



ReNoun

Fact Extraction for **Nominal** Attributes

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

Nouns, Queries & Relations


Google  



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About 18,700,000 results (0.31 seconds)

Defense Official: Military Advised Obama Not to Make ...
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 ...




Google  

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About 39,000,000 results (0.25 seconds)

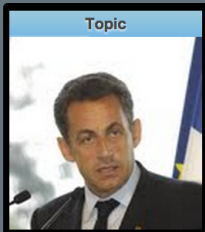
Valerie Jarrett - Wikipedia, the free encyclopedia
en.wikipedia.org/wiki/Valerie_Jarrett ▾ Wikipedia ▾
Valerie Bowman Jarrett (born November 14, 1956) is a Senior **Advisor** to the Jarrett is one of President **Obama's** longest serving **advisers** and confidantes and ...
[James E. Bowman](#) - [Barbara 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](#)



Nouns as Attributes

| KB | % Noun Attributes | % Verb Attributes |
|-----------------|--------------------------|--------------------------|
| DBpedia | 96 | 4 |
| Freebase | 97 | 3 |



Topic

Nicolas Sarkozy ^{en}



Created by metaweb on 10/22/2006

mid: /m/02ps9k notable type: /government/politician notable for: /government/politician on the web: [Wikipedia.org](#)

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. [-]

Properties

118n

Keys

Links



• People /people

Freebase Commons

Person /people/person



Date of birth /people/person/date_of_birth

✓ 2013-12-07

1/28/1955

Place of birth /people/person/place_of_birth

✓ 2013-12-07

Paris

Country of nationality /people/person/nationality

Country of nationality ▾

France

Hungary

Gender /people/person/gender

✓ 2013-12-07

Male

Profession /people/person/profession

Profession ▾

Politician

Lawyer

Spokesperson

Religion /people/person/religion

Catholicism

Ethnicity /people/person/ethnicity

French people

Parents /people/person/parents

Parents ▾

Andrée Mallah

Pal Sarkózy de Nagy-Bocsa

Children /people/person/children

Nouns as Attributes

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| Freebase | 97 | 3 |

entity Nicolas Sarkozy > Ex-spouse relation/attribute

entity Marie-Dominique Culioli Cécilia Attias entity

Cécilia Attias - Wikipedia, the free encyclopedia

en.wikipedia.org/wiki/Cécilia_Attias - Wikipedia

When her **husband** was a minister, Cécilia **Sarkozy** had an office next to his, ... announcement by stating that the **Sarkozys** had actually officially **divorced**.
 Background - Political life - Personal life - Cécilia Attias Foundation for ...

Cecilia Attias tells how friends tried to snap up Sarkozy after ...

www.dailymail.co.uk/.../Cecilia-Attias-tells-friends-tried-snap-... - Daily Mail

Oct 4, 2013 - **Sarkozy's ex-wife** reveals how 'several of her friends' dumped their husbands in desperate rush to become France's next First Lady after her ...

Sarkozy's ex-wife 'berated' Libya's Gaddafi - France 24

www.france24.com/.../20131003-france-cecilia-attias-sarkozy-... - France 24

Oct 3, 2013 - The **ex-wife** of former French president Nicolas **Sarkozy**, Cécilia, claims in a new book that she delivered a blistering verbal attack on Libya's ...

Nicolas Sarkozy's 'shocking comments' lost him election ...

www.telegraph.co.uk > ... > Nicolas Sarkozy - The Daily Telegraph

Oct 3, 2013 - Nicolas **Sarkozy** displayed a "worrying impulsiveness" and his "shocking ... She also settles a few scores with her **ex-husband**, notably over the ...

Sarkozy's ex-wife talks of regret, scolding Gaddafi - The Local

www.thelocal.fr/.../cecilia-attias-sarkozy-gaddafi-libya-fouquets-royal -

Oct 4, 2013 - She's been locked in a room with Libyan dictator Colonel Gaddafi, at whom

Nicolas Sarkozy

Former President of France



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. [Wikipedia](#)

Born: January 28, 1955 (age 59), Paris, France

Height: 5' 5" (1.65 m)

Presidential term: May 16, 2007 – May 15, 2012

Party: Union for a Popular Movement

Spouse: Carla Bruni (m. 2008), Cécilia Attias (m. 1996–2007), Marie-Dominique Culioli (m. 1982–1996)

Siblings: Olivier Sarkozy, Guillaume Sarkozy, François Sarközy de Nagy-Bocsa, Caroline Sarközy de Nagy-Bocsa

Feedback



About 307,000 results (0.22 seconds)

News for **hollande's ex-girlfriend**



Valérie Trierweiler's memoirs are 'blow to Hollande's heart'

Telegraph.co.uk · 5 days ago

The bestselling book by President **Hollande's** jilted **ex-girlfriend** is like "an arrow in the heart" as the unpopular president struggles to win back ...

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-hollandes-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** Valérie Trierweiler that he "doesn't like the race" owing to his wife's ...



gazprom's banking arm



Web

Shopping

News

Images

Videos

More ▾

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About 195,000 results (0.50 seconds)

[EU sanctions target Rosneft and **Gazprom's** oil business ...](#)

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 ▾ 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... 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

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

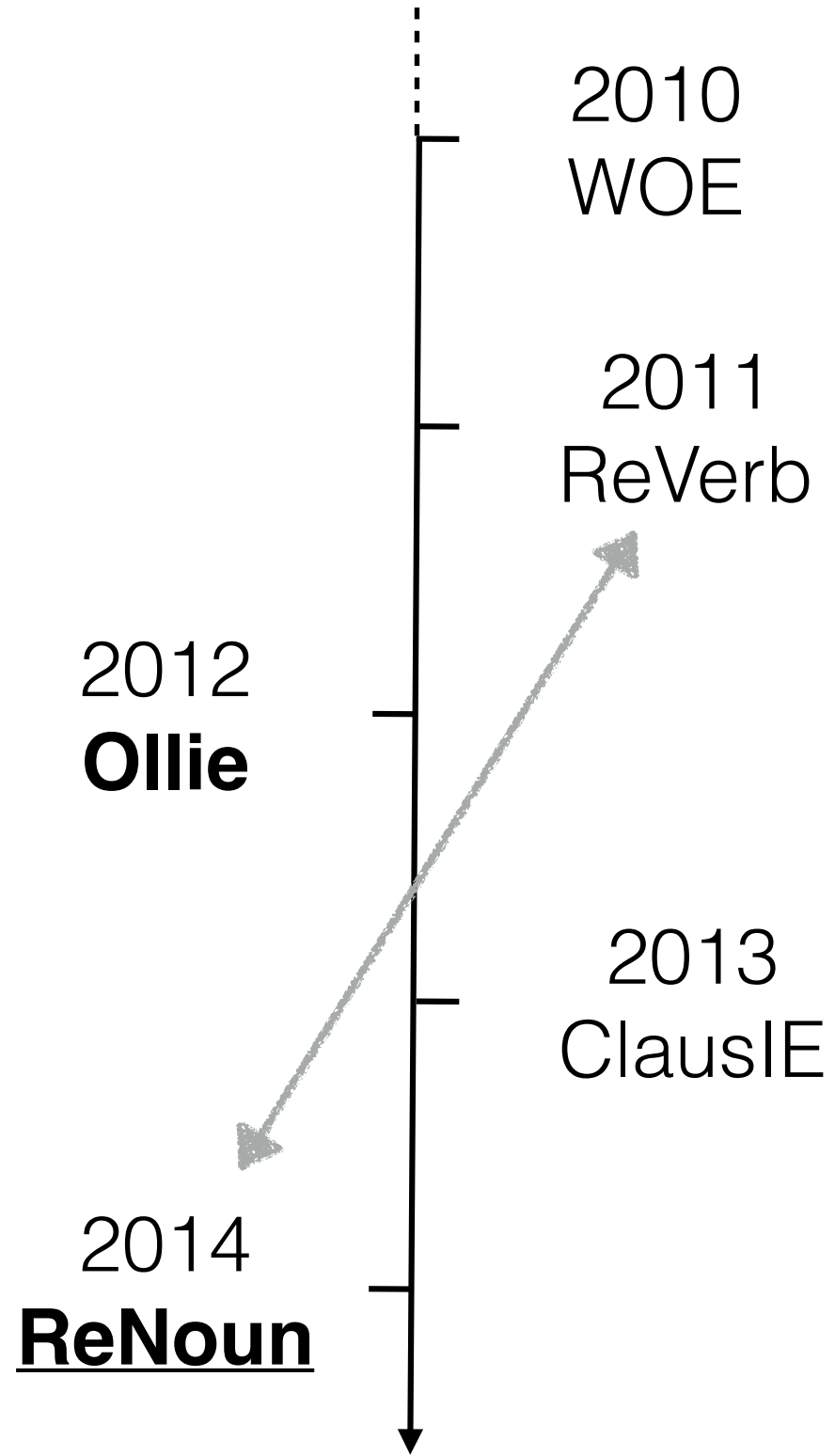
.. *Gazprom*'s *banking arm* *Gazprombank*
is owned by the company's pension fund...

Fact/
triple



Before the details:

What's missing from
the state of the art?



2010
WOE

2011
ReVerb

2012
Ollie

2013
ClauseE

2014
ReNoun

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



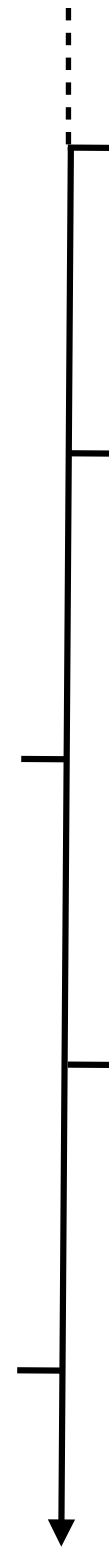
2010
WOE

2011
ReVerb

2012
Ollie

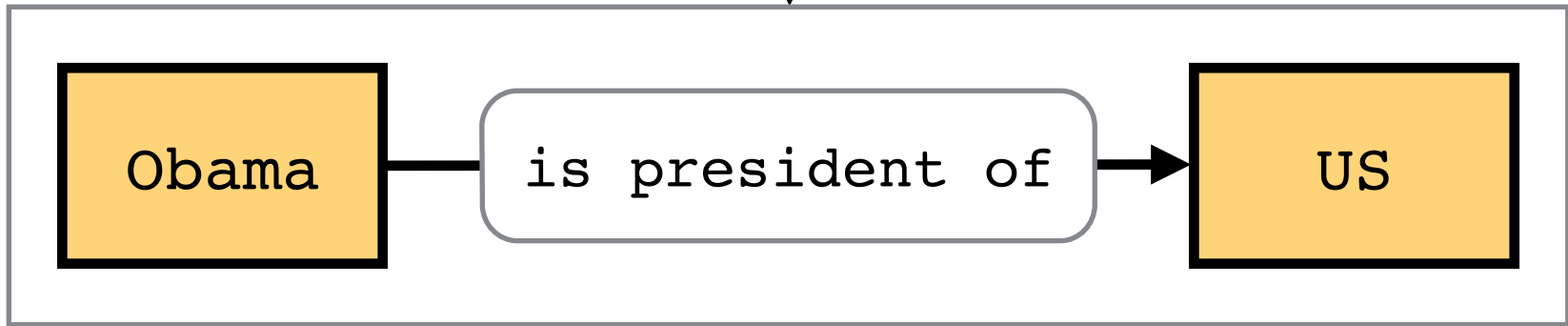
2013
ClausIE

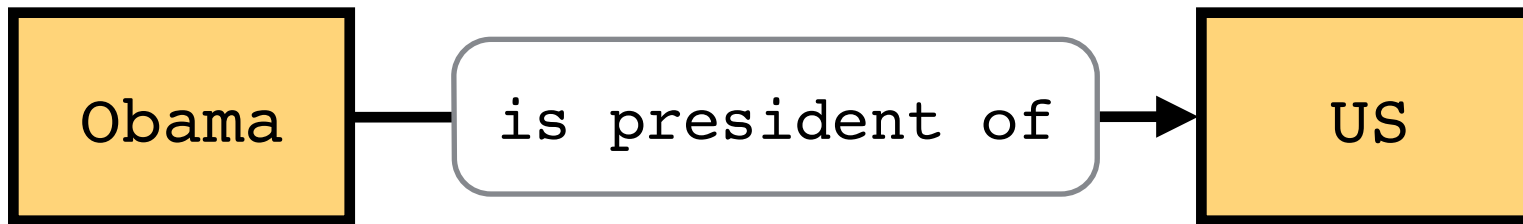
2014
ReNoun



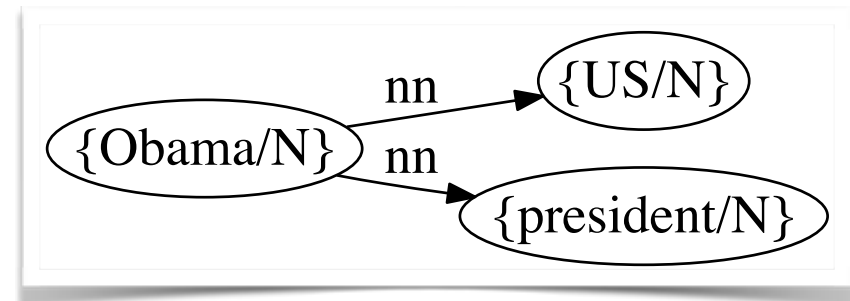
Let's see **Ollie**...

Obama is the president of the 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

coach

president

president

province

province

banking arm

banking arm

caucus chairman

caucus chairman

foreign policy chief

foreign policy chief

state assemblyman

state assemblyman

*** Ollie handles verbs, ReNoun doesn't!**

Ollie*
[EMNLP'12]

vs.

ReNoun
[this talk]

coach

president

province

coach

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province

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caucus chairman

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banking arm

caucus chairman

foreign policy chief

state assemblyman

*** Ollie handles verbs, ReNoun doesn't!**

Ollie*
[EMNLP'12]

vs.

ReNoun
[this talk]

| | Ollie* [EMNLP'12] | ReNoun [this talk] |
|----------------------------------|--|--|
| Fat head (218) | <p>coach</p> <p>president</p> <p>province</p> | <p>coach</p> <p>president</p> <p>province</p> |
| Long tail (60K) | <p>banking arm</p> <p>caucus chairman</p> <p>foreign policy chief</p> <p>state assemblyman</p> | <p>banking arm</p> <p>caucus chairman</p> <p>foreign policy chief</p> <p>state assemblyman</p> |

*** Ollie handles verbs, ReNoun doesn't!**

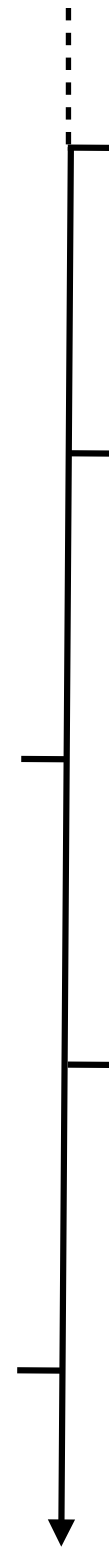
2010
WOE

2011
ReVerb

2012
Ollie

2013
ClausIE

2014
ReNoun



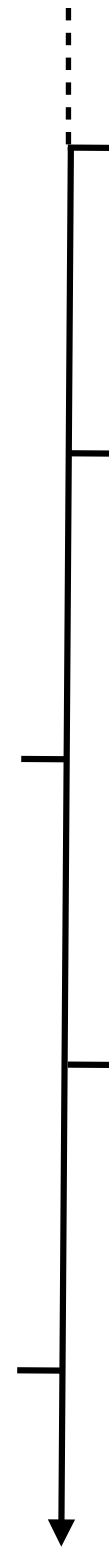
2010
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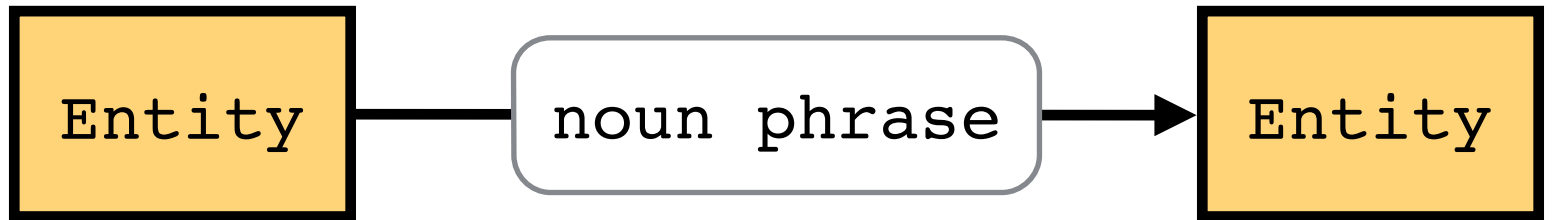
2014
ReNoun



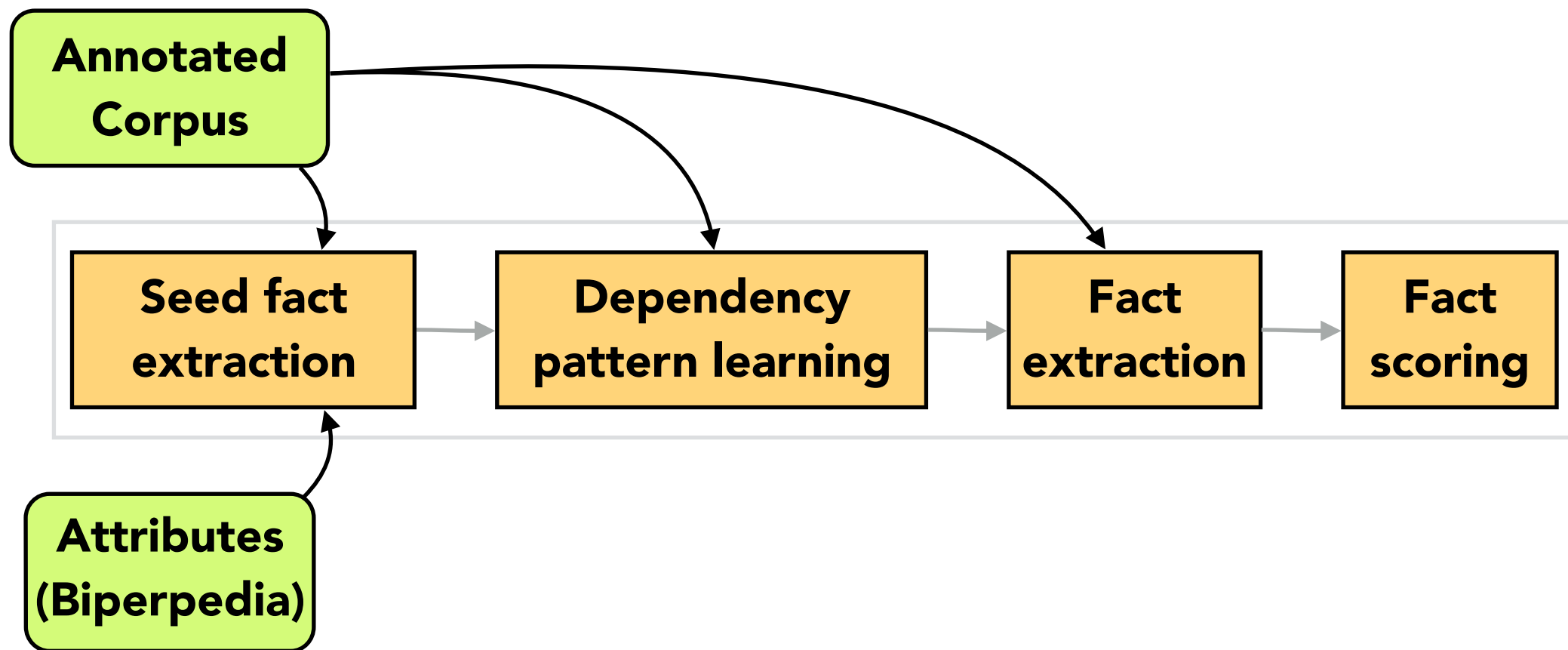
... now, **ReNoun** is upon us!

Relations are expressed using **noun phrases**.

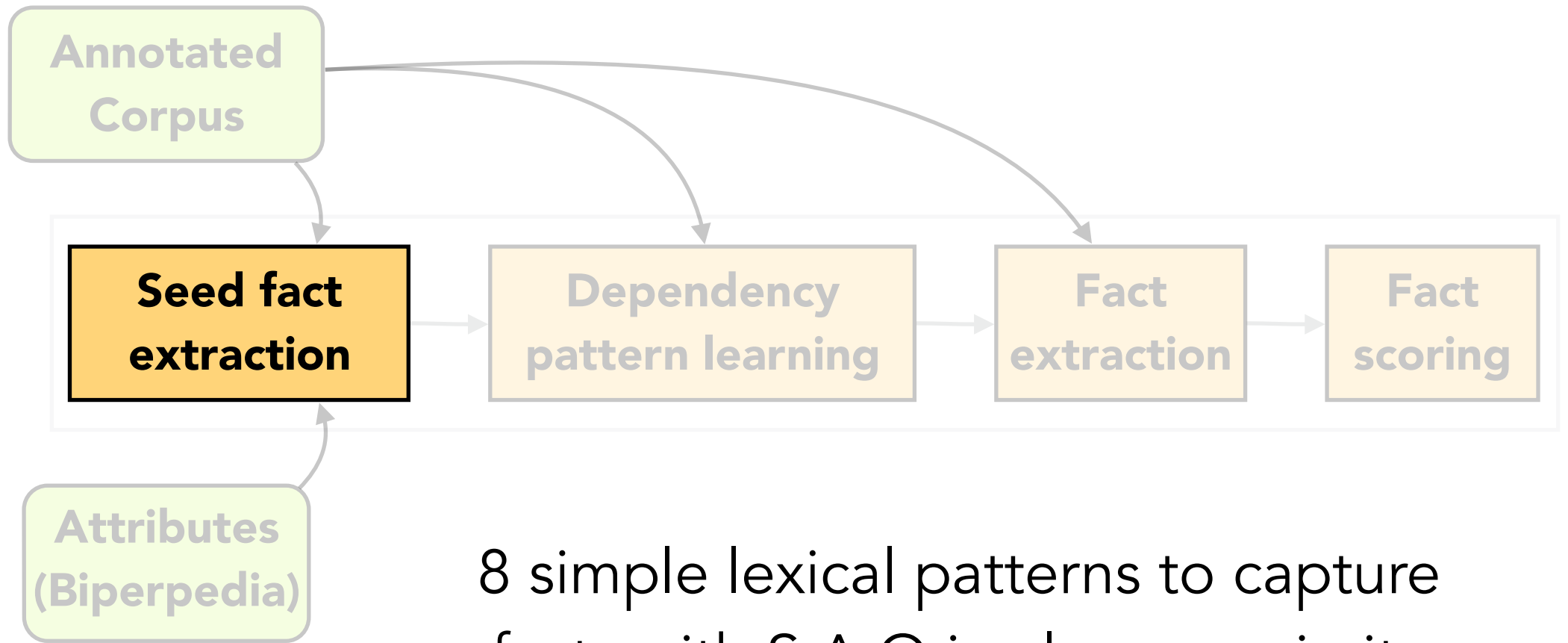
ReNoun
[this talk]



ReNoun

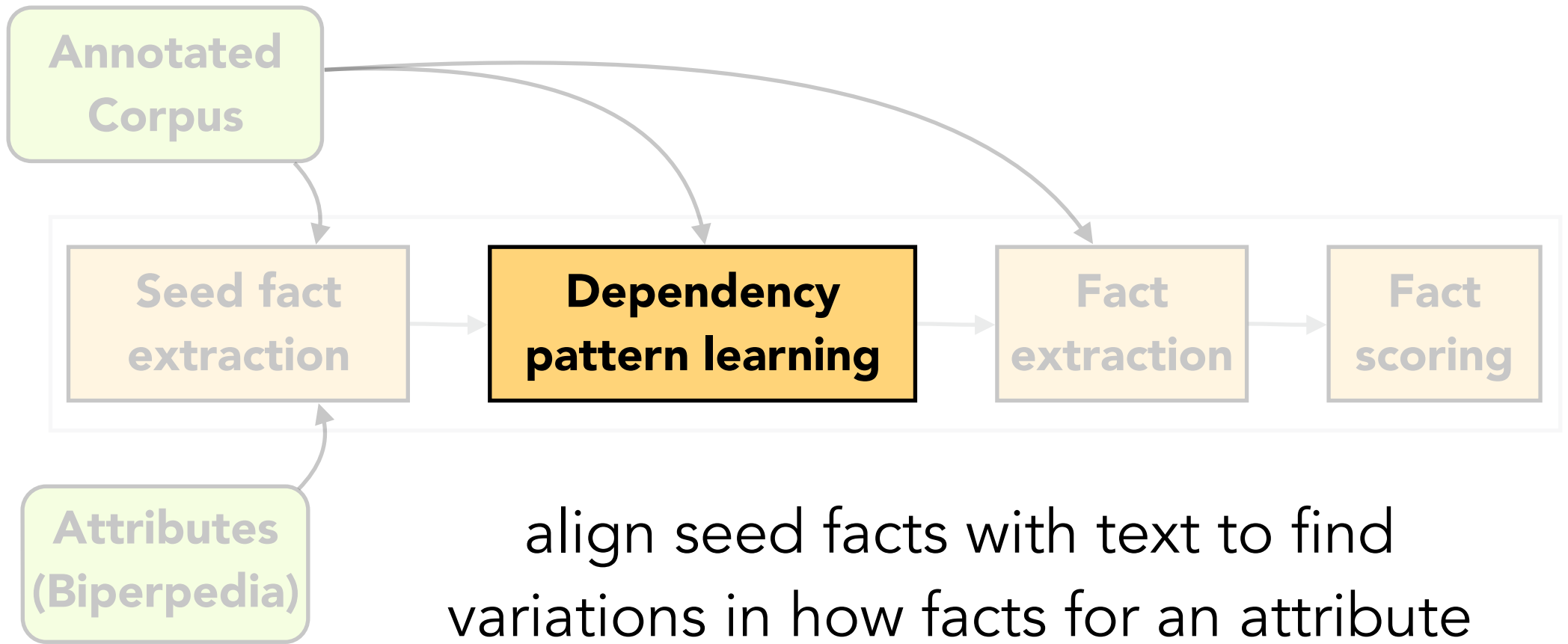


*Google CEO Larry Page
started his term in 2011.*

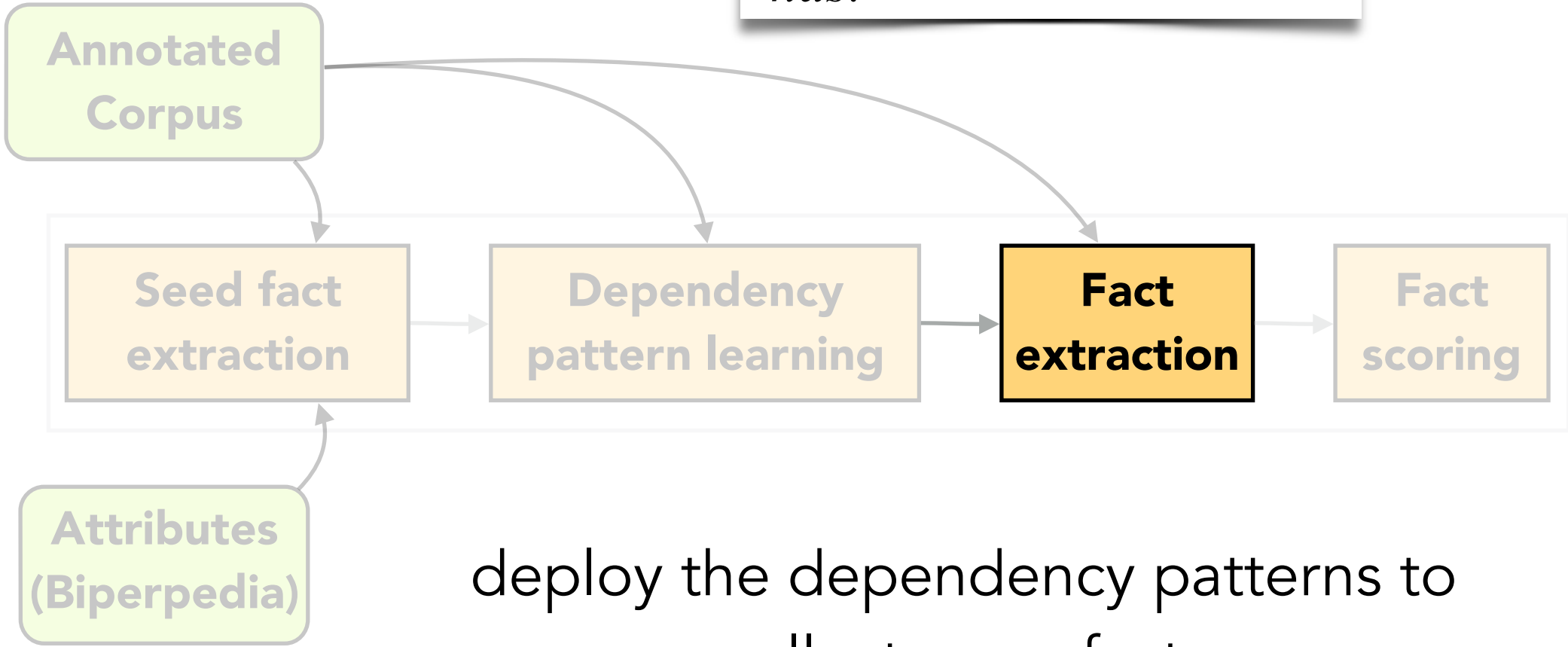


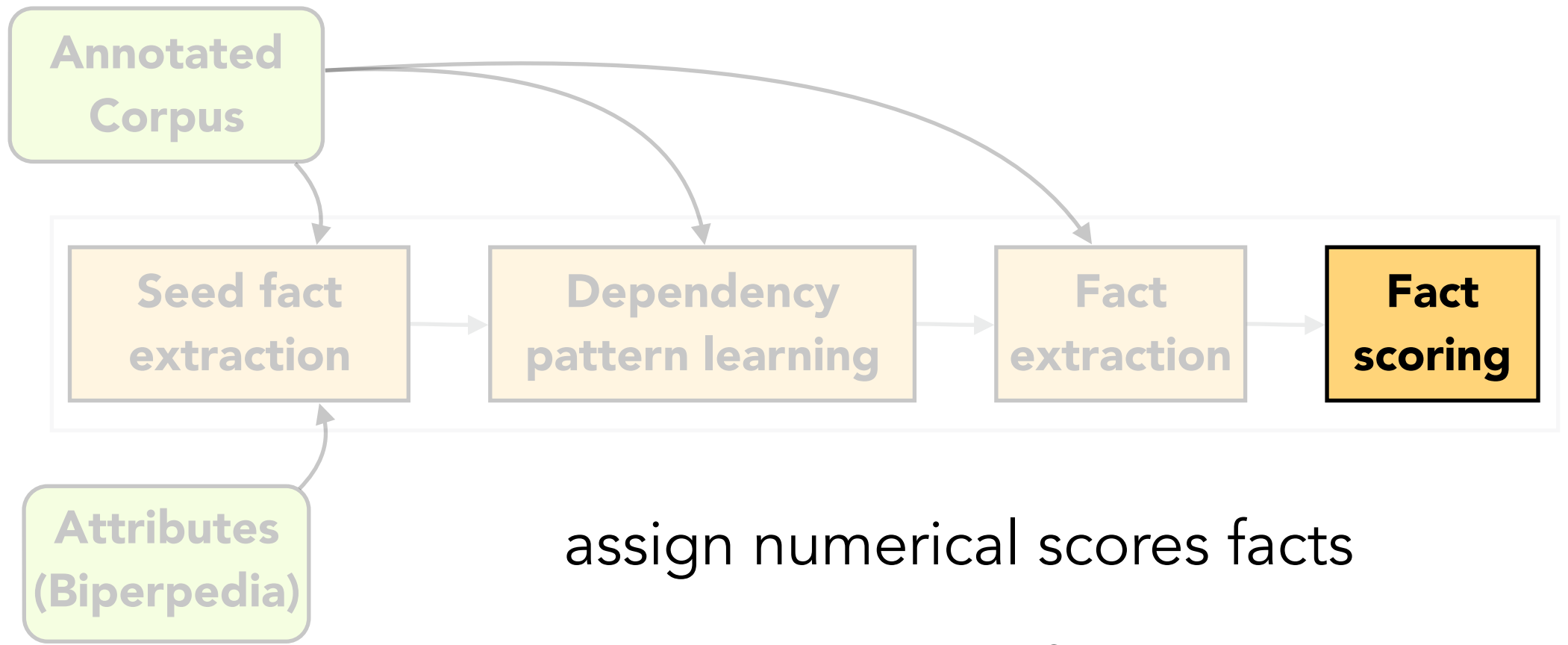
8 simple lexical patterns to capture facts with S A O in close proximity

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



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

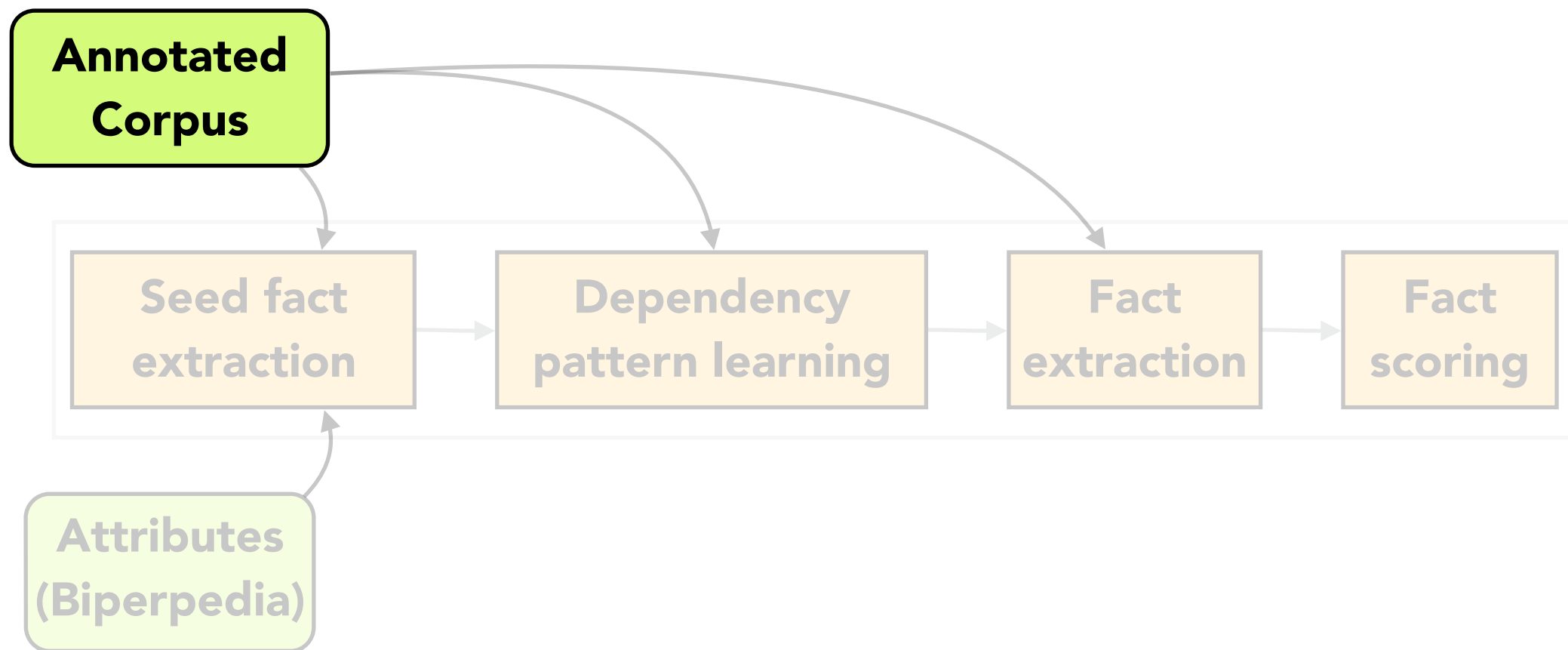





assign numerical scores facts

score \propto extracted fact is correct

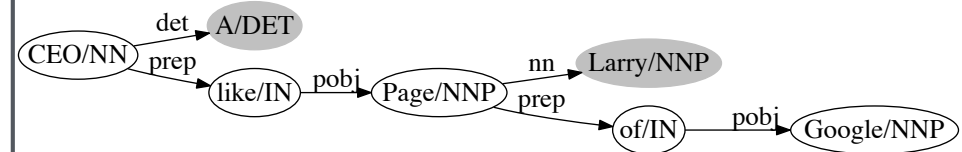
ReNoun



Annotated Corpus

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

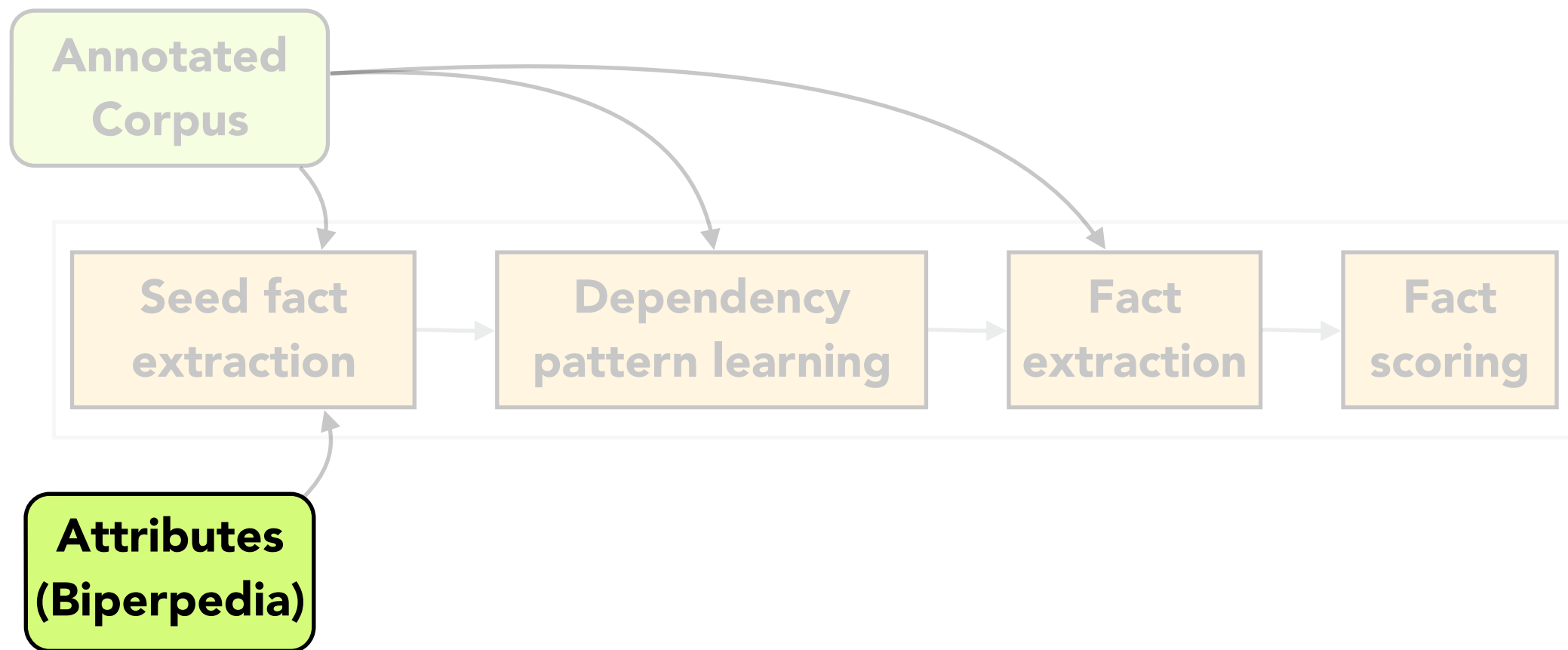
400x10⁶ news documents



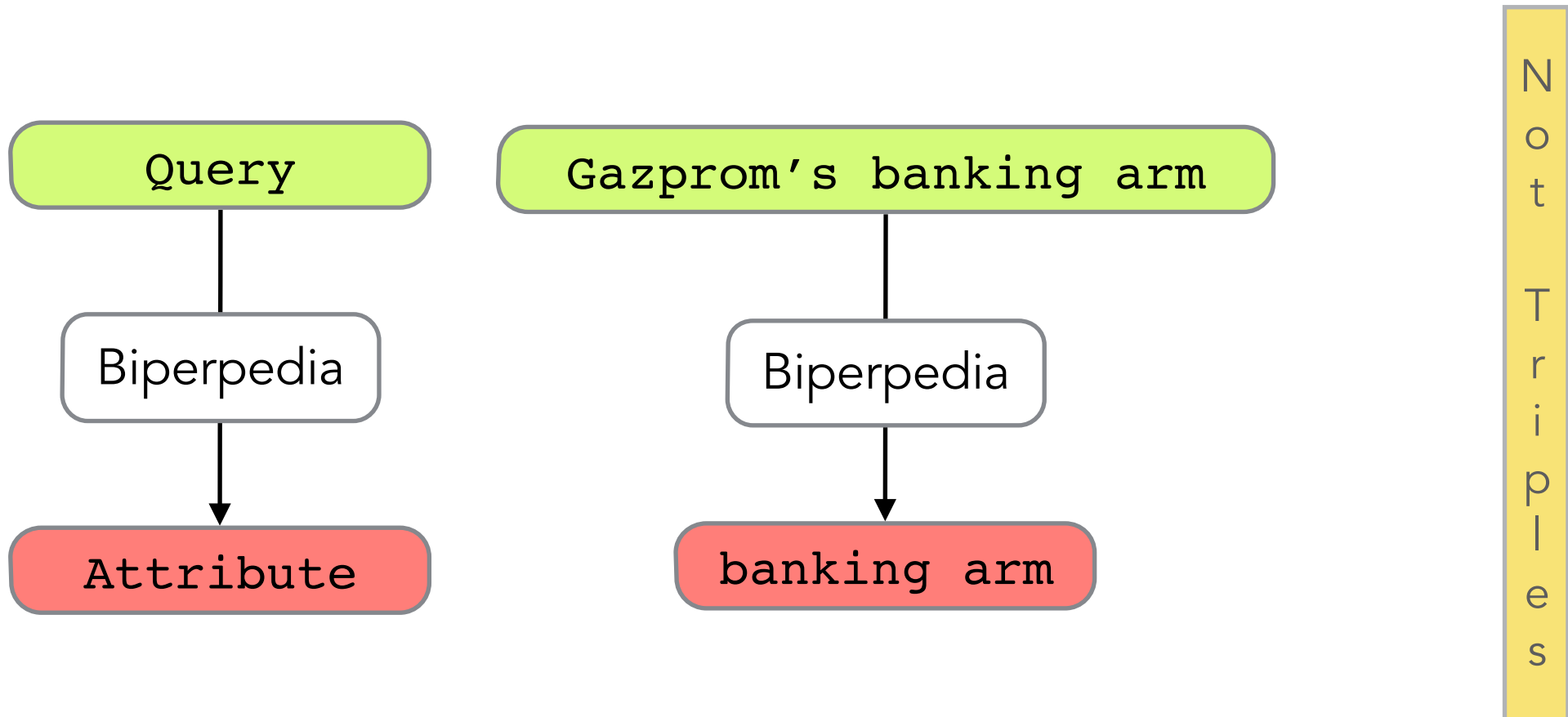
[Google]₁ [CEO]₂ [Larry Page]₂ started his term in 2011, when [he]₂ succeeded [Eric Schmidt]₃.

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

ReNoun

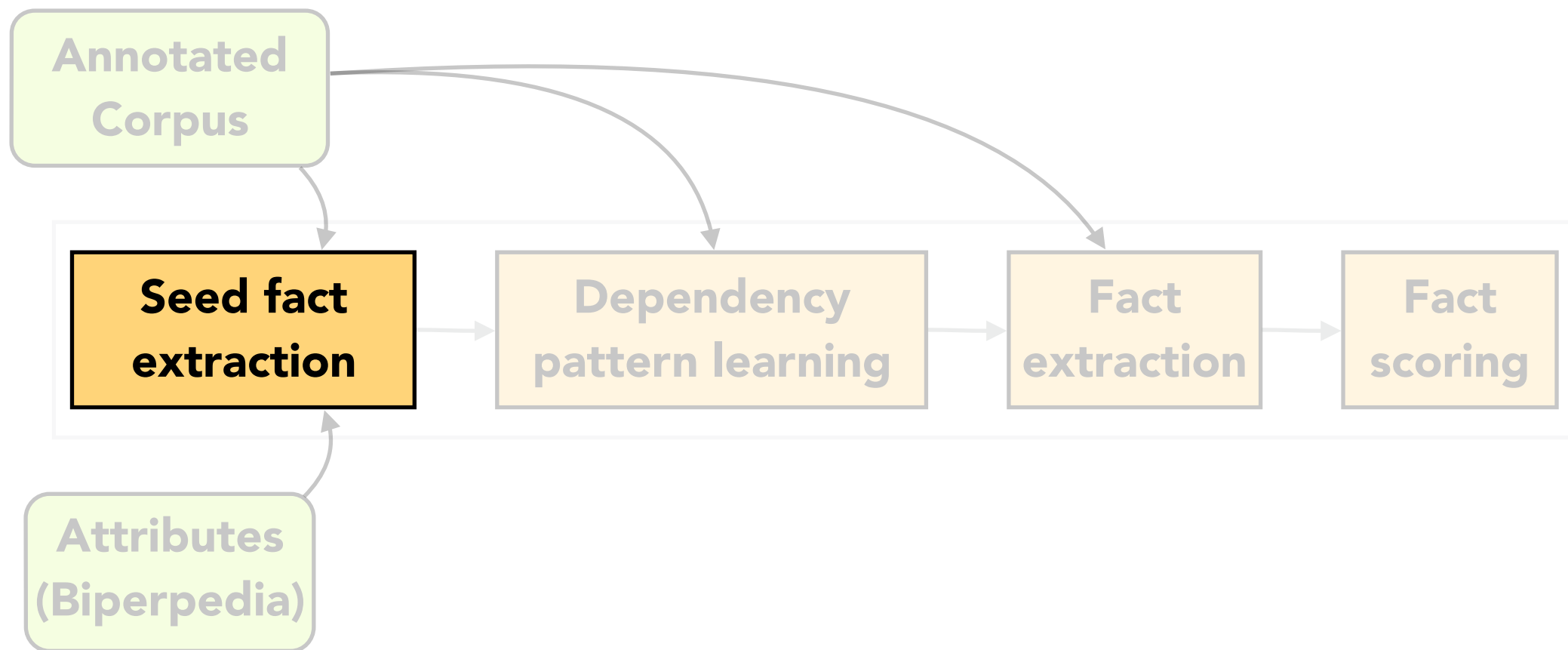


Attributes: Biperpedia [Gupta et al., VLDB'14]



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

ReNoun



Seed fact extraction

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

#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]₁ [CEO]₂ [Larry Page]₂ started his term in 2011, when [he]₂ succeeded [Eric Schmidt]₃.

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

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| 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

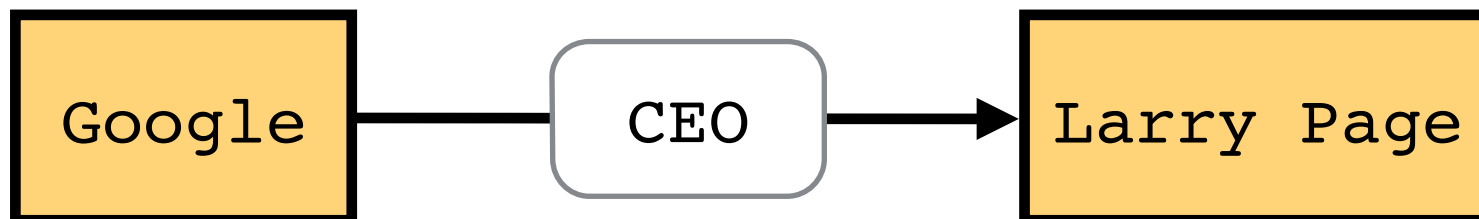
[Google]₁ [CEO]₂ [Larry Page]₂ started his term in 2011, when [he]₂ succeeded [Eric Schmidt]₃.

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

Seed fact extraction

Result

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



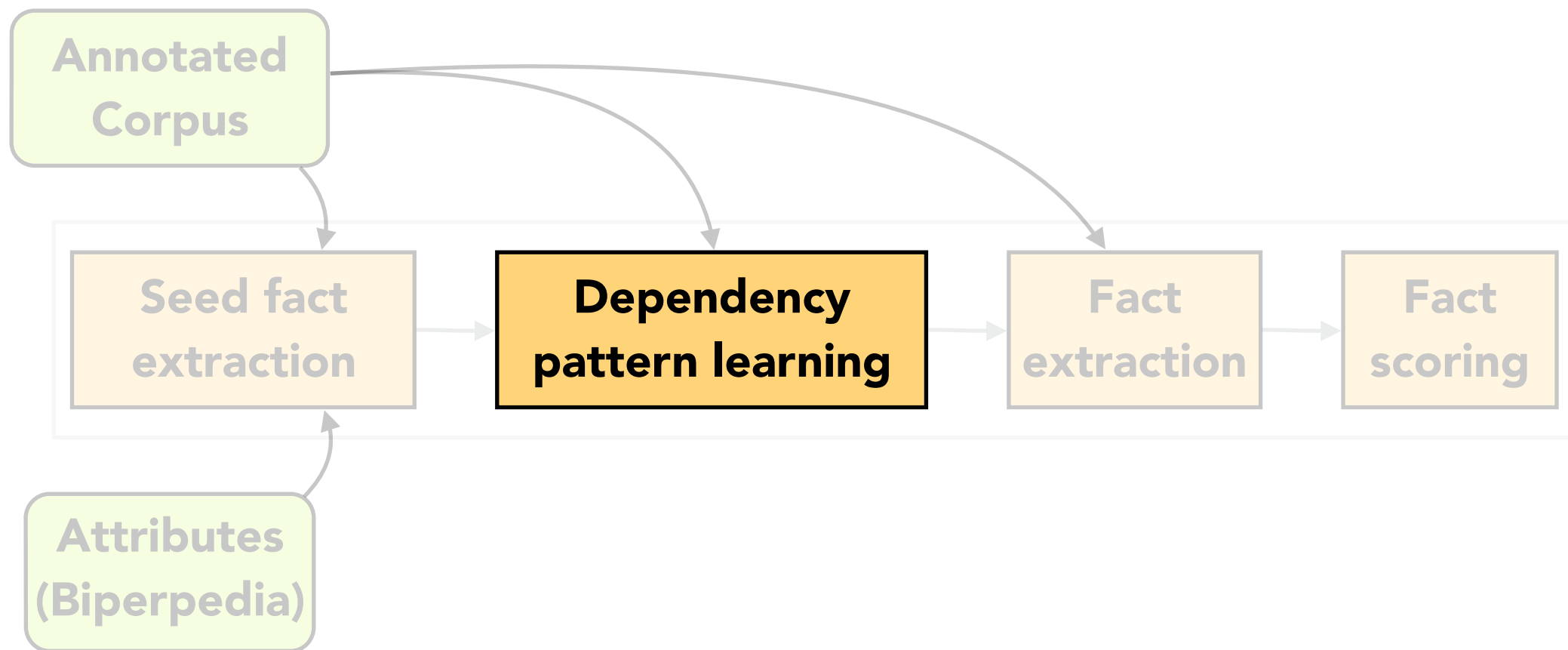
Seed fact extraction

139M Seed facts, 680K unique

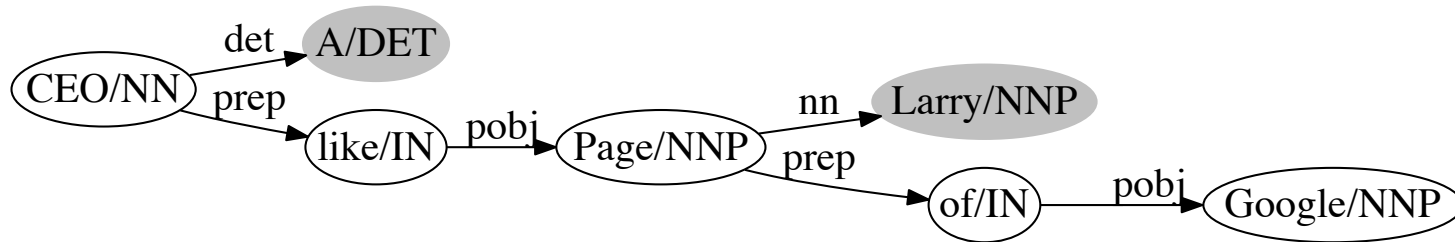
| | Accuracy* |
|-----------|-----------|
| Fat head | 65/100 |
| Long tail | 80/100 |

*random sample of 100 seed facts

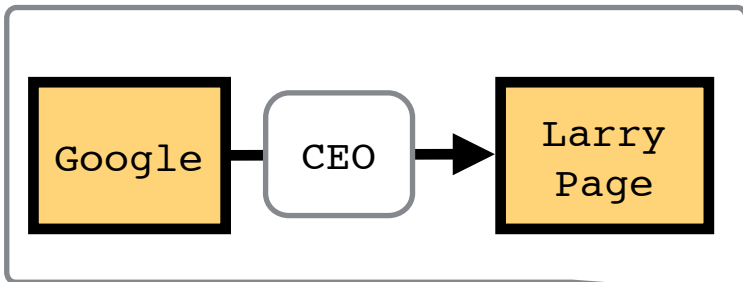
ReNoun



A [CEO]₁, like [Larry Page]₂ of [Google]₃, is usually a busy person.



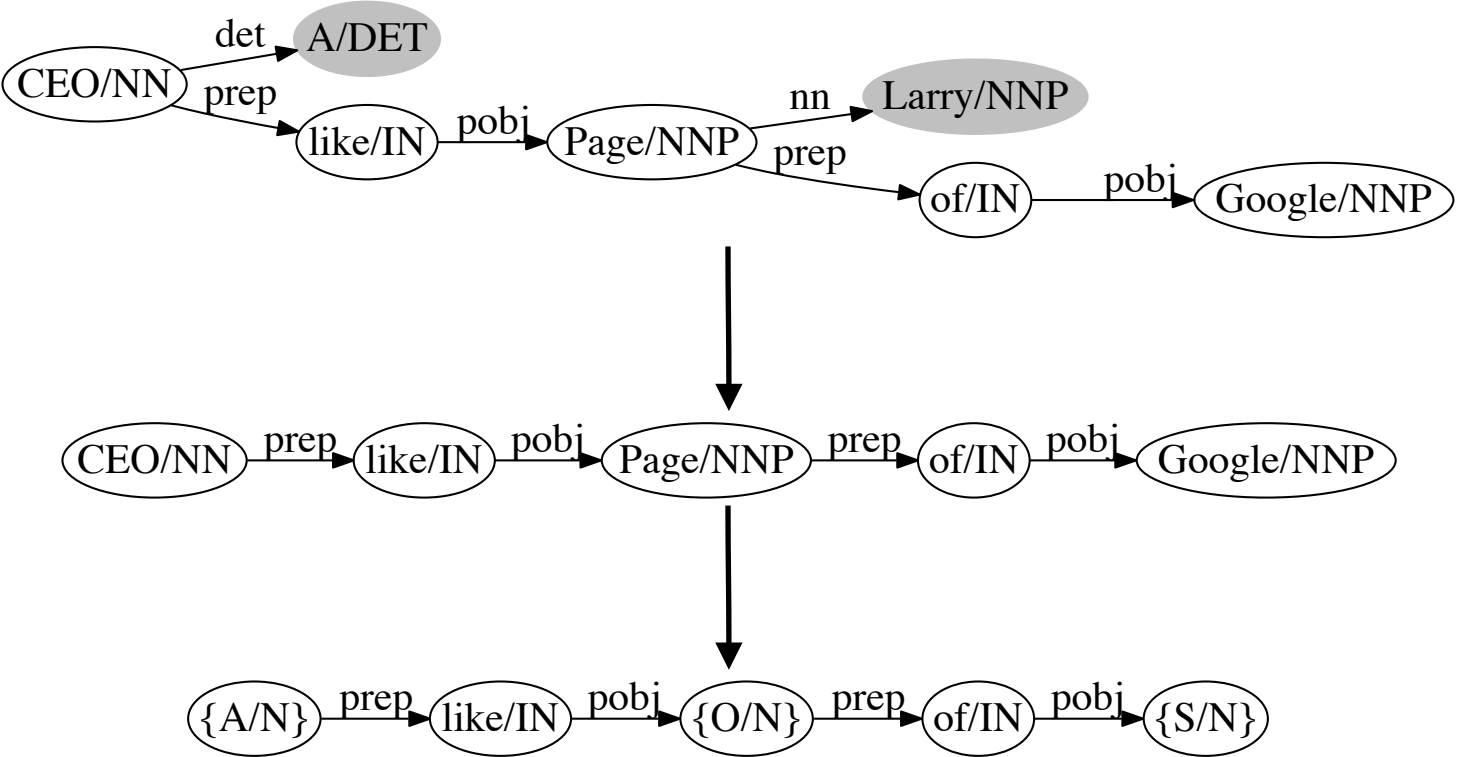
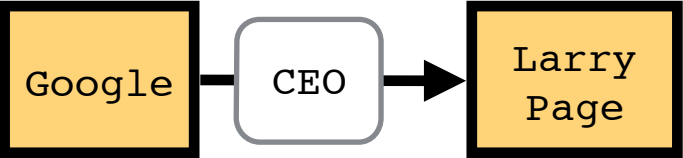
Annotated Corpus

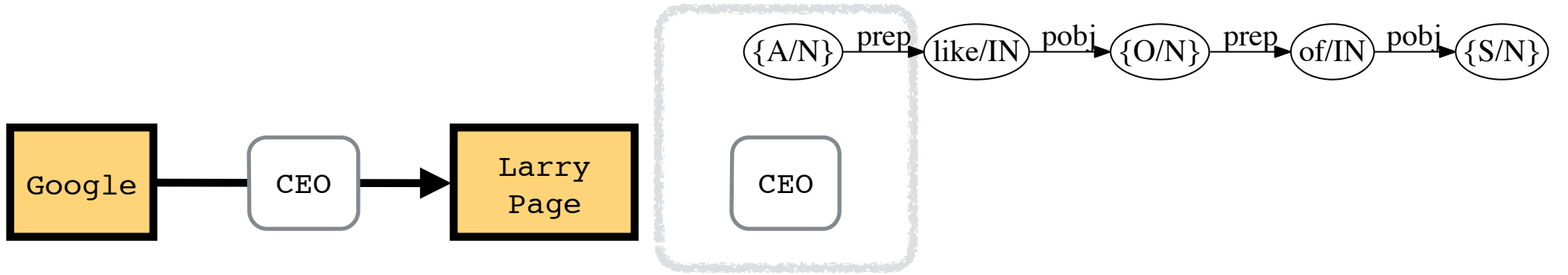


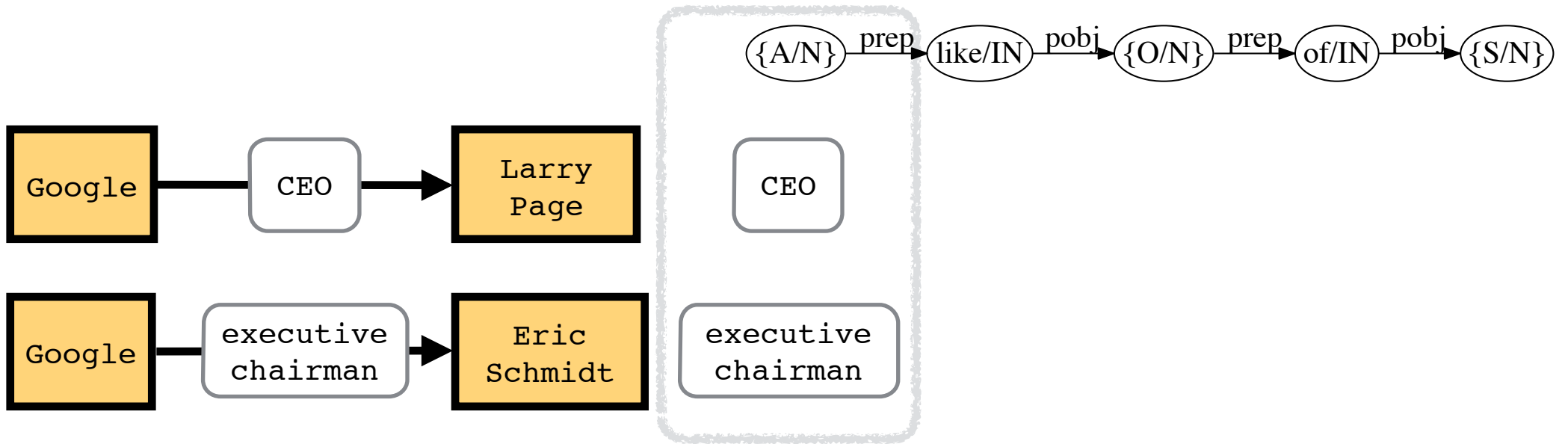
Seed fact extraction

Dependency pattern learning

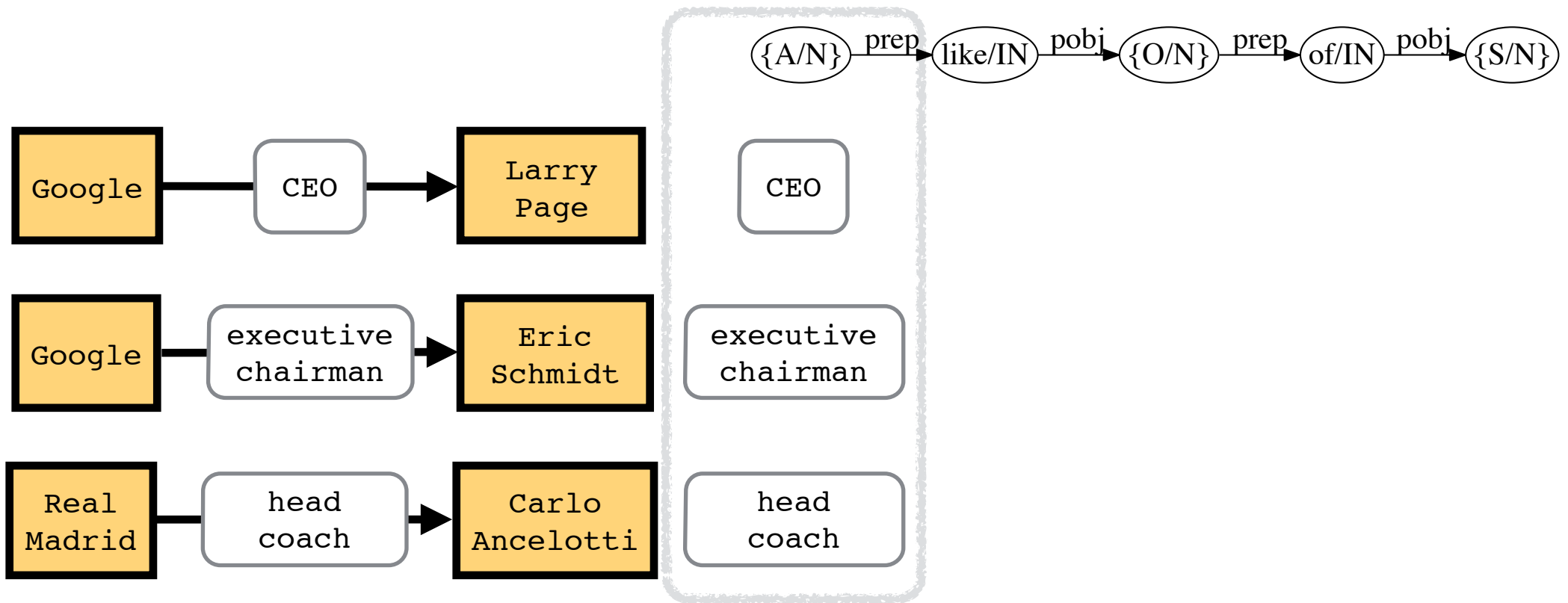
Dependency pattern learning





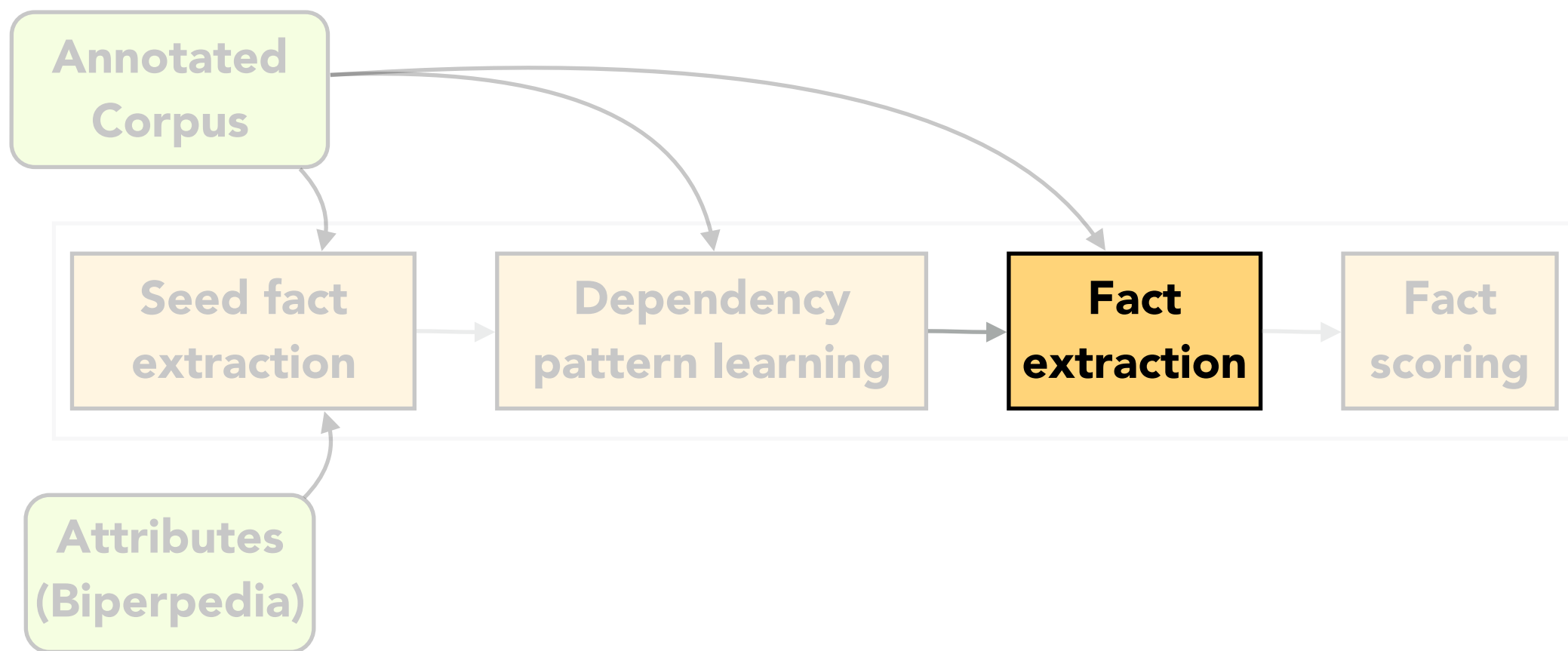


Same pattern could apply to multiple attributes...



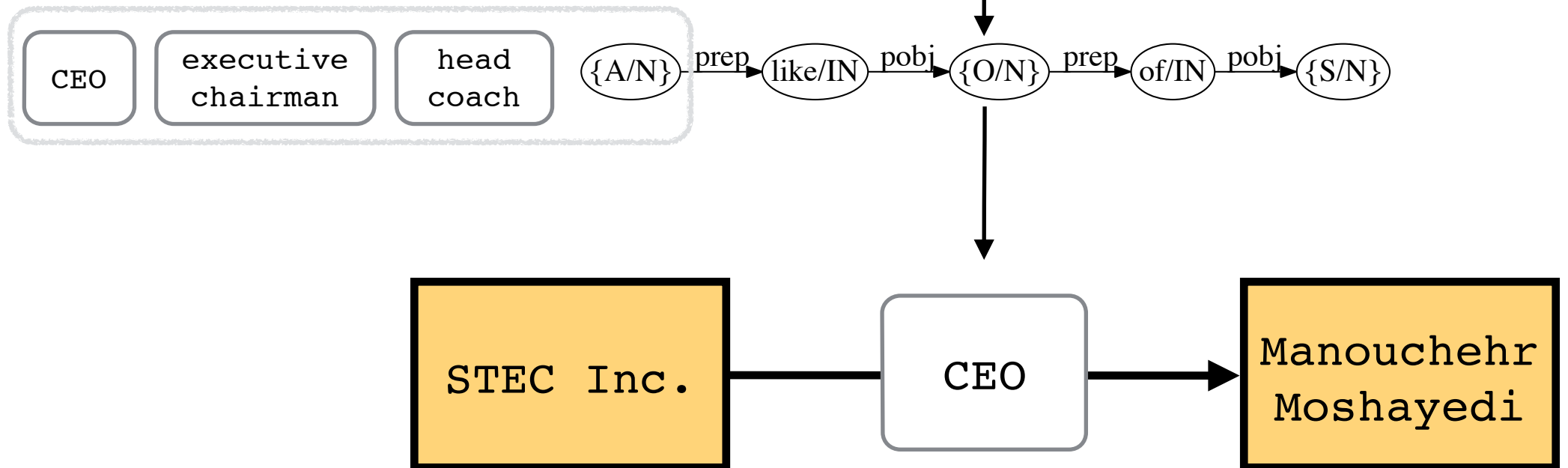
Same pattern could apply to multiple attributes...
 ...useful for scoring

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.



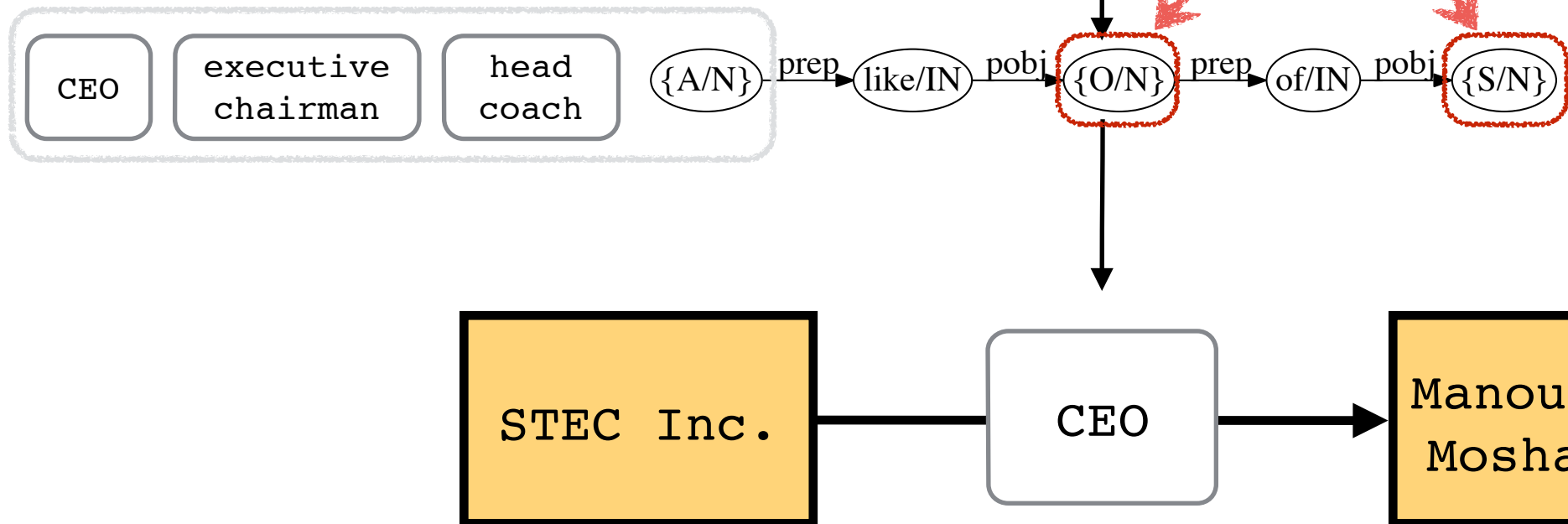
Argument order

Seed fact extraction

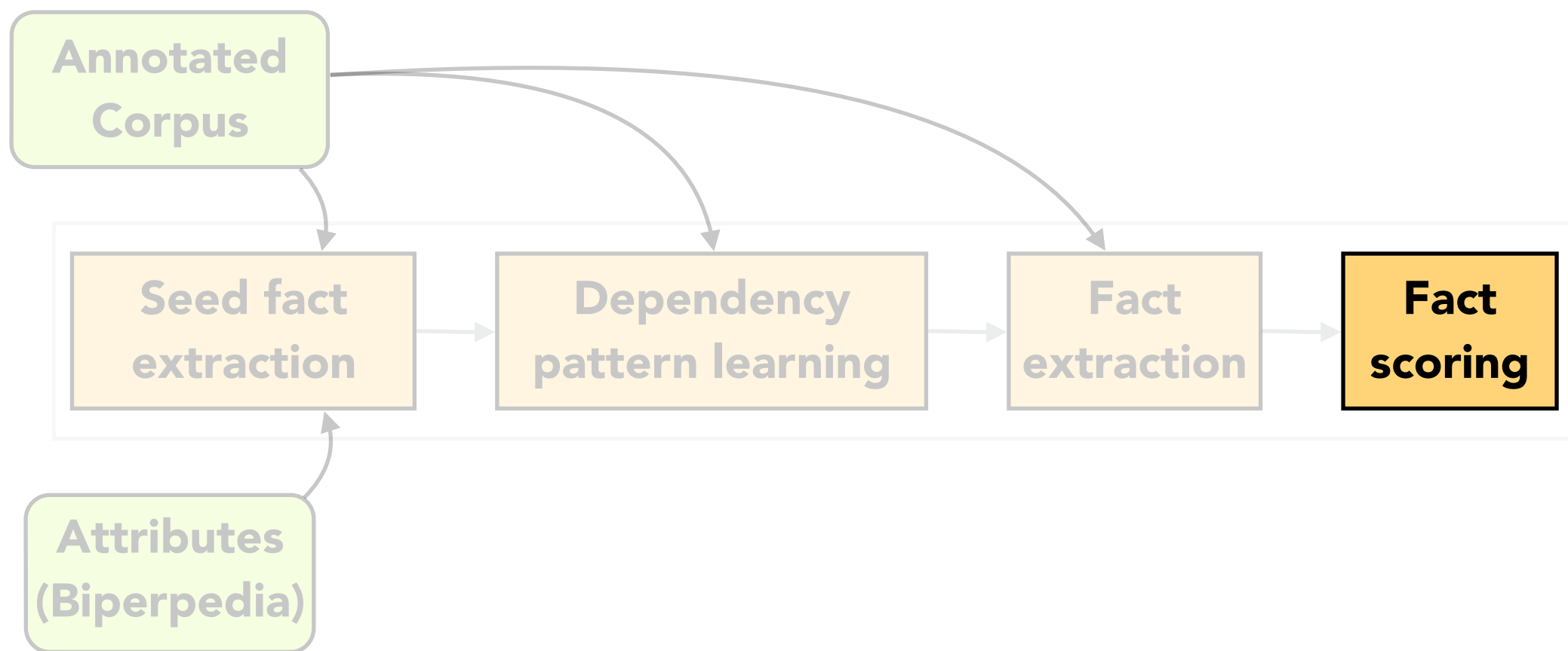
#1: A in Biperpedia & one of 8 pattern applies

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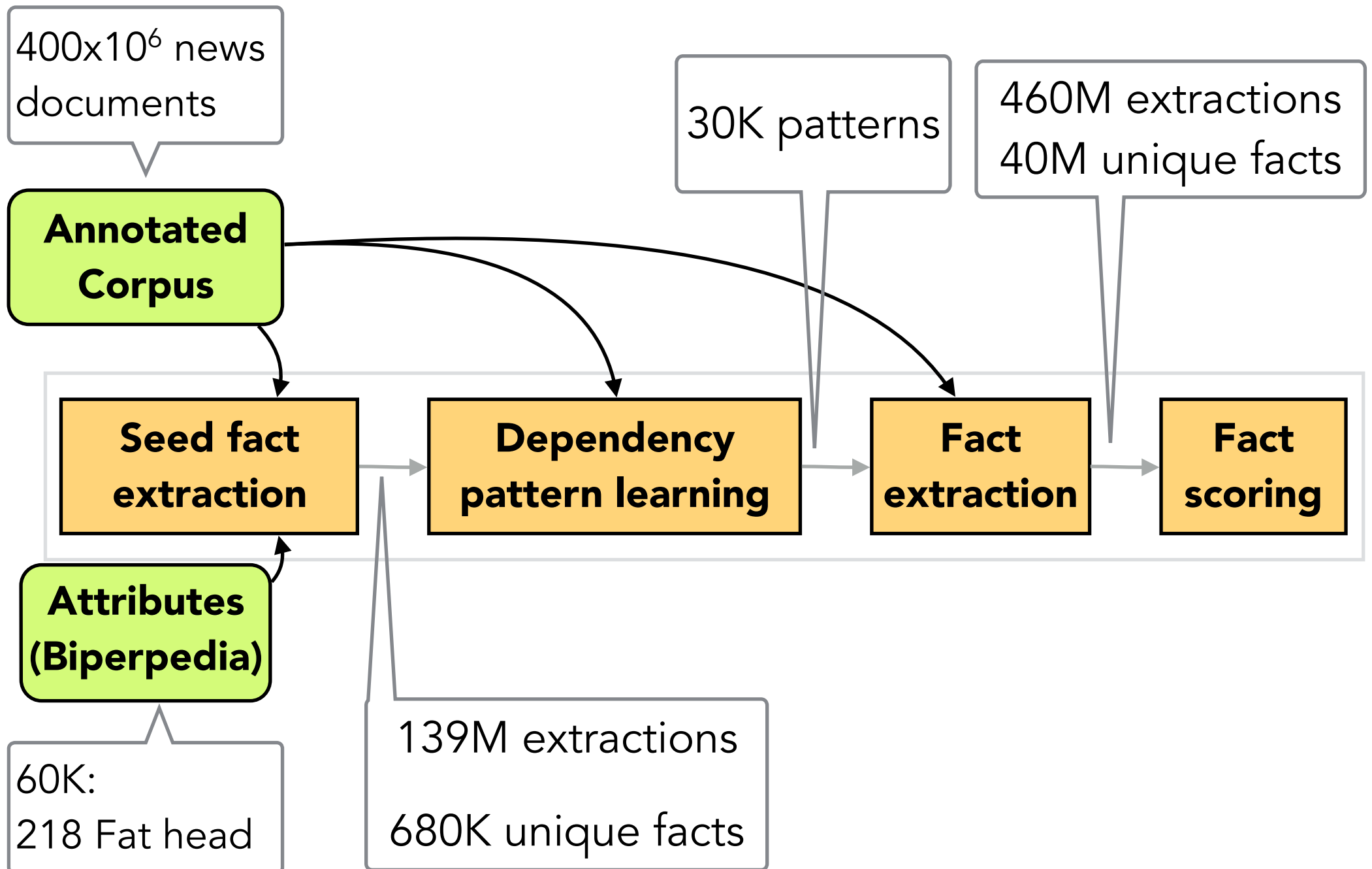
A CEO, like Manouchehr Moshayedi of STEC Inc., is not allowed to trade his company's stocks based on information only he has.



ReNoun



Some Numbers ...



Ollie*
[EMNLP'12]

vs.

ReNoun
[this talk]



| | | | |
|---------------------------|-----------|---|------------|
| Fat head (218) | 99 | : | 100 |
| Long tail (60K) | 31 | : | 100 |

*** Ollie handles verbs, ReNoun doesn't!**

Ollie
[EMNLP'12]

vs.

ReNoun
[this talk]

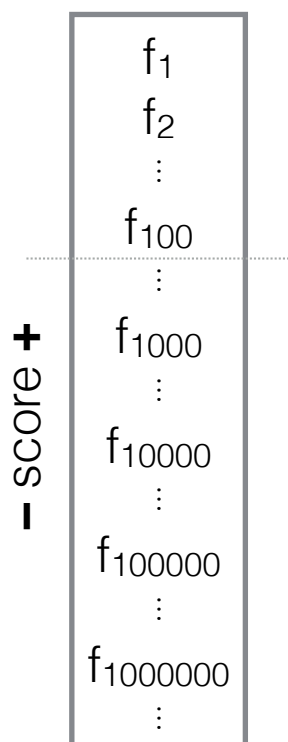
100

:

48

- 25/52 not in Biperpedia (mostly meaningless)
- Action: "*Obama's citation of the Bible*" (Coref kills these)

Results - Precision & #Attributes

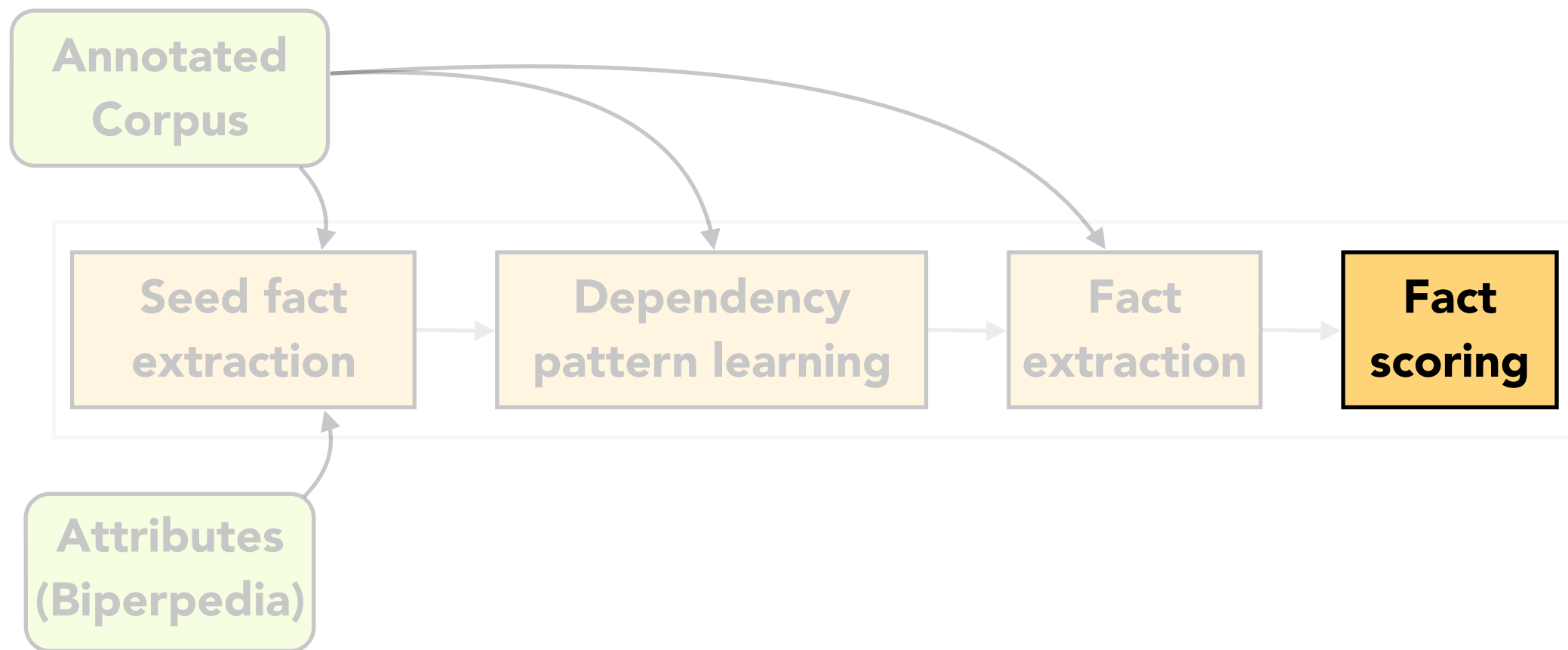


| k | Fat head | | Long tail | |
|--------|-----------|-------|-----------|-------|
| | precision | #attr | precision | #attr |
| 10^2 | 1.00 | 8 | 1.00 | 50 |
| 10^3 | 0.98 | 36 | 1.00 | 294 |
| 10^4 | 0.96 | 78 | 0.98 | 1548 |
| 10^5 | 0.82 | 106 | 0.96 | 5093 |
| 10^6 | 0.74 | 124 | 0.70 | 7821 |
| all | 0.18 | 141 | 0.26 | 11178 |

Results - Attributes w/o Facts

| <i>Cause</i> | FH | LT | Example |
|----------------------------|-----------|------------|----------------|
| Vague | 23 | 37 | culture |
| Numeric | 4 | 26 | rainfall |
| Object in in Freebase | 11 | 6 | email |
| Plural | 30 | 15 | member firms |
| Bad attribute | 3 | 4 | newsies |
| Value expected | 6 | 12 | nationality |
| Σ | 77 | 100 | |

ReNoun



Fact Scoring

$$\text{Score}(\boxed{\text{S}} \rightarrow \text{A} \rightarrow \boxed{\text{O}}) = \sum_{p \in \text{patterns}(\boxed{\text{S}} \rightarrow \text{A} \rightarrow \boxed{\text{O}})} \text{score}(p)$$

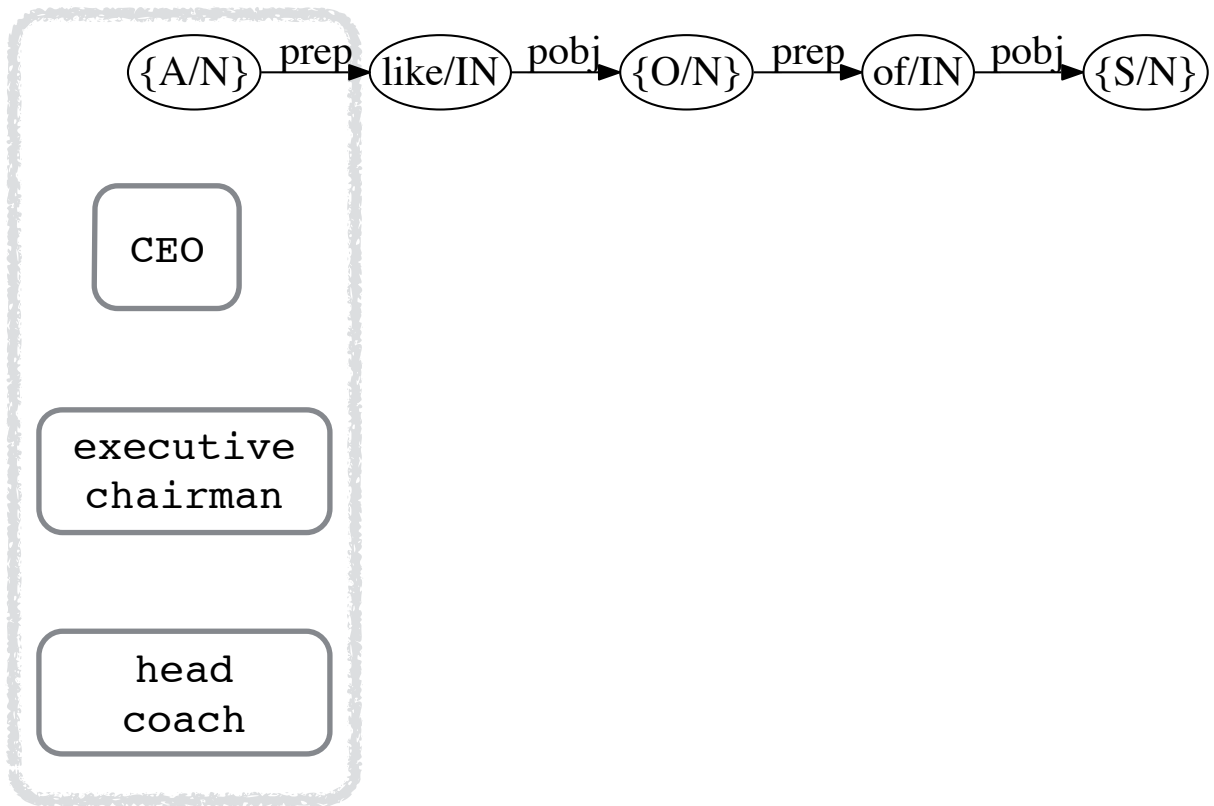
$$\text{score}(p) = \text{freq}(p) \times \boxed{\text{coh}(p)}$$

Fact Scoring

Pattern coherence $coh(p)$

$coh(p)$ high $\rightarrow p$ admits less noise

$coh(p)$ low $\rightarrow p$ admits more noise



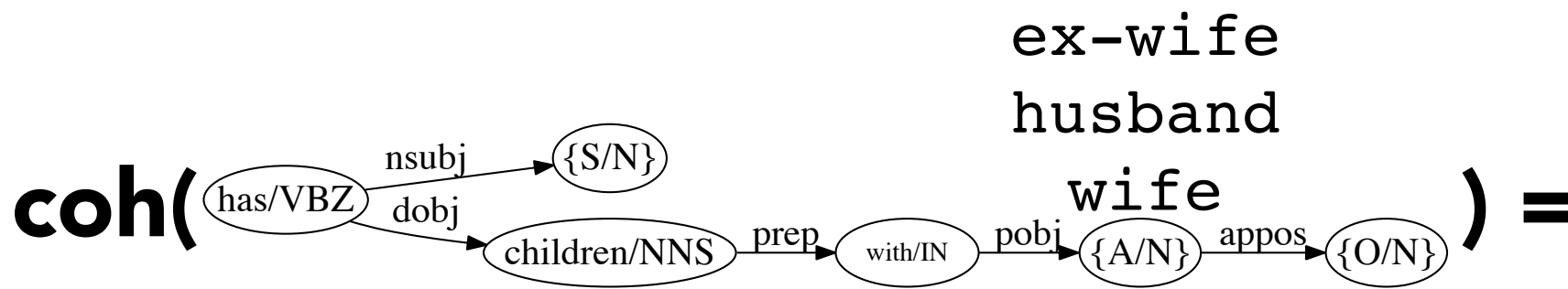
coh(p)

$$\text{coh}(\{O/N\} \xrightarrow{nn} \{A/N\} \xrightarrow{nn} \{S/N\}) = 0.093$$

Chelsea F.C. general manager Jose Mourinho
General Motors subsidiary Opel

$$\text{coh}(\text{has/VBZ} \xrightarrow{\text{nsubj}} \{S/N\} \xrightarrow{\text{dobj}} \text{children/NNS} \xrightarrow{\text{prep}} \text{with/IN} \xrightarrow{\text{pobj}} \{A/N\} \xrightarrow{\text{appos}} \{O/N\}) = 0.429$$

Barack has two children with his wife Michelle
Putin has two children with his ex-wife Lyudmilla



**Avg(coh(ex-wife, husband),
 coh(ex-wife, wife),
 coh(husband, wife))**

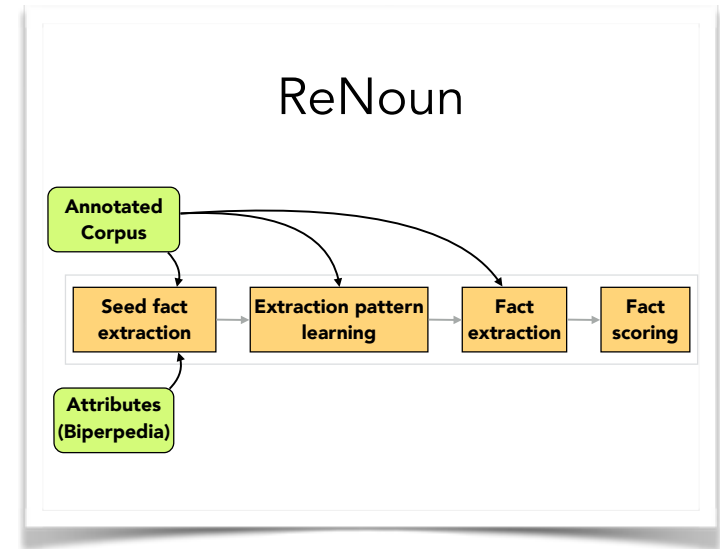
[Mikolov et al., ICLR'13]

**coh(husband, wife) =
 cos (word2vec(husband), word2vec(wife))**



Summary

| | Ollie [EMNLP'12] | vs. | ReNoun [this talk] |
|-----------|----------------------|-----|-----------------------|
| Fat head | coach | | coach |
| | president | | president |
| | province | | province |
| Long tail | banking arm | | banking arm |
| | caucus chairman | | caucus chairman |
| | foreign policy chief | | foreign policy chief |
| | state assemblyman | | state assemblyman |

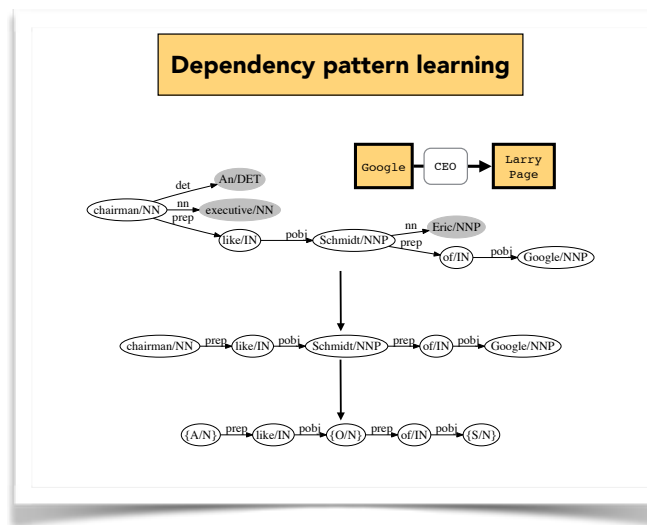


Seed fact extraction

#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 |

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



Fact Scoring

$$\text{Score}(S \rightarrow A \rightarrow O) = \sum_{p \in \text{patterns}(S \rightarrow A \rightarrow O)} \text{score}(p)$$

$$\text{score}(p) = \text{freq}(p) \times \text{coh}(p)$$