where each vertex has the same number of edges (degree).

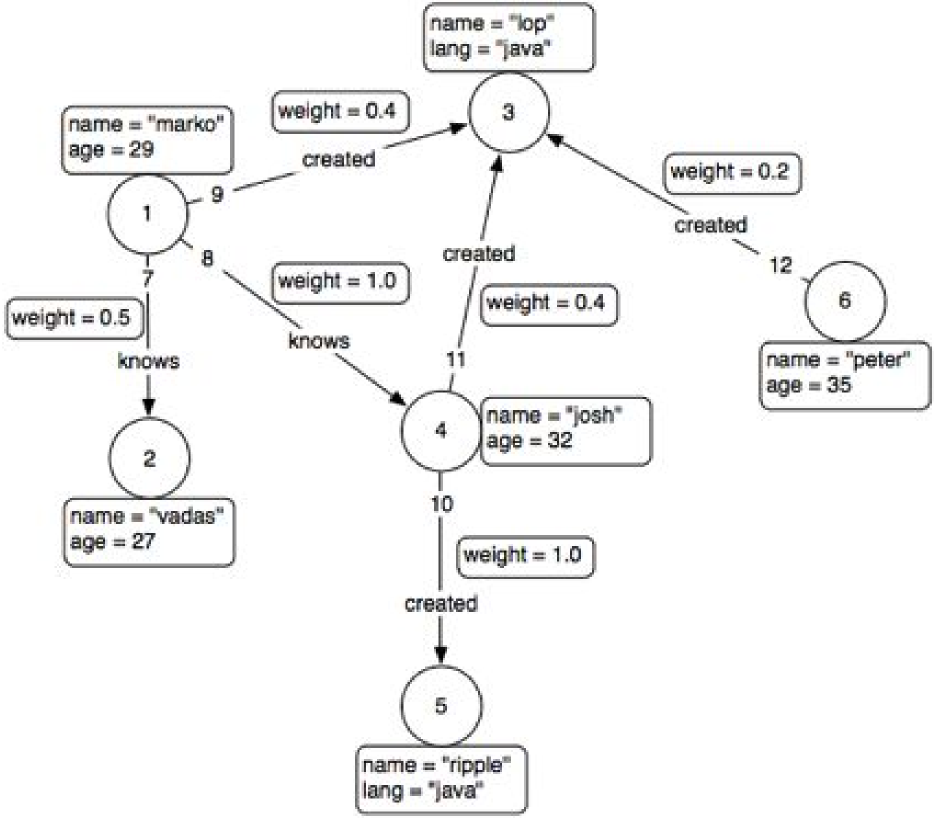
- **Multigraph**

  Graph where multiple edges with same end nodes are permitted

- **Acyclic graphs**

  Graphs which have no cycle

Property Graph



Nodes and edges have properties that can be included in Queries.

Why Graphs?

- Graphs are Central to Analytics
  - Data is not just getting bigger, it’s getting more connected
  - In many use cases, the relationship between data points provides as much value or more than the data points themselves
- Discovering data relationships and interdependencies is critical to many applications
  - fraud detection
  - better understanding customer relationships
  - ranking web pages or people in social networks
- Graph analytics is a powerful tool for understanding and exploiting the connections in data
- Graph applications are everywhere today

Graph Use cases

- Recommendation engines
- Anomaly/Fraud Detection
- Network Analysis/Route planning
- Social Networks
- Identity/Access Management
- Graph-based search
- Master Data Management

Graph is the ‘Natural’ way to represent and query highly connected data

Graph Databases

Titan

IBM Graph

- Provide OLTP (Online Transaction Processing) capabilities.
- Focus on optimizing storage and querying of graph data: vertices, edges, and associated metadata
- Alternative when complexity of graph data makes classic RDBMS inadequate
- Typically work with small sections of the graph
- Example Query engines
  - Gremlin (Tinkerpop)
  - Motif Findings (Neo4J)

Graph processing

APACHE GIRAPH

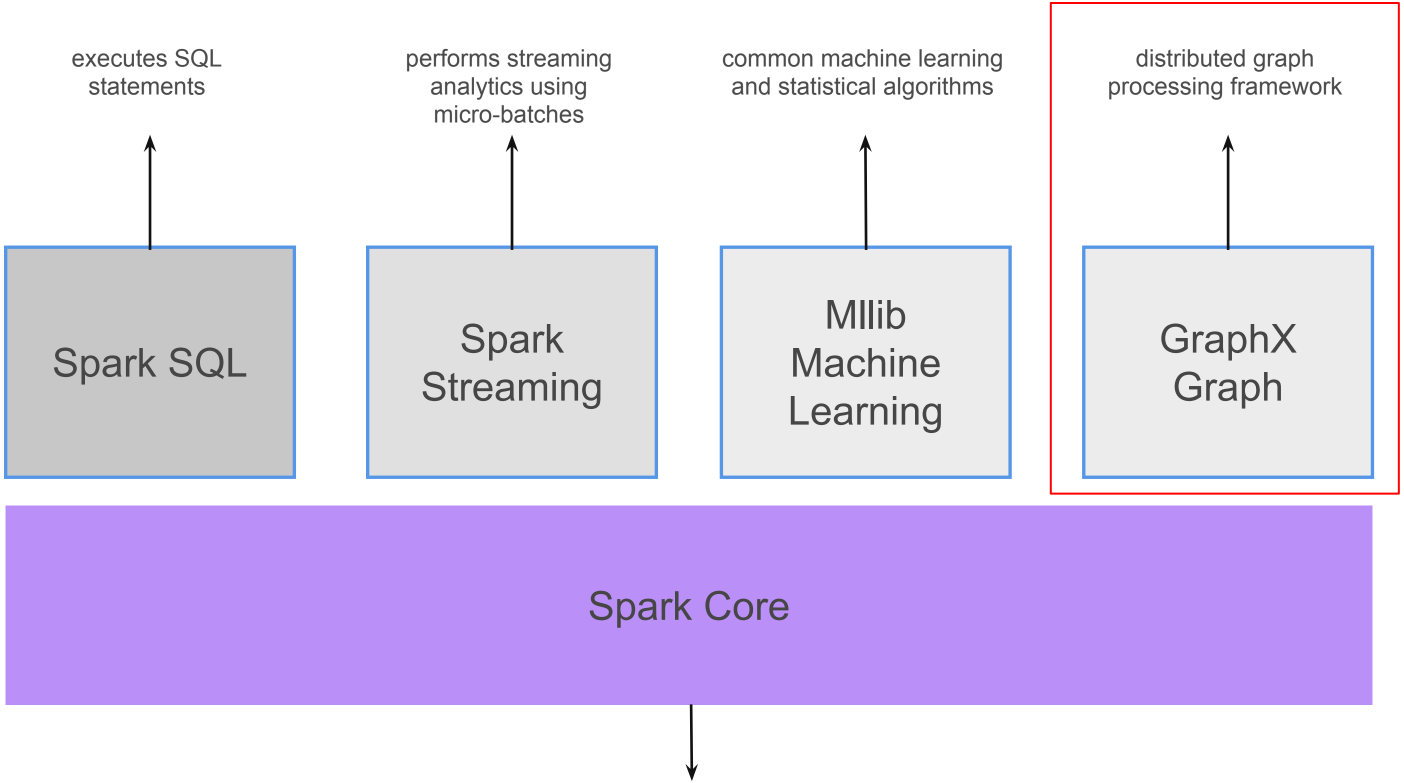
GraphLab

Spark GraphX

- Focuses on data analytics (OLAP or Online Analytical processing) on Graphs
- Suited when relational databases are inadequate because of the data high dimensionality
- Scalability: Distributed Graph-parallel support e.g. BSP (Bulk synchronous processing)
- Example building block operations:
  - Subgraph extractions
  - Neighborhood aggregation
  - …
- Example algorithms:
  - BFS: Breadth First Search
  - PageRank
  - Collaborative Filtering

Apache Spark GraphX

Spark Core Libraries



executes SQL statements

performs streaming analytics using micro-batches

common machine learning and statistical algorithms

distributed graph processing framework

Spark SQL

Spark Streaming

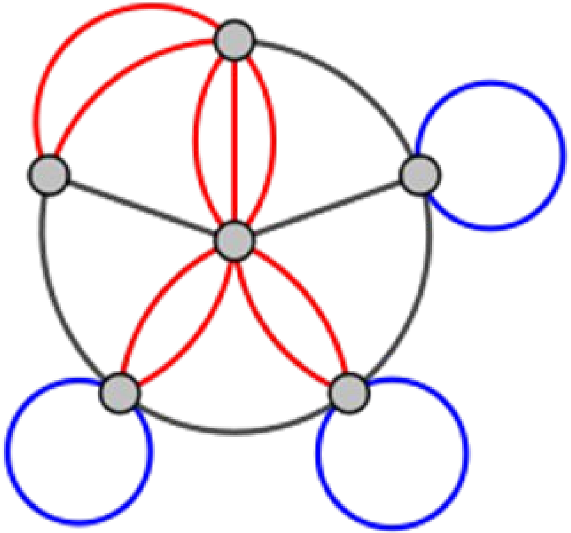
Mllib Machine Learning

GraphX Graph

Spark Core

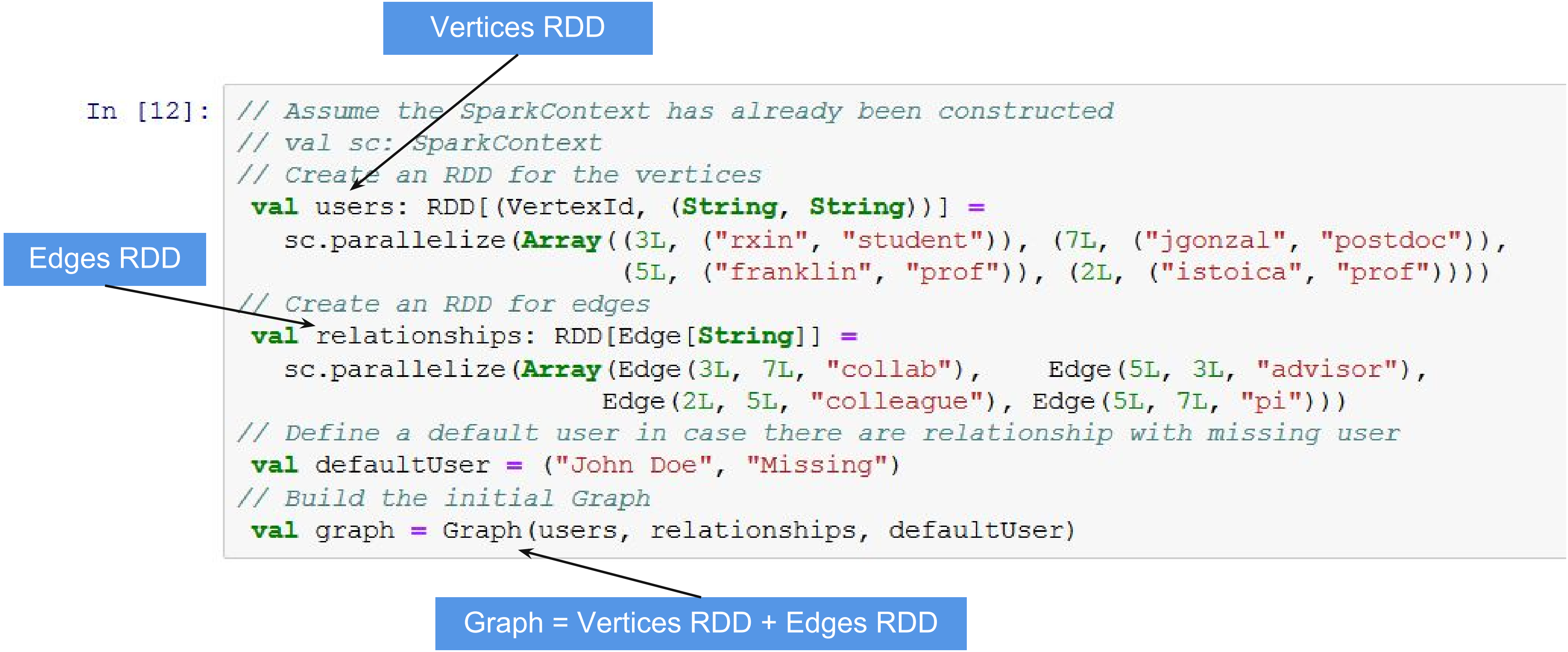
general compute engine, handles distributed task dispatching, scheduling and basic I/O functions

Apache Spark GraphX



- Graph Processing System, not a database
- Directed multigraph with properties attached to each vertex and edges
- Exposes a set of fundamental operators that support graph computation:
  - Subgraph, joinVertices, aggregateMessages, etc…
- Provides algorithms to simplify analytics tasks
  - PageRank, BFS, Triangle Counting, etc…
- Massively parallel: Built on top of Spark RDD

Constructing a property graph with GraphX



Vertices RDD

Edges RDD

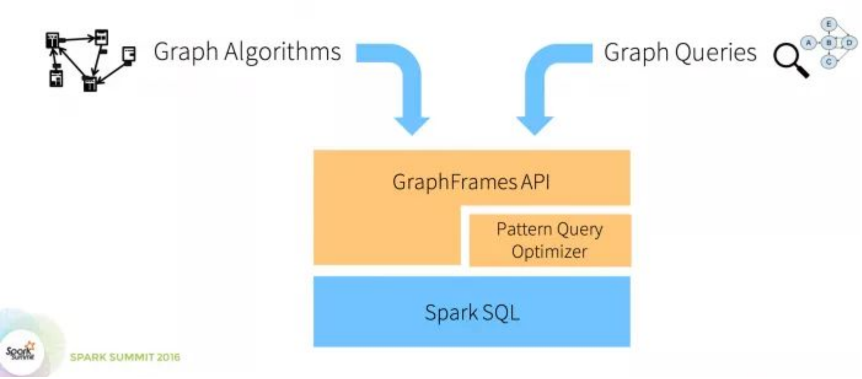
In [12]:

```
// Assume the SparkContext has already been constructed
// val sc: SparkContext
// Create an RDD for the vertices
 val users: RDD[(VertexId, (String, String))] =
   sc.parallelize(Array((3L, ("rxin", "student")), (7L, ("jgonzal", "postdoc")),
                        (5L, ("franklin", "prof")), (2L, ("istoica", "prof"))))
// Create an RDD for edges
 val relationships: RDD[Edge[String]] =
   sc.parallelize(Array(Edge(3L, 7L, "collab"),    Edge(5L, 3L, "advisor"),
                       Edge(2L, 5L, "colleague"), Edge(5L, 7L, "pi")))
// Define a default user in case there are relationship with missing user
 val defaultUser = ("John Doe", "Missing")
// Build the initial Graph
 val graph = Graph(users, relationships, defaultUser)
```

Graph = Vertices RDD + Edges RDD

GraphFrames

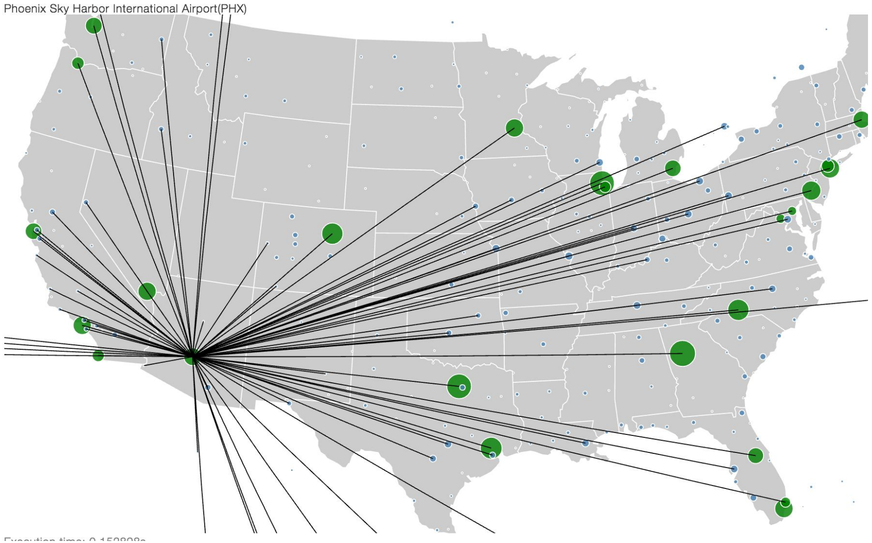
GraphFrames Overview



- Add-on component built on top of GraphX: available on spark-packages.org
- Addresses main limitations of GraphX:
  - Python APIs
  - Uses DataFrames instead of lower-level RDDs: therefore can leverage Catalyst query optimizations
- GraphX-GraphFrame conversion
- Added Feature:
  - Motif finding

https://spark-packages.org/package/graphframes/graphframes

Demo: Create a GraphFrame from airport and flight data

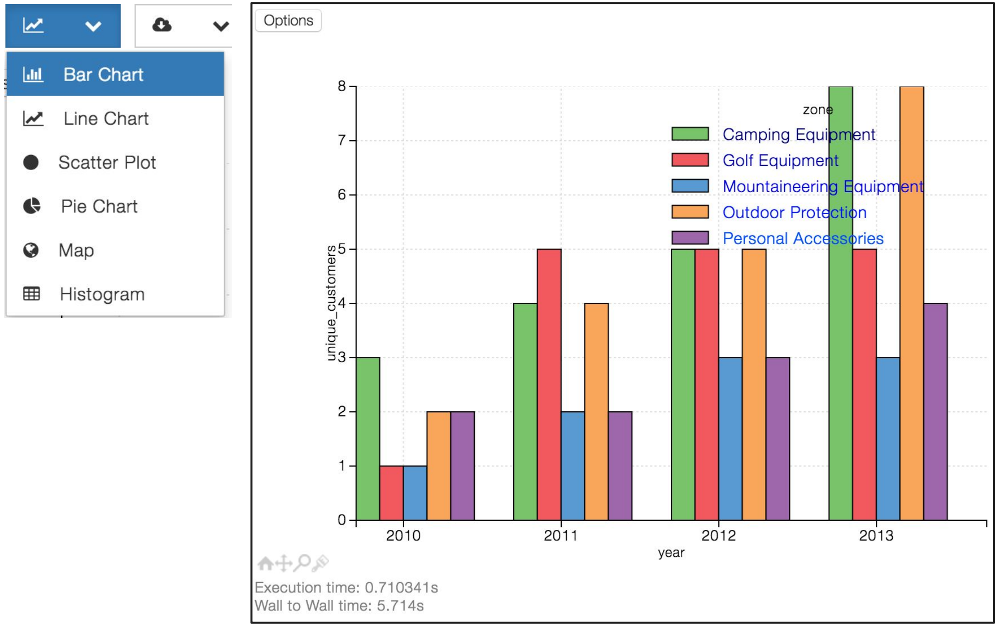

Phoenix Sky Harbor International Airport(PHX)
Execution time: 0.152808s

Demo Steps:

1. Load airport and flight data from Cloudant database
2. Build the Vertex and Edge DataFrame
3. Build the GraphFrame
4. Visualize the graph using PixieDust
5. Graph computation using the Python APIs
6. More Graph Computation using the Scala AggregateMessages API and PixieDust Scala bridge

A word about PixieDust

An Open Source Library that simplifies and improves Jupyter Python Notebooks



```
Execution time: 0.710341s
Wall to Wall time: 5.714s
```

Jupyter + Pixiedust =

1. PackageManager
2. Visualizations
3. Cloud Integration
4. Scala Bridge
5. Extensibility
6. Embedded Apps

https://github.com/ibm-cds-labs/pixiedust

Do code now!

Resources

- Big thanks to David Taieb for the great work building most of this notebook!!
- http://spark.apache.org
- http://www.ibm.com/analytics/us/en/technology/cloud-data-services/spark-as-a-service
- http://datascience.ibm.com
- https://developer.ibm.com/clouddataservices/2016/07/15/intro-to-apache-spark-graphframes/
- https://developer.ibm.com/clouddataservices/2016/10/11/pixiedust-magic-for-python-notebook/
- https://developer.ibm.com/clouddataservices/2016/01/15/real-time-sentiment-analysis-of-twitter-hashtags-with-spark/
- https://developer.ibm.com/clouddataservices/2016/08/04/predict-flight-delays-with-apache-spark-mllib-flightstats-and-weather-data/
- https://github.com/ibm-cds-labs/spark.samples
- https://github.com/ibm-cds-labs/pixiedust

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