Bachelor Degree Programme in Applied Computer Science and Artificial Intelligence

SAPIENZA
UNIVERSITÀ DI ROMA

13. Data Warehousing – Introduction to the Multidimensional Model

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Multidimensional model

event in the real world

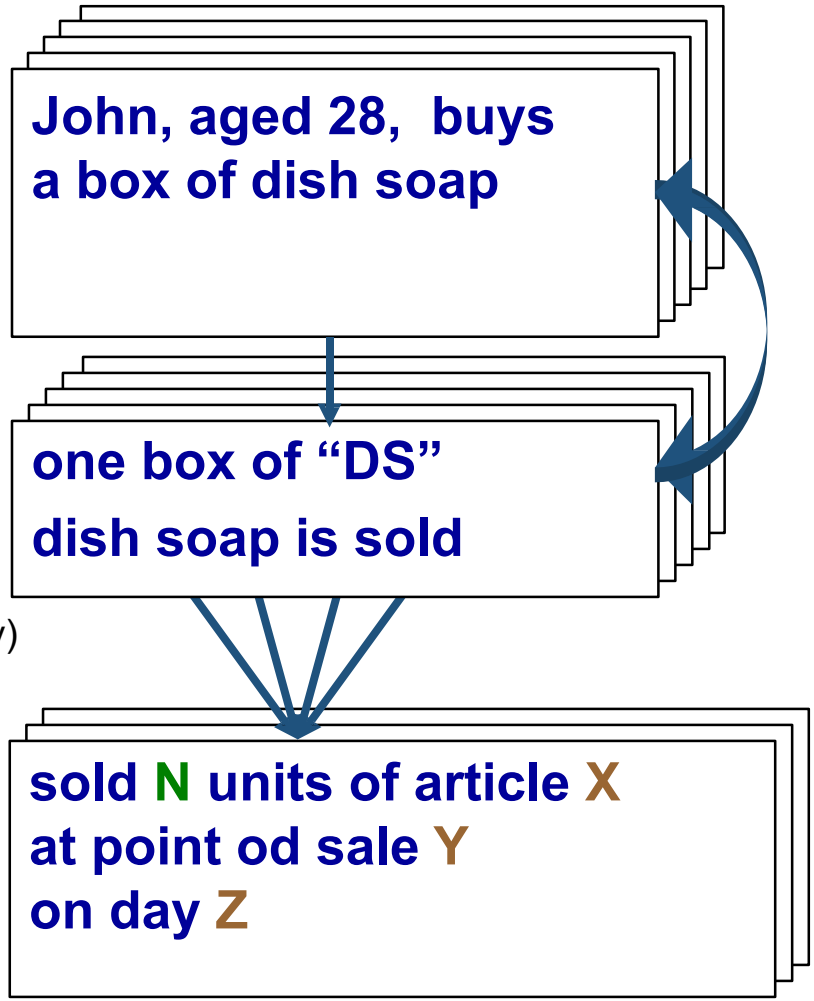
DB design:
selection of all and only features
having operational relevance

datum in the operational DB
(rappresenting the event)

DW design:
..., definition of aggregations (with a given granularity)
of analytic interest to some users

fact in the enterpise DW

(measurement in an n-dimensional space)



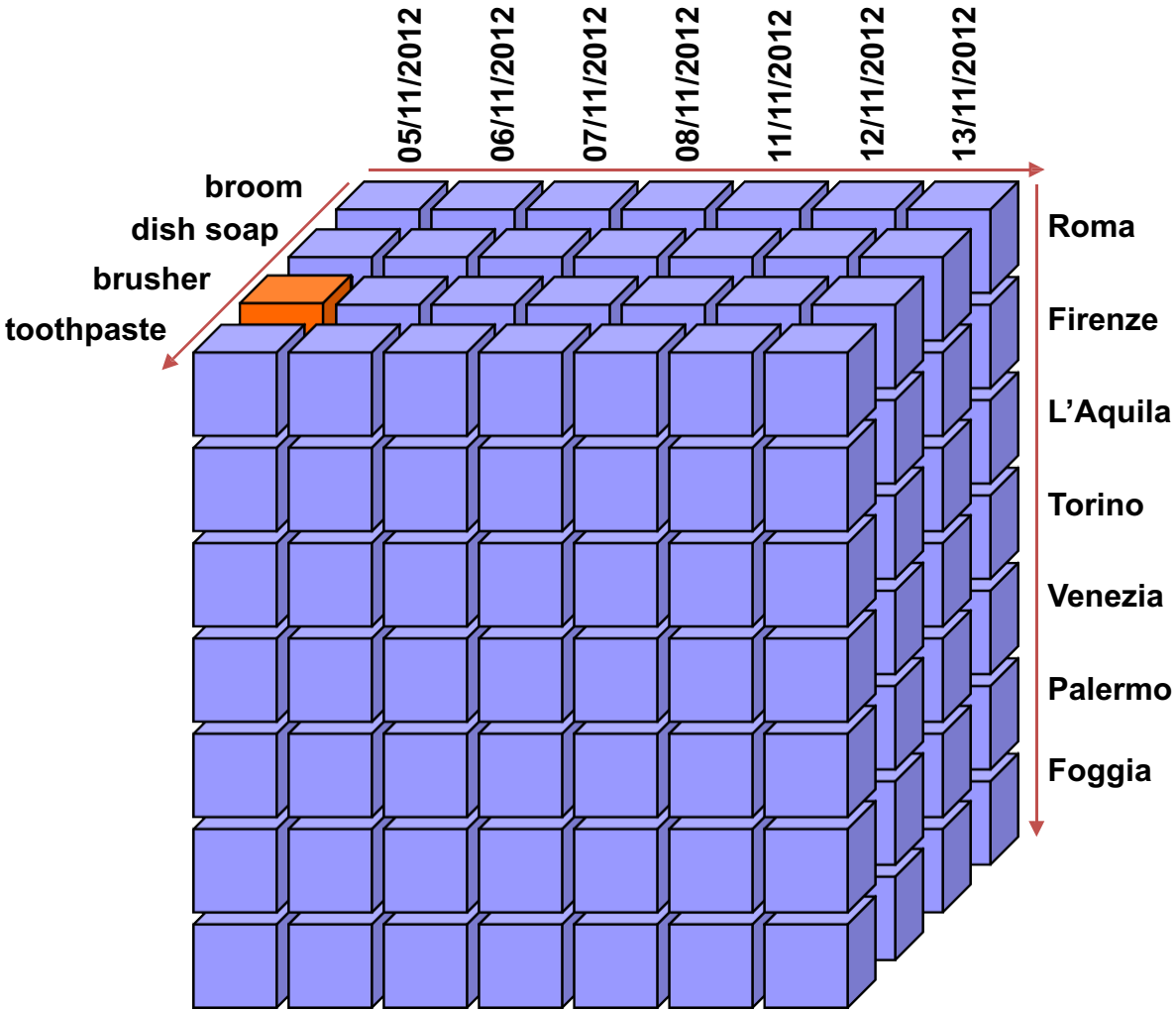
Events and Facts

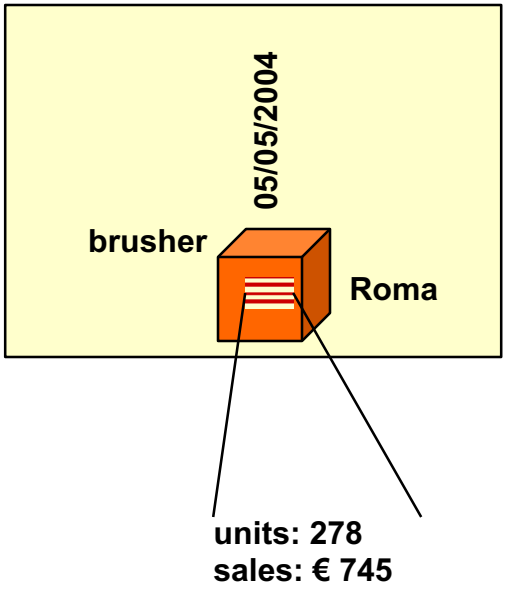
- **EVENT** (in the real world) and **FACT** (of interest) are terms whose meaning is determined by the granularity (level of detail) of the multidimensional representation of the Data Warehouse

Example of FACT:

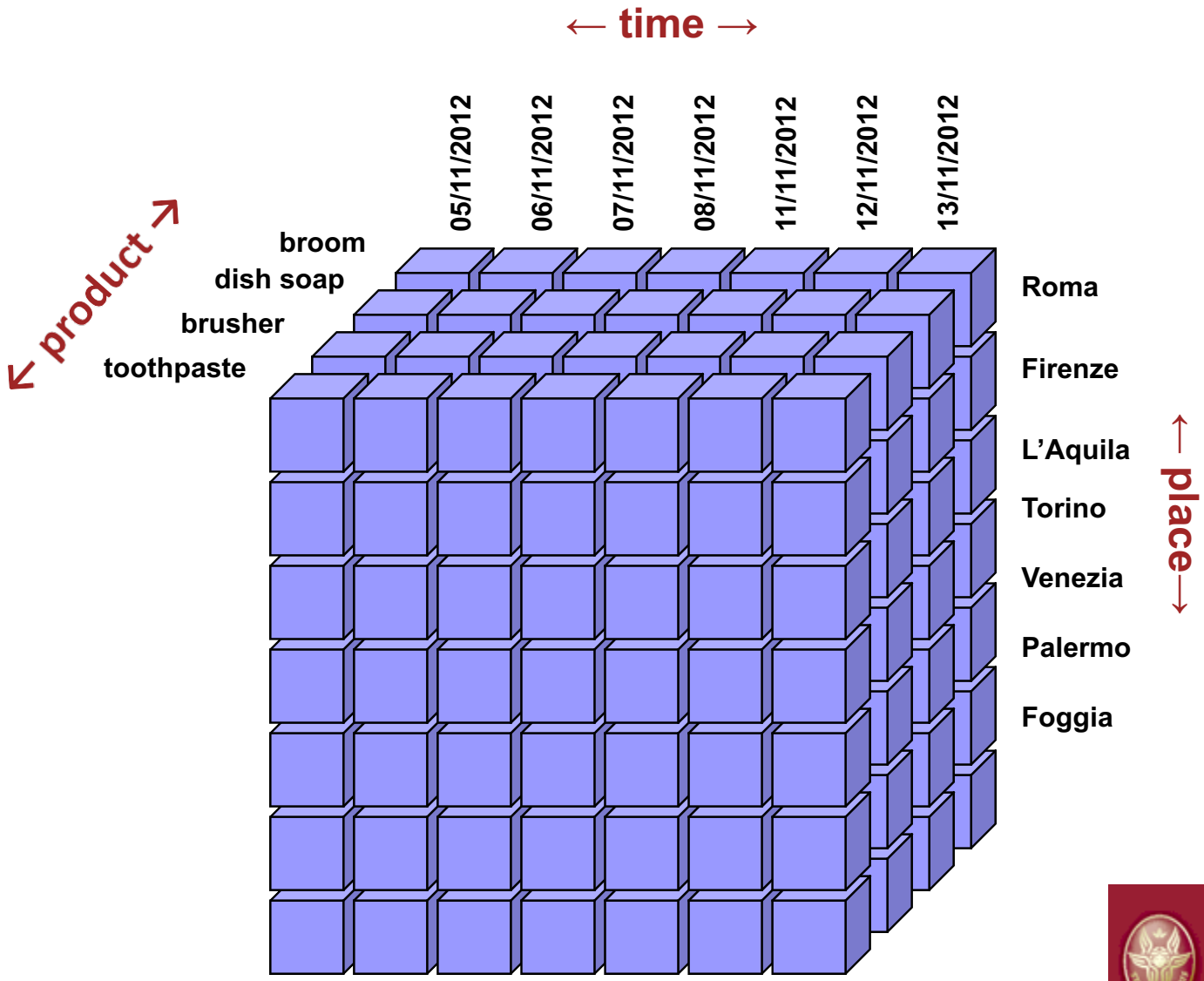
on **02/05/2012** in **"Rome 23"** PoS (Point of Sale) **278** boxes of **soap** have been sold, cashing **745** Euro

Multidimensional Cube





Dimensions



A relational schemafor the multidimensional cube

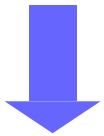
TABLE(dimens-1, …, dimens-k, measur-1, …, measur-h)

Example:

SALES(product, city, date, numUnitsSold, sales)

dimensions
(classification attributes)

measurements
(variables, metrics, indicators, …)



IDENTIFICATIVE KEY

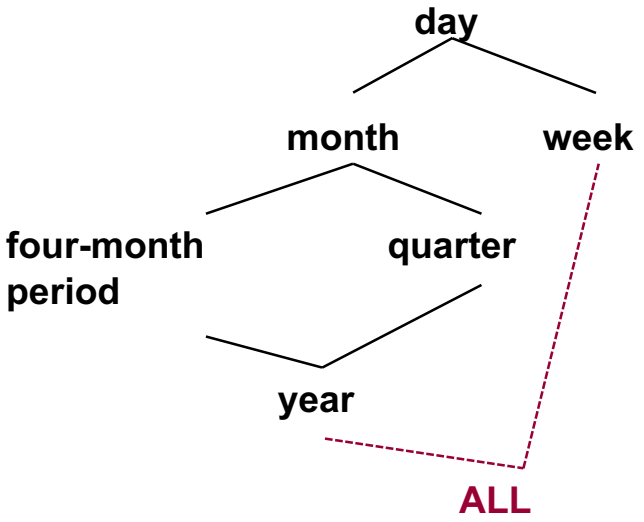
Functional dependence: **dimensions → measurements**

In the example: **product, city, date → numUnitsSold, sales**

Dimensional hierarchy

- Each dimension is associated with a hierarchy that groups the values at different levels of aggregation (also orthogonally)
- Each node of the hierarchy is called DIMENSIONAL ATTRIBUTE

Example (time dimension):



Functional Dependencies:

day→ week
day → month
month → quarter
month → four-month-period
quarter → year
four-month-period → year

Access to Data Warehouse

Reporting

- predefined needs (poss., parametrized)
- automated extraction of information

OLAP

- analysis needs that are not identifiable in advance (browsing on dimensions and indicators)
- interactive data exploration, searching for information of interest

Data Mining

- analysis needs that are not identifiable in advance
- (semi)automatic data exploration

Reporting

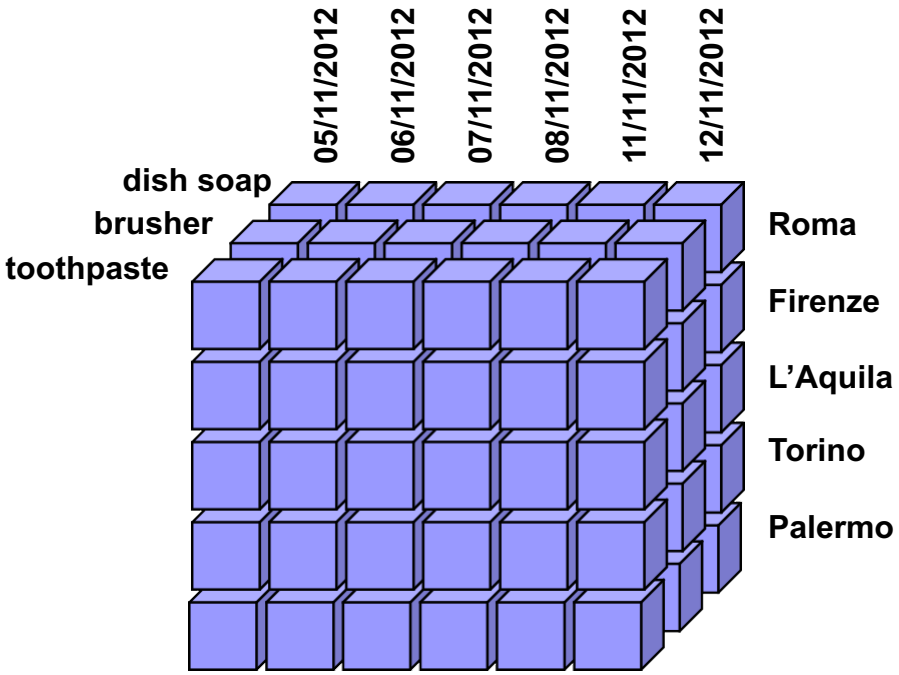
Report with predefined structure and format

- query
  - typically based on restrictions and / or aggregations
- presentation
  - interleaved with text data
  - in tabular and / or graphic form
  - customized with environment variables (date, user, ...)
- generation
  - on user demand
  - periodic
  - under specified conditions
- distribution
  - preview/print, e-mail, web, …

OLAP

- implementation:
  - analysis session, divided into a series of steps, each dependent on the results obtained previously
- tipical users:
  - domain experts, not necessarily computer experts

OLAP: example



OLAP – Basic operations in the multidimensional model

RESTRICTION (filtering based on values)

- selection on specific values of dimensional attributes
- in case of equality with a single value, the operator is called SLICING (one dimension disappears)

AGGREGATION (level of abstraction increases)

- considered one dimension, group one dimensional attribute to a higher level of granularity
- joining up to the highest level (the most generic, consisting of a single value), a dimension disappears

OLAP: Roll-Up Operator

- Aggregation along one dimension

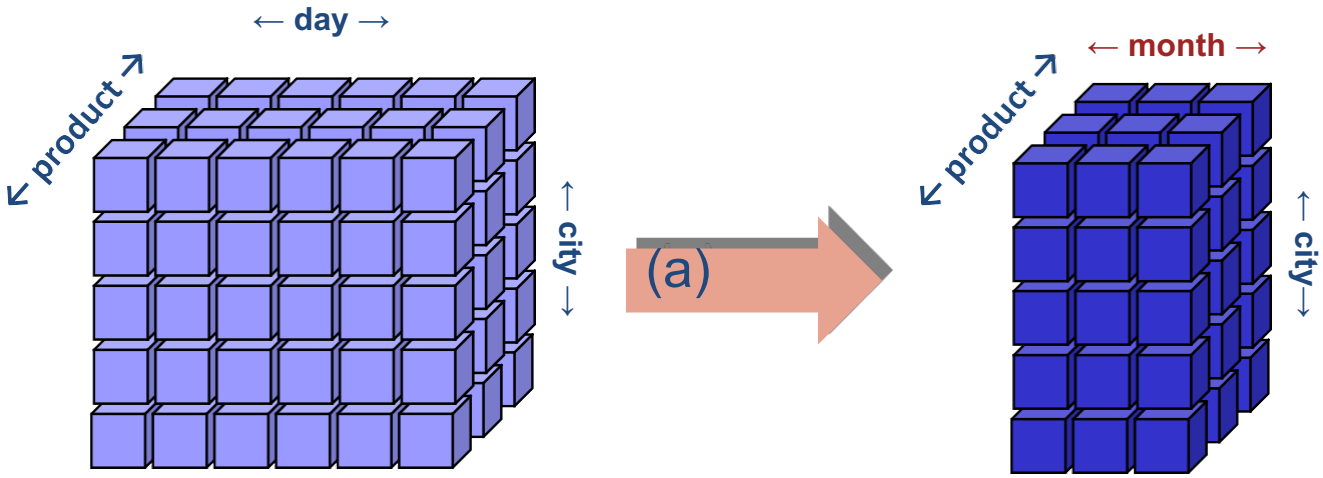
  → use of an aggregate operator on a measurement attribute

Examples:

a. sales of each product by city and month

b. daily sales per city (total on all products)

c. daily sales by product (North / Central / South)



OLAP: Aggregative Operators

DISTRIBUTIVE: computable from:

1. partial aggregates

– Examples: SUM, MAX, MIN, …

ALGEBRAIC: computable from:

1. partial aggregates
2. finite set of support information

– Examples : weighted AVG, standard deviation, …

OLISTIC: computable from:

1. original data

– Example: rank of an array

OLAP: Drill-Down Operator

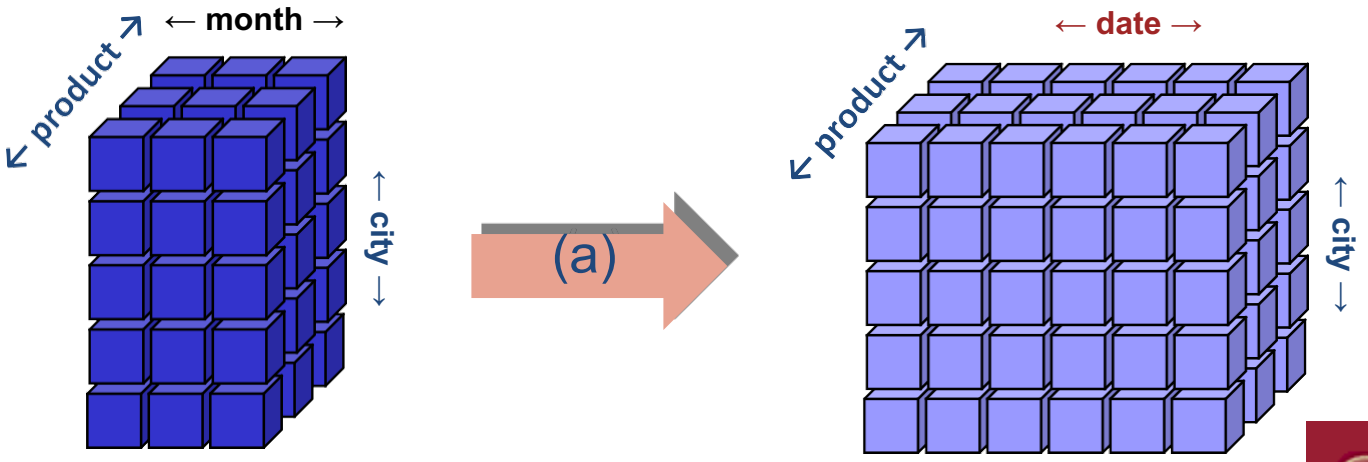
Disaggregation over one dimension

→ disaggregated data are assumed to be available

Examples:

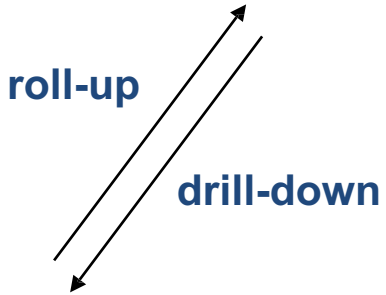
a. from “sales of each product by city and month” to “daily sales”

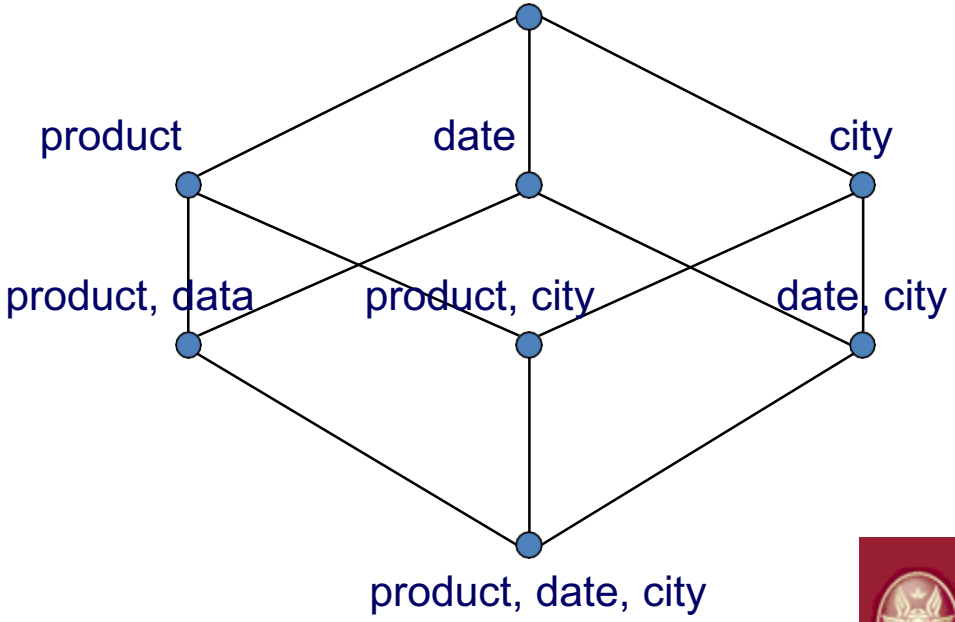
b. from “monthly sales by city (total on all products)” to “daily sales by city and product”



OLAP: Cuboids (dimensions)

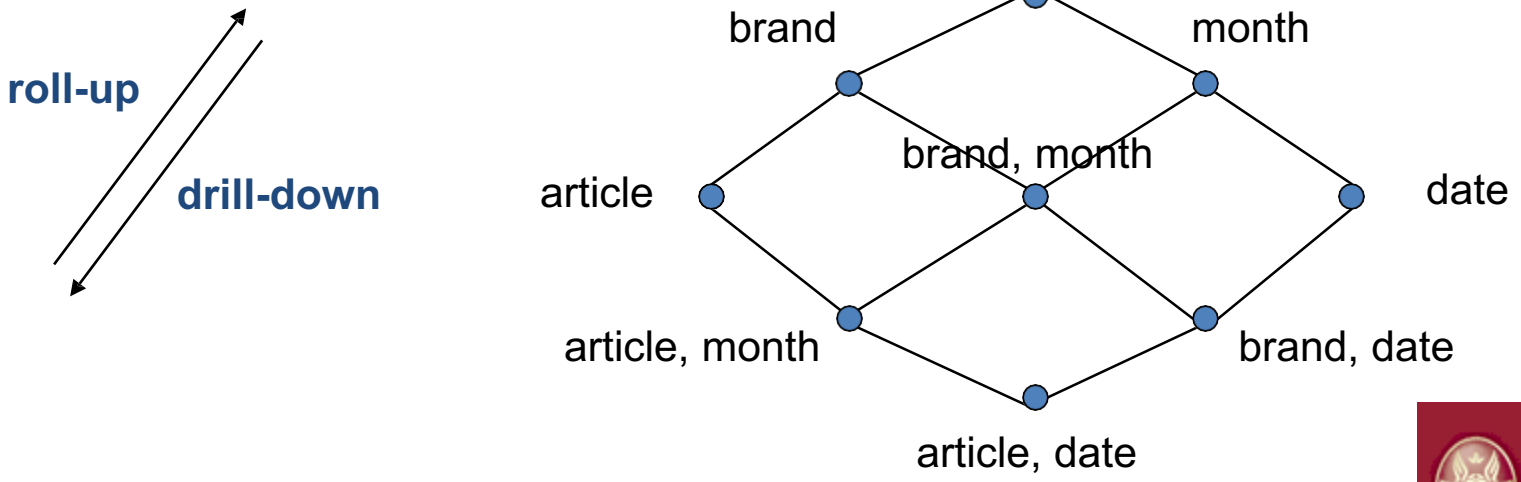
- given a data cube, you can perform different roll-up operations up to the disappearance of a dimension
- given a k-dimensional data cube, there exist 2k possible cuboids





OLAP: Cuboids (aggregation levels)

- given a data cube, you can perform different roll-up operations, increasing the aggregation level (up to the disappearance of a dimension)
- given a k-dimensional data cube, resp. with n1, n2, …, nk agregation levels, there exist n1×n2 ×…×nk possible cuboids



OLAP: Slice-and-Dice Operators

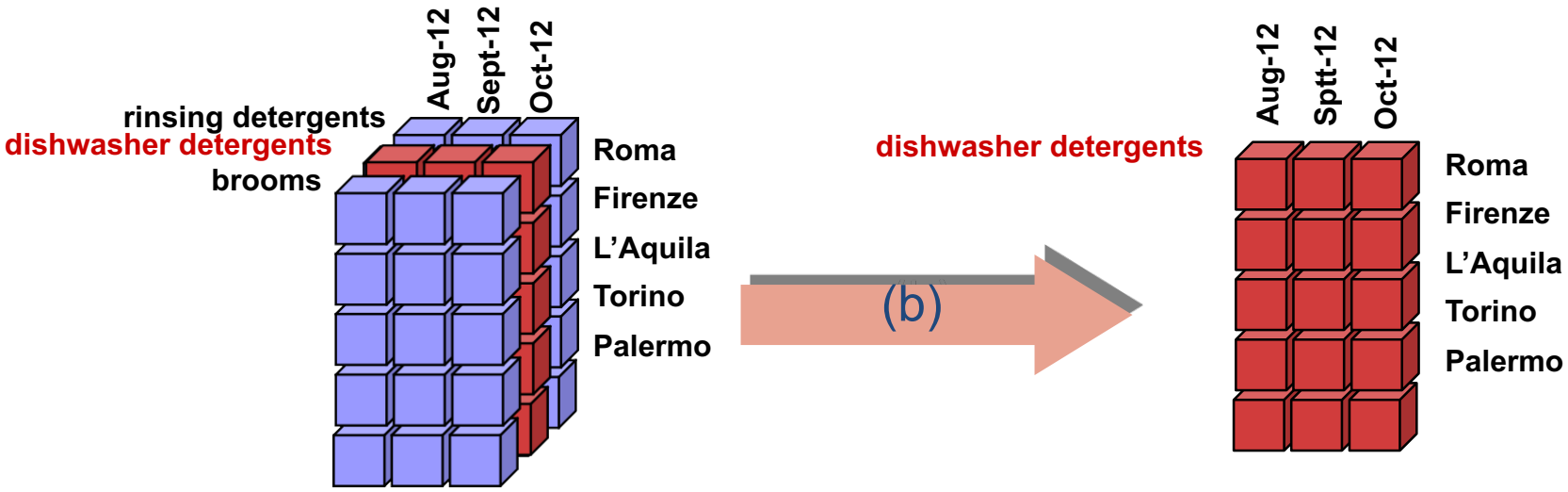
Selection (up to “slicing”)

Examples:

from “monthly sales of products by city” to:

a. monthly sales of products by city in central Italy

b. monthly sales by city of dishwasher detergents



OLAP: Pivoting Operators

- Rotating dimensions on a bidimensional table
  - Example:
    a. from: sales of (products by month) by (city)
    b. to: sales of (products by city) by (month)

		RM	FI	AQ	TO	PA
rinsing det	aug-12	34	23	12	56	65
	sep-12	56	45	23	44	67
	oct-12	76	34	34	55	45
dishw. det.	aug-12	57	46	35	79	88
	sep-12	79	68	46	67	90
	oct-12	99	57	57	78	68
brooms	aug-12	46	35	24	68	77
	sep-12	68	57	35	56	79
	oct-12	88	46	46	67	57

		aug-12	sep-12	oct-12
rinsing det.	RM	34	56	76
	FI	23	45	34
	AQ	12	23	34
	TO	56	44	55
	PA	65	67	45
dishw. det.	RM	57	79	99
	FI	46	68	57
	AQ	35	46	57
	TO	79	67	78
	PA	88	90	68
brooms	RM	46	68	88
	FI	35	57	46
	AQ	24	35	46
	TO	68	56	67
	PA	77	79	57

OLAP: Drill-Through Operator

- access data at a level of aggregation lower than the Data Warehouse
- access to reconciled data (three-level architecture) or to the operational DB
- a sort of extreme Drill-Down

OLAP: Drill-Across Operators

- Correlate data from two or more cubes, based on the dimensional values, returning the value in a new cube

Example:

Starting from

- sales by product, date, city
- employees by city

calculate:

- average sales by product, employee

Books on Datawarehouses

- Matteo Golfarelli, Stefano Rizzi «Data Warehouse Design – Modern Principles and Methodologies», McGraw-Hill, 2009
- Matteo Golfarelli, Stefano Rizzi «Data Warehouse – Teoria e Pratica della Progettazione» (2a ed.), McGraw-Hill, 2006