On the Complexity of Managing Probabilistic XML Data

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Outline

Imprecise Data and Imprecise Tasks

Observations

- Many tasks generate imprecise data, with some confidence value.
- Need for a way to manage this imprecision, to work with it throughout an entire complex process.

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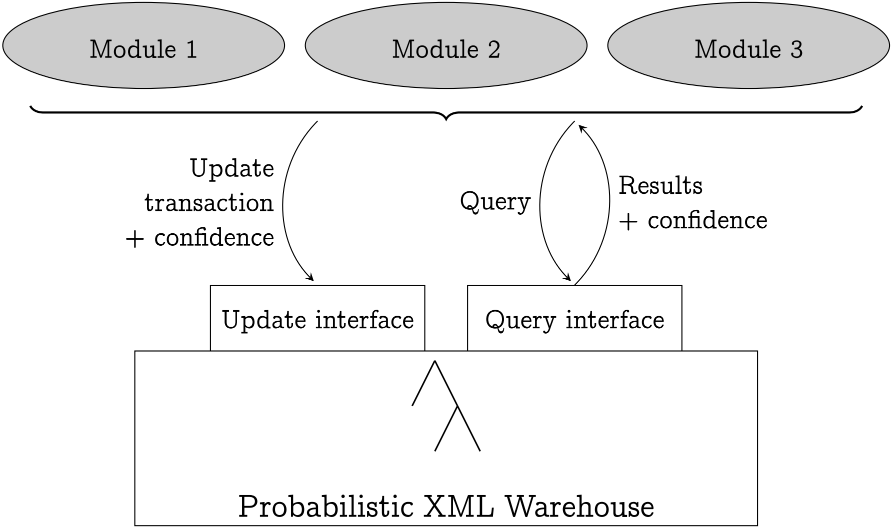

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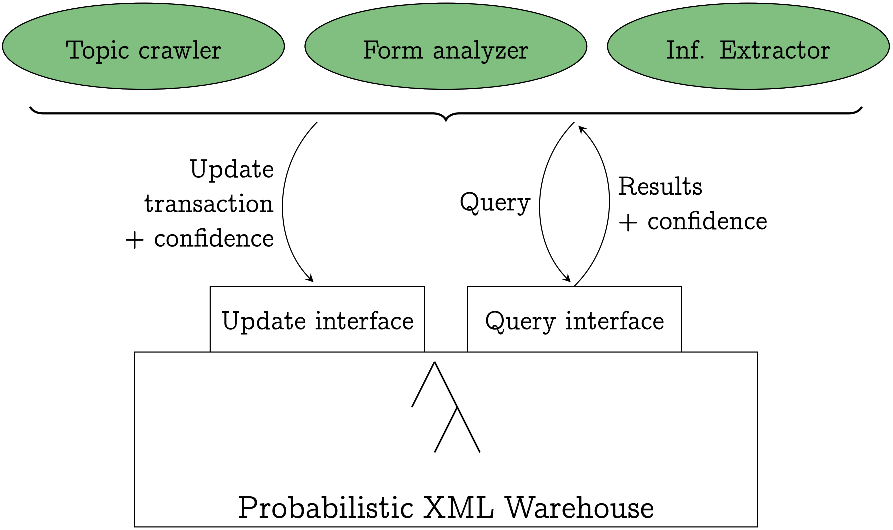

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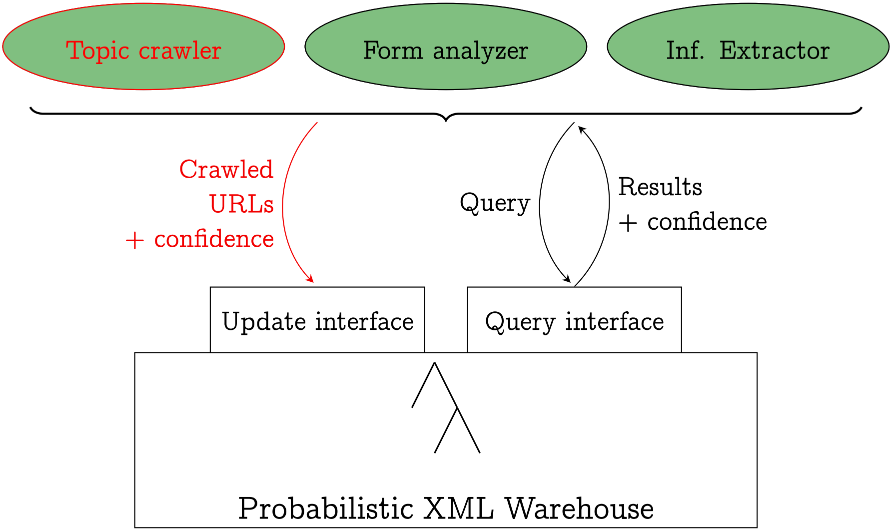

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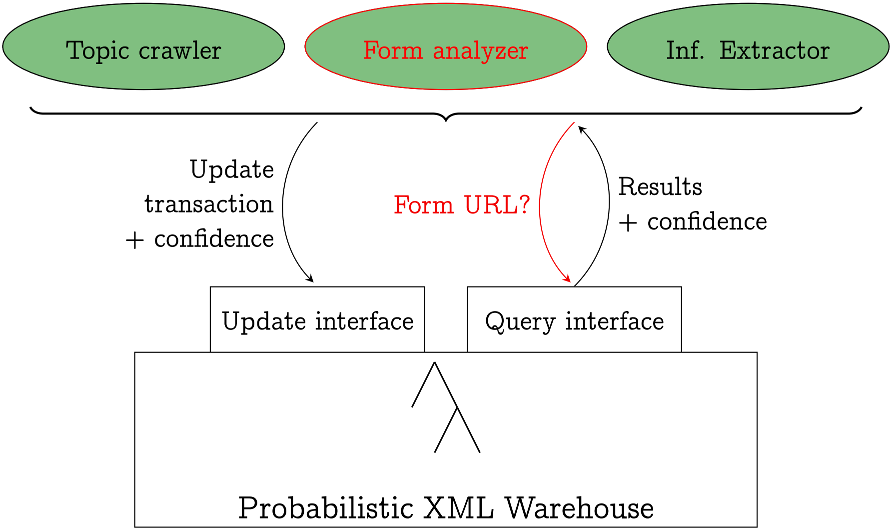

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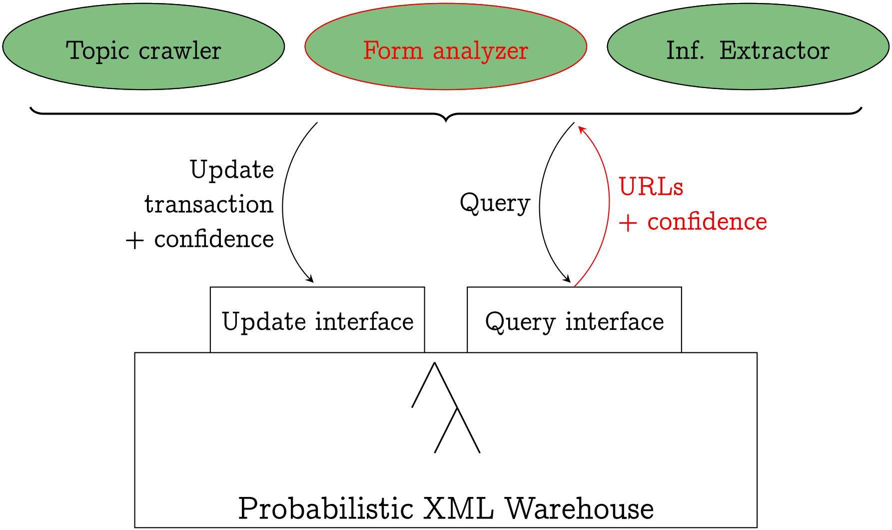

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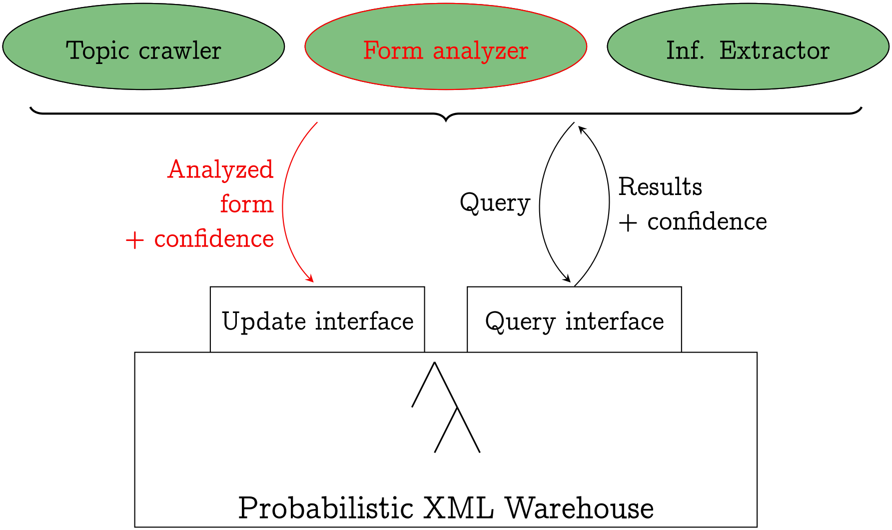

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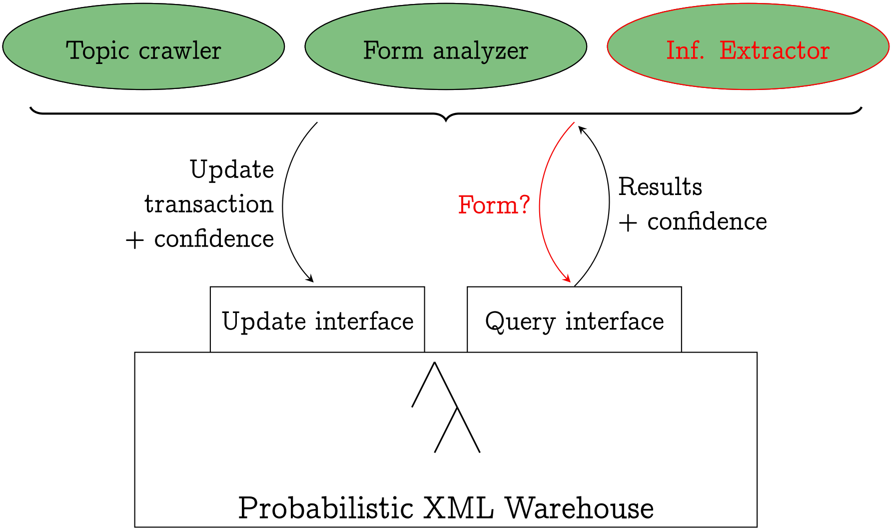

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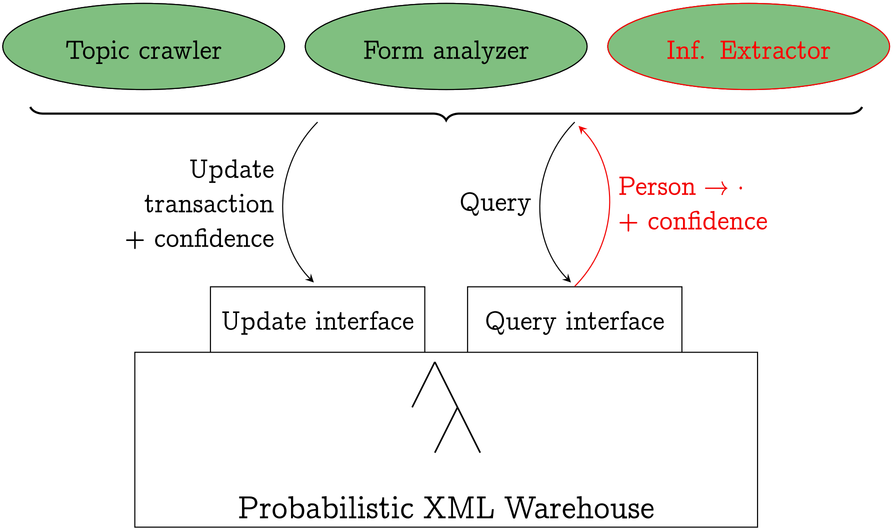

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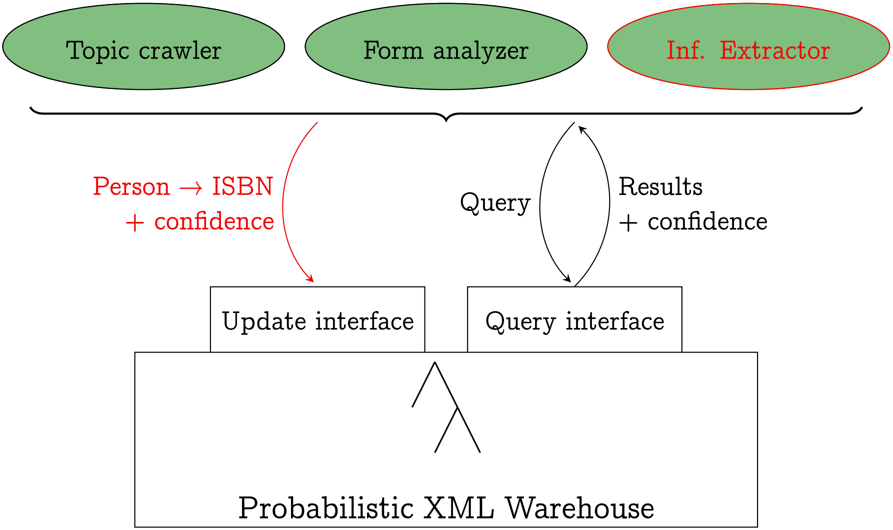

Probabilistic Trees

Framework

- Unordered data trees
- Details: no attributes, no mixed content. . .

(multiset semantics)

Sample space: Set of all such data trees.

Probabilistic tree (prob-tree): Representation of a discrete probability distribution over this sample space.

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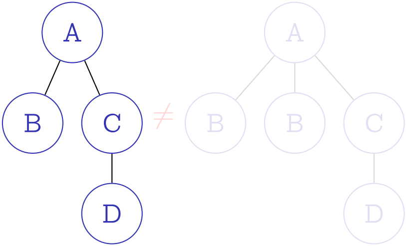

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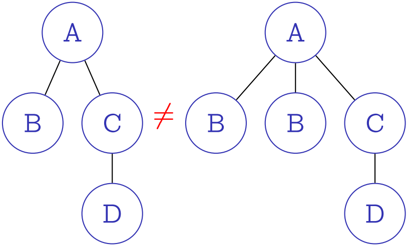

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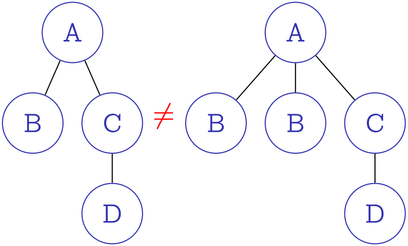

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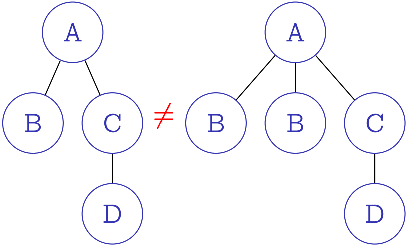

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Prob-tree model defined in [Abiteboul & Senellart 2006]. Here, we tackle complexity questions about it:

- What is the complexity of queries and updates?
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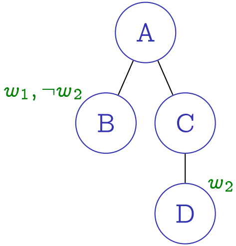
The Prob-Tree Model

- Data tree with event conditions (conjunction of probabilistic events or negations of probabilistic events) assigned to each node.
- Probabilistic events are boolean random variables, assumed to be independent, with their own probability distribution.
- Representation *à la* [Imieliński & Lipksi 1984].



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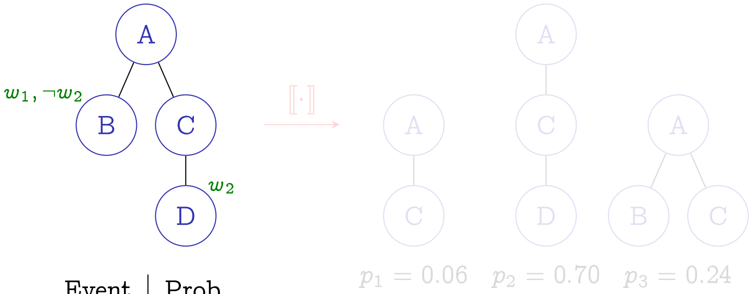

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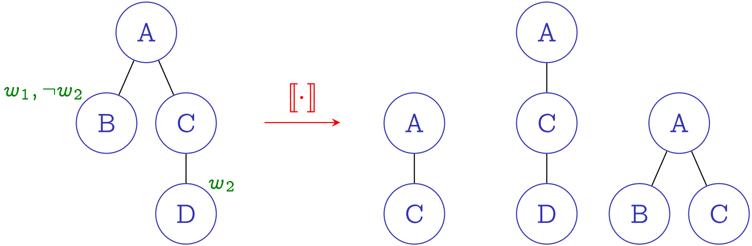

$p_1 = 0.06$ $p_2 = 0.70$ $p_3 = 0.24$

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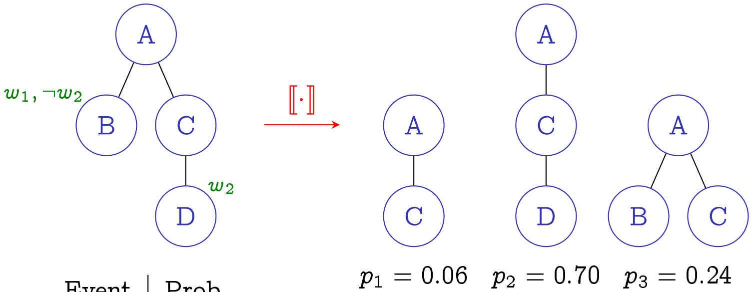

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Locally Monotone Queries

Query: function that maps a data tree t to a set of subtrees of t containing its root.

Definition

A query Q is locally monotone if, for any data trees u, t' and t such that $u \leqslant t' \leqslant t$, $u \in Q(t) \iff u \in Q(t')$.

Examples

- Tree-pattern queries with joins are locally monotone.
- "Return the root node if it has no A child, nothing otherwise." is not locally monotone.

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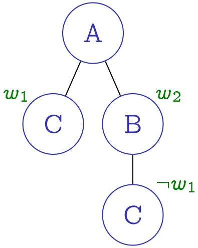

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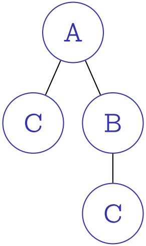

Underlying data tree.

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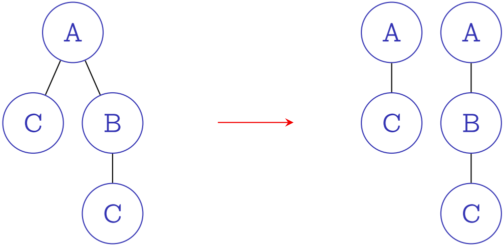

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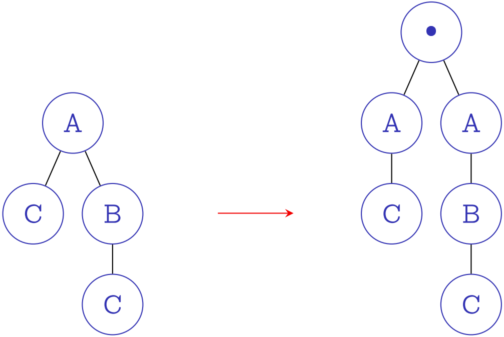

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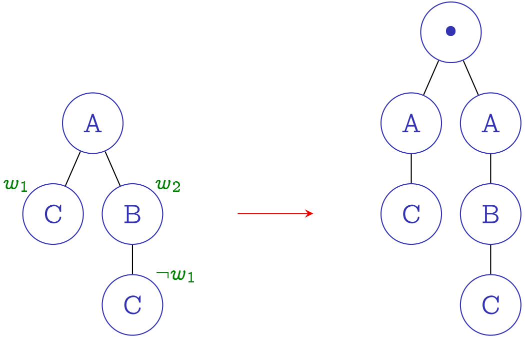

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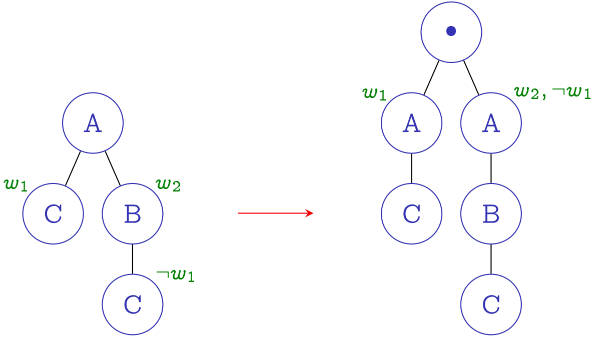
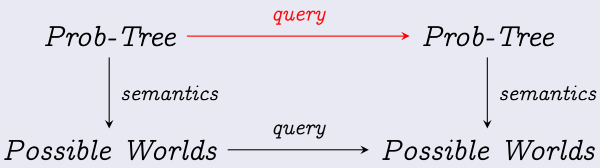


Consistence of Queries on Prob-Trees

Theorem



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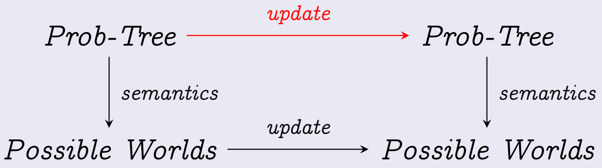

Complexity Results

T: prob-tree with underlying data tree t.
time$(Q(t))$: complexity of the query Q over the data tree t.

Upper bounds for operations on T:

Operation	Complexity
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Two Notions of Equivalence

What does it mean for two prob-trees to represent the same information?

Two different notions:

Structural Equivalence: we keep the same event variables.

Semantic Equivalence: we only consider the possible worlds semantics.

Complexity results? Relation between these two notions?

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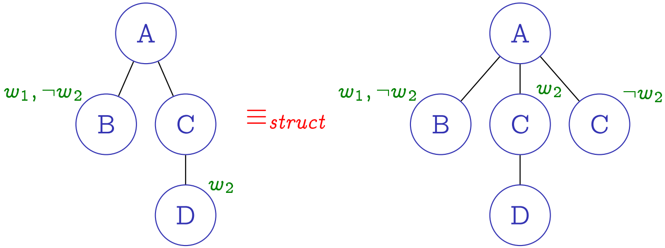

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*Structural Equivalence is a **coRP** problem: there exists a randomized polynomial-time algorithm that returns true if two prob-trees are equivalent, and false with probability $\geqslant 1/2$ otherwise.*

Based on the notion of count-equivalence:

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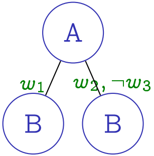

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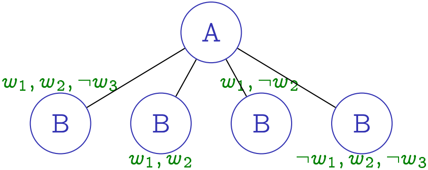

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(see [Green, Karvounarakis & Tannen 2007]).

Polynomial-time randomized algorithm for determining if a multivariate polynomial is zero [Schwartz 1980].

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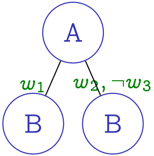

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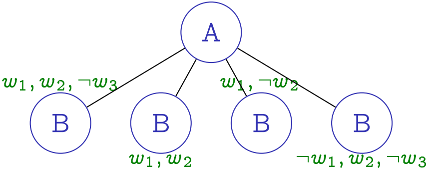

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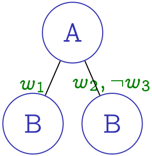

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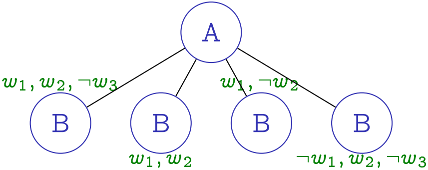

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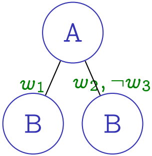

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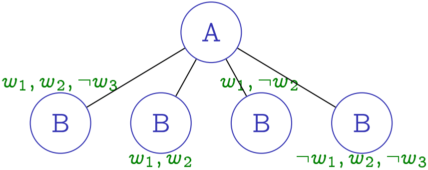

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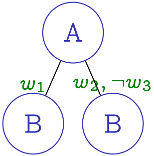

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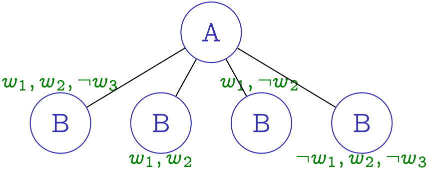

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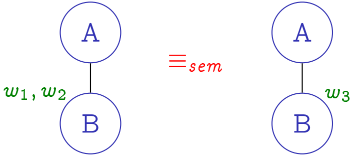

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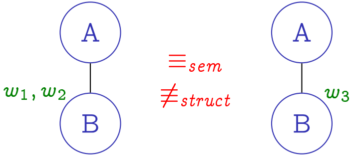

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1. *If* $T \equiv_{struct} T'$, *then* $T \equiv_{sem} T'$
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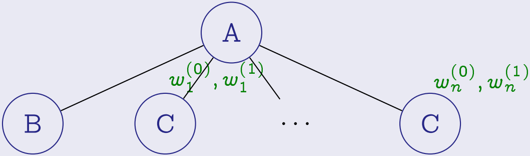
Merci.

Proof of the Exponential Complexity of Deletion

Proof.

Deletion d: "If the root has a C-child, then delete all B-children of the root."

$T =$



$\forall i, \pi(w_i) = 1/2$

Then, it can be shown that if $T' \equiv_{struct} d(T)$, at least 2^n literals appear in T'.

□

◂ Return to theorem

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