XML and Databases
XPath evaluation (2)

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Week 9

Recap from last week

1. Node Selection algorithm: can be used for full XPath (with filters, `ancestor` and `parent` axes, ...), but is not very efficient and cannot work in streaming.

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Today

Automata algorithm for XPath with backward filters

Streaming?

To answer a query in streaming, you are only allowed to use memory proportional to **the depth** of the tree.

In practice you might need a stack whose size is at most the depth of the tree. You are not allowed to buffer the whole document, load it into memory with DOM or precompute another data-structure using a SAX parser (DAG, tables,...).

Automata and XPath

For the XPath query:

```
//a/b//d
```

Automata and XPath

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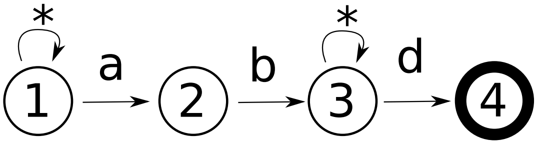
We can execute the NFA:



XPath with backward filters

What about the query:

```
//a[./ancestor::c/parent::b]/b//d[./parent::e]
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XPath with backward filters

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$$\texttt{//a[}\underbrace{\texttt{./ancestor::c/parent::b}}_{\text{when is this true ?}}\texttt{]/b//d[./parent::e]}$$

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3. Whose parent is a b

XPath with backward filters

What about the query:

$$\texttt{//a[}\underbrace{\texttt{./ancestor::c/parent::b}}_{\text{when is this true ?}}\texttt{]/b//d[./parent::e]}$$

1. The node must be an `a` $\Rightarrow$ The descendant of
2. With an ancestor `c`
3. Whose parent is a `b`

XPath with backward filters

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$$\texttt{//a[}\underbrace{\texttt{./ancestor::c/parent::b}}_{\text{when is this true ?}}\texttt{]/b//d[./parent::e]}$$

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XPath with backward filters

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2. With an ancestor `c` ⇒ a node `c`
3. Whose parent is a `b` ⇒ which is the child of a `b`

XPath with backward filters

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$$\Rightarrow \texttt{//b/c//*}$$

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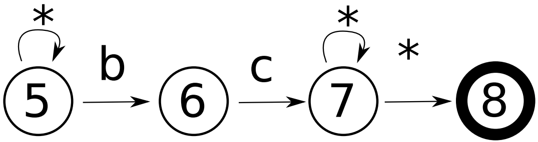
XPath and backward filters

```
//b/c//*
```

XPath and backward filters

`//b/c//*`

This is a simple query! We can use the automaton:



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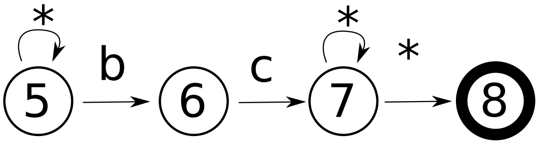
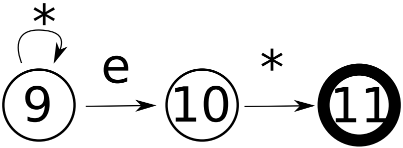


And also: [./parent::e] becomes //e/* for which we can use:

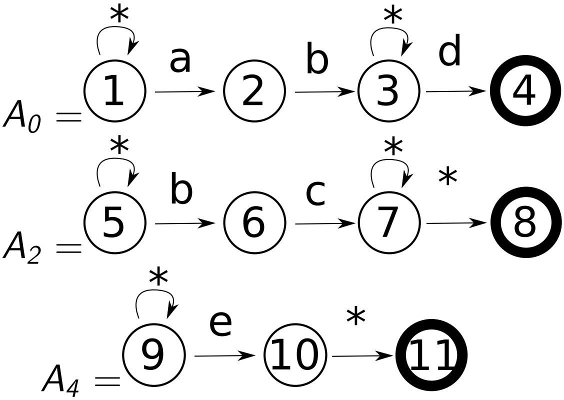


Running the automata

From

`//a[./ancestor::c/parent::b]/b//d[./parent::e]`

we get



A_0 is the automaton for the "main" XPath expression. The other A_i automata correspond to the filter which must be checked for state i of automaton A_0.

Query transformation algorithm

1. Split the query into a "main" downward query and its filters.
   e.g.:
   `//a[./ancestor::c/parent::b]/b//d[./parent::e]`
   becomes:
   `//a/b//d` , `./ancestor::c/parent::b` , `./parent::e`

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   becomes:
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2. The main query is unchanged. Transform the backward queries into forward ones. e.g.:
   `//a/b//d` , `./ancestor::c/parent::b` , `./parent::e`
   becomes:
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   becomes:
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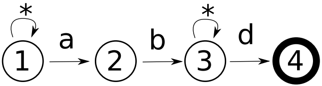
3. Transform each query obtained in step 2 into an NFA.

XPath evaluation algorithm over SAX events

Remember, to evaluate an NFA, you keep track of the current states that you have reached, in a **set of states** S.

When you read a label, for each state in S, you compute the destination states according to the transitions and put them in a state S'.

For instance with: 

if your current set of states is $\{1, 3\}$ and you see an a-node, you go into the states $\{1, 2, 3\}$. Now, we just have several automata, so we keep several sets of states.

"Reading a label" corresponds to seeing a `startElement(...)`

XPath evaluation algorithm over SAX events

Assume you have an automaton class: `Auto` with the following methods:

- StateSet `transition(String label, StateSet S)`: Computes the set of states reachable from the states in S, with a given label.

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Assume you have an automaton class: `Auto` with the following methods:

- StateSet `transition(String label, StateSet S)`: Computes the set of states reachable from the states in S, with a given label.
- `bool isFinal(StateSet S)` returns true is a final state of the automaton is in S.

XPath evaluation algorithm over SAX events

Assume that your main query has states: $\{1, \ldots, N\}$ You need:

- An array `AAutos[N+1]` containing `Auto` objects. `AAutos[0]` contains the automaton for the main query, `AAutos[i]` contains the automaton for state `i` of the main query (can be `null` if there is no automaton for that state)
- A counter the preorder number
- A `Stack` which will contain arrays of set of states. Each array has size `N+1` the cell `i` of such an array contains the current set of states for automaton `AAutos[i]`.

XPath evaluation algorithm over SAX events

Initialisation : Create an array `States[N+1]` and put in `States[i]` the set containing the initial state of `AAutos[i]` (put `null` if `AAutos[i] == null`). Push `States` on the `Stack`.

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For $i = 1$ to N

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    if (AAutos[i] != null)
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AAutos[i].transition(label,States[i])
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`AAutos[0].transition(label,States[0])`

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```
      if (AAutos[i] == null ||
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leave q in `Stemp`, otherwise remove it.

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startElement(String label) (continued) :

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        NextStates[0] = Stemp
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XPath evaluation algorithm over SAX events

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```
        NextStates[0] = Stemp
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XPath evaluation algorithm over SAX events

startElement(String label) (continued) :

```
NextStates[0] = Stemp
if (AAutos[0].isFinal(NextStates[0]))
  print the current preorder
```

XPath evaluation algorithm over SAX events

startElement(String label) (continued) :

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NextStates[0] = Stemp
if (AAutos[0].isFinal(NextStates[0]))
  print the current preorder
Push NextStates on the stack
```

XPath evaluation algorithm over SAX events

startElement(String label) (continued) :

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NextStates[0] = Stemp
if (AAutos[0].isFinal(NextStates[0]))
  print the current preorder
Push NextStates on the stack
Increment preorder counter
```

XPath evaluation algorithm over SAX events

startElement(String label) (continued) :

```
NextStates[0] = Stemp
if (AAutos[0].isFinal(NextStates[0]))
```

print the current preorder

Push `NextStates` on the stack

Increment preorder counter

endElement(String label) : Just pop the stack!

Next week

- Adding following-sibling/preceding siblings
- More hints/pseudo code on how to implement automata