XML as a Semistructured Data Model

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Overview

- What is “Semistructured Data”?
- Basic ideas and goals of XML?
- data model, representation ...

Relational Data Model

- database = schema + contents
- schema/metadata: relation names, attributes
- contents: tupels

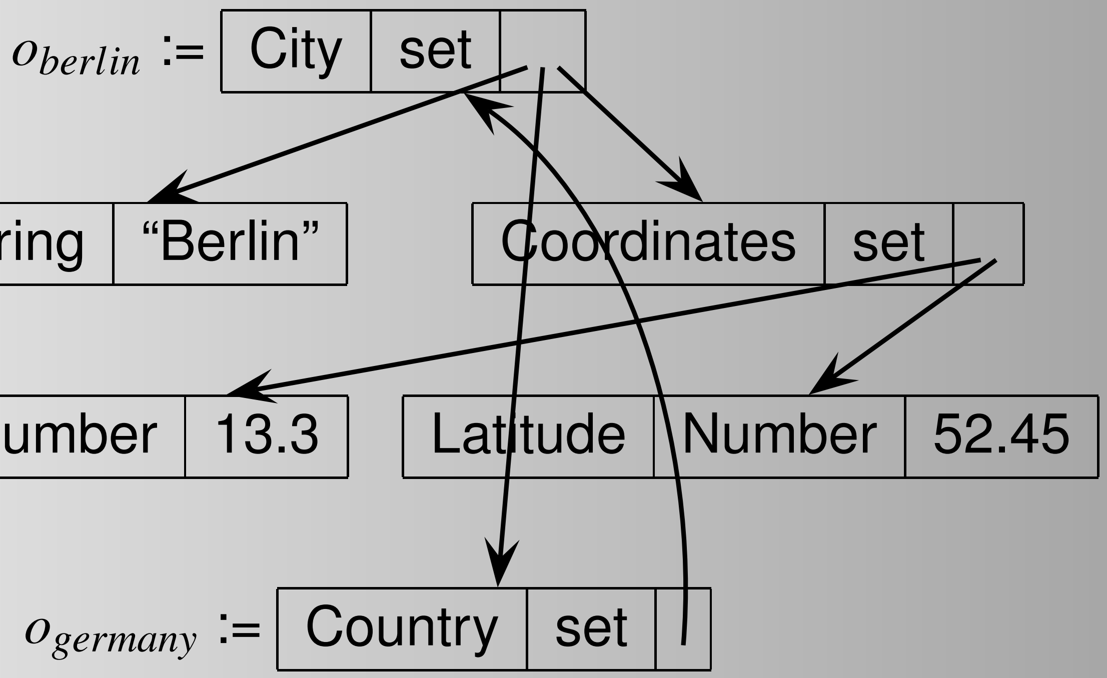
Country				
Name	**code**	**Population**	**Capital**	**...**
Germany	D	83536115	Berlin	..
Belgium	B	10170241	Brussels	..
Canada	CDN	28820671	Ottawa	..
..	..	..	..	..

Semistructured Data

- less fixed schema
- self-describing – metadata are contained in the data

OEM: Object Exchange Model (U Stanford, 1995)

- each object has a label, a type, and a value,
- complex values are represented as sets of references



o_{berlin} := City set

Name String “Berlin”

Coordinates set

Longitude Number 13.3

Latitude Number 52.45

$o_{germany}$:= Country set

Document Data Model

- tree-like, nested
- flexible schema, certain structuring elements

  document = contents + markup
- markup-languages
  - logical markup: sectioning ⇒ tree structure
  - optical markup: fonts, colors
- well-known examples: HTML, $\LaTeX$
- logical markup satisfies predefined constraints

HTML Example

```
<HTML>
    <HEAD><TITLE>Lecture: Computer Science I </TITLE></HEAD>
    <BODY>
        <H1>Computer Science I</H1>
        <UL><LI>Introduction </LI>
               <LI>Java</LI>
               <LI>Data Structures</LI>
        </UL>
        <P>Schedule:
        </P>
        <TABLE>
              <TR><TH>Date</TH><TH>Topic</TH></TR>
              <TR><TD>1.1.01</TD><TD><FONT COLOR="RED">Holiday</FONT></TD></TR>
              <TR><TD>8.1.01</TD><TD>Intro UNIX</TD></TR>
        </TABLE>
    </BODY>
</HTML>
```

XML: Requirements and Goals ($\sim$ 1996)

Processing and representation of semistructured data

Combination of

- database applications
  relational DB/SQL, OODB/OQL, OEM/OQL ...
  query languages, efficiency for large data sets
- document management
  SGML, HTML, transformation languages

⇒ flexible, expressive data model/language

Idea: data as contents + markup

SGML: expressive, flexible, complex

HTML: simple, concise, non-flexible

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eXtensible Markup Language

“HTML with freely definable tags”

XML Example: MONDIAL

```
<mondial>
 <country car_code=“B”
   area=“30510” capital=“cty-Brussels”
   memberships=“org-eu org-nato ..”>
   <name>Belgium</name>
   <population>
     10170241
   </population>
   <city id=“cty-Brussels”
     country=“B”>
     <name>Brussels</name>
     <population year=“95”>
       951580
     </population>
   </city>
   :
 </country>
```

```
 <organization id=“org-eu” abbrev=“EU”
     headq=“cty-Brussels”>
   <name>Europ. Union</name>
   <abbrev>EU</abbrev>
   <members type=“member”
     country=“GR F E A D I B L . . . ”/>
   <members type=“applicant”
     country=“AL CZ . . . ”/>
 </organization>
 <organization id=“org-nato” abbrev=“NATO”
   headq=“cty-Brussels” . . . >
   :
 </organization>
 :
 :
 :
</mondial>
```

XML: Requirements and Goals

Much more than “only” a markup language is required.
XML is more than only the Extensible Markup Language:

- The Markup Language serves only as string representation of XML data
  - compare (since early/mid 2000s): JSON (JavaScript Object Notation)
    - string representation of objects ... convertible into JavaScript objects
    - (actually, similar to the 1990s ODMG/CORBA “OIF – object interchange format” idea – the CORBA architecture itself was a middleware predecessor of the 2000s Web Services)
- The XML world provides much more ...

XML: Requirements and Goals

Processing and representation of semistructured data

- flexible, expressive language: XML ✓
  - storage, queries
  - browsing, presentation

  ⇒ data model

  ⇒ efficient data structures and algorithms

  ⇒ several kinds of languages to handle XML data
- “Internet-wide” data format
  - distributed, autonomous data sources

    ⇒ standardization of interfaces
  - Electronic Data Interchange (cf. ODMG/CORBA)

    simple data transmission

    ⇒ string representation (Unicode)

XML as a Data Model/Data Structure

- relational data model is a data structure

compare: data structure “List”

- textual specification:
  A list is a sequence of elements ...
- abstract datatype:
  specifies a signature of operations and their algebraic specification (basic data manipulation language):
  create an empty list, append to a list, search in a list, . . .
- implementations in class libraries
- representation as a character string:
  [1,4,9,16,25,36,49,63,81]

The XML Data Model

“XML” is defined analogously:

- Idea: an abstract data model
  what information is contained in an XML document?
  W3C XML Information Set
- abstract datatype and implementations
  which operations?
  W3C Document Object Model (DOM)
- a character string representation
  how is XML data represented?
  data exchange format
  W3C XML

+ several languages to work with this data model

The Abstract XML Data Model

- an XML *instance* is a tree
  (optionally also regarded as a nested structure)
- consisting of a lot of *nodes*
- of different *node types*.
- node type *document*: a distinguished root element.
- node type *element*: the tree structure consists of elements:
  - *element type* e.g. TABLE or country
  - *element contents*, among other things consisting of *subelements*
    (⇒ recursive structure),
    TABLE: TR-subelements; these again have TH and TD subelements
- node type *text*: most simple nodes in the element contents; text nodes are leafs.

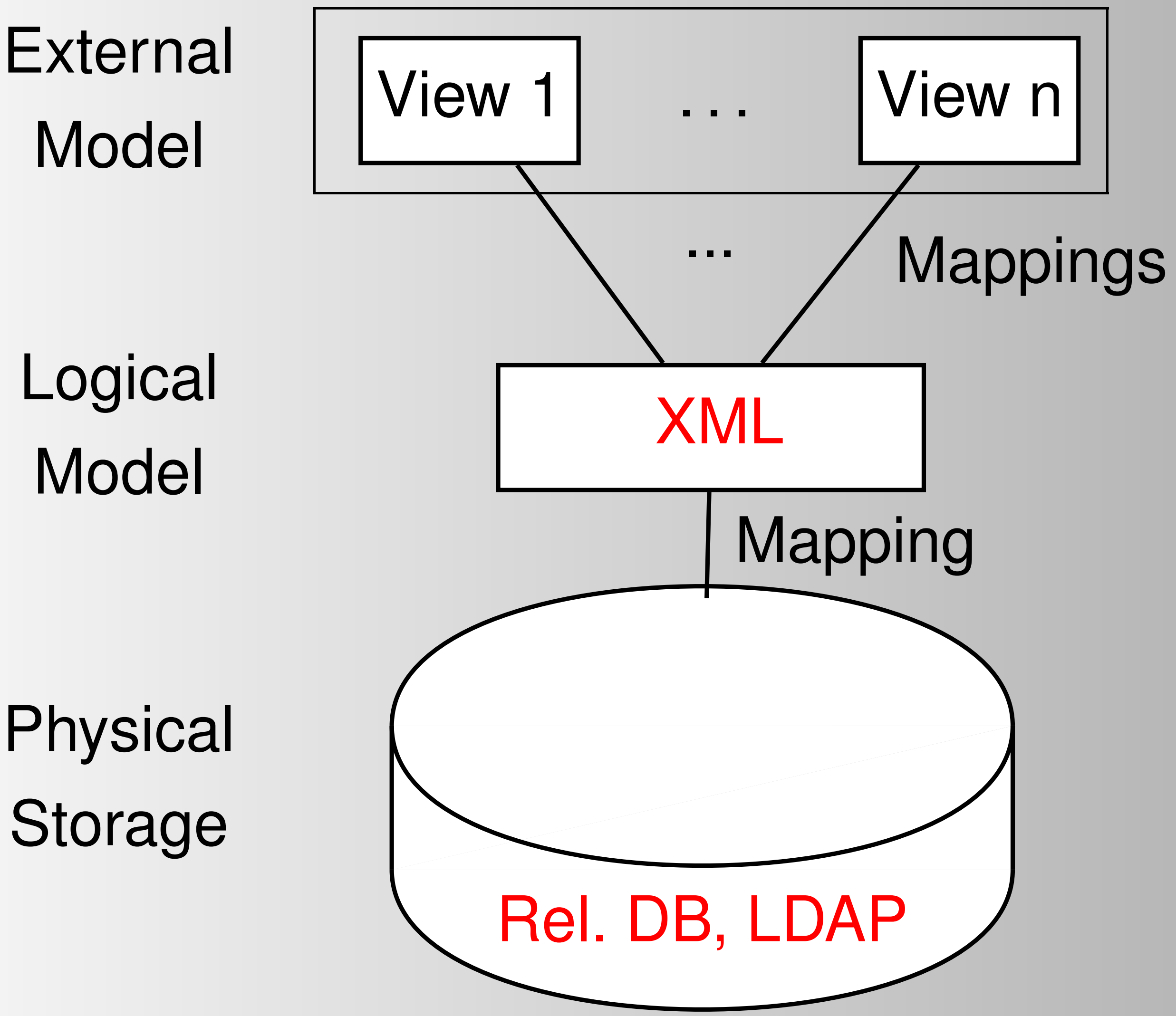
The Abstract XML Data Model (cont'd)

- node type *attribute*: elements may have attributes
  - each *attribute node* is a (name, value)-pair:
  - it has an *attribute name* – color, car_code
  - and an attribute value – “red”, “D”
  - different *attribute types*:
    (abbrev, “EU”), (area, “30510”): CDATA,
    (car_code, “D”), (id, “cty-Brussels”), (id, “org-eu”): ID,
    (capital, “cty-Brussels”): IDREF,
    (members, “B D F”): IDREFS
- for text contents and attribute values: basic XML as a document format makes no distinction between strings, numbers, etc. – everything is a just a string.

The Document Object Model (DOM)

- defines a system of abstract datatypes:
  - Document
  - Element
  - Attribute
  - constructors
  - accessors, e.g. on elements:
    - return the type of the element (“country”, “population”)
    - traversing all child nodes (iterator)
    - access to attribute nodes (set + iterator)
- (reference) implementations in C++ (libxml) and Java
- different internal storage variants

3-Level Architecture of DBS



- Queries
- Export

- optional: Schema

The Character String Representation

- uses the same format as known from HTML
  - tags as parentheses <country>...</country>
  - text contents
    <country><name>Germany</name></country>
  - attributes <country car_code="D">...</country>
- can be kept in a file; is "human-readable"; can be edited;
- can be transmitted by simplest communication protocols;
- independent from
  - operating system
  - actual XML implementation
- is only one representation of XML data
- (from file or via data exchange) – must be parsed into a suitable (e.g. DOM) data structure before actual data processing

XML Interfaces and Languages

Outlook to the next lessons:

“Family” of concepts around XML

- XML: definitions and details
- query languages
  - XPath: addressing, navigation
  - XQuery: queries (analogous to SQL)
- schema definition and description languages
  - DTDs: document-oriented XML applications
  - XML Schema: database-oriented XML
- transformation languages
  - XSL / XSLT stylesheets
- and some more