UC Berkeley EECS
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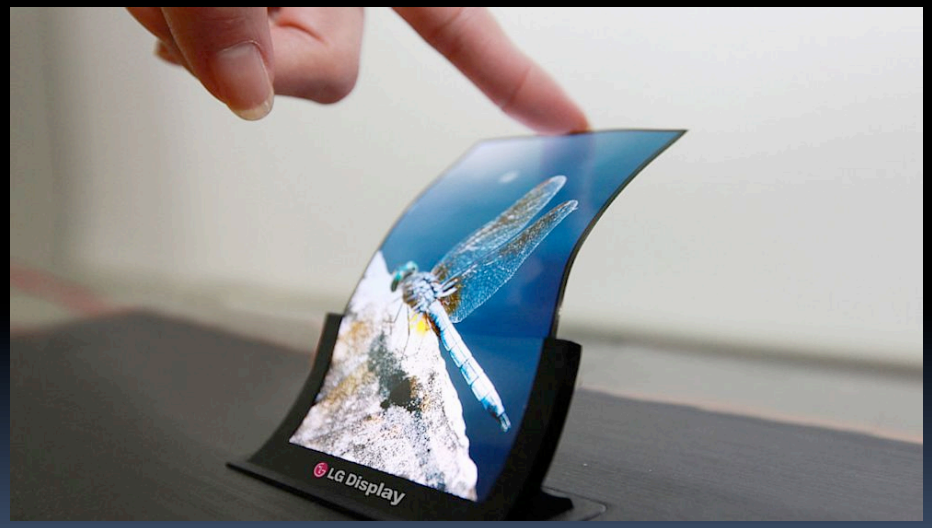
The Beauty and Joy of Computing

Data

Bendable Displays!!!



http://abcnews.go.com/Technology/lgs-flexible-screens-rolling-off-factory-lines/story?id=20498107

Data and Information facilitate knowledge

- Computing enables and empowers new methods of information processing that have led to monumental change across disciplines, from art to business to science.
- Managing & interpreting an overwhelming amount of raw data is part of the foundation of our information society and economy.
- People use computers and computation to translate, process, and visualize raw data, and create information.
- Computation and computer science facilitate and enable a new understanding of data and information that contributes knowledge to the world.
- You will work with data using a variety of computational tools and techniques to better understand the many ways in which data is transformed into information and knowledge.

Ubiquitous data

…we work with it all the time:

- Data is collected any moment of your life
- Data is stored, copied, transmitted, deleted, edited.
- Computers perform operations on data
- Data enters and exits through sensors
- We can measure it!
  - 1 bit = '0'|'1'
  - 1 Byte = 8 bit
  - 1 KB = 1024 Bytes, 1MB = 1024kB, 1GB = 1024MB, 1TB=1024GB, 1PB=1024TB, 1EB=1024PB, …

How much is?

- **1 KB?**
  - Paragraph of text
- **1 MB?**
  - 4 Mega pixel JPEG (compressed) image
- **1 GB?**
  - One hour of SD TV or 7 minutes of HDTV
- **1 TB?**
  - 2,000 hours of audio (uncompressed), 17,000 hours of MP3s
- **1 PB?**
  - Enough data to store the DNA of the entire population of the US – three times!

The "biggest" data?

What do you think is the biggest data overall?

a) Text
b) Images
c) DNA
d) Videos
e) Census Data

Big Data

- Netflix is said to use 1 PB to store the videos for streaming.
- World of Warcraft is stored on 1.3PB to maintain the game.
- Internet Archive: About 10PB
- AT&T transfers about 30PB of data through its networks each *day.*
- YouTube processes about 40PB of videos a ***day.***
  - Multimedia data *biggest* data!

Challenges

- **Storage**
  - No single hard disk/memory unit can store the data
  - Need to parallelize harddisks
  - All the problems of concurrent programming!
    - How to access the data?
    - What if a disk fails?
    - How fast is the access (read, write, delete)?
    - Physical limits: Energy cooling

Techniques that Help: Lossless Compression

- Entropy compression reduces data volume by removing redundant information
- This compression is reversible but has mathematically proven limits.

- Example:

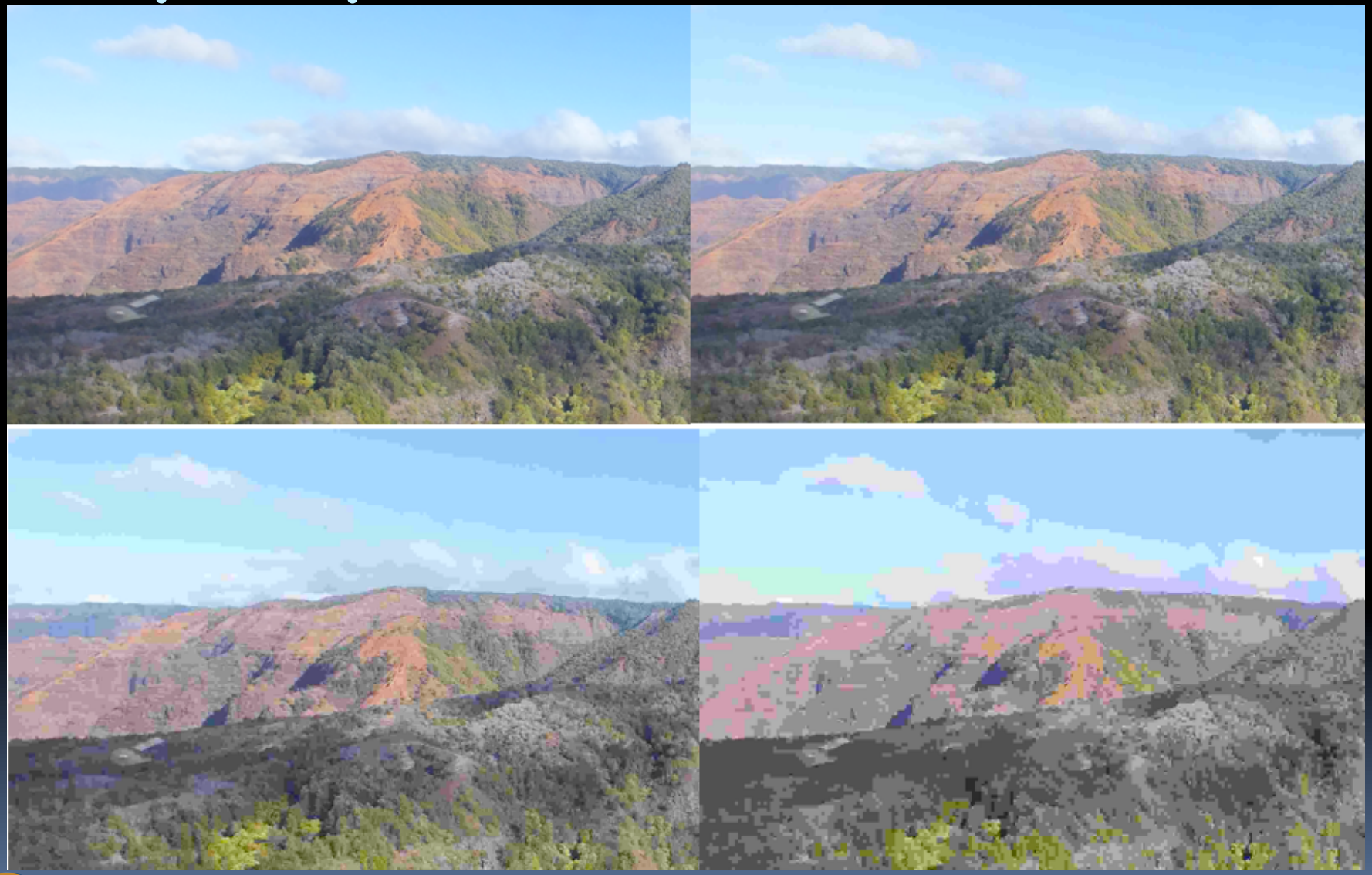
AAAAAABBBBBCCC -> 6A5B3C

Techniques that Help: Lossy Compression

- Lossy compression reduces data volume by removing irrelevant information
- This compression is not fully reversible but only has perceptual limits.

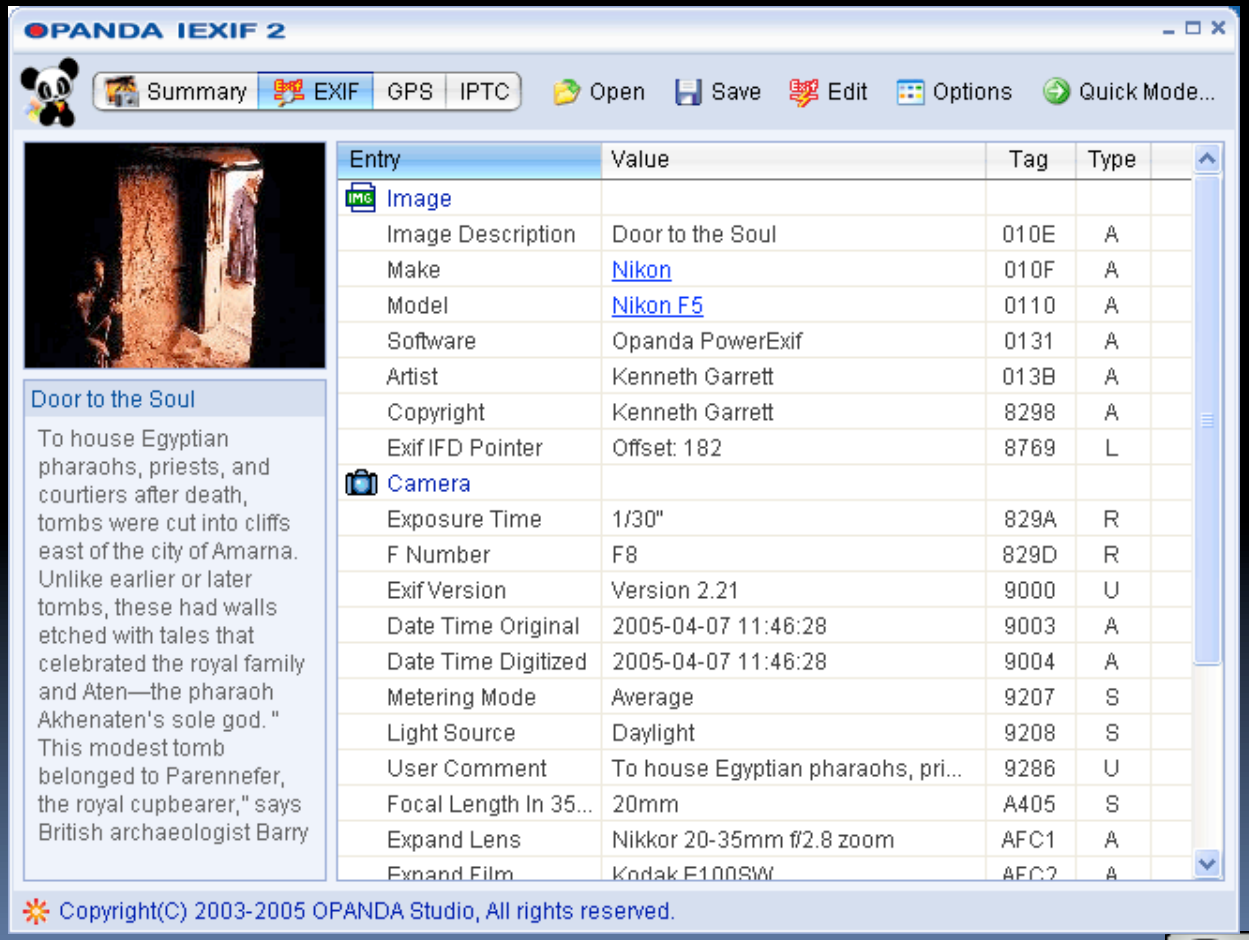
- Compression needs an agreement on decompression = "format"

Lossy Compression: JPEG



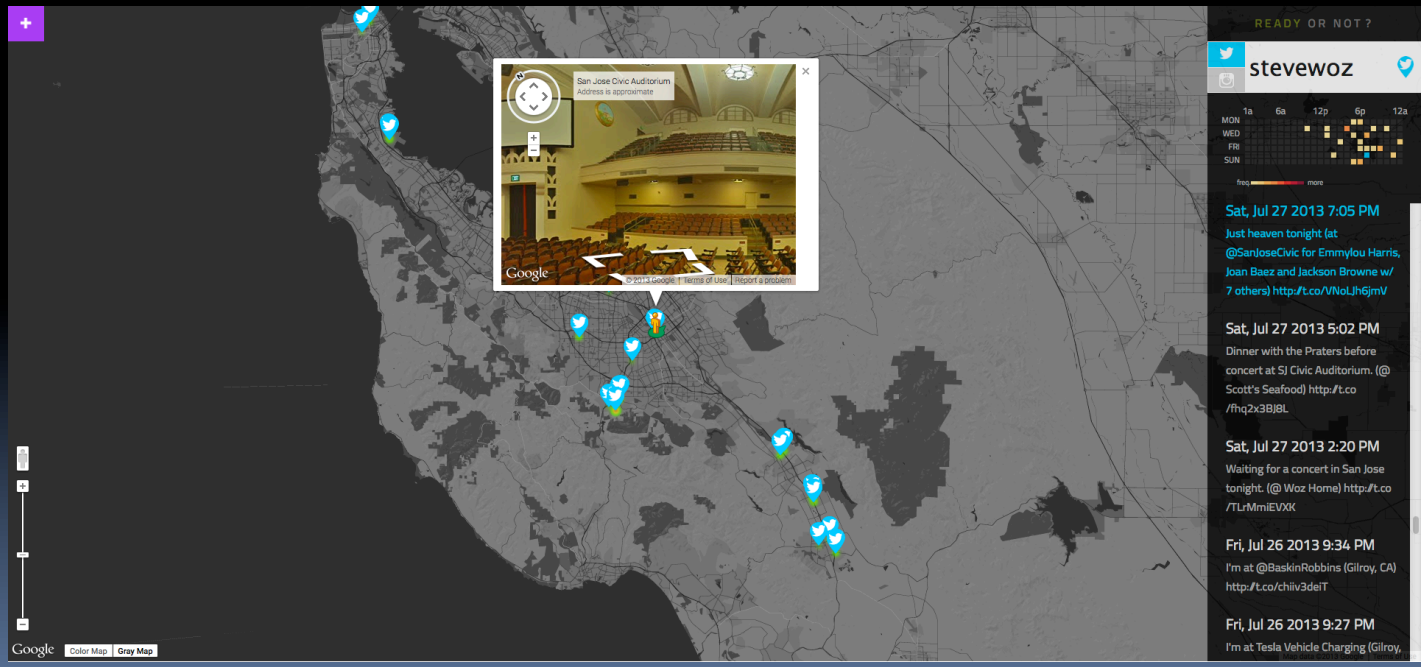
Techniques that help: Metadata

- Metadata: Data about data. Helps processing of data, e.g. search
- Example:



Two Main Reason for Digital Data

- Digital data can be copied without loss.
- Digital data can be processed by a computer, e.g. for search
- Problems:
  - Privacy
  - Security



One Main Reason for Big Data

- **Analyzing data at Internet-scale helps understand the world on never before seen scale.**
- **Useful for empirical sciences:**
  - What are the economic trends based on Google searches?
  - Are there animals that dance to music without human training?
  - How is the flu progressing?
    - `www.google.org/flutrends/us/

Correlation does not Imply Causality!

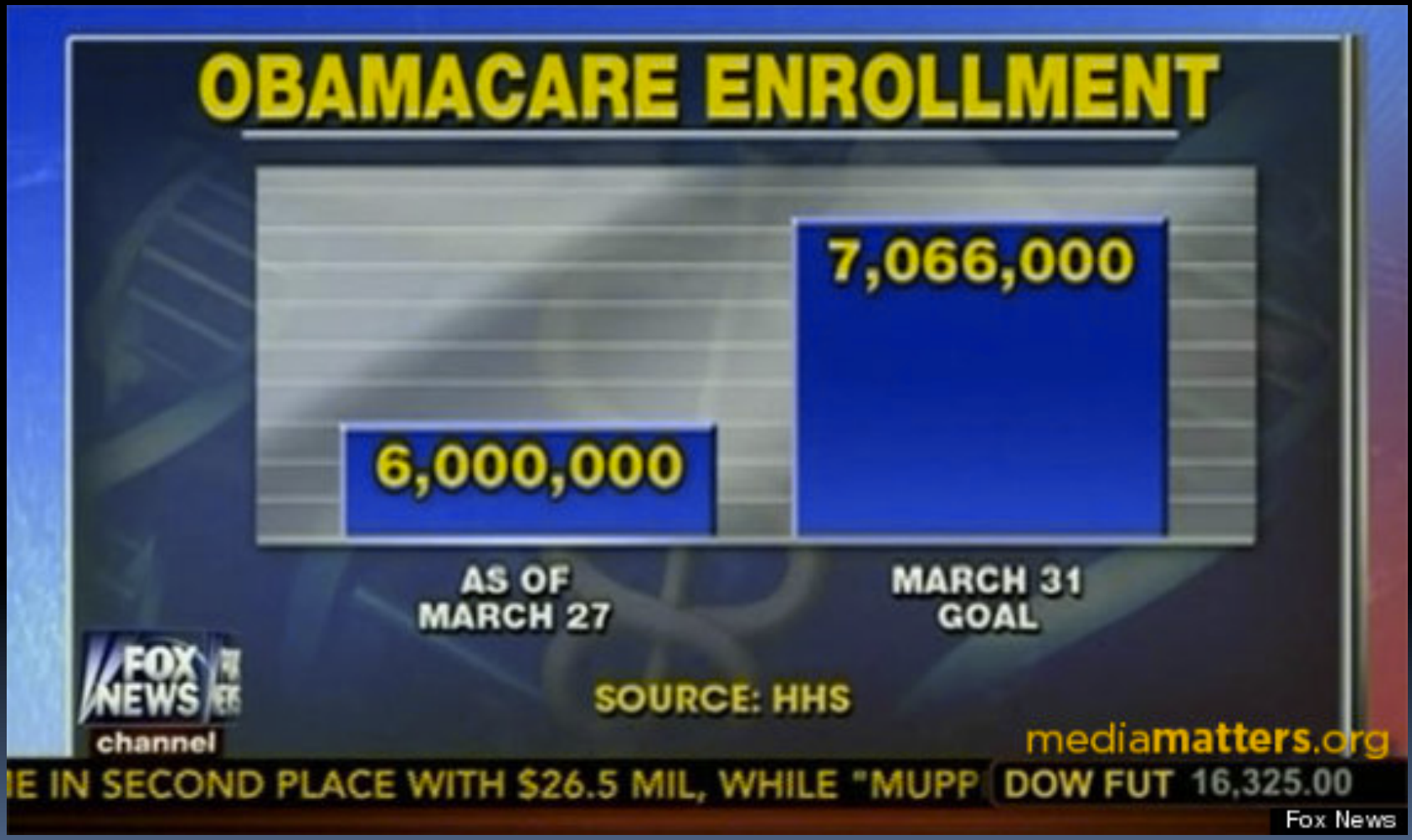
- **cum hoc ergo propter hoc logical fallacy:**
  - A occurs in correlation with B.
  - Therefore, A causes B.
- **Just because A and B are correlated does not necessarily imply one causes the other! It could be that…**
  - A may be the cause of B
  - B may be the cause of A
  - some unknown third factor C may actually be the cause of A and B.
  - A caused B AND B caused A. This is a self-reinforcing system.
    - E.g., "preditor-prey" relationships
  - the "relationship" is a coincidence or so complex or indirect that it is more effectively called a coincidence (i.e. two events occurring at the same time that have no direct relationship to each other besides the fact that they are occurring at the same time).

Is Data the Solution to Everything?

- "Even" Internet data is biased
- It's easy to draw conclusions too quickly
- Sometimes finding the questions to ask is the hard part…
- E.g., NetFlix Prize
  - "Predict whether someone will enjoy a movie based on how much they liked or disliked other movies"
  - Dataset: users and movie ratings
  - What questions can we ask of this data set?

www.huffingtonpost.com/2014/03/31/fox-news-obamacare-graphic_n_5063582.html

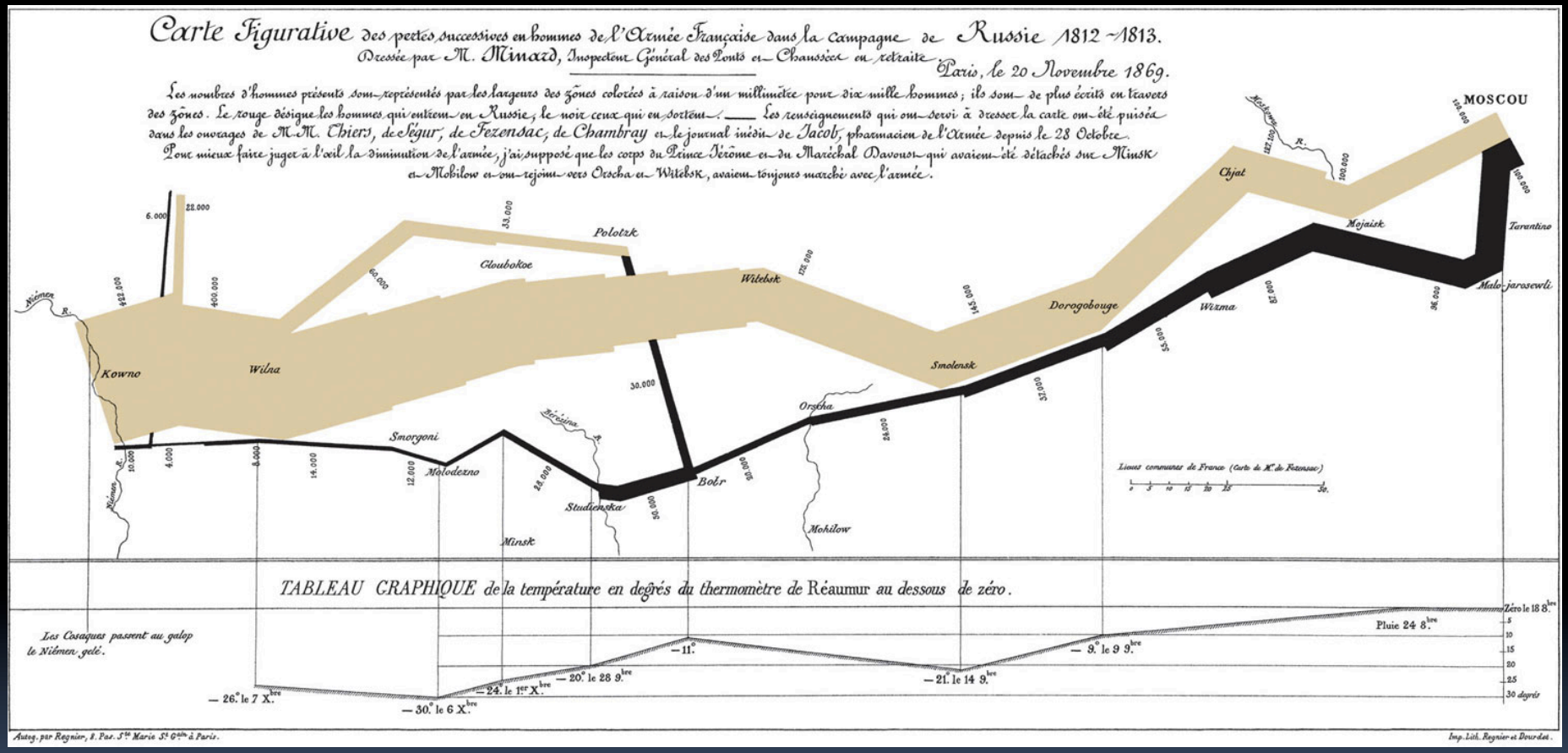
Visualization … Epic FAIL



Fox News Graphic on the "Obamacare" Enrollment as of 2014-03-27

www.edwardtufte.com/tufte/posters

Visualization … Epic WIN



Charles Joseph Minard, Napoleon's 1812 Russian Campaign

Summary

- The right questions need to be answered by the proper data.
- The rewards are high but handling data is an ongoing challenge to computer scientists as well as security specialists and privacy preservers.