Semi-Structured Data and XML

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Information Integration - I

Problem: related data exists in many places. They talk about the same things, but differ in model, schema, conventions (*e.g.*, terminology).

How should one retrieve data from different places?

Examples:

In the real world, every bar has its own database.

- ✓ Some may have relations like beer-price; others have a Microsoft Word file from which the menu is printed.
- ✓ Some keep phones of manufacturers but not addresses.
- ✓ Some distinguish beers and ales; others do not.

Information Integration - II

- ✓ Warehousing:
  Store copies of information from each data source centrally, combine into a global schema. Query data stored at the warehouse. Reconstruct (recopy) data daily/weekly/monthly, but do not try to keep it up-to-date.

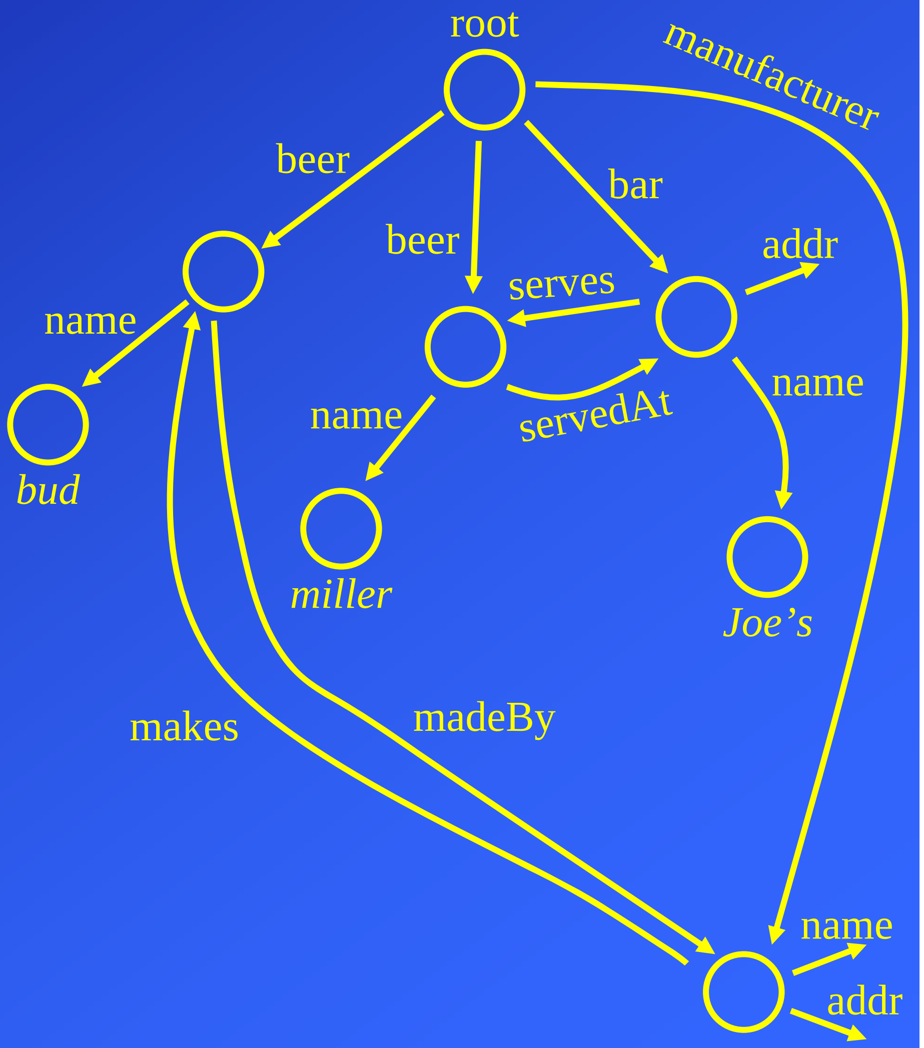
- ✓ Mediation:
  Create a view of all information, but do not make copies. Answer queries by sending appropriate queries to sources (no local data).

Semi-Structured Data

- ✓ Semi-structured data model allows information from several sources, with related but different properties, to be fit together in one whole. Thus, suitable for
  - ➢ integration of databases
  - ➢ sharing information on the Web
- ✓ Semi-structured data is data that may be irregular or incomplete and have a structure that may change rapidly or unpredictably.
  - ➢ It generally has some structure, but does not conform to a fixed schema
  - ➢ "Schemaless" and self-describing, i.e., data carries information about its own schema (e.g., in terms of XML element tags)
- ✓ Characteristics
  - ➢ Heterogeneous
  - ➢ Irregular structure
  - ➢ Large evolving schema
- ✓ Major application: XML documents

Semi-Structured Data:
Graph Representation

- ✓ Collection of nodes
  - ➢ Atomic values on *leaf* nodes
  - ➢ *Interior* nodes have one or more arcs
- ✓ Nodes connected in a general rooted graph structure
- ✓ Labels on arcs
  - ➢ name of attribute/type
  - ➢ relationship
- ✓ Example: Beer-Bar-Manufacturer



Extensible Markup Language (XML)

Data Models & Database System Architectures
- Chronological Overview -

✓	Network Data Models	(1964)
✓	Hierarchical Data Models	(1968)
✓	Relational Data Models	(1970)
✓	Object-oriented Data Models	(~ 1985)
✓	Object-relational Data Models	(~ 1990)
✓	***Semistructured Data Models (XML 1.0)***	***(~1998)***

Extensible Markup Language (XML)

- ✓ Standard of the World Wide Web Consortium (W3C) in 1998
- ✓ An XML document is only a file of characters
- ✓ Similar to HTML, but
  - ➢ HTML uses tags for *formatting* (e.g., “italic”).
  - ➢ XML uses tags for *structure* (e.g., “this is an address”).
- ✓ Two modes:
  - ➢ *Well-formed XML* allows you to invent your own tags, much like labels in semi-structured data.
  - ➢ *Valid XML* involves a Document Type Definition (DTD) that tells the labels and gives a grammar for how they may be nested.

XML:
Tags

- ✓ Tags are text surrounded by brackets, i.e., <. . .>
- ✓ Tags come in matching pairs, e.g.,
  <FOO> is balanced by </FOO>
- ✓ Nesting allowed (start and end in same range), e.g.,
  <BAR> <NAME></NAME> </BAR>
- ✓ Unbalanced tags not allowed, e.g.,
  <P>, <BR>, and <HR> in HTML

XML:
Well-Formed XML

- ✓ Minimal requirement:
  XML declaration and root tags surrounding entire body

```
<? XML VERSION = "1.0" STANDALONE = "yes" ?>
<XXX>
                .....
</XXX>
```

NOTE 1:
XML version

NOTE 2:
there is no DTD specified

XML:
Well-Formed XML: Example

```
<?XML VERSION = "1.0" STANDALONE = "yes"?>
<BARS>
      <BAR>  <NAME>Joe's Bar</NAME>
             <BEER> <NAME>Bud</NAME>
                    <PRICE>2.50</PRICE>
             </BEER>
             <BEER> <NAME>Miller</NAME>
                    <PRICE>3.00</PRICE>
             </BEER>
      </BAR>
      <BAR>
             ...
      </BAR>
</BARS>
```

NOTE 1:
only balanced tags

NOTE 2:
value between two surrounding tags

NOTE 3:
nesting within the same range

XML:
Document Type Definitions (DTD)

- ✓ Essentially a grammar describing the legal nesting of tags
- ✓ Intention is that DTD’s will be standards for a domain, used by everyone preparing or using data in that domain
  Example: a DTD for describing protein structure; a DTD for describing bar menus, etc.
- ✓ Structure of a DTD:

```
<!DOCTYPE root tag [
        <!ELEMENT name (components)>
        ... more elements ...
]>
```

- ✓ The root-tag is used to surround the document which uses these rules

XML: Elements of a DTD

- ✓ An *element* is a name (its tag) and a parenthesized description of tags within an element.
- ✓ Special case: `(#PCDATA)` after an element name means it is text.
- ✓ Each element name is a tag.
- ✓ Its components are the tags that appear nested within, in the order specified.
- ✓ Multiplicity of a tag is controlled by:
  1. `*` = zero or more of.
  2. `+` = one or more of.
  3. `?` = zero or one of.
- ✓ In addition: | = "or."

XML:
DTD: Example

```
<!DOCTYPE Bars [
    <!ELEMENT BARS (BAR*)>
    <!ELEMENT BAR (NAME, BEER+)>
    <!ELEMENT NAME (#PCDATA)>
    <!ELEMENT BEER (NAME, PRICE)>
    <!ELEMENT PRICE (#PCDATA)>
]>
```

NOTE 1:
BARS is root-tag

NOTE 2:
multiplicity of tags

NOTE 3:
name (and price) has a text value

NOTE 4:
Inside <BARS>-tag we'll find zero or more <BAR>-tags

NOTE 5:
a BAR has a name and serves one or more beers (which again has components)

XML:
Using a DTD

- ✓ To use a DTD, set `STANDALONE = "no"`:

```
<?XML VERSION = "1.0" STANDALONE = "no"?>
```

- ✓ Either
  - ➢ Include the DTD as a preamble, or
  - ➢ Follow the `XML` tag by a `DOCTYPE` declaration with the root tag, the keyword `SYSTEM`, and a file where the DTD can be found.

XML:
Using a DTD: Example

```
<?XML VERSION = "1.0" STANDALONE = "no"?>
<!DOCTYPE Bars SYSTEM "bar.dtd">
   <!ELEMENT BARS (BAR*)>
   <!ELEMENT BAR (NAME, BEER+)>
   <!ELEMENT NAME (#PCDATA)>
   <!ELEMENT BEER (NAME, PRICE)>
   <!ELEMENT PRICE (#PCDATA)>
]>
<BARS>
   <BAR><NAME>Joe's Bar</NAME>
        <BEER> <NAME>Bud</NAME>
               <PRICE>2.50</PRICE></BEER>
        <BEER> <NAME>Miller</NAME>
               <PRICE>3.00</PRICE></BEER>
   </BAR>
   <BAR> ...
</BARS>
```

NOTE 1:
DTD may be in a separate file

NOTE 2:
DTD may be included as a preamble

NOTE 3:
BARS is root-tag and surround the document which uses these rules

NOTE 4:
BEER has a name and a price

NOTE 5:
BAR has a name and serves one or more beers.

XML:
Attribute Lists

- ✓ Opening tags can have “arguments” that appear within the tag, in analogy to constructs like `<A HREF = ...>` in HTML.

- ✓ Keyword `!ATTLIST` introduces a list of attributes and their types for a given element in the DTD.

- ✓ Example of declaration:

```
<!ELEMENT BAR (NAME BEER*)>
<!ATTLIST BAR type = "sushi" | "sports" | "other">
```

- ✓ Bar objects can have a type, and the value of that type is limited to the three strings shown.

- ✓ Example of use:

```
<BAR type = "sports">
        . . .
</BAR>
```

XML:
ID’s and IDREF’s

- ✓ `ID` is used to give a unique name for an element/object

- ✓ `IDREF` is used to provide pointers to elements/object (by the `ID`-name), and multiple object references within one tag is allowed. `IDREFS` is used if there might be a set of references

- ✓ Analogous to `NAME = foo` and `HREF = #foo` in HTML

- ✓ Allows the structure of an XML document to be a general graph, rather than just a tree.

XML:
ID’s and IDREF’s: Example

✓ Let us include in our `Bars` document type elements that are the manufacturers of beers, and have each beer object link, with an `IDREF`, to the proper manufacturer object:

```
<!DOCTYPE Bars [
     <!ELEMENT BARS (BAR*)>
     <!ELEMENT BAR (NAME, BEER+)>
     <!ELEMENT NAME (#PCDATA)>
     <!ELEMENT MANUFACTURER (ADDR,...)>
           <!ATTLIST MANUFACTURER (name ID)>
     <!ELEMENT ADDR (#PCDATA)>
     <!ELEMENT BEER (NAME, PRICE)>
           <!ATTLIST BEER (manf IDREF)>
     <!ELEMENT PRICE (#PCDATA)>
]>
...
<MANUFACTURER name= ="X">...</MANUFACTURER>
...
<BEER manf="X"><NAME>Bud</NAME><PRICE>2.50</PRICE></BEER>
```

NOTE 1:
`MANUFACTURER` has a name-`ID`

NOTE 2:
`BEER` has a poiner to a manufacturer

NOTE 3:
The `IDREF` value in `BEER` equals the `ID` value in the corresponding `manufacturer`

Summary

- ✓ Semi-structured data
- ✓ Extensible Markup Language (XML)