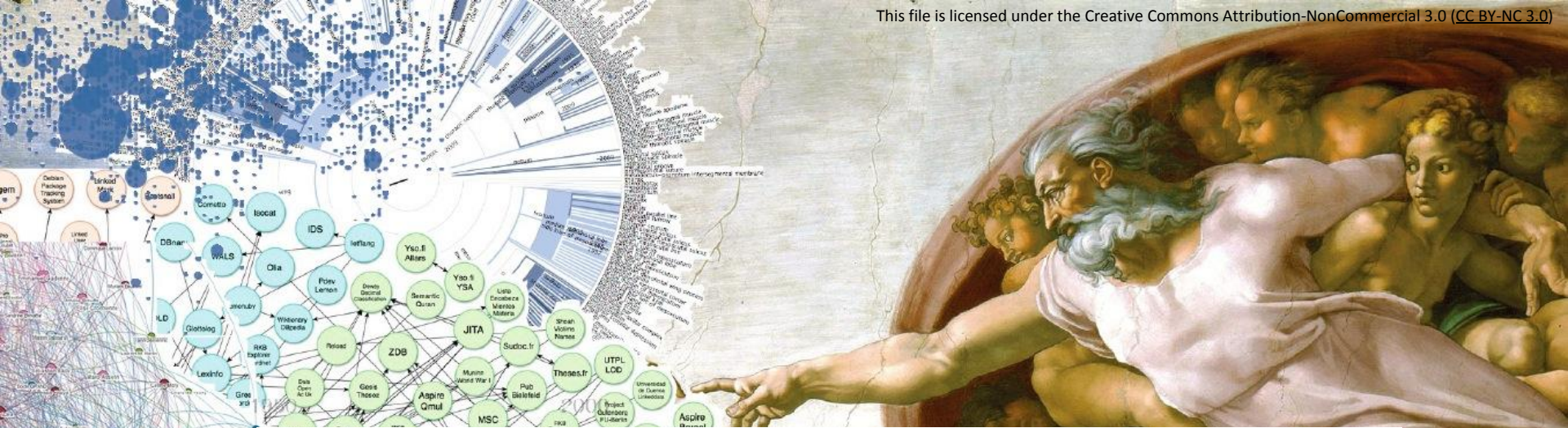




Information Service Engineering

Lecture 4 - Linked Data Engineering II

4.7 Linked Data Knowledge Graphs

 **FIZ Karlsruhe**

Leibniz Institute for Information Infrastructure

 **Hasso Plattner Institut**

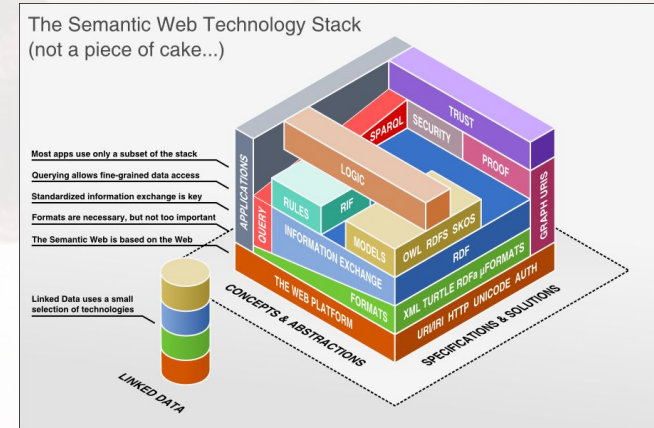

Karlsruher Institut für Technologie

Prof. Dr. Harald Sack & Dr. Maria Koutraki
FIZ Karlsruhe
Leibniz Institute for Information Infrastructure
Karlsruhe Institute of Technology
Spring 2018

Information Service Engineering

Lecture 4: Linked Data Engineering II

- 4.1 Linked Data Principles
- 4.2 Web Ontology Language OWL
- 4.3 Web Ontology Language OWL II
- 4.4 How to Query RDF with SPARQL
- 4.5 Complex Queries with SPARQL
- 4.6 More Complex SPARQL Queries
- 4.7 Linked Data Knowledge Graphs**



The Web of Data

Linked Data

- Linked Open Data (LOD) denote publicly available (RDF) Data in the Web, identified via URI and accessible via HTTP. Linked data link to other data via URI.

The Web of Data

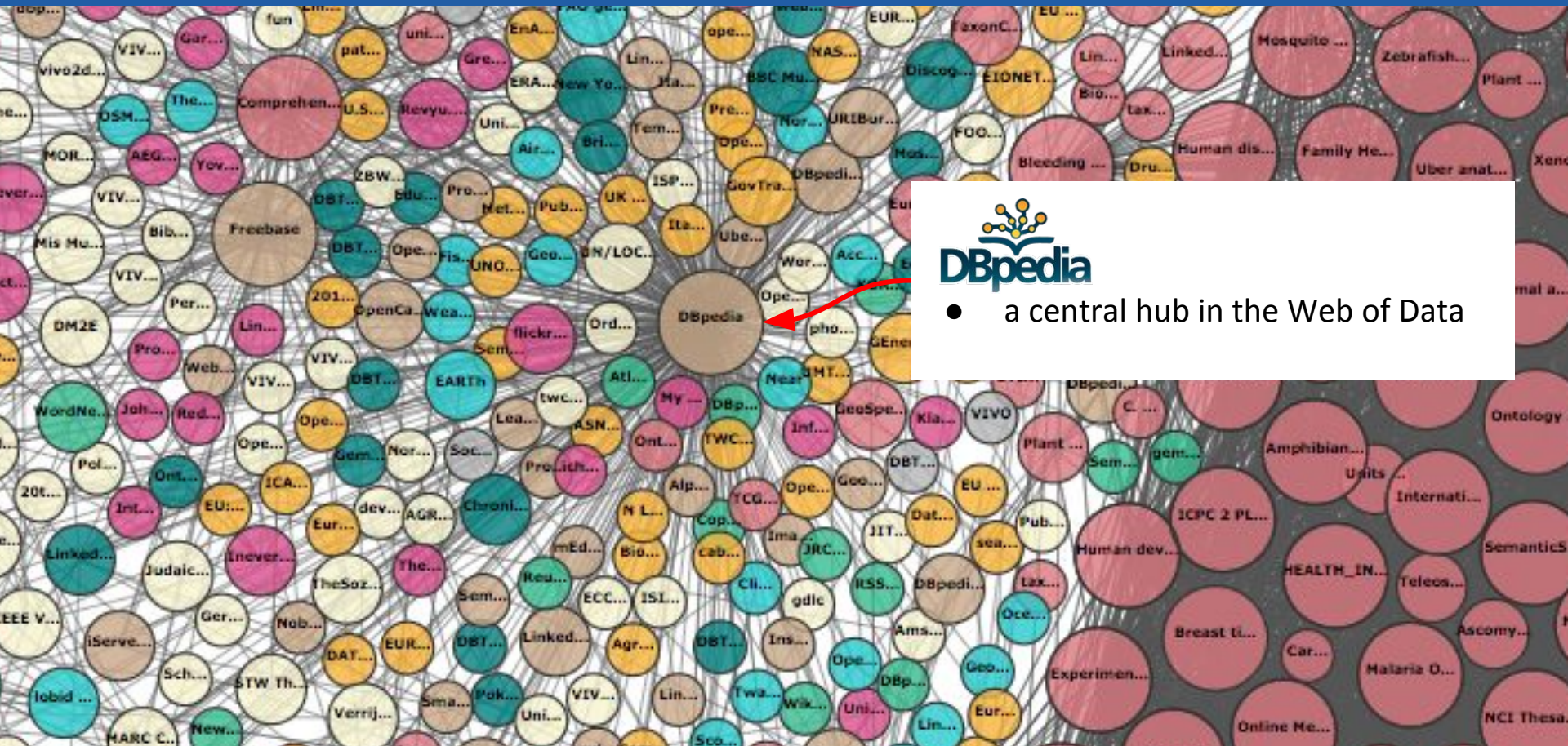
- 9,960 datasets
- >149 billion facts
- >800 million links
(April 2017)

<http://stats.lod2.eu/>

<http://lod-cloud.net/>

DBpedia

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- a central hub in the Web of Data

English version of the DBpedia knowledge graph (as by June 2017)

- describes 4.58 million things,
- of which 4.22 million are classified in a consistent [ontology](#)
- including 1,445,000 persons,
- 735,000 places (including 478,000 populated places),
- 411,000 creative works
 - including 123,000 music albums,
 - 87,000 films and
 - 19,000 video games,
- 241,000 organizations
 - including 58,000 companies and 49,000 educational institutions,
- 251,000 species and
- 6,000 diseases.



DBpedia Naming Conventions

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<https://en.wikipedia.org/wiki/Pluto>



WIKIPEDIA
The Free Encyclopedia

<http://dbpedia.org/resource/Pluto>

Entity Identifier

<http://dbpedia.org/page/Pluto>

HTML version

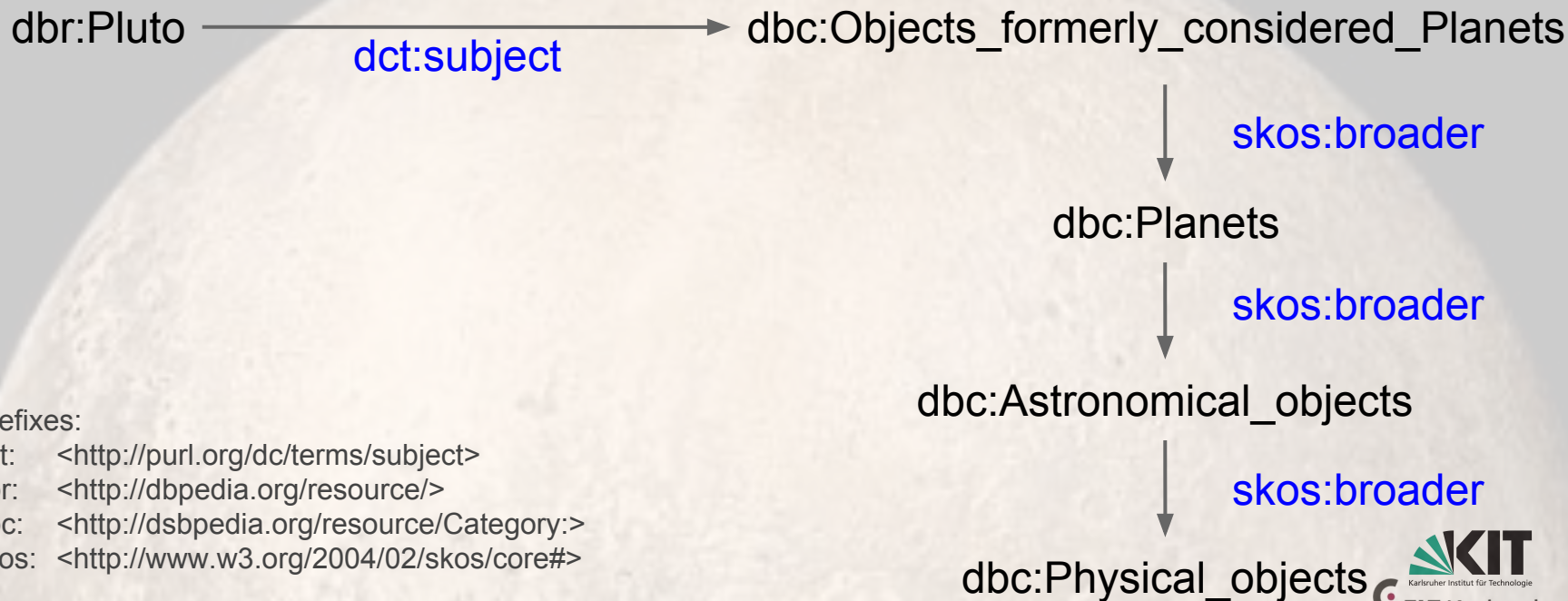
<http://dbpedia.org/data/Pluto>

RDF/XML version



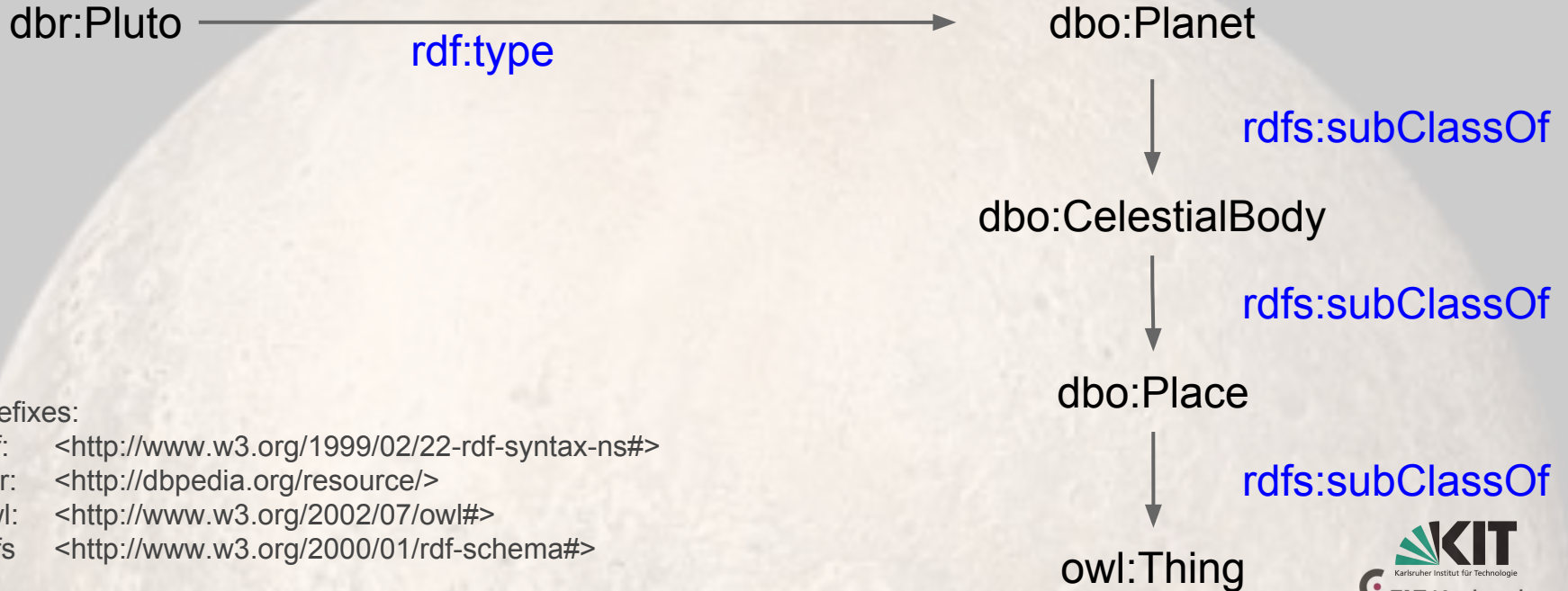
DBpedia Category System - Wikipedia Categories

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DBpedia Category System - DBpedia Ontology

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From Wikipedia to DBpedia

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<http://en.wikipedia.org/wiki/Pluto>



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The Free Encyclopedia

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Pluto

From Wikipedia, the free encyclopedia

This article is about the dwarf planet. For other uses, see Pluto (disambiguation).

Pluto (minor-planet designation: **134340 Pluto**) is a dwarf planet in the Kuiper belt, a ring of bodies beyond Neptune. It was the first Kuiper belt object to be discovered, and is the largest and second-most-massive known dwarf planet in the Solar System and the ninth-largest and tenth-most-massive known object directly orbiting the Sun. It is the largest known trans-Neptunian object by volume but is less massive than Eris, a dwarf planet in the scattered disc. Like other Kuiper belt objects, Pluto is primarily made of ice and rock^{[1][4]} and is relatively small—about one-sixth the mass of the Moon and one-third its volume. It has a moderately eccentric and inclined orbit during which it ranges from 30 to 49 astronomical units or AU (4.4–7.3 billion km) from the Sun. This means that Pluto periodically comes closer to the Sun than Neptune, but a stable orbital resonance with Neptune prevents them from colliding. In 2014, Pluto was 32.6 AU from the Sun. Light from the Sun takes about 5.5 hours to reach Pluto at its average distance (39.4 AU).^[16]

Pluto was discovered in 1930 by Clyde Tombaugh, and was originally considered the ninth planet from the Sun. After 1992, its status as a planet fell into question following the discovery of several objects of similar size in the Kuiper belt. In 2005, Eris, which is 27% more massive than Pluto, was discovered, which led the International Astronomical Union (IAU) to define the term "planet" formally for the first time the following year.^[15] This definition excluded Pluto and reclassified it as a member of the new "dwarf planet" category (and specifically as a *plutoid*).^[17] Some astronomers think that Pluto, as well as the other dwarf planets, should be considered planets.^{[18][19][20]}

Pluto has five known moons: Charon (the largest, with a diameter just over half that of Pluto), Styx, Nix, Kerberos, and Hydra.^[21] Pluto and Charon are sometimes considered a binary system because the barycenter of their orbits does not lie within either body.^[22] The IAU has not formalized a definition for binary dwarf planets, and Charon is officially classified as a moon of Pluto.^[23]

On 14 July 2015, the *New Horizons* spacecraft became the first spacecraft to fly by Pluto.^{[24][25][26]} During its brief flyby, *New Horizons* made detailed measurements and observations of Pluto and its moons.^[27]

Contents

- History
 - 1.1 Discovery
 - 1.2 Name
 - 1.3 Planet X disproved
 - 1.4 Classification
 - 1.4.1 IAU classification
- Orbit and rotation
 - 2.1 Relationship with Neptune
 - 2.1.1 Other factors
 - 2.2 Rotation
 - 2.3 Daylight
 - 2.4 Quasi-satellite
- Geology
 - 3.1 Surface
 - 3.2 Internal structure
- Mass and size
- Atmosphere
- Satellites
- Origin
- Observation and exploration
 - 8.1 Observation
 - 8.2 Exploration
- Gallery
- See also

<http://dbpedia.org/resource/Pluto>

Create account Log in

Read

View source

View history

Search



Pluto



Near-true-colour image composite of Pluto taken by the New Horizons spacecraft on 14 July 2015 from a distance of 450,000 kilometres

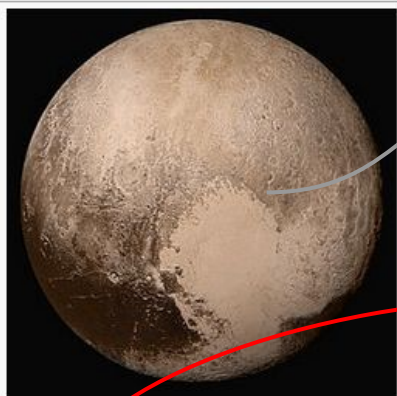
Discovery	Clyde W. Tombaugh
Discovered by	18 February 1930
Designations	
MPC designation	134340 Pluto
Pronunciation	 <i>/ˈplʊtoʊ/</i>
Named after	Pluto
Minor planet category	Dwarf planet
Trans-Neptunian object	Plutoid
Kuiper belt object	Plutino
Adjectives	Plutonian
Orbital characteristics ⁽¹⁾⁽⁶⁾	
Epoch J2000	
Aphelion	40,318 AU (7,311,000,000 km)
Perihelion	29,656 AU (4,437,000,000 km) (5 September 1989) ^[1]
Semi-major axis	39,487 AU (5,874,000,000 km)
Eccentricity	0.248 97
Orbital period	247.94 years ^[2] 90 570 d ^[2]
Synodic period	366.73 days ^[2]
Average orbital velocity	4.67 km/s ^[2]



Wikipedia Infobox Extraction - Raw Properties

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Pluto 



<http://dbpedia.org/resource/Pluto>

<http://dbpedia.org/property/discoverer>

Discovered by

Clyde W. Tombaugh

http://dbpedia.org/resource/Clyde_Tombaugh

Discovery date 16 February 1936

Designations

MPC designation 134340 Pluto

Pronunciation  [/ˈpluːtoʊ/](#)

Named after Pluto

Minor planet category Dwarf planet

Trans-Neptunian object

Plutoid

Kuiper belt object

Plutino

Adjectives Plutonian

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Discovered by	Clyde W. Tombaugh
----------------------	-------------------

Discovery date	10 February 1990
----------------	------------------

Designations	
MPC designation	134340 Pluto

Pronunciation  /'plʌ:ɡəri/

Named after [Pluto](#)

Minor planet	Dwarf planet
--------------	--------------

category	Trans-Neptunian object
	Plutoid

Kuiper belt object

Plutino

https://en.wikipedia.org/wiki/Template:Infobox_planet



Designations

Alternative names *alt_names*

Orbital characteristics

Semi-major axis	<i>semimajor</i>
------------------------	------------------

Eccentricity *eccentricity*

Orbital period *period*

Average orbital speed *avg_speed*

Inclination *inclination*

Angular distance angular dis

~~Longitude of~~ *long perias*

periastron

Time of periastron *time_perias*

plitude *semi-amplitude*

<http://mappings.dbpedia.org/server/ontology/classes/Plane>

Label (el): Πλανήτης
Label (ja): 惑星
Label (de): Planet
Label (pl): planeta
Label (ca): planeta
Label (pt): Planeta
Label (en): planet
Label (es): planeta
Label (nl): planeet
Label (fr): planète
Label (ga): pláinéad
Label (sl): planet
Super classes: CelestialB

Properties on Planet:				
Name	Label	Domain	Range	Comment
absoluteMagnitude (edit)	absolute magnitude	CelestialBody	<i>xsd:double</i>	
albedo (edit)		Planet	<i>xsd:double</i>	reflection coefficient
apopsis (edit)	apopsis	CelestialBody	Length	
apofocus (edit)	apofocus	CelestialBody	<i>xsd:string</i>	
apparentMagnitude (edit)	apparent magnitude	Planet	<i>xsd:double</i>	
constellation (edit)	constellation	CelestialBody	<i>owl:Thing</i>	
detectionMethod (edit)	Method of discovery	Planet	<i>xsd:string</i>	
discovered (edit)	discovery date	CelestialBody	<i>xsd:date</i>	
epoch (edit)	epoch	Planet	<i>xsd:string</i>	moment in time used as a reference point for some time-vaying astronomical quantity
escapeVelocity (edit)	escape velocity	Planet	Speed	
maxAbsoluteMagnitude (edit)	maximum absolute magnitude	CelestialBody	<i>xsd:double</i>	
maxApparentMagnitude	maximum apparent magnitude	CelestialBody	<i>xsd:double</i>	

```
dbo:discoverer rdfs:domain owl:Thing ;
               rdfs:range   dbo:Person .
```

<http://dbpedia.org/resource/Pluto>

<http://dbpedia.org/ontology/discoverer>

[http://dbpedia.org/resource/Clyde Tombaugh](http://dbpedia.org/resource/Clyde_Tombaugh)

Collaboratively edited knowledge graph operated by the Wikimedia Foundation



Main page
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Project chat
Create a new item
Recent changes
Random item
Query Service
Nearby
Help
Donate

Tools
What links here
Related changes
Special pages
Permanent link
Page information
Concept URI
Cite this page

English Not logged in [Talk](#) [Contributions](#) [Create account](#) [L](#)

Item [Discussion](#) [Read](#) [View history](#)

Harald Sack (Q30078997)

Semantic Web researcher

edit

[In more languages](#)

Statements

instance of	human	edit
	0 references	
		+ add reference
		+ add

sex or gender	male	edit
	0 references	
		+ add reference
		+ add

given name	Harald	edit
	0 references	
		+ add reference

<https://www.wikidata.org/>

Wikidata

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Pluto (Q339) — Identifier

dwarf planet in the Solar System

134340 Pluto I (134340) Pluto I Sol |

Statements

instance of



plutino

value

edit

0 references

+ add reference



plutoid

edit

0 references

+ add reference



dwarf planet

edit

start time

13 September 2006

subject of the statement

IAU definition of planet

0 references

+ add reference



trans-Neptunian object

edit

0 references

+ add reference

+ add

statements

property

reference

qualifiers

<https://www.wikidata.org/wiki/Q339>

Wikidata SPARQL Query Service

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 Wikidata Query

Examples

Prefixes

Tools

Help

occu

```
1 PREFIX wd: <http://www.wikidata.org/entity/>
2 PREFIX wdt: <http://www.wikidata.org/prop/direct/>
3
4 SELECT DISTINCT ?politician ?cause ?politicianLabel ?causeLabel WHERE {
5   ?politician wdt:P106 wd:Q82955 .      # find items that have "occupation (P106): politician (Q82955)"
6   ?politician wdt:P509|wdt:P1196 ?cause .    # with a P509 (cause of death) or P1196 (manner of death) claim
7   ?cause wdt:P279* wd:Q149086 .      # ... where the cause is a subclass of (P279*) homicide (Q149086)
8   # ?politician wdt:P39 wd:Q11696 .    # Uncomment this line to include only U.S. Presidents
9
10  SERVICE wikibase:label { bd:serviceParam wikibase:language "en" }
11 }
12
```

Press [CTRL-SPACE] to activate auto completion.

Data updated a few seconds ago

Run

Clear

2464 Results in 2948 ms

Display

Download

Link

Search

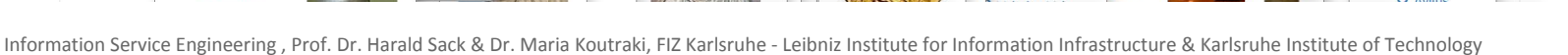
politician	cause	politicianLabel	causeLabel
Q:wd:Q67715	Q:wd:Q132821	Peter von Heydebreck	murder
Q:wd:Q1440	Q:wd:Q132821	Didius Julianus	murder
Q:wd:Q2501353	Q:wd:Q8454	Lon Non	capital punishment
Q:wd:Q76638	Q:wd:Q132821	Gregor Strasser	murder
Q:wd:Q134123	Q:wd:Q8454	Prince Kiril of Bulgaria	capital punishment
Q:wd:Q7231	Q:wd:Q132821	Rosa Luxemburg	murder

Which politicians have died not of natural causes?

[SPARQL query](#)

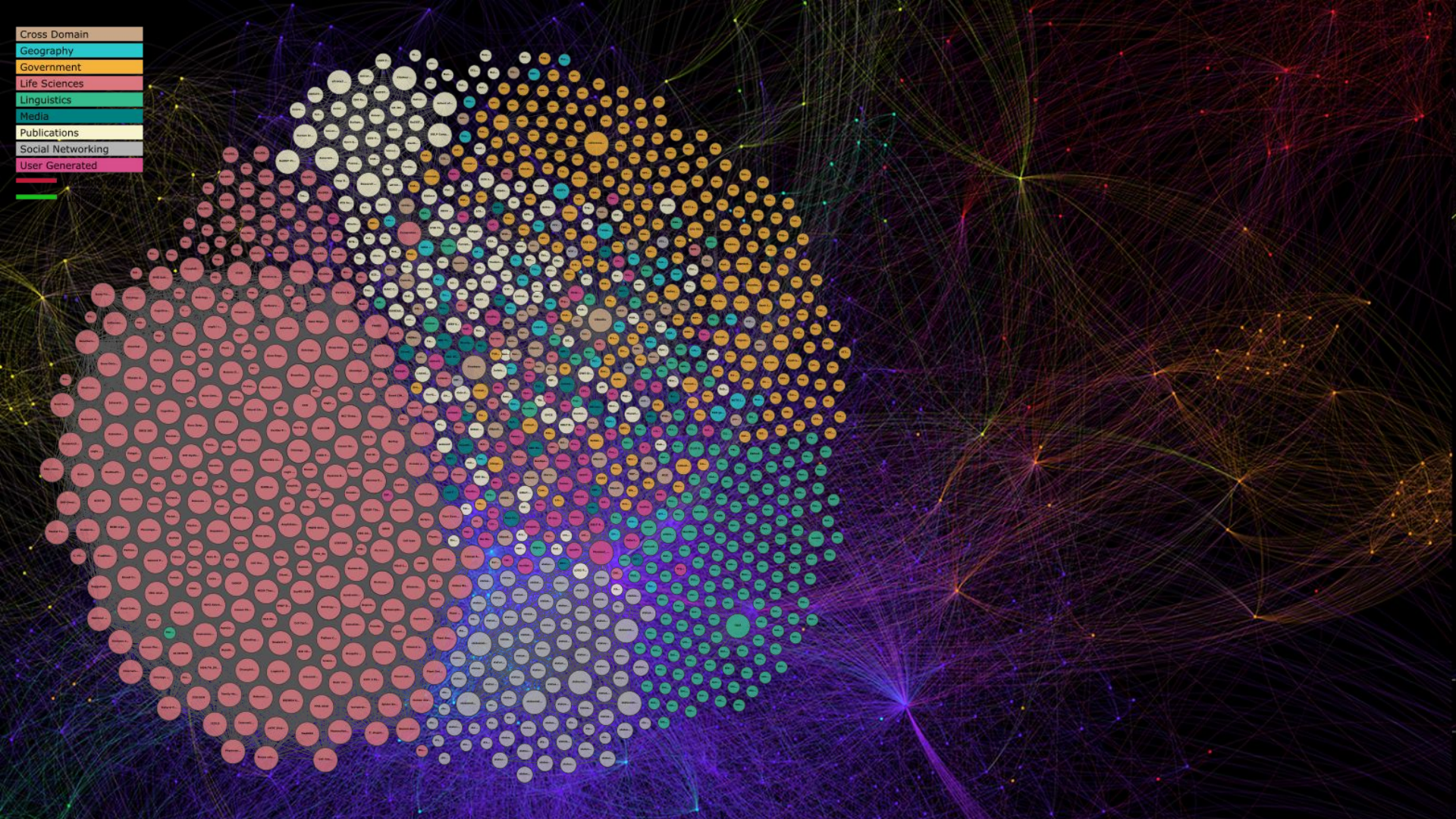
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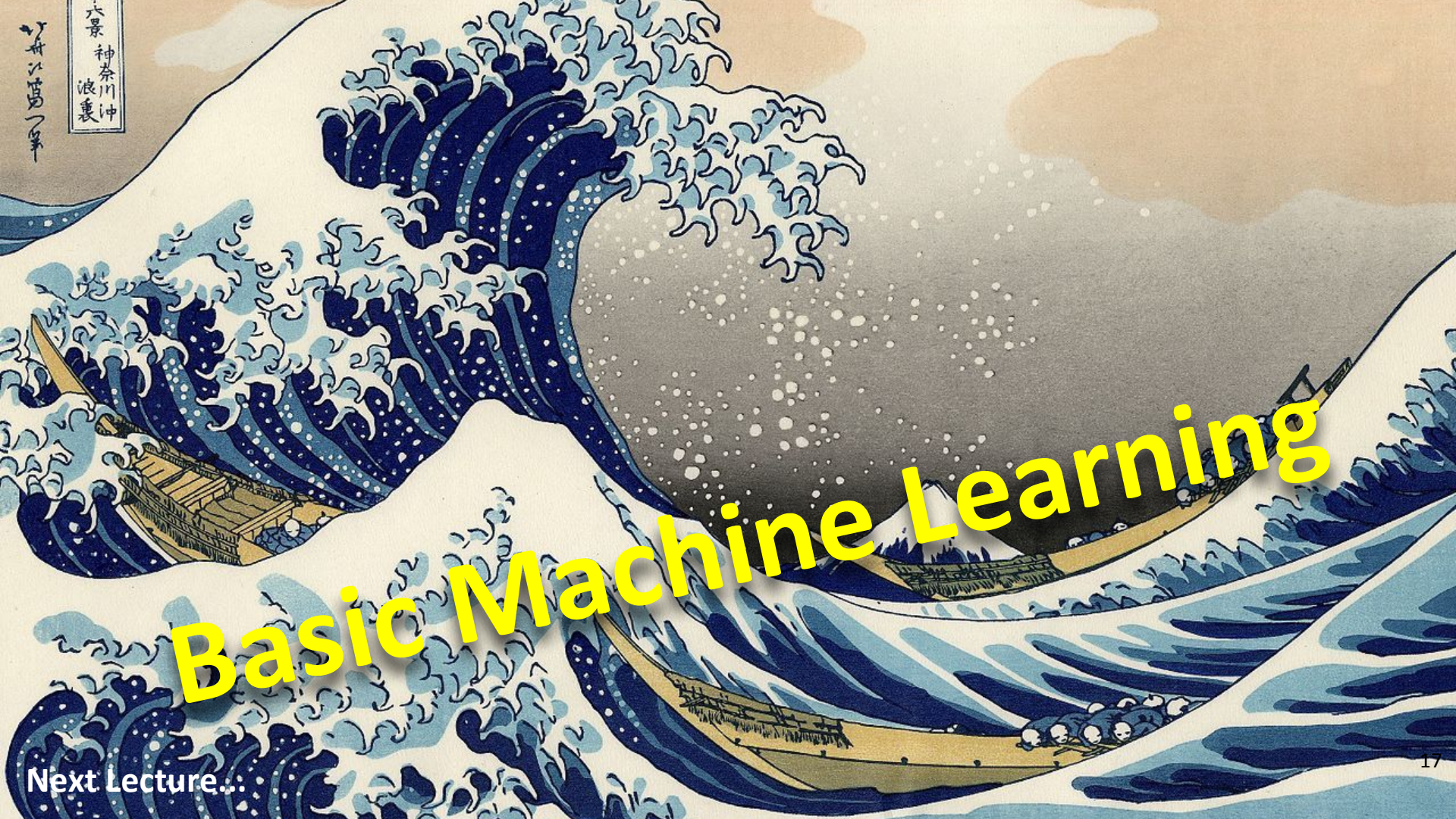
Timeline      91 results in 934 ms  Code  Download  Link



SPARQL query

- Cross Domain
- Geography
- Government
- Life Sciences
- Linguistics
- Media
- Publications
- Social Networking
- User Generated





Basic Machine Learning

Next Lecture...

Picture References:

- P.3, 16: The Linking Open Data Cloud Diagram, <http://lod-cloud.net/>
- P.4: Chariot of grotesques and scrollwork drawn by two fantasy animals and pushed by a satyr, whose head is trapped in a large shell, by Cornelis Bos (1550s), <https://www.rijksmuseum.nl/nl/zoeken/objecten?q=%22cornelis+bos%22&p=18&ps=12&st=Objects&ii=5#/RP-P-OB-6266,209>
- P.17: Hokusai, The Great Wave off Kanagawa (神奈川沖波裏), from 36 Views of Mount Fuji, (1829-1832), https://commons.wikimedia.org/wiki/File:The_Great_Wave_off_Kanagawa.jpg

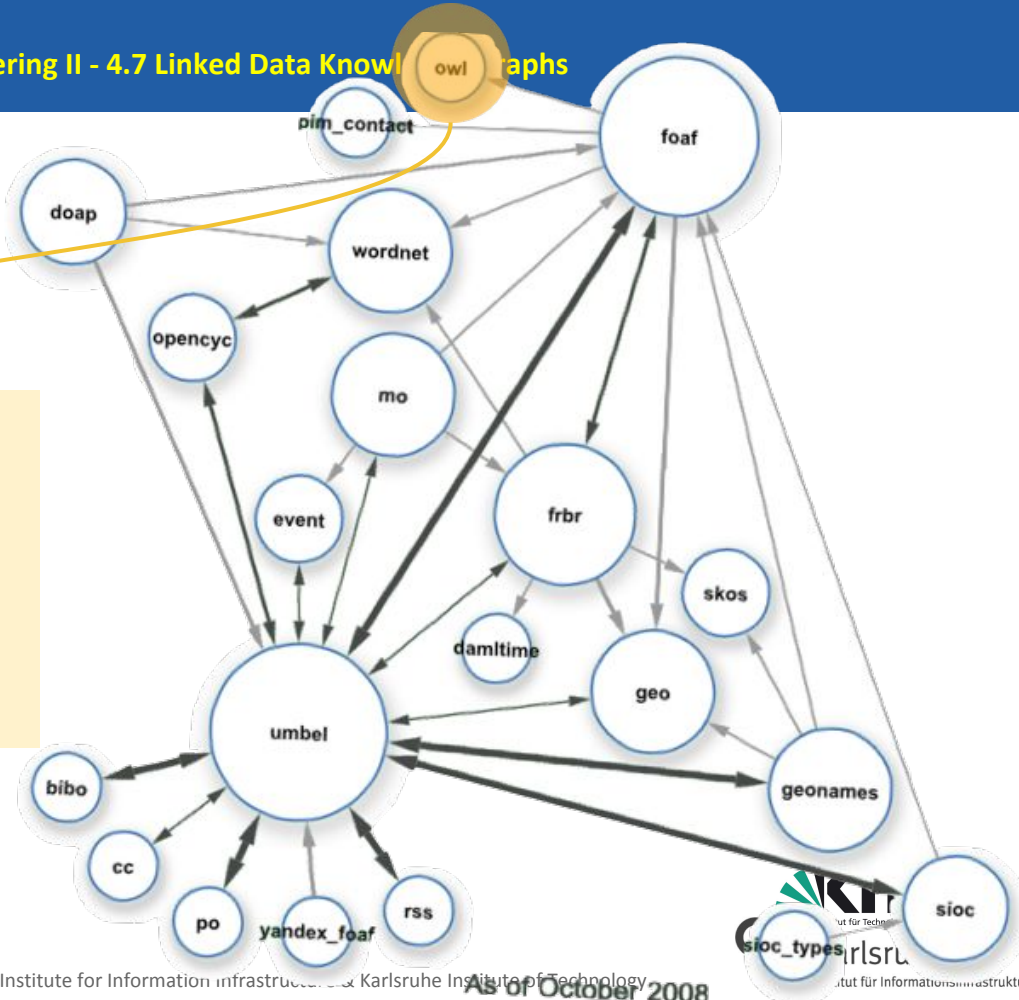
Linked Data Backbone

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- Ontologies that keep the Linked Data Cloud together

- **OWL**
`owl:sameAs` connects identical individuals
`owl:equivalentClass` connects equivalent classes

`dbr:Neil_Armstrong owl:sameAs wd:Q1615 .`



Linked Data Backbone

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- **SKOS**

- „Simple Knowledge Organization System“
- based on RDF and RDFS
- applied for definitions and mappings of vocabularies and ontologies
 - `skos:Concept` (classes)
 - `skos:narrower`
 - `skos:broader`
 - `skos:related`
 - `skos:exactMatch`,
`skos:narrowMatch`,
`skos:broadMatch`,
`skos:relatedMatch`

