# Database Applications

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Sem 3 2022

Fall

420-331-DW

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Drop in Tuesday 8h30 - 10h00

Database design is our primary goal

- Design tables & relationships
- Creating procedures & functions
- Writing a client-side application
  - becomes much more meaningful

Oracle → MySQL → SQL Server

same company

PL Sql is the most popular

Oracle is very weird

PDBORA19C is our primary DB

SQL Developer → Database development

Java for client side application

Maven Building

JAR Building

Junit Testing

# What do you need to succeed

Notebook/Pen

Network Device → Laptop for DB

Enthusiasm

Hand written notes for memory retention

Programming excercises will be given in class

Review previous Lectures
Have the slides & support material handy

Welcome survey on moodle

Welcome Survey

Be inclusive

# lectures & Labs

Assignments build towards the group project

SQL today → PLSQL Packages PL/SQL Review → Client side dev

↳ Date base design → Designing Java Projects → Designing Procedure

↳ Project → DB security → NO SQL

Some assignments will be very useful.

Project is Done week 12

| | | | |
|---|---|---|---|
| Mid Term | 15% | 10 assignments | Group Project 25% |
| Final | 30% | 30% | |

## Ponderation

| | |
|---|---|
| Classes | 3h/week |
| Labs | " " |
| Homework | " " |

## Guide for how to spend your time

| | |
|---|---|
| Weekly Review | 1hr/week |
| 10 Assignments | 1hr/week |

Studying for exams
3h midterm
4hr final
13hr Project

45hr homework in total

# Project

Excel spreadsheet → Database
Excel as the poor man's database

Take spreadsheet & turn it into a database

- Review SQL Syntax
- Create tables
- Write & execute queries

Every week is a graded assignment

File must run from start to finish

Always needs an SQL File

Drop errors will be ignored

Rerunability- Drop conflicts Must be dropped in the right order

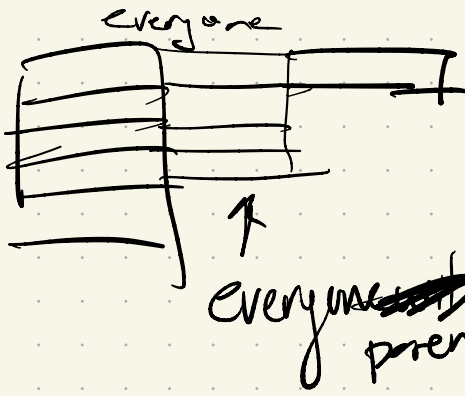
# Assignment #1

For each household show the address and #occupants

Select h.address, count(p.pid)
FROM home h INNER JOIN person p ON
p.hid = h.hid
GROUP BY h.hid;

2) Write a query that shows all grandfathers

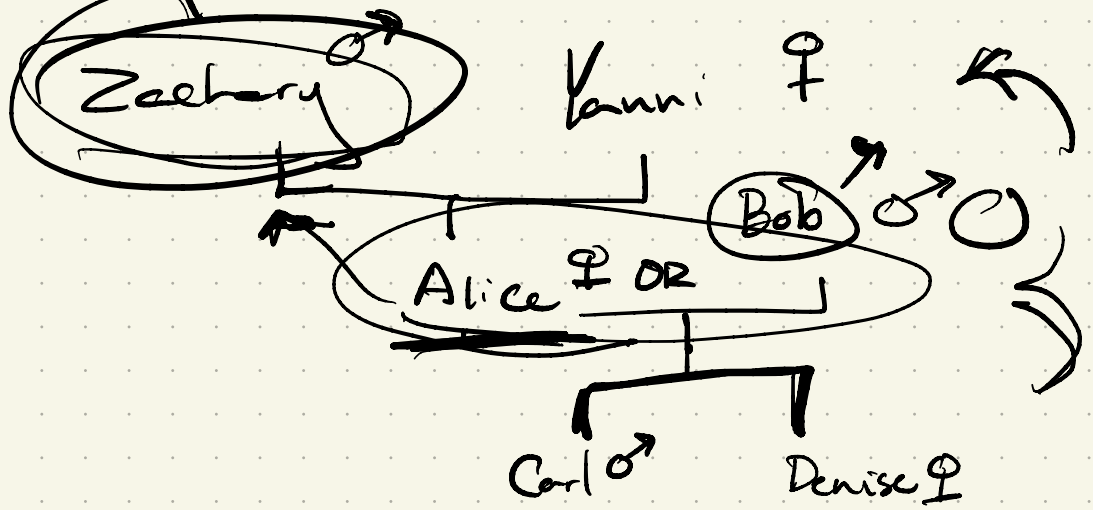
Select




Select p3.firstname, p3.lastname FROM

3) Select p.firstname, p.lastname
WHERE p.mother_id NOTNULL OR p.father_id = NOTNULL
AND o.id = 0001
↳ Need to include occupation

Select Max(Sum(c




bob bob Zack

g.pid = f.father_id
g.pid = f.mother_id

fpid

Ask for slides

# SQL Review

Aug 24th 2022

2 New things at the end

SQL interacts w/ Relational Databases

Core more about this over than last
↳ Data Control Language → Managing users / Permissions

Data Definition Language

Data Manipulation Language → Selects

DML
↳ Select chooses columns to display from a table
↳
↳
↳ Where clauses help us restrict what we select
↳ can chain multiple w/ AND / OR
↳ then other functions such as LIKE 'Mik%' % → wild card of t

Aggregate functions
↳ Multiple rows of Data
↳ Sum, COUNT, MAX, MIN
↳ When we combine a single column with an agregate function we need a group-by clause

Ex. SQL Review. SQL on moe

```
Select * Books from JUSTLEE

Select * FROM Books WHERE Cost > 20;

Select sum(cost) from books WHERE cost >20;
```

Need ERD to help

# Create & Insert Data to tables

→ Create constructs tables if they don't already exist
  ↳ Needs to include data types
  ↳ Can't create tables that already exist

→ INSERT adds data to those tables
  ↳ Any Primary Key or foreign key constraints must be met

→ Update Modifies existing data
  ↳ A where clause is needed to we know what Data is to be modified

## Primary / Foreign Keys

- Primary Keys ensure your rows have a unique identifier
- Foreign Keys help connect tables through their primary key
- Must DROP tables in the proper order

## Code Activity # 2

```
CREATE TABLE addresses (          ← Plural
    id char(4) PRIMARY KEY,
    street_number number(10) NOT NULL,    ← Should be a Varchar2(20)
    Street varchar2(50) NOT NULL,
    city varchar2(50) NOT NULL,
    province varchar2(15) NOT NULL,
    postal_code char(6) NOT NULL
    );

INSERT INTO addresses
```

# GRANT modifies permissions

- GRANT can be used to modify permissions for tables, procedures & functions
- Revoke is the opposite of GRANT

SELECT, INSERT, UPDATE & more can be controlled w/ GRANT

BY Default all of my tables are only visible to me

## GRANT Syntax

GRANT <DML> ON <table_name> TO <username>

A21399660

A21422443

Scoping by user spaces

-- shows all tables

## Indices

↳ Provide a way to speed up read access

When Designing tables, accessing ~~tables~~ data quickly & efficiently is key

PK helps uniquely identify rows.

What if the dat

↳

Index dg is a side table that is used to

CREATE INDEX genre_idx on books(genre);

CREATE INDEX cost_IN1

Genre is a fix list of categories
Cost does not have a lot of repeats

Indices are more useful for fixed list w/ repetition

Indexes introduce overhead
→ Not every column should be indexed
→

Indexs require maintenance by the DBMS
↳ Drop unused indices that are not being used.

First TIME you run an index it has to Populate the index, so it is not faster yet. so it gets faster on the subsequent queries.

# Views

Views let us hold complex expressions

- A view is a DB object that can hold a relation defined by a query
- Views are created with a select statement and are executed everytime they are accessed
- Use select to access the view

```
CREATE VIEW book_cost AS
select title,cost from books;

SELECT * FROM author_views;
```

Allows us to have our data nicely in the back, but the client

## Dynamic VIEW

- Created w/ simple create view statement
- Query is rerun everytime the view is called
- Can be complex

## Materialized View

- Created w/ CREATE MATERIALIZED VIEW
  Result of the query is cached (stored)

  Insert, updates, must be maintained.

SELECTS will be faster

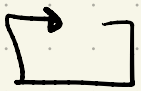
## Code ex

```
CRETE VIEW title_author_view AS
SELECT b.title,fname, a.lname, b.cost
FROM books b INNER JOIN bookauthor ba
ON ba.isbn = b.isbn
INNER JOIN author a on a.authorid = ba.authorid;
```

# Packages

→ Procedural Language

PL/SQL provides a programming language to SQL



Loops

objects

procedures
functions

invented 1993

## Packages help organize our code

DB objects are global to our user

Naming conflicts can arise.

Packages encapsulate code.

Important how we organize our code.

Can't have two functions of the same name since they are global.

Packages can be shared

Packages can be seen as a complete application

→ Code can be centralized inside a package

→ Procedures and functions can be reused inside the package

→ Types, cursors, variables and exceptions can be declared inside a package and used across functions & procedures

Just like all our source files in Java make a complete application

Packages can have more than just procedures & functions

Appear in the packages part of the tree

Packages have Two components

**Package specification**

What we need to define what a user is allowed to interact with

**Package Body**

Packages have a public name

Specifications define procedures functions, exceptions. Anything needed by a user

All packages have a specification

```
CREATE PACKAGE <packagename> AS
    OR REPLACE <package item]>;

END <packagename>
```

ex.

CREATE OR REPLACE PACKAGE emp_mgmt AS

FUNCTION hire (last_name VARCHAR2

RETURN NUMBER;

PROCEDURE (procname & all parameters)

END emp_mgmt; I think it's like c++

These are all public

Variables, exceptions, type can be used directly

- Since their values are publicly accessible variables, types and exceptions can be accessed without additional code

Procedures & Functions are implemented in the Package body.

→ Package body defines the implementation of procedures & functions

→ It must contain all the procedures and functions in the package specification

It contains additional methods that are not in the specification

CREATE OR REPLACE PACKAGE BODY <name> AS

...

Function create dept ( copy header from spec )

fill the body w/ code

How to define a function

```
CREATE OR REPLACE Function get_dept_name (dept_id number)
    RETURN VARCHAR2 is
        dept_name varchar2(200);
BEGIN SELECT dept_name INTO dept_name from
        hr.departments WHERE department_id = dept_id;
    RETURN (dept_name);
END;
```

Variable / parameters should be meaningful BUT

NOT the same name as your table field

Recall Anonymous blocks

Call functions in anonymous blocks

```
DECLARE
    result varchar2(200)
BEGIN
    result := get_dept_id(10);
    dbms_output.put_line(result);
END;
```

Aug 31st

Started w/ code activity

Changing package specifications impacts the user.

Dev Codes Package ⇒ Spec indicates what is public ⇒ different dev calls package subprograms

if we change the spec, we break what new developers using our code

Google Maps API — Backwards compatibility could be critical for existing code

Code needs to be changed

Needs to be recompiled.
↳ Code changes
↳ recompile
↳ ship

Now code needs to be retested.

# fixing Backward Compatibility

↳ Don't rename
  ↳ wrap initial function w/ a function w/ a better name

  ↳ warn users that original name is depreciated and they need to change their function names.

→ give clients users time

git commit -m "Meaningful to OTHER programmers"
should be something that isn't obvious from the git diff.

Why did you commit?

# PL/SQL Subprograms: Procedures & Functions

↳ lets us group common functionality

## Procedures

No Return Value

Should modify the DB
UPDATE, INSERT, DELETE

Can use other stored procedures & functions

IN, OUT IN OUT

Can be called by Java (JDBC)

## Functions

Has a return value
Used to compute a result
Does NOT modify the DB

Cannot execute other stored procedures, but can use stored functions
Can be used in select

Can be executed EXECUTE myproc(...);

Anon Block

Procedure Params have 3 Modes

IN → Passes value to the subprogram
↳ Constant

Create Procedure findMin(x IN number, y IN number) {

-- code block

Can read x & y but cannot manipulate them

OUT
↳ Return a value to the caller
↳ Acts like a variable
↳ No initial value
↳ Users need to create a variable of the right type

(x IN number, y IN number, z OUT NUMBER)

z := n

DECLARE
a number := 5; b number := 4; c number;
findMin(a, b, c);
out(c);

Swap (int a, int b) functions can only return one thing

Swap (a in ~~, b IN ~~, c OUT —, d OUT —)

IN OUT

↳ Both passes & returns a value to the calling program

↳ initialized with the value of the calling context

↳ Acts like a variable

Look at example on slide 9

- Open our existing HRPackages.sql file
- Add a new procedure called add_dept_manager(dept_name, manager_id, dept_id) where the procedure updates the manager_id of the provided department in the HR.departments table
  - The procedure should return to the caller the id of the department that was changed
- Call the add_dept_manager procedure from an anonymous PL/SQL block and print the dept_id. Add the manager id 200 to "Treasury"

DBlab 3

Book_purchasers

Creates an array of people who ordered a book

Slow_purchasers

Cursor for books table

or books %Rowtype;

~~author~~ customer_id_array;

who book purchasers

for i in 1 .. (var) book_purchasers.COUNT // Loop through my array

for arow in (Select * from Books)

Loop

--Build the output string here

output := arow.isbn || ' ' || arow.name

customers := book_purchasers(arow.isbn);

for i in 1.. customersCount

Loop

firstLastName := (Select fname, lname FROM cust

# Database II

## PL/SQL Varrays & cursors

Cursors & Varrays help us deal with multiple rows of data

Loops in PL/SQL

Varrays → PL/SQL Lists.

Cursors → lets us loop through queries w/ multiple data

while LOOP

```
a:=0;
WHILE a<5 LOOP
    a:=a+1;
    dbms_output.put_line(a);
END LOOP;
```

PL/SQL starts at 1, not 0

for loops

```
FOR a in 1..5 LOOP
    dbms_output.put_line('a is: ' || a)
END LOOP;
```

add_book

- take any parameter
- if the book isbn does not exist, create the book
- if the book exist, update only the different fields.

VARRAY → Store multiple piece of data

- Declared as a type
- Stores information of that type
- Resizes to fit the content (like a List in java)
- index is 1-based (not like java which is 0 based)

```
CREATE TYPE numberarray IS VARRAY(100) OF NUMBER;
```

```
DECLARE
    myarray numberarray;
BEGIN
    myarray(1) := 10;
    myarray(2) := 20;
    myarray(2) := 30;
END;
```

Define the ~~TYPE~~ in the Spec

Round brackets.

BULK COLLECT INTO

works similarly to SELECT INTO.

- Requires a query that returns multiple rows
- Has to be the same type as the array is declared to hold
- Has to be able to hold all the data.

```
CREATE isbnarraytype IS VARRAY(100) OF VARCHAR2(200);
DECLARE
    isbnarray isbnarraytype;
Begin
    SELECT isbn BULK
```

Loops iterate through the varray

- Any loop can be used
- COUNT, LIMIT, FIRST, LAST, NEXT(), PRIOR()
  are all functions on the VARRAY that can help us inside the loop
- Count starts at 1

Cursors

↳ Way of managing a given query

↳ Represents multiple pieces of data

Can be iterated over

Used to manipulate results from a select statement that returns multiple rows

↳ Can be declared as types or used directly in a for loop.

```
BEGIN
   FOR a_row IN (SELECT title FROM books)
    LOOP
        dbms_output.put_line(a_row.title);
    END LOOP;
/

BEGIN
   FOR a_row IN (SELECTION * FROM books)
   LOOP
        dbms_output.put_line(a_row.isbn);
        dbms_output.put_line(a_row.cost );
  END LOOP;
END;
```

Cursor variable automatically contains the selected column names

With select we can control the name of the variables
→ Members can be accessed in . notation

# Responding To runtime errors ≠ exceptions

Exceptions are a mechanism for handling errors

Applications generate exceptions when unwanted behaviours occur

↳ Let's us communicate errors to a user

↳ We can define our own exceptions

System Defined Error

- NO_DATA_FOUND
- VALUE_ERROR
- DIVIDE_BY_ZERO

USER DEFINED
↳ Any errors

PL/SQL uses Exception Blocks to catch Errors

Exception is a block like Declare or Begin

Combined w/ WHEN keyword exceptions can be caught

Unnamed exceptions can be caught w/ 'OTHERS'

```
DECLARE
BEGIN
EXCEPTION
    WHEN <exception 1> THEN
    WHEN OTHER THEN
        stuff for all exceptions, this is not great.
```

```
DECLARE
    vname VARCHAR2(50) := 'Bob';
    vSalary NUMBER(6,2);
BEGIN
    SELECT salary INTO vsalary WHERE name = vname;
            dbms_output.putline(vname);
END;
```

if Bob doesn't exist ⇒ No_data_found

vsalary is too small ⇒ VALUE_ERROR

More then one piece of data ⇒ TOO_MANY_ROWS

```
DECLARE
    vname VARCHAR2(50) := 'Bob';
    vSalary NUMBER(6,2);
BEGIN
    SELECT salary INTO vsalary WHERE name = vname;
            dbms_output.putline(vname);
EXCEPTION
        WHEN no_data_found THEN
                <stuff>
END;
```

DUP_VAL_ON_INDEX

# RAISING CUSTOM EXCEPTIONS

Allows us to communicate our own errors to users

Better control over errors and code flow

Exceptions can be defined inside packages like any other type

These exceptions can be raised or caught

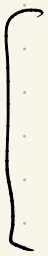
adding to a package →

my_exception EXCEPTION

Raise is how we 'throw' exceptions in PL/SQL

Raise raises the exception

Exceptions bubble up until someone catches it w/ an exception block



Custom Exceptions Must be defined before they can be caught or thrown

Define an exception in a package

↓

Raise an exception in a function or procedure

↓

Real World

Catchs are meant help the developper.

```
CREATE PROCEDURE

< Update statement >

    IF SQL%NOTFOUND THEN   -- checks if it updated rows
        RAISE my_package.e_invalid_dept_id;
    END IF;
```

① Define the error in specs.

② Give an error if no city

add exception to the get_city_name( )
^
block

Assignment

Clarification →

when there are multiple exceptions in a procedure/function

As soon as you hit an exception, you move straight to the Exception

We can have multiple begin ends in an anonymous block

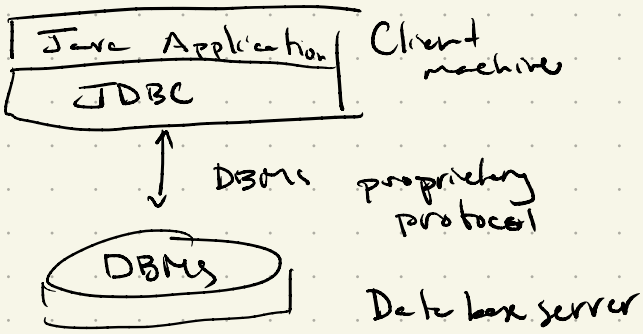
# Introduction to JDBC

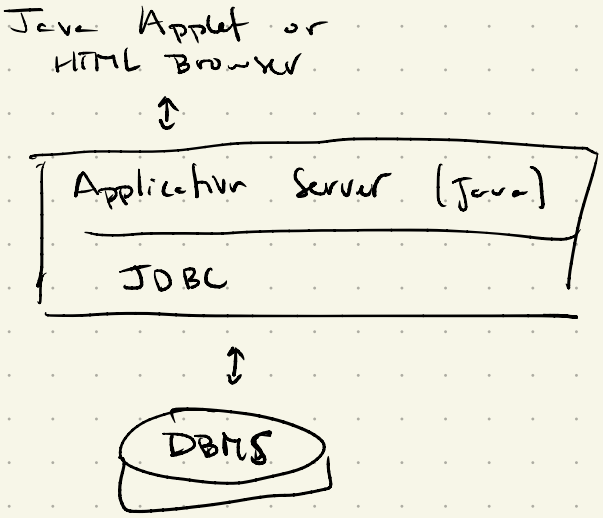
Dirk went very fast this lecture, these notes are super incomplete. Check the slides.

Java Data Base Connectivity lets Java talk to RDBMS

↳ Java can't talk to RDBMS on it's own

A library is needed to provide that functionality



JDBC lets us talk to multiple database technology

Each DBMS is different

- JDBC just tells us what it looks like to connect to a DB using java

→ We need a driver which tells us how to connect

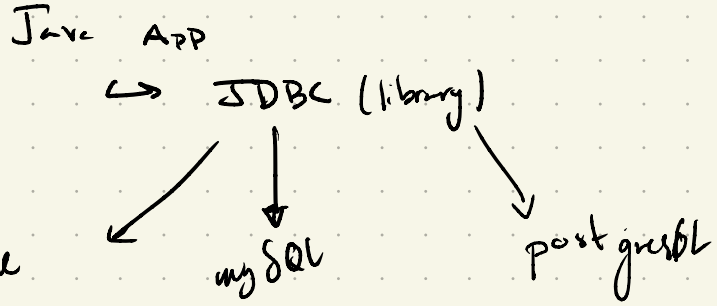
Types of JDBC driver

Type 1: Drivers that implements the JDBC API as mapping to another data access API

→ 2: Drivers that are written

3: Drivers that use pure Java

4: Pure java and implement the network protocol
(us) → for a specific data source.
Client connects directly to the data source.



# Use Maven to handle JDBC

```
<!--
https://mvnrepository.com/artifact/com.oracle.database.jdbc/ojdbc10 -->
    <dependency>
      <groupId>com.oracle.database.jdbc</groupId>
      <artifactId>ojdbc10</artifactId>
      <version>19.16.0.0</version>
    </dependency>
```

Create a Maven project like in 3c0

Modify pom.xml to include JDBC

- This tells Maven we need ojdbc

JDBC implements the Java.sql interface  import java.sql.*;

↳ Java defines a set of methods to talk to RDBMS

↳ defined into the java.sql package

- Import java.sql
- Connect to DB
- Create a statement of some kind

Connecting needs a username & password

String url =

Correction conn = DriverManager.getConnection(url, User.user, User.pwd)

Prepared statements send info to the database.

PreparedStatement statement = conn.preparedStatement("select * From books")

result = statement.executeQuery();

statement.setString(1, <arg>);

prepared statements are very flexible

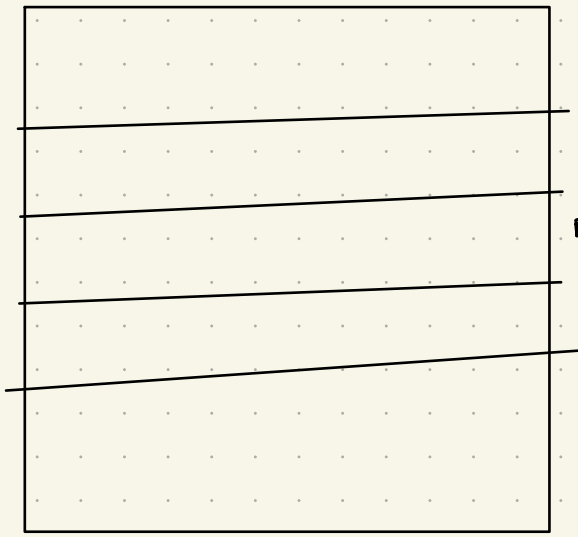
executeQuery(query)

executeUpdate(query)

to Non-select queries (update, delete)

ResultSets are returned by queries

- What is returned behaves like a cursor
- Each result needs to be iterated through
- At a moment, a result represents a single row



← Starts Here

```
ResultSet result =
    statement.executeQuery(  );
while (result.next()) {
    System.
```

returns true if there is another row, then moves to it.

result.next() dynamically

each call to next() fetches a new row

getXXX methods help fetch data

from a given column

↳ Have needs to know the Type

```
while (result.next()) {
    String title =
      result.getString('title');
    double cost =
      result.getDouble('cost');
```

Managing Connections is important.

↳ we have to open & close connections

- Prepared Statements & Connects are all talking to the database.
- have to close Prepared Statements / Connections

```
if( ! statement.isClosed()){
        statement.close();
}
if( ! conn.isClosed()){
        Conn.close();
}
```