

Data-centric XML

Parser Interfaces: SAX

XML Programming Models

- Treat XML as text
 - useful for interactive creation of documents (text editors)
 - also useful for programmatic generation of documents
 - need guarantee for well-formedness somehow
 - very difficult for XML input
 - in certain application contexts, additional constraints on XML may simplify processing, e.g. restriction to us-ascii, avoiding CDATA sections, etc.

XML Programming Models (2)

- Treat XML as events
 - use separate XML parser (e.g. as a library)
 - parser invokes callback functions for parsing “events”:
 - start of an element, including attributes
 - end of an element
 - character data content
 - ...
 - applications need to maintain state
 - advantage: parser does not need to maintain state, can thus process large documents quickly

XML Programming Models (3)

- Treat XML documents as trees
 - Allows random access to all parts of the document
 - Requires potentially large in-memory representation
 - Different notions of how to represent XML in a tree:
 - XML Infoset
 - DOM (Document Object Model)
 - XPath
 - XSLT: Post-Schema Validation Infoset (PSVI)
 - Tree structure typically accessed through APIs

XML Programming Models (4)

- Transformation
 - Application assumption: Output is again a structure document (e.g. XML)
 - Processing is defined by means of rules associating input and output
 - XSLT: Pattern-matching over input document, templates for output document
 - Used either stand-alone, or embedded in some larger application

XML Programming Models (5)

- Abstracting XML away
 - Use some tool/library to produce application-oriented data representation
 - Use XML “under the hood”:
 - Web Services
 - XMI: XML Model Interchange

Common Problems

- What you get is not what you saw
 - parsers abstract from lexical representation
 - order of attributes
 - expansion of CDATA sections and references
 - retrieval of default values for attributes
 - ...
- Omission of certain constructs (e.g. comments)
 - Applications should not use comments to store essential information
- Application needs out-of-band information
 - processing instructions
 - notations
 - unparsed entities

SAX: Simple API for XML

- Event-oriented programming interface
- Originally specified by Tim Bray, Peter Murray-Rust, and David Megginson for Java
 - Java package `org.xml.sax`
- Current version: SAX 2
 - added support for namespaces
- Spec available at <http://www.saxproject.org/>
- Implementations available for many languages
 - Java, Python, Perl, Eiffel, ...
- Many implementations available
 - Apache Xerces (C++ & Java), MSXML, Oracle XML Parser, PyXML, ...

SAX 2 Overview

- Interfaces implemented by the processor (reader)
 - XMLReader: primary interface
 - Attributes: access to attributes in start-tag callback
 - Locator (optional): access to source URI+line position
 - XMLReaderFactory: creation of new readers
- Interfaces implement by the application
 - ContentHandler: primary interface, for tags and character data
 - DTDHandler: receives basic DTD events (notations, unparsed entities)
 - EntityResolver: Must provide input stream for external entities
 - ErrorHandler: invoked upon errors in the document

SAX 2 Overview (2)

- Standard classes: objects encapsulating processing state
 - InputSource: carry public and system identifiers
 - SaxException: base class for SAX errors
 - SAXParseException, SAXNotSupportedException, SAXNotRecognizedException
 - DefaultHandler: Base class implementing all handlers
- Standard Extensions: available only in some implementations
 - Attributes2: Access to DTD information about attributes
 - DeclHandler: Callback for DTD declarations (attributes, elements, entities)
 - EntityResolver2: advanced resolution of entities and external DTD subset
 - LexicalHandler: callback for various lexical information (comments, CDATA sections)
 - Locator2: additional source information (XML version, encoding)

SAX Overview (3)

- Features and Properties: Configuration of parser
 - whether or not to perform validation
 - whether or not to provide namespace URIs
 - whether or not to use various extension interfaces

Obtaining a Reader

```
try{
  // optionally pass class name, e.g. "org.apache.xerces.parsers.SAXParser"
  XMLReader parser = XMLReaderFactory.createXMLReader();
  MyHandler handler = new MyHandler();
  parser.setContentHandler(handler); // install a custom handler
  parser.parse("http://www slashdot.org/slashdot.xml"); // parse the document
  handler.saveResults(); // retrieve results from handler
} catch(SAXParseException e){
  // syntax error in document
} catch(SAXException e){
  // no parsers found
} catch(IOException e){
  // Error accessing the resource
}
```

Content Handlers

```
package org.xml.sax;  
public interface ContentHandler {  
    public abstract void setDocumentLocator (Locator locator);  
    public abstract void startDocument () throws SAXException;  
    public abstract void endDocument () throws SAXException;  
  
    public void startPrefixMapping (String prefix, String uri) throws  
    SAXException;  
    public void endPrefixMapping (String prefix) throws SAXException;
```

Content Handlers (2)

```
public abstract void startElement (String namespaceURI, String localName,  
    String qName, Attributes atts) throws SAXException;  
public abstract void endElement (String namespaceURI, String localName,  
    String qName) throws SAXException;  
public abstract void characters (char ch[], int start, int length)  
    throws SAXException;  
public abstract void ignorableWhitespace (char ch[], int start, int length)  
    throws SAXException;  
public void processingInstruction (String target, String data)  
    throws SAXException;  
public void skippedEntity (String name) throws SAXException;  
}
```

Content Handlers (3)

- `setDocumentLocator`: optionally called by parser before calling anything else
- `startDocument/endDocument`: called exactly once
- `startPrefixMapping/endPrefixMapping`: provide current prefixes
 - for expansion of prefixed attribute values(!)
- `startElement/endElement`: provide element name and namespace information
 - namespace URI/localName optional depending on namespaces property
 - attributes only includes explicit attributes (specified or defaulted)
 - xmlns attributes provided only if the namespace-prefixes feature is true

Content Handlers (4)

- **characters**: provide PCDATA as a Unicode string
 - reader may split characters over several calls (!), e.g. for line breaks, CDATA sections, references
 - all data in a single call must come from the same external entity, so that locator information is useful
- **ignorableWhitespace**: reports white space in element content
 - usage is optional, must be used by validating parsers
- **skippedEntity**: report entity reference that is not expanded
 - may be called by non-validating parsers for any external entity
 - may also be called if external-general-entities/external-parameter-entities is false.

XMLReader: Configuration

```
package org.xml.sax;  
public interface XMLReader  
{  
    public boolean getFeature (String name)  
        throws SAXNotRecognizedException, SAXNotSupportedException;  
    public void setFeature (String name, boolean value)  
        throws SAXNotRecognizedException, SAXNotSupportedException;  
    public Object getProperty (String name)  
        throws SAXNotRecognizedException, SAXNotSupportedException;  
    public void setProperty (String name, Object value)  
        throws SAXNotRecognizedException, SAXNotSupportedException;
```

XMLReader: Event Handlers

```
public void setEntityResolver (EntityResolver resolver);  
public EntityResolver getEntityResolver ();
```

```
public void setDTDHandler (DTDHandler handler);  
public DTDHandler getDTDHandler ();
```

```
public void setContentHandler (ContentHandler handler);  
public ContentHandler getContentHandler ();
```

```
public void setErrorHandler (ErrorHandler handler);  
public ErrorHandler getErrorHandler ();
```

XMLReader: Parsing

```
public void parse (InputSource input)
    throws IOException, SAXException;

public void parse (String systemId)
    throws IOException, SAXException;
}
```

InputSources

```
package org.xml.sax;
public class InputSource {
    public InputSource();
    public InputSource (String systemId);
    public InputSource (java.io.InputStream byteStream);
    public InputSource (java.io.Reader characterStream);
    // getters omitted
    public void setPublicId (String publicId);
    public void setSystemId (String systemId);
    public void setByteStream (InputStream byteStream);
    public void setEncoding (String encoding);
    public void setCharacterStream (Reader characterStream);
};
```

Locators

```
package org.xml.sax;  
public interface Locator {  
    public abstract String getPublicId ();  
    public abstract String getSystemId ();  
    public abstract int getLineNumber ();  
    public abstract int getColumnNumber ();  
}
```

- positions are only approximations; they cannot be used for editing

SAX Features

- Feature names are URLs
 - start with `http://xml.org/sax/features/`
 - `external-general-entities`
 - `external-parameter-entities`
 - `is-standalone` (read-only)
 - `namespaces` (default: true)
 - `namespace-prefixes` (default:false)
 - `resolve-dtd-uris` (default:true)
 - `string-interning`
 - `validation`
 - `xmlns-uris` (false)
 - ...

Filters

- Receive all events and delegate them to a next handler in a processing chain
- allow modular development of XML applications
- Base class: `org.xml.sax.helpers.XMLFilterImpl`
 - implements both reader and handler interfaces
- Install “parent” reader with `.setParent`
- Invoke “outermost” `.parse()`

Alternative Implementation Language

- MSXML4, using C++

```
struct MyContent : public SAXContentHandlerImpl {  
    MyContent();  
    virtual ~MyContent();
```

```
    virtual HRESULT STDMETHODCALLTYPE startElement(  
        wchar_t __RPC_FAR *pwchNamespaceUri,    int cchNamespaceUri,  
        wchar_t __RPC_FAR *pwchLocalName,        int cchLocalName,  
        wchar_t __RPC_FAR *pwchQName,           int cchQName,  
        ISAXAttributes __RPC_FAR *pAttributes);
```



```
virtual HRESULT STDMETHODCALLTYPE endElement(  
    wchar_t __RPC_FAR *pwchNamespaceUri,    int cchNamespaceUri,  
    wchar_t __RPC_FAR *pwchLocalName,        int cchLocalName,  
    wchar_t __RPC_FAR *pwchQName,           int cchQName);  
  
virtual HRESULT STDMETHODCALLTYPE startDocument();  
};
```

```

HRESULT STDMETHODCALLTYPE MyContent::startElement(...)
{
    int l; wchar_t * ln, * vl; int lnl, vll;
    prt(L"<%s",pwchLocalName,cchLocalName);
    pAttributes->getLength(&l);
    for ( int i=0; i<l; i++ ) {
        pAttributes->getLocalName(i,&ln,&lnl);
        prt(L" %s=", ln, lnl);
        pAttributes->getValue(i,&vl,&vll);
        prt(L "\"%s\"", vl, vll);
    }
    printf(">");
    return S_OK;
}

```