

Introduction to SQL

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- ▶ Three Subsystems: data description, data access and privileges
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- ▶ The language is case-sensitive, but I use upper case for keywords.

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- ▶ Web interfaces to data, especially dynamic data

Uses of Databases

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- ▶ Traditional rules may not be as important

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- ▶ PROC SQL in SAS

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- ▶ Tables are two-dimensional with rows (observations) and columns (variables)
- ▶ Limited mathematical and summary operations available
- ▶ Very good at combining information from several tables

Finding Your Way Around the Server

Since a single server can support many databases, each containing many tables, with each table having a variety of columns, it's easy to get lost when you're working with databases. These commands will help figure out what's available:

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- ▶ `SHOW DATABASES;`
- ▶ `SHOW TABLES IN database;`
- ▶ `SHOW COLUMNS IN table;`
- ▶ `DESCRIBE table;` - shows the columns and their types

Variable Types

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- ▶ FLOAT(*p*) - floating point number with *p* binary digits of precision

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```
CREATE TABLE kids(id CHAR(6),  
                   race SMALLINT,  
                   age DECIMAL(6,3),  
                   height DECIMAL(7,3),  
                   weight DECIMAL(7,3),  
                   sex SMALLINT);
```

Entering observations into a table

We could now enter individual items with the `INSERT` command:

```
INSERT INTO kids VALUES(100011,2,10.346,  
                          148.5,38.95,1);
```

This quickly gets tedious. We can automate the process using the `LOAD DATA` command:

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LOAD DATA INFILE 'kids.tab'  
          INTO TABLE kids  
          FIELDS TERMINATED BY '\t';
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LOAD DATA INFILE 'kids.tab'  
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This will read an entire tab-separated file into the database in one command.

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- ▶ **RLIKE** operator allows regular expressions
- ▶ Use **AND**(`&&`) and **OR**(`||`) to combine conditions

Updating a Table

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For example, to add one to the weight of an observation in the **kids** table where **id** is 101311 and **age** is between 9 and 10, we could use:

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For example, to add one to the weight of an observation in the `kids` table where `id` is 101311 and `age` is between 9 and 10, we could use:

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Be careful with `UPDATE`, because if you don't provide a `WHERE` clause, all the rows of the table will be changed.

The `SELECT` statement

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```
SELECT columns or computations  
FROM table  
WHERE condition  
GROUP BY columns  
HAVING condition  
ORDER BY column [ASC | DESC]  
LIMIT offset,count;
```

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SELECT * FROM kids WHERE age BETWEEN 17 AND 18  
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Other functions (`ABS()`, `FLOOR()`, `ROUND()`, `SQRT()`, etc.) may also be available.

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[▶ View](#)

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```
FROM kids GROUP BY sex,race;
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SELECT race,SUM(height > 150)/COUNT(*)  
      FROM kids GROUP BY race;
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[▶ View](#)

Selecting based on Summaries

Summaries can't be used in the **WHERE** clause, but they can be used in the **HAVING** clause. For example, suppose we wanted to find all the **IDs** in the **kids** database for which there were less than 2 observations:

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This doesn't work - it only gives the first observation for each id.

Subqueries

By putting a **SELECT** statement in parentheses, you can use it in other **SELECT** statements as if it were another table.

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This is considerably faster than the previous query.

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A similar thing can be done when there are grouping variables:

```
SELECT k.id,k.sex,k.race,k.age,
      k.weight,k.height FROM kids AS k,
      (SELECT sex,race,max(weight) AS weight from
      kids) AS m WHERE k.sex=m.sex AND
      k.race=m.race AND k.weight=m.weight;
```

[▶ View](#)

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Music Collection Example

Traditionally, redundancy is the enemy of database design, because it wastes storage space and increase data entry errors. For this reason, may traditional databases have a separate table for each attribute of importance. For example, suppose we have a collection of songs, organized into albums. Rather than store each song as a row with the album title and artist, we would create three tables: one for songs(tracks), one for albums, and one for artists.

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Album		Artist		Track	
alid	INT	aid	INT	tid	INT
aid	INT	name	VARCHAR(40)	alid	INT
title	VARCHAR(60)			time	INT
				title	VARCHAR(40)
				filename	VARCHAR(14)

A Look at the Tables

```
mysql> select * from album limit 1,5;
```

+-----+-----+-----+-----+			
	alid		aid title
+-----+-----+-----+-----+			
	140		102 Ugetsu
	150		109 Born To Be Blue
	151		109 Connecticut Jazz Party
	152		109 Easy Does It
	153		109 In Person
+-----+-----+-----+-----+			

5 rows in set (0.03 sec)

```
mysql> select * from artist limit 1,5;
```

+-----+-----+-----+		
	aid	name
+-----+-----+-----+		
	109	Bobby Timmons
	134	Dizzy Gillespie
	140	Elmo Hope
	146	Erroll Garner
	159	Horace Silver
+-----+-----+-----+		

5 rows in set (0.03 sec)

```
mysql> select * from track limit 1,5;
```

+-----+-----+-----+-----+-----+-----+					
	tid		alid		time title filename
+-----+-----+-----+-----+-----+-----+					
	1713		139		413 Sincerely Diane (alternate take) 1077698286.mp3
	1714		139		384 Yama 1077698288.mp3
	1715		139		404 When your lover has gone 1077698290.mp3
	2276		139		398 So tired 1077699502.mp3
	3669		139		408 Sincerely Diana 1077702347.mp3
+-----+-----+-----+-----+-----+-----+					

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SELECT with multiple tables

Produce a list of album titles along with artist:

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SELECT SUM(time) as duration
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Unfortunately, all we have are the album ids, not the names

SELECT with multiple tables(cont'd)

To improve our previous example, we need to combine the track information with album and artist information. Suppose we want to find the 10 longest albums in the collection:

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```
SELECT a.title,r.name,  
       SUM(time) AS duration  
FROM track AS t, album as a, artist as r  
WHERE t.alid = a.alid AND a.aid = r.aid  
GROUP BY t.alid ORDER BY duration DESC  
LIMIT 1,10;
```

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LIMIT 1,10;
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- ▶ Load up data structures with entire tables
- ▶ Use as little or as much pure SQL as you like

These ideas are illustrated using the music collection data, R, python, and perl

Using SQL in R

```
library(RMySQL)
drv = dbDriver("MySQL")
con = dbConnect(drv,dbname="dbname",user="user",pass="pass")
rs = dbSendQuery(con,statement="select * from album")
album = fetch(rs,n=-1)
rs = dbSendQuery(con,statement="select * from track")
track = fetch(rs,n=-1)
rs = dbSendQuery(con,statement="select * from artist")
artist = fetch(rs,n=-1)

tracks = data.frame(
  album = factor(track$alid,levels=album$alid,
                  labels=album$title),
  artist = factor(merge(track[, "alid", drop=FALSE],
                        album[, c("alid", "aid")], by="alid")$aid,
                  levels=artist$aid,
                  labels=artist$name),
  time = track$time)

res = aggregate(tracks$time,
                list(album=tracks$album,artist=tracks$artist),sum)
res = res[order(res$x,decreasing=TRUE),]
print(res[1:10,])
```

Using SQL in python

```
#!/usr/bin/python

from MySQLdb import *

con = connect(user='user',passwd='pass',db='dbname')
cursor = con.cursor()
cursor.execute('select * from track')
tracks = cursor.fetchall()

durations = {}
for t in tracks:
    durations[t[1]] = durations.get(t[1],0) + t[2]

alids = durations.keys()
alids.sort(lambda x,y:cmp(durations[y],durations[x]))

for i in range(10):
    cursor.execute(
        'select title,aid from album where alid = %d' % alids[i])
    title,aid = cursor.fetchall()[0]
    cursor.execute('select name from artist where aid = %d' % aid)
    name = cursor.fetchall()[0][0]
    print '%s\t%s\t%d' % (title,name,durations[alids[i]])
```

Using SQL in perl

```
#!/usr/bin/perl
use DBI;
$dbh = DBI->connect('DBI:mysql:dbname:localhost','user','pass');

$sth = $dbh->prepare('select * from album');
$sth->execute();
while((@row) = $sth->fetchrow()){
    $album{$row[0]} = $row[2];
    $artist{$row[0]} = $row[1];
}

$sth = $dbh->prepare('select * from artist');
$sth->execute();
$artist{$row[0]} = $row[1] while((@row) = $sth->fetchrow());

$sth = $dbh->prepare('select * from track');
$sth->execute();
$duration{$row[1]} += $row[2] while((@row) = $sth->fetchrow());

@salbum = sort({$duration{$b} <=> $duration{$a}} keys(%duration));
foreach $i (0..9){
    print
        "$album{$salbum[$i]}\t$artist{$artist{$salbum[$i]}}\t",
        "$duration{$salbum[$i]}\n"
}
```

```
mysql> select * from kids;
```

id	race	age	height	weight	sex
100011	2	10.346	148.500	38.950	1
100011	2	11.282	157.100	44.100	1
100011	2	14.428	165.950	57.800	1
100011	2	15.321	167.050	59.650	1
100031	1	10.920	158.000	63.700	1
100031	1	11.917	161.000	68.500	1
100031	1	13.007	162.750	85.950	1
.					
308091	1	9.460	138.000	39.000	1
308091	1	10.740	147.500	53.100	1
308091	1	11.359	151.750	57.050	1
308101	1	9.800	152.350	38.500	2
308101	1	10.781	159.335	48.235	2
308101	1	11.701	164.285	51.700	2

20704 rows in set (0.18 sec)

```
mysql> select age,race,height,weight from kids
      -> where weight > 80 and height < 150;
```

+-----+-----+-----+-----+			
age	race	height	weight
+-----+-----+-----+-----+			
12.429	2	147.800	83.000
11.674	2	149.350	82.950
14.414	2	149.300	86.750
+-----+-----+-----+-----+			

3 rows in set (0.06 sec)

```
mysql> select * from kids order by height desc;
```

+-----+-----+-----+-----+-----+-----+						
id	race	age	height	weight	sex	
+-----+-----+-----+-----+-----+-----+						
302941	2	19.657	201.905	83.820	2	
300861	2	17.804	201.850	126.610	2	
302941	2	16.572	201.795	76.670	2	
300861	2	14.833	201.520	124.245	2	
300861	2	18.781	201.520	123.310	2	
302941	2	18.611	201.410	83.710	2	
107061	2	17.626	201.300	82.005	2	
302941	2	15.537	201.190	72.820	2	
304441	1	17.946	201.190	67.430	2	
116741	1	17.338	201.025	72.710	2	
+-----+-----+-----+-----+-----+-----+						
10 rows in set (0.10 sec)						

```
mysql> select * from kids
      -> where age between 17 and 18
      -> and weight between 180 and 185;
```

id	race	age	height	weight	sex
304741	1	17.875	194.150	184.250	2

1 row in set (0.03 sec)

```
mysql> select max(height) from kids
      ->      where age between 10 and 11 and race = 1;
+-----+
| max(height) |
+-----+
|      178.750 |
+-----+
1 row in set (0.06 sec)
```

```
mysql> select sex,race,count(*) as n,  
        -> avg(weight/(height*height)*10000) as bmi  
        -> from kids group by sex,race;
```

+-----+-----+-----+-----+				
sex	race	n	bmi	
+-----+-----+-----+-----+				
1	1	4977	21.312670406	
1	2	5532	23.489962065	
2	1	4973	19.153469602	
2	2	5222	21.040500147	
+-----+-----+-----+-----+				

4 rows in set (0.12 sec)

```
mysql> select race,sum(height > 150)/count(*)
      -> from kids group by race;
```

race	sum(height > 150)/count(*)
1	0.85
2	0.89

2 rows in set (0.05 sec)

```
mysql> select id from kids
      ->      group by id having count(*) < 2;
+-----+
| id      |
+-----+
| 101051  |
| 103181  |
| 103191  |
| 107231  |
| 109001  |
| . . .  |
| 207291  |
| 207961  |
| 302241  |
| 304561  |
| 307081  |
+-----+
22 rows in set (0.10 sec)
```

```
mysql> select * from kids group by id having count(*)=10;
+-----+-----+-----+-----+-----+-----+
| id      | race | age      | height  | weight  | sex |
+-----+-----+-----+-----+-----+-----+
| 100031 | 1    | 10.920   | 158.000 | 63.700  | 1   |
| 100041 | 1    | 10.070   | 159.500 | 51.700  | 2   |
| 100071 | 2    | 10.630   | 139.700 | 37.500  | 1   |
| 100081 | 2    | 9.110    | 152.130 | 36.795  | 2   |
| 100091 | 2    | 9.200    | 148.250 | 54.150  | 1   |
|        |      |          |          |          |     |
| 308021 | 1    | 9.330    | 157.850 | 41.470  | 2   |
| 308041 | 1    | 10.810   | 157.025 | 38.060  | 2   |
| 308061 | 1    | 10.120   | 156.200 | 32.780  | 2   |
| 308071 | 1    | 10.990   | 138.500 | 29.450  | 1   |
| 308081 | 1    | 9.920    | 152.900 | 31.130  | 2   |
+-----+-----+-----+-----+-----+-----+
1303 rows in set (0.11 sec)
```

```
mysql> select * from kids where id in
->      (select id from kids group by id
->      having count(*)=10);
```

id	race	age	height	weight	sex
100011	2	10.346	148.500	38.950	1
100011	2	11.282	157.100	44.100	1
100011	2	12.336	163.900	51.150	1
100011	2	13.388	166.450	57.400	1
100011	2	14.428	165.950	57.800	1
.					
308081	1	14.803	183.700	55.935	2
308081	1	15.780	183.590	54.780	2
308081	1	16.865	184.195	58.905	2
308081	1	17.864	184.580	56.320	2
308081	1	18.631	184.195	56.100	2

13030 rows in set (35 min 33.96 sec)

```
mysql> select * from kids inner join
-> (select id from kids group by id having count(*)=10)
-> as a using(id);
```

id	race	age	height	weight	sex
100011	2	10.346	148.500	38.950	1
100011	2	11.282	157.100	44.100	1
100011	2	12.336	163.900	51.150	1
100011	2	13.388	166.450	57.400	1
100011	2	14.428	165.950	57.800	1
.					
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308081	1	15.780	183.590	54.780	2
308081	1	16.865	184.195	58.905	2
308081	1	17.864	184.580	56.320	2
308081	1	18.631	184.195	56.100	2

13030 rows in set (11.89 sec)

```
mysql> select * from kids  
      -> having weight = max(weight);  
Empty set (0.00 sec)
```

◀ Return

```
mysql> select * from kids
      -> where weight = (select max(weight) from kids);
+-----+-----+-----+-----+-----+-----+
| id      | race | age      | height  | weight  | sex |
+-----+-----+-----+-----+-----+-----+
| 304741  | 1    | 18.680   | 192.940 | 189.695 | 2   |
+-----+-----+-----+-----+-----+-----+
1 row in set (0.03 sec)
```

```
mysql> select k.id,k.sex,k.race,k.age,k.weight,k.height
-> from kids as k, (select sex,race,max(weight) as weight
-> from kids group by sex,race) as m
-> where k.sex = m.sex and k.race = m.race and
-> k.weight = m.weight;
```

id	sex	race	age	weight	height
207201	2	2	19.405	173.360	191.565
207931	1	2	19.674	151.200	164.900
208171	1	1	18.633	128.500	168.100
304741	2	1	18.680	189.695	192.940

4 rows in set (0.34 sec)

```
mysql> select a.title,r.name from album as a,artist as r where a.aid = r.aid;
```

title	name
A Night in Tunisia	Art Blakey & Jazz Messengers
Ugetsu	Art Blakey & Jazz Messengers
Born To Be Blue	Bobby Timmons
Connecticut Jazz Party	Bobby Timmons
Easy Does It	Bobby Timmons
In Person	Bobby Timmons
Moanin' Blues	Bobby Timmons
The Prestige Trio Sessions	Bobby Timmons
Soul Man Soul Food	Bobby Timmons
Soul Time	Bobby Timmons
Workin' Out	Bobby Timmons
1945-1950 Small Groups	Dizzy Gillespie
.	
Live at the Circle Room and Mo	Nat King Cole
Birth of the Cole 1938-1939	Nat King Cole
Rockin' Boppin' & Blues	Nat King Cole
WWII Transcriptions	Nat King Cole
Oscar Peterson And Clark Terry	Oscar Peterson
A Tribute To My Friends	Oscar Peterson
The Oscar Peterson Trio Live At Zardi's - Disc One	Oscar Peterson
The Oscar Peterson Trio Live At Zardi's - Disc Two	Oscar Peterson
Skol	Oscar Peterson
Oscar Peterson and Dizzy Gillespie	Oscar Peterson
Overseas	Tommy Flanagan
The Tommy Flanagan Trio	Tommy Flanagan
Trio & Sextet	Tommy Flanagan

72 rows in set (0.02 sec)

```
mysql> select alid,sum(time) as duration
      -> from track group by alid order by duration desc;
+-----+-----+
| alid | duration |
+-----+-----+
| 150  | 6057    |
| 286  | 5664    |
| 264  | 5028    |
| 156  | 4764    |
| 158  | 4674    |
|      | . . . . |
| 343  | 2031    |
| 263  | 1865    |
| 281  | 1749    |
| 280  | 1611    |
| 287  | 1519    |
| 203  | 1061    |
+-----+-----+
72 rows in set (0.04 sec)
```

```
mysql> select a.title,r.name,sum(time) as duration
-> from track as t,album as a,artist as r
-> where t.alid=a.alid and a.aid = r.aid
-> group by t.alid
-> order by duration desc limit 1,10;
```

title	name	duration
My Funny Valentine	Miles Davis	5664
Trio	Kenny Drew	5028
Soul Man Soul Food	Bobby Timmons	4764
Workin' Out	Bobby Timmons	4674
The All-Stars Sessions	Elmo Hope	4636
The Oscar Peterson Trio Live At Zardi's - Disc Two	Oscar Peterson	4567
Memories Of You	Erroll Garner	4538
Elmo Hope	Elmo Hope	4536
WWII Transcriptions	Nat King Cole	4456
The Oscar Peterson Trio Live At Zardi's - Disc One	Oscar Peterson	4355

10 rows in set (0.10 sec)