

# XML and Semantic Web Technologies

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Course on XML and Semantic Web Technologies, summer term 2012

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XML and Semantic Web Technologies

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## 1. What is XML?

## 2. What is the Semantic Web?

## 3. Overview

## 4. Organizational stuff

XML is ...

- ... the extensible markup language.
- ... facilitates the separation of content from presentation.
- ... (from a perspective of HTML) allowing the definition of own tags.
- ... (from a perspective of SGML) a subset of SGML.
- ... a W3C recommendation since 1998.

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## XML and Semantic Web Technologies / 1. What is XML?



### XML allows the definition of own tags

```

1 <html>
2 <head><link rel="stylesheet" href="books.css"
3   type="text/css"></head>
4 <body>
5 <p>
6   <span class="author">Shelly Powers</span>:
7   <span class="title">Practical RDF</span>, 2003.
8 </p>
9   <span class="author">Eric T. Ray</span>:
10  <span class="title">Learning XML</span>, 2003.
11 </body>
12 </html>

```

Figure 1: Markup of elements in HTML with class attribute.

```

1 <page>
2 <p>
3   <author>Shelly Powers</author>:
4   <title>Practical RDF</title>, 2003.</p>
5 <p>
6   <author>Eric T. Ray</author>:
7   <title>Learning XML</title>, 2003.</p>
8 </page>

```

Figure 2: Markup of elements in XML with custom tags.

```

1 .author { color: red; }
2 .title { font-style: italic; }

```

Figure 3: CSS stylesheet to render HTML document.



Figure 4: Rendered HTML document.

## Markup

Markup is text that is added to the data of a document in order to convey information about it.

I would not sell Attila for  
\$1,000,000, says John.

Figure 5: Sample document.

a) `<sentence><subclause><subject>I  
</subject> <predicate>would not sell  
</predicate> <object>Attila</object> for  
$1,000,000</subclause>,  
<predicate>says</predicate>  
<subject>John</subject>.</sentence>`

b) `\person[ref="John"]{I} would not sell  
\dog{Attila} for $1,000,000, says  
\person{John}.`

c) `<i><b>I</b> would not sell Attila for  
$1,000,000,</i> says John.`

Figure 6: Different kinds of markup of a text:  
a) markup of syntactic structures (XML syntax),  
b) markup of entities (L<sup>A</sup>T<sub>E</sub>X syntax),  
c) markup of rendering attributes (XML syntax).

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## XML and Semantic Web Technologies / 1. What is XML?

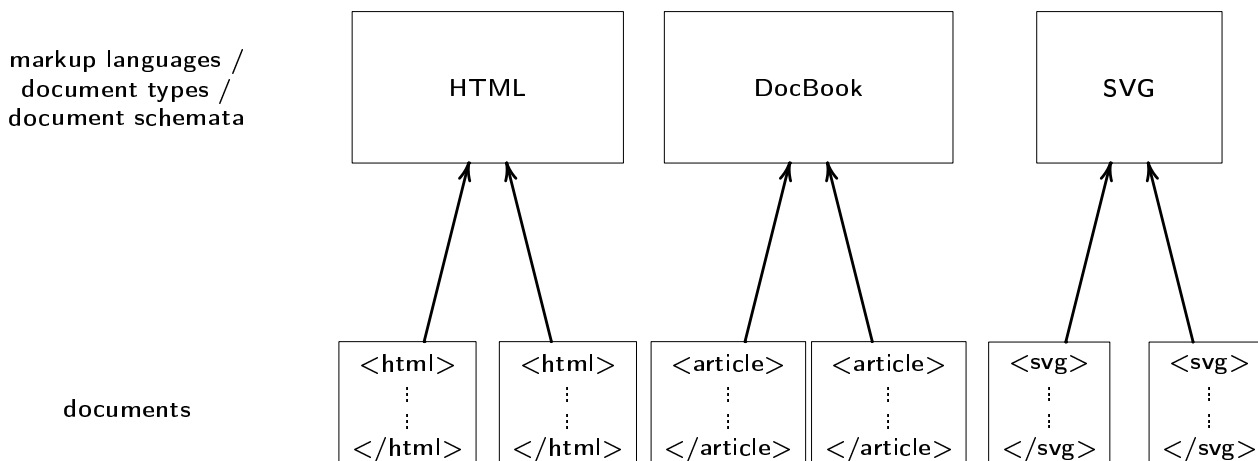


Figure 7: Documents can be described by markup languages.

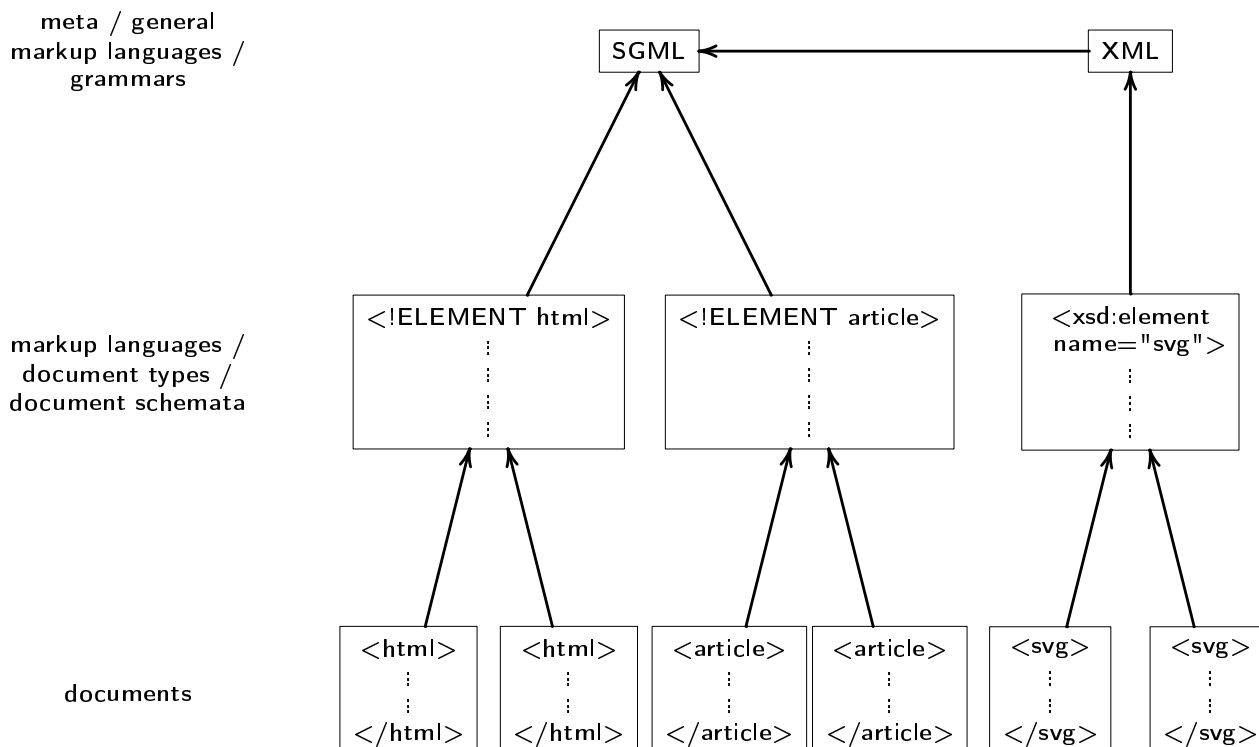


Figure 8: Markup languages can be described by meta markup languages.

## From a Historical Perspective [Cou02]

**1967** Tunncliffe on **the separation of the information content of documents from their format** (invention of **generic coding**).

**late '60s** Rice on a universal catalog of parameterized 'editorial structure' tags.

**late '60s GenCode Project** (Scharpf, GCA).

**1969 Generalized Markup Language (GML;** Goldfarb, Mosher, Lorie; IBM).

**1978** Foundation of a committee on Information Processing by ANSI.

**1980** First draft, **1986** publication of SGML standard (ANSI/ISO).

**1990 HTML 1** (Berners-Lee, CERN).

**1994** Foundation of **World Wide Web Consortium (W3C)**.

**1995** HTML 2, **1997** HTML 3.2 recommendation (W3C).

**1996** First draft, **1998** publication of **XML** recommendation (W3C).

## XML Applications: XHTML

```

1 <!DOCTYPE HTML PUBLIC
2  "-//W3C//DTD HTML 4.01 Transitional//EN">
3 <html>
4 <head>
5   <title>Hello, world!</title>
6 </head>
7 <body>
8   <h1>Hello, world!</h1>
9   <p><a href=http://www.w3c.org>W3C</a>.
10  <p>Another paragraph.
11  <hr>
12 </body>
13 </html>

```

Figure 9: HTML document.

```

1 <?xml version="1.0"?>
2 <!DOCTYPE html PUBLIC
3  "-//W3C//DTD XHTML 1.0 Transitional//EN"
4  "http://www.w3.org/TR/xhtml1/DTD/xhtml1-transitional.dtd">
5 <html>
6 <head>
7   <title>Hello, world!</title>
8 </head>
9 <body>
10  <h1>Hello, world!</h1>
11  <p><a href="http://www.w3c.org">W3C</a>.</p>
12  <p>Another paragraph.</p>
13  <hr/>
14 </body>
15 </html>

```

Figure 10: Corresponding XHTML document.

## XML Applications: SVG

```

1 <?xml version="1.0"?>
2 <svg xmlns="http://www.w3.org/2000/svg">
3   <g style="fill-opacity:0.7; stroke:black; stroke-width:0.1cm;">
4     <circle cx="6cm" cy="2cm" r="100" style="fill:red;"
5           transform="translate(0,50)" />
6     <circle cx="6cm" cy="2cm" r="100" style="fill:blue;"
7           transform="translate(70,150)" />
8     <circle cx="6cm" cy="2cm" r="100" style="fill:green;"
9           transform="translate(-70,150)" />
10  </g>
11 </svg>
12

```

Figure 11: SVG sample document.

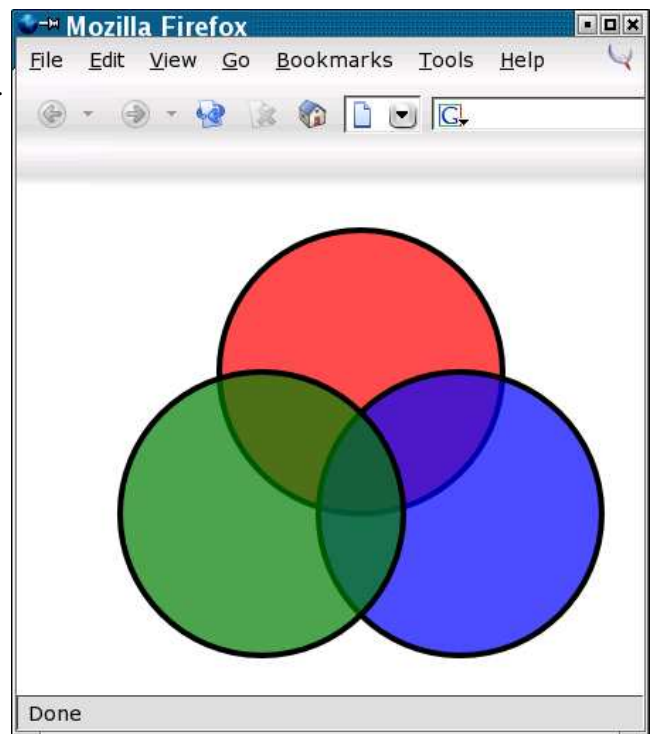


Figure 12: Rendered SVG sample document.

## XML Applications: XML User-Interface Language (XUL)

XUL is implemented in Mozilla and allows to build user interfaces from descriptions in XML documents.

```

1 <?xml version="1.0"?>
2 <?xml-stylesheet href="chrome://global/skin/" type="text/css"?>
3
4 <window id="example-window" title="xul-buttons"
5     xmlns:html="http://www.w3.org/1999/xhtml"
6     xmlns="http://www.mozilla.org/keymaster/gatekeeper/there.is.only.xul">
7   <button label="Normal"/>
8   <button label="Disabled" disabled="true"/>
9   <button label="Default" default="true"/>
10 </window>
  
```

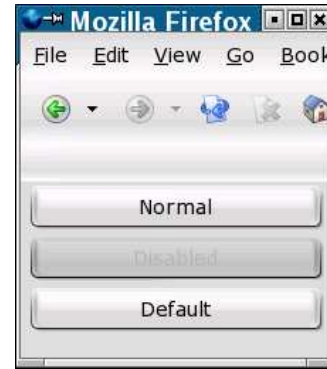
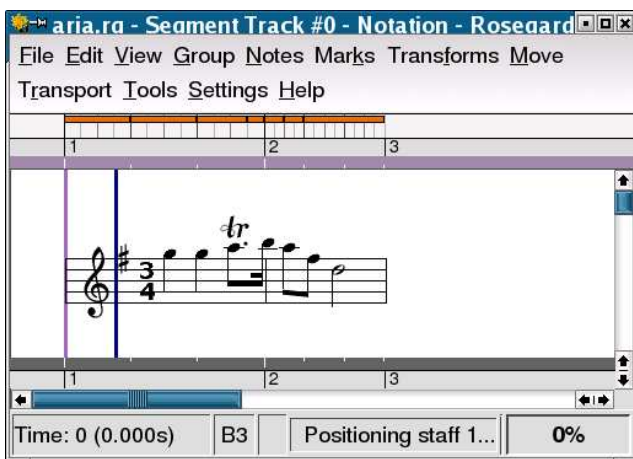


Figure 14: Rendered XUL sample document.

Figure 13: XUL sample document.

## XML Applications: MusicXML

MusicXML is a industry standard for the markup of sheet music (v1.0, <http://www.musicxml.org/>)



```

1 <?xml version="1.0"?>
2 <!DOCTYPE score-partwise PUBLIC
3   "-//Recordare//DTD MusicXML 0.6 Partwise//EN"
4   "http://www.musicxml.org/dtds/partwise.dtd">
5 <score-partwise>[...]
6 <part id="0">
7   <measure number="1">
8     <attributes>
9       <divisions>960</divisions>
10      <time><beats>3</beats><beat-type>4</beat-type></time>
11      <clef><sign>G</sign><line>2</line></clef>
12      <key><fifths>1</fifths><mode>major</mode></key>
13    </attributes>
14    <note>
15      <pitch><step>G</step><octave>5</octave></pitch>
16      <duration>960</duration>
17      <voice>1</voice><type>quarter</type>
18    </note>
19    <note>
20      <pitch><step>G</step><octave>5</octave></pitch>
21      <duration>960</duration>
22      <voice>1</voice><type>quarter</type>
23    </note>[...]
24  </part>
25 </score-partwise>
  
```

Figure 15: Rendering of the sample MusicXML document by Rosegarden.

Figure 16: Sample MusicXML document.

## 1. What is XML?

## 2. What is the Semantic Web?

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### The Current Web

#### Resources:

- identified by URI's,
- untyped

#### Links:

- non-descriptive

Semantics has to be gleaned from content, e.g., context around a link anchor.

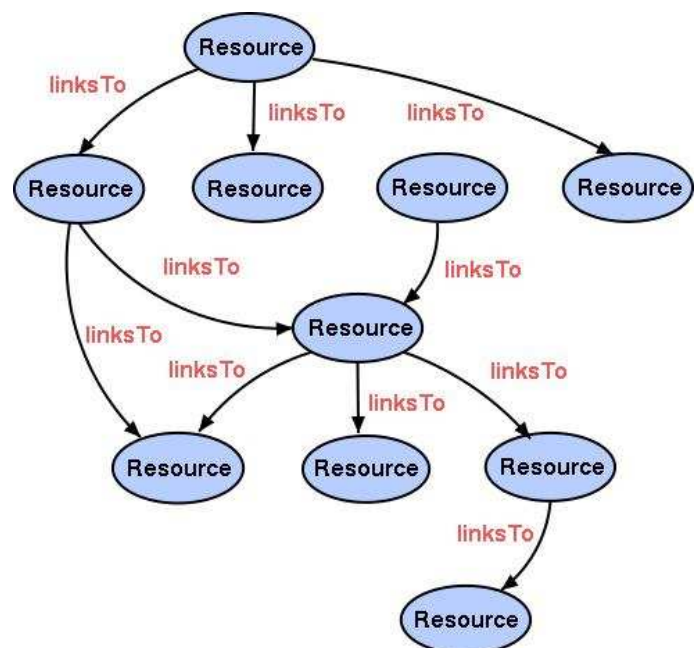


Figure 17: A sample of the current net [Mil04].

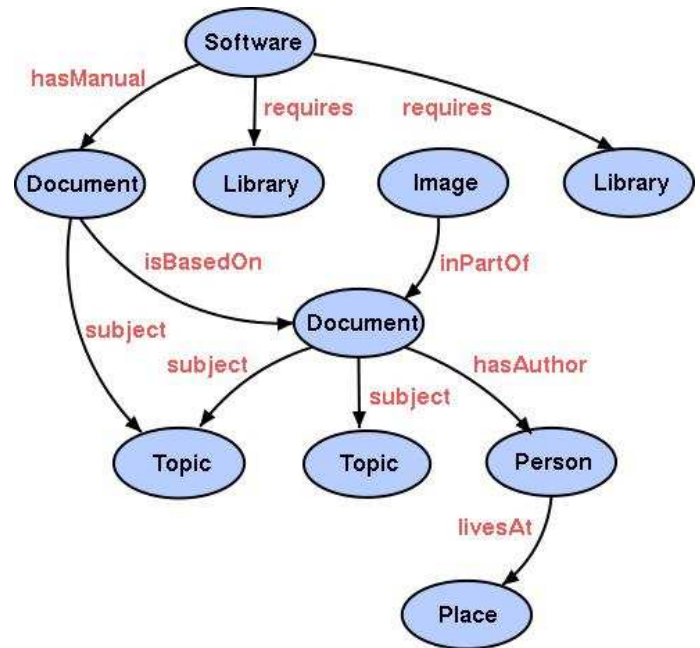
## The Semantic Web

### Resources:

- Globally Identified by URI's or Locally scoped (Blank)
- Extensible
- Relational

### Links:

- Identified by URI's
- Extensible
- Relational



Semantics can be inferred from types of resources and links and known relations between resource / links of specific types.

Figure 18: The same sample as semantic web [Mi104].

## Semantic Web Applications

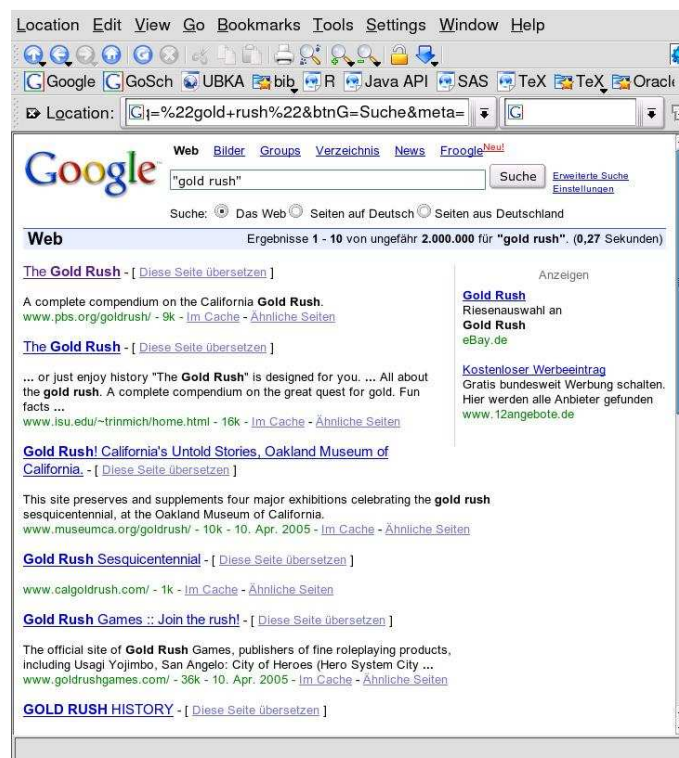


Figure 19: Looking for "Gold Rush" in Google.



## Semantic Web Applications



Figure 20: "Gold Rush" on IMDB.

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## Semantic Web Applications

Semantic Web technologies typically are used for

- information retrieval
- information extraction
- information integration

You can think of Semantic Web as a hybridization of

- XML technologies (data representation) and
- logics (inference)

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### XML and Semantic Web Technologies / 3. Overview

## XML

- Syntax.
- Document Tree Model.

```

1 <?xml version="1.0"?>
2 <!DOCTYPE html PUBLIC
3   "-//W3C//DTD XHTML 1.0 Transitional//EN"
4   "http://www.w3.org/TR/xhtml1/DTD/xhtml1-transitional.dtd">
5 <html>
6   <head>
7     <title>Hello, world!</title>
8   </head>
9   <body>
10    <h1>Hello, world!</h1>
11    <p><a href="http://www.w3c.org">W3C</a>.</p>
12    <p>Another paragraph.</p>
13    <hr/>
14  </body>
15 </html>

```

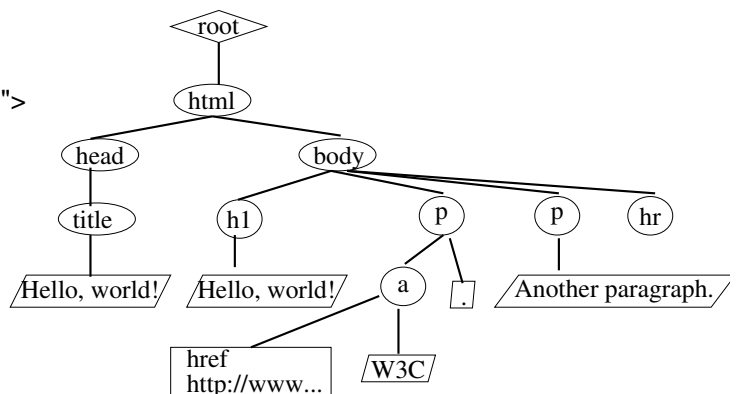


Figure 21: XML sample file (here: XHTML).

Figure 22: Corresponding document tree.

## Document Type Definitions (DTDs)

DTDs describe the syntax of SGML or XML documents.

```

1 <?xml version="1.0"?>
2 <!DOCTYPE books SYSTEM "books.dtd">
3 <books>
4   <book>
5     <author><fn>Rainer</fn><sn>Eckstein</sn></author>
6     <author><fn>Silke</fn><sn>Eckstein</sn></author>
7     <title>XML und Datenmodellierung</title>
8     <year>2004</year>
9   </book>
10  <book>
11    <author><fn>Erik T.</fn><sn>Ray</sn></author>
12    <title>Learning XML</title>
13    <year edition="2">2003</year>
14  </book>
15 </books>

```

Figure 23: A valid books-document.

```

1 <!ELEMENT books (book*)>
2 <!ELEMENT book (author+, title, year)>
3 <!ELEMENT author (fn, sn)>
4 <!ELEMENT fn (#PCDATA)>
5 <!ELEMENT sn (#PCDATA)>
6 <!ELEMENT title (#PCDATA)>
7 <!ELEMENT year (#PCDATA)>
8 <!ATTLIST year
9   edition CDATA #IMPLIED>

```

Figure 24: A simple DTD for a book list.

```

1 <?xml version="1.0"?>
2 <!DOCTYPE books SYSTEM "books.dtd">
3 <books>
4   <book lang="english">
5     <author><sn>Ray</sn><fn>Erik T.</fn></author>
6     <title>Learning XML</title>
7     <publisher>O'Reilly</publisher>
8   </book>
9 </books>

```

Figure 25: An invalid books-document.

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## XML Schema

XML Schema is a more powerful, XML specific alternative for specifying the syntax of XML documents, that replaces DTDs.

```

1 <?xml version="1.0"?>
2 <!DOCTYPE books SYSTEM "books.dtd">
3 <books>
4   <book>
5     <author><fn>Rainer</fn><sn>Eckstein</sn></author>
6     <author><fn>Silke</fn><sn>Eckstein</sn></author>
7     <title>XML und Datenmodellierung</title>
8     <year>2004</year>
9   </book>
10  <book>
11    <author><fn>Erik T.</fn><sn>Ray</sn></author>
12    <title>Learning XML</title>
13    <year edition="2">2003</year>
14  </book>
15 </books>

```

Figure 26:

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```

1 <xsd:schema xmlns:xsd="http://www.w3.org/2001/XMLSchema"
2 <xsd:element name="books">
3   <xsd:complexType><xsd:sequence>
4     <xsd:element name="book" maxOccurs="unbounded">
5       <xsd:complexType><xsd:sequence>
6         <xsd:element name="author" maxOccurs="unbounded"
7           <xsd:complexType><xsd:sequence>
8             <xsd:element name="fn"/>
9             <xsd:element name="sn"/>
10          </xsd:sequence></xsd:complexType>
11        </xsd:element>
12        <xsd:element name="title"/>
13        <xsd:element name="year">
14          <xsd:complexType><xsd:simpleContent>
15            <xsd:extension base="xsd:string">
16              <xsd:attribute name="edition" use="optional"
17                type="xsd:integer"/>
18            </xsd:extension>
19          </xsd:simpleContent></xsd:complexType>
20        </xsd:element>
21      </xsd:sequence></xsd:complexType>
22    </xsd:element>
23  </xsd:sequence></xsd:complexType>
24 </xsd:element>
25 </xsd:schema>

```

Figure 27:

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## XML Linking

- XML namespaces,
- XPath,
- XLink,
- XPointer

//p/text()

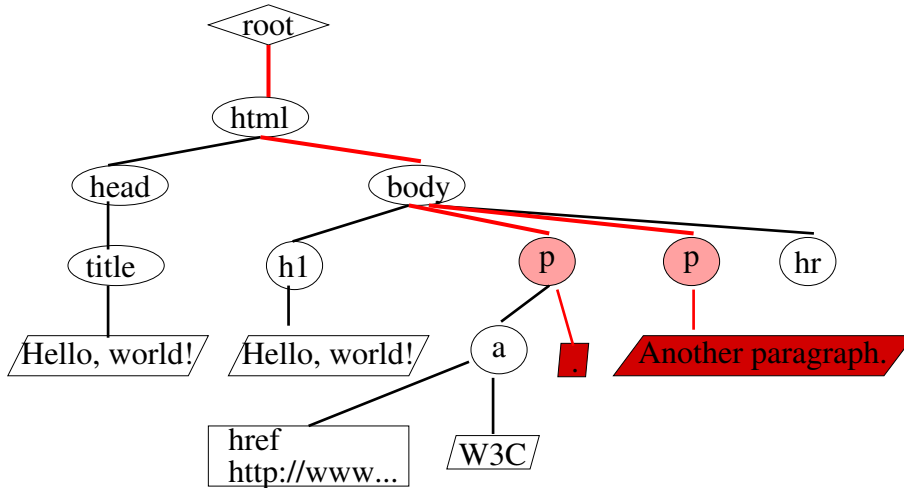


Figure 28: Selected nodes by XPath expression `//p/text()`.

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## XML Stylesheet Language (XSLT)

XSLT stylesheets are used to transform XML documents into another (XML) representation.

Most frequent application is transformation to HTML (rendering).

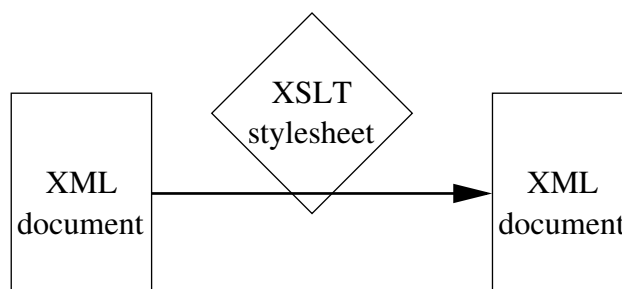


Figure 29: XSLT stylesheets transform XML documents.

## XML Stylesheet Language (XSLT)

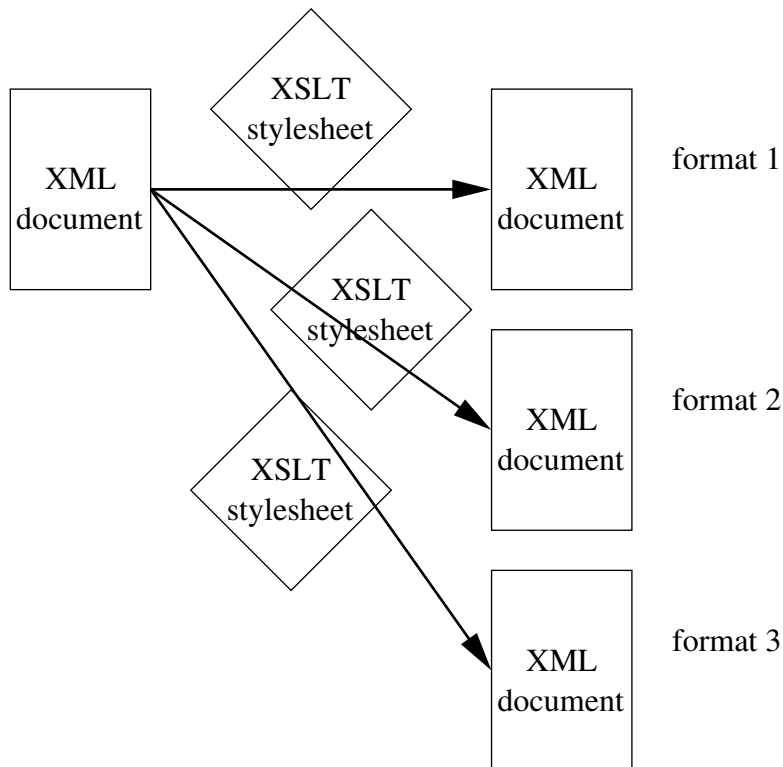


Figure 30: Different XSLT stylesheets transform to different target XML documents.

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## XML Stylesheet Language (XSLT)

```

1 <?xml version="1.0" encoding="utf-8"?>
2 <xsl:stylesheet xmlns:xsl="http://www.w3.org/1999/XSL/Transform"
3   version="1.0">
4   <xsl:output method="html"/>
5
6   <xsl:template match="/">
7     <html><body bgcolor="#FFFFFF"><ol>
8       <xsl:apply-templates/>
9     </ol></body></html>
10  </xsl:template>
11
12  <xsl:template match="book">
13    <li>
14      <xsl:apply-templates select="author[1]/fn"/><xsl:text> </xsl:text>
15      <xsl:apply-templates select="author[1]/sn"/>
16      <xsl:for-each select="author[position()>1]">
17        <xsl:text>, </xsl:text>
18        <xsl:apply-templates select="fn"/><xsl:text> </xsl:text>
19        <xsl:apply-templates select="sn"/>
20      </xsl:for-each>
21      <xsl:text>: </xsl:text>
22      <em><xsl:apply-templates select="title"/></em><xsl:text>, </xsl:text>
23      <xsl:apply-templates select="year"/><xsl:text>.</xsl:text>
24    </li>
25  </xsl:template>
26 </xsl:stylesheet>

```

Figure 31: A sample XSLT stylesheet for rendering books-documents.

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## XML Query Language (XQuery)

XQuery is a SQL-like query language for XML documents.

|  |  |
|--|--|
| <pre> 1 &lt;?xml version="1.0"?&gt; 2 &lt;!DOCTYPE books SYSTEM "books.dtd"&gt; 3 &lt;books&gt; 4   &lt;book&gt; 5     &lt;author&gt;&lt;fn&gt;Erik T.&lt;/fn&gt;&lt;sn&gt;Ray&lt;/sn&gt;&lt;/author&gt; 6     &lt;title&gt;Learning XML&lt;/title&gt; 7     &lt;year edition="2"&gt;2003&lt;/year&gt; 8   &lt;/book&gt; 9   &lt;book&gt; 10    &lt;author&gt;&lt;fn&gt;Rainer&lt;/fn&gt;&lt;sn&gt;Eckstein&lt;/sn&gt;&lt;/author&gt; 11    &lt;author&gt;&lt;fn&gt;Silke&lt;/fn&gt;&lt;sn&gt;Eckstein&lt;/sn&gt;&lt;/author&gt; 12    &lt;title&gt;XML und Datenmodellierung&lt;/title&gt; 13    &lt;year&gt;2004&lt;/year&gt; 14  &lt;/book&gt; 15  &lt;book&gt; 16    &lt;author&gt;&lt;fn&gt;Martin&lt;/fn&gt;&lt;sn&gt;Schader&lt;/sn&gt;&lt;/author&gt; 17    &lt;author&gt;&lt;fn&gt;Lars&lt;/fn&gt;&lt;sn&gt;Schmidt-Thieme&lt;/sn&gt;&lt;/author&gt; 18    &lt;title&gt;Java&lt;/title&gt; 19    &lt;year&gt;2003&lt;/year&gt; 20  &lt;/book&gt; 21 &lt;/books&gt; </pre> | <pre> 1 xquery version "1.0"; 2 3 declare namespace f= 4   "http://cgnm.informatik.uni-freiburg.de/xml"; 5 6 declare function f:authors-sortstring(\$author) as xs:string { 7   string-join( 8     for \$a in \$author 9     return concat(\$a/sn, " ", \$a/fn), 10    " ") 11 }; 12 13 &lt;books&gt; { 14   for \$t in //*/title 15   let \$r := \$t/.. 16   where contains(\$t, 'XML') 17   order by f:authors-sortstring(\$r/author), \$r/year 18   return \$r 19 } &lt;/books&gt; </pre> |
|--|--|

A sample books document.

Querying a books-document by XQuery.

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## Resource Description Framework (RDF)

RDF allows the "description of resources" via triples (subject, object, predicate).

RDF has a graphical and a XML representation.

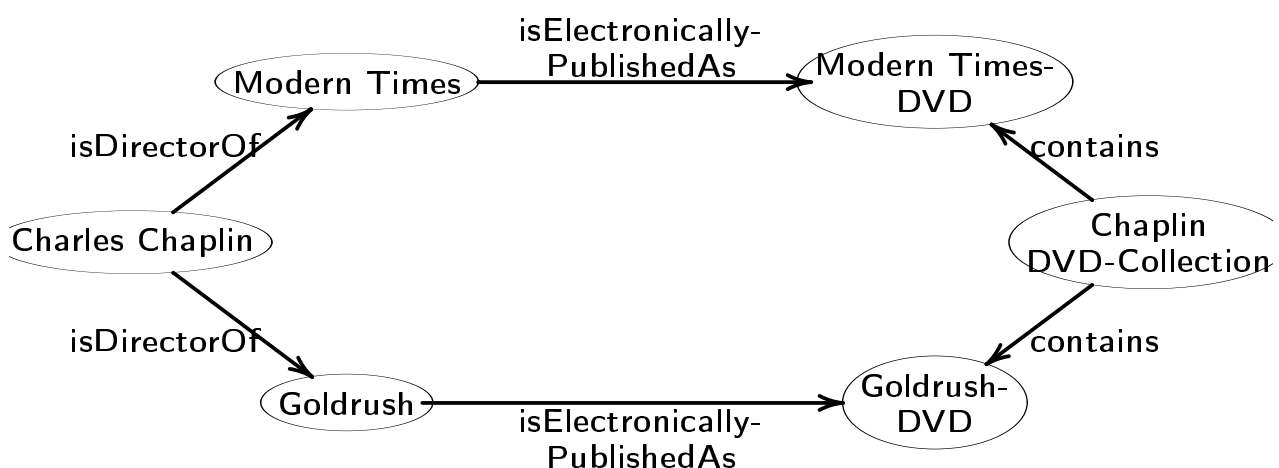


Figure 32: Sample semantic network.

## RDF Schema

RDF Schema has specific constructs for expressing classes and properties.

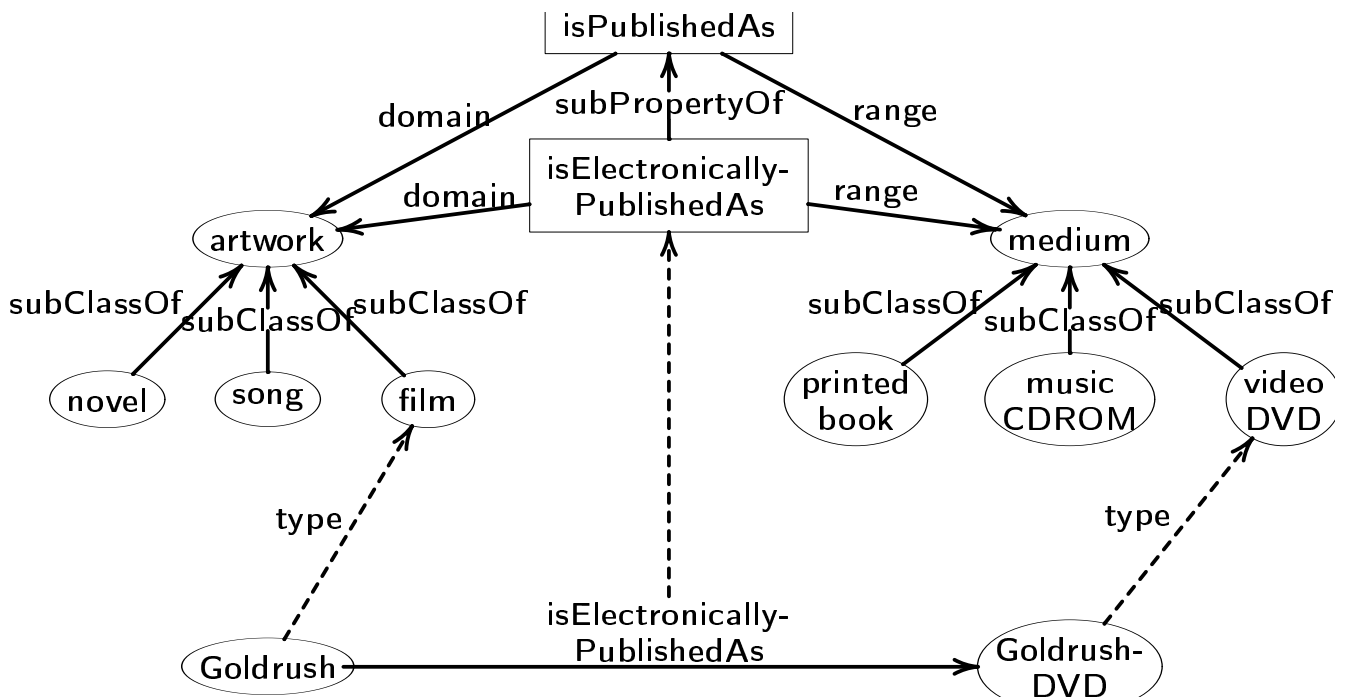


Figure 33: RDF Schema description of classes and properties in the sample semantic network.

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## Web Ontology Language (OWL)

OWL adds more expressive modelling constructs, e.g., to express, that the range of a given predicate depends on the subject.

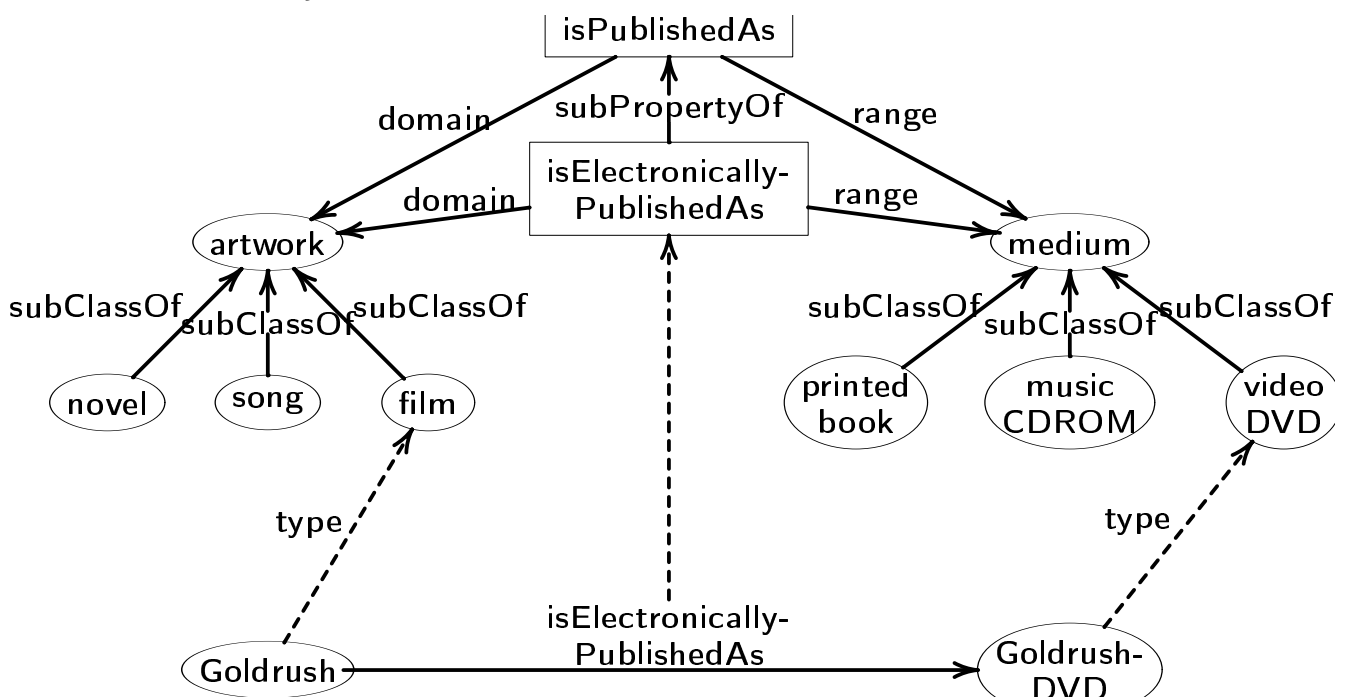


Figure 34: With RDF Schema one cannot model, that films always are electronically published on Video-DVDs.

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## Semantic Web Layer Cake

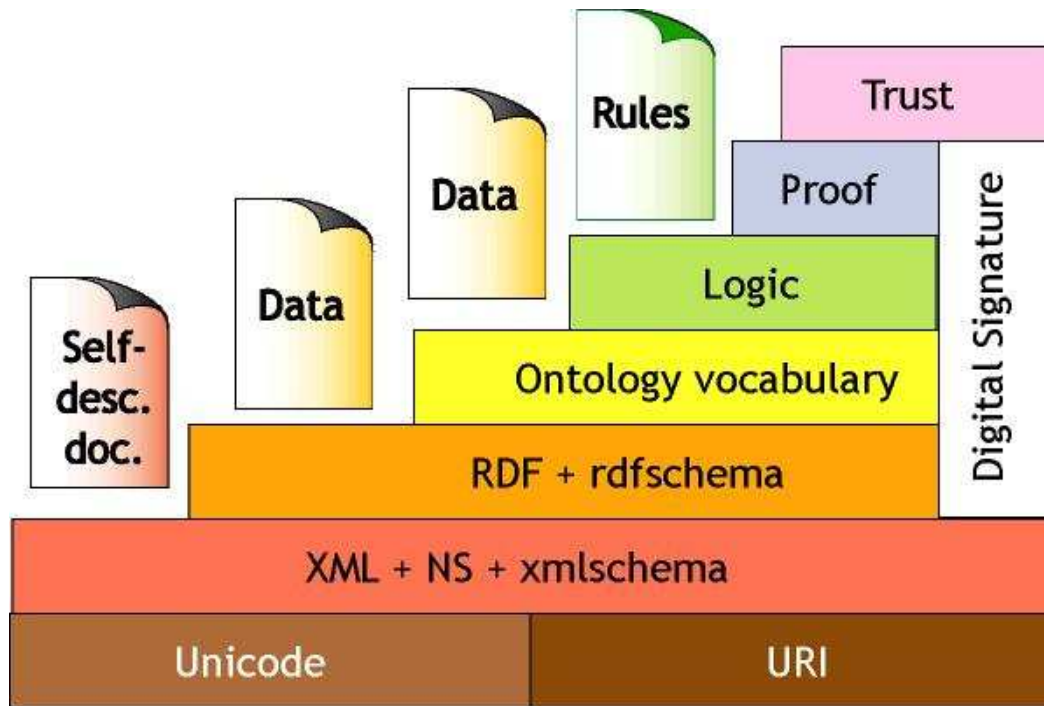


Figure 35: Semantic Web Layers (Berners-Lee).

## What the course eventually will cover

If we have time:

- RDF rule and query languages
- RDF inferencing
- XML and Databases
- More practical examples
- ...



## What the course (probably) will not cover

- APIs for programming with XML as DOM, SAX, etc.
- Extensive descriptions of complex XML applications (e.g., XML based markup languages) as SVG, XForms, etc.
- Detailed instructions for the usage of tools.
- "Process models" and best practices.

But upcoming winter term we will offer

**Praktikum on XML and Semantic Web Technologies**

### **1. What is XML?**

### **2. What is the Semantic Web?**

### **3. Overview**

### **4. Organizational stuff**

## Some books

- Rainer Eckstein and Silke Eckstein. *XML und Datenmodellierung*. dpunkt.verlag, 2003
- Charles F. Goldfarb and Paul Prescod. *XML Handbook*. Prentice Hall PTR, 5th edition, 2003
- Eric T. Ray. *Learning XML*. O'Reilly, 2003
- Howard Katz, editor. *XQuery from the experts: a guide to the W3C XML query language*. Addison-Wesley, Boston, 2004
- Shelly Powers. *Practical RDF*. O'Reilly, 2002
- Grigoris Antoniou and Frank Van Harmelen. *A Semantic Web Primer*. MIT Press, 2004
- W3C recommendations at <http://www.w3.org>.

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## Some First XML Software

- XML Processors / Parsers:
  - Apache Xerxes (<http://xml.apache.org/xerces2-j/index.html>).  
v3.1.1: XML 1.1; Namespaces 1.1, XML Schema 1.0.
- XSLT Processor:
  - Apache Xalan (<http://xml.apache.org/xalan-j/index.html>).  
v2.7.1: XSLT 1.0, XPath 1.0.
- XQuery & XSLT Processor:
  - Saxon (<http://saxon.sourceforge.net>; Michael H. Kay).  
v9.4: XSLT 2.0, XPath 2.0; XQuery 1.0.

## Exercises and tutorials

- There will be a weekly sheet with two exercises handed out **each Tuesday** in the lecture.  
1st sheet will be handed out next Tue. 24.4.
- Solutions to the exercises can be submitted until **every next Tuesday** before the lecture  
1st sheet is due Tue. 1.5.
- Exercises will be corrected by your tutor.
- Tutorials **each Tuesday 14-16**  
1st tutorial at Tue. 24.4.

## Exam and credit points

- There will be an exam at end of term  
(2h, 4 problems).
- You can get up to 10% of the points as bonus points from the tutorial.
- The course gives 8 ECTS (3+2 SWS).
- This is a MSc course.

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