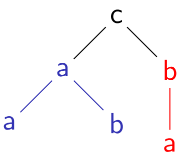
Stackless Processing of Streamed Trees

Corentin Barloy, Filip Murlak, Charles Paperman

LINKS seminar

Processing streamed trees

XML encoding of trees:



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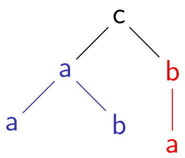

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- validation
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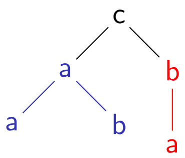

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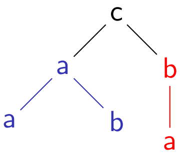

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Two problems:

- validation - decide whether a tree complies with a given specification.
- querying - select all nodes satisfying a given query.

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RPQs: the path from the root belongs to a given regular language.

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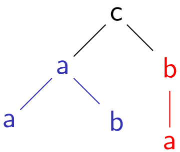
Evaluate the RPQ ca^*b:



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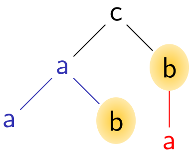

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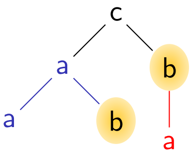

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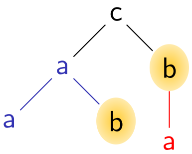

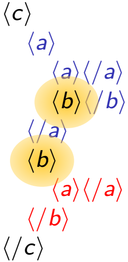

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Motivation: Path Queries = Order-invariant Queries.

Evaluation in constant memory

Which RPQs can be evaluated in constant memory?

Theorem (Effective characterisation)

RPQ L can be evaluated in constant memory $\Leftrightarrow$ L is (almost) reversible

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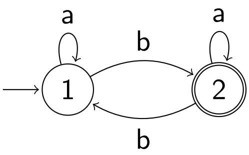

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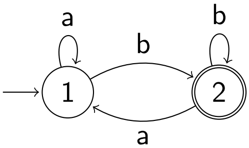

We can check last letters for free: $\begin{matrix} \{a,b\}^* b \\ //b \end{matrix}$ is doable.

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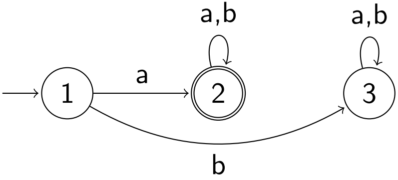

We can check the root for free: $\begin{matrix} a\{a,b\}^* \\ a// \end{matrix}$ is doable.

Proof sketch

$\Leftarrow$: If L is reversible then it can be evaluated in constant memory.

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Algorithm:

- When an opening tag is read, follow the transition in the automaton.
- When a closing tag is read, follow the transition in the reverse automaton.

Proof sketch

$\Rightarrow$: $\begin{array}{c}(a+b+c)^*ab\\ //a/b\end{array}$ cannot be evaluated in constant memory.

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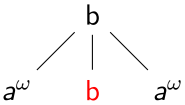

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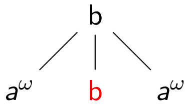

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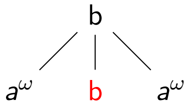

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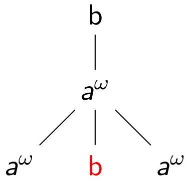

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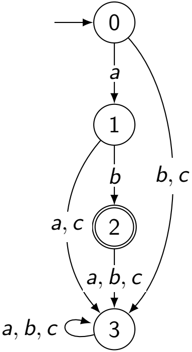
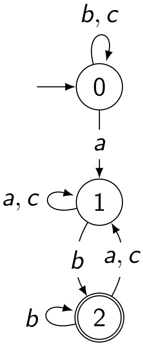
Limitations of constant memory evaluation

Many queries cannot be evaluated in constant memory.



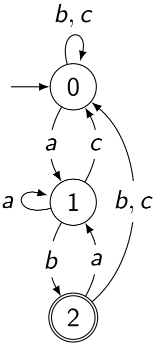
ab

$/a/b$



$(a+b+c)^*a(a+b+c)^*b$

$//a//b$



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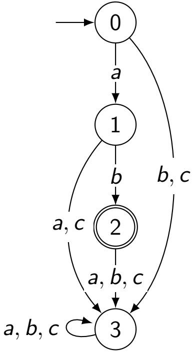

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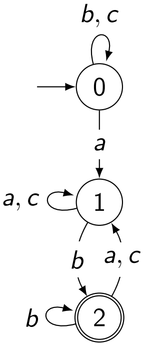

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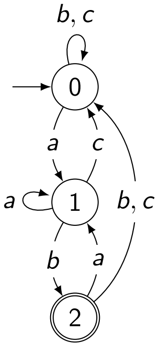

$(a+b+c)^*ab$

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They can be evaluated using a stack, but this is costly (memory linear in the depth).

Stackless queries
(Evaluation in logarithmic memory)

Stackless automata

Main ingredients:
- a finite state machine,
- a counter that stores the current depth in the tree,
- a finite number of registers where the counter values can be stored,
- can compare register values with the current depth.

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Evaluating:

$(a+b+c)^*a(a+b+c)^*b$

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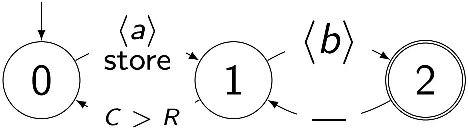

Effective characterisation of stackless RPQs

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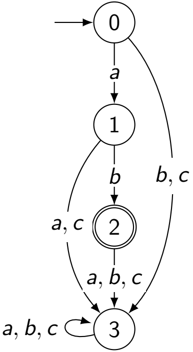

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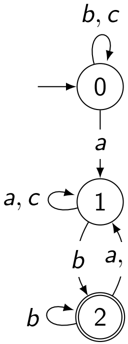

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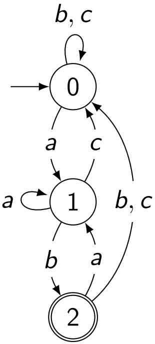

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Algorithm:

- When an opening tag is read, follow the transition in the automaton.
  If there is a change of SCC, store the depth in a register.
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  If the depth reached is stored, resume the computation in the previous SCC instead.

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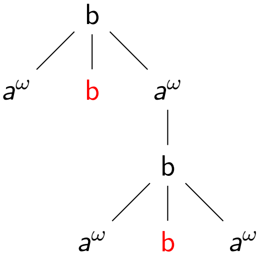

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The set of trees such that all a's are at the same depth.

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Finding a sequence of consecutive siblings is not stackless.

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Segoufin & Vianu solved it for fully recursive DTDs.

We solve it for tree languages of the form: each branch is in language L.

General problem still open, both for constant-memory and our stackless model.

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- Ongoing work on vectorization.