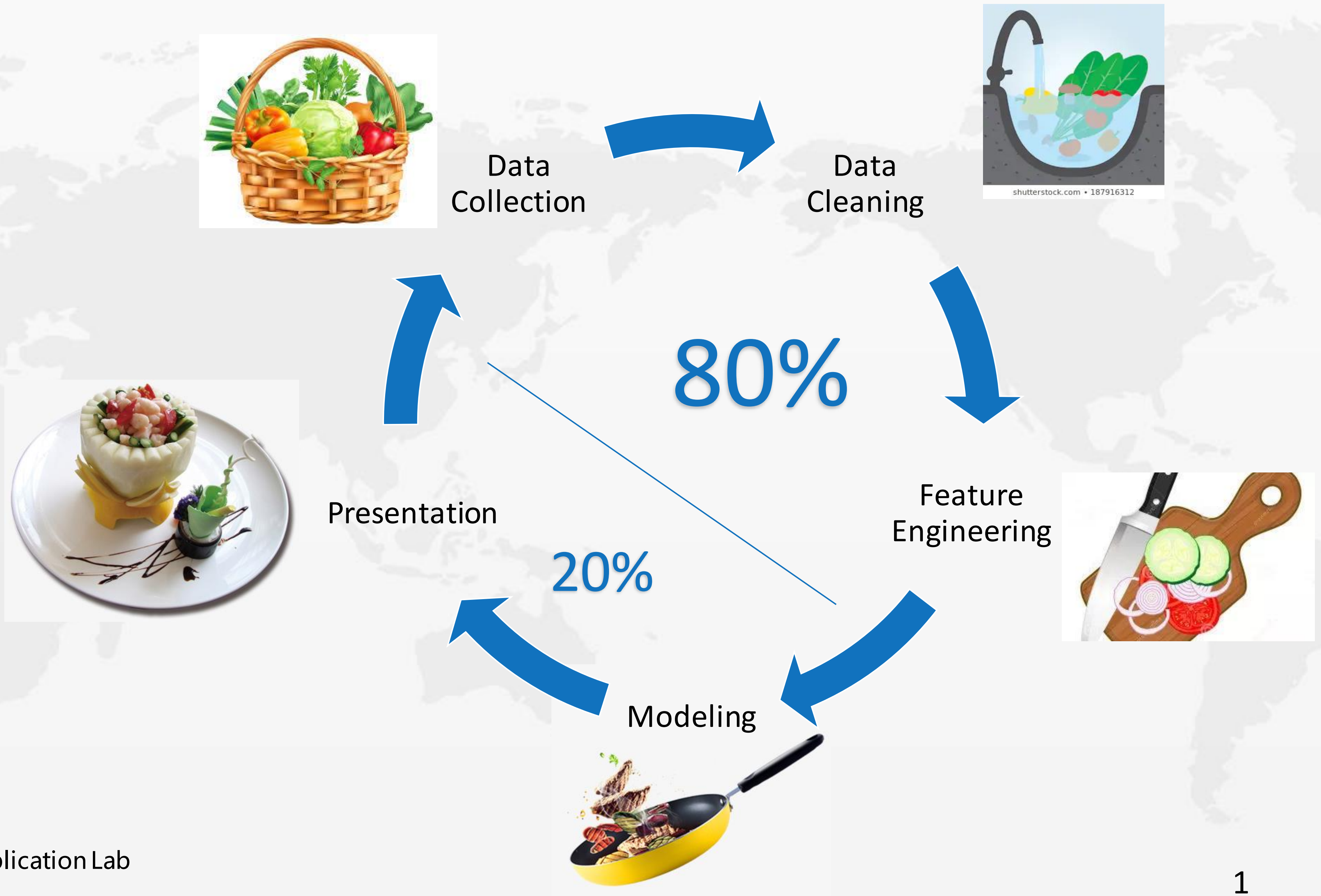
Data Application Lab

Data Preparation For Data Science Process

Date Science vs Cooking



Outline

Data Environment

- Data Science Process
- Data Source
- Data File Format
- Data Types
- Data Quality

Data Preparation

- Data Cleansing
- Regex
- Missing Data Handling
- Outlier
- Data Transformation
- Demo

Web Data Processing

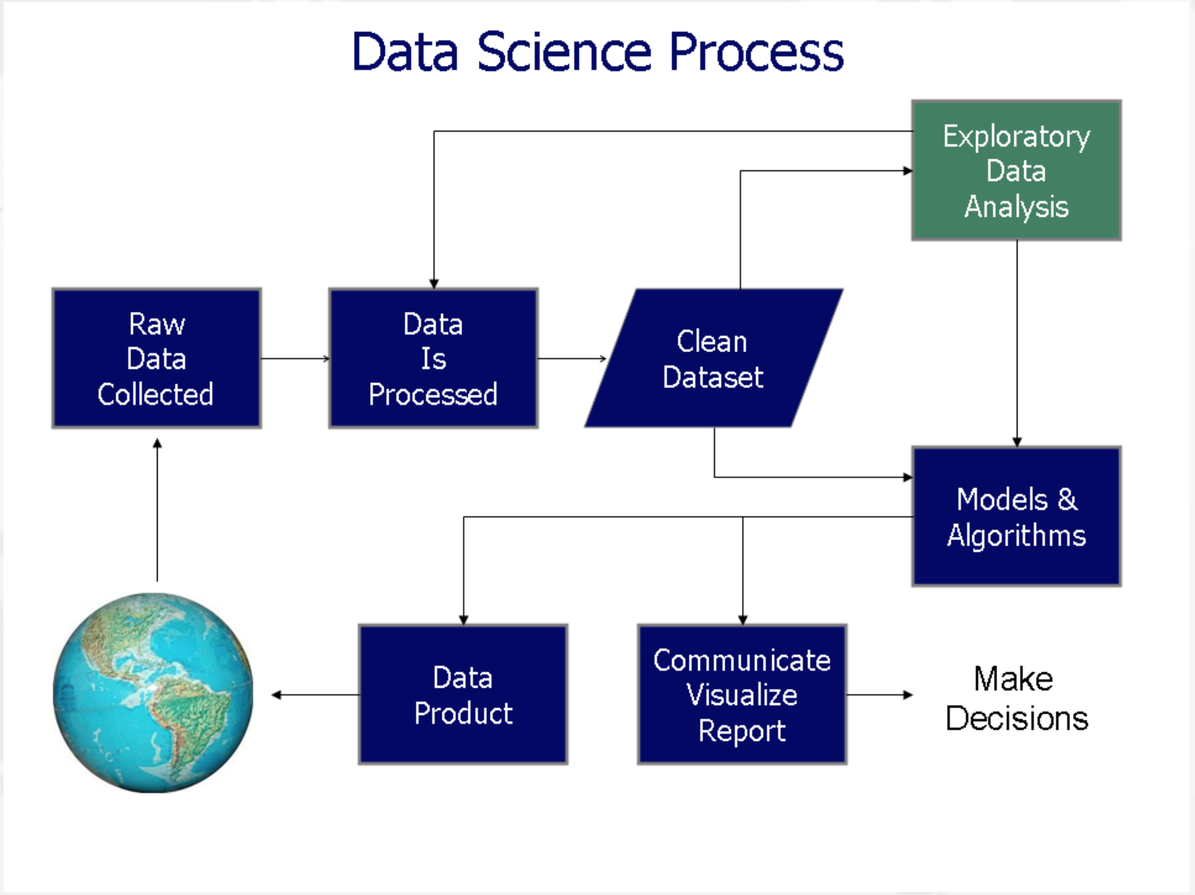
- HTML Page Structure
- Regular expressions to extract data
- Beautiful soup to extract data
- Demo

Data Environment

1

Introduction: Data Science Process

1. Problem Statement
2. Data Collection & Storage
3. **Data Preparation**
   1) **Access Data**
   2) **Clean Data**
   3) **Transform Data**
4. Exploratory Data Analysis & Visualization
5. Modeling
6. Presentation or Productization



Data Source: Business View

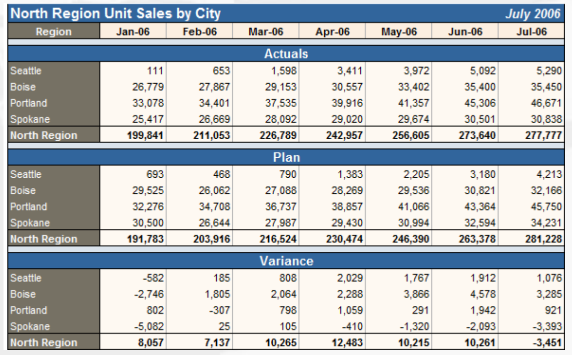
- Application Generated
  - Internal Application
  - Client-Facing Application
  - Third Party Application: Salesforce/Google Marketing Platform
- Client Provided
  - Sales
  - Accounting/Finance
- Third Party Purchased
  - Marketing Research Company
  - Moody's/Credit Reporting Agency
- Public Data
  - Census Data
  - Twitter
  - Sports
- Manually Collected
  - Survey
  - Campaign

Data Source: Technical View

- Data File
  - Spreadsheet/Excel
  - Text file
    - Delimited: csv/tsv
    - Fixed Length
- Database/Data Warehouse
  - RDBMS: SqlServer/Oracle/MySql/Postgres
  - NoSQL DB: MangoDB/Amazon DynamoDB
  - Data Warehouse: Teradata/Amazon Redshift/Snowflake
- HDFS/Spark
  - Parquet
- Cloud/AWS
  - S3
- Other
  - Semi-Structured: Json/XML, html
  - Unstructured: image/text/voice/video

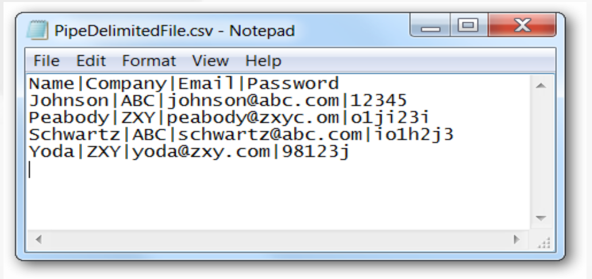
Data File: Structured Data

- Excel:
  - Most common; most problematic
  - Problem: double header, merged cells, color, date
- Delimited format
  - Most common; most preferred
  - Common delimited (csv); tab delimited(tsv); “|” delimited
  - Problem: delimiter in data field. E.g. Los Angles, CA
  - Problem: encoding
- Fixed length
  - Each column length is fixed
  - Problem: Oversized column

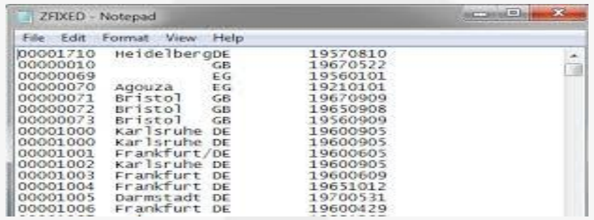


North Region Unit Sales by City — July 2006

Region	Jan-06	Feb-06	Mar-06	Apr-06	May-06	Jun-06	Jul-06
Actuals							
Seattle	111	653	1,598	3,411	3,972	5,092	5,290
Boise	26,779	27,867	29,153	30,557	33,402	35,400	35,450
Portland	33,078	34,401	37,535	39,916	41,357	45,306	46,671
Spokane	25,417	26,669	28,092	29,020	29,674	30,501	30,838
North Region	**199,841**	**211,053**	**226,789**	**242,957**	**256,605**	**273,640**	**277,777**
Plan							
Seattle	693	468	790	1,383	2,205	3,180	4,213
Boise	29,525	26,062	27,088	28,269	29,536	30,821	32,166
Portland	32,276	34,708	36,737	38,857	41,066	43,364	45,750
Spokane	30,500	26,644	27,987	29,430	30,994	32,594	34,231
North Region	**191,783**	**203,916**	**216,524**	**230,474**	**246,390**	**263,378**	**281,228**
Variance							
Seattle	-582	185	808	2,029	1,767	1,912	1,076
Boise	-2,746	1,805	2,064	2,288	3,866	4,578	3,285
Portland	802	-307	798	1,059	291	1,942	921
Spokane	-5,082	25	105	-410	-1,320	-2,093	-3,393
North Region	**8,057**	**7,137**	**10,265**	**12,483**	**10,215**	**10,261**	**-3,451**



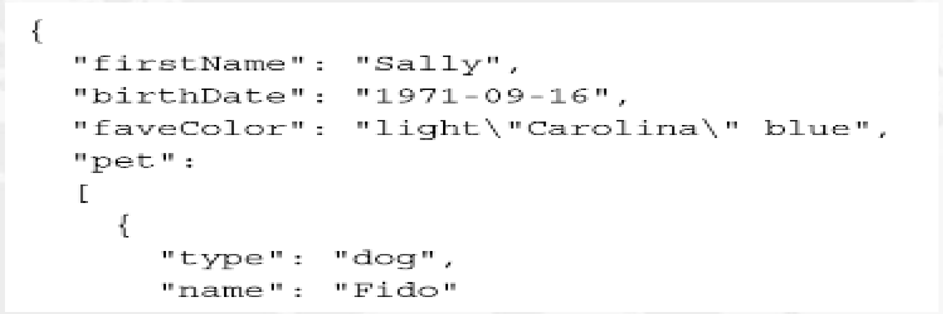
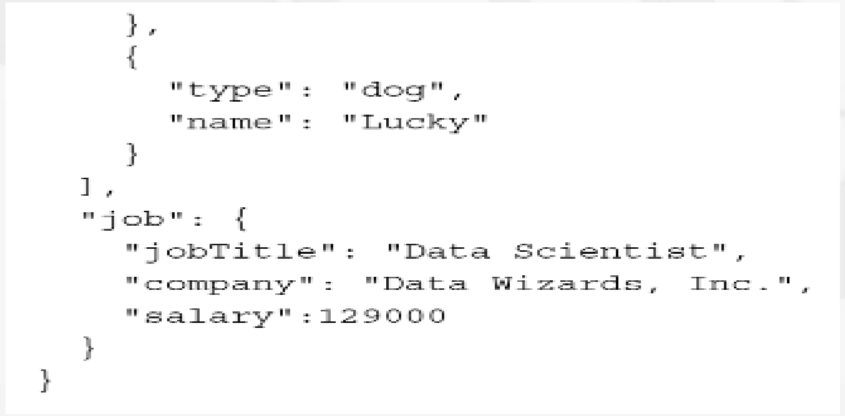
```
Name|Company|Email|Password
Johnson|ABC|johnson@abc.com|12345
Peabody|ZXY|peabody@zxyc.om|o1ji23i
Schwartz|ABC|schwartz@abc.com|io1h2j3
Yoda|ZXY|yoda@zxy.com|98123j
```



```
00001710  HeidelbergDE         19570810
00000010            GB         19670522
00000069            EG         19560101
00000070  Agouza    EG         19210101
00000071  Bristol   GB         19670909
00000072  Bristol   GB         19650908
00000073  Bristol   GB         19560909
00001000  Karlsruhe DE         19600905
00001000  Karlsruhe DE         19600905
00001001  Frankfurt/DE         19600605
00001002  Karlsruhe DE         19600905
00001003  Frankfurt DE         19600609
00001004  Frankfurt DE         19651012
00001005  Darmstadt DE         19700531
00001006  Frankfurt DE         19600429
```

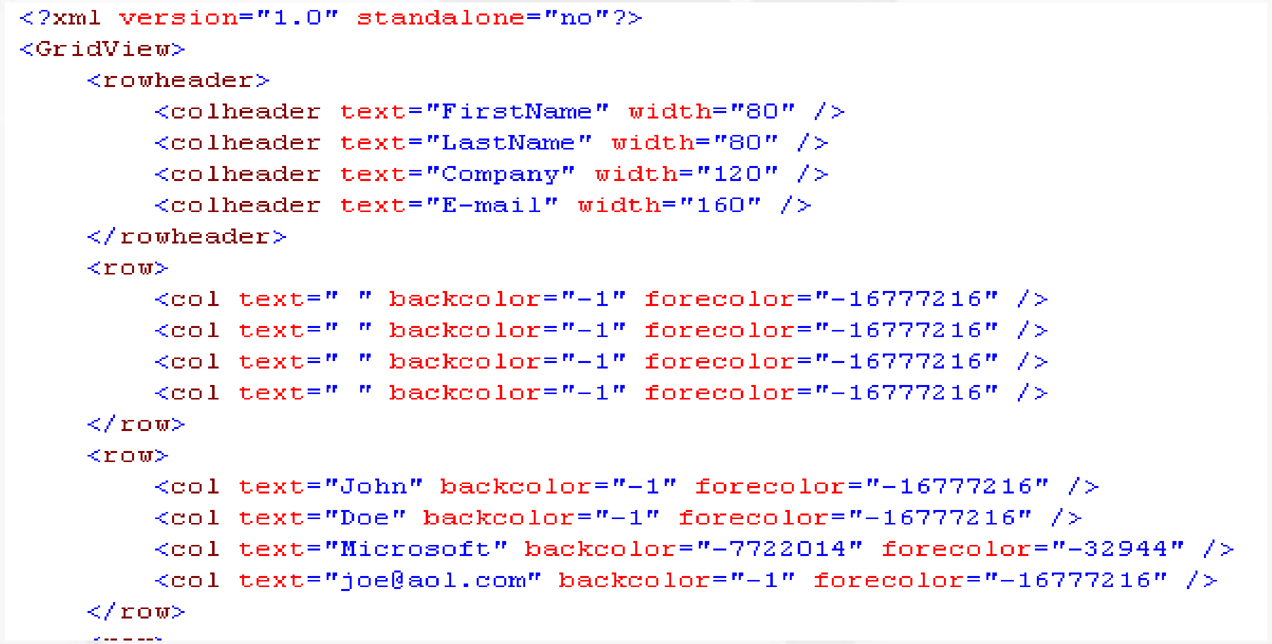
Data File: Semi - structured

JSON: JAVASCRIPT OBJECT NOTATION

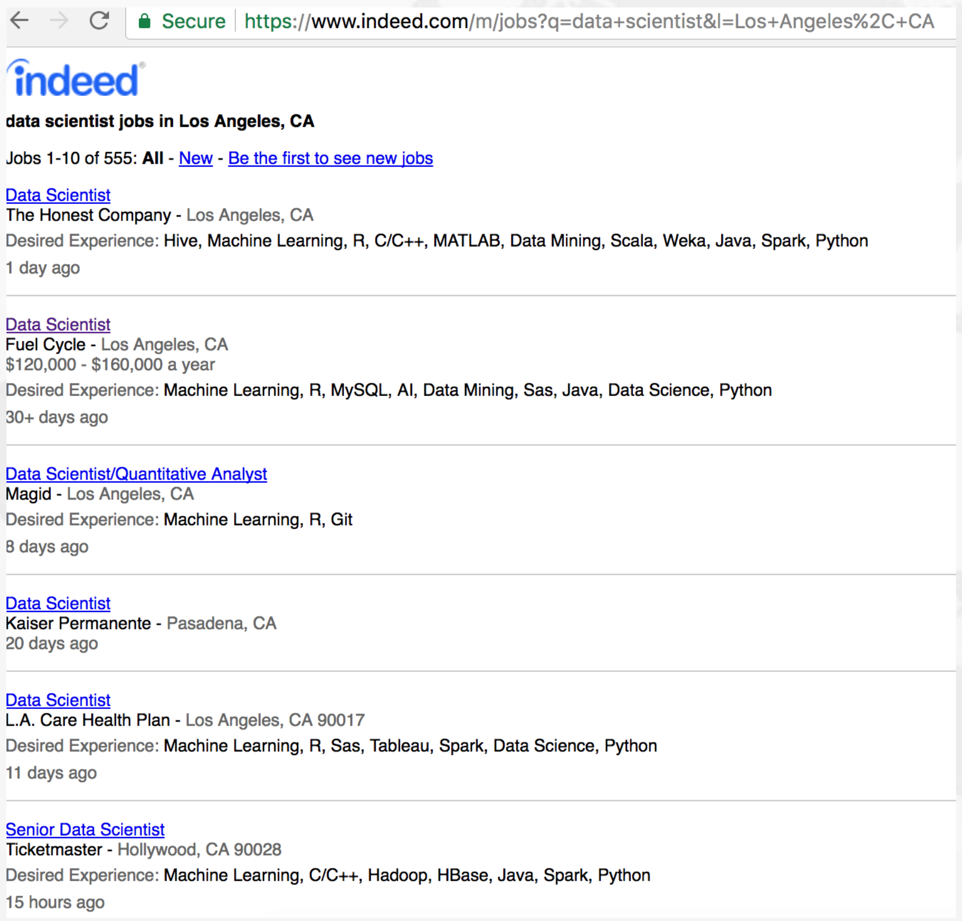
```
{
  "firstName": "Sally",
  "birthDate": "1971-09-16",
  "faveColor": "light\"Carolina\" blue",
  "pet":
  [
    {
      "type": "dog",
      "name": "Fido"
    },
    {
      "type": "dog",
      "name": "Lucky"
    }
  ],
  "job": {
    "jobTitle": "Data Scientist",
    "company": "Data Wizards, Inc.",
    "salary":129000
  }
}
```

XML: EXTENSIBLE MARKUP LANGUAGE



```
<?xml version="1.0" standalone="no"?>
<GridView>
    <rowheader>
        <colheader text="FirstName" width="80" />
        <colheader text="LastName" width="80" />
        <colheader text="Company" width="120" />
        <colheader text="E-mail" width="160" />
    </rowheader>
    <row>
        <col text=" " backcolor="-1" forecolor="-16777216" />
        <col text=" " backcolor="-1" forecolor="-16777216" />
        <col text=" " backcolor="-1" forecolor="-16777216" />
        <col text=" " backcolor="-1" forecolor="-16777216" />
    </row>
    <row>
        <col text="John" backcolor="-1" forecolor="-16777216" />
        <col text="Doe" backcolor="-1" forecolor="-16777216" />
        <col text="Microsoft" backcolor="-7722014" forecolor="-32944" />
        <col text="joe@aol.com" backcolor="-1" forecolor="-16777216" />
    </row>
```

Web Data: HTML - Unstructured



Secure | https://www.indeed.com/m/jobs?q=data+scientist&l=Los+Angeles%2C+CA

indeed

data scientist jobs in Los Angeles, CA

Jobs 1-10 of 555: **All** - New - Be the first to see new jobs

Data Scientist
The Honest Company - Los Angeles, CA
Desired Experience: Hive, Machine Learning, R, C/C++, MATLAB, Data Mining, Scala, Weka, Java, Spark, Python
1 day ago

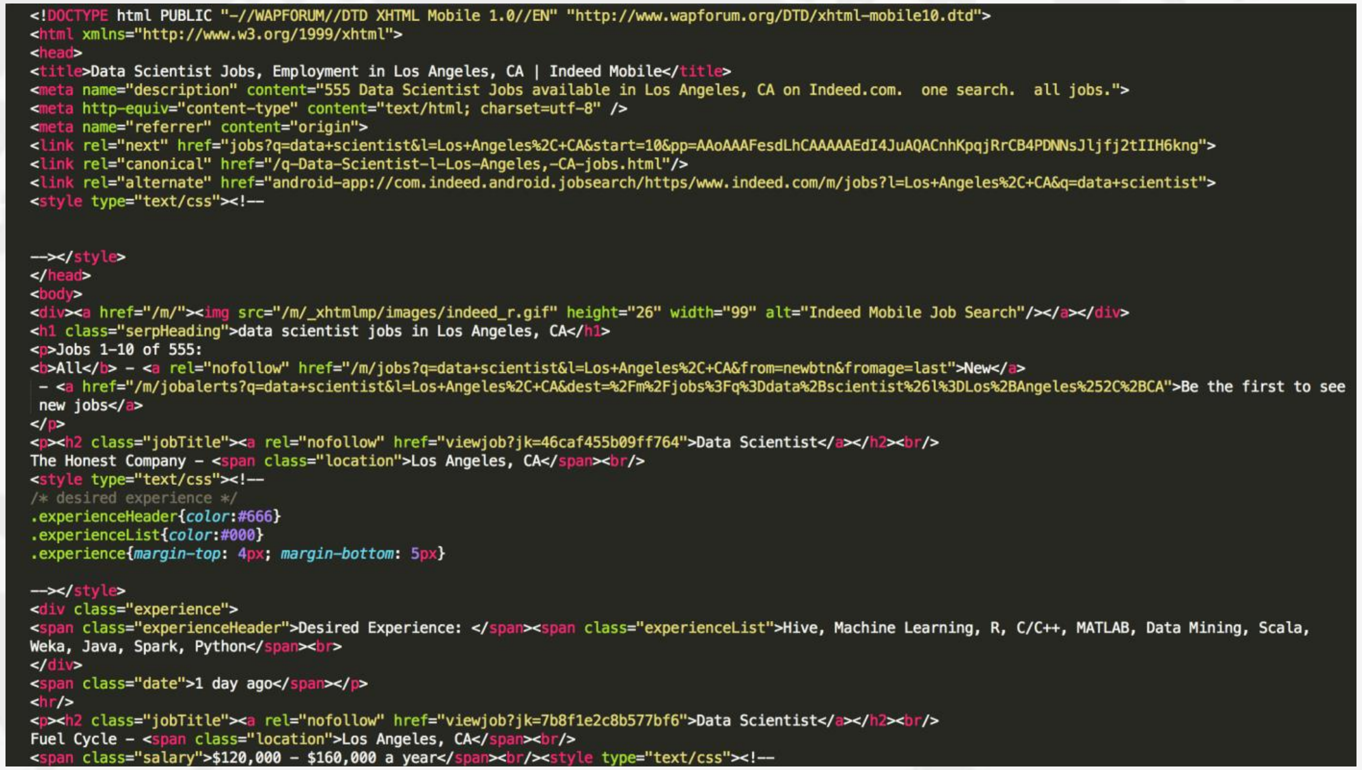
Data Scientist
Fuel Cycle - Los Angeles, CA
$120,000 - $160,000 a year
Desired Experience: Machine Learning, R, MySQL, AI, Data Mining, Sas, Java, Data Science, Python
30+ days ago

Data Scientist/Quantitative Analyst
Magid - Los Angeles, CA
Desired Experience: Machine Learning, R, Git
8 days ago

Data Scientist
Kaiser Permanente - Pasadena, CA
20 days ago

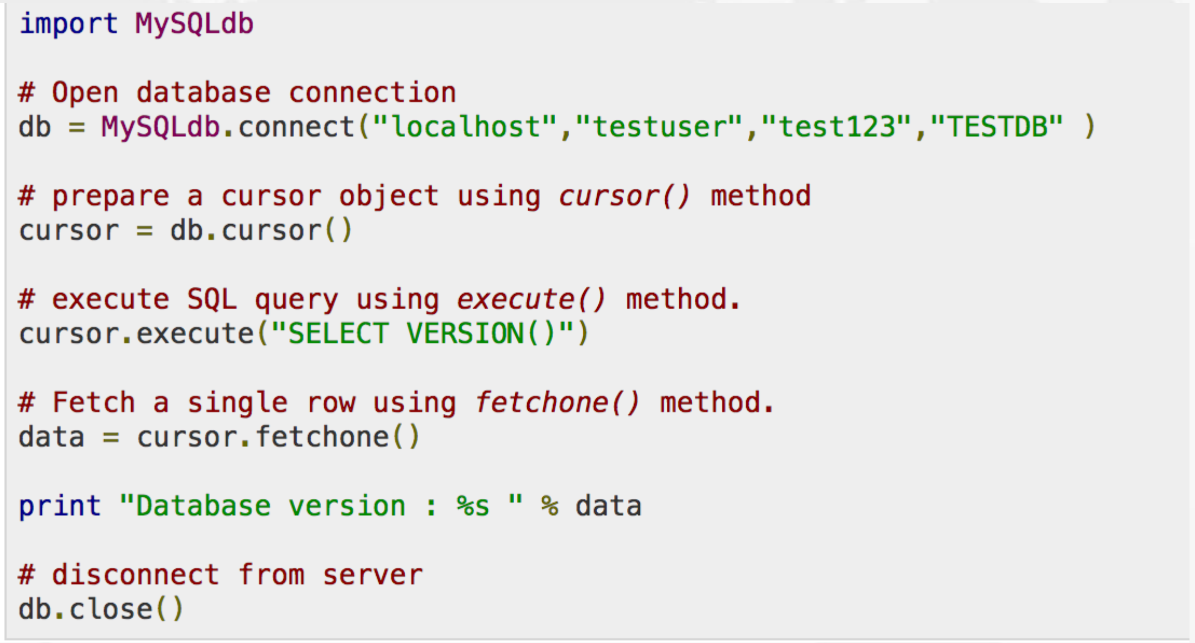
Data Scientist
L.A. Care Health Plan - Los Angeles, CA 90017
Desired Experience: Machine Learning, R, Sas, Tableau, Spark, Data Science, Python
11 days ago

Senior Data Scientist
Ticketmaster - Hollywood, CA 90028
Desired Experience: Machine Learning, C/C++, Hadoop, HBase, Java, Spark, Python
15 hours ago



```
<!DOCTYPE html PUBLIC "-//WAPFORUM//DTD XHTML Mobile 1.0//EN" "http://www.wapforum.org/DTD/xhtml-mobile10.dtd">
<html xmlns="http://www.w3.org/1999/xhtml">
<head>
<title>Data Scientist Jobs, Employment in Los Angeles, CA | Indeed Mobile</title>
<meta name="description" content="555 Data Scientist Jobs available in Los Angeles, CA on Indeed.com.  one search.  all jobs.">
<meta http-equiv="content-type" content="text/html; charset=utf-8" />
<meta name="referrer" content="origin">
<link rel="next" href="jobs?q=data+scientist&l=Los+Angeles%2C+CA&start=10&pp=AAoAAAFesdLhCAAAAAEdI4JuAQACnhKpqjRrCB4PDNNsJljfj2tIIH6kng">
<link rel="canonical" href="/q-Data-Scientist-l-Los-Angeles,-CA-jobs.html"/>
<link rel="alternate" href="android-app://com.indeed.android.jobsearch/https/www.indeed.com/m/jobs?l=Los+Angeles%2C+CA&q=data+scientist">
<style type="text/css"><!--


--></style>
</head>
<body>
<div><a href="/m/"><img src="/m/_xhtmlmp/images/indeed_r.gif" height="26" width="99" alt="Indeed Mobile Job Search"/></a></div>
<h1 class="serpHeading">data scientist jobs in Los Angeles, CA</h1>
<p>Jobs 1-10 of 555:
<b>All</b> - <a rel="nofollow" href="/m/jobs?q=data+scientist&l=Los+Angeles%2C+CA&from=newbtn&fromage=last">New</a>
 - <a href="/m/jobalerts?q=data+scientist&l=Los+Angeles%2C+CA&dest=%2Fm%2Fjobs%3Fq%3Ddata%2Bscientist%26l%3DLos%2BAngeles%252C%2BCA">Be the first to see
 new jobs</a>
</p>
<p><h2 class="jobTitle"><a rel="nofollow" href="viewjob?jk=46caf455b09ff764">Data Scientist</a></h2><br/>
The Honest Company - <span class="location">Los Angeles, CA</span><br/>
<style type="text/css"><!--
/* desired experience */
.experienceHeader{color:#666}
.experienceList{color:#000}
.experience{margin-top: 4px; margin-bottom: 5px}

--></style>
<div class="experience">
<span class="experienceHeader">Desired Experience: </span><span class="experienceList">Hive, Machine Learning, R, C/C++, MATLAB, Data Mining, Scala,
Weka, Java, Spark, Python</span><br>
</div>
<span class="date">1 day ago</span></p>
<hr/>
<p><h2 class="jobTitle"><a rel="nofollow" href="viewjob?jk=7b8f1e2c8b577bf6">Data Scientist</a></h2><br/>
Fuel Cycle - <span class="location">Los Angeles, CA</span><br/>
<span class="salary">$120,000 - $160,000 a year</span><br/><style type="text/css"><!--
```

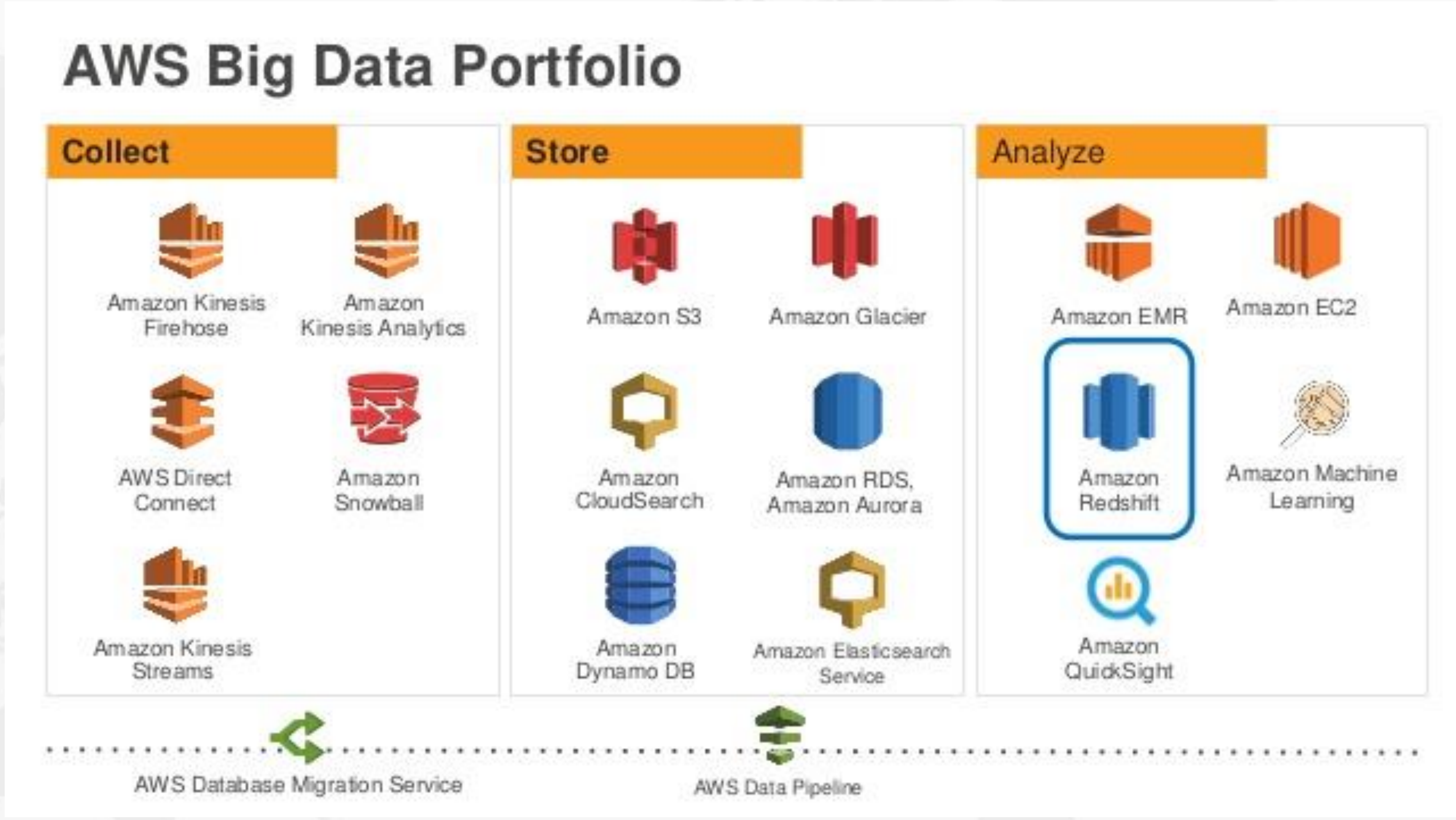
Data Source: RDBMS



```
import MySQLdb

# Open database connection
db = MySQLdb.connect("localhost","testuser","test123","TESTDB" )

# prepare a cursor object using cursor() method
cursor = db.cursor()

# execute SQL query using execute() method.
cursor.execute("SELECT VERSION()")

# Fetch a single row using fetchone() method.
data = cursor.fetchone()

print "Database version : %s " % data

# disconnect from server
db.close()
```

Data Source: HDFS & Cloud

- HDFS
  - Text file and table
  - MapReduce vs Spark
- Cloud Storage and Computing
  - AWS
  - Microsoft Azure
  - Google Could Platform



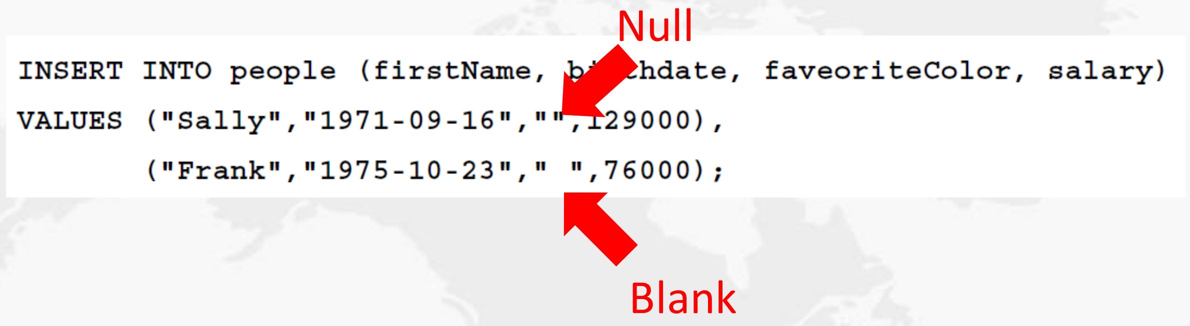
Data Types

- Numeric
  - Discrete: Count; Rating; Grade
  - Continuous: Revenue; Distance; Home Value
  - Watch out: data range! E.g. FICO
- Binary (Dummy)
  - Special case of numeric
  - E.g.: IsMale; HasCar; Pass/Fail
- Categorical
  - Usually contains characters: Gender, Product, Geo, etc.
  - Can be consist of pure numbers: SSN, Zipcode, Phone Number
  - Watch out: Valid Values
- Dates and Time
  - Date, Time, Datetime, Timestamp
  - Watch out: Time Zone!
  - UTC = Coordinated Universal Time = GMT = Greenwich Mean Time
- Missing

Data Types: Missing

- Null
  - Absence of everything; missing; empty

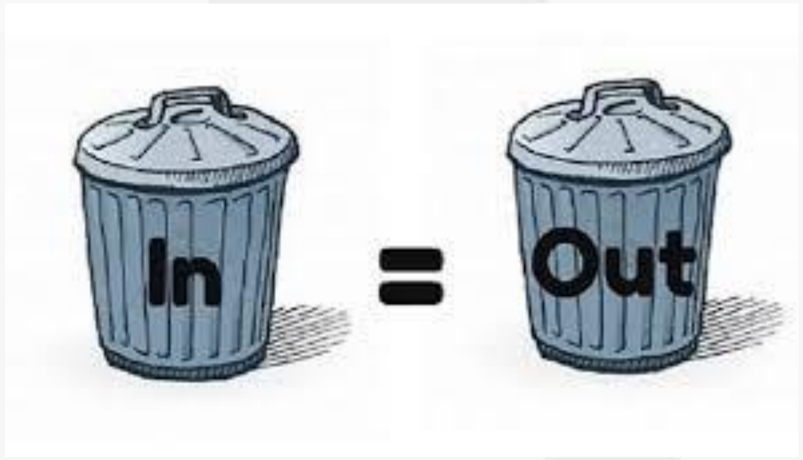
- Blank
  - " " or "   " or any invisible characters
  - Can mean missing
  - Can mean "N/A"
- N/A
  - Can mean "not available": e.g. Age
  - Can mean "not applicable": e.g. Middle Name
  - Can mean "no answer": e.g. Customer Satisfaction Rating on a Questionnaire



```
INSERT INTO people (firstName, birthdate, faveoriteColor, salary)
VALUES ("Sally","1971-09-16","",129000),
       ("Frank","1975-10-23"," ",76000);
```

Data Quality Issues

- Incorrect/Invalid Entry
  - age = 203; gender = 'X'; price = -100; weekday=8
- Missing Data
  - N/A; Null; " "; Unknown
- Unstructured Data
  - merged cell; double header; html
- Conflicting Data
  - click =1000; Impression = 200
- Duplicates
  - double loading; double counting
- Outlier
  - House Price > $1B; Annual Income < $500



Data Preparation Best Practice

2

Data Preparation Steps

- **Data Access**
- **Data Cleansing**
- **Handle Missing Data**
- **Identity Outlier**
- **Transform Data**
  - **One hot encoding: categorical to numerical**
  - **Normalization/Standardization**
  - **Log transformation**

Data Quality Check
Data Visualization

Data Cleansing: Techniques

- **Integrate:** integrate various data sources; integrate multiple columns
  - Merge sales units, sales revenue, price into one dataset
  - Combine year, month and date
- **Conform**: Conform the inconsistent values.
  - Na, n/a => missing
  - Los Angeles, L.A. => LA
- **Filter**: Filter out the columns and rows not needed for modeling
- **Group**: Group many categorical values into a few buckets
- **Aggregate**: Aggregate/Disaggregate date to the desired dimensions
- **Derive**: Extract or calculate new metrics based on existing metrics.
  - Price =Revenue/Units
  - Extract seasonality from sales
  - Regex

Data Cleansing: Regex 101

a single character of: a, b or c	**[abc]**
a character except: a, b or c	**[^abc]**
a character in the range: a-z	**[a-z]**
a character not in the range: a-z	**[^a-z]**
a character in the range: a-z or A-Z	**[a-zA-Z]**
any single character	**.**
any whitespace character	**\s**
any non-whitespace character	**\S**
any digit	**\d**
any non-digit	**\D**
any word character	**\w**
any non-word character	**\W**

capture everything enclosed	**(...)**
match either a or b	**(a|b)**
zero or one of a	**a?**
zero or more of a	**a***
one or more of a	**a+**
exactly 3 of a	**a{3}**
3 or more of a	**a{3,}**
between 3 and 6 of a	**a{3,6}**
start of string	**^**
end of string	**$**

https://regex101.com

Data Cleansing: Useful Regex

- Extract
  - Extract url from html: <a href=" https://www.dataapplab.com/ ">DataAppLab</a>
  - Regex = /href="([^"]*)/, Replace = $1
- Replace
  - Reverse last name and first name: San, Zhang => Zhang San
  - Regex=/([a-zA-Z]+),\s*([a-zA-Z]+)/, Replace = $2 $1
- Match/Validation
  - Validate a valid email
  - Regex =/^([a-z0-9_\.-]+)@([\da-z\.-]+)\.([a-z\.]{2,6})$/i

Missing Data: Types

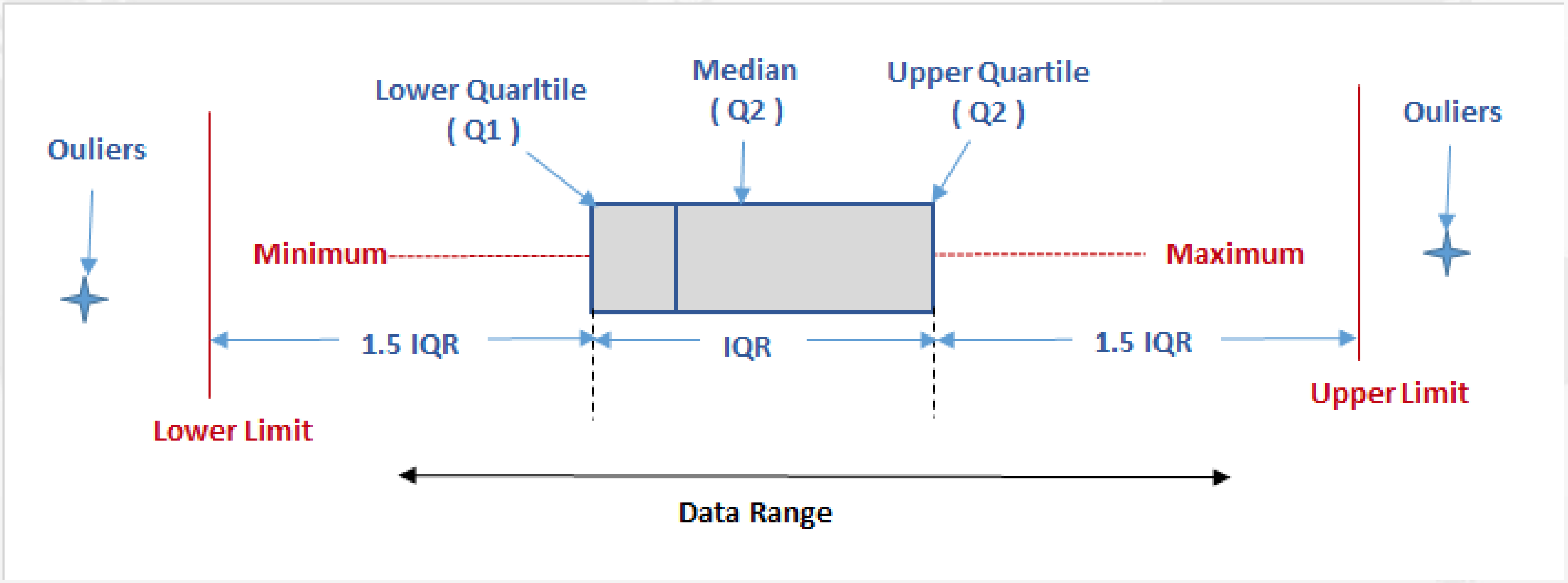
- **Missing completely at random: MCAR**
  - Roll a dice
  - Lottery number
- **Not missing at random: NMAR**
  - missing values are systematic
  - Income: higher income is less likely to respond
  - Weight: higher weight is less likely to respond
  - Smoking
- **Missing at random: MAR**
  - Most Common
  - Missing values can somewhat be predicted by known info
  - Know height, missing weight
  - Know # of rooms, missing sqrt

Missing Data: Handling

- Impute from other attributes
  - Impute weight from height
- Impute from other observations
  - Majority vote (categorical)
  - Mean of same/similar group (numerical)
  - Carry last value (time series)
  - Linear fill (time series)
  - Carry same trend (time series)
- “Missing” Category: not missing at random
- Dummy Variable—indicator of missing
- Remove row or column

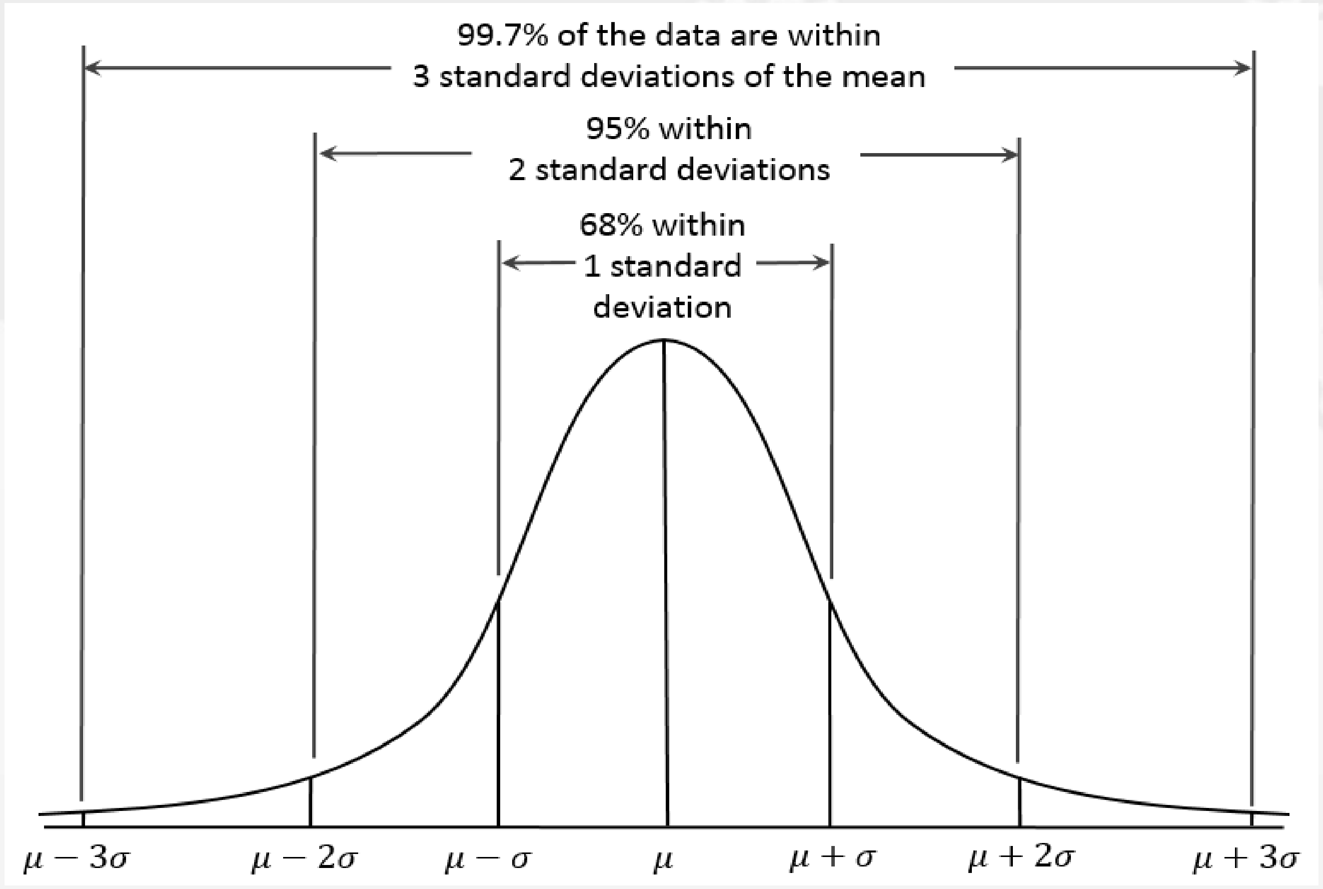
Outliers: 1.5 IQR

- Check the frequency distribution of the data
- Box-plot: An outlier is a point of data that lies over 1.5 IQRs(interquartile range) below the first quartile (Q1) or above third quartile (Q3) in a given data set.



Outlier: Normal Distribution

- Outlier: 2 or 3 STD from mean


99.7% of the data are within 3 standard deviations of the mean
95% within 2 standard deviations
68% within 1 standard deviation
$\mu - 3\sigma$
$\mu - 2\sigma$
$\mu - \sigma$
μ
$\mu + \sigma$
$\mu + 2\sigma$
$\mu + 3\sigma$

Outlier: Other Technics

- Univariable Outlier:
  - Median Absolute Deviation
- Multivariate Outlier
  - Mahalanobis Distance

Data Transformation: Normalization vs Standardization

	Normalization	Standardization
Formula	$x_{new} = \frac{x - x_{min}}{x_{max} - x_{min}}$	$x_{new} = \frac{x - \mu}{\sigma}$
Pro	• Bounded (0,1) • Apply to all distribution	• Works well for normal distribution
Con	• Make outliers "normal"	• Unbounded • Only works well for normal distribution

Transformation: When to Normalize

- Linear Model
  - Recommended
  - Doesn’t change model accuracy
  - Easier to compare coefficient: larger coefficient, larger impact
  - Intercept well interpreted: the expected value of Yi when the predictors are set to their means
  - Avoid coefficient like 10^-9 when one variable has a very large scale
  - Cons: More difficult to interpret the model in terms of on unit change in Xi
- Tree Model
  - Not necessary as the scale is irrelevant
- Logistic Regression
  - Typically not needed
- SVM
  - Recommended
  - Help with faster converge

Transformation: Log

Linear Model; Skewed Data

- Log Predictor

$$y = e^{ax} + \mathrm{b} \xrightarrow{\text{log x item}} y = ax' + \mathrm{b}$$

- Log Outcome

$$y = ln\ (ax + \mathrm{b}) \xrightarrow{\text{log y item}} y' = ax + \mathrm{b}$$

- Log both equation

$$y = e^c * x_1{}^{a} * x_2{}^{b} \xrightarrow{\text{log both sides}} \ln y = c + ax_1 + \mathrm{bx}_2$$

Demo

- **Use Python to clean Airbnb listings data (from file)**

Web Data Preparation

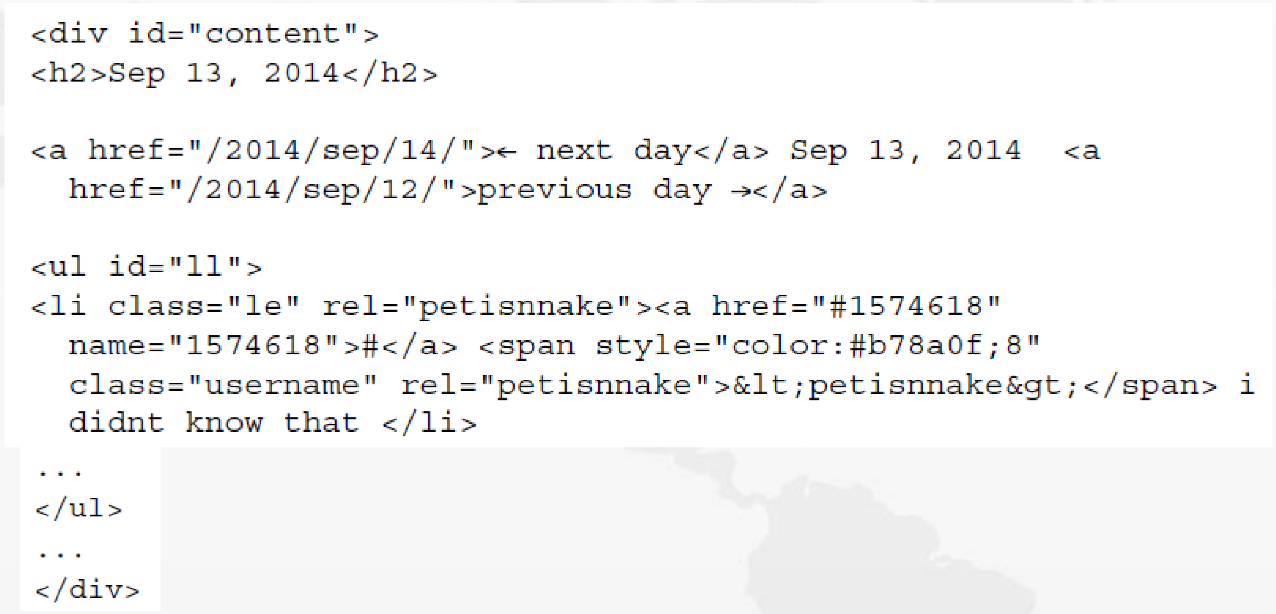
3

Web data raw format: HTML

Understanding the HTML Page Structure

HTML can be parsed in two ways:

- The line-by-line delimiter model
- The tree structure model



```
<div id="content">
<h2>Sep 13, 2014</h2>

<a href="/2014/sep/14/">← next day</a> Sep 13, 2014  <a
  href="/2014/sep/12/">previous day →</a>

<ul id="ll">
<li class="le" rel="petisnnake"><a href="#1574618"
  name="1574618">#</a> <span style="color:#b78a0f;8"
  class="username" rel="petisnnake">&lt;petisnnake&gt;</span> i
  didnt know that </li>
...
</ul>
...
</div>
```

Web Scraping: Line by Line

The line-by-line delimiter model

```
<div id="content">
<h2>Sep 13, 2014</h2>

<a href="/2014/sep/14/">← next day</a> Sep 13, 2014  <a
  href="/2014/sep/12/">previous day →</a>

<ul id="ll">
<li class="le" rel="petisnnake"><a href="#1574618"
  name="1574618">#</a> <span style="color:#b78a0f;8"
  class="username" rel="petisnnake">&lt;petisnnake&gt;</span> i
  didnt know that </li>
...
</ul>
...
</div>
```

- <h2></h2> tags as delimiters to extract the date
- <li></li> tags as delimiters to extract text
- Rel="" as delimiters to extract user name
- From the end of </span> to the beginning of </li> is the actual line message

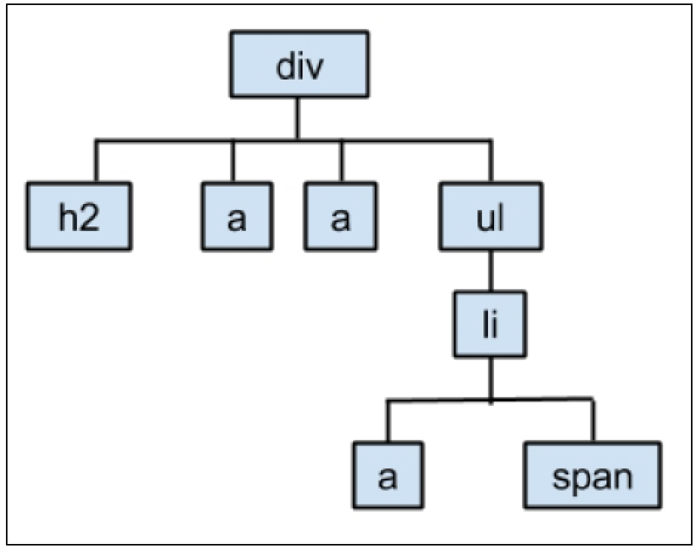
Extract date by Regex: <h2>(.+)<\/h2>

Extract message by Regex : <\/span>(.+)<\/li>

Web Scraping: Tree Model

The tree structure model: we can consider the structure of HTML as a tree structure

```
<div id="content">
<h2>Sep 13, 2014</h2>

<a href="/2014/sep/14/">← next day</a> Sep 13, 2014  <a
  href="/2014/sep/12/">previous day →</a>

<ul id="ll">
<li class="le" rel="petisnnake"><a href="#1574618"
  name="1574618">#</a> <span style="color:#b78a0f;8"
  class="username" rel="petisnnake">&lt;petisnnake&gt;</span> i
  didnt know that </li>
...
</ul>
...
</div>
```



Extract date by beautifulSoup: div.h2.text

Extract message by beautifulSoup: div.ul.li.text

Demo

- Use Python Beautifulsoup to collect and clean job listing data from indeed.com

Homework

- Got to indeed.com and scrape first 50(or how many you want) pages of data scientist jobs (without limiting the location) and analyze on below questions:
  - What’s the distribution of data scientists’ salary
  - What’s the geographic distribution of the jobs
  - What are the top 10 skills required for data scientist jobs: NLTK

Q&A

4