Visual thinking

Visualizations

"Science and art have in common *intense seeing,* the wide-eyed observing that generates empirical information."

Edward Tufte in *Beautiful Evidence*

A picture is worth a thousand words…?

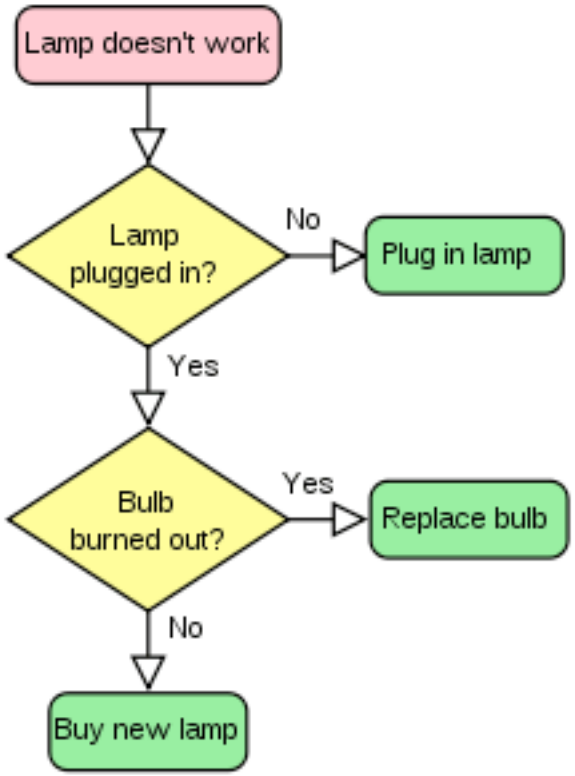
- try to express the following in pictures:

  “If yellowtail is more than R50 a kilo at Cape Fish Market, go to Pick ‘n Pay.”

A picture is worth a thousand words…?

- Good design is not about pictures versus words. Rather:
  - When are images most effective?
  - When are words and other symbols most effective?
  - How should we combine words and images?

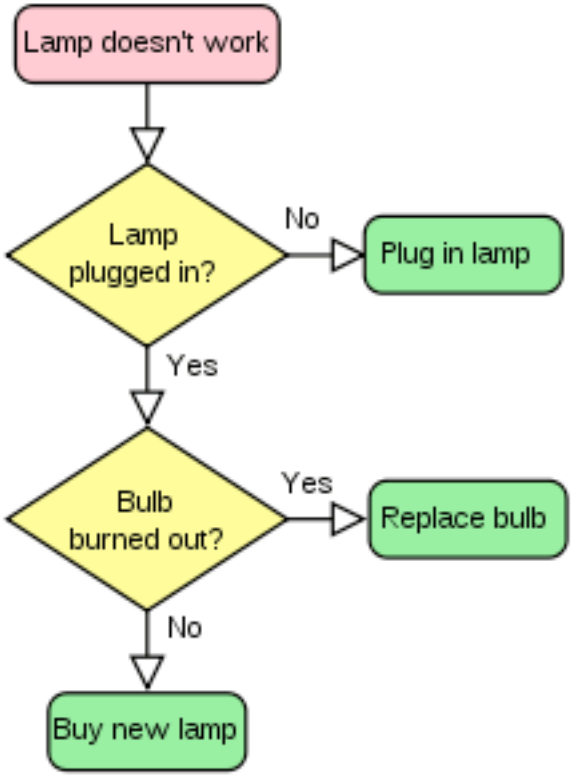
Flowcharts


Lamp doesn't work
Lamp plugged in?
No
Plug in lamp
Yes
Bulb burned out?
Yes
Replace bulb
No
Buy new lamp

Pseudocode

```
if not lamp_working:
    if not lamp_plugged_in:
        plug_in_lamp()
    else if lamp_burned_out:
        replace_bulb()
    else:
        buy_new_lamp()
```

Flowcharts versus pseudocode




```
if not lamp_working:
    if not lamp_plugged_in:
        plug_in_lamp()
    else if lamp_burned_out:
        replace_bulb()
    else:
        buy_new_lamp()
```

Which is easier to understand?

Linguistic expressions

Have

- A rich set of socially invented arbitrary symbols
- A form of logic:
  - “if” , “ands”, “buts”
- processed in language area of the brain
- culturally dependent

Linguistic expressions

Supports complex logical relationships between abstract ideas

Visual representations

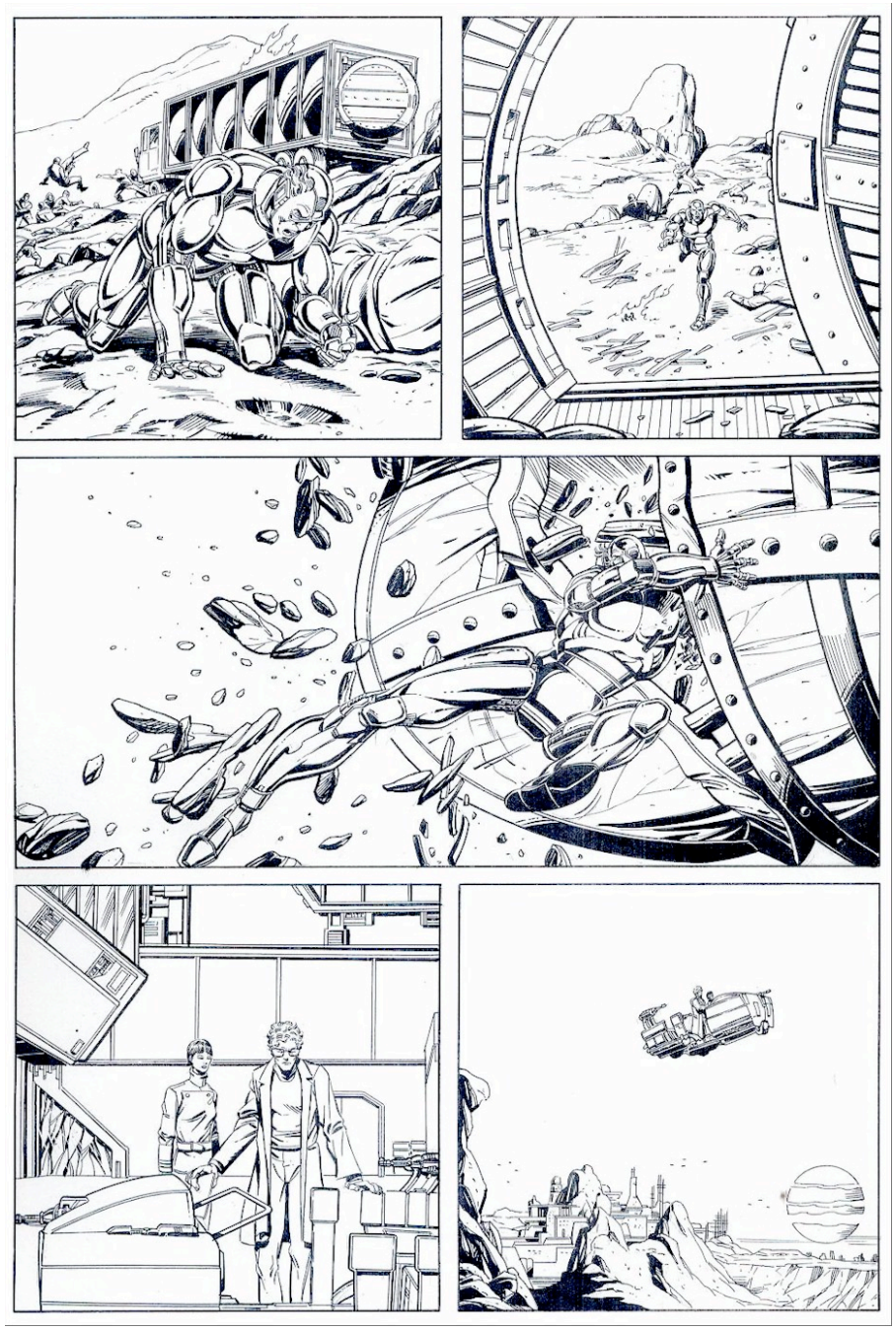
- Visual representations can incorporate a kind of logic, but it is very different from the more abstract logic of natural language
  - logic of pattern, object and space
    - connected to, inside, outside, part-of
    - structural relationships
  - processed in the visual, not language, area of the brain
  - not (or less) culturally dependent

Visual representations

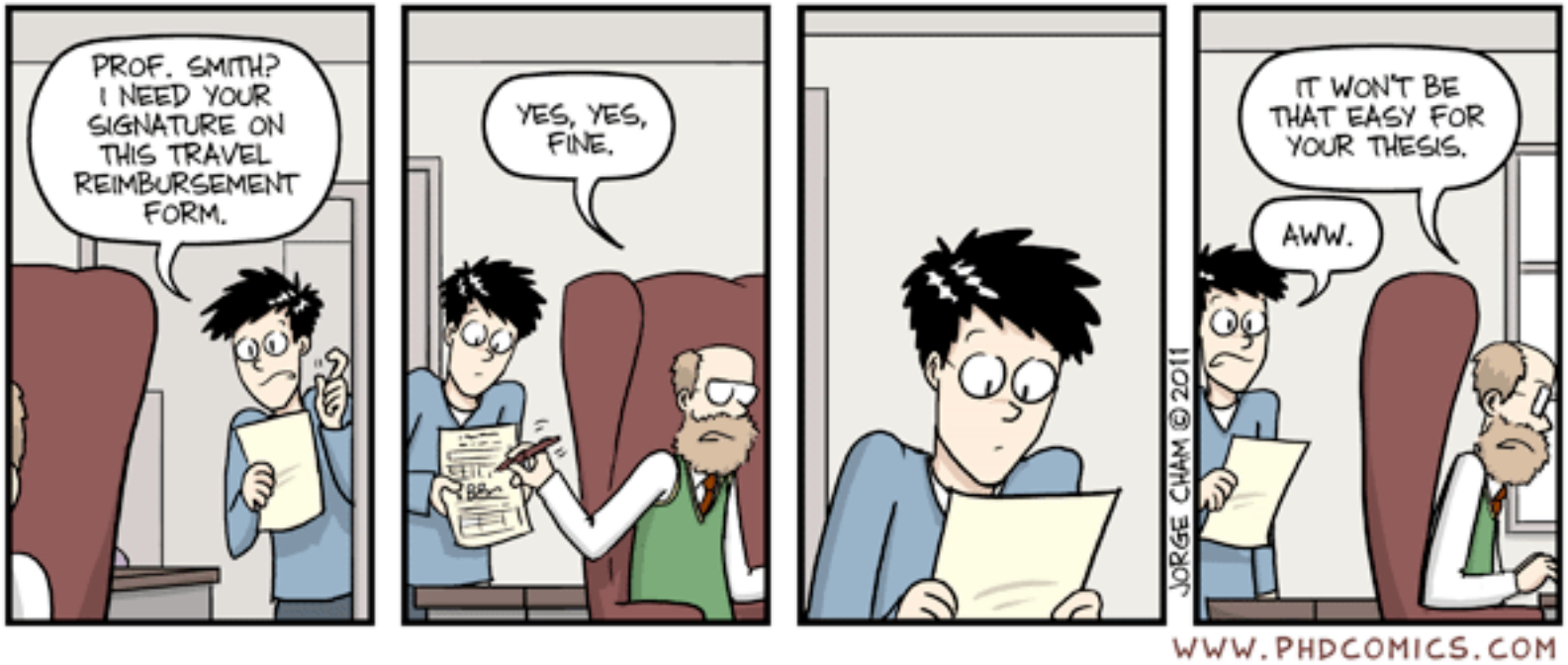
- instantaneous scene gist
- rapid exploration of spatial structure, relationships, emotions and motivations

Narrative

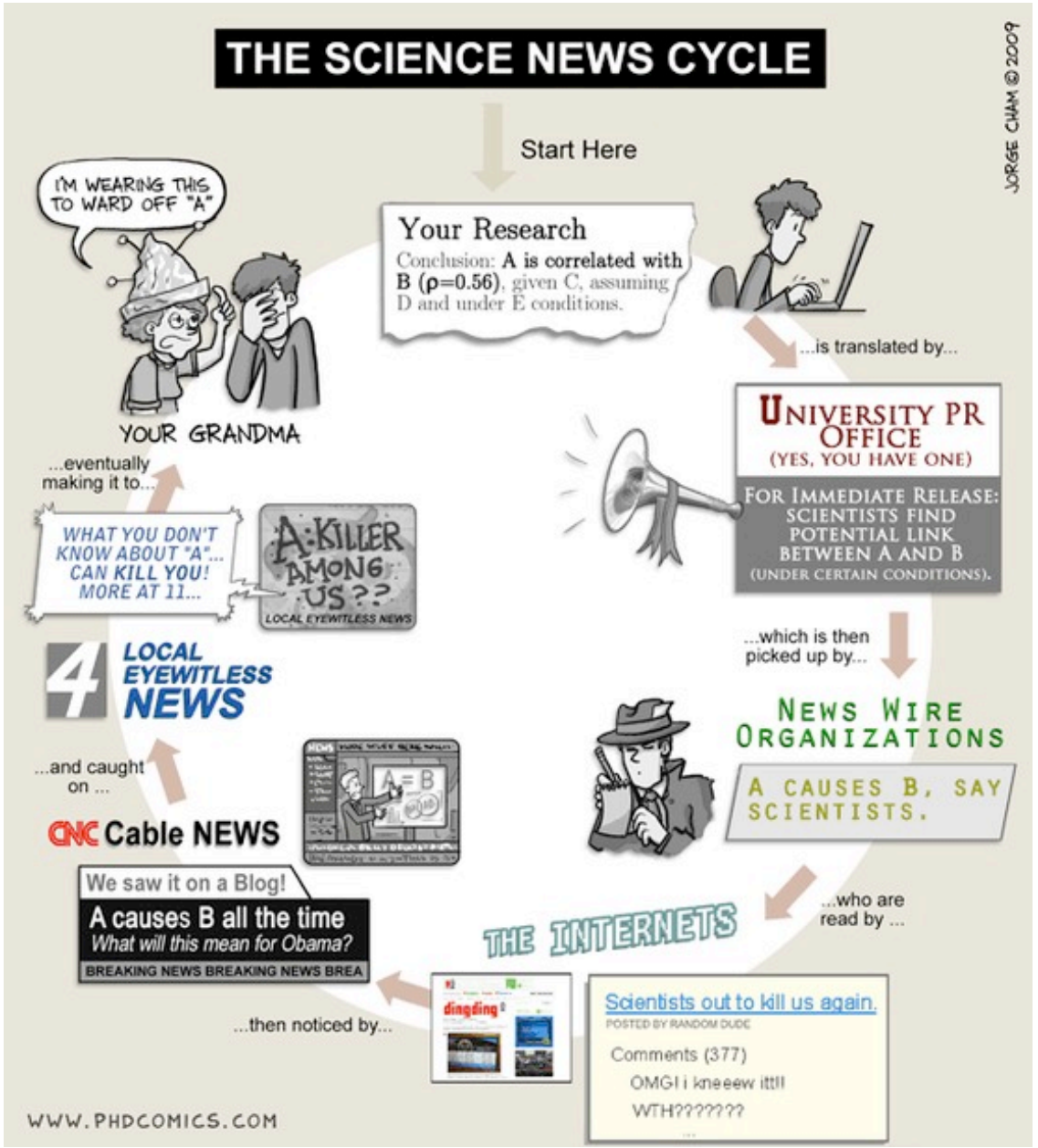
- can be carried through language or visual or both



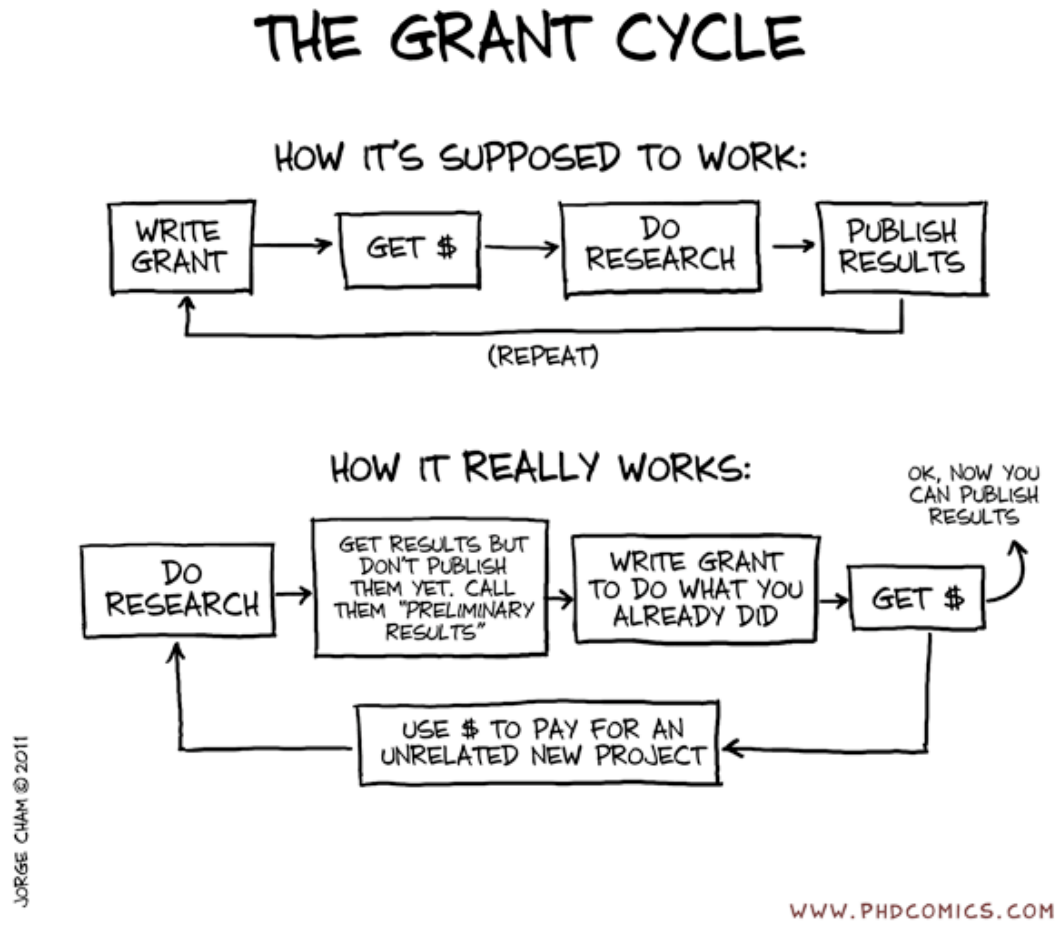
Both


PROF. SMITH? I NEED YOUR SIGNATURE ON THIS TRAVEL REIMBURSEMENT FORM.
YES, YES, FINE.
IT WON'T BE THAT EASY FOR YOUR THESIS.
AWW.
JORGE CHAM © 2011
WWW.PHDCOMICS.COM

One page narrative



One page narrative



Creative meta-seeing

Studies of how artists and designers work suggest that, although the germ of an idea may often come purely through thought, the major work of creative design is done through interaction with some rapid production medium:

sketch, clay etc.

Stages in the creative process

- visual concept
- externalization
- constructive critique
- consolidation and extension

Visualization

- visualization: graphical representation of some data or concepts
  - tools for visual thinking

"Evidence presentations should be created in accord with the **common analytical tasks** at hand, which usually involve **understanding causality**, making **multivariate comparisons**, examining **relevant evidence**, and assessing the **credibility of evidence and conclusions**."

Edward Tufte in *Beautiful Evidence* [own emphasis]

Information visualization depicts quantified data by systematically mapping it into visual images

Uses graphic language of points, lines, curves, simple shapes and other graphic primitives

We seek to represent, and hence understand, all kinds of data sets

visualization is a tool for discovering patterns, connections and structure in data

Mapped pictures*

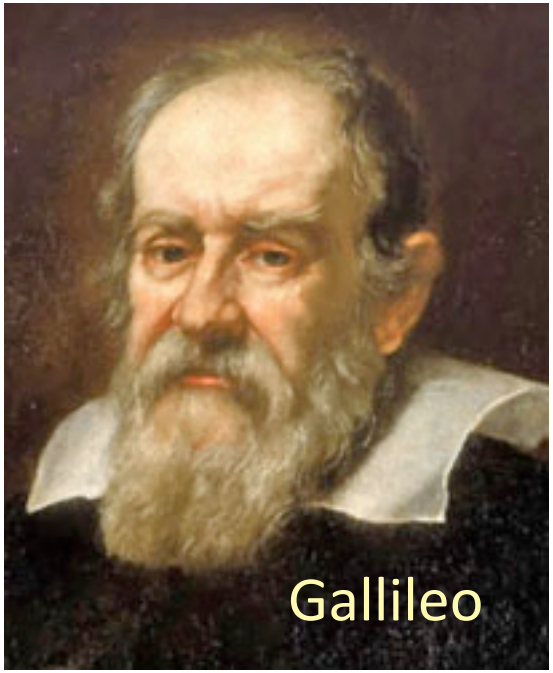
Images as evidence and explanation: mapped pictures combine representational images with scales, diagrams, overlays, numbers, words, images

Detailed annotations can make a figure **credible quantitative evidence**

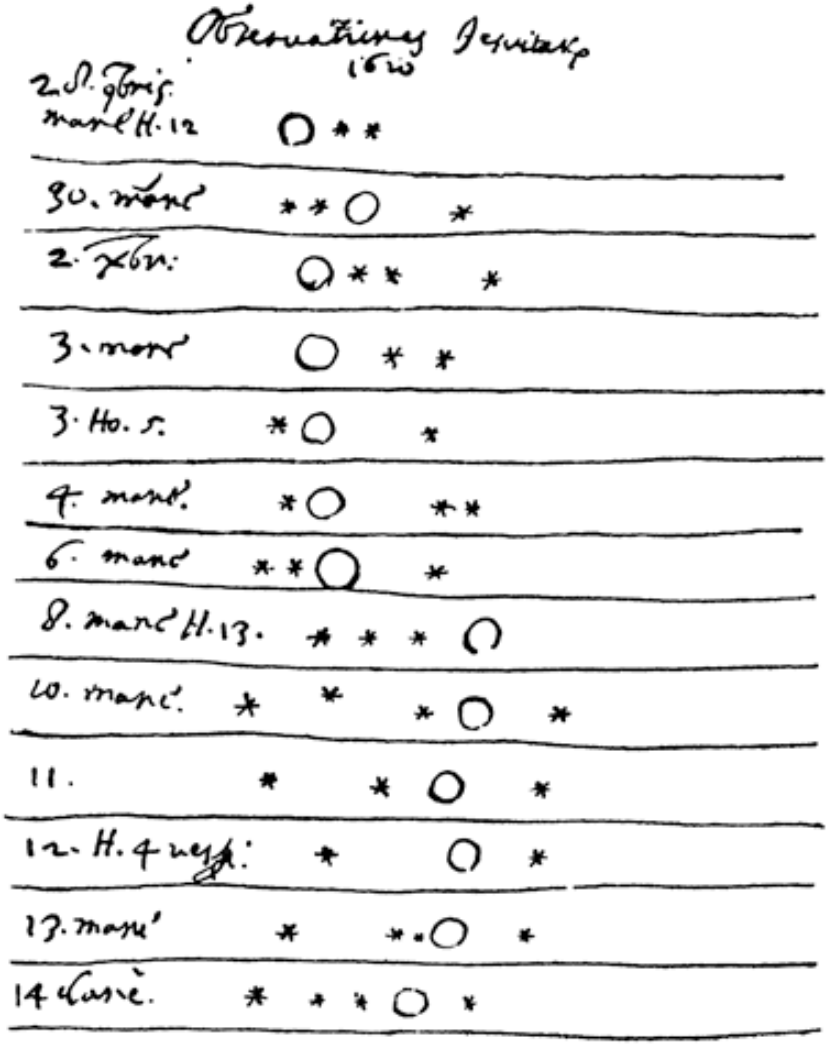
- has **explanatory power**

"Beautiful Evidence" by Edward Tufte, Graphics Press LLC

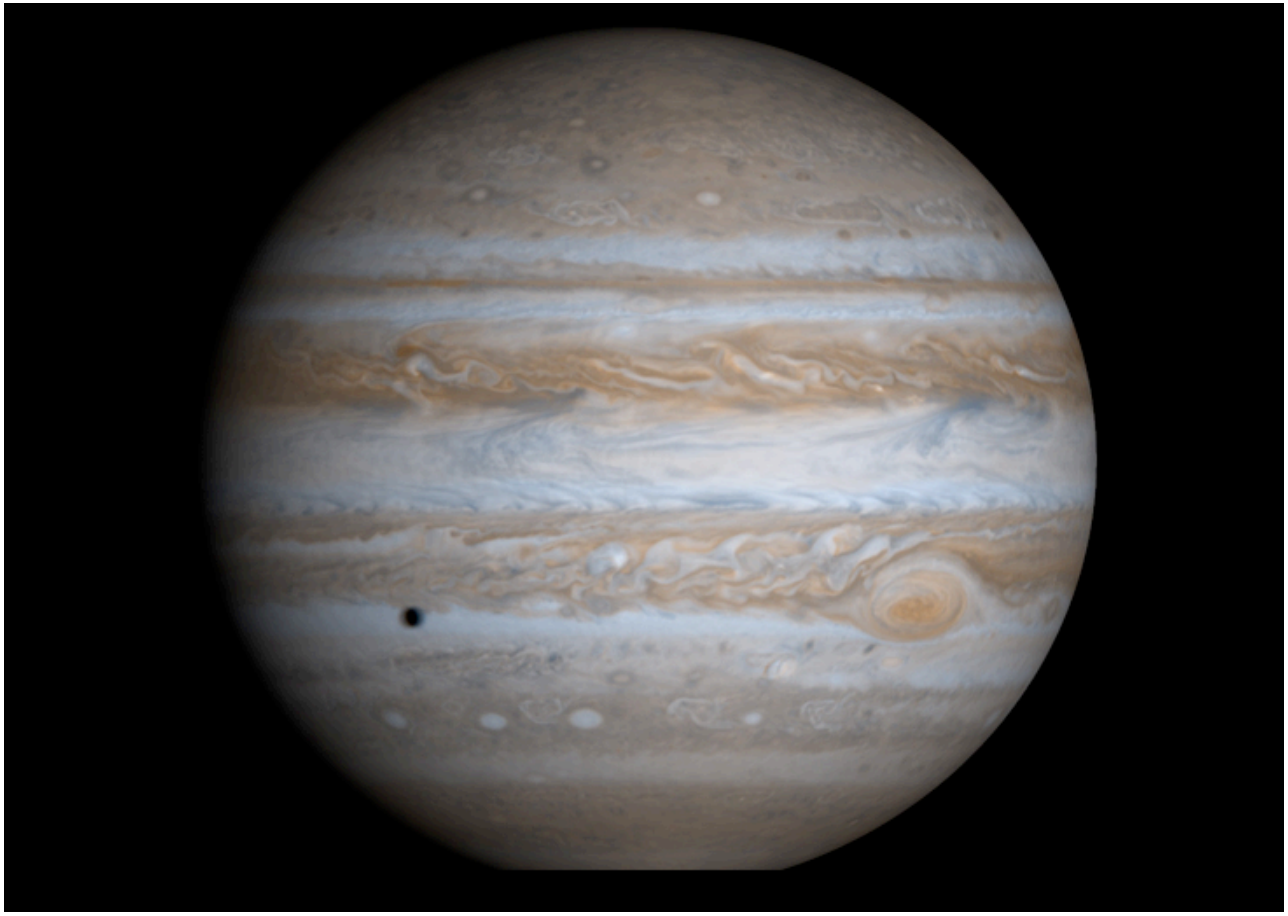
Mapped pictures have a long history…



Galileo's notebook on Jupiter



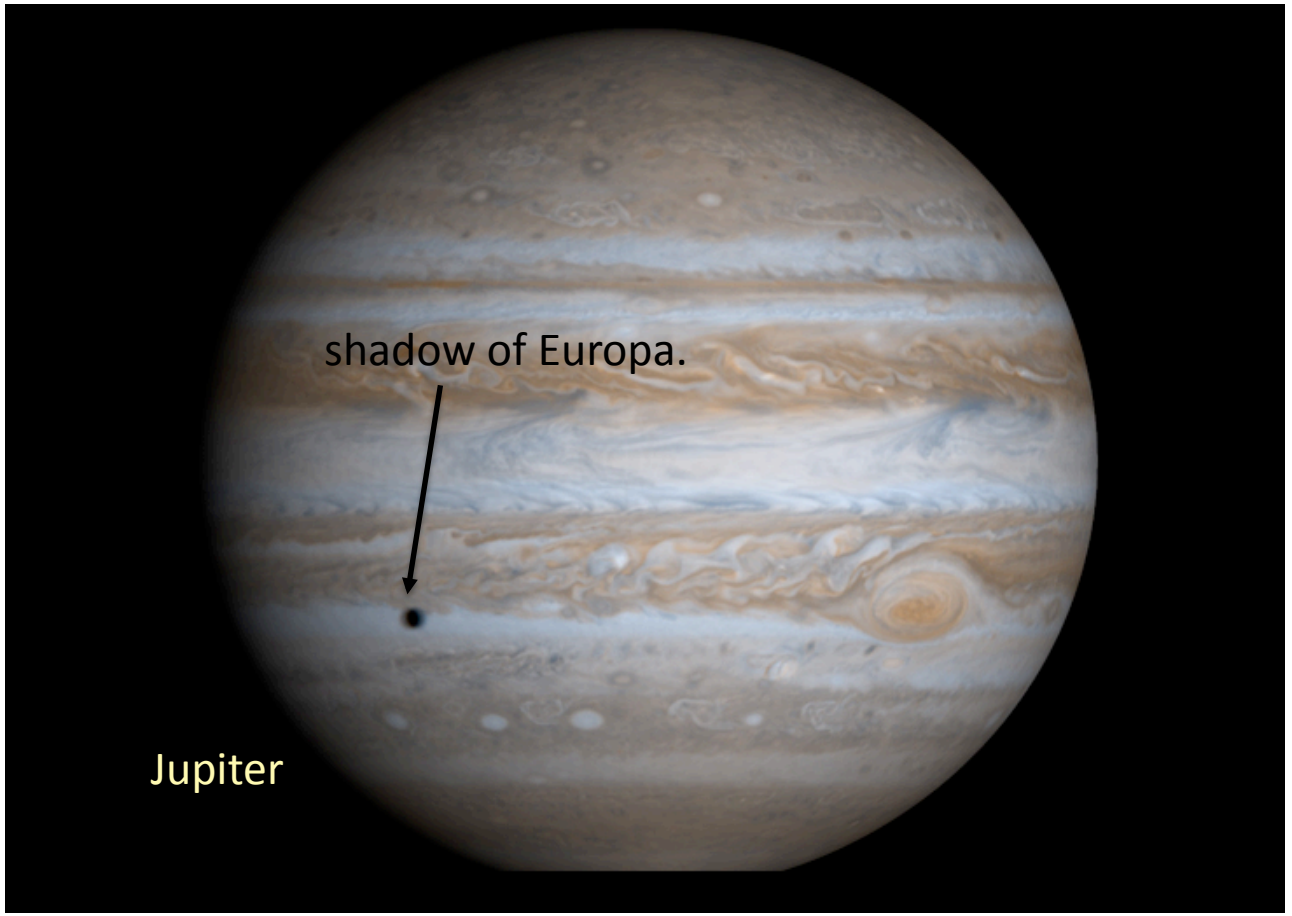
But are not used enough today…



Too many scientific images today are just celebratory photographs: **no scale** of measurement or relevant **comparison**

Jupiter again… from http://solarsystem.nasa.gov

How about some scale?



Earth

Most explanatory and evidential images should be mapped, placed in an appropriate context for comparison and located on a universal grid of measurement

Data graphics

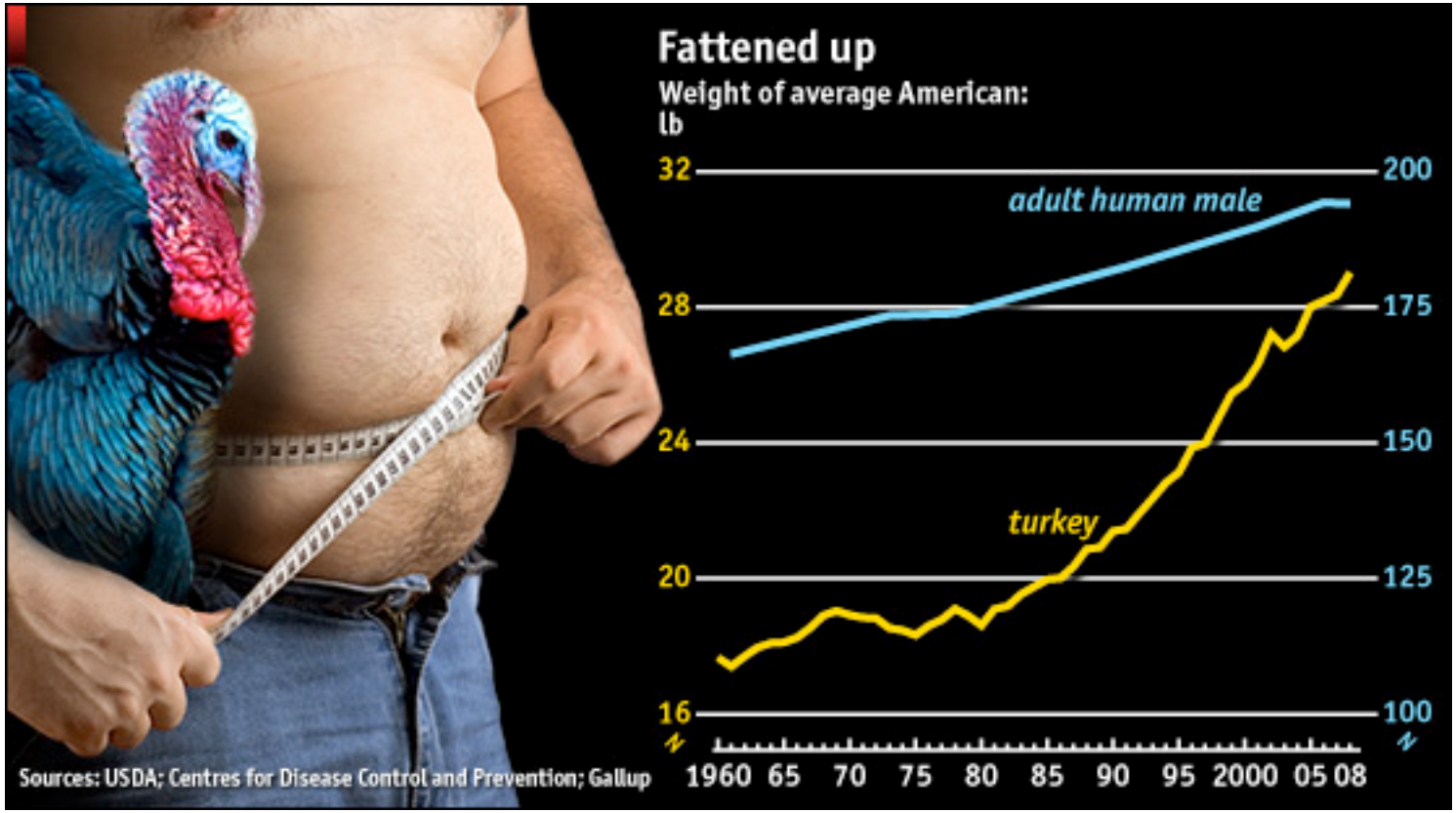
- Visually display measured quantities by means of points, lines, a coordinate system, numbers, symbols, words, shading and colour.

- At their best, instruments for reasoning about quantitative information

The Theory of Data Graphics

- Data graphics should draw the viewer's attention to the **sense** and **substance** of the **data**,
  - not to methodology, graphic design, something else

Data graphics: Examples

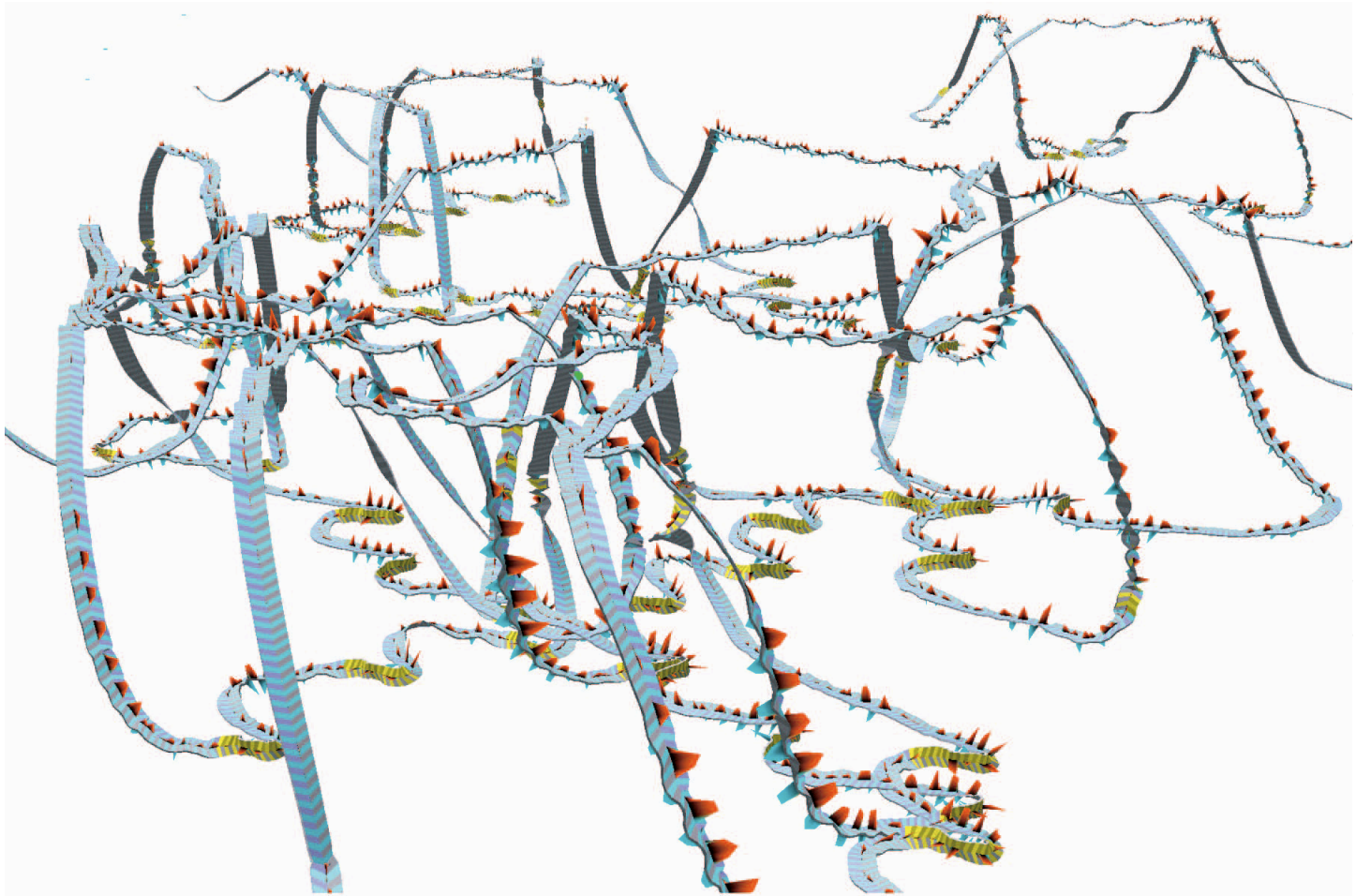


From *The Economist*, Nov 26th 2009 *Web only*

Graphical displays should reveal the data

- show the data
- induce the viewer to think about substance rather than methodology, graphic design, the technology of graphic production, or something else
- avoid distorting what the data have to say
- present many numbers in a small space
- make large data sets coherent
- encourage the eye to compare different pieces of data
- reveal the data at several levels of detail, from broad overview to fine structure
- serve a reasonably clear purpose
- be closely integrated with the statistical and verbal descriptions of the data set

Data Graphics: Examples



Visualizing the Underwater Behavior of Humpback Whales,

Colin Ware,

Roland Arsenault, Matthew Plumlee,

David Wiley

IEEE Computer Graphhics and Applicatiions, 2006, July/ August, 14-18

TrackPlot showing several hours of whale foraging behavior. This is an oblique view looking down on the water. The animal is mostly either at the surface or on the bottom, with steep transitions between.

A critical look at data graphics/ visualizations

- Is colour/size/texture used effectively?
- Could the use of texture/depth cues improve the graphic? Justify your answer.
- A good graphic enables visual queries to be processed rapidly. For Figure 2, list two distinct visual queries that are likely to be processed rapidly/slowly by our visual cortex for this graphic. Justify your answers.

A critical look at data graphics/ visualizations

There are right ways and wrong ways to show data; there are displays that reveal the truth and displays that do not. [E. R. Tufte]

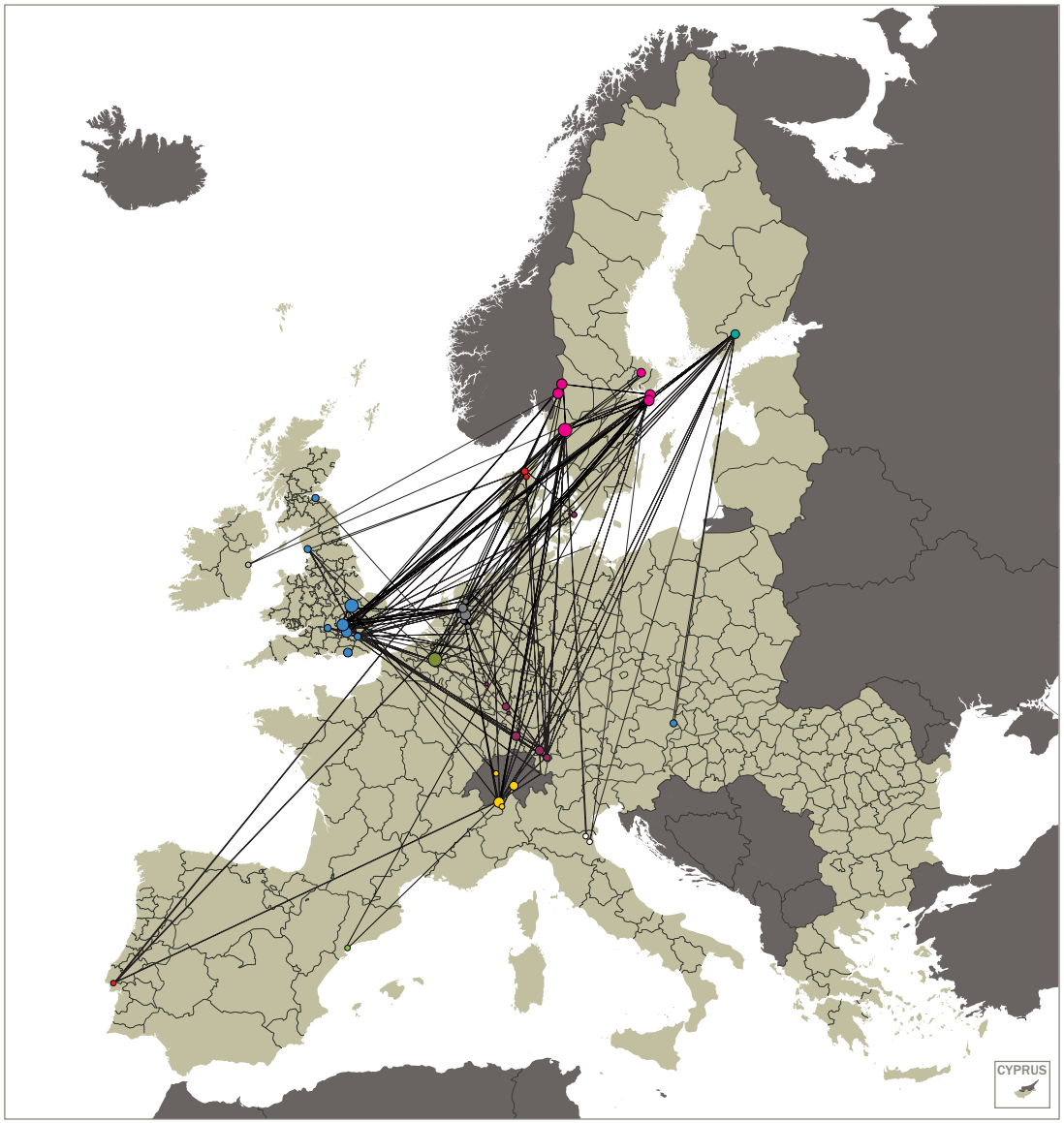
- In your opinion, does Figure X show the data a right way or a wrong way? Justify your answer

A critical look at data graphics/ visualizations

- Examine the graphic in Figure. Your task is to redesign and improve this graphic: try to make at least 3 improvements to the design. For each design decision, explain why the original was imperfect and justifying your improvement in terms of your knowledge of the way our visual system works and what makes graphical objects distinct. You may use diagrams in your answer.

wheel of seasonal food

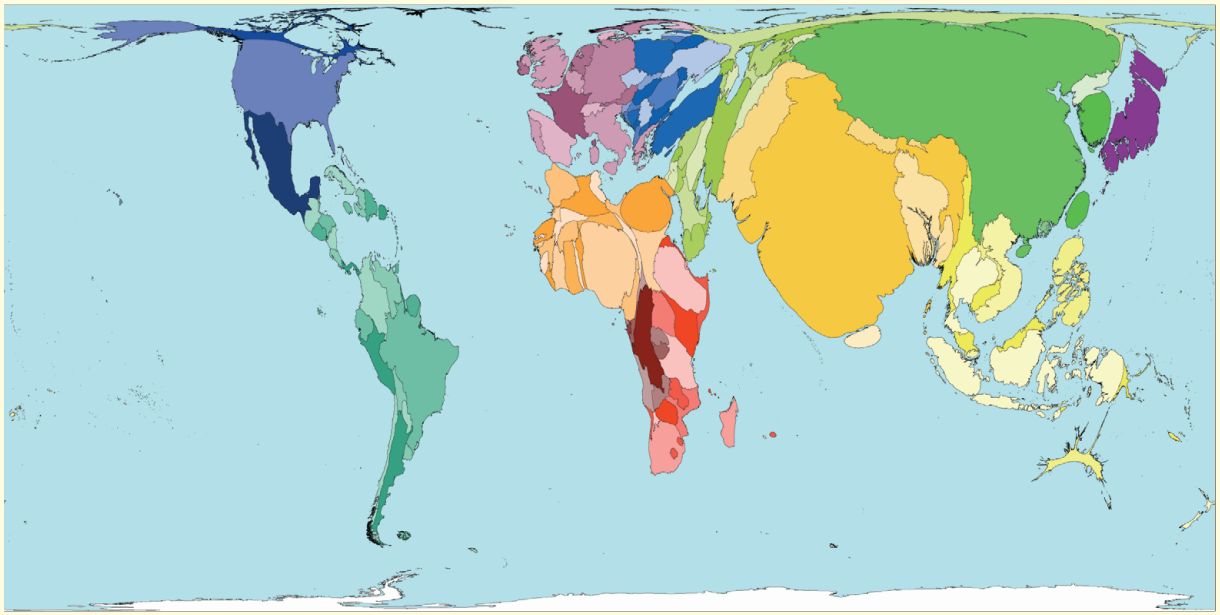
FIGURE II.1.4 FP6 R&D collaborations between European universities that cooperate in more than ten research projects



Source: DG Research
Data: EUPRO (Austrian Research Centres)

Total Population

The University Of Sheffield. The Leverhulme Trust Geographical Association
Produced by the SASI group (Sheffield) and Mark Newman (Michigan)

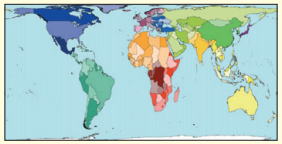


In Spring 2000 world population estimates reached 6 billion; that is 6 thousand million. The distribution of the earth's population is shown in this map.

India, China and Japan appear large on the map because they have large populations. Panama, Namibia and Guinea-Bissau have small populations so are barely visible on the map.

Population is very weakly related to land area. However, Sudan, which is geographically the largest country in Africa, has a smaller population than Nigeria, Egypt, Ethiopia, Democratic Republic of Congo, South Africa or Tanzania.

The size of each territory shows the relative propotion of the world's population living there.



Land area

Technical notes

- Data source: United Nations Development Programme, 2004, Human Development Report.
- Population data is from 2002
- The population not included is estimated as 2 to 3 million (see Appendix map 2).
- See website for further information.

MOST AND FEWEST PEOPLE

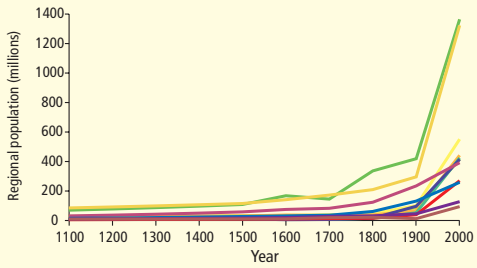
Rank	Territory	Value
1	China	1295
2	India	1050
3	United States	291
4	Indonesia	217
5	Brazil	176
6	Pakistan	150
7	Russian Federation	144
8	Bangladesh	144
9	Japan	128
10	Nigeria	121

millions

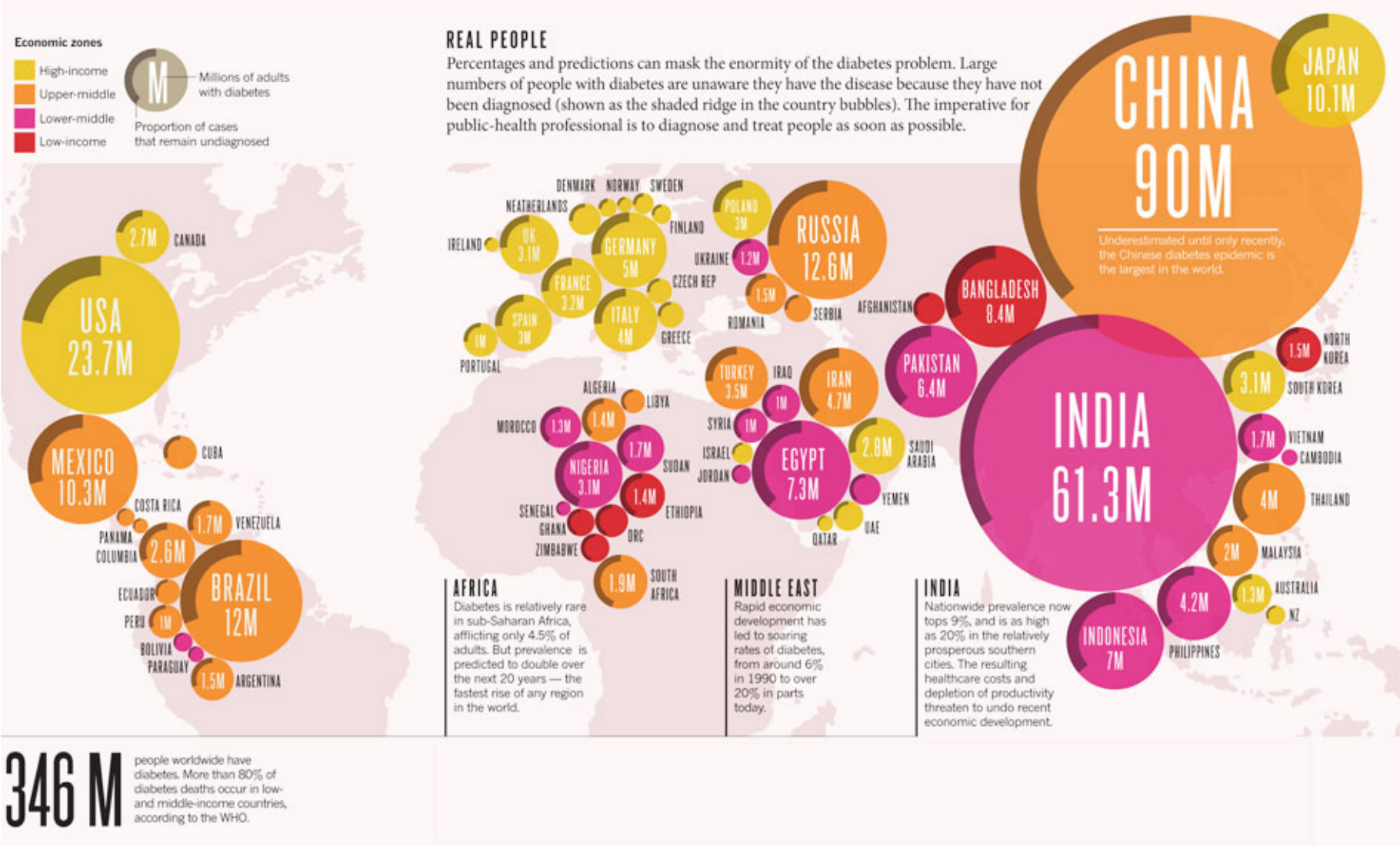
Rank	Territory	Value
191	Saint Kitts & Nevis	42
192	Monaco	34
193	Liechtenstein	33
194	San Marino	27
195	Palau	20
196	Cook Islands	18
197	Nauru	13
198	Tuvalu	10
199	Niue	2
200	Holy See	1

thousands

WORLD POPULATION BY REGION

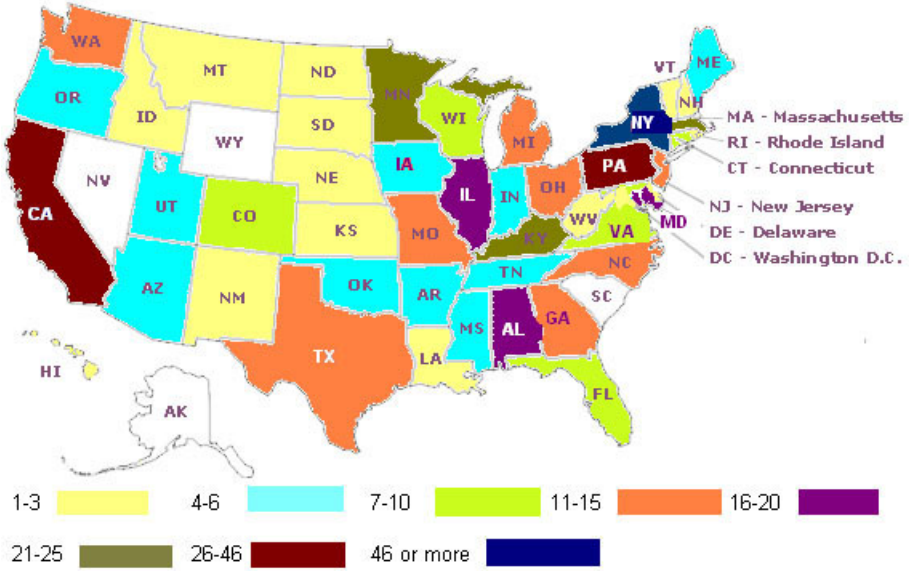


"Out of every 100 persons added to the population in the coming decade, 97 will live in developing countries."
Hania Zlotnik, 2005

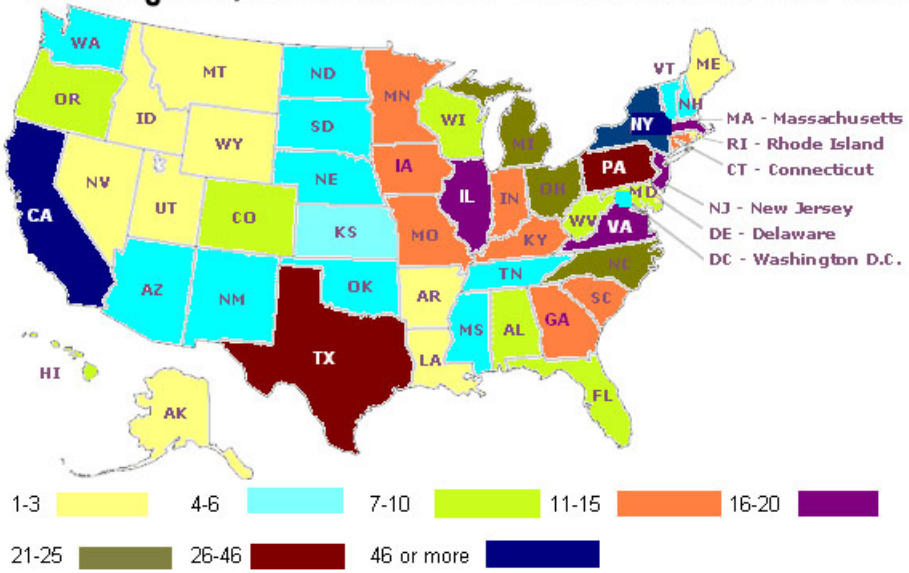


visualization from: “Diabetes in Numbers”, Tony Scully, Nature, vol 485, pg S2-S3, 17 May 2012

WAC Programs in the United States in 1987



WAC Programs/Initiatives in the United States in 2006-2008



PeopleGarden: Creating Data Portraits for Users

A user's PeopleFlower changes over time.

· The numbers of petals increases as more messages are posted, just as a flower opens up.

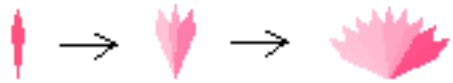
· Older petals move to the left as newer petals are added

to the right, to maintain symmetry. The overall shape

of a flower is determined by how many petals it has.

· Each petal fades over time showing time since posting.

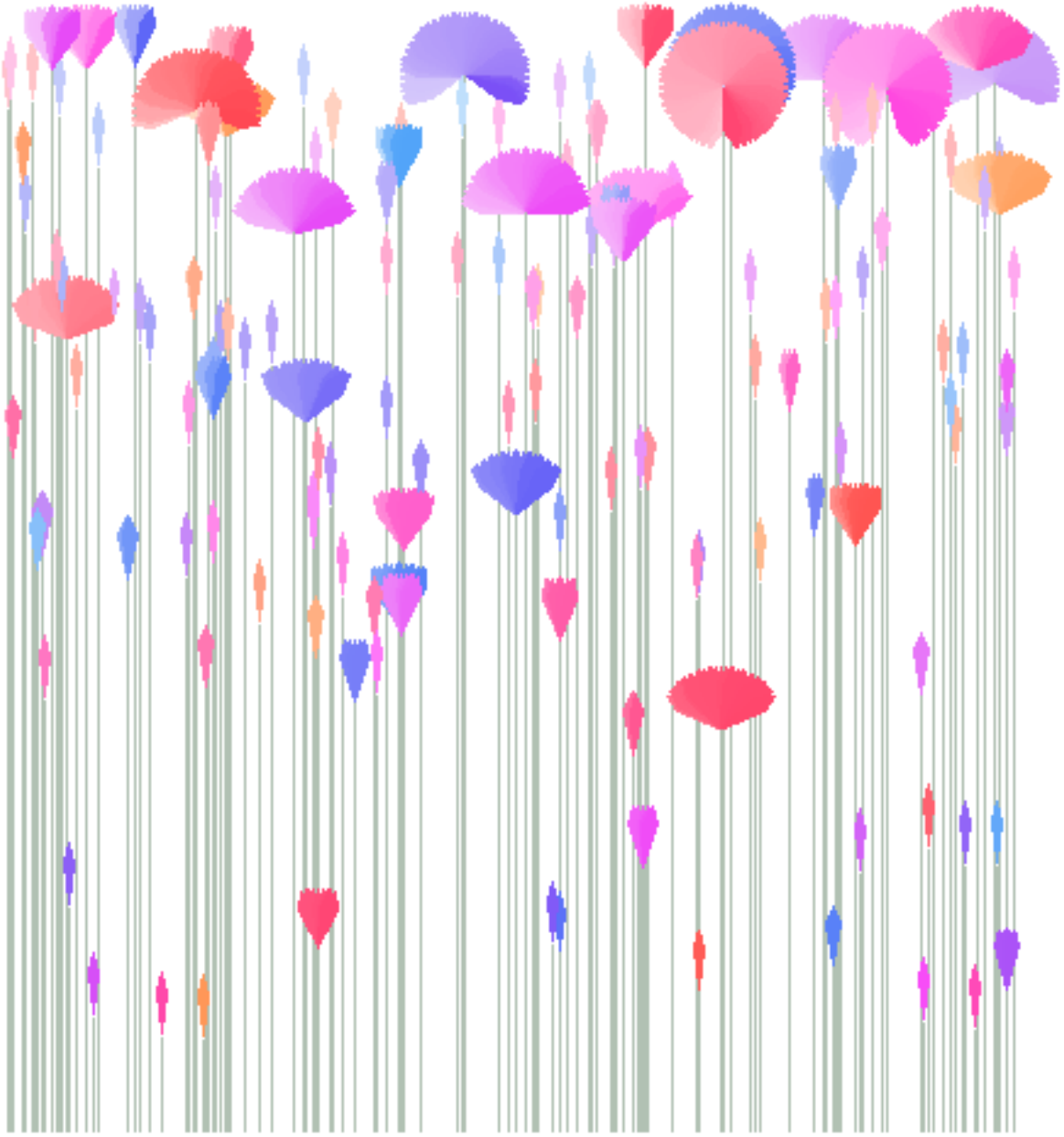
· A marked difference in saturation of adjacent petals, seen in the rightmost flower, denotes a gap in posting.



same PeopleFlowers with petals colored by whether the post starts a new conversation (i.e. initial posts versus replies)

http://graphics.lcs.mit.edu/~becca/papers/pgarden

- A PeopleGarden showing messages from a message board with 1200 postings over a 2-month period. Height of flower denotes amount of time a user has been at the board.



Contextualized Monitoring and Root Cause Discovery in IPTV Systems Using Data Visualization

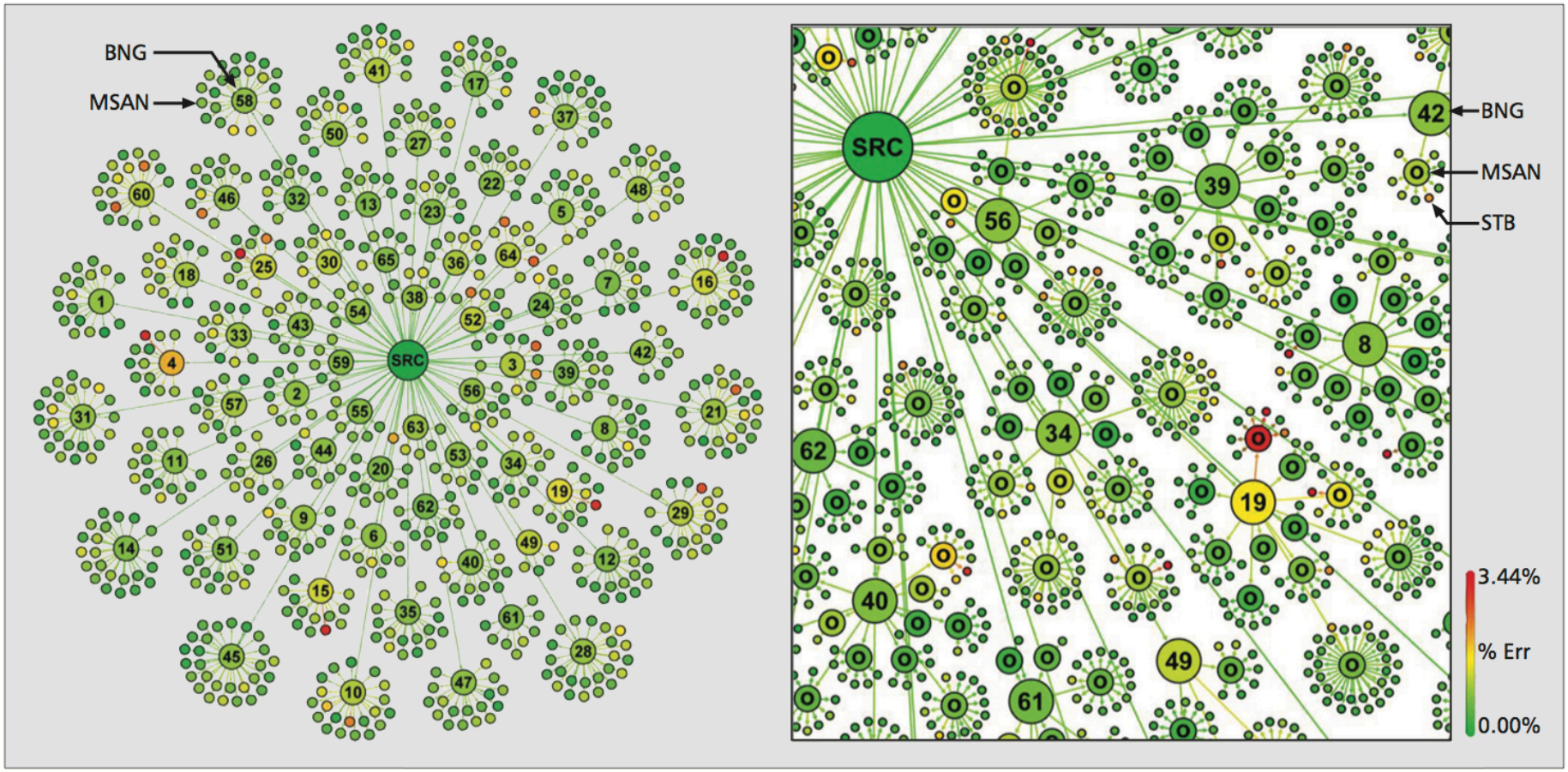
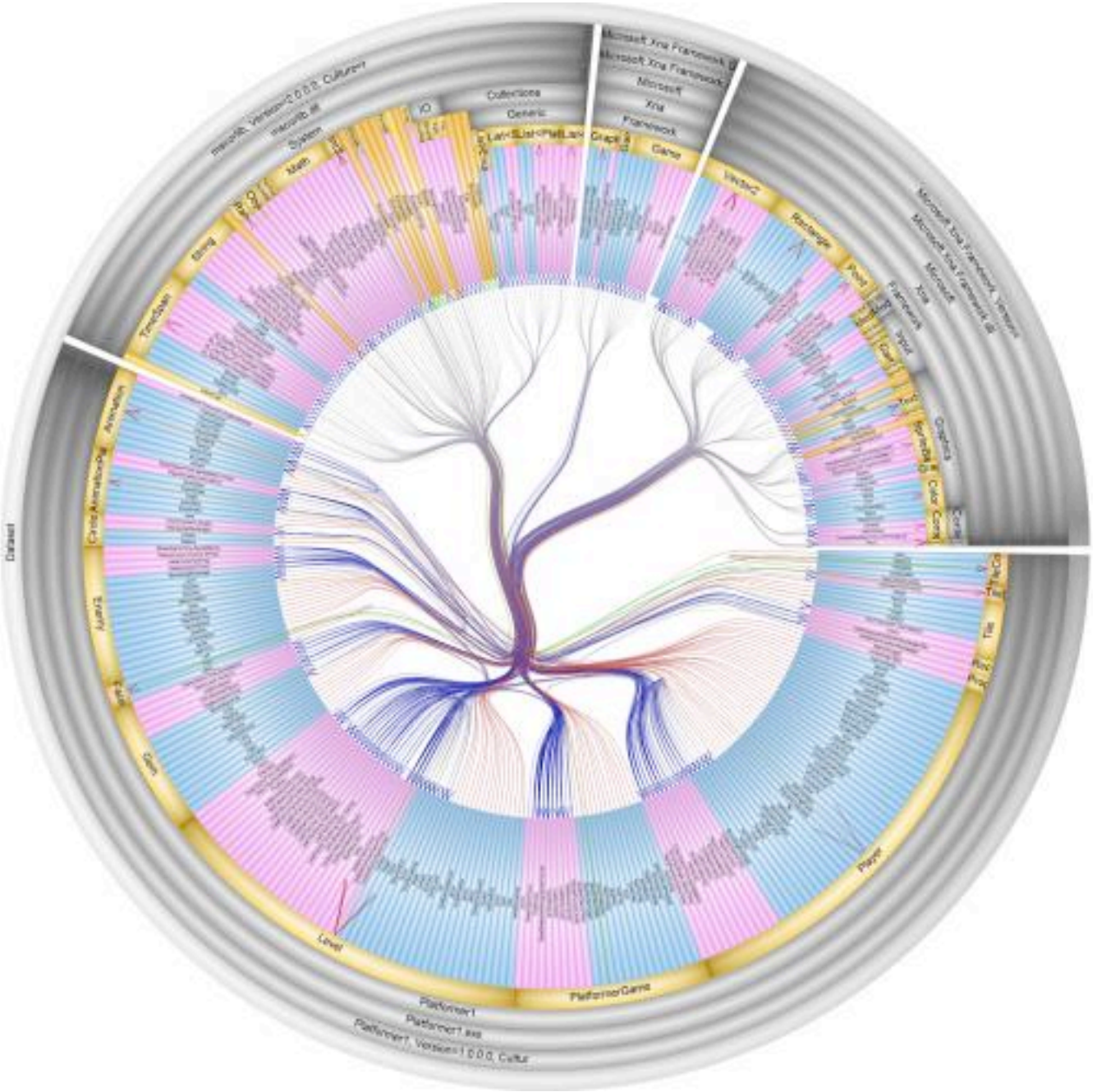


Figure 3. *IPTV network topology map obtained by working back from the end nodes (tree leaves) and matching them to common ancestors. The first graph shows the entire network from the source (SRC) to MSANs with the BNGs numbered from 1 to 65; the second picture shows a zoomed-in section of a larger graph with an additional hierarchical level: the end users. Node size in both graphs is a function of logical distance from the source. Node color indicates percentage of transport stream errors (green is low, red is high). BNGs are marked with numbers, while MSANs in the second graph are marked with a circle. End-node labels in both graphs were omitted for clarity. Created using the open source GePhi software.*

The Radial view of SolidSX shows source code elements as nested rectangles in the outer rings. The relations between these elements, such as call and inheritance relations, are shown as curved arrows. The color on both elements and relations are used to encode attributes or metrics.



http://bit.ly/7qCHo2

Tips for project

- do background searches for visualizations for similar problems and different visualizations for the same problem

Information visualization

Visualcomplexity.com

- Online gallery with best projects in information visualization
- focused on visualization of networks