Simple API for XML (SAX)

Asst. Prof. Dr. Kanda Runapongsa (krunapon@kku.ac.th)
Dept. of Computer Engineering
Khon Kaen University

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Topics

- Parsing and application
- SAX event model
- SAX event handlers
- Apache Xerces
- JAXP
- When to use SAX

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SAX API

- SAX API is based on an event-driven processing model where
  - The data elements are interpreted on a sequential basis
  - The callbacks are called based on selected constructs
- It uses a sequential read-only approach and does not support random access to the XML elements

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SAX Features

- Event-driven
  - You provide event handlers
- Fast and lightweight
  - Document does not have to be entirely in memory
- Sequential read access only
- One-time access
- Does not support modification of document

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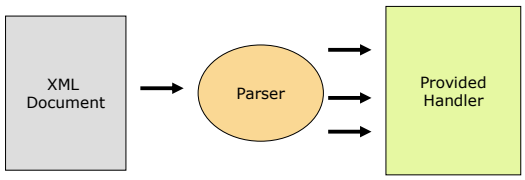
SAX Operational Model



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SAX Programming

- Collection of Java interfaces and classes
  - Package org.xml.sax
- Interfaces
  - Parser
    - XMLReader
  - Event handlers
    - ContentHandler

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SAX Event Handlers

- Interfaces
  - ContentHandler
  - ErrorHandler
  - DTDHandler
  - EntityResolver
  - Attributes
- Class
  - DefaultHandler

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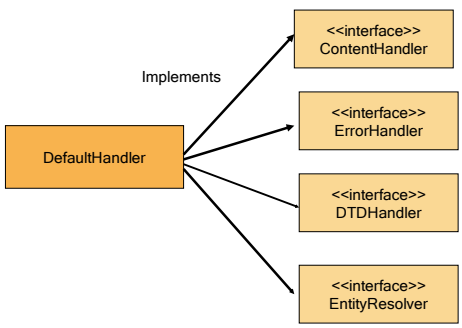
SAX Event Handlers



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SAX Event-based

<?xml version="1.0"?> → startDocument
<nation> → startElement: nation
  <name> → startElement: name
    Thailand → Characters: Thailand
  </name> → endElement: name
  <location> → startElement: location
    Asia → characters: Asia
  </location> → endElement: location
</nation> → endElement: nation
→ endDocument

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ContentHandler Interface

```
public interface ContentHandler{
  void startDocument () throws SAXException;
  void endDocument() throws SAXException;
  void startElement(String namespace, String name, String
  qName, Attributes atts) throws SAXException;
  void endElement(String namespace, String name, String qName)
  throws SAXException;
  void characters(char [ ] ch, int start, int length) throws
  SAXException;
  void ignorableWhiteSpace(char [ ]ch, int start, int length) throws
  SAXException;
  void processingInstruction(String target, String data) throws
  SAXException;
  void setDocumentLocator(Locator locator);
  void startPrefixMapping(String prefix, String uri) throws
  SAXException;
  void endPrefixMapping(String prefix) throws SAXException;
  void skippedEntity(String name) throws SAXException;}
```

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DefaultHandler Class

- Helper class
- Implements
  - ContentHandler
  - ErrorHandler
  - DTDHandler
  - EntityResolver
- Just subclass and override the methods you are interested in

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ContentHandler and DefaultHandler

- There are eleven methods declared in the ContentHandler interface.
- Few SAX programs actually use all eleven methods
- SAX includes the org.xml.sax.helpers.DefaultHandler class that implements the ContentHandler interface
- By extending DefaultHandler, we only have to override methods we actually care about

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Most Frequently Used Methods (1/2)

- **startDocument()** This method is called only once at the start of the XML document
  - public void startDocument()
- **endDocument()** This method is called when the parser reaches the end of the XML document
  - public void endDocument()
- **characters()** This method is called from character data residing inside an element
  - public void characters(char[] text, int start, int length)

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Most Frequently Used Methods (2/2)

- **startElement()** This method is called every time a new opening tag of an element is encountered (for example, <element>)
  - public void startElement(String namespaceURI, String localName, String qualifiedName,
    Attributes atts)
- **endElement()** This method is called when an element ends (for example, </element>)
  - public void endElement(String namespaceURI, String localName, String qualifiedName)

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What the ContentHandler Does not Tell You

- The type of quotes that surround attributes
- Whether empty elements are represented as
  - <name></name> or
  - <name/>
- Whether an attribute was specified in the instance document or defaulted in from the DTD or schema

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Handling Attributes

- Attributes are not reported through separate callbacks
- Instead an Attributes object containing all the attributes of an element is passed to the startElement() method

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Attributes Interface

```
public interface Attributes {
        public abstract int getLength();
        public abstract int getIndex(String qName);
        public abstract int getIndex(String namespace,
                                     String name)
        public abstract String getLocalName(int index)
        public abstract String getQName(int index)
        public abstract String getType(int index)
        public abstract String getType(String qName)
        public abstract String getType(String namespace,
                String name)
        public abstract String getValue(String qName)
        public abstract String getValue(String namespace,
                                     String name)
        public abstract String getValue(int index)
        public abstract String getURI(int index)
}
```

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Handling Attributes Example

```
public void startElement(String namespaceURI, String
   localName, String qName, Attributes atts)
{
   int length = atts.getLength();
   if (length > 0)
   {
        System.out.println("Element <"+qName+">       has
   the following attributes");
        for (int i = 0; i < length; i++)
        {
                System.out.println(" " +
                atts.getQName(i) + " = "
                        + atts.getValue(i));
        }
   }
}
```

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ErrorHandler Interface

```
public interface ErrorHandler{
   void error(SAXParserException e)
   throws SAXException
   void fatalError(SAXParseException e)
   throws SAXException
   void warning(SAXParseException e)
   throws SAXException
}
```

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ErrorHandler Example

```
public class SAXWithErrrorHandler extends
   DefaultHandler { …
   public void fatalError(SAXParseException
   exception)
   {
      System.err.println("FATAL ERROR! " +
         exception.getMessage());
   } …
   public static void main(String[] args)
        throws SAXException, IOException { …
        parser.setContentHandler(handler);
        parser.setErrorHandler(handler);
        …
   }
}
```

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SAX Programming Procedures (Using Xerces)

Create XML Parser	XMLReader parser = XMLReaderFactory.createXMLReader();
Create Event Handler	myHandler handler = new myHandler();
Call Parser and Set Event Handler	parser.parse(args[0]); parser.setContentHandler(handler);
Parse Handling	SAX parser calls methods on the event handler
Event Handler Processing	public void startDocument() { System.out.println("XML Document Start"); }

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XMLReader Instance

- Concrete implementation instance "bound" to XMLReader interface
- Has to be created before parsing
- Gets created by using static method of createXMLReader() method of helper class XMLReaderFactory

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XMLReader Example1

```
XMLReader parser = null;
try {
  // Get SAX parser instance reading
  // org.xml.sax.driver  system property
  parser =
    XMLReaderFactory.createXMLReader();
  // Parse the document
} catch (SAXException ex) {
     // Couldn't create XMLReader
    // either because org.xml.sax.driver sytem
    property
    // was not set or set incorrectly
}
```

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XMLReader Example2

```
XMLReader parser = null;
try {
  // Create an instance of Apache's Xerces
  // SAX parser
  parser =
  XMLReaderFactory.createXMLReader("org.apa
  che.xerces.parsers.SAXParser");
  // Parse the document
} catch (SAXException ex) {
  // Couldn't create XMLReader maybe because
  // org.apache.xerces.parsers.SAXParser class is
  // not in classpath
}
```

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Setting Features

- setFeature(String, boolean) method of XMLReader interface
  - The first argument is feature name
  - The second argument is the boolean value. Set to true if we want to activate that feature
- Sample Feature Names
  - Validation: http://xml.org/sax/features/validation
  - Namespace Awareness: http://xml.org/sax/features/namespaces
  - Schema Validation: http://apache.org/xml/features/validation/schema

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Parse Methods

- void parse(String uri) throws SAXException, IOException
- void parse(InputSource source) throws SAXException, IOException
- Example:

```
XMLReader parser =
  XMLReaderFactory.createXMLReader()
  ;
parser.parse("c:/employee.xml")
```

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XMLReader Example3

```
XMLReader parser = null;
try {
  // Create an instance of Apache's Xerces // SAX
  parser
  parser =
  XMLReaderFactory.createXMLReader("org.apa
  che.xerces.parsers.SAXParser");
  // Parse the document
  parser.parse("c:/employee.xml");
} catch (SAXException ex) {
  // Catch any exception during parsing
}
```

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Simple SAX Example: Parser

```
import org.xml.sax.*;
import org.xml.sax.helpers.*;
import java.io.IOException;
public class SimpleSAX {
    public static void main(String[] args) {
        XMLReader parser = null;
        try {
            // Create XML (non-validating) parser
            parser =
XMLReaderFactory.createXMLReader("org.apache.xerces.parsers.SAXPar
ser");
            /*  Create event handler */
            myContentHandler handler = new
                myContentHandler();
            parser.setContentHandler(handler);
            // Call parsing method
            parser.parse(args[0]);
        } catch (SAXException ex) {
            System.err.println(ex.getMessage());
        } catch (Exception ex) {
            System.err.println(ex.getMessage());
        }}}
```

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Event Handler Example: myContentHandler

```
class myContentHandler extends DefaultHandler
{
    // ContentHandler methods
    public void startDocument() {
                System.out.println("XML Document START");
    }
    public void endDocument() {
                System.out.println("XML Document END");
    }
    public void startElement(String namespace, String name, String
        qName, Attributes atts) {
                System.out.println("<" + qName + ">");
    }
    public void endElement(String namespace, String name, String
        qName) {
                System.out.println("</" + qName + ">");
    }
    public void characters(char[] chars, int start, int length) {
        System.out.println(new String(chars, start, length));
    }
}
```

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Receiving Documents

- The parser invokes startDocument() as soon as it begins parsing a new document before it invokes any other methods in ContentHandler
- It calls endDocument() after it's finished parsing the document and will not report any further content from that document

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Receiving Elements

- When the parser encounters a start tag, it calls the startElement() method
- When the parser encounters an end tag, it calls the endElement() method
- When the parser encounters an empty-element tag, it calls the startElement() method and then the endElement() method

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Receiving Characters

- When the parser reads #PCDATA, it passes this text to the characters() method as an array of chars
- Parsers are allowed to break up character data any way desired
- Character data are in Unicode regardless of encoding scheme specified in XML documents

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Processing XML with JAXP SAX

- Major steps for parsing using JAXP:
  - Getting Factory and Parser classes to perform XML parsing
  - Setting options such as namespaces, validation, and features
  - Creating a defaultHandler implementation class

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Getting a Factory Class

- Obtain a factory class using the SAXParserFactory's static newInstance() method
  - SAXParserFactory factory = SAXParserFactory.newInstance();

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Getting and Using a SAXParser Class

- Obtain the SAX parser class from the factory by calling the newSAXParser() static method
  - SAXParser parser = factory.newSAXParser();
- Parse the XML data by calling the parse method
  - parser.parse("methodCall.xml", handler);
  - The second argument is the handler with type ContentHandler

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JAXP/SAX Code Sample

```
import javax.xml.parsers.*;
import org.xml.sax.*;
import org.xml.sax.helpers.*;
public class JAXPEcho  extends DefaultHandler {
   // Use an instance of ourselves as the SAX event handler
   DefaultHandler handler = new JAXPEcho();
   // Use the default (non-validating) parser
   SAXParserFactory factory =
   SAXParserFactory.newInstance();
   // Parse the input
  SAXParser saxParser = factory.newSAXParser();
  saxParser.parse( new File("employee.xml"), handler);
   …
}
```

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Benefits of SAX

- It is very simple
- It is very fast
- Useful when custom data structures are needed to model the XML document
- Can parse files of any size without impacting memory usage
- Can be used to gather a subset of a document's information

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Drawbacks of SAX

- SAX provides read-only access
- Developers need to model the documents themselves
  - Design the model
  - Write appropriate event handlers
  - Create data structures in programs
- No random access to documents

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When to Use SAX

- When we want to only read XML documents
- When we need to process very large XML documents
- When we have a limited amount of memory
- When we want to have a very fast and efficient parser

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Summary

- SAX API is based on an event-driven processing model
- SAX Parser usually extends DefaultHandler to override only interested methods
- When using Xerces, use XMLReader
- When using JAXP, use SAXParserFactory and SAXParser
- SAX is fast and simple, but it provides read-only access in a sequential fashion

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References

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