
XML Technologies

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Web pages:

MFF: <http://www.ksi.mff.cuni.cz/~holubova/NPRG036/>

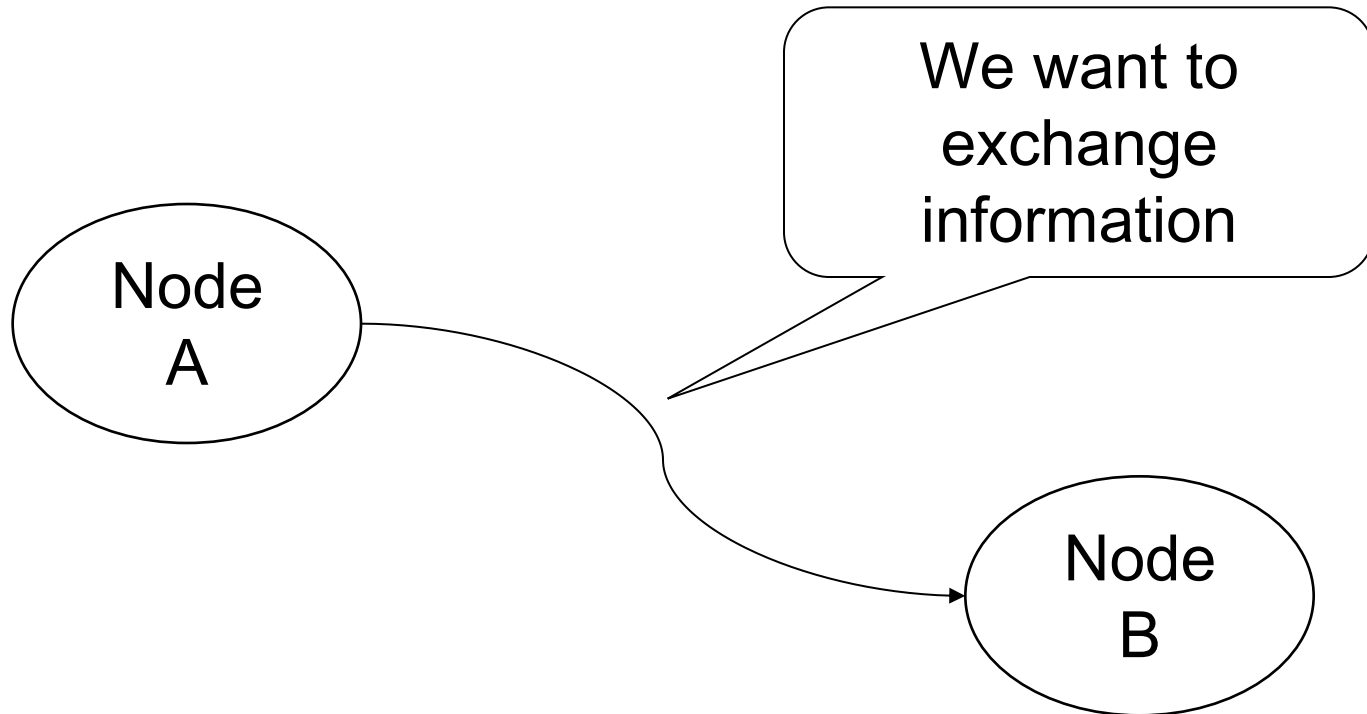
FEL: <http://www.ksi.mff.cuni.cz/~holubova/A7B36XML/>

Outline

- Introduction to XML format, overview of XML technologies
 - DTD
 - XML data models
 - Interfaces for XML data
 - XPath
 - XSLT
 - XQuery, XQuery Update
 - XML schema languages
 - SQL/XML
 - An overview of standard XML formats
 - XML data persistence
-

Introduction to XML format

Motivation



E.g. we want to send a message...

Tim Berners-Lee,
Robert Cailliau

Hi!

My Internet does not work!
Steve J.

P.S. Help me!

... as a unstructured text?

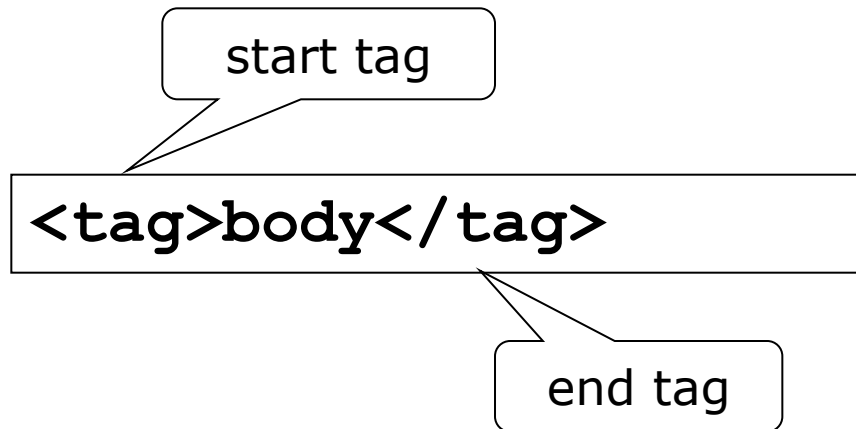
Tim Berners-Lee, Robert Cailliau Hi!
My Internet does not work! Steve J.
P.S. Help me!

... as a unstructured text?

Tim Berners-Lee, Robert Cailliau Hi!
My Internet does not work! Steve J.
P.S. Help me!

But how to find out (automatically)
who sends the message?

Let us introduce tags...



We can tag parts of the message...

```
<address>Tim Berners-Lee</address>  
<address>Robert Cailliau</address>  
<intro>Hi!</intro>  
<text>My Internet does not work!</text>  
<signature>Steve J.</signature>  
<PS>Help me!</PS>
```

data

metadata

And the whole message...

```
<message>
  <address>Tim Berners-Lee</address>
  <address>Robert Cailliau</address>
  <intro>Hi!</intro>
  <text>My Internet does not
work!</text>
  <signature>Steve J.</signature>
  <PS>Help me!</PS>
</message>
```

In general to process the data automatically

To show the correct content in a browser it is not sufficient...

D:\Konference\EurOpen\2004\zprava.xml - Microsoft Internet Explorer

Soubor Úpravy Zobrazit Oblíbené Nástroje Nápověda

Zpět Hledat Oblíbené Média

Adresa D:\Konference\EurOpen\2004\zprava.xml

Stránku XML nelze zobrazit

Vstup XML nelze zobrazit pomocí šablony stylů XSL. Opravte tuto chybu a klepněte na tlačítko [Aktualizovat](#), nebo akci zopakujte později.

V obsahu (content) typu Text byl nalezen neplatný znak. Při zpracování prostředku file:///D:/Konference/EurOpen/2004/zprava.xml došlo k chybě. Řádek 5, pozice 19

```
<text>Pozdrav z
```

```
<message>
  <address>Tim Berners-Lee</address>
  <address>Robert Cailliau</address>
  <intro>Hi!</intro>
  <text>My Internet does not work!</text>
  <signature>Steve J.</signature>
  <PS>Help me!</PS>
</message>
```

We need more information

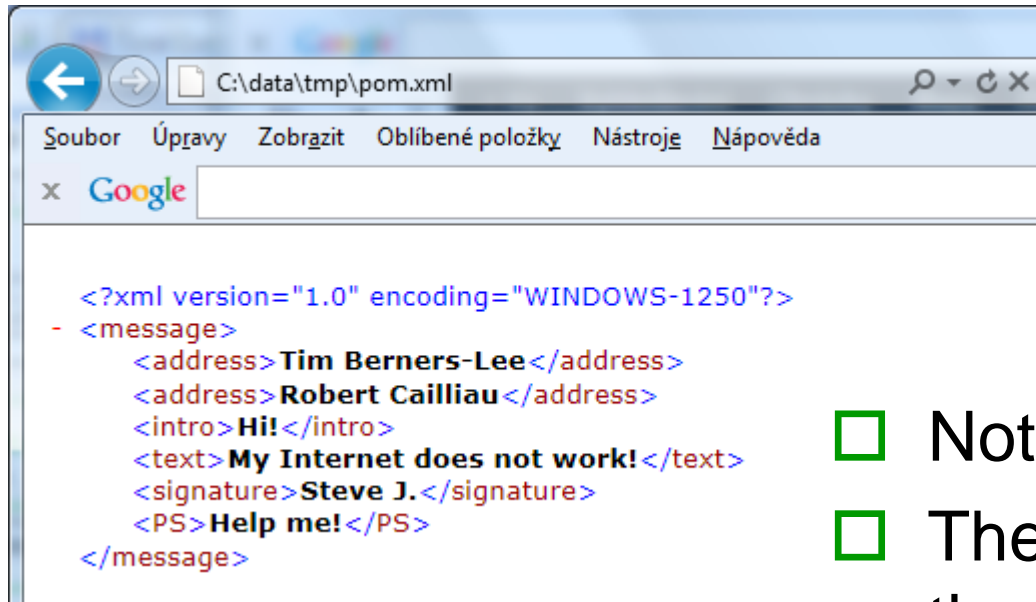
Format:

- XML + version

Encoding:

- By default the document is in ISO 10646 ([Unicode](#))
 - To communicate with the whole world we can use **UTF-8**
 - Compatible with ASCII
 - Contains all characters of all languages
 - For the Czech language we have **ISO-8859-2** or **Windows-1250**
-

Better, but...

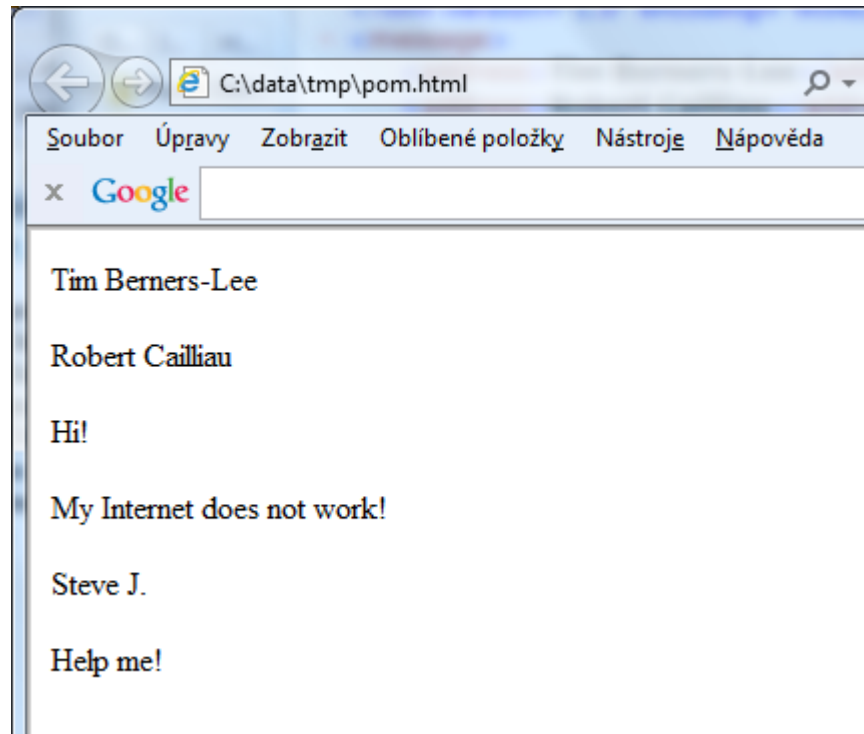


- Not much user friendly
- The browser shows also the meta data

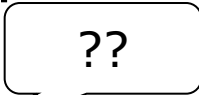
We can, e.g., transform the document into HTML

```
<html encoding="windows-1250">
  <head>
    <title>Message from: Steve J.</title>
  </head>
  <body>
    <p>Tim Berners-Lee</p>
    <p>Robert Cailliau</p>
    <p>Hi!</p>
    <p>My Internet does not work!</p>
    <p>Steve J.</p>
    <p>Help me!</p>
  </body>
</html>
```

Now the browser “knows” what to do with the data



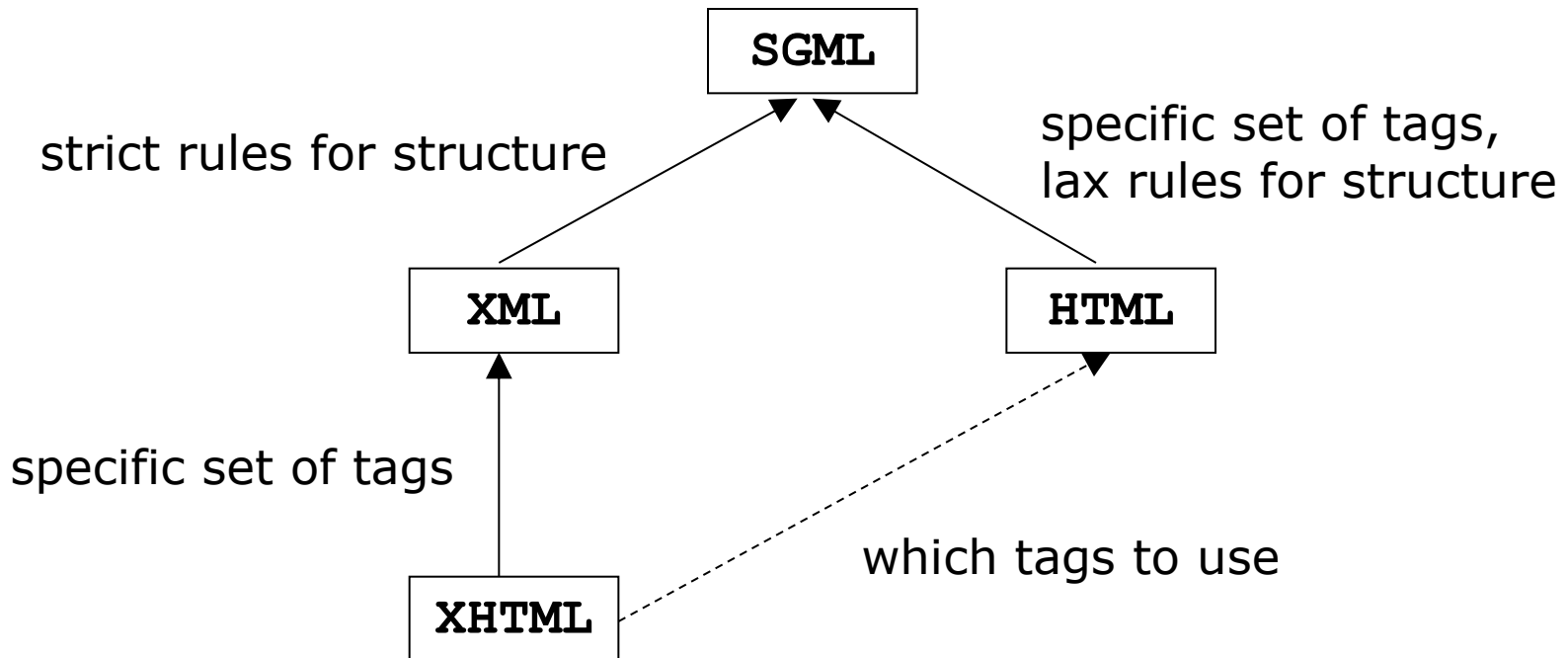
What is the general aim?

- Pure data are hard to process automatically
 - We need to: 
 - Ensure that a particular software understands the data
 - Add meaning (semantics) of particular data fragments
 - E.g. HTML – describes visualization of data for an HTML browser
 - Problem 1: What if we are not interested just in visualization?
 - Problem 2: HTML has lax rules for structure
 - Complex processing
 - Solution: XML
-

XML

- XML (eXtensible Markup Language) is a format for transfer and exchange of general data
 - Extensible Markup Language (XML) 1.0 (Fifth Edition)
 - <http://www.w3.org/TR/xml/>
 - Extensible Markup Language (XML) 1.1 (Second Edition)
 - <http://www.w3.org/TR/xml11/>
 - XML is a subset (application) of SGML (Standard Generalized Markup Language - ISO 8879) – from 1986
 - XML does not deal with data presentation
 - It enables to tag parts of the data
 - The meaning of the tags depends on the author
 - Presentation is one possible example
-

SGML vs. XML vs. HTML vs. XHTML



XML Document

- XML document is **well-formed**, if:
 - It has introductory prolog
 - Start and end tags nest properly
 - Each element has a **start** and an **end tag**
 - Corresponding tags have the same name (case sensitivity)
`<a>`
 - Pairs of tags do not cross
`<a>`
 - The whole document is enclosed in a single **root element**
-

Prolog

- ❑ An information for the SW that it works with an XML document
 - It must contain declaration of XML version
 - ❑ We have 1.0 and 1.1
 - It can contain information about encoding and if the document is standalone
- ❑ Version:
`<?xml version="1.1"?>`
- ❑ Encoding other than UTF-8:
`<?xml version="1.1" encoding="iso-8859-2"?>`
- ❑ Standalone document:
`<?xml version="1.1" standalone="yes"?>`

always lowercase

Elements

```
<?xml version="1.1" encoding="iso-8859-2"?>
<message>
  <address>
    <name>Tim Berners-Lee</name>
    <street>Northern 12</street>
  </address>
  <intro>Hi!</intro>
  <text>My <it>Internet</it> does not work!</text>
  <signature>Steve J.</signature>
  <attachment/>
</message>
```

Element with
element
content

Element with text
content

Element with mixed
content

Empty element

Root element

```
<attachment></attachment>
```

Attributes

```
<?xml version="1.1" encoding="iso-8859-2"?>
<message>
  <address>
    <name>Tim Berners-Lee</name>
    <street>Northern 12</street>
  </address>
  <intro>Hi!</intro>
  <text>My <it>Internet</it> does not work!</text>
  <signature>Steve J.</signature>
  <attachment fig="image01.jpg" />
</message>
```

Element with
an attribute

Attribute
name

Attribute
value

Other Items of XML Document

```
<?xml version="1.1" encoding="iso-8859-2"?>
<message>
  <!-- to whom the message should be sent? -->
  <address>Jan Amos</address>
  <text>
    <![CDATA[
      for (i=0; i < 10; i++)
      {
        document.writeln("<p>Hi!</p>");
      }
    ]]>
  </text>
  <signature>Steve J.</signature>
  <date><?php echo Date("d.m.Y")?></date>
</message>
```

Comment

CDATA
section

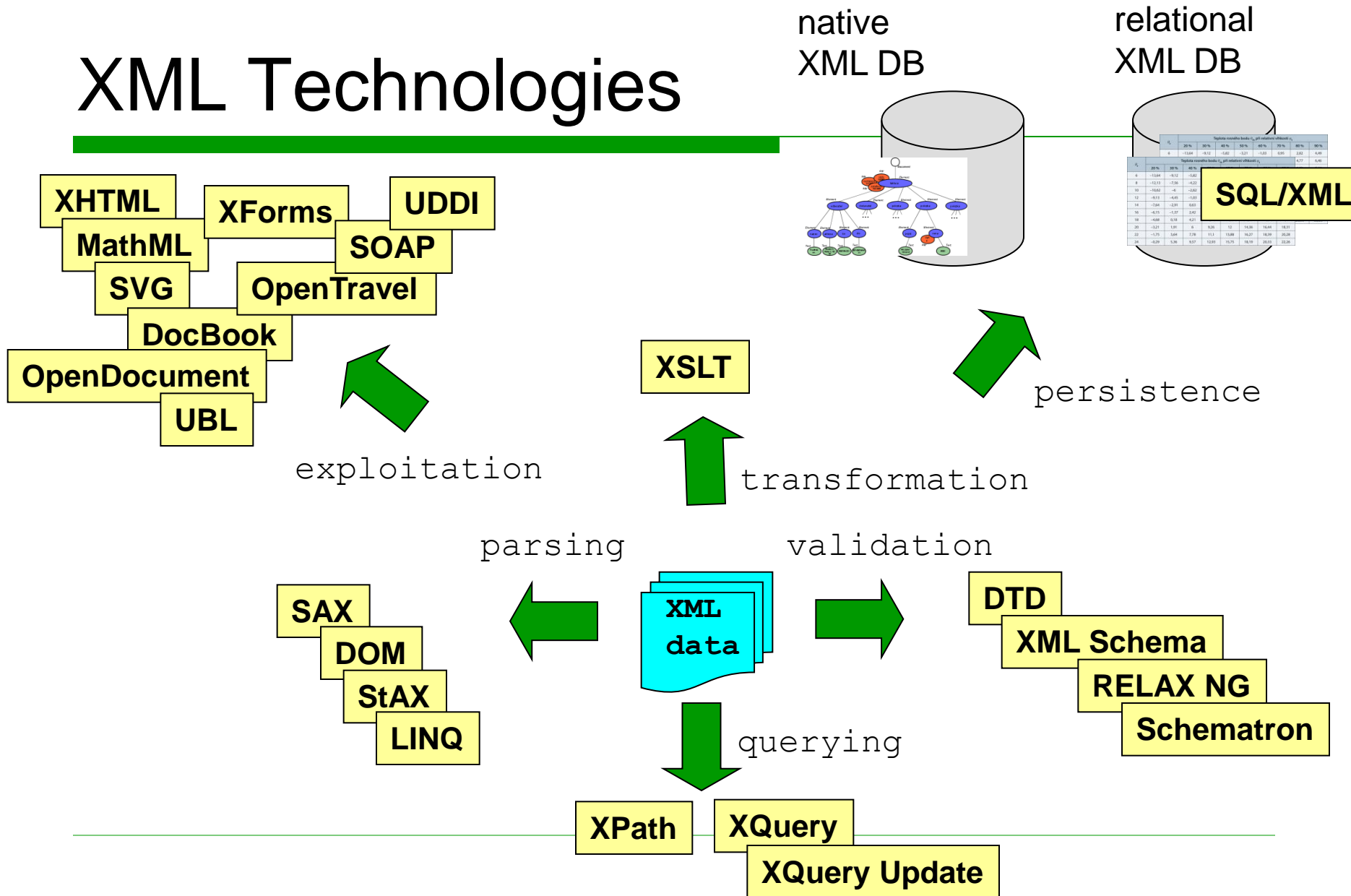
Processing
instruction

XML Technologies

- XML is not only about the tags
 - XML = basic format for data description
 - XML documents
- XML technologies = a family of technologies to process XML data
 - Description of allowed content, data interface, parsing of data, information extraction (querying), transformation into other formats, ...
 - W3C (WWW Consortium) standards
- Efficient implementation of the standards
 - Parsers, validators, query evaluators, XSL transformers, data persistence, ...
- Standard XML formats
 - Where XML is used

<http://www.w3.org/>

XML Technologies





DTD



DTD

- Problem: Well-formedness is insufficient
 - We need to restrict the set of tags and their content
 - Document Type Definition (**DTD**) describes the structure (grammar) of an XML document
 - Using regular expressions
 - **Valid** XML document = well-formed XML document corresponding to a given grammar
 - There are also other languages – **XML Schema**, Schematron, RELAX NG, ...
-

Structure of a Valid Document

```
<?xml version="1.0" ?>  
<!DOCTYPE root-element [  
  ...  
>  
<root-element> ... </root-element>
```

Declaration of a document type

- Can be **internal** (grammar specified within DOCTYPE) or **external** (a reference to a separate file with the grammar)
 - There is no significant use for internal rules
 - Usually only for testing
 - Both can be used at the same time
 - Internal declarations have higher priority
-

Example: external and internal DTD

```
<?xml version="1.0" encoding="UTF-8"?>
<!DOCTYPE greeting [
  <!ELEMENT greeting (#PCDATA)>
]>
<greeting>Hello, world!</greeting>
```

```
<?xml version="1.0"?>
<!DOCTYPE greeting SYSTEM "greeting.dtd">
<greeting>Hello, world!</greeting>
```

```
<?xml version="1.0"?>
<!DOCTYPE html PUBLIC "-//W3C//DTD XHTML 1.0 Strict//EN"
"http://www.w3.org/TR/xhtml1/DTD/xhtml1-strict.dtd">
<html> ... </html>
```

PUBLIC "public identifier" "URI"

Basic DTD Tags

- Document type declaration

<!DOCTYPE ... >

upper case!!

- Element type declaration

<!ELEMENT ... >

- Declaration of a list of attributes

<!ATTLIST ... >

- Declaration of an entity

<!ENTITY ... >

- Declaration of a notation

<!NOTATION ... >

Declaration of an Element Type

```
<!ELEMENT parent (child*)>
```

```
<parent>  
  <child> ... </child>  
  <child> ... </child>  
  ...  
</parent>
```

- Element name + declaration of allowed content
 - Empty, any, text, mixed, element
-

Declaration of an Element Type

,	... sequence
	... selection
?	... iteration (0 or 1)
+	... iteration (1 or more)
*	... iteration (0 or more)

- Empty content
<!ELEMENT attachment EMPTY>
- Any content
<!ELEMENT container ANY>
- Text content
<!ELEMENT surname (#PCDATA)>
- Mixed content
<!ELEMENT text (#PCDATA | it | bold)*>
- Element content
<!ELEMENT message (address, text)>

(name, (author | editor)?, p*, (title, p+)*)

Declaration of an Attribute


The order is in the document arbitrary

```
<!ATTLIST person number ID #REQUIRED
              employed CDATA #FIXED "yes"
              holiday (yes|no) "no">
```

- Attributes of element **person**
- Attribute **number** is a unique ID and compulsory (#REQUIRED)
- Attribute **employed** contains text (CDATA), it has a constant value (#FIXED) „yes“
- Attribute **holiday** can have one of the given values („yes“ or „no“), implicit value is „no“

???

Data Types of Attributes

- ❑ CDATA – arbitrary text string
 - ❑ Enumeration of values
 - ❑ ID – unique identifier (**within the content of the document**), it must be a string of letters, numbers and characters „-“, „_“, „.“, „:“, „_“, preferably in ASCII, it must start with a letter or character „_“
 - ❑ IDREF – reference to an ID of any element in the document
 - ❑ IDREFS – list of references (delimited with white spaces) to IDs
 - ❑ NMTOKEN – string similar to ID, not unique, can start with a number
 - ❑ NMTOKENS – list of NMTOKENs
 - ❑ ENTITY – link to an external **entity** 
 - ❑ ENTITIES – list of links to external entities
-

Presence of Attributes

- ❑ #REQUIRED – the attribute is compulsory
 - ❑ #IMPLIED – the attribute is optional
 - ❑ #FIXED – the attribute has a fixed value
-

Entity Declaration

- In practice only the trivial cases are usually used
- Entity = association of a name and a value which is later (repeatedly) used
- Classification 1:
 - Parsed = the text which replaces the link to an entity becomes a part of the document
 - We refer using references
 - Unparsed = a resource which can contain anything (e.g. binary data = an image, a video)
 - We refer using attributes of type ENTITY/ENTITIES
 - It must be associated with a **notation**
- Classification 2:
 - General – in XML documents
 - Parameter – in DTDs
- Classification 3: Internal vs. external



later

Character Entities

- A possibility to insert a character with any code
 - Hexadecimal or decimal

```
Solve inequality 3x &#x3C; 5
```

- Pre-defined entities for special characters

```
Solve inequality 3x &lt; 5
```

&	... amp
<	... lt
>	... gt
'	... apos
"	... quot

General Entity

- Internal (hence of course parsed) entity
 - Usage: Repeating parts of XML documents

```
<!ENTITY status "working draft">
```

```
<note>The current status of the  
document is &status;</note>
```

- External parsed entity
 - Usage: Modularity of XML documents

```
<!ENTITY xml-serial SYSTEM "xml-serial.txt">
```

General Entities

- External **unparsed** entity
 - Usage: Reference to non-XML data

or PUBLIC

```
<?xml version="1.0" encoding="windows-1250"?>
<!DOCTYPE message [
  <!NOTATION avi SYSTEM
    "C:/Program Files/Video Player/Player.exe">
  <!ENTITY video SYSTEM "video.avi" NDATA avi>
  <!ELEMENT video-holiday (#PCDATA)>
  <!ATTLIST video-holiday src ENTITY>
]>
```

Declaration of a notation

```
<message>I enclose the <video-holiday
src="video">video</video-holiday> from
holiday.</message>
```

Parameter Entity

□ Internal entity

- Usage: repeating parts of DTDs

!!!

```
<!ELEMENT rental (car*)>
<!ENTITY % attributes
    "color (blue|white|black) #REQUIRED
    speed (high|low) #IMPLIED" >
<!ELEMENT car (#PCDATA)>
<!ATTLIST car %attributes; >
<!ELEMENT motorcycle (#PCDATA)>
<!ATTLIST motorcycle %attributes; >
<!ELEMENT bike (#PCDATA)>
<!ATTLIST bike %attributes; >
```


Parameter Entity

- External entity
 - Usage: Modularity of DTDs

```
<!ENTITY % ISOLat2 SYSTEM "iso-pub.ent">  
...  
%ISOLat2;  
...
```

Conditional Sections

```
<![ENTITY % draft 'INCLUDE' ]>
<![ENTITY % final 'IGNORE' ]>

<![%draft;[
<![ELEMENT book (comments*, title, body,
supplements?)]>
]]>
<![%final;[
<![ELEMENT book (title, body, supplements?)]>
]]>
```

DTD – Bigger Example

```
<!ELEMENT employees (person)+>
<!ELEMENT person (name, email*, relations?)>
  <!ATTLIST person id ID #REQUIRED>
  <!ATTLIST person note CDATA #IMPLIED>
  <!ATTLIST person holiday (yes|no) "no">
<!ELEMENT name ((first, surname)|(surname, first))>
<!ELEMENT first (#PCDATA)>
<!ELEMENT surname (#PCDATA)>
<!ELEMENT email (#PCDATA)>
<!ELEMENT relations EMPTY>
  <!ATTLIST relations superior IDREF #IMPLIED>
  <!ATTLIST relations subordinates IDREFS #IMPLIED>
```

The End
