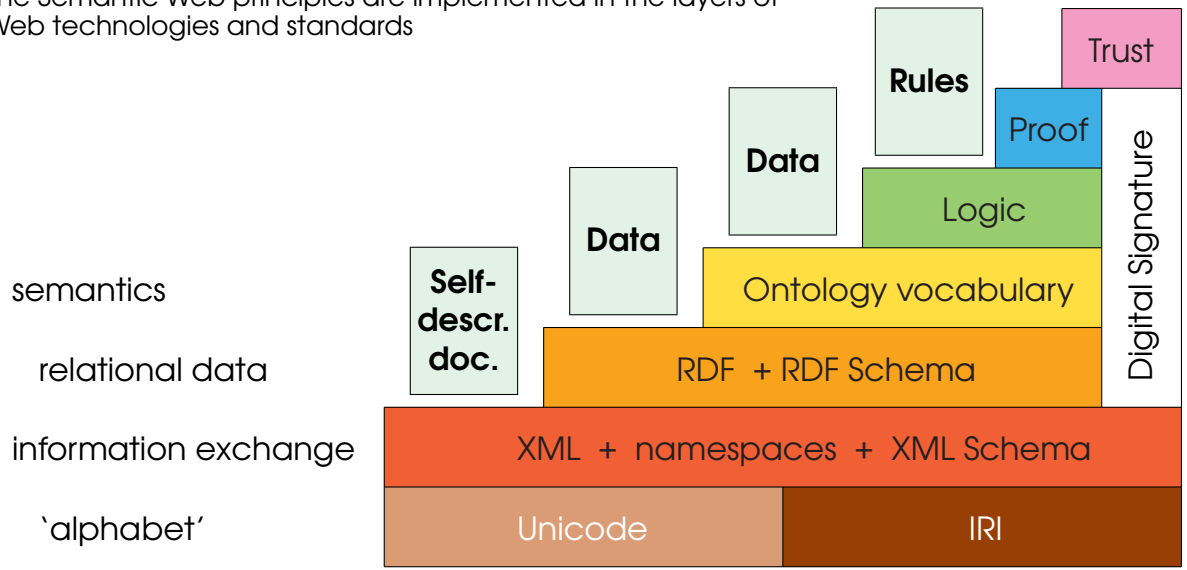
Layered approach

(by T. Berners-Lee)

The Semantic Web principles are implemented in the layers of Web technologies and standards



If HTML and the Web made all the online documents look like one huge **book**, RDF, schema, and inference languages will make all the data in the world look like one huge **database** — Weaving the Web, 1999

Alphabet: Unicode and IRI

- **Unicode** is an industry standard designed to allow text and symbols from **all of the writing systems in the world** to be consistently represented and manipulated by computers. For details visit `http://www.unicode.org/`
- A **Uniform Resource Identifier (URI)** is a string of ASCII characters used to identify a resource (`http://www.w3.org/Addressing/URL/URI_Overview.html`). (Internationalised) **IRIs** extend URIs by using the Universal Character Set An IRI can be classified as a locator or a name or both:

- A Uniform Resource Locator (URL) is an IRI that, in addition to identifying a resource, provides means of obtaining a representation of the resource by describing its primary access mechanism or network 'location.' E.g., the URL `http://www.bbc.com/` is a URI that identifies a resource (BBC's home page) and implies that a representation of that resource is obtainable via HTTP from a network host named `www.bbc.com`
- A Uniform Resource Name (URN) is an IRI that identifies a resource by name in a particular namespace. A URN can be used to talk about a resource without implying its location. E.g., the URN **urn:isbn:0-395-36341-1** is a URI that, like an International Standard Book Number (ISBN), allows one to talk about a book, but doesn't suggest where and how to obtain an actual copy of it

Information exchange: structured Web documents

SGML — standard generalised markup language:

Historically, electronic manuscripts contained control codes or macros that caused documents to be formatted in a particular way (‘specific coding’). In contrast, generic coding, which began in the late 1960s, uses **descriptive tags** (for example, ‘heading,’ rather than ‘format-17’). Also in the late 1960s, New York book designer S. Rice proposed the idea of a universal catalog of parameterised ‘editorial structure’ tags.

In 1969, C. **G**oldfarb was leading an IBM research project on integrated law office information systems. Together with E. **M**osher and R. **L**orie he invented the **Generalised Markup Language**, **GML**, as a means of allowing the text editing, formatting, and information retrieval subsystems to share documents. Instead of a simple tagging scheme GML introduced the concept of a

formally-defined document type with an explicit nested element structure.

The first working draft of the **GML standard SGML** was published in 1980.

For details consult, e.g., `http://www.w3.org/MarkUp/SGML/` and `http://www.isgmlug.org/sgmlhelp/g-index.htm`

HTML

HTML (hypertext markup language) is an SGML application.

HTML is a **markup language** designed for the creation of web pages with hypertext and other information to be displayed in a web browser. HTML is used to structure information — denoting certain text as headings, paragraphs, lists and so on — and can be used to describe the **appearance** of a document.

It describes information as collections of documents connected by **hyperlinks**.

Originally defined by Tim Berners-Lee, HTML is now an international standard. Later HTML specifications are maintained by the W3C; see `http://www.w3.org/MarkUp/`

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```
<h2>A Semantic Web Primer</h2>
<i>by <b>G. Antoniou</b> and <b>F. van Harmelen</b> </i>
<br />The MIT Press
<br />ISBN 0-262-01210-3
```

- Do you understand the meaning of the piece above?

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- Do you understand the meaning of the piece above?
- What about machines?

HTML (cont.)

- **Human reading:**

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HTML (cont.)

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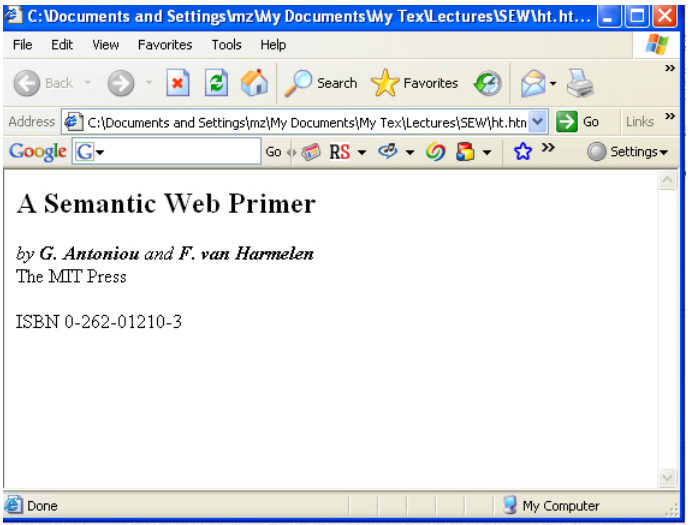
- **Machine 'reading':**



HTML (cont.)

- **Human reading:**

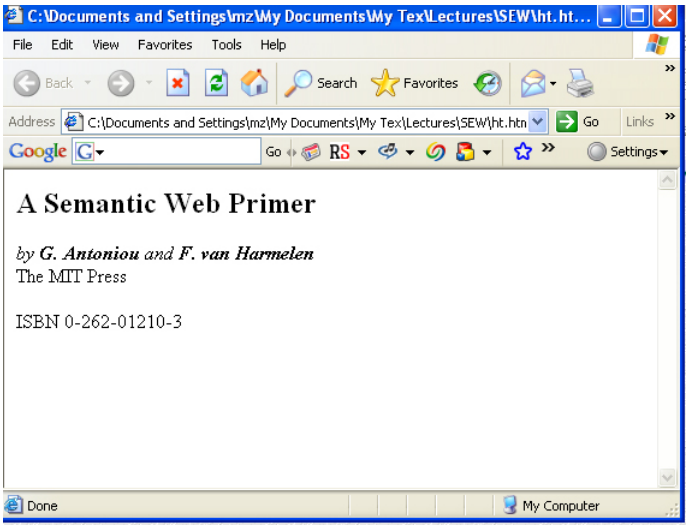
"A Semantic Web Primer" is a book written by G. Antoniou and F. van Harmelen and published by the MIT Press. Its ISBN is 0-262-01210-3.

- **Machine 'reading':**

Can the machine 'understand' that "A Semantic Web Primer" is the **title**?

Can the machine 'understand' that G. Antoniou and F. van Harmelen are the **authors** of this book?

How can we **query** such documents?



- HTML documents simply **display** information and **links** to other documents.
- HTML is based on a **fixed** set of tags.

XML (eXtensible Markup Language)

- XML is another **SGML** application see `http://www.w3.org/XML/`

  `http://www.w3schools.com/xml/xml_whatis.asp`

  - XML is based on **tags**
  - tags may be nested
  - tags must be closed

<booktitle>A Semantic Web Primer</booktitle>

element

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  - XML is based on **tags**
  - tags may be nested
  - tags must be closed

<booktitle>A Semantic Web Primer</booktitle>

element

- XML documents give more structural information about their pieces and relations between them through the **nesting structure**

```
<book>
  <title>A Semantic Web Primer</title>
  <author>G. Antoniou</author>
  <author>F. Van Harmelen</author>
  <publisher>The MIT Press</publisher>
  <ISBN>0-262-01210-3</ISBN>
</book>
```

thus, the *author* element 'refers' to the enclosing *book* element, so we can find the authors of the book 'A Semantic Web Primer'

XML (cont.)

- XML allows the representation of information that is also **machine-accessible**
- XML **separates** content from formatting

  (XML was designed to carry data, not to display data)
- XML is a **metalanguage** for markup:
  it doesn't have a fixed set of tags but allows users to define tags of their own

  XML applications (extensions) for various domains:

  MathML (mathematics), BSML (bioinformatics), NewsML, etc.
- XML is not a single markup language that can be extended for other uses, but rather it is a **common notation** that markup languages can build upon.
  (You can define your own markup languages,

  e.g., for describing recipes, football players, etc.)
- XML was designed to transport and store data
- XML can serve as a **uniform data exchange format** → W3C Semantic Web

The XML syntax

```
<?xml version="1.0" encoding="UTF-16"?>
<email>
  <head>
    <from address="michael@dcs.bbk.ac.uk">Michael Zakharyaschev</from>
    <to address="mark@dcs.bbk.ac.uk">Mark Levene</to>
    <subject>REF impact</subject>
  </head>
  <body>
    <!-- the actual content is here -->
  </body>
</email>
```

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prolog

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```

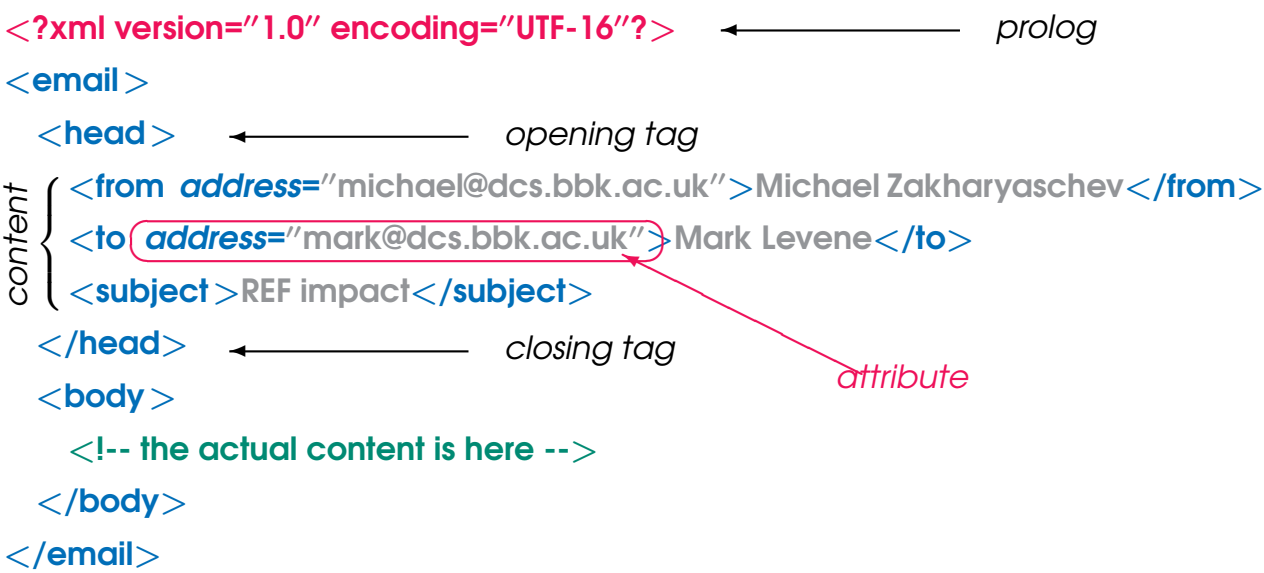
prolog

opening tag

content

closing tag

The XML syntax



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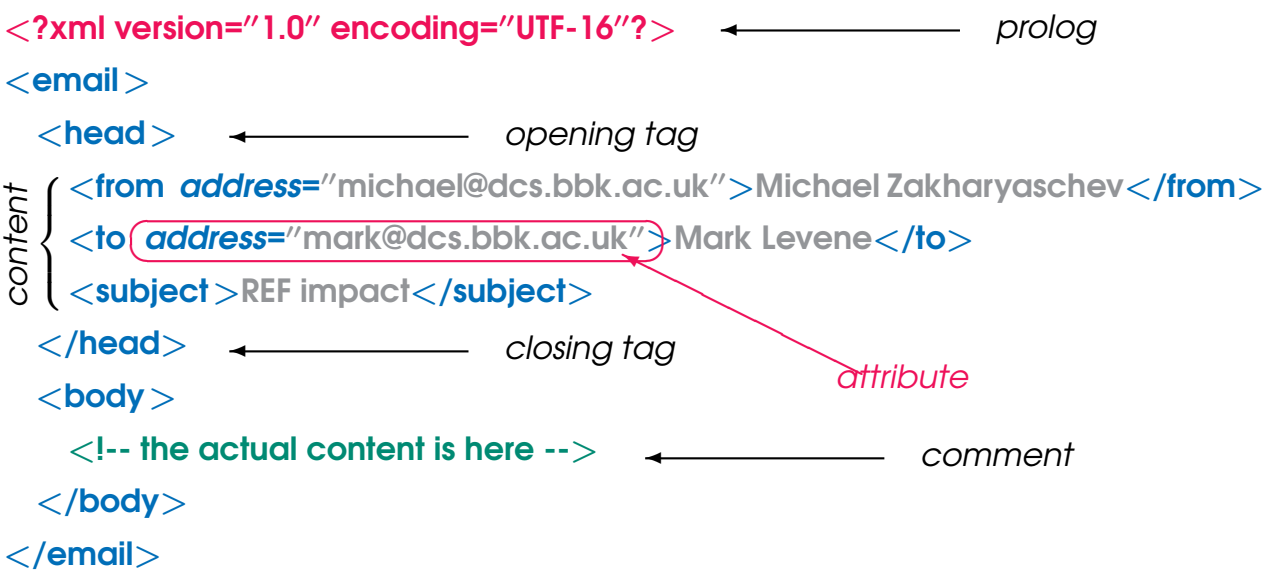

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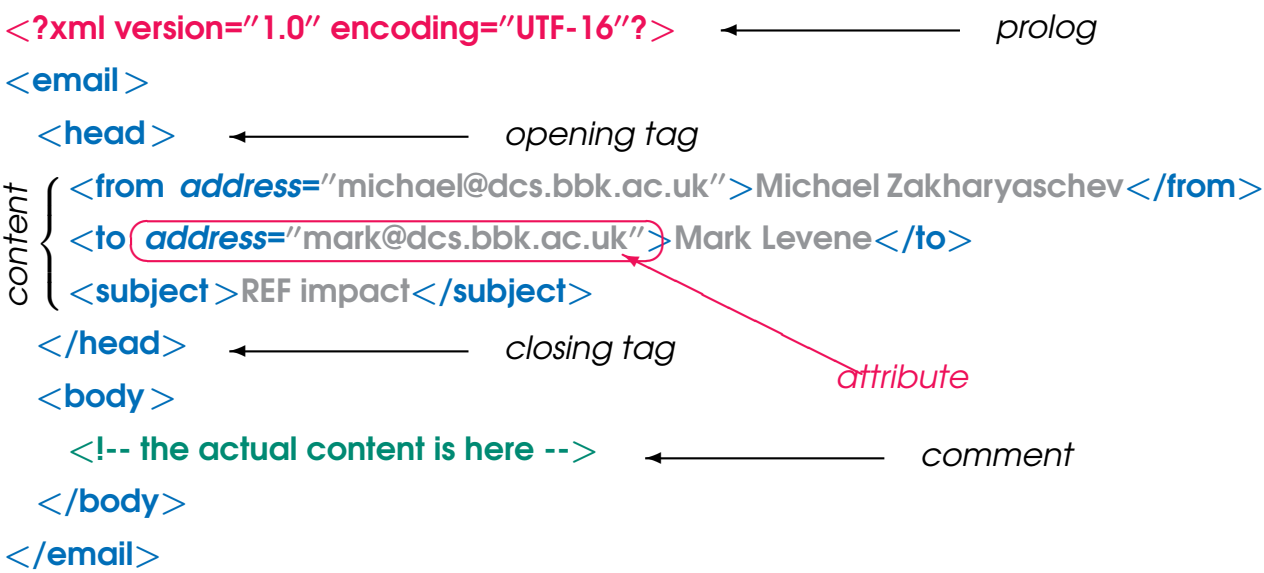

Syntactic correctness: **well-formed XML documents**

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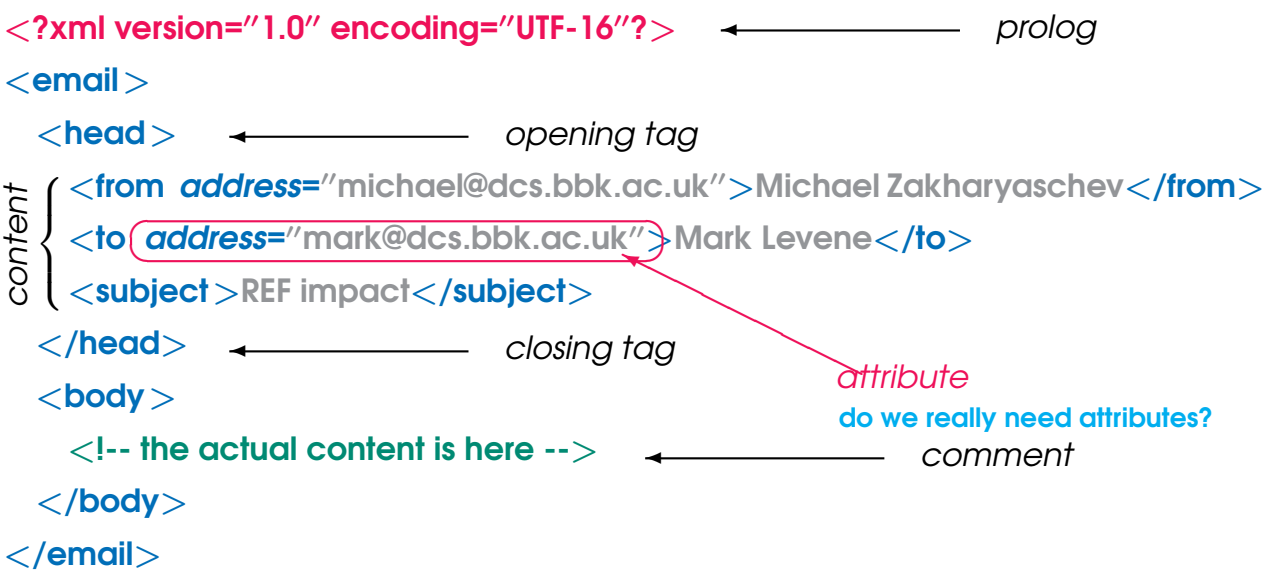

Syntactic correctness: **well-formed XML documents**

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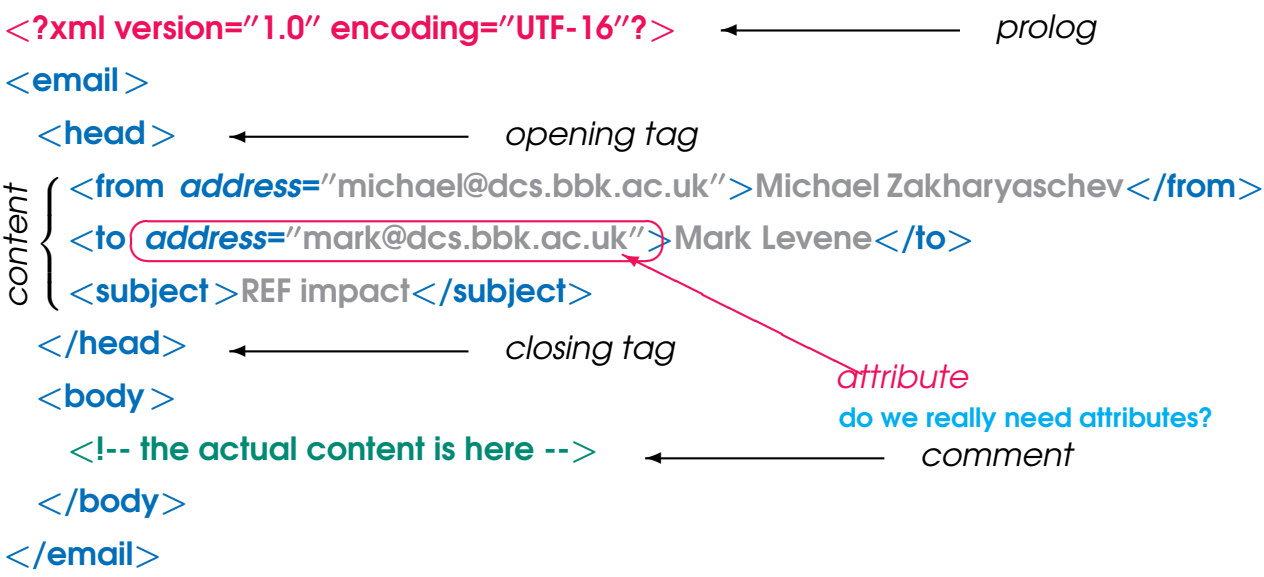
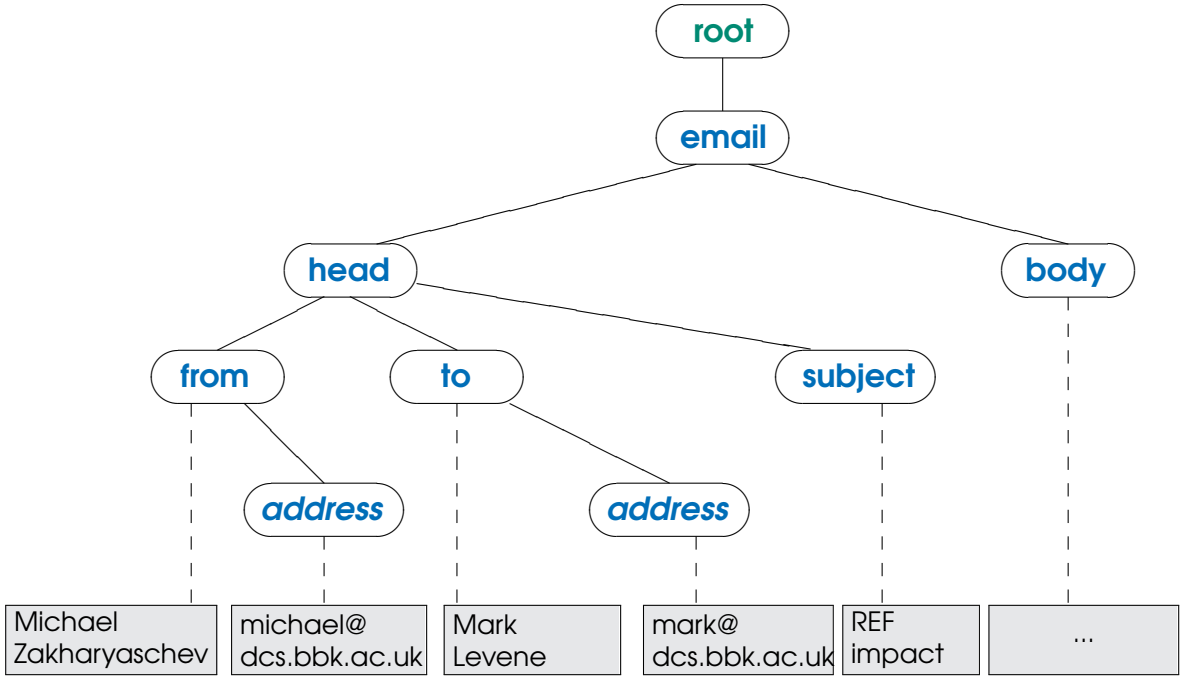


Syntactic correctness: **well-formed XML documents**

NB. XML syntax is not part of this module, but you should be able to 'read' XML documents

The tree model of XML documents

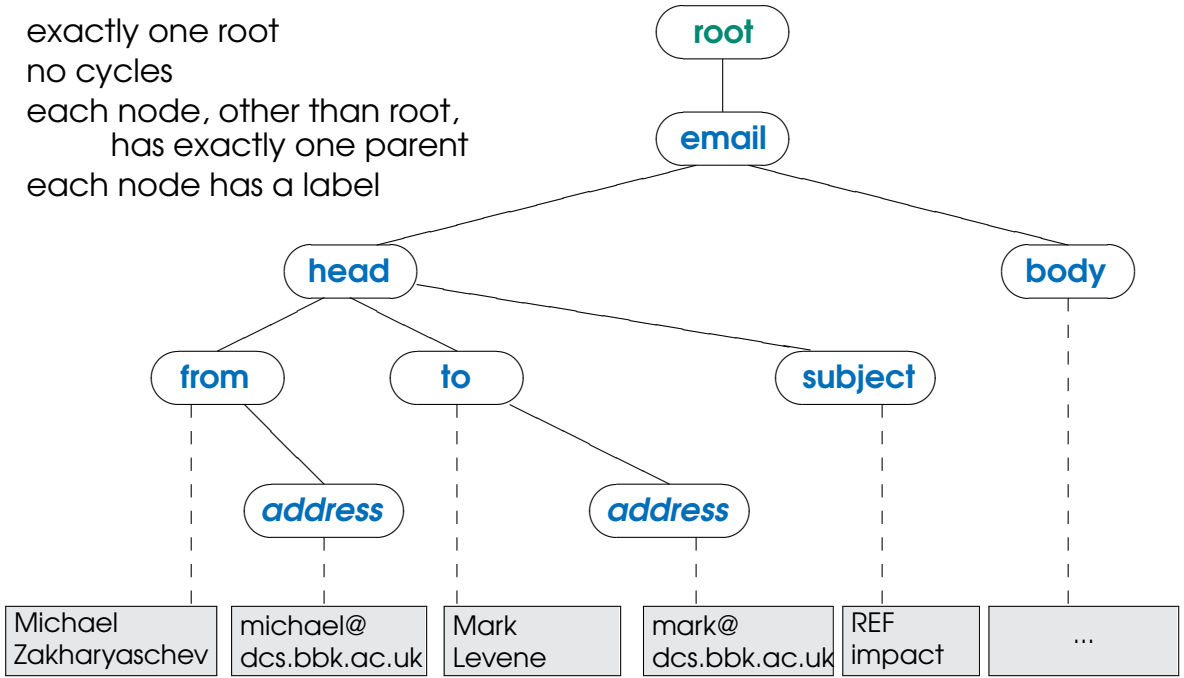
(**tree** is a special type of **graph**)



The tree model of XML documents

(**tree** is a special type of **graph**)

- exactly one root
- no cycles
- each node, other than root, has exactly one parent
- each node has a label



the **order** of elements is **important**

Structuring XML documents

Imagine two applications that try to **communicate**, and that they wish to use the same **vocabulary**.

For this purpose it is necessary to define

- all the element and attribute names that may be used;
- the structure:
  - what values an attribute may take;
  - which elements may or must occur within other elements;
  - etc.

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There are two ways of defining the structure of XML documents:

- Document Type Definition (DTD), used already for SGML documents
- XML Schema, a significantly richer language
  - based on **XML** (DTD uses a separate syntax);
  - provides a sophisticated **set of data types** (DTD is limited to strings only);
  - allows one to define **new types** by extending or restricting existing ones.

XML Schema: example

XML-schema is a document describing the valid format of XML data-sets: what elements are (not) allowed at any point, their attributes, the number of occurrences, etc.

```
<schema xmlns="http://www.w3.org/2001/XMLSchema" version="1.0">
    <element name="email" type="emailType" />

    <complexType name="emailType">
        <sequence>
            <element name="head" type="headType" />
            <element name="body" type="bodyType" />
        </sequence>
    </complexType>

    <complexType name="headType">
        <sequence>
            <element name="from" type="addressType" />
            <element name="to" type="addressType" minOccurs="1"
                                                  maxOccurs="unbounded" />
            <element name="subject" type="string" />
        </sequence>
    </complexType>
    ...
</schema>
```

XML Schema

- elements <element *name*="..." ... />
  - *type*="..."
  - *minOccurs*="x", where x may be any natural number (1 by default)
  - *maxOccurs*="x", where x may be any natural number or unbounded (1 by default)

XML Schema

- elements <element *name*="..." ... />
  - *type*="..."
  - *minOccurs*="x", where x may be any natural number (1 by default)
  - *maxOccurs*="x", where x may be any natural number or unbounded (1 by default)

- attributes <attribute *name*="..." ... />
  - *type*="..."
  - *use*="x", where x may be optional or required
  - *default*="..."
    the attribute is to appear unconditionally with the supplied value used whenever the attribute is not actually present
  - *fixed*="..."
    the attribute value if present must equal the supplied constraint value, and if absent receives the supplied value as for default

XML Schema: data types

- built-in data types: (used in RDF, OWL, etc.)
  - numerical: **integer**, **short**, **byte**, **long**, **float**, **decimal**
  - string: **string**, **ID**, **IDREF**, **language**
  - date and time: **time**, **date**, **dateTime**, ...

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User-defined data types:

- simple data types (**cannot have attributes**)

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User-defined data types:

- simple data types (**cannot have attributes**)

- complex data types
  - **sequence** — a sequence of existing data type elements, the appearance of which in a predefined order is important
  - **all** — a collection of elements that must appear, but the order of which is not important
  - **choice** — a collection of elements, of which one will be chosen.

Namespaces

Problem: name clashes

Namespaces

Problem: name clashes

Solution: different prefix for each schema

prefix:name

```
<?xml version="1.0" encoding="UTF-16"?>
<vu:instructors xmlns:uky="http://www.uky.edu/schema"
                xmlns:gu="http://www.gu.au/schema"
                xmlns:vu="http://www.vu.com/schema">
    <uky:faculty uky:title="lecturer" uky:name="John Smiths" />
    <gu:academicStaff gu:title="lecturer" gu:name="Mate Jones" />
</vu:instructors>
```

- namespace declaration `xmlns:prefix="location"`
- location used by default `xmlns="location"`

A **namespace** is a context in which a group of one or more identifiers might exist. An identifier defined in a namespace is associated with that namespace.

What can XML do?

So far:

XML Does not DO Anything and was not designed to DO anything!
XML document is just pure information wrapped in XML tags.

XSL (eXtensible Stylesheet Language) is a family of recommendations for defining XML document transformation and presentation.

XSL is an XML application. It consists of three parts:

- XSLT — a language for transforming XML documents
- XPath — a language for navigating in XML documents
- XSL-FO — a language for formatting XML documents

For more information visit:

http://www.w3schools.com/xsl/xsl_languages.asp

http://www.w3.org/Style/XSL/

Querying XML documents: XPath

http://www.w3.org/TR/xpath, http://www.w3schools.com/xpath/default.asp

```
<?xml version="1.0" encoding="UTF-16"?>
<library xmlns="http://www.lib.org/schema"
         location="Bremen">

  <author name="Jorge Luis Borges">
    <book title="Labyrinths" />
    <book title="Doctor Brodie's Report" />
    <book title="The Garden of Forking Paths" />
  </author>

  <author name="Adolfo Bioy Casares">
    <book title="The Invention of Morel" />
  </author>

  <author name="Julio Cortázar">
    <book title="Bestiario" />
    <book title="Un tal Lucas" />
  </author>

  ...
</library>
```

Querying XML documents: XPath

http://www.w3.org/TR/xpath, http://www.w3schools.com/xpath/default.asp

XPath expressions

- /library/author

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- /library/author
- //author

  (anywhere in the document)
- /library/@location

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XPath expressions

- /library/author
- //author

  (anywhere in the document)
- /library/@location

  (attribute node)
- //book/@title="Bestiario"

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<?xml version="1.0" encoding="UTF-16"?>
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XPath expressions

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- //author

  (anywhere in the document)
- /library/@location

  (attribute node)
- //book/@title="Bestiario"

  (attribute node)
- //book[@title="Bestiario"]

  (filter expression;
  all books with the title)

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- //author

  (anywhere in the document)
- /library/@location

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  (attribute node)
- //book[@title="Bestiario"]

  (filter expression;
  all books with the title)
- //author[1]

  (the first node)
- //author[1]/book[last()]

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XPath expressions

- /library/author
- //author

  (anywhere in the document)
- /library/@location

  (attribute node)
- //book/@title="Bestiario"

  (attribute node)
- //book[@title="Bestiario"]

  (filter expression;
  all books with the title)
- //author[1]

  (the first node)
- //author[1]/book[last()]

  (the last node)
- //book[not @title]

```
<?xml version="1.0" encoding="UTF-16"?>
<library xmlns="http://www.lib.org/schema"
         location="Bremen">
  <author name="Jorge Luis Borges">
    <book title="Labyrinths" />
    <book title="Doctor Brodie's Report" />
    <book title="The Garden of Forking Paths" />
  </author>
  <author name="Adolfo Bioy Casares">
    <book title="The Invention of Morel" />
  </author>
  <author name="Julio Cortázar">
    <book title="Bestiario" />
    <book title="Un tal Lucas" />
  </author>
  ...
</library>
```

Querying XML documents: XPath

http://www.w3.org/TR/xpath, http://www.w3schools.com/xpath/default.asp

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  (all books without a title)

```
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<library xmlns="http://www.lib.org/schema"
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  </author>

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    <book title="Bestiario" />
    <book title="Un tal Lucas" />
  </author>

  ...
</library>
```

see next page for explanations

XPath syntax

1. **/library/author** addresses all **author** elements that are children of the **library** element, which resides immediately below the root

2. **//author** // means that we should consider **all** elements in the document and check whether they are of type **author**

3. **/library/@location** symbol **@** is used to denote attribute nodes

4. **//book/@title="Bestiario"** addresses all **title** attribute nodes within **book** elements anywhere in the document with value "Bestiario"

5. **//book[@title="Bestiario"]** addresses all books with title "Bestiario"

6. **//author[1]** addresses the first **author** element node in the document

7. **//author[1]/book[last()]** addresses the last **book** element within the first **author** element node in the document

8. **//book[not @title]** addresses all **book** element nodes without a **title** attribute

XML: summary

- XML is a metalanguage that allows users to define markup for their documents using **tags**, a standard syntax for **meta data**.
- Nesting of tags introduces **structure**. The structure of documents can be enforced using **schemas** or DTDs.
- XML **separates** content and structure from formatting.
- XML is the ***de facto* standard** for the representation of structured information on the Web and supports machine processing of information.
- XML is supported by **query languages**.
- XML creates application-independent documents and data.
- XML has become the universal syntax for exchanging data between organisations.

The impact of XML has been so extensive that it can be considered as a **data revolution**.

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The impact of XML has been so extensive that it can be considered as a **data revolution**.

- But is XML powerful enough for the purposes of the Semantic Web?

JSON: JavaScript Object Notation

JSON is an open-standard file format that uses human-readable text to transmit data objects consisting of attribute-value pairs and array data types. It is a very common data format used for asynchronous browser-server communication, including as a **replacement for XML**.

JSON was derived from JavaScript, and many programming languages include code to generate and parse JSON-format data. The official Internet media type for JSON is application/json. JSON filenames use the extension .json.

JSON Schema specifies a JSON-based format to define the structure of JSON data for validation, documentation, and interaction control. It provides a contract for the JSON data required by a given application, and how that data can be modified.

XML is simpler than SGML, but JSON is much simpler than XML. JSON has a much smaller grammar and maps more directly onto the data structures used in modern programming languages.

JSON example: describing a person

```
{
  "firstName":  "John",
  "lastName":  "Smith",
  "isAlive":  true,
  "age":  25,
  "address": {
    "streetAddress":  "21 2nd Street",
    "city":  "New York",
    "state":  "NY",
    "postalCode":  "10021-3100"
  },
  "phoneNumbers":  [
    {
      "type":  "home",
      "number":  "212 555-1234"
    },
    {
      "type":  "office",
      "number":  "646 555-4567"
    },
    {
      "type":  "mobile",
      "number":  "123 456-7890"
    }
  ],
  "children":  [],
  "spouse":  null
}
```