DSCI LECTURE 2

SURVEY OF VISUALIZATION TECHNIQUES, INTRODUCTION TO WEB TECHNOLOGIES

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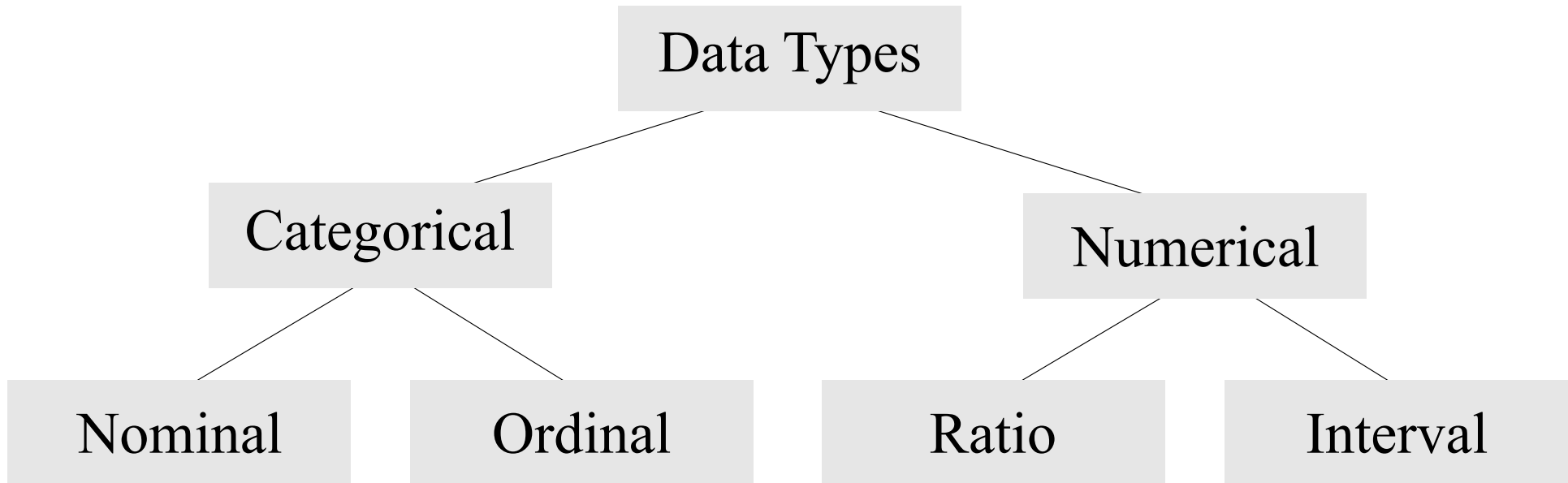
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School of Engineering
Integrated Media Systems Center

OUTLINE

- Data
- Visualization Techniques
- Introduction to WEB Technologies
- Sample quiz questions

Data *is plural (from the latin "what is given")*

*A single piece of data is called a **datum***

DATA TYPES

```
                    ┌──────────────┐
                    │  Data Types  │
                    └──────────────┘
                    /              \
           ┌──────────────┐    ┌──────────────┐
           │ Categorical  │    │  Numerical   │
           └──────────────┘    └──────────────┘
            /          \          /          \
     ┌─────────┐  ┌─────────┐  ┌─────────┐  ┌──────────┐
     │ Nominal │  │ Ordinal │  │  Ratio  │  │ Interval │
     └─────────┘  └─────────┘  └─────────┘  └──────────┘
```

The methods used to display, summarize, and analyze data depend on the type of the variables

CATEGORICAL DATA

Nominal
○ No natural ordering
○ Difference not meaningful
○ $=\neq$

Ordinal
○ Logical ordering
○ Difference (not) meaningful
○ $=\neq<>$

---

gender (male, female)
ethnicity (African American, Asian, Caucasian, Hispanics)
nationality

levels of happiness
levels of difficulty

QUALIFIED CATEGORICAL DATA

Binomial: right/left, true/false

Dichotomous: hot/cold

vs.

Non-dichotomous: Likert scale

Strongly Disagree	Disagree	Neither Agree nor Disagree	Agree	Strongly Agree

NUMERICAL DATA

Ratio

○ Ordered
○ Differences meaningful
○ Doubling meaningful
○ 0 fixed
○ $= \neq <> -\%$

Kelvin: $40^o K = 2 \times 20^o K$

height
weight

Interval

○ Ordered
○ Differences meaningful
○ Doubling **not** meaningful
○ 0 arbitrary
○ $= \neq <> -$

Celsius: $40^o C \neq 2 \times 20^o C$

calendar year
letter grade

DATA MODELS

Conceptual model	Semantic description of data entities and their relations
Logical model	*Implementation independent* data design representation
Physical model	*Implementation dependent* details by which data is actually stored

Data models definitions with relational data model example

VISUALIZATION REFERENCE MODEL*
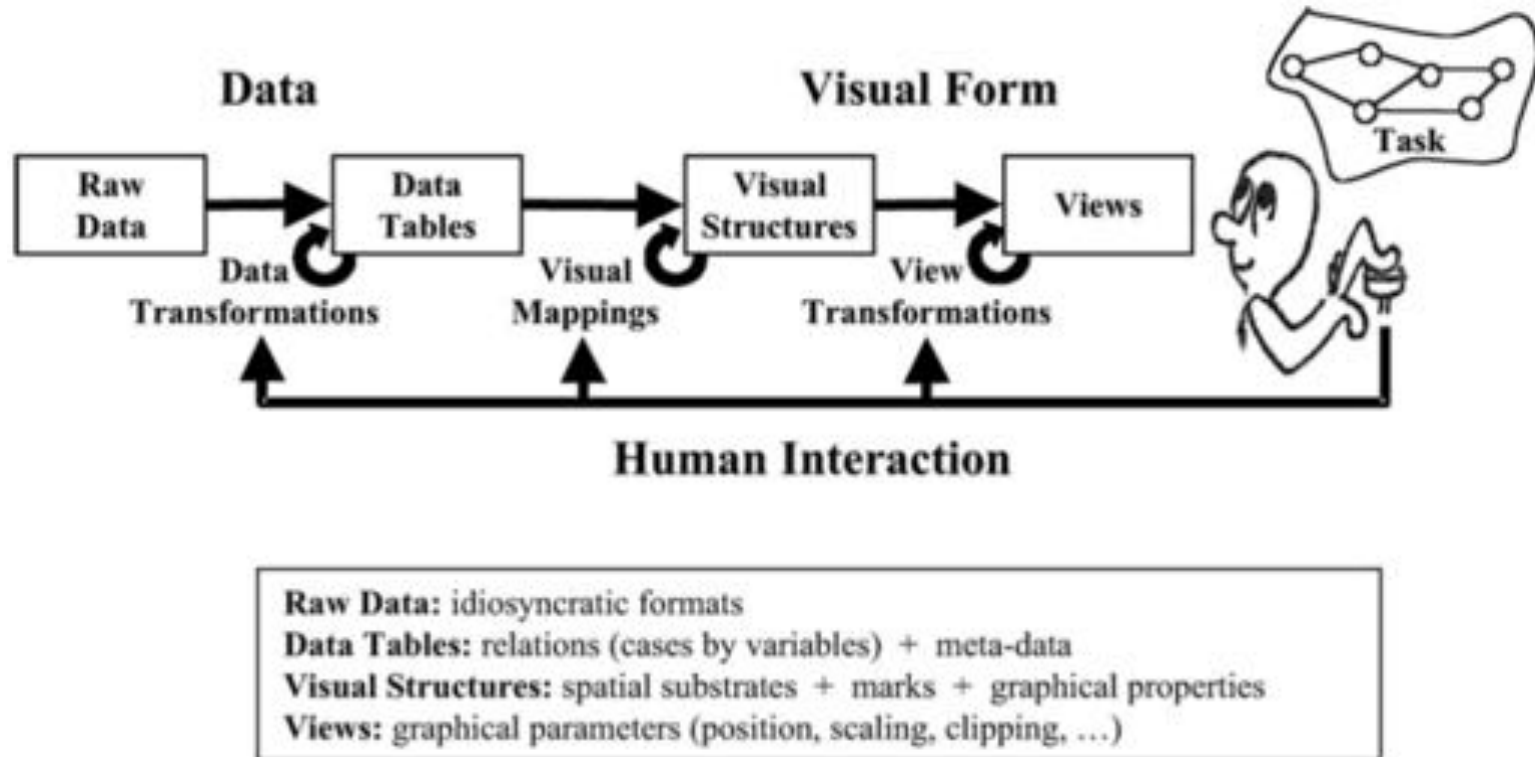
Visualization can be described as the mapping of data to visual form that supports human interaction in a workplace for visual sense making.

* Card, Stuart, J. D. Mackinlay, and B. Shneiderman. "Information visualization." Human-computer interaction: design issues, solutions, and applications. 2009.

OUTLINE

- Data
- <mark>Visualization Techniques</mark>
- Introduction to WEB Technologies
- Sample quiz questions

VISUALIZATIONS TAXONOMY BY TECHNIQUE & DATA TYPE

1. Charts
2. Graphs and Trees
3. Clouds
4. Temporal
5. Geospatial and Mapping

Other taxonomy*: one-, two-, three-dimensional data, temporal and multi-dimensional data, and tree and network data.

* The eyes have it: A task by data type taxonomy for information visualizations, Shneiderman, Ben, IEEE Symposium on Visual Languages, 1996.

1. CHARTS WITH MARKS AS DOTS

SCATTERPLOT
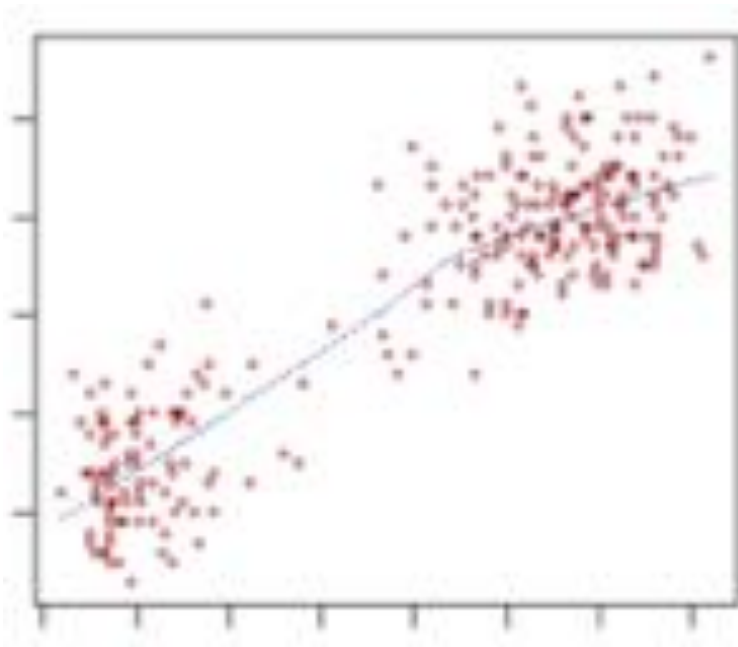
2+ variables in Cartesian coordinates

BUBBLE CHART
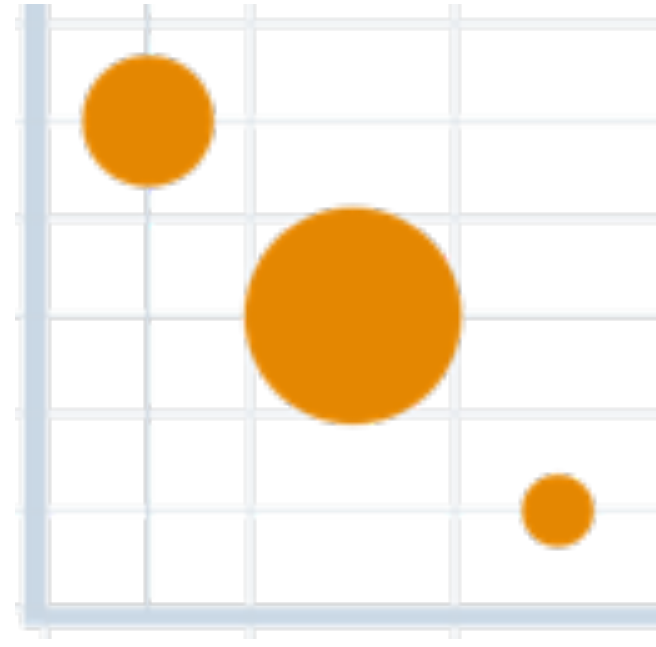
3 continuous variables: bubble center (2) and radius (1)

1. CHARTS WITH MARKS AS BARS

BAR CHART

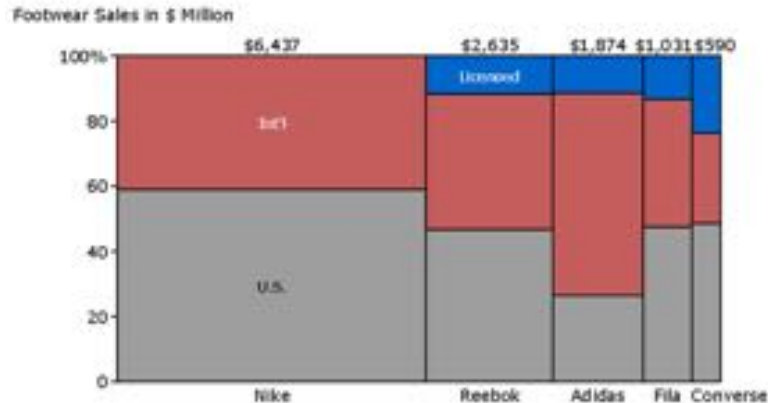Bar length proportional to continuous variable

LOLLIPOP CHART
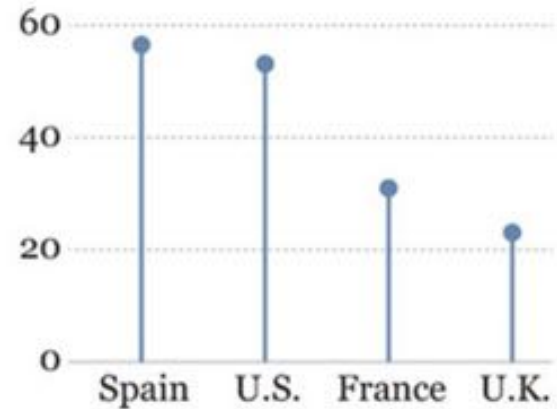
Line length proportional to continuous variable and data point

1. CHART <u>LAYOUTS</u> WITH MARKS AS BARS

MARIMEKKO (MEKKO) CHART

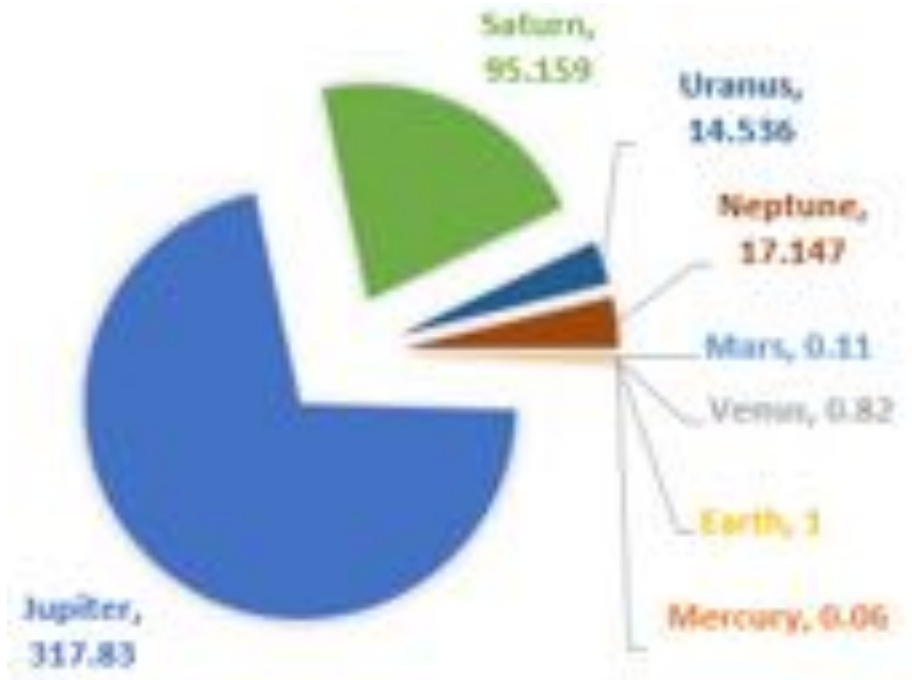Bar chart where the width encodes relative size. Also called Mekko chart.

WATERFALL CHART

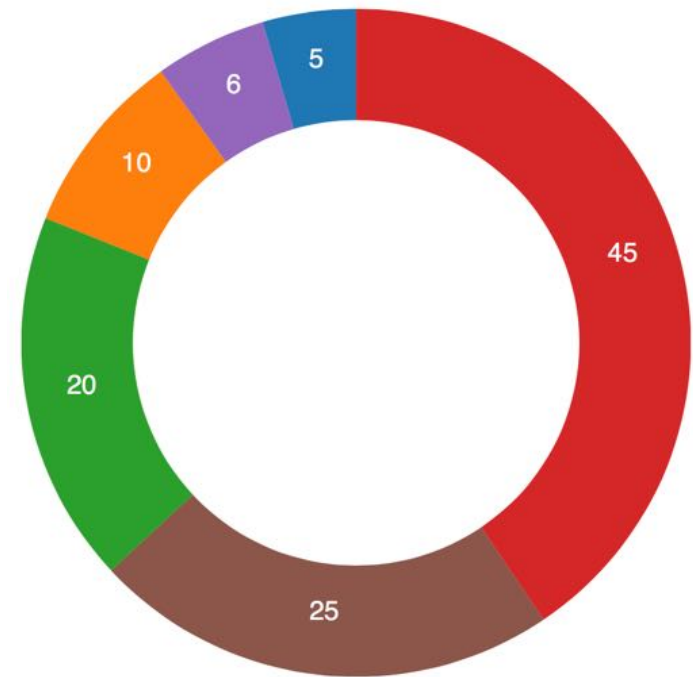Cumulative effects of sequence of positive and negative variations

1. PIE CHARTS WITH MARKS AS ARCS

PIE CHART

Exploded pie chart. In pie charts, the angle and area of each slice is proportional to the quantity represented.
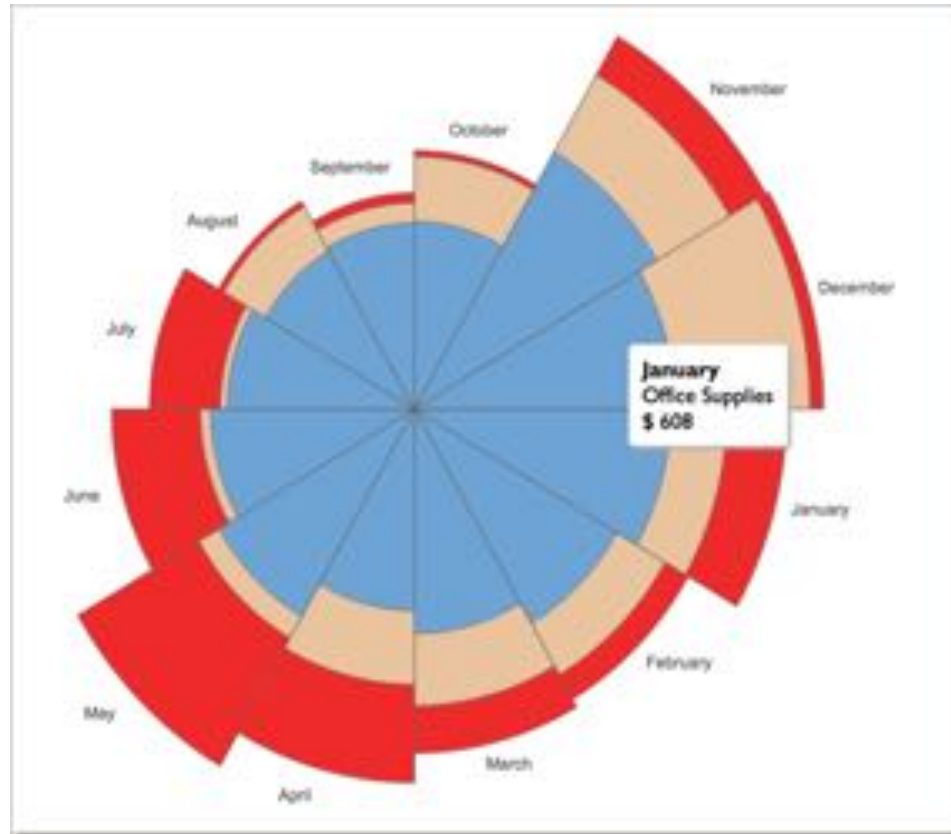
DONUT CHART

Pie Chart with centre area cut out. Angle encodes proportion.

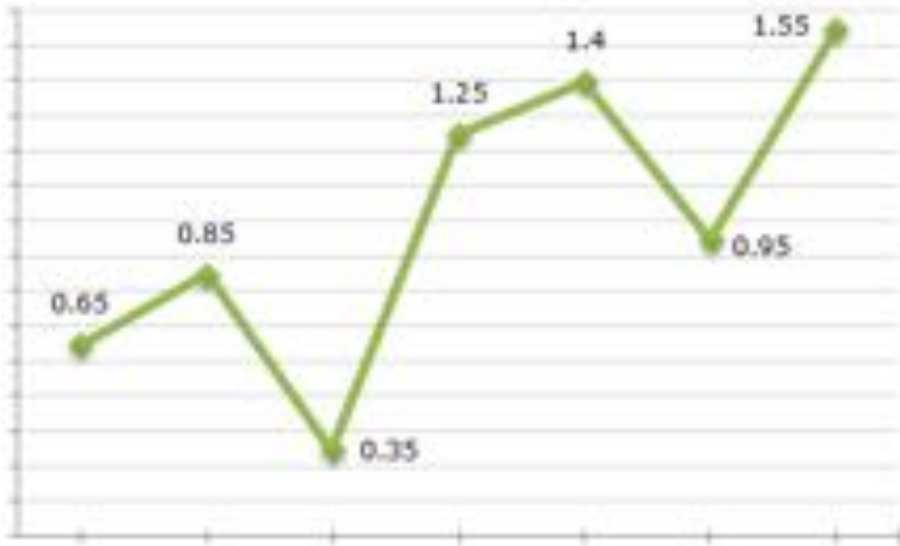# 1. PIE CHARTS LAYOUTS WITH MARKS AS ARCS

COXCOMB CHART

Similar to a pie chart with slices of same angle, radius encodes value, colors different categories. Stacked bar chart with radial layout.

1. CHARTS WITH MARKS AS LINES

LINE CHART

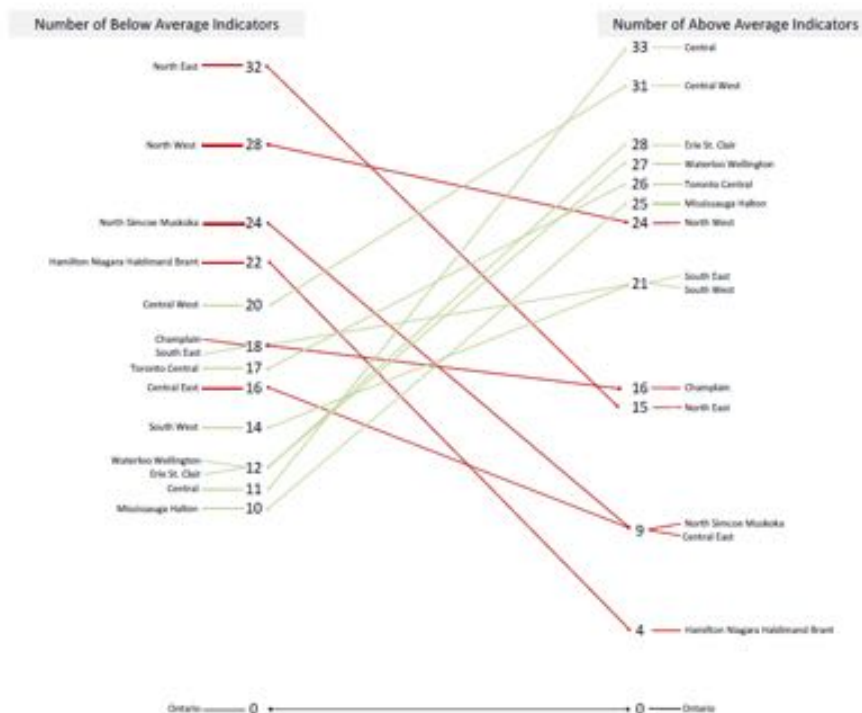Trends on continuous variables, e.g., time-series

SPARKLINE

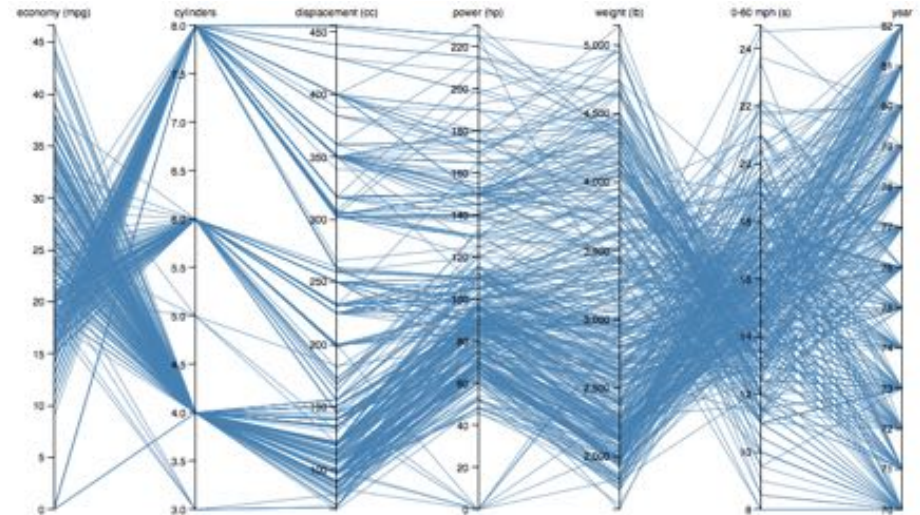Trends on small window size [Tufte 2004]

1. CHARTS LAYOUTS WITH MARKS AS LINES

SLOPEGRAPH

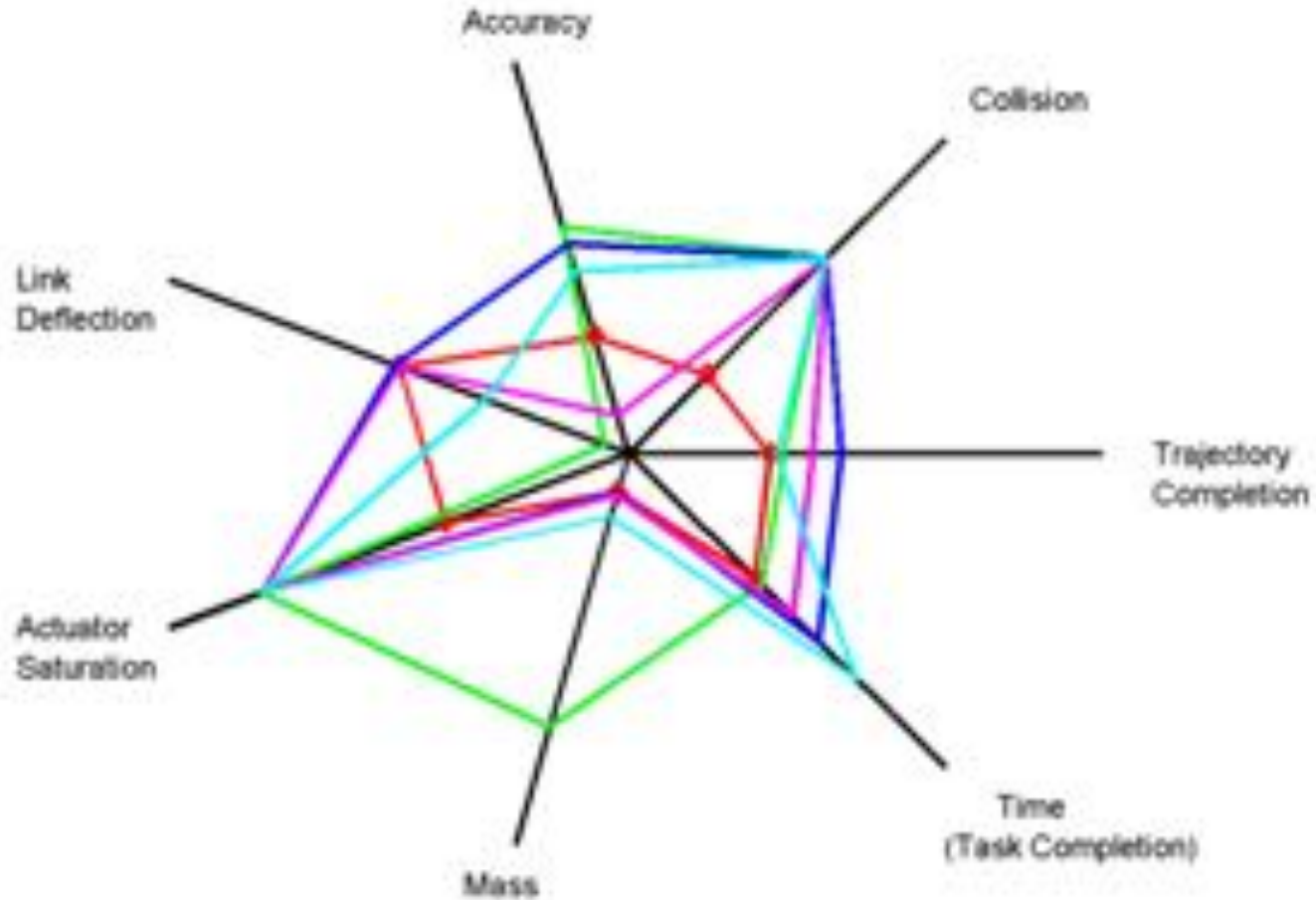Shows data values, trends [Tufte 1983]

PARALLEL COORDINATES

Multivariate data.

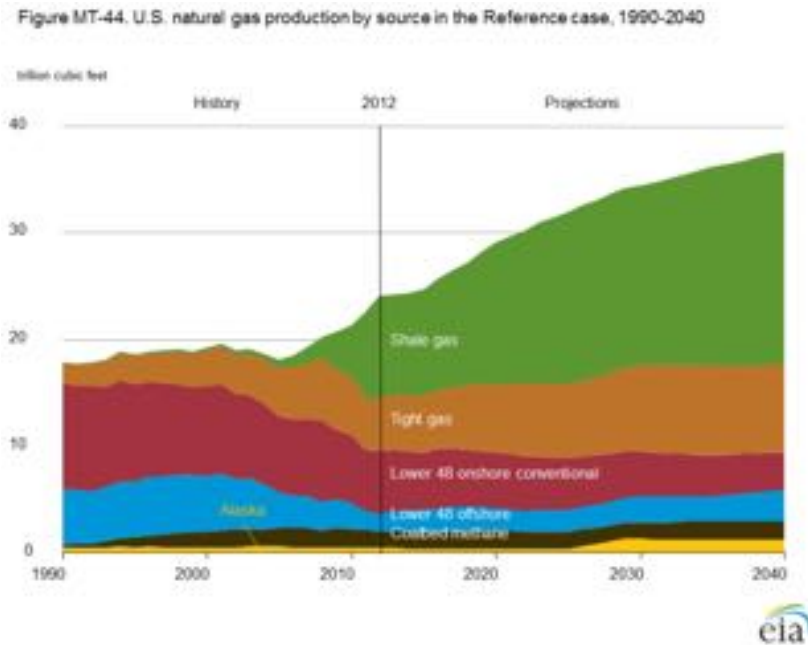# 1. CHARTS LAYOUTS WITH MARKS AS LINES

RADAR CHART

Multivariate data. Also named web, spider, star, cobweb, polar, or Kiviat.

1. CHARTS WITH MARKS AS AREAS

AREA CHART

Figure MT-44. U.S. natural gas production by source in the Reference case, 1990-2040

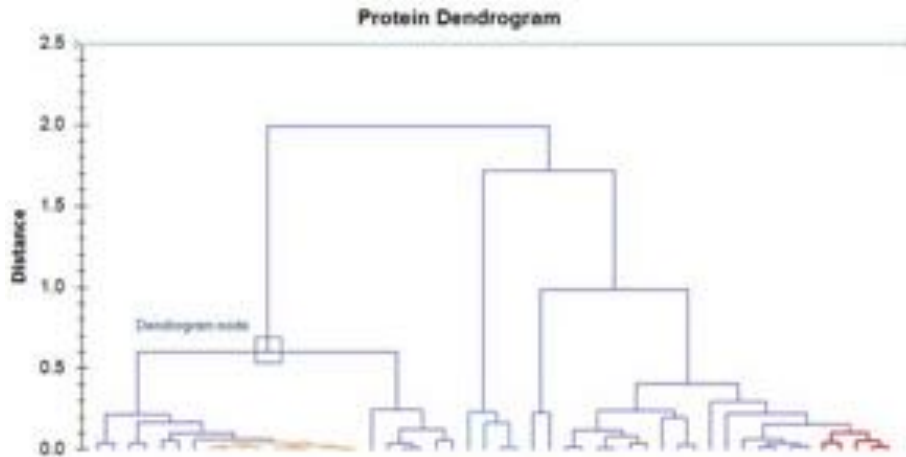Show cumulative or proportions and trends

STREAMGRAPH
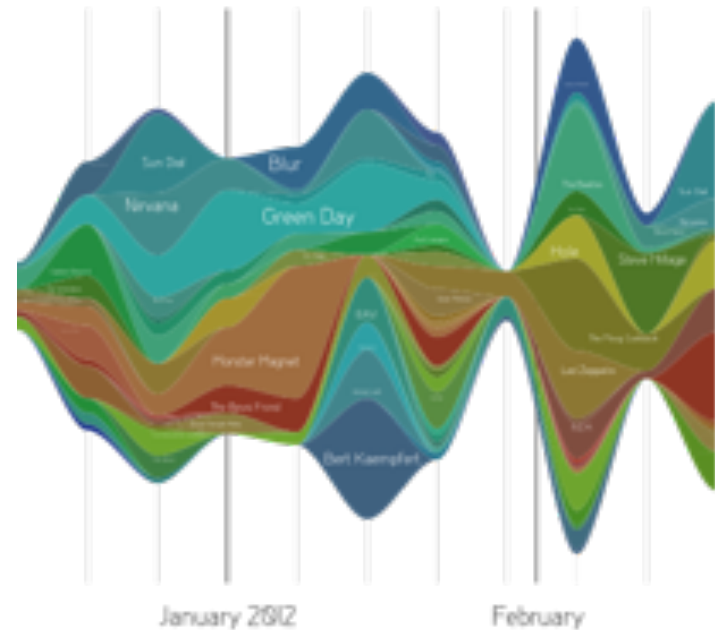
Type of stacked area chart which is displaced around a central axis, resulting in a flowing, organic shape

2. GRAPHS AND TREES: HIERARCHIES

DENDROGRAM

From Greek dendro *"tree"* and gramma *"drawing"*.

REINGOLD–TILFORD TREE (<u>LAYOUT</u>)
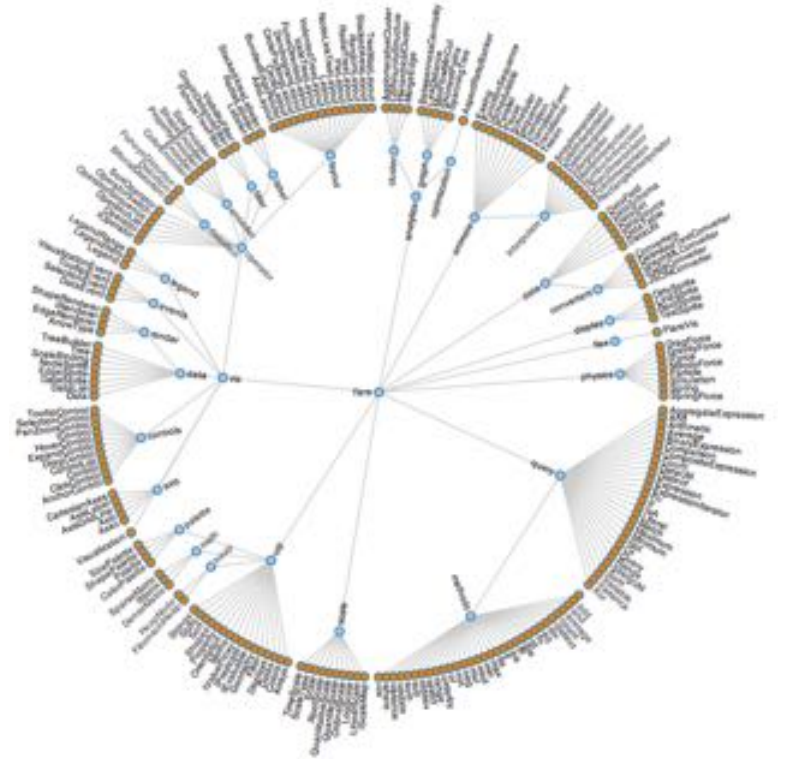
Hierarchical data as linked tree in a radial layout

2. GRAPHS AND TREES: HIERARCHIES

TREEMAP

Hierarchical data as nested rectangles. Area proportional to value.

SUNBURST

Hierarchical data as rings. Center is root node. Angles are equal or proportional to value.

2. GRAPHS AND TREES: FLOWCHARTS

ALLUVIAL DIAGRAM
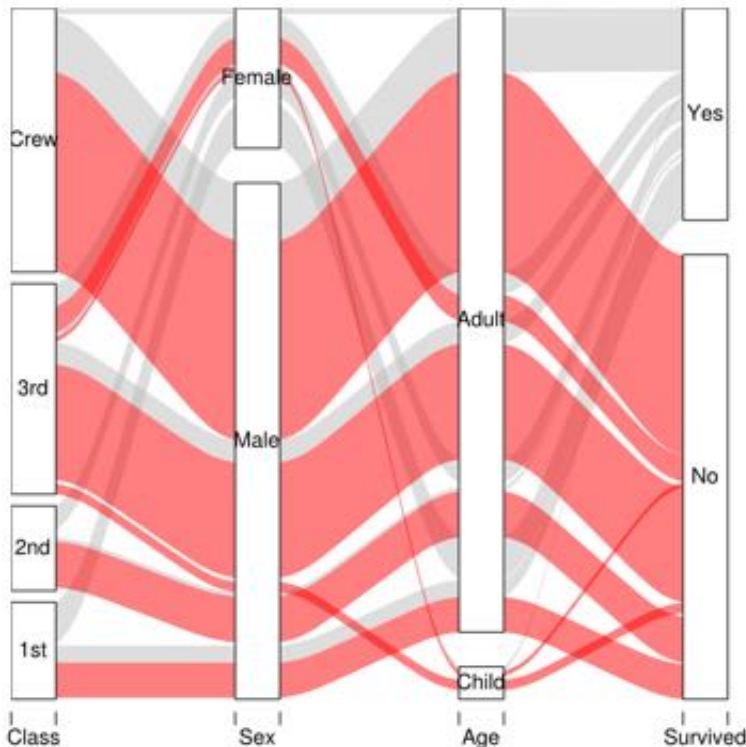
Shows relations between multivariate data. Named after alluvial fans formed by soil deposited by streaming water.

SANKEY DIAGRAM
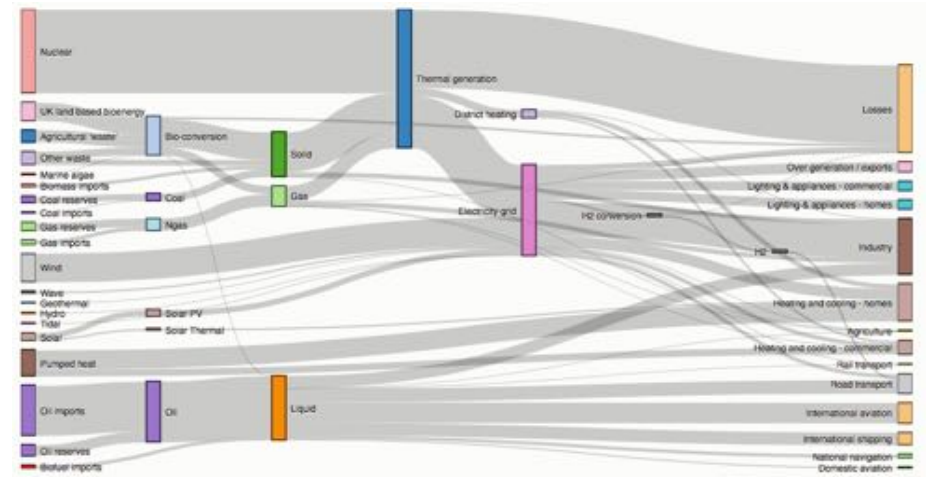
Magnitude of flow between nodes in a network

2. GRAPHS AND TREES: NETWORKS

NETWORK GRAPH
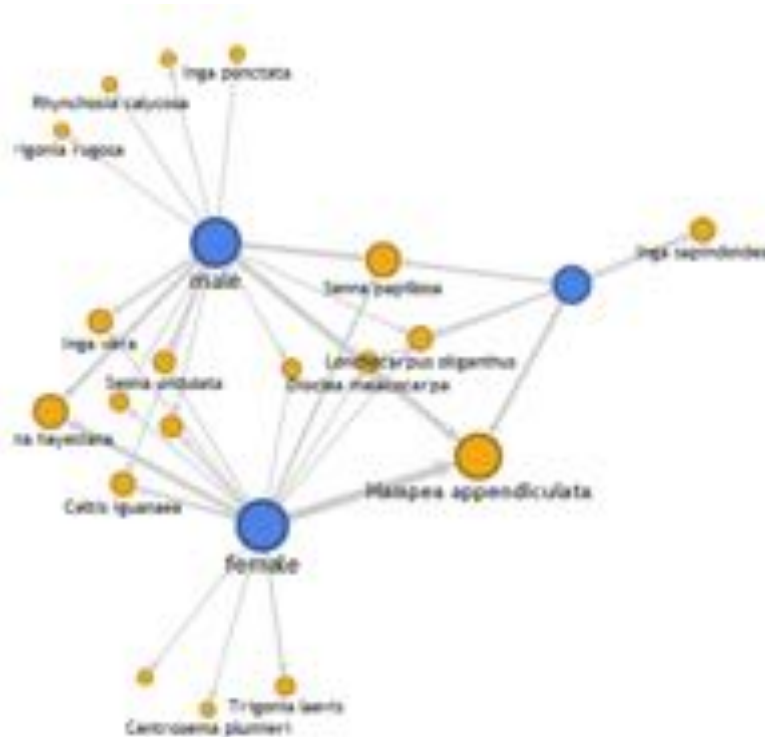
Relationships (lines) between entities (nodes)

2. GRAPHS AND TREES: MATRIX

HEAT MAP
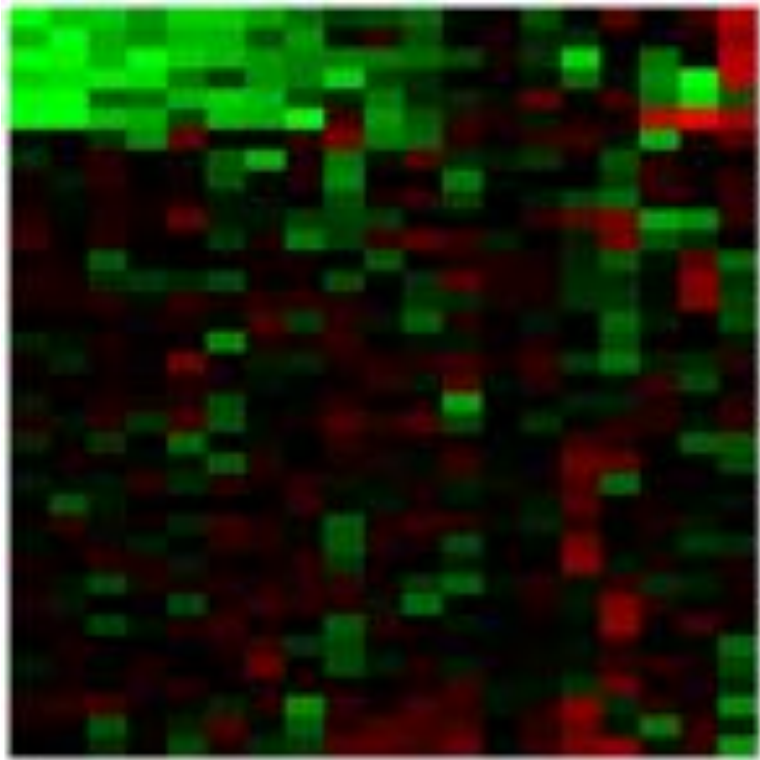
Matrix values as colors

CHORD DIAGRAM
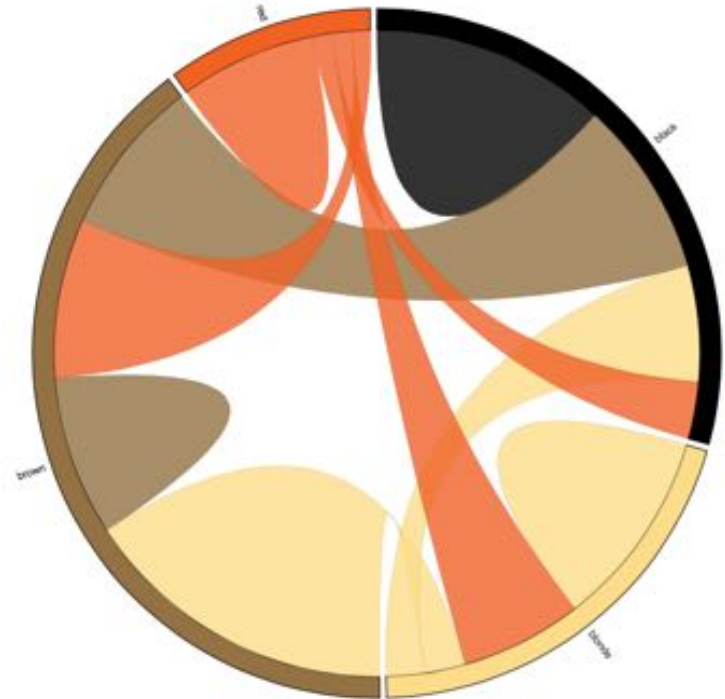
Shows directed relationships among a group of entities in a matrix

3. CLOUDS

WORD CLOUD

BUBBLE CLOUD

CIRCLE PACKING

Bubble cloud layout with hierarchical information as enclosing circles

4. TEMPORAL

TIME SERIES PLOT

Values ordered in time as a line chart

GANTT CHART
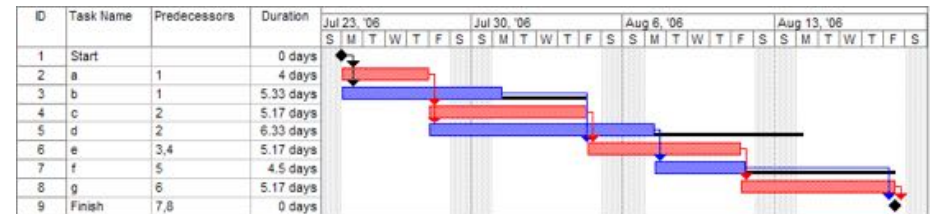
Schedule with tasks layed out on time axis

TIMELINE
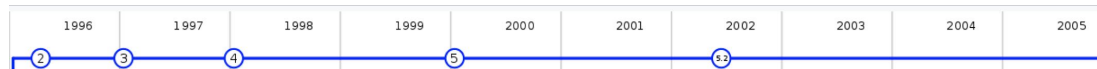
Events layed out on time axis

5. GEOSPATIAL AND MAPPING: THEMATIC MAPS

CHOROPLETH
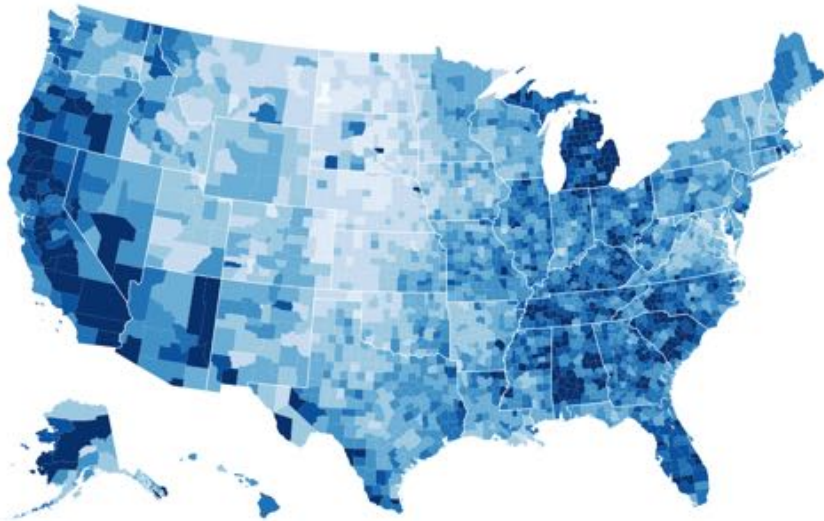
Areas are shaded or patterned in proportion to variable

PROPORTIONAL SYMBOL MAP

Scaled symbols show data for areas/locations. Also called Graduated Symbol Map.

5. GEOSPATIAL AND MAPPING: THEMATIC MAPS

DOT MAP
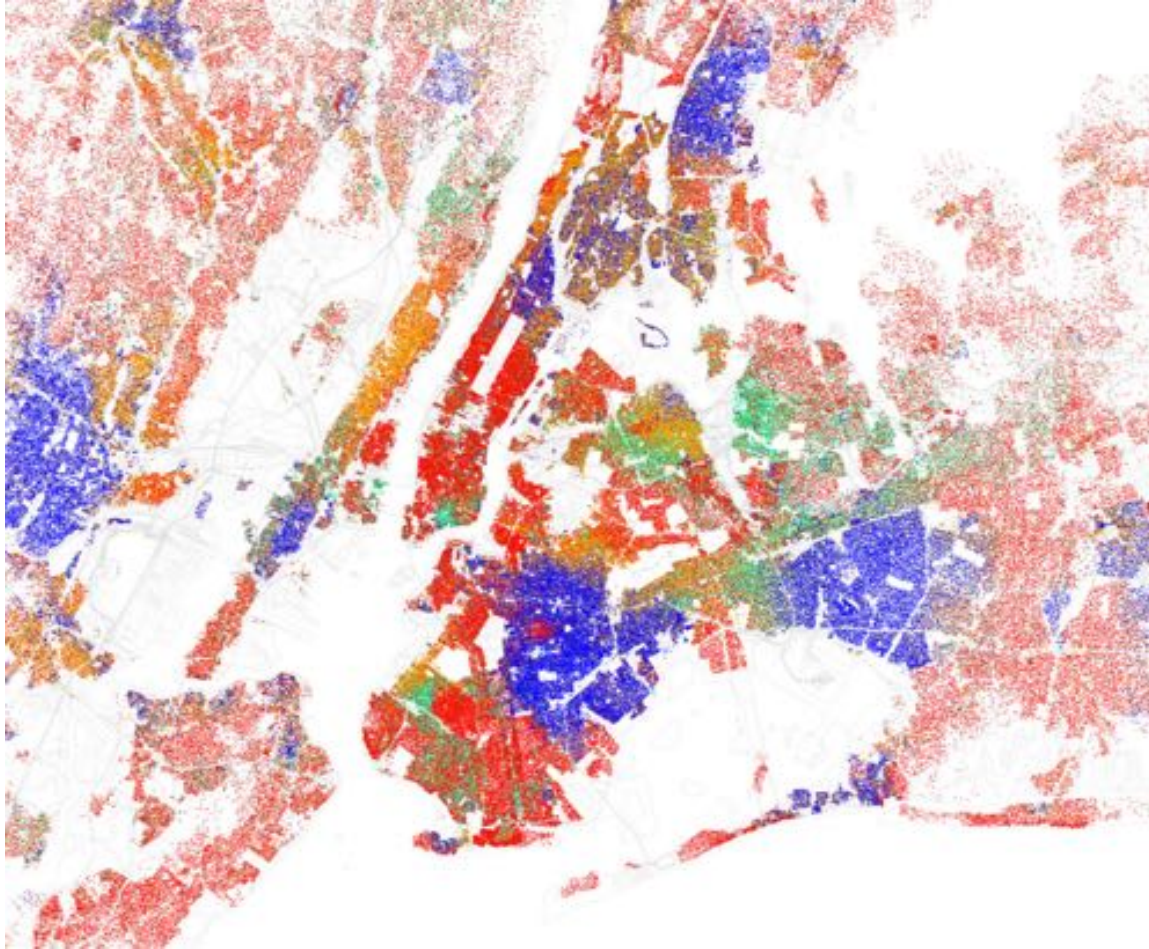
Can be used to locate each occurrence of a phenomenon. One-to-one or one-to-many.

5. GEOSPATIAL AND MAPPING: THEMATIC MAPS

CARTOGRAM
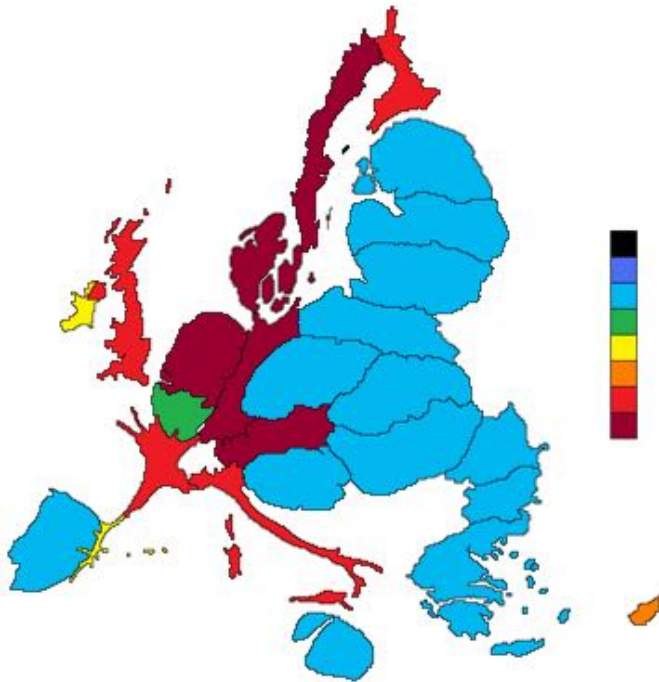
ISOPLETH

Area used to display value. Distortion used to show continuous variables
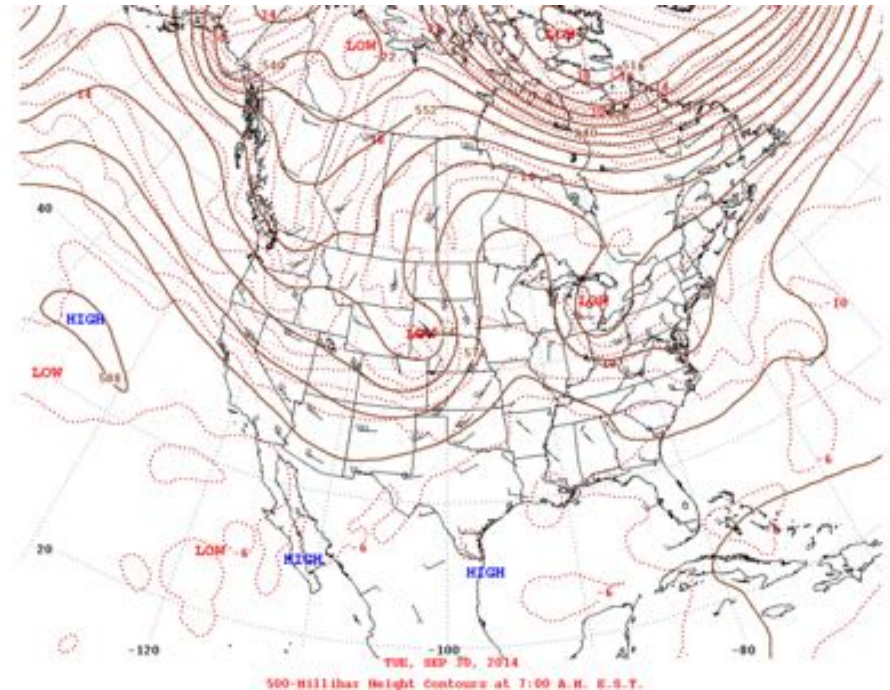
Use contours to show continuous variables. Also called Isarithmic.

5. GEOSPATIAL AND MAPPING: OTHER NAMED

TOPOGRAPHIC

Quantitative representation of land relief using contour lines

NAUTICAL
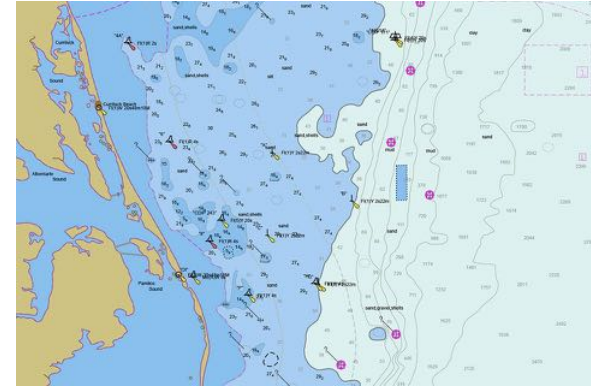
Charts of maritime/coastal areas

IMAGE BASED

Maps using satellite or aerial imagery

Polar chart by Florence Nightingale, 1858

Minard's map, 1858

Napoleon's Russian campaign of 1812, Charles Joseph Minard, 1861
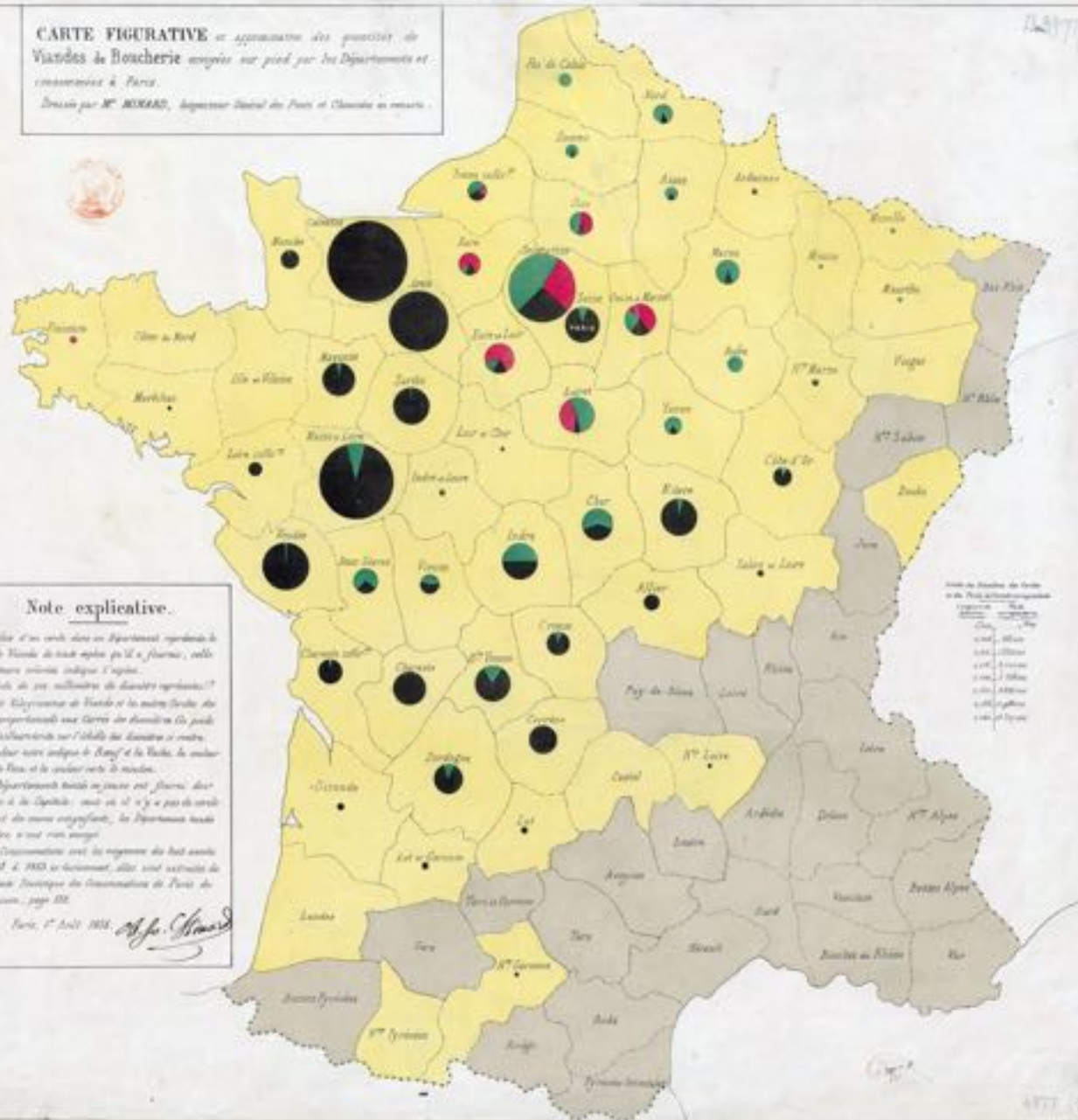
OUTLINE

- Data
- Visualization Techniques
- Introduction to WEB Technologies
- Sample quiz questions

THE WEB

- Clients use Uniform Resource Locators (URL) to query servers: `www.usc.edu`
- Hyper Text Transfer Protocol (HTTP) used to transfer content: `https`://www.usc.edu
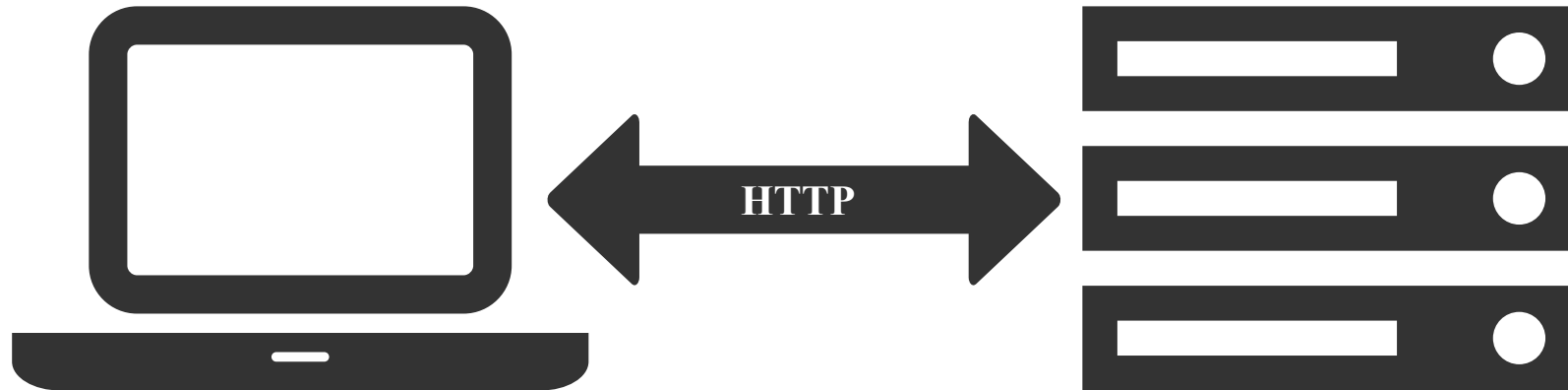
Client

Server

Browsers render:
- HTML, CSS, SVG
- Execute Javascript

Servers (e.g., node, nginx, Apache) serve:
- Static and dynamic HTML pages
- Content such as JSON, CSV, images,...

ASYNCHRONOUS COMMUNICATIONS
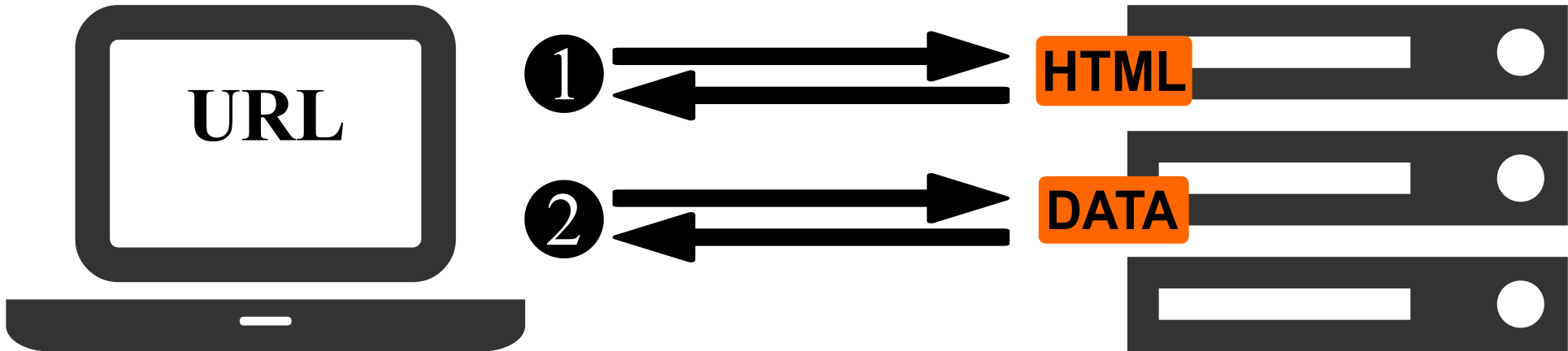
Browser and server communicate asynchronously:
- Using Asynchronous JavaScript & HTML (AJAX)
- Implemented in visualization libraries as promises:

```
//load cars.json
d3.json("https://raw.githubusercontent.com/vega/vega/main/docs/data/cars.json")
  .then((data) => {
    console.log(data);
    //open console: Command + Option + J (Mac) or Control + Shift + J (Windows, Linux, ChromeOS)
  });
```

WEB LANGUAGES

1. HTML
2. CSS
3. Javascript

1. HTML

- HTML stands for *"Hyper-Text Markup Language"*
- Defines the page semantics or meaning
- Whitespace and line breaks are disregarded
- HTML document as a tree of HTML elements
- Elements specified as tags with attributes:

```
<tag attribute="value"></tag>
```

- Two attributes used to identify elements:
    - class: *"class"* of elements, multiple classes per element

    ```
    <tag class="definition blue"></tag>
    ```

    - id: uniquely identify an element, only one id per document

    ```
    <tag id="tag0"></tag>
    ```

BASIC HTML ELEMENTS

Element	Description
<!DOCTYPE html>	Standard document type declaration (first line of document).
html	Surrounds all HTML content in a document.
head	Tag containing all document metadata (e.g., title).
title	Title shown on top of browser window.
body	Visible content in the page.
h1, h2, h3, h4, h5, h6	Headers of different levels.
p	Paragraph (block-level element).
span	Portion of text (inline element).
div	Division within the document (block-level element).
em	Emphasize text, rendered in italic.
strong, b	Emphasize text, rendered in boldface.
a	Hyperlink, rendered in underlined, blue text.
svg	SVG element for rendering vector graphics.

BASIC INDEX.HTML

```html
<!DOCTYPE html>
<html>
  <head>
    <title>Page title</title>
  </head>

  <body>
    <!-- This is an HTML comment -->
    <!-- Visible HTML elements are placed in the body -->
  </body>
</html>
```

SVG

- SVG stands for *"Scalable Vector Graphics"*
- Used for 2D vector graphics, not for raster (images) or 3D

```
<svg width="800" height="200" style="background-color: honeydew">
  <circle cx="300" cy="120" r="50" fill="steelblue"/>
  <text x="300" y="120">Apples</text>
  <circle cx="100" cy="100" r="50" fill="orange"/>
  <text x="100" y="100">Pears</text>
  <rect x="500" y="50" width="200" height="100" fill="orange"/>
  <text x="450" y="100">Oranges</text>
</svg>
```


MDN - SVG: Scalable Vector Graphics

42
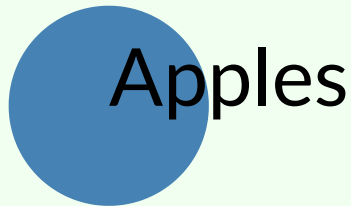
2. CSS

- ○ CSS stands for *"Cascading Style Sheets"*
- ○ Used to define the appearance of HTML elements
- ○ Three ways to use CSS in HTML:

```html
<!-- Inline -->
<p style="color: blue">Inline style</p>

<!-- Embedded -->
  <style>
  p { color: blue; }
</style>

<!-- External -->
<head>
  <link rel="stylesheet" type="text/css" href="style.css">
  <!-- p { color: blue; } placed in style.css -->
</head>
```

<u>Inline</u> overrides <u>Embedded</u> overrides <u>External</u>

CSS SELECTORS

Selectors are specified as: <u>element name</u>, <u>class</u> or <u>id</u> attributes

div	div elements
.foo	elements with class foo
#foo	elements with id foo
div.foo	div elements with class foo
div#foo	div elements with id foo
div .foo	elements with class foo `inside` a div
div #foo	elements with id foo `inside` a div
div , .foo	div elements `and` elements with class foo
div p .foo	elements with class foo in a p in a div

CSS SELECTORS EXAMPLES

```css
h1 { color: red; }    /* all h1 */

h1 h2 { font-weight: bold; } /* all h2 inside h1 */

h1, h2 { font-weight: bold; } /* all h1 and h2 */

p strong {
  color: orange;
  font-weight: bold; } /* all strong inside p */

#chapter1 { color: blue }    /* element with id chapter1 */

.pastoral { color: green }    /* all with class pastoral */

div.pastoral { color: green }    /* div elements with class pastoral */
```

In CSS files, later rules override earlier ones when more than one selector applies to an element

3. JAVASCRIPT

New language coming up

Meanwhile, Netscape and Sun Microsystems reportedly will announce later today they are teaming to create easy-to-use computer programming language for Internet access.

The new programming, called Javascript, will be distributed free over the Internet.

The programming would allow even non-technical users to customize information accessible on the World Wide Web.

For example, the software could allow users to view an always updated stock ticker of their own portfolio.

By distributing Javascript for free, Sun and Netscape hope they, rather than Microsoft, can set the Internet's next programming standard, reaping resulting sales of related products that use the Javascript approach.

Microsoft is expected to unveil its version of an Internet programming language later this week.

Unlike Javascript, which can run on any operating system, Microsoft's programming language will only be compatible with its software.

- Scripting language for Web pages
- Created by Brendan Eich
- Some resemblances with Java
- Implemented in browsers and non-browser, e.g., node
- MDN JavaScript documentation
- ECMAScript (ES) Web standard versions, e.g., ES6
- Used in the browser for:
  - User interaction
  - Asynchronous communications
  - Control the browser
  - Alter the content

Published in The Sentinel of Carlisle, Pennsylvania, Dec 4, 1995.

INCLUDING JAVASCRIPT IN WEB PAGES

○ Inline

```
<script type="text/javascript">
  //JavaScript code here
</script>
```

○ External

```
<script src="script.js"></script>
```

The use of the `.js` extension is a convention

MAIN JAVASCRIPT LANGUAGE FEATURES

- Object-oriented language
- Everything is mutable
- Dynamic typing
- First-class functions
- Function level scope

MAIN JAVASCRIPT LANGUAGE FEATURES

○ Object-oriented language

```
//denotes a comment
obj = {first: 'Joseph', last: 'Priestley'}; //object literal
obj.first  //'Joseph' (preferred)
obj['first']  //same as obj.first
```

○ Everything is mutable

○ Dynamic typing

○ First-class functions

○ Function level scope

MAIN JAVASCRIPT LANGUAGE FEATURES

- ○ Object-oriented language
- ○ Everything is mutable

```
obj = {first: 'Joseph', last: 'Priestley'};
obj.first = 'Joe'    //now first is 'Joe'
```

- ○ Dynamic typing
- ○ Function level scope
- ○ First-class functions

MAIN JAVASCRIPT LANGUAGE FEATURES

○ Object-oriented language
○ Everything is mutable
○ Dynamic typing

```javascript
//primitive types
var foo = true;        //Boolean
var foo = null;        //Null
var foo = undefined;   //Undefined
var foo = 2.3;         //Number
var foo = 'bar'        //String
```

○ First-class functions
○ Function level scope

MAIN JAVASCRIPT LANGUAGE FEATURES

○ Object-oriented language
○ Everything is mutable
○ Dynamic typing
○ First-class functions

```javascript
//functions treated similar to any other variable
var pi = function() { return Math.PI; }  //assign function to a variabl

function add(a, f) { return a + f(); }
add(1, pi);  //pass function as argument

//closure
function addPi() {
  //return function
  return function(a) { return a + Math.PI; }
}
```

≡ Function level scope

MAIN JAVASCRIPT LANGUAGE FEATURES

- Object-oriented language
- Everything is mutable
- Dynamic typing
- First-class functions
- Function level scope

```javascript
var b = 5;  //global scope, i.e., at the top of the script
//same as b = 5;

function f(a) {
  var b = 3;  //local scope, i.e., within the scope of the function
  return a + b;
}

b;  //5
```

DECLARATION AND INITIALIZATION

With variables:

```
//declaration
var a;  //function scoped
let b;  //block scoped
//a = b = undefined

//declaration & assignment
const G = 9.81; //block scoped constant
c = a;  //same as var c = a;

//assignments
b = G;  //now b = 9.81
```

With functions:

```
//declaration: "function declaration"
function add(a, b) {
  return a + b;
}

//declaration & assignment: "function expression"
var add = function(a, b) {
  return a + b;
};  //; at the end!

//function expression alternative: arrow functions
var add = (a, b) => { return a + b; }
var add = (a, b) => a + b
```

An arrow function expression is a compact alternative to a traditional function expression, but is limited and can't be used in all situations.

JAVASCRIPT HOISTING

Hoisting refers to the moving of variable <u>declarations</u> at the top of their <u>scope</u> when the script is parsed

<u>Declarations</u> are *hoisted*, <u>initializations</u> are *not*

Before hoisting	After hoisting

```
var a;
a = 2;
var b = 5;

var add = function (a, b) {
  return a + b;
};

function func(a) {
  var b = 3;
  var c = a + b;
  return c;
}
```

```
//hoisted declarations
var a, b, add;

function func(a) {
  var b, c;
  b = 3;
  c = a + b;
  return c;
}

//assignments
a = 2;
b = 5;
add = function (a, b) {
  return a + b;
};
```

CLOSURES

A closure is the combination of a function and the lexical environment within which that function was declared.

```javascript
function exampleClosure(arg1, arg2) {   //closure
  var localVar = 2;
  function exampleReturned(innerArg) {   //inner function (declaration)
    return ((arg1 + arg2) / (localVar + innerArg));
  }
  return exampleReturned;   //reference to inner function
}

var globalVar = exampleClosure(2, 4);

console.log(globalVar);   //[Function: exampleReturned]

globalVar(4);   //1 = ((2 + 4) / (2 + 4))
```

OUTLINE

○ Data
○ Visualization Techniques
○ Introduction to WEB Technologies
○ <mark>Sample quiz questions</mark>

What is the type of dollar amounts?

A. Dichotomous

B. Nominal

C. Interval

D. Ratio

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B. Nominal
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What is the type of this data?
Chinese, French, American, Greek, Swiss

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B. Quantitative Ratio

C. Qualitative Nominal

D. Qualitative Ordinal

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Chinese, French, American, Greek, Swiss

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B. Quantitative Ratio
C. Qualitative Nominal ←
D. Qualitative Ordinal

What is the type of this data in Fahrenheit scale?
$60^o F, 70^o F, 80^o F, 90^o F, 100^o F, 110^o F$

A. Numerical Interval

B. Numerical Ratio

C. Categorical Nominal

D. Categorical Ordinal

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☰

What is the type of this data?

Strongly Disagree	Disagree	Neither Agree nor Disagree	Agree	Strongly Agree

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What elements the following CSS rule selects:

```css
div,a.important {
  color: 'red'
}
```

A. Hyperlinks with class important inside a div

B. Hyperlink with class important and div elements

C. Hyperlink with id important inside a div

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