XML & XPath

DSCI 551

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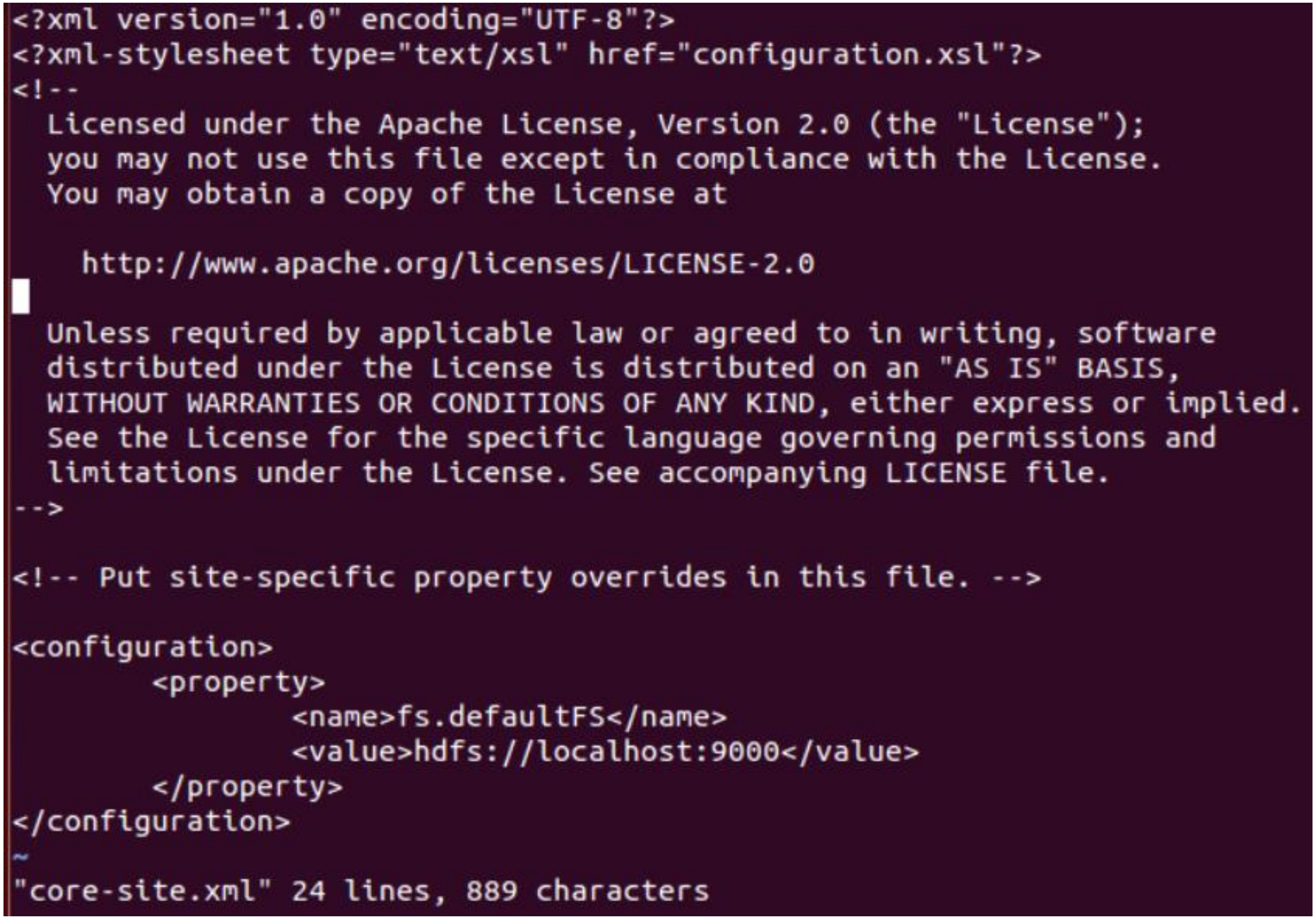

```
<?xml version="1.0" encoding="UTF-8"?>
<?xml-stylesheet type="text/xsl" href="configuration.xsl"?>
<!--
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-->

<!-- 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 (ordered tree)
  - 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*

- *Ajax (x – XML)*
- *jquery ($.ajax(…, format='XML'/'JSON'))*

SGML

- Derived from IBM’s GML (generalized ML) developed in 1960’s
  - Charles Goldfarb, Edward Mosher, and Raymond Lorie
  - For sharing of large-project documents

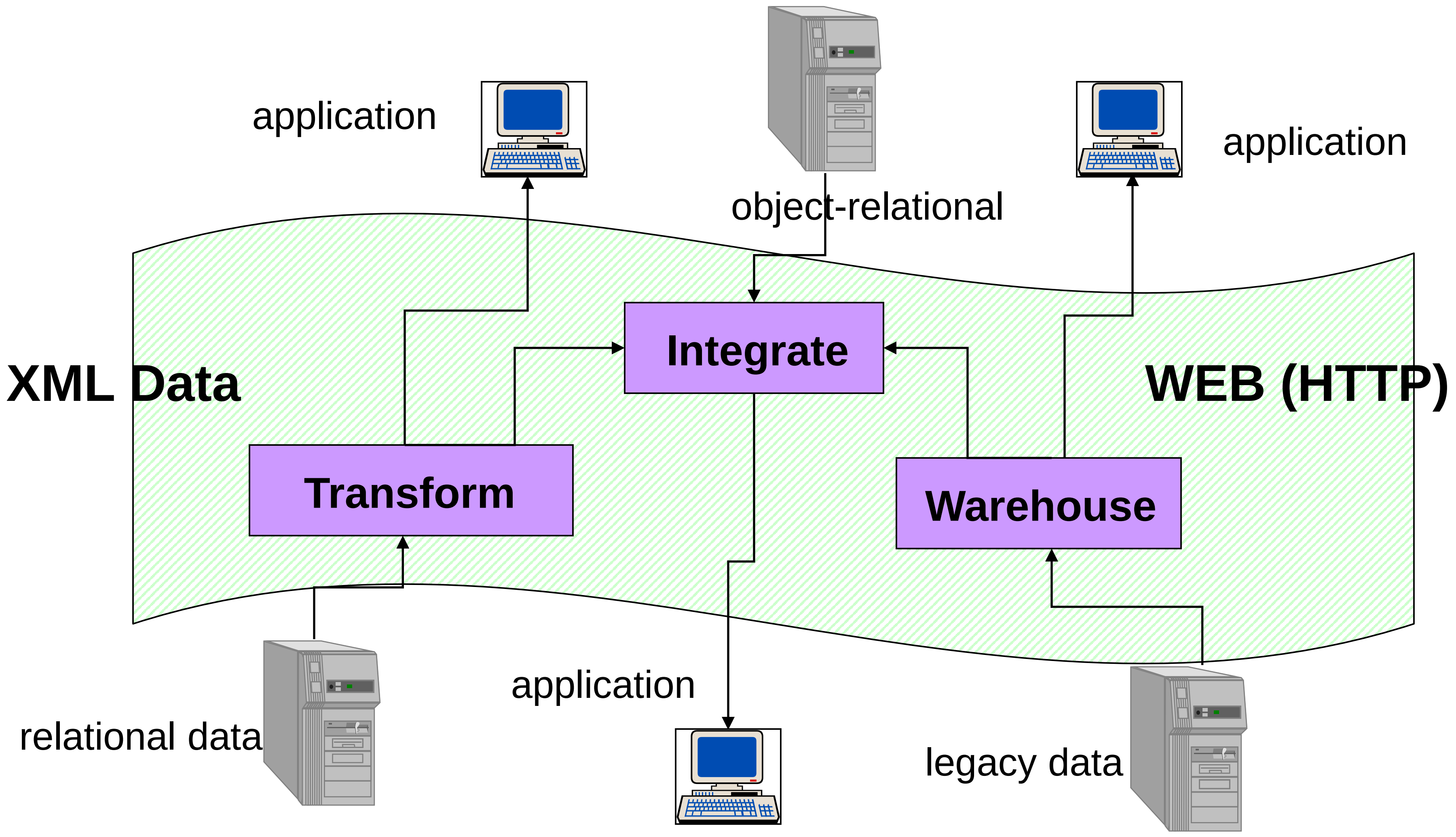
- Basis for HTML & XML
  - XML is roughly an augmented subset (adds more restrictions)
  - HTML is an application of SGML

Why XML is of Interest to Us

- XML is a syntax (serialization format) for data

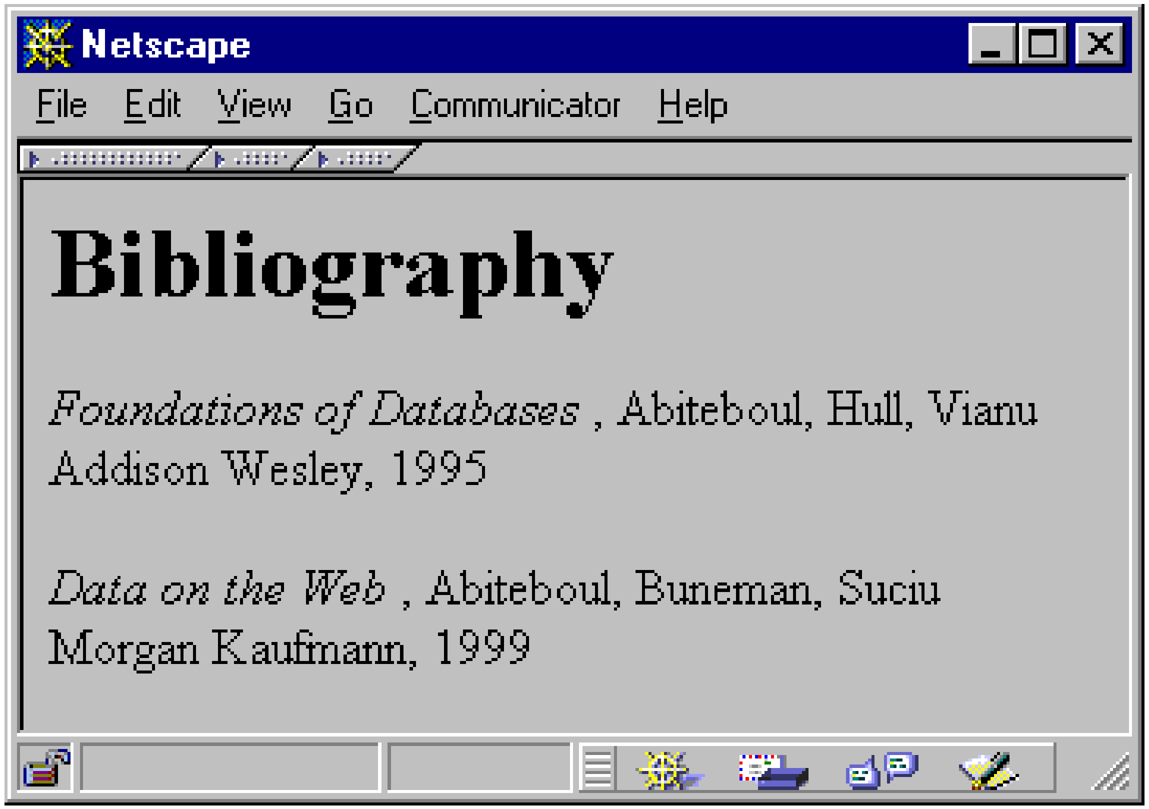
- This is exciting because:
  - Can translate *any* data to XML
  - Can ship XML over the Web (HTTP)
  - Can input XML into any application
  - Thus: data sharing and exchange on the Web

XML Data Sharing and Exchange



Specific data management tasks

From HTML to XML



Bibliography

Foundations of Databases , Abiteboul, Hull, Vianu
Addison Wesley, 1995

Data on the Web , Abiteboul, Buneman, Suciu
Morgan Kaufmann, 1999

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

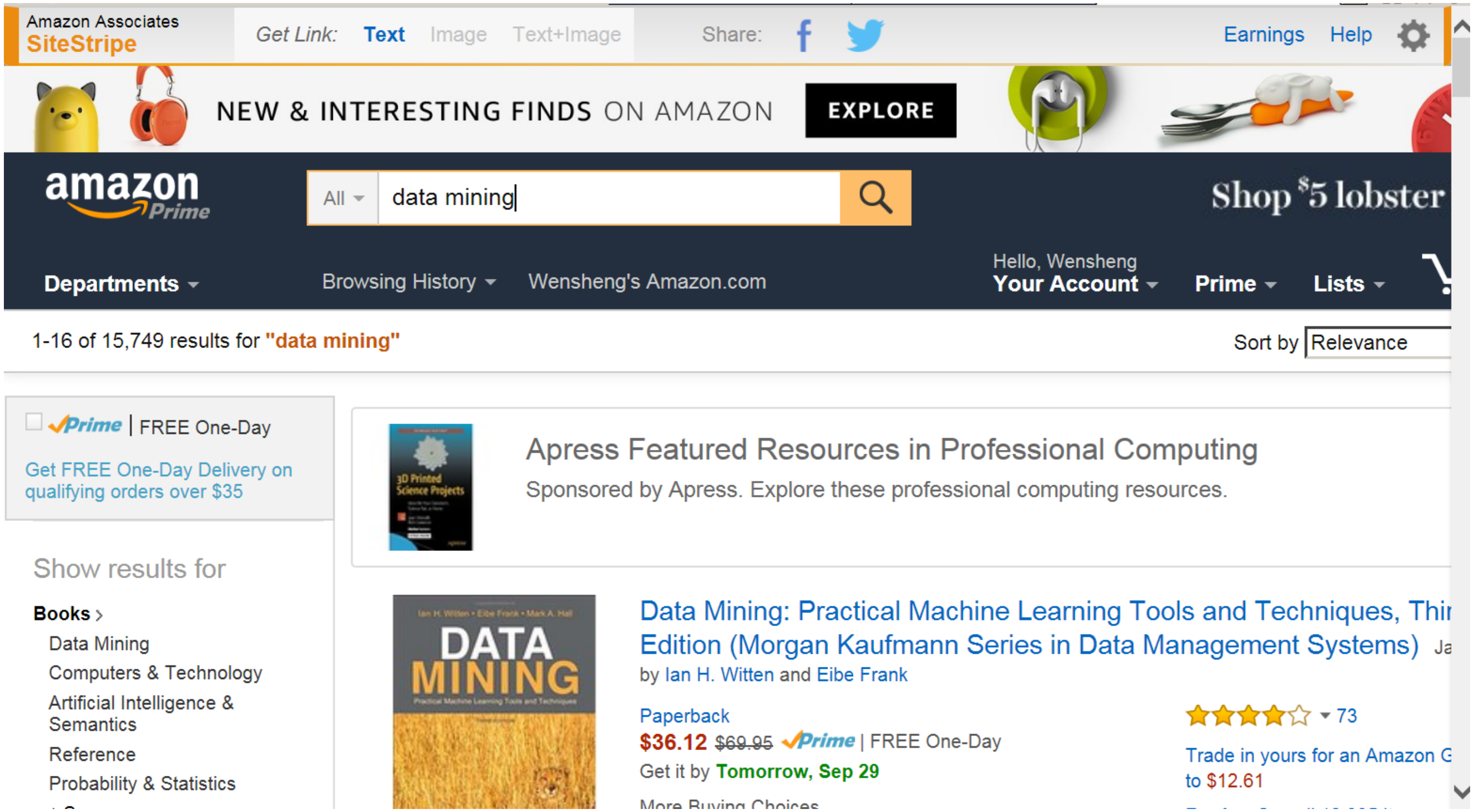
- A software system designed to support interoperable machine-to-machine interaction over a network (from Wikipedia)

- Use http for machine-machine communications of files
  - E.g., in XML & JSON formats

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)



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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 (no content): <red></red> abbrv. <red/>
  - Note that an empty element can have attributes
  - <author age="25”/>
- 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>
…
```

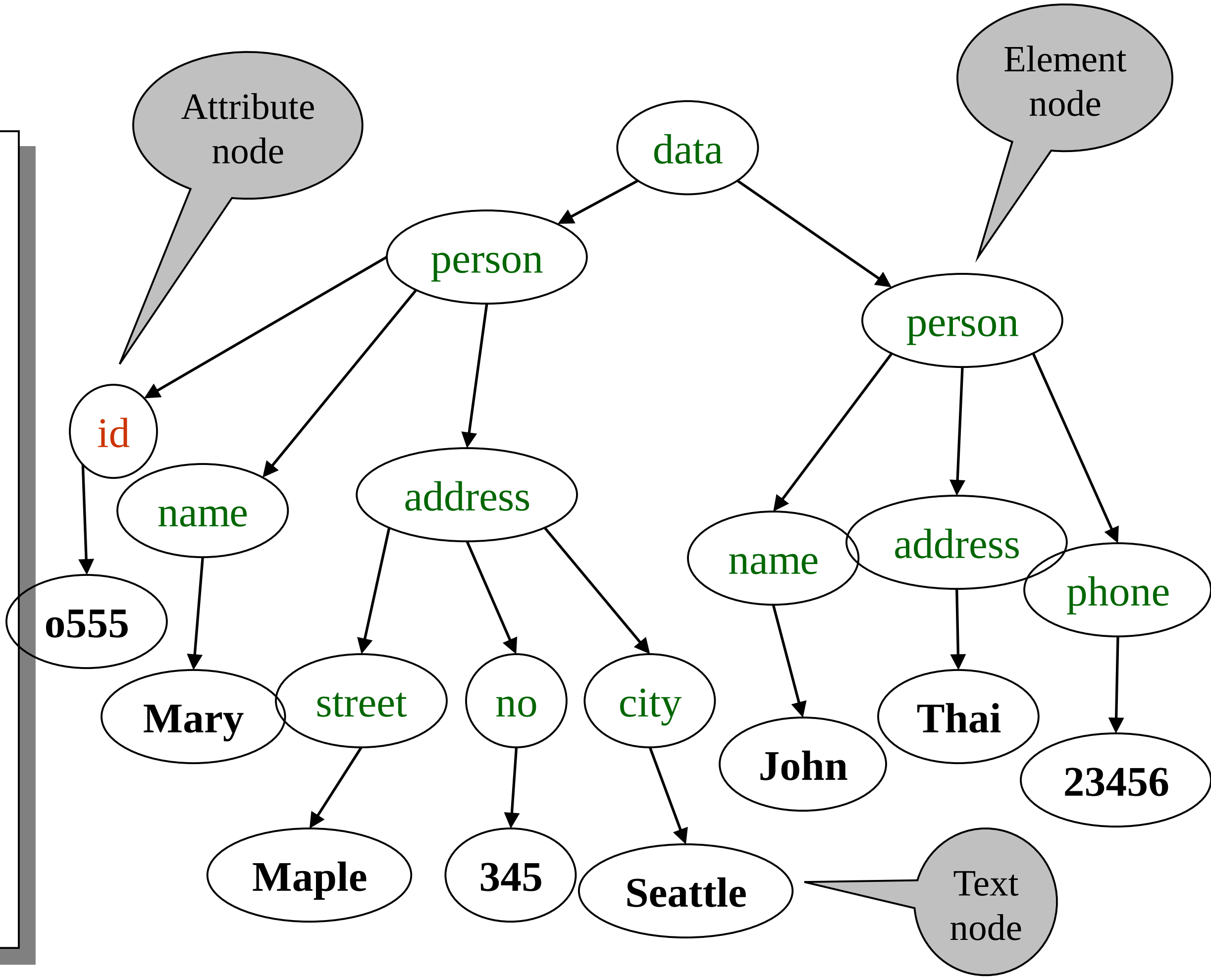
attributes are alternative ways to represent data

Attributes

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

XML structure: an ordered tree

```
<data>
        <person id="o555" >
                <name> Mary </name>
                <address>
                        <street> Maple </street>
                        <no> 345 </no>
                        <city> Seattle </city>
                </address>
        </person>
        <person>
                <name> John </name>
                <address> Thailand  </address>
                <phone> 23456  </phone>
        </person>
</data>
```



Order matters & index starts from 1 !!!

XML Data

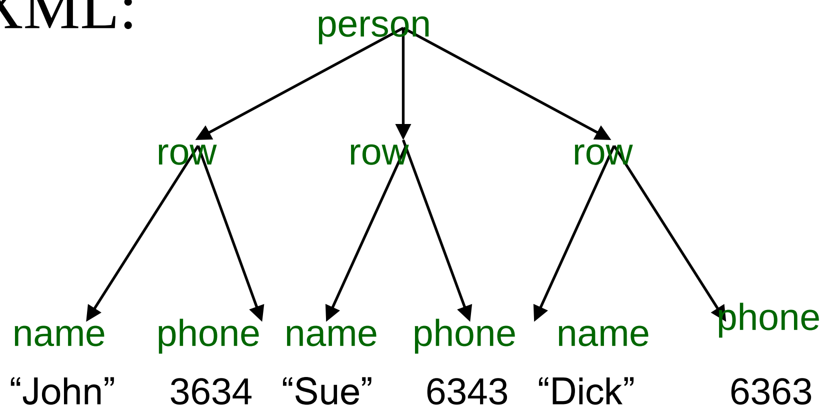
- XML is self-describing
- Schema elements become part of the data
  - Relational schema: person(name, phone)
  - In XML <persons>, <name>, <phone> are part of the data, and are repeated many times
- Consequence: XML is much more flexible
- XML = semi-structured data

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

- A set of markup for describing schema of XML data
- 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)>
]>
```

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>
```

XML schema

```
<?xml version="1.0"?>
<xs:schema xmlns:xs="http://www.w3.org/2001/XMLSchema"
targetNamespace="https://www.w3schools.com"
xmlns="https://www.w3schools.com"
elementFormDefault="qualified">

<xs:element name="note">
  <xs:complexType>
    <xs:sequence>
      <xs:element name="to" type="xs:string"/>
      <xs:element name="from" type="xs:string"/>
      <xs:element name="heading" type="xs:string"/>
      <xs:element name="body" type="xs:string"/>
    </xs:sequence>
  </xs:complexType>
</xs:element>
```

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

XML

sequence

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

```
<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

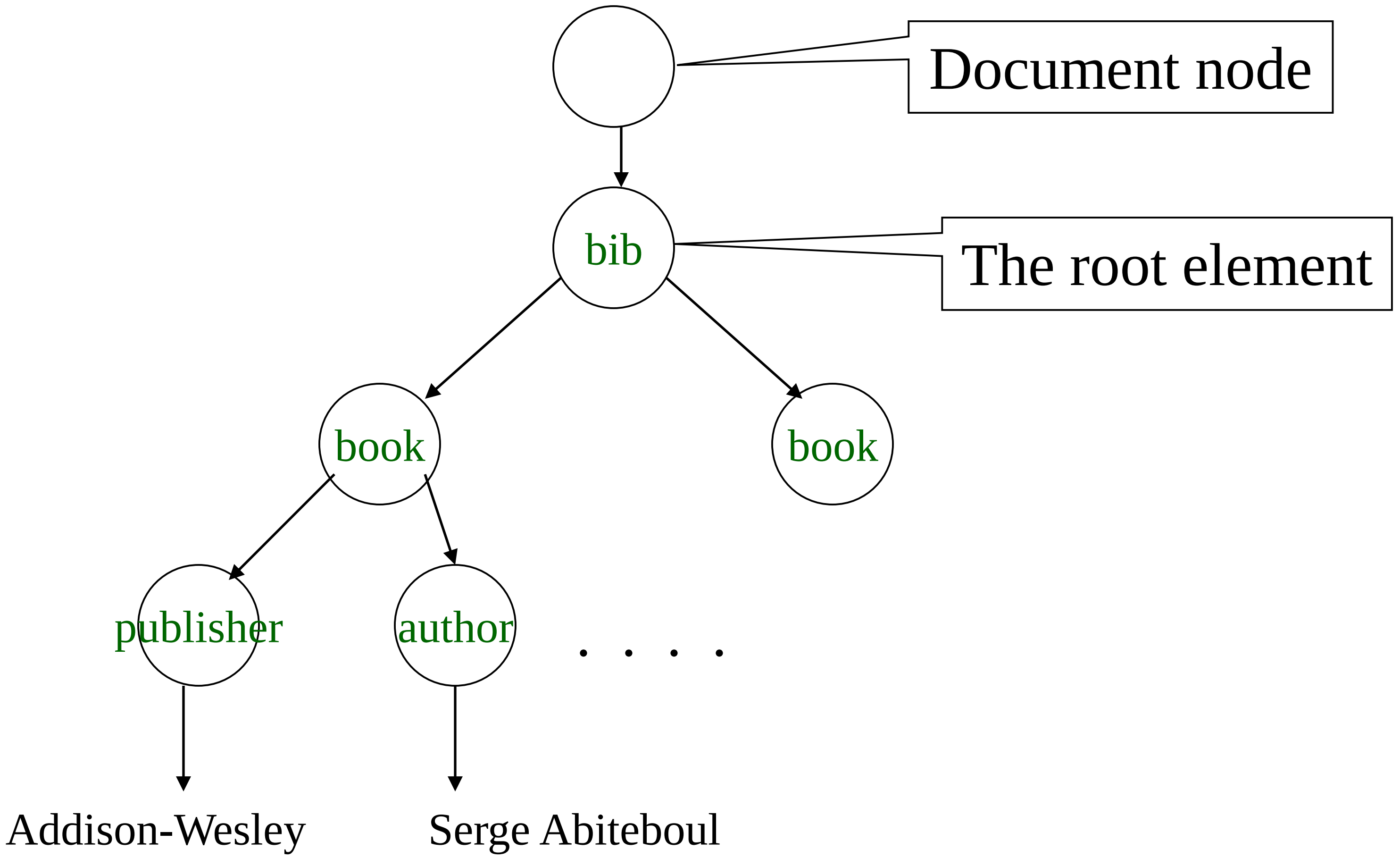
- XML:
  - What is it and why do we care?
  - Data model
  - Query language: XPath

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)

//: finding descendants

```
//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 text nodes
- * = 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

Is it the same as ?

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

Xpath: Attribute nodes

- /bib/book/@*
  - Return all attribute nodes of book elements

- 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 (***first***) author subelment contains the word 'Ullman' in its text node
(note contains is case-sensitive)

What about //book/author[contains(., "Ullman")] ?

Xpath: More Predicates

- /bib/book[author = "Victor Vianu"]
- /bib/book[author/text() = "Victor Vianu"]
- /bib/book/author[. = 'Victor Vianu']

Xpath: More Predicates

- /bib/book[price > 30 or year > 1995]
- /bib/book[price > 30 and year >= 1995]
- /bib/book[not(price > 30)]

Parenthesis required for not

- Note: and, or, not should be all lowercases

Xpath: More Predicates

- /bib/book[not(publisher)]

- What about /bib/book[author[not(node())]]?

Xpath: alternatives

```
/bib/book|/bib/cd
```

Return book and cd elements under /bib

Questions

What do these return?

```
//*
```

```
//@*
```

Resources

- Comparison of SGML and XML
  - https://www.w3.org/TR/NOTE-sgml-xml-971215/
- XML
  - http://www.w3schools.com/xml/default.asp
- XPath
  - http://www.w3schools.com/xml/xml_xpath.asp

Resources

- Testers
  - https://codebeautify.org/Xpath-Tester (no support for alternation such as "/bib/(book|cd)", but /bib/book|/bib/cd is ok)
  - https://www.freeformatter.com/xpath-tester.html (no support for "contains", but support both forms of alternations above)
  - http://www.xpathtester.com/xpath