



Universidad del Caribe

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CANCUN, QUINTANA ROO, MÉXICO

CONOCIMIENTO Y CULTURA PARA EL DESARROLLO HUMANO

Computo de alto desempeño

Clústeres y beckmark

Jiménez Sánchez / Ismael

Ingeniería en Datos e Inteligencia Organizacional

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Instalamos git

```
noe@Cluster: ~/galera-docker/galera
noe@Cluster:~$ git clone https://github.com/hweidner/galera-docker.git
Command 'git' not found, but can be installed with:
sudo apt install git
noe@Cluster:~$ sudo apt install git
[sudo] password for noe:
Reading package lists... Done
Building dependency tree... Done
Reading state information... Done
The following additional packages will be installed:
  git-man liberror-perl
Suggested packages:
  git-daemon-run | git-daemon-sysvinit git-doc git-email git-gui gitek gitweb
  git-cvs git-mediawiki git-svn
The following NEW packages will be installed:
  git git-man liberror-perl
3 upgraded, 3 newly installed, 0 to remove and 232 not upgraded.
Need to get 4,884 kB of archives.
After this operation, 24.5 MB of additional disk space will be used.
Do you want to continue? [Y/n] y
Get:1 http://archive.ubuntu.com/ubuntu noble/main amd64 liberror-perl all 0.17029-2 [25.6 kB]
Get:2 http://archive.ubuntu.com/ubuntu noble-updates/main amd64 git-man all 1:2.43.0-1ubuntu7.2 [1,100 kB]
Get:3 http://archive.ubuntu.com/ubuntu noble-updates/main amd64 git amd64 1:2.43.0-1ubuntu7.2 [3,679 kB]
Fetched 4,884 kB in 2s (2,307 kB/s)
Selecting previously unselected package liberror-perl.
Reading database ... 151973 files and directories currently installed.)
Preparing to unpack .../liberror-perl_0.17029-2_all.deb ...
Unpacking liberror-perl (0.17029-2) ...
Selecting previously unselected package git-man.
Preparing to unpack .../git-man_1:2.43.0-1ubuntu7.2_all.deb ...
Unpacking git-man (1:2.43.0-1ubuntu7.2) ...
Selecting previously unselected package git.
Preparing to unpack .../git_1:2.43.0-1ubuntu7.2_amd64.deb ...
Unpacking git (1:2.43.0-1ubuntu7.2) ...
```

Instalamos Docker

```
Apr 4 20:57
noe@Cluster: ~/galera-docker/galera
Processing triggers for man-db (2.12.0-4build2) ...
noe@Cluster:~$ git clone https://github.com/hweidner/galera-docker.git
Cloning into 'galera-docker'...
remote: Enumerating objects: 32, done.
remote: Counting objects: 100% (4/4), done.
remote: Compressing objects: 100% (4/4), done.
remote: Total 32 (delta 0), reused 1 (delta 0), pack-reused 28 (from 1)
Receiving objects: 100% (32/32), 8.85 KiB | 1.47 MiB/s, done.
Resolving deltas: 100% (12/12), done.
noe@Cluster:~$ cd galera-docker
noe@Cluster:~/galera-docker$ ls /a
ls: cannot access '/a': No such file or directory
noe@Cluster:~/galera-docker$ ls -a
.  Dockerfile  .git  LICENSE.txt  startup.sh
.. galera.cnf  .gitignore  README.md
noe@Cluster:~/galera-docker$ docker build -t mycluster/galera .
Command 'docker' not found, but can be installed with:
sudo snap install docker # version 27.5.1, or
sudo apt install docker.io # version 26.1.3-0ubuntu1-24.04.1
sudo apt install podman-docker # version 4.9.3+ds1-1ubuntu0.2
See 'snap info docker' for additional versions.
noe@Cluster:~/galera-docker$ sudo snap install docker
docker 27.5.1 from Canonical✓ installed
noe@Cluster:~/galera-docker$ docker build -t mycluster/galera .
ERROR: permission denied while trying to connect to the Docker daemon socket at unix:///var/run/docker.sock: Head "http://%2Fvar%2Frun%2Fdocker.sock/_ping": dial unix /var/run/docker.sock: connect: permission denied
noe@Cluster:~/galera-docker$ sudo docker ps
CONTAINER ID   IMAGE     COMMAND   CREATED   STATUS    PORTS   NAMES
noe@Cluster:~/galera-docker$ sudo usermod -aG docker $USER
usermod: group 'docker' does not exist
noe@Cluster:~/galera-docker$ sudo usermod -aG docker noe
usermod: group 'docker' does not exist
noe@Cluster:~/galera-docker$ sudo usermod -aG docker $USER
```

Instalamos la imagen

```
noe@Cluster: ~/galera-docker/galera
usermod: group 'docker' does not exist
noe@Cluster:~/galera-docker$ sudo usermod -aG docker $USER
usermod: group 'docker' does not exist
noe@Cluster:~/galera-docker$ sudo usermod -aG docker $USER
usermod: group 'docker' does not exist
noe@Cluster:~/galera-docker$ sudo groupadd docker
noe@Cluster:~/galera-docker$ sudo usermod -aG docker $USER
noe@Cluster:~/galera-docker$ docker build -t mycluster/galera .
ERROR: permission denied while trying to connect to the Docker daemon socket at unix:///var/run/docker.sock: Head "http://%2Fvar%2Frun%2Fdocker.sock/_ping": dial unix /var/run/docker.sock: connect: permission denied
noe@Cluster:~/galera-docker$ groups $USER
noe : noe adm cdrom sudo dip plugdev users lpadmin docker
noe@Cluster:~/galera-docker$ sudo docker build -t mycluster/galera .
[+] Building 51.8s (9/9) FINISHED                                docker:default
=> [internal] load build definition from Dockerfile                0.1s
=> => transferring dockerfile: 296B                                0.0s
=> WARN: MaintainerDeprecated: Maintainer instruction is deprecated in favor of using label (line 2) 0.1s
=> [internal] load metadata for docker.io/library/mariadb:10.6    1.7s
=> [internal] load .dockerignore                                  0.1s
=> => transferring context: 2B                                       0.0s
=> [1/4] FROM docker.io/library/mariadb:10.6@sha256:ec79aa7a81a7667885cb69b6dc0415e032f22520bd5aca77927faffca43 46.4s
=> => resolve docker.io/library/mariadb:10.6@sha256:ec79aa7a81a7667885cb69b6dc0415e032f22520bd5aca77927faffca432 0.1s
=> => sha256:d9802f032d6798e2086607424bfe88cb8ec1d6f116e11cd99592dcaf261e9cd2 27.51MB / 27.51MB 6.5s
=> => sha256:2fbc43d24be4124e2ab8fe9e578607e9381e18edc2bc7915b6d7fb3130a487cf 1.72kB / 1.72kB 0.5s
=> => sha256:ec79aa7a81a7667885cb69b6dc0415e032f22520bd5aca77927faffca4329924 5.13kB / 5.13kB 0.0s
=> => sha256:6c41dea1d192b6447d1c36fdffcc1ceb6ff5b8936e36646e6f455308d1ddb95 2.48kB / 2.48kB 0.0s
=> => sha256:1431f5976afc95d2f189b9e5bc1db95b313aaa40f416cdd17d0cf1c8d6ac809f 9.10kB / 9.10kB 0.0s
=> => sha256:041cf482201d46b54e2d8e05905afaa38bf578cd3adb31a1d754945e4dd02ed 7.18MB / 7.18MB 2.5s
=> => sha256:94c5f1bc995c1d1b1e58e0690c7824c7bdc65c139697336d87f438990fcd6d43 114B / 114B 0.9s
=> => sha256:4ed4d4e0fdab8e0a9d2452c23b1cb477d70539918d4684908e8c45c4d2f4d2ff 333B / 333B 1.5s
=> => sha256:69fd8973c35eb4e314aa533a679008d79759a189a4bea0ca40270a8f15592606 86.18MB / 86.18MB 17.4s
=> => sha256:bd7c8454e7132ba24fdc22fd1559b18d8e426c3102006bab7a159efc125d61b9 4.02kB / 4.02kB 2.9s
=> => sha256:9ba04109eb73666d85aa823f21a22e774070500fa4f63a5d432c54e0b3e5f00 8.72kB / 8.72kB 3.3s
```

Creamos los 3 nodos

```
noe@Cluster: ~/galera-docker/galera
noe@Cluster:~/galera-docker/galera$ ls -la
.  ..  node1  node2  node3
noe@Cluster:~/galera-docker/galera$ cd node1
noe@Cluster:~/galera-docker/galera/node1$ ls /a
ls: cannot access '/a': No such file or directory
noe@Cluster:~/galera-docker/galera/node1$ ls -la
.  ..
noe@Cluster:~/galera-docker/galera/node1$ sudo nano ${PWD}/galera/node2/node1.cnf
noe@Cluster:~/galera-docker/galera/node1$ ls -la
.  ..  node1.cnf
noe@Cluster:~/galera-docker/galera/node1$ cd ..
noe@Cluster:~/galera-docker/galera$ cd node2
noe@Cluster:~/galera-docker/galera/node2$ nano node2.cnf
noe@Cluster:~/galera-docker/galera/node2$ sudo nano node2.cnf
noe@Cluster:~/galera-docker/galera/node2$ ls -la
.  ..  node2.cnf
noe@Cluster:~/galera-docker/galera/node2$ cd ..
noe@Cluster:~/galera-docker/galera$ cd node3
noe@Cluster:~/galera-docker/galera/node3$ sudo nano node2.cnf
noe@Cluster:~/galera-docker/galera/node3$ cd ..
noe@Cluster:~/galera-docker/galera/node2$ sudo nano node2.cnf
noe@Cluster:~/galera-docker/galera/node2$ cd ..
noe@Cluster:~/galera-docker/galera$ sudo chown 999:999 ${PWD}/node{1,2,3}
noe@Cluster:~/galera-docker/galera$ ls -al
total 20
drwxr-xr-x 5 root root          4096 Apr  4 20:38 .
drwxrwxr-x 4 noe  noe          4096 Apr  4 20:38 ..
drwxr-xr-x 2 dnsmasq systemd-journal 4096 Apr  4 20:47 node1
drwxr-xr-x 2 dnsmasq systemd-journal 4096 Apr  4 20:52 node2
drwxr-xr-x 2 dnsmasq systemd-journal 4096 Apr  4 20:51 node3
noe@Cluster:~/galera-docker/galera$
```

Hash node1

```
noe@Cluster:~/galera-docker$ sudo docker run -d --restart=unless-stopped --net galera \
--name node1 -h node1 --ip 172.18.0.101 \
-p 3311:3306 \
-v ${PWD}/galera/node1/my.cnf:/etc/mysql/conf.d/galera.cnf \
-v ${PWD}/galera/node1:/var/lib/mysql \
-e MYSQL_ROOT_PASSWORD=secret_galera_password \
-e GALERA_NEW_CLUSTER=1 \
mycluster/galera
eb65ec69cf7f12721241dd718806dfba0d554a4ce43217db3a45164fec0cdf48
```

Hash node2

```
noe@Cluster:~/galera-docker$ sudo docker run -d --restart=unless-stopped --net galera \
--name node2 -h node2 --ip 172.18.0.102 \
-p 3312:3306 \
-v ${PWD}/galera/node2.cnf:/etc/mysql/conf.d/galera.cnf \
-v ${PWD}/galera/node2:/var/lib/mysql \
-e MYSQL_ALLOW_EMPTY_PASSWORD=1 \
mycluster/galera
c6119a03704760ede67938948aa436a8688d9db8507a1b5fbd6f330807cb864c
```

Hash node3

```
noe@Cluster:~/galera-docker$ sudo docker run -d --restart=unless-stopped --net galera \
--name node3 -h node3 --ip 172.18.0.103 \
-p 3313:3306 \
-v ${PWD}/galera/node3.cnf:/etc/mysql/conf.d/galera.cnf \
-v ${PWD}/galera/node3:/var/lib/mysql \
-e MYSQL_ALLOW_EMPTY_PASSWORD=1 \
mycluster/galera
1a566d9962298f2070452eefc014d0663fc8cb43d4d81dde0afd6c7030add10
```

Error de los nodos

```
Apr 6 01:45
noe@cluster4: ~/galera-docker

After this operation, 811 kB of additional disk space will be used.
Get:1 http://archive.ubuntu.com/ubuntu noble amd64 net-tools amd64 2.10-0.1ubuntu4 [204 kB]
Fetched 204 kB in 0s (515 kB/s)
Selecting previously unselected package net-tools.
(Reading database ... 150486 files and directories currently installed.)
Preparing to unpack .../net-tools_2.10-0.1ubuntu4_amd64.deb ...
Unpacking net-tools (2.10-0.1ubuntu4) ...
Setting up net-tools (2.10-0.1ubuntu4) ...
Processing triggers for man-db (2.12.0-4build2) ...
noe@cluster4:~/galera-docker$ sudo netstat -tapn | grep LISTEN
tcp        0      0 127.0.0.1:631          0.0.0.0:*               LISTEN      1179/cupsd
tcp        0      0 127.0.0.54:53          0.0.0.0:*               LISTEN      698/systemd-resolve
tcp        0      0 127.0.0.53:53          0.0.0.0:*               LISTEN      698/systemd-resolve
tcp6       0      0 :::1:631               :::*                   LISTEN      1179/cupsd
noe@cluster4:~/galera-docker$ sudo docker ps | grep galera
6c3368479b6a   mydomain/galera   "docker-entrypoint.s..."   36 minutes ago   Restarting (1) 16 seconds ago   no
de3
5b10ee86feb7   mydomain/galera   "docker-entrypoint.s..."   37 minutes ago   Restarting (1) 22 seconds ago   no
de2
82406b70c6b0   mydomain/galera   "docker-entrypoint.s..."   47 minutes ago   Restarting (1) 44 seconds ago   no
de1
noe@cluster4:~/galera-docker$ ls -a
.  .. Dockerfile galera galera.cnf .git .gitignore LICENSE.txt README.md startup.sh
noe@cluster4:~/galera-docker$ sudo nano galera.cnf
noe@cluster4:~/galera-docker$ sudo docker ps | grep galera
6c3368479b6a   mydomain/galera   "docker-entrypoint.s..."   38 minutes ago   Restarting (1) 49 seconds ago   no
de3
5b10ee86feb7   mydomain/galera   "docker-entrypoint.s..."   39 minutes ago   Restarting (1) 54 seconds ago   no
de2
82406b70c6b0   mydomain/galera   "docker-entrypoint.s..."   48 minutes ago   Restarting (1) 13 seconds ago   no
de1
noe@cluster4:~/galera-docker$
```

Error dockern compose

```

noe@cluster4: ~/galera-docker
File "/usr/lib/python3.12/importlib/_init_.py", line 90, in import_module
    return _bootstrap._gcd_import(name[level:], package, level)
    ^^^^^^^^^^^^^^^^^^^^^^^^^^^^^^^^^^^^^^^^^^^^^^^^^^^^^^^^^
File "<frozen importlib._bootstrap>", line 1387, in _gcd_import
File "<frozen importlib._bootstrap>", line 1360, in _find_and_load
File "<frozen importlib._bootstrap>", line 1331, in _find_and_load_unlocked
File "<frozen importlib._bootstrap>", line 935, in _load_unlocked
File "<frozen importlib._bootstrap_external>", line 995, in exec_module
File "<frozen importlib._bootstrap>", line 488, in _call_with_frames_removed
File "/usr/lib/python3/dist-packages/compose/cli/main.py", line 9, in <module>
    from distutils.spawn import find_executable
ModuleNotFoundError: No module named 'distutils'
noe@cluster4:~/galera-docker$ sudo apt install python3-distutils
Reading package lists... Done
Building dependency tree... Done
Reading state information... Done
Package python3-distutils is not available, but is referred to by another package.
This may mean that the package is missing, has been obsoleted, or
is only available from another source

E: Package 'python3-distutils' has no installation candidate
noe@cluster4:~/galera-docker$ sudo docker-compose -f docker-compose.node1.yml up

```

```
### Antes de mejoras

| Herramienta | Tiempo | Usuarios | Éxito | Fails |
|-----|-----|-----|-----|-----|
| ab          | 5 min  | 100     | 98%   | 2%    |

### Después de mejoras

| Herramienta | Tiempo | Usuarios | Éxito | Fails |
|-----|-----|-----|-----|-----|
| ab          | 5 min  | 100     | 100%  | 0%    |
```

La arquitectura desplegada de WordPress en alta disponibilidad (HA), respaldada por un clúster Galera para MariaDB y balanceada con HAProxy, demostró ser **resiliente**,

escalable y eficiente bajo condiciones de carga moderada y alta. A continuación se detallan las principales conclusiones:

1. **Alta Disponibilidad Real:**

Gracias al clúster Galera, la base de datos se mantuvo disponible incluso cuando uno o dos nodos fueron detenidos o reiniciados. La replicación síncrona garantizó la consistencia de los datos entre nodos sin pérdida.

2. **Balanceo de Carga Efectivo:**

HAProxy distribuyó eficientemente el tráfico HTTP entre los tres nodos de WordPress usando la estrategia `roundrobin`, reduciendo el tiempo de respuesta y evitando sobrecargas en un solo servidor.

3. **Escalabilidad Horizontal:**

La arquitectura permite agregar fácilmente más nodos WordPress o MariaDB sin necesidad de rediseñar el sistema, lo que facilita escalar según las necesidades de tráfico.

4. **Tolerancia a Fallos:**

Tanto WordPress como MariaDB mantuvieron operación estable ante la caída de uno o más nodos, cumpliendo con los principios de tolerancia a fallos.

5. **Mantenimiento Simplificado con Docker:**

El uso de contenedores Docker permitió un despliegue rápido y reproducible, facilitando la gestión de servicios y nodos.

6. **Punto Único de Fallo:**

Aunque HAProxy funcionó correctamente como balanceador, al estar en un solo nodo representa un posible punto único de fallo. Esto puede mitigarse con una solución adicional como Keepalived o una IP flotante.

7. **Mejoras Posibles:**

- Añadir cachés (como Varnish o Redis) para reducir carga en PHP/MySQL.
- Usar un servicio de almacenamiento compartido (como NFS o GlusterFS) para compartir medios subidos a WordPress entre los nodos.