Dr Renata Borovica-Gajic
David Eccles

INFO90002 Database Systems & Information Modelling

Lecture 09
SQL

RA Homework Example Instances

Find all pairs of sailors in which the older sailor has a lower rating

Reserves (R1)

sid	bid	day
22	101	10/10/96
58	103	11/12/96

Sailors 1 (S1)

sid	sname	rating	age
22	dustin	7	45.0
31	lubber	8	55.5
58	rusty	10	35.0

Sailors 2 (S2)

sid	sname	rating	age
28	yuppy	9	35.0
31	lubber	8	55.5
44	guppy	5	35.0
58	rusty	10	35.0

Boats

bid	bname	color
101	Interlake	blue
102	Interlake	red
103	Clipper	green
104	Marine	red

RA solution

- Find all pairs of sailors in which the older sailor has a lower rating

$$\rho\ (S1(1 \longrightarrow sid1, 2 \longrightarrow sname1, 3 \longrightarrow rating1, 4 \longrightarrow age1), Sailors)$$

$$\rho\ (S2(1 \longrightarrow sid2, 2 \longrightarrow sname2, 3 \longrightarrow rating2, 4 \longrightarrow age2), Sailors)$$

$$\pi_{\text{sname1,sname2}}(\text{S1} \bowtie_{\text{age1}>\text{age2} \wedge \text{rating1}<\text{rating2}} \text{S2})$$

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SQL – Part 1

Introduction to DDL, DML & Referential Integrity

What is SQL

- SQL – or SEQUEL is a language used in relational databases
- DBMS support CRUD
  - Create, Read, Update, Delete commands
- SQL supports CRUD
  - Create, Select, Update, Delete commands
- Other info
  - You can see the 2011 standard of SQL at
    - http://www.jtc1sc32.org/doc/N2151-2200/32N2153T-text_for_ballot-FDIS_9075-1.pdf
  - Wikipedia has several sections on SQL (good for *generic* syntax)
    - http://en.wikipedia.org/wiki/Category:SQL_keywords

SQL Language

- Provides the following capabilities:
  - Data Definition Language (DDL)
    - To define and set up the database
    - CREATE, ALTER, DROP
  - Data Manipulation Language (DML)
    - To maintain and use the database
    - SELECT, INSERT, DELETE, UPDATE
  - Data Control Language (DCL)
    - To control access to the database
    - GRANT, REVOKE
  - Other Commands
    - Administer the database
    - Transaction Control
    - START TRANSACTION
    - BEGIN, END

How We Use SQL

- In **Implementation** of the database
  - Take the tables we design in physical design
  - Implement these tables in the database using create commands
- In **Use** of the database
  - Use Select commands to read the data from the tables, link the tables together etc
  - Use alter, drop commands to update the database
  - Use insert, update, delete commands to change data in the database

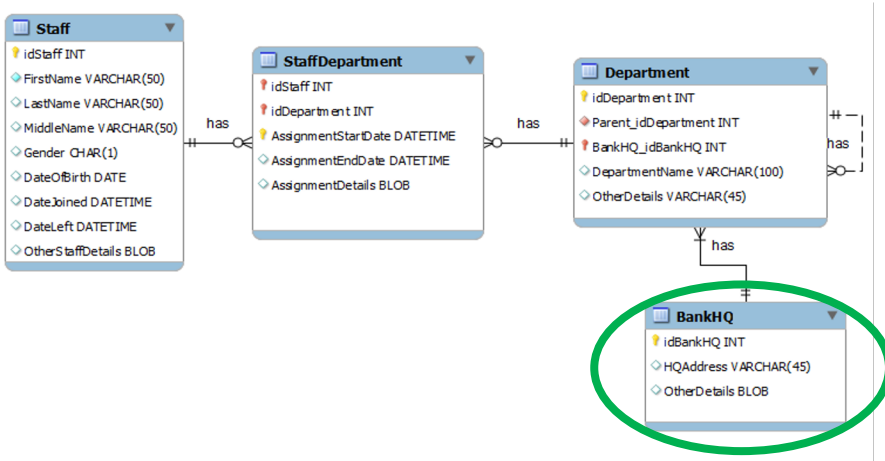
SQL Context in Development Process

1.
```
CREATE TABLE BankHQ (
     BankHQID                  INT                  AUTO_INCREMENT,
     HQAddress                 VARCHAR(120)         NOT NULL,
     OtherHQDetails            VARCHAR(100),
PRIMARY KEY(BankHQID)
);
```

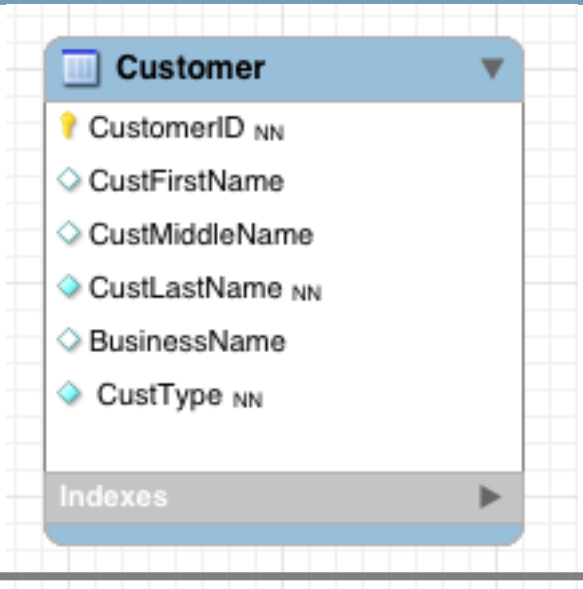
2.
```
INSERT INTO BankHQ VALUES
(1, "23 Charles St Peterson North 2022", "Main Branch");
INSERT INTO BankHQ VALUES
(2, "213 Jones Rd Parkville North 2122", "Sub Branch");
```

3.
```
SELECT *
FROM BankHQ;
```

BankHQID	HQAddress	OtherHQDetails
1	23 Charles St Peterson North 2022	Main Branch
2	213 Jones Rd Parkville North 2122	Sub Branch



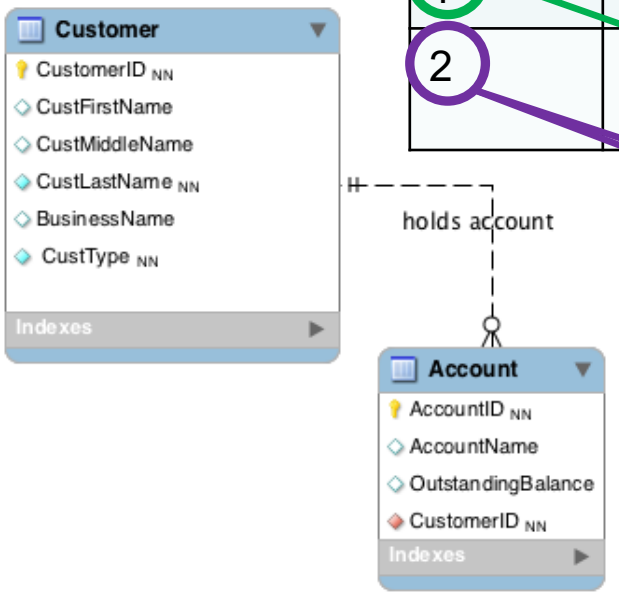
CREATE Table: Review




```
CREATE TABLE Customer (
     CustomerID              INT                          AUTO_INCREMENT,
     CustFirstName           VARCHAR(12),
     CustMiddleName          VARCHAR(14),
     CustLatName             VARCHAR(20)                  NOT NULL,
     Business Name           VARCHAR(100),
     CustType                ENUM("Personal","Company")   NOT NULL,
PRIMARY KEY(CustomerID)
)
```

Foreign keys: Review

- We looked at Customer
  - A customer can have a number of Accounts
  - The tables get linked through a foreign key



CustID	Customer FirstName	CustMiddle Name	CustLast Name	Business Name	CustType
1	Peter		Smith		Personal
2	James		Jones	JJ Enterprises	Company

AccountID	AccountName	Outstanding Balance	CustID
01	Peter Smith	245.25	1
05	JJ Ent.	552.39	2
06	JJ Ent. Mgr	10.25	2

SQL CREATE Statement (With FK)

```
CREATE TABLE Account (
     AccountID                INT                          AUTO_INCREMENT,
     AccountName              VARCHAR(12),
     OutstandingBalance       DECIMAL(10,2)                NOT NULL,
     CustomerID               VARCHAR(20)                  NOT NULL,
PRIMARY KEY(AccountID),
FOREIGN KEY (CustomerID) REFERENCES Customer(CustomerID)
          ON DELETE RESTRICT
          ON UPDATE CASCADE
)
```

Insert Data

```
INSERT INTO  Customer (CustomerID, CustFirstName, CustLastName, CustType)
          VALUES (DEFAULT, "Peter", "Smith", "Personal");

INSERT INTO  Customer
         VALUES (DEFAULT, "James", NULL, "Jones", "JJ Enterprises", "Company");

INSERT INTO  Customer
         VALUES (DEFAULT, "", NULL, "Smythe", "", "Company");
```

Specifies which columns will be entered

No column specification means ALL columns need to be entered

Customer

CustID	CustomerFirst Name	CustMiddle Name	CustLastName	BusinessName	CustType
1	Peter	NULL	Smith	NULL	Personal
2	James	NULL	Jones	JJ Enterprises	Company
3		NULL	Smythe		Company

What does **NULL mean?**

Null Island: The Busiest Place That Doesn't Exist:
https://www.youtube.com/watch?v=bjvIpI-1w84
by the channel MinuteEarth

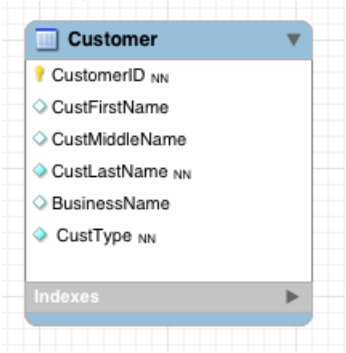
The SELECT Statement: Detail

- A cut down version of the SELECT statement – MySQL

- SELECT [ALL | DISTINCT] *select_expr* [, *select_expr* ...]
  - List the columns (and expressions) that are returned from the query
- [FROM *table_references*]
  - Indicate the table(s) or view(s) from where the data is obtained
- [WHERE *where_condition*]
  - Indicate the conditions on whether a particular row will be in the result
- [GROUP BY {*col_name* | *expr* } [ASC | DESC], ...]
  - Indicate categorisation of results
- [HAVING *where_condition*]
  - Indicate the conditions under which a particular category (group) is included in the result
- [ORDER BY {*col_name* | *expr* | *position*} [ASC | DESC], ...]
  - Sort the result based on the criteria
- [LIMIT {[*offset*,] *row_count* | *row_count* OFFSET *offset*}]
  - Limit which rows are returned by their return order (ie 5 rows, 5 rows from row 2)

Order is important! E.g. LIMIT **cannot** go before GROUP BY or HAVING

Select Examples



SELECT * FROM Customer;
= Give me all information you have about customers

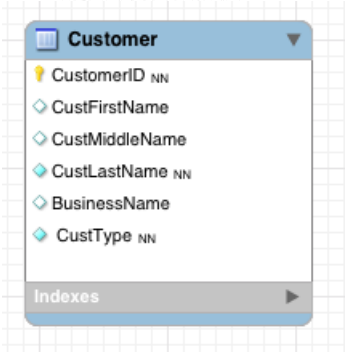
SQL

```
SELECT *
FROM Customer
```

RESULT

CustomerID	CustFirstName	CustMiddleName	CustLastName	BusinessName	CustType
1	Peter	NULL	Smith	NULL	Personal
2	James	NULL	Jones	JJ Enterprises	Company
3	Akin	NULL	Smithies	Bay Wart	Company
4	Julie	Anne	Smythe	Konks	Company
5	Jen	NULL	Smart	BRU	Company
6	Lim	NULL	Lam	NULL	Personal
7	Kim	NULL	Unila	Saps	Company
8	James	Jay	Jones	JJ's	Company
9	Keith	NULL	Samson	NULL	Personal

Select Examples : Projection



In Relational Algebra:

$$\pi_{CustLastName}(Customer)$$

In SQL:

```
SELECT CustLastName
FROM Customer;
```

Result

CustLastName
Smith
Jones
Smithies
Smythe
Smart
Lam
Unila
Jones
Samson

NOTE: MySQL doesn't discard duplicates. To remove them use DISTINCT in front of the projection list.

Select Examples: Selection

In Relational Algebra:

$$\sigma_{cond1 \wedge cond2 \vee cond3}(Rel)$$

In SQL:

```
WHERE cond1 AND cond2
      OR cond3
```

In Relational Algebra:

$$\pi_{CustLastName}(\sigma_{CustLastName="Smith"}(Customer))$$

In SQL:

```
SELECT CustLastName
FROM Customer
WHERE CustLastName = "Smith";
```

Result

CustLastName
Smith

Select **Examples: LIKE clause**

- In addition to arithmetic expressions, string conditions are specified with the LIKE clause

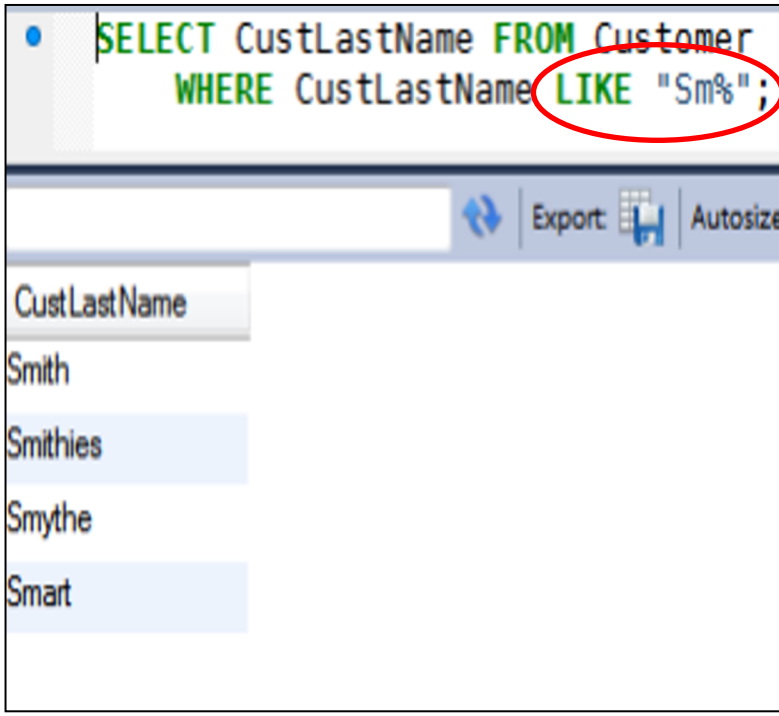
LIKE "REG_EXP"

% Represents zero, one, or multiple characters
_ Represents a single character

Examples:

WHERE CustomerName LIKE 'a%'	Finds any values that start with "a"
WHERE CustomerName LIKE '%a'	Finds any values that end with "a"
WHERE CustomerName LIKE '%or%'	Finds any values that have "or" in any position
WHERE CustomerName LIKE '_r%'	Finds any values that have "r" in the second position
WHERE CustomerName LIKE 'a_%_%'	Finds any values that start with "a" and are at least 3 characters in length
WHERE ContactName LIKE 'a%o'	Finds any values that start with "a" and end with "o"

SQL:



Aggregate Functions

Aggregate functions operate on the (sub)set of values in a column of a relation (table) and return a single value

- AVG()
  - Average value
- MIN()
  - Minimum value
- MAX()
  - Maximum value
- COUNT()
  - Number of values
- SUM()
  - Sum of values

- Plus others
  - http://dev.mysql.com/doc/refman/8.0/en/group-by-functions.html
- N.B. All of these except for COUNT() ignore null values and return null if all values are null. COUNT() counts the rows not the values and thus even if the value is NULL it is still counted.

Aggregate Examples: Count/AVG

COUNT() - returns the number of records
AVG() - average of the values

Examples:

```
SELECT COUNT(CustomerID)
FROM Customer;
```

= How many customers do we have (cardinality)

```
SELECT AVG(OutstandingBalance)
FROM Account;
```

= What is the average balance of ALL ACCOUNTS

```
SELECT AVG(OutstandingBalance)
FROM Account
WHERE CustomerID= 1;
```

= What is the average balance of Accounts of Customer 1

```
SELECT AVG(OutstandingBalance)
FROM Account
GROUP BY CustomerID;
```

= What is the average balance **PER CUSTOMER**

GROUP BY / HAVING

- **Group by** groups all records together over a set of attributes
- Frequently used with aggregate functions
- **Example:**

  *What is the average balance **PER CUSTOMER?***

```
SELECT AVG(OutstandingBalance)
FROM Account
GROUP BY CustomerID;
```

- The only way to put a selection condition over a group by statement is by using **having** clause
- **Example:**

  What is the exact average balance per customer for customers whose average balance is under 10000?

```
SELECT AVG(OutstandingBalance)
FROM Account
GROUP BY CustomerID
HAVING AVG(OutstandingBalance)  < 10000
```

Column renaming

We can rename the column name of the output by using the AS clause

```
SELECT CustType, Count(CustomerID)
    FROM Customer
    GROUP BY CustType;
```

Export: Autosize:

CustType	Count(CustomerID)
Personal	3
Company	6

```
SELECT CustType, Count(CustomerID) AS Count
    FROM Customer
    GROUP BY CustType;
```

Export: Autosize:

CustType	Count
Personal	3
Company	6

ORDER BY

- Orders records by particular column(s)

ORDER BY XXX ASC/DESC (ASC is default)

SQL

```
SELECT CustLastName, CustType
    FROM Customer
    ORDER BY CustLastName;
```

RESULT

CustLastName	CustType
Jones	Company
Jones	Company
Lam	Personal
Samson	Personal
Smart	Company
Smith	Personal
Smithies	Company
Smythe	Company
Unila	Company

```
SELECT CustLastName, CustType
    FROM Customer
    ORDER BY CustLastName DESC;
```

CustLastName	CustType
Unila	Company
Smythe	Company
Smithies	Company
Smith	Personal
Smart	Company
Samson	Personal
Lam	Personal
Jones	Company
Jones	Company

Limit and Offset

- LIMIT number - limits the output size
- OFFSET number - skips first 'number' records

```
SELECT CustLastName, CustType
    FROM Customer
    ORDER BY CustLastName
    LIMIT 5;
```

Export:

CustLastName	CustType
Jones	Company
Jones	Company
Lam	Personal
Samson	Personal
Smart	Company

```
SELECT CustLastName, CustType
    FROM Customer
    ORDER BY CustLastName
    LIMIT 5
    OFFSET 3;
```

Export:

CustLastName	CustType
Samson	Personal
Smart	Company
Smith	Personal
Smithies	Company
Smythe	Company

CustLastName	CustType
Jones	Company
Jones	Company
Lam	Personal
Samson	Personal
Smart	Company
Smith	Personal
Smithies	Company
Smythe	Company
Unila	Company

Joining tables together

- SELECT * FROM **Rel1, Rel2**; - this is a **cross product**

```
SELECT * FROM Customer, Account;
```

Export: Autosize:

CustomerID	CustFirstName	CustMiddleName	CustLastName	BusinessName	CustType	AccountID	AccountName	OutstandingBalance	CustomerID
1	Peter	NULL	Smith	NULL	Personal	1	Peter Smith	245.25	1
2	James	NULL	Jones	JJ Enterprises	Company	1	Peter Smith	245.25	1
3	Akin	NULL	Smithies	Bay Wart	Company	1	Peter Smith	245.25	1
1	Peter	NULL	Smith	NULL	Personal	2	JJ ENt.	552.39	2
2	James	NULL	Jones	JJ Enterprises	Company	2	JJ ENt.	552.39	2
3	Akin	NULL	Smithies	Bay Wart	Company	2	JJ ENt.	552.39	2
1	Peter	NULL	Smith	NULL	Personal	3	JJ ENt. Mgr	10.25	2
2	James	NULL	Jones	JJ Enterprises	Company	3	JJ ENt. Mgr	10.25	2
3	Akin	NULL	Smithies	Bay Wart	Company	3	JJ ENt. Mgr	10.25	2

Not very useful…

Typically we would like to find:

For every record in the Customer table list every record in the Account table

Joins: Different Types

- **Inner/Equi join**:
  - Joins the tables over keys

```
SELECT * FROM Customer INNER JOIN Account
  ON Customer.CustomerID = Account.CustomerID;
```

CONDITION

Export: Autosize:

CustomerID	CustFirstName	CustMiddleName	CustLastName	BusinessName	CustType	AccountID	AccountName	OutstandingBalance	CustomerID
1	Peter	NULL	Smith	NULL	Personal	1	Peter Smith	245.25	1
2	James	NULL	Jones	JJ Enterprises	Company	2	JJ ENt.	552.39	2
2	James	NULL	Jones	JJ Enterprises	Company	3	JJ ENt. Mgr	10.25	2

- **Natural Join:**
  - Joins the tables over keys. The condition does not have to be specified (natural join does it automatically), but key attributes have to have the *same name.*

```
SELECT * FROM Customer NATURAL JOIN Account;
```

Export: Autosize:

CustomerID	CustFirstName	CustMiddleName	CustLastName	BusinessName	CustType	AccountID	AccountName	OutstandingBalance
1	Peter	NULL	Smith	NULL	Personal	1	Peter Smith	245.25
2	James	NULL	Jones	JJ Enterprises	Company	2	JJ ENt.	552.39
2	James	NULL	Jones	JJ Enterprises	Company	3	JJ ENt. Mgr	10.25

Joins: Different Types

- **Outer join**:
  - Joins the tables over keys
  - Can be *left* or *right* (see difference below)
  - Includes records that **don't match** the join from the other table

```
SELECT * FROM Customer LEFT OUTER JOIN Account
    ON Customer.CustomerID = Account.CustomerID;
```

Export: Autosize:

CustomerID	CustFirstName	CustMiddleNa	CustLastName	BusinessName	CustType	AccountID	AccountName	OutstandingBalance	CustomerID
1	Peter	NULL	Smith	NULL	Personal	1	Peter Smith	245.25	1
2	James	NULL	Jones	JJ Enterprises	Company	2	JJ ENt.	552.39	2
2	James	NULL	Jones	JJ Enterprises	Company	3	JJ ENt. Mgr	10.25	2
3	Akin	NULL	Smithies	Bay Wart	Company	NULL	NULL	NULL	NULL

```
SELECT * FROM Customer RIGHT OUTER JOIN Account
    ON Customer.CustomerID = Account.CustomerID;
```

Export: Autosize:

CustomerID	CustFirstName	CustMiddleName	CustLastName	BusinessName	CustType	AccountID	AccountName	OutstandingBalance	CustomerID
1	Peter	NULL	Smith	NULL	Personal	1	Peter Smith	245.25	1
2	James	NULL	Jones	JJ Enterprises	Company	2	JJ ENt.	552.39	2
2	James	NULL	Jones	JJ Enterprises	Company	3	JJ ENt. Mgr	10.25	2

What's examinable

- You need to know how to write SQL
  - DDL
  - DML
  - SELECT

Next Lecture

- SQL Summary
  - Overview of concepts, more examples