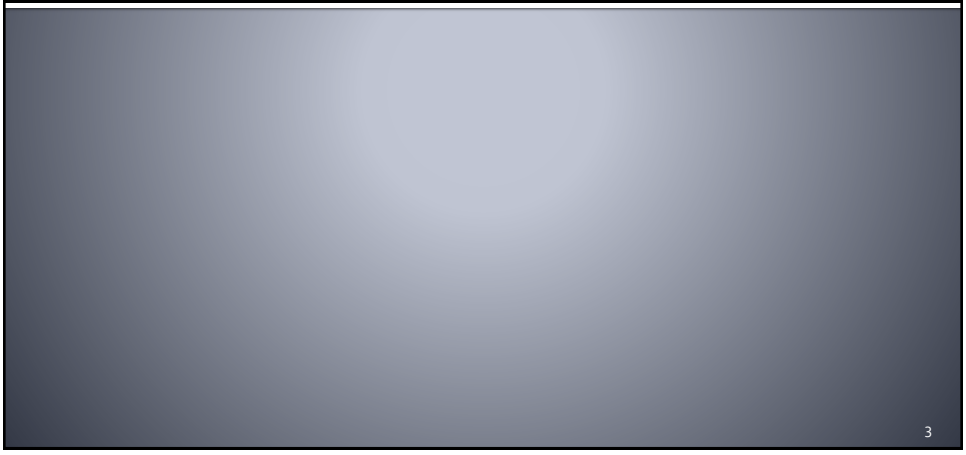
Big data: architectures and data analytics

MapReduce patterns

Summarization Patterns

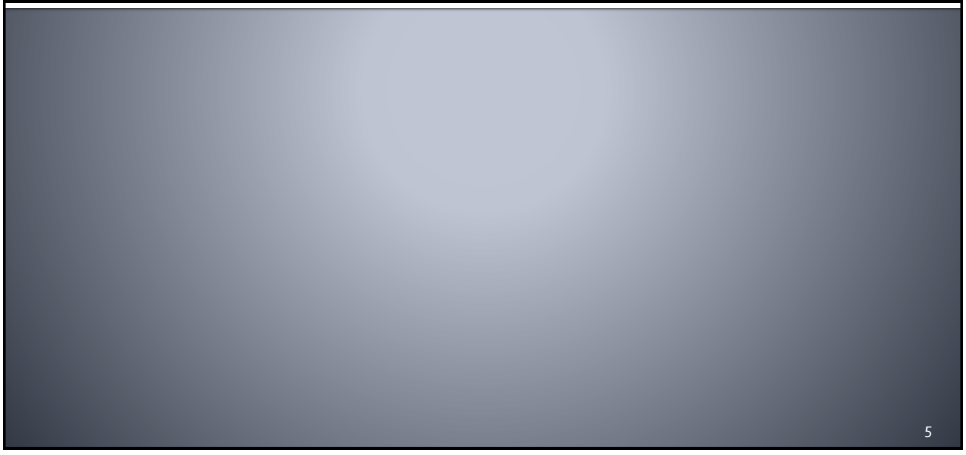


Summarization patterns

- 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



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Numerical Summarizations

- 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, …

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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

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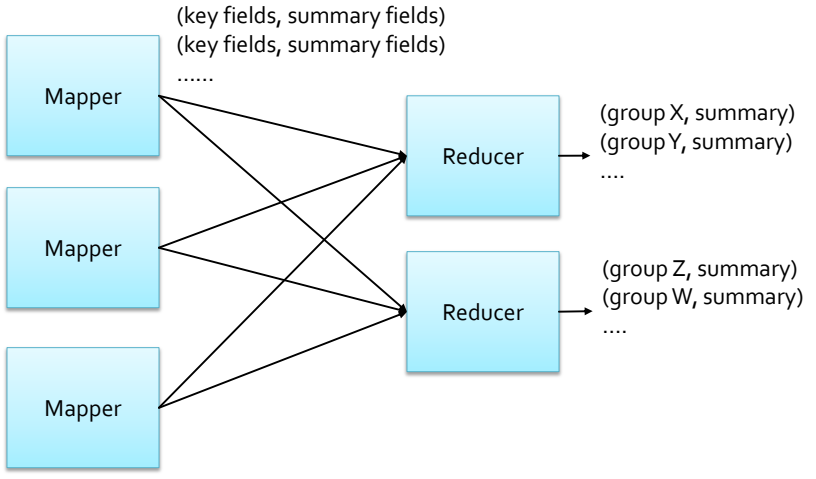
Numerical Summarizations - structure



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Numerical Summarizations

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

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Summarization Patterns

Inverted Index Summarizations

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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

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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
  - There is no values to aggregate

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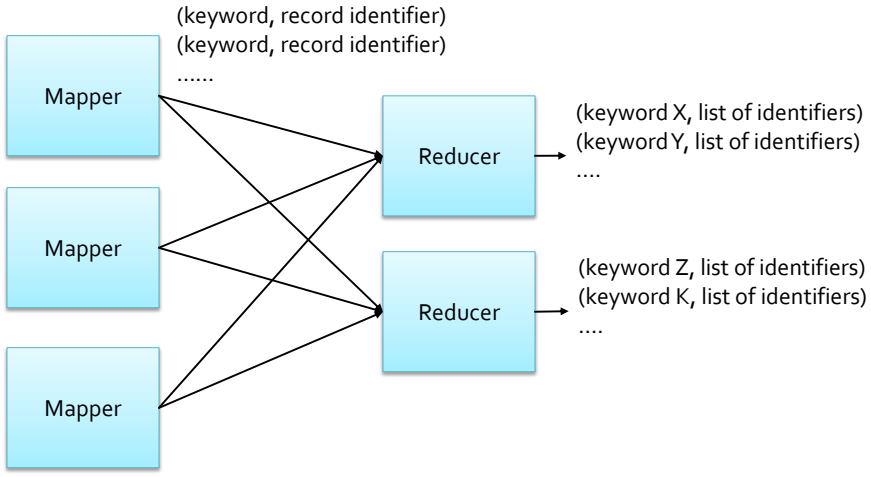
Inverted Index Summarizations - structure



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Inverted Index Summarizations

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

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Summarization Patterns

Counting with Counters

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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, …

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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

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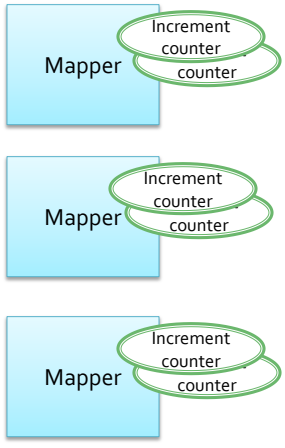
Counting with Counters - structure



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Counting with Counters

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

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Filtering Patterns

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Filtering Patterns

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

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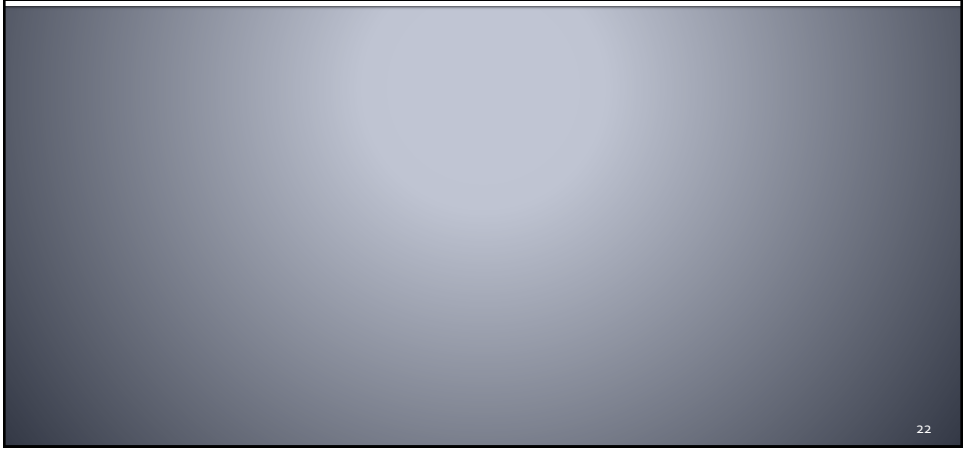
Filtering Patterns

Filtering



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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

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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)

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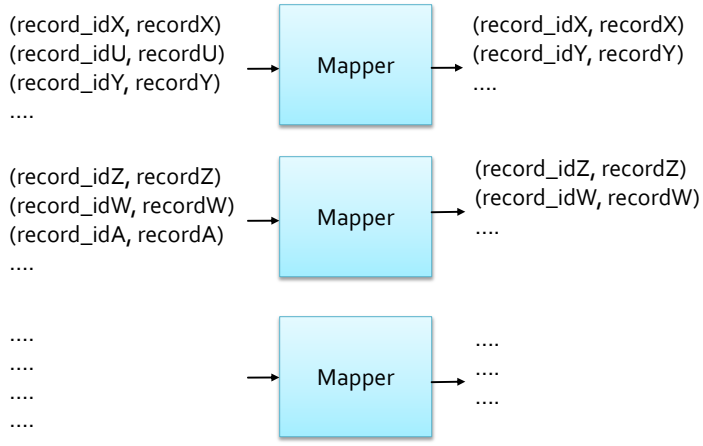
Filtering - structure



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Filtering

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

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Filtering Patterns

Top K

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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

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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

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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

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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

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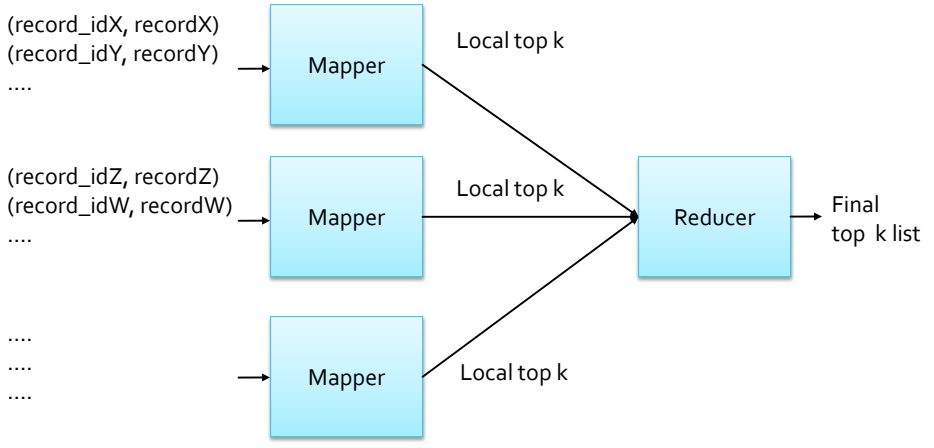
Top K - structure



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Top K

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

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Filtering Patterns

Distinct

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Distinct

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

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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

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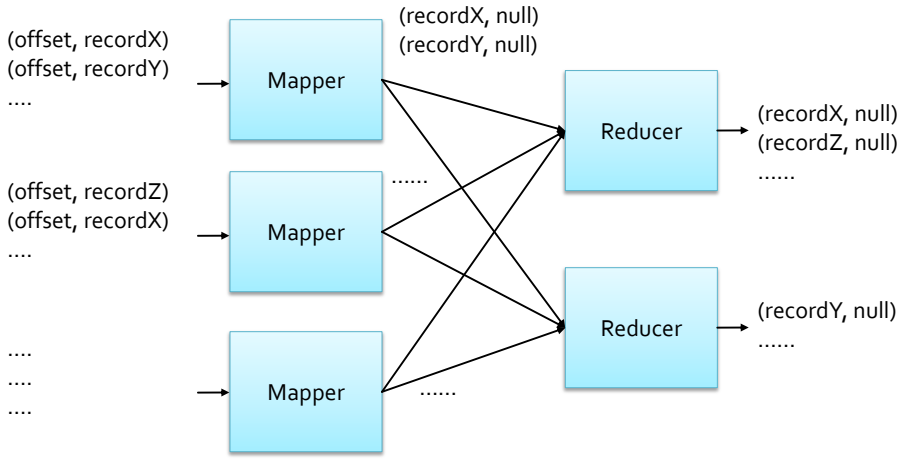
Distinct - structure



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Distinct

- Known uses
  - Duplicate data removal
  - Distinct value selection

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