

# CS685: DATA MINING DATA WAREHOUSING

Arnab Bhattacharya  
arnabb@cse.iitk.ac.in

Computer Science and Engineering,  
Indian Institute of Technology, Kanpur  
<http://web.cse.iitk.ac.in/~cs685/>

1<sup>st</sup> semester, 2021-22  
Mon 1030-1200 (online)

# Data Warehousing

- A **data warehouse** is a data storage system, usually separate from the original database

# Data Warehousing

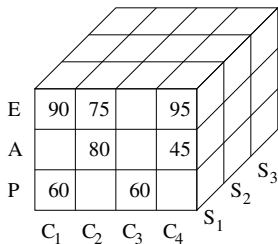
- A **data warehouse** is a data storage system, usually separate from the original database
- It has four important features
  - ① *Subject-oriented*: It is modeled around subjects, e.g., sales, customers, etc.
  - ② *Integrated*: It organizes information from multiple sources into a single storage
  - ③ *Time-variant*: It stores information across different time points
  - ④ *Non-volatile*: It stores data permanently and requires only two operations, construction and access

# Data Warehousing

- A **data warehouse** is a data storage system, usually separate from the original database
- It has four important features
  - ① *Subject-oriented*: It is modeled around subjects, e.g., sales, customers, etc.
  - ② *Integrated*: It organizes information from multiple sources into a single storage
  - ③ *Time-variant*: It stores information across different time points
  - ④ *Non-volatile*: It stores data permanently and requires only two operations, construction and access
- A data warehouse is a semantically consistent data store that serves as a physical implementation of a decision support model
- **Data warehousing** is the process of constructing and using data warehouses

# Data Warehouse Model

- A data warehouse is modeled as a multidimensional data model or **data cube**
- *Dimensions* of a data cube are attributes important for that analysis
- Each dimension has a corresponding **dimension table** that stores metadata about the dimension
- Numeric values about the subject of the data warehouse are *facts*
- The **fact table** stores information about them



# Cuboids

- Any subset of a data cube is a **cuboid**
- It is essentially the result of “group by” operator

# Cuboids

- Any subset of a data cube is a **cuboid**
- It is essentially the result of “group by” operator
- All cuboids together form a **lattice of cuboids**
- **Base cuboid**: no summarization, at level nD
- **Apex cuboid**: full summarization, at level 0D

# Cube Operations

- compute cube operator computes aggregation over *all* subsets of dimensions specified
- For example, specifying the dimensions as item, time and loc, the cuboids computed are (item, time, loc), (item, time), (time, loc), (loc, item), (item), (time), (loc) and ()
- Total of  $2^n$  cuboids
- () implies empty group by, i.e., dimensions are not grouped



# Cube Operations

- compute cube operator computes aggregation over *all* subsets of dimensions specified
- For example, specifying the dimensions as item, time and loc, the cuboids computed are (item, time, loc), (item, time), (time, loc), (loc, item), (item), (time), (loc) and ()
- Total of  $2^n$  cuboids
- () implies empty group by, i.e., dimensions are not grouped
- Cuboids can be pre-computed and materialized
- *No materialization*: No non-base cuboid is precomputed
- *Full materialization*: Full cube is precomputed
- *Partial materialization*: Some *subcubes* are precomputed based on usage and storage
- **Iceberg cube**: computes those subcubes whose size (number of tuples) is above a threshold

# OLAP Operations

- OLAP stands for *online analytical processing*
- OLTP stands for *online transactional processing*

# OLAP Operations

- **OLAP** stands for *online analytical processing*
- **OLTP** stands for *online transactional processing*
- Different operations
  - **Roll up (drill up)**: Summarize by going up the level
  - **Drill down (roll down)**: Go down the level
  - **Slice**: Project operation; on only one dimension
  - **Dice**: Select operation; on more than one dimensions
  - **Pivot (rotate)**: Rotate for better or alternate visualization
  - **Drill across**: Summarize across different fact tables
  - **Drill through**: Access underlying relational data through base cuboids

# OLAP Operations

- **OLAP** stands for *online analytical processing*
- **OLTP** stands for *online transactional processing*
- Different operations
  - **Roll up (drill up)**: Summarize by going up the level
  - **Drill down (roll down)**: Go down the level
  - **Slice**: Project operation; on only one dimension
  - **Dice**: Select operation; on more than one dimensions
  - **Pivot (rotate)**: Rotate for better or alternate visualization
  - **Drill across**: Summarize across different fact tables
  - **Drill through**: Access underlying relational data through base cuboids
- How is OLAP related to data mining?

# OLAP Operations

- **OLAP** stands for *online analytical processing*
- **OLTP** stands for *online transactional processing*
- Different operations
  - **Roll up (drill up)**: Summarize by going up the level
  - **Drill down (roll down)**: Go down the level
  - **Slice**: Project operation; on only one dimension
  - **Dice**: Select operation; on more than one dimensions
  - **Pivot (rotate)**: Rotate for better or alternate visualization
  - **Drill across**: Summarize across different fact tables
  - **Drill through**: Access underlying relational data through base cuboids
- How is OLAP related to data mining?
- It essentially facilitates data analysis by efficiently providing summaries, projections, etc.

# OLAP Implementation

- Different server models to implement OLAP operations
- **Relational OLAP (ROLAP)**: Uses a relational database backend
- **Multidimensional OLAP (MOLAP)**: Uses multidimensional arrays
- **Hybrid OLAP (HOLAP)**: Hybrid system that tries to exploit scalability of ROLAP in lower levels and efficiency of MOLAP in higher levels

# OLAP Implementation

- Different server models to implement OLAP operations
- **Relational OLAP (ROLAP)**: Uses a relational database backend
- **Multidimensional OLAP (MOLAP)**: Uses multidimensional arrays
- **Hybrid OLAP (HOLAP)**: Hybrid system that tries to exploit scalability of ROLAP in lower levels and efficiency of MOLAP in higher levels
- For data mining, OLAM systems
- **OLAM** stands for *online analytical mining*
- Integrates data mining operations directly into OLAP systems