

CS54701: Information Retrieval

Question Answering

5 April, 2016

Prof. Chris Clifton



Web Search in 2020?

The web, it is a changing.

What will people do in 2020?

- Type key words into a search box?
- Use the Semantic Web?
- Speak to your computer with natural language search?
- Use social or “human powered” search?



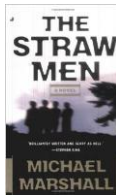


Getting information



The common person's view? [From a novel]

"I like the Internet. Really, I do. Any time I need a piece of shareware or I want to find out the weather in Bogota ... I'm the first guy to get the modem humming. But as a source of information, it sucks. You got a billion pieces of data, struggling to be heard and seen and downloaded, and anything I want to know seems to get trampled underfoot in the crowd."



Michael Marshall. *The Straw Men*. HarperCollins,



"Information retrieval"



- The name "information retrieval" is standard, but as traditionally practiced, it's not really right
- All you get is document retrieval, and beyond that the job is up to you



The future?

- Some scattered ideas from the corporate world

Courtesy Chris Manning



Google (2014-2015) What's been happening?

- “Mobilegeddon” (Apr 21, 2015):
 - “Mobile friendliness” as a major ranking signal
- “Pigeon” update (July 2014):
 - More use of distance and location in ranking signals
- “App Indexing” (Android, iOS support May 2015)
 - Search results can take you to an app
- Why?
 - About half of all searches are now from mobile
 - Making/wanting good changes, but obvious self-interest in trying to keep people using mobile web rather than apps



Google What's been happening? 2014

- New search index at Google:
“Hummingbird”
 - <http://www.forbes.com/sites/roberthof/2013/09/26/google-just-revamped-search-to-handle-your-long-questions/>
- Answering long, “natural language” questions better
 - Partly to deal with spoken queries on mobile
- More use of the Google Knowledge Graph
 - Concepts versus words



What's been happening

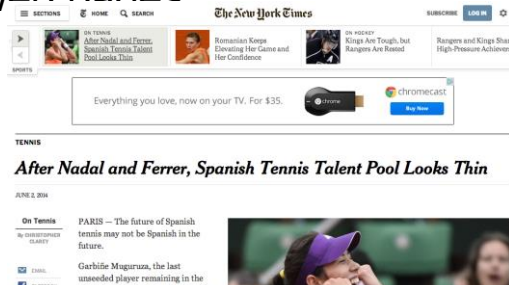
- Google Knowledge Graph
- Facebook Graph Search
- Bing's Satori
- Things like Wolfram Alpha

Common theme: Doing graph search over structured knowledge rather than traditional text search



What's been happening

- More semi-structured information embedded in web pages
 - schema.org



```
275 <p class="byline-column">
276   On Tennis
277   <p class="byline">By
278   itemtype="http://schema.org/Person"
279   itemid="http://topics.nytimes.com/top/reference/timestopics/people/c/christopher_clarey/index.html">
280   <a
href="http://topics.nytimes.com/top/reference/timestopics/people/c/christopher_clarey/index.html" rel="author"
title="More Articles by CHRISTOPHER CLAREY">
name="Christopher Clarey" itemprop="name">CHRISTOPHER CLAREY</span>
</p>
```



What's been happening

- Move to mobile favors a move to speech which favors "natural language information search"
 - Will we move to a time when over half of searches are spoken?





Towards intelligent agents

Two goals

- Things not strings
- Inference not search



Two paradigms for question answering

- Text-based approaches
 - TREC QA, IBM Watson
- Structured knowledge-based approaches
 - Apple Siri, Wolfram Alpha, Facebook Graph Search

(And, of course, there are hybrids, including some of the above.)

At the moment, structured knowledge is back in fashion, but it may or may not last



Example from Fernando Pereira (GOOG)



painkillers that don't thin blood × Search

painkillers that don't thin blood
painkillers that don't cause constipation
painkillers that don't cause nausea
painkillers that don't upset stomach frequent query
painkillers that don't

About 89,300 results (0.14 seconds) [Advanced search](#)

painkillers that don't upset stomach × Search

About 29,700 results (0.15 seconds) [Advanced search](#)

► [Symptoms of Crohn's](#) www.crohnsnline.com Do You Know the Signs of Crohn's? Read About Symptoms and More Now. Sponsored link

[Best Pain Reliever, Over the Counter Pain Relievers, Prescription ...](#)
For **stomach upset**, eating or drinking milk before you take a painkiller can help. ... **Don't** expect **painkillers** to relieve all your pain, but the best pain ...
www.healthblurbs.com/best-pain-reliever-over-the-counter-pain-relievers-prescription-analgesic-painkillers/ - Cached - Similar

[Why do painkillers make your stomach hurt? - Yahoo! Answers](#)
Aug 30, 2008 ... **stomach upset**, reflux/indigestion, or if severe ulcers ... I often take **painkillers** FOR **stomach** aches lol. **Don't** do this again. 2 years ago ...
answers.yahoo.com > Health > Other - Health - Cached - Similar

[How are painkillers bad for you? - Apr 13, 2010](#)
[What effect do painkillers have on you? - Sep 30, 2009](#)
[What's the difference between OTC painkillers? \(Advil, Aleve\) ... - Nov 19, 2008](#)
[Is it bad to take painkillers on an empty stomach? - Aug 20, 2008](#)
[More results from answers.yahoo.com »](#)

[Phys Ed: Does Ibuprofen Help or Hurt During Exercise? - NYTimes.com](#)
Sep 1, 2009 ... When are ibuprofen and other anti-inflammatory **painkillers** justified? ... Can't take NSAIDS due to **upset stomach**. — bonemri ... Perhaps part of the problem is that you **don't** always have the option to rest your injury if ...
well.blogs.nytimes.com/.../phys-ed-does-ibuprofen-help-or-hurt-during-exercise/ - Cached - Similar

class negation synonyms

About 29,700 results (0.15 seconds) [Advanced search](#)

[Symptoms of Crohn's](#)
Sponsored link


www.crohnsnline.com Do You Know the Signs of Crohn's? Read About Symptoms and More Now.

[Best Pain Reliever. Over the Counter Pain Relievers, Prescription ...](#)
 For **stomach upset**, eating or drinking milk before you take a painkiller can help. ... **Don't** expect **painkillers** to relieve all your pain, but the best pain ...
www.healthblurbs.com/best-pain-reliever-over-the-counter-pain-relievers-prescription-analgesic-painkillers/ - Cached - Similar

[Why do painkillers make your stomach hurt? - Yahoo! Answers](#)
 Aug 30, 2008 ... **stomach upset**, reflux/indigestion, or if severe ulcers ... I often take **painkillers** FOR **stomach** aches lol. **Don't** do this again. 2 years ago ...
answers.yahoo.com > Health > Other - Health - Cached - Similar

[How are painkillers bad for you? - Apr 13, 2010](#)
[What effect do painkillers have on you? - Sep 30, 2009](#)
[What's the difference between OTC painkillers? \(Advil, Aleve ... - Nov 19, 2008](#)
[Is it bad to take painkillers on an empty stomach? - Aug 20, 2008](#)
[More results from answers.yahoo.com »](#)

[Phys Ed: Does Ibuprofen Help or Hurt During Exercise? - NYTimes.com](#)
 Sep 1, 2009 ... When are ibuprofen and other anti-inflammatory **painkillers** justified? ... Can't take NSAIDs due to **upset stomach**. — bonemri ... Perhaps part of the problem is that you **don't** always have the option to rest your injury if ...
well.blogs.nytimes.com/.../phys-ed-does-ibuprofen-help-or-hurt-during-exercise/ - Cached - Similar



Related concepts may not match question

About 19,200 results (0.21 seconds) [Advanced search](#)

[TYLENOL® Official Site](#)
Sponsored link

Tylenol.com Pain Relief from TYLENOL. Get Information and Coupons Here.
[Head & Body Pain - Arthritis Pain - Sinus - Cold & Flu](#)

[Ovarian hyperstimulation syndrome \(OHSS\): Treatments and drugs ...](#)
 To ease abdominal discomfort, take over-the-counter **painkillers** such as acetaminophen (**Tylenol**) others) or ibuprofen (Advil, Motrin, others). ...
www.mayoclinic.com/.../DSECTION=treatments-and-drugs - Cached - Similar

tylenol ⇒ painkiller



Text can identify synonyms

painkiller "adverse effects include" stomach

Search

About 266,000 results (0.14 seconds)

Advanced search

[Painkiller Comparison Chart](#)

Oct 31, 2008 ... Chart showing prescription and non-prescription **painkillers** and what they are used for. ... menstrual pain, fever, Common **adverse effects include**: nausea, ... asthma,

upset stomach not for last pregnancy trimester. ...
www.disabled-world.com/.../painkiller-chart.shtml - Cached - Similar

[\[PDF\] List of Painkillers and what they are used for: Over the Counter ...](#)

File Format: PDF/Adobe Acrobat - [Quick View](#)

Common **adverse effects include**: nausea, dyspepsia, gastrointestinal ulceration/bleeding.

... **upset stomach**, not for last pregnancy trimester. Individuals ...
healingwithsoftlasers.com/.../Painkiller%20side%20effects%20chart%20.pdf

upset stomach ⇒ adverse effect (on stomach)



tylenol stomach

Search

About 1,390,000 results (0.28 seconds)

Advanced search

[Pain Relievers And Upset Stomach - Tylenol Extra Strength Pain ...](#)

Tylenol Extra Strength Pain Reliever Fever Reducer 100 Caplets - User Rating: 5 stars.

Review Summary: Taking the wrong pain reliever can cause you **stomach** ...

[www.epinions.com/Wellness & Beauty/Health Aids](http://www.epinions.com/Wellness&Beauty/HealthAids) - Cached - Similar

[Treatment: Pain: Merck Manual Home Edition](#)

TYLENOL has virtually no useful anti-inflammatory activity, does not affect the blood's ability to clot, and has almost no adverse effects on the **stomach** ...

www.merck.com/mmhe/sec06/ch078/ch078d.html - Cached - Similar

tylenol ⇒ no adverse effects (on stomach)
⇒ no upset stomach



This took us from Query

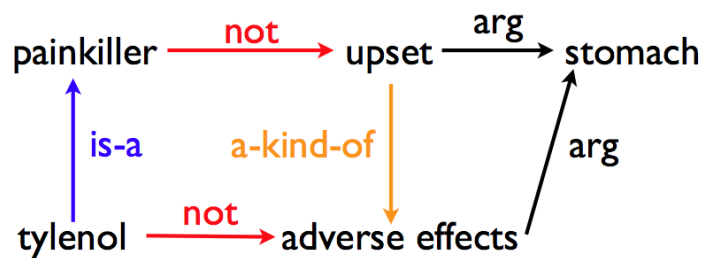
painkiller

upset

stomach



To Answer



“Things, not strings”

From	To	Requires
Term	Concept	Parsing, disambiguation, coreference
Term identity	Entailment	Concept relations
Co-occurrence	Syntactic relation	Document structure, parsing
Term index	Semantic index	Concept disambiguation, inference



Slides from Patrick Pantel (MSFT)

Structured Recommendations

RELATED MOVIES

-  Dreams
-  Ran
-  Dersu Uzala
-  Throne of Blood
-  Yojimbo
-  Stray Dog

Entity Detection

Seven Samurai

82,800,000 results

WEB IMAGES VIDEO SHOPPING BLOGS MORE

Also try: [seven samurai movie](#), [seven samurai remake](#), [more...](#)



Play trailer

Structured Data

[Seven Samurai \(1954\)](#)
[movies.yahoo.com](#)
Yahoo! B+ A Japanese farming village, constantly besieged and pillaged by an army of bandits, recruits seven independent... [more](#)

Running Time: 2 hr 40 min
 Directed by: [Akira Kurosawa](#)
 Starring: [Takashi Shimura](#), [Toshiro Mifune](#), [Yoshio Inaba](#), [Seiji Miyaguchi](#), ... [more](#)


Google How old is mariah carey

Web Images News Shopping Videos More Search tools

About 102,000,000 results (0.55 seconds)

45 years (March 27, 1970)
Mariah Carey, Age

Direct Answer



Madonna 56 years Nick Cannon 34 years Jennifer Lopez 45 years

Mariah Carey
Singer-songwriter

Structured Data

Listen now

Google Play Listen with free trial

Spotify Listen for free


Mariah Carey is an American singer, songwriter, record producer, and occasional actress. She rose to prominence after releasing her self-titled debut studio album Mariah Carey in 1990; it went multiplatinum ...

Born: March 27, 1970 (age 45), Huntington, NY
Height: 5' 9" (1.75 m)
Children: Moroccan Scott Cannon, Monroe Cannon
Spouse: Nick Cannon (m. 2008), Tommy Mottola (m. 1993–1998)

Songs

Without You	1993	Music Box
Hero	1993	Music Box
I Want to Know Wh...	2009	Memoirs of an I...
I'll Be There	1990	Mariah Carey
We Belong Together	2005	The Emancipatio...

Albums View 20+ more



Mariah Carey - Wikipedia, the free encyclopedia
en.wikipedia.org/wiki/Mariah_Carey - Wikipedia -
Mariah Carey was born on March 27, 1969 or 1970 in Huntington, New York. Her father, Alfred Roy, was of African American and Venezuelan (including Afro-Venezuelan) descent, while her mother, Patricia (Hickey), is of White Irish descent.
Nick Cannon - Tommy Mottola - Albums - Me, I Am Mariah... The Elusive ...

Nick Cannon & Mariah Carey Fighting: Split Caused By ...
hollywoodlife.com/.../nick-cannon-mariah-carey-fightin... - Hollywood Life -
Aug 22, 2014 - Nick Cannon and Mariah Carey announced their separation after six years of marriage, and now HollywoodLife.com has learned EXCLUSIVELY what caused the power couple to split up. Nick Cannon, 33, and Mariah Carey, 44, have separated after six years of marriage, and two beautiful children together.

Mariah Carey - Biography - Music Producer, Film Actress ...
www.biography.com/people/mariah-carey-9542177 - FYI -
Mariah Carey was born March 27, 1970, in Huntington, Long Island, New York, and began taking voice lessons at age four. At 18 she signed with Columbia ...

Mariah Carey Divorce Explained: Nick Cannon Cheating ...
www.celebritylundy.com/.../mariah-carey-divorce-nick-cannon-cheat... -
Aug 29, 2014 - Mariah Carey Divorce Explained: Nick Cannon Cheating and Paying For 23-Year Old Mistress Jasmine Sanders and Dancer Brittany Dailey.

Stanford University

Query Answering

Google how old is christopher manning

Web News Shopping Images Videos More Search tools

About 11,000,000 results (0.54 seconds)

48 years (September 18, 1965)
Christopher D. Manning, Age

Feedback

Christopher Manning, Stanford NLP - The Stanford NLP
nlp.stanford.edu/manning/ -
Mar 1, 2013 - **Chris Manning** works on systems and formalisms that can intelligently process and produce human languages. His research concentrates on ...

Rocchio algorithm - Wikipedia, the free encyclopedia
en.wikipedia.org/wiki/Rocchio_algorithm - Wikipedia -
From Wikipedia, the free encyclopedia **Christopher D. Manning**, Prabhakar Raghavan, Hinrich Schütze: An Introduction to Information Retrieval, page 181.
Algorithm - Time complexity - Usage - Limitations



But not always...

Google search results for "how old is Pandu Nayak".

Google search bar: how old is Pandu Nayak

Results: About 1,440,000 results (0.42 seconds)

Pandu Nayak
www.pandunayak.com/
About me. I am currently at Google, working on various aspects of Search Quality. I am particularly interested in query understanding and helping users ...

Pandu Nayak | LinkedIn
www.linkedin.com/pub/pandu-nayak/1/ab7/b20
Houston, Texas Area - Engineering Manager, Product Management at FMC Technologies
As a LinkedIn member, you'll join 250 million other professionals who are sharing connections, ideas, and opportunities. See who you and Pandu Nayak know ...

PANDU NAYAK profiles | LinkedIn
www.linkedin.com/pub/dir/PANDU/NAYAK
View the profiles of professionals named PANDU NAYAK on LinkedIn. There are 5 professionals named PANDU NAYAK, who use LinkedIn to exchange ...



Patrick Pantel talk (Then) Current experience

Bing search results for "jetbeam rrt-0".

Bing search bar: jetbeam rrt-0

Results: 1-10 of 6,600 results

RELATED SEARCHES

- JETBeam RRT 0 Review
- JETBeam Flashlights
- JETBeam RRT-0 R5
- JETBeam Raptor
- JETBeam M1X
- JETBeam
- RRT-0 R5
- 240 Lumens

ALL RESULTS

JETBeam RRT-0 R5 with Infinite Ramping LED Flashlight ...
Going Gear JETBeam RRT-0 R5 with Infinite Ramping LED Flashlight [jetbeamr0r5] - The popular RRT-0 has been updated to be an even more versatile flashlight. ...
goinggear.com/index.php?main_page=product_info&Path=14_22&products_id=438 - Mark as spam

Jetbeam RRT-0
Now In Stock! Model: RRT-0 (S2) Specially designed for Military, Law Enforcement, Self-defense, Hunting, Search & Rescue and General Outdoors The Rapid ...
www.jetbeamusa.com/products/RRT%2d0.html - Mark as spam

JETBeam RRT-0 Overview With Lots of Pictures
I got my JETBeam RRT-0 Raptor today. All I can say is to JETBeam! This thing is a ... PICTURES QUICKLY BEFORE MY HEAD EXPLODES!!! Ok... it didnt ...
323 replies since November 2009
www.candlepowerforums.com/vb/showthread.php?248375-JETBeam-RRT-0-Overview-With-Lots-of-... - Mark as spam

JETBeam Flashlights
Specification: Model: JETBeam RRT-0(R2) Flashlight; Specially designed for Military, Law Enforcement, Self-defense, Hunting, Search & Rescue and Outdoorsman
jetbeamblog.com - Mark as spam



Desired experience: Towards actions

Recognize entity in query

Actions easily accessible

Web Images Videos Shopping News Maps More | MSN Hotmail

bing MS Beta

jetbeam rrt-0

Web Videos More

ENTITY

JETBeam RRT-0 Flashlight (Product)

ACTIONS

Read Reviews

Watch Demo Video

Product Comparisons

Social Discounts

Find Locally

Buy Online

Price Predictions

RELATED SEARCHES

JETBeam RRT 0

Review

JETBeam Flashlights

ALL RESULTS

1-10 of 6,600 results - Advanced

JETBeam RRT-0 R5 with Infinite Ramping LED Flashlight

Going Gear JETBeam RRT-0 R5 with Infinite Ramping LED Flashlight [jetbeamrt0r5] - The popular RRT-0 has been updated to be an even more versatile flashlight, ... goinggear.com/index.php?main_page=product_info&cPath=14_22&products_id=438 Mark as spam

Jetbeam RRT-0

Now In Stock! Model: RRT-0 (S2) Specially designed for Military, Law Enforcement, arch & Rescue and General Outdoors The Rapid ... oducts/RR7%200.html Mark as spam

review With Lots of Pictures

1 Raptor today. All I can say is to JETBeam! This thing is ... BEFORE MY HEAD EXPLODES!! Ok... it didnt ... 323 replies since November 2009 www.candlepowerforums.com/vb/showthread.php?248375-JETBeam-RRT-0-Overview-With-Lots-of... Mark as spam

JETBeam Flashlights

Specification: Model: JETBeam RRT-0(R2) Flashlight. Specially designed for Military, Law Enforcement, Self-defense, Hunting, Search & Rescue and Outdoorsman jetbeamblog.com Mark as spam



Politician

Recognize entity in query

Actions easily accessible

Web Images Videos Shopping News Maps More | MSN Hotmail

bing MS Beta

Obama

Web Visual Search News Images Videos More

ENTITY

Barack Obama (President)

ACTIONS

Watch Weekly Address

Follow Social Updates

Read Biography

View Approval Ratings

Support Candidacy

RELATED SEARCHES

Barack Obama

Official Obama Website

www.BarackObama.com Respect. Empower. Include. Win. Join Barack Obama's campaign now.

Other ideas: obama barack bio - president obama website

Obama for America | 2012

Barackobama.com is the official re-election campaign website of President Barack Obama. Visit the site for the latest updates from the Obama campaign, 2012 election news ... www.barackobama.com Mark as spam

Obama - Wikipedia, the free encyclopedia

career - Legislative career ... Presidential campaigns

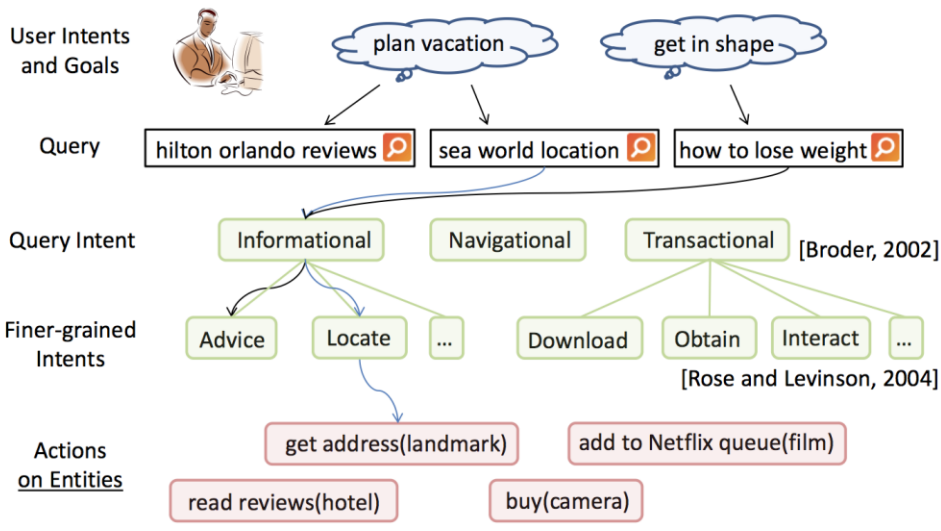
in Obama II (born August 4, 1961) is the 44th and current President of

ates. He is the first African American to hold the office. Obama ... rg/wiki/Obama Mark as spam

k Obama and other U.S. politicians by office, state, and branch of government



Actions vs. Intents

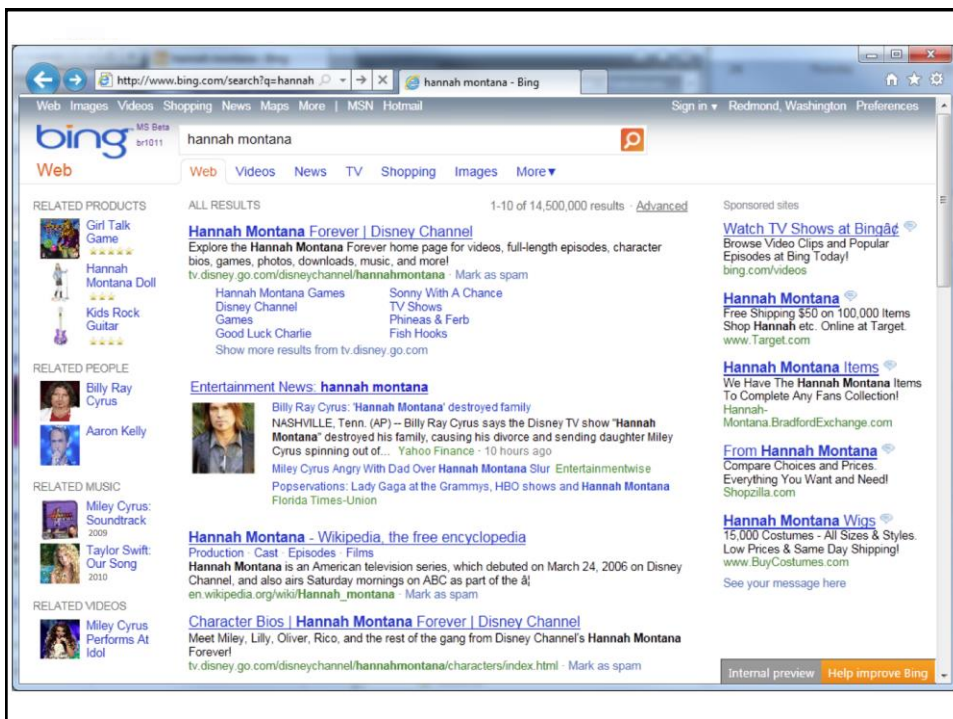
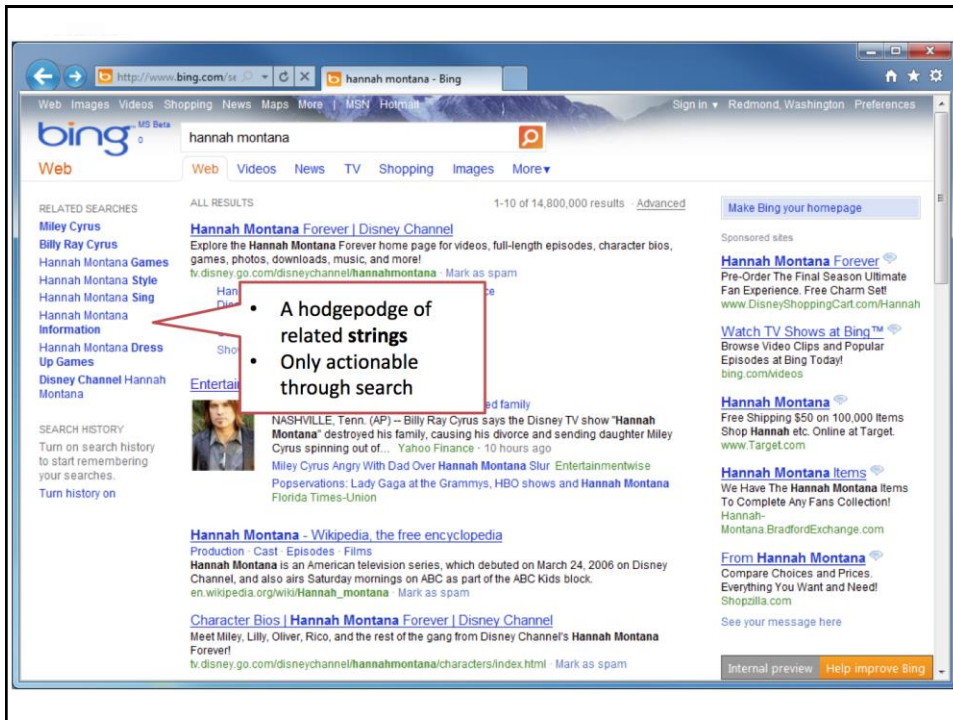


Learning actions from web usage logs

- Three months of us-en web logs
- Annotate with Freebase entities
- Keep queries with an entity in set of 21 types
- Filter out navigational queries
- Filter out clicked hosts that weren't clicked at least 100 times

2,164,579 (query, host) pairs over 3 months	235,385 entities	21 types
	129,088 contexts	58,123 hosts

get reviews	←	Orlando hotel reviews
read biography		Does Hope Solo have a boyfriend?
download software		Free Winzip download
watch shows online		watch family guy online



http://www.bing.com/search?q=hannah montana - Bing

Web Images Videos Shopping News Maps More | MSN Hotmail

Sign in Redmond, Washington Preferences

Big Wins

- Typed relations
- User Interface accesses structured data
- Click through experience can now leverage strongly-typed identifier

RELATED PRODUCTS

Girl Talk Game

Hannah Montana Doll

Kids Rock Guitar

RELATED PEOPLE

Billy Ray Cyrus

Aaron Kelly

RELATED MUSIC

Miley Cyrus Soundtrack

Taylor Swift Our Song

RELATED VIDEOS

Miley Cyrus Performs At Idol

Character Bios | [Hannah Montana Forever](#) | [Disney Channel](#)

Meet Miley, Lilly, Oliver, Rico, and the rest of the gang from Disney Channel's *Hannah Montana Forever*!

tv.disney.go.com/disneychannel/hannahmontana/characters/index.html - Mark as spam

Internal preview Help improve Bing

http://www.bing.com/search?q=hannah montana - Bing

Web Images Videos Shopping News Maps More | MSN Hotmail

Sign in Redmond, Washington Preferences

Big Wins

- Typed relations
- User Interface accesses structured data
- Click through experience can now leverage strongly-typed identifier
- Brokered Actions (one click conversions)

RELATED PRODUCTS

Girl Talk Game

Hannah Montana Doll

Kids Rock Guitar

RELATED PEOPLE

Billy Ray Cyrus

Aaron Kelly

RELATED MUSIC

Miley Cyrus Soundtrack

Taylor Swift Our Song

RELATED VIDEOS

Miley Cyrus Performs At Idol

[Add to Amazon Cart](#)

[Connect on Twitter](#)

[Play track](#)

[Hannah Montana Forever](#) | [Disney Channel](#)

[Hannah Montana Forever](#) home page for bios, games, photos, downloads, music, and more!

tv.disney.go.com/disneychannel/hannahmontana -

Hannah Montana Games

Sonny With A

Disney Channel

TV Shows

Phineas & Fe

Good Luck Charlie

Fish Hooks

Show more results from tv.disney.go.com

Entertainment News: [Hannah Montana](#)

Billy Ray Cyrus: 'Hannah Montana' de

NASHVILLE, Tenn. (AP) -- Billy Ray Cyrus says the Disney TV show 'Hannah Montana' destroyed his family, causing his divorce and sending daughter Miley Cyrus spinning out of ... Yahoo Finance - 10 hours ago

Miley Cyrus Angry With Dad Over [Hannah Montana Slur](#) Entertainmentwise

Poppersations: Lady Gaga at the Grammys, HBO shows and [Hannah Montana](#) Florida Times-Union

Montana.BradfordExchange.com

[From Hannah Montana](#)

Compare Choices and Prices. Everything You Want and Need! Shopzilla.com

[Hannah Montana Wigs](#)

15,000 Costumes - All Sizes & Styles. Low Prices & Same Day Shipping! www.BuyCostumes.com

See your message here

Internal preview Help improve Bing



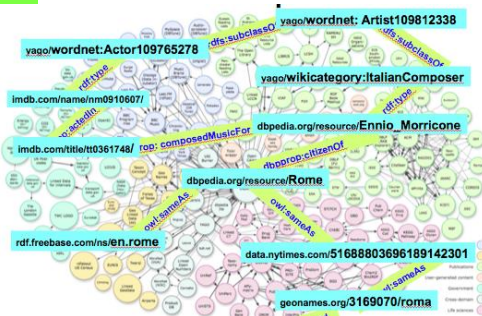
Incorporate structured info?

- and linked to a canonical reference
 - Freebase, dbPedia, Yago2, (WordNet)

http://.../wiki/Dollars_Triology
http://.../wiki/The_Good_the_Bad
http://.../wiki/Clint_Eastwood
http://.../wiki/Honorary_Academy

http://.../wiki/The_Good_the_Bad
<http://.../wiki/Metallica>
[http://.../wiki/Bellagio_\(casino\)](http://.../wiki/Bellagio_(casino))
http://.../wiki/Ennio_Morricone

http://.../wiki/Sergio_Leone
http://.../wiki/The_Good_the_Bad
http://.../wiki/For_a_Few_Dollars
http://.../wiki/Ennio_Morricone



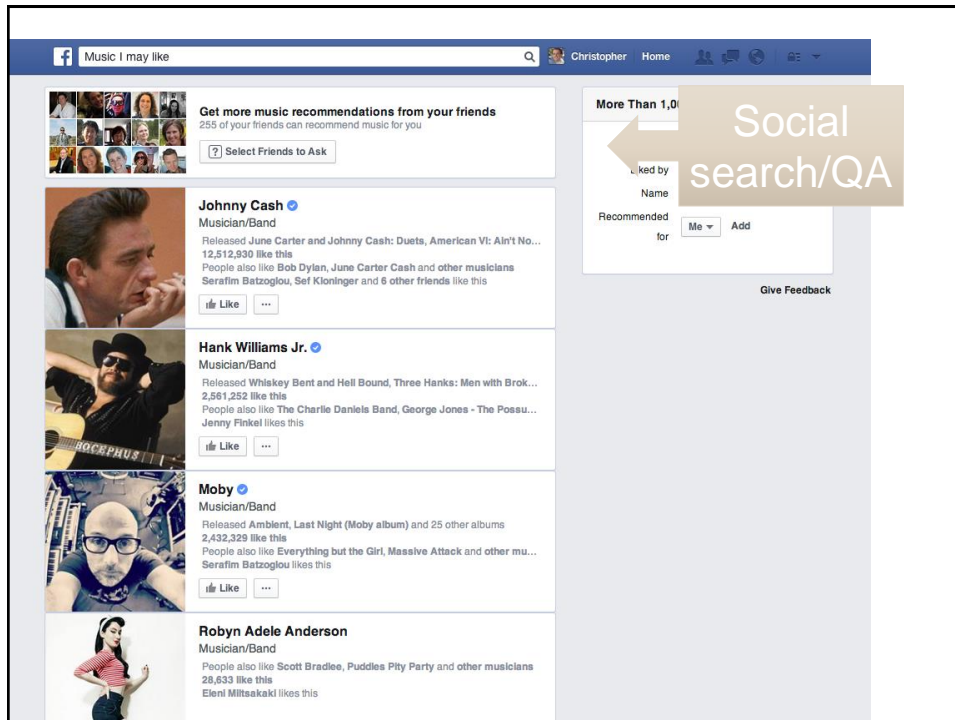
Facebook Graph Search

Search for people, places and things

- My friends
- Photos of my friends
- Restaurants nearby
- Games my friends play
- Music my friends like
- Photos I have liked

places

- Cities visited by my family
- Restaurants in San Francisco, California
- Indian restaurants liked by my friends from India
- Tourist attractions in Italy visited by my friends
- Restaurants in New York liked by Chefs
- Countries my friends have visited



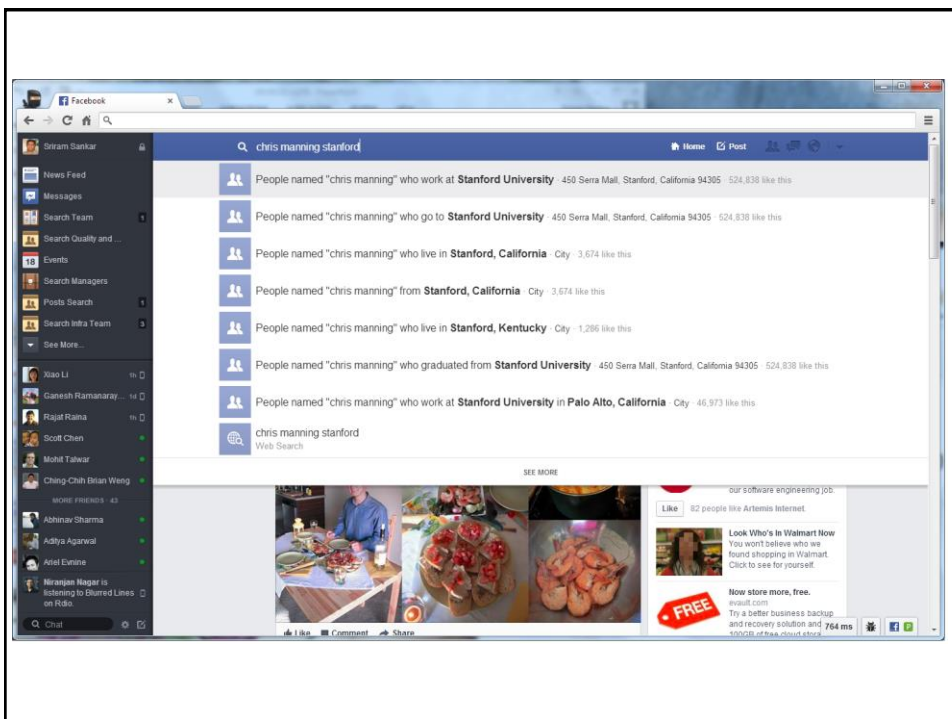
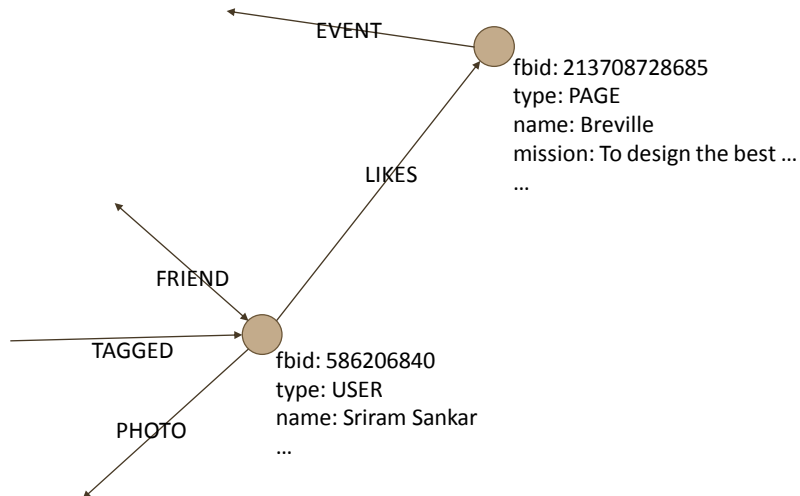
The Facebook Graph

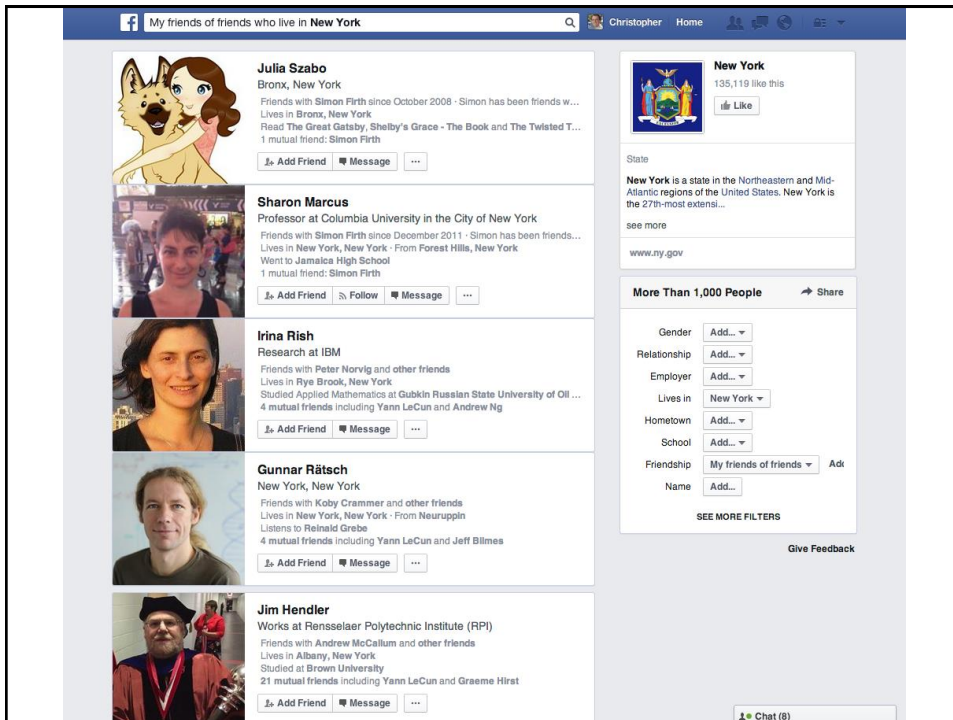
- Collection of entities and their relationships
- Entities (users, pages, photos, etc.) are *nodes*
- Relationships (friendship, checkins, tagging, etc.) are *edges*
- Nodes and edges have metadata
- Nodes have a unique id – the *fbid*





Facebook Graph Snippet

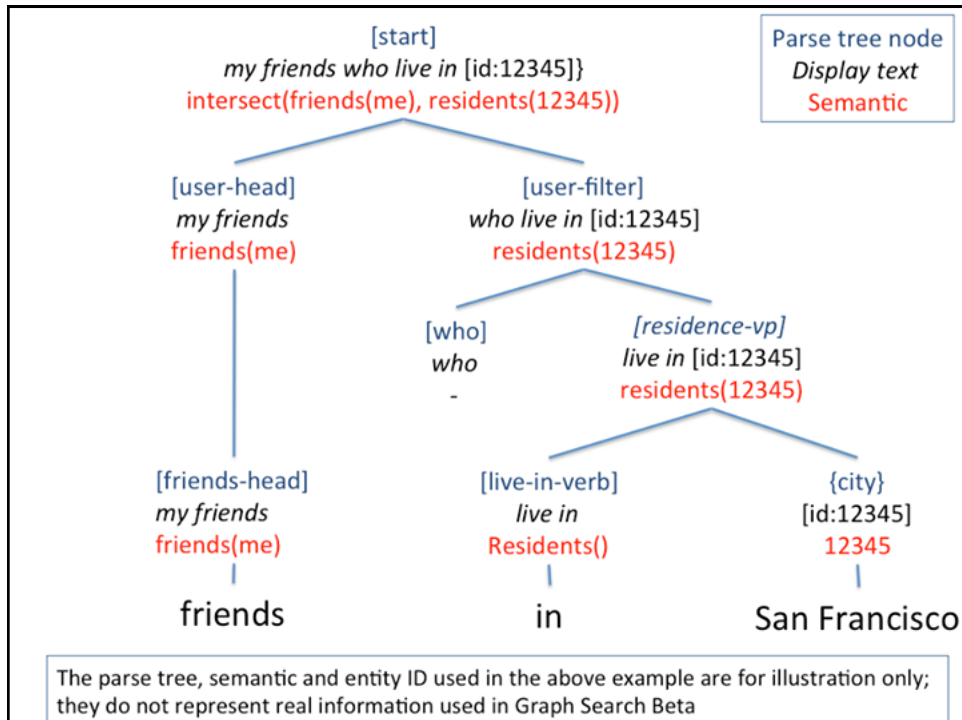




Facebook Graph Search

- Uses a weighted context free grammar (WCFG) to represent the Graph Search query language:
- [start] => [users] \$1
- [users] => my friend friends(me)
- [users] => friends of [users] friends(\$1)
- [users] => {user} \$1
- [start] => [photos] \$1
- [photos] => photos of [users] photos(\$1)
- A terminal symbol can be an entity, e.g., {user}, {city}, {employer}, {group}; it can also be a word/phrase, e.g., friends, live in, work at, members, etc. A parse tree is produced by starting from [start] and expanding the production rules until it reaches terminal symbols.

<https://www.facebook.com/notes/facebook-engineering/under-the-hood-the-natural-language-interface-of-graph-search/10151432733048920>
<http://spectrum.ieee.org/telecom/internet/the-making-of-facebooks-graph-search>



3 approaches to question answering: Knowledge-based approaches (Siri)

- Build a semantic representation of the query
 - Times, dates, locations, entities, numeric quantities
- Map from this semantics to query structured data or resources
 - Geospatial databases
 - Ontologies (Wikipedia infoboxes, dbPedia, WordNet, Yago)
 - Restaurant review sources and reservation services
 - Scientific databases
 - Wolfram Alpha



Text-based (mainly factoid) QA



- **QUESTION PROCESSING**
 - Detect question type, answer type, focus, relations
 - Formulate queries to send to a search engine
- **PASSAGE RETRIEVAL**
 - Retrieve ranked documents
 - Break into suitable passages and rerank
- **ANSWER PROCESSING**
 - Extract candidate answers (as named entities)
 - Rank candidates
 - using evidence from relations in the text and external sources

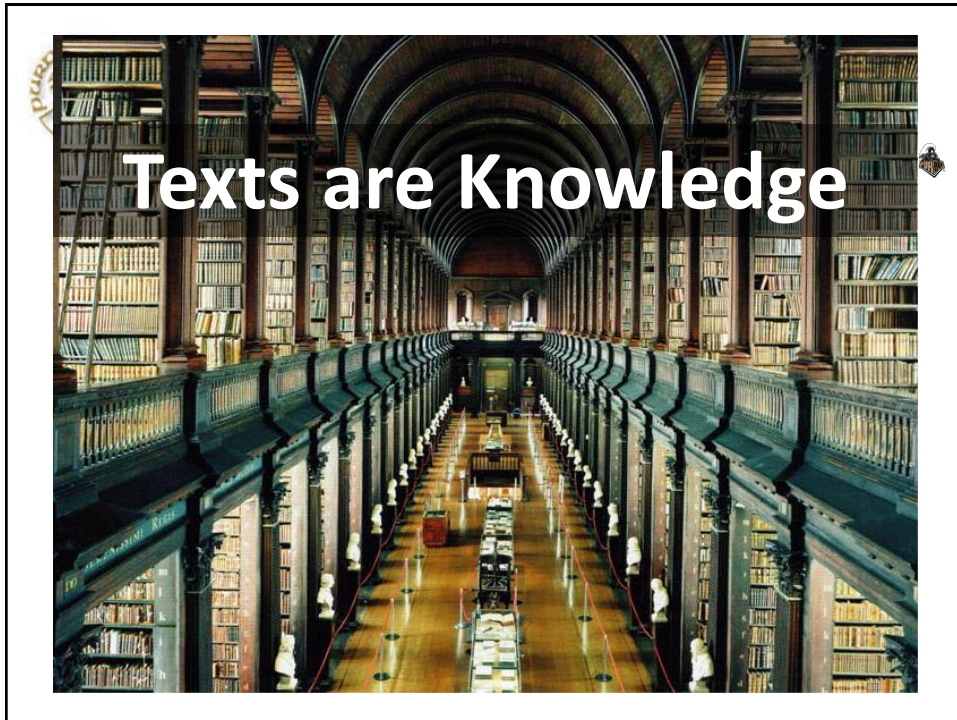


Hybrid approaches (IBM Watson)



- Build a shallow semantic representation of the query
- Generate answer candidates using IR methods
 - Augmented with ontologies and semi-structured data
- Score each candidate using richer knowledge sources
 - Geospatial databases
 - Temporal reasoning
 - Taxonomical classification

56



Is the goal to go from language to knowledge bases?

- For humans, going from the largely unstructured language on the web to actionable information is effortlessly easy
- But for computers, it's rather **difficult!**
- This has suggested to many that if we're going to produce the next generation of intelligent agents, which can make decisions on our behalf
 - Answering our routine email
 - Booking our next trip to Fijithen we still first need to construct **knowledge bases**
- To go *from languages to information*



Knowledge: Not just semantics but pragmatics

- Pragmatics = taking account of context in determining meaning
- Search engines are great because they inherently take into account pragmatics (“associations and contexts”)
 - [the national] → The National (a band)
 - [the national ohio] → The National - Bloodbuzz Ohio – YouTube
 - [the national broadband] → www.broadband.gov



Inference directly in text: Natural Logic (van Benthem 2008, MacCartney & Manning 2009)

- Q *Who is Beyoncé Knowles's husband?*
Q' *Beyoncé Knowles's husband is X.*

A *Beyoncé's marriage to rapper Jay-Z and portrayal of Etta James in Cadillac Records (2008) influenced her third album I Am... Sasha Fierce (2008).*





Task – Answer Sentence Selection



- Given a factoid question, find the sentence that
 - Contains the answer
 - Can sufficiently support the answer

Q

S₁

S₂

Scott Wen-tau Yih (ACL 2013) paper



Who won the best actor Oscar in 1973?



[Best Supporting Actor Oscar](#)
[Best Actor Oscar](#)
[Mister Roberts](#)
[Save the Tiger](#)

Jack Lemmon



John Uhler "Jack" Lemmon III was an American actor and musician. He starred in more than 60 films including *Som...* [en.wikipedia.org](#)

www.imdb.com

[Jack Lemmon - Wikipedia, the free encyclopedia](#)

Who won the best actor Oscar in 1973?

American actor and musician. He starred in more than 60 films including ...

Jack Lemmon - IMDb

www.imdb.com/name/nm0000493



Born Feb 08, 1925 - Died Jun 27, 2001 · [News](#) · [341 photos](#) · [Biography](#)
Actor: *The Apartment* (1960) · *Some Like It Hot* (1959) · *Glengarry Glen Ross* (1992) · *Grumpy Old Men* (1993). **Jack Lemmon's** father was the ...

Images of jack lemmon

bing.com/images



Spouse: *Felicia Fan* (1962 - 2001) · *Cynthia Stone* (1950 - 1956)
Children: *Chris Lemmon* · *Courtney Lemmon*
Buried: *Westwood Village Memorial Park Cemetery*
Awards: *Academy Award for Actor in a Leading Role* [+](#)

