course:
Database Systems (NDBI025)
SS2011/12

lecture 5:

SQL – embedded SQL, external applications, SQL/XML

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Today's lecture outline

- embedded SQL – „internal" database applications
  - stored procedures
  - cursors
  - triggers
- SQL/XML
  - XML data type + functions integrated into SQL SELECT
- „external" database applications (using interfaces/libraries)
  - ODBC, JDBC, ADO.NET
  - object-relational mapping libraries
    - Java Hibernate

Programming in embedded SQL

- procedural extensions of SQL
  - std. SQL is a subset (i.e., that's why embedded)
  - MS SQL Server – Transact SQL (T-SQL)
  - Oracle – PL/SQL
- benefits
  - controlling statements (if-then, for, while)
    - cannot be just scripted
  - cursors (iterative scan of tables)
  - smaller networking overhead (code on server), pre-compiled
  - triggers – general integrity constraints
  - better security (access rights control for server code)
- cons
  - proprietary extensions, cannot be simply transferred
  - SQL 1999 standard, but not respected by industry much

Structure (MS SQL Server)

DECLARE section
BEGIN … **END**

E.g.:

```
DECLARE @avg_age FLOAT
BEGIN
SELECT @avg_age = AVG(age) FROM Employee
END
```

Stored procedures (MS SQL Server)

CREATE PROCEDURE *procname* [; *number*]
[*declaration_parameter* [, ...]]
[WITH RECOMPILE]
AS commands [;]

- parameter declaration
  - *@name type* [= *expression*] [OUT[PUT]]
    - OUT[PUT] parameter is output
- *number* allows multiple versions of the same procedure
- procedure call
  - EXEC[UTE] procname [expression [, ...]]
    - parameters are passed w.r.t. order
  - EXEC[UTE] procname [@name=expression [, ...]]
    - parameters are passed w.r.t. names

Stored procedures, example

```
CREATE PROCEDURE Payment
    @accSource VARCHAR(25),
    @accTarget VARCHAR(25),
    @amount INTEGER = 0
  AS
  BEGIN
      UPDATE Accounts SET balance = balance - @amount
       WHERE account=@accSource;

      UPDATE Accounts SET balance = balance + @amount
       WHERE account=@accTarget;
  END

EXEC Payment '21-87526287/0300', '78-9876287/0800', 25000;
```

Stored procedures (MS SQL Server)

CREATE FUNCTION *funcname* [; *number*]
([*declaration_parameter* [, ...]]) **RETURNS** type
[WITH RECOMPILE]
AS commands [;]

- parameter declaration
  - *@name type* [= *expression*] [OUT[PUT]]
    - OUT[PUT] parameter is output
- *number* allows multiple versions of the same procedure
- procedure call
  - funcname([expression [, ...]])
    - parameters are passed w.r.t. order
  - funcname(procname [@name=expression [, ...]])
    - parameters are passed w.r.t. names

Stored procedures, example

```
CREATE FUNCTION AccBalance(
    @acc VARCHAR(25)
    ) RETURNS INTEGER
  AS
  DECLARE @ret INTEGER;
  BEGIN
      SELECT @ret =balance
       FROM Accounts
       WHERE account=@acc;

      RETURN @acc;
  END

SELECT AccBalance(account) AS bal FROM …
```

Cursors (MS SQL Server)

- declaration
  - C [SCROLL] **CURSOR FOR**
    SELECT …;
- data retrieval
  - **FETCH**
    {NEXT | PRIOR | ABSOLUTE n | RELATIVE n | LAST | FIRST}
    FROM C
    [INTO @variable [, …]]
  - If cursor not declared using SCROLL, only NEXT is allowed

Cursors, example (tax payment)

```
DECLARE
    Cur CURSOR FOR
        SELECT *
        FROM Accounts;
    BEGIN
        OPEN Cur
        DECLARE @acc int, @bal int;
        FETCH NEXT FROM Cur INTO @acc, @bal;
        WHILE @@FETCH_STATUS=0
        BEGIN
          Payment(@acc, '21-87526287/0300', @bal*0.01)
          FETCH NEXT FROM Cur INTO @acc, @bal;
        END;
        CLOSE Cur;
        DEALLOCATE Cur;
    END
```

Triggers – DML triggers

- event-executed stored procedure (table/view event)
- allows to extend integrity constraint logics
  - ***inserted, deleted*** – logical tables with the same structure as the table the trigger is bound on

CREATE TRIGGER trigger_name **ON** { table | view }
[WITH ENCRYPTION]
{ FOR | AFTER | INSTEAD OF }
{ [INSERT] [,] [UPDATE] [,] [DELETE] }
[WITH APPEND]
AS
[{IF UPDATE (column) [{ AND | OR } UPDATE (column)] ...
| IF (COLUMNS_UPDATED (bitwise_operator updated_bitmask
)}]
sql_statement [...]

DML triggers (example)

```
CREATE TRIGGER LowCredit ON Purchasing.PurchaseOrderHeader
AFTER INSERT
AS
DECLARE @error_count int

SELECT @error_count = count (*)
    FROM inserted i JOIN Purchasing.Vendor v on v.VendorID = i.VendorID
    WHERE v.CreditRating=5

IF @error_count > 0
BEGIN
    RAISERROR ('Vendor''s credit rating is too low to accept new purchase orders.', 16, 1)
    ROLLBACK TRANSACTION
END
```

DDL triggers

CREATE TRIGGER trigger_name **ON** { ALL SERVER | DATABASE }
[WITH <ddl_trigger_option> [,...n]]
{ FOR | AFTER } { event_type | event_group } [,...n] **AS**
{sql_statement [;] [,...n] | EXTERNAL NAME < method specifier > [;] }
<ddl_trigger_option> ::= [ENCRYPTION] [EXECUTE AS Clause]
    <method_specifier> ::= assembly_name.class_name.method_name

DDL triggers (example)

```
CREATE TRIGGER safety ON DATABASE FOR
   DROP_SYNONYM
AS
   RAISERROR ('You must disable Trigger "safety" to drop
   synonyms!',10, 1) ROLLBACK
```

What is SQL/XML

- An extension of SQL for XML data (SQL 2003)
  - New built-in data type called XML
  - Querying over XML data
- Note: SQL/XML ≠ SQLXML
  - SQLXML is Microsoft technology in MS SQL Server (not standard)
  - Similar strategy, but different approach
  - Not a standard
- The key aspect is an XML value
  - Intuitively: an XML element or a set of XML elements
  - Its semantics results from XML Infoset data model
    - Standard of XML data model = tree consisting of nodes representing elements, attributes, text values, ...
    - graph formalism for XML

XML Data Publishing

- Generating of XML data (of type XML) from relational data
  - XMLELEMENT – creating an XML element
  - XMLATTRIBUTES – creating XML attributes
  - XMLFOREST – creating a sequence of XML elements
  - XMLCONCAT – concatenation of XML values into a single value
  - XMLAGG – creating a sequence of elements from a group of rows

XMLELEMENT

```
Employees (id, first, surname, dept, start)
```

- Creating an XML value for:
  - Name of an element
  - (Optional) list of attribute declarations
  - (Optional) list of expressions declaring element content

```
SELECT E.id,
  XMLELEMENT ( NAME "emp",
    E.first || ' ' || E.surname ) AS xvalue
FROM Employees E WHERE ...
```

id	xvalue
1001	<emp>George Clooney</emp>
...	...

XMLELEMENT – subelements

```
SELECT E.id,
  XMLELEMENT ( NAME "emp",
    XMLELEMENT ( NAME "name",
      E.first || ' ' || E.surname ),
    XMLELEMENT ( NAME "date", E.start )
  ) AS xvalue
FROM Employees E WHERE ...
```

id	xvalue
1001	<emp> <name>George Clooney</name> <date>2000-05-24</date> </emp>
...	...

XMLATTRIBUTES

```
SELECT E.id,
  XMLELEMENT ( NAME "emp",
    XMLATTRIBUTES ( E.id AS "empid" ),
    E.first || ' ' || E.surname ) AS xvalue
FROM Employees E WHERE ...
```

id	xvalue
1001	<emp empid="1001">George Clooney</emp>
...	...

XMLFOREST

```
SELECT E.id,
  XMLELEMENT ( NAME "emp",
    XMLFOREST (
      E.first || ' ' || E.last AS "name",
      E.start AS "date" ) ) AS xvalue
FROM Employees E
WHERE ...
```

id	xvalue
1001	<emp> <name>George Clooney</name> <date>2000-05-24</date> </emp>
...	...

XMLAGG

- XMLAGG is an aggregation function combined with GROUP BY
  - Similarly to SUM, AVG etc.
- XMLAGG accepts only XML expressions (values)
- The expression is evaluated for each row in group G created by the GROUP BY expression
- The results are concatenated into a single resulting value
- The result can be sorted using ORDER BY

XMLAGG

```
SELECT XMLELEMENT (
  NAME "dept",
  XMLATTRIBUTES (E.dept AS "name"),
  XMLAGG (
    XMLELEMENT (NAME "emp", E.surname)
    ORDER BY E.surname )
  ) AS xvalue
FROM Employees E
GROUP BY E.dept
```

xvalue
<dept name="hr"> <emp>Clooney</emp> <emp>Pitt</emp> </dept>
<dept name="accountant"> ... </dept>
...

XML Type

- Type XML can be used at same places as SQL data types (e.g., NUMBER, VARCHAR, …)
  - Column type, SQL variable, …
- The XML type can be
  - Queried (XMLQUERY)
  - Transformed into relational data (XMLTABLE)
  - Tested (XMLEXISTS)

Sample Data – Table EmpXML

id	ColEmpXML
1001	<emp> <first>George</first> <surname>Clooney</surname> <date>2000-05-24</date> <dept>hr</dept> </emp>
1006	<emp> <first>Brad</first> <surname>Pitt</surname> <date>2001-04-23</date> <dept>hr</dept> </emp>
…	…

XMLQUERY

```
SELECT
  XMLQUERY (                                  XQuery query
    'for $p in $col/emp return $p/surname',
    PASSING EmpXML.ColEmpXML AS "col"
    RETURNING CONTENT NULL ON EMPTY ) AS result
FROM EmpXML WHERE …
```

result
<surname>Clooney</surname>
<surname>Pitt</surname>
…

XMLTABLE

```
SELECT result.*
  FROM EmpXML, XMLTABLE (
    'for $p in $col/emp return $p',
    PASSING EmpXML.ColEmpXML AS "col"
    COLUMNS firstname VARCHAR(40) PATH 'first'
                      DEFAULT 'unknown',
            lastname  VARCHAR(40) PATH 'surname'
  ) AS TableResult
```

XQuery query

XPath expressions over XML data returned by the query

TableResult

firstname	lastname
George	Clooney
Brad	Pitt
unknown	Banderas

Assumption: We do not know first name of Banderas.

XMLEXISTS

```
SELECT id
FROM EmpXML
WHERE
  XMLEXISTS ( '/emp/date lt "2001-04-23"'
    PASSING BY VALUE EmpXML.ColEmpXML )
```

XPath query

id
1001
1006
…

Database applications

- DBI026
  - Oracle and MS SQL Server (alternatives)
    - embedded SQL, administration
    - external applications
    - indexing, optimisations
    - transactions
    - security
  - see http://www.ms.mff.cuni.cz/~kopecky/vyuka/dbapl/

External database programming

- external/standalone applications (i.e., outside DBMS environment) use standardized interfaces
  - ODBC (Open DataBase Connectivity)
    - 1992, Microsoft
  - JDBC (Java DataBase Connectivity)
    - using ODBC (mostly), or native driver/protocol, network driver
  - ADO.NET library (Active Data Objects .NET)
    - over OLE DB, ODBC, or directly drivers to MS SQL Server, Oracle
    - higher-level, faster and more reliable (than ODBC)
- „seminative" database object oriented programming using object-relational mapping
  - Java Hibernate
  - the same for Microsoft .NET

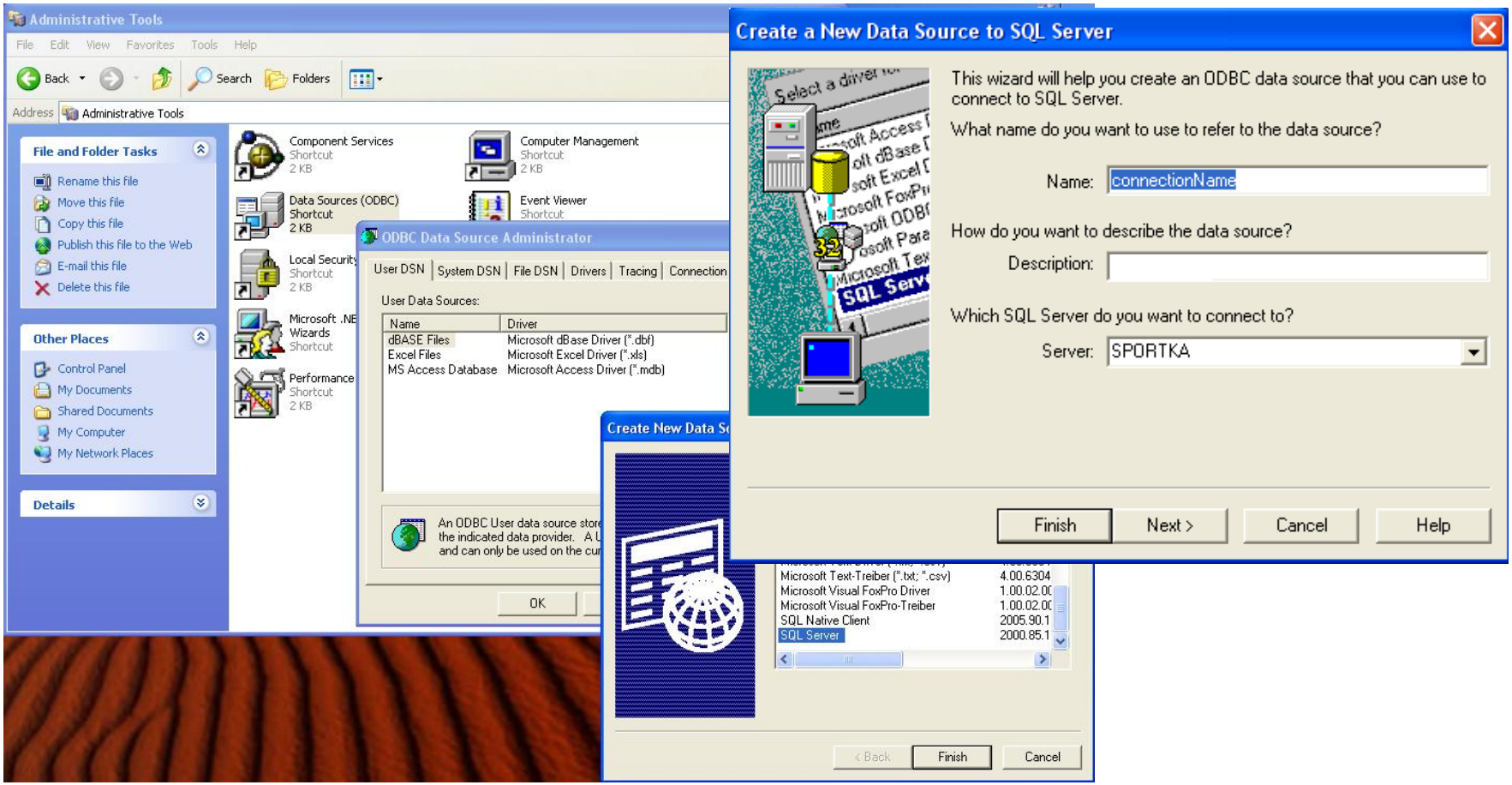
Java Hibernate Framework

- provides persistence to Java objects, i.e., provides „real" object oriented database programming
- mapping definition between object and its persistent state in database necessary (xml file for every class)
- simplification: memory manager organizes objects directly in database (+ uses main memory as a cache when accessing object)
- HQL (Hibernate query language)
  - object query language
  - Hibernate translates HQL into SQL

Relational vs. object approach

- object-to-tables mapping brings some overhead, not visible to the user (is both good and bad)
  - implementation of object DBMS using relational DBMS
- relational DBMS suitable for data-intensive applications and batch nature (uniform actions over many instances)
  - here object DBMS would be inefficient due to creation of many small objects that are created uniformly, i.e., individual „materialization" into general objects is not necessary
- object DBMS suitable for „Enterprise applications", where DBMS performance is not the bottleneck
  - relational DBMS provide low-level access to data, i.e., programmer forced to manage the database

ODBC, Windows configuration



ODBC, application (C#)

```
using System.Data.Odbc;
OdbcConnection DbConnection = new OdbcConnection("DRIVER={SQL
    Server};SERVER=MyServer;Trusted_connection=yes;DATABASE=northwind; ");
DbConnection.Open();
OdbcCommand DbCommand = DbConnection.CreateCommand();
DbCommand.CommandText = "SELECT * FROM Employee";
OdbcDataReader DbReader = DbCommand.ExecuteReader();

int fCount = DbReader.FieldCount;

while( DbReader.Read()) {
    Console.Write( ":" );
    for (int i = 0; i < fCount; i++) {
        String col = DbReader.GetString(i); Console.Write(col + ":");
    }
    Console.WriteLine();
}

DbReader.Close(); DbCommand.Dispose(); DbConnection.Close();
```

JDBC, application (Java)

```
Class.forName( "com.somejdbcvendor.TheirJdbcDriver" );

Connection conn = DriverManager.getConnection( "jdbc:somejdbcvendor:other data needed by
    some jdbc vendor", "myLogin", "myPassword" );

Statement stmt = conn.createStatement();

try {
    stmt.executeUpdate( "INSERT INTO MyTable( name ) VALUES ( 'my name' ) " );
    }
finally { stmt.close(); }
```

ADO.NET, aplikace (C#)

using ODBC:

```
SqlConnection connection = new
    SqlConnection("server=localhost;database=myDatabase;uid=sa;pwd=");
```

using OLE DB (sqloledb = SQL Server, msdaora = Oracle):

```
OleDbConnection connection = new OleDbConnection
      ("provider=sqloledb;server=localhost;database="+"myDatabase;uid=sa;pwd=");

connection.Open();

SqlCommand command = new SqlCommand("SELECT * FROM table", connection);
command.ExecuteNonQuery();
```

Java Hibernate – example

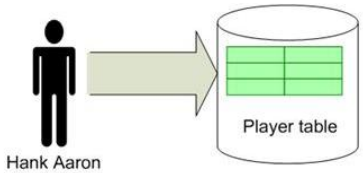
```
public class BallPlayer {
 private Long id;
 private String name;
 private String nickname;
 private Calendar dob;
 private String birthCity;
 private short uniformNumber;
 //getter and setter methods removed here for brevity.
}
```

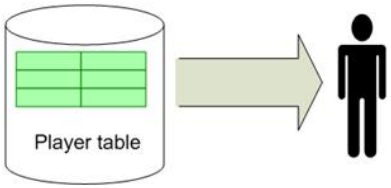
BallPlayer
id
name
nickname
dob
birthCity
uniformNumber

```
create table player (
 id integer primary key,
 name varchar not null,
 nickname varchar,
 date_of_birth date,
 city_of_birth varchar,
 uniform_number integer
);
```

Player	
PK	id
	name nickname date_of_birth city_of_birth uniform_number

```
Calendar dob = Calendar.getInstance();
dob.set(1934, Calendar.FEBRUARY, 5);
BallPlayer player = new BallPlayer();
player.setName("Henry Louis Aaron");
player.setNickname("Hammerin' Hank");
player.setDob(dob);
player.setBirthCity("Mobile, AL");
player.setUniformNumber((short) 44);
```






```
SessionFactory sessionFactory = new
Configuration().configure().  buildSessionFactory();
Session session = sessionFactory.openSession();
Transaction transaction = session.beginTransaction();
session.save(player);
transaction.commit();
session.close();
```

```
SessionFactory sessionFactory = new
Configuration().configure().buildSessionFactory();
Session session = sessionFactory.openSession();
Transaction transaction = session.beginTransaction();
BallPlayer aPlayer = (BallPlayer) session.get(BallPlayer.class,
transaction.commit();
session.close();
```

```
INSERT INTO PLAYER VALUES(5,'Henry Louis Aaron','Hammerin''
Hank','1934-02-05','Mobile, AL',44)
```

```
select ballplayer0_.id as id0_0_, ballplayer0_.name as name0_0_,
ballplayer0_.nickname as nickname0_0_, ballplayer0_.date_of_birth as
date4_0_0_, ballplayer0_.city_of_birth as city5_0_0_,
ballplayer0_.uniform_number as uniform6_0_0_ from Player ballplayer0_
where ballplayer0_.id=1
```

Java Hibernate – example

```
<?xml version="1.0" encoding="utf-8"?>
<!DOCTYPE hibernate-configuration
 PUBLIC "-//Hibernate/Hibernate Configuration DTD//EN"
 "http://hibernate.sourceforge.net/hibernate-configuration-3.0.dtd">
<hibernate-configuration>
 <session-factory>
   <property name="dialect"> org.hibernate.dialect.HSQLDialect</property>
   <property name="connection.driver_class"> org.hsqldb.jdbcDriver</property>
   <property name="connection.url"> jdbc:hsqldb:hsql:
//localhost/baseballdb</property>
   <property name="connection.username">sa</property>
   <property name="connection.password"></property>
   <property name="show_sql">true</property>
   <mapping resource="com/intertech/domain/BallPlayer.hbm.xml" />
 </session-factory>
</hibernate-configuration>
```

```
<?xml version="1.0" encoding="UTF-8"?>
<!DOCTYPE hibernate-mapping PUBLIC
   "-//Hibernate/Hibernate Mapping DTD 3.0//EN"
   "http://hibernate.sourceforge.net/hibernate-mapping-3.0.dtd">
<hibernate-mapping>
       <class name="com.intertech.domain.BallPlayer" table="Player">
               <id name="id">
                       <generator class="sequence">
                               <param name="sequence">common_seq</param>
                       </generator>
               </id>
               <property name="name" />
               <property name="nickname" />
               <property name="dob" column="date_of_birth" />
               <property name="birthCity" column="city_of_birth" />
               <property name="uniformNumber" column="uniform_number" />
       </class>
</hibernate-mapping>
```

Equivalents of Java Hibernate for Microsoft.NET Framework

- ADO.NET Entity Framework
- NHibernate
- Persistor.NET
- etc.