

Probabilistic XML: Survey and Challenges

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- 1 Motivation
- 2 Existing Work
- 3 Challenges

Numerous sources of **uncertain data**:

- Measurement errors
- Data integration from contradicting sources
- Imprecise mappings between heterogeneous schemata
- Imprecise automatic process (information extraction, natural language processing, etc.)
- Imperfect human judgment

Objective

Not to pretend this imprecision does not exist, and manage it as rigorously as possible throughout a long, automatic and human, potentially complex, process.

Especially:

- Use probabilities to represent the confidence in the data
- Query data and retrieve probabilistic results
- Allow adding, deleting, modifying data in a probabilistic way
- (If possible) Keep throughout the process lineage/provenance information, so as to ensure traceability

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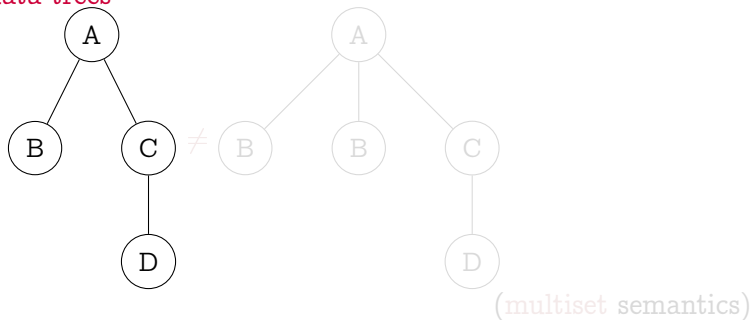
- Extensive literature about probabilistic relational databases [DRS09, Wid05, Koc09]
- Different typical querying languages: conjunctive queries vs tree-pattern queries (possibly with joins)
- Cases where a tree-like model might be appropriate:
 - No schema or few constraints on the schema
 - Independent modules **annotating** freely a content warehouse
 - Inherently tree-like data (e.g., mailing lists) with naturally occurring queries involving the descendant axis

Remark

Some results can be transferred from one model to the other. In other cases, connection much trickier (see later)!

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Unordered data trees

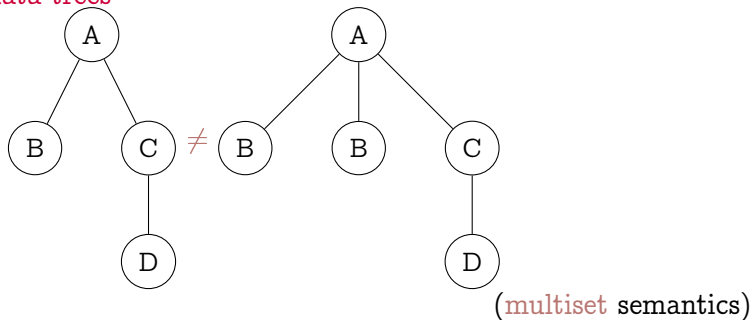


Sample space: Set of all such data trees.

Probabilistic XML database: (Succinct) representation of a discrete probability distribution over this sample space (= a set of possible worlds).

Trees and possible worlds

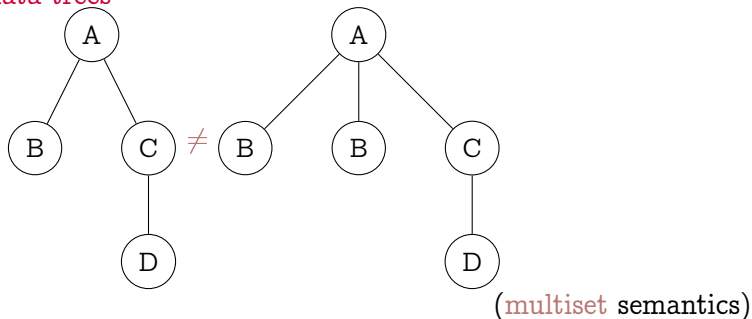
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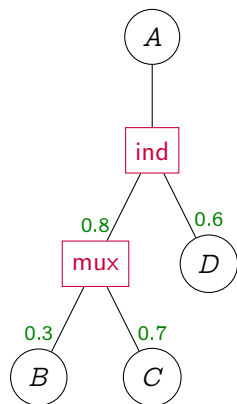
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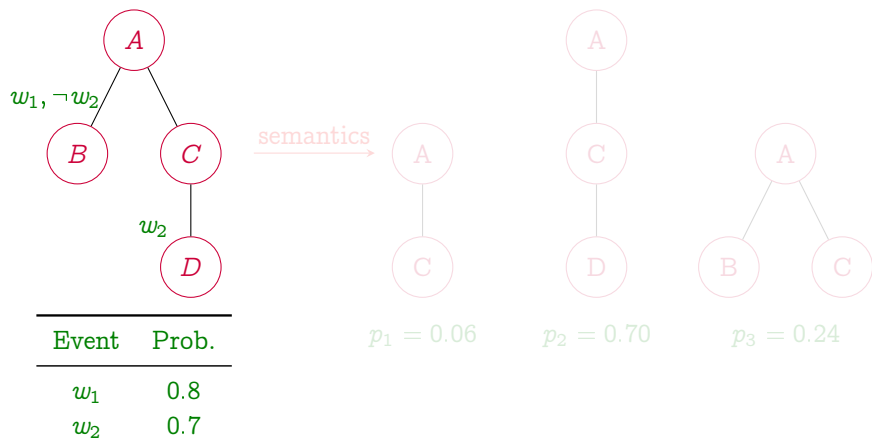
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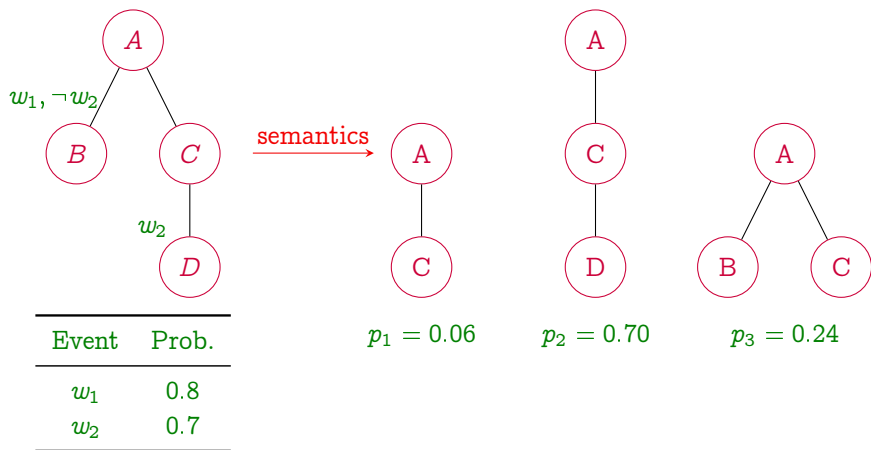


- Tree with **ordinary** (circles) and **distributional** (rectangles) nodes
- Distributional nodes specify how their **children** can be **randomly selected** (here, independently or in a mutually exclusive way)
- **Possible-world semantics**: every possible selection of children of distributional nodes, with associated probability
- No long-distance probabilistic dependencies in the tree!
- Minor generalizations of **ind** and **mux** also exist

Arbitrary dependencies [AS06]



- Conjunctions of independent events on each node of the tree [IL84]
- Expresses arbitrarily complex dependencies
- Bonus: events can track lineage [FGT08]



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Summary of results (data complexity)

	Local dependencies	Arbitrary dependencies
Expressiveness	Full expressive power [AS06, KKS08]	
Compactness	AD exponentially more compact than LD [Sen07, KKS08]	
Queries		
• tree-pattern	PTIME [KKS09]	$FP^{\#P}$ -complete [KKS08]
• with joins	$FP^{\#P}$ -complete	$FP^{\#P}$ -complete
• project-free	PTIME	PTIME [SA07]
• TP + HAVING	PTIME [CKS08]	$FP^{\#P}$ -complete
Tree automaton (typing, MSO)	PTIME [CKS09]	$FP^{\#P}$ -complete
Updates	Intractable [AKSS09]	Insertions tractable, Deletions intractable [SA07]

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Relational case

(Block-independent disjoint model, [DS07])

- Some conjunctive queries are **PTIME**
- Others are **#P-hard**
- Complex conditions to separate the two

XML case (Local dependencies)

- Tree pattern queries are **PTIME**
- Tree pattern queries with (non-trivial) joins are **#P-hard**

- Why does the XML case seem simpler?
- Is there some insight to be gained from one case to the other?
- Translating XML data and queries to the relational case yields queries with self-joins, a less well-understood setting

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- Most probabilistic database models assume **discrete** probabilistic distributions
- Sensor networks, unknown values: need for **continuous** distributions! (uniform, Gaussian, Poisson, etc.)
- Some existing works on query answering over continuous distributions [CKP03, DGM⁺04] but no clear semantics
- **Claim:** this is not more difficult than the discrete case, as long as integration/differentiation are easy (symbolically or numerically) for the considered distributions
- Discrete distributions can be modeled as **Diracs**



Tractable extensions of the local dependency model

- Arbitrary dependencies: **not tractable**
- Local dependencies: **not practical**
- Somewhere in between?
 - What makes the arbitrary dependency model hard?
 - How can the local dependency model be generalized, while remaining tractable?
- And can we go further? cf. XML schemas
 - Trees of unbounded depth
 - Trees of unbounded width
 - Infinite trees?



But where do probabilities come from?!

- Do the numbers assigned as probabilities in PDBMS really make sense?
- In some cases, sources of “good” probabilities:
 - Statistics
 - Conditional Random Fields
- What about the rest? Does it really make sense to model uncertainty with probabilities?

A system that just works

- Nothing else than toy systems exist for probabilistic XML
- What should it be based upon:
 - a probabilistic relational DBMS?
 - a native XML DBMS?
- Systems issue: distribution, indexing, etc.
- And need for a killer application! Probabilistic content warehouse?

Merci.



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