INFO/CS 4302
Web Information Systems

FT 2012

Week 5: Web Architecture: Structured Formats – Part 3 (XML Manipulations)

(Lecture 8)

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RECAP

XML & Related Technologies overview

Purpose	Structured content	Define Document Structure	Access Document Items	Transform Document
	XML	**XML Schema**	**XPath**	**XSLT**
	JSON	**RELAX NG**	**DOM**	
	YAML	DTD		

XML Meta Documents

- Express constraints on an xml document:
  - What element names and attributes to use
  - How often an element may occur
  - How elements are nested (complex elements)
  - What values attributes may have
  - What content elements may have… etc.
- Examples:
  - DTD (Document Type Definition developed for SGML)
  - XML Schema
  - RELAX NG

XML Schema & RELAX NG

- XML Schema
  - W3C recommendation
  - Powerful & complex (3-part recommendation)
- RELAX NG
  - Tree constraint language written in XML (with additional compact notation)
  - Integrate well with data type libraries (such as from XML Schema)
  - Supports namespaces
  - For many purposes equivalent to XML Schema

RECAP: XPath

- Context Node (starting point)
  - current node in XML document that is basis of path evaluation
  - Default: root element (which is the 'document')
- Location steps (selection of node sets)
  - Sequence of node specifications
  - Evaluation of each node specification creates a new context (within the previous context)
  - Like file paths
- Predicates: used to define a node with a specific value (i.e. to restrict the node set returned)
- Axes: define directions of movement of a step relative to current node
- Location path expressions can consist of several steps:
  - A step: axisname::nodetest[predicate]
  - As a default, child axis is used; hence when axis name missing, assume child of the node named in the node test part of the expression
  - child::actor/child::name[@gender="female"]

    → actor/name[@gender="female"]
- Result is node, set of nodes, subtree, set of subtrees

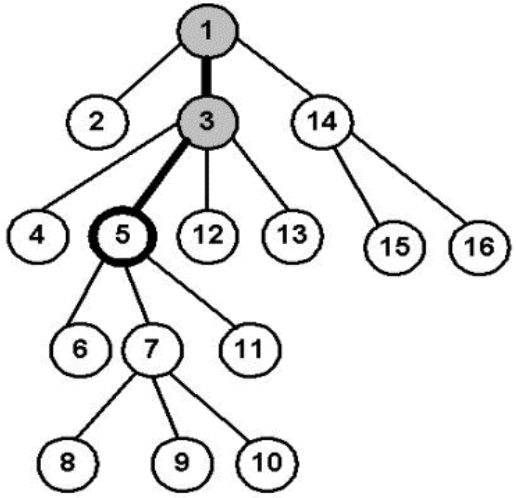
RECAP: XPath

- Like regular expressions for text, XPath finds specific portions within an XML document tree

axisname::nodetest[predicate]

AxisNames:

1. ancestor
2. ancestor-or-self
3. attribute
4. child
5. descendant
6. descendant-or-self
7. following
8. following-sibling
9. namespace
10. parent
11. preceding
12. preceding-sibling
13. self



AxisNames:

1. ancestor
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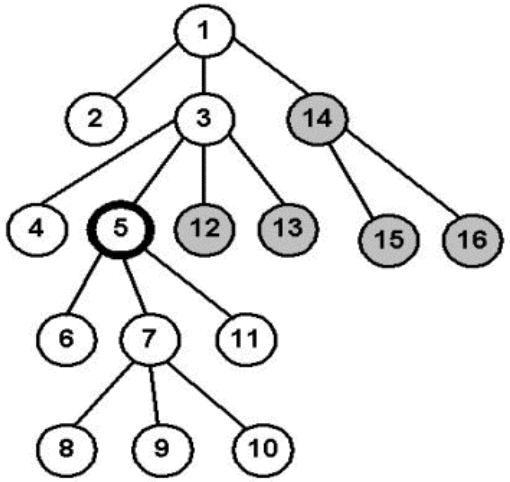
8. following-sibling
9. namespace
10. parent
11. preceding
12. preceding-sibling
13. self



Eric Wilde (2006) http://dret.net/lectures/xml-fall06/xpath

Xpath Expressions

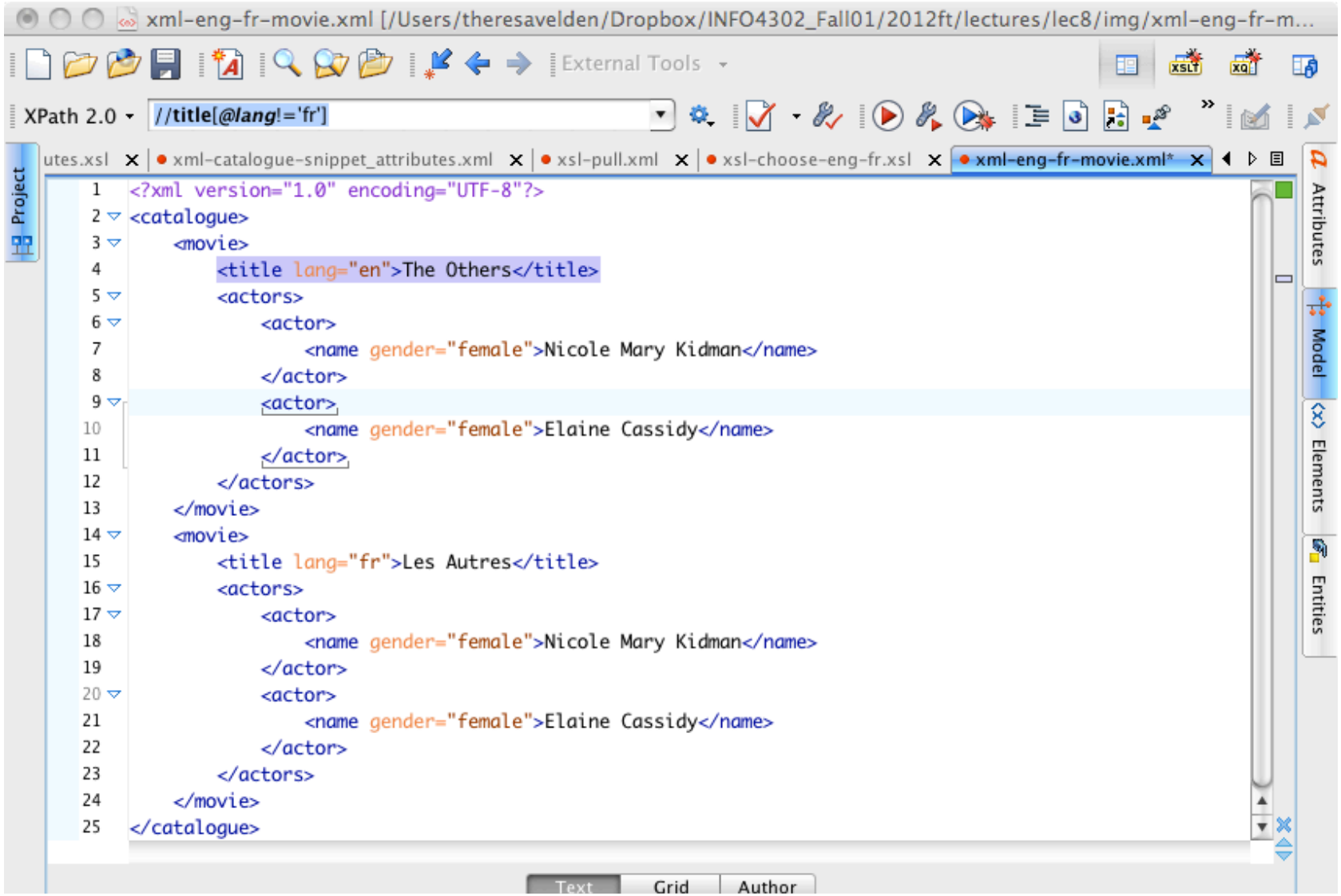
/catalogue/movie/actors/child::node()
/catalogue/movie/actors/child::text()
/catalogue/movie/actors/node()
/catalogue/movie/actors/text()

/catalogue/movie/child::*/child::actor
/catalogue/movie/child::*/child::node()

```xml
<?xml version="1.0" encoding="UTF-8"?>
<catalogue>
    <movie>
        <title lang="en">The Others</title>
        <actors>
            <actor>
                <name gender="female">Nicole Mary Kidman</name>
            </actor>
            <actor>
                <name gender="female">Elaine Cassidy</name>
            </actor>
        </actors>
    </movie>
    <movie>
        <title lang="fr">Les Autres</title>
        <actors>
            <actor>
                <name gender="female">Nicole Mary Kidman</name>
            </actor>
            <actor>
                <name gender="female">Elaine Cassidy</name>
            </actor>
        </actors>
    </movie>
</catalogue>
```

XPath expressions

- Demo XPath in oxygen



XPath expressions

Additional XPath Resource:

Article by Tobias Schlitt and Jacob Westhoff

html: http://schlitt.info/opensource/blog/0704_xpath.html#clarification-of-terms

pdf: http://westhoffswelt.de/data/portfolio/xpath.pdf

XSLT (XSL TRANSFORMATIONS)

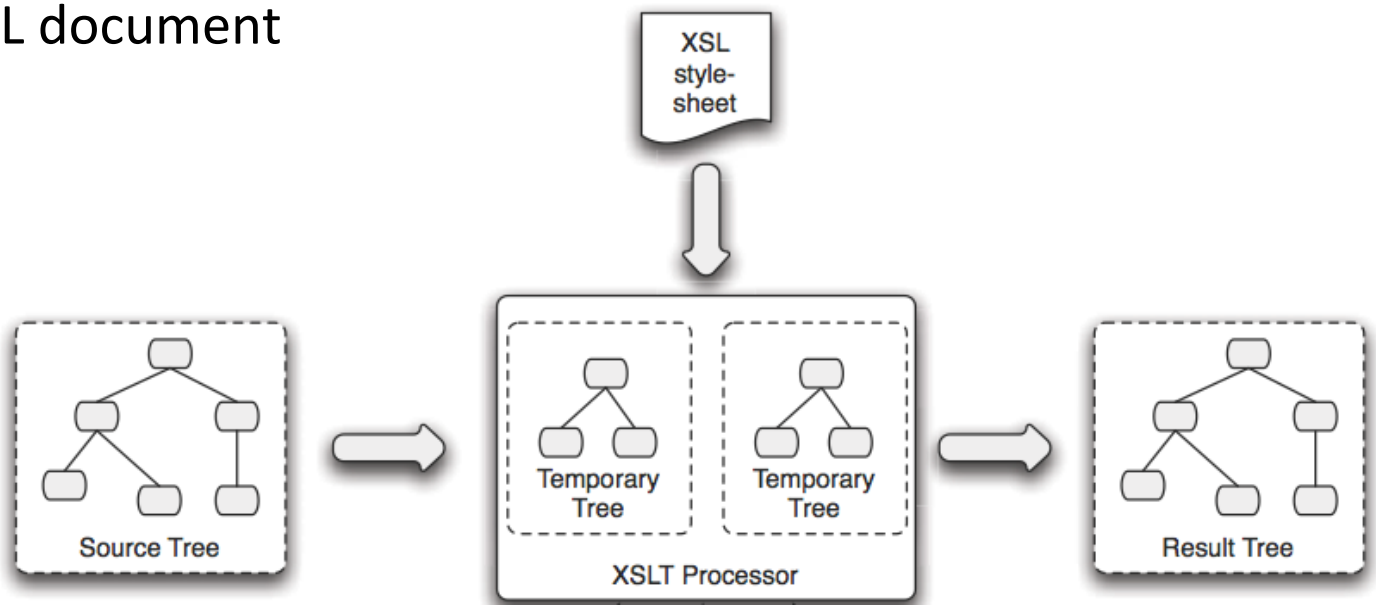
XSLT

Is an **XML oriented programming language**

- Uses XML as its syntax
- Uses XPath to select subsets of an XML document
- Weakly typed
- Not designed for large programming tasks
- **Standard language for XML-to-XML transformations**
- Is a functional programming language (hard to get used to for people trained in procedural languages)
  - Functions are first-class citizens, supports passing functions as arguments to other functions
  - Iteration usually done by recursion

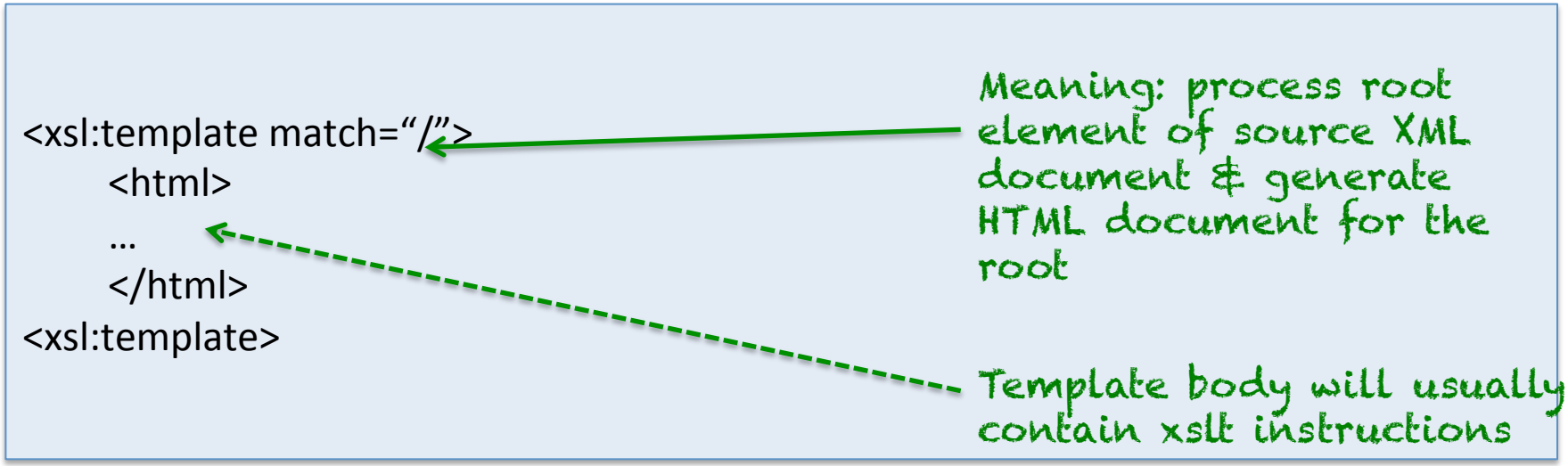
XSLT

- A transformation in the XSLT language is expressed in the form of an XSL stylesheet
  - root element: <xsl:stylesheet>
  - an xml document using the XSLT namespace, i.e. tags are in the namespace http://www.w3.org/1999/XSL/Transform
- The body is a set of templates or rules
  - The 'match' attribute specifies an XPath of elements in source tree
  - Body of template specifies contribution of source elements to result tree
- You need an XSLT processor to apply the style sheet to a source XML document



XSLT

- The transformation is achieved by a set of **template rules**
- A template rule associates a **pattern** with a **sequence constructor**
  - The pattern matches nodes in the source document "for nodes satisfying pattern X do this"
  - The resulting nodes and atomic values can be used to produce parts of a result tree



Simple Template

XSLT

```
<xsl:template match="/">
    <html>
    …
        <xsl:for-each select="actor/name">
            <h3>Name:</h3>
            <p><xsl:value-of select="."></p>
        <xsl:for-each>
    </html>
<xsl:template>
```

Process all name nodes that are children of actor nodes

- Output a h3 heading
- Generate a paragraph element
- Output the string value of the current node (i.e. the text content of the name element)

Template Body w XSLT instructions

XSLT

```
<xsl:template match="/">
    <html>
    …
        <xsl:for-each select="actor/name">
            <h3>Name:</h3>
            <p><xsl:value-of select="."></p>
        <xsl:for-each>
    </html>
<xsl:template>
```

XPath expressions!

```
<xsl:template match="/">
    <html>
    …
        <xsl:for-each select="actor/name[@gender="female"]">
            <h3>Name:</h3>
            <p><xsl:value-of select="."></p>
        <xsl:for-each>
    </html>
<xsl:template>
```

Extracts only the names of female actors

XSLT

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

Here root, but could be some other XPath expression!

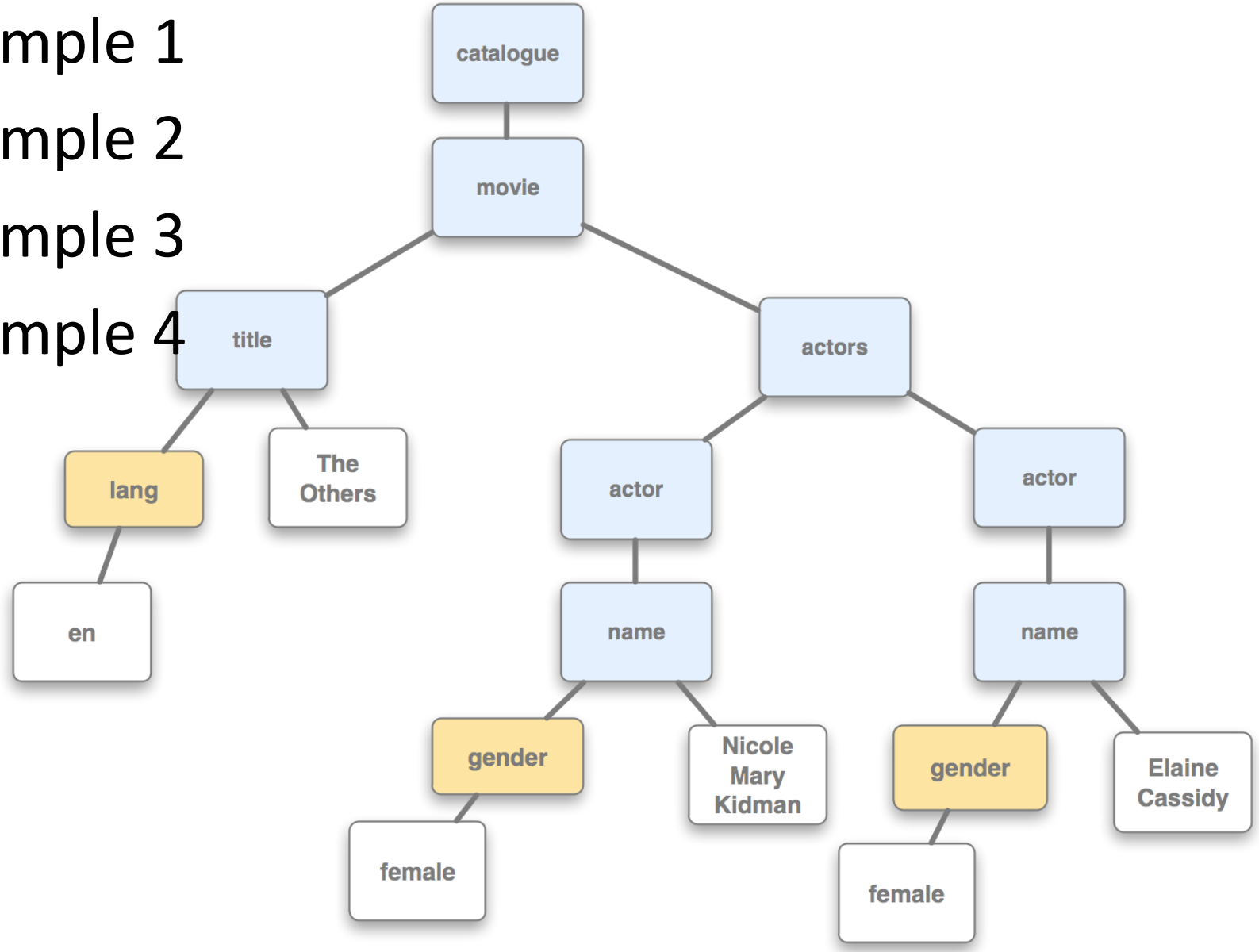
- Non-xsl element are literals
- Elements from xsl namespace are transform instructions
- match attribute value is XPath expression setting context for execution of body
- Sequential execution within template
- <xsl:apply-templates/>
  - Set context to next tree step (default: depth first)
  - Re-evaluate rules (recurse)

XSLT

- The transformation is achieved by a set of template rules
- A template rule associates a pattern, which matches nodes in the source document
- The output is part of a result tree
- Default behavior of an XSL stylesheet is tree traversal
  - The text of the 'document' it outputs is produced technically by concatenating all text nodes
  - By default XSLT traverses the entire document and copies all text nodes
  - Note: attributes are not children of element nodes! (think of them as properties of elements with a value)
- The output format can be specified
  - E.g. <xsl:output encoding="UTF-8" indent="yes" method="html" />
  - Default output is xml

XSLT – In-class Exercise

- Example 1
- Example 2
- Example 3
- Example 4



XSLT: Example 1 – Default Behavior

Example: Minimal XSL

```
<?xml version="1.0" encoding="UTF-8" ?>
<xsl:stylesheet version="1.0" xmlns:xsl="http://www.w3.org/1999/XSL/Transform">
</xsl:stylesheet>
```

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

<!-- catalogue_snippet.xml  Created: 2012-09-08 17:09 -->

<catalogue>
    <movie>
        <title lang="en">The Others</title>
        <actors>
            <actor>
                <name gender="female">Nicole Mary Kidman</name>
            </actor>
            <actor>
                <name gender="female">Elaine Cassidy</name>
            </actor>
        </actors>
    </movie>
</catalogue>
```

Simple XML Source Document incl. elements and element attributes

XSLT: Example 1 – Default Behavior

- The text of the ‘document’ it outputs is produced technically by concatenating all text nodes
- By default XSLT traverses the entire document and copies all text nodes
- It works its way through the document recursively

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

    The Others



        Nicole Mary Kidman



        Elaine Cassidy
```

XML Result Document

simple text content

XSLT: Example 2

```
▼<xsl:stylesheet xmlns:xsl="http://www.w3.org/1999/XSL/Transform" version="1.0">
   <xsl:output method="text"/>
  ▼<xsl:template match="*">
     <xsl:text>( Element:</xsl:text>
     <xsl:value-of select="local-name()"/>
     <xsl:apply-templates select="* | @*"/>
     <xsl:text>)</xsl:text>
   </xsl:template>
  ▼<xsl:template match="@*">
     <xsl:text>Attribute:</xsl:text>
     <xsl:value-of select="local-name()"/>
   </xsl:template>
 </xsl:stylesheet>
```

[optional] defines output format (default is xml)

Not necessarily needed to generate text in output; can be useful to control line breaks and white space

XSLT: Example 2

```xml
<xsl:stylesheet xmlns:xsl="http://www.w3.org/1999/XSL/Transform" version="1.0">
  <xsl:output method="text"/>
  <xsl:template match="*">
    <xsl:text>( Element:</xsl:text>
    <xsl:value-of select="local-name()"/>
    <xsl:apply-templates select="* | @*"/>
    <xsl:text>)</xsl:text>
  </xsl:template>
  <xsl:template match="@*">
    <xsl:text>Attribute:</xsl:text>
    <xsl:value-of select="local-name()"/>
  </xsl:template>
</xsl:stylesheet>
```

XSL Stylesheet

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

<!-- catalogue_snippet.xml  Created: 2012-09-08 17:09 --

<catalogue>
    <movie>
        <title lang="en">The Others</title>
        <actors>
            <actor>
                <name gender="female">Nicole Mary Kidman</name>
            </actor>
            <actor>
                <name gender="female">Elaine Cassidy</name>
            </actor>
        </actors>
    </movie>
</catalogue>
```

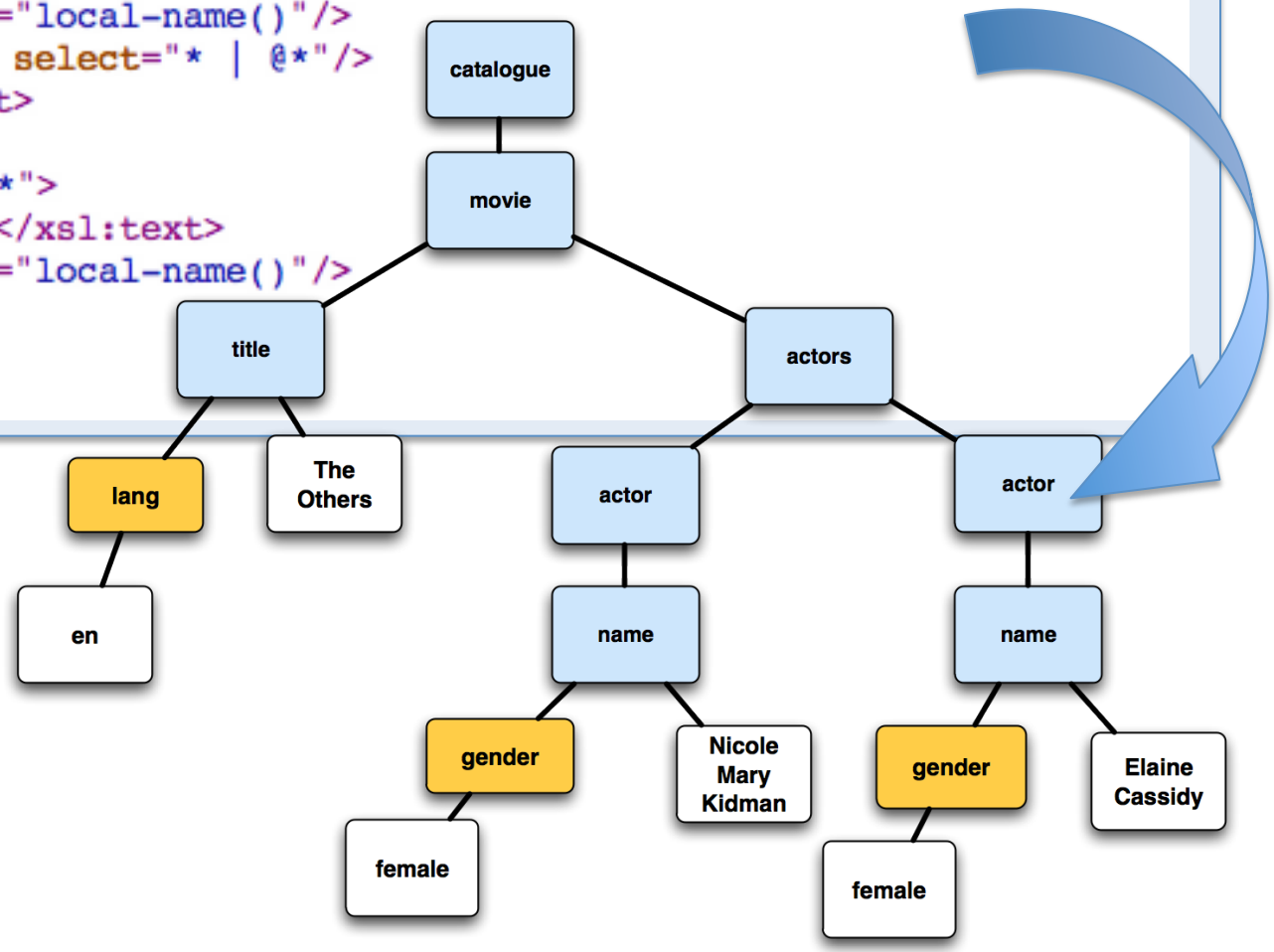
XML Source Document

Result?

XSLT: Example 2

```
<xsl:stylesheet xmlns:xsl="http://www.w3.org/1999/XSL/Transform" version="1.0">
  <xsl:output method="text"/>
  <xsl:template match="*">
    <xsl:text>( Element:</xsl:text>
    <xsl:value-of select="local-name()"/>
    <xsl:apply-templates select="* | @*"/>
    <xsl:text>)</xsl:text>
  </xsl:template>
  <xsl:template match="@*">
    <xsl:text>Attribute:</xsl:text>
    <xsl:value-of select="local-name()"/>
  </xsl:template>
</xsl:stylesheet>
```

XSL Stylesheet



XML Source Document

Result?

XSLT: Example 2

(Element:catalogue(Element:movie
(Element:titleAttribute:lang)(Element:actors
(Element:actor(Element:nameAttribute:gender))
(Element:actor(Element:nameAttribute:gender)))))

XML Result Document
simple text content

Examples 3 + 4

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

<!-- catalogue_simple.xml  Created: 2012-09-08 17:09 -->

<catalogue>
  <movie>
    <title>The Others</title>
    <actors>
      <actor>
        <name>Nicole Mary Kidman</name>
      </actor>
      <actor>
        <name>Elaine Cassidy</name>
      </actor>
      <actor>
        <name>Christopher Eccleston</name>
      </actor>
      <actor>
        <name>Alakina Mann</name>
      </actor>
      <actor>
        <name>Eric Sykes</name>
      </actor>
      <actor>
        <name>Fionnula Flanagan</name>
      </actor>
```

Simple XML Source Document:

Catalogue of movies (title > text) and actors in those movies (name > text)

XSLT: Example 3 (Pull Model)

Pull Model = all patterns are pulled into the root template

```
<?xml version="1.0" encoding="UTF-8"?>
<xsl:stylesheet version="1.0" xmlns:xsl="http://www.w3.org/1999/XSL/Transform">

    <xsl:output encoding="UTF-8" indent="yes" method="html" />

    <xsl:template match="/">
        <html>
            <body>
                <h2>Movies</h2>
                <xsl:for-each select="/catalogue/movie">
                    <xsl:for-each select="title">
                        <h4><xsl:value-of select="."/></h4>
                    </xsl:for-each>
                </xsl:for-each>
            </body>
        </html>
    </xsl:template>

</xsl:stylesheet>
```

root element processing

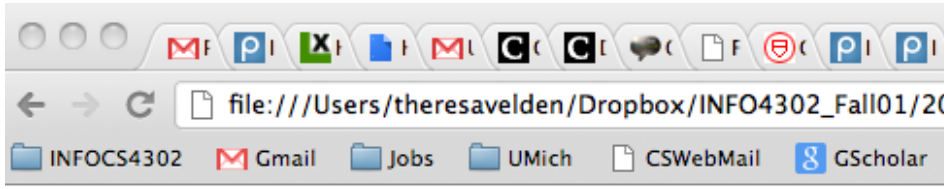
non-xslt elements are literal result elements (may contain xslt or other literal result elements)

XSLT: Example 3 (Pull Model)

Pull Model = all patterns are pulled into the root template

```
<html>
  <body>
    <h2>Movies</h2>

    <h4>The Others</h4>

    <h4>The Sea Inside</h4>

    <h4>Waiting for the Hearse</h4>

    <h4>The Animatrix</h4>

    <h4>My Darling Clementine</h4>

  </body>
</html>
```

HTML Result Document



Movies

The Others

The Sea Inside

Waiting for the Hearse

The Animatrix

My Darling Clementine

Operación Ogro

Repas de bébé

Vicky Cristina Barcelona

The Godfather Part II

The Spiderwick Chronicles

Day of the Fight

The Son's Room

XSLT: Example 4 (Push Model)

Push Model = template pushes nodes out to be handled by other templates

Processing of root node

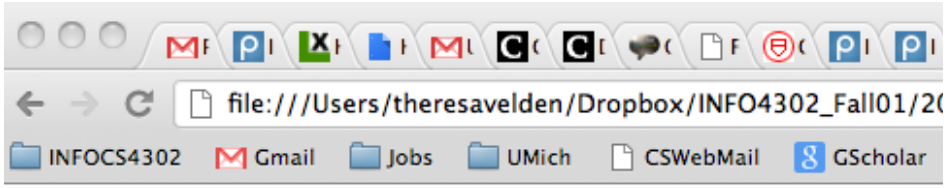
```
1
2   <?xml version="1.0" encoding="UTF-8"?>
3   <xsl:stylesheet version="1.0"
4       xmlns:xsl="http://www.w3.org/1999/XSL/Transform">
5
6       <xsl:output encoding="UTF-8" indent="yes" method="html" />
7
8   <xsl:template match="/">
9   <html>
10      <body>
11          <h2>Movies</h2>
12          <xsl:apply-templates/>
13      </body>
14  </html>
15  </xsl:template>
16
17  <xsl:template match="movie">
18      <xsl:apply-templates select="title"/>
19  </xsl:template>
20
21  <xsl:template match="title">
22      <h4><xsl:value-of select="."/></h4>
23  </xsl:template>
24
25  </xsl:stylesheet>
```

Look for other templates starting from current context (already handled)

XSLT: Example 4 Output

```
<html>
  <body>
    <h2>Movies</h2>

    <h4>The Others</h4>

    <h4>The Sea Inside</h4>

    <h4>Waiting for the Hearse</h4>

    <h4>The Animatrix</h4>

    <h4>My Darling Clementine</h4>

  </body>
</html>
```

HTML Result Document



Movies

The Others

The Sea Inside

Waiting for the Hearse

The Animatrix

My Darling Clementine

Operación Ogro

Repas de bébé

Vicky Cristina Barcelona

The Godfather Part II

The Spiderwick Chronicles

Day of the Fight

The Son's Room

The Green Mile

XSLT: ‘Pull Model’ vs ‘Push Model’

- One-template XSLT (Pull Model) is an easier way to get started
- For easy matching tasks pattern is sufficient
- However, for complex tasks this is the XSLT equivalent of ‘spaghetti code’
- In homework on XSLT you will be asked to apply several templates and practice avoiding spaghetti code

(Some) XSLT elements/XSLT instructions

XSLT Element	Description
`xsl:apply-templates`	Finds correct template to apply
`xsl:template`	Defines a template
`xsl:element`	Generates an element
`xsl:attribute`	Generates attribute node
`xsl:value-of`	Evaluates *select* and outputs value
`xsl:text`	Generates text literaly
`xsl:copy` and `xsl:copy-of`	Shallow/deep copy of a node
`xsl:choose`	Conditional testing
`xsl:for-each`	Cycle based on test
`xsl:if`	Conditional test
`xsl:sort`	Sort the elements

Source: W3C http://www.w3.org/Consortium/Offices/Presentations/XSLT_XPATH/#(19)

XSLT: Conditional Instructions

- Programming languages typically provide 'if-then, else' constructs
- XSLT provides
  - If-then: **<xsl:if>**
  - If-then-(elif-then)*-else: **<xsl:choose>**

XML Source Document

```xml
<?xml version="1.0" encoding="UTF-8"?>
<catalogue>
    <movie>
        <title lang="en">The Others</title>
        <actors>
            <actor>
                <name gender="female">Nicole Mary Kidman</name>
            </actor>
            <actor>
                <name gender="female">Elaine Cassidy</name>
            </actor>
        </actors>
    </movie>
    <movie>
        <title lang="fr">Les Autres</title>
        <actors>
            <actor>
                <name gender="female">Nicole Mary Kidman</name>
            </actor>
            <actor>
                <name gender="female">Elaine Cassidy</name>
            </actor>
        </actors>
    </movie>
</catalogue>
```

xsl:if

```
<?xml version="1.0" encoding="UTF-8"?>
<xsl:stylesheet version="1.0" xmlns:xsl="http://www.w3.org/1999/XSL/Transform">

    <xsl:output encoding="UTF-8" indent="yes" method="html" />

    <xsl:template match="/">
        <html>
            <body>
                <h2>Movies</h2>
                <xsl:for-each select="catalogue/movie/title">
                        <xsl:if test="@lang='en'">
                            <h4><xsl:value-of select="."/> (English title)</h4>
                        </xsl:if>
                </xsl:for-each>
            </body>
        </html>
    </xsl:template>

</xsl:stylesheet>
```

xsl:if

```
<html>
  <body>
    <h2>Movies</h2>
    <h4>The Others (English title)</h4>
  </body>
</html>
```

HTML Result Document

xsl:choose

```
<?xml version="1.0" encoding="UTF-8"?>
<xsl:stylesheet version="1.0" xmlns:xsl="http://www.w3.org/1999/XSL/Transform">

    <xsl:output encoding="UTF-8" indent="yes" method="html" />

    <xsl:template match="/">
        <html>
            <body>
                <h2>Movies</h2>
                <xsl:for-each select="catalogue/movie/title">
                        <xsl:choose>
                            <xsl:when test="@lang='en'">
                                <h4><xsl:value-of select="."/> (English title)</h4>
                            </xsl:when>
                            <xsl:when test="@lang='fr'">
                                <h4><xsl:value-of select="."/> (French title)</h4>
                            </xsl:when>
                        </xsl:choose>
                </xsl:for-each>
            </body>
        </html>
    </xsl:template>

</xsl:stylesheet>
```

xsl:choose

```
<html>
  <body>
    <h2>Movies</h2>
    <h4>The Others (English title)</h4>
    <h4>Les Autres (French title)</h4>
  </body>
</html>
```

HTML Result Document

xsl:choose

```
<?xml version="1.0" encoding="UTF-8"?>
<xsl:stylesheet version="1.0" xmlns:xsl="http://www.w3.org/1999/XSL/Transform">

    <xsl:output encoding="UTF-8" indent="yes" method="html" />

    <xsl:template match="/">
        <html>
            <body>
                <h2>Movies</h2>
                <xsl:for-each select="catalogue/movie/title">
                        <xsl:choose>
                            <xsl:when test="@lang='en'">
                                <h4><xsl:value-of select="."/> (<xsl:value-of select="@lang"/>.)</h4>
                            </xsl:when>
                            <xsl:when test="@lang='fr'">
                                <h4><xsl:value-of select="."/> (<xsl:value-of select="@lang"/>.)</h4>
                            </xsl:when>
                        </xsl:choose>
                </xsl:for-each>
            </body>
        </html>
    </xsl:template>

</xsl:stylesheet>
```

Xsl:choose

```
<html>
  <body>
    <h2>Movies</h2>
    <h4>The Others (en.)</h4>
    <h4>Les Autres (fr.)</h4>
  </body>
</html>
```

HTML Result Document

More on XSLT (& XML):

- Lecture: 'XML Foundations' by Eric Wilde, School of Information, UC Berkeley Fall 2010

  http://dret.net/lectures/xml/

DOM (DOCUMENT OBJECT MODEL)

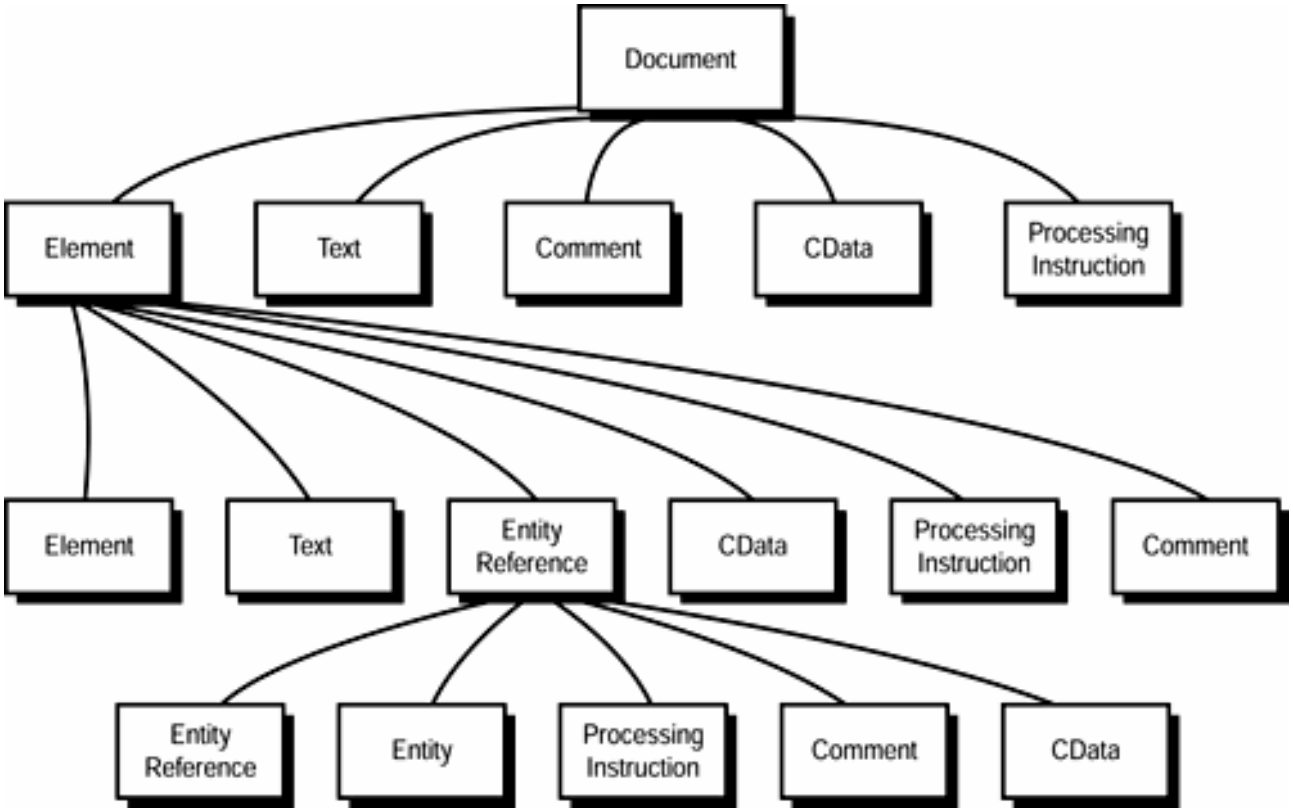
Well-formed XML Documents

- If an xml document is well-formed if it can be transformed deterministically (parsed) to a single infoset (DOM)

DOM – Document Object Model

- API for manipulating document tree
  - Language independent; implemented in lots of languages
  - Suitable for XML and other document formats
  - Core notion of a **node**
- **W3C Specifications**
  - **Level 1:** functionality and navigation within a document
  - **Level 2**: modules and options for specific content models (XML, HTML, CSS)
  - **Level 3**: further content model facilities (e.g. XML validation handlers)

DOM (Core) Level 1



DOM tree constraints

- Root must be Document
- Root children: one node and optionally Processing Instructions, DocumentType, Comment, Text
- Children of element must be either element, comment or text
- Attributes are properties of elements (not their children), and are not member of the DOM tree
- Children of attribute must be text

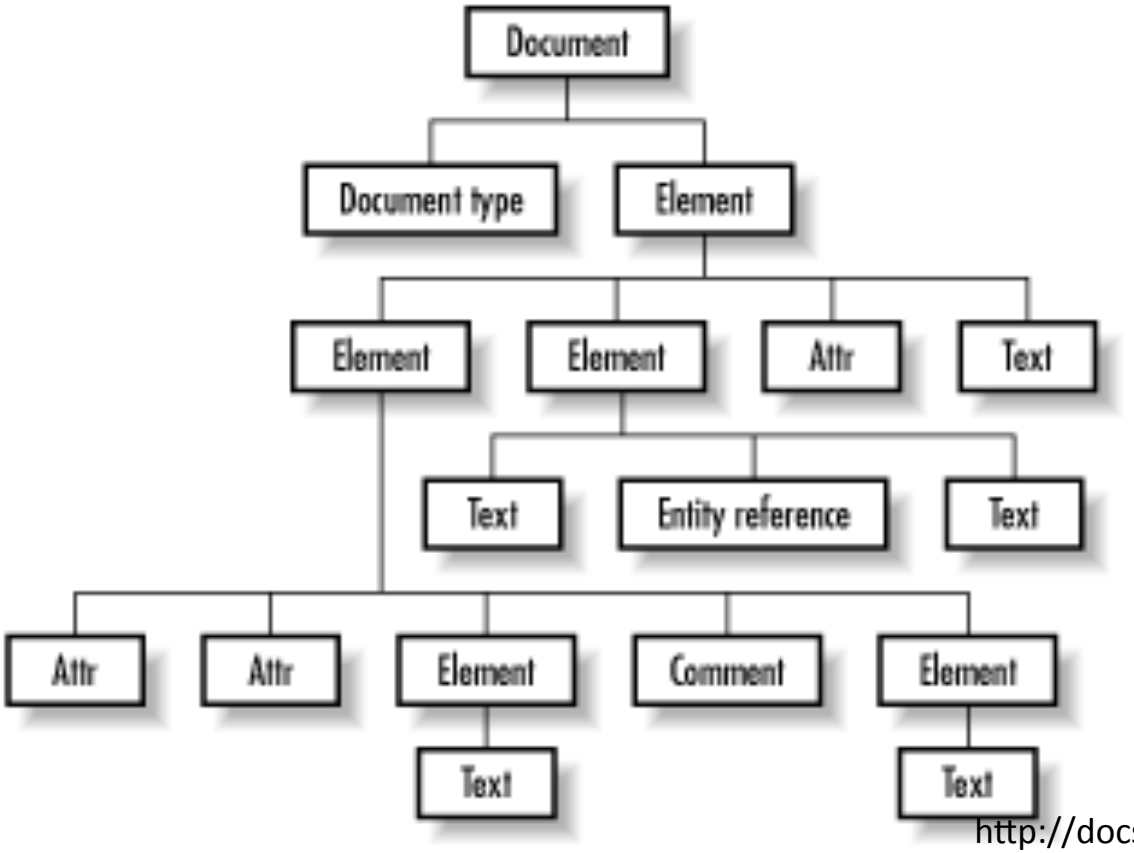
W3C DOM Node Types

Node type	Description	Children
Document	Represents the entire document (the root-node of the DOM tree)	Element (max. one), ProcessingInstruction, Comment, DocumentType
DocumentFragment	Represents a "lightweight" Document object, which can hold a portion of a document	Element, ProcessingInstruction, Comment, Text, CDATASection, EntityReference
DocumentType	Provides an interface to the entities defined for the document	None
ProcessingInstruction	Represents a processing instruction	None
EntityReference	Represents an entity reference	Element, ProcessingInstruction, Comment, Text, CDATASection, EntityReference
Element	Represents an element	Element, Text, Comment, ProcessingInstruction, CDATASection, EntityReference
Attr	Represents an attribute	Text, EntityReference
Text	Represents textual content in an element or attribute	None
CDATASection	Represents a CDATA section in a	None

		CDATASection, EntityReference
DocumentType	Provides an interface to the entities defined for the document	None
ProcessingInstruction	Represents a processing instruction	None
EntityReference	Represents an entity reference	Element, ProcessingInstruction, Comment, Text, CDATASection, EntityReference
Element	Represents an element	Element, Text, Comment, ProcessingInstruction, CDATASection, EntityReference
Attr	Represents an attribute	Text, EntityReference
Text	Represents textual content in an element or attribute	None
CDATASection	Represents a CDATA section in a document (text that will NOT be parsed by a parser)	None
Comment	Represents a comment	None
Entity	Represents an entity	Element, ProcessingInstruction, Comment, Text, CDATASection, EntityReference
Notation	Represents a notation declared in the DTD	None

Parsing XML Document Model (DOM)

- Using DOM for a programming language requires definition of interfaces and classes ("language bindings" provide API)
- Complete in-memory representation of entire tree



http://docstore.mik.ua/orelly/xml/jxml/ch05_01.htm

Parsing XML

- Alternative to DOM: SAX (open source software)
  - Event driven, sequential
  - Mostly hierarchical, no' sibling' concept
  - More memory efficient
  - Good for quick, less intensive parsing that does not require easy-to-use, clean interface

http://docstore.mik.ua/orelly/xml/jxml/ch05_01.htm

Thursday

- Course Projects: Question & Answer Session
- Structured Formats – Part 4: JSON / YAML