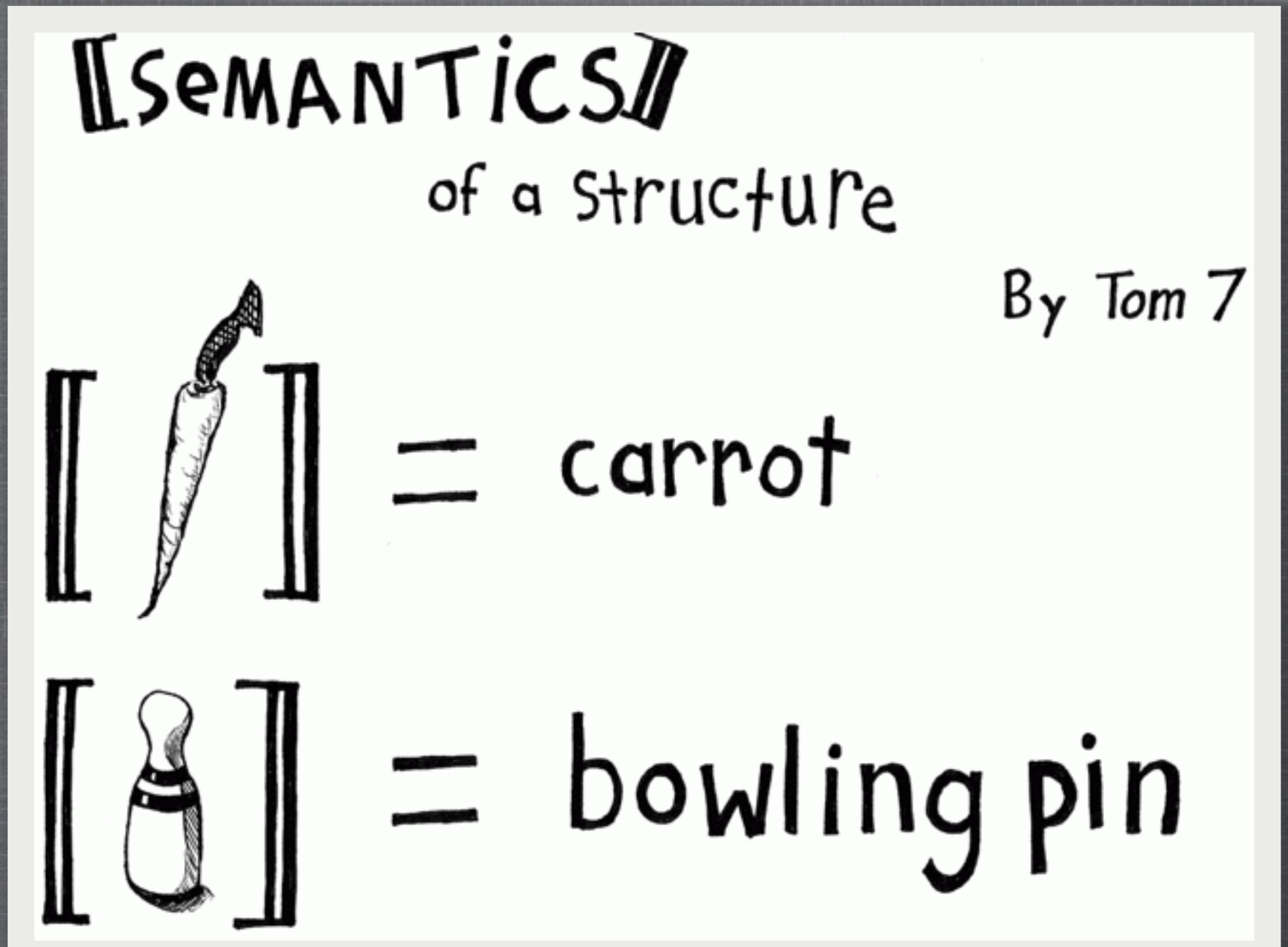
INFO116

Models of Semantics



HOW TO REPRESENT SEMANTICS?

- We want semantics to do something for us. What?
- Which precise problems it can help us solve?
  - Less abstract than *integration* and *abstraction*
- *Prescriptive (formal)* vs *descriptive (implicit)* semantics

PRESCRIPTIVE SEMANTICS

- Special logical languages to encode knowledge
- Logical language provides the tools for representation and reasoning, but the content must be created from scratch
- Allows us to add new information to existing resources in a precise and formal way.

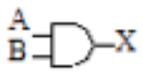
SOME TYPES

- Different expressivity (what it can say)
  - Boolean logic
  - first-order logic
  - modal logics
  - Relational algebra/calculus
  - RDF (Resource Description Framework)
  - description logics
  - OWL

BOOLEAN

- Truth tables
- AND, OR, NAND, NOR, NOT, XOR
- *Cats AND Dogs*

AND



$X = A \cdot B$

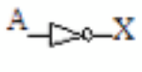
A	B	X
0	0	0
0	1	0
1	0	0
1	1	1

OR

$X = A + B$

A	B	X
0	0	0
0	1	1
1	0	1
1	1	1

NOT



$X = \bar{A}$

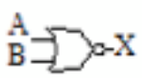
A	X
0	1
1	0

NAND

$X = \overline{A \cdot B}$

A	B	X
0	0	1
0	1	1
1	0	1
1	1	0

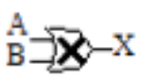
NOR



$X = \overline{A + B}$

A	B	X
0	0	1
0	1	0
1	0	0
1	1	0

EOR



$X = A \oplus B$

A	B	X
0	0	0
0	1	1
1	0	1
1	1	0

FOL

- First-order logic deals with objects, functions, and relationships
- Boolean operators (and, or, not, implies, etc.)
- quantifiers (universal and existential)
- *All things that are cats which love (all?) dogs*

$$(\forall x.(P(x) \wedge Q(x)) \leftrightarrow ((\forall x.P(x)) \wedge (\forall x.Q(x)))$$
$$(\exists x.(P(x) \wedge Q(x)) \rightarrow ((\exists x.P(x)) \wedge (\exists x.Q(x)))$$
$$(\exists x.(P(x) \vee Q(x)) \leftrightarrow ((\exists x.P(x)) \vee (\exists x.Q(x)))$$
$$((\forall x.P(x)) \vee (\forall x.Q(x))) \rightarrow (\forall x.(P(x) \vee Q(x))$$
$$(\exists x.\forall y.R(x,y)) \rightarrow (\forall y.\exists x.R(x,y))$$
$$(\neg(\exists x.P(x))) \leftrightarrow (\forall x.(\neg P(x))$$
$$(\neg(\forall x.P(x))) \leftrightarrow (\exists x.(\neg P(x))$$
$$(\neg(\exists x\rho t.P(x))) \leftrightarrow (\forall x\rho t.(\neg P(x))$$
$$(\neg(\forall x\rho t.P(x))) \leftrightarrow (\exists x\rho t.(\neg P(x))$$
$$(\forall x.(x = t \rightarrow F(x))) \leftrightarrow F(t)$$
$$(\exists x.(x = t \wedge F(x))) \leftrightarrow F(t)$$

MODAL LOGIC

- A modal is an expression like *necessarily* or *possibly*
- include logics for belief, for tense and other temporal expressions, for the deontic (moral) expressions such as 'it is obligatory that' and 'it is permitted that', and many others.
- *Cats which might like dogs at night.*

Logic	Symbols	Expressions Symbolized
Modal Logic	□	It is necessary that ..
	◊	It is possible that …
Deontic Logic	*O*	It is obligatory that …
	P	It is permitted that …
	F	It is forbidden that …
Temporal Logic	*G*	It will always be the case that …
	F	It will be the case that …
	H	It has always been the case that .
	P	It was the case that …
Doxastic Logic	*Bx*	*x* believes that …

SUMMARY OF TRADITIONAL LOGICS

- Complex
  - representation
  - reasoning
- Specialized
- Expressivity vs. computability

A SIMPLER CALCULUS

- Relational Algebra/Calculus
- finitary relations and five primitive closure operators
  - selection
  - projection
  - Cartesian product
  - set union
  - set difference
- Joins

RELATIONAL ALGEBRA

Implemented in SQL.

```
SELECT *
FROM employee NATURAL JOIN department;
```

Natural join (⋈) [edit source | edit beta]

"Natural join" redirects here. For the SQL implementation, see Natural join (SQL).

Natural join (▷◁) is a binary operator that is written as (*R* ▷◁ *S*) where *R* and *S* are relations.[6] The result of the natural join is the set of all combinations of tuples in *R* and *S* that are equal on their common attribute names. For an example consider the tables *Employee* and *Dept* and their natural join:

Employee

Name	EmpId	DeptName
Harry	3415	Finance
Sally	2241	Sales
George	3401	Finance
Harriet	2202	Sales

Dept

DeptName	Manager
Finance	George
Sales	Harriet
Production	Charles

Employee ▷◁ ***Dept***

Name	EmpId	DeptName	Manager
Harry	3415	Finance	George
Sally	2241	Sales	Harriet
George	3401	Finance	George
Harriet	2202	Sales	Harriet

COMBINATION FRIED RICE

- Relational algebra useful in describing objects, relations
- Very fast retrieval, reasoning
- But limited ...

  =>

  - Description logics, OWL, RDF

DESCRIPTION LOGIC

- family of restricted FOL languages
- useful for discussing worlds that are organized into objects

Axiom	DL Syntax	Example
`subClassOf`	$C_1 \sqsubseteq C_2$	Human $\sqsubseteq$ Animal $\sqcap$ Biped
`sameClassAs`	$C_1 \equiv C_2$	Man $\equiv$ Human $\sqcap$ Male
`subPropertyOf`	$P_1 \sqsubseteq P_2$	hasDaughter $\sqsubseteq$ hasChild
`samePropertyAs`	$P_1 \equiv P_2$	cost $\equiv$ price
`disjointWith`	$C_1 \sqsubseteq \neg C_2$	Male $\sqsubseteq \neg$Female
`sameIndividualAs`	$\{i_1\} \equiv \{i_2\}$	{President_Bush} $\equiv$ {G_W_Bush}
`differentIndividualFrom`	$\{i_1\} \sqsubseteq \neg\{i_2\}$	{john} $\sqsubseteq \neg$ {peter}
`inverseOf`	$P_1 \equiv P_2^-$	hasChild $\equiv$ hasParent$^-$
`transitiveProperty`	$P^+ \sqsubseteq P$	ancestor$^+ \sqsubseteq$ ancestor
`uniqueProperty`	$\top \sqsubseteq \leqslant 1\, P.\top$	$\top \sqsubseteq \leqslant 1$ hasMother.$\top$
`unambiguousProperty`	$\top \sqsubseteq \leqslant 1\, P^-.\top$	$\top \sqsubseteq \leqslant 1$ isMotherOf$^-.\top$
`range`	$\top \sqsubseteq \forall P.C$	$\top \sqsubseteq \forall$hasParent.Human
`domain`	$\top \sqsubseteq \forall P^-.C$	$\top \sqsubseteq \forall$hasParent$^-$.Human
i `type` C	$i : C$	john : Man
$i_1\ P\ i_2$	$\langle i_1, i_2 \rangle : P$	$\langle$john, peter$\rangle$: hasParent

OWL

- OWL is a family of knowledge representation languages for modelling ontologies
- OWL comes in three flavours
  - OWL-Full
  - OWL-DL
  - OWL-Lite
- Uses RDF / RDFS

RDF

- The Resource Description Framework
- W3C specification
- Data model (for writing metadata)
- Similar to classic conceptual modelling approaches such as entity–relationship or class diagrams
  - making statements about resources

RDF TRIPLES

- The *subject* denotes the resource, and the *predicate* denotes traits or aspects of the resource and expresses a relationship between the subject and the *object*.
- S - P - O
- Sky - hasColor - Blue
- *Serialized* as XML, Turtle, N3, N-triples

RDF GRAPHS


http://www.w3.org/2000/10/swap/pim/contact#Person
http://www.w3.org/1999/02/22-rdf-syntax-ns#type
http://www.w3.org/People/EM/contact#me
http://www.w3.org/2000/10/swap/pim/contact#fullName
Eric Miller
http://www.w3.org/2000/10/swap/pim/contact#mailbox
mailto:em@w3.org
http://www.w3.org/2000/10/swap/pim/contact#personalTitle
Dr.

RDF TRIPLES

- http://www.w3.org/People/EM/contact#me, http://www.w3.org/2000/10/swap/pim/contact#fullName, "Eric Miller"
- http://www.w3.org/People/EM/contact#me, http://www.w3.org/2000/10/swap/pim/contact#mailbox, em@w3.org
- http://www.w3.org/People/EM/contact#me, http://www.w3.org/2000/10/swap/pim/contact#personalTitle, "Dr."
- http://www.w3.org/People/EM/contact#me, http://www.w3.org/1999/02/22-rdf-syntax-ns#type, http://www.w3.org/2000/10/swap/pim/contact#Person

RDF AND ONTOLOGIES

- RDF statements can be used to define class (unary relation) instances, property (binary relation) instances, collections, etc.

<rdf:Description ID="PassengerVehicle">

<rdf:type resource="http://www.w3.org/2000/01/rdf-schema#Class"/>

<rdfs:subClassOf rdf:resource="#MotorVehicle"/>

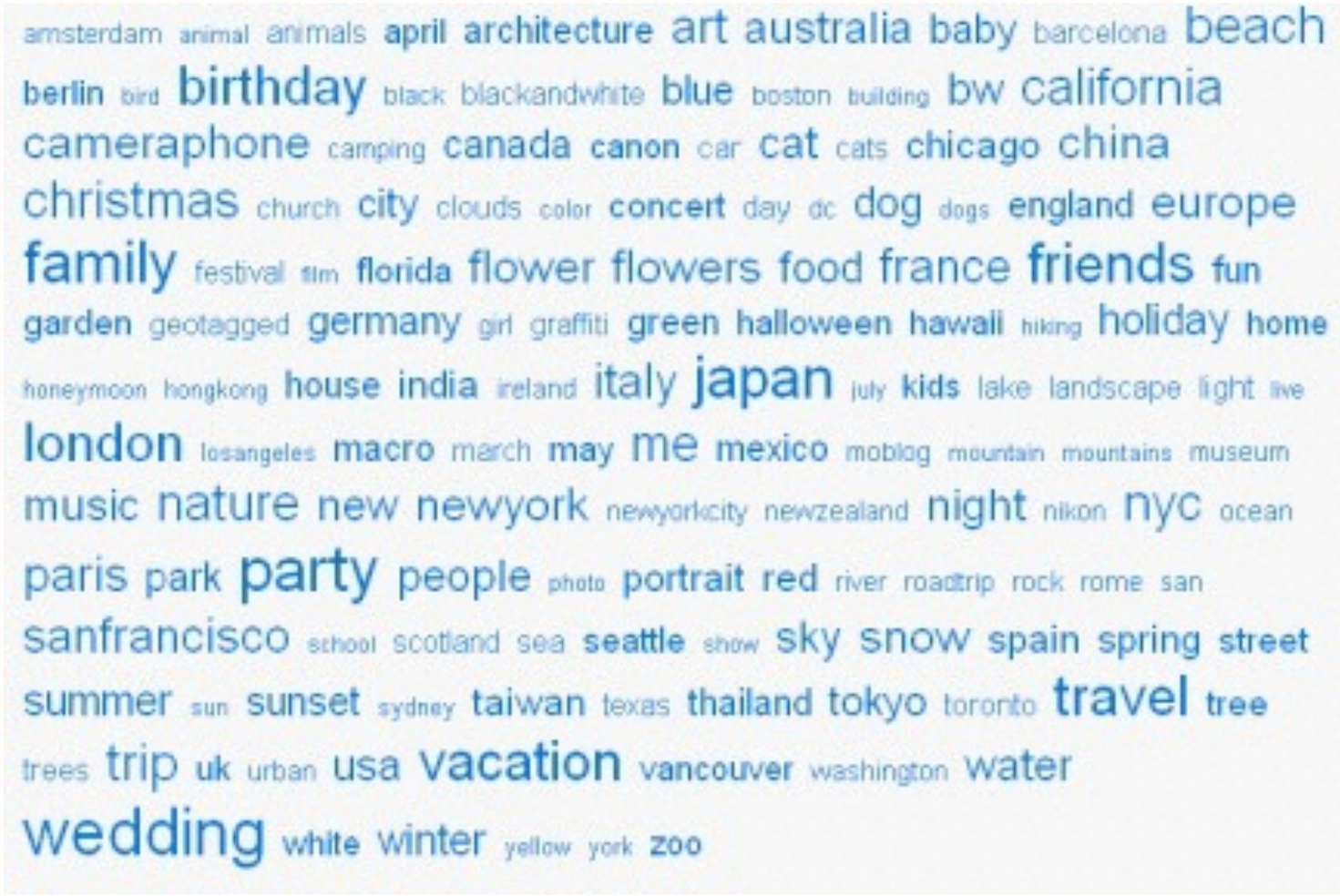
</rdf:Description>

DESCRIPTIVE SEMANTICS

- capture contemporary usages of terms, to eventually promote consensus
- provide some notation which captures the existing use of terms
  - XML
  - Entity-Relationship Model (ERM) and Unified Modelling Language (UML)
  - ControlledVocabulary,Thesaurus,andTaxonomy
  - Folksonomy

FOLKSONOMY

- "Bottom up" classification



CONTROLLED VOCABULARY,THESAURUS, TAXONOMY

- Using words to describe concepts
- Controlled vocabulary mandates the use of preferred/normalized terms to refer to the concept.
  - Libraries, journal publications, etc.
  - Nobody likes them!
- Thesaurus groups words by similarity of meaning

WORDNET

- Lexical database
- Groups words by synset

Noun

- S: (n) **dog**, domestic dog, Canis familiaris (a member of the genus Canis (probably descended from the common wolf) that has been domesticated by man since prehistoric times; occurs in many breeds) *"the dog barked all night"*
- S: (n) frump, **dog** (a dull unattractive unpleasant girl or woman) *"she got a reputation as a frump"; "she's a real dog"*
- S: (n) **dog** (informal term for a man) *"you lucky dog"*
- S: (n) cad, bounder, blackguard, **dog**, hound, heel (someone who is morally reprehensible) *"you dirty dog"*
- S: (n) frank, frankfurter, hotdog, hot dog, **dog**, wiener, wienerwurst, weenie (a smooth-textured sausage of minced beef or pork usually smoked; often served on a bread roll)
- S: (n) pawl, detent, click, **dog** (a hinged catch that fits into a notch of a ratchet to move a wheel forward or prevent it from moving backward)
- S: (n) andiron, firedog, **dog**, dog-iron (metal supports for logs in a fireplace) *"the andirons were too hot to touch"*

Verb

- S: (v) chase, chase after, trail, tail, tag, give chase, **dog**, go after, track (go after with the intent to catch) *"The policeman chased the mugger down the alley"; "the dog chased the rabbit"*

TAXONOMY

- relations including hypernomy, meronymy, ...

  dog, domestic dog, Canis familiaris

  => canine, canid

  => carnivore

  => placental, placental mammal, eutherian, eutherian mammal

  => mammal

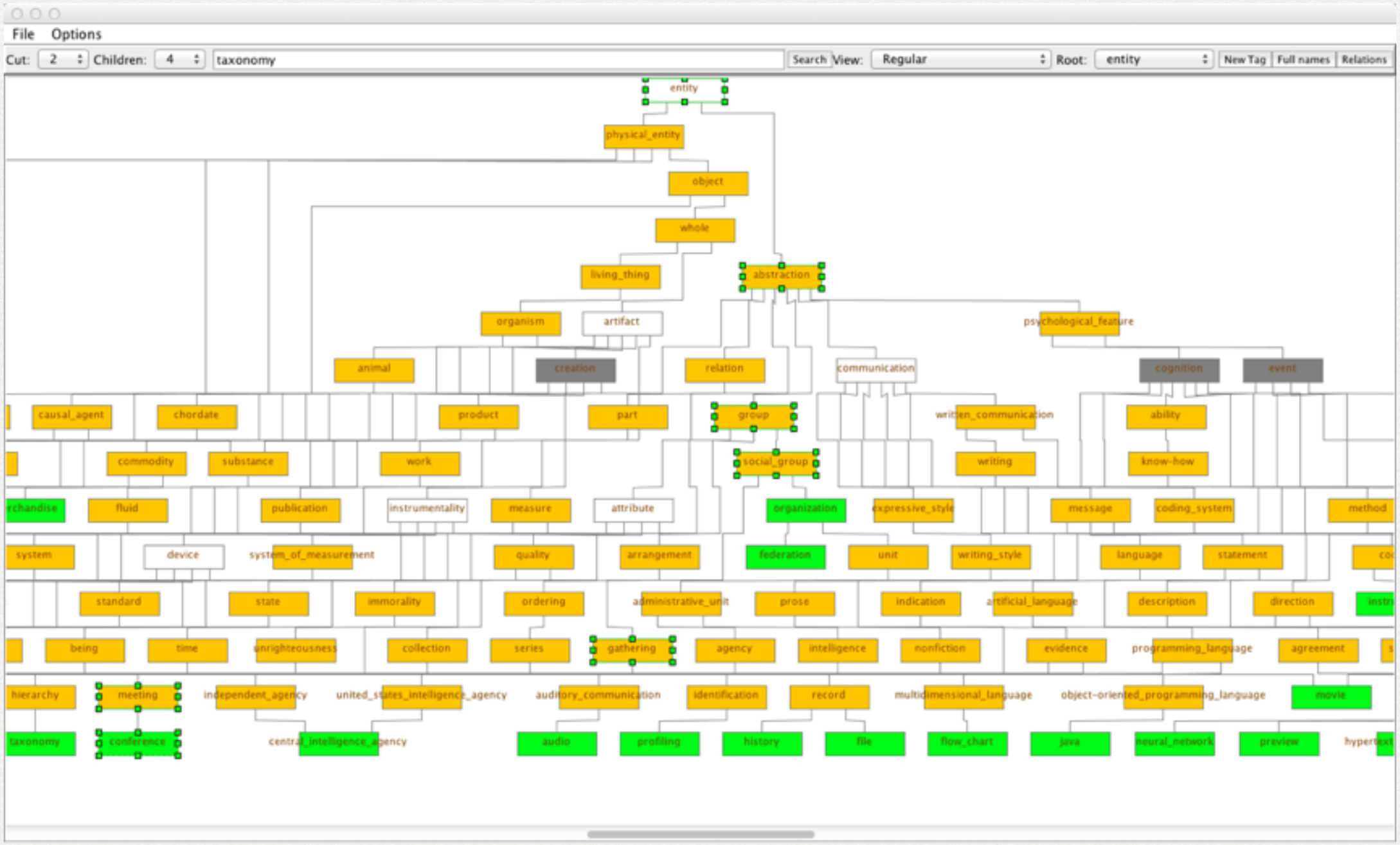
  => vertebrate, craniate

  => chordate

  => animal, animate being, beast, brute, creature, fauna

  => ...

TAXONOMIC INFERENCE "ABSTRACTION"



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a platform-independent object-oriented programming language

Created 2013-07-02T16:02:39

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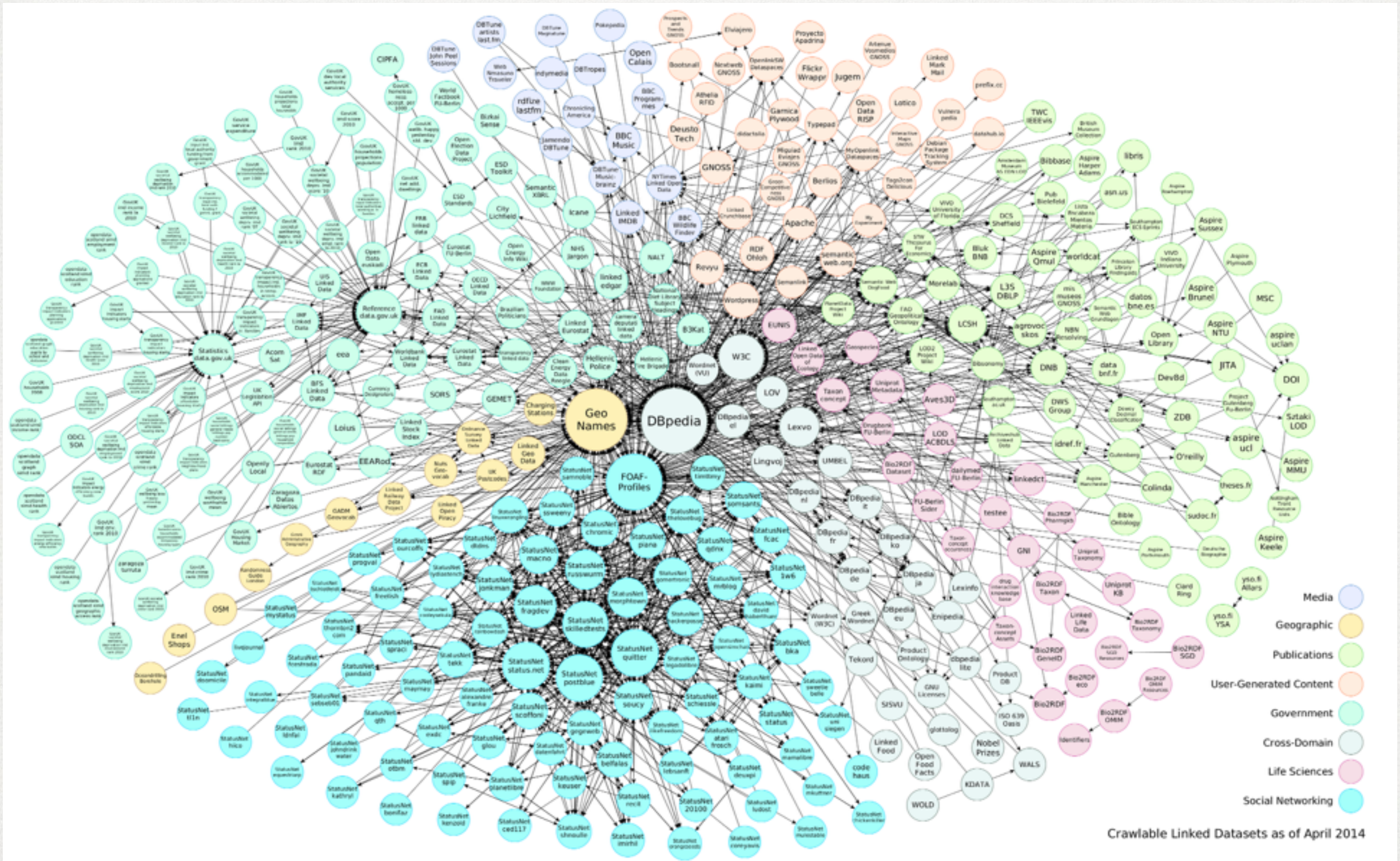
DATA, DATA, DATA

- LOD (Linked Open Data)
  - Use URIs to identify things.
  - Use HTTP URIs so that these things can be referred to and looked up ("dereferenced") by people and user agents.
  - Provide useful information about the thing when the URI is dereferenced, using standard formats such as RDF/XML.
- Include links to other, related URIs in the exposed data to improve discovery of other related information on the Web.
- http://data.dws.informatik.uni-mannheim.de/lodcloud/2014/ISWC-RDB/index.html

LOD CLOUD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dataHub.io
TWC IEEEvis
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Open Election Data Project
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Berlios
MyOpenLink Dataspaces
Debian Package Tracking System
Bibbase
Aspire Harper Adams
libris
asn.us
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ESD Standards
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Linked Crunchbase
Apache
VIVO University of Florida
DCS Sheffield
Lists Bricabrac Maestos Materia
Southampton ECS Eprints
Aspire Sussex
FRB linked data
Eurostat FU-Berlin
Open Energy Info Wiki
NHS Jargon
NALT
RDF Ohloh
Revyu
Bluk BNB
Aspire Qmul
worldcat
Aspire Plymouth
Open Data euskadi
RCB Linked Data
OECD Linked Data
Wine Foundation
linked edgar
Wordpress
Semantic web.org
Morelab
L3S DBLP
Princeton Library Findingaids
VIVO Indiana University
Aspire Brunel
MSC
US Linked Data
FAO Linked Data
Brazilian Politicians
Linked Eurostat
Reference data.gov.uk
B3Kat
EUNIS
TAO Geopolitical Ontology
LCSH
mis museos GNOSS
datos bne.es
Aspire NTU
aspire uclan
IMF Linked Data
Statistics data.gov.uk
Acorn Sat
eea
Worldbank Linked Data
Eurostat Linked Data
Transparency linked data
Hellenic Police
Hellenic Fire Brigade
Wordnet (VU)
W3C
LOV
Lexvo
Taxon concept
Uniprot Metadata
Aves3D
DNB
data bnf.fr
agrovoc skos
NBN Resolving
Open Library
JITA
DOI
Sztaki LOD
BFS Linked Data
UK Legislation API
Currency Ontologies
SORS
GEMET
Changing Stations
Geo Names
DBpedia
DBpedia el
Drugbank FU-Berlin
LOD ACBDLS
Bibsonomy
Southampton ac.uk
DWS Group
Dewey Decimal Classification
ZDB
DevBd
ODCL SOA
Loius
Linked Stock Index
Ordnance Survey Linked Data
Eurostat RDF
EEARod
Openly Local
Linked Geo Data
Nuts Geo-vocab
UK Postcodes
FOAF-Profiles
Lingvoj
UMBEL
Bio2RDF Dataset
idref.fr
Gutenberg
O'reilly
aspire ucl
Zaragoza Datos Abiertos
GADM Geovocab
Linked Railway Data Project
Linked Open Piracy
DBpedia nl
DBpedia it
FU-Berlin Sider
dailymed FU-Berlin
linkedct
Aspire Manchester
Colinda
theses.fr
Aspire MIMU
Aspire Keele
Bible Ontology
sudoc.fr
testee
GNI
Uniprot Taxonomy
Deutsche Biographie
Aspire Northampton
Aspire Northumbria
OSM
Enel Shops
Ordnance Survey Boroughs
Kandomness Guide London
DBpedia fr
DBpedia ko
DBpedia de
DBpedia ja
DBpedia eu
Lexinfo
Bio2RDF Taxon
Uniprot KB
Clard Ring
yso.fi Allars
yso.fi YSA
Wordnet (W3C)
Greek Wordnet
Enipedia
Linked Life Data
Bio2RDF Taxonomy
Tekond
Product Ontology
dbpedia lite
Bio2RDF GeneID
Bio2RDF SGD
Bio2RDF eco
Bio2RDF OMIM
Product DB
GNU Licenses
SISVU
ISO 639 Oasis
Bio2RDF
Linked Food
glottolog
Nobel Prizes
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