DATA ANALYTICS

Unit 1:Data Sources and Representations

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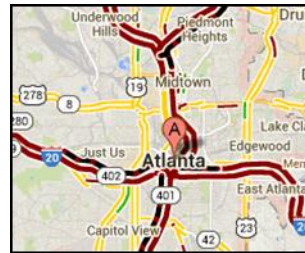
Data Sources

- There has been enormous data growth in both commercial and scientific databases due to advances in data generation and collection technologies

- New mantra
  - Gather whatever data you can whenever and wherever possible.

- Expectations
  - Gathered data will have value either for the purpose collected or for a purpose not envisioned.
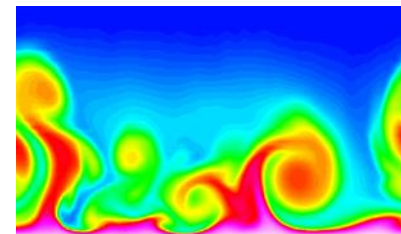

Cyber Security

E-Commerce

Traffic Patterns

Social Networking: Twitter

Sensor Networks

Computational Simulations

Data Sources

- Lots of data is being collected and warehoused
  - Web data
    - Yahoo has Peta Bytes of web data
    - Facebook has billions of active users
  - purchases at department/ grocery stores, e-commerce
    - Amazon handles millions of visits/day
  - Bank/Credit Card transactions

Data Sources

- Data collected and stored at enormous speeds
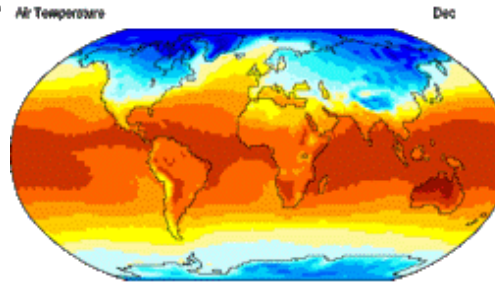 - remote sensors on a satellite
    - NASA EOSDIS archives over petabytes of earth science data / year
  - telescopes scanning the skies
    - Sky survey data
  - High-throughput biological data
  - scientific simulations
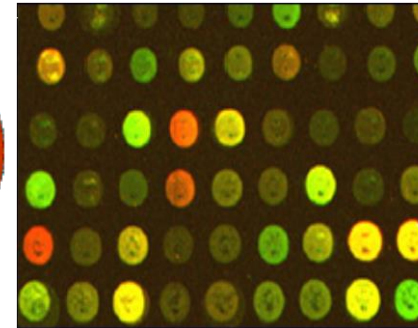   - terabytes of data generated in a few hours
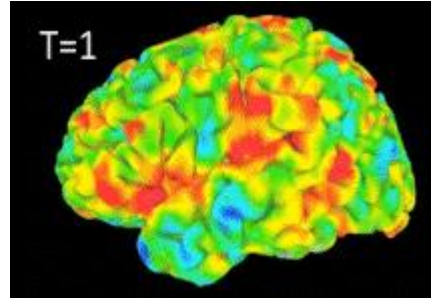
fMRI Data from Brain

Sky Survey Data

Surface Temperature of Earth

Gene Expression Data

What is Data?

- Collection of *data objects* and their *attributes*

- An *attribute* is a property or characteristic of an object
  - Examples: eye color of a person, temperature, etc.
  - Attribute is also known as variable, field, characteristic, dimension, or feature

- A collection of attributes describe an *object*
  - Object is also known as record, point, case, sample, entity, or instance

Attributes

Objects

Tid	Refund	Marital Status	Taxable Income	Cheat
1	Yes	Single	125K	No
2	No	Married	100K	No
3	No	Single	70K	No
4	Yes	Married	120K	No
5	No	Divorced	95K	Yes
6	No	Married	60K	No
7	Yes	Divorced	220K	No
8	No	Single	85K	Yes
9	No	Married	75K	No
10	No	Single	90K	Yes

A More Complete View of Data

- Data may have parts

- Attributes (objects) may have relationships with other attributes (objects)

- More generally, data may have structure

- Data can be incomplete

Attribute Values

- *Attribute values* are numbers or symbols assigned to an attribute for a particular object

- Distinction between attributes and attribute values
  - Same attribute can be mapped to different attribute values
    - Example: height can be measured in feet or meters

  - Different attributes can be mapped to the same set of values
    - Example: Attribute values for ID and age are integers
    - But properties of attribute values can be different

Types of Attributes

- There are different types of attributes
  - Nominal
    - Examples: ID numbers, eye color, zip codes
  - Ordinal
    - Examples: rankings (e.g., taste of potato chips on a scale from 1-10), grades, height {tall, medium, short}
  - Interval
    - Examples: calendar dates, temperatures in Celsius or Fahrenheit.
  - Ratio
    - Examples: temperature in Kelvin, length, counts, elapsed time (e.g., time to run a race)

Discrete and Continuous Attributes

- Discrete Attribute
  - Has only a finite or countably infinite set of values
  - Examples: zip codes, counts, or the set of words in a collection of documents
  - Often represented as integer variables.
  - Note: binary attributes are a special case of discrete attributes

- Continuous Attribute
  - Has real numbers as attribute values
  - Examples: temperature, height, or weight.
  - Practically, real values can only be measured and represented using a finite number of digits.
  - Continuous attributes are typically represented as floating-point variables.

Data Representations

- Structured
- Unstructured
- Semi structured

- Structured data means that the data is described in a matrix form with labelled rows and columns.

STRUCTURED DATA

- Any data that is not originally in the matrix form with rows and columns is an unstructured data.

Unstructured Data

What you find in the 'wild' (text, images, audio, video)

Data Representations
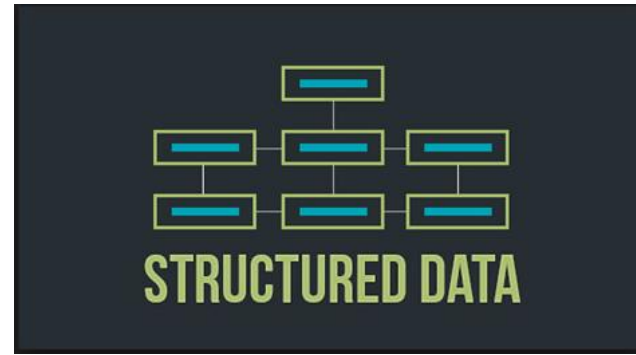
- relational databases and spreadsheets.

- text and multimedia content. photos and graphic images, videos, streaming instrument data, webpages, PDF files, PowerPoint presentations, emails, blog entries, wikis and word processing documents.

- XML documents and NoSQL databases.

- For example, word processing software now can include metadata showing the author's name and the date created, with the bulk of the document just being unstructured text.

Data Representations

- Record
    - Relational records
    - Data matrix, e.g., numerical matrix, crosstabs
    - Document data: text documents: term-frequency vector
    - Transaction data
- Graph and network
    - World Wide Web
    - Social or information networks
    - Molecular Structures

Data Representations

- Ordered
    - Video data: sequence of images
    - Temporal data: time-series
    - Sequential Data: transaction sequences
    - Genetic sequence data
- Spatial, image and multimedia:
    - Spatial data: maps
    - Image data:
    - Video data:

Data Representations-Record Data

- Data that consists of a collection of records, each of which consists of a fixed set of attributes

Tid	Refund	Marital Status	Taxable Income	Cheat
1	Yes	Single	125K	No
2	No	Married	100K	No
3	No	Single	70K	No
4	Yes	Married	120K	No
5	No	Divorced	95K	Yes
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9	No	Married	75K	No
10	No	Single	90K	Yes

Data Representations-Data Matrix

- If data objects have the same fixed set of numeric attributes, then the data objects can be thought of as points in a multi-dimensional space, where each dimension represents a distinct attribute

- Such data set can be represented by an m by n matrix, where there are m rows, one for each object, and n columns, one for each attribute

Projection of x Load	Projection of y load	Distance	Load	Thickness
10.23	5.27	15.22	2.7	1.2
12.65	6.25	16.22	2.2	1.1

Data Representations-Document Data

- Each document becomes a `term' vector,
  - each term is a component (attribute) of the vector,
  - the value of each component is the number of times the corresponding term occurs in the document.

	team	coach	play	ball	score	game	win	lost	timeout	season
Document 1	3	0	5	0	2	6	0	2	0	2
Document 2	0	7	0	2	1	0	0	3	0	0
Document 3	0	1	0	0	1	2	2	0	3	0

Data Representations-Transaction data

- A special type of record data, where

  - each record (transaction) involves a set of items.

  - For example, consider a grocery store. The set of products purchased by a customer during one shopping trip constitute a transaction, while the individual products that were purchased are the items.

TID	Items
1	Bread, Coke, Milk
2	Beer, Bread
3	Beer, Coke, Diaper, Milk
4	Beer, Bread, Diaper, Milk
5	Coke, Diaper, Milk

Data Representations

- **Graph Data**

- Examples: Generic graph and HTML Links
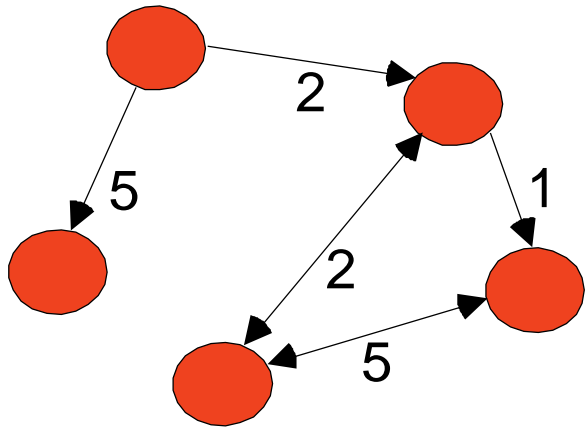

```
<a href="papers/papers.html#bbbb">
Data Mining </a>
<li>
<a href="papers/papers.html#aaaa">
Graph Partitioning </a>
<li>
<a href="papers/papers.html#aaaa">
Parallel Solution of Sparse Linear System of Equations </a>
<li>
<a href="papers/papers.html#ffff">
N-Body Computation and Dense Linear System Solvers
```
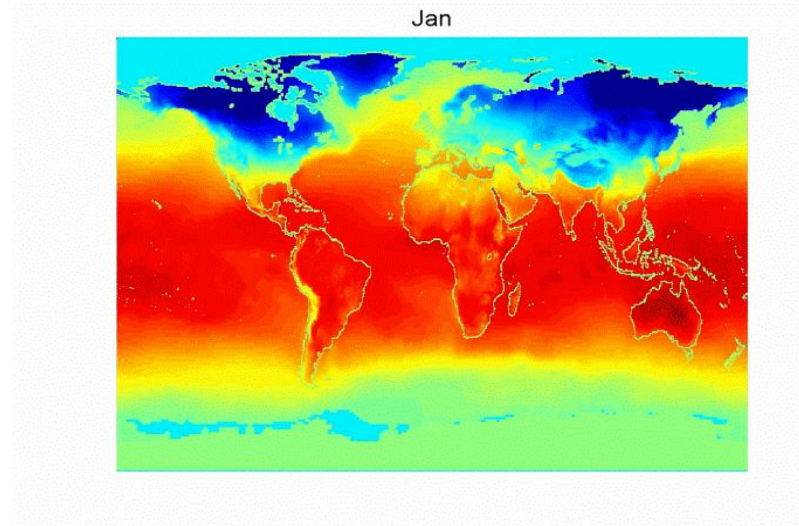
- **Chemical Data**

- Benzene Molecule: C_6H_6

Data Representations-Ordered Data
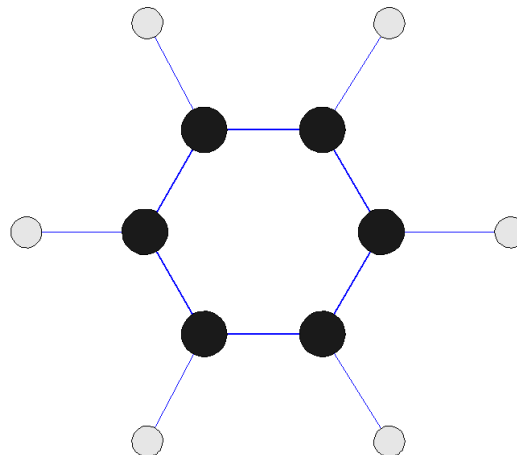
- Sequences of transactions

Items/Events

(A B)   (D) (C E)
(B D)   (C) (E)
(C D)   (B) (A E)

An element of the sequence

- Spatio-Temporal Data
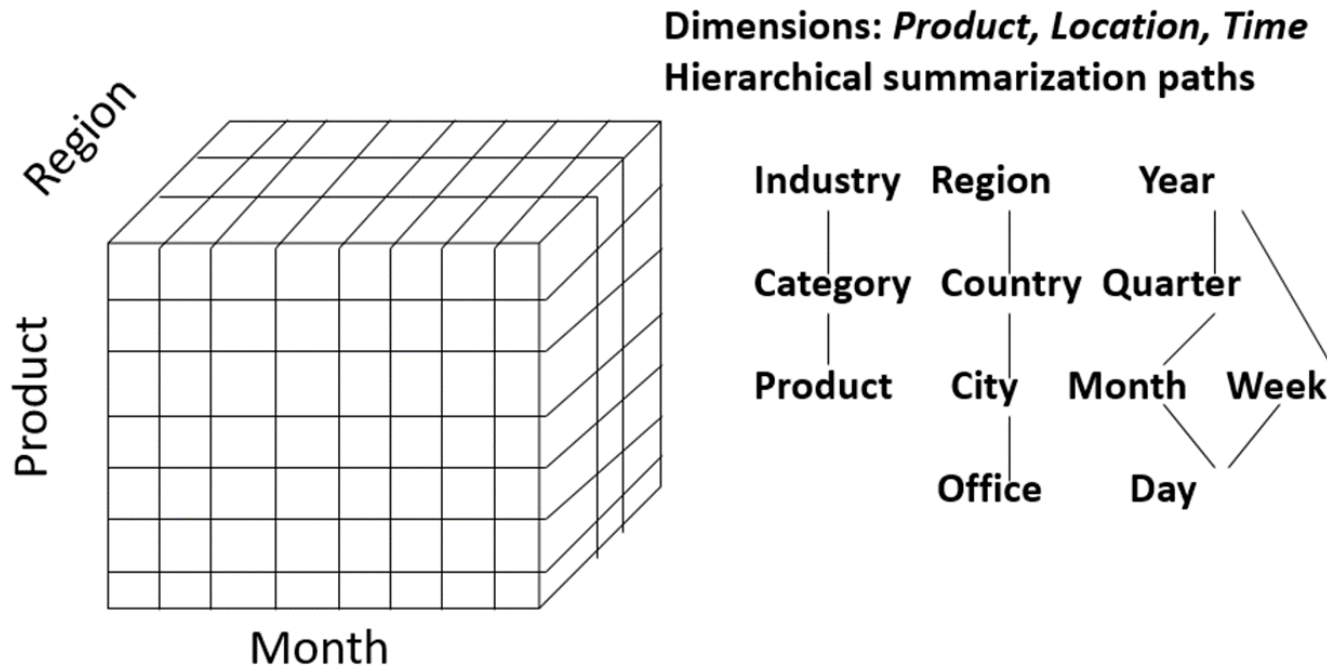

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- Genomic sequence data

```
GGTTCCGCCTTCAGCCCCGCGCC
CGCAGGGCCCGCCCCGCGCCGTC
GAGAAGGGCCCGCCTGGCGGGCG
GGGGGAGGCGGGGCCGCCCGAGC
CCAACCGAGTCCGACCAGGTGCC
CCCTCTGCTCGGCCTAGACCTGA
GCTCATTAGGCGGCAGCGGACAG
GCCAAGTAGAACACGCGAAGCGC
TGGGCTGCCTGCTGCGACCAGGG
```
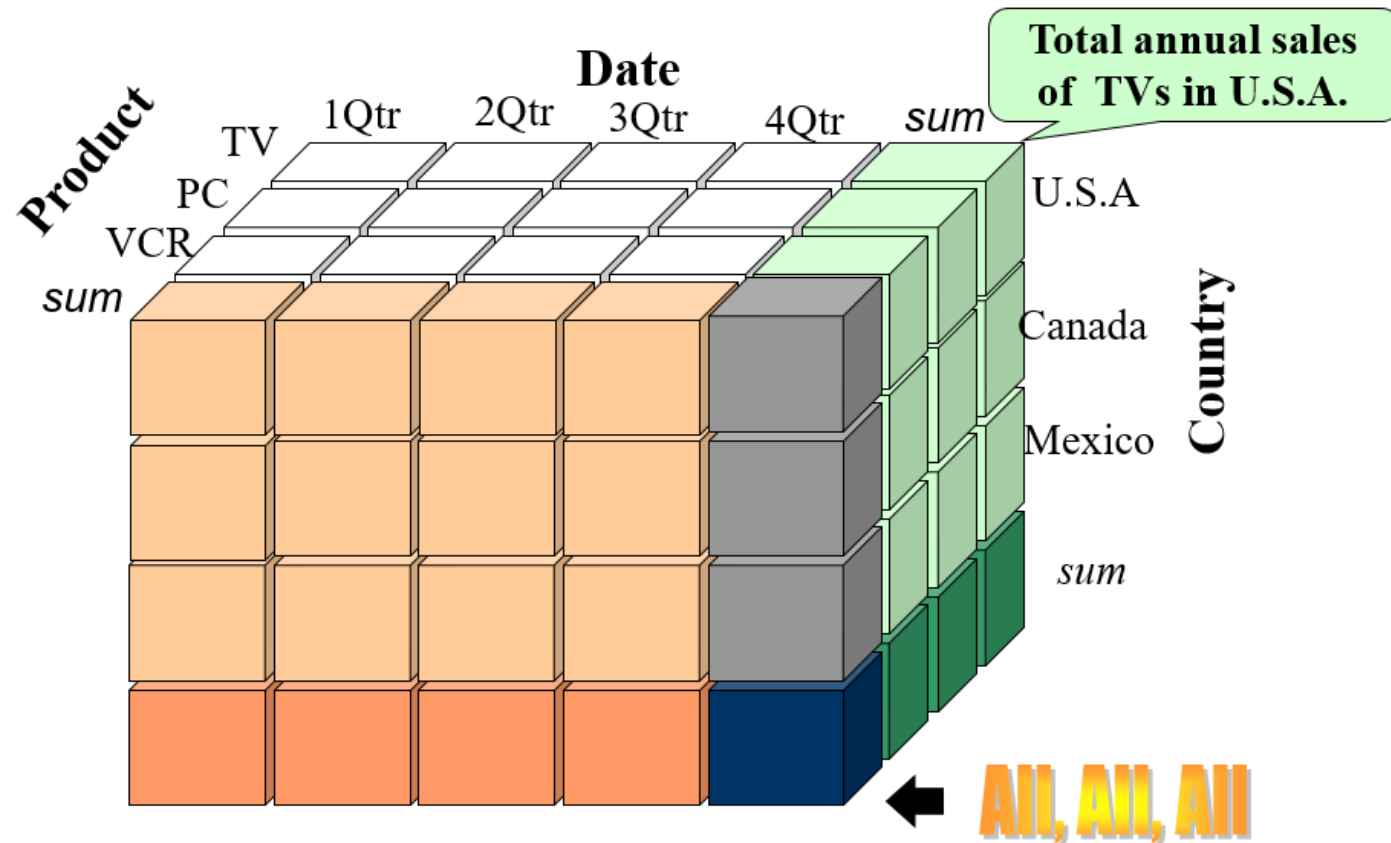
Data Representations- Data Warehouse

"A data warehouse is a subject-oriented, integrated, time-variant, and nonvolatile collection of data in support of management's decision-making process."—W. H. Inmon

Sales volume as a function of product, month, and region

Dimensions: *Product, Location, Time*
Hierarchical summarization paths

Industry	Region	Year	
Category	Country	Quarter	
Product	City	Month	Week
	Office	Day	

Data Representations

A Sample Data Cube

Typical OLAP Operations

- Roll up (drill-up): summarize data
  - by climbing up hierarchy or by dimension reduction
- Drill down (roll down): reverse of roll-up
  - from higher level summary to lower level summary or detailed data, or introducing new dimensions
- Slice and dice: project and select
- Pivot (rotate):
  - reorient the cube, visualization, 3D to series of 2D planes
- Other operations
  - drill across: involving (across) more than one fact table
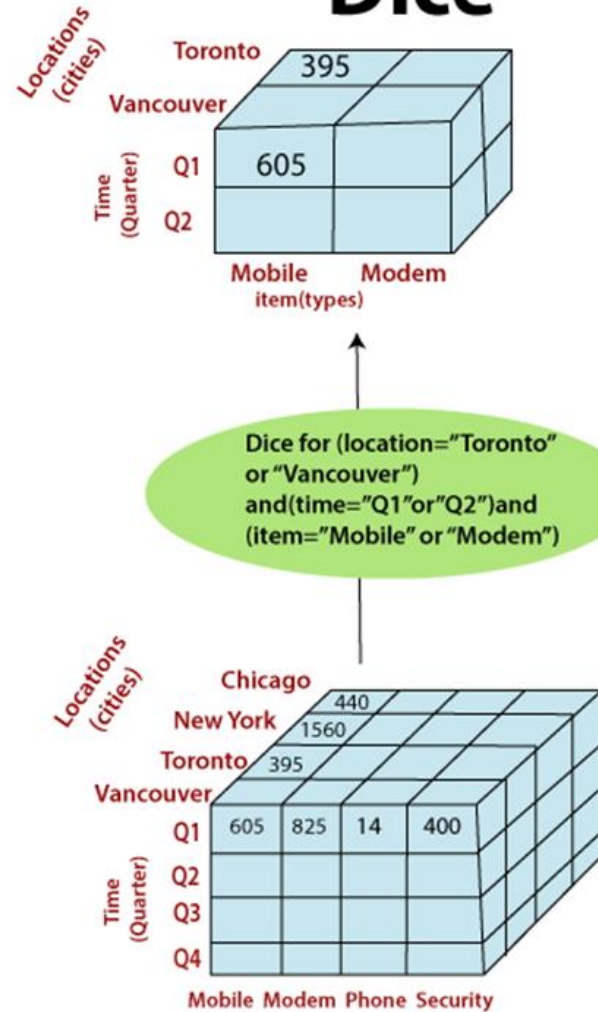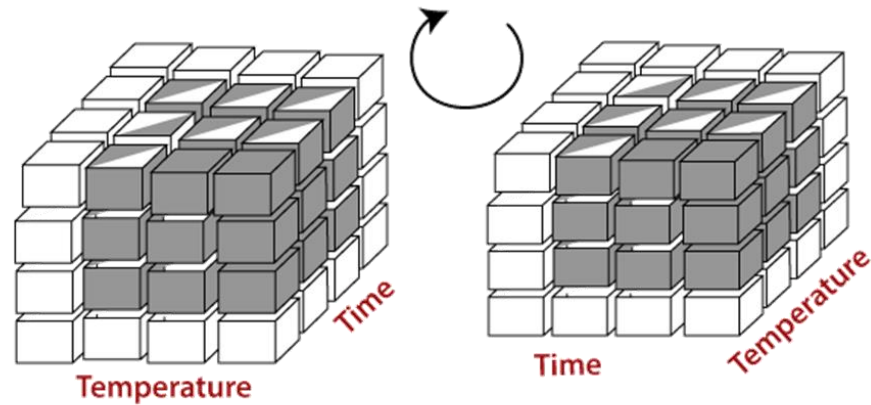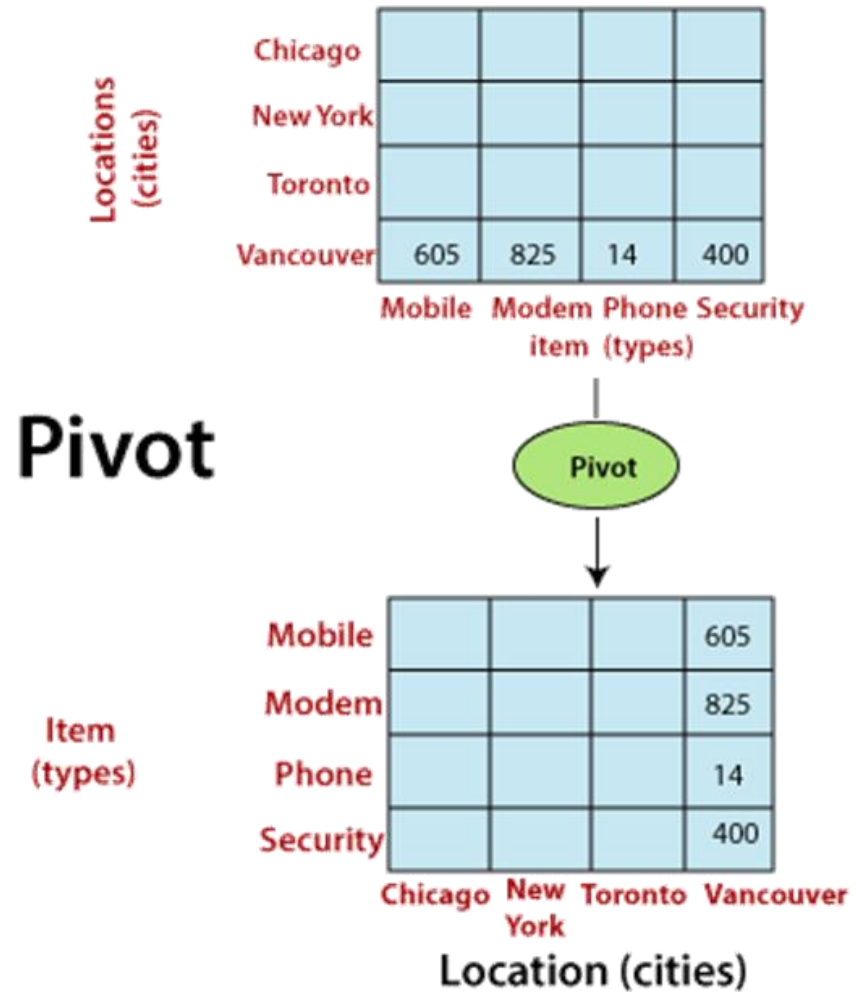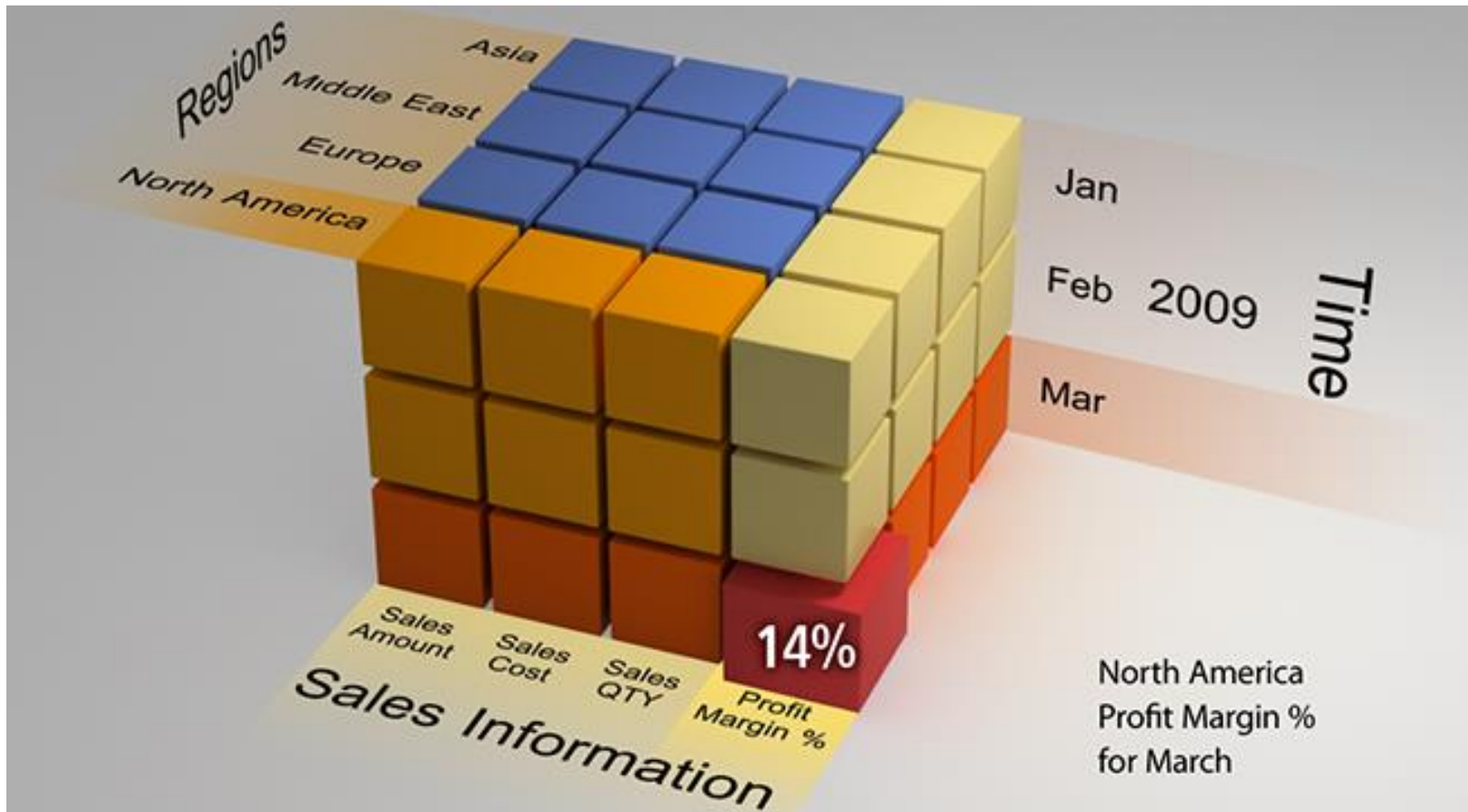 - drill through: through the bottom level of the cube to its back-end relational tables (using SQL)

Typical OLAP Operations

Typical OLAP Operations

Typical OLAP Operations
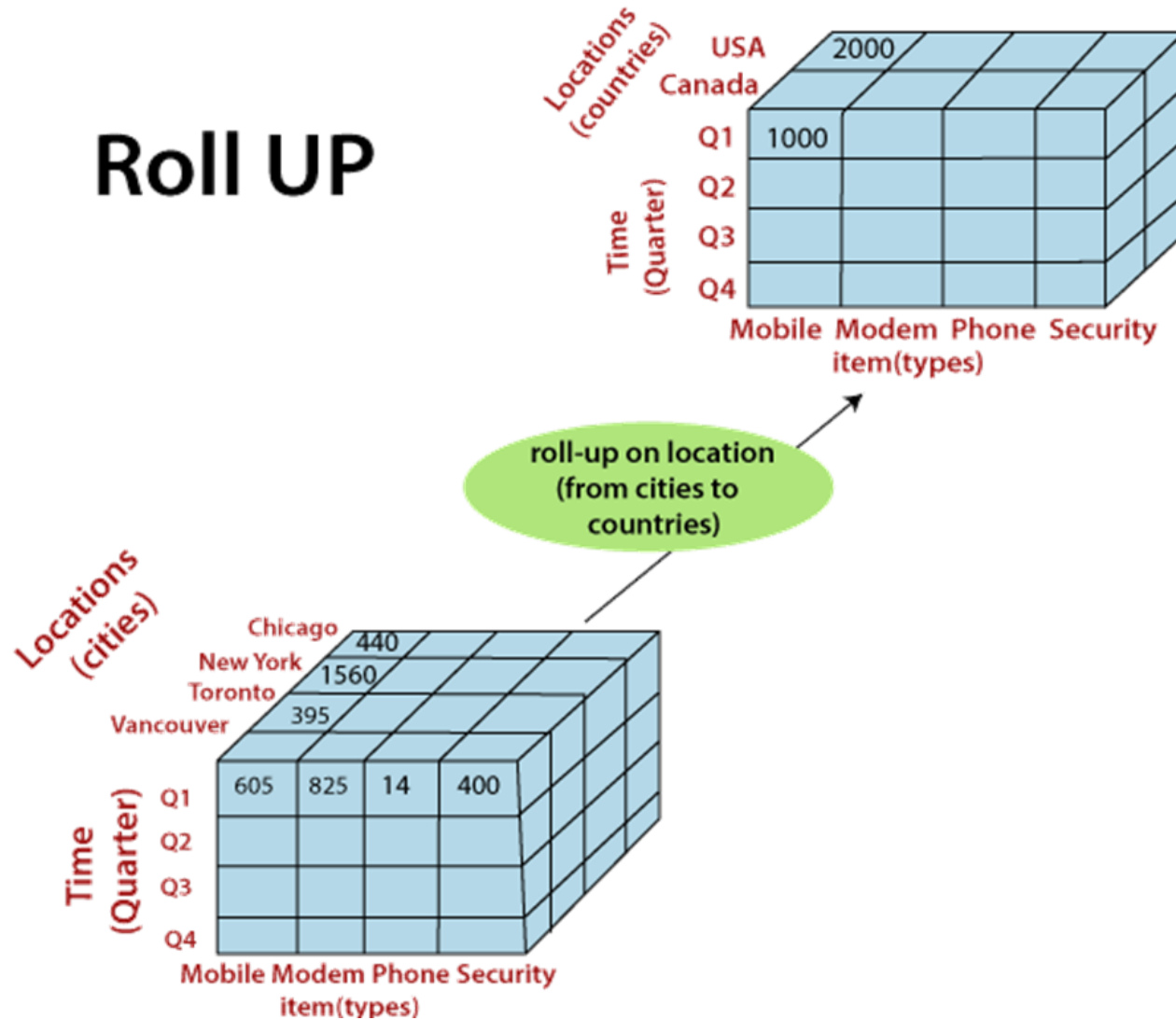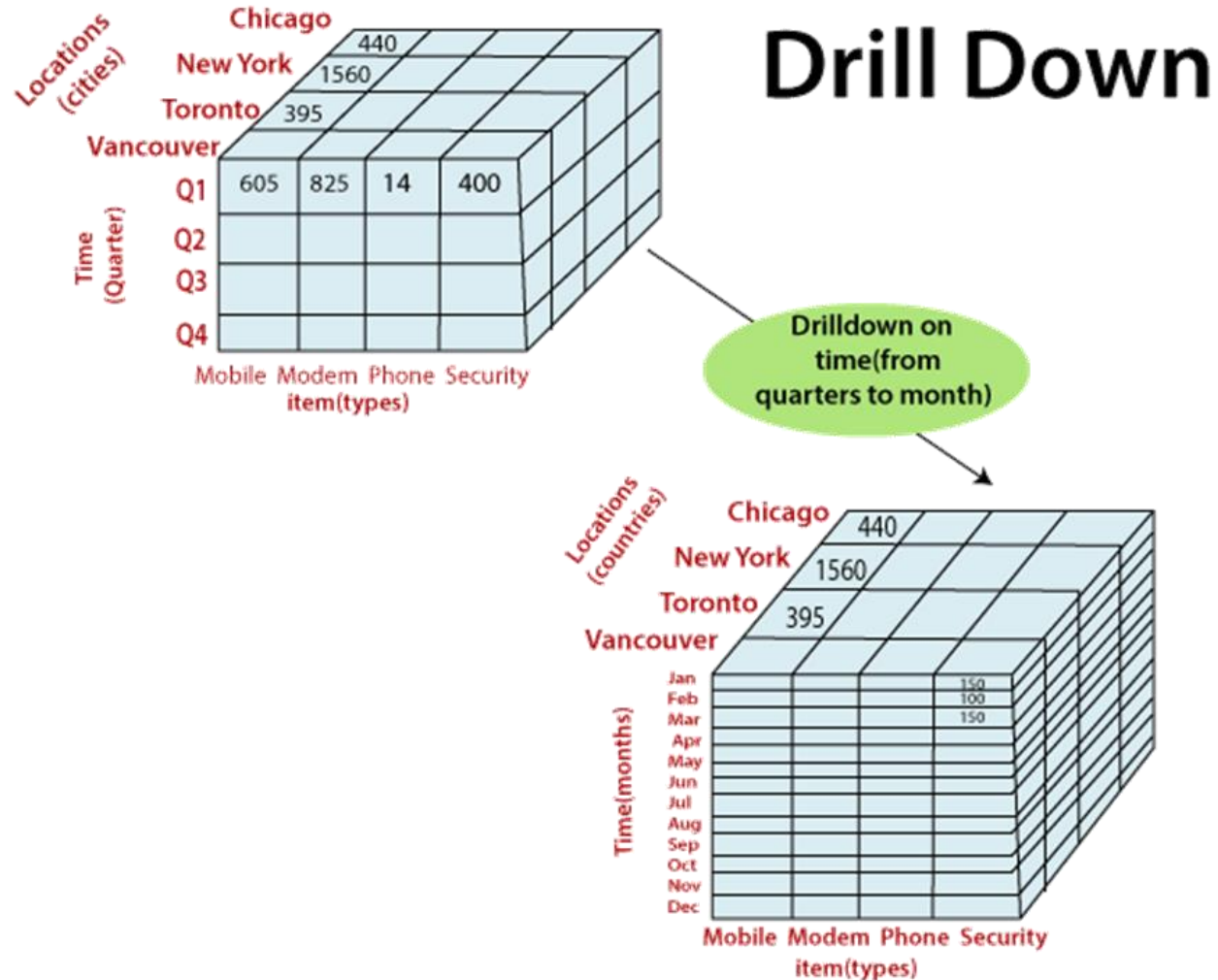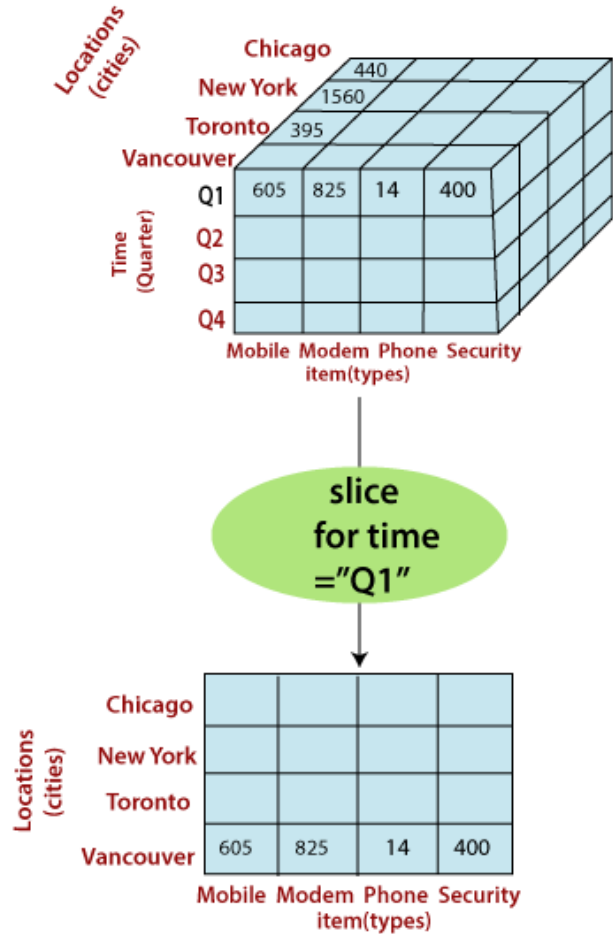
Typical OLAP Operations

OLAP Processing

www.busitelce.com%2Fdata-warehousing%2F5-bi-dw-fundamentals-what-is-olap-online-analytical-processing

Assignment

- Identify an application for each of the data representation you have learnt

- Download a dataset from Kaggle and identify the different types of attributes

References

Text Book:

- Data Mining: Concepts and Techniques by Jiawei Han, Micheline Kamber and Jian Pei, The Morgan Kaufmann Series in Data Management Systems, 3rd Edition.

- Introduction to Data Mining , Tan, Steinbach, Kumar, 2nd Edition

THANK YOU

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