XML

Document Type Definitions

XML Schema

Well-Formed and Valid XML

- *Well-Formed XML* allows you to invent your own tags.
- *Valid XML* conforms to a certain DTD.

Well-Formed XML

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

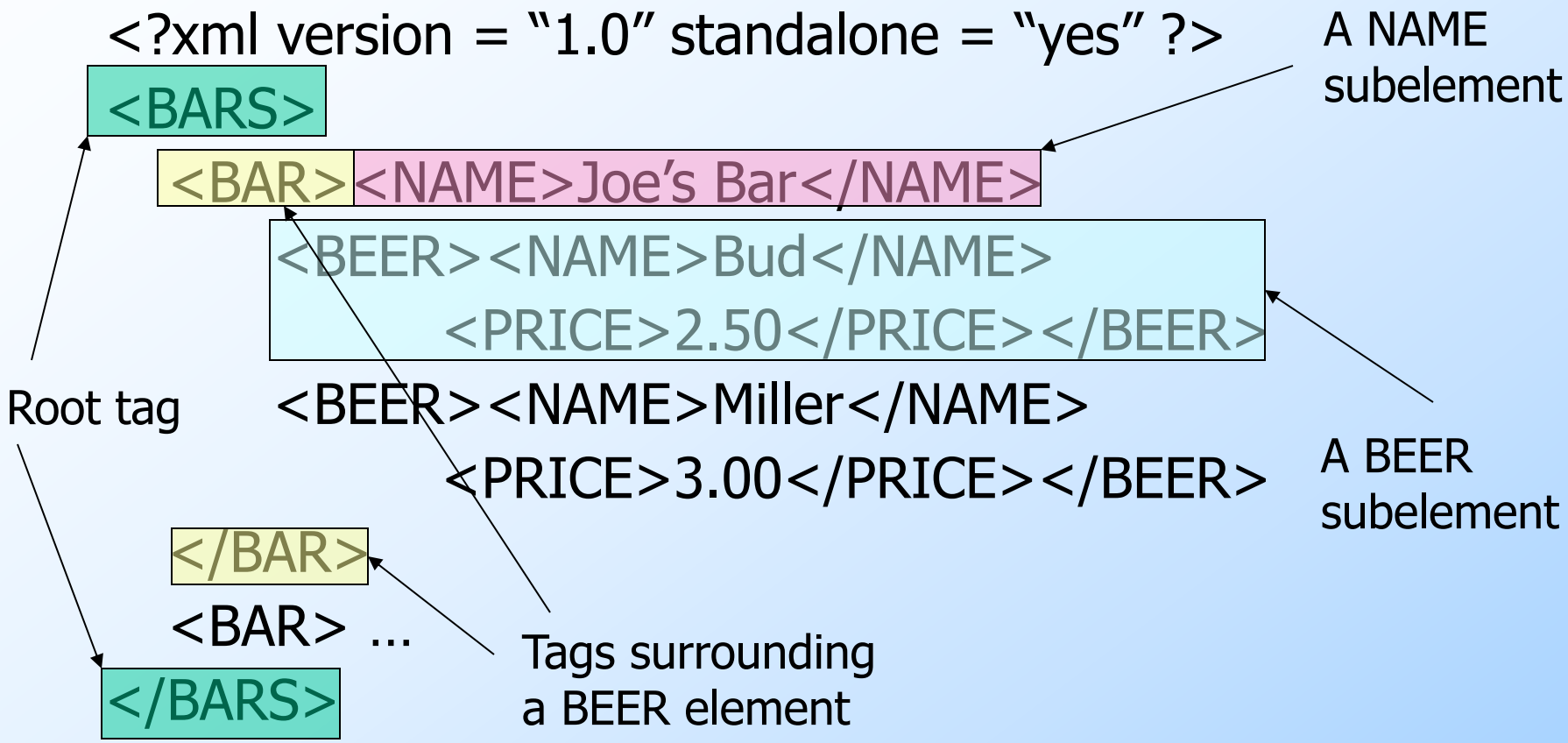
```
<?xml version = ”1.0”
  standalone = ”yes” ?>
```

  - “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/>
- Tags may be nested arbitrarily.
- XML tags are case-sensitive.

Example: Well-Formed XML



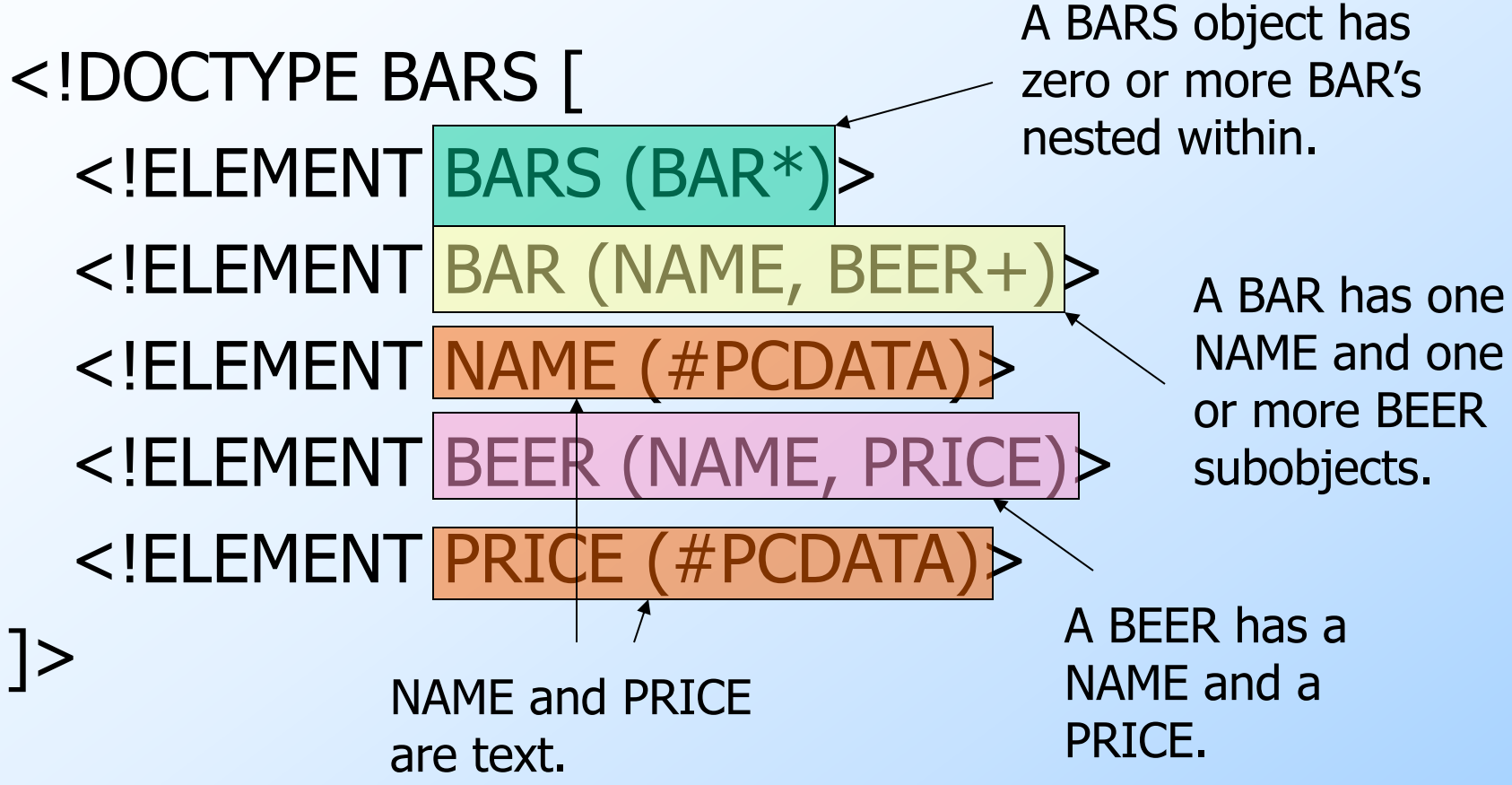
DTD Structure

```
<!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:

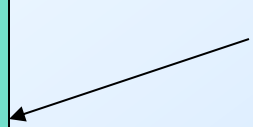
```
<!ELEMENT NAME (
  (TITLE?, FIRST, LAST) | IPADDR
)>
```

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)

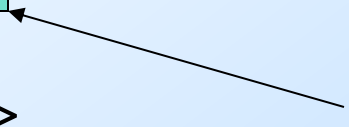
```
<?xml version = "1.0" standalone = "no" ?>
<!DOCTYPE BARS [
    <!ELEMENT BARS (BAR*)>
    <!ELEMENT BAR (NAME, BEER+)>
    <!ELEMENT NAME (#PCDATA)>
    <!ELEMENT BEER (NAME, PRICE)>
    <!ELEMENT PRICE (#PCDATA)>
]>
<BARS>
    <BAR><NAME>Joe's Bar</NAME>
        <BEER><NAME>Bud</NAME> <PRICE>2.50</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.
  - 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 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 refer to any number of other elements.

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

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: 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>
```

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

XML Schema

- A more powerful way to describe the structure of XML documents.
- XML-Schema declarations are themselves XML documents.
  - They describe “elements” and the things doing the describing are also “elements.”

Structure of an XML-Schema Document

```
<? xml version = … ?>
<xs:schema xmlns:xs =
  ”http://www.w3.org/2001/XMLschema”>
                . . .
</xs:schema>
```

So uses of ”xs” within the schema element refer to tags from this namespace.

Defines ”xs” to be the *namespace* described in the URL shown. Any string in place of ”xs” is OK.

The xs:element Element

- Has attributes:
  1. name = the tag-name of the element being defined.
  2. type = the type of the element.
     - Could be an XML-Schema type, e.g., xs:string.
     - Or the name of a type defined in the document itself.

Example: xs:element

```
<xs:element name = "NAME"
    type = "xs:string" />
```

- Describes elements such as

  <NAME>Joe's Bar</NAME>

Complex Types

- To describe elements that consist of subelements, we use xs:complexType.
  - Attribute name gives a name to the type.
- Typical subelement of a complex type is xs:sequence, which itself has a sequence of xs:element subelements.
  - Use minOccurs and maxOccurs attributes to control the number of occurrences of an xs:element.

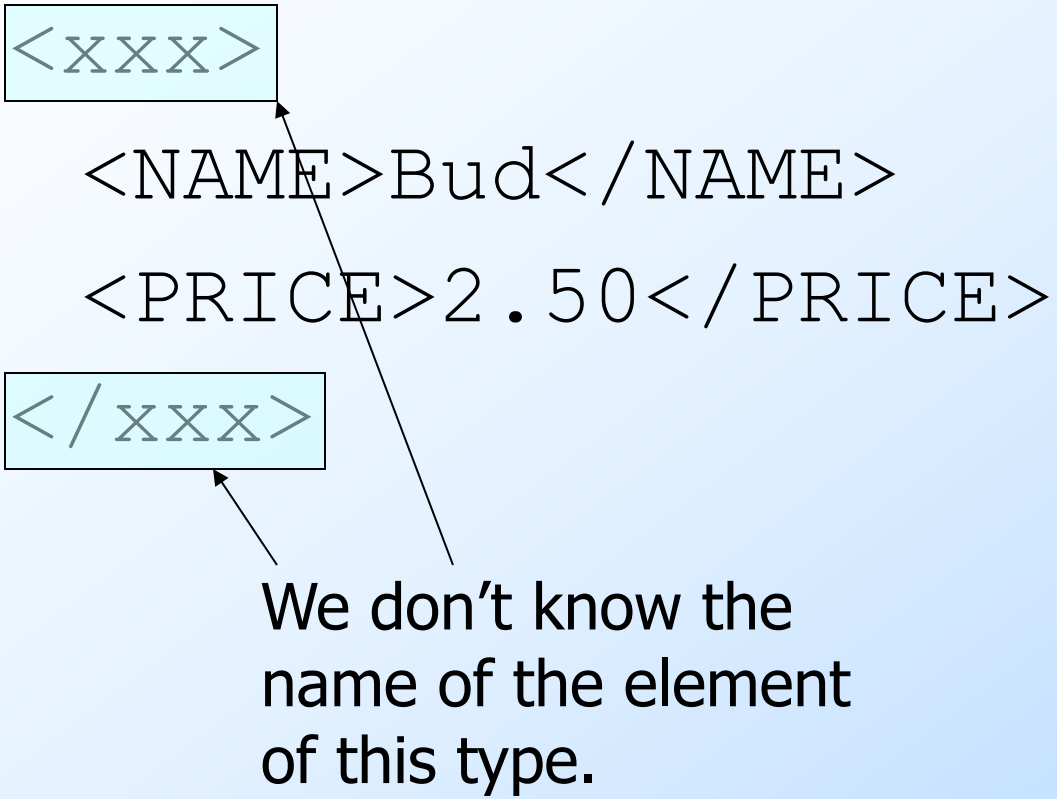
Example: a Type for Beers

```
<xs:complexType name = "beerType">
  <xs:sequence>
    <xs:element name = "NAME"
      type = "xs:string"
      minOccurs = "1" maxOccurs = "1" />
    <xs:element name = "PRICE"
      type = "xs:float"
      minOccurs = "0" maxOccurs = "1" />
  </xs:sequence>
</xs:complexType>
```

Exactly one occurrence

Like ? in a DTD

An Element of Type beerType



Example: a Type for Bars

```
<xs:complexType name = "barType">
  <xs:sequence>
    <xs:element name = "NAME"
      type = "xs:string"
      minOccurs = "1" maxOccurs = "1" />
    <xs:element name = "BEER"
      type = "beerType"
      minOccurs = "0" maxOccurs =
          "unbounded" />
  </xs:sequence>
</xs:complexType>
```

Like * in a DTD

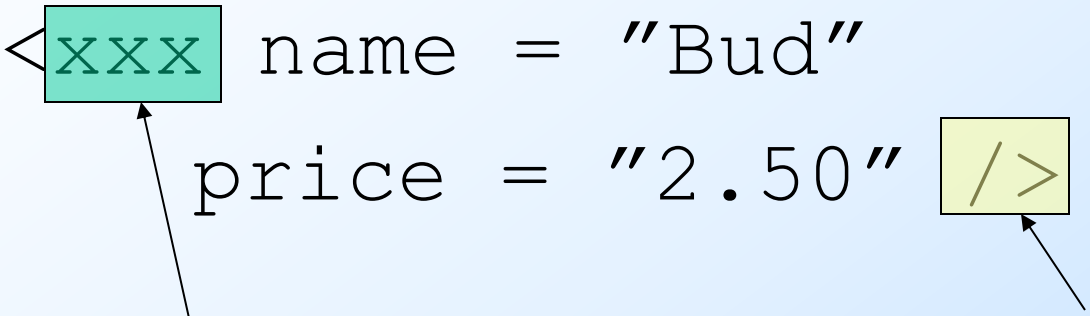
xs:attribute

- xs:attribute elements can be used within a complex type to indicate attributes of elements of that type.
- attributes of xs:attribute:
  - name and type as for xs.element.
  - use = ”required” or ”optional”.

Example: xs:attribute

```
<xs:complexType name = ”beerType”>
  <xs:attribute name = ”name”
     type = ”xs:string”
     use = ”required” />
  <xs:attribute name = ”price”
     type = ”xs:float”
     use = ”optional” />
</xs:complexType>
```

An Element of This New Type beerType



Restricted Simple Types

- xs:simpleType can describe enumerations and range-restricted base types.
- name is an attribute
- xs:restriction is a subelement.

Restrictions

- Attribute base gives the simple type to be restricted, e.g., xs:integer.
- xs:{min, max}{Inclusive, Exclusive} are four attributes that can give a lower or upper bound on a numerical range.
- xs:enumeration is a subelement with attribute value that allows enumerated types.

Example: license Attribute for BAR

```
<xs:simpleType name = ”license”>
  <xs:restriction base = ”xs:string”>
    <xs:enumeration value = ”Full” />
    <xs:enumeration value = ”Beer only” />
    <xs:enumeration value = ”Sushi” />
  </xs:restriction>
</xs:simpleType>
```

Example: Prices in Range [1,5)

```
<xs:simpleType name = ”price”>
  <xs:restriction
     base = ”xs:float”
     minInclusive = ”1.00”
     maxExclusive = ”5.00” />
</xs:simpleType>
```

Keys in XML Schema

- An xs:element can have an xs:key subelement.
- Meaning: within this element, all subelements reached by a certain *selector* path will have unique values for a certain combination of *fields*.
- Example: within one BAR element, the name attribute of a BEER element is unique.

Example: Key

```
<xs:element name = ”BAR” … >
    . . .
  <xs:key name = ”barKey”>
     <xs:selector xpath = ”BEER” />
     <xs:field xpath = ”@name” />
  </xs:key>
    . . .
</xs:element>
```

And @ indicates an attribute rather than a tag.

XPath is a query language for XML. All we need to know here is that a path is a sequence of tags separated by /.

Foreign Keys

- An xs:keyref subelement within an xs:element says that within this element, certain values (defined by selector and field(s), as for keys) must appear as values of a certain key.

Example: Foreign Key

- Suppose that we have declared that subelement NAME of BAR is a key for BARS.
  - The name of the key is barKey.
- We wish to declare DRINKER elements that have FREQ subelements. An attribute bar of FREQ is a foreign key, referring to the NAME of a BAR.

Example: Foreign Key in XML Schema

```
<xs:element name = ”DRINKERS”
    . . .
  <xs:keyref name = ”barRef”
     refers = ”barKey”
     <xs:selector xpath =
         ”DRINKER/FREQ” />
     <xs:field xpath = ”@bar” />
  </xs:keyref>
</xs:element>
```