

Integration of knowledge extracted from text and data as open-world semantic graphs

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SW and LOD

- The Semantic Web is a loosely defined program to make web semantics more explicit and machine-processable
 - W3C standards: RDF, OWL, SPARQL, RIF, JSON-LD
 - Triple languages (RDF as abstract data structure)

data: • `d:Miles_Davis do:recordLabel d:Columbia_Records .`

schema: • `do:Musical_Artist r:subClassOf do:Person .`

query: • `select ?x where {?x a do:Musical_Artist} .`

inferences

schema: • `do:Musical_Artist owl:equivalentClass [do:Artist [some :plays :Music]]` .

data: • `d:Miles_Davis a do:Artist ; :plays d:Jazz . d:Jazz a :Music` .

more data: • `-> d:Miles_Davis a do:Musical_Artist` .

query • `select ?x where {?x a do:Musical_Artist}` .

w/entailment: • `-> d:Miles_Davis`

- Linked (Open) Data is a set of principles to publish data on the Web
 - open formats
 - W3C triple formats (RDF, JSON-LD, SPARQL)
 - URI
 - vocabularies (aka schemas or ontologies)
 - links (owl:sameAs the most used)

describe

dbpedia:Paris_Diderot_University

- http://dbpedia.org/resource/Bernard_Teissier (*describe*)
 - <http://dbpedia.org/property/workplaces> (*describe*)
 - http://dbpedia.org/resource/Paris_Diderot_University
 - <http://dbpedia.org/ontology/almaMater> (*describe*)
 - http://dbpedia.org/resource/Paris_Diderot_University
- http://dbpedia.org/resource/Jean-Pierre_Bourguignon (*describe*)
 - <http://dbpedia.org/property/almaMater> (*describe*)
 - http://dbpedia.org/resource/Paris_Diderot_University
 - <http://dbpedia.org/ontology/almaMater> (*describe*)
 - http://dbpedia.org/resource/Paris_Diderot_University
- http://dbpedia.org/resource/Yves_Colin_de_Verdi%C3%A8re (*describe*)
 - <http://dbpedia.org/property/almaMater> (*describe*)
 - http://dbpedia.org/resource/Paris_Diderot_University
 - <http://dbpedia.org/ontology/almaMater> (*describe*)
 - http://dbpedia.org/resource/Paris_Diderot_University
- http://dbpedia.org/resource/Jean-Yves_Girard (*describe*)
 - <http://dbpedia.org/property/almaMater> (*describe*)
 - http://dbpedia.org/resource/Paris_Diderot_University
 - <http://dbpedia.org/property/workplaces> (*describe*)
 - http://dbpedia.org/resource/Paris_Diderot_University
 - <http://dbpedia.org/ontology/almaMater> (*describe*)
 - http://dbpedia.org/resource/Paris_Diderot_University
- http://dbpedia.org/resource/Paris_Diderot_University (*describe*)
 - <http://www.w3.org/1999/02/22-rdf-syntax-ns#type> (*describe*)
 - <http://dbpedia.org/ontology/Organisation>
 - <http://www.opengis.net/gml/Feature>
 - <http://umbel.org/umbel/rc/University>
 - <http://schema.org/Organization>
 - <http://dbpedia.org/ontology/Agent>
 - <http://umbel.org/umbel/rc/EducationalOrganization>
 - <http://schema.org/CollegeOrUniversity>
 - <http://dbpedia.org/class/yago/EduCAtionalInstitutionsEstablishedIn1971>
 - <http://dbpedia.org/ontology/EducationalInstitution>
 - <http://schema.org/EducationalOrganization>
 - <http://www.w3.org/2002/07/owl#Thing>
 - <http://dbpedia.org/class/yago/UniversitiesAndCollegesInFrance>
 - <http://dbpedia.org/ontology/University>
 - <http://www.w3.org/2002/07/owl#sameAs> (*describe*)
 - http://cs.dbpedia.org/resource/Univerzita_Paříž_VII
 - http://es.dbpedia.org/resource/Universidad_de_Paris_VII_Denis_Diderot
 - http://ru.dbpedia.org/resource/Университет_Париж_Дидро
 - http://sw.cyc.com/concept/Mx4rvBCk7a5wSR6sgp_pV7uPVg
 - http://fr.dbpedia.org/resource/Université_Paris_VII_-_Diderot
 - <http://rdf.freebase.com/ns/m.07sp60>
 - http://de.dbpedia.org/resource/Universität_Paris_VII
 - <http://dbpedia.org/property/chancellor> (*describe*)
 - Maurice Quénet
 - Chancellor of the Universities of Paris
 - <http://dbpedia.org/ontology/abstract> (*describe*)
 - L'université Paris Diderot est une université pluridisciplinaire située à Paris en France, et elle est une des sept universités de l'académie de Paris. Elle déménagement en 2007 du campus de Jussieu, elle est principalement implantée dans le quartier de Paris Rive Gauche. L'université est membre du Pl domaine des sciences, des formations du domaine de la santé, des sciences humaines et sociales, ainsi que des arts, lettres et langues. Ses activités de grands organismes de recherche) et regroupent près de 2 300 doctorants et 2 000 enseignants-chercheurs. Elle forme près de 25 000 étudiants. Parmi l deux autres ont exercé la fonction de ministre de l'éducation nationale en France.
 - Университет Париж VII имени Дени Дидро — французский государственный университет, основан в 1970 году вследствие разделения Униве Шанхайского университета Цзяо Тун занимает 101 — 151 место, 35-38 место в рейтинге европейских университетов, и 4-5 место в рейтинге d
 - Trường Đại học Paris 7, còn gọi là Trường Đại học Paris Diderot, là một trong nhiều trường đại học của vùng Paris. Trường Đại học này nằm ở Quậ

Search: <input type="text"/> eng		<Albert_Einstein>	
<ul style="list-style-type: none"> ← <Elsa_Einstein> ← <Mileva_Marić> 	<isMarriedTo>		<ul style="list-style-type: none"> *albert_einstein@jbo *Albert Einstein@af *Albert Einstein@als *Albert Einstein@ang *Albert Einstein@arg *Albert Einstein@ast *Albert Einstein@aym *Albert Einstein@bam *Albert Einstein@bcl *Albert Einstein@bos *Albert Einstein@bre *Albert Einstein@cat *Albert Einstein@cbk-zam *Albert Einstein@ces *Albert Einstein@cos *Albert Einstein@cym *Albert Einstein@dan *Albert Einstein@deu *Albert Einstein@diq *Albert Einstein@eng → ...
<ul style="list-style-type: none"> ← <id_1gjh4l_1co_1m6tzj> ← <id_1m87rp4_1co_h1old> ← <id_1m87rp4_1cp_unqotr> ← <id_b2dl_1co_1yicwj> ← <id_tiwmcu_16x_11ovtp> ← <id_tiwmcu_16x_1ad43sb> ← <id_tiwmcu_ab2_1t9dir> ← <id_tiwmcu_ab2_9o3zmc> ← <id_tiwmcu_ab2_ec4aec> ← <id_vw40n3_1co_1yicwj> ← <id_zival_1co_167wix7> ← <id_zival_1cp_h1old> 	<extractionSource>		
<ul style="list-style-type: none"> ← <Einstein_family> 	<hasChild>		
<ul style="list-style-type: none"> <137824_2000_BD19> <47> <Aant_Elzinga> <Aarau> <Aaron_Bernstein> <Abbé_Pierre> <Abelardo_L_Rodriguez_Market_Mexico_City> <About_Time_(book)> <Abraham_Akaka> <Abraham_Cronbach> <Abraham_Flexner> <Abraham_Maskow> <Abraham_Pais> <Abraham_Sachs> <Absent-minded_professor> <Absorption_refrigerator> <Academic_genealogy_of_theoretical_physicists> <A_Canticle_for_Leibowitz> <Accademia_doi_Lincei> <Adagio_for_Strings> ... 	<linksTo>		<ul style="list-style-type: none"> <Aarau> <Abba_Ebar> <Abraham_Pais> <Adolf_Hitler> <Aether_theories> <African-American_Civil_Rights_Movement_(1898-1954)> <Albert_Einstein's_brain> <Alfred_Kleiner> <Annalen_der_Physik> <Annus_Mirabilis_papers> <Antwerp> <Arnold_Sommerfeld> <Baden-Württemberg> <Baer's_law> <BBC> <BBC_News> <Bell's_theorem> <Bern> <Bertrand_Russell> <Bose-Einstein_statistics> ...
<ul style="list-style-type: none"> ← <Arthur_Schopenhauer> ← <Baruch_Spinoza> ← <David_Hume> ← <Ernst_Mach> ← <Moritz_Schlick> ← <Thomas_Young_(scientist)> 	<influences>		
			<ul style="list-style-type: none"> rdfs:label
			<ul style="list-style-type: none"> <hasAcademicAdvisor>
			<ul style="list-style-type: none"> <Alfred_Kleiner> →
			<ul style="list-style-type: none"> <linksTo>
			<ul style="list-style-type: none"> <Princeton_New_Jersey> →
			<ul style="list-style-type: none"> <hasGivenName>
			<ul style="list-style-type: none"> *Albert@eng →
			<ul style="list-style-type: none"> <wasBornIn>
			<ul style="list-style-type: none"> <Ulm> →
			<ul style="list-style-type: none"> <hasFamilyName>
			<ul style="list-style-type: none"> *Einstein@eng →
			<ul style="list-style-type: none"> skos:prefLabel
			<ul style="list-style-type: none"> *Albert Einstein@eng →
			<ul style="list-style-type: none"> <isMarriedTo>
			<ul style="list-style-type: none"> <Elsa_Einstein> → <Elsa_Einstein> → <Mileva_Marić> →
			<ul style="list-style-type: none"> *A_Einstein@eng *Alber Einstein@eng *Alber Enstien@eng *Albert Einstein@eng *Albert einstein@eng *Albert Einstein's@eng *Albert Einstien@eng *Albert Einstin@eng *Albert Einstein@eng *Albert Enstien@eng *Albert Einstin@eng *Albert LaFache Einstein@eng *Al Einstein@eng *A Tribute to Einstein@eng *Compassionate Zionism and Albert Einstein@eng *Einsetein@eng *Einstein, Albert@eng *Einstein@eng *Einsteinian@eng

describe yago:Albert_Einstein

create topology

RelFinder

URL

between examples

(1) Weather Report

(2) Miles Davis

add clear Find Relations

Filter by: relations: (76/76)

length class link connect...

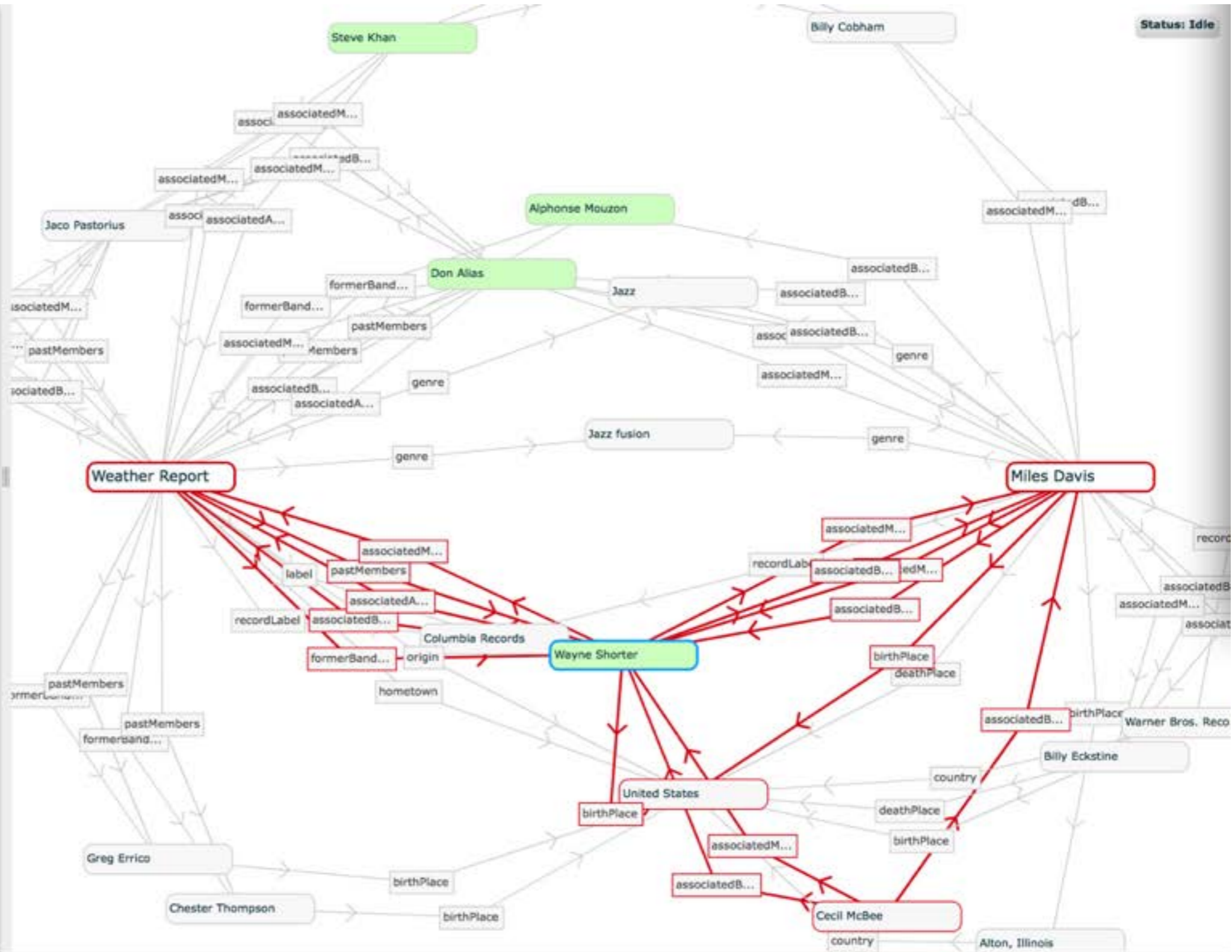
number of objects	num	vi
1	28/28	
2	48/48	

Wayne Shorter

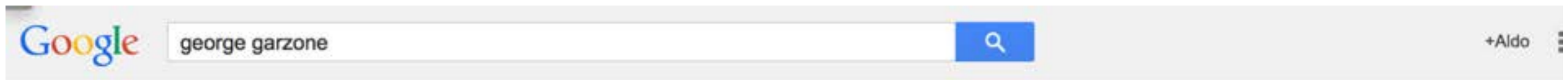
More Infos: dbpedia.org



Wayne Shorter (born August 25, 1933) is an American jazz saxophonist and composer. Jazz critic Ben Ratliff of the New York Times wrote that Shorter is "generally acknowledged to be jazz's greatest living composer." Many of Shorter's compositions have become jazz standards. His output has earned worldwide recognition, critical praise and various commendations, including multiple Grammy Awards. Shorter first came to wide prominence in the late 1950s as a member of



a success SW story: the knowledge graph



Web Videos News Images Shopping More Search tools

About 186,000 results (0.32 seconds)

George Garzone

www.georgegarzone.com/

George Garzone. along with. Ernesto Jodos piano, Pepi Taveira drums, Jerónimo Carmona bass. 20th anniversary of the legendary record store's Jazz Minton ...

George Garzone - Wikipedia, the free encyclopedia

en.wikipedia.org/wiki/George_Garzone - Wikipedia

George Garzone (born September 23, 1950) is a saxophonist and jazz educator residing in New York City. Saxophonist George Garzone is a member of The ...
[Biography](#) - [Discography](#) - [Performances with prominent ...](#) - [Notable students](#)

Images

[Report images](#)



[More images for george garzone](#)

Meet JodyJazz Artist George Garzone - JodyJazz Saxophon...

www.jodyjazz.com/endorser/GeorgeGarzone

Saxophonist George Garzone is a member of The Fringe, a jazz trio founded in 1972 that includes bassist John Lockwood and drummer Bob Gullotti, that ...

George Garzone on Articulating with 8th Notes - YouTube



www.youtube.com/watch?v... - YouTube

Nov 9, 2010 - Uploaded by D'Addario Woodwinds

I Want to Talk About You versión George Garzone e invitadosby

George Garzone

Musical Artist

George Garzone is a saxophonist and jazz educator residing in New York City. Saxophonist George Garzone is a member of The Fringe, a jazz trio founded in 1972 that includes bassist John Lockwood and ... [Wikipedia](#)

Born: September 23, 1950 (age 63), [Boston, Massachusetts, United States](#)

Education: [Berklee College of Music](#)

Albums: [One Two Three Four, Four's and Two's, Alone](#)



People also search for



[Jerry Bergonzi](#)



[Joe Lovano](#)



[Danilo Pérez](#)



[Dave Liebman](#)



[Donny McCaslin](#)

[Feedback](#) / [More info](#)

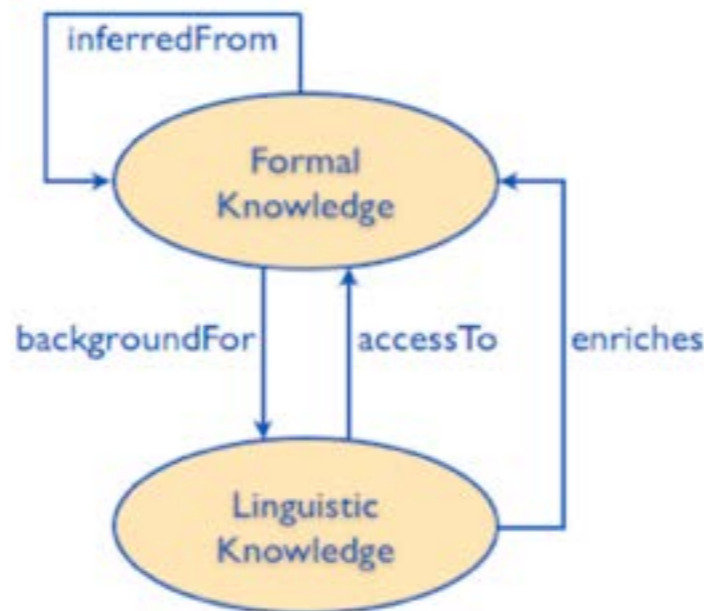
LOD - NLP interface

- Reuse NLP output in LOD (triple enrichment)
- Reuse LOD in NLP systems (background knowledge)

Knowledge Extraction and the SW

- Historically SW mainly worked on *ontology learning*
 - unconvincing results: sparseness, core knowledge difficult to catch, etc. (cf. Coppola et al. 2009, Blomqvist, 2009)
 - natural language understanding known to be an AI-complete problem
- The paradigm of *machine reading* (Etzioni, 2006) fits the lightweight and/or data-driven trend of current SW
- More important, *semantic technologies* in the large need hybridization

*QA, NL querying on LD,
full text search jointly with
queries, ...*



Apple Siri, Google Now,
SRI startup Desti

Facebook Social Graph

Google Knowledge Graph

IBM Watson

OIE, NELL, BabelNet, ...

Some projects in the interface

- Projects dealing with the architecture of the interface
 - Apache Stanbol (platform for integrating LOD querying, indexing, and refactoring with NLP text analyzers)
 - NERD (integration of NER systems)
 - FOX / conTEXT (LOD hybridization and visual analytics out of NER)
 - FRED (LOD hybridization out of multiple NLP analyzers, running on top of Boxer, Stanbol, WSD, NER, plus pattern-based NL semantics)
- Projects using the interface
 - DELPH-IN (RDF for Minimal Recursion Semantics)
 - Quepy
 - BabelNet, OIE, NELL, IBM Watson, Google KG, ...



In this demo we demonstrate the use of the [Quepy](#) framework by generating queries to be ran in the [DBpedia](#) database or the [Freebase](#) database.

[Read the tutorial](#) to create an application like this one or [view the finished code](#).

To learn more about the framework [check out the documentation](#) or the [source code](#) at [github](#).

[Tweet](#)

Try it yourself:

1. Ask a question

Start by asking a question in natural language and watch the query generated:

Question:

2. Get a query

This query was generated for the question "Music genre of Weather Report"

```
SPARQL EDIT
PREFIX owl: <http://www.w3.org/2002/07/owl#>
PREFIX rdfs: <http://www.w3.org/2000/01/rdf-schema#>
PREFIX rdf: <http://www.w3.org/1999/02/22-rdf-syntax-ns#>
PREFIX foaf: <http://xmlns.com/foaf/0.1/>
PREFIX skos: <http://www.w3.org/2004/02/skos/core#>
PREFIX quepy: <http://www.mochinalis.com/quepy#>
PREFIX dbpedia: <http://dbpedia.org/ontology/>
PREFIX dbpprop: <http://dbpedia.org/property/>
PREFIX dbpedia-owl: <http://dbpedia.org/ontology/>

SELECT DISTINCT ?x2 WHERE {
  ?x0 rdf:type dbpedia-owl:Band.
  ?x0 rdfs:label "Weather Report"@en.
  ?x0 dbpedia-owl:genre ?x1.
  ?x1 rdfs:label ?x2.
}
```

```
MQL EDIT
[[
  "/music/artist/genre": [[
    "/type/object/name": [{}]]
  ]],
  "/type/object/name--": "Weather Report",
  "/type/object/type": "/music/musical_group"
]]
```

3. Get an answer

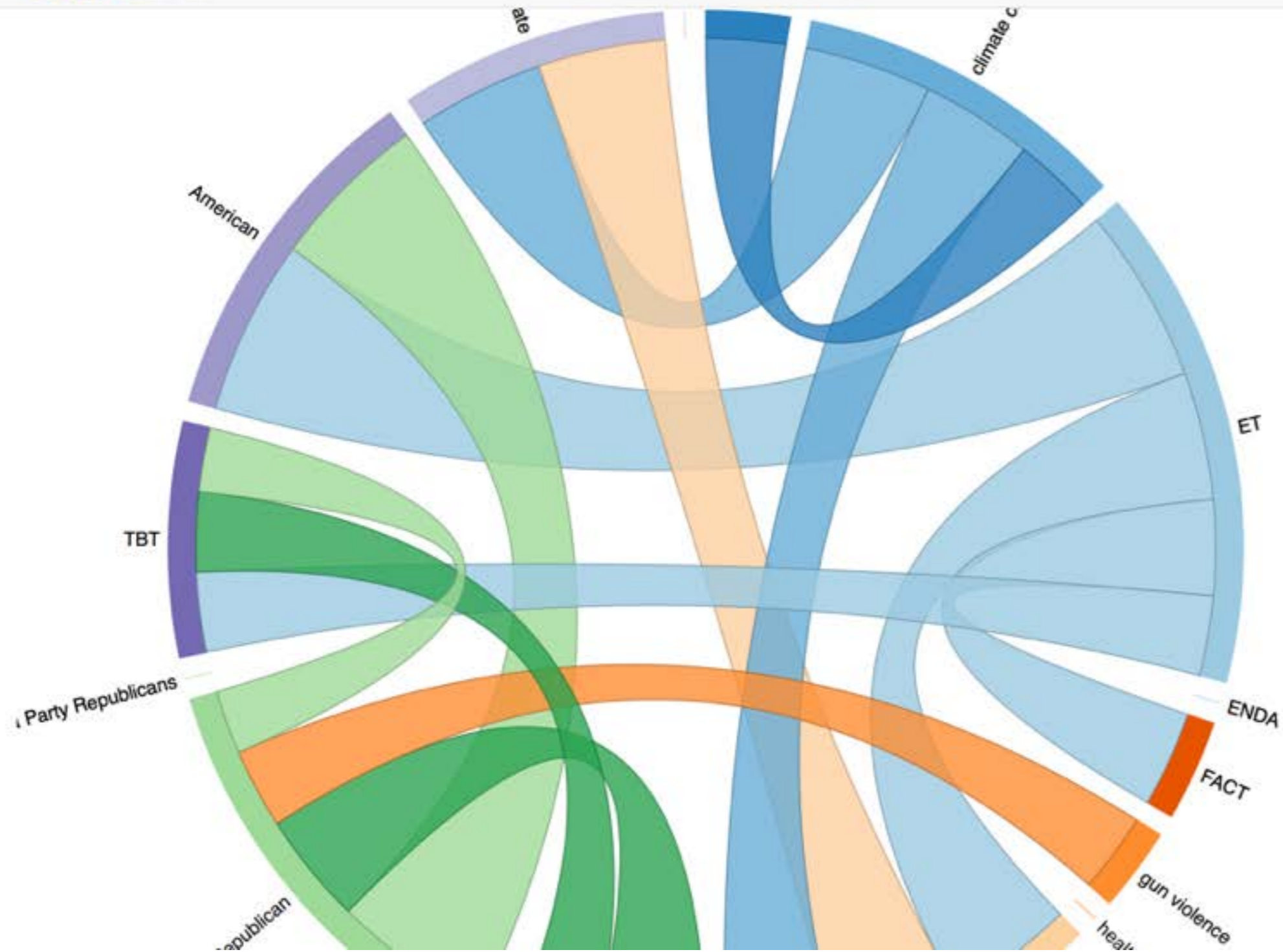
Click the button to query the [DBpedia](#) database and see if there's any answer for this query.

Cleaned answer

Rock music
Jazz
Jazz fusion

```
Raw
{
  "head": {
    "link": [],
    "vars": [
      "x2"
    ]
  },
  "results": {
    "distinct": false,
    "ordered": true,
  }
}
```

NL interface to SPARQL



correlate extracted
entities

Question:

No paraphrases found.

1 answers from 4 sentences in 1 source (cached)

Catania (4)

Catania



Catania ([ka'tanja] (listen); Greek: Κατάνη – Katáne; Latin: Catāna and Catīna) is an Italian city on the east coast of Sicily facing the Ionian Sea, between Messina and Syracuse. It is the capital of the homonymous province, and is the second-largest city in Sicily and the tenth in Italy. Catania is known for its seismic history, having been destroyed by a catastrophic earthquake in 1169, another in 1693, and several volcanic eruptions from the neighboring Mount Etna volcano, the most violent of which was in 1669. Catania has had a long and eventful history, having been founded in the 8th century BC. In the 14th century and the...

Types:

- location (Nell)
- /location/location (FreeBase)
- /location/statistical_region (FreeBase)
- /protected_sites/listed_site (FreeBase)
- city (Nell)
- /location/dated_location (FreeBase)
- /location/citytown (FreeBase)
- /periodicals/newspaper_circulation_area (FreeBase)

Extracted from these sources:

4 results from "what is largest city in Sicily?"
 Interpretation: (\$x, be largest city in, sicily)

Evidence for: (catania, be largest city in, sicily)

1. With around three hundred and twenty thousand inhabitants **Catania** is the second largest city in **Sicily** . (via ClueWeb12)
2. **Catania** is the second largest city in **Sicily** and the tenth largest in **Italy** . (via ClueWeb12)
3. **Catania** is the second largest city in **Sicily** after **Palermo** . (via ClueWeb12)
4. After **Palermo** , about 250 kilometres away , **Catania** is the second largest city in **Sicily** . (via ClueWeb12)

Source: Freebase, licensed under CC-BY
 Other content from Wikipedia, licensed under CC BY-SA

projecting NLP results to structured data

BabelNet 2.0

A very large multilingual encyclopedic dictionary and semantic network

search • explore • publications • download


Type a term: English search

Noun

Meaning: Wayne Shorter • ID: bn:02261696n • Type: Named Entity [\[details\]](#) [\[explore\]](#)

Senses:

- Wayne Shorter, Wayne Shorter, Wayne Shorter, ויין שורטר, Wayne Shorter, ウェイン・ショーター, Шортер, Уэйн, Wayne Shorter
- Shorter, Wayne Shorter, ויין שורטר, ויין שורטר, ויין שורטר, Wayne Shorter, Уэйн Шортер



Glosses:

- Wayne Shorter is an American jazz saxophonist and composer.
- Wayne Shorter est un saxophoniste et compositeur de jazz américain.
- Wayne Shorter ist ein US-amerikanischer Jazz-Saxophonist und -Komponist.
- ויין שורטר הוא סקסופוניסט ומלחין ג'אז אמריקאי.
- Suo padre aveva l'abitudine di ascoltare la radio in casa dopo il rientro dal lavoro.
- ウェイン・ショーター (Wayne Shorter, 1933年8月25日 -) は、ジャズのテナーサクソ・ソプラノサクソ奏者。
- Уэйн Шортер — американский джазовый тенор- и сопрано-саксофонист и композитор, многократный обладатель Грэмми, которого называют величайшим композитором в джазе из ныне живущих.
- Wayne Shorter es un saxofonista y compositor estadounidense de jazz.

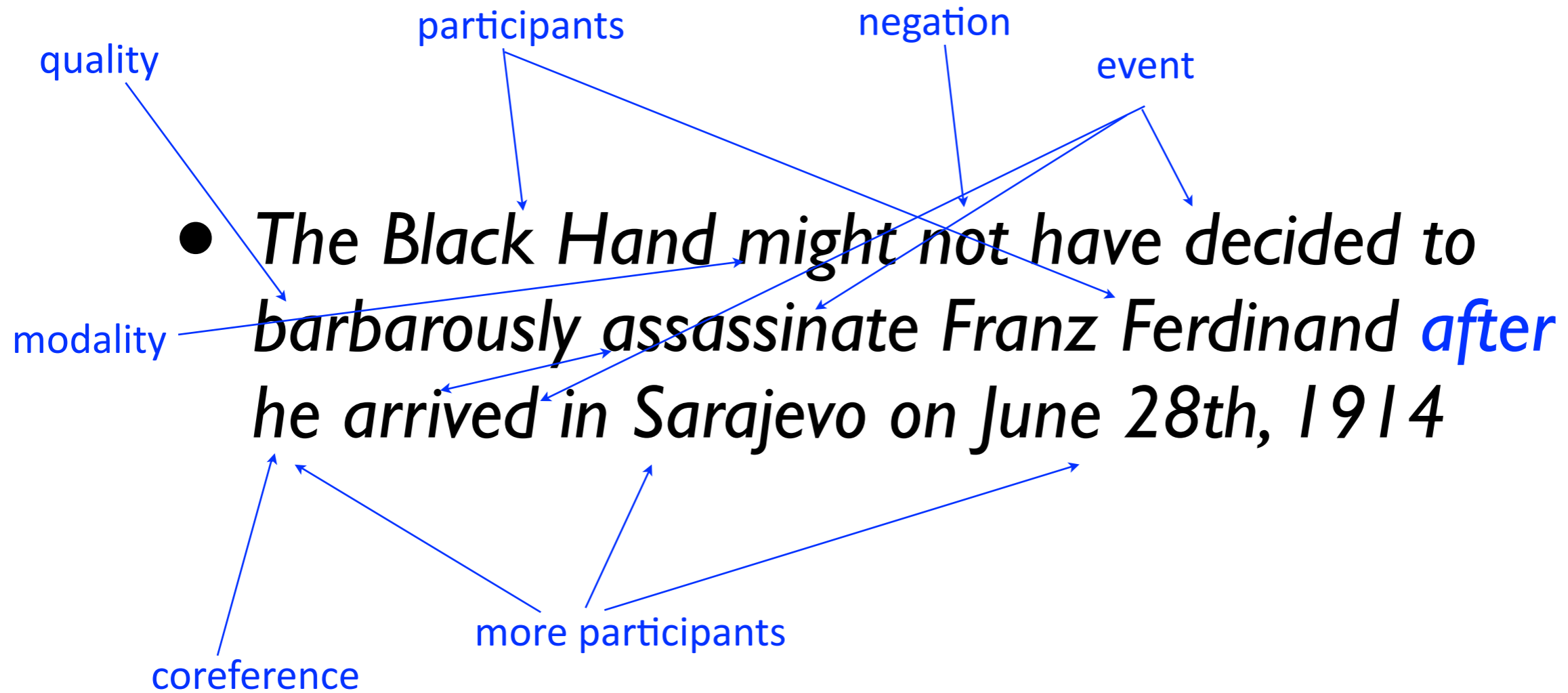
Categories:

- Modal jazz saxophonists, Crossover jazz saxophonists, Jazz fusion saxophonists, Hard bop saxophonists, Post-bop saxophonists, Jazz tenor saxophonists, American jazz composers, American jazz soprano saxophonists, American jazz tenor saxophonists, American composers, African-American musicians, Grammy Award-winning artists, Miles Davis, People from Newark, New Jersey, American Buddhists, Members of Sōka Gakkai, 1933 births, Living people, Blue Note Records artists, Vee-Jay Records artists, Weather Report members, Converts to Buddhism, Converts to Sōka Gakkai, Saxophoniste de jazz, Compositeur de jazz, Compositeur américain, Naissance en 1933, Naissance à Newark, Komponist (Jazz), US-amerikanischer Komponist, Jazz-Saxophonist, Fusion-Musiker, Grammy-Preisträger, US-Amerikaner, Geboren 1933, Mann, Sassofonisti jazz, Sassofonisti fusion, Personalità legate a Newark, Gruppi e musicisti della Columbia Records, Saxofonistas de jazz de Estados Unidos, Saxos tenores, Saxos sopranos, Saxos alto, Compositores de jazz de Estados Unidos, Músicos de bop, Músicos de jazz-rock, Músicos de jazz moderno, Clarinetistas de jazz de Estados Unidos,

DBPedia: [Wayne Shorter](#)

creating
large
knowledge
bases from
WSD

deep machine reading



Open Information Extraction

```
pc5: NLPapps mac$ java -Xmx512m -jar reverb-latest.jar <<<"The Black Hand might not have decided to barbarously assassinate Franz Ferdinand after he arrived in Sarajevo on June 28th, 1914."
```

```
Initializing ReVerb extractor...Done.
```

```
Initializing confidence function...Done.
```

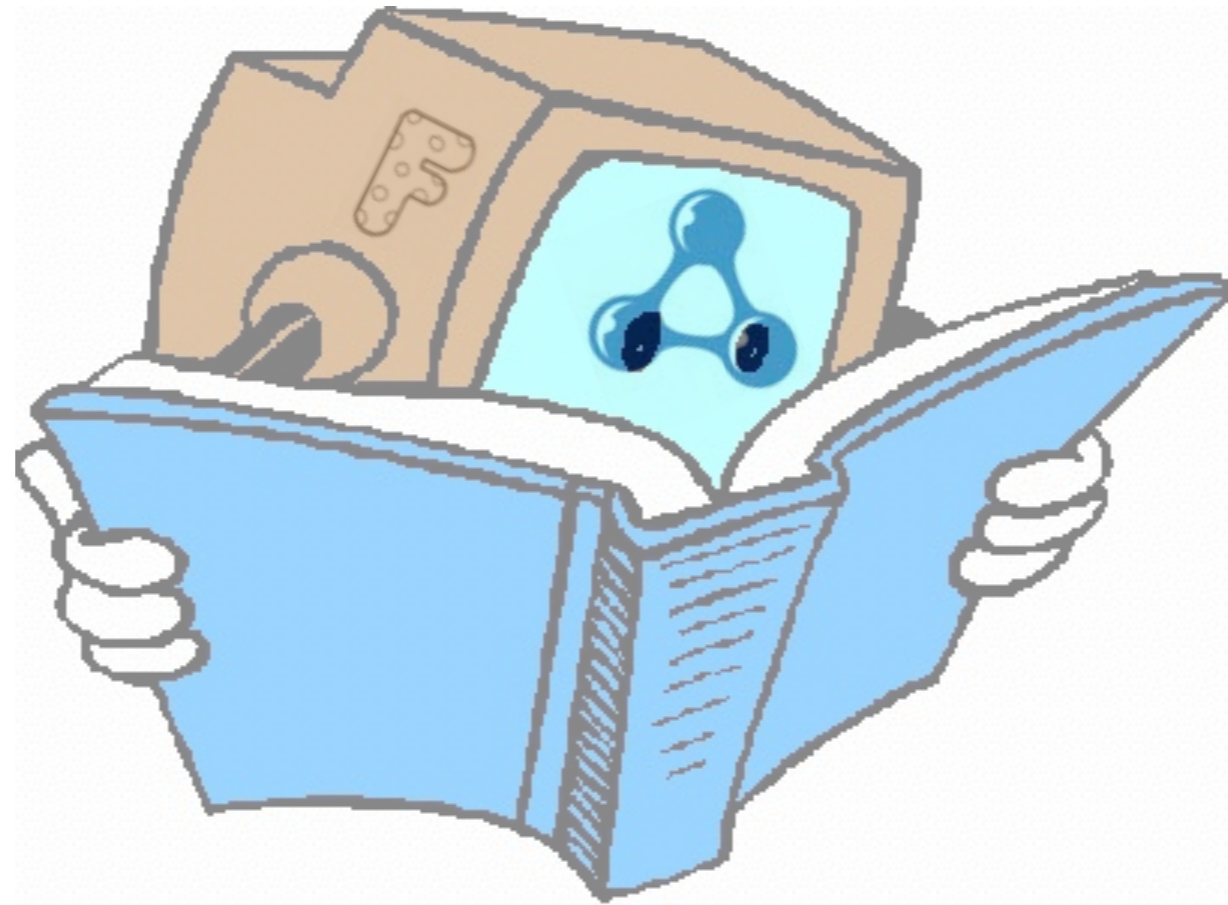
```
Initializing NLP tools...Done.
```

```
Starting extraction.
```

```
stdin    1  he  arrived in  Sarajevo  13  14  14  16  16
10.2200632195721161  The Black Hand might not have decided to barbarously
assassinate Franz Ferdinand after he arrived in Sarajevo on June 28th , 1914 .
DT NNP NNP MD RB VB VBN TO RB VB NNP NNP IN PRP VBD IN NNP IN NNP JJ , CD .
B-NP I-NP I-NP B-VP I-VP I-VP I-VP I-VP I-VP I-VP I-VP B-NP I-NP B-SBAR B-NP B-VP
B-PP B-NP B-PP B-NP I-NP I-NP I-NP O he arrive in sarajevo
```

```
Done with extraction.
```

```
Summary: 1 extractions, 1 sentences, 0 files, 1 seconds
```



A Machine Reader for the Semantic Web

Aldo Gangemi, Valentina Presutti, Francesco Draicchio,
Andrea Giovanni Nuzzolese, Diego Reforgiato Recupero

STLab ISTC-CNR Rome, U. Paris 13

<http://wit.istc.cnr.it/stlab-tools/fred>

FRED integrates
*NER, SenseTagging, WSD, Tax. Ind.,
Relation/Event/Role Extraction*

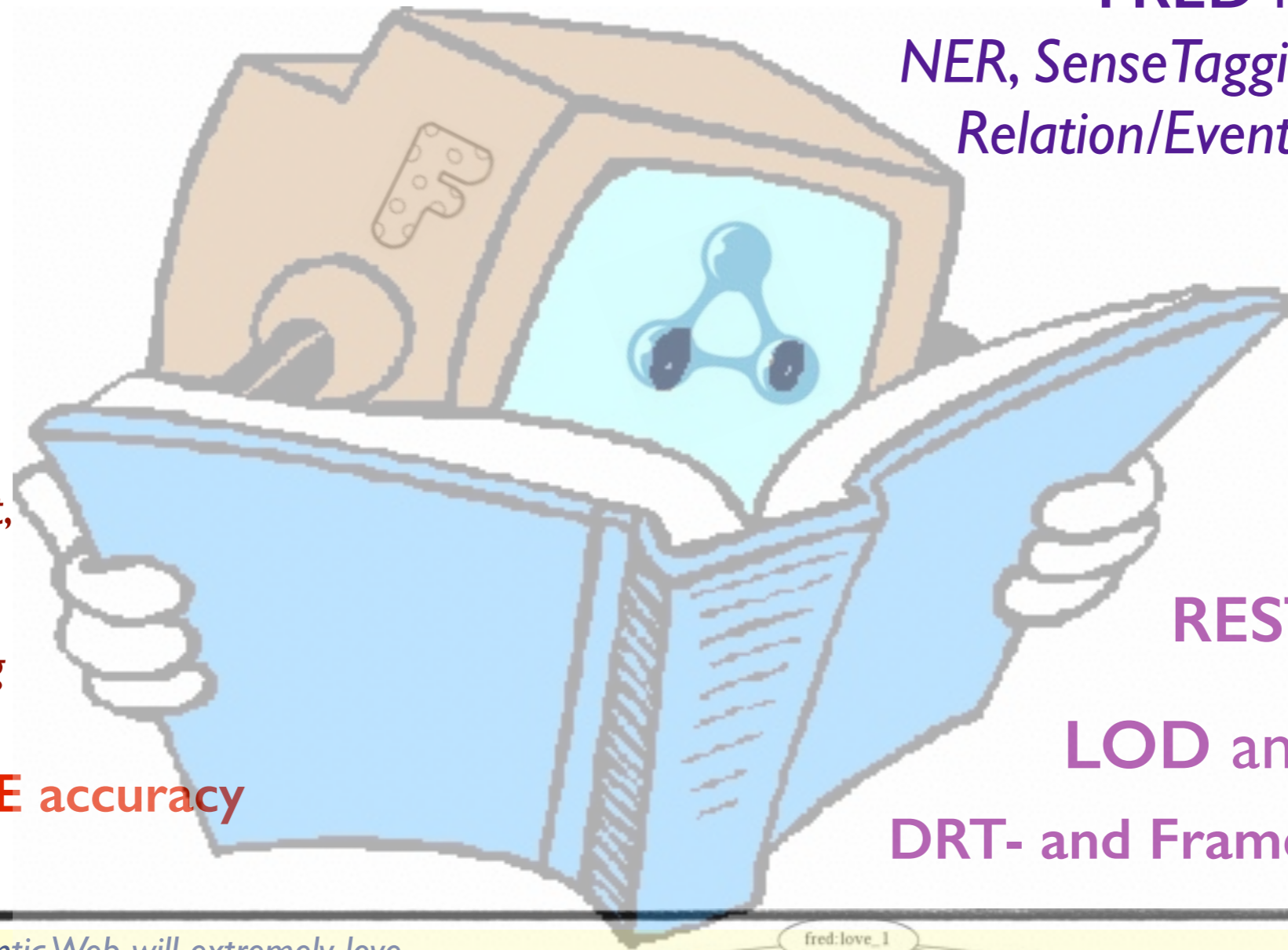
Apache Stanbol
RDF, OWL

Earmark

RESTful

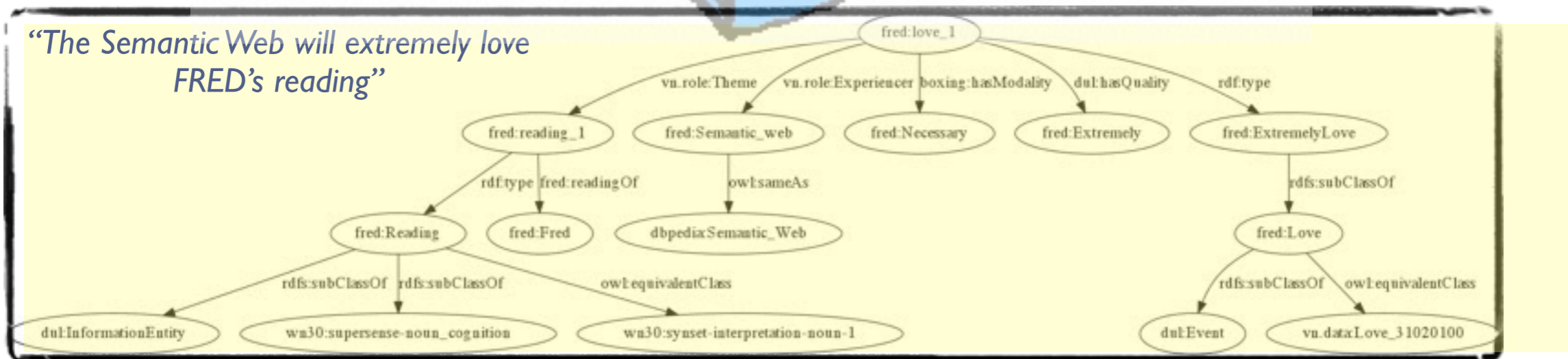
LOD and ODP design

DRT- and Frame-based



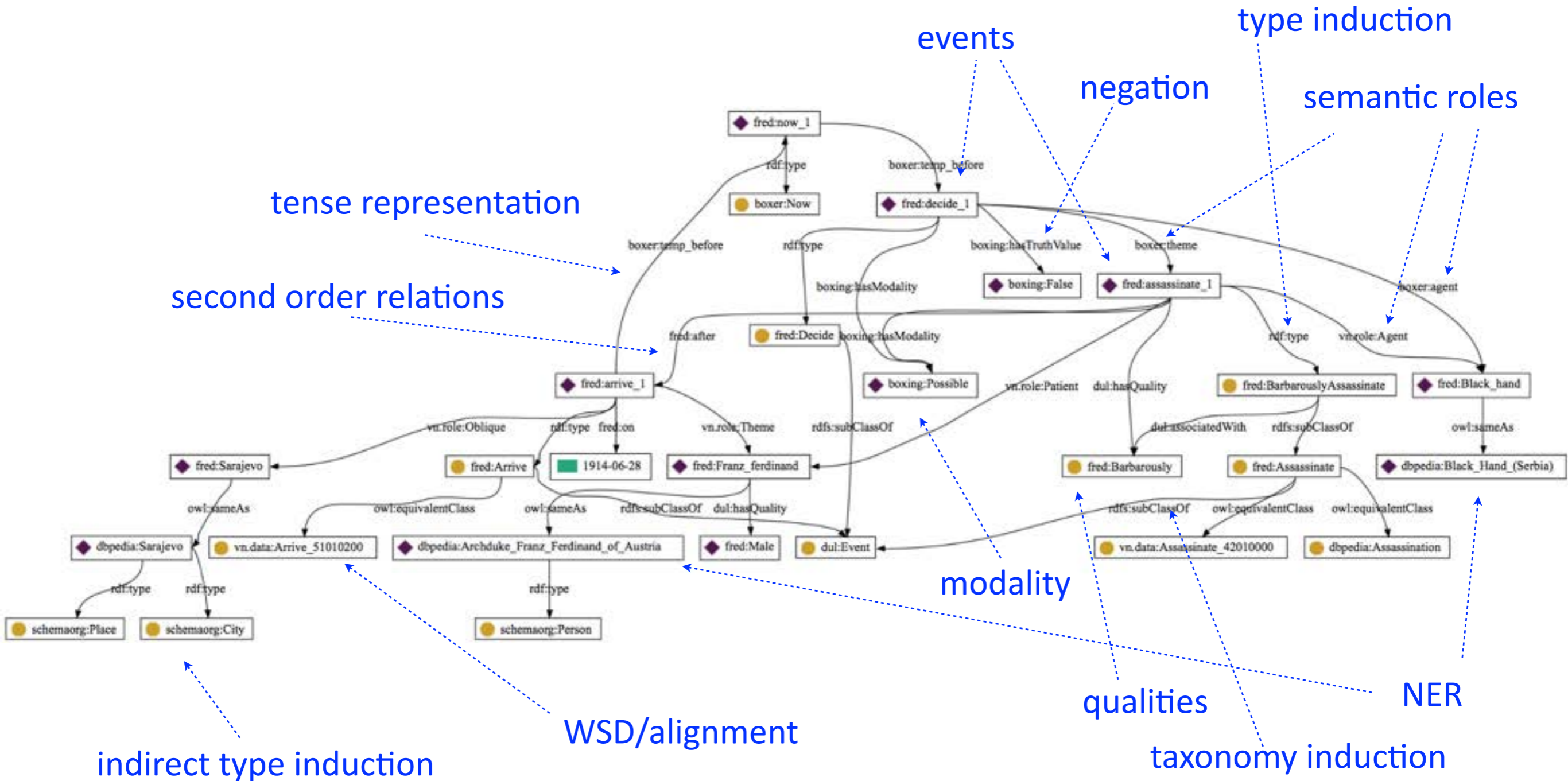
Aligned to *WordNet, VerbNet, FrameNet, DOLCE+DnS, DBpedia, schema.org*

High EE and RE accuracy



machine reading to rdf

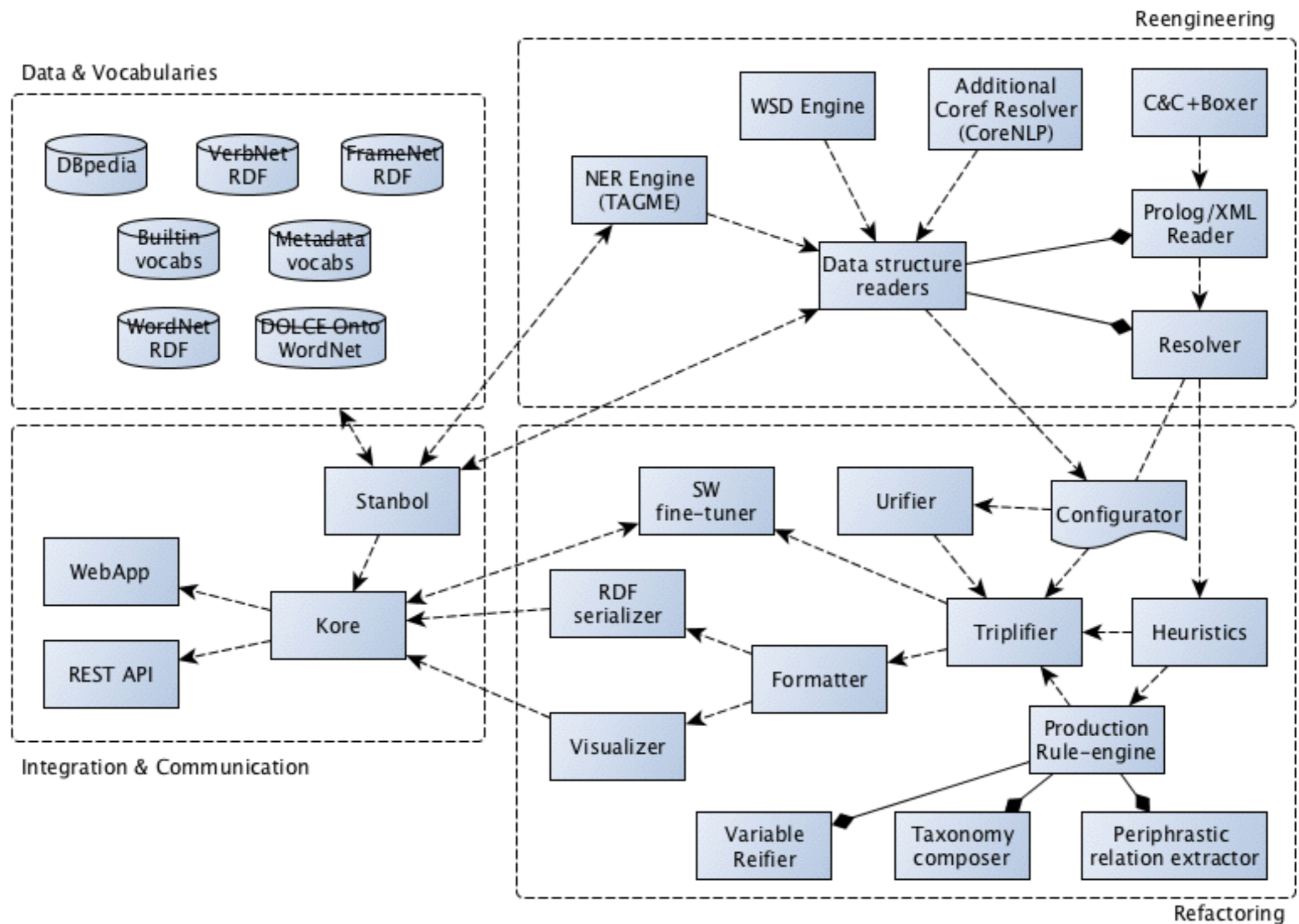
“The Black Hand might not have decided to barbarously assassinate Franz Ferdinand after he arrived in Sarajevo on June 28th, 1914”



+ configurable namespaces and

Earmark text spans with semiotic relations to graph entities (denotes, hasInterpretant)

FRED's architecture



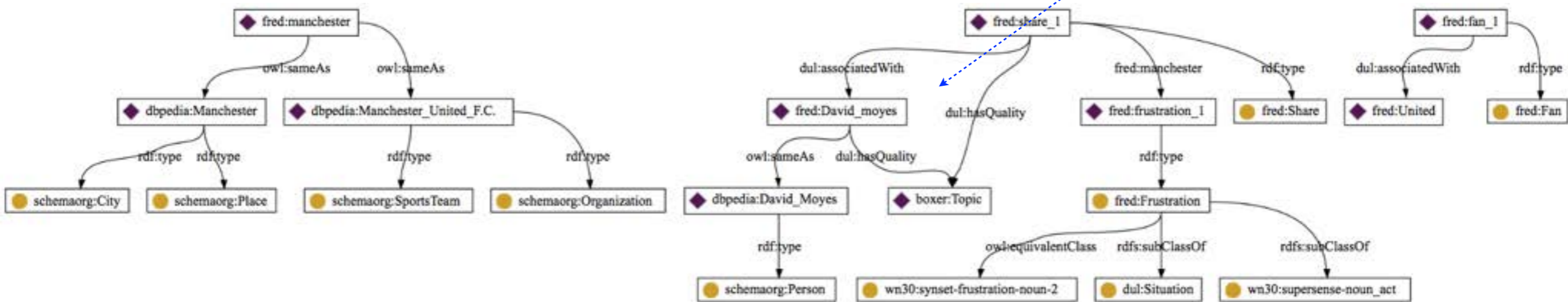
Superfresh results

- Evaluation on a set of named graphs produced from a composite sample of sentences with 4 text types
- Named graphs modularized by *motifs*: query patterns that extract elementary logical patterns
- Gold treatment of graphs by expert annotators, good inter-rater agreement (Kendall's W)
- Implemented method to create NL/SW *graph banks*
 - analogous to syntactic treebanks, meaning banks

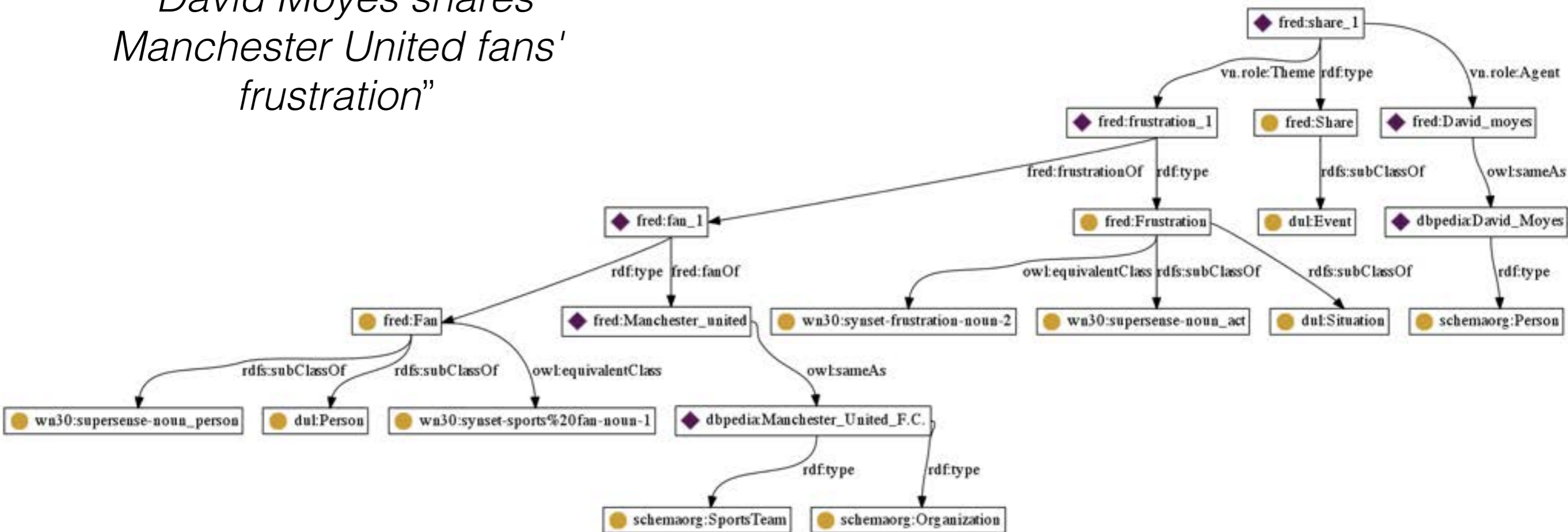
Measure	Value
W on articles	0.86 p=<0.0001
W on definitions	0.74 p=<0.0001
W on news	0.62 p=<0.0001
W on tweets	0.65 p=<0.0001
W globally	0.73 p=<0.0001
Avg. Pearson Corr.	0.73

Goldenring

share : NNS
Syntactic parsers still fail!



"David Moyes shares Manchester United fans' frustration"



Motifs

Motif	Sample distribution	As FRED RDF
BINARIZED	4.72	A binary relation constructed (projected) out of an n-ary one
EQUIVALENCE	13.65	<code>owl:equivalentClass</code>
IDENTITY	4.29	<code>owl:sameAs</code>
MODALITY	0.69	<code>boxing:hasModality</code>
N-ARY	19.31	Any subgraph (degree=1) having a <code>dul:Event</code> or <code>boxing:Situation</code> as root
NEGATION	0.6	<code>boxing:hasTruthValue</code> , applied to n-ary structures
PROPERTY	23.43	Any property assertion
SUBCLASS	21.46	<code>rdfs:subClassOf</code>
TYPE	11.85	<code>rdf:type</code>
<i>All</i>	100	

Fresh results

“motifs”

Class of triples	Precision r1	Recall r1	F1 r1	Precision r2	Recall r2	F1 r2	Precision r3	Recall r3	F1 r3	Avg. Precision	Avg. Recall	Avg. F1
<i>Global without structure triples</i>	0.84	0.92	0.88	0.87	0.92	0.89	0.88	0.92	0.9	0.86	0.92	0.89
BINARIZED	0.76	0.95	0.85	0.91	0.98	0.94	0.89	0.98	0.93	0.85	0.97	0.91
EQUIVALENCE	0.64	0.77	0.7	0.74	0.68	0.71	0.74	0.68	0.71	0.71	0.71	0.71
IDENTITY	0.9	0.87	0.88	0.95	0.98	0.96	0.92	0.98	0.95	0.92	0.94	0.93
MODALITY	0.88	1	0.93	0.79	1	0.88	0.88	1	0.93	0.85	1.00	0.91
N-ARY	0.88	0.89	0.88	0.89	0.93	0.91	0.94	0.94	0.94	0.90	0.92	0.91
NEGATION	0.86	1	0.92	0.86	1	0.92	0.86	1	0.92	0.86	1.00	0.92
PROPERTY	0.85	0.94	0.89	0.84	0.95	0.89	0.85	0.95	0.9	0.85	0.95	0.89
SUBCLASS	0.88	1	0.94	0.92	1	0.96	0.93	1	0.96	0.91	1.00	0.95
TYPE	0.9	0.97	0.93	0.93	0.96	0.94	0.92	0.96	0.94	0.92	0.96	0.94
ARTICLES	0.85	0.9	0.87	0.85	0.91	0.88	0.86	0.91	0.88	0.85	0.91	0.88
DEFINITIONS	0.81	0.91	0.86	0.88	0.93	0.9	0.89	0.94	0.91	0.86	0.93	0.89
NEWS	0.87	0.97	0.92	0.92	0.93	0.92	0.93	0.93	0.93	0.91	0.94	0.92
TWEETS	0.79	0.89	0.84	0.83	0.92	0.87	0.85	0.92	0.88	0.82	0.91	0.86
EQUIVALENCE with WSD only	0.57	0.44	0.5	0.7	0.43	0.53	0.7	0.43	0.53	0.66	0.43	0.52
EQUIVALENCE with NER only	0.81	0.22	0.35	0.83	0.2	0.32	0.82	0.2	0.32	0.82	0.21	0.33
GLOBAL without WSD	0.87	0.91	0.89	0.89	0.91	0.9	0.9	0.92	0.91	0.89	0.91	0.90
TYPE with structure triples	0.96	0.99	0.97	0.97	0.99	0.98	0.97	0.99	0.98	0.97	0.99	0.98
OVERALL (incl. Structure triples)	0.87	0.94	0.9	0.9	0.96	0.93	0.91	0.96	0.93	0.89	0.95	0.92
OVERALL, but without WSD	0.9	0.94	0.92	0.92	0.96	0.94	0.92	0.96	0.94	0.91	0.95	0.93

text types

Open graphs

- Why open-world? Because it's the web, with incomplete knowledge
- Integration between NLP and SW
 - “The Black Hand might not have decided to barbarously assassinate Franz Ferdinand after he arrived in Sarajevo on June 28th, 1914”
 - d: Sarajevo
 - d: Sarajevo :locatedIn d: FormerAustrianEmpire , d: Bosnia
 - d: Bosnia :partOf d: Yugoslavia

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ng1914

• d: Sarajevo :locatedIn d: FormerAustrianEmpire , d: Bosnia

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Open graphs

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 - “The Black Hand might not have decided to barbarously assassinate Franz Ferdinand after he arrived in Sarajevo on June 28th, 1914”

• d: Sarajevo

• d: Sarajevo :locatedIn d: FormerAustrianEmpire , d: Bosnia

• d: Bosnia :partOf d: Yugoslavia

ng 1929

```
graph TD; Sarajevo --- FormerAustrianEmpire; Bosnia --- FormerAustrianEmpire; Bosnia --- Yugoslavia; Sarajevo --- Yugoslavia; Sarajevo --- ng1929[ng 1929];
```

Open graphs

- Why open-world? Because it's the web, with incomplete knowledge
- Integration between NLP and SW
 - “The Black Hand might not have decided to barbarously assassinate Franz Ferdinand after he arrived in Sarajevo on June 28th, 1914”



- More with events, relations, tense representation, sentiment ...
 - “The Black Hand might not have decided to barbarously assassinate Franz Ferdinand after he arrived in Sarajevo on June 28th, 1914”
 - ...
 - ...