Reporte de Instalación y Configuración de Galera 4 Cluster con MariaDB en Ubuntu Server

1. Introducción

El objetivo de esta tarea es la instalación y configuración de un Galera 4 Cluster con MariaDB en Ubuntu Server. El cluster se compone de tres nodos, siendo inicialmente configurado con dos nodos. Se realizó un benchmark para medir el rendimiento de la base de datos y se compararon los tiempos de respuesta entre un cluster de 2 nodos y uno de 3 nodos. La instalación se llevó a cabo en máquinas virtuales usando VirtualBox.

2. Requisitos y Herramientas

- **Sistema operativo:** Ubuntu Server
- **Versión de MariaDB:** [especificar versión]
- **Galera Cluster versión:** 4
- **Virtualización:** VirtualBox
- **Benchmark:** Herramienta de benchmarking de MariaDB (por ejemplo, `mysqlslap`)

3. Proceso de Instalación

3.1 Preparación del entorno en VirtualBox

Se crearon dos máquinas virtuales con Ubuntu Server, asignándoles los siguientes recursos:

- **Nodo 1 (IP 192.168.56.104)**
- **Nodo 2 (IP 192.168.56.105)**
-

3.2 Instalación de MariaDB y Galera Cluster

1. **Instalar herramientas necesarias en ambos nodos:**
    a. sudo apt -y install net-tools
    b. sudo apt -y install software-properties-common
    c. sudo apt update

d. sudo apt -y install mariadb-server mariadb-client galera-4
e. sudo apt -y install galera-arbitrator-4
f. sudo apt -y install mariadb-client libmariadb3

2. **Detener el servicio de MySQL en ambos nodos:**
   a. `systemctl stop mysql`
   b. `systemctl status mysql`

3. **Configurar Galera Cluster en ambos nodos:**
   a. **Editar el archivo `/etc/mysql/mariadb.conf.d/60-galera.cnf` en ambos nodos y configurar los siguientes parámetros:**
   b. **vi /etc/mysql/mariadb.conf.d/60-galera.cnf**

4. Reemplazar el contenido del documento por el siguiente:(en mi caso)

```
[mysqld]
binlog_format=ROW
default-storage-engine=innodb
innodb_autoinc_lock_mode=2
bind-address=0.0.0.0

# Galera Provider Configuration
wsrep_on=ON
wsrep_provider=/usr/lib/galera/libgalera_smm.so

# Galera Cluster Configuration
wsrep_cluster_name="test_cluster"
wsrep_cluster_address="gcomm://192.168.56.104,192.168.56.105,192.168.56.106"  # Aquí añades las IPs de todos los nodos

# Galera Synchronization Configuration
wsrep_sst_method=rsync

# Galera Node Configuration
wsrep_node_address="192.168.56.104"
wsrep_node_name="nodo1"

```

Nota: Cambiar a modo solo anfitrion

5. **Iniciar el primer nodo y crear el cluster: En el primer nodo, ejecutar:**
   a. `galera_new_cluster`

```
root@nodo1:/home/orbe# galera_new_cluster
root@nodo1:/home/orbe#
```

6. **Verificar estado de mariadb**
   a. `systemctl status mysql`

```
root@nodo1:/home/orbe# systemctl status mysql
● mariadb.service - MariaDB 10.11.8 database server
     Loaded: loaded (/usr/lib/systemd/system/mariadb.service; enabled; preset: enabled)
     Active: active (running) since Sun 2025-02-16 01:22:51 UTC; 1min 26s ago
       Docs: man:mariadbd(8)
             https://mariadb.com/kb/en/library/systemd/
    Process: 4876 ExecStartPre=/usr/bin/install -m 755 -o mysql -g root -d /var/run/mysqld (code=exited, status=0/SUCCESS)
    Process: 4878 ExecStartPre=/bin/sh -c systemctl unset-environment _WSREP_START_POSITION (code=exited, status=0/SUCCESS)
    Process: 4880 ExecStartPre=/bin/sh -c [ ! -e /usr/bin/galera_recovery ] && VAR= ||   VAR=`cd /usr/bin/..; /usr/bin/galera_recovery`; [ $? >
    Process: 5008 ExecStartPost=/bin/sh -c systemctl unset-environment _WSREP_START_POSITION (code=exited, status=0/SUCCESS)
    Process: 5010 ExecStartPost=/etc/mysql/debian-start (code=exited, status=0/SUCCESS)
   Main PID: 4989 (mariadbd)
     Status: "Taking your SQL requests now..."
      Tasks: 15 (limit: 29680)
     Memory: 107.2M (peak: 110.2M)
        CPU: 1.720s
     CGroup: /system.slice/mariadb.service
             └─4989 /usr/sbin/mariadbd --wsrep-new-cluster --wsrep_start_position=e6740c4b-eb4b-11ef-85c7-f64b3b3462ef:16

Feb 16 01:22:51 nodo1 mariadbd[4989]: Version: '10.11.8-MariaDB-0ubuntu0.24.04.1'  socket: '/run/mysqld/mysqld.sock'  port: 3306  Ubuntu 24.04
Feb 16 01:22:51 nodo1 mariadbd[4989]: 2025-02-16  1:22:51 2 [Note] WSREP: Lowest cert index boundary for CC from group: 17
Feb 16 01:22:51 nodo1 mariadbd[4989]: 2025-02-16  1:22:51 2 [Note] WSREP: Min available from gcache for CC from group: 1
Feb 16 01:22:51 nodo1 mariadbd[4989]: 2025-02-16  1:22:51 2 [Note] WSREP: Server nodo1 synced with group
Feb 16 01:22:51 nodo1 mariadbd[4989]: 2025-02-16  1:22:51 2 [Note] WSREP: Server status change joined -> synced
Feb 16 01:22:51 nodo1 mariadbd[4989]: 2025-02-16  1:22:51 2 [Note] WSREP: Synchronized with group, ready for connections
Feb 16 01:22:51 nodo1 mariadbd[4989]: 2025-02-16  1:22:51 2 [Note] WSREP: wsrep_notify_cmd is not defined, skipping notification.
Feb 16 01:22:51 nodo1 systemd[1]: Started mariadb.service - MariaDB 10.11.8 database server.
Feb 16 01:22:51 nodo1 /etc/mysql/debian-start[5013]: Upgrading MariaDB tables if necessary.
Feb 16 01:22:51 nodo1 /etc/mysql/debian-start[5029]: Triggering myisam-recover for all MyISAM tables and aria-recover for all Aria tables
root@nodo1:/home/orbe#
```

7. **Verificar el tamaño del cluster: En el primer nodo**
   a. **mysql -u root -p -e "SHOW STATUS LIKE 'wsrep_cluster_size'"**

```
root@nodo1:/home/orbe# mysql -u root -p -e "SHOW STATUS LIKE 'wsrep_cluster_size'"
Enter password:
+--------------------+-------+
| Variable_name      | Value |
+--------------------+-------+
| wsrep_cluster_size | 1     |
+--------------------+-------+
```

8. **Es hora de realizar las pruebas de sysbench con un nodo**
   a. **Set de pruebas de sysbench:**

- **oltp_delete**

sysbench --threads=1 --time=60 --rate=0 --db-driver=mysql --mysql-user=root --events=0 oltp_delete run

1 nucleo

```
root@nodo1:/home/orbe# sysbench --threads=1 --time=60 --rate=0 --db-driver=mysql --mysql-user=root --events=0 oltp_delete run
sysbench 1.0.20 (using system LuaJIT 2.1.0-beta3)

Running the test with following options:
Number of threads: 1
Initializing random number generator from current time


Initializing worker threads...

Threads started!

SQL statistics:
    queries performed:
        read:                            0
        write:                           3967
        other:                           84862
        total:                           88829
    transactions:                        88829  (1480.39 per sec.)
    queries:                             88829  (1480.39 per sec.)
    ignored errors:                      0      (0.00 per sec.)
    reconnects:                          0      (0.00 per sec.)

General statistics:
    total time:                          60.0011s
    total number of events:              88829

Latency (ms):
         min:                                    0.07
         avg:                                    0.67
         max:                                  141.26
         95th percentile:                        1.16
         sum:                                59855.37

Threads fairness:
    events (avg/stddev):           88829.0000/0.00
    execution time (avg/stddev):   59.8554/0.00
```

sysbench --threads=2 --time=60 --rate=0 --db-driver=mysql --mysql-user=root --events=0 oltp_delete run

2 nucleos

```
root@nodo1:/home/orbe# sysbench --threads=2 --time=60 --rate=0 --db-driver=mysql --mysql-user=root --events=0 oltp_delete run
sysbench 1.0.20 (using system LuaJIT 2.1.0-beta3)

Running the test with following options:
Number of threads: 2
Initializing random number generator from current time


Initializing worker threads...

Threads started!

SQL statistics:
    queries performed:
        read:                            0
        write:                           1306
        other:                           912968
        total:                           914274
    transactions:                        914274 (15235.71 per sec.)
    queries:                             914274 (15235.71 per sec.)
    ignored errors:                      0      (0.00 per sec.)
    reconnects:                          0      (0.00 per sec.)

General statistics:
    total time:                          60.0060s
    total number of events:              914274

Latency (ms):
         min:                                    0.06
         avg:                                    0.13
         max:                                  179.70
         95th percentile:                        0.18
         sum:                               119174.99

Threads fairness:
    events (avg/stddev):           457137.0000/1503.00
    execution time (avg/stddev):   59.5875/0.01
```

- **oltp_insert**

1 nucleos

sysbench --threads=1 --time=60 --rate=0 --db-driver=mysql --mysql-user=root --events=0 oltp_insert run

```
root@nodo1:/home/orbe# sysbench --threads=1 --time=60 --rate=0 --db-driver=mysql --mysql-user=root --events=0 oltp_insert run
sysbench 1.0.20 (using system LuaJIT 2.1.0-beta3)

Running the test with following options:
Number of threads: 1
Initializing random number generator from current time


Initializing worker threads...

Threads started!

SQL statistics:
    queries performed:
        read:                            0
        write:                           15438
        other:                           0
        total:                           15438
    transactions:                        15438  (257.28 per sec.)
    queries:                             15438  (257.28 per sec.)
    ignored errors:                      0      (0.00 per sec.)
    reconnects:                          0      (0.00 per sec.)

General statistics:
    total time:                          60.0023s
    total number of events:              15438

Latency (ms):
         min:                                    1.87
         avg:                                    3.88
         max:                                   26.35
         95th percentile:                        7.30
         sum:                                59938.99

Threads fairness:
    events (avg/stddev):           15438.0000/0.00
    execution time (avg/stddev):   59.9390/0.00
```

2 nucleos

sysbench --threads=2 --time=60 --rate=0 --db-driver=mysql --mysql-user=root --events=0 oltp_insert run

```
root@nodo1:/home/orbe# sysbench --threads=2 --time=60 --rate=0 --db-driver=mysql --mysql-user=root --events=0 oltp_insert run
sysbench 1.0.20 (using system LuaJIT 2.1.0-beta3)

Running the test with following options:
Number of threads: 2
Initializing random number generator from current time


Initializing worker threads...

Threads started!

SQL statistics:
    queries performed:
        read:                            0
        write:                           20877
        other:                           0
        total:                           20877
    transactions:                        20877  (347.92 per sec.)
    queries:                             20877  (347.92 per sec.)
    ignored errors:                      0      (0.00 per sec.)
    reconnects:                          0      (0.00 per sec.)

General statistics:
    total time:                          60.0049s
    total number of events:              20877

Latency (ms):
         min:                                    2.06
         avg:                                    5.74
         max:                                  122.27
         95th percentile:                        9.39
         sum:                               119907.38

Threads fairness:
    events (avg/stddev):           10438.5000/5.50
    execution time (avg/stddev):   59.9537/0.00
```

- **oltp_point_select**

sysbench --threads=1 --time=60 --rate=0 --db-driver=mysql --mysql-user=root --events=0 oltp_point_select run

```
root@nodo1:/home/orbe# sysbench --threads=1 --time=60 --rate=0 --db-driver=mysql
 --mysql-user=root --events=0 oltp_point_select run
sysbench 1.0.20 (using system LuaJIT 2.1.0-beta3)

Running the test with following options:
Number of threads: 1
Initializing random number generator from current time


Initializing worker threads...

Threads started!

SQL statistics:
    queries performed:
        read:                            117539
        write:                           0
        other:                           0
        total:                           117539
    transactions:                        117539 (1958.92 per sec.)
    queries:                             117539 (1958.92 per sec.)
    ignored errors:                      0      (0.00 per sec.)
    reconnects:                          0      (0.00 per sec.)

General statistics:
    total time:                          60.0008s
    total number of events:              117539

Latency (ms):
         min:                                    0.06
         avg:                                    0.51
         max:                                    5.38
         95th percentile:                        0.81
         sum:                                59824.35

Threads fairness:
    events (avg/stddev):           117539.0000/0.00
    execution time (avg/stddev):   59.8244/0.00

root@nodo1:/home/orbe#
```

sysbench --threads=2 --time=60 --rate=0 --db-driver=mysql --mysql-user=root --events=0 oltp_point_select run

```
root@nodo1:/home/orbe# sysbench --threads=2 --time=60 --rate=0 --db-driver=mysql --mysql-user=root --events=0 oltp_point_select run
sysbench 1.0.20 (using system LuaJIT 2.1.0-beta3)

Running the test with following options:
Number of threads: 2
Initializing random number generator from current time


Initializing worker threads...

Threads started!

SQL statistics:
    queries performed:
        read:                            1191106
        write:                           0
        other:                           0
        total:                           1191106
    transactions:                        1191106 (19850.46 per sec.)
    queries:                             1191106 (19850.46 per sec.)
    ignored errors:                      0      (0.00 per sec.)
    reconnects:                          0      (0.00 per sec.)

General statistics:
    total time:                          60.0020s
    total number of events:              1191106

Latency (ms):
         min:                                    0.07
         avg:                                    0.10
         max:                                   70.71
         95th percentile:                        0.15
         sum:                               119229.80

Threads fairness:
    events (avg/stddev):           595553.0000/850.00
    execution time (avg/stddev):   59.6149/0.01
```

- **oltp_read_only**

1 nucleos

sysbench --threads=1 --time=60 --rate=0 --db-driver=mysql --mysql-user=root --events=0 oltp_update_index run

```
root@nodo1:/home/orbe# sysbench --threads=1 --time=60 --rate=0 --db-driver=mysql
 --mysql-user=root --events=0 oltp_update_index run
sysbench 1.0.20 (using system LuaJIT 2.1.0-beta3)

Running the test with following options:
Number of threads: 1
Initializing random number generator from current time


Initializing worker threads...

Threads started!

SQL statistics:
    queries performed:
        read:                            0
        write:                           56
        other:                           125633
        total:                           125689
    transactions:                        125689 (2094.76 per sec.)
    queries:                             125689 (2094.76 per sec.)
    ignored errors:                      0      (0.00 per sec.)
    reconnects:                          0      (0.00 per sec.)

General statistics:
    total time:                          60.0008s
    total number of events:              125689

Latency (ms):
         min:                                    0.04
         avg:                                    0.48
         max:                                  113.30
         95th percentile:                        0.77
         sum:                                59818.41

Threads fairness:
    events (avg/stddev):           125689.0000/0.00
    execution time (avg/stddev):   59.8184/0.00
```

2 nucleos

sysbench --threads=2 --time=60 --rate=0 --db-driver=mysql --mysql-user=root --events=0 oltp_update_index run

```
root@nodo1:/home/orbe# sysbench --threads=2 --time=60 --rate=0 --db-driver=mysql --mysql-user=root --events=0 oltp_update_index run
sysbench 1.0.20 (using system LuaJIT 2.1.0-beta3)

Running the test with following options:
Number of threads: 2
Initializing random number generator from current time


Initializing worker threads...

Threads started!

SQL statistics:
    queries performed:
        read:                            0
        write:                           526
        other:                           1111832
        total:                           1112358
    transactions:                        1112358 (18536.60 per sec.)
    queries:                             1112358 (18536.60 per sec.)
    ignored errors:                      0      (0.00 per sec.)
    reconnects:                          0      (0.00 per sec.)

General statistics:
    total time:                          60.0072s
    total number of events:              1112358

Latency (ms):
         min:                                    0.04
         avg:                                    0.11
         max:                                  215.73
         95th percentile:                        0.15
         sum:                               119317.52

Threads fairness:
    events (avg/stddev):           556179.0000/6946.00
    execution time (avg/stddev):   59.6588/0.01
```

- **oltp_read_write**

1 Nucleo

sysbench --threads=1 --time=60 --rate=0 --db-driver=mysql --mysql-user=root --events=0 oltp_read_write run

```
root@nodo1:/home/orbe# sysbench --threads=1 --time=60 --rate=0 --db-driver=mysql --mysql-user=root --events=0 oltp_read_write run
sysbench 1.0.20 (using system LuaJIT 2.1.0-beta3)

Running the test with following options:
Number of threads: 1
Initializing random number generator from current time


Initializing worker threads...

Threads started!

SQL statistics:
    queries performed:
        read:                            45668
        write:                           10712
        other:                           8860
        total:                           65240
    transactions:                        3262   (54.36 per sec.)
    queries:                             65240  (1087.27 per sec.)
    ignored errors:                      0      (0.00 per sec.)
    reconnects:                          0      (0.00 per sec.)

General statistics:
    total time:                          60.0026s
    total number of events:              3262

Latency (ms):
         min:                                    7.00
         avg:                                   18.39
         max:                                   31.28
         95th percentile:                       22.69
         sum:                                59979.99

Threads fairness:
    events (avg/stddev):           3262.0000/0.00
    execution time (avg/stddev):   59.9800/0.00
```

2 Nucleos

sysbench --threads=2 --time=60 --rate=0 --db-driver=mysql --mysql-user=root --events=0 oltp_read_write run

```
root@nodo1:/home/orbe# sysbench --threads=2 --time=60 --rate=0 --db-driver=mysql --mysql-user=root --events=0 oltp_read_write run
sysbench 1.0.20 (using system LuaJIT 2.1.0-beta3)

Running the test with following options:
Number of threads: 2
Initializing random number generator from current time


Initializing worker threads...

Threads started!

SQL statistics:
    queries performed:
        read:                            88046
        write:                           22393
        other:                           15341
        total:                           125780
    transactions:                        6289   (104.79 per sec.)
    queries:                             125780 (2095.72 per sec.)
    ignored errors:                      0      (0.00 per sec.)
    reconnects:                          0      (0.00 per sec.)

General statistics:
    total time:                          60.0168s
    total number of events:              6289

Latency (ms):
         min:                                    5.67
         avg:                                   19.08
         max:                                   51.80
         95th percentile:                       25.74
         sum:                               119978.42

Threads fairness:
    events (avg/stddev):           3144.5000/10.50
    execution time (avg/stddev):   59.9892/0.01
```

- **oltp_update_index**

1 Nucleo

sysbench --threads=1 --time=60 --rate=0 --db-driver=mysql --mysql-user=root --events=0 oltp_update_index run

```
root@nodo1:/home/orbe# sysbench --threads=1 --time=60 --rate=0 --db-driver=mysql --mysql-user=root --events=0 oltp_update_index run
sysbench 1.0.20 (using system LuaJIT 2.1.0-beta3)

Running the test with following options:
Number of threads: 1
Initializing random number generator from current time


Initializing worker threads...

Threads started!

SQL statistics:
    queries performed:
        read:                            0
        write:                           10567
        other:                           1400
        total:                           11967
    transactions:                        11967  (199.44 per sec.)
    queries:                             11967  (199.44 per sec.)
    ignored errors:                      0      (0.00 per sec.)
    reconnects:                          0      (0.00 per sec.)

General statistics:
    total time:                          60.0018s
    total number of events:              11967

Latency (ms):
         min:                                    0.08
         avg:                                    5.01
         max:                                   15.36
         95th percentile:                        9.22
         sum:                                59956.08

Threads fairness:
    events (avg/stddev):           11967.0000/0.00
```

2 Nucleos

sysbench --threads=2 --time=60 --rate=0 --db-driver=mysql --mysql-user=root --events=0 oltp_update_index ru

```
root@nodo1:/home/orbe# sysbench --threads=2 --time=60 --rate=0 --db-driver=mysql --mysql-user=root --events=0 oltp_update_index run
sysbench 1.0.20 (using system LuaJIT 2.1.0-beta3)

Running the test with following options:
Number of threads: 2
Initializing random number generator from current time


Initializing worker threads...

Threads started!

SQL statistics:
    queries performed:
        read:                            0
        write:                           15766
        other:                           2126
        total:                           17892
    transactions:                        17892  (298.16 per sec.)
    queries:                             17892  (298.16 per sec.)
    ignored errors:                      0      (0.00 per sec.)
    reconnects:                          0      (0.00 per sec.)

General statistics:
    total time:                          60.0082s
    total number of events:              17892

Latency (ms):
         min:                                    0.05
         avg:                                    6.70
         max:                                   25.24
         95th percentile:                       11.87
         sum:                               119927.39

Threads fairness:
    events (avg/stddev):           8946.0000/41.00
    execution time (avg/stddev):   59.9637/0.00
```

- **oltp_update_non_index**

1 Nucleo

sysbench --threads=1 --time=60 --rate=0 --db-driver=mysql --mysql-user=root --events=0 oltp_update_non_index run

```
root@nodo1:/home/orbe# sysbench --threads=1 --time=60 --rate=0 --db-driver=mysql --mysql-user=root --events=0 oltp_update_non_index run
sysbench 1.0.20 (using system LuaJIT 2.1.0-beta3)

Running the test with following options:
Number of threads: 1
Initializing random number generator from current time


Initializing worker threads...

Threads started!

SQL statistics:
    queries performed:
        read:                            0
        write:                           10522
        other:                           1446
        total:                           11968
    transactions:                        11968  (199.45 per sec.)
    queries:                             11968  (199.45 per sec.)
    ignored errors:                      0      (0.00 per sec.)
    reconnects:                          0      (0.00 per sec.)

General statistics:
    total time:                          60.0033s
    total number of events:              11968

Latency (ms):
         min:                                    0.11
         avg:                                    5.01
         max:                                   16.42
         95th percentile:                        9.39
         sum:                                59969.38

Threads fairness:
    events (avg/stddev):           11968.0000/0.00
    execution time (avg/stddev):   59.9694/0.00
```

2 Nucleos

sysbench --threads=2 --time=60 --rate=0 --db-driver=mysql --mysql-user=root --events=0 oltp_update_non_index run

```
root@nodo1:/home/orbe# sysbench --threads=2 --time=60 --rate=0 --db-driver=mysql --mysql-user=root --events=0 oltp_update_non_index run
sysbench 1.0.20 (using system LuaJIT 2.1.0-beta3)

Running the test with following options:
Number of threads: 2
Initializing random number generator from current time


Initializing worker threads...

Threads started!

SQL statistics:
    queries performed:
        read:                            0
        write:                           15914
        other:                           2049
        total:                           17963
    transactions:                        17963  (299.34 per sec.)
    queries:                             17963  (299.34 per sec.)
    ignored errors:                      0      (0.00 per sec.)
    reconnects:                          0      (0.00 per sec.)

General statistics:
    total time:                          60.0085s
    total number of events:              17963

Latency (ms):
         min:                                    0.06
         avg:                                    6.68
         max:                                  184.92
         95th percentile:                       11.87
         sum:                               119954.18

Threads fairness:
    events (avg/stddev):           8981.5000/23.50
    execution time (avg/stddev):   59.9771/0.00
```

- **oltp_write_only**

1 Nucleo

sysbench --threads=1 --time=60 --rate=0 --db-driver=mysql --mysql-user=root --events=0 oltp_write_only run

```
root@nodo1:/home/orbe# sysbench --threads=1 --time=60 --rate=0 --db-driver=mysql --mysql-user=root --events=0 oltp_write_only run
sysbench 1.0.20 (using system LuaJIT 2.1.0-beta3)

Running the test with following options:
Number of threads: 1
Initializing random number generator from current time


Initializing worker threads...

Threads started!

SQL statistics:
    queries performed:
        read:                            0
        write:                           23901
        other:                           14631
        total:                           38532
    transactions:                        6422   (107.03 per sec.)
    queries:                             38532  (642.17 per sec.)
    ignored errors:                      0      (0.00 per sec.)
    reconnects:                          0      (0.00 per sec.)

General statistics:
    total time:                          60.0021s
    total number of events:              6422

Latency (ms):
         min:                                    3.58
         avg:                                    9.34
         max:                                   34.83
         95th percentile:                       13.46
         sum:                                59955.38

Threads fairness:
    events (avg/stddev):           6422.0000/0.00
    execution time (avg/stddev):   59.9554/0.00
```

2 Nucleos

sysbench --threads=2 --time=60 --rate=0 --db-driver=mysql --mysql-user=root --events=0 oltp_write_only run

```
root@nodo1:/home/orbe# sysbench --threads=2 --time=60 --rate=0 --db-driver=mysql --mysql-user=root --events=0 oltp_write_only run
sysbench 1.0.20 (using system LuaJIT 2.1.0-beta3)

Running the test with following options:
Number of threads: 2
Initializing random number generator from current time


Initializing worker threads...

Threads started!

SQL statistics:
    queries performed:
        read:                            0
        write:                           41661
        other:                           23613
        total:                           65274
    transactions:                        10879  (181.29 per sec.)
    queries:                             65274  (1087.74 per sec.)
    ignored errors:                      0      (0.00 per sec.)
    reconnects:                          0      (0.00 per sec.)

General statistics:
    total time:                          60.0080s
    total number of events:              10879

Latency (ms):
         min:                                    4.39
         avg:                                   11.02
         max:                                   45.15
         95th percentile:                       15.27
         sum:                               119940.56

Threads fairness:
    events (avg/stddev):           5439.5000/11.50
    execution time (avg/stddev):   59.9703/0.00
```

- **select_random_points**

1 Nucleo

sysbench --threads=1 --time=60 --rate=0 --db-driver=mysql --mysql-user=root --events=0 select_random_points run

```
root@nodo1:/home/orbe# sysbench --threads=1 --time=60 --rate=0 --db-driver=mysql --mysql-user=root --events=0 select_random_points run
sysbench 1.0.20 (using system LuaJIT 2.1.0-beta3)

Running the test with following options:
Number of threads: 1
Initializing random number generator from current time


Initializing worker threads...

Threads started!

SQL statistics:
    queries performed:
        read:                            3627
        write:                           0
        other:                           0
        total:                           3627
    transactions:                        3627   (60.43 per sec.)
    queries:                             3627   (60.43 per sec.)
    ignored errors:                      0      (0.00 per sec.)
    reconnects:                          0      (0.00 per sec.)

General statistics:
    total time:                          60.0155s
    total number of events:              3627

Latency (ms):
         min:                                    3.78
         avg:                                   16.54
         max:                                  271.22
         95th percentile:                       23.95
         sum:                                59986.31

Threads fairness:
    events (avg/stddev):           3627.0000/0.00
    execution time (avg/stddev):   59.9863/0.00
```

2 Nucleos

sysbench --threads=2 --time=60 --rate=0 --db-driver=mysql --mysql-user=root --events=0 select_random_points run

```
root@nodo1:/home/orbe# sysbench --threads=2 --time=60 --rate=0 --db-driver=mysql --mysql-user=root --events=0 select_random_points run
sysbench 1.0.20 (using system LuaJIT 2.1.0-beta3)

Running the test with following options:
Number of threads: 2
Initializing random number generator from current time


Initializing worker threads...

Threads started!

SQL statistics:
    queries performed:
        read:                            666384
        write:                           0
        other:                           0
        total:                           666384
    transactions:                        666384 (11105.73 per sec.)
    queries:                             666384 (11105.73 per sec.)
    ignored errors:                      0      (0.00 per sec.)
    reconnects:                          0      (0.00 per sec.)

General statistics:
    total time:                          60.0024s
    total number of events:              666384

Latency (ms):
         min:                                    0.07
         avg:                                    0.18
         max:                                   13.21
         95th percentile:                        0.27
         sum:                               119057.49

Threads fairness:
    events (avg/stddev):           333192.0000/21880.00
    execution time (avg/stddev):   59.5287/0.02
```

- **select_random_ranges**

1 Nucleo

sysbench --threads=1 --time=60 --rate=0 --db-driver=mysql --mysql-user=root --events=0 select_random_ranges run

```
root@nodo1:/home/orbe# sysbench --threads=1 --time=60 --rate=0 --db-driver=mysql --mysql-user=root --events=0 select_random_ranges run
sysbench 1.0.20 (using system LuaJIT 2.1.0-beta3)

Running the test with following options:
Number of threads: 1
Initializing random number generator from current time


Initializing worker threads...

Threads started!

SQL statistics:
    queries performed:
        read:                            8662
        write:                           0
        other:                           0
        total:                           8662
    transactions:                        8662   (144.35 per sec.)
    queries:                             8662   (144.35 per sec.)
    ignored errors:                      0      (0.00 per sec.)
    reconnects:                          0      (0.00 per sec.)

General statistics:
    total time:                          60.0049s
    total number of events:              8662

Latency (ms):
         min:                                    1.83
         avg:                                    6.92
         max:                                   18.80
         95th percentile:                        9.56
         sum:                                59971.83

Threads fairness:
    events (avg/stddev):           8662.0000/0.00
    execution time (avg/stddev):   59.9718/0.00
```

2 Nucleos

sysbench --threads=2 --time=60 --rate=0 --db-driver=mysql --mysql-user=root --events=0 select_random_ranges run

```
root@nodo1:/home/orbe# sysbench --threads=2 --time=60 --rate=0 --db-driver=mysql --mysql-user=root --events=0 select_random_ranges run
sysbench 1.0.20 (using system LuaJIT 2.1.0-beta3)

Running the test with following options:
Number of threads: 2
Initializing random number generator from current time


Initializing worker threads...

Threads started!

SQL statistics:
    queries performed:
        read:                            651714
        write:                           0
        other:                           0
        total:                           651714
    transactions:                        651714 (10860.85 per sec.)
    queries:                             651714 (10860.85 per sec.)
    ignored errors:                      0      (0.00 per sec.)
    reconnects:                          0      (0.00 per sec.)

General statistics:
    total time:                          60.0031s
    total number of events:              651714

Latency (ms):
         min:                                    0.07
         avg:                                    0.18
         max:                                   11.64
         95th percentile:                        0.26
         sum:                               119070.40

Threads fairness:
    events (avg/stddev):           325857.0000/7309.00
    execution time (avg/stddev):   59.5352/0.01
```

La práctica mostró que aumentar el número de hilos mejora el rendimiento de la base de datos en la mayoría de los escenarios de carga concurrente, especialmente en operaciones de lectura, escritura, actualización y eliminación. Sin embargo, la magnitud de la mejora depende de la naturaleza de la prueba y de la capacidad de la base de datos para manejar múltiples hilos de manera eficiente. Para cargas de trabajo con un solo hilo, las bases de datos pueden tener un rendimiento más limitado, pero para cargas de trabajo concurrentes, como las que involucran múltiples usuarios o procesos simultáneos, el uso de 2 hilos demostró ser una mejora significativa.

Esto resalta la importancia de ajustar la cantidad de hilos en función de la carga de trabajo real de la base de datos, para obtener el mejor rendimiento en un entorno de producción.