Querying Complex Structured Databases

Cong Yu – Yahoo! Research
H. V. Jagadish – Univ. of Michigan

presented by **Arnab Nandi** – Univ. of Michigan

VLDB 2007, Vienna, Austria
September 27th, 2007

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–

A step toward database usability

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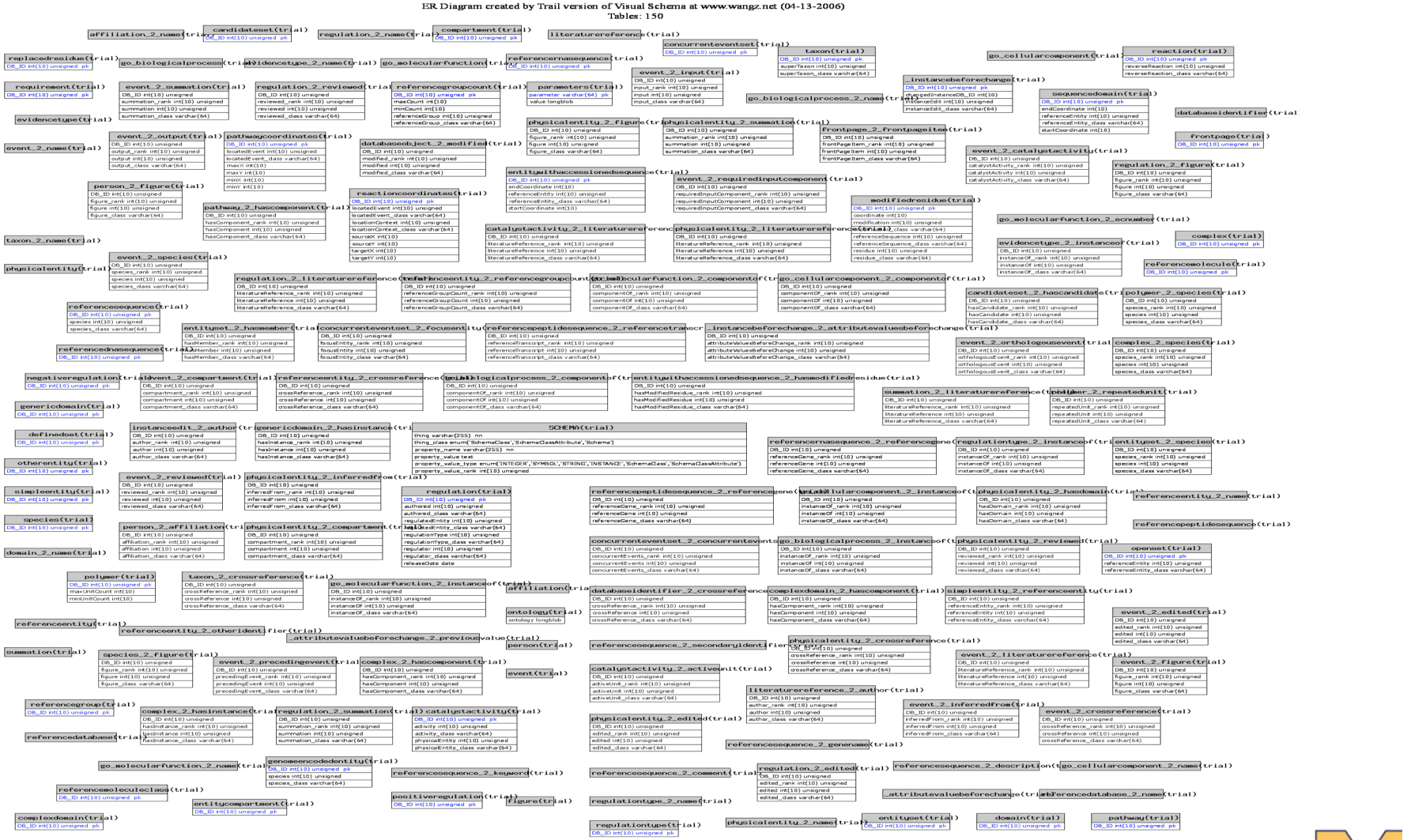
Databases Are Complex



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Databases Are Complex

The *usability costs* are gradually becoming the bottleneck for many database applications!

Database Usability

- A recent focus of our research group to address the following challenges facing the “real” users of databases:

Database Usability

- A recent focus of our research group to address the following challenges facing the “real” users of databases:
  - Unknown/complicated query language
  - unknown/complex schema
  - lack of instantaneous feedback on results
  - lack of effective tracking of provenance
  - rigid process of database content creation

Database Usability

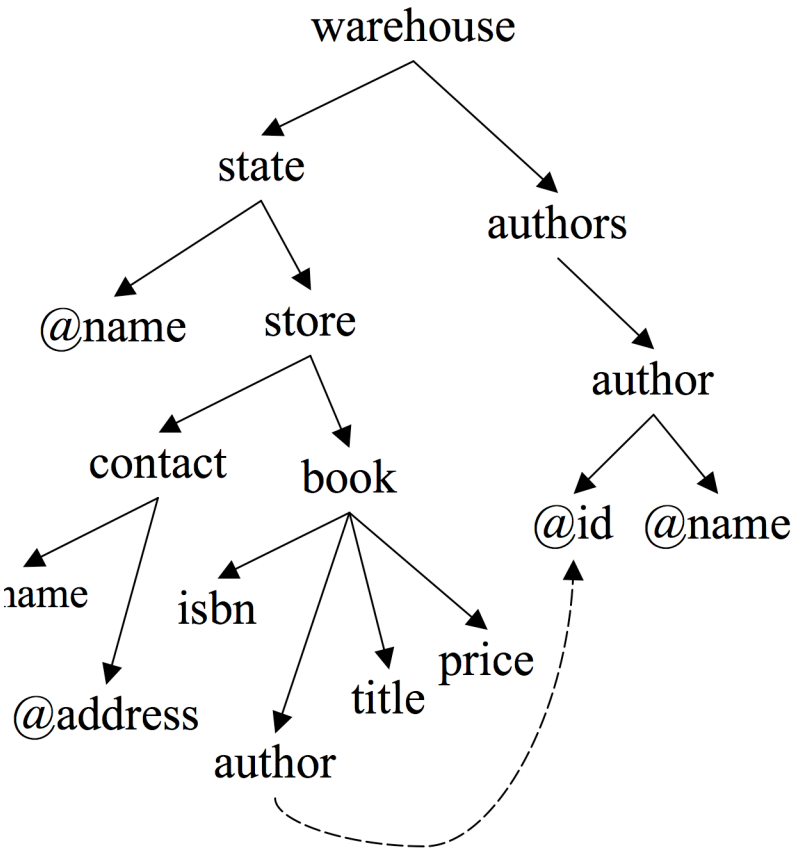
- A recent focus of our research group to address the following challenges facing the “real” users of databases:

Unknown/complex schema

Challenge of Query Language

- SQL/XQuery are too complicated for our users (i.e., biologists) to learn and use
  - Some of those users are even quite tech-savvy!
  - Still, they do not have the working knowledge of SQL/XQuery to pose the queries they have in mind
  - Simpler query interfaces is much more preferred

Challenge of Schema



XQuery:

```
for   $a in doc()//author,
      $s in doc()//store
let   $b in $s/book
where $s/contact/@name =
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return { $a/name, count($b) }
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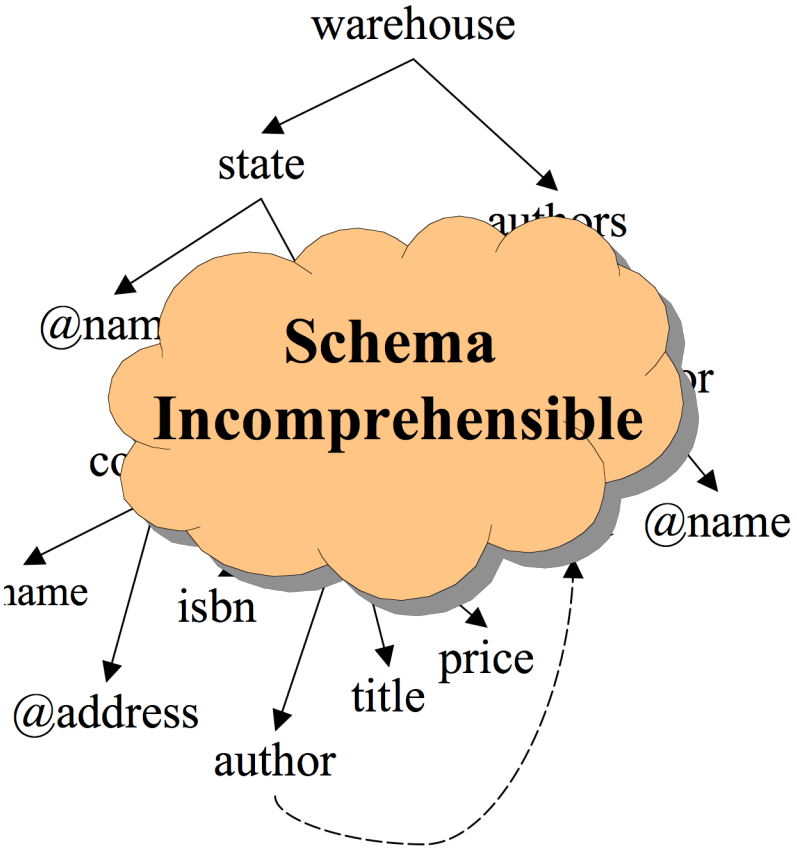

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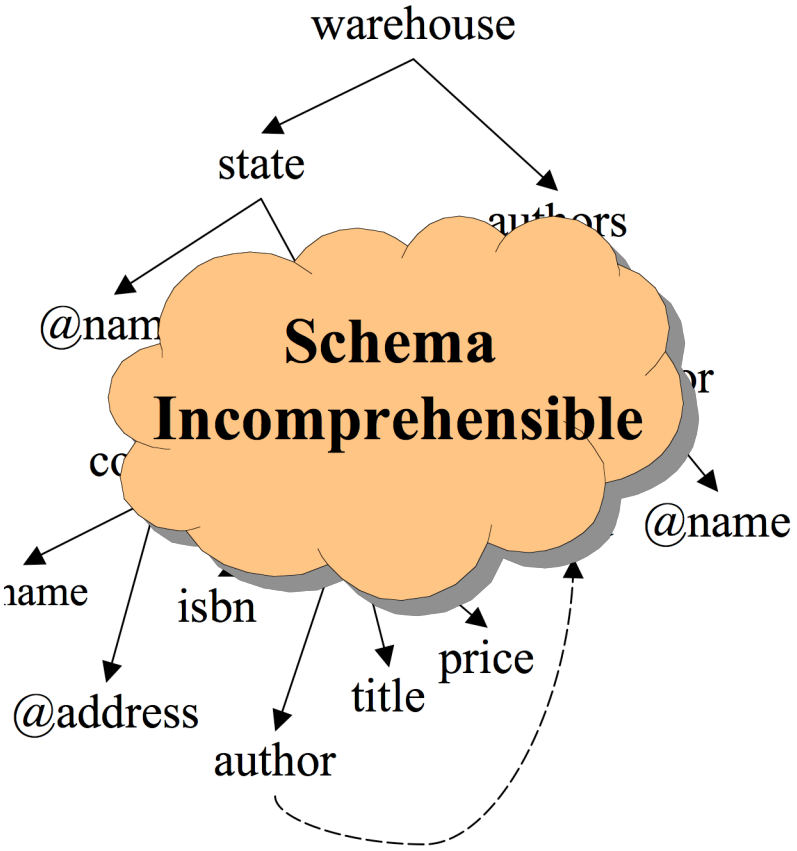

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- Establish a novel query model based on three principles:
  - Flexible requirement on **schema knowledge**
  - Maintaining the same **query result quality** as a structured query can achieve
  - Minimum increase in **query evaluation cost**

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  - Flexible requirement on **schema knowledge**
  - Maintaining the same **query result quality** as a structured query can achieve
  - Minimum increase in **query evaluation cost**
- Built upon several previous works
  - Structure-free query models
  - Schema summarization

Outline

- Background and Motivation
- Issues with Current Approaches
- Schema-Based Matching Semantics
- Meaningful Summary Query Model
- Conclusion

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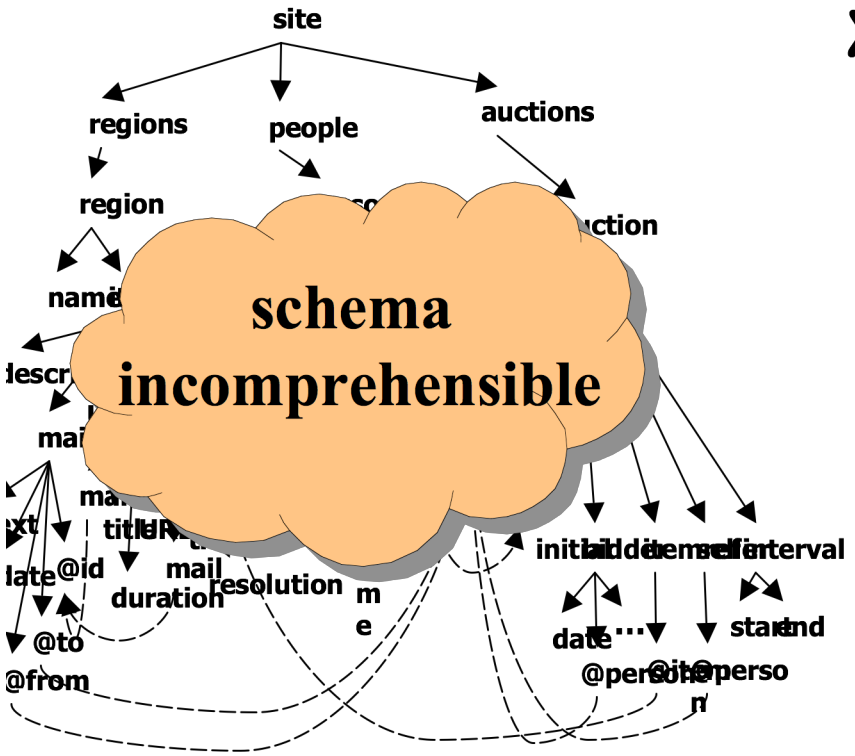
Structure-Free Query Model



XQuery:

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for   $a in doc()//region/item,
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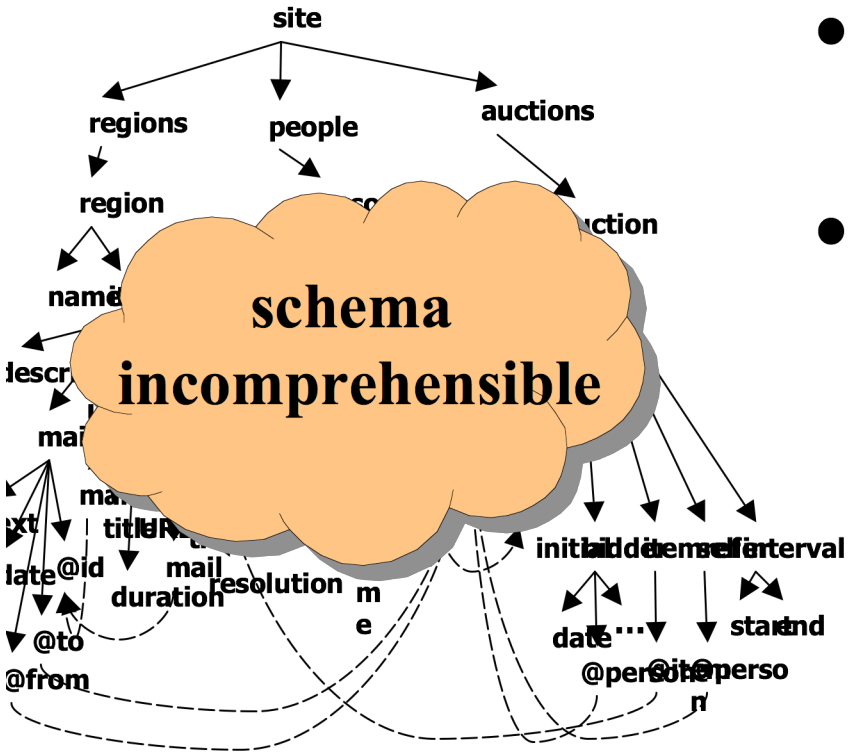
Structure-Free Query Model



- Simple Keyword Search
  [name; peter; address; asia]
- Labeled Keyword Search
  [name:peter; address:asia]

A Simple Example

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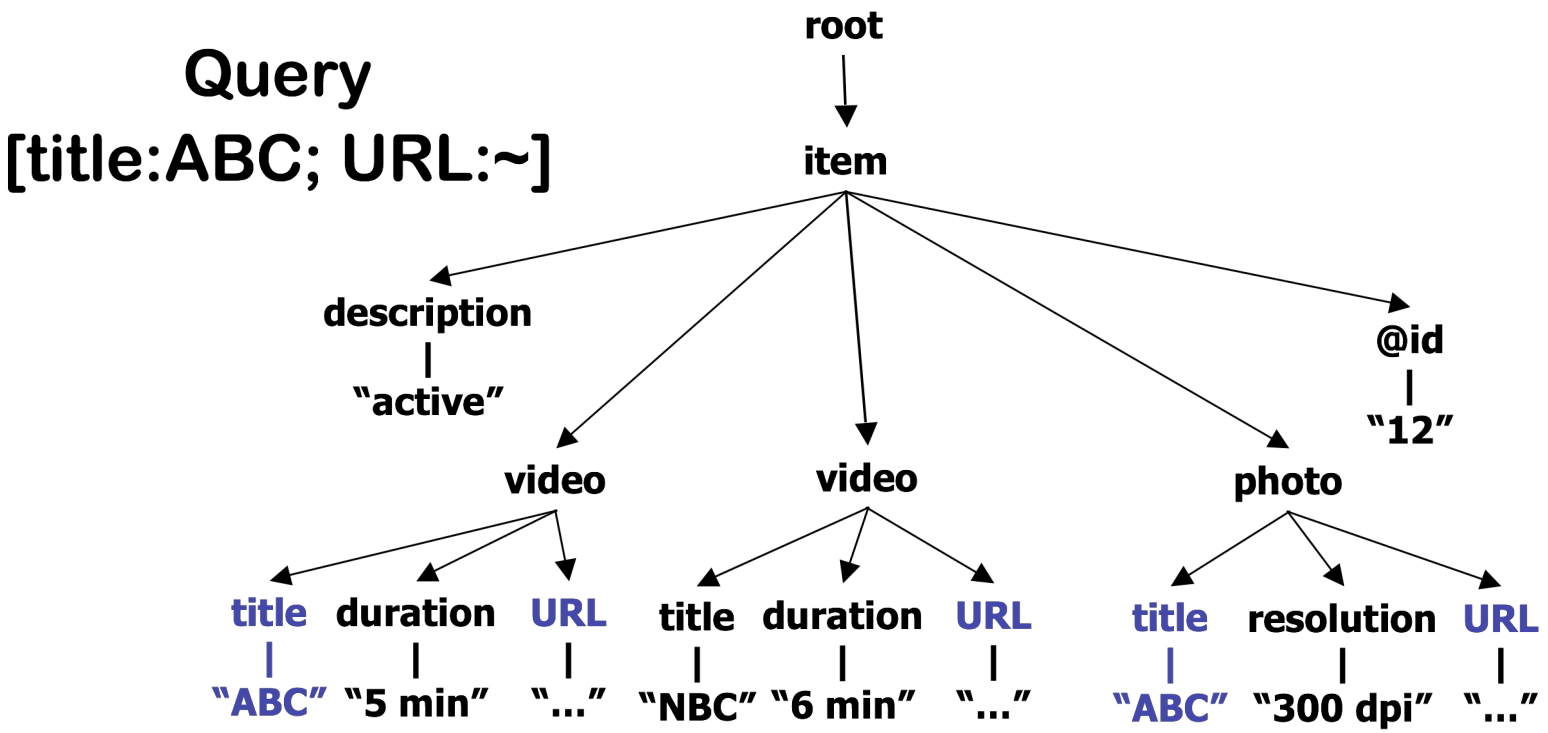

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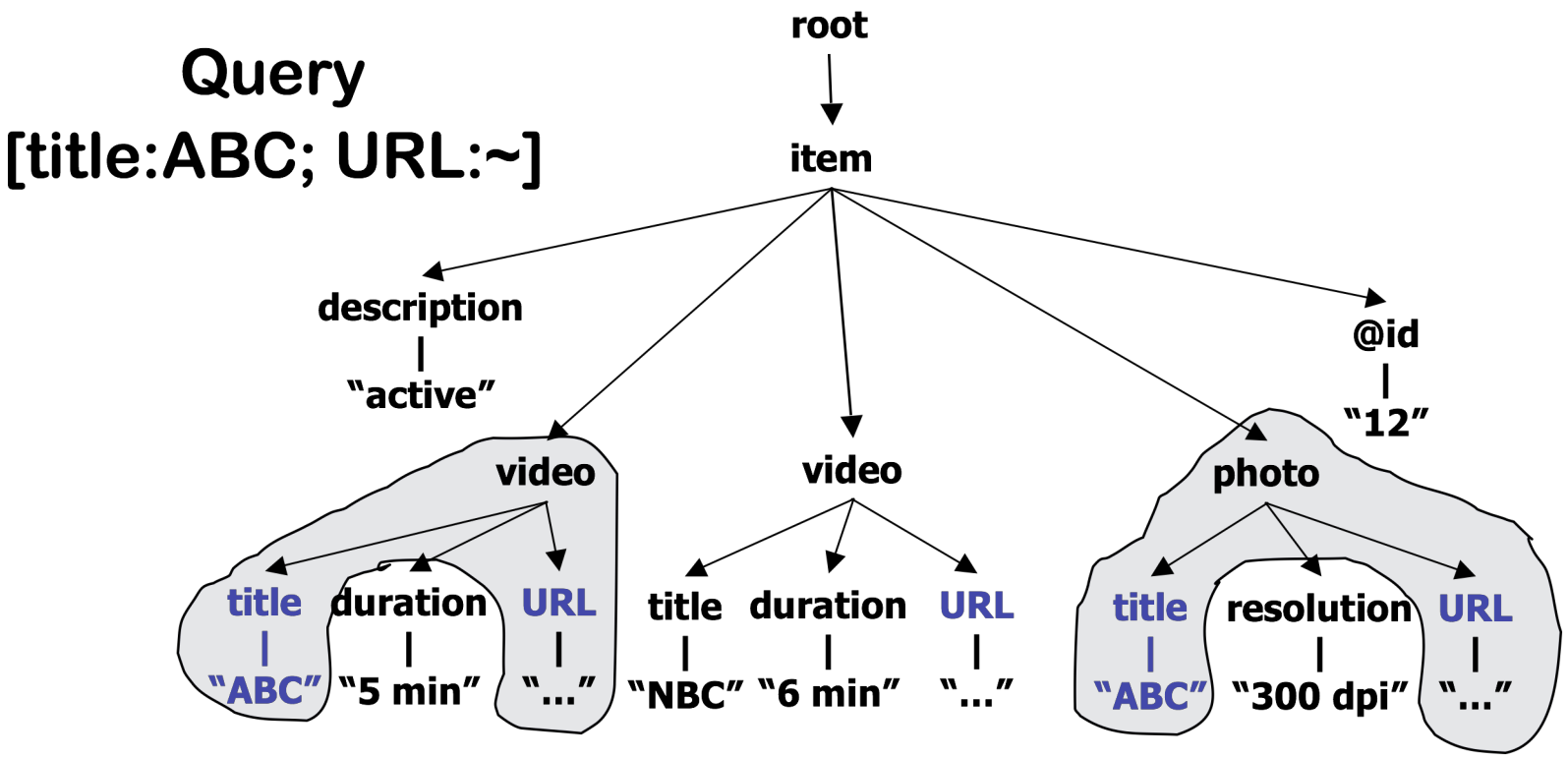

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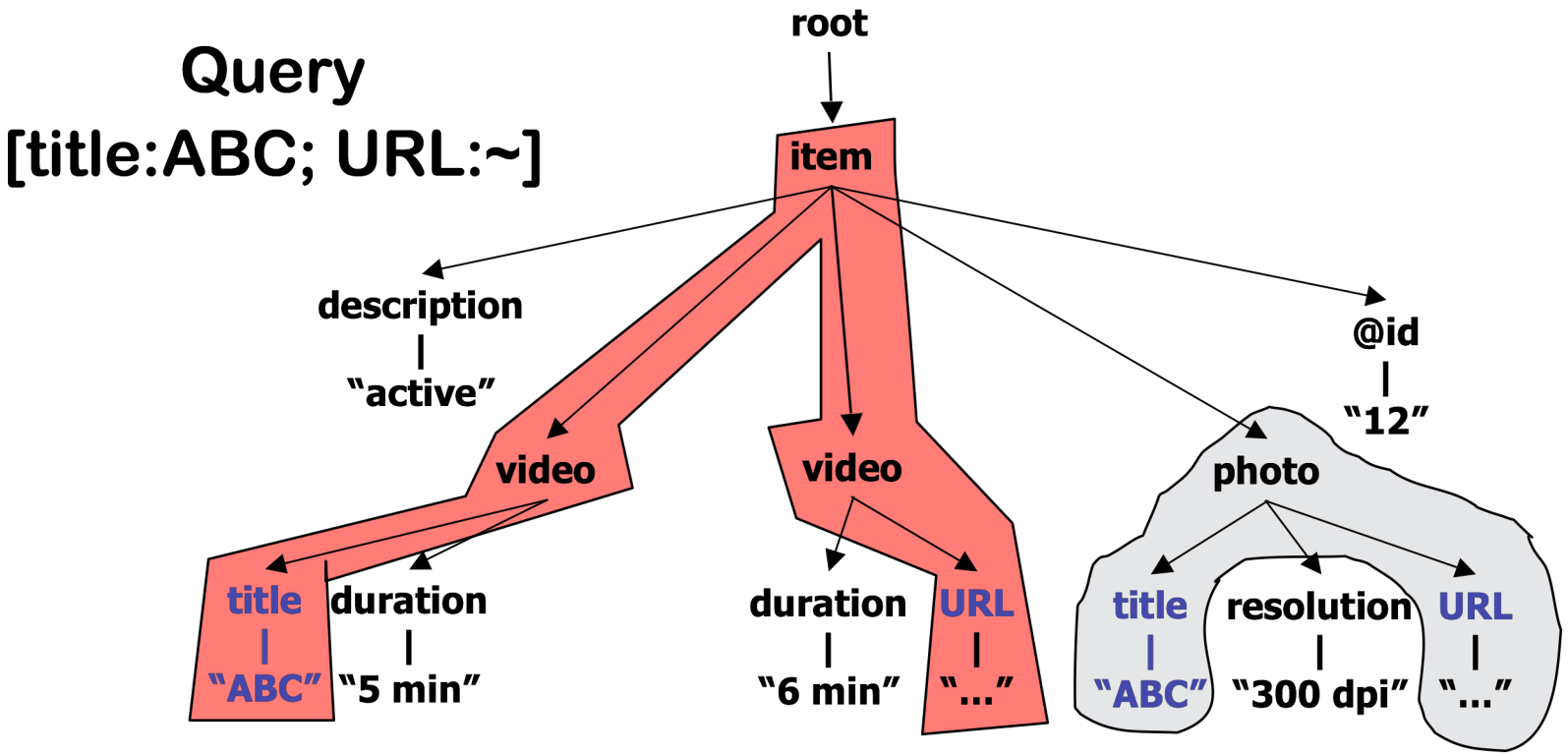

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- Rely on content-based matching semantics
  - High query evaluation cost due to the need to examine non-meaningful data fragments
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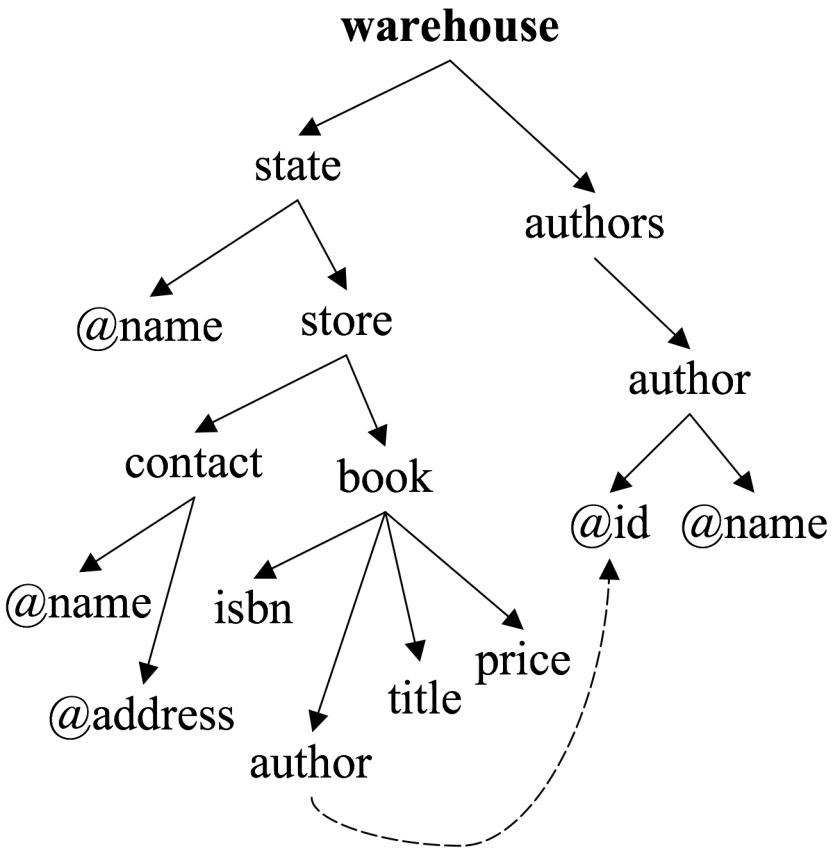
Solution: Schema summary-based query construction

Schema Summary



- For database with complex schemas, a much simpler schema that summarizes the database can be generated [YJ06]
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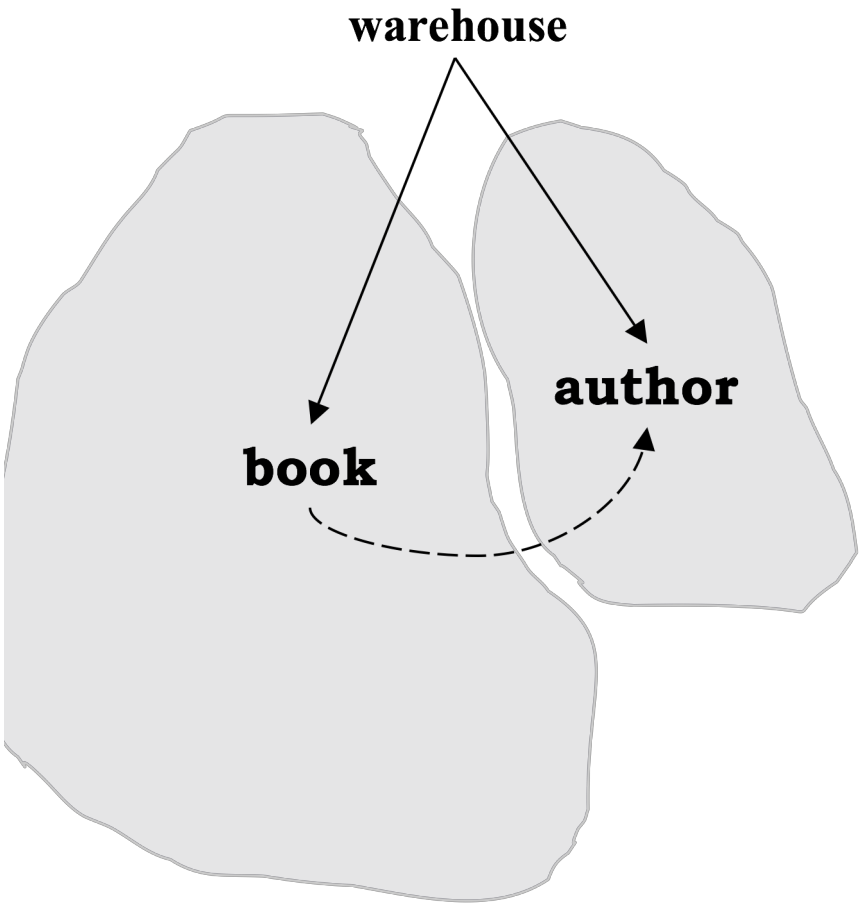

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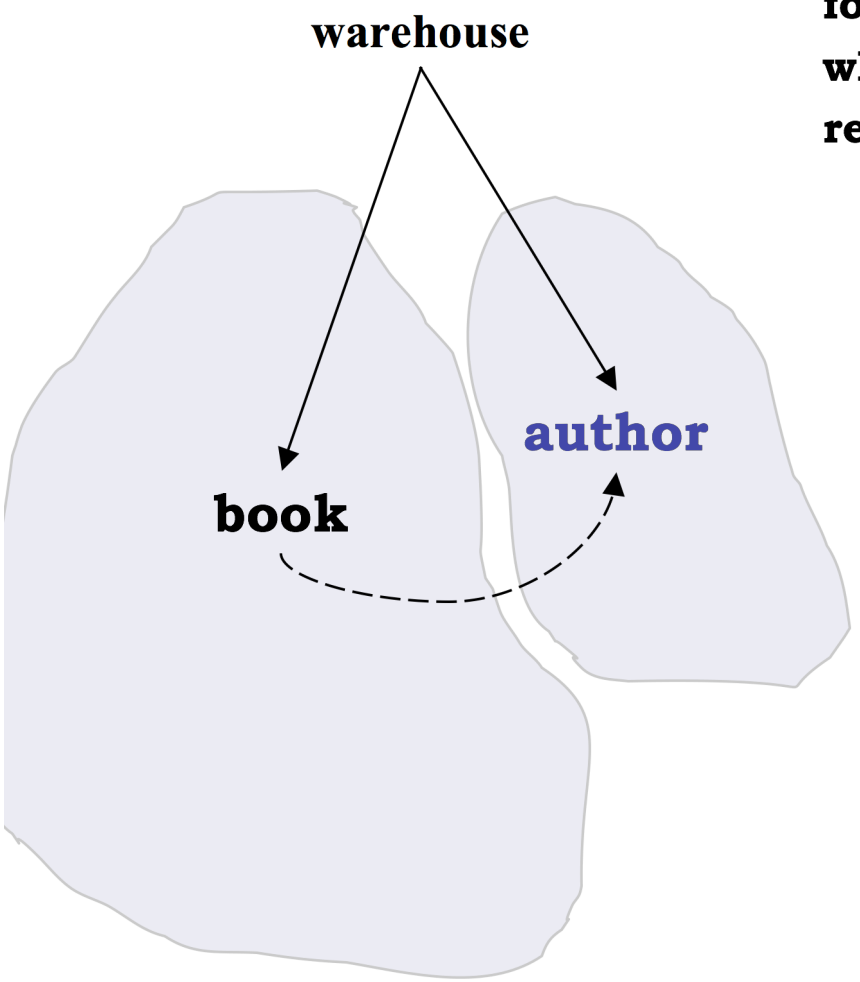

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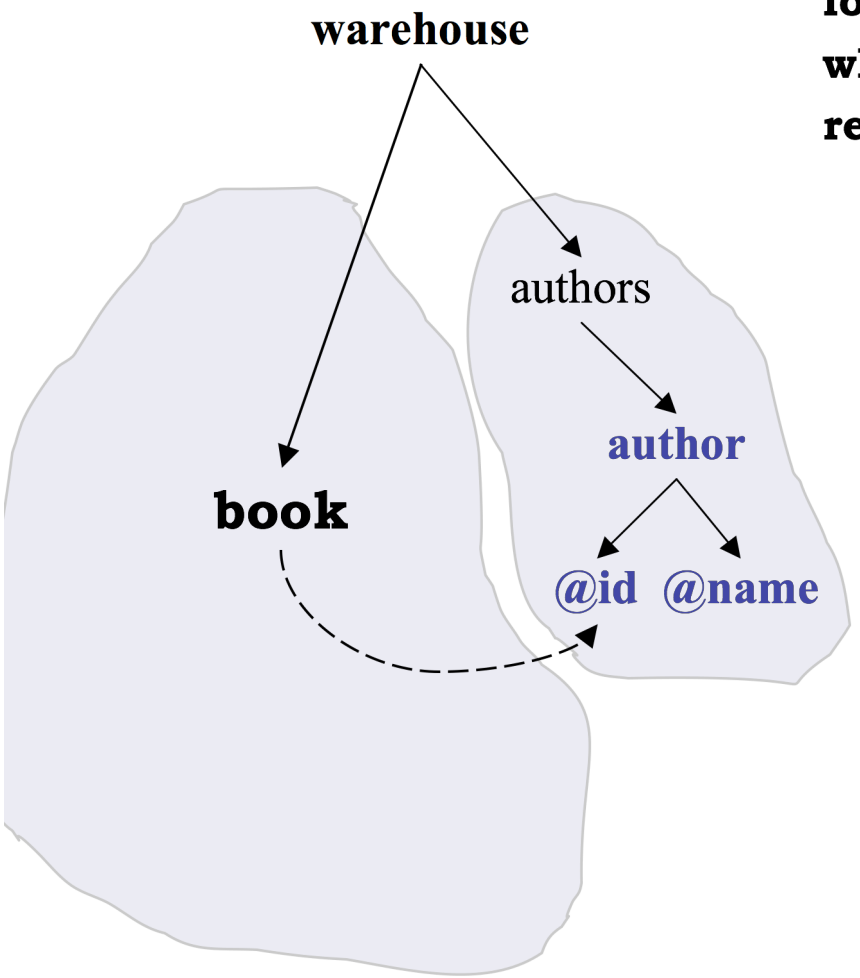

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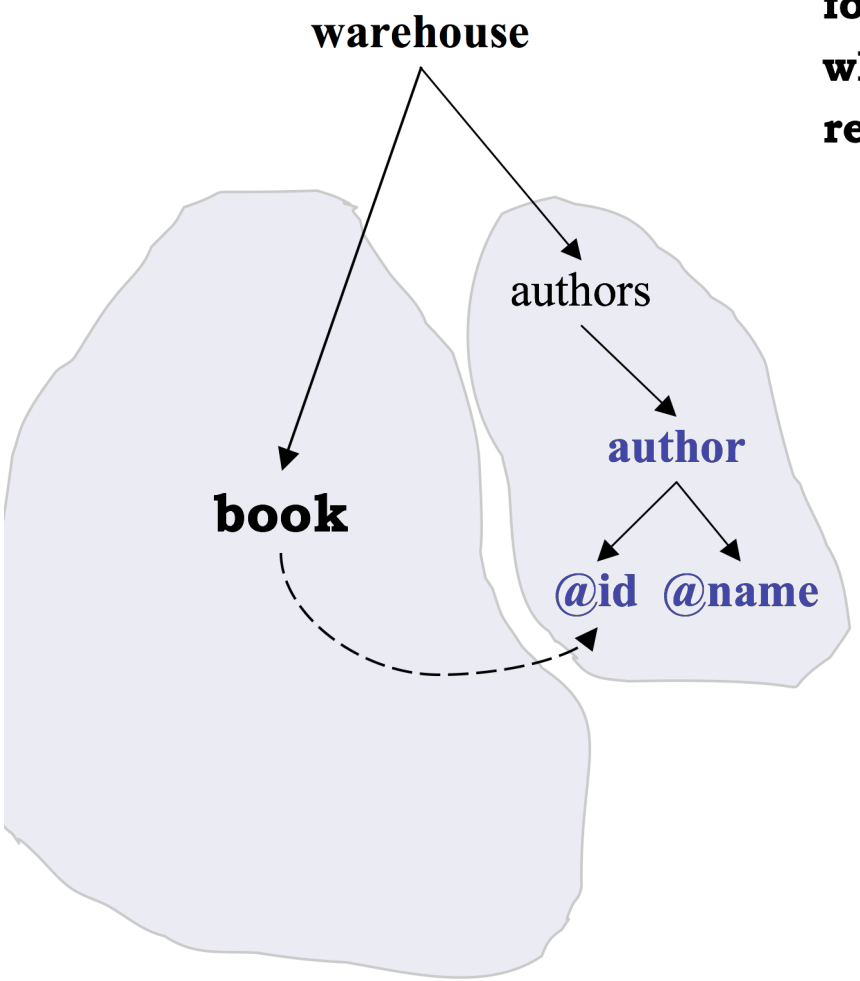

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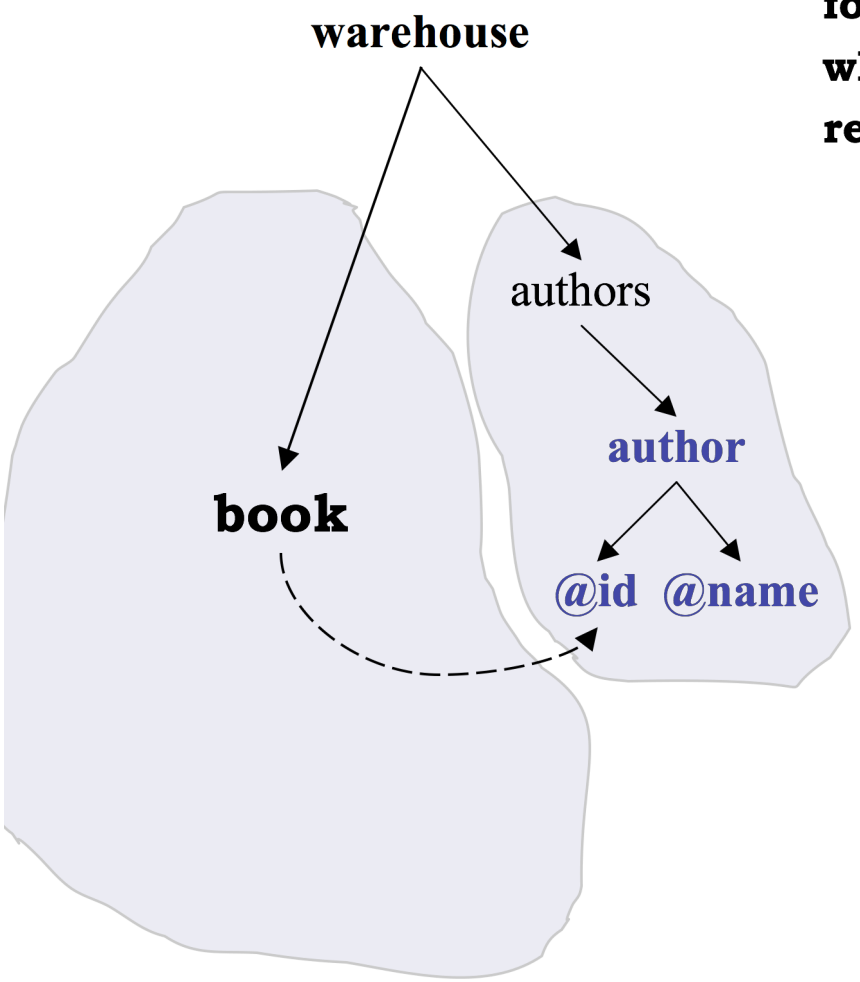

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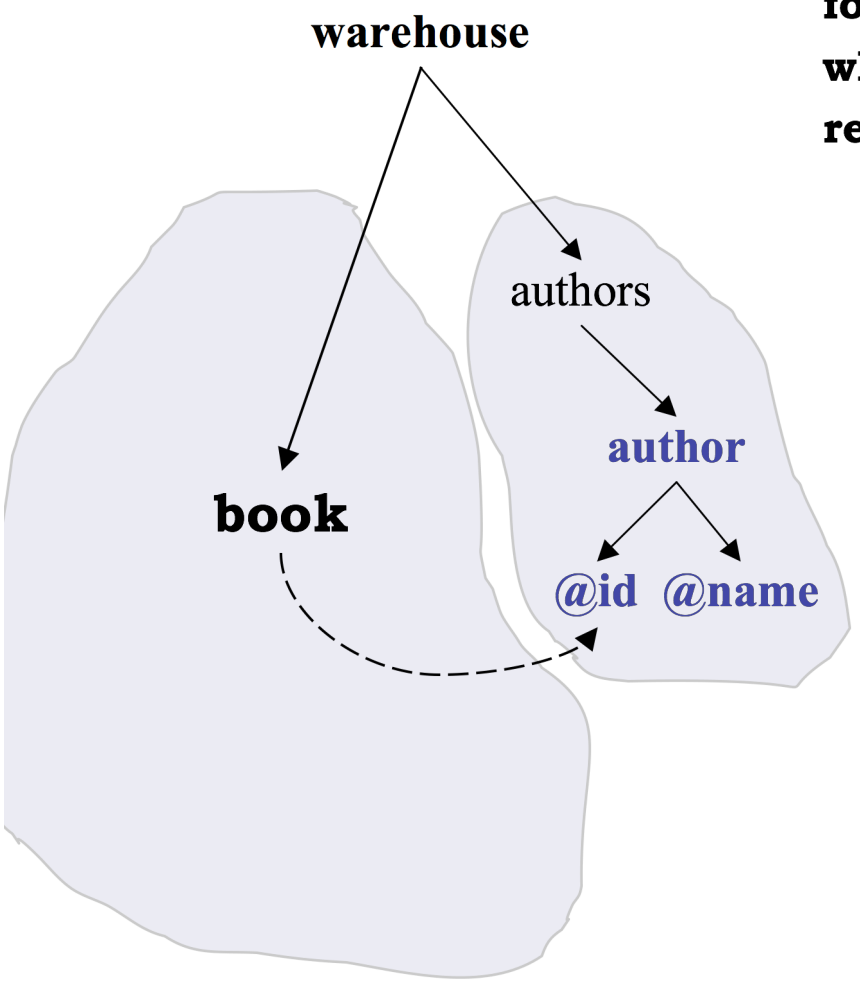

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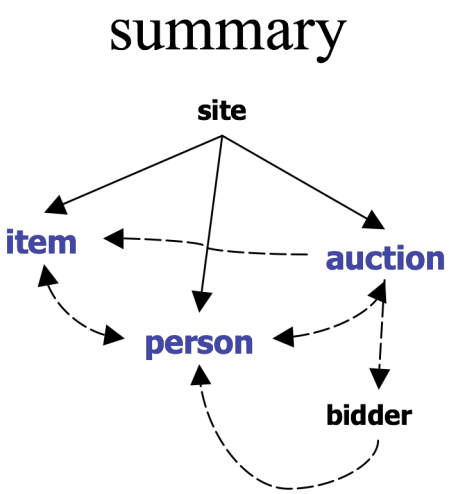
- Only relevant part of the schema needs to be visited!
- Problems …

Problem with Complex Queries



- Query: retrieve auction that are *sold* by the person named “peter” in “chicago” and *contain* items that are “antiques” in region “asia”

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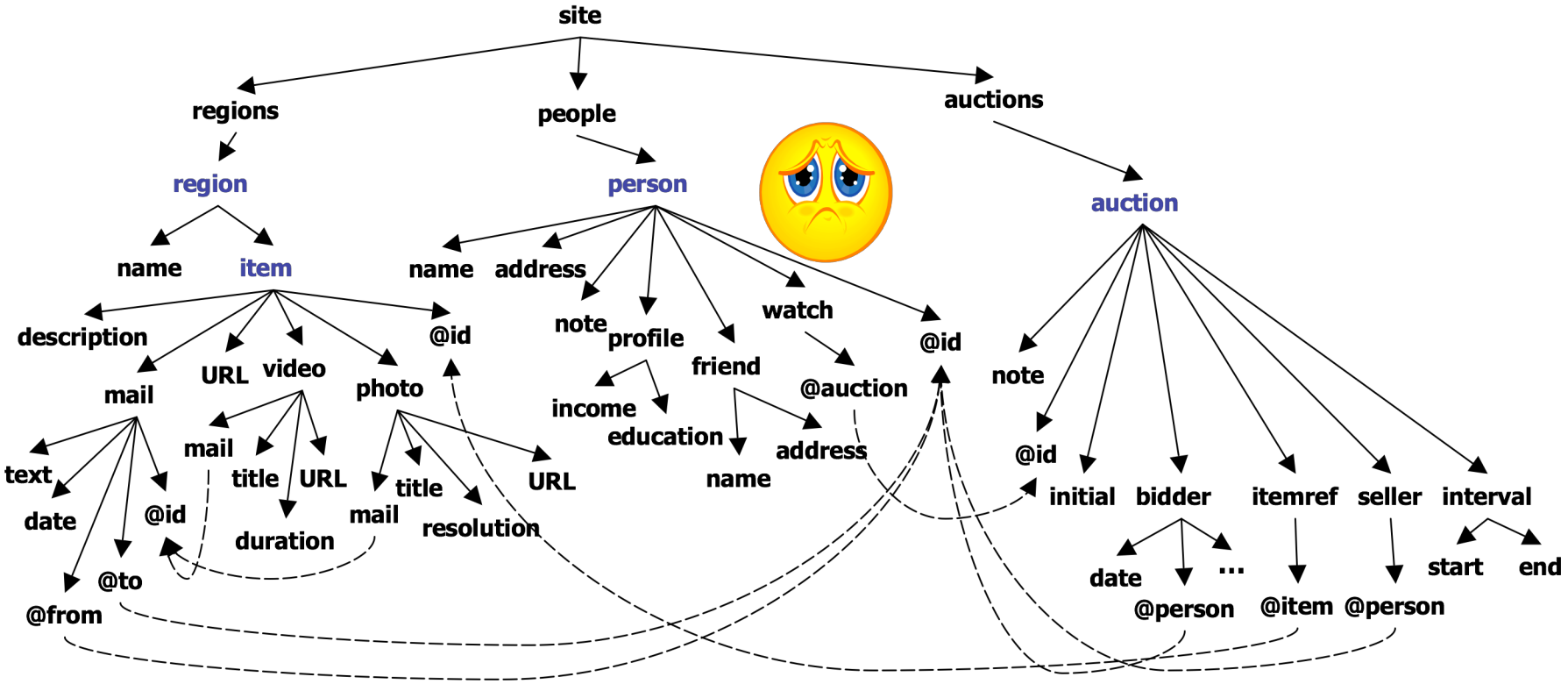

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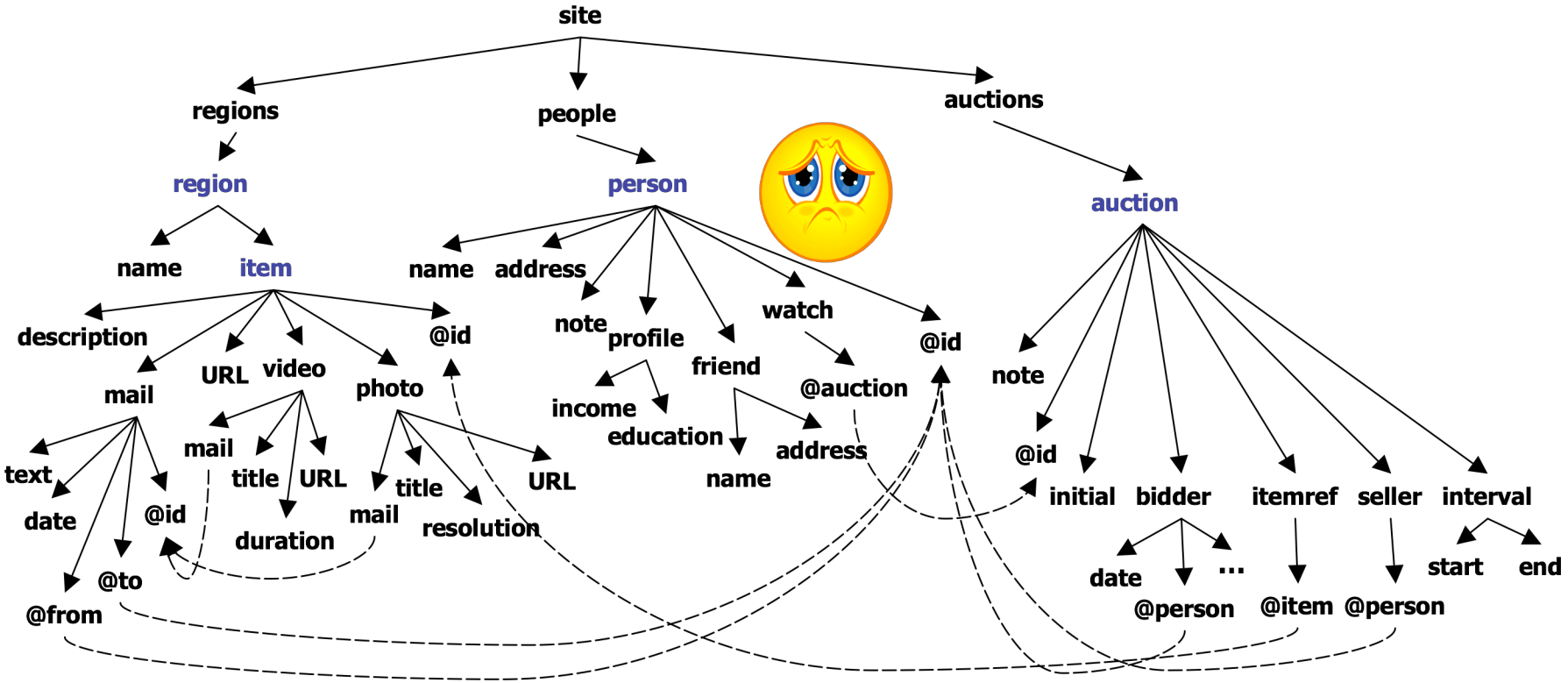

Constructing complex queries requires the expansion of the summary into the entire schema!

Our Solution

- Content-based matching semantics
- Curse of query and schema complexity

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Schema-Based Matching Semantics

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Summary-Based Query Model

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- Two components:

Meaningful Schema Pattern

- Meaningful Schema Pattern
  - A schema sub-graph
  - Satisfying certain semantic conditions: Basic / Related-Entity / Non-Redundant

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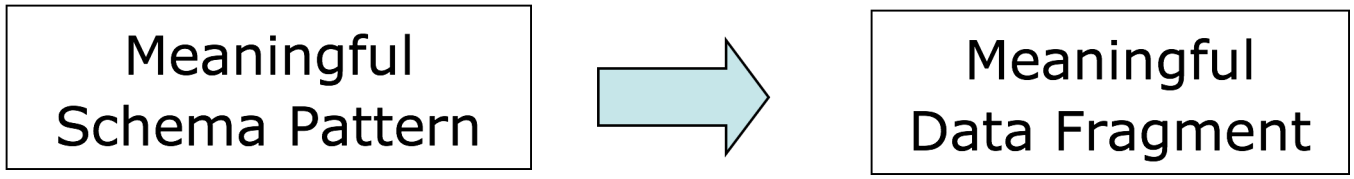
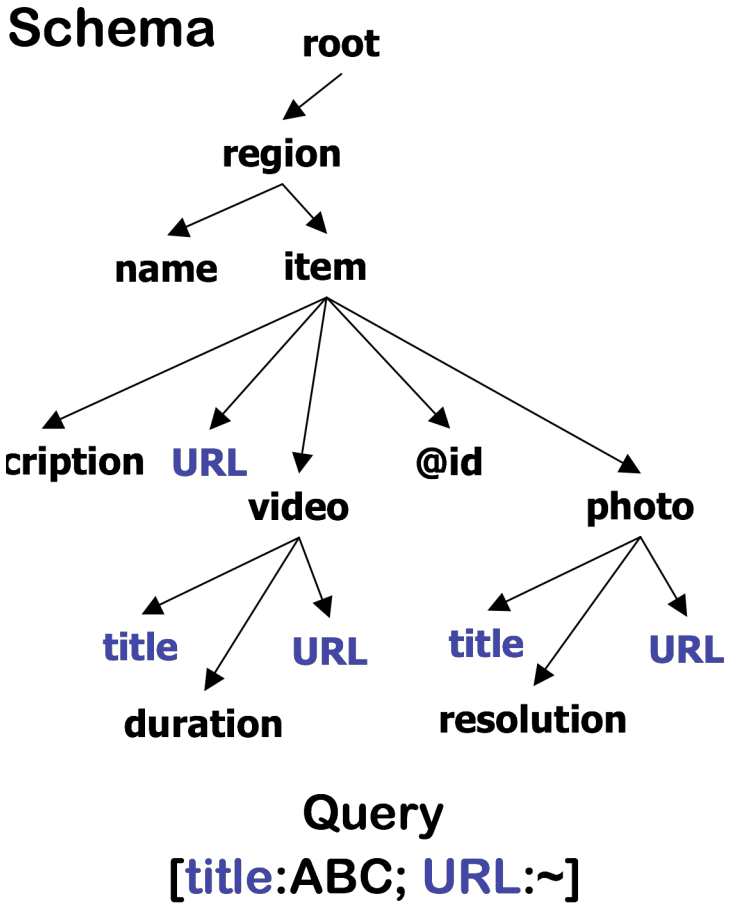


- Meaningful Data Fragment
  - A data subtree
  - Result of querying the database with the meaningful schema pattern

Basic Matching Semantics



- Inspired by content-based semantics
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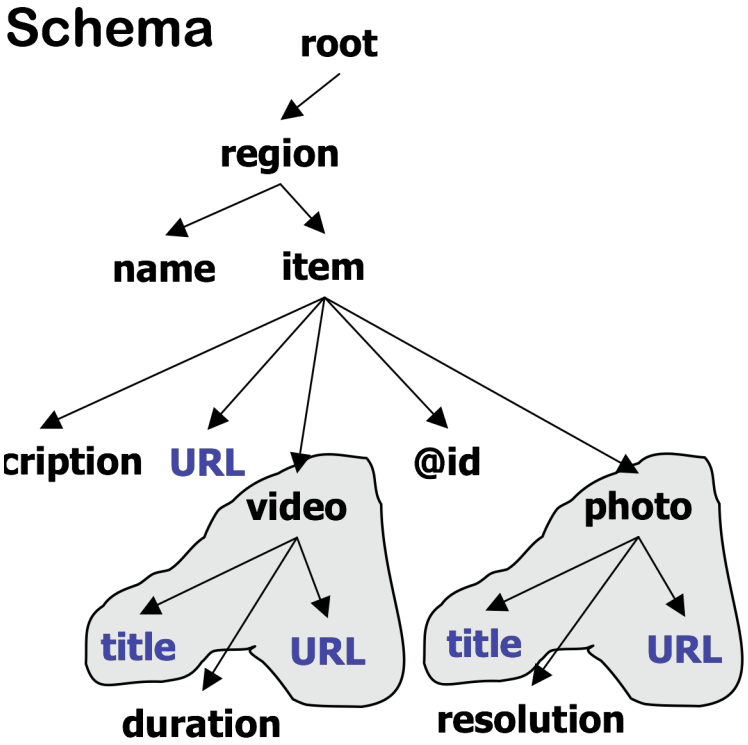

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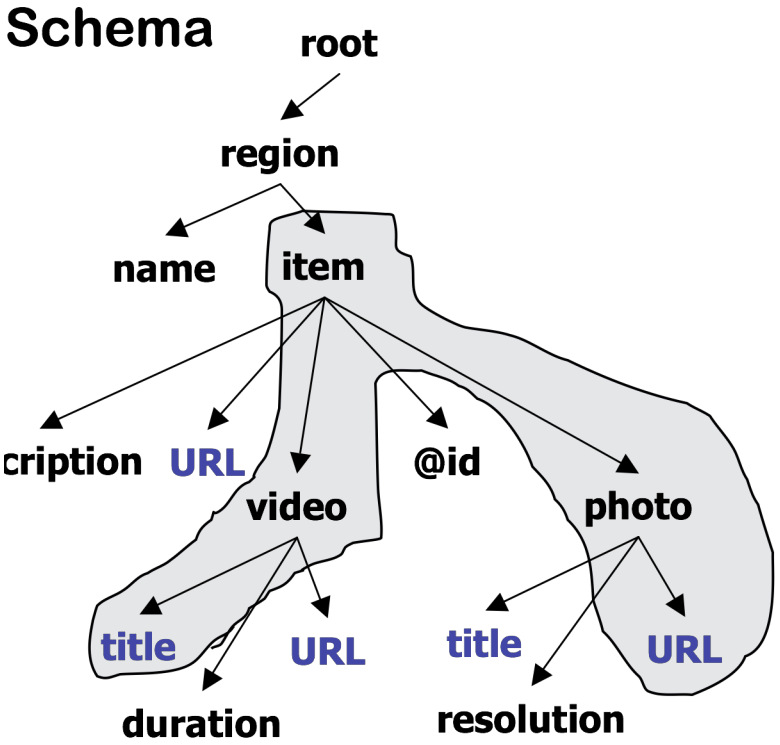

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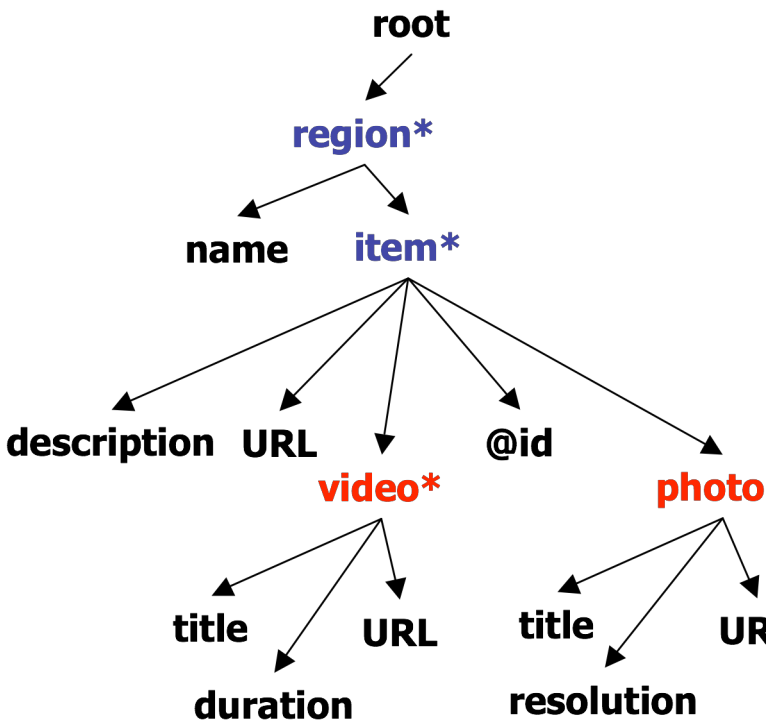
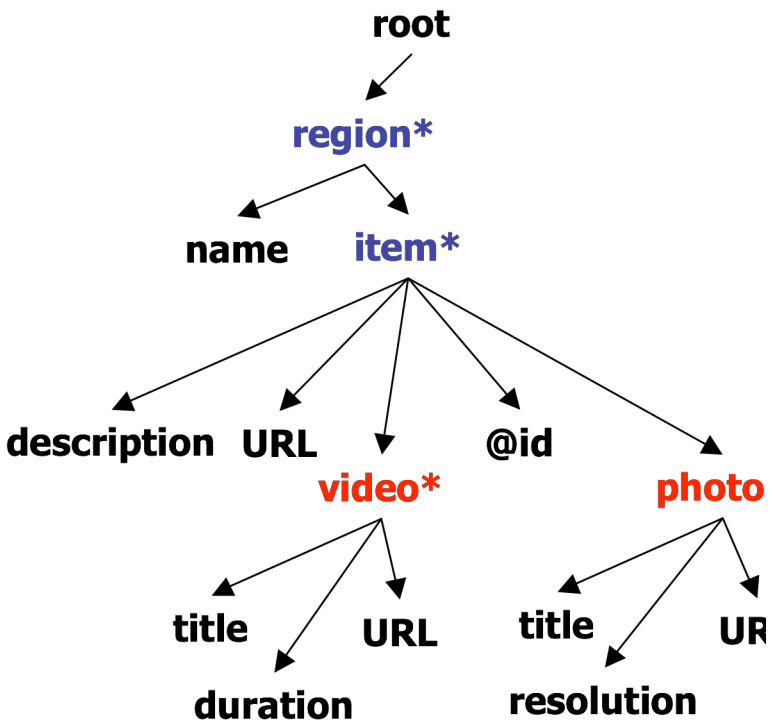
Schema Hints

- Element repeatability
  - Repeatable elements are *entities*
  - Non-repeatable elements are *attributes* of their "parent" entities



Schema Hints

Attributes of the same entity are meaningfully related



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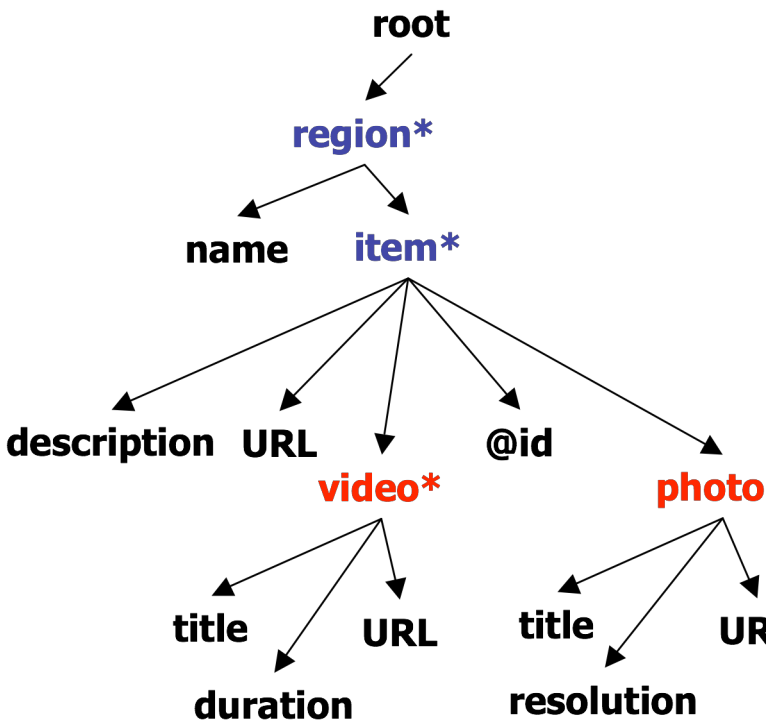

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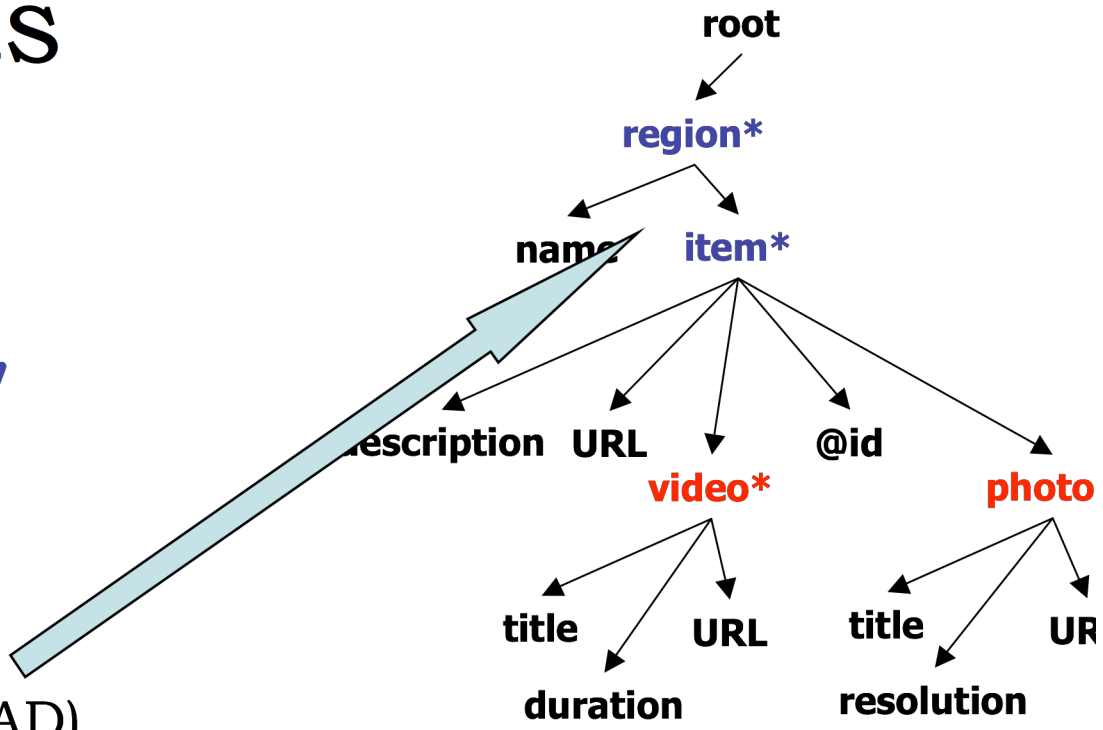

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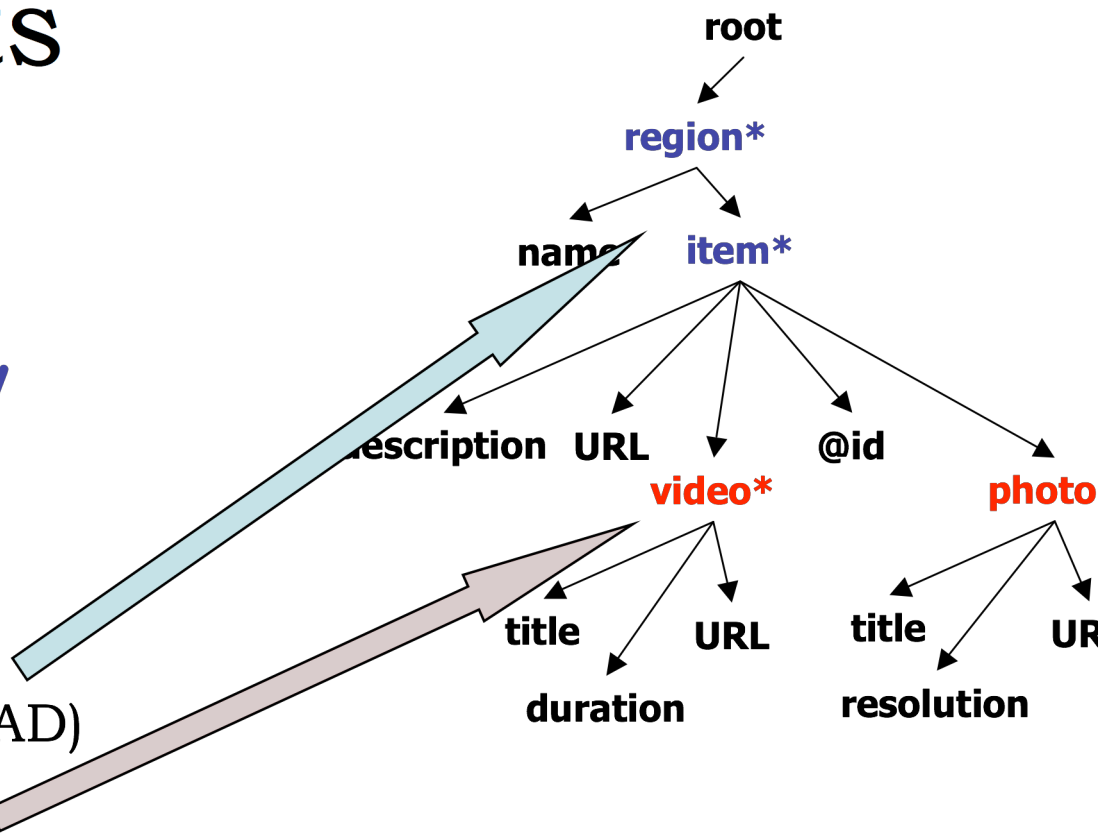

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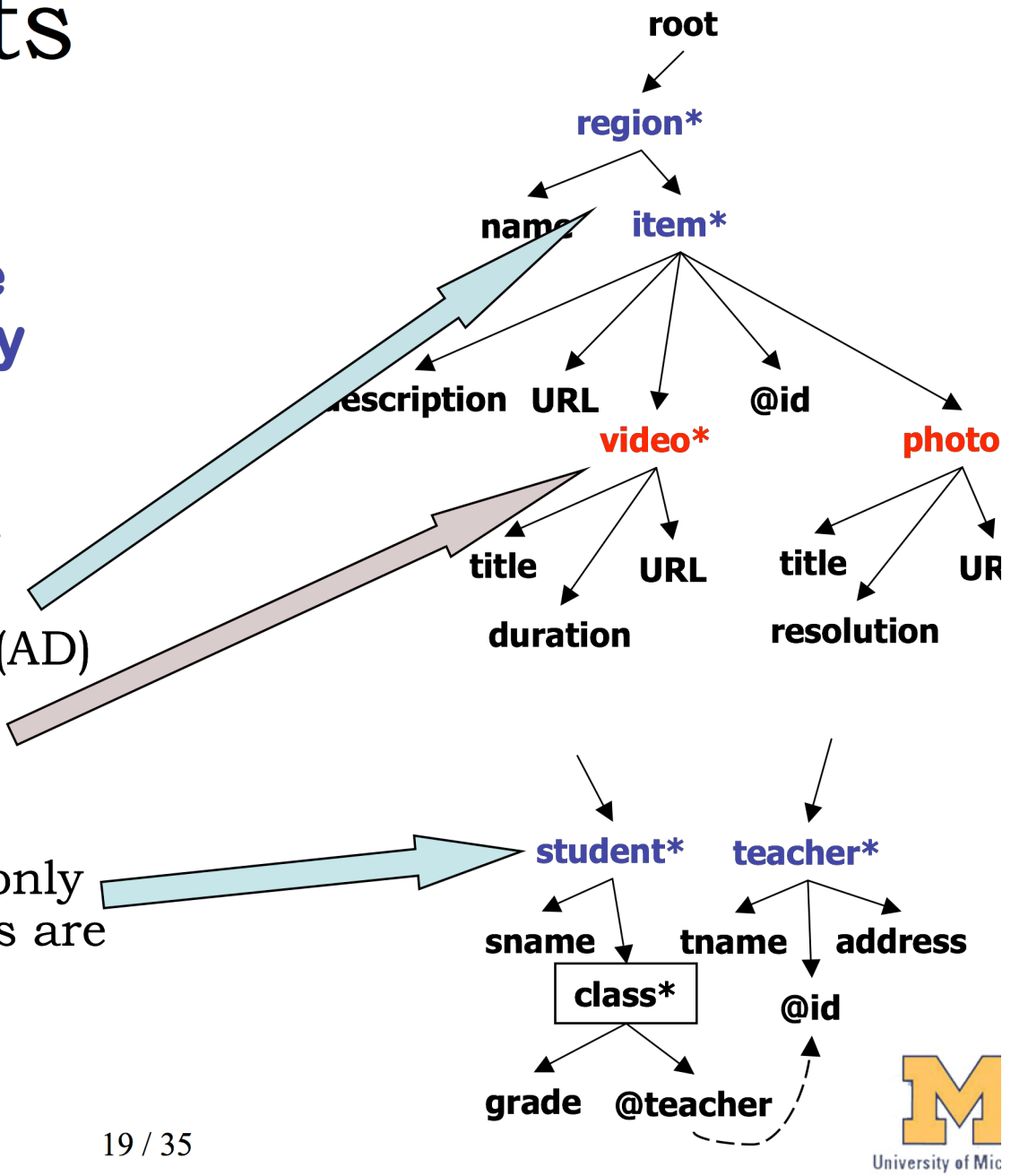
  - Sibling with common descendant (SIB-D) – only occur when value links are present



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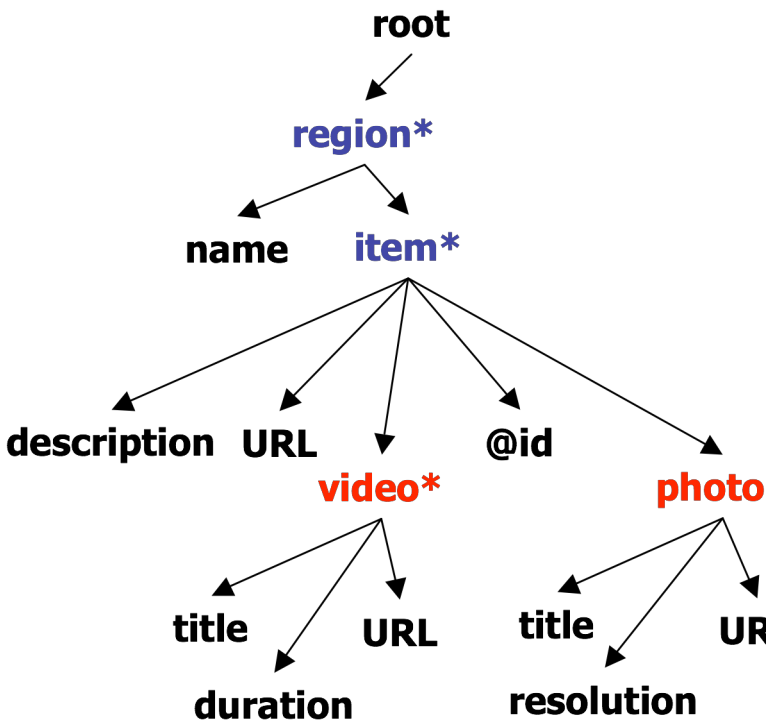
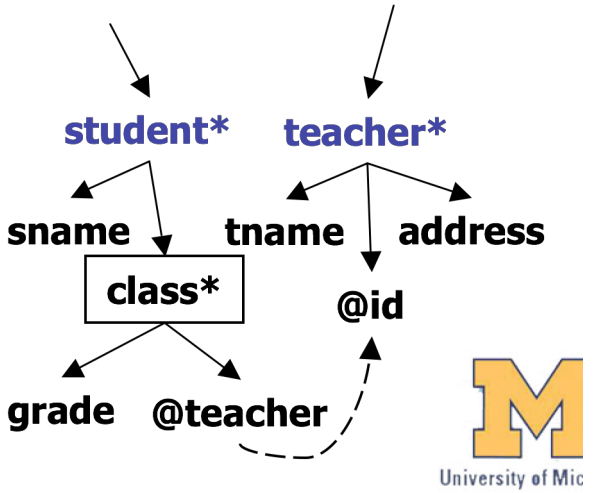
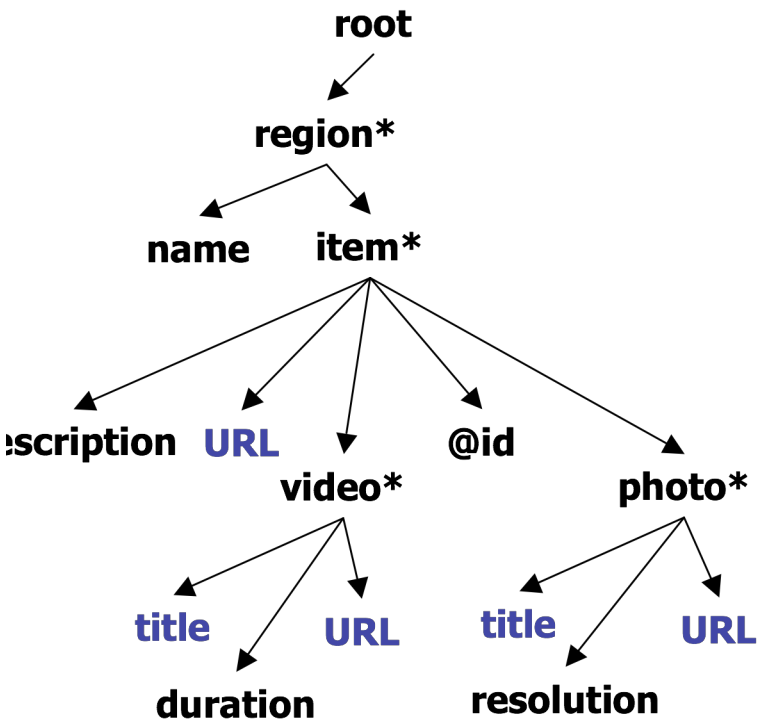


Entities with AD and SIB-D relationships are meaningfully related



Advanced Matching Semantics



Query
[title:ABC; URL:~]

- Related-Entity (RE):
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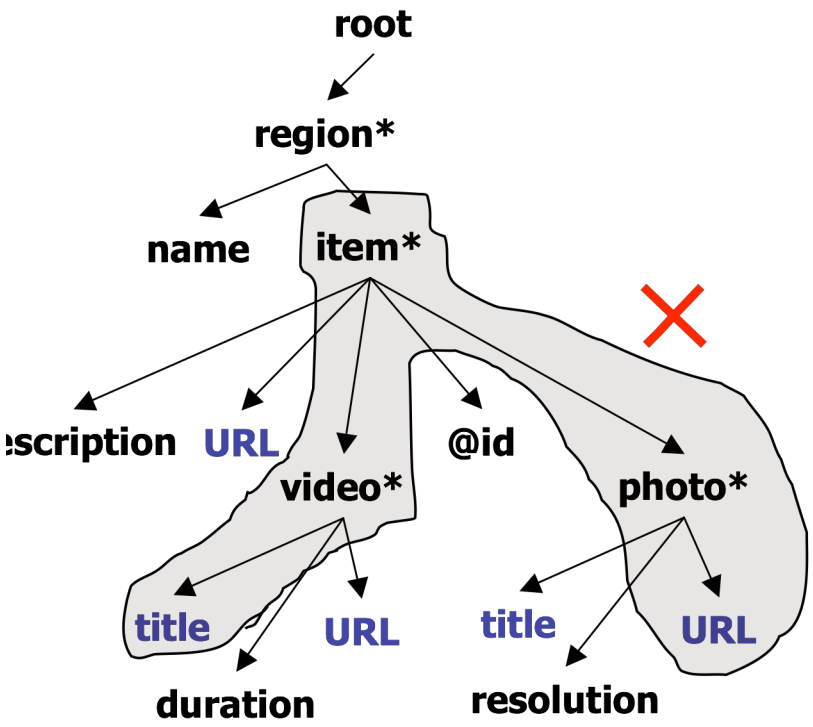

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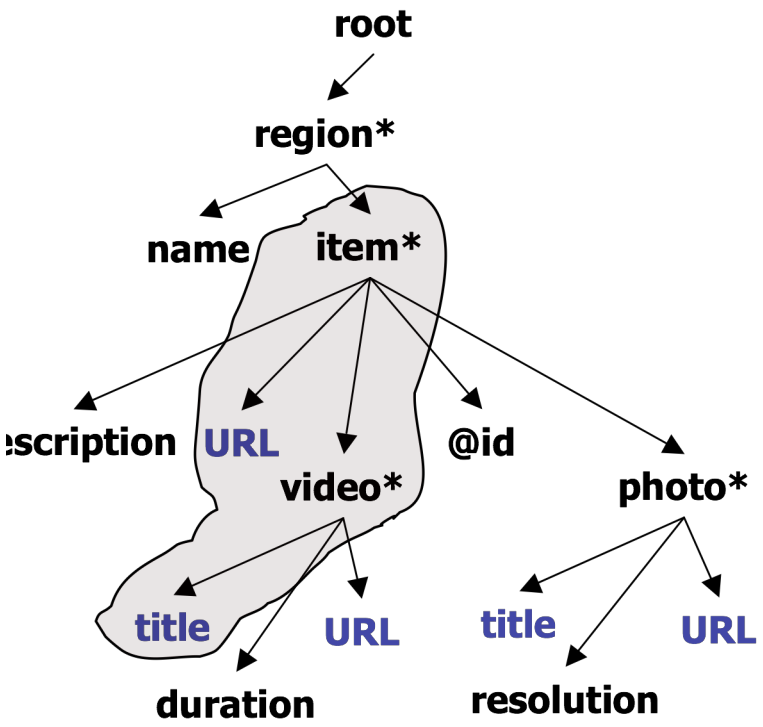

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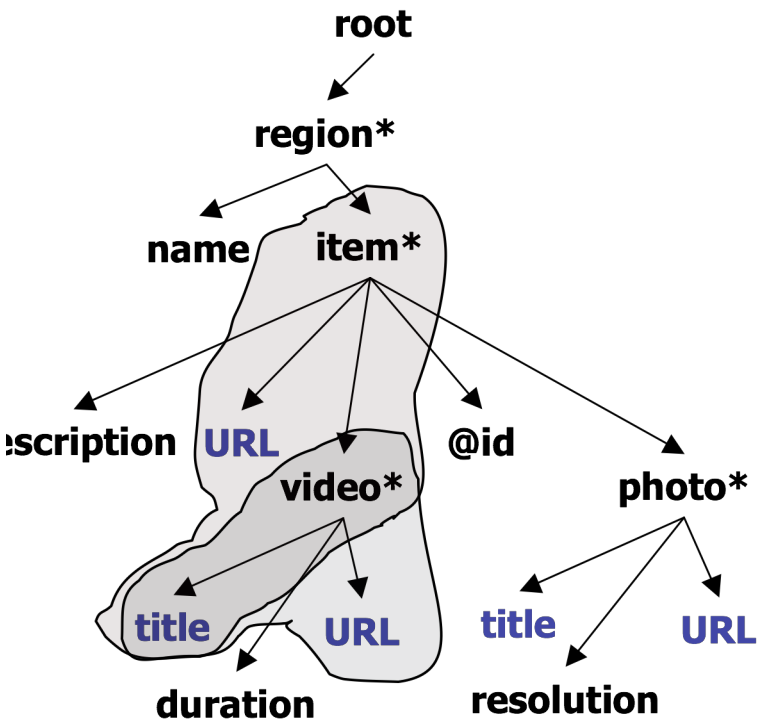

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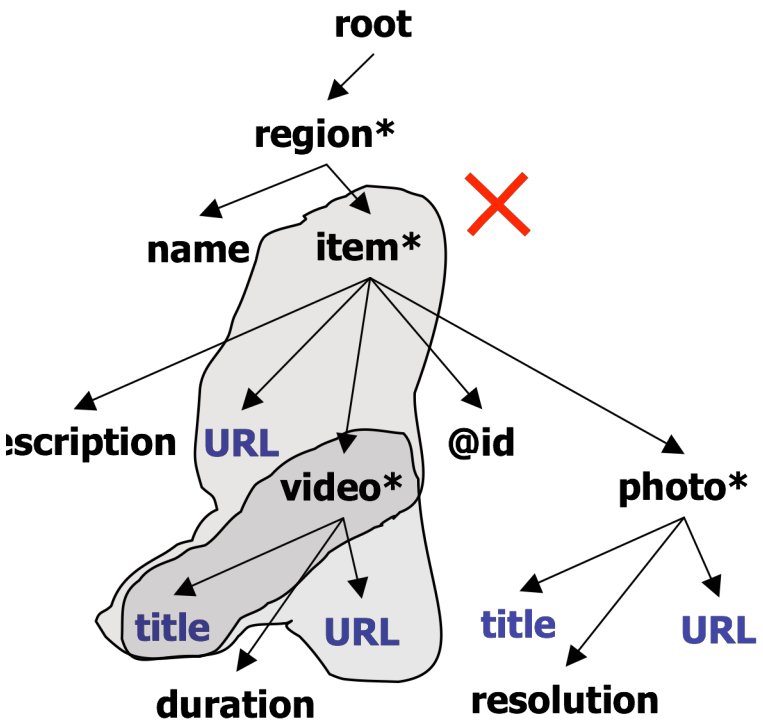

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- Non-Redundant (NR):
  - Satisfy RE semantics
  - No other schema pattern satisfies RE Semantics, and yet contains a strict subset of entity elements

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  - Avoid data specific erroneous matches
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- Limitations
  - Not enough flexibility in query semantics
- Need to incorporate “some” schema information into the query!

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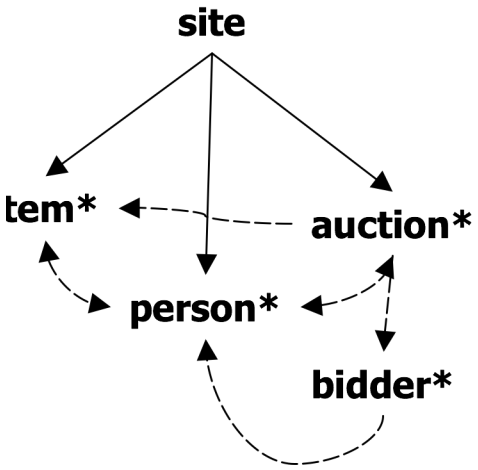
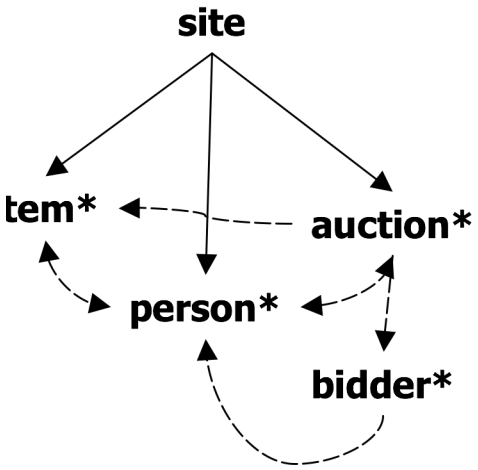
- Leverages *schema summary* (as partial schema information) for the basic structure of the query
- Leverages *schema-based matching semantics* for fetching information from hidden schemas

Example MSQ Query



- Query: retrieve auction that are *sold* by the person named “peter” in “chicago” and *contain* items that are “antiques” in region “asia”

Example MSQ Query

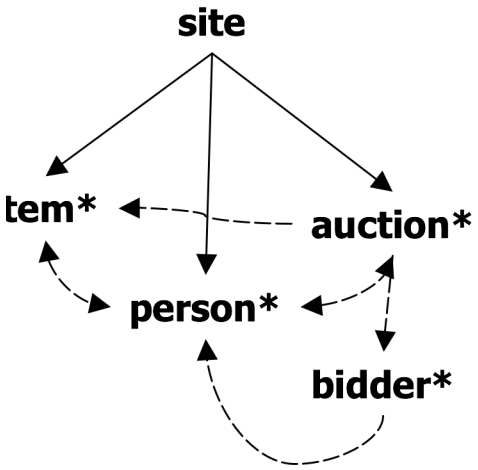



```
for     $a  in /site//auction
        $i  in /site//item
        $p  in /site//person
where       ($a, $p,        ) and
             ($a, $i,           )
return  $a
```

Basic Query Structure

- Query: retrieve auction that are *sold* by the person named “peter” in “chicago” and *contain* items that are “antiques” in region “asia”

Example MSQ Query



Structure-Free Conditions

```
set   $c1 = item[region:asia; item:antiques],
      $c2 = person[name:peter; address:chicago]
for   $a  in /site//auction.MF(),
      $i  in /site//item.MF($c1),
      $p  in /site//person.MF($c2)
where MR($a, $p,"sold" ) and
      MR($a, $i, "contains")
return $a
```

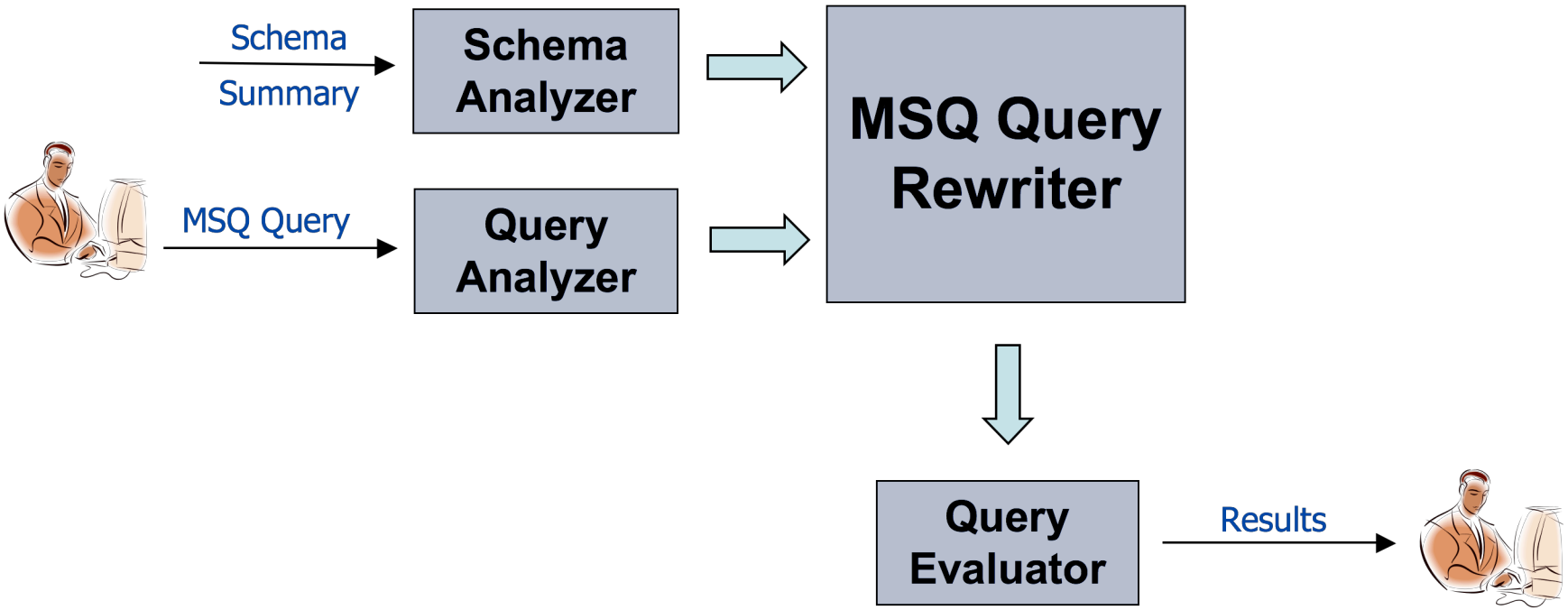
Basic Query Structure

- Query: retrieve auction that are *sold* by the person named "peter" in "chicago" and *contain* items that are "antiques" in region "asia"
- MF: Meaningful Fragment
- MR: Meaningful Relationship

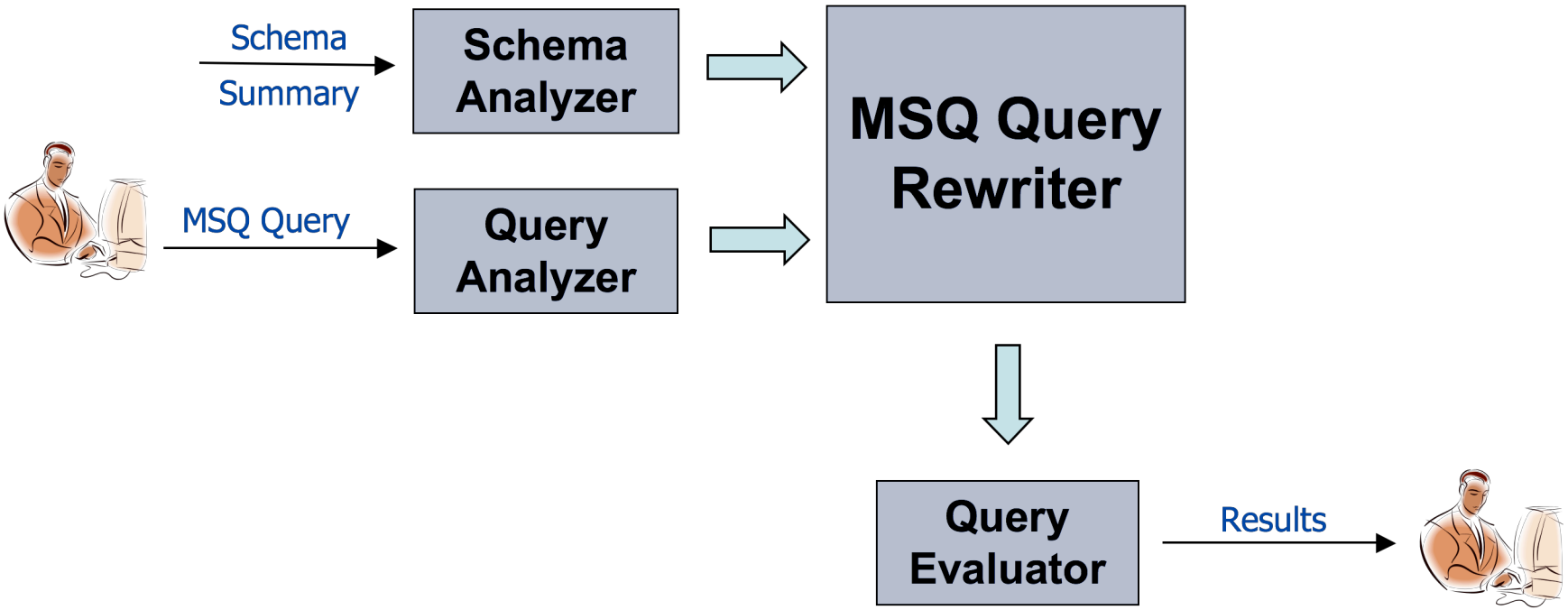
Benefits of MSQ Query Model

- The user only establishes the overall structure of the query (conceptual simplicity)
  - Express the details as labeled keyword conditions
  - Let the system automatically figure out the exact structured query
- The user can still express complex queries (e.g., with aggregate conditions)
- Schema knowledge can be easily injected into the query if available

Evaluating MSQ Queries



Evaluating MSQ Queries



Analyzing MSQ Query

MSQ Query [User Specify]

```
set $c1 = item[region:asia;
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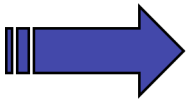

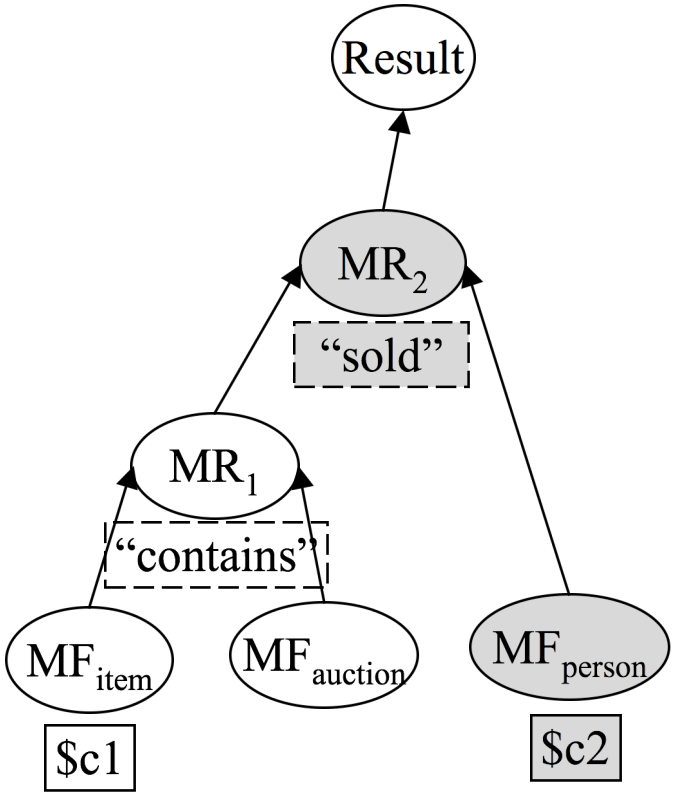

Analyzing MSQ Query

MSQ Query [User Specify]

```
set $c1 = item[region:asia;
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    $c2 = person[name:peter;
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where MR($a, $p, "sold") and
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```
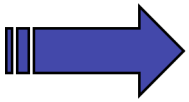
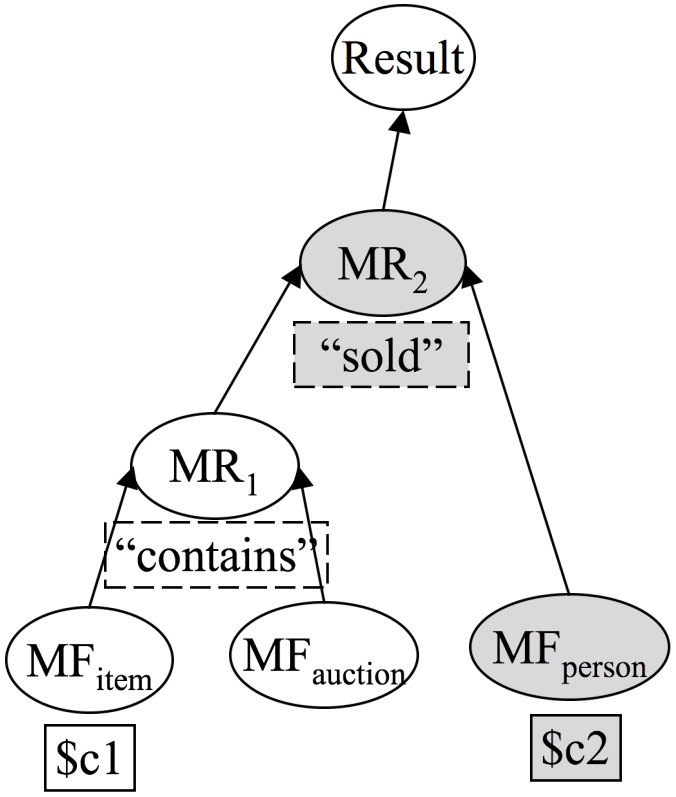
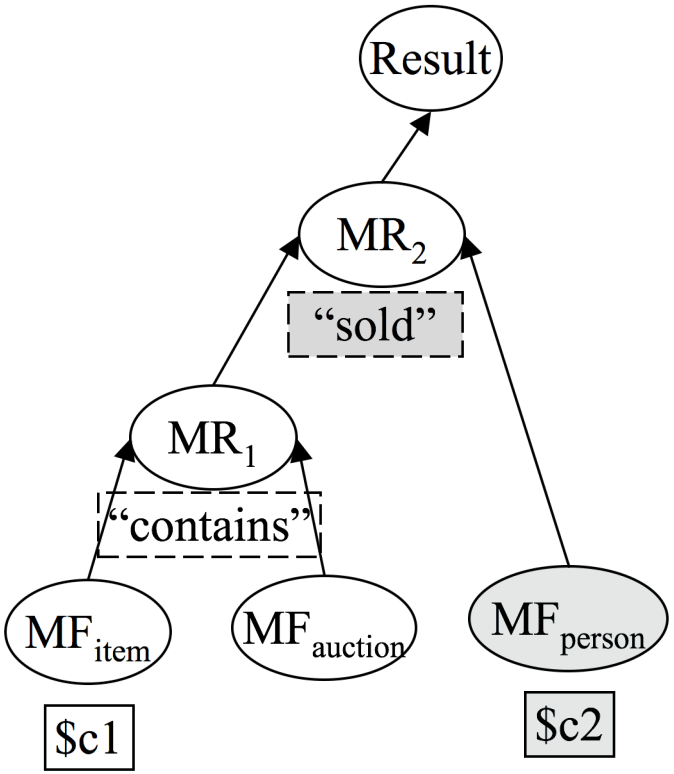



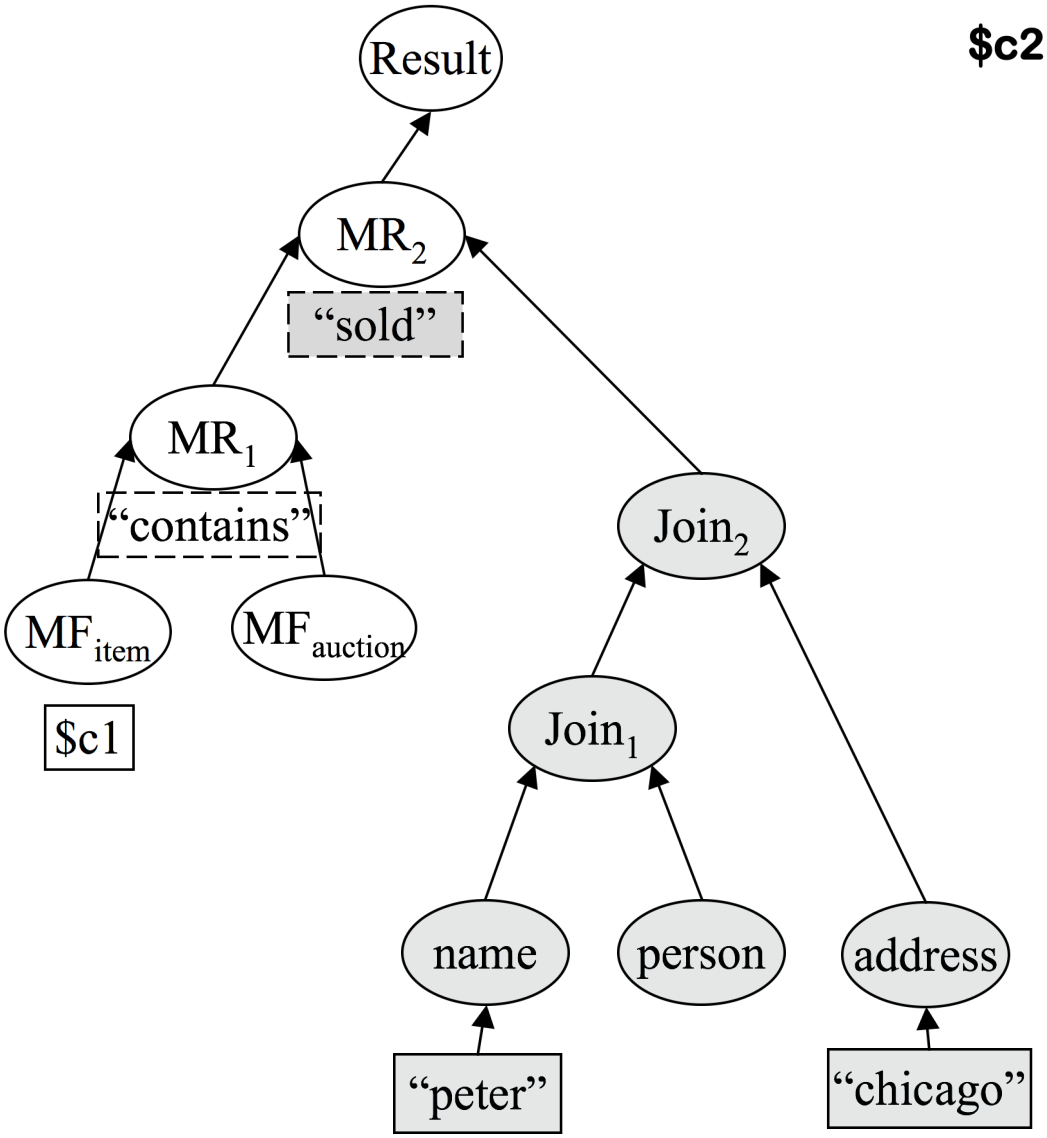


MSQ Query Rewriting Algorithm



$c2 = person[name:peter;
address:chicago]

MSQ Query Rewriting Algorithm



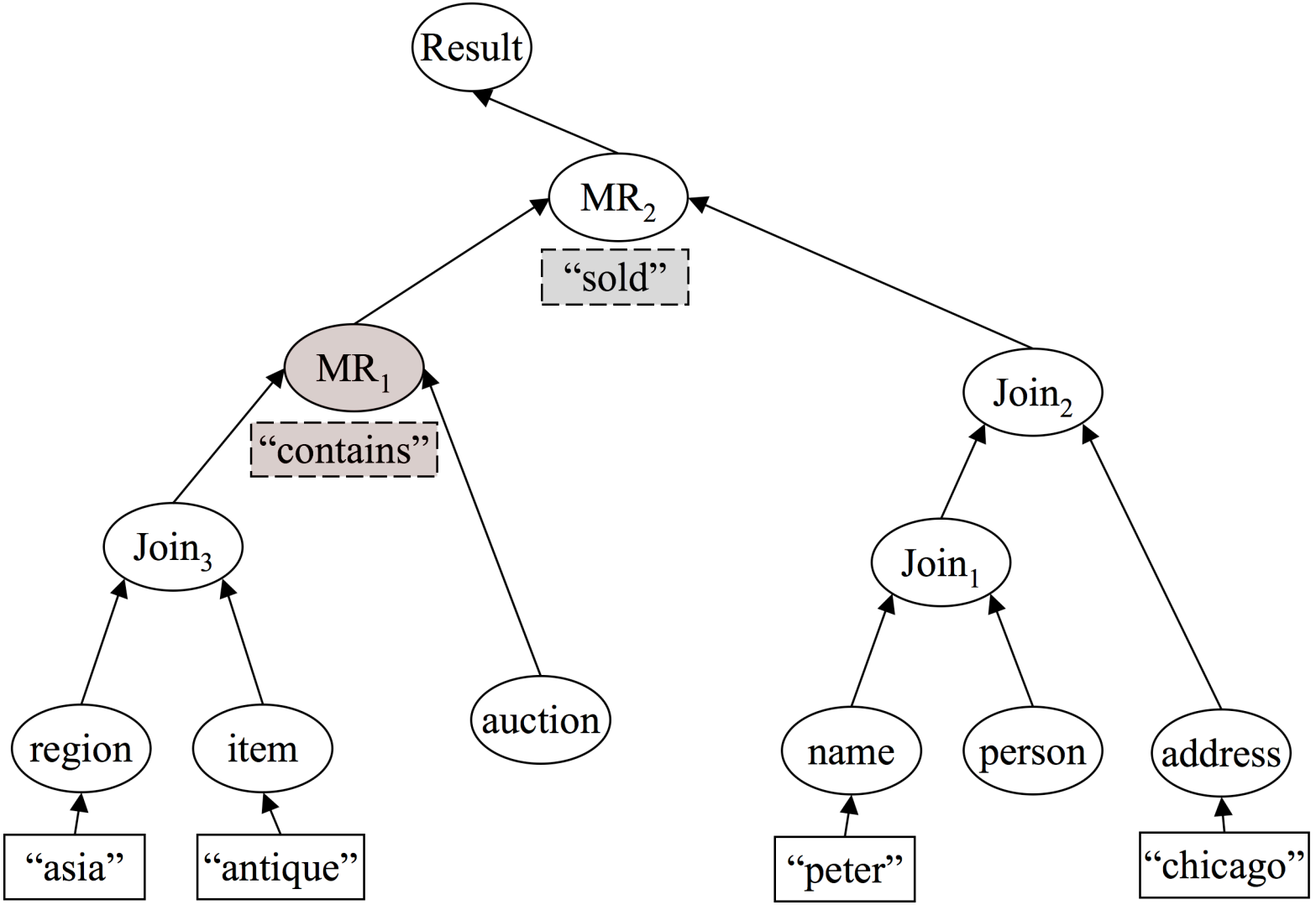
$c2 = person[name:peter; address:chicago]

Identify MSP

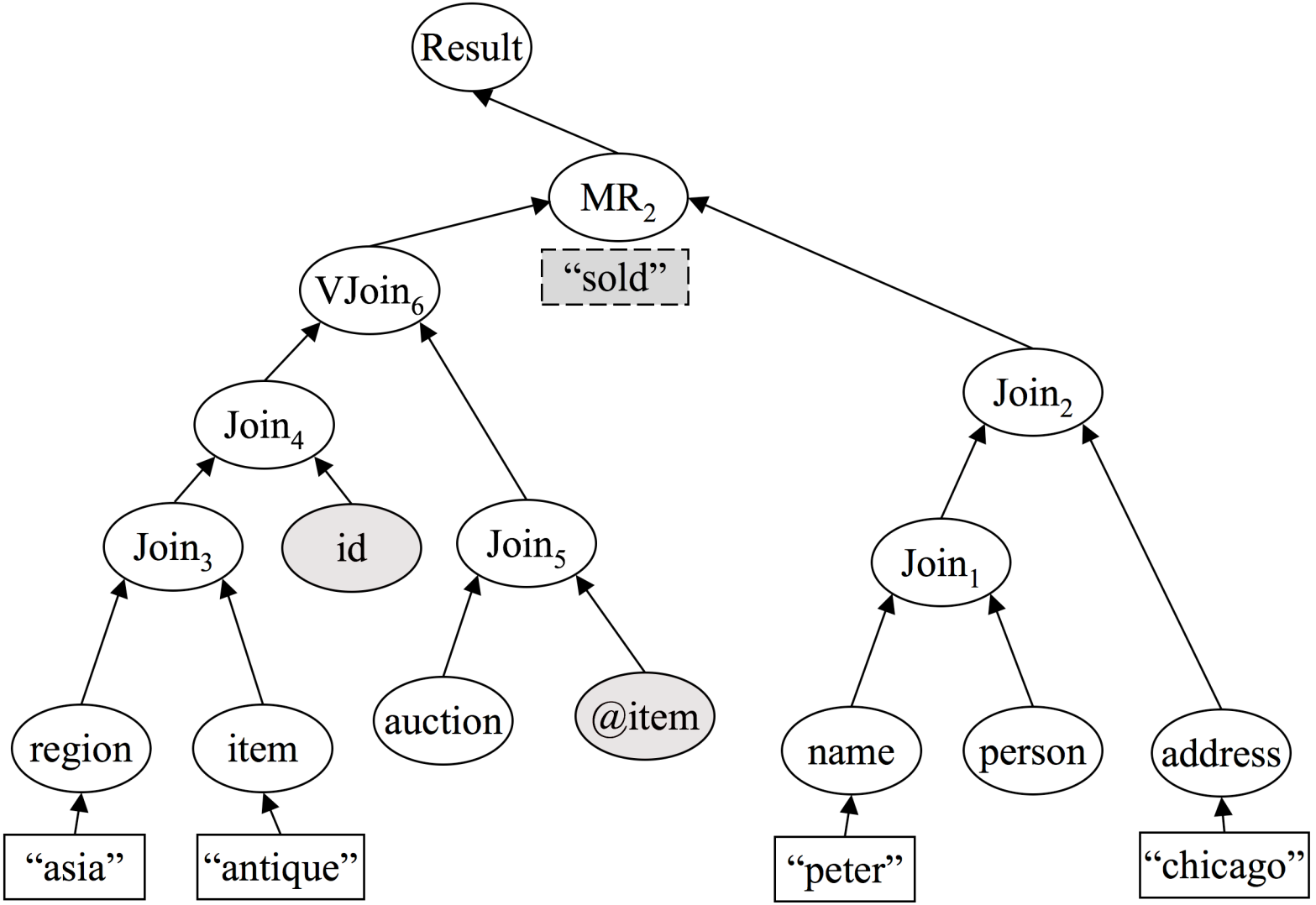
person*

name **address**

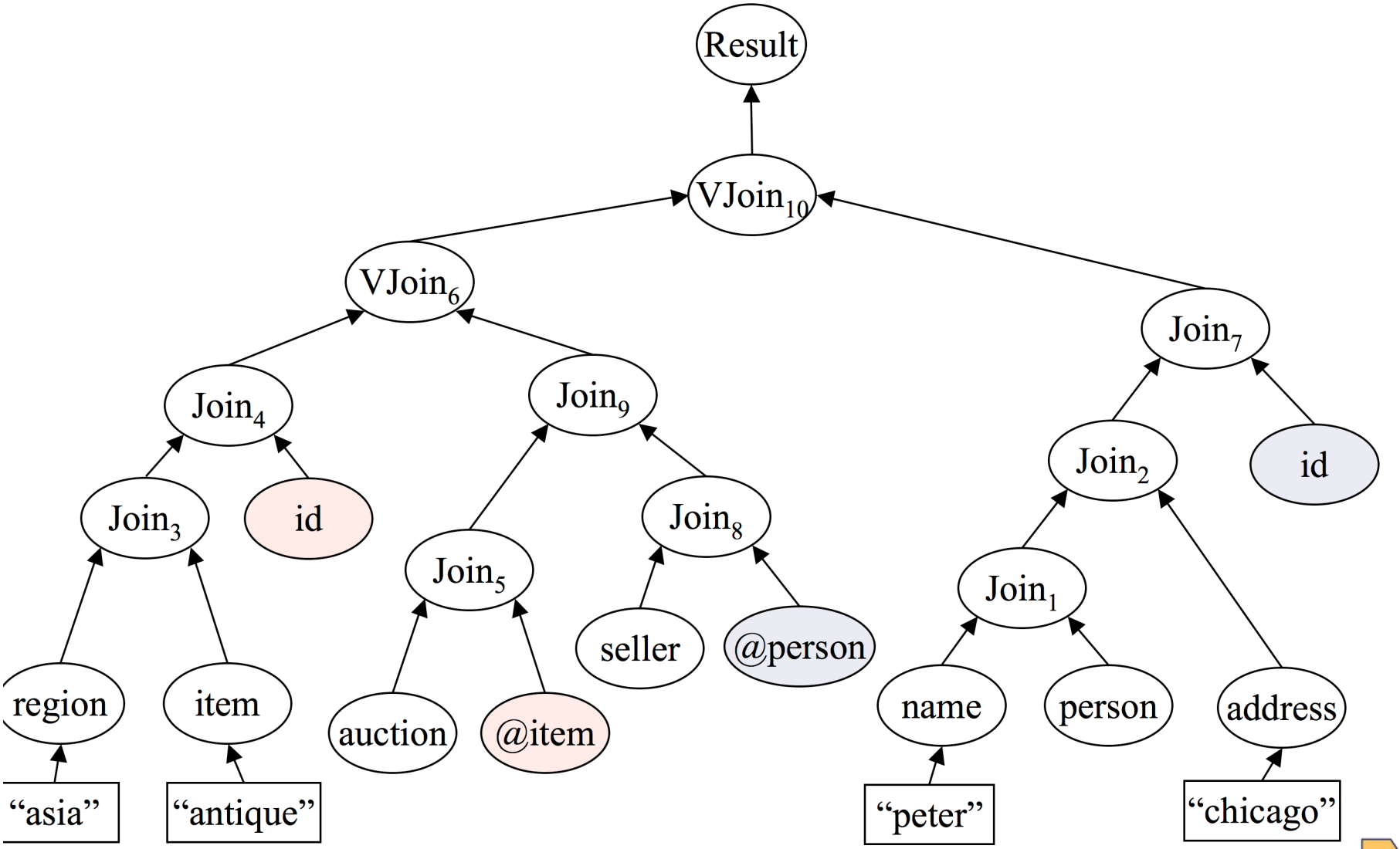
MSQ Query Rewriting Algorithm



MSQ Query Rewriting Algorithm



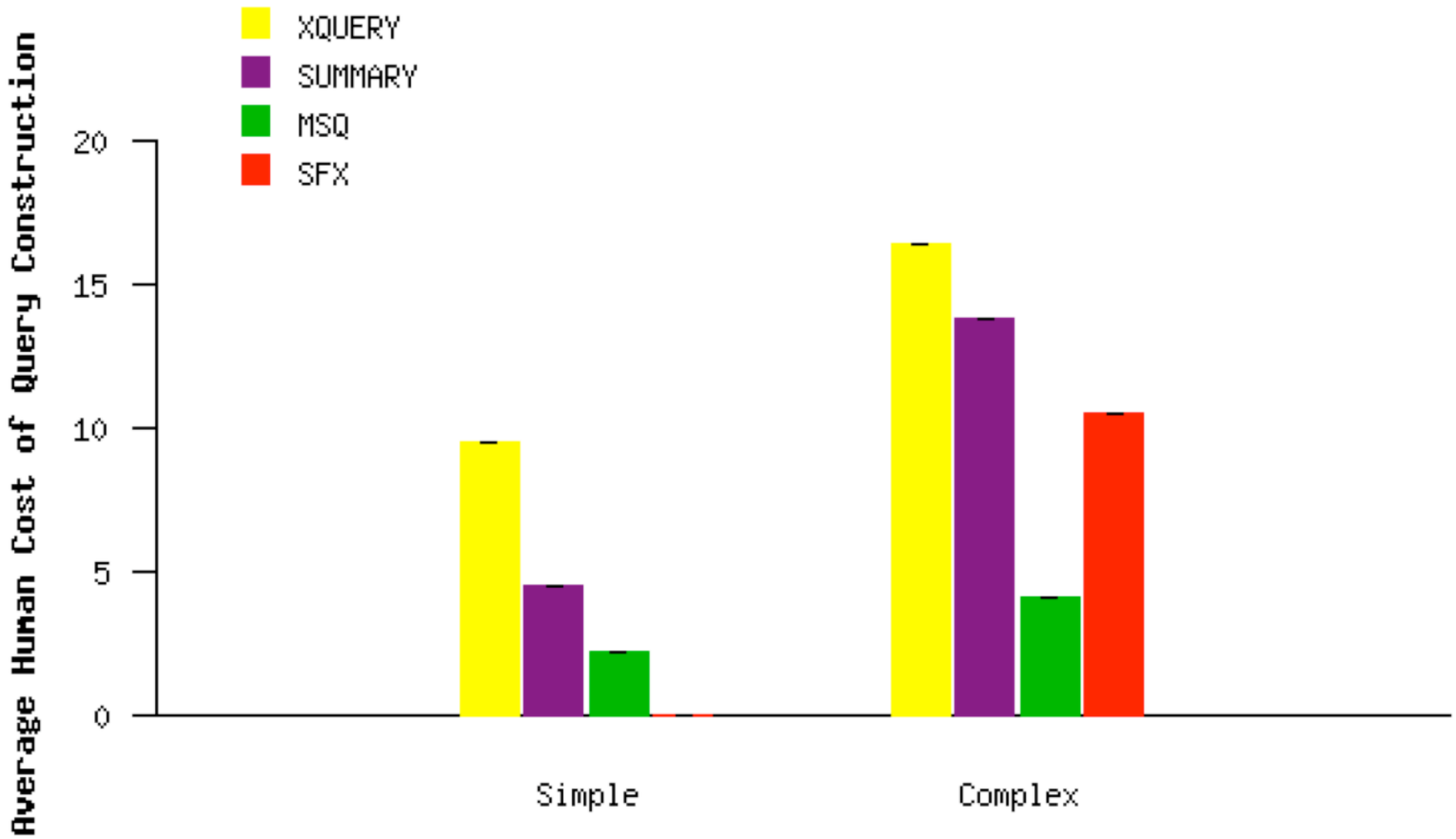
Final Evaluation Tree



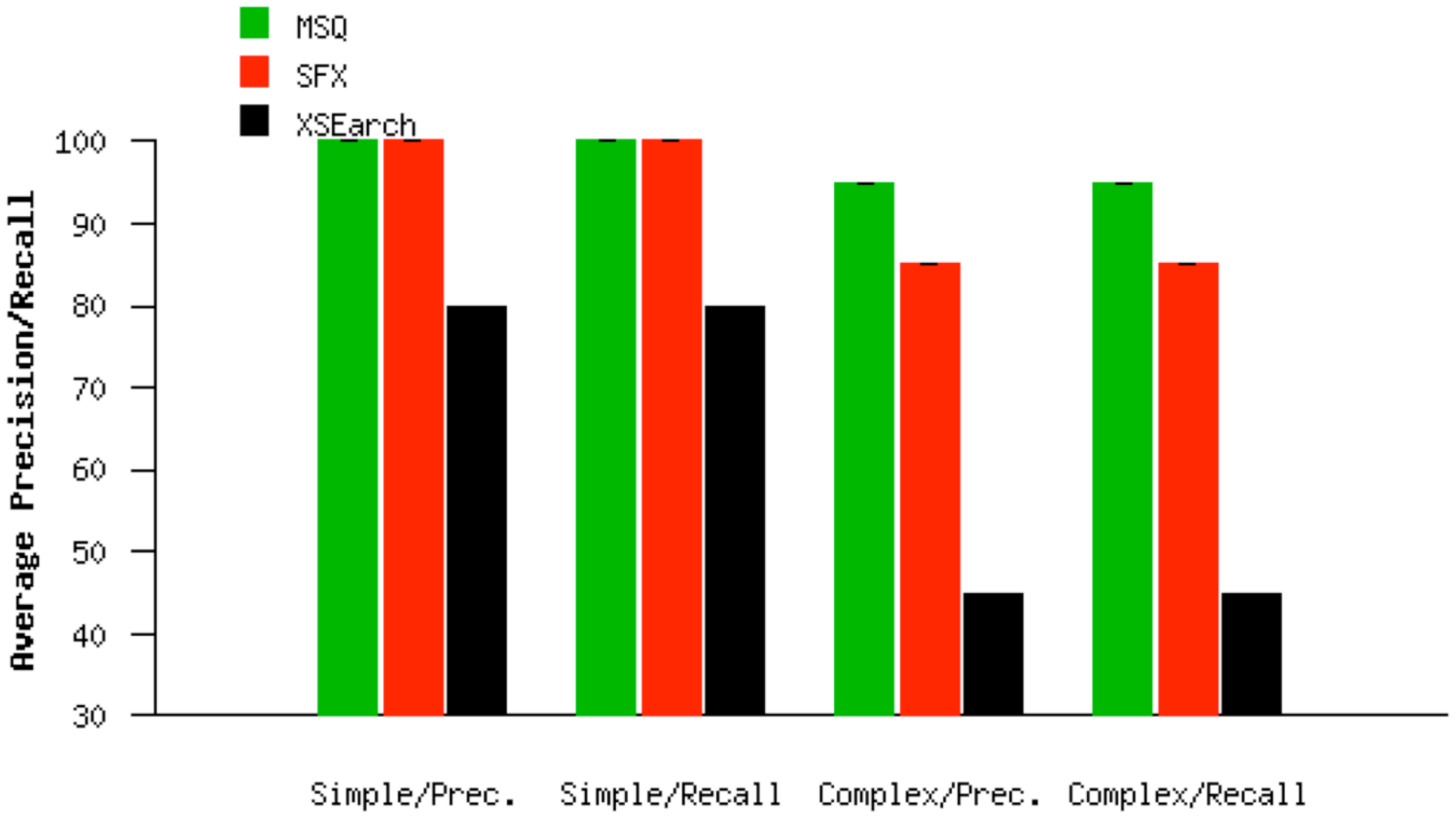
Experimental Evaluation

- XMark and MiMI datasets
  - 20 queries for XMark, 52 queries for MiMI
- Compare with four alternative strategies
  - XQuery (XQUERY)
  - Summary-Based Exploration (SUMMARY)
  - Labeled Keyword (XSEarch)
  - Schema-Free XQuery (SFX)
- Divide queries into *simple* and *complex*

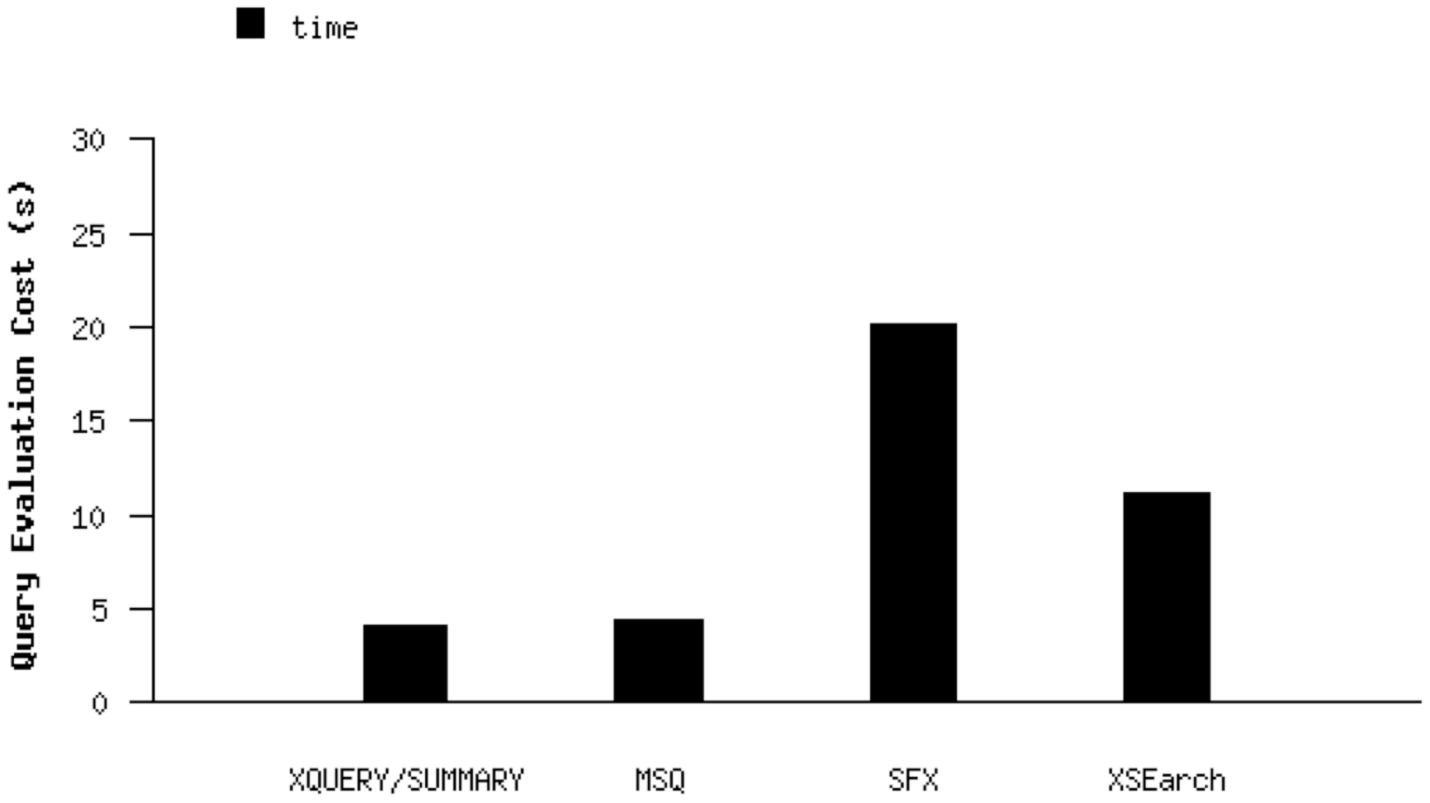
Human Cost of Querying



Result Quality (Precision & Recall)



Query Performance



Conclusion

- We proposed a novel query model called Meaningful Summary Query (MSQ)
  - Leverages schema-based semantics to improve query performance while maintaining result quality
  - Enables ordinary users to query on the schema summary directly

Questions ?

http://www.eecs.umich.edu/db/usable