XML Query Languages

XPATH
XQUERY

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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.

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* are names that are given values inside opening tags.

Document Nodes

- Formed by doc(URL) or document(URL) (or doc(filename) or document(filename)

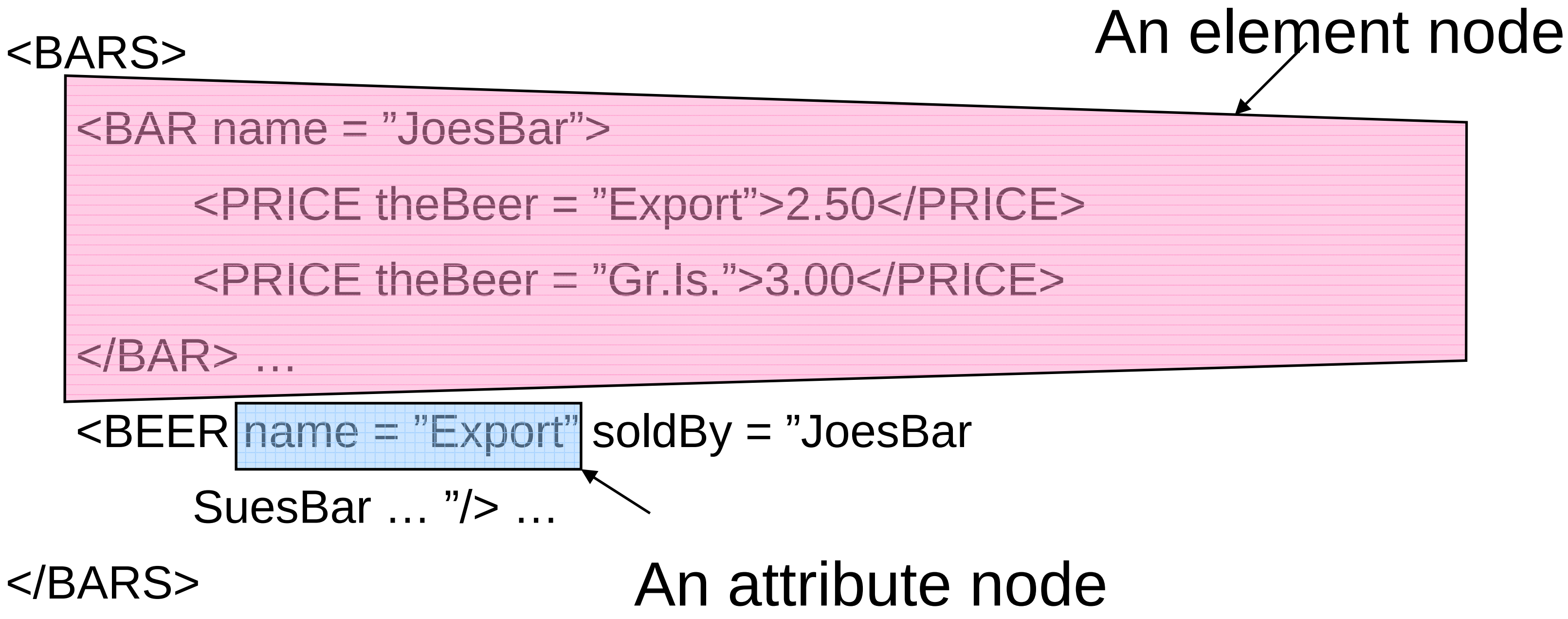
- Example: doc(“/usr/class/cs145/bars.xml”)

- All XPath (and XQuery) queries refer to a doc node, either explicitly or implicitly.

Example 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>
]>
```

Example Document



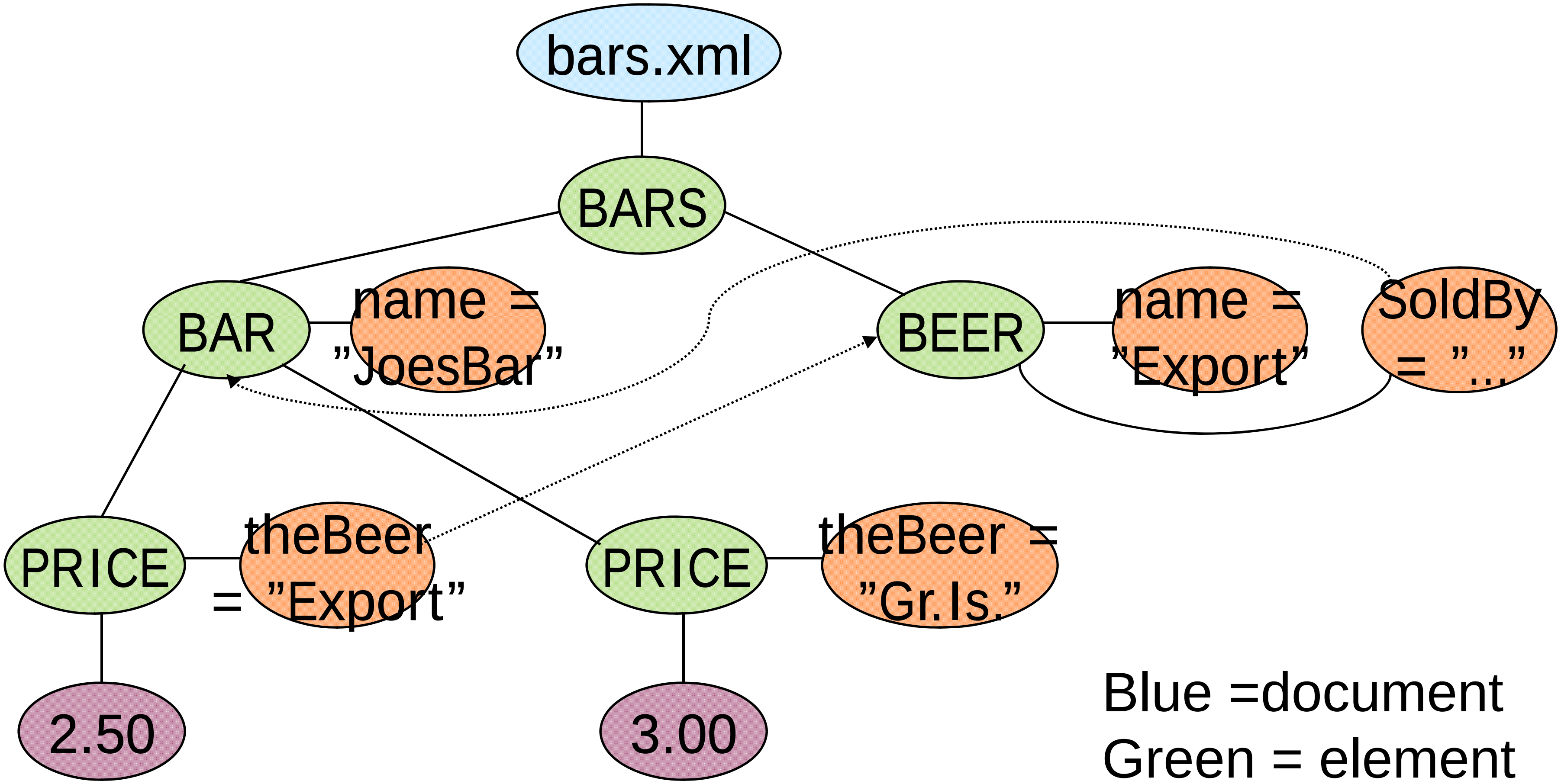
```
<BARS>
    <BAR name = ”JoesBar”>
            <PRICE theBeer = ”Export”>2.50</PRICE>
            <PRICE theBeer = ”Gr.Is.”>3.00</PRICE>
    </BAR> …
    <BEER name = ”Export” soldBy = ”JoesBar
            SuesBar … ”/> …
</BARS>
```

An element node

An attribute node

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

Nodes as Semistructured Data



Blue =document
Green = element
Orange = attribute
Purple = primitive
value

XPATH and XQUERY

- XPATH is a language for describing paths in XML documents.
  - Really think of the semi-structured data graph and *its* paths.
  - The result of the described path is a sequence of items.
  - Compare with SQL:
    - SQL is a language for describing relations in terms of other relations.
    - The result of a query is a relation (bag) made up of tuples
- XQUERY is a full query language for XML documents with power similar to SQL.

Path Descriptors

- Simple path descriptors are sequences of tags separated by slashes (/).
  - The format used is strongly reminiscent of UNIX naming conventions.
  - Construct the result by starting with just the doc node and processing each tag from the left.
- If the descriptor begins with /, then the path starts at the root and has those tags, in order.
- If the descriptor begins with //, then the path can start anywhere.

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,…”>
  </BEER> ...
</BARS>
```

/BARS/BAR/PRICE describes the set with these two PRICE objects as well as the PRICE objects for any other bars.

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,...”>
  </BEER> ...
</BARS>
```

//PRICE describes the same PRICE objects, but only because the DTD forces every PRICE to appear within a BARS and a BAR.

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/*

```
<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>
```

/BARS/* captures all BAR and BEER objects, such as these.

Attributes

- In XPATH, we refer to attributes by prepending @ to their name.

- Attributes of a tag may appear in paths as if they were nested within that tag.

Example: /BARS/*/@name

```
<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>
```

/BARS/*/@name selects all name attributes of immediate subobjects of the BARS object.

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[PRICE < 2.75]

```
<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

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 object is selected, along with any other prices for Miller.

Axes

- In general, path expressions allow us to start at the root and execute a sequence of steps to find a set of nodes at each step.
- At each step, we may follow any one of several *axes*.
- The default axis is child:: --- go to any child of the current set of nodes.

Example: Axes

- /BARS/BEER is really shorthand for /BARS/child::BEER .
- @ is really shorthand for the attribute:: axis.
  - Thus, /BARS/BEER[@name = "Bud"] is shorthand for

    /BARS/BEER[attribute::name = "Bud"]

More Axes

- Some other useful axes are:
  1. parent:: = parent(s) of the current node(s).
  2. descendant-or-self:: = the current node(s) and all descendants.
     - Note: // is really a shorthand for this axis.
  3. ancestor::, ancestor-or-self, etc.

XQuery

- XQuery extends XPath to a query language that has power similar to SQL.
- Uses the same sequence-of-items data model as XPath.
- XQuery is an expression language.
  - Like relational algebra --- any XQuery expression can be an argument of any other XQuery expression.

FLWR Expressions

- The most important form of XQuery expressions involves for-, let-, where-, return- (FLWR) clauses.

1. A qurey begins with one or more for and/or let clauses.
   - The for’s and let’s can be interspersed.
2. Then an optional where clause.
3. A single return clause.

Form:

for *variable* in *expression*

let *variable := expression*

where *condition*

return *expression*

Semantics of FLWR Expressions

- Each for creates a loop.
  - let produces only a local variable assignment.
- 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.
  - So return can be thought of as “add to result”

FOR Clauses

FOR <variable> IN <path expression>,...

- Variables begin with $.
- A FOR variable takes on each object in the set denoted by the path expression, in turn.
- Whatever follows this FOR is executed once for each value of the variable.

Example: FOR

```
FOR $beer IN /BARS/BEER/@name
RETURN
   <BEERNAME>$beer</BEERNAME>
```

- $beer ranges over the name attributes of all beers in our example document.
- Result is a list of tagged names, like
  <BEERNAME>Bud</BEERNAME>
  <BEERNAME>Miller</BEERNAME>...

LET Clauses

LET <variable> := <path expression>,...

- Value of the variable becomes the ***set*** of objects defined by the path expression.
- Note LET does not cause iteration; FOR does.

Example: LET

```
LET $beers := /BARS/BEER/@name
RETURN
   <BEERNAMES>$beers</BEERNAMES>
```

- Returns one object with all the names of the beers, like:

```
<BEERNAMES>Bud, Miller,...</BEERNAMES>
```

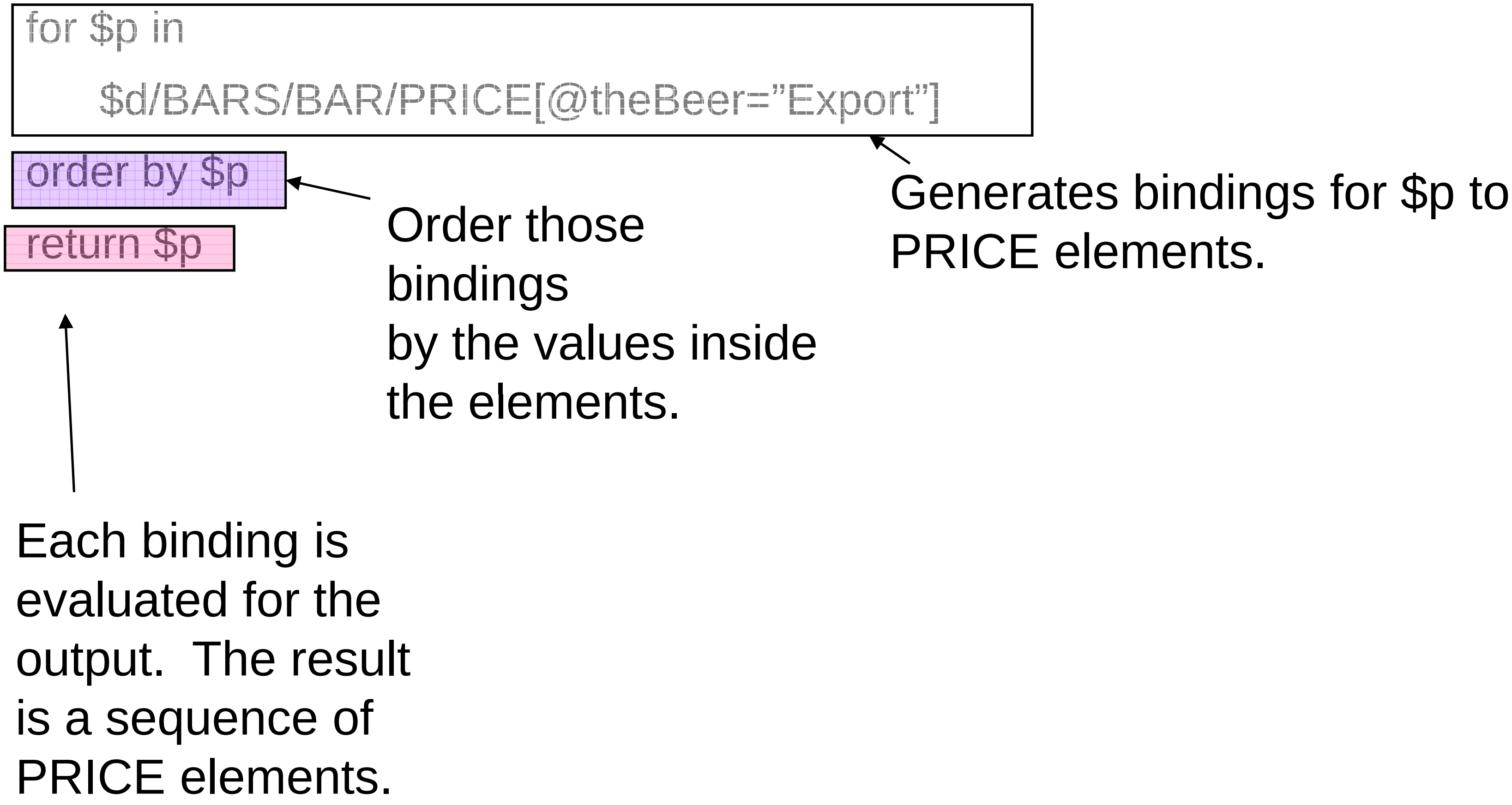
Order-By Clauses

- 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 Export, lowest price first.

```
let $d := document(”bars.xml”)
```



```
for $p in
     $d/BARS/BAR/PRICE[@theBeer=”Export”]
order by $p
return $p
```

Generates bindings for $p to PRICE elements.

Order those bindings by the values inside the elements.

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

Following IDREF's

- XQUERY (but not XPATH) allows us to use paths that follow attributes that are IDREF's.
- If *x* denotes a set of IDREF's, then *x*=>*y* denotes all the objects with tag *y* whose ID's are one of these IDREF's.

Example

- Find all the beer objects where the beer is sold by Joe’s Bar for less than 3.00.
- Strategy:

1. $beer will for-loop over all beer objects.
2. For each $beer, let $joe be either the Joe’s-Bar object, if Joe sells the beer, or the empty set of bar objects.
3. Test whether $joe sells the beer for < 3.00.

Example: The Query

Attribute soldBy is of type IDREFS. Follow each ref to a BAR and check if its name is Joe’s Bar.

```
FOR $beer IN /BARS/BEER
LET $joe := $beer/@soldBy=>BAR[@name=“JoesBar”]
LET $joePrice := $joe/PRICE[@theBeer=$beer/@name]
WHERE $joePrice < 3.00
RETURN <CHEAPBEER>$beer</CHEAPBEER>
```

Only pass the values of $beer, $joe, $joePrice to the RETURN clause if the string inside the PRICE object $joePrice is < 3.00

Find that PRICE subobject of the Joe’s Bar object that represents whatever beer is currently $beer.

Aggregations

- XQuery allows the usual aggregations, such as sum, count, max, min.
- They take any sequence as argument.
- E.g. find bars where all beers are under $5.

```
let $bars = doc(”bars.xml”)/BARS
for $price in $bars/BAR/PRICE
where max($price) < 5
return $bar/BAR/@name
```