菩萨相谈

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Data Science

Brian Sletten

@bsletten

09/29/2014

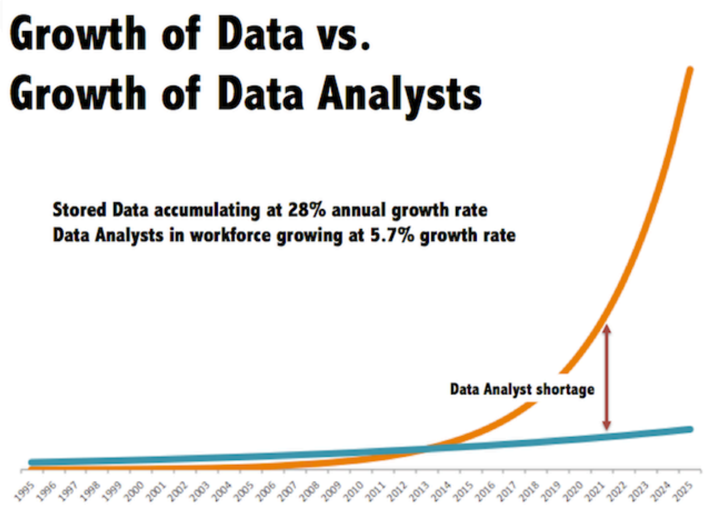
Speaker Qualifications

- Specialize in next-generation technologies
- Author of "Resource-Oriented Architecture Patterns for Webs of Data"
- Speaks internationally about REST, Semantic Web, Security, Visualization, Architecture
- Worked in Defense, Finance, Retail, Hospitality, Video Game, Health Care and Publishing Industries
- One of Top 100 Semantic Web People

Agenda

- Introduction
- Data Science Techniques
- Programming
- Visualization
- Machine Learning
- Data Mining
- Big Data
- Linked Data

Introduction



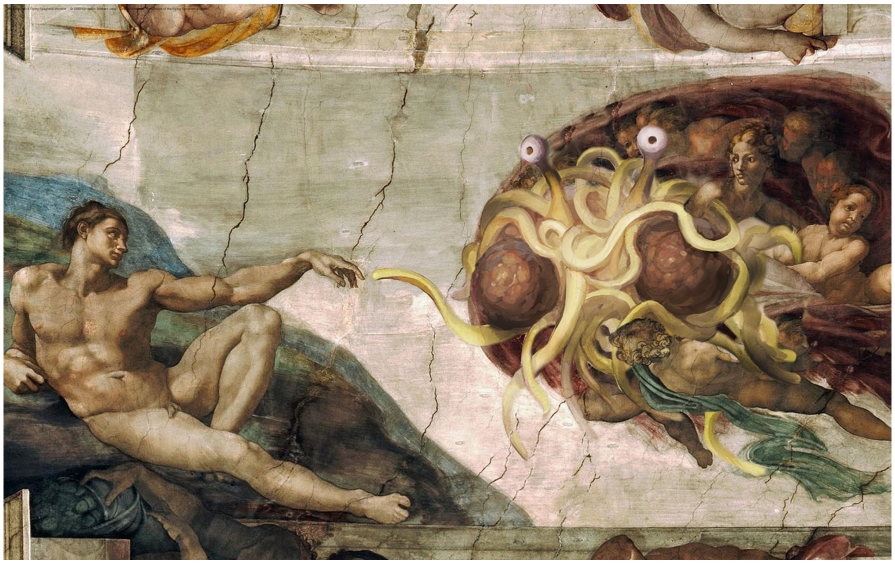
Growth of Data vs.
Growth of Data Analysts

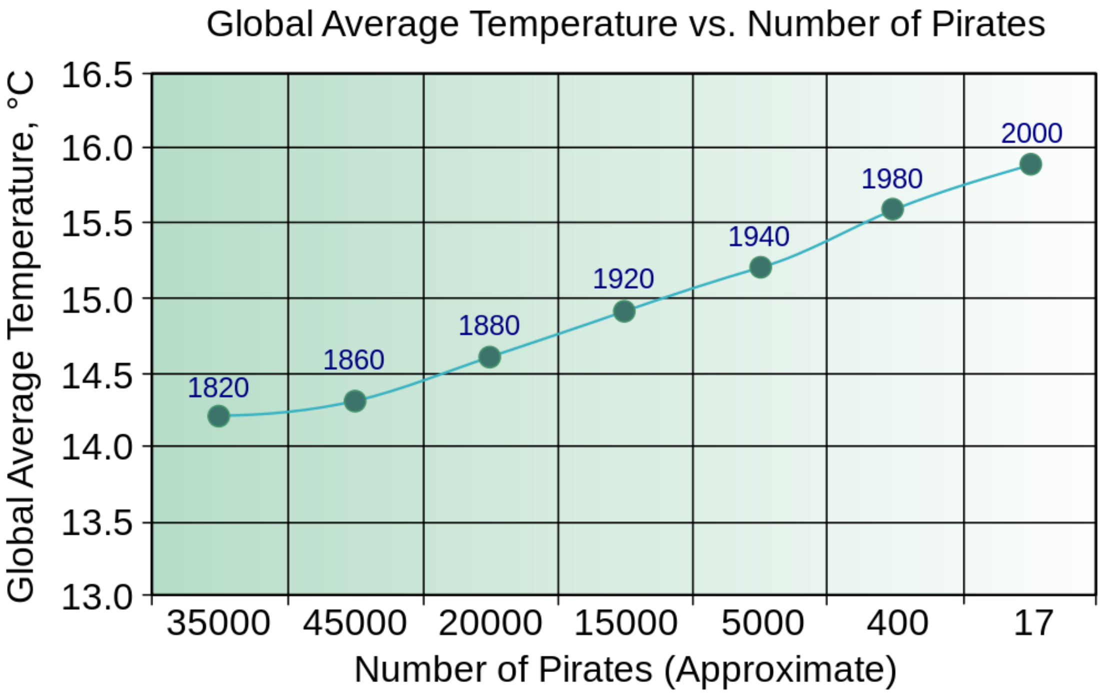
Stored Data accumulating at 28% annual growth rate
Data Analysts in workforce growing at 5.7% growth rate

http://www.delphianalytics.net/wp-content/uploads/2013/04/GrowthOfDataVsDataAnalysts.png

> “We’re witnessing the beginning of a massive, culturally saturated feedback loop where our behavior changes the product and the product changes our behavior. Technology makes this possible: infrastructure for large-scale data processing, increased memory, and bandwidth, as well as a cultural acceptance of technology in the fabric of our lives. This wasn’t true a decade ago.”

Cathy O'Neil and Rachel Schutt





Global Average Temperature vs. Number of Pirates
Global Average Temperature, °C
16.5
16.0
15.5
15.0
14.5
14.0
13.5
13.0
1820
1860
1880
1920
1940
1980
2000
35000
45000
20000
15000
5000
400
17
Number of Pirates (Approximate)

“ Correlation is not causation.”

“ Empirically observed covariation is a necessary but not sufficient condition for causality.”

edvard Tufte

> “Correlation is not causation but it sure is a hint.”

edvard Tufte

So What?

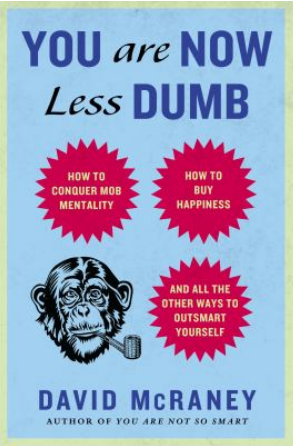
- Unrelated (Pirates and Climate Change)
- Reverse Causation (Windmills Cause Wind)
- Bi-Directional Causation (Temperature/Pressure)
- Common Causal Variable (Sleeping with your shoes on causes headaches)

> “Long before worrying about how to convince others, you first have to understand what's happening yourself.”

Andrew Gelman

> “Naïve realism, also known as direct realism or common sense realism, is a philosophy of mind rooted in a theory of perception that claims that the senses provide us with direct awareness of the external world.”

Wikipedia
http://en.wikipedia.org/wiki/Naïve_realism


YOU are NOW
Less DUMB
HOW TO CONQUER MOB MENTALITY
HOW TO BUY HAPPINESS
AND ALL THE OTHER WAYS TO OUTSMART YOURSELF
DAVID McRANEY
AUTHOR OF YOU ARE NOT SO SMART

1951 Princeton/Dartmouth Game

- Storied rivalry
- Princeton's star player had his nose broken
- Princeton player snapped a Dartmouth player's leg
- Princeton won 13-0
- Editorials from both schools blamed the other
- Two versions of Truth

They Saw a Game

- Albert Hastorf (Dartmouth) and Hadley Cantril (Princeton) showed the game again to students from both schools
- Asked them to notice infractions, penalties, fill out a questionnaire
- Princeton students 'saw' twice as many infractions by Dartmouth players than Dartmouth students did
- Dartmouth students saw a 'rough but fair' game

> “In brief, the data here indicate that there is no such 'thing' as a 'game' existing 'out there' in its own right which people merely 'observe.' The game 'exists' for a person and is experienced by him only insofar as certain happenings have significances in terms of his purpose.”

Hastorf and Cantril
They Saw a Game

> “Everything that has ever happened to you has happened inside your skull.”

David McRaney
You Are Now Less Dumb

Comparing the Students

- All male
- Ethnic and socioeconomically similar
- Same part of the country
- Same age
- Same basic culture and religious beliefs
- Different schools

> “It’s a real problem, though, when politicians, CEOs, and other people with the power to change the way the world works start bungling their arguments for or against things based on self-delusion generated by imperfect minds and senses.”

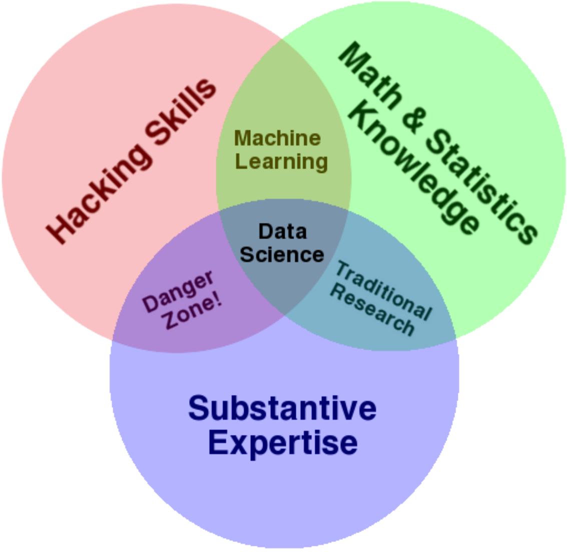
David McRaney
You Are Now Less Dumb

Real World Issues

- Foods and Cancer
- Vaccination and Autism
- Global Warming
- GMOs

> “Data scientist: n. person who is better at statistics than any software engineer and better at software engineering than any statistician.”
>
> Josh Wills

> “There's a distinct lack of respect for researchers in academia and industry labs who have been working on this kind of stuff for years, and whose work is based on decades (in some cases, centuries) of work by statisticians, computer scientists, mathematicians, engineers and scientists of all types.”
>
> Cathy O'Neil and Rachel Schutt



http://drewconway.com/zia/2013/3/26/the-data-science-venn-diagram

> “Data science is the civil engineering of data. Its acolytes possess a practical knowledge of tools and materials, coupled with a theoretical understanding of what is possible.”

Cathy O'Neil and Rachel Schutt

Data Science Strategy

- Engineering and Infrastructure for collection and logging
- Privacy Access policies
- Role in Decision Making Process

> “Narratives are meaning transmitters. They are history-preservation devices. They create and maintain cultures, and they forge identities that emerge out of the malleable, imperfect memories of life events.”

David McRaney
You Are Now Less Dumb

> “Your narrative bias makes it nearly impossible for you to really absorb the information from the outside world without arranging it into causes and effects.”

David McRaney
You Are Now Less Dumb

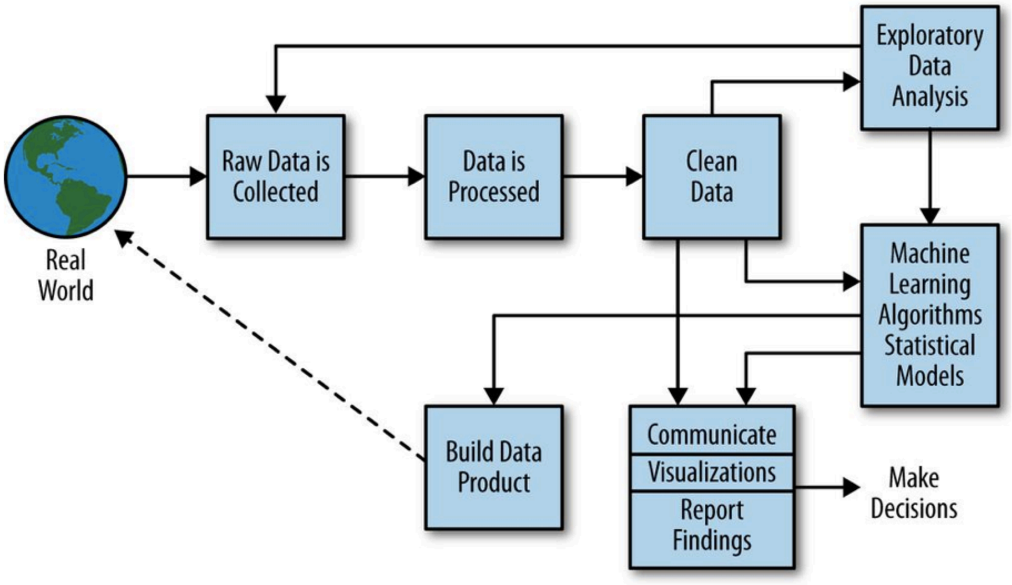
> “Your ancestors invented the scientific method because the common belief fallacy renders your default strategies for making sense of the world generally awful and prone to error.”

David McRaney
You Are Now Less Dumb

“Your natural tendency is to start from a conclusion and work backward to confirm your assumptions, but the scientific method drives down the wrong side of the road and tries to disconfirm your assumptions.”

David McRaney
You Are Now Less Dumb

Data Science Techniques


Exploratory Data Analysis
Real World
Raw Data is Collected
Data is Processed
Clean Data
Machine Learning Algorithms Statistical Models
Build Data Product
Communicate Visualizations Report Findings
Make Decisions

Doing Data Science (O'Neil and Schutt)

Math

- Statistics
- Linear Algebra
- Numerical Analysis
- Calculus

Statistics

- Observations and Samples
- Bias
- Modeling
- Distributions
- Fitting a model
- Overfitting

Techniques

- Linear Regression
- k Nearest Neighbor
- k Means clustering
- Decision Trees

Programming

Programming Languages

- C/C++
- Fortran
- Python
- Julia
- R

Python

- General Purpose, High-Level Programming Language
- Emphasis on readability
- Expressive syntax
- Supports OO, FP, Procedural Programming
- Dynamic
- CPython/Jython

SciPy

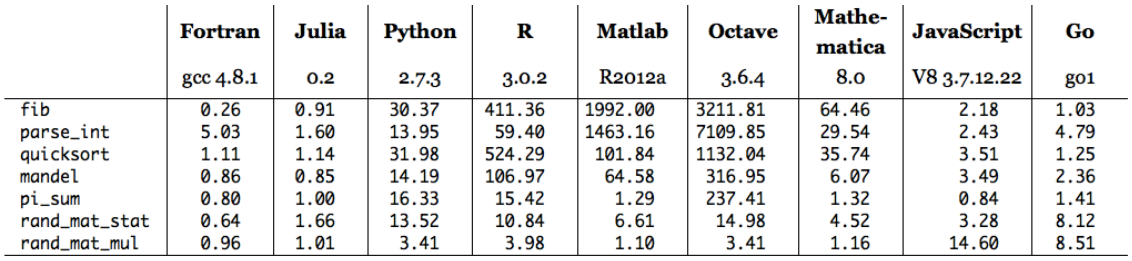
- Ecosystem of open-source packages for science, math and engineering
- NumPy
- SciPy
- Matplotlib
- IPython
- Sympy
- pandas

SciPy/NumPy

- Numerical analysis
- Optimization problems
- N-Dimensional Arrays
- Linear Algebra
- Fourier transformations

Julia

- An attempt to create a high-performance, general purpose numerical language
- Think: MATLAB meets Fortran, Python and Lisp
- LLVM-based JIT Compiler
- Growing base of packages
- Impressive performance benchmarks
- MIT License



	Fortran	Julia	Python	R	Matlab	Octave	Mathe-matica	JavaScript	Go
	gcc 4.8.1	0.2	2.7.3	3.0.2	R2012a	3.6.4	8.0	V8 3.7.12.22	go1
fib	0.26	0.91	30.37	411.36	1992.00	3211.81	64.46	2.18	1.03
parse_int	5.03	1.60	13.95	59.40	1463.16	7109.85	29.54	2.43	4.79
quicksort	1.11	1.14	31.98	524.29	101.84	1132.04	35.74	3.51	1.25
mandel	0.86	0.85	14.19	106.97	64.58	316.95	6.07	3.49	2.36
pi_sum	0.80	1.00	16.33	15.42	1.29	237.41	1.32	0.84	1.41
rand_mat_stat	0.64	1.66	13.52	10.84	6.61	14.98	4.52	3.28	8.12
rand_mat_mul	0.96	1.01	3.41	3.98	1.10	3.41	1.16	14.60	8.51

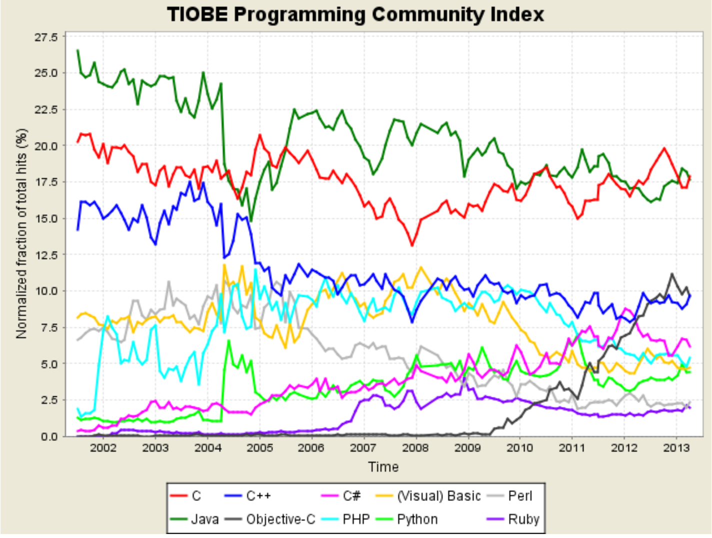
Figure: benchmark times relative to C (smaller is better, C performance = 1.0).

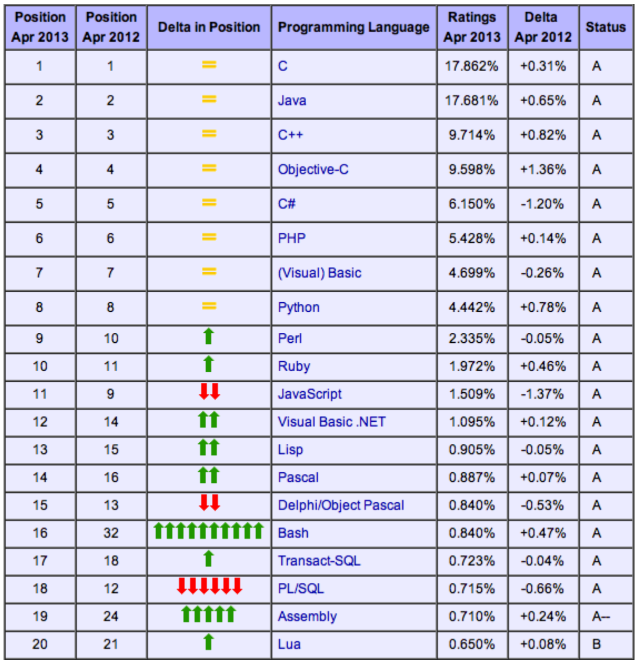
Nerdy Language Features

- Multiple dispatch
- Dynamic type system
- Built-in package manager
- Lisp-like macros and other metaprogramming fu
- Ability to call C/Python functions
- Supports parallel and distributed processing
- Coroutines

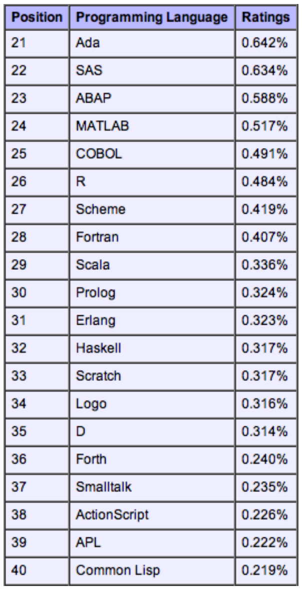
R

- Created by Ross Ihaka and Robert Gentleman
- Maintained by the R Development Core Team
- Part of the GNU Project
- Commercial support
- Implemented in C, Fortran and R





Position Apr 2013	Position Apr 2012	Delta in Position	Programming Language	Ratings Apr 2013	Delta Apr 2012	Status
1	1	=	C	17.862%	+0.31%	A
2	2	=	Java	17.681%	+0.65%	A
3	3	=	C++	9.714%	+0.82%	A
4	4	=	Objective-C	9.598%	+1.36%	A
5	5	=	C#	6.150%	-1.20%	A
6	6	=	PHP	5.428%	+0.14%	A
7	7	=	(Visual) Basic	4.699%	-0.26%	A
8	8	=	Python	4.442%	+0.78%	A
9	10	↑	Perl	2.335%	-0.05%	A
10	11	↑	Ruby	1.972%	+0.46%	A
11	9	↓↓	JavaScript	1.509%	-1.37%	A
12	14	↑↑	Visual Basic .NET	1.095%	+0.12%	A
13	15	↑↑	Lisp	0.905%	-0.05%	A
14	16	↑↑	Pascal	0.887%	+0.07%	A
15	13	↓↓	Delphi/Object Pascal	0.840%	-0.53%	A
16	32	↑↑↑↑↑↑↑↑↑↑	Bash	0.840%	+0.47%	A
17	18	↑	Transact-SQL	0.723%	-0.04%	A
18	12	↓↓↓↓↓↓	PL/SQL	0.715%	-0.66%	A
19	24	↑↑↑↑↑	Assembly	0.710%	+0.24%	A--
20	21	↑	Lua	0.650%	+0.08%	B

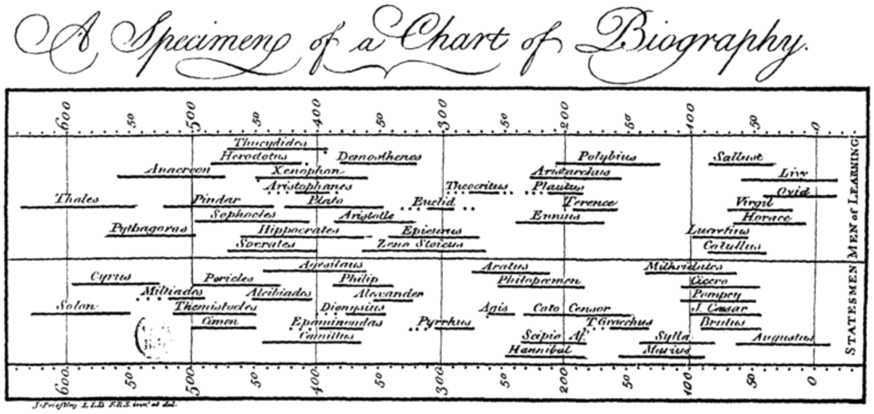


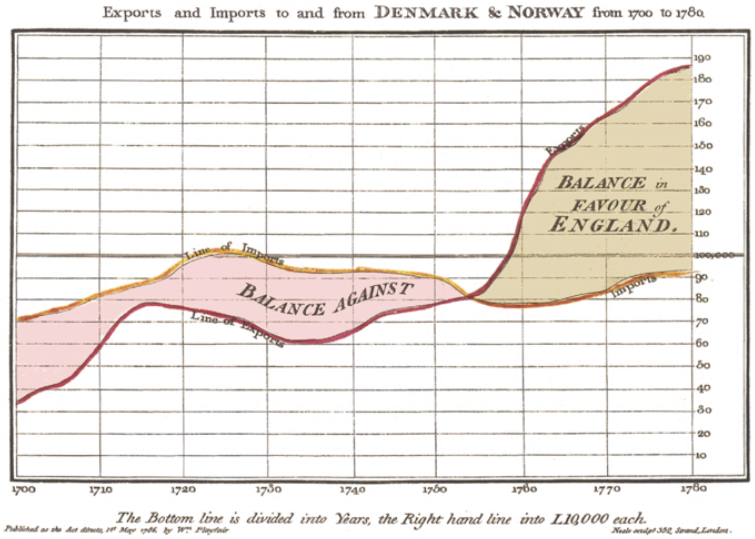
Position	Programming Language	Ratings
21	Ada	0.642%
22	SAS	0.634%
23	ABAP	0.588%
24	MATLAB	0.517%
25	COBOL	0.491%
26	R	0.484%
27	Scheme	0.419%
28	Fortran	0.407%
29	Scala	0.336%
30	Prolog	0.324%
31	Erlang	0.323%
32	Haskell	0.317%
33	Scratch	0.317%
34	Logo	0.316%
35	D	0.314%
36	Forth	0.240%
37	Smalltalk	0.235%
38	ActionScript	0.226%
39	APL	0.222%
40	Common Lisp	0.219%

Supports

- Basic Math
- Statistical Analysis
- Optimization Problems
- Signal Processing
- Graphics and Visualization
- Data Mining
- Machine Learning

Visualization


A Specimen of a Chart of Biography.
600
50
500
50
400
50
300
50
200
50
100
50
0
Thucydides
Herodotus
Demosthenes
Polybius
Sallust
Anacreon
Xenophon
Aristarchus
Liv
Aristophanes
Theocritus
Plautus
Ovid
Thales
Pindar
Plato
Euclid
Terence
Virgil
Sophocles
Aristotle
Ennius
Horace
Pythagoras
Hippocrates
Epicurus
Lucretius
Socrates
Zeno Stoicus
Catullus
Agesilaus
Aratus
Mithridates
Cyrus
Pericles
Philip
Philopoemen
Cicero
Miltiades
Alcibiades
Alexander
Pompey
Solon
Themistocles
Dionysius
Agis
Cato
Censor
J. Caesar
Cimon
Epaminondas
Pyrrhus
T. Gracchus
Brutus
Camillus
Scipio Af.
Sylla
Augustus
Hannibal
Marius
MEN of LEARNING
STATESMEN
J. Priestley L.L.D. F.R.S. inv. et del.


Exports and Imports to and from DENMARK & NORWAY from 1700 to 1780.
190
180
170
160
150
140
130
120
110
100,000
90
80
70
60
50
40
30
20
10
1700
1710
1720
1730
1740
1750
1760
1770
1780
Line of Imports
Line of Exports
BALANCE AGAINST
Exports
Imports
BALANCE in FAVOUR of ENGLAND.
The Bottom line is divided into Years, the Right hand line into L10,000 each.
Published as the Act directs, 1st May 1786, by Wm. Playfair
Neele sculpt 352, Strand, London.

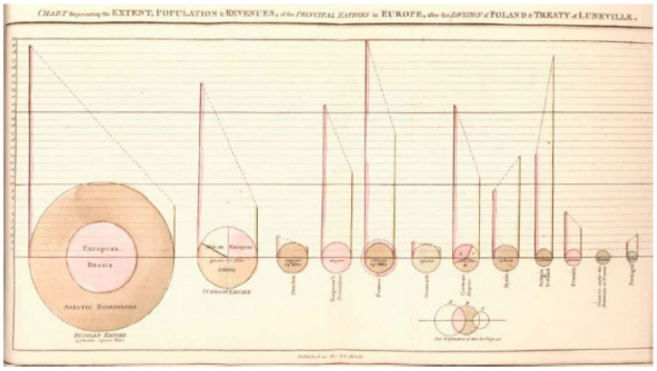
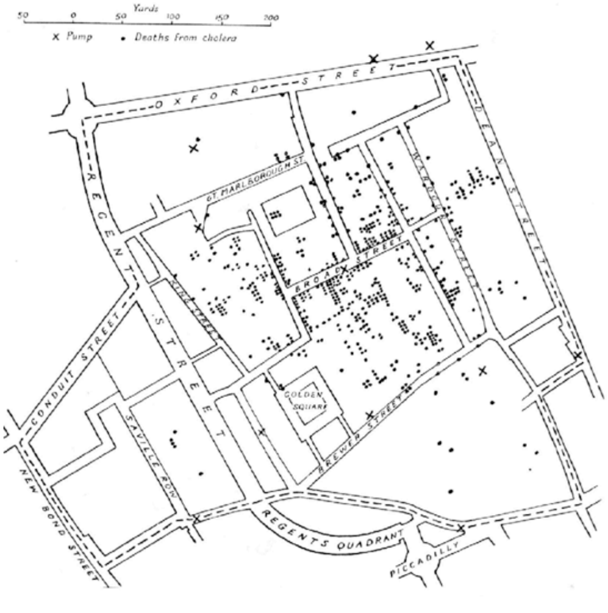
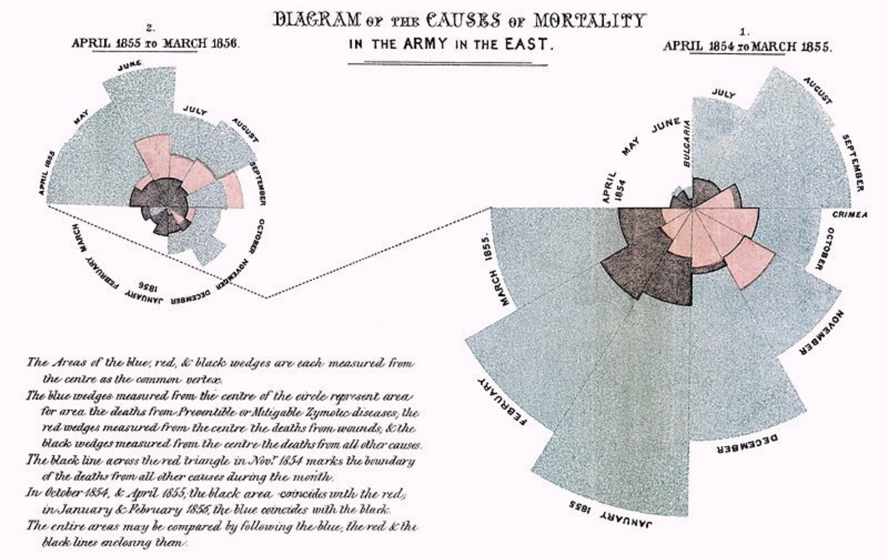


CHART Representing the EXTENT, POPULATION & REVENUES, of the PRINCIPAL NATIONS in EUROPE, after the DIVISION of POLAND & TREATY of LUNEVILLE.
European Russia
Asiatic Dominions
Russian Empire
Turkish Empire
Sweden
France
Spain
Portugal


Yards
50
0
50
100
150
200
× Pump
• Deaths from cholera
OXFORD STREET
REGENT STREET
GT. MARLBOROUGH ST
BROAD STREET
DEAN STREET
CONDUIT STREET
SAVILLE ROW
NEW BOND STREET
GOLDEN SQUARE
BREWER STREET
REGENTS QUADRANT
PICCADILLY



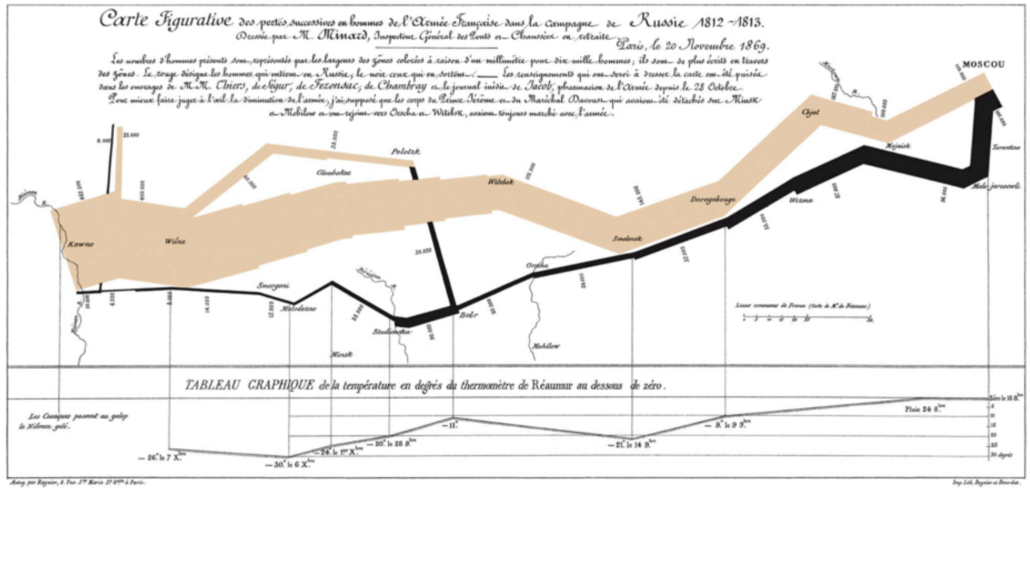
The Areas of the blue, red, & black wedges are each measured from the centre as the common vertex.

The blue wedges measured from the centre of the circle represent area for area the deaths from Preventible or Mitigable Zymotic diseases, the red wedges measured from the centre the deaths from wounds, & the black wedges measured from the centre the deaths from all other causes.

The black line across the red triangle in Novr. 1854 marks the boundary of the deaths from all other causes during the month.

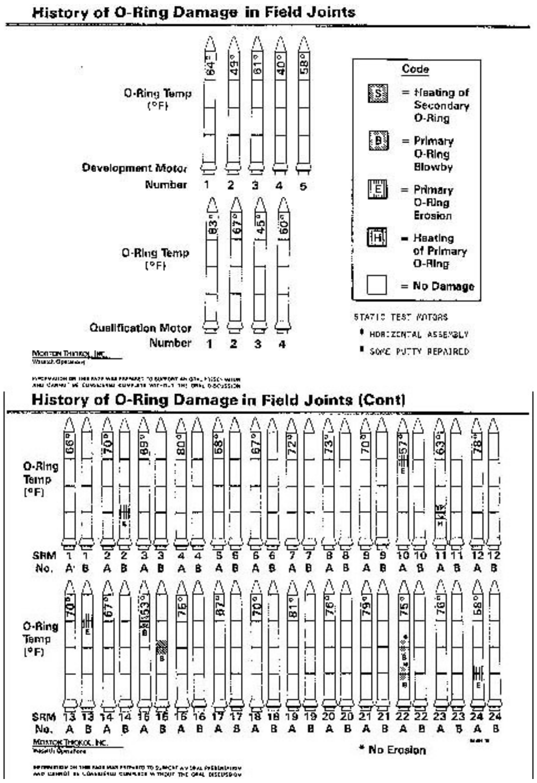
In October 1854, & April 1855, the black area coincides with the red, in January & February 1856, the blue coincides with the black.

The entire areas may be compared by following the blue, the red & the black lines enclosing them.



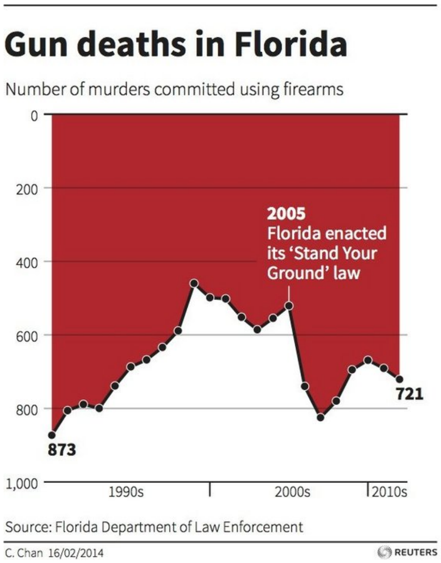
Les nombres d'hommes présents sont représentés par les largeurs des zônes colorées à raison d'un millimètre pour dix mille hommes; ils sont de plus écrits en travers des zônes. Le rouge désigne les hommes qui entrent en Russie, le noir ceux qui en sortent. — Les renseignements qui ont servi à dresser la carte ont été puisés dans les ouvrages de MM. Thiers, de Ségur, de Fezensac, de Chambray et le journal inédit de Jacob, pharmacien de l'Armée depuis le 28 Octobre.

Pour mieux faire juger à l'œil la diminution de l'armée, j'ai supposé que les corps du Prince Jérôme et du Maréchal Davoust qui avaient été détachés sur Minsk et Mohilow et ont rejoint vers Orscha et Witebsk, avaient toujours marché avec l'armée.



Techniques

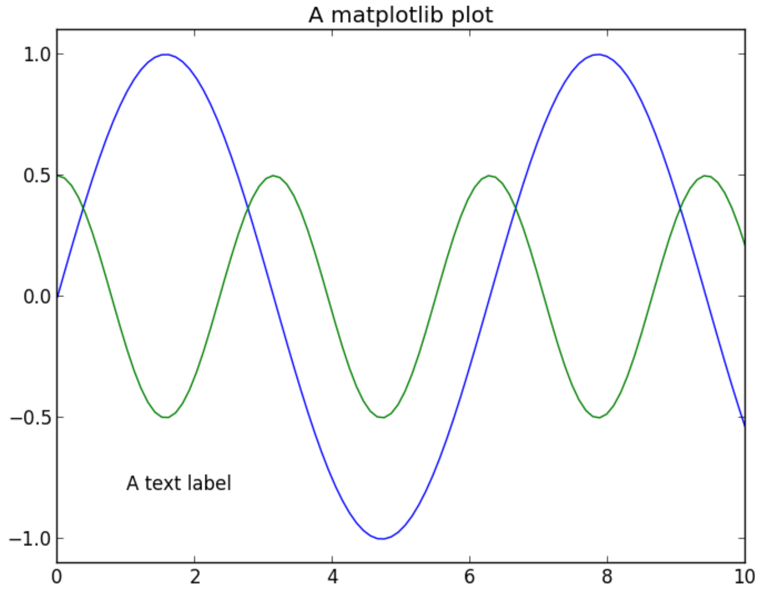
- Graphical Analysis
- Presentation Graphics



PYTHON

```
ipython -pylab

x = linspace( 0, 10, 100 )
plot( x, sin(x) )
plot( x, 0.5*cos(2*x) )
title( "A matplotlib plot" )
text( 1, -0.8, "A text label" )
ylim( -1.1, 1.1 )
savefig( 'matplotlib.png' )
```



d3.js

- Data-Driven Documents
- JavaScript library that uses HTML, SVG and CSS
- Bind data to the DOM
- Data-driven transformations

URL

https://github.com/mbostock/d3/wiki/Gallery

URL

http://mbostock.github.io/d3/talk/20111116/iris-splom.html

URL

http://bost.ocks.org/mike/uberdata/

URL

http://exposedata.com/parallel/

URL

http://mbostock.github.io/d3/tutorial/circle.html

Machine Learning

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Data Mining

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Big Data

> “First, it is a bundle of technologies. Second, it is a potential revolution in measurement. And third, it is a point of view, or philosophy, about how decisions will be— and perhaps should be— made in the future.”

Steve Lohr, New York Times (2013-10-09)

Everything You Know About Something

ID	Col1	Col2	Col3	Col4	Col5	Col6	....	ColN
Thing1	Value1	Value2	Value3	Value4	Value5	Value6	....	ValueN

Everything You Know About Everything

ID	Col1	Col2	Col3	Col4	Col5	Col6	....	ColN
Thing1	Value1	Value2	Value3		Value5		....	ValueN
Thing2	Value1		Value3	Value4	Value5	Value6	....	ValueN
Thing3		Value2	Value3		Value5	Value6	....	ValueN
Thing4	Value1	Value2	Value3	Value4	Value5	Value6	....	ValueN
...	...	...	...	...	...	...	....	...

Distribute Rows in their Entirety

ID	Col1	Col2	Col3	Col4	Col5	Col6	....	ColN
Thing1	Value1	Value2	Value3		Value5		....	ValueN
Thing3		Value2	Value3		Value5	Value6	....	ValueN

Distribute Columns in their Entirety

ID	Col2	Col3	Col5	ColN
Thing1	Value2	Value3		ValueN
Thing3	Value2	Value3	Value5	ValueN
Thing4	Value2	Value3	Value5	ValueN
...	...	...	...	...

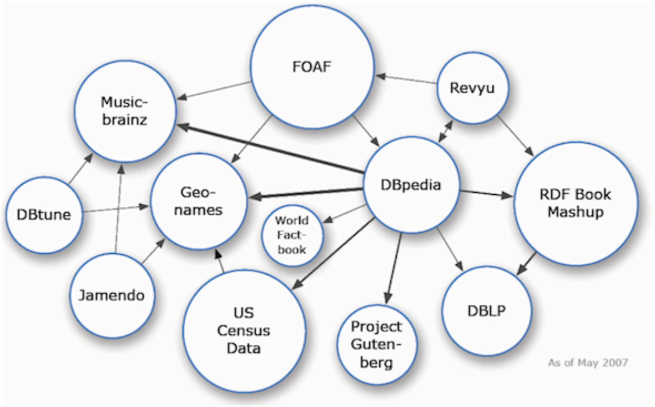
Linked Data

Distribute Arbitrary Cells

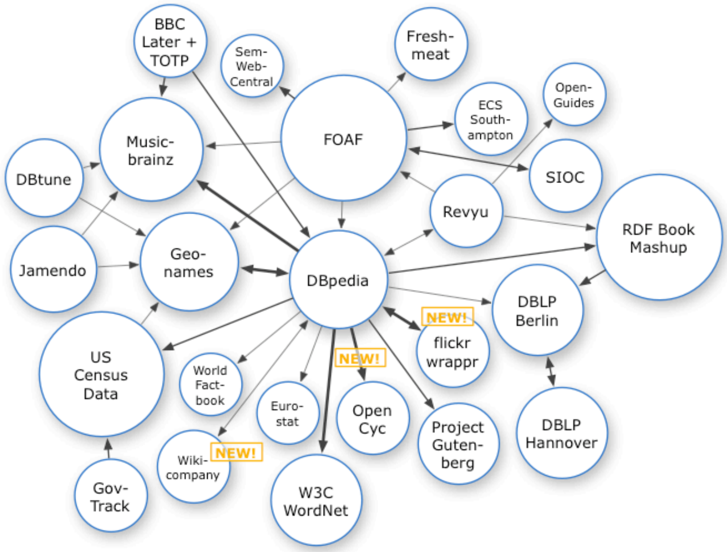
ID	Col2	Col3	Col5	ColN
Thing1		Value3		ValueN
Thing3			Value5	ValueN
Thing4	Value2	Value3		ValueN
...	...	...	...	...

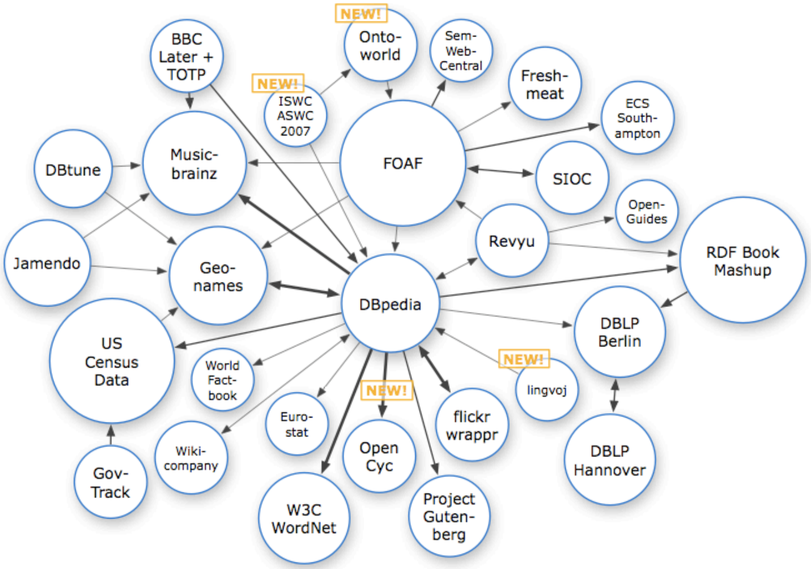
Linking Open Data Project

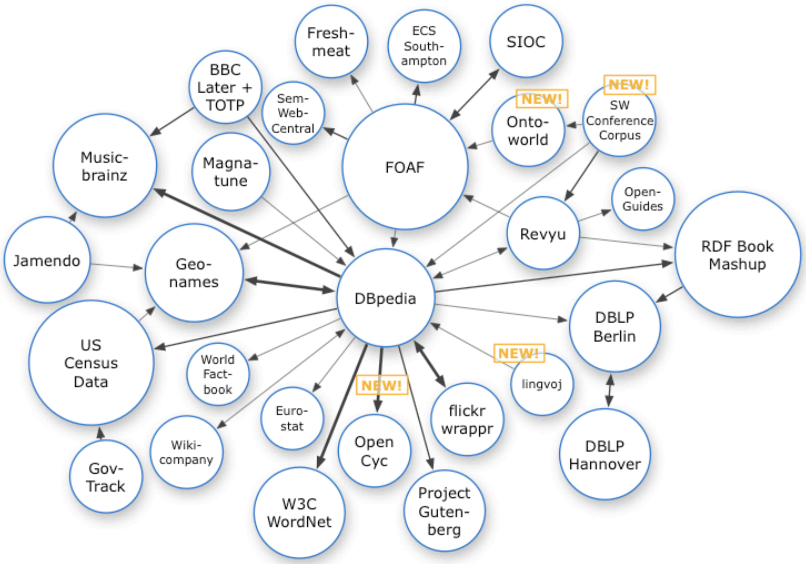
- Started in 2007 by W3C Semantic Web Education and Outreach(SWEO) Interest Group
- Make data freely available
- Doubled in size every 10 months

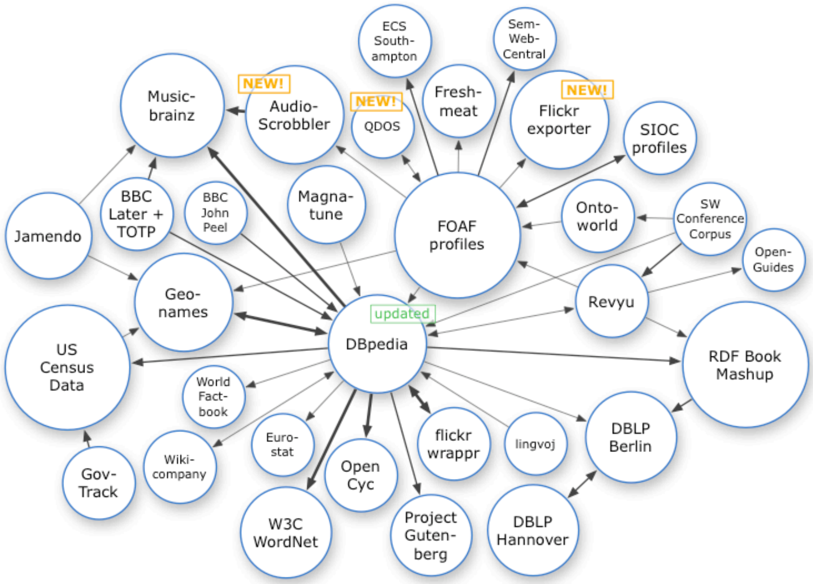


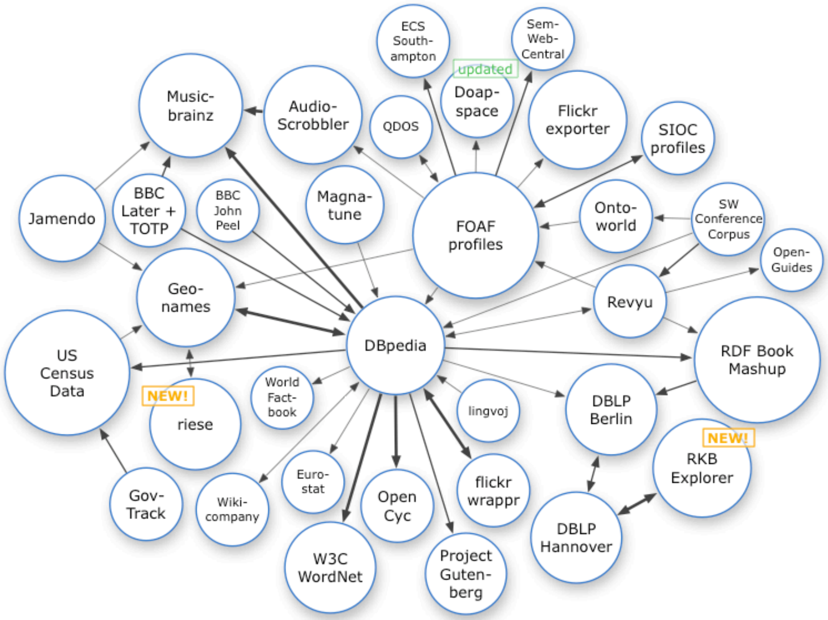
As of May 2007




NEW!
Onto-world
Sem-Web-Central
BBC Later + TOTP
NEW!
ISWC ASWC 2007
Fresh-meat
ECS South-ampton
DBtune
Music-brainz
FOAF
SIOC
Open-Guides
Jamendo
Geo-names
Revyu
RDF Book Mashup
DBpedia
US Census Data
World Fact-book
NEW!
DBLP Berlin
NEW!
lingvoj
Euro-stat
flickr wrappr
Open Cyc
Wiki-company
Gov-Track
DBLP Hannover
W3C WordNet
Project Guten-berg


Fresh-meat
ECS South-ampton
SIOC
BBC Later + TOTP
Sem-Web-Central
NEW!
Onto-world
NEW!
SW Conference Corpus
Music-brainz
Magna-tune
FOAF
Open-Guides
Revyu
RDF Book Mashup
Jamendo
Geo-names
DBpedia
DBLP Berlin
US Census Data
World Fact-book
NEW!
lingvoj
NEW!
Euro-stat
flickr wrappr
Open Cyc
Wiki-company
Gov-Track
DBLP Hannover
W3C WordNet
Project Guten-berg


ECS South-ampton
Sem-Web-Central
NEW!
Music-brainz
NEW!
Audio-Scrobbler
NEW!
QDOS
Fresh-meat
Flickr exporter
SIOC profiles
BBC Later + TOTP
BBC John Peel
Magna-tune
FOAF profiles
Onto-world
SW Conference Corpus
Jamendo
Open-Guides
Geo-names
updated
Revyu
US Census Data
DBpedia
RDF Book Mashup
World Fact-book
Euro-stat
flickr wrappr
lingvoj
DBLP Berlin
Gov-Track
Wiki-company
Open Cyc
W3C WordNet
Project Guten-berg
DBLP Hannover


ECS South-ampton
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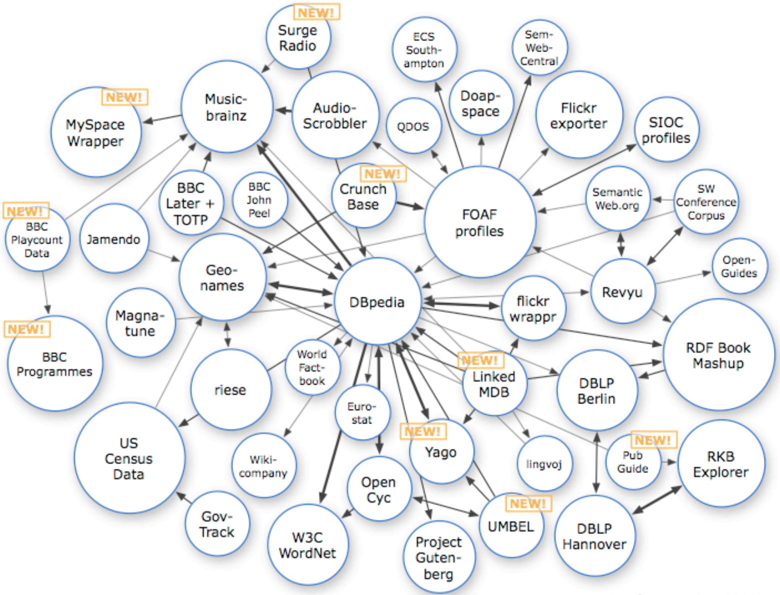
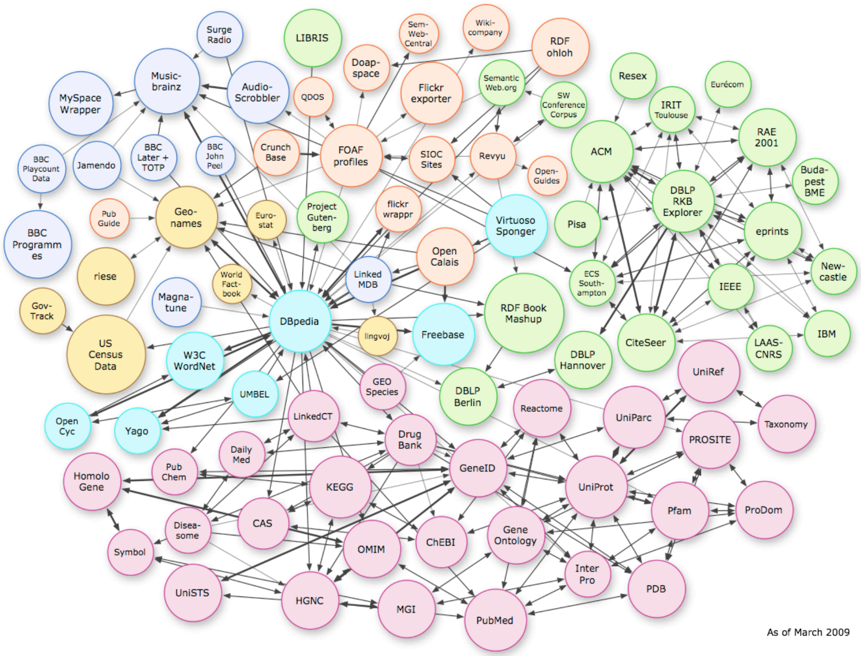
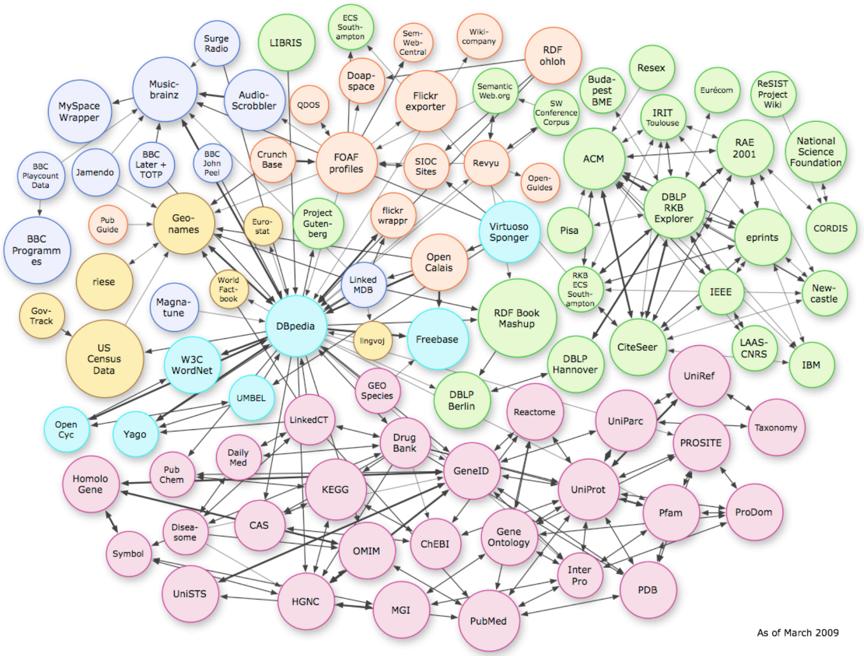


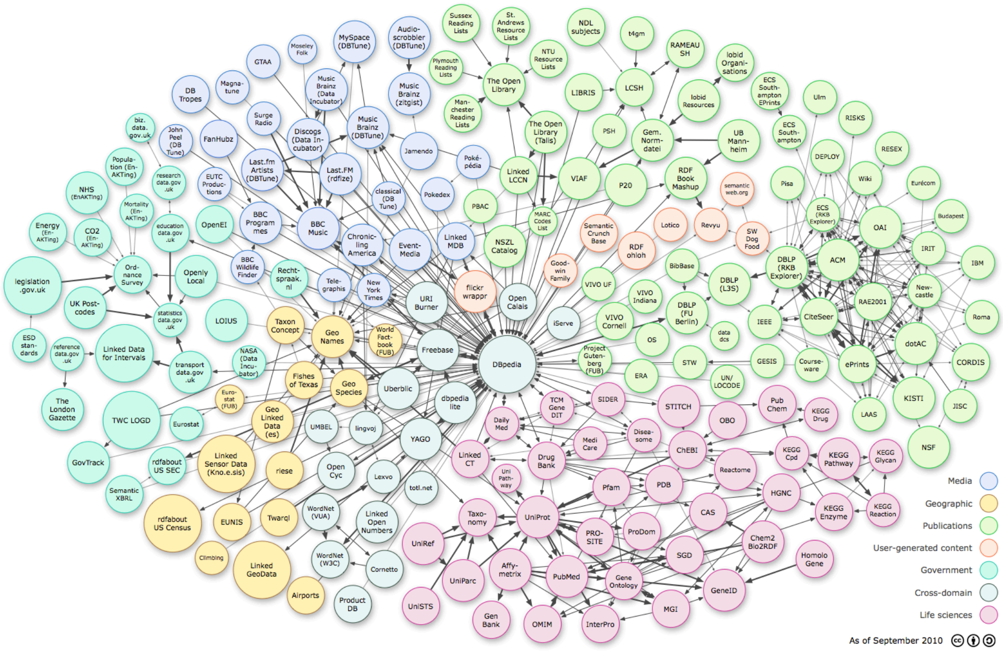
As of September 2008



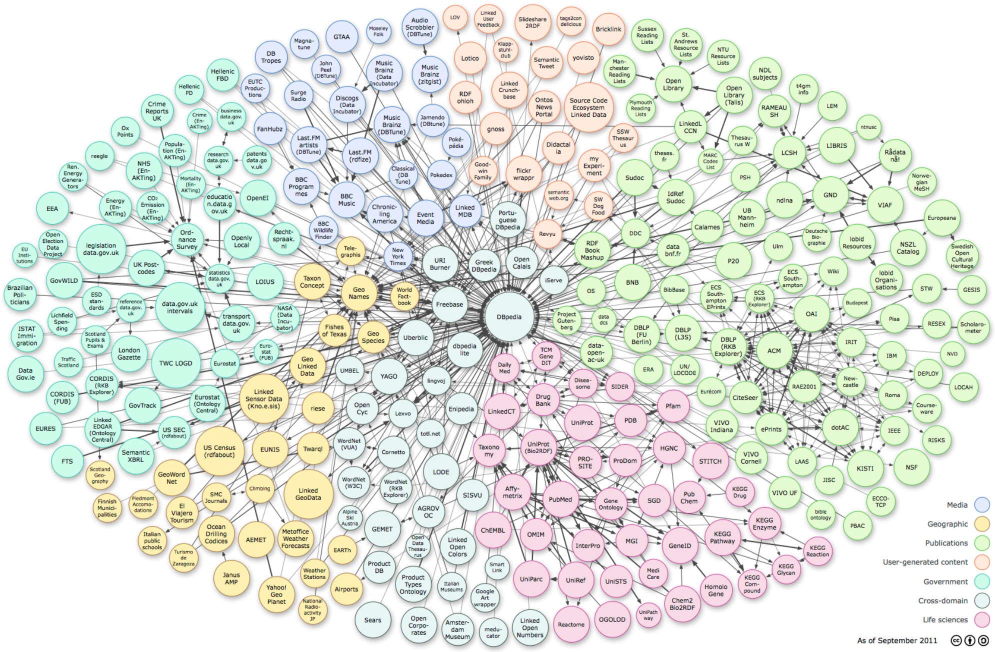
As of March 2009



As of March 2009

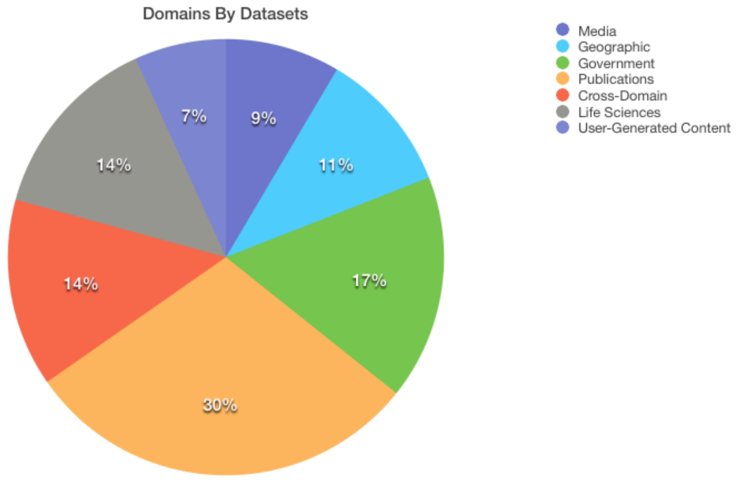


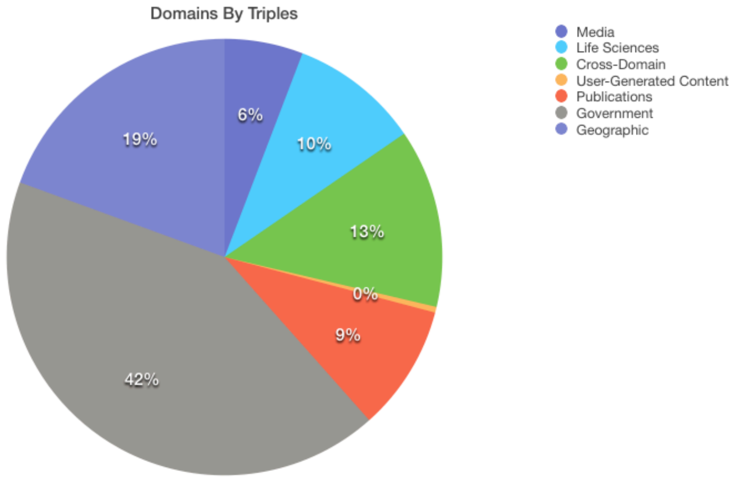
As of September 2010 🅭🅯🄎

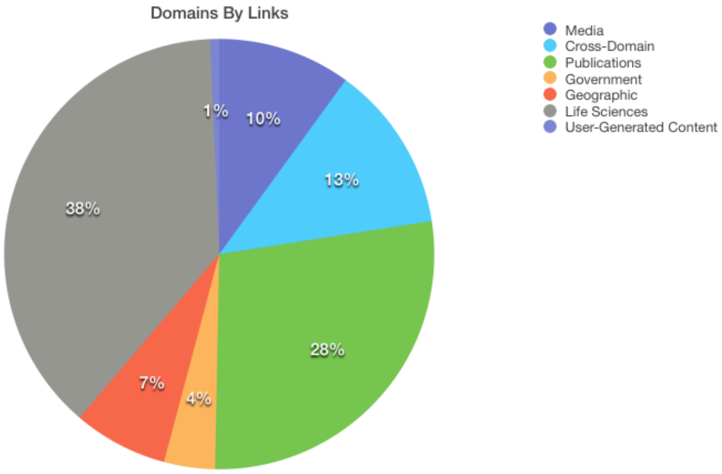


Domain	# Datasets	# Triples	# Links
Media	25	1,800,000,000	50,000,00
Geographic	31	6,000,000,000	35,000,000
Government	49	13,000,000,000	19,000,000
Publications	87	2,900,000,000	140,000,000
Cross-Domain	41	4,100,000,000	63,000,000
Life Sciences	41	3,000,000,000	191,000,000
User-Generated Content	20	134,000,000	3,400,000
Total	295	31,000,000,000	504,000,000

http://lod-cloud.net/state/


Domains By Datasets
Media
Geographic
Government
Publications
Cross-Domain
Life Sciences
User-Generated Content
9%
11%
17%
30%
14%
14%
7%


Domains By Triples
Media
Life Sciences
Cross-Domain
User-Generated Content
Publications
Government
Geographic
6%
10%
13%
0%
9%
42%
19%



DBPedia

- Linked Dataset derived from Wikipedia
- Creative Commons Attribution-ShareAlike 3.0 License
- GNU Free Documentation License
- Multi-domain
- Consensus-based
- Kept current by Wikipedia activity
- Multi-lingual

DBPedia Numbers (English Version)

http://dbpedia.org/About

- Describes 4 million things
- 3.22 million are classified by an ontology
- 832,000 people
- 639,000 places
- 372,000 creative works
- 209,000 organizations
- 226,000 species
- 5,600 diseases

DBPedia Numbers (Non-English Version)

http://dbpedia.org/About

- 119 Localized Language Versions
- Describe 24.9 million things (w/ repetition)
- 16.8 million are connected to English DBPedia

DBPedia Summary

http://wiki.dbpedia.org/Datasets39/DatasetStatistics?v=dqp

- Overall 12.6 million unique things
- 24.6 million links to images
- 27.6 million links to pages
- 45 million links to other RDF datasets
- 67 million links to Wikipedia categories
- 41.2 million links to YAGO categories
- 2.46 billion RDF triples
- 470 million (English), 1.98 billion (Non-English)

Use Cases

http://wiki.dbpedia.org/UseCases?v=ene

- Improve Wikipedia Search
- Include DBPedia data in your documents
- Support for Geographic Data
- Documentation Classification, Annotation
- Multi-Domain Ontology

DBPedia

http://dbpedia.org

Most Important Query Ever Run

http://tinyurl.com/n9hhs68

HTML

http://www.r-bloggers.com/sparql-with-r-in-less-than-5-minutes/

HTML

http://linkedscience.org/tools/sparql-package-for-r/tutorial-on-sparql-package-for-r/

Books

Data Science Books

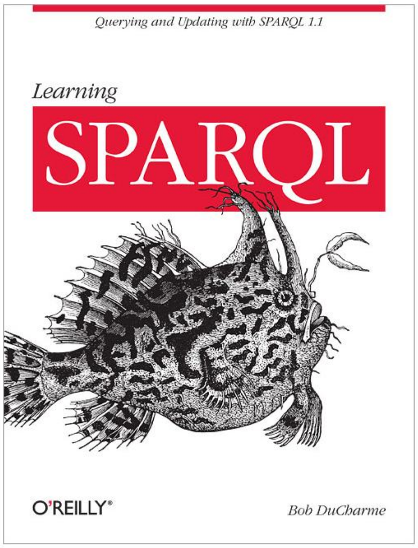
- Data Analysis w/ Open Source Tools, Philipp K. Janet (ORA)
- Data Smart: Using Data Science to Transform Information into Insight, John W. Foreman (Wiley)
- Doing Data Science : Straight Talk from the Frontline, Cathy O'Neil, Rachel Schutt (ORA)
- The R Book, Michael J. Crawley (Wiley)
- R Tutorial w/ Bayesian Statistics Using OpenBUGS, Chi Yau
- Applied Predictive Modeling, Max Kuhn and Kjell Johnson (Springer)
- Introductory Statistics w/ R, Peter Dalgaard (Wiley)
- Think Stats, Allen B. Downey (ORA)
- R Cookbook, Paul Teetor (ORA)
- R Graphics Cookbook, Winston Chang (ORA)

HTML

http://www.quora.com/Data-Science/How-do-I-become-a-data-scientist

HTML

http://cm.bell-labs.com/cm/ms/departments/sia/doc/datascience.pdf



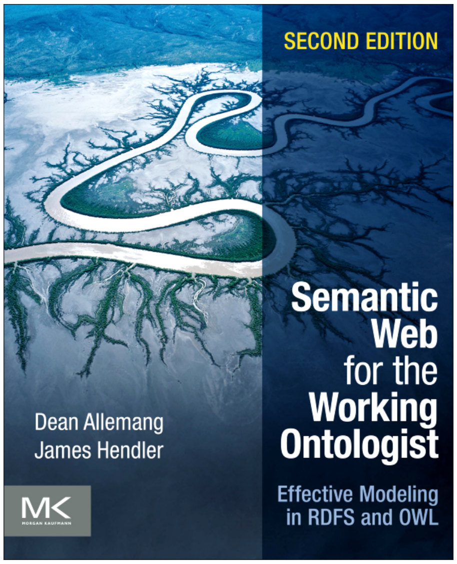
Querying and Updating with SPARQL 1.1

Learning

SPARQL

O'REILLY®

Bob DuCharme



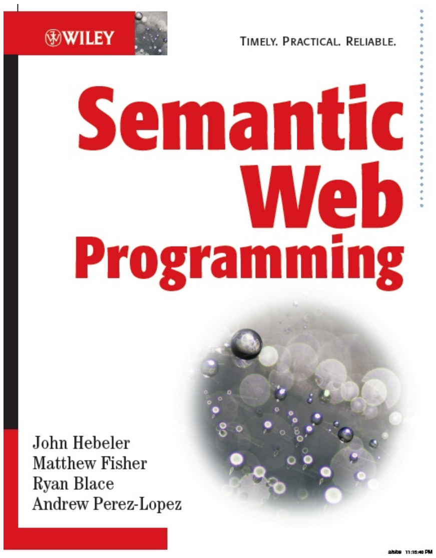
SECOND EDITION

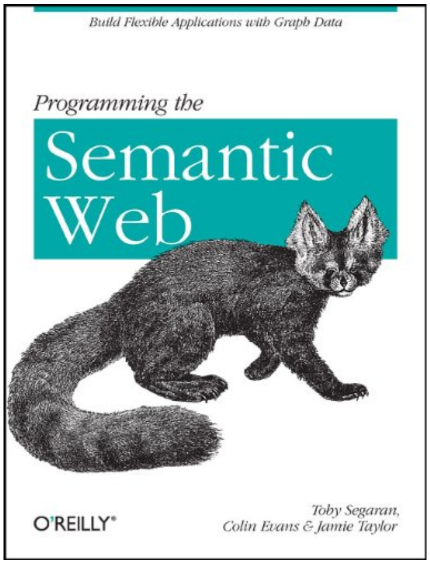
Semantic Web for the Working Ontologist

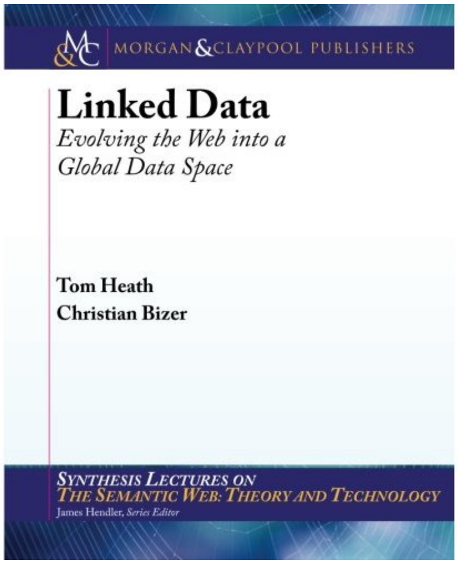
Effective Modeling in RDFS and OWL

Dean Allemang
James Hendler

MK MORGAN KAUFMANN


WILEY
TIMELY. PRACTICAL. RELIABLE.
Semantic Web Programming
John Hebeler
Matthew Fisher
Ryan Blace
Andrew Perez-Lopez


Build Flexible Applications with Graph Data
Programming the Semantic Web
O'REILLY®
Toby Segaran,
Colin Evans & Jamie Taylor



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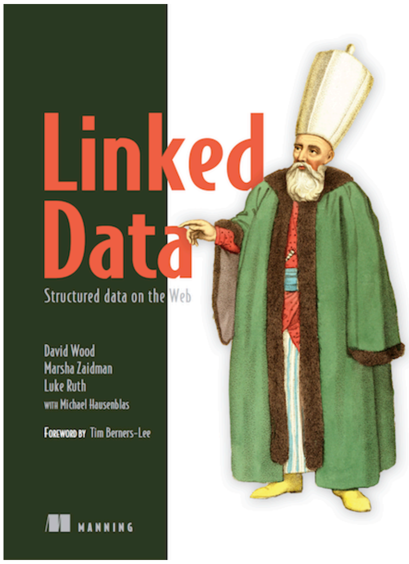
Linked Data

Evolving the Web into a Global Data Space

Tom Heath
Christian Bizer

SYNTHESIS LECTURES ON
THE SEMANTIC WEB: THEORY AND TECHNOLOGY
James Hendler, *Series Editor*



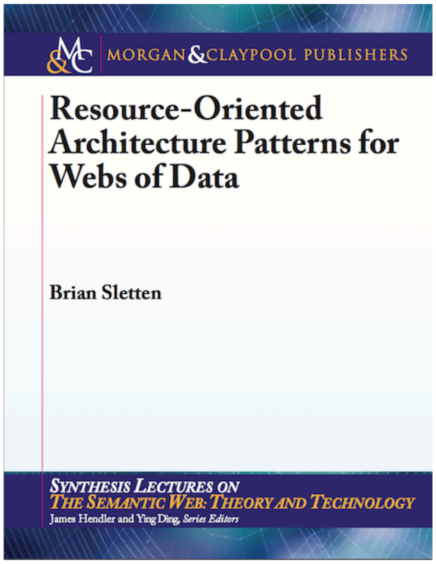
Linked Data

Structured data on the Web

David Wood
Marsha Zaidman
Luke Ruth
with Michael Hausenblas

Foreword by Tim Berners-Lee

MANNING



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Questions?

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