Introduction to Big Data

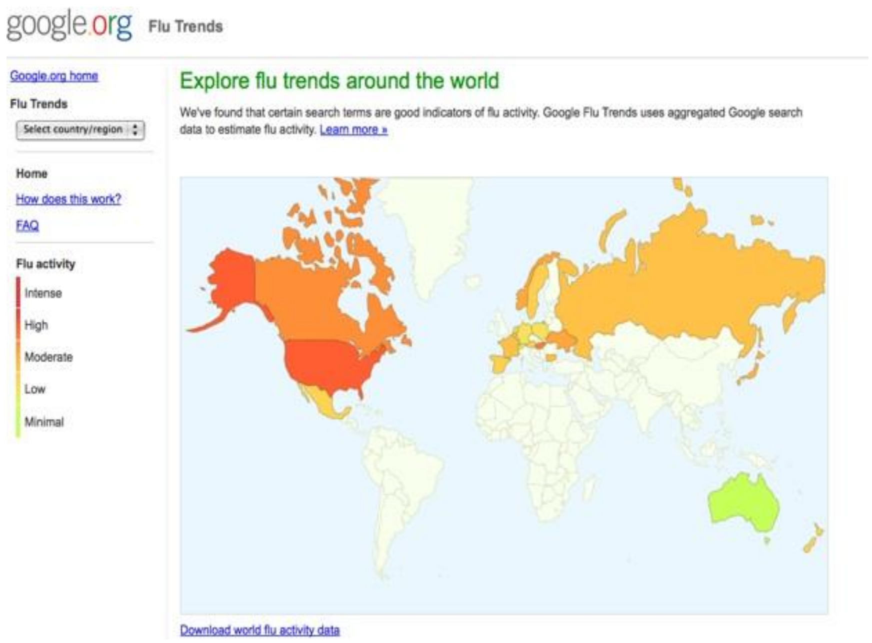
Based on “Big Data: Hype or Hallelujah?” by Elena Baralis
http://dbdmg.polito.it/wordpress/wp-content/uploads/2010/12/BigData_2015_2x.pdf

Big data

big data
information
search
management
science
analysis
based
research
petabytes
storage
large
software
future
internet
billion
use
sets
new
size
volume
exabytes
technology
years
process
real
business
databases
million time
approaches
development
every
technologies
processing
decision
online institute
users
many
used
uses
rate
parallel
terms
market
sensor
san
world
social
critiques
national systems
massive
now
year
shutterstock

BIG
DATA
STORAGE
COMPLEX
ANALYTICS
TECHNOLOGIES
INFORMATION
DATABASES
RESEARCH
EXAMPLES
PETABYTES
SHARED
DISTRIBUTED
GENOMICS APPLIED
LARGE
PROCESSING
PROCESS
DEFINITION
WORKING
ONE
STORE
BIOLOGICAL
PRACTITIONERS
PERFORMANCE
COST
SET
MOVING
TOOLS
RELATIONAL
MPP
CITATION
TARGET
USE
GARTNER
CAPTURE
CAPACITY
SOCIAL
LARGER
DISK
TOLERABLE
NETWORKS
SOFTWARE
GROW
SAN
NEEDED
HUNDREDS
TERABYTES
CONTINUES
WITHIN
SETS
MANAGEMENT
SENSOR
INTERNET
INCLUDE
TIME
PARALLEL
SYSTEMS
CASE
ELAPSED
DIFFICULTY
EVERY
MANAGE
CURRENT
LOGS
RECORDS
SEARCH
USING
ALSO
ABILITY
SIZE
BUSINESS
MASSIVELY
fotolia

Google Flu trends



google.org Flu Trends

Google.org home

Flu Trends

Select country/region

Home

How does this work?

FAQ

Flu activity

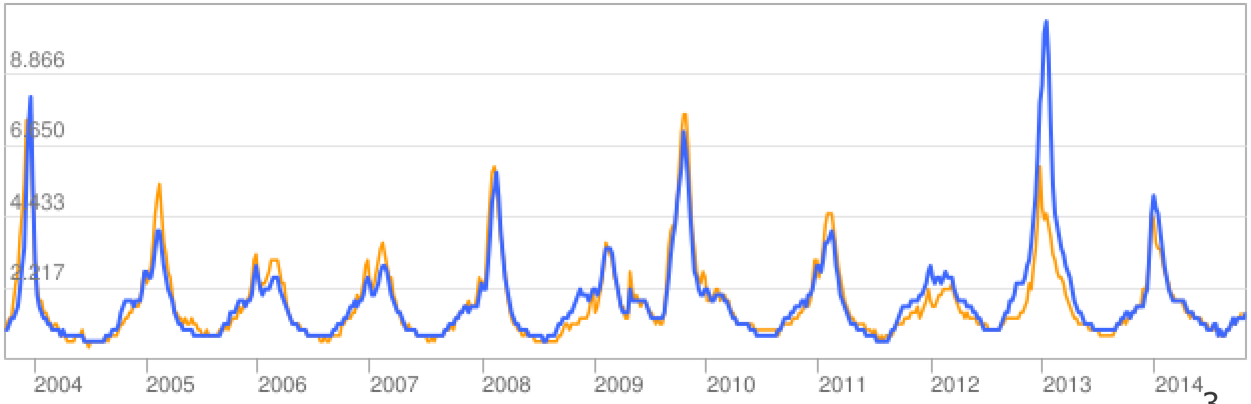
- Intense
- High
- Moderate
- Low
- Minimal

Explore flu trends around the world

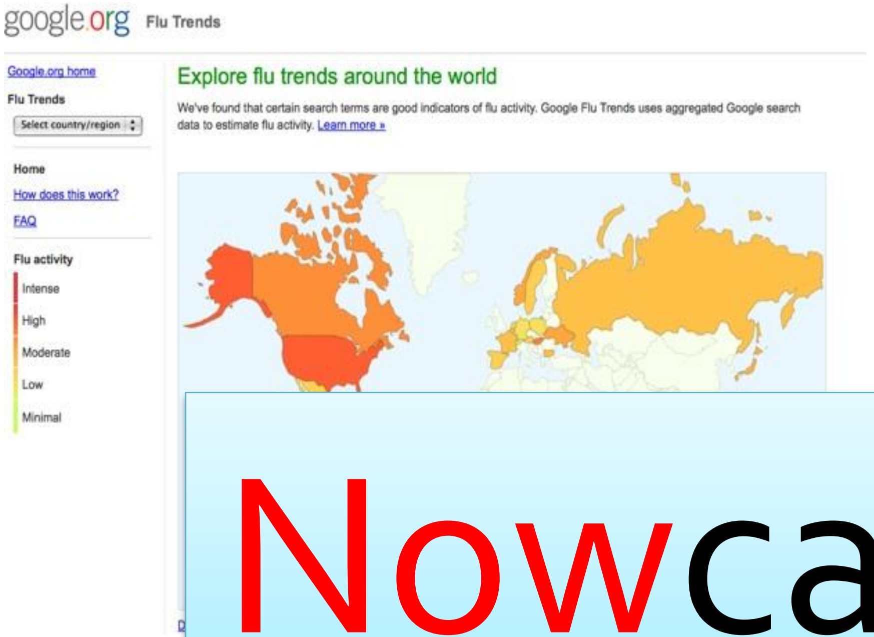
We've found that certain search terms are good indicators of flu activity. Google Flu Trends uses aggregated Google search data to estimate flu activity. Learn more »

Download world flu activity data

- February 2010
  - Google detected flu outbreak two weeks ahead of CDC data (Centers for Disease Control and Prevention – U.S.A)
  - Based on the analysis of Google search queries



Google Flu trends

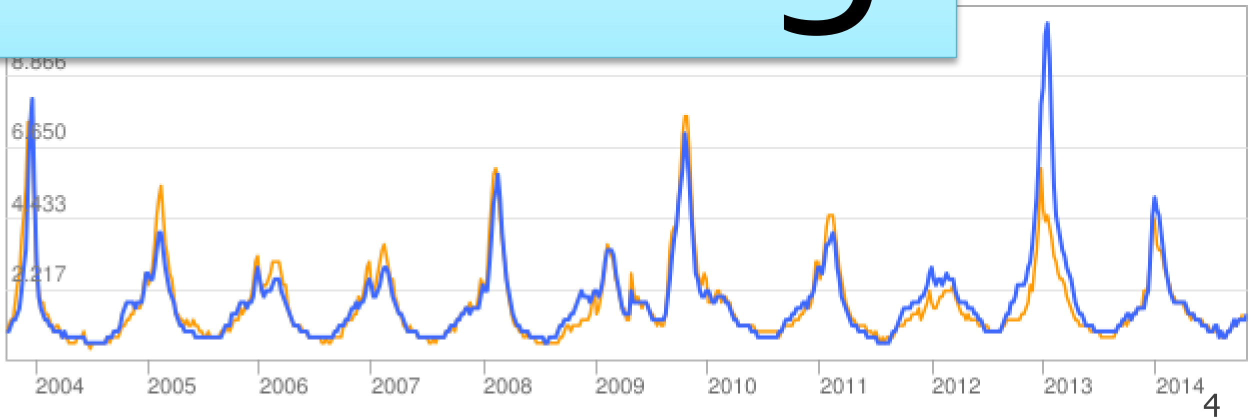


Explore flu trends around the world

We've found that certain search terms are good indicators of flu activity. Google Flu Trends uses aggregated Google search data to estimate flu activity. Learn more »

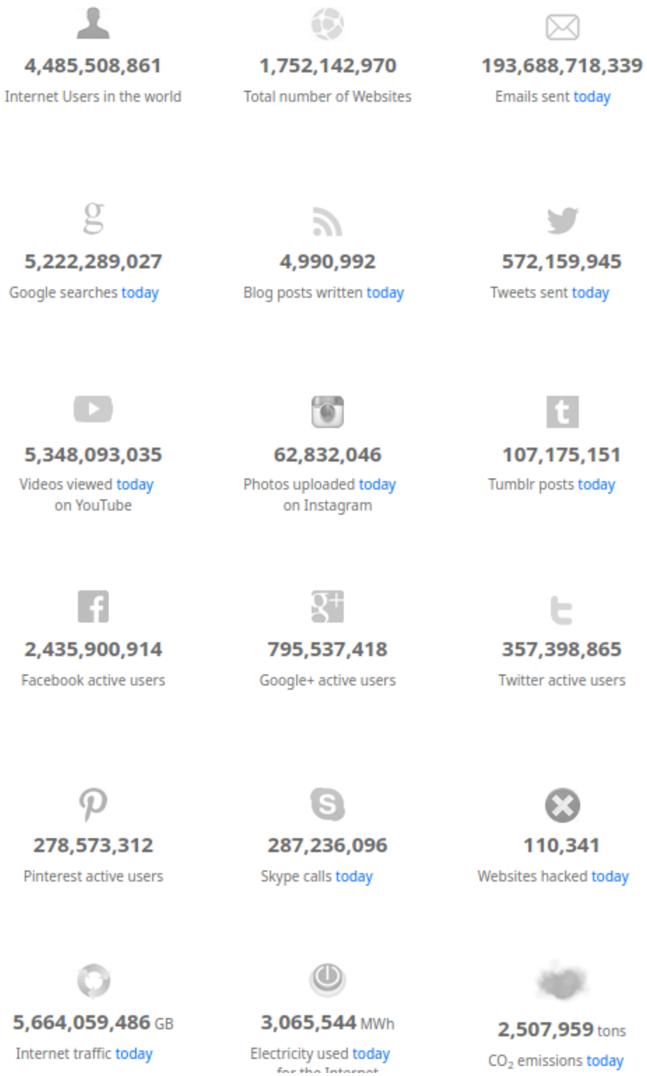
- February 2010
  - Google detected flu outbreak two weeks ahead of CDC data (Centers for Disease Control and S.A)
  - alysis of
ueries

Nowcasting



Data on the Internet…

- Internet live stats
  - http://www.internetlivestats.com/

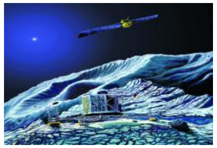


4,485,508,861 Internet Users in the world	1,752,142,970 Total number of Websites	193,688,718,339 Emails sent today
5,222,289,027 Google searches today	4,990,992 Blog posts written today	572,159,945 Tweets sent today
5,348,093,035 Videos viewed today on YouTube	62,832,046 Photos uploaded today on Instagram	107,175,151 Tumblr posts today
2,435,900,914 Facebook active users	795,537,418 Google+ active users	357,398,865 Twitter active users
278,573,312 Pinterest active users	287,236,096 Skype calls today	110,341 Websites hacked today
5,664,059,486 GB Internet traffic today	3,065,544 MWh Electricity used today for the Internet	2,507,959 tons CO_2 emissions today

Who generates big data?

- User Generated Content (Web & Mobile)
  - E.g., Facebook, Instagram, Yelp, TripAdvisor, Twitter, YouTube

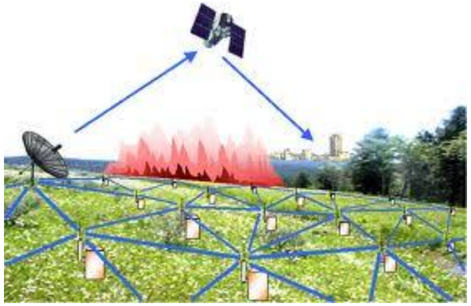
- Health and scientific computing

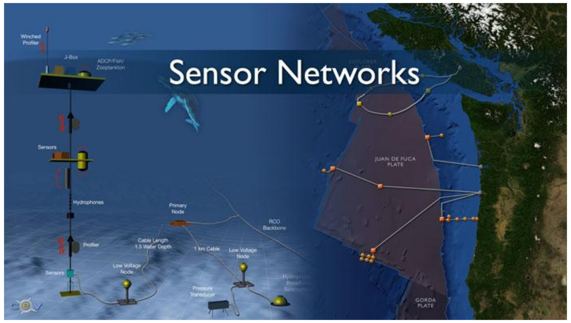


Who generates big data?

- Log files
  - Web server log files, machine system log files

- Internet Of Things (IoT)
  - Sensor networks, RFIDs, smart meters





An example of Big data at work

Crowdsourcing

Sensing

Map data

Computing

Real time traffic info

Travel time forecast/nowcast

What is big data?

CONSULTANTS SAY THREE QUINTILLION BYTES OF DATA ARE CREATED EVERY DAY.
DilbertCartoonist@gmail.com
IT COMES FROM EVERYWHERE. IT KNOWS ALL.
ACCORDING TO THE BOOK OF WIKIPEDIA, ITS NAME IS "BIG DATA."
BIG DATA
©2012 Scott Adams, Inc./Dist. by Universal Uclick
BIG DATA LIVES IN THE CLOUD. IT KNOWS WHAT WE DO.

- Many different definitions
  - "Data whose scale, diversity and complexity require new architectures, techniques, algorithms and analytics to manage it and extract value and hidden knowledge from it"

What is big data?

CONSULTANTS SAY THREE QUINTILLION BYTES OF DATA ARE CREATED EVERY DAY.
IT COMES FROM EVERYWHERE. IT KNOWS ALL.
ACCORDING TO THE BOOK OF WIKIPEDIA, ITS NAME IS "BIG DATA."
BIG DATA
BIG DATA LIVES IN THE CLOUD. IT KNOWS WHAT WE DO.

DilbertCartoonist@gmail.com

©2012 Scott Adams, Inc./Dist. by Universal Uclick

- Many different definitions
  - "Data whose **scale**, **diversity** and **complexity** require new architectures, techniques, algorithms and analytics to manage it and extract value and hidden knowledge from it"

What is big data?

CONSULTANTS SAY THREE QUINTILLION BYTES OF DATA ARE CREATED EVERY DAY.
DilbertCartoonist@gmail.com
IT COMES FROM EVERYWHERE. IT KNOWS ALL.
ACCORDING TO THE BOOK OF WIKIPEDIA, ITS NAME IS "BIG DATA."
BIG DATA
©2012 Scott Adams, Inc./Dist. by Universal Uclick
BIG DATA LIVES IN THE CLOUD. IT KNOWS WHAT WE DO.

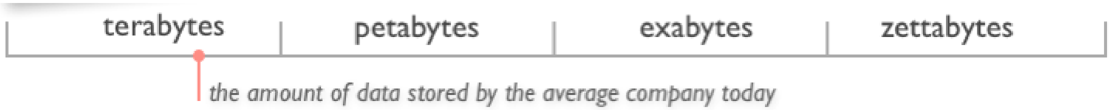
- Many different definitions
  - "Data whose scale, diversity and complexity require new **architectures**, **techniques**, **algorithms** and **analytics** to manage it and extract value and hidden knowledge from it"

The Vs of big data

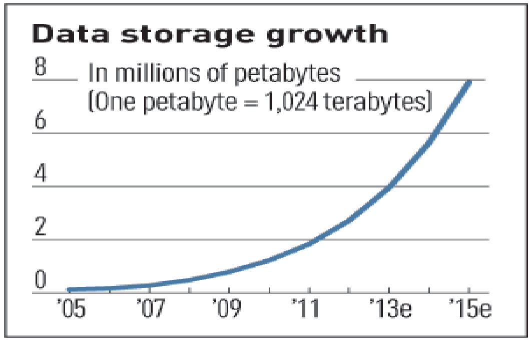
- The 3Vs of big data
  - Volume: scale of data
  - Variety: different forms of data
  - Velocity: analysis of streaming data
- … but also
  - Veracity: uncertainty of data
  - Value: exploit information provided by data

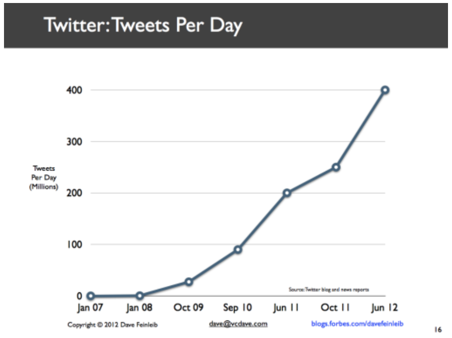
The Vs of big data

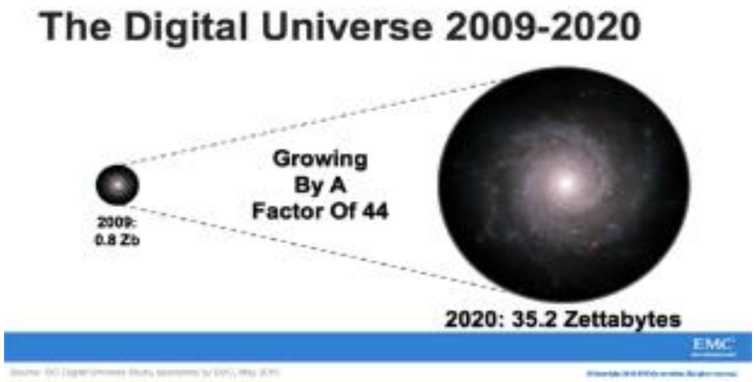
- Volume



  - Data volume increases exponentially over time
  - 44x increase from 2009 to 2020
    - Digital data 35 ZB in 2020

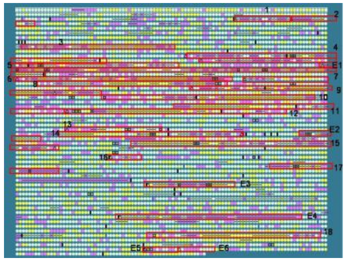


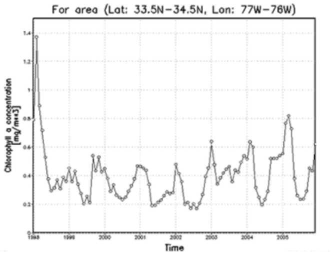


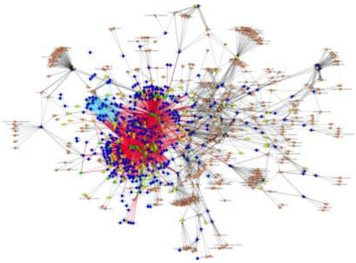


The Vs of big data

- Variety
  - Various formats, types and structures
    - Numerical data, image data, audio, video, text, time series



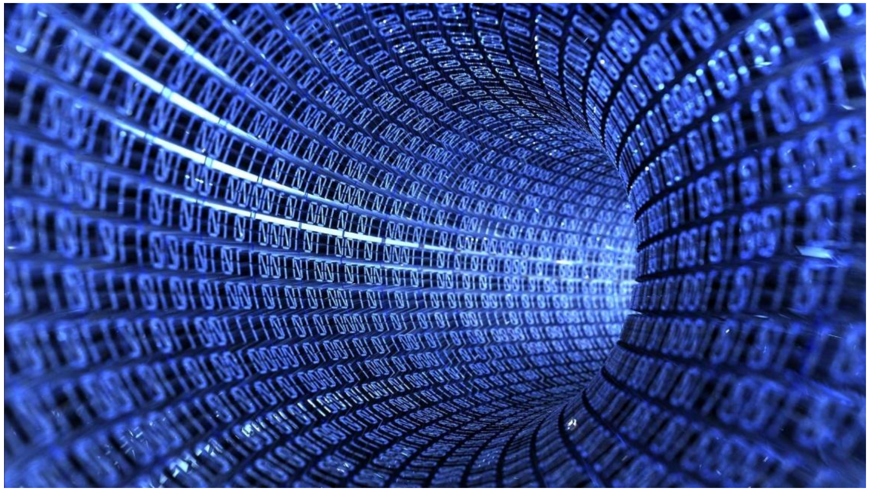

For area (Lat: 33.5N-34.5N, Lon: 77W-76W)
Chlorophyll a concentration [mg/m+3]
Time



  - A single application may generate many different formats
    - Heterogeneous data
    - Complex data integration problem

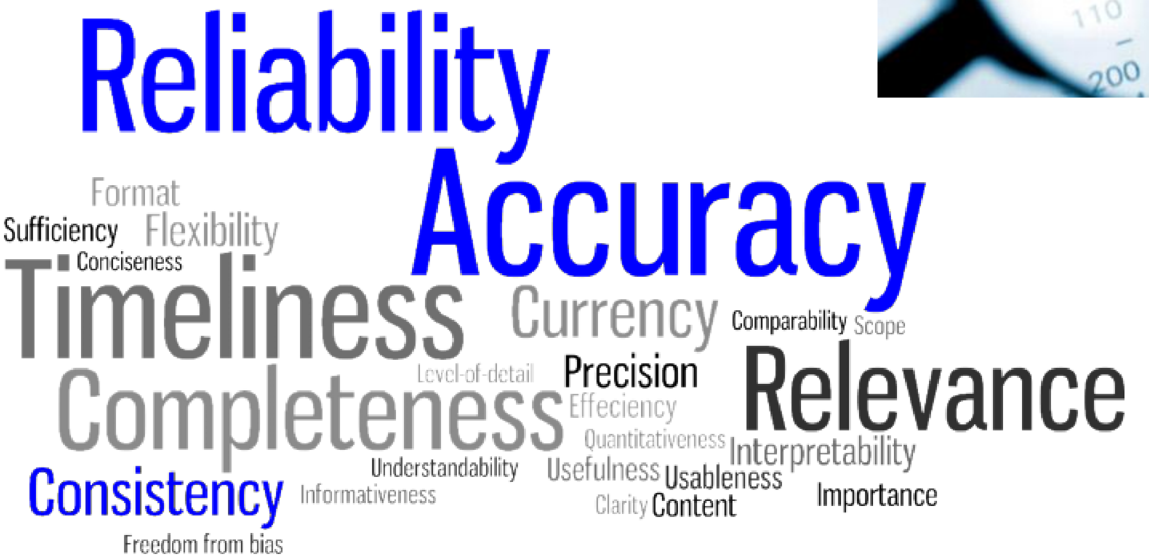
The Vs of big data

- Velocity
  - Fast data generation rate
    - Streaming data
  - Very fast data processing to ensure timeliness



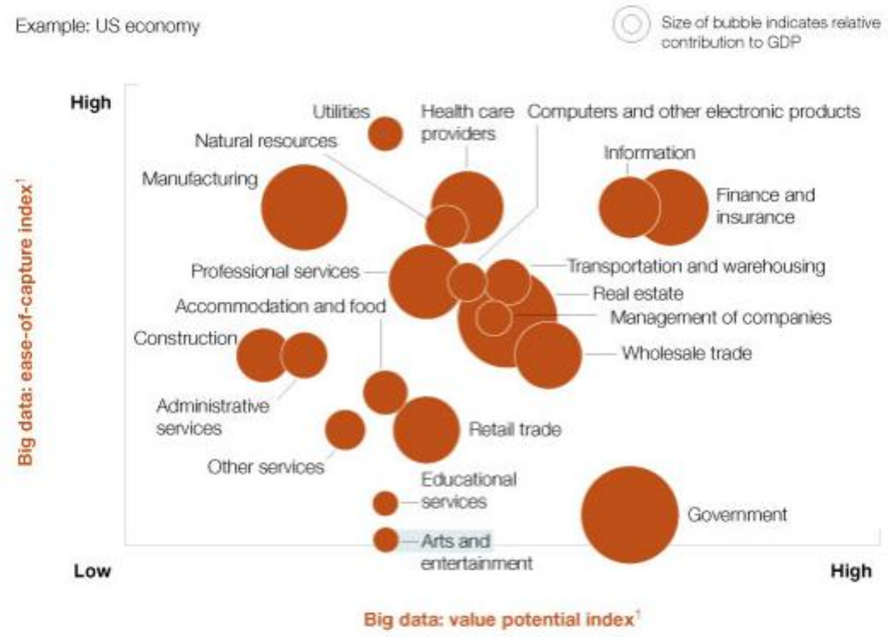
The Vs of big data

- Veracity
  - Data quality



The Vs of big data

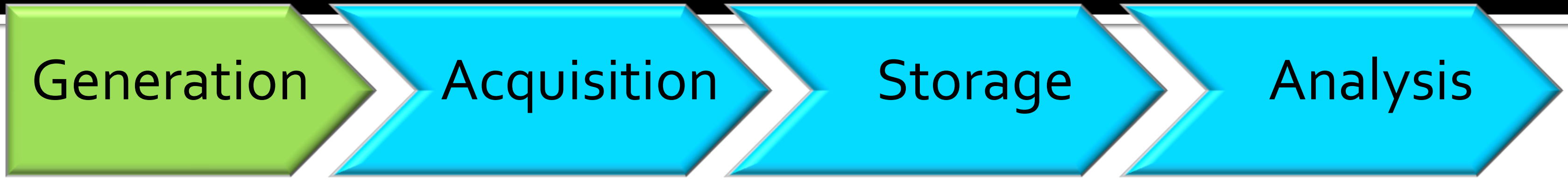
- Value
  - Translate data into business advantage



[1] For detailed explication of metrics, see appendix in McKinsey Global Institute full report *Big data: The next frontier for innovation, competition, and productivity*, available free of charge online at mckinsey.com/mgi.

Source: US Bureau of Labor Statistics; McKinsey Global Institute analysis

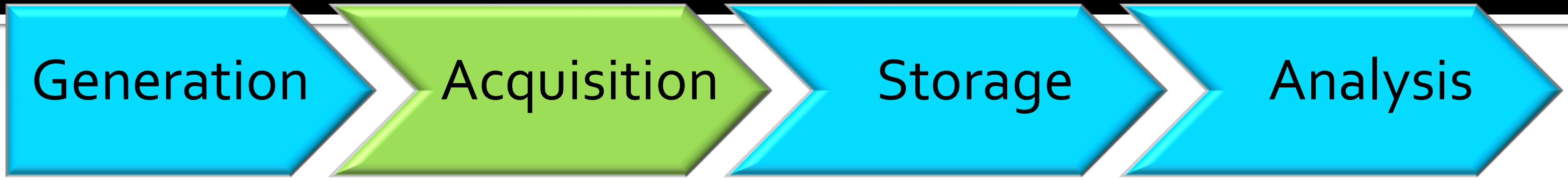
Big data value chain



Generation → Acquisition → Storage → Analysis

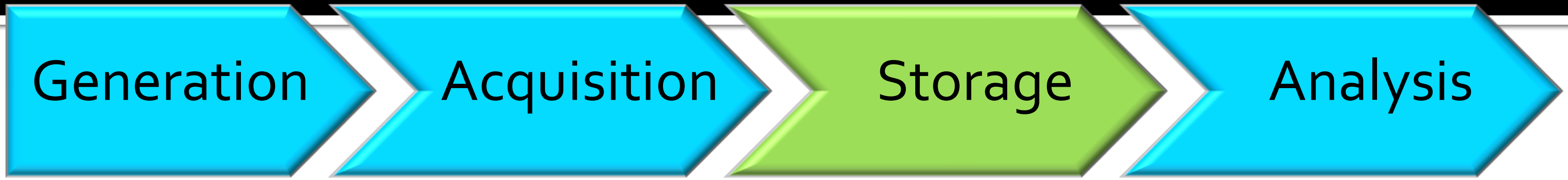
- Generation
  - Passive recording
    - Typically structured data
    - Bank trading transactions, shopping records, government sector archives
  - Active generation
    - Semistructured or unstructured data
    - User-generated content, e.g., social networks
  - Automatic production
    - Location-aware, context-dependent, highly mobile data
    - Sensor-based Internet-enabled devices

Big data value chain



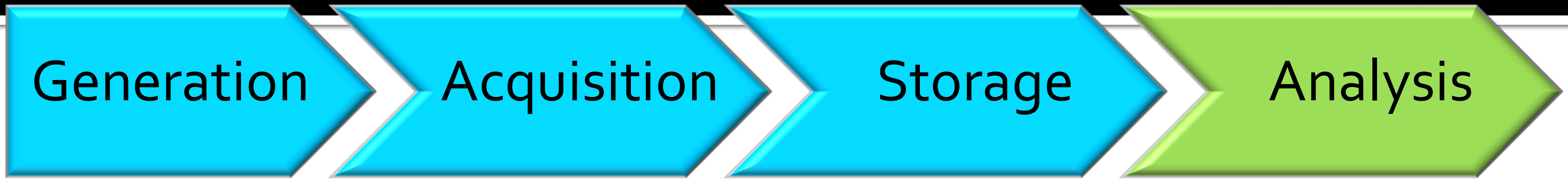
- Acquisition
  - Collection
    - Pull-based, e.g., web crawler
    - Push-based, e.g., video surveillance, click stream
  - Transmission
    - Transfer to data center over high capacity links
  - Preprocessing
    - Integration, cleaning, redundancy elimination

Big data value chain



- Storage
  - Storage infrastructure
    - Storage technology, e.g., HDD, SSD
    - Networking architecture, e.g., DAS, NAS, SAN
  - Data management
    - File systems (HDFS), key-value stores (Memcached), column-oriented databases (Cassandra), document databases (MongoDB)
  - Programming models
    - MapReduce, stream processing, graph processing

Big data value chain


Generation

Acquisition

Storage

Analysis

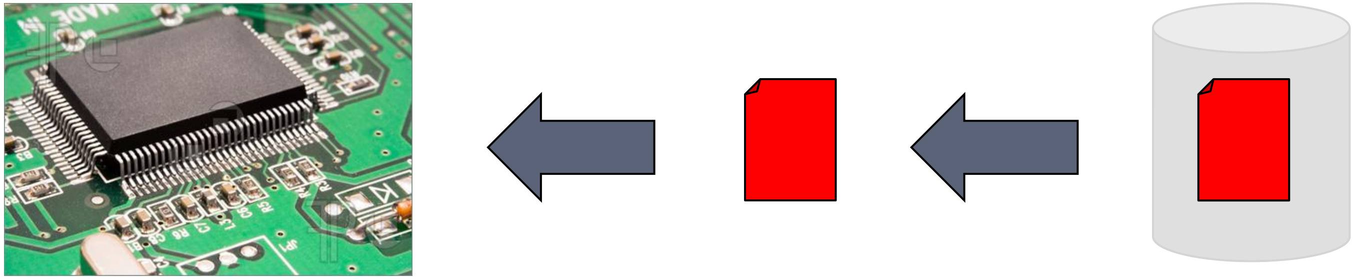
- Analysis
  - Objectives
    - Descriptive analytics, predictive analytics, prescriptive analytics
  - Methods
    - Statistical analysis, data mining, text mining, network and graph data mining
    - Clustering, classification and regression, association analysis
  - Diverse domains call for customized techniques

Big data challenges

- Technology and infrastructure
  - New architectures, programming paradigms and techniques are needed
- Data management and analysis
  - New emphasis on "data"
  - ➡ **Data science**

The bottleneck

- Processors process data
- Hard drives store data
- We need to transfer data from the disk to the processor



The solution

- Transfer the processing power to the data
- Multiple distributed disks
  - Each one holding a portion of a large dataset
- Process in parallel different file portions from different disks