OLAP Operations

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References

- A. Vaisman and E. Zimányi, Data Warehouse Systems: Design and Implementation, Springer, 2014 (chpt 3)
- J. Han and M. Kamber, Data Mining: Concepts and Techniques, Morgan Kaufmann, 2001 (chpt. 2)
- C. Ciferri, R. Ciferri, L.I. Gómez, M. Schneider, A.A. Vaisman, E. Zimányi, Cube algebra: a generic user-centric model and query language for OLAP cubes. Int. J. Data Warehousing Mining 9(2), 39–65, 2013
- A. Wichert, H. Galhardas, SAD slides, MEIC/IST

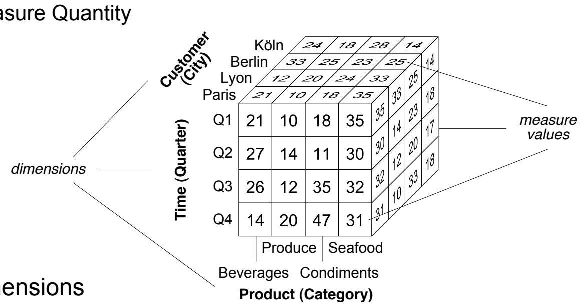
Recap. the multidimensional model

- Multidimensional model enables one to view data from multiple perspectives and at several levels of detail

Example

Dimensions: perspectives used to analyze the data

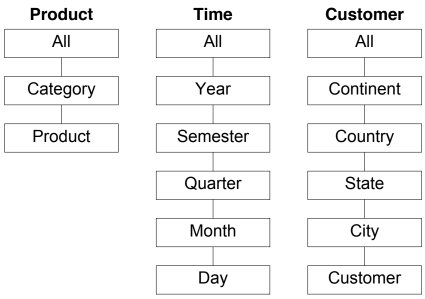
- **Example**: A 3-dimensional cube for sales data with dimensions Product, Time, and Customer, and a measure Quantity



- Attributes describe dimensions
  - Product dimension may have attributes ProductNumber and UnitPrice (not shown)
- Cells or facts have associated numeric values called measures
  - Each cell of the data cube represents Quantity of units sold by category, quarter, and customer's city

Hierarchies

- Allow viewing data at several granularities
  - Define a sequence of mappings relating **lower-level**, detailed concepts to **higher-level** ones
  - The lower **level** is called the child and the higher level is called the parent
  - The hierarchical structure of a dimension is called the dimension schema
  - A dimension instance comprises all members at all levels in a dimension
- Example
  - Hierarchies of the Product, Time, and Customer dimensions



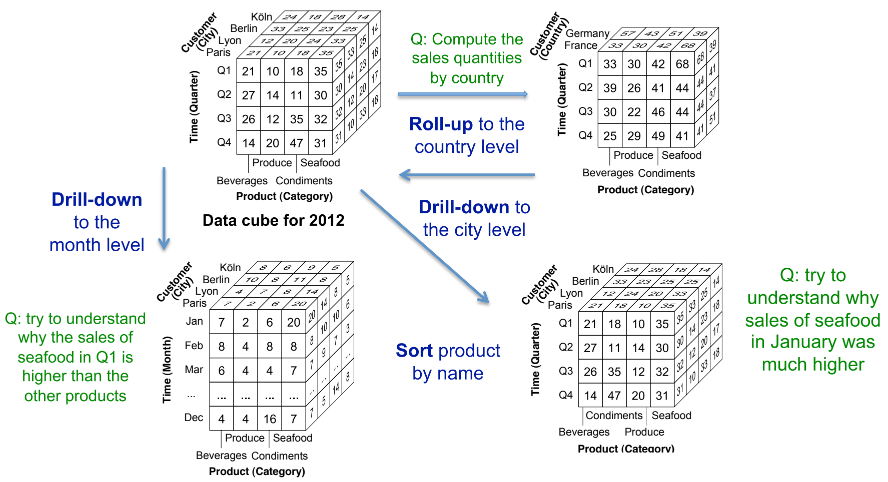
Outline

- OLAP operations

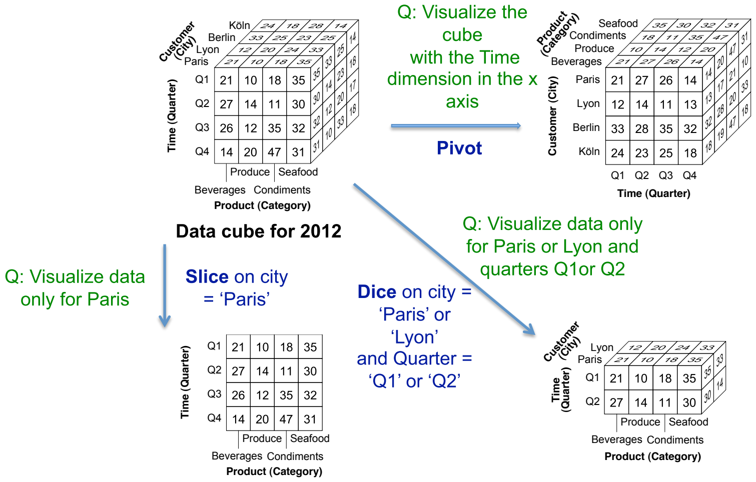
OLAP Operations: definition

- Allows these perspectives and several levels of detail to be materialized by exploiting dimensions and their hierarchies
- Provide an interactive data analysis environment
- Supported by OLAP modules
  - Ex: Saiku (Pentaho)

OLAP Operations (1)



OLAP Operations (2)



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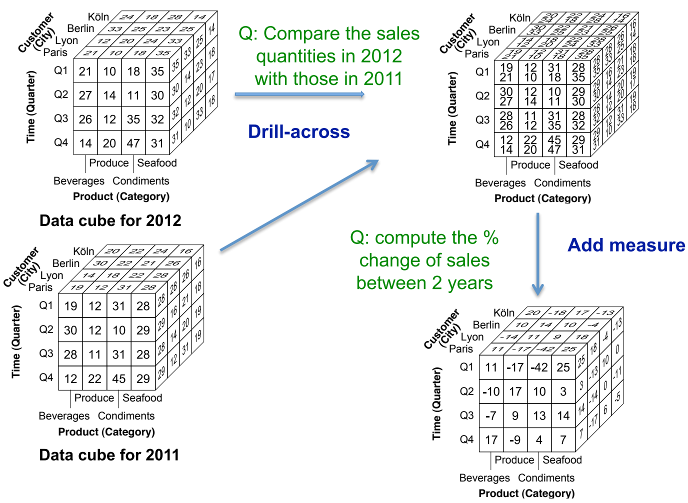
OLAP Operations (3)



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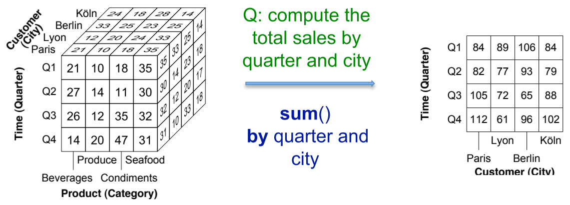
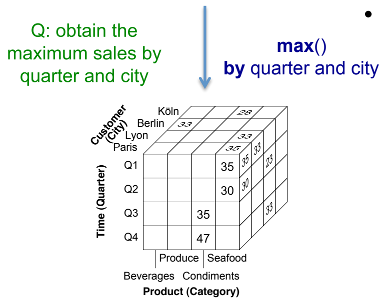
OLAP Operations (4)



Data cube for 2012



- According to the authors of the book, agg. functions can be classified as:
  - cumulative: compute the measure value of a cell from several other cells(e.g., SUM; COUNT, AVG)
  - filtering: filter the members of a dimension that appears in the result (MIN, MAX); must compute not only the aggregated value but also detemine the dimension members that belong to the result

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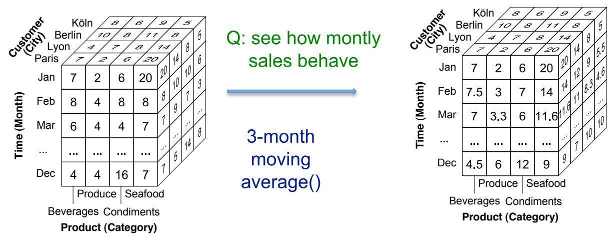
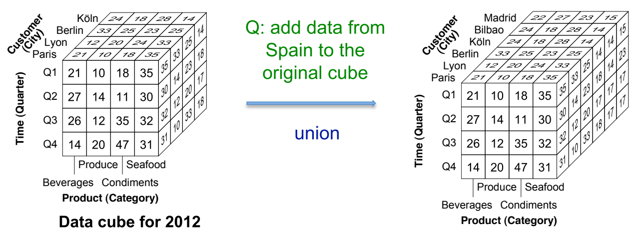
OLAP Operations (5)





Data cube for 2012

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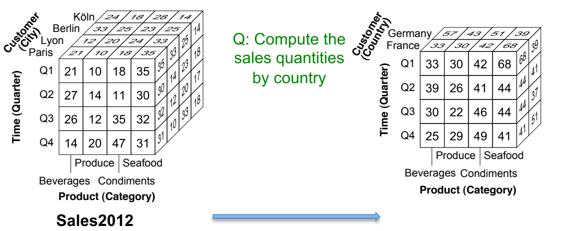
Algebra of OLAP Operations

- There **is not yet a standard definition** of OLAP operations in a similar way to the relational algebra
- Many proposals of OLAP algebra in the literature
- We adopt the one proposed in **[Ciferri et al 2013]**

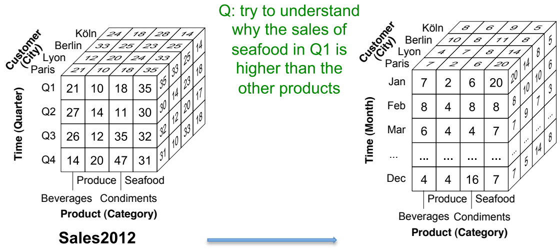
Algebra of OLAP Operations - rollup



ROLLUP(Sales2012, Customer ➔ Country, SUM(Quantity))

- **Roll-up**: aggregates measures along a dimension hierarchy (using an aggregate function) to obtain measures at a coarser granularity
  ROLLUP(CubeName, (Dimension ➔ Level), AggFunction(Measure))

Algebra of OLAP Operations – drill-down

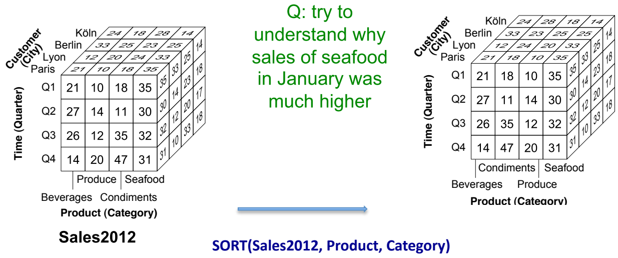


Q: try to understand why the sales of seafood in Q1 is higher than the other products

DRILLDOWN(Sales2012, Time ➔ Month)

- **Drill-down** moves from a more general level to a more detailed level in a hierarchy
  - **DRILLDOWN(CubeName, (Dimension ➔ Level))**

Algebra of OLAP Operations – sort

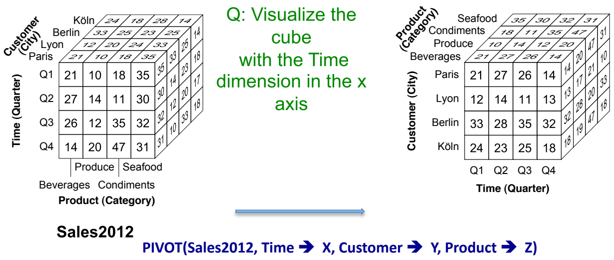


Q: try to understand why sales of seafood in January was much higher

SORT(Sales2012, Product, Category)

- **Sort** returns a cube where the members of a dimension have been sorted
  - **SORT(CubeName, Dimension, Expression [ASC | DESC])**
  - where the members of Dimension are sorted according to the value of Expression

Algebra of OLAP Operations – pivot



- **Pivot (or rotate):** rotates the axes of a cube to provide an alternative presentation of data
  - **PIVOT(CubeName, (Dimension ➔ Axis)*)**
  - where the axes are specified as {X; Y; Z; X1; Y1; Z1; : : :}.

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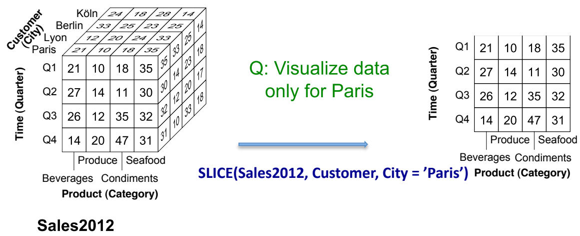
Algebra of OLAP Operations – slice



- **Slice**: removes a dimension in a cube so a cube of n-1 dimensions is obtained from a cube of n dimensions
  - **SLICE(CubeName, Dimension, Level = Value)**
- Dimension will be dropped by fixing a single Value in the Level; other dimensions unchanged
- Slice supposes that the granularity of the cube is at the specified level of the dimension

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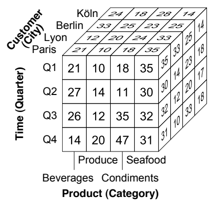
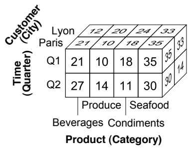
Algebra of OLAP Operations – dice



Sales2012

Q: Visualize data only for Paris or Lyon and quarters Q1or Q2

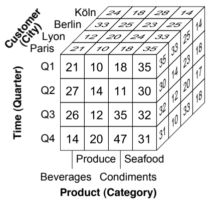


DICE(Sales2012, (Customer.City = 'Paris' OR Customer.City = 'Lyon') AND (Time.Quarter = 'Q1' OR Time.Quarter = 'Q2'))

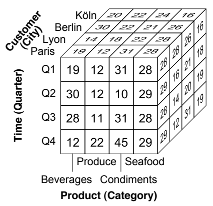
- **Dice**: keeps the cells of a cube that satisfy a Boolean condition Φ
  - **DICE(CubeName, Φ)**
- Φ is a Boolean condition over dimension levels, attributes, and measures.

Algebra of OLAP Operations – drill-across

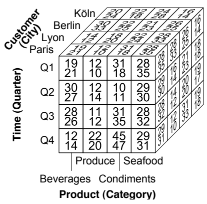
Sales2012



Sales2011



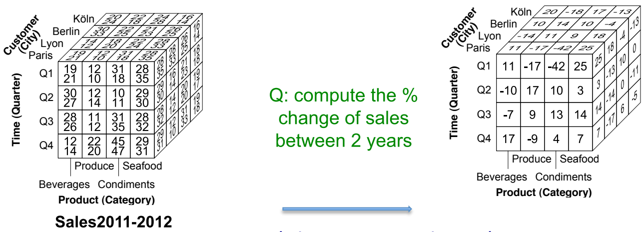
Q: Compare the sales quantities in 2012 with those in 2011



Sales2011-2012 ← DRILLACROSS(Sales2011, Sales2012)

- **Drill-across**: combines cells from two data cubes that have the same schema
  - **DRILLACROSS(CubeName1, CubeName2, [Condition])**

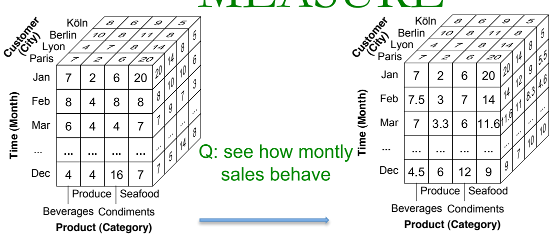
Algebra of OLAP Operations – ADD-MEASURE



ADDMEASURE(Sales2011-2012, PercChange = (Quantity2011-Quantity2012)/Quantity2011)

- **Add Measure**: adds new measures to a cube
  - **ADDMEASURE(CubeName, (NewMeasure = Expression)*)**
- **Drop measure**: Deletes a measure from a cube schema
  - **DROPMEASURE(CubeName, Measure*)**

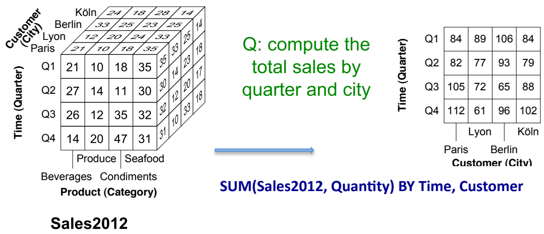
Algebra of OLAP Operations – ADD-MEASURE



ADDMEASURE(Sales2012, MovAvg = AVG(Quantity) OVER Time 2 CELLS PRECEDING)

- Another ex:
  - Computes the value of a cell by aggregating the measures of several nearby cells

Algebra of OLAP Operations – aggregate functions



- **Aggregation functions** in OLAP are also needed at the current granularity, that is without performing roll-up.
  - **AggFunction(CubeName, Measure) [BY Dimension*]**
  - Cumulative: compute the measure value of a cell from several other cells; examples are SUM, COUNT, and AVG
  - Filtering: Filters the members of a dimension that appear in the result; examples are MIN and MAX. Filtering functions compute not only the aggregated value, but also the members of the dimension that belong to the result

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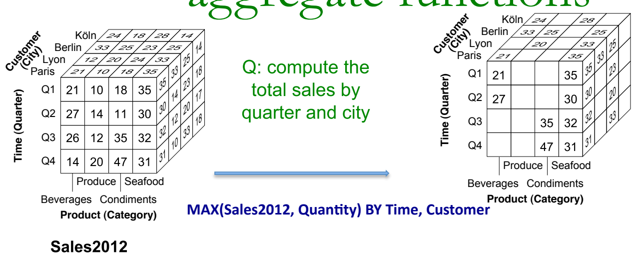
Algebra of OLAP Operations – aggregate functions



- Another example: max sales by quarter and city

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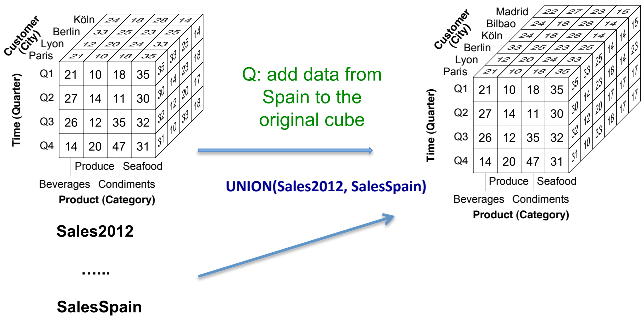
Algebra of OLAP Operations – union, difference, drill-through



- **Union** merges two cubes having the same schema but disjoint instances
- Ex: If CubeSpain is a cube having the same schema as the original cube but containing only the sales to Spanish customers, we can perform:
- **Difference** removes the cells in a cube that belong to another one; the two cubes must have the same schema
- **Drill-through** allows to move from data at the bottom level in a cube to data in the operational systems from which the cube was derived; Could be used when trying to determine the reason for outlier values in a data cube

Next Lecture

- Conceptual Data Warehouse Design