Materialized views for P2P XML warehousing

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Problem statement and contributions

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efficient and flexible XML content sharing in peet-to-peer networks based on a DHT.

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Contributions

- An architecture for flexible management of XML materialized views on a DHT
- View advertisement algorithms
- Query rewriting algorithms
- ViP2P: full platform for distributed XML view management

Outline

1. **Introduction**
2. **Algebraic query rewriting**
   - Tree patterns for views and queries
   - Algebraic rewriting & operators
3. **Rewriting algorithms**
4. **View management**
   - View definitions index/lookup
5. **Experiments**
6. **Conclusion**

XML materialized views on a DHT

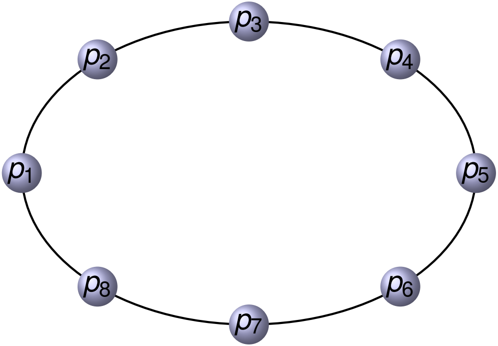
Declare tree pattern XML views over the network data

Fill in the views with XML data

Answer tree pattern queries using the existing views

- View definition lookup
- Query rewriting $\Rightarrow$ logical plan
- Translation to a (distributed) physical plan
- Execution of the physical plan

Architecture overview



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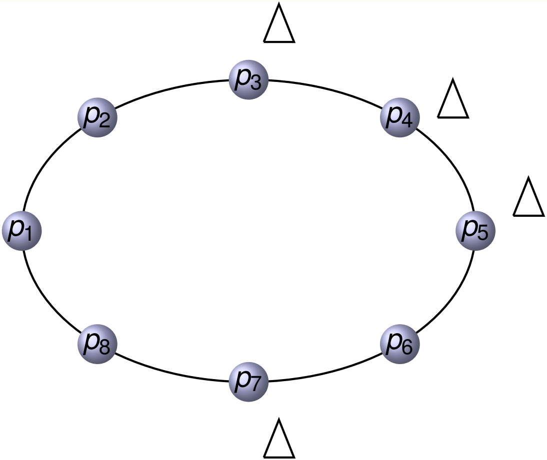
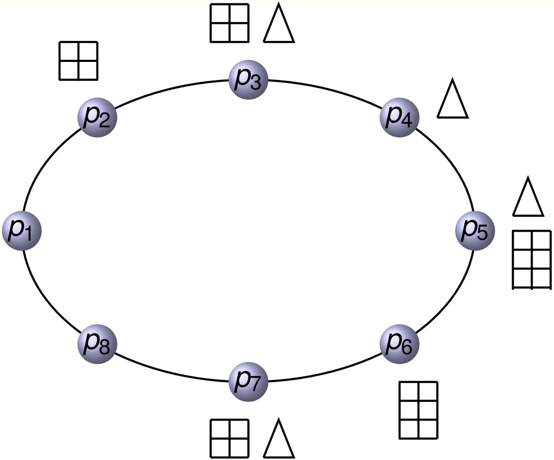


The peers may store:

- documents

Architecture overview



The peers may store:

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- views

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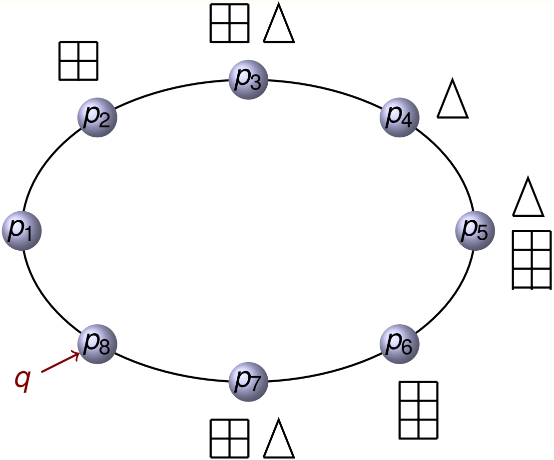

When q arrives:

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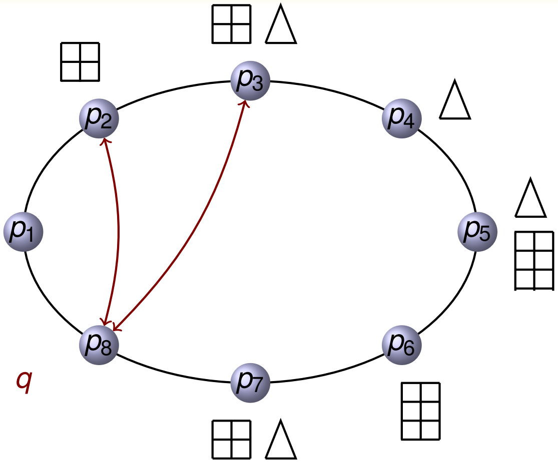

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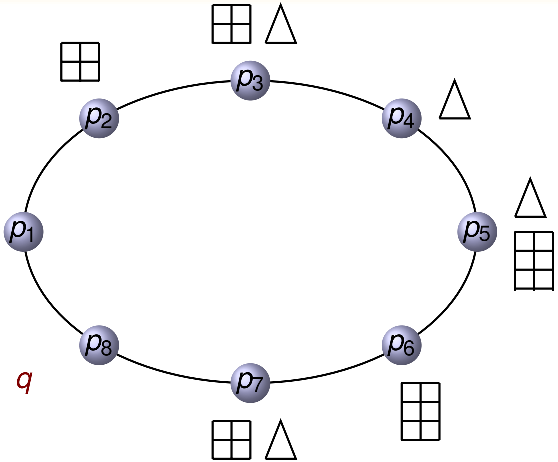

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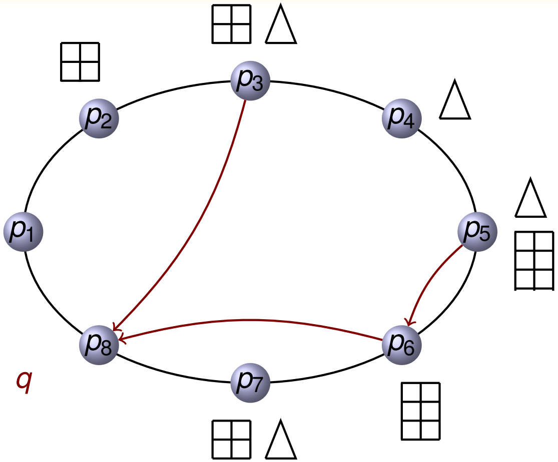

When *q* arrives:

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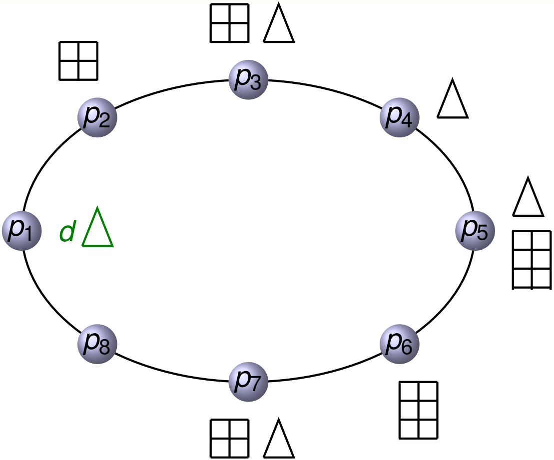

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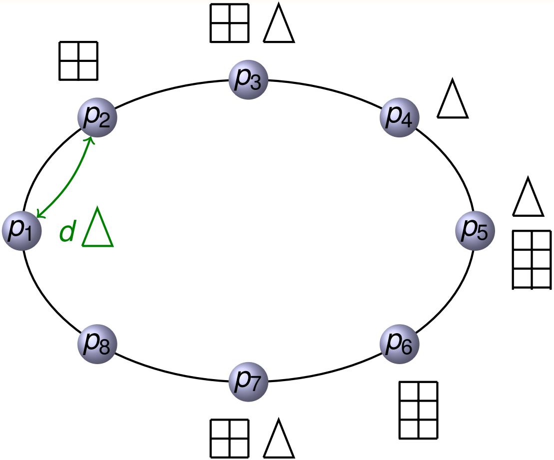

When d arrives:

- search view definitions for which $v_i(d) \neq \emptyset$

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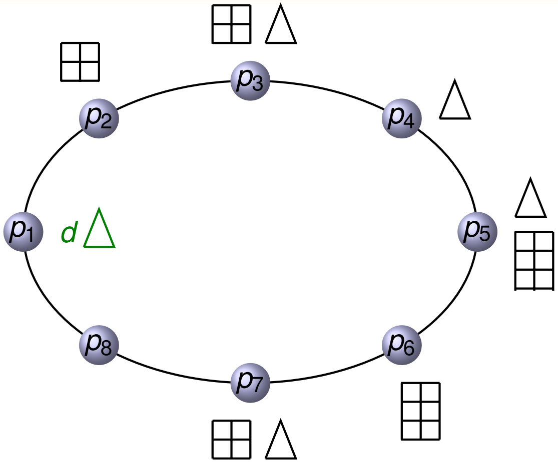

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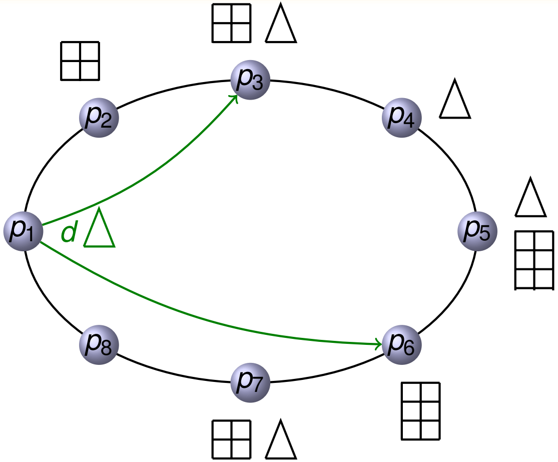

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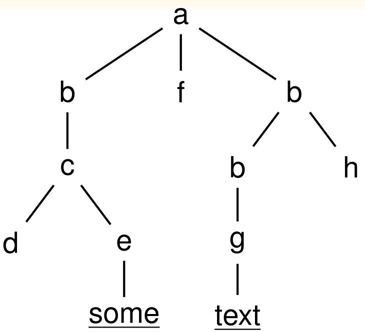
- compute $v_i(d)$
- send results

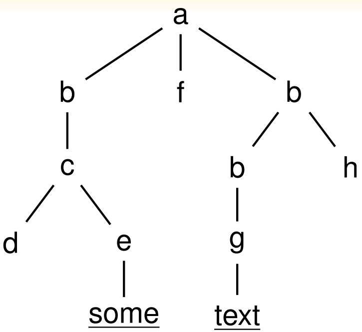
Tree patterns for views and queries



b_{cont}

b_{cont}

Tree patterns for views and queries



b_{cont}

b_{cont}
<c><d / ><e>some< / e>< / c>< / b>

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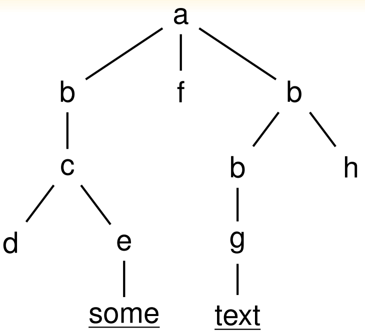

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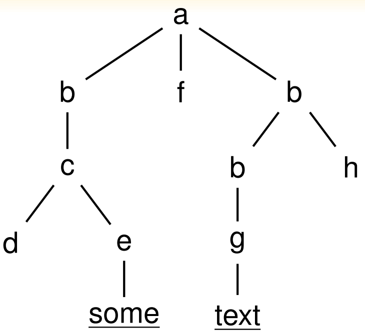

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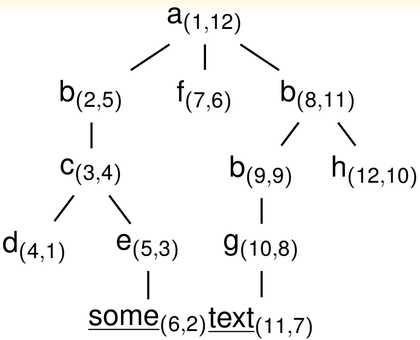

$b_{id,cont}$

b_{id}	b_{cont}

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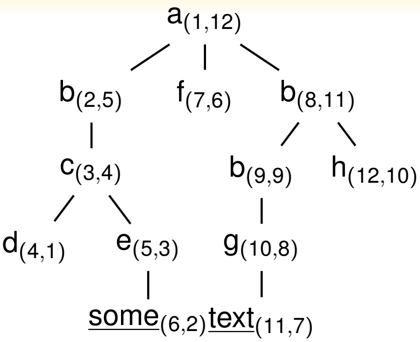

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(2,5)	<c><d/><e>some</e></c>

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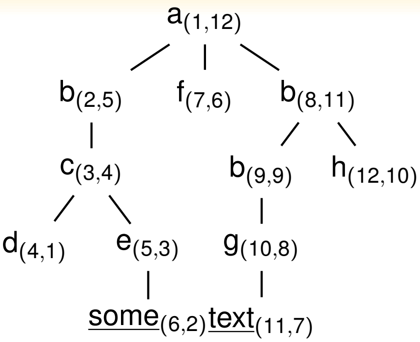

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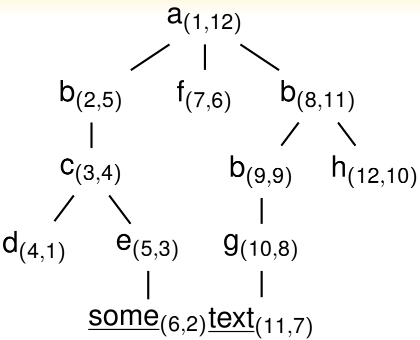

$b_{id,cont}$

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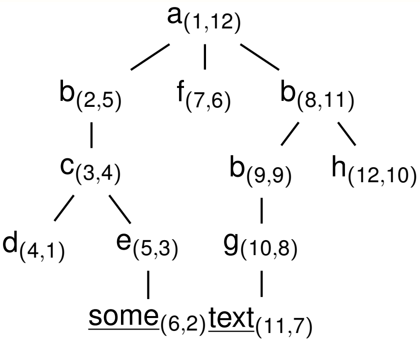

a_{id}	b_{val}

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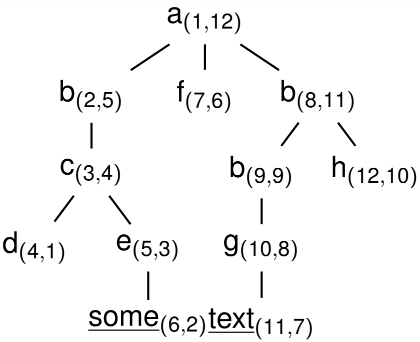

a_{id}	b_{val}
(1,12)	some

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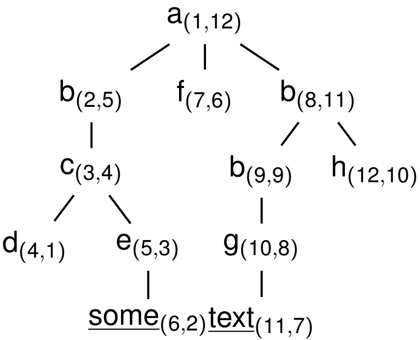

a_{id}	b_{val}
(1,12)	some
(1,12)	text

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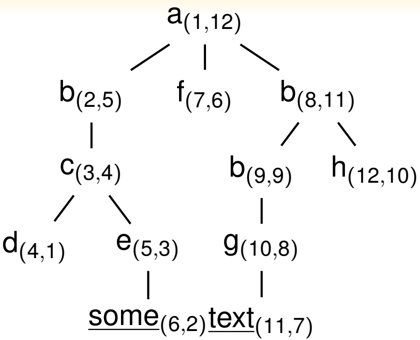

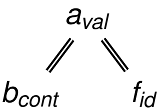

a_{val}	b_{cont}	f_{id}

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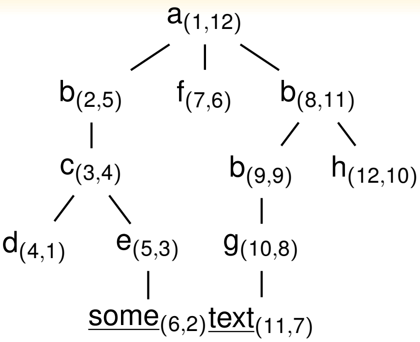

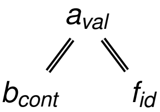

a_{val}	b_{cont}	f_{id}
some text	<c><d / ><e>some< / e>< / c>< / b>	(7,6)

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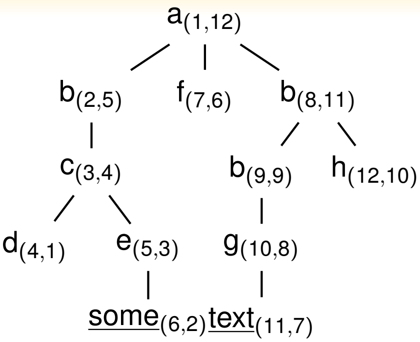

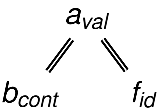

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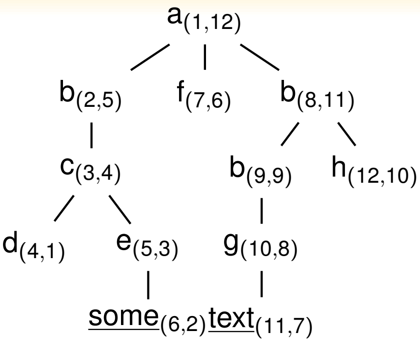

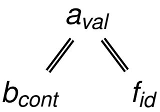

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some text	<g>text</g><h/>	(7,6)
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Algebraic rewriting & operators

Let $q \in \mathcal{P}$ be a query and $\mathcal{V} = \{v_1, v_2, \ldots, v_k\}$ a set of views.
A **rewriting** of q using $\mathcal{V}$ is an algebraic expression

$$e(v_1, v_2, \ldots, v_k)$$

such that $e(\mathcal{D}) = q(\mathcal{D})$ for any document set $\mathcal{D}$

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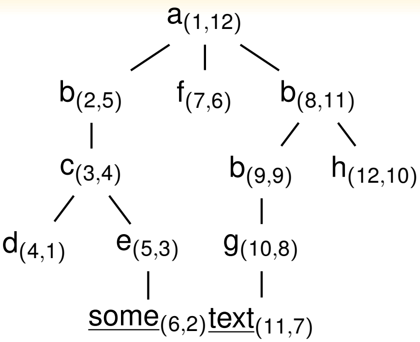
Algebra operators

$scan(v)$	$\times$
$\pi_{cols}(op)$	$\pi^{o}(op)$
$sort_{cols}(op)$	$\sigma_{cond}(op)$

$nav_{i,np}(op)$ evaluates *np* over the *cont* attribute *op.i*

Navigation example



b_{cont}

b_{cont}	$nav_{b.cont,g_{val}}(b_{cont})$

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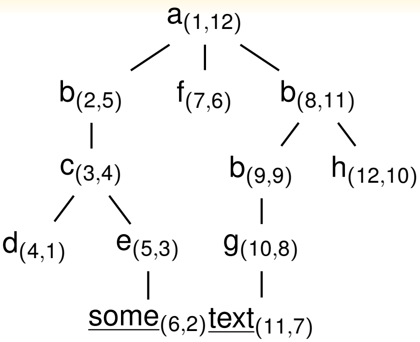

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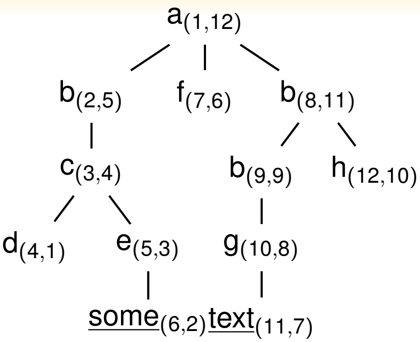

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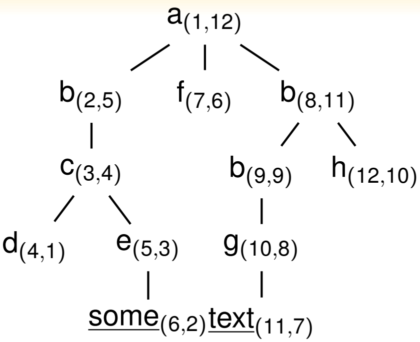

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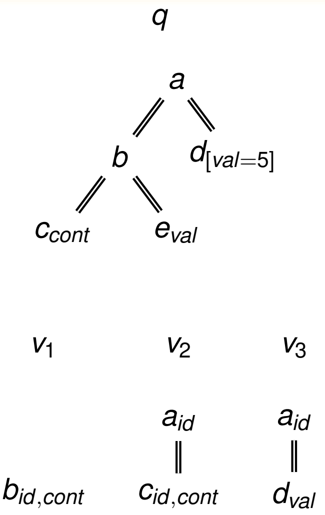

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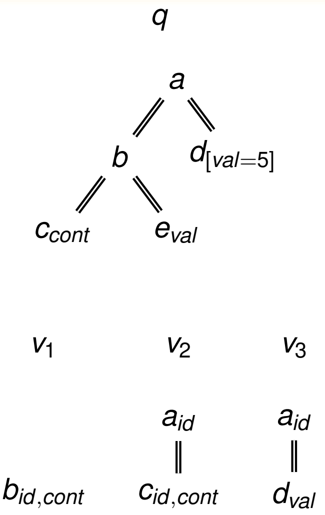

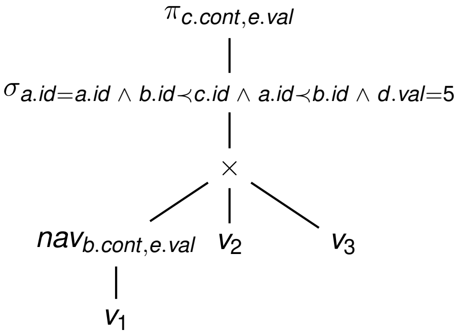

Finding query rewritings

Idea:

Compute covers of the query nodes with the view nodes.

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q	v_1	v_2
a_{id}		
$\Vert$		
b_{id}	a_{id}	b_{id}

Finding query rewritings

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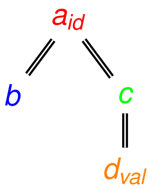
q



v

$a_{id,cont}$

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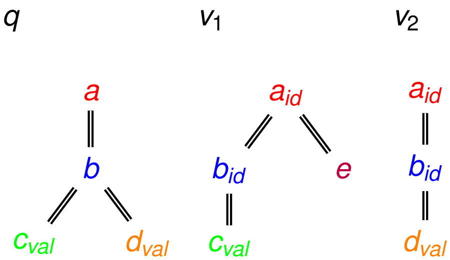

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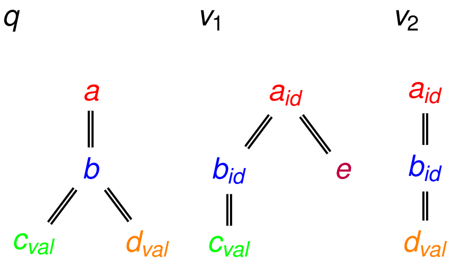

No rewriting

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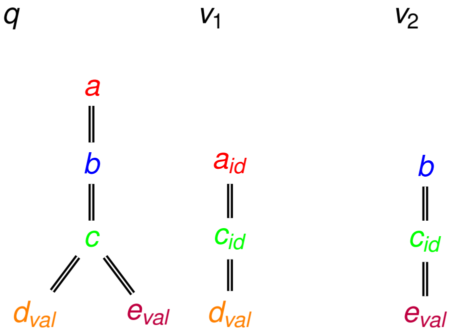

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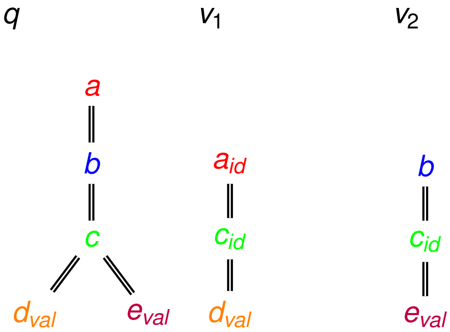

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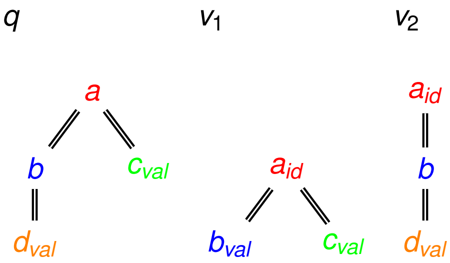

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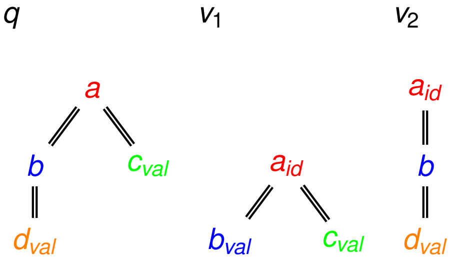

No rewriting

Set enumeration algorithms

SE (Subset Enumeration)

- For each new subset, check if a rewriting can be found
- Test minimality at the end

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- Like SE but enumerates sets from the smallest to the largest
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- Test minimality at the end

ISE (Increasing Subset Enumeration)

- Like SE but enumerates sets from the smallest to the largest
- Finds minimal rewritings first

Inefficiency of SE and ISE

SE and ISE try all possible subsets and repeat work

Bottom-up algorithms

Use smaller partial rewritings to build bigger ones

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DPR (Dynamic Programming Rewriting)

- Dynamic programming style

Bottom-up algorithms

Use smaller partial rewritings to build bigger ones

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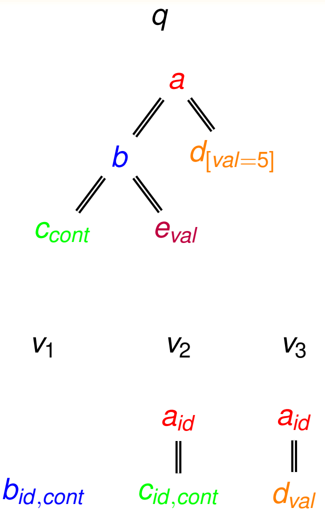
- Dynamic programming style

DFR (Depth First Rewriting)

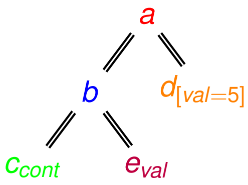
- Greedy based on the biggest query coverage

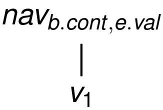
Bottom-up rewriting

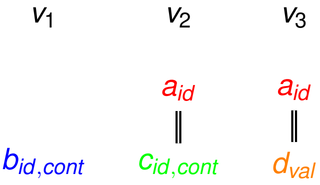


Bottom-up rewriting

q







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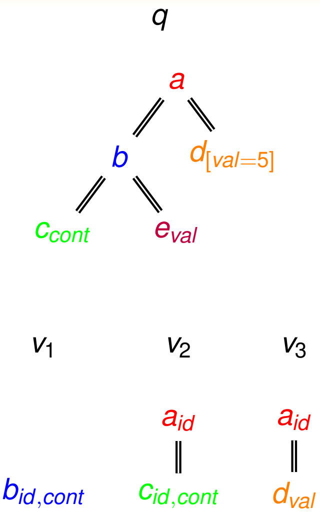

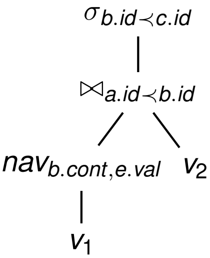

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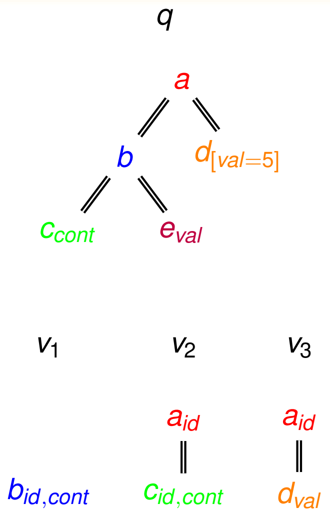
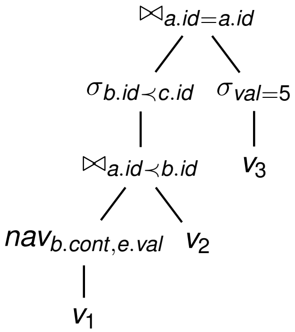
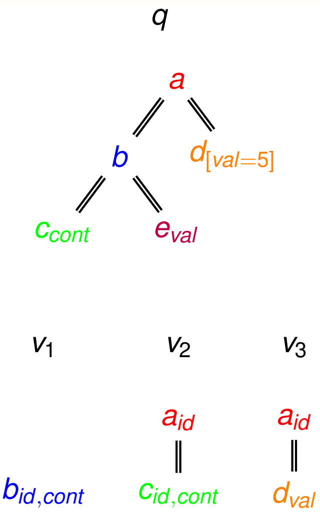
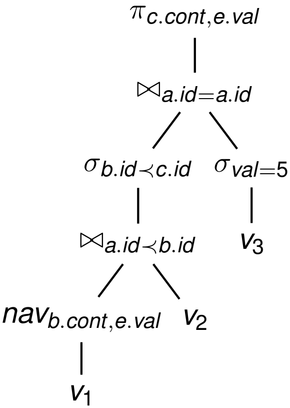


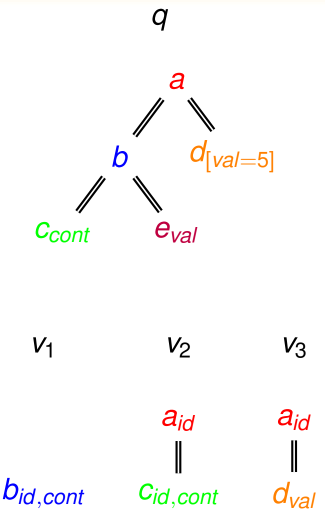


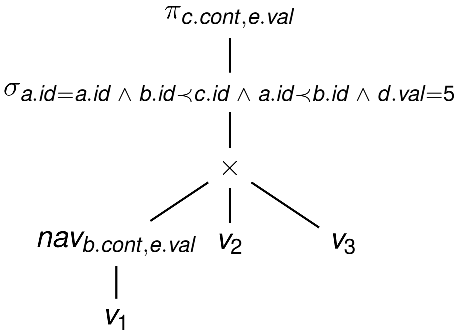
Bottom-up rewriting





Bottom-up rewriting





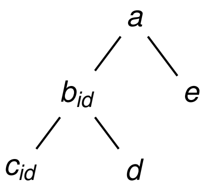
Rewriting algorithms trade-offs

SE, ISE, DPR and DFR are correct and complete.
They produce all minimal canonical rewritings of q given $\mathcal{V}$.

- Which rewritings are ”good”?
  - The one which leads to the best physical plan
  - We learn this too late!
- Heuristic: a good rewriting uses the **smallest number** of views.
  - DFR typically finds fast a solution which is reasonably good
  - ISE, DPR will need more time but return better quality results. They produce rewritings towards the end of the search

View indexing and lookup for query rewriting

Query q asked at peer $p \Rightarrow p$ needs to find useful views



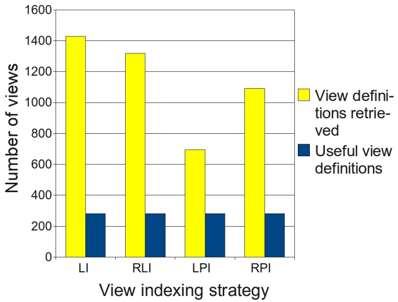
LI index keys	**LI** & **RLI** lookup keys	**RLI** index keys	**LPI** index keys	**LPI** & **RPI** lookup keys	**RPI** index keys
a, b c, d e	a, b c, d e	b, c	$a/b/c$, $a/b/d$, a/e	a/b, a/c a/d, a/e b/c, b/d $a/b/c$, $a/b/d$	a/b $a/b/c$

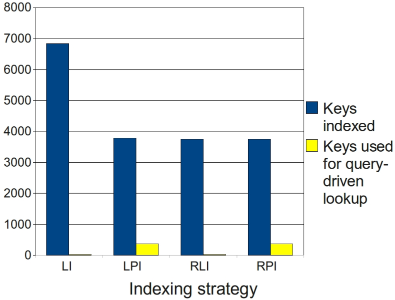
ViP2P platform

- Fully implemented using Java 6 (294 classes, **60.000** lines of code)
- Used Berkeley DB (version 3.3.75) to store view data
- Used FreePastry (version 2.1) as our DHT network
- Experiments carried on *Grid5000* using **250 machines**
- **1000 ViP2P peers** were deployed

View look up performance

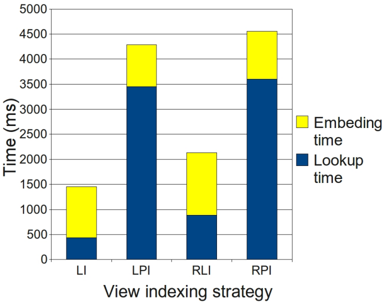
We used 1440 views related to but different from query *q*





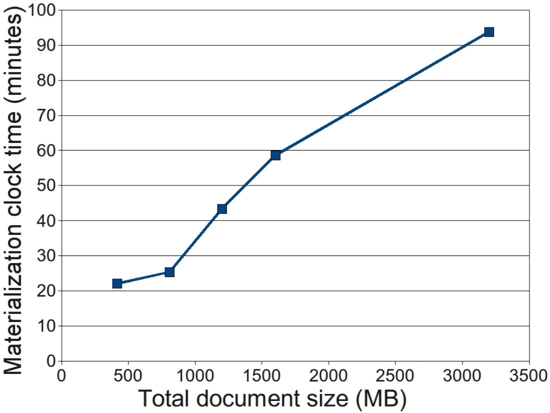
View look up performance

We used 1440 views related to but different from query *q*

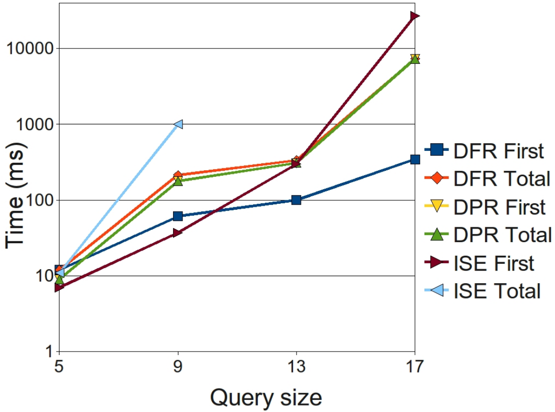


View building

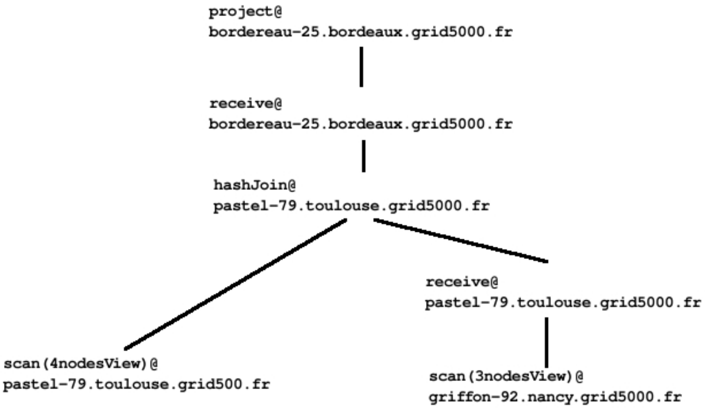
Indexed 2000 XMark documents and 500 views (70 related to the documents)



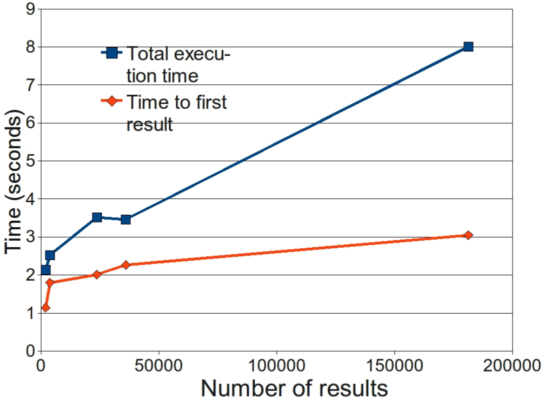
Performance of rewriting algorithms



Query execution



Query execution



Related work

XML on DHTs [GWJD03, BC06, SHA05, AMP+08]

- We have the most generic approach

XPath query rewriting [BOB+04, XO05, CDO08, TYÖ+08]

- XPath: wildcard *, union
- Rewritings: intersection, navigations, joins
- They don't have multiple returning nodes

Rewriting with structural constrains [ABMP07]

- Centralized setting
- Dataguide [GW97] constraints

Summing up

- ViP2P: data access support structures for DHT based XML data management
- All the presented algorithms have been fully implemented in a functional Java based platform
- Presented at DataX 2009 (no proceedings)
- Extended version submitted for publication
- Visit us at vip2p.saclay.inria.fr!

Thank you!

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