XML

Semistructured Data

Extensible Markup Language

Document Type Definitions

Framework

1. *Information Integration* : Making databases from various places work as one.
2. *Semistructured Data* : A new data model designed to cope with problems of information integration.
3. *XML* : A standard language for describing semistructured data schemas and representing data.

The Information-Integration Problem

- Related data exists in many places and could, in principle, work together.
- But different databases differ in:
  1. Model (relational, object-oriented?).
  2. Schema (normalized/unnormalized?).
  3. Terminology: are consultants employees? Retirees? Subcontractors?
  4. Conventions (meters versus feet?).

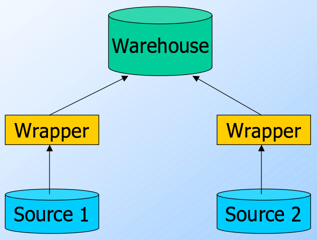
Example

- Every bar has a database.
  - One may use a relational DBMS; another keeps the menu in an MS-Word document.
  - One stores the phones of distributors, another does not.
  - One distinguishes ales from other beers, another doesn't.
  - One counts beer inventory by bottles, another by cases.

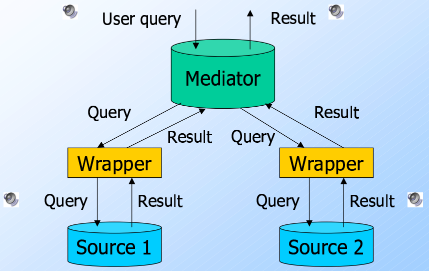
Two Approaches to Integration

1. *Warehousing* : Make copies of the data sources at a central site and transform it to a common schema.
   - Reconstruct data daily/weekly, but do not try to keep it more up-to-date than that.
2. *Mediation* : Create a view of all sources, as if they were integrated.
   - Answer a view query by translating it to terminology of the sources and querying them.

Warehouse Diagram



A Mediator



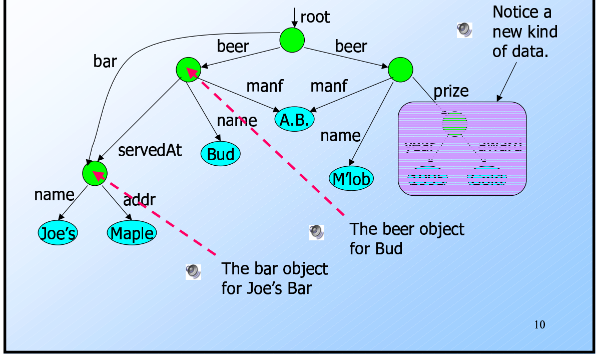
Semistructured Data

- Purpose: represent data from independent sources more flexibly than either relational or object-oriented models.
- Think of objects, but with the type of each object its own business, not that of its "class."
- Labels to indicate meaning of substructures.

Graphs of Semistructured Data

- Nodes = objects.
- Labels on arcs (attributes, relationships).
- Atomic values at leaf nodes (nodes with no arcs out).
- Flexibility: no restriction on:
  - Labels out of a node.
  - Number of successors with a given label.

Example: Data Graph



Notice a new kind of data.

The beer object for Bud

The bar object for Joe's Bar

XML

- XML = Extensible Markup Language.
- While HTML uses tags for formatting (e.g., "italic"), XML uses tags for semantics (e.g., "this is an address").
- Key idea: create tag sets for a domain (e.g., genomics), and translate all data into properly tagged XML documents.

Well-Formed and Valid XML

- *Well-Formed XML* allows you to invent your own tags.
  - Similar to labels in semistructured data.
- *Valid XML* involves a DTD (Document Type Definition), which limits the labels and gives a grammar for their use.

Well-Formed XML

- Start the document with a *declaration*, surrounded by <? … ?> .
- Normal declaration is:

```
<? XML VERSION = "1.0"
  STANDALONE = "yes" ?>
```

  - "Standalone" = "no DTD provided."
- Balance of document is a *root tag* surrounding nested tags.

Tags

- Tags, as in HTML, are normally matched pairs, as <FOO> … </FOO> .
- Tags may be nested arbitrarily.
- Tags requiring no matching ender, like <P> in HTML, are also permitted.

Example: Well-Formed XML

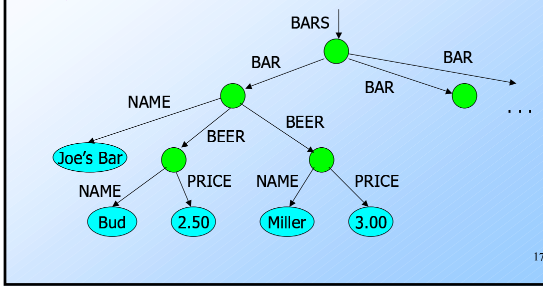
```
<? XML VERSION = "1.0" STANDALONE = "yes" ?>
<BARS>
  <BAR><NAME>Joe's Bar</NAME>
     <BEER><NAME>Bud</NAME>
          <PRICE>2.50</PRICE></BEER>
     <BEER><NAME>Miller</NAME>
          <PRICE>3.00</PRICE></BEER>
  </BAR>
  <BAR> …
</BARS>
```

XML and Semistructured Data

- Well-Formed XML with nested tags is exactly the same idea as trees of semistructured data.
- We shall see that XML also enables nontree structures, as does the semistructured data model.

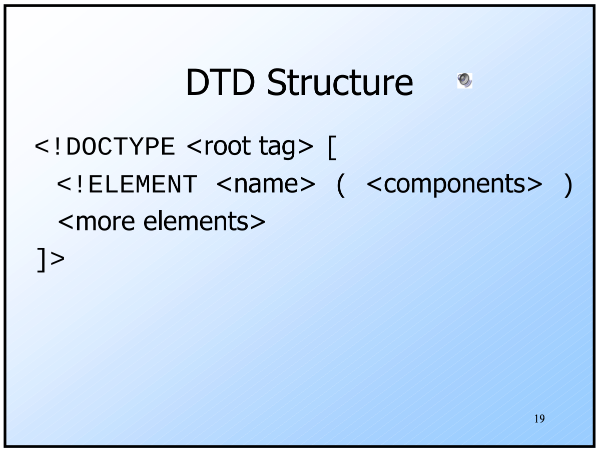
Example

- The <BARS> XML document is:



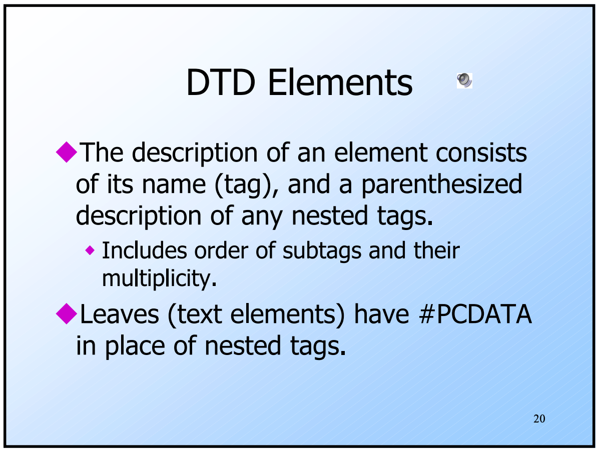
Document Type Definitions

- Essentially a context-free grammar for describing XML tags and their nesting.
- Each domain of interest (e.g., electronic components, bars-beers-drinkers) creates one DTD that describes all the documents this group will share.



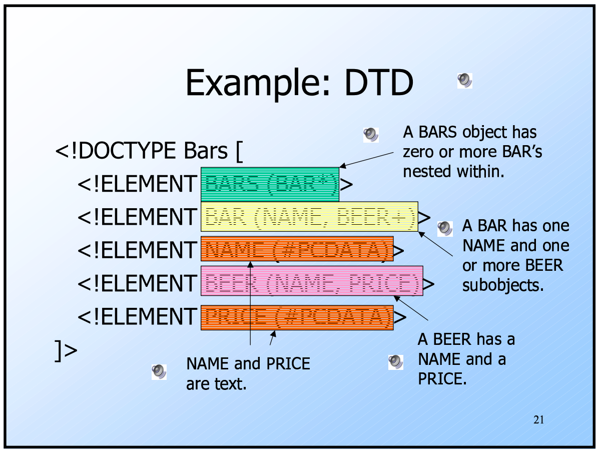
DTD Structure

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



DTD Elements

- The description of an element consists of its name (tag), and a parenthesized description of any nested tags.
  - Includes order of subtags and their multiplicity.
- Leaves (text elements) have #PCDATA in place of nested tags.



Example: DTD

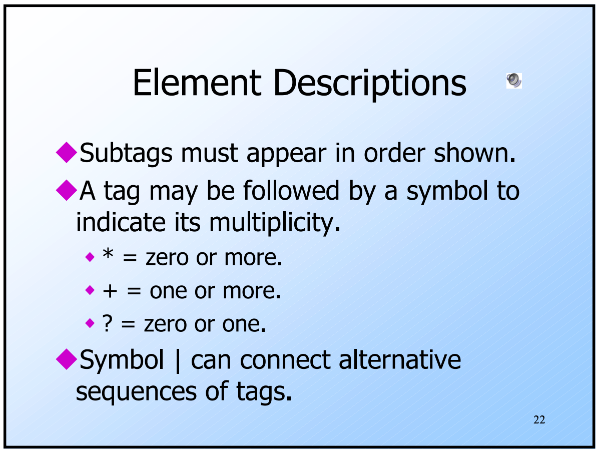
```
<!DOCTYPE Bars [
  <!ELEMENT BARS (BAR*)>
  <!ELEMENT BAR (NAME, BEER+)>
  <!ELEMENT NAME (#PCDATA)>
  <!ELEMENT BEER (NAME, PRICE)>
  <!ELEMENT PRICE (#PCDATA)>
]>
```

A BARS object has zero or more BAR's nested within.

A BAR has one NAME and one or more BEER subobjects.

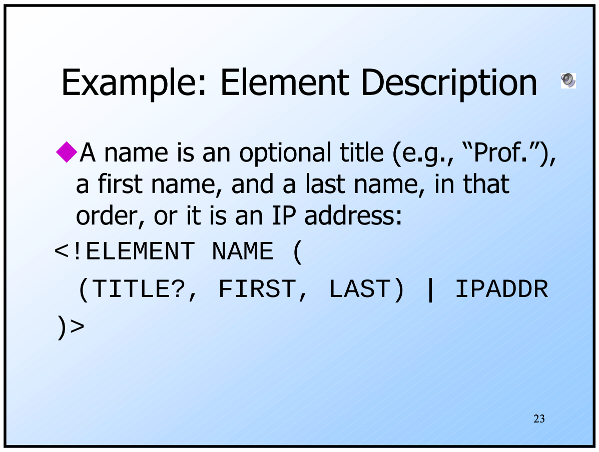
A BEER has a NAME and a PRICE.

NAME and PRICE are text.



Element Descriptions

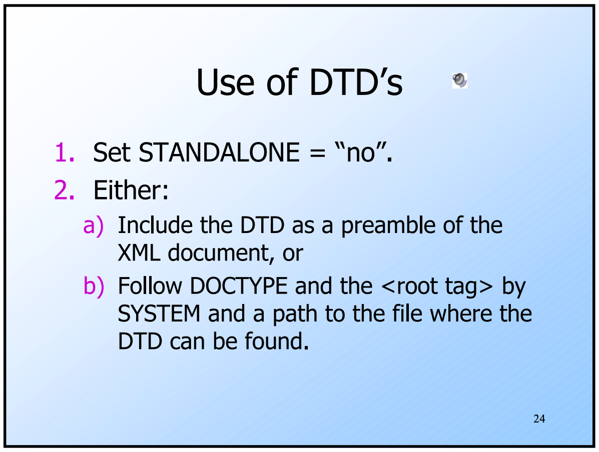
- Subtags must appear in order shown.
- A tag may be followed by a symbol to indicate its multiplicity.
  - * = zero or more.
  - + = one or more.
  - ? = zero or one.
- Symbol | can connect alternative sequences of tags.



Example: Element Description

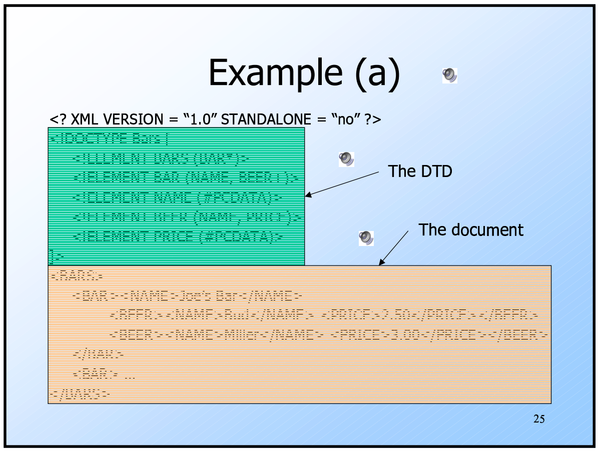
- A name is an optional title (e.g., "Prof."), a first name, and a last name, in that order, or it is an IP address:

```
<!ELEMENT NAME (
  (TITLE?, FIRST, LAST) | IPADDR
)>
```



Use of DTD's

1. Set STANDALONE = "no".
2. Either:
   a) Include the DTD as a preamble of the XML document, or
   b) Follow DOCTYPE and the <root tag> by SYSTEM and a path to the file where the DTD can be found.



Example (a)

```
<? XML VERSION = "1.0" STANDALONE = "no" ?>
<!DOCTYPE Bars [
    <!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>
```

The DTD
The document

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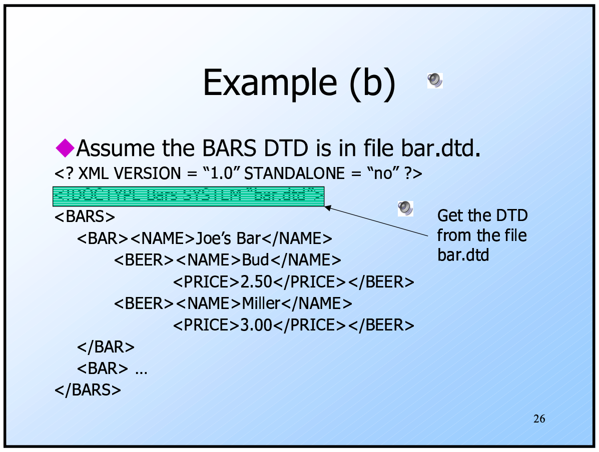

Example (b)

◆Assume the BARS DTD is in file bar.dtd.

```
<? XML VERSION = "1.0" STANDALONE = "no" ?>
<!DOCTYPE Bars SYSTEM "bar.dtd">
<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>
```

Get the DTD
from the file
bar.dtd

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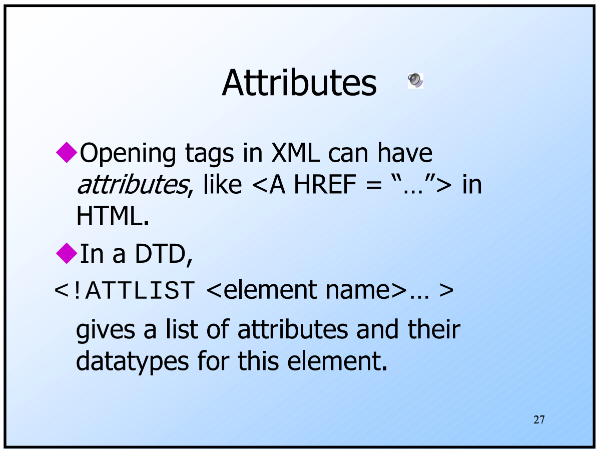

Attributes

◆Opening tags in XML can have *attributes*, like <A HREF = "…"> in HTML.

◆In a DTD,

<!ATTLIST <element name>… >

gives a list of attributes and their datatypes for this element.

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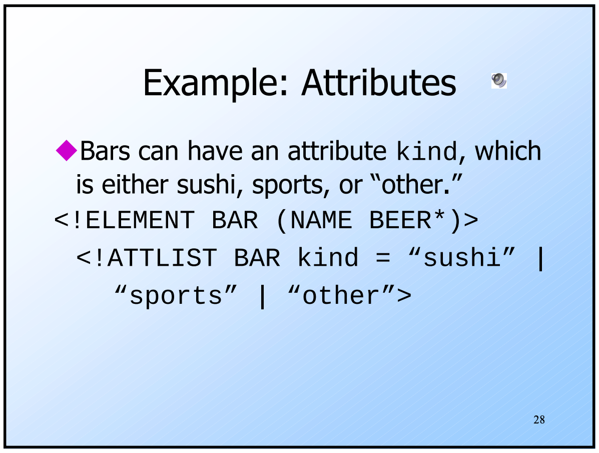

Example: Attributes

◆Bars can have an attribute `kind`, which is either sushi, sports, or "other."

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

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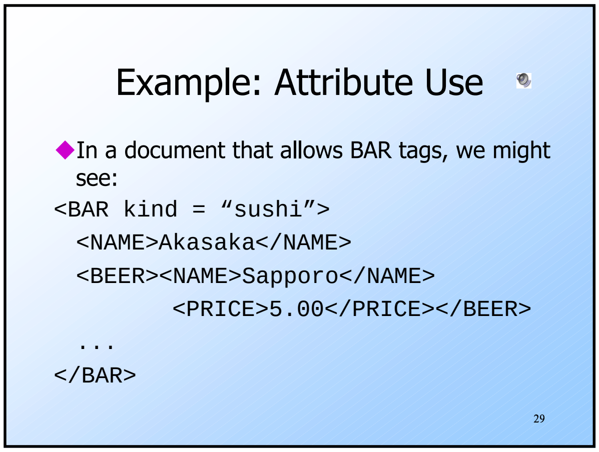

Example: Attribute Use

◆In a document that allows BAR tags, we might see:

```
<BAR kind = "sushi">
  <NAME>Akasaka</NAME>
  <BEER><NAME>Sapporo</NAME>
          <PRICE>5.00</PRICE></BEER>
  ...
</BAR>
```

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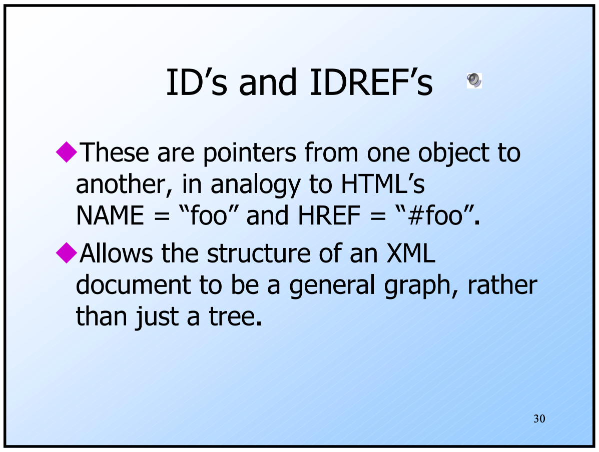

ID's and IDREF's

◆These are pointers from one object to another, in analogy to HTML's NAME = "foo" and HREF = "#foo".

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

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Creating ID's

- Give an element *E* an attribute *A* of type ID.
- When using tag <*E*> in an XML document, give its attribute *A* a unique value.
- Example:

```
<E  A = "xyz">
```

Creating IDREF's

- To allow objects of type *F* to refer to another object with an ID attribute, give *F* an attribute of type IDREF.
- Or, let the attribute have type IDREFS, so the *F*–object can refer to any number of other objects.

Example: ID's and IDREF's

- Let's redesign our BARS DTD to include both BAR and BEER subelements.
- Both bars and beers will have ID attributes called `name`.
- Bars have PRICE subobjects, consisting of a number (the price of one beer) and an IDREF `theBeer` leading to that beer.
- Beers have attribute `soldBy`, which is an IDREFS leading to all the bars that sell it.

The DTD

```
<!DOCTYPE Bars [
   <!ELEMENT BARS (BAR*, BEER*)>
   <!ELEMENT BAR (PRICE+)>
      <!ATTLIST BAR name = ID>
   <!ELEMENT PRICE (#PCDATA)>
      <!ATTLIST PRICE theBeer = IDREF>
   <!ELEMENT BEER ()>
      <!ATTLIST BEER name = ID, soldBy = IDREFS>
]>
```

Bar objects have name as an ID attribute and have one or more PRICE subobjects.

PRICE objects have a number (the price) and one reference to a beer.

Beer objects have an ID attribute called name, and a soldBy attribute that is a set of Bar names.

Example Document

```
<BARS>
  <BAR name = "JoesBar">
     <PRICE theBeer = "Bud">2.50</PRICE>
     <PRICE theBeer = "Miller">3.00</PRICE>
  </BAR> …
  <BEER name = "Bud", soldBy = "JoesBar,
     SuesBar,…">
  </BEER> …
</BARS>
```