SQL Queries

CS 377: Database Systems

Today and Next Lecture

1. Basic Single Table Queries
    1. Select-From-Where Query
    2. Useful Operators
    3. Exercise: Company Database
2. Multi-table Queries
    1. Join
    2. Aliasing

SQL Query

Basic form is called a *mapping* or a *SELECT-FROM-WHERE block*

```
SELECT <attribute list>
FROM   <table list>
WHERE  <condition on the tables>
```

SQL Query <—> Relational Algebra

SELECT <attribute list>
FROM <table list>
WHERE <condition on the tables>

cartesian product of relations is formed

conditions of the form attr1 op constant/attr2

Does not remove duplicates as SELECT in relational algebra

$$\pi_{<\text{attribute list}>}\sigma_{<\text{condition}>}(R_1 \times R_2 \times \cdots \times R_n)$$

Example: Product Database

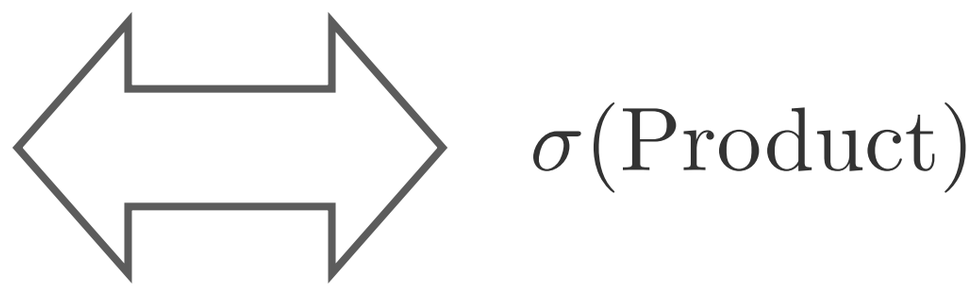
PRODUCT

Name	Category	Price	Manufacter
iPad	Tablet	$399.00	Apple
Surface	Tablet	$299.00	Microsoft
Kindle	eReader	$79.00	Amazon
Macbook Air	Laptop	$999.99	Apple

Simple SQL Query: * SELECTOR

- Selects all the values of the selected tuples for *all the attributes*

- Example:
  SELECT *
  FROM Product;



Name	Category	Price	Manufacter
iPad	Tablet	$399.00	Apple
Surface	Tablet	$299.00	Microsoft
Kindle	eReader	$79.00	Amazon
Macbook Air	Laptop	$999.99	Apple

Selection Query Using *

$$\sigma_{\text{Category='Tablet'}}(\text{Product})$$

```
SELECT *
FROM   Product
WHERE  Category = 'Tablet';
```

Name	Category	Price	Manufacter
iPad	Tablet	$399.00	Apple
Surface	Tablet	$299.00	Microsoft

Projection Query

SELECT Name, Category
FROM Product;

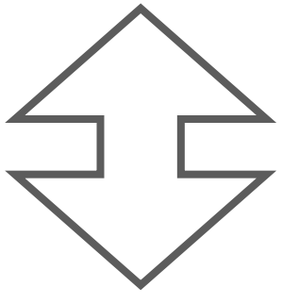
$$\Leftrightarrow \pi_{\text{Name,Category}}(\text{Product})$$

$$\Updownarrow$$

Name	Category
iPad	Tablet
Surface	Tablet
Kindle	eReader
Macbook Air	Laptop

Select-Project Query

```
SELECT Name, Category
FROM   Product
WHERE  Manufactor = 'Apple'
```



Name	Category
iPad	Tablet
Macbook Air	Laptop

SQL Details

- SQL commands are case **insensitive**
  - SELECT = select = Select
- Values are case **sensitive**
  - Apple =/= apple
- Single quotes should be used for constants
  - ‘Apple’ instead of “Apple”

Exercise: Company Database

- Retrieve the birthdate and address of the employee whose name is ‘John B. Smith”
- List the SSN, last name, and department number of all employees
- List the department number and name of all departments
- List the projects under department number 5

DISTINCT: Eliminate Duplicates

- SQL outputs duplicate values by default
  - Relation is a **multi-set (bag) of tuples** vs a set of tuples
  - Favored for database efficiency
- Syntax:

  SELECT DISTINCT <attr list>
  FROM <table>;

Removes duplicate values

Example Query: DISTINCT

- **SELECT Category**
  FROM Product;

Category
Tablet
Tablet
eReader
Laptop

- **SELECT DISTINCT Category**
  FROM Product;

Category
Tablet
eReader
Laptop

SQL Details: WHERE Conditions

```
SELECT <attribute list>
FROM   <table list>
WHERE  <condition on the tables>
```

What can go in here?

- Attribute names of the relation(s) used in the **FROM** clause
- Comparison operators: =, <>, <, >, <=, >=
- Arithmetic operations: +, -, *, /

SQL Details: WHERE Conditions

- Logical operators to combine conditions: **AND**, **OR**, **NOT**
- Operations on strings (e.g., concatenation)
- Membership test
- Pattern matching

IN: Member of Set Test

- Tests whether a value is contained in a set
  - True if attribute value is a member of the set of values
  - False otherwise
- Syntax:

```
SELECT <attr list>
FROM   <table>
WHERE attr IN ( set of values);
```

Example Queries: IN

- Find the name and prices of products made by Amazon or Microsoft:

```
SELECT name, price
FROM   Product
WHERE  Manufacter IN ('Amazon', 'Microsoft');
```

- Find the name of products whose made by Amazon or Microsoft and are tablets:

```
SELECT name
FROM   Product
WHERE  (Manufacter, Category) IN (('Amazon',
'Tablet'), ('Microsoft', 'Tablet'));
```

LIKE: Simple String Pattern Matching

- Syntax:

```
SELECT *
FROM   Products
WHERE  Name LIKE '%Air';
```

Substring comparison for partial strings

- Supports 2 wildcard characters
  - Underscore (_) matches exactly one character (equivalent to ? in the UNIX shell)
  - Percent (%) matches 0 or more characters (equivalent to * in the UNIX shell)

Example Queries: LIKE

- Find names of products whose company start with ‘A’:

```
SELECT name
FROM   Product
WHERE  Company LIKE ’A%’;
```

- Find the name and price of products with the word Air in them:

```
SELECT name, price
FROM   Product
WHERE  name LIKE ‘%Air%;
```

SQL: IS NULL

- Test if an attribute contains the NULL value
- Syntax:
  attr IS NULL
- Example: Find employees that have NULL value in the salary attribute

```
SELECT *
FROM   employee
WHERE  salary IS NULL
```

SQL: NOT IN and IS NOT NULL

- Tests whether a value is not contained in a set or not a null value respectively
- Syntax looks similar to the IN and IS NULL operators:
  attr NOT IN (set of values)
  attr IS NOT NULL

SQL: Three-Value Logic

AND

	TRUE	FALSE	UNKNOWN
TRUE	TRUE	FALSE	UNKNOWN
FALSE	FALSE	FALSE	FALSE
UNKNOWN	UNKNOWN	FALSE	UNKNOWN

OR

	TRUE	FALSE	UNKNOWN
TRUE	TRUE	TRUE	TRUE
FALSE	TRUE	FALSE	UNKNOWN
UNKNOWN	TRUE	UNKNOWN	UNKNOWN

NOT

TRUE	FALSE	UNKNOWN
FALSE	TRUE	UNKNOWN

SQL: ORDER BY

- Sort the tuples in a query based on the values of some attributes
- Default order is in ascending order of the values (ASC)
- Syntax:

```
SELECT <attribute list>
FROM   <table list>
WHERE  <condition on the tables>
ORDER BY <attribute-list> ASC | DESC;
```

sorting by multiple columns is just separated with a comma

Example Query: ORDER BY

- Sort employees by their salary value in descending order

```
SELECT      fname, lname, salary
FROM        employee
ORDER BY    salary DESC;
```

- Sort employees by their salary figures and within the same salary figure, by their last name

```
SELECT      fname, lname, salary
FROM        employee
ORDER BY    salary, lname;
```

SQL: LIMIT

- Limit the output to be only the specified number of tuples
  - Useful if your table has many relations and you just want to sanity check your work
  - Can be used with ORDER BY to get a maximum or minimum value
- Syntax:

```
SELECT <attribute list>
FROM   <table list>
WHERE  <condition on the tables>
LIMIT  <number of tuples>;
```

Exercise: Company Database (2)

- What are the first and last names of employees who live in Houston?
- What are the SSNs of the top 5 employees who worked the most hours on project number Y? List them in descending order
- Which departments are project X, project Y, and project Z controlled by?

Multi-table Queries

Recap: SQL Query

```
SELECT <attribute list>
FROM   <table list>
WHERE  <condition on the tables>
```

$$\Updownarrow$$

$$\pi_{<\text{attribute list}>}\sigma_{<\text{condition}>}(R_1 \times R_2 \times \cdots \times R_n)$$

Example Query: Cartesian Product

SELECT ssn, lname, dno, dnumber, dname
FROM employee, department;

ssn	lname	dno	dnumber	dname
111-12-2345	Kirk	5	5	Research
111-12-2345	Kirk	5	4	Administration
111-12-2345	Kirk	5	1	Headquarters
222-23-2222	McCoy	4	5	Research
222-23-2222	McCoy	4	4	Administration
222-23-2222	McCoy	4	1	Headquarters
...	...	...	...	...
134-52-2340	Scott	5	5	Research
134-52-2340	Scott	5	4	Administration
134-52-2340	Scott	5	1	Headquarters

SQL: Join Operation

- Relational algebra expression

$$R_1 \bowtie_{\text{condition}} R_2 = \sigma_{\text{condition}}(R_1 \times R_2)$$

  - Cartesian product followed by a selection operation

- SQL command

  - **FROM** clause specifies Cartesian product operation

  - **WHERE** clause specifies condition of the selection operation

Example Query: Join

```
SELECT ssn, lname, dno, dnumber, dname
FROM   employee, department
WHERE  dno = dnumber;
```

ssn	lname	dno	dnumber	dname
111-12-2345	Kirk	5	5	Research
222-23-2222	McCoy	4	4	Administration
134-23-2345	Sulu	4	4	Administration
234-13-3840	Chapel	1	1	Headquarters
134-52-2340	Scott	5	5	Research

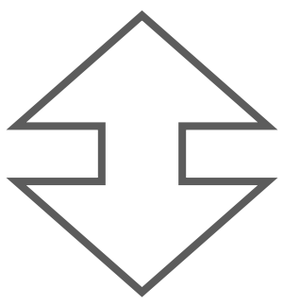
SQL: Join Part II

- Several equivalent ways to write a basic join
- Method 1 is to just use Cartesian Product on the FROM clause
- Method 2 syntax:

```
SELECT <attribute list>
FROM   <table1>
JOIN     <table2> ON <join condition>
WHERE  <condition on the tables>
```

Example Query: Join Part II

```
SELECT ssn, lname, dno, dnumber, dname
FROM   employee, department
WHERE  dno = dnumber;
```



```
SELECT ssn, lname, dno, dnumber, dname
FROM   employee
JOIN   department ON dno = dnumber;
```

Example Query: Join in RA

Query: Find the name and address of employees working in the ‘Research’ department

RA expression:

$$\mathrm{RD} = \sigma_{\mathrm{Dname}=\text{‘Research’}}(\mathrm{DEPARTMENT})$$

$$\mathrm{RE} = \mathrm{RD} \bowtie_{\mathrm{Dnumber}\ =\ \mathrm{Dno}} \mathrm{EMPLOYEE}$$

$$\mathrm{Answer} = \pi_{\mathrm{fname,lname,Address}}(\mathrm{RE})$$

Example Query: Join in SQL

Q: Find the name and address of employees working in the 'Research' department

- SQL expression 1

```
SELECT fname, lname, address
FROM   employee, department
WHERE dname='Research' AND dno = dnumber;
```

- SQL expression 2

```
SELECT fname, lname, address
FROM   employee
JOIN   department ON dno = dnumber
WHERE dname='Research';
```

join condition

selection condition

Exercises: Company Database (3)

- Find the name of employees in the ‘Research’ department who earn over $30,000
- Find the name of employees who work on the project ‘ProductX’
- For the projects located in ‘Stafford’, find the name of the project, the name of the controlling department, the last name of the department’s manager, his address, and birthdate

SQL: Ambiguity

What happens if we wanted a list of employees with the name of their dependents and the projects the employee works on?

```
SELECT essn, pno, dep_name
FROM Project, Dependent
WHERE essn = essn;
```

Ambiguous attribute names: the same name for two (or more) attributes in different relations

SQL: Qualifying Attribute Names

- Ambiguous attributed names that appear in the same query need to be made explicit (otherwise cannot tell which relation it is from)
- Qualify (prefix) the attribute name with the source relation name
  - Can be done in **SELECT** or **WHERE** clause
- SQL syntax: **<relation>.<attr>**

Example Query: Qualifying Attribute Names

Find project numbers of projects worked on by employees who have a daughter named ‘Alice’

```
SELECT   pno
FROM     works_on, dependent
WHERE    works_on.essn = dependent.essn
  AND    name = ‘Alice’;
```

SQL: Ambiguity Take 2

What if we wanted a list of each employees first name, last name, and their manager's first name and last name

```
SELECT fname, lname, fname, lname
FROM   employee, employee
WHERE  superssn = ssn;
```

Ambiguous attribute names that won't be solved by qualifying their relation

SQL: Aliasing

- Need to use the same relation multiple times in a **SELECT** command and every attribute name of that relation will be ambiguous
- Use an alias or identifier that follows a relation name in the **FROM** clause of a **SELECT** command

SQL: Aliasing Syntax

- SQL Syntax:
  SELECT <alias1>.<attr1>, <alias2>.<attr2>
  FROM <relation1> <alias1>, <relation2> <alias 2>
  WHERE <alias1>.<A> = <alias2>.A;
- No comma between alias and relation name!
- Refer to the relation using the given alias in other parts of query

Example Query: Aliasing

List each employees first name, last name, and their manager's first name and last name

```
SELECT e.fname, e.lname, m.fname, m.lname
FROM   employee e, employee m
WHERE  e.superssn = m.ssn;
```

e and m are called aliases or tuple variables for employee relation

SQL: Arithmetic Operations

- Any arithmetic expression (that makes sense) can be used in the **SELECT** clause

- Example: Show the effect of giving all employees who work on the 'ProductX' project a 10% raise

```
SELECT    fname, lname, 1.1*salary
FROM      employee, works_on, project
WHERE     ssn = essn
   AND    pno = pnumber
   AND    pname = 'ProductX'
```

Exercises: Company Database (4)

- What are the names of the departments that are located in Boston?
- Find the name of the manager who is in charge of the ‘Research’ department located in Atlanta
- What are the names of the children whose parents work on project X?

Nested Queries

Review: Basic SQL Retrieval Query

A SQL query can consist of several clauses, but only **SELECT** and **FROM** are mandatory

```
SELECT <attribute list>
FROM   <table list>
[WHERE  <condition on the tables (join or selection)>]
[ORDER BY <attribute list>]
[LIMIT <number of tuples>]
```

Subquery

- Subquery: A parenthesized **SELECT-FROM-WHERE** statement which results in a relation of tuples
- Syntax:
  (**SELECT**-command)
- Usage
  - Inside **WHERE** clause (nested query)
  - Inside **FROM** clause (temporal relation)

Nested Query

- Nested query is when a subquery is specified within the **WHERE** clause of another query, called the outer query

- Syntax:

```
SELECT ...
FROM ...
WHERE ... (SELECT ...
           FROM ...
           WHERE ...)
```

Nested Query

Nested Query Forms

- Forms of nested query:
  - Set membership: **IN** and **NOT IN**
  - Set comparison:
    compareOp ANY or **compareOp ALL**
  - Test for empty relation: **EXIST**
- In theory, nesting can be arbitrarily deep but in practice the number of levels is limited

Example Query: Nested Query

Retrieve the name and address of all employees who work for the 'Research' department

- Soln #1:
```
SELECT fname, lname
FROM   employee, department
WHERE dno = dnumber
    AND dname = 'Research';
```

- Soln #2:
```
SELECT fname, lname
FROM EMPLOYEE
WHERE dno IN (SELECT dnumber
              FROM department
              WHERE dname = 'Research')
```

Example Query: Nested Query (2)

Find fname, lname of employees that do not have any dependents

```
SELECT fname, lname
FROM   employee
WHERE  ssn NOT IN (SELECT essn
                   FROM   dependent);
```

Correlated Nested Queries

- Correlated: inner query (query in the **WHERE** clause) uses one or more attributes from relation(s) specified in the outer query

- Uncorrelated: inner query is a stand-alone query that can be executed independently from the outer query

- Example Syntax:

```
SELECT ...
FROM   R1
WHERE  attr1 IN (SELECT attr2
                 FROM   R2
                 WHERE R2.attr3 = R1.attr4)
```

Example Query: Correlated Nested Query

Retrieve the name of each employee who has a dependent with the same name as the employee

```
SELECT   e.fname, e.lname
FROM     employee AS e
WHERE    e.ssn IN (SELECT essn
                   FROM    dependent
                   WHERE   essn = e.ssn
                   AND     e.fname = name);
```

Correlated Nested Query Execution

- FOR (each tuple X in the outer query) DO {
  Execute inner query using attribute value of tuple X
  }

- Example:

```
SELECT fname, lname, salary, uno
FROM    employee a
WHERE salary >= ALL (SELECT salary
                     FROM    employee a
                     WHERE  b.dno = a.dno)
```

Correlated Nested Query Execution (2)

FName	LName	DNo	Salary
John	Smith	4	50,000
James	Bond	4	80,000
Jane	Brown	3	60,000
Jennifer	Wallace	5	30,000
James	Borg	1	55,000
Joyce	English	5	25,000
Alicia	Wong	4	70,000

- Outer tuple a =

John	Smith	4	50,000

WHERE 50,000 >= ALL (SELECT salary FROM employee b where b.dno = 4)
=> FALSE

Correlated Nested Query Execution (2)

FName	LName	DNo	Salary
John	Smith	4	50,000
James	Bond	4	80,000
Jane	Brown	3	60,000
Jennifer	Wallace	5	30,000
James	Borg	1	55,000
Joyce	English	5	25,000
Alicia	Wong	4	70,000

- Outer tuple a =

James	Bond	4	80,000

WHERE 80,000 >= ALL (SELECT salary FROM employee b where b.dno = 4)
=> TRUE (select tuple)

Correlated Nested Query Execution (2)

FName	LName	DNo	Salary
James	Bond	4	80,000
Jane	Brown	3	60,000
Jennifer	Wallace	5	30,000
James	Borg	1	55,000

```
SELECT fname, lname, salary, uno
FROM    employee a
WHERE salary >= ALL (SELECT salary FROM
employee a WHERE  b.dno = a.dno)
```

Correlated Nested Query Scope

Scoping rules defines where a name is visible

- Each nesting level constitutes a new inner scope
- Names of relations and their attributes in outer query are visible in the inner query but not the converse
- Attribute name specified inside an inner query is associated with nearest relation

Example: Scoping Nested Queries

```
SELECT <attribute list from R1 and/or R2>
FROM     R1, R2
WHERE  <conditions from R1 and/or R2> AND
        (SELECT <attribute list from R1, R2, R3 and/or R4>
         FROM     R3, R4
         WHERE <conditions from R1, R2, R3, and/or R4>)
```

- Attributes of R1 and R2 are visible in the inner query
- Attributes of R3 and R4 are not visible in the outer query

Example: Scoping Nested Queries (2)

```
SELECT <attribute list from R1 and/or R2>
FROM     R1, R2
WHERE  <conditions from R1 and/or R2> AND
       (SELECT  x
        FROM     R3, R4
        WHERE <conditions from R1, R2, R3, and/or R4>)
```

- If R3 or R4 contains the attribute name x, then x refers to that attribute in R3 or R4
- If R3 and R4 does not contain the attribute name x, then x in the inner query refers to the attribute in R1 or R2

SQL Query: EXISTS

- Checks whether the result of a correlated nested query is empty (contains no tuples) or not
- Example: Retrieve the names of employees who have no dependents

```
SELECT fname, lname
FROM   employee
WHERE  NOT EXISTS (SELECT *
                   FROM   dependent
                   WHERE ssn = essn);
```

SQL Query: Aggregate Functions

- **COUNT**, **SUM**, **MAX**, **MIN**, **AVG** can be used in the **SELECT** clause

- Example: Find the sum, maximum, minimum, and average salary among all employees in the Research department

```
SELECT SUM(salary), MAX(salary)
       MIN(salary), AVG(salary)
FROM   employee, department
WHERE  dno = dnumber AND dname = 'Research'
```

SQL Query: Aggregate Functions (2)

- Name given to the selected aggregate function attribute is the same as the function call
  - **SELECT MAX(salary), MIN(salary), AVG(salary)**
    FROM employee;

max(salary)	min(salary)	avg(salary)

- Rename selected attributes with AS alias clause inside the SELECT clause
  - **SELECT MAX(salary) AS max, MIN(salary) AS min, AVG(salary) AS average**
    FROM employee;

SQL Example: Aggregate Function

Retrieve the names of all employees who have two or more dependents

```
SELECT lname, fname
FROM   employee
WHERE  ( SELECT COUNT (*)
         FROM   dependent
         WHERE  ssn = essn) >= 2;
```

SQL Query: GROUP BY

- Apply aggregate functions to subgroups of tuples in a relation
  - Corresponds to grouping and aggregate function in RA
  - Grouping attributes: attributes used to group the tuples
  - Function is applied to each subgroup independently
- Syntax:

```
SELECT      <attribute list>
FROM        <table list>
WHERE       <condition on the tables>
GROUP BY <grouping attributes>
```

GROUP BY Execution

A query with **GROUP BY** clause is processed as follows:

1. Select the tuples that satisfies the **WHERE** condition
2. Selected tuples from (1) are grouped based on their value in the grouping attributes
3. One or more set functions is applied to the group

SQL Example: GROUP BY

For each department, retrieve the department number, the number of employees in the department, and their average salary

```
SELECT    dno, count(*), avg(salary)
FROM      employee
GROUP BY dno
```

SQL Query: GROUP BY details

- What happens if we do not include certain grouping attributes in the **SELECT** clause?

- What happens if we include an attribute in the **SELECT** clause that is not in the group by attribute list?

SQL Query: GROUP BY details

- What happens if we do not include certain grouping attributes in the **SELECT** clause?

  Ans: The query still executes but you have no idea what the result means anymore

- What happens if we include an attribute in the **SELECT** clause that is not in the group by attribute list?

SQL Query: GROUP BY details

- What happens if we do not include certain grouping attributes in the **SELECT** clause?

  Ans: The query still executes but you have no idea what the result means anymore

- What happens if we include an attribute in the **SELECT** clause that is not in the group by attribute list?

  Ans: In theory, this should not be allowed as you can not produce a single value for non-grouping attributes. However, some implementations returns one of the tuples.

SQL Query: HAVING

- **HAVING** clause specifies a selection condition on groups (rather than individual tuples)
- Filters out groups that do not satisfy the group condition
- Syntax:

```
SELECT      <attribute list>
FROM         <table list>
WHERE       <condition on the tables>
GROUP BY <grouping attributes>
HAVING      <group condition>
```

SQL Query: HAVING Details

- If a SQL query uses **HAVING** clause, then there **MUST** be a **GROUP BY** clause
- Group condition is a condition on a set of tuples
- Can’t use non-grouping attribute inside the **HAVING** clause
- Most common form of group condition is: SetFunction(<attr>) RelationalOperator <value>

SQL Query: HAVING Process Order

1. Select tuples that satisfy the **WHERE** condition
2. Selected tuples from (1) are grouped based on their value in the grouping attributes
3. Filter groups so only those satisfying the condition are left
4. Set functions in the **SELECT** clause are applied to these groups

SQL Example: HAVING

For each project on which more than two employees work, retrieve the project number, project name, and the number of employees who work on that project

```
SELECT      pnumber, pname, COUNT(*)
FROM        project, works_on
WHERE       pnumber = pno
GROUP BY    pnumber, pname
HAVING      COUNT(*) > 2;
```

SQL Example: HAVING (2)

For each department with at least 2 employees, find the department name, and the number of employees in that department that earns greater than $40K

```
SELECT      dname, COUNT(ssn)
FROM        department, employee
WHERE       dnumber = dno
  AND       salary > 40000
GROUP BY    dname
HAVING      COUNT(ssn) > 2;
```

Is this right? What does it return?

SQL Example: HAVING (2)

- Previous query only counts the number of departments that have at least 2 employees that earn more then $40K.

-
```
SELECT    dname, COUNT(ssn)
FROM      employee, department
WHERE     dno = dnumber
  AND     dno IN ( SELECT      dno
                   FROM        employee
                   GROUP BY    dno
                   HAVING      COUNT(ssn) >= 2)
  AND     salary > 40000
GROUP BY dname
```

Summary of SQL Queries

```
SELECT      [DISTINCT] <attribute list>
FROM         <table list>
[WHERE      <condition on the tables>]
[GROUP BY <grouping attributes>]
[HAVING      <group condition>]
[ORDER BY  <attribute list>   ASC | DESC]
[LIMIT       <number of tuples>]
```

This has every possible clause of a SQL command included

Exercises: Company Database (5)

- What are the SSN of the employees who work on at least 2 projects?
- What is the name of the project where the employees have worked the highest number of hours (total)?
- Which department has the highest number of dependents?
- What department(s) has no projects?

MySQL: Useful Commands

MySQL: Useful commands

- Discovering information about your database and tables:
  SHOW DATABASES — list all databases
  USE <DBName> — set current database to DBName
  SELECT DATABASE() — get the name of the current DB
  DESCRIBE <TableName> — display the structure of table

- Insert a tuple into database:
  INSERT INTO <TableName> VALUES (a_1, a_2, …, a_N);

- Select tuples from a table:
  SELECT * from <TableName>;

MySQL: Useful commands

- Create user account:
  CREATE USER ‘userid’@‘hostname’ IDENTIFIED BY ‘password’;

- Create user from any (wildcard) host:
  CREATE USER ‘userid’@‘%’ IDENTIFIED BY ‘password’;

- Granted access to database.table:
  GRANT <permission> ON database.table TO ‘user’@‘host’;

- Grant All permission to all tables in database:
  GRANT ALL ON <DBName>.* TO ‘user’@‘host’;

MySQL Demo Company Database

MySQL Workbench

- Open source, integrated development environment for MySQL database system
  - SQL Editor
  - Data modeling
  - Data administration + performance monitoring
- Works on Windows, Linux, Mac OS X
- https://www.mysql.com/products/workbench/

MySQL Workbench DEMO

SQL Queries: Recap

- Basic query form
- Useful operators:
  - *, DISTINCT, IN, LIKE, ORDER BY, LIMIT, IS NULL
- Multi-table queries
  - Join
  - Aliasing and qualification
  - Nested queries
- Additional operators and commands
  - Set operations, GROUP BY, HAVING