Practical Update Management in Ontology-based Data Access

Giuseppe De Giacomo[1] Domenico Lembo[1] Xavier Oriol[2]
Domenico Fabio Savo[1] Ernest Teniente[2]

[1] Sapienza Università di Roma

SAPIENZA
UNIVERSITÀ DI ROMA

[2] Universidad Politècnica de Catalunya

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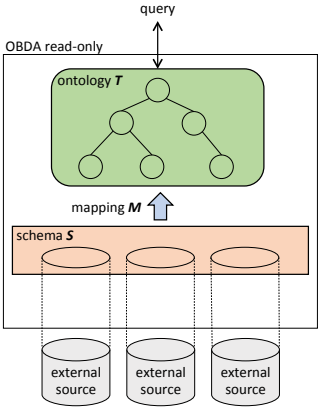
(Read-only) Ontology-based Data Access Systems

Ontology-based data access (OBDA) is a (virtual) data integration paradigm.



- The ontology provides a formal conceptualization of a domain of interest.
- The mapping specifies the relationship between the ontology and the source schema
- In OBDA, users access only the ontology, while the external data sources remain autonomous

– So far, huge research effort on query answering (**read-only OBDA**)
– Less attention to instance-level updates, i.e., changes at the extensional level of the OBDA system (write-also OBDA)

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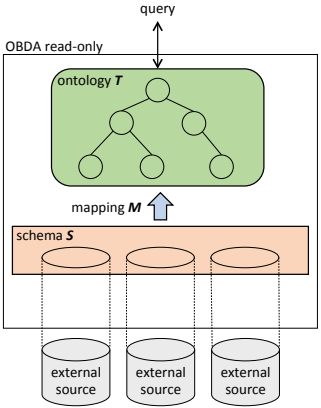

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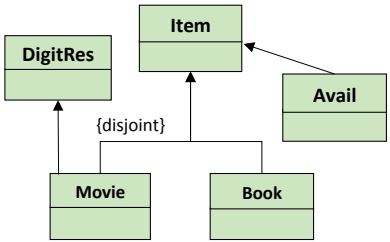
Example: ontology-level insertion

Ontology (TBox)



Source Database:
T_Movie(Alien), T_Book(Ubik),
T_Copy(Ubik,C1), T_Copy(Ubik,C2),
T_Borrow(C1,Bob)

Mapping:
Movie(x):- T_Movie(x)
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Insert Item(Matrix) → If we push the update to the sources we have to insert T_Movie(Matrix), T_Book(Matrix), or T_Copy(Matrix,_?_)!

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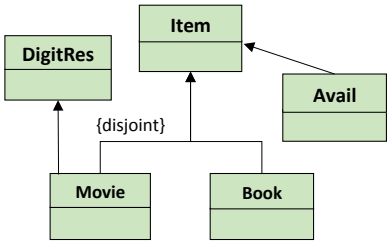

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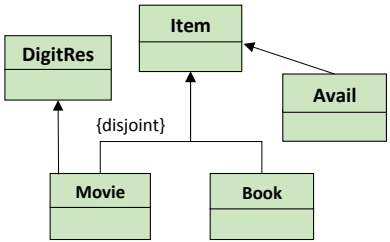

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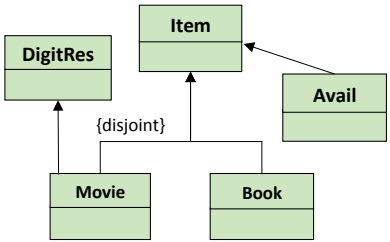

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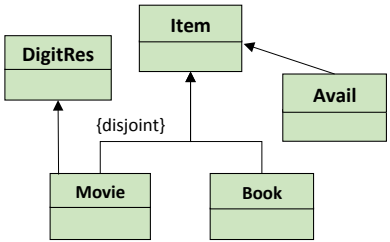

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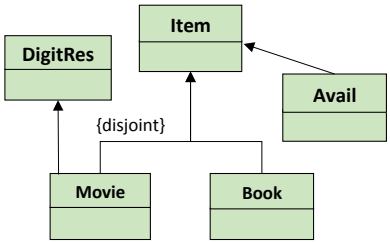

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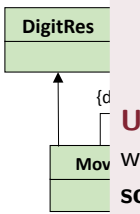

Ontology-level Update (pushed to the sources)

Unwanted Behaviour: we cannot always find a reasonable way to push the update at the sources. Also, we **compromise sources autonomy**

ow(y,z)

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Write-also Ontology-based Data Access

We use auxiliary **ins/del tables** to store the changes without modifying the sources, and change the mapping $\mathcal{M}$ into a mapping $\mathcal{M}'$ in the following way:

1. For each atomic concept/role N, add $N(\vec{x})$:- $ins\_N(\vec{x})$;
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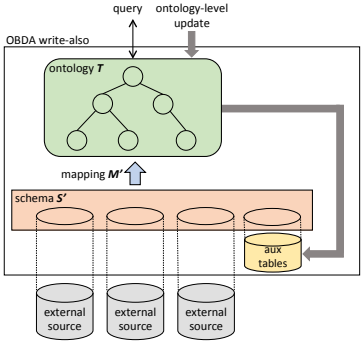

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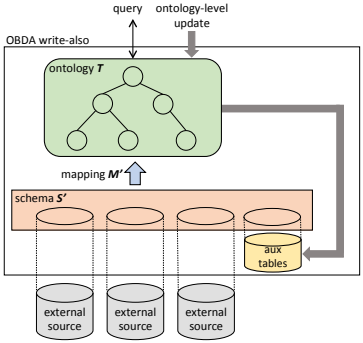

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Dealing with inconsistency

Problem: new information may **contradict** the old one.

Example: We want **insert** Book(Alien), but the system implies Movie(Alien) and the ontology states that Book $\sqsubseteq \neg$Movie

We use an update operator that:

- obeys to the **success of update principle** (e.g., after the update Book(Alien) has to be **implied**);
- obeys to the **minimal change principle**: to preserve consistency **minimal** deletions are performed (e.g., Movie(Alien) has **not** to be implied after the update);
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This update semantics is presented in *[De Giacomo et al. ISWC16]* for stand-alone ontologies.
For *DL-Lite*$_\mathcal{A}$ (i.e., OWL 2 QL) ontologies the result of the update is **unique**, and can be computed through a non-recursive Datalog program.

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Non-recursive Datalog encoding for ontology-level updates

To compute the actions we need to accomplish ontology-level updates, we use a Datalog program (adapted from *[De Giacomo et al. ISWC16]*).

Example: As said, in response to an update **Insert** Book(Alien), our operator realizes the asked insertion, and additionally asks to **remove** Movie(Alien) and **insert** DigitRes(Alien).

ins_Book_req(Alien). T_Movie(Alien).

Book(x) :- T_Book(x). ins_Book'(x) :- ins_Book_req(x),¬Book(x).
Movie(x) :- T_Movie(x). del_Movie'(x) :- Movie(x), ins_Book_req(x).
ins_DigitRes'(x):- del_Movie'(x),¬del_DigRes(x).
... ...

According to the program results we modify ins/del tables as follows:

foreach *fact ins_N'($\vec{t}$)* **do if** *del_N($\vec{t}$)* **then** remove *del_N($\vec{t}$)* **else** insert *ins_N($\vec{t}$)*
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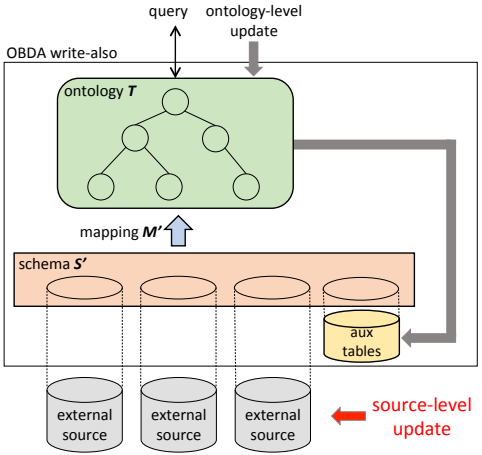
Source-level updates

What happens when the sources are updated?



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What happens when the sources are updated?

- The sources are modified in any case.
- We compute how source updates **are reflected** at the ontology level, based on the mapping (we use event rules by *[Urpí et al. VLDB92]*).

  Example:

  $\text{ins\_Book\_sl(x)} \;\text{ :- ins\_T\_Book(x)}, \neg\, \text{T\_Book(x)}.$
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  We align **ins/del** tables (e.g., remove ins_Movie(StarWars) if ins_Movie_sl(StarWars) holds because of ins_T_Movie(StarWars)) since this info comes now from the sources) .

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Turning source-level into ontology-level updates: Incoherency problem

ontology-level updates induced by source-level ones may be incoherent (i.e., the update alone might contradict the ontology):

- As usual in update theory, we assume that ontology-level updates directly specified by users are coherent with the ontology.
- Instead, ontology-level updates induced by source level ones simply reflect the behaviour of the (autonomous) sources, which are not required to maintain data that satisfy the ontology.

Example: a source-level update may at the same time insert both

$$\mathsf{T\_Movie(DaVinciCode)} \text{ and } \mathsf{T\_Book(DaVinciCode)},$$

which turned into an ontology-level update actually asks to insert both

$$\mathsf{Movie(DaVinciCode)} \text{ and } \mathsf{Book(DaVinciCode)},$$

which thus contradict $\mathsf{Movie} \sqsubseteq \neg\mathsf{Book}$.

Dealing with incoherent updates

We repair the ontology-level updates **inferred** by source-level ones:

Given one such update $\mathcal{U} = \langle \mathcal{A}^+, \mathcal{A}^- \rangle$, where $\mathcal{A}^+$ are insertions and $\mathcal{A}^-$ are deletions, and a *DL-Lite*$_\mathcal{A}$ TBox $\mathcal{T}$, we take the intersection $\mathcal{A}^+_{rep}$ of all the maximal $\mathcal{T}$-consistent subsets of the $\mathcal{T}$-closure of $\mathcal{A}^+$.
Then the repaired update is $\mathcal{U}_{rep} = \langle \mathcal{A}^+_{rep}, \mathcal{A}^- \rangle$.

Note: the $\mathcal{T}$-closure of an ABox $\mathcal{A}$ is the set $\{\alpha \mid \alpha \text{ is a fact s.t. } \langle \mathcal{T}_p, \mathcal{A} \rangle \models \alpha\}$, where $\mathcal{T}_p$ is the set of all positive inclusions in $\mathcal{T}$.

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$\mathcal{A}^+_{rep} = \{\textbf{Item(DaVinciCode),DigitRes(DaVinciCode)}\}$

Source-level updates: wrapping up the technique

1. We defined a second non-recursive Datalog program that
   - turns source-level updates into ontology-level ones (by adapting event rules from [Urpí et al. VLDB92])
   - separates coherent updates from incoherent ones
   - repairs incoherent updates
2. On the basis of the evaluation of the above program on top of the current state of the data at the sources and auxiliary tables and the update at the sources we
   (i) align ins/del tables, and
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Conclusions

- We have defined a framework for write-also OBDA that allows for both ontology-level and sources-level updates.
- We also provide practical algorithms based on non-recursive Datalog programs for computing both kinds of updates.
- In doing this, we have devised solutions to deal with incoherent updates, as those possibly induced by source-level updates.
- We have shown that computing both ontology-level and source-level updates is in AC^0 w.r.t. data complexity, which is the usual desired complexity for OBDA tasks.

- We are currently working on an implementation and evaluation of our technique, as well as on the investigation of alternative semantics to deal with incoherent updates.


ngiyabonga
danke
謝謝
рахмат
teşekkür ederim
Баярлалаа
спасибо
thank you
gracias
tapadh leat
dank je
mochchakkeram
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obrigado
sukriya
kop khun krap
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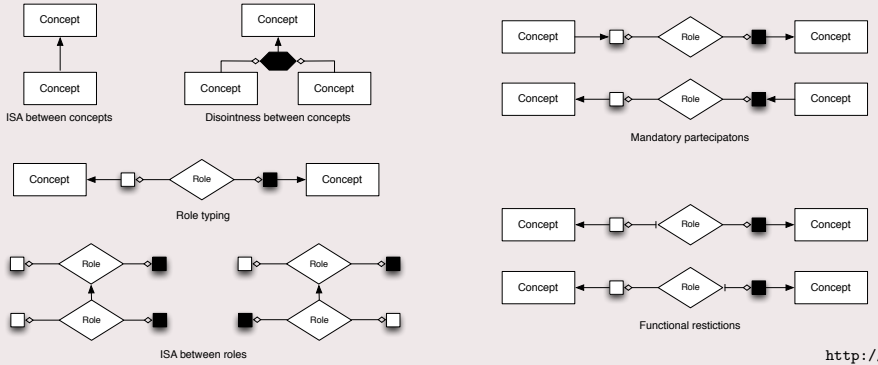
мерси
감사합니다
ধন্যবাদ
ευχαριστώ

DL-Lite$_\mathcal{A}$ constructs



Graphol diagrams
http://www.dis.uniroma1.it/~graphol

DL-Lite$_\mathcal{A}$ key properties

- Most expressive variant of *DL-Lite*
- Essentially OWL 2 QL + functional restrictions
- Captures most UML class diagrams/ER (except complete hierarchies)
- A bit first-order rewritability of UCQ