The XPath Language

Pierre Genevès
CNRS

M2R – University of Grenoble, 2009–2010

Why XPath?

Search, selection and extraction of information from XML documents are essential for any kind of XML processing.

→ XPath is the W3C standard language for expressing traversal and navigation in XML trees.

XPath Introduction

- A common syntax and semantics for many web languages
- A W3C recommendation (www.w3.org/TR/xpath)
- Compact syntax, not in XML, for use within XML attributes
- A language for expressing paths
- XPath operates on the logical (tree) structure of XML documents, not on their syntax

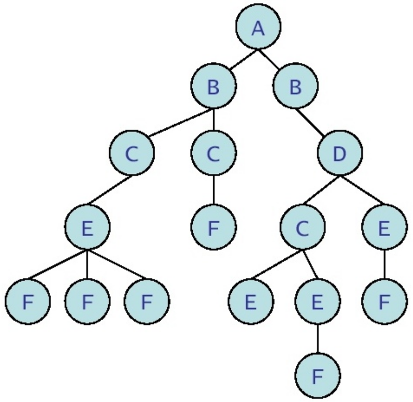
XPath Expressions

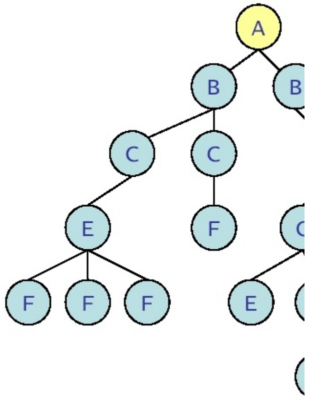
- XPath provides a powerful mechanism for navigating in XML trees: the *location path*
- A *location path* is a sequence of *location steps* separated by '/':

$$\underbrace{\texttt{child} :: \texttt{chapter}}_{\textit{location step}} / \underbrace{\overbrace{\texttt{descendant}}^{\textit{axis}} :: \overbrace{\texttt{section}}^{\textit{nodetest}}}_{\textit{location step}} / \underbrace{\texttt{child} :: \texttt{para}}_{\textit{location step}}$$

Evaluating a *location path*

- Starting from a context node, a *location path* returns a *node-set*
- Each node of this *node-set* becomes in turn the context node for evaluating the next *step*

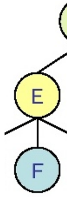




Context node

Evaluation Context

- Every XPath expression is evaluated with respect to a *context* that includes:
  - the *context node*
  - 2 integers > 0 obtained from the evaluation of the last *step*:
    - *context size*: the number of nodes in the *node-set*
    - *context position*: the index of the context node in the *node-set*
  - a set of variable bindings (the bindings are expressed in the host language)
- Navigation "propagates" the *context*: evaluation of a*step* yields a new *context state*
- Remark: a *location path* starting with '/' indicates that the initial *context* is set to the root of the document, such a *location path* is called "*absolute*"



nt:

Zoom on *location steps*

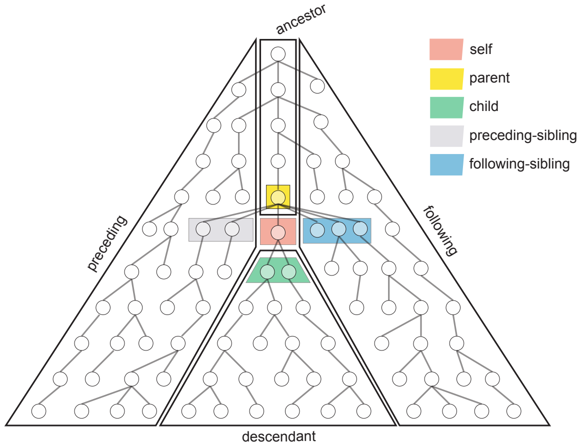
- A each navigation step, nodes can be filtered using *qualifiers*
- General syntax of a *location step*:

$$\mathit{axis}::\mathit{nodetest}[\mathit{qualifier}][\mathit{qualifier}]$$

- A *location step* is composed of 3 parts:
  1. an *axis*: specify the relation between the context node and returned nodes
  2. a *nodetest*: type and name of returned nodes
  3. optional *qualifiers* that further filter nodes
- Qualifiers are applied one after the other, once the selection is performed by the *axis* and *nodetest*
- A qualifier returns a *node-set* that is filtered by the next qualifier
- Exemple :
  - `child::section[child::para]`

Axes

- Indicates where in the tree (with respect to the context node) selected nodes must be searched
- XPath defines 13 *axes* allowing navigation, including:



- 5 *axes* define a partition of tree nodes

Axes

- Each *axis* has a direction: forward or backward (w.r.t *document ordering*)
- Other axes:
  - `ancestor-or-self`, `descendant-or-self`
  - `attribute`: selects attributes of the context node (element)
  - `namespace`: selects namespace nodes of the context node

Nodetest

- The *nodetest* of a *location step* indicates which nodes must be chosen on the considered *axis*
- A *nodetest* filters nodes based on *kind* and *name*

Kind Test	Semantics
`node()`	let any node pass
`text()`	preserve text nodes only
`comment()`	preserve comment nodes only
`processing-instruction()`	preserve processing instructions

Name test

- A *nodetest* can be a *name test*, preserving only nodes with given name

Name Test	Semantics
name	preserve **element** nodes with tag *name* only
	(for attribute axis: preserve attributes)
*	preserve **element** nodes with arbitrary tag names
	(for attribute axis: preserve attributes)

- Remarks:
  - $path/axis\text{::}* \subseteq path/axis\text{::node()}$
  - $path/\text{attribute::node()} \not\subseteq path/\text{child::node()}$

Qualifier

- A *qualifier* filters a *node-set* depending on the *axis* and returns a new*node-set*
- A *qualifier* is a boolean expression evaluated depending on the *context*:
  - context node
  - *context size*: number of nodes in the *node-set*
  - *context position*: index of the context node in the *node-set*, in the order of the document (or in reverse document order for *backward* axes)
- Each node of a *node-set* is kept only if the evaluation of the *qualifier* for this node returns *true*
- Examples:
  - `following-sibling::para[position()=last()]`
  - `child::para[position() mod 2 = 1]`

Value Comparisons

- *Qualifiers* may include comparisons:

$$path[path_1\ \mathbf{eq}\ path_2] \qquad \mathbf{eq} \in \{=,\ !=,\ <,\ >,\ <=,\ >=\}$$

- Existential semantics:

$$node\text{-}set_1\ \mathbf{eq}\ node\text{-}set_2$$
$$\text{iff}$$
$$\exists n_1 \in node\text{-}set_1, \exists n_2 \in node\text{-}set_2 \mid \texttt{string-value}(n_1)\ \mathbf{eq}\ \texttt{string-value}(n_2)$$

- `string-value`(*n*): concatenation of all descendant text nodes in *document order*
- Example: `descendant::chapter[child::section="Conclusion"]`

→ all "`chapter`" nodes whose at least one "`section`" child has *string-value* "Conclusion".

- Comparisons may involve (implicit) type casting (ex: `a[b>7]`)

General XPath Expressions

- A general XPath *expression* is a *location path*, or a union of *location paths* separated by '|'
- *Qualifiers* may include boolean expressions:
  $\mathtt{path[(}path\ \mathbf{eq}\ path\mathtt{)\ or\ (}qualifier\ \mathtt{and\ not(}qualifier\mathtt{))]}$
- An XPath expression may include *variables* (notation: $x)
  - variables are bound by the host language (*i.e.* they are constants ☺)
  - they are part of the evaluation context

Observation on Data Value Comparisons

- Assume variable $x is bound to a *node-set*
- What do you think of the following XPath expressions e_1 and e_2?

$$\underbrace{\texttt{\$x="foo"}}_{e_1} \qquad \underbrace{\texttt{not(\$x!="foo")}}_{e_2}$$

- e_1 is different from e_2:

→ e_1 is true iff there exists a node in $x which has *string-value* foo;

→ e_2 is true iff all nodes in $x have string *string-value* foo.

- Owing to negation and comparison defined by existential quantification, we can formulate universal quantification...
  - "`chapter`" nodes whose all children "`section`" are empty[1]?

  → `descendant::chapter[not(child::section!="")]`

[1] have an empty *string-value*

Basic Functions

- *Node-sets* are not the only types of XPath expressions: there are *boolean*, *numerical* and *string* expressions too
- Every XPath implementation must provide at least a list of basic functions called *Core Function Library* (c.f. appendix)
- Examples:
  - `last()`: a number, the *context size*
  - `position()`: a number, the *context position*
  - `count(`*`node-set`*`)`: number of nodes in the *node-set*
  - `concat(`*`string, string, string*`*`)`: concatenate several strings
  - `contains(`*`str1, str2`*`)`: boolean, true if *`str1`* contains *`str2`*
  - ...
- Any XPath expression can be used within a *qualifier*, for instance:

```
descendant::recipe[count(descendant::ingredients)<5 and
contains(child::title, "cake")]
```

Abbreviated Syntax

- `child::` is the default axis, it can be omitted
- `@` is a shorthand for `attribute::`
- `//` is a shorthand for `/descendant-or-self::node()/`
- `.` is a shorthand for `self::node()`
- `..` is a shorthand for `parent::node()`
- `[4]` is a shorthand for `[position()=4]`

Example	Expanded Form
`book/section`	`child::book/child::section`
`p[@id="bla"]`	`child::p[attribute::id="bla"]`
`.//p`	`self::node()/descendant-or-self::node()/child::p`
`../title`	`parent::node()/child::title`
`p[3]`	`child::p[position()=3]`

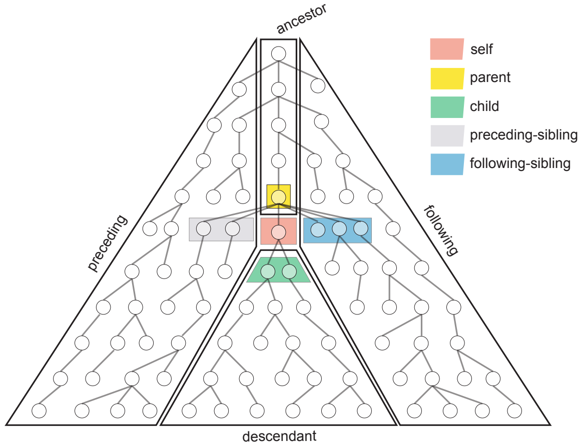
Question...

What do you think of the following XPath expressions e_1 et e_2?

$$\underbrace{\texttt{self::title}}_{e_1} \qquad \underbrace{\texttt{parent::node()/child::title}}_{e_2}$$

Question...

Can we rewrite the XPath expression `following::p` without the axis `following`?



XPath: A Core Component for XML Technologies

- XPath is used in:
  - XSLT: selection of document parts to be transformed
  - XPointer: identification of XML fragments
  - XLink: definition of hypertext links
  - XQuery: XPath is the (main) subset of the query language
  - XML Schema: expressing the tree region in which unicity is guaranteed
  - XForms: expressing dependencies (data bindings)
  - ...
- Often, it is even the **essential** component

Appendix

XPath *Core Function Library*

Functions over *node-sets*

- last(): a number, the *context size*
- position(): a number, the *context position*
- count(*node-set*): number of nodes in the *node-set*
- id(*object*): selects elements by their unique ID
- local-name(*node-set*): returns the local part of the expanded-name of the node in the argument *node-set* that is first in document order.
- namespace-uri(*node-set*): returns the namespace URI of the expanded-name of the node in the argument *node-set* that is first in document order
- name(*node-set*): returns a string containing the whole name of the node in the argument *node-set* that is first in document order

String Functions

- string(*object*): convert *object* to a string
- concat(*string*, *string*, *string**): concatenate several strings
- start-with(*string1*, *string2*) : boolean, true if *string1* starts with *string2*
- contains(*str1*, *str2*) : boolean, true if *str1* contains *str2*
- substring-before(*string1*, *string2*): the substring of *string1* before the first occurrence of *string2*
- substring-after(*string1*, *string2*): the substring of *string1* after the first occurence of *string2*
- substring(*string*, *number1*, *number2*): the substring of *string* that starts at position *number1* and whose length is *number2*
- string-length(*string*): number of characters in *string*
- normalize-space(*string*): remove beginning, ending and double spaces
- translate(*s1*, *s2*, *s3*): replace in *s1* each char of *s2* by the char of same position in *s3*
  example : `translate("bar","abc","ABC")` returns `BAr`

Boolean Functions

- boolean(*object*): convert *object* into boolean, returns true if non zero number, non empty *node-set*, string with non zero length
- not(*boolean*): negation of *boolean*
- true()
- false()
- lang(*string*): the language (attribute xml:lang) of context node is the same or a sublanguage of *string*

Arithmetic Functions

- `number(`*`object`*`)`: convert *`object`* into a number
- `sum(`*`node-set`*`)`: sum of the (type casted) number representation of each node in the *`node-set`*
- `floor(`*`number`*`)`: greatest integer less or equal to *`number`*
- `ceiling(`*`number`*`)`: smallest integer greater than or equal to *`number`*
- `round(`*`number`*`)`: the closest integer of *`number`*

Operator Precedence

1. <=, <, >=, >
2. =, `!=`
3. `and`
4. `or`