Big data: architectures and data analytics

MapReduce patterns

Data Organization 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

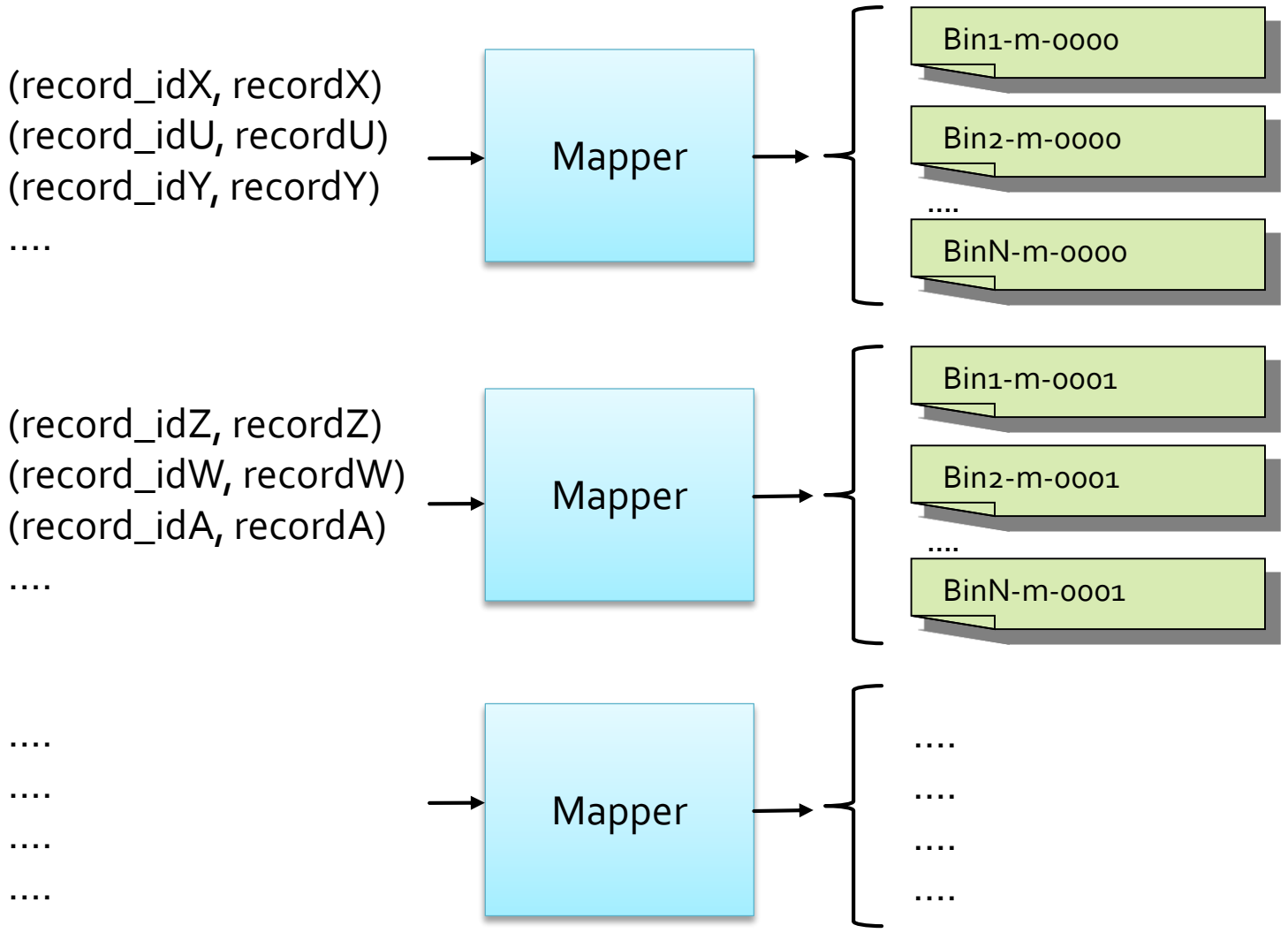
Binning

- 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 heterogonous 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

Binning - structure



Data Organization Patterns

Shuffling

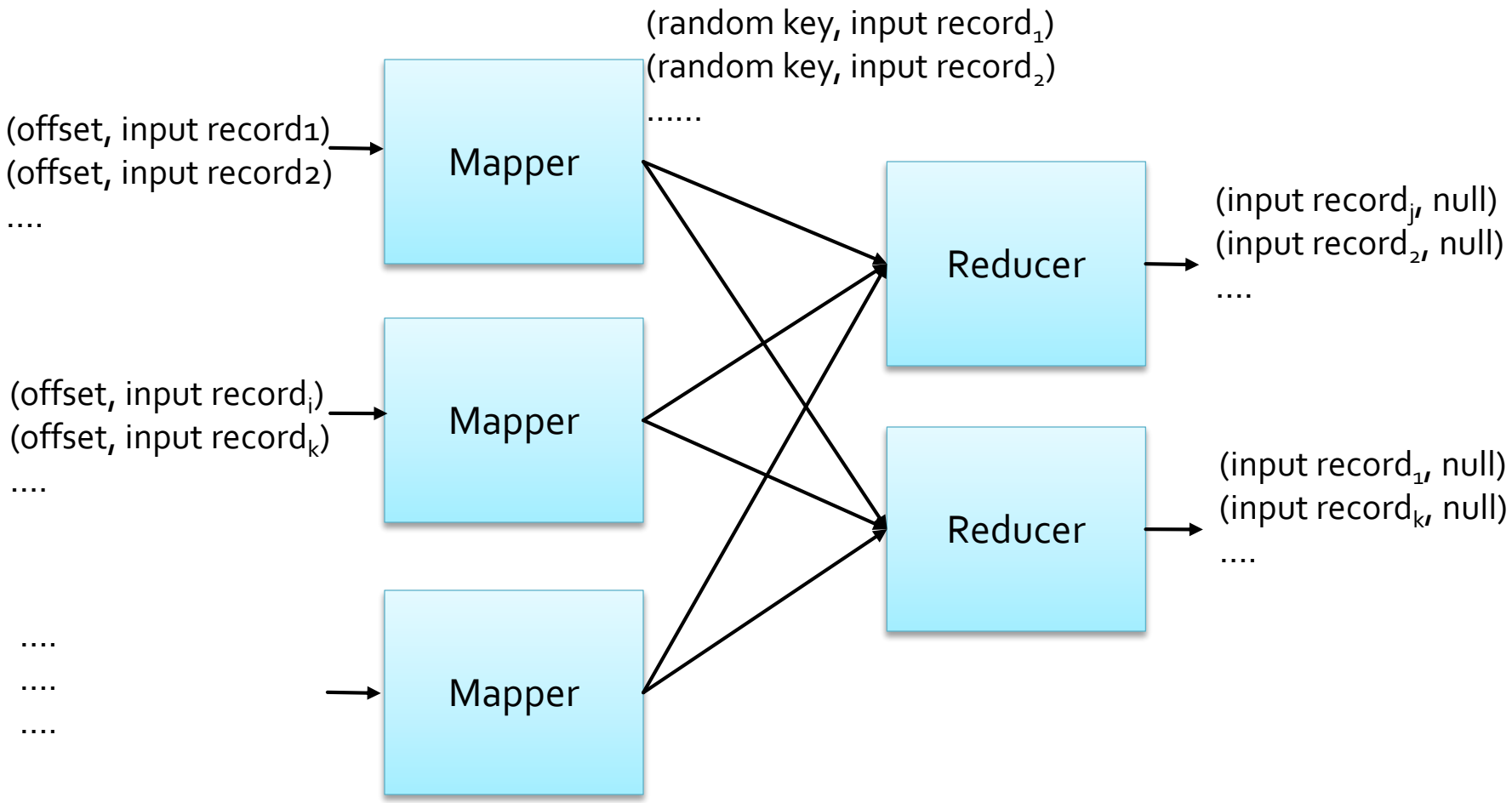
Shuffling

- 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)

Shuffling - structure

- Mappers
  - Emit one (key, value) for each input record
    - key is a random key (i.e., a random number)
    - value is the input record
- Reducers
  - Emit one (key, value) pair for each value in [list-of-values] of the input (key, [list-of-values]) pair

Shuffling - structure



Metapatterns

Metapatterns

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

Metapatterns

Job Chaining

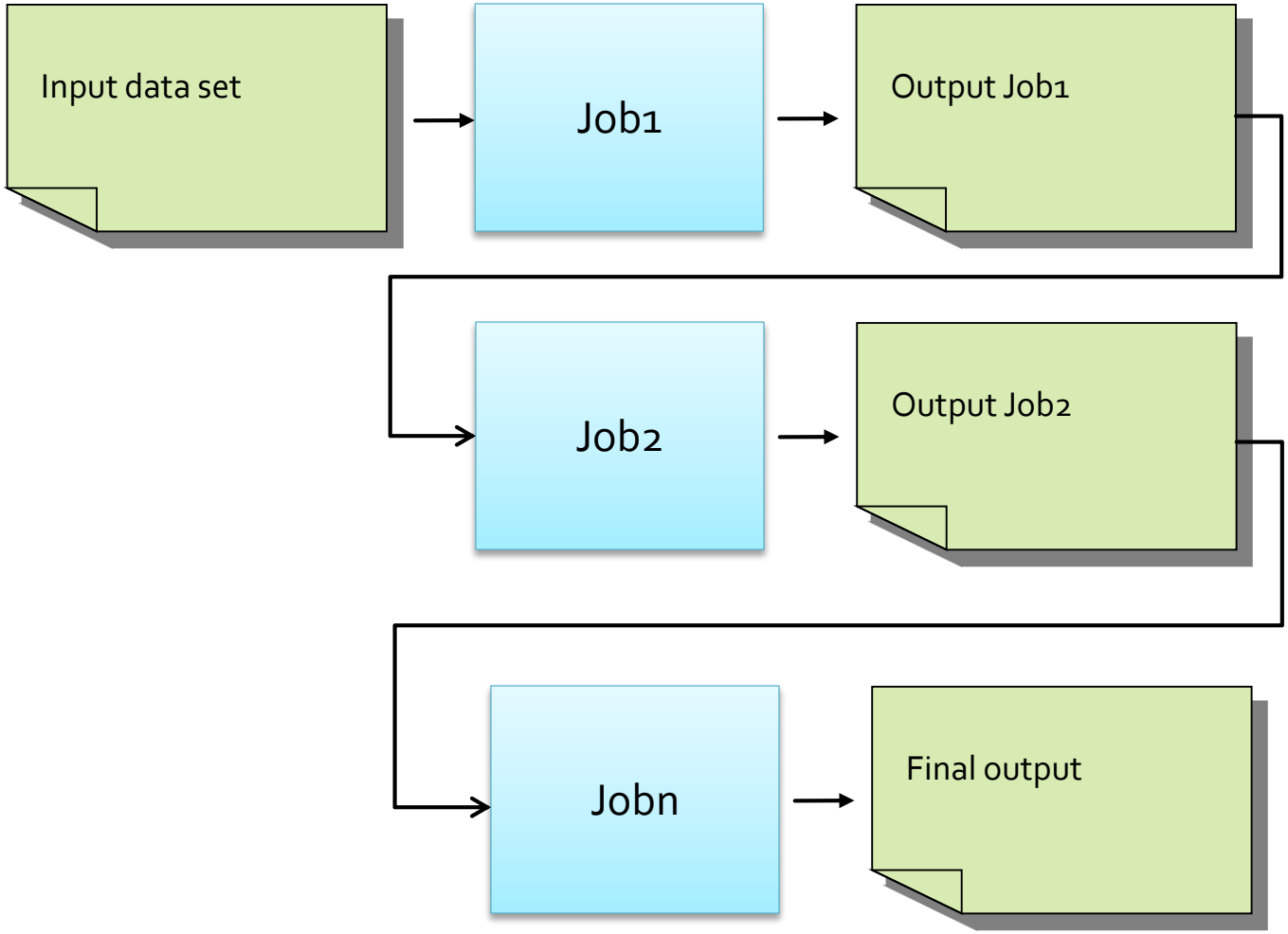
Job Chaining

- 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 application 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 implement by a MapReduce Job
    - i.e., it is associated with a mapper, a reducer (and a combiner if it is useful)

Job Chaining - structure



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

Join Patterns

- Are use 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)

Join Patterns

Reduce side natural 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

Reduce side natural join - structure

- 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

Reduce side natural join - structure

- 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")

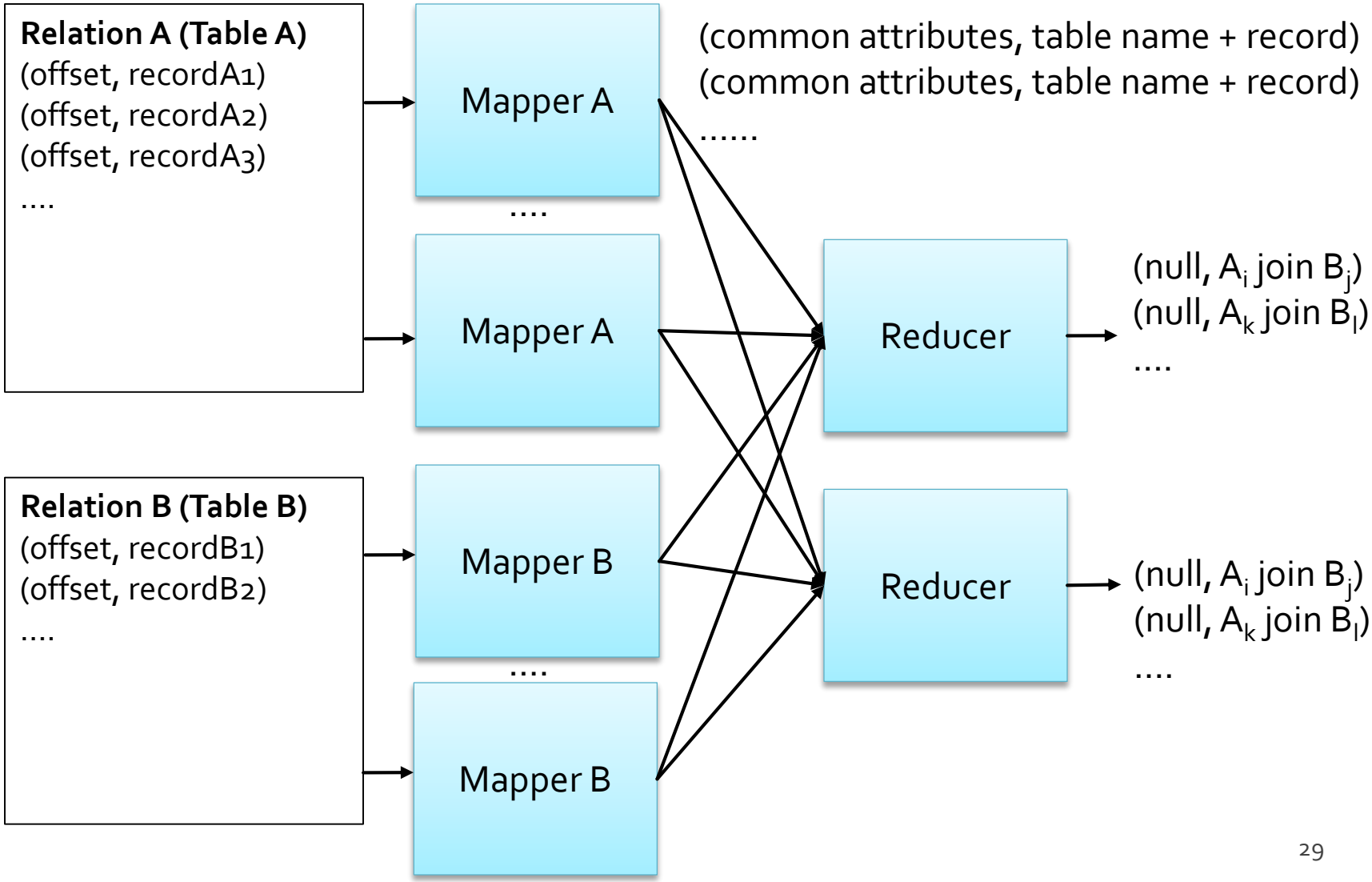
Reduce side natural join - structure

- Reducers
  - Iterate over the values associated with each key (value of the common attributes) and compute the "local natural join" for the current key
    - Generate a copy for each pair of values such that one record is a record of the first table and the other is the record of the other table

Reduce side natural join - structure

- 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")

Reduce side natural join - structure



Join Patterns

Map side natural join

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

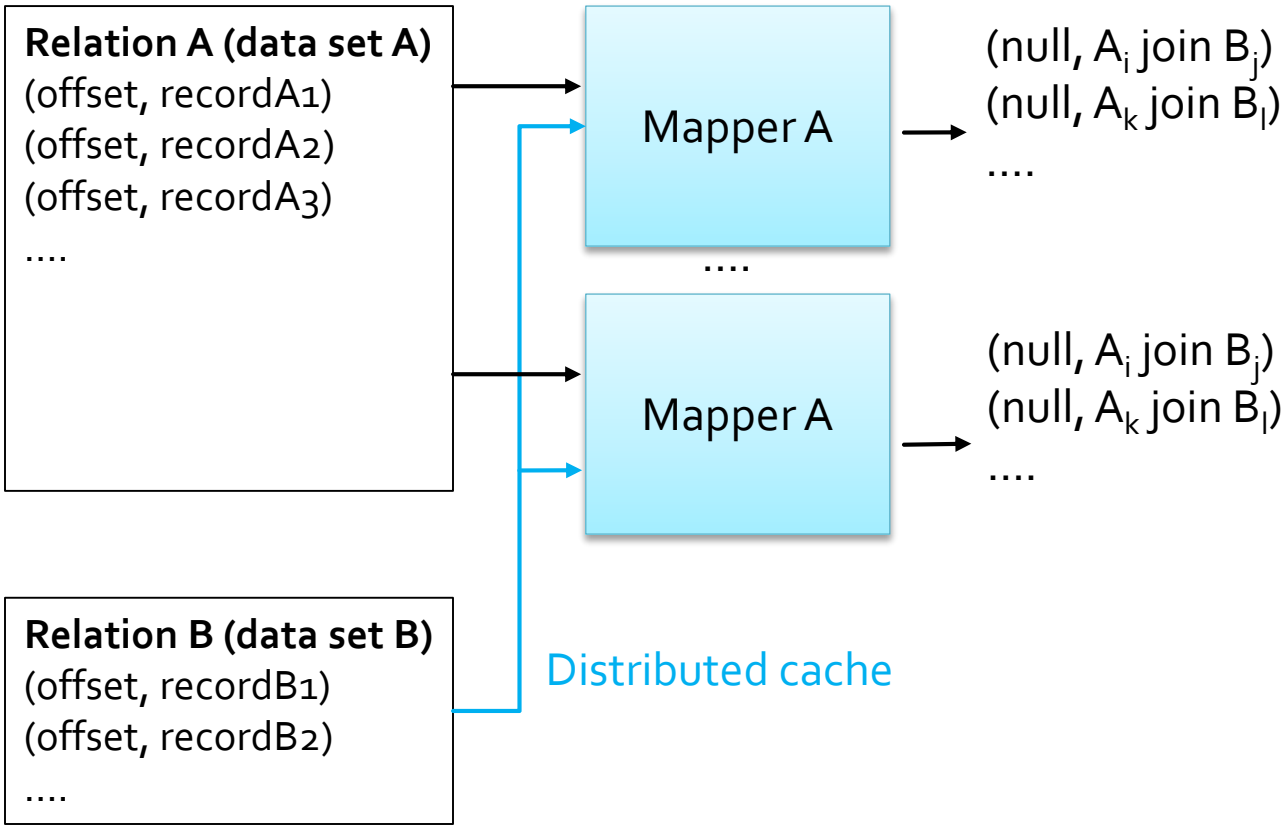
Map side natural join - structure

- 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

Map side natural join - structure



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)