Structured Materialized Views for XML Queries

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Outline

1. Context: rewriting XQuery using nested views
2. Pattern containment under summary constraints
   - Path summary
   - Summary based containment
3. Summary based query rewriting
4. Experimental results
5. Conclusions

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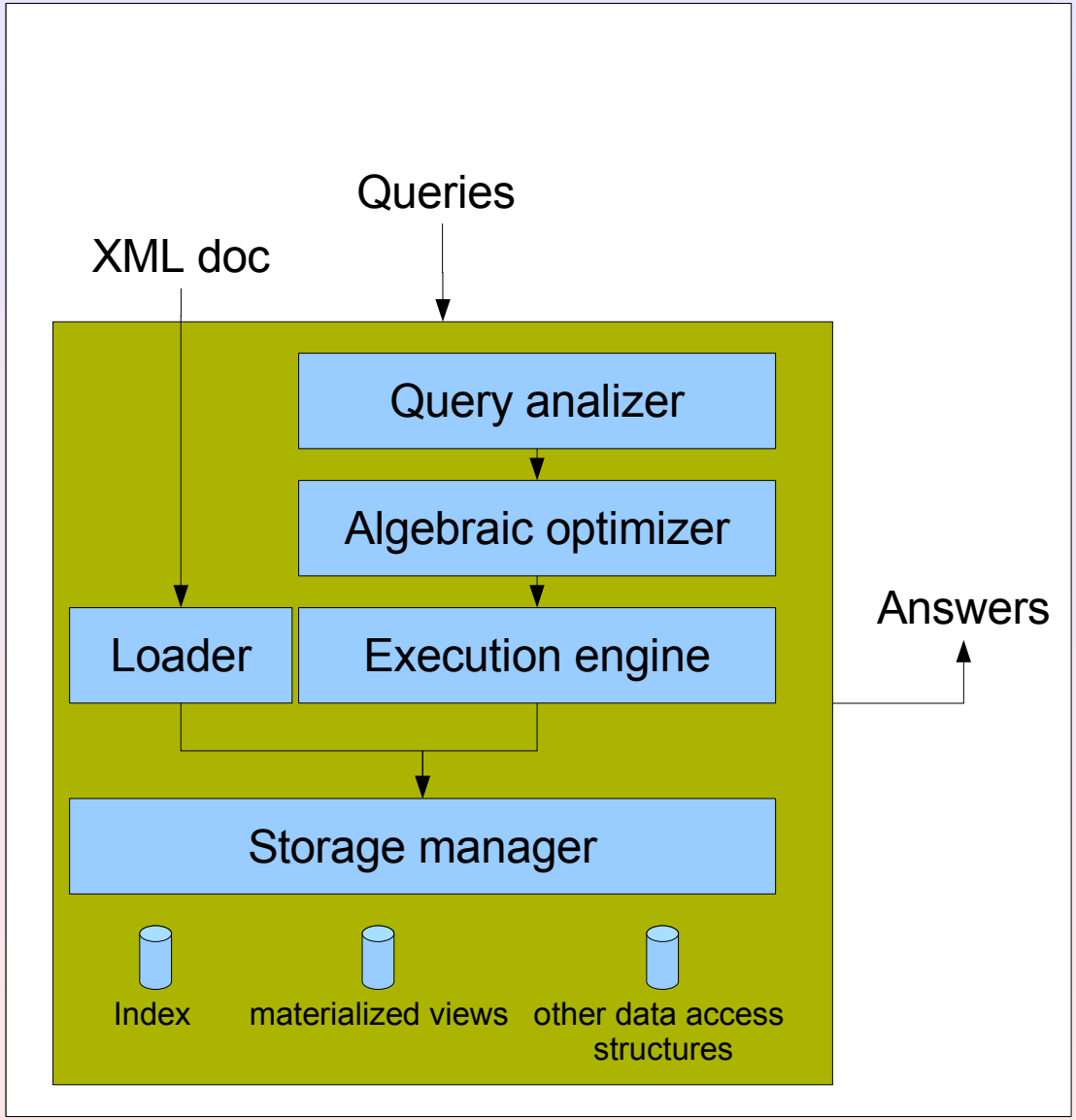

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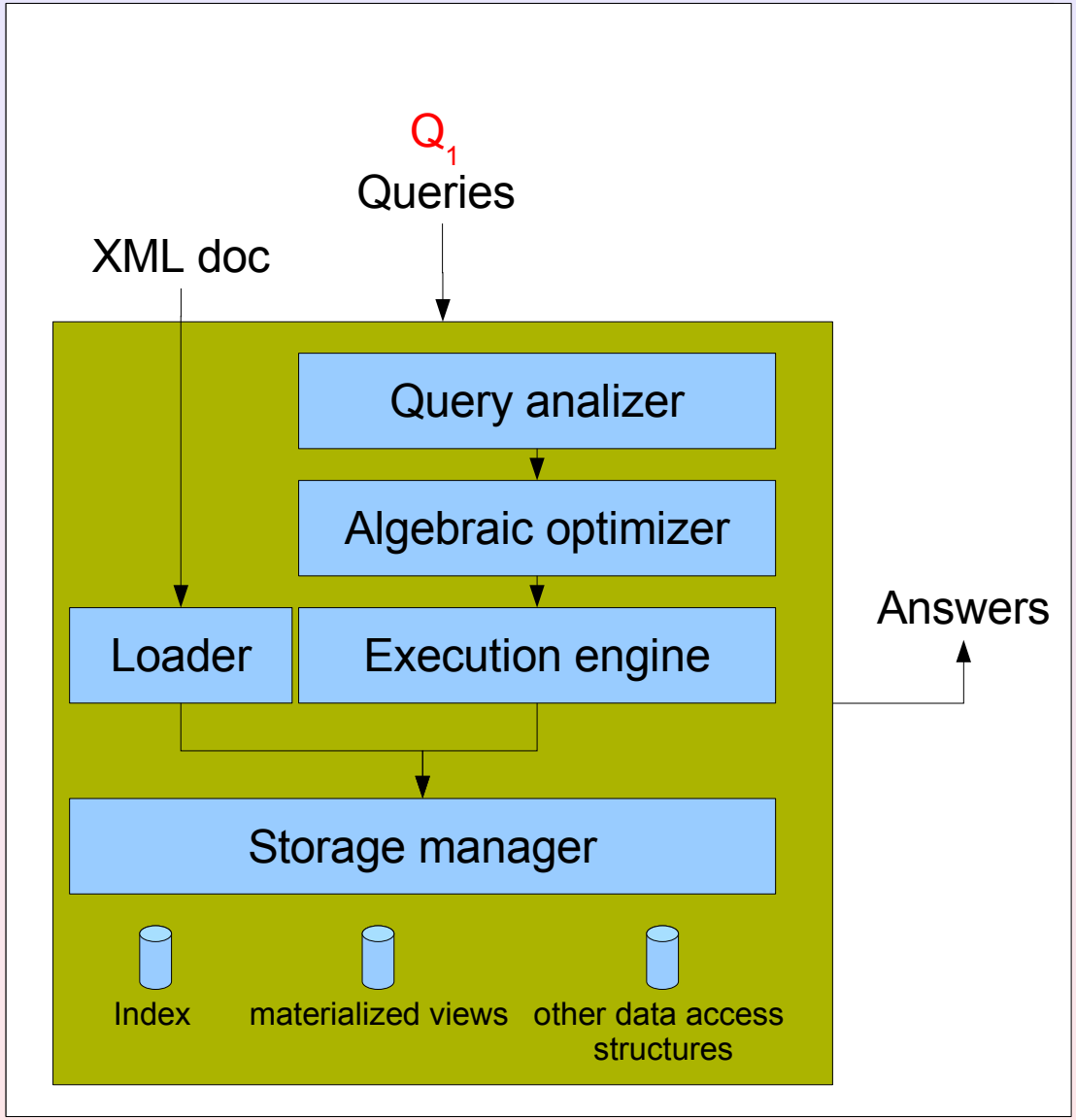

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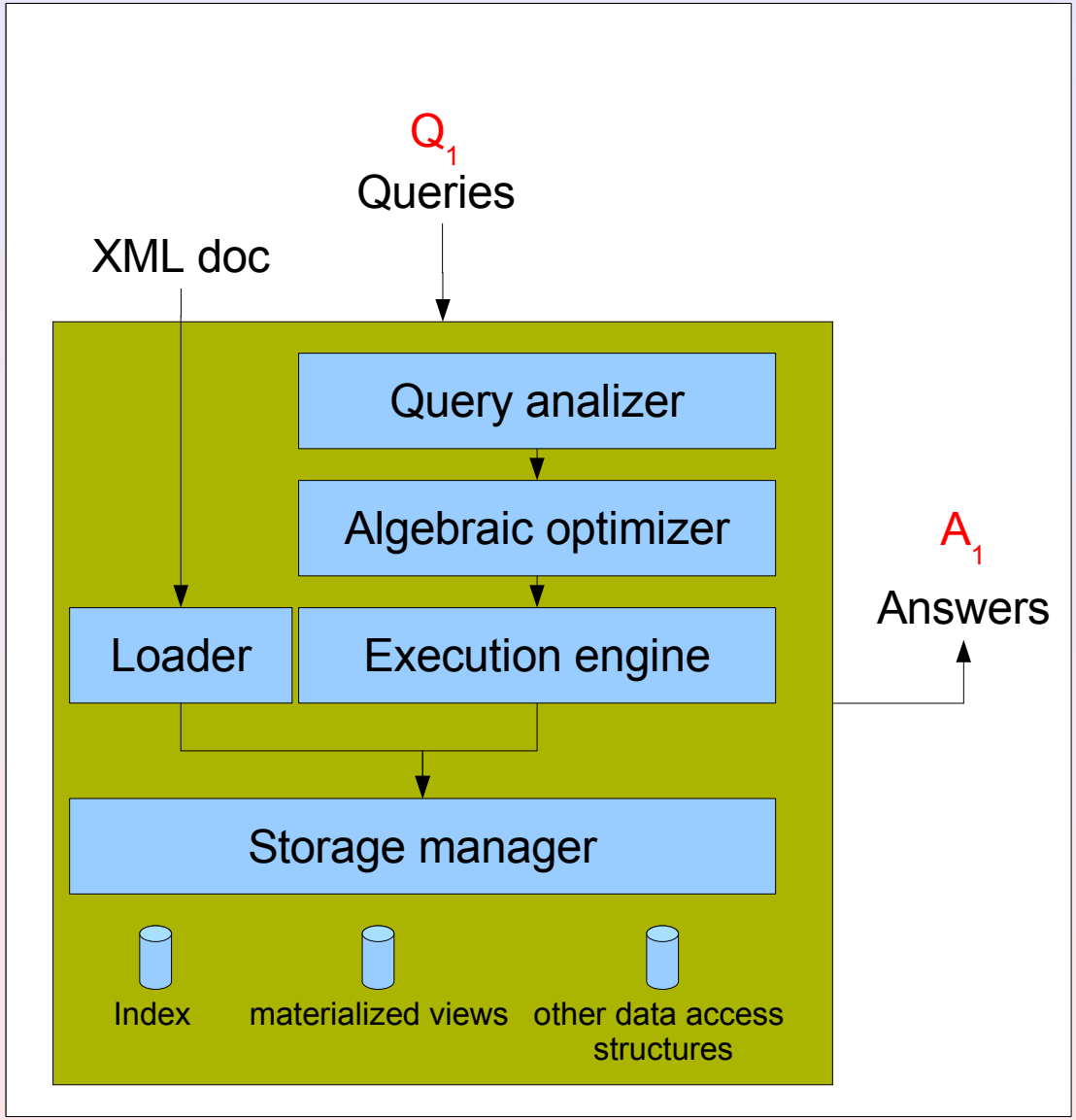

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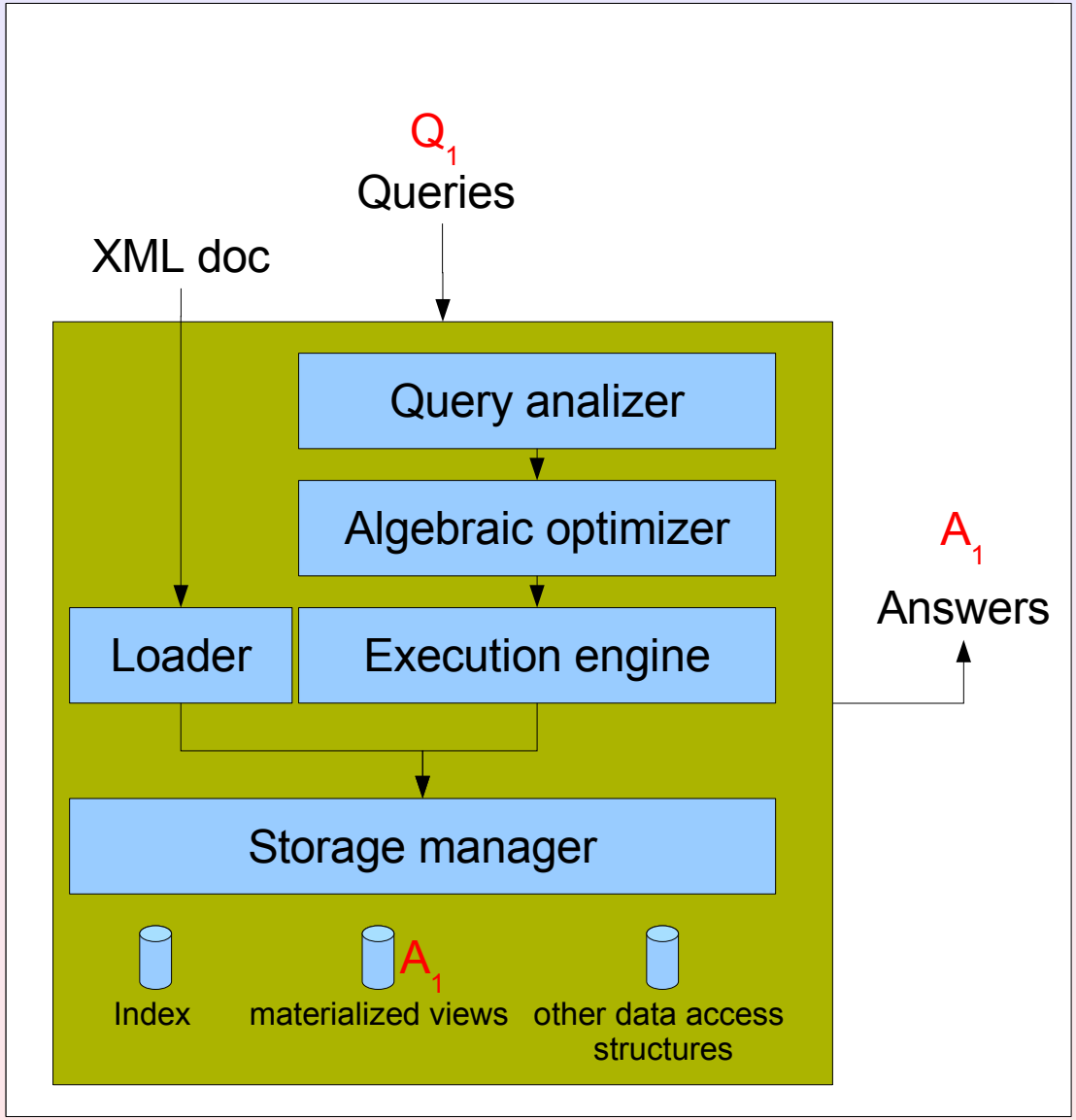

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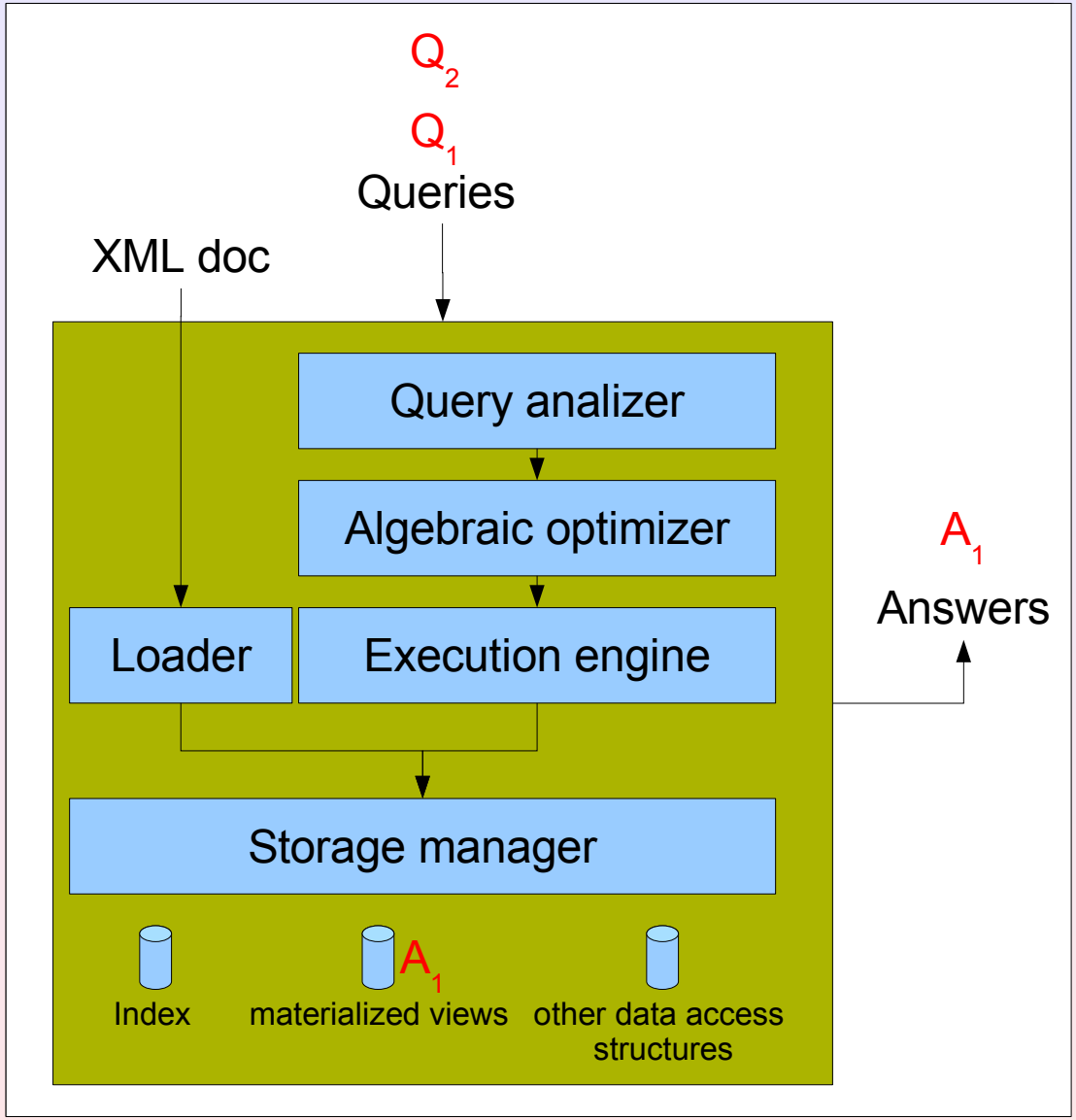

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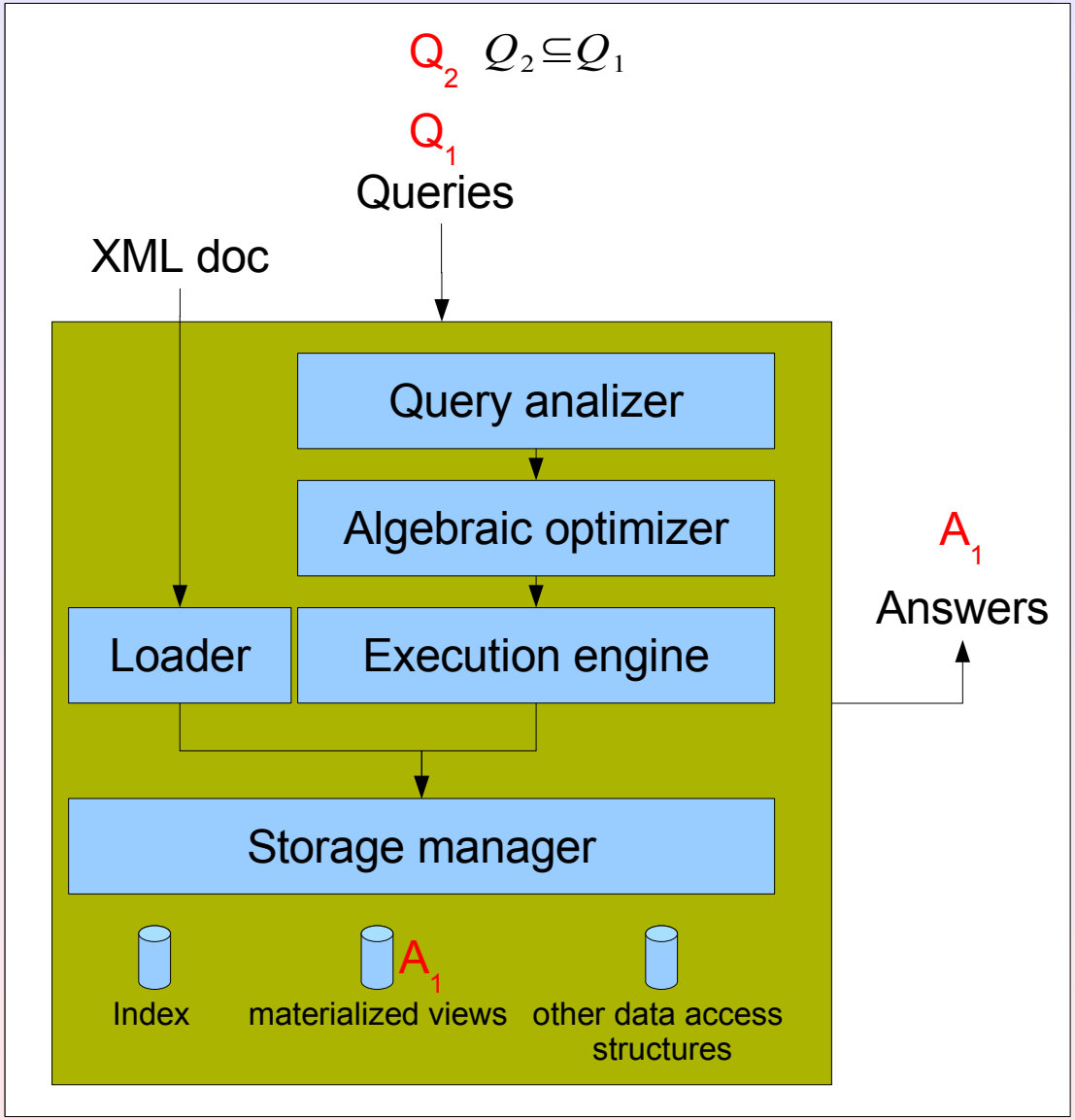

Related works

XPath containment and equivalence

- No constraints:
  - S. Amer-Yahia 2001, Deutsch and Tannen, 2001; Miklau and Suciu, 2002
- DTD constraints:
  - Wood 2003 ,Neven and Schwentick 2003

XPath rewriting

- Balmin et al, 2004, weak path usage
- Wanhong Xu et al 2005
- Lakshmanan et al, 2006, MCR under path summary constraints

XQuery containment and rewriting

- Halevy et al. 2004
- Onose et al. 2006, equivalent rewriting

We address XAM containment and rewriting under path summaries constraints.

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Materialized views for XML: Query

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for $x in //item return
    <res>
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        {$x//keyword}
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- Use an XQuery view that materialize the whole query.
- Problems:
  - The *complexity* of the XQuery language
  - Difficult to *understand and combine* multiple XQuery views

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- XPath: V=//item
  - Q=$E_1(V)$
  - Problems: V is big, E_1 is complex
- XPath: V1=//item/name, V2=//item//keyword
  - $Q = E_2(V_1, V_2)$
  - XQuery semantics: output an empty res element even if no *name*, *keyword*!
  - Problem: How to combine V_1 and V_2? Answer: ID!

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Materialized views for XML: Enhanced Tree Patterns

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for $x in //item return
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- Store IDs in the view V_1=//item ID, V_2=//name ID, V_3=//keyword ID
  - $Q = V_1 \bowtie\!\!\sqsubset_{ID} V_2 \bowtie\!\!\sqsubset_{ID} V_3$
  - Problem: still store too much!
- ID, Val, Cont in the view definition
  - $Q = V_1 \bowtie\!\!\sqsubset_{ID} V_2 \bowtie\!\!\sqsubset_{ID} V_3$
  - Can I eliminate the joins? Express outer joins algebraically

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  - Can I eliminate the joins? Bypass auto nested edges

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  - Can I eliminate the joins? Express subtree navigation

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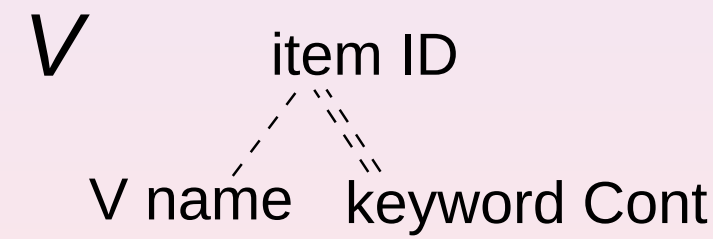
- Store ID, Cont, Val + optional edges



- $Q = GroupBy_{ID}(V)$
- Can I eliminate the need for group by? Annotations

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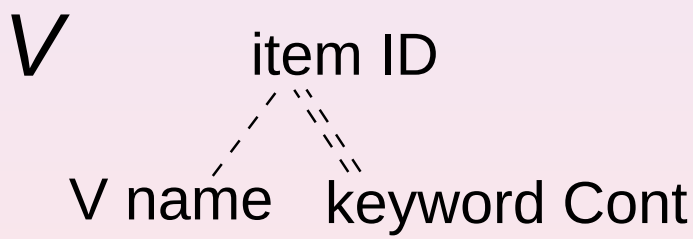

  - $Q = GroupBy_{ID}(V)$
  - Can I eliminate the need for group by? Add nesting!

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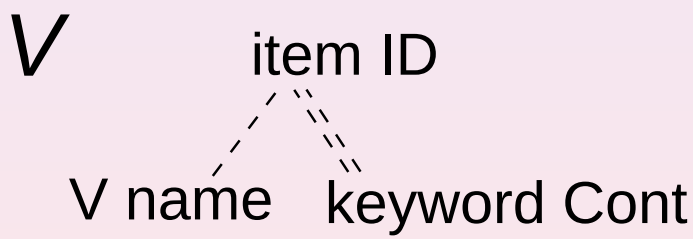

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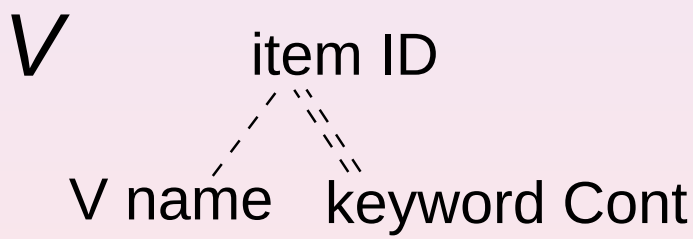

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Materialized views for XML: XML Access Modules

```
for $x in //item return
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```
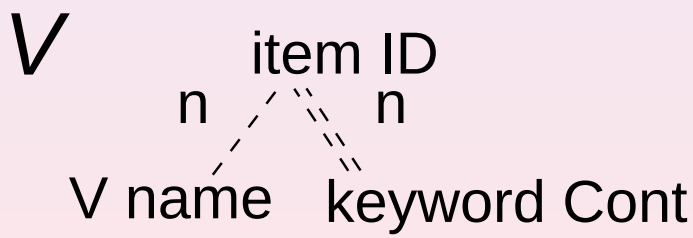
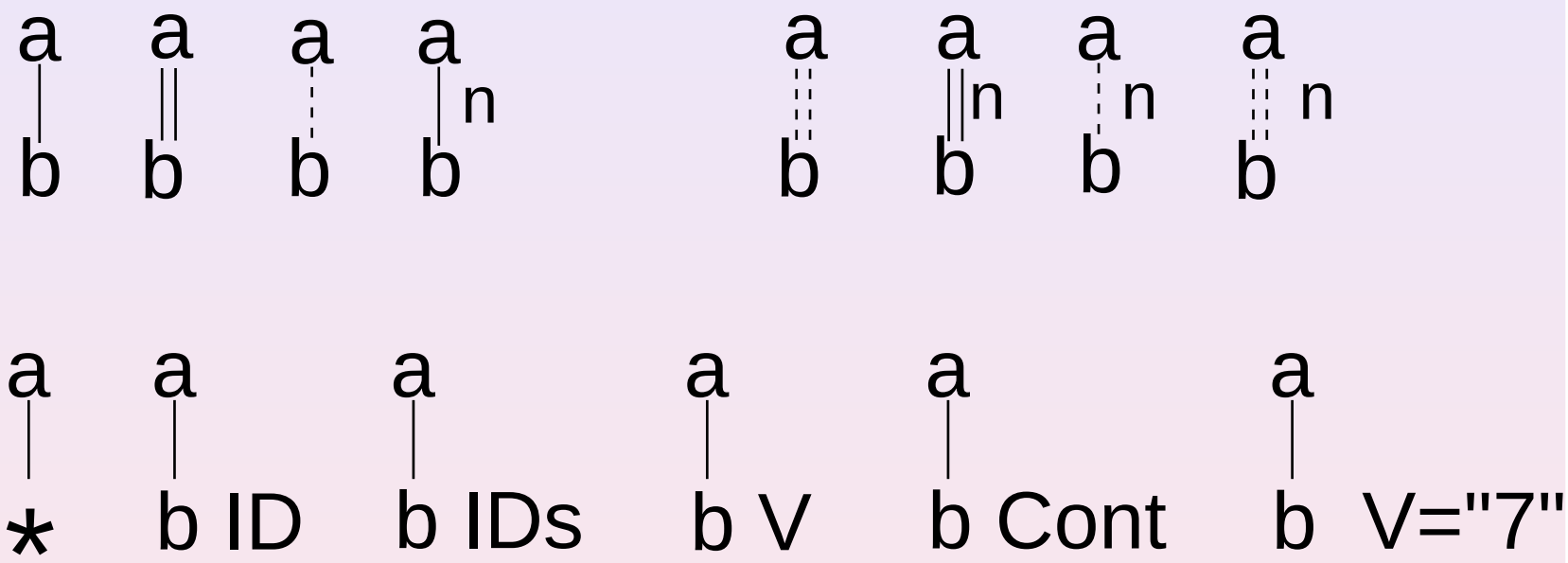

- XML Access Modules = tree patterns with IDs, Val, Cont + optional and nested edges + value predicates



- $Q = V$

XAMs by examples



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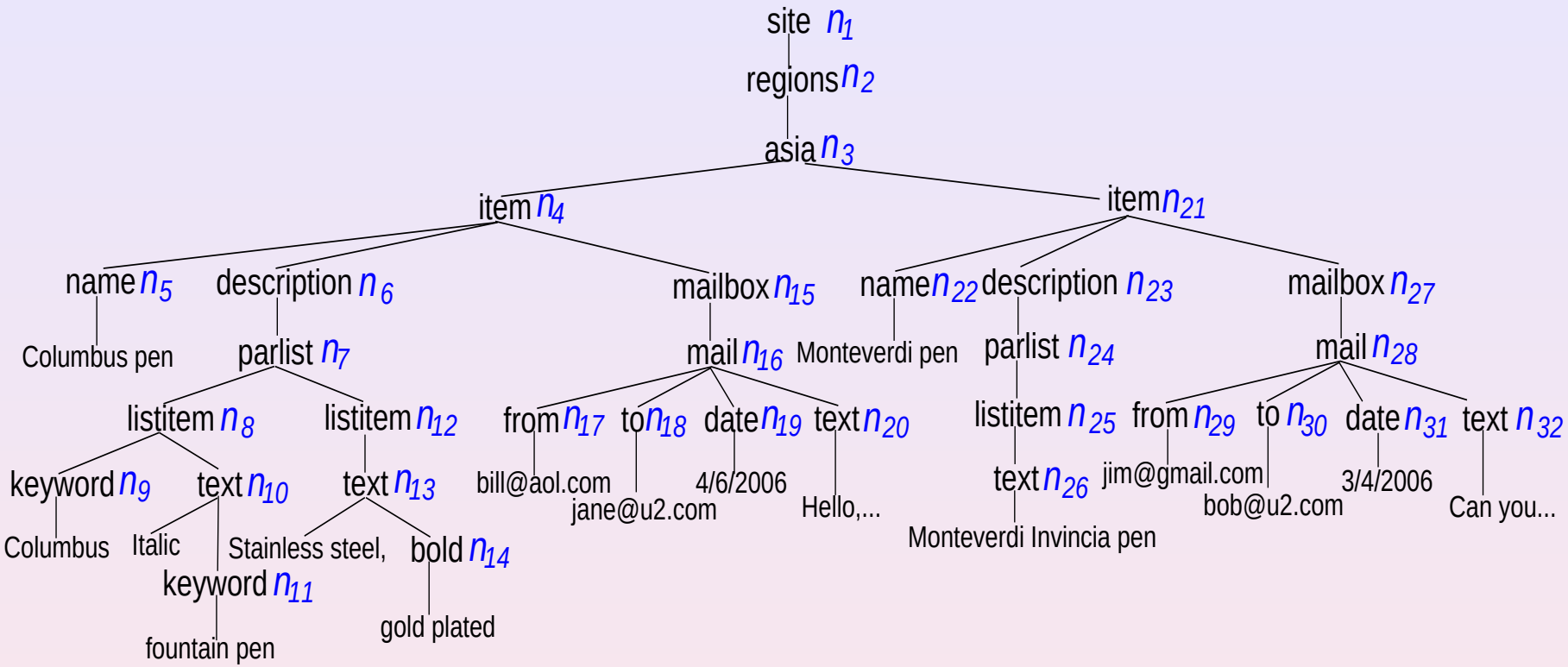

V_1

ID	V
n_5	Columbus pen
n_{22}	Monteverdi pen

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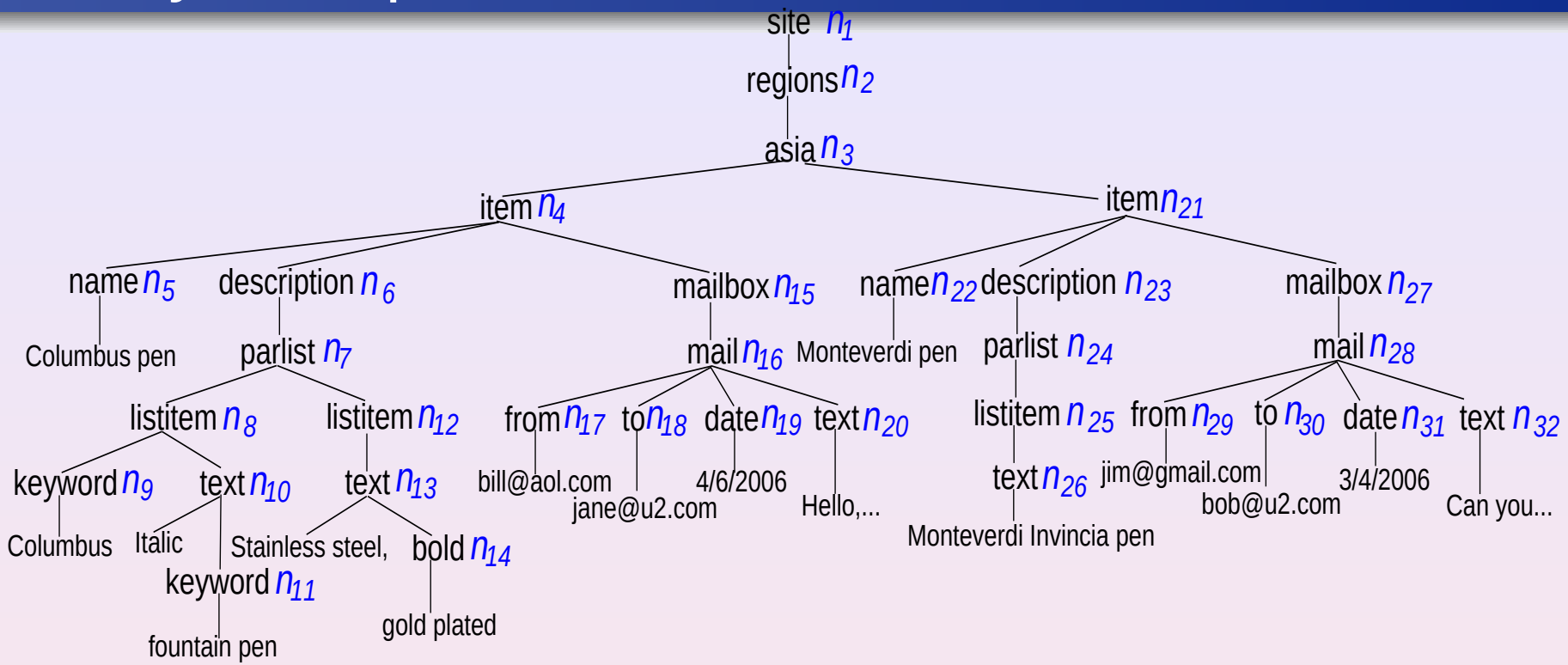
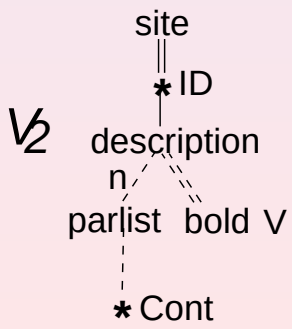
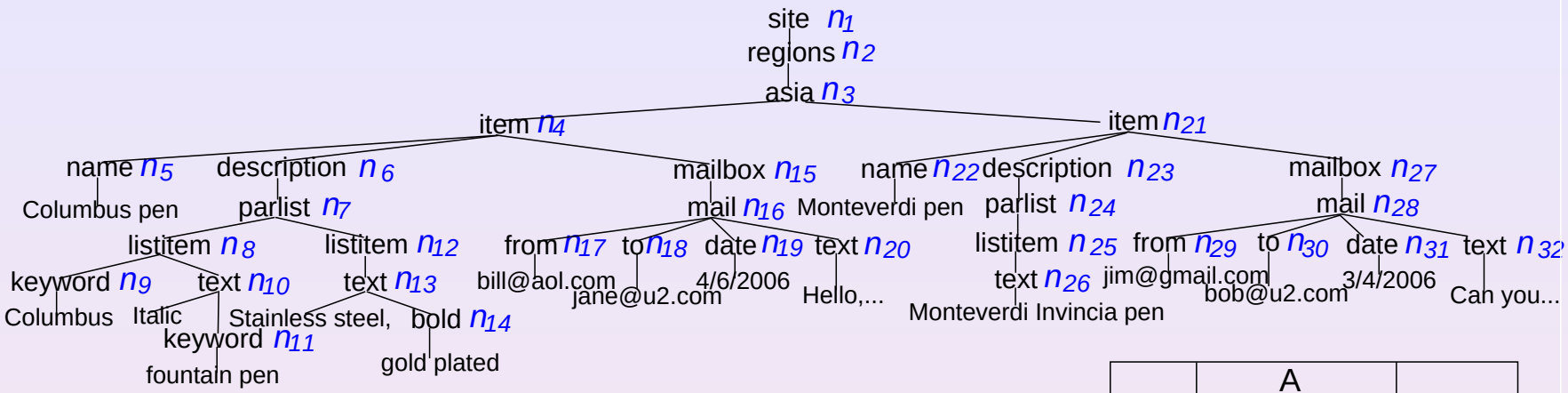




ID	A C	V
n_4	<listitem><keyword>Columbus</keyword><text>Italic <keyword>fountain pen</keyword></text> </listitem>	gold plated
	<listitem><text>Stainless steeel, <bold>gold plated</bold></text> </listitem>	
n_{21}	<listitem><text>Monteverdi Invincia pen</text></listitem>	$\perp$

Rewriting XQuery using XAMs



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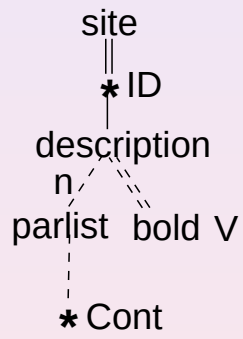
V_2



ID	A C	V
n_4	. . . . . .	gold plated
n_{21}	. . .	$\perp$

```
for $x in //item[//mail] return
    <res> {$x/name/text(),
        for $y in $x//listitem return
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```
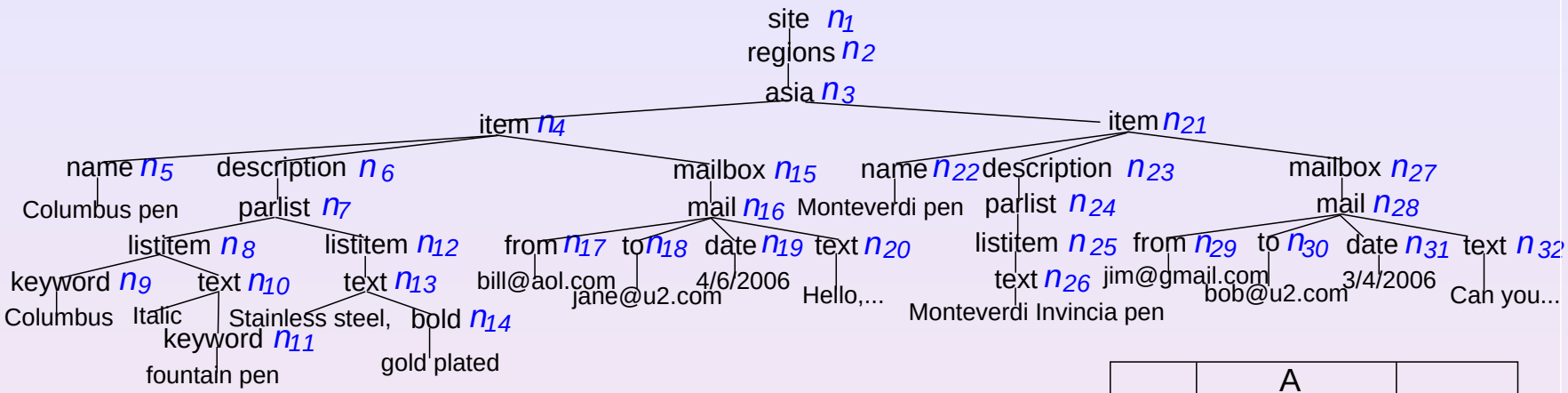

Rewriting XQuery using XAMs



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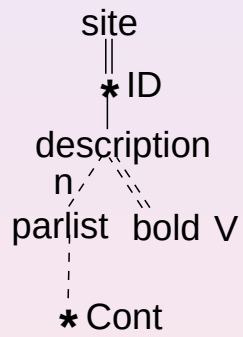

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If document structure is known

$V_2 \bowtie V_1$

item ANCESTOR−OF name

ID	A: C	V	ID	V

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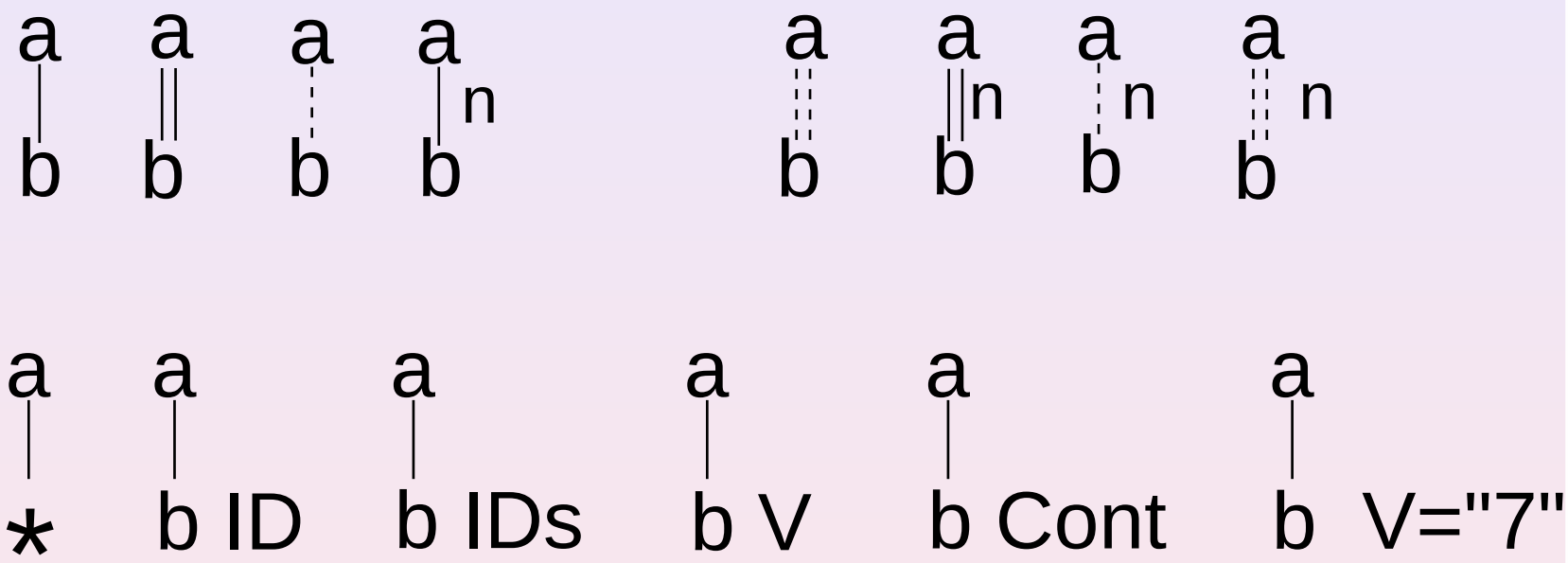

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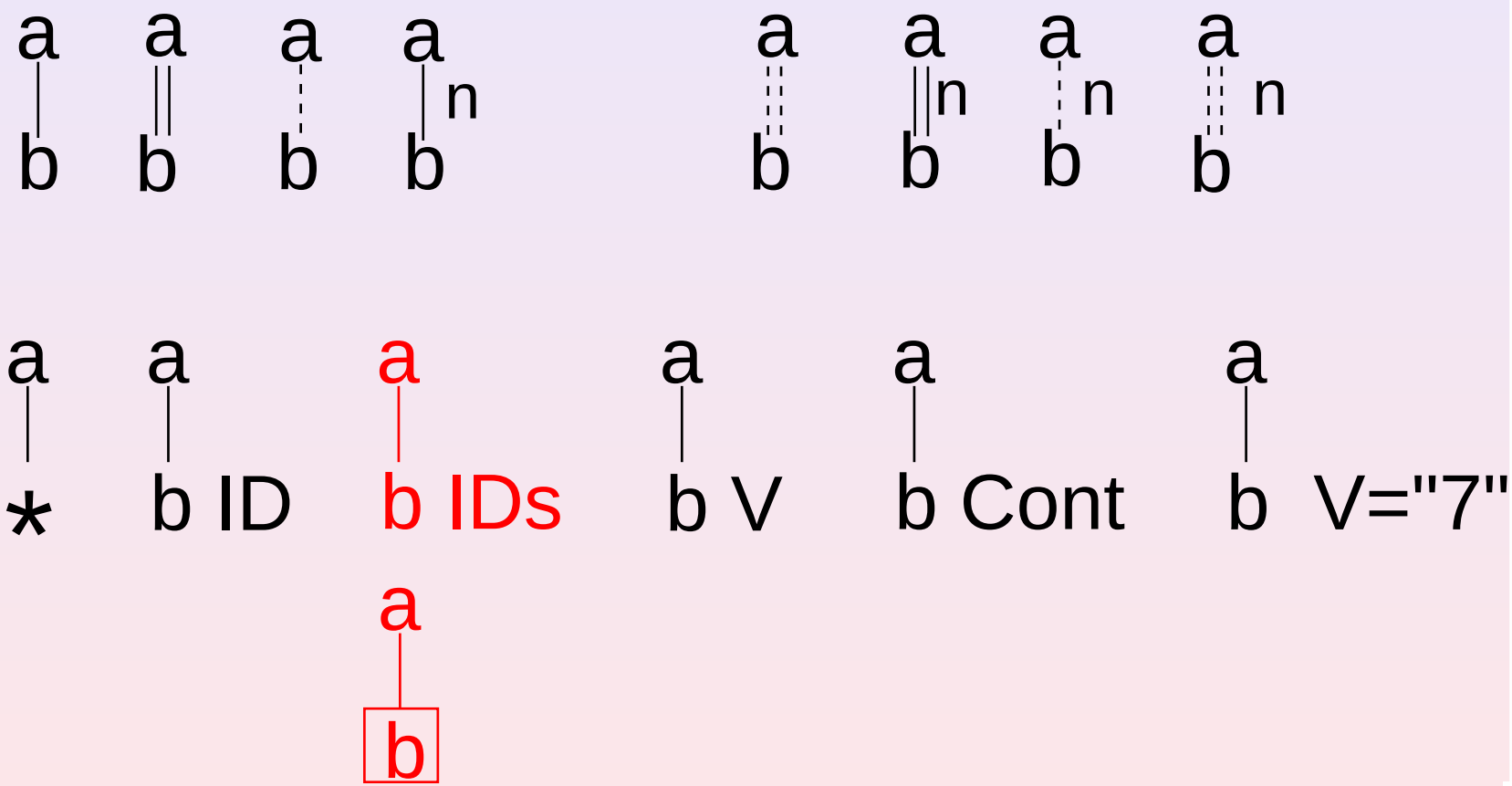

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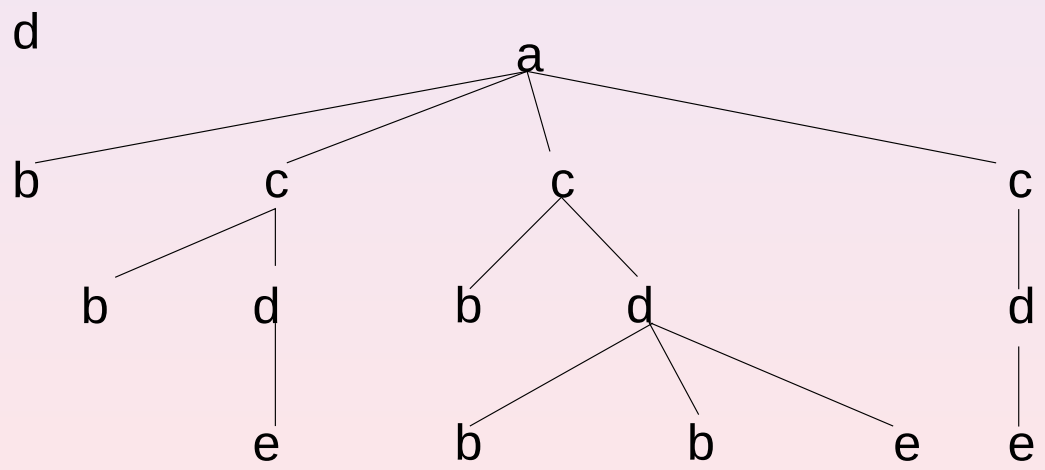
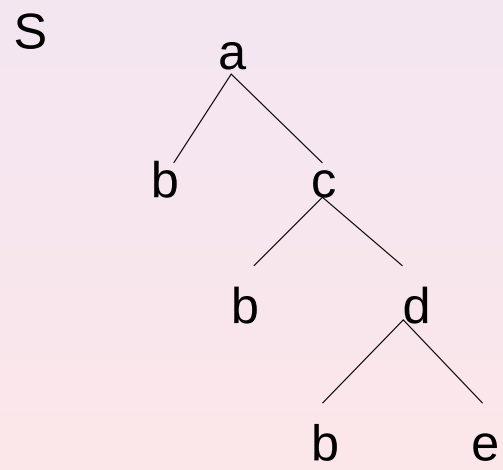
Simple summary of a document d:

- root, label and parent-preserving mapping $\phi : d \rightarrow S$
- the children of a summary node have distinct labels

A document d' conforms to a path summary S ($S \models d'$) iff $\exists \phi' : d' \rightarrow S$





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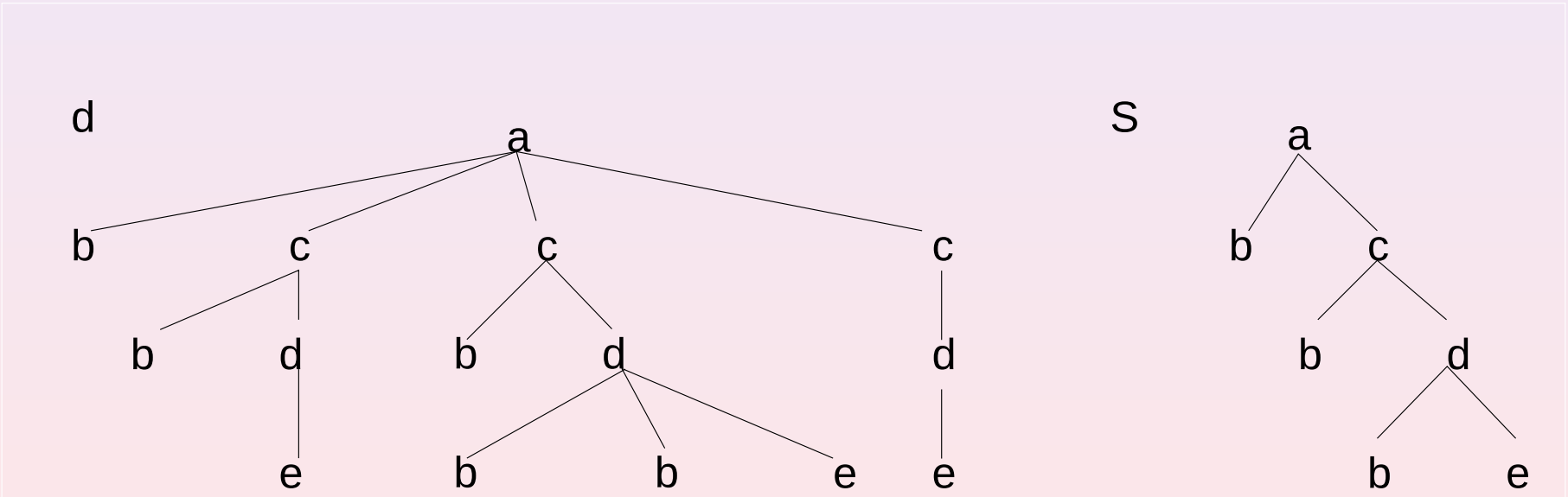

Path summary

Simple summary of a document d:

- root, label and parent-preserving mapping $\phi : d \rightarrow S$
- the children of a summary node have distinct labels

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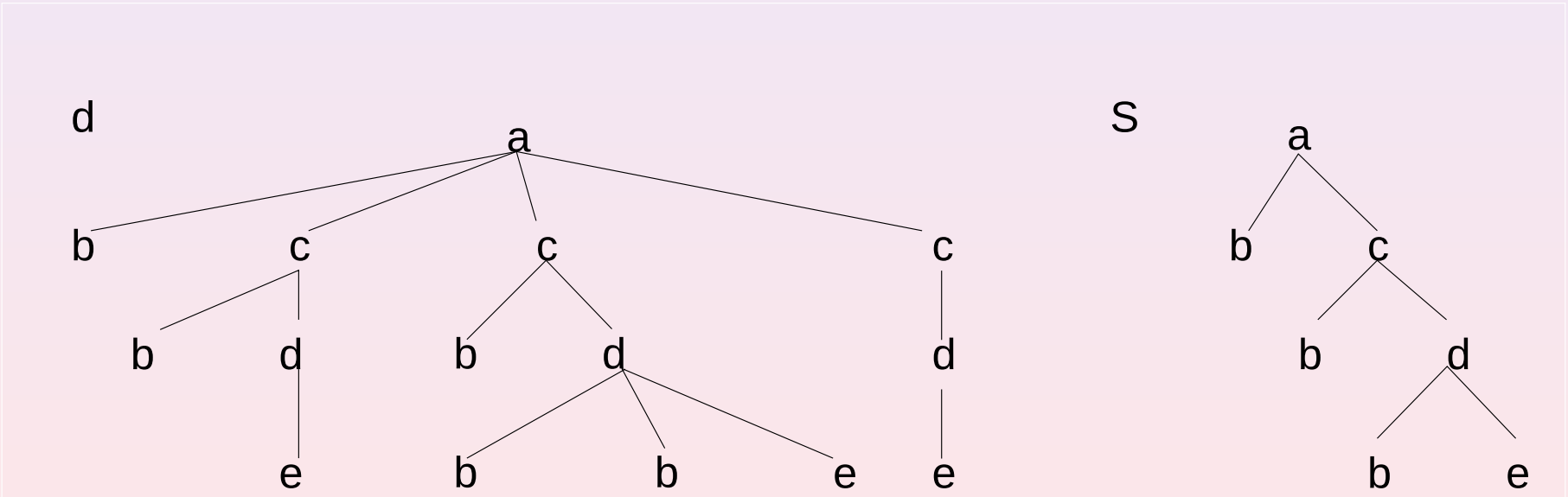

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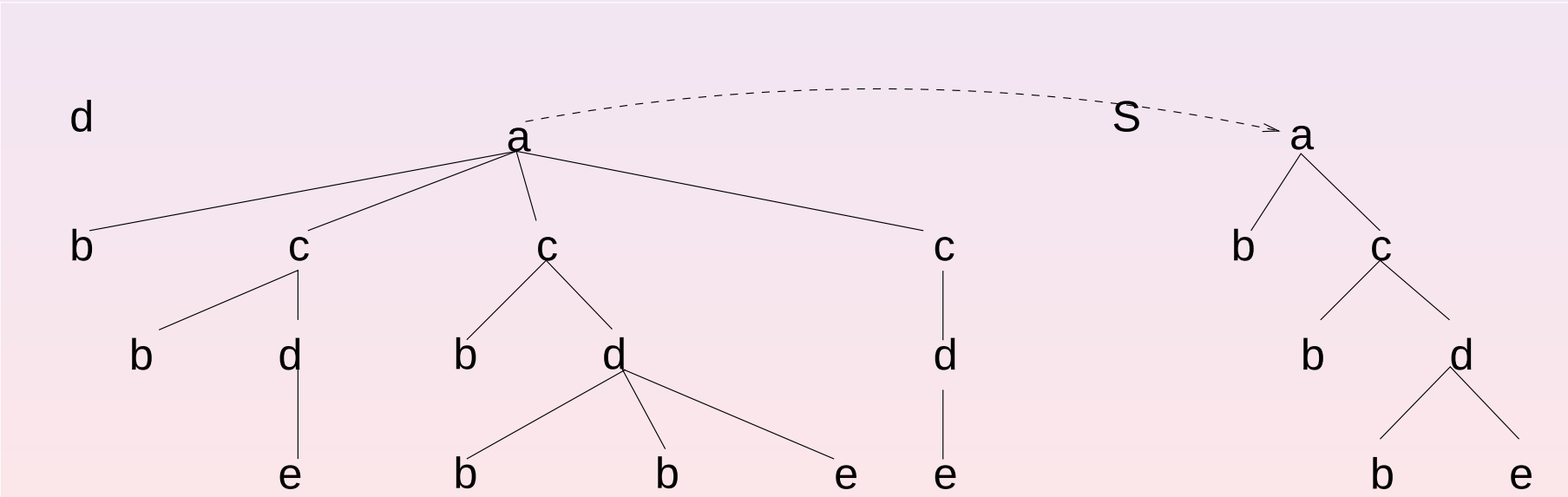

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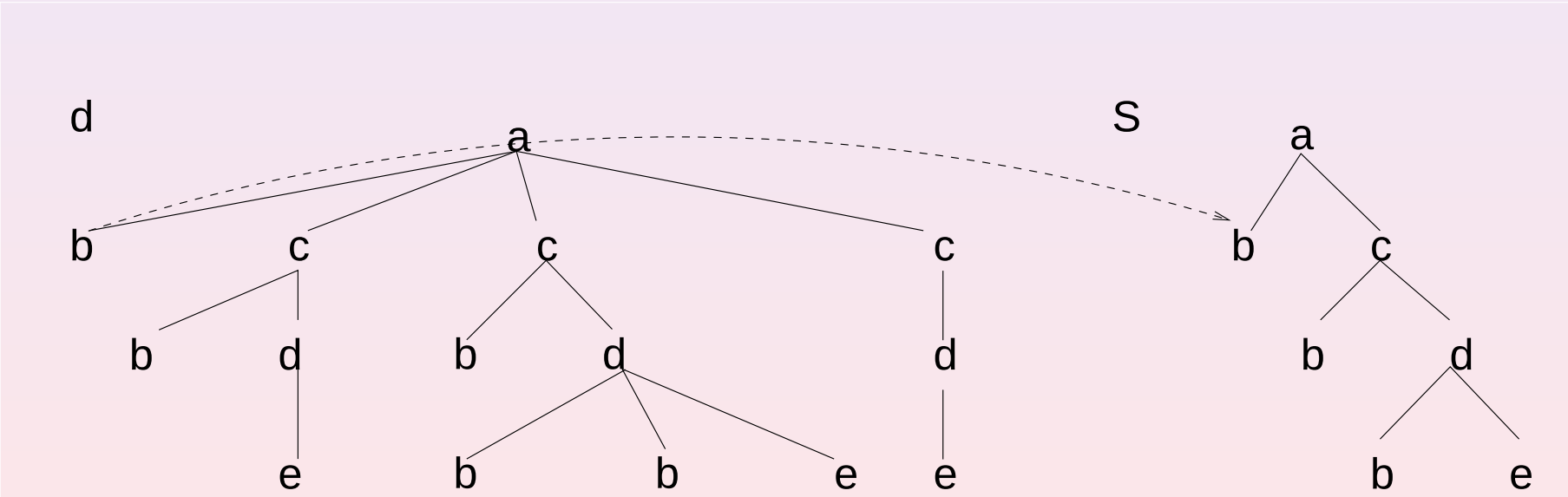

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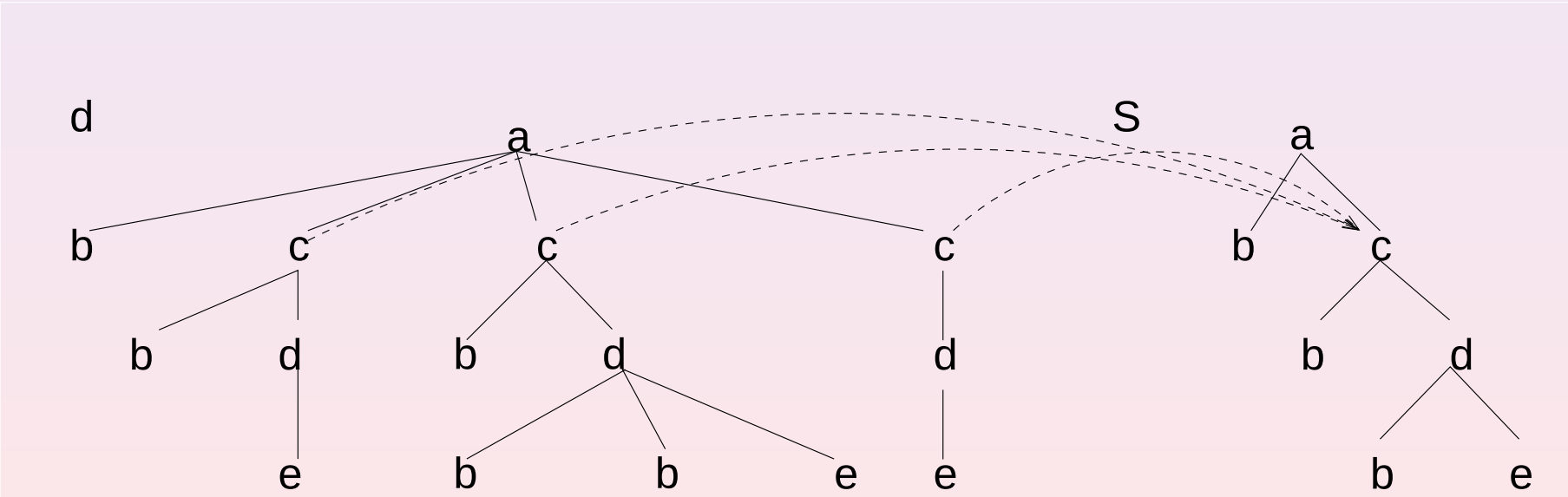

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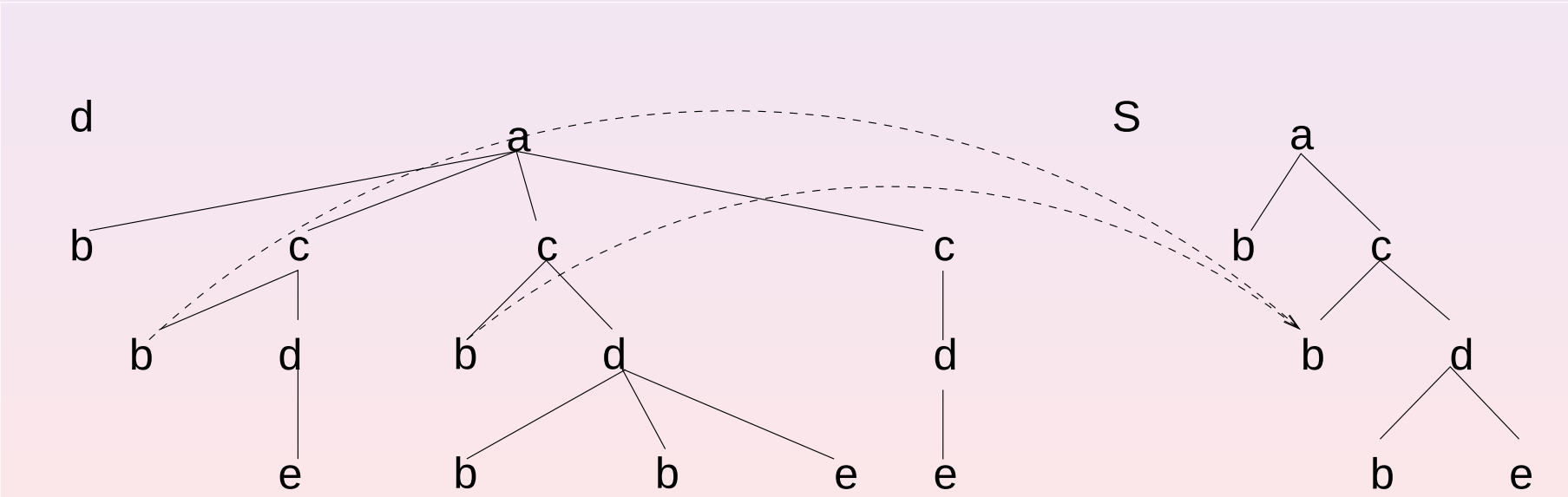

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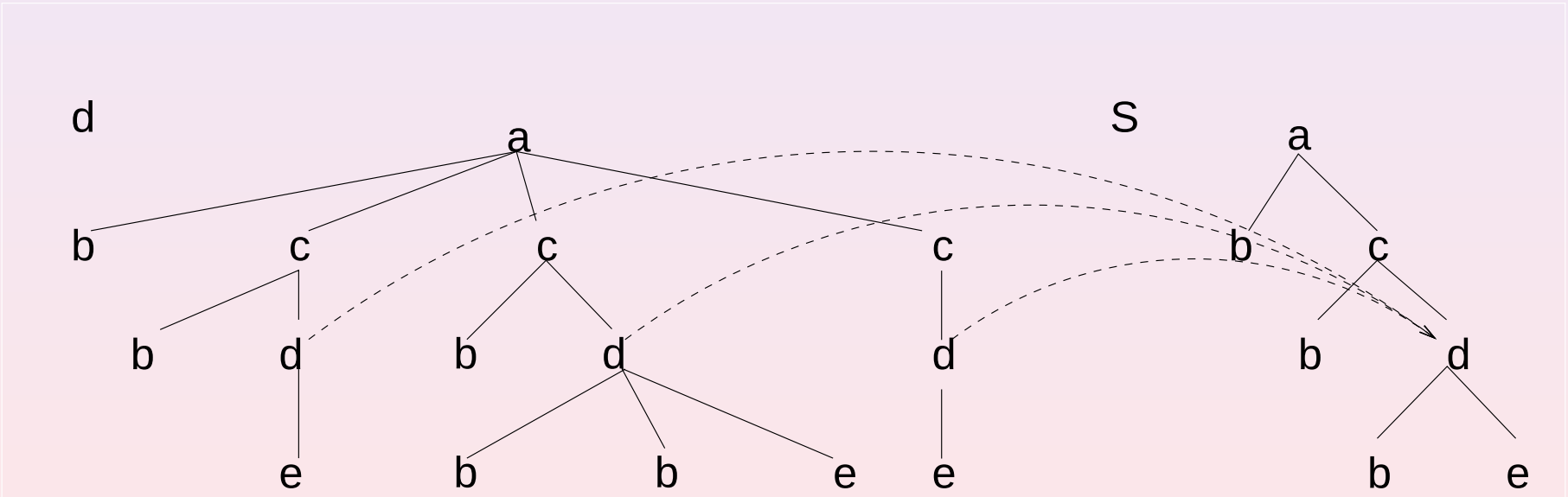
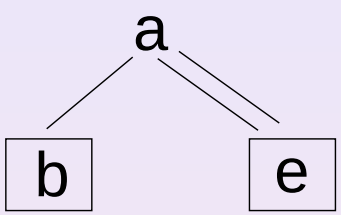
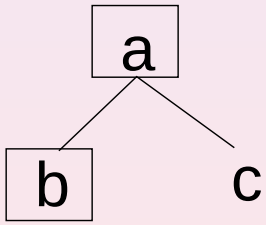


Path summaries and XAMs in query rewriting

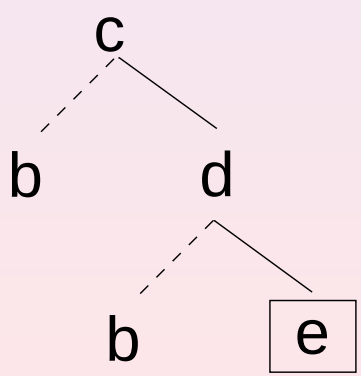
Q



V1



V2



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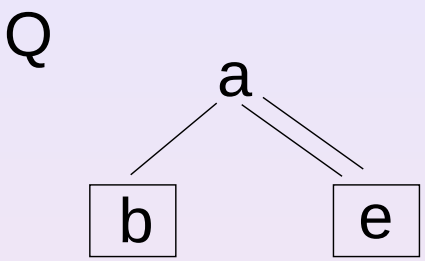

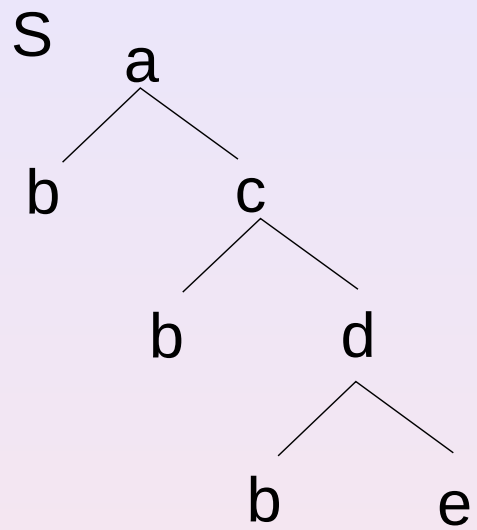

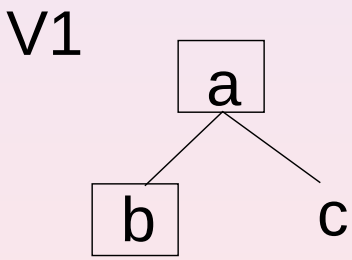

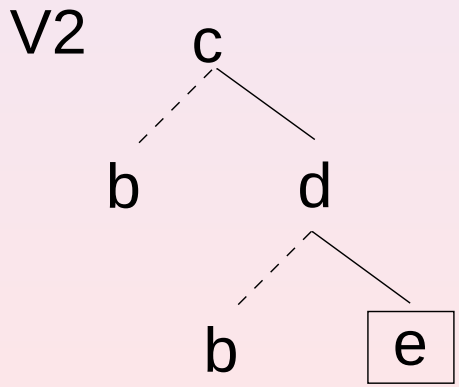

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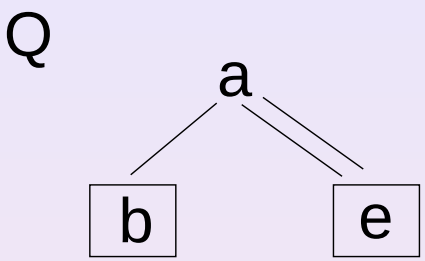

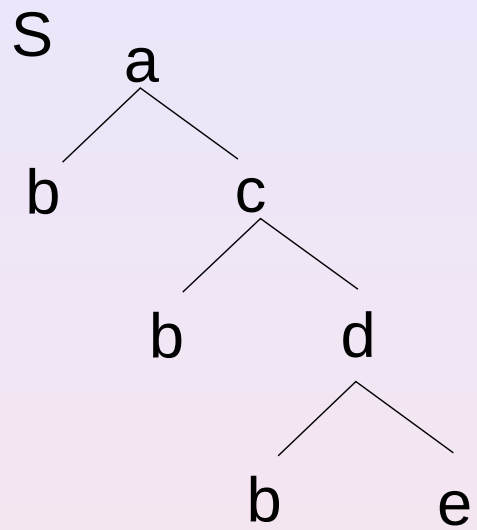

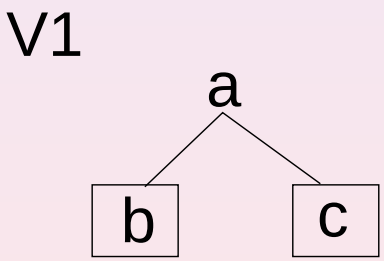

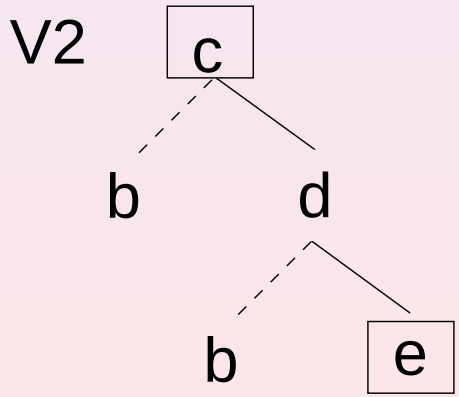

Summary based containment

Definition

$p \subseteq_S p'$ *iff* for any t such that $S \models t$, $p(t) \subseteq p'(t)$.

Problem: infinitely many trees t

Solution:

- consider trees from a finite set canonical model of S
- if no canonical tree is a counter-example then $p \subseteq_S p'$

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Summary based containment

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p is S-contained in p' *iff* for any t such that $S \models t$, $p(t) \subseteq p'(t)$.

Proposition: $p \subseteq_S p'$ iff

$\forall\, t_p \in mod_S(p)$ the return tuple of $p(t_p) \in p'(t_p)$.

Outline

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Query rewriting: problem statement

Input: Path summary S, XQuery Q, set of XAMs $X_1, X_2, \ldots, X_n$

Output: all minimal algebraic expressions $e(X_1, X_2, \ldots, X_n)$ (up to algebraic equivalence) s.t. $\forall\, d$ conforming to S

$$Q(d) = e(X_1, X_2, ..., X_n)(d)$$

Algebra: σ , Π, $\bowtie_{ID}$, $\bowtie\!\!\sqsubset_{ID}$, $\bowtie_{\prec}$, $\bowtie\!\!\sqsubset_{\prec}$ (variants: ancestor-descendent, nested joins), *Nest*, *Unnest*, *Nav* and $\cup$

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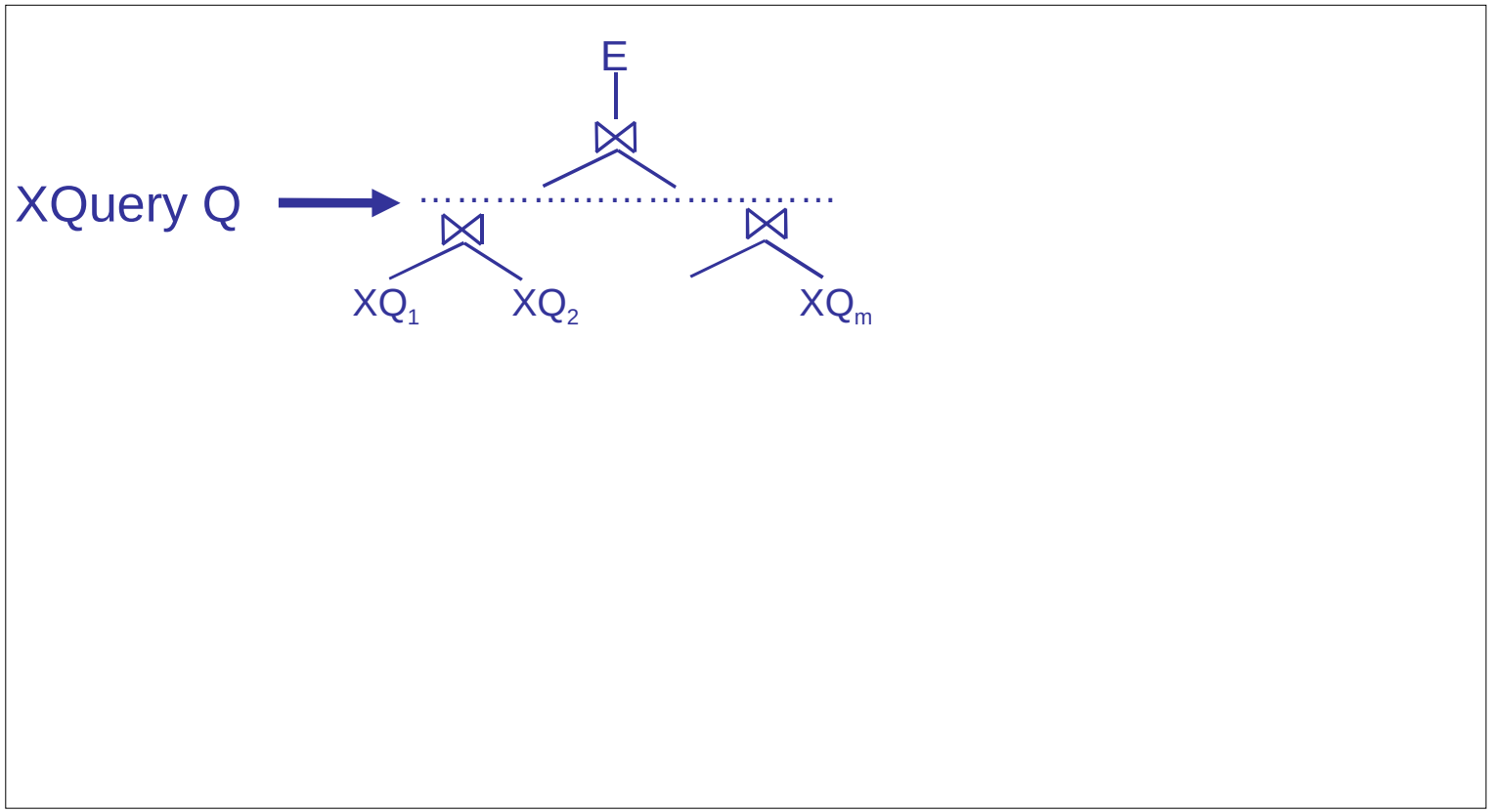
Query rewriting algorithm

XQuery Q

Query rewriting algorithm



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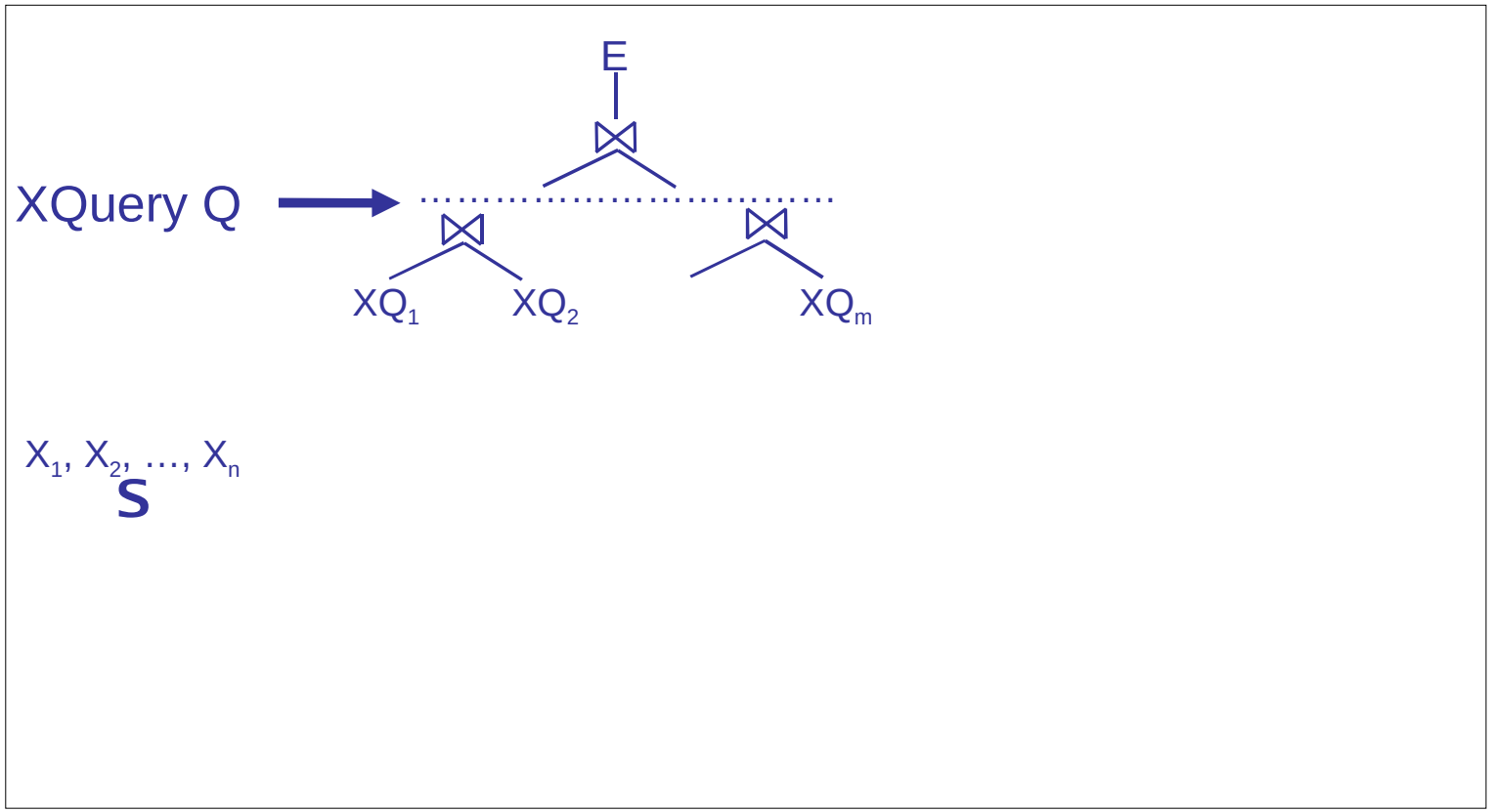

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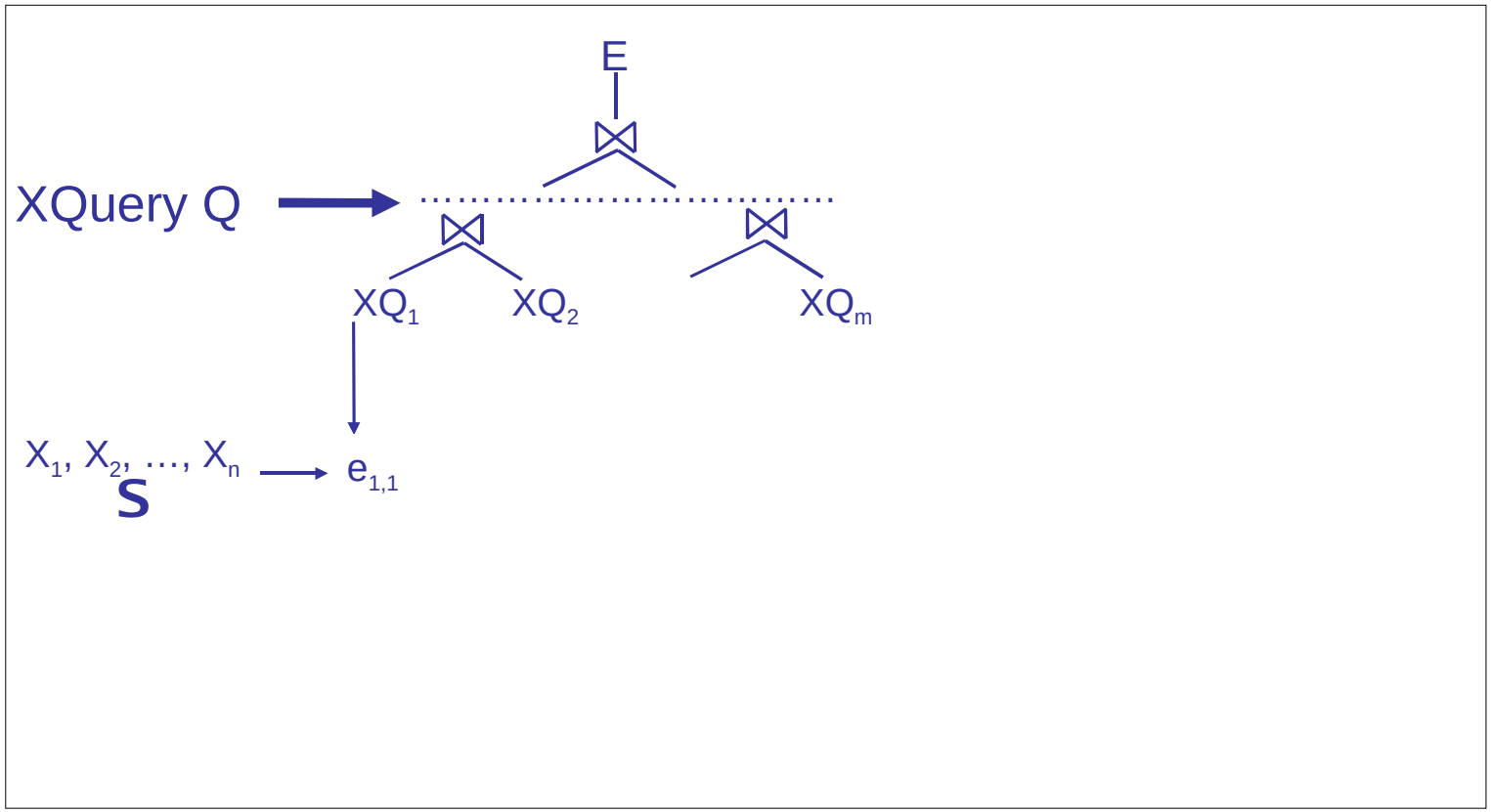

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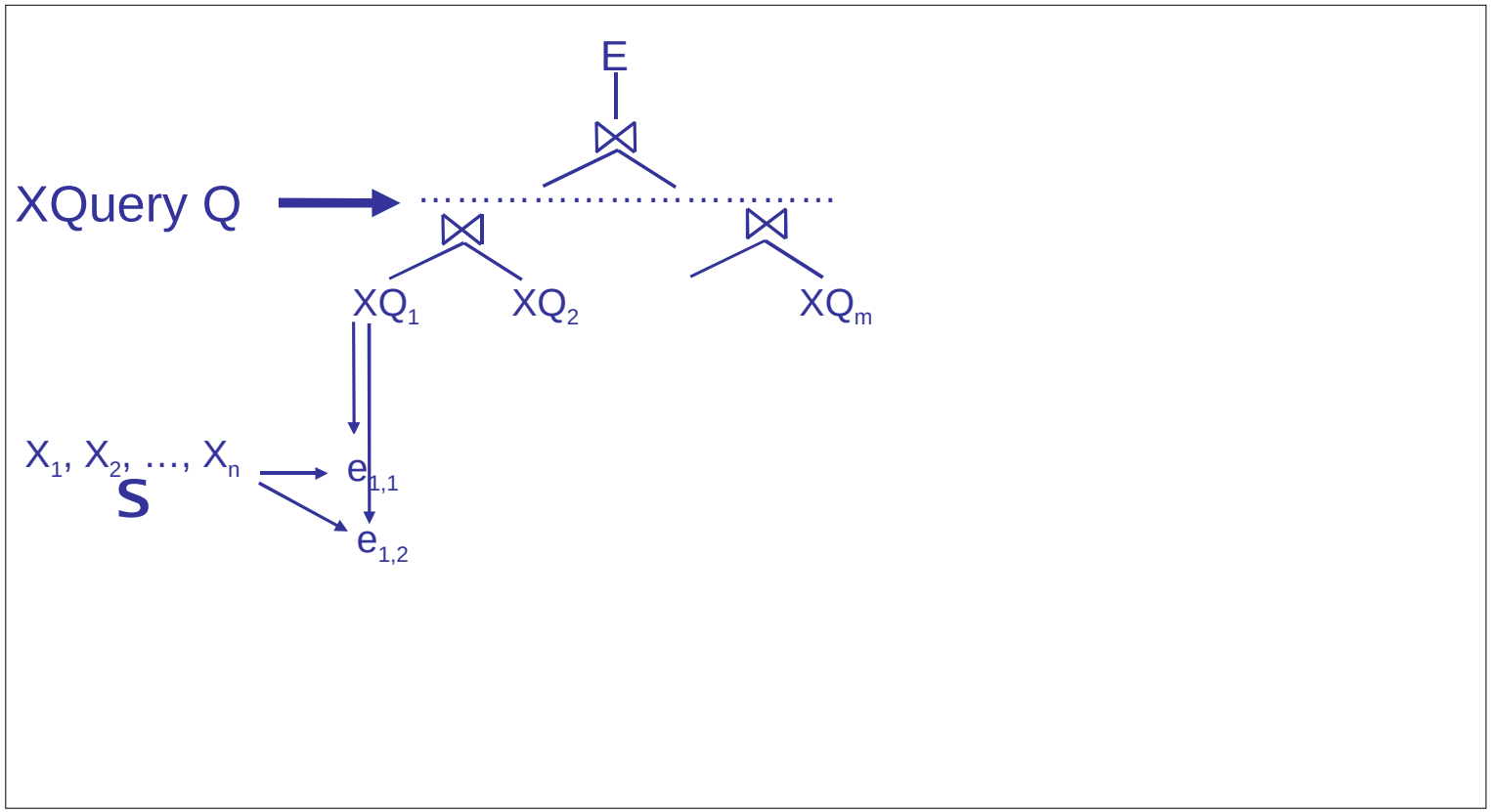

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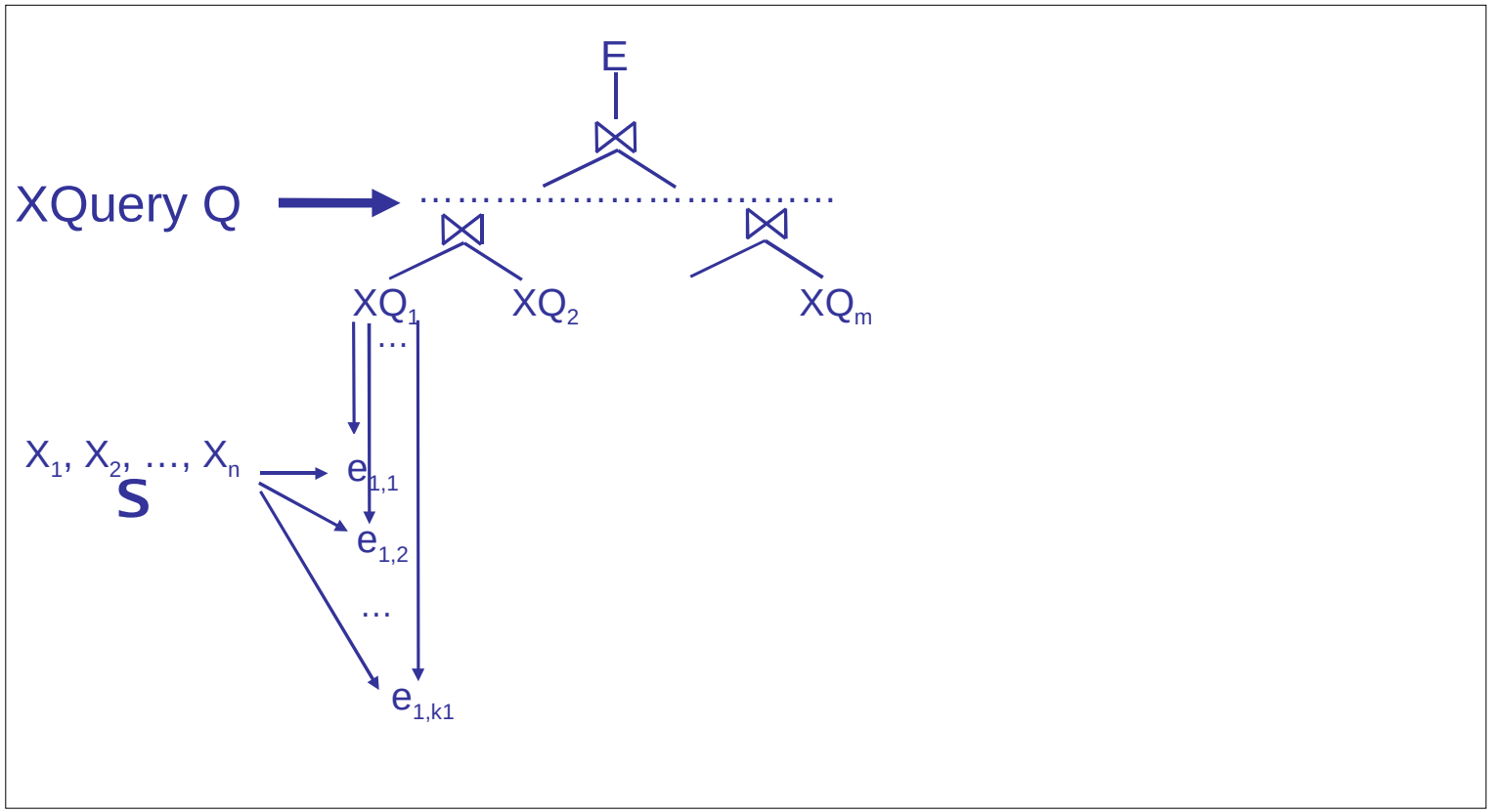

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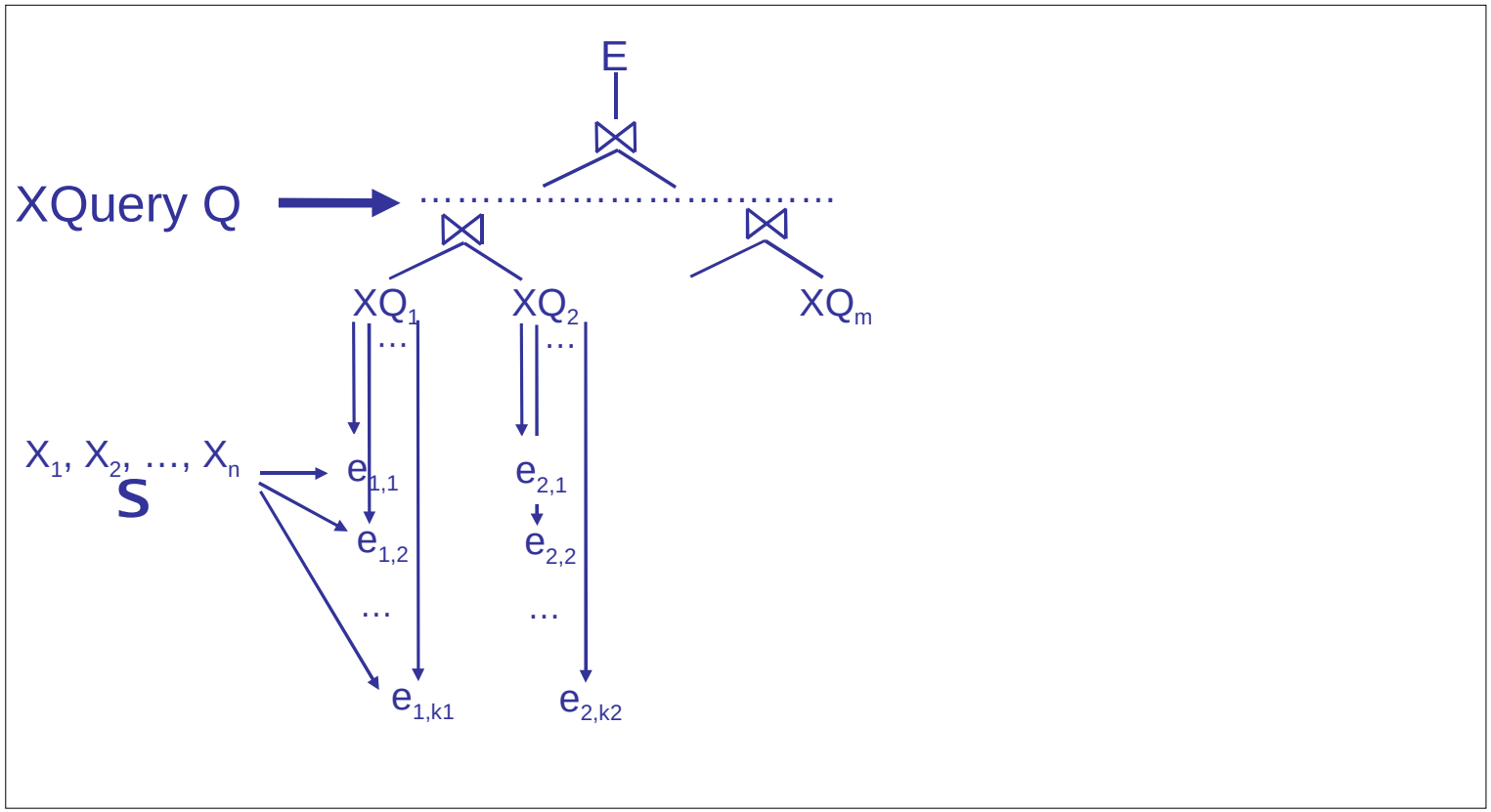

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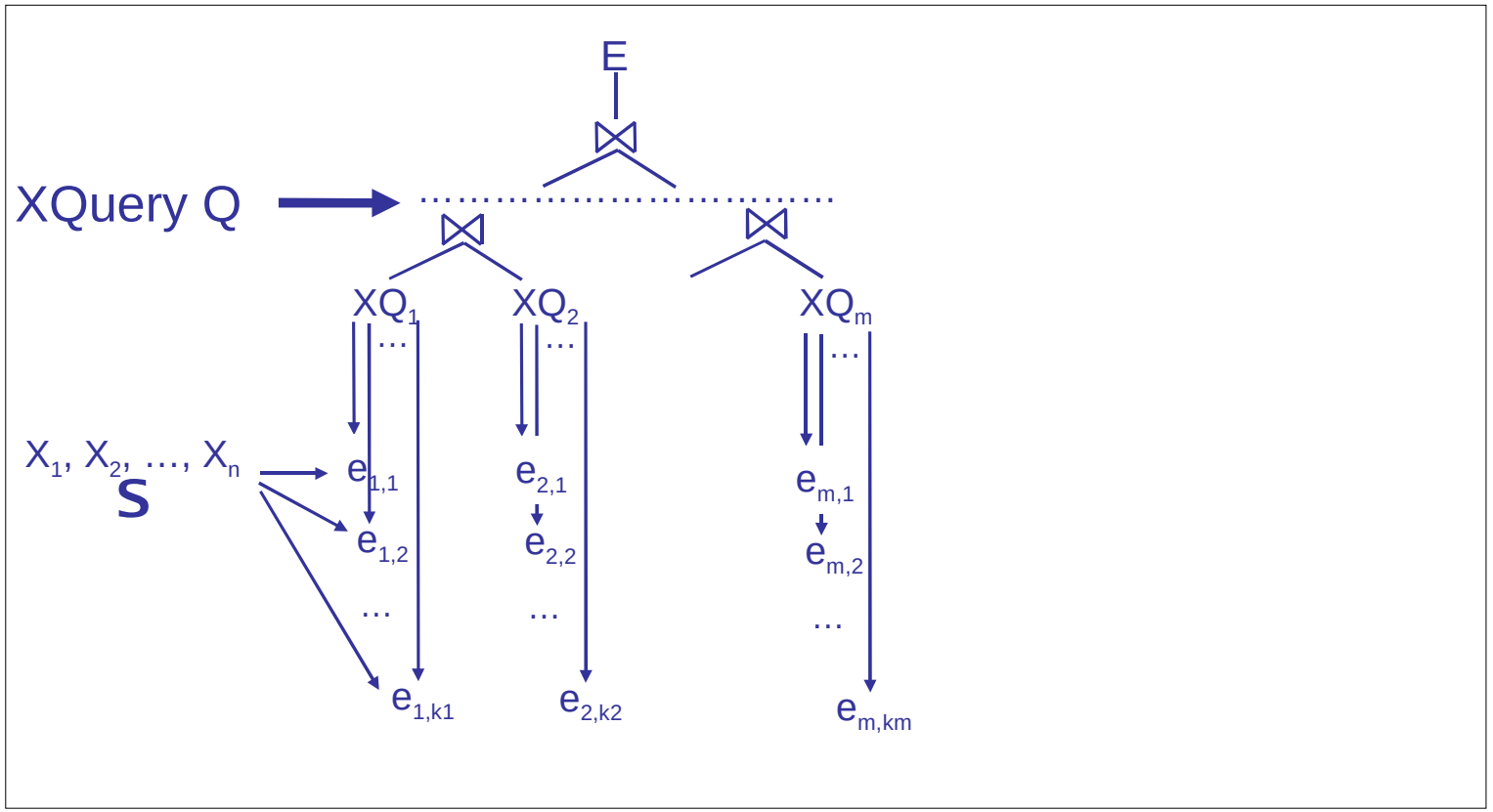

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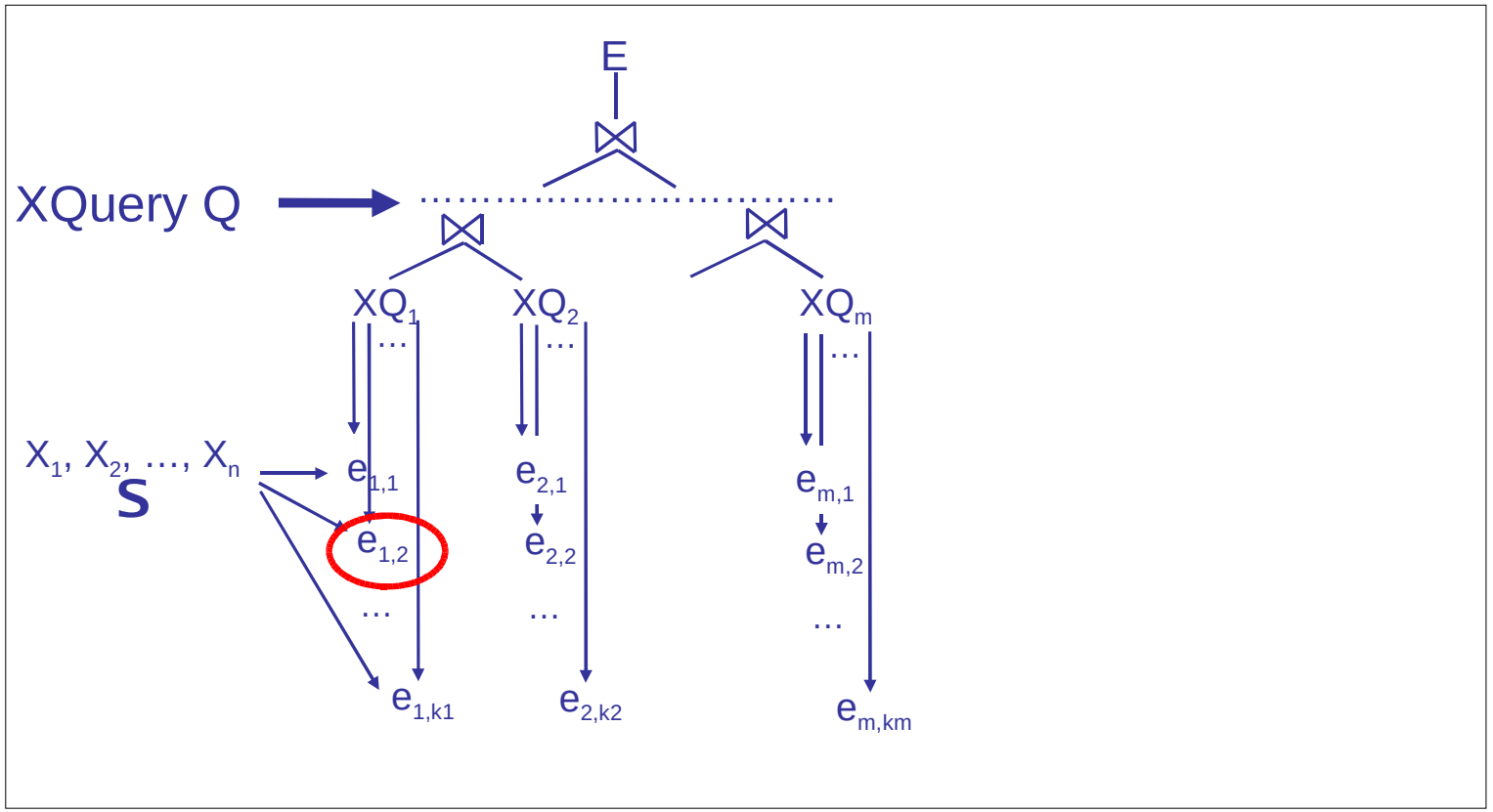

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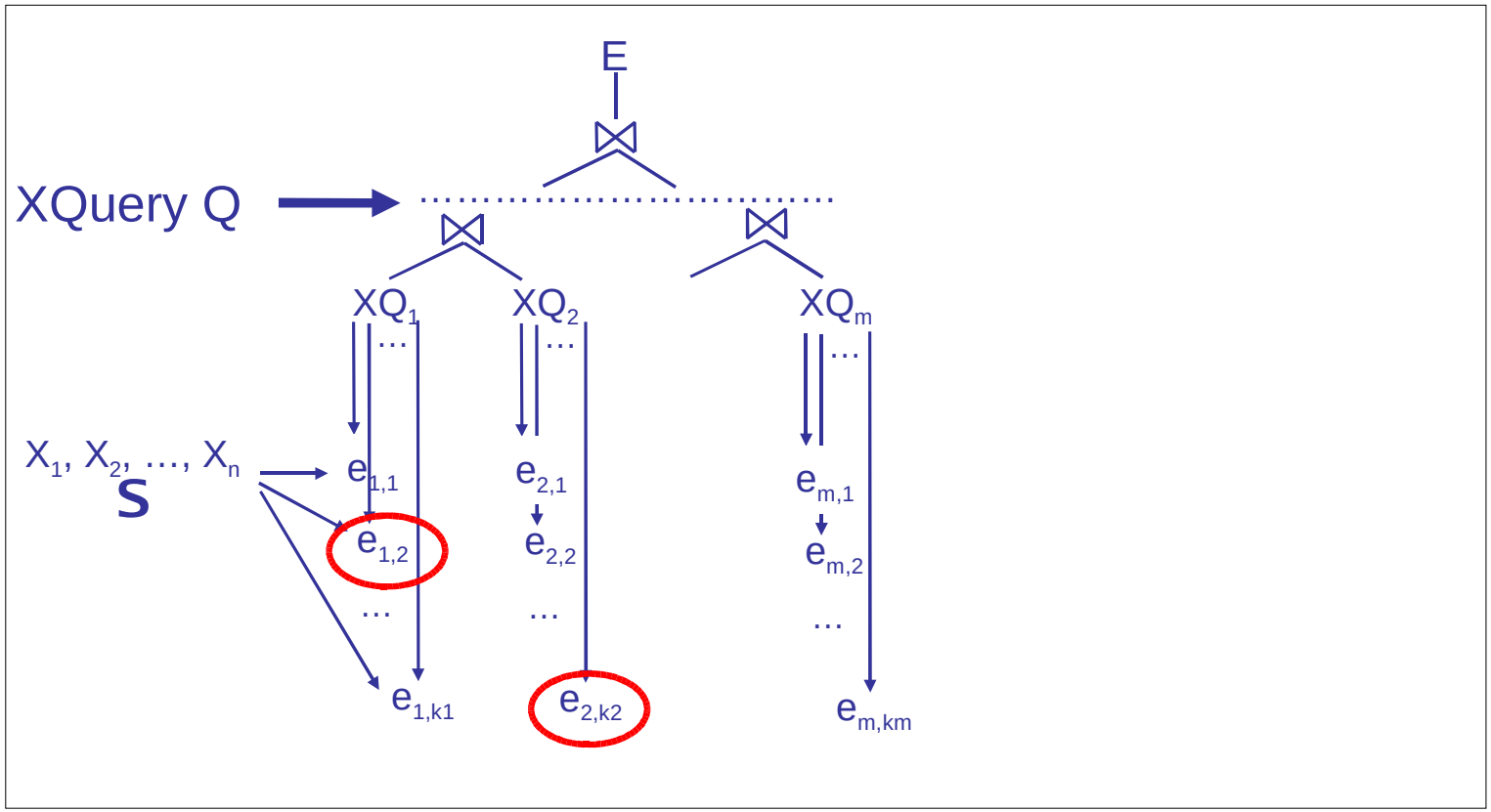

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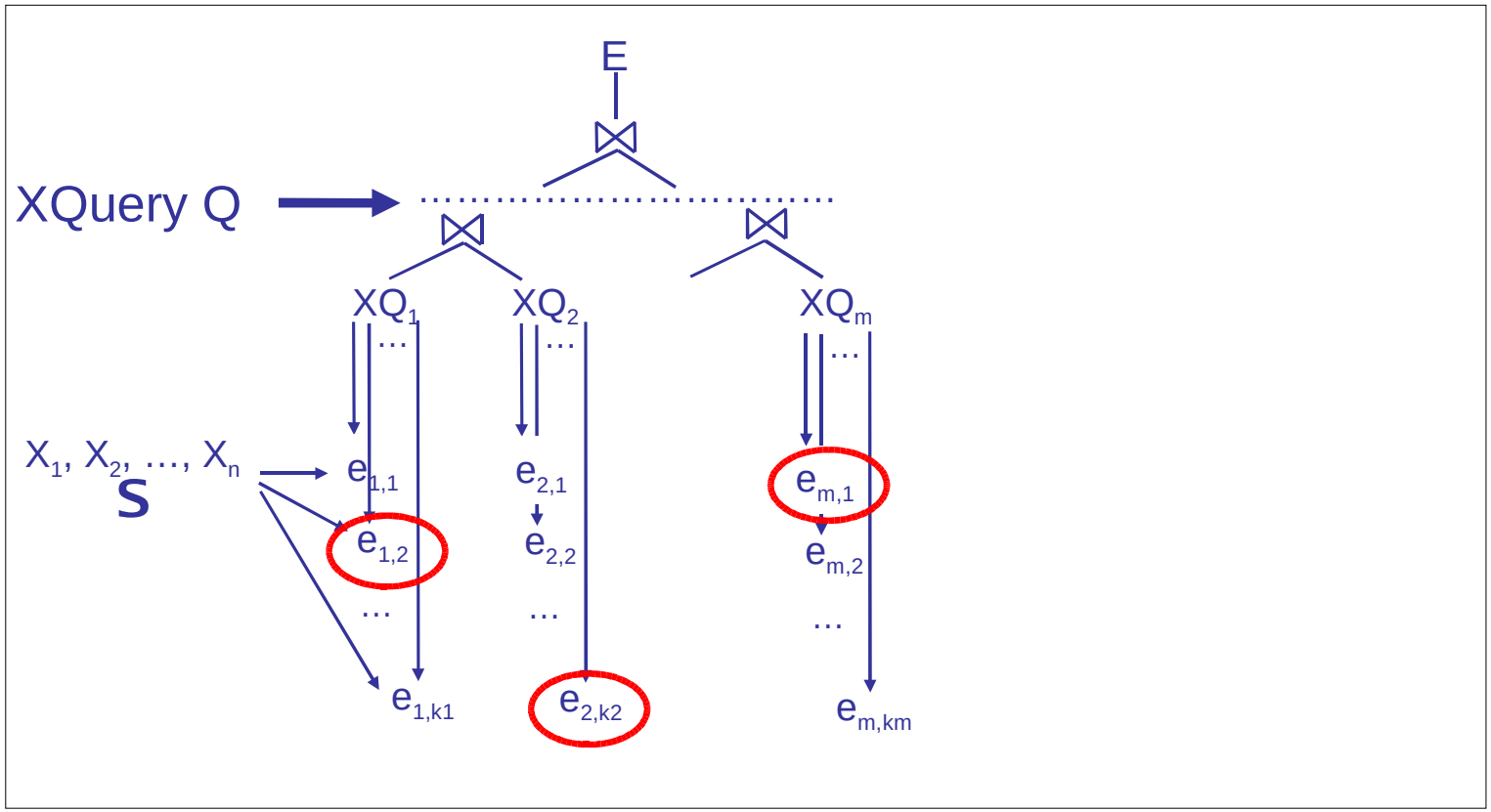

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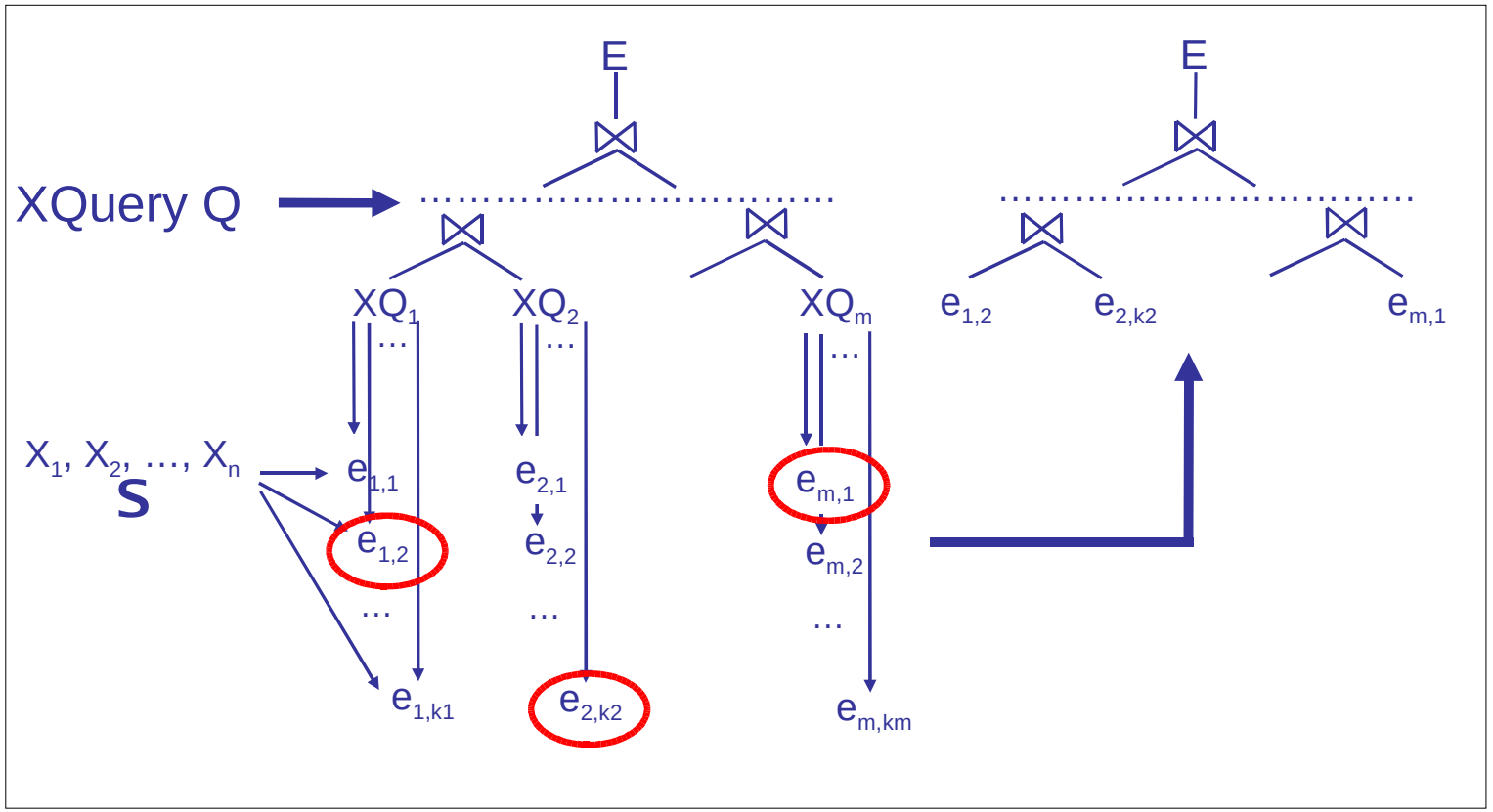

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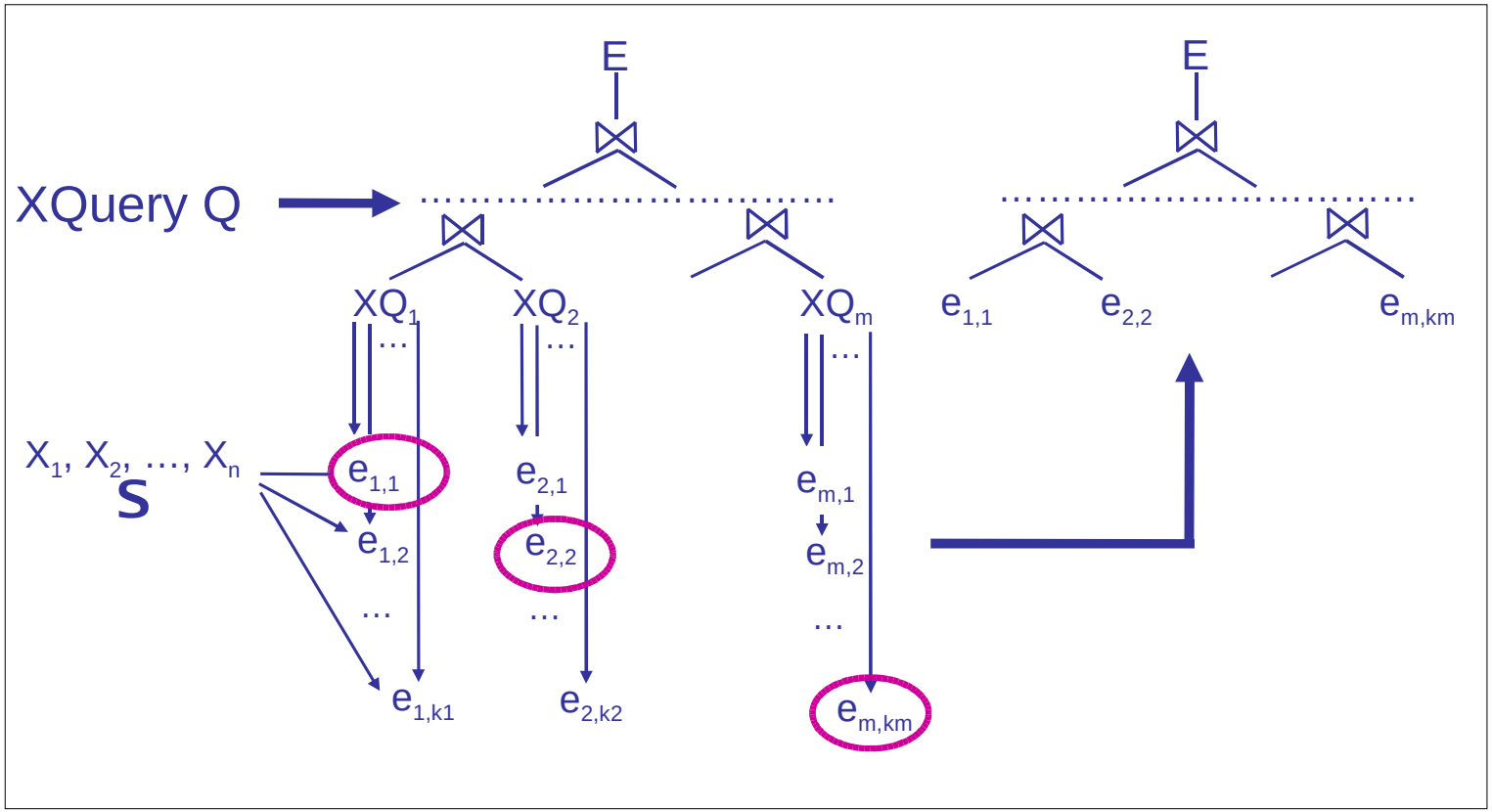


Zoom on XAM rewriting

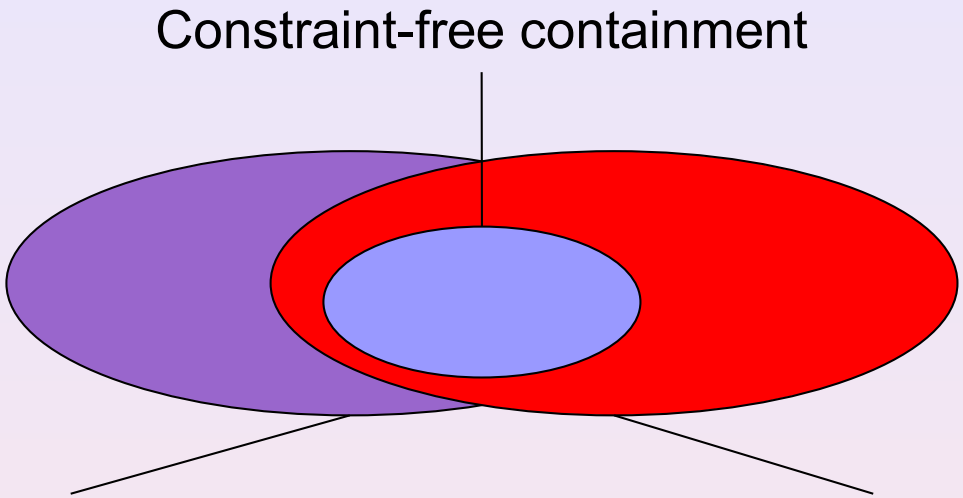
Rewriting one query XAM

- In the presence of a summary bucket algorithms would be incomplete
- Inflationary algorithm:
  - Builds (structural) joins
  - a plan is a full rewriting when its equivalent XAM is $\equiv_S$ to the query XAM.
  - XAM containment algorithm under S constraints
- When to stop: no new plans or plans outgrow a certain size
- Agressive summary-based pruning of plans to keep search space manageable

Full results

- XAM language
  - Value and structure predicates
  - Nesting
  - Optional edges
  - Structural and non-structural IDs
- Enhanced summaries: integrity constraints (required children)

Summary vs. DTD constraints



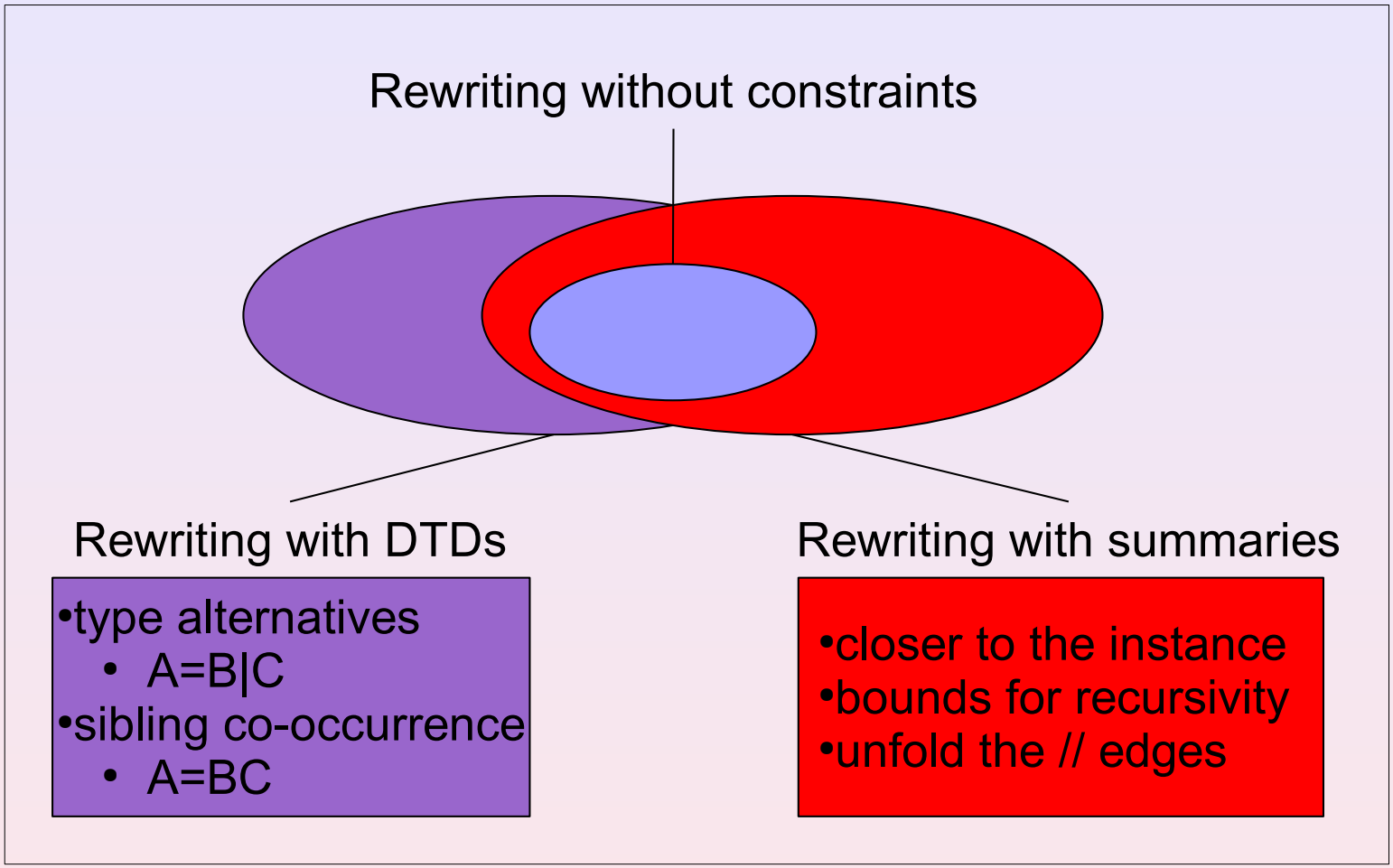
DTD-based containment

- type alternatives
  - A=B|C
- sibling co-occurrence
  - A=BC

Summary based containment

- closer to the instance
- bounds for recursivity
- unfold the // edges

Summary vs. DTD constraints



Example: Is there a rewriting //a=//b/a + //c/a ?

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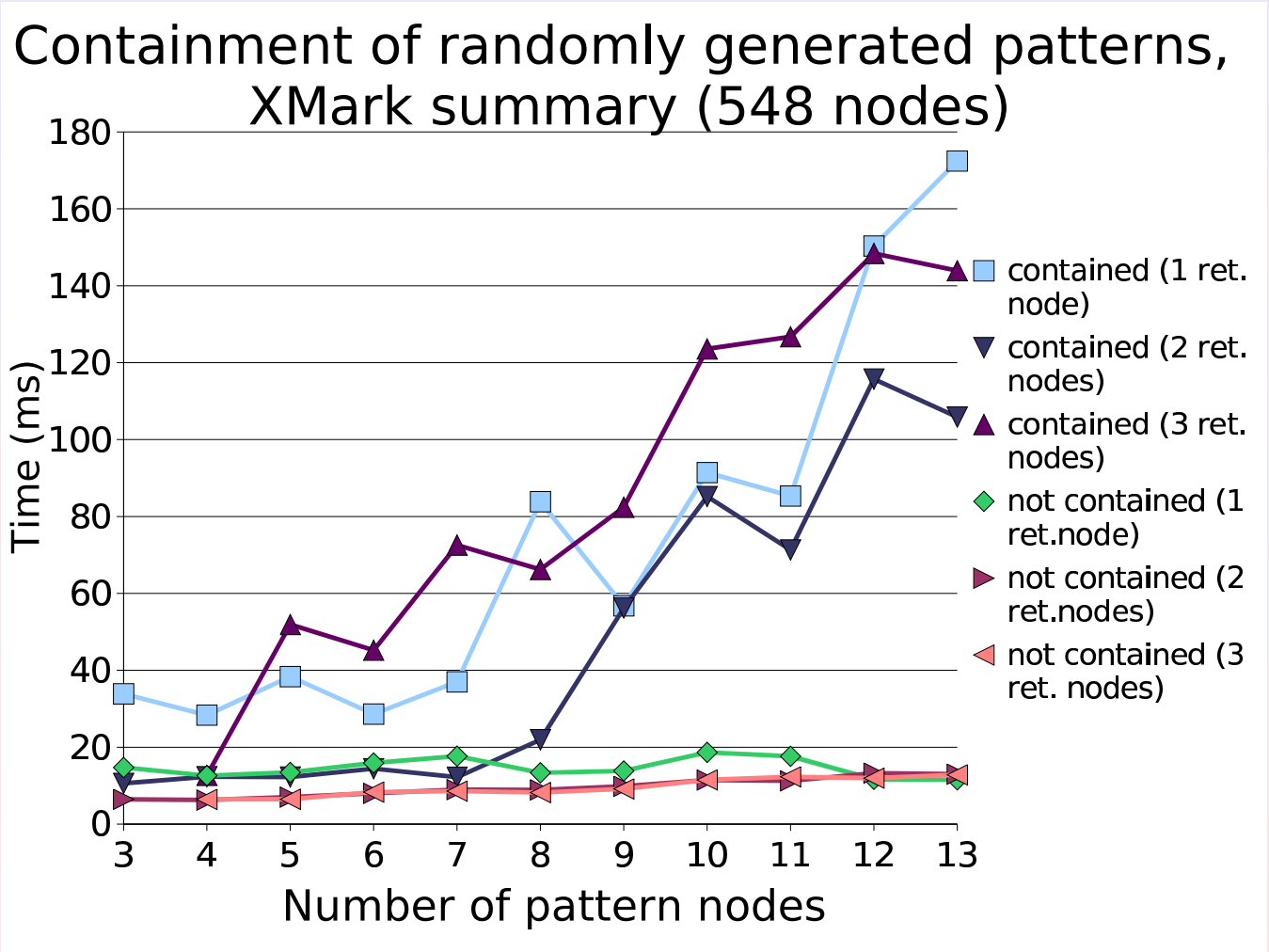
Experimental setting

ULoad prototype, Java 1.5, 1GHz CPU, 1GB RAM

- Documents
  - DBLP 2005 (280MB)
  - XMark (233MB)
- Queries
  - XMark query patterns
  - Randomly generated patterns based on DBLP and XMark path summaries
- Views
  - 1 view per each XMark tag (IDs V)
  - randomly generated patterns based on XMark and DBLP

Pattern containment results



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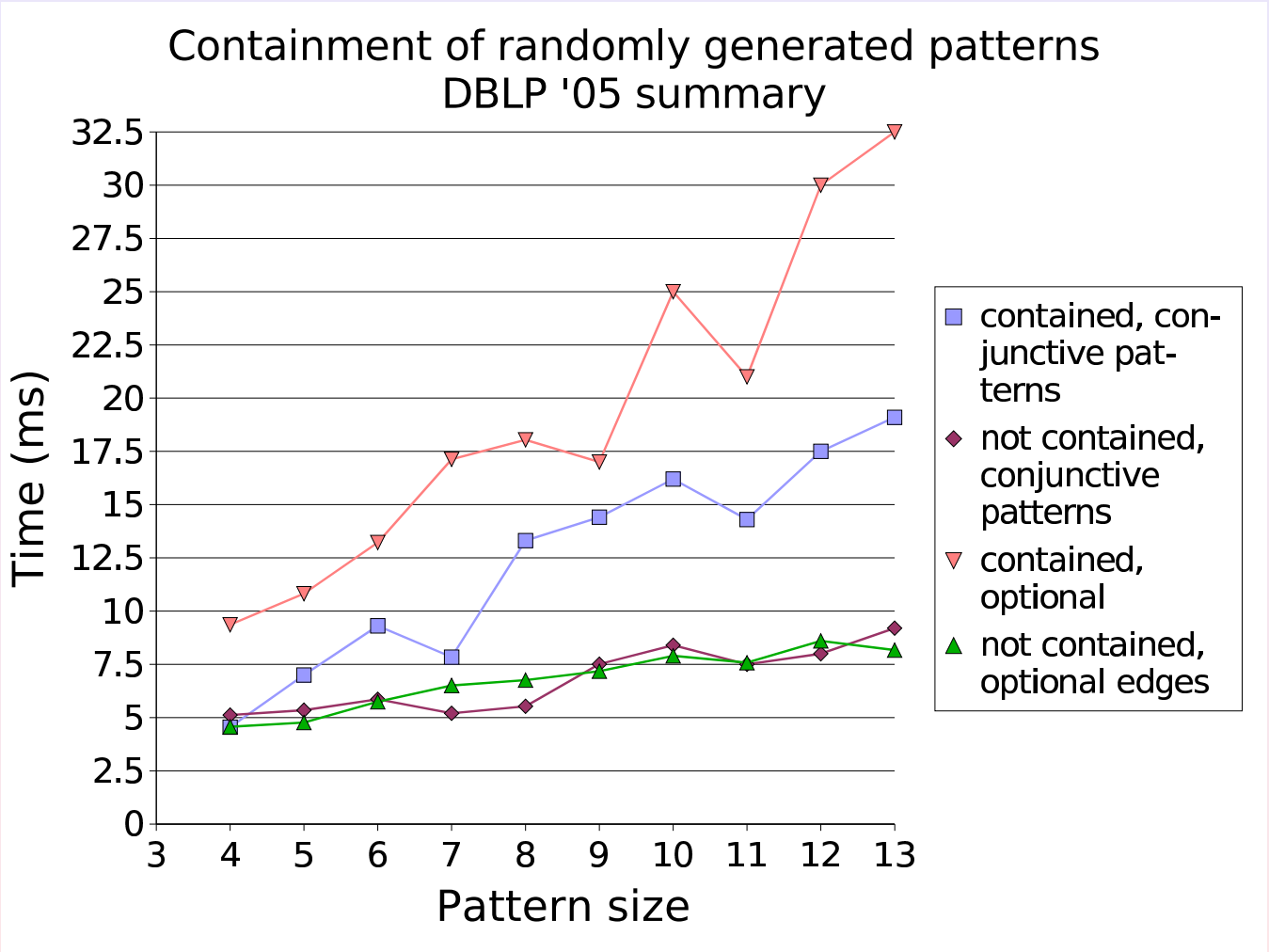
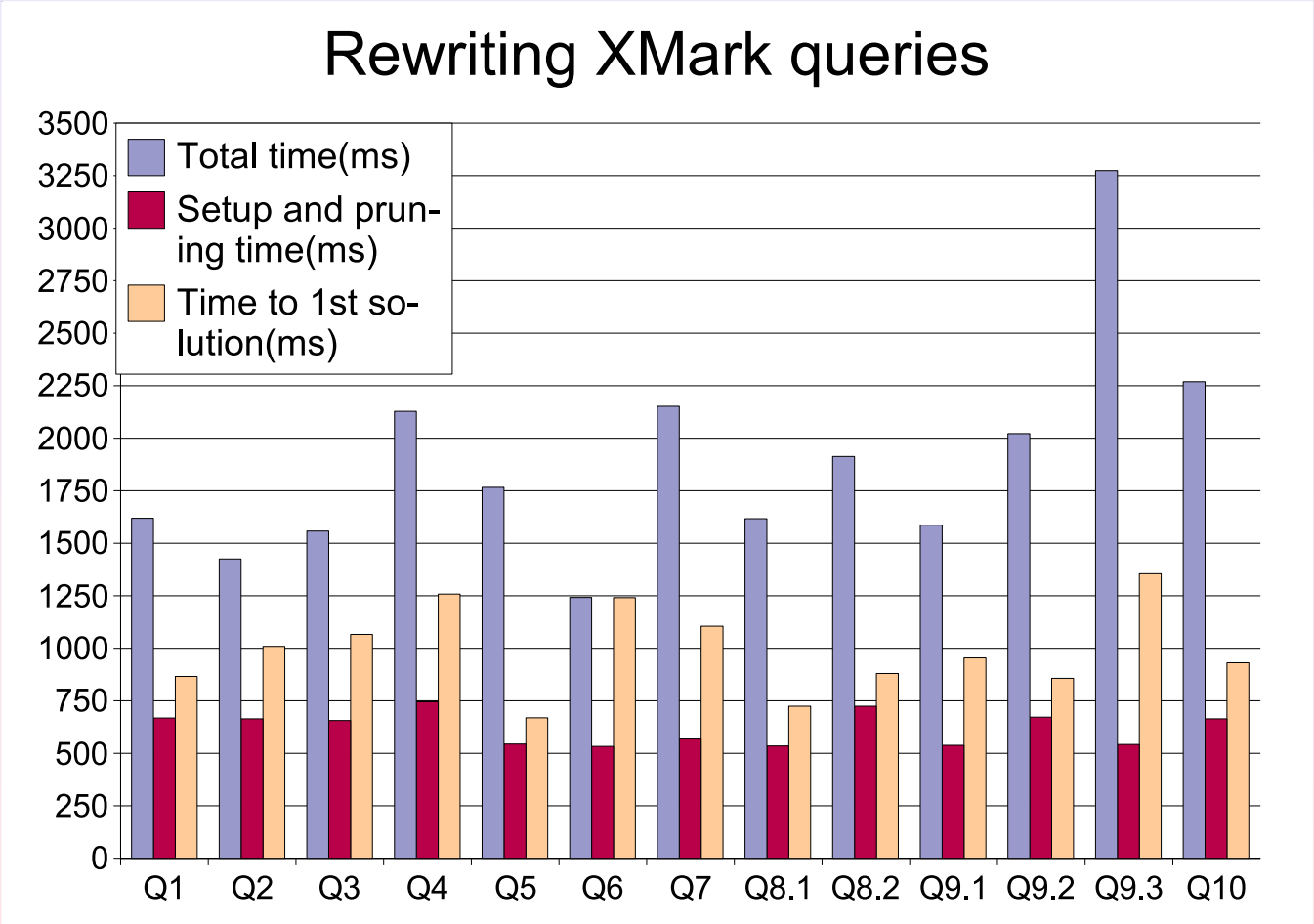


Query rewriting

- 183 views: 100 generated + 83 tag partition



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Conclusions

Contributions

- XML query pattern containment and equivalent rewriting based on summary constraints
- exploiting detailed informations about view contents and IDs expressed by XAMs
- query rewriting using XAMs is feasible

Future work

- Cost-based materialized view selection
- View maintenance in the presence of updates

Questions?

More information

- ULoad, XAM home: http://gemo.futurs.inria.fr/projects/XAM/
- A.Arion, V.Benzaken, I.Manolescu: ”XML Access Modules: Towards Physical Independence in XML Databases”, [XIMEP2005]
- A.Arion, V.Benzaken, I.Manolescu, R.Vijay: ”ULoad: Finding the Best Storage for your XML Management Application”, [VLDBDemo2005]
- A.Arion, V.Benzaken, I.Manolescu, Y.Papakonstantinou and R.Vijay: ”Algebra-Based Tree Pattern Extraction from XQuery”, [FQAS2006]
- I.Manolescu, V.Benzaken, A.Arion and Y.Papakonstantinou: ”Structured Materialized views for XML Queries”, INRIA report, http://hal.inria.fr, 2006