Document Object Model

DOM

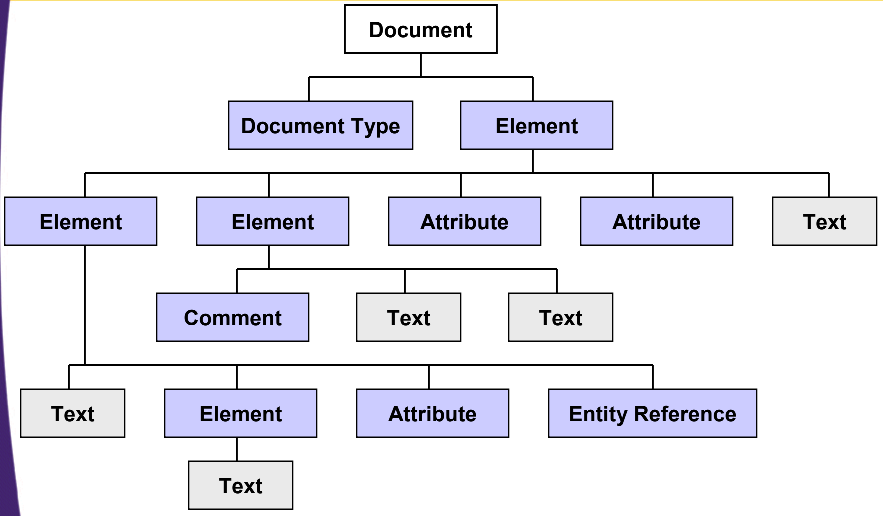
Agenda

- Introduction to DOM
- Java API for XML Parsing (JAXP)
- Installation and setup
- Steps for DOM parsing
- Example
  - Representing an XML Document as a JTree
- DOM or SAX?

Document Object Model (DOM)

- **DOM supports navigating and modifying XML documents**
  - Hierarchical tree representation of document
    - Tree follows standard API
    - Creating tree is vendor specific
- **DOM is a language-neutral specification**
  - Bindings exists for Java, C++, CORBA, JavaScript
- **DOM Versions**
  - DOM 1.0 (1998)
  - DOM 2.0 Core Specification (2000)
  - Official Website for DOM
    - `http://www.w3c.org/DOM/`

DOM Tree



Document

Document Type

Element

Element

Element

Attribute

Attribute

Text

Comment

Text

Text

Text

Element

Attribute

Entity Reference

Text

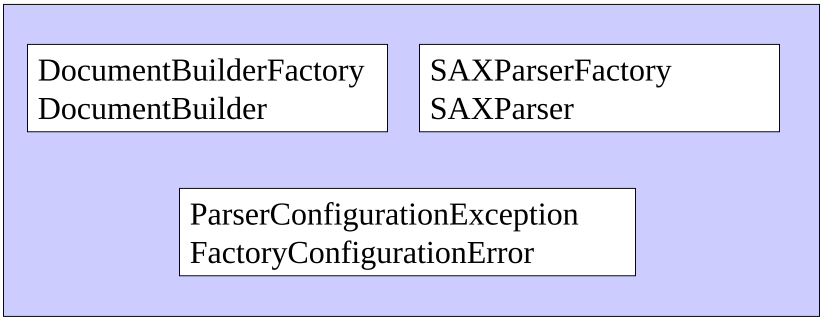
DOM Advantages and Disadvantages

- **Advantages**
  – Robust API for the DOM tree
  – Relatively simple to modify the data structure and extract data
- **Disadvantages**
  – Stores the entire document in memory
  – As DOM was written for any language, method naming conventions don’t follow standard Java programming conventions

Java API for XML Parsing (JAXP)

- **JAXP provides a vendor-neutral interface to the underlying DOM or SAX parser**

`javax.xml.parsers`



DocumentBuilderFactory
DocumentBuilder

SAXParserFactory
SAXParser

ParserConfigurationException
FactoryConfigurationError

DOM Installation and Setup (JDK 1.4)

- All the necessary classes for DOM and JAXP are included with JDK 1.4
  - See `javax.xml.*` packages
- For DOM and JAXP with JDK 1.3 see following viewgraphs

DOM Installation and Setup (JDK 1.3)

1. Download a DOM-compliant parser
   - Java-based DOM parsers at `http://www.xml.com/pub/rg/Java_Parsers`
   - Recommend Apache Xerces-J parser at `http://xml.apache.org/xerces-j/`
2. Download the Java API for XML Processing (JAXP)
   - JAXP is a small layer on top of DOM which supports specifying parsers through system properties versus hard coded
   - See `http://java.sun.com/xml/`
   - Note: Apache Xerces-J already incorporates JAXP

DOM Installation and Setup (continued)

3. **Set your `CLASSPATH` to include the DOM (and JAXP) classes**

```
set CLASSPATH=xerces_install_dir\xerces.jar;
              %CLASSPATH%
```

or

```
setenv CLASSPATH xerces_install_dir/xerces.jar:
                 $CLASSPATH
```

- For servlets, place `xerces.jar` in the server's `lib` directory
  - Note: Tomcat 4.0 is prebundled with `xerces.jar`
- Xerces-J already incorporates JAXP
  - For other parsers you may need to add `jaxp.jar` to your classpath and servlet `lib` directory

DOM Installation and Setup (continued)

4. **Bookmark the DOM Level 2 and JAXP APIs**

– DOM Level 2
  - `http://www.w3.org/TR/DOM-Level-2-Core/`

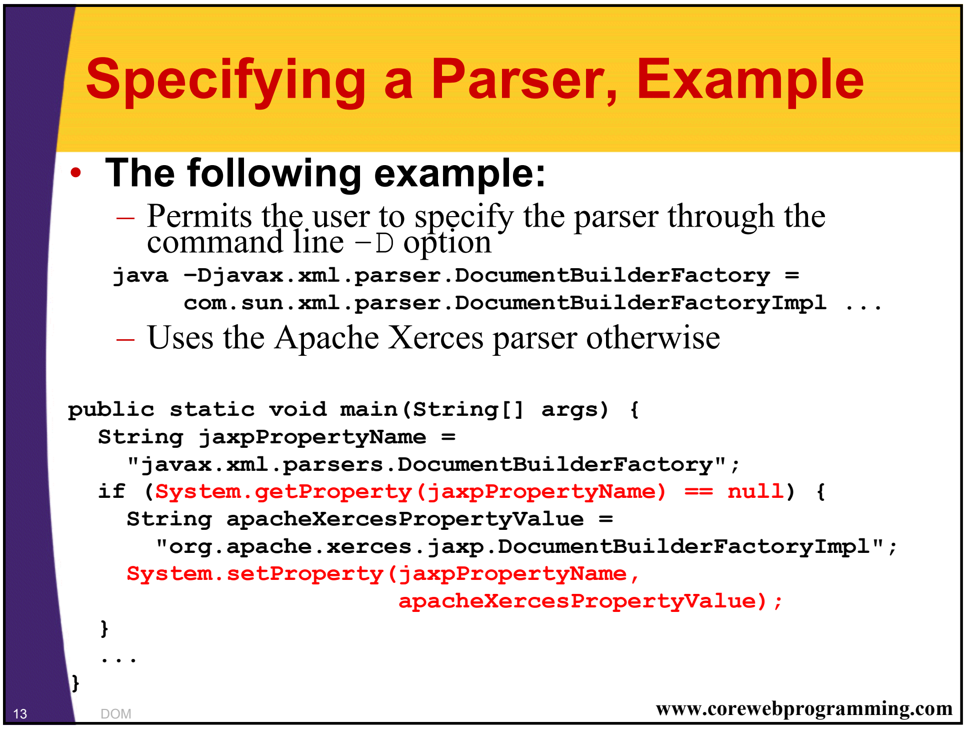
– JAXP
  - `http://java.sun.com/xml/jaxp/dist/1.1/docs/api/index.html`

Steps for DOM Parsing

1. Tell the system which parser you want to use
2. Create a JAXP document builder
3. Invoke the parser to create a Document representing an XML document
4. Normalize the tree
5. Obtain the root node of the tree
6. Examine and modify properties of the node

Step 1: Specifying a Parser

- **Approaches to specify a parser**
  - Set a system property for `javax.xml.parsers.DocumentBuilder-Factory`
  - Specify the parser in `jre_dir/lib/jaxp.properties`
  - Through the J2EE Services API and the class specified in `META-INF/services/ javax.xml.parsers. DocumentBuilder-Factory`
  - Use system-dependant default parser (check documentation)



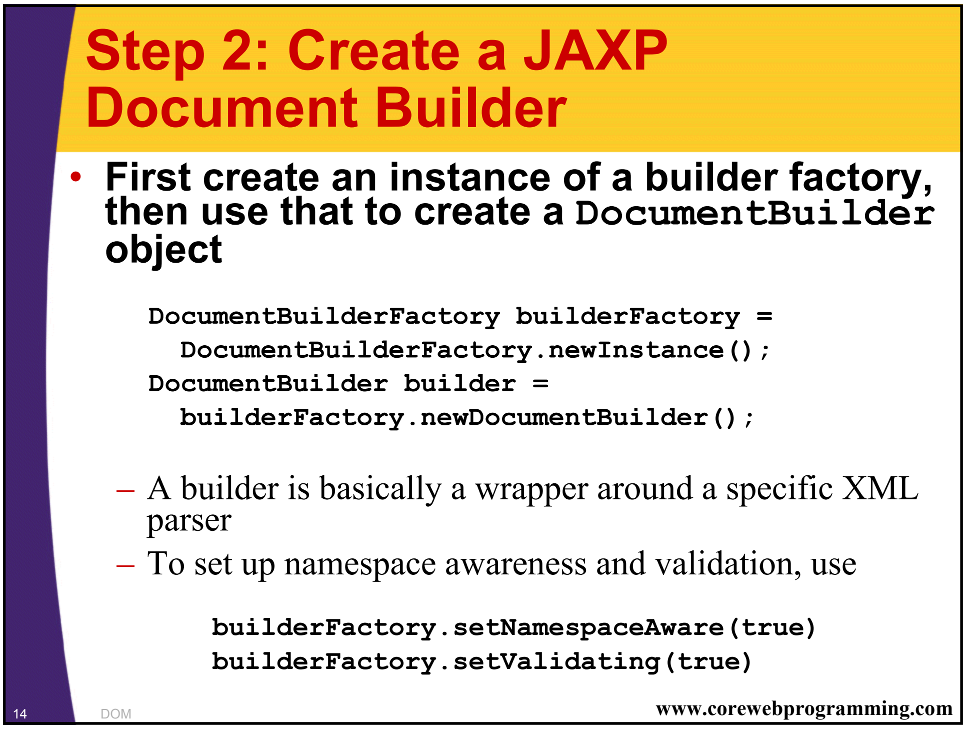
Specifying a Parser, Example

- **The following example:**
  - Permits the user to specify the parser through the command line -D option

```
java -Djavax.xml.parser.DocumentBuilderFactory =
     com.sun.xml.parser.DocumentBuilderFactoryImpl ...
```

  - Uses the Apache Xerces parser otherwise

```
public static void main(String[] args) {
  String jaxpPropertyName =
    "javax.xml.parsers.DocumentBuilderFactory";
  if (System.getProperty(jaxpPropertyName) == null) {
    String apacheXercesPropertyValue =
      "org.apache.xerces.jaxp.DocumentBuilderFactoryImpl";
    System.setProperty(jaxpPropertyName,
                       apacheXercesPropertyValue);
  }
  ...
}
```



Step 2: Create a JAXP Document Builder

- **First create an instance of a builder factory, then use that to create a `DocumentBuilder` object**

```
DocumentBuilderFactory builderFactory =
  DocumentBuilderFactory.newInstance();
DocumentBuilder builder =
  builderFactory.newDocumentBuilder();
```

  - A builder is basically a wrapper around a specific XML parser
  - To set up namespace awareness and validation, use

```
builderFactory.setNamespaceAware(true)
builderFactory.setValidating(true)
```

Step3: Invoke the Parser to Create a Document

- **Call the `parse` method of the `DocumentBuilder`, supplying an XML document (input stream)**

```
Document document = builder.parse(someInputStream);
```

  - The `Document` class represents the parsed result in a tree structure
  - The XML document can be represented as a:
    - URI, represented as a string
    - `InputStream`
    - `org.xml.sax.InputSource`

Step 4: Normalize the Tree

- **Normalization has two affects:**
  - Combines textual nodes that span multiple lines
  - Eliminates empty textual nodes

```
document.getDocumentElement().normalize();
```

Step 5: Obtain the Root Node of the Tree

- **Traversing and modifying the tree begins at the root node**

```
Element rootElement = document.getDocumentElement();
```

  - An `Element` is a subclass of the more general `Node` class and represents an XML element
  - A `Node` represents all the various components of an XML document
    - Document, Element, Attribute, Entity, Text, CDATA, Processing Instruction, Comment, etc.

Step 6: Examine and Modify Properties of the Node

- **Examine the various `node` properties**
  - getNodeName
    - Returns the name of the element
  - getNodeType
    - Returns the node type
    - Compare to `Node` constants
      - `DOCUMENT_NODE`, `ELEMENT_NODE`, etc.
  - getAttributes
    - Returns a `NamedNodeMap` (collection of nodes, each representing an attribute)
      - Obtain particular attribute node through `getNamedItem`
  - getChildNodes
    - Returns a `NodeList` collection of all the children.

Step 6: Examine and Modify Properties of the Node (cont)

- **Modify the document**
  - setNodeValue
    - Assigns the text value of the node
  - appendChild
    - Adds a new node to the list of children
  - removeChild
    - Removes the child node from the list of children
  - replaceChild
    - Replace a child with a new node

DOM Example: Representing an XML Document as a JTree

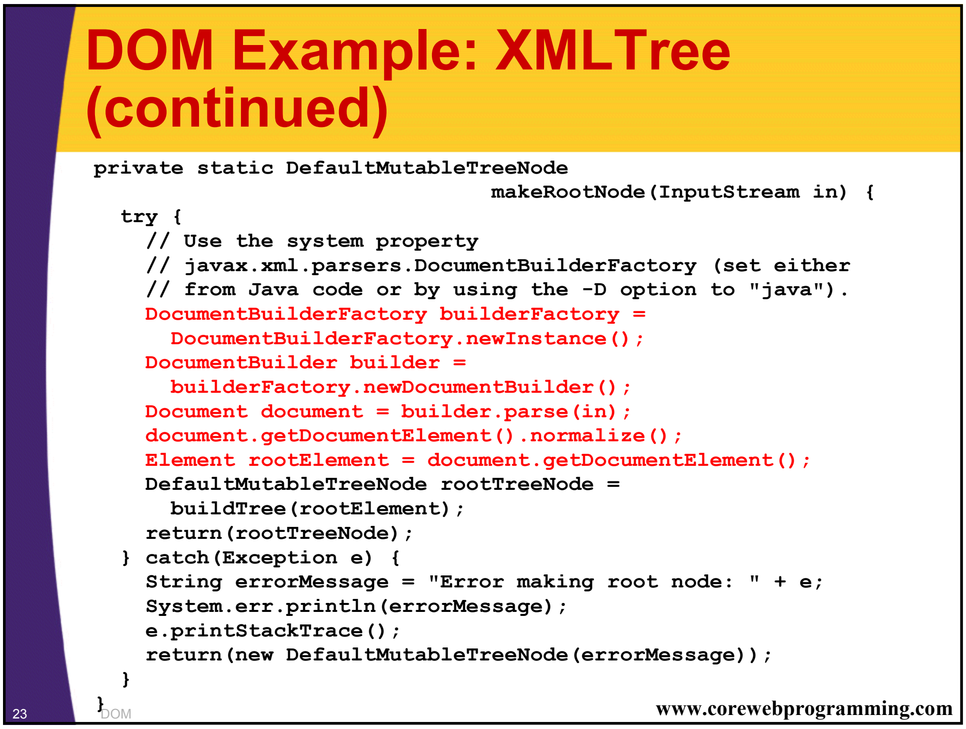
- **Approach**
  - Each XML document element is represented as a tree node (in the `JTree`)
  - Each tree node is either the element name or the element name followed by a list of attributes

DOM Example: Representing an XML Document as a JTree

- **Approach (cont.)**
  - The following steps are performed:
    1. Parse and normalize the XML document and then obtain the root node
    2. Turn the root note into a `JTree` node
       - The element name (`getNodeName`) is used for the tree node label
       - If attributes are present (`node.getAttributes`), then include them in the label enclosed in parentheses
    3. Look up child elements (`getChildNodes`) and turn them into `JTree` nodes, linking to their parent tree node
    4. Recursively apply step 3 to all child nodes

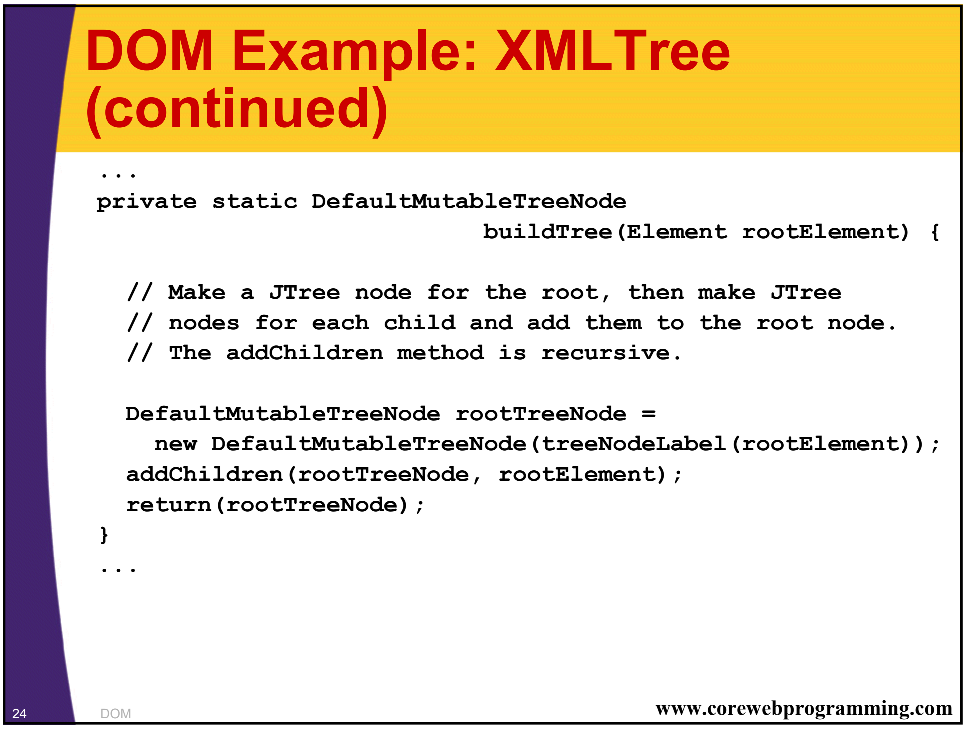
DOM Example: XMLTree

```
import java.awt.*;
import javax.swing.*;
import javax.swing.tree.*;
import java.io.*;
import org.w3c.dom.*;
import javax.xml.parsers.*;

/** Given a filename or a name and an input stream,
 *  this class generates a JTree representing the
 *  XML structure contained in the file or stream.
 *  Parses with DOM then copies the tree structure
 *  (minus text and comment nodes).
 */

public class XMLTree extends JTree {
  public XMLTree(String filename) throws IOException {
    this(filename, new FileInputStream(new File(filename)));
  }

  public XMLTree(String filename, InputStream in) {
    super(makeRootNode(in));
  }
```



DOM Example: XMLTree (continued)

```
private static DefaultMutableTreeNode
                                makeRootNode(InputStream in) {
  try {
    // Use the system property
    // javax.xml.parsers.DocumentBuilderFactory (set either
    // from Java code or by using the -D option to "java").
    DocumentBuilderFactory builderFactory =
      DocumentBuilderFactory.newInstance();
    DocumentBuilder builder =
      builderFactory.newDocumentBuilder();
    Document document = builder.parse(in);
    document.getDocumentElement().normalize();
    Element rootElement = document.getDocumentElement();
    DefaultMutableTreeNode rootTreeNode =
      buildTree(rootElement);
    return(rootTreeNode);
  } catch(Exception e) {
    String errorMessage = "Error making root node: " + e;
    System.err.println(errorMessage);
    e.printStackTrace();
    return(new DefaultMutableTreeNode(errorMessage));
  }
}
```



DOM Example: XMLTree (continued)

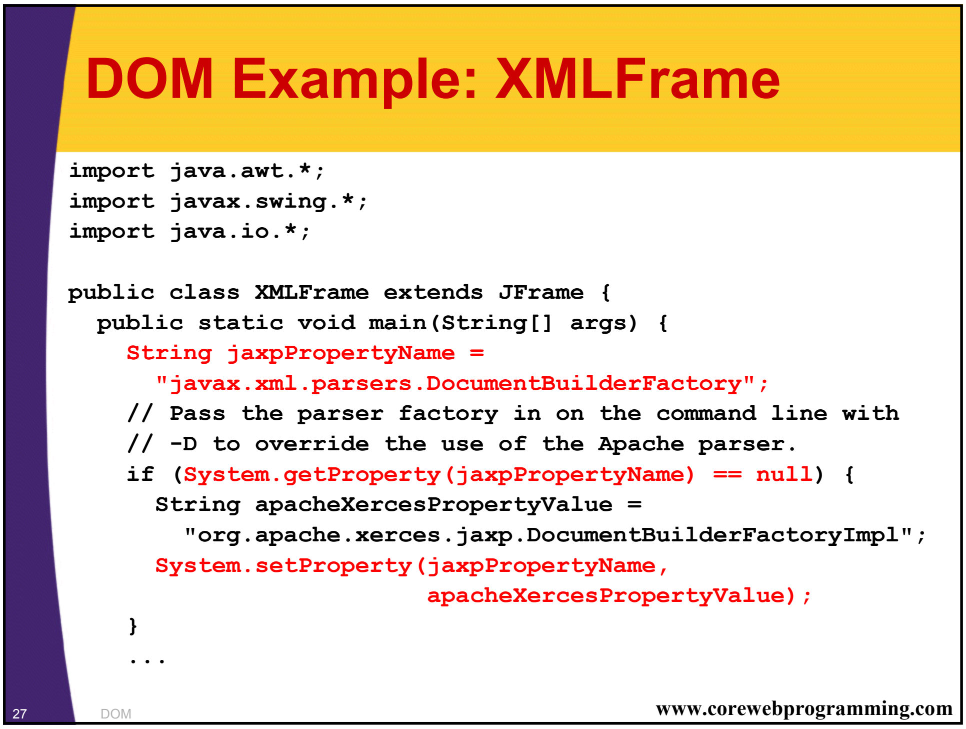
```
...
private static DefaultMutableTreeNode
                              buildTree(Element rootElement) {

  // Make a JTree node for the root, then make JTree
  // nodes for each child and add them to the root node.
  // The addChildren method is recursive.

  DefaultMutableTreeNode rootTreeNode =
    new DefaultMutableTreeNode(treeNodeLabel(rootElement));
  addChildren(rootTreeNode, rootElement);
  return(rootTreeNode);
}
...
```

DOM Example: XMLTree (continued)

```
private static void addChildren
   (DefaultMutableTreeNode parentTreeNode, Node parentXMLElement) {
   // Recursive method that finds all the child elements and adds
   // them to the parent node. Nodes corresponding to the graphical
   // JTree will have the word "tree" in the variable name.
   NodeList childElements =
     parentXMLElement.getChildNodes();
   for(int i=0; i<childElements.getLength(); i++) {
     Node childElement = childElements.item(i);
     if (!(childElement instanceof Text ||
           childElement instanceof Comment)) {
       DefaultMutableTreeNode childTreeNode =
         new DefaultMutableTreeNode
           (treeNodeLabel(childElement));
       parentTreeNode.add(childTreeNode);
       addChildren(childTreeNode, childElement);
     }
   }
 }
```

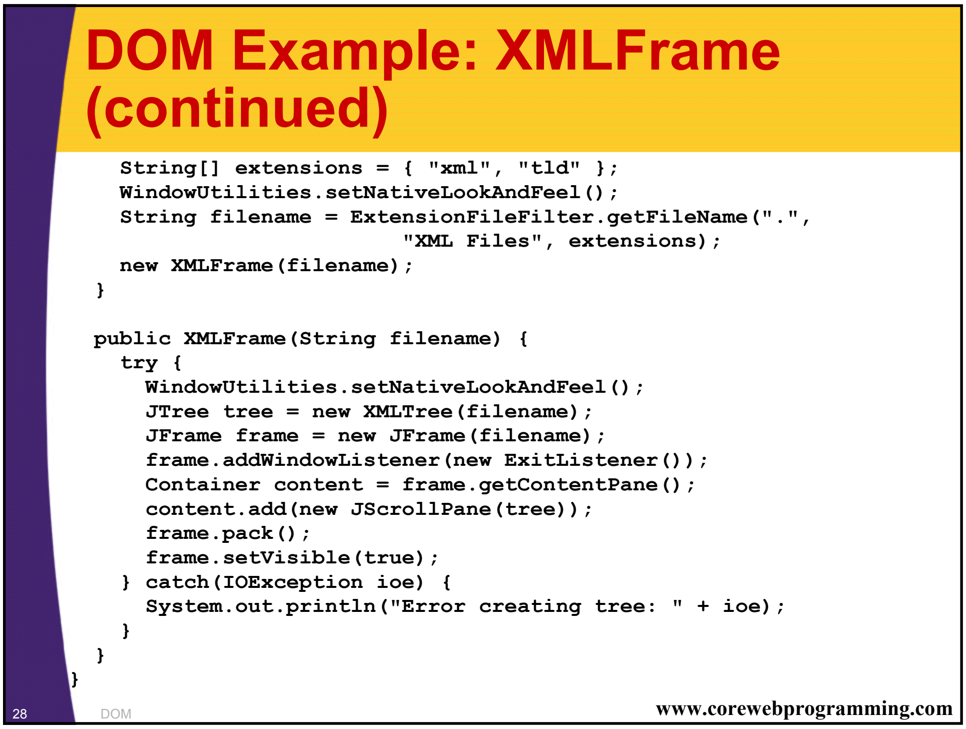
DOM Example: XMLTree (continued)

```
  ...
  private static String treeNodeLabel(Node childElement) {
    NamedNodeMap elementAttributes =
      childElement.getAttributes();
    String treeNodeLabel = childElement.getNodeName();
    if (elementAttributes != null &&
        elementAttributes.getLength() > 0) {
      treeNodeLabel = treeNodeLabel + " (";
      int numAttributes = elementAttributes.getLength();
      for(int i=0; i<numAttributes; i++) {
        Node attribute = elementAttributes.item(i);
        if (i > 0) {
          treeNodeLabel = treeNodeLabel + ", ";
        }
        treeNodeLabel =
          treeNodeLabel + attribute.getNodeName() +
          "=" + attribute.getNodeValue();
      }
      treeNodeLabel = treeNodeLabel + ")";
    }
    return(treeNodeLabel);
  }
}
```



DOM Example: XMLFrame

```
import java.awt.*;
import javax.swing.*;
import java.io.*;

public class XMLFrame extends JFrame {
  public static void main(String[] args) {
    String jaxpPropertyName =
      "javax.xml.parsers.DocumentBuilderFactory";
    // Pass the parser factory in on the command line with
    // -D to override the use of the Apache parser.
    if (System.getProperty(jaxpPropertyName) == null) {
      String apacheXercesPropertyValue =
        "org.apache.xerces.jaxp.DocumentBuilderFactoryImpl";
      System.setProperty(jaxpPropertyName,
                         apacheXercesPropertyValue);
    }
    ...
```



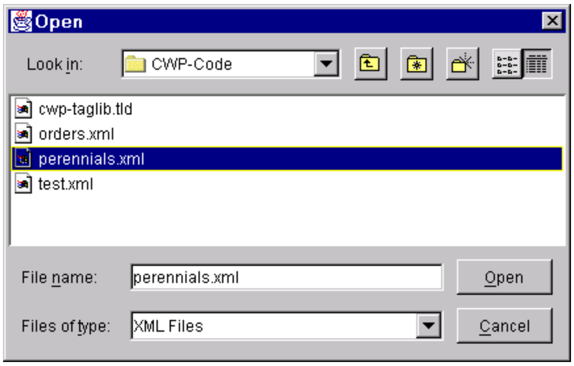
DOM Example: XMLFrame (continued)

```
    String[] extensions = { "xml", "tld" };
    WindowUtilities.setNativeLookAndFeel();
    String filename = ExtensionFileFilter.getFileName(".",
                                  "XML Files", extensions);
    new XMLFrame(filename);
  }

  public XMLFrame(String filename) {
    try {
      WindowUtilities.setNativeLookAndFeel();
      JTree tree = new XMLTree(filename);
      JFrame frame = new JFrame(filename);
      frame.addWindowListener(new ExitListener());
      Container content = frame.getContentPane();
      content.add(new JScrollPane(tree));
      frame.pack();
      frame.setVisible(true);
    } catch(IOException ioe) {
      System.out.println("Error creating tree: " + ioe);
    }
  }
}
```

DOM Example: perennials.xml

```
<?xml version="1.0"?>
<!DOCTYPE perennials SYSTEM "dtds/perennials.dtd">
<perennials>
  <daylily status="in-stock">
    <cultivar>Luxury Lace</cultivar>
    <award>
      <name>Stout Medal</name>
      <year>1965</year>
    </award>
    <award>
      <name note="small-flowered">Annie T. Giles</name>
      <year>1965</year>
    </award>
    <award>
      <name>Lenington All-American</name>
      <year>1970</year>
    </award>
    <bloom code="M">Midseason</bloom>
    <cost discount="3" currency="US">11.75</cost>
  </daylily>
  ...
<perennials>
```

DOM Example: Results



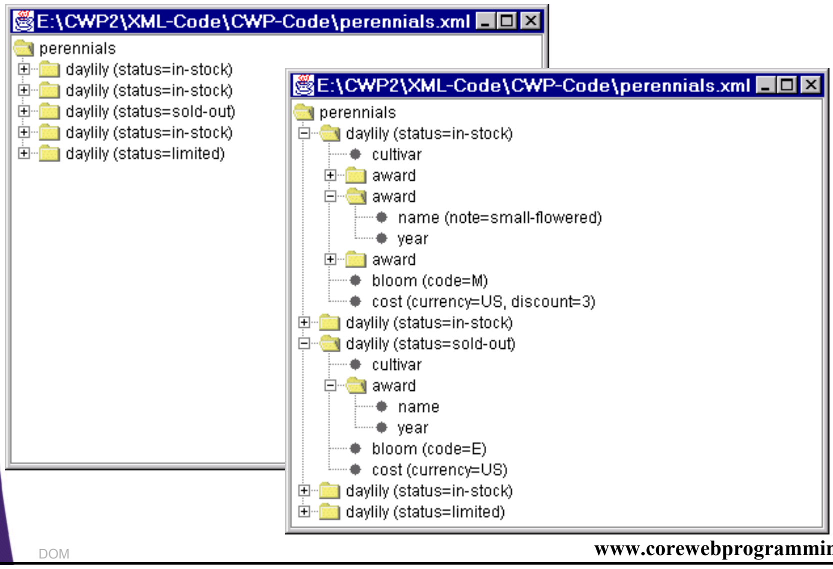
Look in: CWP-Code

cwp-taglib.tld
orders.xml
perennials.xml
test.xml

File name: perennials.xml

Files of type: XML Files

DOM Example: Results (continued)



```
E:\CWP2\XML-Code\CWP-Code\perennials.xml
perennials
⊞ daylily (status=in-stock)
⊞ daylily (status=in-stock)
⊞ daylily (status=sold-out)
⊞ daylily (status=in-stock)
⊞ daylily (status=limited)
```

```
E:\CWP2\XML-Code\CWP-Code\perennials.xml
perennials
⊟ daylily (status=in-stock)
    ● cultivar
    ⊞ award
    ⊟ award
        ● name (note=small-flowered)
        ● year
    ⊞ award
    ● bloom (code=M)
    ● cost (currency=US, discount=3)
⊞ daylily (status=in-stock)
⊟ daylily (status=sold-out)
    ● cultivar
    ⊟ award
        ● name
        ● year
    ● bloom (code=E)
    ● cost (currency=US)
⊞ daylily (status=in-stock)
⊞ daylily (status=limited)
```

DOM or SAX?

- **DOM**
  - Suitable for small documents
  - Easily modify document
  - Memory intensive; load the complete XML document
- **SAX**
  - Suitable for large documents; saves significant amounts of memory
  - Only traverse document once, start to end
  - Event driven
  - Limited standard functions

Summary

- DOM is a tree representation of an XML document in memory
  - DOM provides a robust API to easily modify and extract data from an XML document
- JAXP provides a vendor-neutral interface to the underlying DOM or SAX parser
- Every component of the XML document is represent as a Node
- Use normalization to combine text elements spanning multiple lines

core WEB programming

Questions?