Common Patterns in Spark Data Processing

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Common Patterns in Spark Programming

In this chapter you will learn

- What kinds of processing and analysis Spark is best at
- How to implement an iterative algorithm in Spark

Common Spark Use Cases (1)

- **Spark is especially useful when working with any combination of:**
  - Large amounts of data
    - Distributed storage
  - Intensive computations
    - Distributed computing
  - Iterative algorithms
    - In-memory processing and pipelining

Common Spark Use Cases (2)

- **Examples**
  - Risk analysis
    - “How likely is this borrower to pay back a loan?”
  - Recommendations
    - “Which products will this customer enjoy?”
  - Predictions
    - “How can we prevent service outages instead of simply reacting to them?”
  - Classification
    - “How can we tell which mail is spam and which is legitimate?”

Spark Examples

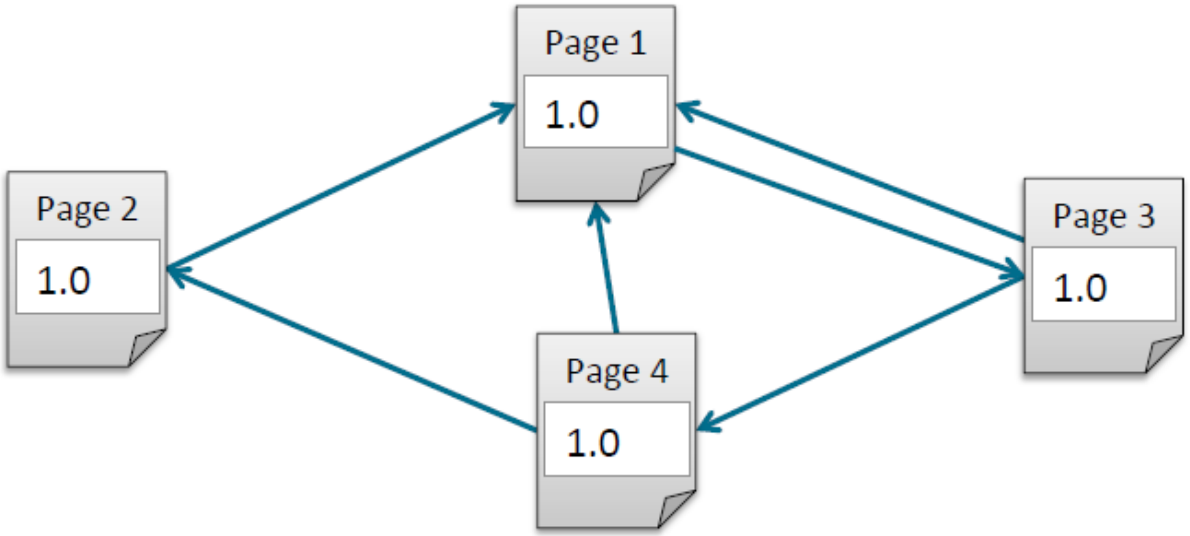
- **Spark includes many example programs that demonstrate some common Spark programming patterns and algorithms**
  - k-means
  - Logistic regression
  - Calculate pi
  - Alternating least squares (ALS)
  - Querying Apache web logs
  - Processing Twitter feeds
- **Examples**
  - **`$SPARK_HOME/examples/lib`**
    - **`spark-examples-`*`version`*`.jar` – Java and Scala examples**
    - **`python.tar.gz` – Pyspark examples**

Example: PageRank

- **PageRank gives web pages a ranking score based on links from other pages**
  - Higher scores given for more links, and links from other high ranking pages
- **Why do we care?**
  - PageRank is a classic example of big data analysis (like WordCount)
    - Lots of data – needs an algorithm that is distributable and scalable
    - Iterative – the more iterations, the better than answer

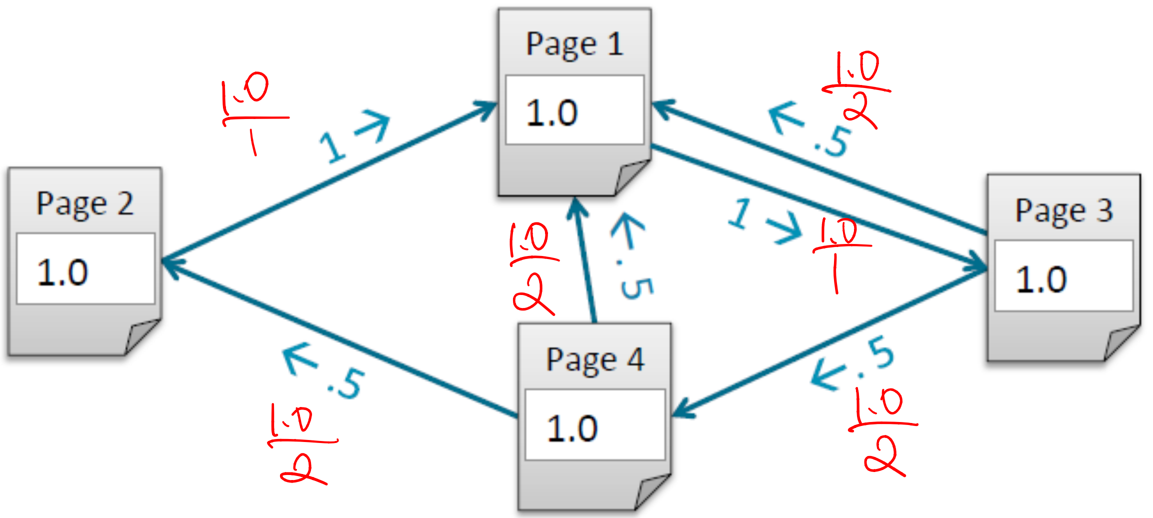
PageRank Algorithm (1)

1. **Start each page with a rank of 1.0**



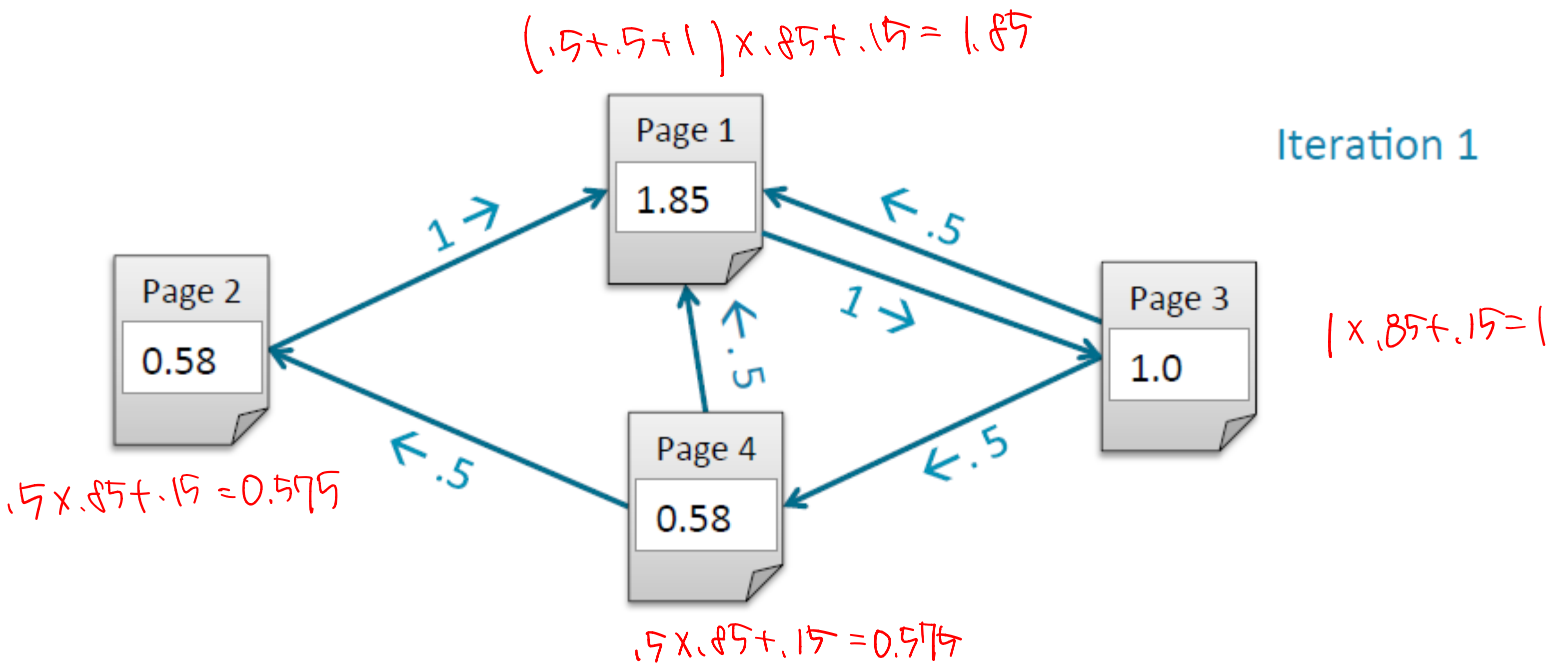
PageRank Algorithm (2)

1. **Start each page with a rank of 1.0**
2. **On each iteration:**
   1. each page contributes to its neighbors its own rank divided by the number of its neighbors: $contrib_p = rank_p / neighbors_p$



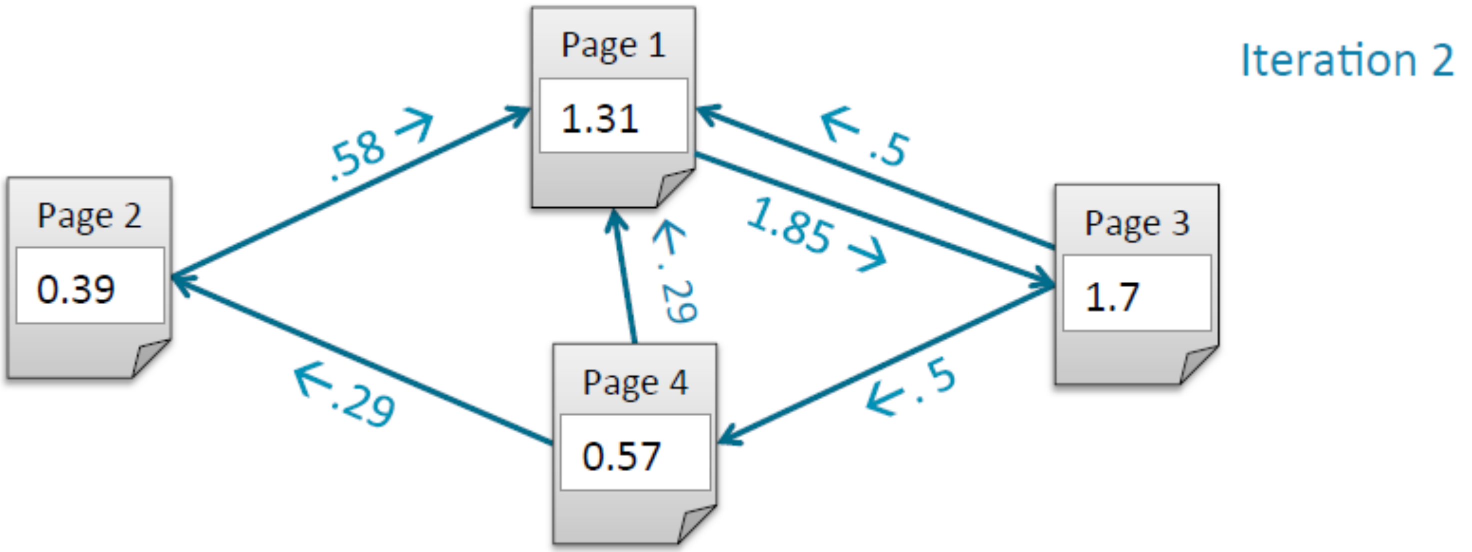
PageRank Algorithm (3)

1. **Start each page with a rank of 1.0**
2. **On each iteration:**
   1. each page contributes to its neighbors its own rank divided by the number of its neighbors: $contrib_p = rank_p / neighbors_p$
   2. Set each page's new rank based on the sum of its neighbors contribution: new-rank = Σcontribs * .85 + .15



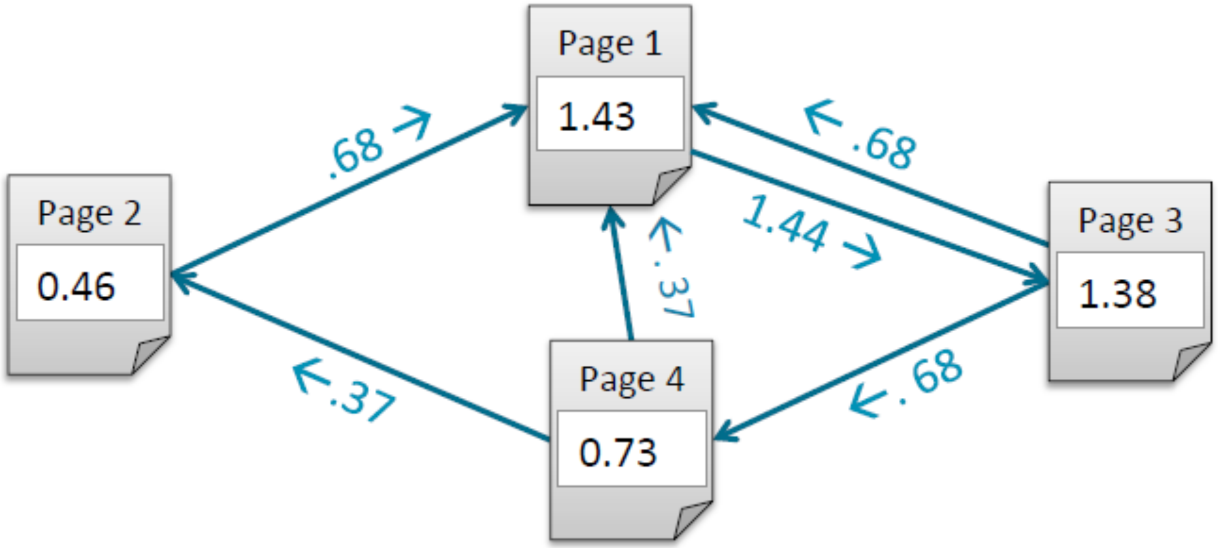
PageRank Algorithm (4)

1. **Start each page with a rank of 1.0**
2. **On each iteration:**
   1. each page contributes to its neighbors its own rank divided by the number of its neighbors: $contrib_p = rank_p / neighbors_p$
   2. Set each page's new rank based on the sum of its neighbors contribution: new-rank = Σcontribs * .85 + .15
3. **Each iteration incrementally improves the page ranking**



PageRank Algorithm (5)

1. **Start each page with a rank of 1.0**
2. **On each iteration:**
   1. each page contributes to its neighbors its own rank divided by the number of its neighbors: $contrib_p = rank_p / neighbors_p$
   2. Set each page's new rank based on the sum of its neighbors contribution: $new\text{-}rank = \Sigma contribs * .85 + .15$
3. **Each iteration incrementally improves the page ranking**



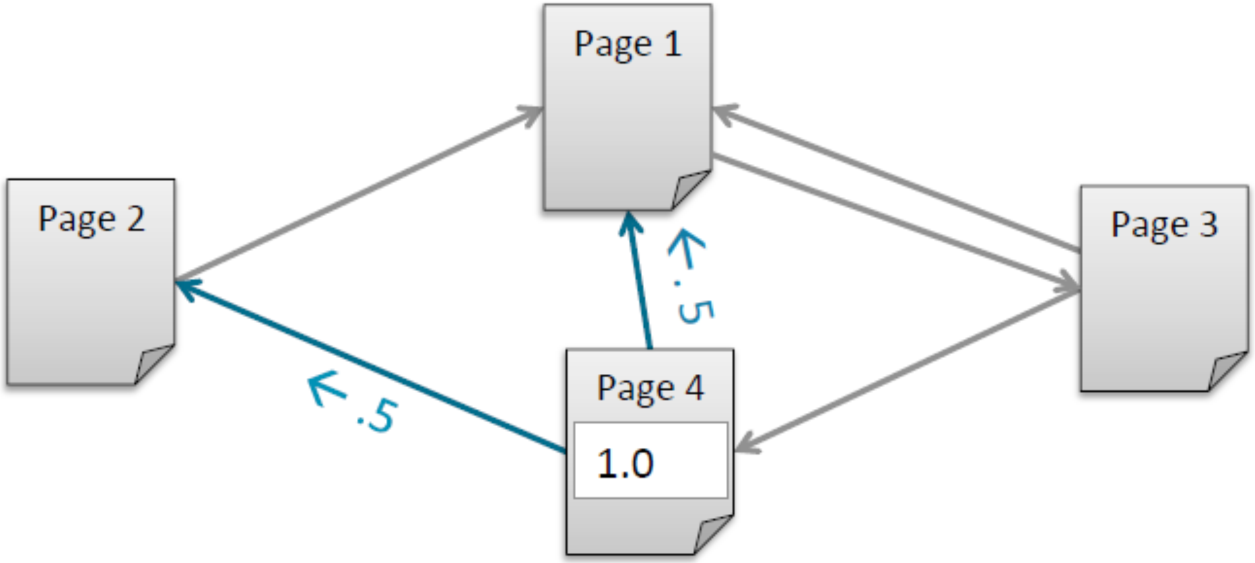
Iteration 10
(Final) ⇒ converging

PageRank in Spark: Neighbor Contribution Function

```
def computeContribs(neighbors, rank):
    for neighbor in neighbors: yield(neighbor, rank/len(neighbors))
```

neighbors: [page1,page2]
rank: 1.0

(page1,.5)
(page2,.5)

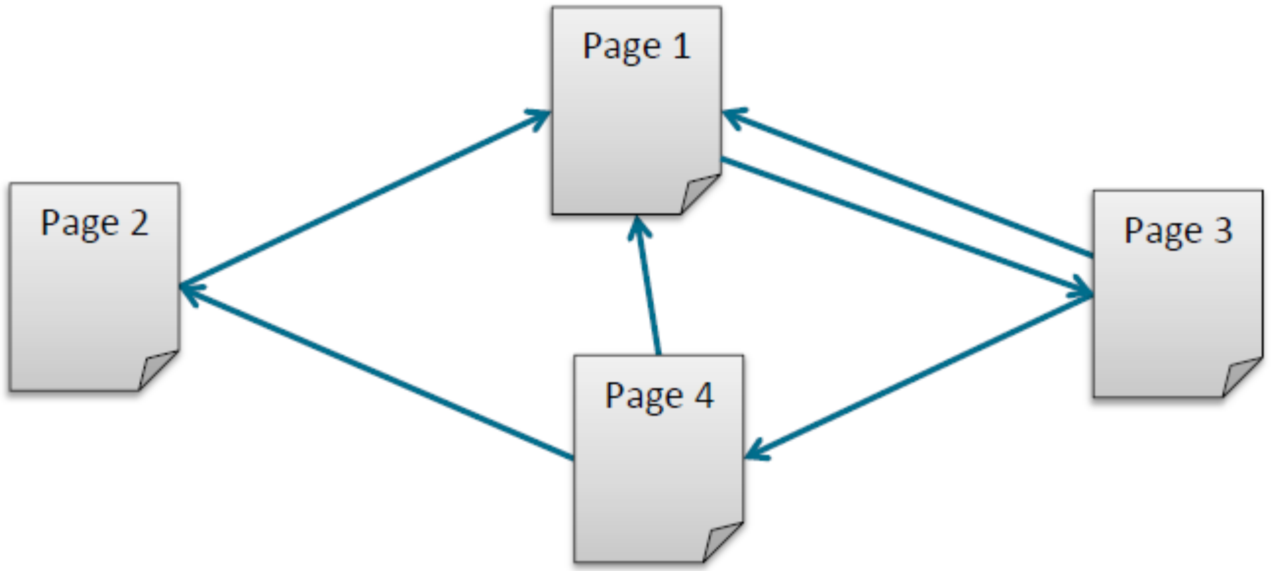


PageRank in Spark: Example Data

Data Format:
source-page destination-page
...

src dst

```
page1 page3
page2 page1
page4 page1
page3 page1
page4 page2
page3 page4
```



PageRank in Spark: Pairs of Page Links

```
def computeContribs(neighbors, rank):…

links = sc.textFile(file)\
    .map(lambda line: line.split())\
    .map(lambda pages: (pages[0],pages[1]))\
    .distinct()
```

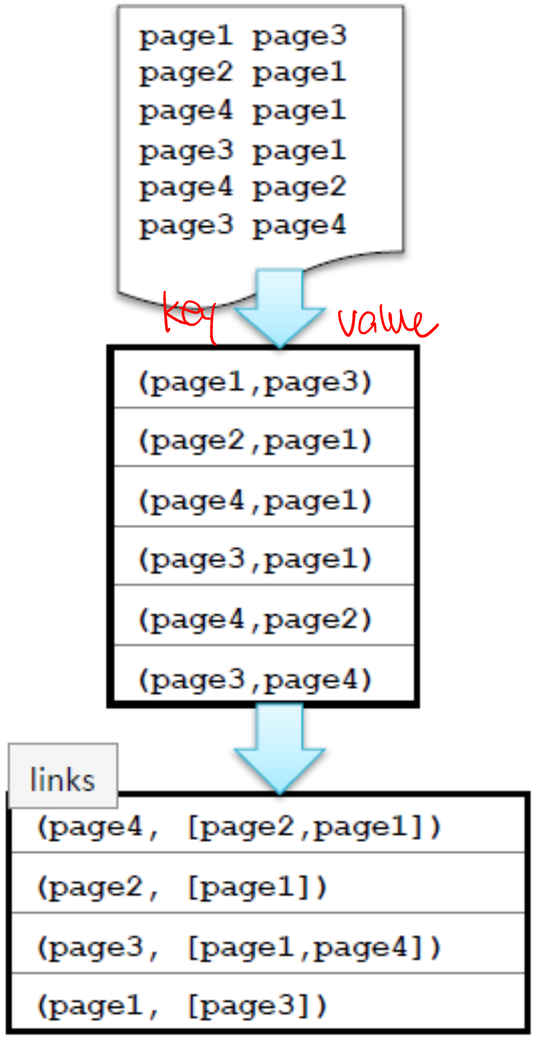
```
page1 page3
page2 page1
page4 page1
page3 page1
page4 page2
page3 page4
```

```
(page1,page3)
(page2,page1)
(page4,page1)
(page3,page1)
(page4,page2)
(page3,page4)
```

PageRank in Spark: Page Links Grouped by Source Page

```
def computeContribs(neighbors, rank):…

links = sc.textFile(file)\
    .map(lambda line: line.split())\
    .map(lambda pages: (pages[0],pages[1]))\
    .distinct()\
    .groupByKey()
```

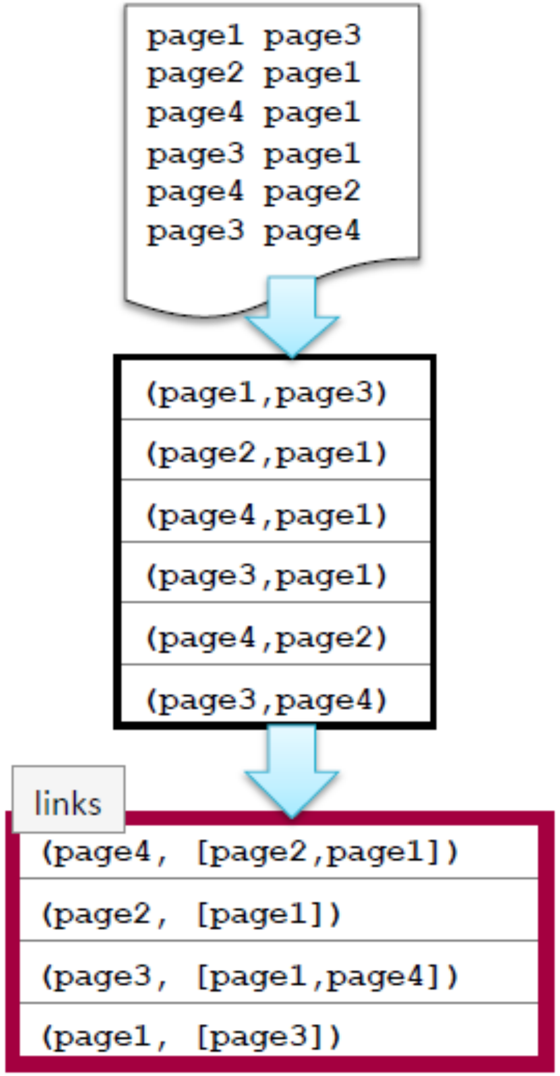


PageRank in Spark: Persisting the Link Pair RDD

```
def computeContribs(neighbors, rank):...

links = sc.textFile(file)\
    .map(lambda line: line.split())\
    .map(lambda pages: (pages[0],pages[1]))\
    .distinct()\
    .groupByKey()\
    .persist()
```

⇒ keep link set in MEM
iteratively usage
prevent re-computing every time
Link graph caching in MEM



PageRank in Spark: Set Initial Ranks

```
def computeContribs(neighbors, rank):…

links = sc.textFile(file)\
    .map(lambda line: line.split())\
    .map(lambda pages: (pages[0],pages[1]))\
    .distinct()\
    .groupByKey()\
    .persist()

ranks=links.map(lambda (page,neighbors): (page,1.0))
```

initialize

links
(page4, [page2,page1])
(page2, [page1])
(page3, [page1,page4])
(page1, [page3])

ranks
(page4, 1.0)
(page2, 1.0)
(page3, 1.0)
(page1, 1.0)

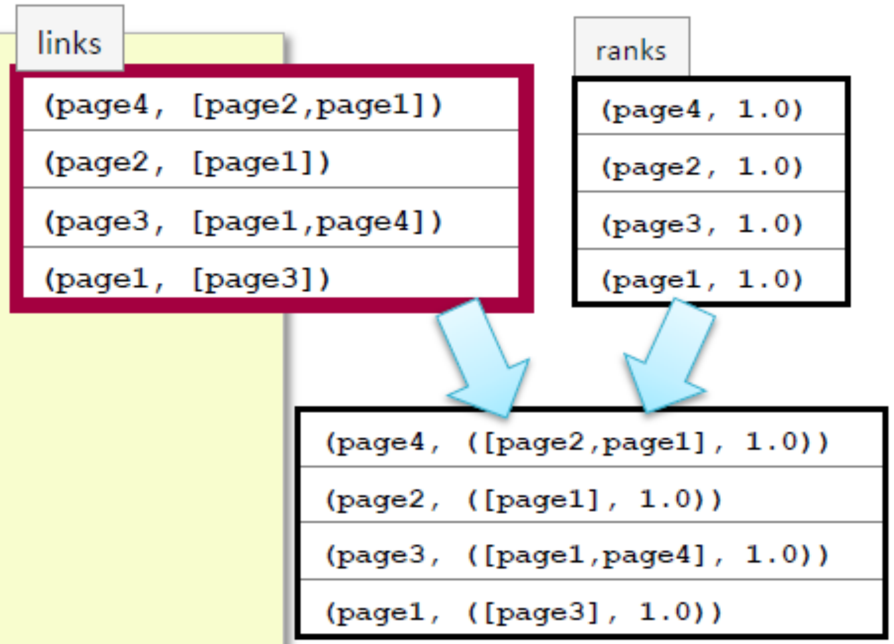
PageRank in Spark: First Iteration (1)

```
def computeContribs(neighbors, rank):…

links = …

ranks = …

for x in xrange(10):
  contribs=links\
    .join(ranks)
```



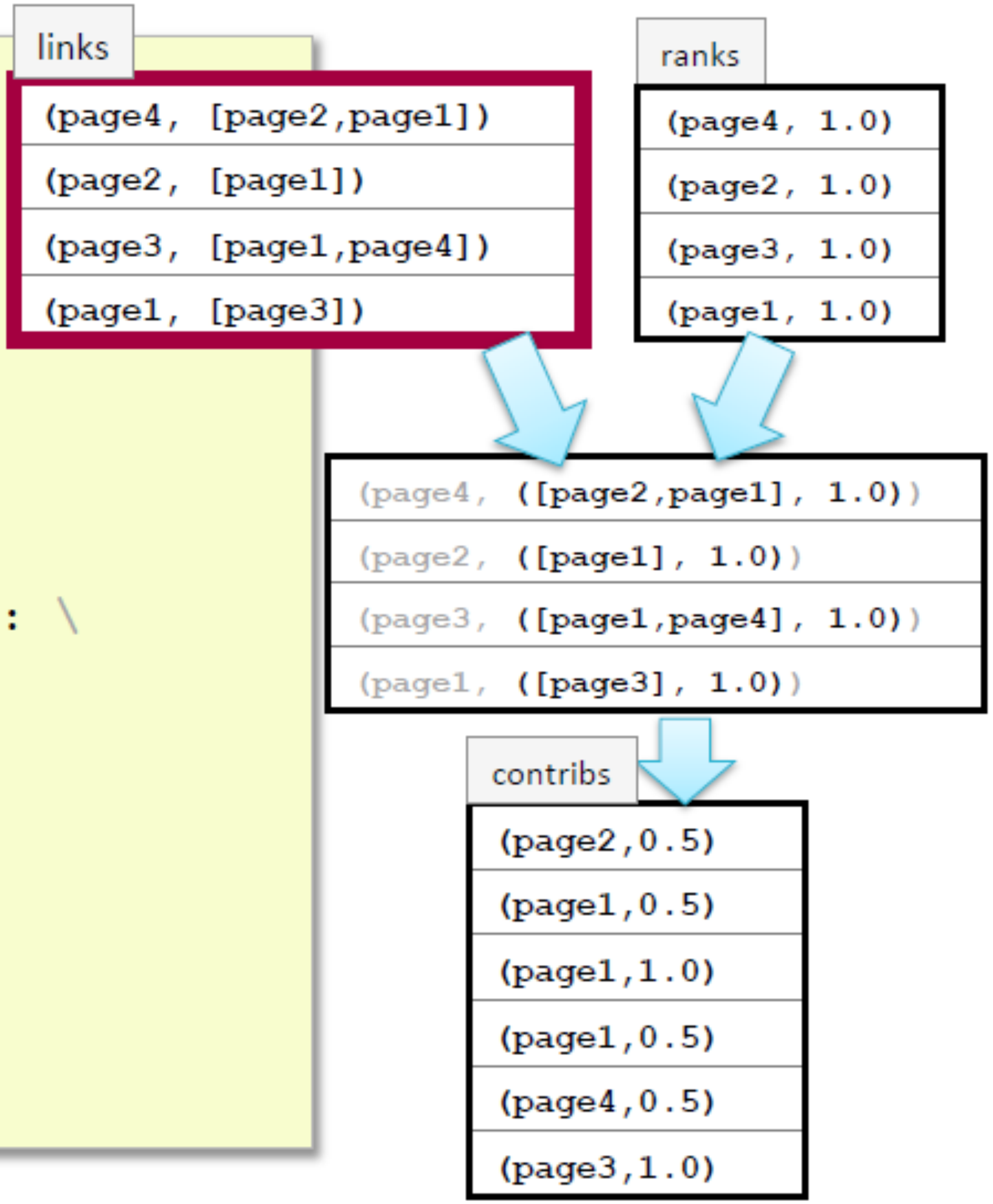
PageRank in Spark: First Iteration (2)

```
def computeContribs(neighbors, rank):...

links = ...

ranks = ...

for x in xrange(10):
  contribs=links\
    .join(ranks)\
    .flatMap(lambda (page,(neighbors,rank)): \
       computeContribs(neighbors,rank))
```



PageRank in Spark: First Iteration (3)

```
def computeContribs(neighbors, rank):…

links = …

ranks = …

for x in xrange(10):
  contribs=links\
    .join(ranks)\
    .flatMap(lambda (page,(neighbors,rank)): \
       computeContribs(neighbors,rank))
  ranks=contribs\
    .reduceByKey(lambda v1,v2: v1+v2)
```

contribs

(page2,0.5)
(page1,0.5)
(page1,1.0)
(page1,0.5)
(page4,0.5)
(page3,1.0)

⇩

(page4,0.5)
(page2,0.5)
(page3,1.0)
(page1,2.0)

PageRank in Spark: First Iteration (4)

```
def computeContribs(neighbors, rank):…

links = …

ranks = …

for x in xrange(10):
  contribs=links\
    .join(ranks)\
    .flatMap(lambda (page,(neighbors,rank)): \
       computeContribs(neighbors,rank))
  ranks=contribs\
    .reduceByKey(lambda v1,v2: v1+v2)\
    .map(lambda (page,contrib): \
         (page,contrib * 0.85 + 0.15))
```

contribs
(page2,0.5)
(page1,0.5)
(page1,1.0)
(page1,0.5)
(page4,0.5)
(page3,1.0)

(page4,0.5)
(page2,0.5)
(page3,1.0)
(page1,2.0)

ranks
(page4,.58)
(page2,.58)
(page3,1.0)
(page1,1.85)

PageRank in Spark: Second Iteration

```
def computeContribs(neighbors, rank):...

links = ...

ranks = ...

for x in xrange(10):
  contribs=links\
    .join(ranks)\
    .flatMap(lambda (page,(neighbors,rank)): \
       computeContribs(neighbors,rank))
  ranks=contribs\
    .reduceByKey(lambda v1,v2: v1+v2)\
    .map(lambda (page,contrib): \
         (page,contrib * 0.85 + 0.15))

for rank in ranks.collect(): print rank
```