

# Utilizing Knowledge Graphs for Text-centric Information Retrieval

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Slides at <http://github.com/laura-dietz/tutorial-utilizing-kg>

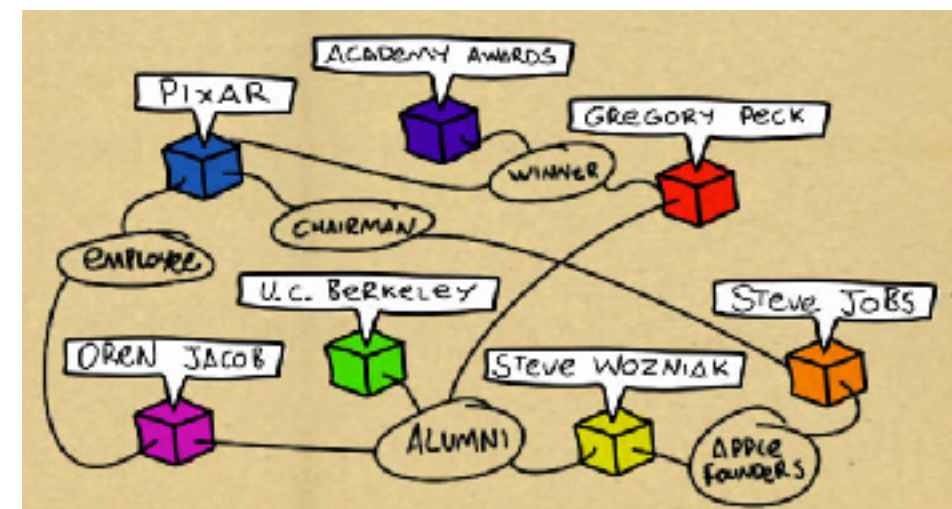
Bibliography at <https://www.mendeley.com/community/entity-linking-and-retrieval/>

# Entity?

- Uniquely identifiable *thing* or *object*
  - “A thing with a distinct and independent existence”
  - people, places, products, companies, etc. etc.

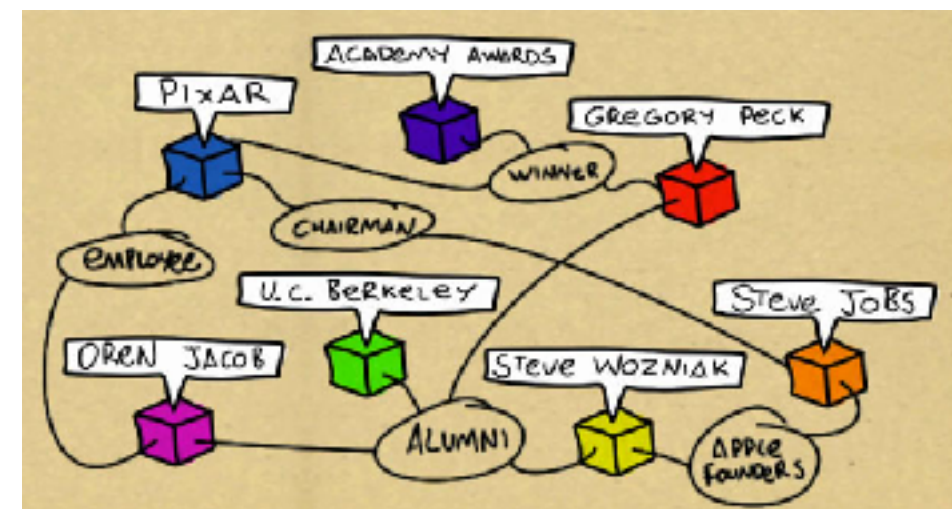
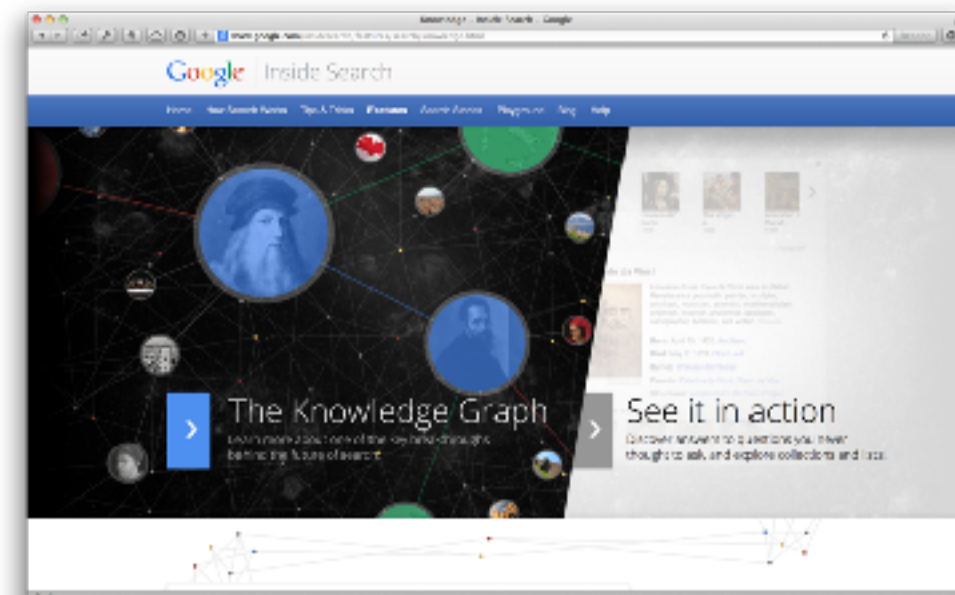
# What's so special about entities?

- ID
- Name(s)
- Type(s)
- Attributes (/Descriptions)
- Relationships to other entities



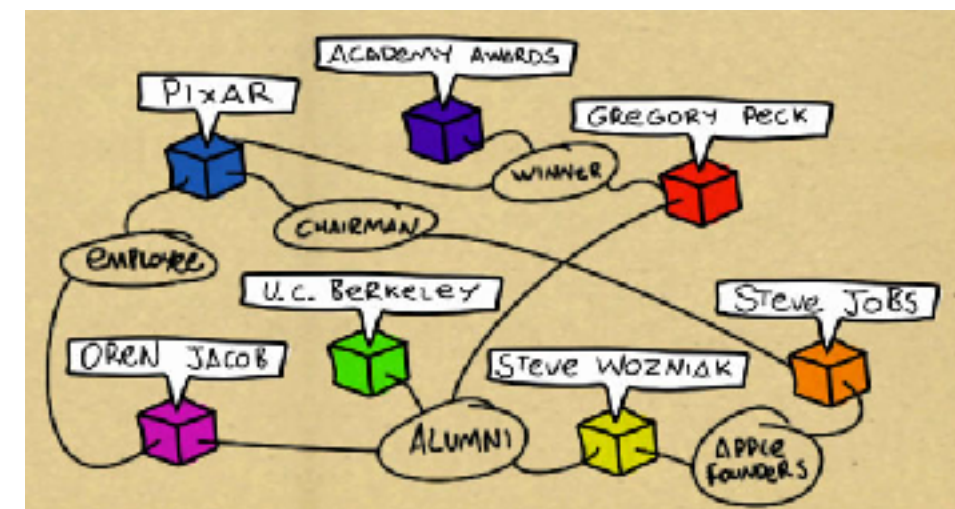
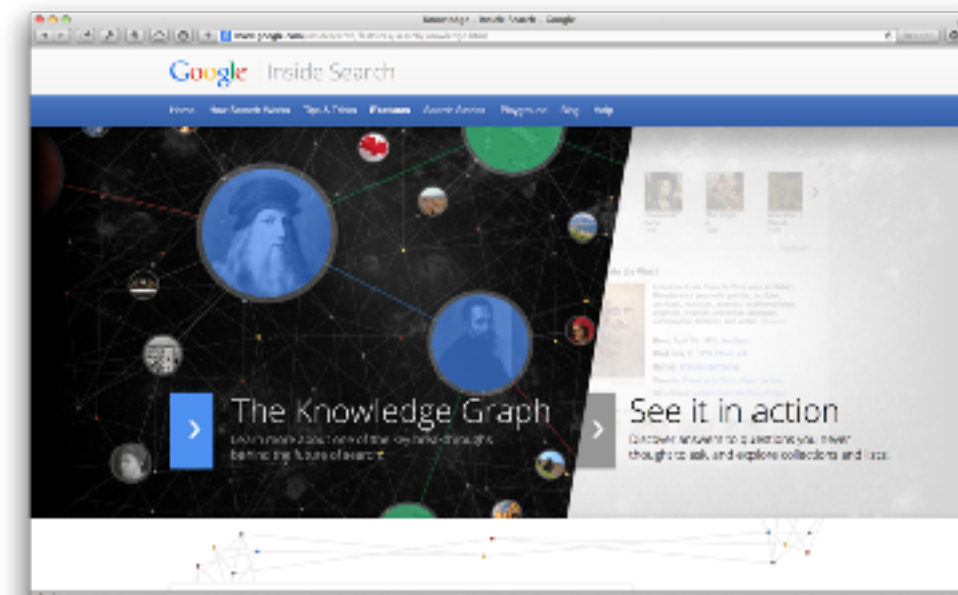
# Knowledge graphs

- A knowledge graph (KG) is a repository of entities and their relations and attributes that is represented as a graph



# Knowledge graphs

- A KG defines:
  - entities
  - attributes
  - types
  - relations
  - (provenance, sometimes)
  - and more
    - external links
    - homepages
    - features
    - etc.



# Knowledge graphs

`dbpedia:Ann_Arbor,_Michigan`

`rdfs:label`

Ann Arbor, Michigan <sup>(en)</sup>

`rdfs:comment`

Ann Arbor is a city in the U.S. state of Michigan and the county seat of Washtenaw County. The 2010 census recorded its population to be 113,934, making it [...]

`dbpedia-prop:areaCode`

734

`dbpedia-prop:populationTotal`

113934 (xsd:integer)

`dbpedia-prop:aprHighF`

59.600000 (xsd:double)

`dbpedia-prop:isPartOf`

[dbpedia:Washtenaw County, Michigan](#)

`dbpedia-prop:timezone`

[dbpedia:Eastern Daylight Time](#)

`owl:sameAs`

[nyt:Ann Arbor, Michigan](#)

[freebase:Ann Arbor, Michigan](#)

[...]

`rdf:type`

[dbpedia-owl:City](#)

[wikidata:Q515](#)

[...]

is `dbpedia-owl:birthPlace` of

[dbpedia:Eric Betzig](#)

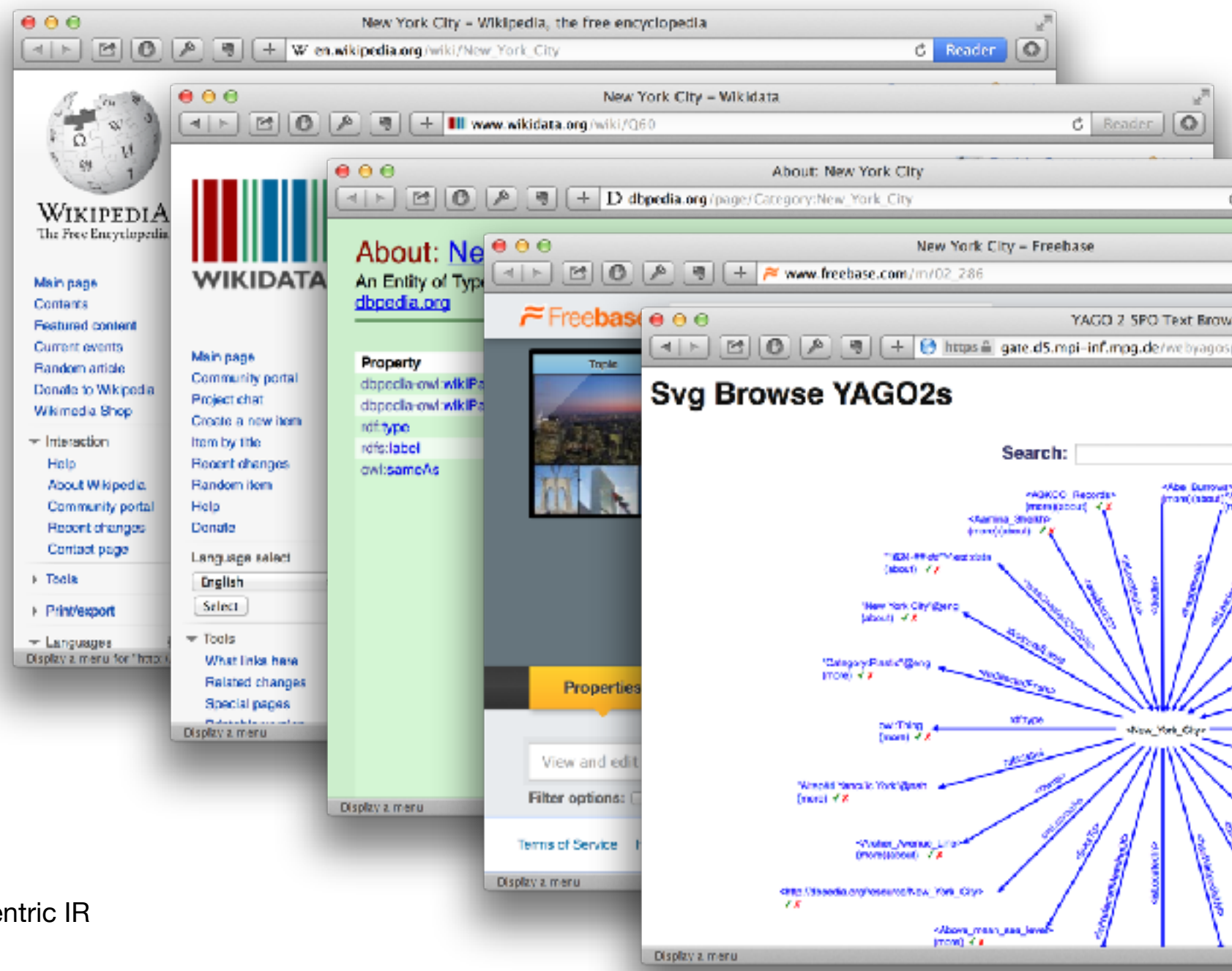
[...]

[...]



# Popular (semi)structured data sources

- Wikipedia
- Wikidata
- DBpedia
- Freebase
- YAGO



# Freebase

- Initially seeded from high-quality open data
  - then maintained mainly by community
- Harvested from many sources
  - Wikipedia, MusicBrainz, and others.
- Acquired by Google in 2010 (GKG)
  - now in read-only mode
- See <http://www.freebase.com/>



# DBpedia

- Extract structured information from Wikipedia
  - infoboxes, categories, and more
  - crowd-sourced community effort
- Open source
  - written in Scala, Java and VSP
  - Virtuoso Universal Server Operating system
- See <http://dbpedia.org/About>

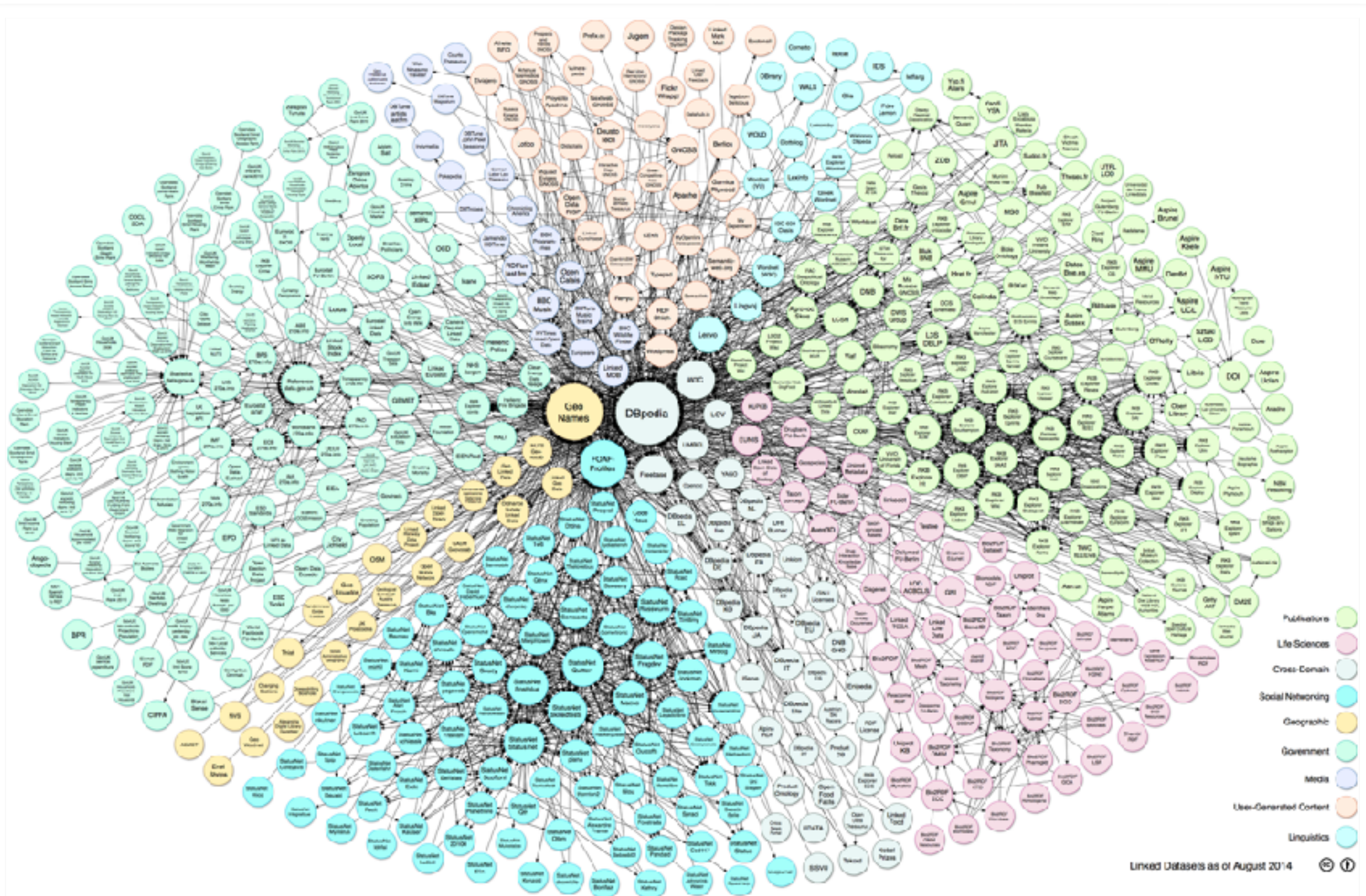
# Wikidata

- Structured information from Wikipedia
  - infoboxes, categories, interlanguage links, and more
  - crowd-sourced community effort
  - “As of December 2015, according to Wikimedia statistics, half of the information in Wikidata is unsourced, another 30% is labeled as having come from Wikipedia.”
- See <http://wikidata.org/>

# YAGO

- Accuracy manually evaluated
  - confirmed accuracy of 95%
  - relations annotated with confidence values
- Anchored in Time and Space
  - Thematic domains (e.g. "music" or "science")
- Based on wikipedia, includes WordNet, and GeoNames
- See <http://www.mpi-inf.mpg.de/yago-naga>

# Linking Open Data (LOD)?





# RDFa, microdata

- schema.org, sitemaps.org
  - used by Google, Bing, Yandex, Yahoo!, IPTC, etc.

The image displays four overlapping screenshots of web pages, each illustrating the use of RDFa or microdata for structured data. The first screenshot (top-left) is from IMDb, showing the title 'The Wire (TV Series 2002–2008)', a rating of 9.6/10, and a description. The second screenshot (middle-left) is from eBay, showing a listing for 'Logitech Revue' with a price range of \$99.99 to \$190.00. The third screenshot (middle-right) is from Ticketmaster, showing a list of 'Washington Huskies Mens Basketball' tickets. The fourth screenshot (bottom-right) is from iSaveurs, showing a recipe for 'Tarte Tatin' with a 45-minute cooking time and a link to the recipe page.

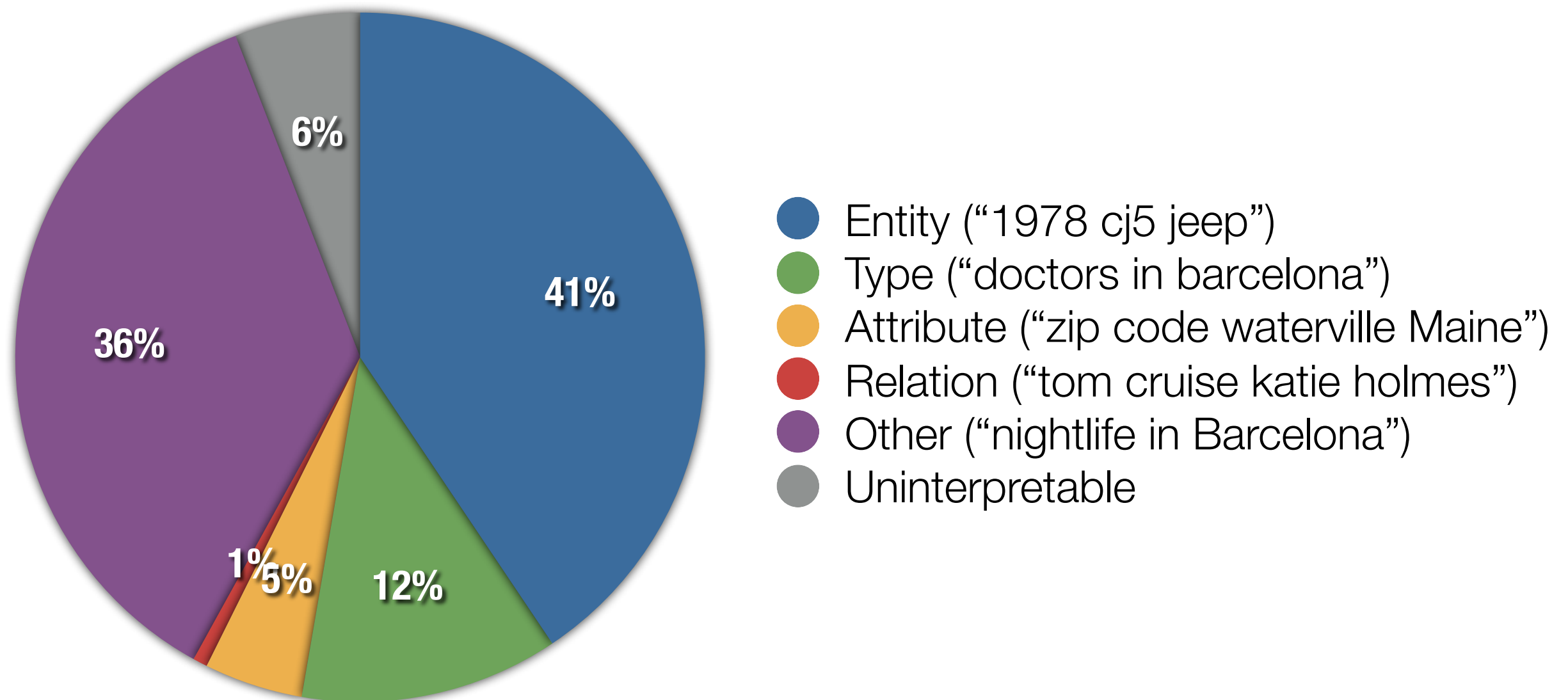
**The Wire (TV Series 2002–2008) - IMDb**  
[www.imdb.com/title/tt0306414/](http://www.imdb.com/title/tt0306414/) [ +? ]  
★★★★★ Rating: 9.6/10 – 44,375 votes  
Baltimore drug scene, seen through the eyes of drug dealers, and law enforcement.  
Starring Dominic West, John Doman, Deirdre Lovejoy.

**Logitech Revue 097855070906 | eBay**  
[www.ebay.com/ctg/Logitech-Revue-/97019743](http://www.ebay.com/ctg/Logitech-Revue-/97019743) [ +? ]  
★★★★★ from 51 users - \$99.99 to \$190.00  
eBay: The Logitech Revue is a media streamer with Google TV, which serves as a complete entertainment system. With its Ethernet interface, this Logitech ...

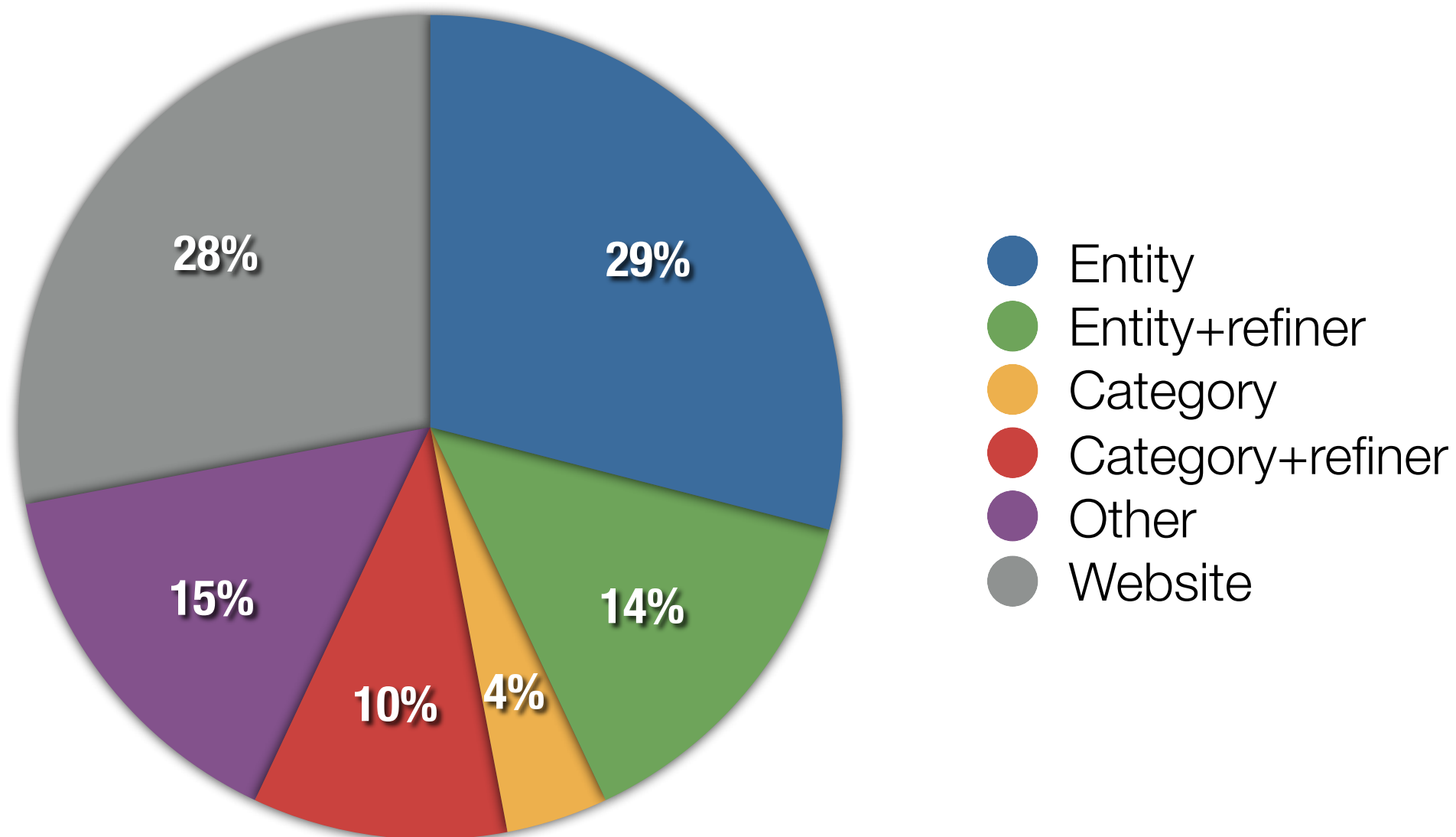
**Washington Huskies Mens Basketball tickets, and ... - Ticketmaster**  
[www.ticketmaster.ca/Washington-Huskies-Mens-Basketball-tickets/art...](http://www.ticketmaster.ca/Washington-Huskies-Mens-Basketball-tickets/art...) [ +? ]  
Results 1 - 10 of 19 – Find and buy Washington Huskies Mens Basketball ...  
Sat 12 Nov Washington Huskies Mens ... - Alaska Airlines Arena at ...  
Sun 13 Nov Washington Huskies Mens ... - Alaska Airlines Arena at ...  
Mon 14 Nov Washi

**Recette Tarte Tatin - testée et approuvée - calorie et ... - iSaveurs**  
[www.isaveurs.com/recette/recette\\_tart...](http://www.isaveurs.com/recette/recette_tart...) - Translate this page [ +? ]  
45 mins  
il y a 1 jour – Recette de cuisine gourmande - Tarte Tatin - pour virginie63 :  
J'adore j'adore, ...  
[http://www.isaveurs.com/recette/recette\\_tarte\\_tatin.php](http://www.isaveurs.com/recette/recette_tarte_tatin.php).

# Distribution of web search queries [Pound et al. 2010]



# Distribution of web search queries [\[Lin et al. 2011\]](#)





# Entity Linking/Retrieval

The screenshot shows a Google search for "ann arbor". The search bar at the top contains "ann arbor" and a magnifying glass icon. Below the search bar, there are tabs for "All", "Flights", "Maps", "News", "Images", "More", "Settings", and "Tools". The "All" tab is selected. Below the tabs, it says "About 234,000,000 results (0.56 seconds)".

The search results are as follows:

- Destination Ann Arbor**  
<https://www.visitannarbor.org/>  
Destination Ann Arbor allows you to discover things to do in Ann Arbor and surrounding area. Host a convention, plan an event, research hotels, & more!  
[Ann Arbor](#) · [Why Choose Ann Arbor?](#) · [Ann Arbor Events](#) · [Ann Arbor Art Fair](#)
- Ann Arbor, Michigan - Wikipedia**  
[https://en.wikipedia.org/wiki/Ann\\_Arbor,\\_Michigan](https://en.wikipedia.org/wiki/Ann_Arbor,_Michigan)  
Ann Arbor is a city in the U.S. state of Michigan and the county seat of Washtenaw County. The 2010 census recorded its population to be 113,934, making it the ...  
[Washtenaw County, Michigan](#) · [Pioneer High School](#) · [Huron High School](#) · [Mayors](#)
- The City of Ann Arbor**  
<https://www.a2gov.org/>  
June 11, 2018 - At approximately 11:30 a. m. on Sunday, June 10, 2018, the City of Ann Arbor was notified of a manhole in the University of Michigan ...

Below the search results is a section titled "Things to do in Ann Arbor" with four cards:

- Nichols Arboretum**  
Wooded park with trails & a peony
- Ann Arbor Hands-On Museum**  
Interactive learning locale for kids
- Matthaei Botanical Gardens**  
Gardens, conservatory & gift
- University of Michigan Museum...**  
Modern environs for diverse collections

Below the "Things to do" section is a link: [Ann Arbor travel guide](#)

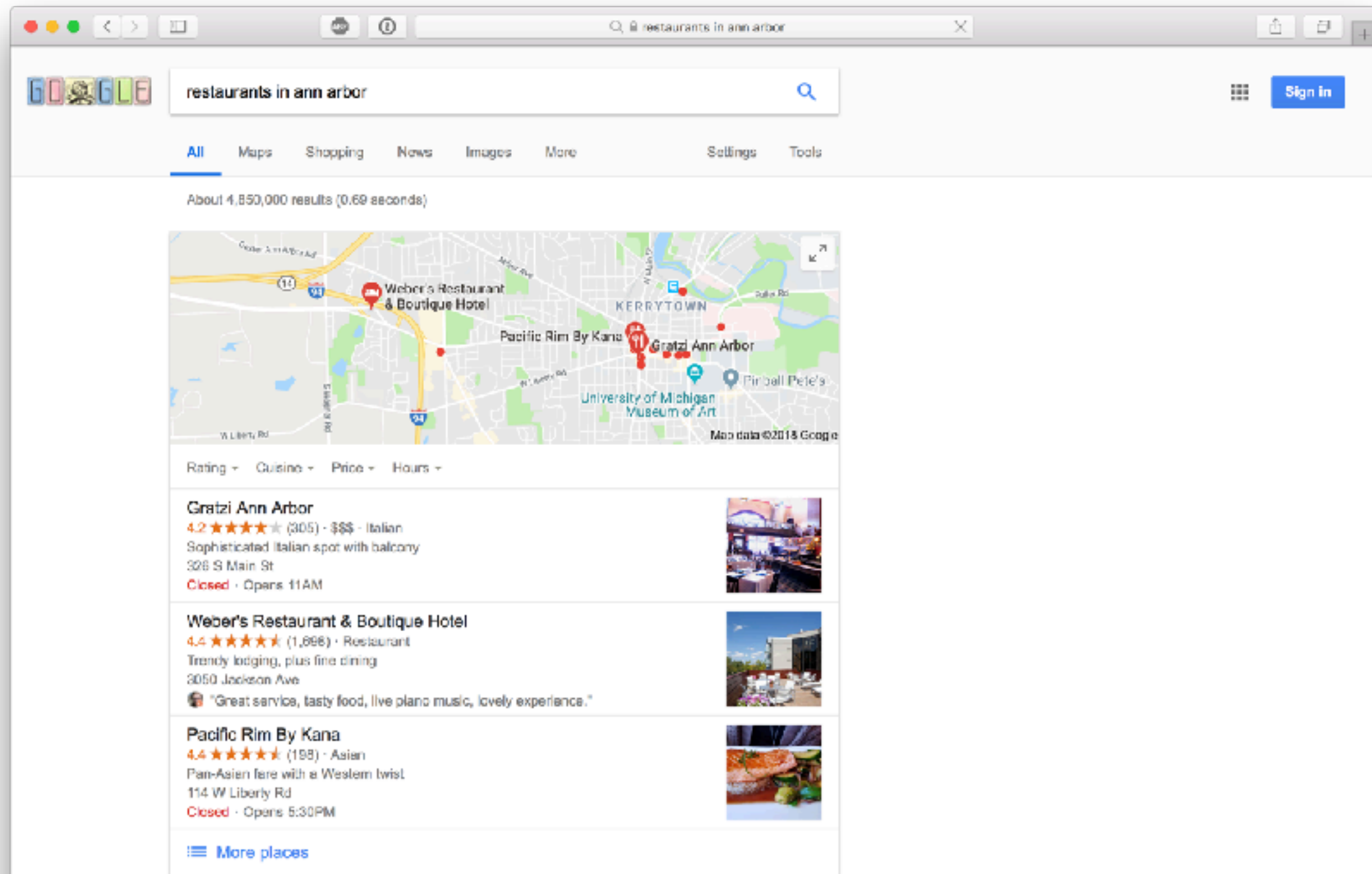
At the bottom of the search results is a news snippet:

**Police discuss recent break-ins, sex assault reports in Ann Arbor ...**  
[www.mlive.com/news/ann-arbor/index.ssf/.../police\\_address\\_slew\\_of\\_break-i.html](http://www.mlive.com/news/ann-arbor/index.ssf/.../police_address_slew_of_break-i.html)  
May 9, 2018 - ANN ARBOR, MI - The reports are alarming, but police say a recent string of break-ins in Ann Arbor - two involving sexual assault - aren't ...

On the right side of the search results is a knowledge panel for "Ann Arbor". It includes:

- A photo of a city street and a map of Ann Arbor.
- Ann Arbor**  
City in Michigan
- Ann Arbor is a city west of Detroit, in the Midwestern state of Michigan. It's home to the sprawling University of Michigan, known for its research programs. The University of Michigan Museum of Art displays works from around the globe and spanning centuries. Science-focused attractions in the city include the Museum of Natural History and the Ann Arbor Hands-On Museum, with kid-friendly interactive exhibits.
- Elevation: 840'
- Weather: 63°F (17°C), Wind NE at 5 mph (8 km/h), 59% Humidity
- Local time: Saturday 8:46 AM
- Population: 120,782 (2016)
- Area code: [Area code 734](#)
- Plan a trip**
  - [Ann Arbor travel guide](#)
  - 3-star hotel averaging \$191
  - 1 h 52 min flight, from \$371
- Colleges and Universities: [University of Michigan](#), [MORE](#)
- Did you know: Ann Arbor is the sixth-largest municipality in Michigan by population (113,934). [wikipedia.org](http://wikipedia.org)
- People also search for [View 10+ more](#)

# Entity Linking/Retrieval



## The 10 Best Ann Arbor Restaurants 2018 - TripAdvisor

[https://www.tripadvisor.com/Restaurants-g29556-Ann\\_Arbor\\_Michigan.html](https://www.tripadvisor.com/Restaurants-g29556-Ann_Arbor_Michigan.html)

Pacific Rim By Kana. 345 Reviews. \$\$\$\$; Asian. The Chop House - Ann Arbor. 335 Reviews. \$\$\$\$; American, Steakhouse. Gandy Dancer. 694 Reviews. \$\$\$\$; American, Seafood. Vinology. 245 Reviews.

Best Restaurants in Ann Arbor ... - Vegan Restaurants in Ann Arbor · Sava's · Isalita

# Entity Linking/Retrieval

The screenshot shows a Google search interface with the query "who won the nobel prize and is from ann arbor michigan". The search results are displayed in a list format. The first result is a snippet from a news article about Eric Betzig winning the Nobel Prize in chemistry in 2014. Below this, there are several search results from various sources, including the Detroit Free Press, The Detroit News, and Wikipedia, all mentioning Eric Betzig and his connection to Ann Arbor, Michigan.

who won the nobel prize and is from ann arbor michigan

About 780,000 results (0.56 seconds)

**Eric Betzig** and two other scientists won science's top prize for their "development of super-resolved fluorescence microscopy." A scientist who grew up in Ann Arbor won the Nobel Prize in chemistry today for developing microscopy technology to see extremely tiny particles more clearly than ever. Oct 8, 2014

[Ann Arbor native Eric Betzig wins Nobel Prize - Detroit Free Press](https://www.freep.com/story/news/local/michigan/2014/10/08/ann-arbor-nobel/16899395/)  
<https://www.freep.com/story/news/local/michigan/2014/10/08/ann-arbor-nobel/16899395/>

About this result Feedback

[Ann Arbor native Eric Betzig wins Nobel Prize - Detroit Free Press](https://www.freep.com/story/news/local/michigan/2014/10/08/ann-arbor-eric-nobel/16899395/)  
<https://www.freep.com/story/news/local/michigan/2014/10/08/ann-arbor-eric-nobel/16899395/>  
Oct 8, 2014 - Eric Betzig and two other scientists won science's top prize for their "development of super-resolved fluorescence microscopy." A scientist who grew up in Ann Arbor won the Nobel Prize in chemistry today for developing microscopy technology to see extremely tiny particles more clearly than ever.

[Ann Arbor native wins Nobel Prize for developing new high-powered ...](https://www.mlive.com/news/ann-arbor/index.../ann_arbor_native_wins_nobel_pr.ht...)  
[https://www.mlive.com/news/ann-arbor/index.../ann\\_arbor\\_native\\_wins\\_nobel\\_pr.ht...](https://www.mlive.com/news/ann-arbor/index.../ann_arbor_native_wins_nobel_pr.ht...)  
Oct 8, 2014 - Ann Arbor native wins Nobel Prize for developing new ... In 1996, Betzig returned to Michigan to work at his father's Chelsea-based company.

[1 winner of Nobel Prize in chemistry from Michigan - The Detroit News](http://www.detroitnews.com/story/news/world/2014/10/08/1-winner-nobel/16898615/)  
[www.detroitnews.com/story/news/world/2014/10/08/1-winner-nobel/16898615/](http://www.detroitnews.com/story/news/world/2014/10/08/1-winner-nobel/16898615/)  
Oct 8, 2014 - 1 winner of Nobel Prize in chemistry from Michigan. Ann Arbor — One of three winners of the Nobel Prize in chemistry is originally from Michigan. Eric Betzig's biography says he was born in Ann Arbor.

[List of University of Michigan faculty and staff - Wikipedia](https://en.wikipedia.org/wiki/List_of_University_of_Michigan_faculty_and_staff)  
[https://en.wikipedia.org/wiki/List\\_of\\_University\\_of\\_Michigan\\_faculty\\_and\\_staff](https://en.wikipedia.org/wiki/List_of_University_of_Michigan_faculty_and_staff)  
The University of Michigan has 8,200 faculty members and roughly 38,000 employees which ... Won the 1980 Nobel Prize in economics for his econometric models ... Kenneth Boulding, noted economist and faculty member 1949–1967; Richard Brauer Accepted a position at University of Michigan in Ann Arbor in 1948.  
Notable faculty: Nobel ... • Notable faculty: past and ... • MacArthur Foundation ...

[Kip S. Thorne, Winner of 2017 Nobel Prize in Physics, Has U-M ...](#)

# Entity Linking/Retrieval

The image shows a screenshot of a Google search results page. The search bar at the top contains the text "UK EU relationships". Below the search bar, the results are displayed. The first result is from Wikipedia, titled "Foreign relations of the United Kingdom - Wikipedia". The second result is from BBC News, titled "Britain and the EU: A long and rocky relationship - BBC News". Below these, there is a section titled "Top stories" which contains a result from ABC News titled "UK Unveils Brexit Plan Calling for Close New EU Relationship". At the bottom, there is a link to "More for UK EU relationships" and another result from Robert Schuman Foundation titled "European Union - United Kingdom relations".

Google

UK EU relationships

Sign in

All News Images Videos Shopping More Settings Tools

About 55,300,000 results (0.80 seconds)

**Foreign relations of the United Kingdom - Wikipedia**  
[https://en.wikipedia.org/wiki/Foreign\\_relations\\_of\\_the\\_United\\_Kingdom](https://en.wikipedia.org/wiki/Foreign_relations_of_the_United_Kingdom) ▼  
The diplomatic foreign relations of the United Kingdom are conducted by the Foreign and ... The UK has been a member state of the European Union (and a member of its predecessors) since 1973, but in 2016 a referendum triggered as a ...  
[History](#) · [Major international disputes](#) ... · [Sovereignty disputes](#)

**Britain and the EU: A long and rocky relationship - BBC News**  
[www.bbc.com/news/uk-politics-26515129](http://www.bbc.com/news/uk-politics-26515129) ▼  
Apr 1, 2014 - Britain and the EU: A long and rocky relationship. The United Kingdom's relationship with the EU - or, in political parlance, "Europe" - has long been one of the most divisive, emotive issues in British politics.

**Top stories**

**UK Unveils Brexit Plan Calling for Close New EU Relationship**  
[ABC News](#) · 3 hours ago

→ [More for UK EU relationships](#)

**European Union - United Kingdom relations**  
[www.robert-schuman.eu/en/european-union-united-kingdom-relations](http://www.robert-schuman.eu/en/european-union-united-kingdom-relations) ▼  
The UK general election on 7th May 2015 will be decisive. ... Foundation presents the complicated relations the UK entertains with its European neighbours. 0.

**Great Britain's relationship with Europe - BRIT POLITICS**

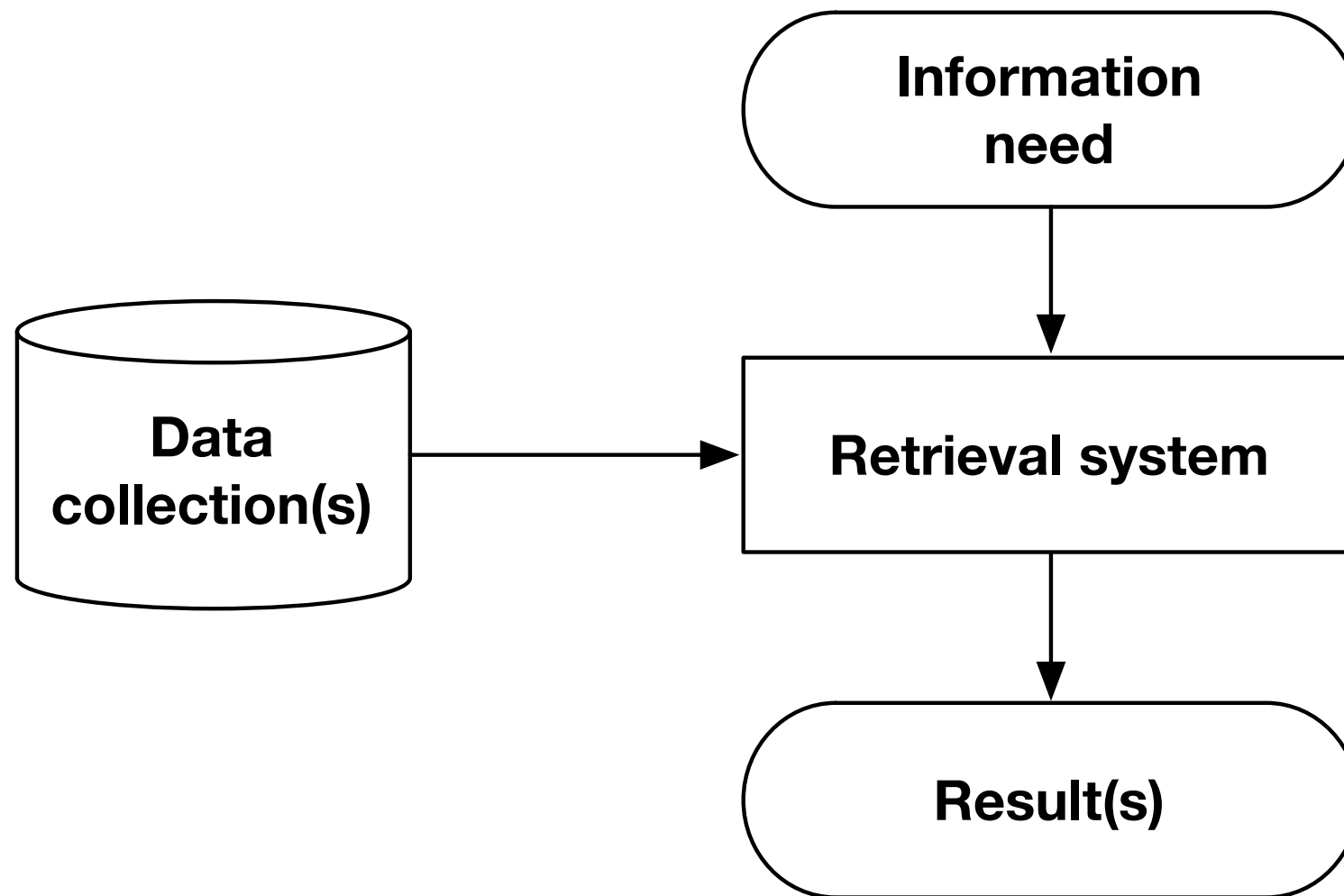
Display a menu

# Today's focus

How to use KGs to improve information access.

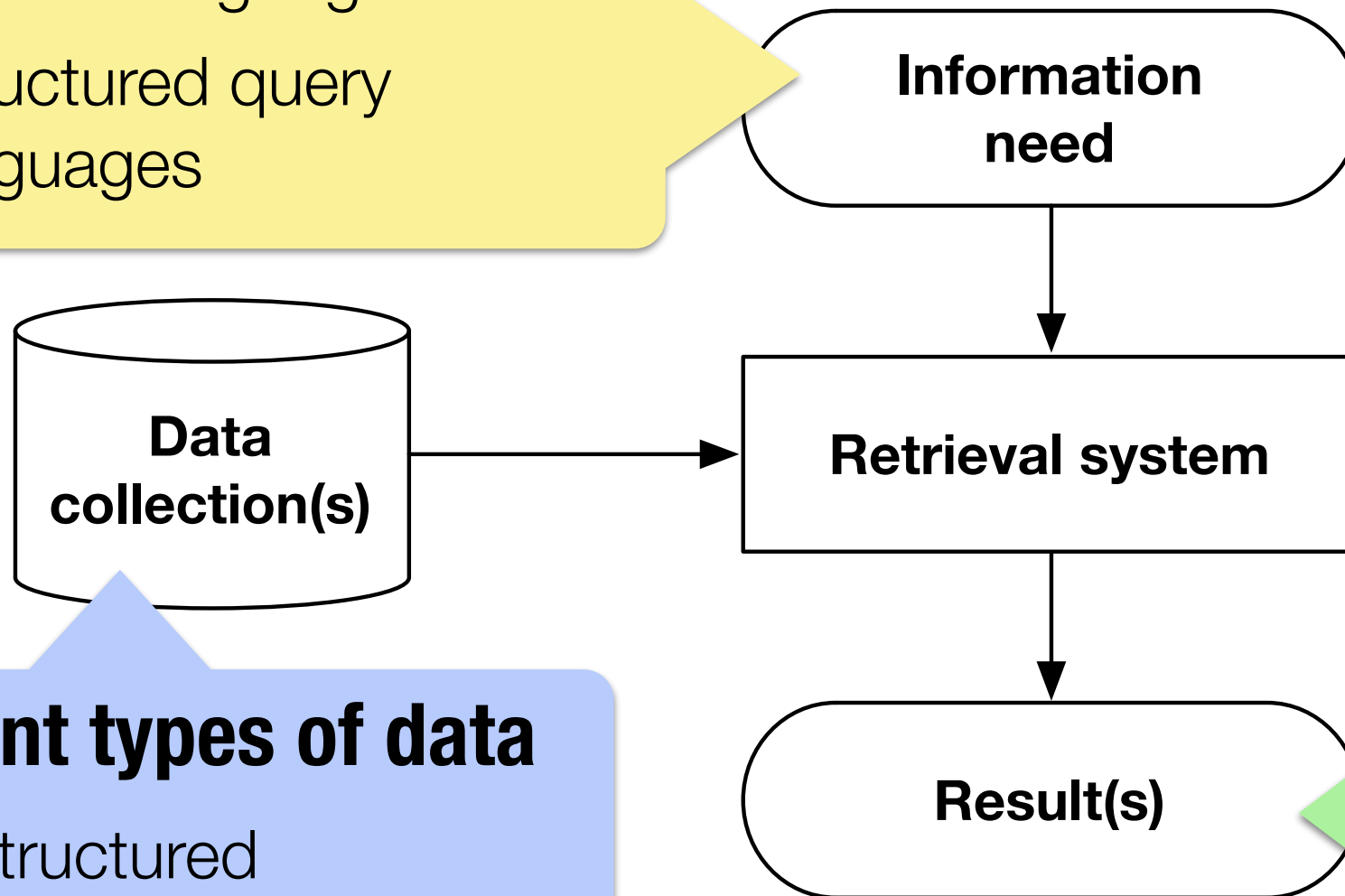


# Birds-eye view



## Many ways to express

- Keyword
- Keyword++
- Natural language
- Structured query languages



## Different types of data

- Unstructured
- Semistructured
- Structured

## Result format

- Ranked list
- Tuples
- (Sub)graphs
- Natural language



# Menu

<b>13:30 - 13:45</b>	Introduction
<b>13:45 - 14:15</b>	Part 1 – Entity linking
<b>14:15 - 15:00</b>	Part 2 – Entity Representation and Retrieval
<b>15:00 - 15:30</b>	Coffee break
<b>15:30 - 16:30</b>	Part 3 – Utilizing KGs in Text-centric IR
<b>16:30 - 17:00</b>	Discussion and wrap-up