Introduction to SQL

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- Used as front end to many databases (mysql, postgresql, oracle, sybase)
- 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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- Rapid queries with no analysis
- Web interfaces to data, especially dynamic data

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- Report Generation
- Normalization, foreign keys, joins, etc.

Newer uses:

- Storage - data is extracted and analyzed in another application
- Backends to web sites
- 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

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

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

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- `DATE`
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- `TIMESTAMP`

`CREATE TABLE` statement

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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'
           INTO TABLE kids
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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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UPDATE kids SET weight=weight + 1
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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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Since the `COUNT` for all columns is the same, the form `COUNT(*)` is often used.
Other functions (`ABS()`, `FLOOR()`, `ROUND()`, `SQRT()`, etc.) may also be available.

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SELECT race,SUM(height > 150)/COUNT(*)
     FROM kids GROUP BY race;
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Selecting based on Summaries

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

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SELECT * FROM kids
      INNER JOIN
      (SELECT id FROM kids
      GROUP BY id
      HAVING COUNT(*) = 10) AS t USING(id);
```

Subqueries

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

View

```
SELECT * FROM kids
      WHERE id IN
      (SELECT id FROM kids
      GROUP BY id
      HAVING COUNT(*) = 10);
```

This may be slow if the number of ids is large.

A more efficient way is to use the subquery in an inner join (discussed later):

View

```
SELECT * FROM kids
      INNER JOIN
      (SELECT id FROM kids
      GROUP BY id
      HAVING COUNT(*) = 10) AS t USING(id);
```

This is considerably faster than the previous query.

Subqueries (cont'd)

Suppose we want to find all information about the observation with maximum weight:

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View

```
SELECT * FROM kids
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     (SELECT MAX(weight) FROM kids);
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A similar thing can be done when there are grouping variables:

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View

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Subqueries can be used to find the correct information:

View

```
SELECT * FROM kids
     WHERE weight =
     (SELECT MAX(weight) FROM kids);
```

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

View

```
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;
```

Making Tables from Queries

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```
DROP TABLE young;
```

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 |
+------+------+------+----------------------------------+----------------+
5 rows in set (0.03 sec)
```

SELECT with multiple tables

Produce a list of album titles along with artist:

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View

```
SELECT a.title,r.name
      FROM album AS a, artist AS r
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Find the sum of the times on each album:

View

```
SELECT SUM(time) as duration
     FROM track GROUP BY alid
     ORDER BY duration DESC;
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View

```
SELECT SUM(time) as duration
     FROM track GROUP BY alid
     ORDER BY duration DESC;
```

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:

SELECT with multiple tables(cont'd)

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View

```
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;
```

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:

View

```
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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- 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];
     $aartist{$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$artist{$aartist{$salbum[$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)
```

Return

```
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)
```

Return

```
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)
```

◂ Return

```
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)
```

Return

```
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)
```

Return

```
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)
```

Return

```
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)
```

Return

```
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)
```

Return

```
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)
```

Return

```
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)
```

◂ Return

```
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 |
                    . . . . .
| 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 (11.89 sec)
```

Return

```
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)
```

Return

```
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)
```

Return

```
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)
```

Return

```
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)
```

Return

```
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)
```

Return