Multiway Join - Usage Guide

Information

`Student Name: Avinash Sorab | DAWG Tag: siu854709544 | Professor: Dr. Wen-Chi Hou`

System Requirements

The project was developed and tested on a laptop that had

- **RAM**: 4GB
- **HDD**: 320GB
- **Processor**: Core i5
- **OS**: Windows 10 Pro

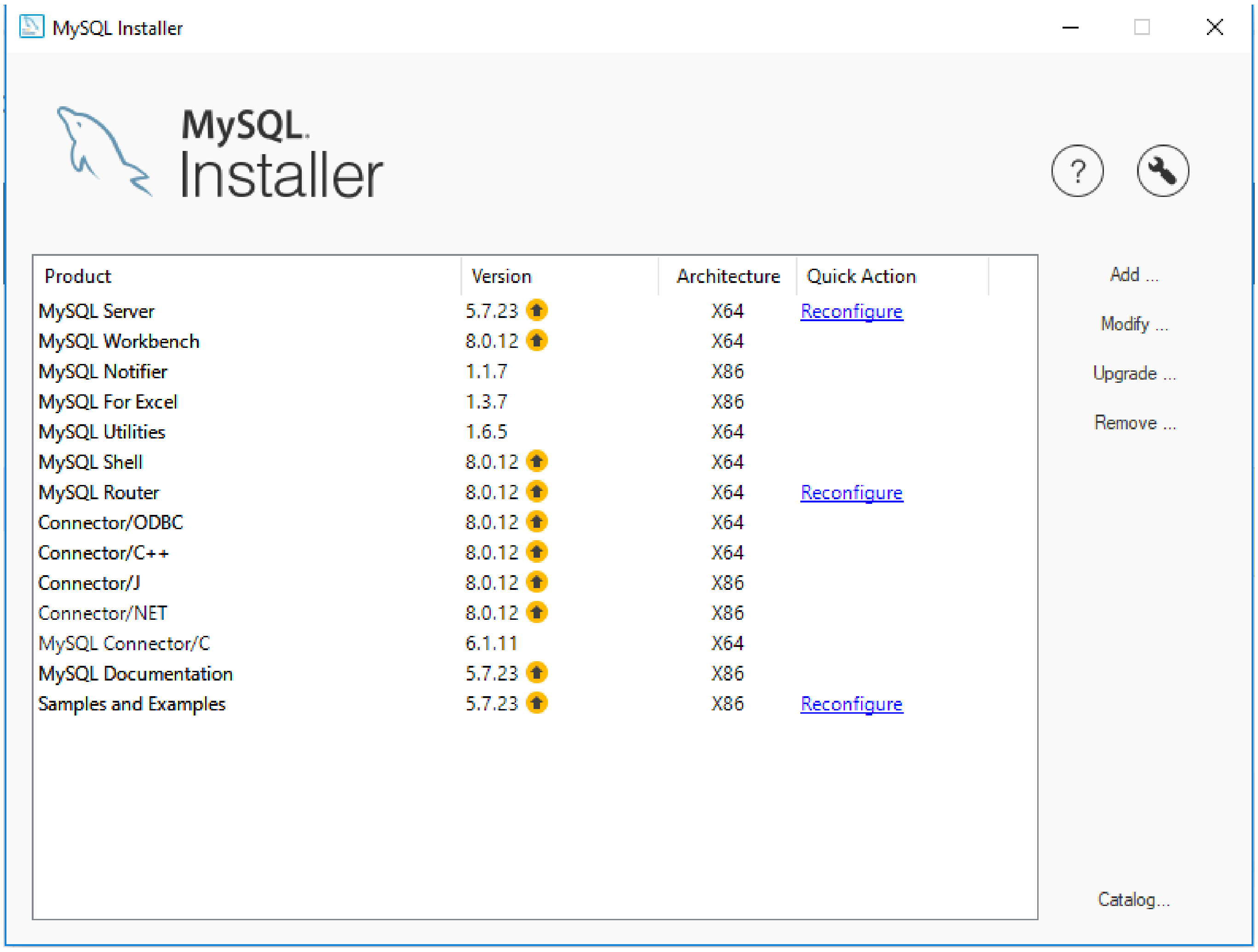
Software Requirements

- **Visual Studio Code** - A light weight code editor that has command line integrated to it. Easy to write code, debugging as it enables us to install intellisense.
  https://code.visualstudio.com/

- **MySQL Installer 5.7.23** (Community Version)
  https://downloads.mysql.com/archives/installer/

Choose the product version from latest to 5.7.23

It'll let you install all the below softwares



Product	Version	Architecture	Quick Action
MySQL Server	5.7.23	X64	Reconfigure
MySQL Workbench	8.0.12	X64	
MySQL Notifier	1.1.7	X86	
MySQL For Excel	1.3.7	X86	
MySQL Utilities	1.6.5	X64	
MySQL Shell	8.0.12	X64	
MySQL Router	8.0.12	X64	Reconfigure
Connector/ODBC	8.0.12	X64	
Connector/C++	8.0.12	X64	
Connector/J	8.0.12	X86	
Connector/NET	8.0.12	X86	
MySQL Connector/C	6.1.11	X64	
MySQL Documentation	5.7.23	X86	
Samples and Examples	5.7.23	X86	Reconfigure

- Make sure you've all these softwares installed below
  Microsoft Visual C++ 2010 Redistributable (x86)
  Microsoft Visual C++ 2010 Redistributable (x64)
  Microsoft Visual C++ 2013 Redistributable (x86)
  Microsoft Visual C++ 2013 Redistributable (x64)
  Microsoft Visual C++ 2015 Redistributable (x86)
  Microsoft Visual C++ 2015 Redistributable (x64)

  to support all the softwares present in the installer.

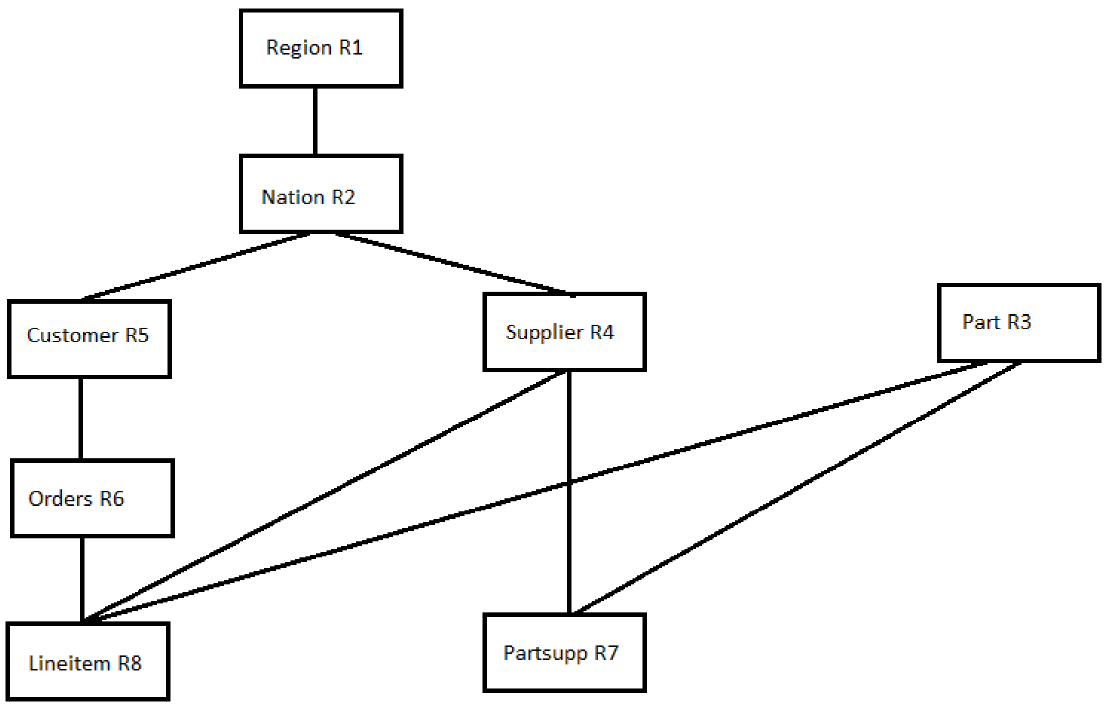
- **Python 3.7.0**
  https://www.python.org/

- **Git 2.19.2.windows.1**
  https://git-scm.com/download/win

Algorithm

Relation Overview

The TPCH benchmark relation used for this is as below



Aligned Tables

There are 11 aligned tables possible in this

- ALIGNED_REGION (R1)
- ALIGNED_NATION (R1 -> R2)
- ALIGNED_PART (R3)
- ALIGNED_SUPPLIER (R2 -> R4)
- ALIGNED_CUSTOMER (R2 -> R5)
- ALIGNED_ORDERS (R5 -> R6)
- ALIGNED_PARTSUPP (R4 -> R7, R3 -> R7)
- ALIGNED_LINEITEM (R4 -> R8, R3 -> R8)

Implementation

- Create aligned tables
- Allow the user to select the relation he wants to create join on
- Ex: if the user selects REGION -> NATION -> SUPPLIER,
  for every single tuple of region, select all the nations and following suppliers which belong to that region (DFS)
- Send it through the log_linear_result function that compares the self_sid of one table with the parent_sid of another table,
- In the below example it compares r1_sid from aligned_region table with r1_sid from aligned_nation table and r2_sid from aligned_nation is compared with r2_sid in aligned_supplier, if they are equal, they'll be logged into a file

```
for tuple1 in aligned_region:
    for tuple2 in aligned_nation:
        for tuple3 in aligned_supplier:
            if(tuple1[1] == tuple2[0] && tuple2[1] == tuple3[0]):
                log_to_file()
```

- For Divergent Graphs, such as REGION -> NATION -> (SUPPLIER, CUSTOMER), Identify the shortest branch,
- Implement linear join for the shortest branch, then implement linear join for another branch and store the result
- Output the crossproduct of both the result.

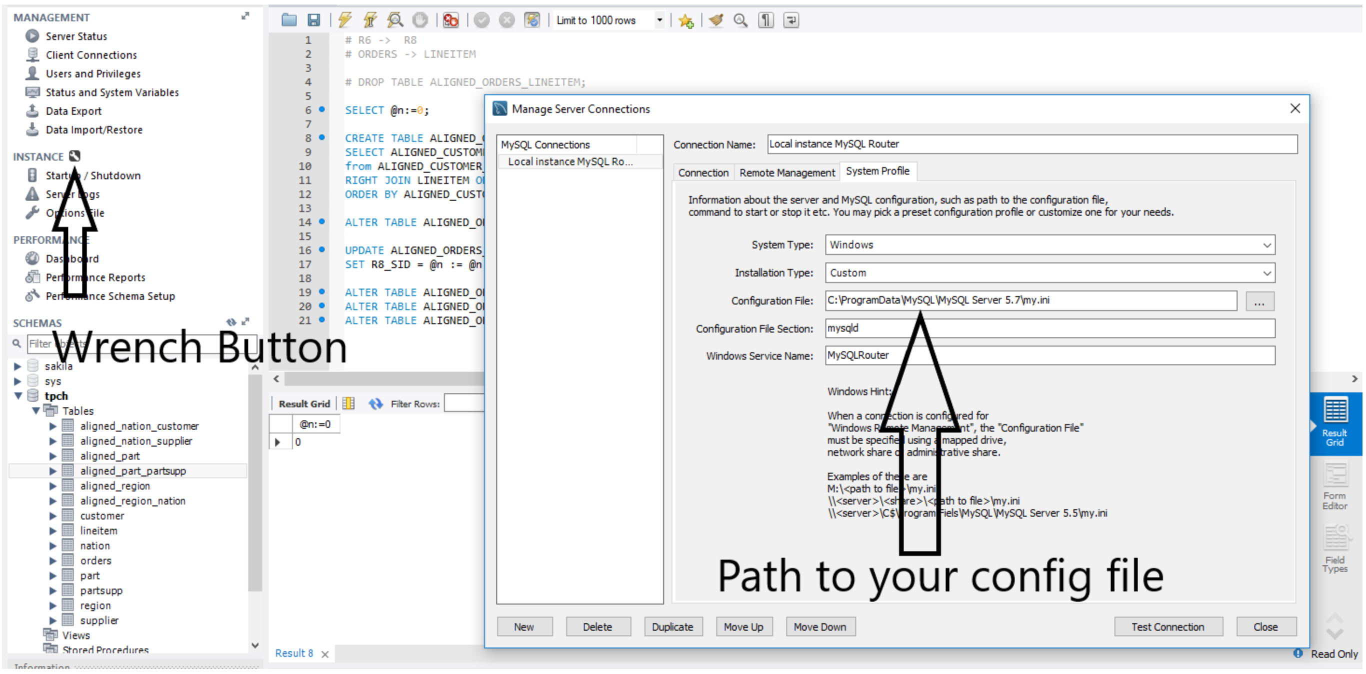
Project Setup

MySQL

- Open MySQL WorkBench

- From the Main Menu -> Server -> Options File, if the file doesn't load then click on the Wrench button beside Instance in the left pane

- A window pops up



```
# R6 ->  R8
# ORDERS -> LINEITEM

# DROP TABLE ALIGNED_ORDERS_LINEITEM;

SELECT @n:=0;

CREATE TABLE ALIGNED_
SELECT ALIGNED_CUSTOM
from ALIGNED_CUSTOMER_
RIGHT JOIN LINEITEM O
ORDER BY ALIGNED_CUST

ALTER TABLE ALIGNED_O

UPDATE ALIGNED_ORDERS_
SET R8_SID = @n := @n

ALTER TABLE ALIGNED_O
ALTER TABLE ALIGNED_O
ALTER TABLE ALIGNED_O
```

@n:=0
0

Manage Server Connections

MySQL Connections: Local instance MySQL Ro...

Connection Name: Local instance MySQL Router

Connection | Remote Management | System Profile

Information about the server and MySQL configuration, such as path to the configuration file, command to start or stop it etc. You may pick a preset configuration profile or customize one for your needs.

System Type: Windows
Installation Type: Custom
Configuration File: C:\ProgramData\MySQL\MySQL Server 5.7\my.ini
Configuration File Section: mysqld
Windows Service Name: MySQLRouter

Windows Hint:

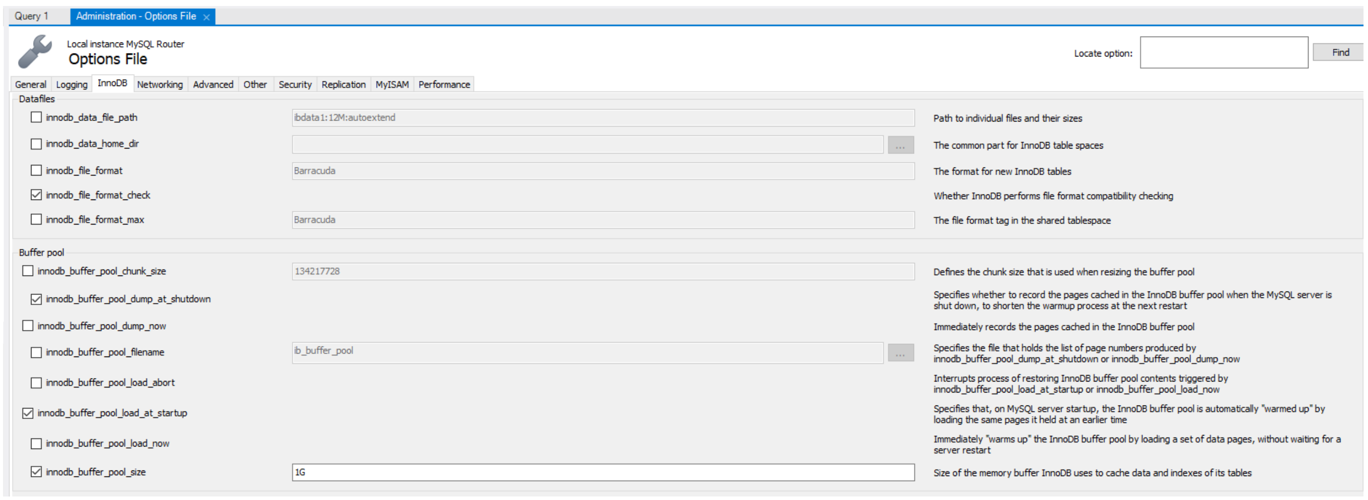
When a connection is configured for "Windows Remote Management", the "Configuration File" must be specified using a mapped drive, network share or administrative share.

Examples of these are
M:\<path to file>\my.ini
\\<server>\<share>\<path to file>\my.ini
\\<server>\C$\Program Fiels\MySQL\MySQL Server 5.5\my.ini

New | Delete | Duplicate | Move Up | Move Down | Test Connection | Close

After this you should be able to open the options file

- Increase the InnoDB Buffer Pool Size from 8M to 1G by going to Main Menu -> Server -> Options File -> InnoDB tab -> Check innodb_buffer_pool_size and change it to 1G



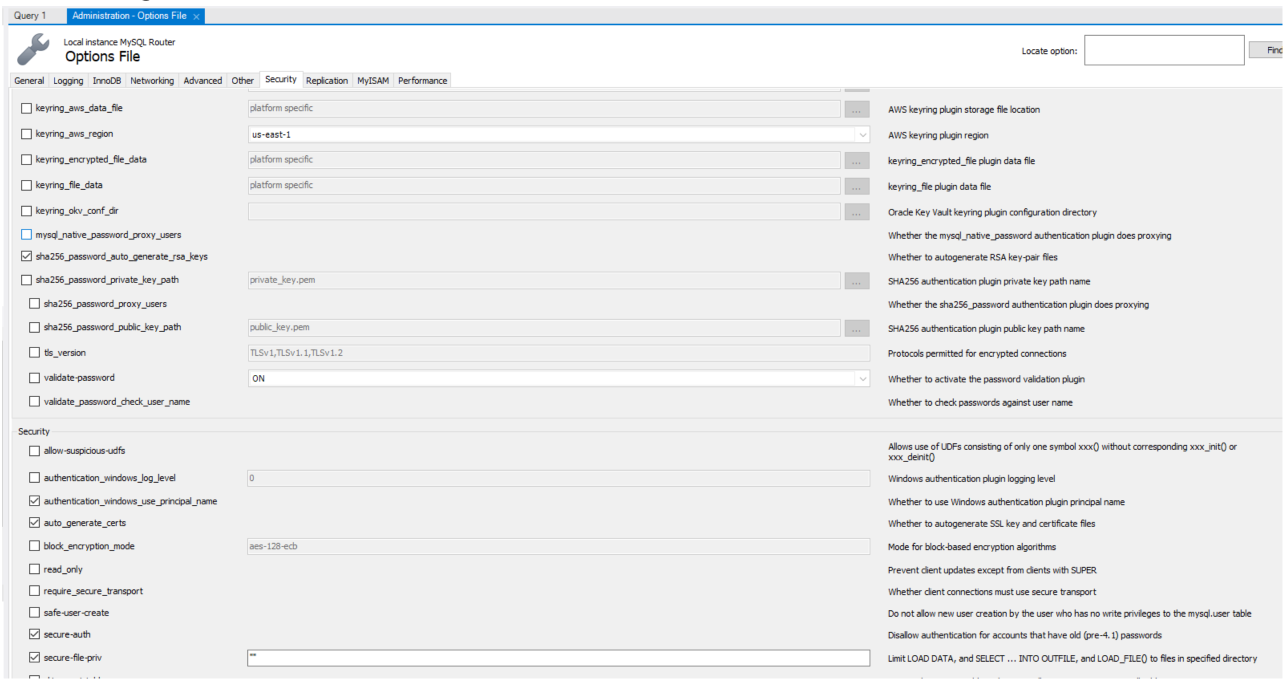
Datafiles

☐	innodb_data_file_path	ibdata1:12M:autoextend	Path to individual files and their sizes
☐	innodb_data_home_dir		The common part for InnoDB table spaces
☐	innodb_file_format	Barracuda	The format for new InnoDB tables
✓	innodb_file_format_check		Whether InnoDB performs file format compatibility checking
☐	innodb_file_format_max	Barracuda	The file format tag in the shared tablespace

Buffer pool

☐	innodb_buffer_pool_chunk_size	134217728	Defines the chunk size that is used when resizing the buffer pool
✓	innodb_buffer_pool_dump_at_shutdown		Specifies whether to record the pages cached in the InnoDB buffer pool when the MySQL server is shut down, to shorten the warmup process at the next restart
☐	innodb_buffer_pool_dump_now		Immediately records the pages cached in the InnoDB buffer pool
☐	innodb_buffer_pool_filename	ib_buffer_pool	Specifies the file that holds the list of page numbers produced by innodb_buffer_pool_dump_at_shutdown or innodb_buffer_pool_dump_now
☐	innodb_buffer_pool_load_abort		Interrupts process of restoring InnoDB buffer pool contents triggered by innodb_buffer_pool_load_at_startup or innodb_buffer_pool_load_now
✓	innodb_buffer_pool_load_at_startup		Specifies that, on MySQL server startup, the InnoDB buffer pool is automatically "warmed up" by loading the same pages it held at an earlier time
☐	innodb_buffer_pool_load_now		Immediately "warms up" the InnoDB buffer pool by loading a set of data pages, without waiting for a server restart
✓	innodb_buffer_pool_size	1G	Size of the memory buffer InnoDB uses to cache data and indexes of its tables

- Go to Security Tab, scroll down till you find secure-file-priv, check it if it's unchecked and set it to "" (blank string)



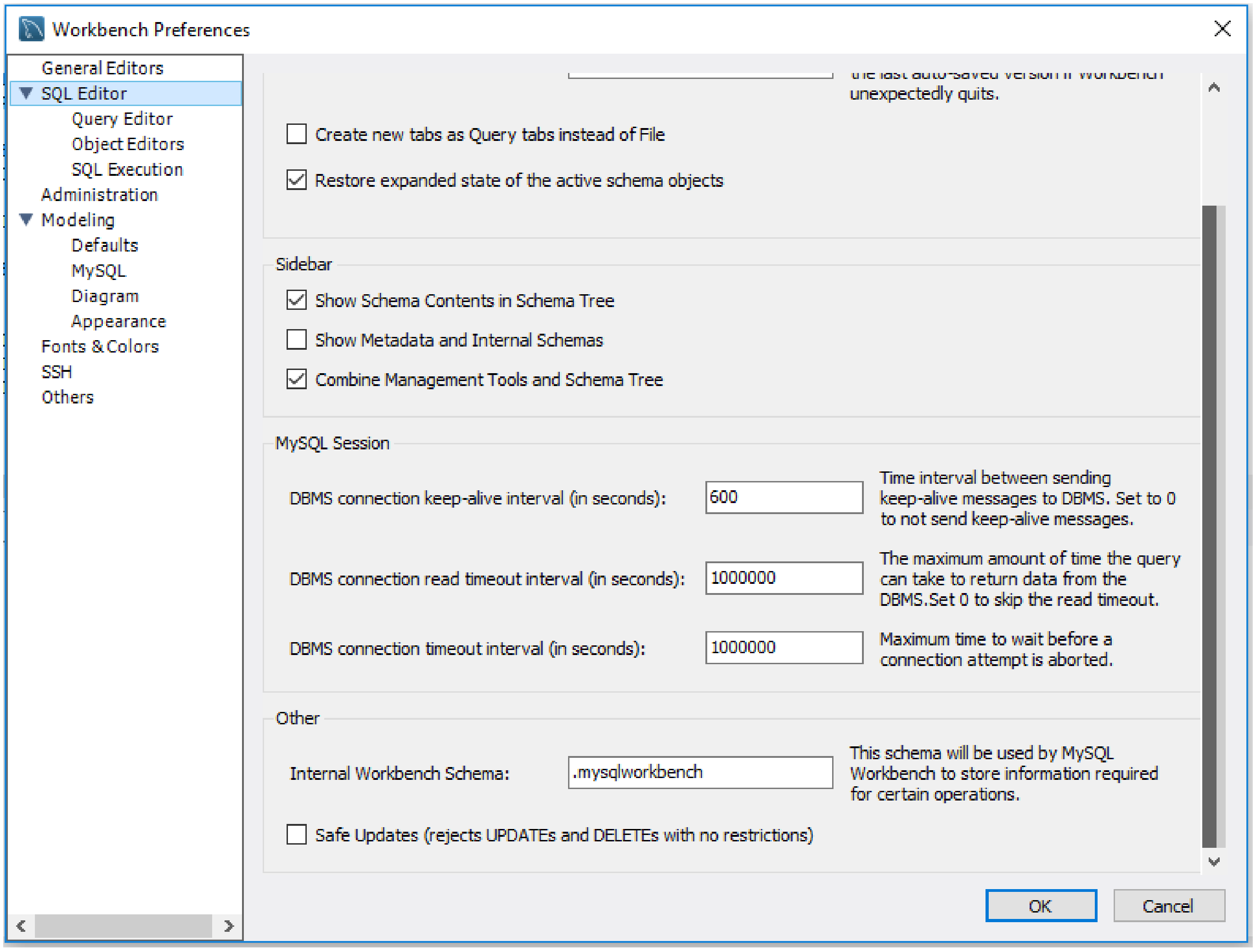
☐	keyring_aws_data_file	platform specific	AWS keyring plugin storage file location
☐	keyring_aws_region	us-east-1	AWS keyring plugin region
☐	keyring_encrypted_file_data	platform specific	keyring_encrypted_file plugin data file
☐	keyring_file_data	platform specific	keyring_file plugin data file
☐	keyring_okv_conf_dir		Oracle Key Vault keyring plugin configuration directory
☐	mysql_native_password_proxy_users		Whether the mysql_native_password authentication plugin does proxying
✓	sha256_password_auto_generate_rsa_keys		Whether to autogenerate RSA key-pair files
☐	sha256_password_private_key_path	private_key.pem	SHA256 authentication plugin private key path name
☐	sha256_password_proxy_users		Whether the sha256_password authentication plugin does proxying
☐	sha256_password_public_key_path	public_key.pem	SHA256 authentication plugin public key path name
☐	tls_version	TLSv1,TLSv1.1,TLSv1.2	Protocols permitted for encrypted connections
☐	validate-password	ON	Whether to activate the password validation plugin
☐	validate_password_check_user_name		Whether to check passwords against user name

Security

☐	allow-suspicious-udfs		Allows use of UDFs consisting of only one symbol xxx() without corresponding xxx_init() or xxx_deinit()
☐	authentication_windows_log_level	0	Windows authentication plugin logging level
✓	authentication_windows_use_principal_name		Whether to use Windows authentication plugin principal name
✓	auto_generate_certs		Whether to autogenerate SSL key and certificate files
☐	block_encryption_mode	aes-128-ecb	Mode for block-based encryption algorithms
☐	read_only		Prevent client updates except from clients with SUPER
☐	require_secure_transport		Whether client connections must use secure transport
☐	safe-user-create		Do not allow new user creation by the user who has no write privileges to the mysql.user table
✓	secure-auth		Disallow authentication for accounts that have old (pre-4.1) passwords
✓	secure-file-priv	""	Limit LOAD DATA, and SELECT ... INTO OUTFILE, and LOAD_FILE() to files in specified directory

- Click on Apply and then close the window

- Disable the Safe Updates by going to Edit -> Preferences -> SQL Editor and scroll down and you'll find an option, uncheck it.



unexpectedly quits.

☐ Create new tabs as Query tabs instead of File

☑ Restore expanded state of the active schema objects

Sidebar

☑ Show Schema Contents in Schema Tree

☐ Show Metadata and Internal Schemas

☑ Combine Management Tools and Schema Tree

MySQL Session

DBMS connection keep-alive interval (in seconds):	600	Time interval between sending keep-alive messages to DBMS. Set to 0 to not send keep-alive messages.
DBMS connection read timeout interval (in seconds):	1000000	The maximum amount of time the query can take to return data from the DBMS.Set 0 to skip the read timeout.
DBMS connection timeout interval (in seconds):	1000000	Maximum time to wait before a connection attempt is aborted.

Other

Internal Workbench Schema:	.mysqlworkbench	This schema will be used by MySQL Workbench to store information required for certain operations.

☐ Safe Updates (rejects UPDATEs and DELETEs with no restrictions)

Creating the schema and tables

- Paste the below code to create schema and tables

```
# CREATE SCHEMA

CREATE SCHEMA `TPCH`;

# CREATE TABLES

#R1
CREATE TABLE region (
        R_REGIONKEY     int PRIMARY KEY,
        R_NAME          CHAR(25),
        R_COMMENT       VARCHAR(152)
);

#R2
CREATE TABLE nation (
        N_NATIONKEY             int PRIMARY KEY,
        N_NAME                  CHAR(25),
        N_REGIONKEY             BIGINT NOT NULL,  -- references R_REGIONKEY
        N_COMMENT               VARCHAR(152)
);
```

```
#R3
CREATE TABLE part (

        P_PARTKEY               int PRIMARY KEY,
        P_NAME                  VARCHAR(55),
        P_MFGR                  CHAR(25),
        P_BRAND                 CHAR(10),
        P_TYPE                  VARCHAR(25),
        P_SIZE                  INTEGER,
        P_CONTAINER             CHAR(10),
        P_RETAILPRICE   DECIMAL,
        P_COMMENT               VARCHAR(23)
);

#R4
CREATE TABLE supplier (
        S_SUPPKEY               int PRIMARY KEY,
        S_NAME                  CHAR(25),
        S_ADDRESS               VARCHAR(40),
        S_NATIONKEY             BIGINT NOT NULL, -- references N_NATIONKEY
        S_PHONE                 CHAR(15),
        S_ACCTBAL               DECIMAL,
        S_COMMENT               VARCHAR(101)
);

#R5
CREATE TABLE customer (
        C_CUSTKEY               int PRIMARY KEY,
        C_NAME                  VARCHAR(25),
        C_ADDRESS               VARCHAR(40),
        C_NATIONKEY             BIGINT NOT NULL, -- references N_NATIONKEY
        C_PHONE                 CHAR(15),
        C_ACCTBAL               DECIMAL,
        C_MKTSEGMENT    CHAR(10),
        C_COMMENT               VARCHAR(117)
);

#R6
CREATE TABLE orders (
        O_ORDERKEY              int PRIMARY KEY,
        O_CUSTKEY               BIGINT NOT NULL, -- references C_CUSTKEY
        O_ORDERSTATUS   CHAR(1),
        O_TOTALPRICE    DECIMAL,
        O_ORDERDATE             DATE,
        O_ORDERPRIORITY CHAR(15),
        O_CLERK                 CHAR(15),
        O_SHIPPRIORITY  INTEGER,
        O_COMMENT               VARCHAR(79)
);

#R7
CREATE TABLE partsupp (
        PS_PARTKEY              BIGINT NOT NULL, -- references P_PARTKEY
        PS_SUPPKEY              BIGINT NOT NULL, -- references S_SUPPKEY
        PS_AVAILQTY             INTEGER,
        PS_SUPPLYCOST   DECIMAL,
        PS_COMMENT              VARCHAR(199),
        PRIMARY KEY (PS_PARTKEY, PS_SUPPKEY)
);

#R8
CREATE TABLE lineitem (
        L_ORDERKEY              BIGINT NOT NULL, -- references O_ORDERKEY
        L_PARTKEY               BIGINT NOT NULL, -- references P_PARTKEY (compound
fk to PARTSUPP)
        L_SUPPKEY               BIGINT NOT NULL, -- references S_SUPPKEY (compound
fk to PARTSUPP)
        L_LINENUMBER    INTEGER,
        L_QUANTITY              DECIMAL,
        L_EXTENDEDPRICE DECIMAL,
        L_DISCOUNT              DECIMAL,
        L_TAX                   DECIMAL,
        L_RETURNFLAG    CHAR(1),
        L_LINESTATUS    CHAR(1),
        L_SHIPDATE              DATE,
        L_COMMITDATE    DATE,
        L_RECEIPTDATE   DATE,
        L_SHIPINSTRUCT  CHAR(25),
        L_SHIPMODE              CHAR(10),
        L_COMMENT               VARCHAR(44),
        PRIMARY KEY (L_ORDERKEY, L_LINENUMBER)
);
```

Loading DATA into Tables

```
# TO LOAD THE DATA FROM TPCH TO WORKBENCH

LOAD DATA CONCURRENT INFILE 'D:\TPCH_1GB\\region.tbl'
INTO TABLE region
FIELDS TERMINATED BY '|'
LINES TERMINATED BY '\n';

LOAD DATA CONCURRENT INFILE 'D:\TPCH_1GB\\nation.tbl'
INTO TABLE nation
FIELDS TERMINATED BY '|'
LINES TERMINATED BY '\n';

LOAD DATA CONCURRENT INFILE 'D:\TPCH_1GB\\part.tbl'
INTO TABLE part
FIELDS TERMINATED BY '|'
LINES TERMINATED BY '\n';

LOAD DATA CONCURRENT INFILE 'D:\TPCH_1GB\\supplier.tbl'
INTO TABLE supplier
```

```
FIELDS TERMINATED BY '|'
LINES TERMINATED BY '\n';

LOAD DATA CONCURRENT INFILE 'D:\TPCH_1GB\\customer.tbl'
INTO TABLE customer
FIELDS TERMINATED BY '|'
LINES TERMINATED BY '\n';

LOAD DATA CONCURRENT INFILE 'D:\TPCH_1GB\\order.tbl'
INTO TABLE orders
FIELDS TERMINATED BY '|'
LINES TERMINATED BY '\n';

LOAD DATA CONCURRENT INFILE 'D:\TPCH_1GB\\partsupp.tbl'
INTO TABLE partsupp
FIELDS TERMINATED BY '|'
LINES TERMINATED BY '\n';

LOAD DATA CONCURRENT INFILE 'D:\TPCH_1GB\\lineitem.tbl'
INTO TABLE lineitem
FIELDS TERMINATED BY '|'
LINES TERMINATED BY '\n';
```

Creating Aligned Tables

```
# R1
# REGION


# DROP TABLE ALIGNED_REGION;

CREATE TABLE ALIGNED_REGION
SELECT * FROM REGION;

ALTER TABLE ALIGNED_REGION ADD R1_SID
INTEGER PRIMARY KEY AUTO_INCREMENT;





# R1 -> R2
# REGION -> NATION

DROP TABLE ALIGNED_REGION_NATION;

SELECT @n:=0;

CREATE TABLE ALIGNED_REGION_NATION
SELECT ALIGNED_REGION.R1_SID, NATION.*
FROM ALIGNED_REGION
RIGHT JOIN NATION ON ALIGNED_REGION.R_REGIONKEY = NATION.N_REGIONKEY
```

```
ORDER BY ALIGNED_REGION.R1_SID;

ALTER TABLE ALIGNED_REGION_NATION ADD R2_SID INTEGER;

UPDATE ALIGNED_REGION_NATION
SET R2_SID = @n := @n + 1;

ALTER TABLE ALIGNED_REGION_NATION ADD PRIMARY KEY(N_NATIONKEY);
ALTER TABLE ALIGNED_REGION_NATION ADD KEY(R1_SID);
ALTER TABLE ALIGNED_REGION_NATION ADD UNIQUE KEY(R2_SID);




# R2 -> R4
# NATION -> SUPPLIER

DROP TABLE ALIGNED_NATION_SUPPLIER;

SELECT @n:=0;

CREATE TABLE ALIGNED_NATION_SUPPLIER
SELECT ALIGNED_REGION_NATION.R2_SID, SUPPLIER.*
FROM ALIGNED_REGION_NATION
RIGHT JOIN SUPPLIER ON ALIGNED_REGION_NATION.N_NATIONKEY = SUPPLIER.S_NATIONKEY
ORDER BY ALIGNED_REGION_NATION.R2_SID;

ALTER TABLE ALIGNED_NATION_SUPPLIER ADD R4_SID INTEGER;

UPDATE ALIGNED_NATION_SUPPLIER
SET R4_SID = @n := @n + 1;

ALTER TABLE ALIGNED_NATION_SUPPLIER ADD PRIMARY KEY(S_SUPPKEY);
ALTER TABLE ALIGNED_NATION_SUPPLIER  ADD KEY(R2_SID);
ALTER TABLE ALIGNED_NATION_SUPPLIER ADD UNIQUE KEY(R4_SID);




# R2 -> R5
# NATION -> CUSTOMER

DROP TABLE ALIGNED_NATION_CUSTOMER;

SELECT @n:=0;

CREATE TABLE ALIGNED_NATION_CUSTOMER
SELECT ALIGNED_REGION_NATION.R2_SID, CUSTOMER.*
FROM ALIGNED_REGION_NATION
RIGHT JOIN CUSTOMER ON ALIGNED_REGION_NATION.N_NATIONKEY = CUSTOMER.C_NATIONKEY
ORDER BY ALIGNED_REGION_NATION.R2_SID;

ALTER TABLE ALIGNED_NATION_CUSTOMER ADD R5_SID INTEGER;
```

```
UPDATE ALIGNED_NATION_CUSTOMER
SET R5_SID = @n := @n + 1;

ALTER TABLE ALIGNED_NATION_CUSTOMER ADD PRIMARY KEY(C_CUSTKEY);
ALTER TABLE ALIGNED_NATION_CUSTOMER  ADD KEY(R2_SID);
ALTER TABLE ALIGNED_NATION_CUSTOMER ADD UNIQUE KEY(R5_SID);






# R3
# PART

# DROP TABLE ALIGNED_PART;

CREATE TABLE ALIGNED_PART
SELECT * FROM PART;

ALTER TABLE ALIGNED_PART ADD R3_SID
INTEGER PRIMARY KEY AUTO_INCREMENT;






# R3 -> R7
# PART -> PARTSUPP

DROP TABLE ALIGNED_PART_PARTSUPP;

SELECT @n:=0;

CREATE TABLE ALIGNED_PART_PARTSUPP
SELECT ALIGNED_PART.R3_SID, PARTSUPP.*
FROM ALIGNED_PART
RIGHT JOIN PARTSUPP ON ALIGNED_PART.P_PARTKEY = PARTSUPP.PS_PARTKEY
ORDER BY ALIGNED_PART.R3_SID;

ALTER TABLE ALIGNED_PART_PARTSUPP ADD R7_SID INTEGER;

UPDATE ALIGNED_PART_PARTSUPP
SET R7_SID = @n := @n + 1;

ALTER TABLE ALIGNED_PART_PARTSUPP ADD PRIMARY KEY(PS_PARTKEY, PS_SUPPKEY);
ALTER TABLE ALIGNED_PART_PARTSUPP ADD KEY(R3_SID);
ALTER TABLE ALIGNED_PART_PARTSUPP ADD UNIQUE KEY(R7_SID);





# R3 ->  R8
# PART -> LINEITEM
```

```
DROP TABLE ALIGNED_PART_LINEITEM;

SELECT @n:=0;

CREATE TABLE ALIGNED_PART_LINEITEM
SELECT ALIGNED_PART.R3_SID, LINEITEM.*
from ALIGNED_PART
RIGHT JOIN LINEITEM ON ALIGNED_PART.P_PARTKEY = LINEITEM.L_PARTKEY
ORDER BY ALIGNED_PART.R3_SID;

ALTER TABLE ALIGNED_PART_LINEITEM ADD R8_SID INTEGER;

UPDATE ALIGNED_PART_LINEITEM
SET R8_SID = @n := @n + 1;

ALTER TABLE ALIGNED_PART_LINEITEM ADD PRIMARY KEY(L_ORDERKEY, L_LINENUMBER);
ALTER TABLE ALIGNED_PART_LINEITEM ADD KEY(R3_SID);
ALTER TABLE ALIGNED_PART_LINEITEM ADD UNIQUE KEY(R8_SID);




# R4 -> R7
# SUPPLIER -> PARTSUPP

DROP TABLE ALIGNED_SUPPLIER_PARTSUPP;

SELECT @n:=0;

CREATE TABLE ALIGNED_SUPPLIER_PARTSUPP
SELECT ALIGNED_NATION_SUPPLIER.R4_SID, PARTSUPP.*
from ALIGNED_NATION_SUPPLIER
RIGHT JOIN PARTSUPP ON ALIGNED_NATION_SUPPLIER.S_SUPPKEY = PARTSUPP.PS_SUPPKEY
ORDER BY ALIGNED_NATION_SUPPLIER.R4_SID;

ALTER TABLE ALIGNED_SUPPLIER_PARTSUPP ADD R7_SID INTEGER;

UPDATE ALIGNED_SUPPLIER_PARTSUPP
SET R7_SID = @n := @n + 1;

ALTER TABLE ALIGNED_SUPPLIER_PARTSUPP ADD PRIMARY KEY(PS_PARTKEY, PS_SUPPKEY);
ALTER TABLE ALIGNED_SUPPLIER_PARTSUPP ADD KEY(R4_SID);
ALTER TABLE ALIGNED_SUPPLIER_PARTSUPP ADD UNIQUE KEY(R7_SID);




# R4 ->  R8
# SUPPLIER -> LINEITEM

DROP TABLE ALIGNED_SUPPLIER_LINEITEM;

SELECT @n:=0;
```

```
CREATE TABLE ALIGNED_SUPPLIER_LINEITEM
SELECT ALIGNED_NATION_SUPPLIER.R4_SID, LINEITEM.*
from ALIGNED_NATION_SUPPLIER
RIGHT JOIN LINEITEM ON ALIGNED_NATION_SUPPLIER.S_SUPPKEY = LINEITEM.L_SUPPKEY
ORDER BY ALIGNED_NATION_SUPPLIER.R4_SID;

ALTER TABLE ALIGNED_SUPPLIER_LINEITEM ADD R8_SID INTEGER;

UPDATE ALIGNED_SUPPLIER_LINEITEM
SET R8_SID = @n := @n + 1;

ALTER TABLE ALIGNED_SUPPLIER_LINEITEM ADD PRIMARY KEY(L_ORDERKEY, L_LINENUMBER);
ALTER TABLE ALIGNED_SUPPLIER_LINEITEM ADD KEY(R4_SID);
ALTER TABLE ALIGNED_SUPPLIER_LINEITEM ADD UNIQUE KEY(R8_SID);




# R5 -> R6
# CUSTOMER -> ORDERS

DROP TABLE ALIGNED_CUSTOMER_ORDERS;

SELECT @n:=0;

CREATE TABLE ALIGNED_CUSTOMER_ORDERS
SELECT ALIGNED_NATION_CUSTOMER.R5_SID, ORDERS.*
FROM ALIGNED_NATION_CUSTOMER
RIGHT JOIN ORDERS ON ALIGNED_NATION_CUSTOMER.C_CUSTKEY = ORDERS.O_CUSTKEY
ORDER BY ALIGNED_NATION_CUSTOMER.R5_SID;

ALTER TABLE ALIGNED_CUSTOMER_ORDERS ADD R6_SID INTEGER;

UPDATE ALIGNED_CUSTOMER_ORDERS
SET R6_SID = @n := @n + 1;

ALTER TABLE ALIGNED_CUSTOMER_ORDERS ADD PRIMARY KEY(O_ORDERKEY);
ALTER TABLE ALIGNED_CUSTOMER_ORDERS ADD KEY(R5_SID);
ALTER TABLE ALIGNED_CUSTOMER_ORDERS ADD UNIQUE KEY(R6_SID);




# R6 ->  R8
# ORDERS -> LINEITEM

SELECT @n:=0;

# DROP TABLE ALIGNED_ORDERS_LINEITEM;

CREATE TABLE ALIGNED_ORDERS_LINEITEM
SELECT ALIGNED_CUSTOMER_ORDERS.R6_SID, LINEITEM.*
from ALIGNED_CUSTOMER_ORDERS
```

```
RIGHT JOIN LINEITEM ON ALIGNED_CUSTOMER_ORDERS.O_ORDERKEY = LINEITEM.L_ORDERKEY
ORDER BY ALIGNED_CUSTOMER_ORDERS.R6_SID;

ALTER TABLE ALIGNED_ORDERS_LINEITEM ADD R8_SID INTEGER;

UPDATE ALIGNED_ORDERS_LINEITEM
SET R8_SID = @n := @n + 1;

ALTER TABLE ALIGNED_ORDERS_LINEITEM ADD PRIMARY KEY(L_ORDERKEY, L_LINENUMBER);
ALTER TABLE ALIGNED_ORDERS_LINEITEM ADD KEY(R6_SID);
ALTER TABLE ALIGNED_ORDERS_LINEITEM ADD UNIQUE KEY(R8_SID);
```

Altering SIDs in the aligned tables (Moving SIDs to 0th and 1st column)

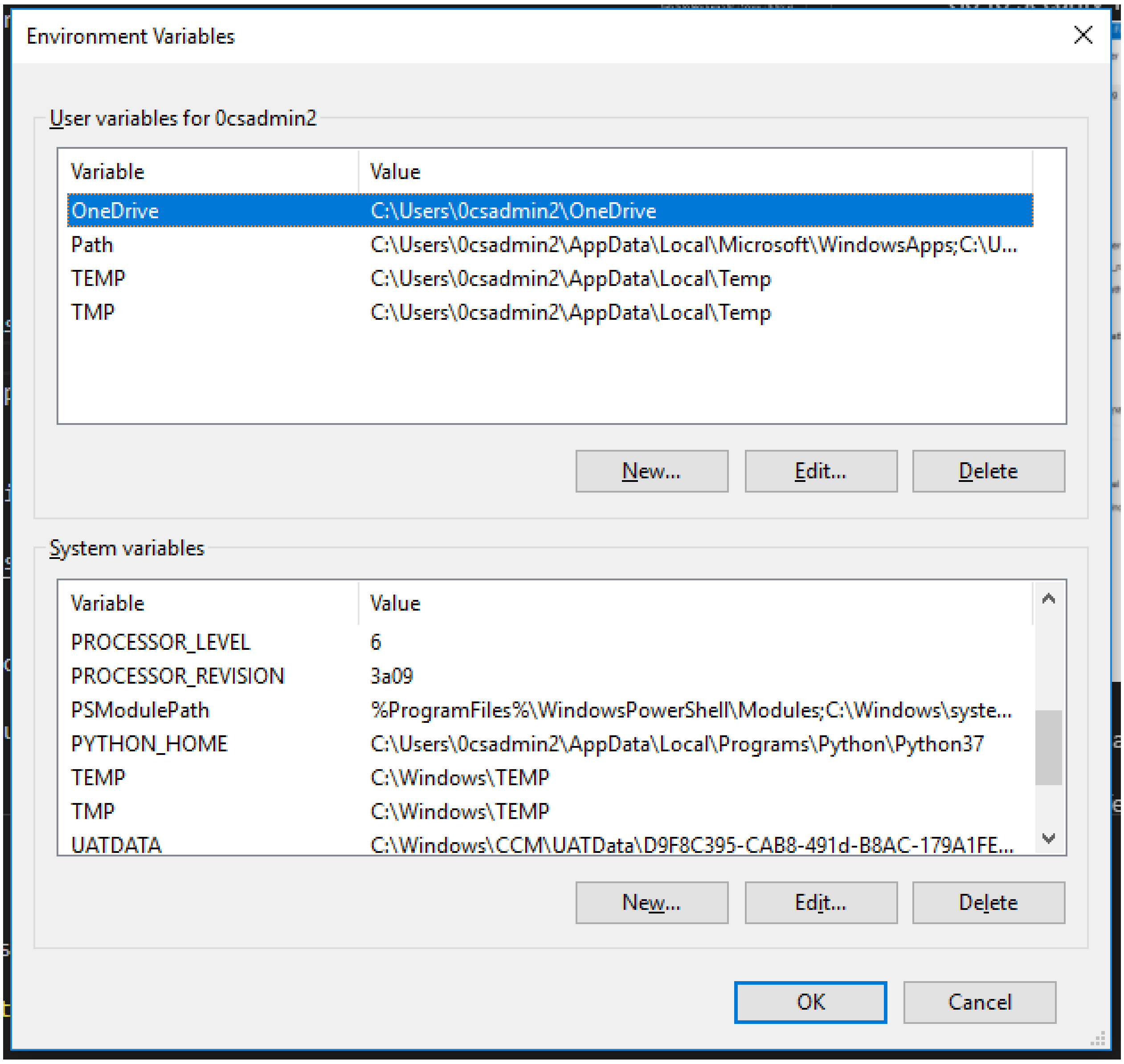
```
# MOVING THE SELF_SIDS AFTER PARENT_SIDS

ALTER TABLE ALIGNED_REGION MODIFY COLUMN R1_SID INTEGER AFTER R_REGIONKEY;
ALTER TABLE ALIGNED_PART MODIFY COLUMN R3_SID INTEGER AFTER P_PARTKEY;
ALTER TABLE ALIGNED_REGION_NATION MODIFY COLUMN R2_SID INTEGER AFTER R1_SID;
ALTER TABLE ALIGNED_NATION_SUPPLIER MODIFY COLUMN R4_SID INTEGER AFTER R2_SID;
ALTER TABLE ALIGNED_NATION_CUSTOMER MODIFY COLUMN R5_SID INTEGER AFTER R2_SID;
ALTER TABLE ALIGNED_CUSTOMER_ORDERS MODIFY COLUMN R6_SID INTEGER AFTER R5_SID;
ALTER TABLE ALIGNED_ORDERS_LINEITEM MODIFY COLUMN R8_SID INTEGER AFTER R6_SID;
ALTER TABLE ALIGNED_SUPPLIER_PARTSUPP MODIFY COLUMN R7_SID INTEGER AFTER R4_SID;
ALTER TABLE ALIGNED_SUPPLIER_LINEITEM MODIFY COLUMN R8_SID INTEGER AFTER R4_SID;
ALTER TABLE ALIGNED_PART_PARTSUPP MODIFY COLUMN R7_SID INTEGER AFTER R3_SID;
ALTER TABLE ALIGNED_PART_LINEITEM MODIFY COLUMN R8_SID INTEGER AFTER R3_SID;
```

Python

After you install python, add python to the ENVIROMENT_VARIABLES in your windows system.

- On your Windows machine, go to *System Properties* -> *Advanced Tab* -> *Environment Variables*



Variable	Value
OneDrive	C:\Users\0csadmin2\OneDrive
Path	C:\Users\0csadmin2\AppData\Local\Microsoft\WindowsApps;C:\U...
TEMP	C:\Users\0csadmin2\AppData\Local\Temp
TMP	C:\Users\0csadmin2\AppData\Local\Temp

Variable	Value
PROCESSOR_LEVEL	6
PROCESSOR_REVISION	3a09
PSModulePath	%ProgramFiles%\WindowsPowerShell\Modules;C:\Windows\syste...
PYTHON_HOME	C:\Users\0csadmin2\AppData\Local\Programs\Python\Python37
TEMP	C:\Windows\TEMP
TMP	C:\Windows\TEMP
UATDATA	C:\Windows\CCM\UATData\D9F8C395-CAB8-491d-B8AC-179A1FE...

You can verify this by opening cmd from anywhere and type python to see if python command line opens up.

You need pip to install most of the python tools

pip

- You can download the code **get-pip.py** from the below link.
  https://bootstrap.pypa.io/get-pip.py
  and run it on python command line
- Navigate to the location where you've downloaded get-pip.py file.

```
> python get-pip.py
```

- It will download and install pip
- Put python and pip executables into a common location
  C:\Python\Scripts
  and add this to the environment variables list so that pip can be run from anywhere

- Verify by typing

```
> pip freeze
```

from anywhere in the window.

flask

- Install flask, the GUI tool that's required to get inputs from the User and show aligned relations

```
> pip install flask
```

- Clone the project from the below link into your system.

```
> git clone https://github.com/avinashsp93/multiwayjoin.git
```

- Open the folder in Visual Studio Code, Press **Ctrl + `**
- Install some important plugins required

```
> pip3 install pandas
> pip3 install mysql-connector-python-rf
```

- Navigate to the .\scripts folder

```
> cd .\scripts
```

- Set the FLASK_APP environment variable

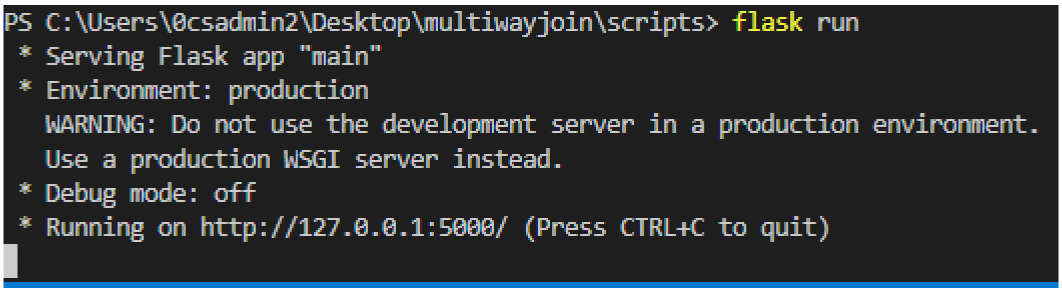
```
> $env:FLASK_APP="main"
```

Project Execution

- Navigate to your project where you've cloned, using commandline
- Run the below command from the commandline

```
> flask run
```

You should be getting below output

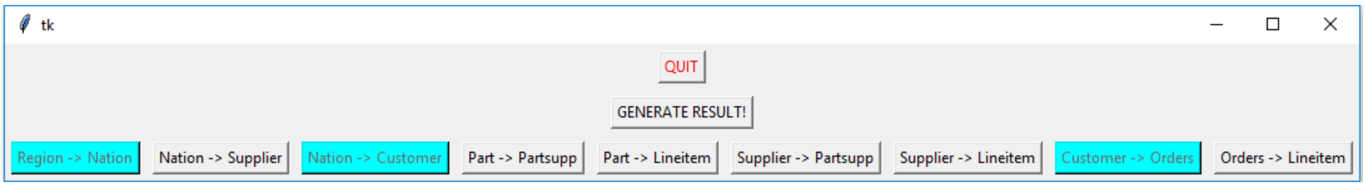


```
PS C:\Users\0csadmin2\Desktop\multiwayjoin\scripts> flask run
 * Serving Flask app "main"
 * Environment: production
   WARNING: Do not use the development server in a production environment.
   Use a production WSGI server instead.
 * Debug mode: off
 * Running on http://127.0.0.1:5000/ (Press CTRL+C to quit)
```

Click on the link http://127.0.0.1:5000/ and open it in chrome browser

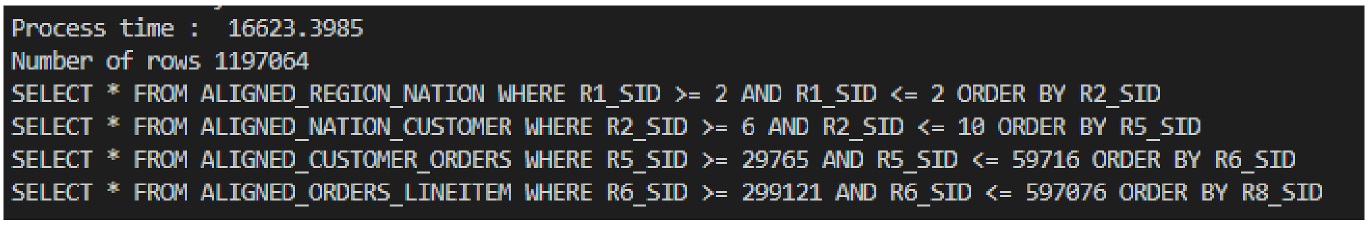
- At this state if you refresh the server, you'll be getting a new tkinter window where the user can specify inputs

Input



- The highlighted cyan color indicates the aligned relation that's going to be created
- Click on **Generate Result** button and head back to command line

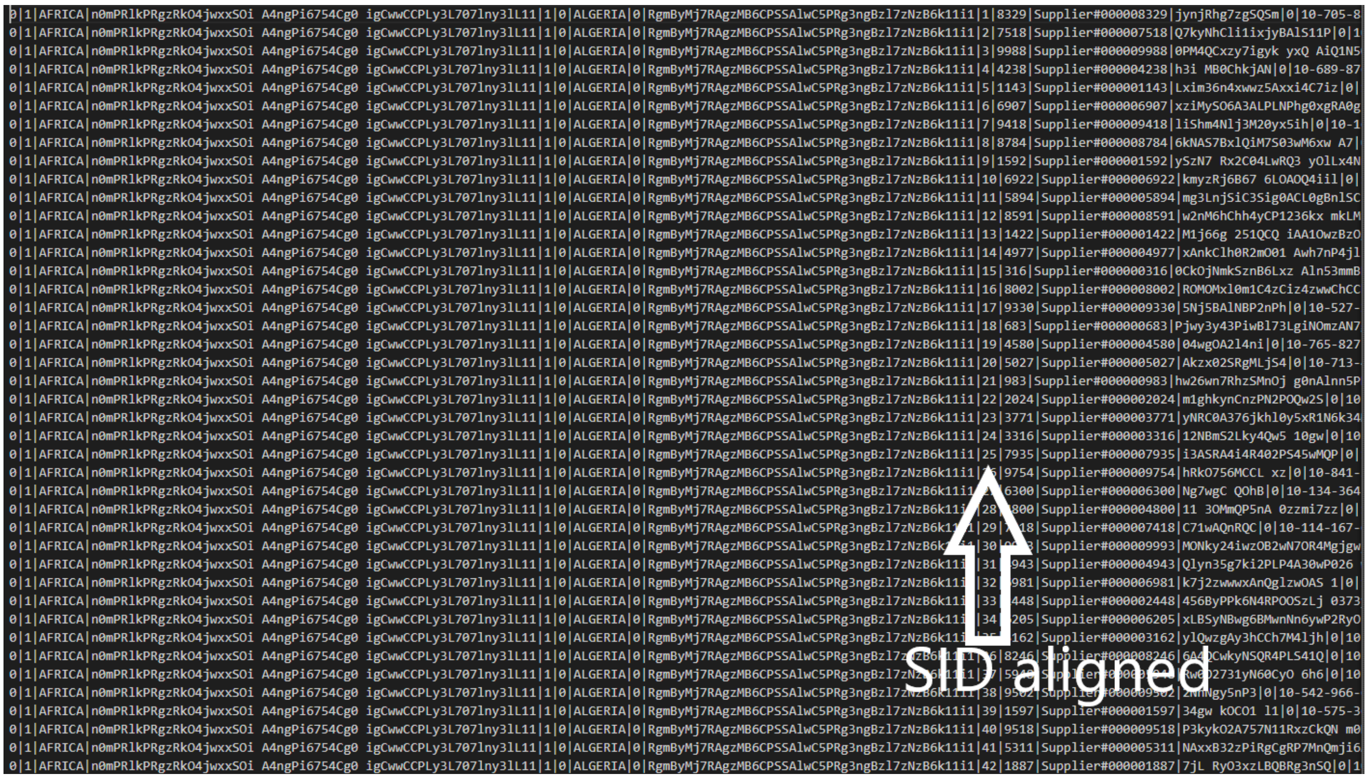
Output



```
Process time :  16623.3985
Number of rows 1197064
SELECT * FROM ALIGNED_REGION_NATION WHERE R1_SID >= 2 AND R1_SID <= 2 ORDER BY R2_SID
SELECT * FROM ALIGNED_NATION_CUSTOMER WHERE R2_SID >= 6 AND R2_SID <= 10 ORDER BY R5_SID
SELECT * FROM ALIGNED_CUSTOMER_ORDERS WHERE R5_SID >= 29765 AND R5_SID <= 59716 ORDER BY R6_SID
SELECT * FROM ALIGNED_ORDERS_LINEITEM WHERE R6_SID >= 299121 AND R6_SID <= 597076 ORDER BY R8_SID
```

Print File

The first few rows



```
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0|1|AFRICA|n0mPRlkPRgzRkO4jwxxSOi A4ngPi6754Cg0 igCwwCCPLy3L707lny3lL11|1|0|ALGERIA|0|RgmByMj7RAgzMB6CPSSAlwC5PRg3ngBzl7zNzB6k11i1|42|1887|Supplier#000001887|7jL RyO3xzLBQBRg3nSQ|0|1
```
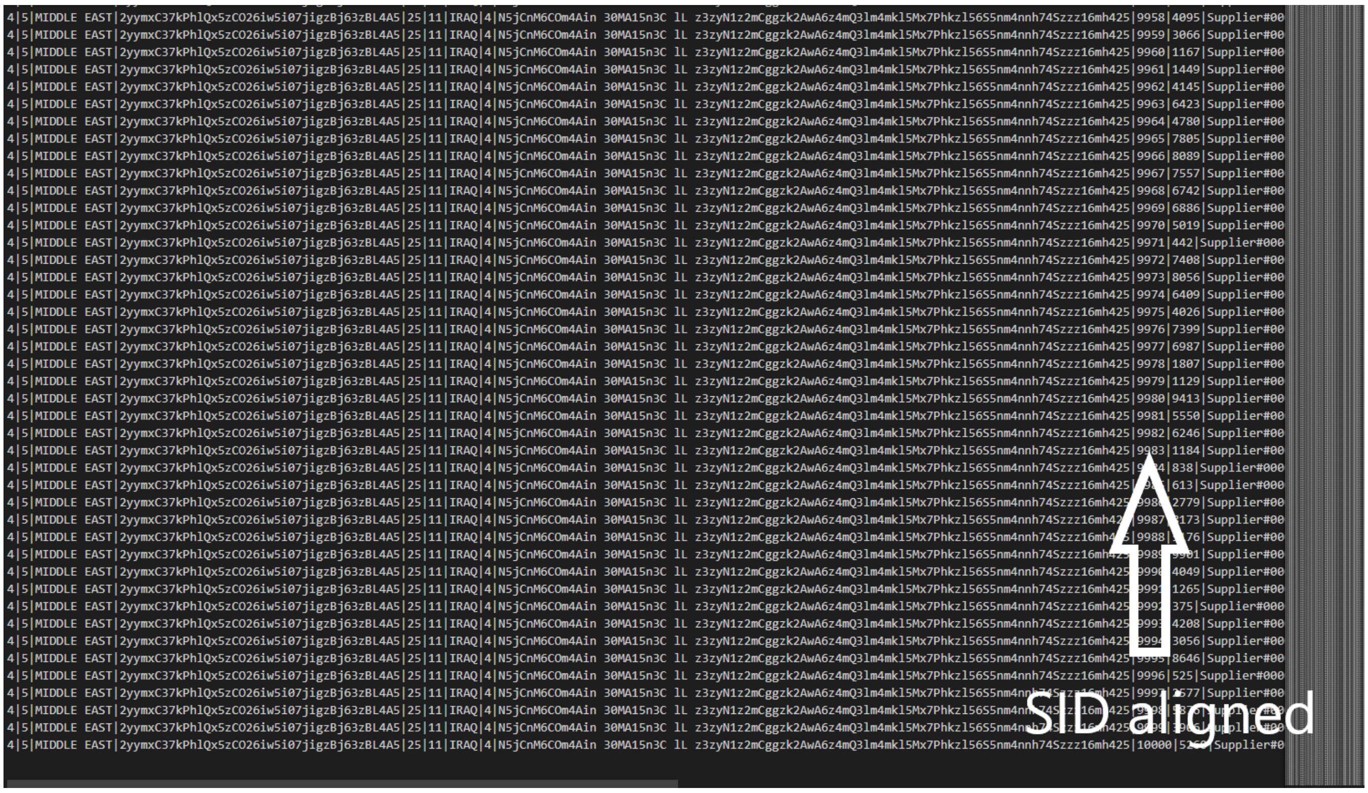

The last few rows



```
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4|5|MIDDLE EAST|2yymxC37kPhlQx5zCO26iw5i07jigzBj63zBL4A5|25|11|IRAQ|4|N5jCnM6COm4Ain 30MA15n3C lL z3zyN1z2mCggzk2AwA6z4mQ3lm4mkl5Mx7Phkzl56S5nm4nnh74Szzz16mh425|9965|7805|Supplier#00
4|5|MIDDLE EAST|2yymxC37kPhlQx5zCO26iw5i07jigzBj63zBL4A5|25|11|IRAQ|4|N5jCnM6COm4Ain 30MA15n3C lL z3zyN1z2mCggzk2AwA6z4mQ3lm4mkl5Mx7Phkzl56S5nm4nnh74Szzz16mh425|9966|8089|Supplier#00
4|5|MIDDLE EAST|2yymxC37kPhlQx5zCO26iw5i07jigzBj63zBL4A5|25|11|IRAQ|4|N5jCnM6COm4Ain 30MA15n3C lL z3zyN1z2mCggzk2AwA6z4mQ3lm4mkl5Mx7Phkzl56S5nm4nnh74Szzz16mh425|9967|7557|Supplier#00
4|5|MIDDLE EAST|2yymxC37kPhlQx5zCO26iw5i07jigzBj63zBL4A5|25|11|IRAQ|4|N5jCnM6COm4Ain 30MA15n3C lL z3zyN1z2mCggzk2AwA6z4mQ3lm4mkl5Mx7Phkzl56S5nm4nnh74Szzz16mh425|9968|6742|Supplier#00
4|5|MIDDLE EAST|2yymxC37kPhlQx5zCO26iw5i07jigzBj63zBL4A5|25|11|IRAQ|4|N5jCnM6COm4Ain 30MA15n3C lL z3zyN1z2mCggzk2AwA6z4mQ3lm4mkl5Mx7Phkzl56S5nm4nnh74Szzz16mh425|9969|6886|Supplier#00
4|5|MIDDLE EAST|2yymxC37kPhlQx5zCO26iw5i07jigzBj63zBL4A5|25|11|IRAQ|4|N5jCnM6COm4Ain 30MA15n3C lL z3zyN1z2mCggzk2AwA6z4mQ3lm4mkl5Mx7Phkzl56S5nm4nnh74Szzz16mh425|9970|5019|Supplier#00
4|5|MIDDLE EAST|2yymxC37kPhlQx5zCO26iw5i07jigzBj63zBL4A5|25|11|IRAQ|4|N5jCnM6COm4Ain 30MA15n3C lL z3zyN1z2mCggzk2AwA6z4mQ3lm4mkl5Mx7Phkzl56S5nm4nnh74Szzz16mh425|9971|442|Supplier#000
4|5|MIDDLE EAST|2yymxC37kPhlQx5zCO26iw5i07jigzBj63zBL4A5|25|11|IRAQ|4|N5jCnM6COm4Ain 30MA15n3C lL z3zyN1z2mCggzk2AwA6z4mQ3lm4mkl5Mx7Phkzl56S5nm4nnh74Szzz16mh425|9972|7408|Supplier#00
4|5|MIDDLE EAST|2yymxC37kPhlQx5zCO26iw5i07jigzBj63zBL4A5|25|11|IRAQ|4|N5jCnM6COm4Ain 30MA15n3C lL z3zyN1z2mCggzk2AwA6z4mQ3lm4mkl5Mx7Phkzl56S5nm4nnh74Szzz16mh425|9973|8056|Supplier#00
4|5|MIDDLE EAST|2yymxC37kPhlQx5zCO26iw5i07jigzBj63zBL4A5|25|11|IRAQ|4|N5jCnM6COm4Ain 30MA15n3C lL z3zyN1z2mCggzk2AwA6z4mQ3lm4mkl5Mx7Phkzl56S5nm4nnh74Szzz16mh425|9974|6409|Supplier#00
4|5|MIDDLE EAST|2yymxC37kPhlQx5zCO26iw5i07jigzBj63zBL4A5|25|11|IRAQ|4|N5jCnM6COm4Ain 30MA15n3C lL z3zyN1z2mCggzk2AwA6z4mQ3lm4mkl5Mx7Phkzl56S5nm4nnh74Szzz16mh425|9975|4026|Supplier#00
4|5|MIDDLE EAST|2yymxC37kPhlQx5zCO26iw5i07jigzBj63zBL4A5|25|11|IRAQ|4|N5jCnM6COm4Ain 30MA15n3C lL z3zyN1z2mCggzk2AwA6z4mQ3lm4mkl5Mx7Phkzl56S5nm4nnh74Szzz16mh425|9976|7399|Supplier#00
4|5|MIDDLE EAST|2yymxC37kPhlQx5zCO26iw5i07jigzBj63zBL4A5|25|11|IRAQ|4|N5jCnM6COm4Ain 30MA15n3C lL z3zyN1z2mCggzk2AwA6z4mQ3lm4mkl5Mx7Phkzl56S5nm4nnh74Szzz16mh425|9977|6987|Supplier#00
4|5|MIDDLE EAST|2yymxC37kPhlQx5zCO26iw5i07jigzBj63zBL4A5|25|11|IRAQ|4|N5jCnM6COm4Ain 30MA15n3C lL z3zyN1z2mCggzk2AwA6z4mQ3lm4mkl5Mx7Phkzl56S5nm4nnh74Szzz16mh425|9978|1807|Supplier#00
4|5|MIDDLE EAST|2yymxC37kPhlQx5zCO26iw5i07jigzBj63zBL4A5|25|11|IRAQ|4|N5jCnM6COm4Ain 30MA15n3C lL z3zyN1z2mCggzk2AwA6z4mQ3lm4mkl5Mx7Phkzl56S5nm4nnh74Szzz16mh425|9979|1129|Supplier#00
4|5|MIDDLE EAST|2yymxC37kPhlQx5zCO26iw5i07jigzBj63zBL4A5|25|11|IRAQ|4|N5jCnM6COm4Ain 30MA15n3C lL z3zyN1z2mCggzk2AwA6z4mQ3lm4mkl5Mx7Phkzl56S5nm4nnh74Szzz16mh425|9980|9413|Supplier#00
4|5|MIDDLE EAST|2yymxC37kPhlQx5zCO26iw5i07jigzBj63zBL4A5|25|11|IRAQ|4|N5jCnM6COm4Ain 30MA15n3C lL z3zyN1z2mCggzk2AwA6z4mQ3lm4mkl5Mx7Phkzl56S5nm4nnh74Szzz16mh425|9981|5550|Supplier#00
4|5|MIDDLE EAST|2yymxC37kPhlQx5zCO26iw5i07jigzBj63zBL4A5|25|11|IRAQ|4|N5jCnM6COm4Ain 30MA15n3C lL z3zyN1z2mCggzk2AwA6z4mQ3lm4mkl5Mx7Phkzl56S5nm4nnh74Szzz16mh425|9982|6246|Supplier#00
4|5|MIDDLE EAST|2yymxC37kPhlQx5zCO26iw5i07jigzBj63zBL4A5|25|11|IRAQ|4|N5jCnM6COm4Ain 30MA15n3C lL z3zyN1z2mCggzk2AwA6z4mQ3lm4mkl5Mx7Phkzl56S5nm4nnh74Szzz16mh425|9983|1184|Supplier#00
4|5|MIDDLE EAST|2yymxC37kPhlQx5zCO26iw5i07jigzBj63zBL4A5|25|11|IRAQ|4|N5jCnM6COm4Ain 30MA15n3C lL z3zyN1z2mCggzk2AwA6z4mQ3lm4mkl5Mx7Phkzl56S5nm4nnh74Szzz16mh425|9984|838|Supplier#000
4|5|MIDDLE EAST|2yymxC37kPhlQx5zCO26iw5i07jigzBj63zBL4A5|25|11|IRAQ|4|N5jCnM6COm4Ain 30MA15n3C lL z3zyN1z2mCggzk2AwA6z4mQ3lm4mkl5Mx7Phkzl56S5nm4nnh74Szzz16mh425|9985|613|Supplier#000
4|5|MIDDLE EAST|2yymxC37kPhlQx5zCO26iw5i07jigzBj63zBL4A5|25|11|IRAQ|4|N5jCnM6COm4Ain 30MA15n3C lL z3zyN1z2mCggzk2AwA6z4mQ3lm4mkl5Mx7Phkzl56S5nm4nnh74Szzz16mh425|9986|2779|Supplier#00
4|5|MIDDLE EAST|2yymxC37kPhlQx5zCO26iw5i07jigzBj63zBL4A5|25|11|IRAQ|4|N5jCnM6COm4Ain 30MA15n3C lL z3zyN1z2mCggzk2AwA6z4mQ3lm4mkl5Mx7Phkzl56S5nm4nnh74Szzz16mh425|9987|[illegible]173|Supplier#00
4|5|MIDDLE EAST|2yymxC37kPhlQx5zCO26iw5i07jigzBj63zBL4A5|25|11|IRAQ|4|N5jCnM6COm4Ain 30MA15n3C lL z3zyN1z2mCggzk2AwA6z4mQ3lm4mkl5Mx7Phkzl56S5nm4nnh74Szzz16mh425|9988|[illegible]76|Supplier#00
4|5|MIDDLE EAST|2yymxC37kPhlQx5zCO26iw5i07jigzBj63zBL4A5|25|11|IRAQ|4|N5jCnM6COm4Ain 30MA15n3C lL z3zyN1z2mCggzk2AwA6z4mQ3lm4mkl5Mx7Phkzl56S5nm4nnh74Szzz16mh425|9989|[illegible]01|Supplier#00
4|5|MIDDLE EAST|2yymxC37kPhlQx5zCO26iw5i07jigzBj63zBL4A5|25|11|IRAQ|4|N5jCnM6COm4Ain 30MA15n3C lL z3zyN1z2mCggzk2AwA6z4mQ3lm4mkl5Mx7Phkzl56S5nm4nnh74Szzz16mh425|9990|4049|Supplier#00
4|5|MIDDLE EAST|2yymxC37kPhlQx5zCO26iw5i07jigzBj63zBL4A5|25|11|IRAQ|4|N5jCnM6COm4Ain 30MA15n3C lL z3zyN1z2mCggzk2AwA6z4mQ3lm4mkl5Mx7Phkzl56S5nm4nnh74Szzz16mh425|9991|1265|Supplier#00
4|5|MIDDLE EAST|2yymxC37kPhlQx5zCO26iw5i07jigzBj63zBL4A5|25|11|IRAQ|4|N5jCnM6COm4Ain 30MA15n3C lL z3zyN1z2mCggzk2AwA6z4mQ3lm4mkl5Mx7Phkzl56S5nm4nnh74Szzz16mh425|9992|375|Supplier#000
4|5|MIDDLE EAST|2yymxC37kPhlQx5zCO26iw5i07jigzBj63zBL4A5|25|11|IRAQ|4|N5jCnM6COm4Ain 30MA15n3C lL z3zyN1z2mCggzk2AwA6z4mQ3lm4mkl5Mx7Phkzl56S5nm4nnh74Szzz16mh425|9993|4208|Supplier#00
4|5|MIDDLE EAST|2yymxC37kPhlQx5zCO26iw5i07jigzBj63zBL4A5|25|11|IRAQ|4|N5jCnM6COm4Ain 30MA15n3C lL z3zyN1z2mCggzk2AwA6z4mQ3lm4mkl5Mx7Phkzl56S5nm4nnh74Szzz16mh425|9994|3056|Supplier#00
4|5|MIDDLE EAST|2yymxC37kPhlQx5zCO26iw5i07jigzBj63zBL4A5|25|11|IRAQ|4|N5jCnM6COm4Ain 30MA15n3C lL z3zyN1z2mCggzk2AwA6z4mQ3lm4mkl5Mx7Phkzl56S5nm4nnh74Szzz16mh425|9995|8646|Supplier#00
4|5|MIDDLE EAST|2yymxC37kPhlQx5zCO26iw5i07jigzBj63zBL4A5|25|11|IRAQ|4|N5jCnM6COm4Ain 30MA15n3C lL z3zyN1z2mCggzk2AwA6z4mQ3lm4mkl5Mx7Phkzl56S5nm4nnh74Szzz16mh425|9996|525|Supplier#000
4|5|MIDDLE EAST|2yymxC37kPhlQx5zCO26iw5i07jigzBj63zBL4A5|25|11|IRAQ|4|N5jCnM6COm4Ain 30MA15n3C lL z3zyN1z2mCggzk2AwA6z4mQ3lm4mkl5Mx7Phkzl56S5nm4nnh74Szzz16mh425|9997|[illegible]577|Supplier#00
4|5|MIDDLE EAST|2yymxC37kPhlQx5zCO26iw5i07jigzBj63zBL4A5|25|11|IRAQ|4|N5jCnM6COm4Ain 30MA15n3C lL z3zyN1z2mCggzk2AwA6z4mQ3lm4mkl5Mx7Phkzl56S5nm4nnh74Szzz16mh425|9998|[illegible]|Supplier#00
4|5|MIDDLE EAST|2yymxC37kPhlQx5zCO26iw5i07jigzBj63zBL4A5|25|11|IRAQ|4|N5jCnM6COm4Ain 30MA15n3C lL z3zyN1z2mCggzk2AwA6z4mQ3lm4mkl5Mx7Phkzl56S5nm4nnh74Szzz16mh425|9999|[illegible]|Supplier#00
4|5|MIDDLE EAST|2yymxC37kPhlQx5zCO26iw5i07jigzBj63zBL4A5|25|11|IRAQ|4|N5jCnM6COm4Ain 30MA15n3C lL z3zyN1z2mCggzk2AwA6z4mQ3lm4mkl5Mx7Phkzl56S5nm4nnh74Szzz16mh425|10000|52[illegible]|Supplier#0
```

Results

Tabular Result (Linear Graph)

Relation	Response Time	Process Time	File Size	Number of Rows	MySQL Time
R -> N	0.01sec	0.02sec	5kB	25	0.078sec

Relation	Response Time	Process Time	File Size	Number of Rows	MySQL Time
R -> N -> S	0.2928sec	0.5299sec	3235kB	10000	0.466sec
R -> N -> C	0.6227sec	5.1313sec	51846kB	150000	13.641sec
R -> N -> C -> O	9.8108sec	1991.81sec	698625kB	1500000	502.583sec
R -> N -> S -> PS	8.2049sec	113.0356sec	380113kB	800000	70.940sec
R -> N -> C -> O -> L	360.4770sec	83487.59sec	2543871kB	6000000	59.750sec
N -> S	0.0330sec	0.5097sec	2302kB	10000	0.937sec
N -> C	0.2478sec	7.1866sec	37855kB	150000	9.009sec
N -> S -> PS	3.9955sec	49.8817sec	305503kB	800000	40.924sec
N -> C -> O	6.8558sec	505.3210sec	558689kB	1500000	120.478sec
S -> PS	0.6798sec	386.4896sec	285045kB	800000	7.422sec

Tabular Result (Divergent Graph)

`Note: The results are tested for smaller segments since the output file used to exceed 10GB because of cross product, rows used to exceed more than a billion`

- For 1 million rows

Relation	Time (Total)	File Size	MySQL Time
R -> N -> (S, C)	15.2480sec	151238kB	10.43sec
R -> N -> (S, C, O)	32.4271sec	334027kB	27.16sec
N -> S -> (PS, L)	1507.0917sec	49870642kB	208.83sec