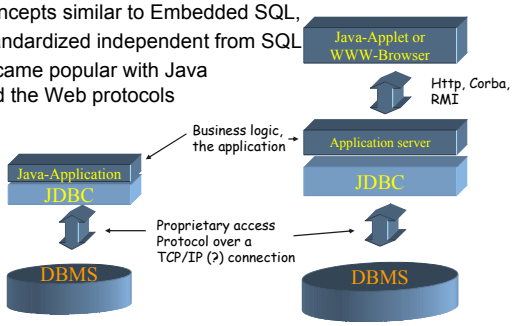
12.4 SQL and Java

- Concepts similar to Embedded SQL,
- Standardized independent from SQL
- became popular with Java and the Web protocols



SQL & Java JDBC und SQLJ

JDBC

- Java call-level interface (API) for SQL DBS
- DB vendor independent
- Supports static and dynamic SQL
- Implemented by nearly all DB vendors

SQLJ

- Is essentially embedded SQL for Java (instead of C)
- Compiles to JDBC method call
- Defined and implemented by major DBS companies (Oracle in particular)

12.4.1 JDBC

Preparation

1. `import java.sql.*;`

2. Load a driver (included in java.sql.*), many vendor products
   `Class.forName("oracle.jdbc.driver.OracleDriver");`
   url is a variable holding the JDBC-Driver and host information

3. Set up the connection to one or more database(s)
   ```
   Connection con = DriverManager.getConnection(
     "jdbc:oracle:thin:@sunset.inf.fu-
     berlin.de:1521:hstarent", username, password);
   ```
   Several connections at a time may be used

4. Create a statement object
   `Statement stmt = con.createStatement();`
   something like a channel, through which queries are sent to the DB
   Note: this is NOT a statement, but a "statement channel".

SQL & Java JDBC

Processing

5. Send SQL strings to be processed, results in a ResultSet object, which is processed with a kind of "hidden cursor"

```
ResultSet rs = stmt.executeQuery("SELECT * FROM
Movies WHERE pricePD > 2" );
```

6. Process the results one after the other

```
while (rs.next())
{ // Loop through each column, getting the
        // column data and displaying
        for (i = 1; i <= numCols; i++)
        {
            if (i > 1) System.out.print(",");
            System.out.print(rs.getString(i));
        }
    }
```

Variable binding by position

JDBC: variable binding, result set iterator

Variable binding and result set

```
java.sql.Statement stmt = con.createStatement();
  ResultSet r = stmt.executeQuery("SELECT a, b, c
                                   FROM Table1");
   while (r.next())
   {
   // print the values for the current row.
     int i = r.getInt("a");
     String s = r.getString("b");
     float f = r.getFloat("c");
     System.out.println("ROW = " + i + " " + s + " " + f);
```

Compare variable binding by position

No explicit cursor, but iterator using methods

```
boolean next() , void close(),
    <JavaType>  get<JavaType> (),
     boolean wasNull()
```

to iterate through the result.
... and many more in JDBC 2.0

SQL and Java Excecptions

```
try {
 // Code that could generate an exception goes here.
 // If an exception is generated, the catch block below
 // will print out information about it. }
catch(SQLException ex) {
   System.out.println("\n--- SQLException caught ---\n");
   while (ex != null) { System.out.println("Message: " +
   ex.getMessage ()); System.out.println("SQLState: " +
   ex.getSQLState ()); System.out.println("ErrorCode: " +
   ex.getErrorCode ()); ex = ex.getNextException();
  System.out.println(""); }
 }
```

process all execptions

```
--- SQLException caught ---
Message: There is already an object named 'Meier' in the database.
Severity 16,
State 1, Line 1
SQLState: 42501      -- Defined as X/Open standard
ErrorCode: 2714      -- Vendor specific
```

JDBC

Accessing columns

- The class ResultSet has methods for each type to access result data by position or by name
- By position:

```
String s = rs.getString(2); // the second
attribute to be bound.
```

- By name:

```
String rs.getString ("b") ;
// get the value of the attribute b of the
// row under the (implicit) cursor
```

- What about ...
  - Input parameters for queries? (... where attr = :val)
  - Positioned updates without an explicit cursor?
  - Exceptions?
  - transactional facilities ?

JDBC

Prepared statements

Subclass of statement

will be compiled,
? Indicates still missing value

```
String mTitle; ....
try {
   java.sql.PreparedStatement prepStmt =
         con.prepareStatement("SELECT count(*)
         FROM M,T where M.title = ? and T.mId = M.mId);
    prepStmt.setString(1, mTitle);
    ResultSet r = prepStmt.executeQuery() ;
    while (r.next())
    {
     int i = r.getInt(1);
    // must get by position, no name available
      System.out.println("Number of tapes for  " +
      movieTitle + " is: " +i)
    }
  } catch(SQLEception {…}
```

Bind value to position (!)
in statement and excecute

Prepared vs non-prepared

- Overhead for compiling SQL-statement basically constant
- Ratio of compile Time / processing time for queries important
- Simple queries: prepare when executed frequently – e.g. in a loop
- Complex queries in a loop: no performance gain
- Many more factors to be analyzed

Very simple performance comparison

```
System: Postgres local
Query: SELECT * FROM city WHERE name ='X'
Time: 150
----------
System: Postgres local
Prepared Query: SELECT * FROM city WHERE
    name ='X'
Time: 60
----------
System: Postgres local
Query:
SELECT DISTINCT A.Name, B.Name
FROM country A, country B, encompasses uA,
encompasses uB, geo_sea gMA, geo_sea gMB
WHERE A.Name < B.Name AND uA.continent=
    'Europa' AND uB.continent = 'Europa'
    ANDuA.country = A.c_ID AND
 uB.country = B.c_ID AND A.c_ID = gMA.c_ID AND
 B.c_ID = gMB.c_ID AND gMA.sea = gMB.sea
Time: 44802
----------
System: Postgres local
Prepared Query: SELECT          DISTINCT
    A.Name, B.Name FROM         country A, ..
Time: 42549
----------
```

all queries executed 100 x
time: msec

```
System: Ora9i local
Query: SELECT * FROM city WHERE ..
Time: 301
----------
System: Ora9i local
Prepared Query: SELECT * FROM city .
Time: 120
----------
System: Ora9i local
Query: SELECT DISTINCT A.Name, B.Name
Time: 1692
----------
System: Ora9i local
Prepared Query:
  SELECT DISTINCT A.Name, B.Name FROM

Time: 1583
----------
```

Ora: more effort into optimizing query

JDBC

Positioned update

- Remember:

```
EXEC SQL DECLARE myCurs CURSOR FOR
          SELECT m#, ppd FROM M WHERE ...
              FOR UPDATE ON ppd:
  ....
  EXEC SQL FETCH myCurs INTO ...
  EXEC SQL UPDATE M SET ppd = ppd + 1
       WHERE CURRENT OF  myCurs     /* delete in
                                    a similar way
...
```

needs a cursor name, but there is no cursor name

- JDBC 1 allows to define a cursor, which may be used in subsquent update / delete statements:

```
public void setCursorName(String name)  throws
SQLException
```

- Much more flexible (anonymous) cursor handling in JDBC 2, `setCursorName` not implemented in Oracle Driver

JDBC: Updates

Updating result sets (JDBC 2.0)

```
Statement stmt = con.createStatement(
             ResultSet.TYPE_SCROLL_SENSITIVE,
             ResultSet.CONCUR_UPDATABLE);
    stmt.setFetchSize(25);

 ResultSet rs = stmt.executeQuery(
     "SELECT emp_no, salary FROM employees");


rs.first();
rs.updateFloat("salary", 10000.0);
rs.updateRow();
```

SQL & Java JDBC

– Transactional properties of connections

JDBC constants:

```
TRANSACTION_NONE
TRANSACTION_READ_UNCOMMITTED
TRANSACTION_READ_COMMITTED
TRANSACTION_REPEATABLE_READ
TRANSACTION_SERIALIZABLE
```

JDBC API:

- `public void setTransactionIsolation(int level) throws SQLExceptionpublic`
- `public void setAutoCommit(boolean autoCommit) -- no autocommit when updating result sets!`
- `public void commit() throws SQLException`
- `public void rollback() throws SQLException`

JDBC

Visibility of changes

– Does TA see it's own changes?
if there is more than one result set in a TA?

```
ResultSet rs = stmt.executeQuery(
     "SELECT emp_no, salary FROM employees");
ResultSet badGuys = stmtx.executeQuery (
  "SELECT emp_no  FROM employees where ....");
...int i = executeUpdate ("DELETE FROM employees");
   rs.updateFloat("salary", 10000.0);
   rs.updateRow();
```

Is the deleted row still visible??

Different ways to perform an update

JDBC updates

– Not visible if result set is scroll-insensitive: no change from other result sets – even in the same TA – are visible

– Updates made in a result set r are visible by operations on r, but not necessarily deletes / inserts (!)

– If sensitive, it depends on connection isolation level

JDBC: calling stored procedures

- Stored procedures may be called directly

simple function expl.

```
CallableStatement cs
= con.prepareCall("{?=call rand(?, 100 ) }");
cs.setInt(2,1); // set arguments
cs.registerOutParameter(1, Types.INTEGER);
  // register type of output
cs.execute();
System.out.println( cs.getInt(1) + ", ");
  // execute and get result value, position 1
```

If stored procedure causes updates:

```
int i = cs.executeUpdate();
```


JDBC and persistent objects

- Persistence of Java Objects

```
ResultSet rs = stmt.executeQuery(
            "SELECT Employee FROM PERSONNEL");
     rs.next();
     Employee emp = (Employee)rs.getObject(1);
```

- Updating objects in the DB

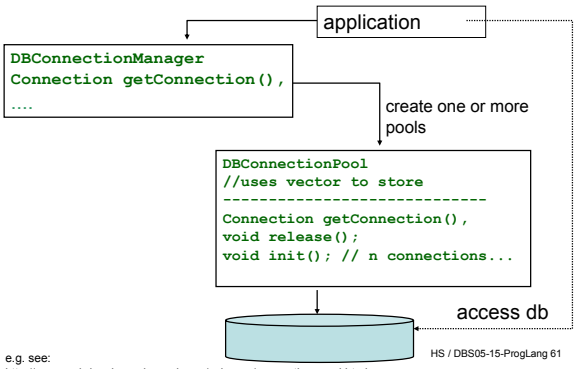
```
emp.setSalary(emp.getSalary() * 1.5);
     PreparedStatement pstmt = con.preparedStatement(
     "UPDATE PERSONNEL SET Employee = ?
      WHERE Employee.no = 1001"));
     pstmt.setObject(1, emp);
     pstmt.executeUpdate();
```

- Persistence frameworks: no SQL statements visible for application programmer.
Persistant object collections may be updated in java terms `emp.setSalary (emp.getSalary*1,5)` and updated in the DB "automatically".

JDBC connection pooling

- Opening a connection is expensive
  – DB login, set up context, check rights, ...
  – up to 1 sec in some systems
- Typical interactive applications (e.g. web shop): many customers, few DB interactions
⇒ heavy overhead caused by setup of DB connection
- Solution
use a set of pre-initialized connections ("connection pool")

JDBC connection manager



e.g. see:
http://www.webdevelopersjournal.com/columns/connection_pool.html

JDBC: programming style

- Do not hard-code connection data but use property file

```
drivers=jdbc:postgresql jdbc:oracle:thin
logfile=D:\\user\\src\\java\\DBConnectionManager\\log.txt

ora.url=jdbc:oracle:thin:@localhost:1521:tarenths
ora.maxconn=2

pg.url=jdbc:postgresql://localhost:5432/geo
pg.user=demo
pg.password=demopw
```

different pools

`init()` method:
Create property object
`Properties dbProp = new Properties();`
and Read property file

JDBC: programming style

- Separate DB interaction and processing
- SQL code goes into a separate object
- Encapsulate DB execution and error handling from application processing

Many advantages, but not always a trivial task.

12.4.2 SQLJ

Part 0: SQLJ Embedded SQL
- Mostly reviewed and implemented
- Integrated with JDBC API
- Oracle has placed Translator source into public domain

Part 1: SQLJ Stored Procedures and UDFs
- Using Java static methods as SQL stored procedures & functions
- Leverages JDBC API

Part 2: SQLJ Data Types
- Pure Java Classes as SQL ADTs
- Alternative to SQL3 Abstract Data Types

SQLJ and JDBC

```
//  SQLJ

int n;
#sql { INSERT INTO emp VALUES (:n)};


//  JDBC

int n;
Statement stmt = conn.prepareStatement
                 ("INSERT INTO emp VALUES (?)");
stmt.setInt(1,n);
stmt.execute ();
stmt.close();
```

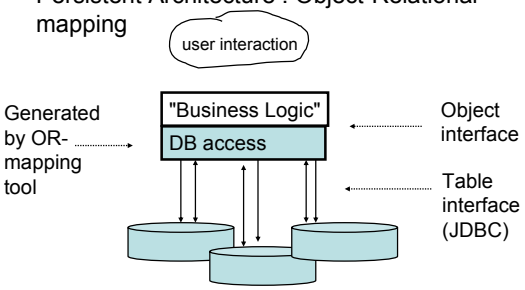

SQLJ Example

```
CREATE TABLE PARTS_MASTER
    (PART_ID NUMBER(8) PRIMARY KEY,
     PART_NAME VARCHAR(40),
     SUPPLIER VARCHAR(200));

CREATE TABLE MRP
   (PART_ID REFERENCES PARTS_MASTER,
    QUANTITY_ON_HAND NUMBER(6),
    REORDER_THRESHOLD NUMBER(6));

// Part of a SQLJ program, showing definition of one method:
  public class inventory {
  ...
    public void pullStock (int part, int quantity)
     throws OutOfStock {
      int on_hand, threshold;

      #sql { SELECT QUANTITY_ON_HAND, REORDER_THRESHOLD
               INTO :on_hand, :threshold FROM MRP
               WHERE PART_ID = :part FOR UPDATE };
```

```
    on_hand -= quantity;
    if (on_hand < threshold) {
      String supplier;
        #sql { SELECT SUPPLIER INTO :supplier
               FROM PARTS_MASTER
               WHERE PART_ID = :part };
        inventory.orderMore(part, quantity, supplier);
    }
    if (on_hand < 0) {
      #sql { ROLLBACK };
      throw new OutOfStock();
    } else {
      #sql { UPDATE MRP SET QUANTITY_ON_HAND = :on_hand
             WHERE PART_ID = :part };
        #sql { COMMIT };
    }
  }
...
}
```

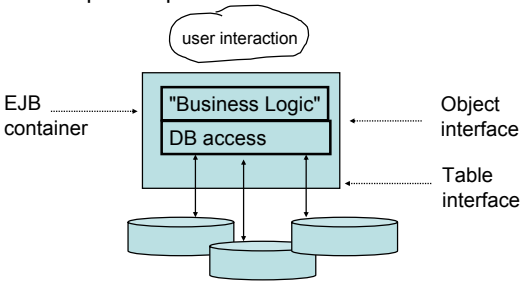

12.5 Components and OR-Mapping

- Persistent Architecture : Object-Relational mapping



Components and OR-Mapping

- Component persistence Architecture



EJB: Enterprise Java Beans, component model for Business related software

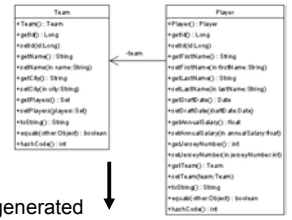
Motivation

- OR mapping
  - hide details of DB schema from application program
  - typical usage:
    - application started from scratch
    - application is rather simple: few persistent classes
    - Relational schema is generated from persistent classes
    - Mapping between tables and persistent classes is generated
    - Most simple approach:
      - "row type" (attributes) = class
      - "row" = "object"
  - Systems: Hibernate, Object Relational Bridge (OJB) and many more

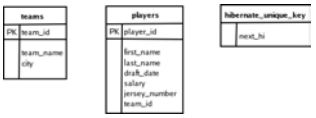
http://www.systemmobile.com/articles/IntroductionToHibernate.html

OR mapping

From Classes
to tables,
from rows
to objects



mapping defined
by developer or generated



OR mapping

- Example continued

Retrieval and update

```
// method: loading the Player's state Player
Session session = SessionFactory.openSession();
player = new Player();
session.load(player, playerId);
player.setAnnualSalary(4000000f) ;
session.saveOrUpdate(player);
```

SQL-like QL allows to retrieve by content

- Advantage:
  - No explicit result set processing
  - Object oriented framework
- Disadvantage
  - overhead compared to JDBC
  - no stored procedures
  - not a big conceptional difference

Components: EJB

- Motivation
  - should support technical issues
    - multi-user (concurrency management) and distributed transaction management
    - security
    - resource management and component lifecycle (threads, database connections, etc.)
    - remote accessibility and component location transparency
    - persistence, chaching
    - tools for bean installation and deploying
  - portability: developping business beans without knowing the particular DB infrastructure

  ⇒ Economic impact!

EJB

- Disadvantage
  - not easy to learn
  - not easy understand side effects
    e.g. concurrency control in DB or in EJB container
    - Container: compromises durability ("changed data on disk?")
    - DB: heavy traffic between EJB cache and DB cache
  - Depend on vendor implementations
    (EJB specification is underspecified)
  - Performance: heavy penalty depending on application

How portability is achieved will not be discussed here -> course on J2EE development

EJB performance

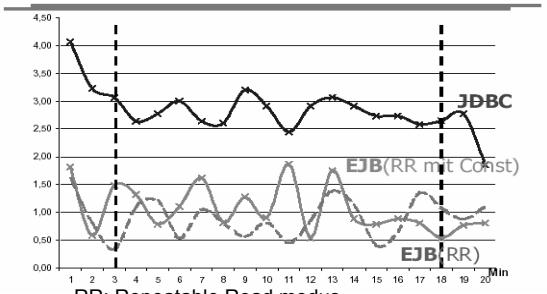
- Comparison of JDBC and EJB architectures using TPC-W*
- TPC-W
  - represents Web application (Business model: online book shop)
    - Browser (Client)
    - Web-Server
    - Application-Server
    - database
  - Measurement on DB size:
    - books: 10.000, Authors: 2.500
    - Customers: 5.000, Addresses 10.000,
  - Transactions defined by TPC-W (search, buy, ...)

* Study by Zink / Hettel, Hamburg, AK Frameworks2000

EJB using "container managed persistence", i.e. automatic mapping between DB objects and EJBs

JDBC / EJB performance comparison

Web Interactions per Second (WIPS)

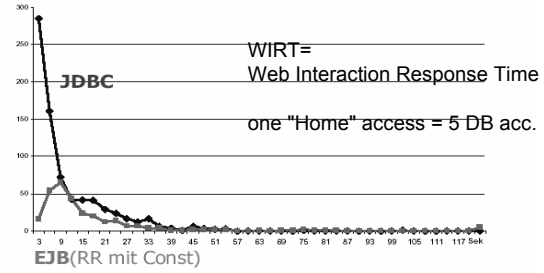


RR: Repeatable Read modus

* source Zink / Hettel, 2000

JDBC / EJB performance comparison

EJB vs. JDBC:
WIRT-Verteilung der Seite "Home"



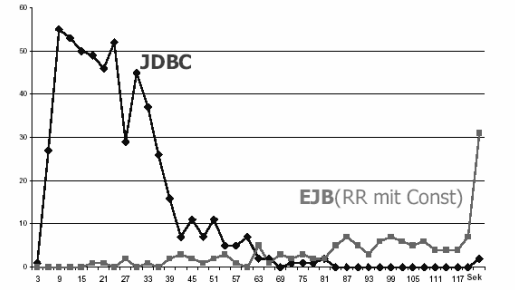
WIRT=
Web Interaction Response Time

one "Home" access = 5 DB acc.

* source Zink / Hettel, 2000

JDBC / EJB performance comparison

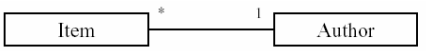
EJB vs. JDBC:
WIRT der Seite „SearchResult“



* source Zink / Hettel, 2000

JDBC / EJB performance comparison

- Search operation: up to 50 associations



- JDBC:
  Database join
- EJB: up tp 50 **`findByPrimaryKey()`** - calls
- EJB solution cannot perform better than JDBC

JDBC / EJB performance comparison

- Investigation shows tendency, but should not be overestimated:
  - EJB 2.0 have been improved
  - Application servers which manage the containers, have been improved
  - "Bean managed persistence" may be tuned

Albert Einstein:
Not everything which can be measured is important, not everything which is important can be measured

Summary

- Access of Database from application program more important than interactive SQL
- cursor : iterator through result sets explicit or implicit
- Dynamic versus static (compiled) SQL
- Stored procedures: important tool
- Transaction = unit of work: very important concept in multi user environments (remember: acid)
- Isolation level: lower levels acceptable in many cases, "seriazalibility" prevents any harm due to read / write conflicts
- JDBC : similar to "call level interface (CLI)
- SQLJ : "Embedded" version, not as important as JDBC (?)
- Persistence frameworks useful in simple applications, questionable in large high performance systems.