Matching Tree Patterns on Partial-trees

Optimizing Tree-Pattern Matching

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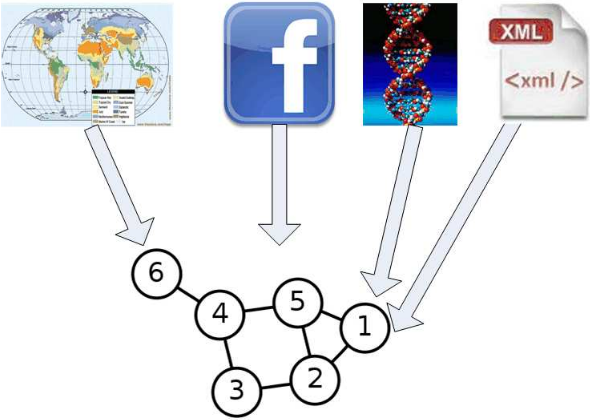
Outline

1. Motivation: Graph querying
2. Background: tree patterns
3. Partial trees - holistic divide and concur

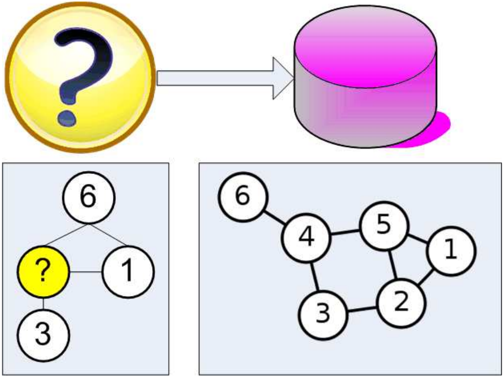
Motivation

Everything is a graph.

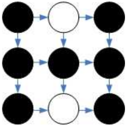


Motivation(cont.)

We need to query everything.



Lets take a picture



- A picture is a graph.

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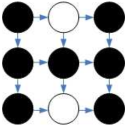

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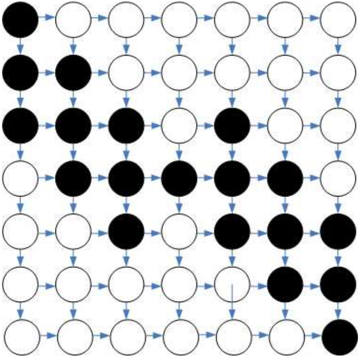
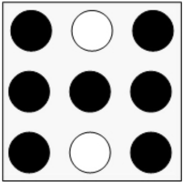


Holistic approach



- Given a graph pattern.

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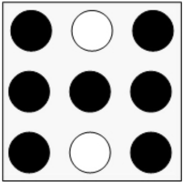
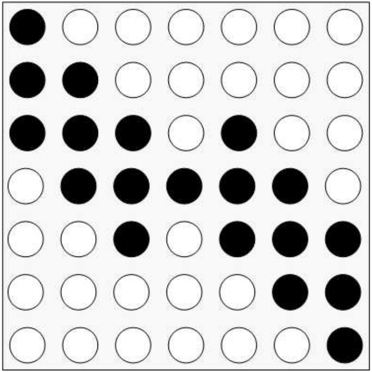


- Given a graph pattern.
- And a graph data,



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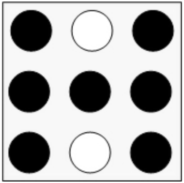
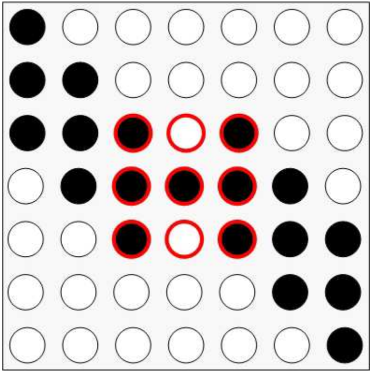


- Given a graph pattern.
- And a graph data,
- The solution is O O.



But Holistic is hard

- A Problem: Holistic pattern matching is NP-hard.
- Even subgraph isomorphism problem [8] is hard.

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- A Solution: divide and concur.

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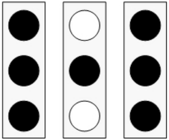

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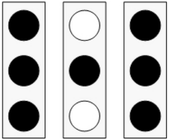

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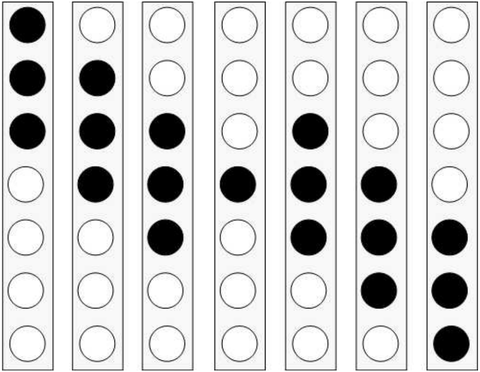

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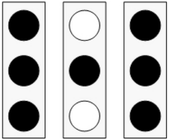

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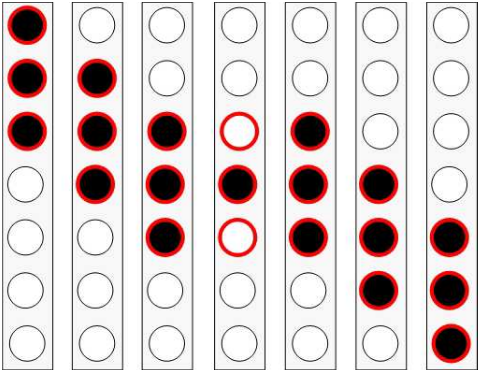
- Partial solutions O O.
- Strings matching is fast $O(P_i \times D_i)$



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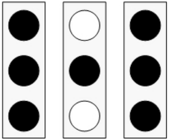

- Divide the pattern a local patterns P_i,
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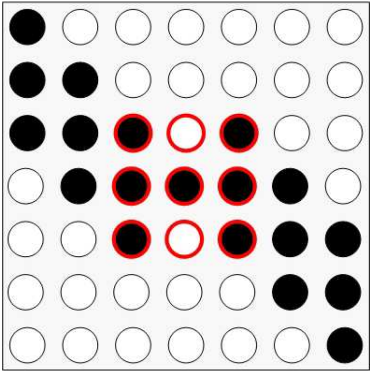
- Join (Concur) Final solution O O.



So local approach is perfect ?

- The answer is NO

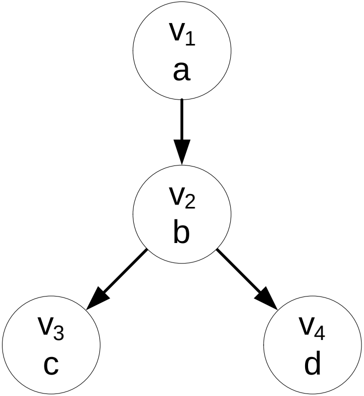
So local approach is perfect ?

- The answer is NO
- The concur is a Pyrrhic victory - i.e. the join costs.
- But lets focus on trees.

Outline

Tree Data Model

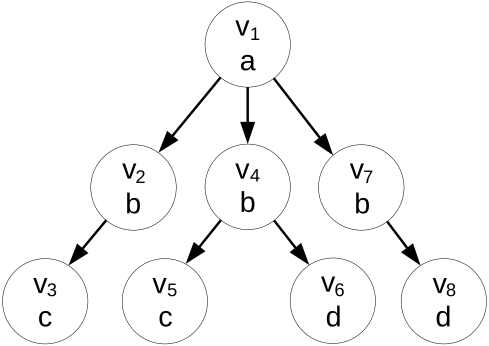
'**Tree pattern**' is a tree



The local approach problem

an example

query: '/a/b[/c]/d'



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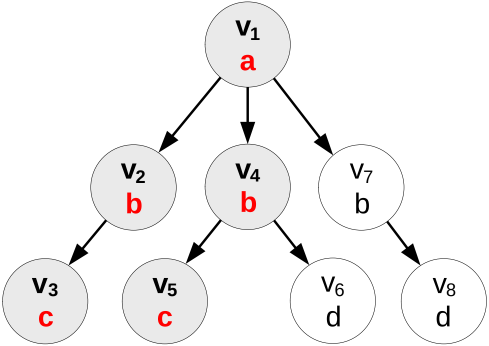

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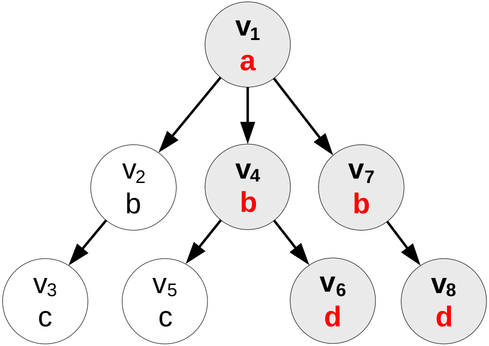

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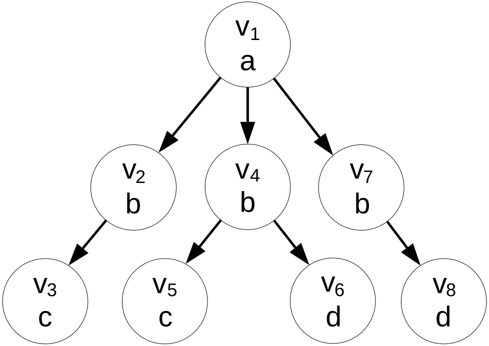

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4. answer:

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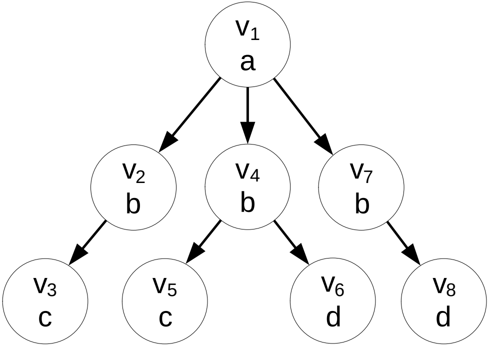

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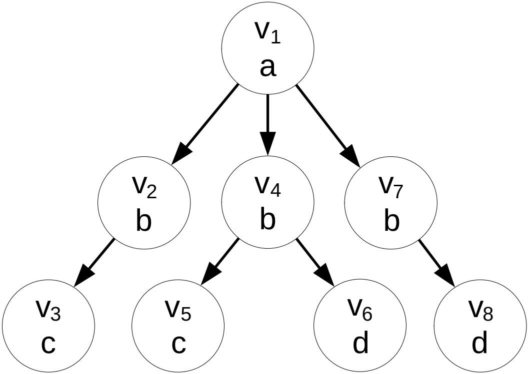

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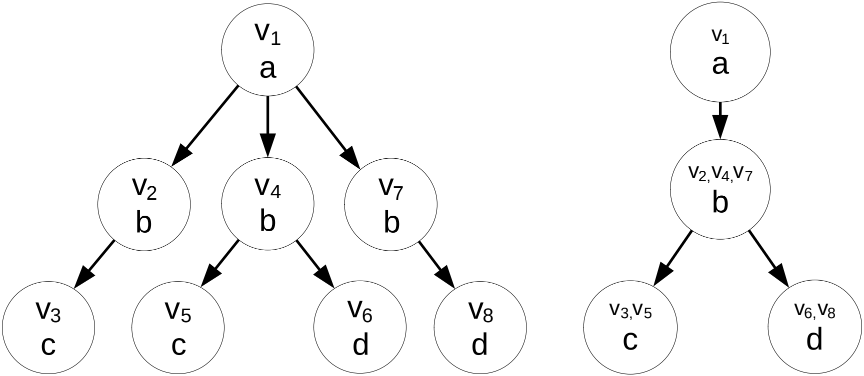

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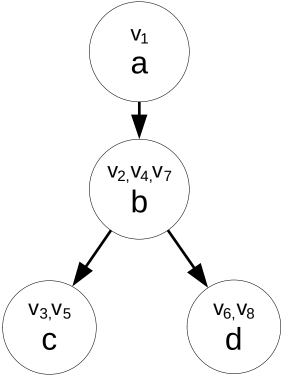

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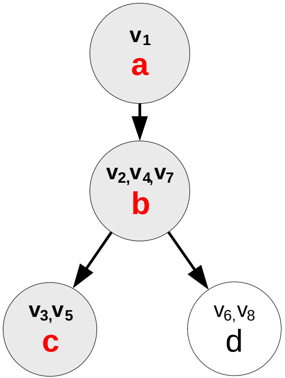

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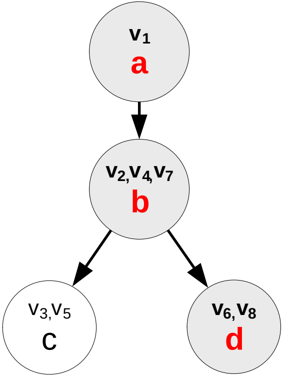

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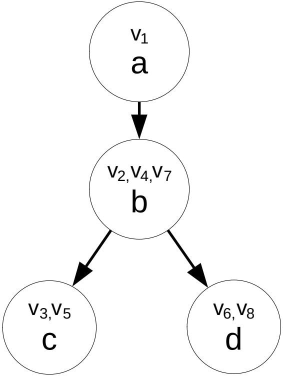
3. answer:

$(v_1,\ldots,v_8)$

Yet Another Pyrrhic victory

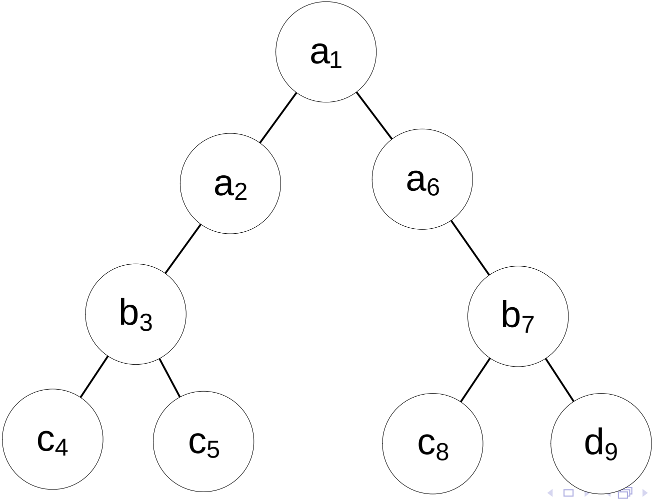


Outline

In the rest of this talk we

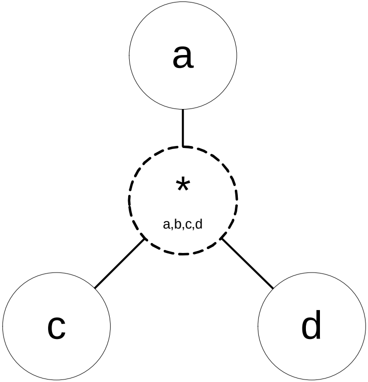
- Supplies a model for
  1. holistic structural-indexing.
  2. holistic lazy pattern matching.
- See experimental results.

Data Model - An example



Query Model: partial-trees

- Two kind of node:
  1. Tree nodes (single label);
  2. Subtree nodes (multiple labels).



Query Model: partial-trees

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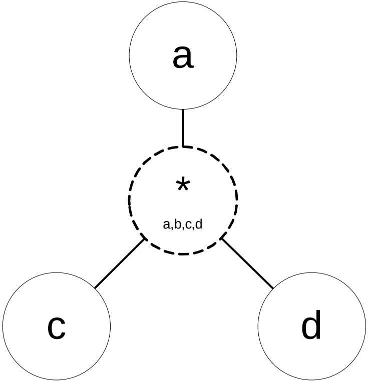
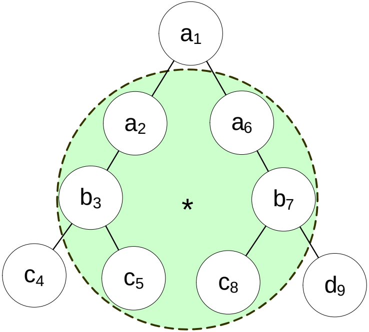
- Same as XPath pattern'/a//c[//d]'



Query matching: partial-trees

- Embedding T_p is obtained from T by a series of edge contractions.
- Embedding function f relates T_p and T nodes.
- Example $f:(v_1,a)$, (v_4,c), (v_9,d), $(v_2,\star)\ldots$
- $Solution(T, T_p) = \bigcup f$.



Query matching: partial-trees(cont.)

- Q: How we match patterns on structural indexes and physical data models?
- A: We model the data as a partial-tree.

Matching a partial-tree pattern on a patrial-tree

$$solution(\overline{T_p}, T_p) \triangleq \bigcup_T solution(T, \overline{T_p})^{-1} \circ solution(T, T_p)$$

Query matching: partial-trees(cont.)

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- A: We model the data as a partial-tree.
- Fast: $O(|\overline{T_p}| \times |T_p|)$.

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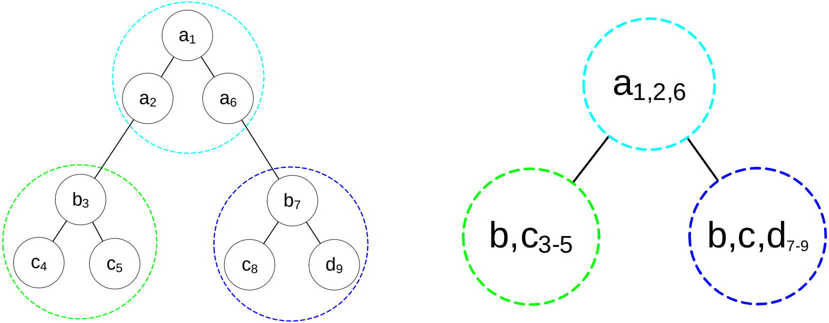
$$solution(\overline{T_p}, T_p) \triangleq \bigcup_T solution(T, \overline{T_p})^{-1} \circ solution(T, T_p)$$

Structural Indexing: partial-trees

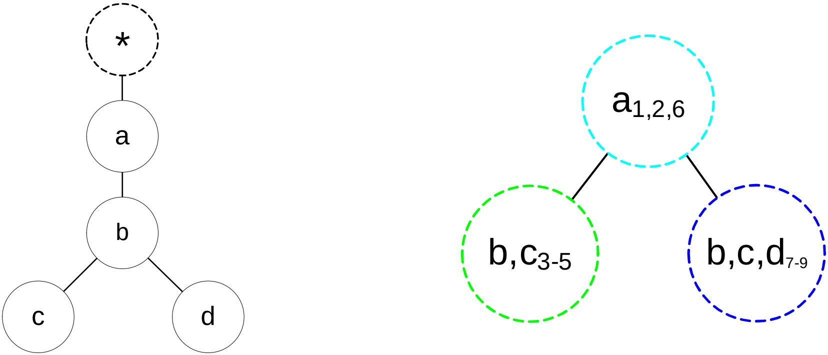
An holistic safe Index:

1. Offline: Embed T into an index $\overline{T_p}$
2. Online: $Solution(\overline{T_p}, T_p)$

Index example: offline phase



Index example: online phase



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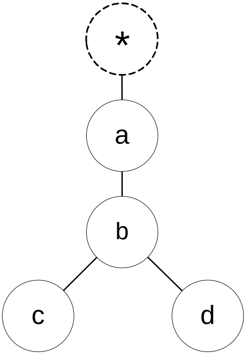
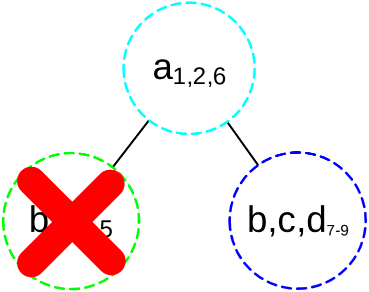
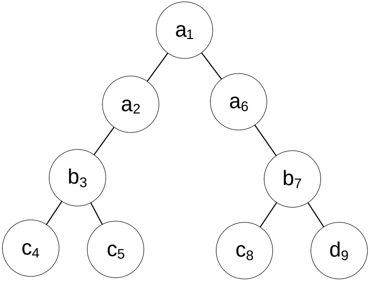




Experimental results: index

Data	K	Average coverage (%)	Average improvement (%)	Average gain	Maximal improvement (%)
DBLP	2	57	95	2887	11.44
DBLP	3	86	87	8095	38.37
DBLP	4	95	81	16424	11.18
DBLP	5	9	72	20283	0.19
DBLP	6	100	58	53726	0.15
DBLP	7	100	44	60168	0.15
DBLP	8	100	47	55841	0.16
XMark	2	0	100	0	100
XMark	3	28	93	1936	58.2
XMark	4	46	78	5717	1.27
XMark	5	17	92	1810	1.16
XMark	6	22	96	627	8.9
XMark	7	28	87	3640	0.42
XMark	8	60	73	9184	0.53

Holistic matching data model: region encoding



Term	(*Doc*, *first*, *last*, *level*)
'a'	$(1,1,9,1)$, $(1,2,5,2)$, $(1,6,9,2)$
'b'	$(1,3,5,3)$, $(1,7,9,3)$
'c'	$(1,4,4,4)$, $(1,5,5,4)$, $(1,8,8,4)$
'd'	$(1,9,9,4)$

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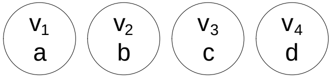

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Holistic matching: history

Holistic matching was developed by following ideas:

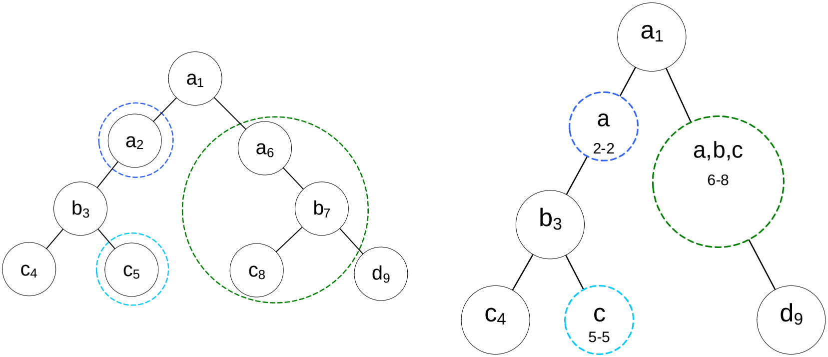
1. Algebraic approach: Binary joins.
2. Algebraic approach: Path joins.
3. Holistic approach: *TwigStack* [4], *Twig*^{2}*Stack*.
4. Holistic approach: *TwigTA*
   - Theoretic foundations.
   - Controls the ‘Laziness’.
   - Predicts unmatched nodes before extraction.
   - Scalable.

Lazy holistic matching: partial-trees

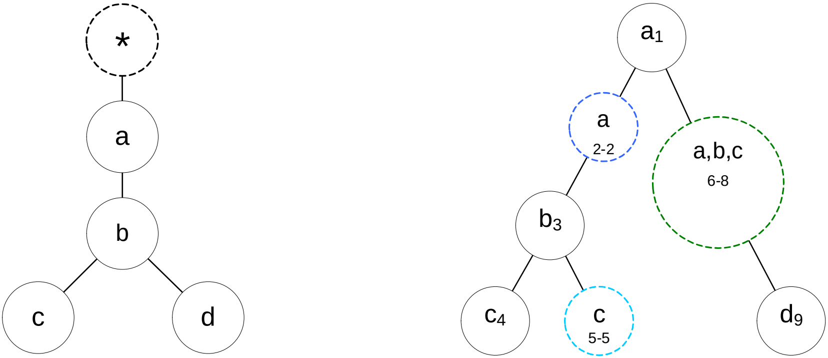
The matching algorithm list of region-encodings of nodes. The algorithm iteratively does the following:

1. Extracts set of node-encodings S.
2. Translates S into a partial tree $\overline{T_p}$.
3. Preforms $Solution(\overline{T_p}, T_p)$ and refines a set of intermediate holistic solutions.

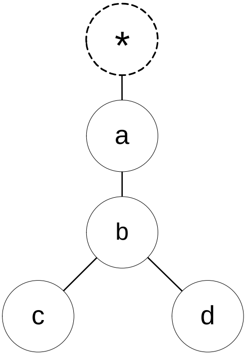
Matching example: iteration I - translates S into $\overline{T_p}$

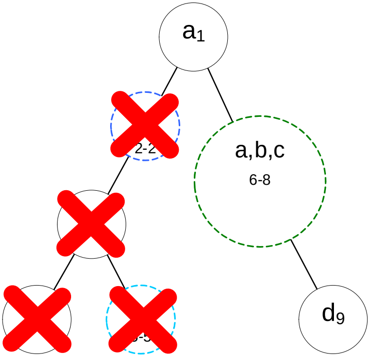


Matching example: iteration I - $Solution(\overline{T_p}, T_p)$

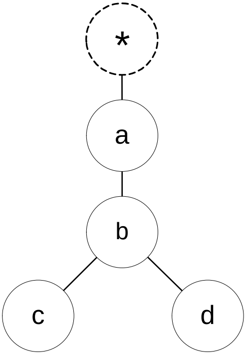


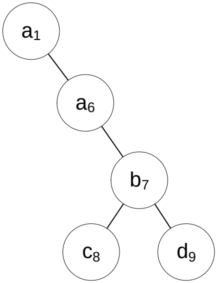
Matching example: iteration I - $Solution(\overline{T_p}, T_p)$



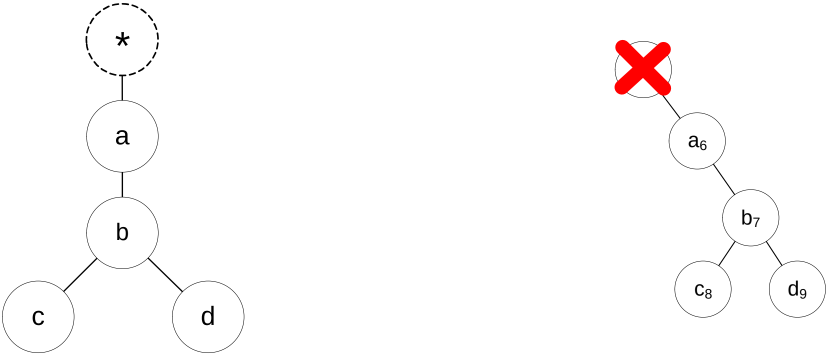


Matching example: iteration II



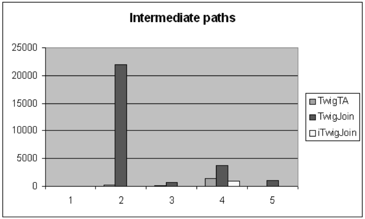


Matching example: iteration II



Experimental results: matching

- *TwigTA*[6] Vs. *TwigStack*[4].
- *TwigTA* prunes up to 99% of the nodes.



Summary

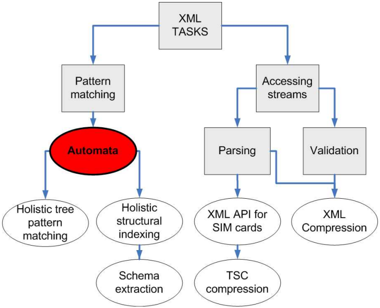
We:

- Understood local vs. holistic tree pattern matching.
- Learn about partial-tree pattern model and applied it for:
  - Holistic structural-indexing;
  - Holistic lazy pattern-matching.

Future Work

- What about graph data, graph patterns?
- What about other domains: RDF, streaming, image mining ?

XML tasks and applications - accomplished in my PhD Thesis [1]



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S.Harrusi, A.Averbuch. Tree automata based holistic twig pattern matching: TA methodology. VLDB 2011.

[1] Optimizing XML Processing, 2010

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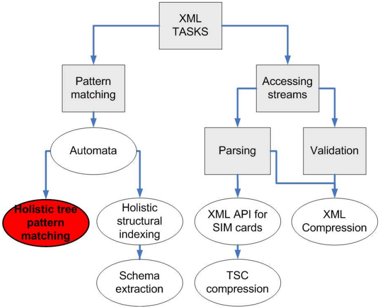

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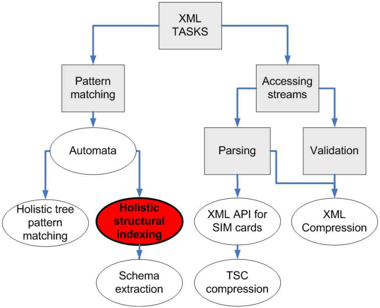

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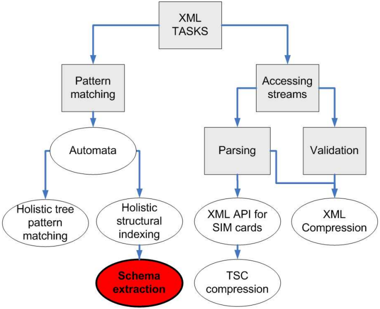

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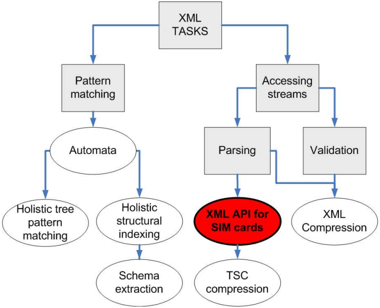

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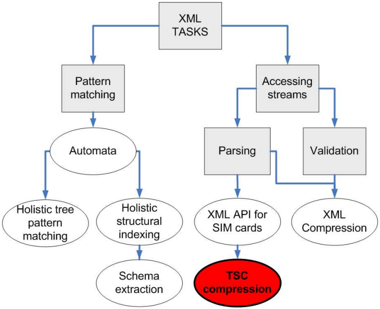

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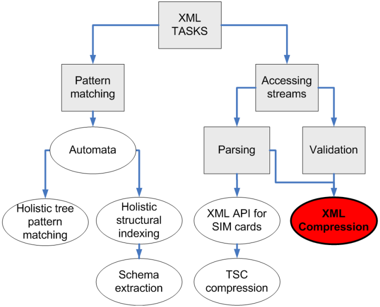

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The End!

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