OptimAX: Optimizing Distributed ActiveXML applications

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Outline

1 Overview
   • WebContent project
   • ActiveXML language

2 A framework for AXML optimization
   • Extended AXML
   • AXML rewriting

3 OptimAX
   • Design Principles
   • Performance

4 Related (sub) problems

5 Conclusion
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5 Conclusion
Distributed web service based applications

WebContent project (R&D project)

- Different services provided by different partners.
- Service call interaction described in (A)XML documents.
- Optimizer needed to optimize the execution plans.
Distributed web service based applications

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The ActiveXML language

Data-centric Web service composition
ActiveXML document = XML document including calls to (continuous) Web services

- A service call contains contact info for the Web service
- When the calls is activated, results are added to the document as siblings of the service call.

```xml
<myPage>
  <axml:sc service="getProgram" peer="tvchannel.com">
    <parameter>Movies</parameter>
  </axml:sc>
</myPage>
```
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<myPage>
  <axml:sc service="getProgram" peer="tvchannel.com">
    <parameter>Movies</parameter>
  </axml:sc>
  <program day="today">
    <movie>Shrek 3</movie>
  </program>
</myPage>
```
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    <parameter>Movies</parameter>
  </axml:sc>
  <program day="today">
    <movie>Shrek 3</movie>
  </program>
  <program day="tomorrow">
    <movie>Persepolis</movie>
  </program>
</myPage>
```
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Data-centric Web service composition
ActiveXML document = XML document including calls to (continuous) Web services
  • A service call contains contact info for the Web service
  • When the calls is activated, results are added to the document as siblings of the service call.

Continuous services may be continuous query services.

Example
Please inform me whenever there is a movie in the TV program (query over an RSS feed).
The ActiveXML peer v2: overview
AXML evaluation

AXML document $d@p_1$, $sc \in d@p_1$ is the call $s@p_2($\textit{in}$)$

Activating $sc$ entails:

- Stream $\textit{in}$ to $p_2$
- Evaluate $s@p_2$
- Stream the results of $s@p_2$ to $p_1$

**Remark**

$\textit{in}$ may contain (continuous) service calls

**Remark**

$s@p_2$ results may contain (continuous) service calls

Call activation can be controlled:

- On a per-call basis
- Globally (per-subtree basis)
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Contributions

A framework for AXML optimization
- A small set of predefined services
- Precise evaluation semantics for AXML documents
- Equivalence-preserving AXML rewriting rules
- Classification of AXML optimization problems

OptimAX, an extensible AXML optimizer
- Search strategies
- Performance
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Extending AXML

Purpose:

- Modest extensions turning AXML into a rich "executable" language
- Optimization = AXML-to-AXML equivalence-preserving rewriting
- Three new services:
  - send
  - receive
  - newNode
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**Purpose:**

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  - receive
  - newNode
How to order the activations of several calls?

- Default activation order: inside-out (activate parameter calls before the parent call)
- User-specified activation order:
  - $sc_1$ activated afterActivated | afterTerminated $sc_2$
The **send** service

Sends (a stream of) (A)XML trees as children of a given node

```xml
<axml:sc service="send" peer="p" id="#1">
  <where node="#2" doc="d2" peer="p2"/>
  <what> ... AXML expression ... </what>
</axml:sc>
```

**Default activation order for send**

A call to **send** is activated before activating the descendant calls.
The **receive** service

Receives (a stream of) (A)XML trees at a given node

```xml
<axml:sc service="receive" peer="p2" id="#2">
  <from node="#1" doc="d1" peer="p1"/>
  <what> ... AXML expression ... </what>
</axml:sc>
```

**Default activation order for receive**

A call to **receive** is activated when the first message from the corresponding **send** arrives.

The **what** child of **receive** only describes data being received. Its calls are not activated.

Global integrity constraint: **send ↔ receive**
The **receive** service

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<axml:sc service="receive" peer="p2" id="#2">
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The **newNode** service

Installs an XML tree as a new document on a peer.

```xml
<axml:sc service="newNode" peer="p3" id="#3">
  <what> ... AXML expression ... </what>
</axml:sc>
```

**Default activation order for newNode**

A call to **newNode** is activated before activating the descendant calls.
AXML activation order

Given a document \( d@p \), the AXML peer \( p \) computes a partial order \( \mathcal{O} \) including:

- all explicit activation order constraints
- as many default order constraints as possible

There can be several legal schedules.
Given a document $d@p$, the AXML peer $p$ computes a partial order $\mathcal{O}$ including:

- all explicit activation order constraints
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There can be several legal schedules.
Our document is installed at peer1.

We want the s1@peer2 and the s2@peer2 to be called by peer2.

We are interested in receiving the final answer at peer1.
Sample legal schedule

- **Services activated:**
  - newNode@peer1
Sample legal schedule

Services activated:
- newNode@peer1
- s2@peer2
Sample legal schedule

Services activated:
- newNode@peer1
- s2@peer2
- s1@peer2
Sample legal schedule

Services activated:
- newNode@peer1
- s2@peer2
- s1@peer2
- send@peer2
Sample legal schedule

Services activated:
- newNode@peer1
- s2@peer2
- s1@peer2
- send@peer2

Data transmission
send@peer2 starts to send data to receive@peer1
Sample legal schedule

Services activated:
- newNode@peer1
- s2@peer2
- s1@peer2
- send@peer2
- receive@peer1

Receive activation
receive@peer1 is activated on first result received by send@peer2
AXML equivalence

AXML fixpoint: the final state of the document (assumed finite)
- Service calls may bring service calls
- Fixpoint is reached after full evaluation

Two documents are equivalent if their fixpoints are identical (modulo terminated service calls)
Two documents are one-stage equivalent if activating all their service calls leads to identical documents
- Do not activate calls included in the results
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Equivalence-preserving AXML rewriting rules

Rules specific to query services:

```
root@p_1
  ↙
q_1@p_1
  ↙
q_2@p_1
```

```
⇔
```

```
root@p_1
  ↙
(q_1 \circ q_2)@p_1
```

Query composition/decomposition

\( q_1@p_1(q_2@p_1) \Leftrightarrow (q_1 \circ q_2)@p_1 \)
Equivalence-preserving AXML rewriting rules

Generic rules:

```
root@p₁

⇒

root@p₁

f@any

⇒

f@p₁

(Instatiation)
```

\[ f@any \implies f@p₁ \text{ (the same } f \text{ service)} \]
Equivalence-preserving AXML rewriting rules

Generic rules:

Delegation

\[
f@p_1(e@p_2) \Rightarrow \#1 : receive@p_1(e@p_2),\newline newNode@p_2(send@p_2(e@p_2, \#1@p_1))
\]
Equivalence-preserving AXML rewriting rules

Generic rules:

\[ \text{root} @ p_1 \]

\[
\begin{array}{c}
\xrightarrow{\text{send}} \\
\xrightarrow{\text{receive}} \\
\xrightarrow{\text{send}} \\
\xrightarrow{\text{receive}} \\
\xrightarrow{\text{send}} \\
\xrightarrow{\text{receive}} \\
\end{array}
\]

\[
\text{Factorization}
\]

\[
r(x(e_1), \ldots, y(e_2)) \Rightarrow r(x(\#1 : e_1), \\
\quad \#2 : \text{send}@p_1(\#1@p_1, \#3@p_1), \ldots, \\
\quad y(\#3 : \text{receive}@p_1)
\]

\[ e_1 \equiv e_2 \]
AXML optimization

Given:

- Rewriting rule set $R$
- Cost function for $sc$ evaluation

Full AXML optimization: repeat until fixpoint

1. choose one among
   1. pick an $sc$ ready to be activated, activate it, add results to the document
   2. pick an AXML subtree $t$ and a rule $r \in R$, rewrite $t$ with $r$

2. so that the total cost of evaluation (+optimization) is minimized

Undecidable if service calls may return other service calls. In the decidable case, exhaustive optimization prior to any activation is optimal.
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In the decidable case, exhaustive optimization prior to any activation is optimal.
One-stage (static) optimization

Given a document $d@p$ and a set of rewriting rules $\mathcal{R}$

1. Let $S := \{d\}$
2. Repeat
   1. Pick a rule $r \in \mathcal{R}$, a document $d_1 \in S$ and a tree $t \in d_1$.
   2. Let $d_2 := r(d_1,t)$. If $d_2 \not\in S$, add $d_2$ to $S$.
3. Until $S$ stationary
4. Return cheapest plan from $S$

One stage optimization - Return cheapest document up to one stage equivalence to $d$. 

One-stage (static) optimization

Given a document \( d \) and a set of rewriting rules \( R \):

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One stage optimization - Return cheapest document up to one stage equivalence to \( d \).
Available with the AXML peer v2 (www.activexml.net)
Extensible set of tree rewriting rules
Search algorithms: depth-first, breadth-first, cost-driven variants
Hint language:
  • "Exhaust factorization, then 20 delegation steps"
  • "Explore at most 50 rewritten plans"
Checks to preserve send-receive channel integrity
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OptimAX performance

We measure: **optimization time and reduction of estimated plan cost**

Synthetic documents:
- deep$n$.xml
- flat$n$.xml
- tree$n$.xml, max fan-out=$6$

Services assigned with uniform probability distribution over $n_d$ services.
Optimization considers a network of $p$ peers.
OptimAX performance

Reduction of estimated cost, tree-n.xml, 3peers

<table>
<thead>
<tr>
<th>n</th>
<th>Reduction %</th>
</tr>
</thead>
<tbody>
<tr>
<td>n = nd</td>
<td></td>
</tr>
<tr>
<td>1</td>
<td></td>
</tr>
<tr>
<td>2</td>
<td></td>
</tr>
<tr>
<td>3</td>
<td></td>
</tr>
<tr>
<td>4</td>
<td></td>
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<td>5</td>
<td></td>
</tr>
<tr>
<td>6</td>
<td></td>
</tr>
<tr>
<td>7</td>
<td></td>
</tr>
<tr>
<td>8</td>
<td></td>
</tr>
<tr>
<td>9</td>
<td></td>
</tr>
</tbody>
</table>

Search space size 3000, depth-first cost-driven strategy
OptimAX performance

Optimization on tree-n.xml, 3 peers

Depth-first cost-driven strategy
OptimAX performance

We compare an exhaustive search with a limited one:

- Cost ratio
- Time ratio

Cost ratio (55 fact. + 55 deleg.) / exhaustive
tree-n.xml, 3 peers

Time ratio (55 fact. + 55 deleg.) / exhaustive
tree-n.xml, 3 peers
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## Related problems from previous works

### Rewriting

Transforming an input or type $\tau_1$ to an output of type $\tau_2$. Extend XML Schema to include the types of services referred by each $sc$ node. **Rewriting problem:** find a sequence of activations which brings the document from type $T_1$ to type $T_2$ \cite{MAM03,AMB05}.

### Distribution

Assimilate service calls to remote tree references. Query evaluation over an AXML document = local + remote evaluation. Query shipping optimization rules \cite{ABC03}.

### Lazy evaluation

Decompose the query: $q@p_1(a(\alpha,f@p_2,\beta)) \Rightarrow q_1@p_1(a(\alpha,\beta)) \oplus q_2@p_1(f@p)$

Prune calls to $f$ such that $q_2(f)$ is empty (irrelevant calls)

Full optimization algorithm (decomposition, call elimination) \cite{ABC04}.
Related problems from previous works

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Decompose the query:

$$q \circ p_1(a(\alpha,f \circ p_2,\beta)) \Rightarrow q_1 \circ p_1(a(\alpha,\beta)) \oplus q_2 \circ p_1(f \circ p)$$

Prune calls to $f$ such that $q_2(f)$ is empty (irrelevant calls). Full optimization algorithm (decomposition, call elimination) [ABC+04].
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Conclusion

ActiveXML: very expressive language for data-driven web service integration

We take a database-oriented perspective: efficient, declarative evaluation of data-intensive computations

Many interesting database problems

Ongoing work: incremental query evaluation, integration with monitoring system

OptimAX demo in ICDE 2008 [AMZb08] and WebContent demo in VLDB 2008 [AAC+08].
Thank you!
References


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