FIT5145 Introduction to Data Science

Module 3

Data Types and Storage

2019 Lecture 5

Monash University

Assignment 1

- Due 6th September 11:55pm
- Using libraries/packages in Python
- Any questions:
    - Post to forum
    - Email: fit5145.allcampuses-x@monash.edu
    - Email your tutors
- For special consideration:
    - email your certificate and filled in special consideration form to

      fit5145.allcampuses-x@monash.edu

Discussion: R

- Powerful language for visualising and building predictive models of data
- Very easy to use with lots of inbuilt functionality.
- Great for exploratory data analysis
- Not as scalable as programming languages: Java, Python,

Discussion: Python versus R

- both are free
- R developed by statisticians for statisticians, huge support for analysis
- Python by computer scientists for general use
- R is better for stand-alone analysis and exploration
- Python lets you integrate easier with other systems
- Python easier to learn and extend than R (better language)
- R has vectors and arrays as first class objects; similar to Matlab!
- R currently less scalable.

See *In data science, the R language is swallowing Python* by Matt Asay, recent blog in *Infoworld*.

Unit Schedule: Modules

Module	Week	Content
1.	1	overview and look at projects
	2	(job) roles, and the impact
2.	3	data business models
	4	application areas and case studies
3.	**5**	**characterising data and "big" data**
	6	**data sources and case studies**
4.	7	resources and standards
	8	resources case studies
5.	9	data analysis theory
	10	data analysis process
6.	11	issues in data management
	12	GUEST SPEAKER & EXAM INFO

Learning Outcomes (Week 5)

By the end of this week you should be able to:

- Characterise data sets used to assess a data science project
- Explain what Big data is
- Understand the V's in Big data
- Understand and analyse the growth laws: Moore's Law, Koomey's Law, Bell's Law and Zimmerman's Law
- Analyze and use shell commands to read and manipulate big data

Characterising Data
(ePub section 3.1)

some general characteristics of data sets used to assess a project

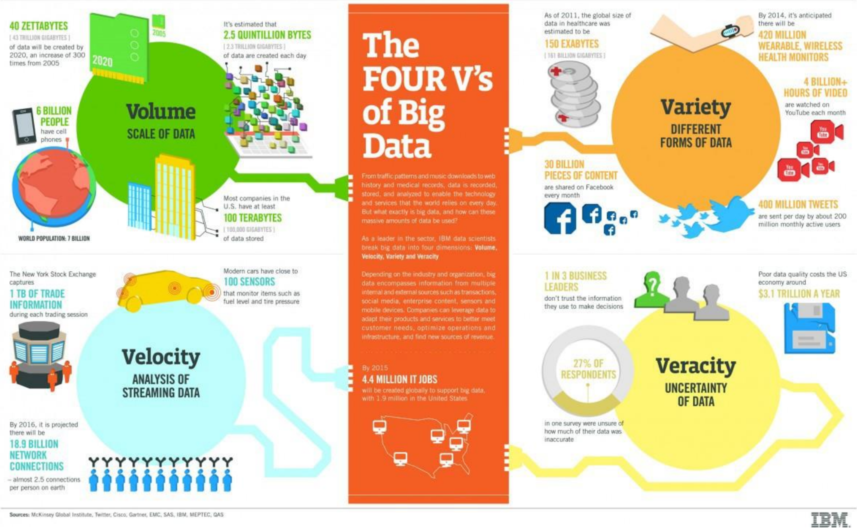
- the V's
  - the first charactisations by someone with a penchant for alliteration
- metadata
  - data about data is critical to understanding
- dimensions of data
  - infographics on data dimensions (how big is "big")
- growth laws
  - understanding the exponential growth

Characterising Data
The V's

the first charactisations of big data were by someone with a penchant for alliteration ... others followed

The Four V's of Big Data

[*"The Four V's of Big Data,"*](#) by IBM (infographic)



Big Data

From [*Big data*](#) on Wikipedia:

> *Big data usually includes data sets with* **sizes beyond the ability of commonly used software tools** *to capture, curate, manage, and process data within a tolerable elapsed time. Big data "size" is a constantly moving target, ...*

- don’t always ask why, can simply detect patterns
- a cost-free byproduct of digital interaction
- enabled by the cloud: affordability, extensibility, agility

Big Data and "V"s

- 2001 Doug Laney produced report describing 3 V's:

  "3-D Data Management: Controlling Data Volume, Velocity and Variety"

- these characterise bigness, adequately
- other V's characterise problems with analysis and understanding

  Veracity: correctness, truth, *i.e.*. lack of ...

  Variability: change in meaning over time, *e.g.*, natural language

- other V's characterise aspirations

  Visualisation: one method for analysis

  Value: what we want to get out of the data

- think of any more? write a blog!

FLUX Question

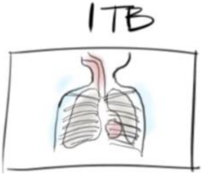
The 3Vs of big data are important because:

A. they are an industry standard
B. they are the basis for the development of more Vs (e.g. Value)
C. they are used to describe in what way a dataset may be too big to handle
D. they are from the influential Gartner Inc

FLUX Question

video “*[Big Ideas: How Big is Big Data?]*” by Patricia Florissa

Which of the following is considered as big data?



B. Healthcare image

A. power point presentation

C. Movie

Summary

BIG DATA is ANY attribute that challenges CONSTRAINTS of a system CAPABILITY or BUSSINESS NEED

Characterising Data
Metadata

data about data is critical to understanding

MetaData

metadata ::= structured information that describes, explains, locates, or otherwise makes it easier to retrieve, use or manage an information resource.

metadata is:

- **data about data**
- **structured** so that a computer can process & interpret it

MetaData (cont.)

MetaData can be:

Descriptive: describes content for identification and retrieval
e.g. title, author of a book

Structural: documents relationships and links
e.g. chapters in a book, elements in XML, containers in MPEG

Administrative: helps to manage information
e.g. version number, archiving date, Digital Rights Management (DRM)

Why Use Metadata

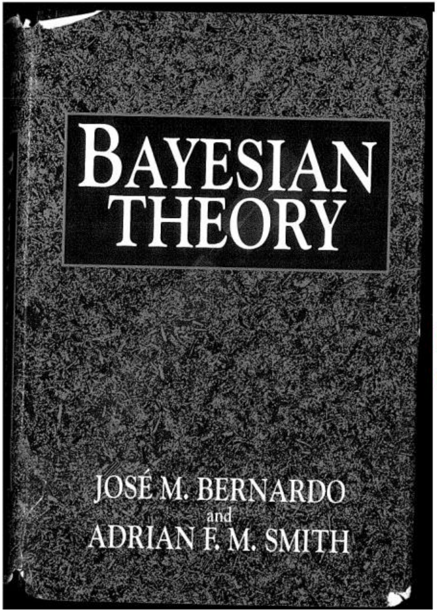
- facilitate data discovery
- help users determine the applicability of the data
- enable interpretation and reuse
- clarify ownership and restrictions on reuse

FLUX Question

Name a type of metadata might be associated with an image.

EXIF Metadata

Book Metadata



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book metadata listed
on about third page

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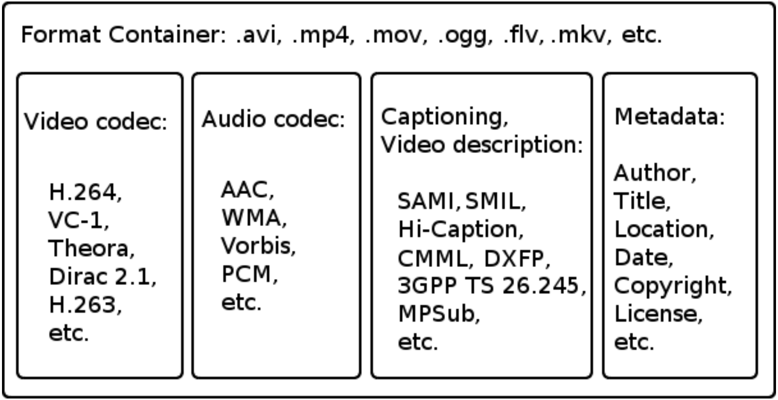
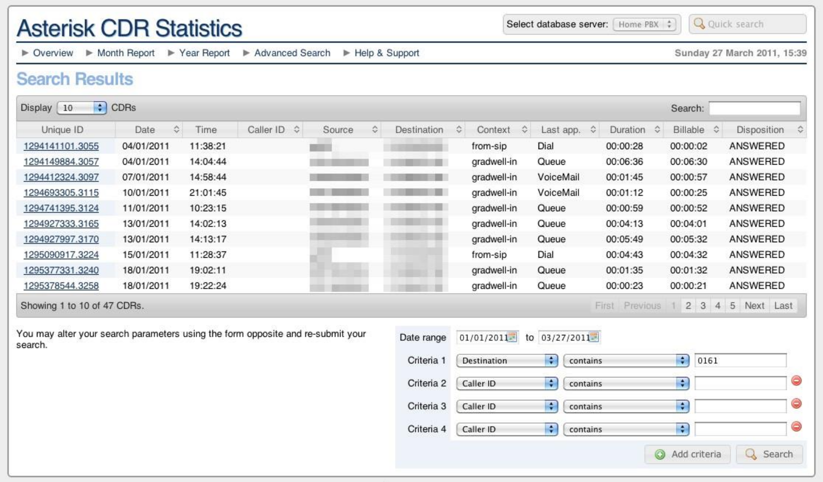


Examples: Call Data Record



Unique ID	Date	Time	Caller ID	Source	Destination	Context	Last app.	Duration	Billable	Disposition
1294141101.3055	04/01/2011	11:38:21				from-sip	Dial	00:00:28	00:00:02	ANSWERED
1294149884.3057	04/01/2011	14:04:44				gradwell-in	Queue	00:06:36	00:06:30	ANSWERED
1294412324.3097	07/01/2011	14:58:44				gradwell-in	VoiceMail	00:01:45	00:00:57	ANSWERED
1294693305.3115	10/01/2011	21:01:45				gradwell-in	VoiceMail	00:01:12	00:00:25	ANSWERED
1294741395.3124	11/01/2011	10:23:15				gradwell-in	Queue	00:00:59	00:00:52	ANSWERED
1294927333.3165	13/01/2011	14:02:13				gradwell-in	Queue	00:04:13	00:04:01	ANSWERED
1294927997.3170	13/01/2011	14:13:17				gradwell-in	Queue	00:05:49	00:05:32	ANSWERED
1295090917.3224	15/01/2011	11:28:37				from-sip	Dial	00:04:43	00:04:32	ANSWERED
1295377331.3240	18/01/2011	19:02:11				gradwell-in	Queue	00:01:35	00:01:32	ANSWERED
1295378544.3258	18/01/2011	19:22:24				gradwell-in	Queue	00:00:23	00:00:21	ANSWERED

Asterix Call Detail Record for an IP phone system

Examples: Javadoc

Self documenting code

```
/**
 * <h1>Function Description</h1> using <b>HTML Tags</b> and {@literal <b> JavaDoc </b> }
 * <ul><li>HTML list element 1</li><li>HTML list element 2</li></ul>
 * For more details: {@link http://www.dvteclipse.com/documentation/sv/Export_HTML_Documentation.html DVT Documentation}
 *
 * @param slave_name - first param
 * @param min_addr - second param
 * @param max_addr - third param
 * @return min_addr
 *
 * @see get_type
 * @see build_phase
 *
 * @author Author's name
 * @version 1.0
 */
function void set_slave_address_map(string slave_name,
  int min_addr, int max_addr);
  ubus_slave_monitor tmp_slave_monitor;
  if( bus_monitor != null ) begin
    // Set slave address map for bus monitor
    bus_monitor.set_slave_configs(slave_name, min_addr, max_addr);
  end
  // Set slave address map for slave monitor
  $cast(tmp_slave_monitor, lookup({slave_name, ".monitor"}));
  tmp_slave_monitor.set_addr_range(min_addr, max_addr);
  return min_addr;
endfunction : set_slave_address_map
```

public void   **set_slave_address_map**(string slave_name, int min_addr, int max_addr)

Function Description

using **HTML Tags** and JavaDoc

- HTML list element 1
- HTML list element 2

For more details: DVT Documentation

Returns:
min_addr

Arguments:
slave_name - first param
min_addr - second param
max_addr - third param

See Also:
get_type
build_phase

Version:
1.0.

Other Metadata Examples

- *IPTC Photo Metadata User Guide*
- *USGS Metadata standards*
- *medical bibliographic data* in XML on PubMed,

  “Lower respiratory tract disorder hospitalizations among children born via elective early-term delivery”

MetaData: Key Concepts

Machine-readable data: data (or metadata) which is in a format that can be understood by a computer
e.g., XML, JSON

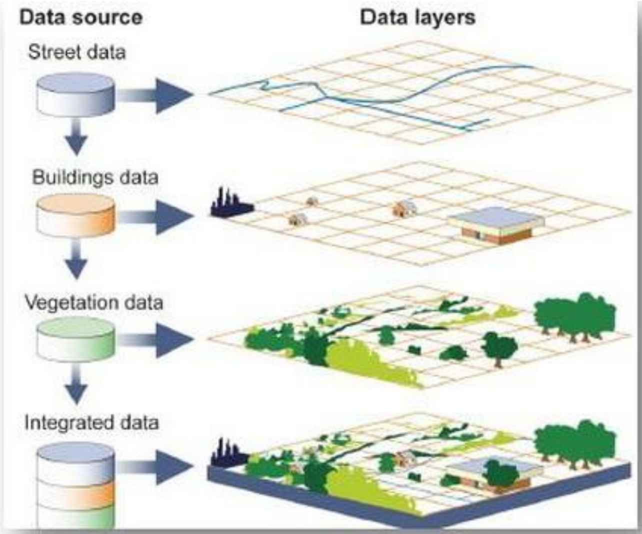
Markup language: system for annotating a document in a way that is syntactically distinguishable from the text
e.g., Markdown, Javadoc

Digital container: file format whose specification describes how different elements of data and metadata coexist in a computer file
e.g., MPEG

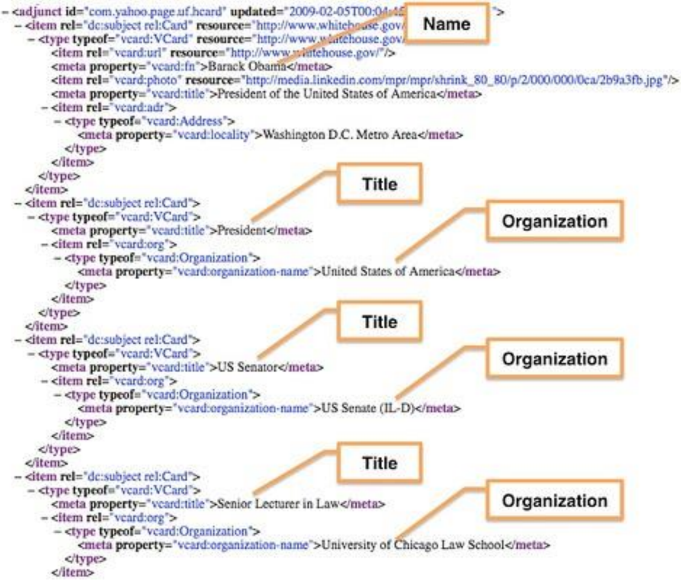
Characterising Data
Kinds of data

a quick walkthrough of different data types

Geospatial Data

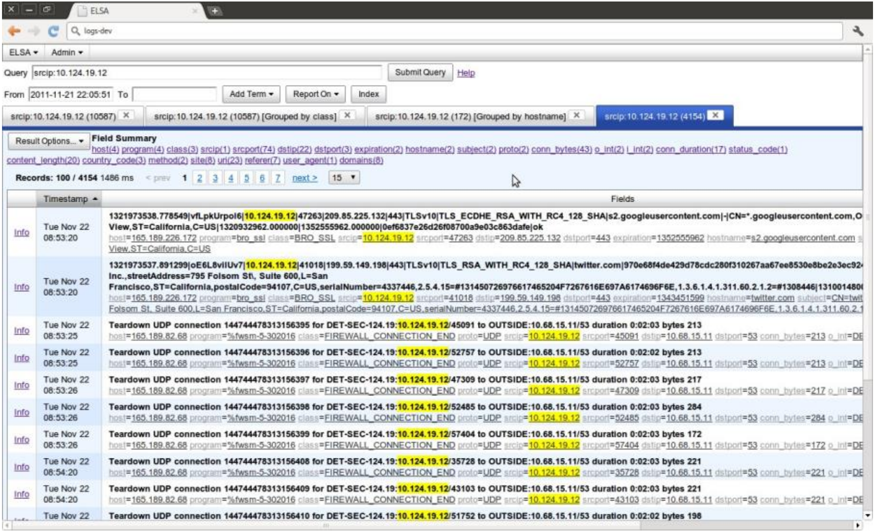


Linked Open Data: XML



```xml
- <adjunct id="com.yahoo.page.uf.hcard" updated="2009-02-05T00:04:4 ">
  - <item rel="dc:subject rel:Card" resource="http://www.whitehouse.gov/
    - <type typeof="vcard:VCard" resource="http://www.whitehouse.gov/
        <item rel="vcard:url" resource="http://www.whitehouse.gov/"/>
        <meta property="vcard:fn">Barack Obama</meta>
        <item rel="vcard:photo" resource="http://media.linkedin.com/mpr/mpr/shrink_80_80/p/2/000/000/0ca/2b9a3fb.jpg"/>
        <meta property="vcard:title">President of the United States of America</meta>
      - <item rel="vcard:adr">
        - <type typeof="vcard:Address">
            <meta property="vcard:locality">Washington D.C. Metro Area</meta>
          </type>
        </item>
      </type>
    </item>
  - <item rel="dc:subject rel:Card">
    - <type typeof="vcard:VCard">
        <meta property="vcard:title">President</meta>
      - <item rel="vcard:org">
        - <type typeof="vcard:Organization">
            <meta property="vcard:organization-name">United States of America</meta>
          </type>
        </item>
      </type>
    </item>
  - <item rel="dc:subject rel:Card">
    - <type typeof="vcard:VCard">
        <meta property="vcard:title">US Senator</meta>
      - <item rel="vcard:org">
        - <type typeof="vcard:Organization">
            <meta property="vcard:organization-name">US Senate (IL-D)</meta>
          </type>
        </item>
      </type>
    </item>
  - <item rel="dc:subject rel:Card">
    - <type typeof="vcard:VCard">
        <meta property="vcard:title">Senior Lecturer in Law</meta>
      - <item rel="vcard:org">
        - <type typeof="vcard:Organization">
            <meta property="vcard:organization-name">University of Chicago Law School</meta>
          </type>
        </item>
```

IP Connection Data



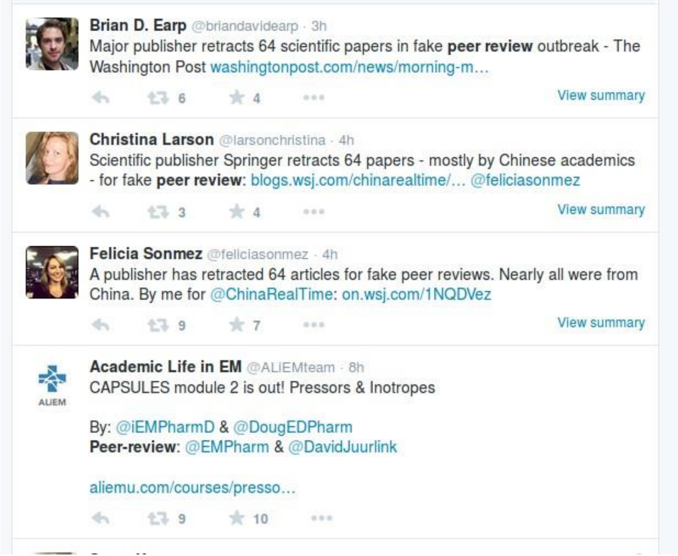
Transactional Data

Trans

Entity: All Entity | Time: Default member: 'All Time Calendar' | Account: All Account

	Credit	Debit	Account	Entity	Transaction	Txn Date
All Transactions	$2,441,364.68	$1,402,410.62				
# 501, BillPaymentCheck	$0.00	$625.00	Checking	Wheeler's Tile Etc.	BillPaymentCheck # 501	12/15/2012
# none, Transfer	$0.00	$500.00	Savings	None	Transfer # none	12/15/2012
# none, ReceivePayment	$440.00	$0.00	Undeposited Funds	Roche, Diarmuid:Garage repairs	ReceivePayment # none	12/15/2012
# none, Bill	$0.00	$670.00	Accounts Payable	Keswick Insulation	Bill # none	12/15/2012
# 6236, PurchaseOrder	$0.00	$65.00	Purchase Orders	Daigle Lighting	PurchaseOrder # 6236	12/15/2012
# 502, BillPaymentCheck	$0.00	$640.92	Checking	Daigle Lighting	BillPaymentCheck # 502	12/15/2012
# 503, BillPaymentCheck	$0.00	$754.50	Checking	Patton Hardware Supplies	BillPaymentCheck # 503	12/15/2012
# 1097, Invoice	$12,420.98	$0.00	Accounts Receivable	Robson, Darci:Robson Clinic	Invoice # 1097	12/15/2012
# 504, BillPaymentCheck	$0.00	$6,935.75	Checking	Perry Windows & Doors	BillPaymentCheck # 504	12/15/2012
# 505, BillPaymentCheck	$0.00	$45.00	Checking	Lew Plumbing	BillPaymentCheck # 505	12/15/2012
# 12/03, Bill	$0.00	$122.68	Accounts Payable	Cal Gas & Electric	Bill # 12/03	12/15/2012
# 506, BillPaymentCheck	$0.00	$1,631.52	Checking	East Bayshore Tool & Supply	BillPaymentCheck # 506	12/15/2012
# 507, BillPaymentCheck	$0.00	$1,358.00	Checking	Timberloft Lumber	BillPaymentCheck # 507	12/15/2012
# 508, BillPaymentCheck	$0.00	$1,476.23	Checking	East Bayshore Tool & Supply	BillPaymentCheck # 508	12/15/2012
# 509, BillPaymentCheck	$0.00	$450.00	Checking	Hopkins Construction Rentals	BillPaymentCheck # 509	12/15/2012
# 510, BillPaymentCheck	$0.00	$896.00	Checking	Timberloft Lumber	BillPaymentCheck # 510	12/15/2012
# 511, BillPaymentCheck	$0.00	$696.52	Checking	East Bayshore Tool & Supply	BillPaymentCheck # 511	12/15/2012
# 512, BillPaymentCheck	$0.00	$400.00	Checking	Patton Hardware Supplies	BillPaymentCheck # 512	12/15/2012
# 513, BillPaymentCheck	$0.00	$1,610.00	Checking	Timberloft Lumber	BillPaymentCheck # 513	12/15/2012

Twitter Data



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Major publisher retracts 64 scientific papers in fake **peer review** outbreak - The Washington Post washingtonpost.com/news/morning-m…
6 4 View summary

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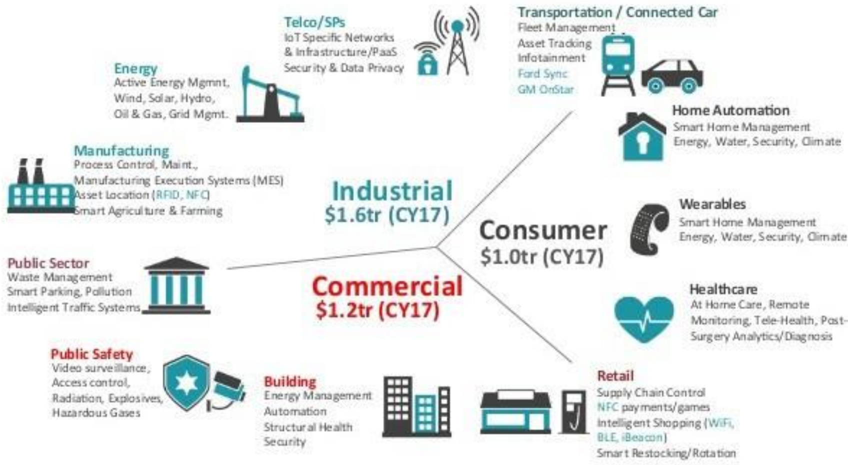
A publisher has retracted 64 articles for fake peer reviews. Nearly all were from China. By me for @ChinaRealTime: on.wsj.com/1NQDVez
9 7 View summary

Academic Life in EM @ALiEMteam · 8h
CAPSULES module 2 is out! Pressors & Inotropes

By: @iEMPharmD & @DougEDPharm
Peer-review: @EMPharm & @DavidJuurlink

aliemu.com/courses/presso…
9 10

Internet of Things Data



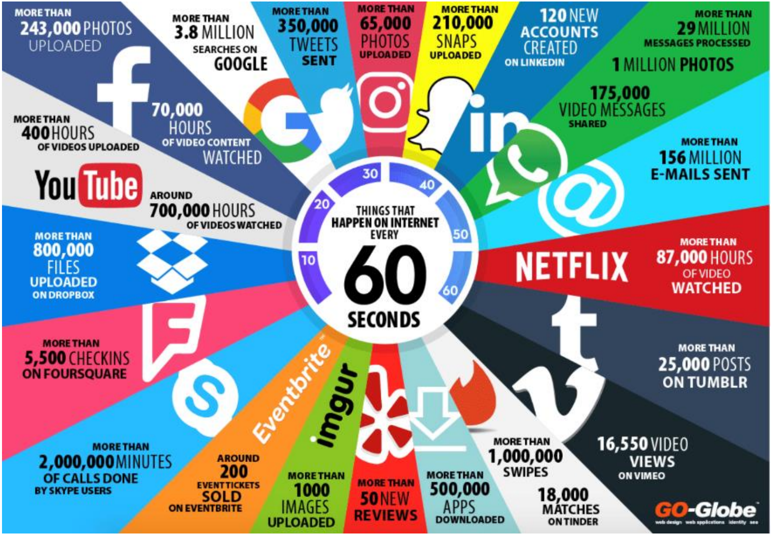
Source: IDC Internet of Things Spending Guide by Vertical Market 2014

Characterising Data
Dimensions of data

infographics on data dimensions (how big is “big”)

Things that happen in 60secs

from *GO-Gulf*



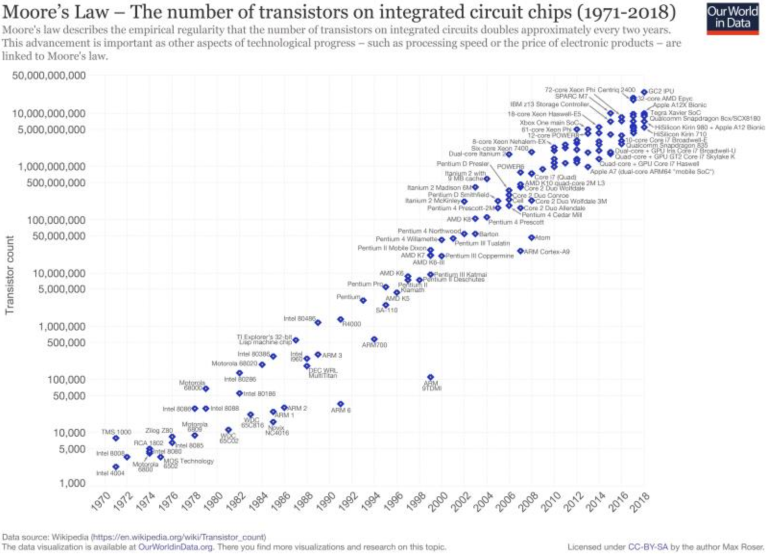
Infographics on Data

- *"Data Science Matters"* from the datascience@berkeley Blog
- *"Intelligence by Variety – Where to Find and Access Big Data"* from Kapow Software
- Social Media Prisma from the *Ethority.de site*

Characterising Data
Growth laws

understanding the exponential growth

Moore’s Law


Moore’s Law – The number of transistors on integrated circuit chips (1971-2018)
Our World in Data
Moore's law describes the empirical regularity that the number of transistors on integrated circuits doubles approximately every two years. This advancement is important as other aspects of technological progress – such as processing speed or the price of electronic products – are linked to Moore's law.
Transistor count
50,000,000,000
10,000,000,000
5,000,000,000
1,000,000,000
500,000,000
100,000,000
50,000,000
10,000,000
5,000,000
1,000,000
500,000
100,000
50,000
10,000
5,000
1,000
1970
1972
1974
1976
1978
1980
1982
1984
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1988
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1992
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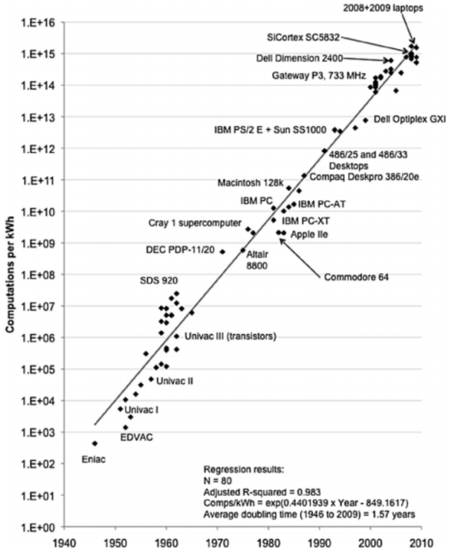
1996
1998
2000
2002
2004
2006
2008
2010
2012
2014
2016
2018
Data source: Wikipedia (https://en.wikipedia.org/wiki/Transistor_count)
The data visualization is available at OurWorldinData.org. There you find more visualizations and research on this topic.
Licensed under CC-BY-SA by the author Max Roser.

Moore's Law

- number of transistors per chip doubles every 2 years (starting from 1975)
- transistor count translates to:
  - more memory
  - bigger CPUs
  - faster memory, CPUs (smaller==faster)
- pace currently slowing

Koomey's Law



By Dr Jon Koomey CC BY-SA 3.0, via Wikimedia Commons

Koomey's Law

- corollary of Moores Law
- amount of battery needed will fall by a factor of 100 every decade
- leads to ubiquitous computing

Bell's Law

Gordon Bell, Digital Equipment Corporation (DEC), 1972

- corollary of Moore's Law and Koomey's Law
- *"Roughly every decade a new, lower priced computer class forms based on a new programming platform, network, and interface resulting in new usage and the establishment of a new industry."*

Yes: PCs, mobile computing, cloud, internet-of-things

No: Java, big data, Hadoop, flash memory

Zimmerman's Law

- Zimmerman is creator of Pretty Good Privacy (PGP), an early encription system
- "surveillance is constantly increasing"
- privacy constantly decreasing

Next Week: Distributed Processing and Data Case Studies (ePub sections 3.3, 3.4)

Homework:

- follow up on some of the case studies in 3.3 yourself!