

A Hitchhiker's guide to Ontology

Fabian M. Suchanek
Télécom ParisTech University
Paris, France

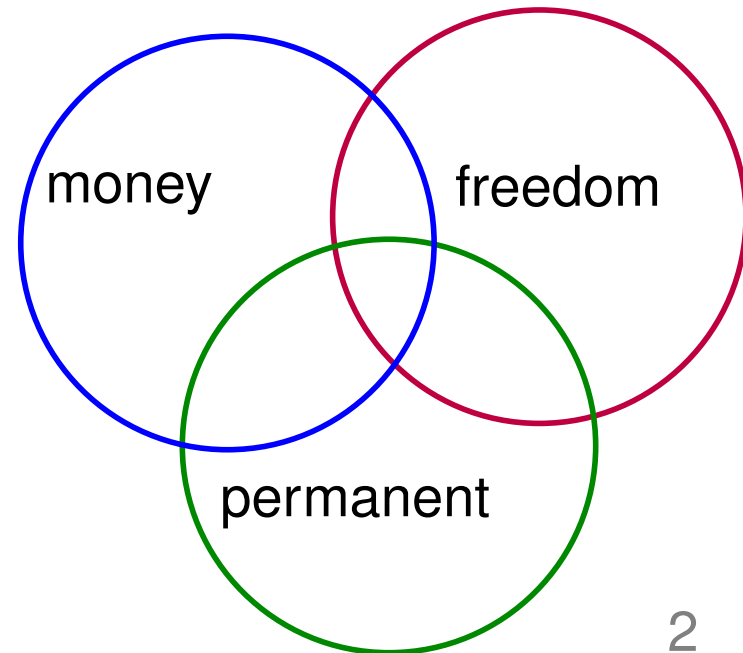
Fabian M. Suchanek

2003:



2005:

2008:



Fabian M. Suchanek

2003: BSc in Cognitive Science

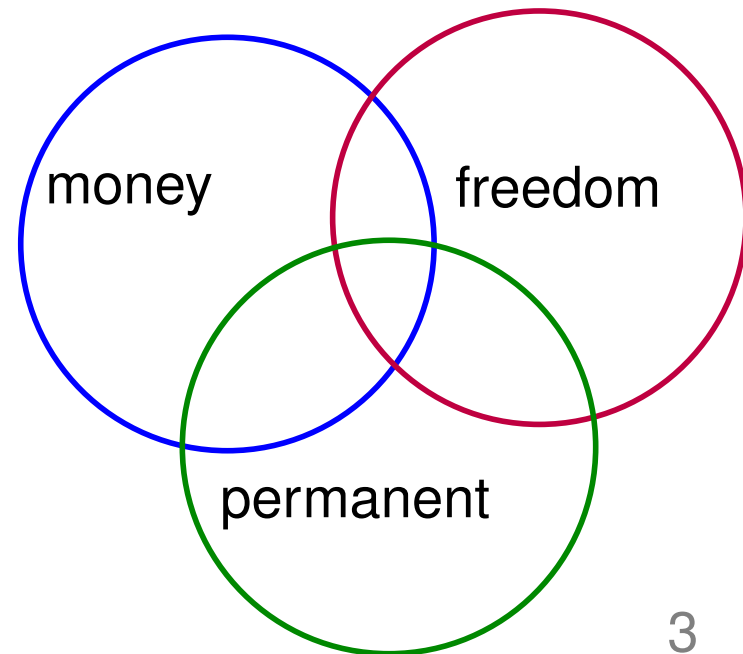
Osnabrück University/DE

2005: MSc in Computer Science

Saarland University/DE

2008: PhD in Computer Science

Max Planck Institute/DE



Fabian M. Suchanek

2003: BSc in Cognitive Science

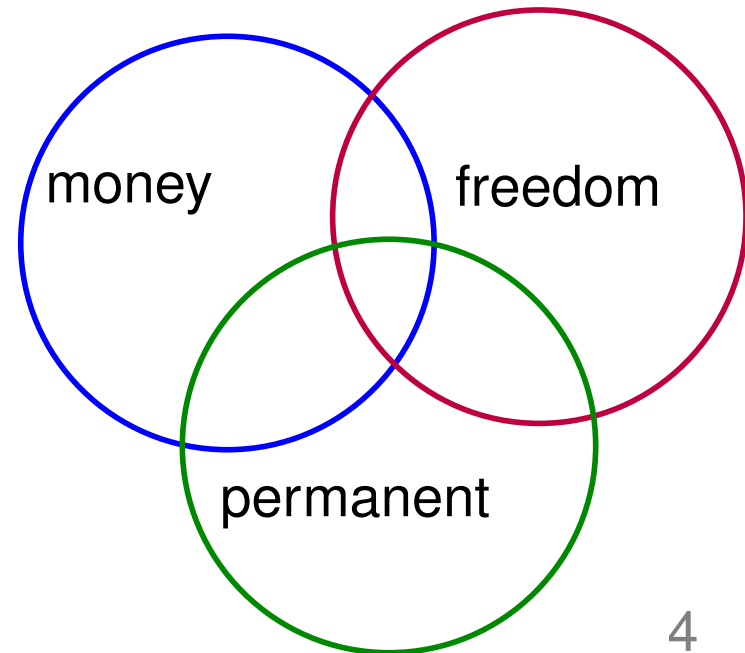
Osnabrück University/DE

2005: MSc in Computer Science

Saarland University/DE

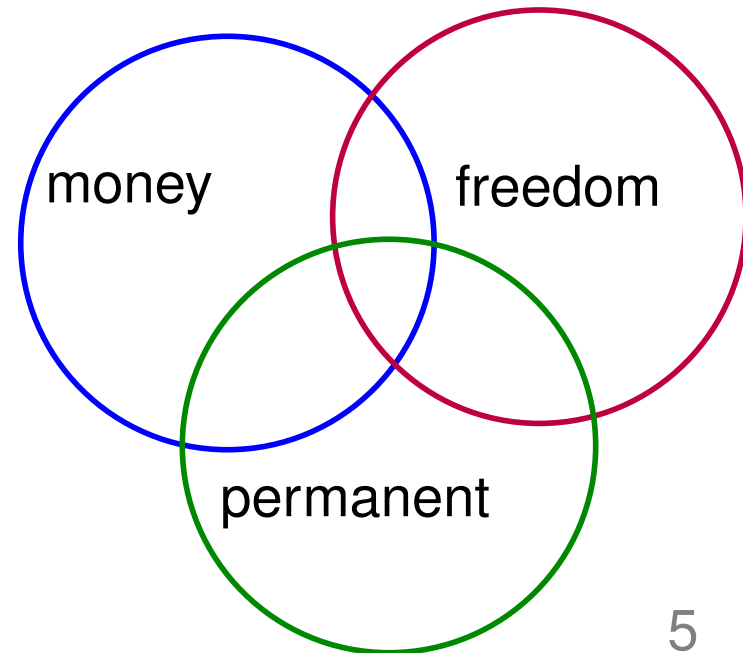
2008: PhD in Computer Science

Max Planck Institute/DE



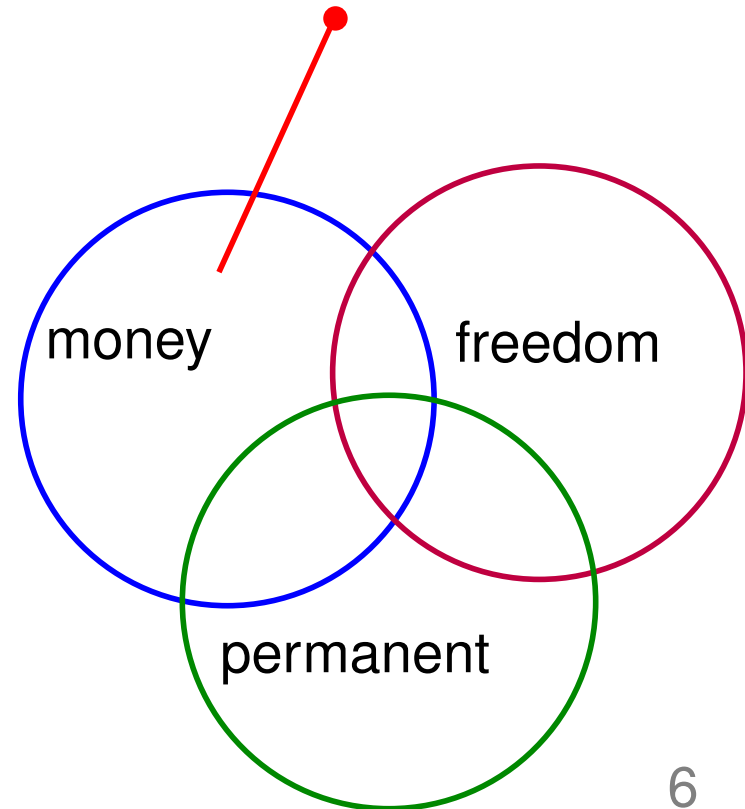
Fabian M. Suchanek

2009: PostDoc at Microsoft Research
Silicon Valley/US



Fabian M. Suchanek

2009: PostDoc at Microsoft Research
Silicon Valley/US

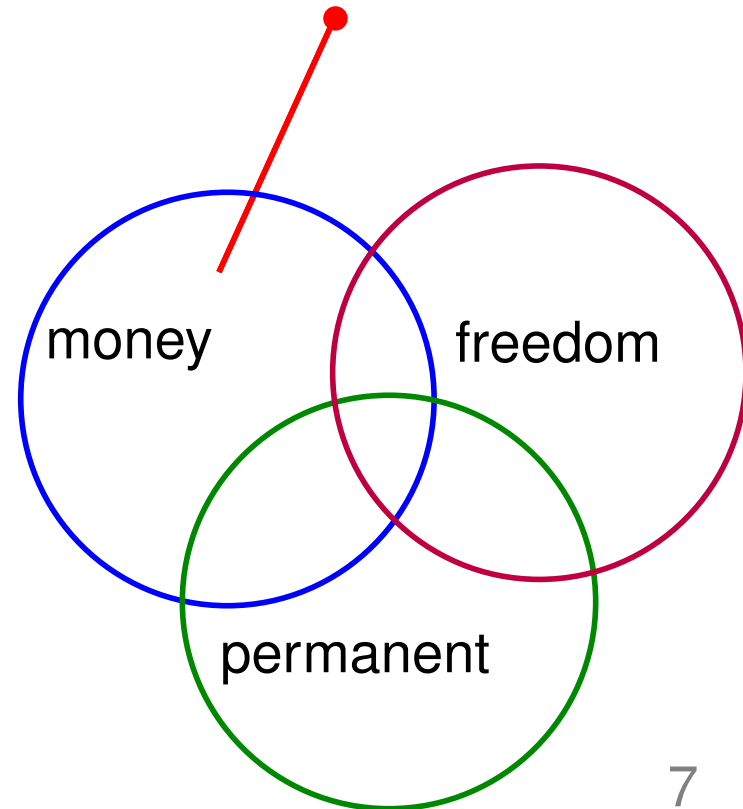


Fabian M. Suchanek

2009: PostDoc at Microsoft Research
Silicon Valley/US



2010: PostDoc
INRIA Saclay/FR

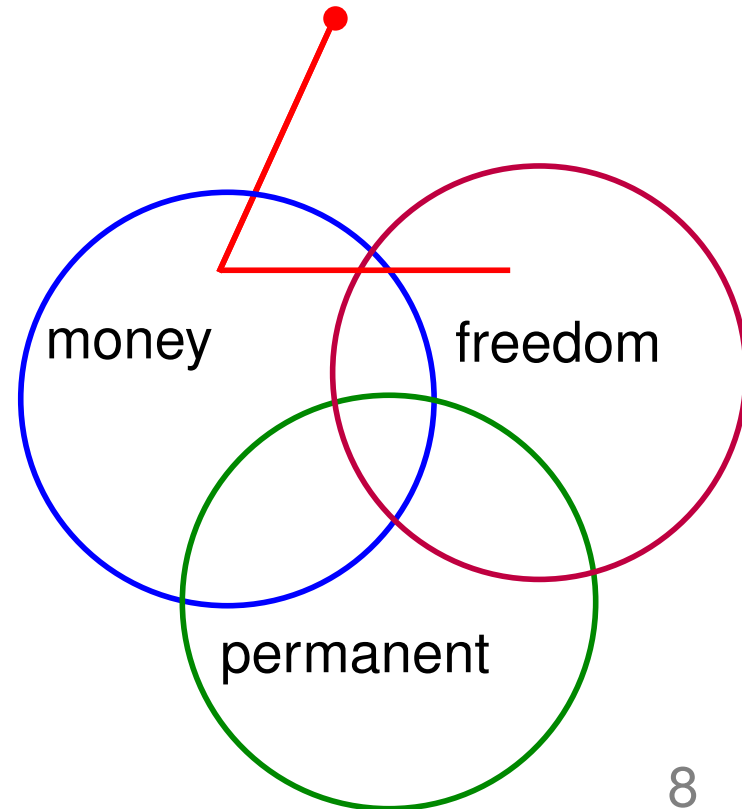


Fabian M. Suchanek

2009: PostDoc at Microsoft Research
Silicon Valley/US



2010: PostDoc
INRIA Saclay/FR

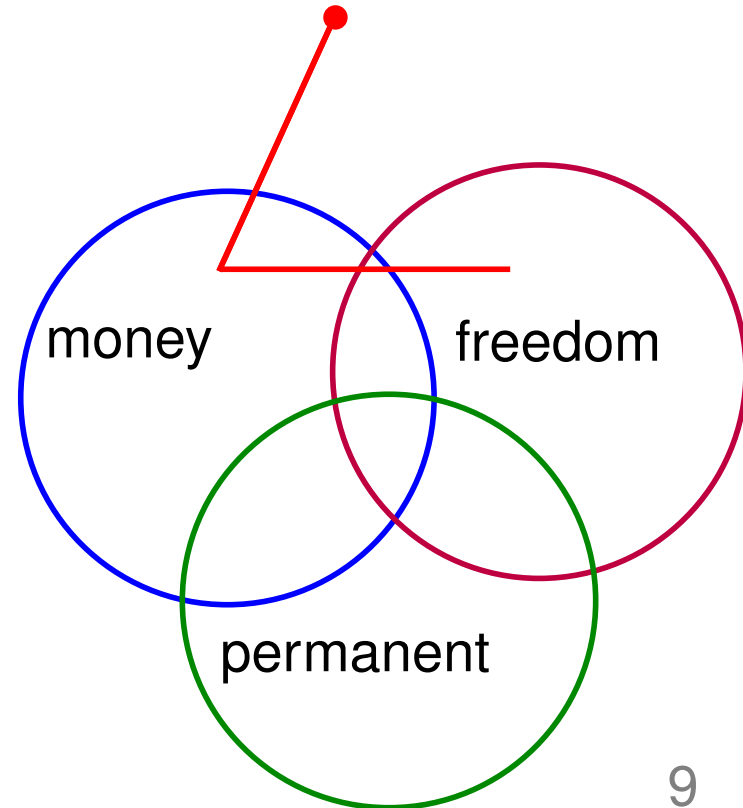


Fabian M. Suchanek

2009: PostDoc at Microsoft Research
Silicon Valley/US

2010: PostDoc
INRIA Saclay/FR

2012: Research group leader
Max Planck Institute/DE

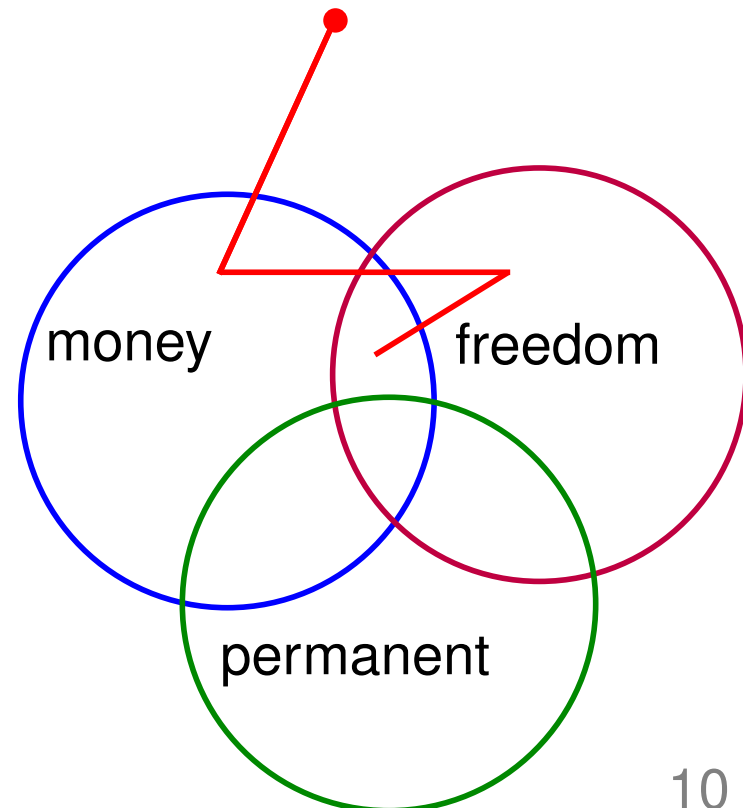


Fabian M. Suchanek

2009: PostDoc at Microsoft Research
Silicon Valley/US

2010: PostDoc
INRIA Saclay/FR

2012: Research group leader
Max Planck Institute/DE



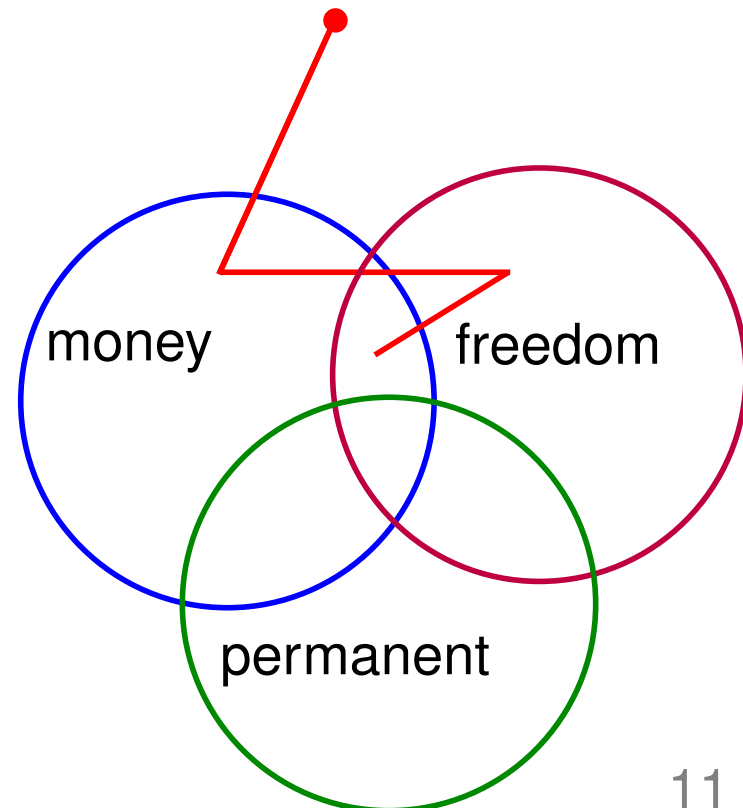
Fabian M. Suchanek

2009: PostDoc at Microsoft Research
Silicon Valley/US

2010: PostDoc
INRIA Saclay/FR

2012: Research group leader
Max Planck Institute/DE

2013: Associate Professor
Télécom ParisTech/FR



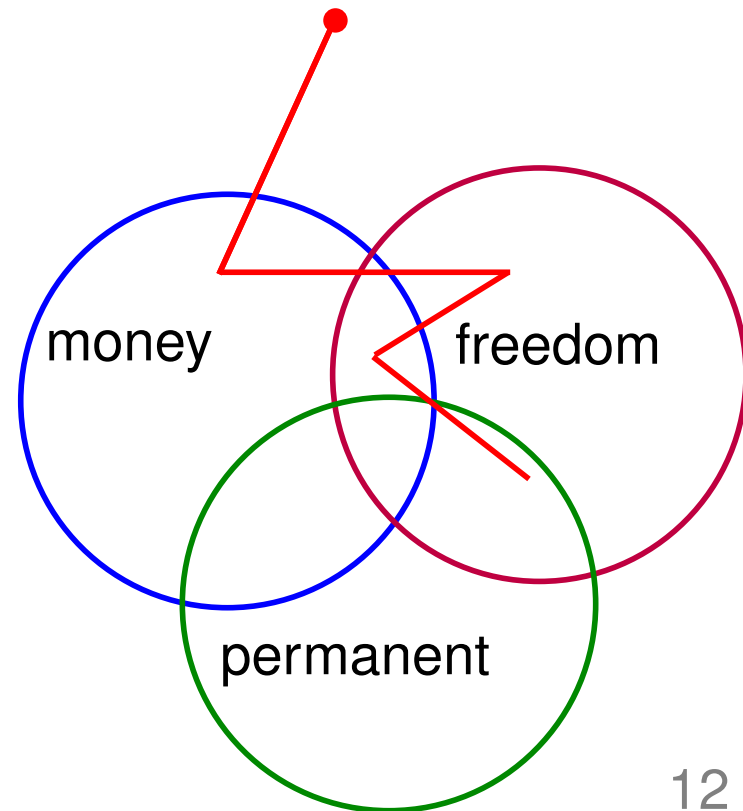
Fabian M. Suchanek

2009: PostDoc at Microsoft Research
Silicon Valley/US

2010: PostDoc
INRIA Saclay/FR

2012: Research group leader
Max Planck Institute/DE

2013: Associate Professor
Télécom ParisTech/FR



Fabian M. Suchanek

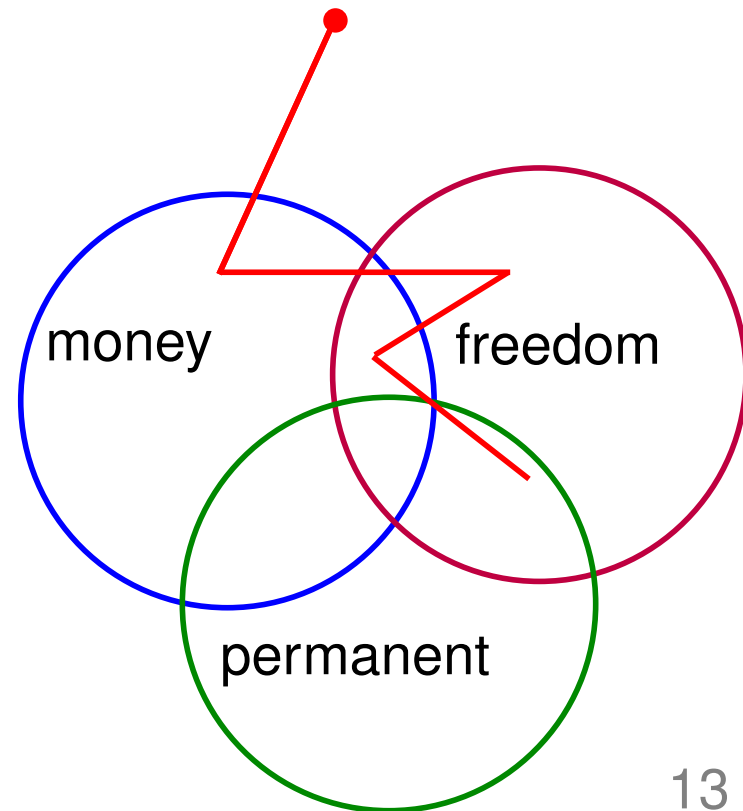
2009: PostDoc at Microsoft Research
Silicon Valley/US

2010: PostDoc
INRIA Saclay/FR

2012: Research group leader
Max Planck Institute/DE

2013: Associate Professor
Télécom ParisTech/FR

2016: Full Professor
Télécom ParisTech/FR



Fabian M. Suchanek

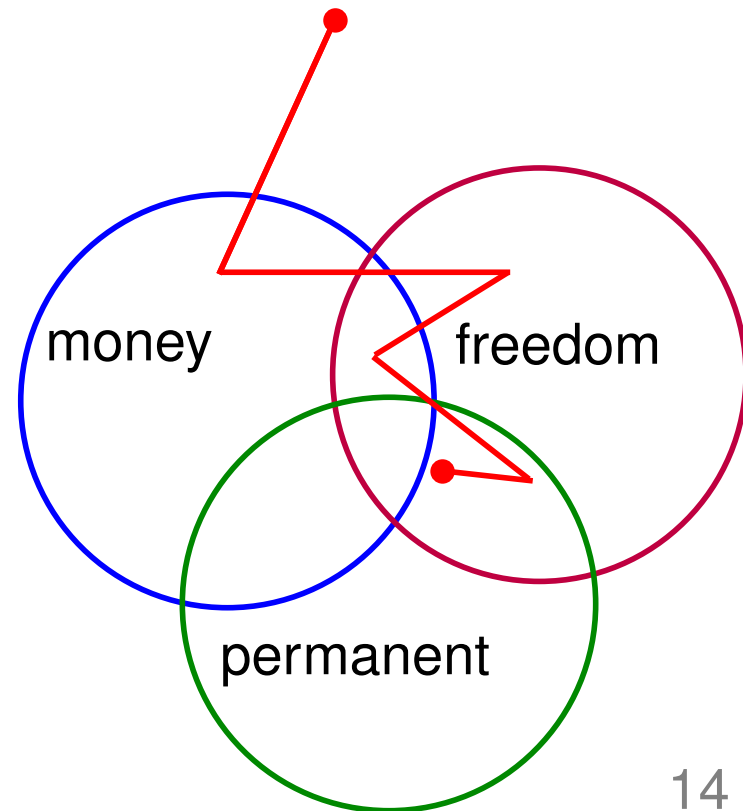
2009: PostDoc at Microsoft Research
Silicon Valley/US

2010: PostDoc
INRIA Saclay/FR

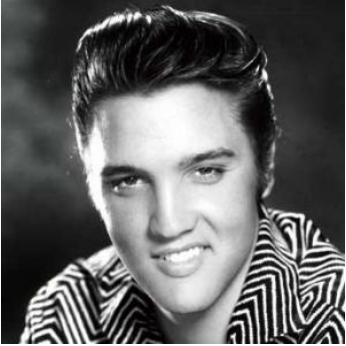
2012: Research group leader
Max Planck Institute/DE

2013: Associate Professor
Télécom ParisTech/FR

2016: Full Professor
Télécom ParisTech/FR

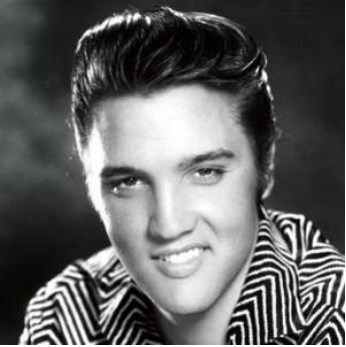


I am an Elvis Fan!



1961

Meeting Elvis Presley

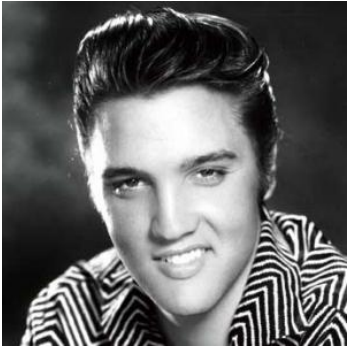


1961



2015

Meeting Elvis Presley



1961



2015



At Elvis' ranch
in New Zealand

Knowledge Cards



Elvis Presley

Elvis Presley - Wikipedia, the free encyclopedia

en.wikipedia.org/wiki/Elvis_Presley ▾ Wikipedia ▾

Elvis Aaron Presley (January 8, 1935 – August 16, 1977) was an American singer and actor. Regarded as one of the most significant cultural icons of the 20th ...

[Priscilla Presley](#) - [Albums discography](#) - [Singles discography](#) - [Michael Lockwood](#)

Elvis Presley Biography - Elvis Life Story - Elvis Presley

www.elvis.com/about-the-king/biography_.aspx ▾ Elvis Presley ▾

Elvis Presley The incredible Elvis life story began when Elvis Aaron Presley was born to Vernon and Gladys Presley in a two-room house in Tupelo, Mississippi, ...

Elvis Presley Official Web Site

www.elvis.com/ ▾ Elvis Presley ▾

Play the **Elvis** Slots on Slotomania. Play slots like a king with the brand new "ELVIS" Slotomania video slots game now available through Facebook! Prev Next.

In the news

Listening to Elvis Presley's Bizarre Album of Stage Banter

[Mental Floss](#) - 20 hours ago

In 1974, **Elvis Presley** released *Havin' Fun With Elvis on Stage*, an album consisting of



[More images](#)

Elvis Presley

Singer

Elvis Aaron Presley was an American singer and actor. Regarded as one of the most significant cultural icons of the 20th century, he is often referred to as "the King of Rock and Roll", or simply, "the King". [Wikipedia](#)

Died: August 16, 1977, [Memphis, Tennessee, United States](#)

Spouse: [Priscilla Presley](#) (m. 1967–1973)

Children: [Lisa Marie Presley](#)

Songs

My Way	1973	Aloha From Hawaii via ...
Jailhouse Rock		
Love Me Tender	1972	As Recorded at Madiso...
Love Me	1972	As Recorded at Madiso...

Knowledge Cards



Elvis Presley

Elvis Presley - Wikipedia, the free encyclopedia

en.wikipedia.org/wiki/Elvis_Presley ▾ Wikipedia ▾

Elvis Aaron Presley (January 8, 1935 – August 16, 1977) was an American singer and actor. Regarded as one of the most significant cultural icons of the 20th ...

[Priscilla Presley](#) - [Albums discography](#) - [Singles discography](#) - [Michael Lockwood](#)

Elvis Presley Biography - Elvis Life Story - Elvis Presley

www.elvis.com/about-the-king/biography_.aspx ▾ Elvis Presley ▾

Elvis Presley The incredible Elvis life story began when Elvis Aaron Presley was born to Vernon and Gladys Presley in a two-room house in Tupelo, Mississippi, ...

Elvis Presley Official Web Site

www.elvis.com/ ▾ Elvis Presley ▾

Play the **Elvis** Slots on Slotomania. Play slots like a king with the brand new "ELVIS" Slotomania video slots game now available through Facebook! Prev Next.

In the news

Listening to Elvis Presley's Bizarre Album of Stage Banter

[Mental Floss](#) - 20 hours ago

In 1974, **Elvis Presley** released *Having Fun With Elvis on Stage*, an album consisting of



Elvis Presley

Singer

Elvis Aaron Presley was an American singer and actor. Regarded as one of the most significant cultural icons of the 20th century, he is often referred to as "the King of Rock and Roll", or simply, "the King". [Wikipedia](#)

Died: August 16, 1977, [Memphis, Tennessee, United States](#)

Spouse: [Priscilla Presley](#) (m. 1967–1973)

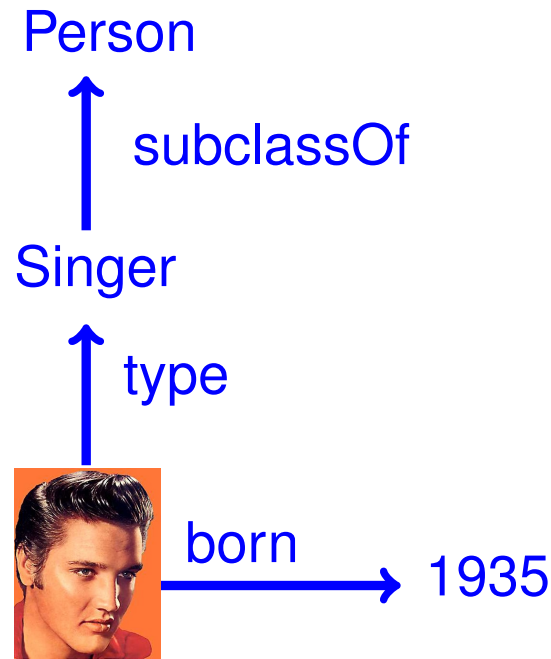
Children: [Lisa Marie Presley](#)

Songs

My Way	1973	Aloha From Hawaii via ...
Jailhouse Rock		
Love Me Tender	1972	As Recorded at Madiso...
Love Me	1972	As Recorded at Madiso

???

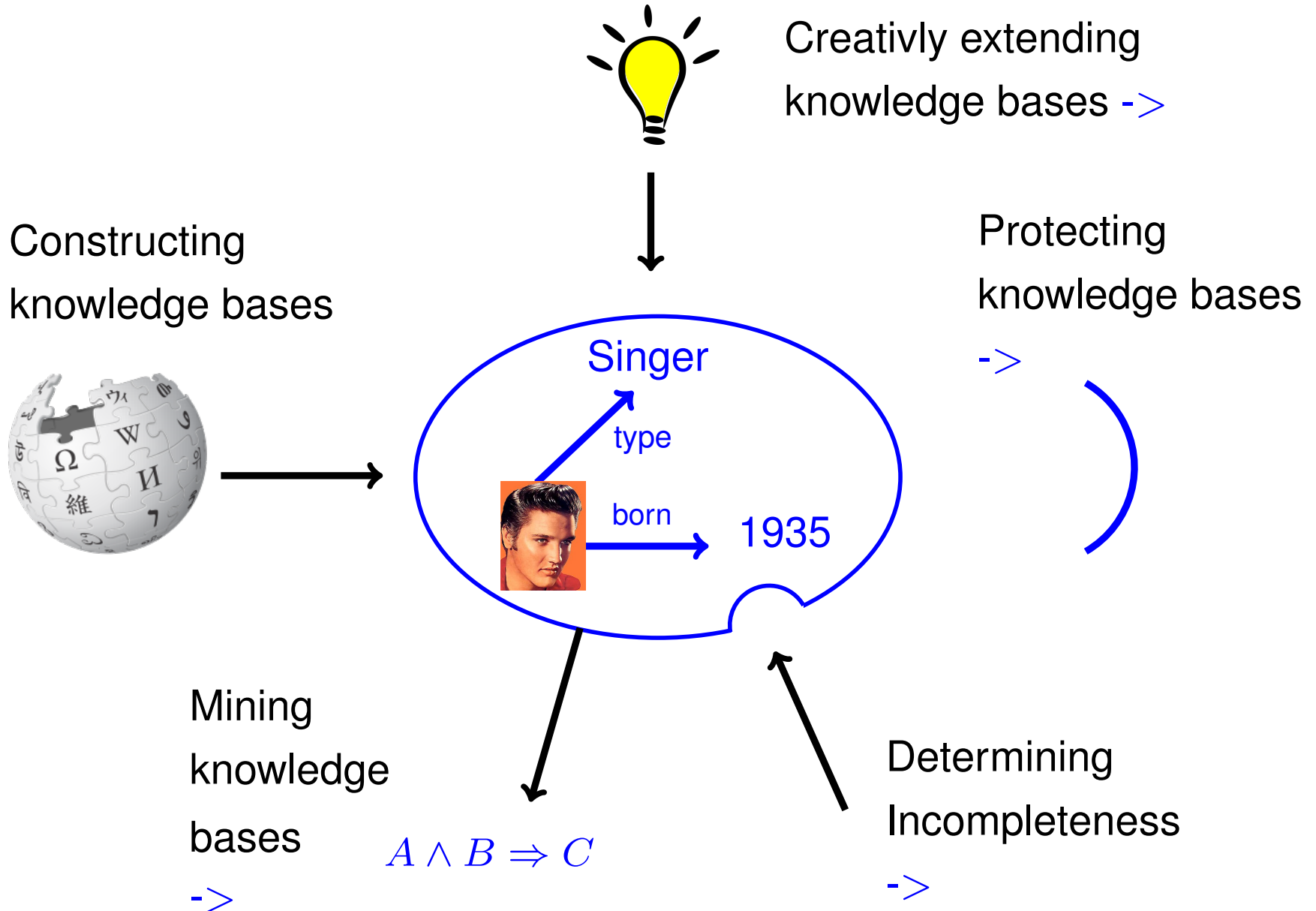
Knowledge Bases



For us, a knowledge base (“KB”, “ontology”) is a graph, where the nodes are entities and the edges are relations.

(We do not distinguish T-Box and A-Box.)

Knowledge Base Life Cycle



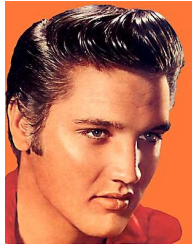
Extracting from Wikipedia

Elvis Presley



WIKIPEDIA
The Free Encyclopedia

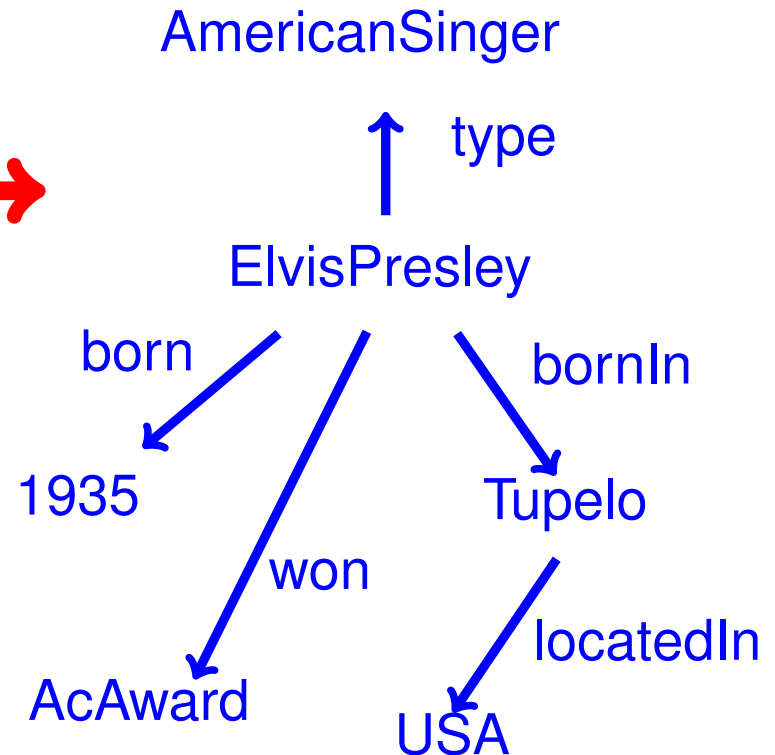
Elvis Presley was one
of the best blah blah
blub blah don't read
this, listen to the
speaker! blah blah blah
blubl blah you are still
reading this! blah blah
blah blah blabbell blah



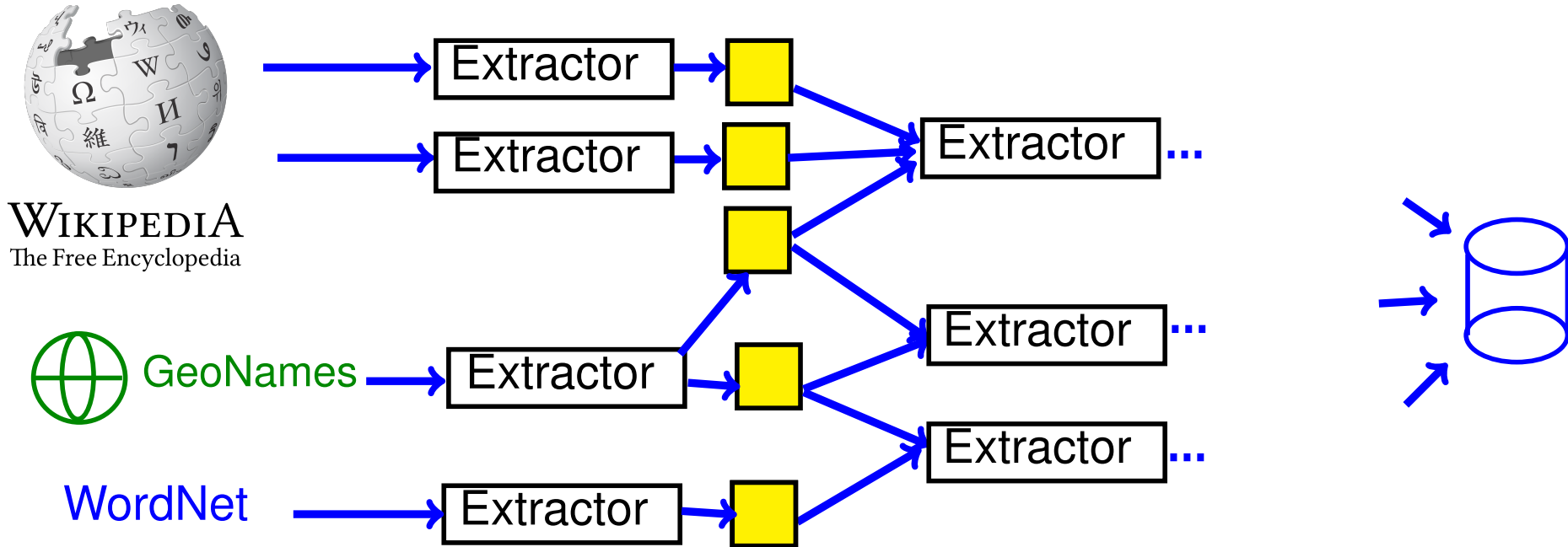
Born: 1935
In: Tupelo
...

Categories:

Rock&Roll, American Singers,
Academy Award winners...



Creating a large knowledge base

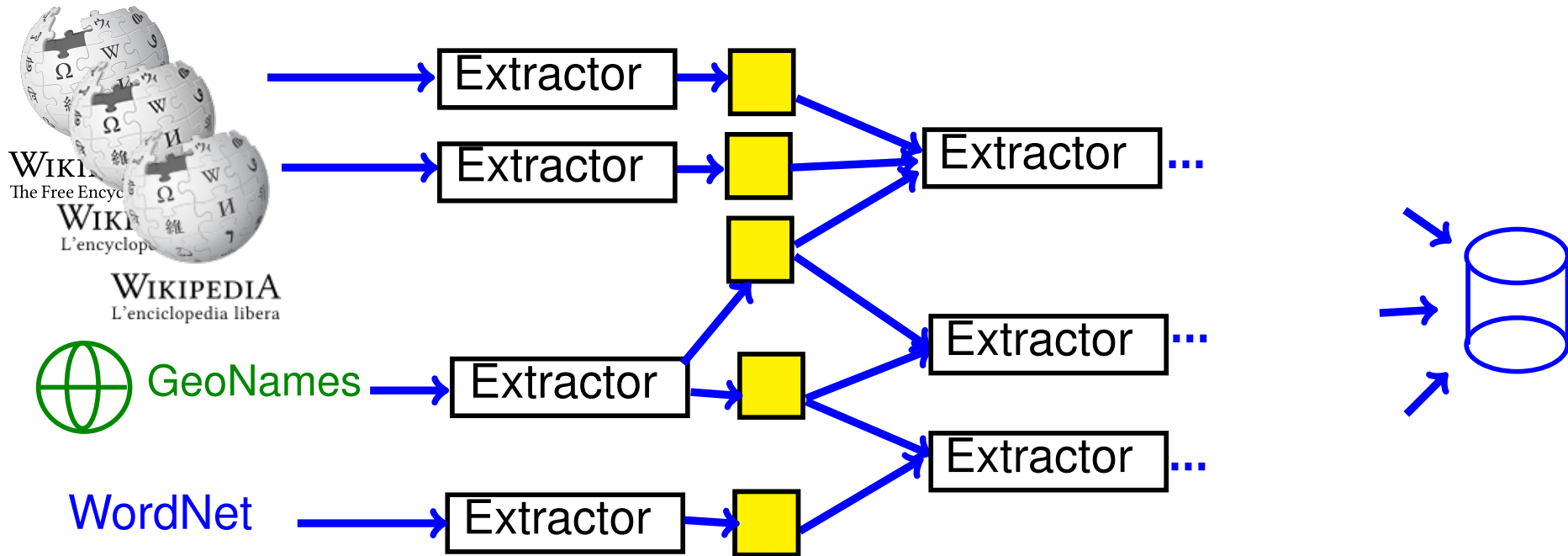


Intermediate extractors

- clean facts
- deduplicate facts and entities
- check consistency

ensuring high quality (95%)

Creating a large knowledge base



Intermediate extractors

- clean facts
- deduplicate facts and entities
- check consistency

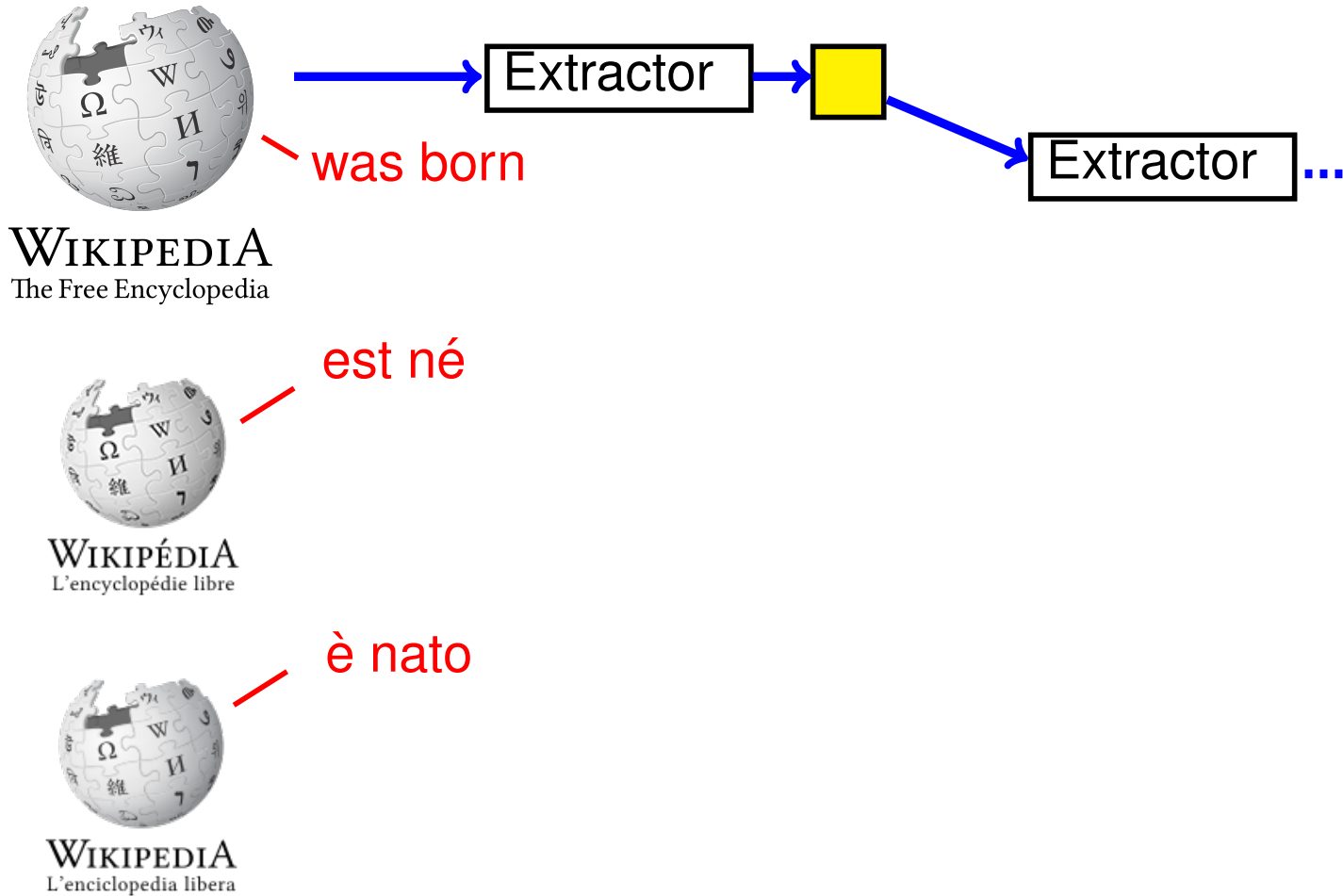
ensuring high quality (95%)

multilingual > 29

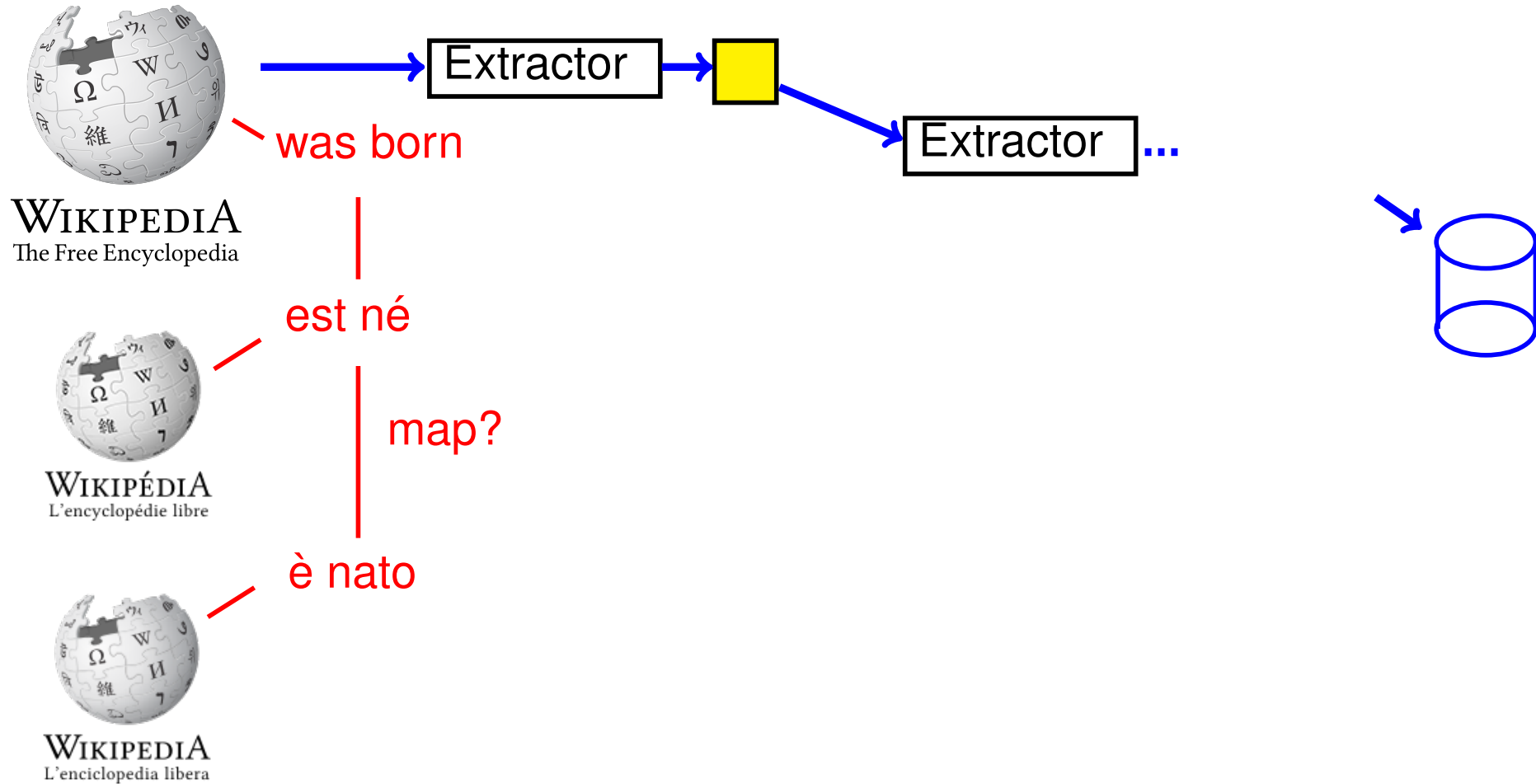
[See it online](#)

[See it locally](#)

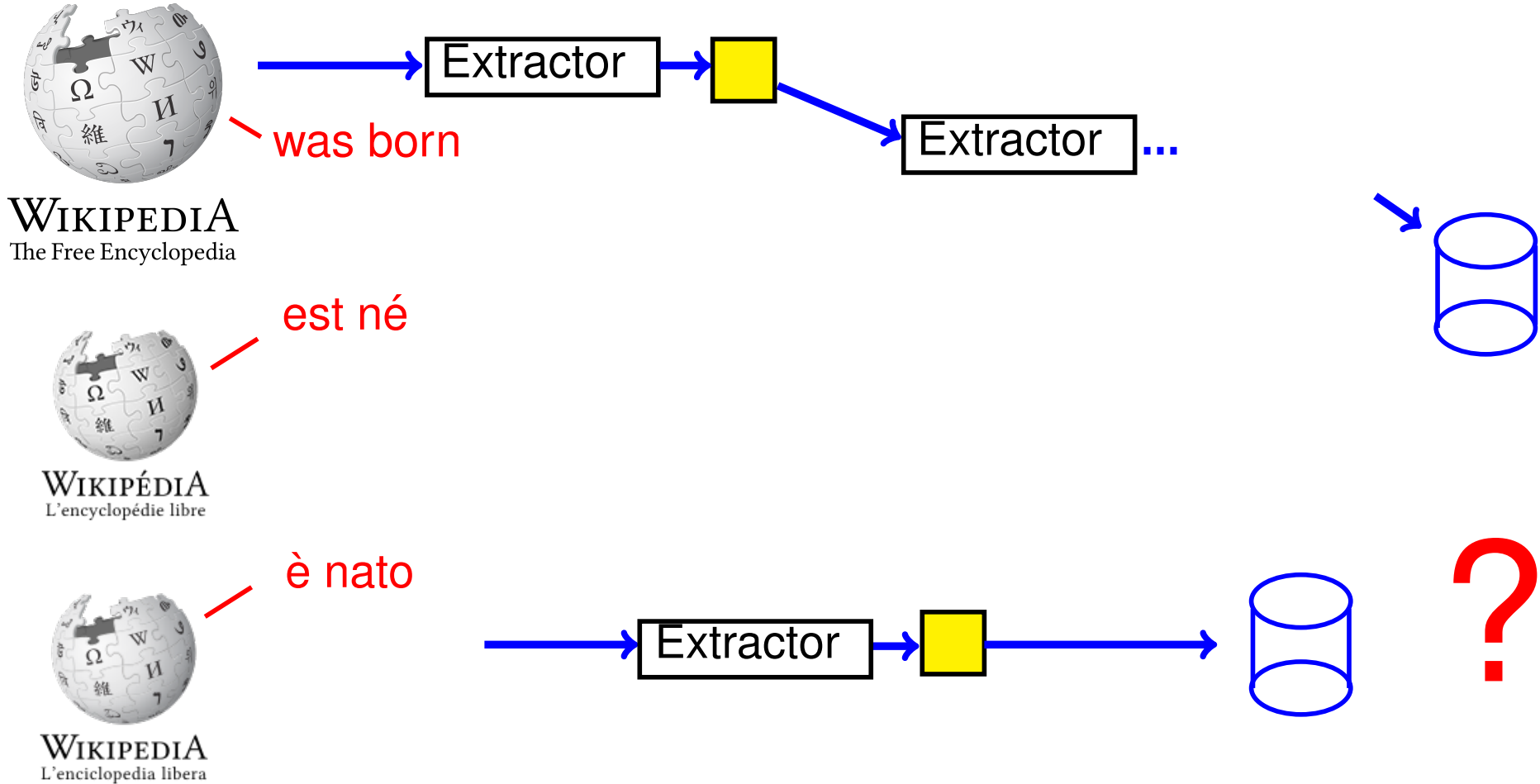
Integrating multilingual Wikis



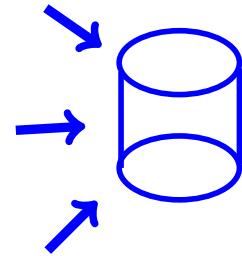
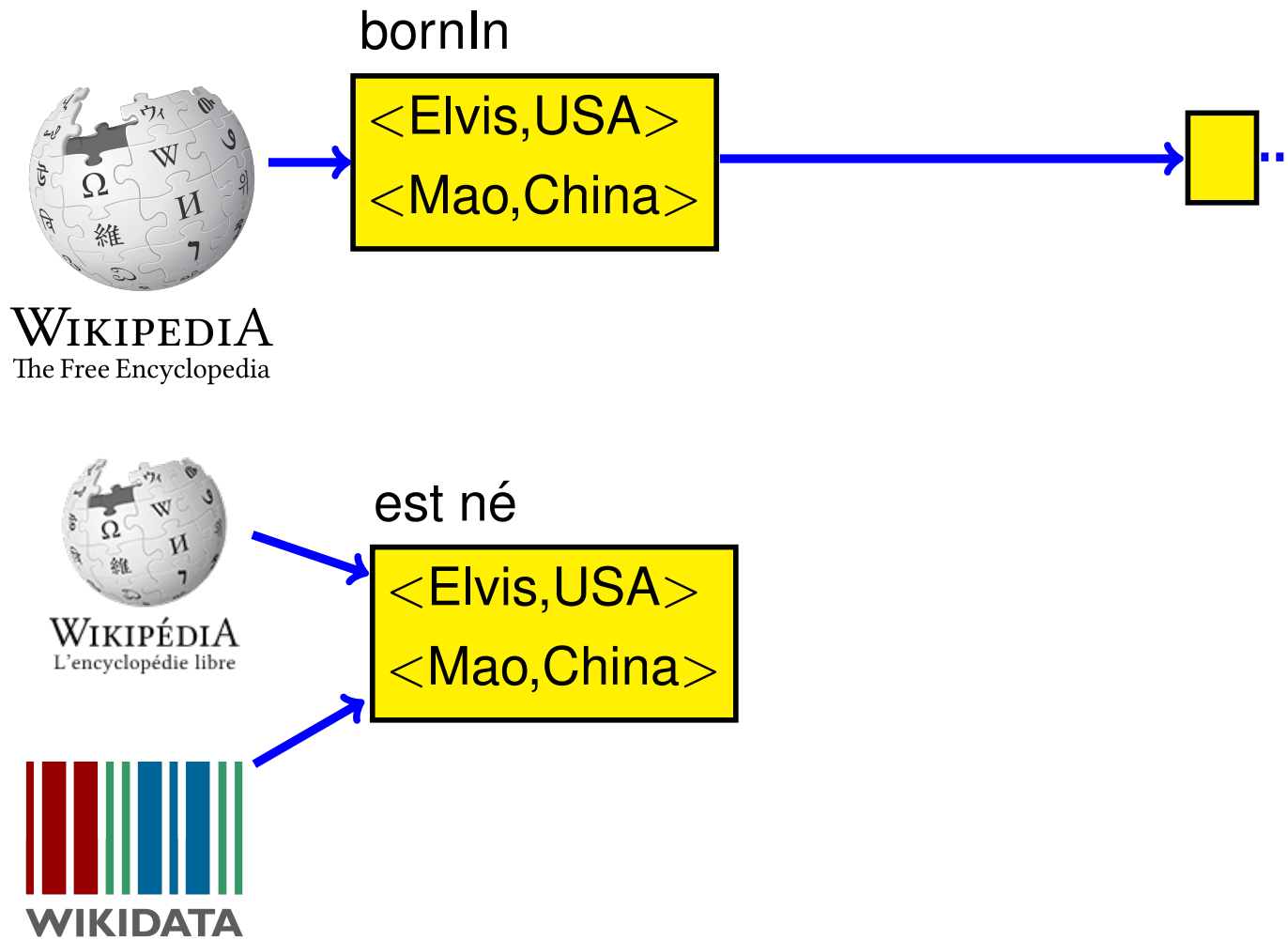
Integrating multilingual Wikis



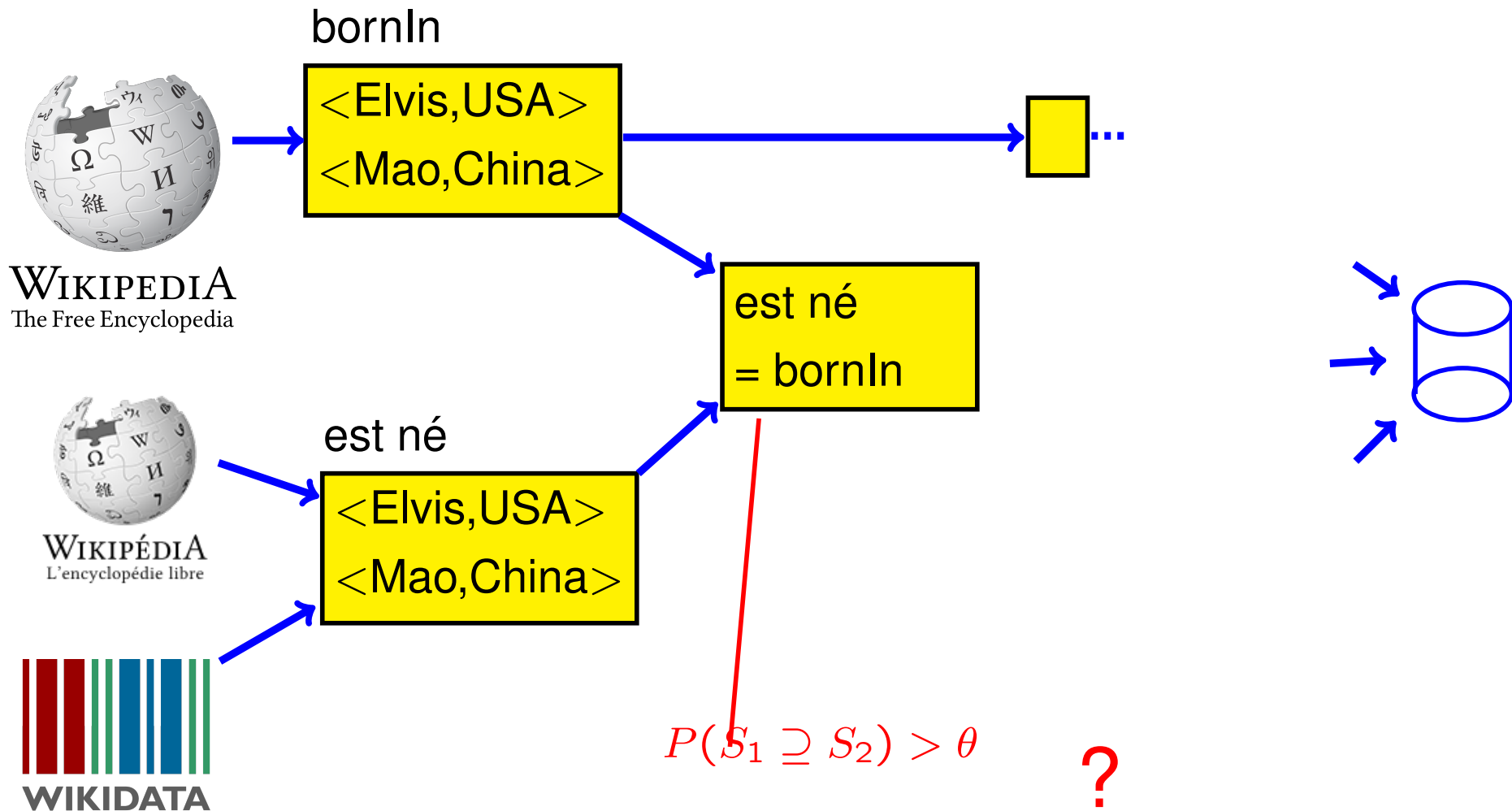
Integrating multilingual Wikis



Integrating multilingual Wikis

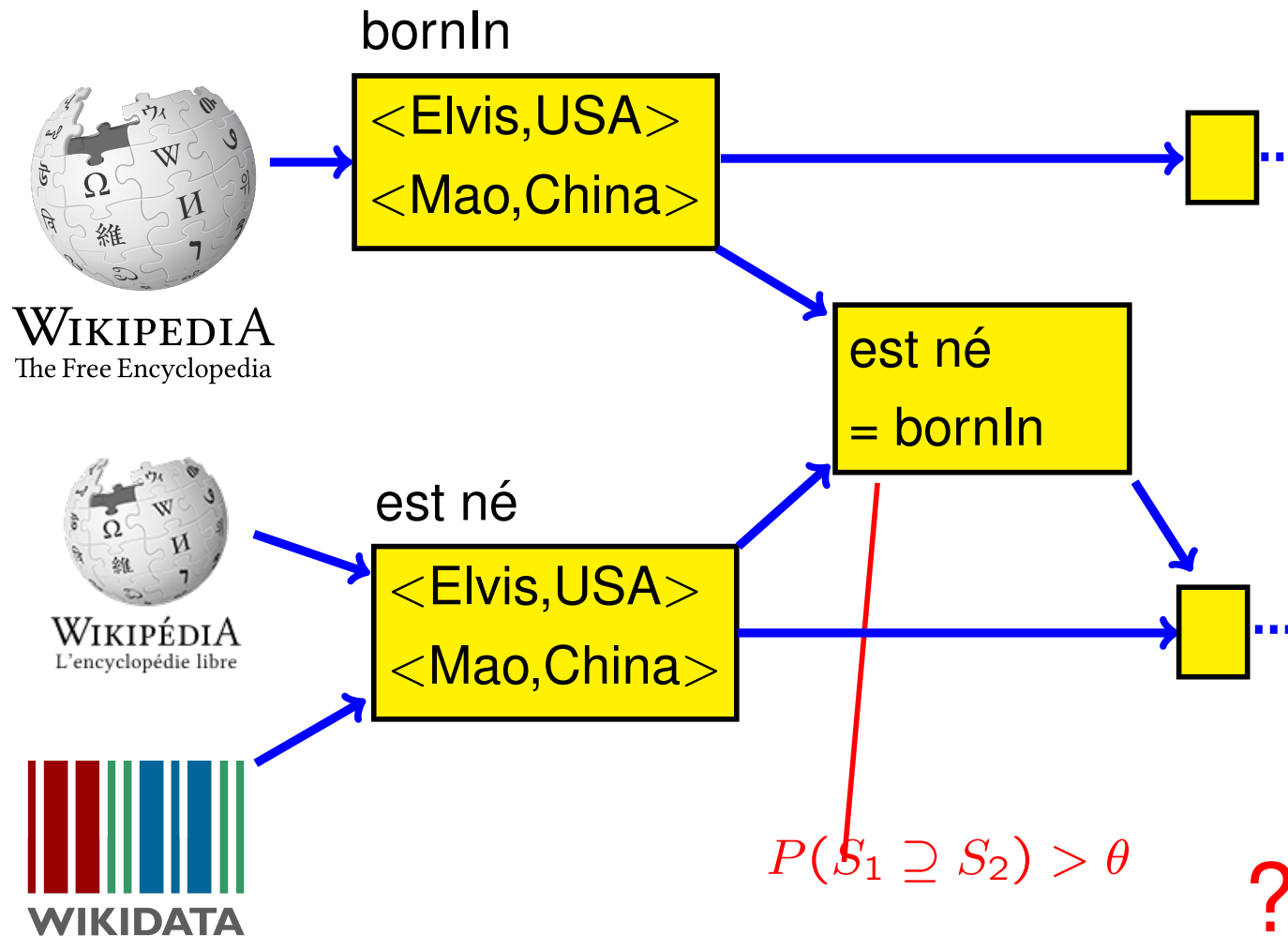


Integrating multilingual Wikis



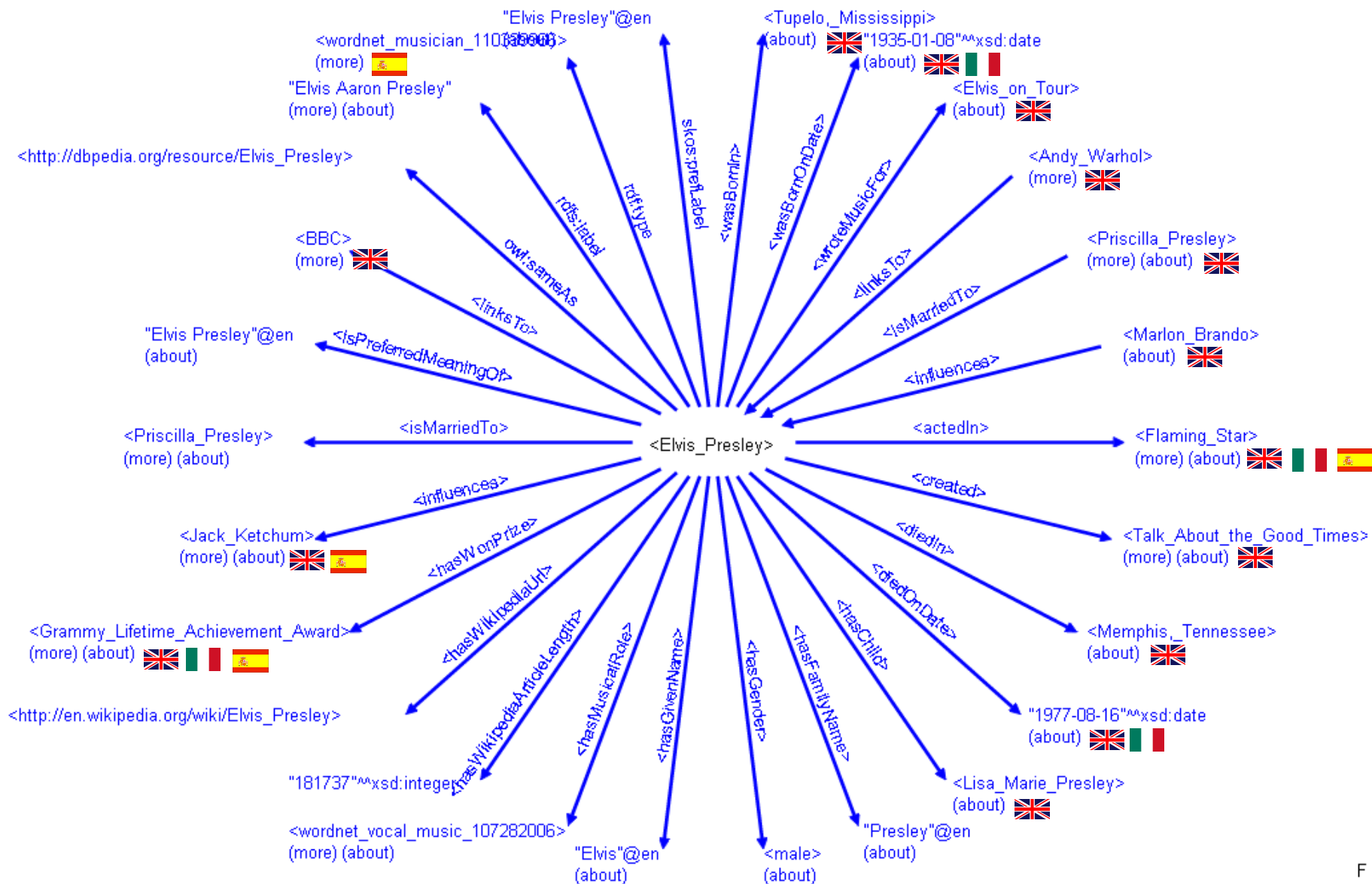
[CIDR 2015]

Integrating multilingual Wikis



[CIDR 2015]

Example: YAGO about Elvis



YAGO: a large knowledge base



<http://yago-knowledge.org>

soon open-source!

Wikipedia + WordNet
time and space
10 languages
100 relations
100m facts
10m entities
95% accuracy
used by DBpedia
and IBM Watson

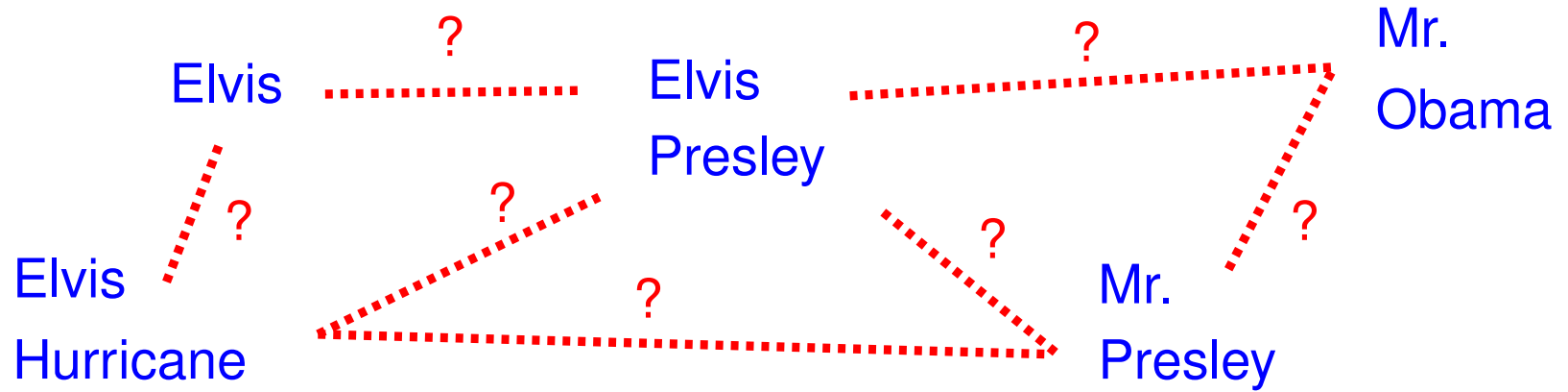
Caveat:
focus on
precision!



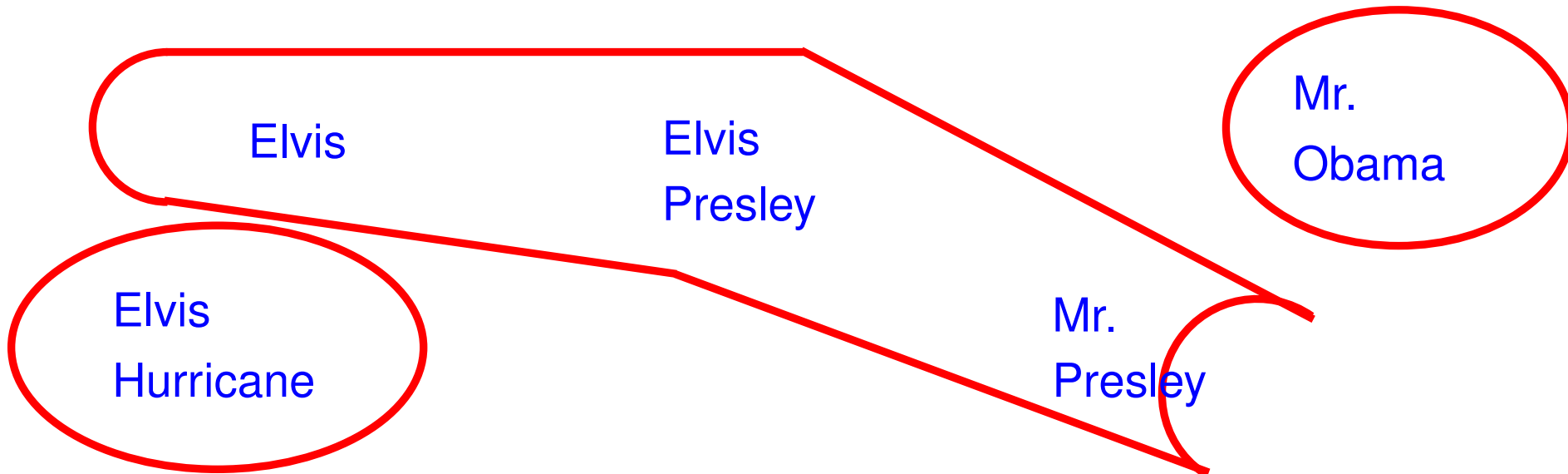
[WWW2007, JWS2008, WWW2011 demo, AIJ2013, WWW2013 demo, CIDR20



Canonicalizing New Entities



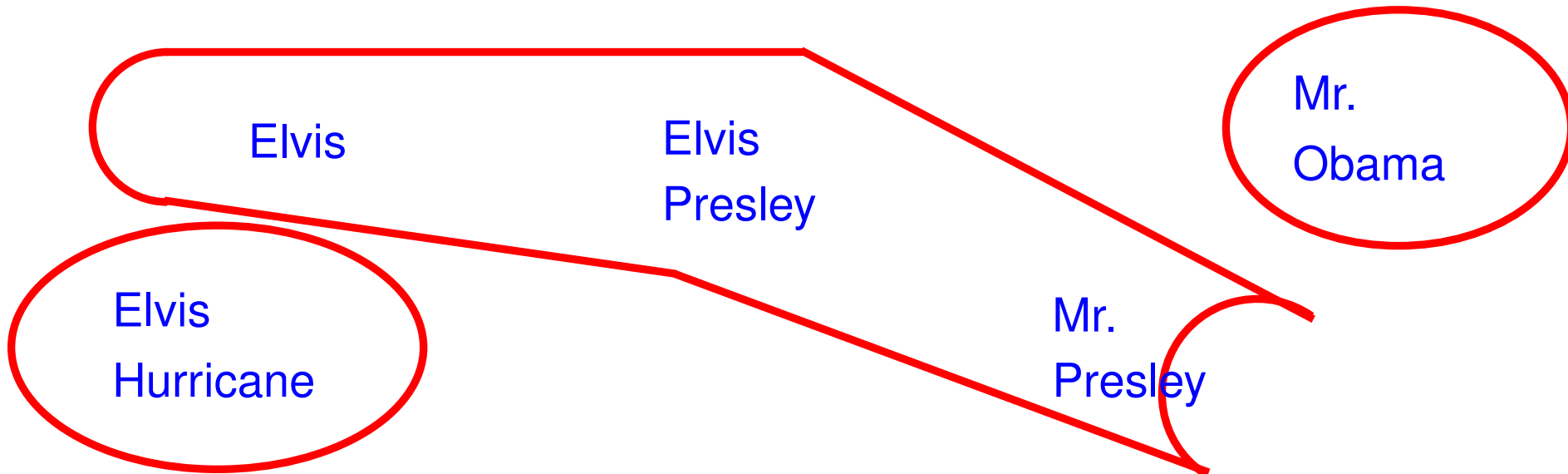
Canonicalizing New Entities



Use hierarchical agglomerative clustering

- TF-IDF token overlap
- Triple overlap
- String Similarity
- Word overlap in source docs
- Type overlap
- Overlap of co-mentions

Canonicalizing New Entities

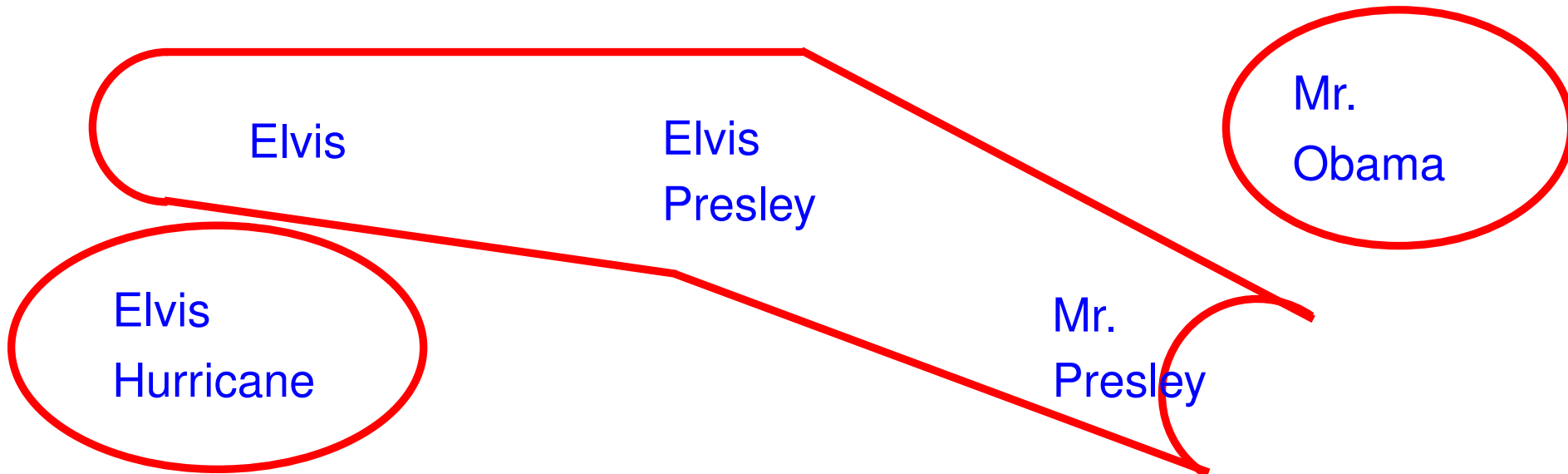


Use hierarchical agglomerative clustering

- TF-IDF token overlap
- Triple overlap
- String Similarity
- Word overlap in source docs
- Type overlap
- Overlap of co-mentions

Machine
Learning

Canonicalizing New Entities



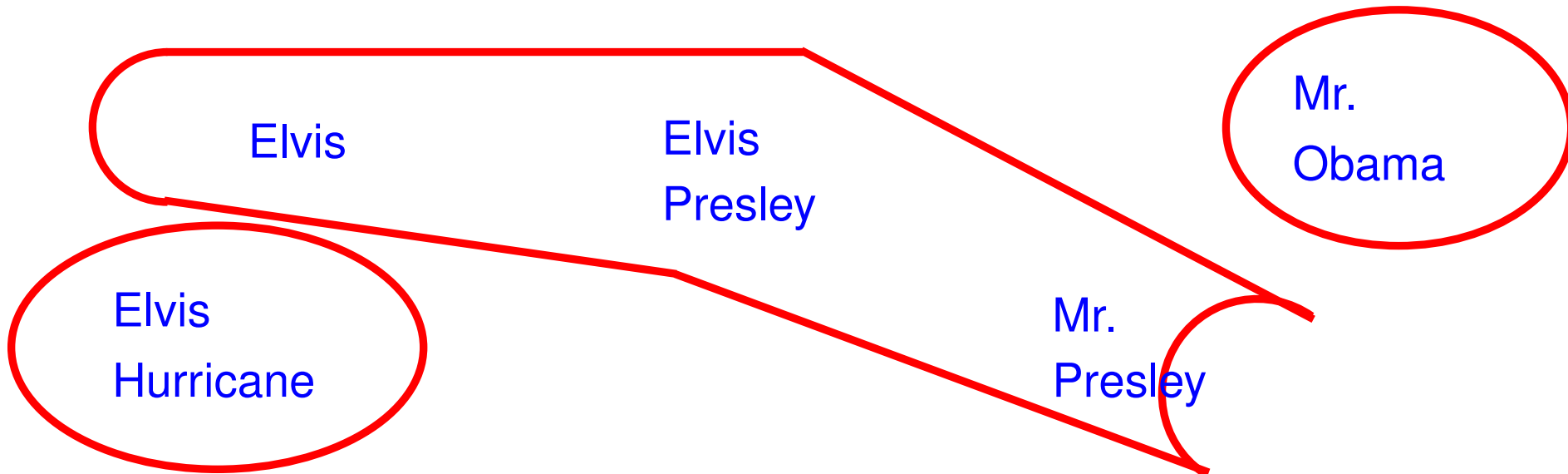
Use hierarchical agglomerative clustering

- TF-IDF token overlap
- Triple overlap
- String Similarity
- Word overlap in source docs
- Type overlap
- Overlap of co-mentions

Machine
Learning

Machine
Learning

Canonicalizing New Entities



Use hierarchical agglomerative clustering

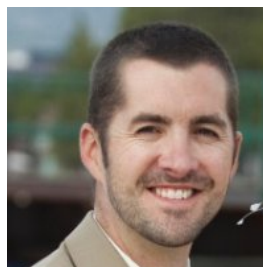
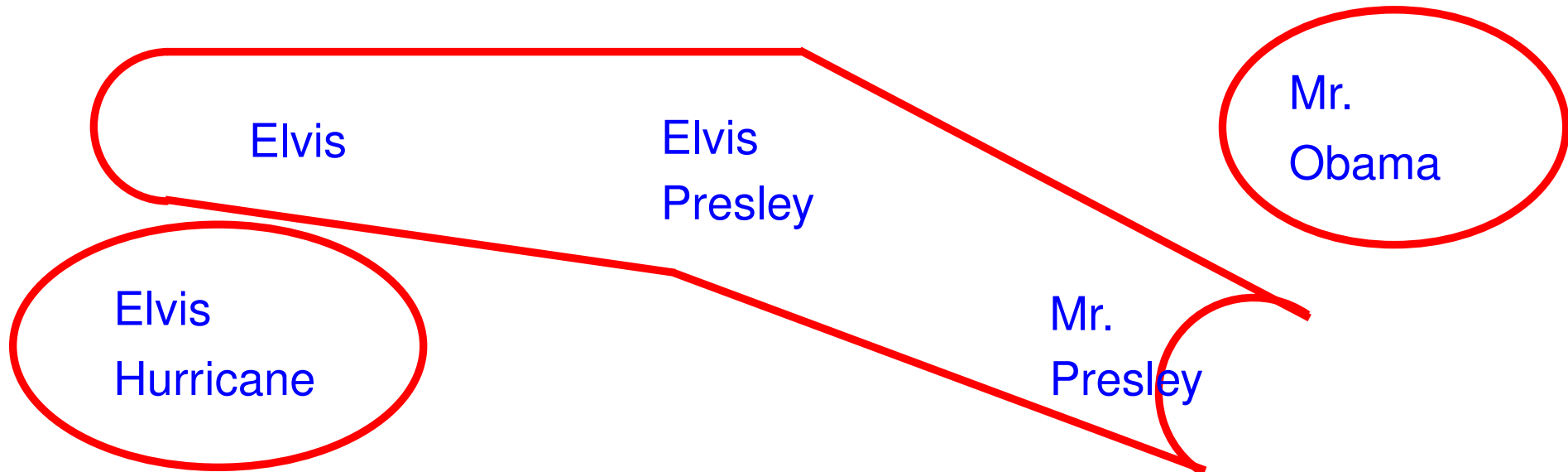
- TF-IDF token overlap
- Triple overlap
- String Similarity
- Word overlap in source docs
- Type overlap
- Overlap of co-mentions

Machine
Learning

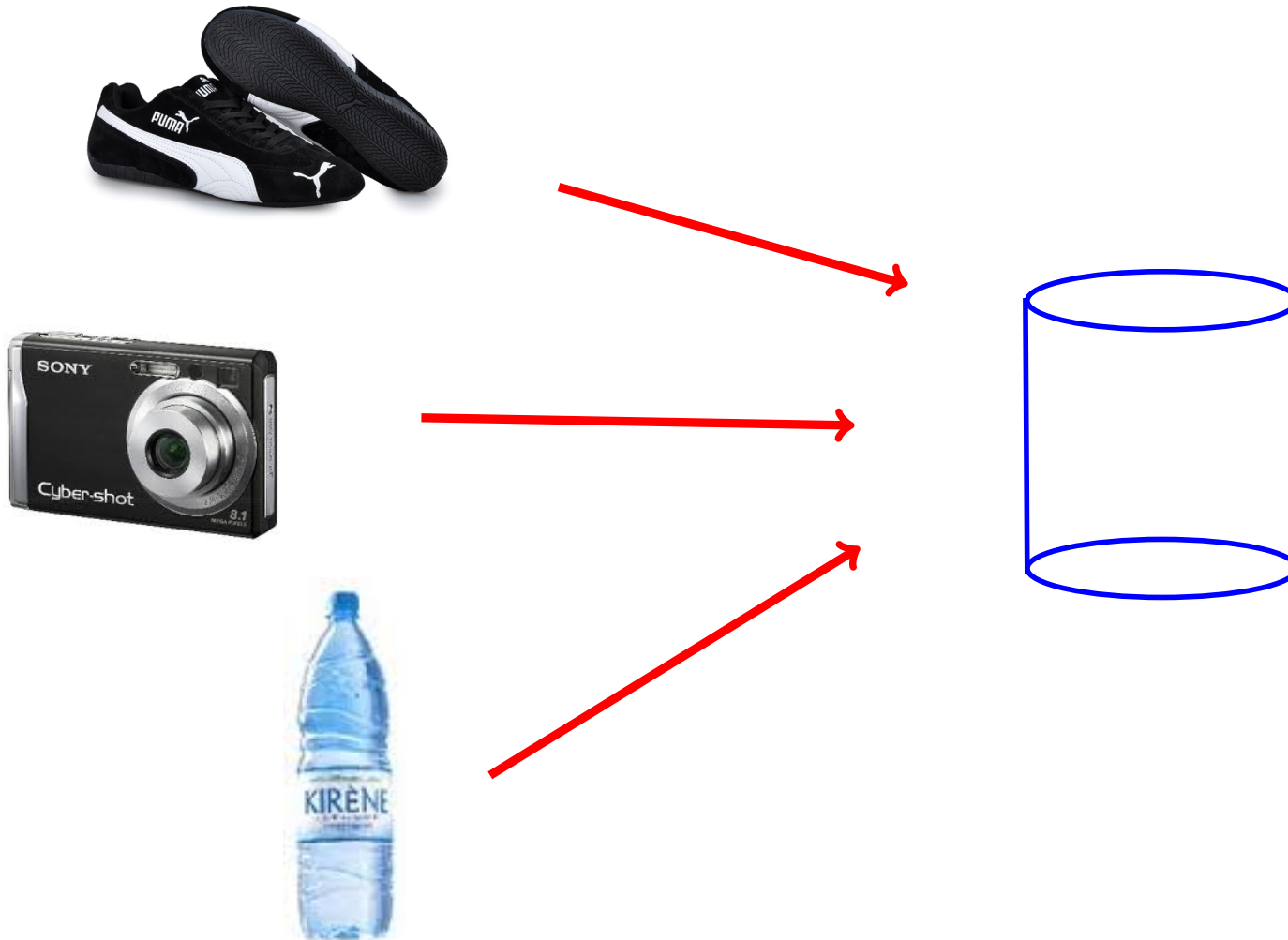
Machine
Learning

[CIKM 2014]

Canonicalizing New Entities



Goal: Harvest entities from the Web



IBEX: Collect unique ids

Puma PowerTech Blaze Running Shoe - Mens - Black/Silver Select Width-M - UPC # 887128476661



© Whittleseacitylac

larger image

AUD99.02

Please Choose:

Size

- ☐ (EUR):40/(US):8.5/(UK):6
- ☐ (EUR):41/(US):9.5/(UK):7
- ☐ (EUR):42,(US):8.5,(UK):7.5
- ☐ (EUR):43,(US):9.5,(UK):8.5
- ☐ (EUR):44,(US):10,(UK):9
- ☐ (EUR):45,(US):11,(UK):10
- ☒ (EUR):46,(US):12,(UK):11

Add to Cart:



Item # 307110

UPC # 887128476661

Go big or go home in the men's Puma PowerTech Blaze running shoe! This performance trainer has upgraded technical features with its OrthoLite® footbed, PowerTech™ cushioning and EverTrack™ abrasion-resistant outsole.

This men's running shoe is best for the **neutral** runner. What is pronation?

Breathable mesh upper with synthetic overlay for structured support

Lace-up closure

887128476661

Unique identifiers can be verified by a checksum.

They exist for products, books, documents, chemicals,...

IBEX: Collect unique ids

Puma PowerTech Blaze Running Shoe - Mens - Black/SilverSelect Width-M - UPC # 887128476661



AUD99.02

Please Choose:

Size

- ☐ (EUR):40/(US)8.5/(UK):6
- ☐ (EUR):41/(US)9.5/(UK):7
- ☐ (EUR):42,(US):8.5,(UK):7.5
- ☐ (EUR):43,(US):9.5,(UK):8.5



Item # 307110

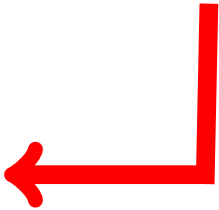
UPC # 887128476661

Go big or go home in the men's Puma PowerTech Blaze running shoe! This performance trainer has upgraded technical features with its OrthoLite® footbed, PowerTech™ cushioning and EverTrack™ abrasion-resistant outsole.

This men's running shoe is best for the **neutral** runner. What is pronation?

Breathable mesh upper with synthetic overlay for structured support
Lace-up closure

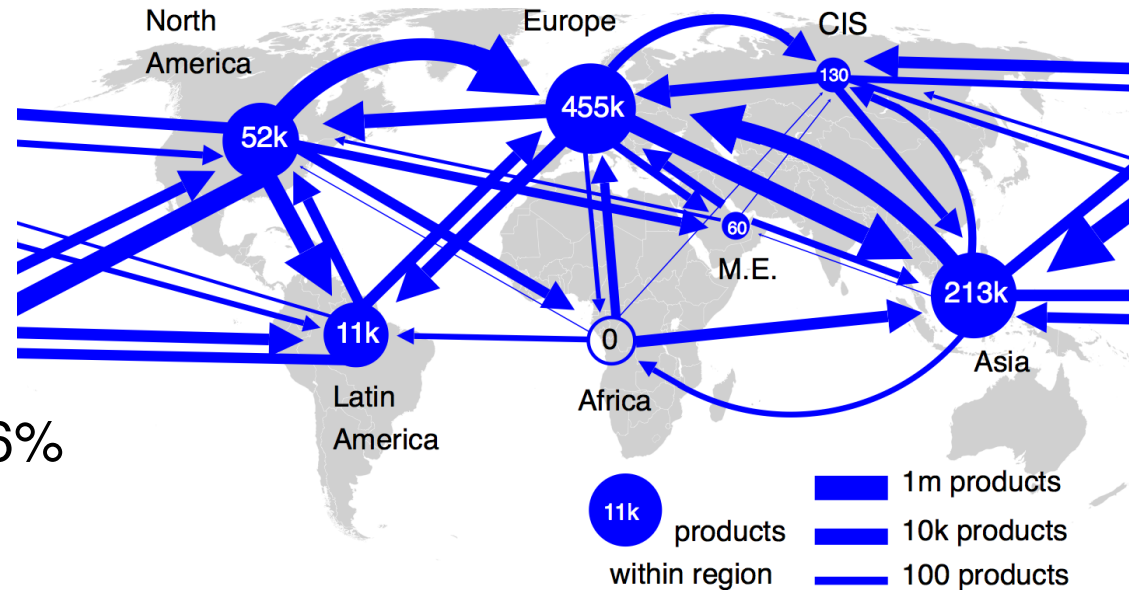
id	name	URL
1234	Puma PowerTech Blaze	u1
1234	Please choose	u1
1234	Puma PowerTech Blaze	u2
1234	Puma Shoe	u2
5678	Please choose	u3
5678	Sony Cybershot TS100	u3
...



IBEX: analyses

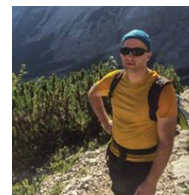
Found

- 13m email addresses with their name
 - 235K chemical products
 - 1.4m books
 - 1.1m products
- ... with an accuracy of 73%-96%



Analyzed

- Global trade flow
- frequent email providers
- frequent people names and more

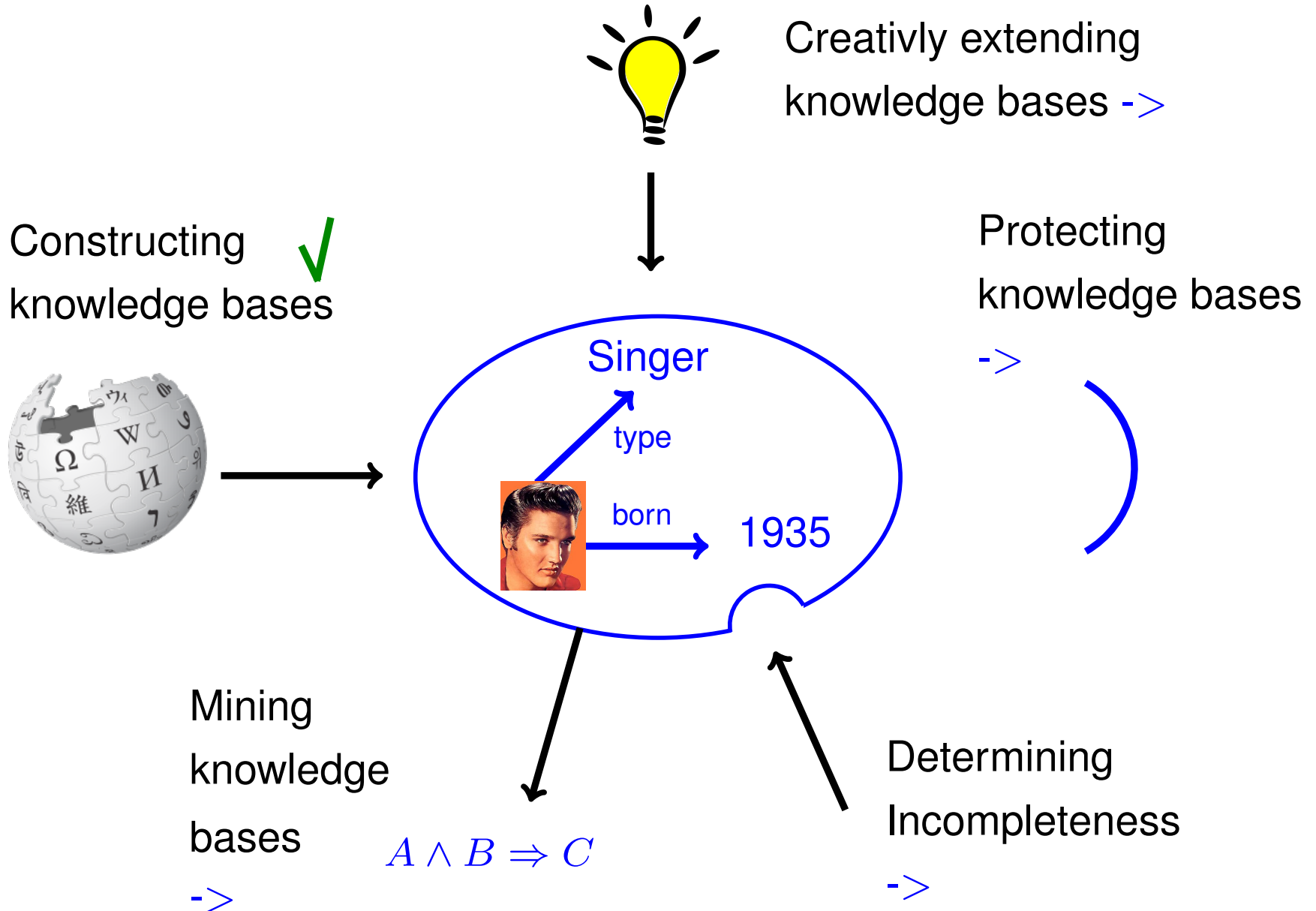


[WebDB 2015]

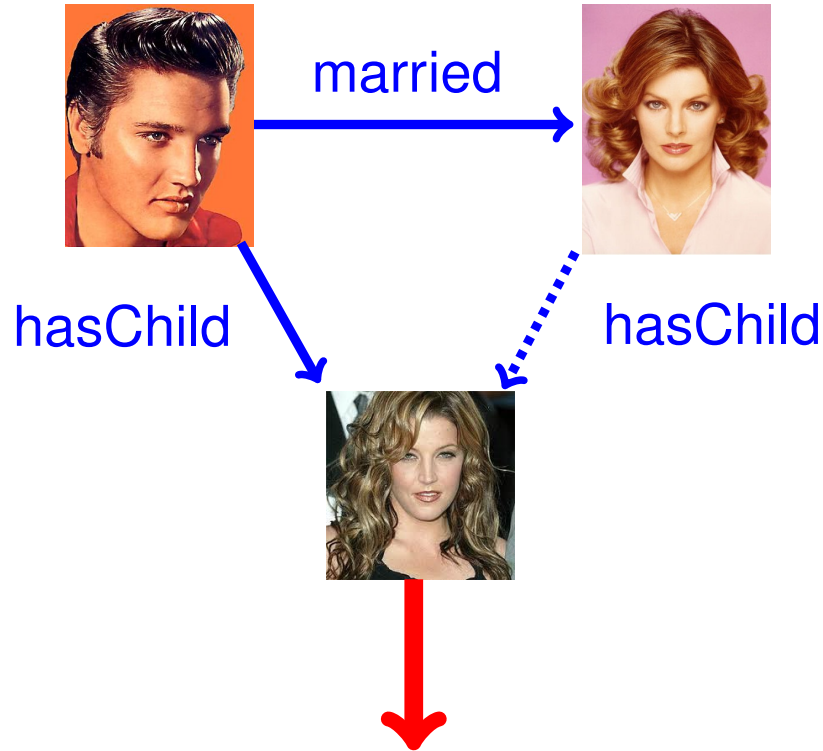
All data available online at

<http://resources.mpi-inf.mpg.de/d5/ibex/>

Knowledge Base Life Cycle

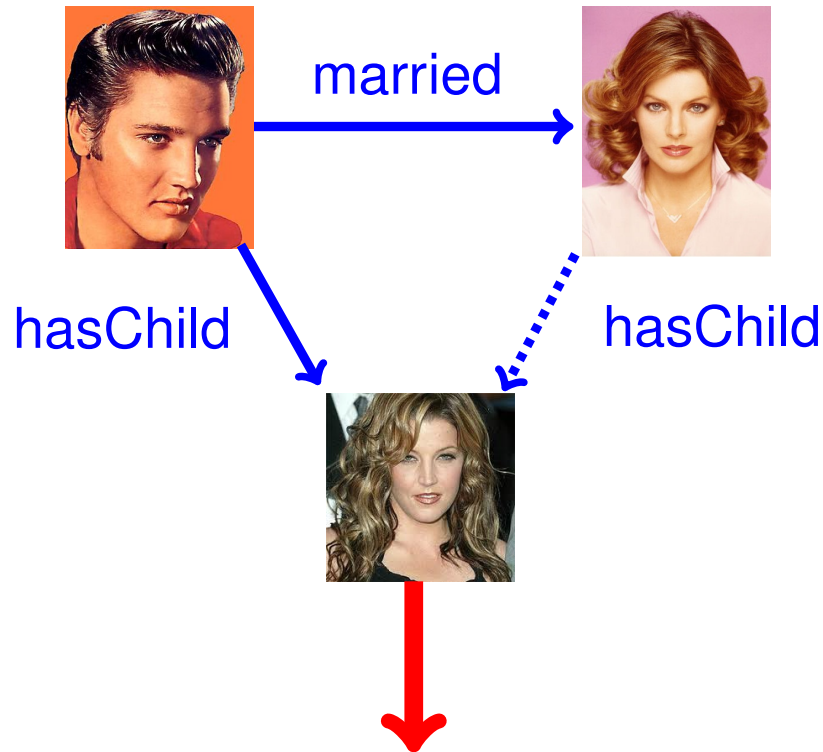


Rule Mining finds patterns



$$married(x, y) \wedge hasChild(x, z) \Rightarrow hasChild(y, z)$$

Rule Mining finds patterns



$$\text{married}(x, y) \wedge \text{hasChild}(x, z) \Rightarrow \text{hasChild}(y, z)$$

But: Rule mining needs counter examples
and RDF ontologies are positive only

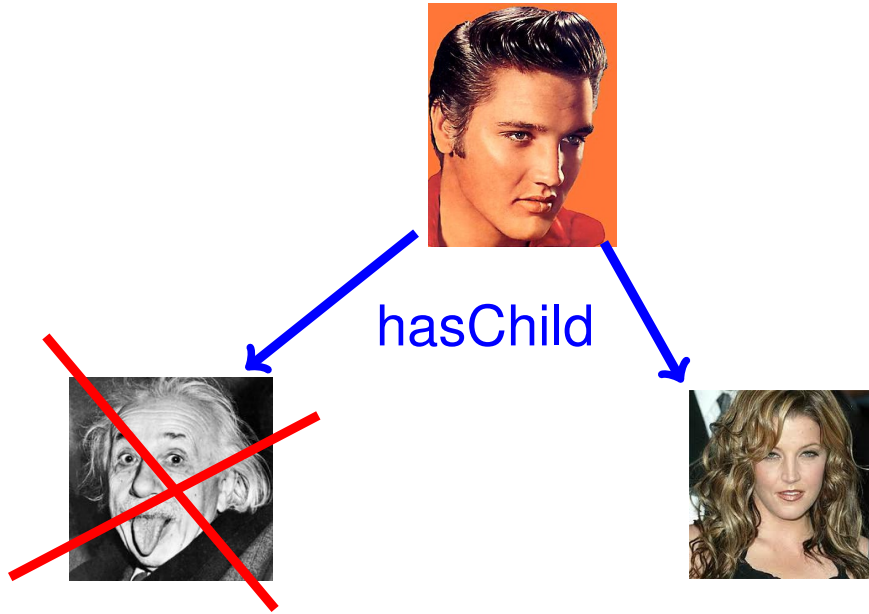
Partial Completeness Assumption



Assumption:

If we know $r(x, y_1), \dots, r(x, y_n)$,
then all other $r(x, z)$ are false.

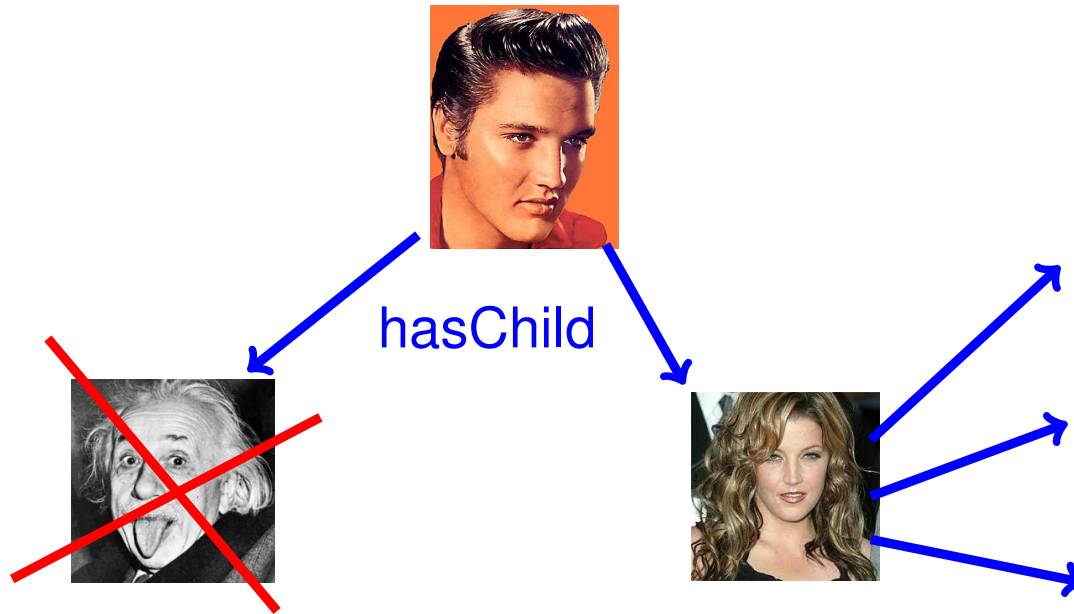
Partial Completeness Assumption



Assumption:

If we know $r(x, y_1), \dots, r(x, y_n)$,
then all other $r(x, z)$ are false.

Partial Completeness Assumption



Assumption:

If we know $r(x, y_1), \dots, r(x, y_n)$,
then all other $r(x, z)$ are false.

Partial Completeness Assumption

$$\text{married}(z, x) \wedge \text{hasChild}(z, y) \Rightarrow \text{hasChild}(x, y)$$

$$\vec{B} \Rightarrow r(x, y)$$

$$\text{conf}(\vec{B} \Rightarrow r(x, y)) = \frac{\#x, y: \vec{B} \wedge r(x, y)}{\#x, y: \exists y': \vec{B} \wedge r(x, y')}$$

of parent-child
relations that we
predict correctly
in the KB

of parent-child
relations that we
predict and where
a child is known

AMIE finds rules in ontologies



AMIE
(5min)

$$r(x, y) \wedge r'(z, y) \Rightarrow r''(x, z)$$

AMIE is based on an efficient in-memory database implementation.

Caveat: rules cannot
predict the unknown
with high precision

AMIE finds rules in ontologies



AMIE
(5min)



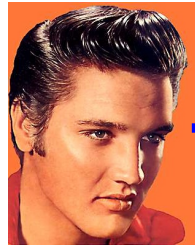
$type(x, pope) \Rightarrow$
 $diedIn(x, Rome)$



[WWW 2013, VLDB journal 2015]



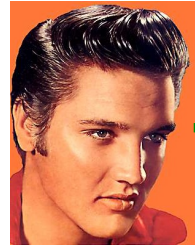
Matching heterogeneous KBs



bornInCountry



USA



bornInCity



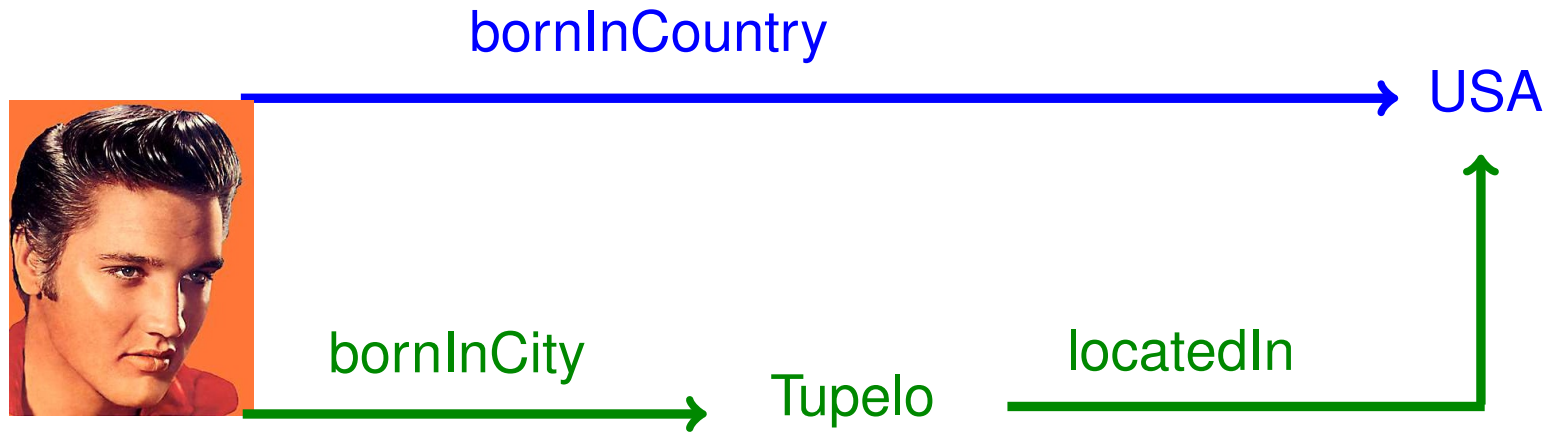
Tupelo

locatedIn

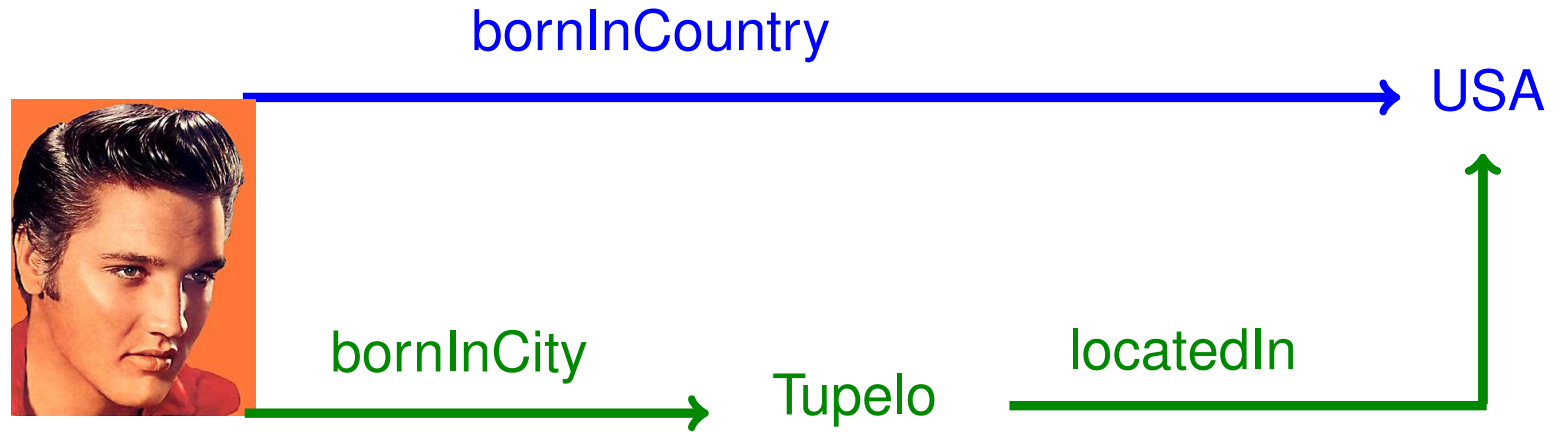


USA

1. Coalesce the KBs



2. Mine rules



$bornInCity(x, y) \wedge locatedIn(y, \Rightarrow) bornInCountry(x, z)$

“ROSA rule”

Caveat:
Spurious
correlations

ROSA rules match ontologies

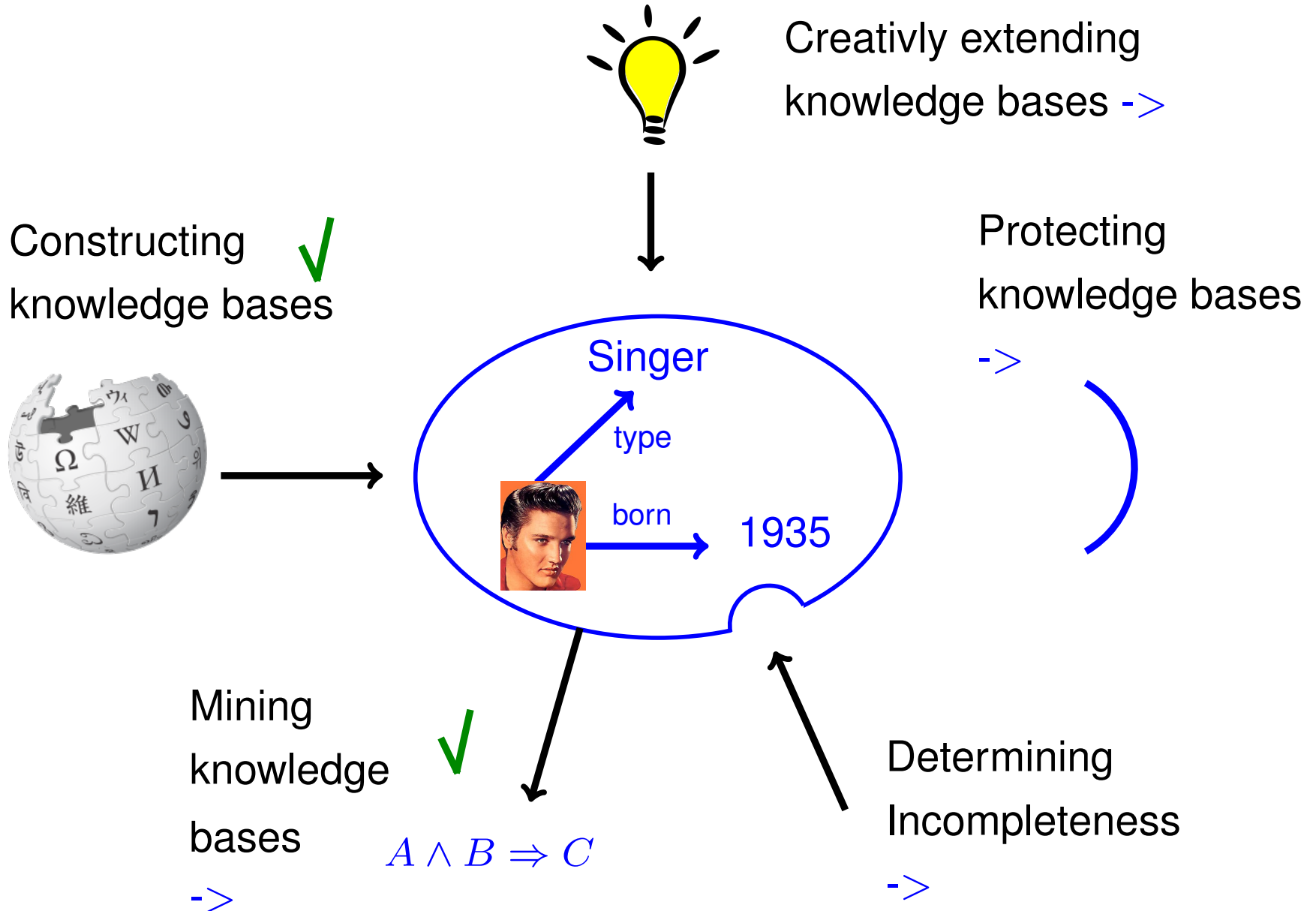


[AKBC 2013]

bornInCity(x, y) ∧ locatedIn(y, \neq) bornInCountry(x, z)

“ROSA rule”

Knowledge Base Life Cycle



Incompleteness



the quality of YAGO w
ls a precision of 95%, as
aks to our brilliant algori

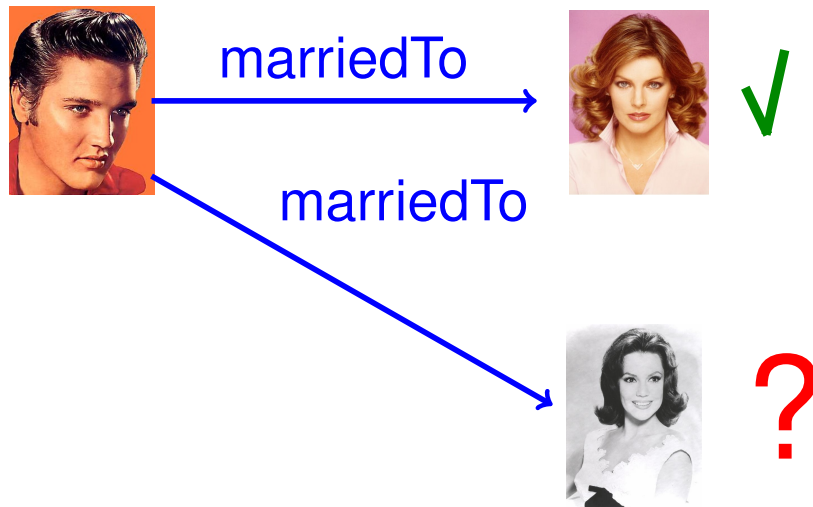
Incompleteness



the quality of YAGO w
ls a precision of 95%, as
aks to our brilliant algori



Incompleteness

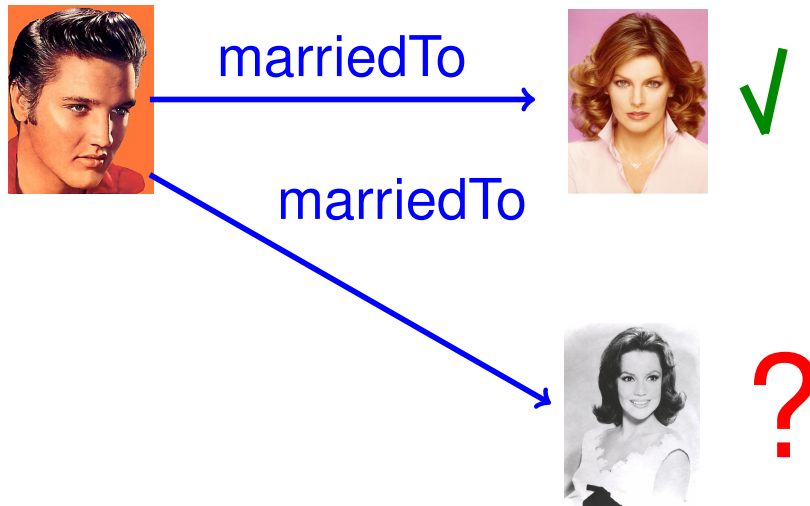


the quality of YAGO w
ls a precision of 95%, as
aks to our brilliant algori



Given a subject s and
a relation r , do we know
all o with $r(s, o)$?

Signals for Incompleteness



Closed World Assumption
Partial Completeness Assumption
Popularity oracle

No-change oracle
Star-pattern oracle
Class-oracle

AMIE oracle: Learn rules such as
 $moreThan_1(x, hasParent) \Rightarrow complete(x, hasParent)$



[>Details](#)

Signals for Incompleteness (F1)

Relation	CWA	PCA	card ₂	Popularity	No change	Star	Class	AMIE
diedIn	60%	22%	—	4%	15%	50%	99%	96%
directed	40%	96%	19%	7%	71%	0%	0%	100%
graduatedFrom	89%	4%	2%	2%	10%	89%	92%	87%
hasChild	71%	1%	1%	2%	13%	40%	78%	78%
hasGender	78%	100%	—	2%	—	86%	95%	100%
hasParent*	1%	54%	100%	—	—	0%	0%	100%
isCitizenOf*	4%	98%	11%	1%	4%	10%	5%	100%
isConnectedTo	87%	34%	19%	—	—	68%	88%	89%
isMarriedTo*	55%	7%	0%	3%	12%	37%	57%	46%
wasBornIn	28%	100%	—	5%	8%	0%	0%	100%

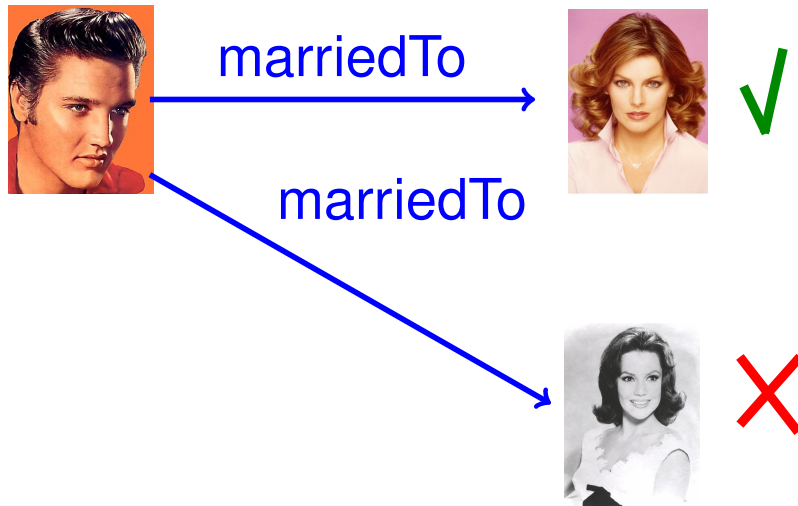
yago
select knowledge

Relation	CWA	PCA	card ₂	Popularity	Star	Class	AMIE
alma_mater	90%	14%	5%	1%	87%	87%	87%
brother	93%	1%	—	1%	94%	96%	96%
child	70%	1%	—	1%	79%	72%	73%
country_of_citizenship*	42%	97%	10%	3%	0%	0%	98%
director	81%	100%	—	3%	94%	89%	100%
father*	5%	100%	6%	9%	89%	8%	100%
mother*	3%	100%	3%	10%	67%*	5%	100%
place_of_birth	53%	100%	7%	5%	55%	0%	100%
place_of_death	89%	35%	1%	2%	81%	81%	96%
sex_or_gender	81%	100%	6%	3%	92%	91%	100%
spouse*	57%	7%	—	1%	54%	54%	55%

WIKIDATA

* = biased training sample

Signals for Incompleteness



AMIE can predict incompleteness

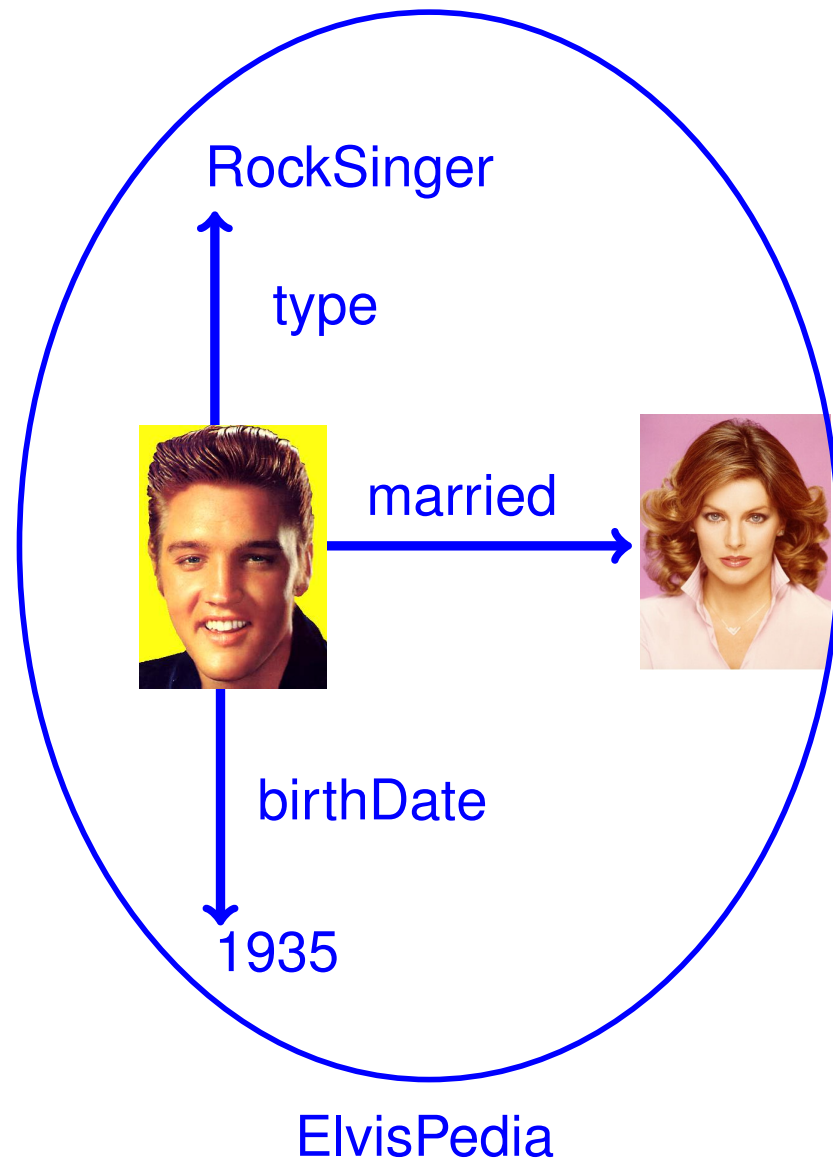
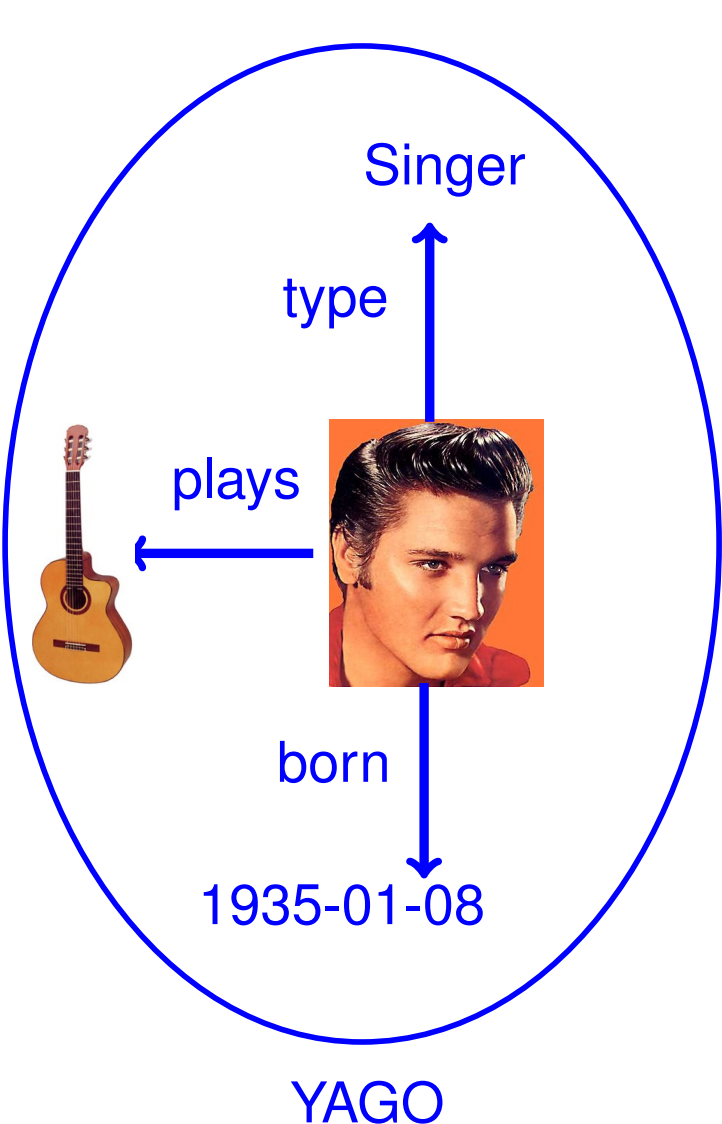
- bornIn: 100% F1-measure
- diedIn: 96%
- directed: 100%
- graduatedFrom: 87%
- hasChild: 78%
- isMarriedTo: 46%
- ... and more.



[WSDM 2017]

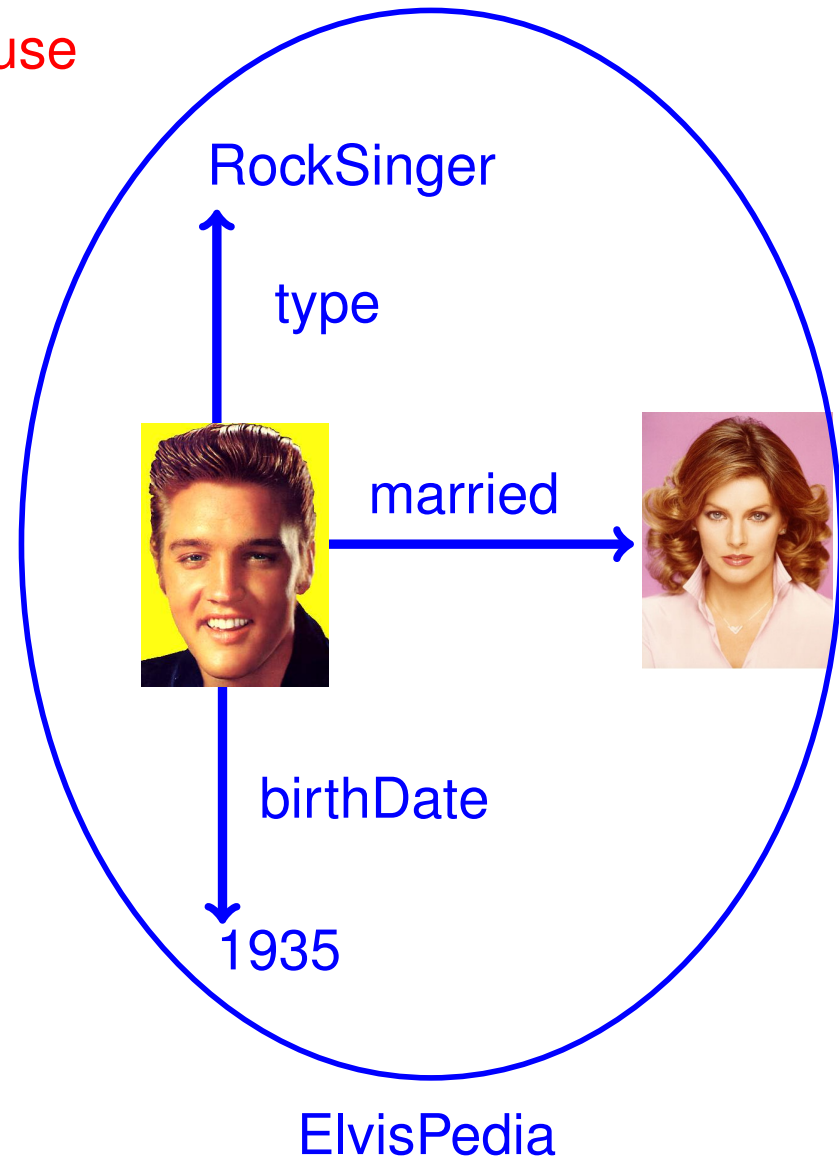
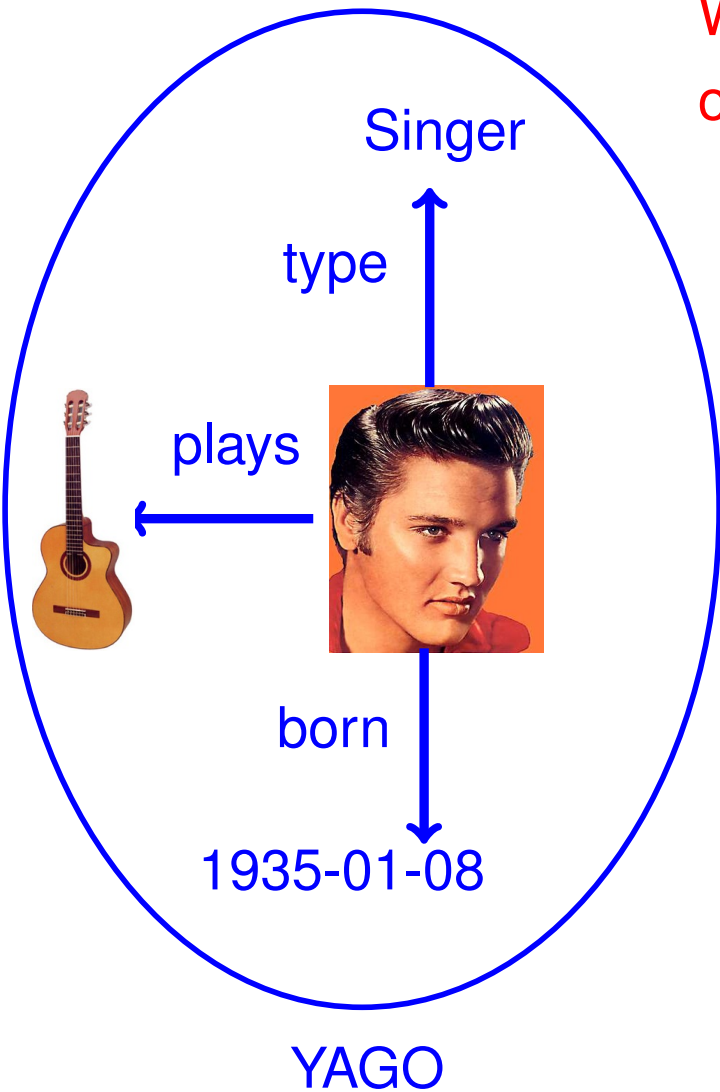
>paris

If incomplete, use another KB

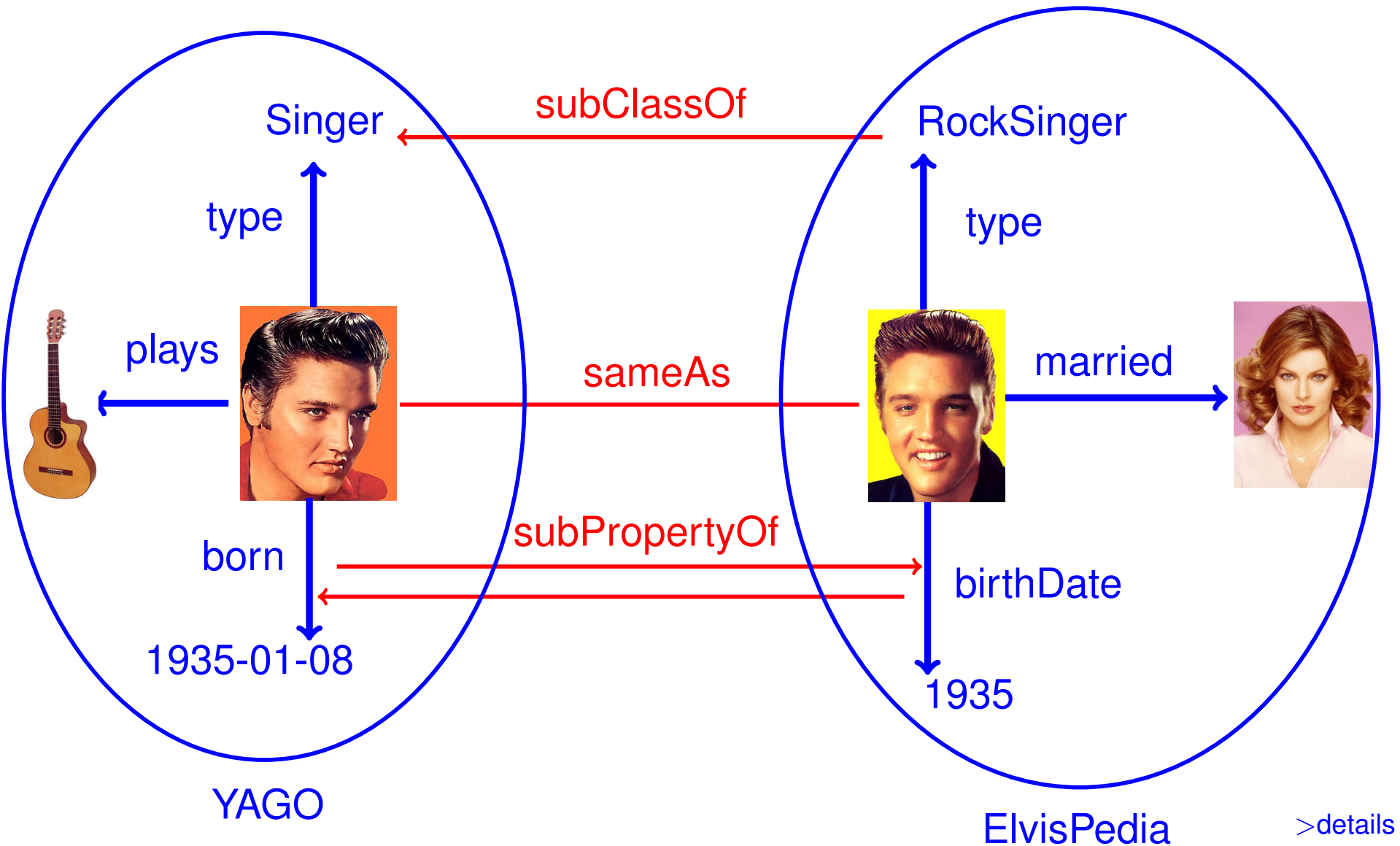


No Links => No Use

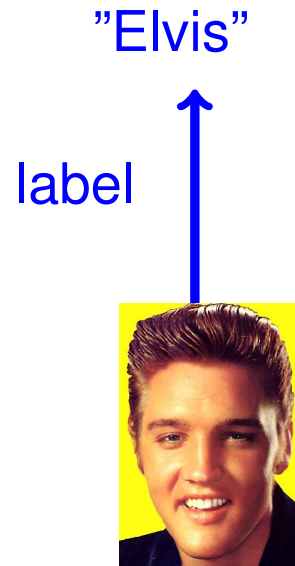
Who is the spouse
of the guitar
player?



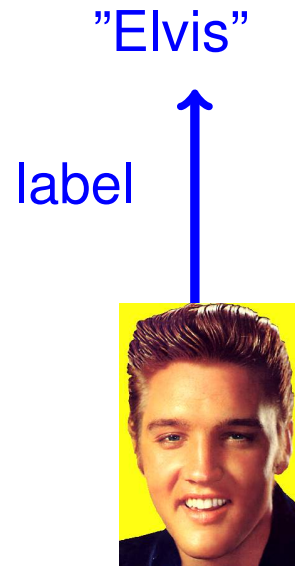
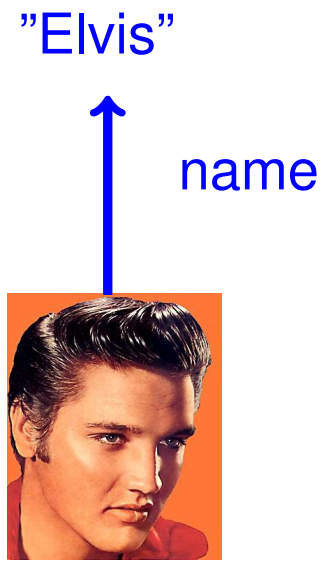
Match classes, entities, & relations



Match classes, entities, & relations

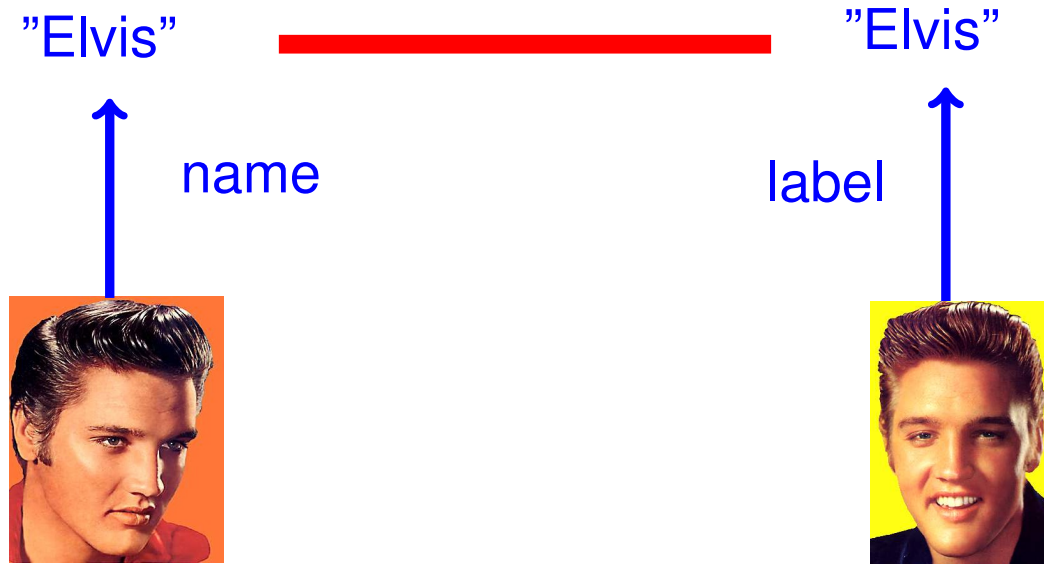


Match classes, entities, & relations



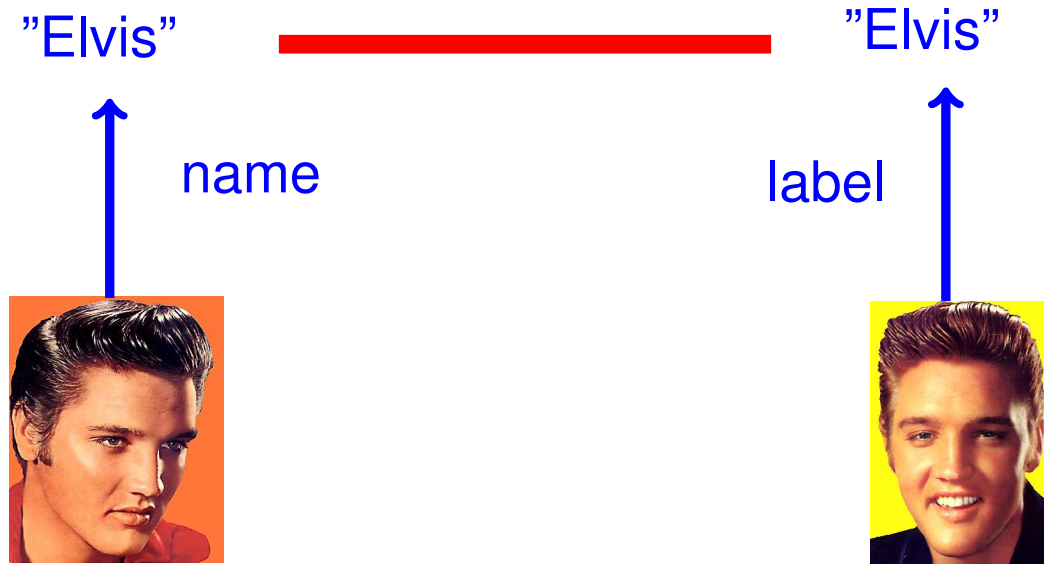
1. Match literals

Match classes, entities, & relations



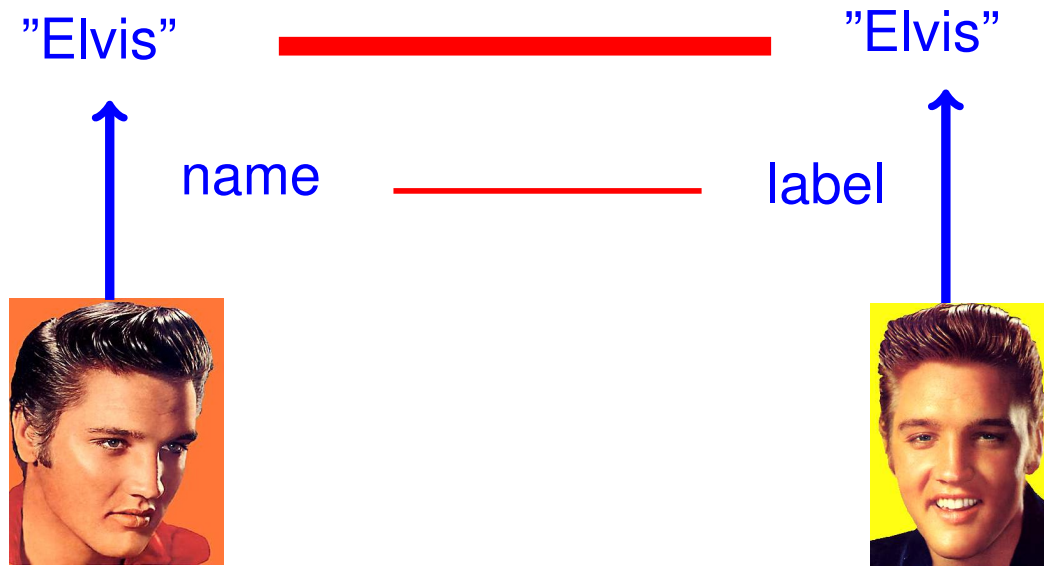
1. Match literals

Match classes, entities, & relations



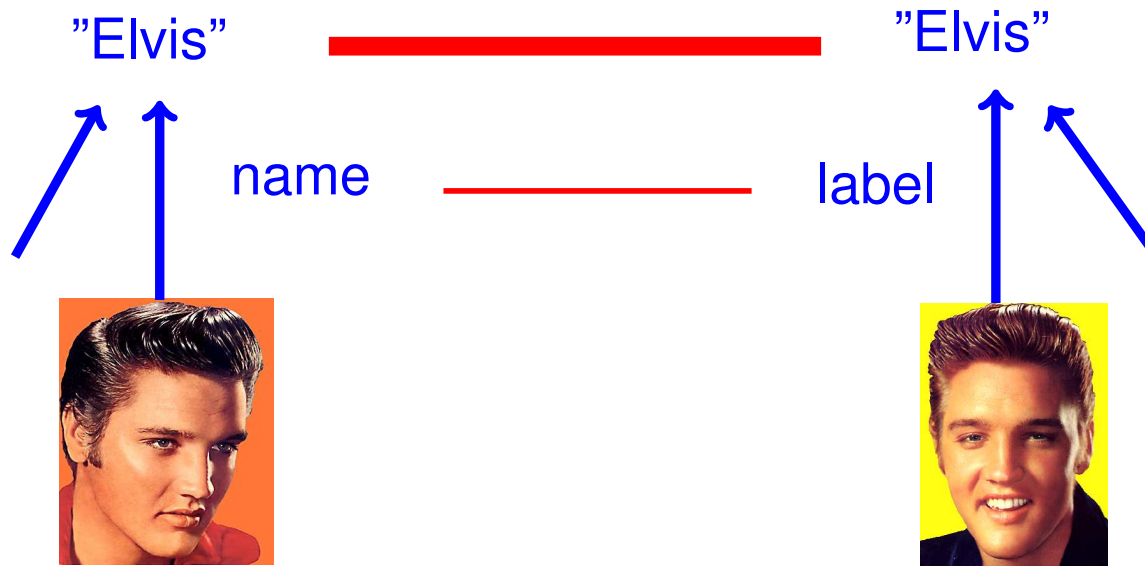
2. Assume small equivalence of all relations

Match classes, entities, & relations



2. Assume small equivalence of all relations

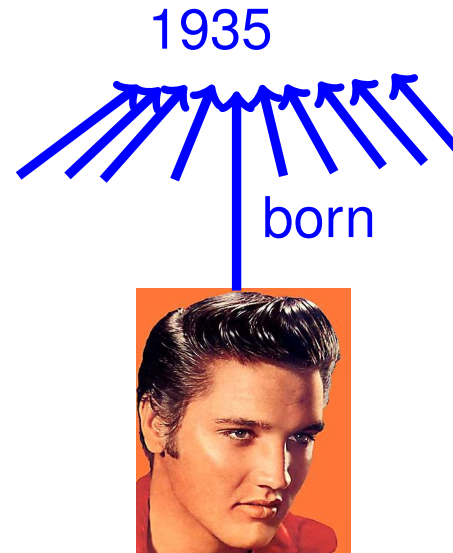
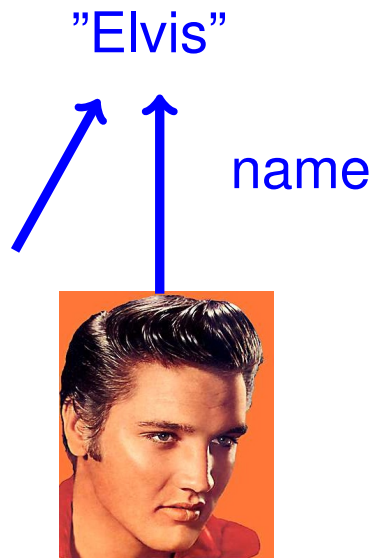
Match classes, entities, & relations



What about matching the entities?

What does it mean that both Elvises share the same name?

Inverse Functionality



$$ifun(r, y) = \frac{1}{\#x:r(x, y)}$$

$$ifun(r) = HM_y ifun(r, y)$$

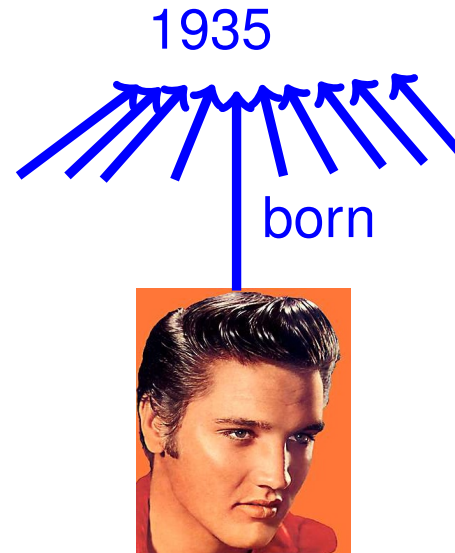
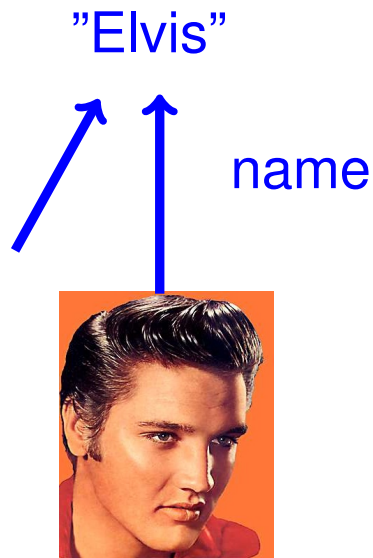
$$ifun(\text{name}, \text{Elvis}) = 1 / 2$$

$$ifun(\text{born}, 1935) = 1/10$$

$$ifun(\text{name}) = 0.9$$

$$ifun(\text{born}) = 0.1$$

Inverse Functionality



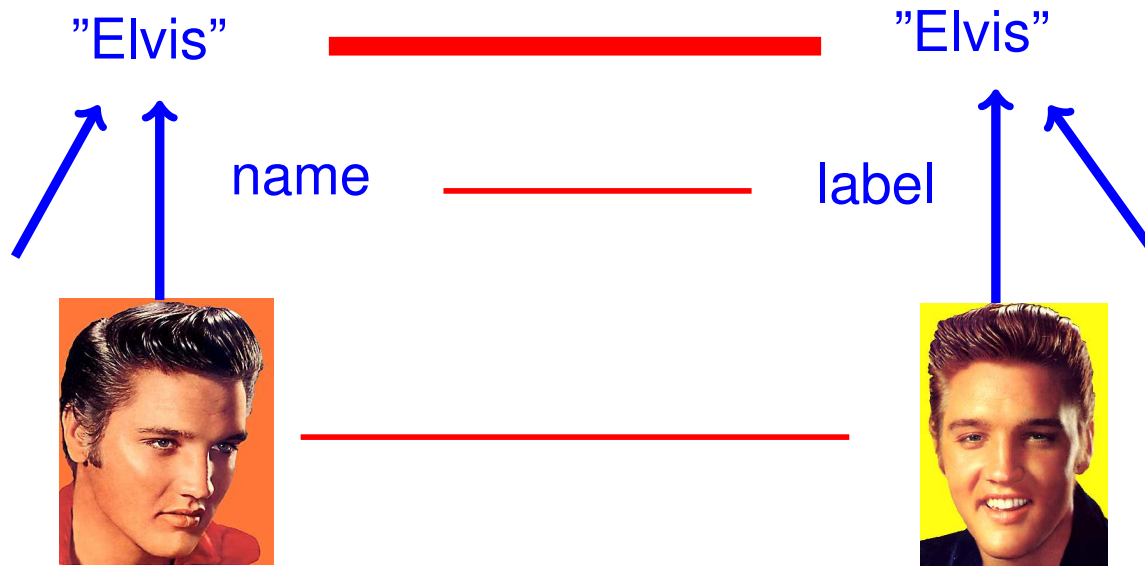
$$ifun(r) = \frac{\#x:\exists y:r(x,y)}{\#x,y:r(x,y)}$$



of subjects
divided by
of facts

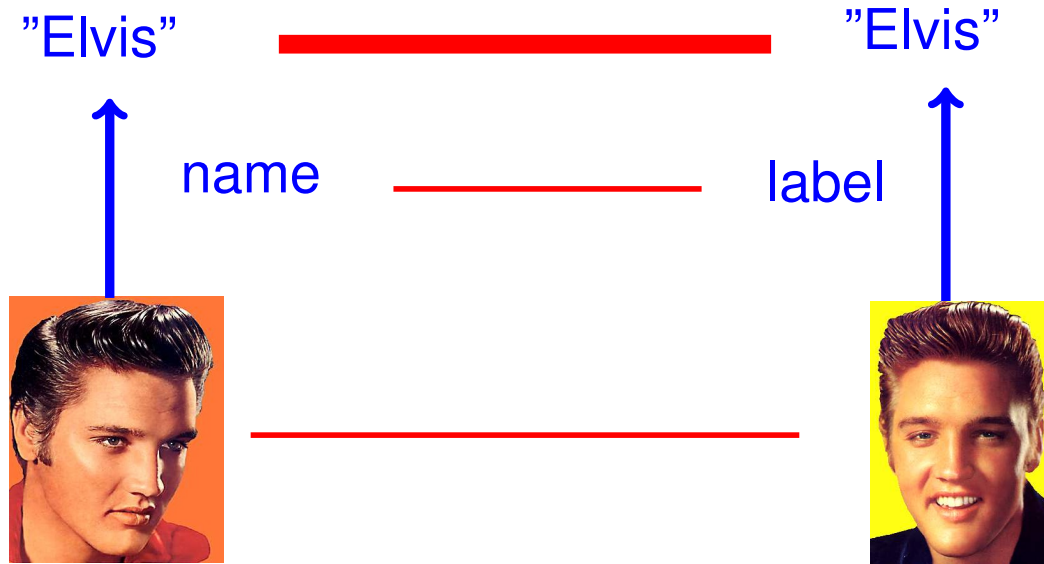
$$ifun(r) = HM_y ifun(r, y)$$

Match classes, entities, & relations



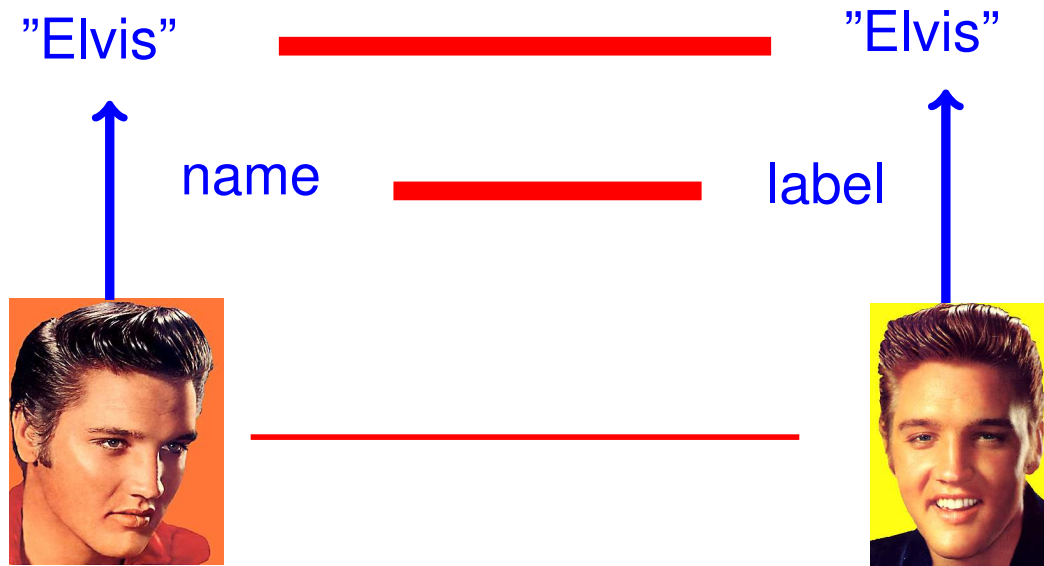
3. If subjects share a relation that is highly inverse functional, and the object is matched, then match the subjects.

Match classes, entities, & relations



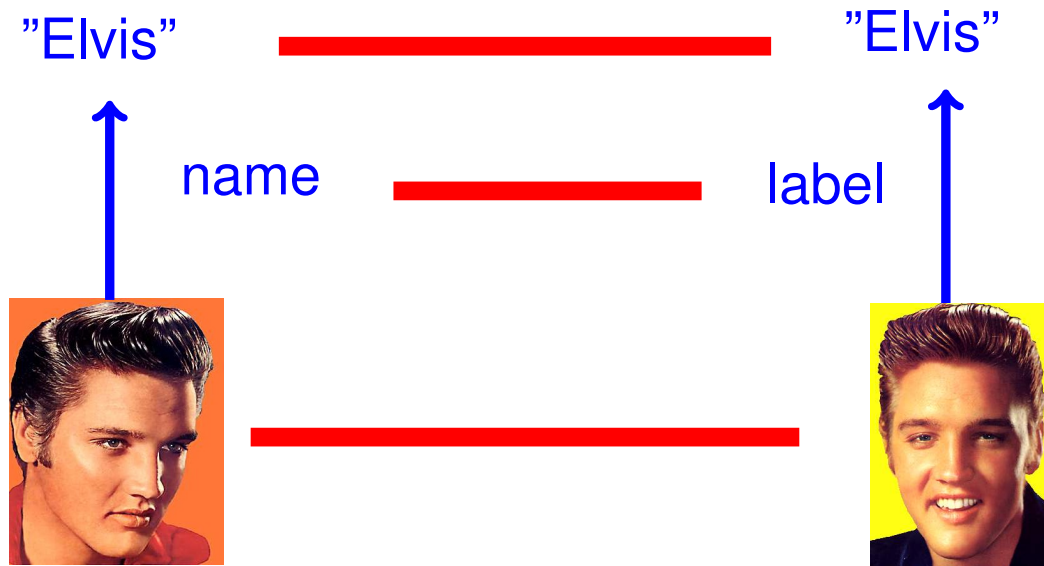
4. If relations share many pairs,
increase their match

Match classes, entities, & relations



4. If relations share many pairs,
increase their match

Match classes, entities, & relations



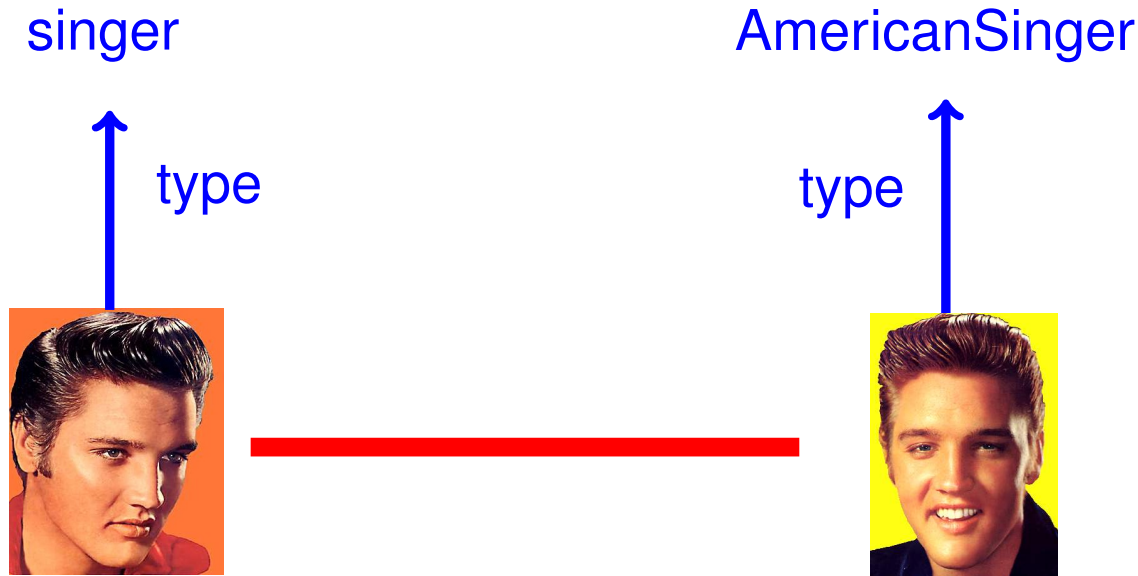
5. Iterate

$$P(e_1 \equiv e_2) = \prod_{\beta} \alpha^{\beta} \dots P(r_1 \subseteq r_2) \dots$$

$$P(r_1 \subseteq r_2) = 42 \phi^{\gamma} \sum \dots P(e_1 = e_2) \dots$$

Caveat: Convergence proof only in subcase

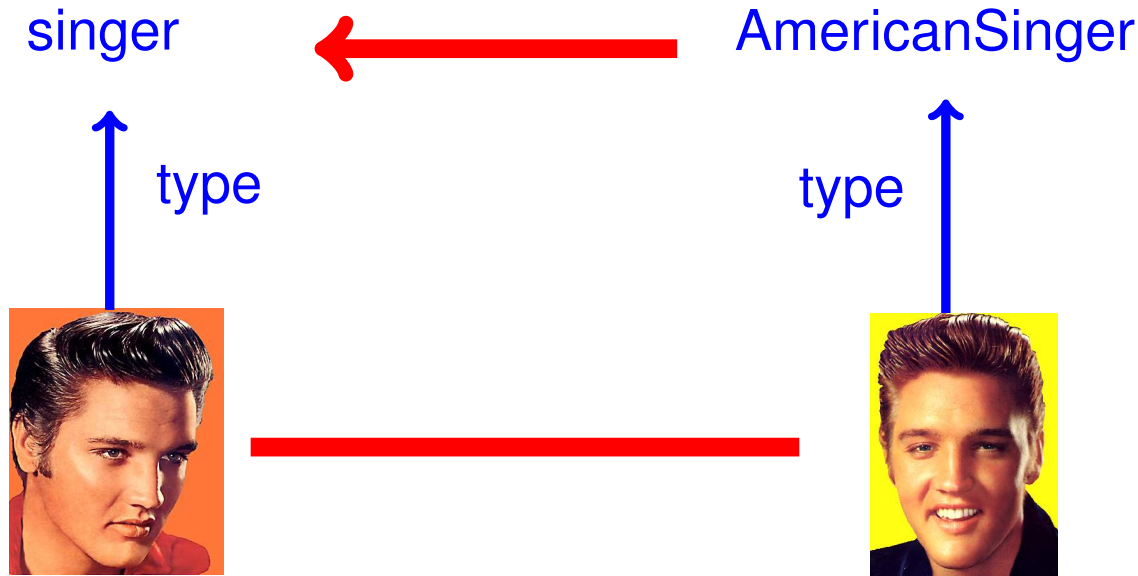
Match classes, entities, & relations



6. Compute class subsumption

$$P(c_1 \subseteq c_2) = \arcsin(4.1125) \times P(e_1 \equiv e_2) \times \dots$$

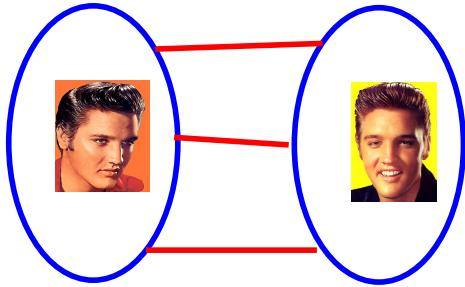
Match classes, entities, & relations



6. Compute class subsumption

Caveat: Class alignment works with “only” 85% precision due to spurious correlation.

PARIS:match entities,classes,relations



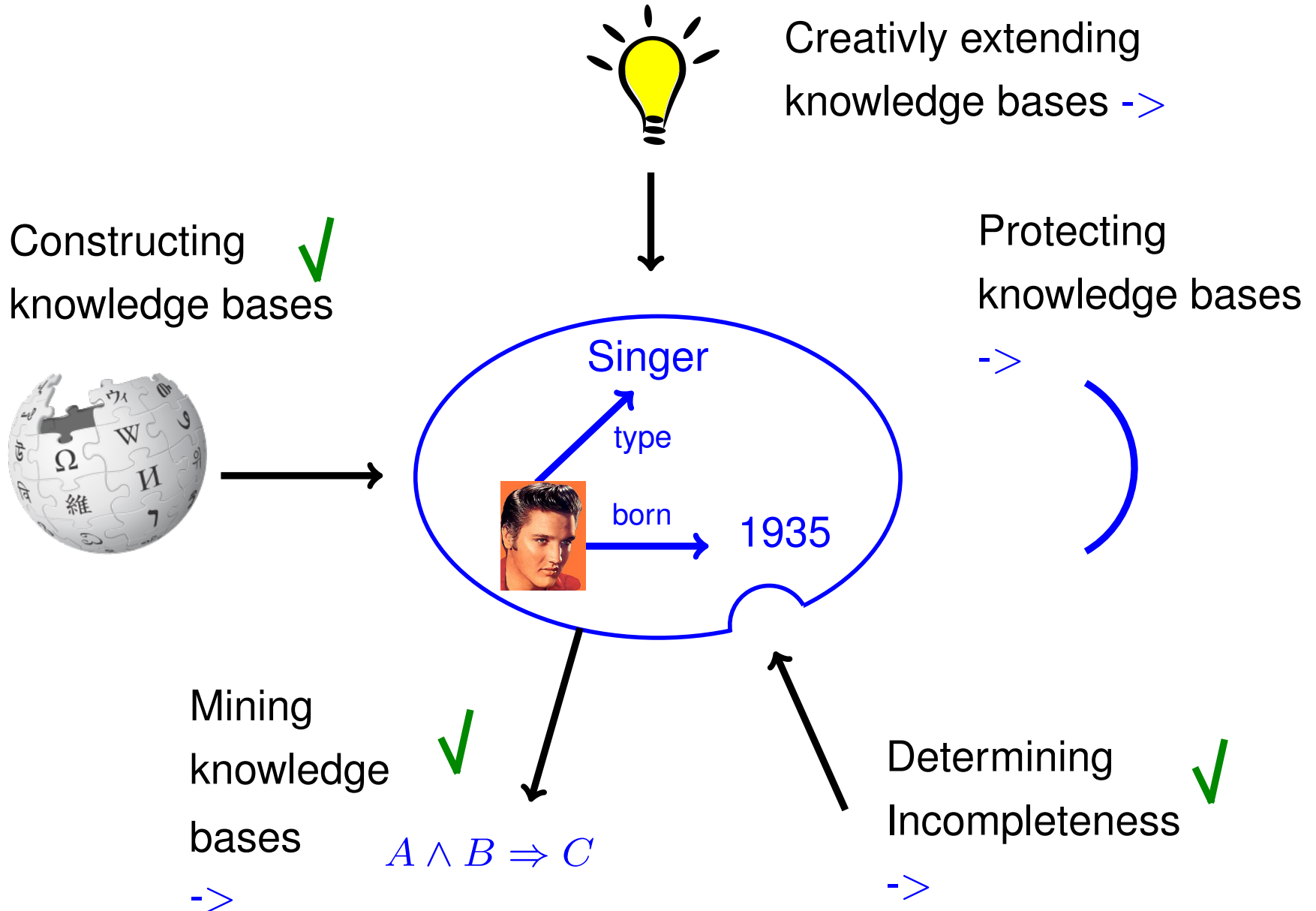
PARIS matches DBpedia & YAGO

- in 2 hours
- with 90% accuracy

[VLDB 2012, APWeb 2014 invited paper]

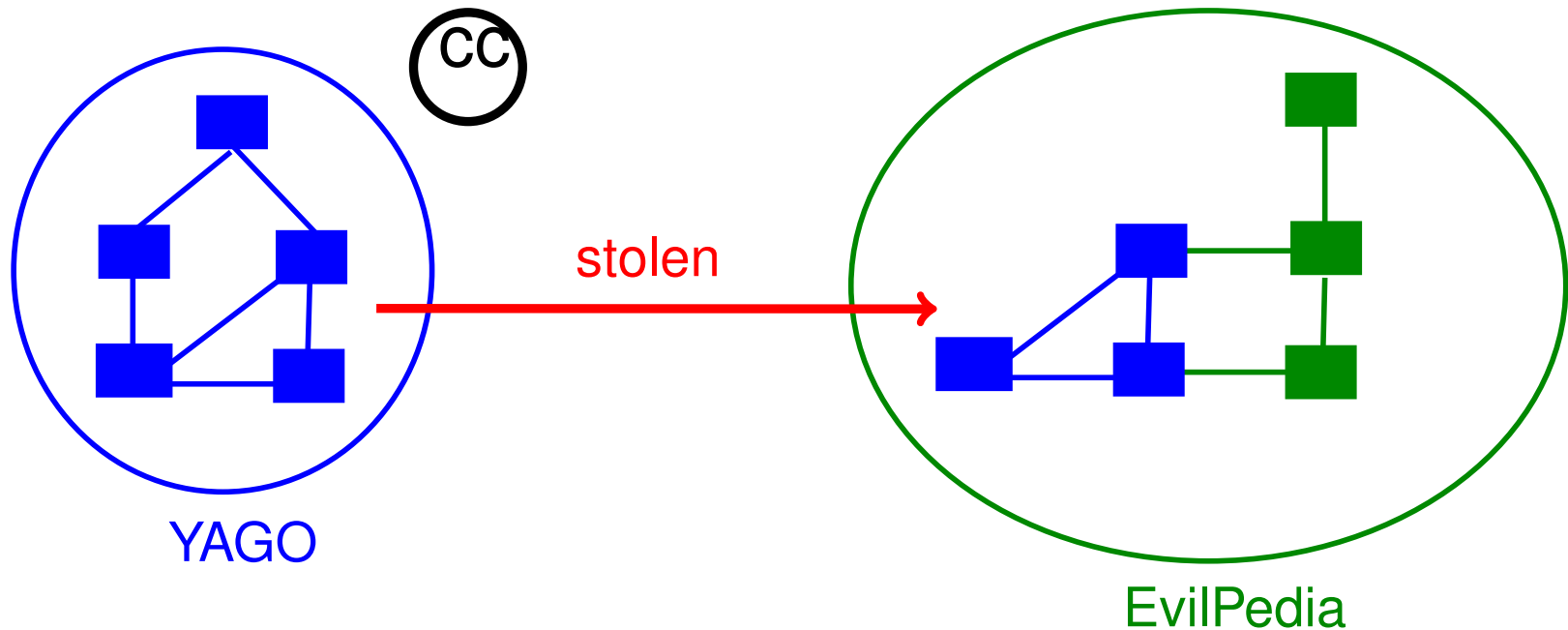


Knowledge Base Life Cycle



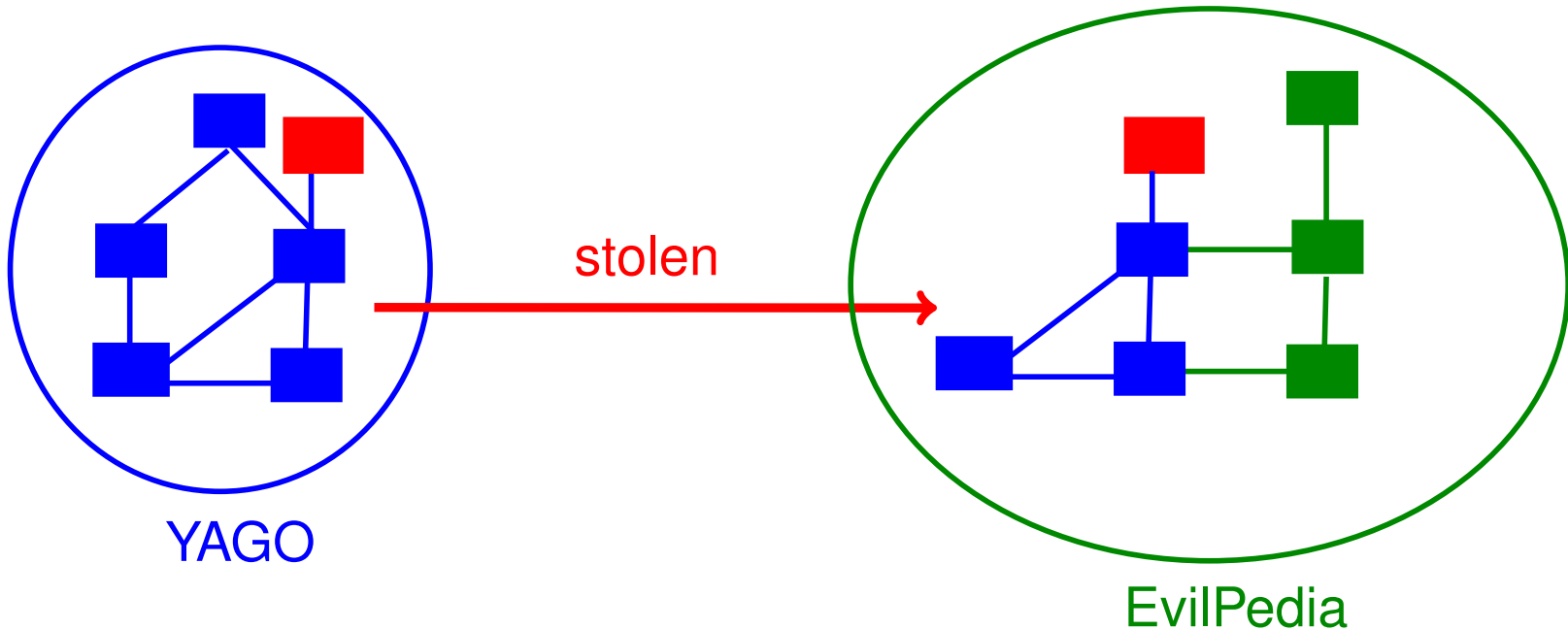
Plagiarism

People may “steal” from other ontologies without giving due credit.
Most ontologies have licenses that require attribution.



Additive Watermarking

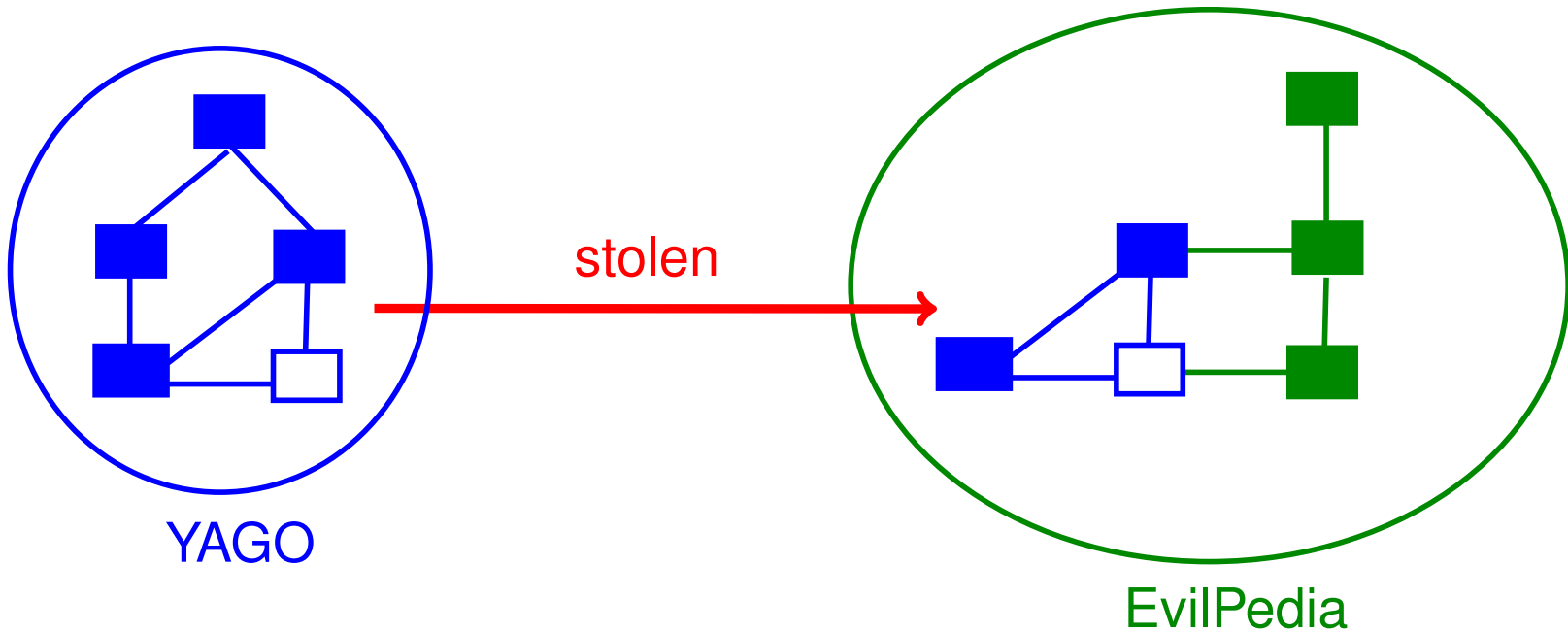
By adding a few fake facts to the source ontology, one can prove theft in the target ontology.



[WWW 2012 demo]

Subtractive Watermarking

One can also prove theft by selectively removing facts from the source ontology.

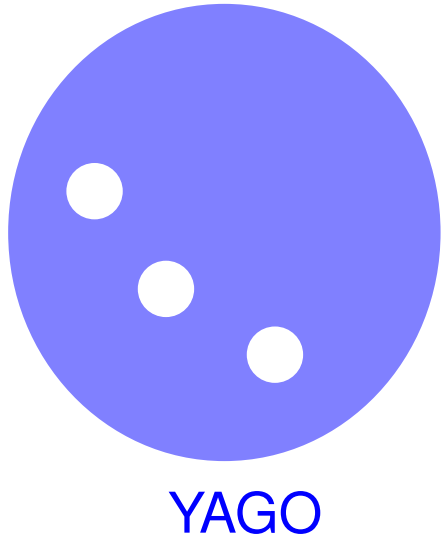


[ISWC 2011]

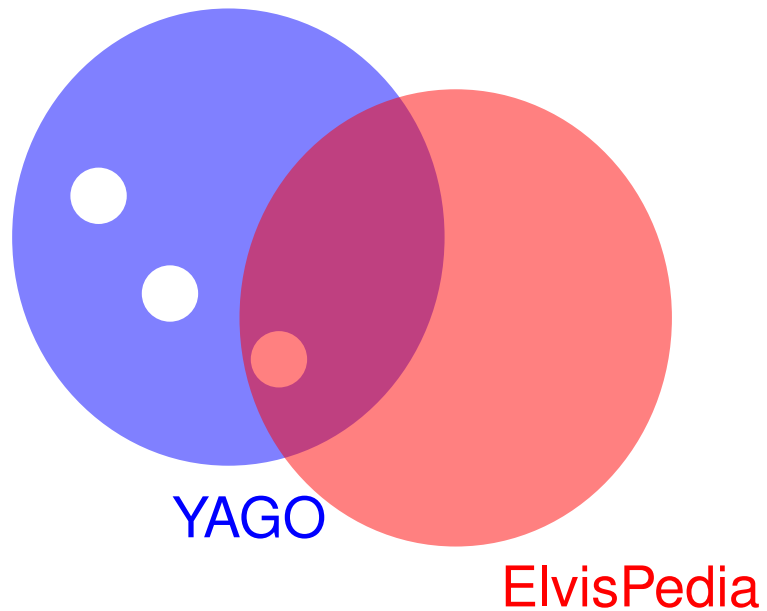
[details](#)>76

[details&DIVINA](#)>99

Subtractive Watermarking



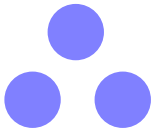
An Innocent KB



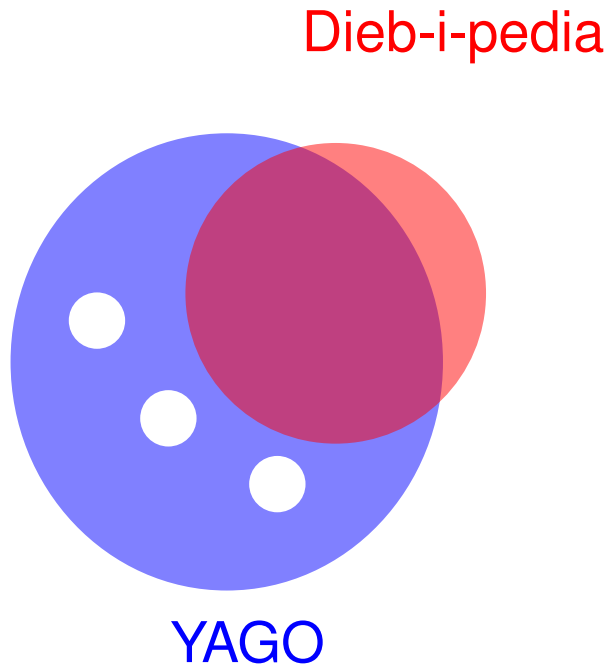
ratio of overlap

\approx

ratio of covered holes



A Stolen KB



high overlap

but

no holes covered

Probability that this
happens by chance

$$\sim (1 - \alpha)^n$$

α : overlap ratio

n : number of holes

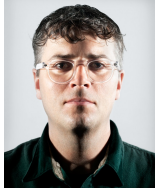
Protecting the user



amazon

Mat Honan

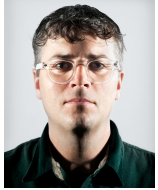
Protecting the user



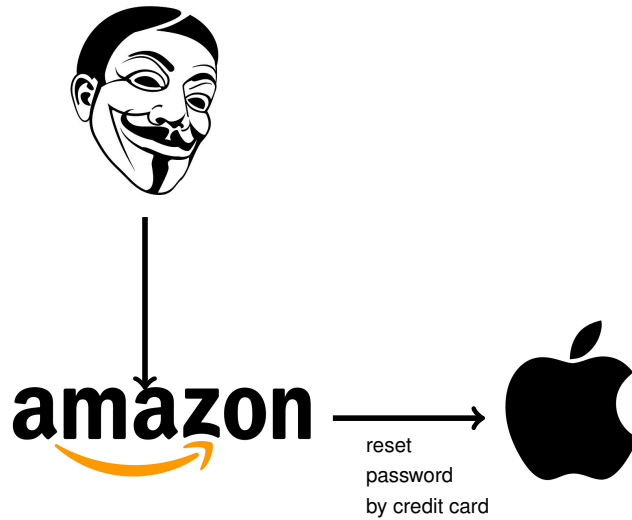
Mat Honan



Protecting the user



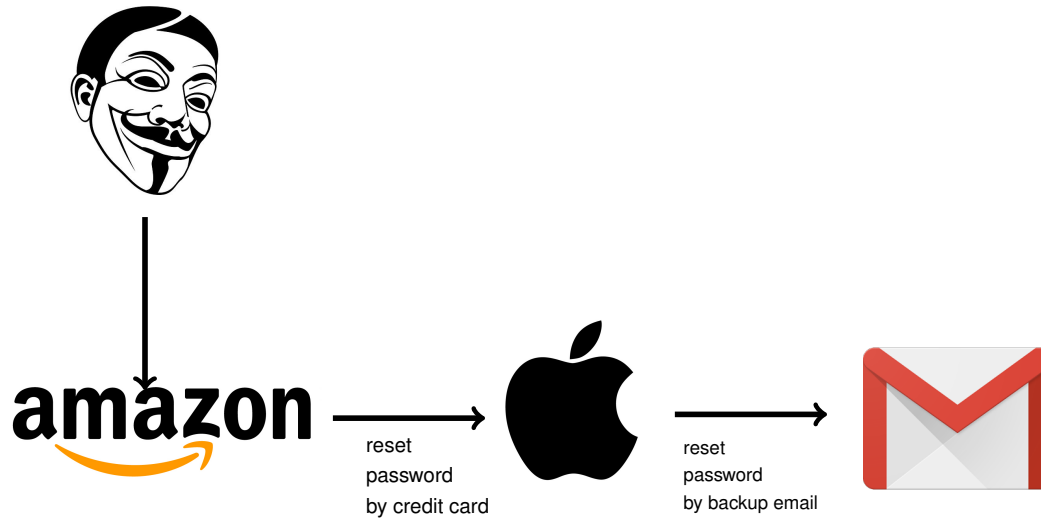
Mat Honan



Protecting the user



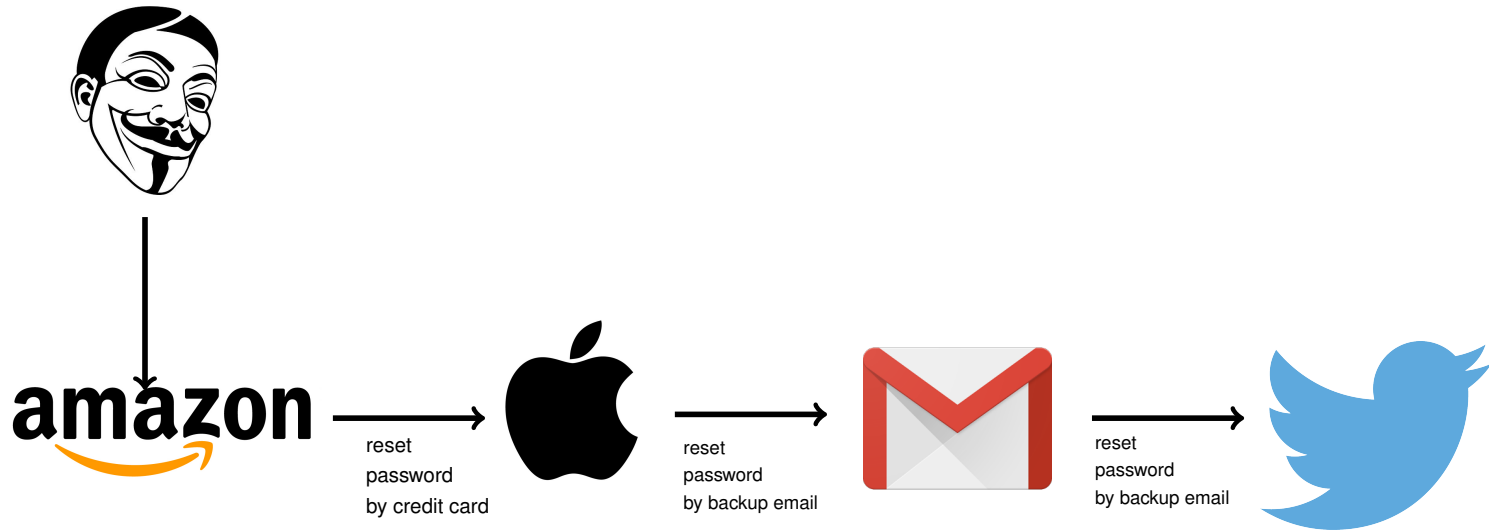
Mat Honan



Protecting the user



Mat Honan

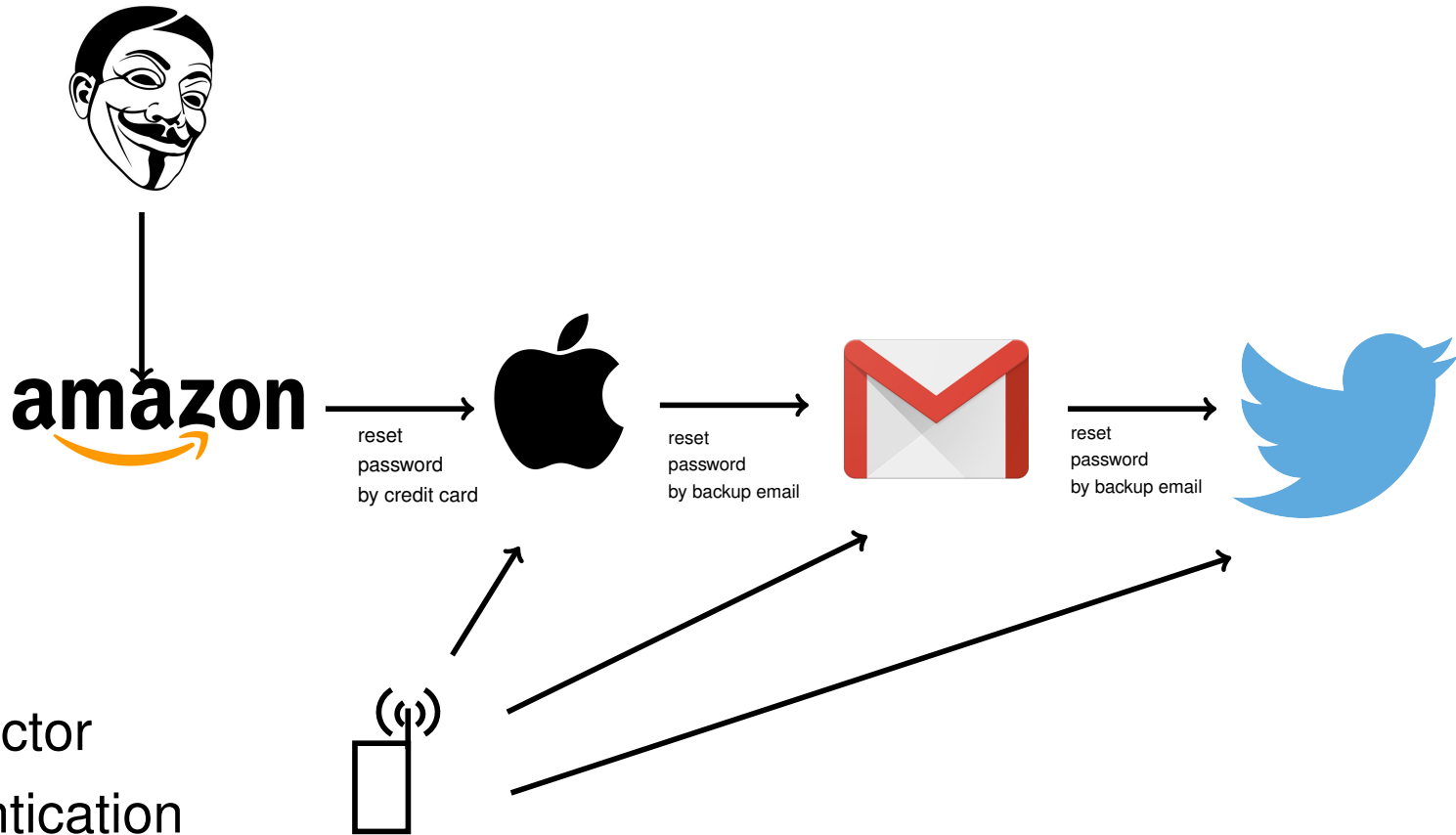


Protecting the user



Mat Honan

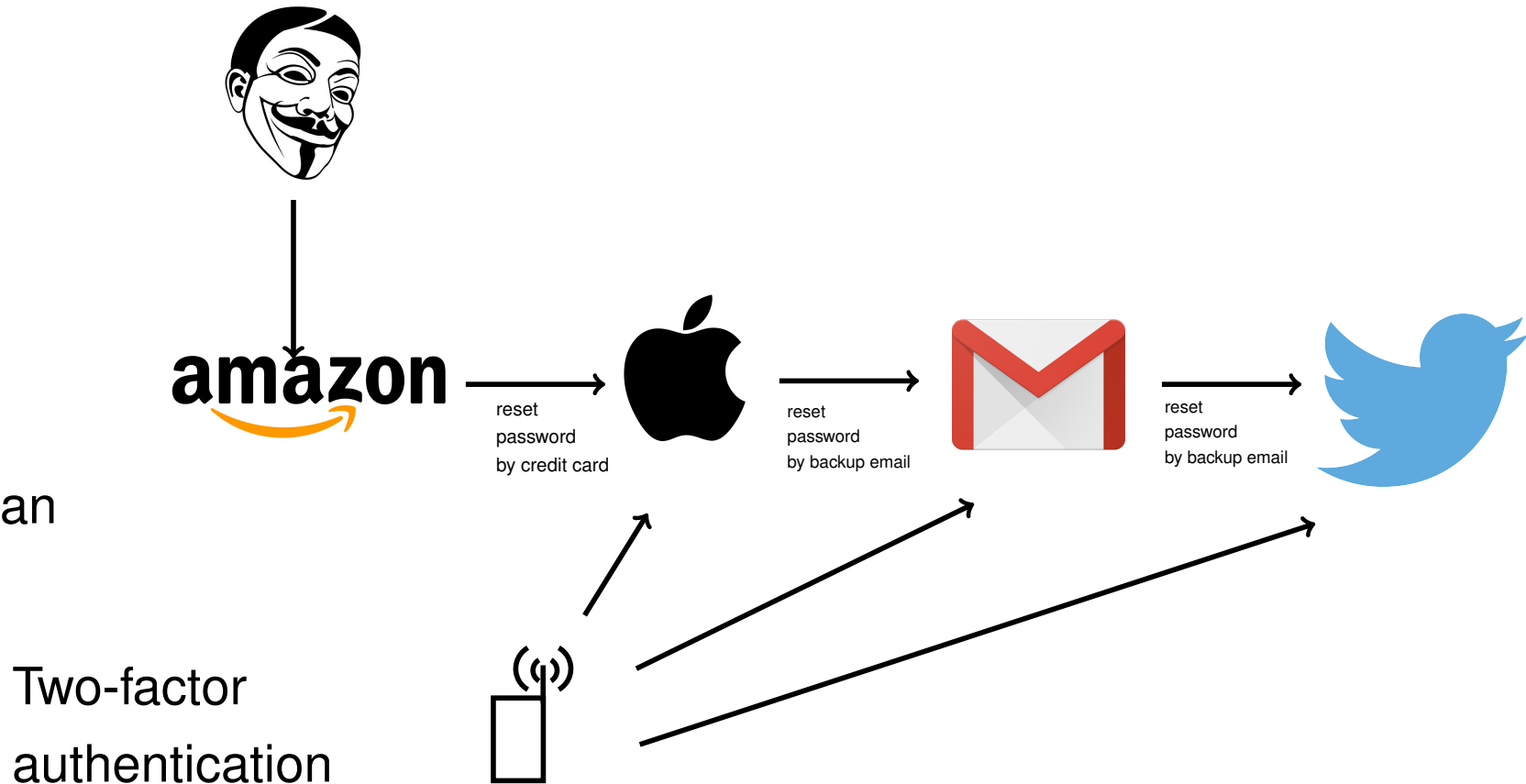
Two-factor
authentication



Protecting the user



Mat Honan

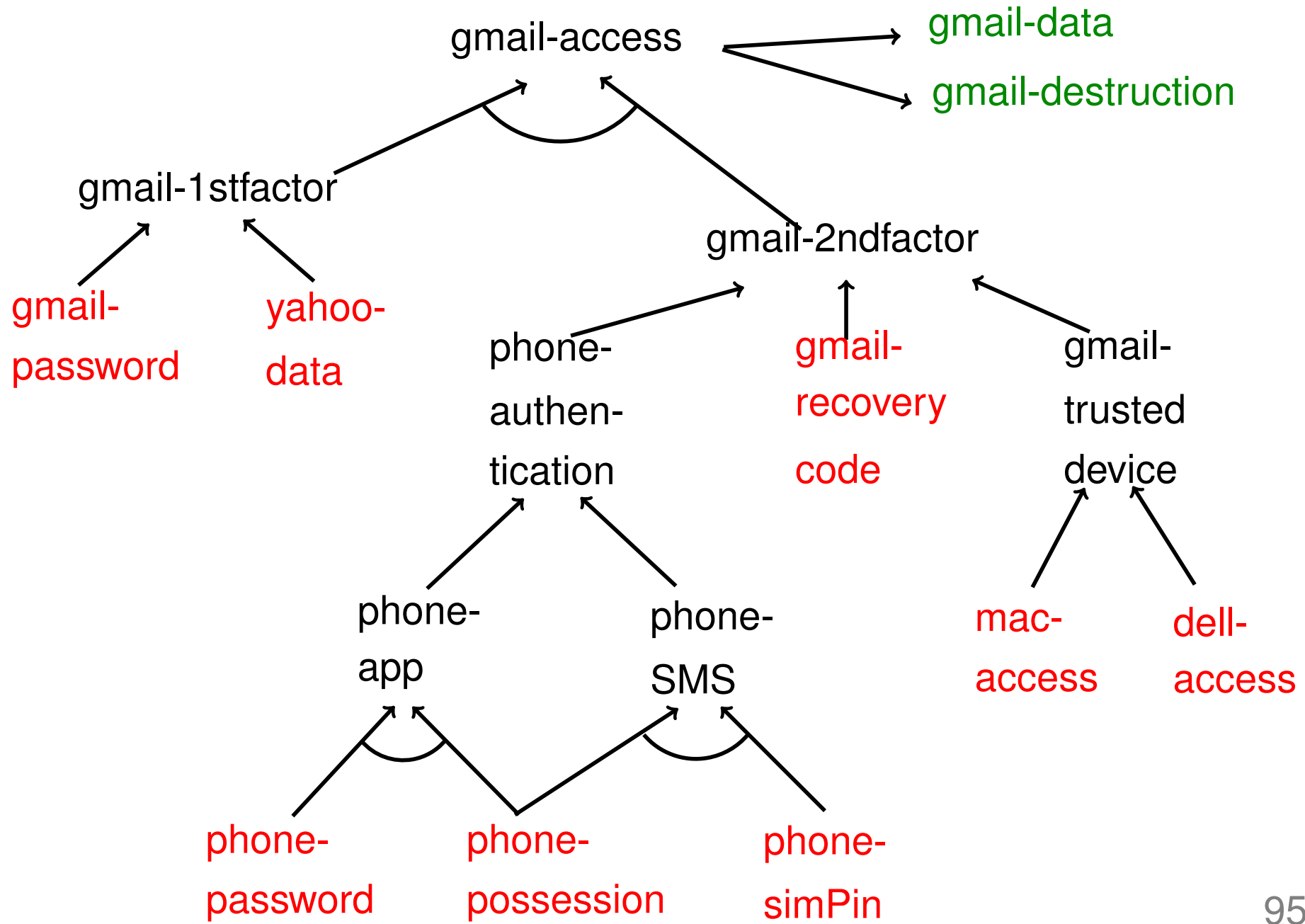


Security: How many keys does a hacker need?

Safety: How many keys can I afford to lose?


Protection: How many keys to destroy my data?

Account Dependencies




DIVINA

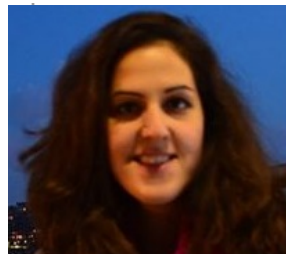
Discovering Vulnerabilities of Internet Accounts

 **Dropbox**

On which computers do you have Dropbox installed?



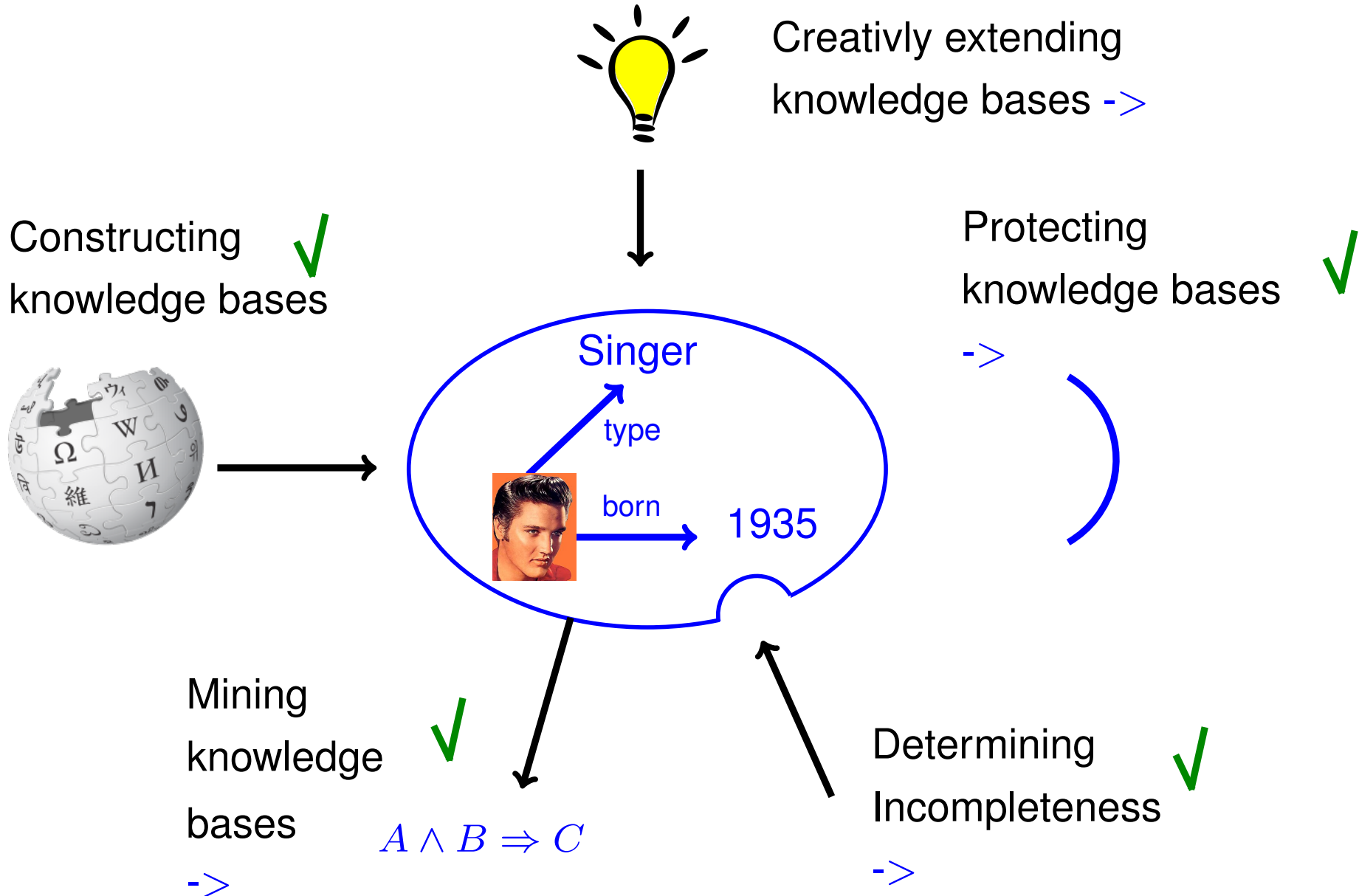
	Safety	Security	Protection
	<div><div></div></div> ✓	<div><div></div></div> ✓	<div><div></div></div> ✗ For online accounts: Consider two-factor



[WWW 2015 demo]

<https://suchanek.name/programs/divina>

Knowledge Base Life Cycle



Combinatorial Creativity



Description Logics do not work

$$Mop \equiv Tool \sqcap \exists has.Stick \sqcap \exists has.Strings$$

$$BabyMop \equiv$$

$$Romper \sqcap \exists has.(Mop \sqcap \neg \exists has.Stick) \sqcap \exists has.Baby$$

$$\equiv \perp$$



+

(



-



)

+



Language for Combinatorial Creativity

$$Mop \equiv Tool \sqcap \exists has.Stick \sqcap \exists has.Strings$$

Subtraction: $Mop - \exists has.\top \equiv Tool \sqcap \exists Strings$

Addition: $Mop + \exists has.\top \equiv Mop$

Succession: $Mop \rightarrow \exists r.\top \equiv Stick$

Selection*: $Mop \uparrow \exists has.\top \equiv \exists has.Stick$

$$Romper + \exists has.(Mop - \exists has.Stick) + \exists has.Baby \\ \equiv BabyMop$$



+

(



-



)

+



Language for Combinatorial Creativity

$$Mop \equiv Tool \sqcap \exists has.Stick \sqcap \exists has.Strings$$

Subtraction: $Mop - \exists has.\top \equiv Tool \sqcap \exists Strings$

Addition: $Mop + \exists has.\top \equiv Mop$

Succession: $Mop \rightarrow \exists r.\top \equiv Stick$

Selection*: $Mop \uparrow \exists has.\top \equiv \exists has.Stick$

1) Descriptive experiments

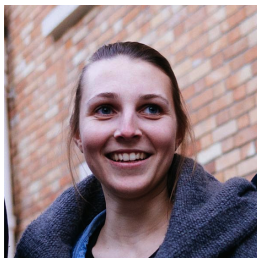
TECH

The 25 Best Inventions

TIME Staff | Nov. 19, 2015

2) Generative experiments

1/3 nonsense, 1/3 exists,
1/3 “imaginable”

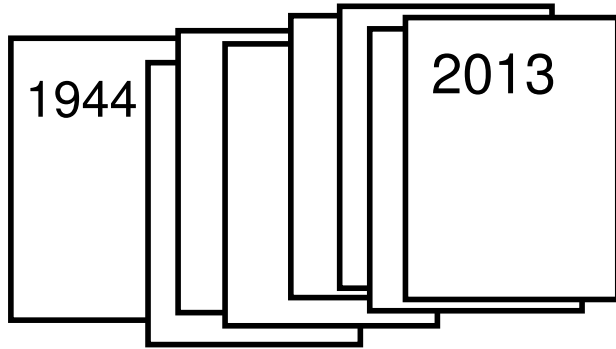


[ISWC 2016
paper & demo]

>LeMonde

Another creative idea...

Le Monde



Mining Le Monde

Le Monde

time

place

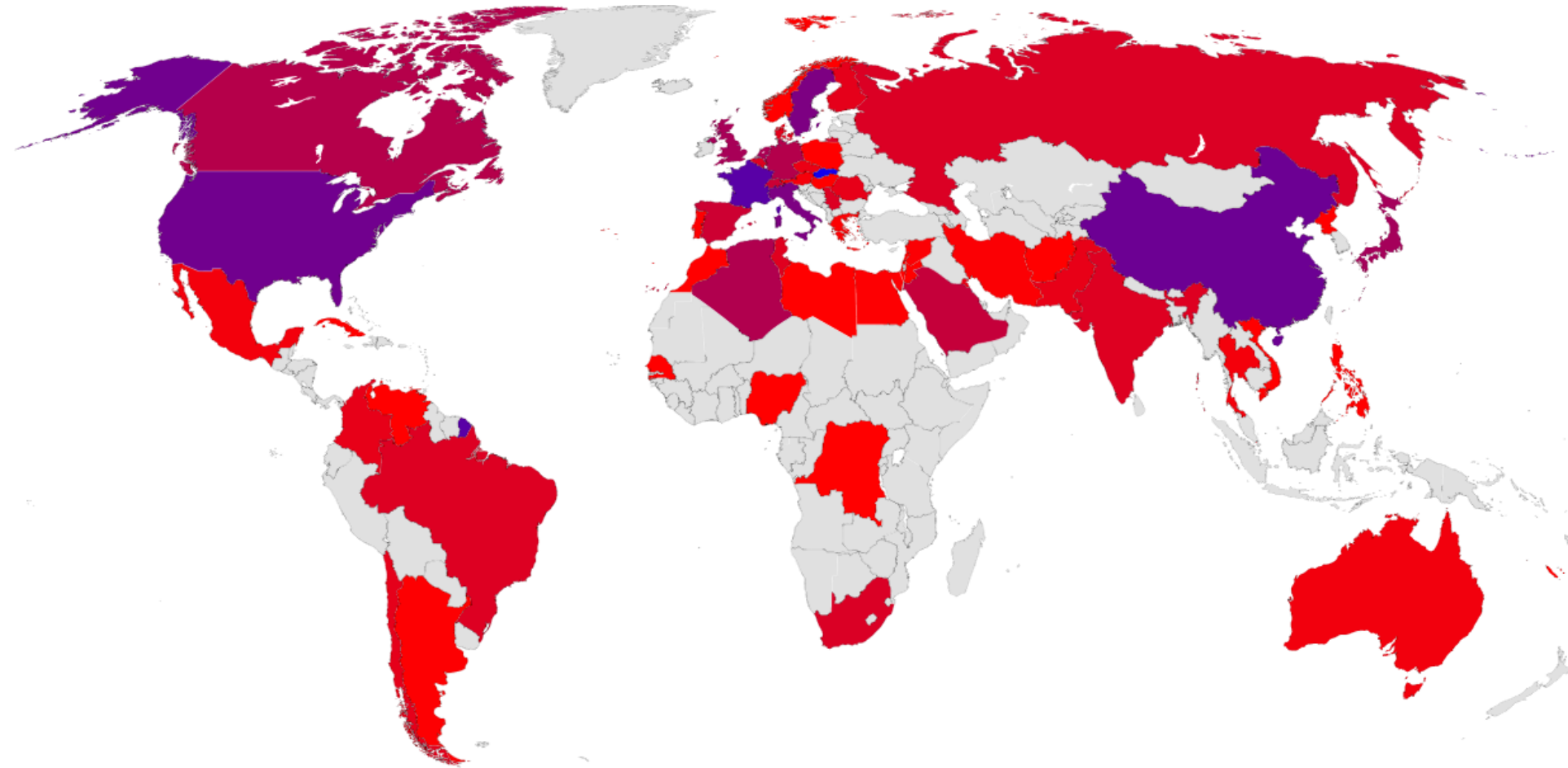
entity

1967

USA



Presence of foreign companies



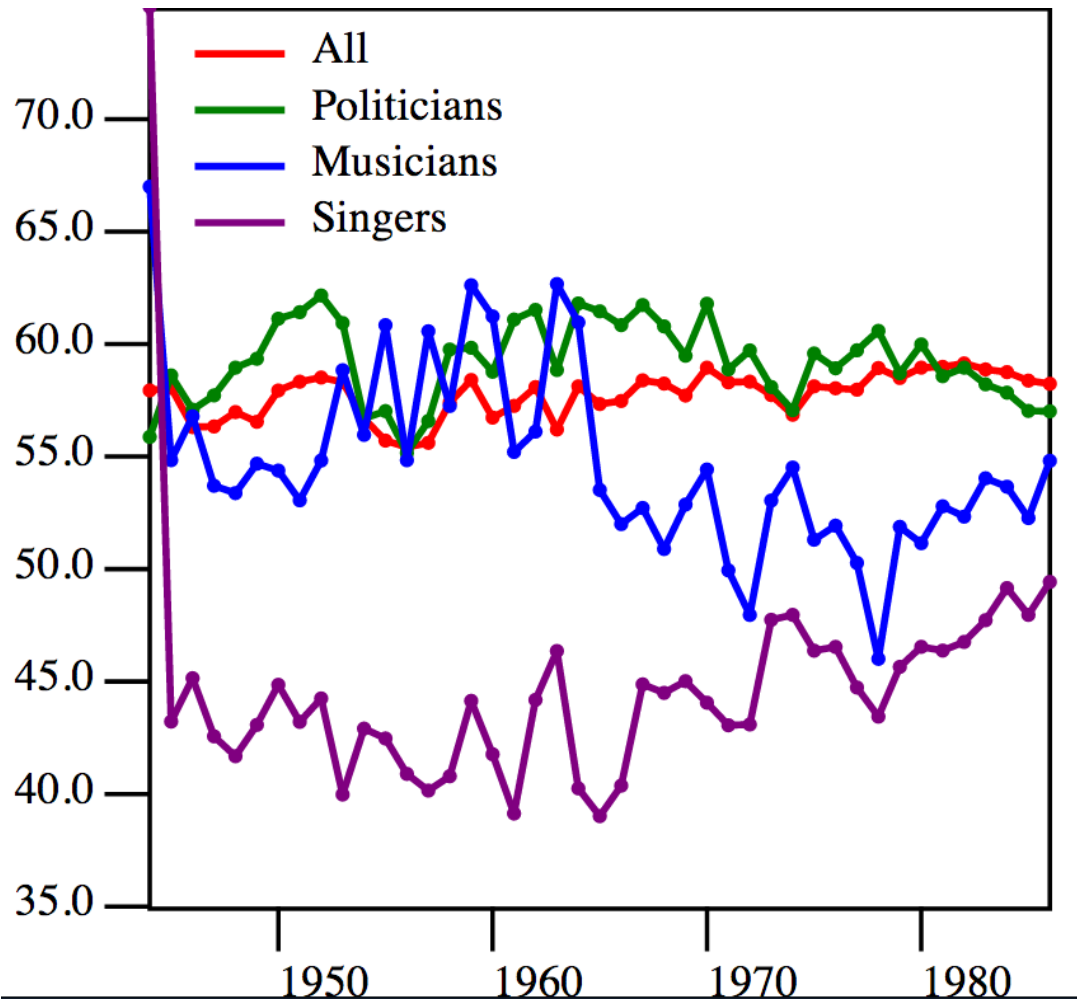
red: many foreign companies mentioned

blue: few foreign companies mentioned

Average age of people mentioned

Le Monde

yAGO
select knowledge

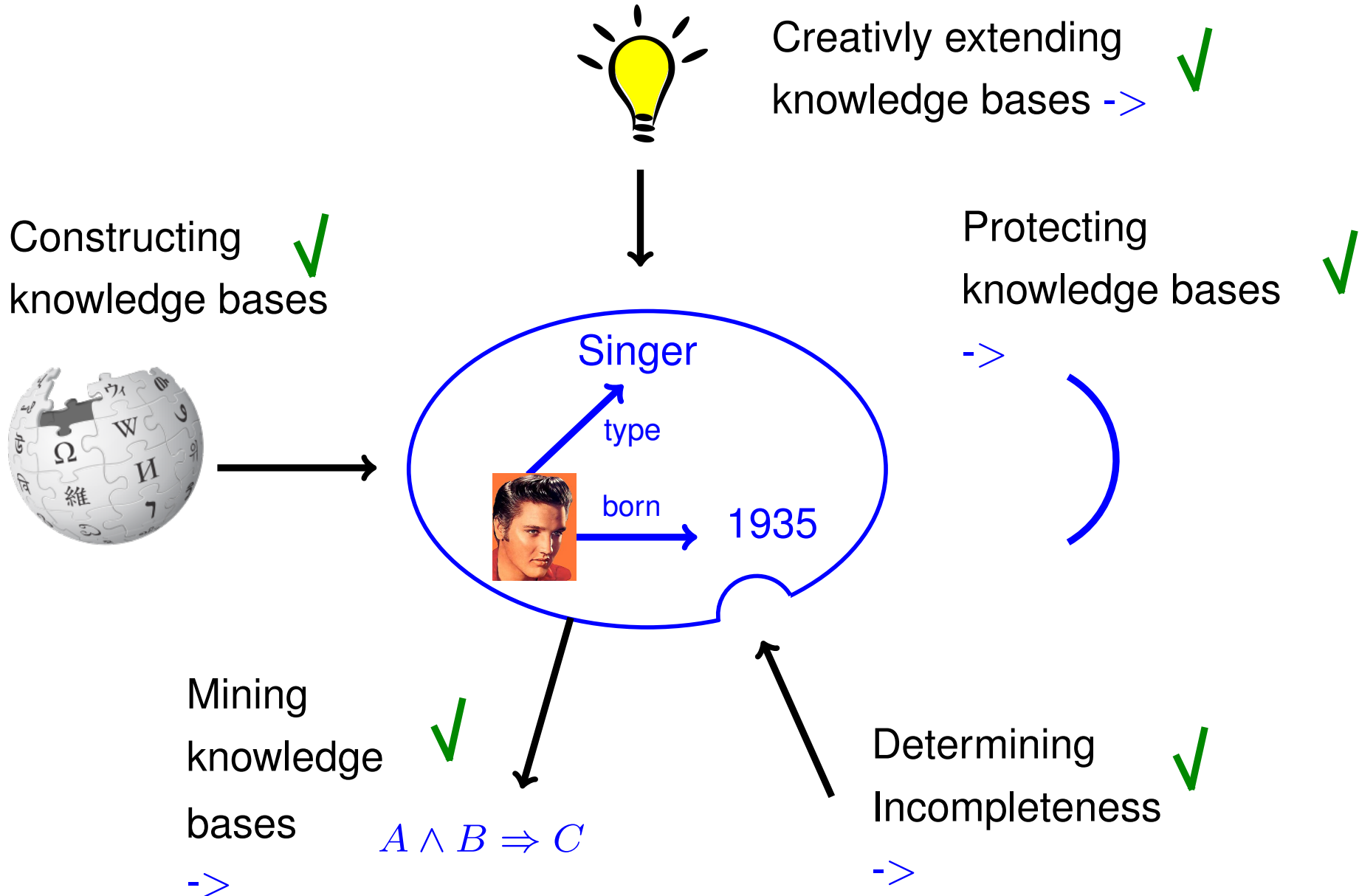


[AKBC 2013]



[VLDB 2014 vision]

Knowledge Base Life Cycle



Is Elvis dead?



Elvis Presley

Singer

Elvis Aaron Presley was an American singer and actor. Regarded as one of the most significant cultural icons of the 20th century, he is often referred to as "the King of Rock and Roll", or simply, "the King". [Wikipedia](#)

Died: August 16, 1977, [Memphis](#) [Tennessee](#), [United States](#)

Spouse: [Priscilla Presley](#) (m. 1967–1973)

Children: [Lisa Marie Presley](#)



???

Elvis $\xrightarrow{\text{died}}$ 1977



Is Elvis dead?



Elvis Presley

Singer

Elvis Aaron Presley was an American singer and actor. Regarded as one of the most significant cultural icons of the 20th century, he is often referred to as "the King of Rock and Roll", or simply, "the King". [Wikipedia](#)

Died: August 16, 1977, [Memphis](#) [Tennessee](#), [United States](#)

Spouse: [Priscilla Presley](#) (m. 1967–1973)

Children: [Lisa Marie Presley](#)



???

Elvis $\xrightarrow{\text{died}}$ 1977



100m statements

95% precision

-> 5m wrong statements

Knowledge Base Life Cycle

