Big data: architectures and data analytics

MapReduce patterns

Data Organization Patterns

- Are used to reorganize/split in subsets the input data
  - Binning
  - Shuffling
- The output of an application based on an organization pattern is usually the input of another application(s)

Data Organization Patterns

Binning

- Goal
  - Organize/move the input records into categories
- Intent
  - Partition a big data set into distinct, smaller data sets ("bins") containing similar records
    - Each partition is usually the input of a following analysis
- Motivation
  - The input data set contains heterogeneous data, but each data analysis usually is focused only on a specific subsets of your data
**Binning - structure**

- Based on a Map-only job
- Driver
  - Sets the list of “bins/output files” by means of MultipleOutputs
- Mappers
  - For each input (key, value) pair, select the output bin/file associated with it and emit a (key,value) in that file
    - key of the emitted pair = key of the input pair
    - value of the emitted pair = value of the input pair
- No combiner or reducer is used in this pattern

**Shuffling**

- **Goal**
  - Randomize the order of the data (records)
- **Motivation**
  - Randomize the order of the data
    - For anonymization reasons
    - For selecting a subset of random data (records)
Metapatterns

- Are used to organize the workflow of a complex application executing many jobs
  - Job Chaining

Job Chaining

- Goal
  - Execute a sequence of jobs (synchronizing them)
- Intent
  - Manage the workflow of complex applications based on many phases (iterations)
    - Each phase is associated with a different MapReduce Job (i.e., one sub-application)
    - The output of a phase is the input of the next one
- Motivation
  - Real applications are usually based on many phases

Job Chaining - structure

- The (single) Driver
  - Contains the workflow of the application
  - Executes the jobs in the proper order
- Mappers, reducers, and combiners
  - Each phase of the complex application is implemented by a MapReduce Job
    - i.e., it is associated with a mapper, a reducer (and a combiner if it is useful)
Complex workflow

- More complex workflows, which execute jobs in parallel, can also be implemented
- However, the synchronization of the jobs become more complex

Join Patterns

- Are used to implement the join operators of the relational algebra (i.e., the join operators of traditional relational databases)
  - Reduce side join
  - Map side join

Join Patterns

- We will focus on the natural join
- However, the pattern is analogous for the other types of joins (theta-, semi-, outer-join)

Reduce side natural join

- Goal
  - Join the content of two relations (i.e., relational tables)
  - Both tables are large
- Motivation
  - The join operation is useful in many applications
There are two mapper classes
• One mapper class for each table

Mappers
• Emit one (key, value) pair for each input record
  • Key is the value of the common attribute(s)
  • Value is the concatenation of the name of the table of the current record and the content of the current record

Suppose you want to join the following tables
• Users with schema userid, name, surname
• Likes with schema userid, movieGenre

The record
• userid=u1, name=Paolo, surname=Garza of the Users table will generate the pair
  • (userid=u1, "Users:name=Paolo,surname=Garza")

While the record
• userid=u1, movieGenre=horror of the Likes table will generate the pair
  • (userid=u1, "Likes:movieGenre=horror")

For instance, the (key, [list of values]) pair
• (userid=u1,["User:name=Paolo,surname=Garza", "Likes:movieGenre=horror", "Likes:movieGenre=adventure"]) will generate the following output (key,value) pairs
  • (userid=u1,"name=Paolo,surname=Garza, genre=horror")
  • (userid=u1,"name=Paolo,surname=Garza, genre=adventure")

For instance, the (key, [list of values]) pair
Map side natural join

- **Goal**
  - Join the content of two relations (i.e., relational tables)
    - One table is large
    - The other is small enough to be loaded in main memory
- **Motivation**
  - The join operation is useful in many applications and frequently one of the two tables is small

Map side natural join - structure

- **Map-only job**
  - One single mapper class
    - Processes the content of the large table
      - Receives one input (key, value) pair for each record of the large table
    - The distributed cache approach is used to "provide" a copy of the small table to all mappers

Map side natural join - structure

- **Mappers**
  - Perform the "local natural join" between the current record (of the large table) and the records of the small table (that is in the distributed cache)
  - The content of the small file is load in the main memory of the mapper during the execution of the setup method

Join Patterns

- Theta-join, Semi-join, Outer-join

- **Theta-join, Semi-join, Outer-join**
  - The SQL language is characterized by many types of joins
    - Theta-join
    - Semi-join
    - Outer-join
  - The same patterns used for implementing the natural join can be used also for the other SQL joins
    - The "local join" in the reducer of the reduce side natural join (in the mapper of the map side natural join) is substituted with the type of join of interest (theta-, semi-, or outer-join)