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

Goal
- Group records/objects by a key field 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 associative), combiners can be used to speed up performances

Numerical Summarizations

- Known uses
  - Word count
  - Record count
  - Min/Max/Count
  - Average/Median/Standard deviation

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

Summarization Patterns

Inverted Index Summarizations
Inverted Index Summarizations - structure

Inverted Index Summarizations

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

Summarization Patterns

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

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

Filtering Patterns

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

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

(\text{record\_idX}, \text{recordX})
(\text{record\_idU}, \text{recordU})

(\text{record\_idY}, \text{recordY})
(\text{record\_idW}, \text{recordW})

(\text{record\_idZ}, \text{recordZ})
(\text{record\_idA}, \text{recordA})

Mapper

Mapper

Mapper

Filtering

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

Filtering Patterns

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 top k list
    - k is usually small (e.g., 10)
    - The current top k-records of each mapper 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 is instantiated
  - 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**

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

**Distinct**

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

**Filtering Patterns**

- Distinct

**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

Distinct

- Known uses
  - Duplicate data removal
  - Distinct value selection