Parallel/Distributed Databases XML

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most slides courtesy of Amol Deshpande

Admin

- Project due today
- Sign up for demo, if you haven't already
- myphpbib.sourceforge.net - example publication DB and API

SQL injection (security)

http://www.securiteam.com/securityreviews/5DP0N1P76E.html

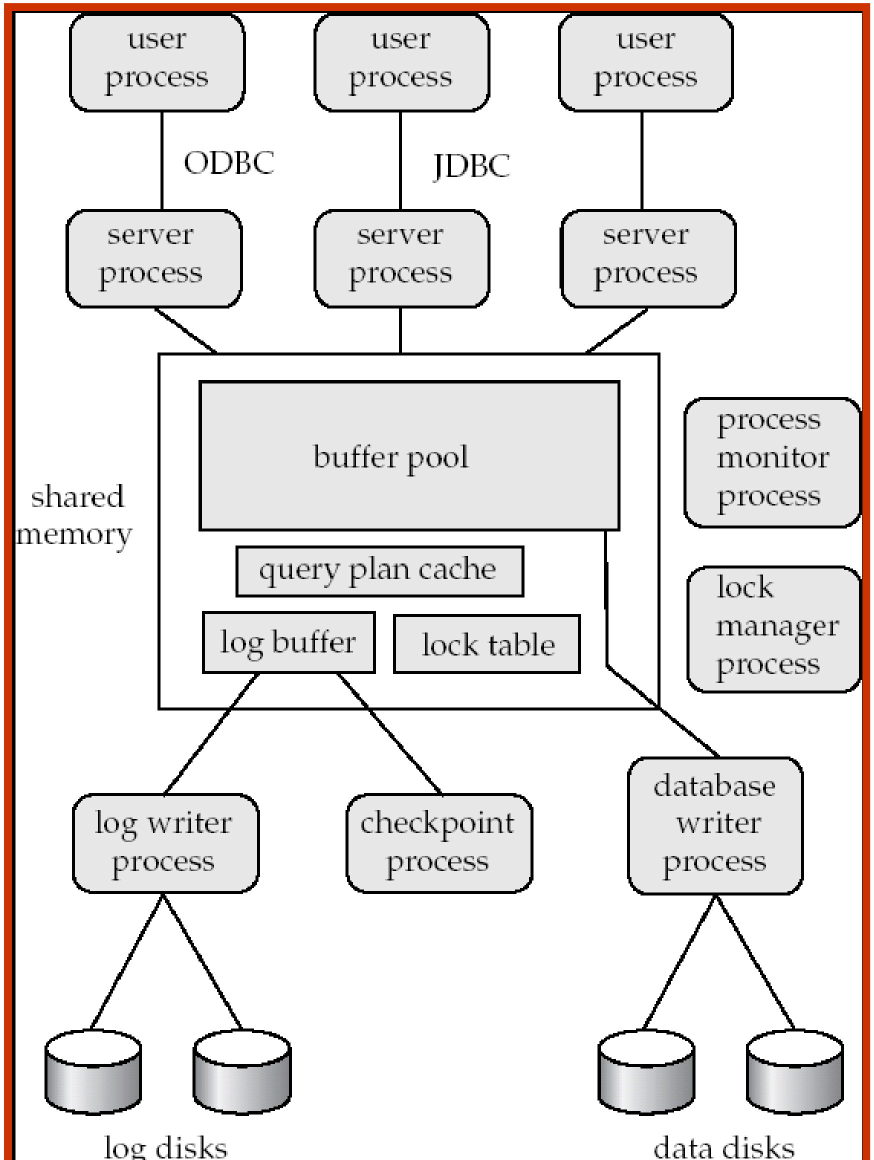
Topics

- Today
  - Database system architectures (Chap. 20)
    - Client-server
  - Parallel and Distributed Systems (Chap. 20, 21, 22)
  - Object Oriented, Object Relational (Chap. 9)
  - XML (Chap. 10)
- Next class…
  - Data warehouses, Information Retrieval, Database Tuning ?

Database System Architectures

- Centralized single-user
- *Client-Server Architectures*
  - Connected over a network typically
  - Back-end: manages the database
  - Front-end(s): Forms, report-writes, *sqlplus*
  - How they talk to each other ?
    - ODBC:
      - Interface standard for talking to the server in C
    - JDBC:
      - In Java
  - Transaction servers vs. data servers

Database System Architectures

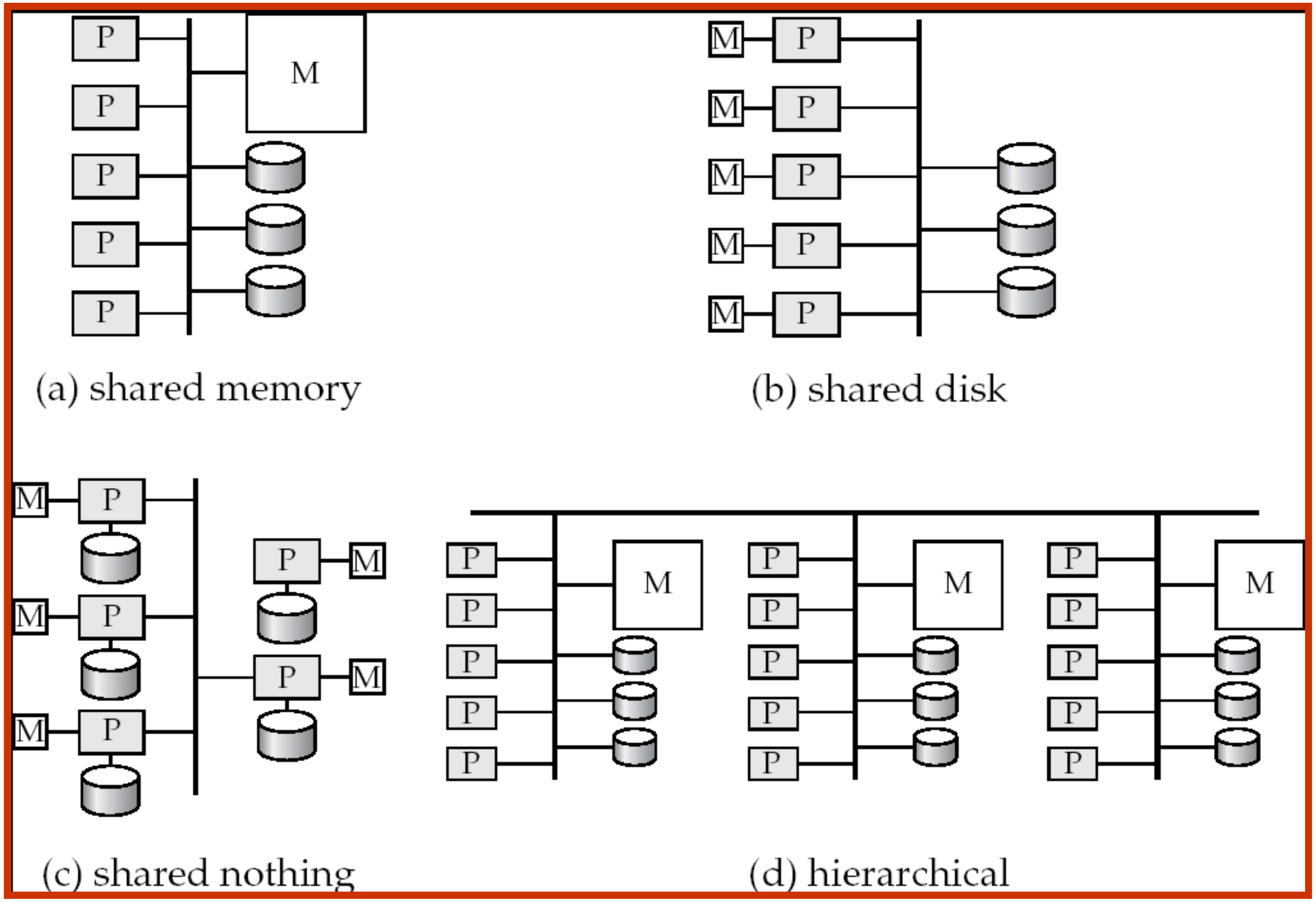


Parallel Databases

- Why ?
  - More transactions per second, or less time per query
  - Throughput vs. Response Time
  - Speedup vs. Scaleup
- Database operations are *embarrassingly parallel*
  - E.g. Consider a join between R and S on R.b = S.b
- But, perfect speedup doesn’t happen
  - Start-up costs (starting 1000s of jobs is expensive)
  - Interference (e.g. shared disk)
  - Skew (not all jobs are the same size)

Parallel Databases

- Shared-nothing vs. shared-memory vs. shared-disk



Parallel Databases

	Shared Memory	Shared Disk	Shared Nothing
Communication between processors	Extremely fast	Disk interconnect is very fast	Over a LAN, so slowest
Scalability ?	Not beyond 32 or 64 or so (memory bus is the bottleneck)	Not very scalable (disk interconnect is the bottleneck)	Very very scalable
Notes	Cache-coherency an issue	Transactions complicated; natural fault-tolerance.	Distributed transactions are complicated (deadlock detection etc);
Main use	Low degrees of parallelism	Not used very often	Everywhere

Distributed Systems

- Over a wide area network
- Typically not done for *performance reasons*
  - For that, use a parallel system
- Done because of necessity
  - Imagine a large corporation with offices all over the world
  - Also, for redundancy and for disaster recovery reasons
- Lot of headaches
  - Especially if trying to execute transactions that involve data from multiple sites
    - Keeping the databases in sync
      - *2-phase commit* for transactions uniformly hated
    - Autonomy issues
      - Even within an organization, people tend to be protective of their unit/department
    - Locks/Deadlock management
  - Works better for query processing
    - Since we are only reading the data

Next…

- Object oriented, Object relational, XML

Motivation

- Relational model:
  - Clean and simple
  - Great for much enterprise data
  - But lot of applications where not *sufficiently rich*
    - Multimedia, CAD, for storing *set data* etc
- Object-oriented models in programming languages
  - Complicated, but very useful
    - Smalltalk, C++, now Java
  - Allow
    - Complex data types
    - Inheritance
    - Encapsulation
- People wanted to manage objects in databases.

History

- In the 1980's and 90's, DB researchers recognized benefits of objects.
- Two research thrusts:
  - OODBMS: extend C++ with transactionally persistent objects
    - Niche Market
    - CAD etc
  - ORDBMS: extend Relational DBs with object features
    - Much more common
    - Efficiency + Extensibility
    - SQL:99 support
- Postgres – First ORDBMS
  - Berkeley research project
  - Became Illustra, became Informix, bought by IBM

Example

- Create User Defined Types (UDT)

```
CREATE TYPE BarType AS (
    name CHAR(20),
    addr CHAR(20)
);
CREATE TYPE BeerType AS (
    name CHAR(20),
    manf CHAR(20)
);
CREATE TYPE MenuType AS (
    bar REF BarType,
    beer REF BeerType,
    price FLOAT
);
```

- Create Tables of UDTs
  - CREATE TABLE Bars OF BarType;
  - CREATE TABLE Beers OF BeerType;
  - CREATE TABLE Sells OF MenuType;

Example

- Querying:
  - SELECT * FROM Bars;
  - Produces “tuples” such as:
    - BarType(’Joe’’s Bar’, ’Maple St.’)
- Another query:
  - SELECT bb.name(), bb.addr()
  - FROM Bars bb;
- Inserting tuples:
  - SET newBar = BarType();
  - newBar.name(’Joe’’s Bar’);
  - newBar.addr(’Maple St.’);
  - INSERT INTO Bars VALUES(newBar);

Example

- UDT’s can be used as types of attributes in a table

```
CREATE TYPE AddrType AS (
    street CHAR(30),
    city CHAR(20),
    zip INT
);
CREATE TABLE Drinkers (
    name CHAR(30),
    addr AddrType,
    favBeer BeerType
);
```

- Find the beers served by Joe:

```
SELECT ss.beer()->name
FROM Sells ss
WHERE ss.bar()->name = ’Joe’’s Bar’;
```

An Alternative: OODBMS

- Persistent OO programming
  - Imagine declaring a Java object to be “persistent”
  - Everything reachable from that object will also be persistent
  - You then write plain old Java code, and all changes to the persistent objects are stored in a database
  - When you run the program again, those persistent objects have the same values they used to have!
- Solves the “impedance mismatch” between programming languages and query languages
  - E.g. converting between Java and SQL types, handling rowsets, etc.
  - But this programming style doesn’t support declarative queries
    - For this reason (??), OODBMSs haven’t proven popular
- OQL: A declarative language for OODBMSs
  - Was only implemented by one vendor in France (Altair)

OODBMS

- Currently a Niche Market
  - Engineering, spatial databases, physics etc…
- Main issues:
  - Navigational access
    - Programs specify go to this object, follow this pointer
  - Not declarative
- Though advantageous when you know exactly what you want, not a good idea in general
  - Kinda similar argument as *network databases vs relational databases*

Summary, cont.

- ORDBMS offers many new features
  - but not clear how to use them!
  - schema design techniques not well understood
    - No good logical design theory for non-1st-normal-form!
  - query processing techniques still in research phase
    - a moving target for OR DBA’s!

- OODBMS
  - Has its advantages
  - Niche market
  - Lot of similarities to XML as well…

XML

- Extensible Markup Language
- Derived from SGML (Standard Generalized Markup Language)
  - Similar to HTML, but HTML is not *extensible*
    - Extensible == can add new tags etc
- Emerging as the *wire format (data interchange format)*

XML

```
<bank-1>
  <customer>
    <customer-name> Hayes </customer-name>
    <customer-street> Main </customer-street>
    <customer-city>   Harrison </customer-city>
    <account>
      <account-number> A-102 </account-number>
      <branch-name>    Perryridge </branch-name>
      <balance>        400 </balance>
    </account>
    <account>
      …
    </account>
  </customer>
     .
     .
</bank-1>
```

Attributes

- Elements can have **attributes**

  <account acct-type = “checking” >
  <account-number> A-102 </account-number>
  <branch-name> Perryridge </branch-name>
  <balance> 400 </balance>
  </account>

- Attributes are specified by *name=value* pairs inside the starting tag of an element
- An element may have several attributes, but each attribute name can only occur once
  - <account acct-type = “checking” monthly-fee=“5”>

Attributes Vs. Subelements

- Distinction between subelement and attribute
  - In the context of documents, attributes are part of markup, while subelement contents are part of the basic document contents
  - In the context of data representation, the difference is unclear and may be confusing
    - Same information can be represented in two ways
      - <account account-number = “A-101”> …. </account>
      - <account>
        <account-number>A-101</account-number> …
        </account>
  - Suggestion: use attributes for identifiers of elements, and use subelements for contents

Namespaces

- XML data has to be exchanged between organizations
- Same tag name may have different meaning in different organizations, causing confusion on exchanged documents
- Specifying a unique string as an element name avoids confusion
- Better solution: use unique-name:element-name
- Avoid using long unique names all over document by using XML Namespaces

```
<bank Xmlns:FB='http://www.FirstBank.com'>
    …
    <FB:branch>
        <FB:branchname>Downtown</FB:branchname>
        <FB:branchcity>   Brooklyn   </FB:branchcity>
    </FB:branch>
    …
</bank>
```

Document Type Definition (DTD)

- The type of an XML document can be specified using a DTD
- DTD constraints structure of XML data
  - What elements can occur
  - What attributes can/must an element have
  - What subelements can/must occur inside each element, and how many times.
- DTD does not constrain data types
  - All values represented as strings in XML
- DTD syntax
  - <!ELEMENT element (subelements-specification) >
  - <!ATTLIST element (attributes) >
- Also – XML Schema (not covered -read in book & online)

Bank DTD

```
<!DOCTYPE bank [
    <!ELEMENT bank ( ( account | customer | depositor)+)>
    <!ELEMENT account (account-number branch-name balance)>
    <! ELEMENT customer(customer-name customer-street
                                                  customer-city)>
    <! ELEMENT depositor (customer-name account-number)>
    <! ELEMENT account-number (#PCDATA)>
    <! ELEMENT branch-name (#PCDATA)>
    <! ELEMENT balance(#PCDATA)>
    <! ELEMENT customer-name(#PCDATA)>
    <! ELEMENT customer-street(#PCDATA)>
    <! ELEMENT customer-city(#PCDATA)>
]>
```

IDs and IDREFs

- An element can have at most one attribute of type ID
- The ID attribute value of each element in an XML document must be distinct
  - Thus the ID attribute value is an object identifier
- An attribute of type IDREF must contain the ID value of an element in the same document

Bank DTD with Attributes

- Bank DTD with ID and IDREF attribute types.

```
<!DOCTYPE bank-2[
    <!ELEMENT account (branch, balance)>
    <!ATTLIST account
            account-number ID        # REQUIRED
            owners         IDREFS # REQUIRED>
    <!ELEMENT customer(customer-name, customer-street,
                                     custome-city)>
    <!ATTLIST customer
            customer-id    ID        # REQUIRED
            accounts       IDREFS # REQUIRED>
    … declarations for branch, balance, customer-name,
                   customer-street and customer-city
]>
```

XML data with ID and IDREF attributes

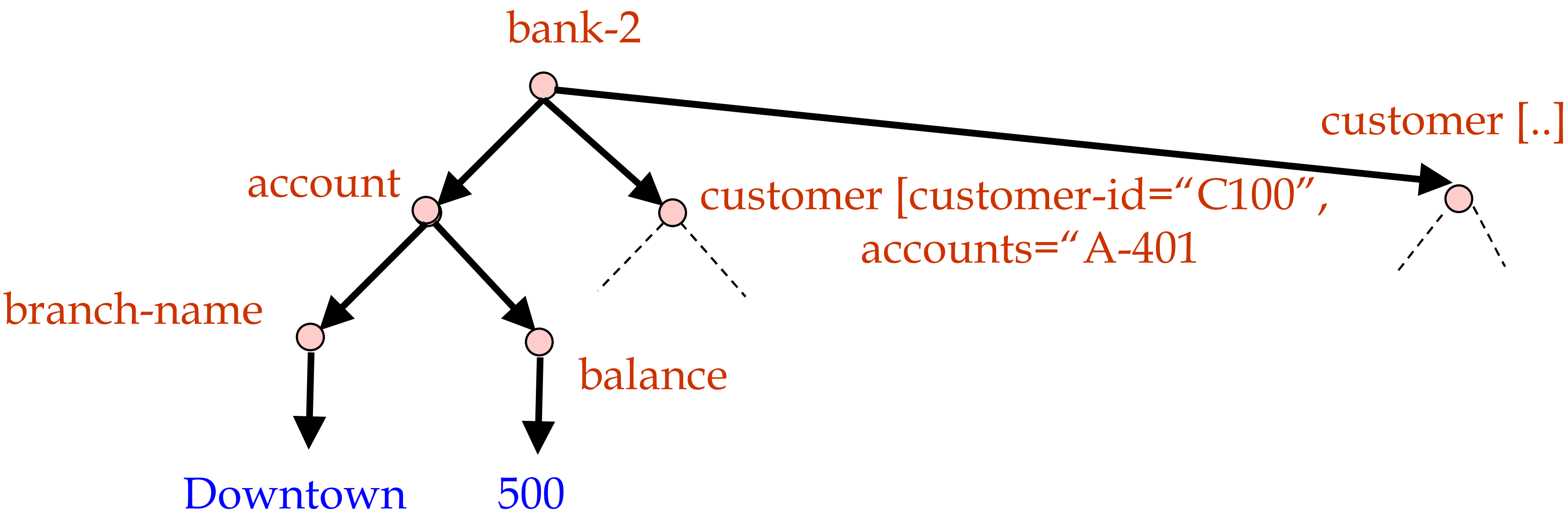
```
<bank-2>
    <account account-number="A-401" owners="C100 C102">
        <branch-name> Downtown </branch-name>
        <balance>         500 </balance>
    </account>
    <customer customer-id="C100" accounts="A-401">
        <customer-name>Joe         </customer-name>
        <customer-street> Monroe  </customer-street>
        <customer-city>     Madison</customer-city>
    </customer>
    <customer customer-id="C102" accounts="A-401 A-402">
        <customer-name> Mary     </customer-name>
        <customer-street> Erin       </customer-street>
        <customer-city>     Newark </customer-city>
    </customer>
</bank-2>
```

Querying and Transforming XML Data

- Standard XML querying/translation languages
  - XPath
    - Simple language consisting of path expressions
    - Forms a basic component of the next two
  - XSLT
    - Simple language designed for translation from XML to XML and XML to HTML
  - XQuery
    - An XML query language with a rich set of features

Tree Model of XML Data

- Query and transformation languages are based on a tree model of XML data



XPath

- /bank-2/customer/customer-name

  <customer-name>Joe</customer-name>

  <customer-name>Mary</customer-name>

- /bank-2/customer/customer-name/text( )

  Joe

  Mary

- /bank-2/account[balance > 400]
  - returns account elements with a balance value greater than 400
- /bank-2/account[balance > 400]/@account-number
  - returns the account numbers of those accounts with balance > 400

Functions in XPath

- /bank-2/account[customer/count() > 2]
  - Returns accounts with > 2 customers
- Boolean connectives and and or and function not() can be used in predicates
- IDREFs can be referenced using function id()
  - E.g. /bank-2/account/id(@owner)
    - returns all customers referred to from the owners attribute of account elements.

More XPath Features

- "//" can be used to skip multiple levels of nodes
  - E.g. /bank-2//customer-name
    - finds any customer-name element *anywhere* under the /bank-2 element, regardless of the element in which it is contained.
- Wild-cards
  - /bank-2/*/customer-name
  - Match any *element* name

XSLT

- A stylesheet stores formatting options for a document, usually separately from document
  - E.g. HTML style sheet may specify font colors and sizes for headings, etc.
- The XML Stylesheet Language (XSL) was originally designed for generating HTML from XML
- XSLT is a general-purpose transformation language
  - Can translate XML to XML, and XML to HTML
- XSLT transformations are expressed using rules called templates
  - Templates combine selection using XPath with construction of results

XSLT Templates

- Example of XSLT template with **match** and **select** part

```
<xsl:template match="/bank-2/customer">
    <xsl:value-of select="customer-name"/>
</xsl:template>
<xsl:template match="*"/>
```

- The match attribute of xsl:template specifies a pattern in XPath
- Elements in the XML document matching the pattern are processed by the actions within the xsl:template element
  - xsl:value-of selects (outputs) specified values (here, customer-name)
- For elements that do not match any template
  - Attributes and text contents are output as is
  - Templates are recursively applied on subelements
- The <xsl:template match="*"/> template matches all elements that do not match any other template
  - Used to ensure that their contents do not get output.

Creating XML Output

- Any text or tag in the XSL stylesheet that is not in the xsl namespace is output as is
- E.g. to wrap results in new XML elements.

```
<xsl:template match="/bank-2/customer">
    <customer>
        <xsl:value-of select="customer-name"/>
    </customer>
</xsl:template>
<xsl:template match="*"/>
```

  - Example output:

```
<customer> Joe   </customer>
<customer> Mary </customer>
```

XQuery

- XQuery is a general purpose query language for XML data
- Currently being standardized by the World Wide Web Consortium (W3C)
  - The textbook description is based on a March 2001 draft of the standard. The final version may differ, but major features likely to stay unchanged.
- Alpha version of XQuery engine available free from Microsoft
- XQuery is derived from the Quilt query language, which itself borrows from SQL, XQL and XML-QL
- XQuery uses a

  for … let … where .. result …

  syntax

  for ⇔ SQL from
  where ⇔ SQL where
  result ⇔ SQL select
  let allows temporary variables, and has no equivalent in SQL

FLWR Syntax in XQuery

- For clause uses XPath expressions, and variable in for clause ranges over values in the set returned by XPath
- Simple FLWR expression in XQuery
  - find all accounts with balance > 400, with each result enclosed in an <account-number> .. </account-number> tag

```
for      $x in /bank-2/account
let         $acctno := $x/@account-number
where $x/balance > 400
return <account-number> $acctno </account-number>
```

- Let clause not really needed in this query, and selection can be done In XPath. Query can be written as:

```
for $x in /bank-2/account[balance>400]
return <account-number> $x/@account-number
                                              </account-number>
```

Joins

- Joins are specified in a manner very similar to SQL

```
for $a  in  /bank/account,
    $c  in  /bank/customer,
    $d  in  /bank/depositor
where   $a/account-number = $d/account-number
    and $c/customer-name = $d/customer-name
return <cust-acct> $c $a </cust-acct>
```

- The same query can be expressed with the selections specified as XPath selections:

```
for  $a in /bank/account
     $c in /bank/customer
     $d in /bank/depositor[
               account-number = $a/account-number and
               customer-name  = $c/customer-name]
return <cust-acct> $c $a</cust-acct>
```

XML: Summary

- Becoming the standard for data exchange
- Many details still need to be worked out !!
- Active area of research…
  - Especially optimization/implementation

Worst...idea...ever!