Spark, GraphX, and Scala

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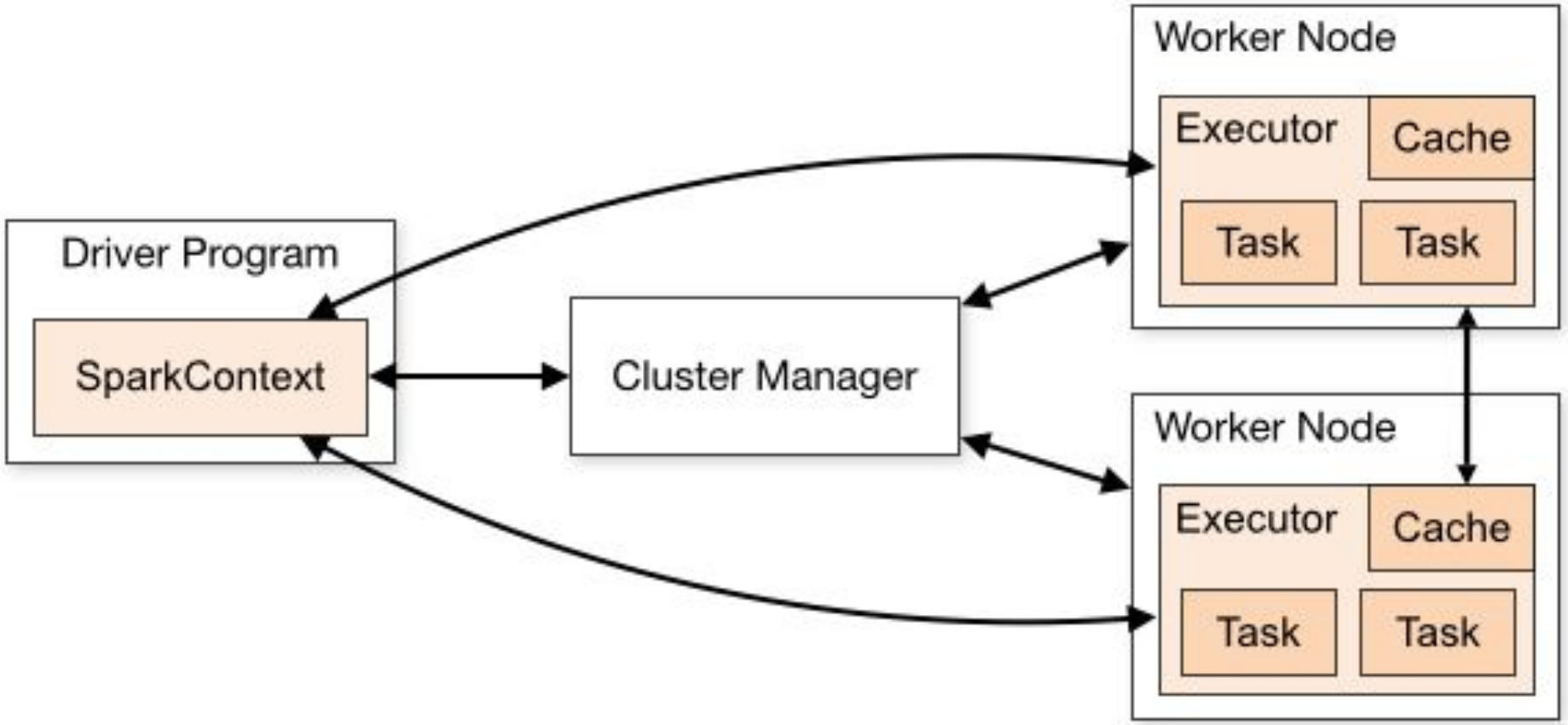
History

- Started as a project at Berkley in 2012
- Main Design Goals
  - Parallelism
  - Fault Tolerance
- Donated to Apache
- GraphX also started at Berkley, then again donated to Apache
- Created in response to linearity of MapReduce

Spark Architecture



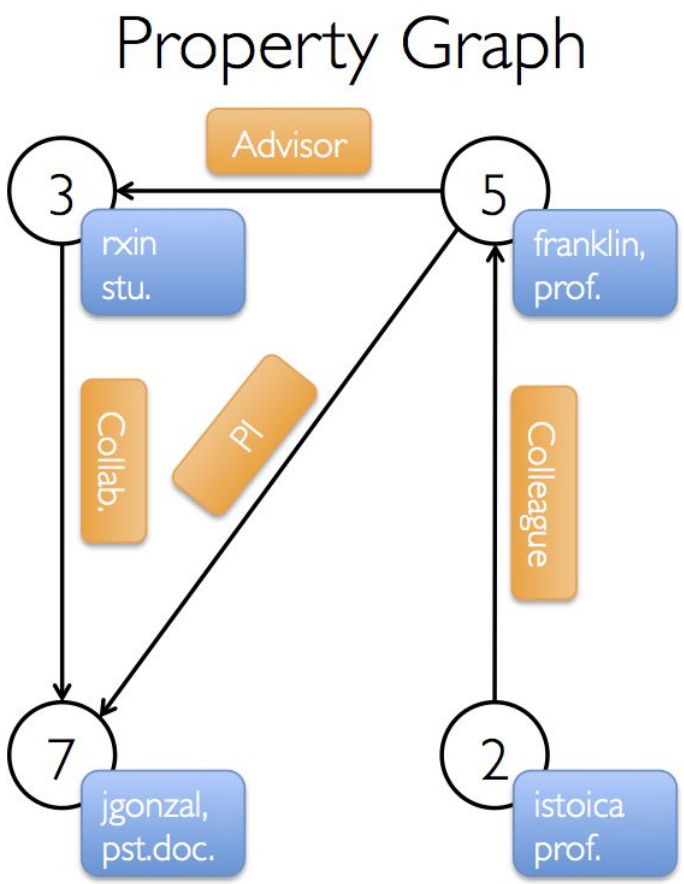
Scala

- Based off of Java
- Compiles into Java Bytecode
- “Aimed to address criticisms of Java”
- Meant to be more functional
  - Type inferencing, immutability, pattern matching
  - Algebraic Data Types and anonymous types
  - Operator overloading, optional parameters

RDDs and Property Graphs

- Resilient Distributed Dataset
- Multisets (Basically Databases)
- Fault Tolerant
- Read only (Not useful for online Data)
- Directed Multigraph with User Defined Objects
- Have basic operations like map, filter, and reduce

Graph as an RDD



Vertex Table

Id	Property (V)
3	(rxin, student)
7	(jgonzal, postdoc)
5	(franklin, professor)
2	(istoica, professor)

Edge Table

SrcId	DstId	Property (E)
3	7	Collaborator
5	3	Advisor
2	5	Colleague
5	7	PI

Graph Code

```
val userGraph: Graph[(String, String), String]
```

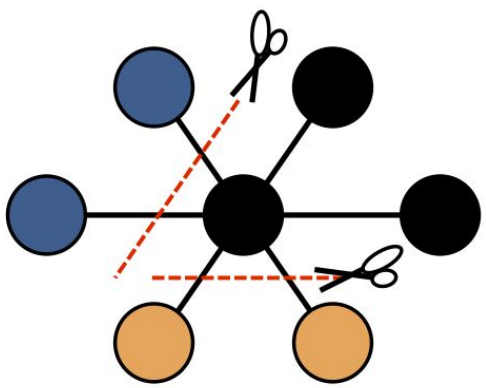
```
// Assume the SparkContext has already been constructed
val sc: SparkContext
// Create an RDD for the vertices
val users: RDD[(VertexId, (String, String))] =
  sc.parallelize(Array((3L, ("rxin", "student")), (7L, ("jgonzal", "postdoc")),
                       (5L, ("franklin", "prof")), (2L, ("istoica", "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)
```

Simple Operations

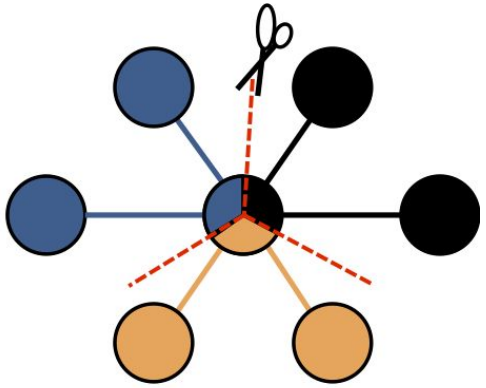
```scala
val graph: Graph[(String, String), String] // Constructed from above
// Count all users which are postdocs
graph.vertices.filter { case (id, (name, pos)) => pos == "postdoc" }.count
// Count all the edges where src > dst
graph.edges.filter(e => e.srcId > e.dstId).count
```

https://spark.apache.org/docs/latest/graphx-programming-guide.html#summary-list-of-operators

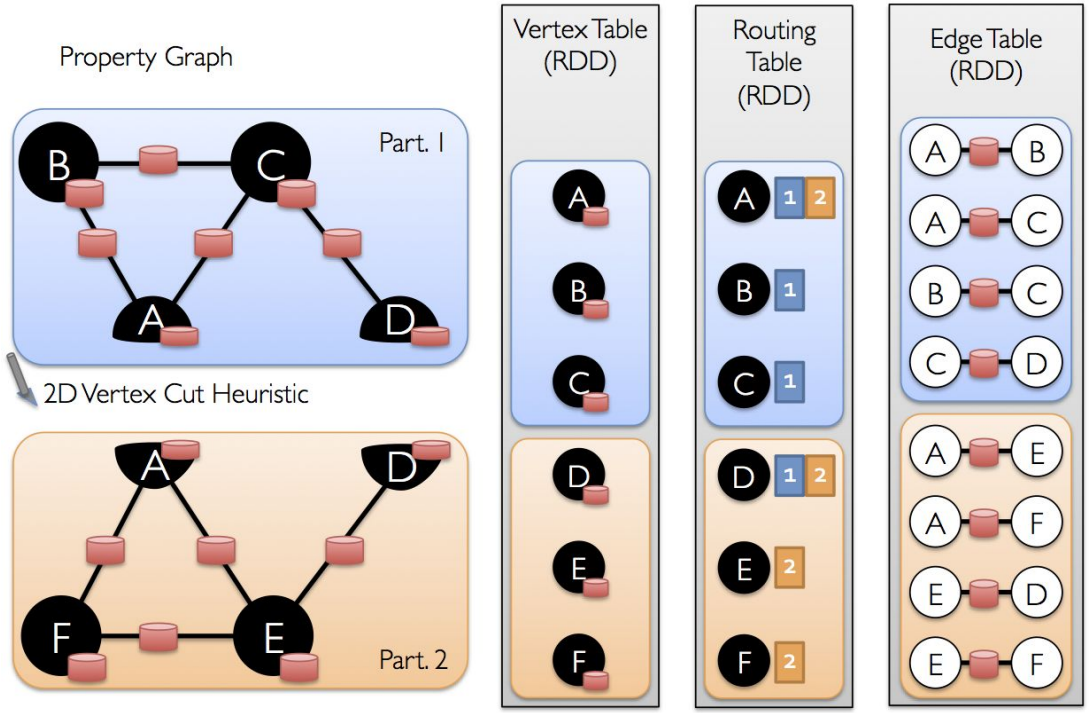
How it Parallelizes



Edge Cut



Vertex Cut



Built in Graph Algorithms

- Label Propagation
- (Strongly) Connected Components
- Triangle Counting
- PageRank
- SVD++

```scala
import org.apache.spark.graphx.{GraphLoader, PartitionStrategy}

// Load the edges in canonical order and partition the graph for triangle count
val graph = GraphLoader.edgeListFile(sc, "data/graphx/followers.txt", true)
  .partitionBy(PartitionStrategy.RandomVertexCut)
// Find the triangle count for each vertex
val triCounts = graph.triangleCount().vertices
// Join the triangle counts with the usernames
val users = sc.textFile("data/graphx/users.txt").map { line =>
  val fields = line.split(",")
  (fields(0).toLong, fields(1))
}
val triCountByUsername = users.join(triCounts).map { case (id, (username, tc)) =>
  (username, tc)
}
// Print the result
println(triCountByUsername.collect().mkString("\n"))
```

Implementation of BFS

```scala
def bfs[VD, ED](graph: Graph[VD, ED], src: VertexId, dst: VertexId): Seq[VertexId] = {
  if (src == dst) return List(src)

  // The attribute of each vertex is (dist from src, id of vertex with dist-1)
  var g: Graph[(Int, VertexId), ED] =
    graph.mapVertices((id, _) => (if (id == src) 0 else Int.MaxValue, 0L)).cache()

  // Traverse forward from src
  var dstAttr = (Int.MaxValue, 0L)
  while (dstAttr._1 == Int.MaxValue) {
    val msgs = g.aggregateMessages[(Int, VertexId)](
      e => if (e.srcAttr._1 != Int.MaxValue && e.srcAttr._1 + 1 < e.dstAttr._1) {
        e.sendToDst((e.srcAttr._1 + 1, e.srcId))
      },
      (a, b) => if (a._1 < b._1) a else b).cache()

    if (msgs.count == 0) return List.empty

    g = g.ops.joinVertices(msgs) {
      (id, oldAttr, newAttr) =>
        if (newAttr._1 < oldAttr._1) newAttr else oldAttr
    }.cache()

    dstAttr = g.vertices.filter(_._1 == dst).first()._2
  }

  // Traverse backward from dst and collect the path
  var path: List[VertexId] = dstAttr._2 :: dst :: Nil
  while (path.head != src) {
    path = g.vertices.filter(_._1 == path.head).first()._2._2 :: path
  }

  path
}
```

Future

- New API in Spark 2, the Dataset
  - Based off RDDs
- GraphFrames
  - WORKS WITH PYTHON!