On-Line Analytical Processing

Chapter 5, Section 6

Warehousing

Data Cubes

Overview

- Traditional database systems are tuned to many, small, simple queries.
- Some new applications use fewer, more time-consuming, *analytic* queries.
- New architectures have been developed to handle analytic queries efficiently.

The Data Warehouse

- The most common form of data integration.
  - Copy sources into a single DB (*warehouse*) and try to keep it up-to-date.
  - Usual method: periodic reconstruction of the warehouse, perhaps overnight.
  - Frequently essential for analytic queries.

OLTP

- Most database operations involve *On-Line Transaction Processing* (OLTP).
  - Short, simple, frequent queries and/or modifications, each involving a small number of tuples.
  - Examples: Answering queries from a Web interface, sales at cash registers, selling airline tickets.

OLAP

- *On-Line Analytical Processing* (OLAP, or "analytic") queries are, typically:
  - Few, but complex queries --- may run for hours.
  - Queries do not depend on having an absolutely up-to-date database.

OLAP Examples

1. Amazon analyzes purchases by its customers to come up with an individual screen with products of likely interest to the customer.

2. Analysts at Wal-Mart look for items with increasing sales in some region.
   - Use empty trucks to move merchandise between stores.

Common Architecture

- Databases at store branches handle OLTP.
- Local store databases copied to a central warehouse overnight.
- Analysts use the warehouse for OLAP.

Star Schemas

A *star schema* is a common organization for data at a warehouse. It consists of:

1. *Fact table* : a very large accumulation of facts such as sales.
   - Often “insert-only.”
2. *Dimension tables* : smaller, generally static information about the entities involved in the facts.

Example: Star Schema

- Suppose we want to record in a warehouse information about every beer sale: the bar, the brand of beer, the drinker who bought the beer, the day, the time, and the price charged.

- The fact table is a relation:

Sales (bar, beer, drinker, day, time, price)

Example -- Continued

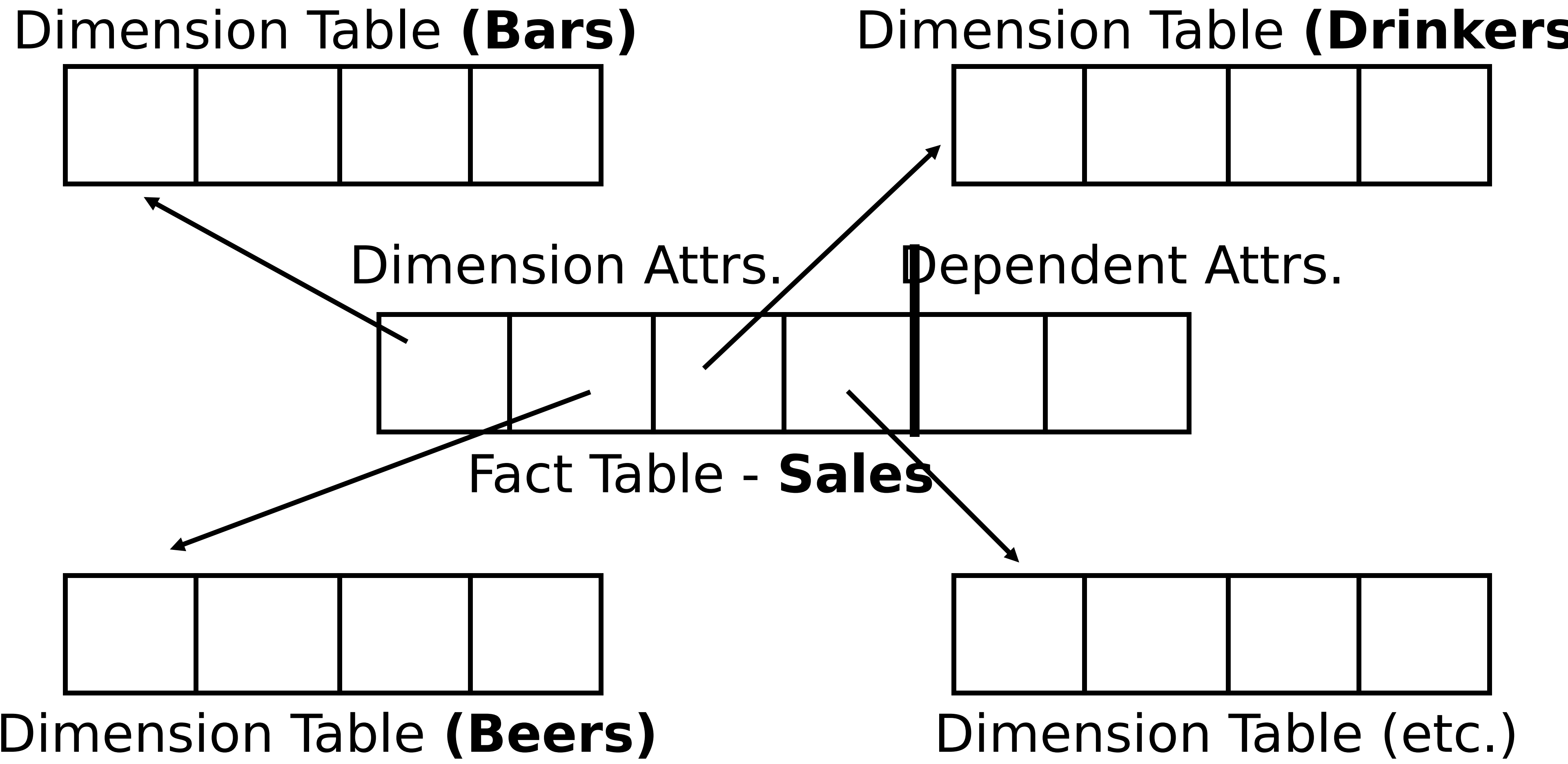
- The dimension tables include information about the bar, beer, and drinker "dimensions":

    Bars(bar, addr, license)

    Beers(beer, manf)

    Drinkers(drinker, addr, phone)

Visualization – Star Schema



Dimensions and Dependent Attributes

Two classes of fact-table attributes:

1. *Dimension attributes* : the key of a dimension table.
2. *Dependent attributes* : a value determined by the dimension attributes of the tuple.

Example: Dependent Attribute

- price is the dependent attribute of our example Sales relation.

- It is determined by the combination of dimension attributes: bar, beer, drinker, and the time (combination of day and time-of-day attributes).

Approaches to Building Warehouses

1. *ROLAP* = "relational OLAP": Tune a relational DBMS to support star schemas.

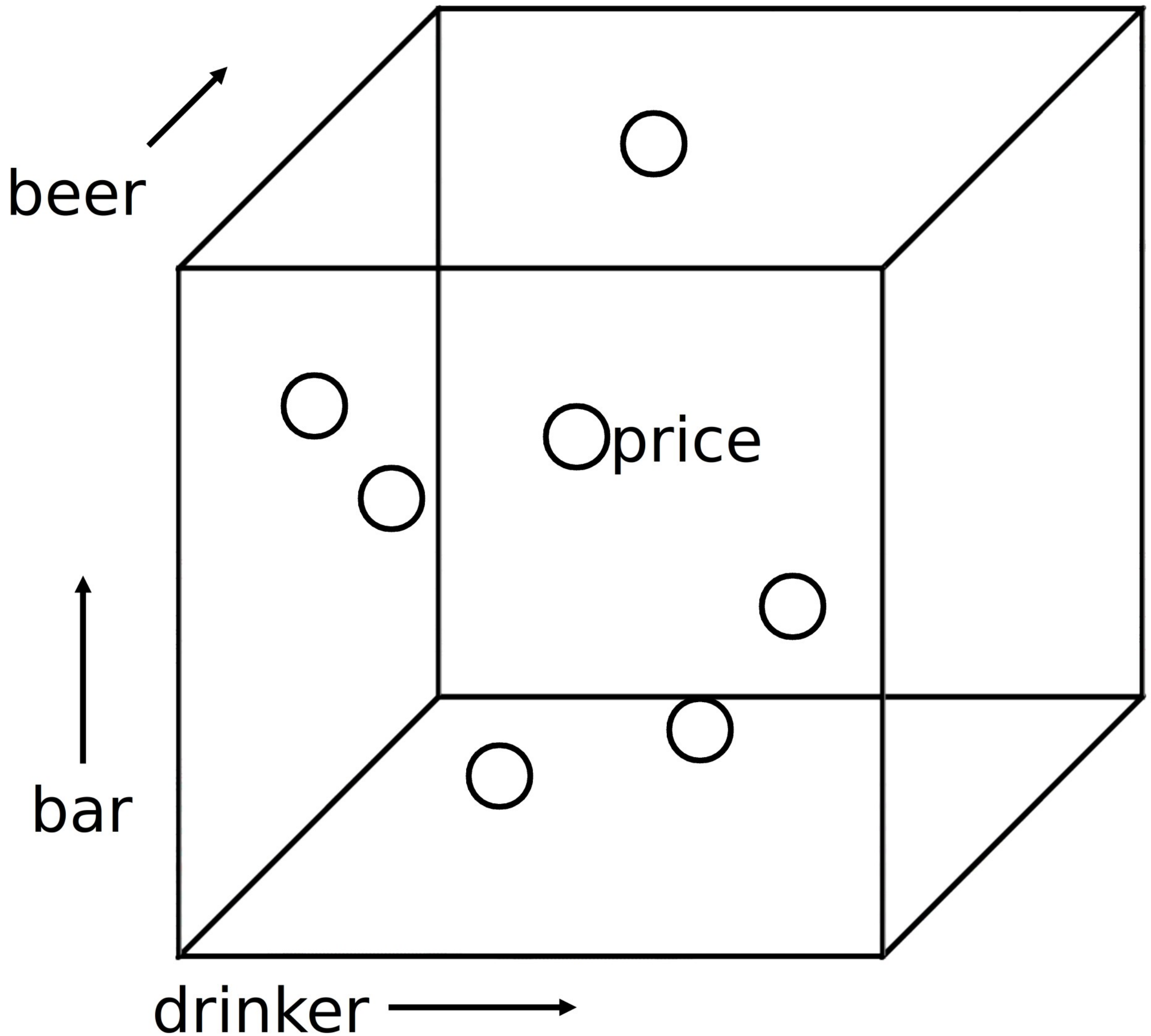
2. *MOLAP* = "multidimensional OLAP": Use a specialized DBMS with a model such as the "data cube."

MOLAP and Data Cubes

- Keys of dimension tables are the dimensions of a hypercube.
  - Example: for the Sales data, the four dimensions are bar, beer, drinker, and time.

- Dependent attributes (e.g., price) appear at the points of the cube.

Visualization -- Data Cubes

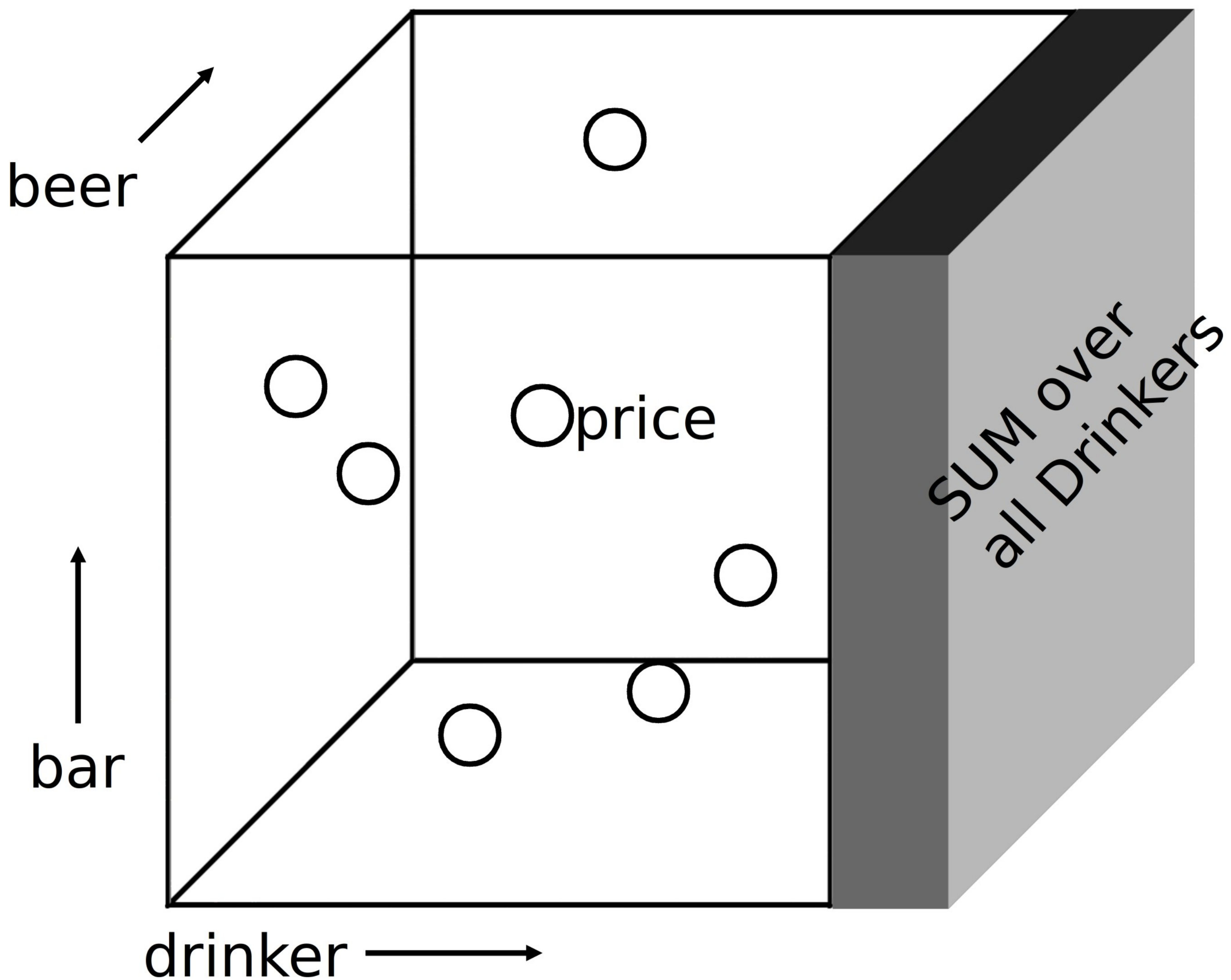


Marginals

- The data cube also includes aggregation (typically SUM) along the margins of the cube.

- The *marginals* include aggregations over one dimension, two dimensions,...

Visualization --- Data Cube w/Aggregation



Example: Marginals

- Our 4-dimensional Sales cube includes the sum of price over each bar, each beer, each drinker, and each time unit (perhaps days).

- It would also have the sum of price over all bar-beer pairs, all bar-drinker-day triples,…

Structure of the Cube

- Think of each dimension as having an additional value *.
- A point with one or more *'s in its coordinates aggregates over the dimensions with the *'s.
- Example: Sales("Joe's Bar", "Bud", *, *) holds the sum, over all drinkers and all time, of the Bud consumed at Joe's.

Drill-Down

- *Drill-down* = “de-aggregate” = break an aggregate into its constituents.

- Example: having determined that Joe’s Bar sells very few Anheuser-Busch beers, break down his sales by particular A.-B. beer.

Roll-Up

- *Roll-up* = aggregate along one or more dimensions.

- Example: given a table of how much Bud each drinker consumes at each bar, roll it up into a table giving total amount of Bud consumed by each drinker.

Example: Roll Up and Drill Down

$ of Anheuser-Busch by drinker/bar

	Jim	Bob	Mary
Joe's Bar	45	33	30
Nut-House	50	36	42
Blue Chalk	38	31	40

Roll up by Bar

$ of A-B / drinker

Jim	Bob	Mary
133	100	112

Drill down by Beer

$ of A-B Beers / drinker

	Jim	Bob	Mary
Bud	40	29	40
M'lob	45	31	37
Bud Light	48	40	35

OLAP in SQL

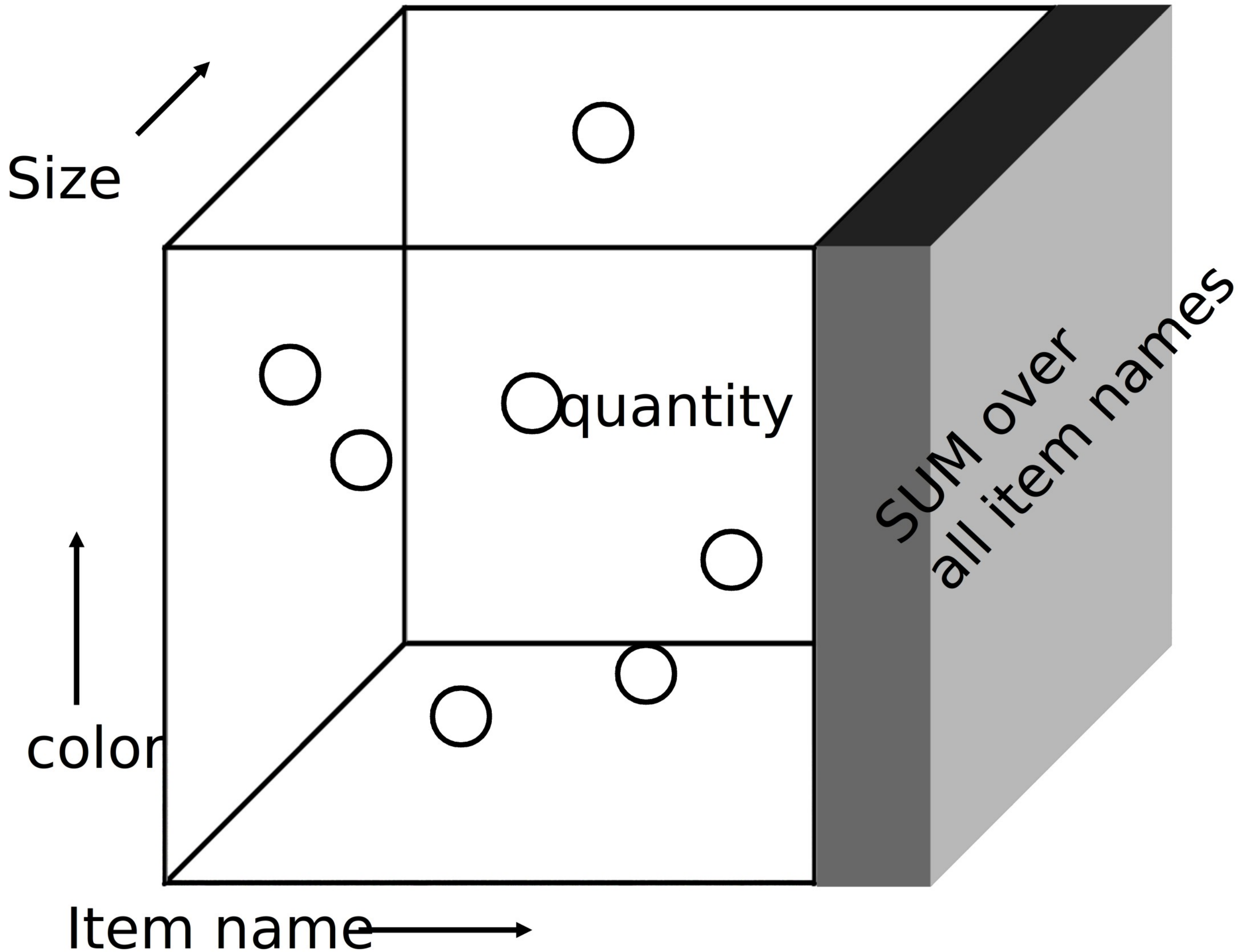
Sales (item-name, color, size, Quantity)

Color: dark, white, pastel

Size: small, medium, large, extra-large

Item-name: shirt, dress, pants, coat, skirt

Visualization --- Data Cube w/Aggregation



Cube operator

select item-name, sum (quantity)
from sales
group by item-name

select item-name, color, sum (quantity)
from sales
group by item-name, color

select item-name, size, sum (quantity)
from sales
group by item-name, size

Cube Operator

group by lists	Corresponding cube portions
(item-name, color, size),	(item-name, color, size),
(item-name, color),	(item-name, color, *)
(item-name, size),	(item-name, *, size),
(color, size)	(*, color, size)
(item-name),	(item-name, *, *),
(color),	(*, color, *)
(size)	(*, *, size)
()	(*, *, *)

Cube operator

select item-name, color, size, sum(quantity)
from Sales
group by cube (item-name, color, size)

Group by Rollup

- Similar to the cube operator but less number f groupings

GROUP BY rollup (itemname, color, clothessize)

generates groupings

(itemname, color, clothessize)

(itemname, color)

(itemname)

()