Update propagation through security views

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Outline

1. Updates and (security) Views
2. View Inversion
3. Update Propagation

Views and Updates

Database views:

- facilitate access to data
- remove irrelevant data
- restructure the presentation of the data

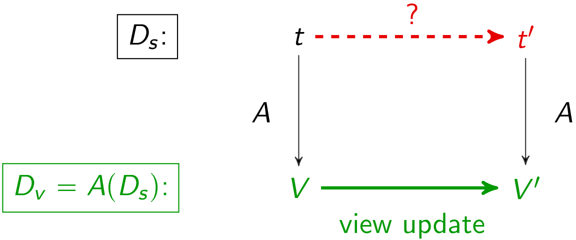
Database *security views*:

- hide sensitive data

View update propagation

- document t, view $V = A(t)$,
- view update by the user: $V \mapsto V'$
- find a propagation: $t \overset{?}{\mapsto} t'$

The update propagation problem



Find an update $t \mapsto t'$ (a propagation of $V \mapsto V'$) such that:

- $t \mapsto t'$ is *side-effect free*: $A(t') = V'$
- $t \mapsto t'$ is *schema compliant*: $t' \models D$;

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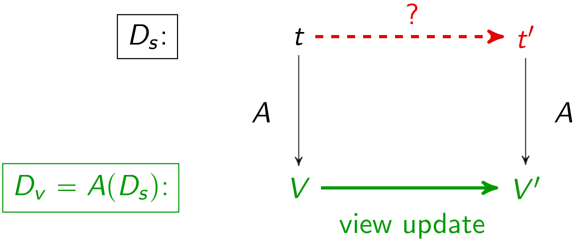

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- $t \mapsto t'$ is *schema compliant*: $t' \models D$;
- $t \mapsto t'$ has *constant complement* [Bancilhon, Spyratos'81] : no modification of the hidden parts

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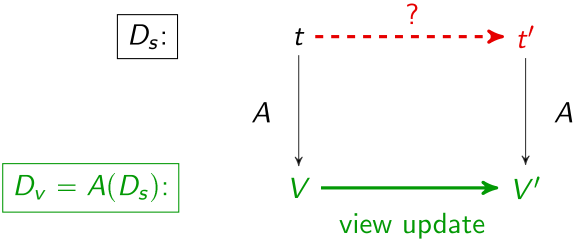

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- $t \mapsto t'$ is *side-effect free*: $A(t') = V'$
- $t \mapsto t'$ is *schema compliant*: $t' \models D$;
- $t \mapsto t'$ is *optimal*: minimal modification of the hidden parts.

Our framework

- XML documents: unranked, ordered trees, with node identifiers.
- Schema: DTD
- View given by an annotation[Farkas et al '02, Fan et al'04.]
  - $A(a, b) = \mathbb{0} \implies$ the nodes labeled b under a node a are not visible
  - $A(a, b) = \mathbb{1} \implies$ the nodes labeled b under a visible node a are visible

  Upward closed visibility of nodes: the descendants of a hidden node are hidden as well (regardless of their annotation)

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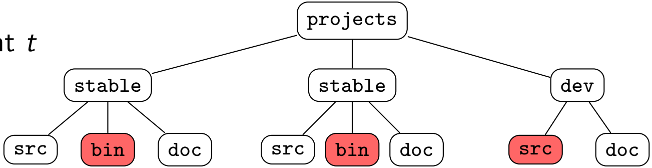

$$A(projects, stable) = A(projects, dev) = A(stable, src) = \ldots = \mathbb{1}$$
$$A(dev, src) = A(stable, bin) = \mathbb{0}$$

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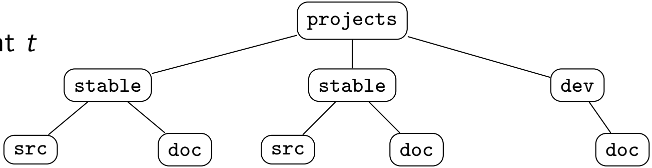

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and updates ?

Editing scripts

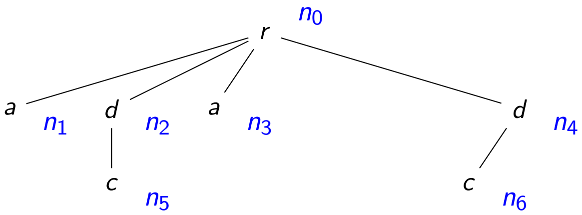
Update

Input tree with nodes labelled:

- *Del*: nodes to be deleted
- *Ins*: nodes to be inserted

* Deletion is recursive: delete whole subtrees

* Insertion of a subtree, not of internal nodes



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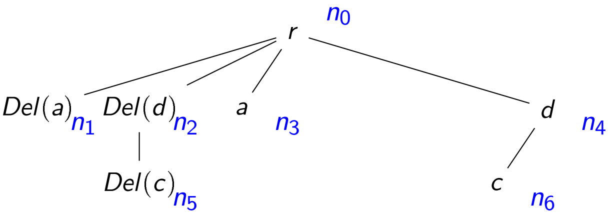

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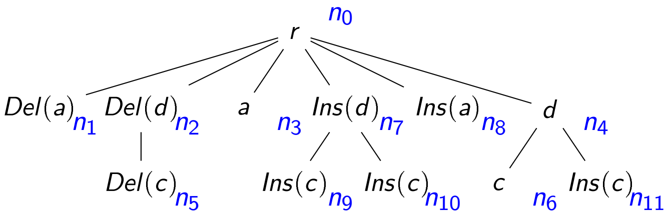

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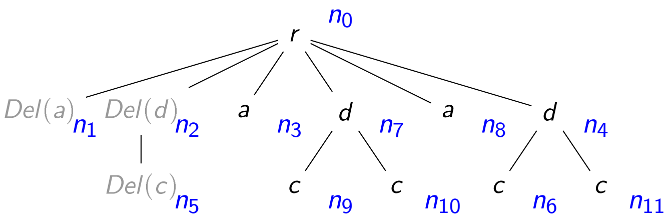


$\Longrightarrow$ captures XQuery Update snapshot semantics

Our framework

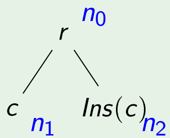
- XML documents: unranked, ordered trees, with node identifiers.
- Schema: DTD
- View given by an annotation.
- Updates are given as editing scripts: the alignment of the input and output document on their common nodes.

Nice properties:

- One can compute a DTD D_v that captures the set of all view documents. Hence the user will only apply view updates that have a propagation
- The constraints are local in a DTD: the modification of a node affects only its siblings and their descendants.

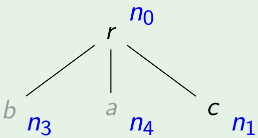
Identifiers, a choice of some consequence

Example

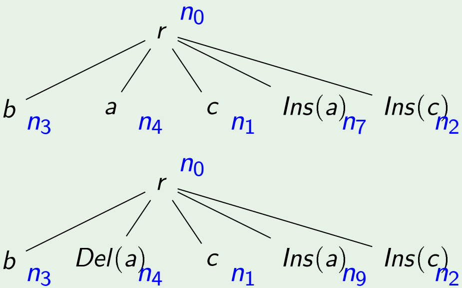


View update

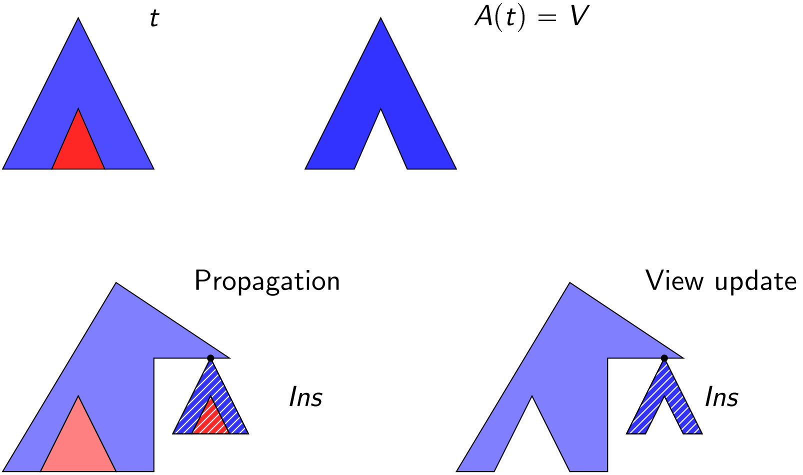
Schema: $r \to b^{\mathbb{0}}(c^{\mathbb{1}} + \epsilon)(a^{\mathbb{0}} \cdot c^{\mathbb{1}})^*$



Source tree



View Inversion



Computing the view inverse

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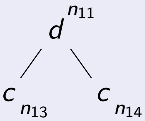

Schema and View:

$$d \to ((a^{\mathbb{0}} + b^{\mathbb{0}}) \cdot c^{\mathbb{1}})^*$$

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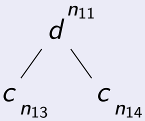

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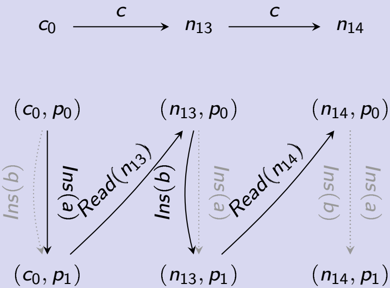
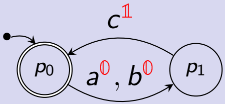
Example of construction



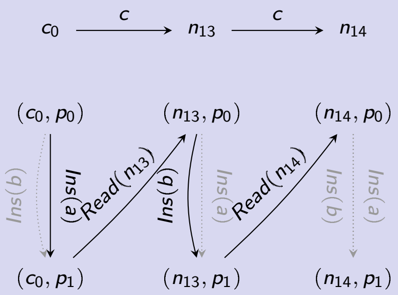


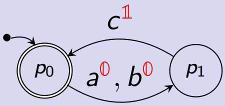
Computing the view inverse

Lemma

H_n captures all possible inversions for the sequence of children of the node n as paths from an initial to a final state.

Example of construction





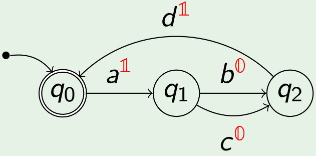
Computing the update propagation

(As for inverse), for every node n common to t_s and $Out(S_v)$, construct a graph G_n representing the set of all possible sequences of children of n in all $Out(S_s)$ for all update propagation S_s.

G_n has to handle insertion and deletion of nodes.

Example

The source DTD



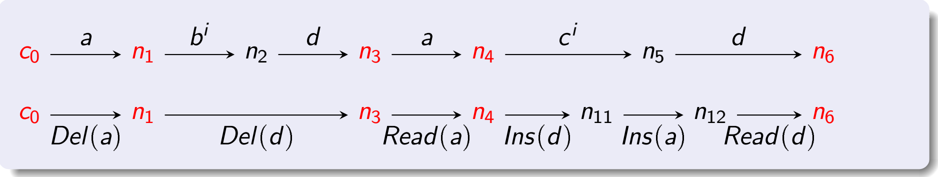
the sequence of children of n in t_s

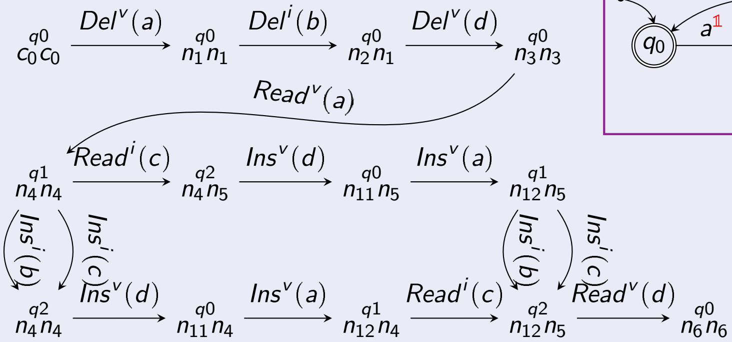
n_1	n_2	n_3	n_4	n_5	n_6
a	b	d	a	c	d

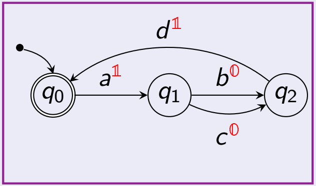
the edit script S_v

n_1	n_3	n_4	n_{11}	n_{12}	n_6
$Del(a)$	$Del(d)$	$Read(a)$	$Ins(d)$	$Ins(a)$	$Read(d)$

Computing the update propagation







Computing the update propagation

Lemma

For each node n, the graph G_n contains all possible update propagations of S_s restricted to the sequence of children of n as paths from an initial to a final node in the graph.

Theorem

The set of graphs G_n for all node n common to t_s and $Out(S_v)$ captures all side-effect free and schema-compliant update propagations of S_v.

As for inversion, the update propagation script S_s is computed bottom-up on the structure of t. Inversion is used when inserting a subtree.

Computing an optimal update propagation

For all node n, construct a graph G_n^* which contains only the optimal update propagations from G_n. The construction is bottom-up.

1. Associate a cost to each edge in G_n:
    - *delete* : the size of the deleted tree;
    - *invisible insert* : the size of the minimal tree with the corresponding root label;
    - *visible insert* : the size of the minimal inversion tree;
    - *invisible read* : 0;
    - *visible read* : the sum of the costs of the optimal propagation graphs for the children, computed recursively.
2. Remove from G_n all non-optimal paths.

Complexity and remarks

- The size of a minimal propagation may be exponential in size of D_s (the minimal tree satisfying a DTD can have an exponential size).

$$r \rightarrow a_n, \qquad a_i \rightarrow a_{i-1} a_{i-1}, \qquad a_0 \rightarrow \epsilon$$

- If for each label a, the tree to be inserted whenever a is (invisibly) inserted is input of the problem, then the optimal propagation is of polynomial size.
- The model can be extended with some simple, local preferences for choosing an optimal propagation (among all possible ones).

Future work

- generalize views, schema ...
- generalize updates
- add constraints to the updates (node typing ...)
- propagating update programs instead of editing script ($V \mapsto V'$)