## Normalization

You are given the following file of campaign contribution data which is a sample taken from the CA campaign for president in 2016. We are interested in fields for candidate name, contributor, contribution amount and date. We are not interested in the last 7 fields.

```
CREATE TABLE campaign
(
  cmte_id      varchar(12),      // campaign id
  cand_id      varchar(12),      // candidate id
  cand_nm      varchar(50),      // candidate name
  contbr_nm         varchar(50), // contributor name
  contbr_city       varchar(40), // contributor city
  contbr_st         varchar(40), // contributor state
  contbr_zip        varchar(20), // contributor zipcode
  contbr_employer   varchar(60), // contributor employer
  contbr_occupation varchar(40), // contributor occupation
  contb_receipt_amt numeric(8,2), // contribution amount
  contb_receipt_dt  varchar(20), // contribution date
  receipt_desc      varchar(255),
  memo_cd      varchar(20),
  memo_text    varchar(255),
  form_tp      varchar(20),
  file_num     varchar(20),
  tran_id      varchar(20),
  election_tp  varchar(20)
);
```

We want to normalize this data by splitting it into 3 tables for candidate, contributor and contribution.

Run the sql script file campaign-CA-2016.sql, which creates a campaign database with a campaign table. Check that there are 180,478 rows in the table by doing a count(*) query.

1. Code create statements for the 3 normalized tables candidate, contributor and contribution. Table candidate should have a primary key of cand_id. Contributor and contribution tables should have a surrogate key of int type defined as autoincrement. Contribution table should have columns for cand_id and contbr_id. But do not define these columns as foreign keys constraints for now. Include your create table statement here.

**CREATE TABLE candidate (**

**cand_id VARCHAR(20) NOT NULL,**

**cand_nm VARCHAR(50),**

**PRIMARY KEY(cand_id));**

```
CREATE TABLE contributor (
contbr_id INT NOT NULL AUTO_INCREMENT PRIMARY KEY,
contbr_nm VARCHAR(50),
contbr_city VARCHAR(40),
contbr_st VARCHAR(40),
contbr_zip VARCHAR(20),
contbr_employer VARCHAR(60),
contbr_occupation VARCHAR(40));

CREATE TABLE contribution (
contb_id INT NOT NULL AUTO_INCREMENT PRIMARY KEY,
contb_receipt_amt NUMERIC(8,2),
contb_receipt_dt VARCHAR(20),
cand_id VARCHAR(20),
contbr_id INT);
```

Create an index on contributor name.

```
create index contributor_nm on contributor(contbr_nm);
```

2. Code 3 insert statements using subselect (read "Inserting from a Query" page 185 in textbook) to select data from the campaign table and insert it into the normalized tables. You should have 22 rows in the candidate table, 61,250 rows in the contributor table, and 180,478 rows in the contribution table. Include your 3 insert statements here.

```
INSERT INTO candidate
SELECT DISTINCT ca.cand_id, ca.cand_nm
FROM campaign ca;

INSERT INTO contributor(contbr_nm, contbr_city, contbr_st, contbr_zip, contbr_employer,
contbr_occupation)
```

```
SELECT DISTINCT ca.contbr_nm, ca.contbr_city, ca.contbr_st, ca.contbr_zip,
ca.contbr_employer, ca.contbr_occupation

FROM campaign ca;


INSERT INTO contribution(contb_receipt_amt, contb_receipt_dt, cand_id, contbr_id)

SELECT ca.contb_receipt_amt, ca.contb_receipt_dt, c.cand_id, cr.contbr_id

FROM campaign ca

INNER JOIN candidate c ON ca.cand_id=c.cand_id

INNER JOIN contributor cr ON ca.contbr_nm=cr.contbr_nm

    AND ca.contbr_st=cr.contbr_st AND ca.contbr_city=cr.contbr_city

    AND ca.contbr_zip=cr.contbr_zip AND ca.contbr_occupation=cr.contbr_occupation

    AND ca.contbr_employer=cr.contbr_employer;
```

3. Alter the contribution table to add foreign key constraints for columns cand_id and contrbr_id. Include your alter table statement here.

```
ALTER TABLE contribution

ADD CONSTRAINT fk_contb_candidate

    FOREIGN KEY (cand_id) REFERENCES candidate(cand_id),

ADD CONSTRAINT fk_contb_contbr

    FOREIGN KEY (contbr_id) REFERENCES contributor(contbr_id);
```

4. Create a view named “vcampaign” that is a join of the 3 normalized tables and has columns `cand_id, cand_nm, contbr_nm, contbr_city, contbr_st, contbr_zip, contbr_employer, contbr_occupation, contb_receipt_amt, contb_receipt_dt`

5.

```
CREATE VIEW vcampaign AS
SELECT ca.cand_id, ca.cand_nm, cr.contbr_nm, cr.contbr_city, cr.contbr_st, cr.contbr_zip,
cr.contbr_employer, cr.contbr_occupation, co.contb_receipt_amt, co.contb_receipt_dt
FROM contributor cr
INNER JOIN contribution co ON cr.contbr_id=co.contbr_id
INNER JOIN candidate ca ON co.cand_id=ca.cand_id;
```

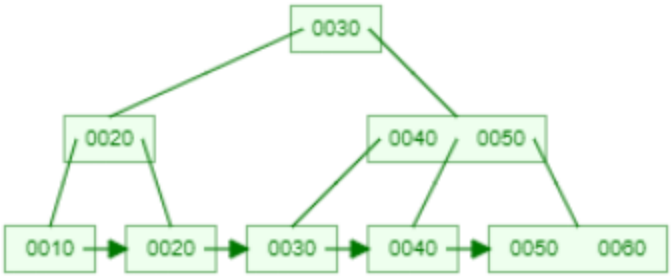
Do a count(*) query using the view and verify there is count of 180,478 rows.

**SELECT COUNT(*) FROM vcampaign;**

## B+ Tree Visualization Exercises

Use the B+ tree simulator at https://www.cs.usfca.edu/~galles/visualization/BPlusTree.html

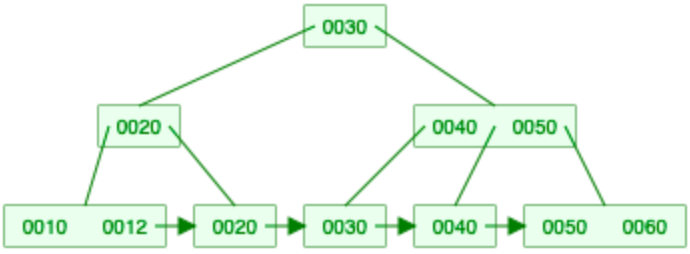
- Set MAX DEGREE = 3  Max Degree is the max number of pointers in an internal (not leaf) node. The max number of values in a node is one less than max degree.  MAX DEGREE is similar to what we called in lecture FAN OUT. In the simulator we use a small value for MAX DEGREE, but remember in real databases, the FAN OUT is typically on the order of 100-200.
- Insert the values (one at a time): 10 20 30 40 50 60
- Your diagram should look like




In the diagram above, the leaf node with 0050 0060 is full, as is the parent node 0040 0050.  Other nodes are not full.

A B+ tree is efficient for doing key lookup and range queries.  However, when new entries have to be inserted or removed from the index due to SQL insert, update or delete statements, there are multiple reads/writes that must be done to maintain the tree nodes in the correct order and the leaf nodes in the correct linked list order.

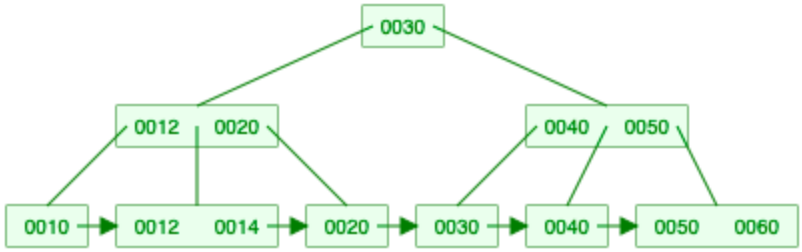
6. Do an insert of key value 12.  Draw or embed a screenshot of the updated index.



7. How many nodes were either created or modified for the insert of 12?

**The node holding 0010 is modified for the insert of 12.**

8. Now do an insert for a key value 14. Show an updated diagram.

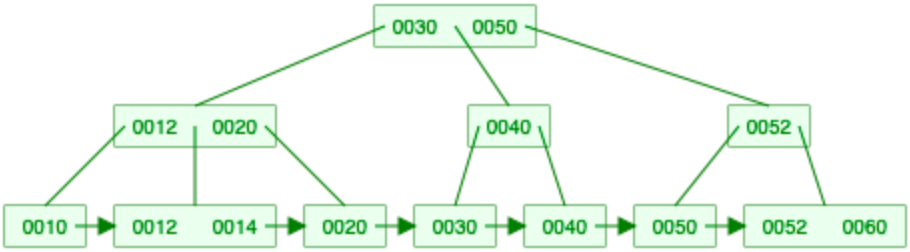



9. How many nodes were either created or modified for an insert of 14?

**The node holding 0020 and the leaf node with 0010 and 0012 were modified.**

- **0010 and 0012 were separated and the leaf node became 0012 and 0014.**
- **The node 0020 gained a 0012 to create that leaf node of 0012 and 0020.**

10. Do an insert of key value 52 and show an updated diagram.




11. How many nodes were either created or modified for an insert of 52?

**5 nodes were modified for an insert of 52.**

**The node 0030 on top gained 0050**

**The leaf node 0040 and 0050 were split up and separated**

**The leaf node 0050 and 0060 is separated and the 0050 node is created separately from the new leaf node of 0052 and 0060.**

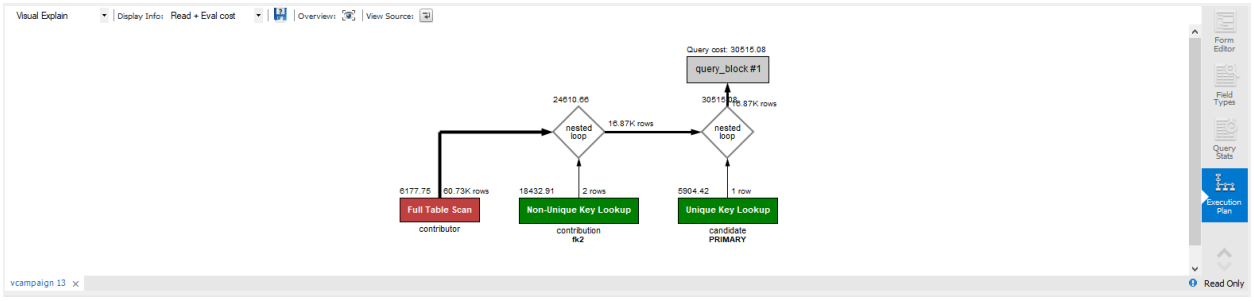
Conclusion: insert, delete of a B tree index may involve several reads/writes.

## Query Plan Exercises

Perform the query

```
select * from vcampaign where contbr_zip = '93933';
```

Then examine the query plan by scrolling down the list of icon the right side of the result panel and selecting the “Execution Plan”.




The query plan depicts how a table is accessed: either by reading the entire table (Full Table Scan Red Rectangle) or using an index (Green Rectangle with index name below the box). An index is unique if it is the primary key index or an index defined on a column that is defined as unique. The query plan also depicts how joins are done. In the diagram a scan of the contributor table is done and each row is joined first to rows in the contribution table by looking up contbr_id using index fk2, and then join with row from candidate table looking cand_id using the primary key index. By default, MySQL creates index on the primary key column(s) and on each foreign key column(s).

Create an index on contbr_zip column in the contributor table

```
create index zip on contributor(contbr_zip);
```

Redo the query and examine the execution plan.

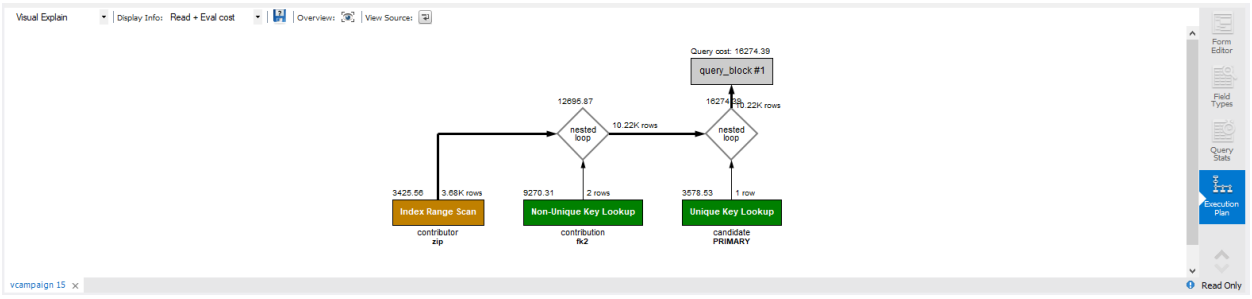
```
select * from vcampaign where contbr_zip = '93933';
```

12. Is the new index being used? Explain in your words the execution plan.

**Yes, the new index is being used in the execution plan. In the diagram, the index zip is being checked and joined with the foreign key that connects contributor to contribution. From here, the candidate table is joined with its primary key.**

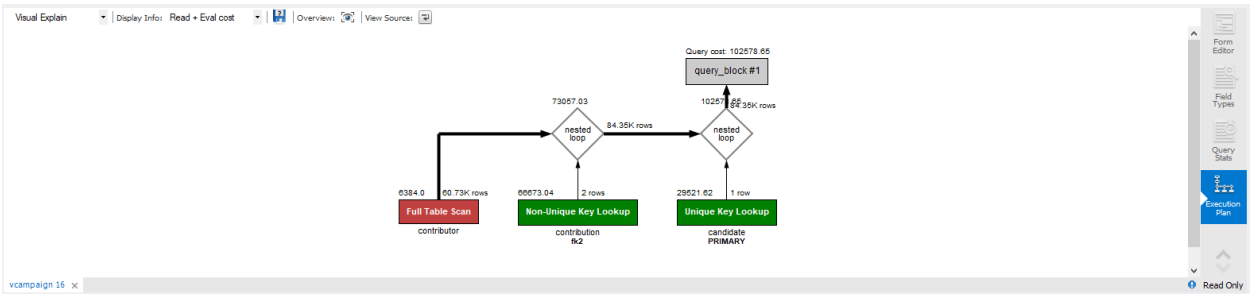
Do a query on vcampaign where contbr_zip is between 93001 and 93599 (the zip codes in LA area)

The query plan is




showing that range scan is done using index on zip.

Change the query to zip between 00001 and 93599. The execution plan is




The zip index is not being used. Why? The MySQL query optimizer realizes that it will be faster to scan all row in contributor for zip between 00001 and 93599 rather than use index. An index is used to search when the result is expected to be a few rows. If many rows are expected, it is faster to just scan the whole table. How does the optimizer know when to use an index and when to scan ? There are statistics kept about each table and each column: the number of rows, the max and min values for each column, the number of distinct values for a column. Pretty clever!

## Concurrency Exercises

### Exclusive locking

Observe the behavior of exclusive locking when two concurrent transactions attempt to update the same row.

For this exercise you will need two connections in the workbench that have auto commit turned off.

- Open a connection
  - menu  Query  uncheck the item "Auto Commit Transactions"
- Open a second connection.
  - To do this use the tab with the "Home" on it to return to the connection page and then open the second connection.
  - menu  Query  uncheck the item "Auto Commit Transactions"

| Instance 1 | Instance 2 | Comments |
|---|---|---|
| | use zagimore;<br>set autocommit = 0;<br>select * from product where productid='1X1';<br>What is the price returned?<br>**100.00** | |
| use zagimore;<br>set autocommit = 0;<br>select * from product where productid='1X1';<br>What is the price returned?<br>**100.00** | | |
| | update product set productprice=productprice+100 where productid='1X1';<br>select * from product where productid='1X1';<br>What is the price returned?<br>**200.00** | Instance 2 has updated the price but has not committed it. Other clients cannot see uncommitted data. |
| select * from product where productid='1X1';<br>What is the price returned?<br>**100.00** | | Since the update by Instance 2 has not been committed and Instance 1 does not see the update and instead see the previously committed value. |
| update product set productprice=productprice+100 where productid='1X1';<br>select * from product where productid='1X1';<br>**Notice the call is Running…** | | |
| | commit; | |
| The call now completes.<br>select * from product where productid='1X1';<br>What is the price returned? **300.00** | | |
| commit; | | |

**Inconsistent Writes**

Alice and Bob are both on duty. One of them may go off duty assuming that they first check that the other is still on duty.

- Open two connections as in the last problem.
- On both connections menu Query uncheck the item "Auto Commit Transactions"
- Create the following table and 2 rows.

```
create table duty (name char(5) primary key, status char(3));
insert into duty values ('Alice' ,'on'), ('Bob', 'on');
commit;
```

| **Instance 1 "Alice"** | **Instance 2 "Bob"** | |
|---|---|---|
| set autocommit=0;<br>select * from duty; | | Alice checks that Bob is on duty. So she updates her status to off duty. |
| update duty<br>set status='off'<br>where name='Alice' | | |
| | set autocommit=0;<br>select * from duty; | Bob checks that Alice is on duty. So he updates his status to off duty. |
| | update duty<br>set status='off'<br>where name='Bob' | |
| commit; | | |
| | commit; | |

What has just happened? Bob and Alice have both gone off duty even though each one checked that the other was on duty. Isn't one of reasons to use a database is for data integrity? But how does the database this to happen? But you must understand how a database system works together with the application to guarantee data integrity.

Databases do exclusive locking on updates to the same row. But in this situation the updates are to two different based data read from two different rows.

13. Based on lecture material there are 2 ways to fix this problem. Pick one and test it out. How did you fix the problem?

    a. **In order to fix this problem, we can serialize each transaction. By doing this, we can lock all of the records until they are read, so before Alice checks if Bob is on duty, only Bob will be able to check and set his status. This will avoid the inconsistent and concurrent reads and limit overwriting one another. The only**

**disadvantage is that there may be longer waits as only one transaction is done at a time.**

## Other Exercises

14. Consider this situation: you try to get cash at an ATM, but the ATM fails after updating your account and committing, but just before cash is dispensed. As a system designer, how do you cope with the situation that the money has been debited from the account and committed but the cash was unable to be dispensed? [ hint: what do you think "compensating transaction" means? do a google search.]

**As a system designer, in order to deal with the situation that the money was unable to be dispensed due to a crash in the system, I would have to refer to the compensating transaction process. By doing this, I will be able to view every operation that was taken and use this to back track and restore the data that was lost while also not messing up any other current transactions.**

15. Consider this situation: you try to buy an airline ticket at a web site. The transaction commits on the server, but crashes just before the message confirming the reservation is sent to the client. As a system designer, how would you cope with the situation of a reservation was made and committed in the database, but the confirmation message was never received by the client?

**In this situation, we could still use the process of compensating transaction since we can undo and reverse the operations up until the successful commits. Since in this case the transaction does commit and crashes only before that message that was supposed to output to the user, it will re run while considering the concurrent transactions, and restore so that message is eventually displayed.**

**What to submit for this assignment?**

Edit this file with your answers to the 14 questions. Submit your answers as a PDF file to the Canvas assignment.