Materialized views for P2P XML warehousing

Ioana Manolescu[1] **Spyros Zoupanos**[1]

[1]GEMO group, INRIA Saclay – Île-de-France, France

3 April 2009

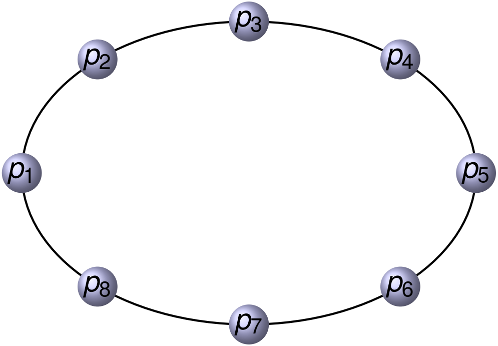
Outline

What is ViP2P (Views in Peer-to-Peer) ?

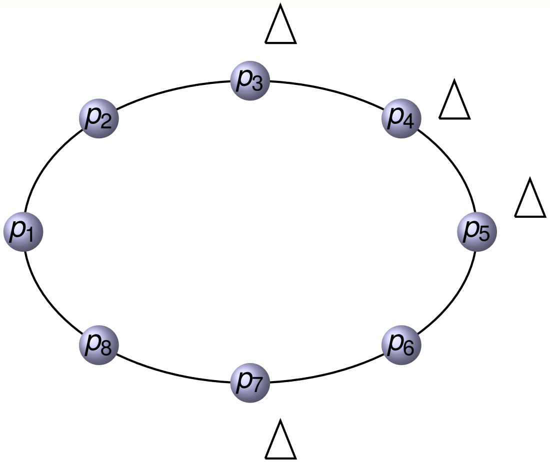
A fully deployed system that permits us to:

- Declare tree pattern XML views
- Fill in the views with XML data
- Reply to tree pattern queries using the existing views
  - View definition lookup
  - Query rewriting
  - Production of a logical plan
  - Translation to a (distributed) physical plan
  - Execution of the physical plan

Architecture overview



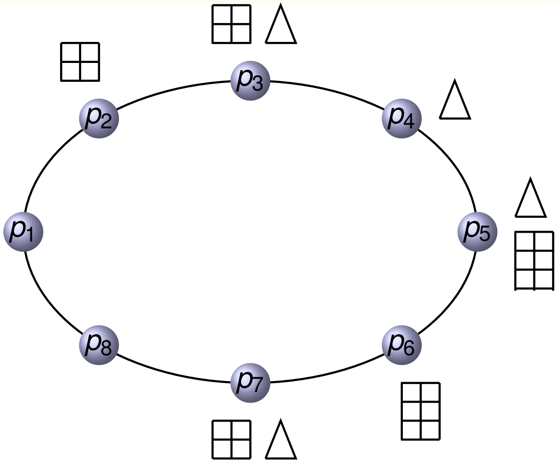
Architecture overview



The peers may store:

- documents

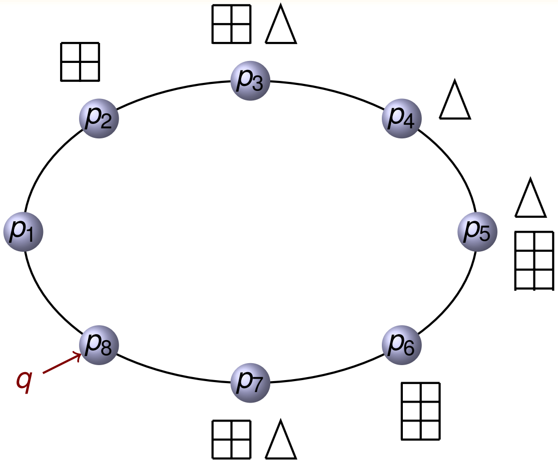
Architecture overview



The peers may store:

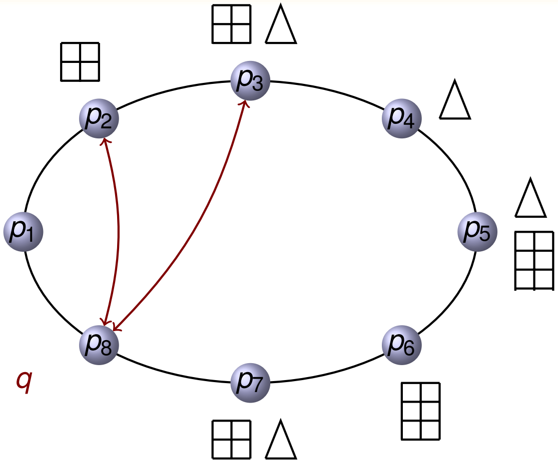
- documents
- views

Architecture overview



When q arrives:

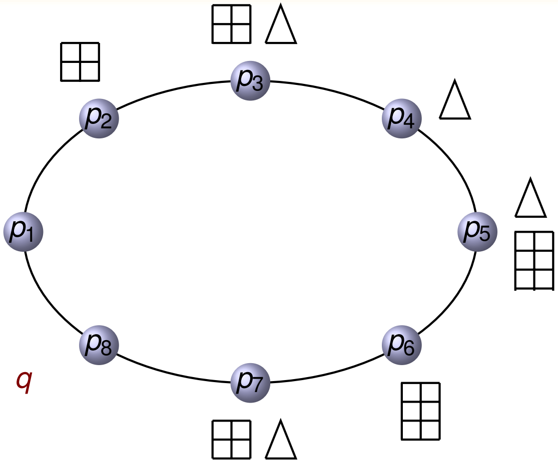
Architecture overview



When q arrives:

- view definition lookup

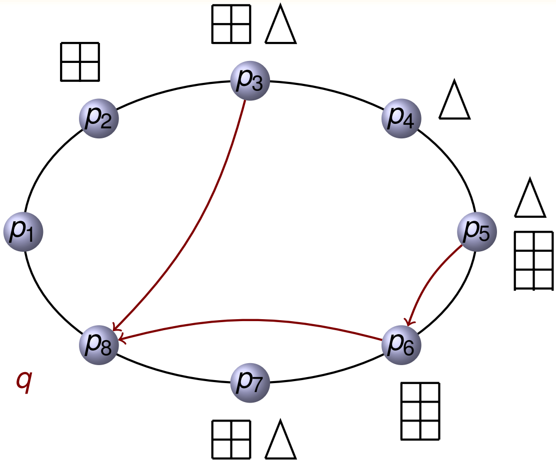
Architecture overview



When q arrives:

- view definition lookup
- rewriting

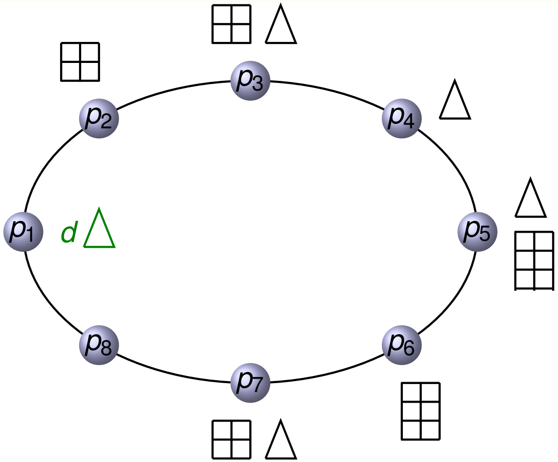
Architecture overview



When *q* arrives:

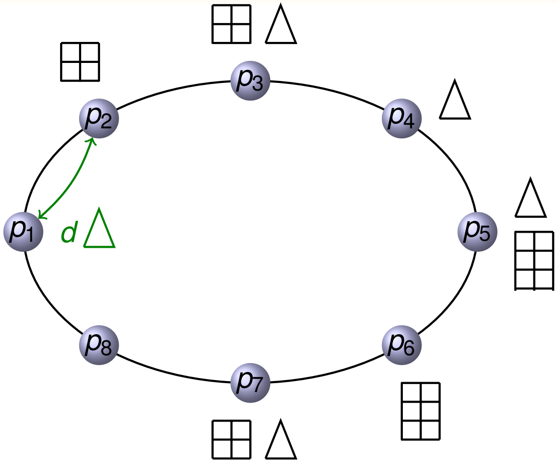
- view definition lookup
- rewriting
- execution of physical plan

Architecture overview



When d arrives:

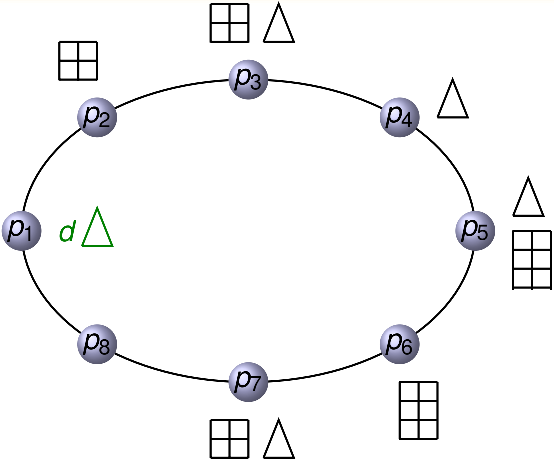
Architecture overview



When d arrives:

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

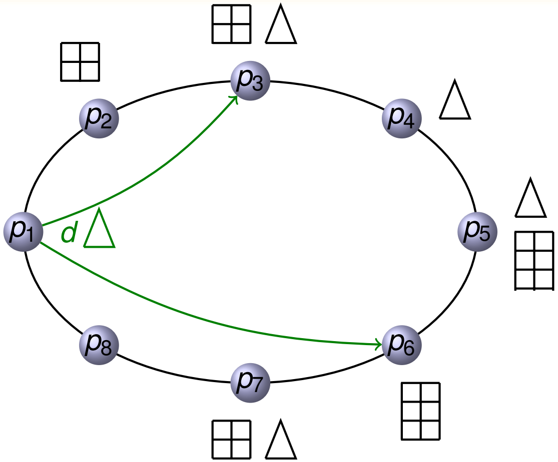
Architecture overview



When d arrives:

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

Architecture overview



When d arrives:

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

Tree pattern dialect P

Representing our queries and views.

- Each pattern node carries a label (element name or attribute name or word).
- All pattern edges correspond to **ancestor-descendant relationships** between nodes.
- A node may be **annotated with** zero or more among the following **labels**: *id*, *cont* and *val*.
- A node may be **annotated with a predicate** of the form $[val = \underline{c}]$ where $\underline{c} \in A_w$.

Pattern equivalence

$p(d)$ is the set of tuples obtained by lining together in a tuple, all *ids* and/or *val* and/or serialized *cont*, for each embedding of p in d.

Two patterns p_1, p_2 are **equivalent**, denoted $p_1 \equiv p_2$, if for any database $\mathcal{D}$, $p_1(\mathcal{D}) = p_2(\mathcal{D})$.

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, $v_i \in \mathcal{P}, 1 \leq i \leq k$. A **rewriting** of q using $\mathcal{V}$ is an algebraic expression $e(v_1, v_2, \ldots, v_k)$, such that $e \equiv q$.

Algebra operators:

- $scan(v)$
- $\pi_{pList}(op)$
- $\sigma_{cond}(op)$ is a **selection** over *op*, where *cond* is a conjunctive predicate using the comparison operants $=$ and $\prec$

Algebraic rewriting & operators

- $nav(op, i, np)$ is a **navigation** operator, applying the navigation described by the pattern np over the i attribute of op
- $op \bowtie_{pred} op'$ is a **join** operator

Interesting cases:

- equality joins on node *id*s.
- structural joins on node *id*s.

Rewriting problem statement

Given a set of views $\mathcal{V}$ and a query q, the **problem of rewriting** q based on $\mathcal{V}$ consists of finding all minimal equivalent rewritings of q, up to **algebraic equivalence.**

Two plans $a_1, a_2 \in \mathcal{A}$ are **algebra-equivalent** if a_2 can be obtained from a_1 via:

- usual rewriting rules from the relational algebra (e.g. pushing selections and projections, join re-ordering etc.);

Rewriting problem statement

Given a set of views $\mathcal{V}$ and a query q, the **problem of rewriting** q based on $\mathcal{V}$ consists of finding all minimal equivalent rewritings of q, up to **algebraic equivalence.**

Two plans $a_1, a_2 \in \mathcal{A}$ are **algebra-equivalent** if a_2 can be obtained from a_1 via:

- usual rewriting rules from the relational algebra (e.g. pushing selections and projections, join re-ordering etc.);
- transitive closure of ancestor-descendant predicates;

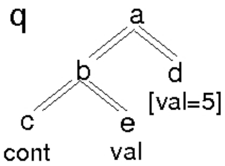
Rewriting problem statement

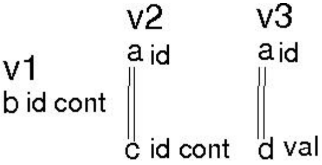
Given a set of views $\mathcal{V}$ and a query q, the **problem of rewriting** q based on $\mathcal{V}$ consists of finding all minimal equivalent rewritings of q, up to **algebraic equivalence.**

Two plans $a_1, a_2 \in \mathcal{A}$ are **algebra-equivalent** if a_2 can be obtained from a_1 via:

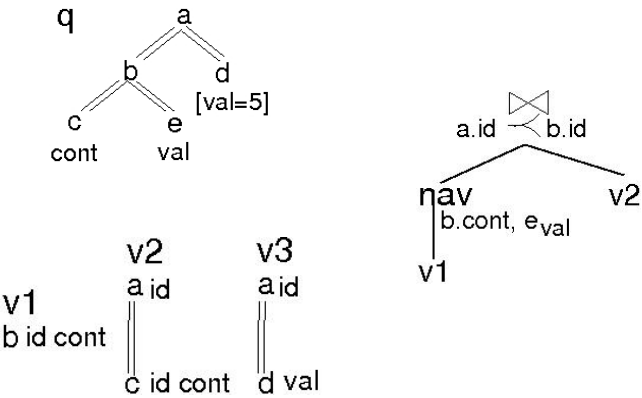
- usual rewriting rules from the relational algebra (e.g. pushing selections and projections, join re-ordering etc.);
- transitive closure of ancestor-descendant predicates;
- or pattern composition.

Rewriting example

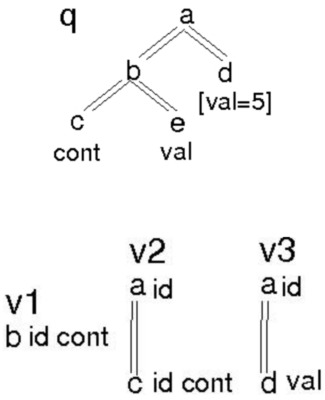


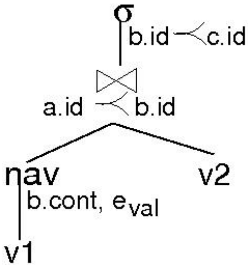


Rewriting example

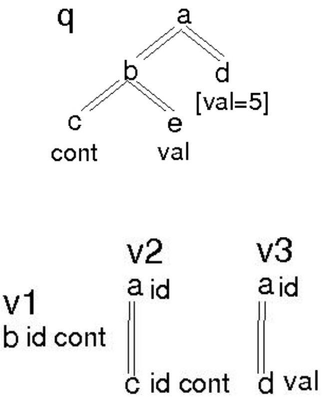


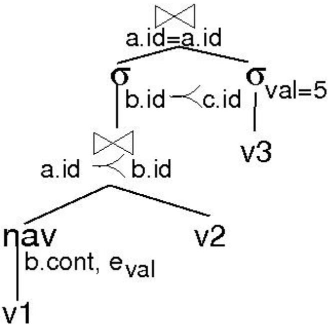
Rewriting example



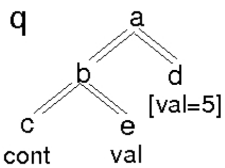


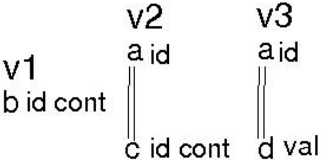
Rewriting example

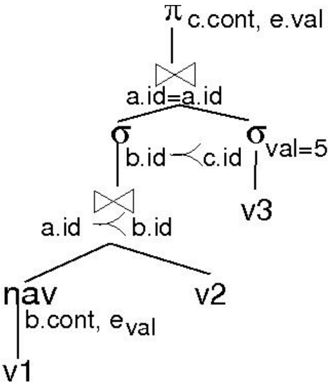




Rewriting example







(plan, pattern) pairs

What data structures to use for rewriting?

We rewrite a tree pattern (target).

We build algebraic plans (tool).

Rewriting manipulates (plan, pattern) pairs

- the plan is always $\equiv$ to the pattern
- initial pattern = v, plan = $scan(v)$
- we build increasingly larger plans and incrementally more complex patterns
- when pattern $\equiv$ query, plan is a solution

Important property

Let v be a view and q be a query. If v can not be embedded in q then no rewriting of q will use v.

Applications:

- prune the initial views used for rewriting
- discard intermediary (plan,pattern) pairs which do not lead to complete rewritings

DPR - dynamic programming rewriting algorithm

- Dynamic programming style
- Proceeds in layers
  - build all *ppp*s joining n views before building a *ppp* of $n + 1$ views
- Builds left-deep plans (to ensure uniqueness) up to algebraic equivalence

Second algorithm DFR - depth first rewriting algorithm

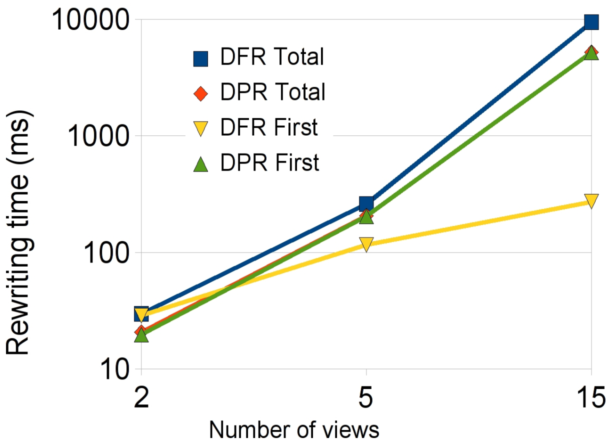
DFR organizes and explores differently its ppps.

- Tries to combine the ppp with the **biggest query coverage** with a *ppp* of 1 view.
- Explores left deep plans, like DPR.

Rewriting algorithms trade-offs

- What kind of rewritings are ”good”?
  - the one which leads to the best physical plan.
  - we learn this too late!
- heuristic: a good rewriting is the one that uses the **smallest number** of views.
  - DFR is going to find fast enough a good solution but not the best.
  - DPR will need more time but returns better quality results.

Performance of rewriting algorithms



View materialization

- Peer p has a view v, peer p_d publishes a document d.
- p indexes v on the DHT by the labels of the view.
- p_d traverses d, looks up all its labels.
- p_d ends up with a superset of answers S_a. It evaluates $v(d)$ for each $v \in S_a$.
- Many views can be evaluated in one document traversal.

Indexing and lookup view definitions

When a query *q* arrives at peer *p*, it has to find useful view definitions for the rewriting algorithm.

4 different strategies have been implemented.

- **Label indexing** (LI):
  - index *v* by each *v* node label.
  - look up by all node labels of *q*.
- **Return label indexing** (RLI):
  - index *v* by the labels of all *v* nodes which project some attributes (at most $|v|$).
  - same as for LI: use the labels of all *q* nodes as lookup keys.

Indexing and lookup view definitions

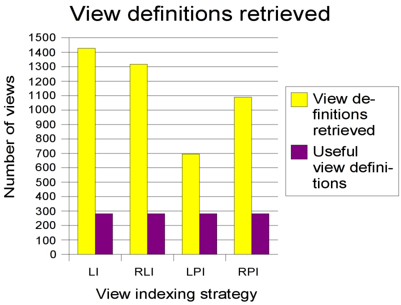
- **Leaf path indexing** (LPI):
  - let $LP(v)$ be the set of all the distinct root-to-leaf label paths of v. Index v using each element of $LP(v)$ as key.
  - look up details in the paper.
- **Return Path Indexing** (RPI):
  - let $RP(v)$ be the set of all rooted paths in v which end in a node that returns some attribute. Index v using each element of $LP(v)$ as key.
  - same as for LPI.

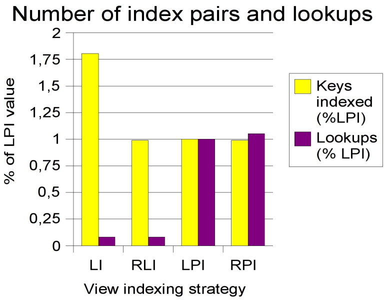
System implementation and configuration

- Platform fully implemented using Java 6.
- Used Berkeley DB (version 3.2.76) to store view data.
- Used FreePastry (version 2.1) as our DHT network.
- Experiments carried on a cluster of 10 PCs with Intel Xeon 5140 CPU @ 2,33 GHz and 4GB of Ram.

View look up performance experiments

For the experiments we used 80 peers, indexed 1440 views related to but different from query *q*.

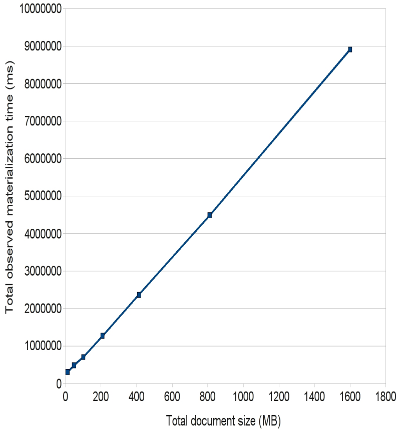


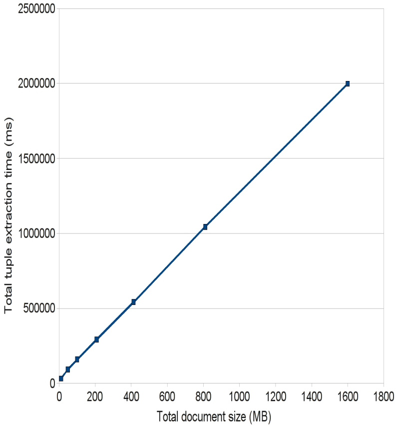


View building and query execution experiments

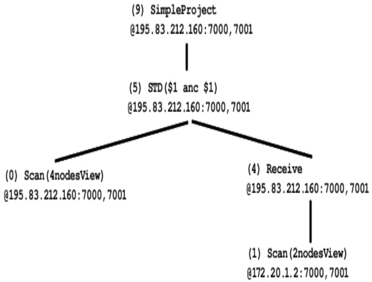
For the experiments we used 30 peers, indexed 100 XMark [SWK+02] documents and 30 views related to these documents.

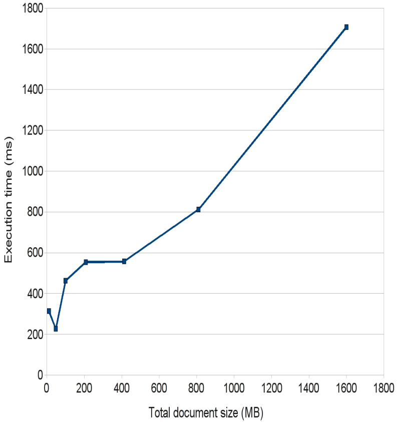
View building





Query execution





Benefits of ViP2P views

We use a data set of 750 XMark [SWK+02] documents having the total size of 20MB, 2 peers and three different view sets to rewrite the query *site*(*item*($description_{cont}$)).

Benefits of ViP2P views

We use a data set of 750 XMark [SWK+02] documents having the total size of 20MB, 2 peers and three different view sets to rewrite the query $site(item(description_{cont}))$.

- $\mathcal{V}_1$ contains the view $site_{cont}$.

Benefits of ViP2P views

We use a data set of 750 XMark [SWK+02] documents having the total size of 20MB, 2 peers and three different view sets to rewrite the query *site*(*item*($description_{cont}$)).

- $\mathcal{V}_1$ contains the view $site_{cont}$.
- $\mathcal{V}_2$ contains three views: $site_{id}$, $item_{id}$ and $description_{id,cont}$. Node-granularity indexing used in [AMP+08] (we also time the transfer of the XML result snippets to the query peer).

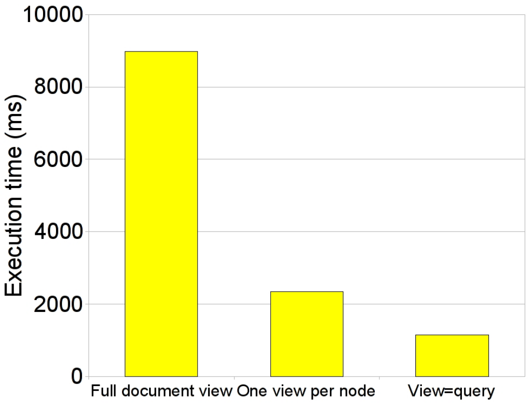
Benefits of ViP2P views

We use a data set of 750 XMark [SWK+02] documents having the total size of 20MB, 2 peers and three different view sets to rewrite the query $site(item(description_{cont}))$.

- $\mathcal{V}_1$ contains the view $site_{cont}$.
- $\mathcal{V}_2$ contains three views: $site_{id}$, $item_{id}$ and $description_{id,cont}$. Node-granularity indexing used in [AMP+08] (we also time the transfer of the XML result snippets to the query peer).
- $\mathcal{V}_3$ contains one view which is exactly q.

Benefits of ViP2P views

We use a data set of 750 XMark [SWK+02] documents having the total size of 20MB, 2 peers and three different view sets to rewrite the query $site(item(description_{cont}))$.



Related work

Indexing documents in the DHT

In [GWJD03, BC06, SHA05, AMP+08] the focus is on indexing documents on DHT so that XML queries can be processed fast.

XPath query rewriting

In [BOB+04, XO05] XPath query rewriting has been considered. They focus on handling more XPath axis, operators such as union etc. We consider richer views, offer more rewriting opportunities and view management in a DHT network

Rewriting with structural constrains

[ABMP07] is a centralized system where they used structural constraints encapsulated in a Dataguide [GW97] to perform rewriting.

Summing up

- Efficient management of large XML warehouses in structured P2P networks requires the ability to deploy data access support structures, which can be tuned closely to fit application needs.
- ViP2P offers the ability to build and maintain complex materialized views.
- 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!

[ABMP07] **Andrei Arion, Véronique Benzaken, Ioana Manolescu, and Yannis Papakonstantinou.**
Structured materialized views for XML queries.
In *VLDB*, pages 87–98, 2007.

[AMP+08] **S. Abiteboul, I. Manolescu, N. Polyzotis, N. Preda, and C. Sun.**
XML processing in DHT networks.
In *ICDE*, 2008.

[BC06] **Angela Bonifati and Alfredo Cuzzocrea.**
Storing and retrieving xpath fragments in structured P2P networks.
Data Knowl. Eng., 59(2), 2006.

[BOB+04] **A. Balmin, F. Ozcan, K. Beyer, R. Cochrane, and H. Pirahesh.**
A framework for using materialized XPath views in XML query processing.
In *VLDB*, 2004.

[GW97] **Roy Goldman and Jennifer Widom.**
Dataguides: Enabling query formulation and optimization in semistructured databases.
In *VLDB*, 1997.

[GWJD03] **L. Galanis, Y. Wang, S.R. Jeffery, and D.J. DeWitt.**
Locating data sources in large distributed systems.
In *VLDB*, 2003.

[SHA05] **Gleb Skobeltsyn, Manfred Hauswirth, and Karl Aberer.**
Efficient processing of XPath queries with structured overlay networks.
In *OTM Conferences (2)*, 2005.

[SWK+02] **Albrecht Schmidt, Florian Waas, Martin L. Kersten, Michael J. Carey, Ioana Manolescu, and Ralph Busse.**
XMark: A benchmark for XML data management.

In *VLDB*, 2002.

[XO05] **W. Xu and M. Ozsoyoglu.**
Rewriting XPath queries using materialized views.
In *VLDB*, 2005.