Big Data

Tutorial #4

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Outline

1) Lecture Recap

2) Exercise Discussion

3) Joins in Spark

4) Communication Costs

5) Homework Exercise

What previously happened...

Lecture Recap

Broadcast Join & Shuffle Join

- Broadcast join:
  - If one table is small (i.e., if it fits completely into the memory of each executor), collect it at the driver
  - Broadcast the complete table to all executors
  - Communication between driver and executors only at the beginning
- Shuffle join:
  - If both tables are big
  - Shuffle: communication between executors
    - Every node talks to every other node
  - Data sharing with respect to keys

Cost Measures for Algorithms

- Two main costs:
  - **Communication costs**, i.e., what does it cost to send data around the network?
    - Measured, for instance, in bytes
  - **Computation costs**, i.e., what are the costs for mappers, reducers, and the system?
    - Measured, for instance, in hours of computing power
- *Communication cost*:
  - Total I/O of all processes
- *Elapsed communication cost*:
  - Max of I/O along any path
- *(Elapsed) computation cost*:
  - Analogous, but count only running time of processes

Efficiency Aspects of Spark

- Volcano Iterator Model
  - Queries are transformed into sequences of operations
- Whole-stage code generation
  - Works well with simple operations
- Vectorization
  - Apply an instruction to an entire array
  - Must be supported by CPU

Retail data

Exercise Discussion

Homework Assignment – Discussion

- Consider the retail dataset again. Answer the following questions in two different ways: using SQL and using Spark code (DataFrame API).

  - How many orders did customers perform at which hour?
  - How frequently was each product bought in the different countries?

- Demo

Natural join, inner join, semi-join, etc.

Joins in Spark

Different Types of Joins

- Natural join

- Inner join

- (Left/right) outer join

- Left semi-join
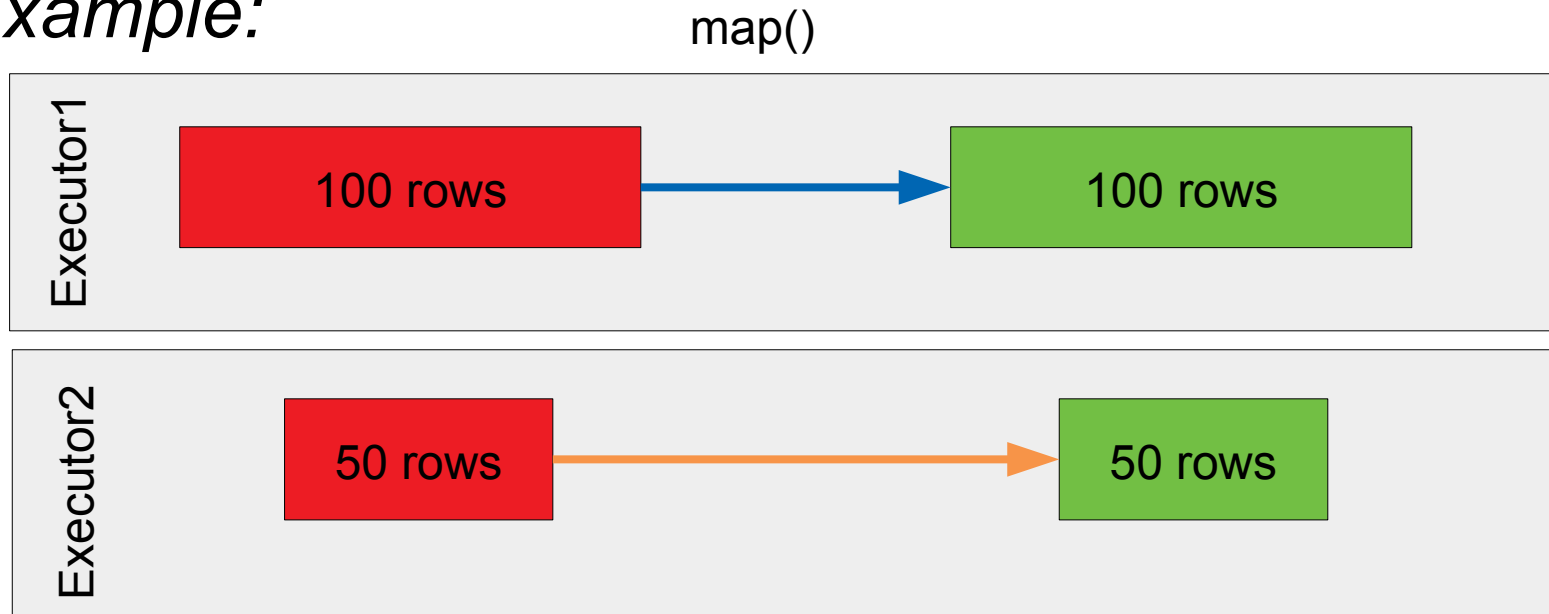
- Left anti-join

- Cross join (cartesian product)

➔ Demo

Considering narrow and wide transformations

Communication Costs

Costs for Narrow Transformation
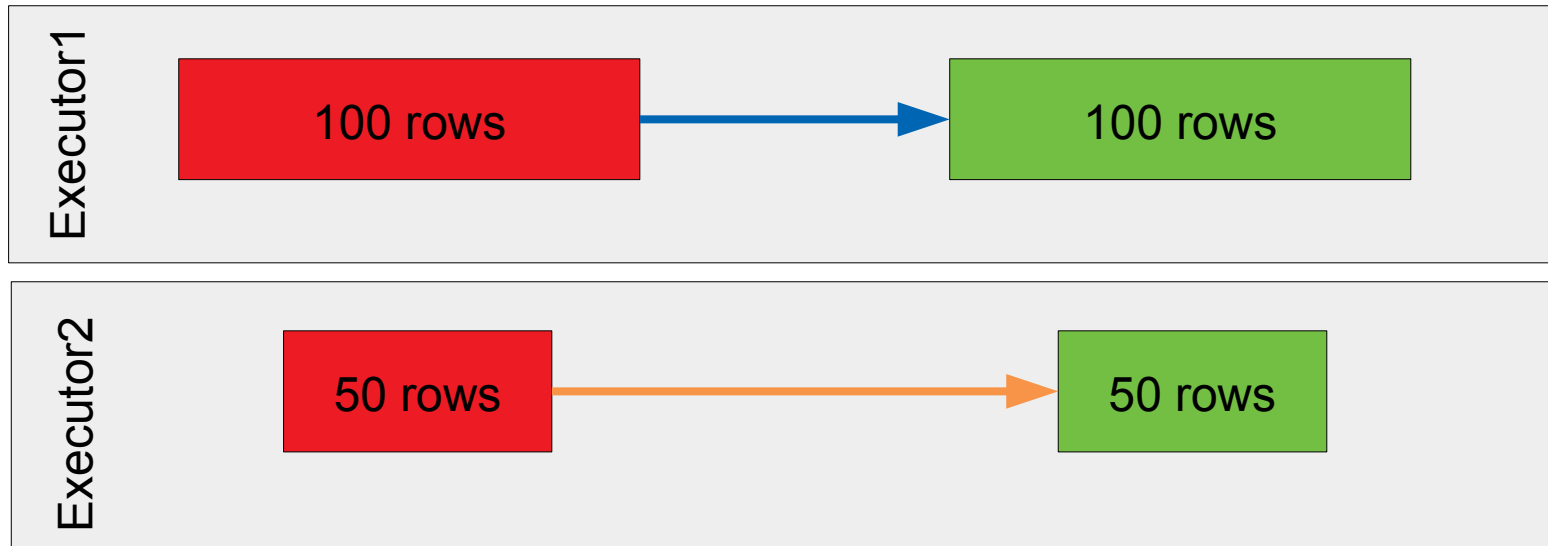
- *Example:*

map()

- Communication cost?

- Elapsed communication cost?

Costs for Narrow Transformation

- *Example:*
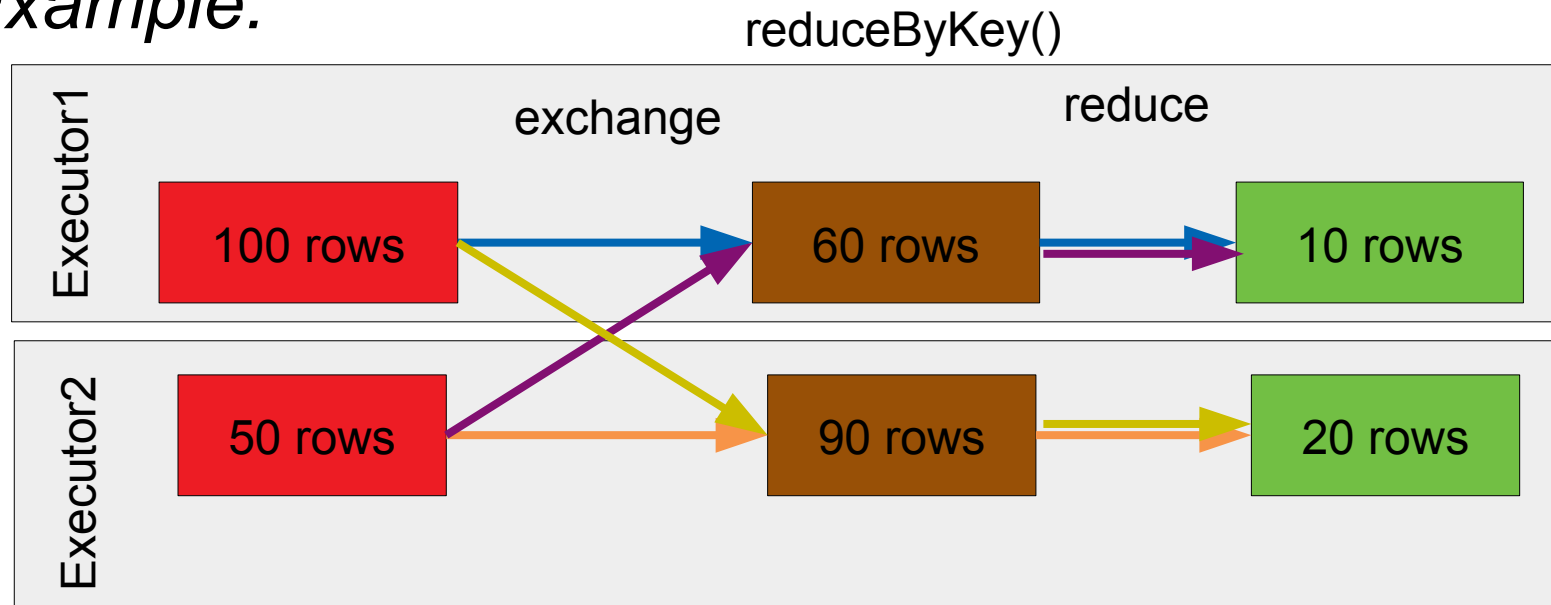
map()

- Communication cost
  = 100 + 100 + 50 + 50 = 300

- Elapsed communication cost
  = max((100 + 100), (50 + 50)) = 200
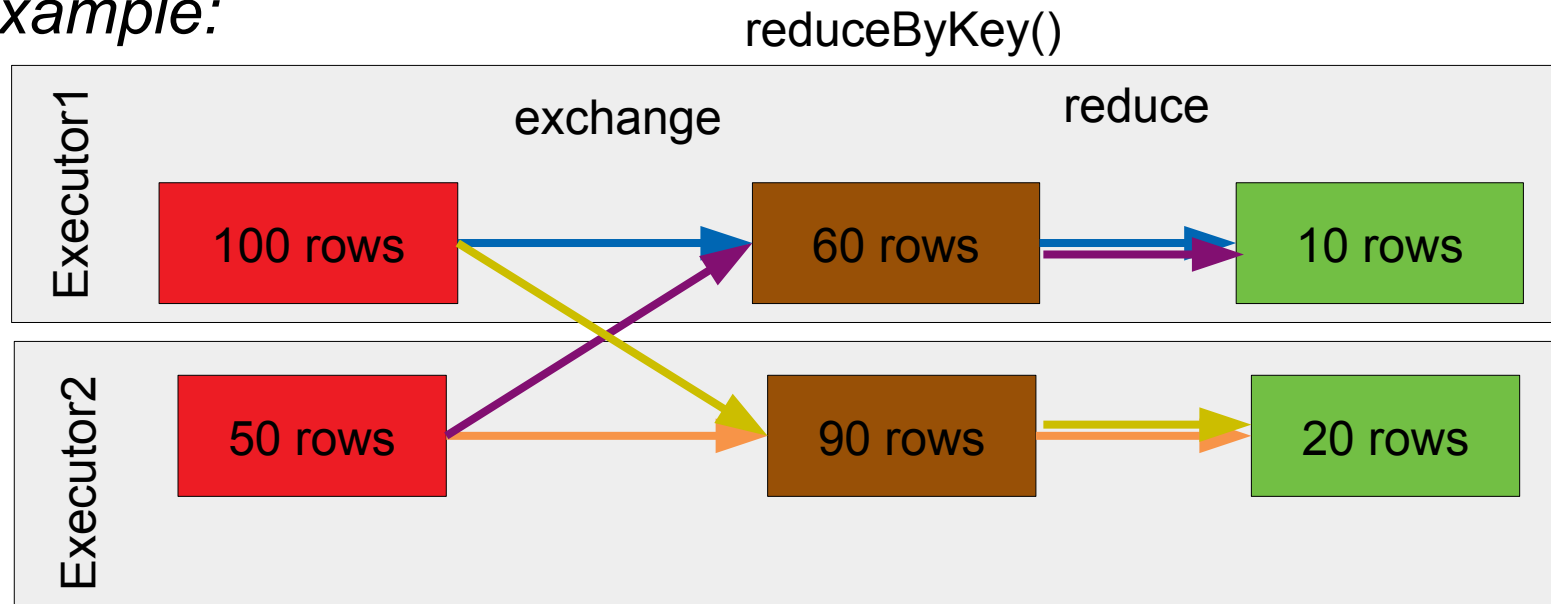
Costs for Wide Transformations (Shuffle)

- *Example:*

- Communication cost?

- Elapsed communication cost?

Costs for Wide Transformations (Shuffle)

- *Example:*

reduceByKey()

- Communication cost

  = exchange cost   + reduce cost

  = [100 + 50 + 60 + 90] + [60 + 90 + 10 + 20]

  = 480

- Elapsed communication cost

  = max(100+2*60+10, 100+2*90+20, 50+2*60+10, 50+2*90+20)

  = max(230, 300, 180, 250)

  = 300

Now it's your turn!

Homework Exercise

Exercise #1 – Spark

1) **Pivot**
   Consider the *Retail dataset* again.
   How many instances of each product were sold in each country?

2) **Joins**
   Just play around with the different join types and make sure you understand each one.
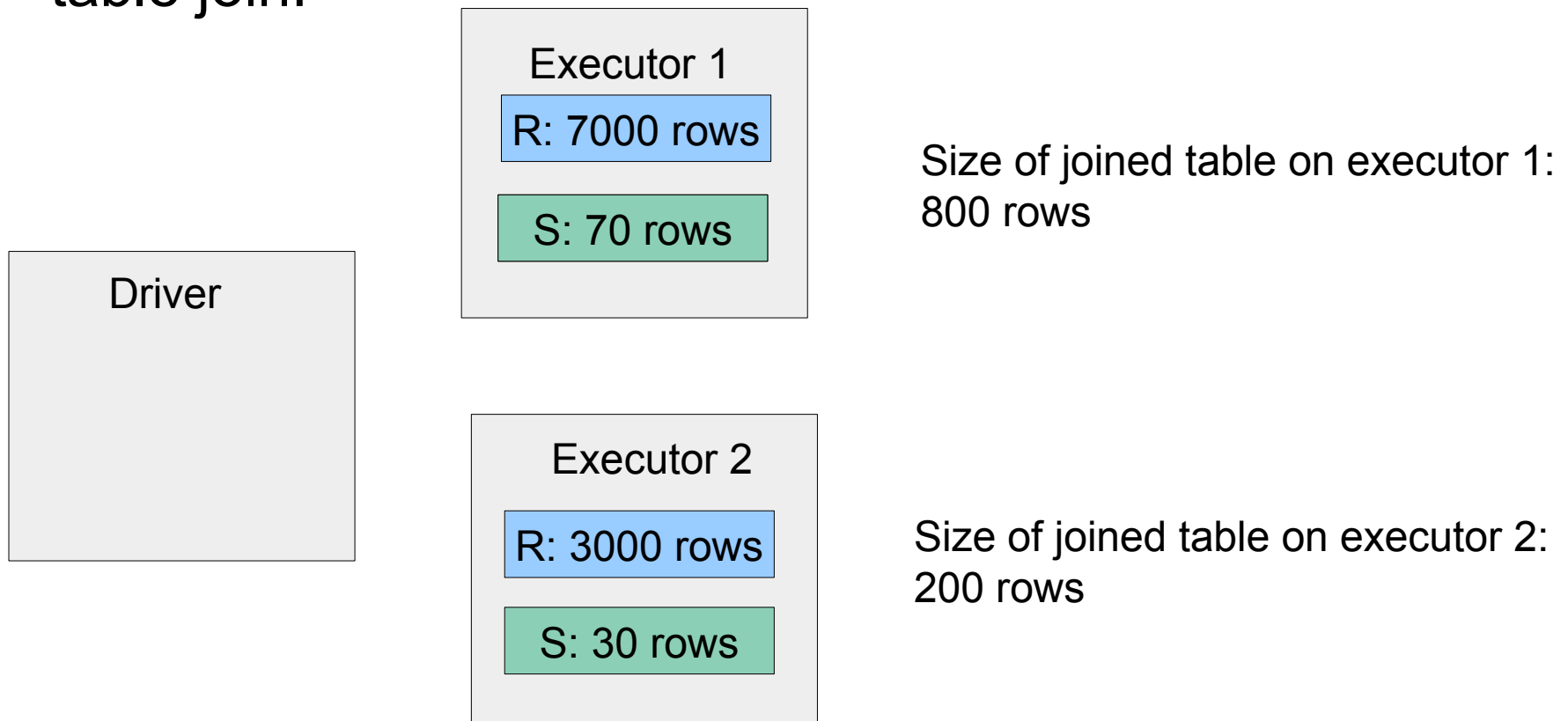   You can utilize `customers.csv` and `orders(2).csv` for this purpose.
   ➔ These files can be found in OLAT under:
      `Tutorial Material/Tutorial04`

Exercise #2 – Communication Cost

- Compute the **communication cost** and the **elapsed communication cost** for the following big table-to-small table join:

Executor 1

R: 7000 rows

S: 70 rows

Size of joined table on executor 1: 800 rows

Driver

Executor 2

R: 3000 rows

S: 30 rows

Size of joined table on executor 2: 200 rows

Thank you for your Attention!

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