XML

Document Type Definitions

XML

- XML stands for eXtensible Markup Language.
- XML was designed to describe data.
- XML has come into common use for the interchange of data over the Internet.

Well-Formed and Valid XML

- *Well-Formed XML* allows you to invent your own tags.
- *Valid XML* conforms to a certain DTD (Document Type Definition).

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** are normally **matched pairs**, as <FOO> … </FOO>.
- **Unmatched tags** also allowed, as <FOO/>
- 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 subelement

Root tag

A BEER subelement

Tags surrounding a BEER element

DTD Structure

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

DTD Elements

- The description of an **element** consists of <u>its name (tag</u>), and a <u>description of any nested tags</u>.
  - 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 <u>symbol to indicate its **multiplicity**</u>.
  - ***** = 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 attributes 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>Homma’s</NAME>
 <BEER><NAME>Sapporo</NAME>
        <PRICE>5.00</PRICE></BEER>
 ...
</BAR>
```

ID's and IDREF's

- **Attributes** can be pointers from one object to another.
- 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 elements of **type *F*** to **refer** to another element with an ID attribute, give *F* an attribute of type **IDREF**.
- Or, let the attribute have type **IDREFS**, so the *F* -element can <u>refer to any number of other elements</u>.

Example: ID's and IDREF's

- A new BARS DTD includes both BAR and BEER subelements.
- BARS and BEERS have **ID attributes** `name`.
- BARS have SELLS subelements, 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 (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>
]>
```

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

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: A 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>
```

Query Languages for XML

XPath

XQuery

The XPath/XQuery Data Model

- Corresponding to the fundamental "relation" of the relational model is: *sequence of items*.
- An *item* is either:
  1. A primitive value, e.g., integer or string.
  2. A *node* (defined next).

Principal Kinds of Nodes

1. *Document nodes* represent entire documents.
2. *Elements* are pieces of a document consisting of some opening tag, its matching closing tag (if any), and everything in between.
3. *Attributes* names that are given values inside opening tags.

DTD for Running Example

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

Example Document

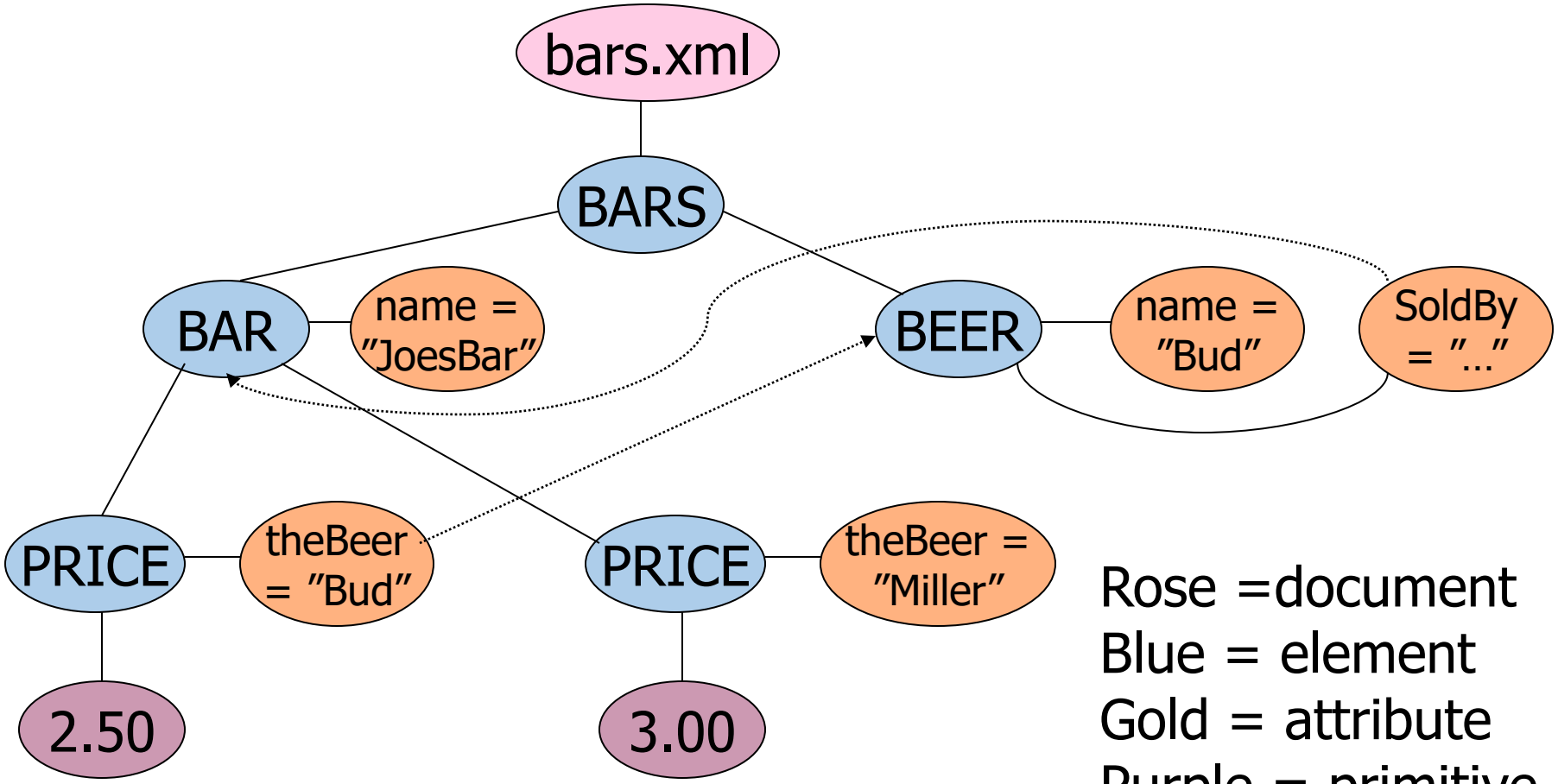
Document node is all of this, plus the header (<? xml version…).

An element node

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

An attribute node

Nodes as Semistructured Data



Rose =document
Blue = element
Gold = attribute
Purple = primitive value

Paths in XML Documents

- **XPath** is a language for describing paths in XML documents.
- The result of the described path is a **sequence of items**.

Path Expressions

- Simple path expressions are sequences of slashes (/) and tags, starting with /.
  - Example: /BARS/BAR/PRICE
- Construct the result by starting with just the doc node and processing each tag from the left.

Example: /BARS

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

One item, the BARS element

Example: /BARS/BAR

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

This BAR element followed by all the other BAR elements

Example: /BARS/BAR/PRICE

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

These PRICE elements followed by the PRICE elements of all the other bars.

Attributes in Paths

- Instead of going to subelements with a given tag, you can go to an **attribute** of the elements you already have.
- An **attribute** is indicated by putting @ in front of its name.

Example: /BARS/BAR/PRICE/@theBeer

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

These attributes contribute ”Bud” ”Miller” to the result, followed by other theBeer values.

Paths that Begin Anywhere

- If the **path** starts from the document node and begins with //*X*, then the first step can <u>begin at the root or any subelement of the root</u>, as long as the tag is *X*.

Example: //PRICE

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

These PRICE elements and any other PRICE elements in the entire document

Wild-Card *

- A **star (*) in place of a tag** represents any one tag.
- Example: /*/*/PRICE represents all price objects at the **third level** of nesting.

Example: /BARS/*

This BAR element, all other BAR elements, the BEER element, all other BEER elements

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

Selection Conditions

- A **condition** inside **[…]** may follow a tag.
- If so, then only paths that have that tag and also **satisfy the condition** are included in the result of a path expression.

Example: Selection Condition

- /BARS/BAR/PRICE[. < 2.75]

The current element.

```
<BARS>
  <BAR name = ”JoesBar”>
      <PRICE theBeer = ”Bud”>2.50</PRICE>
      <PRICE theBeer = ”Miller”>3.00</PRICE>
  </BAR> …
```

The condition that the PRICE be < $2.75 makes this price but not the Miller price part of the result.

Example: Attribute in Selection

- /BARS/BAR/PRICE[@theBeer = ”Miller”]

```
<BARS>
  <BAR name = ”JoesBar”>
      <PRICE theBeer = ”Bud”>2.50</PRICE>
      <PRICE theBeer = ”Miller”>3.00</PRICE>
  </BAR> …
```

Now, this PRICE element is selected, along with any other prices for Miller.

XQuery

- **XQuery** extends XPath to a query language that has power similar to SQL.
- Uses the same sequence-of-items data model.
- XQuery is an expression language.
  - Similarly to SQL

More About Item Sequences

- XQuery will sometimes form sequences of sequences.
- All sequences are flattened.
- Example: (1 2 () (3 4)) = (1 2 3 4).

Empty sequence

FLWR Expressions

XQuery has an expression called a FLWR expression, which is similar to a SQL Select statement that has From and Where clauses.

1. One or more for and/or let clauses.
2. Then an optional where clause.
3. A return clause.

Semantics of FLWR Expressions

- Each for creates a **loop**.
  - let produces only a **local definition**.
- At each iteration of the nested loops, if any, evaluate the where clause.
- If the where clause returns TRUE, invoke the return clause, and append its value to the output.

LET Clauses

let <variable> := <expression>, . . .

- Value of the variable becomes the *sequence* of items defined by the expression.
- Note let does not cause iteration; for does.

Example: FOR

Our example
BARS document

"Expand the en-
closed string by
replacing variables
and path exps. by
their values."

```
for $beer in document("bars.xml")/BARS/BEER/@name
return
  <BEERNAME> {$beer} </BEERNAME>
```

- **$beer** ranges over the name attributes of all beers in our example document.
- **Result** is a sequence of BEERNAME elements:
  <BEERNAME>Bud</BEERNAME>
  <BEERNAME>Miller</BEERNAME> . . .

Example: LET

```
let $d := document(”bars.xml”)
let $beers := $d/BARS/BEER/@name
return
  <BEERNAMES> {$beers} </BEERNAMES>
```

- Returns <u>one element with all the names of the beers</u>, like:

<BEERNAMES>Bud Miller …</BEERNAMES>

Order-By Clauses

- FLWR is really FLWOR: an order-by clause can precede the return.
- Form: order by <expression>
  - With optional ascending or descending.
- The expression is evaluated for each assignment to variables.
- Determines placement in output sequence.

Example: Order-By

- List all prices for Bud, lowest first.

```
let $d := document("bars.xml")
for $p in $d/BARS/BAR/PRICE[@theBeer="Bud"]
order by $p
return $p
```

Order those bindings by the values inside the elements .

Generates bindings for $p to PRICE elements.

Each binding is evaluated for the output. The result is a sequence of PRICE elements.

Aside: SQL ORDER BY

- SQL works the same way; it's the result of the FROM and WHERE that get ordered.
- Example: Using R(a,b),

```
SELECT b FROM R
WHERE b > 10
ORDER BY a;
```

Then, the b-values are extracted from these tuples and printed in the same order.

R tuples with b>10 are ordered by their a-values.

Predicates

- Normally, conditions imply existential quantification.
- Example: /BARS/BAR[@name] means “all the bars that have a name.”
- Example: /BARS/BEER[@soldAt = ”JoesBar”] gives the set of beers that are sold at Joe’s Bar.

Practice

http://videlibri.sourceforge.net/cgi-bin/xidelcgi

```
<?xml version = “1.0” standalone = “no” ?>
<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>
</BARS>
```

```
xquery version "3.0";
/BARS/BAR/NAME

for $price in /BARS/BAR/BEER/PRICE
where $price > 2.5
order by $price
return $price

for $beer in /BARS/BAR/BEER
where $beer/PRICE  > 2.5
order by $beer
return $beer
```

Actions

- Read Chapters 11 about XML DTD and 12 about Xpath and XQuery
- Review slides!