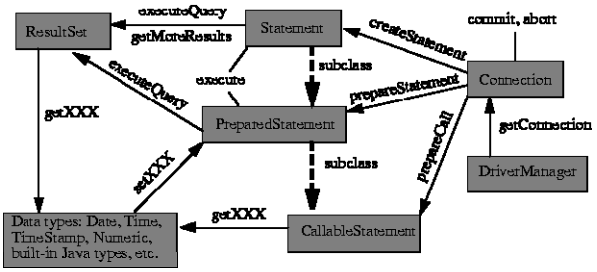
9 Embedding SQL into Programming languages

Lit.: Kemper / Eickler: chap. 4.19-4.23;
Melton: chap. 12,13,17-19, Widom, Ullman, Garcia-Molina: chapt.8
JDBC Literature, e.g.Sun jdbc guide.(see: material)

JDBC core interfaces



from Sun Microsystems: JDBC 2.0 API

Making a connection

```
try {
    Class.forName("oracle.jdbc.OracleDriver"); }
    catch (ClassNotFoundException e)
    {System.out.println ("Driver not found");}
try {
  DriverManager.registerDriver (
          new oracle.jdbc.OracleDriver());
  return DriverManager.getConnection (url1,database, pw );}
 catch (SQLException e){
        System.out.println("SQL-Execption: ");
 }

 }
```

New concept: **`DataSource`** interface:

- logical concept, avoids hard coded Driver / Connection details. Name registered with JNDI naming service, which supplies details
- support of connection pools and transactions

Calling stored procedures

PL/SQL function (from above):

```
create or replace FUNCTION CountryLCity
  (cname IN VARCHAR, p IN int) RETURN int
  IS CURSOR ctry IS
  SELECT *  FROM Country
  WHERE CODE LIKE cname||'%'
        and population >p;
   row# int;
BEGIN
      FOR resRecord IN ctry  LOOP
       row# :=ctry%ROWCOUNT;
        dbms_output.PUT_LINE ('Name: ' ||
           resRecord.name || ', Capital: '||
          resRecord.capital);
   END LOOP;
 RETURN (row#);
END;/
```


JDBC: calling stored procedures

```
try{
CallableStatement cs = con.prepareCall
     ("{ ?=call CountryLCity(?,?)}");
cs.registerOutParameter(1, Types.INTEGER);
cs.setString(2,arg1);
cs.setInt(3,arg2);
cs.executeQuery();
int res = cs.getInt(1);
System.out.println("... "+ res + ", ");
 } catch (SQLException ex) {
System.err.println("Error While
Executing Function Mondial.CountryLCity " +
ex.toString());
}
```

If stored procedure causes updates:

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


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 FROMemployees");



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

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):

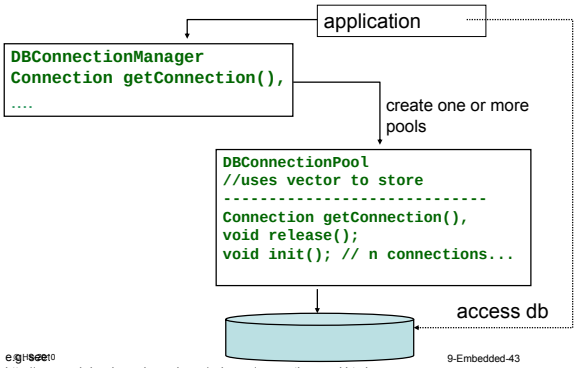
many customers, few DB interactions

⇒ 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

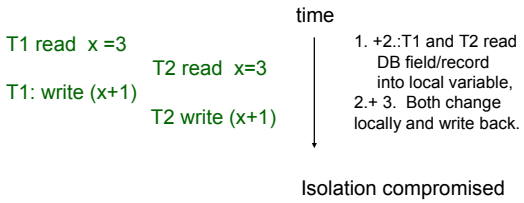
Transactional processing...

... a short introduction

Transaction: a **unit of work** which consists of a **sequence of steps** (operations on the Database)

Isolation of independent application processes T1, T2,...

Lost update



Isolation compromised

Lost update! Database corrupt.

Transaction isolation more demanding than concurrency in programs?

Transaction semantics

DBS has to guarantees certain executional properties

"**All or nothing**" semantics

All effects are made permanent at COMMIT, not before .

TA has no effect after ROLLBACK — ATOMICITY

"Now and forever"

DBS guarantees the effects after COMMIT has been processed successfully — DURABILITY

"Solve concurrency conflicts"

Conflict resolution of concurrent operations on DB

"Keep consistent DB consistent" — ISOLATION

Preservation of integrity

CONSISTENCY

Transactions

How does DB System guarantee the properties?

Implementation of DBS

Application programming: DB transactions

Syntactically mark unit of work:

```
START TRANSACTION    …….   COMMIT;
```

or:

```
START TRANSACTION ……..
   IF (everything_OK) COMMIT
  ELSE ROLLBACK; ENDIF – no effect on DB
```

Exception thrown by system (Transaction abort) if application wants to commit, but DBS cannot guarantee proper execution

SQL & Java: JDBC

Transactional properties of connections

JDBC constants:

```
TRANSACTION_NONE
TRANSACTION_READ_UNCOMMITTED
TRANSACTION_READ_COMMITTED
TRANSACTION_REPEATABLE_READ
TRANSACTION_SERIALIZABLE
```

Different isolation levels

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: 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.

9.4.2 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 };
      }
    }
  ...
  }
```

9.5 OR-Mapping

Motivation

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

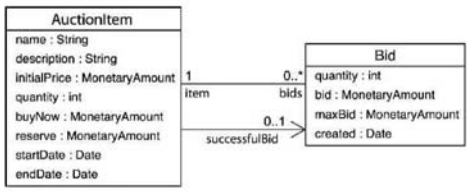
http://www.systemmobile.com/articles/IntroductionToHibernate.html

Goal of OR-Mapping

Take advantage of the things SQL databases do well, without leaving the Java (?) language of objects and classes.

OR-mapping with Hibernate example

From Classes to tables,
from rows to objects



Mapping has to be defined by developer or generated.

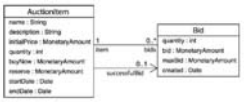
OR Mapping Definition

```
<class name="AuctionItem" table="AUCTION_ITEM">
   <id name="id" column="ITEM_ID">
       <generator class="native"/>
   </id>

   <property name="description" column="DESCR"/>
   <one-to-one name="successfulBid"
                          column="SUCCESSFUL_BID_ID"/>

   <set name="bids" cascade="all" lazy="true">
       <key column="ITEM_ID"/>
       <one-to-many class="Bid"/>
   </set>

</class>
```



OR-Mapping Hibernate example

Expl.: Retrieve an AuctionItem and change the description:

```
Session session = sessionFactory.openSession();
Transaction tx = session.beginTransaction();

AuctionItem item =
   (AuctionItem) session.get(AuctionItem.class, itemId);

item.setDescription(newDescription);

tx.commit();
session.close();
```


OR-Mapping Hibernate example

Retrieve an AuctionItem and change the description, as **detached object**:

```
Session session = sessionFactory.openSession();
Transaction tx = session.beginTransaction();
AuctionItem item =
(AuctionItem) session.get(ActionItem.class, itemId);
tx.commit();
session.close();

item.setDescription(newDescription);

Session session2 = sessionFactory.openSession();
Transaction tx = session2.beginTransaction();
session2.update(item);
tx.commit();
session2.close();
```

reattach!
Danger of lost update?

OR-Mapping Hibernate Example

Retrieve an AuctionItem and create a new persistent Bid:

```
Bid bid = new Bid()
bid.setAmount(bidAmount);
Session session=sessionFactory.openSession();
Transaction tx=session.beginTransaction();

AuctionItem item =
   (AuctionItem)session.get(AuctionItem.class, itemId);

bid.setItem(item);
item.getBids().add(bid);
```

No managed associations!

```
tx.commit();
session.close();
```


Hibernate Query Options

- Hibernate Query Language (HQL)
  object-oriented dialect of ANSI SQL
- Native SQL queries
  direct passthrough with automatic mapping
  named SQL queries in metadata

Similar language concept in .NET: LINQ
a language for querying data sources
(Database/SQL, XML files and more)
integrated in C#, VB

Hibernate Query Language (HQL)

- Make SQL "object-oriented"
  - classes and properties instead of tables and columns
  - supports polymorphism
  - automatic association joining
  - *much* less verbose than SQL
- Full support for relational operations
  - inner/outer/full joins, cartesian product
  - projection, ordering, aggregation and grouping
  - subqueries and SQL functions

OR-Mapping: Hibernate HQL

Most simple HQL query!

```
from AuctionItem;
```

i.e. get all the **AuctionItem**s:

```
List allAuctions =
session.createQuery("from AuctionItem").list();
```


OR-Mapping Hibernate example

```
select item
from AuctionItem item
join item.bids as bid
where item.description like "Hibernate%"
and bid.amount > 100
```

i.e. get all the **AuctionItem**s with a **Bid** worth more than 100 and an item description that starts with "Hibernate".

Hibernate Query: Criteria / HQL

```
List auctionItems =
session.createCriteria(AuctionItem.class).setFetchMode("bids
   ", FetchMode.EAGER)
      .add( Expression.like("description", desc) )
      .createCriteria("successfulBid")
      .add( Expression.gt("amount", minAmount) ).list();
```

Equivalent HQL:

```
from AuctionItem item
left join fetch item.bids
where item.description like :description
and item.successfulbid.amount > :minAmount
```

HQL: Passing Parameters

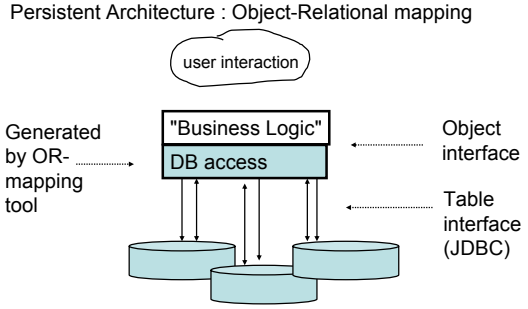
```
Query q = s.createQuery(
      "from foo in class Foo
       where foo.name=:name
      and foo.size=:size");

q.setProperties(fooBean);
```

// fooBean has getName() and getSize() List foos = q.list();

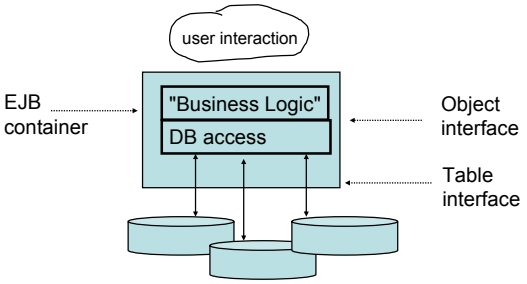
9.5 Components and OR-Mapping

Persistent Architecture : Object-Relational mapping



Components and OR-Mapping

Component persistence Architecture



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

Components: EJB

Motivation **EJB should relieve application from programmer 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, caching
- tools for bean installation and deploying

– portability: developing business beans without knowing the particular DB infrastructure

– **most important: scalability**

EJB

Disadvantage

– not easy to comprehend

– not easy to 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 used to be underspecified)

– Performance: heavy penalty depending on application

Details in courses on SE (?) and
(Distributed) Transaction Processing

EJB performance

Comparison of JDBC and EJB architectures using TPC-W*

* Study by Zink / Hettel, Hamburg, AK Frameworks2000

TPC-W

represents Web application
(Business model: online book shop)

– Browser (Client)
– Web-Server
– Application-Server
– database

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

Measurement on DB size:

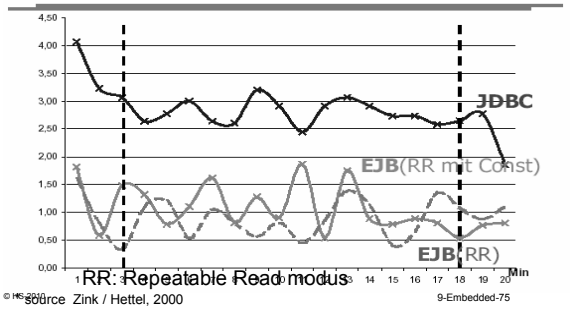
– books: 9.000, Authors: 2.500
– Customers: 5.000, Addresses 9.000,

Transactions defined by TPC-W (search, buy, ...)

JDBC / EJB performance comparison

ATTENTION: pretty OLD study, but tendency is correct.

Web Interactions per Second (WIPS)

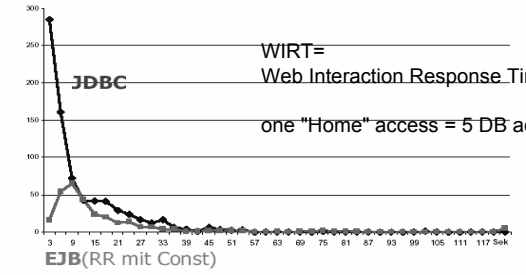


RR: Repeatable Read modus

source Zink / Hettel, 2000

JDBC / EJB performance comparison

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



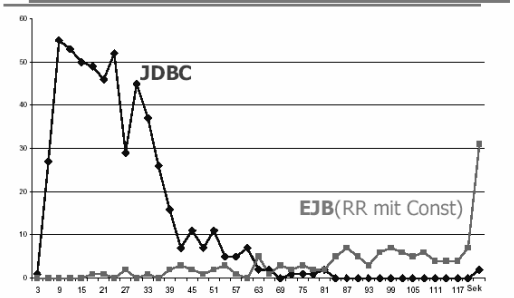
WIRT=
Web Interaction Response Time

one "Home" access = 5 DB acc.

source Zink / Hettel, 2000

JDBC / EJB performance comparison

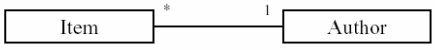
EJB vs. JDBC:
WIRT der Seite „SearchResult“



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 / 3.0 have been improved considerably

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
- **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.
- **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 (details to come)