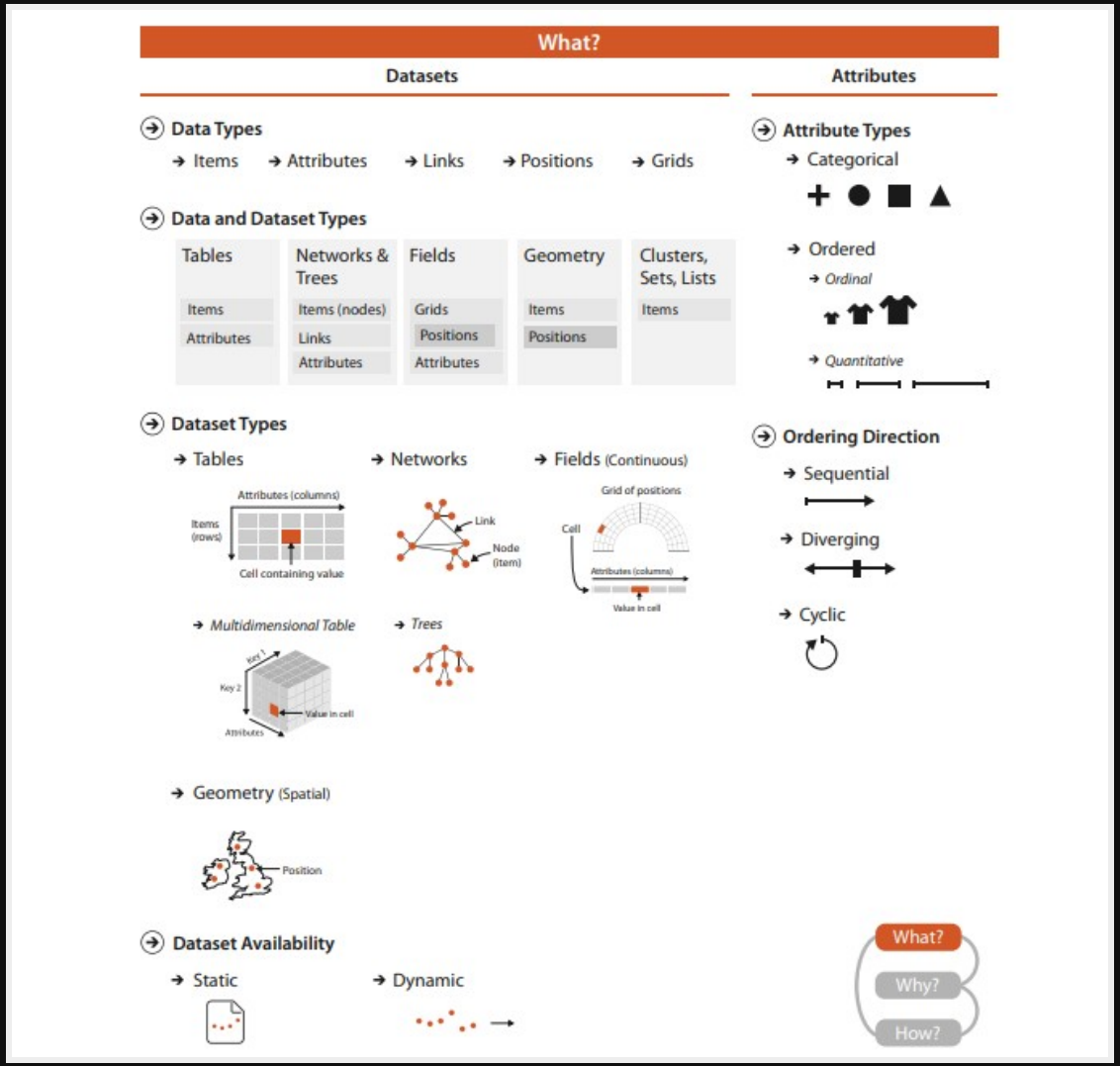
2a: All about data

What is the data like?

What: An overview



Visualization Analysis and Design, chapter 2, Munzner

Why do data semantics and types matter?

What is this?

C32	2021-01-26T17:06:15	C	289	181	37%
C6	2021-01-26T17:06:22	C	332	136	59%
TG2	2021-01-26T17:06:22	C	273	116	58%
BP1	2021-01-26T17:06:21	C	543	308	43%
TGM2	2021-01-26T17:06:22	C	189	129	32%

Better?

Carpark Number	Timestamp	Lot Type	Total Lots	Lots Available	Utilization
HE12	2021-01-26T17:06:10	C	91	4	96%
HLM	2021-01-26T17:06:00	C	583	179	69%
RHM	2021-01-26T17:06:10	C	322	143	56%
BM29	2021-01-26T17:06:21	C	97	8	92%
Q81	2021-01-26T17:06:12	C	96	12	88%
FR3M	2021-01-26T17:06:17	C	228	140	39%

Of course it matters. Would you understand what the data is like if you had to guess at what each column is like?

Properly describing and documenting data in **metadata** allows users to understand what the data is.

Not only expected value types, but expected range, whether a field is a derived value or not, etc.

Data Types

Items

- An item is an individual discrete entity
- E.g. row in a table, node in a network, a polygon area on a map

Attributes

- An attribute is some specific property that can be measured, observed, or logged
- aka variable, dimension, metric

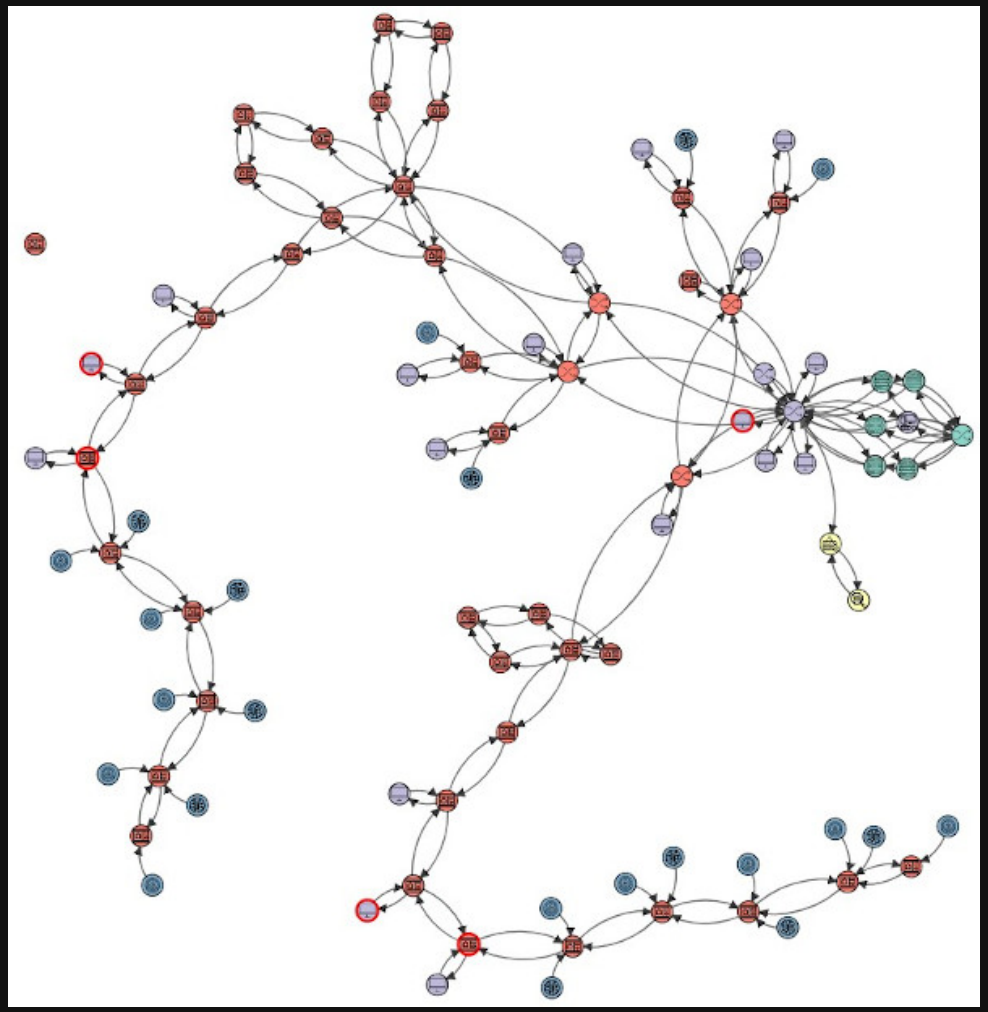
What is an item? What is an attribute?

```
"link": [
  {
    "sender": 1,
    "receiver": 3,
    "link protocol": "",
    "data stream": 1024
  },
  {
    "sender": 2,
    "receiver": 3,
    "link protocol": "",
    "data stream": 1024
  },
  {
    "sender": 3,
    "receiver": 4,
    "link protocol": "",
    "data stream": 1024
  },
  {
    "sender": 3,
    "receiver": 5,
    "link protocol": "",
    "data stream": 1024
  },
```

```
  "node": [
    {
      "id": 1,
      "name": "sensor-plc1",
      "type": "sensor",
      "ip": "",
      "mac": "",
      "port": [""],
      "criticality":5,
      "purdue level":0,
      "known vulnerability":[""],
      "related alert": 0
    },
    {
      "id": 2,
      "name": "actuator-plc1",
      "type": "actuator",
      "ip": "",
      "mac": "",
      "port": [""],
      "criticality":5,
      "purdue level":0,
      "known vulnerability":[""],
      "related alert": 0
    },
```

What is this data?

Better?



Data Types 2

Nodes

- Synonym for item but in the context of networks (graphs)

Links

- A link is a relation between two items
- E.g. social network, computer network

Higher order data types are often compositions of more basic data types

Data Types 3

Position / Regions

- A position is a location in space (typically 2D or 3D)
- May be subject to projections
- E.g. a district on a map, a 3D architectural diagram

Fields / Grids

- A grid specifies how data is sampled geometrically / topologically
- Necessary for sampling continuous data
- E.g. Earth map tiling, CT map scans

Geographic positions / grids

D3 Geographic

Google Map tiles

Data Types 4

Clusters / Sets / Lists

- A **set** is simply an unordered group of items.
- A **list** is a group of items with a specified ordering.
- A **cluster** is a grouping based on attribute similarity, where items within a cluster are more similar to each other than to ones in another cluster.

Data types → dataset types

Data Availability

Static or dynamic?

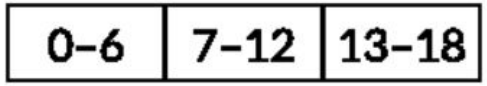
Data Hierarchies

More on hierarchies in D3

Hierarchical datasets lend themselves very well to visualizations like dendograms, trees, treemaps, packed circles.

We'll talk more about specific visualization idioms in a later lecture.

Data scales

Data Scales	Logical Math Operations				Measure of Central Tendency	Examples
	= ≠	< >	+ -	x ÷		
Nominal	✓				mode	
Ordinal	✓	✓			median	
Interval	✓	✓	✓		arithmetic mean	
Ratio	✓	✓	✓	✓	geometric mean	

Levels of measurement (or scale of measure, or data scales), a proposed typology by psychologist Stanley Smith Stevens(1906-1973). Still widely used framework, esp. now in data science.

More reading: Levels of measurement: Nominal, ordinal, interval, ratio, Scribbr, Prita Bandari

Why are data scales important?

Because they highly influence the type of encodings and visualizations possible.

It roughly maps to the qualitative (nominal / categorical) — ordinal — quantitative scale by French cartographer Jacques Bertin (1918-2010).

Qualitative data: represented by groupings

Quantitative data: represented by amounts

Nominal data

Or *categorical* data. Data is **qualitative**.

- Categories can only distinguish whether two things are the same (apples) or different (apples versus oranges).
- Often no implicit ordering, but is part of a hierarchical structure.
- Of course, any arbitrary external ordering can be imposed upon categorical data - e.g. alphabetically - but only if this auxillary information is available. It is not *intrinsic* to the data.
- Examples: City names, file types, music genres.

Ordinal data

Ordinal data can have a qualitative or quantitative quality.

- Data where there is often an implicit ordering in the structure.
- Examples: T-shirt sizes, rankings of university, etc.
- Note: You cannot do arthimetic on these because it has no meaning. E.g. What is the difference between rank 5 and rank 4? Is it the same as between rank 2 and 1? (nope).

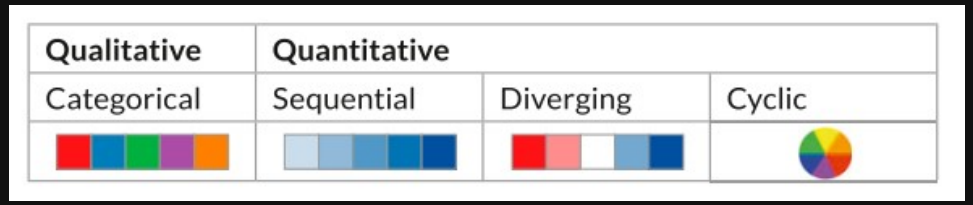
Quantitative data

Typically *interval* or *ratio* data.

- Data where arthimetic has meaning.
- For example where you can say one month you sold 50 units, and the next 100, so you doubled your sales.
- Examples: amount of inventory, temperature, length, weight, etc.

There are more specific distinctions between interval and ratio, but it does not really affect visualization principles as much.

Ordering: Sequential, diverging, cyclic



Like qualitative data variables, qualitative graphic variables (e.g., shape or color hue) have no intrinsic ordering.

In contrast, quantitative graphic variables (e.g., size or color intensity) can have different ordering directions, such as sequential, diverging, or cyclic

For the qualitative data, color is used as an *identity* channel. For quantitative, it is often a *magnitude* channel. We'll discuss color more in later lectures.

So what scale of measure is each attribute?

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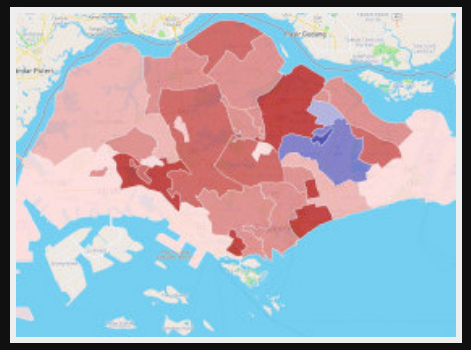
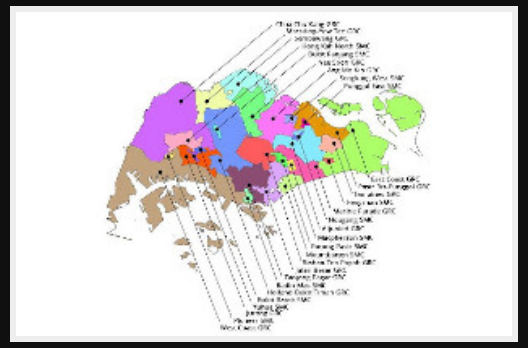
More reading: Is time nominal, ordinal, interval or ratio? Is it categorical or continuous? Peter Flom, Statistical Analysis Consulting

A more detaild example



Elections SG2020



Electoral Divisions

Questions?

Chi-Loong | V/R