XPath and XQuery

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XPath and XQuery

Querying XML documents

Common properties

- Expression languages designed to query XML documents
- Convenient access to document nodes
- Intuitive syntax analogous to filesystem paths
- Comparison and arithmetic operators, functions, etc. . .

XPath

Used within other standards:

- XSLT
- XML Schema
- XPointer
- DOM

XQuery

Standalone standard. Main applications:

- XML data access and processing
- XML databases

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XPath — status

XPath 1.0

- W3C Recommendation, XI 1999
- used within XSLT 1.0, XML Schema, XPointer

XPath 2.0

- Several W3C Recommendations, I 2007:
  - *XML Path Language (XPath) 2.0*
  - *XQuery 1.0 and XPath 2.0 Data Model*
  - *XQuery 1.0 and XPath 2.0 Functions and Operators*
  - *XQuery 1.0 and XPath 2.0 Formal Semantics*
- Used within XSLT 2.0
- Related to XQuery 1.0

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XPath and XQuery Data Model

- Theoretical basis of XPath, XSLT, and XQuery
- XML document tree
- Structures and simple data types
- Basic operations (type conversions etc.)

Differences between 1.0 and 2.0

	XPath 1.0	XPath 2.0
simple data types	`boolean`, `number`, `string`	all XML Schema simple types
structures	node sets	sequences of nodes and simple values

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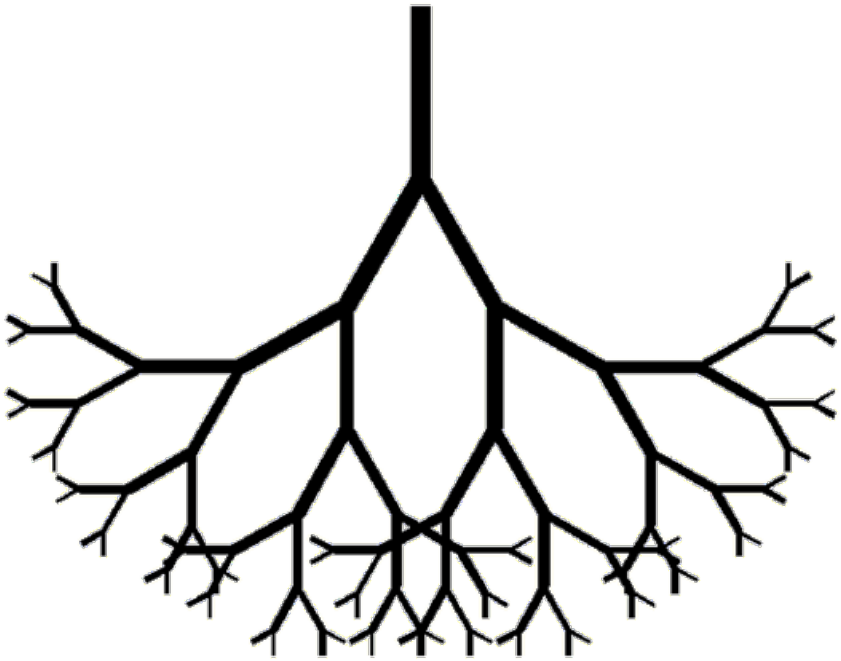
XML document in XPath model

- Document tree
- Physical representation level fully expanded
  - CDATA, references to characters and entities
- No adjacent text nodes
- Namespaces applied and accessible
- XML Schema applied and accessible
  - ! XPath 2.0 “schema aware” processors only
- Attribute nodes as element “properties”
  - ! formally, attribute is not child of element
  - ! however, element is parent of its attributes
- Root of tree — **document node**
  - ! main element (aka document element) is not the root

XPath node kinds

Seven **kinds** of nodes:

- document node (root)
- element
- attribute
- text node
- processing instruction
- comment
- namespace node



Sequences

- Values in XPath 2.0 — **sequences**
- Sequence consists of zero or more **items**
  - nodes
  - atomic values

Sequences properties

- Items order and number of occurrence meaningful
- Singleton sequence equivalent to its item:
  `3.14 = (3.14)`
- Nested sequences implicitly flattened to canonical representation:
  `(3.14, (1, 2, 3), 'Alice') = (3.14, 1, 2, 3, 'Alice')`

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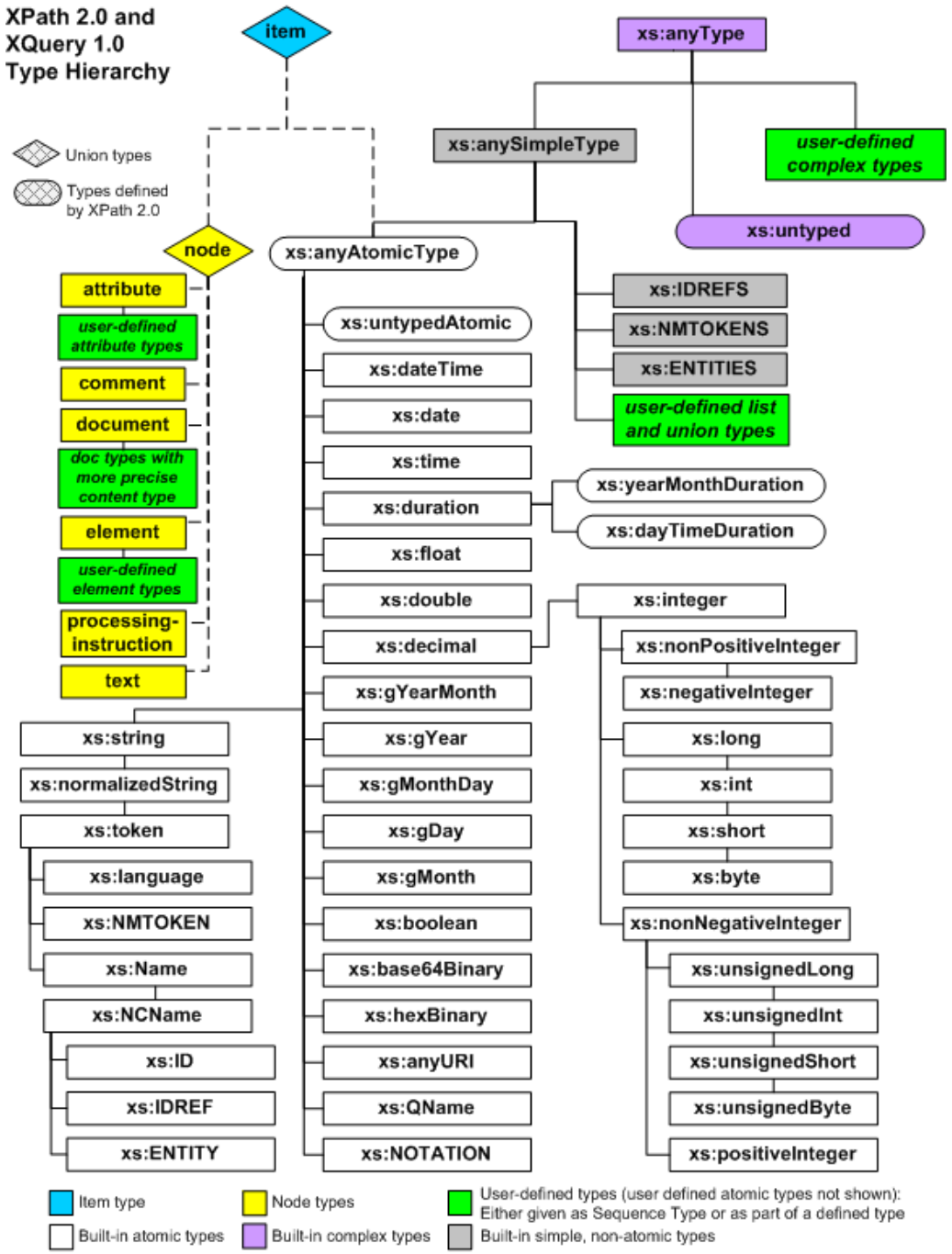
XPath 2.0 and
XQuery 1.0
Type Hierarchy
item
xs:anyType
Union types
Types defined by XPath 2.0
xs:anySimpleType
user-defined complex types
xs:untyped
node
xs:anyAtomicType
attribute
user-defined attribute types
comment
document
doc types with more precise content type
element
user-defined element types
processing-instruction
text
xs:IDREFS
xs:NMTOKENS
xs:ENTITIES
user-defined list and union types
xs:untypedAtomic
xs:dateTime
xs:date
xs:time
xs:duration
xs:yearMonthDuration
xs:dayTimeDuration
xs:float
xs:double
xs:decimal
xs:integer
xs:nonPositiveInteger
xs:negativeInteger
xs:long
xs:int
xs:short
xs:byte
xs:nonNegativeInteger
xs:unsignedLong
xs:unsignedInt
xs:unsignedShort
xs:unsignedByte
xs:positiveInteger
xs:gYearMonth
xs:gYear
xs:gMonthDay
xs:gDay
xs:gMonth
xs:boolean
xs:base64Binary
xs:hexBinary
xs:anyURI
xs:QName
xs:NOTATION
xs:string
xs:normalizedString
xs:token
xs:language
xs:NMTOKEN
xs:Name
xs:NCName
xs:ID
xs:IDREF
xs:ENTITY
Item type
Built-in atomic types
Node types
Built-in complex types
User-defined types (user defined atomic types not shown): Either given as Sequence Type or as part of a defined type
Built-in simple, non-atomic types

Data model in XPath 1.0

- Four types:
  - `boolean`
  - `string`
  - `number`
  - `node set`
- No collection of simple values
- Sets (and not sequences) of nodes

Effective Boolean Value

- Treating any value as boolean
- Motivation: convenience in condition writing, e.g. `if ( person[@passport] ) ...`

Conversion rules

empty sequence	→	**false**
sequence starting with node	→	**true**
single boolean value	→	that value
single empty string	→	**false**
single non-empty string	→	**true**
single number equal to `0` or `NaN`	→	**false**
other single number	→	**true**
other value	→	error

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Atomization

- Treating any sequence as sequence of atomic values
- Motivation: sequences comparison, arithmetic, type casting

Conversion rules (for each item)

atomic value	→	that value
node of declared atomic type	→	node value
node of list type	→	sequence of list elements
node of unknown simple type or one of `xs:untypedAtomic`, `xs:anySimpleType`	→	text content as single item
node with mixed content	→	text content as single item
node with element content	→	error

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Paths — typical XPath application

- `/company/department/person`
- `//person`
- `/company/department[name = 'accountancy']`
- `/company/department[@id = 'D07']/person[3]`
- `./surname`
- `surname`
- `../person[position = 'manager']/surname`

But there is much more to learn about XPath :)

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Literals and variables

Literals

- strings: `'12.5'`, `"He said, ""I don't like it."""`
- numbers: `12`, `12.5`, `1.13e-8`

Variables

- `$x` — reference to variable `x`,
- Variables introduced through:
  - XPath 2.0 (`for`, `some`, `every`)
  - XQuery (FLWOR, `some`, `every`, function parameters)
  - XSLT 1.0 and 2.0 (`variable`, `param`)

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Type casting

Type constructors

- `xs:date("2010-08-25")`
- `xs:float("NaN")`
- `adresy:kod-pocztowy("48-200")` (schema aware processing)
- `string(//obiekt[4])` (valid in XPath 1.0 too)

`cast as` operator

- `"2010-08-25" cast as xs:date`
- ...

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`cast as` operator

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Functions

- Function invocation:
  - `concat('Mrs ', name, ' ', surname)`
  - `count(//person)`
  - `my:fac(12)`
- 150 (XPath 2.0) built-in functions:
- Custom functions defining:
  - XQuery
  - XSLT 2.0
  - execution environment
- EXSLT — de-facto standard of additional XPath functions and extension mechanism for XSLT 1.0

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Chosen built-in XPath functions

Text

concat(s1, s2, ...) substring(s, pos, len)
starts-with(s1, s2) contains(s1, s2)
string-length(s) translate(s, t1, t2)

Numbers

floor(x) ceiling(x)
round(x) abs(x)

Nodes

name(n?) local-name(n?) namespace-uri(n?)
id(s) nilled(n?) document-uri(doc)

Context

current() position()
last() current-time()

Sequences

count(S) sum(S) min(S) max(S) avg(S)
empty(S) reverse(S) distinct-values(S)

Date and time

month-from-date(t)
adjust-date-to-timezone(t, tz)

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Operators

- 68 operators in XPath 2.0 (after overloading expansion)

Arithmetic

- `+` `-` `*` `div` `idiv` `mod` on numbers
- `+` and `-` on `date/time` and `duration`

Node sets / sequences

- `union` `|` `intersect` `except`
- not nodes found — type error
- result without repeats, document order preserved

Logical values

- `and` `or`

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Comparison operators

Atomic comparison (XPath 2.0 only)

- `eq ne lt le gt ge`
- applied to singletons

General comparison (XPath 1.0 and 2.0)

- `= != < <= > >=`
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- XPath 2.0 semantics:
  There exists a pair of items, one from each argument sequences, for which the corresponding atomic comparison holds.
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General comparison — nonobvious behaviour

Equality operator does not check the real equality

`(1, 2) = (2, 3)` – true
`(1, 2) != (1, 2)` – true

Equality is not transitive

`(1, 2) = (2, 3)` – true
`(2, 3) = (3, 4)` – true
`(1, 2) = (3, 4)` – false

Inequality is not just equality negation

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() = ()          – false
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```

Conditional expression (XPath 2.0)

```
if CONDITION
  then RESULT1
  else RESULT2
```

- Effective Boolean Value of CONDITION
- One branch computed

Example

```
if details/price
then
  if details/price >= 1000
  then 'Insured mail'
  else 'Ordinary mail'
else 'No data'
```

Iteration through sequence (XPath 2.0)

```
for $VAR in SEQUENCE
return RESULT
```

- *VAR* assigned subsequent values from *SEQUENCE*
- *RESULT* computer in context where *VAR* is assigned current value
- overall result — (flattened) sequence of subsequent partial results

Examples

```
for $i in (1 to 10)
  return $i * $i

for $p in //person
  return concat($p/name, ' ', $p/surname)
```

Sequence quantifiers (XPath 2.0)

```
some $VAR in SEQUENCE
satisfies CONDITION

every $VAR in SEQUENCE
satisfies CONDITION
```

- Effective Boolean Value of `CONDITION`
- Lazy evaluation allowed
- Arbitrary order of items checking

Examples

```
some $i in (1 to 10)  satisfies $i > 7

every $p in //person  satisfies $p/surname
```

XPath paths

Absolute path

/step/step ...

Relative path

step/step ...

Step — fully expanded syntax

axis::node-test [predicate1] ...[predicateN]

axis direction in document tree

node-test selecting nodes basing on kind, name, ...

predicates arbitrary filtering expressions

Example

```
/descendant::team[attribute::id = '3']/child::person[1]
                                /child::surname/child::text()
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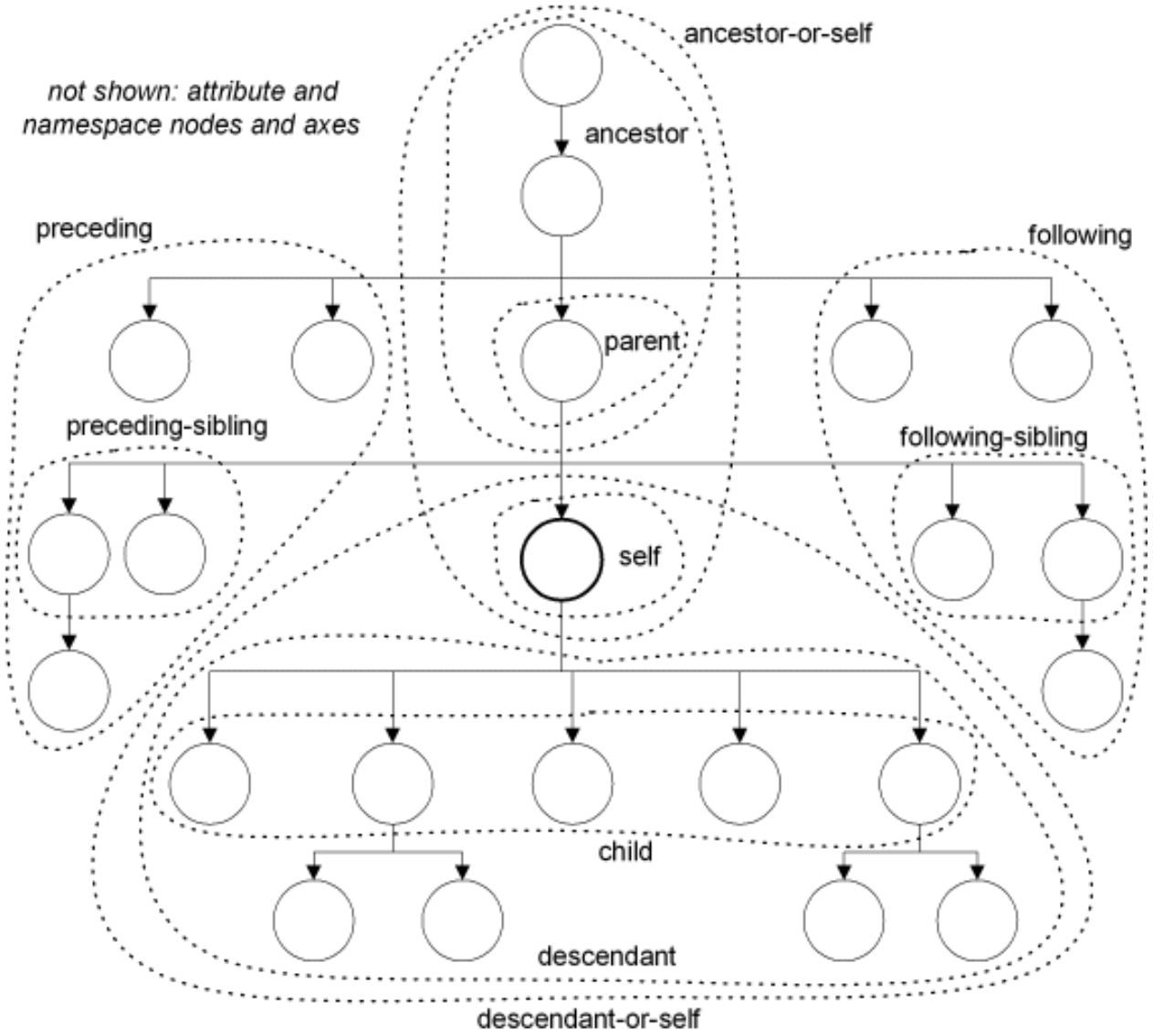
```

Axis

- `child`
- `descendant`
- `parent`
- `ancestor`
- `following-sibling`
- `preceding-sibling`
- `following`
- `preceding`
- `attribute`
- `namespace`
- `self`
- `descendant-or-self`
- `ancestor-or-self`

Axis



cite: *www.GeorgeHernandez.com*

Node test

Kind of node

- `node()`
- `text()`
- `document-node()`
- `element()`
- `attribute()`
- `processing-instruction(xml-stylesheet)`

Kind and name of node

- `element(person)`
- `attribute(id)`
- `processing-instruction(xml-stylesheet)`

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Node test (ctd.)

Kind and type of node

! XPath 2.0 schema aware processing

- `element(*, studentType)`
- `element(person, studentType)`
- `attribute(*, xs:integer)`
- `attribute(id, xs:integer)`

Name of node

! Kind of node default for current axis (element or attribute)

- `person`
- `*`
- `pre:*`
- `*:person`

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Predicates

- Evaluated for each node selected so far (node becomes the context node).
- Every predicate filters result sequence.
- Depending on result type:
  - number — compared to item position (counted from 1)
  - not number — Effective Boolean Value used
- **Filter expressions** — predicates outside paths (XSLT 2.0)

Examples

```
/child::staff/child::person[child::name = 'Patryk']

child::person[child::name = 'Patryk']/child::surname

//person[attribute::passport][3]

(1 to 10)[. mod 2 = 0]
```

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Abbreviated Syntax

- `child` axis may be omitted
- `@` before name indicates `attribute` axis
- `.` instead of `self::node()`
- `..` instead of `parent::node()`
- `//` instead of `/descendant-or-self::node()/`

Example

```
.//object[@id = 'E4']

self::node()/descendant-or-self::node()/
                          child::object[attribute::id = 'E4']
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Evaluation order

- From left to right
- Step by step
  - `//department/person[1]`
  - `(//department/person)[1]`
- Predicate by predicate
  - `//person[@manages and position() = 5]`
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XQuery — *the* query language for XML

Status

- XQuery 1.0 — W3C Recommendation, I 2007
- Data model, functions and operators — shared with XPath 2.0
- Formally: syntax defined from scratch
- Practically: XPath syntax extension

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- Picking up data from XML documents
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- Sorting, grouping, . . .
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- Various output methods (XML, HTML, XHTML, text) — shared with XSLT

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XQuery query structure

- Header and body
- Header consists of declarations:
  - version declaration
  - import
  - flags and options
  - namespace declaration
  - variable or query parameter
  - function

Example

```
xquery version "1.0" encoding "utf-8";
declare namespace foo = "http://example.org";
declare variable $id as xs:string external;
declare variable $doc := doc("example.xml");

$doc//foo:object[@id = $id]
```

FLWOR expression

- Acronym of *For, Let, Where, Order by, Return*
- Replaces `for` from XPath
- Motivation: SQL SELECT

Example

```
for $obj in doc("example.xml")/list/object
  let $prev := $obj/preceding-sibling::element()
  let $prev-name := $prev[1]/@name
  where $obj/@name
  order by $obj/@name
  return
    <div class="result">
      Object named {xs:string($obj/@name)}
      has {count($prev)} predecessors.
      The nearest predecessor name is
      {xs:string($prev-name)}.
    </div>
```

Node constructors — direct

XML document fragment within query

```
for $el in doc("example.xml")//* return
  <p style="color: blue">I have found an element.
    <?pi bla Bla ?>
    <!--Comments and PIs also taken to result-->
  </p>
```

Expressions nested within constructors — braces

```
<result>
  {
    for $el in doc("example.xml")//* return
      <elem depth="{count($el/ancestor::node())}">
      {name($el)}
       </elem>
  }
</result>
```

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Node constructors — computed

Syntax

```
for $el in doc("example.xml")//* return
  element p {
   attribute style {"color: blue"},
   text { "I have found an element."},
   processing-instruction pi { "bla Bla" }
   comment { "Comments and PIs also taken to result" }
  }
```

Application example — dynamically computed name

```
<result>{
  for $el in doc("example.xml")//* return
    element {concat("elem-", name($el))} {
      attribute depth {count($el/ancestor::node())},
      text {name($el)}
}    }
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```

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Custom function definitions

Example

```
declare function
  local:twice($x)
{ 2 * $x };
```

Type declarations example

```
declare function
  local:twice($x as xs:double)
  as xs:double
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  as xs:double
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```

Type declarations

- Type declarations possible (not obligatory) for:
  - variables
  - function arguments and result
  - also in XSLT 2.0
- Capabilities:
  - type name
  - node kind | `node()` | `item()`
  - occurrence modifier (`?`, `*`, `+`, exactly one occurrence by default).
- Examples:
  - `xs:double`
  - `element()`
  - `node()*`
  - `xs:integer?`
  - `item()+`

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