LBSC 690: Week 5

Metadata, Structured Documents, and XML

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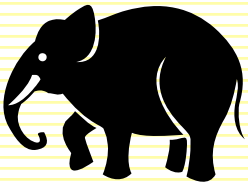
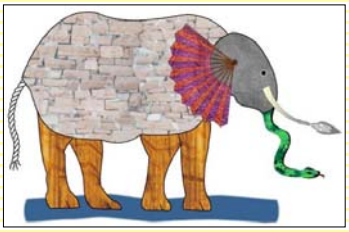
Blind Men and Elephants



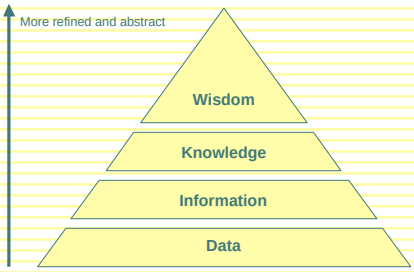
Is this an elephant?



Metadata

- Literally "data about data"
  - "a set of data that describes and gives information about other data" — Oxford English Dictionary

Information Hierarchy



Information Hierarchy

- Data
  - The raw material of information
- Information
  - Data organized and presented in a particular manner
- Knowledge
  - "Justified true belief"
  - Information that can be acted upon
- Wisdom
  - Distilled and integrated knowledge
  - Demonstrative of high-level "understanding"

A (Facetious) Example

- Data
  - 98.6º F, 99.5º F, 100.3º F, 101º F, …
- Information
  - Hourly body temperature: 98.6º F, 99.5º F, 100.3º F, 101º F, …
- Knowledge
  - If you have a temperature above 100º F, you most likely have a fever
- Wisdom
  - If you don't feel well, go see a doctor

Data without Metadata…

… can be pretty useless!

Who:
authored it?
to contact about data?

What:
are contents of database?

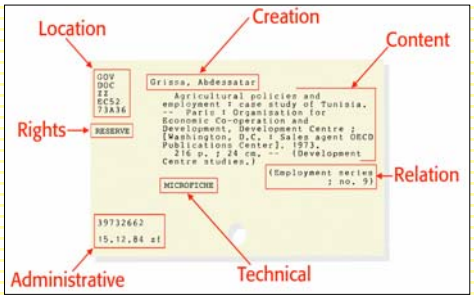
When:
was it collected?
processed? finalized?

Where:
was the study done?

Why:
was the data collected?

How:
were data collected?
processed? Verified?

Early Example of Metadata



Encoding Metadata

- Language for ***expressing*** metadata should be:
  - **Universal** - so all can understand
  - **Flexible** - to incorporate different types
  - **Extensible** - flexible to custom types
  - **Simple** - to encourage adoption
  - **Modular** - so that schemes can be mixed, extended

From: Ian Graham, An Introduction to RDF. http://www.utoronto.ca/ian/talks/

Metadata

- How do we encode metadata?
- How do we encode metadata to support interoperability?

Simple example: **January 31, 2001**
31 janvier 2001
2001-01-31
01-31-2000
31012000

What is the Dublin Core?

- A metadata standard for describing digital resources
- An initiative to create a digital "library card catalog" for the Web
- Dublin Core fields: (all optional)

Title	Creator	Subject
Description	Publisher	Contributor
Date	Type	Format
Identifier	Source	Language
Relation	Coverage	Rights

What's a structured document?

- A structured document is a document whose structure conforms to a certain set of rules
  - Data and metadata encoded in an interoperable manner

What is XML?

- XML = eXtensible Markup Language
- XML is a standard for exchanging structured data
  - Provides standardization at the syntactic level
  - Does **not** provide "meaning" for the tags
- XML is a standard recommended by the W3C

Goals of XML

- Easy to use
- Easy to extend and adapt
- Easy to write programs that use XML
- Support a wide variety of applications
- Should be human legible
- Formal and concise

The Basic Rules

- XML is case sensitive
- All start tags must have end tags
- Elements must be properly nested
- XML declaration is the first statement
  - <?xml version="1.0"?>
- Every document must contain a root element
- Attribute values must have quotation marks
  - <item id="33905">
- Certain characters are reserved for parsing
  - < = '<'

Questions about XML

- How is XML like HTML?
- How is HTML like XML?
- What's the relationship between XML and structured documents?
- How are the rules governing a structured document encoded?

XML: Historic Perspective

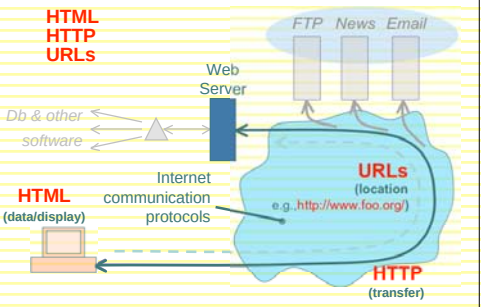
- HTML and the birth of the Web
- HTML is not enough
- Development of XML

This section contains slides adapted from presentations by Ian Graham: http://www.utoronto.ca/ian/talks/

In the beginning...

The foundations of the Web:

HTML
HTTP
URLs



Three Core Technologies

- **HTTP** - HyperText Transfer Protocol
  - A protocol for transferring data between machines on the Internet
- **URL** - Uniform Resource Locator
  - A scheme for referencing the specific location of a resource
- **HTML** - HyperText Markup Language
  - A markup language for encoding information to be read by humans

HTTP and URLs have pretty-well stood the test of time.
But by 1996, HTML was already showing signs of age ....

HTML

- Started with very few tags …
- Language evolved as more tags were added:
  - Forms
  - Tables
  - Fonts
  - Frames
  - …

Problems with HTML

- Desire for personalized tags
  - HTML can't be extended
- Desire to incorporate other types of data
  - Mathematics, database entries, literary text, poems, purchase orders …
  - HTML can't accommodate other types of data
- Desire for automatic processing by software
  - HTML is too messy and inconsistent

Back to the Basics

- HTML was defined using SGML
  - **S**tandard **G**eneralized **M**arkup **L**anguage
  - A meta-language for defining languages
- Complex, sophisticated, powerful
  - … too difficult to use
- Idea: create a simpler version of SGML
  - The birth of XML!

Evolution of XML

- XML can be used to define other languages
- Many XML languages, optimized for different roles
  - MathML: for mathematics
  - SMIL: for synchronized multimedia
  - RSS: for news feeds
  - XHTML: HTML by XML rules
  - RDF: for the Semantic Web
  - …

MathML

- An XML language for defining mathematic formulas

$(a + b)^2$

```
<msup>
  <mfenced>
    <mi>a</mi>
    <mo>+</mo>
    <mi>b</mi>
  </mfenced>
  <mn>2</mn>
</msup>
```

$x^2 + 4x + 4 = 0$

```
<mrow>
  <mrow>
      <msup><mi>x</mi><mn>2</mn></msup>
      <mo>+</mo>
      <mrow>
        <mn>4</mn>
        <mo>&invisibletimes;</mo>
        <mi>x</mi>
      </mrow>
    <mo>+</mo><mn>4</mn>
  </mrow>
  <mo>=</mo><mn>0</mn>
</mrow>
```


MathML

- What advantages does it offer?

SMIL

- Synchronized Multimedia Integration Language
- Integration of multimedia with text, audio, video
- Support in RealPlayer

SMIL Example

```
<smil>
 <head>
  <meta name="title" content="Online Teaching Services promo" />
  <meta name="author" content="Jay Moonah, CAT" />
  <layout type="text/smil-basic-layout">
    <root-layout width="280" height="316" background-color="white"/>
    <region id="AnimChannel1" title="AnimChannel1"
        left="0" top="0" height="265"  width="280" fit="hidden"/>
  </layout>
</head>
<body>
  <par title="Online Teaching Services promo" author="Jay Moonah, CAT" >
    <audio src="final.rm" id="Soundtrack"   title="Soundtrack"/>
    <animation src="otscompfin.swf" id="Animation"
        region="AnimChannel1" title="Animation"   fill="freeze"/>
    <text src="cc.rt" id="caption" region="cc" title="cc" fill="freeze"/>
  </par>
</body></smil>
```


RSS

- RSS = Really Simple Syndication or Rich Site Summary
- An XML format for distributing news headlines on the Web

XHTML: Beyond HTML

```
<?xml version="1.0" encoding="iso-8859-1"?>
<html xmlns="http://www.w3.org/TR/xhtml1" >
<head>
  <title> Title of text XHTML Document </title>
</head>
<body>
<div class="myDiv">
   <h1> Heading of Page </h1>
   <p> here is a paragraph of text. I will include  inside this paragraph
       a bunch of wonky text so that it looks fancy. </p>
   <p>Here is another paragraph with  <em>inline emphasized</em>
       text, and <b> absolutely no</b> sense of humor. </p>
   <p>And another paragraph, this one  with an <img src="image.gif"
       alt="waste of time" />  image, and a <br /> line break. </p>
</div>
</body></html>
```

XHTML

- Just like HTML, but based on XML rules
- Will support integration of different data into a single document

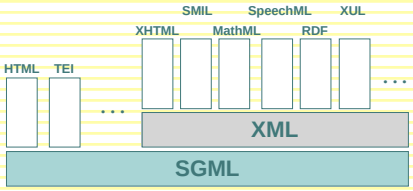
XHTML and other Data

```
<?xml version="1.0" encoding="iso-8859-1"?>
<html xmlns="http://www.w3.org/TR/xhtml1" >
<head>
  <title> Title of XHTML Document </title>
</head><body>
<div class="myDiv">
   <h1> Heading of Page </h1>
    <mathml xmlns="http://www.w3.org/TR/mathml">
        ... MathML markup ...
    </mathml>
    <p> more html stuff goes here </p>
    <smil xmlns="http://www.w3.org/TR/smil1">
        ... SMIL markup ...
    </smil>
</div>
</body></html>
```


And Others...

- **CML** – chemical Markup Lang
- **CellML** – biological models
- **BSML** – bioinformatic sequences
- **MAGE-ML** – Microarray Gene Expression
- **XSTAR** – for archaeological research
- **XMLMARC** – MARC in XML
- **AML** – astronomy markup language
- **SportsML** – for sharing sports data

The XML Family Tree



Mixing XML Dialects

- XML is designed to support the integration of multiple standards
- Allows users to mix elements from different standards
  - Snapping together XML dialects like Lego pieces
  - Based on the notion of "namespaces"

Example

```
<?xml version="1.0"?>
<rdf:RDF
  xmlns:rdf="http://www.w3.org/1999/02/22-rdf-syntax-ns#"
  xmlns:rss="http://purl.org/rss/1.0/"
  xmlns:dc="http://purl.org/dc/elements/1.1/">
 <rss:channel rdf:about="http://www.xml.com/xml/news.rss">
  <rss:title>XML.com</rss:title>
  <rss:link>http://xml.com/pub</rss:link>
  <dc:description>
   XML.com features a rich mix of
   information and services for the XML community.
  </dc:description>
  <dc:subject>XML, RDF, metadata, information
   syndication services</dc:subject>
  <dc:identifier>http://www.xml.com</dc:identifier>
  <dc:publisher>O'Reilly & Associates, Inc.</dc:publisher>
  <dc:rights>Copyright 2000, O'Reilly &
   Associates, Inc.</dc:rights>
 </rss:channel>
</rdf:RDF>
```

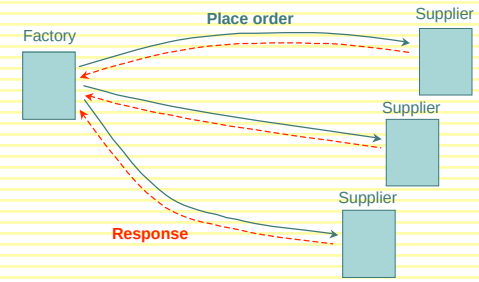
Example from http://www.xml.com/pub/a/2000/10/25/dublincore/

Interoperability

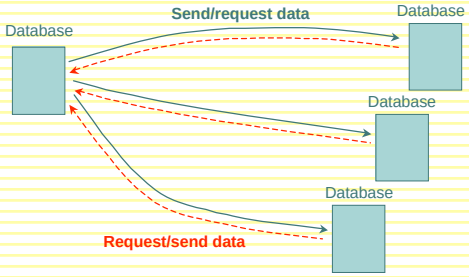
- What does it mean and what's the role of XML?
- XML as a universal format for data interchange
  - Software exchange data as XML-format messages
- Advantages?
  - Eliminates proprietary data formats
  - Promotes interoperability
  - Encourages cooperation
  - Leverages lots of existing XML processing software

Interoperability slides adapted from presentations by Ian Graham: http://www.utoronto.ca/ian/talks/

XML Messaging



XML Messaging



Example Message

```
<partorders xmlns="http://myco.org/Spec/partorders.desc">
 <order ref="x23-2112-2342" date="25aug1999-12:34:23h">
   <desc> Gold sprockel grommets, with matching hamster</desc>
   <part number="23-23221-a12" />
   <quantity units="gross"> 12 </quantity>
   <delivery-date date="27aug1999-12:00h">
 </order>
 <order ref="x23-2112-2342" date="25aug1999-12:34:23h">
    …. Order something else …..
 </order>
</partorders>
```


The next best thing since…

- What's the big deal about XML?
- What does XML not do?
- How do XML tags acquire meaning?
- How do standards arise?

What's wrong with the Web?

- It was meant for humans, not machines
- The current Web contains only data, not knowledge
  - From Web of data to Web of knowledge
- Difficult to
  - Aggregate/compare data across sites
  - Delegate complex tasks to "agents"
  - Formulate complex queries involving multiple constraints
  - …

What is the Problem?

Consider a typical Web page:

This section contains slides adapted from a presentations by Peter F. Patel-Schneider

What we see...

WWW2002

The eleventh international world wide web conference

Sheraton waikiki hotel

Honolulu, hawaii, USA

7-11 may 2002

1 location 5 days learn interact

Registered participants coming from

australia, canada, chile denmark, france, germany, ghana, hong kong, india, ireland, italy, japan, malta, new zealand, the netherlands, norway, singapore, switzerland, the united kingdom, the united states, vietnam, zaire

Register now

On the 7th May Honolulu will provide the backdrop of the eleventh international world wide web conference. This prestigious event ...

Speakers confirmed

Tim berners-lee

Tim is the well known inventor of the Web, ...

Ian Foster

Ian is the pioneer of the Grid, the next generation internet ...

What a machine sees...

Add “meaningful” tags?

<name>WWW2002

THE ELEVENTH INTERNATIONAL WORLD WIDE WEB CONFERENCE</name>

<location>HAWAII

1 LOCATION. 5 DAYS. LEARN. INTERACT.</location>

<date>7-11 May 2002</date>

<slogan>Register now</slogan>

<participants>On the 7th May Honolulu will provide the backdrop of the eleventh international world wide web conference. This prestigious event ...</participants>

<introduction>On the 7th May Honolulu will provide the backdrop of the eleventh international world wide web conference. This prestigious event ...</introduction>

<speaker>Tim berners-lee</speaker>

<bio>Tim is the well known inventor of the Web, ...</bio>

But what about...

<conf>WWW2002

THE ELEVENTH INTERNATIONAL WORLD WIDE WEB CONFERENCE</conf>

<place>HAWAII

1 LOCATION. 5 DAYS. LEARN. INTERACT.</place>

<date>7-11 May 2002</date>

<slogan>Register now</slogan>

<participants>On the 7th May Honolulu will provide the backdrop of the eleventh international world wide web conference. This prestigious event ...</participants>

<introduction>On the 7th May Honolulu will provide the backdrop of the eleventh international world wide web conference. This prestigious event ...</introduction>

<speaker>Tim berners-lee</speaker>

<bio>Tim is the well known inventor of the Web, ...

Machine sees...

Approaches to "Semantics"

- External agreement on meaning of annotations
  - Agree on the meaning of a set of annotation tags, e.g., Dublin core
  - Problems with this approach?
- Use of on-line **ontologies** to specify meaning of annotations
  - Ontologies provide a vocabulary of terms
  - New terms can be formed by combining existing ones
  - Meaning (semantics) of such terms is formally specified
  - Can also specify relationships between terms in multiple ontologies
- Semantic Web takes second approach

Ontology: Origins and History

- A philosophical discipline
  - A branch of philosophy that deals with the nature and the organization of reality
- Science of Being (Aristotle, Metaphysics, IV, 1)
- Tries to answer the questions:
  - What characterizes being?
  - Eventually, what is being?

Ontology in Computer Science

- An ontology is an engineering artifact:
  - It is composed of vocabulary used to describe a certain reality, plus
  - A set of explicit assumptions regarding the intended meaning of the vocabulary
- Thus, an ontology describes a formal specification of a domain:
  - Shared understanding of a domain
  - A model that is formal and machine manipulable
- How does an ontology differ from a taxonomy?

Structure of an Ontology

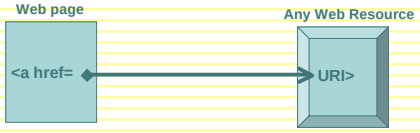
- Names for important concepts in the domain
  - Elephant is a concept whose members are a kind of animal
  - Herbivore is a concept whose members are exactly those animals who eat only plants or parts of plants
  - Adult_Elephant is a concept whose members are exactly those elephants whose age is greater than 20 years
- Background knowledge/constraints on the domain
  - Adult_Elephants wseigh at least 2,000 kg
  - All Elephants are either African_Elephants or Asian_Elephants
  - No individual can be both a Herbivore and a Carnivore

Coding Ontologies

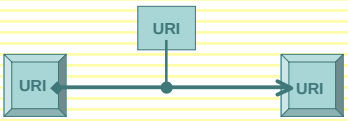
- RDF = Resource Description Framework
- RDF is a graphical model
  - Organized as a directed graph
  - < resource, property, value >

Adding Semantics to Links

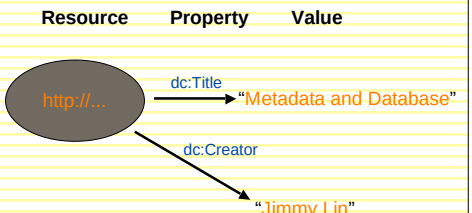
HTML



RDF



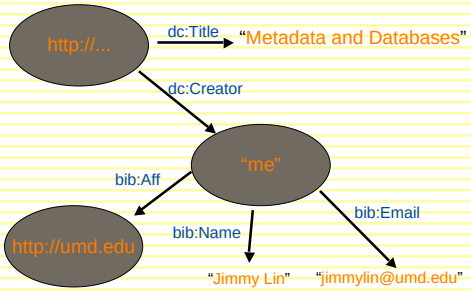
A Simple Example



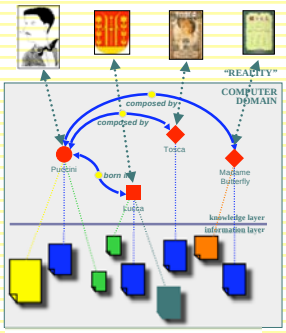
XML Encoding


```
<RDF
    xmlns="http://www.w3.org/TR/ … "
    xmlns:dc="http://purl.org/dc/…" >
  <Description about="http://...">
    <dc:Title> Metadata and Databases </dc:Title>
    <dc:Creator>Jimmy Lin</dc:Creator>
  </Description>
</RDF>
```


Elaborating "me"



The Semantic Web



Web 2.0

- Tagging ("folksonomy")
- Blogging
- The "Long Tail"
- Web services
- Wikipedia

Back to the elephant...

- Concepts covered:
  - Metadata
  - Structured Documents
  - XML
  - Semantic Web
  - Ontologies
- Questions?
- Confused?