

Combining XML querying with ontology reasoning: Xcerpt and DIG

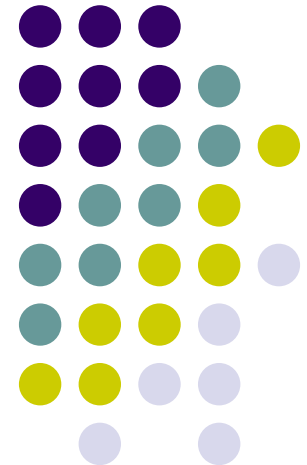
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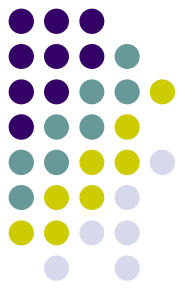
*Ontology and Rule Integration
Workshop*

Athens, GA

November 2006



The problem



- Combining XML queries with ontology queries

- Example

- XML document containing recipes

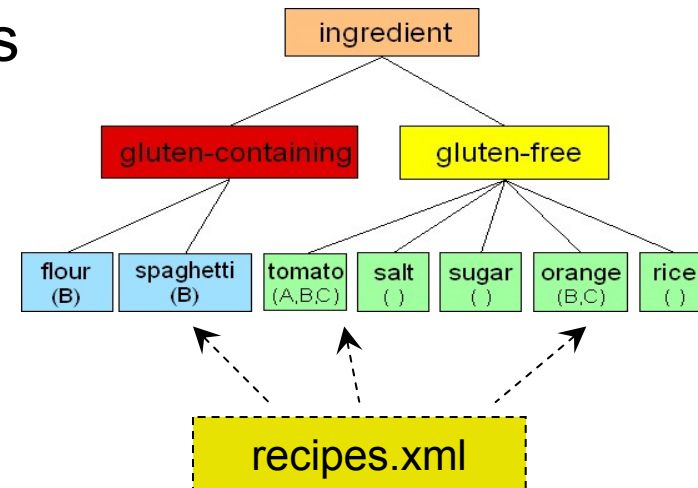
- Ontology

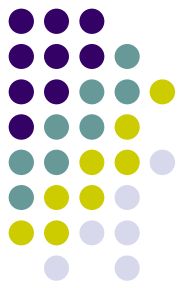
- classifies ingredients
- relates ingredients with vitamins

- Queries

- *Find gluten free recipes* (answer filtering)
- *List recipes together with vitamins they contain* (data enhancement)

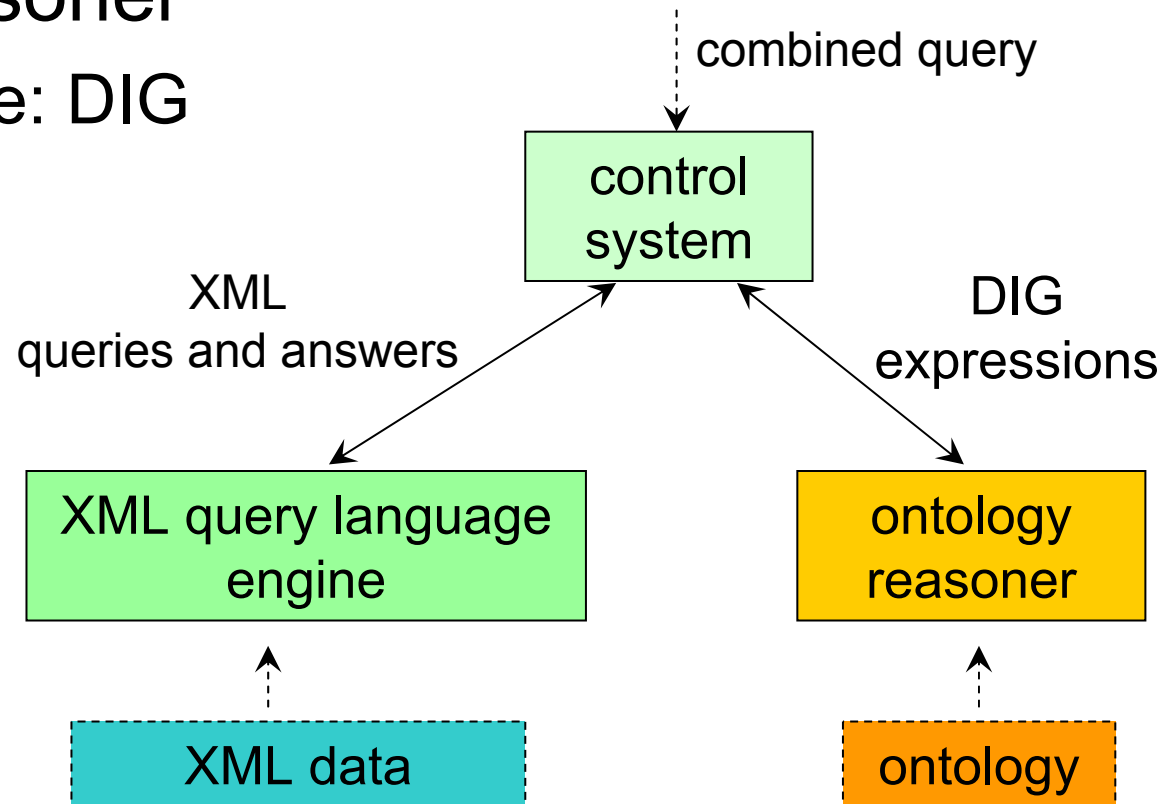
- **Goal:** a hybrid system answering combined queries

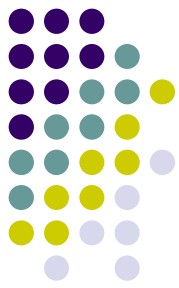




The approach

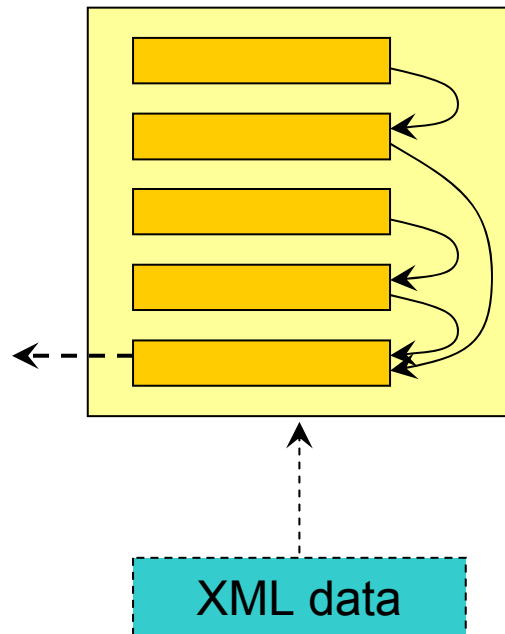
- XML query language
- Ontology reasoner
 - XML interface: DIG



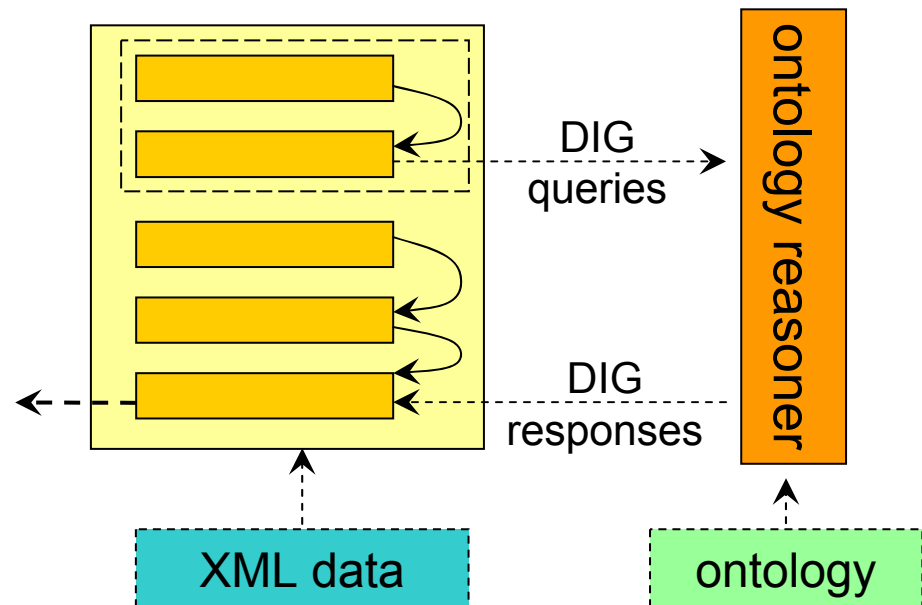


The approach *(cont.)*

- ordinary XML query programs



- extended XML query programs
 - handled by a control system which
 - communicates with reasoner
 - calls XML query engine to execute (parts of) programs





The approach: instantiation

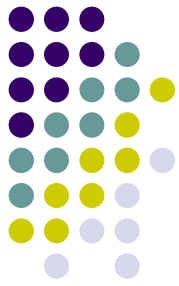
- XML query language
 - **Xcerpt**
 - simple structure of programs: rules
 - simple (fixpoint) semantics
- Ontology reasoner
 - any supporting DIG e.g. Racer
- Control system
 - Extended Xcerpt



Outline

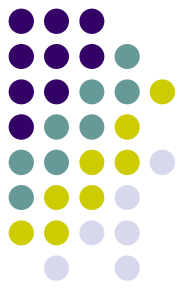
- Preliminaries
 - *Xcerpt*
 - *DIG interface*
- *Extended Xcerpt*
 - *syntax and semantics*
 - *program examples*
- Conclusions

Xcerpt - Introduction



Xcerpt – query and transformation
language for XML [Schaffert *et al.*, 2004]

- inspired by logic programming
- uses pattern matching instead of path navigation



Xcerpt: *Core concepts*

- **data terms**

- model XML documents

`<CD> <title> Stop </title> </CD>` `CD[title["Stop"]]`

- **query terms**

- patterns used to match data terms
 - successful matching results in variable bindings (answer substitutions)

`CD[title [X]]` matches `CD[title["Stop"]]` \Rightarrow `{ X / "Stop" }`

- **construct terms**

- used to build data terms (by applying answer substitutions)

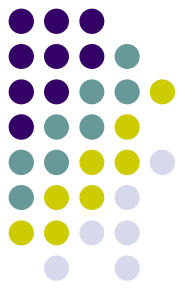


Xcerpt programs

- consist of query rules $c \leftarrow Q$
 - the body Q
 - used to extract XML data
 - consists of query terms
 - connected by *and*, *or* ...
 - possibly associated with external resources
 - the head c
 - a construct term
 - used to build new XML data
 - Xcerpt syntax

CONSTRUCT	GOAL
c	c
FROM	FROM
Q	Q
END	END

Xcerpt query rules - example



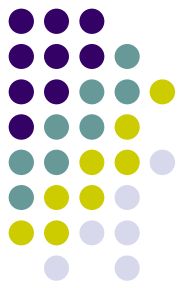
Data term:

```
catalogue[ cd[ title[ "Empire Burlesque" ], artist[ "Bob Dylan" ], year[ "1985" ] ],  
           cd[ title[ "Hide your heart" ], artist[ "Bonnie Tyler" ], year[ "1988" ] ],  
           cd[ title[ "Stop" ], artist[ "Sam Brown" ], year[ "1988" ] ] ]
```

```
title [ TITLE ] ← desc cd[[ title[ TITLE ], year[ "1988" ] ]]
```

Answers: { TITLE / "Hide your heart" }, { TITLE / "Stop" }

Result: title ["Hide your heart"]
title ["Stop"]



DIG interface

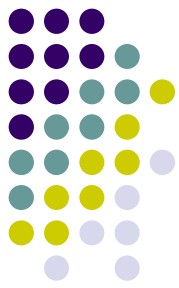
- an XML interface to Description Logics systems
 - by the **DL Implementation Group** [S. Bechhofer]
- XML encoded messages (statements)
 - **Tell**: managing the knowledge base
 - **Ask**: querying the knowledge base
 - **Response**: replying to the queries

```
<children>  
  <catom name="gluten-containing"/>  
</children>
```

Ask

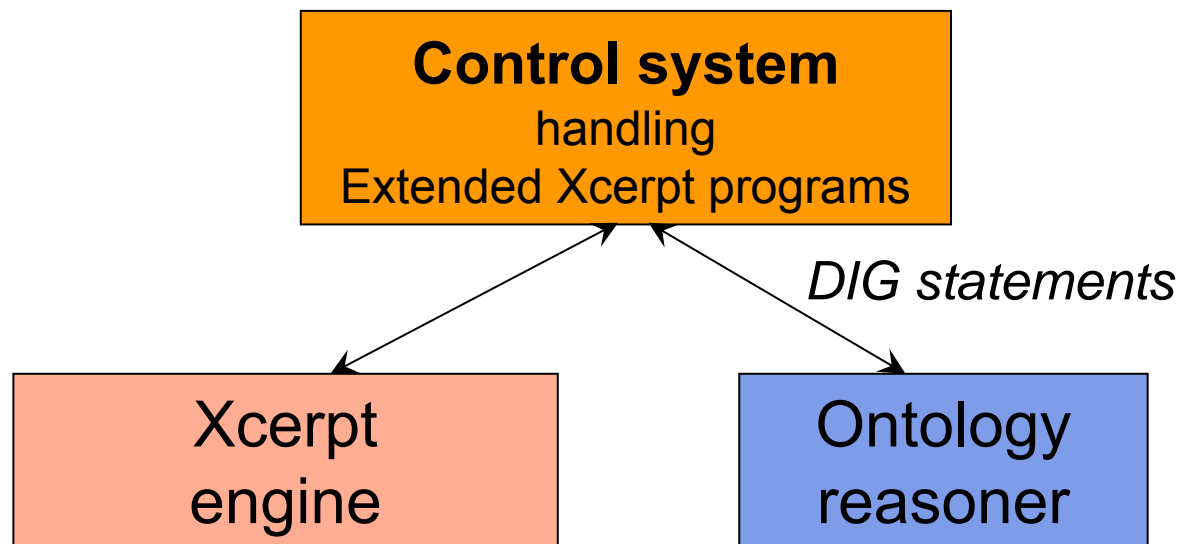
```
<conceptSet>  
  <synonyms> <catom name="flour"/> </synonyms>  
  <synonyms> <catom name="spaghetti"/> </synonyms>  
</conceptSet>
```

Response

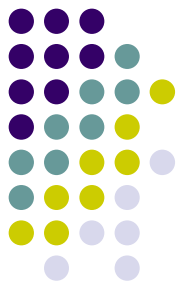


Extended Xcerpt

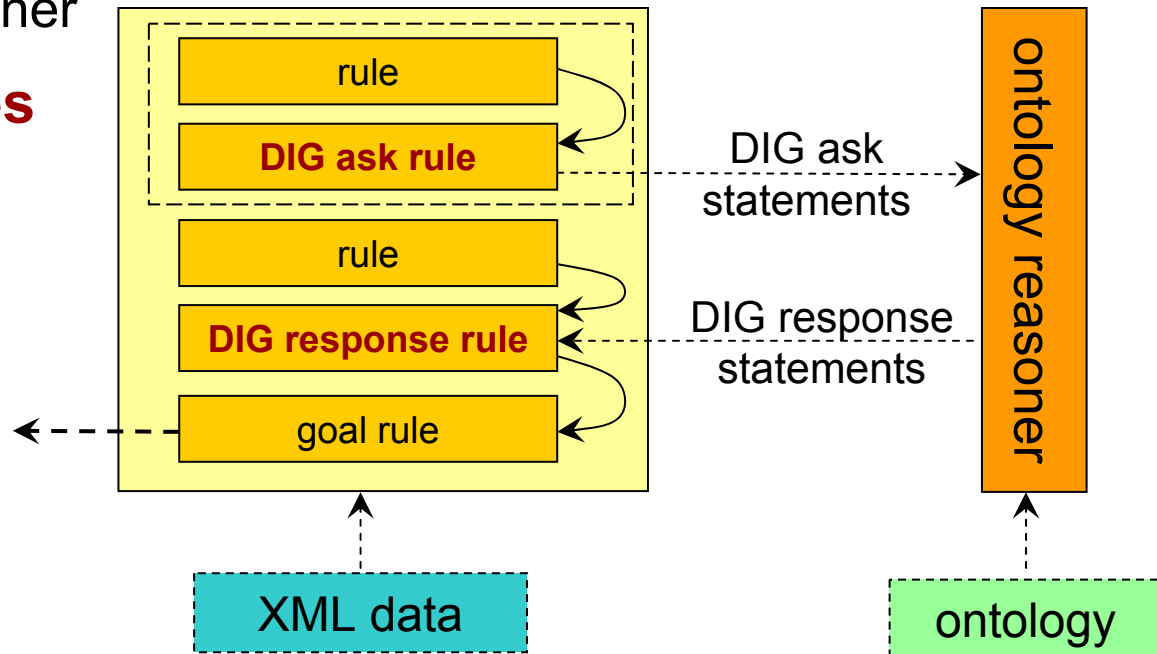
- Xcerpt + ontology reasoner interface
- communication with a reasoner by DIG



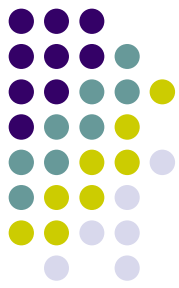
Extended Xcerpt programs



- adding to Xcerpt
 - **DIG ask rules**
 - produce intermediate results (ontology queries) to be sent to reasoner
 - **DIG response rules**
 - query reasoner responses



Extended Xcerpt: *syntax*



- the same as Xcerpt syntax
- some Xcerpt rules distinguished as DIG rules
 - **DIG ask rules** $\#l [a, c] \leftarrow \dots$
 - produce data terms $\#l [a_i, c_i]$
 - a_i - DIG ask statement
 - c_i - a context (to pass data associated with the ask statement)
 - **DIG response rules** $\dots \leftarrow \dots \#l [q_a, q_c] \dots$
 - q_a - query term matching DIG responses
 - q_c - query term matching the context
- rule chaining based on ordinary rule dependence
 - restriction: no DIG rule depends on itself

Extended Xcerpt: *operational semantics*



Evaluate successively the rules of a program:

To obtain results of

- a DIG ask rule $\#l [a, c] \leftarrow \dots$
 - evaluate it in the standard way
to obtain data terms..... $\#l [a_1, c_1] \dots \#l [a_n, c_n]$
 - send DIG ask statements..... a_1, \dots, a_n
 - to the reasoner
 - to obtain replies..... r_1, \dots, r_n
 - build facts $\#l [r_1, c_1] \dots \#l [r_n, c_n]$
- any other Xcerpt rule (including a DIG response rule)
 - use the standard Xcerpt evaluation method

Ontology reasoner

Answer filtering – example



Query: Find recipes with ingredients containing gluten

```

GOAL
  bad-recipes[ all var R ]
FROM
  #gluten[
    true[ [ ] ],
    name[ var R ] ]
END

CONSTRUCT
  #gluten[
    subsumes[
      catom[ attr{ name["gluten-containing"]} ] ]
      catom[ attr{ name[ var N ] } ] ],
    name[ var R ] ]
FROM
  in[ resource[ "file:recipes.xml" ],
    desc recipe[
      name[ var R ],
      desc ingr[ name[ var N ] ] ] ] ]
END
    
```

DIG
response
rule

DIG
ask
rule

recipes.xml:

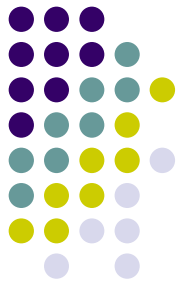
```

recipes[
  recipe[
    name[ "Recipe1" ],
    ingredients[ ingr[ name[ "sugar" ] ],
                 ingr[ name[ "orange" ] ] ],
  recipe[
    name[ "Recipe2" ],
    ingredients[ ingr[ name[ "flour" ] ],
                 ingr[ name[ "salt" ] ] ] ] ] ]
    
```

```

CONSTRUCT
  #gluten[ false[ attr{ id["1"]} ], name[ "Recipe1" ] ]
  subsumes[ attr{ id["1"]} ],
END
catom[ attr{ name["gluten-containing"]} ] ]
Answer substitutions (for the ask rule):
Find all expressions that are not answers
#gluten[ true[ attr{ id["2"]} ], name[ "Recipe1" ] ]
#gluten[ false[ attr{ id["3"]} ], name[ "Recipe1" ] ]
#gluten[ true[ attr{ id["4"]} ], name[ "Recipe2" ] ]
#gluten[ false[ attr{ id["5"]} ], name[ "Recipe2" ] ]
subsumes[ attr{ id["3"]} ], name[ "Recipe2" ] ]
subsumes[ attr{ id["4"]} ], name[ "Recipe1" ] ]
subsumes[ attr{ id["5"]} ], name[ "Recipe2" ] ]
false[ attr{ id["3"]} ], name[ "Recipe1" ] ]
false[ attr{ id["4"]} ], name[ "Recipe2" ] ]
false[ attr{ id["5"]} ], name[ "Recipe2" ] ]
subsumes[ attr{ id["4"]} ], name[ "Recipe2" ] ]
false[ attr{ id["4"]} ], name[ "Recipe2" ] ]
catom[ attr{ name["gluten-containing"]} ] ]
catom[ attr{ name["salt"]} ] ] ]
name[ "Recipe2" ] ]
    
```


Ontology information retrieval - example



Query: Which vitamins are in each recipe?

```

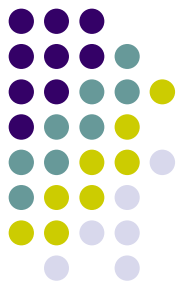
GOAL
  vit-recipes[ all recipe[ var R, all var V ] ]
FROM
  #vitamins[
    conceptSet [[
      synonyms[[ catom[attr{ name [ var V ] } ] ] ] ],
    name[ var R ] ]
END
CONSTRUCT
#vitamins[ conceptSet [attr{ id["1"] }], name[ "Recipe1" ] ]
END CONSTRUCT
#vitamins[
  conceptSet [attr{ id["2"]}, synonyms[
    some[
      catom[ attr{ name [ "B" ] } ] ], synonyms[
      catom[ attr{ name [ "C" ] } ] ] ],
    name[ "Recipe1" ] ]
END
CONSTRUCT
#vitamins[ conceptSet [attr{ id["3"]}, synonyms[
  catom[ attr{ name [ "B" ] } ] ], name[ "Recipe2" ] ]
FROM
  in[ resource[ "file:recipes.xml" ] ]
END
desc recipe[
  name[ var R ] ]
CONSTRUCT
#vitamins[ conceptSet [attr{ id["4"]}],
  desc[ ingr[ name[ var N ] ] ] ]
name[ "Recipe2" ] ]
END
  
```

Ontology elements and their contexts:

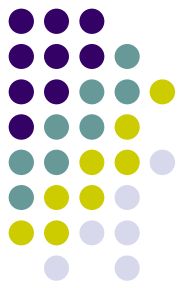
```

children[ attr{ id["1"], some[
  contained_in( B flour ) name[ "Recipe1" ]
  ratom[ attr{ name[ "contained_in" ] } ],
  contained_in( B orange )
  catom[ attr{ name[ "sugar" ] } ] ] ],
children[ attr{ id["2"], (some[
  contained_in( C orange ) name[ "Recipe1" ]
  ratom[ attr{ name[ "contained_in" ] } ],
  catom[ attr{ name[ "orange" ] } ] ] ] ]
recipes.xml
children[ attr{ id["3"], some[
  recipe[
    ratom[ attr{ name[ "contained_in" ] } ],
    catom[ attr{ name[ "flour" ] } ] ] ] ]
  name[ "Recipe1" ] ]
children[ attr{ id["4"], some[
  result[
    ingredients[ some[ "sugar" ] ],
    recipe[
      ratom[ attr{ name[ "contained_in" ] } ],
      catom[ attr{ name[ "salt" ] } ] ] ] ],
  name[ "Recipe2", "B" ], "C" ],
  name[ "Recipe2", "B" ] ]
Facts with reasoner answers:
#vitamins[ conceptSet [attr{ id["1"] }, name[ "Recipe1" ] ] ]
#vitamins[ conceptSet [attr{ id["2"] }, synonyms[
  catom[ attr{ name [ "B" ] } ] ], synonyms[
  catom[ attr{ name [ "C" ] } ] ] ], name[ "Recipe1" ] ]
#vitamins[ conceptSet [attr{ id["3"]}, synonyms[
  catom[ attr{ name [ "B" ] } ] ] ], name[ "Recipe2" ] ]
#vitamins[ conceptSet [attr{ id["4"]}], name[ "Recipe2" ] ]
  
```

Conclusions



- Extension of Xcerpt allowing to query an ontology
 - communication with a reasoner with DIG interface
 - no restrictions on Xcerpt queries and DIG ask statements
 - hybrid approach
 - reusing existing systems: Xcerpt, an ontology reasoner
 - no modification of Xcerpt needed
 - a prototype implementation <http://www.ida.liu.se/digxcerpt/>
- Future work
 - higher level language
 - query rules $C \leftarrow O, Q$ compiled into Extended Xcerpt queries
 - O – ontology query
 - Q – XML query



Related work

- Datalog + DL with logical semantics
 - not applicable to Xcerpt + OWL
- **Hybrid** framework with fixpoint semantics (*Assmann et al, 2006*)
 - ontology reasoning **after** rule reasoning
 - Boolean ontology queries
 - treated like constraints
- Our approach
 - ontology reasoning **interleaved** with rule reasoning
 - arbitrary ontology queries



Thank you!