Modelovanje znanja u formi semantičke mreže/grafa

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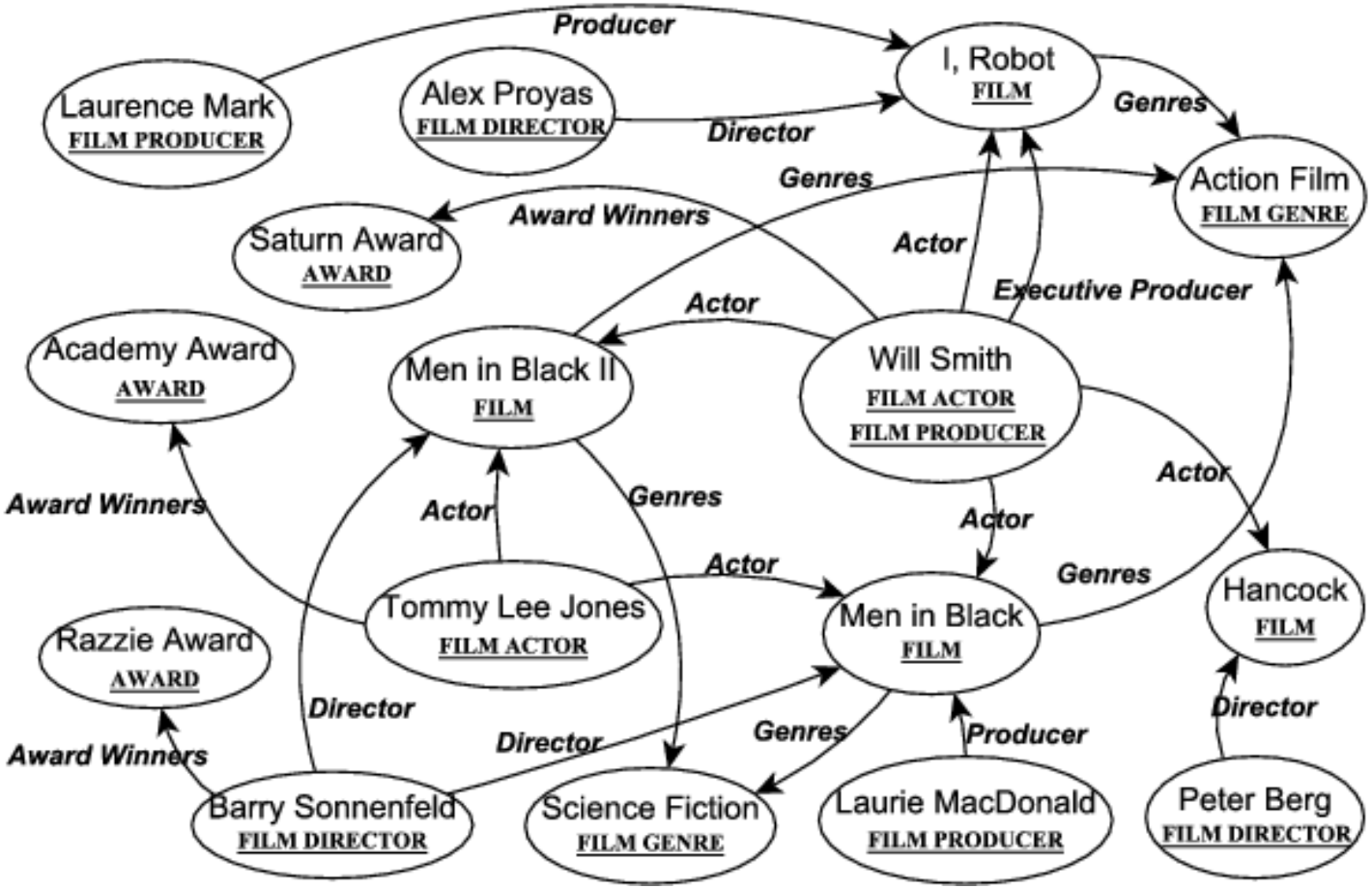
PREGLED PREDAVANJA

- (Semantički) grafovi/mreže za modelovanje znanja
- Grafovi podataka i znanja u komercijalnoj sferi
- Otvoreni, javno dostupni grafovi podataka i znanja
- Gigantski globalni graf
  - Vizija Web-a kao gigantske globalne baze podataka i znanja
  - Kreiranje gigantskih baza znanja kroz automatsko prikupljanje podataka i činjenica sa Web-a

(SEMANTIČKI) GRAFOVI/MREŽE ZA PREDSTAVLJANJE ZNANJA

PRIMER GRAFA ENTITETA I NJIHOVIH RELACIJA



Primer ilustruje
mali segment Freebase baze znanja

Izvor slike:
http://inspirehep.net/record/1286695/plots

PRIMER GRAFA ZDRAVORAZUMSKOG ZNANJA (COMMONSENSE KNOWLEDGE)

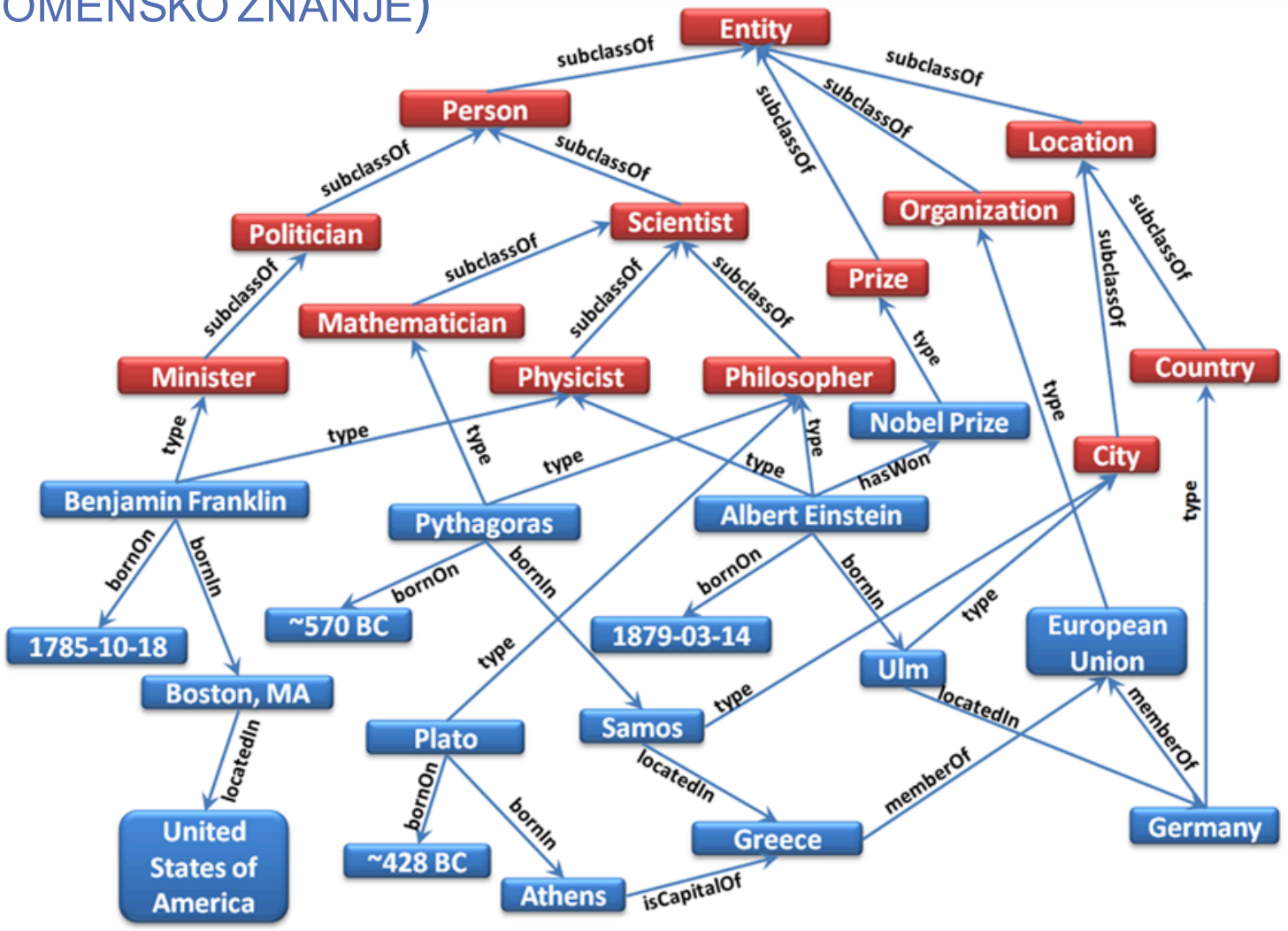
Primer ilustruje
mali segment ConceptNet baze znanja

Izvor slike:
http://www.opasquet.fr/omcsnet/

PRIMER GRAFA KOJI SADRŽI 2 NIVOA ZNANJA:

1) KLASE/KONCEPTE (META-ZNANJE)

2) ENTITETE (DOMENSKO ZNANJE)



Izvor slike:
http://research.microsoft.com/en-us/groups/osa/krr.aspx

GRAFOVI PODATAKA I ZNANJA U KOMERCIJALNOJ SFERI

GOOGLE'S KNOWLEDGE GRAPH

Boyhood

Jelena

Web Images Videos News Maps More Search tools

About 20,300,000 results (0.52 seconds)

Boyhood (2014) - IMDb
www.imdb.com/title/tt1065073/
★★★★☆ Rating: 8/10 - 217,070 votes
Videos. **Boyhood** -- Clip: Talk To Me · **Boyhood** -- Featurette: Behind the Scenes. Photos. Still of Ellar Coltrane in **Boyhood** (2014) Patricia Arquette and Rosanna ...
Full Cast & Crew - Ellar Coltrane - Lorelei Linklater - Patricia Arquette

Boyhood (film) - Wikipedia, the free encyclopedia
https://en.wikipedia.org/wiki/**Boyhood**_(film)
Boyhood is a 2014 American independent coming-of-age drama film, written and directed by Richard Linklater, and starring Patricia Arquette, Ellar Coltrane, ...
Ellar Coltrane - Lorelei Linklater - Patricia Arquette - Richard Linklater

Boyhood (2014) - Rotten Tomatoes
www.rottentomatoes.com/m/**boyhood**/
★★★★★ Rating: 98% - 267 votes
Critics Consensus: Epic in technical scale but breathlessly intimate in narrative scope, **Boyhood** is a sprawling investigation of the human condition.

Boyhood - International Trailer (Universal Pictures) HD ...


www.youtube.com/watch?v=Ys-mbHXyWX4
Apr 25, 2014 - Uploaded by Universal Pictures UK
www.facebook.com/BoyhoodMovieUK. Richard Linklater's **BOYHOOD** -- a fictional drama made with the same ...

In the news

Gordon honored at boyhood home before

Boyhood

2014 film

★★★★☆ 8/10 · IMDb
★★★★★ 98% · Rotten Tomatoes
★★★★★ 100% · Metacritic

The joys and pitfalls of growing up are seen through the eyes of a child named Mason (Ellar Coltrane), his parents (Patricia Arquette, Ethan Hawke) and his sister (Lorelei Linklater). Vignettes, filmed with the same cast over the course of 12 years, capture family meals, road trips, birthday parties… More

Initial release: July 11, 2014 (USA)

Director: Richard Linklater

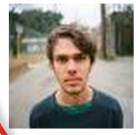
Running time: 2h 46m

Screenplay: Richard Linklater

Awards: Academy Award for Best Actress in a Supporting Role, more

Cast

View 5+ more


Ellar Coltrane


Patricia Arquette


Ethan Hawke


Lorelei Linklater


Zoe Graham

GOOGLE'S KNOWLEDGE GRAPH

"*…Google users will able to browse through the company's '**knowledge graph**,' or its ever-expanding **database** of information **about 'entities'** – people, places and things – **the 'attributes' of those entities** and **how** different **entities are connected** to one another*."

What Google's Search Changes Might Mean for You

Wall Street Journal, March 14, 2012

GOOGLE'S KNOWLEDGE GRAPH

"*…Every piece of information that we crawl, index, or search is analyzed in the context of Knowledge Graph.*"

"*…Almost all the structured data from all of our products like Maps and Finance and Movies and Music are all in the Knowledge Graph, so we can reasonably say that everything we know about is in this canonical form.*"

How a Database of the World's Knowledge Shapes Google's Future

MIT Technology Review, January 27, 2014

GOOGLE'S KNOWLEDGE GRAPH

"*[Google Now] works by using machine learning algorithms to determine what you're doing, then matches this understanding with information stored in what the company calls the Google Knowledge Graph—a database of semantic data describing more than 1 billion people, places, and things. 'To be able assist you … we have to understand the world.'*"

Startup Unleashes Its Clone of Google's 'Knowledge Graph'

Wired, April 6, 2014

FACEBOOK'S ENTITY GRAPH

"Facebook is building a rich stock of knowledge that could make its software smarter and boost the usefulness of its search engine…

…Entities such as colleges and employers are ***learned from data*** *typed* ***in profile pages****; businesses, movies, fictional characters, and other concepts are* ***learned from fan pages*** *created by Facebook users. …* ***analyzing*** *many* ***employment histories*** *on the site allows Facebook's search engine to know that a search for "software engineers" should also return people who say they are "coders."*

Facebook Nudges Users to Catalog the Real World

MIT Technology Review, February 27, 2013

MICROSOFT'S CONCEPT GRAPH

*"The **Microsoft Concept Graph** is a **massive graph of concepts** – more than 5.4 million and growing – that machine-learning algorithms are culling from billions of web pages and years' worth of anonymized search queries."*

"*The technology has potential applications that range from keyword advertising and search enhancement to the development of human-like chatbots.*"

Microsoft researchers release graph that helps machines conceptualize
Microsoft official blog, Nov 1, 2016

BING'S KNOWLEDGE AND ACTION GRAPH

"*Bing has over a billion* ***entities*** *(people, places, and things) and the number is growing every day. For those entities, we have over 21 billion associated* ***facts****, 18 billion links to* ***key actions*** *and over 5 billion* ***relationships between entities****.*

Millions of Bing users around the globe use this rich information every day, in bing.com, Cortana, Xbox, Office and more"

"*knowledge and action graph will be available to developers via a new API*"

Bing announces availability of the knowledge and action graph API

Bing Blogs, 20 August 2015

YAHOO'S KNOWLEDGE GRAPH

*"Spark [a semantic search assistance tool] takes a large **entity graph** as input, … consisting of the most important entities, their most important related entities, and their respective types. This entity graph is drawn from a larger Yahoo! Knowledge Graph, a unified **knowledge base** that provides **key information** about all the **entities** we care about, and **how they relate** to each other."*

Entity Recommendations in Web Search

The 12th International Semantic Web Conference, Oct 2013

LinkedIn: Professional Graph => Economic Graph

"[Economic graph is] *a digital mapping of the global economy, comprised of a profile for every professional, company, job opportunity, the skills required to obtain those opportunities, every higher education organization, and all the professionally relevant knowledge associated with each of these entities*"

"*With these elements in place, we can connect talent with opportunity at massive scale*"

Announcing The LinkedIn Economic Graph Challenge

Oct 14, 2014

OTVORENI, JAVNO DOSTUPNI GRAFOVI PODATAKA I ZNANJA

DBpedia

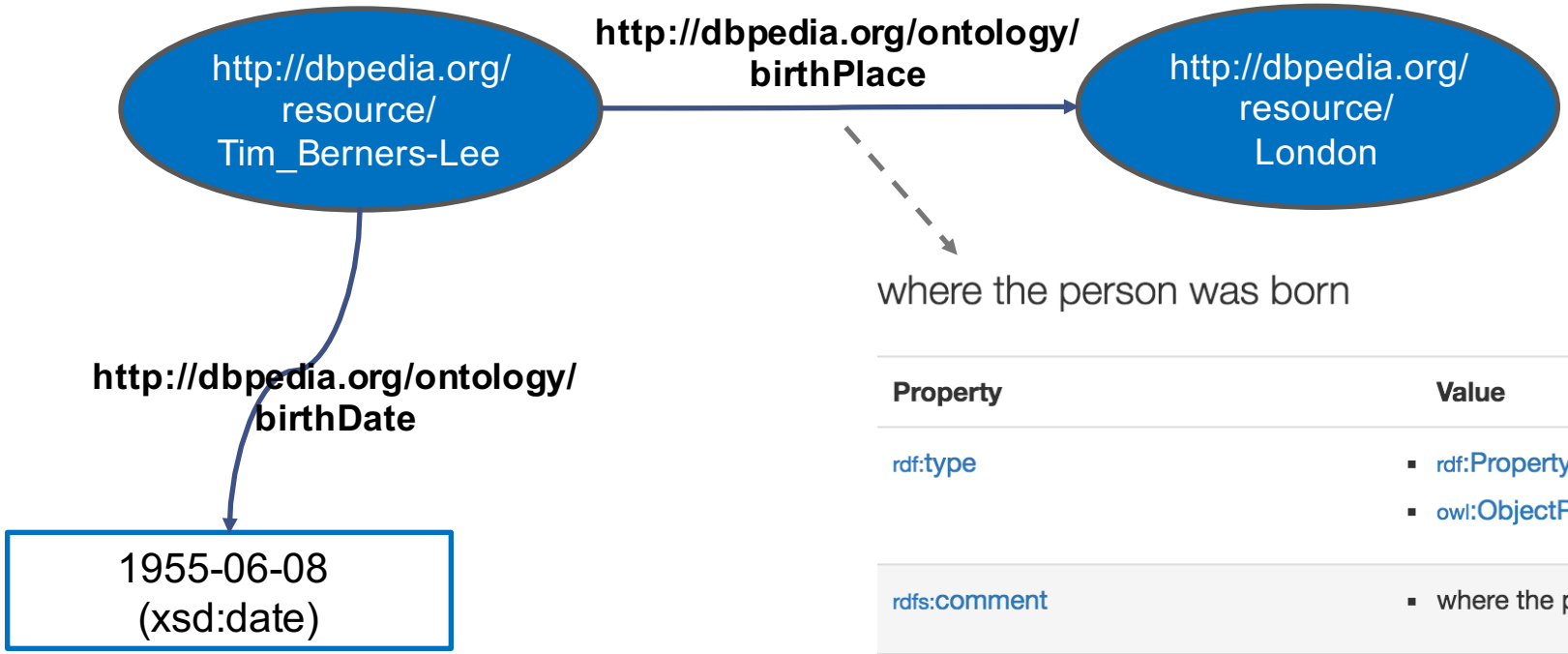
Mašinski čitljiva verzija Wikipedia-e

Podaci preuzeti iz Wikipedia-e su:

- *Strukturirani*: predstavljeni u formi {subjekat-predikat-objekat} tripleta pogodnih za procesiranje
- *Semantički opisani*: semantika svakog elementa tripleta je eksplicitno definisana => može se direktno interpretirati od strane računara

DBpedia

Predstavljanje podataka i znanja u DBpedia-i



Property	Value
rdf:type	▪ rdf:Property ▪ owl:ObjectProperty
rdfs:comment	▪ where the person was born (en)
rdfs:domain	▪ dbo:Person
rdfs:label	▪ birth place (en)
rdfs:range	▪ dbo:Place

DBPEDIA

http://en.wikipedia.org/wiki/San_Francisco

Country	United States
State	California
Founded	June 29, 1776
Incorporated	April 15, 1850[9]
Founded by	José Joaquin Moraga Francisco Palóu
Named for	St. Francis of Assisi
Government	
• Type	Mayor-council
• Body	Board of Supervisors
• Mayor of San Francisco	Ed Lee
• Board of Supervisors	**Supervisors** [show]
• California State Assembly[10][11]	Tom Ammiano (D) Phil Ting (D)
• CA State Senate[12]	Mark Leno (D)
• United States House of Representatives[13][14]	Nancy Pelosi (D) Barbara Lee (D) Jackie Speier (D)
Area[15]	
• Consolidated city-county	231.89 sq mi (600.6 km²)
• Land	46.87 sq mi

```
<http://dbpedia.org/resource/San_Francisco>
  db:country dbpedia:United_States ;
  ...
  db:foundingDate “1776-6-29”^^xsd:date ;
  dbpprop:namedFor
        dbpedia:Francis_of_Assisi ;
  db:governmentType
        dbpedia:Mayor-council_government ;
  ...
```

WIKIDATA

"***Wikipedia's data*** *is buried in 30 million Wikipedia articles in 287 languages from which* ***extraction is*** *inherently* ***very difficult***."

"*Population numbers for Rome, for example, can be found in English and Italian articles about Rome but also in the English article "Cities in Italy." The* ***numbers are all different***."

Osnovni ciljevi WikiData projekta:

- učiniti Wikipedia podatke pristupačnim aplikacijama, tj spremnim za direktno procesiranje;
- obezbediti kontinuiranu tačnost i ažurnost podataka

Wikidata: A Free Collaborative Knowledgebase.
D. Vrandečić, M. Krötzsch. Communications of the ACM 57:10, 2014.

WIKIDATA

"*Wikidata is a project of the Wikimedia Foundation: a **free**, **collaborative**, **multilingual**, **secondary database**, collecting **structured data** to provide support for Wikipedia, Wikimedia Commons, the other Wikimedia projects, and well beyond that*"

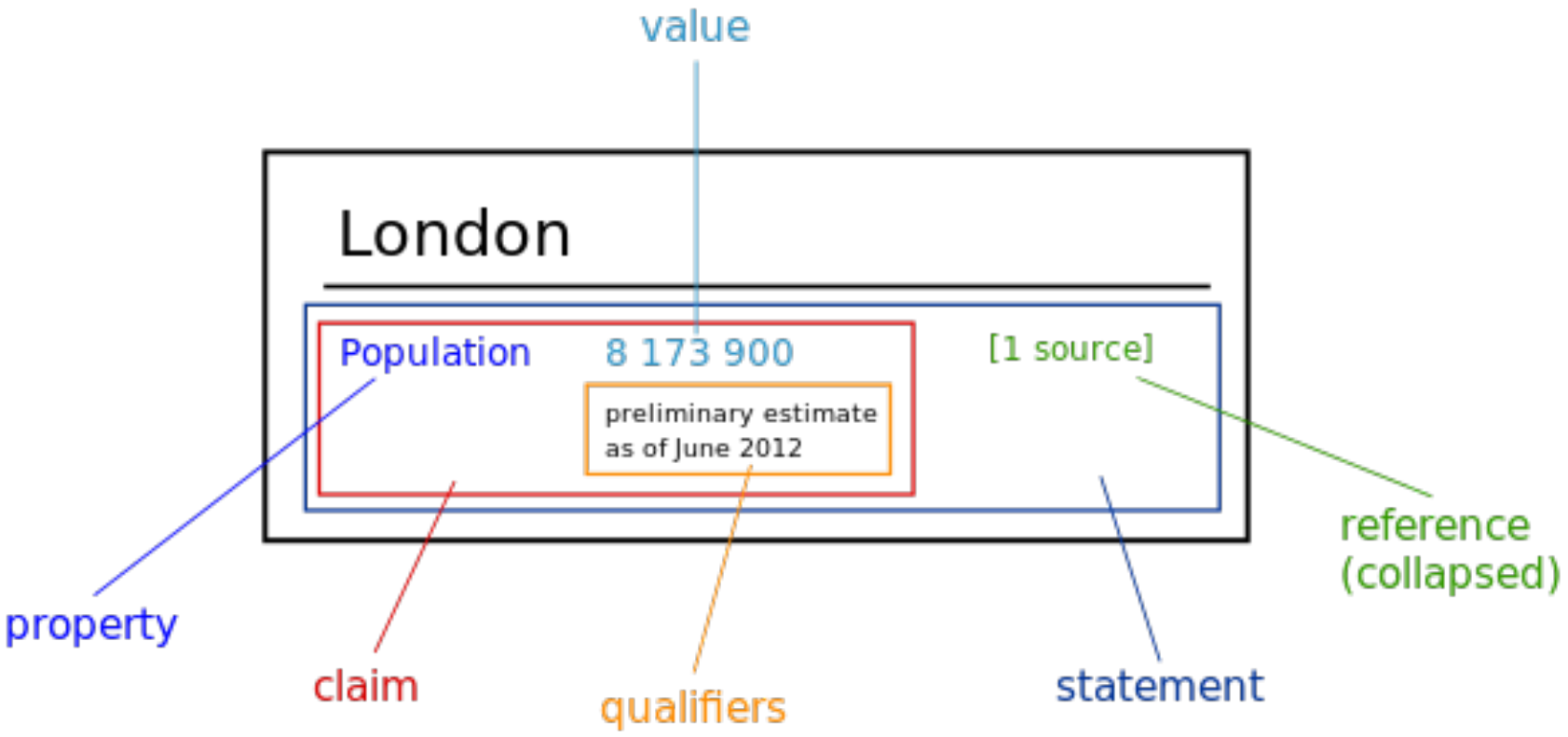
*"A secondary database: Wikidata can record not just statements, but also their sources, thus reflecting the **diversity of knowledge** available and supporting the notion of **verifiability**"*

*"Collecting structured data: [to] allow easy **reuse of** that **data** by Wikimedia projects and third parties, and enable computers to easily process and "understand" it."*

Wikidata:Introduction, August 2015

WIKIDATA

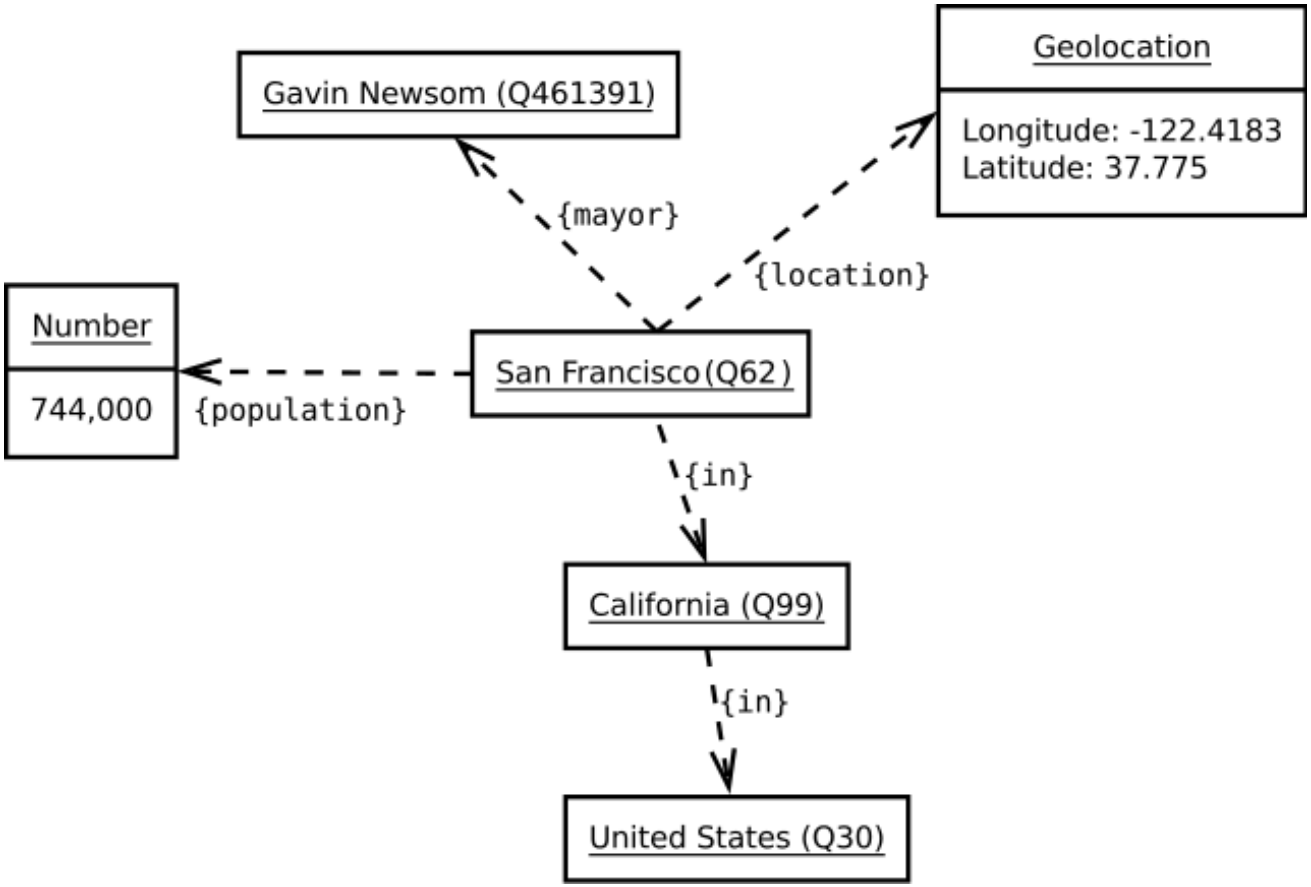
Predstavljanje podataka i znanja u WikiData bazi



"Wikidata statement" by Kaganer, Kolja21, Bjankuloski06en, Lydia Pintscher:
https://commons.wikimedia.org/wiki/File:Wikidata_statement.svg

WIKIDATA

Predstavljanje podataka i znanja u WikiData bazi



"Linked Data - San Francisco" by Jeblad - https://commons.wikimedia.org/wiki/File:Linked_Data_-_San_Francisco.svg

GIGANTSKI GLOBALNI GRAF

GIGANTSKI GLOBALNI GRAF (1):

VIZIJA WEB-A KAO GIGANTSKE GLOBALNE BAZE (GRAFA) PODAKA I ZNANJA

BY SIR TIM BERNERS-LEE

GIGANTSKI GLOBALNI GRAF (1)

***I**nternational **I**nformation **I**nfrastructure (III)*

- graf/mreža računara poznata kao *Internet* ili *Net*
- "*It isn't the cables, it is the computers which are interesting*"

***W**orld **W**ide **W**eb (WWW)*

- graf/mreža dokumenata poznata kao *Web*
- "*It isn't the computers, but the documents which are interesting*"

***G**igantic **G**lobal **G**raph (GGG)*

- graf/mreža entiteta (resursa) i podataka koji ih opisuju
- "*It's not the documents, it is the things they are about which are important*"

TBL's blog post on GGG: http://dig.csail.mit.edu/breadcrumbs/node/215

GIGANTSKI GLOBALNI GRAF (1)

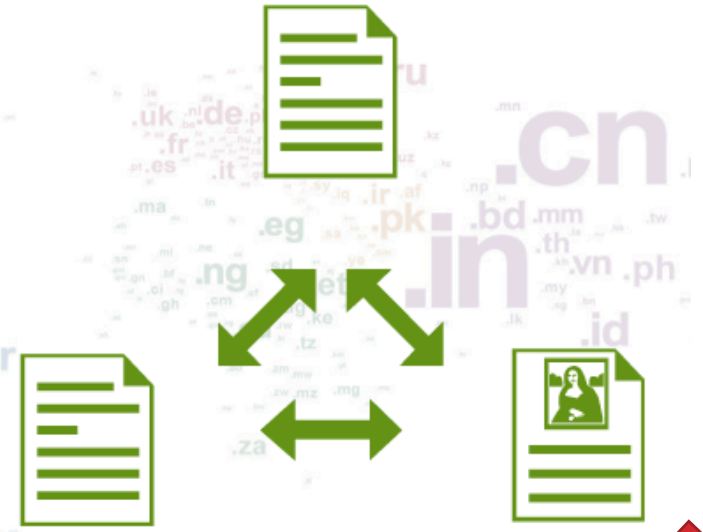
"…*when I book a flight it is the flight that interests me. Not the flight page on the travel site, or the flight page on the airline site, but the URI (issued by the airlines) of the flight itself. …*

And whichever device I use … it will access a situation-appropriate view of an integration of everything I know about that flight from different sources.

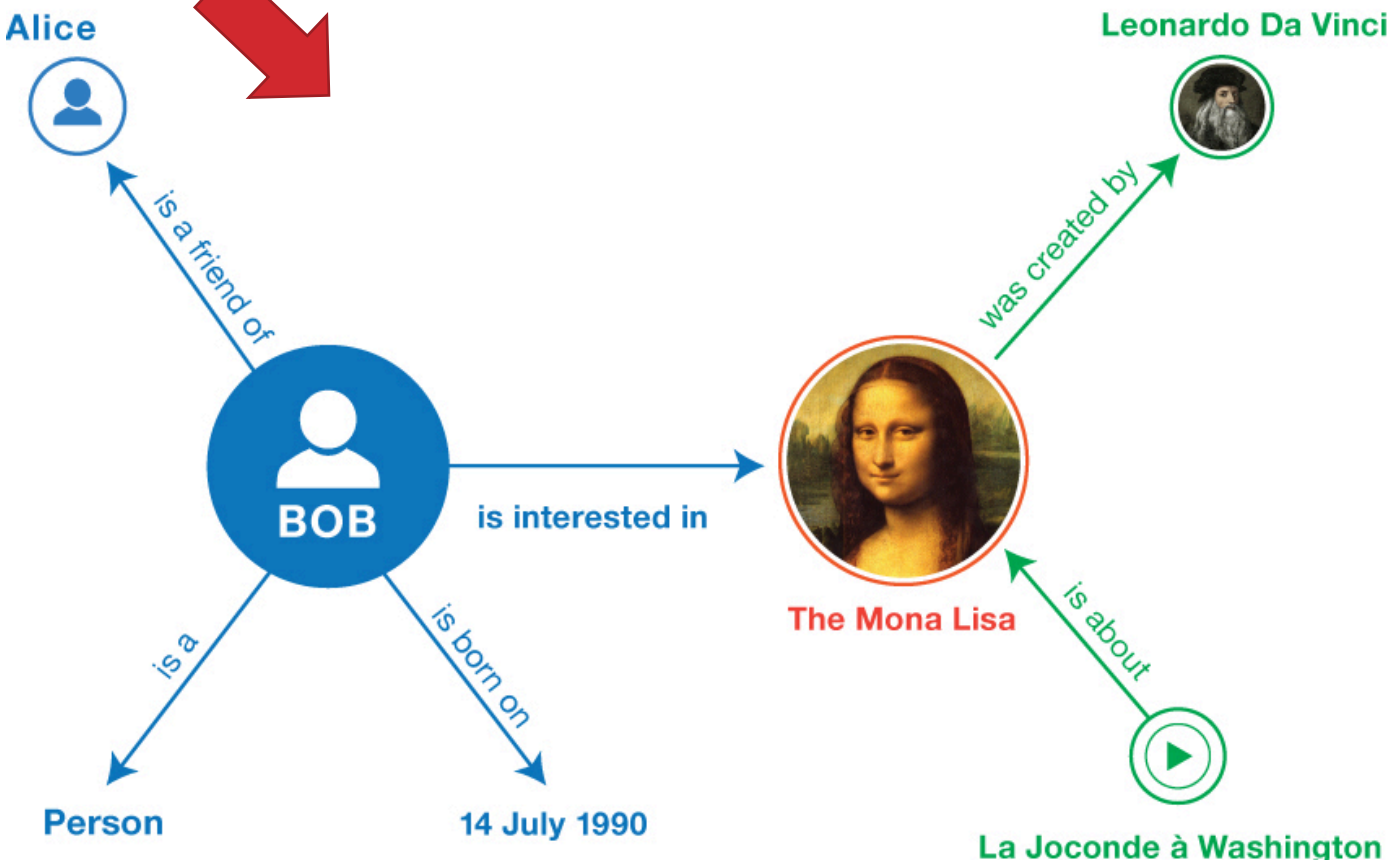
The task of booking and taking the flight will … be primary things in my awareness, the websites involved will be secondary things, and the network and the devices tertiary."

TBL's blog post on GGG: http://dig.csail.mit.edu/breadcrumbs/node/215

WWW (= Web of documents)



GGG (= Web of data)



Izvor slike: http://www.w3.org/TR/2014/NOTE-rdf11-primer-20140225/

WEB DOKUMENATA

Dizajniran za: direktno korišćenje od strane ljudi

Primarni objekti: dokumenti i multi-medija

Stepen strukturiranosti objekata: prilično nizak

Linkovi: između dokumenata (ili njihovih delova)

Semantika sadržaja i linkova: implicitna

Analogija: globalni fajl sistem

WEB PODATAKA

Dizajniran za: ljude koje ‘opslužuju’ programi

Primarni objekti: resursi* i opisi resursa

Stepen strukturiranosti objekata: visok

Linkovi: između dokumenata i između resursa

Semantika sadržaja i linkova: eksplicitna

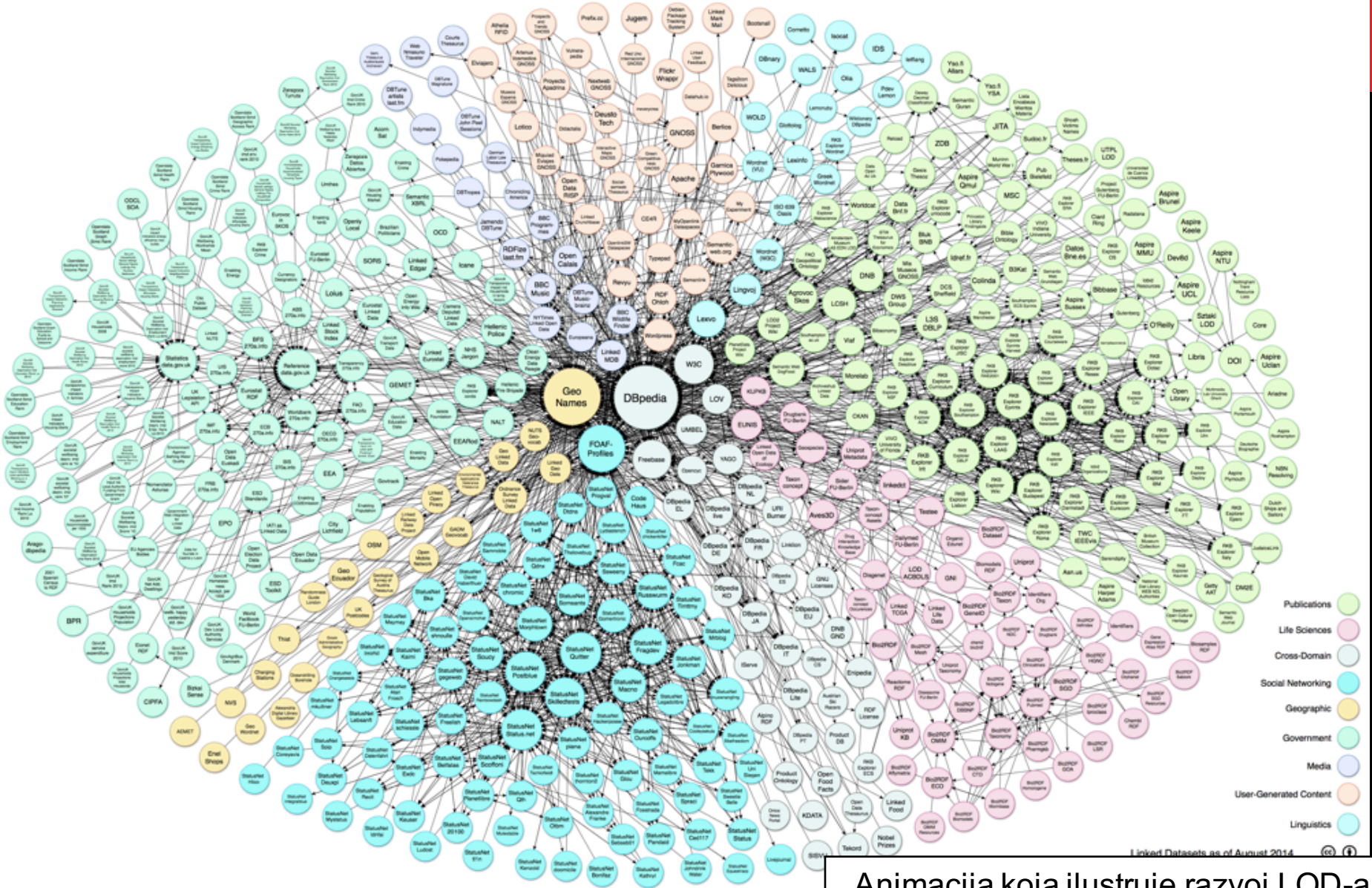
Analogija: globalna baza podataka

* Resurs je bilo šta što se može jedinstveno identifikovati tj. ima svoj URI. Npr., Beograd je resurs, čiji je URI: http://dbpedia.org/resource/Belgrade

WEB DOKUMENATA VS. WEB PODATAKA

	Web dokumenata	**Web podataka**
Dizajniran za	Direktno korišćenje od strane ljudi	Ljude koje 'opslužuju' programi
Primarni objekti	Dokumenti (uključujući multimediju)	Resursi i opisi resursa
Linkovi između	Dokumenata	I dokumenata i resursa
Stepen strukturiranosti	Prilično nizak	Visok
Semantika sadržaja i linkova	Implicitna	Eksplicitna
Analogija	Globalni fajl sistem	Globalna baza podataka

WEB (OTVORENIH) PODATAKA



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

Animacija koja ilustruje razvoj LOD-a: http://goo.gl/49p9Eh

GIGANTSKI GLOBALNI GRAF (2)

Gigantske graf baze znanja koje

- sadrže strukturirane podatke estrahovane iz Web stranica
- kontinuirano rastu i evoluiraju kako bi njihov sadržaj uvek odražavao podatke i znanje Web-a

Karakteristike

- automatizovani sistemi
- kombinuju različite metode m. učenja radi kontinuiranog unapređenja performansi ekstrakcije podataka/činjenica
- predmet intenzivnih istraživanja (u kompanijama i akademiji) sa ciljem unapređenja ekstrakcije podataka i znanja iz teksta

READ THE WEB

Istraživački projekat pri Carnegie Mellon University

- http://rtw.ml.cmu.edu/rtw/

Ciljevi:

- Razvoj sistema m. učenja koji će kontinuirano vršiti ekstrakciju strukturiranih informacija iz nestrukturiranih Web sadržaja
- Razvoj gigantske baze strukturiranog znanja koja
  - u svakom trenutku reflektuje činjenični sadržaj Web-a (tj poseduje svo činjenično znanje koje Web u tom trenutku sadrži),
  - kontinuirano raste kako na nivou instanci, tako i koncepata i relacija
  - može poslužiti kao osnova za brojne AI sisteme

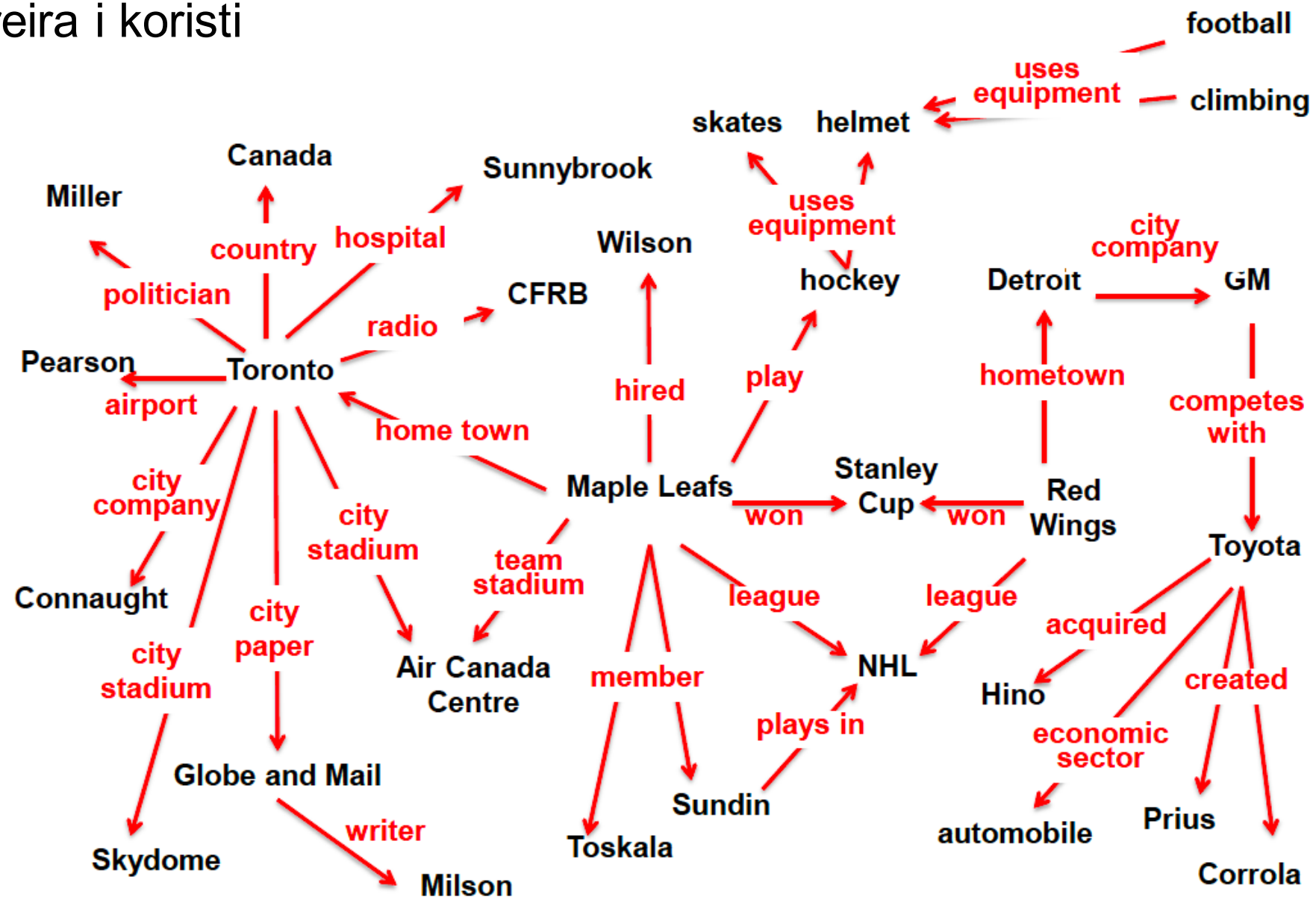
NEVER ENDING LANGUAGE LEARNER (NELL)

NELL je sistem koji se razvija u okviru Read the Web projekta

Kontinuirano (24/7) izvršava 2 zadatka:

- *Reading task*: identifikuje u Web stranicama nove instance klasa i relacija iz svoje baze znanja, i tako proširuje bazu
- *Learning task*: uči da "bolje čita", odnosno da vrši precizniju ekstrakciju informacija iz Web stranica
    - modeli mašinskog učenja na kojima je NELL zasnovan kontinuirano se iznova obučavaju koristeći stalno sve veću bazu znanja kao izvor podataka za trening

Fragment baze (grafa) znanja koji NELL kreira i koristi



Izvor: ACM Webinar "Never-Ending Learning to Read the Web" by Tom Mitchell, April 2013

Možete pratiti NELL dok ‘čita’,

i pomoći mu da ‘nauči’ da bolje ‘čita’

Recently-Learned Facts

twitter

Refresh

instance	iteration	date learned	confidence
estonians is an ethnic group	956	23-oct-2015	97.9
jane_krakowski is an architect	955	20-oct-2015	100.0
cups___spoons is an item found in the kitchen	956	23-oct-2015	99.6
voight_park is a zoo	959	07-nov-2015	90.5
michael_mayer is american	955	20-oct-2015	100.0
bob is a U.S. politician who holds the office of president	959	07-nov-2015	99.2
karl_rove works for fox	956	23-oct-2015	93.8
david_toseland died in the country england	960	23-nov-2015	100.0
cavaliers is a sports team that won the nba_finals	955	20-oct-2015	98.4
logan was born in chicago_south	960	23-nov-2015	99.6

Izvor: Web sajt Read the Web projekta (http://rtw.ml.cmu.edu/rtw/)

GOOGLE'S KNOWLEDGE VAULT (KV)

Probabilistička baza znanja koja bi trebalo da sadrži svo činjenično znanje koje Web poseduje, kao i da se uvećava i menja kako se Web razvija i menja

Predstavljanje znanja:

- koristi {subjekat-predikat-objekat} triplete (poput DBpedia-e),
- svaki triplet ima pridruženi *confidence score* koji predstavlja procenjenu verovatnoću da je triplet tačan

Kombinuje:

- automatizovanu ekstrakciju činjenica iz Web stranica (neizvesno, neprovereno znanje)
- znanje preuzeto iz postojećih baza znanja (provereno, validirano znanje)

GOOGLE'S KNOWLEDGE VAULT (KV)

Poređenje KV-a sa drugim, sličnim bazama znanja

Name	# Entity types	# Entity instances	# Relation types	# Confident facts (relation instances)
Knowledge Vault (KV)	1100	45M	4469	271M
DeepDive [32]	4	2.7M	34	7M[a]
NELL [8]	271	5.19M	306	0.435M[b]
PROSPERA [30]	11	N/A	14	0.1M
YAGO2 [19]	350,000	9.8M	100	4M[c]
Freebase [4]	1,500	40M	35,000	637M[d]
Knowledge Graph (KG)	1,500	570M	35,000	18,000M[e]

Table 1: Comparison of knowledge bases. KV, DeepDive, NELL, and PROSPERA rely solely on extraction, Freebase and KG rely on human curation and structured sources, and YAGO2 uses both strategies. Confident facts means with a probability of being true at or above 0.9.

Izvor: X. Dong et al. 2014. Knowledge vault: a web-scale approach to probabilistic knowledge fusion. In Proceedings of the 20th ACM SIGKDD international conference on Knowledge discovery and data mining (KDD '14) (link)

DIFFBOT'S GLOBAL INDEX

"…in recent months Diffbot has been analyzing websites to build its index at a rate of up to 15 million pages a day.

Its Global Index now contains more than 600 million objects (this can be anything from a celebrity to an Ikea chair model) and 19 billion facts.

'Our approach is fairly radical in that there's no human behind the curtain'

Diffbot … [is] enhancing other search engines including Microsoft's Bing and DuckDuckGo, and powering apps for companies such as Cisco and AOL"

Diffbot Challenges Google Supremacy With Rival Knowledge Graph

Xconomy, June 4, 2015

PREPORUKE

- [article] Diffbot Bests Google's Knowledge Graph To Feed The Need For Structured Data (link)
- [video] Mike Tung, DiffBot CEO, Turning the Web into a Structured Database (link)
- [video] Knowledge Vault: A Web-Scale Approach to Probabilistic Knowledge Fusion (link)
  - predavanje koje objašnjava ideju i značaj KV-a, kao i principe na kojima se prikupljanje znanja zasniva
- [video] Tom Mitchell, Never-Ending Learning to Read the Web (link)
- [video] From Structured Data to Knowledge Graph, Google I/O 2013 (link)