

# XML & XPath

INF 551

Wensheng Wu

```
<?xml version="1.0" encoding="UTF-8"?>
<?xml-stylesheet type="text/xsl" href="configuration.xsl"?>
<!--
  Licensed under the Apache License, Version 2.0 (the "License");
  you may not use this file except in compliance with the License.
  You may obtain a copy of the License at

    http://www.apache.org/licenses/LICENSE-2.0

  Unless required by applicable law or agreed to in writing, software
  distributed under the License is distributed on an "AS IS" BASIS,
  WITHOUT WARRANTIES OR CONDITIONS OF ANY KIND, either express or implied.
  See the License for the specific language governing permissions and
  limitations under the License. See accompanying LICENSE file.
-->

<!-- Put site-specific property overrides in this file. -->

<configuration>
  <property>
    <name>fs.defaultFS</name>
    <value>hdfs://localhost:9000</value>
  </property>
</configuration>
~
"core-site.xml" 24 lines, 889 characters
```

# Agenda

- XML:
  - What is it and why do we care?
  - Data model
  - Query language: XPath

# XML

- eXtensible Markup Language
- XML 1.0 – a recommendation from W3C, 2008
- Root: SGML (standard generalized markup language)
- After the root: a format for sharing *data*

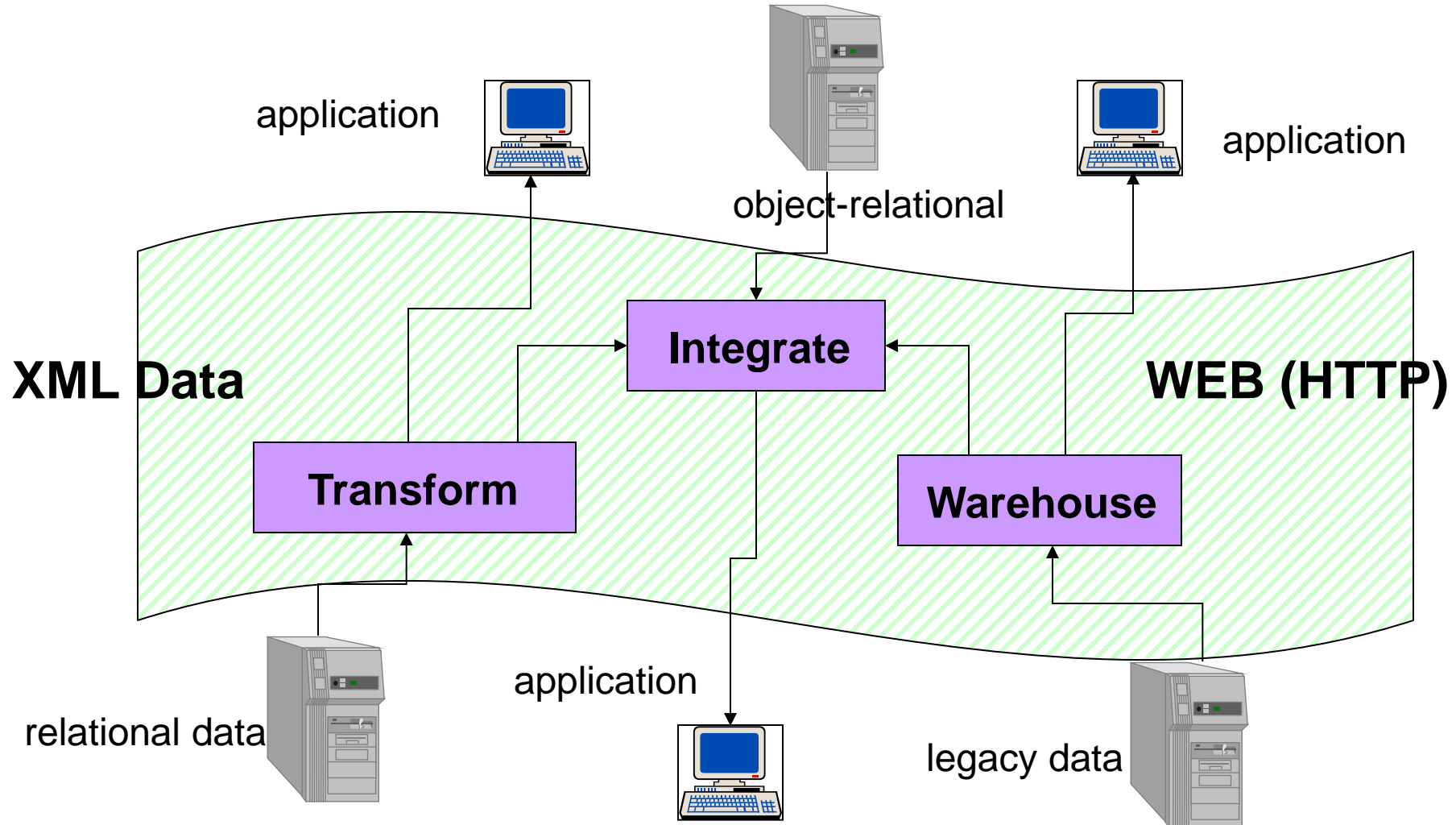
# SGML

- Derived from IBM's GML developed in 1960's
  - Charles Goldfarb, Edward Mosher, and Raymond Lorie
  - For sharing of large-project documents
- Basis for HTML & XML
  - XML is roughly an augmented subset (adds more restrictions)
  - HTML is an application of SGML

# Why XML is of Interest to Us

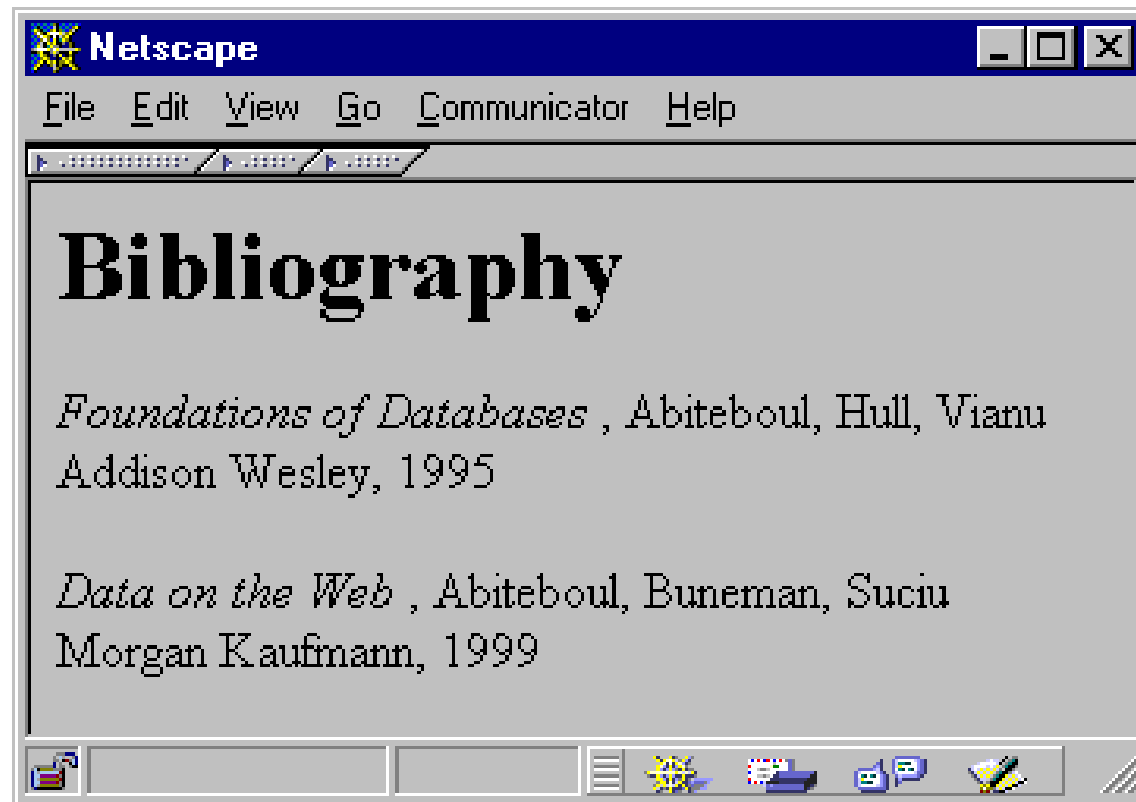
- XML is just syntax (serialization format) for data
  - Note: we have no syntax for relational data
  - But XML is not relational: *semi-structured*
- This is exciting because:
  - Can translate *any* data to XML
  - Can ship XML over the Web (HTTP)
  - Can input XML into any application
  - Thus: **data sharing and exchange on the Web**

# XML Data Sharing and Exchange



Specific data management tasks

# From HTML to XML



HTML describes the presentation



# HTML

<h1> Bibliography </h1>

<p> <i> Foundations of Databases </i>

Abiteboul, Hull, Vianu

<br> Addison Wesley, 1995

<p> <i> Data on the Web </i>

Abiteoul, Buneman, Suciu

<br> Morgan Kaufmann, 1999

# XML

```
<bibliography>
  <book>  <title> Foundations... </title>
           <author> Abiteboul </author>
           <author> Hull </author>
           <author> Vianu </author>
           <publisher> Addison Wesley </publisher>
           <year> 1995 </year>
  </book>
  ...
</bibliography>
```

XML describes the content

# Web Services

- Wikipedia: a software system designed to support interoperable machine-to-machine interaction over a network
- Use http for machine-machine communications of files
  - E.g., in XML & JSON formats
  - WSDL, SOAP (simple object access protocol)

# Web service example (link)

## TempConvert

Click [here](#) for a complete list of operations.

### CelsiusToFahrenheit

#### Test

To test the operation using the HTTP POST protocol, click the 'Invoke' button.

Parameter	Value
Celsius:	<input type="text" value="23"/>
<input type="button" value="Invoke"/>	

#### SOAP 1.1

The following is a sample SOAP 1.1 request and response. The [placeholders](#) shown need to be replaced with actual values.

```
POST /xml/tempconvert.asmx HTTP/1.1
Host: www.w3schools.com
Content-Type: text/xml; charset=utf-8
Content-Length: length
SOAPAction: "http://www.w3schools.com/xml/CelsiusToFahrenheit"

<?xml version="1.0" encoding="utf-8"?>
<soap:Envelope xmlns:xsi="http://www.w3.org/2001/XMLSchema-instance" xmlns:xsd="http://www.w3.org/2001/XMLSchema" xmlns:soap="http://schemas.xmlsoap.org/soap/envelope/">
  <soap:Body>
    <CelsiusToFahrenheit xmlns="http://www.w3schools.com/xml/">
      <Celsius>string</Celsius>
    </CelsiusToFahrenheit>
  </soap:Body>
</soap:Envelope>

HTTP/1.1 200 OK
Content-Type: text/xml; charset=utf-8
```

# Ajax

- Asynchronous Javascript and XML
- Web clients send and receive data from server asynchronously
  - Benefit: more responsive web pages
- Common to use XML, JSON as data format

# Ajax in action (link)

Amazon Associates SiteStripe

Get Link: [Text](#) [Image](#) [Text+Image](#) Share: [f](#) [t](#) [Earnings](#) [Help](#)

NEW & INTERESTING FINDS ON AMAZON [EXPLORE](#)

**amazon** Prime

Shop \$5 lobster

Departments ▾ Browsing History ▾ Wensheng's Amazon.com Hello, Wensheng Your Account ▾ Prime ▾ Lists ▾

1-16 of 15,749 results for "data mining" Sort by [Relevance](#)

☐ | FREE One-Day

Get FREE One-Day Delivery on qualifying orders over \$35

**Apress Featured Resources in Professional Computing**

Sponsored by Apress. Explore these professional computing resources.

Show results for

**Books** ▸

- Data Mining
- Computers & Technology
- Artificial Intelligence & Semantics
- Reference
- Probability & Statistics

**Data Mining: Practical Machine Learning Tools and Techniques, Third Edition (Morgan Kaufmann Series in Data Management Systems)** by Ian H. Witten and Eibe Frank

Paperback **\$36.12** ~~\$69.95~~ | FREE One-Day

Get it by **Tomorrow, Sep 29**

More Buying Choices

★★★★☆ ▾ 73

Trade in yours for an Amazon Gift Card up to **\$12.61**

# XML Terminology

- tags: **book**, **title**, **author**, ...
- start tag: **<book>**, end tag: **</book>**
- elements: **<book>...</book>**, **<author>...</author>**
- elements may be nested:

**<book><author>...</author></book>**

- empty element: **<red></red>** abbrev. **<red/>**
- an XML document: has a single *root element*
- ***Element names are case-sensitive!***

**well formed XML document: if it has matching tags**

# More XML: Attributes

```
<book price = "55" currency = "USD">  
  <title> Foundations of Databases </title>  
  <author> Abiteboul </author>  
  ...  
  <year> 1995 </year>  
</book>
```

attributes are alternative ways to represent data



# Attributes

- `<book price = “55” currency = “USD”>`
- Attribute values must be quoted, either double or single

# More XML: Oids and References

```
<person id="o555"> <name> Jane </name> </person>
```

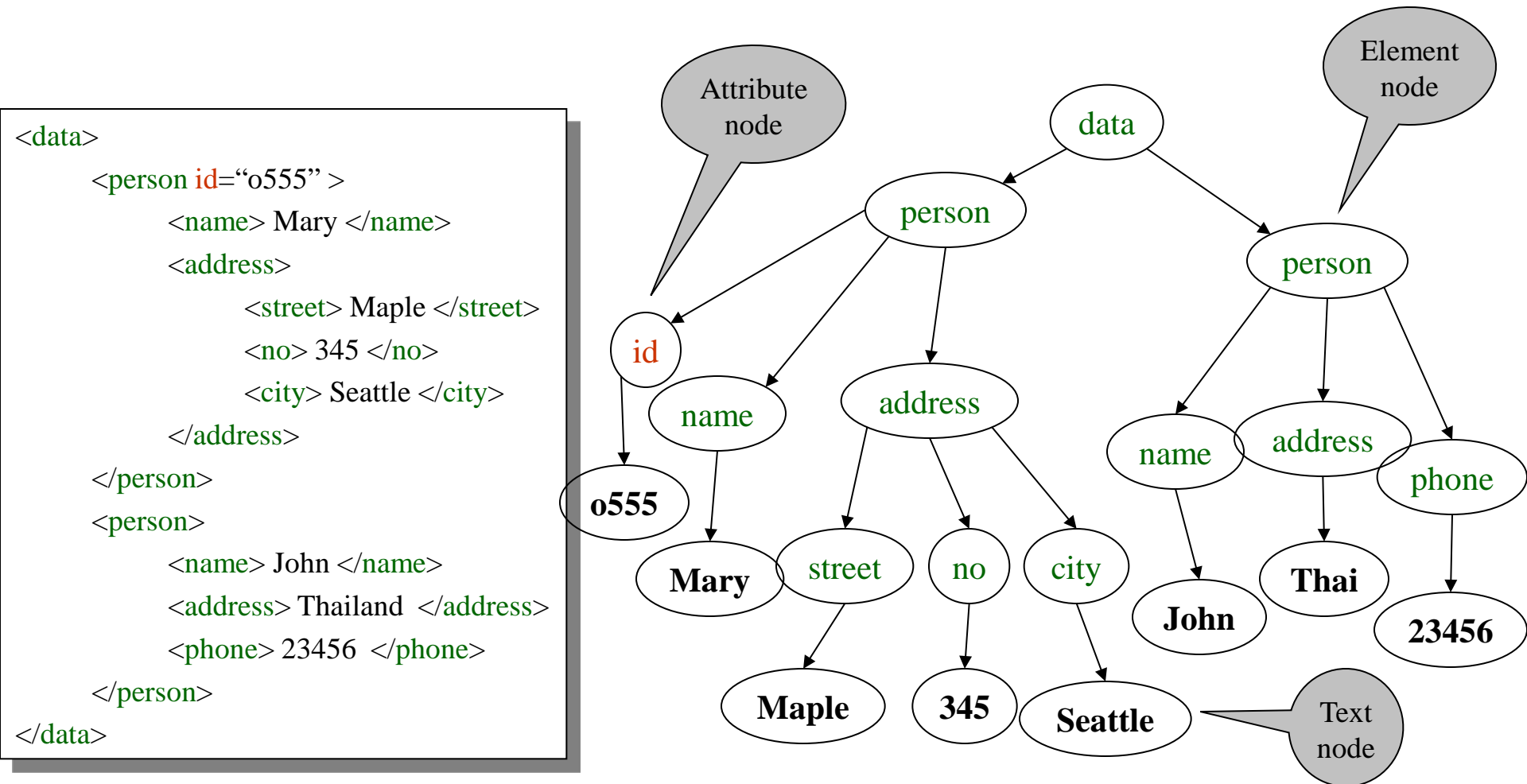
```
<person id="o456"> <name> Mary </name>  
    <children idref="o123 o555"/>
```

```
</person>
```

```
<person id="o123" mother="o456"><name>John</name>  
</person>
```

Must define them in schema

# XML Semantics: an ordered tree



Order matters !!!

# XML Data

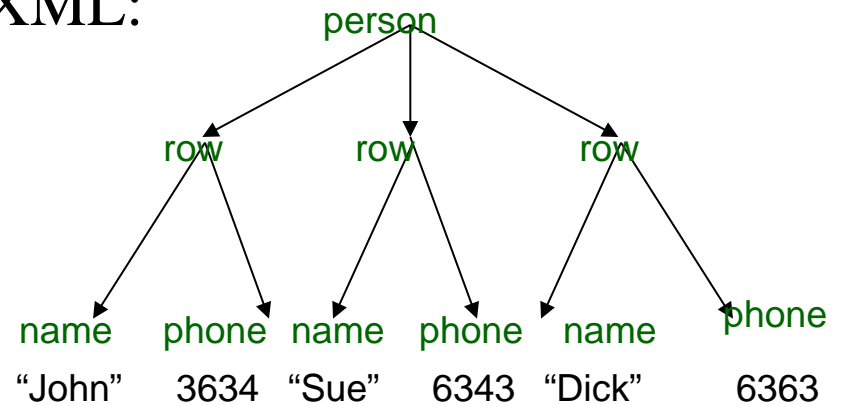
- XML is self-describing
- Schema elements become part of the data
  - Relational schema: `persons(name,phone)`
  - In XML `<persons>`, `<name>`, `<phone>` are part of the data, and are repeated many times
- Consequence: XML is much more flexible
- XML = semistructured data

# Relational Data as XML

person

name	phone
John	3634
Sue	6343
Dick	6363

XML:



```
<person>
  <row> <name>John</name>
    <phone> 3634</phone></row>
  <row> <name>Sue</name>
    <phone> 6343</phone>
  <row> <name>Dick</name>
    <phone> 6363</phone></row>
</person>
```

# XML is Semi-structured Data

- Missing attributes:

```
<person> <name> John</name>  
          <phone>1234</phone>  
</person>  
  
<person> <name>Joe</name>  
</person>
```

← no phone !

- Could represent in  
a table with nulls

name	phone
John	1234
Joe	-

# XML is Semi-structured Data

- Repeated attributes

```
<person> <name> Mary</name>  
          <phone>2345</phone>  
          <phone>3456</phone>  
</person>
```

← two phones !

- Impossible in tables:

name	phone	
Mary	2345	3456

???

# XML is Semi-structured Data

- Attributes with different types in different objects

```
<person> <name> <first> John </first>  
                <last> Smith </last>  
            </name>  
            <phone>1234</phone>  
</person>
```

← structured name !

- Nested structures
- Heterogeneous contents:
  - <bib> contains both <book>'s and <cd>'s



# Document Type Definitions

## DTD

- part of the original XML specification
- an XML document may have a DTD
- XML document:
  - well-formed** = if tags are correctly closed
  - Valid** = if it has a DTD and conforms to it
- validation is useful in data exchange

# Very Simple DTD

→ Root element

```
<!DOCTYPE company [  
  <!ELEMENT company ((person|product)*)>  
  <!ELEMENT person (ssn, name, office, phone?)>  
  <!ELEMENT ssn      (#PCDATA)>  
  <!ELEMENT name      (#PCDATA)>  
  <!ELEMENT office    (#PCDATA)>  
  <!ELEMENT phone     (#PCDATA)>  
  <!ELEMENT product  (pid, name, description?)>  
  <!ELEMENT pid       (#PCDATA)>  
  <!ELEMENT description (#PCDATA)>  
>
```

# Example with attributes

<!ELEMENT artist EMPTY>

<!ATTLIST artist name CDATA #REQUIRED>

<!ATTLIST artist artistID ID #REQUIRED>

<!ELEMENT album EMPTY>

<!ATTLIST album name CDATA #REQUIRED>

<!ATTLIST album albumArtistID IDREF #IMPLIED>

<!ATTLIST album contributingArtistIDs IDREFS  
#IMPLIED>

"Implied" means optional

Example XML:

<artist name="mary", artistID="123"></artist>

# DTD as Part of XML Document

```
<?xml version="1.0"?>
<!DOCTYPE note [
  <!ELEMENT note (to,from,heading,body)>
  <!ELEMENT to (#PCDATA)>
  <!ELEMENT from (#PCDATA)>
  <!ELEMENT heading (#PCDATA)>
  <!ELEMENT body (#PCDATA)>
]>
<note>
  <to>Tove</to>
  <from>Jani</from>
  <heading>Reminder</heading>
  <body>Don't forget me this weekend</body>
</note>
```

# Example XML for Company DTD

Example of valid XML document:

```
<company>
  <person> <ssn> 123456789 </ssn>
            <name> John </name>
            <office> B432 </office>
            <phone> 1234 </phone>
  </person>
  <person> <ssn> 987654321 </ssn>
            <name> Jim </name>
            <office> B123 </office>
  </person>
  <product> ... </product>
  ...
</company>
```

# DTD: The Content Model

`<!ELEMENT tag (CONTENT)>`

content  
model

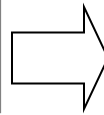
- Content model:
  - Complex = a regular expression over other elements
  - Text-only = #PCDATA/#CDATA
  - Empty = EMPTY
  - Any = ANY
  - Mixed content = (#PCDATA | A | B | C)\*
- #CDATA (#PCDATA)
  - Character data not are (are) parsed by parser
  - Tags inside #PCDATA will be treated as markup

# DTD: Regular Expressions

DTD

sequence

```
<!ELEMENT name  
  (firstName, lastName))
```



XML

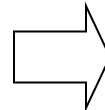
```
<name>  
  <firstName> ..... </firstName>  
  <lastName> ..... </lastName>  
</name>
```

optional

```
<!ELEMENT name (firstName?, lastName))
```

Kleene star

```
<!ELEMENT person (name, phone*)
```



```
<person>  
  <name> ..... </name>  
  <phone> ..... </phone>  
  <phone> ..... </phone>  
  <phone> ..... </phone>  
  .....  
</person>
```

alternation

```
<!ELEMENT person (name, (phone|email)))
```

# Processing instructions

- `<?xml version="1.0" encoding="UTF-8"?>`
- This is the first line of an XML document
  - Declaring that the following is an XML doc...
  - that follows standard version 1.0
  - and whose encoding is UTF-8



# Agenda

- XML:
  - What is it and why do we care?
  - Data model
  - Query language: XPath

# Querying XML Data

- XPath = simple navigation through the tree
- XQuery = the SQL of XML

<bib>

...

<book price="35">

<publisher>Addison-Wesley</publisher>

<author>Serge Abiteboul</author>

<author><first-name>Rick</first-name><last-name>Hull</last-name></author>

<author age="20">Victor Vianu</author>

<title>Foundations of Databases</title>

<year>1995</year>

<price>38.8</price>

</book>

<book price="55">

<publisher>Freeman</publisher>

<author>Jeffrey D. Ullman</author>

<title>Principles of Database and Knowledge Base Systems</title>

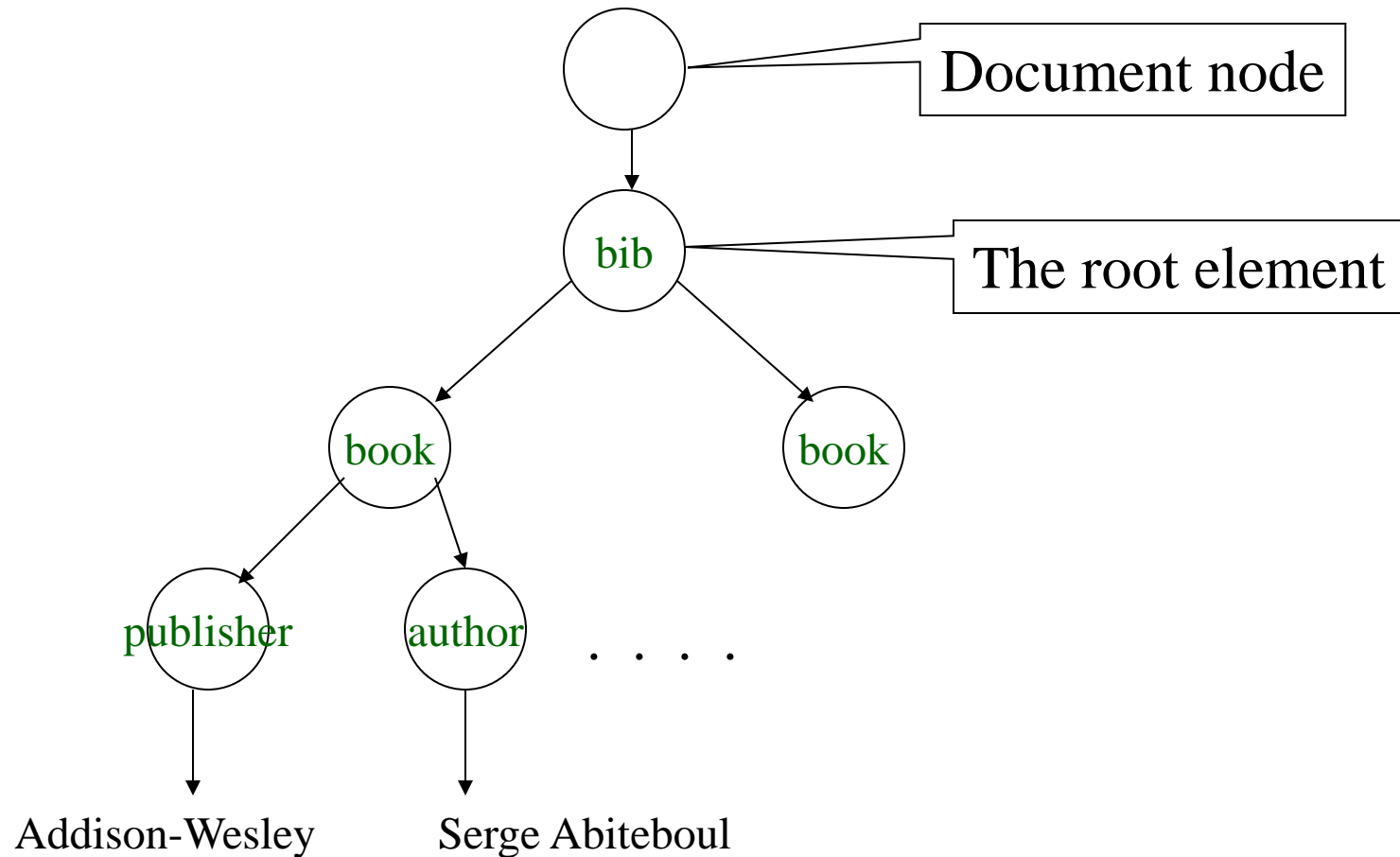
<year>1998</year>

</book>

...

</bib>

# Data Model for XPath



# XPath: Simple Expressions

`/bib/book/year`

Result: `<year> 1995 </year>`  
`<year> 1998 </year>`

`/bib/paper/year`

Result: empty (there were no papers)

# Recursive Search of Children

//author

Result: <author> Serge Abiteboul </author>  
          <author> <first-name> Rick </first-name>  
                    <last-name> Hull </last-name>  
          </author>  
          <author> Victor Vianu </author>  
          <author> Jeffrey D. Ullman </author>

/bib//first-name

Result: <first-name> Rick </first-name>

# Select Child by Index

- Index of children starts from 1
- `//author[1]`
- `/bib/book[2]/author`

# Xpath: Text Nodes

```
/bib/book/author/text()
```

Result: Serge Abiteboul  
Victor Vianu  
Jeffrey D. Ullman

Rick Hull doesn't appear because he has `firstname`, `lastname` elements

## Functions in XPath:

- `text()` = matches the text value
- `*` = matches only element nodes
- `node()` = matches any node (element or text)



# Xpath: Wildcard

`//author/*`

Result: `<first-name>` Rick `</first-name>`  
`<last-name>` Hull `</last-name>`

\* Matches any element

# Xpath: Attribute Nodes

```
/bib/book/@price
```

Result: ['35', '55']

@price means that price has to be an attribute

Same as ?

```
/bib/book[@price]
```

# Xpath: Attribute nodes

- `/bib/book/@*`
  - Return all attribute nodes of book element
- Result:
  - `['35', '55']`

# Xpath: Predicates

```
/bib/book/author[first-name]
```

Return author elements (under /bib/book) which have a child element called "first-name"

Result: `<author> <first-name> Rick </first-name>  
          <last-name> Hull </last-name>  
          </author>`

# Xpath: More Predicates

```
/bib/book/author[firstname][address[//zip][city]]/lastname
```

Return lastname of author elements which have child element firstname and child element "address" which itself has ...

Result: <lastname> ... </lastname>  
<lastname> ... </lastname>

# Xpath: More Predicates

```
/bib/book[@price < 60]
```

```
/bib/book[author/@age < 25]
```



```
/bib/book[author/text()]
```

Return books under bib that have an author element with a text node

# Xpath: More Predicates

```
/bib/book[contains(author, 'Ullman')]
```



Return books under bib whose author subelement contains the word 'Ullman' in its text node  
(note contains is case-sensitive)

# Xpath: More Predicates

- `/bib/book[price > 30 or year > 1995]`
- `/bib/book[price > 30 and year >= 1995]`
- `/bib/book[not(price > 30)]`
- Note: **and**, **or**, **not** should be all lowercases



# Xpath: alternatives

`/bib/book|/bib/cd`

Or

`/bib/(book|cd)`

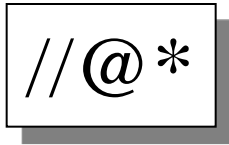
elements under /bib

# Questions

What do these return?



//\*



//@\*

# Resources

- XML

- <http://www.w3schools.com/xml/default.asp>

- XPath

- [http://www.w3schools.com/xml/xml\\_xpath.asp](http://www.w3schools.com/xml/xml_xpath.asp)

# Resources

- Testers
  - <https://codebeautify.org/Xpath-Tester>
  - <https://www.freeformatter.com/xpath-tester.html> ( no support for "contains")
  - <http://www.xpathtester.com/xpath>

# XQuery

- Based on Quilt, which is based on XML-QL
  - Quilt (IBM research project)
  - XML-QL (AT&T research project)
- Extends XPath to express more complex queries
  - XPath expression is itself a valid XQuery

# FLWR (“Flower”) Expressions

FOR ...

LET...

WHERE...

RETURN...



# XQuery

Find all book titles published after 1995:

```
FOR $x IN document("bib.xml")/bib/book  
WHERE $x/year > 1995  
RETURN { $x/title }
```

↗ Similar to:  
Select title  
From book  
Where year > 1995

Result:

```
<title> abc </title>  
<title> def </title>  
<title> ghi </title>
```

# XQuery

Find book titles by the coauthors of “Database Theory”:

```
FOR $x IN bib/book[title/text() = “Database Theory”]/author,  
    $y IN bib/book[author/text() = $x/text()]/title  
RETURN <answer> { $y/text() } </answer>
```

Result:

```
<answer> abc </ answer >  
< answer > def </ answer >  
< answer > ghi </ answer >
```



# Join

- Two-way join
  - FOR clause specifies two lists of objects
  - Where clause specifies the join condition

```
FOR $x IN document("bib.xml")/bib/book,  
      $y IN document("e-book.xml")/book  
WHERE $x/ISBN = $y/ISBN  
RETURN { $x/title }
```