# SPARQL-DL

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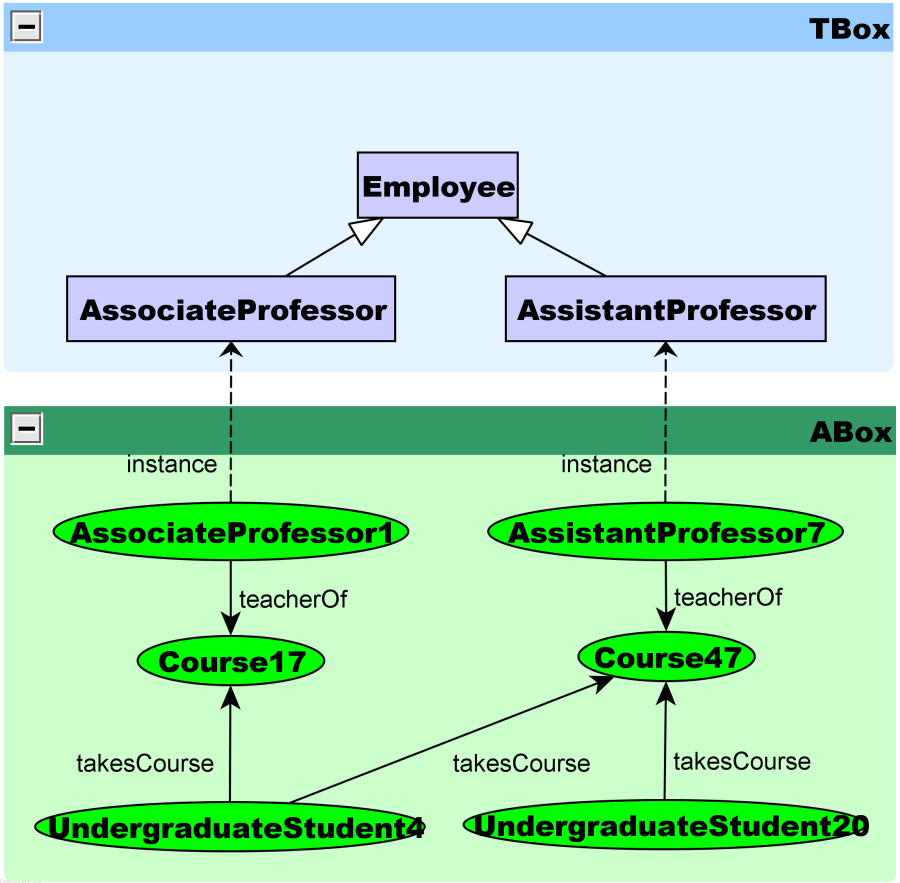
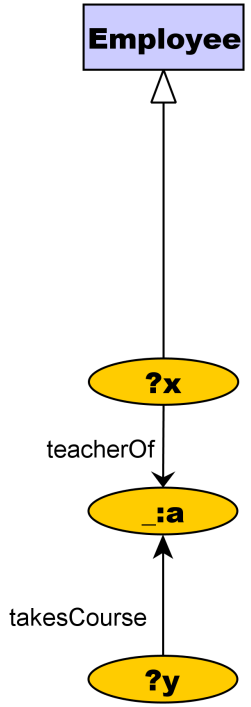



**Conjunctive ABox Queries.**

"Get all teachers and their students."



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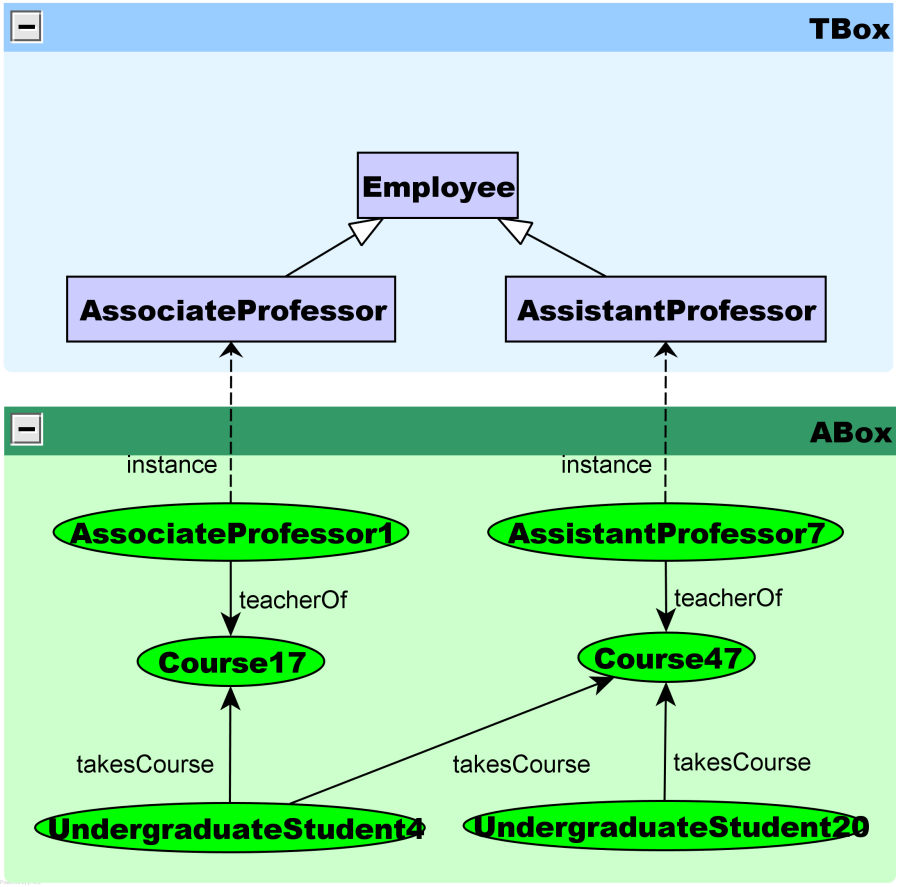


**Mixed TBox/ABox Queries.**

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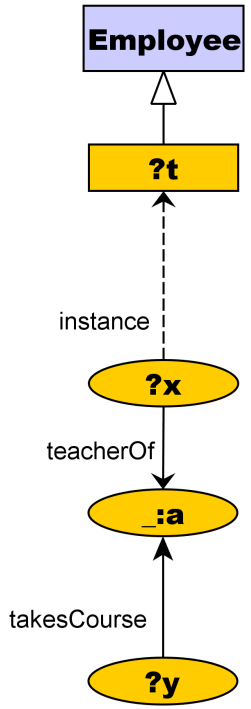
"... together with the type of the teachers."



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## Example (SPARQL-DL)

$\mathrm{Type}(?x, ?t), \mathrm{SubClassOf}(?t, \mathit{Employee}),$
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## Example (SPARQL)

```
SELECT   ?t ?x ?y
WHERE    {
         ?x rdf:type ?t .
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}
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. . . + non-monotonic extension – DirectType($i$, $c$), DirectSubClassOf($c$, $d$), StrictSubClassOf($c$, $d$), DirectSubProperty($p$, $q$), StrictSubPropertyOf($p$, $q$).

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- queries without DifferentFrom atoms with undistinguished variables.

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- ☹ only SPARQL-DL queries with distinguished variables

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**Example**

$cost_{KB}(\text{SubclassOf}(?x, Person)) = classify$
$B(\text{SubclassOf}(?x, Person)) = \#toldSubclasses(Person)$

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- ☹ as it needs to generate and evaluate all query atom orderings, and thus all permutations, it is useless for queries longer than as few as 10 atoms,
- ☹ cost evaluation of each query ordering is linear in the query length, but its quality decreases with the number of distinguished variables.

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- **chooses the cheapest atom in each evaluation step**. At present, *greedy-like* strategy is implemented. In each step cheapest atom $a^* = \arg\min cost(a)$ is chosen according to the following heuristic:

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- more sofisticated heuristic functions for dynamic reordering will be helpful . . ..

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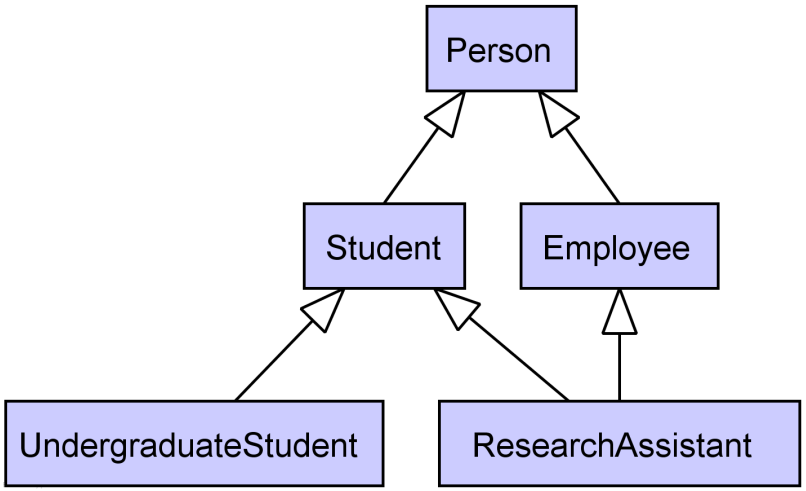


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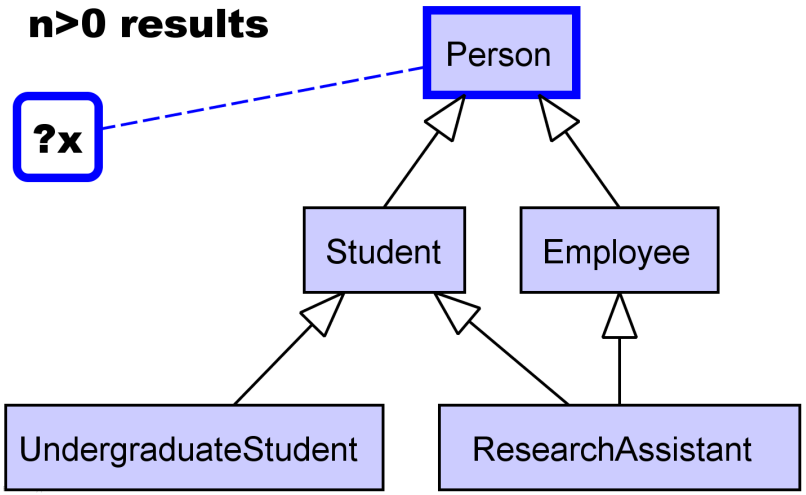


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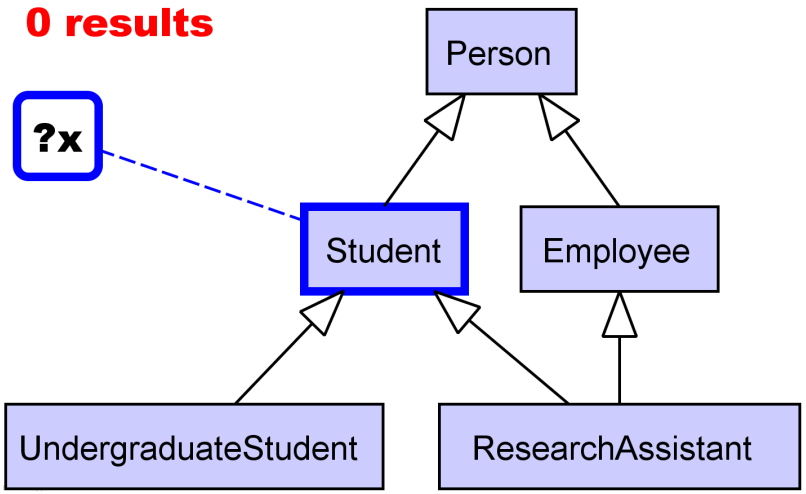


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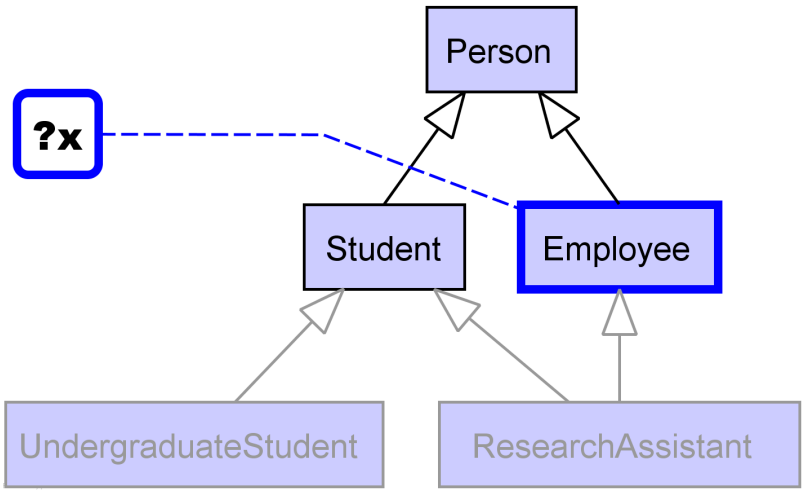


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☺ useful for ontologies with rich taxonomies.

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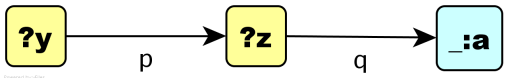
- ☹ which is inefficient in many cases :




We should get rid of as many consistency checks as possible. The problem is when an edge $\mathit{PropertyValue}(?y, \mathrm{p}, ?z)$ is rolled-up to $\exists p \cdot T$. Retrieving instances of this concept in many cases ends-up finding also a valid binding for $?z$, which is then thrown away – and an additional check is performed later.

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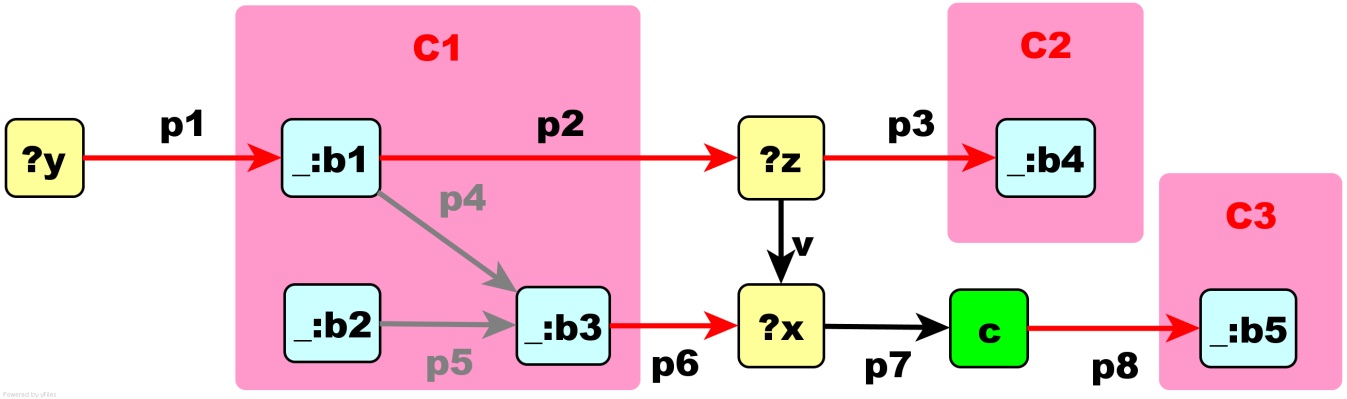

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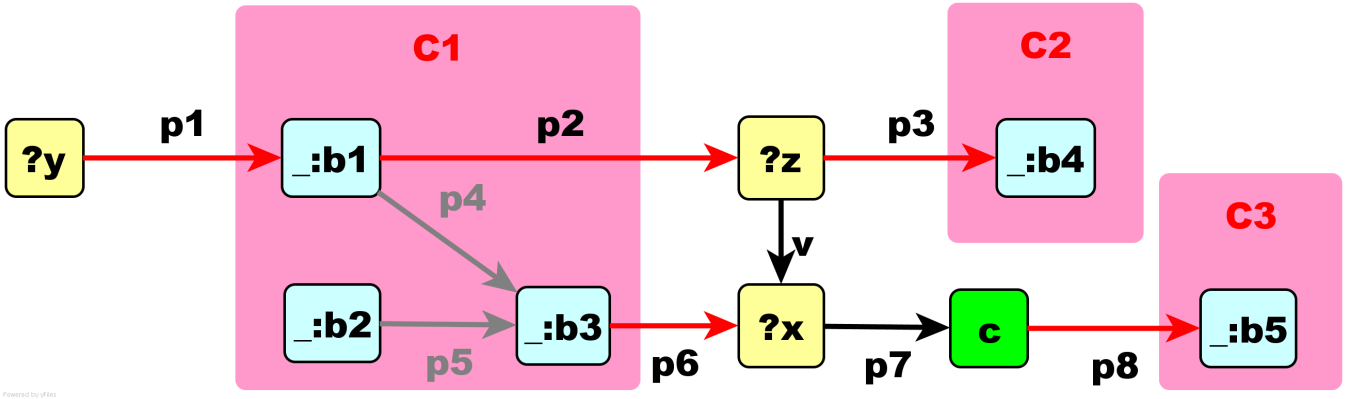


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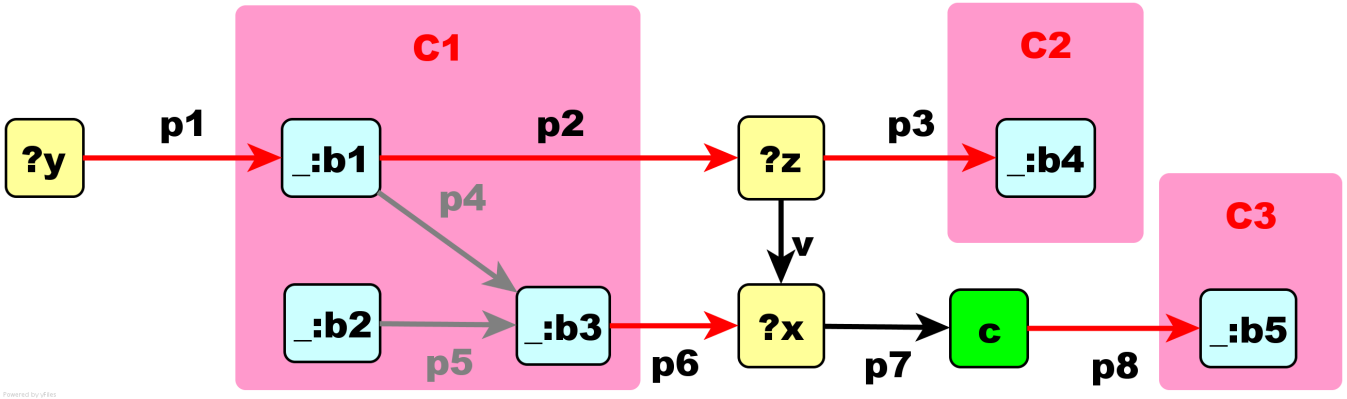


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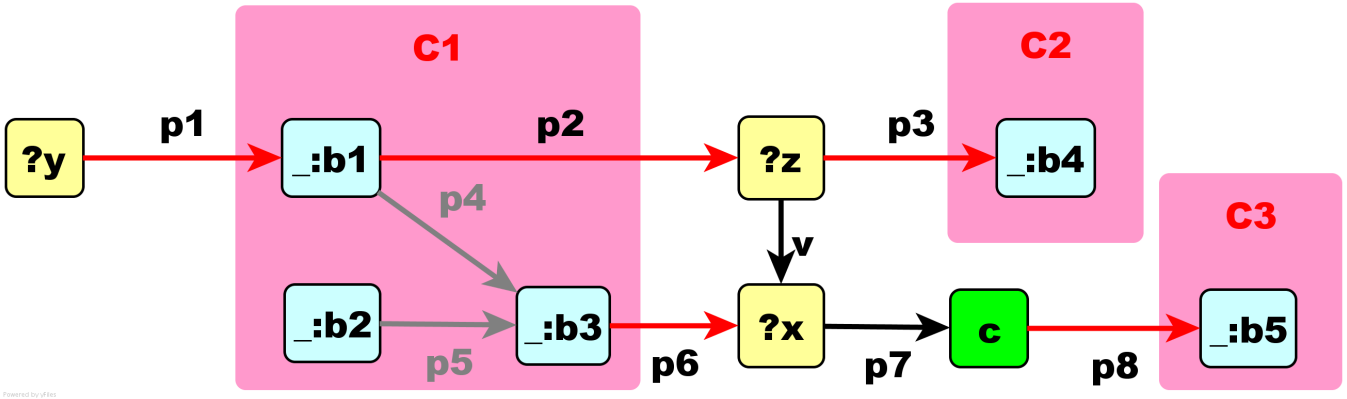


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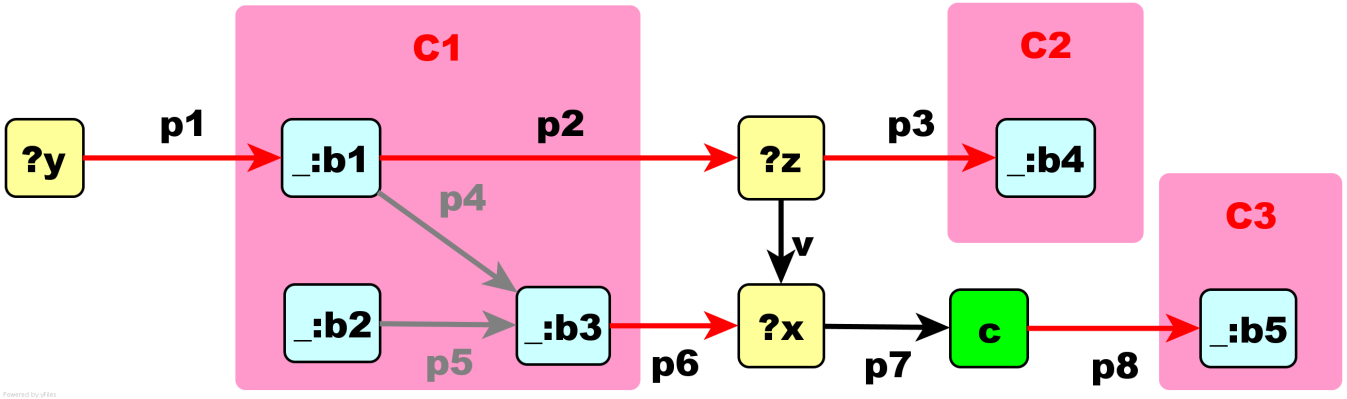


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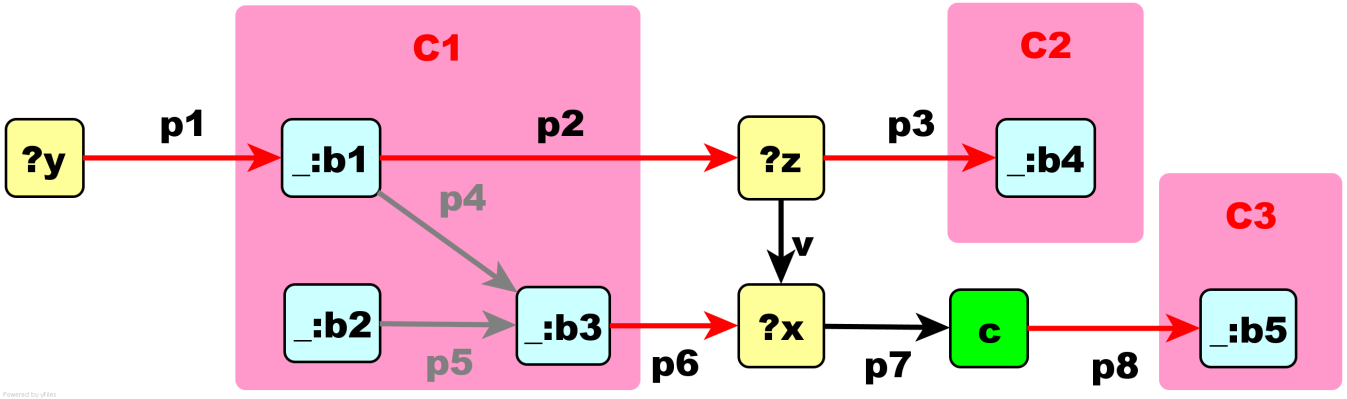


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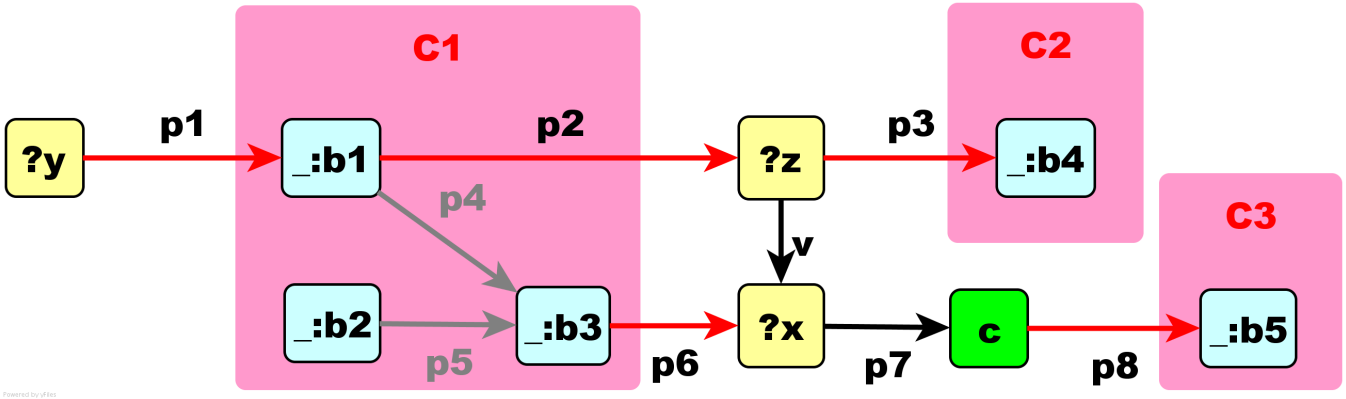


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  **all fast** – distinguished variables are evaluated one by one and a candidate set for each DV is obtained by (cheap) filtering out all obvious non-instances of the rolled-up query.

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  - ☺ . . . thus can be evaluated using the already implemented strategy for queries with distinguished variables.

# Benchmarking with LUBM

## Example (Q1 – Variables in property position)

Find all the graduate students that are related to a course and find what kind of relationship (e.g. `takesCourse`):

$$\text{Type}(?x, \texttt{GraduateStudent}), \text{PropertyValue}(?x, ?y, ?z), \text{Type}(?z, \texttt{Course})$$

## Example (Q2 – Mixed ABox/TBox query)

Find all the students who are also employees and find what kind of employee (e.g. `ResearchAssistant`):

$$\text{Type}(?x, \texttt{Student}), \text{Type}(?x, ?C), \text{SubClassOf}(?C, \texttt{Employee})$$

# Benchmarking with LUBM (2)

## Example (Q3 – Mixed ABox/RBox query)

Find all the members of `Dept0` and what kind of membership (e.g. `worksFor`, `headOf`):

$\mathsf{Type}(?x, \texttt{Person}), \mathsf{PropertyValue}(?x, ?y, \texttt{Dept0}), \mathsf{SubPropertyOf}(?y, \texttt{memberOf})$

## Example (Q7 – Down-monotonic variables)

Find all people that take the same course they teach together with their classification and the course :

$\mathsf{SubClassOf}(?C, \texttt{Thing}), \mathsf{Type}(?x, ?C), \mathsf{PropertyValue}(?x, \texttt{takesCourse}, ?A),$
$\mathsf{PropertyValue}(?x, \texttt{teachingAssistantOf}, ?A)$

# Other Examples

## Example (Q11 – Long conjunctive ABox query)

Find all students and teachers from the same university that have some common publication, the student takes some course taught by the teacher and is a teaching assistent of another course taught by the teacher :

$$\begin{aligned}
&\text{Type}(?w, \texttt{University}), \text{PropertyValue}(?r, \texttt{subOrganizationOf}, ?w),\\
&\text{PropertyValue}(?x, \texttt{memberOf}, ?r), \text{PropertyValue}(?a, \texttt{memberOf}, ?r),\\
&\text{PropertyValue}(?x, \texttt{takesCourse}, ?z), \text{PropertyValue}(?a, \texttt{teacherOf}, ?z),\\
&\text{PropertyValue}(?a, \texttt{teacherOf}, ?z_2), \text{PropertyValue}(?x, \texttt{advisor}, ?b),\\
&\text{PropertyValue}(?x, \texttt{teachingAssistentOf}, ?z_2),\\
&\text{PropertyValue}(?q, \texttt{publicationAuthor}, ?x),\\
&\text{PropertyValue}(?q, \texttt{publicationAuthor}, ?a)
\end{aligned}$$

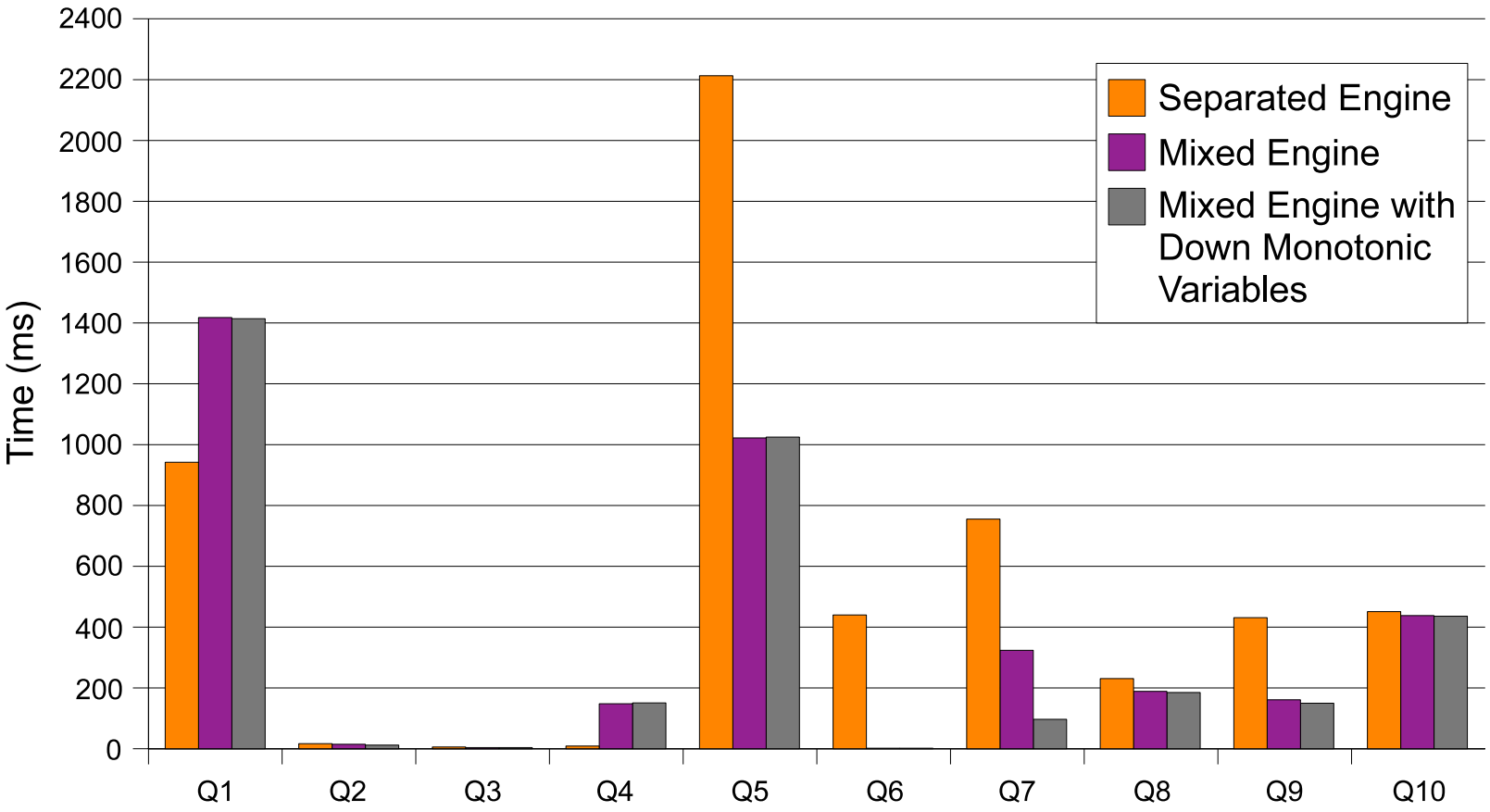
# Other Examples (2)

## Example (Q12 – conjunctive ABox query with undistinguished variable)

Find all students whose advisors teach a course they take :

$$\text{PropertyValue}(?x, \texttt{advisor}, \_ : a), \text{PropertyValue}(\_ : a, \texttt{teacherOf}, ?y),$$
$$\text{PropertyValue}(?x, \texttt{takesCourse}, ?y)$$

# Experiments (results for LUBM(1))



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- optimizations – static query reordering, down-monotonic variables, dynamic query reordering, cores and queries with undistinguished variables

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# Resources



Petr Kremen and Evren Sirin.
SPARQL-DL Implementation Experience.
In *OWLED*, 2008.


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