UK Data Service

Data Pre-processing: Intro and Integration

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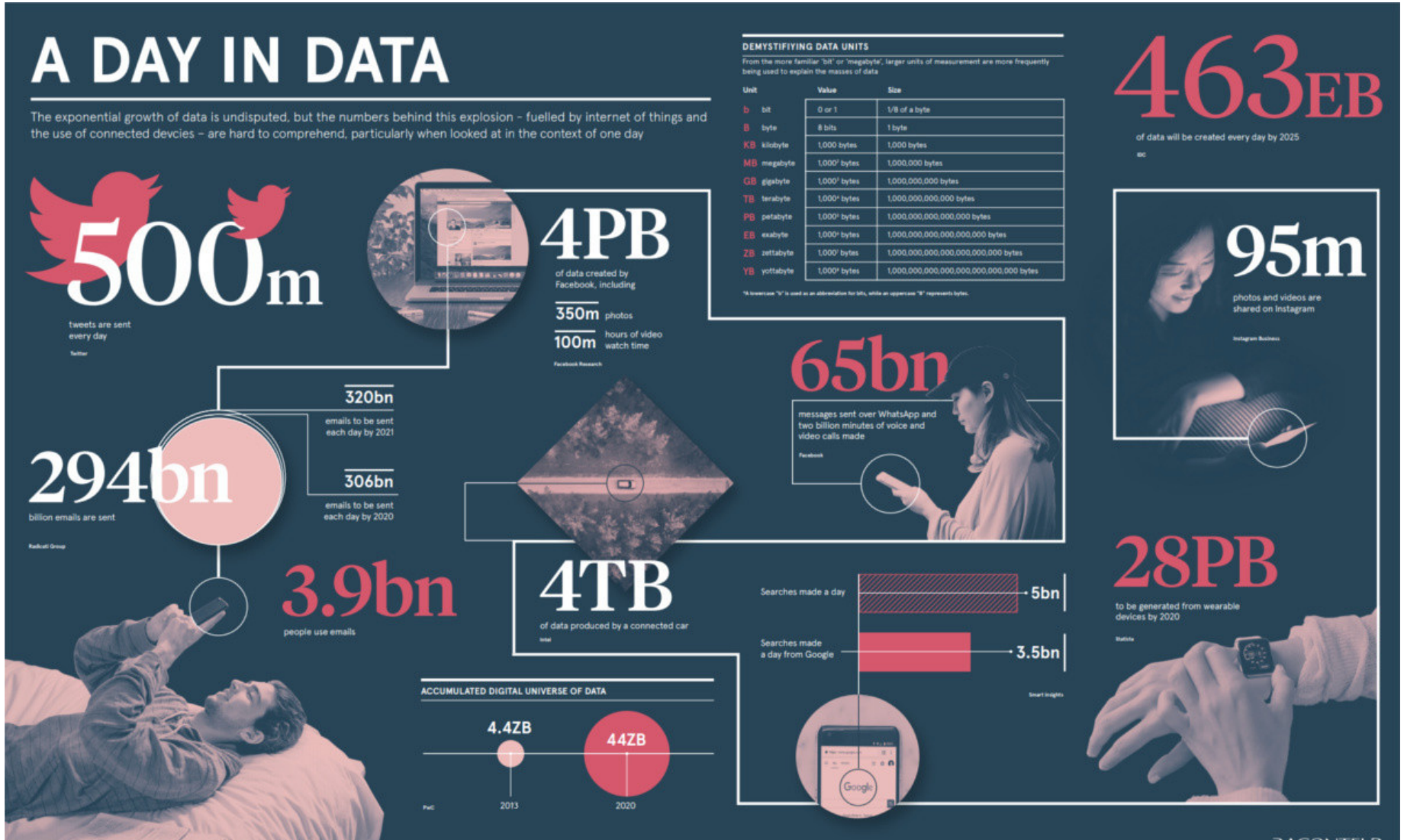
Data Pre-processing

- **Data pre-processing (a.k.a. data preparation)** is the process of manipulating or pre-processing raw data from one or more sources into a structured and clean data set for analysis. It is an important part of **Data Analytics.**

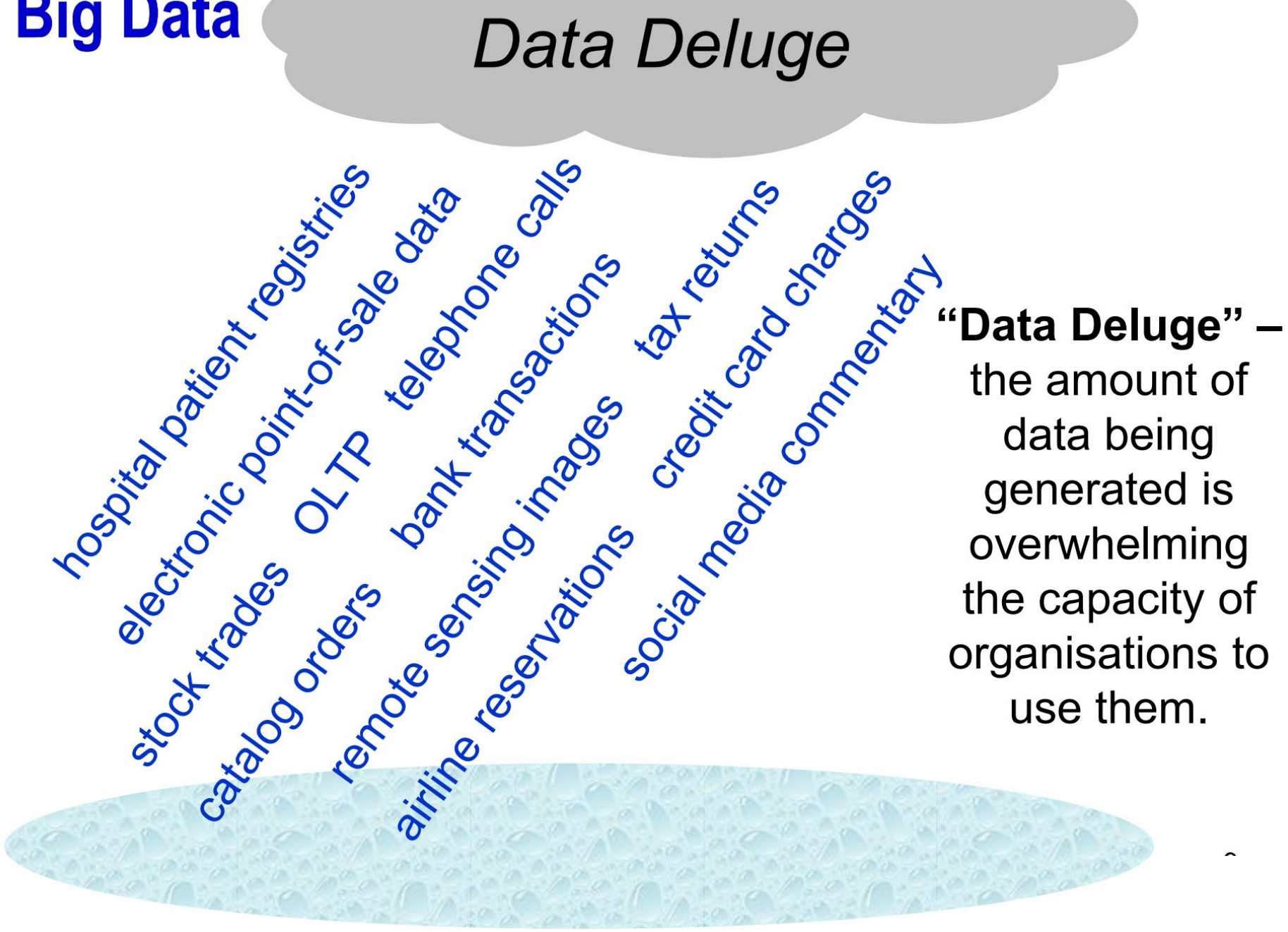
- Data pre-processing includes various tasks and considerations, e.g.
  - Selecting and acquiring data to use
  - Integrating different data sources together
  - Conducting exploratory analysis
  - Cleaning and repairing data, e.g., missing data, inconsistent data
  - Data reduction, transformation, etc.

Data Analytics – The Context

- ‘the sexiest job in the world in the 21st century’



Big Data



"Data Deluge" – the amount of data being generated is overwhelming the capacity of organisations to use them.

Big Data

Data Deluge

Data + preparation + analytics = actionable knowledge

organisations to
use them.

Big Data

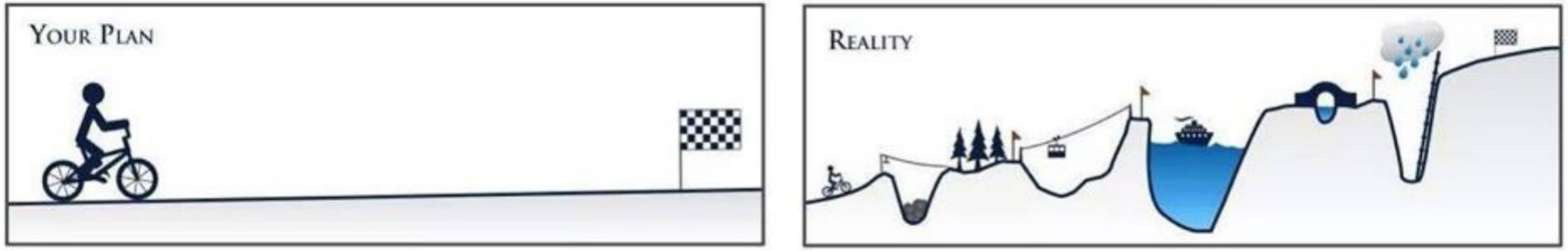
Data Deluge

Data + preparation + analytics = actionable knowledge

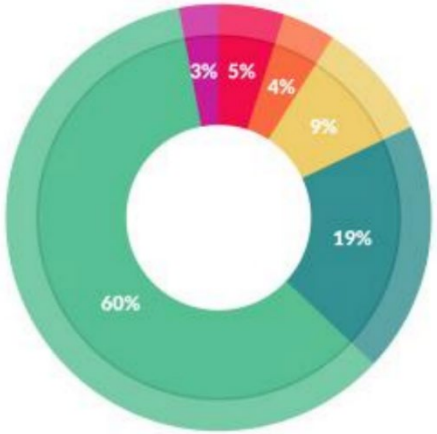
Google Trends, digital banking, Youtube analysis,
Amazon recommendations…

Data Analytics – The Reality

- Data Analytics: Expectation vs. Reality



- Forbes found that “Data preparation accounts for about 80% of the work of data scientists”

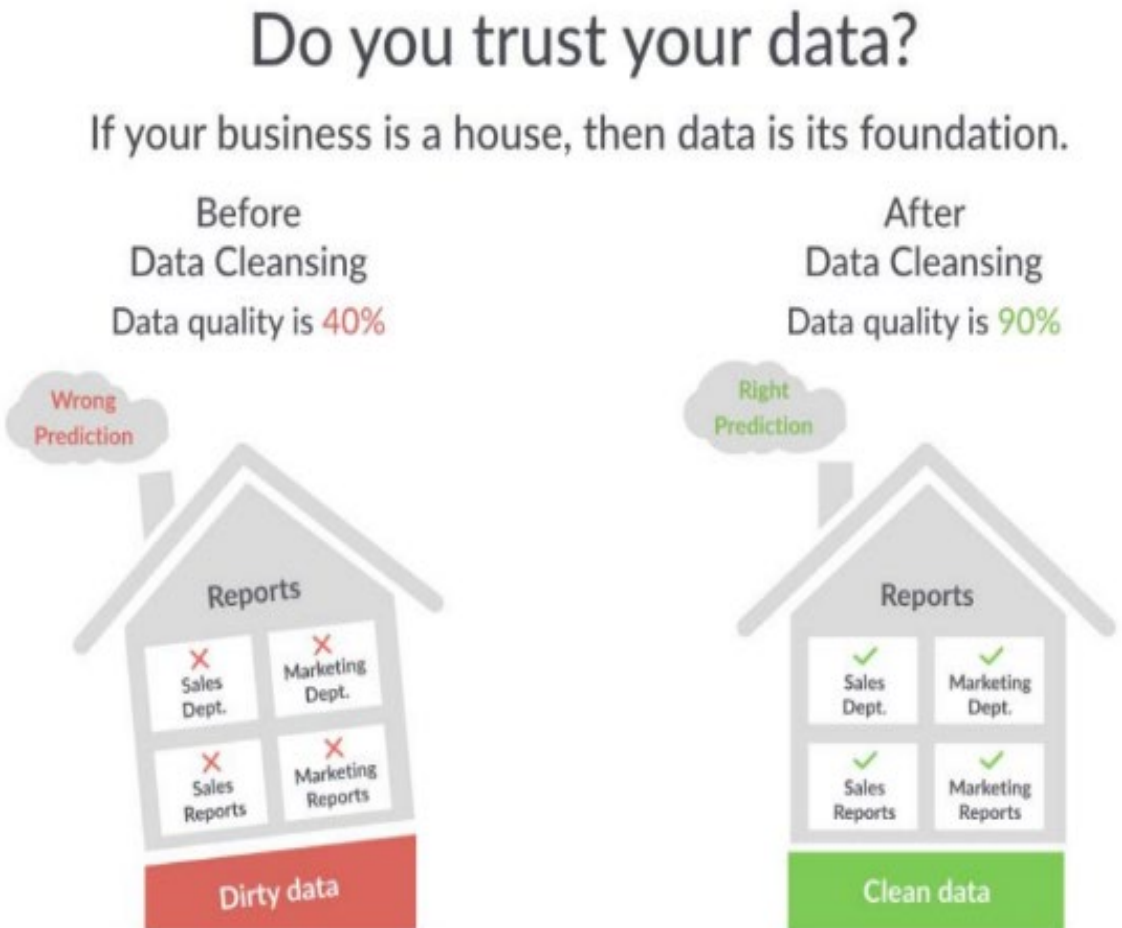


What data scientists spend the most time doing:

- building training sets 3%
- cleaning and organising data 60%
- collecting data sets 19%
- mining data for patterns 9%
- refining algorithms 4%
- other 5%.

Data Preparation

- Data preparation is crucial for getting meaningful results from data analytics.
- Insufficiently prepared data leads to ‘Garbage in, Garbage out’ (GIGO)



How to check data quality?

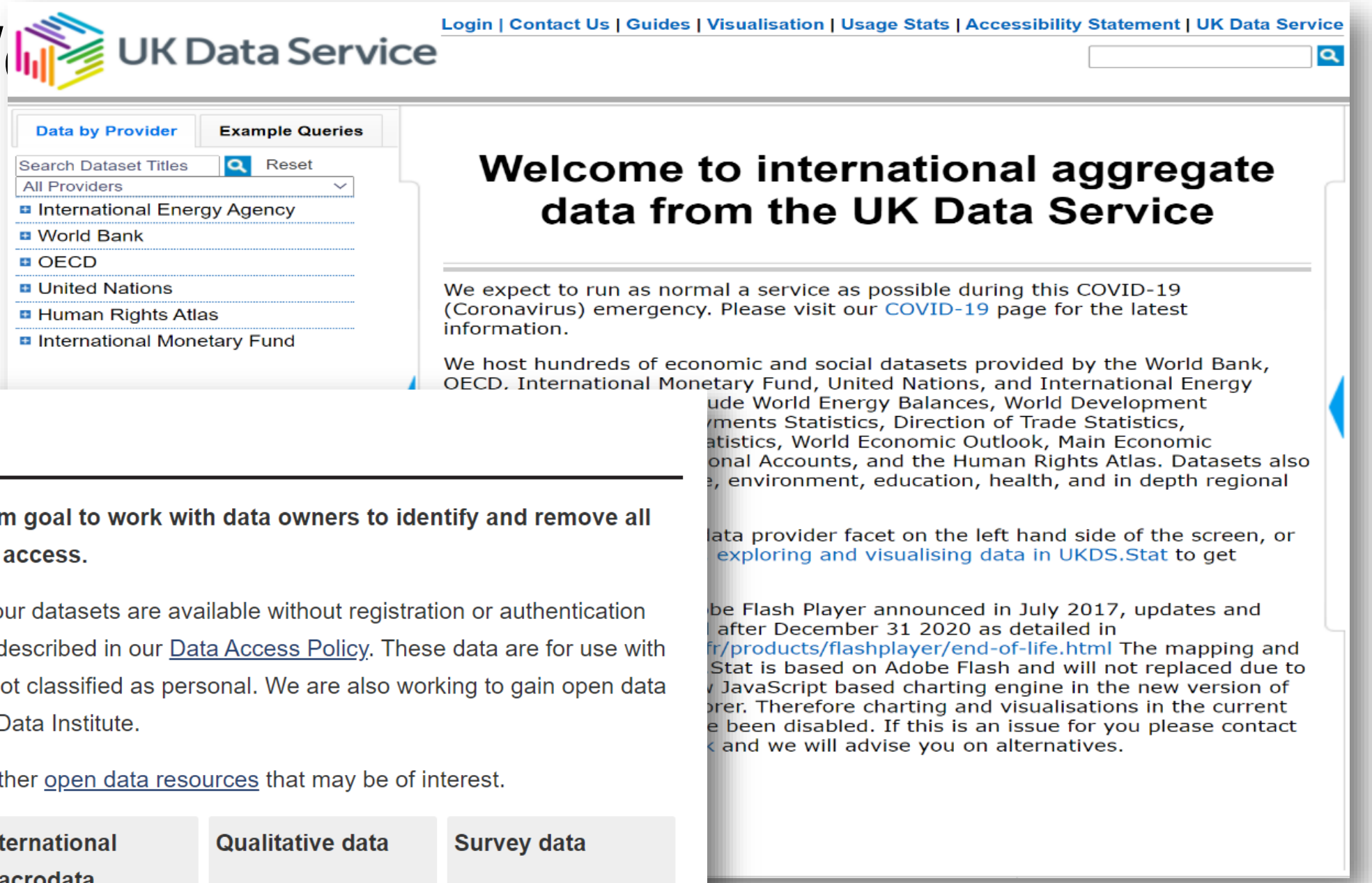
- Meta data: “data about data”
- Understanding data availability, types, quantity, complexity, etc.

- Exploratory Data Analysis (EDA)
- Analyzing data sets to summarize their main characteristics, often with visual methods.

Collecting Data Methods

- Build private databases/data warehouses/etc.
- Scrape from websites
- From third-party platforms, e.g. Statista, World Bank, UKDS.
- ……

UKDS W



Open data

It is our explicit long-term goal to work with data owners to identify and remove all unnecessary barriers to access.

An increasing number of our datasets are available without registration or authentication using open data licences described in our Data Access Policy. These data are for use with an open licence and are not classified as personal. We are also working to gain open data certification via the Open Data Institute.

We also provide links to other open data resources that may be of interest.

Census data	International macrodata	Qualitative data	Survey data

Major Tasks in Data Pre-processing

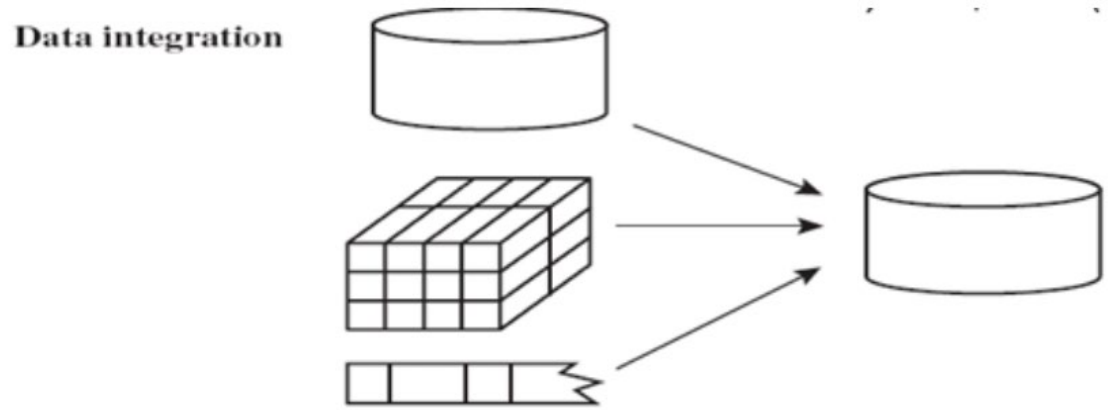
- Data integration - integration of multiple databases, data cubes, or files
- Data description, summarisation and visualisation
- Data cleaning - fill in missing values, smooth noisy data, identify or remove outliers and noisy data, and resolve inconsistencies
- Data reduction - obtain reduced representation in volume but produces the same or similar analytical results
- Data transformation - normalisation and aggregation
- Data discretisation (for numerical data) and generalisation

- **There's no certain order of doing these steps!!**

Data Integration

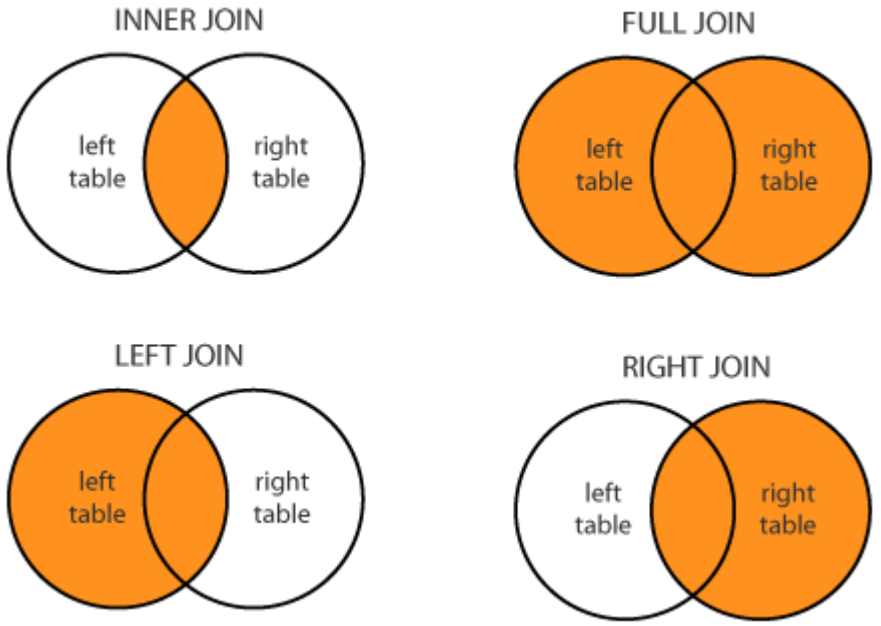
- Data integration: combining data from multiple sources into a unified view
  - To improve data quality
  - To enrich data with additional information
  - To allow reliable data analytics and beyond

- Integrating in-house data within data warehouse together is relatively straightforward (with common attributes and structures across schemas).



Manipulating Data - Joining

- Joining tables:
- Extract and simultaneously process data from more than one table.



Manipulating Data – Inner Join

By default, the joining query performs an ***inner join***, which includes matching rows only in the results.

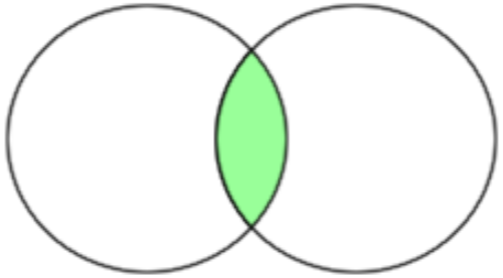
Employee_Payroll

Employee_ID	Salary
120101	163040
120102	108255
120103	87975
120104	92500

Employee_Organization

Employee_ID	Department
120101	Sales Management
120102	Sales Management
120103	Engineering
120105	Administration

Employee_ID	Salary	Department
120101	163040	Sales Management
120102	108255	Sales Management
120103	87975	Engineering



Manipulating Data – Full Outer Join

- A ***full outer join*** includes all rows from both tables.

Employee_Payroll

Employee_ID	Salary
120101	163040
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Employee_Organization

Employee_ID	Department
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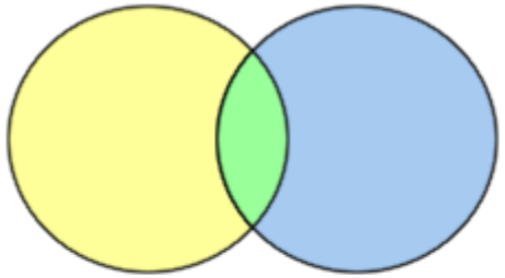


Manipulating Data – Left Join

- A ***left join*** includes all rows from ***the left table.***

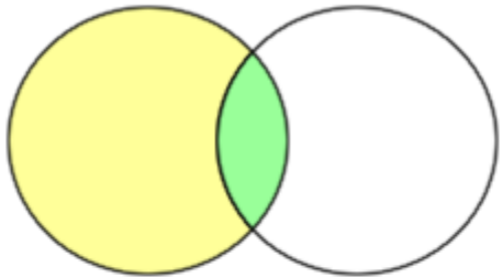
Employee_Payroll

Employee_ID	Salary
120101	163040
120102	108255
120103	87975
120104	92500

Employee_Organization

Employee_ID	Department
120101	Sales Management
120102	Sales Management
120103	Engineering
120105	Administration

Employee_ID	Salary	Department
120101	163040	Sales Management
120102	108255	Sales Management
120103	87975	Engineering
120104	9250	



Difficulties of Integrating Data

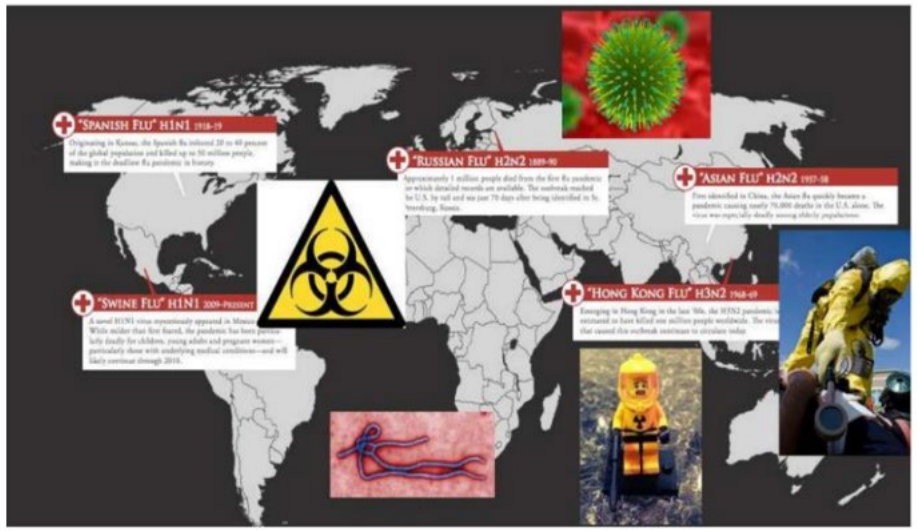
- **Database heterogeneity**
- System Heterogeneity: different operating system, hardware platforms
- Schematic or Structural Heterogeneity: the native model or structure to store data

- **Data value conflicts**
- E.g., metric vs. British units

- **Entity identification**
- E.g., Bill Clinton = William Clinton

Example – Health Surveillance

- Preventing the outbreak of epidemics requires monitoring of occurrences of unusual patterns of symptoms (in real time!)
- Various databases
- Many millions of records
- Privacy and confidentiality concerns



Linking Data

- **Data linkage** is the process of bringing together information from two different records that are believed to belong to the same entity based on matching variables.
- Challenging if errors exists in the key variables

Linking Data

- **Deterministic linkage**
- Agree exactly on the key, e.g. ID number

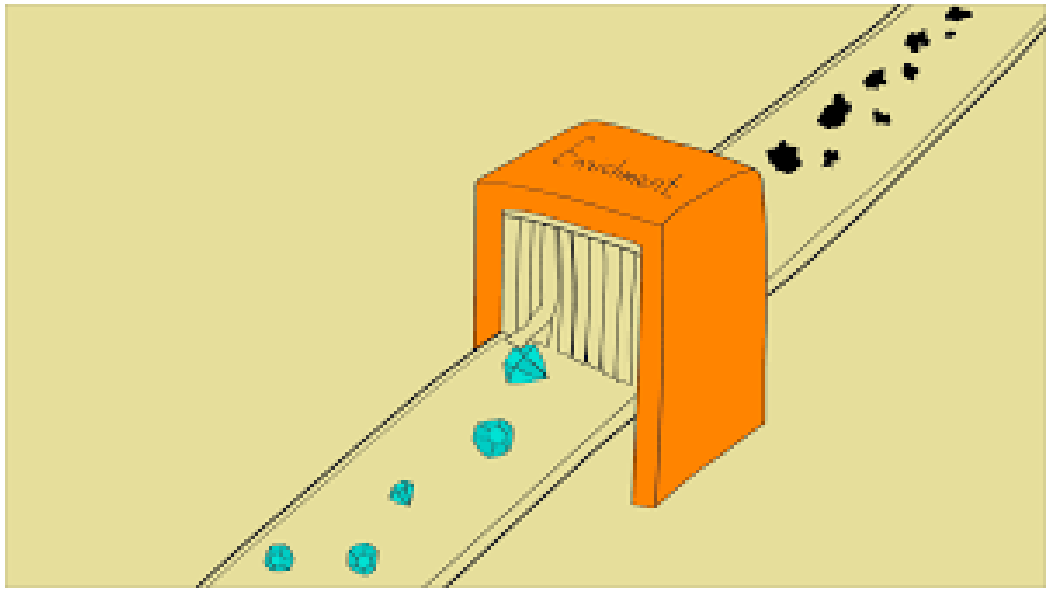
- **Probabilistic linkage**
- Frequency analysis of data values.

Linking Data: Example

Which of these records represent the same person?

Data Set	#	SSN	Name	DOB	Sex	ZIP
Set A	1	000956723	Smith, William	1973/01/02	Male	94701
	2	000956723	Smith, William	1973/01/02	Male	94703
	3	000005555	Jones, Robert	1942/08/14	Male	94701
	4	123001234	Sue, Mary	1972/11/19	Female	94109
Set B	1	000005555	Jones, Bob	1942/08/14		
	2		Smith, Bill	1973/01/02	Male	94701

Enriching Data

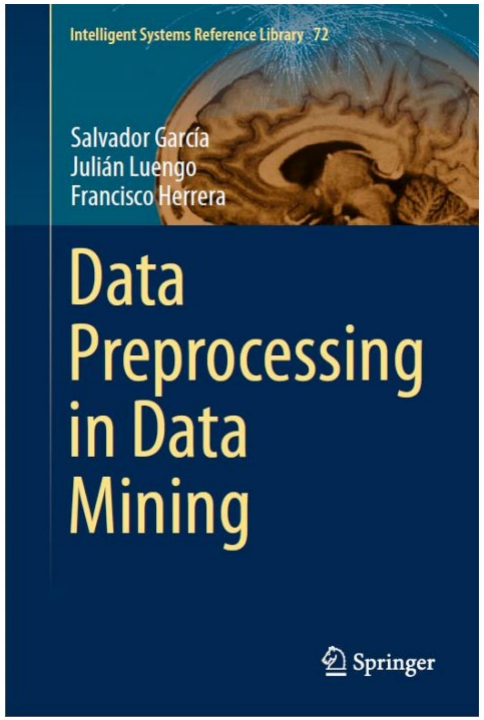


- Data enrichment: the process of introducing more data
- Disparate data from other internal sources or third-party data from external sources

- Provide contextualization with additional data
- Help enrich or validate the data

Acknowledgement

- Some of the content is based on …



García, S., Luengo, J. and Herrera, F., 2015. Data preprocessing in data mining (pp. 59-139). New York: Springer.)