XML & XPath

DSCI 551

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```
<?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 (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

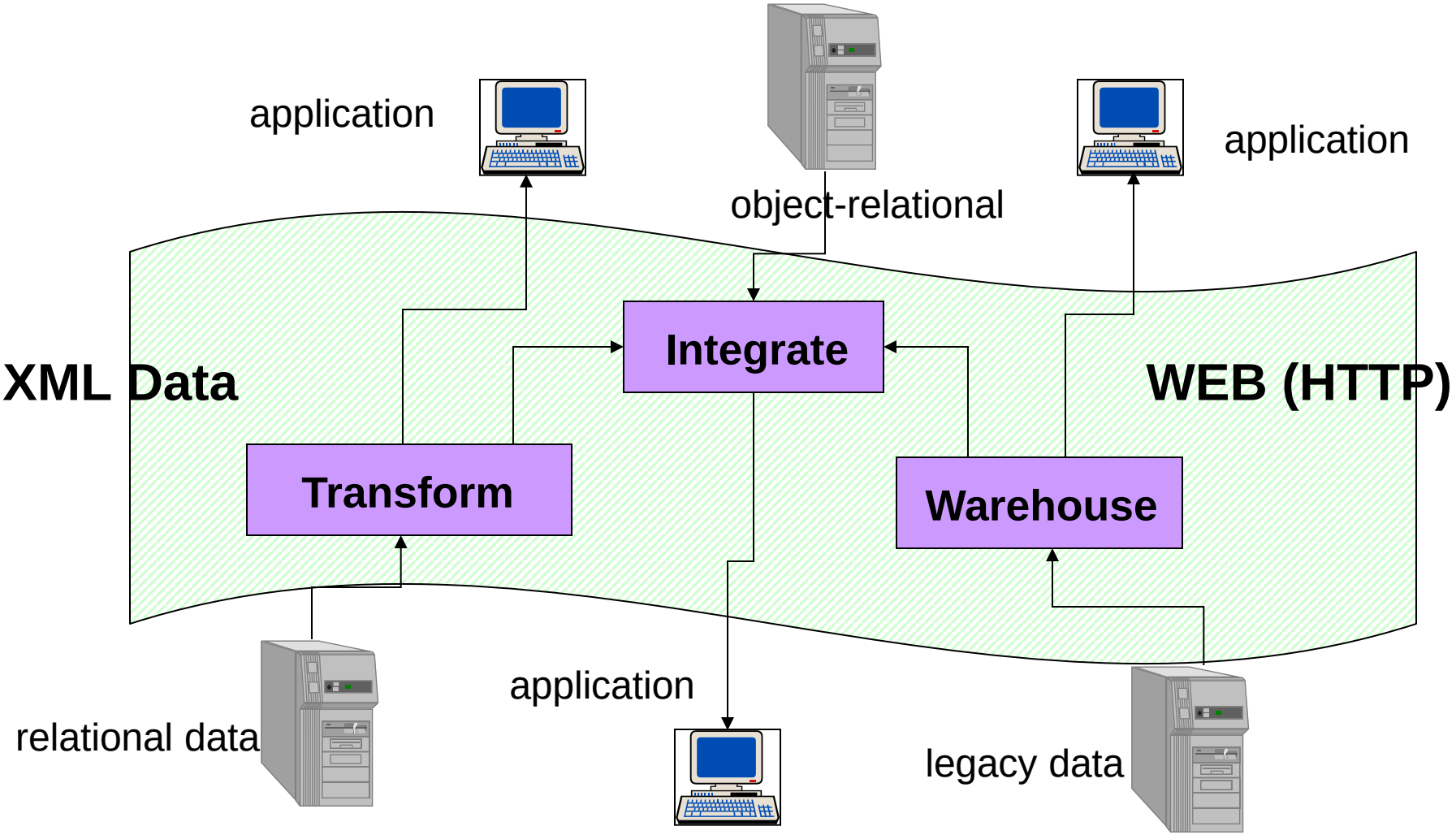
- Basis for HTML & XML
  - XML is roughly an augmented subset (adds more restrictions)
  - HTML is an application of SGML

Why XML is of Interest to Us

- XML is a syntax (serialization format) for data

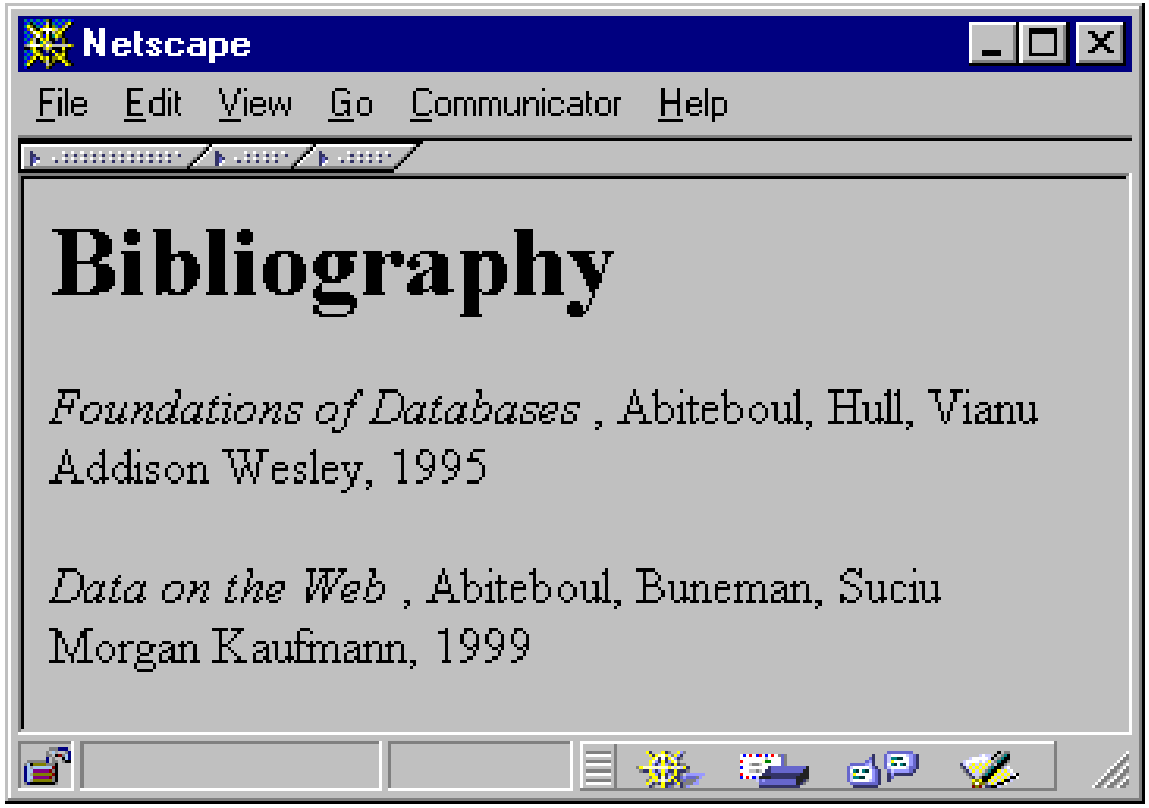
- This is exciting because:
  - Can translate *any* data to XML
  - Can ship XML over the Web (HTTP)
  - Can input XML into any application
  - Thus: data sharing and exchange on the Web

XML Data Sharing and Exchange



Specific data management tasks

From HTML to XML



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

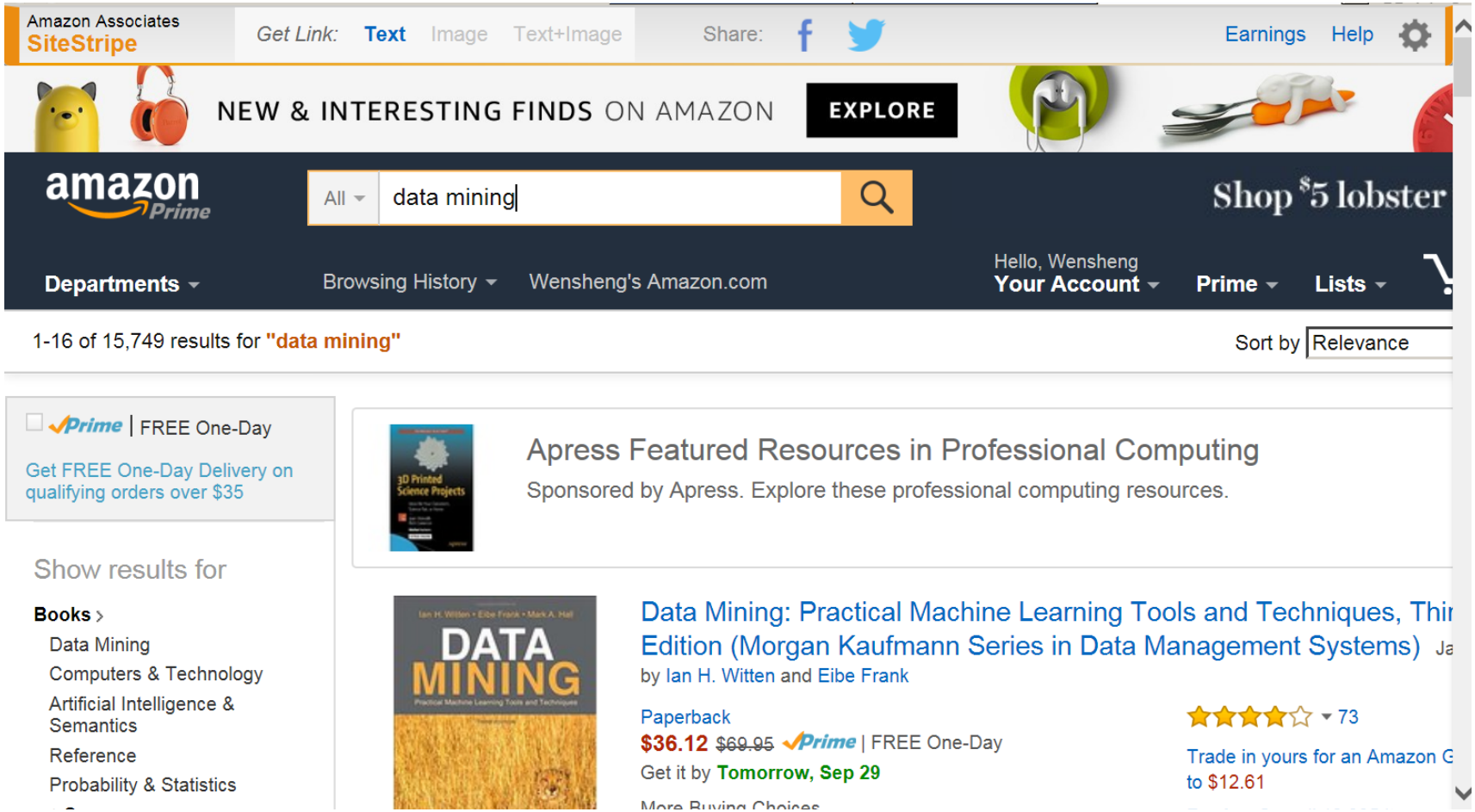
- A software system designed to support interoperable machine-to-machine interaction over a network (from Wikipedia)

- 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)



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>
…
```

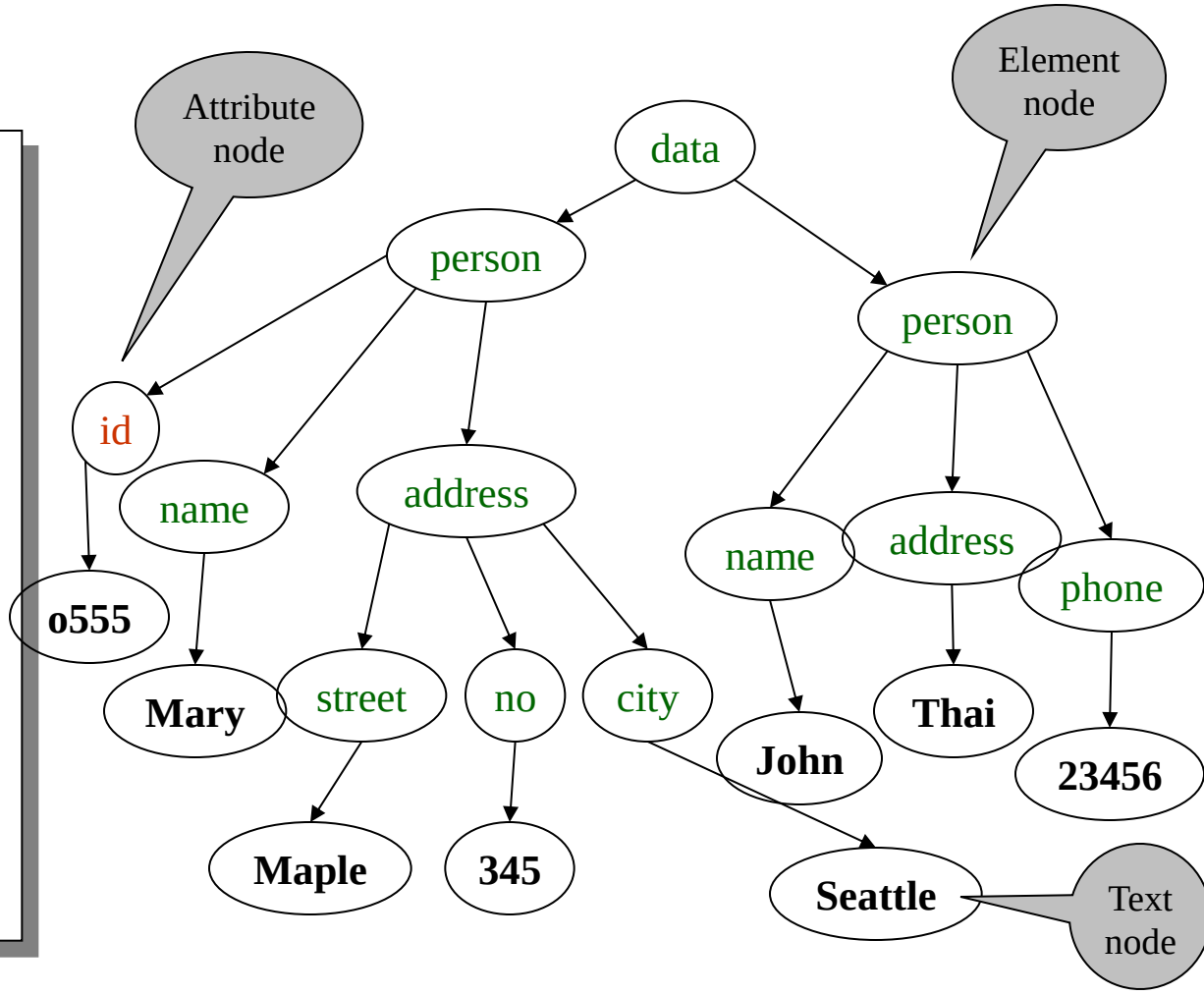
attributes are alternative ways to represent data

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

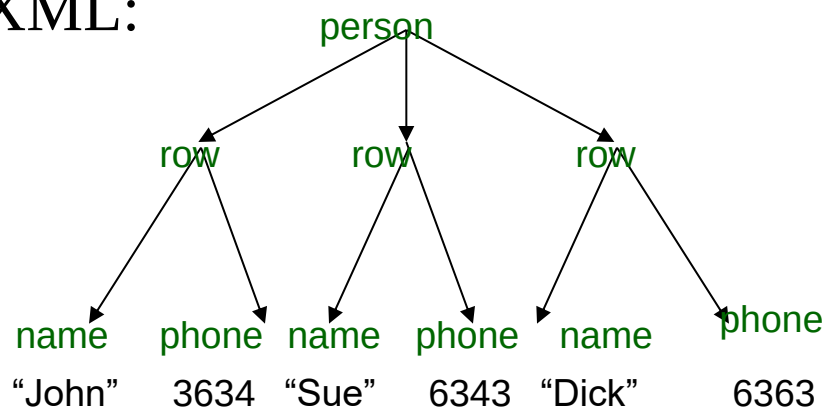
- XML is self-describing
- Schema elements become part of the data
  - Relational schema: person(name, phone)
  - In XML <persons>, <name>, <phone> are part of the data, and are repeated many times
- Consequence: XML is much more flexible
- XML = semi-structured data

Relational Data as XML

person

name	phone
John	3634
Sue	6343
Dick	6363

XML:




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

Product

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	NULL

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

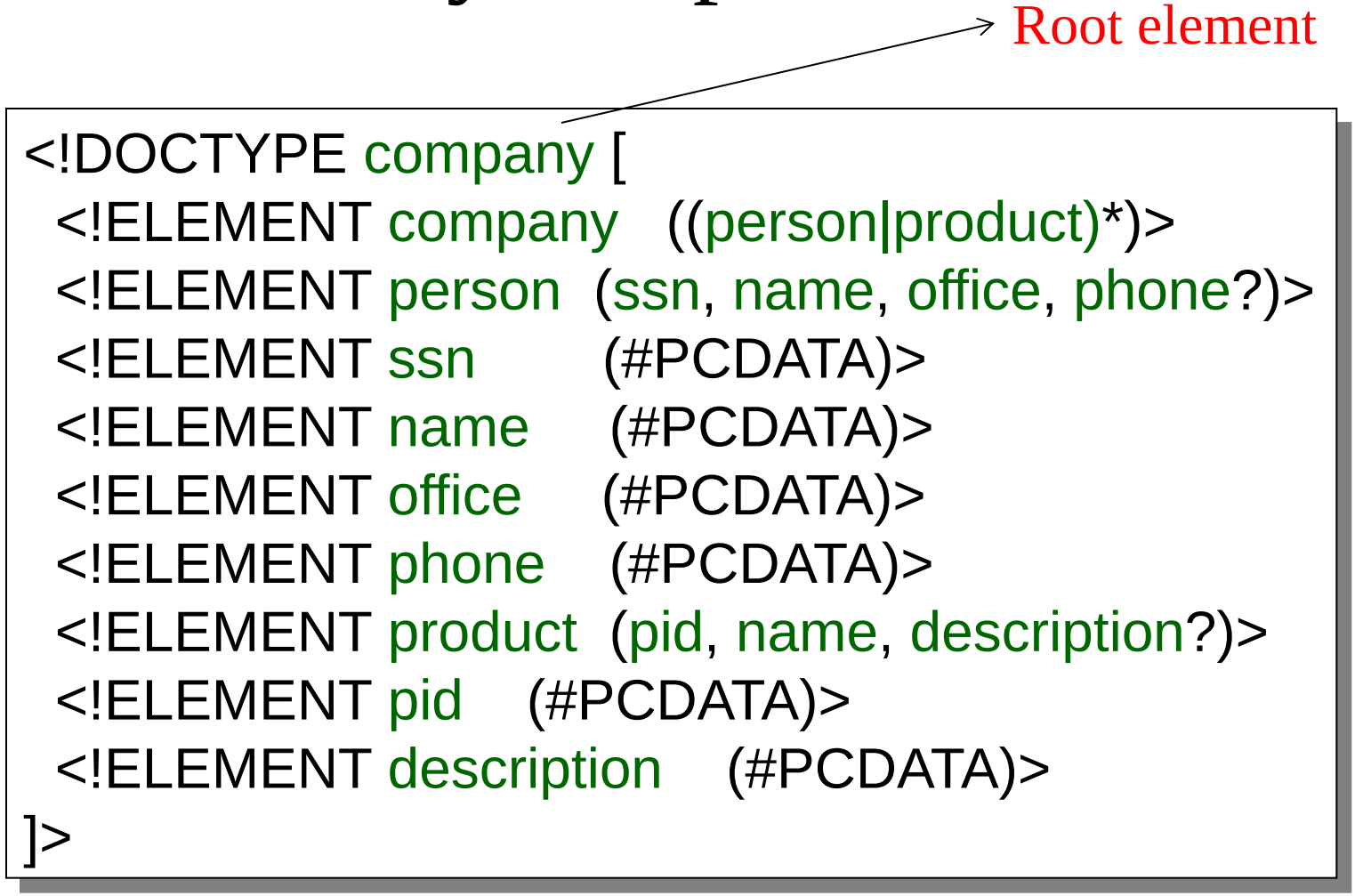
Document Type Definitions DTD

- 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



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

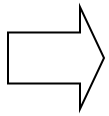
DTD: Regular Expressions

DTD

XML

sequence

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



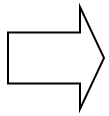
```
<name>
   <firstName>  . . . . . </firstName>
   <lastName>  . . . . . </lastName>
</name>
```

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

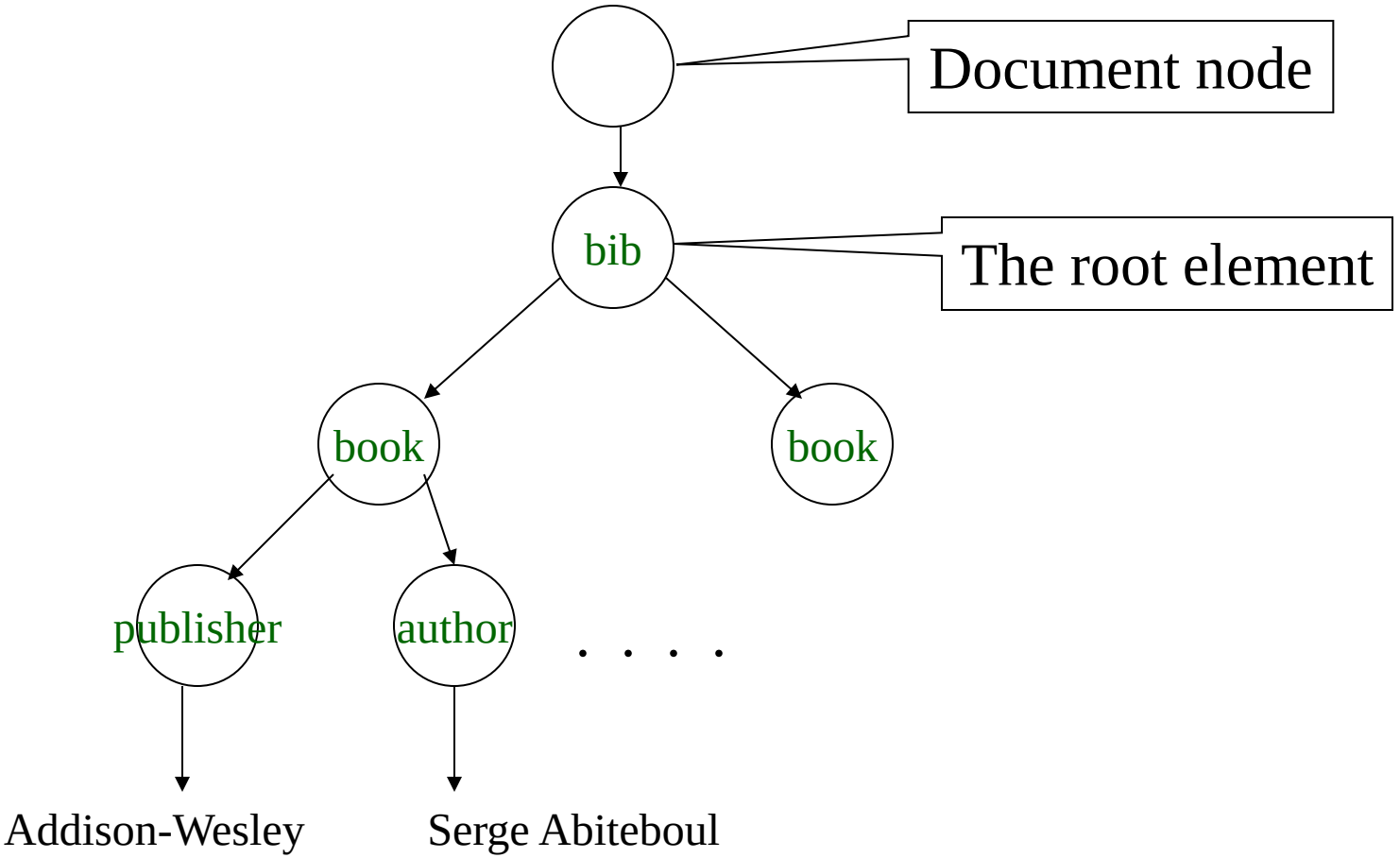
- XML:
  - What is it and why do we care?
  - Data model
  - Query language: XPath

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 …

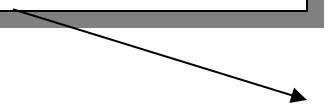
Result: <lastname> … </lastname>
<lastname> … </lastname>

// inside predicate

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

/bib/book[.//first-name]

/bib/book[//first-name]

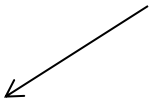


// starts from root here!

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)

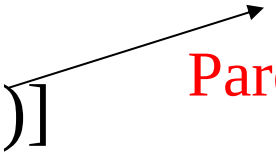
What about //book/author[contains(., "Ullman")] ?

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)]



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

Xpath: More Predicates

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

String functions: substring

- substring(string, start)
  - note start index starts from 1 (not 0)
- substring(string, start, length)

- /bib/book/author[substring(., 1, 1) = "J"]
  - <author>Jeffrey D. Ullman</author>

String function: starts-with

- starts-with(string1, string2)
  - string1 starts with string2
- /bib/book/author[starts-with(., "Serge")]
  - <author>Serge Abiteboul</author>

String function: substring-before

- substring-before(string1, string2)
  - return substring of string1 before the first occurrence of string2 in string1
- /bib/book/author[substring-before(., "Ullman")]
  - <author>Jeffrey D. Ullman</author>
- /bib/book/author[substring-before(., "e") = "J"]
  - <author>Jeffrey D. Ullman</author>

String function: substring-after

- substring-after(string1, string2)
  - return substring of string1 after the first occurrence of string2 in string1
- /bib/book/author[substring-after(., "Ull")]
  - <author>Jeffrey D. Ullman</author>
- /bib/book/author[substring-after(., "Ull") = "man"]
  - <author>Jeffrey D. Ullman</author>

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

XPath functions

- https://developer.mozilla.org/en-US/docs/Web/XML/XPath/Reference/Functions
  - substring
  - starts-with
  - substring-before
  - substring-after

```
<data>
        <person id="100" >
                <name> Mary </name>
                <address>
                        <street>Maple</street>
                        <no>345</no>
                        <city>Seattle</city>
                </address>
                <age>25</age>
        </person>
        <person id="200">
                <name>John</name>
                <address>Thailand </address>
                <phone>23456 </phone>
                <age>30</age>
        </person>
</data>
```