

# Feature Driven Question Answering

Benjamin Van Durme



# Question Answering (QA)

Natural Language Interface to Databases

Information Retrieval (+ Information Extraction)

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1960's, 1970's, ...

build semantic parsers by hand

# Baseball (Green et al., 1961)

*“Where did the Red Sox play on July 7?”*



[Where] did [the Red Sox] play (on [July 7])?



**[ANSWER]**

# Lunar (Woods, 1977)

*“What is the concentration of silicon in S10046?”*



(For The X / (Dataline S10046 Overall SIO2) : T ;

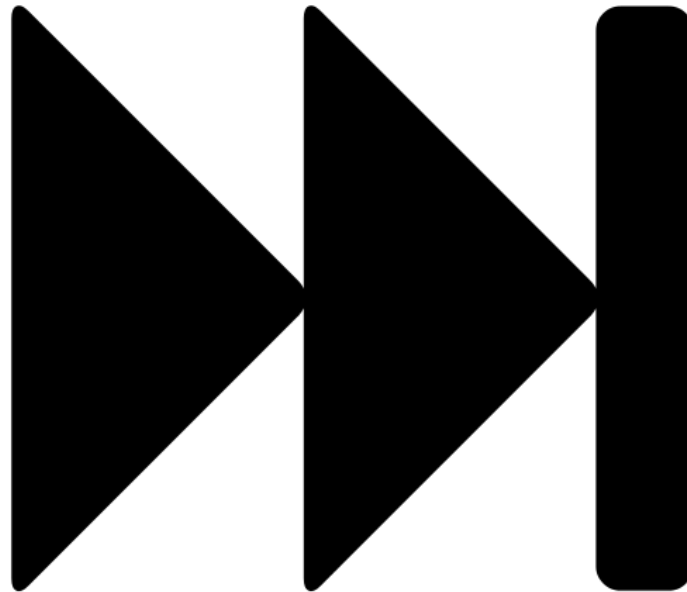
(For Every Y / Thing : (Equal X Y) ;

(Printout Y) ))



**[ANSWER]**

[fast forward]



# Difference?

1960's, 1970's, ...

build grammars by hand

1990's, 2000's

induce grammars from annotations



# Zelle and Mooney (1996)

*“What is the capital of the state with the largest population?”*



```
answer(C,(capital(S,C),  
          largest(P, (state(S), population(S,P))))))
```



**[ANSWER]**

# Zettlemoyer and Collins (2005)

*“What states border texas?”*



$\lambda x. \text{state}(x) \wedge \text{borders}(x, \text{texas})$



**[ANSWER]**

1960's, 1970's, ...

build grammars by hand

1990's, 2000's

induce grammars from annotated questions

2010's

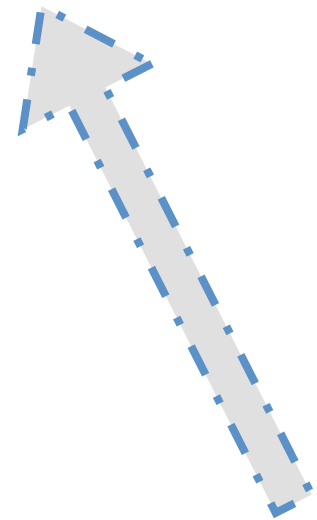
induce grammars based on questions + answers

# Clarke *et al.* (2010)

*“What is the largest state that borders Texas?”*



???



**New Mexico**

# Clarke *et al.* (2010)

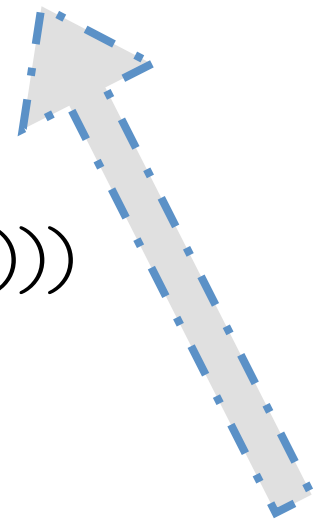
*“What is the largest state that borders Texas?”*

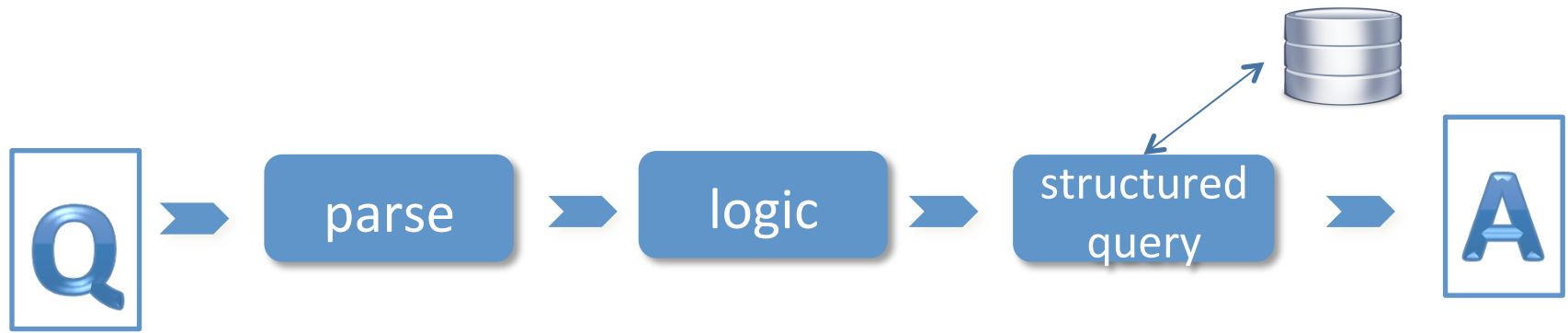


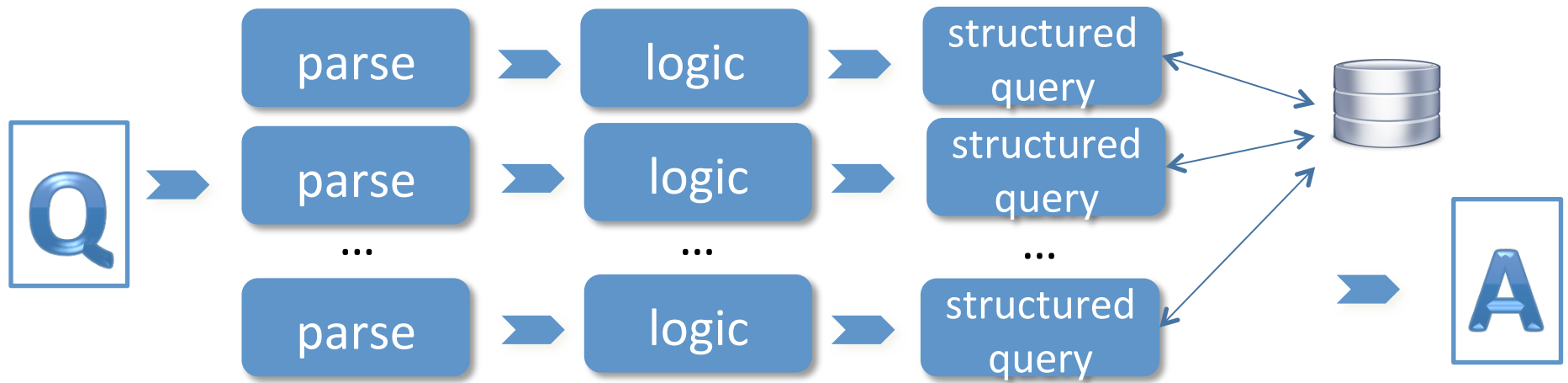
```
largest(state(next_to(const(texas))))
```



**New Mexico**







# Question Answering (QA)

Natural Language Interface to Databases

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# Question Answering (QA)

Natural Language Interface to Databases

Information Retrieval (+ Information Extraction)

*“What is the something something something?”*



$\text{Lambda } x \text{ [constraint1}(x), \text{constraint2}(x), \dots]$

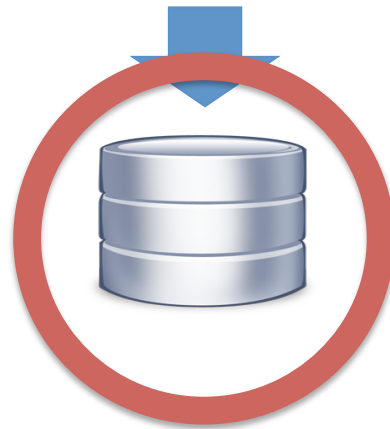


**[ANSWER]**

*“What is the something something something?”*



Lambda x [constraint1(x), constraint2(x), ...]



*“What is the something something something?”*



$\text{Lambda } x [\text{constraint1}(x), \text{constraint2}(x), \dots]$



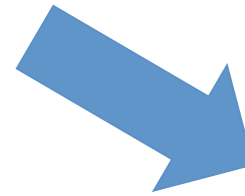
*“What is the something something something?”*



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*“What is the something something something?”*



**[ANSWER]**

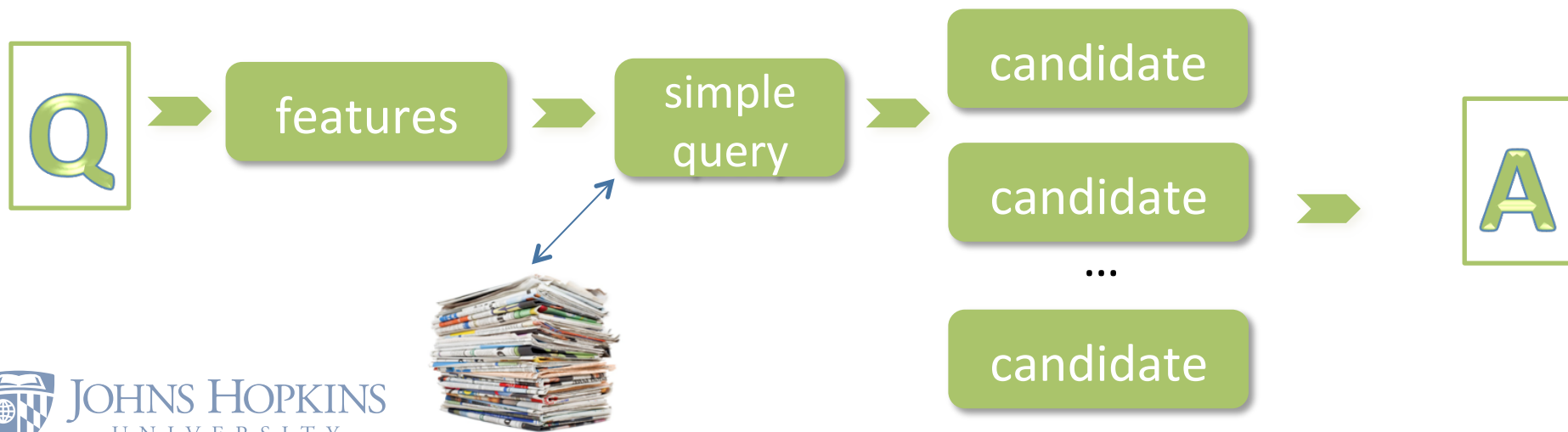
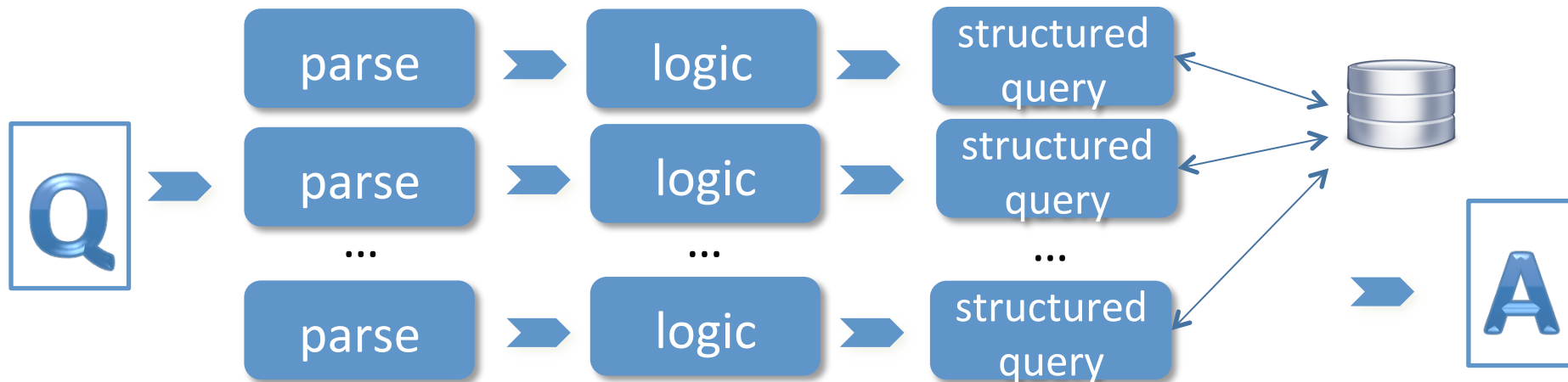
# NIST TREC-8 QA

(Voorhees 1999)

200 questions, each with “snippet” answers

*“How many calories in a Big Mac?”*

*There are 549 calories in 1 burger (7.6 oz) of McDonald's Big Mac Burger. You'd need to walk ...*





Chen and Van Durme (in-progress)

Yao and Van Durme (2014)

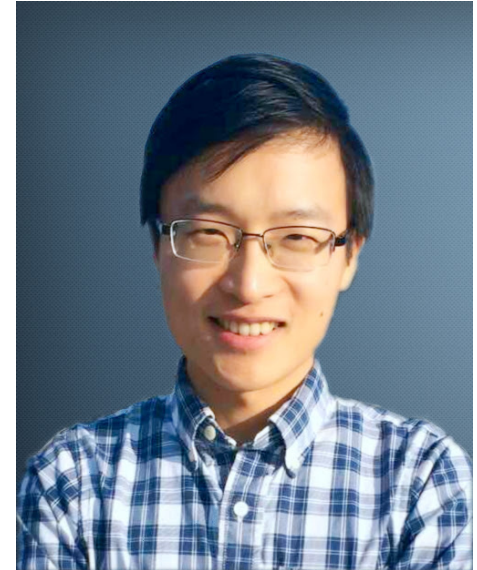
Yao *et al.* (2014)

Yao *et al.* (2013a,b,c)

Van Durme *et al.* (2003)

Nyberg *et al.* (2003)

Xuchen Yao



Chen and Van Durme (in-progress)

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Nyberg *et al.* (2003)



KITT·AI



# Question Answering (QA)

Information Retrieval (+ Information Extraction)

Feature driven answer extraction

Feature driven retrieval

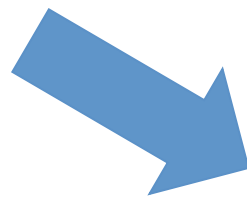
Feature driven QA on a KB

Feature driven answer extraction

Feature driven retrieval

Feature driven QA on a KB

*“What sport does Jennifer Capriati play?”*



**[ANSWER]**

*“What sport does Jennifer Capriati play?”*



*“Capriati hasn't played on the tour since ...”*

*“Tennis player Jennifer Capriati is 23”*

*“Jennifer Capriati enjoys sports”*

*...*

*“What sport does Jennifer Capriati play?”*



*“Capriati hasn't played on the tour since ...”*

*“Tennis player Jennifer Capriati is 23”*

*“Jennifer Capriati enjoys sports”*

*...*

*“What sport does Jennifer Capriati play?”*



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*...*



*“What sport does Jennifer Capriati play?”*

***Tennis** player Jennifer Capriati is 23*

*Tennis*

*player*

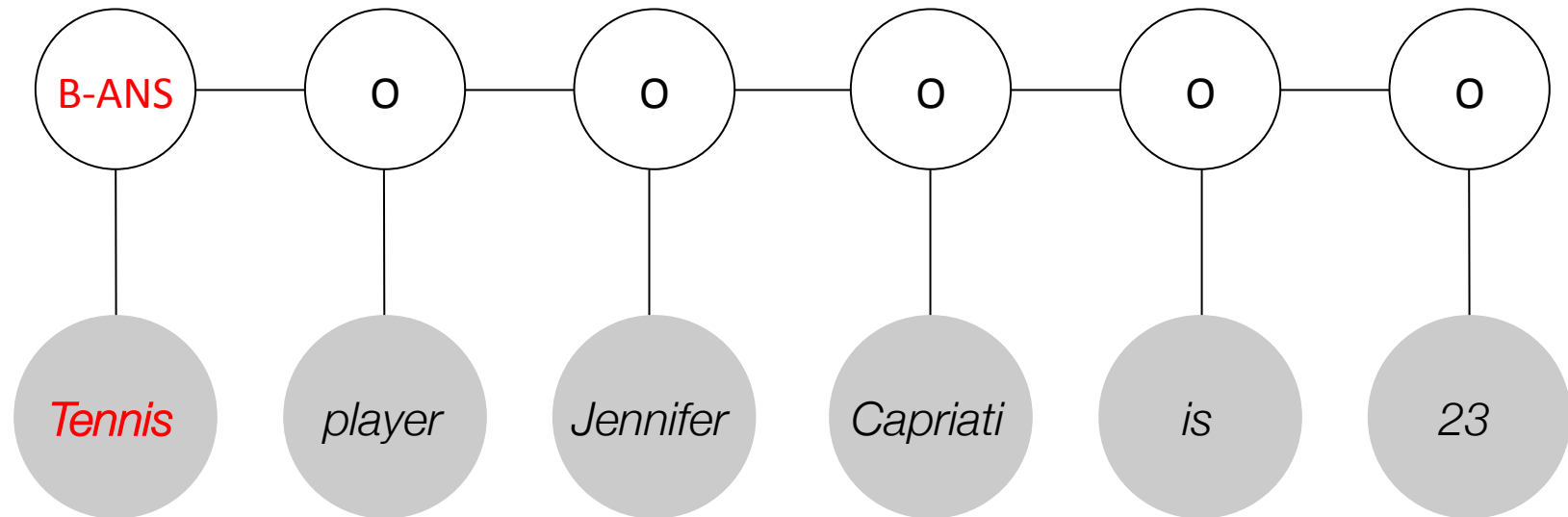
*Jennifer*

*Capriati*

*is*

*23*

*“What sport does Jennifer Capriati play?”*



“BIO” tagging, 3 types of hidden states:

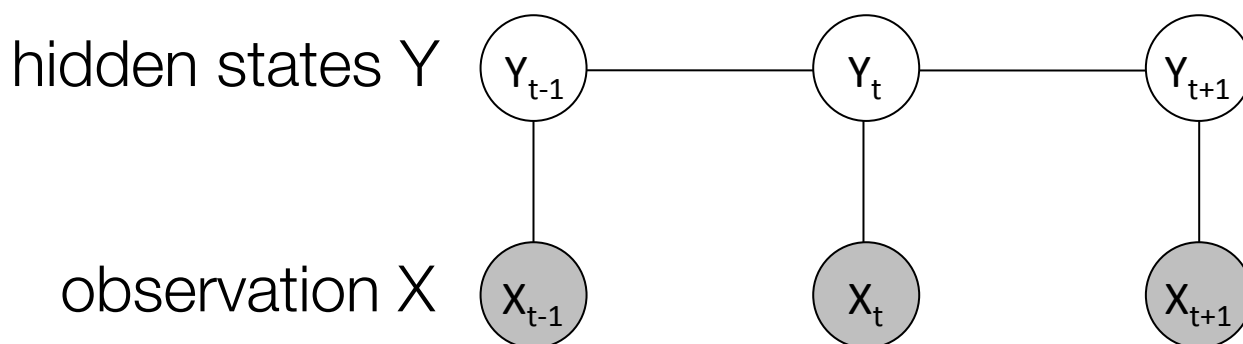
B-ANS (beginning of answer)

I-ANS (inside of answer)

O (outside of answer, i.e., not an answer)

# Answer Extraction as Sequence Tagging

using a linear-chain Conditional Random Field (CRF)



$$p(\mathbf{y} | \mathbf{x}) = \frac{1}{Z(\mathbf{x})} \prod_{t=1}^T \exp\left\{ \sum_{k=1}^K \theta_k f_k(y_t, y_{t-1}, \mathbf{x}_t) \right\}$$

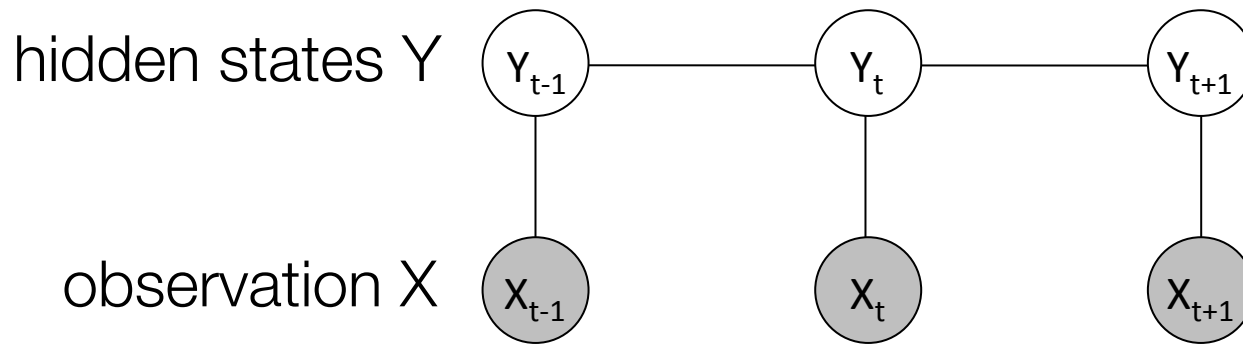
conditional model  $p(\mathbf{y}|\mathbf{x})$  :

$f(y_t, y_{t-1}, \mathbf{x}_t)$  : feature functions

$\theta$  : feature weights (to learn)

# Answer Extraction as Sequence Tagging

using a linear-chain Conditional Random Field (CRF)



conditional model  $p(y|x)$  :

$f(y_t, y_{t-1}, x_t)$  : **feature functions**

$\theta$  : feature weights (to learn)

# NLP is full of features

does question starts with “**what**”, “**where**”, “**who**”, ... ?

what parts of speech?

any named entities, like a **PERSON** or a **LOCATION** ?

automatic alignments between question and passage

(tree) edit distance between question and passage

...

# Joint Features

Question starts with (“*who*”)

AND Passage contains entity of type (PERSON)

Question contains word (“*born*”)

AND Question starts with (“*where*”)

AND Passage contains word (“*birthplace*”)

# Ranking Sentence Candidates

<b>System</b>	<b>MAP</b>	<b>MRR</b>
Wang et al. (2007)	0.6029	0.6852
Heilman and Smith (2010)	0.6091	0.6917
Wang and Manning (2010)	0.5951	0.6951
this paper (48 features)	0.6319	0.7270
+WNsearch	<b>0.6371</b>	0.7301
+WNfeature (11 more feat.)	0.6307	<b>0.7477</b>

Feature driven answer extraction

Feature driven retrieval

Feature driven QA on a KB



Feature driven answer extraction

Feature driven retrieval

Feature driven QA on a KB

*“When was Alaska purchased?”*

*“When was Alaska purchased?”*



*“When was Alaska purchased?”*



*“When was Alaska purchased?”*



Standard search query: ( *alaska, purchased* )

*“When was Alaska purchased?”*



*“Eventually Alaska Airlines will allow all travelers who have purchased electronic tickets through any means ...”*

# Expected Answer Type

<b>work</b>	<b>question/answer types</b>	<b>domain</b>
Harabagiu et al. (2000)	27 named entity labels with many-to-many mapping to answer types of 15 top nodes	TREC
Hovy et al. (2000, 2002)	topology of 94 nodes (47 leaf nodes) analyzing 17,384 questions	answers.com
Hermjakob (2001)	122 question targets from above questions	answers.com
Pasca and Harabagiu (2001)	taxonomy connecting 153 WordNet sub-hierarchies	TREC
Li and Roth (2002)	6 coarse classes and 50 fine classes	TREC
Prager et al. (2006)	flat hierarchy with 80 semantic classes	TREC

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*“When was Alaska purchased?”*

Important learned QA feature

question starts with (“when”)

AND

passage contains entity of type(DATE)

*“When was Alaska purchased?”*

Standard search query: ( *alaska, purchased* )

Improved query: ( *alaska, purchased* ) & contains( DATE )

*“When was Alaska purchased?”*

Improved query: ( *alaska, purchased* ) & contains( DATE )

## Results

**improved search** (17% relative MRR)

**improved extraction** (20% relative F1 for top candidate)

Feature driven answer extraction

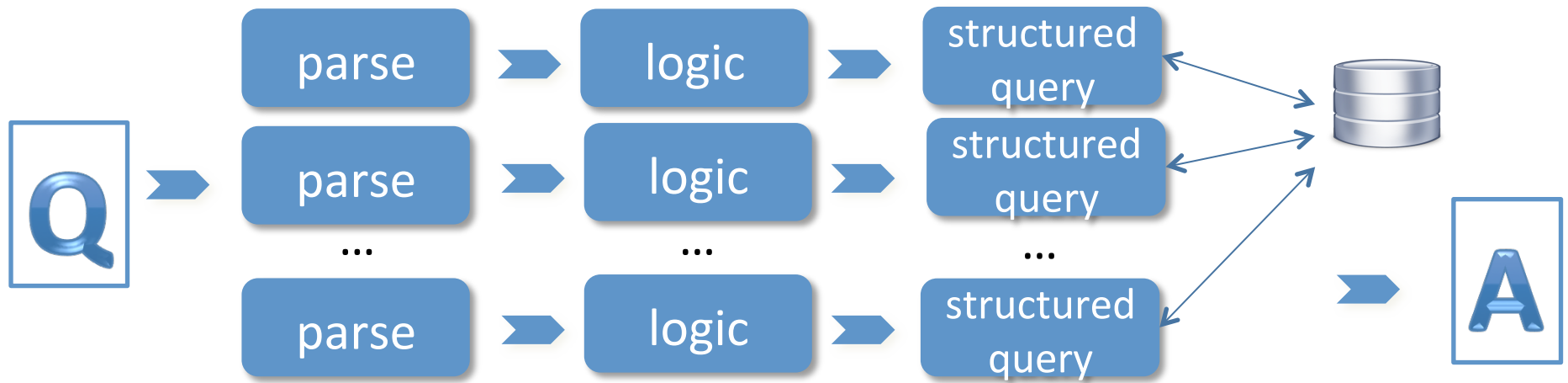
Feature driven retrieval

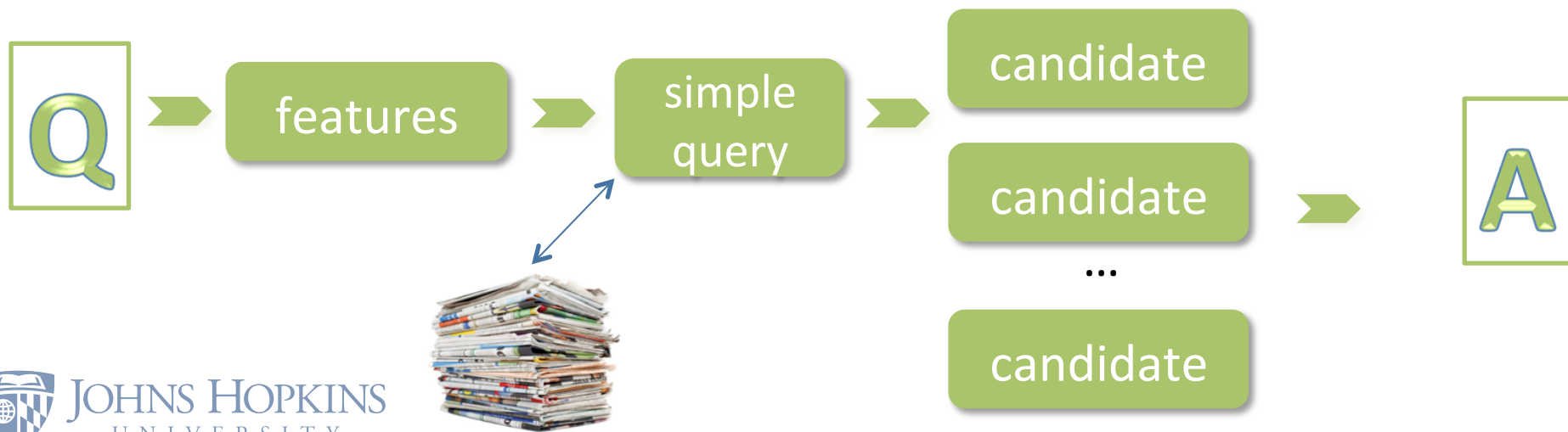
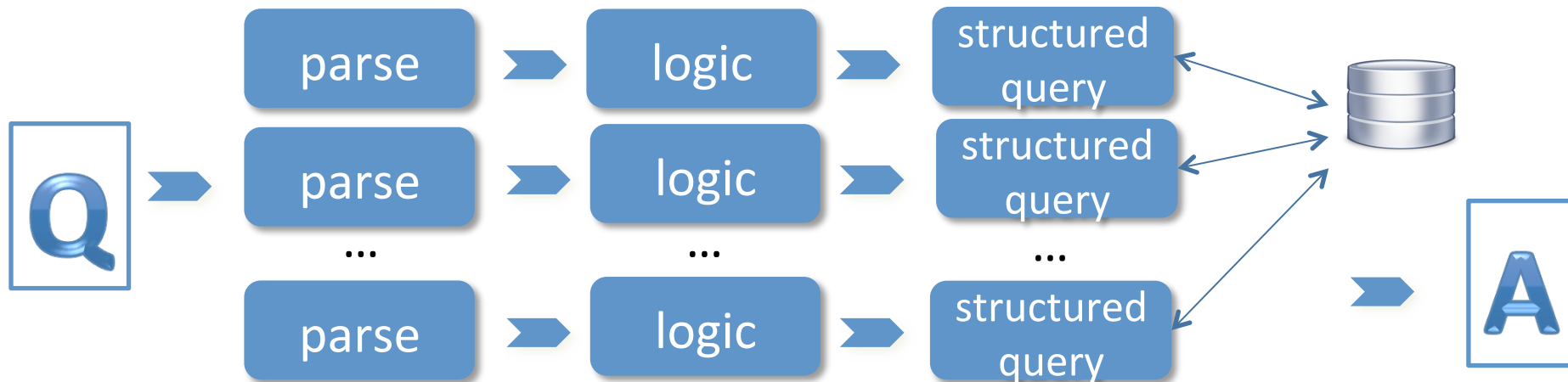
Feature driven QA on a KB

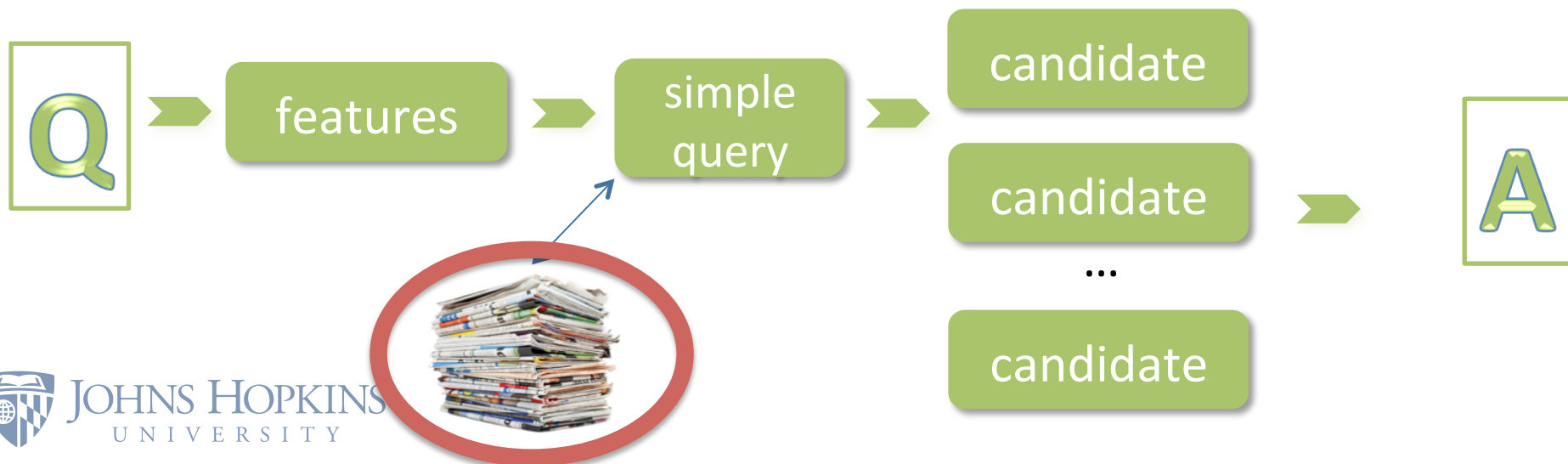
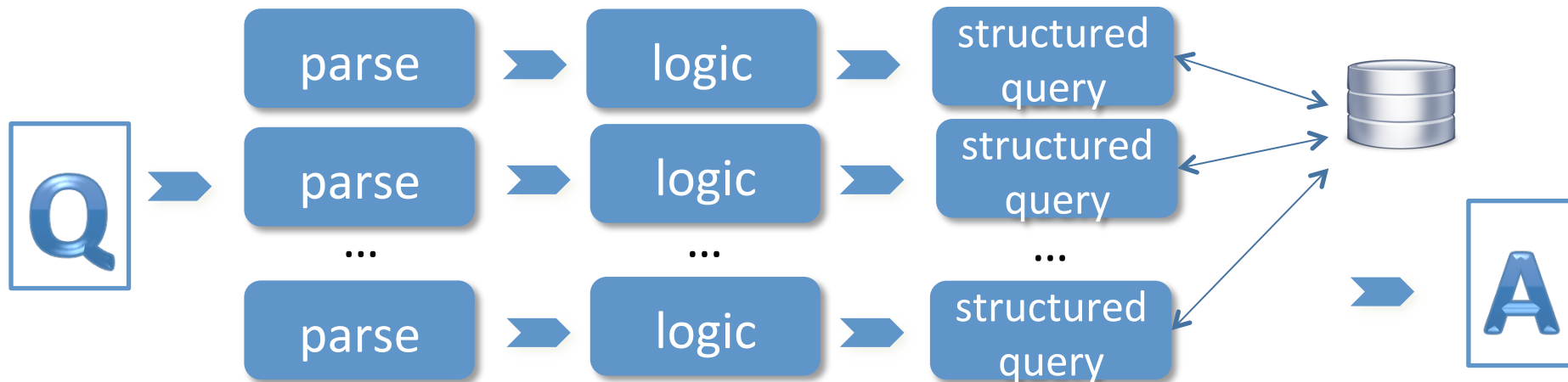
Feature driven answer extraction

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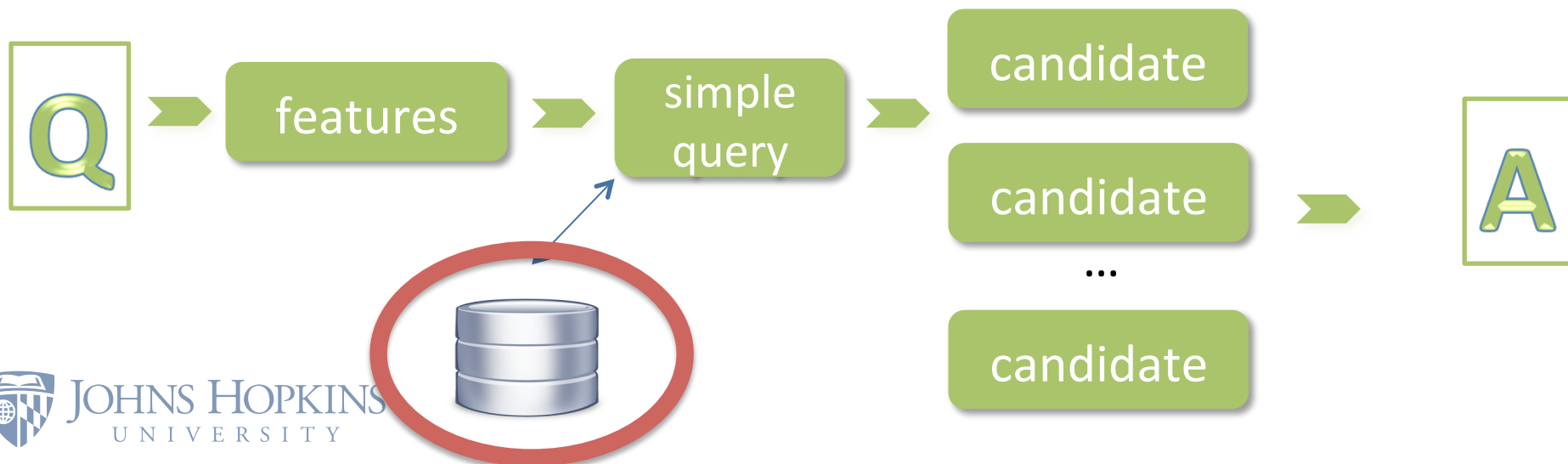
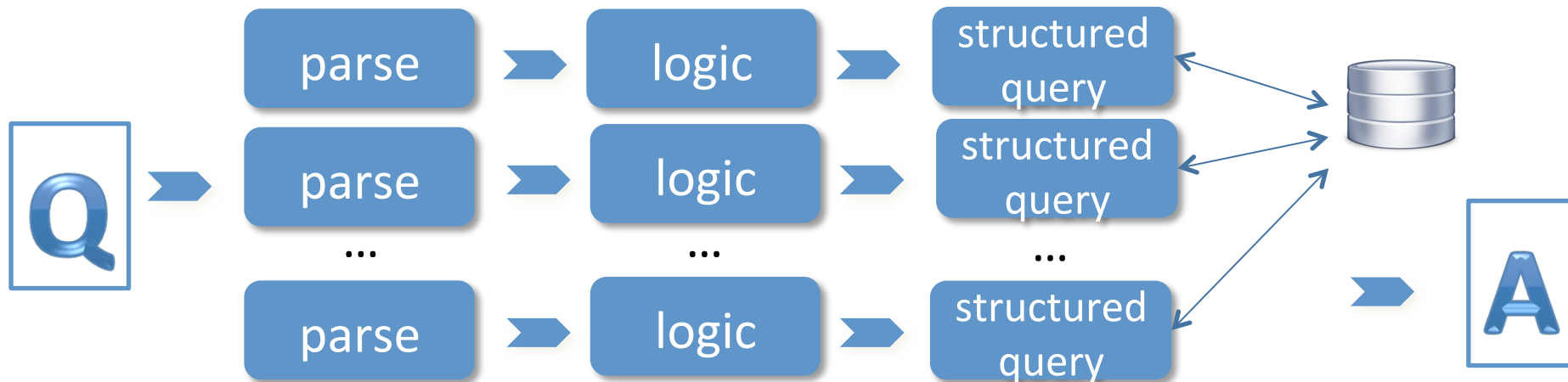
Feature driven QA on a KB



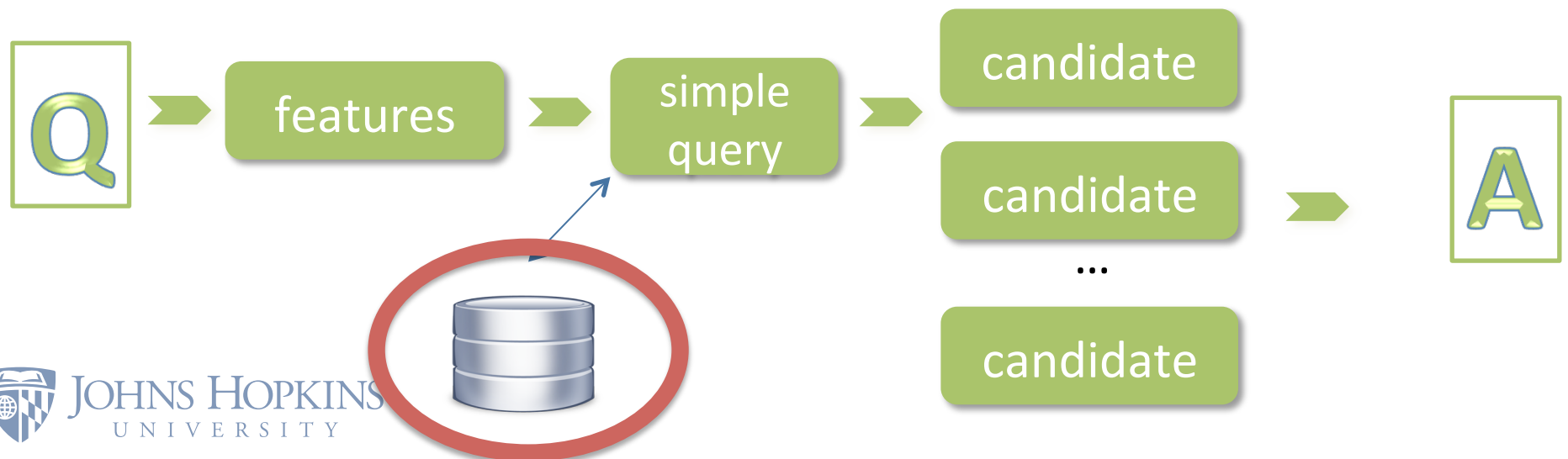






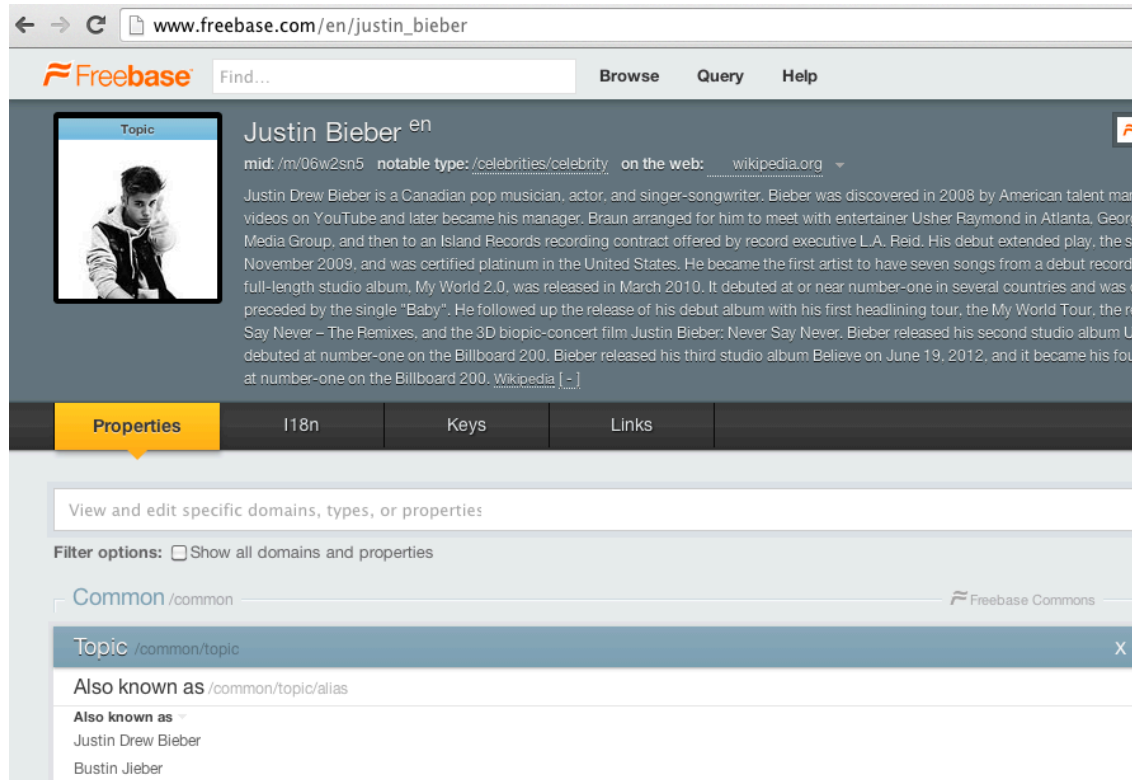


# Question Answering on FreeBase



*who is the brother of Justin Bieber?*

*who is the brother of Justin Bieber?*



← → ↻ [www.freebase.com/en/justin\\_bieber](http://www.freebase.com/en/justin_bieber)

Freebase Find... Browse Query Help

**Justin Bieber**<sup>en</sup>

mid: /m/06w2sn5 notable type: /celebrities/celebrity on the web: wikipedia.org

Justin Drew Bieber is a Canadian pop musician, actor, and singer-songwriter. Bieber was discovered in 2008 by American talent manager Raymond Braun after he posted videos on YouTube and later became his manager. Braun arranged for him to meet with entertainer Usher Raymond in Atlanta, Georgia and then to an Island Records recording contract offered by record executive L.A. Reid. His debut extended play, the seventh in the series, was released on November 2009, and was certified platinum in the United States. He became the first artist to have seven songs from a debut record to reach number-one on the Billboard Hot 100. His full-length studio album, *My World 2.0*, was released in March 2010. It debuted at or near number-one in several countries and was preceded by the single "Baby". He followed up the release of his debut album with his first headlining tour, the *My World Tour*, the remixed album *My World: The Remixes*, and the 3D biopic-concert film *Justin Bieber: Never Say Never*. Bieber released his second studio album *Under the Mistletoe* in November 2010, which debuted at number-one on the Billboard 200. Bieber released his third studio album *Believe* on June 19, 2012, and it became his fourth number-one album on the Billboard 200. [Wikipedia](#) [-]

**Properties** I18n Keys Links

View and edit specific domains, types, or properties

Filter options:  Show all domains and properties

**Common** /common Freebase Commons

**Topic** /common/topic X

**Also known as** /common/topic/alias

**Also known as** ▾

- Justin Drew Bieber
- Bustin Jieber

*who is the brother of Justin Bieber?*

**Siblings** /people/person/sibling\_s

**Sibling** ▾

Jazmyn Bieber

▾ **Jaxon Bieber**



**Jaxon Bieber**  
/m/0gxnnwq  
Jaxon Bieber is the younger half-brother of Justin Bieber.

*Man, Person, Topic*



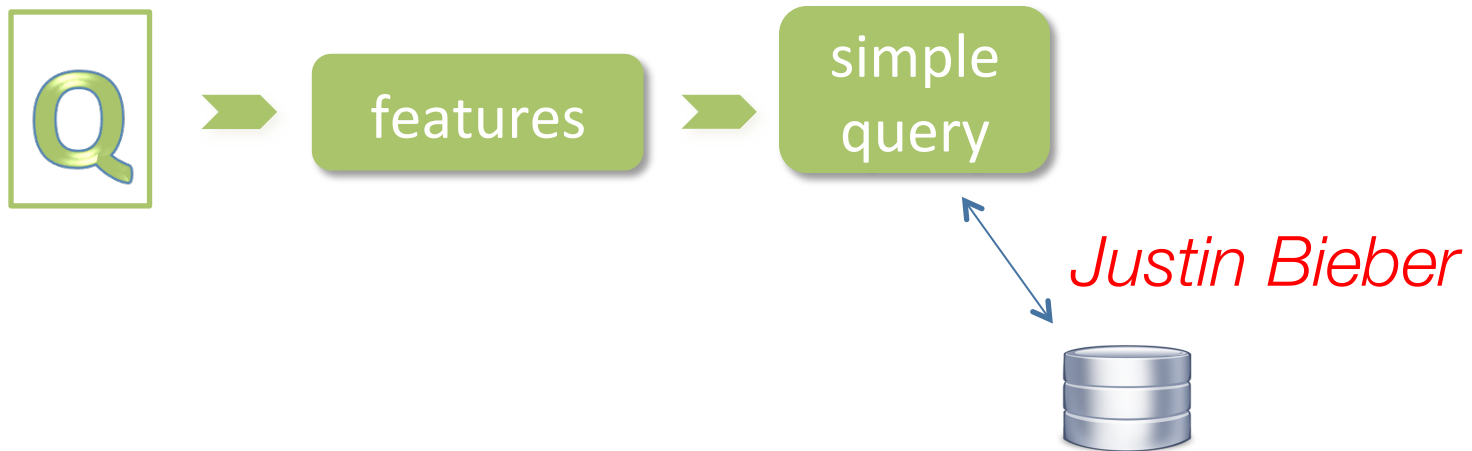
*who is the brother of Justin Bieber?*





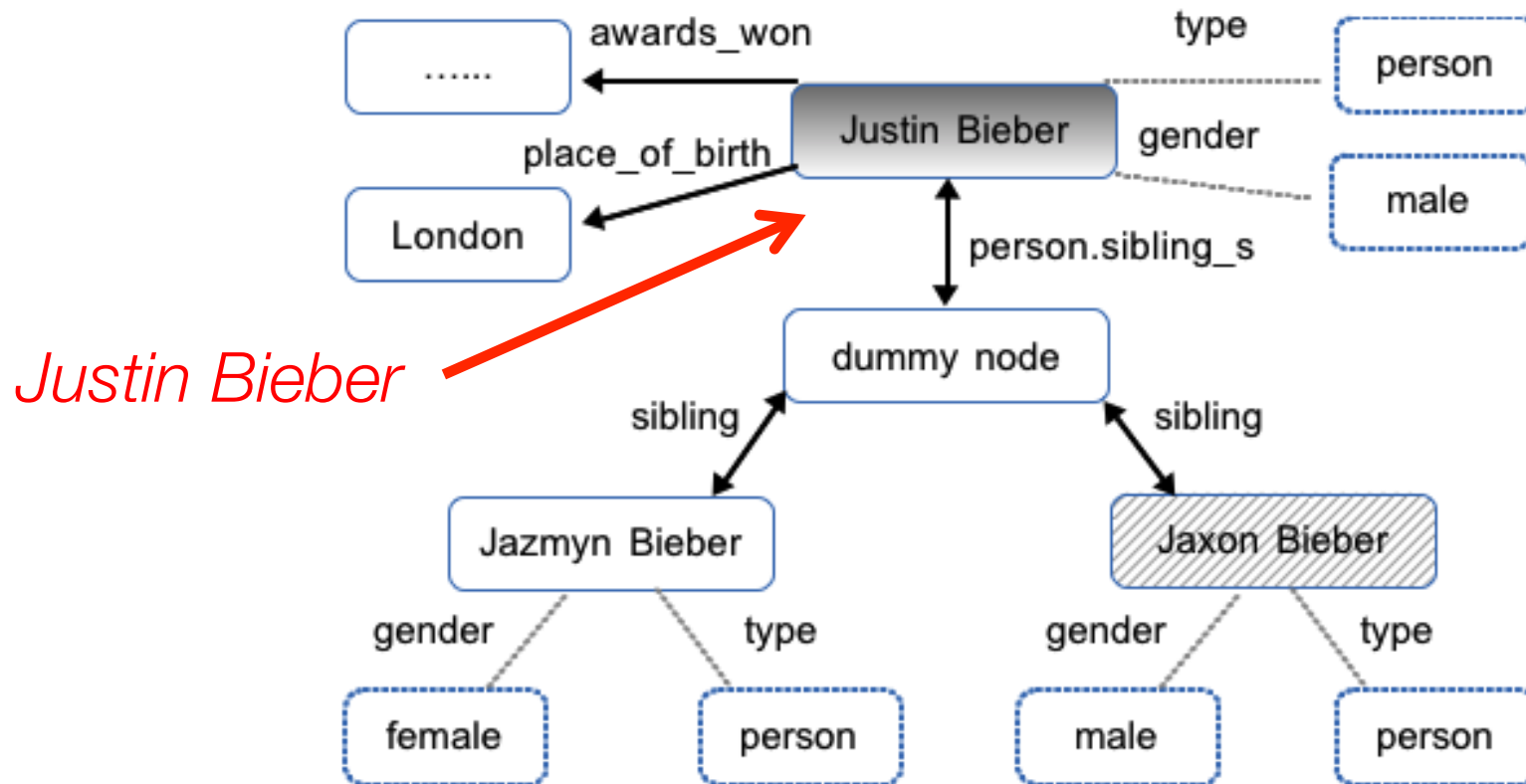
features

*who is the brother of Justin Bieber?*

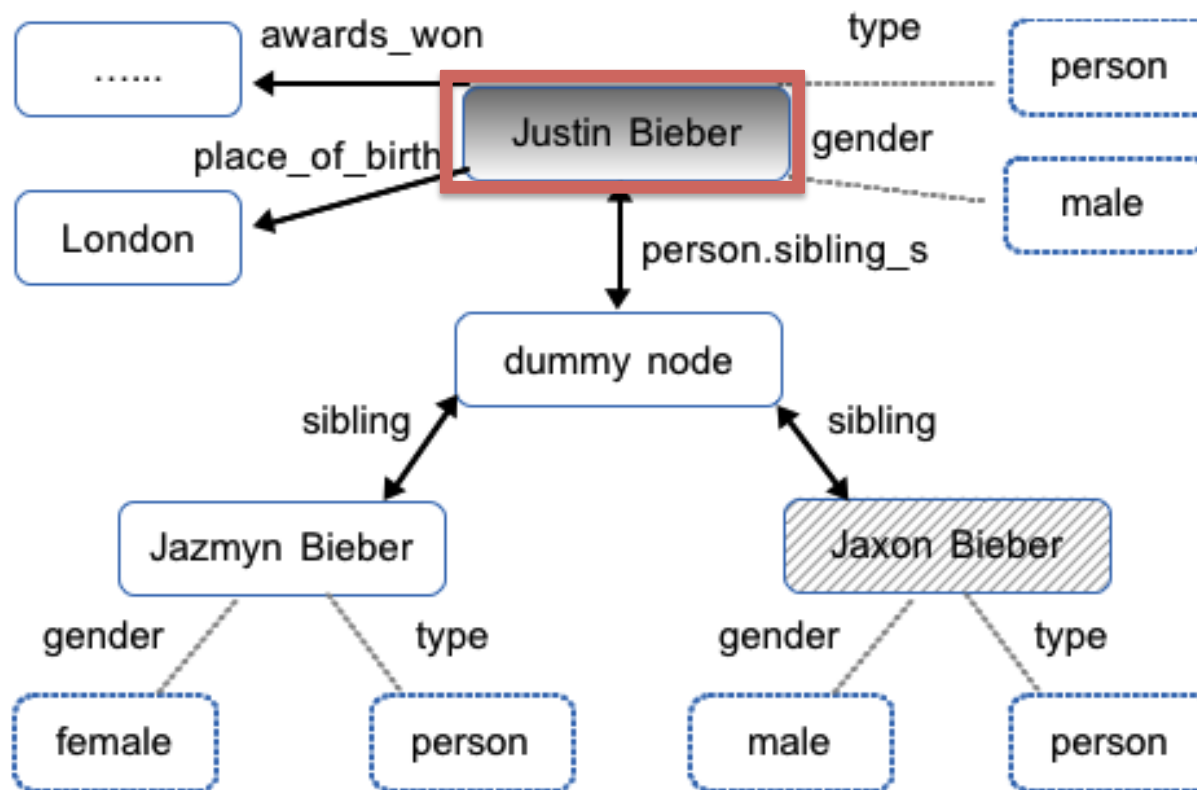




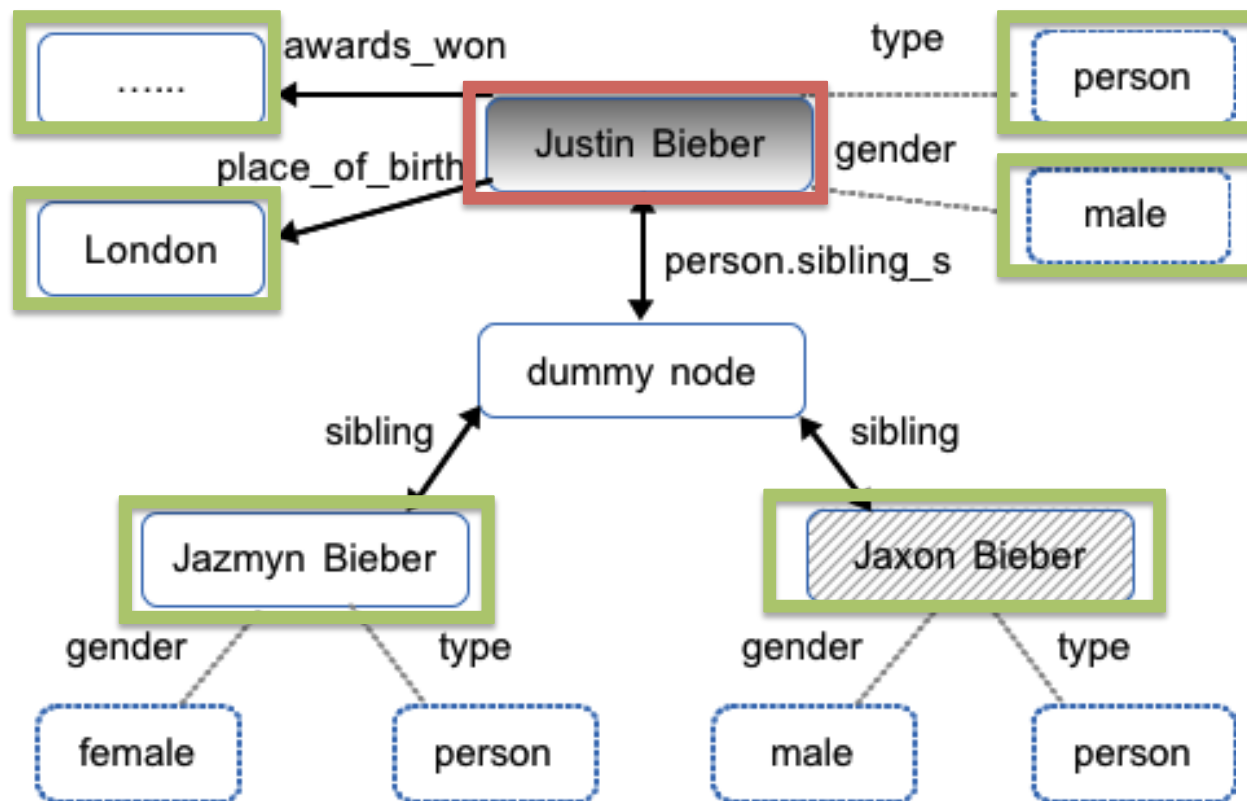
# Freebase Topic Graph

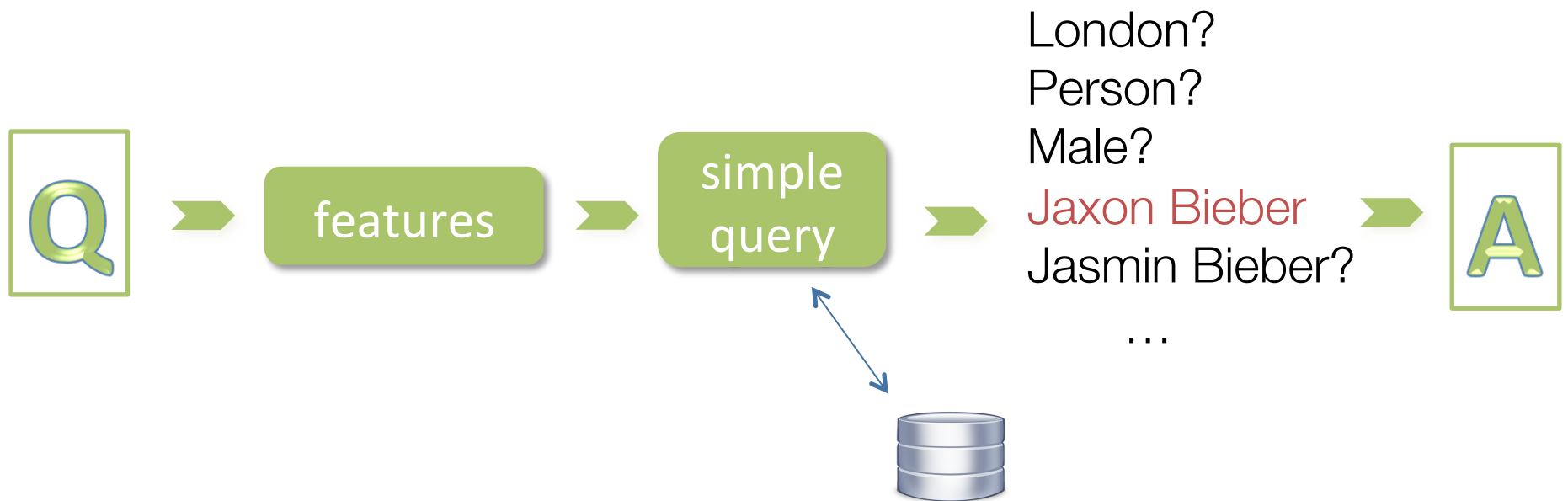


# Freebase Topic Graph



# Freebase Topic Graph





# Features on Graph

extract features for *each* node

---

---

## Justin Bieber

has:awards\_won

has:place\_of\_birth

type:person

...

## Jazmyn Bieber

has:sibling

gender:female

type:person

...

## Jaxon Bieber

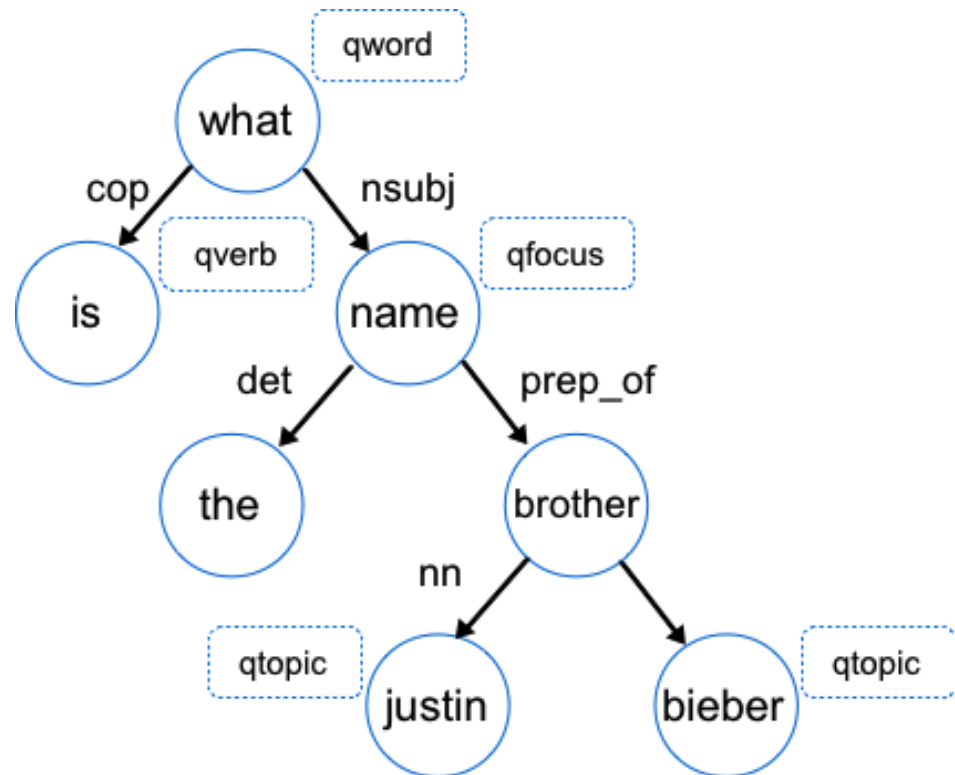
has:sibling

gender:male

type:person

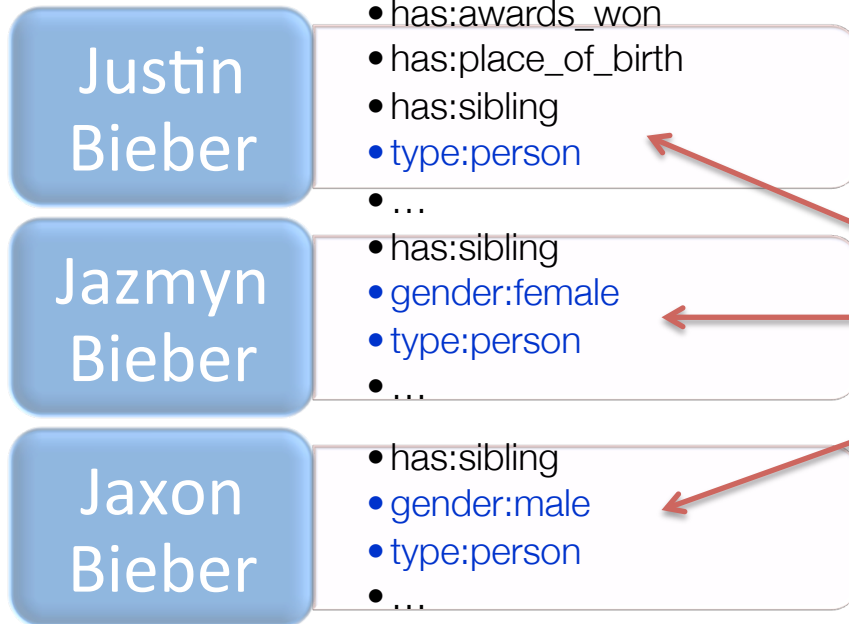
...

# Features on Question

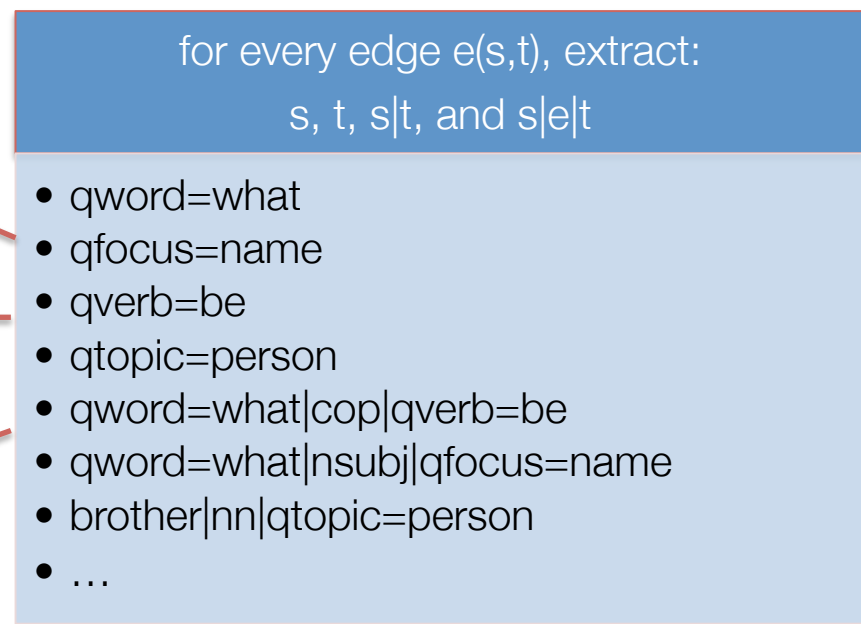


# Joint Features

on graph



on question



# Evaluation

Data: *WebQuestions*

Berant, et. al. (2013)

5810 questions crawled from  
Google Suggest

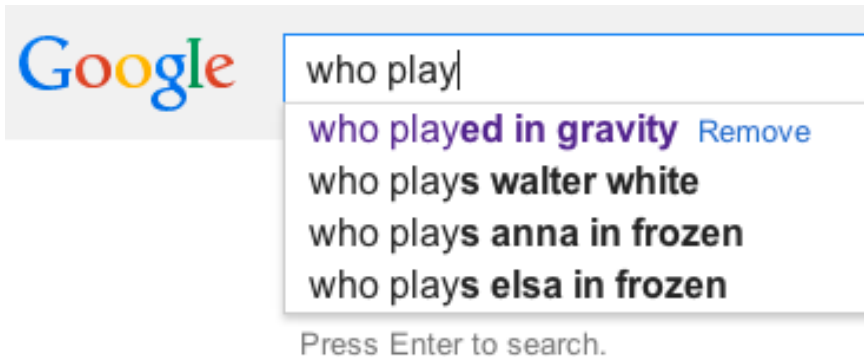


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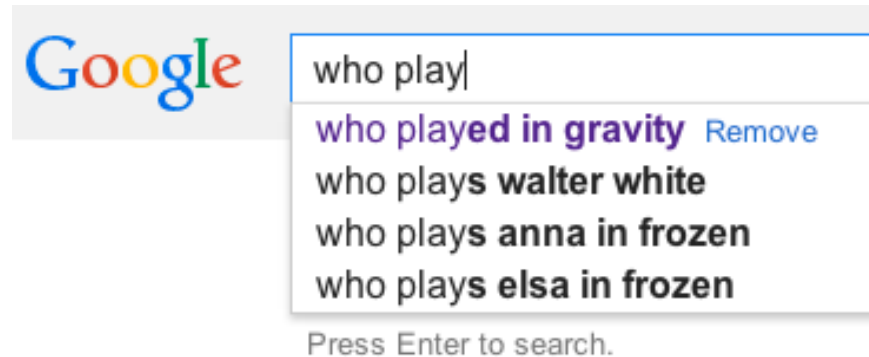


# Evaluation

Data: **WebQuestions**

5810 questions crawled from  
Google Suggest

Berant *et al.* (2013)



*which states does the connecticut river flow through?*

*who does david james play for 2011?*

*what date was john adams elected president?*

*what kind of currency does cuba use?*

*who owns the cleveland browns?*

...

# Model

L1 regularized Logistic Regression

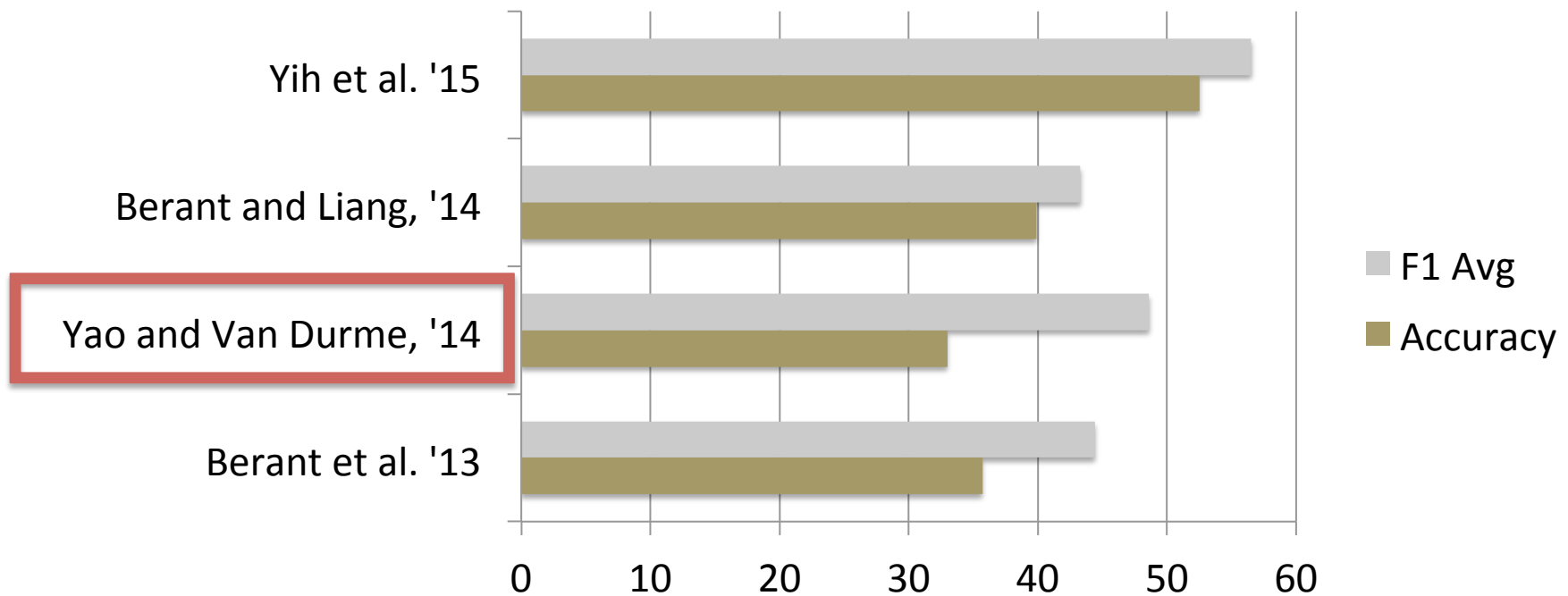
high-performance toolkit: Classias (Okazaki, 2009)

Start with: 7 million feature types extracted

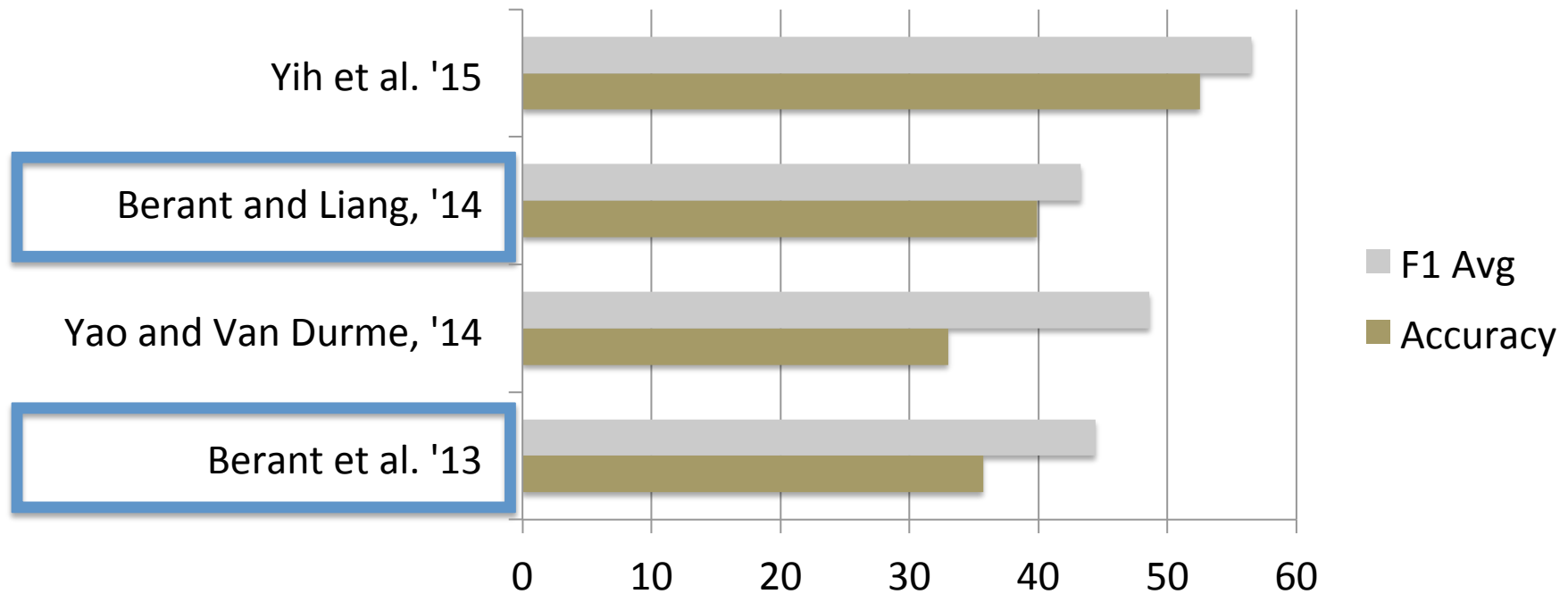
Train for: 4 hours

Result: 30 thousand features with non-zero weight

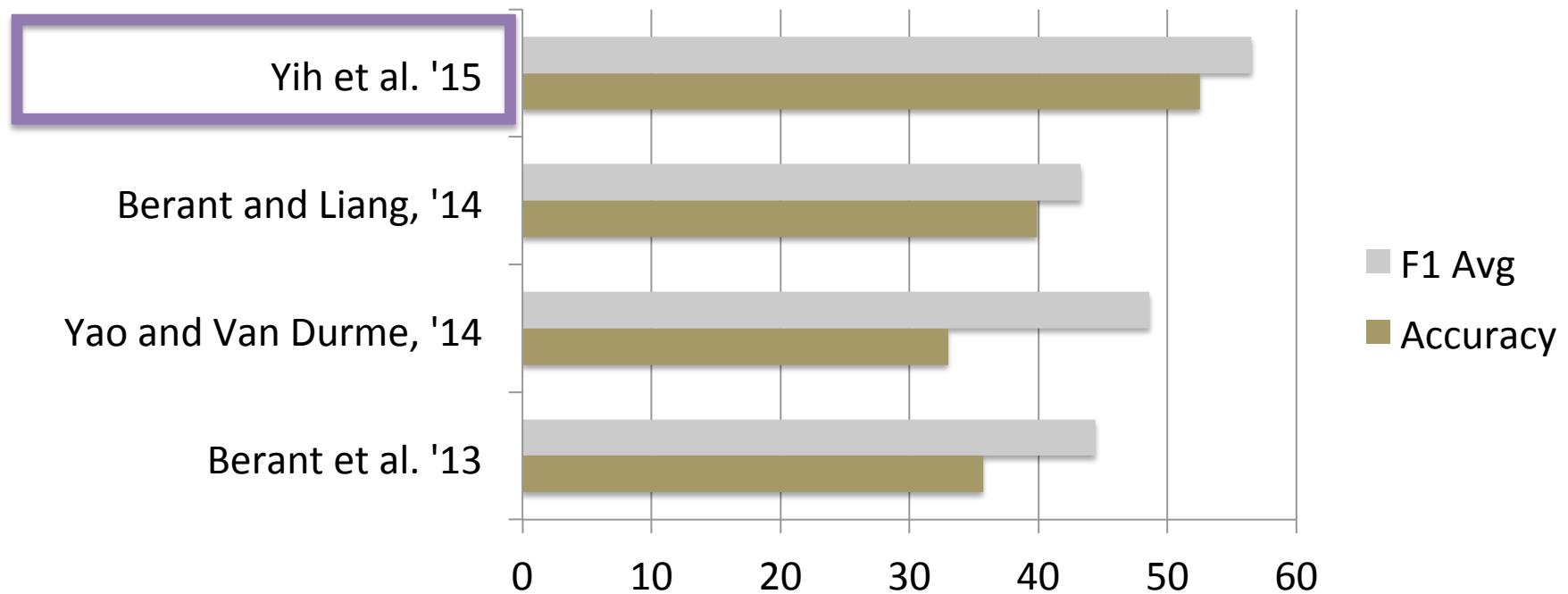
# Our Results



# Stanford



# Microsoft Research



Feature driven answer extraction

Feature driven retrieval

Feature driven QA on a KB

Feature driven answer extraction

Feature driven retrieval

Feature driven QA on a KB



This work supported by ...

The Google logo, featuring the word "Google" in its characteristic multi-colored font.