Part I

MapReduce patterns

Summarization Patterns

Summarization patterns

- Are used to implement applications that produce top-level/summarized view of the data
  - Numerical summarizations (Statistics)
  - Inverted index
  - Counting with counters

Summarization Patterns

Numerical Summarizations

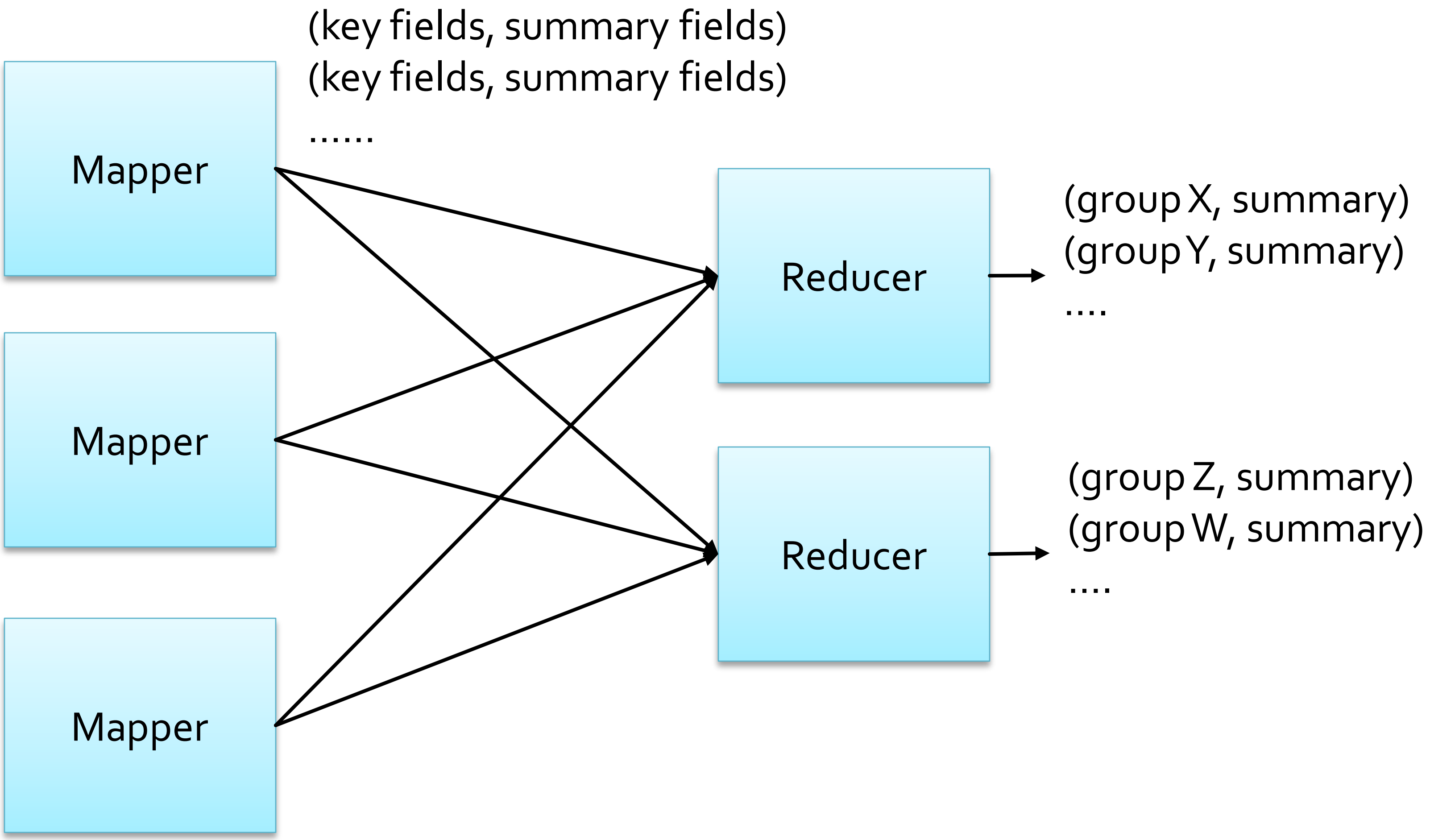
Numerical Summarizations

- Goal
  - Group records/objects by a key field(s) and calculate a numerical aggregate (average, max, min, standard deviation,..) per group
- Provide a top-level view of large input data sets
- Motivation
  - Few high-level statistics can be analyzed by domain experts to identify trends, anomalies, …

Numerical Summarizations - structure

- Mappers
  - Output (key, value) pairs where
    - key is associated with the fields used to define groups
    - value is associated with the fields used to compute the aggregate statistics
- Reducers
  - Receive a set of numerical values for each “group-by” key and compute the final statistics for each “group”
- Combiners
  - If the computed statistic has specific properties (e.g., it is commutative and associative), combiners can be used to speed up performances

Numerical Summarizations - structure



Numerical Summarizations

- Known uses
  - Word count
  - Record count (per group)
  - Min/Max/Count (per group)
  - Average/Median/Standard deviation (per group)

Summarization Patterns

Inverted Index Summarizations

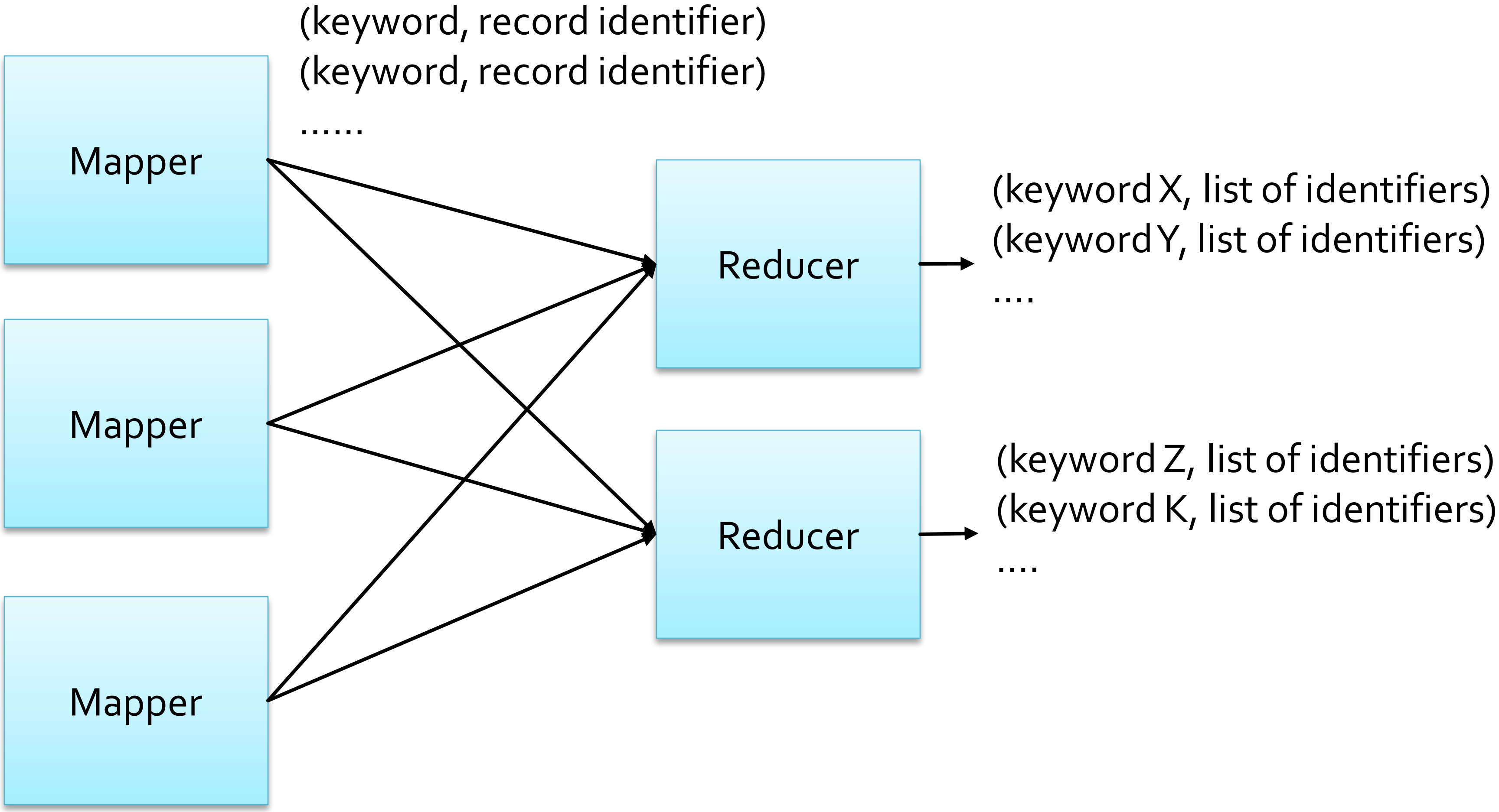
Inverted Index Summarizations

- Goal
  - Build an index from the input data to support faster searches or data enrichment
- Map terms to a list of identifiers
- Motivation
  - Improve search efficiency

Inverted Index Summarizations - structure

- Mappers
  - Output (key, value) pairs where
    - key is the set of fields to index (a keyword)
    - value is a unique identifier of the objects to associate with each “keyword”
- Reducers
  - Receive a set of identifiers for each keyword and simply concatenate them
- Combiners
  - Usually are not useful when using this pattern
  - Usually there are no values to aggregate

Inverted Index Summarizations - structure


(keyword, record identifier)
(keyword, record identifier)
……
Mapper
Mapper
Mapper
Reducer
Reducer
(keyword X, list of identifiers)
(keyword Y, list of identifiers)
….
(keyword Z, list of identifiers)
(keyword K, list of identifiers)
….

Inverted Index Summarizations

- Most famous known use
  - Web search engine
    - Word – List of URLs (Inverted Index)

Summarization Patterns

Counting with Counters

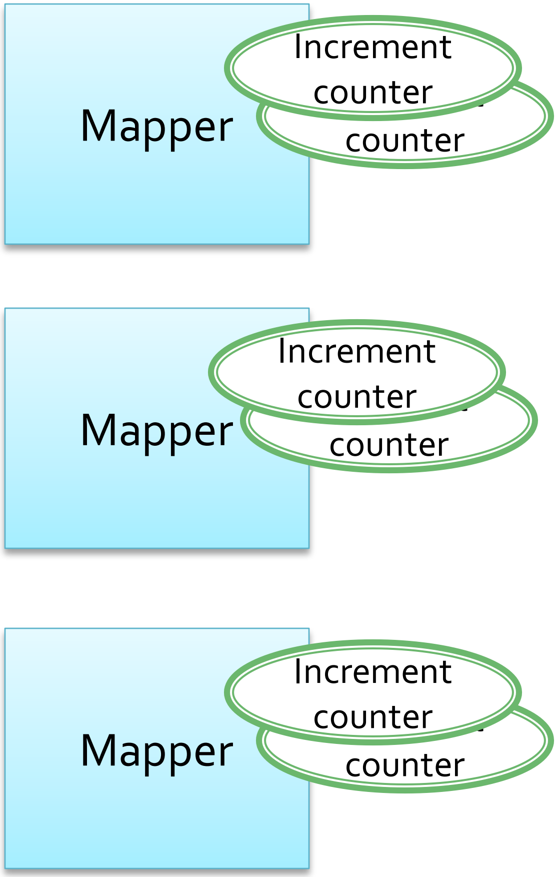
Counting with Counters

- Goal
  - Compute count summarizations of data sets
- Provide a top-level view of large data sets
- Motivation
  - Few high-level statistics can be analyzed by domain experts to identify trends, anomalies, …

Counting with Counters - structure

- Mappers
  - Process each input record and increment a set of counters
- Map-only job
  - No reducers
  - No combiners
- The results are stored/printed by the Driver of the application

Counting with Counters - structure



Mapper

Increment counter

counter

Mapper

Increment counter

counter

Mapper

Increment counter

counter

Counting with Counters

- Known uses
  - Count number of records
  - Count a small number of unique instances
  - Summarizations

Filtering Patterns

Filtering Patterns

- Are used to select the subset of input records of interest
  - Filtering
  - Top K
  - Distinct

Filtering Patterns

Filtering

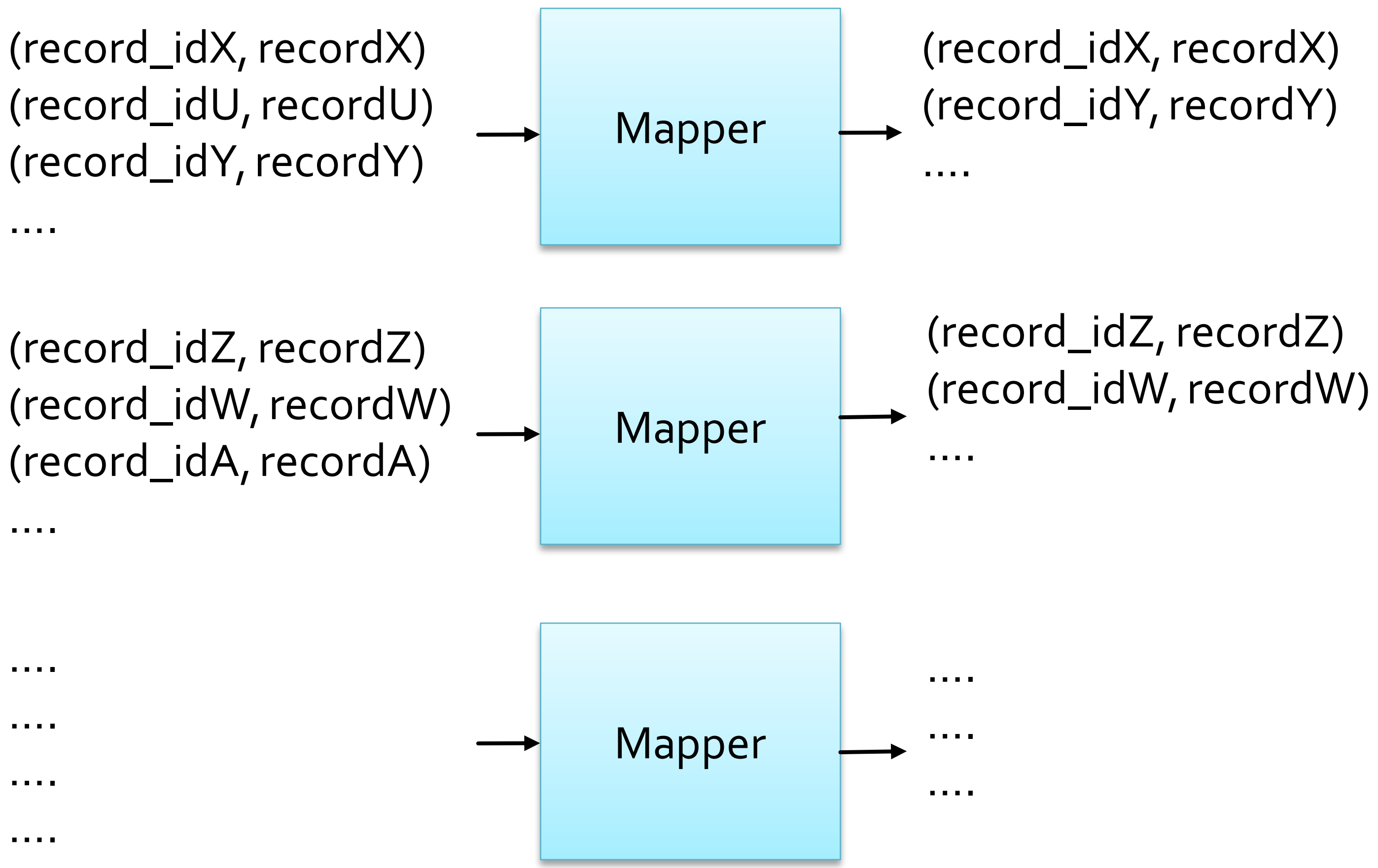
Filtering

- Goal
  - Filter out input records that are not of interest/keep only the ones that are of interest
- Focus the analysis of the records of interest
- Motivation
  - Depending on the goals of your application, frequently only a small subset of the input data is of interest for further analyses

Filtering - structure

- The input of the mapper is a set of records
  - Key = primary key
  - Value = record
- Mappers
  - Output one (key, value) pair for each record that satisfies the enforced filtering rule
    - Key is associated with the primary key of the record
    - Value is associated with the selected record
  - Reducers
    - The reducer is useless in this pattern
    - A map-only job is executed (number of reduce set to 0)

Filtering - structure



(record_idX, recordX)
(record_idU, recordU)
(record_idY, recordY)
....

Mapper

(record_idX, recordX)
(record_idY, recordY)
....

(record_idZ, recordZ)
(record_idW, recordW)
(record_idA, recordA)
....

Mapper

(record_idZ, recordZ)
(record_idW, recordW)
....

....
....
....
....

Mapper

....
....
....

Filtering

- Known uses
  - Record filtering
  - Tracking events
  - Distributed grep
  - Data cleaning

Filtering Patterns

Top K

Top K

- Goal
    - Select a small set of top K records according to a ranking function
- Focus on the most important records of the input data set
- Motivation
    - Frequently the interesting records are those ranking first according to a ranking function
        - Most profitable items
        - Outliers

Top K - structure

- Mappers
  - Each mapper initializes an in-mapper (local) top k list
    - k is usually small (e.g., 10)
    - The current (local) top k-records of each mapper (i.e., instance of the mapper class) can be stored in main memory
    - Initialization performed in the setup method of the mapper
  - The map function updates the current in-mapper top k list

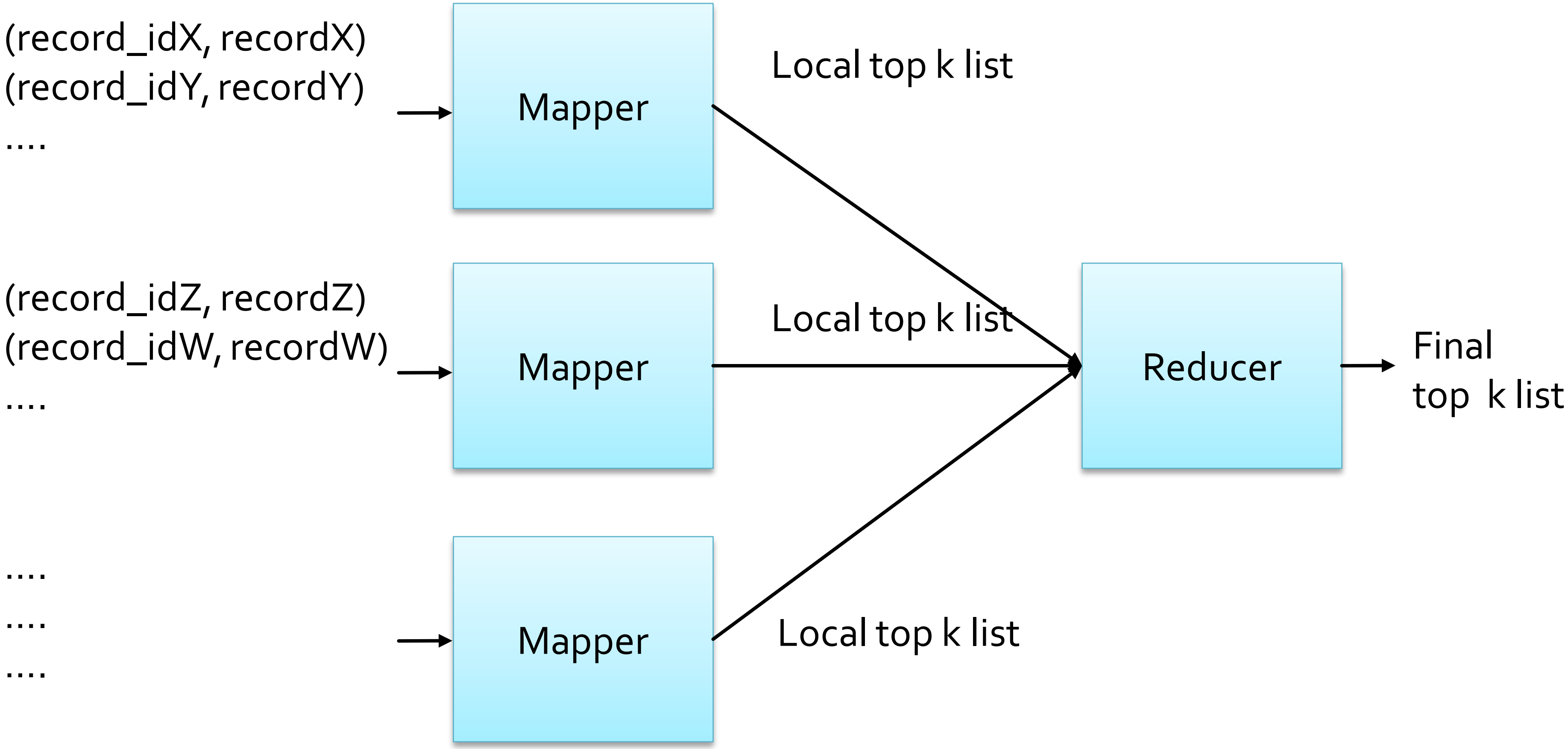
Top K - structure

- Mappers
  - The cleanup method emits the k (key, value) pairs associated with the in-mapper local top k records
    - Key is the “null key”
    - Value is a in-mapper top k record

Top K - structure

- Reducer
  - A single reducer must be instantiated (i.e., **one single instance** of the **reducer** class)
    - One single **global view** over the intermediate results emitted by the mappers to compute the final top k records
  - It computes the final top k list by merging the local lists emitted by the mappers
    - All input (key, value) pairs have the same key
    - Hence, the reduce method is called only once

Top K - structure



Top K

- Known uses
  - Outlier analysis (based on a ranking function)
  - Select interesting data (based on a ranking function)

Filtering Patterns

Distinct

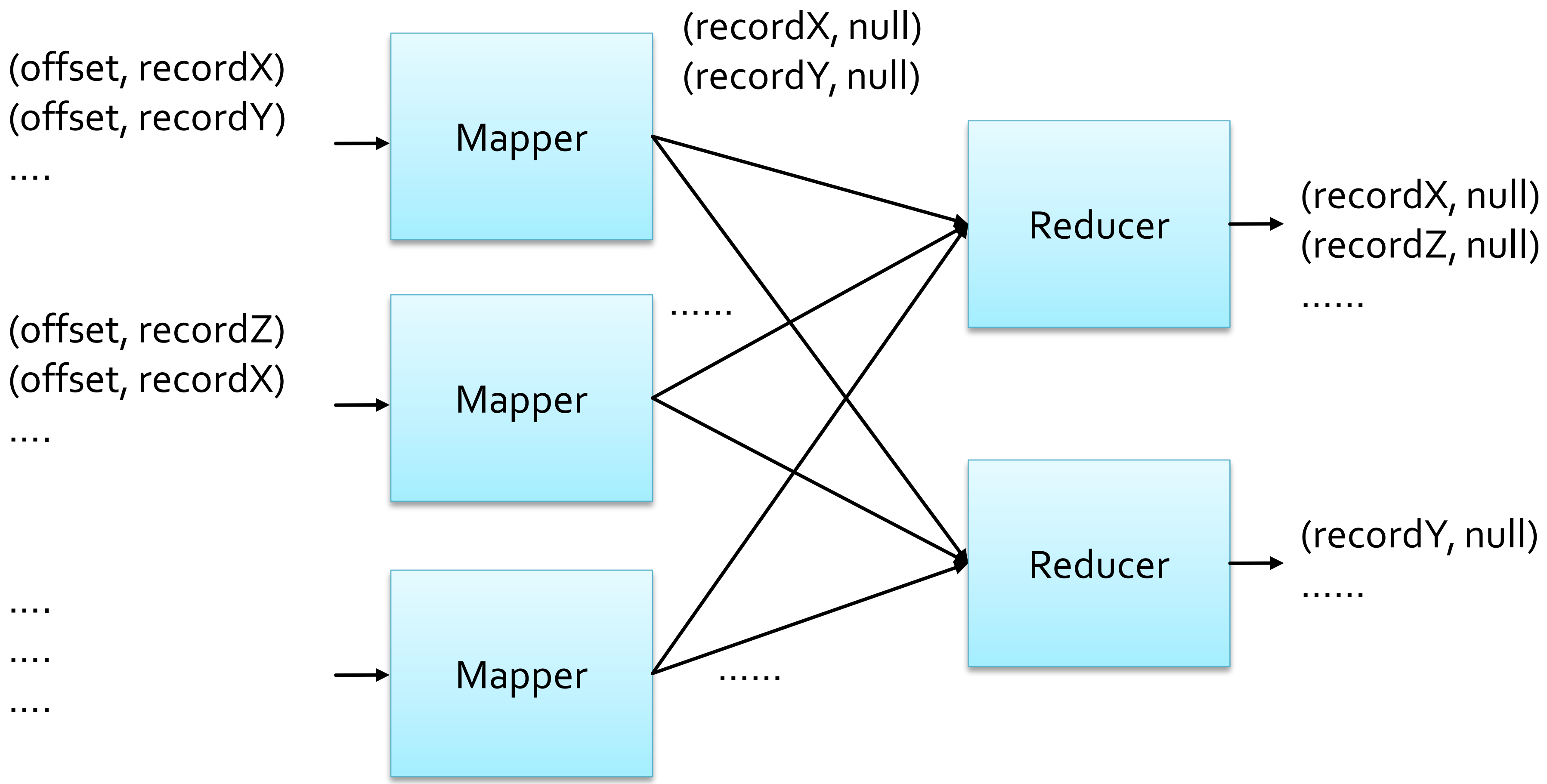
Distinct

- Goal
  - Find a unique set of values/records
- In some applications duplicate records are useless
- Motivation
  - Duplicates records are frequently useless

Distinct - structure

- Mappers
  - Emit one (key, value) pair for each input record
    - Key = input record
    - Value = null value
- Reducers
  - Emit one (key, value) pair for each input (key, list of values) pair
    - Key = input key, i.e., input record
    - Value = null value

Distinct - structure


(offset, recordX)
(offset, recordY)
....

(offset, recordZ)
(offset, recordX)
....

....
....
....

Mapper

Mapper

Mapper

(recordX, null)
(recordY, null)

......

......

Reducer

Reducer

(recordX, null)
(recordZ, null)
......

(recordY, null)
......

Distinct

- Known uses
  - Duplicate data removal
  - Distinct value selection