Merging Uncertain Multi-Version XML Documents

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Merging feature: a need in open environments

- Merging documents related to the same topic or sharing a large common part, e.g., Wikipedia articles


It has been suggested that this article be merged with *Schrödinger picture*, *Heisenberg picture* and *Mathematical formulation of quantum mechanics#Pictures of dynamics* to *Dynamical pictures (quantum mechanics)*. (Discuss) *Proposed since September 2013.*

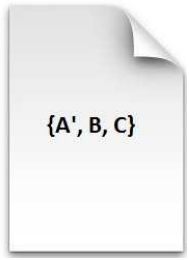
Merging feature: a need in open environments

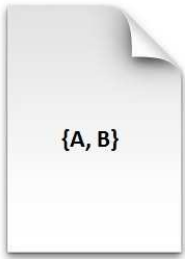
- Merging documents related to the same topic or sharing a large common part, e.g., Wikipedia articles

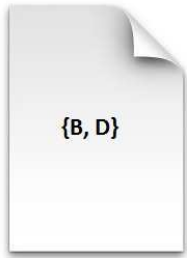
- Recommend the outcome of the merging of contributions of the most trustworthy contributors

- Proposal of a merging operation over multi-version tree-structured documents with uncertain data

Usual Merging Process over Documents

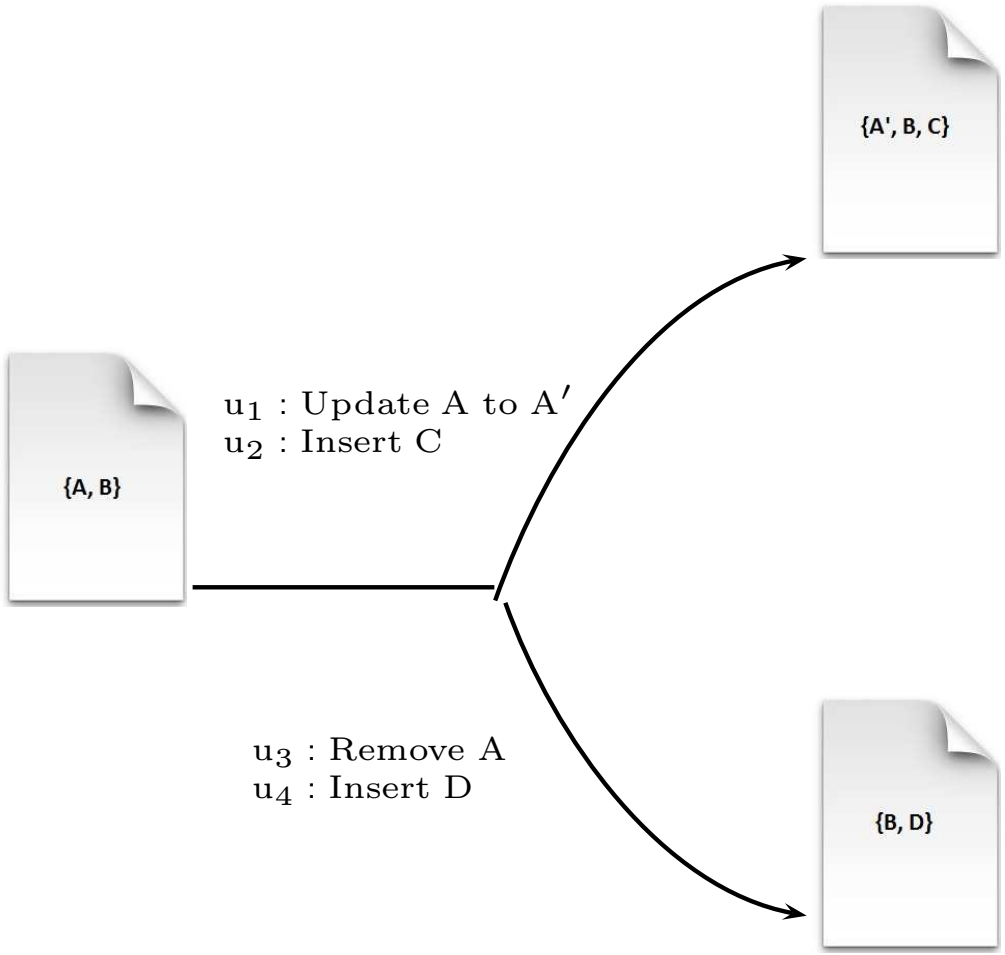






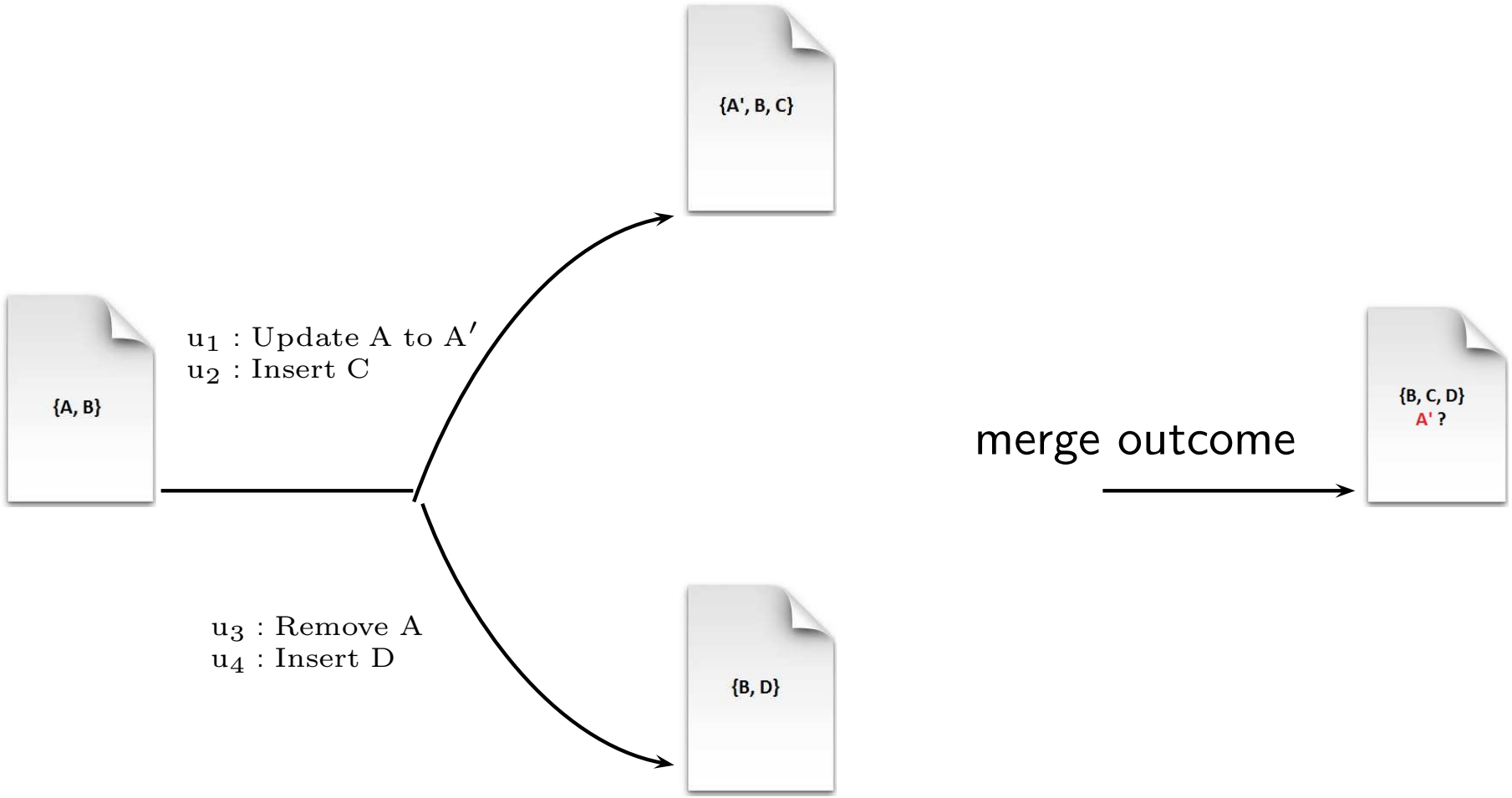
Usual Merging Process over Documents

(i) Change Detection (diff algorithm): $\{u_1, u_2\}$ and $\{u_3, u_4\}$



Usual Merging Process over Documents

(i) Change Detection (diff algorithm): $\{u_1, u_2\}$ and $\{u_3, u_4\}$
(ii) Three merge scenarios: {A', B, C, D}, {B, C, D} and {A, B, C, D}



State-of-the-art XML Merging algorithms

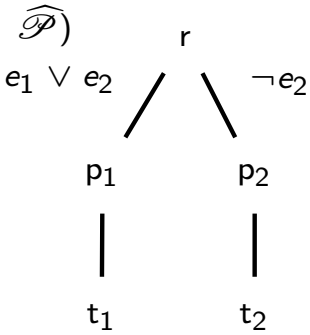
- Diff algorithms, for instance [Lindholm et al., 2006], for documents having tree-like structure
- Two-way merging [Suzuki, 2002], [Ma et al., 2010] vs. Three-way merging [Lindholm, 2004], [Abdessalem et al., 2011]
- All deterministic approaches require human input in the presence of uncertainties, e.g. conflicts handling, for the merge outcome
- Probabilistic merging, proposed in [Ma et al., 2010], does not retain enough information for retrieving back individual merged versions

Outline

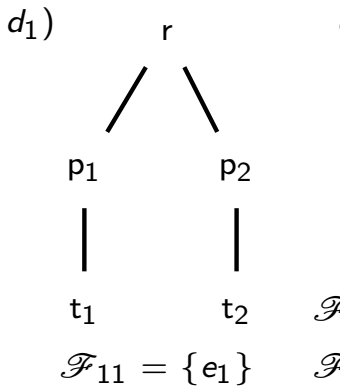
Uncertain Tree-Structured Data

Probabilistic XML [Kimelfeld & Senellart.(2013)]

- Unordered, unranked, and labeled **XML trees** with annotated edges
  - annotations are **propositional formulas** of random Boolean variables



PrXML$^{\text{fie}}$ p-Document



$Pr(e_1) = 0.2$

$Pr(e_2) = 0.8$

$Pr(d_1) = Pr(e_1) \times Pr(\neg e_2)$

$Pr(d_2) = (Pr(\neg e_1) \times Pr(e_2)) + (Pr(e_1) \times Pr(e_2))$

Possible worlds and their probabilities

Uncertain Tree-Structured Data

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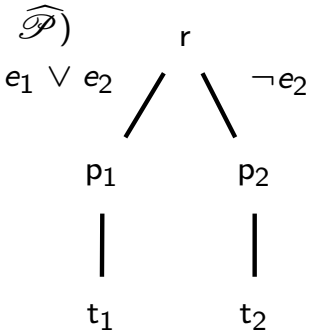

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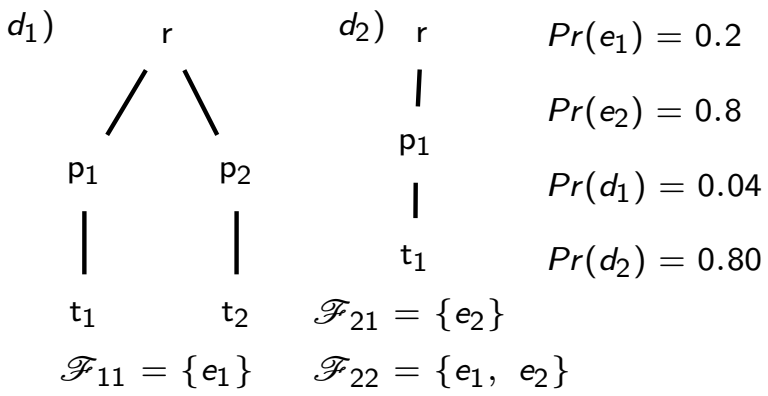

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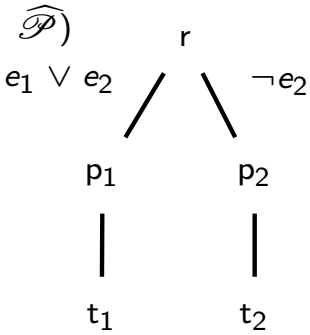

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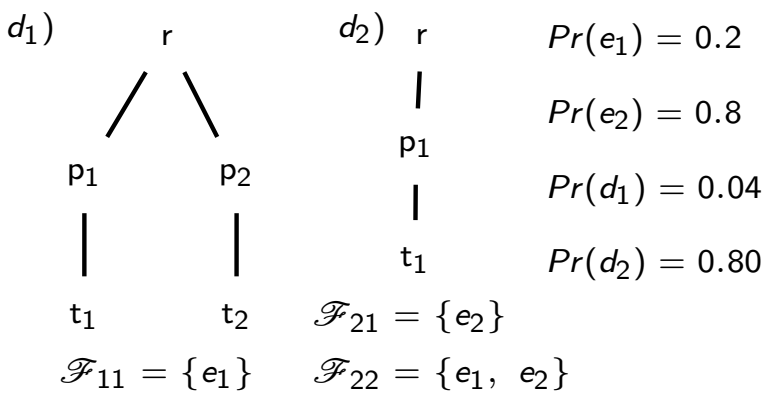


Possible worlds and their probabilities

- Enumerating all possible worlds and their probabilities
- Enable also to model uncertain updates on (uncertain) nodes [Kharlamov et al.(2010)]
- ☞ Integrate such a representation in a typical version control process

Uncertain Multi-Version XML Document

Uncertain Version Control Model

Defines two equivalent views over any uncertain multi-version XML tree

- set $\mathscr{V}$ of random variables $e_0, e_1 \ldots e_n$ modeling the tree states
- infinite set $\mathscr{D}$ of all (unordered) XML trees including the versions

$(\mathscr{G}, \Omega)$: Logical View

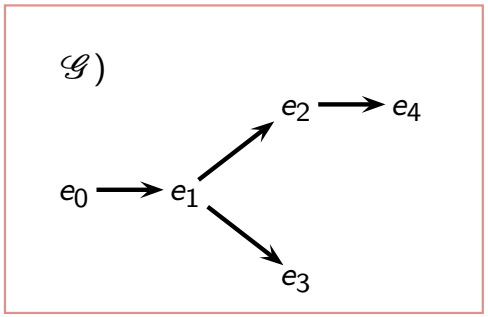
- DAG $\mathscr{G}$ built on variables in $\mathscr{V}$
- Mapping $\Omega : 2^{\mathscr{V} \setminus \{e_0\}} \rightarrow \mathscr{D}$ which computes the possible versions according to sets of valid events

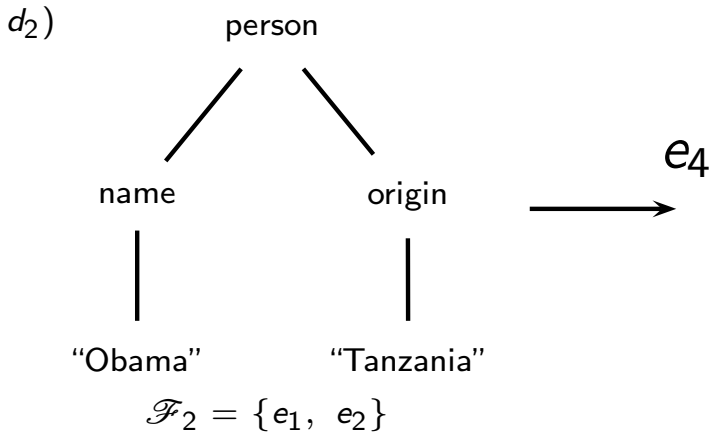
$(\mathscr{G}, \widehat{\mathscr{P}})$: Probabilistic XML Encoding

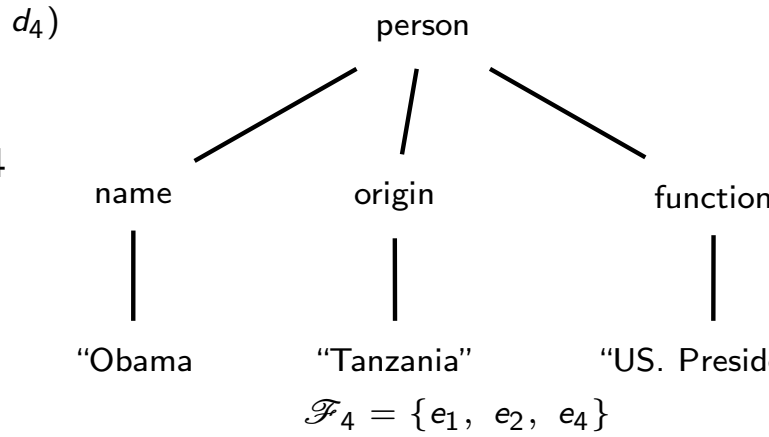
- Similar DAG $\mathscr{G}$ of random variables in $\mathscr{V}$
- Probabilistic XML tree $\widehat{\mathscr{P}}$ which defines the same probability distribution as Ω mapping

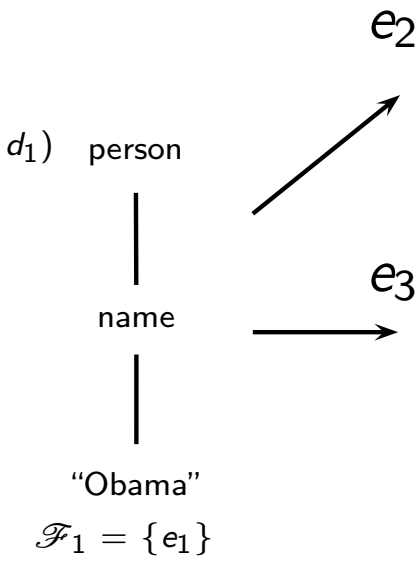
Uncertain Multi-Version XML Document

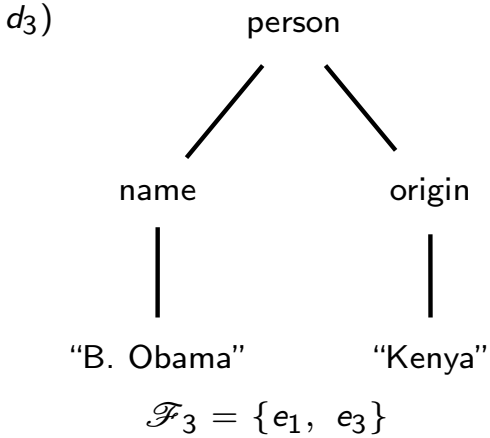
Uncertain Version Control Model (Example)





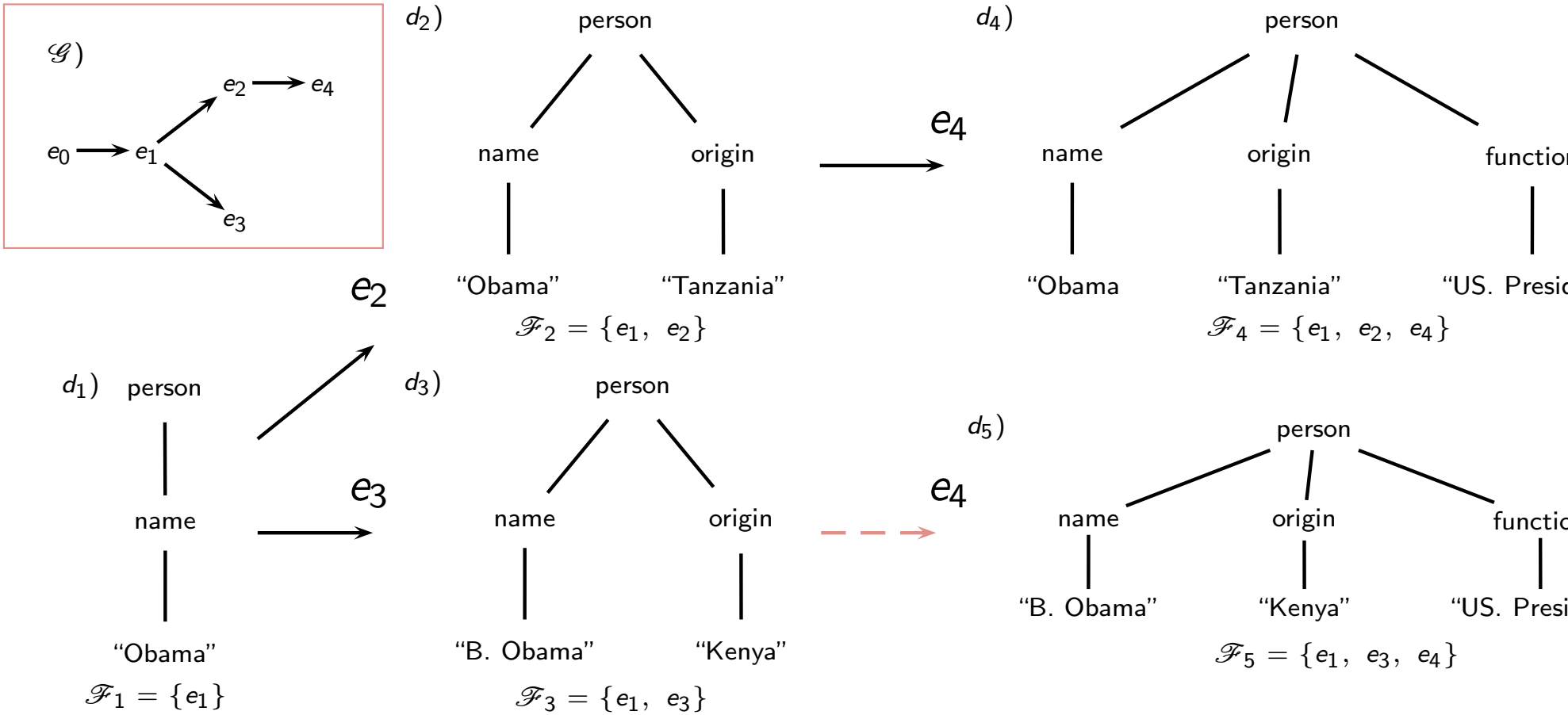






Uncertain Multi-Version XML Document

Uncertain Version Control Model (Example)



Uncertain Multi-Version XML Document

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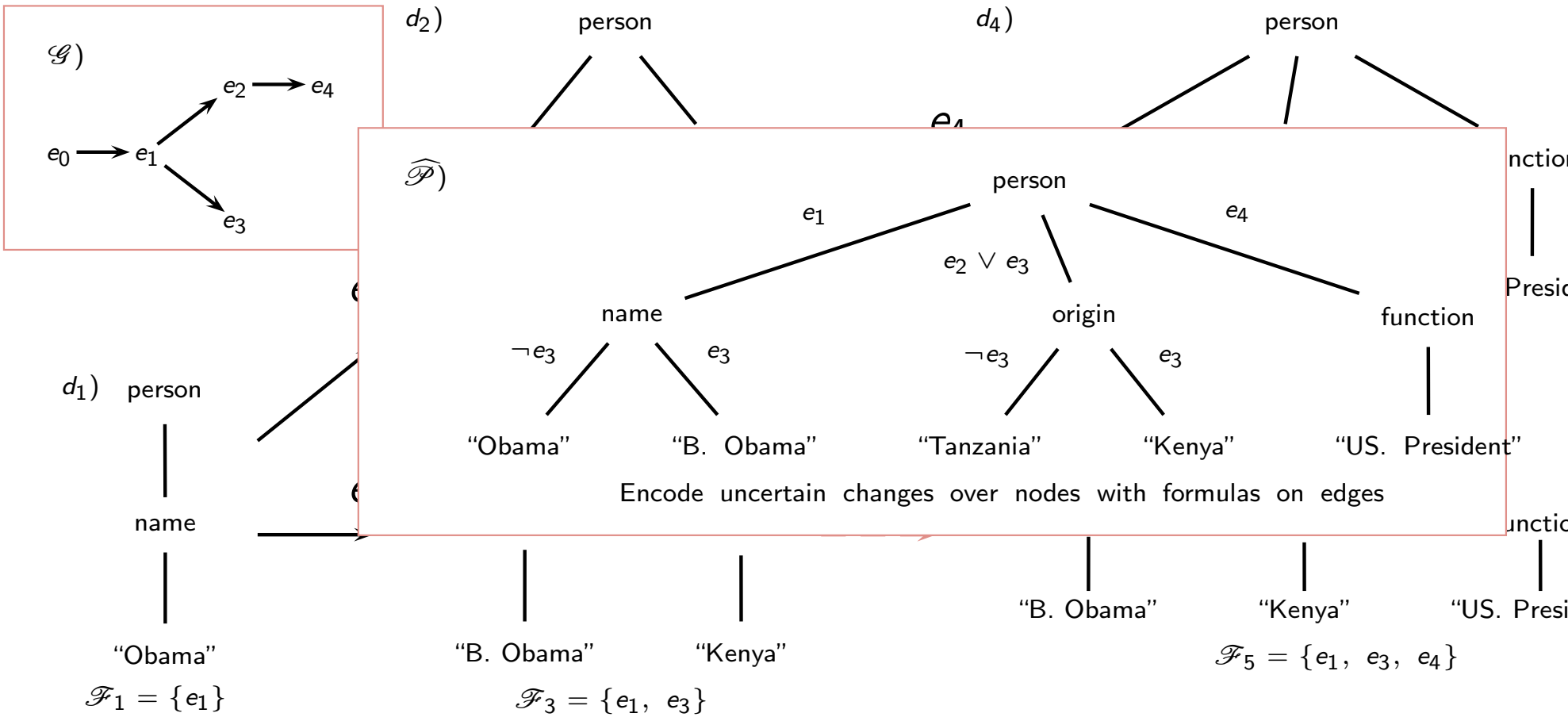


Uncertain XML Merging Operation

Edit Detection

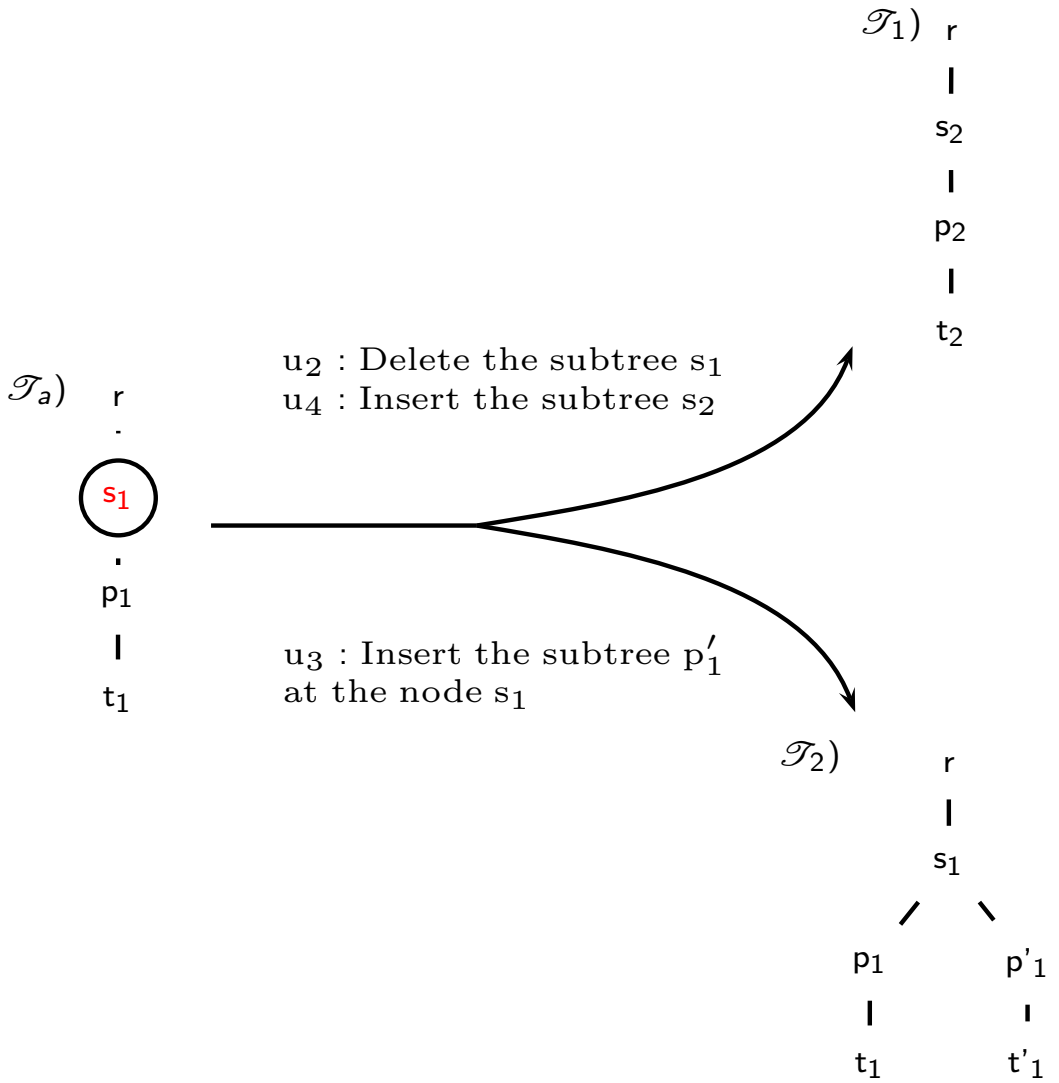
- Three-way procedure *diff3*() detecting node insertions and deletions based on *diff2*() sub-routines

$$diff3(\mathscr{T}_1, \mathscr{T}_2, \mathscr{T}_a) = diff2(\mathscr{T}_a, \mathscr{T}_1) \cup diff2(\mathscr{T}_a, \mathscr{T}_2)$$

- *diff3*() output is an edit script consisting of equivalent, conflicting and independent edits

Uncertain XML Merging Operation

Edit Detection



$diff2(\mathscr{T}_a, \mathscr{T}_1) = \{u_2, u_4\}$
$diff2(\mathscr{T}_a, \mathscr{T}_2) = \{u_3\}$
$diff3(\mathscr{T}_1, \mathscr{T}_2, \mathscr{T}_a) = \{u_2, u_4, u_3\}$

u_2 and u_3 are conflicting edits
u_4 is an independent edit
s_1 is a conflicting node

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- *diff3*() output is an edit script consisting of equivalent, conflicting and independent edits

- $\Delta^{\mathscr{C}}$ is considered as the restriction of *diff3*() to the set of conflicting edits (over conflicting nodes) for the merging

Uncertain XML Merging Operation

Formal Definition(I)

Given the triple (e_1, e_2, e'), an uncertain merge operation is formalized as $\mathfrak{MRG}_{e_1,e_2,e'}$

- events e_1 and e_2 identify the two (uncertain) versions to be merged
- e' (a merge event) is a new event assessing the amount of uncertainty in the merge

An uncertain merging operation $\mathfrak{MRG}_{e_1,e_2,e'}$ on $\mathscr{T}_{mv}$ maps in a logic sense to the formula below

$$\mathfrak{MRG}_{e_1,e_2,e'}(\mathscr{T}_{mv}) := (\mathscr{G} \cup (\{e'\}, \{(e_1, e'), (e_2, e')\}),\ \Omega').$$

Uncertain XML Merging Operation

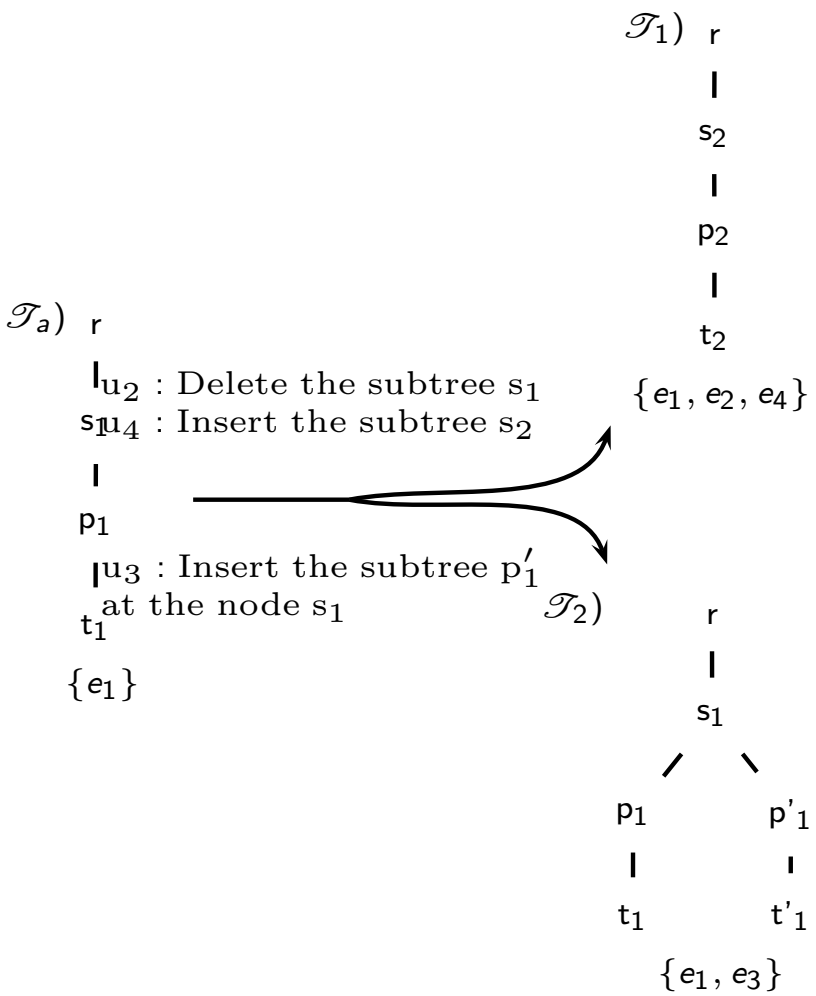
Formal Definition(II)

Let $\mathscr{A}_{e_1} = \{e \mid e \in \mathscr{G},\ e \prec e_1\}$, $\mathscr{A}_{e_2} = \{e \mid e \in \mathscr{G},\ e \prec e_2\}$,
$\mathscr{A}_s = \mathscr{A}_{e_1} \cap \mathscr{A}_{e_2}$
For all subset $\mathscr{F} \in 2^{\mathscr{V} \cup \{e'\}}$, Ω' is computed based on Ω mapping as follows

- if $e' \notin \mathscr{F}$: $\Omega'(\mathscr{F}) := \Omega(\mathscr{F})$;
- if $\{e_1, e_2, e'\} \subseteq \mathscr{F}$: $\Omega'(\mathscr{F}) := \Omega(\mathscr{F} \setminus \{e'\})$;
- if $\{e_1, e'\} \subseteq \mathscr{F} \wedge e_2 \notin \mathscr{F}$: $\Omega'(\mathscr{F}) := [\Omega((\mathscr{F} \setminus \{e'\}) \setminus (\mathscr{A}_{e_2} \setminus \mathscr{A}_s))]^{\Delta_2 - \Delta^{\mathscr{C}}}$;
- if $\{e_2, e'\} \subseteq \mathscr{F} \wedge e_1 \notin \mathscr{F}$: $\Omega'(\mathscr{F}) := [\Omega((\mathscr{F} \setminus \{e'\}) \setminus (\mathscr{A}_{e_1} \setminus \mathscr{A}_s))]^{\Delta_1 - \Delta^{\mathscr{C}}}$;
- if $\{e_1, e_2\} \cap \mathscr{F} = \emptyset \wedge e' \in \mathscr{F}$:
  $\Omega'(\mathscr{F}) := [\Omega((\mathscr{F} \setminus \{e'\}) \setminus ((\mathscr{A}_{e_1} \setminus \mathscr{A}_s) \cup (\mathscr{A}_{e_2} \setminus \mathscr{A}_s)))]^{\Delta_3 - \Delta^{\mathscr{C}}}$;

Uncertain XML Merging Operation

Formal Definition(II)



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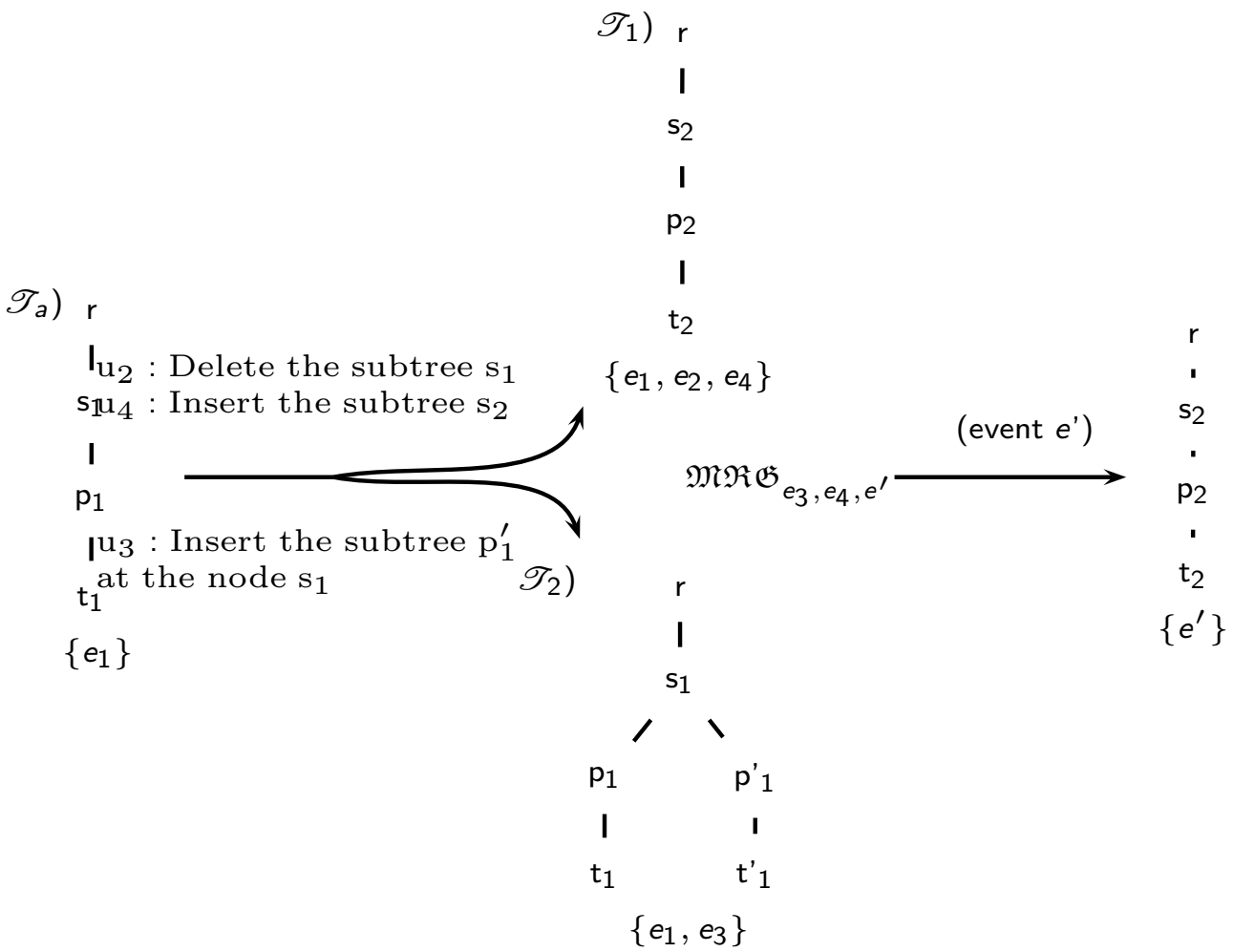

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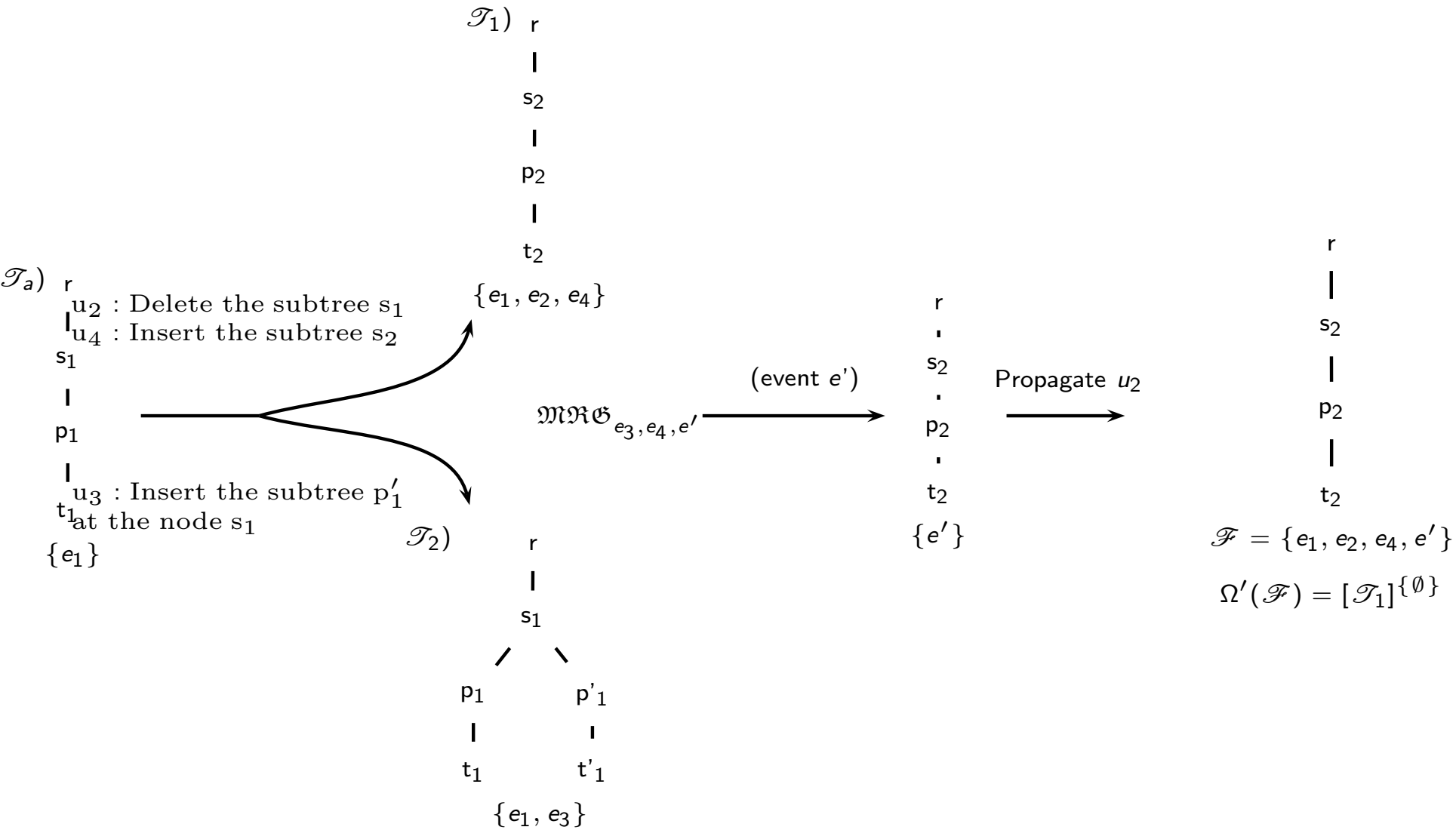

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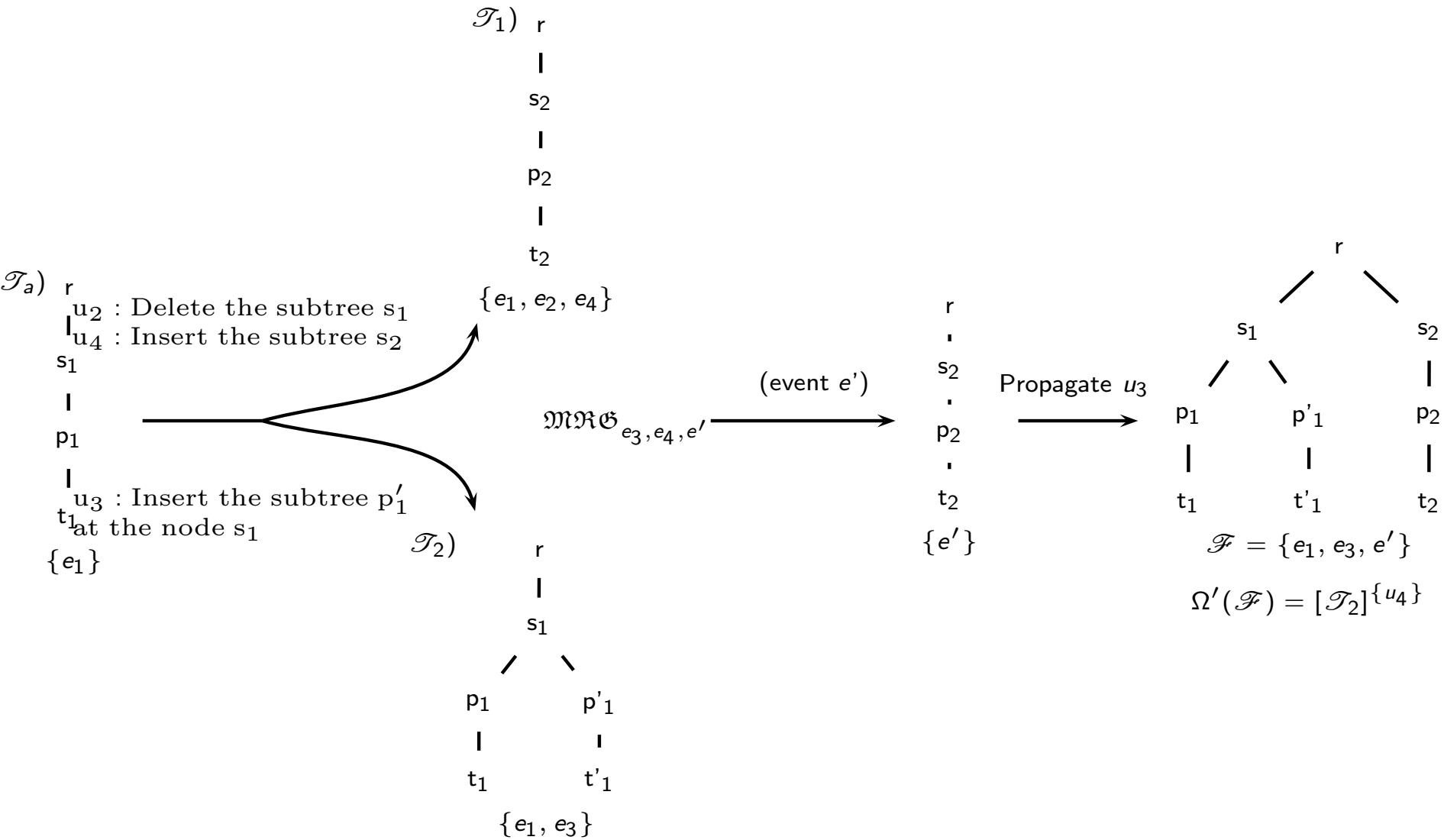

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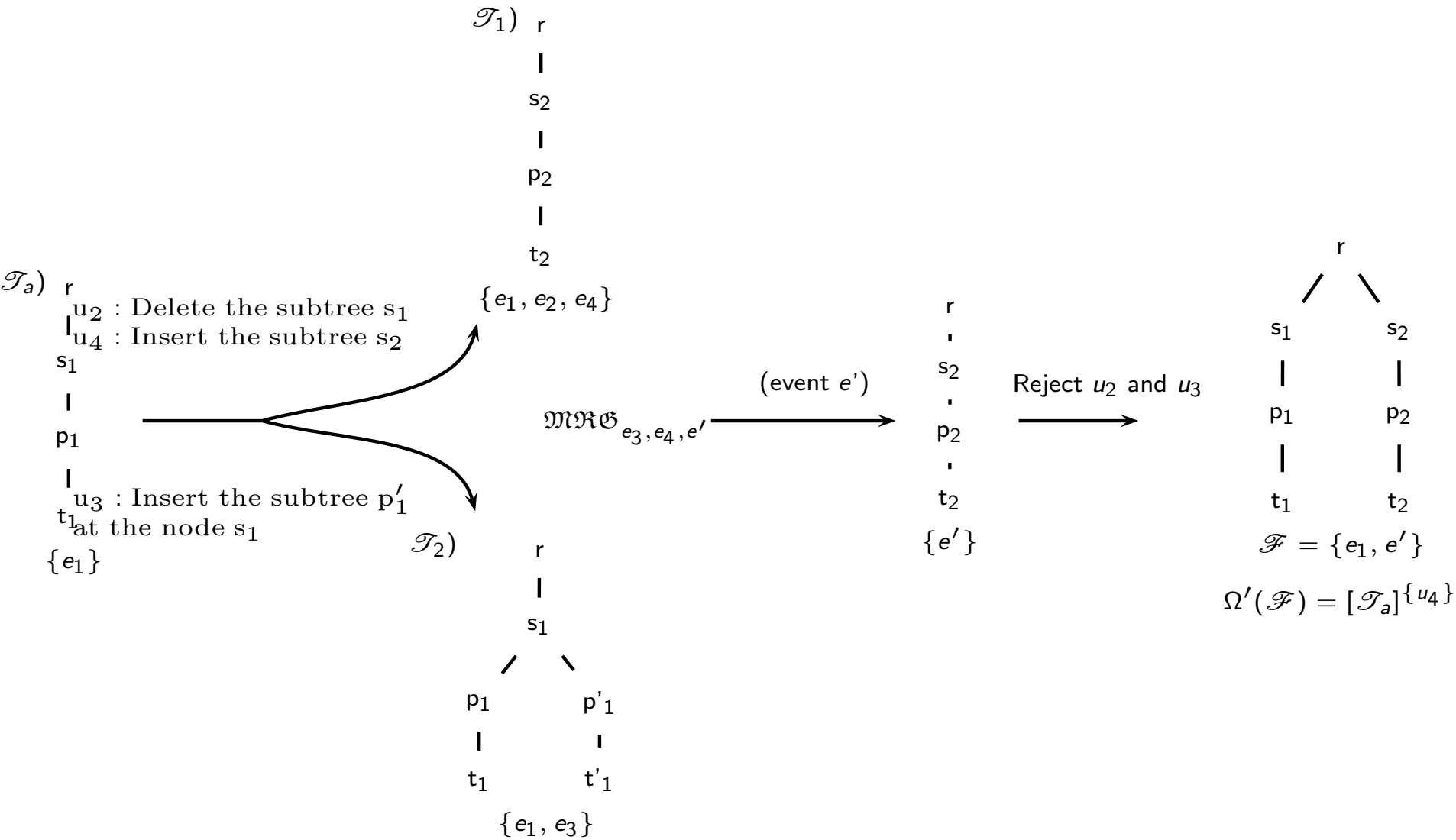


Merging Probabilistic XML (MergePrXML)

Conflicting and Non-conflicting Nodes

- MergePrXML distinguishes conflicting nodes to non-conflicting ones

Under the probabilistic XML Encoding $\widehat{\mathscr{T}_{mv}}$, a given x in $\widehat{\mathscr{P}}$ is a conflicted node with respect to $\mathfrak{MRG}_{e_1,e_2,e'}$ when its lineage $fie^{\uparrow}(x)$ is such that –

1. $fie^{\uparrow}(x) \models \nu_s$;
2. $fie^{\uparrow}(x) \not\models \nu_1$ (or $fie^{\uparrow}(x) \not\models \nu_2$) and;
3. $\exists y \in \widehat{\mathscr{P}}$, $\mathtt{desc}(x, y)$: $fie^{\uparrow}(y) \not\models \nu_s$ and $fie^{\uparrow}(y) \models \nu_2$ (or $fie^{\uparrow}(y) \models \nu_1$)

- $fie^{\uparrow}(x) = \bigwedge_{z \in \widehat{\mathscr{P}},\ z \preceq x}(fie(z))$ and ν_s, ν_1, ν_2 are valuations over $\mathscr{A}_s$, $\mathscr{A}_{e_1}$, $\mathscr{A}_{e_2}$ respectively
- MergePrXML implements $\mathfrak{MRG}_{e_1,e_2,e'}$ as an update operation in $\widehat{\mathscr{P}}$ that only modifies formulas of non-conflicting nodes of the merge

Merging Probabilistic XML (MergePrXML)

Merge Algorithm (I)

Input: $(\mathscr{G}, \widehat{\mathscr{P}})$, e_1, e_2, e'

Output: Merging Uncertain XML Versions in $\widehat{\mathscr{T}_{mv}}$

$\mathscr{G} := \mathscr{G} \cup (\{e'\}, \{(e_1, e'), (e_2, e')\})$;

foreach *non-conflicted node x in* $\widehat{\mathscr{P}} \setminus \widehat{\mathscr{P}}_{|\mathscr{C}_{\{e_1,\ e_2\}}}$ **do**

  `replace`$(fie(x),\ e_1,\ (e_1 \vee e'))$;

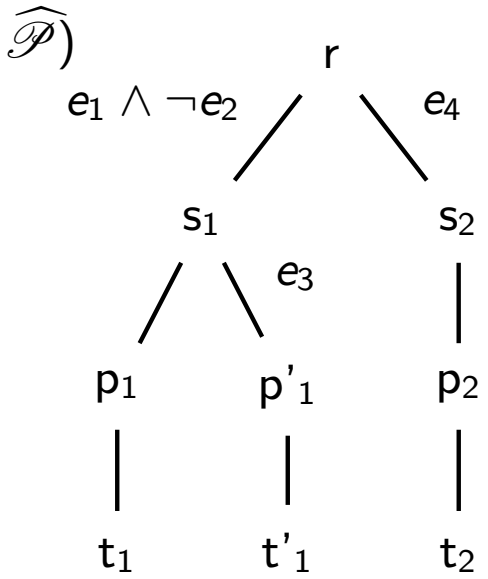
  `replace`$(fie(x),\ e_2,\ (e_2 \vee e'))$;

return $(\mathscr{G}, \widehat{\mathscr{P}})$

✉ MergePrXML performs the merge in time proportional to the size of the formulas of nodes impacted by the updates in merged branches

Merging Probabilistic XML (MergePrXML)

Merge Algorithm (II)



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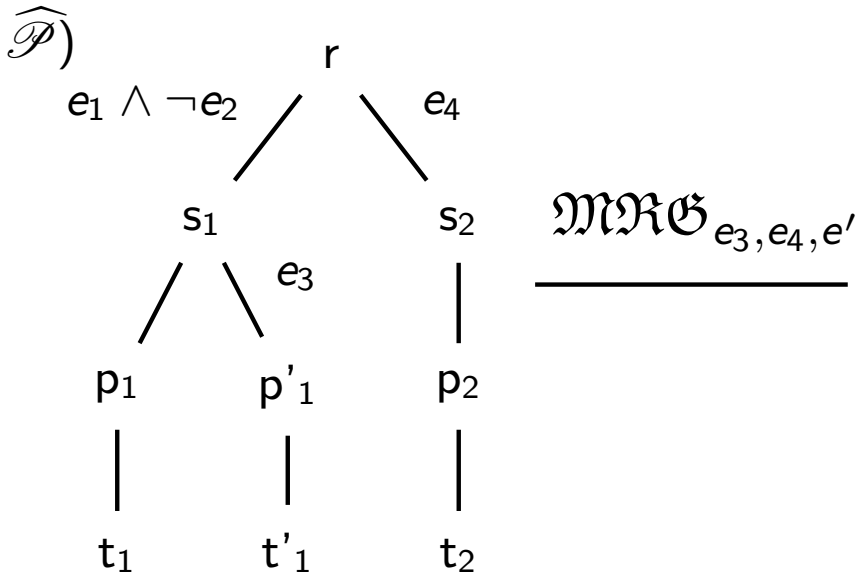

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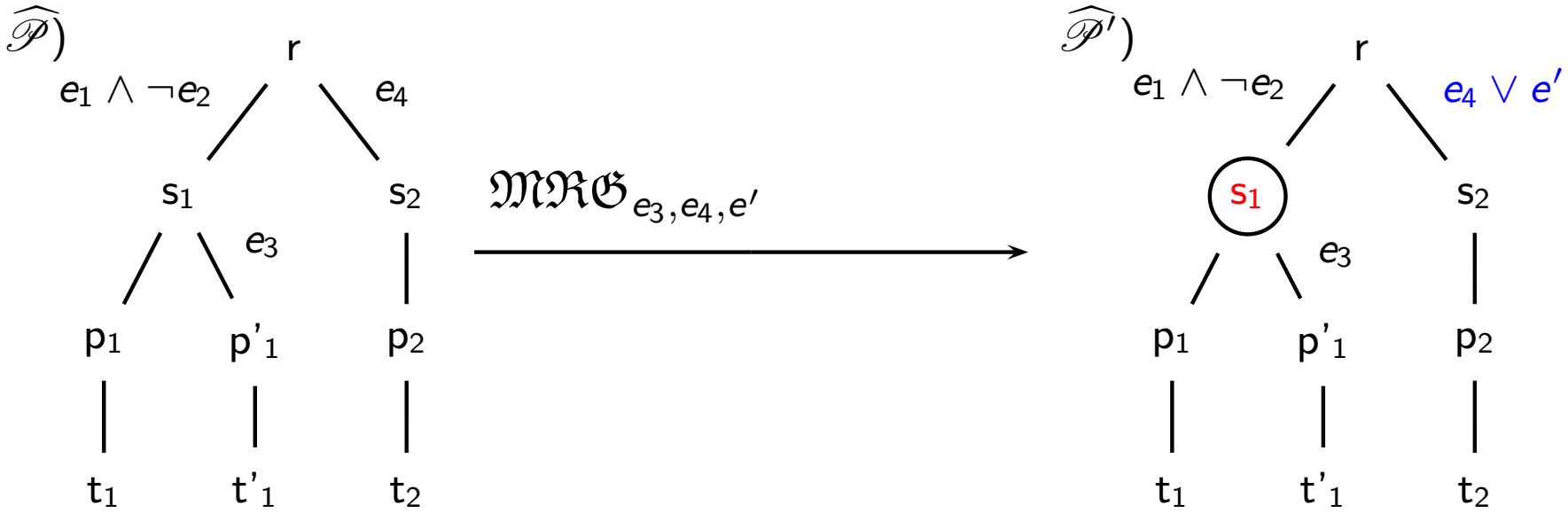

Conclusion and Further Works

- Merging operation over tree-structured multi-version documents with uncertain data
  - implementation of the common deterministic merge scenarios
  - modelling of the amount of uncertainty in the merged versions
- Efficient merging algorithm over Probabilistic XML encoding

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