Representability in *DL-Lite*$_\mathcal{R}$ Knowledge Base Exchange

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Outline

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1. Knowledge Base Exchange
2. Representability in *DL-Lite*$_\mathcal{R}$
3. Conclusions

Knowledge Base Exchange

Problem

given a mapping $\mathcal{M}$ and a source knowledge base (KB) $\mathcal{K}_1$,
compute a target KB $\mathcal{K}_2$ that is a *solution* for $\mathcal{K}_1$ under $\mathcal{M}$.

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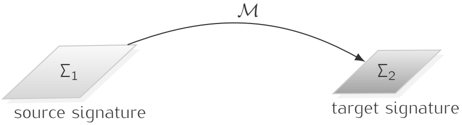

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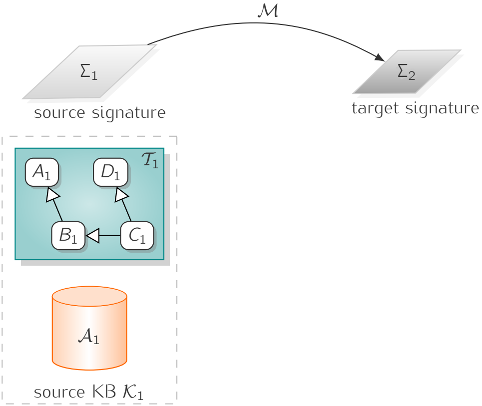

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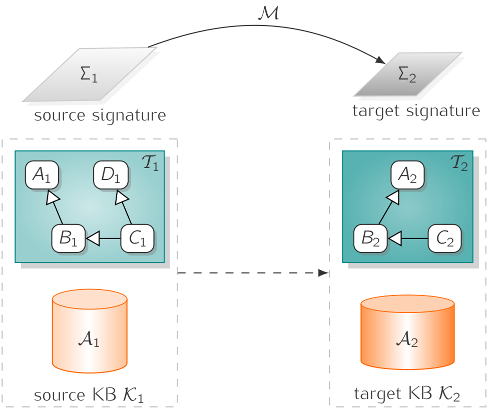

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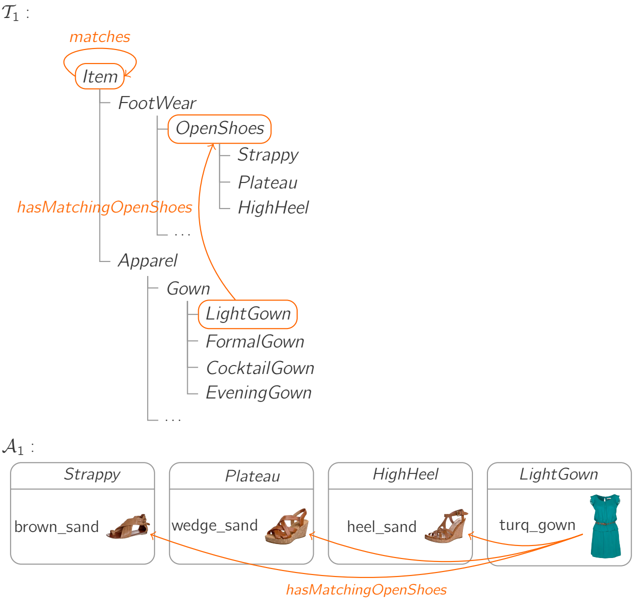

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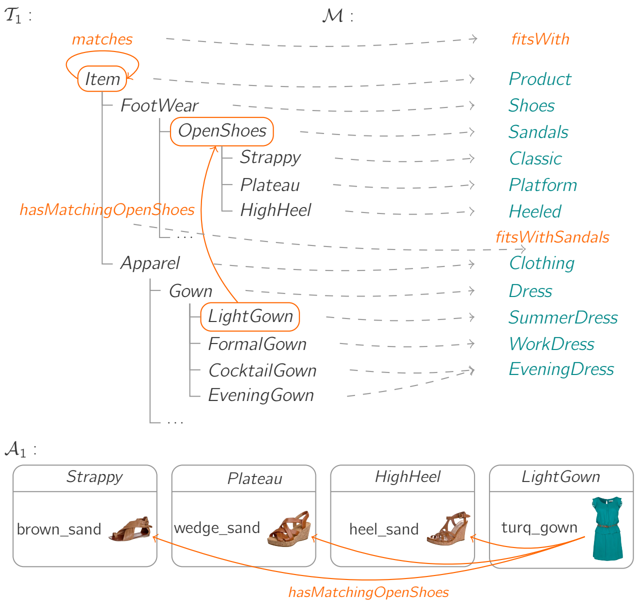

Example: Universal Solution

Definition

$\mathcal{K}_2$ is a *universal solution* for $\mathcal{K}_1$ under $\mathcal{M}$ if $\text{Mod}(\mathcal{K}_2) = \text{Mod}(\mathcal{K}_1 \cup \mathcal{M})|_{\Sigma_2}$.

Theorem

If $chase_{\mathcal{T}_1}(\mathcal{A}_1)$ is finite, then $chase_{\mathcal{T}_1 \cup \mathcal{M}, \Sigma_2}(\mathcal{A}_1)$ is a universal solution for $\langle \mathcal{T}_1, \mathcal{A}_1 \rangle$ under $\mathcal{M}$.

$\mathcal{T}_1 \cup \mathcal{M}$:

- *Item* → *Product*
  - *FootWear* → *Shoes*
    - *OpenShoes* → *Sandals*
      - *Strappy* → *Classic*
      - *Plateau* → *Platform*
      - *HighHeel* → *Heeled*
  - *Apparel* → *Clothing*
    - *Gown* → *Dress*
      - *LightGown* → *SummerDress*
    - …

$\mathcal{A}_1$:

Strappy

Plateau

HighHeel

LightGown

$\mathcal{A}_2^{univ}$:

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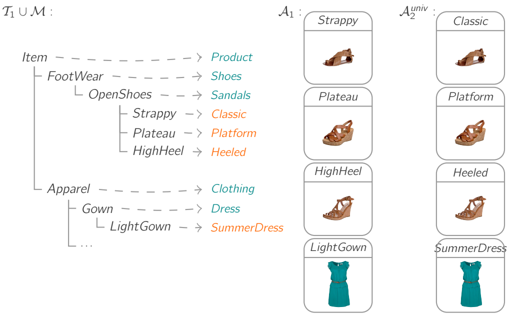

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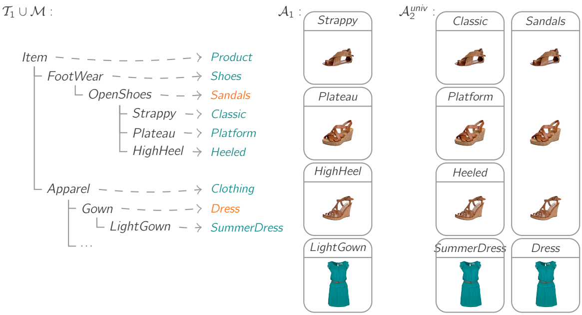

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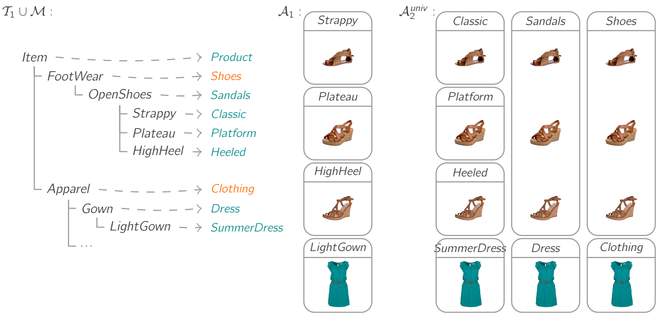

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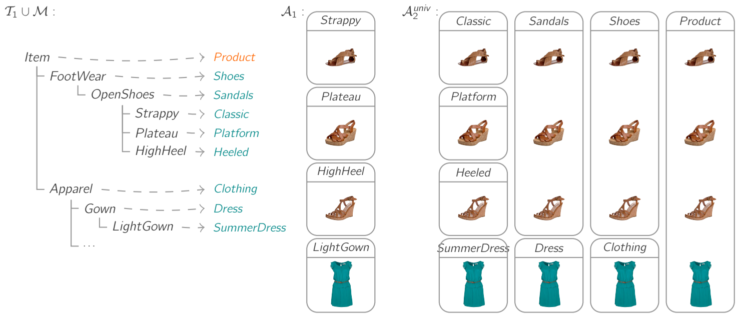

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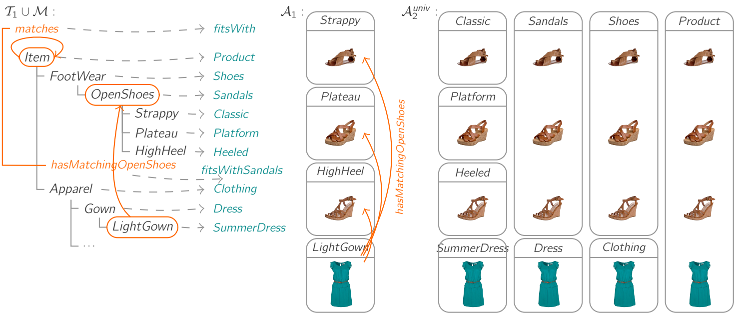

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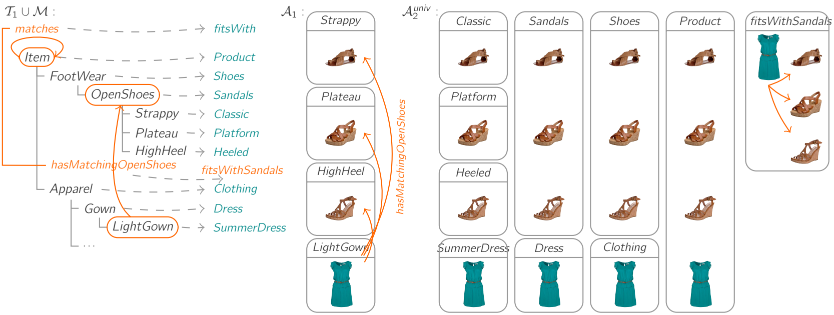

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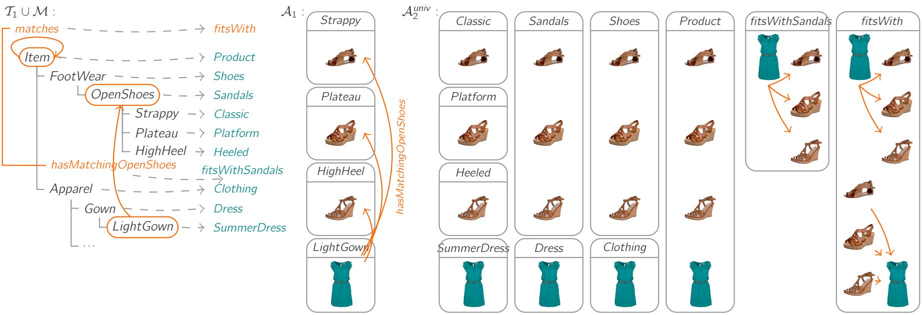
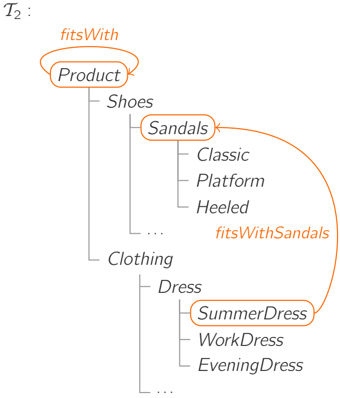


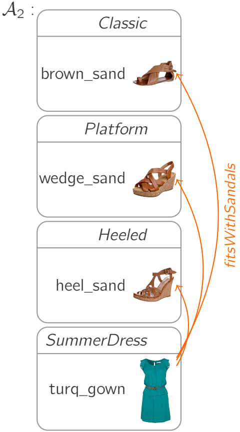
Example: Universal UCQ-solution

Definition

$\mathcal{K}_2$ is a *universal UCQ-solution* for $\mathcal{K}_1$ under $\mathcal{M}$ if for each UCQ q over Σ_2,

$$cert(q, \langle \mathcal{T}_1 \cup \mathcal{M}, \mathcal{A}_1 \rangle) = cert(q, \mathcal{K}_2).$$





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given a mapping $\mathcal{M}$ and a source TBox $\mathcal{T}_1$, decide whether there exists a target TBox $\mathcal{T}_2$, such that for each ABox $\mathcal{A}_1$ over Σ_1,

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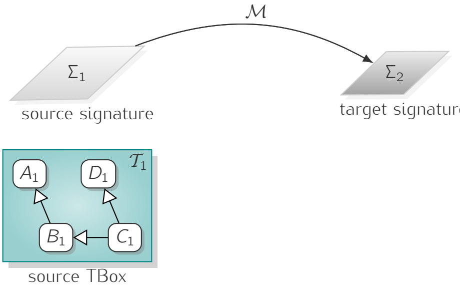

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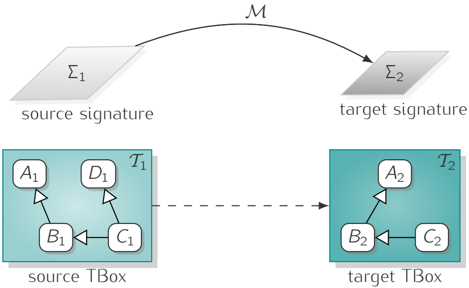

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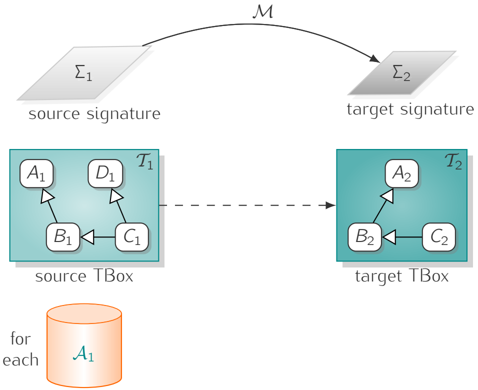

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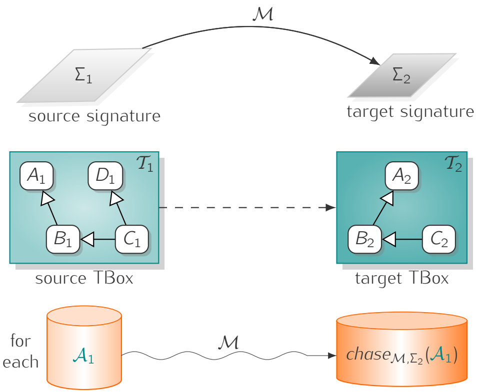

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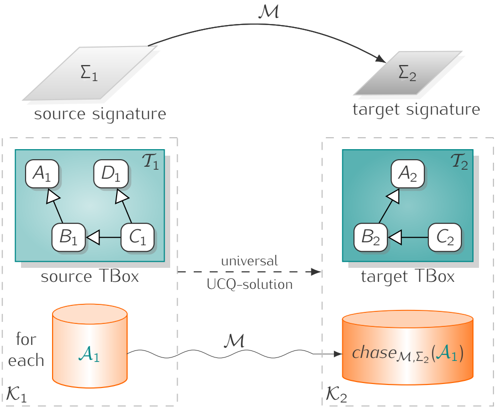


Representability: Example

$\mathcal{T}_1$:

- *FootWear*
  - *OpenShoes*

$\mathcal{M}$:

- *FootWear* ⇢ *Shoes*
- *OpenShoes* ⇢ *Sandals*

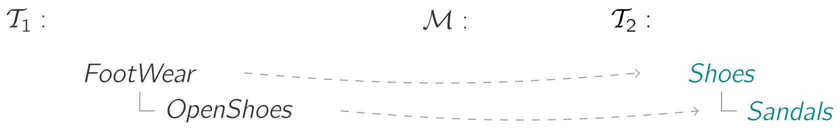
Representability: Example

$\mathcal{T}_1$: $\mathcal{M}$: $\mathcal{T}_2$:

FootWear ⇢ *Shoes*

└ *OpenShoes* ⇢ └ *Sandals*

Representability: Example



It is easy to see that $\mathcal{T}_2$ is a UCQ-representation of $\mathcal{T}_1$ under $\mathcal{M}$:

for each ABox $\mathcal{A}_1$ of the form $\{\mathit{OpenShoes}(\mathsf{s})\}$ or $\{\mathit{FootWear}(\mathsf{s})\}$,

$$\mathit{chase}_{\mathcal{T}_1 \cup \mathcal{M}, \Sigma_2}(\mathcal{A}_1) = \mathit{chase}_{\mathcal{M} \cup \mathcal{T}_2, \Sigma_2}(\mathcal{A}_1),$$

hence $\langle \mathcal{T}_2, \mathit{chase}_{\mathcal{M},\Sigma_2}(\mathcal{A}_1) \rangle$ is a universal UCQ-solution for $\langle \mathcal{T}_1, \mathcal{A}_1 \rangle$ under $\mathcal{M}$.

Representability: Progress

- In DL11, we solved the representability problem for *DL-Lite*$_{RDFS}$, i.e., TBox inclusions of the form

$$\begin{aligned} A_1 &\sqsubseteq A_2 \\ \exists R_1 &\sqsubseteq A_2 \\ R_1 &\sqsubseteq R_2 \end{aligned}$$

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\end{aligned}
$$

- In this work we address inclusions of the form

$$A_1 \sqsubseteq \exists R_2$$

Thus, we solve the representability problem for $DL\text{-}Lite_{\mathcal{R}}^{pos}$, the fragment of $DL\text{-}Lite_{\mathcal{R}}$ without disjointness assertions.

Checking Representability

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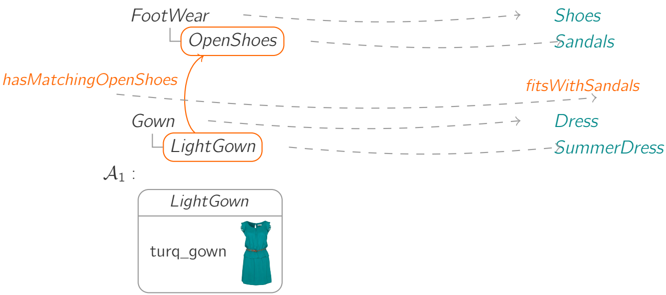
  - We also show that these conditions are necessary.

In what follows, I will show how to ensure that for each ABox $\mathcal{A}_1$ over Σ_1

$$chase_{\mathcal{T}_1 \cup \mathcal{M}, \Sigma_2}(\mathcal{A}_1) \rightarrow chase_{\mathcal{M} \cup \mathcal{T}_2, \Sigma_2}(\mathcal{A}_1).$$

Inclusion $A_1 \sqsubseteq \exists R_2$

$\mathcal{T}_1 \cup \mathcal{M}$:



Inclusion $A_1 \sqsubseteq \exists R_2$

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$\mathcal{A}_1$:

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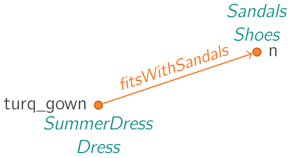

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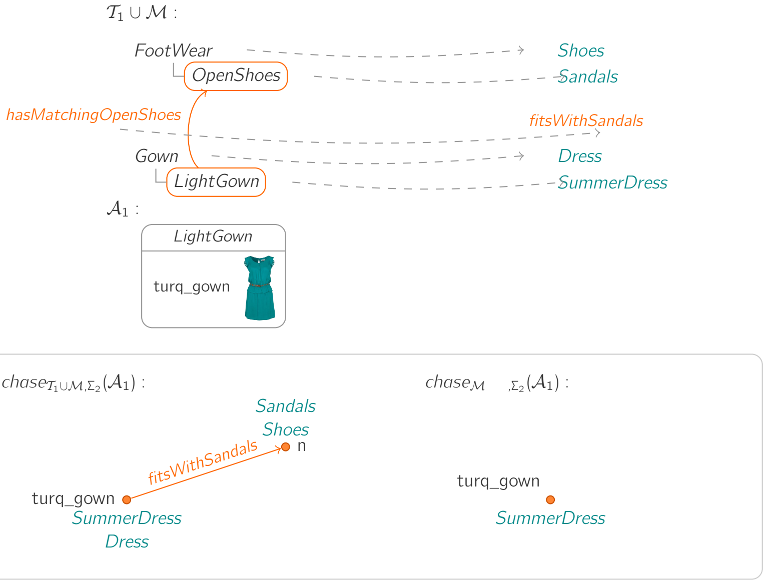

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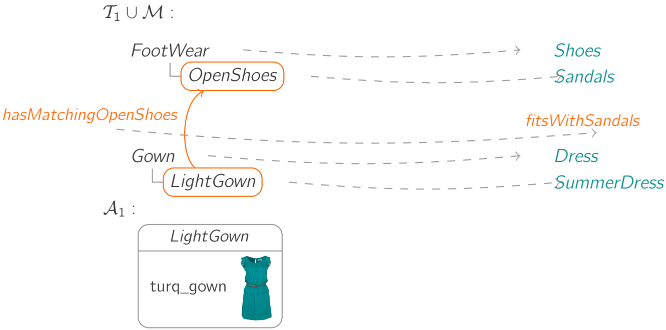

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$\mathcal{T}_1 \cup \mathcal{M}$:

FootWear ⇢ *Shoes*

└ *OpenShoes* ⇢ *Sandals*

hasMatchingOpenShoes ⇢ *fitsWithSandals*

Gown ⇢ *Dress*

└ *LightGown* ⇢ *SummerDress*

$\mathcal{A}_1$:

LightGown	
turq_gown	

$chase_{\mathcal{T}_1 \cup \mathcal{M}, \Sigma_2}(\mathcal{A}_1)$:

turq_gown (*SummerDress*, *Dress*) —*fitsWithSandals*→ n (*Sandals*, *Shoes*)

$chase_{\mathcal{M} \cup \mathcal{T}_2, \Sigma_2}(\mathcal{A}_1)$:

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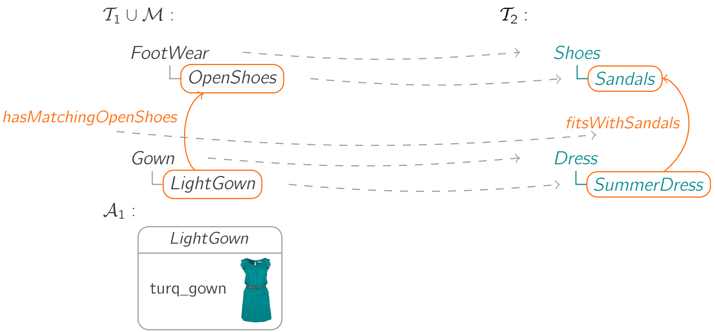

Inclusion $A_1 \sqsubseteq \exists R_2$ cont.

$\mathcal{T}_1 \cup \mathcal{M}$:

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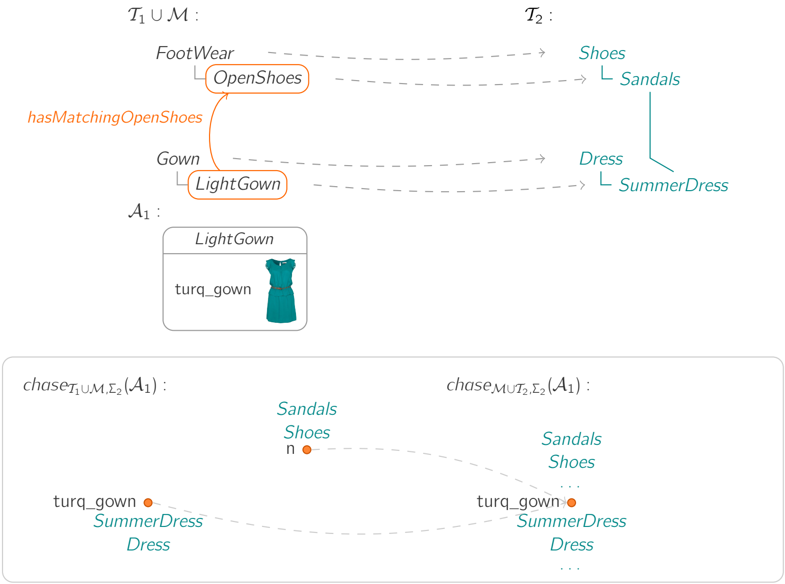

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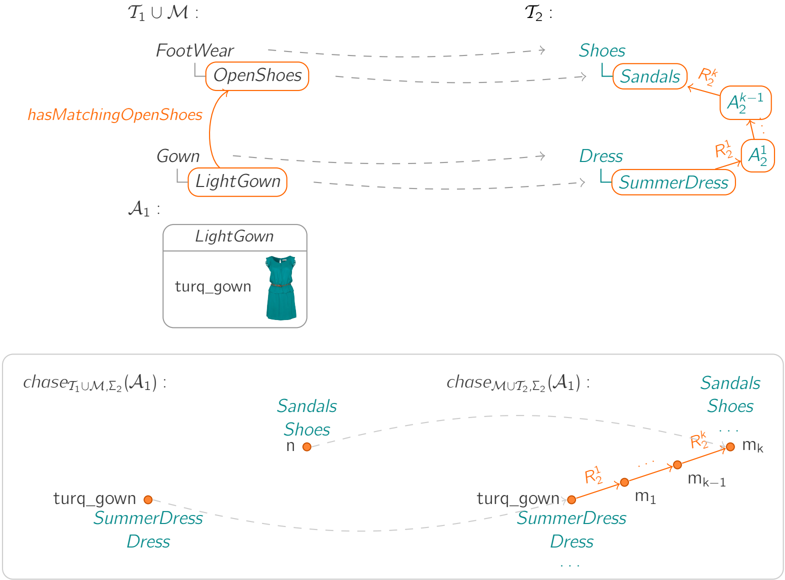


Deciding Representability in *DL-Lite*$_\mathcal{R}^{pos}$

Theorem

Let $\mathcal{M}$ be a DL-Lite$_\mathcal{R}^{pos}$ mapping and $\mathcal{T}_1$ a DL-Lite$_\mathcal{R}^{pos}$ TBox over Σ_1. Then we can check whether $\mathcal{T}_1$ is representable under $\mathcal{M}$ in polynomial time.

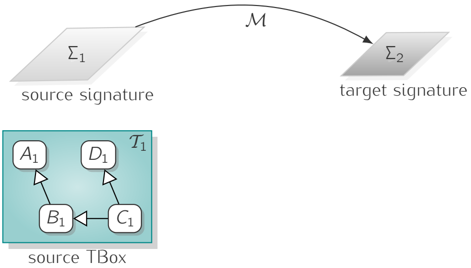
This algorithm is similar to the one for *DL-Lite*$_{RDFS}$:

- we construct the maximal possible TBox over Σ_2 and check whether it is a representation.
- If the check fails, then $\mathcal{T}_1$ is not representable under $\mathcal{M}$. Otherwise, this TBox is a representation.

Weak Representability

Problem

given a mapping $\mathcal{M}$ and a source TBox $\mathcal{T}_1$, decide whether there exists a mapping $\mathcal{M}^\star$ such that $\mathcal{M} \subseteq \mathcal{M}^\star$, $\mathcal{T}_1 \cup \mathcal{M} \models \mathcal{M}^\star$, and $\mathcal{T}_1$ is UCQ-representable under $\mathcal{M}^\star$.



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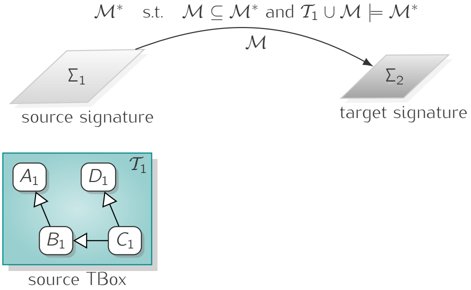

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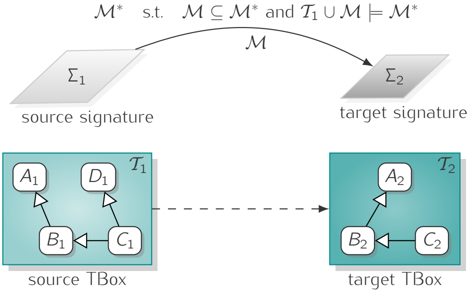

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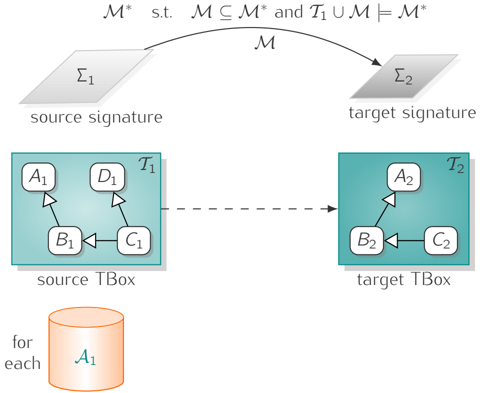

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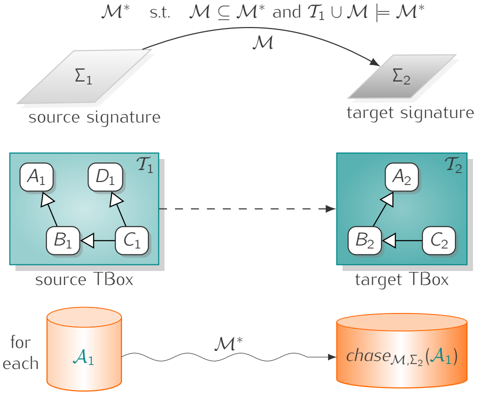

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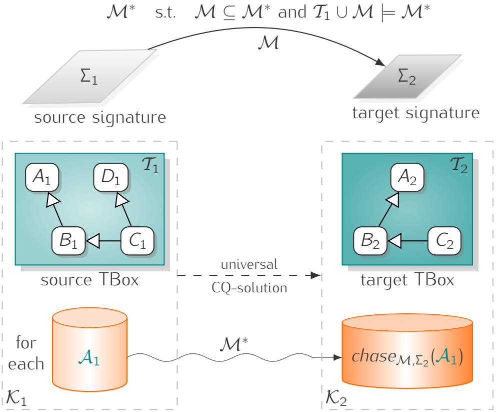

Deciding Weak Representability

Recall that every $\mathit{DL\text{-}Lite}_{\mathit{RDFS}}$ TBox is weakly representable under every $\mathit{DL\text{-}Lite}_{\mathit{RDFS}}$ mapping ($\mathcal{M}^\star$ is the maximal mapping s.t. $\mathcal{T}_1 \cup \mathcal{M} \models \mathcal{M}^\star$).

However, there exist a $\mathit{DL\text{-}Lite}_{\mathcal{R}}^{\mathit{pos}}$ mapping $\mathcal{M}$ and TBox $\mathcal{T}_1$ s.t.
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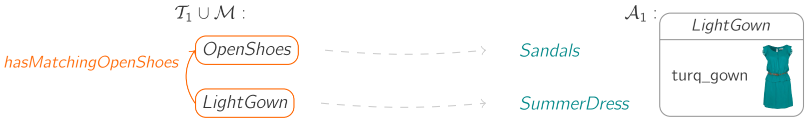

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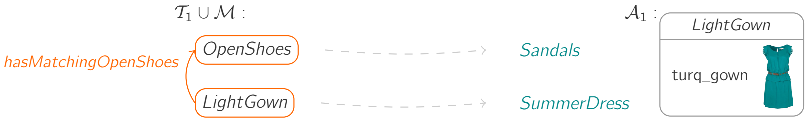

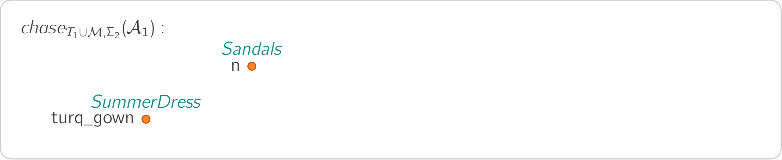

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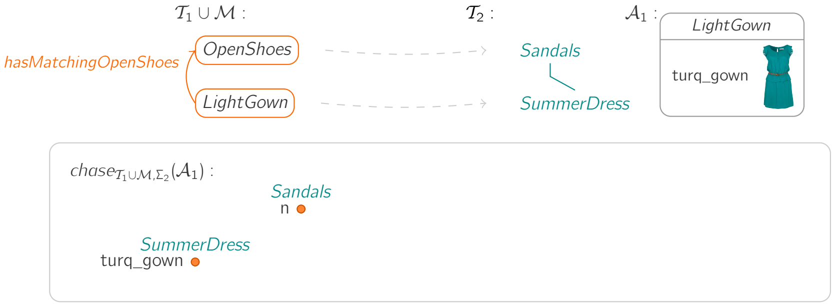

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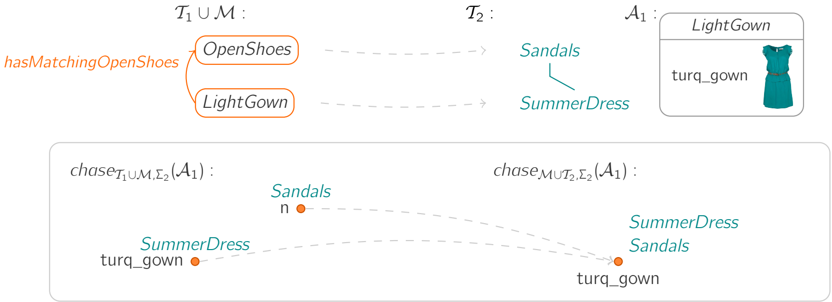

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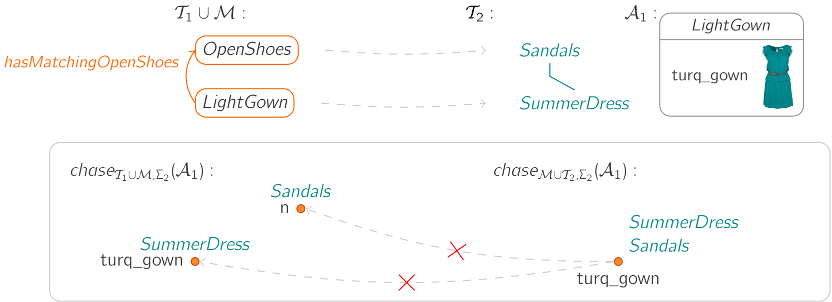

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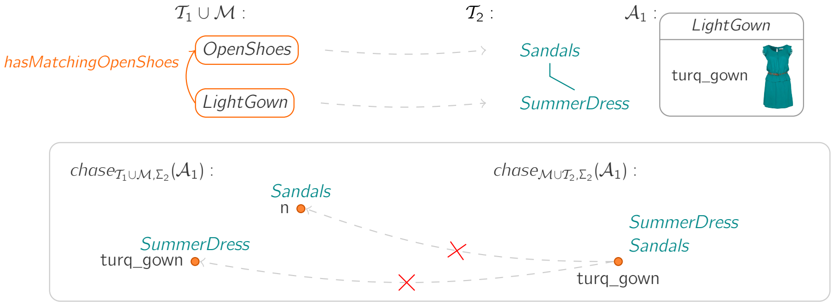

Theorem

Weak representability can be solved in polynomial time for DL-Lite$_{\mathcal{R}}^{pos}$ *mappings and TBoxes.*

Outline

Conclusions and Future Work

- We continued our work on KB exchange in *DL-Lite*.
- We addressed the problem of UCQ-representability in *DL-Lite*$_{\mathcal{R}}^{pos}$, the fragment of *DL-Lite*$_{\mathcal{R}}$ without disjointness assertions.
- We showed that the problem of representability and weak representability of a *DL-Lite*$_{\mathcal{R}}^{pos}$ TBox under a *DL-Lite*$_{\mathcal{R}}^{pos}$ mapping is decidable in polynomial time.
- To solve representability in full *DL-Lite*$_{\mathcal{R}}$ it remains to add disjointness constraints.
- There are also other open problems in the context of KB exchange, e.g., computing universal solutions, checking solution etc.

Thank you
for your attention!