OLAP QUERIES

Online Analytic Processing
OLAP

OLAP

- **OLAP:** Online Analytic Processing

- **OLAP queries are complex queries that**
  - Touch large amounts of data
  - Discover patterns and trends in the data
  - Typically expensive queries that take long time
  - Also called decision-support queries

- **In contrast to OLAP:**
  - ***OLTP***: Online Transaction Processing
  - OLTP queries are simple queries, e.g., over banking or airline systems
  - OLTP queries touch small amount of data for fast transactions

Select salary
From Emp
Where ID = 100;

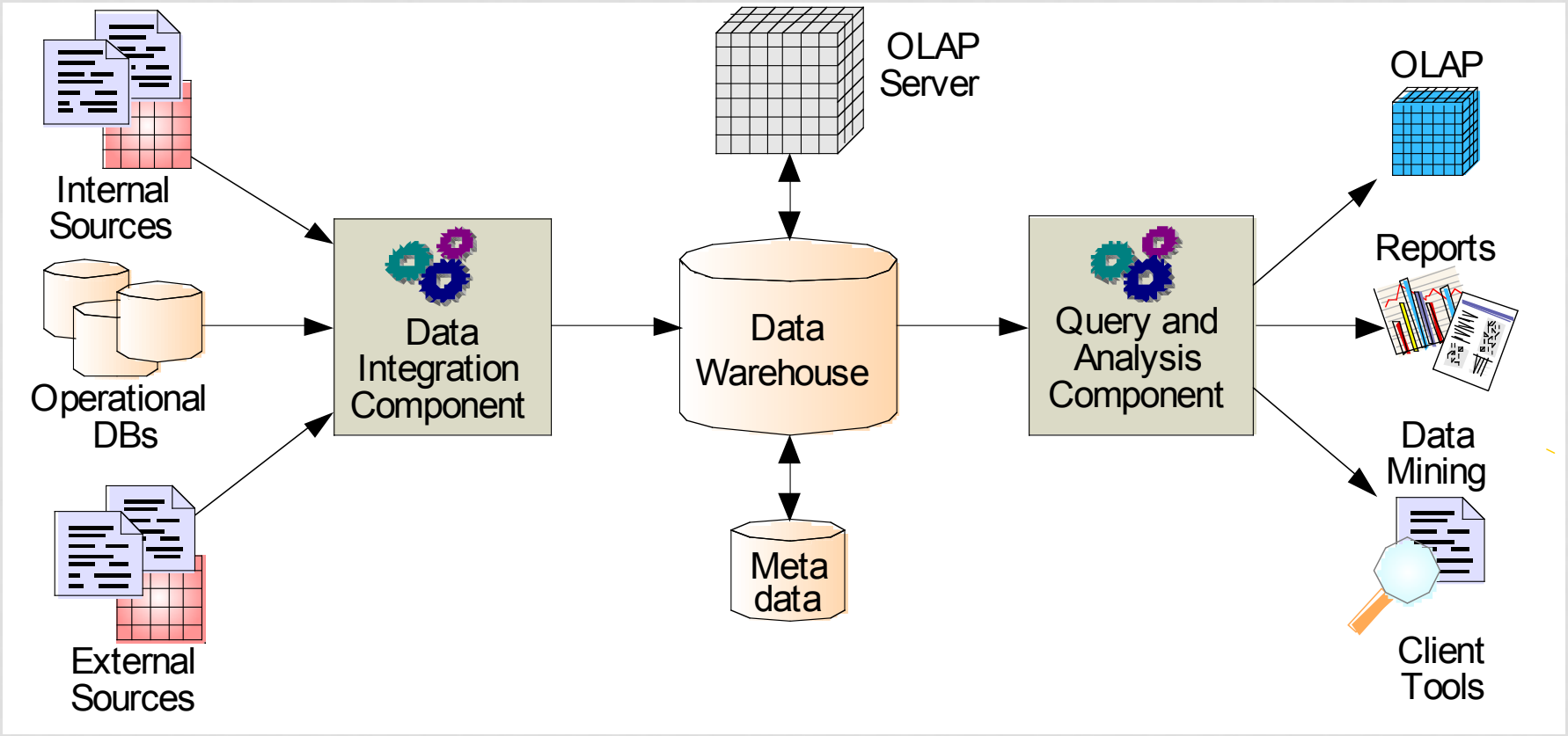
OLTP vs. OLAP

- **On-Line Transaction Processing (OLTP):**
  - technology used to perform updates on operational or transactional systems (e.g., point of sale systems)

- **On-Line Analytical Processing (OLAP):**
  - technology used to perform complex analysis of the data in a data warehouse

OLAP is a category of software technology that enables analysts, managers, and executives to gain insight into data through fast, consistent, interactive access to a wide variety of possible views of information that has been transformed from raw data to reflect the dimensionality of the enterprise as understood by the user.
[source: OLAP Council: www.olapcouncil.org]

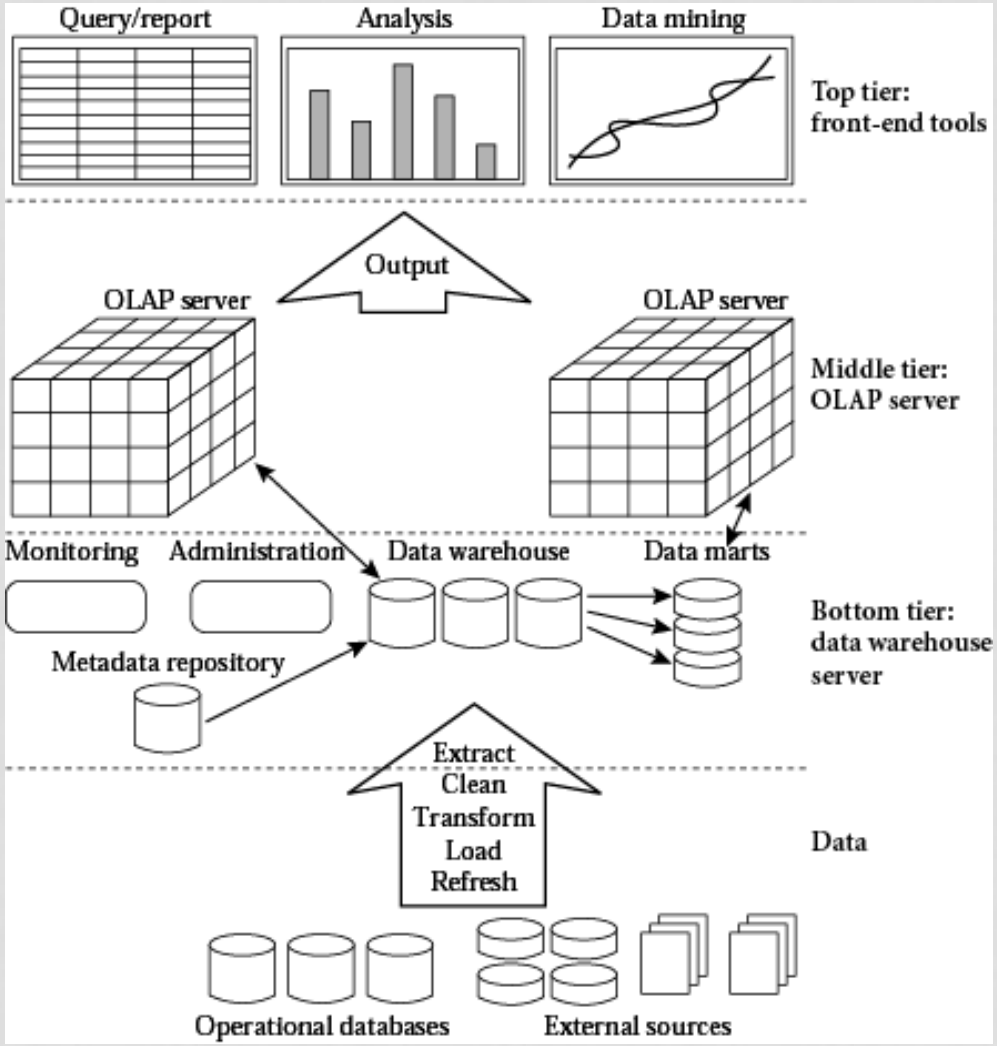
OLAP AND DATA WAREHOUSE



OLAP AND DATA WAREHOUSE

- Typically, OLAP queries are executed over a separate copy of the working data
  - Over data warehouse
- Data warehouse is periodically updated, e.g., overnight
  - OLAP queries tolerate such out-of-date gaps
- **Why run OLAP queries over data warehouse??**
  - Warehouse collects and combines data from multiple sources
  - Warehouse may organize the data in certain formats to support OLAP queries
  - OLAP queries are complex and touch large amounts of data
    - They may lock the database for long periods of time
    - Negatively affects all other OLTP transactions

OLAP ARCHITECTURE



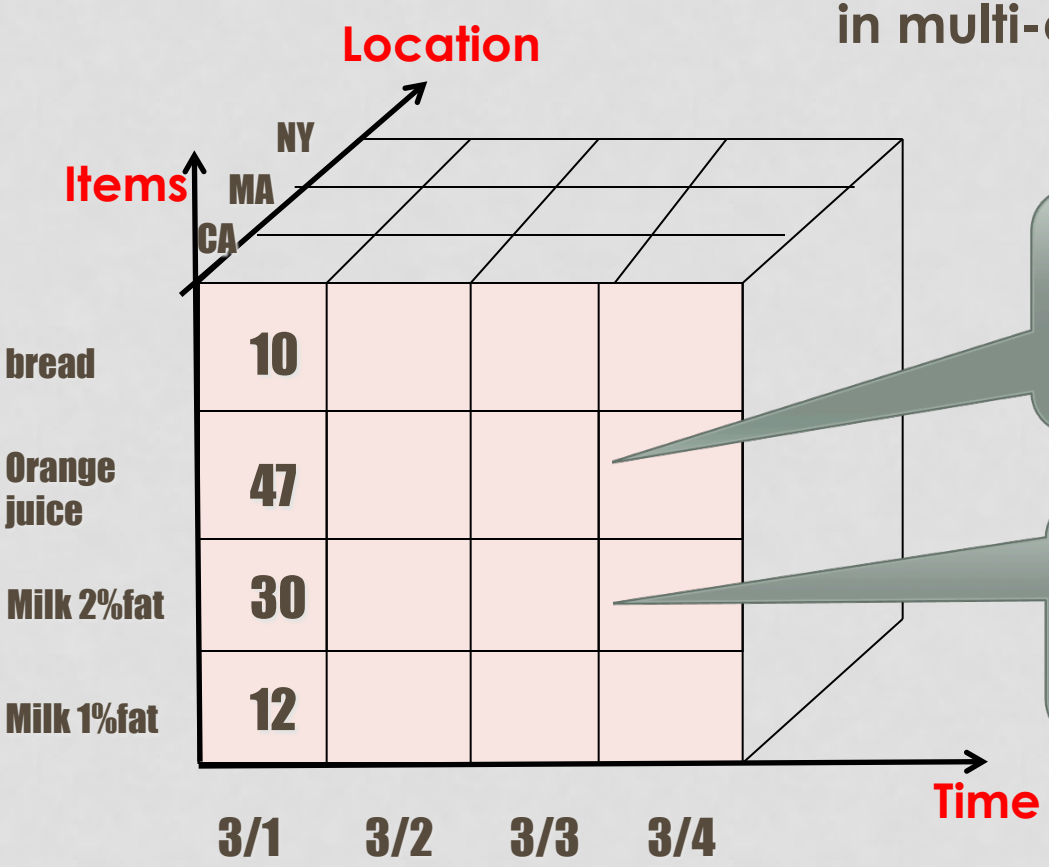
EXAMPLE OLAP APPLICATIONS

- **Market Analysis**
  - Find which items are frequently sold over the summer but not over winter?
- **Credit Card Companies**
  - Given a new applicant, does (s)he a credit-worthy?
  - Need to check other similar applicants (age, gender, income, etc…) and observe how they perform, then do prediction for new applicant

OLAP queries are also called "decision-support" queries

MULTI-DIMENSIONAL VIEW

- Data is typically viewed as points in multi-dimensional space

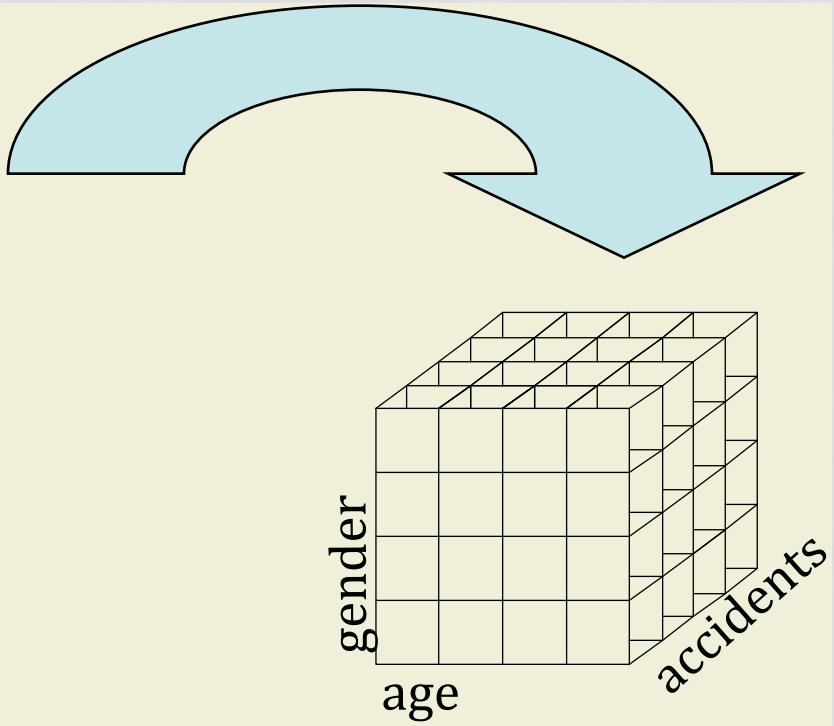


Raw data cubes (raw level without aggregation)

Typical OLAP applications have many dimensions

ANOTHER EXAMPLE

gender	age	accident
Male	27	3
Male	37	1
Male	37	0
Male	37	1
Male	49	2
Male	39	4
Male	43	0
Male	41	2
Male	49	1
Male	44	2
Male	43	3
Male	53	4
Male	60	0
Female	26	0
Female	39	0
Female	45	2
Female	41	2
Female	39	1
Female	37	0
Female	43	1

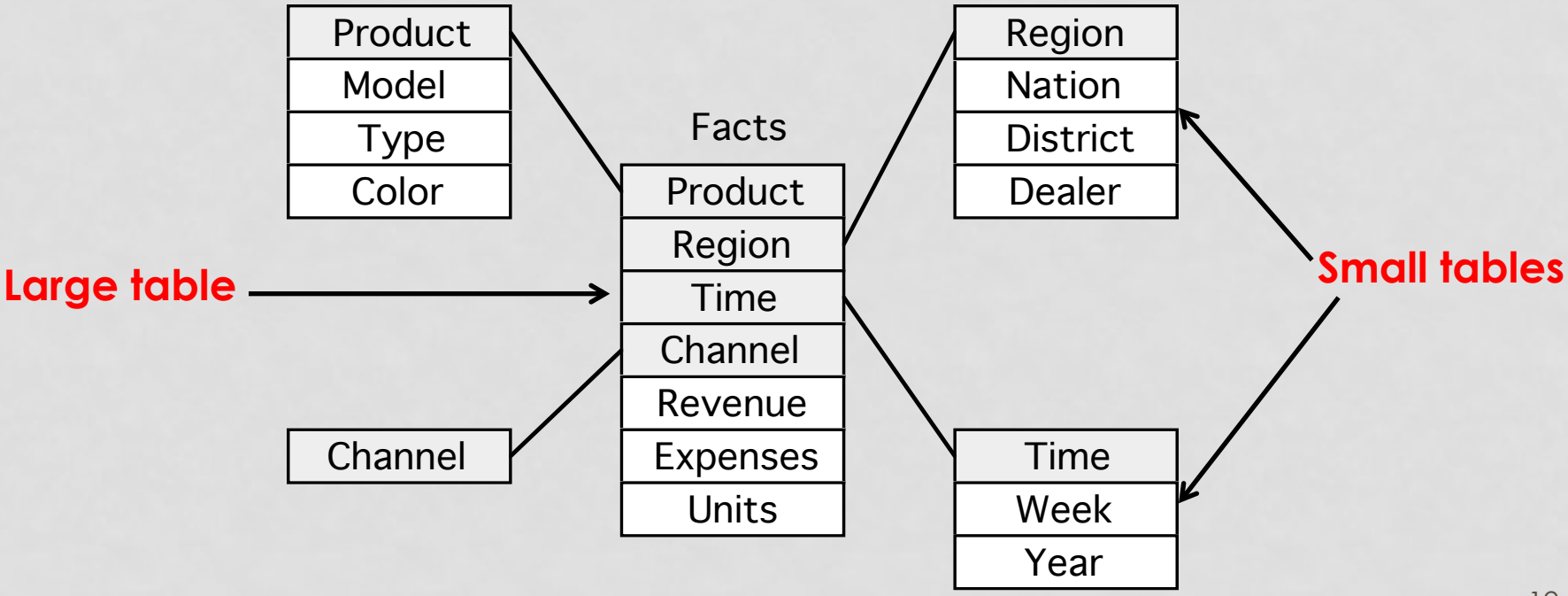


APPROACHES FOR OLAP

- **Relational OLAP (ROLAP)**
- **Multi-dimensional OLAP (MOLAP)**
- **Hybrid OLAP (HOLAP) = ROLAP + MOLAP**

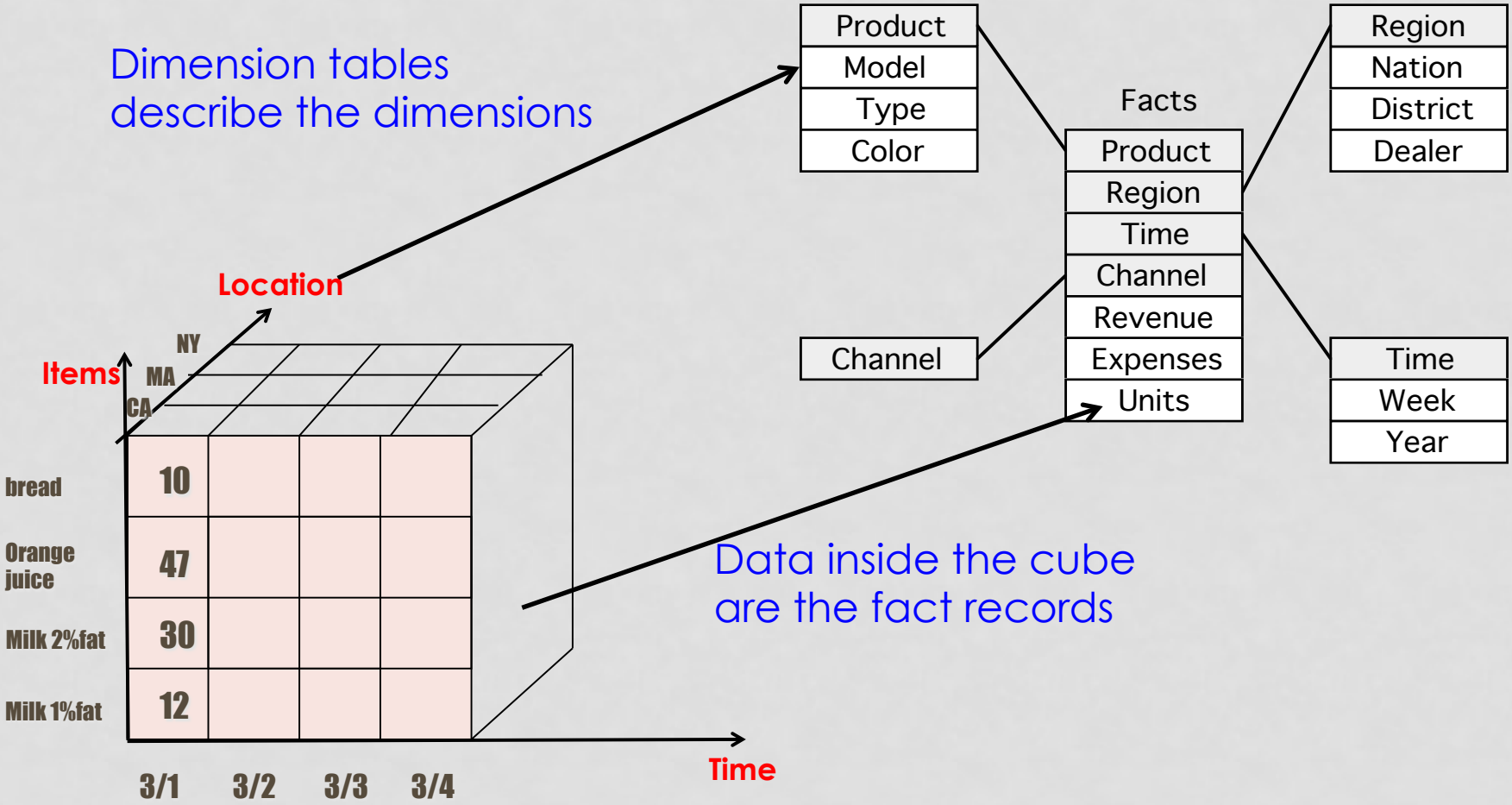
RELATIONAL OLAP: ROLAP

- Data are stored in relational model (tables)
- Special schema called ***Star Schema***
- One relation is the ***fact table***, all the others are ***dimension tables***



CUBE vs. STAR SCHEMA

Dimension tables
describe the dimensions



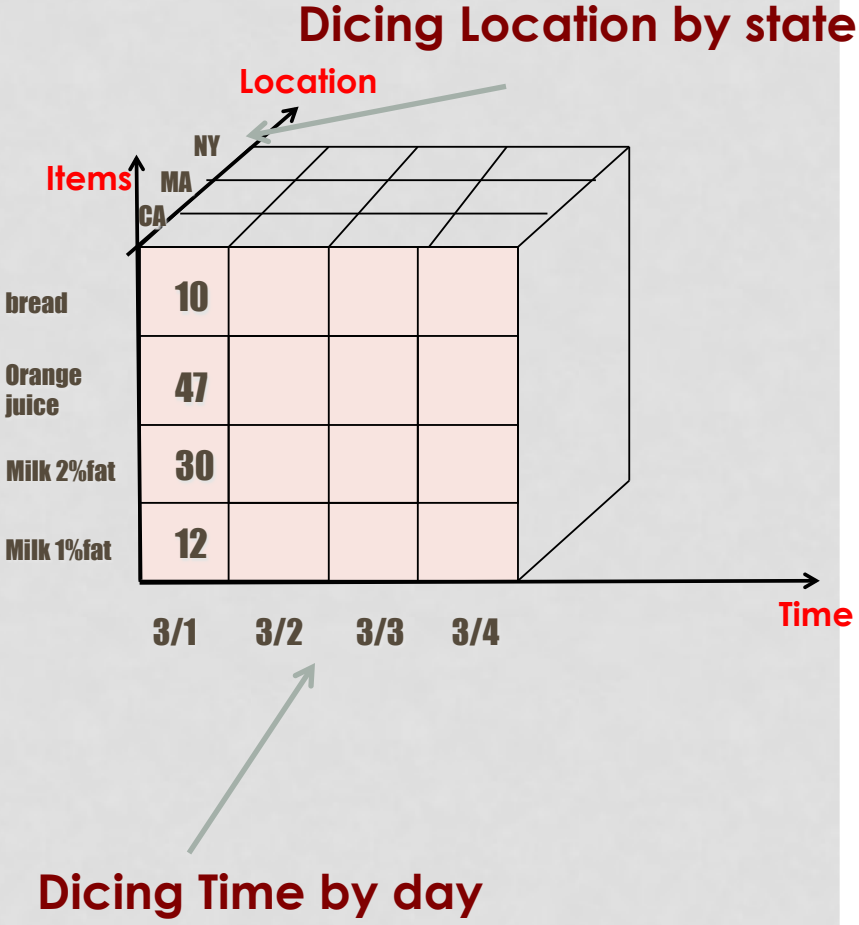
Data inside the cube
are the fact records

ROLAP: EXTENSIONS TO DBMS

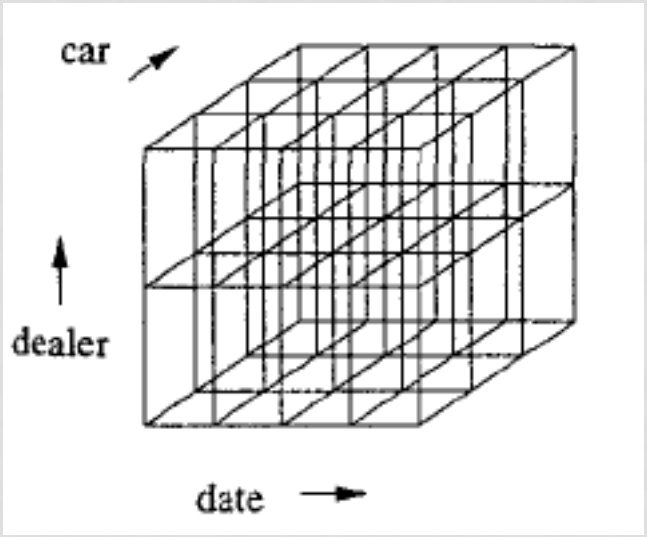
- Schema design
- Specialized scan, indexing and join techniques
- Handling of aggregate views (querying and materialization)
- Supporting query language extensions beyond SQL
- Complex query processing and optimization
- Data partitioning and parallelism

SLICING & DICING

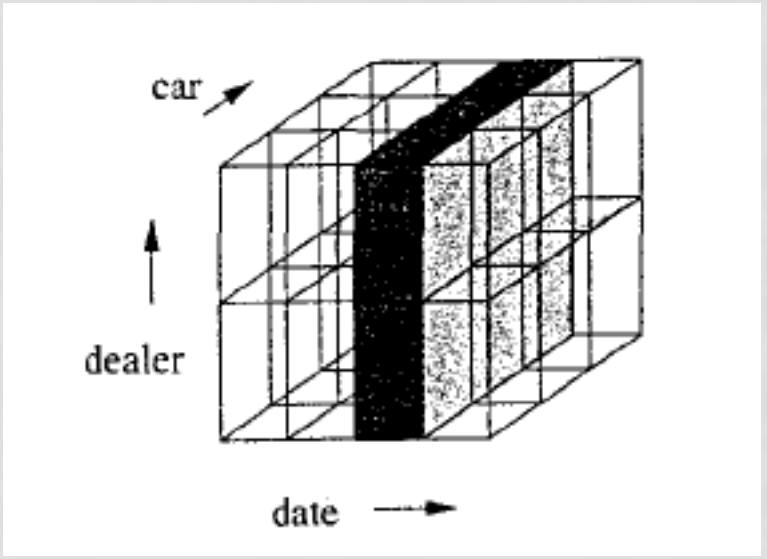
- **Dicing**
  - how each dimension in the cube is divided
  - Different granularities
  - When building the data cube
- **Slicing**
  - Selecting slices of the data cube to answer the OLAP query
  - When answering a query



SLICING & DICING: EXAMPLE 1



Dicing



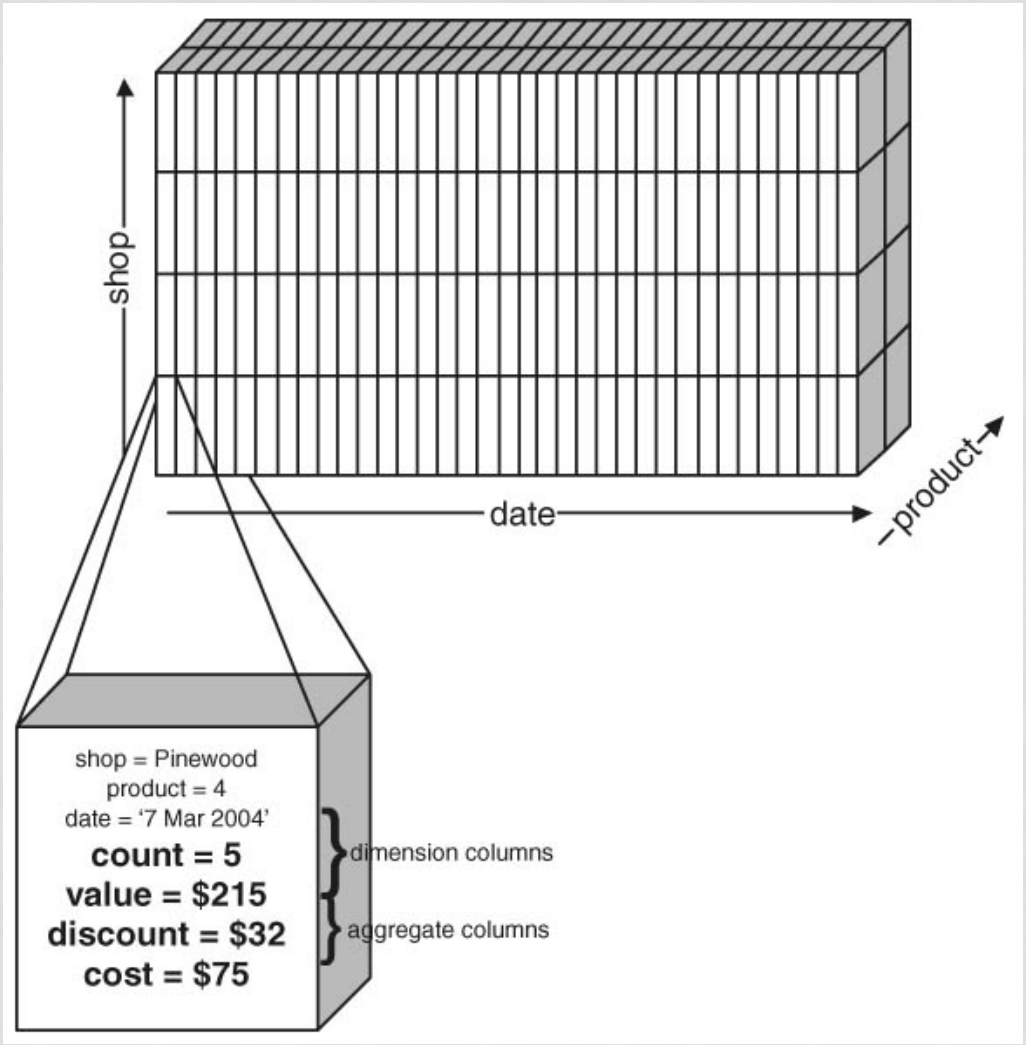
Slicing

Slicing operation in ROLAP is basically:

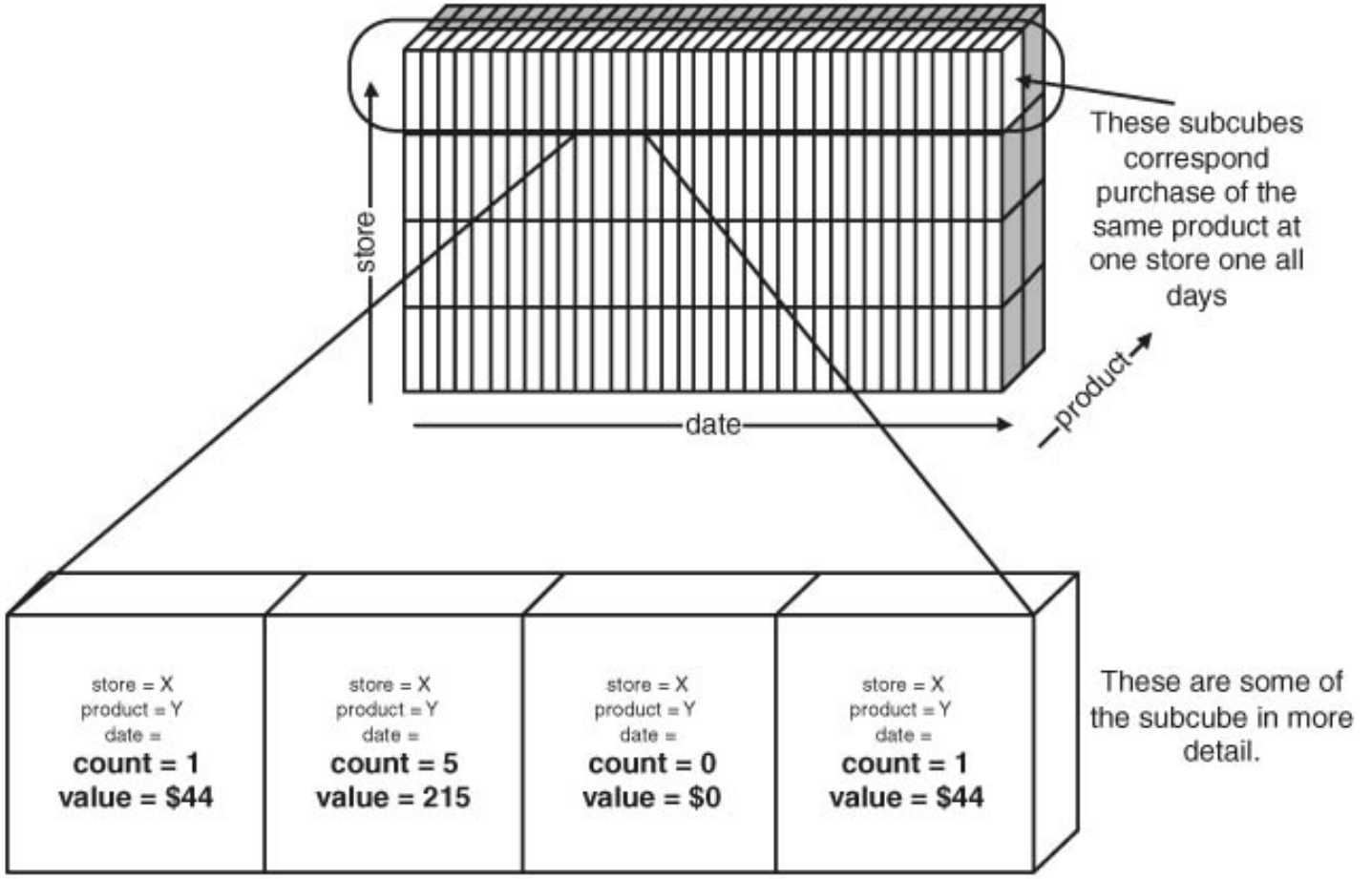
-- Selection conditions on some attributes (WHERE clause) +

-- Group by and aggregation

SLICING & DICING: EXAMPLE 2



SLICING & DICING: EXAMPLE 3



DRILL-DOWN & ROLL-UP

Region	Sales variance
Africa	105%
Asia	57%
Europe	122%
North America	97%
Pacific	85%
South America	163%

Drill-down
(Group by Nation)

Roll-up
(group by Region)

Nation	Sales variance
China	123%
Japan	52%
India	87%
Singapore	95%

ROLAP: DRILL-DOWN & ROLL-UP

```
SELECT dealer, year, SUM(price)
FROM (Sales NATURAL JOIN Autos) JOIN Days ON date = day
WHERE model = 'Gobi' AND
      color = 'red' AND
      (year = 2001 OR year = 2002)
GROUP BY year, dealer;
```

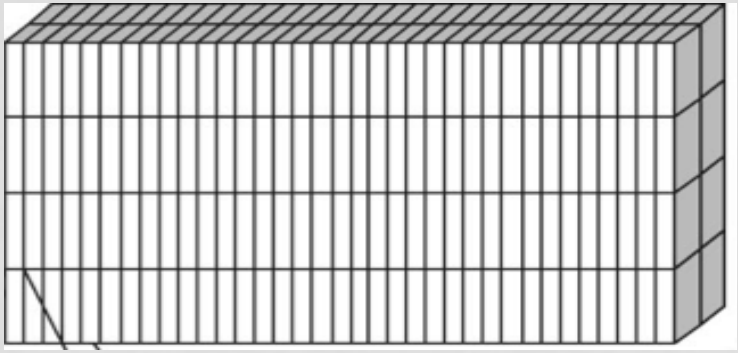
Drill-down

Roll-up

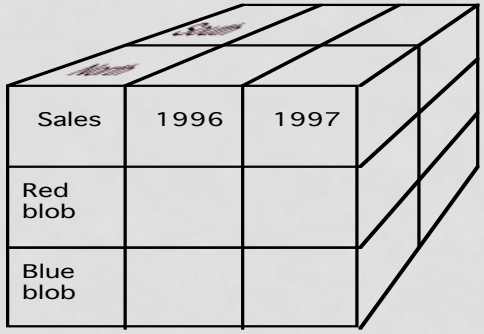
```
SELECT dealer, month, SUM(price)
FROM (Sales NATURAL JOIN Autos) JOIN Days ON date = day
WHERE model = 'Gobi' AND color = 'red'
GROUP BY month, dealer;
```

MOLAP

- Unlike ROLAP, in MOLAP data are stored in special structures called "***Data Cubes***" **(Array-bases storage)**
- **Data cubes pre-compute and aggregate the data**
  - Possibly several data cubes with different granularities
  - Data cubes are aggregated materialized views over the data
- As long as the data does not change frequently, the overhead of data cubes is manageable



Every day, every item, every city



Every week, every item category, every city

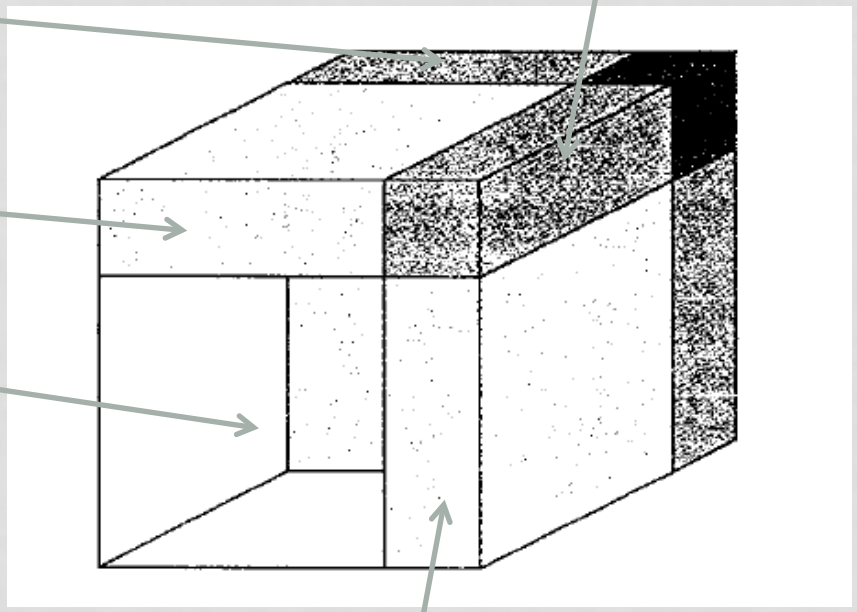
MOLAP: CUBE OPERATOR

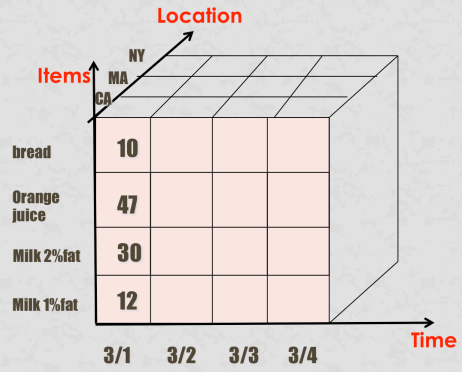
Aggregation over the X,Y

Aggregation over the Z axis

Aggregation over the Y axis

Raw-data (fact table)





Aggregation over the X axis

MOLAP & ROLAP

- Commercial offerings of both types are available
- In general, **MOLAP** is good for smaller warehouses and is optimized for canned queries
- In general, **ROLAP** is more flexible and leverages relational technology
- **ROLAP** May pay a performance penalty to realize flexibility

OLTP vs. OLAP

	OLTP	OLAP
User	• Clerk, IT Professional	• Knowledge worker
Function	• Day to day operations	• Decision support
DB Design	• Application-oriented (E-R based)	• Subject-oriented (Star, snowflake)
Data	• Current, Isolated	• Historical, Consolidated
View	• Detailed, Flat relational	• Summarized, Multidimensional
Usage	• Structured, Repetitive	• Ad hoc
Unit of work	• Short, Simple transaction	• Complex query
Access	• Read/write	• Read Mostly
Operations	• Index/hash on prim. Key	• Lots of Scans
# Records accessed	• Tens	• Millions
#Users	• Thousands	• Hundreds
Db size	• 100 MB-GB	• 100GB-TB
Metric	• Trans. throughput	• Query throughput, response

Source: Datta, GT

OLAP: SUMMARY

- OLAP stands for Online Analytic Processing and used in decision support systems
  - Usually runs on data warehouse
- In contrast to OLTP, OLAP queries are complex, touch large amounts of data, try to discover patterns or trends in the data
- **OLAP Models**
  - **Relational (ROLAP):** uses relational star schema
  - **Multidimensional (MOLAP):** uses data cubes