MANCHESTER 1824

The University of Manchester

COMP60411: Modelling Data on the Web

Tree Data Models

Week 3

Tim Morris & Uli Sattler
University of Manchester

Reminder: Plagiarism & Academic Malpractice

- We assume that you have all by now successfully completed the
  Plagiarism and Malpractice Test
- ...if you haven't:
  do so **before** you submit **any** coursework (assignment or assessment)
- ...because we work under the assumption that
  - you know what you do
  - you take pride in your own thoughts & your own writing
  - you don't steal thoughts or words from others
- ...and if you don't, and submit coursework where you have
  copied other people's work without correct attribution
  it costs you **at least** marks or more, e.g., your MSc

Reminder

We maintain 3 sources of information:

- **syllabus** …/pgt/COMP60411/syllabus/
- **materials** …/pgt/COMP60411/
  - growing continuously
  - with slides, reading material, etc
  - with TA lab times
- **Blackboard** via **myManchester**
  - growing continuously
  - Forums
    - General
    - Week 1, Week 2, …
  - Coursework

Subscribe
Read
Contribue

Coursework - Week 1 and 2

- Short essays, SE1: looks mostly good
  - use a **good spell & grammar checker!**
  - qualify your statements:
    - “All users can understand a picture” is NOT true!
  - use suitable verbs & technical terms
  - think about
    - caveats,
    - examples,
    - concrete situations
  - avoid
    - **non sequiturs**

Always:

- check our **feedback** in the **rubrics**
- if you can’t find them, ask us in **labs**

Today

We will encounter new things:

Tree data models:

1. Data Structure formalisms: XML (including name spaces)
2. Schema Language: RelaxNG
3. Data Manipulation: XPath, DOM and Python

General concepts:

more on

- Self-Describing
- Trees
- Regular Expressions
- Internal & External Representation, Parsing
- Validation, valid, …
- Format

XML
a data model with
a tree-shaped internal representation

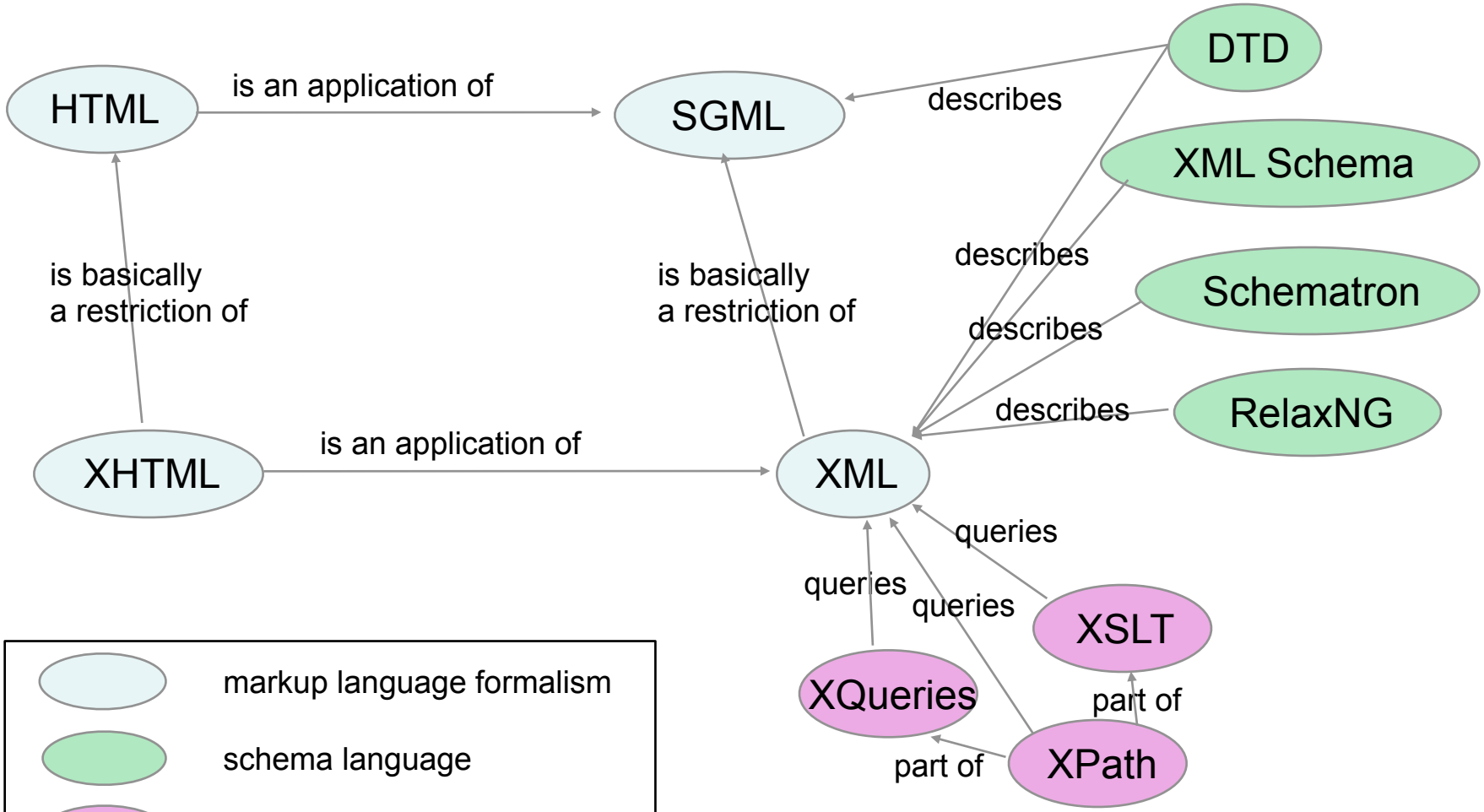
XML

- is another formalism for the representation of *semi-structured data*
  - e.g., used by UniProt
  - suitable for humans and computers
- is *not* designed to specify the lay-out of documents
  - this what html, css and others are for
- alone will not solve the problem of **efficiently querying (web) data:**
  - we might have to use RDBMSs technology as well
  - see COMP62421

A brief history of XML

- **GML** (Generalised Markup Language), 60ies, IBM
- **SGML** (Standard Generalised Markup Language), 1985:
  - flexible, expressive, with DTDs
  - custom tags
- **HTML** (Hypertext Markup Language), early 1990ies:
  - application of SGML
  - designed for **presentation of documents**
  - single document type, presentation-oriented tags, e.g., <h1>...</h1>
  - led to the web as we know it
- **XML**, 1998 first edition of XML 1.0 (now 4th edition)
  - a **W3C** standard
  - subset/fragment of SGML
  - designed
    - to be “web friendly”
    - for the **exchange/sharing of data**
    - to allow for the principled decentralized extension of HTML and
    - the elimination or radical reduction of **errors** on the web
- XHTML is an application of XML
  - almost a fragment of HTML

A rough map of a part of Acronym World



Back to our very simple XML example

Running example from last week:

{name: {first:"Uli", last: "Sattler"},
tel: 56182,
tel: 56176,
email:"sattler@cs.man.ac.uk"}

like JSON,
XML documents
are
text documents

In (badly layed-out) XML:

```
<person><name><first>Uli</first><last>Sattler</last></name><tel>56182</tel>
    <tel>56176</tel><email>sattler@cs.man.ac.uk</email></person>
```

Back to our very simple XML example

Running example from last week:

{name: {first:"Uli", last: "Sattler"},
tel: 56182,
tel: 56176,
email:"sattler@cs.man.ac.uk"}

like JSON, XML documents are **text** documents

In (the same but better layed-out) XML:

```
<person>
   <name>
      <first>Uli</first>
      <last>Sattler</last>
   </name>
   <tel>56182</tel>
   <tel>56176</tel>
   <email>sattler@cs.man.ac.uk</email>
</person>
```

Back to our very simple XML example

Running example from last week:

{name: {first:"Uli", last: "Sattler"},
tel: 56182,
tel: 56176,
email:"sattler@cs.man.ac.uk"}

Use an **XML editor** to work with XML documents

In (still the same) XML with syntax highlighting:

```
<person>
   <name>
      <first>Uli</first>
      <last>Sattler</last>
   </name>
   <tel>56182</tel>
   <tel>56176</tel>
   <email>sattler@cs.man.ac.uk</email>
</person>
```

Back to our very simple XML example

Running example from last week:

{name: {first:"Uli", last: "Sattler"},
tel: 56182,
tel: 56176,
email:"sattler@cs.man.ac.uk"}

Design choices for **format** for your data affect query-ability, robustness

In a different XML-based **format**, well layed-out, with syntax highlighting:

```
<person>
   <name first="Uli" last="Sattler"/>
   <phone>
      <number value="56182"/>
      <number value="56176"/>
   </phone>
   <email>
      <address value="sattler@cs.man.ac.uk"/>
   </email>
</person>
```

```
<person>
   <name>
      <first>Uli</first>
      <last>Sattler</last>
   </name>
   <tel>56182</tel>
   <tel>56176</tel>
   <email>sattler@cs.man.ac.uk</emai
</person>
```

An XML Example

© Scott Adams, Inc./Dist. by UFS, Inc.

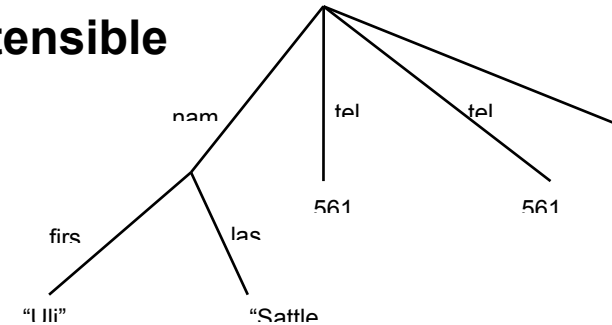
A **snippet of XML** describing the above Dilbert cartoon

```
<cartoon copyright="United Feature Syndicate" year="2000">
        <prolog>
        <series>Dilbert</series>
        <author>Scott Adams</author>
        <characters>
           <character>The Pointy-Haired Boss</character>
           <character>Dilbert</character>
        </characters>
        </prolog>
             <panels>
                <panel colour="none">
                   <scene> Pointy-Haired Boss and Dilbert sitting at table. </scene>
                   <bubbles>
                      <bubble>
                         <speaker>Dilbert</speaker>
                         <speech>You haven't given me enough resources to do my project.</speech>
                      </bubble>
                   </bubbles>
                </panel>
                ...
        </panels>
    </cartoon>
```

What is XML?

Technical terms, when used for the first time, are marked **red**

- XML is a specialization of SGML
- XML is a W3C standard since 1998, see http://www.w3.org/XML/
- XML was designed to be **simple, generic,** and **extensible**
- an **XML document** is a **piece of text** that
  - describes
    - structure
    - data
  - has internal representation of a **tree: DOM tree** or **infoset**
  - is divided into smaller pieces called **elements** (associated with **nodes** in tree), which can
    - contain elements - nesting!
    - contain text/data
    - have attributes
- an XML document consists of (some administrative information followed by)
  - a **root** element containing all other elements



Example

And here is the full XML document

```
<?xml version="1.0" encoding="UTF-8"?>
<!DOCTYPE cartoon SYSTEM "cartoon.dtd">
<cartoon copyright="United Feature Syndicate" year="2000">
    <prolog>
    <series>Dilbert</series>
    <author>Scott Adams</author>
    <characters>
        <character>The Pointy-Haired Boss</character>
        <character>Dilbert</character>
    </characters>
    </prolog>
    <panels>
        ....
    </panels>
</cartoon>
```

Administrative Information

Root element

What is XML? (ctd)

The above mentioned **administrative information** of an XML document:

1. **XML declaration**, e.g., <?xml version="1.0" encoding="iso-8859-1"?> (optional) identifies the
   - XML version (1.0) and
   - character encoding (iso-8859-1)
2. **document type declaration** (optional) references a (specific) schema called **Document Type Definition**
   - e.g. <!DOCTYPE cartoon SYSTEM "cartoon.dtd">
   1. a DTD constrains the structure, content & tags of a document
   2. can either be local or remote
3. then we find the **root element**
4. which in turn contains other elements with possibly more elements....

XML Elements

- **elements** are delimited by **tags**
- **tags** are enclosed in angle brackets, e.g., <panel>, </from>
- tags are case-sensitive, i.e., <FROM> is not the same as <from>
- we distinguish
  - **start tags**: <...>, e.g., <panel>
  - **end tags**: </...>, e.g., </from>
- a pair of matching start- and end tags delimits an **element** (like parentheses)
- **attributes** specify properties of an element
  e.g., <cartoon **copyright**="United Feature Syndicate">

Example

And here is the full XML document

```
<?xml version="1.0" encoding="UTF-8"?>
  <!DOCTYPE cartoon SYSTEM "cartoon.dtd">
  <cartoon copyright="United Feature Syndicate" year="2000">
    <prolog>
    <series>Dilbert</series>
    <author>Scott Adams</author>
    <characters>
      <character>The Pointy-Haired Boss</character>
      <character>Dilbert</character>
    </characters>
    </prolog>
    <panels>
      ....
    </panels>
  </cartoon>
```

element

Example

And here is the full XML document

```
<?xml version="1.0" encoding="UTF-8"?>
    <!DOCTYPE cartoon SYSTEM "cartoon.dtd">
    <cartoon copyright="United Feature Syndicate" year="2000">
        <prolog>
        <series>Dilbert</series>
        <author>Scott Adams</author>
        <characters>
            <character>The Pointy-Haired Boss</character>
            <character>Dilbert</character>
        </characters>
        </prolog>
        <panels>
            ....
        </panels>
    </cartoon>
```

Attributes

Start Tag

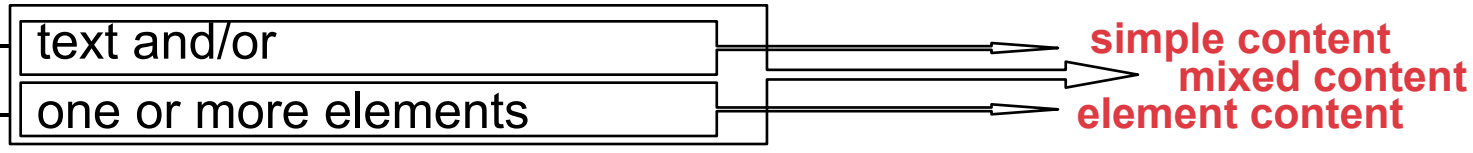
End Tag

XML Core Concepts: elements *(the main concept)*

```
<element-name attr-decl1 ... attr-decln>
    content
</element-name>
```

```
<cartoon copyright="United Feature">
    content
</cartoon>
```

- arbitrary number of attributes is allowed
- each *attr-decli* is of the form `attr-name="attr-value"`
- but each *attr-name* occurs **at most once** in one element
- the *content* can be
  - empty
  - text and/or
  - one or more elements



  - ...those *contained* elements are the element's **child elements**
- an empty element can be abbreviated as
  <element-name attr-decl1 ... attr-decln/>

Example

© Scott Adams, Inc./Dist. by UFS, Inc.

```
<?xml version="1.0" encoding="UTF-8"?>
    <!DOCTYPE cartoon SYSTEM "cartoon.dtd">
    <cartoon copyright="United Feature Syndicate" year="2000">
       <prolog>
       <series>Dilbert</series>
       <author>Scott Adams</author>
       <characters>
          <character>The Pointy-Haired Boss</character>
          <character>Dilbert</character>
       </characters>
       </prolog>
       <panels>
          ....
       </panels>
    </cartoon>
```

Simple content

Element content

XML Core Concepts: Prologue - XML declaration

More at http://www.w3.org/TR/REC-xml/

<?xml *param1 param2 ...*?>

Each *parami* is in the form

parameter-name="parameter-value"

<?xml version="1.0" encoding="US-ASCII" standalone="yes"?>

Parameters for

- the **xml version** used within document
- the **character encoding**
- whether document is **standalone** or uses external declarations (see validity constraint for when standalone="yes" is required)

An XML document *should have* an XML declaration (but does not need to)

XML Core Concepts: Prologue - Doctype declaration

<!DOCTYPE *element-name* PUBLIC "*pub-id*" "*f-name*.dtd" |
SYSTEM "*f-name*.dtd" |
[*dt-declarations*]>

No DTD in this course!

- at most one such declaration, before root element
  - links document to (a simple) **schema** describing its structure
- *element-name* is the name of the **root element** of the document
- the optional *dt-declarations* is
  - called **internal subset**
  - a list of **document type definitions**
- the optional *f-name*.dtd refers to the **external subset** also containing **document type definitions**

- e.g., <!DOCTYPE html PUBLIC "http://www.abc.org/dtds/html.dtd"
"http://www.abc.org/dtds/html.dtd" >

What is XML? (ctd)

- in XML, the set of tags/element names is not fixed
  - ...you can use whatever you want (within spec)
  - in HTML, the tag set is fixed
  - <h1>, <b>, <ul>,...

- elements can be **nested,** to **arbitrary** depth

     ...

- the same **element name** can occur many times in a document,
  - e.g.,

    ... ...

- XML itself is **not** a markup language,
  but we can **specify** markup languages with XML
  - an XML document can **contain** or **refer to** its specification: !DOCTYPE

How to view or edit XML?

- XML is **not *really* for human consumption**
  - far too verbose
  - in contrast to HTML, your **browser** won't easily help:
    - you can only do a "view source" or
    - first *style it* (using XSLT or CSS, later more) to transform XML into HTML
- **XML is text**, so you can use your favourite editor, e.g., emacs in XML mode
- Or you can use an **XML editor**, e.g., XMLSpy, Stylus Studio, <oXygen/>, MyEclipse, and many more
- <oXygen/> runs on the lab machines
  - it supports many features
  - query languages
  - schemas, etc.
  - has been given to us for free: license details are in Blackboard

XML versus HTML

- XML is always case sensitive, i.e., "Hello" is different from "hello"
  - HTML isn't: it uses SGML's default "ignore case"
- in XML, all tags must be present
  - in HTML, some "tag omission" may be permissible (e.g.,
)
- in XML, we have a special way to write empty elements <myname/>
  - which can't be used in HTML
- in XML, all attribute values must be quoted, e.g., <name lang= "eng">...
  - in SGML (and therefore in HTML) this is only required if value contains space
- in XML, attribute names cannot be omitted
  - in HTML they may be omitted using shorttags

XML versus JSON

XML

- no arrays/lists/vectors
- IR is tree-shaped
- an element can have many elements with same name
- has many schema languages
- W3C standard
- supports namespaces
- has its own query languages
  - XPath
  - XQuery
  - XSLT
- supported by numerous libraries
- comprehensive datatype support

JSON

- has arrays/lists/vectors
- not tree-shaped
- an object cannot have repeated key
- has 1 schema languages
- not a W3C standard
- supported by numerous libraries
- rather basic datatype support
- less verbose than XML

Read & think critically about these and other points.

When is an XML document well-formed?

An XML document is **well-formed** if

1. there is exactly one root element
2. tags, <, and > are correct (incl. no un-escaped < or & in character data)
3. tags are properly nested
4. attributes are unique for each tag and attribute values are quoted
5. no comments inside tags

Let's test our understanding via some Kahoot quiz: go to kahoot.it

Well-formedness is a very weak property:
basically, it only ensures that we can **parse a document into a tree**

Well-formedness is a very weak property: basically, it only ensures that we can parse a document into a **tree**…

the document's
internal representation

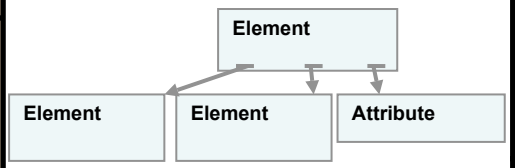
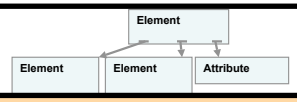
An **Internal Representation** for XML documents

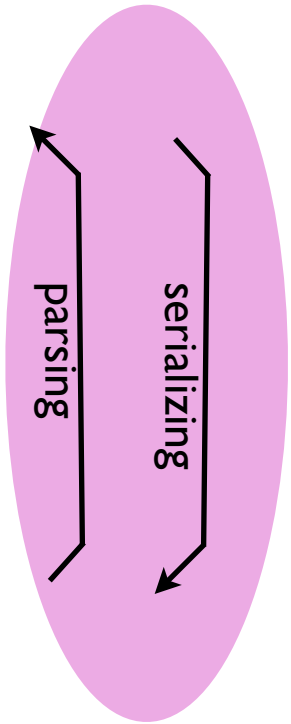
- An XML document is a **piece of text**
  - it has tags, etc.
  - it has **no** nodes, structure, successors, etc.
  - it may have whitespace, new lines, etc.

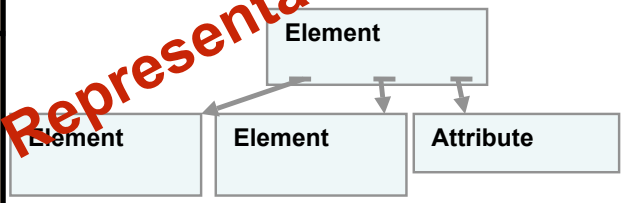
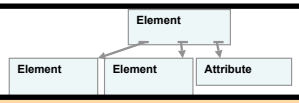
```
<?xml version="1.0" encoding="UTF-8"?>
<!DOCTYPE cartoon SYSTEM
"cartoon.dtd">
<cartoon copyright="United Feature
Syndicate" year="2000"><prolog>
<series>Dilbert</series><author>Scott
Adams<author><characters><character>The
Pointy-Haired
Boss<character><character>Dilbert<charact
er> </characters></prolog><panels>
    ....</panels></cartoon>
```

- having an **InR** for XML documents makes many things easier:
  - talking about **structure**: documents, elements, nodes, child-nodes etc.
  - ignoring things like **whitespace** issues, etc.
  - implementing software that handles XML
  - specifying schema languages, other formalisms around it
  - ➡ think of relational model as basis for rel. DBMSs

- this has motivated the
  - **XML Information Set** recommendation,
  - Document Object Model, **DOM**, and others
- unsurprisingly, they model an XML document as a **tree**

Level		Data unit examples	Information or Property
cognitive			
application			
tree adorned with...			
namespace	schema		nothing / a schema
tree			well-formedness
token	complex	<foo:Name t="8">Bob	
	simple	<foo:Name t="8">Bob	
character		< foo:Name t="8">Bob	which encoding (e.g., UTF-8)
bit		10011010	



Level		Data unit examples	Information or Property required
cognitive			
application			
tree adorned with...			
namespace	schema		nothing / a schema
tree			well-formedness
token	complex	<foo:Name t="8">Bob	
	simple	<foo:Name t="8">Bob	
character		<foo:Name t="8">Bob	which encoding (e.g., UTF-8)
bit		10011010	

Internal Representation

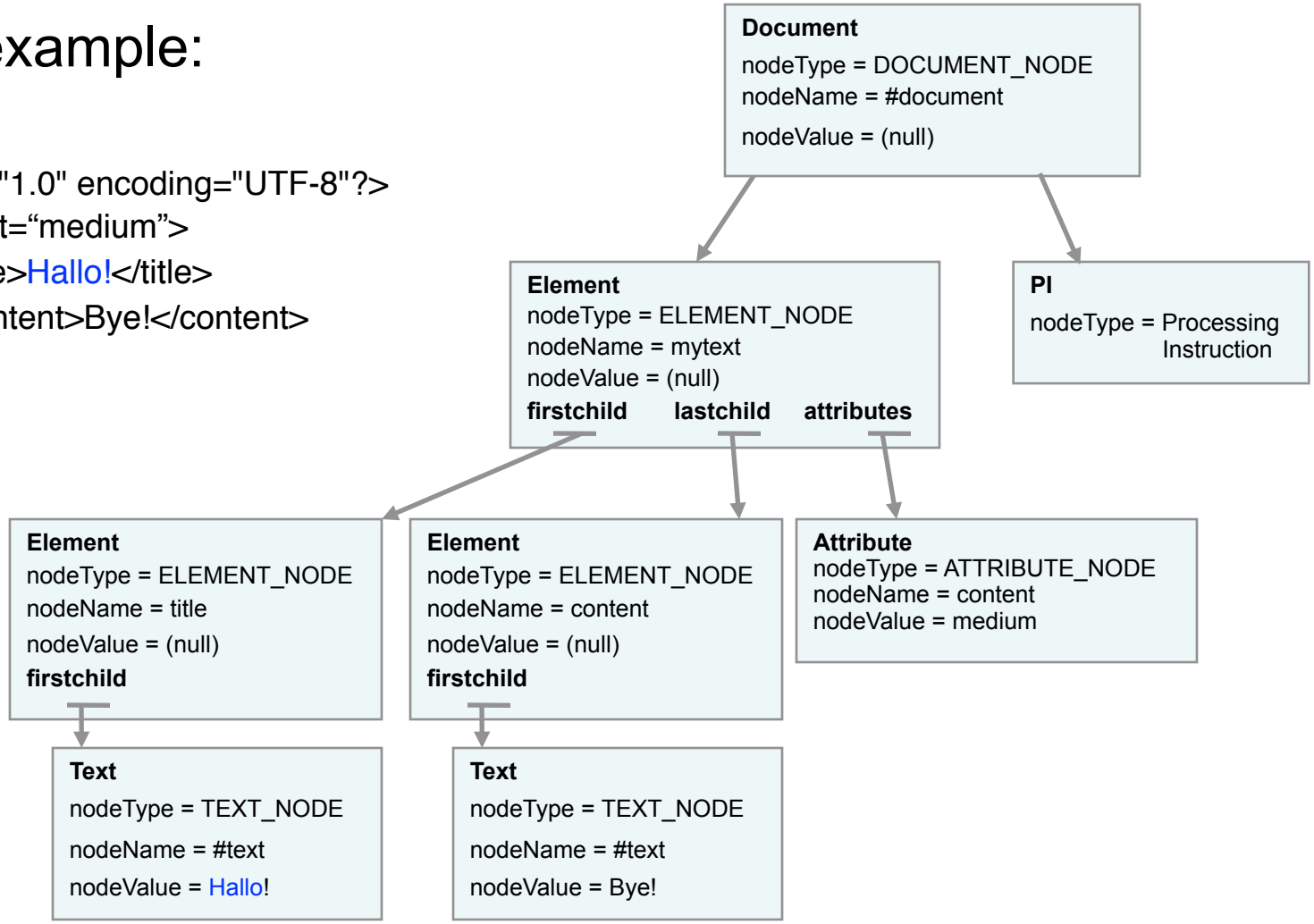
External Representation

DOM
an API
and
an internal Representation
for XML

DOM trees as an InR for XML documents

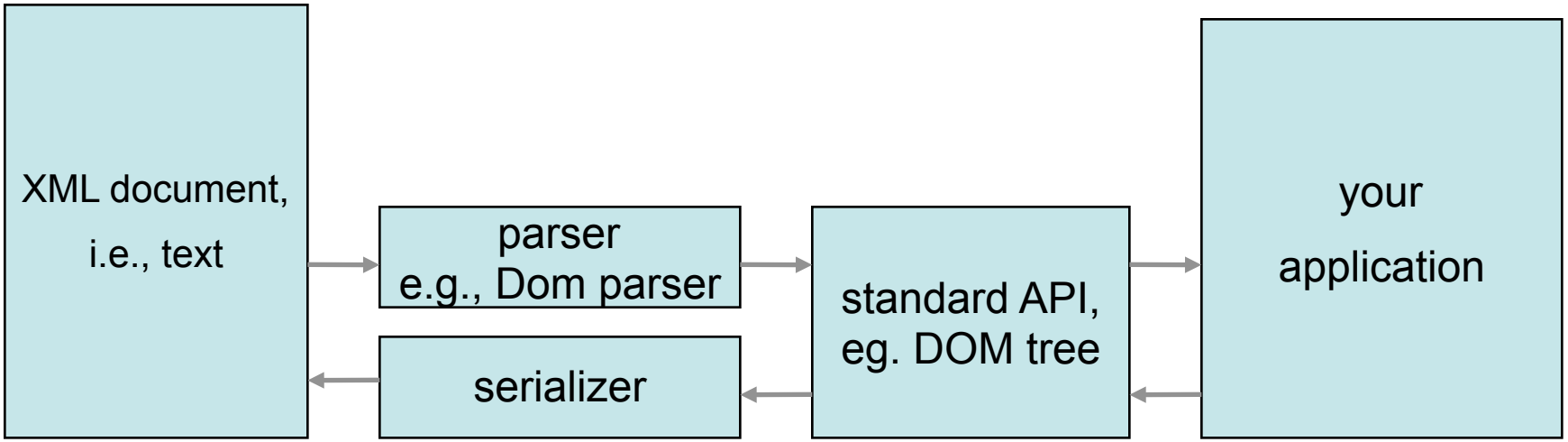
A simple example:

```
<?xml version="1.0" encoding="UTF-8"?>
<mytext content="medium">
        <title>Hallo!</title>
        <content>Bye!</content>
</mytext>
```



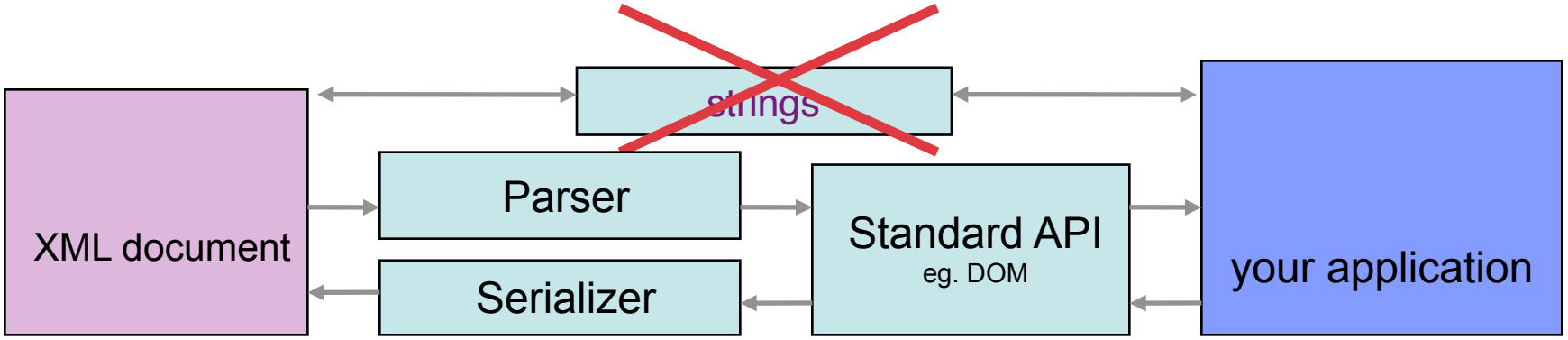
DOM: InR for XML documents

- we will use the **DOM tree** as an internal representation:
  it can be viewed as an implementation of the slightly more abstract **infoset**
- DOM is **a platform & language independent specification of an API for accessing an XML document in the form of a tree**
  - "DOM parser" is a parser that outputs a DOM tree
  - but DOM is much more

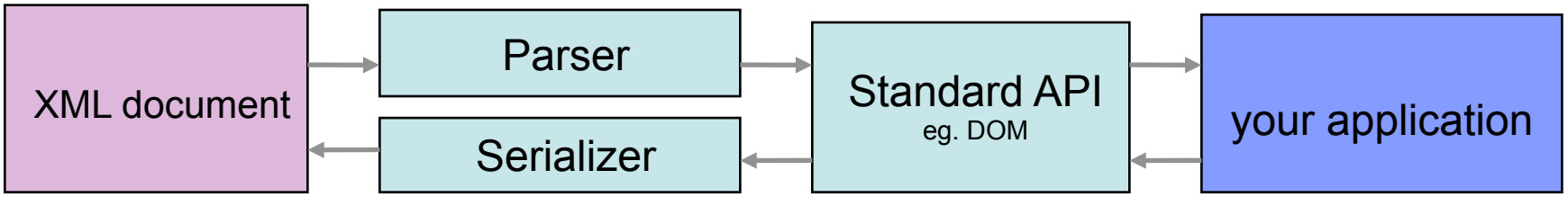


Programmatic Manipulation of XML Documents

As a rule, whenever we manipulate (XML) documents in an application, we should use standard APIs:



Parsing & Serializing XML documents

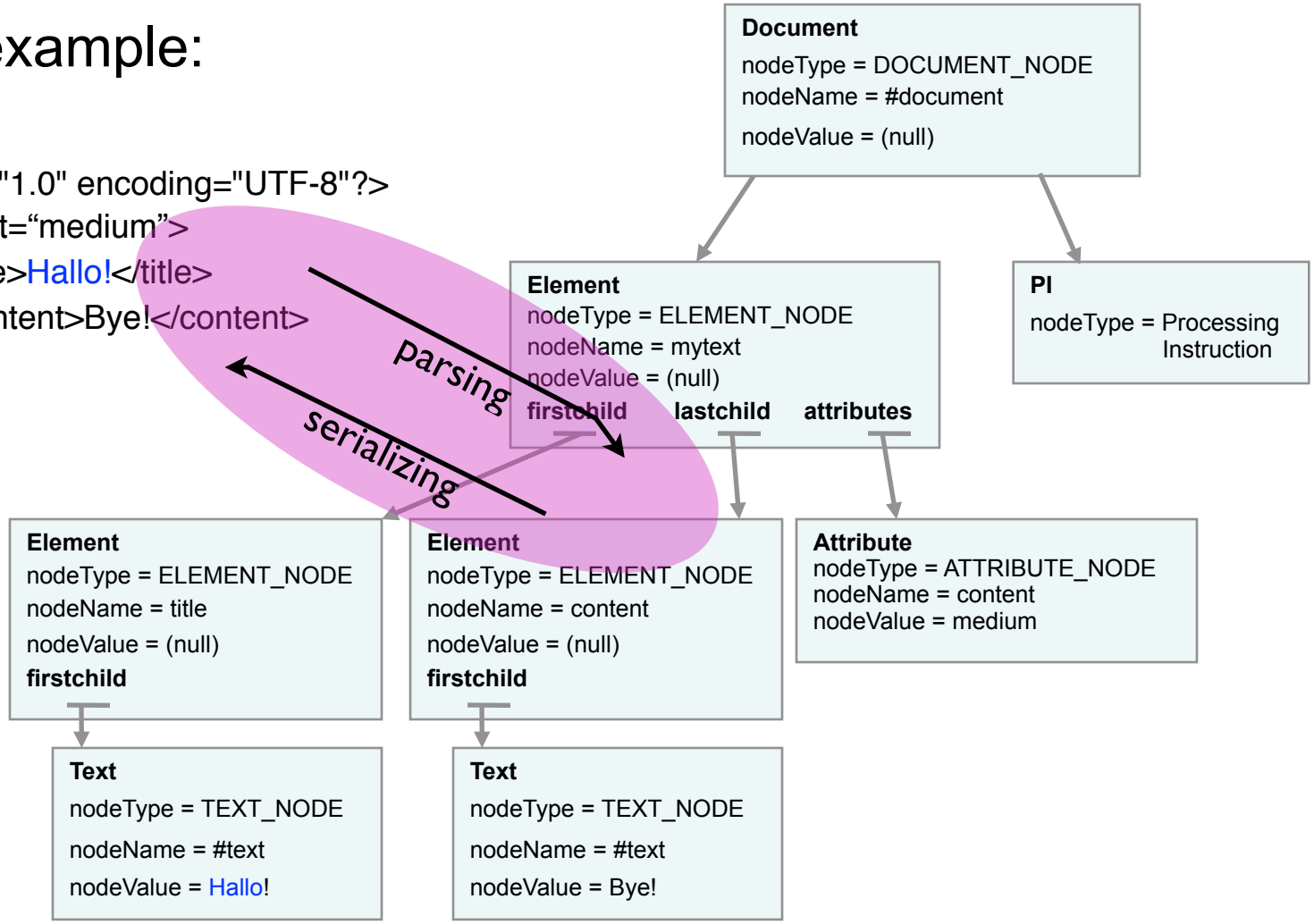


- **parser**:
  - reads & analyses XML document
  - **may** generate parse tree that reflect document's element structure e.g., DOM tree
    - with nodes labelled with
      - tags,
      - text content, and
      - attributes and their values
- **serializer:**
  - takes a data structure, e.g., some trees, linked objects, etc.
  - generates an XML document
- **round tripping:**
  - XML ➙ tree ➙ XML
  - ...doesn't have to lead to identical XML document...more later

DOM trees as an InR for XML documents

A simple example:

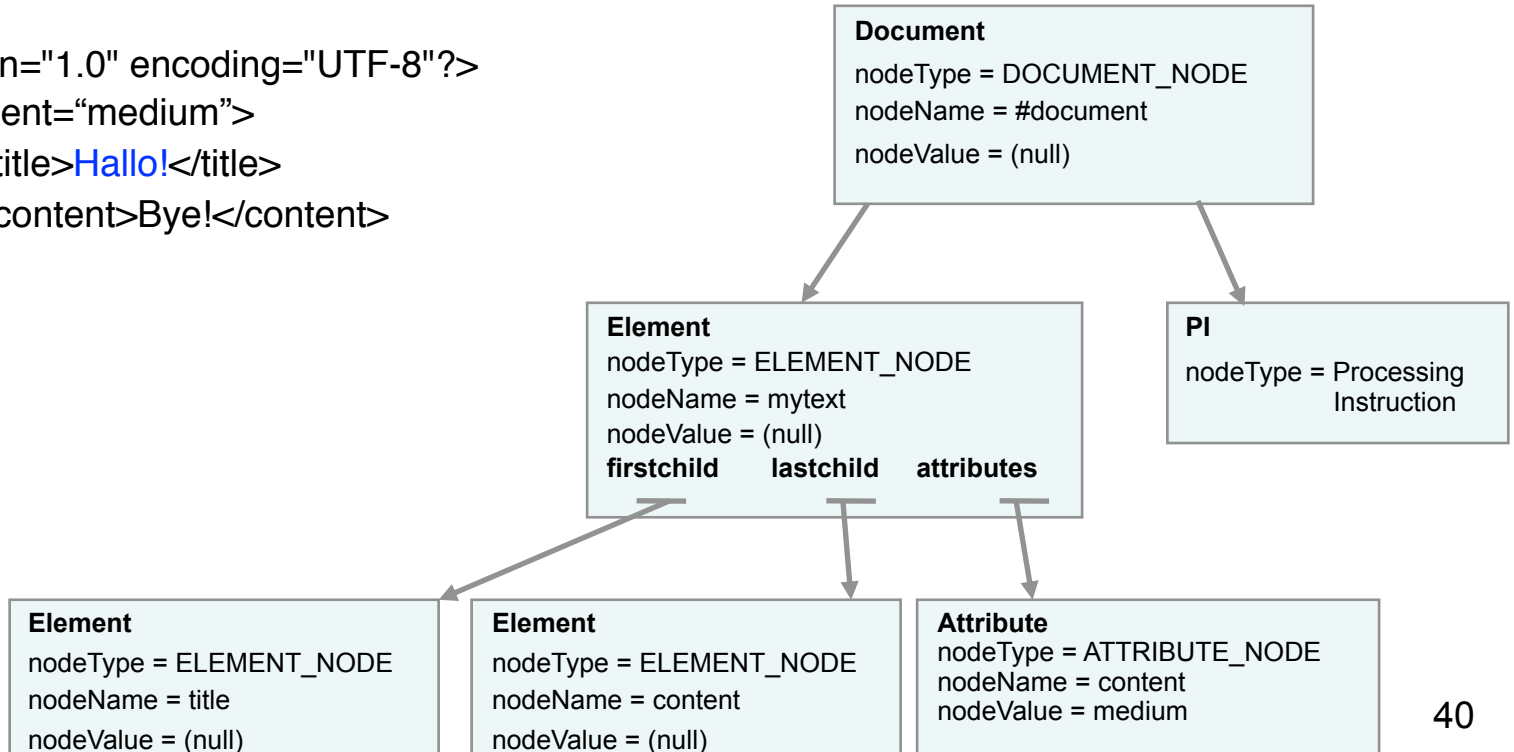
```
<?xml version="1.0" encoding="UTF-8"?>
<mytext content="medium">
        <title>Hallo!</title>
        <content>Bye!</content>
</mytext>
```



DOM trees as an InR for XML documents

- In general, we have the following correspondence:
  - XML document D → tree t(D)
  - element e in D → node t(e) in t(D)
  - empty element → leaf node
  - root element e in D → **not** root node in t(D), but document node

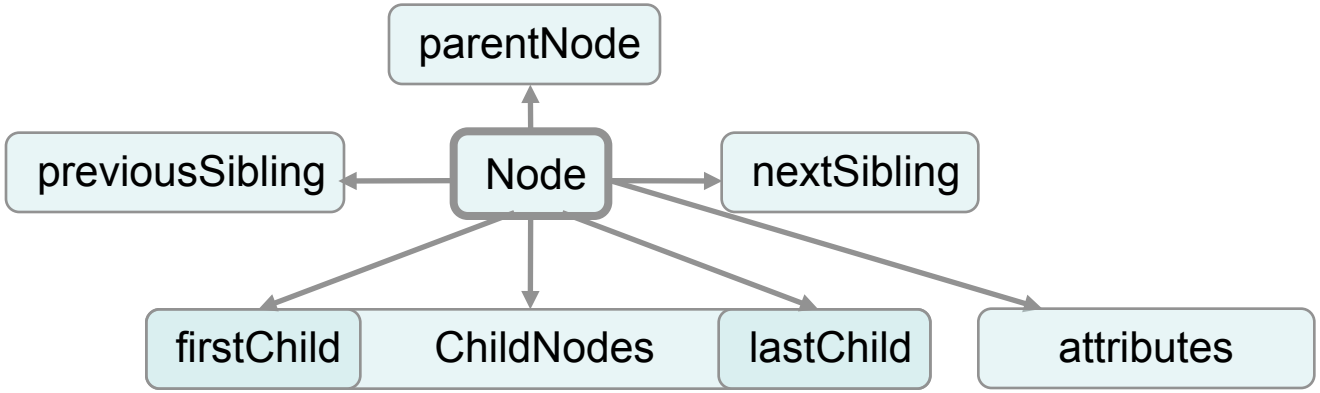
```
<?xml version="1.0" encoding="UTF-8"?>
<mytext content="medium">
        <title>Hallo!</title>
        <content>Bye!</content>
</mytext>
```



DOM trees as an InR for XML documents

- In general, we have the following correspondence:
  - XML document D → tree t(D)
  - element e in D → node t(e) in t(D)
  - empty element → leaf node
  - root element e in D → **not** root node in t(D), but document node

- DOM's **Node interface** provides the following attributes to navigate around a node in the DOM tree:



- and also methods such as appendChild, hasAttributes, insertBefore, etc.

DOM by example

mydocument.xml:

```
<mytext content="medium">
        <title>Hallo!</title>
        <body>Bye!</body>
</mytext>
```

A little Python3 example:

"if 1st child of **mytext**s is "**Hallo**" return the content of 2nd child"

1. let a parser build the DOM of mydocument.xml

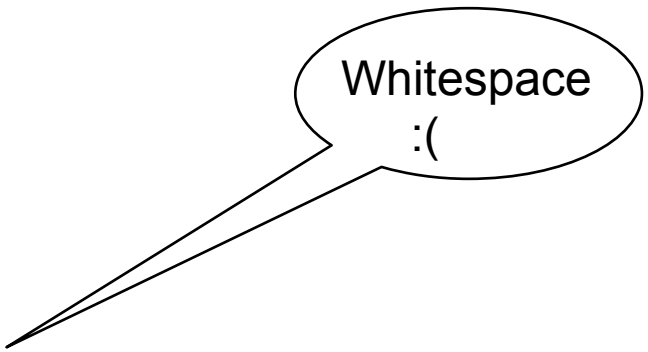
```
import xml.dom.minidom
import sys
filename_xml = sys.argv[1]
dom = xml.dom.minidom.parse(filename_xml)
```

2. Retrieve all "mytext" nodes into a NodeList interface:

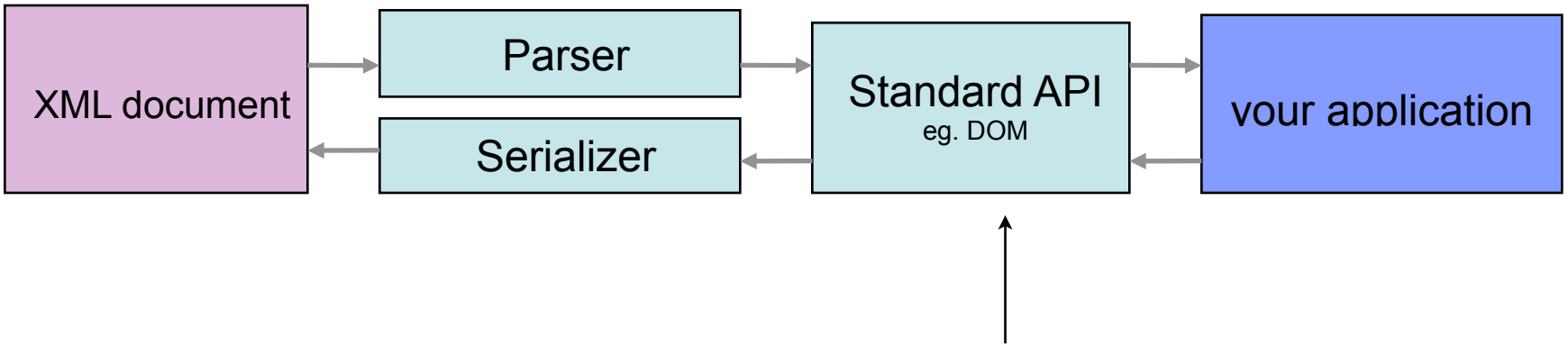
```
mytextNodes = dom.getElementsByTagName("mytext")
```

3. Navigate and retrieve all contents:

```
for textnode in mytextNodes:
   titleNode = textnode.childNodes[1]
   titlenodetext = titleNode.childNodes[0]
    if titlenodetext.nodeValue == "Hallo!":
        bodynode = textnode.childNodes[3]
        print("The hallo message is %s "    % bodynode.childNodes[0].nodeValue)
```



Parsing XML



- **DOM parsers** parse an XML document into a DOM tree
  - this might be huge/not fit in memory
  - your application may take a few relevant bits from it and build an own datastructure, so (DOM) tree was short-loved/built in vain

- **SAX parsers** work very differently
  - they don't build a tree but
  - go through document depth first and "shout out" their findings...

Self-Describing

Self-describing?!

- XML is said to be **self-describing**...what does this mean?

```
<a123>
   <b345 b345="$%#987">Hi there!</b345>
</a123>
```

- ...is this well-formed?
- ...can you understand what this is about?
- Let's again compare to **CSV** (comma separated values):
  - each line is a **record**
  - commas separate **fields** (and no commas in fields!)
  - each record has the same number of fields

```
Bijan, Parsia, 2.32
Uli,    Sattler, 2.24
```

  - ...can you understand what this is about?

Self-describing?!

- One way of translating our example into XML
  - ...can you understand what this is about?

```
Bijan, Parsia, 2.32
Uli,   Sattler, 2.24
```

```
<csvFile>
  <record>
    <field>Bijan</field>
    <field>Parsia</field>
    <field>2.32</field>
  </record>
  <record>
    <field>Uli</field>
    <field>Sattler</field>
    <field>2.21</field>
  </record>
</csvFile>
```

Self-describing?!

- Let's consider a **self-describing CSV (ExCSV)**
  - first line is **header** with **field names**
  - ...can you understand what this is about?

```
Name,Surname,Room
Bijan, Parsia, 2.32
Uli,    Sattler, 2.24
```

- We could even **generically** translate such CSVs in XML:

```
<csvFile>
   <record>
      <name>Bijan</name>
      <surname>Parsia</surname>
      <room>2.32</room>
   </record>
   <record>
      <record>Uli</name>
      <surname>Sattler</surname>
      <room>2.21</room>
   </record>
</csvFile>
```

or, manually, even better:

```
<addresses>
   <address>
      <name>Bijan</name>
      <surname>Parsia</surname>
      <room>2.32</room>
   </address>
   <address>
      <name>Uli</name>
      <surname>Sattler</surname>
      <room>2.21</room>
   </address>
</addresses>
```

Self-describing versus Guessability

- We can go a long way by **guessing**
  - CSV is *not easily* guessable
    - requires background knowledge
  - ExCSV is *more* guessable
    - still some guessing
    - could read the field tags and guess intent
    - had to guess the record type address
  - Guessability is tricky

```
Bijan,Parsia, 2.32
Uli,Sattler,  2.24
```

```
Name,Surname,Room
Bijan,Parsia,2.32
Uli,Sattler,2.24
```

```
<address>
    <name>Bijan</name>
    <surname>Parsia</surname>
    <room>2.32</room>
</address>
```

- Is self-describing just being more or less guessable?

Self-describing

> *The Essence of XML* (Siméon and Walder 2003):
> "From the **external representation** one should be able to derive the corresponding **internal representation**."

- **External**: the XML document, i.e., text!
- **Internal**:
  - e.g., the DOM tree, our application's interpretation of the content
  - seems easy, but: in
    - <room>2.32</room> is "2.32" a string or a number?
    - <height>2.32</height> is "2.32" a string or a number?
    - …what should a DOM/your parser do?

- Are CSV, ExCSV, XML self-describing?

Self-describing

- Given
  1. a base format, e.g., ExCSV
  2. a/some specific document(s), e.g.,

```
Name, Surname, Room
Bijan, Parsia, 2.32
Uli,   Sattler, 2.24
```

  - what suitable data structure can we extract?
    - CSV, ExCSV: tables, flat records, arrays, lists, etc.
    - XML: labelled, ordered trees of (unbounded) depth!

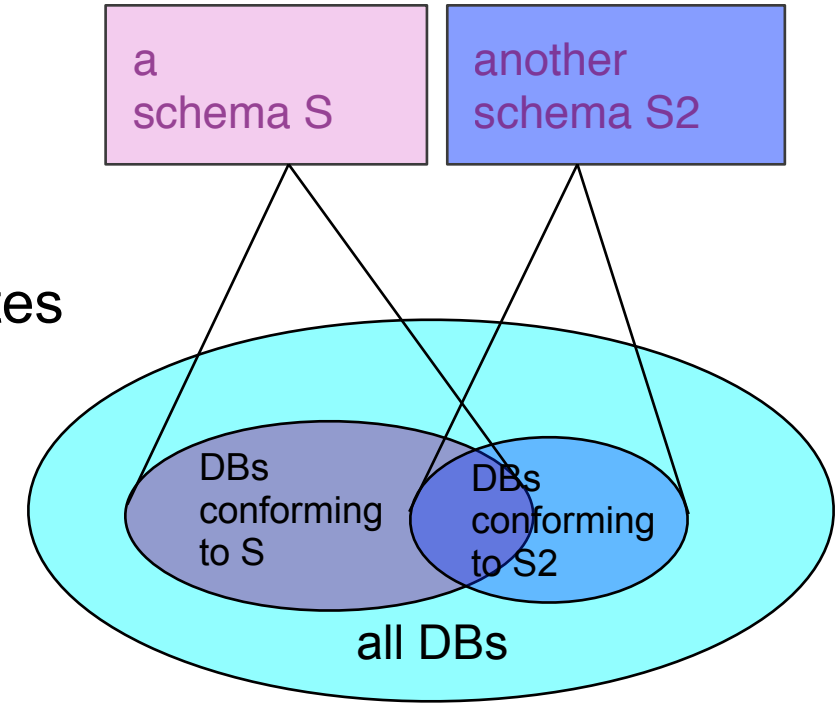
- Clearly, you could parse *specific* CSV files into trees,
  but you need to use *extra-CSV* information for that

Schemas!

Schemas: what are they?

A **schema** is a description

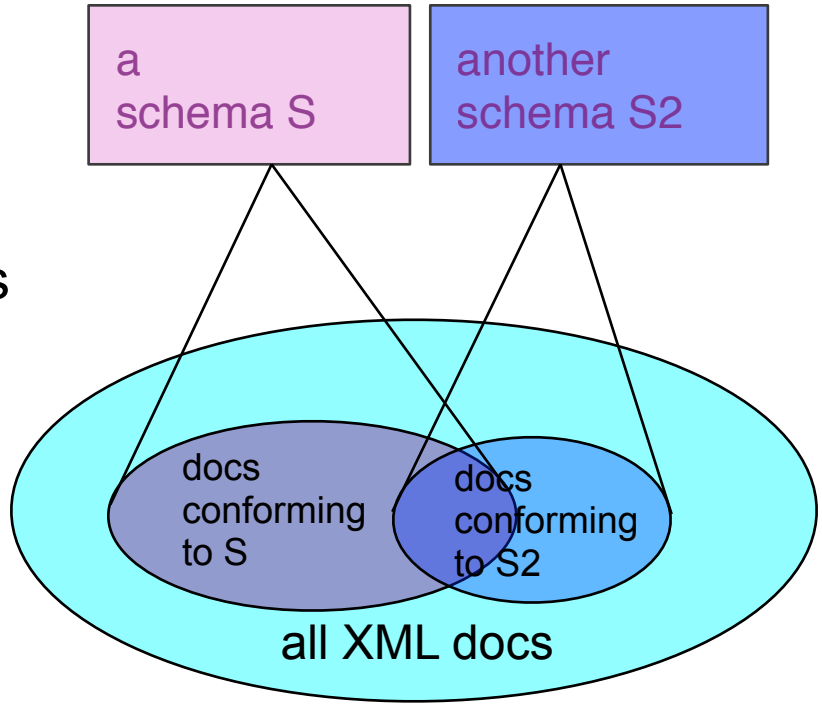
- of **DBs**: describes
  - tables,
  - their names and their attributes
  - keys, keyrefs
  - integrity constraints



Schemas: what are they?

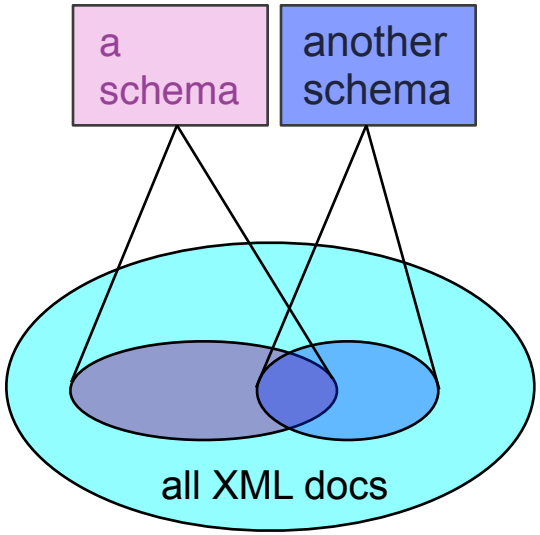
A **schema** is a description

- of **DBs**: describes
  - tables,
  - their names and their attributes
  - keys, keyrefs
  - integrity constraints
- of **XML documents**: describes
  - tag names
  - attribute names
  - structure:
    - how elements are nested
    - which elements have which attributes
  - data: what values (strings? numbers?) go where



Schemas: why?

- RDBMS
  - No database without schema
  - DB schema determines tables, attributes, names, etc.
  - Query optimization, integrity, etc.
- XML (and JSON)
  - No schema *needed* at all!
  - Well-formed XML can be
    - parsed to yield data that can be
    - manipulated, queried, etc.
  - Non-well formed XML....not so much
  - Well-formedness is a **universal minimal schema**



Schemas for XML: why?

- Well-formedness is minimal
  - any name can appear as an element or attribute name
  - any shape of content/structure of nesting is permitted
- Few applications want that…
- we'd like to rely on/share a **format**
  - core concepts that result in
  - core (tag & attribute) **names** and
  - **intended structure**
  - **intended data types**
    e.g., string for names,
    integer for age
  - although you might want to keep it **extensible & flexible**

```
<addresses>
  <name>
    <address>Bijan</address>
    <surname>Parsia</surname>
    <room>2.32</room>
  </name>
  <room>
    <room><room>
        Uli</room> </room>
    <room>Sattler</room>
    <room>2.21</room>
  </room>
</addresses>
```

```
<addresses>
  <address>
    <name>Bijan</name>
    <surname>Parsia</surname>
  </address>
  <address>
    <name>Uli</name>
    <minit>M<minit>
    <surname>Sattler</surname>
    <room>2.21</room>
  </address>
</addresses>
```

Schemas for XML: why?

- A schema describes aspects of documents:
  - what's **legal:**
    what a document can/may contain
  - what's **expected:**
    what a document must contain
  - what's **assumed:**
    default values
- Two **modes** for using a schema
  - **descriptive**:
    - describing documents
    - for other people
    - so that they know how to serialize their data
  - **prescriptive**:
    - prevent your application from using wrong documents

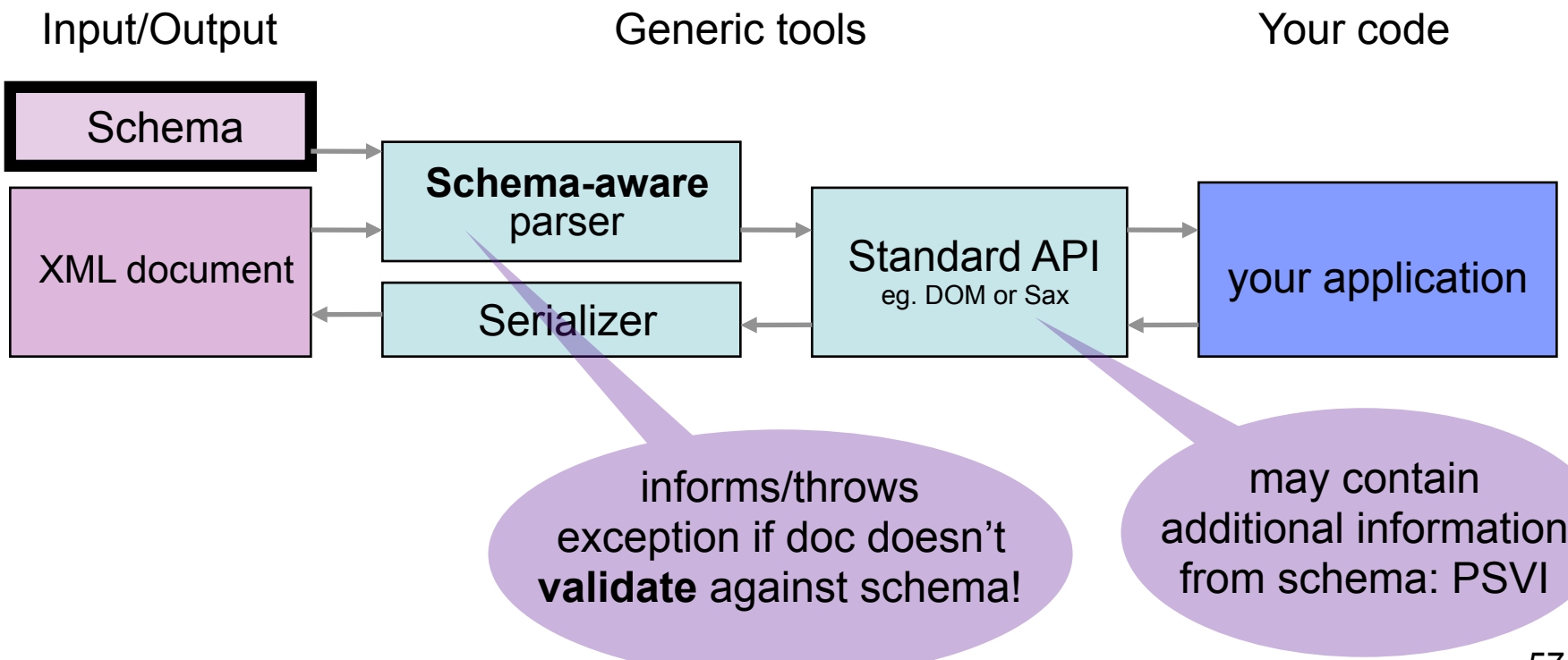
```
<addresses>
  <address>
    <name>Bijan</name>
    <surname>Parsia</surname>
  </address>
  <address>
    <name>Uli</name>
    <minit>M<minit>
    <surname>Sattler</surname>
    <room>2.21</room>
  </address>
</addresses>
```

Benefits of an (XML) schema

- **Specification**
  - you document/describe/publish your format
  - so that it can be used across multiple implementations
- As **input** for applications
  - applications can do **error-checking** in a **format independent** way
    - checking whether an XML document conforms to a schema can be done by a **generic** tool (see CW2),
    - no need to be changed when schema changes
    - automatically!

Benefits of an (XML) schema

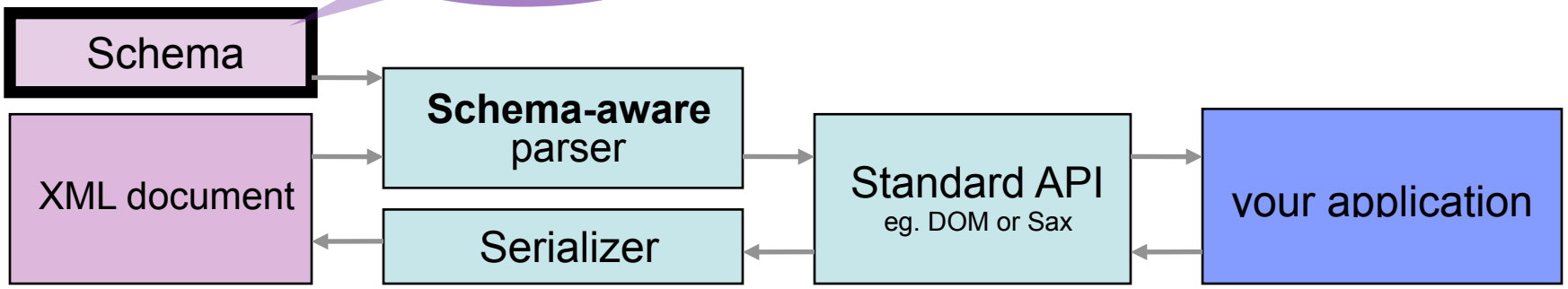
- **Specification**
- As **input** for applications
  - applications can do **error-checking** in a **format independent** way



your 3rd schema language

RelaxNG, a very powerful schema language for XML

to formulate



RelaxNG: a schema language

- RelaxNG was designed to be a **simpler** schema language
  - than XML Schema (XSD)
  - described in a readable on-line book by Eric Van der Vlist
- and allows us to describe XML documents in terms of their **tree abstractions**:
  - no default attribute values
  - no entity declarations
  - no key/uniqueness constraints
  - minimal datatypes: only “token” and “string” (like DTDs, similar to JSON Schema)
  - but a mechanism to use XSD datatypes
- since it is so simple/flexible
  - it’s (claimed/designed to be) easy to use
  - it doesn’t have complex constraints on description of element content like determinism/1-unambiguity
  - it’s claimed to be reliable
  - but you need other tools to do other things (like datatypes and attributes)

RelaxNG: “a” side of Validation

General: reasons why one would want to validate an XML document:

- ensure that structure is ok
- ensure that values in elements/attributes are of the correct data **type**
- generate PSVI to work with
- check constraints on co-occurrence of elements/how they are related
- check other integrity constraints, eg. a person’s age vs. their mother’s age
- check constraints on elements/their value against external data
  - postcode correctness
  - VAT/tax/other numeric constraints
  - spell checking

later!

...only few of these checks can be carried out by validating against schemas...

RelaxNG was designed to

1. describe/validate structure and
2. link to datatype validators to type check values of elements/attributes

RelaxNG: basic principles

later

- RelaxNG is based on **patterns** (similar to XPath expressions):
  - a pattern is a description of a set of valid node sets
  - we can view our example as different combinations of different parts, and design **patterns** for each

A first RelaxNG schema:

```
grammar {
 start =
   element name {
      element first { text },
      element last { text }
 }}
```

To describe documents like:

```
<?xml version="1.0" encoding="UTF-8"?>
 <name>
        <first>Harry</first>
        <last>Potter</last>
</name>
```

```
<?xml version="1.0" encoding="UTF-8"?>
 <name>
        <first>Magda</first>
        <last>Potter</last>
</name>
```

RelaxNG: good to know

RelaxNG comes in 2 syntaxes

- the compact syntax

```
grammar {
 start =
   element name {
      element first { text },
      element last { text }
 }}
```

  - succinct
  - human readable
- the XML syntax

```
<grammar
  xmlns="http:..."
  xmlns:a="http:.."
  datatypeLibrary="http:...>
   <start>
      <element name="name">
         <element name="first"><text/></element>
         <element name="last"><text/></element>
      </element>
   </start>
</grammar>
```

  - verbose
  - machine readable

✓ **Trang** converts between the two, phew! (and also into/from other schema languages)

✓ Trang can be used from <Oxygen>

RelaxNG - to describe structure:

- 3 kinds of **patterns**, for the 3 “central” nodes:
  - text

```
text
```

  - attribute

```
attribute age { text },
attribute type { text },
```

  - element

```
element name {
   element first { text },
   element last { text }}
```

  - these can be combined:
    - ordered groups
    - unordered groups
    - choices
- we can constrain cardinalities of patterns
- text nodes
  - can be marked as “data” and linked
- we can specify libraries of patterns

RelaxNG: ordered groups

- we can **name** patterns
- in “chains”
- we can use **regular expressions** ,, **?**, ✱, |, and **+**

```
<?xml version="1.0" encoding="UTF-8"?>
<people>
  <person age="41">
    <name>
      <first>Harry</first>
      <last>Potter</last>
    </name>
    <address>4 Main Road </address>
    <project type="epsrc" id="1">
      DeCompO
    </project>
    <project type="eu" id="3">
      TONES
    </project>
  </person>
  <person>....
</people>
```

```
grammar { start =  people-element

people-element = element people
        { person-element+ }

person-element = element person {
                    attribute age { text },
                    name-element,
                    address-element+,
                    project-element✱}

name-element = element name {
                    element first { text },
                    element middle { text }?,
                    element last { text } }

address-element = element address { text }

project-element = element project {
                    attribute type { text },
                    attribute id {text},
                    text  }}
```

RelaxNG: different styles

- so far, we modelled 'element centric'...we can model 'content centric':

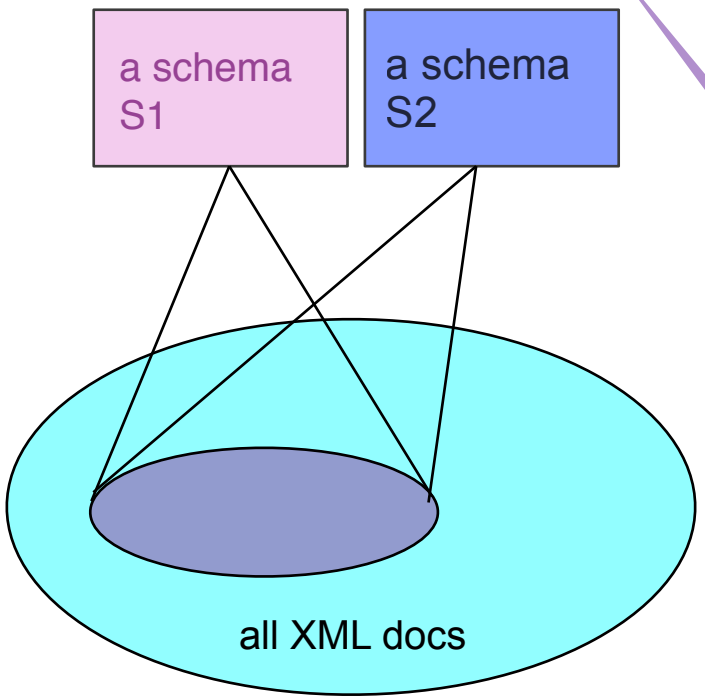
```
grammar { start =  people-description

people-description = element people
        { person-description+ }

person-description = element person {
                       attribute age { text },
                       name-description,
                       address-description+,
                       project-description*}

name-description = element name {
                     element first { text },
                     element middle { text }?,
                     element last { text } }

address-description = element address { text }

project-description = element project {
                       attribute type { text },
                       attribute id {text},
                      text  }}
```

```
grammar { start =
        element people {people-content}

people-content =
       element person { person-content }+

person-content = attribute age { text },
                 element name {name-content},
                 element address { text }+,
                 element project {project-content}*

name-content =  element first { text },
                 element middle { text }?,
                 element last { text }

project-content = attribute type { text },
                  attribute id {text},
                  text  }
```

Claim: A document is valid wrt left one iff it is valid wrt right one.

Documents being **valid** wrt schema

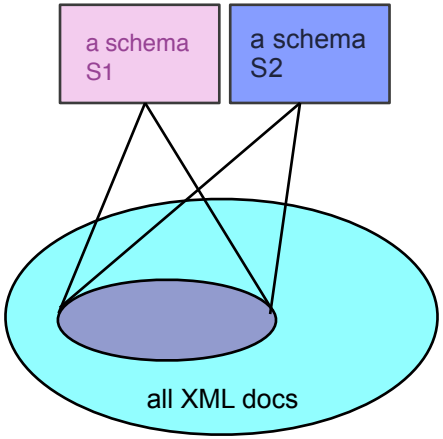
A document is valid wrt S1 iff it is valid wrt S2.



What does that mean?

Documents being valid wrt schema

- Validity of XML documents wrt a RelaxNG schema
  - is a complex concept because RelaxNG is a **powerful** schema language:
    - other schema languages, e.g. DTDs, are less powerful, so
      - describing things is harder,
      - describing some things is impossible, but
      - validity is easily defined
  - we concentrate here on **simple** RelaxNG schemata:
    - for each element name X,
      use a “macro” X-description
    - only patterns of the form
      - start = X-description
      - X-description = element X { text }
        or
      - X-description = element X expression
        where expression is a **regular expression over** “…-description”s
        …and exactly 1 such pattern per “…-description”



Simple RelaxNG schemas

- Is this schema simple?

```
grammar { start =  people-description

people-description = element people { person-description+ }

person-description = element person {
                        attribute age { text },
                        name-description,
                        address-description+,
                        project-description*}

name-description = element name {
                      element first { text },
                      element middle { text }?,
                      element last { text } }

address-description = element address { text }

project-description = element project {
                        attribute type { text },
                        attribute id {text},
                            text  }}
```

- for each element name X, use a “macro” X-description
- only patterns of the form
  - start = X-description
  - X-description = element X { text } or
  - X-description = element X expression where expression is a **regular expression over** “…-description”s …and exactly 1 such pattern per “…-description”

Simple RelaxNG schemas

- Is this schema simple?

```
grammar { start =  people-description

people-description = element people { person-description+ }

person-description = element person { name-description,
                                      address-description+,
                                      project-description*}

name-description = element name {first-description,
                                 middle-description?,
                                 last-description }

first-description = element first { text }
middle-description = element middle { text }
last-description = element last { text }

address-description = element address { text }

project-description = element project { text  }}
```

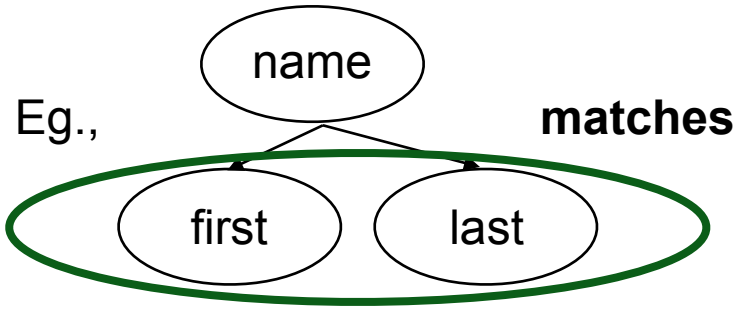
- for each element name X, use a “macro” X-description
- only patterns of the form
  - start = X-description
  - X-description = element X { text } or
  - X-description = element X expression where expression is a **regular expression over** “…-description”s …and exactly 1 such pattern per “…-description”

Documents described by a RelaxNG schema

- An node *n* with name ***X*** **matches** an expression
  - element ***X*** {text} if ***X*** has a single child node of text content
  - element ***X*** expression if the sequence of *n's* child node names matches expression, after dropping all "-description" in expression

Documents described by a RelaxNG schema

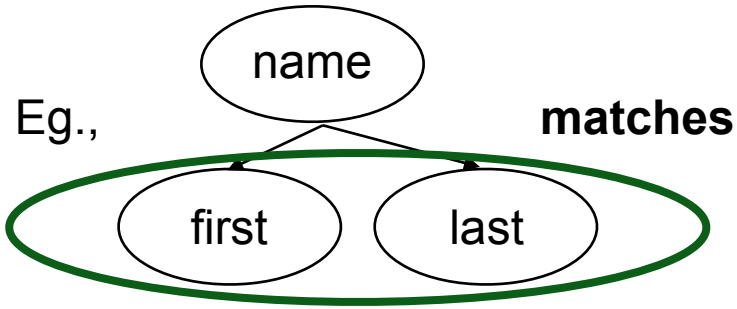
- A node *n* with name ***X*** **matches** an expression
  - element ***X*** {text} if ***X*** has a single child node of text content
  - element ***X*** expression if the sequence of *n's* child node names matches expression, after dropping all "-description" in expression

- Eg., 

matches element name {first-description, middle-description?, last-description }

Documents described by a RelaxNG schema

- A node *n* with name ***X*** **matches** an expression
  - element ***X*** {text} if ***X*** has a single child node of text content
  - element ***X*** expression if the sequence of *n's* child node names matches expression, after dropping all "-description" in expression

- Eg., 

matches element name {first-description, middle-description?, last-description }

An XML document *D* ***is valid wrt*** a simple RelaxNG schema *S* if

- *D*'s root node name is *X* iff *S* contains start = *X*-description
- each node n in D matches its description,
  I.e., if n's name is *X,* then *S* contains a statement
  X-description = *Y* and *n* matches *Y*.

RelaxNG: validity by example

Is this document valid wrt this RelaxNG schema?

```
<?xml version="1.0" encoding="UTF-8"?>
 <name>
        <first>Harry</first>
        <middle>Bob</middle>
</name>
```

```
grammar { start =  people-description

people-description = element people { person-
description+ }

person-description = element person {
name-description,}

name-description = element name {
                                    first-description,
                                   middle-description?,
                                    last-description }

first-description = element first { text }
middle-description = element middle { text }
last-description = element last { text }
}
```

RelaxNG: validity by example

Is this document valid wrt this RelaxNG schema?

```
<?xml version="1.0" encoding="UTF-8"?>
 <name>
        <first>Harry</first>
        <middle>Bob</middle>
        <last>Potter</last>
</name>
```

```
grammar { start =  people-description

people-description = element people { person-
description+ }

person-description = element person {
name-description,}

name-description = element name {
                                    first-description,
                                   middle-description?,
                                    last-description }

first-description = element first { text }
middle-description = element middle { text }
last-description = element last { text }
}
```

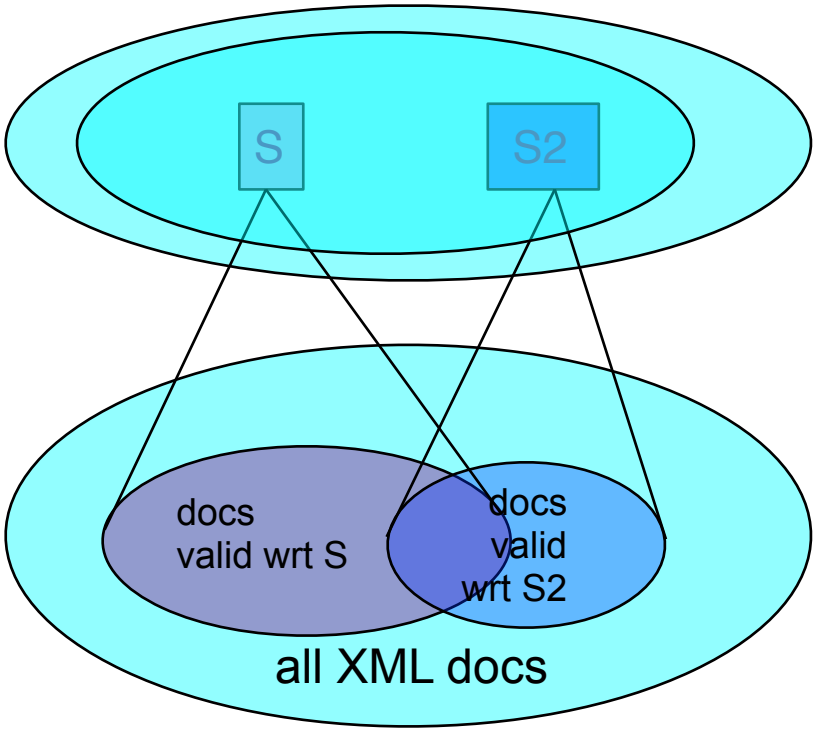
RelaxNG: validity by example

Is this document valid wrt this RelaxNG schema?

```
<?xml version="1.0" encoding="UTF-8"?>
<people>
  <person>
    <name>
      <first>Magda</first>
      <last>Potter</last>
    </name>
  </person>
</people>
```

```
grammar { start =  people-description

people-description = element people { person-
description+ }

person-description = element person {
name-description,}

name-description = element name {
                                    first-description,
                                   middle-description?,
                                    last-description }

first-description = element first { text }
middle-description = element middle { text }
last-description = element last { text }
}
```

Documents valid against RelaxNG schemas



just defined

process, possibly implemented

- careful: “is valid” is different from “validates against”

RelaxNG: regular expressions in XML syntax

```
grammar { start =  people-element

people-element = element people
          { person-element+ }

person-element = element person {
                        attribute age { text },
                        name-element,
                        address-element+,
                        project-element*}

name-element = element name {
                        element first { text },
                        element middle { text }?,
                        element last { text } }

address-element = element address { text }

project-element = element project {
                        attribute type { text },
                        attribute id {text},
                        text  }}
```

```
<?xml version="1.0" encoding="UTF-8"?>
<grammar xmlns="http://relaxng.org/ns/
structure/1.0">
 <start>
  <ref name="people-element"/>
 </start>

 <define name="people-element">
  <element name="people">
   <oneOrMore>
    <ref name="person-element"/>
   </oneOrMore>
  </element>
 </define>

 <define name="person-element">
  <element name="person">
   <attribute name="age"/>
   <ref name="name-element"/>
   <oneOrMore>
    <ref name="address-element"/>
   </oneOrMore>
   <zeroOrMore>
    <ref name="project-element"/>
   </zeroOrMore>
  </element>
 </define>

 <define name="name-element">
  <element name="name">
   <element name="first">
    <text/>
   </element>
   <optional>
    <element name="middle">
     <text/>
    </element>
   </optional>
   <element name="last">
    <text/>
   </element>
  </element>
 </define>

 <define name="address-element">
  <element name="address">
   <text/>
  </element>
 </define>

 <define name="project-element">
  <element name="project">
   <attribute name="type"/>
   <attribute name="id"/>
   <text/>
  </element>
 </define>
</grammar>
```

RelaxNG: ordered groups

- we can combine patterns in **fancy ways:**

```
grammar {start =  element people {people-content}
people-content = element person { person-content }+

person-content = HR-stuff,
                 contact-stuff

HR-stuff = attribute age { text },
           project-content

contact-stuff = attribute phone { text },
           element name {name-content},
           element address { text }

name-content =  element first { text },
                element middle { text }?,
                element last { text }
project-content = element project {
          attribute type { text },
                attribute id {text},
                text  }+}
```

```
<?xml version="1.0" encoding="UTF-8"?>
<people>
  <person age="41">
    <name>
      <first>Harry</first>
      <last>Potter</last>
    </name>
    <address>4 Main Road </address>
    <project type="epsrc" id="1">
      DeCompO
    </project>
    <project type="eu" id="3">
      TONES
    </project>
  </person>
  <person>....
</people>
```

RelaxNG: structure description summary

- RelaxNG's specification of structure differs from DTDs and XML Schema (XSD):
  - grammar oriented
  - 2 syntaxes with automatic translation
  - flexible: we can gather different aspects of elements into different patterns
  - unconstrained: no constraints regarding unambiguity/1-ambiguity/deterministic content model/Unique Particle Constraints/Element Declarations Consistent
  - we also have an "ALL" construct for unordered groups, "interleave" &:

here, the patterns must appear in the specified order, (except for attributes, which are allowed to appear in any order in the start tag):

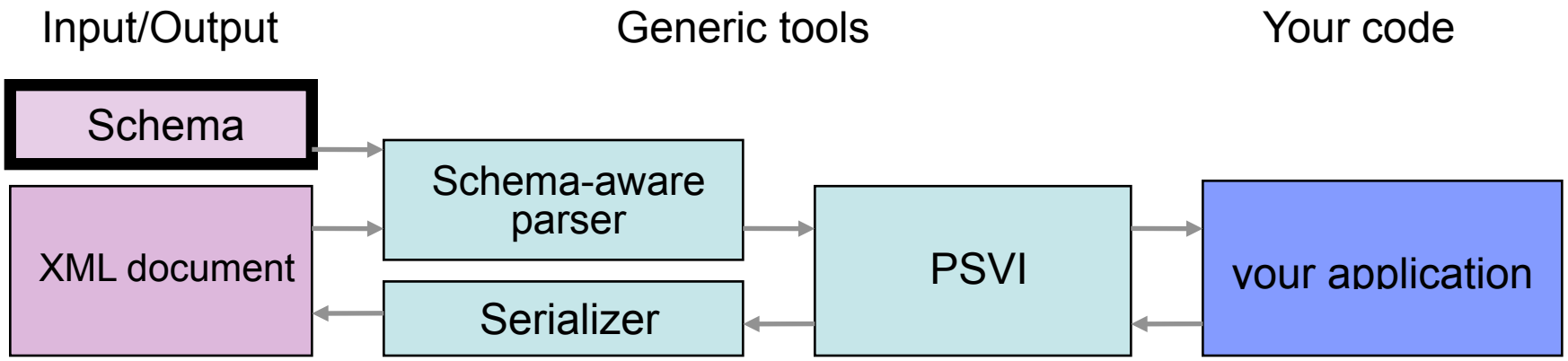
```
element person {
        attribute age { text},
      attribute phone { text},
        name-element ,
        address-element+ ,
        project-element*}
```

here, the patterns can appear any order:

```
element person {
        attribute age { text } &
      attribute phone { text} &
        name-element &
        address-element+ &
        project-element*}
```

Remember: Benefits of an (XML) schema

- **Specification**
  - you document/describe/publish your format
  - so that it can be used across multiple implementations
- As **input** for applications
  - applications can do **error-checking** in a **format independent** way
    - checking whether an XML document conforms to a schema can be done by a **generic** tool (see CW3),
    - no need to be changed when schema changes
    - automatically!



Validity of XML documents w.r.t. RelaxNG

- Try <oXygen/>
  - for your coursework
  - to write XML documents and RelaxNG schemas
  - it can check
    - whether your document is well-formed and
    - whether your document conforms to your schema!

XPath

XML documents...

There are various standards, tools, APIs, data models for XML:

- to **describe** XML documents &
  validate XML document against:
  - we have seen: RelaxNG
  - today: XML Schema
- to parse & **manipulate** XML documents programmatically:
  - we have seen & worked with: DOM (there's also SAX, etc.)
  - today, we will learn about **XPath** and **XQuery**
- transform an XML document into another XML document or
  into an instance of another formats,
  e.g., html, excel, relational tables
  - ….another form of **manipulation**

Manipulation of XML documents

- **XPath** for navigating through and querying of XML documents

- **XQuery**
  - more expressive than XPath, uses XPath
  - for querying and data manipulation
  - Turing complete
  - designed to access large amounts of data, to interface with relational systems
- **XSLT**
  - similar to XQuery in that it uses XPath, ...
  - designed for “styling”, together with XSL-FO or CSS

- contrast this with **DOM** and **SAX**:
  - a collection of APIs for programmatic manipulation
  - includes data model and parser
  - to build your own applications

XPath

- designed to navigate to/select parts in a **well-formed** XML document
- no transformational capabilities (as in XQuery and XSLT)
- is a W3C standard:
  - XPath 1.0 is a 1999 W3C standard
  - **XPath 2.0** is a 2007 W3C standard **that extends/is a superset of XPath 1.0**
    - richer set of WXS types & schema sensitive queries
  - XPath 3.0 is a 2014 W3C standard
- allows to select/define *parts* of an XML document: **sequence of nodes**
- uses **path expressions**
  - to navigate in XML documents
  - to select node-lists in an XML document
  - similar to expressions in a traditional computer file system
- provides numerous built-in functions
  - e.g., for string values, numeric values, date and time comparison, node and QName manipulation, sequence manipulation, Boolean values, etc.
- Contrast with SQL!

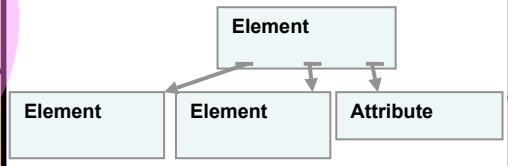
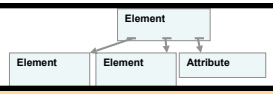
XML Schema later more

sequence vs set?

rm */*/*.pdf

XPath: Datamodel

- remember how an XML document can be seen as a node-labelled tree
  - with element names as labels: *its DOM tree*
- XPath operates on the abstract, logical tree structure of an XML document, rather than its surface, text syntax
  - *but not on its DOM tree*!
- XPath uses **XQuery/XPath Datamodel**
  - there is a translation at http://www.w3.org/TR/xpath20/#datamodel
    - see XPath process model…
  - it is similar to the DOM tree
    - easier
    - handles attributes differently

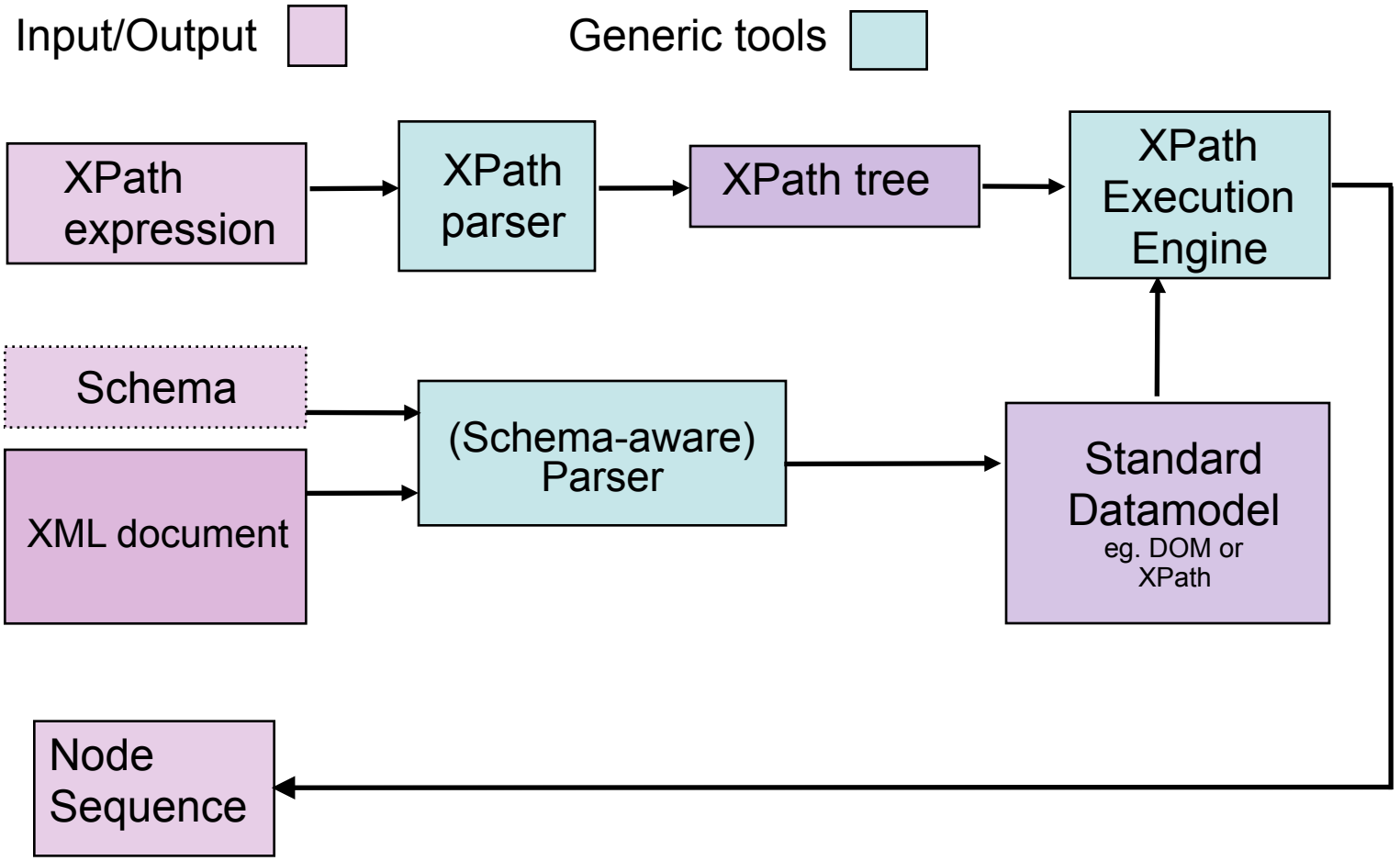
Level		Data unit examples	Information or Property required
cognitive			
application			
tree adorned with...			
namespace	schema		nothing / a schema
tree			well-formedness
token	complex	<foo:Name t="8">Bob	
	simple	<foo:Name t="8">Bob	
			which encoding

choice:
DOM tree
Infoset
XPath
....

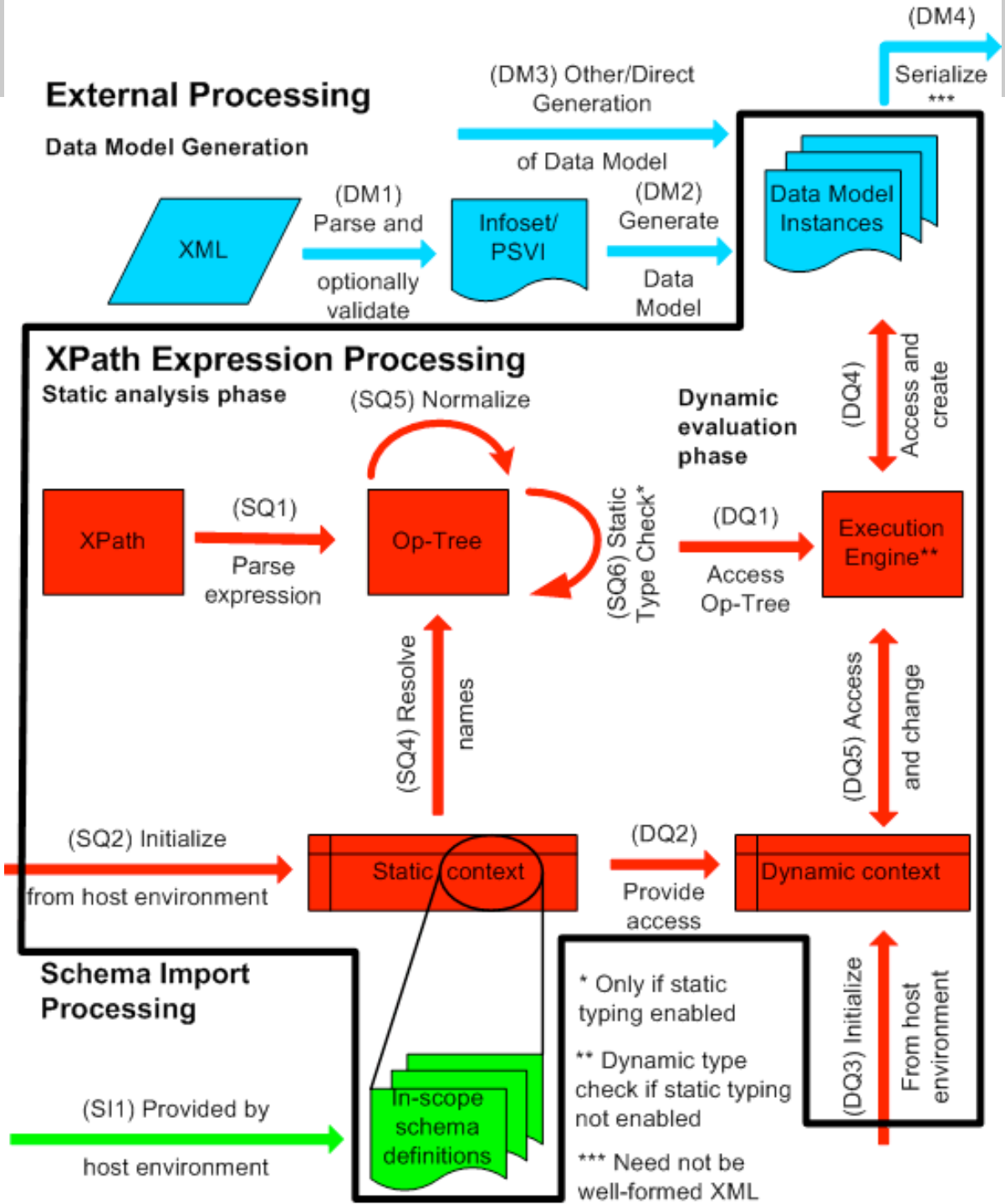
parsing

serializing

XPath processing - a simplified view

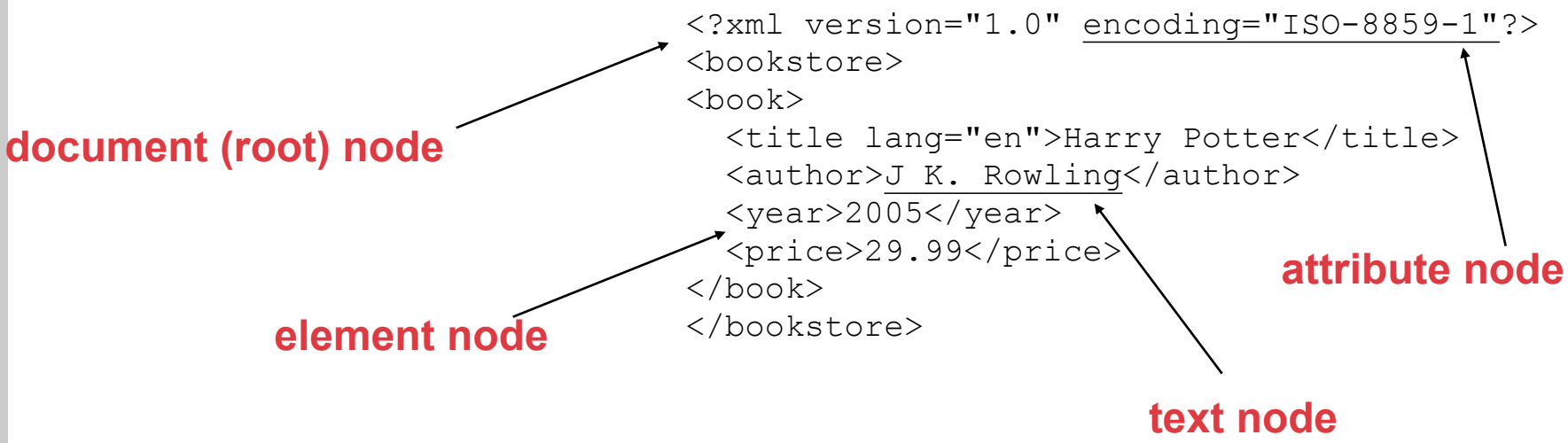


XPath processing - a more detailed view



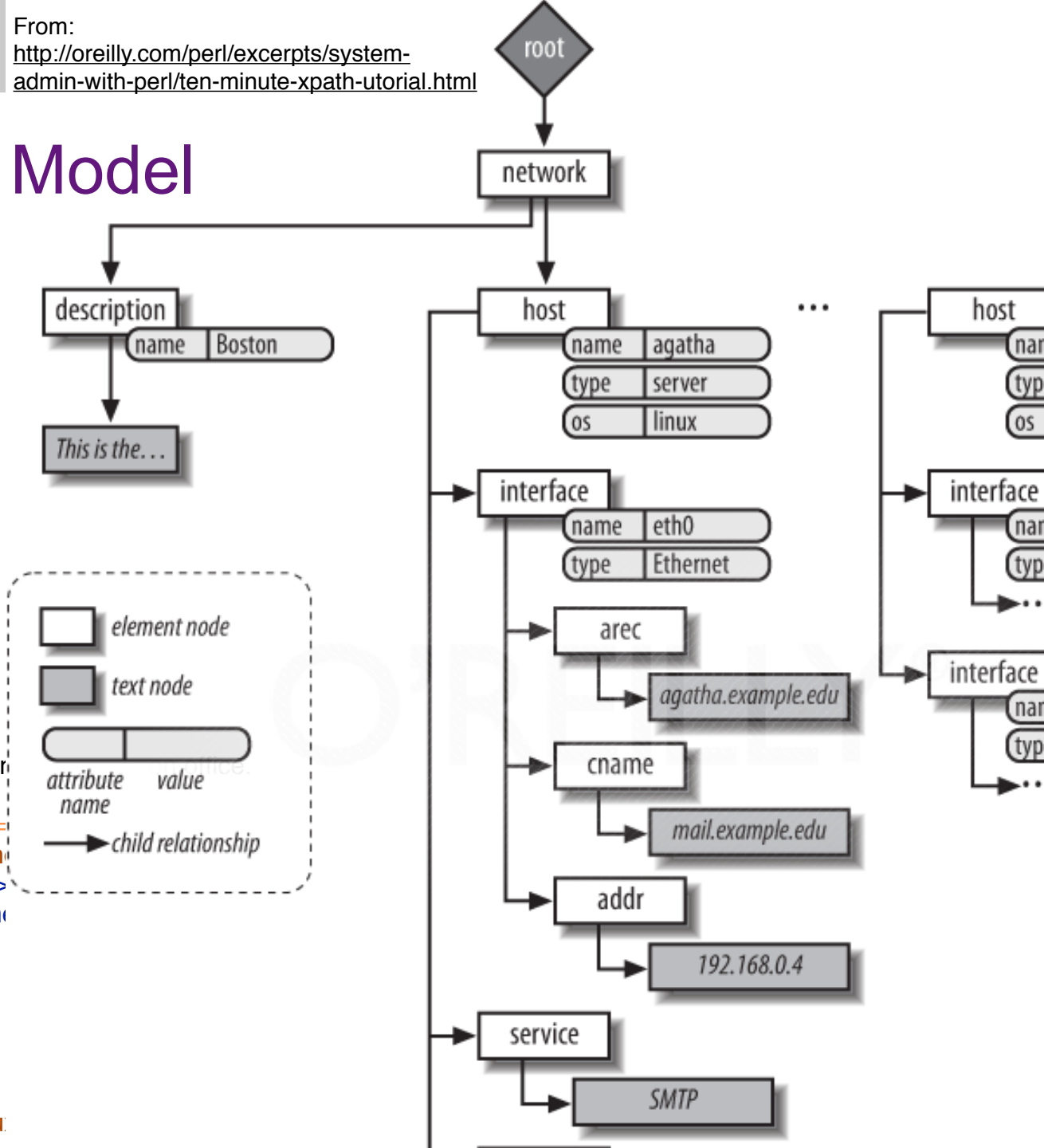
XPath: Datamodel

- the XPath DM uses the following concepts
- **nodes**:
  - element
  - attribute
  - text
  - namespace
  - processing-instruction
  - comment
  - document (root)
- **atomic value**:
  - behave like nodes without children or parents
  - is an atomic value, e.g., xsd:string
- **item**: atomic values or nodes



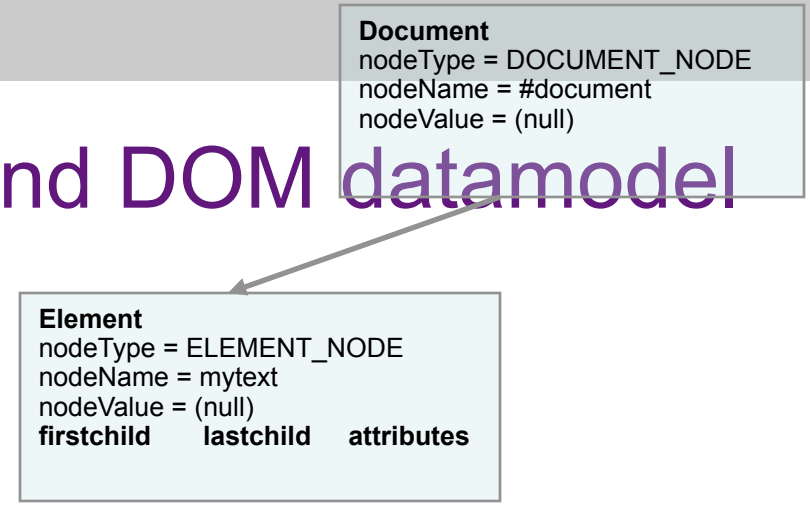
From: http://oreilly.com/perl/excerpts/system-admin-with-perl/ten-minute-xpath-utorial.html

XPath Data Model




```
<?xml version="1.0" encoding="UTF-8"?>
<network>
  <description name="Boston">
    This is the configuration of our networ
  </description>
  <host name="agatha" type="server" os=
    <interface name="eth0" type="Ethern
      <arec>agatha.example.edu</arec>
      <cname>mail.example.edu</cnam
      <addr>192.168.0.4</addr>
    </interface>
    <service>SMTP</service>
    <service>POP3</service>
    <service>IMAP4</service>
  </host>
  <host name="gil" type="server" os="linu
```

Comparison XPath DM and DOM datamodel



- XPath DM and DOM DM are similar, but different
  - most importantly regarding names and values of nodes but also structurally (see ★)
  - in XPath, only attributes, elements, processing instructions, and namespace nodes have names, of form (local part, namespace URI)
  - whereas DOM uses pseudo-names like #document, #comment, #text
  - In XPath, the **value** of an element or root node is the concatenation of the values of all its text node *descendants*, not null as it is in DOM:
    - e.g, XPath value of <a>AB is “AB”
  - ★ XPath does not have separate nodes for CDATA sections (they are merged with their surrounding text)
  - XPath has no representation of the DTD
    - or any schema

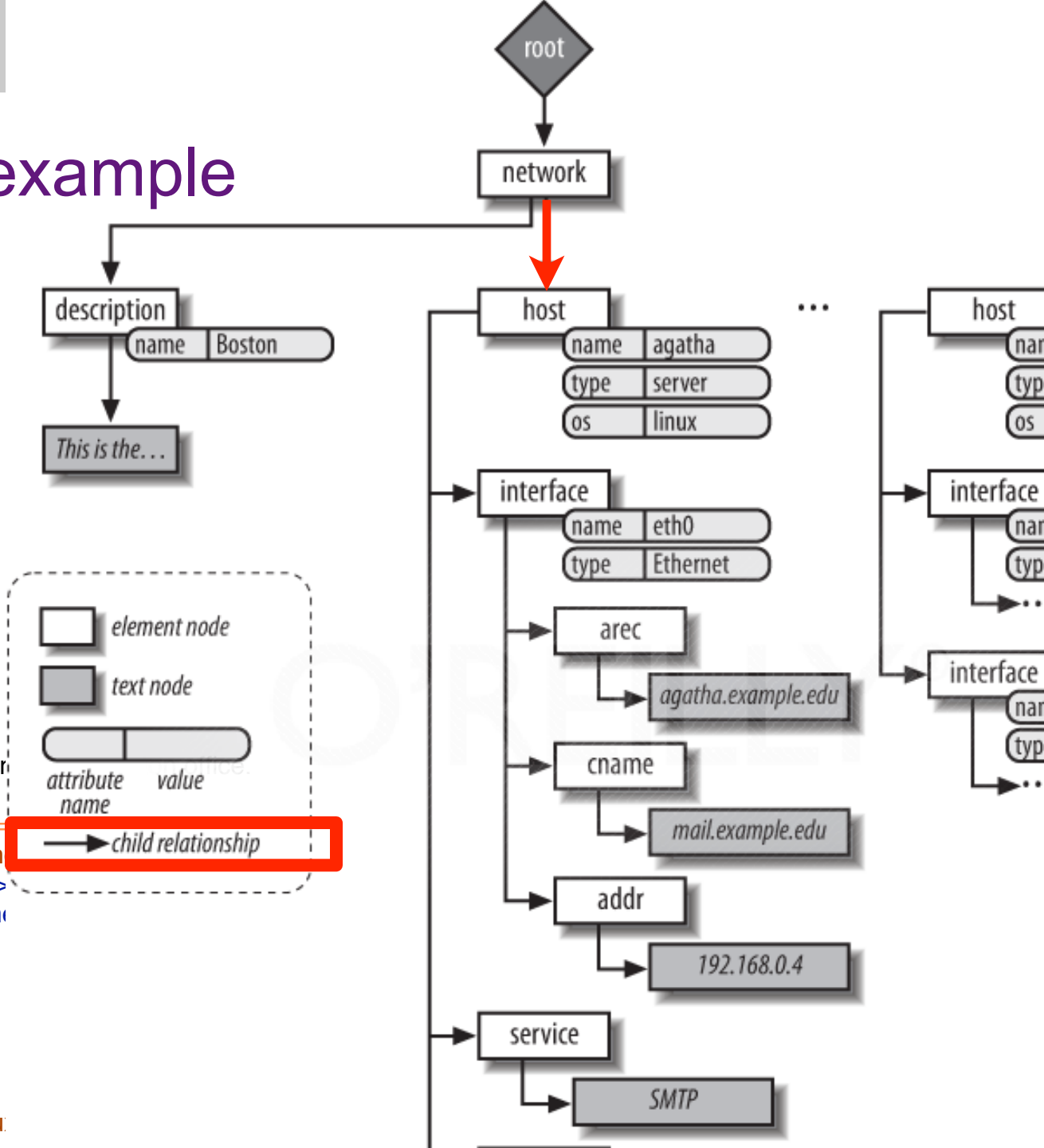
```
<N>here is some text and
<![CDATA[some CDATA < >]]>
</N>
```

XPath: core terms — relation between nodes

- We know **trees** already:
  - each node has at most one **parent**
    - each node but the root node has exactly one parent
    - the root node has no parent
  - each node has zero or more **children**
  - **ancestor** is the transitive closure of parent,
    i.e., a node's parent, its parent, its parent, ...
  - **descendant** is the transitive closure of child,
    i.e., a node's children, their children, their children, ...
- when evaluating an XPath expression *p*, we assume that we know
  - which document and
  - which **context** we are evaluating *p* over
  - … we see later how they are chosen/given
- an **XPath expression** evaluates to a **node sequence**,
  - a **node** is a document/element/attribute node or an atomic value
  - **document order** is preserved among items

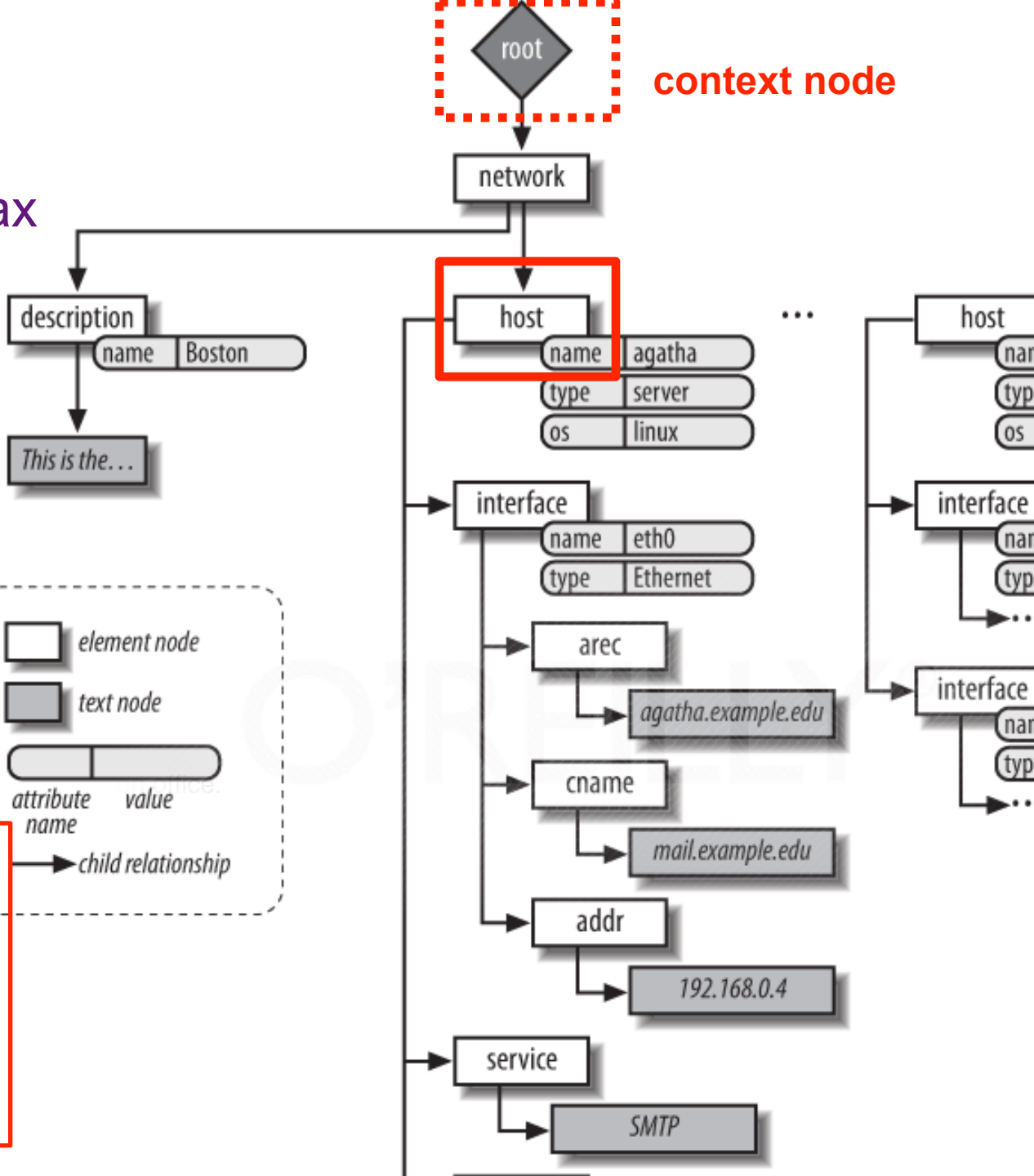
XPath - by example

```
<?xml version="1.0" encoding="UTF-8"?>
<network>
  <description name="Boston">
    This is the configuration of our networ
  </description>
  <host name="agatha" type="server" os=
    <interface name="eth0" type="Ethern
      <arec>agatha.example.edu</arec>
      <cname>mail.example.edu</cnam
      <addr>192.168.0.4</addr>
    </interface>
    <service>SMTP</service>
    <service>POP3</service>
    <service>IMAP4</service>
  </host>
  <host name="gil" type="server" os="linu
```



XPath - abbreviated syntax by example

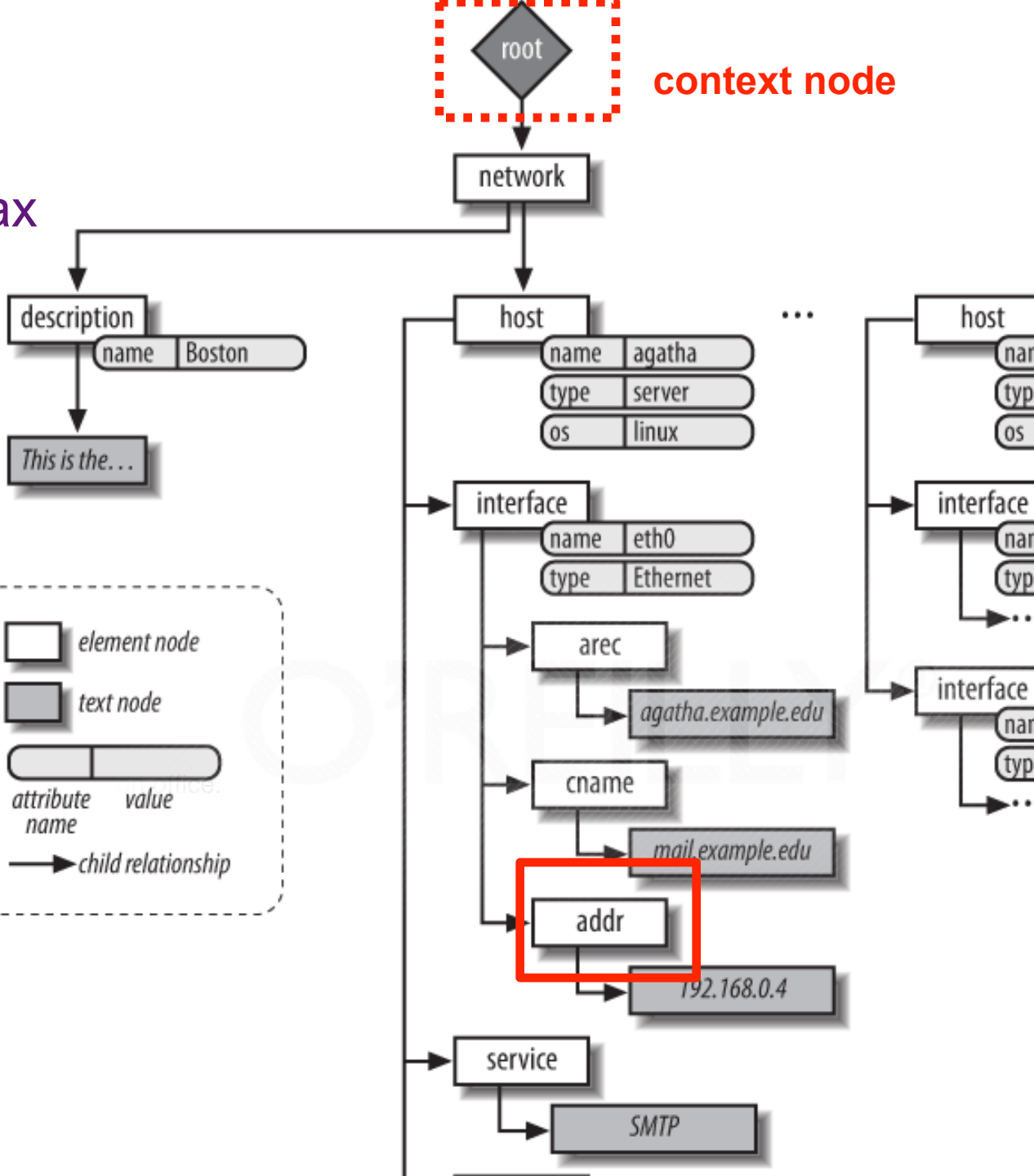
XPath expression:
/[2]




```
<?xml version="1.0" encoding="UTF-8"?>
<network>
  <description name="Boston">
    This is the configuration of our networ
  </description>
  <host name="agatha" type="server" os=
    <interface name="eth0" type="Ethern
      <arec>agatha.example.edu</arec>
      <cname>mail.example.edu</cnam
      <addr>192.168.0.4</addr>
    </interface>
    <service>SMTP</service>
    <service>POP3</service>
    <service>IMAP4</service>
  </host>
  <host name="gil" type="server" os="linu
```

XPath - abbreviated syntax by example

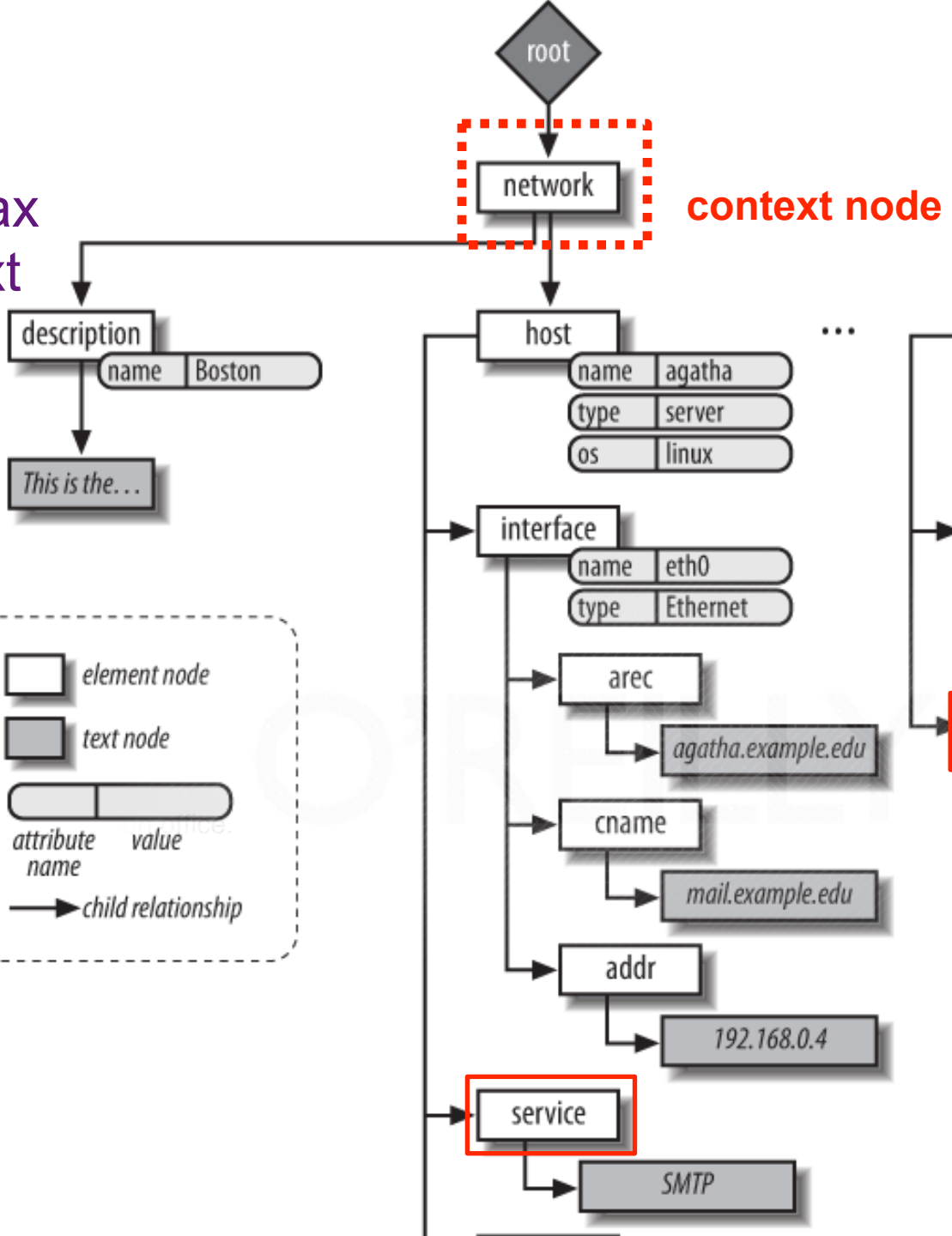
XPath expression:
/[2]/*[1]/*[3]




```
<?xml version="1.0" encoding="UTF-8"?>
<network>
  <description name="Boston">
    This is the configuration of our networ
  </description>
  <host name="agatha" type="server" os=
    <interface name="eth0" type="Ethern
      <arec>agatha.example.edu</arec>
      <cname>mail.example.edu</cnam
      <addr>192.168.0.4</addr>
    </interface>
    <service>SMTP</service>
    <service>POP3</service>
    <service>IMAP4</service>
  </host>
  <host name="gil" type="server" os="linu
```

XPath - abbreviated syntax know your context node

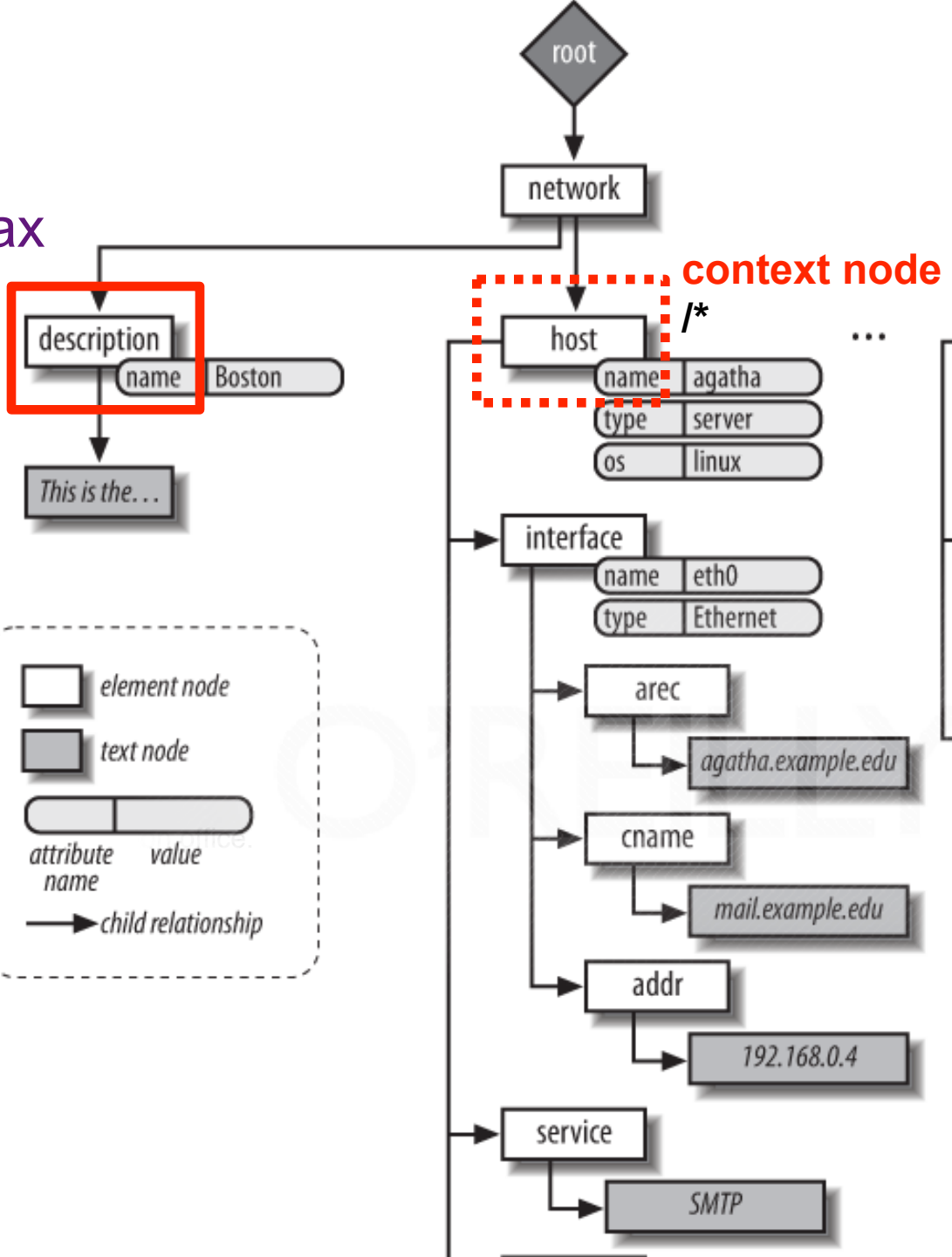
XPath expression:
/[2]




```
<?xml version="1.0" encoding="UTF-8"?>
<network>
  <description name="Boston">
    This is the configuration of our networ
  </description>
  <host name="agatha" type="server" os=
    <interface name="eth0" type="Ethern
      <arec>agatha.example.edu</arec>
      <cname>mail.example.edu</cnam
      <addr>192.168.0.4</addr>
    </interface>
    <service>SMTP</service>
    <service>POP3</service>
    <service>IMAP4</service>
  </host>
  <host name="gil" type="server" os="linu
```

XPath - abbreviated syntax absolute paths

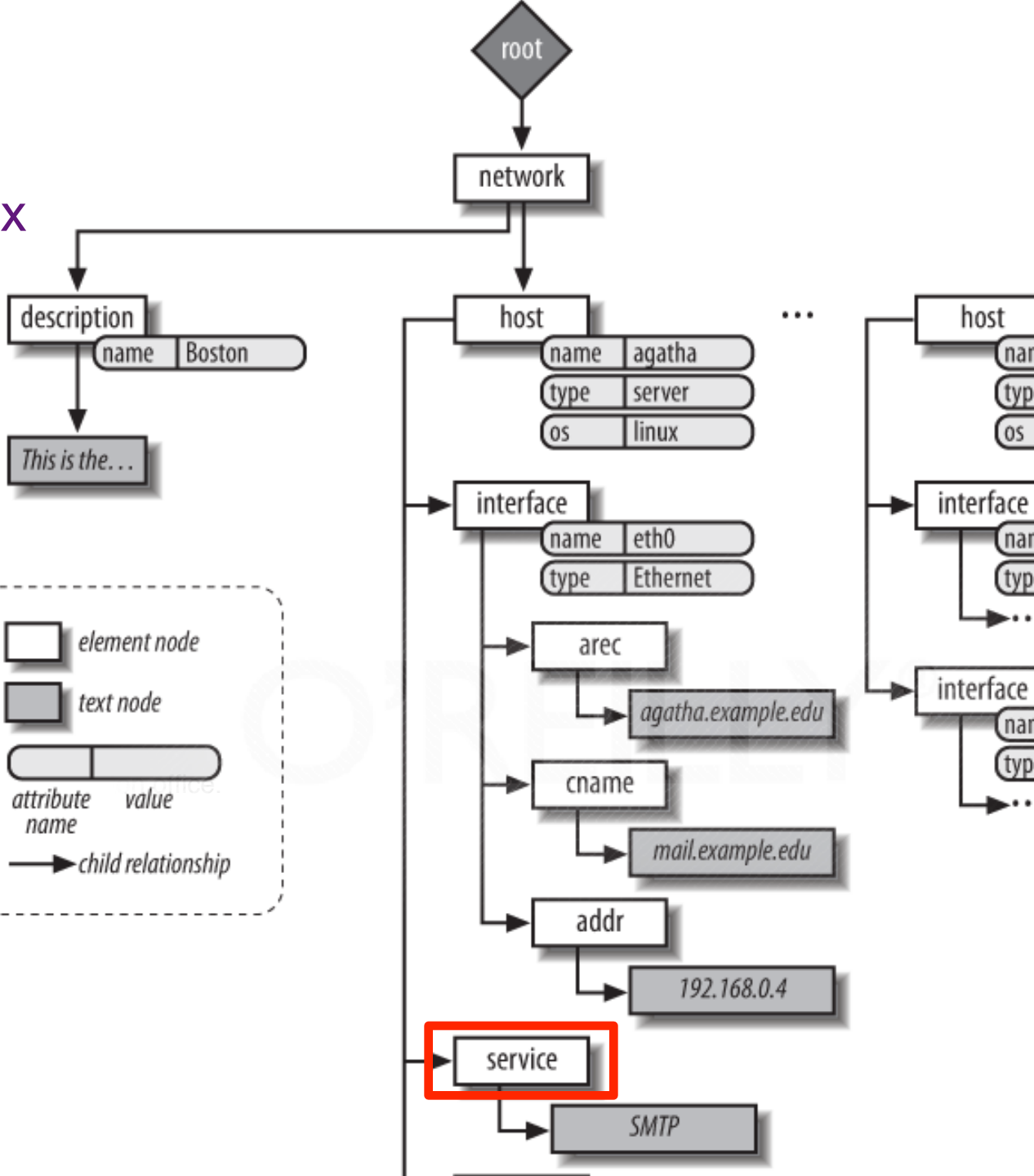
XPath expression:
/*/*[1]




```
<?xml version="1.0" encoding="UTF-8"?>
<network>
  <description name="Boston">
    This is the configuration of our networ
  </description>
  <host name="agatha" type="server" os=
    <interface name="eth0" type="Ethern
      <arec>agatha.example.edu</arec>
      <cname>mail.example.edu</cnam
      <addr>192.168.0.4</addr>
    </interface>
    <service>SMTP</service>
    <service>POP3</service>
    <service>IMAP4</service>
  </host>
  <host name="gil" type="server" os="linu
```

XPath - abbreviated syntax local globally

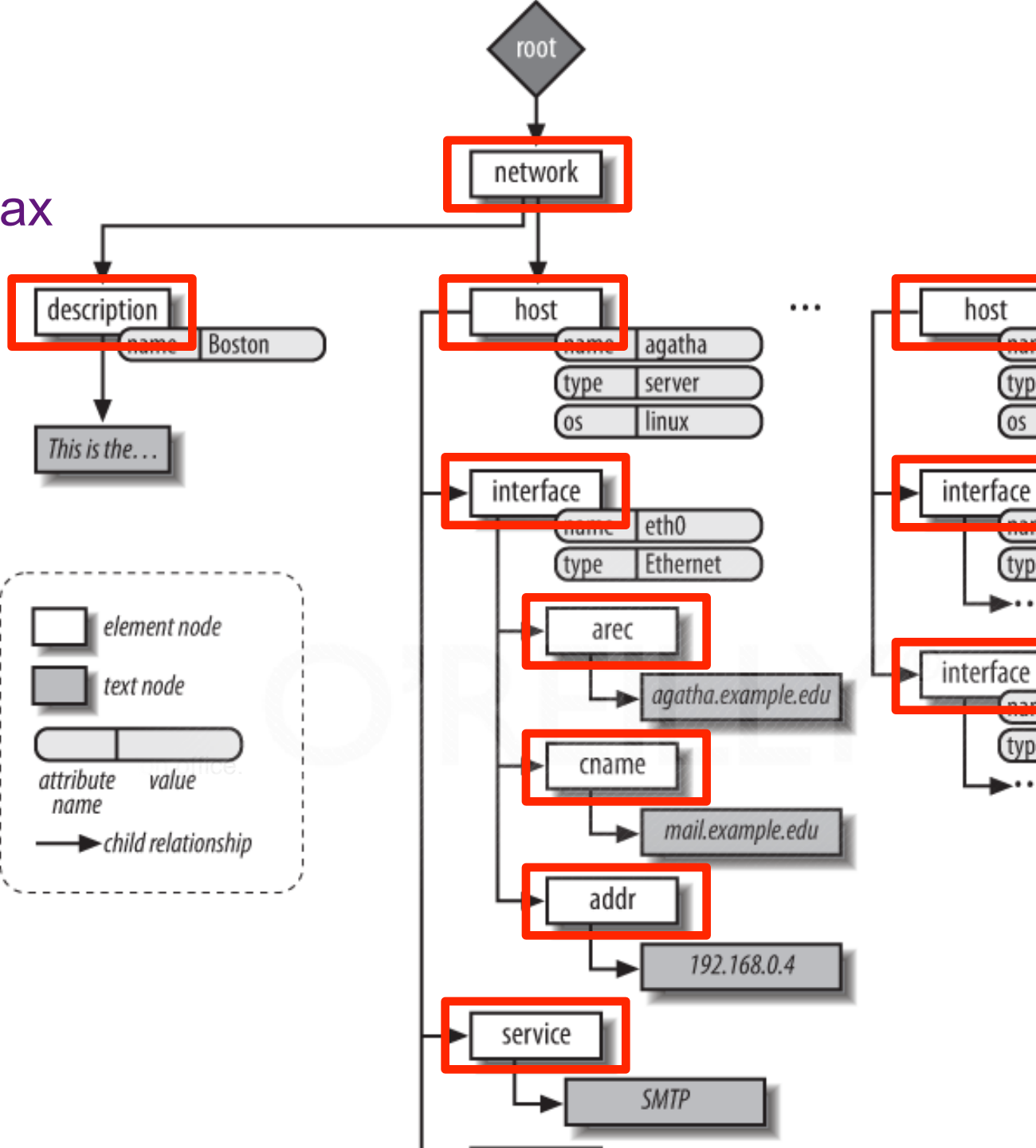
XPath expression:
//service




```
<?xml version="1.0" encoding="UTF-8"?>
<network>
   <description name="Boston">
      This is the configuration of our networ
   </description>
   <host name="agatha" type="server" os=
      <interface name="eth0" type="Ethern
         <arec>agatha.example.edu</arec>
         <cname>mail.example.edu</cnam
         <addr>192.168.0.4</addr>
      </interface>
      <service>SMTP</service>
      <service>POP3</service>
      <service>IMAP4</service>
   </host>
   <host name="gil" type="server" os="linu
```

XPath - abbreviated syntax local globally

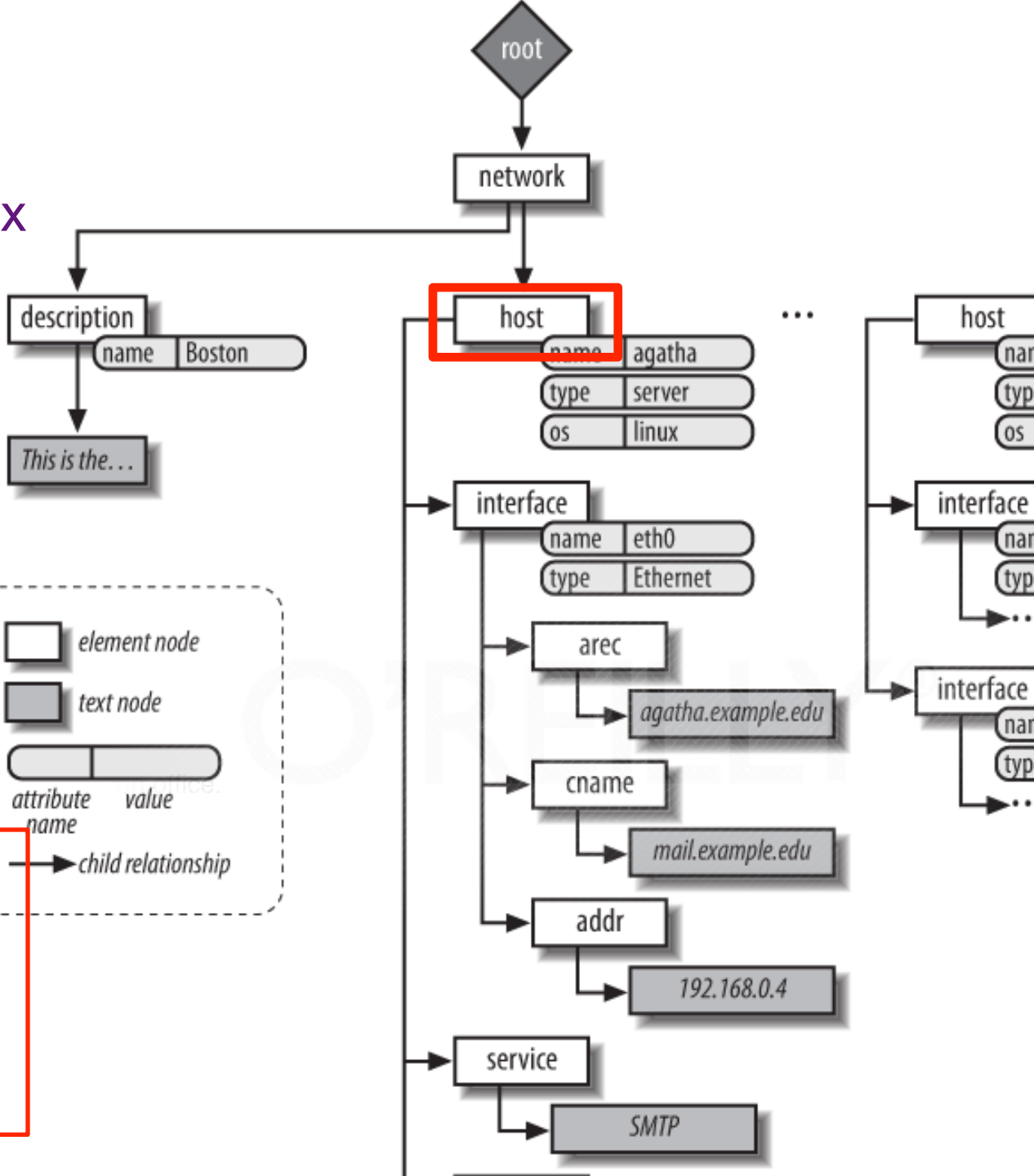
XPath expression:
//*




```
<?xml version="1.0" encoding="UTF-8"?>
<network>
  <description name="Boston">
    This is the configuration of our networ
  </description>
  <host name="agatha" type="server" os=
    <interface name="eth0" type="Ethern
      <arec>agatha.example.edu</arec>
      <cname>mail.example.edu</cnam
      <addr>192.168.0.4</addr>
    </interface>
    <service>SMTP</service>
    <service>POP3</service>
    <service>IMAP4</service>
  </host>
  <host name="gil" type="server" os="linu
```

XPath - abbreviated syntax attributes in filters

XPath expression:
//*[@name="agatha"]




```
<?xml version="1.0" encoding="UTF-8"?>
<network>
  <description name="Boston">
    This is the configuration of our networ
  </description>
  <host name="agatha" type="server" os=
    <interface name="eth0" type="Ethern
      <arec>agatha.example.edu</arec>
      <cname>mail.example.edu</cnam
      <addr>192.168.0.4</addr>
    </interface>
    <service>SMTP</service>
    <service>POP3</service>
    <service>IMAP4</service>
  </host>
  <host name="gil" type="server" os="linu
```

Find more about XPath:
read up and
play with examples,
e.g., in

MANCHESTER 1824

The University of Manchester

XML Namespaces

or,

making things “simpler”

by

making them much more complex

An observation

- "**plus**" elements may occur in different situations
- e.g in arithmetic expression (see CW2/3, M3) and in regular expressions:

```
<plus>
   <int value="4"/>
   <int value="5"/>
</plus>
```

for 4+5

```
<plus>
   <choice>
      <star>A</star>
      <star>B </star>
   </choice>
</plus>
```

for (A*|B*)+

- We have an **element name conflict**!
- How do we distinguish plus[arithmetic] and plus[reg-exp]?
  - semantically?
  - in a combined document?

Unique-ing the names (1)

- We can add some characters

```
<calcplus>
   <int value="4"/>
   <int value="5"/>
</calcplus>
```

```
<regexplus>
   <choice>
      ...
   </choice>
</regexplus>
```

- No name clash now
  - But the “meaningful” part of name (plus) is hard to see
  - “calcplus” isn’t a real word!

Unique-ing the names (2)

- We can use a separator or other convention

```
<calc:plus>
   <int value="4"/>
   <int value="5"/>
</calc:plus>
```

```
<regex:plus>
   <choice>
      ...
   </choice>
</regex:plus>
```

- No name clash now
  - The “meaningful” part of the name is **clear**
  - The disambiguator is **clear**
    - But we still can get **clashes**
      - e.g., 2 calc:plus with different rounding!?
    - Need a **registry** to coordinate?

Unique-ing the names (3)

- Use URIs for disambiguation

```
<http://bjp.org/calc/:plus>
   <int value="4"/>
   <int value="5"/>
</http://bjp.org/calc/:plus>

<http://uli.org/calc/:plus>
   <rat value="4"/>
   <rat value="5.5"/>
</http://uli.org/calc/:plus>
```

```
<http://bjp.org/regex/:plus>
   <choice>
      ...
   </choice>
</http://bjp.org/regex/:plus>
```

- No name clash now
  - The "meaningful" part of the name **clear**
  - The disambiguator is **clear**
    - Clashes are hard to get
    - Existing URI allocation mechanism
  - But not well formed!

Uniquing the names (4)

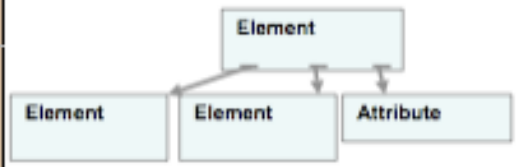
- Combine the (2) and (3)!

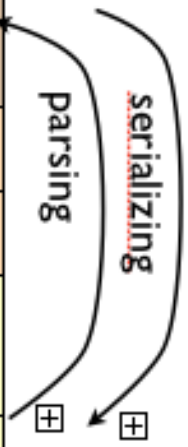
```
<calc:plus
        xmlns:calc="http://bjp.org/calc/">
   <int value="4"/>
   <int value="5"/>
</calc:plus>
```

```
<regex:plus xmlns:regex="http://bjp.org/regex/">
    <choice>
        ...
    </choice>
</regex:plus>
```

- No name clash now
  - The “meaningful” part of the name **clear**
  - The disambiguator is **clear**
    - Clashes are hard to get
    - Existing URI allocation mechanism
  - But well formed!
- But the model doesn’t know

Layered!

Level		Data unit examples	Information or Property required	
cognitive				
application				
tree adorned with...				
namespace	schema		nothing	a schema
tree			well-formedness	
token	complex	<foo:Name t="8">Bob		
	simple	<foo:Name t="8">Bob		
character		< foo:Name t="8">Bob	which encoding (e.g., UTF-8)	
bit		10011010		



Anatomy & Terminology of Namespaces

```
<calc:plus
        xmlns:calc="http://bjp.org/calc/">
   <int value="4"/>
   <int value="5"/>
</calc:plus>
```

- **Namespace declarations**, e.g., xmlns:calc="http://bjp.org/calc/"
  - looks like/can be treated as a normal attribute
- **Qualified names** ("QNames"), e.g., calc:plus consist of
  - **Prefix**, e.g., calc
  - **Local name**, e.g., plus
- **Expanded name,** e.g., {http://bjp.org/calc/}plus
  - they don't occur in doc
  - but we can talk about them!
- **Namespace name**, e.g., http://bjp.org/calc/

We don't need a prefix

```
<plus
        xmlns="http://bjp.org/calc/">
   <int value="4"/>
   <int value="5"/>
</plus>
```

```
<calc:plus
        xmlns:calc="http://bjp.org/calc/">
   <int value="4"/>
   <int value="5"/>
</calc:plus>
```

- We can have **default** namespaces
  - Terser/Less cluttered
  - Retro-fit legacy documents
  - Safer for non-namespace aware processors
- But trickiness!
  - What's the expanded name of "int" in each document?

{http://bjp.org/calc/}int

{}int

  - Default namespaces and attributes interact weirdly...

Multiple namespaces

- We can have **multiple declarations**
- Each declaration has a **scope**
- The **scope** of a declaration is:
  - the element where the declaration **appears** together with
  - **the descendants** of that element...
    - ...**except** those descendants which have a **conflicting declaration**
      - (and their descendants, etc.)
    - I.e., a declaration with the same prefix
- Scopes nest and shadow
  - Deeper nested declarations redefine/overwrite outer declarations

```
<plus xmlns="http://bjp.org/calc/"
      xmlns:n="http://bjp.org/numbers/ >
  <n:int value="4"/>
  <n:int value="5"/>
</plus>
```

```
<plus xmlns="http://bjp.org/calc/">
  <int xmlns="http://bjp.org/numbers/
       value="4"/>
  <int value="5"/>
</plus>
```

Let's test our understanding...

```
<a:expression xmlns="foo1" xmlns:a="foo2" xmlns:b="bah">
    <b:plus xmlns:a="foobah">
        <int value="3"/>
        <a:int value="3"/>
    </b:plus>
</a:expression>
```

Let's test our understanding via some Kahoot quiz: go to kahoot.it

Some more about NS in our future

- Issues: Namespaces are increasingly controversial
- Modelling principles
- Schema language support

Phew - Summary of today

We have seen many things - you'll deepen your understanding in coursework:

Tree data models:

1. Data Structure formalisms: XML (including name spaces)
2. Schema Language: RelaxNG
3. Data Manipulation: XPath, DOM and Python

General concepts:

- Semi-structured data
- Self-Describing (again)
- Trees (again)
- Regular Expressions (again)
- Internal & External Representation, Parsing (again)
- Validation, valid, …
- Format

Next: Coursework Old & New

- Quiz
- Short essay
- M3: build a JSON schema (next week: RelaxNG!)
  - as an extension to a given one
  - for arithmetic expressions
  - test your schema, share tests
- CW3:
  - use python and DOM to parse XML document with arithmetic expression, compute value of arithmetic expression after validating it against RelaxNG schema
  - test your program, share tests

- do Quiz first, then CW3 and M3, then SE3

- …see you in the labs!