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Fact Extraction for **Nominal** Attributes

Mohamed Yahya, Steven Whang,  
Rahul Gupta, and Alon Halevy



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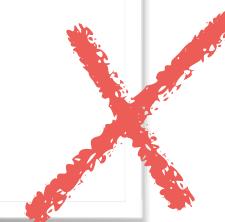
insider.foxnews.com/.../defense-official-military-**advised**-obama-not-ma... ▾

Jun 6, 2014 - A senior Defense official tells Fox News that military officials **advised** President **Obama** not to make the prisoner swap, calling it "like handing ...

### Meet the Controversial Muslim Leader Who Has **Advised** the ...

www.nationaljournal.com/.../meet-the-controversial-mus... ▾ National Journal ▾

Sep 29, 2014 - In a speech last week laced with references to religion, President **Obama** called on Muslim leaders and youth alike to reject the barbaric ...



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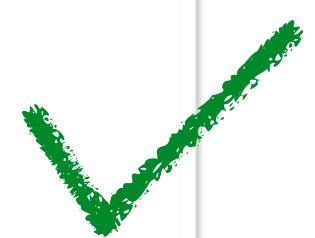
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en.wikipedia.org/wiki/Valerie\_Jarrett ▾ Wikipedia ▾

Valerie Bowman Jarrett (born November 14, 1956) is a Senior **Advisor** to the .... Jarrett is one of President **Obama's** longest serving **advisers** and confidantes and ...

James E. Bowman - Barbara T. Bowman - Vernon Jarrett



### Senior **Advisor** to the President of the United States ...

en.wikipedia.org/.../Senior\_Advisor\_to\_the\_President\_of\_the\_... ▾ Wikipedia ▾

Senior **Advisor** is a title used within the Executive Branch of the United States ... Rand Beers · District of Columbia, December 23, 2013, present, Barack **Obama** ...

Responsibilities - Prior administrations - List of Senior Advisors to the ... - See also

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## Nicolas Sarkozy en

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Nicolas Sarkozy is a French politician who served as the 23rd President of France from 16 May 2007 until 15 May 2012. Before his presidency, he was the leader of the Union for a Popular Movement. Under Jacques Chirac's presidency he served as Minister of the Interior in Jean-Pierre Raffarin's first two governments, then was appointed Minister of Finances in Raffarin's last government and again Minister of the Interior in Dominique de Villepin's government. Sarkozy was also president of the General council of the Hauts-de-Seine department from 2004 to 2007 and mayor of Neuilly-sur-Seine, one of the wealthiest communes of France, from 1983 to 2002. He was Minister of the Budget in the government of Édouard Balladur during François Mitterrand's last term. In foreign affairs, he promised a strengthening of the entente cordiale with the United Kingdom and closer cooperation with the United States. During his term, he faced the late-2000s financial crisis and the Arab Spring. He married Italian-French singer-songwriter Carla Bruni on 2 February 2008 at the Élysée Palace in Paris. [...]

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1/28/1955

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✓ 2013-12-07

Paris

##### Country of nationality /people/person/nationality

###### Country of nationality

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Hungary

##### Gender /people/person/gender

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Male

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###### Profession

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Lawyer

Spokesperson

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[Telegraph.co.uk](#) · 5 days ago

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[Hollande Saviour Is ECB as Ex-Partner Adds to Woes: Euro ...](#)

Businessweek · 1 day ago

[Francois Hollande bids to escape domestic trouble with Iraq ...](#)

Telegraph.co.uk · 3 days ago

## More news for hollande's ex-girlfriend

### [Hollande's ex tells all - CNN.com](#)

[www.cnn.com/2014/09/04/world/.../hollande-ex-girlfriend-book/](#) CNN ▾

Sep 4, 2014 - French President's **ex-girlfriend** reveals intimate details in new book. By Margot Haddad ... **Hollande's** ex publishes revealing book. STORY ...

### [Francois Hollande's ex-partner rushes to his defence after ...](#)

[news.nationalpost.com/.../francois-hollande-ex-partner-rus.../](#) ▾ National Post ▾

Sep 5, 2014 - Francois **Hollande** made sure doctors kept his spurned **ex-girlfriend**, Valerie Trierweiler, drugged on "astronomical" amounts of tranquillisers ...

### [Hollande hits back at ex-girlfriend's claims that he 'doesn't ...](#)

[www.telegraph.co.uk](#) · ... · Europe · France · The Daily Telegraph ▾

Sep 5, 2014 - François **Hollande** hit back today at damaging claims by his **ex-girlfriend** Valerie Trierweiler that he has been "driving himself



gazprom's banking arm



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### EU sanctions target Rosneft and **Gazprom's** oil business ...

[www.montrealgazette.com/business/imposes.../story.html](http://www.montrealgazette.com/business/imposes.../story.html) The Gazette ▾

Sep 12, 2014 - BRUSSELS - New European Union sanctions against Russia announced Friday toughen financial penalties on the country's **banks, arms** ...

### EU sanctions target Rosneft and **Gazprom's** oil business ...

[www.winnipegfreepress.com › Business](http://www.winnipegfreepress.com › Business) ▾ Winnipeg Free Press ▾

Sep 12, 2014 - EU sanctions target Rosneft and **Gazprom's** oil business, **banks, arms** firms and lawmakers. By: Juergen Baetz, The Associated Press.

### European Union Demand Lifts **Gazprom** Earnings - The ...

[www.nytimes.com/.../european-union-demand-lifts-g...](http://www.nytimes.com/.../european-union-demand-lifts-g...) The New York Times ▾

Apr 29, 2014 - **Gazprom's** banking arm, Gazprombank, is owned by the company's ...  
For comparison, the price-to-earnings ratio of Gazprom's domestic ...

### Focus on Politics and Economics of Russia and Eastern Europe

[books.google.com/books?isbn=1600213170](http://books.google.com/books?isbn=1600213170)

Ulric R. Nichol - 2007 - Business & Economics

Hence, Gazprom all of a sudden finds itself with investment requirements ... Then, Dresdner Kleinwort Wasserstein supplied **Gazprom's** banking arm with ...

This talk is about  
**extracting facts**  
centered around  
**noun phrases (=attributes)**

coach  
president  
province

banking arm  
caucus chairman  
foreign policy chief  
state assemblyman

# (Open) Information Extraction

*...Gazprom's banking arm Gazprombank  
is owned by the company's pension fund...*

# (Open) Information Extraction

Text

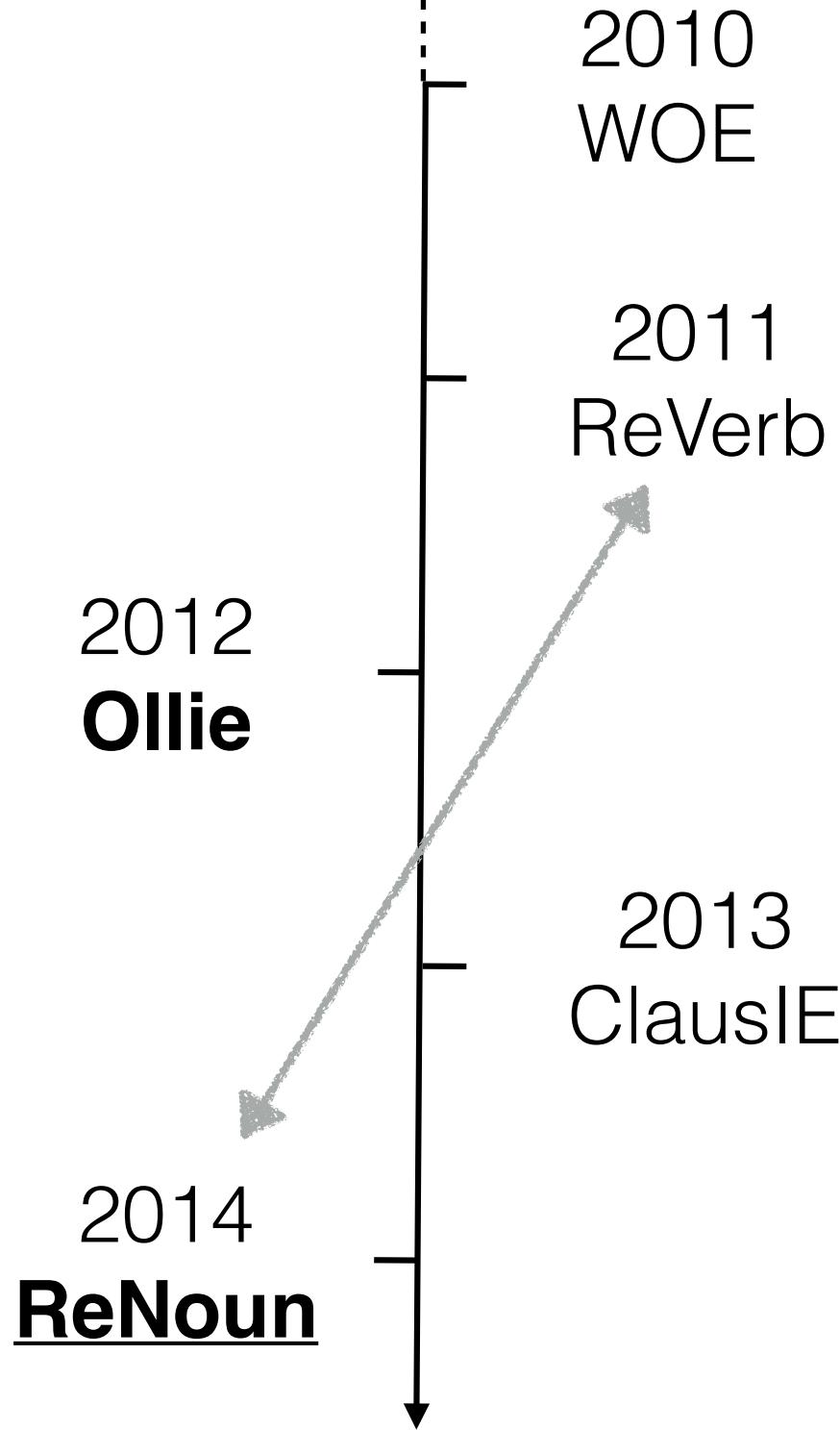
.. **Gazprom**'s *banking arm* **Gazprombank**  
*is owned by the company's pension fund...*

Fact/  
triple



Before the details:

What's missing from  
the state of the art?



2012  
**Ollie**



2014  
**ReNoun**

2010  
WOE

2011  
ReVerb

2013  
ClausIE

Notable exception,  
check it out!  
[WWW'13]





2012  
**Ollie**

2014  
**ReNoun**

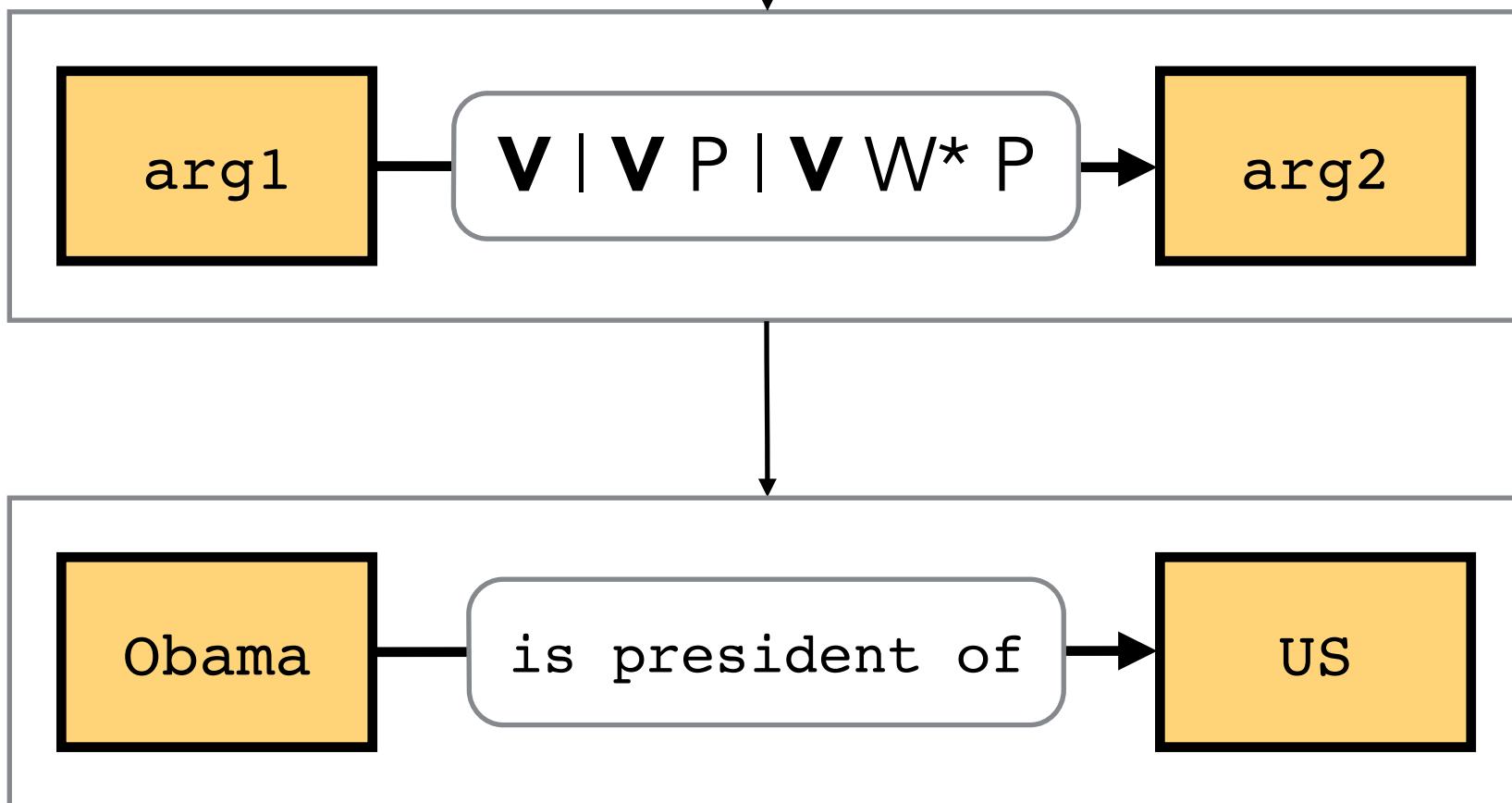
2010  
WOE

2011  
ReVerb

2013  
ClausIE

Let's see **Ollie**...

*Obama is the president of  
the US.*



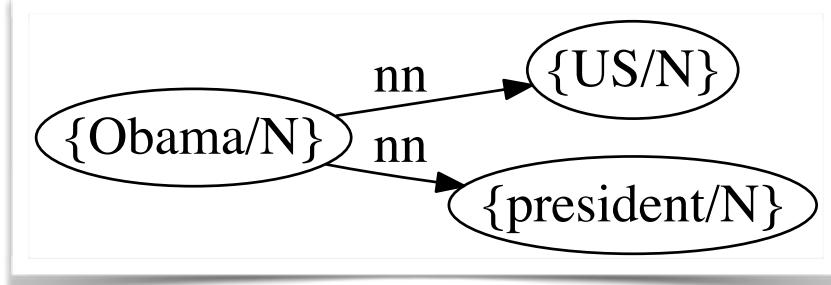
Obama

is president of

US



U.S. President Barack Obama departs the White House  
for Democratic Party fund raisers in New York City ...



# Ollie\*

[EMNLP'12]

vs.

# ReNoun

[this talk]

coach

president

province

banking arm

caucus chairman

foreign policy chief

state assemblyman

coach

president

province

banking arm

caucus chairman

foreign policy chief

state assemblyman

\* Ollie handles verbs, ReNoun doesn't!

**Ollie\***  
**[EMNLP'12]**

**vs.**

**ReNoun**  
**[this talk]**

coach

president

province

banking arm

caucus chairman

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state assemblyman

coach

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foreign policy chief

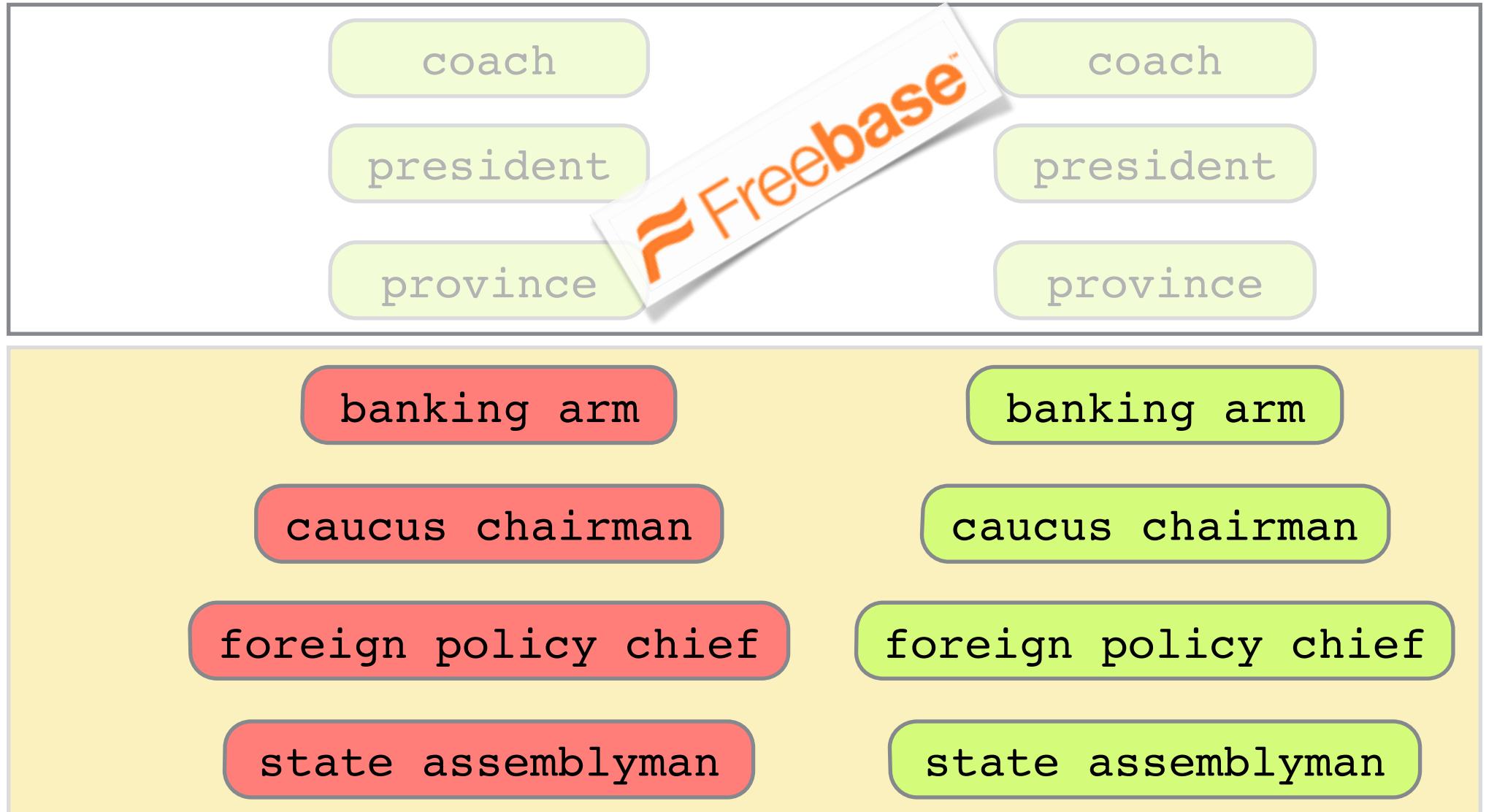
state assemblyman

\* Ollie handles verbs, ReNoun doesn't!

**Ollie\***  
**[EMNLP'12]**

**vs.**

**ReNoun**  
**[this talk]**

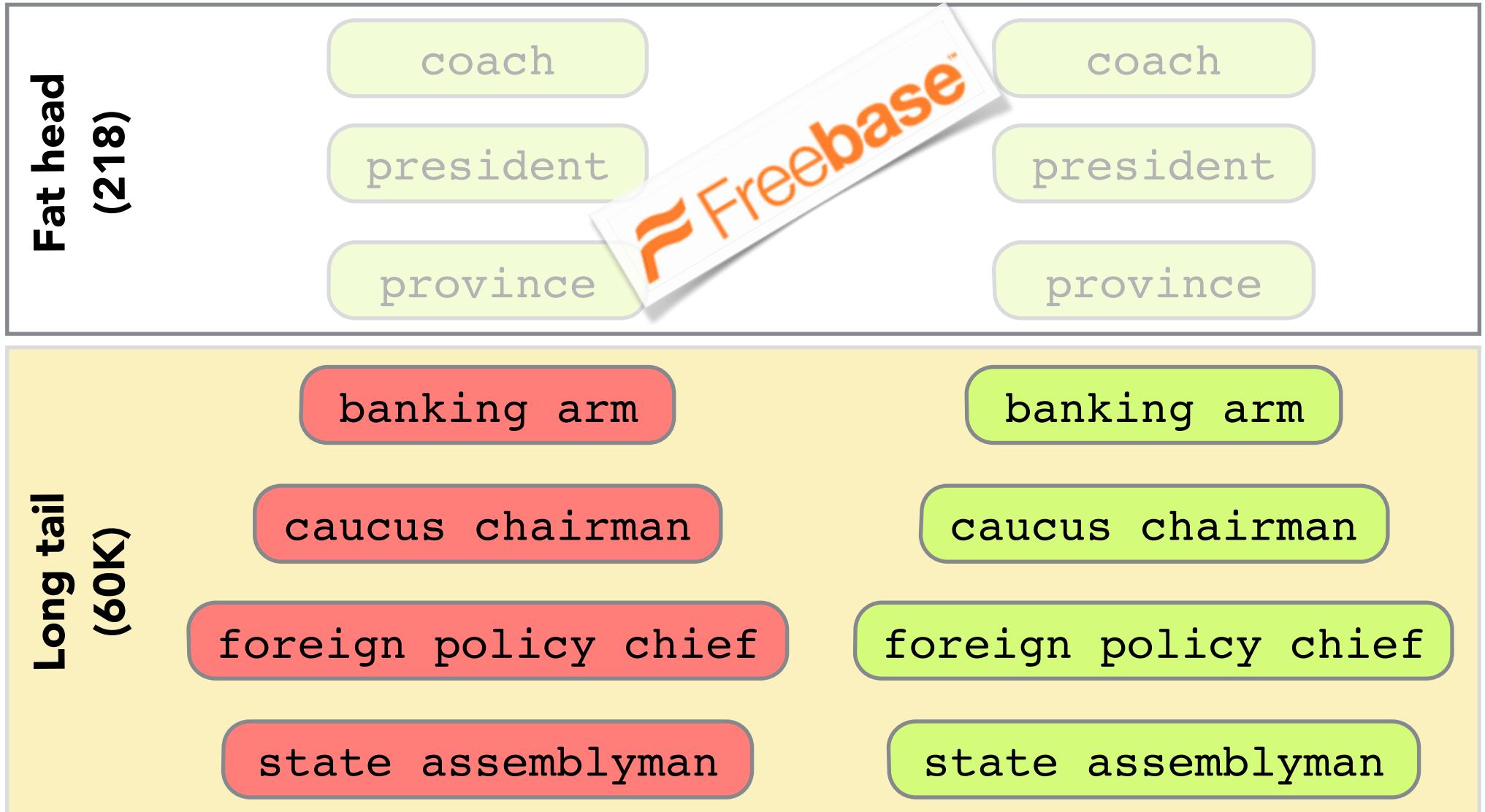


\* Ollie handles verbs, ReNoun doesn't!

**Ollie\***  
**[EMNLP'12]**

vs.

**ReNoun**  
**[this talk]**



\* Ollie handles verbs, ReNoun doesn't!



2012  
**Ollie**

2014  
**ReNoun**

2010  
WOE

2011  
ReVerb

2013  
ClausIE



2014  
**ReNoun**

2012  
**Ollie**

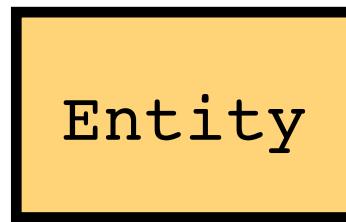
2010  
WOE

2011  
ReVerb

2013  
ClausIE

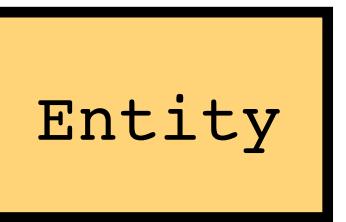
... now, **ReNoun** is upon us!

ReNoun  
[this talk]

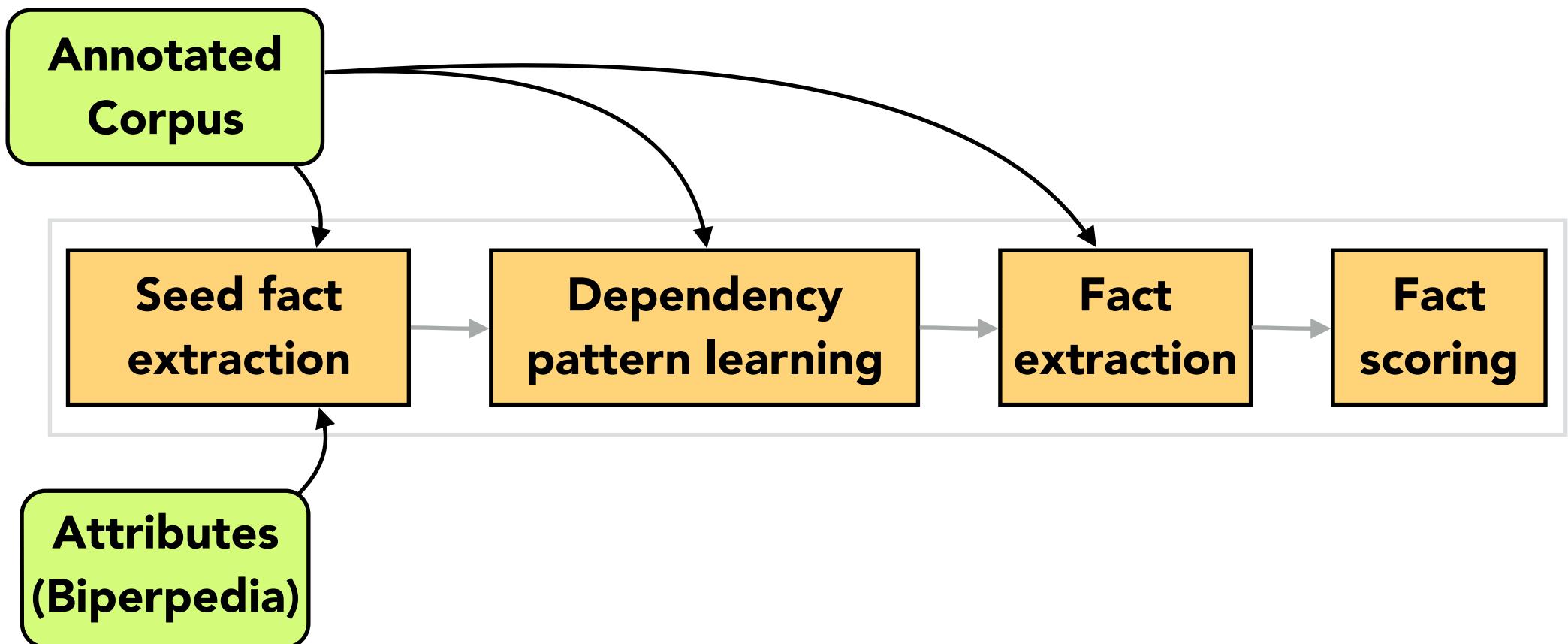


Relations are expressed  
using **noun phrases**.

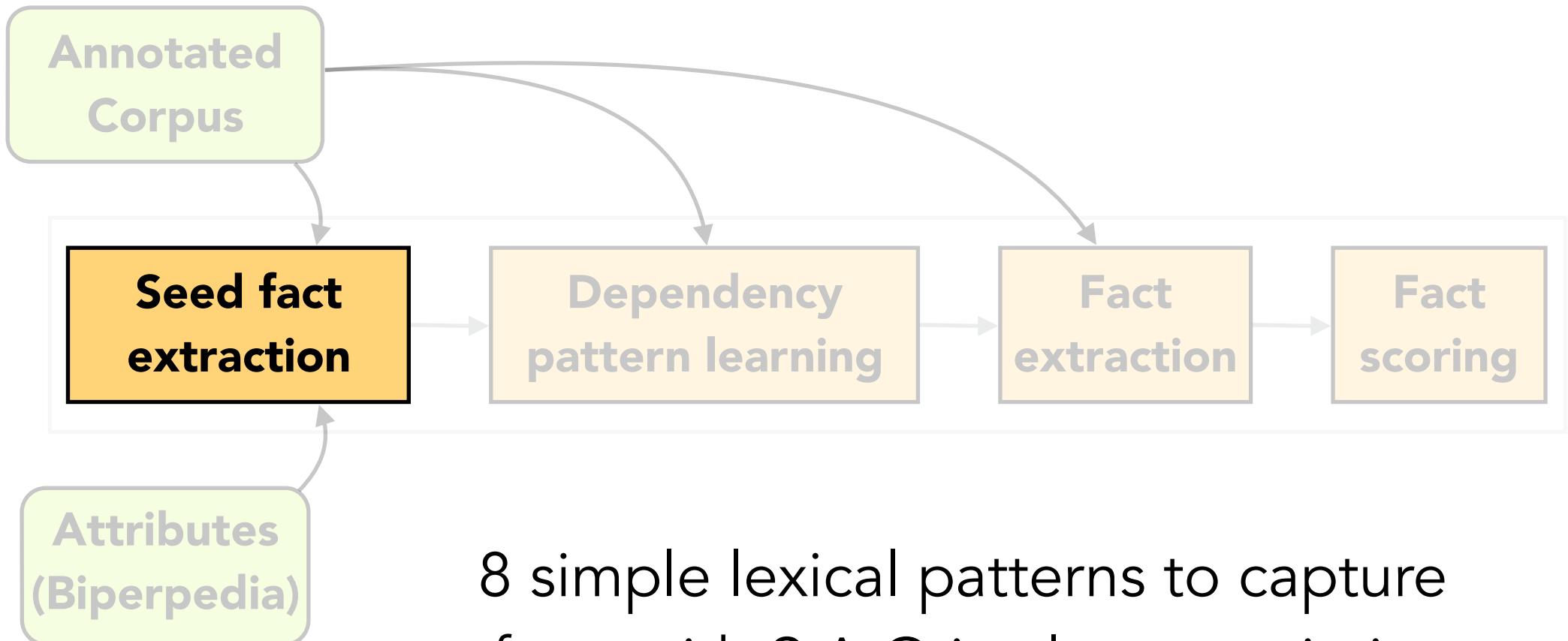
noun phrase



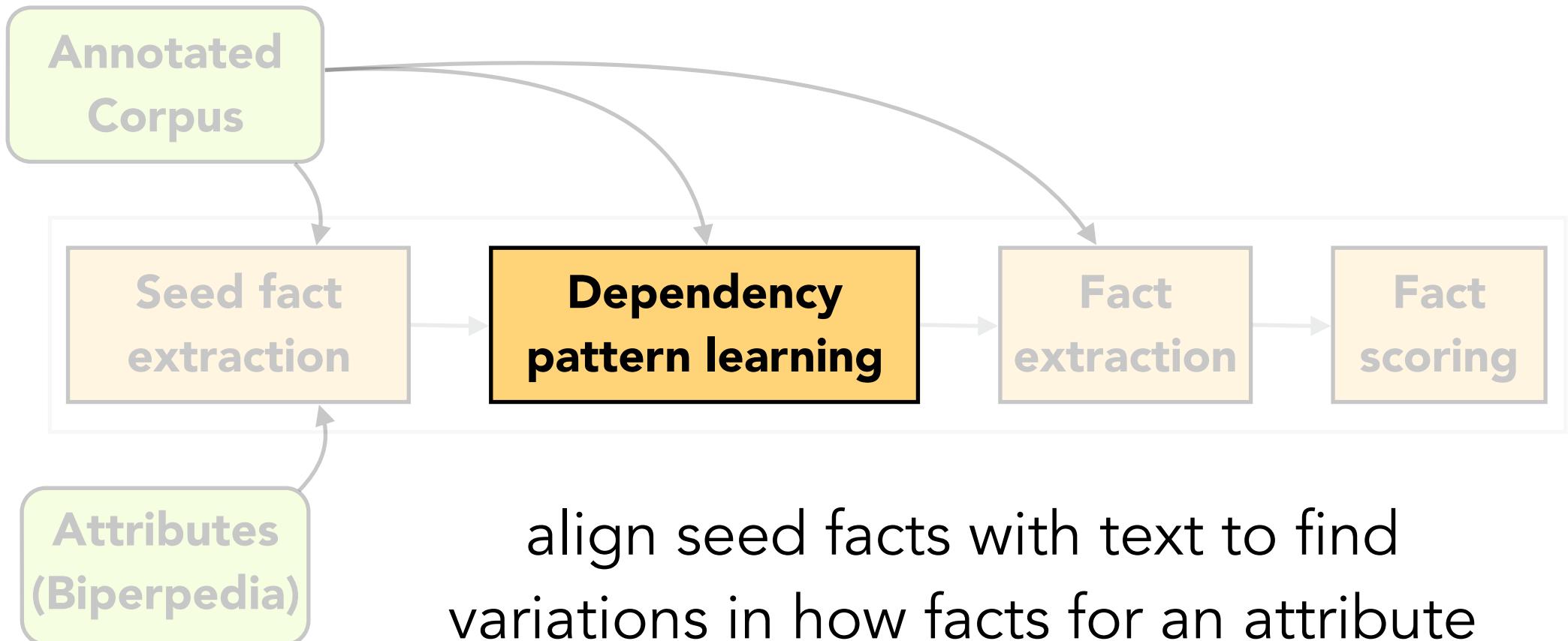
# ReNoun



*Google CEO Larry Page started his term in 2011.*

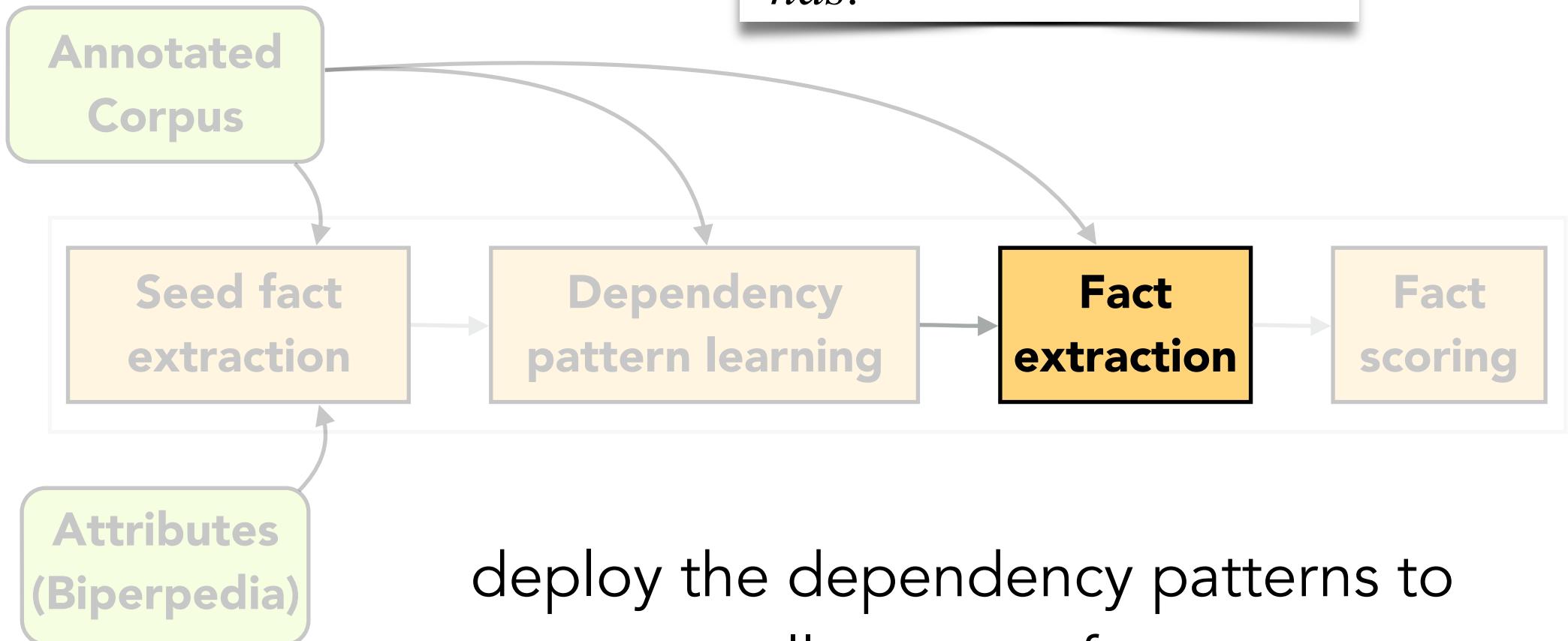


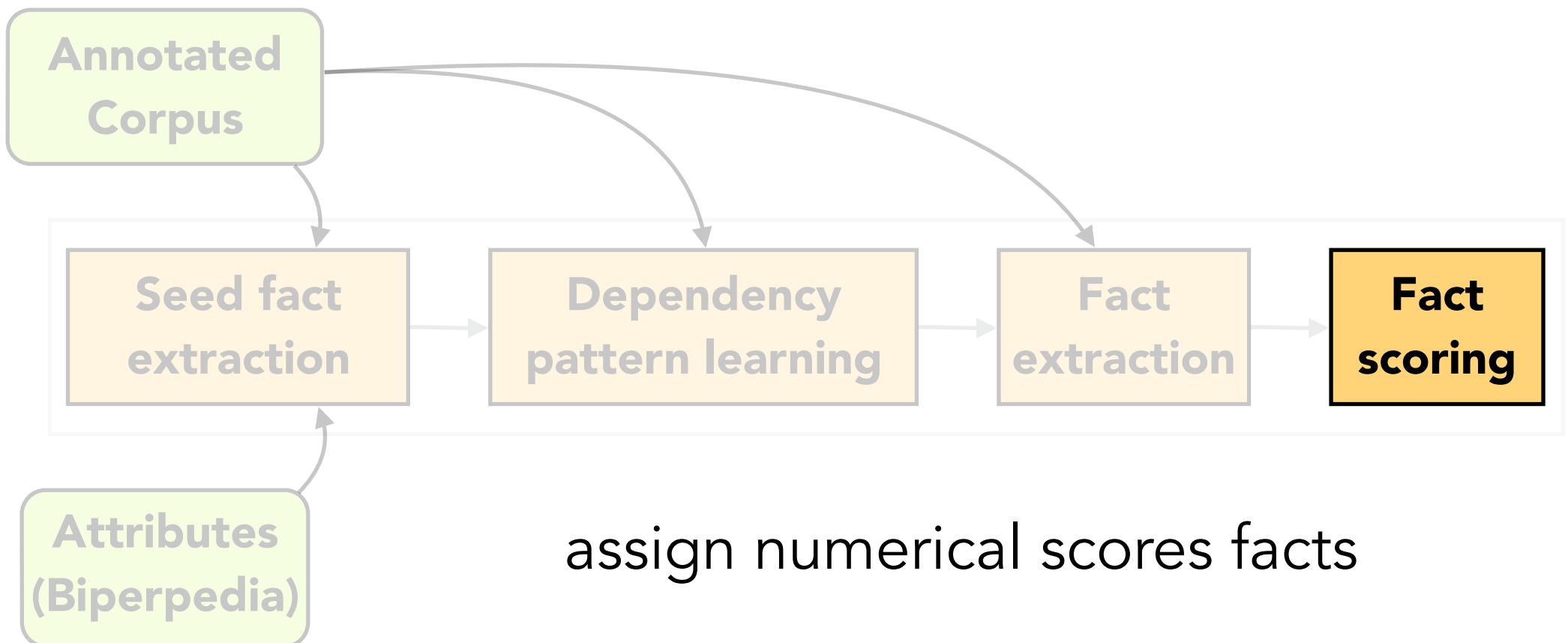
*A CEO, like Larry Page of Google, is usually a busy person.*



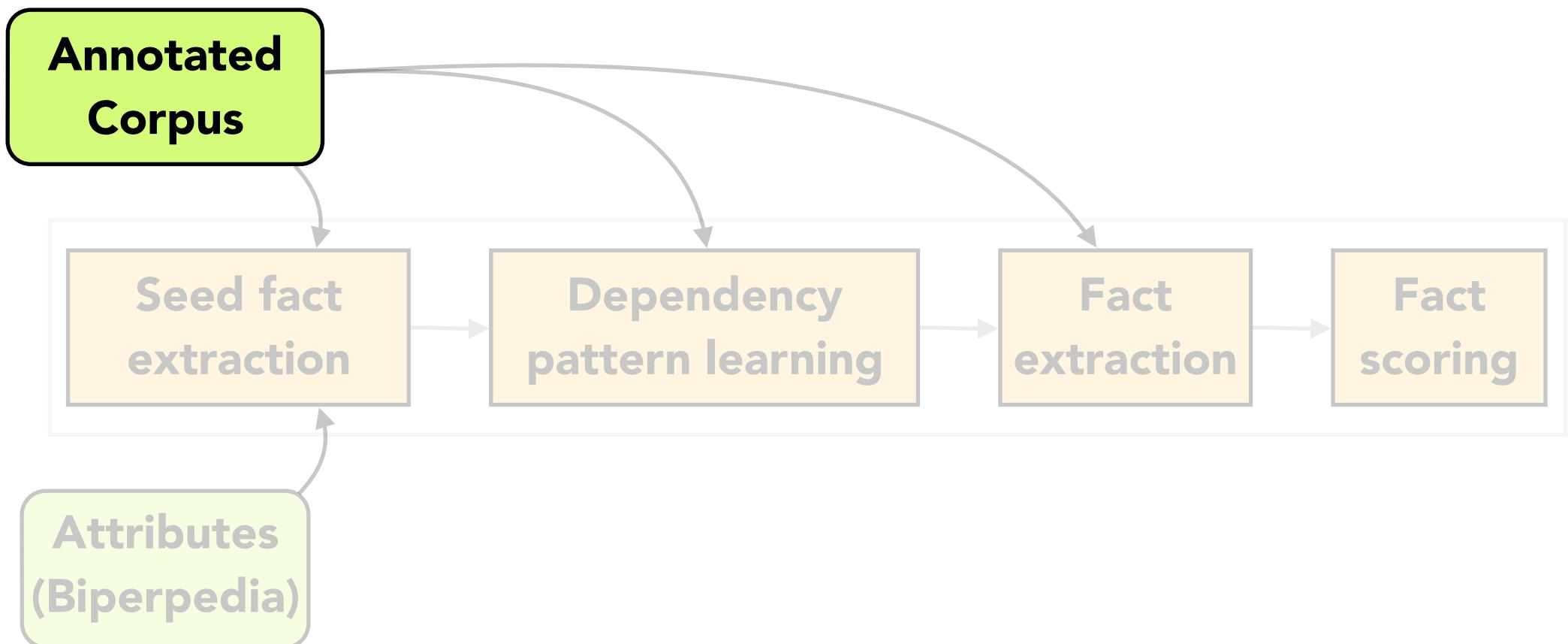
align seed facts with text to find  
variations in how facts for an attribute  
are expressed

*A CEO, like Manouchehr Moshayedi of STEC Inc., is not allowed to trade his company's stocks based on information only he has.*





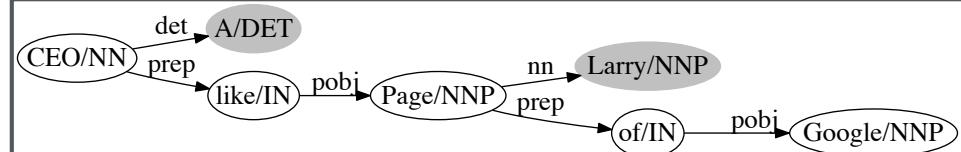
# ReNoun



# Annotated Corpus

1. Dependency parses,
2. Noun phrase chunks,
3. NER,
4. Coreference resolution,
5. Entity resolution to  Freebase

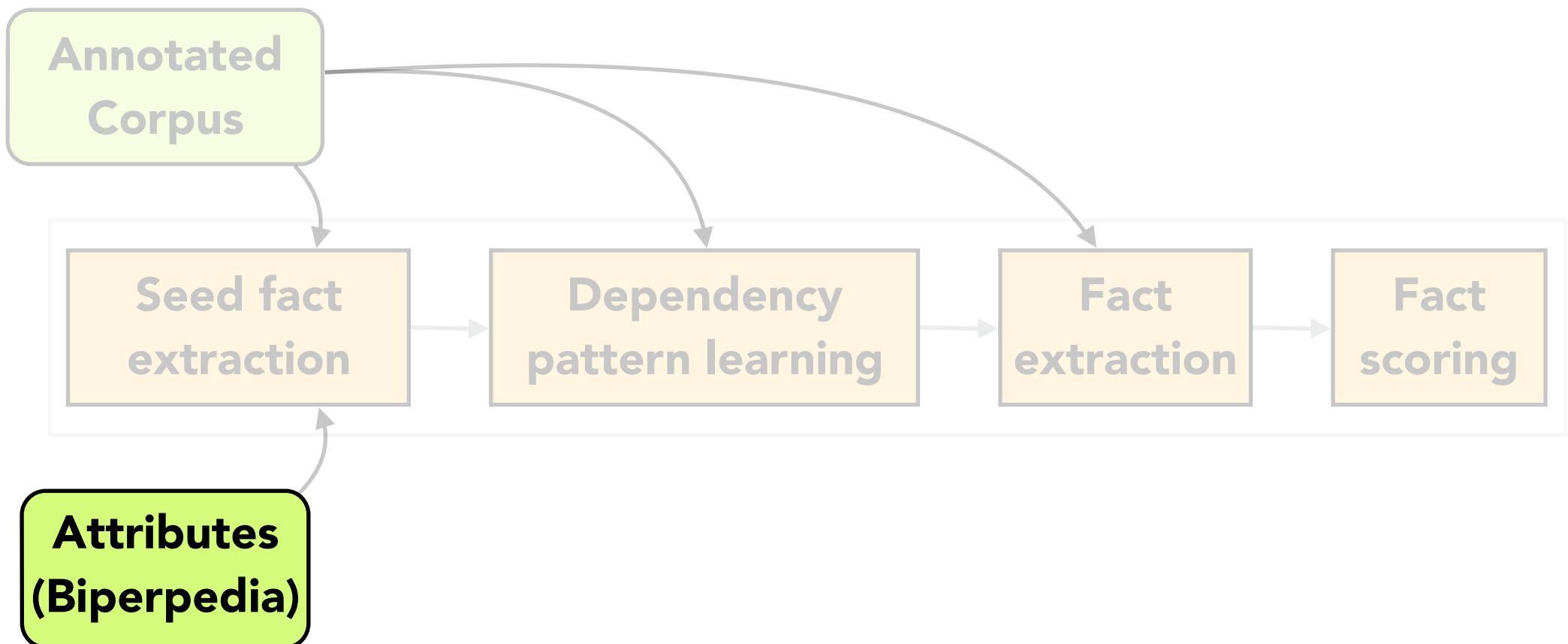
$400 \times 10^6$  news  
documents



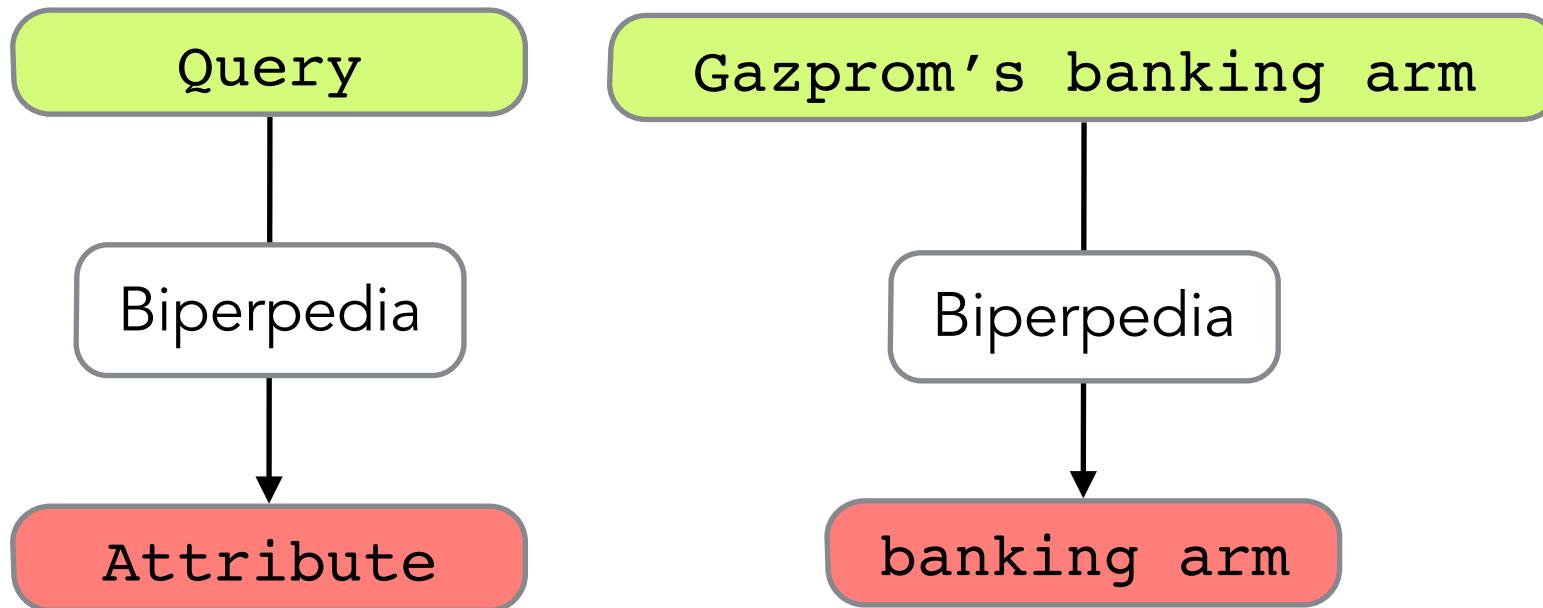
*[Google]<sub>1</sub> [CEO]<sub>2</sub> [Larry Page]<sub>2</sub> started his term in 2011,  
when [he]<sub>2</sub> succeeded [Eric Schmidt]<sub>3</sub>.*

Cluster	Phrase	Freebase ID
1	Google	/m/045c7b
2	Larry Page, CEO, he	/m/0gjpq
3	Eric Schmidt	/m/0gjpq

# ReNoun

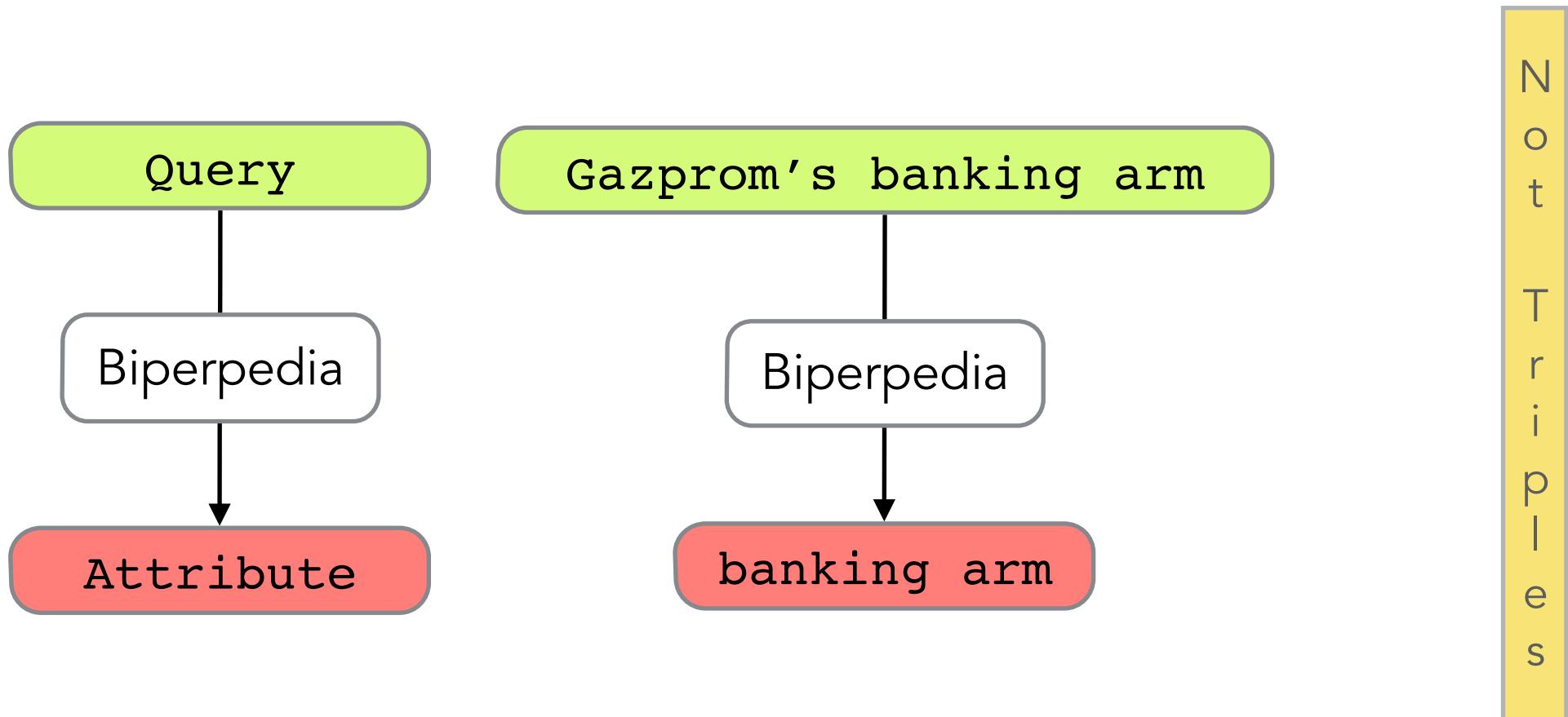


# Attributes: Biperpedia [Gupta et al., VLDB'14]



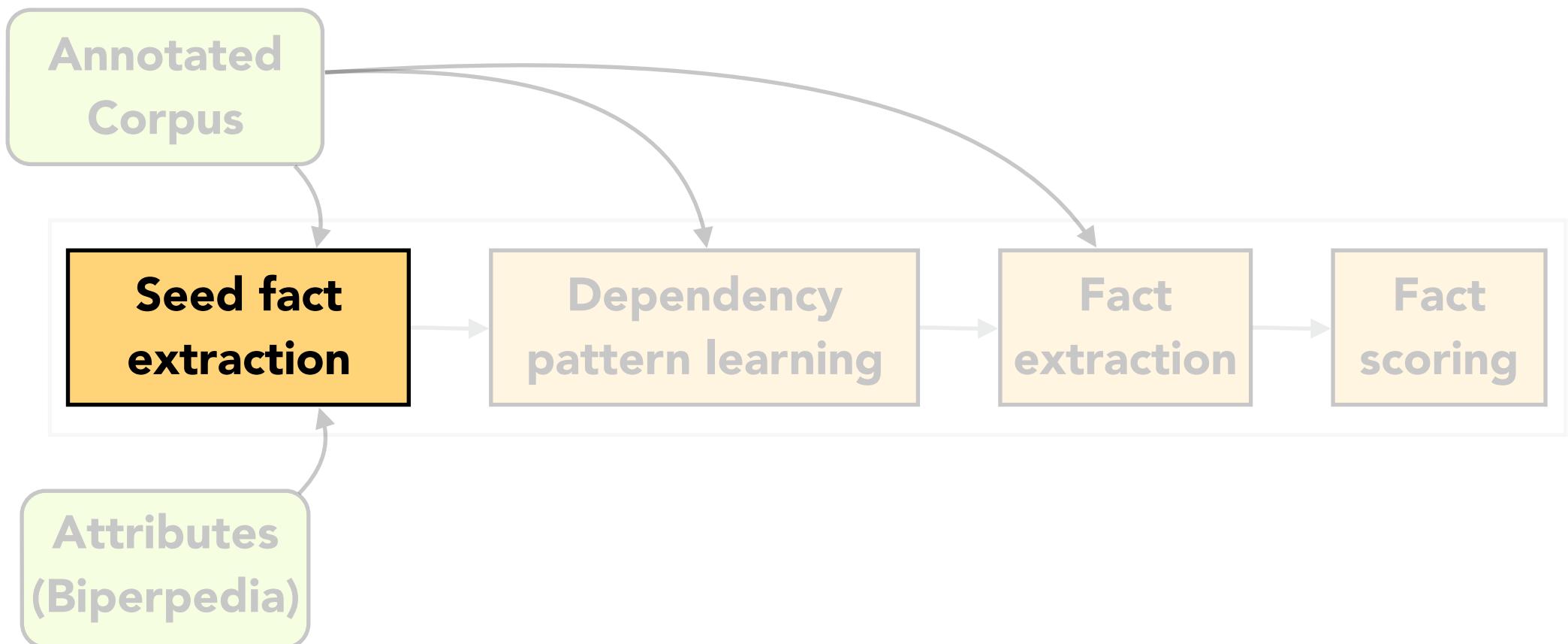
for more details, see the VLDB'14 paper, also [Lee et al., ICDE'13] and [Pasca & van Durma, IJCAI'07 ]

# Attributes: Biperpedia [Gupta et al., VLDB'14]



for more details, see the VLDB'14 paper, also [Lee et al., ICDE'13] and [Pasca & van Durma, IJCAI'07 ]

# ReNoun



# Seed fact extraction

[Google]<sub>1</sub> [CEO]<sub>2</sub> [Larry Page]<sub>2</sub> started his term in 2011, when [he]<sub>2</sub> succeeded [Eric Schmidt]<sub>3</sub>.

## #1: A in Biperpedia & one of 8 pattern applies

#	Pattern	Example
1	the A of S, o	the CEO of Google, Larry Page
2	the A of S is o	the CEO of Google is Larry Page
3	o, S A	Larry Page, Google CEO
4	o, S's A	Larry Page, Google's CEO
5	o, [the] A of S	Larry Page, [the] CEO of Google
6	SAO	Google CEO Larry Page
7	SA, o	Google CEO, Larry Page
8	S's A, o	Google's CEO, Larry Page

# Seed fact extraction

[Google]<sub>1</sub> [CEO]<sub>2</sub> [Larry Page]<sub>2</sub> started his term in 2011, when [he]<sub>2</sub> succeeded [Eric Schmidt]<sub>3</sub>.

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6	SAO	Google CEO Larry Page
7	SA, O	Google CEO, Larry Page
8	S's A, O	Google's CEO, Larry Page

# Seed fact extraction

## #2: A and O Corefer

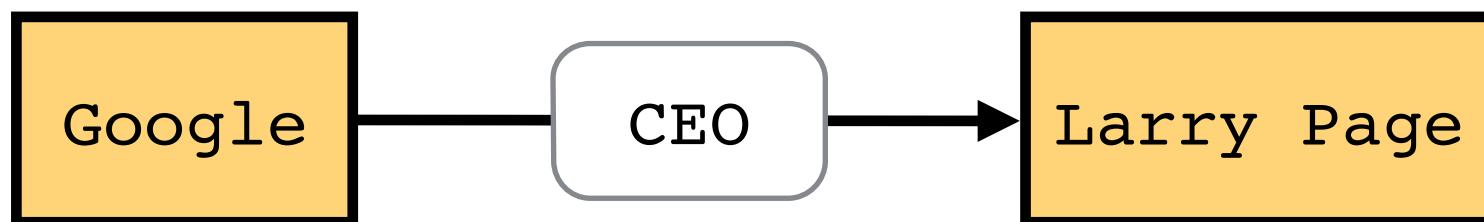
*[Google]<sub>1</sub> [CEO]<sub>2</sub> [Larry Page]<sub>2</sub> started his term in 2011,  
when [he]<sub>2</sub> succeeded [Eric Schmidt]<sub>3</sub>.*

Cluster	Phrase	Freebase ID
1	Google	/m/045c7b
2	Larry Page, CEO, he	/m/0gjpq
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# Seed fact extraction

## Result

*[Google]<sub>1</sub> [CEO]<sub>2</sub> [Larry Page]<sub>2</sub> started his term in 2011,  
when [he]<sub>2</sub> succeeded [Eric Schmidt]<sub>3</sub>.*



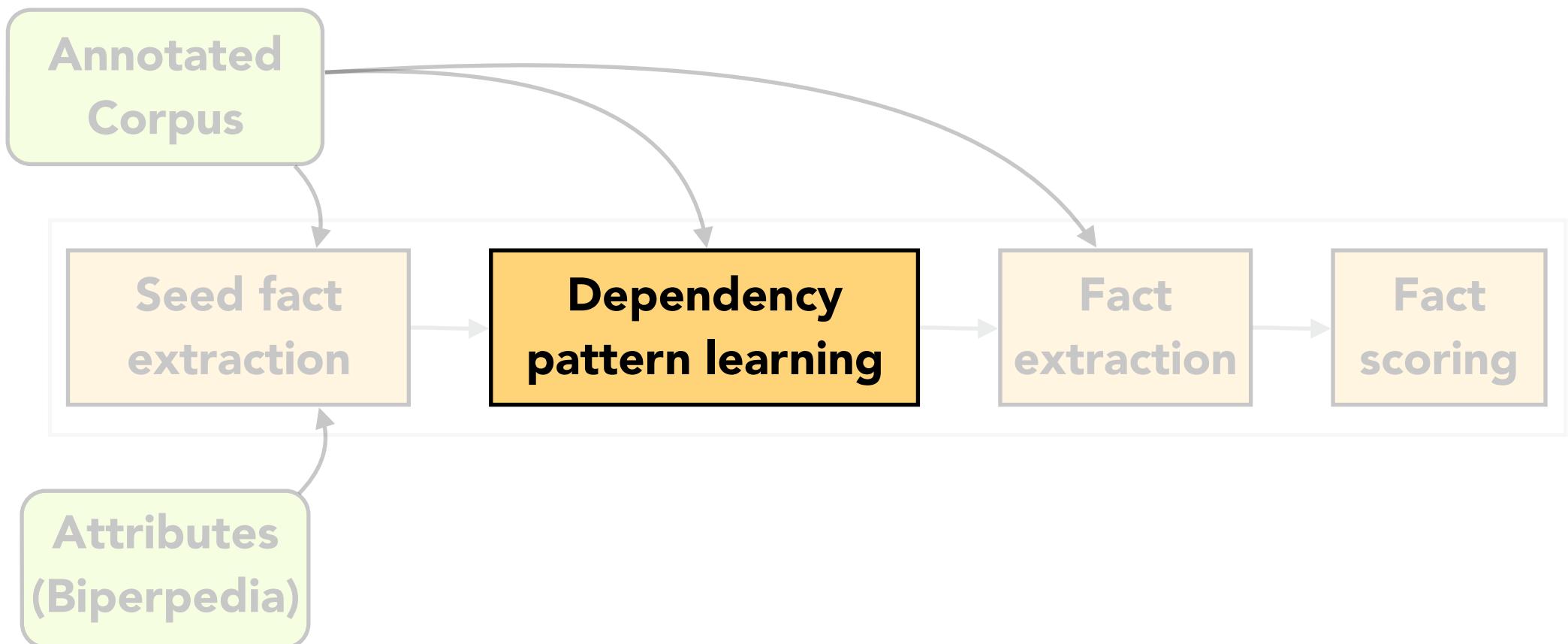
## Seed fact extraction

139M Seed facts, 680K unique

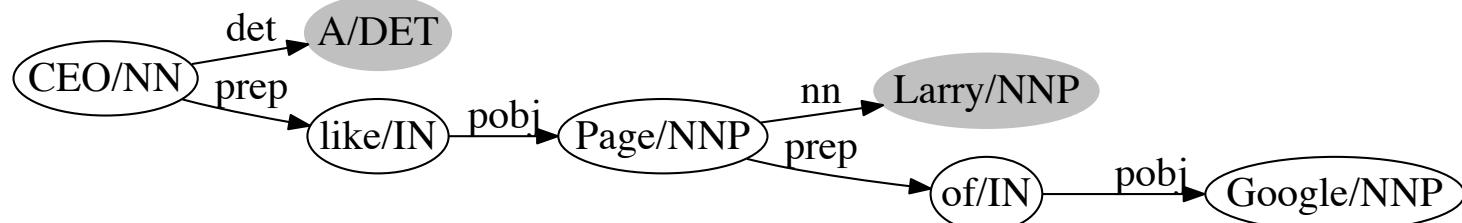
Accuracy*	
Fat head	65/100
Long tail	80/100

\*random sample of 100 seed facts

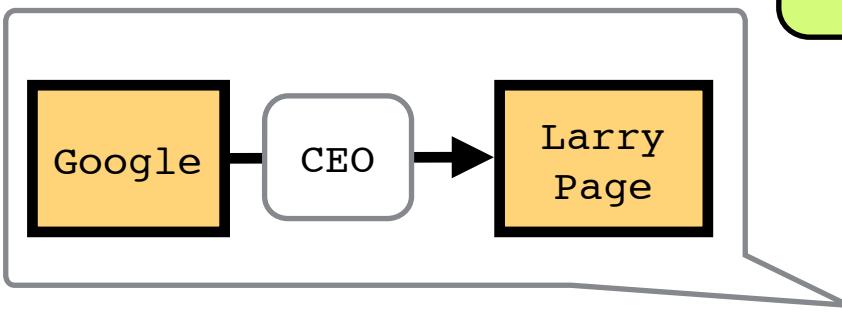
# ReNoun



*A [CEO]<sub>1</sub>, like [Larry Page]<sub>2</sub> of [Google]<sub>3</sub>, is usually a busy person.*



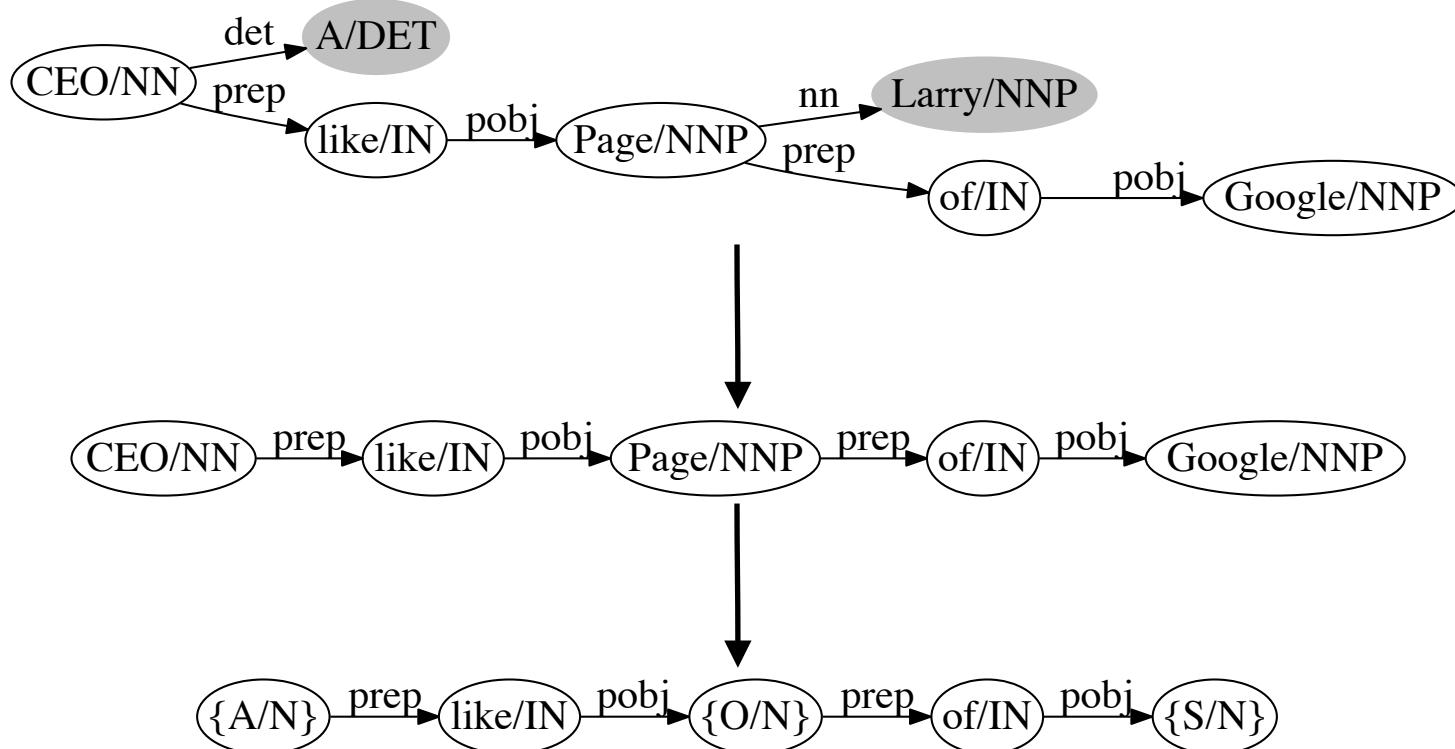
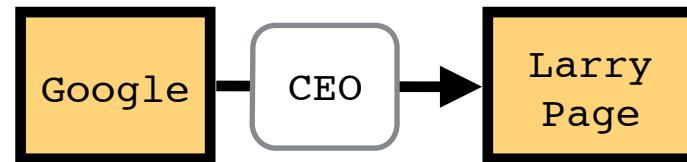
Annotated  
Corpus

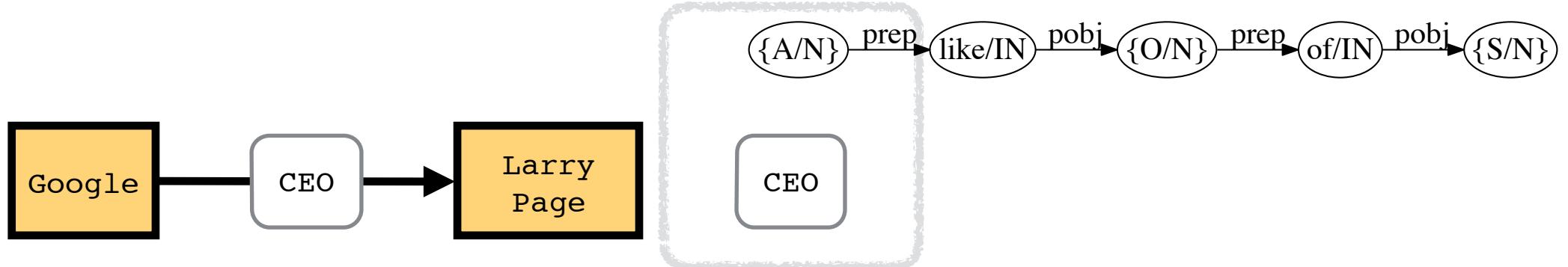


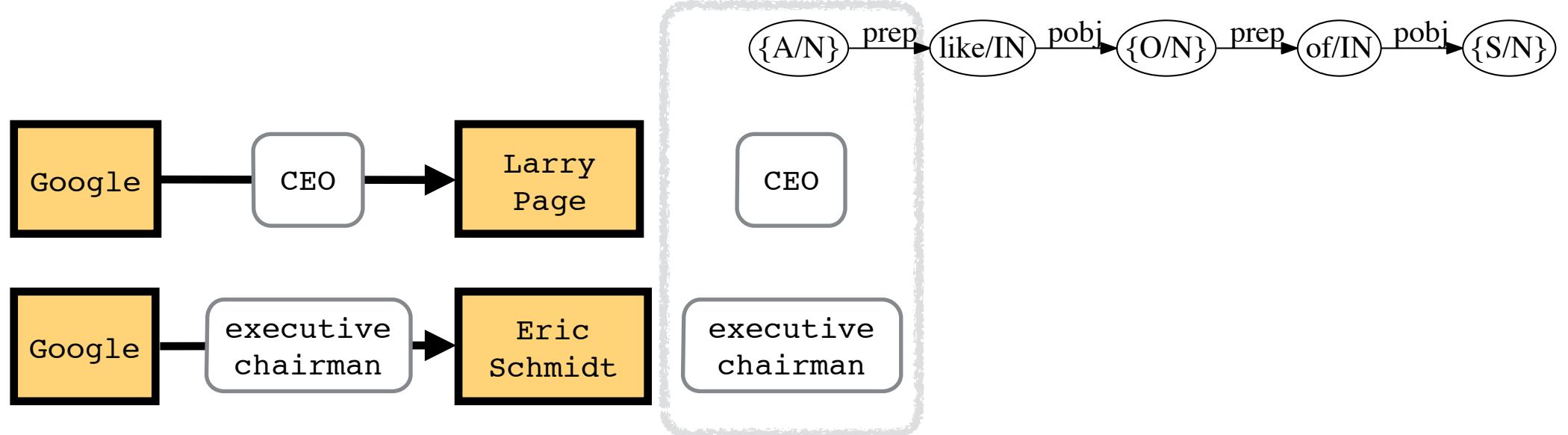
Seed fact  
extraction

Dependency  
pattern learning

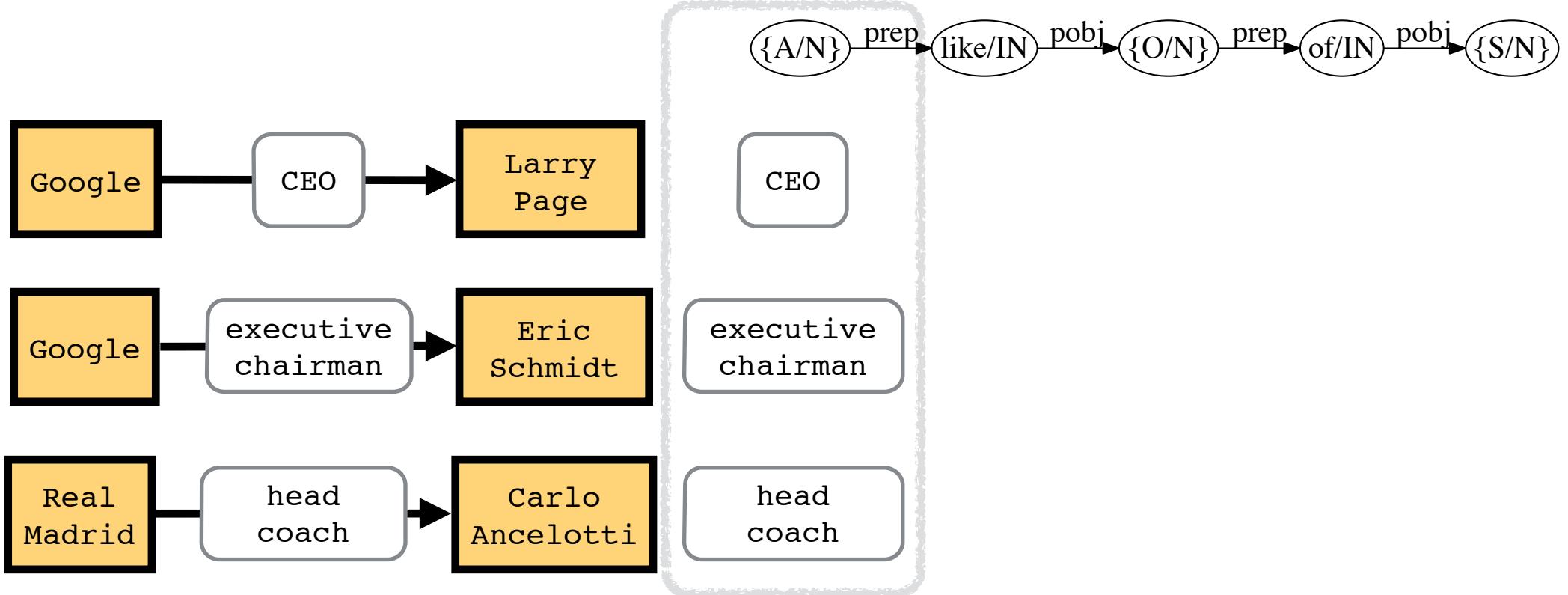
# Dependency pattern learning





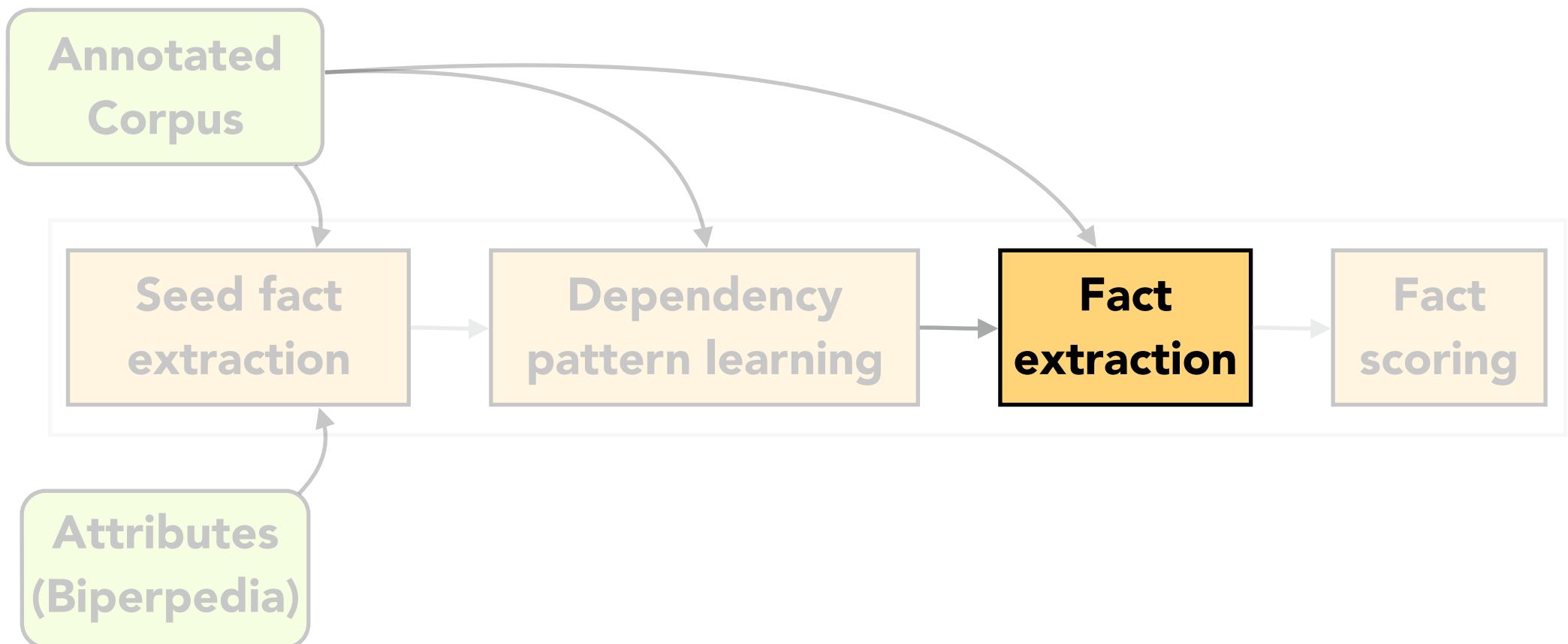


Same pattern could apply to multiple attributes...



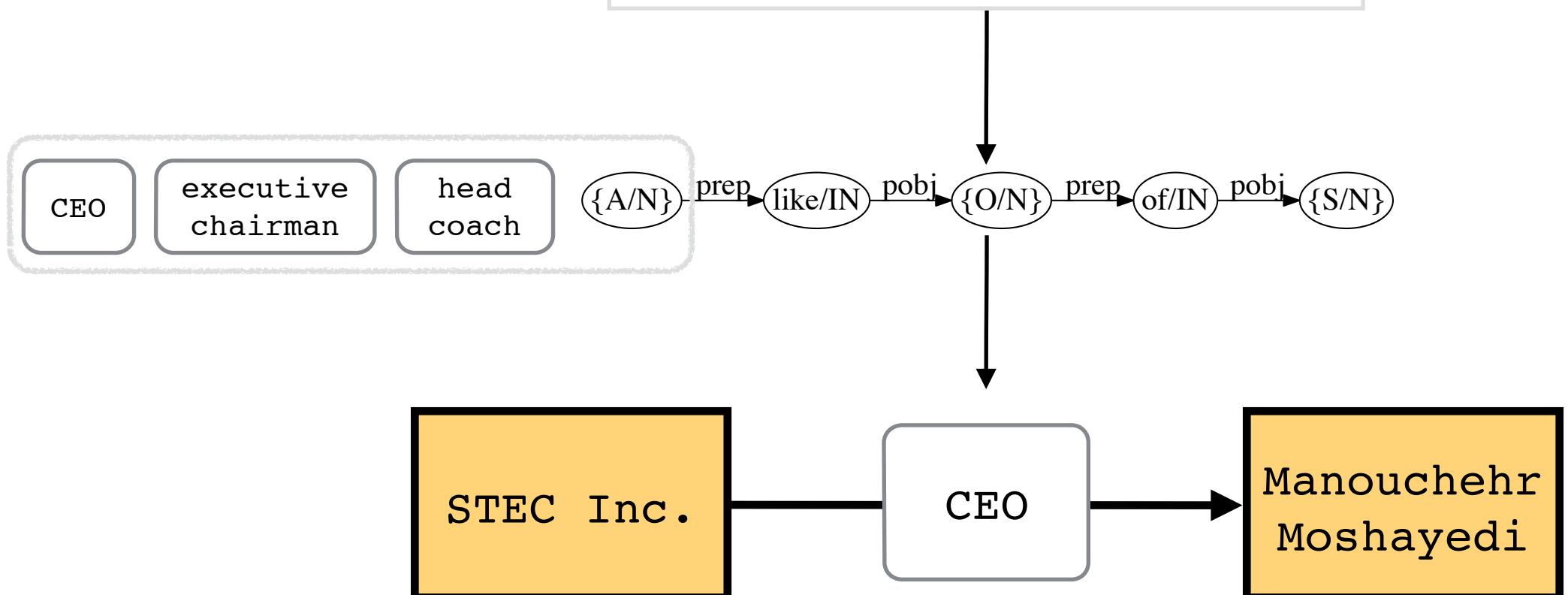
Same pattern could apply to multiple attributes...  
...useful for scoring

# ReNoun



# Fact extraction

*A CEO, like Manouchehr Moshayedi of STEC Inc., is not allowed to trade his company's stocks based on information only he has.*



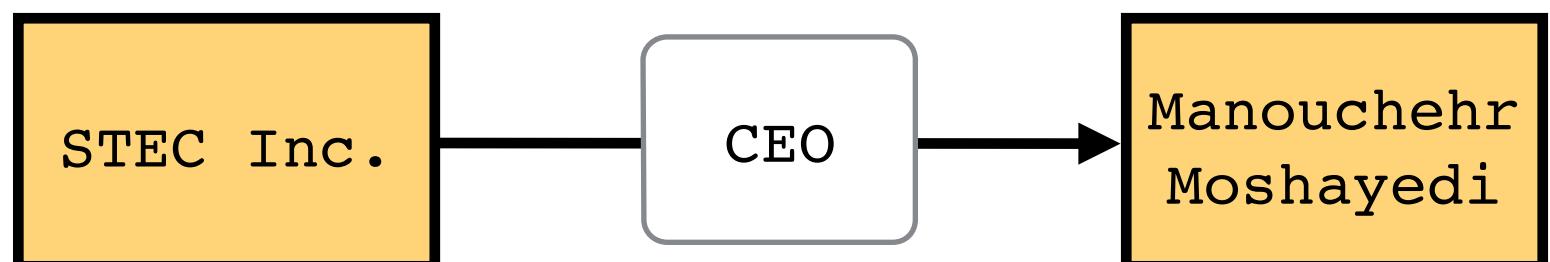
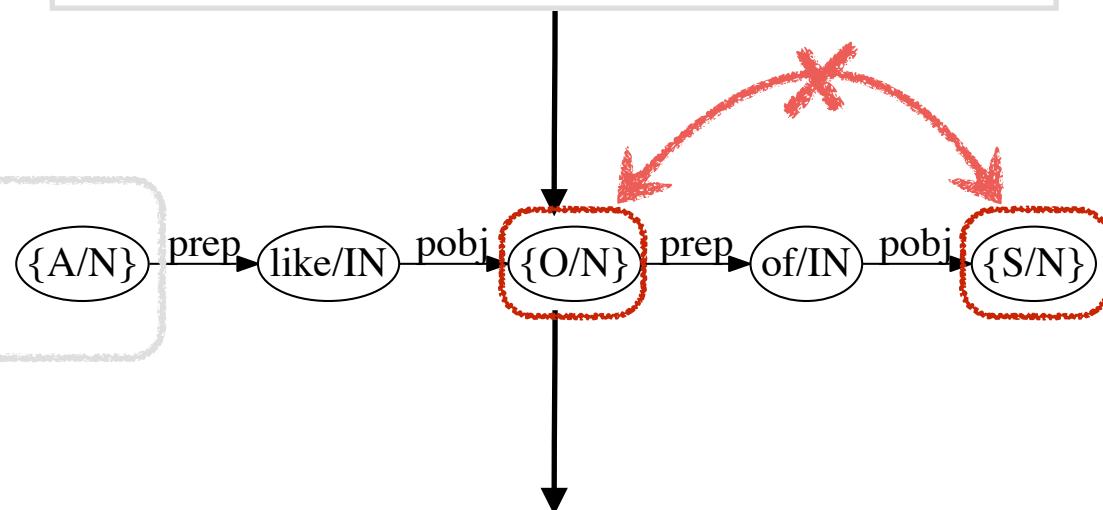
# Argument order

**Seed fact extraction**

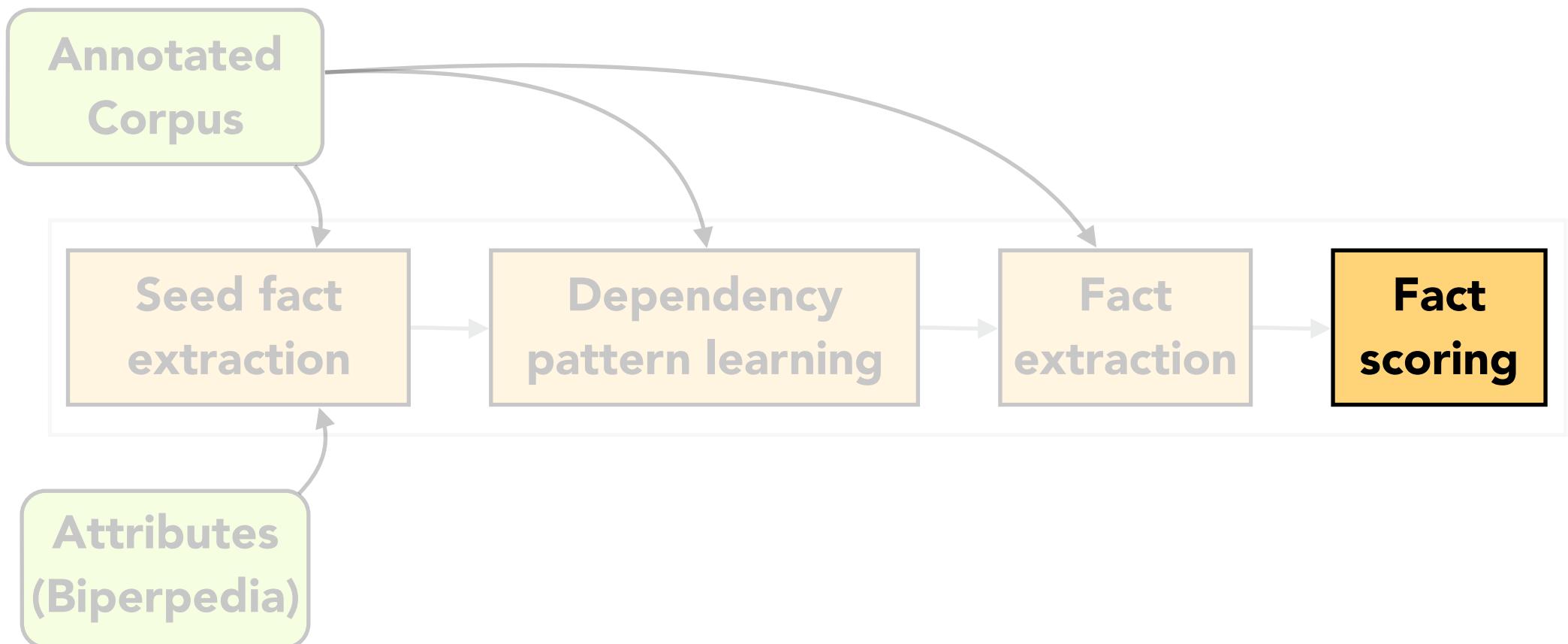
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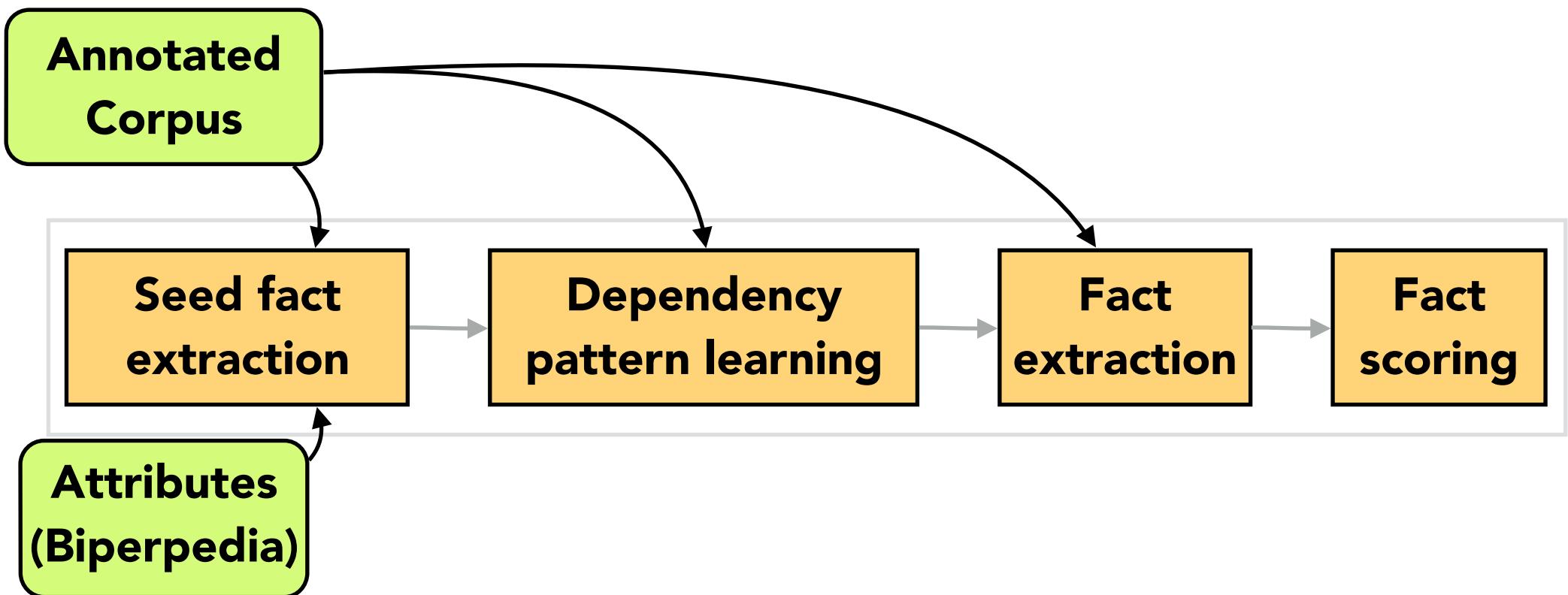
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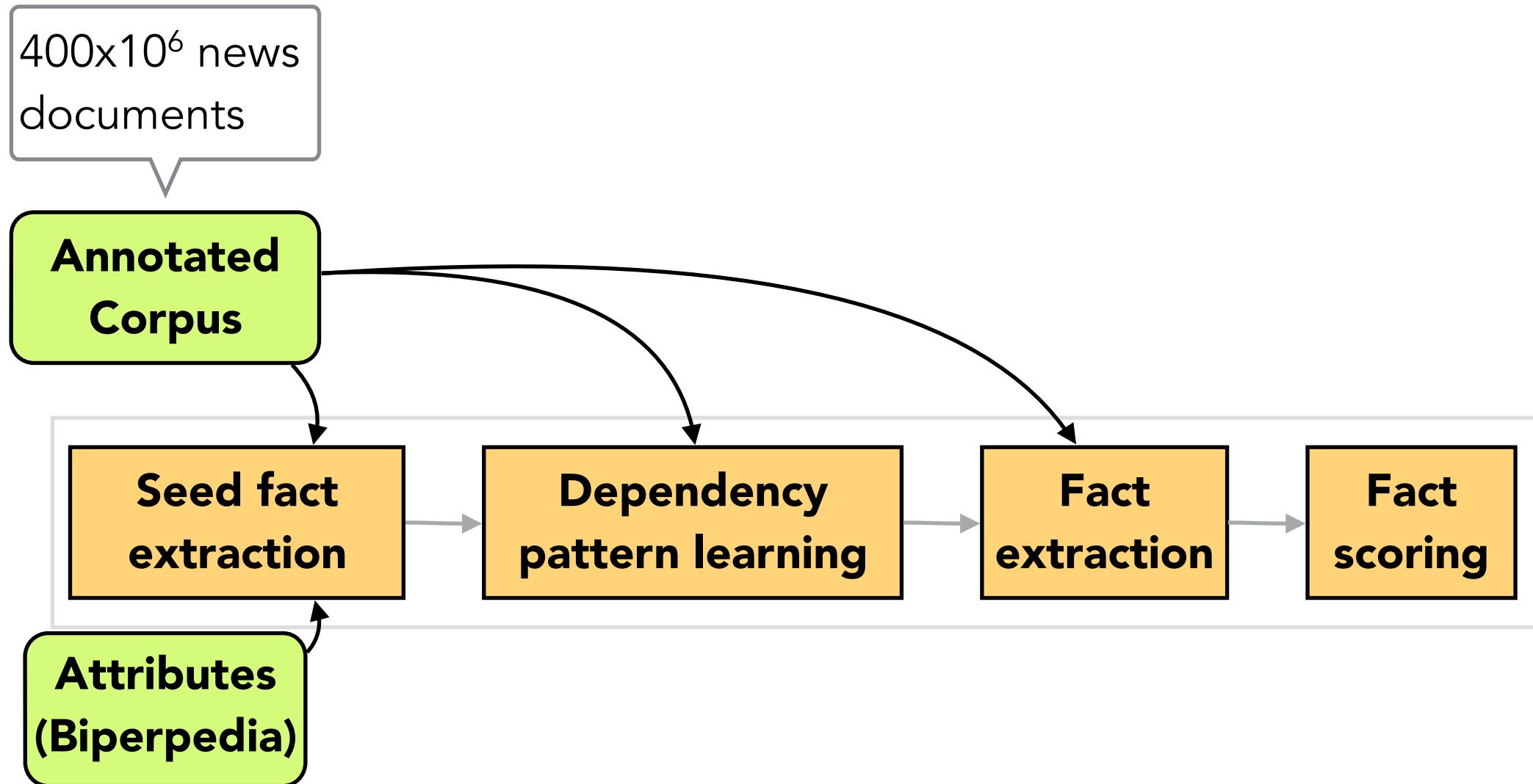
# ReNoun



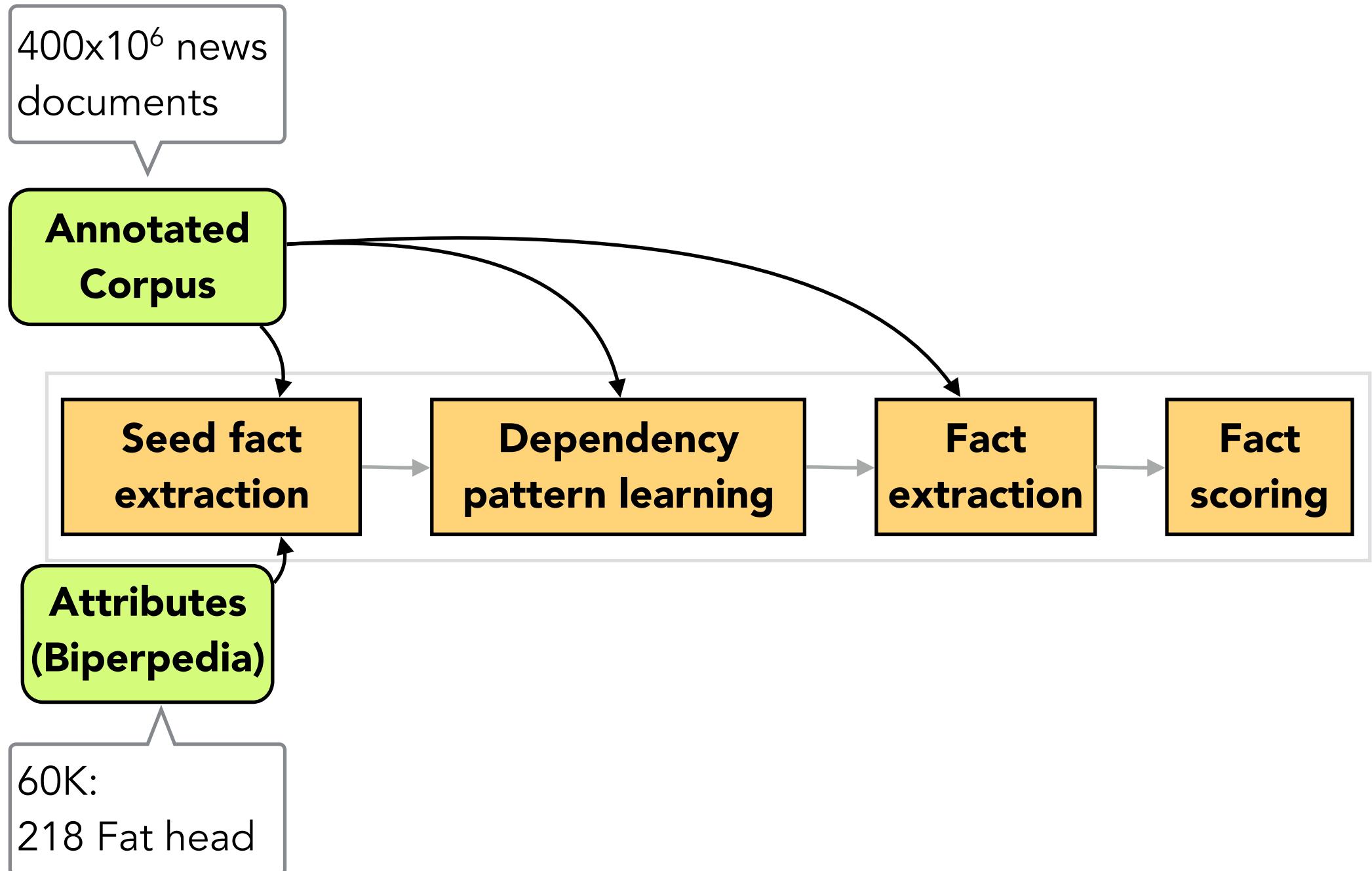
# Some Numbers ...



# Some Numbers ...



# Some Numbers ...



# Some Numbers ...

