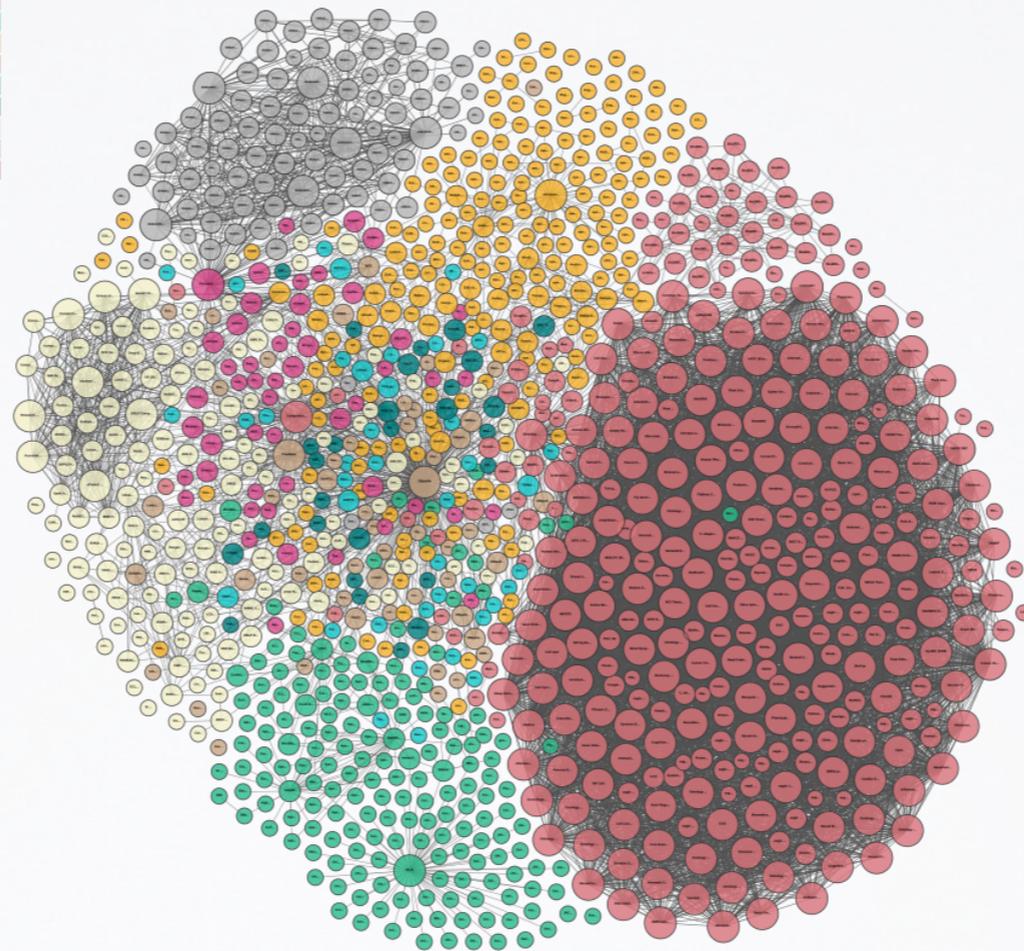


PUTTING CLAIMS INTO PERSPECTIVE WITH BACKDROP

Julien Leblay - AI Cloud Research Team



WEB DATA: CHALLENGES



WEB DATA: CHALLENGES



Scale

Linked Open Data (2017)

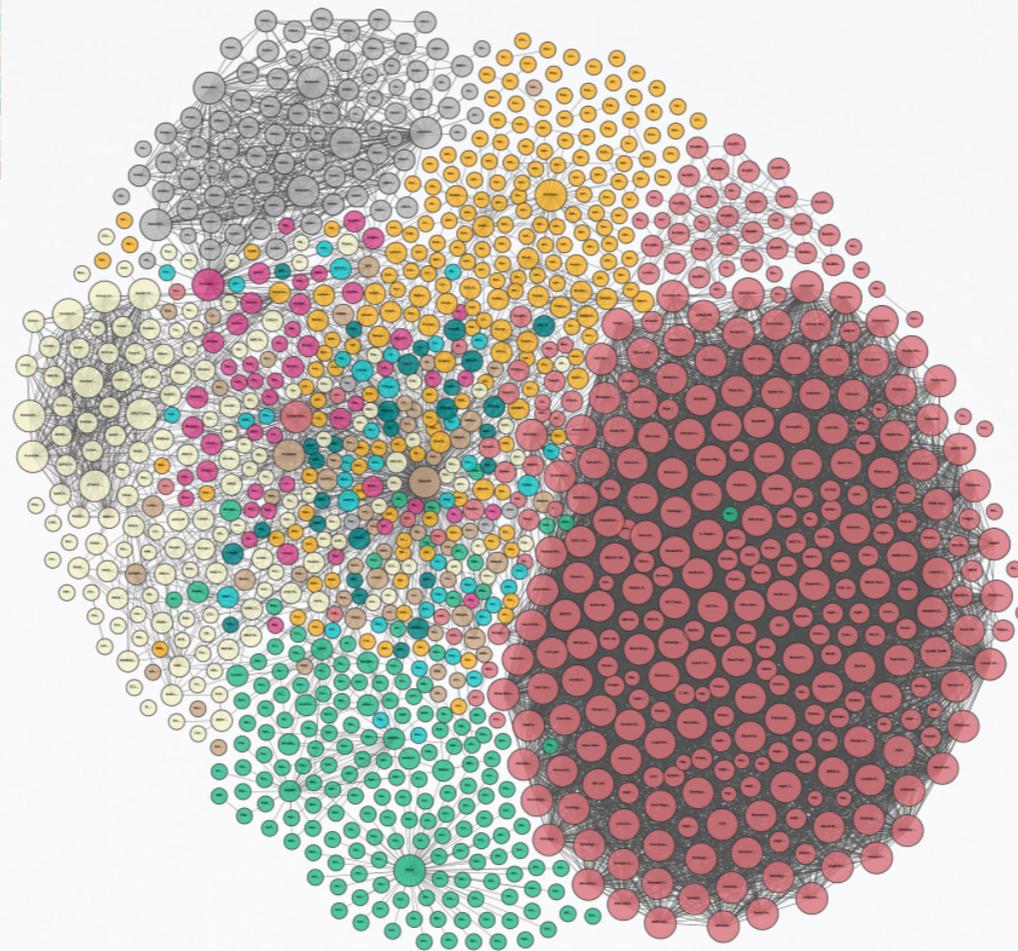
150B triples over 3000 datasets and endpoint

Web Data Commons Crawls (2016)

44B triples, 9.5B entities

Domains: 34M (5M with triples)

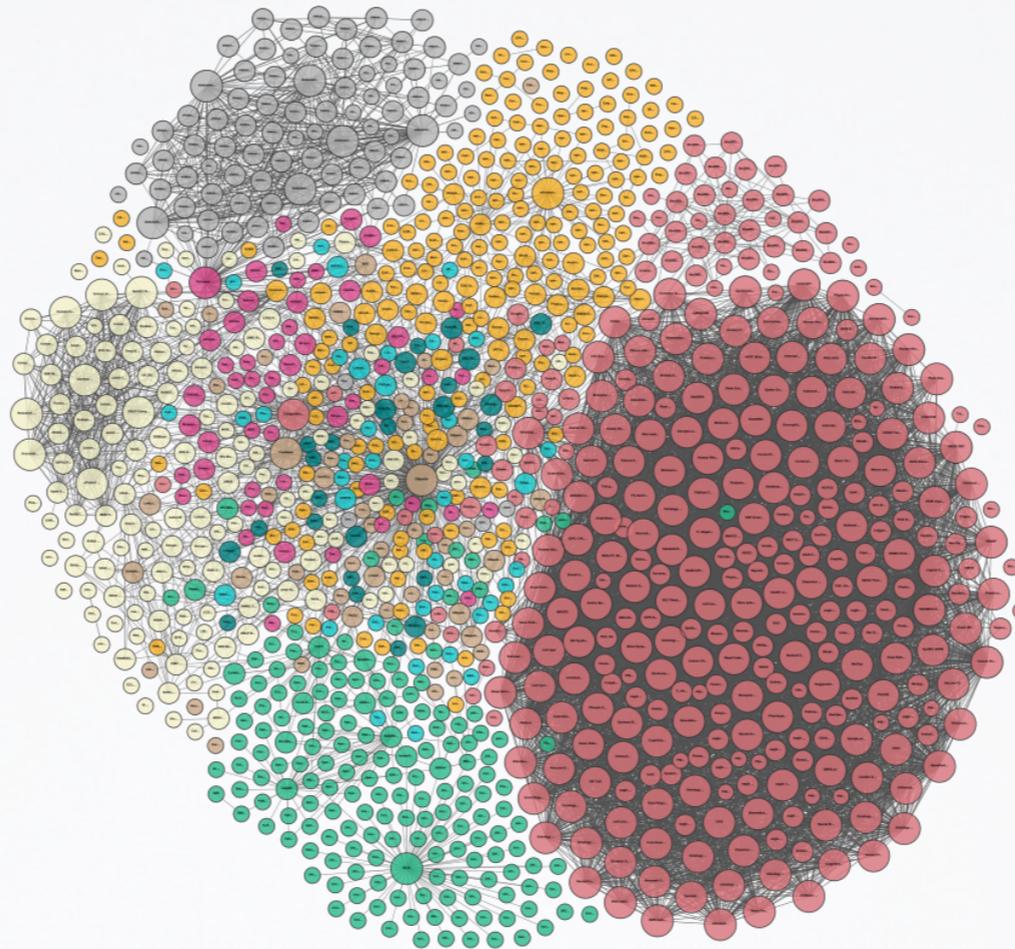
Pages: 3.1B (1.2B with triples)



WEB DATA: CHALLENGES



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Quality/Bias

Linked Open Data (2017)

6971 out of 9960 datasets (701%) have errors

Generally no validation authority

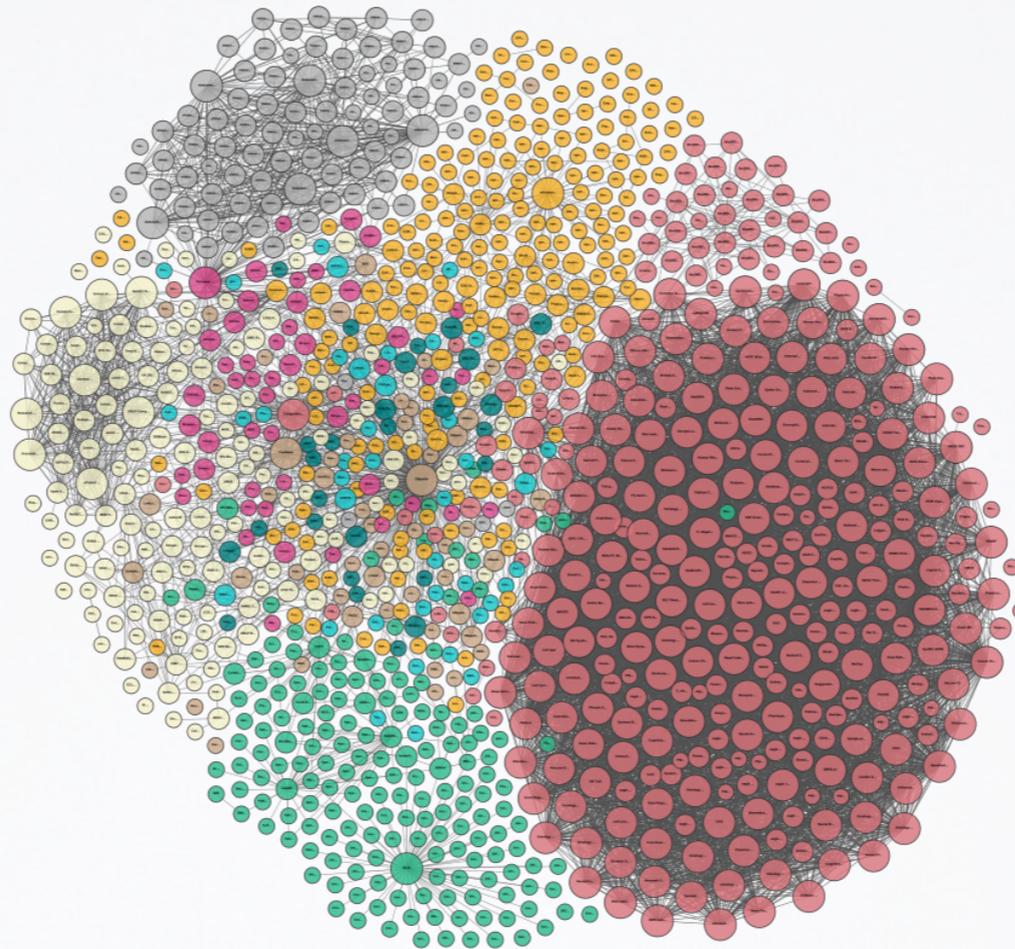
Data or sources are routinely

- ▶ missing
- ▶ outdated
- ▶ inconsistent
- ▶ etc.

WEB DATA: CHALLENGES



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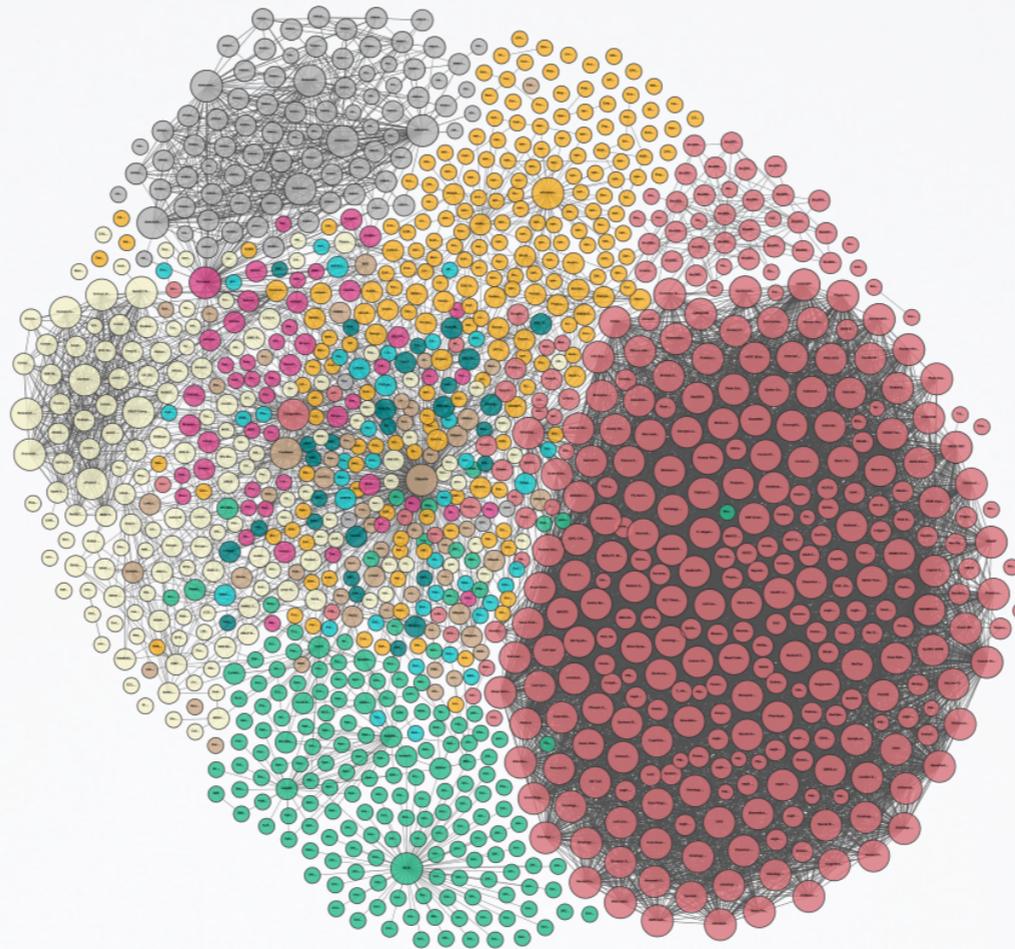
Heterogenous



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Heterogenous



DEALING WITH THE TRUTH



Problem

The data is **incomplete**

DEALING WITH THE TRUTH



Problem

The data is **incomplete**

Data

party(JohnDoe, Tory)
party(JohnDoe, Labour)

Query

Eurosceptic(JohnDoe) ?

DEALING WITH THE TRUTH



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party(JohnDoe, Labour)

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Answer: **NO**

DEALING WITH THE TRUTH



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Solution

Deductive databases
e.g. Datalog, Sparql 1.1

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party(JohnDoe, Tory)
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party(x, Tory) \rightarrow Eurosceptic(x)

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Answer: **NO**



Answer: **YES**

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DEALING WITH THE TRUTH



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Graphical models

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DEALING WITH THE TRUTH



Problem

The data is **uncertain**

Solution

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Graphical models

Data

party(JohnDoe, Tory)

party(JohnDoe, Labour)

Semantics

\neg party(x, Tory) \vee Eurosceptic(x) : 10

\neg party(x, Labour) \vee \neg Eurosceptic(x) : 2

Query

Eurosceptic(JohnDoe) ?

Answer: **65%**

DEALING WITH THE TRUTH



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party(JohnDoe, Labour)

Semantics (e.g. Markov Logic)

$\neg \text{party}(x, \text{Tory}) \vee \text{Euro sceptic}(x) : 10$

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DEALING WITH THE TRUTH



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Query

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DEALING WITH THE TRUTH



Problem

The data and semantics are **contextual**

Labour \neq Eurosceptic



Tory = Eurosceptic

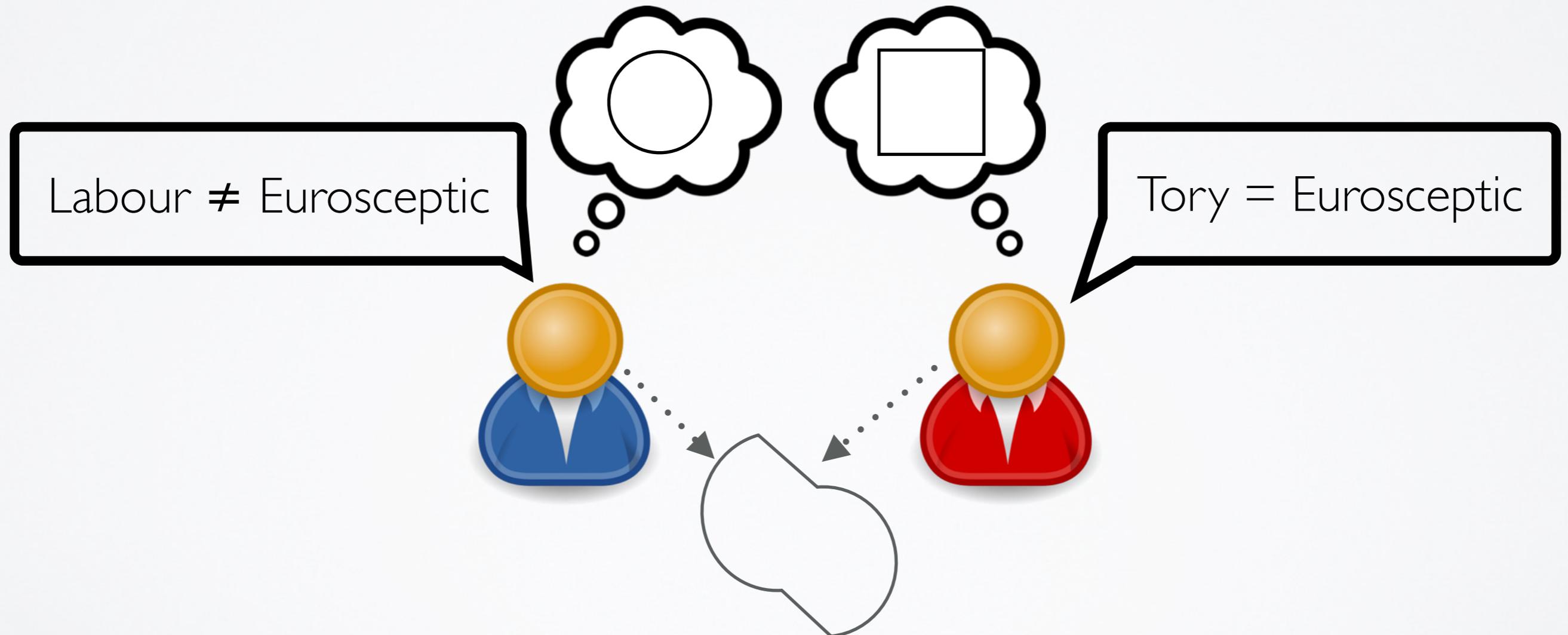


DEALING WITH THE TRUTH

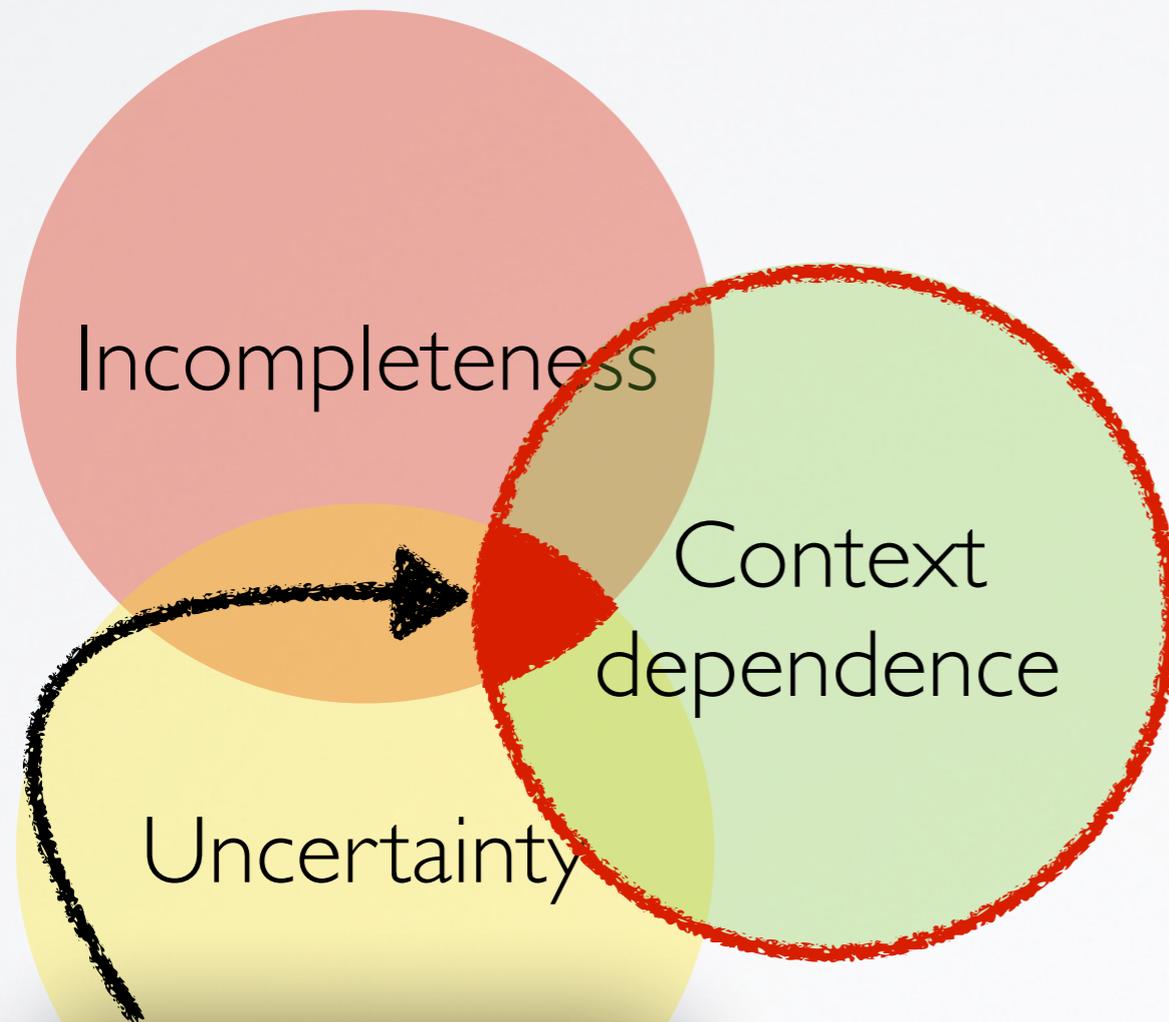


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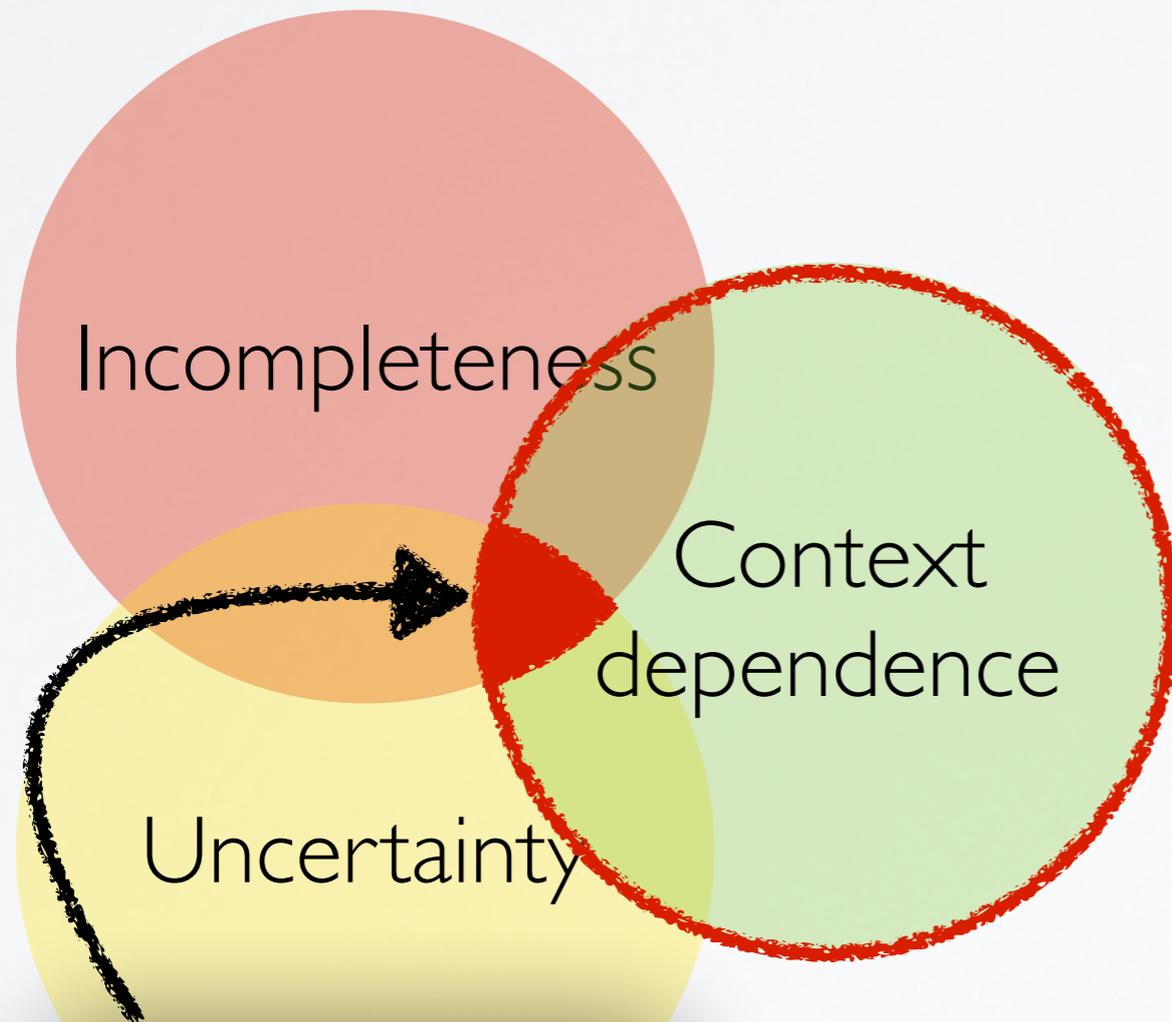


GOAL: VERACITY AS A FUNCTION OF CONTEXT



This work
Exploring how
context affects
veracity

GOAL: VERACITY AS A FUNCTION OF CONTEXT

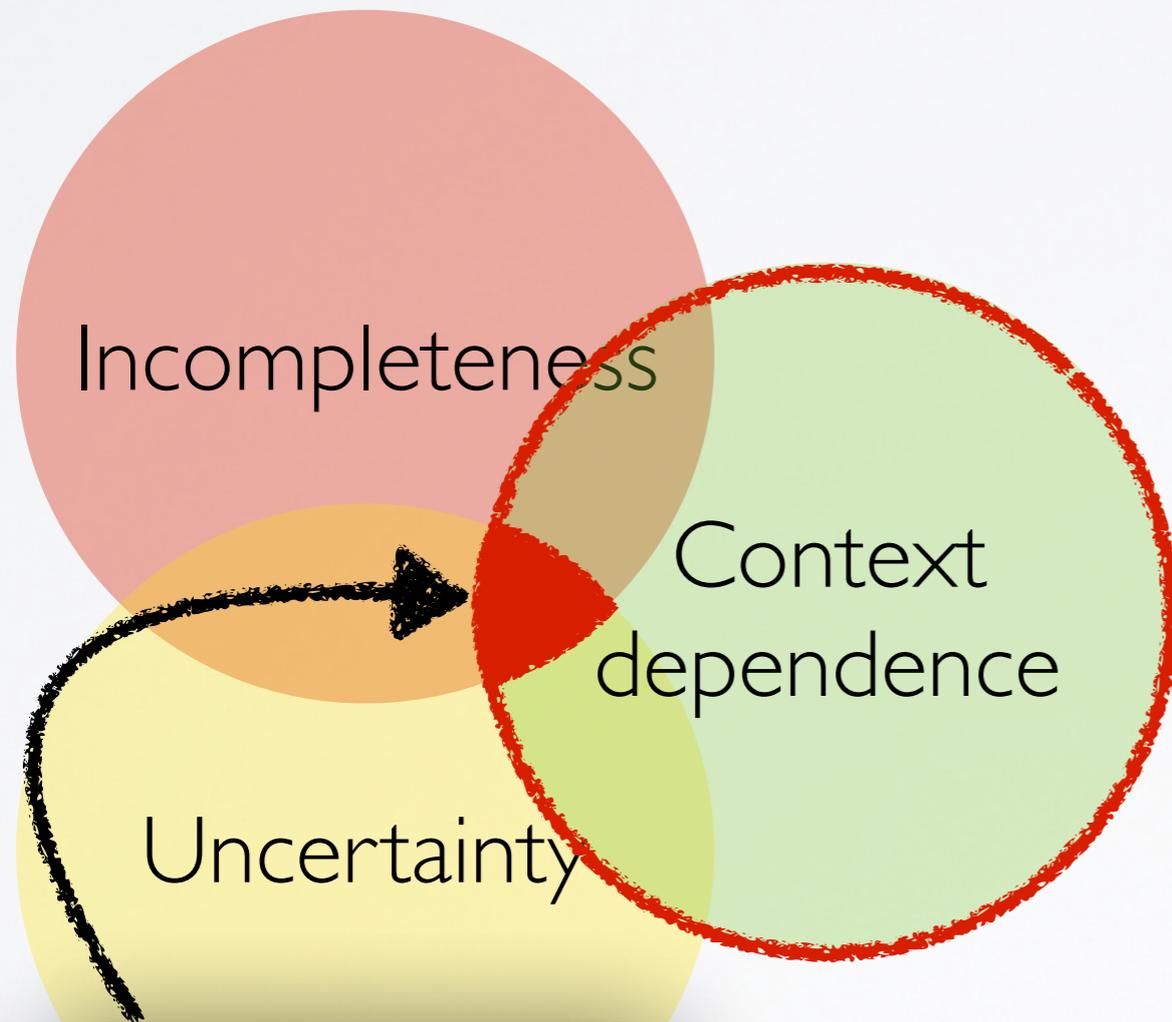


Objective 1: Assess the veracity of facts with respect to context

Eurosceptic(JohnDoe) [2013, 2016] → 25%
bbc → 75%

This work
Exploring how **context** affects **veracity**

GOAL: VERACITY AS A FUNCTION OF CONTEXT



This work
Exploring how **context** affects **veracity**

Objective 1: Assess the veracity of facts with respect to context

Eurosceptic(JohnDoe) [2013, 2016] → 25%
bbc → 75%

Objective 2: Explore which contexts make a fact true beyond a threshold

Eurosceptic(JohnDoe): 50% → [2005, 2016]
bbc

DEFINING CONTEXT



DEFINING CONTEXT



Desiderata

DEFINING CONTEXT



Desiderata

- **Expressive:** describing a wide range of contexts

DEFINING CONTEXT



Desiderata

- **Expressive:** describing a wide range of contexts
- **Adaptable:** should be applicable to existing data model

DEFINING CONTEXT



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- **Expressive:** describing a wide range of contexts
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- **Non-intrusive:** should not require to modify legacy data

DEFINING CONTEXT



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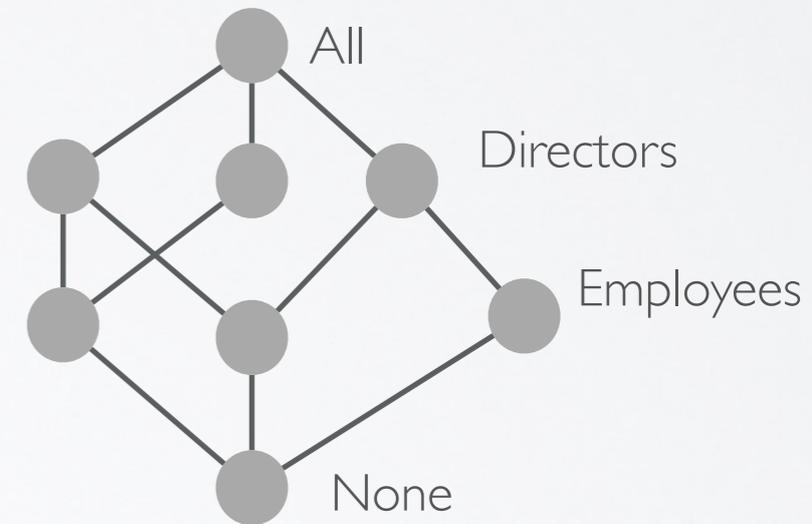
Annotations

- Annotations **enrich data** with additional (and *orthogonal*) **metadata**
- We borrow, with slight adjustments, to **provenance semi-rings**
 - Commonly used to **model various semantics** on the top of set semantics. E.g. lineage, bag semantics, fuzzy logic, etc.

ANNOTATIONS AS CONTEXT



- In our case, annotations are taken from **finite lattices**



`party(JohnDoe, Tory)cardinality=10`

`party(JohnDoe, Tory)source=bbc`

`party(JohnDoe, Tory)timespan=[2007, 2010]`

`party(JohnDoe, Tory)security=confidential`

Data

party(JohnDoe, Tory)
party(JohnDoe, Labour)
supports(JohnDoe, Brexit)
opposes(Labour, Brexit)

Axioms

bachelorFrom(X, Y) \rightarrow CollegeGrad(X)
party(X, Tories) \rightarrow Eurosceptic(X)
party(X, Y) \wedge opposes(Y, Z) \rightarrow opposes(X, Z)
supports(X, Y) \wedge opposes(X, Y) $\rightarrow \perp$

CollegeGrad(X) \rightarrow opposes(X, Brexit)
party(X, Tories) \rightarrow support(X, Brexit)

Data

party(JohnDoe, Tory)	:{([2005, 2016], {bbc})}
party(JohnDoe, Labour)	:{([1980, 2008], {afp})}
supports(JohnDoe, Brexit)	:{([2005, 2016], {bbc})}
opposes(Labour, Brexit)	:{([-∞, +∞], {afp, cnn})}

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 party(X, Tories) \rightarrow support(X, Brexit)

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party(JohnDoe, Tory)	$:\{([2005, 2016], \{bbc\})\}$
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Intuition

These facts and axioms only hold within those contexts.

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CollegeGrad(X) \rightarrow opposes(X, Brexit)	: 6.0
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Soft

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This axiom is more plausible than that one

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CONTEXTUAL CHASE



Hard axioms

$\text{Eurosceptic}(X) \rightarrow \text{support}(X, \text{Brexit})$	$:\{([-\infty, +\infty], \{\text{afp}, \text{bbc}\})\}$
$\text{party}(X, \text{Tories}) \rightarrow \text{Eurosceptic}(X)$	$:\{([2007, 2013], \{\text{bbc}, \text{cnn}\})\}$
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\perp	$:\{([2005, 2008], \{\text{afp}\})\}$

Data (contextual closure)

party(JohnDoe, Tory) :{([2005, 2012], {afp, bbc}), ([2007, 2012], {afp})}
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supports(JohnDoe, Brexit) :{([2005, 2016], {afp, bbc, cnn})}
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Eurosceptic(JohnDoe) :{([2007, 2012], {afp})}
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⊥ :{([2005, 2008], {afp})}

Soft axioms

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Contextual interpretation: probability distribution over contexts

$$P(x) = Z^{-1} \exp \left[\pi(x) \times \sum_i w_i n_i(x) \right]$$

Data (contextual closure)

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supports(JohnDoe, Brexit)	:{([2005, 2016], {afp, bbc, cnn})}
opposes(Labour, Brexit)	:{([-∞, +∞], {afp, cnn})}
Eurosceptic(JohnDoe)	:{([2007, 2012], {afp})}
opposes(JohnDoe, Brexit)	:{([1980, 2008], {afp})}
⊥	:{([2005, 2008], {afp})}

Soft axioms

CollegeGrad(X) → opposes(X, Brexit)	: 6.0
party(X, Tories) → support(X, Brexit)	: 3.0

Contextual interpretation: probability distribution over contexts

$$P(x) = Z^{-1} \exp \left[\pi(x) \times \sum_i w_i n_i(x) \right]$$

All facts and axioms are context-independent ⇒ all contexts are equiprobable

QUERY ANSWERING



Scoring function: given a conjunction, the sum of probabilities of contexts in which it holds

$$\beta(x) = \sum_{\{w \mid w \preceq x, \mathcal{D} \cup \Sigma \models_{K, \alpha_w} \phi\}} P(w)$$

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Intuition
For any given input context \mathbf{K} , aggregate the probabilities of context in which Φ holds and contained in \mathbf{K} .



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?-Euroscptic(?x) : ([2000, 2017], τ)

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For each answer a

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Threshold queries

?-Euro sceptic(?x) / 0.5

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?-Euroscptic(?x) : ([2000, 2017], τ)



For each answer a

return a : $\beta(a)$

Threshold queries

?-Euroscptic(?x) / 0.5



Find all contexts s.t. $\beta(a) > .5$

OPTIMIZATION

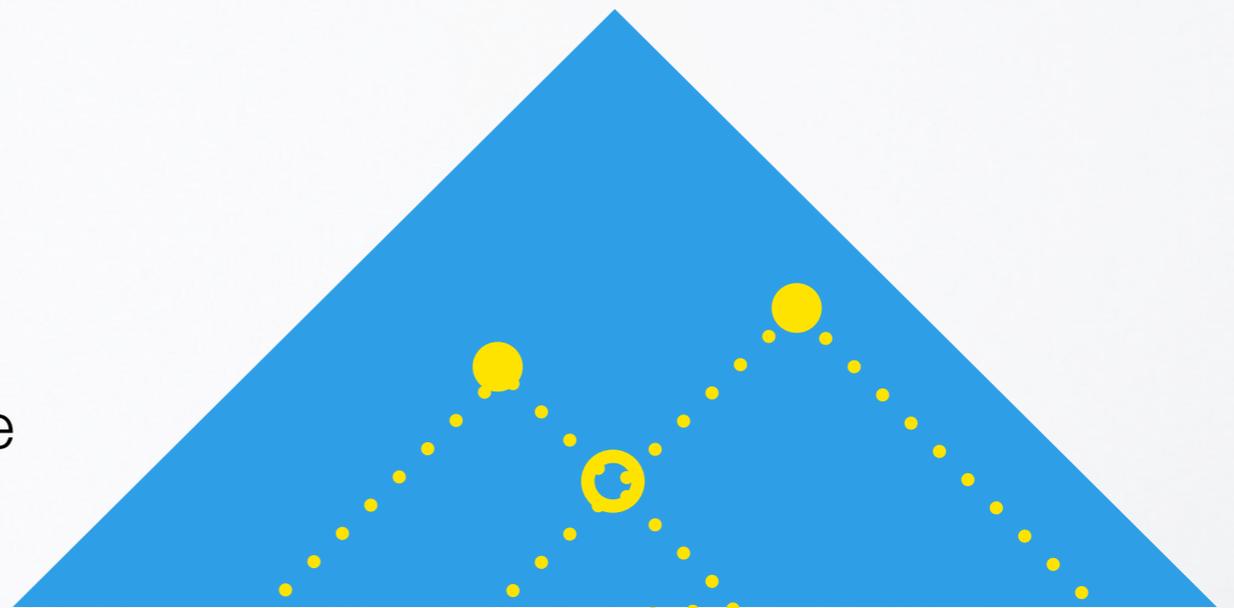


- Observation: Multiple contexts share the same axioms and assertions; they all share the same probabilities
- We can partition the lattices into such equivalence classes, and compute the probabilities for a single *representative* context of each class.
- We can easily get the list of *active* context texts from the data, and compute the set of equivalence classes from them.

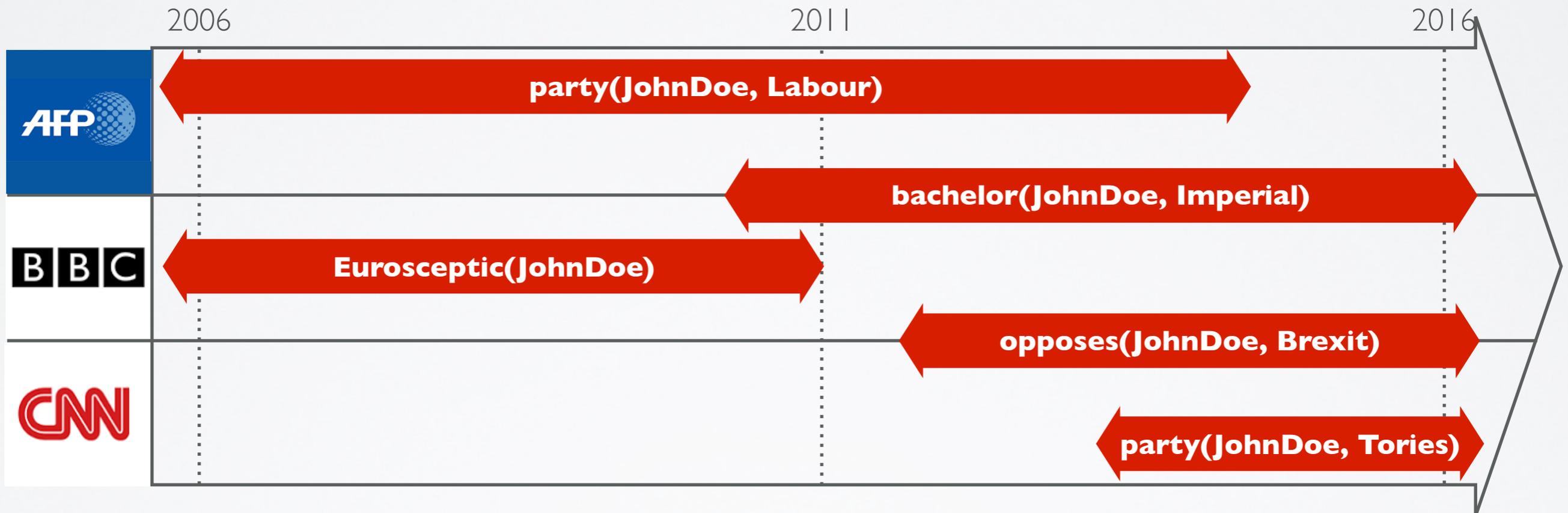
Example

LOD Movie Critiques Scenario

- 39K facts before closure (45K a.er),
- 20 hard axioms
- 7 soft axioms
- 46K distinct contexts
- Chase and finding of eq. classes : ~1s
- Contextual interpretation:
20 minutes. In comparison, the exhaustive interpretation computation requires hours.

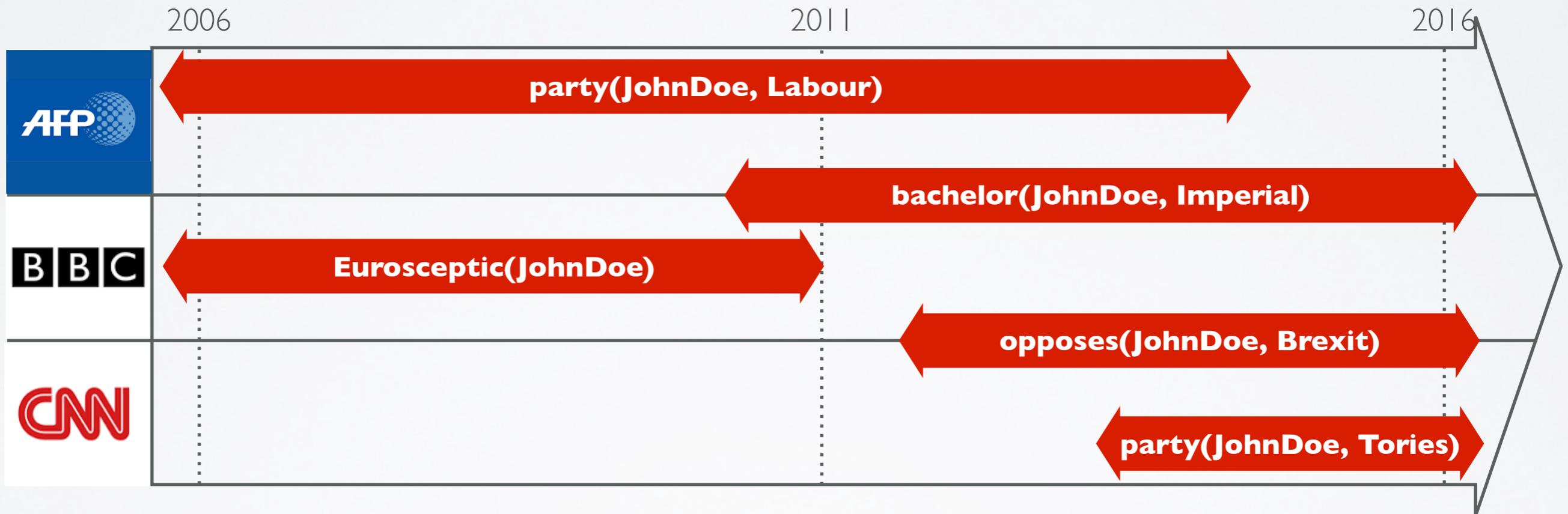


EXAMPLE

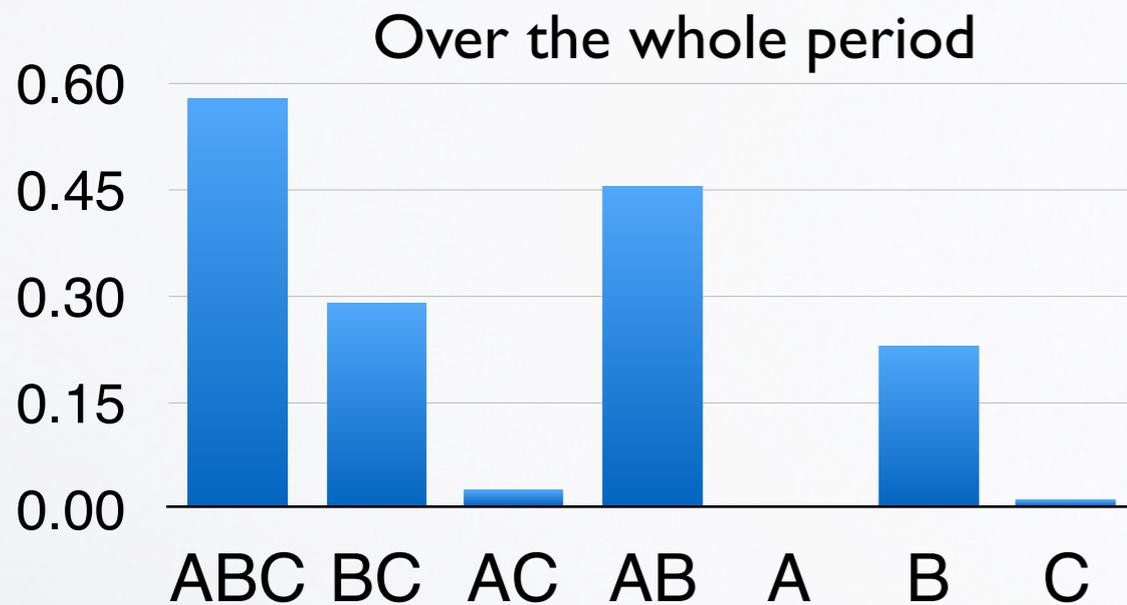


Eurosceptic(JohnDoe)?

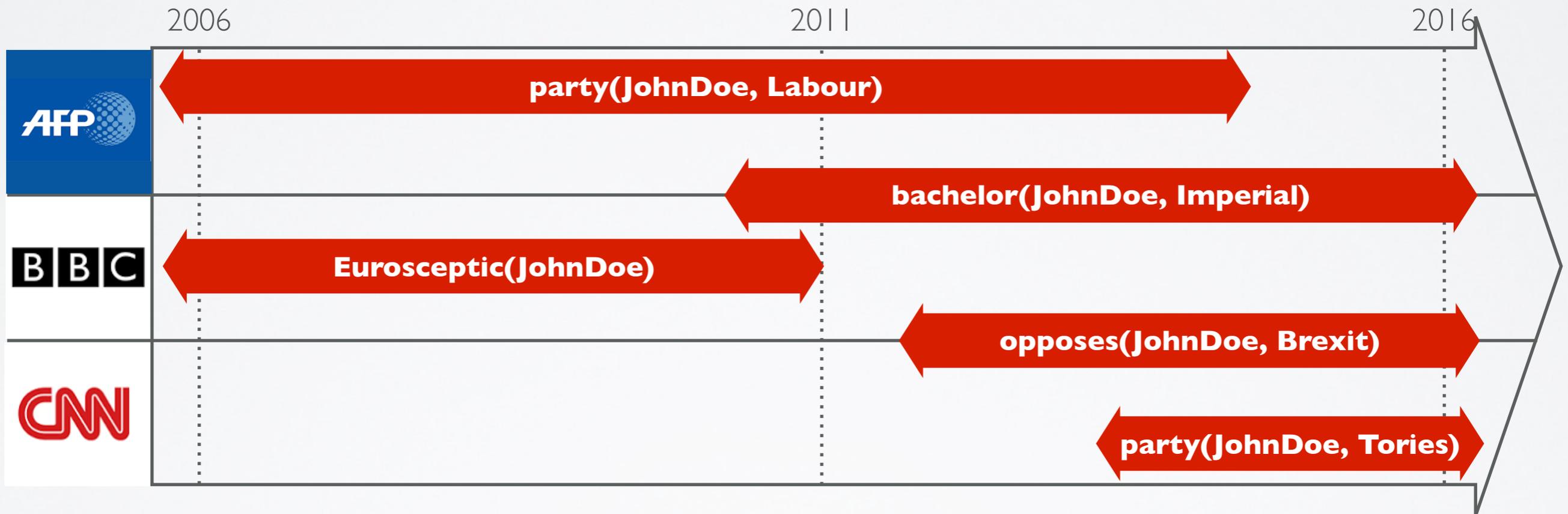
EXAMPLE



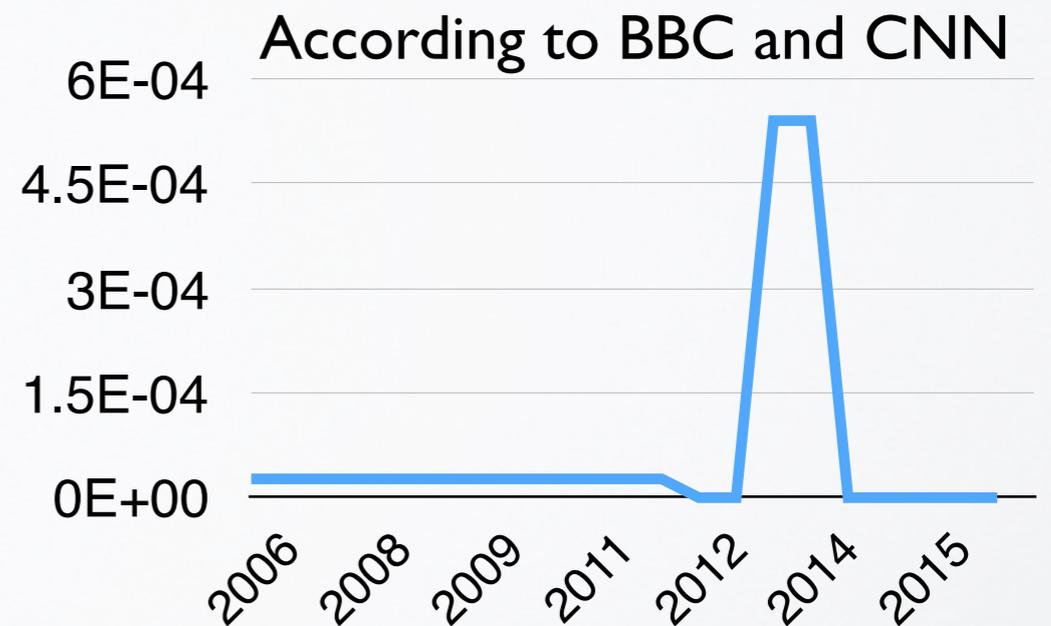
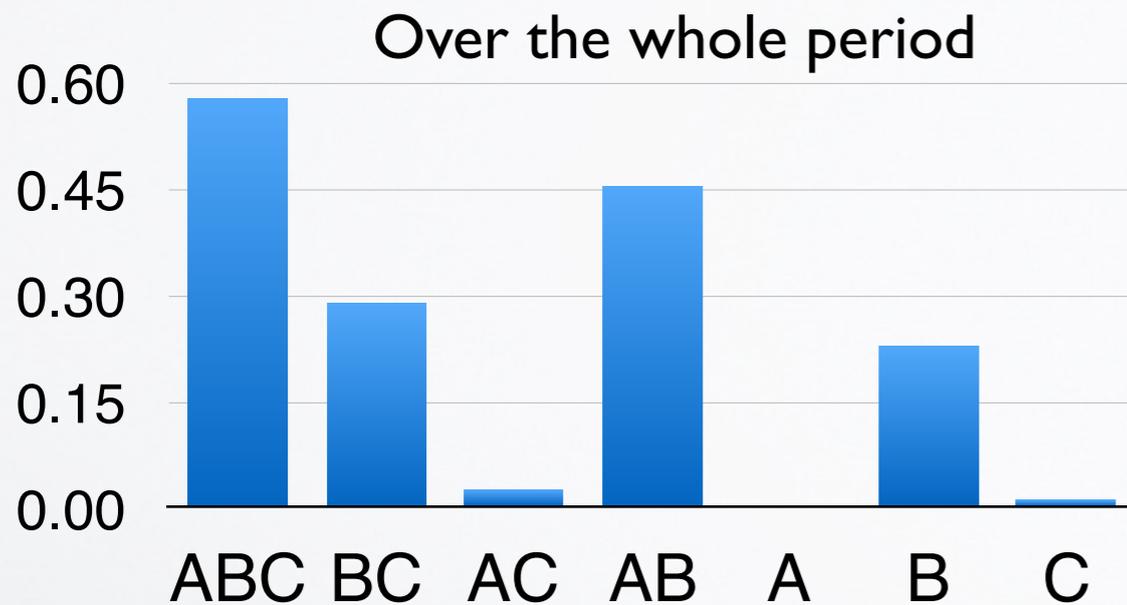
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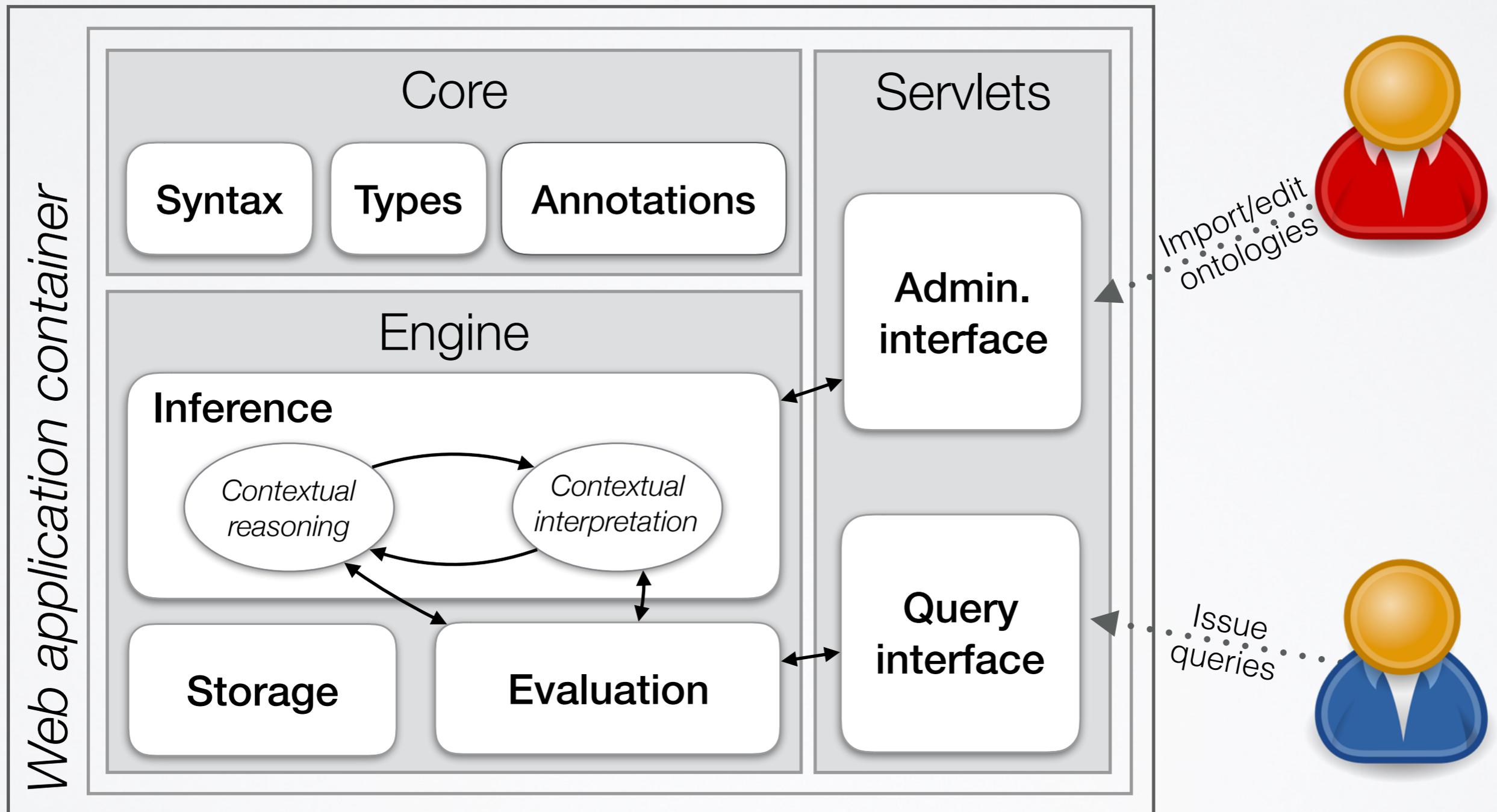
EXAMPLE



Eurosceptic(JohnDoe)?



BACKDROP'S ARCHITECTURE



BACKDROP'S USER INTERFACE



Movie Critiques

Context

- Time frame: ["1995":year, "2018":year]
- Provenance for all sources

Knowledge Base

Summary (details)

- 26 types
- No contradiction.

No. of assertions (Total: 45278)

Proportion of soft vs. hard axioms (Total: 28)

Time frame [1995,2018] ranging over Provenance for 5 sources

Search:

- ?x
- Her
- Lost in Translation
- Avengers: Age of Ultron
- The Prestige
- Vicky Cristina Barcelona
- Iron Man 2
- The Other Boleyn Girl
- Hail, Caesar!
- Don Jon
- Captain America: Civil War
- Captain America: The Winter Soldier
- The Jungle Book
- The Horse Whisperer
- Lucy
- The SpongeBob SquarePants Movie
- In Good Company
- Match Point**
- Scoop

Time frame [1995,2018] ranging over Provenance for all sources

Time frame [1995,2018] ranging over Provenance for all sources

ID	Name	Axiom	Start	End	Source	Edit
o19	genre(?film, "horror film")	→ mainstreamGenre(?film).	2002	2017	11 source(s)	Edit Delete
o2	audienceRating(?film,?b) ^ criticRating(?film,?c) ^ ?b<		1950	2020	11 source(s)	Edit Delete
o20	genre(?film, "sports film")	→ mainstreamGenre(?film).	2002	2017	11 source(s)	Edit Delete
o21	genre(?film, "biographical film")	→ controversialGenre...	1998	2017	11 source(s)	Edit Delete
o22	genre(?a, "LGBT-related film")	→ controversialGenre(?...	2002	2017	11 source(s)	Edit Delete
o23	genre(?film,?g) ^ category(?film,?c) → genre(?film,?c).		2000	2017	1 source(s)	Edit Delete
o24	genre(?film,?g) ^ category(?film,?c) → category(?film,...		2000	2017	1 source(s)	Edit Delete
o25	mainstreamGenre(?film) ^ controversialGenre(?film) →...		1950	2020	11 source(s)	Edit Delete
o3	criticRating(?film,?r) ^ "50":integer<		1950	2020	11 source(s)	Edit Delete
o4	audienceRating(?film,?r) ^ "50":integer<		1950	2020	11 source(s)	Edit Delete

FUTURE WORK



- **Model**

- Learning (weight, annotations)
- Allowing variable in annotation

In queries: Did criminality decrease under Giuliani's mayoralty ?

```
mayorOf("Giuliani", ?city): ([?start, ?end], _), crime(?rate1):([?start, ?end], ?city),  
    mayorOf(?other, ?city): ([_, ?start], _), crime(?rate2):([_, ?start], ?city),  
    ?rate1 < ?rate2
```

In constraints: Forcing annotations in constraints

```
graduate(?x, ?y):[?from, ?to], LawSchool(?y) -> Lawyer(?x):[?end, _]
```

- Equality Generating Dependencies (key constraints)

- **User interface**

- Threshold queries
- More lattices
- More visualizations

- **Scalability**

- Incremental updates interpretation computation
- Deployment on large scale data platform

THANK YOU
for your attention

