Data Handling and Aggregation

VISUALIZATION ON THE WEB

Adapted from: http://learnjsdata.com/read_data.html

DATA LOADING

CSV File Format

- Text-based representation of tabular data
- A file contains a set of rows/lines
  - Each line has a sequence of fields, separated by commas
  - Optionally, the first row of the file may contain field names
- By convention, the separator is a comma ‘,’
  - We may also have tabs ‘\t’ (called TSV) or other symbolds (callsed DSV)

CSV Example

```
source,target,value,groupsource,grouptarget
Napoleon,Myriel,1,1,1
Mlle.Baptistine,Myriel,8,1,1
Mme.Magloire,Myriel,10,1,1
Mme.Magloire,Mlle.Baptistine,6,1,1
CountessdeLo,Myriel,1,1,1
Geborand,Myriel,1,1,1
Champtercier,Myriel,1,1,1
Cravatte,Myriel,1,1,1
Count,Myriel,2,1,1
OldMan,Myriel,1,1,1
Valjean,Labarre,1,2,2
Valjean,Mme.Magloire,3,2,1
[...]
```

JSON Format

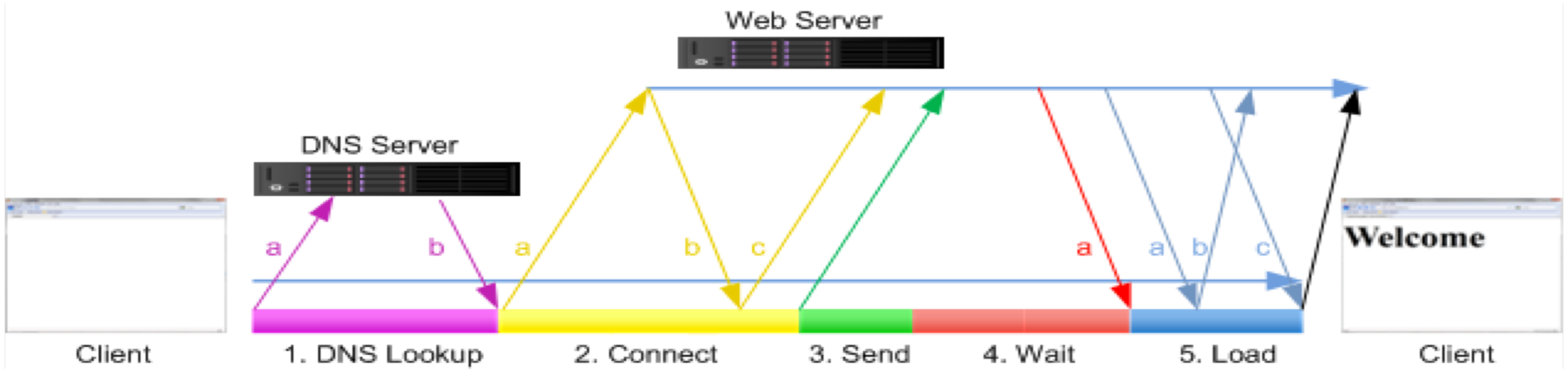
- Text-based representation of hierarchical data
- Used to encode structured objects
- Based on the definition of a key-value pairs

JSON Example

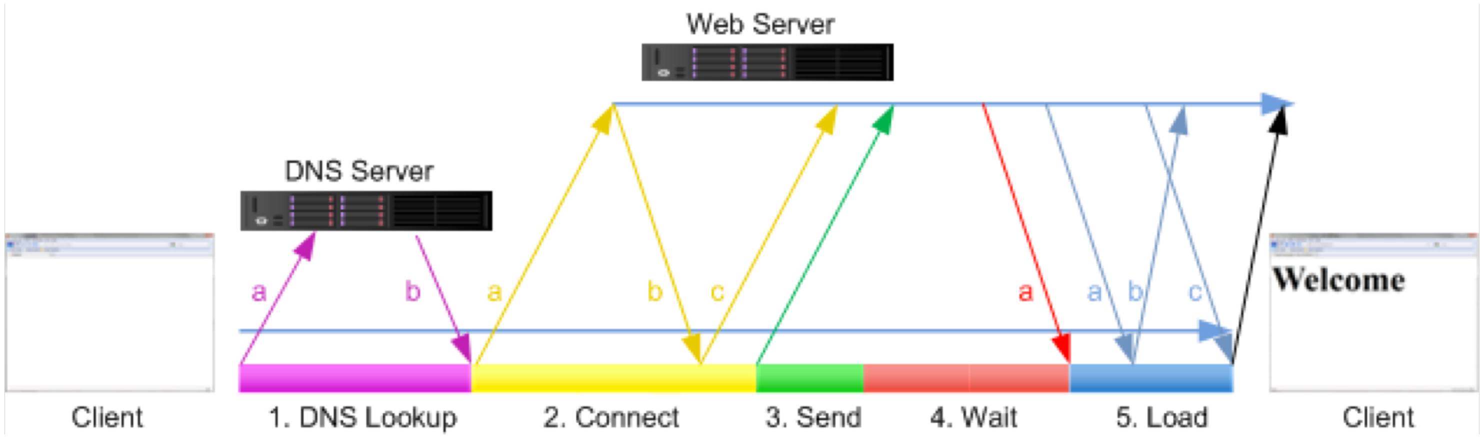
```json
{
  "firstName": "John",
  "lastName": "Smith",
  "isAlive": true,
  "age": 27,
  "address": {
    "streetAddress": "21 2nd Street",
    "city": "New York",
    "state": "NY",
    "postalCode": "10021-3100"
  },
  "phoneNumbers": [
    {
      "type": "home",
      "number": "212 555-1234"
    },
    {
      "type": "office",
      "number": "646 555-4567"
    },
    {
      "type": "mobile",
      "number": "123 456-7890"
    }
  ],
  "children": [],
  "spouse": null
}
```

HTTP

- 3. Send
- HTTP Request
  - Methods to tell server what the client need
- HTTP Methods:
  - GET; POST; PUT; DELETE; OPTIONS;…



HTTP



- 4. Wait and 5. Load
- HTTP Response
  - Read Response Codes
  - Read data

- HTTP Response Codes
  - 1xx – Informational
  - 2xx – Success
  - 3xx – Redirection
  - 4xx – Client Error
  - 5xx – Server Error

Data loading - Promises

- The most common file types are handled by specific functions in D3
  - csv, json, tsv, dsv
- CSV

```
d3.csv("/data/cities.csv»)
  .then(function(data) {
     // data contains the whole dataset
     console.log(data[0]);
   })
   .catch(function(error){
      // handle error
   });
=> {city: "seattle", state: "WA", population: "652405",
land area: "83.9"}
```

Data processing and cleaning

```
=> {city: "seattle", state: "WA", population: "652405", land area: "83.9"}
```

- All values are parsed as string. We need to do type conversion manually.
- We iterate over an array of values by using an iterator anonymous function with `map()`

```
d3.csv("/data/cities.csv»)
 .then(function(data) {
  return data.map(function(d){
    return {
      city : d.city,
      state : d.state,
      population : +d.population,
      land_area : +d["land area"]
    })
 })
 .catch(function(error){
   // ...
 };
```

Loading Multiple files

- To load multiple files that are needed for the application, we can use `Promise.al()` method

```
const files = ["/data/cities.csv", "/data/animals.csv"];
let promises = [];

files.forEach(function(url){
  promises.push(d3.csv(url));
});

Promises.all(promises)
  .then(function(values){
    analyze(values[0], values[1])
  });

function analyze(cities, animals) {
  console.log(cities[0]);
  console.log(animals[0]);
}
=> {city: "seattle", state: "WA", population: "652405", land area: "83.9"}
{name: "tiger", type: "mammal", avg_weight: "260"}
```

Statistics and Summary

```
var data = [
  {"city":"seattle", "state":"WA",
"population":652405, "land_area":83.9},
  {"city":"new york", "state":"NY",
"population":8405837, "land_area":302.6},
  {"city":"boston", "state":"MA",
"population":645966, "land_area":48.3},
  {"city":"kansas city", "state":"MO",
"population":467007, "land_area":315}
];
```

Statistics and summary of data

- Min, Max and Extent

```
var minLand = d3.min(data, function(d) {
return d.land_area; });
console.log(minLand); // => 48.3
var maxLand = d3.max(data, function(d) {
return d.land_area; });
console.log(maxLand); // => 315
var landExtent = d3.extent(data, function(d)
{ return d.land_area; });
console.log(landExtent);  // => [48.3, 315]
```

- Average, Median, Deviation

Statistics and summary of data

- Min, Max and Extent
- Average, Median, Deviation

```
var landAvg = d3.mean(data, function(d) { return
d.land_area; });
console.log(landAvg); // => 187.45
var landMed = d3.median(data, function(d) {
return d.land_area; });
console.log(landMed); // => 193.25
var landSD = d3.deviation(data, function(d) {
return d.land_area; });
console.log(landSD); // => 140.96553952414519
```

Iteration, Map and Reduce

- Javascript `map()` function allows to transform our data into a new dataset
- The function takes an array in input and produce a new array with the result of calling a function on each element of the input

map() example

```
var smallData = data.map(function(d,i) {
  return {
    name: d.city.toUpperCase(),
    index: i + 1,
    rounded_area: Math.round(d.land_area)
  };
});
console.log(data[0]);
console.log(smallData[0]);

=> {city: "seattle", state: "WA", population:
652405, land_area: 83.9}
  {name: "SEATTLE", index: 1, rounded_area: 84}
```

Filtering

- To select a subset of avaiable rows we use the function filter()

```
var large_land = data.filter(function(d) {
return d.land_area > 200; });
console.log(JSON.stringify(large_land));
=> [{"city":"new
york","state":"NY","population":8405837,"land_a
rea":302.6},
  {"city":"kansas
city","state":"MO","population":467007,"land_ar
ea":315}]
```

Sorting

- To sort rows of a dataset, we use the function `sort()`
- The sorting is done inplace (it modifies the original data)
- Sorting is done according to a comparator function. The comparator is given two entries a and b of the data and should return -1 (if a is smaller than b), 0 (if a and b are equal), +1 (if a il larger than b)

Sorting Example

```
data.sort(function(a,b) {
  return b.population - a.population;
});
console.log(JSON.stringify(data));
=> [{"city":"new
york","state":"NY","population":8405837,"land_area":
302.6},

{"city":"seattle","state":"WA","population":652405,"
land_area":83.9},

{"city":"boston","state":"MA","population":645966,"l
and_area":48.3},
   {"city":"kansas
city","state":"MO","population":467007,"land_area":3
15}]
```

Reducing

- A family of functions that takes a whole array and reduce it to a single value
- Eg: sum, average, median
- Sum

```
var landSum = data.reduce(function(sum, d) {
  return sum + d.land_area;
}, 0);
console.log(landSum);
=> 749.8
```

Reducing

- Function reduce() takes two parameters
  - A function to compute the aggregated value, that takes in input the value computed at the previous step of the iteration and the current value
  - An initial value of the aggregate. If this value is not specified, the initial value is set to the value of the first element and the iteration starts from the second entry.

Chaining

- The functional declaration of these transformation enable function chaining

```
var bigCities = data.filter(function(d) { return
d.population > 500000; })
  .sort(function(a,b) { return a.population -
b.population; })
  .map(function(d) { return d.city; });
console.log(bigCities);
=> ["boston", "seattle", "new york"]
```

Grouping

Example data

```
var expenses = [
  {"name":"jim","amount":34,"date":"11/12/2015"},
  {"name":"carl","amount":120.11,"date":"11/12/2015"},
  {"name":"jim","amount":45,"date":"12/01/2015"},
  {"name":"stacy","amount":12.00,"date":"01/04/2016"},
  {"name":"stacy","amount":34.10,"date":"01/04/2016"},
  {"name":"stacy","amount":44.80,"date":"01/05/2016"}
];
```

Slice data by values

- Group rows by value

```
var expensesByName = d3.nest()
  .key(function(d) { return d.name; })
  .entries(expenses);
=> expensesByName = [
  {"key":"jim","values":[
    {"name":"jim","amount":34,"date":"11/12/2015"},
    {"name":"jim","amount":45,"date":"12/01/2015"}
  ]},
  {"key":"carl","values":[
    {"name":"carl","amount":120.11,"date":"11/12/2015"}
  ]},
  {"key":"stacy","values":[
    {"name":"stacy","amount":12.00,"date":"01/04/2016"},
    {"name":"stacy","amount":34.10,"date":"01/04/2016"},
    {"name":"stacy","amount":44.80,"date":"01/05/2016"}
  ]}
];
```

Summarize data by values in each group

```
var expensesAvgAmount = d3.nest()
  .key(function(d) { return d.name; })
  .rollup(function(v) { return d3.mean(v,
function(d) { return d.amount; }); })
  .entries(expenses);
console.log(expensesAvgAmount);
=> [
  {"key":"jim","values":39.5},
  {"key":"carl","values":120.11},
  {"key":"stacy","values":30.3}
]
```

Crossfilter.js

http://square.github.io/crossfilter/

Crossfilter

- Crossfilter is a library for multidimensional filtering
- Two basic concepts:
  - Dimension: a property of the data to exploit to split items (i.e. a column in a relational table)
  - Groups: to aggregate rows by values in a dimension (i.e. like a groupby in SQL)

Example from VC 2008

```
[
{"EncounterDate":"2005-04-
26","NumDeaths":0,"Passengers":6,"RecordNotes":null,"RecordType":"Interdicti
on","USCG_Vessel":"Cunningham","VesselType":"Raft","year":2005,"Month":"2005
-04","EncounterCoords":[-
80.14622349209523,24.53605142362535],"LaunchCoords":[null,null]},
{"EncounterDate":"2005-05-
15","NumDeaths":0,"Passengers":11,"RecordNotes":null,"RecordType":"Interdict
ion","USCG_Vessel":"Forthright","VesselType":"Rustic","year":2005,"Month":"2
005-05","EncounterCoords":[-
80.75496221688965,24.72483828554483],"LaunchCoords":[-
79.65932674368925,23.70743135623052]},
{"EncounterDate":"2005-02-
25","NumDeaths":0,"Passengers":6,"RecordNotes":null,"RecordType":"Interdicti
on","USCG_Vessel":"Pompano","VesselType":"Raft","year":2005,"Month":"2005-
02","EncounterCoords":[-
80.32020594311533,25.02156920297054],"LaunchCoords":[null,null]},
{"EncounterDate":"2005-04-
13","NumDeaths":0,"Passengers":6,"RecordNotes":null,"RecordType":"Interdicti
on","USCG_Vessel":"Tripoteur","VesselType":"Raft","year":2005,"Month":"2005-
04","EncounterCoords":[-
80.15149489716094,24.57412215015249],"LaunchCoords":[-
79.65999190070923,23.73619147168514]}
]
```

Basic statistics

```
var cf = crossfilter(migrants);
// how many report?
// select count(*) from migrants
console.log("num reports",
cf.groupAll().reduceCount().value());

// select sum(Passengers) from migrants
console.log("num passengers",
cf.groupAll().reduceSum(function(d){return
d.Passengers}).value())

// select sum(NumDeaths) from migrants
console.log("num deaths",
cf.groupAll().reduceSum(function(d){return
d.NumDeaths}).value())
```

Dimensions and Filtering

- Define a dimension by providing a function to select a value for each row

```
var dVesselType = cf.dimension(function(d){return d.VesselType});
// select count(*) from migrants where VesselType=="Rustic”
dVesselType.filter("Rustic");
console.log("num reports
(Rustic)",cf.groupAll().reduceCount().value());
// select sum(Passengers) from migrants where VesselType=="Rustic”
console.log("num passengers (Rustic)",
cf.groupAll().reduceSum(function(d){return d.Passengers}).value())
// select sum(NumDeaths) from migrants where VesselType=="Rustic”
console.log("num deaths (Rustic)",
cf.groupAll().reduceSum(function(d){return d.NumDeaths}).value())
// select VesselType, count(*) from migrants group by VesselType
var countVesselType = dVesselType.group().reduceCount();
console.log(countVesselType.all());
```

RESTful and APIs with Express.js

API Restful Layer

- Visualization on web browser can not have a direct access to DBMS or other persistence layers
- The only data available should be reachable via HTTP(s) protocol
- To expose data from the backend to the web, we implement a RESTful API layer

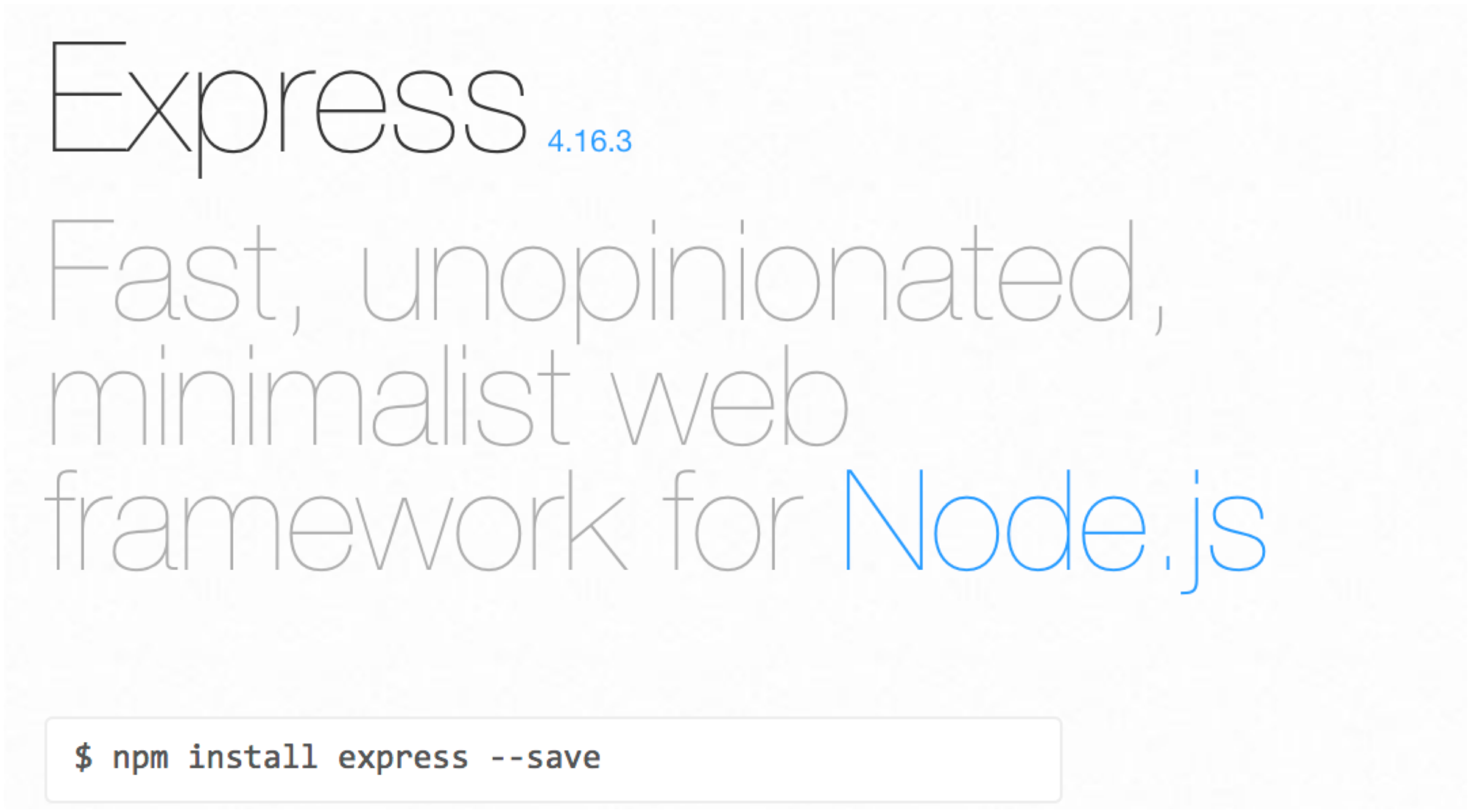
Application Programming Interface

- Definition of a series of endpoints to let other programs to use or interact with a service
- Acronym REST stands for Representational State Transfer
  - Defines a set of guidelines to allow a web service to expose internal functionalities to the internet

API RESTful interface to access data

- In our context we may use API interfaces to access data
- The endpoints need to be accessible via web (HTTP protocol)
- The endpoints are realized using an extension of a web server
  - HTTP protocol: this server provides the mechanism to provide a response to each request
  - Application server: for each request, we execute some program within the server to provide a response

Express.js


Express 4.16.3

Fast, unopinionated, minimalist web framework for Node.js

```
$ npm install express --save
```

http://expressjs.com/

Case study on Vast Challenge 2015

- See https://github.com/va602aa-2019/Express_rest
- Create a DB (for this example we are using SQLite)
- Load data from CSV files of challenge into the tables

Creation of the DB and import of the data

```
sqlite3 vast2015_mc1.db
SQLite version 3.8.5 2014-08-15 22:37:57
Enter ".help" for usage hints.
sqlite> create table movements(ts text, id integer, tag text,x
integer, y integer);
sqlite> .separator ","
sqlite> .import park-movement-Fri.csv movements
sqlite> .import park-movement-Sat.csv movements
sqlite> .import park-movement-Sun.csv movements
```

The .import command appends new rows read from the CSV file to the existing table. If called more than once on the same file may create duplicate rows. All the rows are mapped to the corresponding ordinal column. We should remove the headers loaded from the files

Convert timestamp column

```
sqlite> create table movs as select id,
datetime(replace(ts,'-6-','-06-')) as ts, x, y,
tag from movements ;
sqlite> drop table movements;
sqlite> VACUUM;
```

Optimize performances

```
sqlite> .indices
sqlite> create index if not exists idx_movs_id
on movs(id);
sqlite> create index if not exists idx_movs_ts
on movs(ts);
```