XML Technology Overview

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Administrivia

- Fire escapes
- Who am I?
- Pink sheets
- Green sheets
- Timing.

This course

- What we will (and won't) be covering
- The handouts
- Course website:

`http://www-uxsup.csx.cam.ac.uk/~jw35/courses/xml/`.

XML itself

In the beginning...

- SGML
  - Invented in the 1970's at IBM
  - Now ISO standard 8879
  - A "semantic and structural markup language for text documents"
- HTML is the most famous 'application' of SGML
- XML is a reformulation of SGML
  - Missing out the complicated and redundant features
  - A W3C-endorsed standard
  - Designed for easy parsing
  - A "meta-markup language for text documents"
- *XML* is simple
  - it's the rest of the technology that's powerful
  - and in places complicated
- XML isn't just a web technology.

XML Documents

- XML documents contain text, never binary data
- These can be manipulated by any tool that understand text
- An XML document could be a disk file
  - but it could as easily be a field in a database
  - or delivered over a network connection
- When delivered by a web server, they will probably have a media type of **`text/xml`** or **`application/xml`**
- However the approved modern usage is to use something more like **`application/svg+xml`**.

Elements

- XML documents mainly consist of *elements*
- Have a *start-tag* and an *end-tag*

```
<name>
  Computing Service
</name>
```

- Everything between the tags is the element's *content*
- Whitespace is part of the content, though applications may ignore it
- Empty elements can be written: **`<name/>`**
- ...but not **`<name>`**.

Tag names

- Have no intrinsic meaning
- Are case sensitive
- Can contain any alphanumeric character, underscore(_), hyphen(-), and dot (.)
- Colon (:) should be avoided
  - it has a special meaning which we'll come to shortly
- Must start with a letter or underscore
- Names starting 'xml...' (in any case) are reserved.

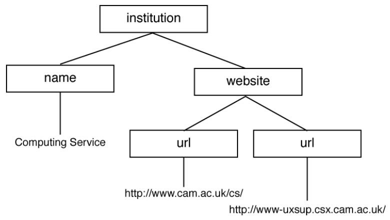
Elements within elements

- Consider

```
<institution>
  <name>Computing Service</name>
  <address>New Museums Site, Pembroke Street</address>
  <website>
    <url>http://www.cam.ac.uk/cs/</url>
    <url>http://www-uxsup.csx.cam.ac.uk/</url>
  </website>
</institution>
```

- The **<institution>** element contains 3 'children': a **<name>** element, an **<address>** element and a **<website>** element
- The **<website>** element itself contains 2 **<url>** elements.

XML documents as a tree



XML document styles

- Record orientated

```
<institution>
  <name>Computing Service</name>
  <address>New Museums Site, Pembroke Street</address>
  <website>
    <url>http://www.cam.ac.uk/cs/</url>
    <url>http://www-uxsup.csx.cam.ac.uk/</url>
  </website>
</institution>
```

- Mixed content

```
<handbook>
  <para>
  The <inst>Computing Service</inst> provides
  services, including <service>Hermes</service>
  and <service>Raven</service>. It is <em>really
  important</em> that you find out how to access
  these services.
  </para>
</handbook>
```

Attributes

- Elements can have *attributes*
- Name/value pairs in the start tag
- Name and value separated by '=' and optional white space
- Value enclosed in single or double quotes. Always
- Pairs separated by white space

```
<institution type="non"   key = 'ucs'>
    <name>
      Computing Service
    </name>
</institution>
```

- Each attribute can appear only once in any particular tag
- Attribute names follow the same rules as element names
- When to use attribute values, when content?.

Character References

- Some characters can't appear as themselves in character data
  - e.g. **<** and **&** are never allowed
  - Some characters can't be typed easily, e.g. Â¥
- They can be represented as
  - an entity reference, e.g. **<**
  - a numeric character reference, e.g. **<**
  - a hexadecimal numeric character reference, e.g. **<**
- XML pre-defines only 5 entity references
  - **<** for the less-than symbol: **<**
  - **&amp**; for the ampersand: **&**
  - **>** for the greater-than symbol: **>**
  - **"** for straight, double quotation marks: **"**
  - **'** for the apostrophe, a.k.a the straight quote: **'**.

Character sets and encodings

- XML documents are 'text documents' containing 'characters'
- Internally, XML processors work in Unicode, a.k.a ISO 10646
- But computers can only process sequences of octets
- Characters are mapped to octets by two-stage process
  - A *character set* maps characters to numbers
  - An *encoding* maps those numbers to bytes
- The name of an encoding refers to a combination of these, for example
  - **iso-8859-1**, a.k.a ISO Latin-1, defines a sub-set of characters, mainly European, mapped to numbers on the range 0-255 which are directly encoded as octets
  - **UCS-2** consists of the first 65,536 characters from Unicode encoded as a pair of bytes
  - **UTF-8** encodes all the characters from Unicode using a variable number of bytes. Unicode characters 0-127 (ASCII) encode to the same single byte as ASCII.

The XML declaration

- XML documents *should* start with an XML declaration

```
<?xml version="1.0" encoding="UTF-8"?>
```

- If present, it *must* be the *very* first thing in the document
- In the absence of other information it is used to guess the character encoding
- It contains 3 things that look like attributes (though they aren't):
  - version: 1.0 or *perhaps* 1.1
  - encoding: the character encoding used in the document. Optional, default from external metadata
  - standalone. Optional, default no.

Processing instructions

- Intended for passing information to particular parsers
- Look like a tag starting **<?** immediately followed by an XML name, and ending **?>**
- The rest is arbitrary, but often looks like a sequence of attributes

```
<?xml-stylesheet href="person.css" type="test/css" ?>
```

- They are not entities: no end tag; no nesting
- XML declarations are not processing instructions.

CDATA

- Raw characters can appear between '`<![CDATA[`' and '`]]>`'
- To a parser this is identical to the equivalent text expressed using entities
- Very useful for including XML examples in XML!

```
<![CDATA[
  <tag1>
    <!-- comment here -->
    <tag2>foo</tag2>
  </tag1>
]]>
```

- Beware that the sequence '`]]>`' can not itself appear in an XML document - use '`]]>`'.

Comments

- XML documents can contain *comments*
- They start with `<!--`
- and end `-->`
- They may not contain `--`
- XML parsers are not required to preserve comments

```
<!-- insert example here -->
```

Well-formedness

- XML documents are required to be 'well formed'
- Every start-tag must have an end-tag
- Elements must not overlap
- One and only one root element
- Attribute values must be quoted
- No more than one attribute with the same name in any element
- No comments or processing instructions inside tags
- No un-escaped '`<`' or '`&`' in character data.

XML: Summary

- A meta-markup language
- XML documents are text, processed internally in Unicode
- They contain
  - *elements* (surrounded by *tags*)
  - an *XML declaration*
  - *comments*
  - *processing instructions*
- Elements can have *attributes* and can nest
- Character data can contain *references*
- Two general styles: *record orientated* vs. *mixed content*
- XML documents must be well formed.

Document Type Definitions

Defining XML documents

- XML is used to create languages - XML *applications*
- How are these languages defined?
- Use a set of rules about what elements and attributes are required where
- This set of rules is a *schema*
- A document that abides by these rules is said to be *valid*
- There are various languages for expressing schemas
- We'll concentrate on Document Type Definition (DTD)
- Many XML tools can check a document against a DTD, including
  - **`xmllint`** from Gnome libxml (common on Linux systems, even if they don't run Gnome)
  - James Clark's **`onsgmls`**
  - The website at

`http://www.stg.brown.edu/service/xmlvalid/`

Document Type Definition

- Old, quirky, and with a limited syntax
- Inherited from SGML
- DTDs are not themselves XML documents
- They let you define:
  - Elements and their nesting
  - The attributes of each element
  - Short cuts (a.k.a. Entities)
- Even if you never write one of these, the ability to read them is invaluable.

Defining Elements

- Write `<!ELEMENT tag content>`
- *tag* is the name of the element being defined
- *content* is
  - **`EMPTY`** if the element must be empty
  - **`ANY`** if the element can contain text or any other element (bad idea)
  - `(content)`, where *content* can be...

What can appear as *content*?

- '`#PCDATA`' - character data:

```
<!ELEMENT name (#PCDATA)>
```

- The name of a single other element:

```
<!ELEMENT founded (date)>
```

- A comma-separated sequence of other elements:

```
<!ELEMENT institution (name,address,website)>
```

- A '|'-separated list of alternatives:

```
<!ELEMENT website (url|hostname)>
```

- Anywhere an element name can appear, you can also have either sort of list in brackets

```
<!ELEMENT institution (seeother|(name,address))>
```

Repeating elements

- Element names, and bracketed lists, can be followed by:
  - '`?`' if the element (or list) can occur zero or one times
  - '`*`' if the element (or list) can occur zero or more times
  - '`+`' if the element (or list) can occur one or more times
- '`*`', applied to a list of choices implies any number of any of the choices, in any order
- '`#PCDATA`' can only appear in a list of choices if there is a '`*`' in force

```
<!ELEMENT institution
            (name,note?,address+,contact*,seeother*)>
<!ELEMENT para (#PCDATA|inst|service|em|address)*>
```

Defining Attributes

- Write `<!ATTLIST tag attribute type default>`
- ***`tag`*** is the element in which this attribute appears
- ***`attribute`*** is the name of the attribute
- ***`type`*** is one of:
  - `CDATA` if the attribute's value consists of plain characters
  - `(choice_1|choice_2|...)` where each *choice_n* represents one possibility
- ***`default`*** is one of:
  - `#REQUIRED` if the attribute must appear
  - `#IMPLIED` if the attribute is optional and has no default
- There are additional types: ID, IDREF, IDREFS, NMTOKEN and NMTOKENS
- ... and other defaults: "value" and #FIXED "value".

Defining entities

- Entities are shortcuts to save typing
- You can define your own entities in a DTD
- Confusingly, the can stand for text in the DTD itself ...
- ... *or* in the document the DTD describes.

Shortcuts for the document being described

- An 'Internal General Entity'

```
<!ENTITY uoc "the University of Cambridge">
```

- With that in our DTD, our XML document can say

```
Here at &uoc; we all love our work
```

- Entities are oftern used to stand for characters that are hard to type

```
<!ENTITY copy "&#169;">
```

- Or we can define an 'External General Entity'

```
<!ENTITY footer SYSTEM "/boilerplate/footer.xml">
```

- Then we can include footer.xml by saying `&footer;`
- External General Entities are useful if you want to maintain your XML document in multiple files
- External General Entities dont need to have a single root element but otherwise must be well formed.

Shortcuts for the DTD

- An 'Internal Parameter Entity' acts as a 'macro' inside the DTD

```
<!ENTITY % contact_details "name,address,website">
```

- Now, instead of saying

```
<!ELEMENT department (name,address,website)>
<!ELEMENT college (name,address,website)>
```

- we can say

```
<!ELEMENT department (%contact_details;)>
<!ELEMENT college (%contact_details;)>
```

- An 'External Parameter Entity' lets us include sections of DTD just like external general entities do for XML documents

```
<!ENTITY % website_stuff SYSTEM "website.dtd">
```

- This can be useful for 'modulising' DTDs.

Associating DTDs with XML documents

- To be valid, an XML document must include a reference to its DTD in a 'Document Type Declaration'
  - Note that 'Document Type Definition' and 'Document Type Declaration' have the same initials - DTD means 'Document Type Definition'
- The Document Type Declaration comes after the XML Declaration and before the start-tag of the root element
- The Document Type Declaration can either refer to a DTD in a seperate document
  - called an *External DTD Subset*
- Or can contain it in-line
  - called an *Internal DTD Subset.*

Using External DTD Subsets

- To refer to a DTD in a local file, you need something like

```
<?xml version="1.0" encoding="UTF-8" standalone="no"?>
<!DOCTYPE institutions SYSTEM "/dtd/inst.dtd">
<institutions>
   ...
</institutions>
```

- The thing after 'SYSTEM' is a URL
- 'Official' DTDs can be named using a 'Formal Public Identifier' (FPI). FPIs are just names in a fixed format
- To refer to a DTD by FPI you need something like

```
<!DOCTYPE book PUBLIC
      "-//OASIS//DTD DocBook XML V4.2//EN"
"http://www.oasis-open.org/docbook/xml/4.0/docbookx.dtd
```

- A 'catalogue' then maps the FPI to an appropriate copy of the corresponding DTD document
- The URL is a backup in case the FPI can't be resolved.

Using Internal DTD Subsets

- The DTD can be included in-line between square brackets

```
<?xml version="1.0" encoding="UTF-8" standalone="yes"?>
<!DOCTYPE institutions [
  <!ELEMENT institution (name,address)>
  <!ELEMENT name (#PCDATA)>
  <!ELEMENT address (#PCDATA)>
]>
<intuitions>
  ...
</institutions>
```

- You can have both at once, but note:
  - element declarations can't be overridden
  - the internal subset can override entities in the external subset.

DTDs: Summary

- A *schema* is a set of rules defining an *XML Application*
- An XML document conforming to a schema is said to be *valid*
- A *Document Type Definition* is one language for doing this
- Lets you define elements and their nesting, attribute, entities
- A DTD can be associated with an XML document by including a *Document Type Declaration*.

Namespaces

What's the problem?

- The need to include elements from one XML Application within documents belonging to a different one
- e.g. use a 'People' application to add contact details for people in Institutions
- ... but People uses `<name>` for the names of people, and Institution uses `<name>` for the names of institutions.

And the solution is...

- Add a application-specific prefix to elements and attributes
  - perhaps `<people:name>` and `<institution:name>`
- But we still need a way to create unique names
- For that we use URIs
- These URIs are called 'Namespace Names'
- Since URLs are URIs they are often used
  - ... but they don't have to point to anything!

```
http://purl.org/dc/
http://www.w3c.org/TR/REC-rdf-syntax#
http://www.w3.org/1999/XSL/Transform
```

- But we can't use URIs directly in tag names, so we either declare a default namespace, or we associate the name with a prefix and use the prefix.

Associating names with elements - default namespace

- We can declare a default namespace with an xmlns attribute

```
<title xmlns="http://purl.org/dc/">...</title>
```

- This namespace applies to the element it is declared in and to all its children

```
<institution type="acad"
        xmlns="http://www.example.org/inst">
  <name>Division of Anaesthesia</name>
  <contact method="tel">+44 1223 217889</contact>
  <website>
    <url xmlns="http://www.example.org/url">
      http://www.medschl.cam.ac.uk/anaesthetics/
    </url>
  </website>
</institution>
```

Associating names with elements - by prefix

- We can declare a nickname or *prefix*

```
<dc:title xmlns:dc="http://purl.org/dc/">
   ...
</dc:title>
```

- Prefix and element name are written separated by ':'
- Each namespaces often has a 'conventional' prefixes, like `dc` for `http://purl.org/dc/` above, but they can be anything

```
<snoopy:title xmlns:snoopy="http://purl.org/dc/">
   ...
</snoopy:title>
```

- Prefixes are available to the element they are declared in and to all its children

```
<institution type="acad"
        xmlns:inst="http://www.example.org/inst">
  <inst:name>Division of Anaesthesia</name>
  <contact method="tel">+44 1223 217889</contact>
</institution>
```

Attributes

- Attributes can be associated with a namespace
  - but normally are not
  - in which case they are in no namespace
- The default namespace *doesn't* apply to attributes.

Namespaces: Summary

- Namespaces allow XML schemas to be combined
- Namespace names are URIs
- These URIs are often URLs, but don't have to point to anything
- You can associate a default namespace with an element and its children with **`xmlns="..."`**
- You can define a prefix for use in an element and its children with **`xmlns:`*`prefix`*`="..."`**.

Transforming XML - XSLT

XSLT

- Specifies rules to transform one XML document into another
- An XSLT stylesheet contains rules consisting of
  - a pattern, and
  - a template
- An XSLT processor tries to match parts of the input document to each patterns
- If it can, it process the template and saves the results
- When processing is finished, these results are used to create an output document
- To apply an XML stylesheet you need a processor. Some examples include:
  - **`xsltproc`** from Gnome libxml (common on Unix systems, even if they don't run Gnome)
  - The Apache project's Xalan processor, available in Java and C++ versions
  - Michael Kay's SAXON.

An Example Document

- We'll use *inst.xml* for the following examples:

```
<?xml version="1.0"?>
<!DOCTYPE institutions SYSTEM "inst.dtd">

<institutions>

 ...

 <institution type="acad">
  <name>Division of Anaesthesia</name>
  <contact type="tel">+44 1223 217889</contact>
  <website>
   <url>http://www.medschl.cam.ac.uk/anaesthetics/</url>
  </website>
 </institution>

 ...

</institutions>
```

XSLT Stylesheets are XML documents

- See *example1.xslt*:

```
<?xml version="1.0"?>

<xsl:stylesheet
  xmlns:xsl="http://www.w3.org/1999/XSL/Transform"
  version="1.0">

</xsl:stylesheet>
```

- The namespace name must be exactly as above
- the version attribute is required
- This is a complete, though largely useless, stylesheet
- For reasons that we'll get to later, applying it to *inst.xml* returns all the text from within elements but nothing else!.

A simple template rule

- See *example2.xslt*:

```
<?xml version="1.0"?>

<xsl:stylesheet
  xmlns:xsl="http://www.w3.org/1999/XSL/Transform"
  version="1.0">

<xsl:template match="institution">
  An institution
</xsl:template>

</xsl:stylesheet>
```

- In effect this says
  - for every **`<institution>`** element
  - output "An institution"
  - and ignore the element's content
- Anything other than XSLT tags is automatically added to the result of the transformation.

Adding elements

- See *example3.xslt*:

```
<?xml version="1.0"?>

<xsl:stylesheet
  xmlns:xsl="http://www.w3.org/1999/XSL/Transform"
  version="1.0">

  <xsl:template match="institution">
    <heading>An institution</heading>
  </xsl:template>

</xsl:stylesheet>
```

- Tags not in the XSLT namespace are also added to the results
- The style sheet must remain well formed.

Including information from the input document

- See *example4.xslt*:

```
<?xml version="1.0"?>

<xsl:stylesheet
  xmlns:xsl="http://www.w3.org/1999/XSL/Transform"
  version="1.0">

  <xsl:template match="institution">
    <heading>
      <xsl:value-of select="name"/>
    </heading>
  </xsl:template>

</xsl:stylesheet>
```

- **`xsl:value-of`** add a value to the results
- What to add is identified by the "select" attribute
- The value of an element is its text content after all the tags have been removed.

Controlling processing order

- See *example5.xslt*:

```
<xsl:template match="institutions">
  <heading>Here are a list of website URLs</heading>
  <xsl:apply-templates select="institution"/>
  <footing>Information provided by webmaster</footing
</xsl:template>

<xsl:template match="institution">
  <xsl:apply-templates select="website"/>
</xsl:template>

<xsl:template match="website">
  <site>
    <xsl:value-of select="url"/>
  </site>
</xsl:template>
```

- **`xsl:apply-templates`** lets you choose when particular elements will be processed.

The rest of XSLT

- There is much more to XSLT than we've covered here, including
  - Modes
  - Named templates
  - Numbering and sorting output elements
  - Conditional processing
  - Iteration
  - Extension elements.

XSLT: Summary so far

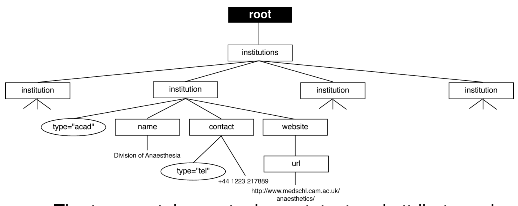
- XSLT transforms one XML document into another
- It does so using templates that are triggered by patterns in the input document
- Within templates, text and non-xslt elements are copied to the output document
- **`<xsl:value-of>`** can insert the string value of an element into the output
- **`<xsl:apply-templates>`** controls the processing order.

XPath

XPath

- XSLT needs a general way to identify parts of the input document
- Enter XPath, a non-XML language to identify parts of an XML document
- Used in XSLT **`match=`** and **`select=`** attributes
- In **`<xsl:template match="institution">`**, "institution" is an XPath expression, referring to elements of type "institution"
- XPATH is also used in XPointer, XML Schema, XForms, etc.

XPath's view of the world



- The tree contains root, element, text and attribute nodes
- .. .also comment, processing-instruction, and namespace nodes (but that's not important right now)
- Root node is not the same as the root element.

Location paths

- Identify a set of 'nodes' in a document
- Operate relative to a 'context node' (c.f current directory)
- Simplest is a single element name

```
<xsl:apply-templates select="contact">
```

- "/" matches the root node

```
<xsl:apply-templates select="/">
```

- Attribute nodes can be selected using a "@" and the attribute name

```
<xsl:value-of select="@type">
```

- Text nodes can be selected using **`text()`**

```
<xsl:value-of select="text()">
```

- All of these can be chained together

```
<xsl:value-of select="website/url">
```

More paths

- Wildcards:
  - * - all element node
  - @* - all attribute nodes
  - node() - all nodes

```
institution/*/website
```

- Paths can specify alternatives with '|'

```
contact | website
```

- '.' represents current node
- '..' represents the current node's parent

```
../../name
```

- A leading '/' makes a path absolute
- '//' selects from all descendants

```
/institutions//url
```

Predicates

- An XPath expression commonly selects more than one node
- Sometimes you don't want all of them
- Each step in a location path can have a condition attached
- This is called a *predicate*
- The predicate contains a boolean expression

```
//contact[@method="tel"]
//institution[@type="acad"]/contact[@method="tel"]
```

Unabbreviated Location Paths

- So far we've been using abbreviated location paths
- There is an unabbreviated form that's even more powerful
- For example **`child::institution/attribute::type`** is the same as **`institution/@type`**
- Abbreviated paths allow you to navigate along the folowing
  - child and parent
  - self
  - attribute
  - descendant-or-self
- The unabbreviated form additionally lets you navigate
  - ancestor
  - following and preceding
  - following-sibling and preceding-sibling
  - namespace
  - descendant
  - ancestor-or-self.

Other sorts of XPath expression

- So far we've looked only at location paths
- These return *node-sets* which identify a set of nodes in a document
- XPath expressions can also represent numbers, strings, and booleans
- Most types convert as you might expect, for example an empty node-set is 'false' when used as a boolean
- XPATH also provides useful built-in functions, for example
  - **`position()`** returns the position of the current node in the node-set being processed
  - **`round()`** rounds a number to the nearest integer
  - **`concat()`** joins strings
  - ..etc.

XSLT reprise - default rules

- XSLT processors start by trying to process the root node
- If nothing else matches they apply some default template rules
- For element and root nodes:

```
<xsl:template match="*|/">
  <xsl:apply-templates/>
</xsl:template>
```

- For text and attribute nodes:

```
<xsl:template match="text()|@*">
  <xsl:value-of select".">
</xsl:template>
```

- Taken together, this means that all element nodes will be visited and the text from each added to the results
- While there is a default rule for attribute nodes, none of the default rules cause attributes to be processed.

XPath: Summary

- A language to identify parts of an XML document
- Used by XPATH and other XML technologies
- Needs it's own tree view of the data
- *Location paths* select nodes from the tree
- There are abbreviated and unabbreviated forms of location paths
- *Predicates* can filter node sets
- XPath expressions can also return numbers, strings, and booleans
- XPath includes a number of useful functions.

Programing with XML

Programing with XML

- While XML may be human readable, humans shouldn't *have* to read it
- So we want programs to do so
- Two approaches, exemplified by two standardised APIs
  - DOM (the Document Object Model)
  - SAX (the Simple API for XML)
- Implementations of both are available for Java, Perl, Python, C, etc., etc.

DOM

- Originally developed for working on HTML and XML in a browser context
- Involves parsing an entire document into an interlinked set of objects and traversing the resulting tree
- Successive versions defined as 'levels'
- Most recent is Level 3
- Defined in OS- and language-independent form, translated to concrete implementation in the various languages
- Upside being the ability to easily traverse the tree, add and delete parts, etc.
- Downside is the need to parse and store the entire document in memory
- See *dom.pl.*

SAX

- Originally defined for Java API, but subsequently ported
- An event-based API for reading XML
- Normal implementation involves a parser that invokes a user-supplied function for each event
- Upside:
  - Don't need to hold the entire tree in memory
  - Incremental processing possible
- Downside:
  - Can be harder to program
  - Need to maintain your own data structures to keep track of tree position, result data, etc.
- Note that many DOM implementations use a SAX parser to build the DOM tree
- See *sax.pl*.

XML Programming: Summary

- While human readable, XML is really for programs
- There are two main approaches
  - Tree-based, as exemplified by the DOM
  - Event based,as exemplified by SAX.

Some other core XML technologies

XSL Formatting Objects (XSL-FO)

- An XML application for describing the layout of text on a page
- Normally created as the target of an XSLT transformation
- See *example7.xslt*
- This can be hard, but that's because laying out pages is hard
- Needs a processor to convert XSL-FO to print
- Most free ones seem to be poor
- Examples include
  - The Apache project's FOP
  - Sebastian Rahtz's PassiveTeX.

XML Schema

- DTD's are traditionally used when defining XML schemas
- But they are limited in what they can do
- and are not themselves expressed in XML
- *XML Schema*, a W3C recommendation, attempts to address this
- Can describe complex restrictions on elements and attributes
- Understands namespaces
- Multiple XML Schemas can be combined
- There are yet more schema languages, such as RELAX NG and Schematron.

XLinks

- An attribute-based syntax for attaching links to XML documents
- Like HTML's **<a>** tag on steroids
  - Unidirectional
  - Bidirectional
  - Multidirectional

```
<book xmlns:xlink="http://www.w3.org/1999/xlink"
   xlink:type="simple"
   xlink:href=
    "http://ftp.archive.org/etext/etext93/wizoz10.txt">
```

XPointer

- A non-XML syntax for identifying locations inside XML documents
- Intended to be used as a fragment identifier in a URL
- Leverages XPath

```
http://www.example.org/
          inst.dtd#xpointer(//institution[1])
```

Other stuff

- XInclude - technology for combining XML documents
- XForms - reformulation and extension of HTML forms
- ... and many more.

Example XML applications

Narrative

- Text Encoding Initiate (TEI)
- DocBook
- OpenOffice
- XHTML
  - Can be created as the output from an XSLT transformation - for example see *example6.xslt*
  - Even on-the-fly by modern browsers
  - Can also be styled using CSS - see *example1.css*.

Data-oriented

- SVG - scalable vector graphics
- RSS and Atom - content summary
- Jabber - Instant Messaging carried by XML
- Web services - XML-RPC, SOAP carrying information over XML.

Where to go from here?

- Choose what interests you
- Remember it's a *huge* field
- Explore the available resources
  - in print
  - in the standards and recommendations
  - elsewhere on the web.

That's All Folks

If you have been, thanks for listening