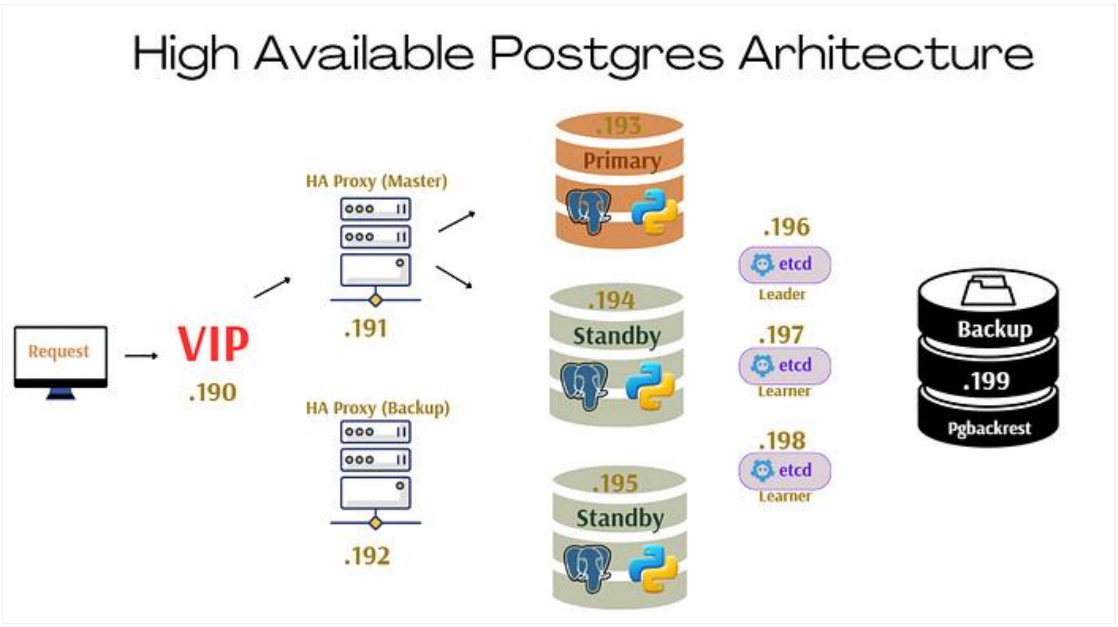
PostgreSQL with Patroni: Installation and Configuration

In this document, we will set up a PostgreSQL Patroni Cluster step by step. Our goal is to create a highly available PostgreSQL cluster. The installation process will follow these steps:

1. Etcd Cluster Installation
2. PostgreSQL + Patroni Installation
3. HAProxy + Keepalived Installation
4. pgBackRest Backup Solution Setup

We will use the following server infrastructure:

- .190 → VIP
- .191 → HAProxy Primary Node
- .192 → HAProxy Secondary Node
- .193 → PostgreSQL Node 1
- .194 → PostgreSQL Node 2
- .195 → PostgreSQL Node 3
- .196 → Etcd Node 1
- .197 → Etcd Node 2
- .198 → Etcd Node 3
- .199 → Backup Node



Now, let's proceed with the first step: Etcd Cluster Installation.

Etcd Installation

Etcd is a key-value store service used by Patroni for distributed database management. We will set up a three-node etcd cluster.

Step 1: Install Etcd Binaries

Perform the following steps on all etcd nodes:

```
dnf -y install curl wget vim

ETCD_RELEASE=$(curl -s https://api.github.com/repos/etcd-io/etcd/releases/latest | grep
tag_name | cut -d '"' -f 4)
echo $ETCD_RELEASE
wget https://github.com/etcd-io/etcd/releases/download/${ETCD_RELEASE}/etcd-
${ETCD_RELEASE}-linux-amd64.tar.gz
tar xvf etcd-${ETCD_RELEASE}-linux-amd64.tar.gz

cd etcd-${ETCD_RELEASE}-linux-amd64

mv etcd* /usr/local/binls /usr/local/bin

etcd --version
etcdctl version
etcdutl version
```

Step 2: Create Directories and Users

```
mkdir -p /var/lib/etcd/
mkdir /etc/etcd
groupadd --system etcd
useradd -s /sbin/nologin --system -g etcd etcd

chown -R etcd:etcd /var/lib/etcd/ && chmod 0775 /var/lib/etcd/
```

Step 3: Systemd Service File

```
# vi /etc/systemd/system/etcd.service
[Unit]
Description=Etcd - Highly Available Key Value Store

Documentation=man:etcd
After=network.target
Wants=networkonline.target

[Service]
Environment=DAEMON_ARGS=

Environment=ETCD_NAME=%H
Environment=ETCD_DATA_DIR=/var/lib/etcd/default
EnvironmentFile=/etc/etcd/etcd.conf
Type=notify
User=etcd
PermissionsStartOnly=true
ExecStart=/usr/local/bin/etcd $DAEMON_ARGS
Restart=on-abnormal
LimitNOFILE=65536
[Install]
WantedBy=multi-user.target
```

Step 4: Etcd Configuration

Etcd Node 1 (.196)

```
# cat /etc/etcd/etcd.conf

[Member]

ETCD_LISTEN_PEER_URLS="http://**.**.**.196:2380,http://localhost:2380"
ETCD_LISTEN_CLIENT_URLS="http://localhost:2379,http://**.**.**.196:2379"
ETCD_DATA_DIR="/var/lib/etcd/default"

[Clustering]

ETCD_INITIAL_ADVERTISE_PEER_URLS="http://**.**.**.196:2380"
ETCD_ADVERTISE_CLIENT_URLS="http://**.**.**.196:2379"
ETCD_INITIAL_CLUSTER="etcd1=http://**.**.**.196:2380,etcd2=http://**.**.**.197:2380,etcd3=http://**.**.**.198:2380"
```

```
ETCD_INITIAL_CLUSTER_TOKEN="etcd-cluster"
ETCD_INITIAL_CLUSTER_STATE="new"
ETCD_NAME="etcd1"
ETCD_ELECTION_TIMEOUT=5000
ETCD_HEARTBEAT_INTERVAL=1000
ETCD_ENABLE_V2=true
```

Etcd Node 2 (.197)

```
# cat /etc/etcd/etcd.conf

[Member]
ETCD_LISTEN_PEER_URLS="http://**.**.**.197:2380,http://localhost:2380"
ETCD_LISTEN_CLIENT_URLS="http://localhost:2379,http://**.**.**.197:2379"
ETCD_DATA_DIR="/var/lib/etcd/default"

[Clustering]
ETCD_INITIAL_ADVERTISE_PEER_URLS="http://**.**.**.196:2380"
ETCD_ADVERTISE_CLIENT_URLS="http://**.**.**.197:2379"
ETCD_INITIAL_CLUSTER="etcd1=http://**.**.**.196:2380,etcd2=http://**.**.**.197:2380,et
cd3=http://**.**.**.198:2380"
ETCD_INITIAL_CLUSTER_TOKEN="etcd-cluster" ETCD_INITIAL_CLUSTER_STATE="new"
ETCD_NAME="etcd2"
ETCD_ELECTION_TIMEOUT=5000
ETCD_HEARTBEAT_INTERVAL=1000
ETCD_ENABLE_V2=true
```

Etcd Node 3 (.198)

```
# cat /etc/etcd/etcd.conf
[Member]

ETCD_LISTEN_PEER_URLS="http://**.**.**.198:2380,http://localhost:2380"
ETCD_LISTEN_CLIENT_URLS="http://localhost:2379,http://**.**.**.198:2379"
ETCD_DATA_DIR="/var/lib/etcd/default"

[Clustering]

ETCD_INITIAL_ADVERTISE_PEER_URLS="http://**.**.**.198:2380"
ETCD_ADVERTISE_CLIENT_URLS="http://**.**.**.198:2379"
ETCD_INITIAL_CLUSTER="etcd1=http://**.**.**.196:2380,etcd2=http://**.**.**.197:2380,et
cd3=http://**.**.**.198:2380"
ETCD_INITIAL_CLUSTER_TOKEN="etcd-cluster"
ETCD_INITIAL_CLUSTER_STATE="new"
ETCD_NAME="etcd3"
ETCD_ELECTION_TIMEOUT=5000
ETCD_HEARTBEAT_INTERVAL=1000
ETCD_ENABLE_V2=true
```

Step 4: Start Etcd Service

```
Copysystemctl enable etcd
systemctl start etcd
systemctl status etcd
```

Step 5: Verify Etcd Cluster Status

```
etcdctl member list

etcdctl --endpoints=**.**.**.196:2379,**.**.**.197:2379,**.**.**.198:2379 endpoint status
--write-out=table

Expected output:
+------------------+------------------+---------+---------+-----------+------------+-----------+------------+----------
----------+--------+
|    ENDPOINT      |        ID        | VERSION | DB SIZE | IS LEADER | IS LEARNER | RAFT TERM |
RAFT INDEX | RAFT APPLIED INDEX | ERRORS |
+------------------+------------------+---------+---------+-----------+------------+-----------+------------+----------
----------+--------+
| **.**.**.196:2379 | 84ebce0bfc393c1 |  3.5.11 |   29 kB |     false |      false |        40 |
100512574 |          100512574 |        |
| **.**.**.197:2379 | 76d84aedaf38bba4 |  3.5.11 |   29 kB |      true |      false |        40 |
100512574 |          100512574 |        |
| **.**.**.198:2379 | b3d60bce62f139c |  3.5.11 |   29 kB |     false |      false |        40 |
100512574 |          100512574 |        |
+------------------+------------------+---------+---------+-----------+------------+-----------+------------+----------
----------+--------+
```

Patroni Installation Guide

Step 1: Installing Required Packages

```
# apply each postgres node
dnf -y install https://dl.fedoraproject.org/pub/epel/epel-release-latest-9.noarch.rpm
#(https://yum.postgresql.org/)

dnf install -y https://download.postgresql.org/pub/repos/yum/reporpms/EL-9-x86_64/pgdg-
redhat-repo-latest.noarch.rpm
dnf -qy module disable postgresq

l# Install PostgreSQL:

dnf install -y postgresql13-server
dnf install -y postgresql13-contrib
dnf install -y postgresql13-devel# Install Patroni
yum install patroni
yum install python3-urllib3
yum install patroni-etcd.x86_64
```

```
cp -p /usr/share/doc/patroni/postgres0.yml /etc/patroni/patroni.yml
```

Step 2: Node 1 (.193) Configuration

```
#vi /etc/patroni/patroni.yml----------------------------

scope: clusternamespace: /var/lib/pgsql/config/name: node1restapi:
  listen: **.**.**.193:8008
  connect_address: **.**.**.193:8008etcd:
  host: **.**.**.196:2379
  host: **.**.**.197:2379
  host: **.**.**.198:2379bootstrap:
 dcs:
  ttl: 30
  loop_wait: 10
  retry_timeout: 10
  maximum_lag_on_failover: 1048576
  postgresql:
   use_pg_rewind: true
   use_slots: true
   parameters:
 initdb:
 - encoding: UTF8
 - data-checksums
 - waldir: /pg_wal
 - wal-segsize=512
 pg_hba:
 - host replication replicator 127.0.0.1/32 scram-sha-256
 - host replication replicator **.**.**.193/32 scram-sha-256
 - host replication replicator **.**.**.194/32 scram-sha-256
 - host replication replicator **.**.**.195/32 scram-sha-256
 - host all all **.**.**.***/24 scram-sha-256

# Please separate your database usage per node per IP block for system security
 users:
  admin:
   password: admin
   options:
    - createrole
    - createdbpostgresql:
 listen: **.**.**.193:5432
 connect_address: **.**.**.193:5432
 data_dir: /pg_data/data
 bin_dir: /usr/pgsql-13/bin
 pgpass: /tmp/pgpass
 authentication:
  replication:
   username: replicator
   password: test123
  superuser:
   username: postgres
```

```
    password: test123
  create_replica_methods:
    - pgbackrest
    - basebackup
  pgbackrest:
   command: pgbackrest --stanza=pg_backup restore --type=none
   keep_data: True
   no_params: True
  basebackup:
    checkpoint: 'fast'tags:
    nofailover: false
    noloadbalance: false
    clonefrom: false
    nosync: false
```

Step 3: Node 2 (.194) Configuration

```
# vi /etc/patroni/patroni.yml---------------------------

scope: cluster
namespace: /var/lib/pgsql/config/
name: node2

restapi:
    listen: **.**.**.194:8008
    connect_address: **.**.**.194:8008

etcd:
    host: **.**.**.196:2379
    host: **.**.**.197:2379
    host: **.**.**.198:2379

bootstrap:

  dcs:
    ttl: 30
    loop_wait: 10
    retry_timeout: 10
    maximum_lag_on_failover: 1048576
    postgresql:
      use_pg_rewind: true
      use_slots: true
      parameters:
  initdb:
  - encoding: UTF8
  - data-checksums
  - waldir: /pg_wal
  - wal-segsize=512
  pg_hba:
  - host replication replicator 127.0.0.1/32 scram-sha-256
```

```
 - host replication replicator **.**.**.193/32 scram-sha-256
 - host replication replicator **.**.**.194/32 scram-sha-256
 - host replication replicator **.**.**.195/32 scram-sha-256
 - host all all **.**.**.***/24 scram-sha-256

# Please separate your database usage per node per IP block for system security
 users:
   admin:
     password: admin
     options:
       - createrole
       - createdbpostgresql:
 listen: **.**.**.194:5432
 connect_address: **.**.**.194:5432
 data_dir: /pg_data/data
 bin_dir: /usr/pgsql-13/bin
 pgpass: /tmp/pgpass
 authentication:
   replication:
     username: replicator
     password: test123
   superuser:
     username: postgres
     password: test123
 create_replica_methods:
   - pgbackrest
   - basebackup
 pgbackrest:
  command: pgbackrest --stanza=pg_backup restore --type=none
  keep_data: True
  no_params: True
 basebackup:
   checkpoint: 'fast'tags:
   nofailover: false
   noloadbalance: false
   clonefrom: false
   nosync: false
```

Step 4: Node 3 (.195) Configuration

```
Copy# vi /etc/patroni/patroni.yml----------------------------
scope: cluster
namespace: /var/lib/pgsql/config/
name: node3
restapi:
   listen: **.**.**.195:8008
   connect_address: **.**.**.195:8008

etcd:
   host: **.**.**.196:2379
```

```
    host: **.**.**.197:2379
    host: **.**.**.198:2379

bootstrap:
  dcs:
    ttl: 30
    loop_wait: 10
    retry_timeout: 10
    maximum_lag_on_failover: 1048576
    postgresql:
      use_pg_rewind: true
      use_slots: true
      parameters:
  initdb:
  - encoding: UTF8
  - data-checksums
  - waldir: /pg_wal
  - wal-segsize=512
  pg_hba:
  - host replication replicator 127.0.0.1/32 scram-sha-256
  - host replication replicator **.**.**.193/32 scram-sha-256
  - host replication replicator **.**.**.194/32 scram-sha-256
  - host replication replicator **.**.**.195/32 scram-sha-256
  - host all all **.**.**.***/24 scram-sha-256

# Please separate your database usage per node per IP block for system security
  users:
    admin:
      password: admin
      options:
        - createrole
        - createdbpostgresql:
  listen: **.**.**.195:5432
  connect_address: **.**.**.195:5432
  data_dir: /pg_data/data
  bin_dir: /usr/pgsql-13/bin
  pgpass: /tmp/pgpass
  authentication:
    replication:
      username: replicator
      password: test123
    superuser:
      username: postgres
      password: test123
  create_replica_methods:
    - pgbackrest
    - basebackup
  pgbackrest:
   command: pgbackrest --stanza=pg_backup restore --type=none
   keep_data: True
   no_params: True
  basebackup:
    checkpoint: 'fast'tags:
    nofailover: false
    noloadbalance: false
    clonefrom: false
    nosync: false
```

Step 5: Start Patroni Service

```
systemctl enable patroni
systemctl start patroni
systemctl status patroni
```

Step 6: Check Cluster Status

```
patronictl -c /etc/patroni/patroni.yml list

Expected Output:

+ Cluster: cluster --+---------+-----------+----+-----------+
| Member   | Host        | Role    | State     | TL | Lag in MB |
+----------+-------------+---------+-----------+----+-----------+
| node1    | **.**.**.193 | Replica | streaming |  2 |         0 |
| node2    | **.**.**.194 | Leader  | running   |  2 |           |
| node3    | **.**.**.195 | Replica | streaming |  2 |         0 |
+----------+-------------+---------+-----------+----+-----------+
```

HAProxy Installation

Step 1: Installing Required Package

```
dnf install haproxy.x86_64
```

Step 2: Configure HAProxy for Primary Node

```
# vim /etc/haproxy/haproxy.cfg

#for master haproxy node

global
   maxconn 1000
   log 127.0.0.1 local0
defaults
   log global
   mode tcp
   retries 2
   timeout client 20m
   timeout connect 4s
   timeout server 20m
   timeout check 5slisten stats
   mode http
   bind *:7000
   stats enable
   stats uri /
frontend a_listen_fe#bind *:5000#bind *:5001
acl is-read-service-dead nbsrv(standby) lt 1
use_backend postgres if is-read-service-dead
default_backend standby
listen postgres
      bind **.**.**.190:5000
      option httpchk OPTIONS/master
      http-check expect status 200
      default-server inter 3s fall 4 rise 3 on-marked-down shutdown-sessions
      server node1 **.**.**.193:5432 maxconn 1000 check port 8008
      server node2 **.**.**.194:5432 maxconn 1000 check port 8008
      server node3 **.**.**.195:5432 maxconn 1000 check port 8008
      server node4 **.**.**.199:5432 maxconn 1000 check backup port 8008listen standby
      bind **.**.**.190:5001
      option httpchk OPTIONS/replica
      http-check expect status 200
      default-server inter 3s fall 4 rise 3 on-marked-down shutdown-sessions
      server node1 **.**.**.193:5432 maxconn 1000 check port 8008
      server node2 **.**.**.194:5432 maxconn 1000 check port 8008
      server node3 **.**.**.195:5432 maxconn 1000 check port 8008
```

Step 3: Configure HAProxy for Secondary Node

```
#for Secondary haproxy node
# -----------------------

global
   maxconn 100
   log 127.0.0.1 local0
defaults
   log global
   mode tcp
   retries 2
   timeout client 120m
   timeout connect 4s
   timeout server 120m
   timeout check 5s
listen stats
   mode http
   bind *:7000
   stats enable
   stats uri /
frontend a_listen_fe#bind *:5000#bind *:5000
acl is-read-service-dead nbsrv(standby) lt 1
use_backend postgres if is-read-service-dead
```

```
default_backend standby
listen postgres
       bind **.**.**.190:5000
       option httpchk OPTIONS/master
       http-check expect status 200
       default-server inter 3s fall 4 rise 3 on-marked-down shutdown-sessions
       server node1 **.**.**.193:5432 maxconn 1000 check port 8008
       server node2 **.**.**.194:5432 maxconn 1000 check port 8008
       server node3 **.**.**.195:5432 maxconn 1000 check port 8008
       server node4 **.**.**.199:5432 maxconn 1000 check backup port 8008listen standby
       bind **.**.**.190:5001
       option httpchk OPTIONS/replica
       http-check expect status 200
       default-server inter 3s fall 4 rise 3 on-marked-down shutdown-sessions
       server node1 **.**.**.193:5432 maxconn 1000 check port 8008
       server node2 **.**.**.194:5432 maxconn 1000 check port 8008
       server node3 **.**.**.195:5432 maxconn 1000 check port 8008
```

Step 4: Ceck HAProxy Status

```
systemctl start haproxy.service
systemctl status haproxy.service
systemctl enable haproxy.service
```

Keepalived Installation

Step 1: Installing Required Package

```
dnf install keepalived.x86_64
```

Step 2: Configure Keepalived for Primary Node

```
#for Primary haproxy node
#----------------------
# vi /etc/keepalived/keepalived.conf

global_defs {}
vrrp_script chk_haproxy {
   script "killall -0 haproxy" # widely used idiom
   interval 2 # check every 2 seconds
   weight 2 # add 2 points of prio if OK}
vrrp_instance VI_1 {
   interface ens192
   state MASTER
   priority 101
   virtual_router_id 51
   authentication {
       auth_type PASS
       auth_pass test123
   }
   virtual_ipaddress {
       **.**.**.190/24
```

```
  }
  unicast_src_ip **.**.**.191  # This node
  unicast_peer {
  **.**.**.192              # Other nodes
  }
  track_script {
    chk_haproxy
  }}
```

Step 3: Configure Keepalived for Secondary Node

```

#for Secondary haproxy node
#-----------------------
# vi /etc/keepalived/keepalived.conf

global_defs {}
vrrp_script chk_haproxy {
  script "killall -0 haproxy" # widely used idiom
  interval 2 # check every 2 seconds
  weight 2 # add 2 points of prio if OK}
vrrp_instance VI_1 {
  interface ens192
  state BACKUP
  priority 99
  virtual_router_id 51
  authentication {
    auth_type PASS
    auth_pass test123
  }
  virtual_ipaddress {
    **.**.**.190/24
  }
  unicast_src_ip **.**.**.192  # This node
  unicast_peer {
  **.**.**.191              # Other nodes
  }
  track_script {
    chk_haproxy
  }}
```

Step 4: Ceck Keepalived Status

```
systemctl start keepalived
systemctl status keepalived
systemctl enable keepalived
```

pgBackRest Installation

Step 1: Installing the Required Package

```
yum install pgbackrest
```

Step 2: Configure pgBackRest on Backup Node

```
vi /etc/pgbackrest.conf

[global]
repo1-path=/pg_backup/pg_backup_patroni
repo1-retention-full=14
repo1-retention-full-type=time
repo1-host-user=pgbackrest
archive-check=n
process-max=1
log-level-console=info
log-path=/pg_backup/pgbackrest/log
log-level-file=debug
start-fast=y
delta=y
compress-level=3
[pg_backup]
pg1-host=**.**.**.193
pg1-host-user=postgres
pg1-database=postgres
pg1-path=/pg_data/data
pg1-port=5432
pg2-host=**.**.**.194
pg2-host-user=postgres
pg2-database=postgres
pg2-path=/pg_data/data
pg2-port=5432
pg3-host=**.**.**.195
pg3-host-user=postgres
pg3-database=postgres
pg3-path=/pg_data/data
pg3-port=5432
```

Step 3: Configure PostgreSQL Nodes

For node1, edit the Patroni configuration file:

```
patronictl -c /etc/patroni/patroni.yml edit-config
# Add the following archive_command:
archive_command = 'pgbackrest --stanza=pg_backup archive-push %p && cp -i %p
/var/lib/pgsql/archive/%f'
```

Also, configure the pgBackRest settings for node1 in /etc/pgbackrest.conf:

```
# Repeat similar configurations for node2 and node3.

[global]
repo1-host=**.**.**.199
repo1-host-user=pgbackrest
log-level-console=info
```

```
log-level-file=debugdelta=y
[pg_backup]
pg1-path=/pg_data/data
recovery-option=primary_conninfo=host=**.**.**.190 user=replication
```

Repeat similar configurations for node2 and node3.

Step 4: Initialize the pgBackRest Stanza on the Backup Node

```
pgbackrest --stanza=pg_backup stanza-create
pgbackrest --stanza=pg_backup check --log-level-console=info
```

Step 5: Run Full and Incremental Backups

```
pgbackrest --stanza=pg_backup --type=full backup
# For incremental backups
pgbackrest --stanza=pg_backup --type=incr backup
```

Step 6: Check the Status of pgBackRest Backups

```
pgbackrest --stanza=pg_backup info
```

Conclusion

In this guide, we've successfully walked through the setup of a highly available PostgreSQL cluster using Patroni. By configuring the Etcd cluster for distributed configuration management, setting up PostgreSQL with Patroni for automatic failover and replication, and implementing HAProxy and Keepalived for load balancing and high availability, we ensure a resilient and fault-tolerant system. Additionally, by integrating pgBackRest for backup solutions, we've set up a reliable mechanism for disaster recovery, which is crucial for maintaining data integrity and availability. This high availability setup ensures that even if one or more nodes fail, the cluster can continue to function seamlessly, minimizing downtime and ensuring business continuity.