CS213
Principles of Database Systems(H)

Chapter 14

Shiqi YU 于仕琪

yusq@sustech.edu.cn

Most contents are from Yuxuan Ma's slides

History of databases

Pre-computer technologies:

Printing press
Dewey decimal system
Punched cards

1940-50

1950-60
- Magnetic tape
- "flat" (sequential) files
- Magnetic Disk

1960-70
- Indexed-Sequential Access Mechanism (ISAM)
- Hierarchical model
- Network Model
- IMS
- Relational Model defined

1970-80
- IDMS
- ADABAS
- System R
- Oracle V2

1980-90
- dBase
- DB2
- Ingres
- Informix
- Sybase
- SQL Server

1990-2000
- Access
- Postgres
- MySQL

2000-2010
- Hadoop
- Vertica
- Cassandra
- Riak
- Hana
- Aerospike
- HBase
- Dynamo
- MongoDB
- Redis
- VoltDB
- Neo4J

From Guy Harrison's slides

Beyond Storage: Data Analytics

What is Data (Revisited)

data noun, plural in form but singular or plural in construction, often attributive

Save Word

da·ta | \ ˈdā-tə, ˈda- *also* ˈdä- \

Definition of *data*

1 : factual information (such as measurements or statistics) used as a basis for reasoning, discussion, or calculation

// the *data* is plentiful and easily available

— H. A. Gleason, Jr.

// comprehensive *data* on economic growth have been published

— N. H. Jacoby

2 : information in digital form that can be transmitted or processed

3 : information output by a sensing device or organ that includes both useful and irrelevant or redundant information and must be processed to be meaningful

factual information (such as measurements or statistics) used as a basis for reasoning, discussion, or calculation

https://www.merriam-webster.com/dictionary/data

Basic Statistical Descriptions

Overall picture of your data

Basis of exploratory data analysis

- Mean $$\bar{x} = \frac{\sum_{i=1}^{N} x_i}{N} = \frac{x_1 + x_2 + \cdots + x_N}{N}.$$

- Median $$\mathrm{Q}_{\frac{1}{2}}(x) = \begin{cases} x'_{\frac{n+1}{2}}, & \text{if } n \text{ is odd.} \\ \frac{1}{2}(x'_{\frac{n}{2}} + x'_{\frac{n}{2}+1}), & \text{if } n \text{ is even.} \end{cases}$$

- Variance $$\sigma^2 = \frac{1}{N}\sum_{i=1}^{N}(x_i - \bar{x})^2 = \left(\frac{1}{N}\sum_{i=1}^{N} x_i^2\right) - \bar{x}^2,$$

Relationship between Data Objects: Data (Dis)Similarity

Measurement of relationships

- Commonly used in many statistical methods and data mining algorithms

Dissimilarity Matrix & Distance Measures

$$\begin{bmatrix} 0 & & & & \\ d(2,1) & 0 & & & \\ d(3,1) & d(3,2) & 0 & & \\ \vdots & \vdots & \vdots & & \\ d(n,1) & d(n,2) & \cdots & \cdots & 0 \end{bmatrix}$$

Euclidean	$d(x,y) = \sqrt{\sum (x_i - y_i)^2}$
Squared Euclidean	$d(x,y) = \sum (x_i - y_i)^2$
Manhattan	$d(x,y) = \sum \lvert (x_i - y_i) \rvert$
Canberra	$d(x,y) = \sum \frac{\lvert x_i - y_i \rvert}{\lvert x_i + y_i \rvert}$
Chebychev	$d(x,y) = \max(\lvert x_i - y_i \rvert)$
Bray Curtis	$d(x,y) = \frac{\sum \lvert x_i - y_i \rvert}{\sum x_i + y_i}$
Cosine Correlation	$d(x,y) = \frac{\sum (x_i y_i)}{\sqrt{\sum (x_i)^2 \sum (y_i)^2}}$
Pearson Correlation	$d(x,y) = \frac{\sum (x_i - \bar{x})(y_i - \bar{y})}{\sqrt{\sum (y_i - \bar{y})^2} \sqrt{\sum (y_i - \bar{y})^2}}$
Uncentered Peason Correlation	$d(x,y) = \frac{\sum x_i y_i}{\sqrt{\sum (y_i - \bar{y})^2} \sqrt{\sum (y_i - \bar{y})^2}}$
Euclidean Nullweighted	Same as Euclidean, but only the indexes where both x and y have a value (not NULL) are used, and the result is weighted by the number of values calculated. Nulls must be replaced by the missing value calculator (in dataloader).

What is Big Data?

A collection of data sets so large and complex

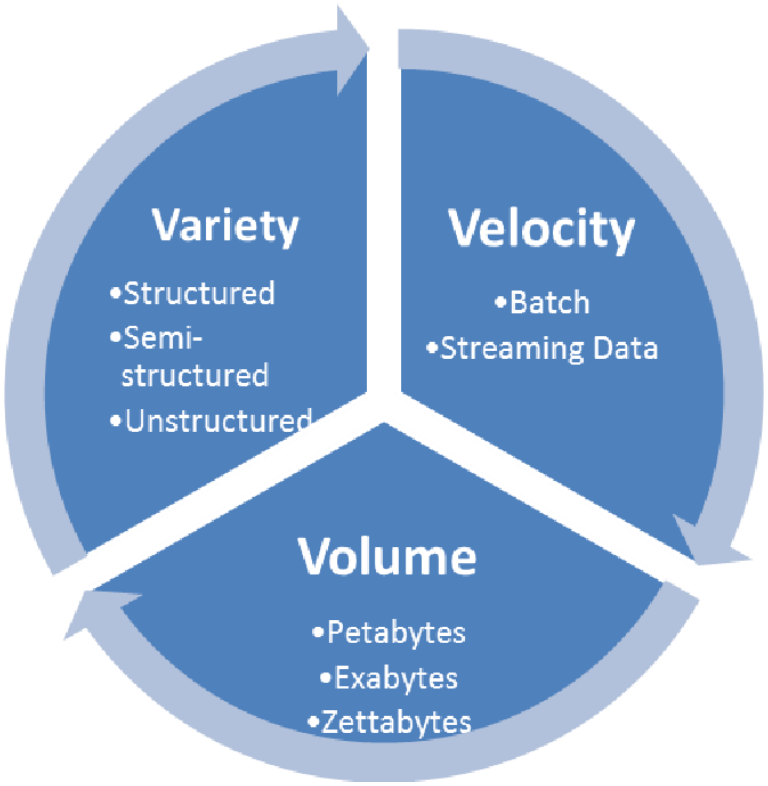
Three Dimensions of Big Data

Volume
- From GB to TB, PB, or higher

Velocity
- Processing speed

Variety
- Text, sensor data, multimedia, …

Other (new) aspects:
- Veracity: Trustworthiness
- Value: Worth of data



World is changing faster and faster

George Chernilevsky

2005

2020
GLOBAL CITIZEN
ONE WORLD
TOGETHER AT HOME
GLOBAL CITIZEN
World Health Organization

2013
NBC NEWS
Michael Sohn / AP

2023

The Emergence of Data Science

2016: “Trump vs. Clinton: How Big Data and scientists helped Trump win the election”

Digital campaigning

The role of technology in the presidential election

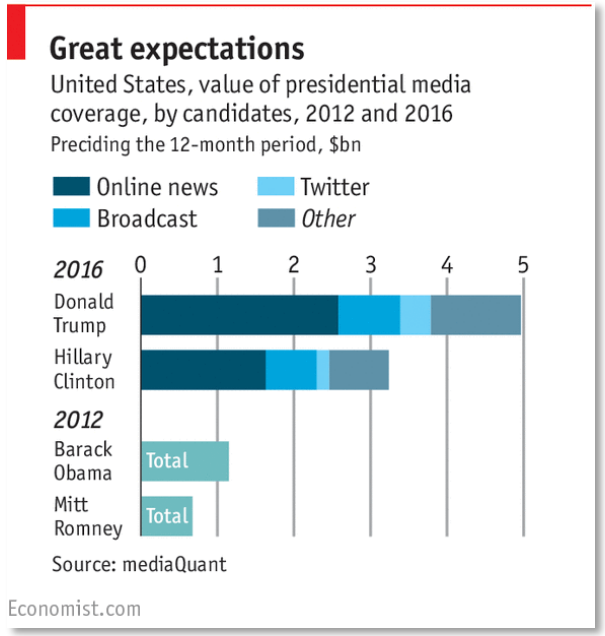
All latest updates

From fake news to big data, a post mortem is under way

Nov 20th 2016 | United States

Timekeeper Like 916 Tweet

EARLY in America’s presidential campaign, pundits compared the contest between Hillary Clinton and Donald Trump to a fight between a large tanker and Somali pirates. This turned out to be particularly true of the digital campaigns: a massive data battleship lost to a chaotic flotilla of social-media speedboats. The big question now is what this means for future elections, both in America and abroad.



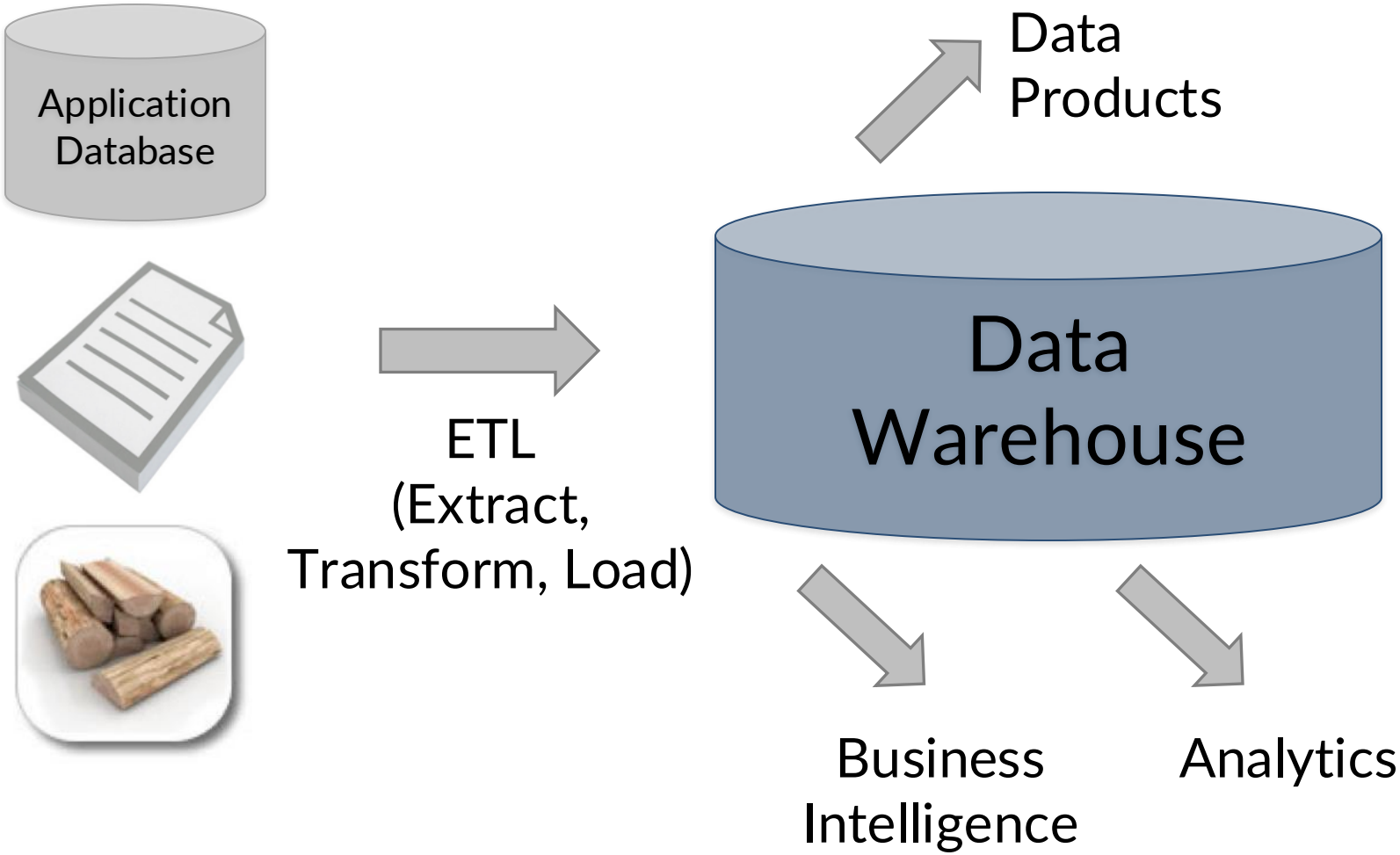
Data source

Data provided by web sites.

Data generated by users

- Web logs
- Page view data
- Mobile apps, which is clicked, how long, etc.
- Data from sensors (IoT, shared bikes).
- User upload, posts, comments, like/dislike, video streaming, etc.

Standard Architecture



Instantiations(1) - Businesspersons

Data Sources
- Web pages
- Excel

Extract-Transform-Load (ETL)
- Copy & paste

Data Warehouse
- Excel

- BI and Analytics
  - Excel functions
  - Excel charts
  - VB scripts?
  - Visualization tools: Power BI, Tableau

Instantiations(2) - Programmers

Data Sources

- Web scraping, web services API
- CSV files
- Database queries

ETL

- wget, curl, Beautiful Soup, lxml, ...

- Data Warehouse
  - Files
- Analytics
  - Numpy, pandas, Matplotlib, R, Octave, ...

Instantiations(3) - Enterprises

Data Sources

- Application databases(Oracle, IBM, ...)
- Intranet files
- Application log files

ETL

- Infomatica, IBM DataStage, ...

- Data Warehouse
  - Teradata, Oracle, IBM DB2, ...
- Business Intelligence & Analytics
  - SAS, SPSS, R, ...
  - Power BI, Tableau, Spotfire, ...

Instantiations(4) – Web Companies

Data Sources

- Application databases
- Logs
- Web crawl data

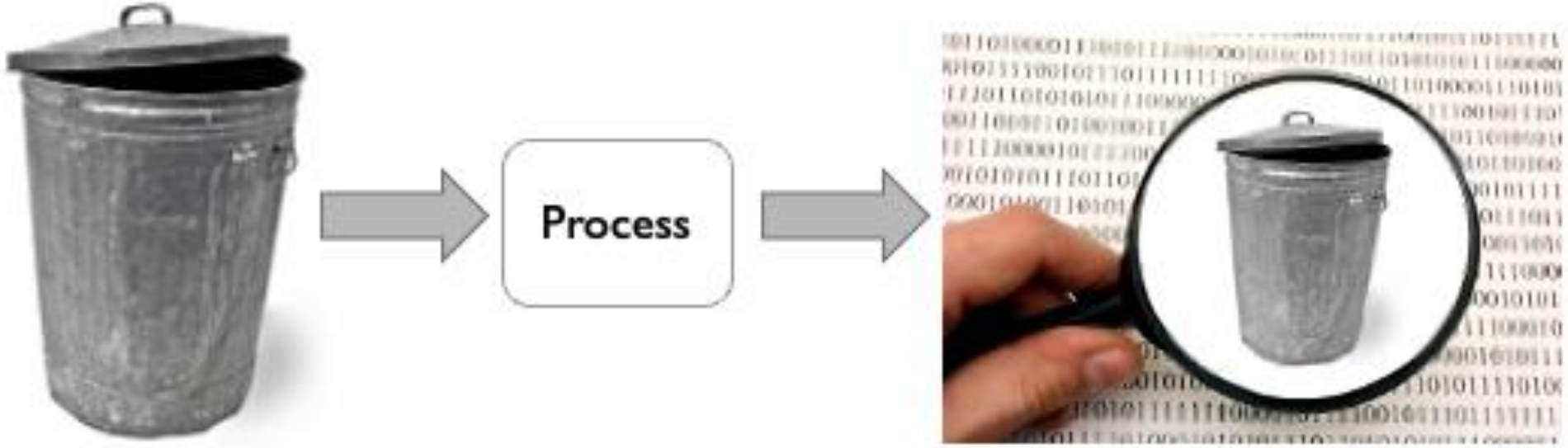
ETL

- Apache Flume, Apache Sqoop, …

- Data Warehouse
  - Hadoop-based: Hive, Hbase
  - Microsoft Azure, Amazon Redshift
- Business Intelligence & Analytics
  - Argus, R, …

“Garbage in, garbage out.”

Raw data can always be **DIRTY**!



Data Quality

Data quality: data has quality if it satisfies the requirements of its intended use

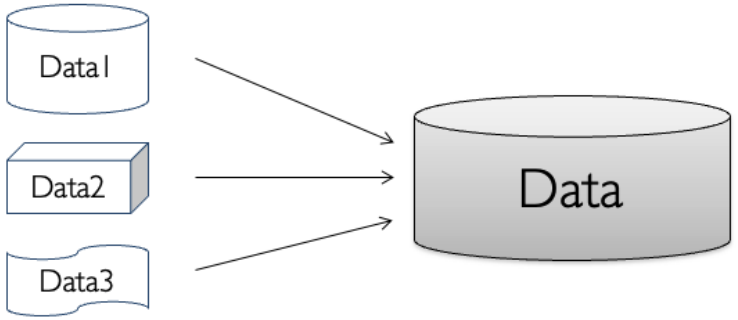
- Accuracy
- Completeness
- Consistency
- Timeliness
- Believability
- Interpretability

Data Integration

Data integration involves combining data residing in different sources and providing users with a unified view of these data.

- Remember "views" in DBMS?

Management of data from m



Customer (source 1)

CID	*Name*	*Street*	*City*	*Sex*
11	Kristen Smith	2 Hurley Pl	South Fork, MN 48503	0
24	Christian Smith	Hurley St 2	S Fork MN	1

Client (source 2)

Cno	*LastName*	*FirstName*	*Gender*	*Address*	*Phone/Fax*
24	Smith	Christoph	M	23 Harley St, Chicago IL, 60633-2394	333-222-6542 / 333-222-6599
493	Smith	Kris L.	F	2 Hurley Place, South Fork MN, 48503-5998	444-555-6666

Customers (integrated target with cleaned data)

No	*LName*	*FName*	*Gender*	*Street*	*City*	*State*	*ZIP*	*Phone*	*Fax*	*CID*	*Cno*
1	Smith	Kristen L.	F	2 Hurley Place	South Fork	MN	48503-5998	444-555-6666		11	493
2	Smith	Christian	M	2 Hurley Place	South Fork	MN	48503-5998			24	
3	Smith	Christoph	M	23 Harley Street	Chicago	IL	60633-2394	333-222-6542	333-222-6599		24

Typical Data Cleaning and Integration Workflow

Data analysis

- Detailed inspection before operations

Conflicts resolution

- Resolve data confliction between data sources to be integrated

Definition of transformation workflow and mapping rules

- Workflow methods for schema adaption and transformation

Verification of Workflow

- Verify each steps

Transformation

- start the process

Load and Store Data

File-based Storage

- Simplest way & easy to manage
- Scalability is low

Database & DBMS

- What we have learned for 10+ weeks

Data Warehouse

Data Warehouse

A data warehouse is a **subject-oriented**, **integrated**, **time-varient**, and **nonvolatile** collection of data in support of management's decision making process.

-- W. H. Inmon, "Building the Data Warehouse". 1996.

Loosely Speaking, a data warehouse refers to a data repository that is **maintained separately** from an organization's operational databases.

-- J. Han and M. Kamber, "Data Mining: Concepts and Techniques", 3rd ed., 2011.

Differences between Databases and Data Warehouses

	DB	DW
Characteristics	operational processing	informational processing
Orientation	transaction	analysis
User	terminal users: clerk, database administrator(DBA)	knowledge workers: manager, analyst, executive
Function	everyday operations	long-term informational requirements decision support
Data	current, up-to-date	historic, accuracy maintained over time
Access	read/write	mostly read
Focus	data in	information/knowledge out
Size	GB to high-order GB	>=TB

Data Analysis

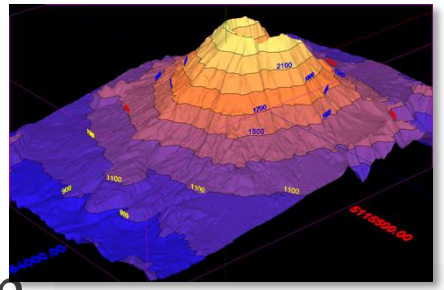
Exploratory Data Analysis

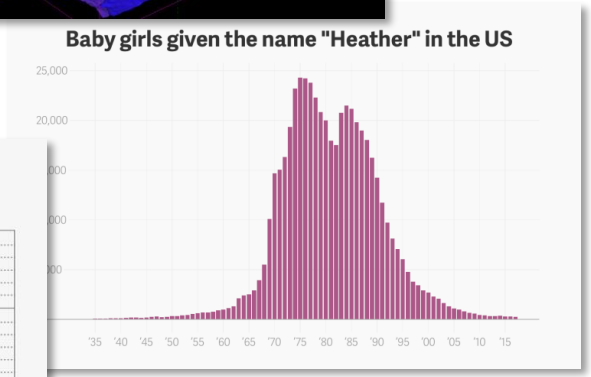
Data Mining

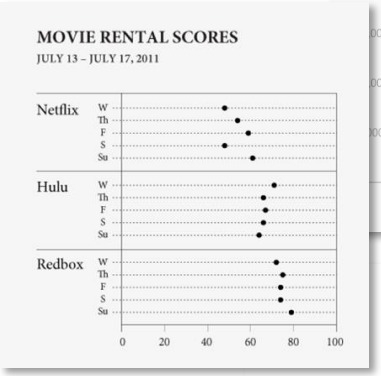
Exploratory Data Analysis (EDA)

Based on statistics

- Data visualization-driven method
- Summary of main characteristics in easy-to-understand form

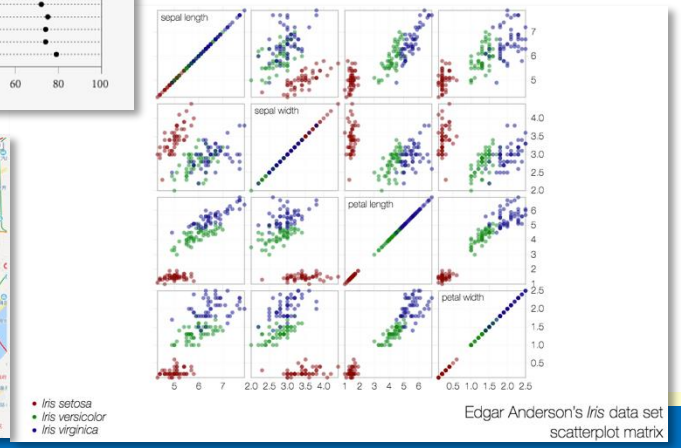






Types of data visualization methods in EDA:

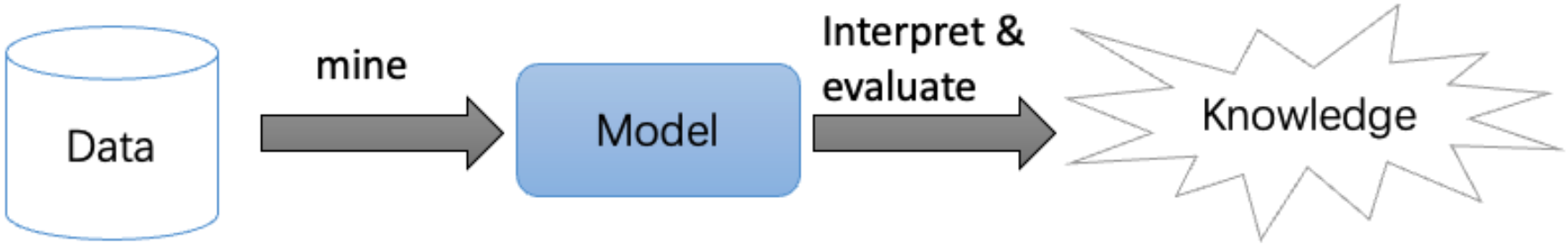
- Plotting of raw data
- Plotting of statistical values
- Multiple coordinated views (Dashboard)



Data Mining

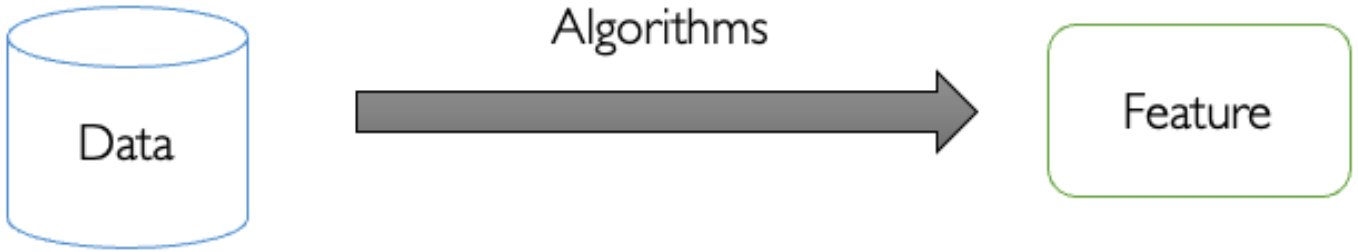
"Data Mining, also popularly referred to as knowledge discovery from data (KDD), is the automated or convenient extraction of patterns representing knowledge implicitly stored or captured in large databases, data warehouses, the Web, other massive repositories, or data streams."

-- H. Jiawei and M. Kamber, "Data Mining: Concepts and Techniques", 3rd ed., 2011.

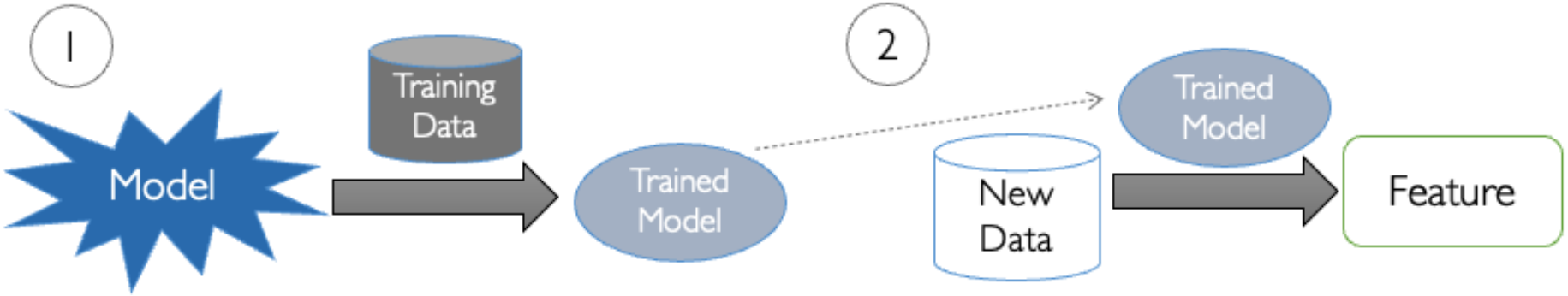


Tasks in Data Mining

Descriptive Tasks



Predictive Tasks



Descriptive Tasks

Concept Description

- Describe features of data directly

Association Analysis

- Analyze “feature-value” pairs that occur frequently in data

Clustering

- Group data on the principle of maximizing the intra-class similarity and minimizing the inter-class similarity

Outlier Detection

- Analyze objects that do not comply with the general behavior or model of the data

Predictive Tasks

Regression

- Model the relationship between a scalar response and a number of variables

Classification

- Find a model/function that describes and distinguish data classes or concepts based on analysis of a set of training data

Evolution Analysis

- Analyze temporal and spatial patterns in dataset, model these patterns and predict data in unknown spatio-temporal positions

Data Visualization

- Visualization is the creation and study of the visual representation of data

Input: data

Output: visual form

Goal: insight

城市交通可视化控制平台
客运流量统计
同比
本月当前车流量
2,230 辆
本月当前人流量
2,230 人
上月累计车流量
2,230 辆
上月累计人流量
2,230 人
准备发车：
9 辆
驾驶中车辆：
33 辆
危险驾驶行为多维分析
单位：万
运营公司1号
运营公司2号
1月
2月
3月
4月
5月
6月
7月
优秀驾驶员安全评分分析
运营公司1号
33.33%
运营公司2号
33.33%
电车4路
车辆编号：粤A11111
发车时间：17:36:00
当前站点：叮叮叮叮叮站
武汉交通员工宿舍-北
126户
武汉交通员工宿舍-南
126户
客流预测和运力配置分析
日
月
年
单位：万
车辆配置
预测客流
线路ETA预计到达时间预测分析
地图视图
区域视图
街道视图

3D可视化智慧仓储中心基地
基地总览 Overview
60
运输次数
918.8
160
代运车辆
2
基地预警
基地消防情况 Fire monitoring
91
91
基地运输车辆 Parking lot
库存容量用量 Enery consumption
库存容量用量统计 Enery consumption
10-1
10-2
10-3
10-4
10-5
10-6
10-7
园区环境监测 Environmental monitoring

Why Do We Need Visualization?

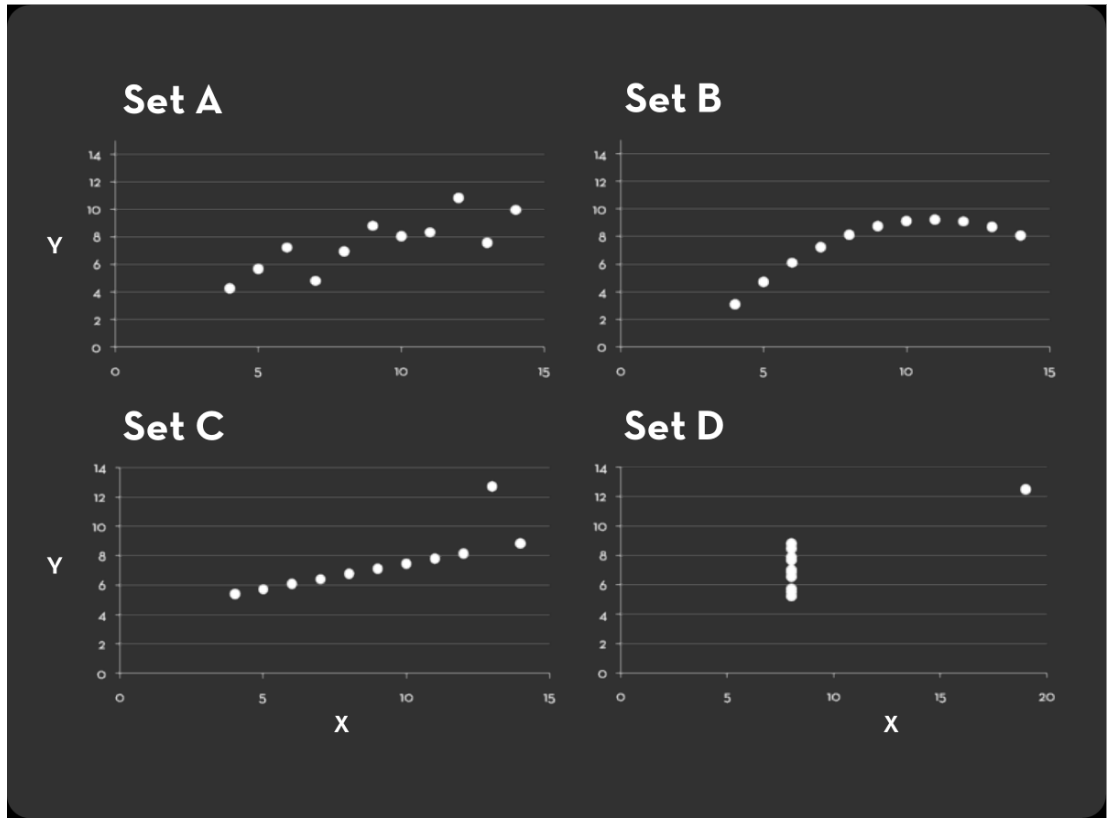
Sometimes, statistics may not work

Set A		Set B		Set C		Set D	
X	Y	X	Y	X	Y	X	Y
10	8.04	10	9.14	10	7.46	8	6.58
8	6.95	8	8.14	8	6.77	8	5.76
13	7.58	13	8.74	13	12.74	8	7.71
9	8.81	9	8.77	9	7.11	8	8.84
11	8.33	11	9.26	11	7.81	8	8.47
14	9.96	14	8.1	14	8.84	8	7.04
6	7.24	6	6.13	6	6.08	8	5.25
4	4.26	4	3.1	4	5.39	19	12.5
12	10.84	12	9.11	12	8.15	8	5.56
7	4.82	7	7.26	7	6.42	8	7.91
5	5.68	5	4.74	5	5.73	8	6.89

Summary Statistics
$u_X = 9.0$ $\sigma_X = 3.317$
$u_Y = 7.5$ $\sigma_Y = 2.03$

Linear Regression
$Y = 3 + 0.5\,X$
$R^2 = 0.67$

[Anscombe 73]



A Guide to NoSQL Databases

Traversy Media@YouTube

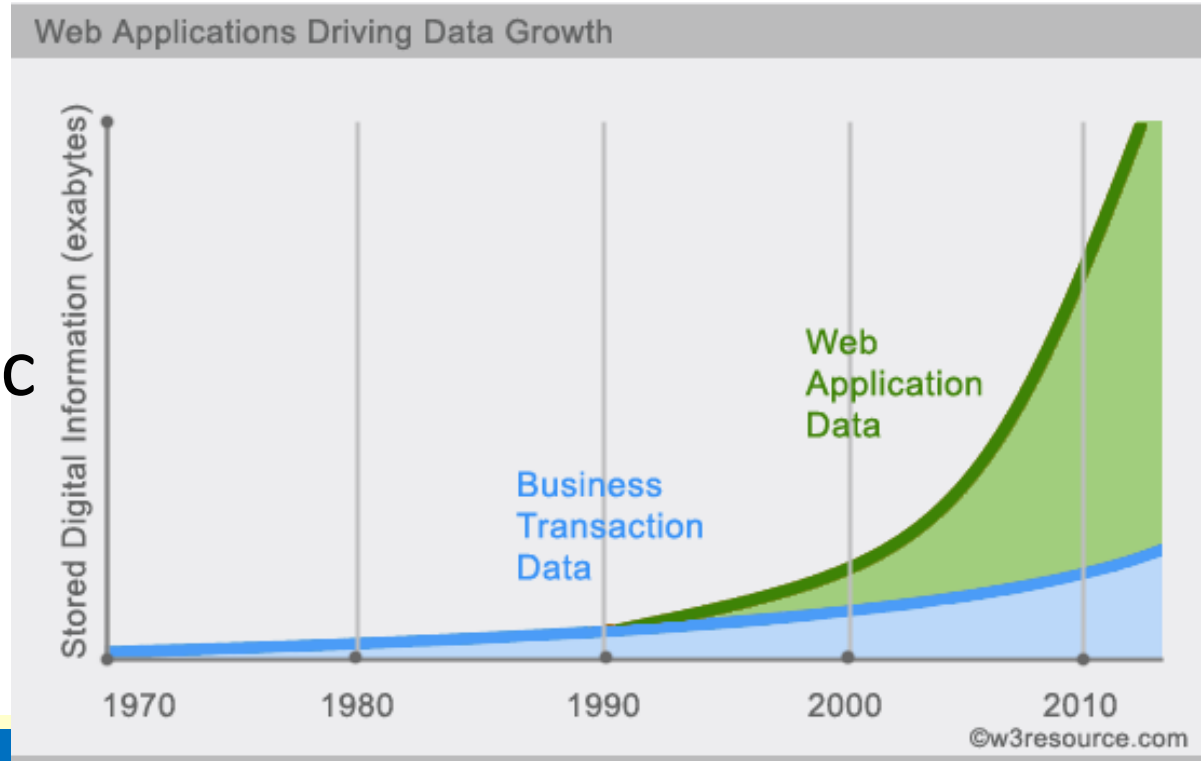
https://www.youtube.com/watch?v=uD3p_rZPBUQ

What is NoSQL?

- Stands for “NOT ONLY SQL”
- A **Non-Relational** database (No Tables)
- A flexible database used for **big data** & **real-time** web apps
- Multiple types of NoSQL databases

What is Big Data?

- A term for data sets that are so large that traditional methods of storage & processing are inadequate.
- Massive increase in data volume within the last decade or so
- Social networks, search engines, etc
- Challenges in storage, capture, analysis, transfer, etc

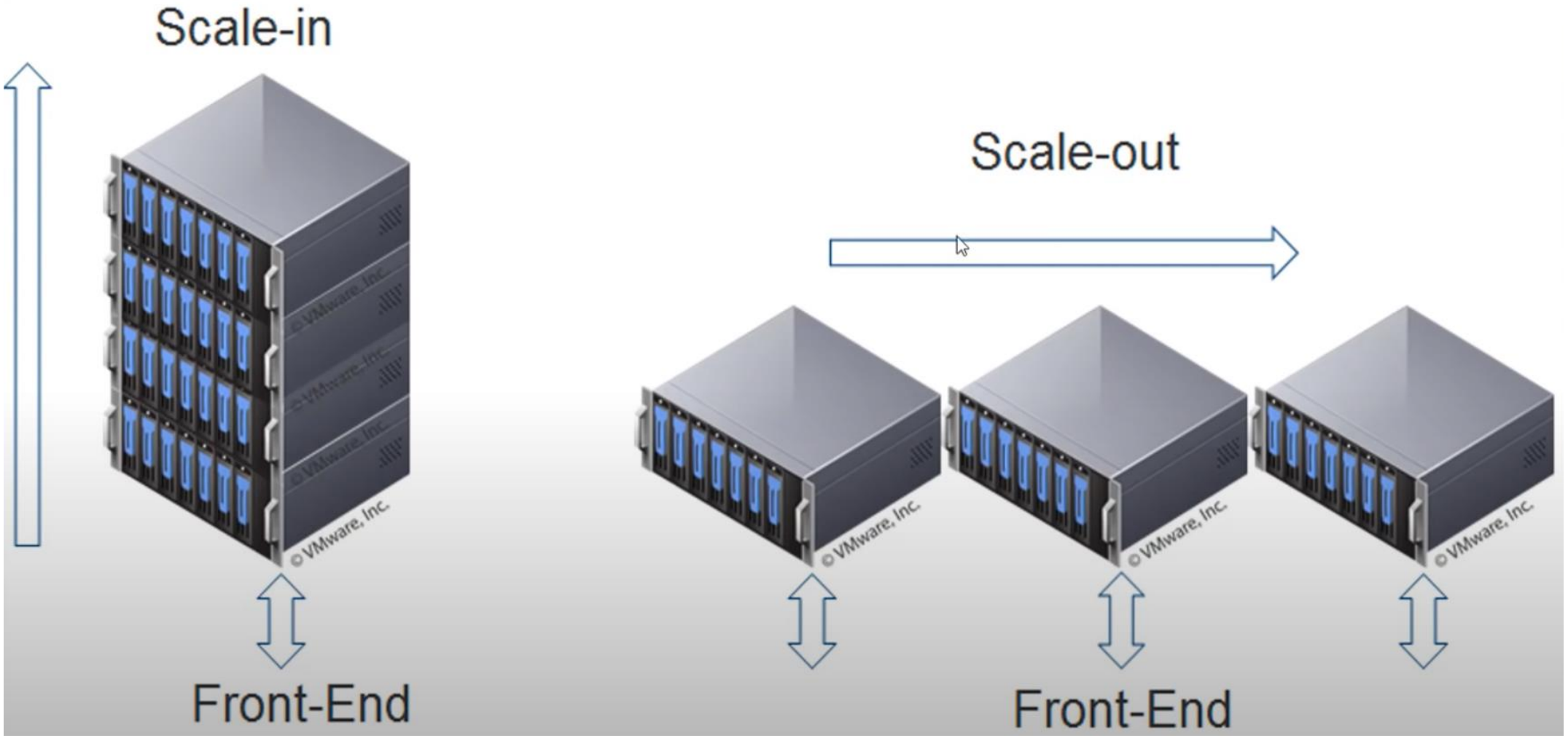


https://www.runoob.com/mongodb/nosql.html

Advantages of NoSQL over RDBMS

- Handles Big Data
- Data Models – No predefined schema
- Data Structure – NoSQL handles unstructured data
- Cheaper to manage
- Scaling – Scale out / horizontal scaling

Scale Out vs Scale UP



Advantages of RDBMS over NoSQL

- Better for relational data
- Normalization
- Well known language (SQL)
- Data Integrity
- ACID Compliance (atomicity, consistency, isolation, durability)

Types of NoSQL Databases

- Document Databases [MongoDB, CouchDB]
- Column Databases [Apache Cassandra]
- Key-Value Stores [Redis, Couchbase Server]
- Cache Systems [Redis, Memcache]
- Graph Databases [Neo4]

MongoDB examples

- MongoDB stores documents in collections. Collections are analogous to tables in relational databases.
- Data is stored in json files.

https://docs.mongodb.com/manual/core/databases-and-collections/

MongoDB examples

id	user_name	email	age	city
1	Mark Hanks	mark@abc.com	25	Los Angeles
2	Richard Peter	richard@abc.com	31	Dallas

```
{
    "_id": ObjectId("5146bb52d8524270060001f3"),
    "age": 25,
    "city": "Los Angeles",
    "email": "mark@abc.com",
    "user_name": "Mark Hanks"
}
{
    "_id": ObjectId("5146bb52d8524270060001f2"),
    "age": 31,
    "city": "Dallas",
    "email": "richard@abc.com",
    "user_name": "Richard Peter"
}
```

https://www.runoob.com/mongodb/mongodb-databases-documents-collections.html

Beyond Tables: More Data Types

Semi-Structured Data

Many applications require storage of complex data, whose schema changes often

The relational model's requirement of atomic data types may be **an overkill**

- E.g., storing set of interests as a set-valued attribute of a user profile may be simpler than normalizing it

Data exchange can benefit greatly from semi-structured data

- Exchange can be between applications, or between back-end and front-end of an application
- Web-services are widely used today, with complex data fetched to the front-end and displayed using a mobile app or JavaScript

JSON and **XML** are widely used semi-structured data models

Features of Semi-Structured Data Models

Flexible schema

- Wide column representation: allow each tuple to have a different set of attributes, can add new attributes at any time
- Sparse column representation: schema has a fixed but large set of attributes, by each tuple may store only a subset

Features of Semi-Structured Data Models

Multivalued data types

- Sets, multisets
  - E.g.,: set of interests: `{"basketball", "cooking", "anime", "jazz"}`
- Key-value map (or just map for short)
  - Store a set of key-value pairs
  - E.g.,
    - `{(brand, Apple), (ID, MacBook Air), (size, 13), (color, silver)}`
  - Operations on maps
    - `put(key, value)`
    - `get(key)`
    - `delete(key)`

Features of Semi-Structured Data Models

Arrays

- Widely used for scientific and monitoring applications
- E.g., readings taken at regular intervals can be represented as array of values instead of (time, value) pairs
  - [5, 8, 9, 11] instead of {(1,5), (2, 8), (3, 9), (4, 11)}

Array database: a database that provides specialized support for arrays

- E.g., compressed storage, query language extensions, etc.
- Oracle GeoRaster, PostGIS, SciDB, etc

Nested Data Types

Hierarchical data is common in many applications

JSON (JavaScript Object Notation)

- Widely used today

XML (eXtensible Markup Language)

- Earlier generation notation, still used extensively


```
{
    "contentLink": {
        "id": 6,
        "workId": 0,
        "guidValue": "ca287bcd-6790-4ac1-9132-ccc
        "providerName": null,
        "url": "/en/alloy-plan/",
        "expanded": null
    },
    "name": "Alloy Plan",
    "language": {
        "link": "/en/alloy-plan/",
        "displayName": "English",
        "name": "en"
    },
    "existingLanguages": [
        {
            "link": "/en/alloy-plan/",
            "displayName": "English",
            "name": "en"
        }
    ]
}
```



```
<project xmlns="http://maven.apache.org/POM/4.0.0"
         xmlns:xsi="http://www.w3.org/2001/XMLSchema-instance"
         xsi:schemaLocation="http://maven.apache.org/POM/4.0.0
         http://maven.apache.org/xsd/maven-4.0.0.xsd">
    <modelVersion>4.0.0</modelVersion>

    <groupId>com.spring.aspect</groupId>
    <artifactId>SpringAspect</artifactId>
    <version>0.0.1-SNAPSHOT</version>
    <url>http://maven.apache.org</url>
    <dependencies>
        <dependency>
            <groupId>junit</groupId>
            <artifactId>junit</artifactId>
            <version>4.0.1</version>
            <scope>test</scope>
        </dependency>
    </dependencies>

</project>
```

JSON

Textual representation widely used for data exchange

Types: integer, real, string, and

- Objects: key-value maps, i.e. sets of (attribute name, value) pairs
- Arrays: also key-value maps (from offset to value)

```
{
    "ID": "22222",
    "name": {
        "firstname: "Albert",
        "lastname: "Einstein"
    },
    "deptname": "Physics",
    "children": [
        {"firstname": "Hans", "lastname": "Einstein" },
        {"firstname": "Eduard", "lastname": "Einstein" }
    ]
}
```

JSON

JSON is ubiquitous in data exchange today

- Widely used for web services
  - Most modern applications are architected around on web services

PostgreSQL supports JSON format columns

```
create table json_test (
    id serial not null primary key,
    student json not null
);

insert into json_test (student) values ('{"name": "aaa", "age": 20, "major": {"primary": "cs", "minor":
"math"}}');
insert into json_test (student) values ('{"name": "bbb", "major": {"primary": "math", "minor": "physics"}}');
insert into json_test (student) values ('{"name": "ccc", "age": 19, "major": {"primary": "biology"}}');
```

JSON

JSON is ubiquitous in data exchange today

- Widely used for web services
  - Most modern applications are architected around on web services

PostgreSQL supports JSON format columns

```
-- select all content from the column
select * from json_test;

-- select a value of a key with "->"
select student -> 'major' -> 'minor' from json_test;
```

	id	student
1	1	{"name": "aaa", "age": 20, "major": {"primary": "cs", "minor": "math"}}
2	2	{"name": "bbb", "major": {"primary": "math", "minor": "physics"}}
3	3	{"name": "ccc", "age": 19, "major": {"primary": "biology"}}

	?column?
1	"math"
2	"physics"
3	<null>

XML

XML uses tags to mark up text

- Tags make the data self-documenting
- Tags can be hierarchical

```
<course>
    <course id>CS-101</course id>
    <title>Intro. to Computer Science</title>
    <dept name>Comp. Sci.</dept name>
    <credits>4</credits>
</course>
```

```
<info>
    <name>aaa</name>
    <age>20</age>
    <major>
        <primary>cs</primary>
        <minor>math</minor>
    </major>
</course>
```

Textual Data

Information retrieval: querying of unstructured data

- Simple model of keyword-based queries
  - Given query keywords, retrieve documents containing all the keywords
- More advanced models rank relevance of documents
- Today, keyword queries return many types of information as answers
  - E.g., a query “cricket” typically returns information about ongoing cricket matches

Relevance ranking

- Essential since there are usually many documents matching keywords

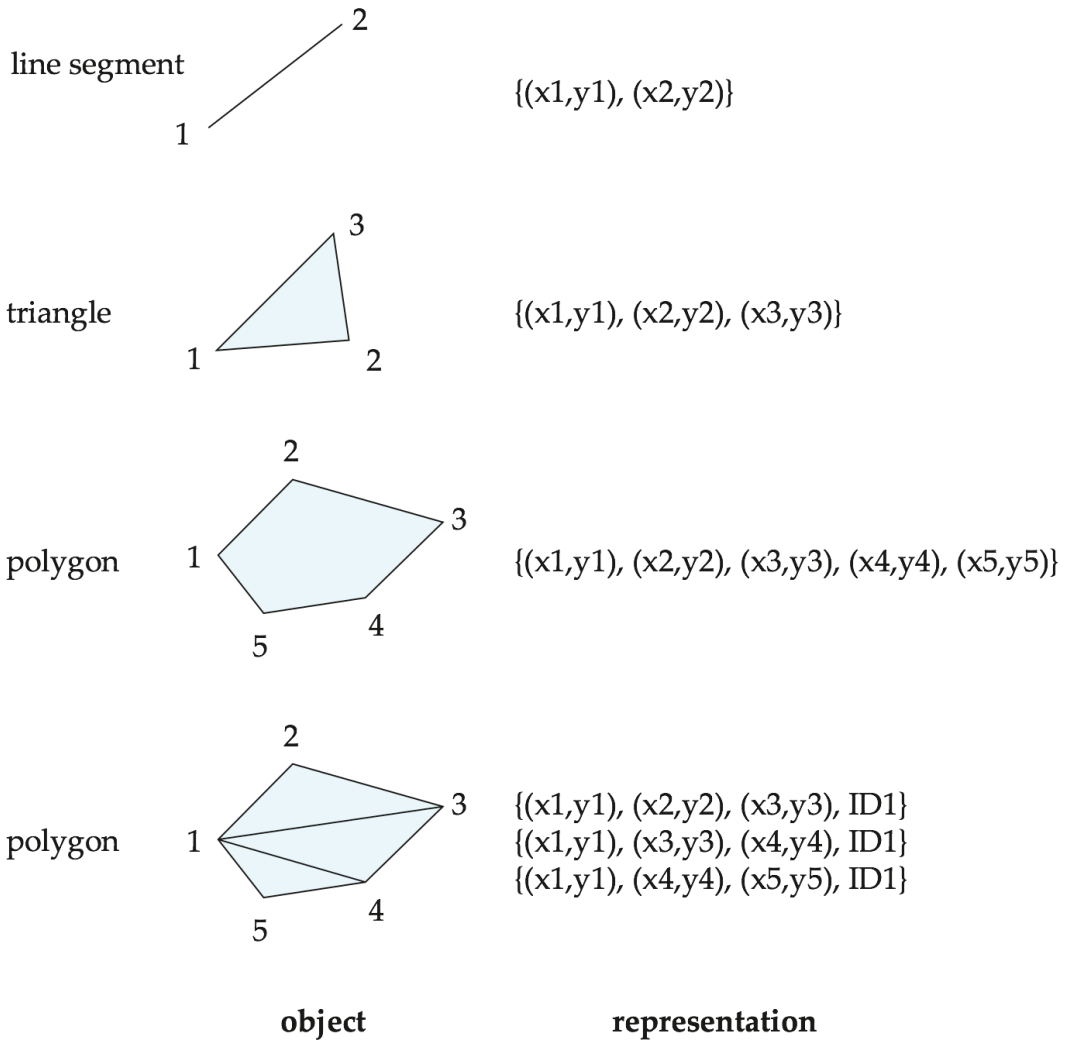
Spatial Data

Spatial databases store information related to spatial locations, and support efficient storage, indexing and querying of spatial data.

- **Geographic data**: road maps, land-usage maps, topographic elevation maps, political maps showing boundaries, land-ownership maps, and so on.
  - Geographic information systems (GIS) are special-purpose databases tailored for storing geographic data.
  - Round-earth coordinate system may be used
    - (Latitude, longitude, elevation)
- **Geometric data**: design information about how objects are constructed
  - E.g., designs of buildings, aircraft, layouts of integrated-circuits.
  - 2 or 3 dimensional Euclidean space with (X, Y, Z) coordinates

Representation of Geometric Information

Various geometric constructs can be represented in a database in a normalized fashion



NoSQL Database

"Not Only SQL"

- Useful when working with a huge quantity of data when nature of data does not require a relational model
- Usually not built on tables and queried by SQL

Examples

- Document store – MongoDB
- Graph structure – Neo4j
- Key-value storage – Redis, LevelDB
- Tabular – Apache Hbase (Hadoop-based)

Beyond PostgreSQL: More DBMS

Commercial & Open-Source Solutions

Commercial Relational DBMS:

Oracle Database

Microsoft SQL Server

IBM DB2

...

Open-Source Counterparts:

- MySQL (MariaDB)
- PostgreSQL
- ...

Commercial & Open-Source Solutions

Factors to consider open-source databases

- Cost
  - Open-source databases are generally free
- Customizability
  - Add your own features in the source code
- Community support
  - Documentations, bug fixes, discussions

Commercial & Open-Source Solutions

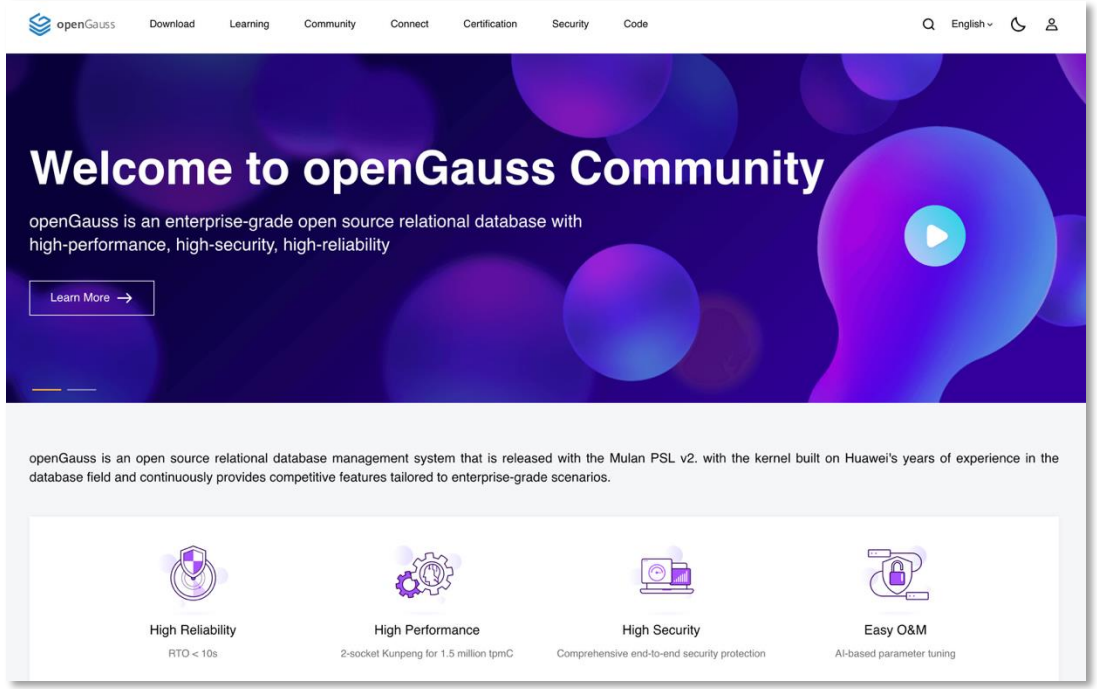
Factors to consider commercial databases

- Technical support
  - Guaranteed professional services
- Usability
  - Generally easier to deploy and use
  - Can be seamlessly integrated into other commercial products
- Feature support
  - Enterprise-level feature extension (More functions, useful SQL syntax, etc.)

openGauss

Relational DBMS from Huawei

- Enterprise-grade open-source relational database
- Client-server architecture
- High-performance, high-reliability, high-security
- Community support
- * Compatible to PostgreSQL clients



https://www.opengauss.org/en/

Key Differences between openGauss and PostgreSQL

originated from PostgreSQL-XC (eXtensible Cluster)

Fundamental differences in the architecture and key technologies, especially in the storage engine and query optimizer

关键差异化因素		openGauss	PostgreSQL
运行时模型	执行模型	线程池模型，高并发连接切换代价小、内存损耗小，执行效率高，一万并发连接比最优性能损耗<5%。	进程模型，数据库进通过共享内存实现通讯和数据共享。每个进程对应一个并发连接，存在切换性能损耗，导致多核扩展性问题。
事务处理	并发控制	64位事务ID，使用CSN解决动态快照膨胀问题；NUMA-Aware引擎优化改造解决“五把大锁。	事务ID回卷，长期运行性能因为ID回收周期大幅波动；存在“五把大锁”的问题，导致事务执行效率和多处理器多核扩展性存在瓶颈。
	日志和检查点	增量Checkpoint机制，实现性能波动<5%。	全量checkpoint，性能短期波动>15%。
	鲲鹏NUMA	NUMA改造、cache-line padding、原生spin-lock。	NUMA多核能力弱，单机两路性能TPMC <60w。
数据组织	多引擎	行存、列存、内存引擎，在研DFV存储和原位更新。	仅支持行存。
SQL引擎	优化器	支持SQL Bypass, CBO吸收工行等企业场景优化能力。	支持CBO，复杂场景优化能力一般。
	SQL解析	ANSI/ISO标准SQL92、SQL99和SQL2003和企业扩展包。	ANSI/ISO标准SQL92、SQL99和SQL2003。

Intricity101@YouTube

1. What is Hodoop
2. What is Hadoop: SQL Comparison
3. What is Hadoop: Why it scales
4. What is a Data Lake
5. What is NoSQL
6. Why Hadoop is Dying
7. Why born in the cloud matters

What will be the next?