XML

Semistructured Data

Extensible Markup Language

Document Type Definitions

Slides due to Jeff Ullman @ Stanford, used with permission

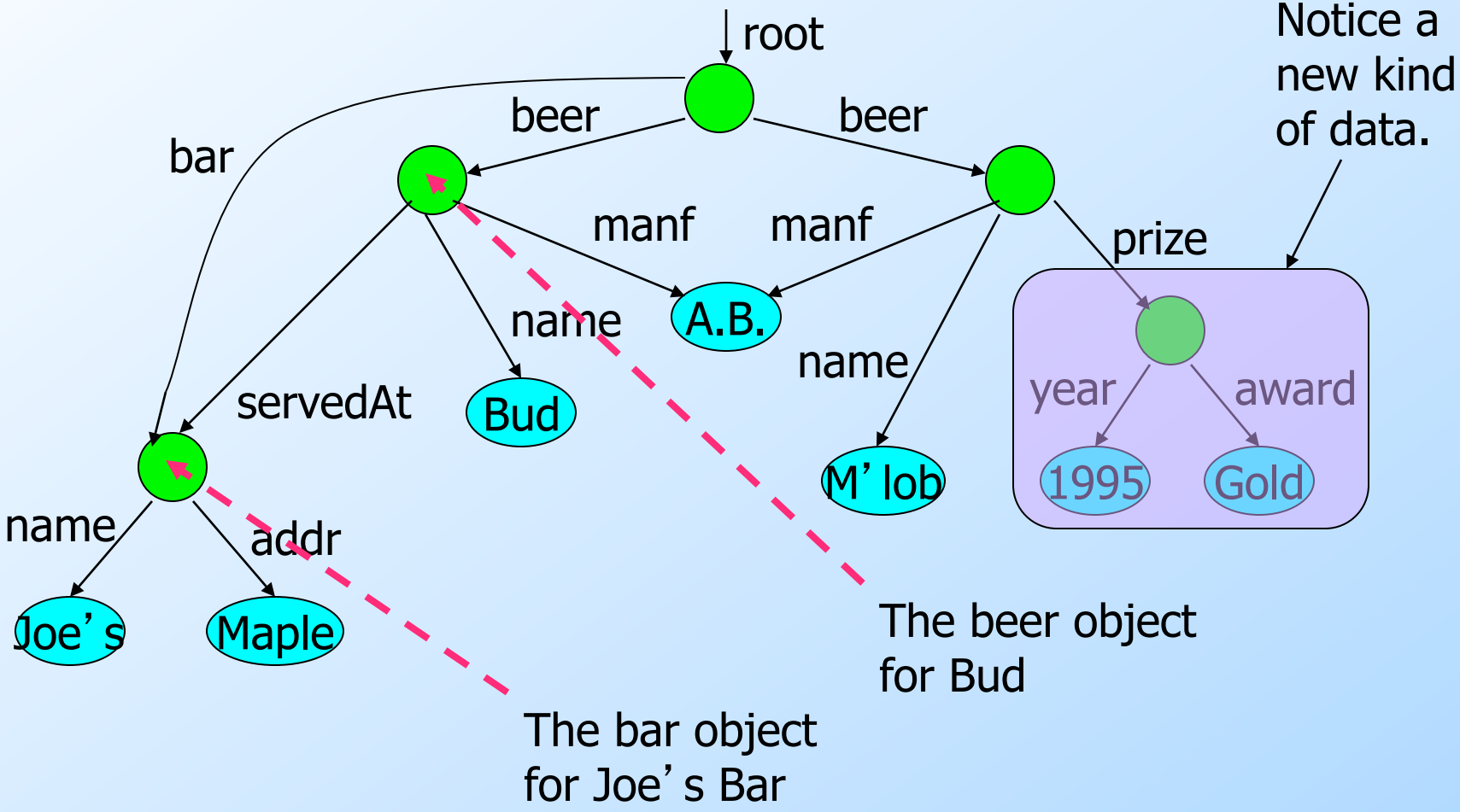
Semistructured Data

- Another data model, based on trees.
- Motivation: flexible representation of data.
  - Often, data comes from multiple sources with differences in notation, meaning, etc.
- Motivation: sharing of *documents* among systems and databases.
- Motivation: semistructured data is out there
  - genomics databases
  - HTML pages, SGML documents

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



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*), a grammar for tags.

Well-Formed XML

- Start the document with a *declaration*, surrounded by <?xml … ?> .
- 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.
- XML tags are case sensitive.

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>
```

A NAME subobject

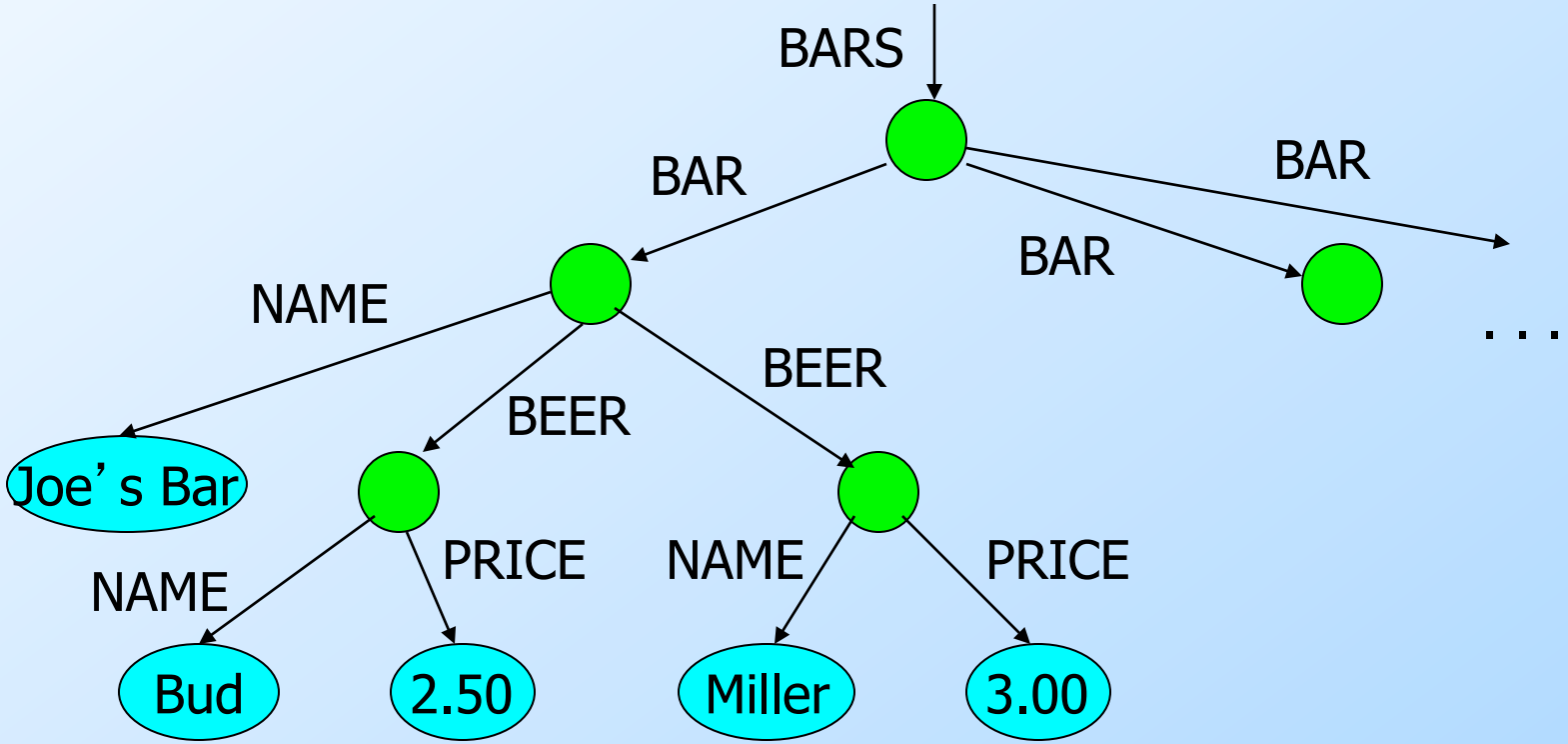
A BEER subobject

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:



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 (*Parsed Character DATA*) 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)>
]>
```

The DTD

The document

```
<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>
```

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

Attributes

- Opening tags in XML can have *attributes*.
- In a DTD,

`<!ATTLIST` *E* `...>`

declares an attribute for element *E*, along with its datatype.

Example: Attributes

- Bars can have an attribute `kind`, a character string describing the bar.

```
<!ELEMENT BAR (NAME BEER*)>
  <!ATTLIST BAR kind CDATA
    #IMPLIED>
```

Character string type; no tags

Attribute is optional opposite: #REQUIRED

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>
```

Note attribute values are quoted

ID's and IDREF's

- Attributes can be pointers from one object to another.
  - Compare 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.

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 SELLS 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

Bar elements have name as an ID attribute and have one or more SELLS subelements.

```
<!DOCTYPE BARS [
   <!ELEMENT BARS (BAR*, BEER*)>
   <!ELEMENT BAR (SELLS+)>
      <!ATTLIST BAR name ID #REQUIRED>
   <!ELEMENT SELLS (#PCDATA)>
      <!ATTLIST SELLS theBeer IDREF #REQUIRED>
   <!ELEMENT BEER EMPTY>
      <!ATTLIST BEER name ID #REQUIRED>
      <!ATTLIST BEER soldBy IDREFS #IMPLIED>
]>
```

SELLS elements have a number (the price) and one reference to a beer.

Explained next

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

Example Document

```
<BARS>
  <BAR name = “JoesBar”>
      <SELLS theBeer = “Bud”>2.50</SELLS>
      <SELLS theBeer = “Miller”>3.00</SELLS>
  </BAR> …
  <BEER name = “Bud” soldBy = “JoesBar
      SuesBar …”/> …
  </BARS>
```

Empty Elements

- We can do all the work of an element in its attributes.
  - Like BEER in previous example.
- Another example: SELLS elements could have attribute `price` rather than a value that is a price.

Example: Empty Element

- In the DTD, declare:

```
<!ELEMENT SELLS EMPTY>
  <!ATTLIST SELLS theBeer IDREF #REQUIRED>
  <!ATTLIST SELLS price CDATA #REQUIRED>
```

- Example use:

```
<SELLS theBeer = “Bud” price = “2.50”/>
```

Note exception to
“matching tags” rule