CARLSON SCHOOL
OF MANAGEMENT
UNIVERSITY OF MINNESOTA

MSBA 6330
Big Data Analytics

Professor De Liu

Agenda

- Instructor
- Introduction to Big Data
- Syllabus

Course introduction

INSTRUCTOR

About the Instructor

- Dr. De Liu (刘德)
- Originally from Shandong Province, China
- Associate Professor & 3M Fellow in Business Analytics
- Research interests:

Social media and commerce

Internet auctions

Crowdfunding

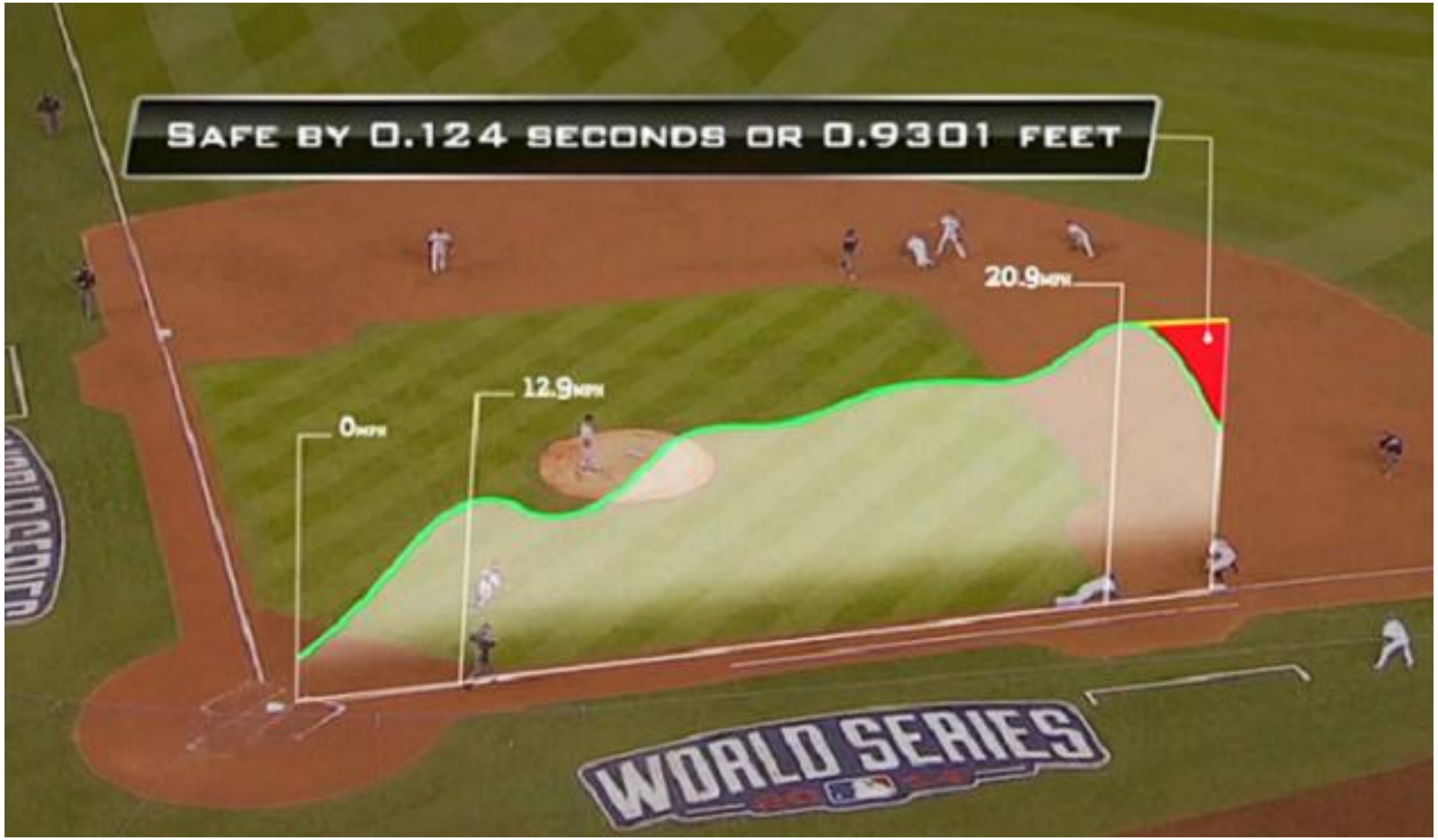
Gamification

Course introduction

START FROM A USE CASE

How big data helps Major League Baseball (MLB)?

Player Tracking Systems Powered by Big Data



Seconds after the play completed, the player tracker systems showed that if Hosmer had maintained his speed instead of diving to the bag, he would have been safe by about a foot

Behind the scene

- Data capturing
  - A Doppler radar system sits behind home plate, sampling ball position 2000 times a second.
  - Two stereoscopic imaging devices, sampling positions of players on the field 30 times a second.
  - Brief written notes of each play entered by personnel on the field after the action is over
  - ~ 30 JSON docs per second per game, 7TB per game.
- Data transmission
  - Seconds after a player is completed, data is transmitted from stadium to cloud servers

Behind the scene (cont.)

- Data analytics
  - within milliseconds of data transmission, parallel processing of data began
  - e.g. measuring player speed, forecasting/what if analysis, visualization
- Delivering results
  - Results of analysis are delivered to the Internet destinations
  - e.g. customers’ mobile phones and broadcaster’s monitors

More Use Cases of Big Data

- United Healthcare mines customer calls
  - Turn voice data into text, then analyze it with Natural Language Processing (NLP) software to detect consumer attitudes, using Hadoop and NoSQL.

- Medtronic: Using Hadoop + Spark + R to achieve 50+ speed up than SQL Server in analyzing billions of clinical observations to predict heart failure

- NeuroID: Loan fraud detection by analyzing real-time mouse-movements data
  - Analyzing mouse trajectory when people fill out loan application forms online to flag fraudulent cases (Hibbeln et al 2014). Data is streamed and analyzed on Amazon cloud.

What’s special about big data?

Course introduction

BIG DATA: CONCEPT AND OPPORTUNITIES

What is big data?

Big Data: "large volumes of high velocity, complex, and variable data that require advanced techniques and technologies to enable the capture, storage, distribution, management and analysis of the information

-- *from a US Congress Report in 2012*

What are the characteristics of big bata?

Volume

Velocity

Variety

Doug Laney, Gartner (2001)

Veracity

Value

Bernad Marr, “Big Data” (2015)

D. Laney, 3D data management: controlling data volume, velocity and variety, META Group Res. Note 6 (2001) 70.
B. Marr, Big Data: Using SMART Big Data, Analytics and Metrics to Make Better Decisions and Improve Performance, John Wiley & Sons, 2015.

Volume

There were 5 exabytes of information created between the dawn of civilization through 2003,

but that much information is now created every 2 days.

- Eric Schmidt, 2010

Some Examples of Big Data

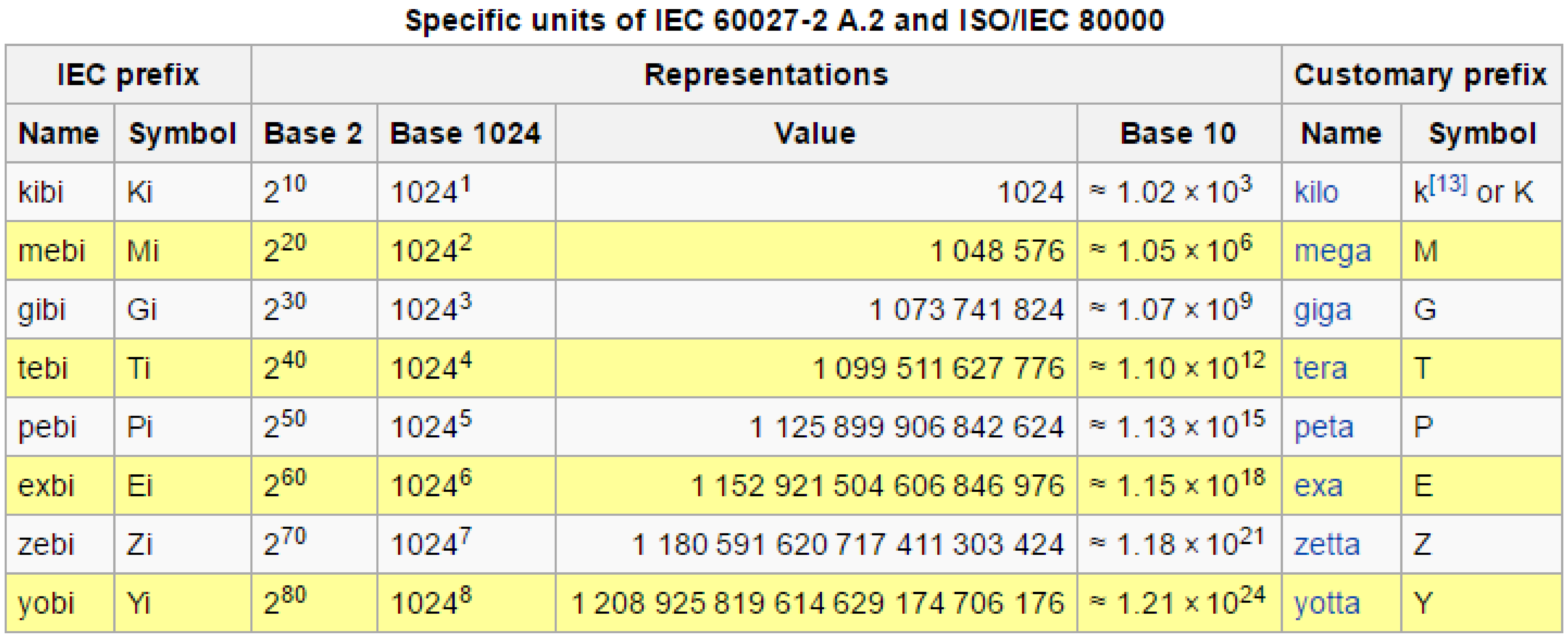
- Every day…
  - Over 2.25 billion shares are traded on the New York Stock Exchange
  - Facebook stores 4.5 billion "Likes"
  - Google processes about 24 petabytes of data
- Every minute…
  - Facebook users share nearly 2.5 million pieces of content
  - Email users send 204,000,000 messages

24 petabytes =

X 24,576

How big is “big”?

- 50% consider datasets between Terabyte and Petabye to be big.
- Whatever is considered “high volume” today will be even higher tomorrow.



Specific units of IEC 60027-2 A.2 and ISO/IEC 80000

IEC prefix		Representations				Customary prefix	
Name	Symbol	Base 2	Base 1024	Value	Base 10	Name	Symbol
kibi	Ki	2^{10}	1024^{1}	1024	≈ 1.02×10^{3}	kilo	k[13] or K
mebi	Mi	2^{20}	1024^{2}	1 048 576	≈ 1.05×10^{6}	mega	M
gibi	Gi	2^{30}	1024^{3}	1 073 741 824	≈ 1.07×10^{9}	giga	G
tebi	Ti	2^{40}	1024^{4}	1 099 511 627 776	≈ 1.10×10^{12}	tera	T
pebi	Pi	2^{50}	1024^{5}	1 125 899 906 842 624	≈ 1.13×10^{15}	peta	P
exbi	Ei	2^{60}	1024^{6}	1 152 921 504 606 846 976	≈ 1.15×10^{18}	exa	E
zebi	Zi	2^{70}	1024^{7}	1 180 591 620 717 411 303 424	≈ 1.18×10^{21}	zetta	Z
yobi	Yi	2^{80}	1024^{8}	1 208 925 819 614 629 174 706 176	≈ 1.21×10^{24}	yotta	Y

How much data?

- There are about 5,000,000 articles in the English Wikipedia 2015. How much data is that
  - if the articles are stored in plain text (compressed)? 11.5 GB
  - If the articles and edit histories are stored in XML text (compressed)?

    100 GB
  - If the articles and edit histories are stored in XML text (uncompressed)?

    10 TB

Source: https://en.wikipedia.org/wiki/Wikipedia:Size_of_Wikipedia

What are the challenges and opportunities associated with large volumes of data?

Opportunities of Big Volume

"It's not who has the best algorithm that wins, it's who has the most data" (Andrew Ng)

The Challenge of Big Volume

- Question: How much time does it take to read one Terabyte of data from hard disk into memory?

1 TB = 1024 GB = 1024*1024 MB = 1,048,576 MB

1,048,576/100/3600 = 2.91 hour

Velocity

- Velocity: Data in motion
  - The speed at which data is created processed and analyzed continues to accelerate.
- Examples of high velocity data:
  - Twitter processes 340 million messages / per day
  - Trend Micro processes 6 TB of data/day to identify new security threats
  - Financial institutions process more than 10,000 credit card transactions/second
  - Amazon Web Services fields more than 650,000 requests / second
  - Large Hadron Collider produces 572 terabytes of data per second
  - MLB game generates 2.5 Terabytes / hour.

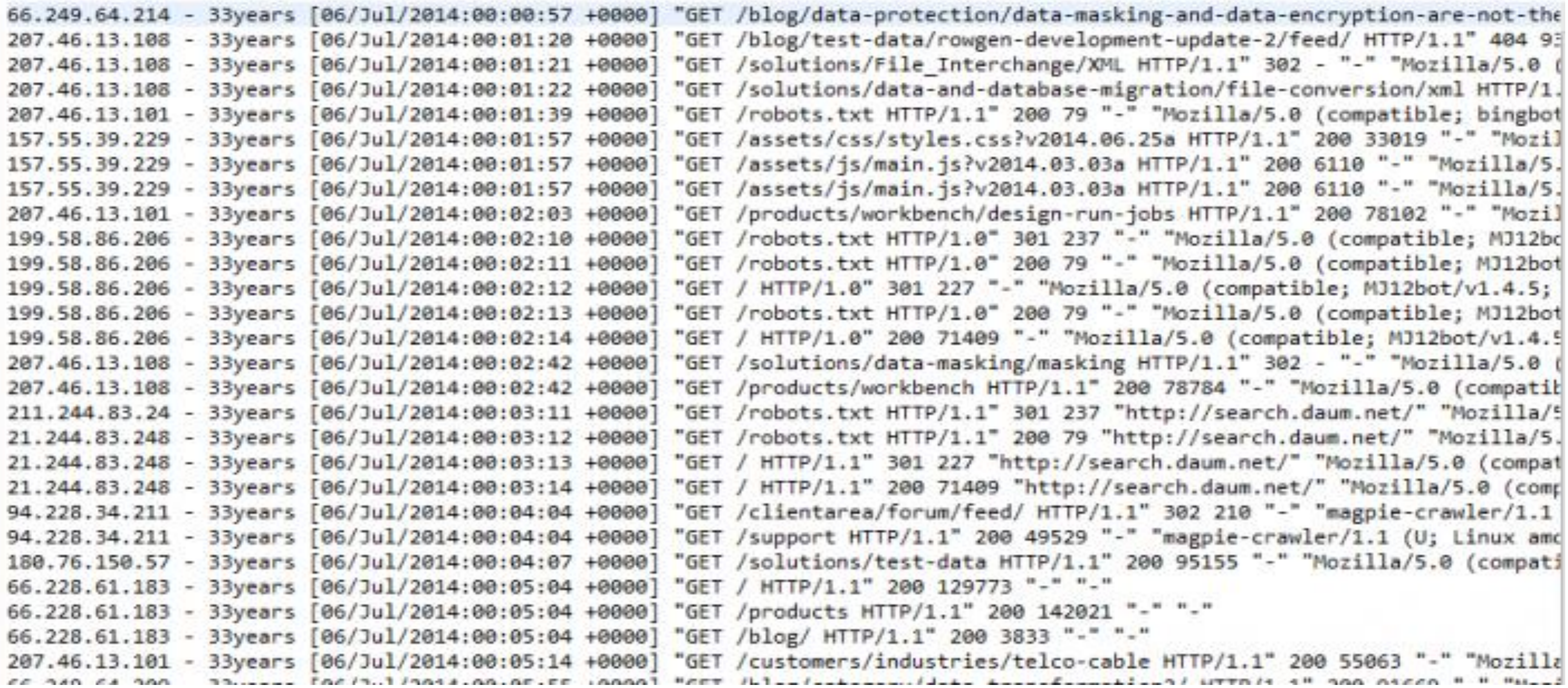
Fantastic velocity and where to find them

- Can you think of an every-day example of high velocity data around you?

What are the challenges and opportunities associated with high velocity data?

An example of high velocity data

- Imagine you work for an e-commerce company that has 5 TB of web log data per day



```
66.249.64.214 - 33years [06/Jul/2014:00:00:57 +0000] "GET /blog/data-protection/data-masking-and-data-encryption-are-not-the
207.46.13.108 - 33years [06/Jul/2014:00:01:20 +0000] "GET /blog/test-data/rowgen-development-update-2/feed/ HTTP/1.1" 404 9
207.46.13.108 - 33years [06/Jul/2014:00:01:21 +0000] "GET /solutions/File_Interchange/XML HTTP/1.1" 302 - "-" "Mozilla/5.0 (
207.46.13.108 - 33years [06/Jul/2014:00:01:22 +0000] "GET /solutions/data-and-database-migration/file-conversion/xml HTTP/1.
207.46.13.101 - 33years [06/Jul/2014:00:01:39 +0000] "GET /robots.txt HTTP/1.1" 200 79 "-" "Mozilla/5.0 (compatible; bingbot
157.55.39.229 - 33years [06/Jul/2014:00:01:57 +0000] "GET /assets/css/styles.css?v2014.06.25a HTTP/1.1" 200 33019 "-" "Mozil
157.55.39.229 - 33years [06/Jul/2014:00:01:57 +0000] "GET /assets/js/main.js?v2014.03.03a HTTP/1.1" 200 6110 "-" "Mozilla/5.
157.55.39.229 - 33years [06/Jul/2014:00:01:57 +0000] "GET /assets/js/main.js?v2014.03.03a HTTP/1.1" 200 6110 "-" "Mozilla/5.
207.46.13.101 - 33years [06/Jul/2014:00:02:03 +0000] "GET /products/workbench/design-run-jobs HTTP/1.1" 200 78102 "-" "Mozil
199.58.86.206 - 33years [06/Jul/2014:00:02:10 +0000] "GET /robots.txt HTTP/1.0" 301 237 "-" "Mozilla/5.0 (compatible; MJ12bo
199.58.86.206 - 33years [06/Jul/2014:00:02:11 +0000] "GET /robots.txt HTTP/1.0" 200 79 "-" "Mozilla/5.0 (compatible; MJ12bot
199.58.86.206 - 33years [06/Jul/2014:00:02:12 +0000] "GET / HTTP/1.0" 301 227 "-" "Mozilla/5.0 (compatible; MJ12bot/v1.4.5;
199.58.86.206 - 33years [06/Jul/2014:00:02:13 +0000] "GET /robots.txt HTTP/1.0" 200 79 "-" "Mozilla/5.0 (compatible; MJ12bot
199.58.86.206 - 33years [06/Jul/2014:00:02:14 +0000] "GET / HTTP/1.0" 200 71409 "-" "Mozilla/5.0 (compatible; MJ12bot/v1.4.
207.46.13.108 - 33years [06/Jul/2014:00:02:42 +0000] "GET /solutions/data-masking/masking HTTP/1.1" 302 - "-" "Mozilla/5.0 (
207.46.13.108 - 33years [06/Jul/2014:00:02:42 +0000] "GET /products/workbench HTTP/1.1" 200 78784 "-" "Mozilla/5.0 (compatib
211.244.83.24 - 33years [06/Jul/2014:00:03:11 +0000] "GET /robots.txt HTTP/1.1" 301 237 "http://search.daum.net/" "Mozilla/
21.244.83.248 - 33years [06/Jul/2014:00:03:12 +0000] "GET /robots.txt HTTP/1.1" 200 79 "http://search.daum.net/" "Mozilla/5.
21.244.83.248 - 33years [06/Jul/2014:00:03:13 +0000] "GET / HTTP/1.1" 301 227 "http://search.daum.net/" "Mozilla/5.0 (compat
21.244.83.248 - 33years [06/Jul/2014:00:03:14 +0000] "GET / HTTP/1.1" 200 71409 "http://search.daum.net/" "Mozilla/5.0 (comp
94.228.34.211 - 33years [06/Jul/2014:00:04:04 +0000] "GET /clientarea/forum/feed/ HTTP/1.1" 302 210 "-" "magpie-crawler/1.1
94.228.34.211 - 33years [06/Jul/2014:00:04:04 +0000] "GET /support HTTP/1.1" 200 49529 "-" "magpie-crawler/1.1 (U; Linux am
180.76.150.57 - 33years [06/Jul/2014:00:04:07 +0000] "GET /solutions/test-data HTTP/1.1" 200 95155 "-" "Mozilla/5.0 (compati
66.228.61.183 - 33years [06/Jul/2014:00:05:04 +0000] "GET / HTTP/1.1" 200 129773 "-" "-"
66.228.61.183 - 33years [06/Jul/2014:00:05:04 +0000] "GET /products HTTP/1.1" 200 142021 "-" "-"
66.228.61.183 - 33years [06/Jul/2014:00:05:04 +0000] "GET /blog/ HTTP/1.1" 200 3833 "-" "-"
207.46.13.101 - 33years [06/Jul/2014:00:05:14 +0000] "GET /customers/industries/telco-cable HTTP/1.1" 200 55063 "-" "Mozilla
```

- How do you analyze such data?
  - Assume a Gigabit network

Why are we interested in processing log data?

Let’s Do the Math

Assuming a gigabit network, 1024 Mbps = 1Gbps

Sending 1 GB requires 8 seconds

Sending 1 TB requires 1024*8 /3600 = 2.27 Hours

Sending 5 TB requires 5*1024*8/3600 = 12 Hours!

Variety

- **Variety**: the complexity of multiple data types, including structured, semi-structured and unstructured data.
- They are also different forms:
  - **Structured**: transactional
  - **Semi-structured**: sensor data, logs, RFID
  - **Unstructured**: reviews, images, tweets, audio, video
- Inside or outside of enterprises
  - **Internal**: transactional systems, server logs, emails, chats, etc
  - **External**: social media, sensor networks, weather data, geographic data, census, macroeconomic data, third party data providers

Fantastic variety and where to find them

- Can you think of an every-day example of high variety data around you?

Data Variety in Health Care

- 80% of information in healthcare industry is unstructured data, e.g.
  - Outputs from medical devices
  - Doctor's notes
  - Lab results
  - Medical imaging
  - Medical correspondence
  - Clinical data
  - Patient behavior and sentiment data
  - Genomic data

What are the challenges and opportunities associated with high variety?

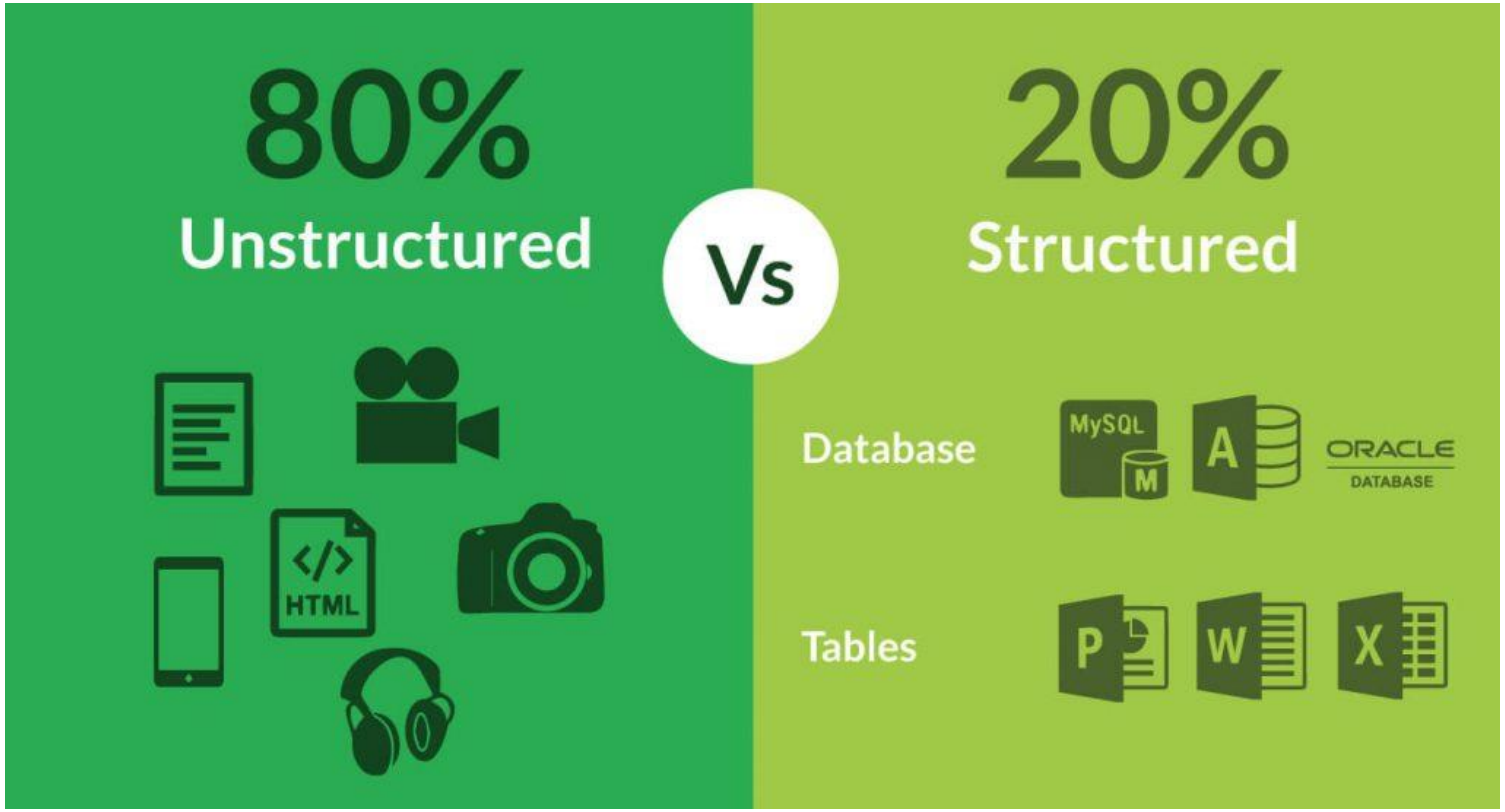
Opportunity of high variety data

- Half of the battle is to get quality signals

- Big data provides a way to capture and analyze novel data sources (e.g. social media, click stream, imagery, sensor data)

Challenges associated with variety

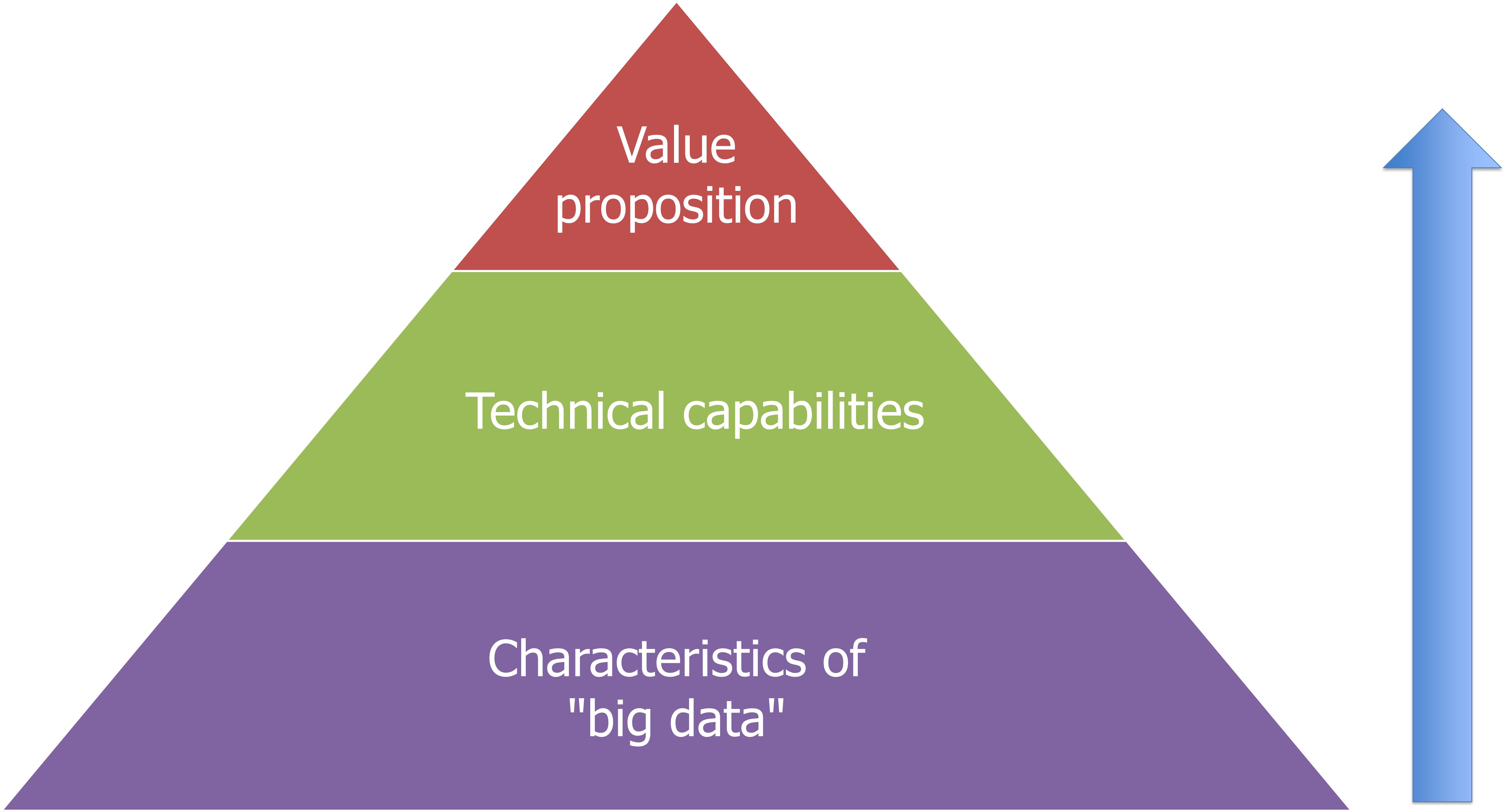
- Many earlier data technologies are not flexible enough to deal with large variety of semi- or un-structured data



What about 2 other V’s

- **Verasity** refers to data uncertainty
  - – Large volumes of disparate data being ingested at high speed are only useful if the information is correct. Incorrectly indexed data or spelling mistakes could make complete datasets useless and thus the veracity is important.
- **Value**: Big data has many valuable applications
  - – Value is a multifaceted property of big data. As the volume of data grows the incremental value of each data point begins to decrease. As the variety of data available increases, not all the data may aid in product development, sales, or system management. Big data is not the retention of all data; some data needs to remain volatile.

Organizational Implications of 5 V’s



Value proposition

Technical capabilities

Characteristics of "big data"

Course introduction

BIG DATA: HOW ARE COMPANIES USING BIG DATA?

How critical is big data to companies?

Without big data analytics, companies are blind and deaf, wandering out onto the web like deer on a freeway.

- Geoffrey Moore, author and consultant

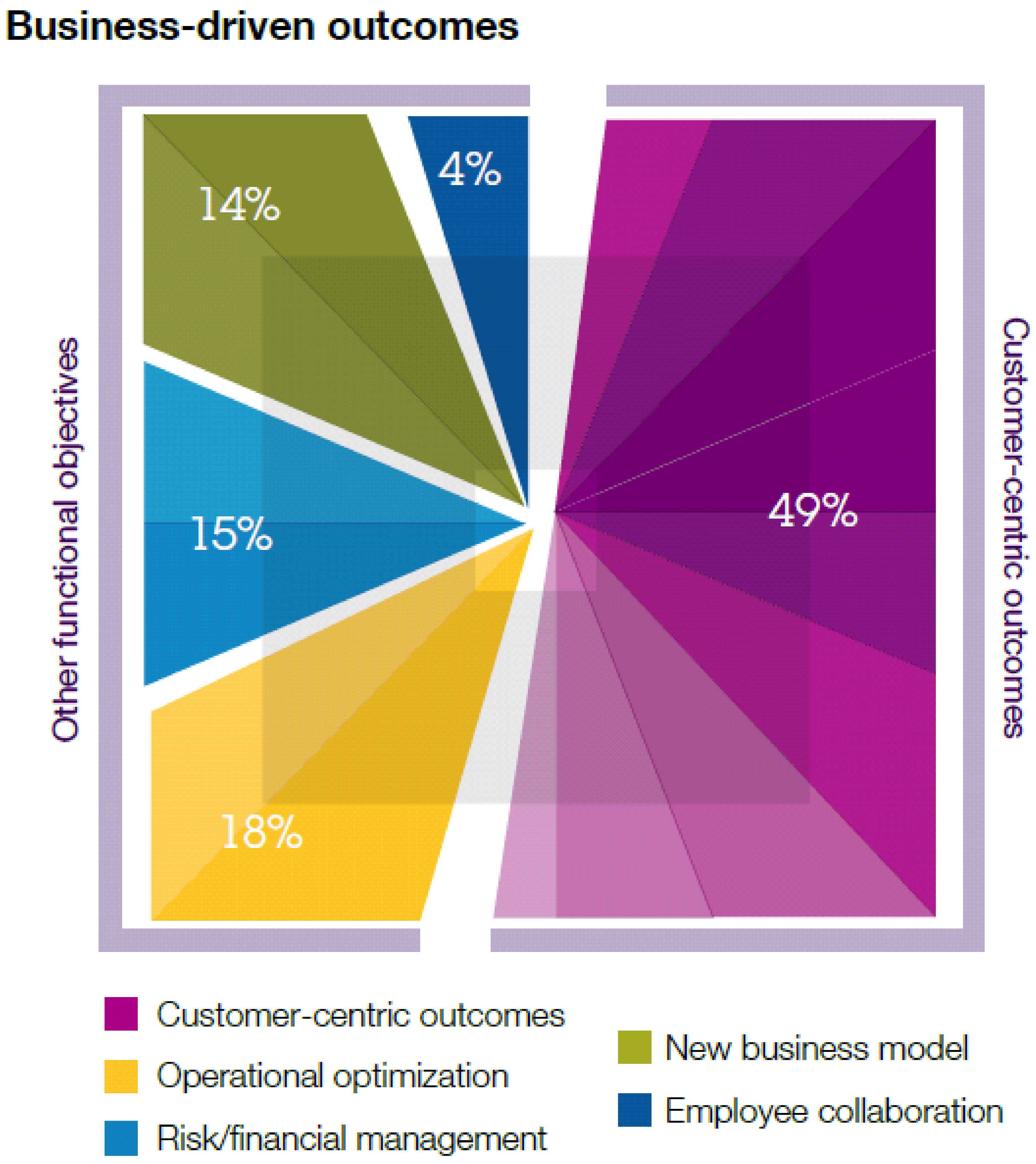
How Are Companies Using Big Data?

- Big data has reached a point of **mainstream adoption** within Fortune 1000 firms
  - In 2016, 62.5% have at least one instance of big data in production. In 2018, 97.2% are investing in building or launching big data and AI initiatives
- **Chief Data Officer (CDO)** is well established
  - 54% named a CDO in 2016, compared to 12% in 2012.
  - 62.5% named a CDO in 2018, compared to 12% in 2012
  - "Data is essentially the new oil, and the CDO is beginning to be recognized as the linchpin for tackling one of the most important problems in enterprises today: driving value from data"

Sources: NewVantage. 2018. “Big Data Executive Survey 2018,” *NewVantage Partner Report*.

How Are Companies Using Big Data? (continue)

- Customer-centric activities are the top priority



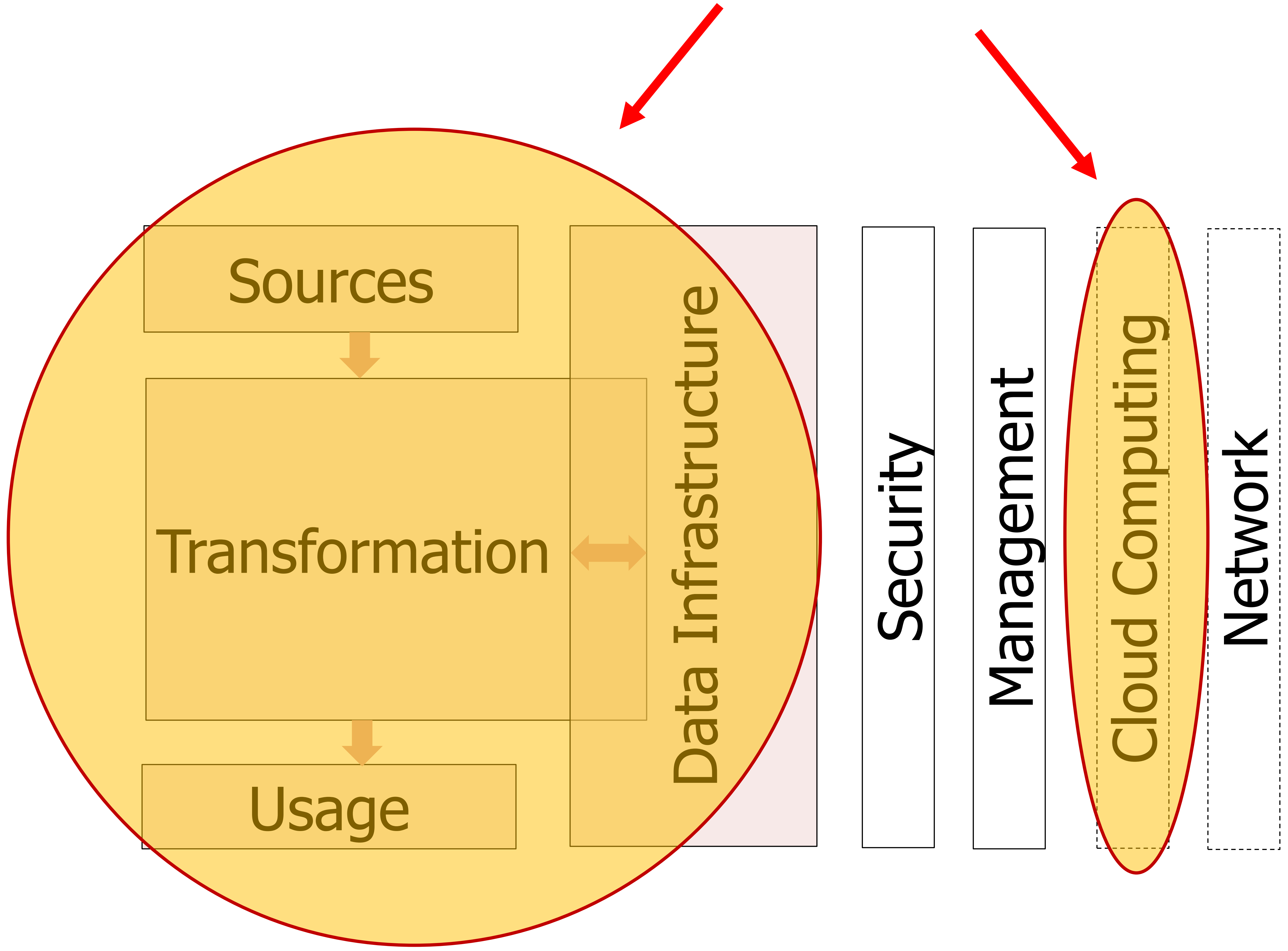
Source: Analytics: The real-world use of big data
© 2012 IBM, IBM Institute for Business Value

Course introduction

THE FOCUS OF THIS COURSE

Where does this course fit?

This course: Big data for Data Analysts



Source: Geoffrey Fox and Wo Chang, CCL Meeting Presentation, 2013

Course Topics

- Learn through hands-on examples
  - Hadoop: MapReduce/HDFS/YARN
  - Data ingestion: Scoop
  - Data analysis / ETL: Hive
  - Spark: Core Spark, Spark SQL,
  - Machine Learning: Spark MLlib
  - Streaming: Spark Streaming
  - Cloud computing: Amazon AWS

Course Objectives

- Develop an understanding of the big data ecosystem, the kinds of problems it aims to solve, the characteristics of big data technologies, and their key advantages and disadvantages.

- Develop core competencies in using a variety of essentially big data tools (such as Scoop, Hive, Spark, and Cloud computing) and processes to solve data science problems at scale.