Étude de transférabilité des clés pour le liage de données entre graphes de connaissances

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LABORATOIRE INTERDISCIPLINAIRE DES SCIENCES DU NUMÉRIQUE

Ingénierie des Connaissances
04 juillet 2023, Strasbourg, France

Motivation : linking entities across knowledge graphs

DBpedia

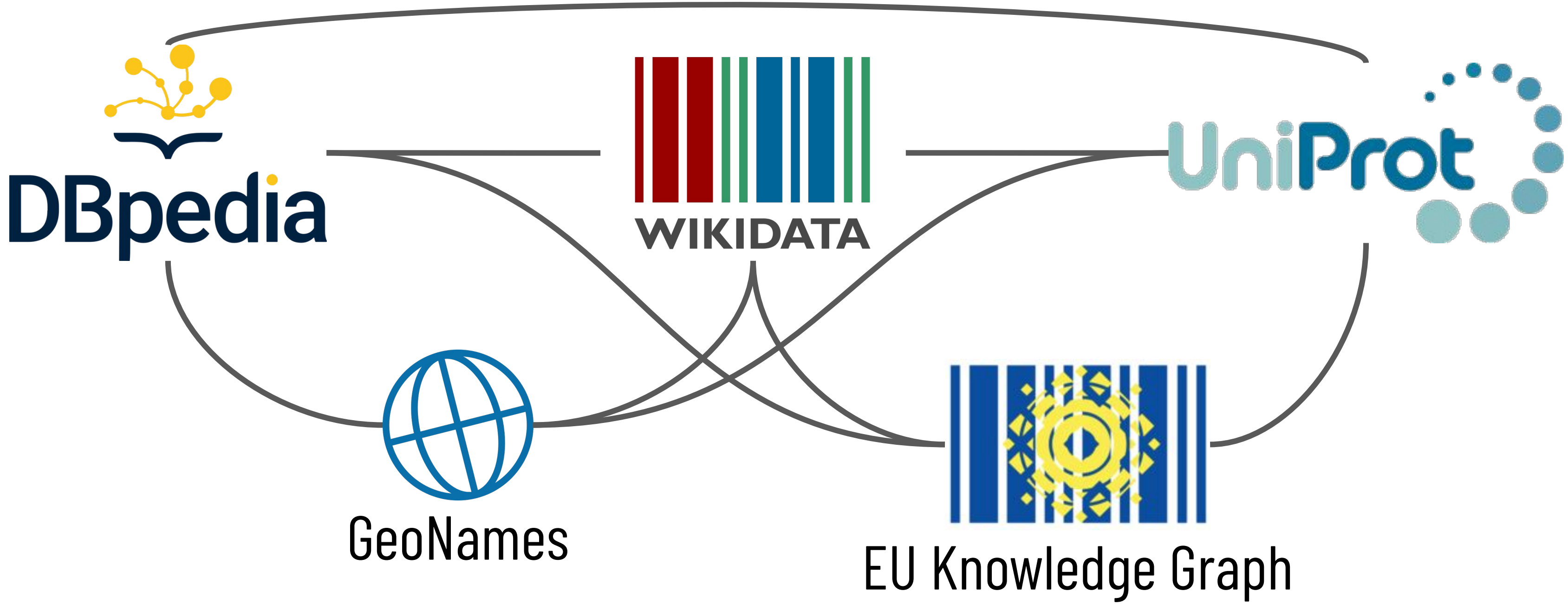
WIKIDATA

UniProt

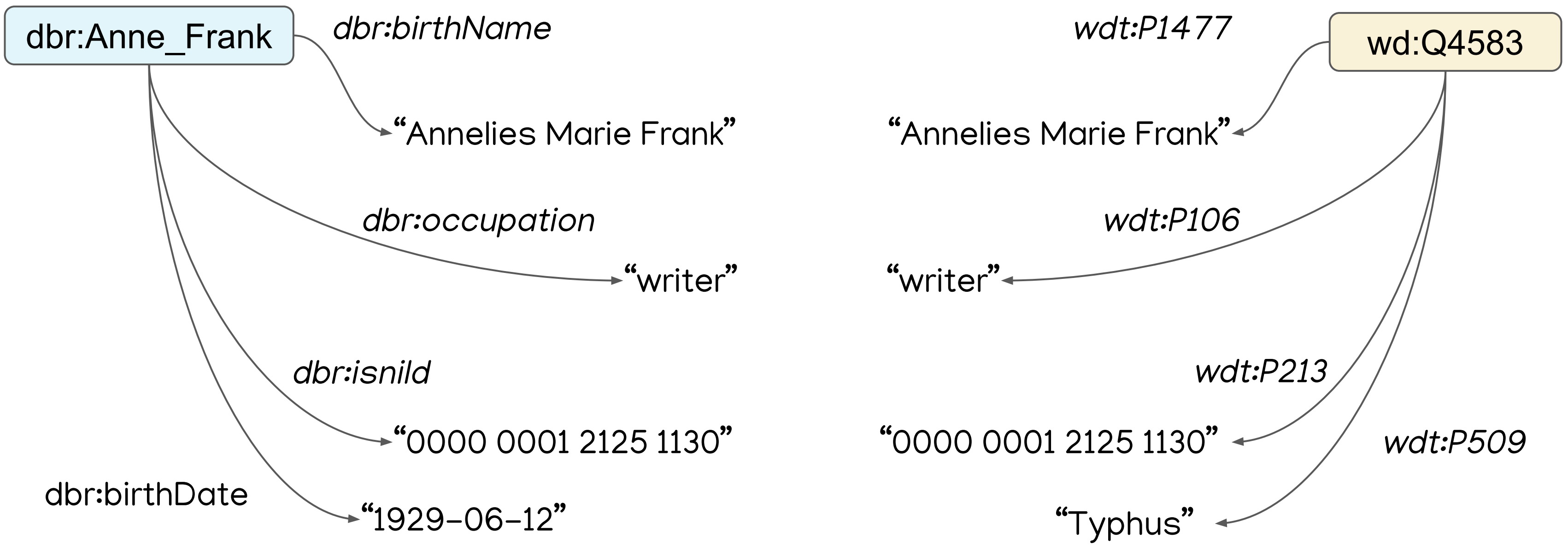
GeoNames

EU Knowledge Graph

Motivation : linking entities across knowledge graphs



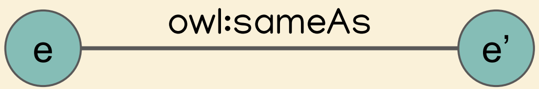
Entity linking problem in heterogeneous KGs



Motivation : linking entities across knowledge graphs

Machine learning based

- Embeddings, Tensors, GNN, ...
- Requires seeds



- Harder to explain to neophytes

Key based

- Does not require seeds
- Easy to explain
- Time consuming

Definition of Keys and Exception rate

We consider S-Keys [Atencia et al 14] that follows the semantics of OWL2 keys (**owl:hasKey**)

$$\forall x \forall y \forall z_1 ... z_n (C(x) \wedge C(y) \wedge \bigwedge_{i=1}^{n} (p_i(x, z_i) \wedge p_i(y, z_i)) \rightarrow \ x = y)$$

$$K = \{dbr : birthName, dbr : occupation\}$$

	BirthName	***Occupation***
e_1	Annelies Marie Frank	Writer
e_2	Alan Mathison Turing	
e_3	Alice Allison Dunnigan	Writer
e_4	Michelle Williams	Actor Singer
e_5	Michelle Williams	Actor TV host

[Atencia et al 14] Defining Key Semantics for the RDF Datasets: Experiments and Evaluations. ICCS 2014: 65-78

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$$K = \{dbr : birthName, dbr : occupation\}$$

$$ex(k) = 2 \qquad ex(k)_{norm} = \frac{ex(k)}{\#Entities} = \frac{2}{5}$$

	BirthName	***Occupation***
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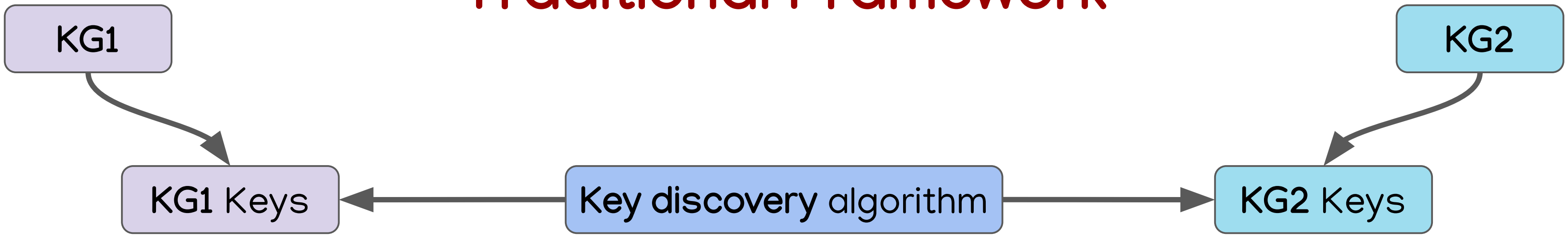
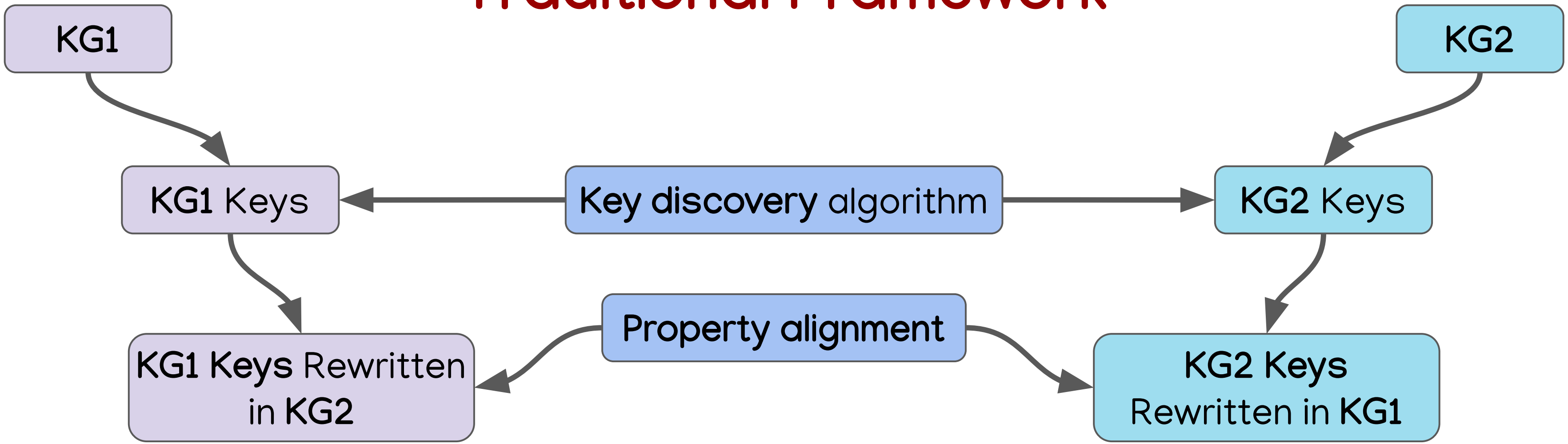
Traditional Framework



Traditional Framework



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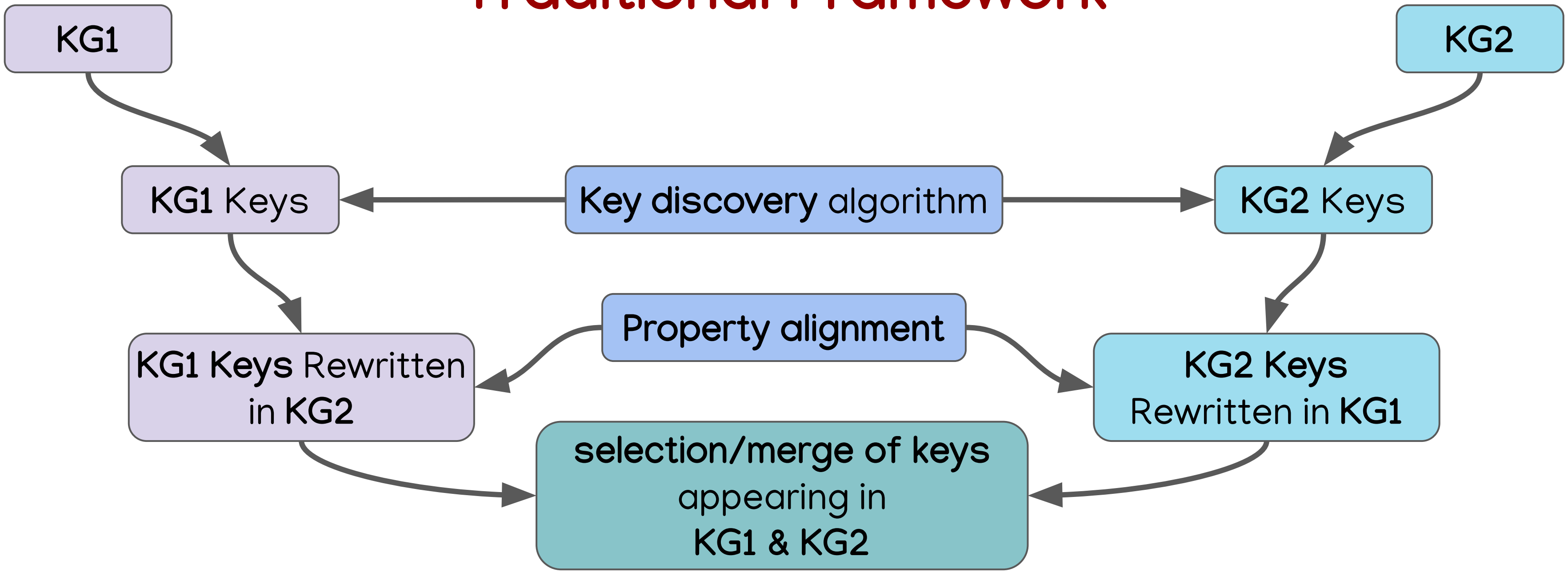

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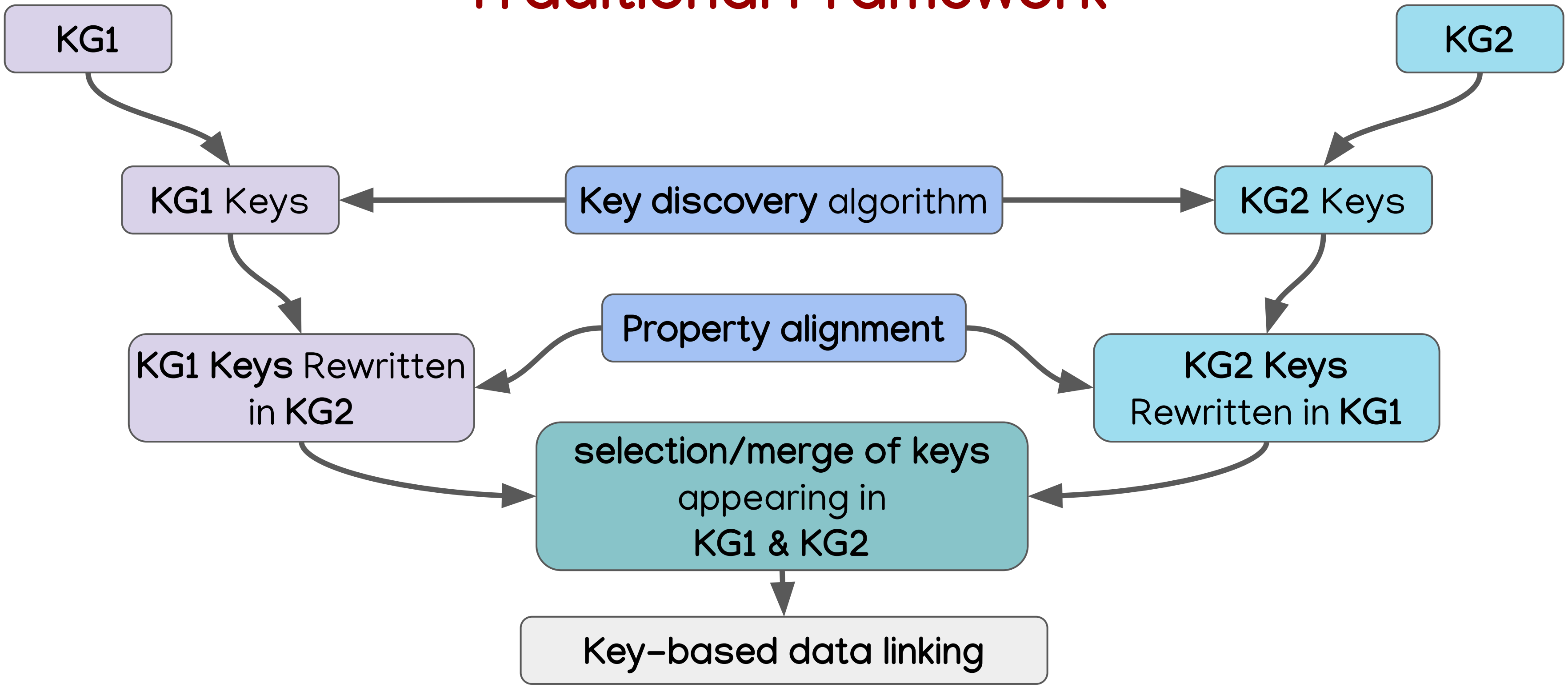
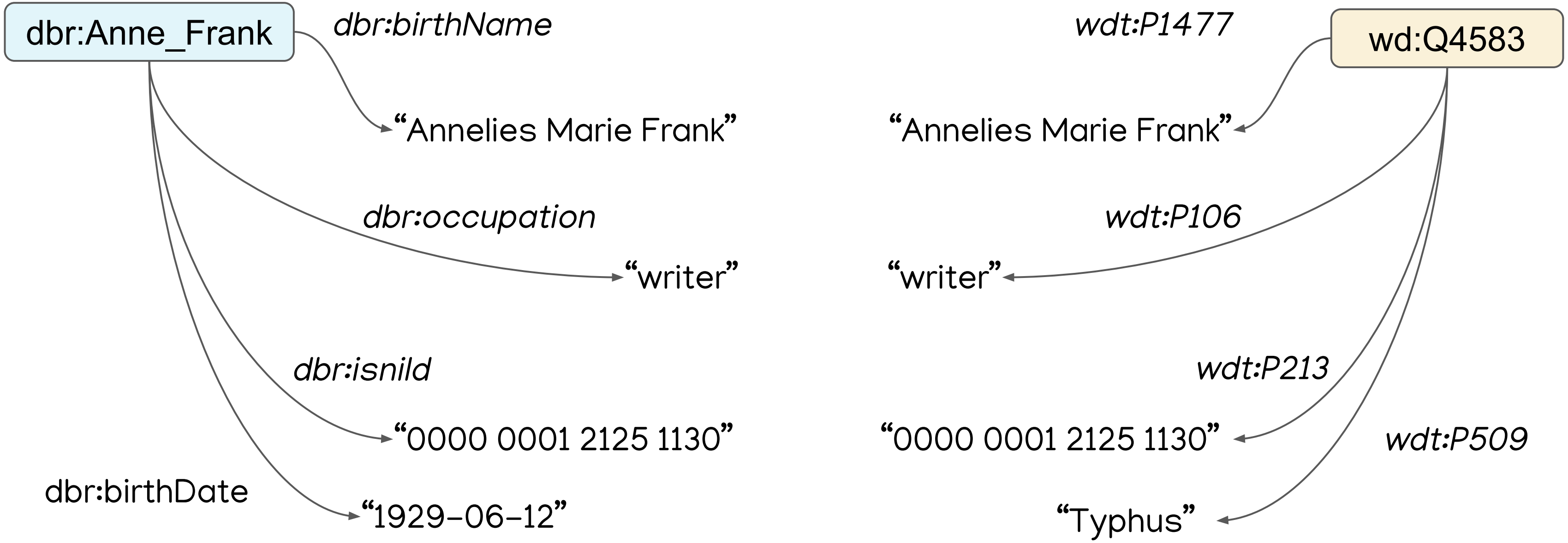


Running example of a key-based entity linking



Running example of a key-based entity linking

Key discovery algorithm

$$K_1 = \{dbr : isnId\}$$

$$K'_1 = \{wdt : P1477, wdt : P106\}$$

$$K'_2 = \{wdt : P213\}$$

$$K'_3 = \{wdt : P1477, wdt : P509\}$$

Running example of a key-based entity linking

Key discovery algorithm

Property alignment

dbr:birthName · *wdt:P1477*

EquivalentProperty

dbr:occupation · *wdt:P106*

EquivalentProperty

dbr:isnild · *wdt:P213*

EquivalentProperty

dbr:birthDate *wdt:P509*

Running example of a key-based entity linking

Key discovery algorithm

Property alignment

Key rewriting

dbr:birthName ············ wdt:P1477

$$K'r_1 = \{(wdt : P1477 \equiv dbr : birthName), (wdt : P106 \equiv dbr : occupation)\}$$

dbr:occupation ············ wdt:P106

dbr:isnild ············ wdt:P213

$$Kr_1 = \{(dbr : isnId \equiv wdt : P213)\}$$

$$K'r_2 = \{(wdt : P213 \equiv dbr : isnId)\}$$

Running example of a key-based entity linking

Key discovery algorithm

Property alignment

Key rewriting

$$K'r_1 = \{(wdt : P1477 \equiv dbr : birthName), (wdt : P106 \equiv dbr : occupation)\}$$

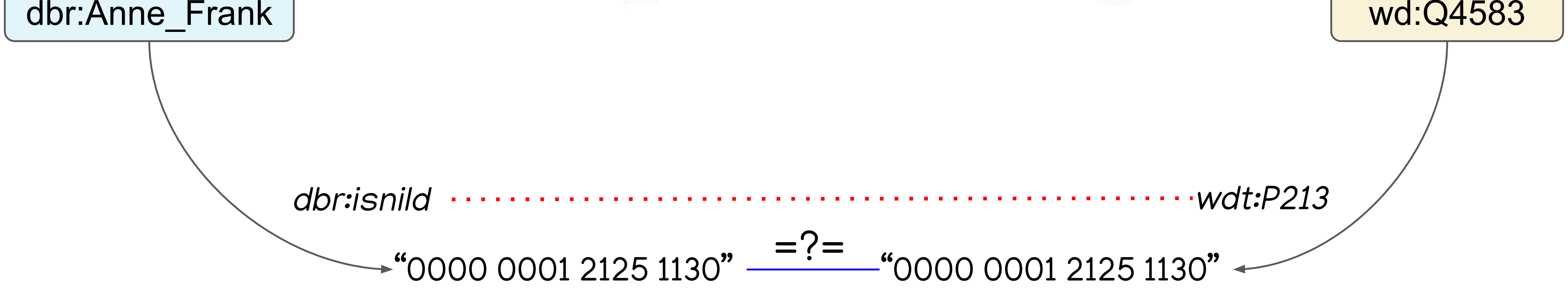
Key merge

$$Kr_1 = \{(dbr : isnId \equiv wdt : P213)\}$$

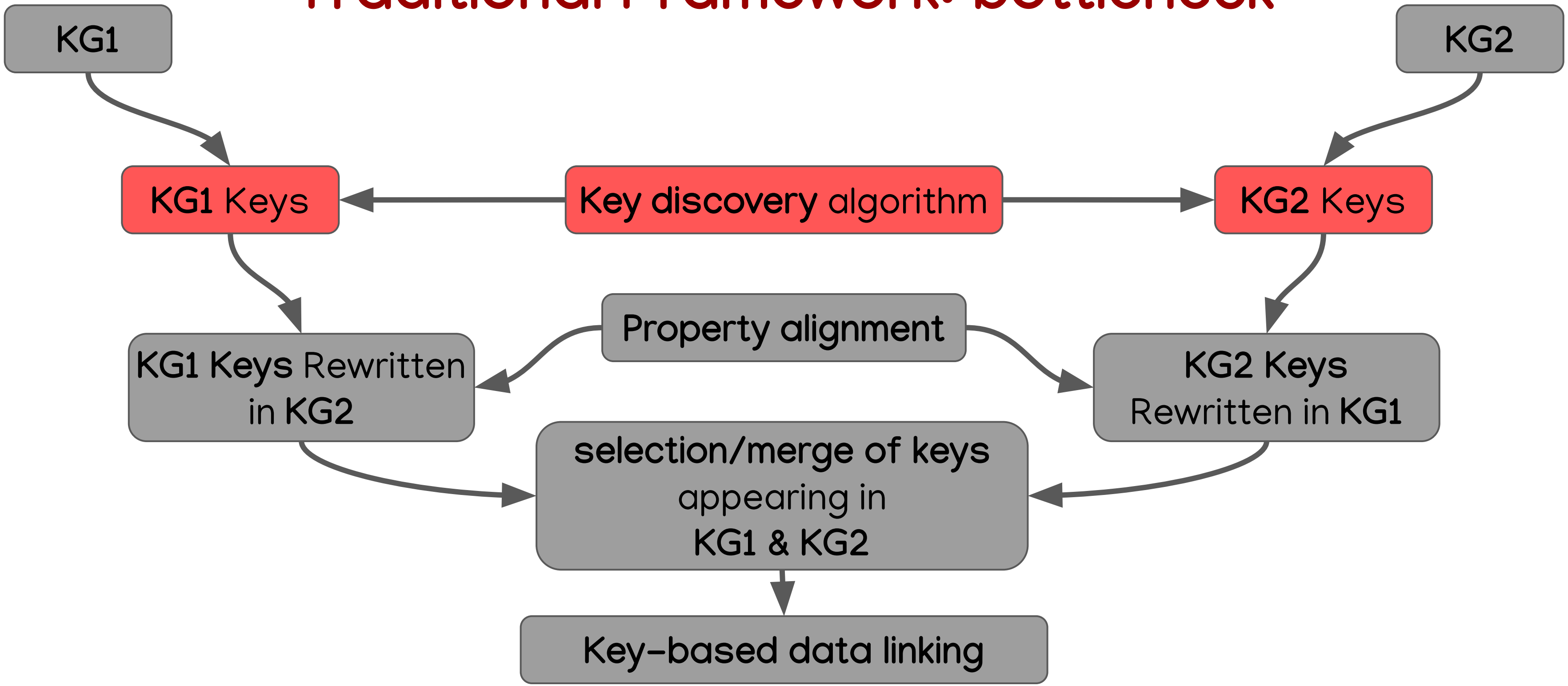
$$K'r_2 = \{(wdt : P213 \equiv dbr : isnId)\}$$

Running example of a key-based entity linking

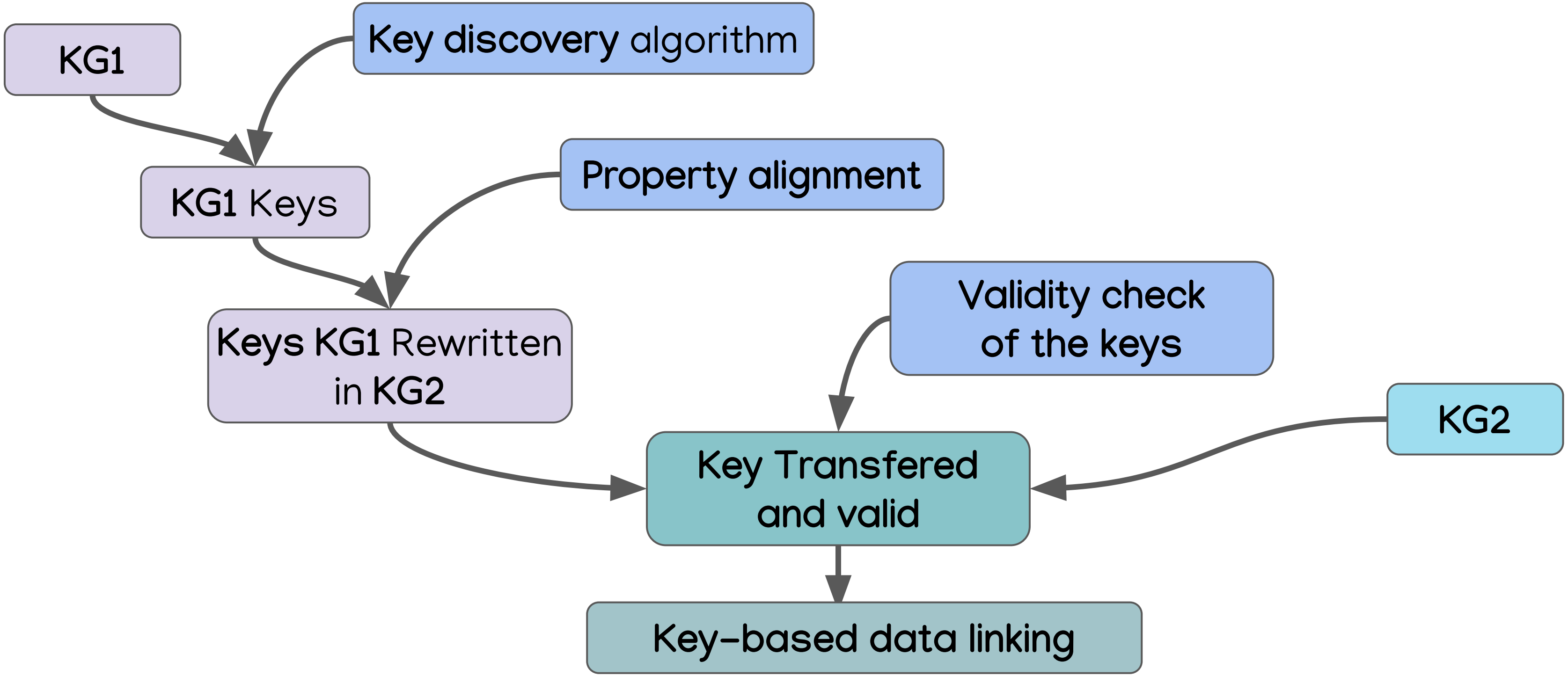
$$Kr_1 = \{(dbr : isnId \equiv wdt : P213)\}$$



Traditional Framework: bottleneck



Key transfer-based framework



Validity check of the keys

Is a key found in KG1 and rewritten in KG2 be a key in the KG2 ?

$$Kr_1 = \{(dbr : isnId \equiv wdt : P213)\}$$

Validity check of the keys

$$Kr_1 = \{(dbr : isnId \equiv wdt : P213)\}$$

	P1477 (BirthName)	*P106 (Occupation)*	*P213 (isnild)*
e_1	Annelies Marie Frank	Writer	0000 0001 2125 1130
e_2	Alan Mathison Turing		
e_3	Alice Allison Dunnigan	Writer	0000 0000 2348 3667
e_4	Michelle Williams	Actor Singer	
e_5	Michelle Williams	Actor TV host	

Validity check of the keys

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$$ex(Kr_2)_{norm} = 0$$

Validity check of the keys

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$$ex(Kr_2)_{norm} = 0.2$$

Validity check of the keys

$$Kr_1 = \{(dbr : isnId \equiv wdt : P213)\}$$

	P1477 (BirthName)	P106 (Occupation)	P213 (isnId)
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$$ex(Kr_2)_{norm} = 1$$

Validity check of the keys

Relative exception rate :

$$ex^R(k) = \frac{ex(k)}{support(k)}$$

Support : $support(k) = \mid \{x \mid \forall p \in prop(k), \exists y, (x, p, y) \in G\} \mid$

Research questions

- How much time do we gain ?

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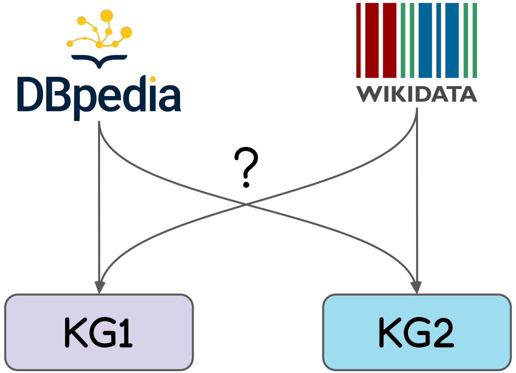
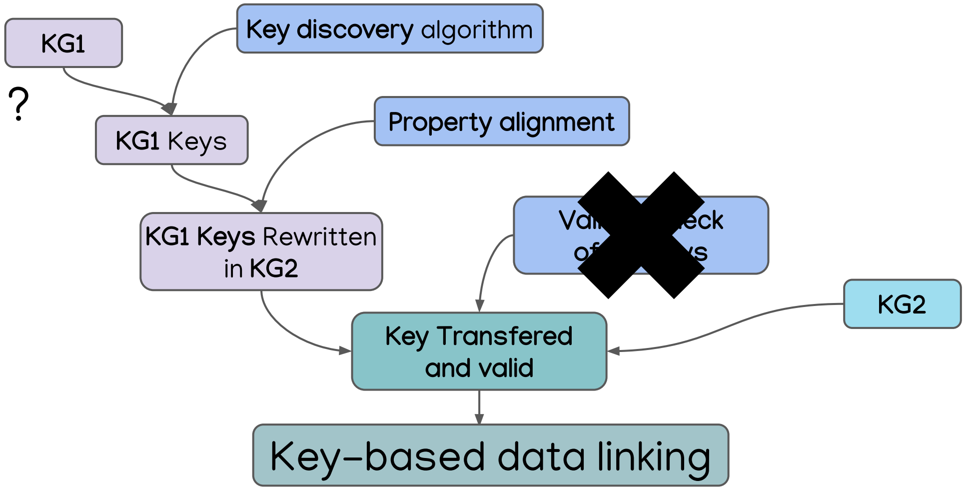
- Which graph for KG1 and KG2 ?



Research questions

- How much time do we gain ?
- Which graph for KG1 and KG2 ?
- Is the validity check necessary ?



Research questions

- How much time do we gain ?
- Which graph for KG1 and KG2 ?
- Is the validity check necessary ?
- How well this framework can perform on the linkage problem ?

Experiments: datasets

	# Triples	# Entities	# Relations
Wikidata : Q5	7 503 002	3 020 916	135
DBpedia : Human	12 474 844	1 863 013	239

Knowledge Graphs stats

Evaluation Results

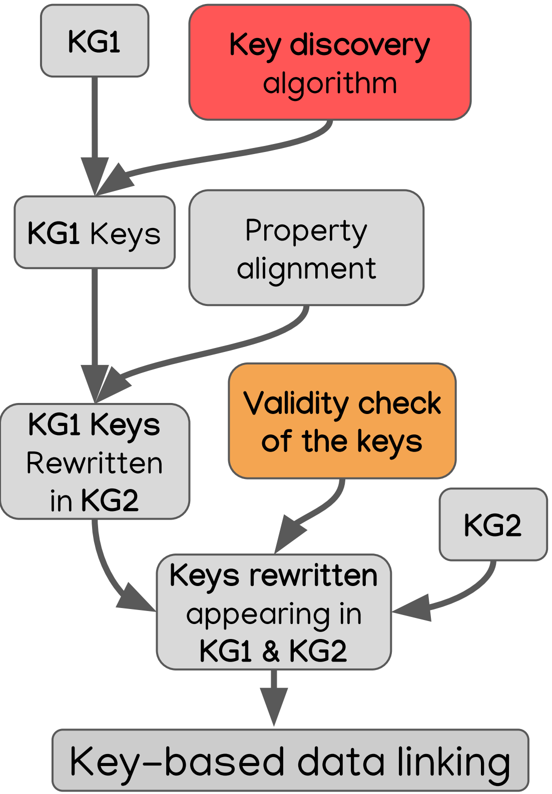
How much time was gained ?

	0	0.5%	1%	2%	3%	4%	5%	10%
New Start DB	100.95%	101.64%	101.61%	101.67%	101.70%	101.69%	101.71%	101.59%
New Start WK	4.52%	4.05%	4.05%	4.19%	4.10%	4.11%	4.08%	4.01%

Time relative of the new framework compared to the typical Framework

With a **good starting point,** we are able to drastically **reduce** the **total running time.**

Evaluation Results



Which graph for KG1 and KG2 ?

	# Triples	# Entities	# Relations
Wikidata : Q5	7 503 002	**3 020 916**	**135**
DBpedia : Human	12 474 844	**1 863 013**	**239**

Knowledge Graphs stats

KG1 should be the graph with the **fewest relations** to reduce the running time.

If we have a **similar number of relations,** ones should prioritize the **fewest entities** for KG2.

Evaluation Results

Is the validity check necessary ?

	ex^{R}_{max}	0%	0.5%	1%	2%	3%	4%	5%	10%
Start DB	**Key Rewritten Not verified**	69	64	64	64	65	65	65	68
	Key Rewritten Verified	49	52	52	54	56	56	56	60
Start WK	**Key Rewritten Not verified**	82	82	82	82	83	83	83	83
	Key Rewritten Verified	41	48	48	49	52	54	55	57

Number of Keys Rewritten before and after Verification

We cannot remove the **validity check** as we have a **great number of keys** that **degenerate.**

Evaluation Results

How well this framework can perform on the linkage ?

	ex^{R}_{max}	0%	0.5%	1%	2%	3%	4%	5%	10%
Start DB	**DB**	0.32%	80.72%	80.72%	80.72%	80.72%	80.72%	80.72%	80.72%
	WK	0.90%	28.88%	28.88%	28.89%	28.89%	28.89%	28.89%	28.89%
Start WK	**WK**	0.31%	0.88%	0.88%	0.88%	1.01%	1.03%	1.03%	1.03%
	DB	0.10%	80.73%	80.73%	80.73%	80.73%	80.73%	80.73%	80.73%

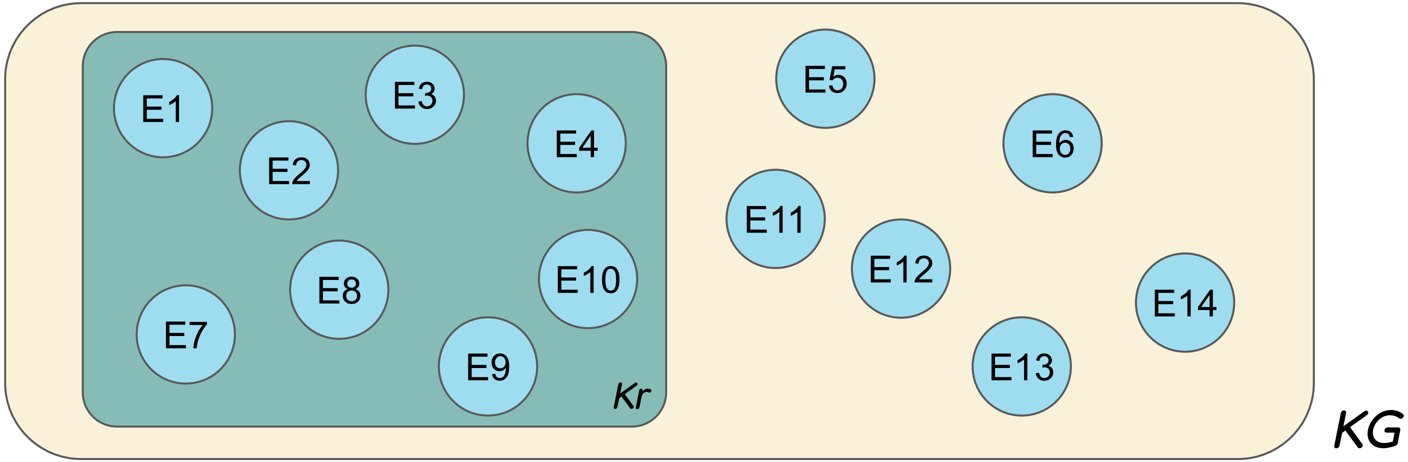
Percentage of entities that are distinguishable from every other by at least a key rewritten

DBpedia performs **well** with this **framework,** while the **start** with **Wikidata** is **poor.**

Evaluation Results

How well this framework can perform on the linkage ?

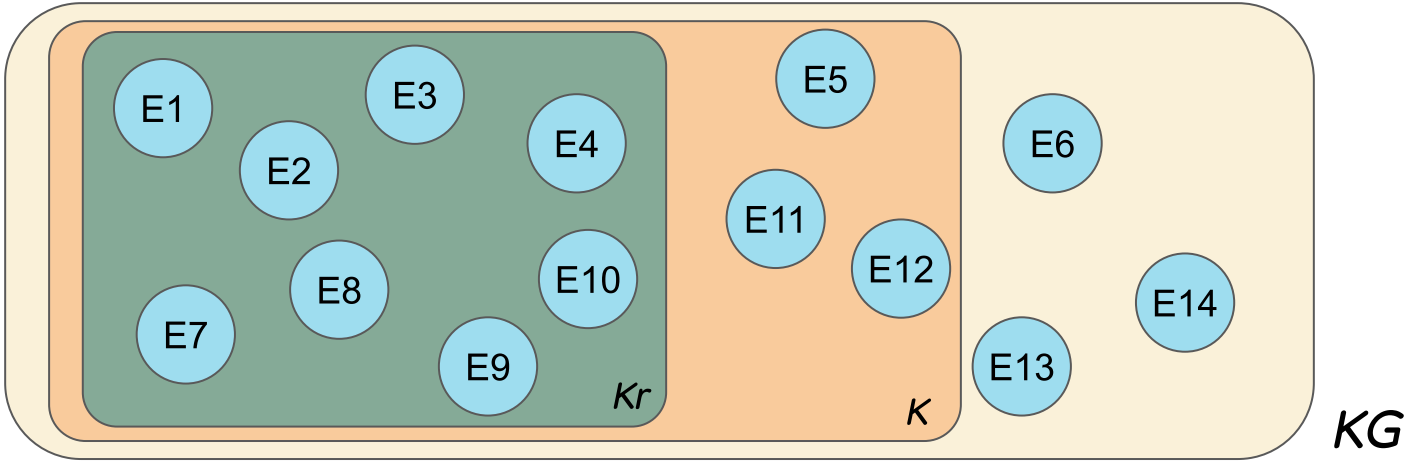
$$\frac{\#\ \textit{Entities Differentiated by a Kr}}{\#\ \textit{Entities}}$$



Evaluation Results

How well this framework can perform on the linkage ?

$$\frac{\#\ \textit{Entities Differentiated by a } Kr}{\#\ \textit{Entities Differentiated by a } K}$$



Evaluation Results

How well this framework can perform on the linkage ?

ex^{R}_{max}		0%	0.5%	1%	2%	3%	4%	5%	10%
Start DB	**DB**	0.39%	100%	100%	100%	100%	100%	100%	100%
	WK	18.67%	601.74%	600.60%	600.77%	600.50%	600.50%	600.50%	599.75%
Start WK	**WK**	6.46%	18.27%	18.24%	18.24%	20.98%	21.28%	21.28%	21.29%
	DB	0.12%	100%	100%	100%	100%	100%	100%	100%

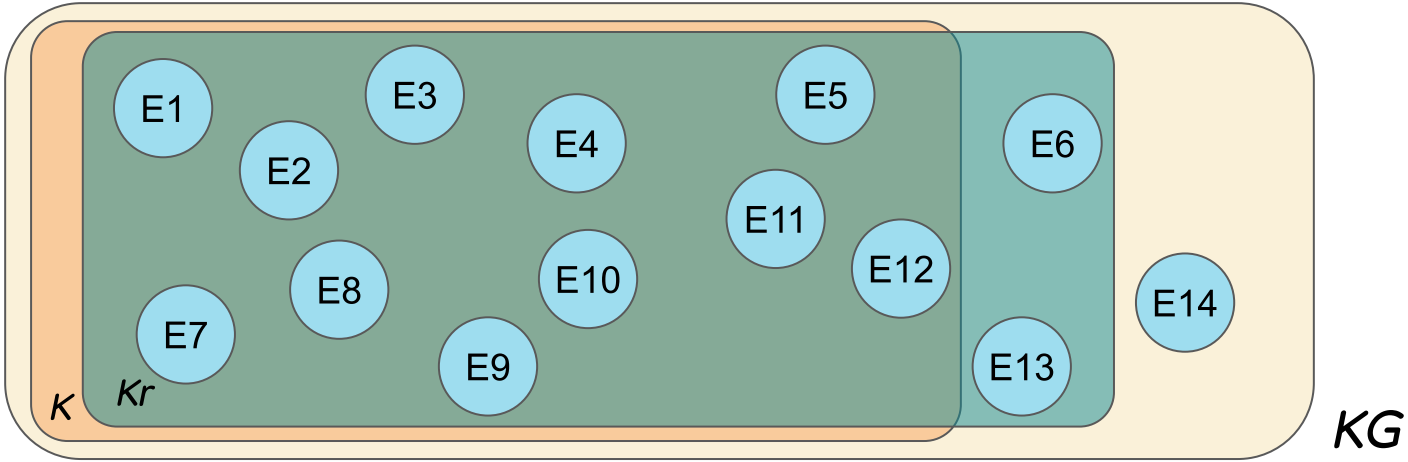
Percentage of entities (among those that are distinguished by a key from the graph) that are distinguishable from every other by at least a key rewritten

Through this metric we observe that **Wikidata** is better than we **anticipated** and this **framework** allows **better results** for **Wikidata** than the **traditional framework.**

Evaluation Results

How well this framework can perform on the linkage ?

$$\frac{\text{\# Entities Differentiated by a } Kr}{\text{\# Entities Differentiated by a } K}$$



Conclusion

- A **faster framework** to perform **key based entity linking.**
- A new definition of key validity based on **relative exception rate**
- A mixed result for the linking problem.
    - Close to the number of entities that can be differentiated through keys
    - Not enough entities to fully link all the entities

Future works

- **Deep study** of the behavior of **keys** under this new **relative exception rate**

- Use of a Catalog (**KeyMap**) to have an even **faster framework:**
  - We could store the keys found on KG1 and directly apply them to KGx, given by a new user

- Define an **unsupervised framework** for **machine learning based methods :**
  - We could overcome the **seed issue** by finding them through **our framework.**

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	Step	0	0.5%	1%	2%	3%	4%	5%	10%
Common DB & WK	*Key discovery DB*	313	301	306	296	301	301	303	307
	Key discovery WK	8.6	6.6	6.7	6.7	6.7	6.6	6.6	6.7
	Total	**322**	**308**	**313**	**302**	**308**	**308**	**310**	**314**
New Start DB	*Key discovery DB*	313	301	306	296	301	301	303	307
	Verification	11.7	11.7	11.7	11.7	11.9	11.9	11.9	11.7
	Total	**324.9**	**313.1**	**318.0**	**308.0**	**313.4**	**313.5**	**315.4**	**319.1**
New Start WK	*Key discovery WK*	8.6	6.6	6.7	6.7	6.7	6.6	6.6	6.7
	Verification	5.9	5.8	6.0	6.0	6.0	6.0	6.0	6.0
	Total	**14.6**	**12.5**	**12.7**	**12.7**	**12.6**	**12.7**	**12.7**	**12.6**

*Running time in **minute** per scenario and step*

Results

Is the validity check necessary ?

Reduce the necessity with a better Property Alignment. Especially because a transformer approach has a worst precision on abbreviation/unknown words.

"BAnQ author ID" ⇔ *"**Bibliothèque et Archives nationales du Québec** author ID"*

	Precision
Transformer (MPNET)	86.3%

But we could always be have difference in the data and thus we may still want this step.