Type Based XML Projection

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Outline

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```
<bib>
 <book year="1994">
  <title>TCP/IP Illustrated</title>
  <author><last>Stevens</last><first>W.</first></author>
  <publisher>Addison-Wesley</publisher>
  <price>65.95</price>
 </book>
 <book year="1992">
  <title>Advanced Programming in the Unix environment</title>
  <author><last>Stevens</last><first>W.</first></author>
  <publisher>Addison-Wesley</publisher>
  <price>65.95</price>
 </book>
 ...
</bib>
```

Projecting XML Documents, Amélie Marian and Jérome Siméon, VLDB 2003.

Queries + document based optimizations, it has some drawbacks :

- Does not take into account backward axis.
- Performances degrade in the presence of `//`

Indeed, with a query like :

```
/descendant-or-self::title/child::text()
```

one has to iterate through the whole document.

Solution : Queries + **type** based optimisations

By using a DTD and a given set of queries, we can statically infer a *projector* for the set of queries and use it to prune the document.
Main advantages :

- Pruning is efficient
- Take into account // and backward axis
- Pruning is sound : executing the query on the projected document gives the same result as on the original.
- Pruning is precise and even exact for a large class of documents

Outline

Definition (DTD)

A DTD is a pair (X, E) where X is a distinguished name (the root) and E is a set of productions of the form

$$\{X_1 \to R_1,\ \ldots, X_n \to R_n\}$$

where each R_i is of the form :

$$a_i[\textit{Regexp}] \text{ or String}$$

where a_i is a unique `tag` name and Regexp a regular expression of X_i. Names(E) is the set of names occuring in E.

Definition (Projector)

For a given DTD (X, E) a type projector for (X, E) is a set of names $\mathcal{P}$ such that :

1. $\mathcal{P} \subseteq$ *Names(E)*
2. $\forall X_i \in \mathcal{P}$ *there is at least one derivation from* X *to* X_i *in* E

Definition (Pruning)

The pruning (or projection) of a document D valid w.r.t a DTD (X, E) with the projector $\mathcal{P}$ is a document D' where every node not generated by a name in $\mathcal{P}$ is erased (replaced by the empty sequence).

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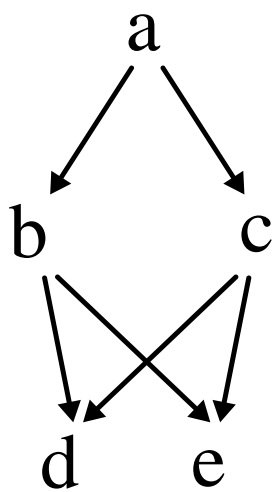
```
<!ELEMENT a   (b,c)>
<!ELEMENT b   (d,e)>
<!ELEMENT c   (d,e)>
<!ELEMENT d   (#PCDATA)>
<!ELEMENT e   (#PCDATA)>
```



/descendant-or-self::c

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$$X_a \to \mathtt{a}[X_b, X_c]$$
$$X_b \to \mathtt{b}[X_d, X_e] \quad X_c \to \mathtt{c}[X_d, X_e]$$
$$X_d \to \mathtt{String} \quad X_e \to \mathtt{String}$$

```
<a>
 <b>
  <d>LotsOfData</d>
  <e>SuperLongString<e/>
 </b>
 <c>
  <d>bar</d>
  <e>foo<e/>
 </c>
</a>
```

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 </c>
</a>
```

Definition (XPath (1.0))

$$
\begin{array}{lcl}
Q & ::= & \mathit{Axis} :: \mathit{Test} \\
 & | & \mathit{Axis} :: \mathit{Test}[\mathit{Expr}] \\
 & | & Q/Q
\end{array}
\qquad
\begin{array}{lcl}
\mathit{Expr} & := & Q \\
 & | & \mathit{Expr}\ op\ \mathit{Expr} \\
 & | & f(\mathit{Expr}, \ldots, \mathit{Expr}) \\
 & | & Base
\end{array}
$$

$$
\begin{array}{lcl}
\mathit{Axis} & ::= & \texttt{self} \mid \texttt{child} \mid \texttt{descendant} \mid \texttt{parent} \mid \texttt{ancestor} \mid \ldots \\
\mathit{Test} & ::= & tag \mid \texttt{node()} \mid \texttt{text()}
\end{array}
$$

Definition (Simple path)

$$
\begin{array}{lcl}
Q & ::= & \mathit{Axis} :: \mathit{Test} \\
 & | & \mathit{Axis} :: \mathit{Test}[\mathit{Cond}] \\
 & | & Q/Q
\end{array}
\qquad
\begin{array}{lcl}
\mathit{Cond} & := & \mathit{SPath} \\
 & | & \mathit{Cond}\ \texttt{or}\ \mathit{Cond}
\end{array}
$$

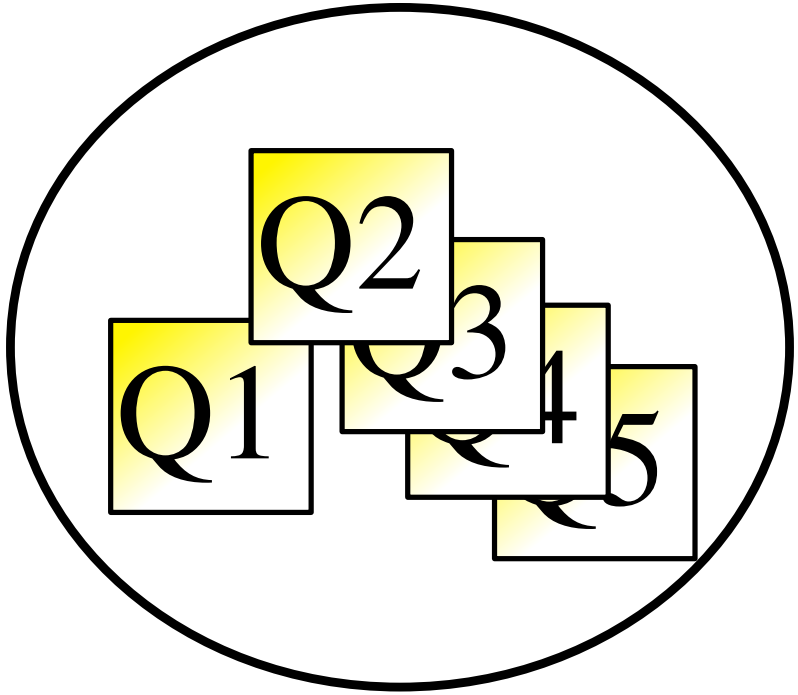
$$
\begin{array}{lcl}
\mathit{SPath} & ::= & \mathit{Axis} :: \mathit{Test} \\
 & | & \mathit{Axis} :: \mathit{Test}/\mathit{SPath}
\end{array}
$$

Outline

Static inference :

Overall process

Static inference :



Overall process

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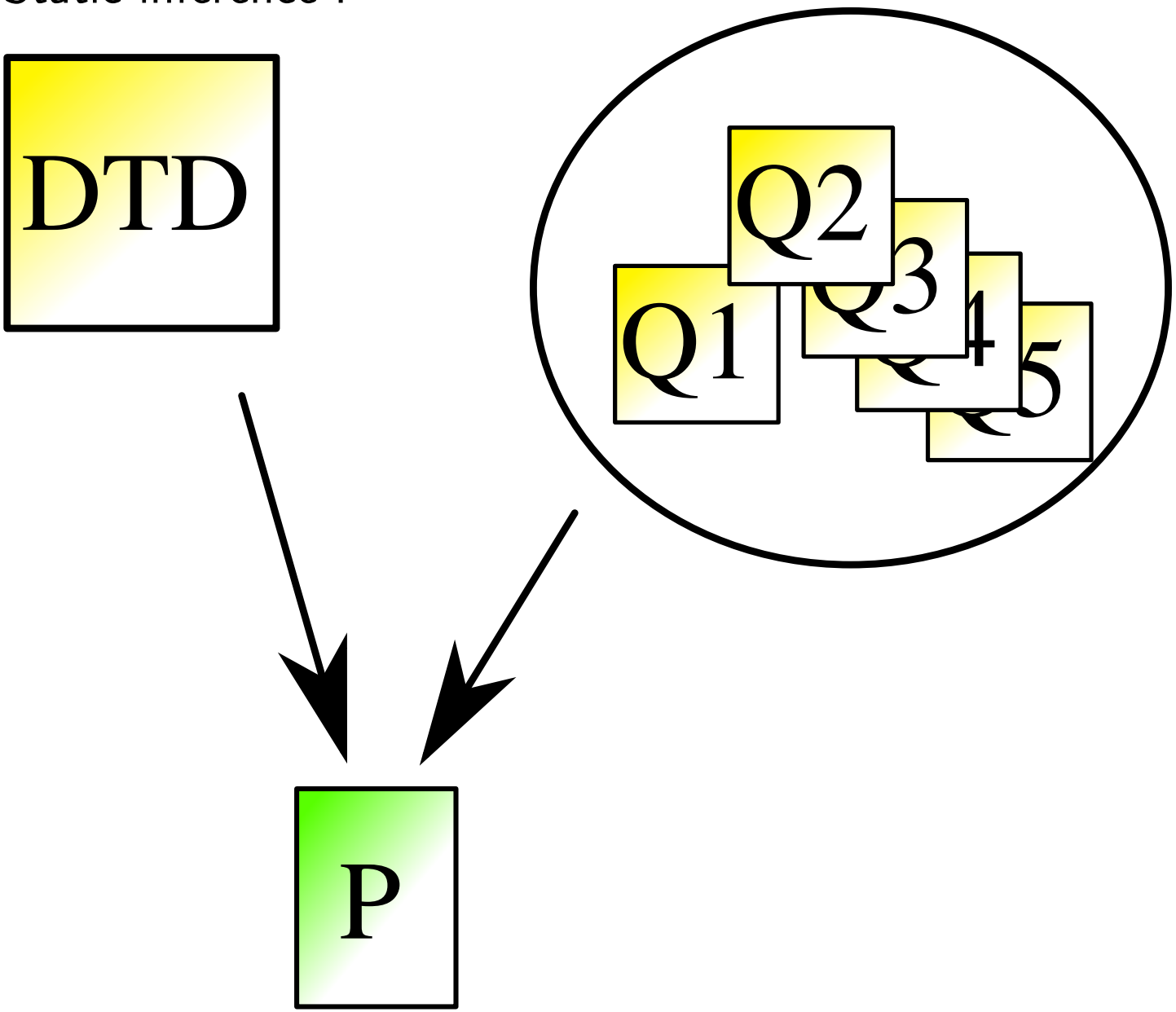
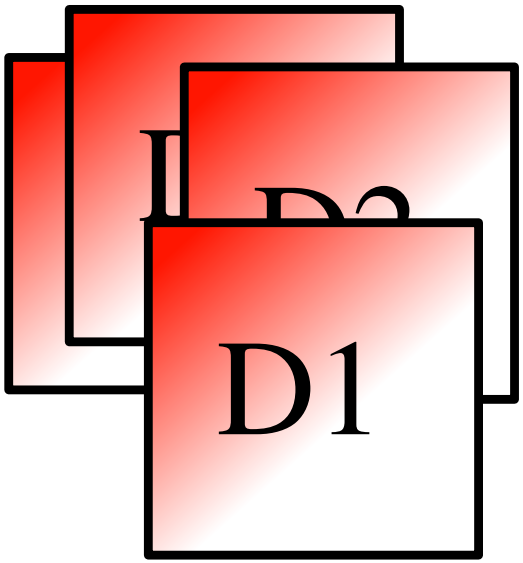


Overall process

Runtime :



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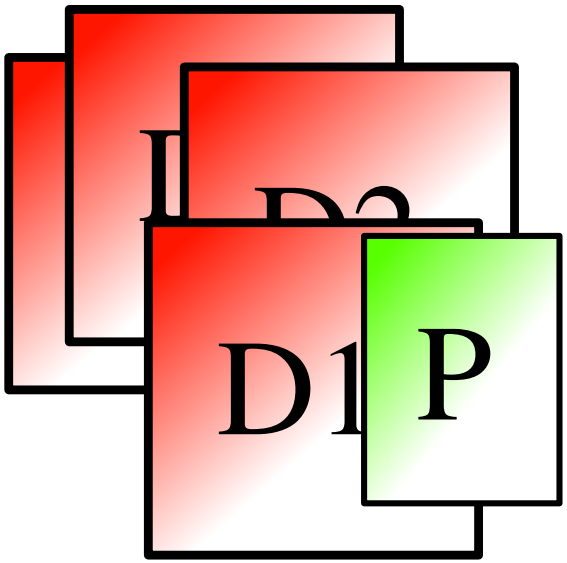

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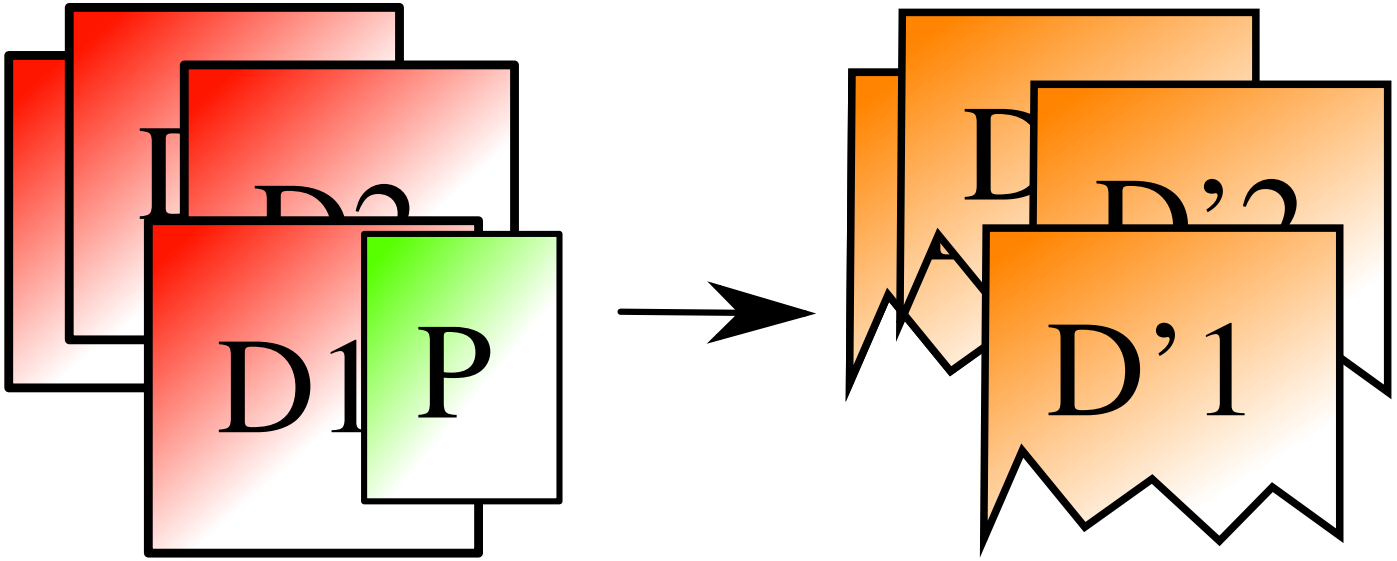

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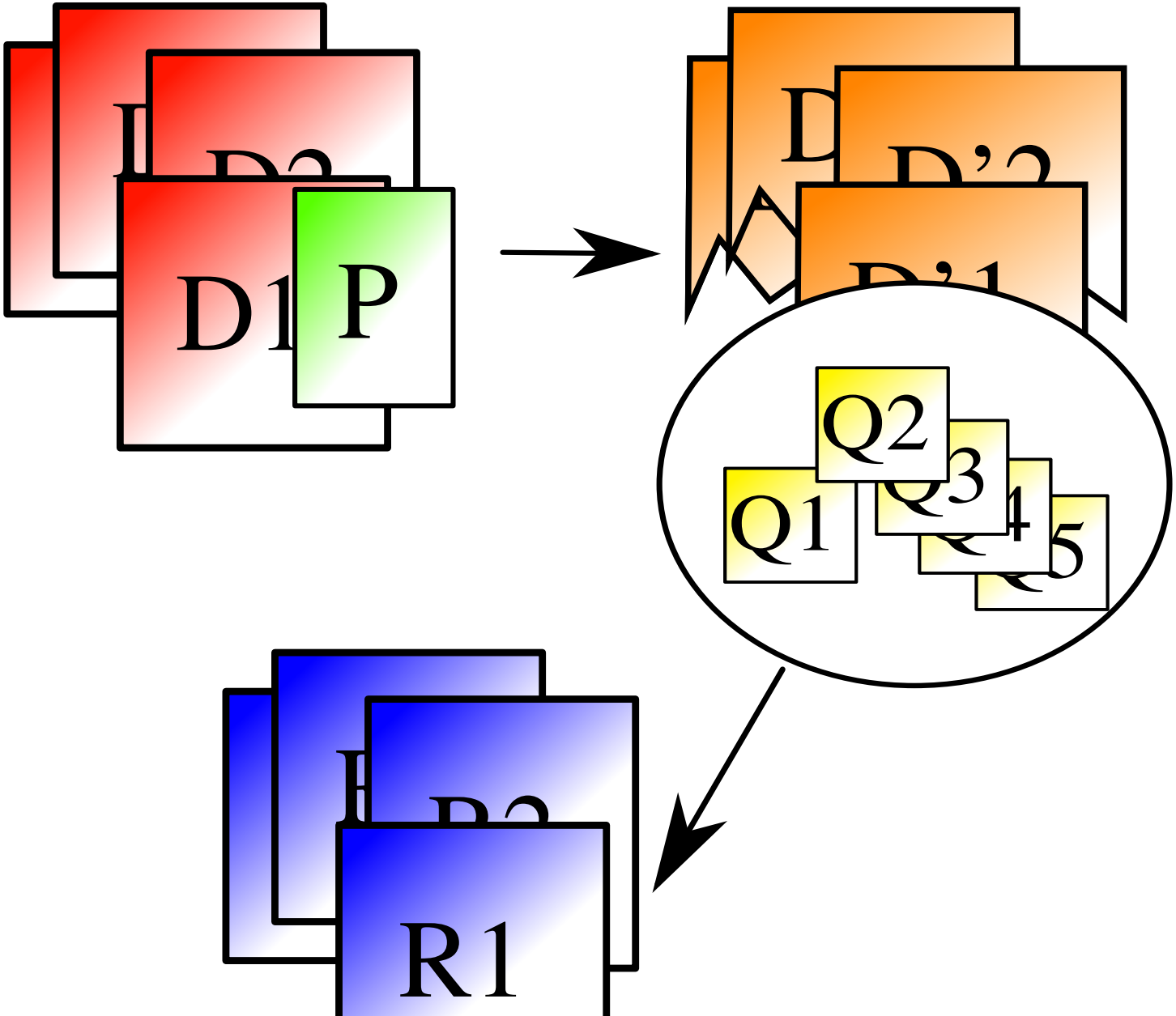
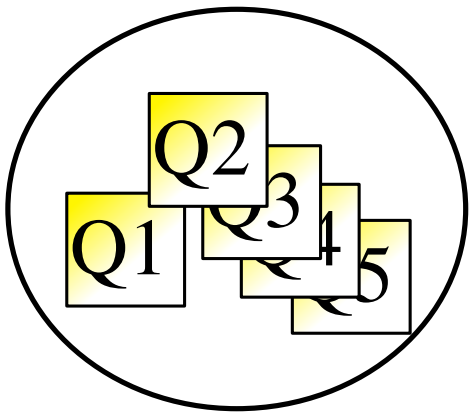
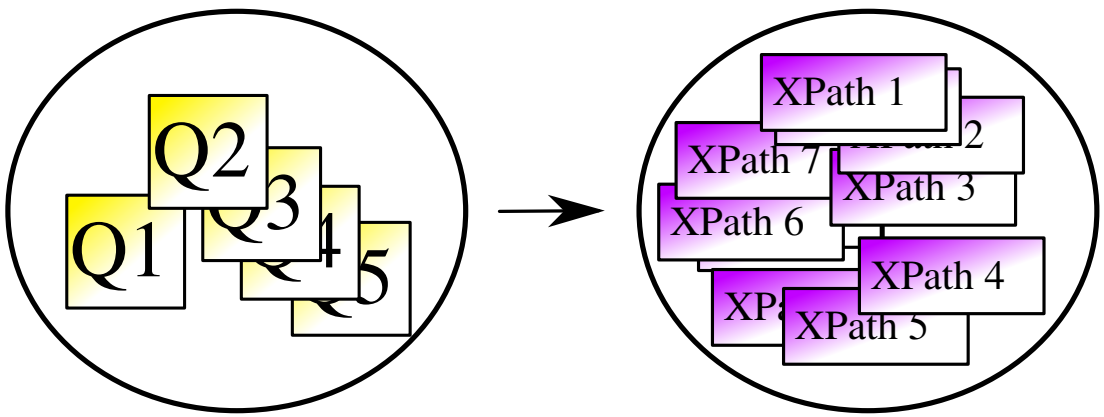



Q2
Q1

Static inference



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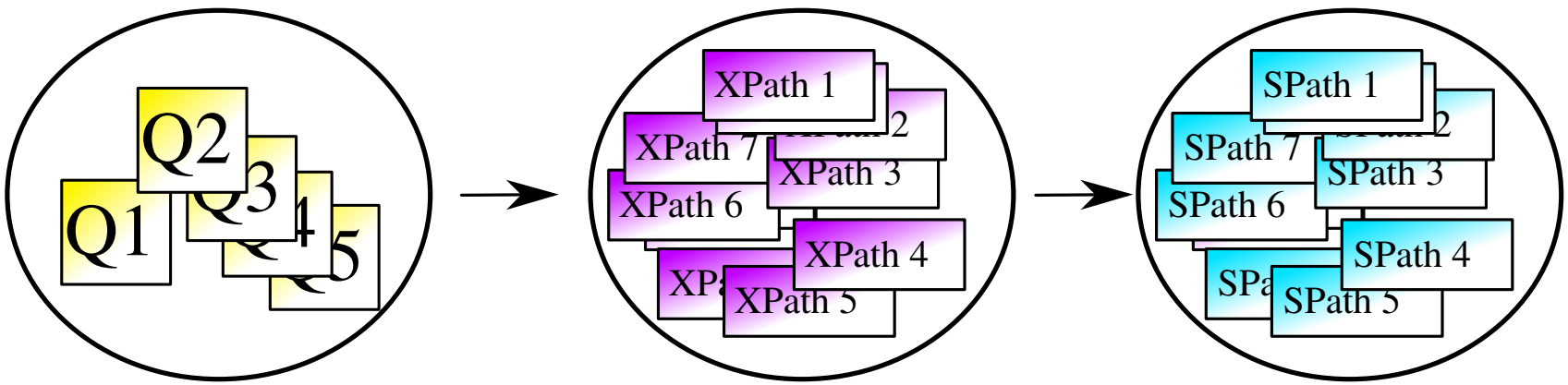

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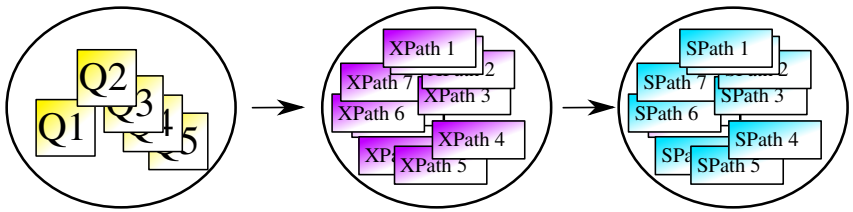
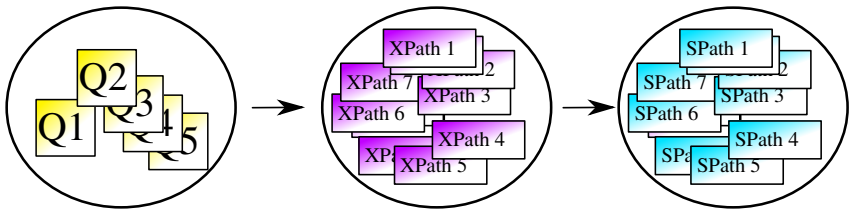


SPath 1

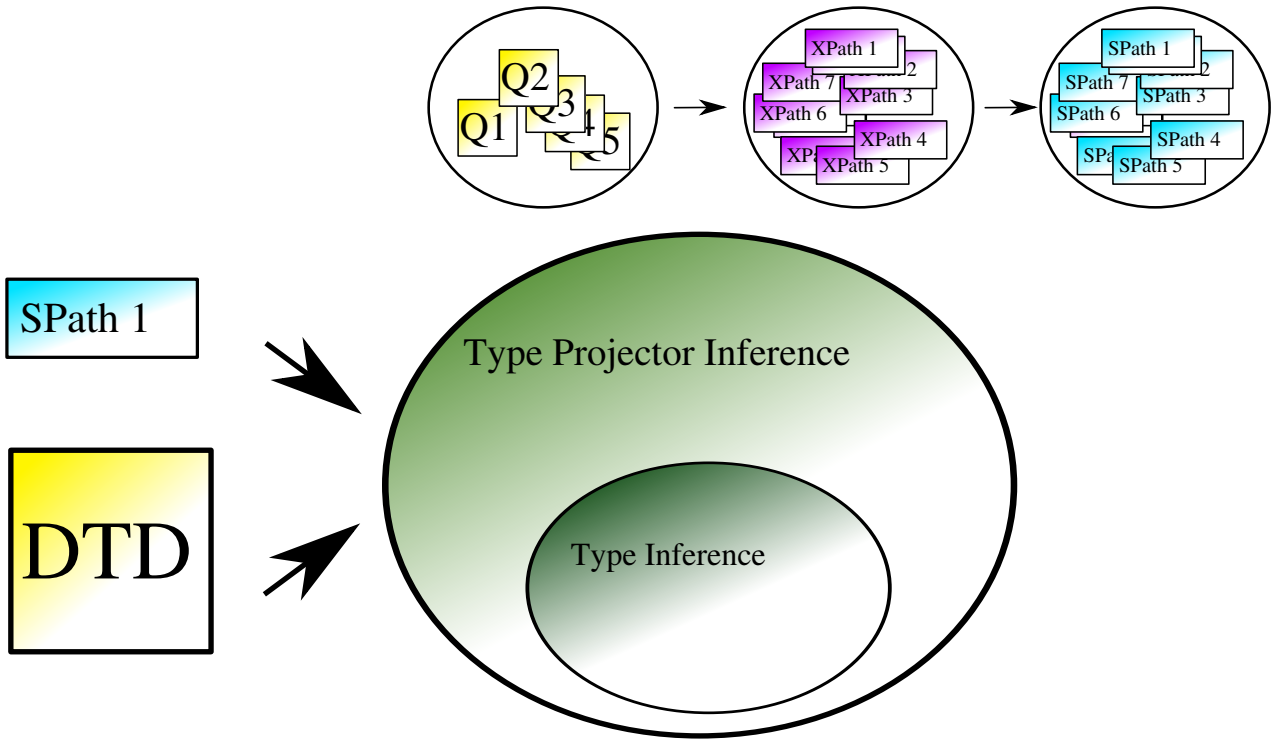
Static inference



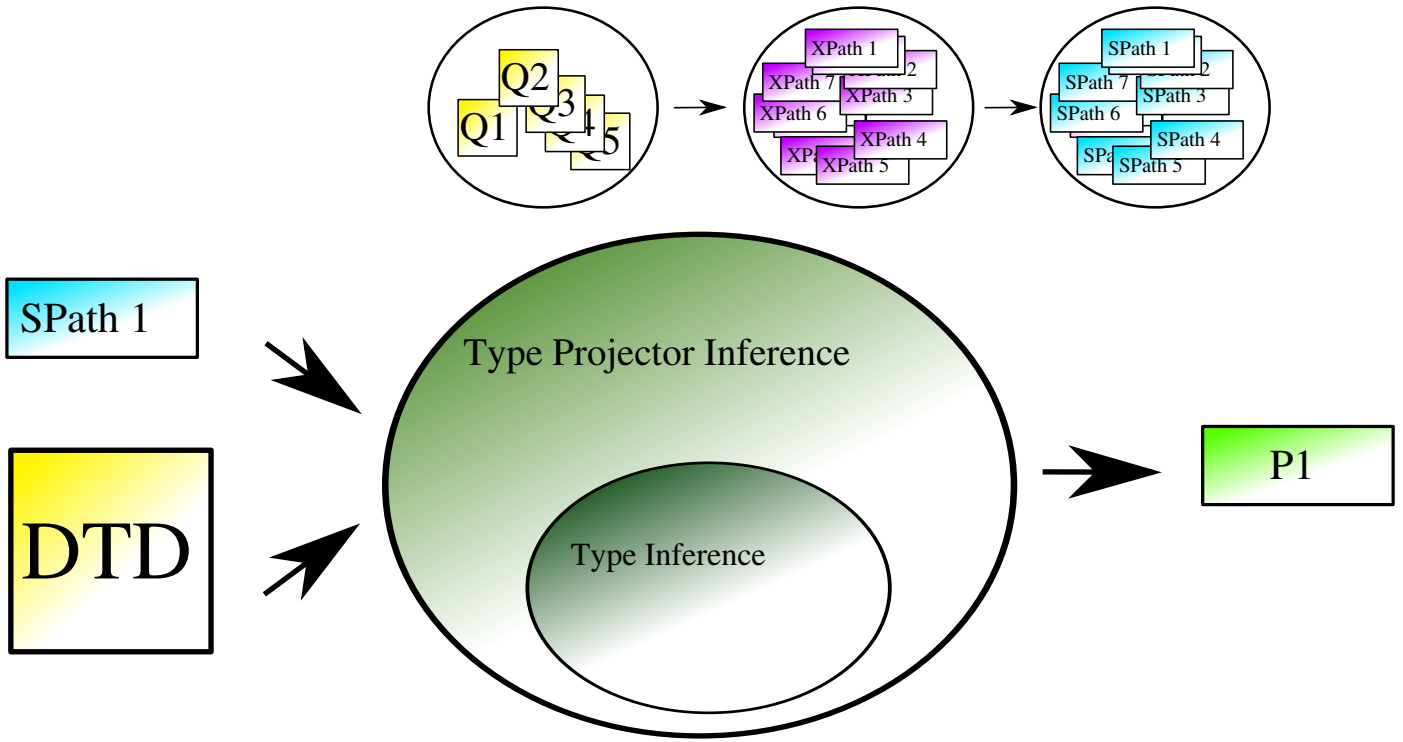
SPath 1

DTD

Static inference



Static inference



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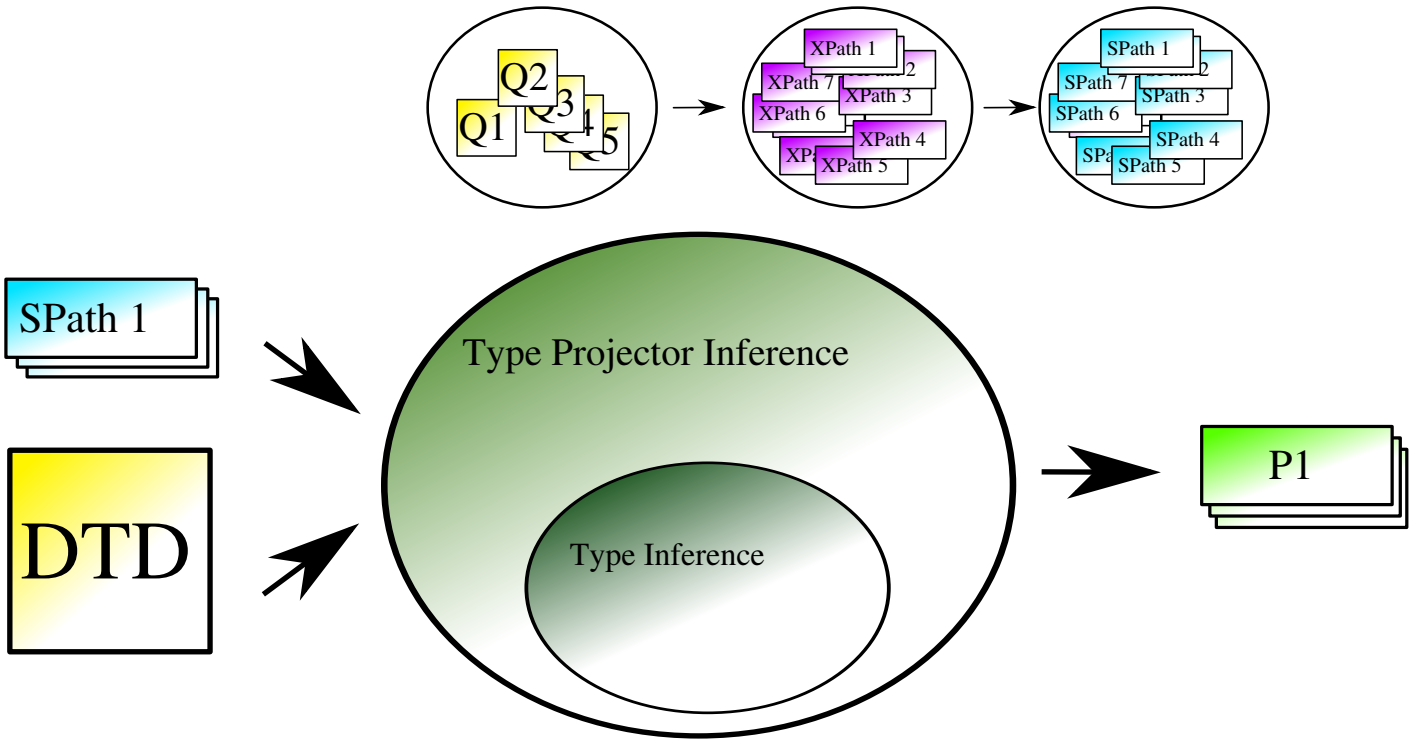
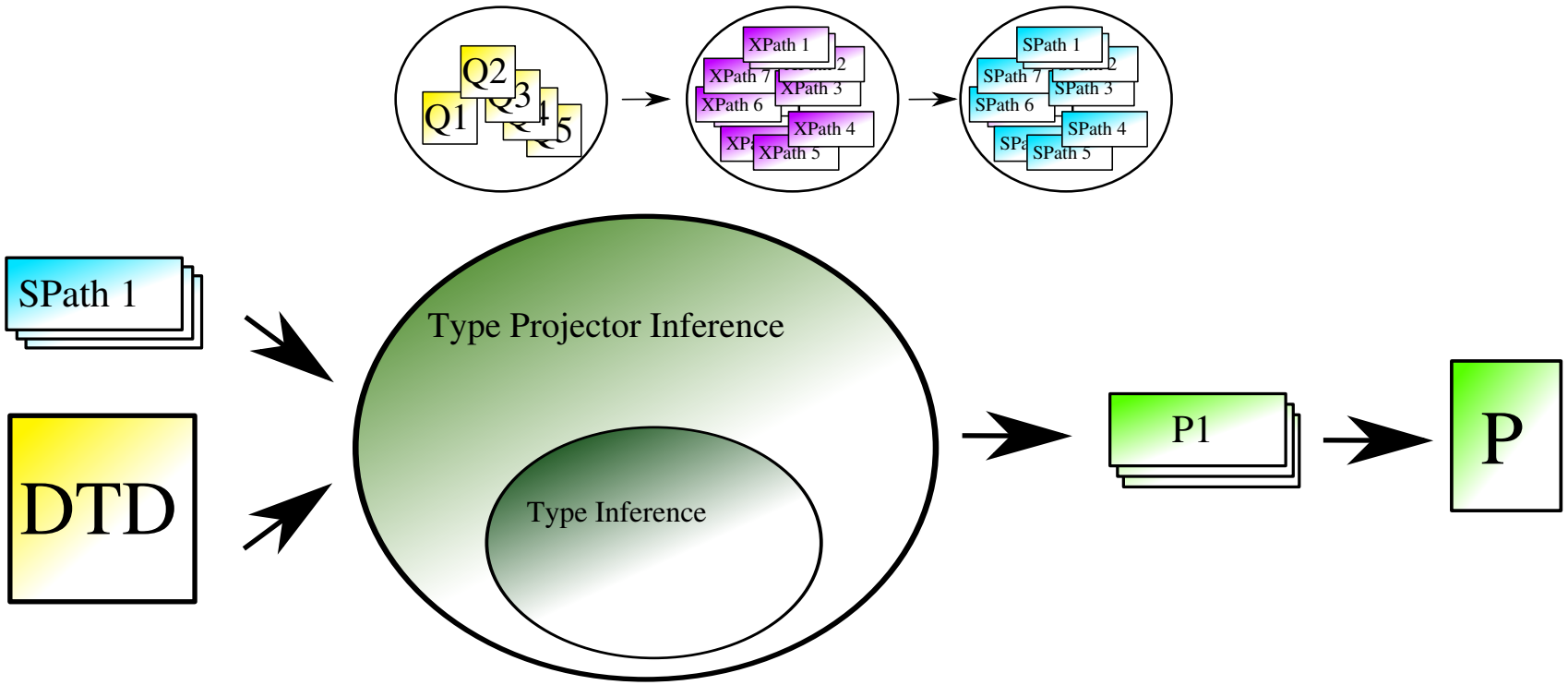


Static inference



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Type T is the set of names of types of nodes in the result.

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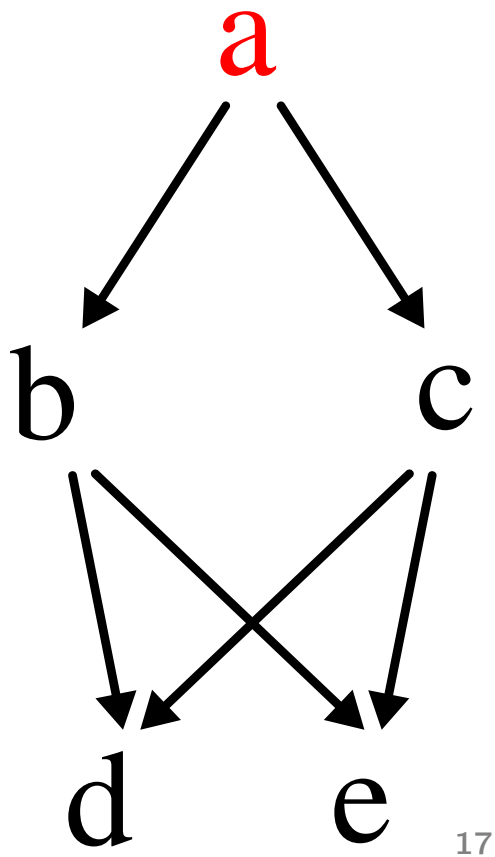

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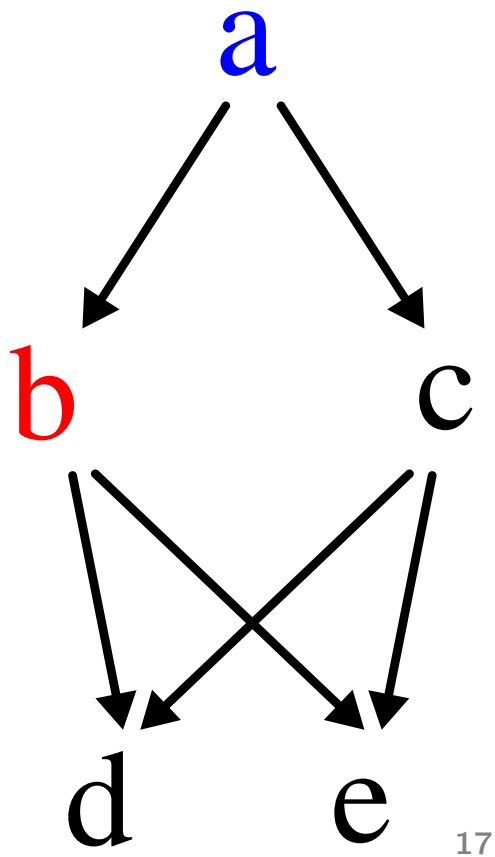

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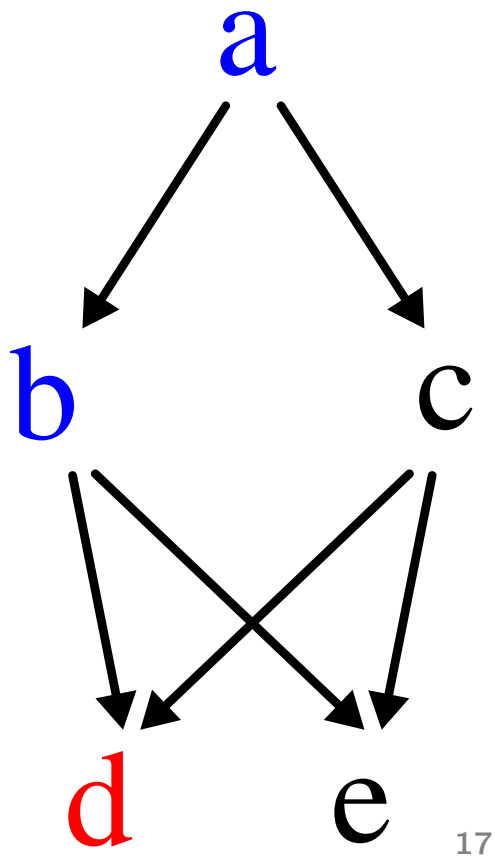

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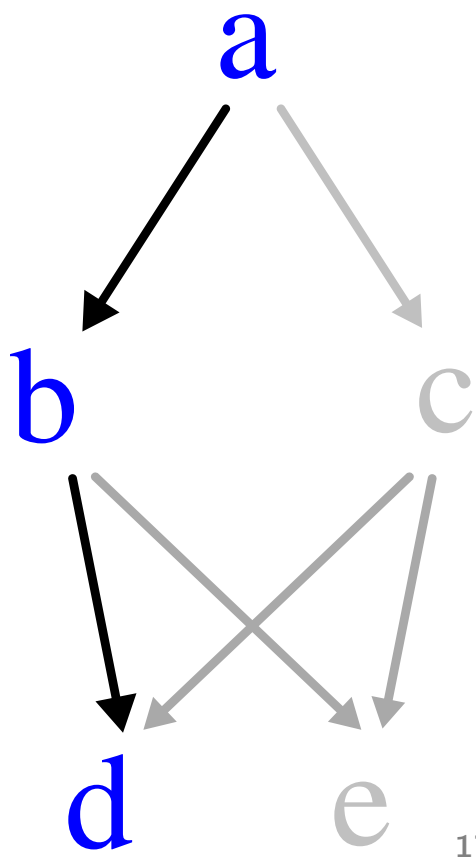
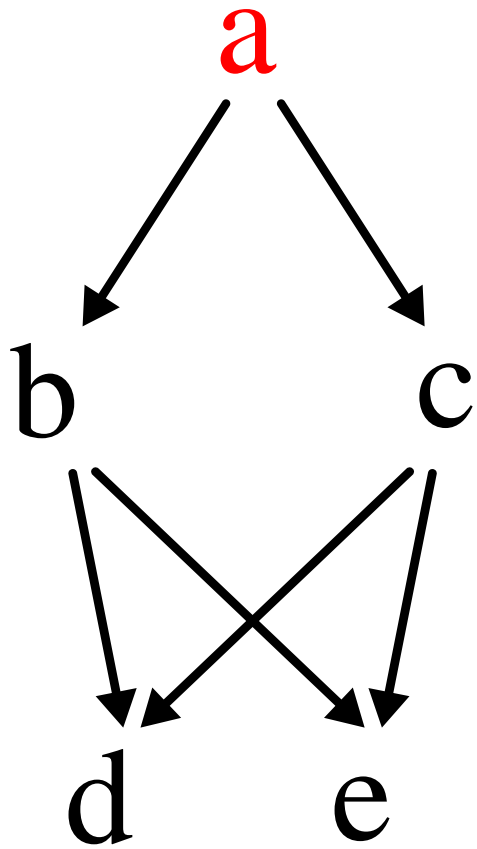


```
//*/self::b/child::d
```

`//*/self::b/child::d`

1. `typeinf(DTD,{`X_a`},//*)`



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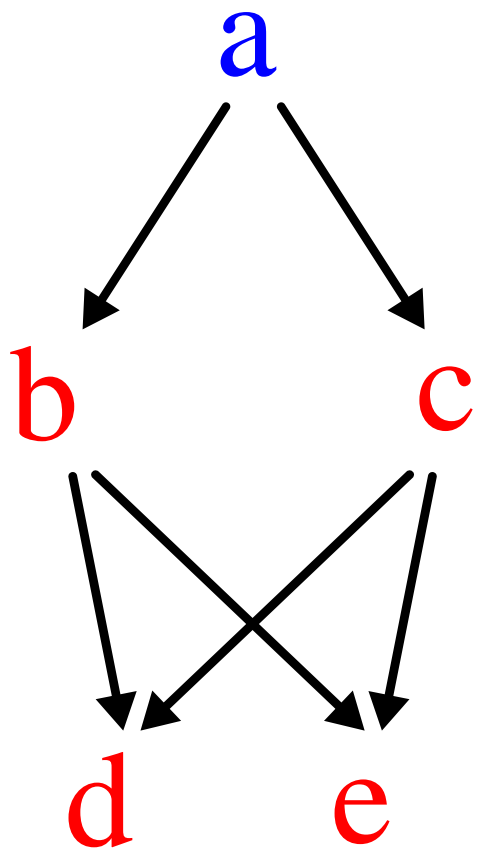

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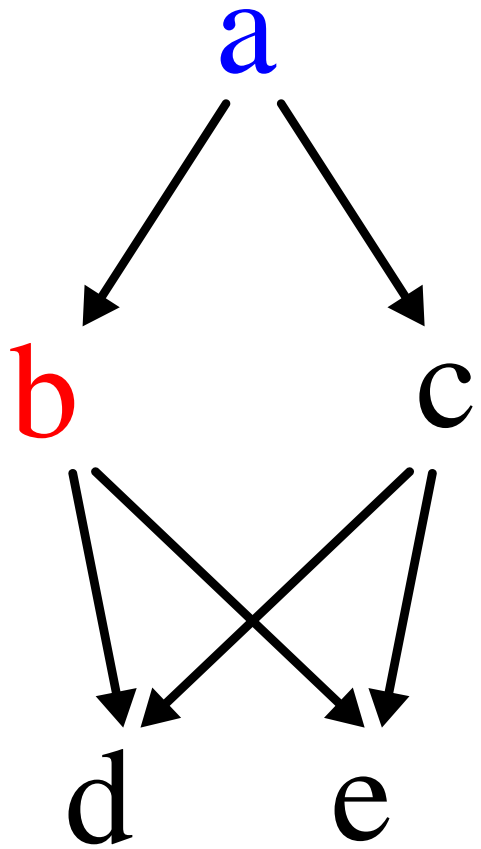

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   1. `typeinf(DTD,`$\{X_b\}$`,self::b/child::d)` $= \{X_d\}$
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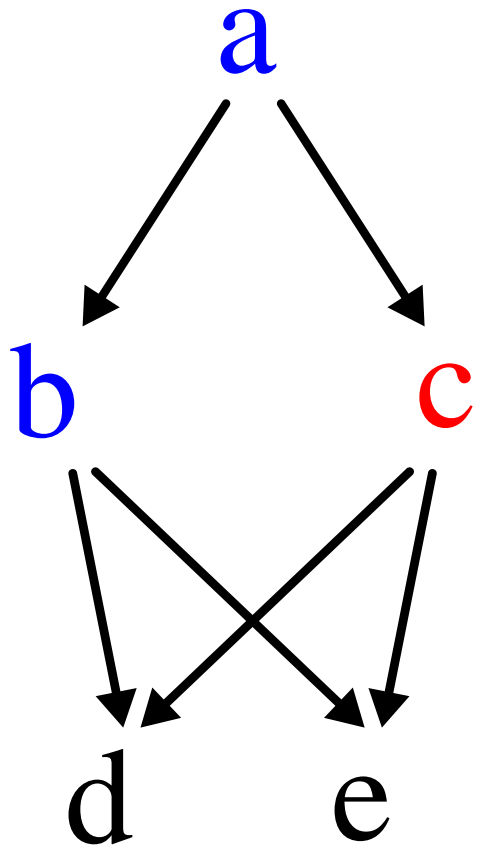

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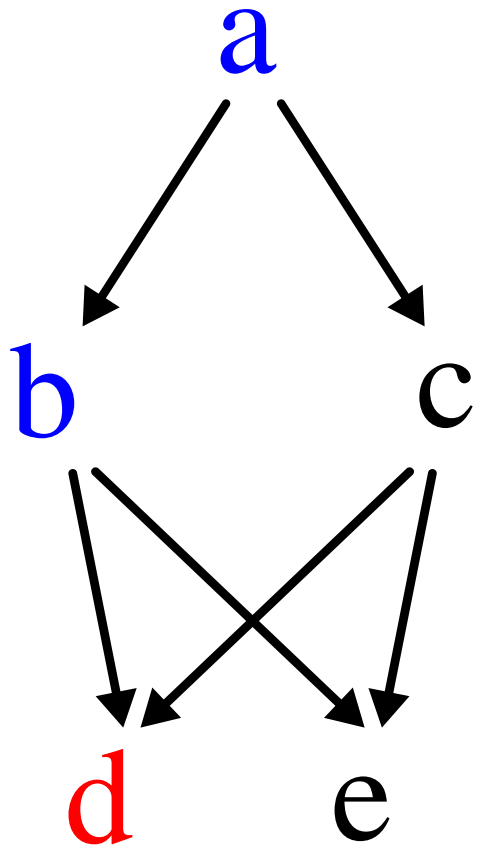

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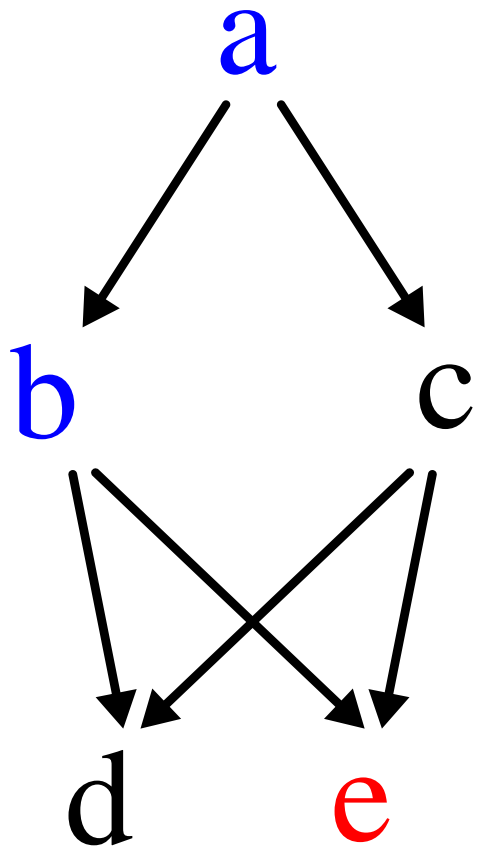
   4. typeinf(DTD,$\{X_e\}$,self::b/child::d)$= \varnothing$



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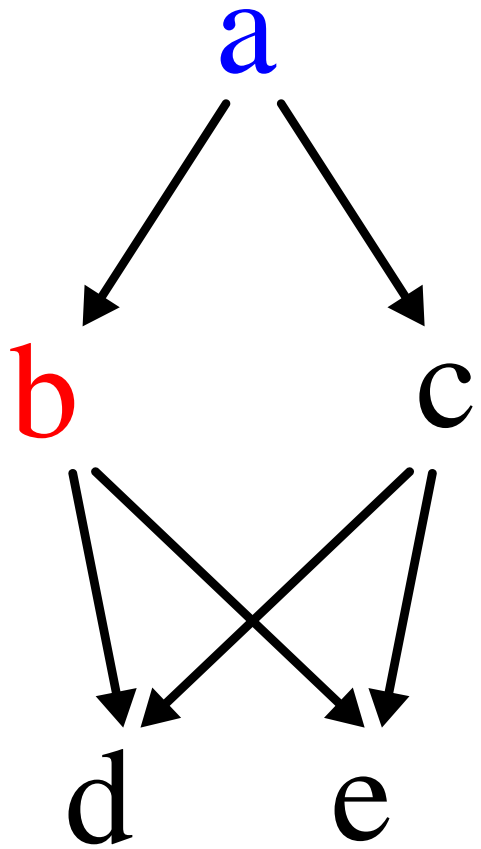

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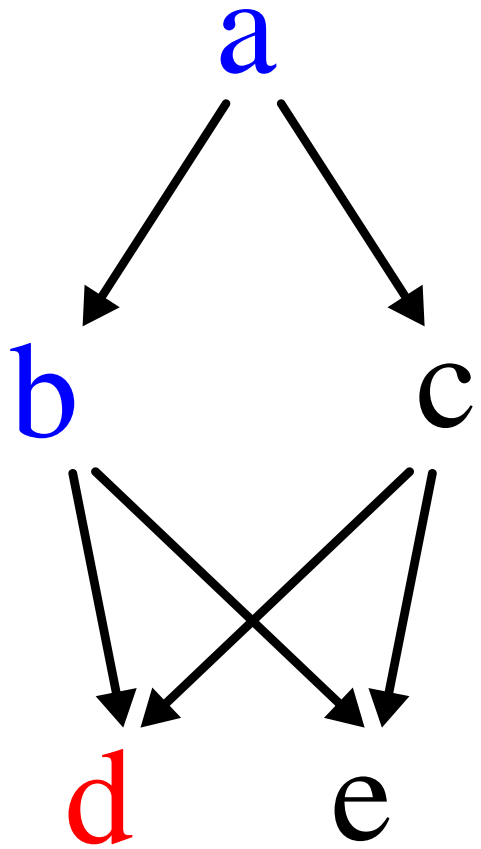

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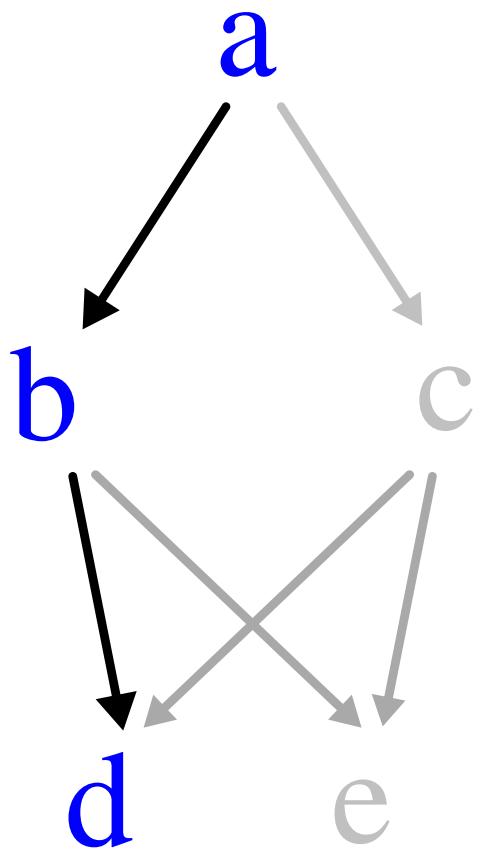

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/self::a/child::b/child::d/parent::node()/child::d
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/self::a/child::b/child::d/parent::node()/child::d

1. typeinf(DTD,$\{X_a\}$,self::a)$= \{X_a\}$
2. typeinf(DTD,$\{X_a\}$,child::b)$= \{X_b\}$
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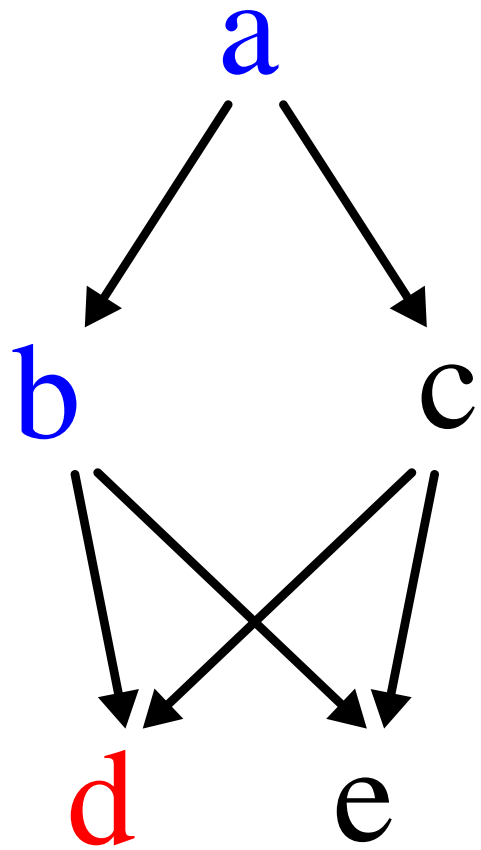

/self::a/child::b/child::d/parent::node()/child::d

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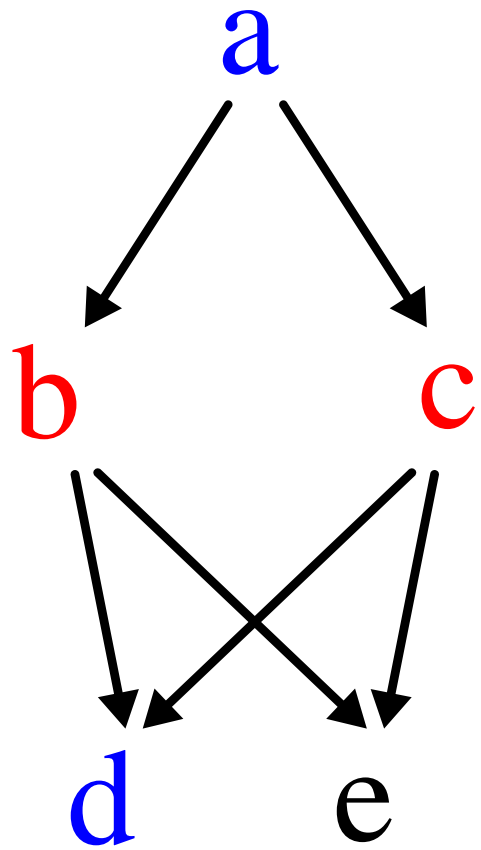
4. typeinf(DTD,$\{X_d\}$,parent::node())$= \{X_b, X_c\}$



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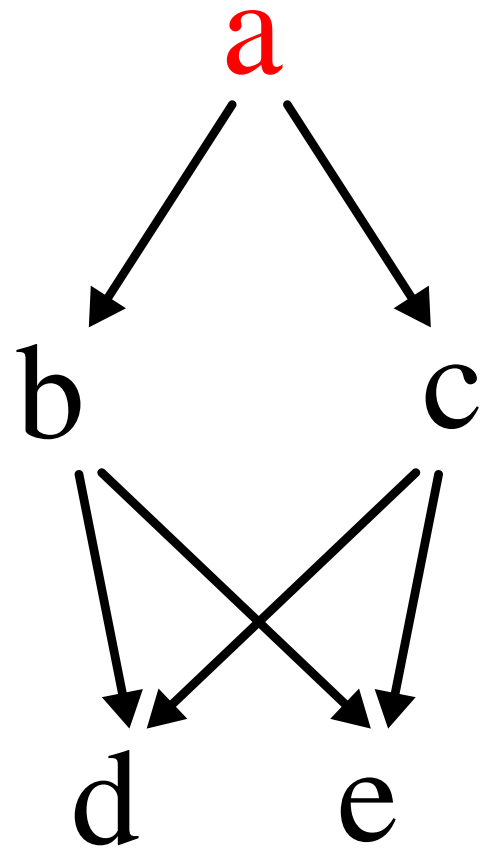

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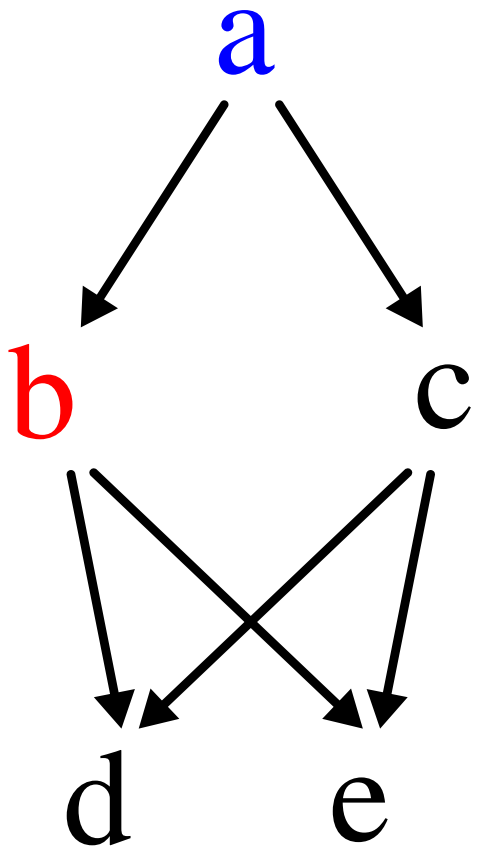

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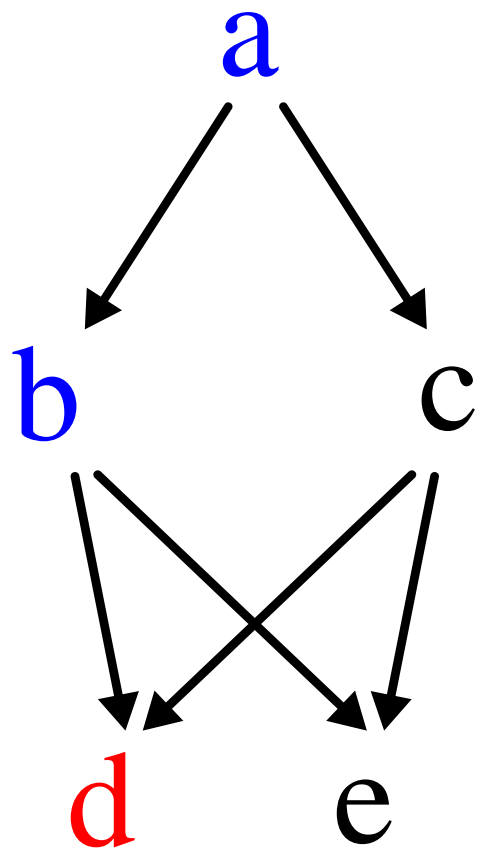

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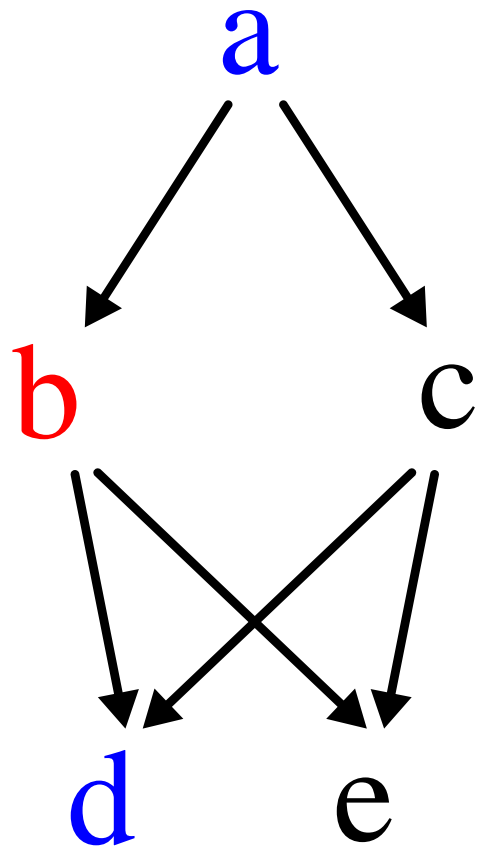

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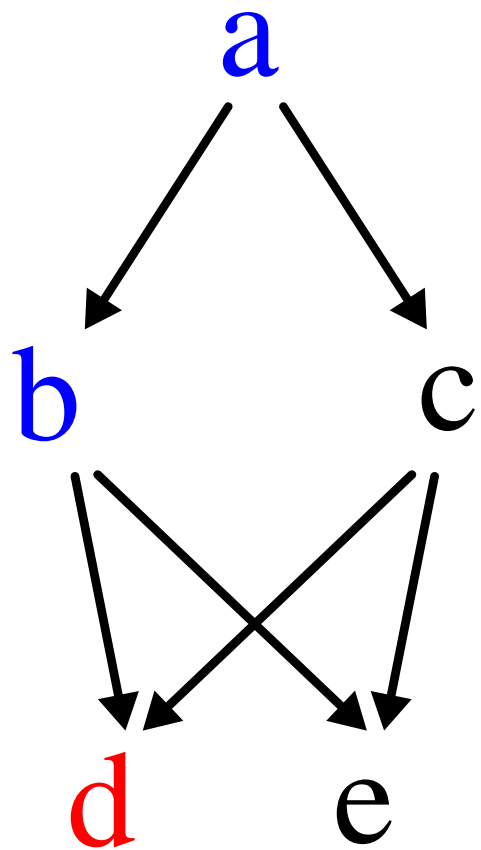

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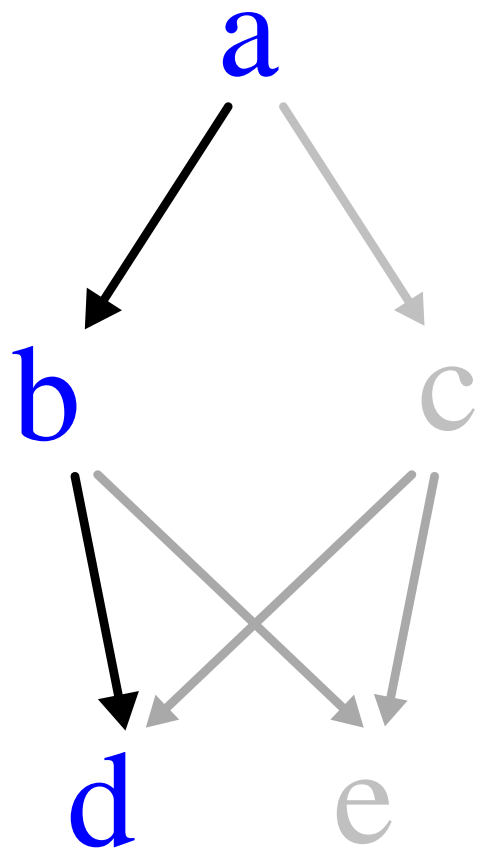

Outline

Theorem (Soundness)

Let D be a document valid w.r.t a DTD (X, E) and p a path. Let $\mathcal{P}$ the type projector deduced from p. Let D' be the projection of D with $\mathcal{P}$.

$$\mathtt{eval}(p, D) = \mathtt{eval}(p, D')$$

Completeness

Pruning is precise . . .

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Theorem (Completeness)

$\mathcal{P} = \{X_1, \ldots, X_n\}$ the type projector associated with a path p and a DTD (X, E). Let $\mathcal{P}' = \mathcal{P} \backslash \{X_i\}$. There exists D a document and it's projection D' such that :

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Completeness holds with :

- some restrictions on the DTD (*star-guarded*, non-recursive,. . .)

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Protocol :

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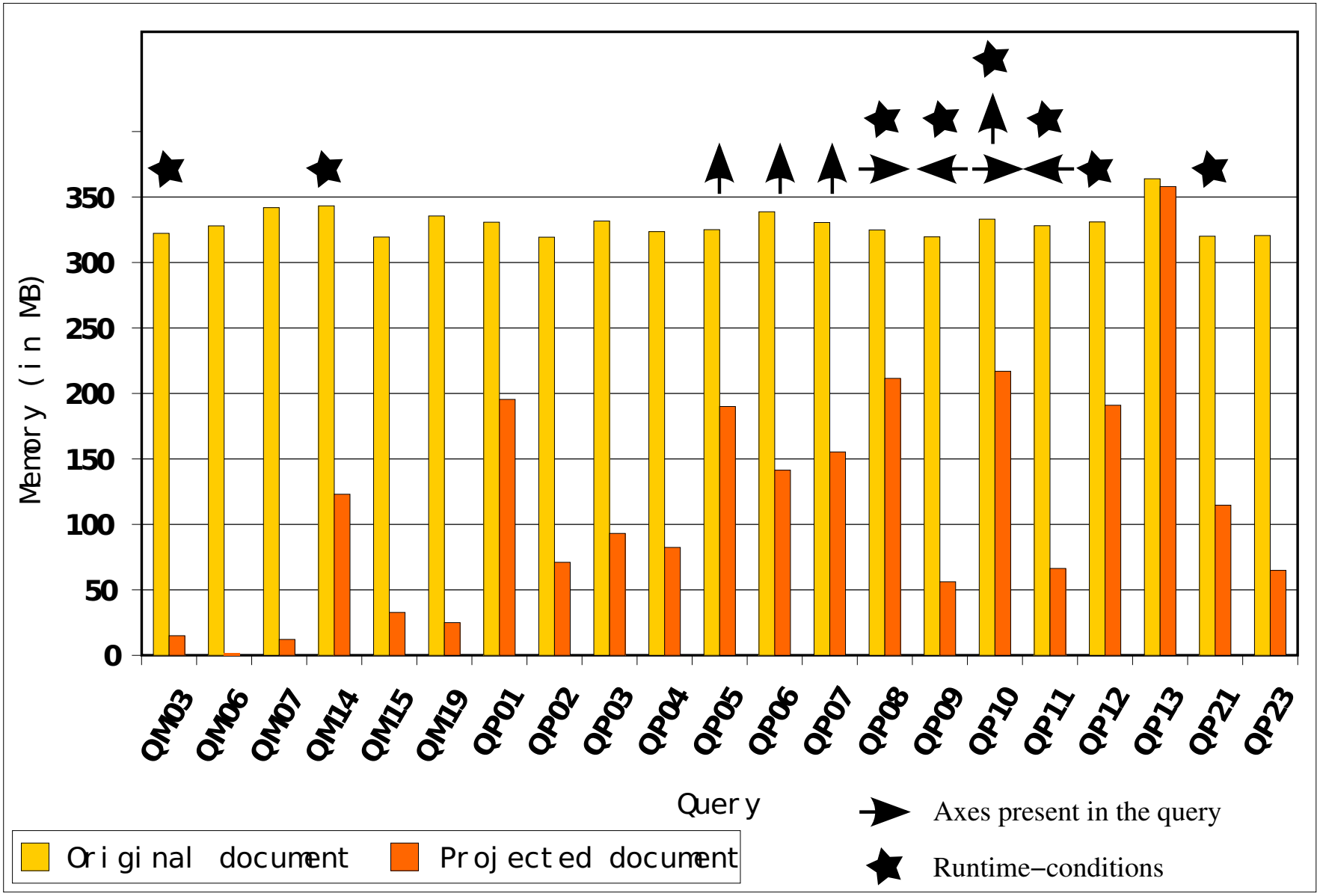
- Prunning is one pass bufferless traversal of the document.
- In practice, computing the type projector is fast.



Memory used to process a 56 MB document with Galax.

Gain

	QM03	QM06	QM07	QM14	QM15	QM19
	★			★		
Original Size (MB)	930	2048	1100	202	2048	964
Pruned Size(MB)	25	5,3	42	139	24	24
Memory Usage (MB)	374	90	380	512	245	512
% of original size	2.5	0.3	3.4	69.6	1.15	2.5
Gain in Speed ($\times$ faster)	17.8	110.1	28.2	3.9	62.6	7.5

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Features : handles backward as well as following/preceding axes.

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- *No additional cost at runtime*.

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- integration with a query engine.