OptimAX: Optimizing Distributed ActiveXML applications

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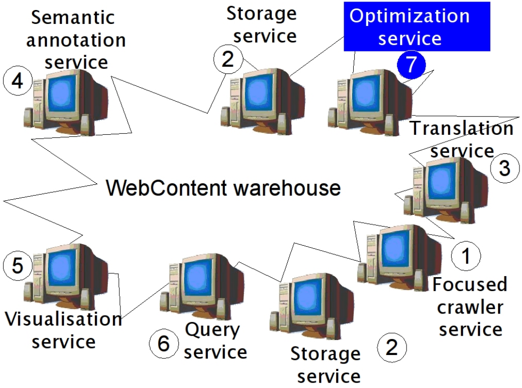
Outline

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

Outline

Distributed web service based applications

WebContent project (R&D project)



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- Service call interaction described in (A)XML documents.
- Optimizer needed to optimize the execution plans.

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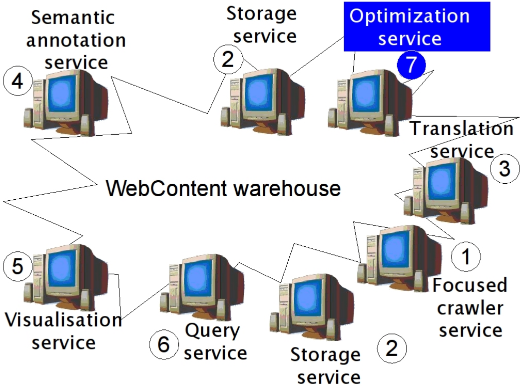

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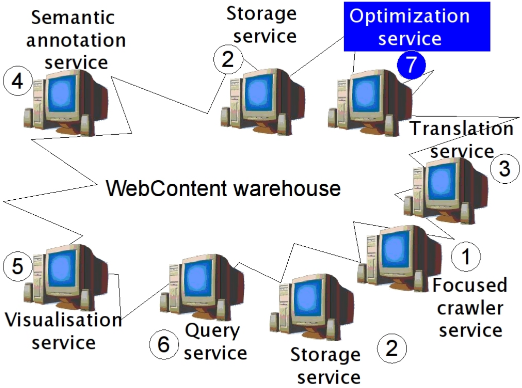

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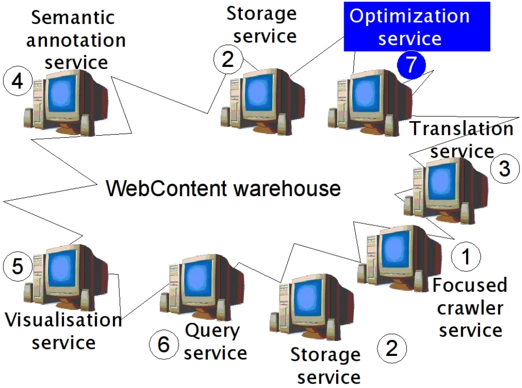

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The ActiveXML language

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.

```
<myPage>
 <axml:sc service="getProgram" peer="tvchannel.com">
  <parameter>Movies</parameter>
 </axml:sc>
</myPage>
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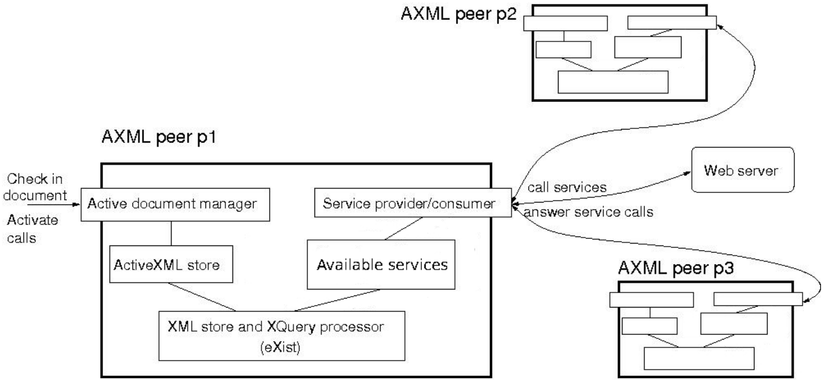
Continuous services may be continuous query services.

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 $s@p_2(\$in)$
Activating sc entails:

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

Remark

$\$in$ 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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AXML as an executable language

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

```
<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

```
<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` $\Leftrightarrow$ `receive`

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The newNode service

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

```
<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 $\mathscr{O}$ including:

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

There can be several legal schedules.

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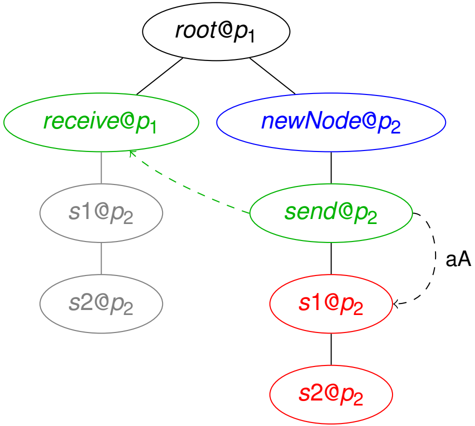
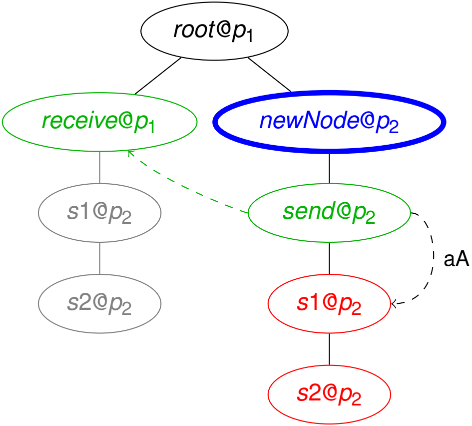
Sample legal schedule



- 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.

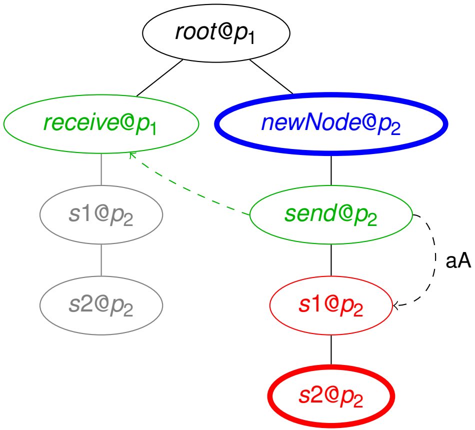
Sample legal schedule



Services activated:

- newNode@peer1

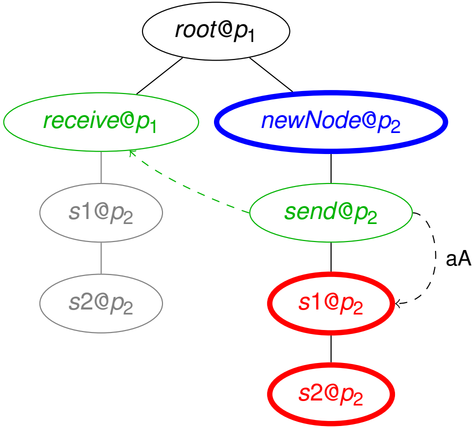
Sample legal schedule



Services activated:

- newNode@peer1
- s2@peer2

Sample legal schedule



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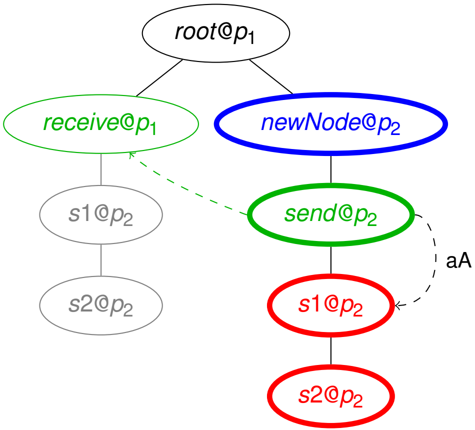

Services activated:

- newNode@peer1
- s2@peer2
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- send@peer2

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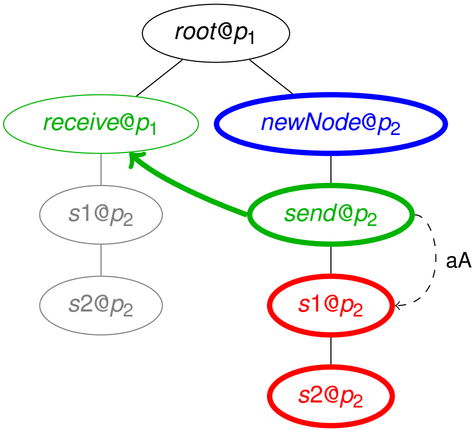

Services activated:

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- s2@peer2
- s1@peer2
- send@peer2

Data transmition

send@peer2 starts to send data to receive@peer1

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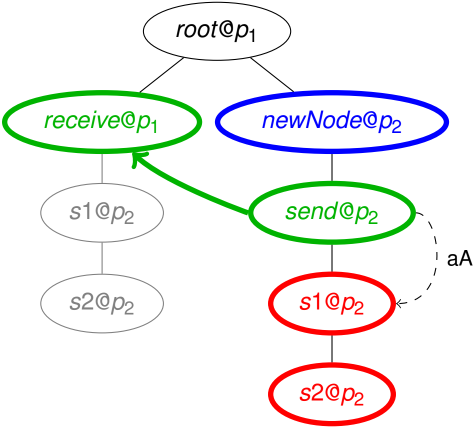

Services activated:

- 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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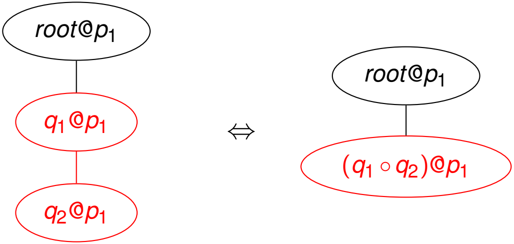
Equivalence-preserving AXML rewriting rules

Rules specific to query services:

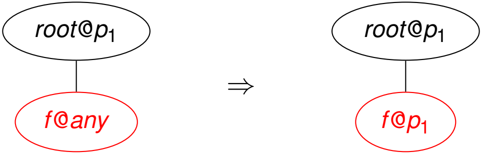


Query composition/decomposition

$q_1@p_1(q_2@p_1) \Leftrightarrow (q_1 \circ q_2)@p_1$

Equivalence-preserving AXML rewriting rules

Generic rules:



Instatiation

$f@any \Rightarrow f@p_1$ (the same f service)

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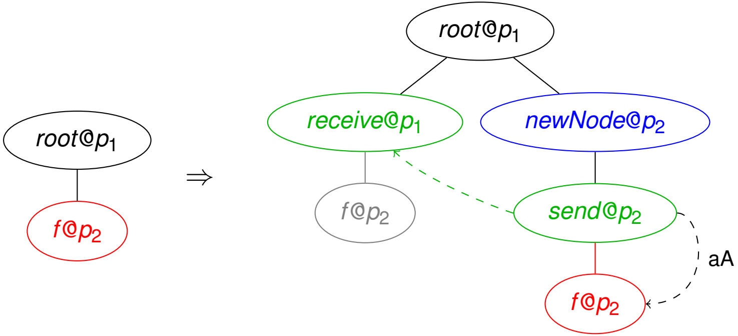

Delegation

$$f@p_1(e@p_2) \quad \Rightarrow \quad \begin{array}{l} \#1 : receive@p_1(e@p_2), \\ newNode@p_2(send@p_2(e@p_2, \#1@p_1)) \end{array}$$

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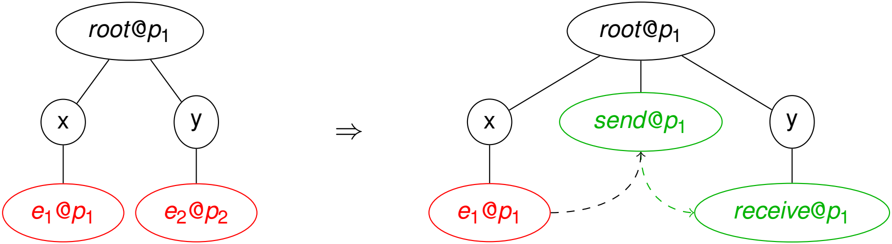

Factorization

$$r(x(e_1),\ldots,y(e_2)) \quad\Rightarrow\quad r(x(\#1:e_1),$$
$$e_1 \equiv e_2 \qquad\qquad \#2:send@p_1(\#1@p_1,\#3@p_1),\ldots,$$
$$y(\#3:receive@p_1)$$
$$)$$

AXML optimization

Given:

- Rewriting rule set $\mathscr{R}$
- 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 $r \in \mathscr{R}$, 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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One-stage (static) optimization

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

1. Let $S := \{d\}$
2. Repeat
   1. Pick a rule $r \in \mathscr{R}$, a document $d_1 \in S$ and a tree $t \in d_1$.
   2. Let $d_2 := r(d_1, t)$. If $d_2 \notin S$, 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.

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Generic ActiveXML optimizer: OptimAX

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

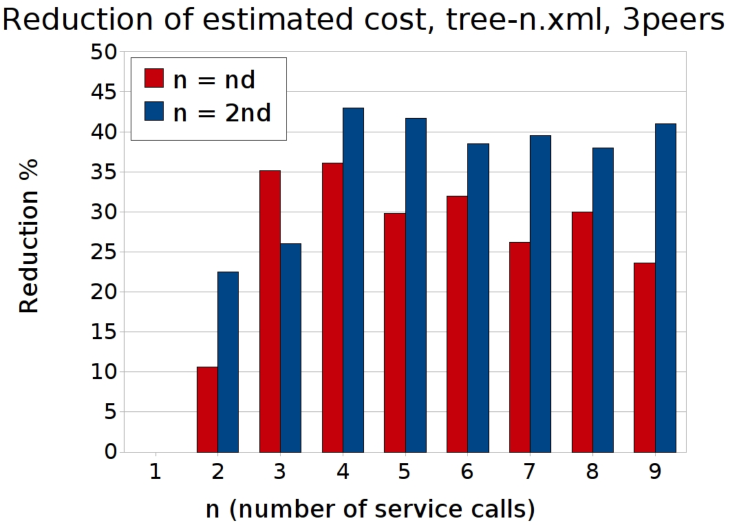
Synthetic documents:

- deep*n*.xml
- flat*n*.xml
- tree*n*.xml, max fan-out=6

Services assigned with uniform probability distribution over n_d services.

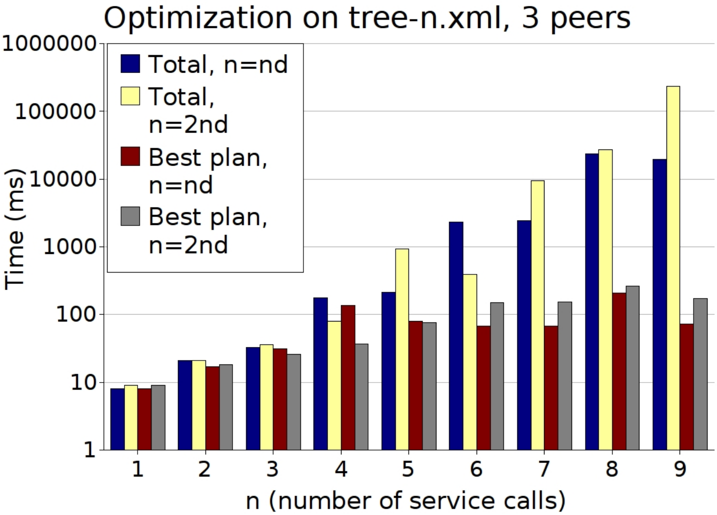
Optimization considers a network of p peers.

OptimAX performance



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

OptimAX performance

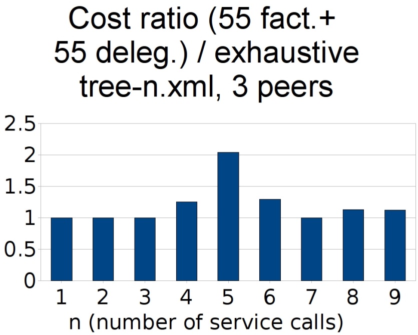


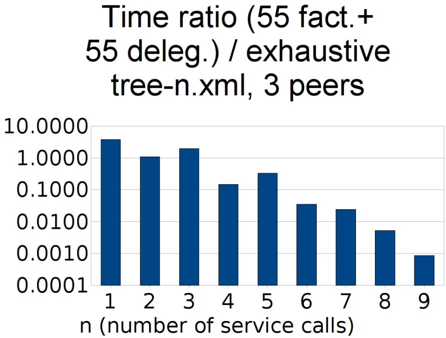
Depth-first cost-driven strategy

OptimAX performance

We compare an exhaustive search with a limited one:

- Cost ratio
- Time ratio





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Related problems from previous works

Rewriting

Transforming an input or type τ_1 to an output of type τ_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 [MAA+03,AMB05].

Distribution

Assimilate service calls to remote tree references.
Query evaluation over an AXML document = local + remote evaluation.
Query shipping optimization rules [ABC+03].

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) [ABC+04]

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Distribution

Assimilate service calls to remote tree references.
Query evaluation over an AXML document = local + remote evaluation.
Query shipping optimization rules [ABC+03].

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) [ABC+04]

Outline

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!

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