Slides originally from:

- http://web.stanford.edu/class/cs276/

- Then modified by Don Patterson

Christopher Manning
Pandu Nayak

Introduction to

Information Retrieval

CS276: Information Retrieval and Web Search
Lecture 19: Web Question Answering

Web Search in 2020?

The web, it is a changing.

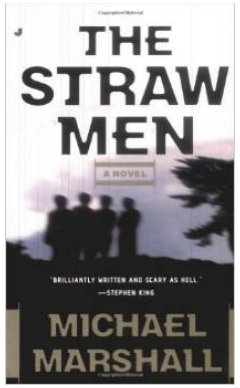
What will people do in 2020?

- 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, 2002.

"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

What do we know that's happening?

- Much of what is going on is in the products of companies, and there isn't exactly careful research explaining or evaluating it

Google
What's been happening? 2014–2015

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

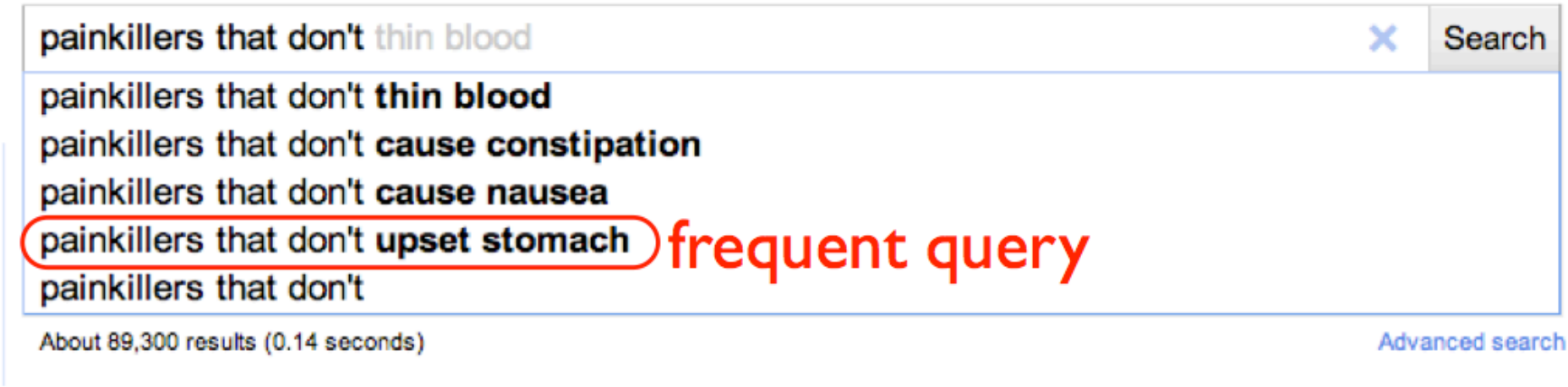
Two paradigms for question answering

- 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 upset stomach ✕ Search

About 29,700 results (0.15 seconds) Advanced search

Sponsored link

Symptoms of Crohn's
www.crohnsonline.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, Aleeve ... - 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

painkillers that don't upset stomach Search

About 29,700 results (0.15 seconds) Advanced search

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

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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

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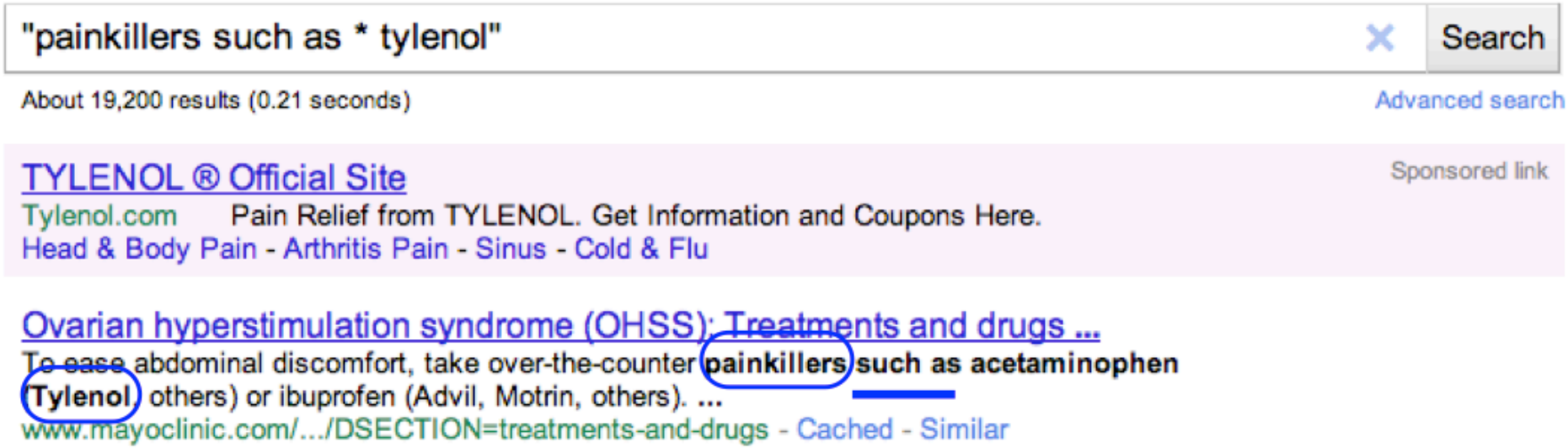
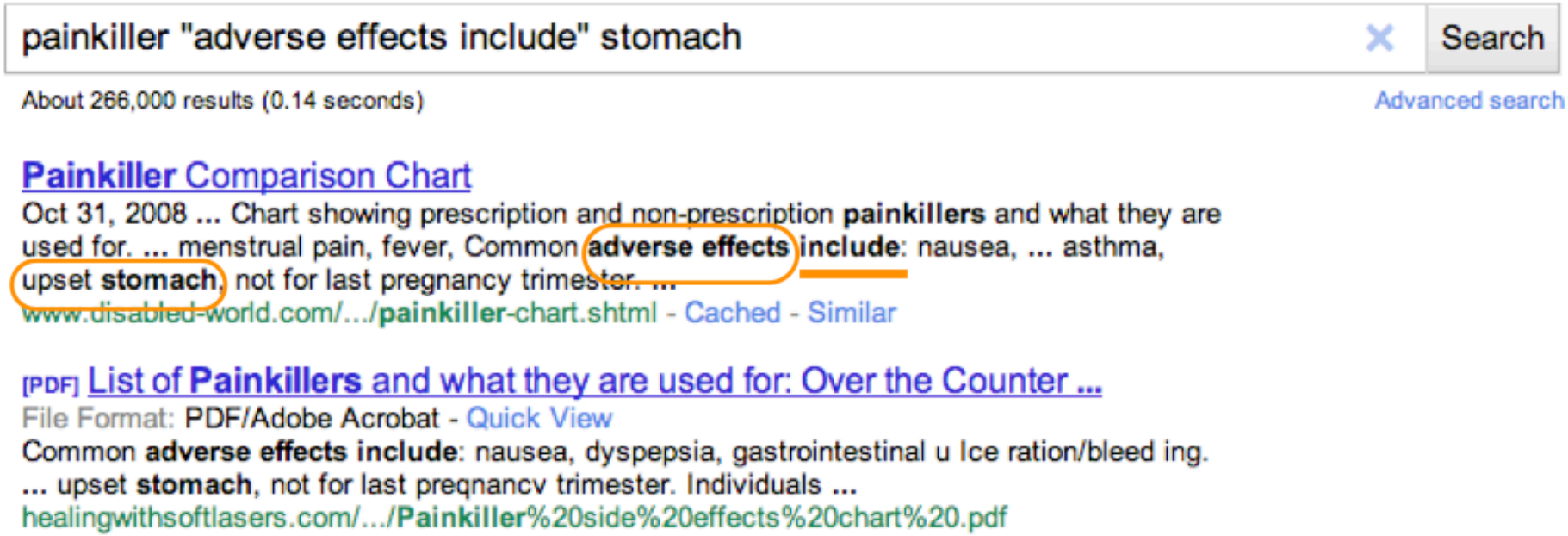
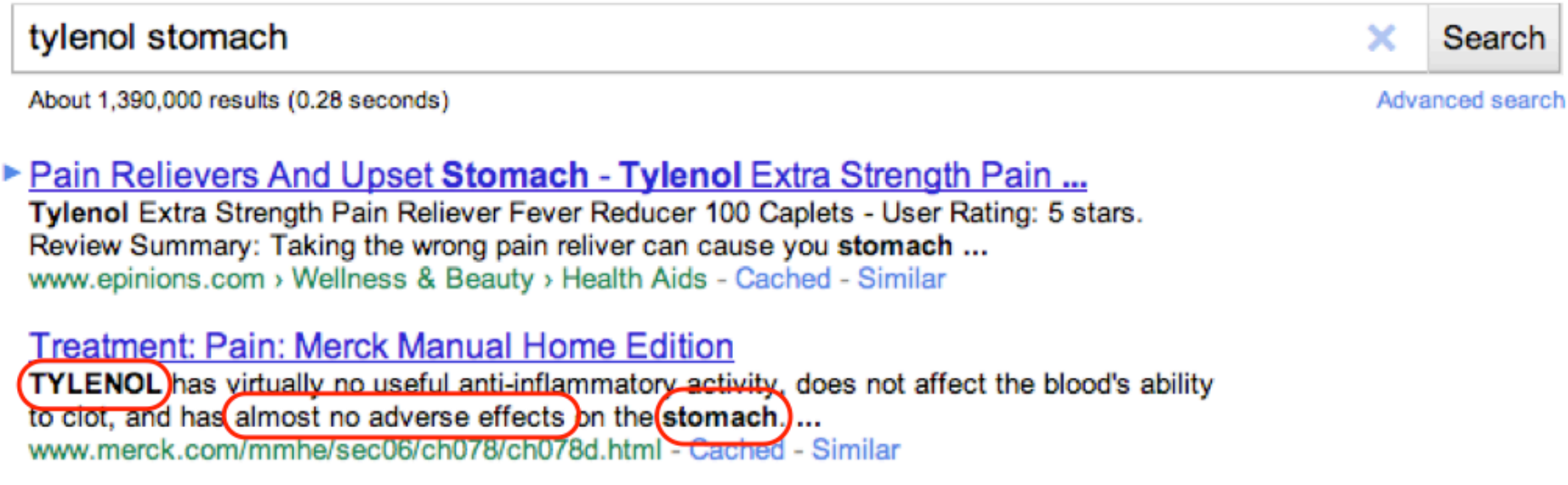
well.blogs.nytimes.com/.../phys-ed-does-ibuprofen-help-or-hurt-during-exercise/ - Cached - Similar



tylenol ⇒ painkiller



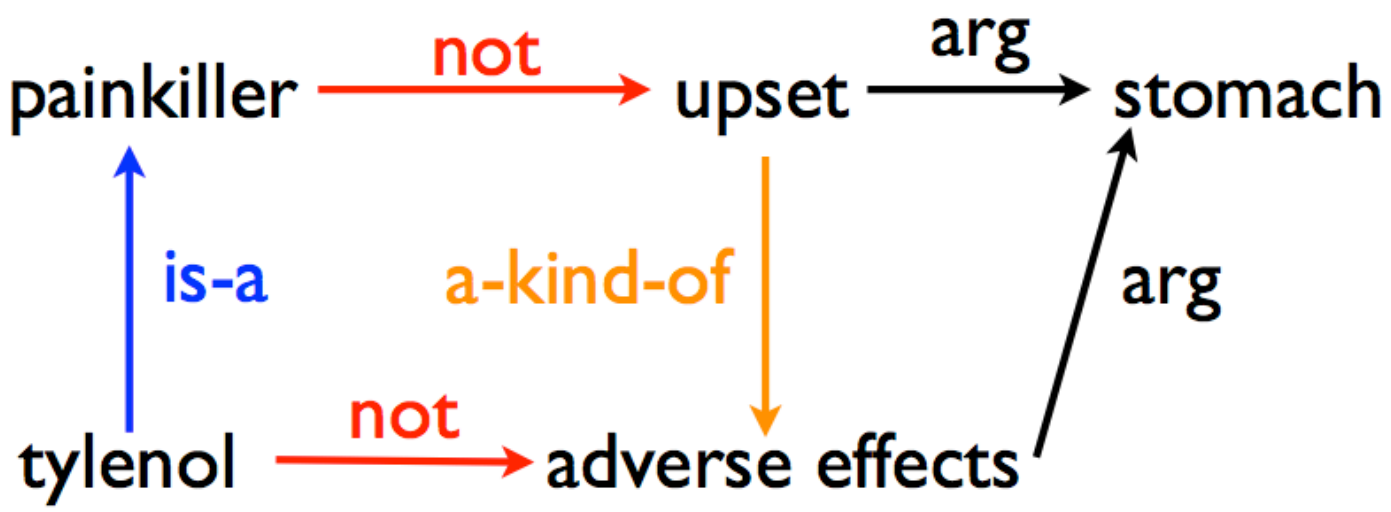
upset stomach ⇒ adverse effect (on stomach)



tylenol ⇒ no adverse effects (on stomach)

⇒ no upset stomach

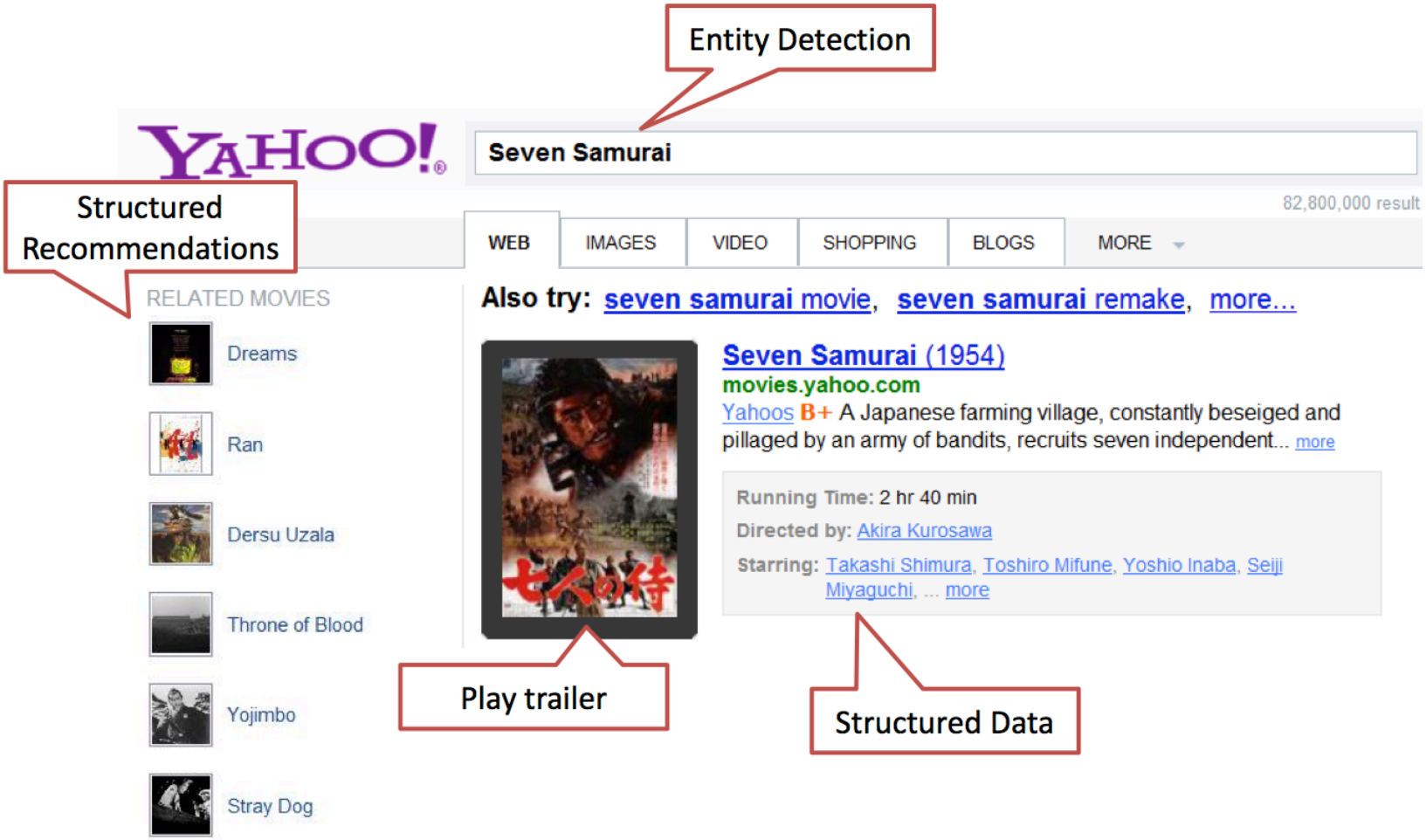
painkiller upset stomach

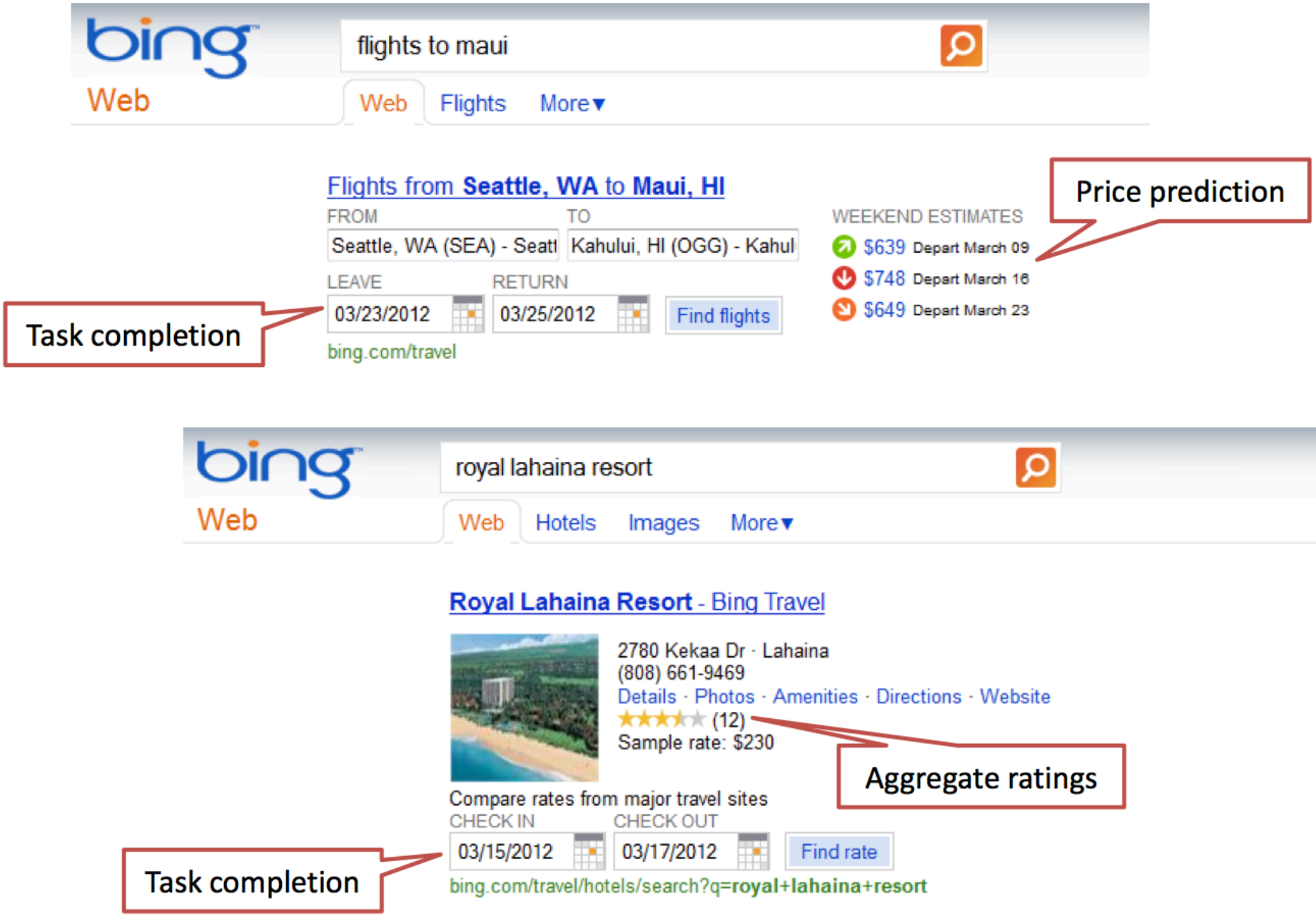

painkiller
not
upset
arg
stomach
is-a
a-kind-of
arg
tylenol
not
adverse effects

"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)

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Flights
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TO
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Kahului, HI (OGG) - Kahul
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RETURN
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03/25/2012
Find flights
bing.com/travel
WEEKEND ESTIMATES
$639 Depart March 09
$748 Depart March 16
$649 Depart March 23
Price prediction
Task completion
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Hotels
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Royal Lahaina Resort - Bing Travel
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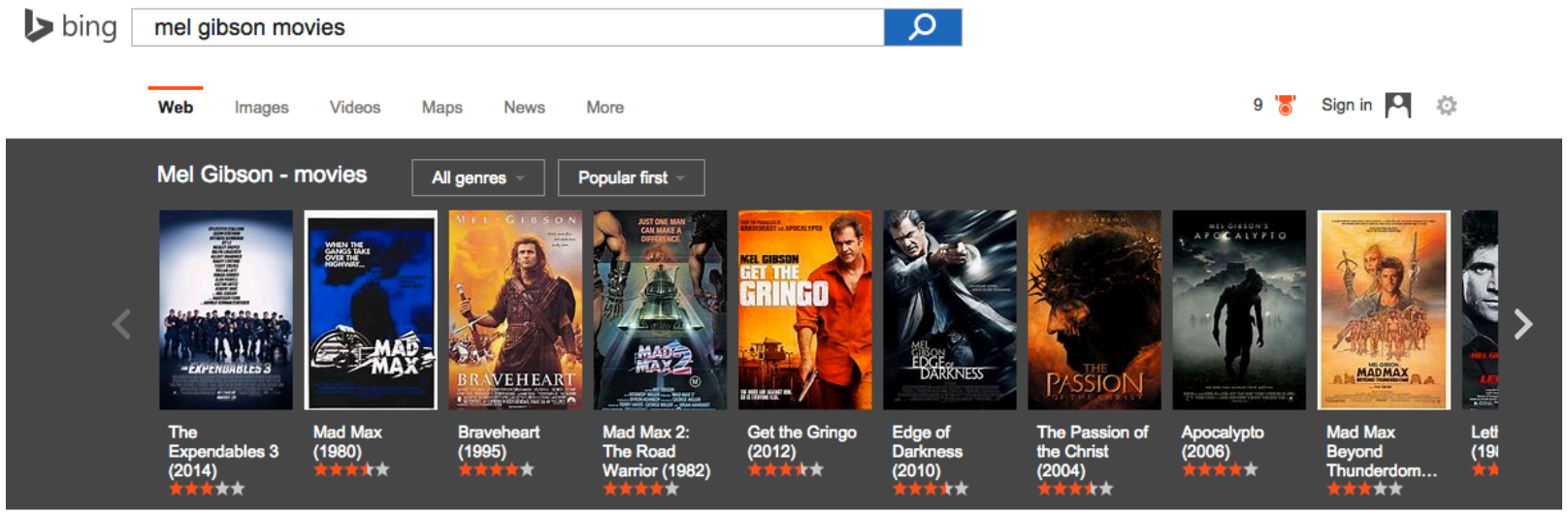
(808) 661-9469
Details · Photos · Amenities · Directions · Website
(12)
Sample rate: $230
Aggregate ratings
Compare rates from major travel sites
CHECK IN
CHECK OUT
03/15/2012
03/17/2012
Find rate
bing.com/travel/hotels/search?q=royal+lahaina+resort
Task completion



Mel Gibson - IMDb
www.imdb.com/name/nm0000154
Born Jan 03, 1956 · 59 years old · 368 photos
Mel Gibson, Actor: **Braveheart**. **Mel** Columcille Gerard **Gibson** was born January 3, 1956 in Peekskill, New York, USA, as the sixth of eleven children of Hutton **Gibson**, a ...
Biography · Awards · Films · News

Mel Gibson Movies | Movies.com
www.movies.com/actors/mel-gibson/mel-gibson-movies/p181347
50 rows · Get the full **list** of all **Mel Gibson movies**. See who they starred with and ...
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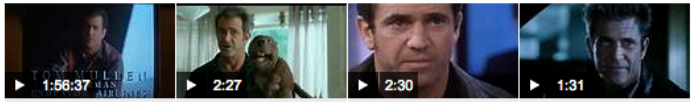
Videos of **mel gibson movies**
bing.com/videos



Ransom (1996) - Full Movie	'The Beaver' Trailer	Ransom Trailer HQ (1996)	Payback Trailer
YouTube	YouTube	YouTube	YouTube

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Mel Gibson - Wikipedia, the free encyclopedia
en.wikipedia.org/wiki/Mel_Gibson
Mel Colm-Cille Gerard **Gibson** AO (born January 3, 1956) is an American actor and filmmaker. He is most well known as an action hero, for roles such as Martin Riggs in ...
Early life · Career · Film work · Prospective films · Personal life

Mel Gibson filmography - Wikipedia, the free encyclopedia

Mel Gibson
American Actor

Mel Colm-Cille Gerard Gibson AO is an American actor and filmmaker. He is most well known as an action hero, for roles such as Martin Riggs in the Lethal Weapon buddy cop film series and Max Rockatansky in the first three films in the Ma... +

Wikipedia · IMDb · Facebook

Born: Jan 03, 1956 (age 59) · Peekskill

Height: 5' 10" (1.77 m)

Romance: Oksana Grigorieva · Oksana Pochepa

Spouse: Robyn Moore Gibson (1980 - 2011)

Children: Hannah Gibson (Daughter) · Christian Gibson (Son) · Edward Gibson (Son) · Louis Gibson (Son) · William Gibson (Son) +

Upcoming movies: Hacksaw Ridge

People also search for
See all (10+)

Oksana Grigorieva Former partner	Sylvester Stallone	Harrison Ford	Arnold Schwarzenegger	Robert Downey Jr.

Google How old is mariah carey manning@stanford.edu

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About 102,000,000 results (0.55 seconds)

45 years (March 27, 1970)

Mariah Carey, Age

Direct Answer

Madonna
56 years

Nick Cannon
Spouse
34 years

Jennifer Lopez
45 years

Feedback

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.celebdirtylaundry.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.

Mariah Carey

Structured Data

Singer-songwriter

Ads 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 ... Wikipedia

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

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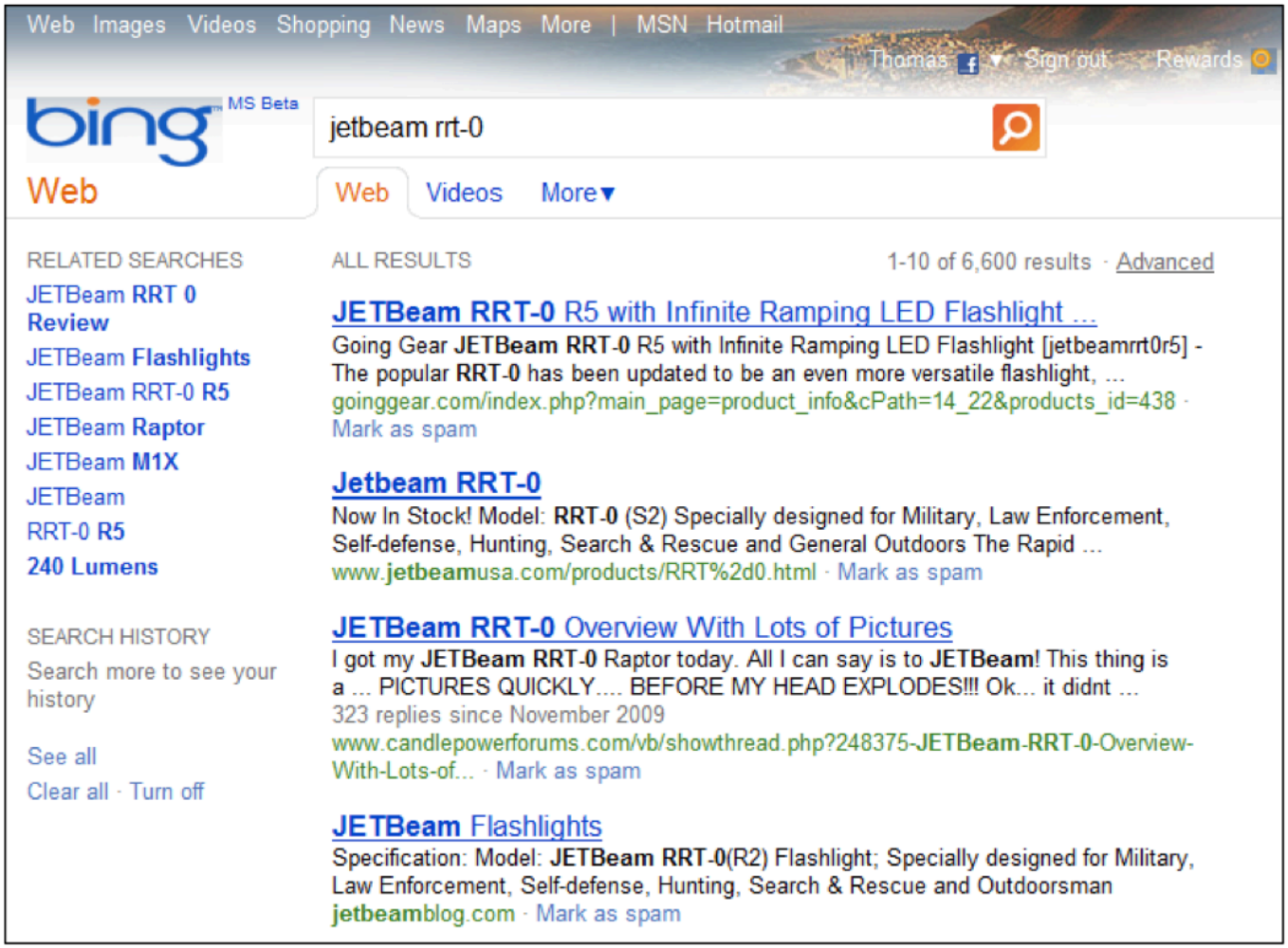
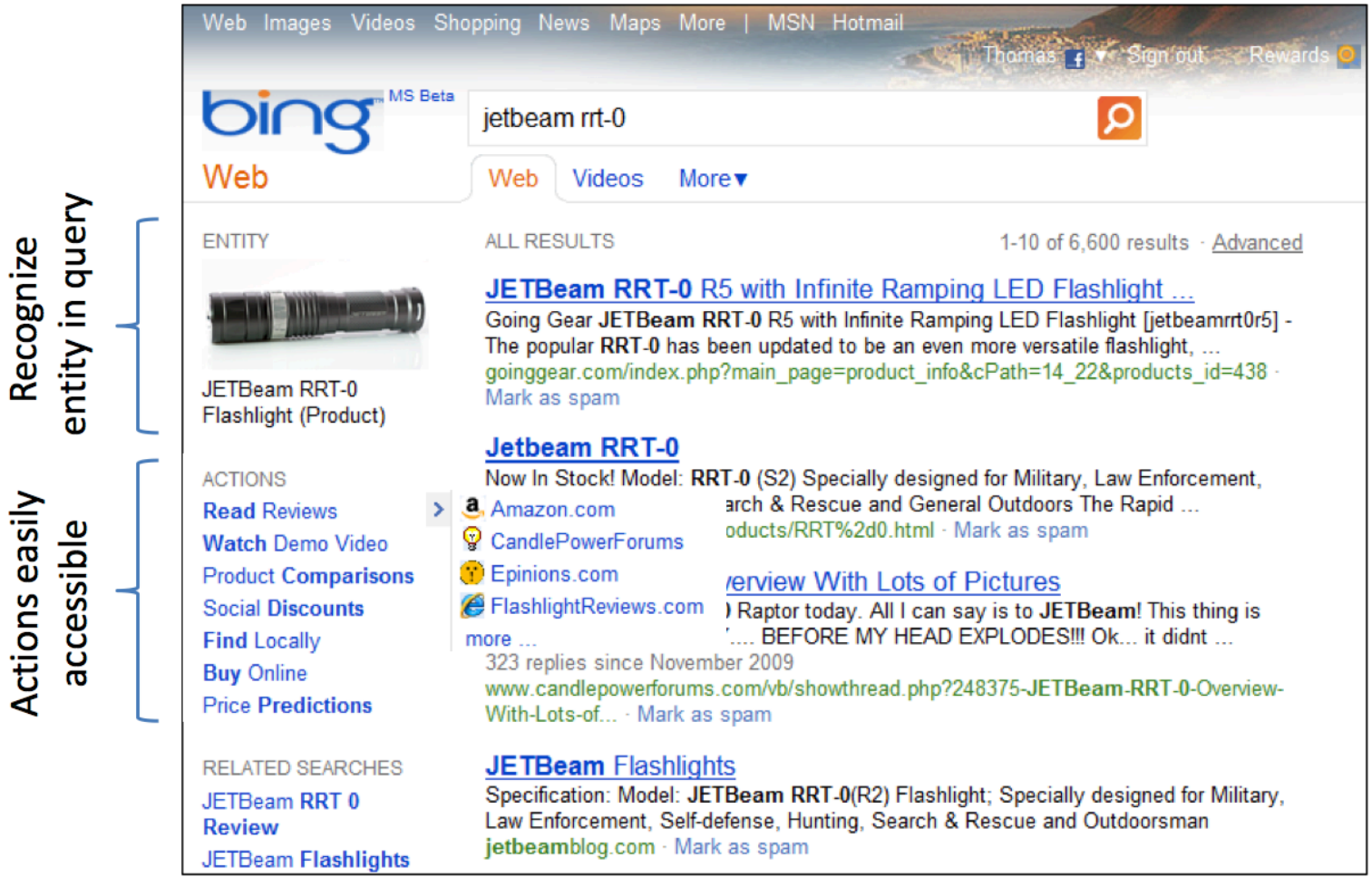
Patrick Pantel talk
(Then) Current experience



Desired experience: Towards actions



Politician

Recognize entity in query
Actions easily accessible
Web Images Videos Shopping News Maps More | MSN Hotmail
Thomas ▾ Sign out Rewards
bing MS Beta
Obama
Web
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
Facebook
Twitter
LinkedIn
MySpace
more ...
RELATED SEARCHES
ALL RESULTS
1-10 of 511,000 results · Advanced
Official Obama Website
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www.BarackObama.com · Respect. Empower. Include. Win. Join Barack Obama's campaign now.
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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 ...
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career · Legislative career ... · Presidential campaigns
ein 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 ...
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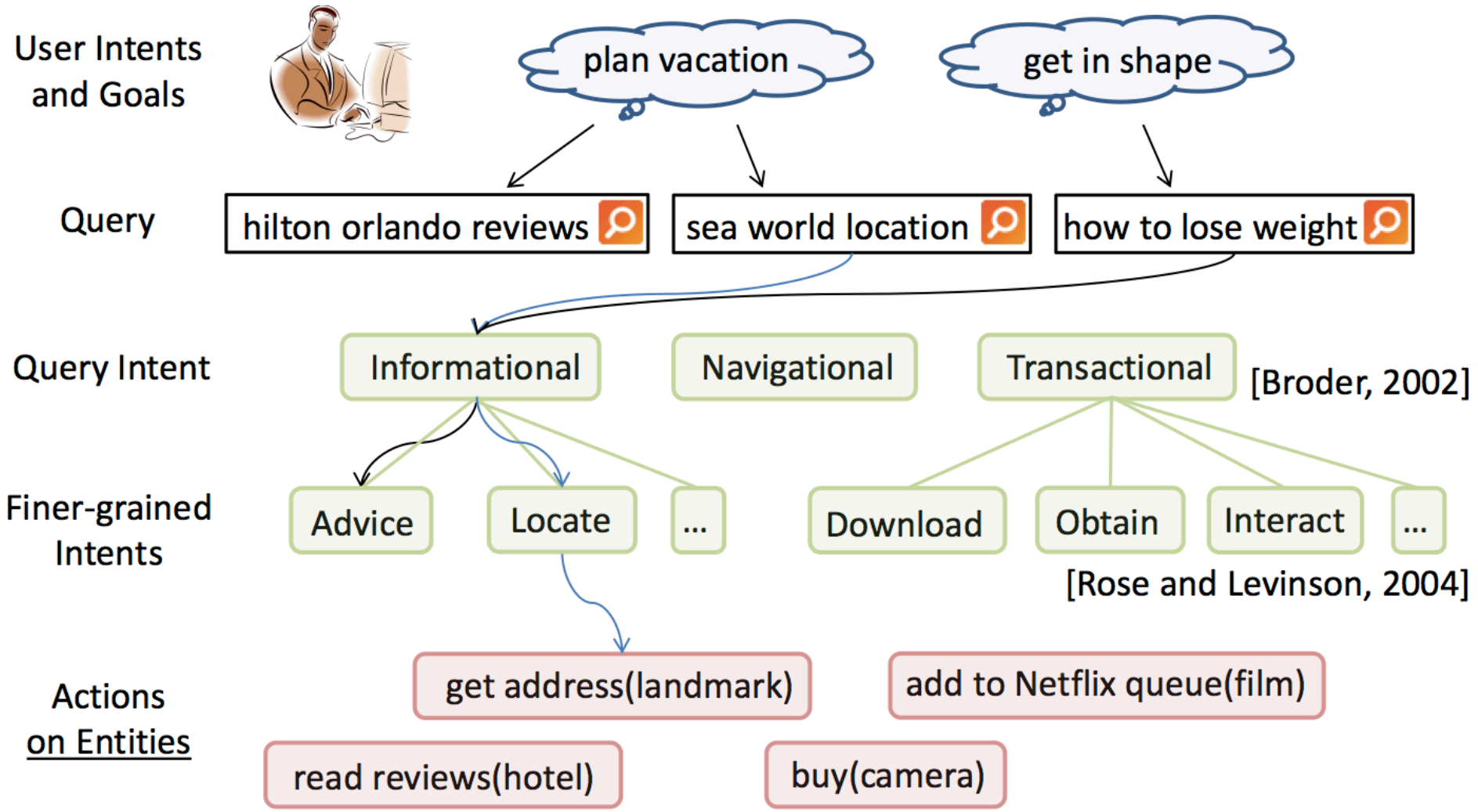
k Obama and other U.S. politicians by office, state, and branch of government

Actions vs. Intents



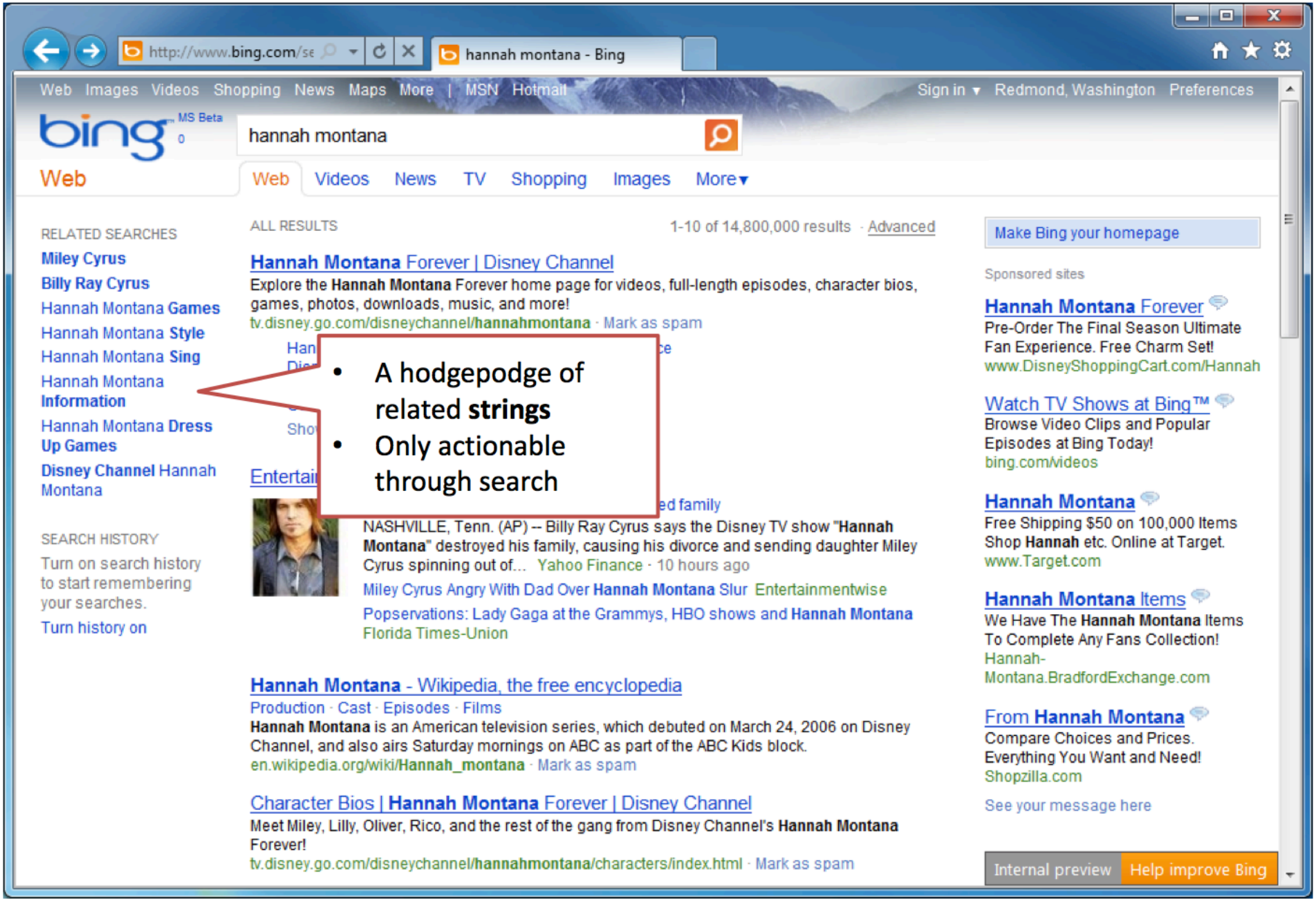
Learning actions from web usage logs

- Three months of us-en web logs
- Annotate with Freebase entities

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

- 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

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/se
hannah montana - Bing
Web Images Videos Shopping News Maps More | MSN Hotmail
Sign in ▾ Redmond, Washington Preferences
bing MS Beta 0
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Web
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Miley Cyrus
Billy Ray Cyrus
Hannah Montana Games
Hannah Montana Style
Hannah Montana Sing
Hannah Montana Information
Hannah Montana Dress Up Games
Disney Channel Hannah Montana
SEARCH HISTORY
Turn on search history to start remembering your searches.
Turn history on
ALL RESULTS
1-10 of 14,800,000 results · Advanced
Hannah Montana Forever | Disney Channel
Explore the Hannah Montana Forever home page for videos, full-length episodes, character bios, games, photos, downloads, music, and more!
tv.disney.go.com/disneychannel/hannahmontana · Mark as spam
• A hodgepodge of related strings
• Only actionable through search
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
Popservations: Lady Gaga at the Grammys, HBO shows and Hannah Montana Florida Times-Union
Hannah Montana - Wikipedia, the free encyclopedia
Production · Cast · Episodes · Films
Hannah Montana is an American television series, which debuted on March 24, 2006 on Disney Channel, and also airs Saturday mornings on ABC as part of the ABC Kids block.
en.wikipedia.org/wiki/Hannah_montana · Mark as spam
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
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Sponsored sites
Hannah Montana Forever
Pre-Order The Final Season Ultimate Fan Experience. Free Charm Set!
www.DisneyShoppingCart.com/Hannah
Watch TV Shows at Bing™
Browse Video Clips and Popular Episodes at Bing Today!
bing.com/videos
Hannah Montana
Free Shipping $50 on 100,000 Items Shop Hannah etc. Online at Target.
www.Target.com
Hannah Montana Items
We Have The Hannah Montana Items To Complete Any Fans Collection!
Hannah-Montana.BradfordExchange.com
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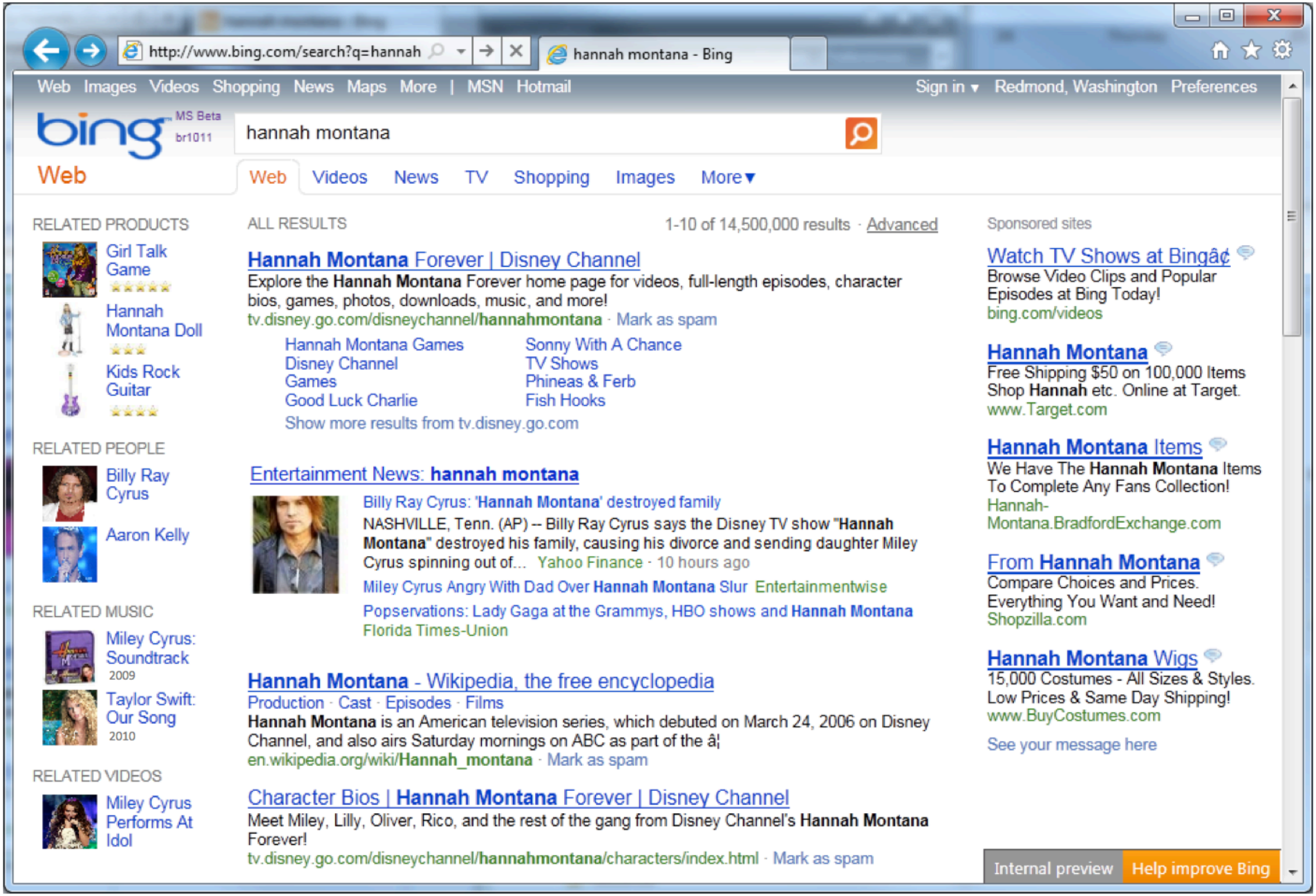
Compare Choices and Prices. Everything You Want and Need!
Shopzilla.com
See your message here
Internal preview
Help improve Bing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Web
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Taylor Swift: Our Song
2010
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Sonny With A Chance
TV Shows
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Billy Ray Cyrus: 'Hannah Montana' destroyed family
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
Popservations: Lady Gaga at the Grammys, HBO shows and Hannah Montana Florida Times-Union
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Hannah Montana is an American television series, which debuted on March 24, 2006 on Disney Channel, and also airs Saturday mornings on ABC as part of the â¦
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Browse Video Clips and Popular Episodes at Bing Today!
bing.com/videos
Hannah Montana
Free Shipping $50 on 100,000 Items
Shop Hannah etc. Online at Target.
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Hannah Montana Items
We Have The Hannah Montana Items To Complete Any Fans Collection!
Hannah-Montana.BradfordExchange.com
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Compare Choices and Prices. Everything You Want and Need!
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15,000 Costumes - All Sizes & Styles. Low Prices & Same Day Shipping!
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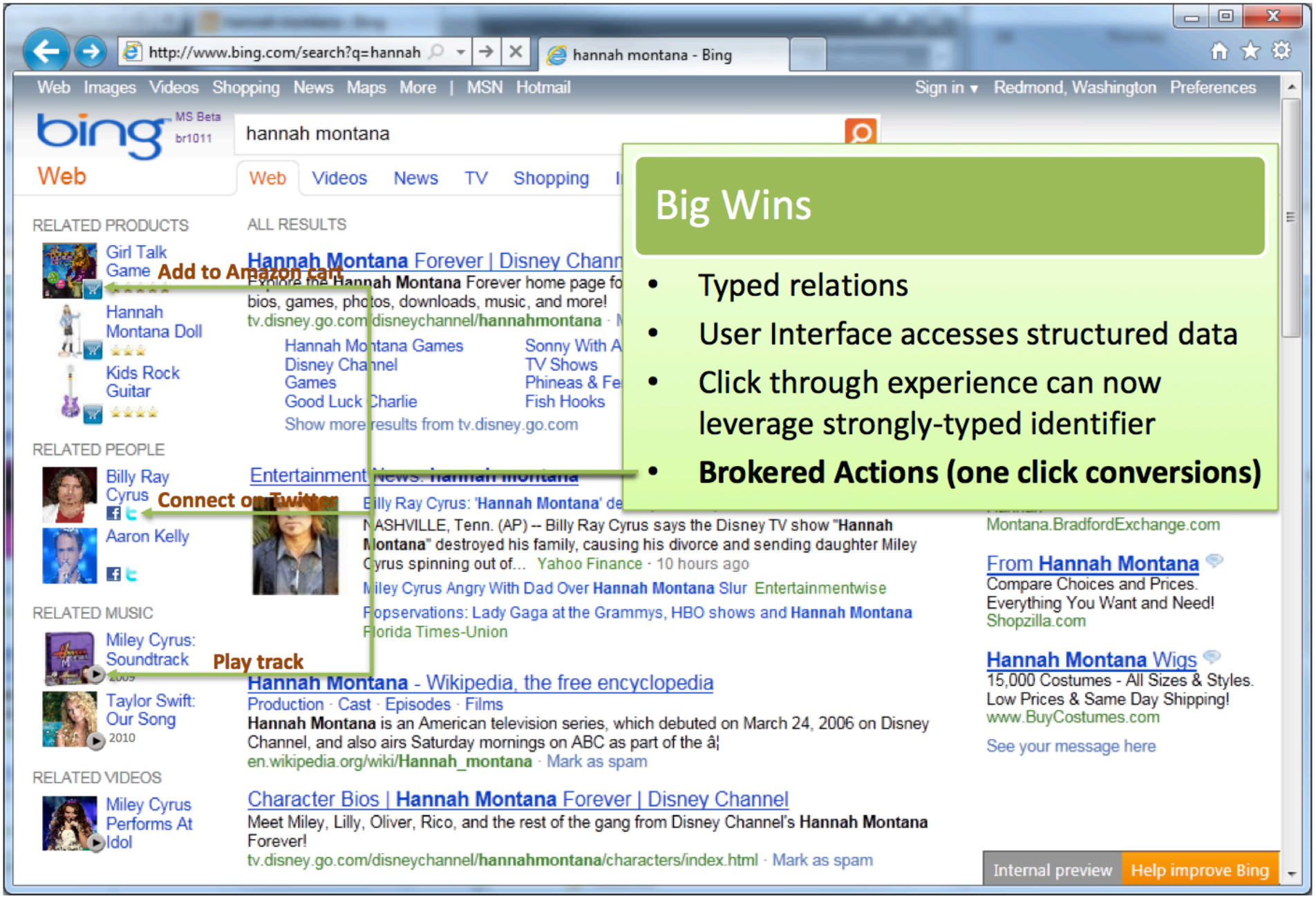
Aaron Kelly
RELATED MUSIC
Miley Cyrus Soundtrack
2009
Taylor Swift Our Song
2010
RELATED VIDEOS
Miley Cyrus Performs At Idol
Show more results from tv.disney.go.com
Big Wins
• Typed relations
• User Interface accesses structured data
• Click through experience can now leverage strongly-typed identifier
Billy Ray (BillyRay Cyrus)
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
en.wikipedia.org/wiki/Hannah_montana · Mark as spam
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

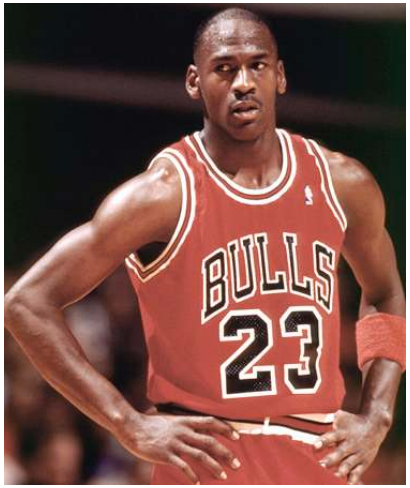


Big Wins

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

Entity disambiguation and linking

- Key requirement is that entities get identified
  - Named entity recognition (e.g., Stanford NER!)
- and disambiguated
  - Entity linking (or sometimes "Wikification")
    - e.g., Michael Jordan the basketballer or the ML guy



Mentions, Meanings, Mappings [G. Weikum]

Sergio talked to Ennio about Eli's role in the Ecstasy scene. This sequence on the graveyard was a highlight in Sergio's trilogy of western films.

?

KB

Sergio means Sergio_Leone
Sergio means Serge_Gainsbourg
Ennio means Ennio_Antonelli
Ennio means Ennio_Morricone
Eli means Eli_(bible)
Eli means ExtremeLightInfrastructure
Eli means Eli_Wallach
Ecstasy means Ecstasy_(drug)
Ecstasy means Ecstasy_of_Gold
trilogy means Star_Wars_Trilogy
trilogy means Lord_of_the_Rings
trilogy means Dollars_Trilogy

Eli (bible)
Eli Wallach
Ecstasy (drug)
Ecstasy of Gold
Star Wars Trilogy
Lord of the Rings
Dollars Trilogy

Mentions (surface names)

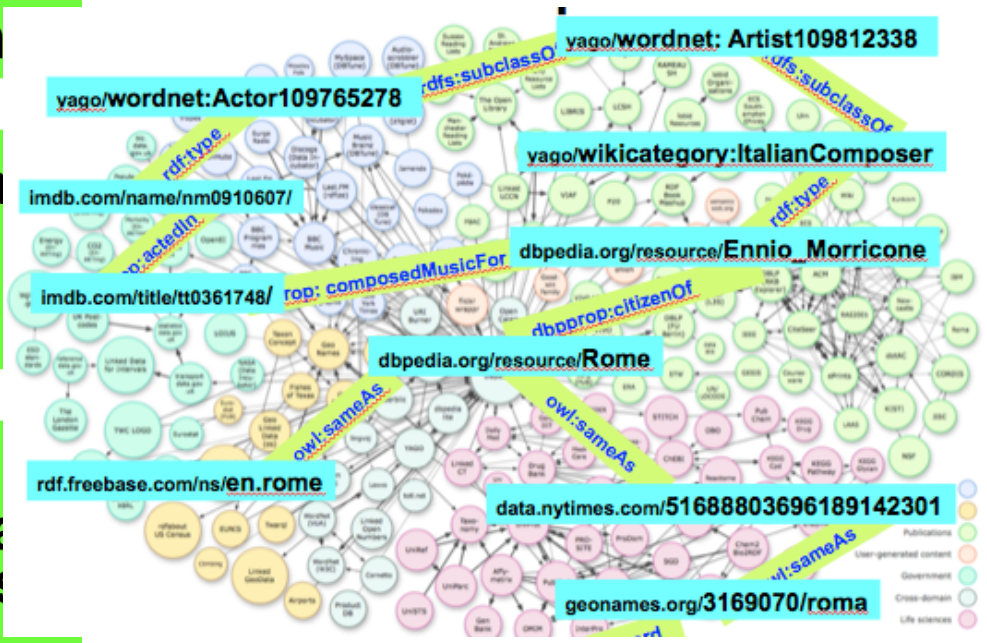
Entities (meanings)

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

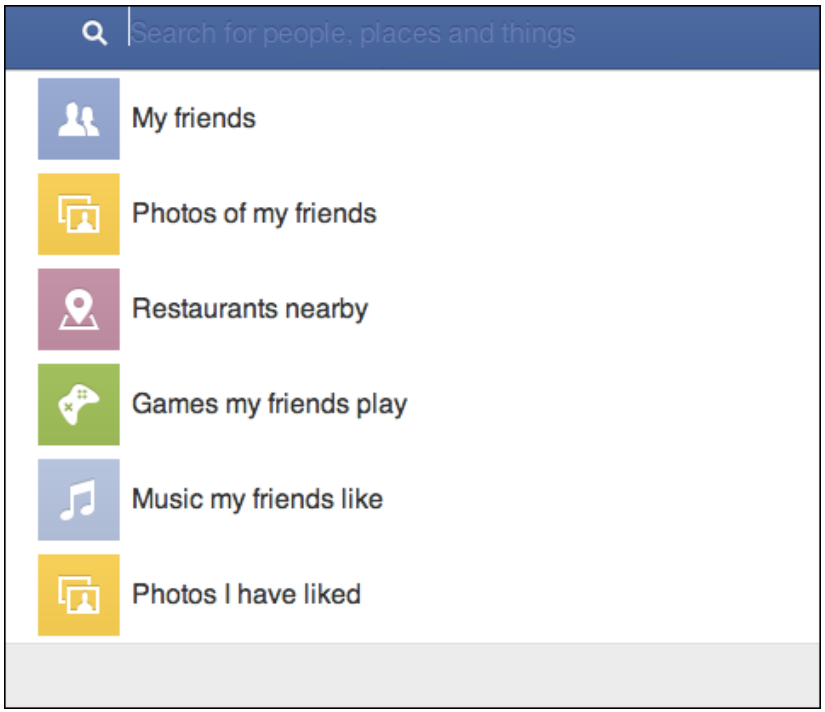
http://.../wiki/Dollars_Trilogy
http://.../wiki/The_Good,_the_Bad,_
http://.../wiki/Clint_Eastwood
http://.../wiki/Honorary_Academ

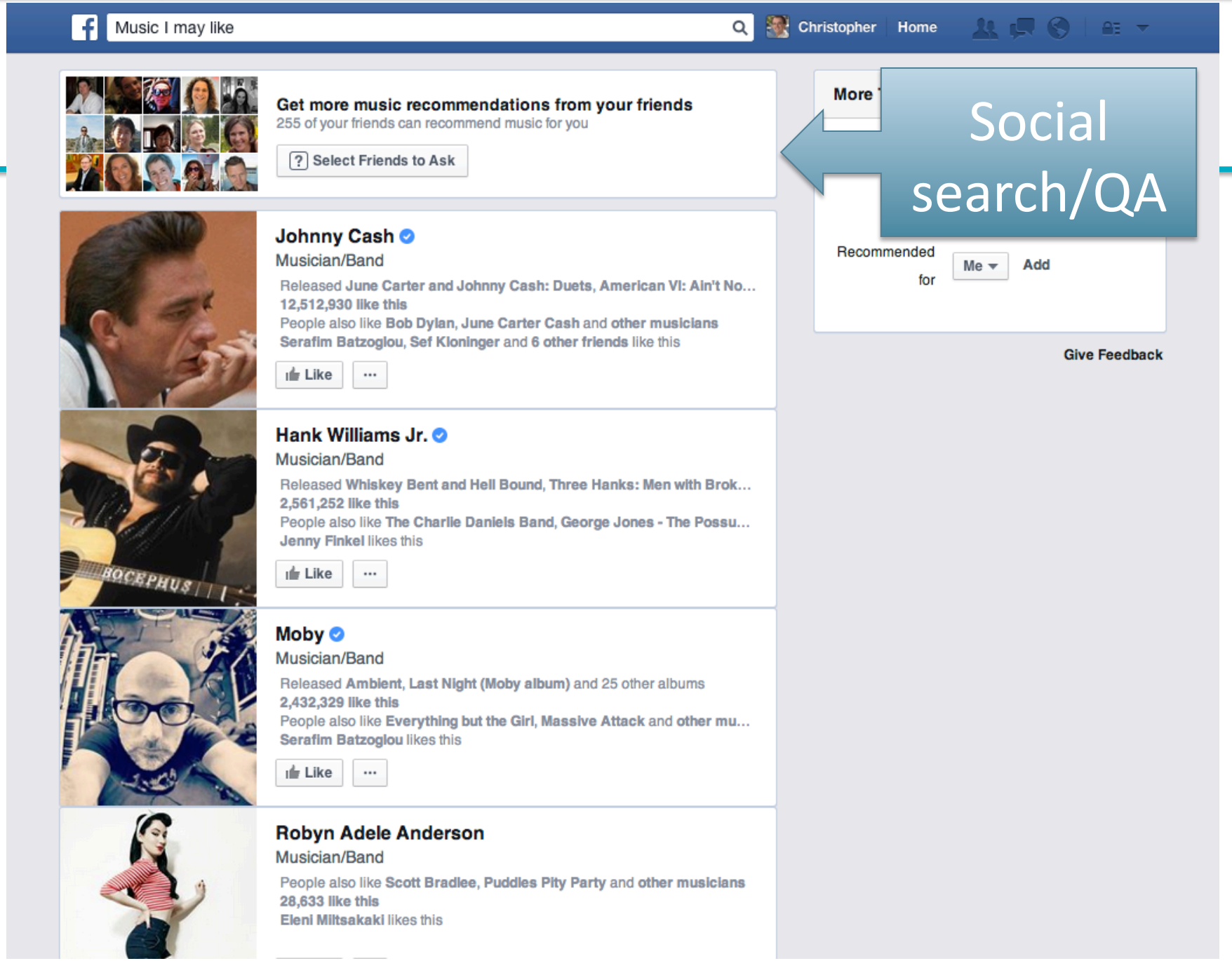
http://.../wiki/The_Good,_the_Ba
http://.../wiki/Metallica
http://.../wiki/Bellagio_(casino)
http://.../wiki/Ennio_Morricone

http://.../wiki/Sergio_Leone
http://.../wiki/The_Good,_the_Ba
http://.../wiki/For_a_Few_Dollars
http://.../wiki/Ennio_Morricone



Facebook Graph Search

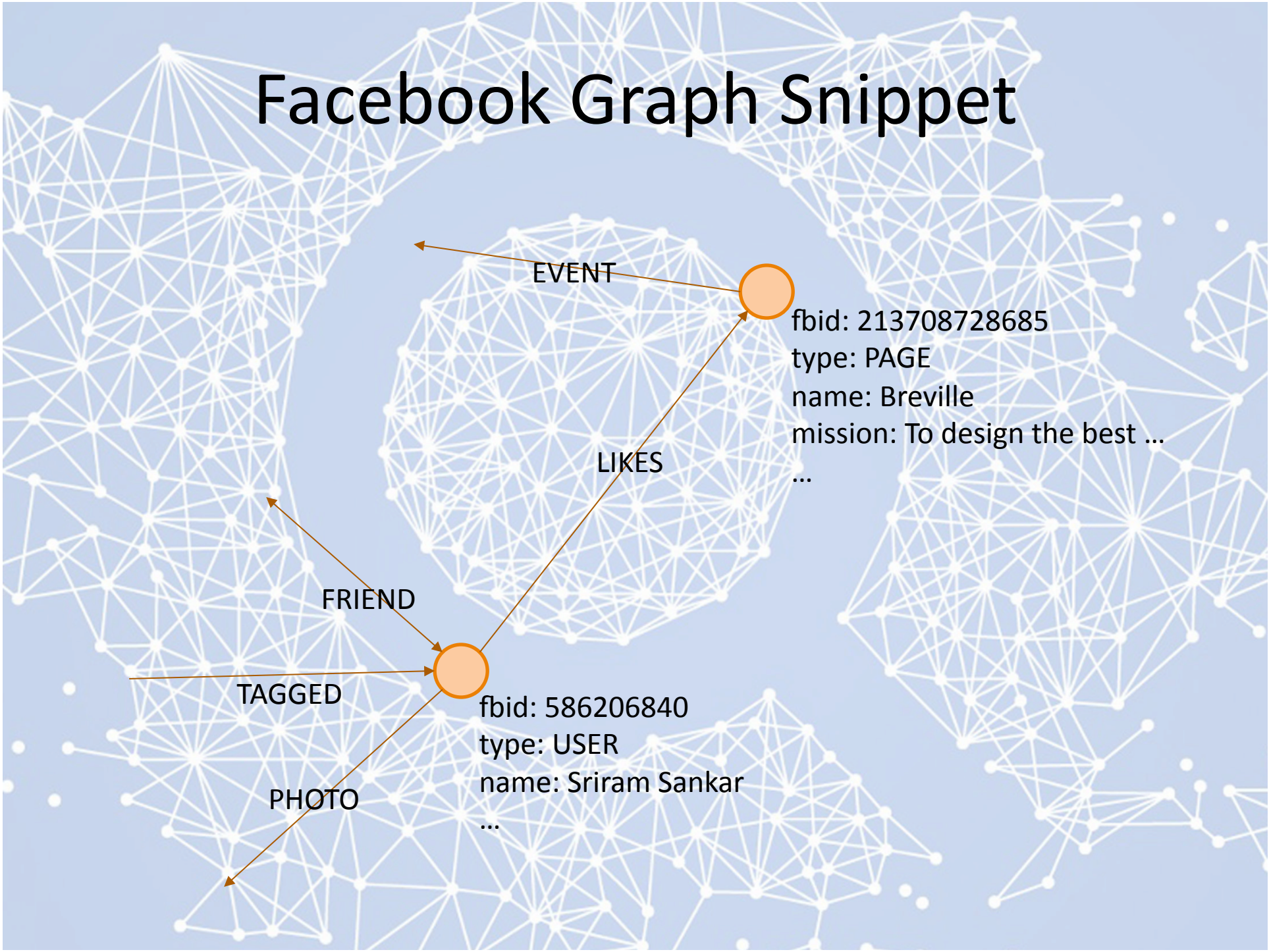


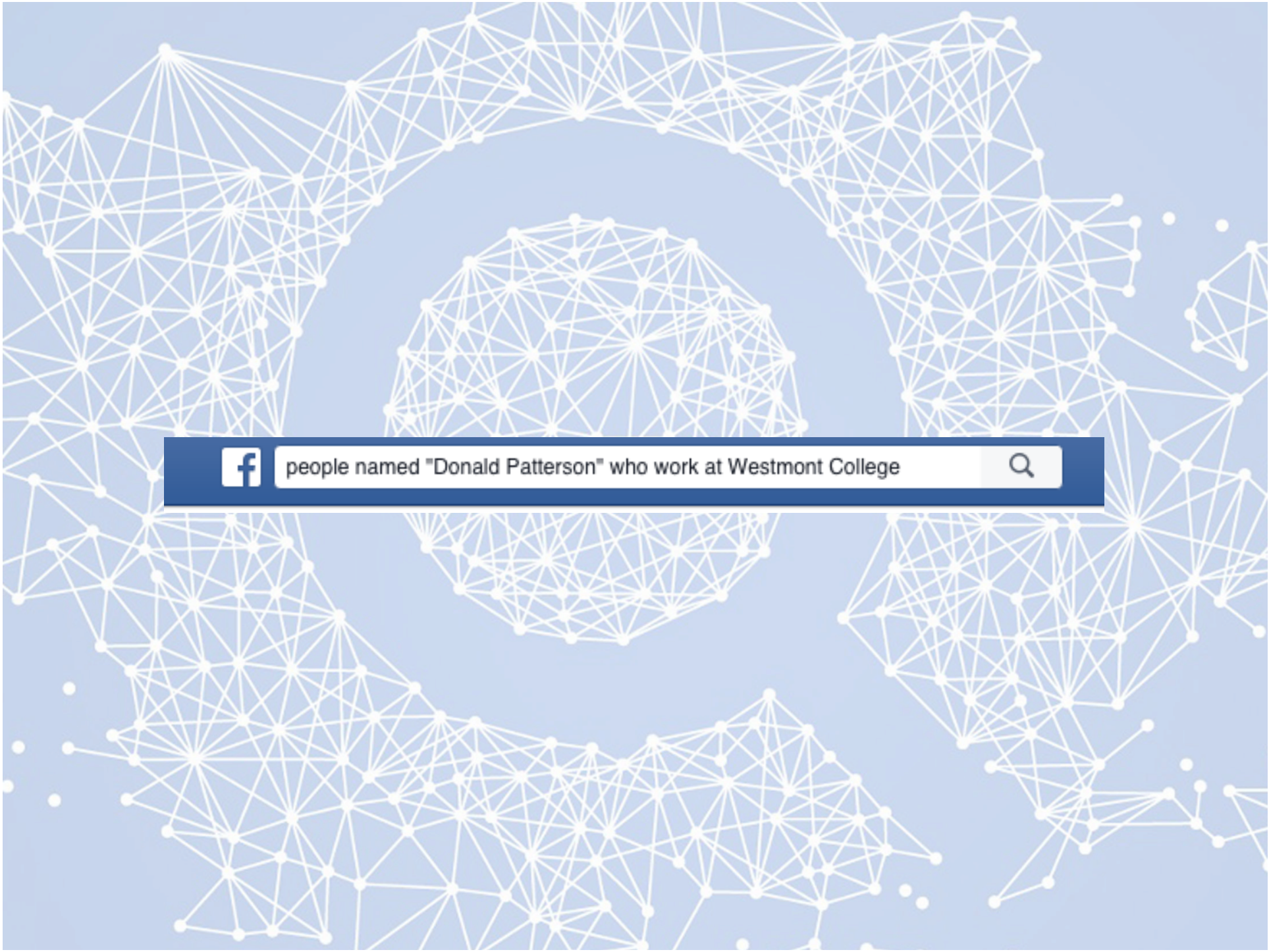

Music I may like
Christopher
Home
Get more music recommendations from your friends
255 of your friends can recommend music for you
Select Friends to Ask
More
Social search/QA
Recommended for
Me
Add
Give Feedback
Johnny Cash
Musician/Band
Released June Carter and Johnny Cash: Duets, American VI: Ain't No...
12,512,930 like this
People also like Bob Dylan, June Carter Cash and other musicians
Serafim Batzoglou, Sef Kloninger and 6 other friends like this
Like
Hank Williams Jr.
Musician/Band
Released Whiskey Bent and Hell Bound, Three Hanks: Men with Brok...
2,561,252 like this
People also like The Charlie Daniels Band, George Jones - The Possu...
Jenny Finkel likes this
Like
Moby
Musician/Band
Released Ambient, Last Night (Moby album) and 25 other albums
2,432,329 like this
People also like Everything but the Girl, Massive Attack and other mu...
Serafim Batzoglou likes this
Like
Robyn Adele Anderson
Musician/Band
People also like Scott Bradlee, Puddles Pity Party and other musicians
28,633 like this
Eleni Miltsakaki likes this

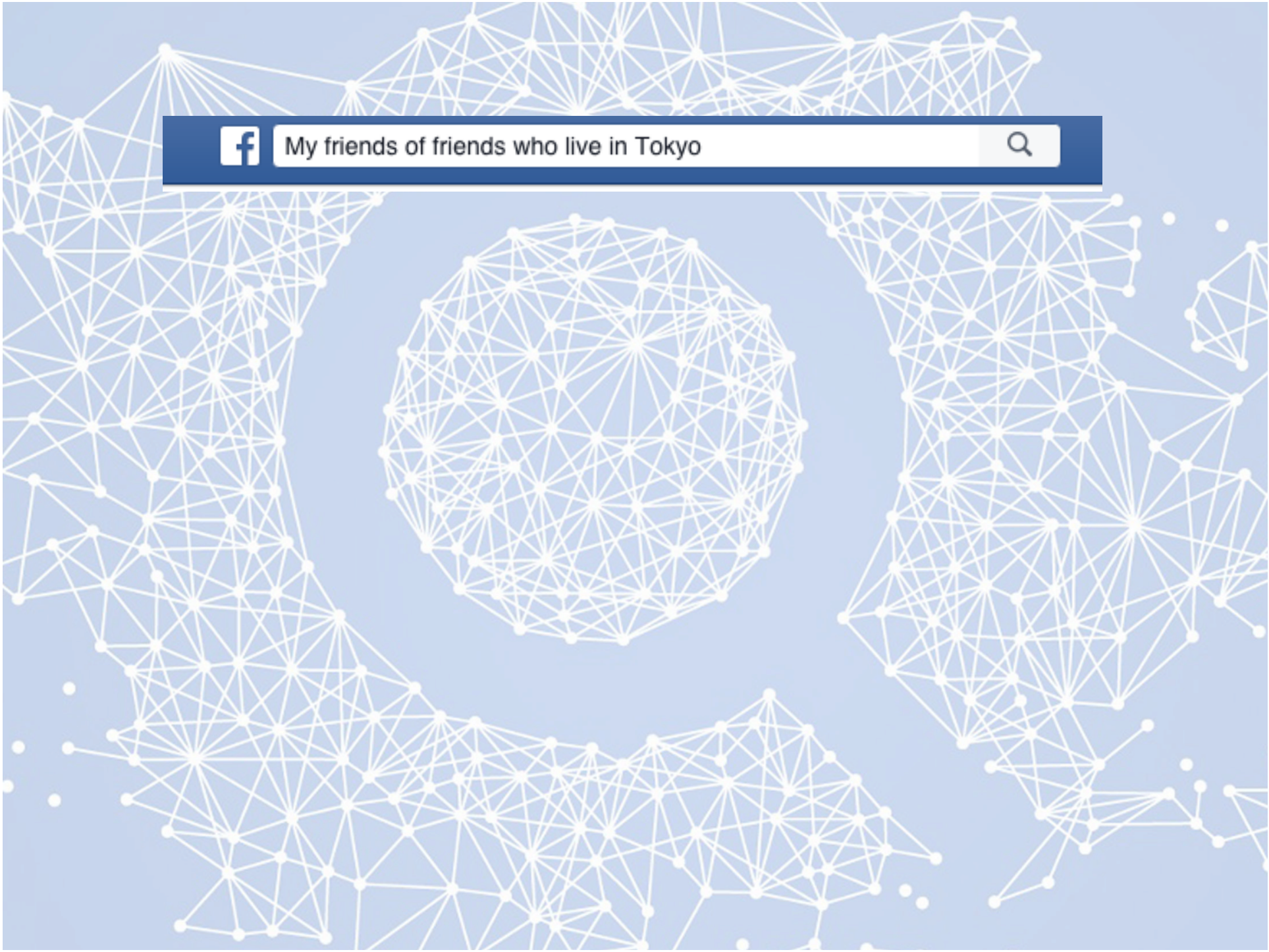
The Facebook Graph

- 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



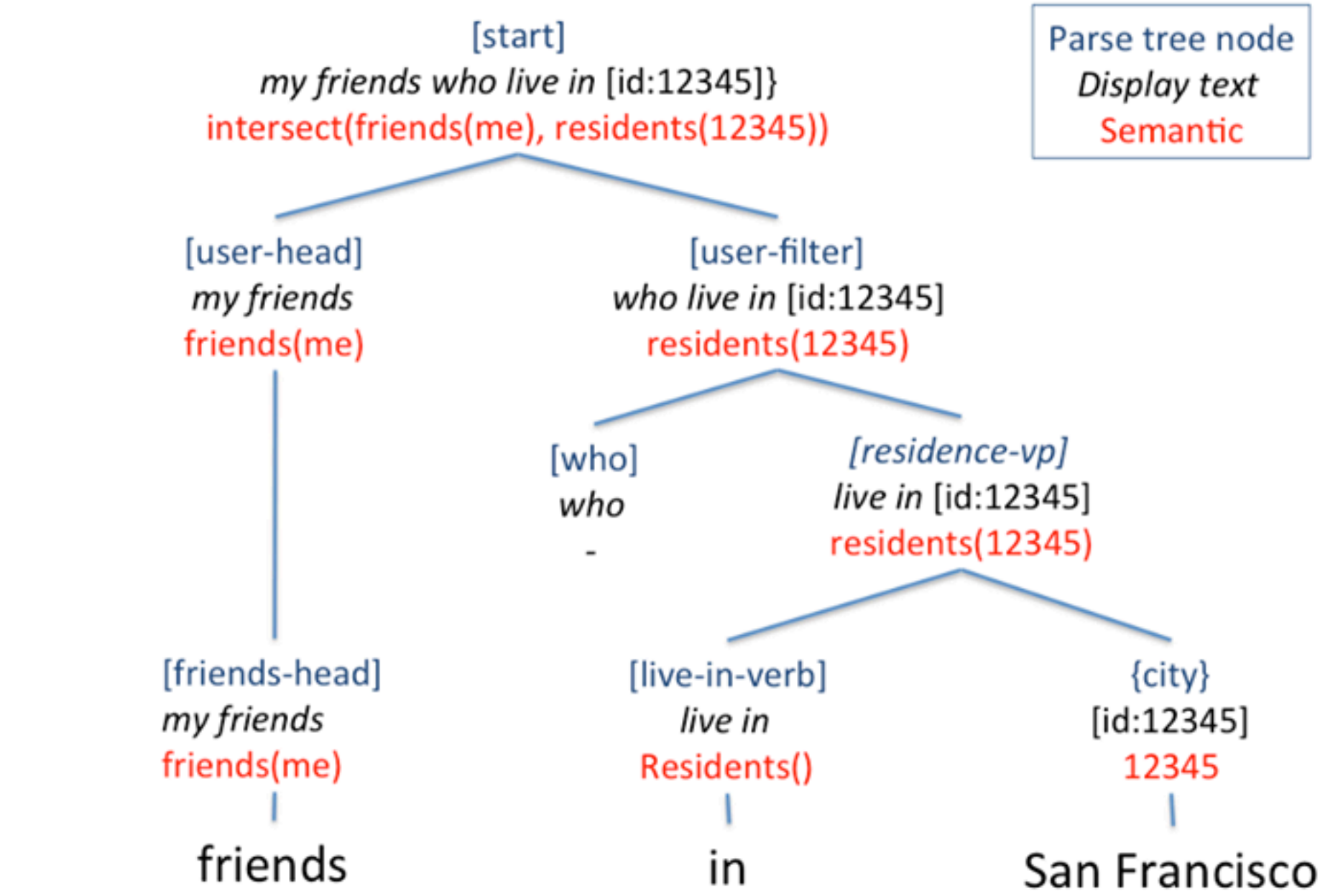

people named "Donald Patterson" who work at Westmont College


My friends of friends who live in Tokyo

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



The parse tree, semantic and entity ID used in the above example are for illustration only; they do not represent real information used in Graph Search Beta

third prime minister of Australia

Australia's third prime minister

Australia's 3rd prime minister

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