# Partitioning

Big Data Analysis with Scala and Spark Heather Miller

"Partitioning"?

In the last session, we were looking at an example involving groupByKey, before we discovered that this operation causes data to be *shuffled* over the network.

Grouping all values of key-value pairs with the same key requires collecting all key-value pairs with the same key on the same machine.

We concluded the last session asking ourselves, But how does Spark know which key to put on which machine?

Before we try to optimize that example any further, let's first take a quick detour into what partitioning is...

### Partitions

The data within an RDD is split into several *partitions*. **Properties of partitions:** 

- Partitions never span multiple machines, i.e., tuples in the same partition are guaranteed to be on the same machine.
- Each machine in the cluster contains one or more partitions.
- The number of partitions to use is configurable. By default, it equals the total number of cores on all executor nodes.

#### Two kinds of partitioning available in Spark:

- Hash partitioning
- Range partitioning

#### Customizing a partitioning is only possible on Pair RDDs.

### Hash partitioning

Back to our example. Given a Pair RDD that should be grouped:

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groupByKey first computes per tuple (k, v) its partition p:

p = k.hashCode() % numPartitions

Then, all tuples in the same partition p are sent to the machine hosting p.

Intuition: hash partitioning attempts to spread data evenly across partitions based on the key.

### Range partitioning

Pair RDDs may contain keys that have an *ordering* defined.

Examples: Int, Char, String, ...

For such RDDs, *range partitioning* may be more efficient. Using a range partitioner, keys are partitioned according to:

an *ordering* for keys
a set of *sorted ranges* of keys

*Property:* tuples with keys in the same range appear on the same machine.

### Hash Partitioning: Example

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= K.7.4

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- Furthermore, suppose that hashCode() is the identity (n.hashCode() == n).
- In this case, hash partitioning distributes the keys as follows among the partitions:
  - partition 0: [8, 96, 240, 400, 800]
  - partition 1: [401]
  - ▶ partition 2: []
  - partition 3: []

The result is a very unbalanced distribution which hurts performance.

p = K %

### Range Partitioning: Example

Using *range partitioning* the distribution can be improved significantly:

- Assumptions: (a) keys non-negative, (b) 800 is biggest key in the RDD.
- Set of ranges: [1, 200], [201, 400], [401, 600], [601, 800]

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- Set of ranges: [1, 200], [201, 400], [401, 600], [601, 800]

In this case, range partitioning distributes the keys as follows among the partitions:

- partition 0: [8, 96]
- partition 1: [240, 400]
- ▶ partition 2: [401]
- ▶ partition 3: [800]

The resulting partitioning is much more balanced.

### Partitioning Data

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There are two ways to create RDDs with specific partitionings:

1. Call partitionBy on an RDD, providing an explicit Partitioner. 2. Using transformations that return RDDs with specific partitioners.

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Creating a RangePartitioner requires:

- 1. Specifying the desired number of partitions.
- 2. Providing a Pair RDD with ordered keys. This RDD is sampled to create a suitable set of *sorted ranges*.

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Creating a RangePartitioner requires:

- 1. Specifying the desired number of partitions.

2. Providing a Pair RDD with ordered keys. This RDD is sampled to create a suitable set of *sorted ranges*. Important: the result of partitionBy should be persisted. Otherwise, the partitioning is repeatedly applied (involving shuffling!) each time the partitioned RDD is used.

#### Partitioner from parent RDD:

Pair RDDs that are the result of a transformation on a *partitioned* Pair RDD typically is configured to use the hash partitioner that was used to construct it.

#### **Automatically-set partitioners:**

Some operations on RDDs automatically result in an RDD with a known partitioner – for when it makes sense.

For example, by default, when using sortByKey, a RangePartitioner is used. Further, the default partitioner when using groupByKey, is a HashPartitioner, as we saw earlier.

Operations on Pair RDDs that hold to (and propagate) a partitioner:

- cogroup foldByKey
- groupWith combineByKey
- ▶ join > partitionBy
- leftOuterJoin ▶ sort
- rightOuterJoin
- groupByKey
- reduceByKey

#### All other operations will produce a result without a partitioner.

mapValues (if parent has a partitioner) flatMapValues (if parent has a partitioner) filter (if parent has a partitioner)

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Consider the map transformation. Given that we have a hash partitioned Pair RDD, why would it make sense for map to lose the partitioner in its result RDD?

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Because it's possible for map to change the key . E.g.,:

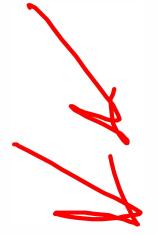
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rdd.map((k: String, v: Int) =>("dob



In this case, if the map transformation preserved the partitioner in the result RDD, it no longer make sense, as now the keys are all different.

Hence <u>mapValues</u>. It enables us to still do map transformations without changing the keys, thereby preserving the partitioner.