Escalabilidade Horizontal com Postgres-XL

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PgConf Brasil 2018

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- **Parte 2: Desempenho**
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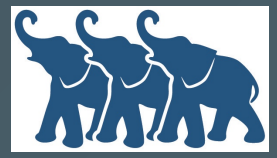
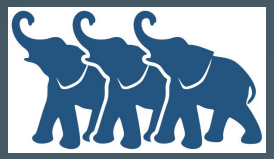
Parte 1: Conceitos

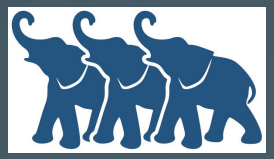


O que é Postgres-XL?



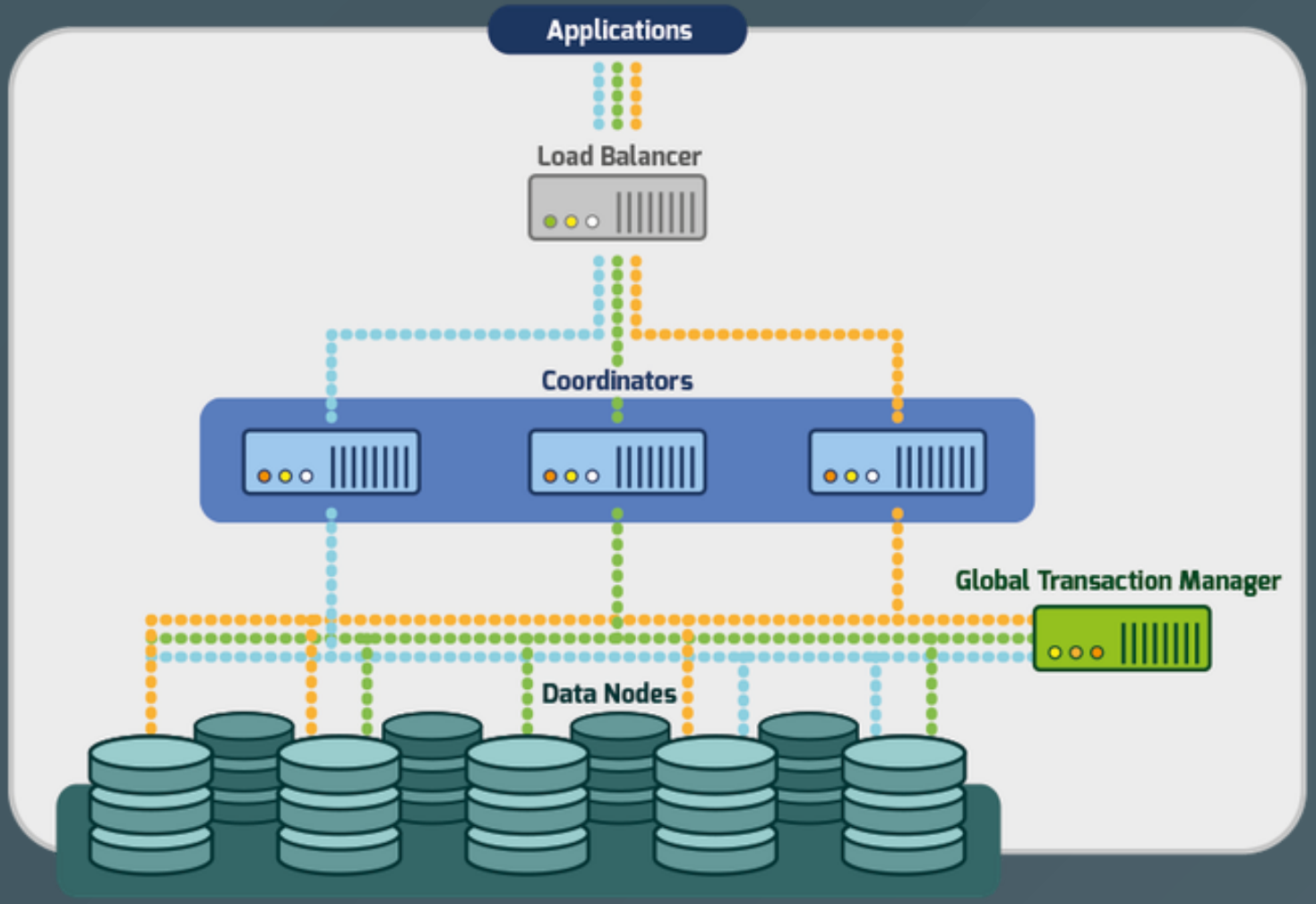
- É uma versão do PostgreSQL
  - **Melhor desempenho**
  - **Melhor escalabilidade**
- Open Source
- Mesma licença que o PostgreSQL
- Desenvolvimento iniciou há muitos anos, muitas pessoas e empresas envolvidas

O que é Postgres-XL?

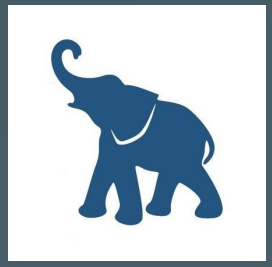


- **Scale-Out**
- Escalabilidade de leitura e escrita
  - Queries maiores divididas igualmente
  - Queries de apenas 1 chave tocam apenas 1 nodo
- **MPP**: Massive Parallel Processing
- Cluster-wide **ACID**
- **Big Data**

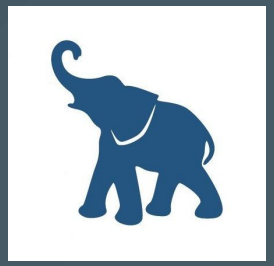
Arquitetura



Coordinator

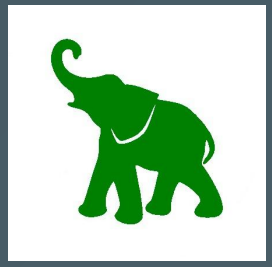


Coordinator

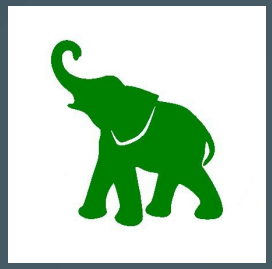


- **Parsing** and **planning** para queries
- Sabe como as tabelas estão distribuídas e usa essa informação para o planejamento
- Aplicações se conectam a ele
- É possível ter vários no mesmo cluster
- Não existe coordinator "mestre"
- Não é um componente crítico para o cluster

Datanode

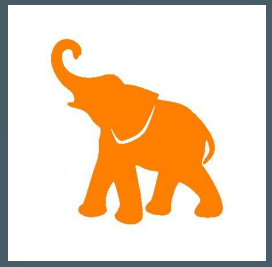


Datanode

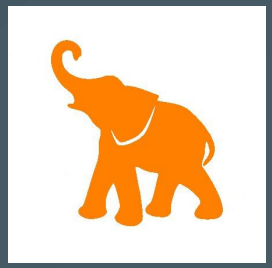


- Onde os dados são armazenados
- Execução local de consultas
- **Aplicações não se conectam a ele!!**
- Componente crítico para o cluster
  - Cada datanode pode ter vários **standbys**
- Falha de um nodo pode causar **erro** em DML/DDL (se a tabela não for replicada, erro em DQL também)

GTM



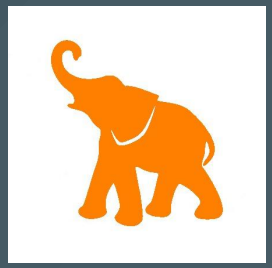
GTM



- **Global Transaction Manager**
- Componente central e único no cluster
- **GXID**: identificadores de transação globalmente visíveis e consistentes
- **Snapshots** para transações sendo executadas no cluster inteiro
- Graças a ele o cluster é totalmente **ACID**

GTM

- **SPOF??**



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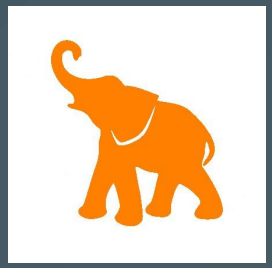
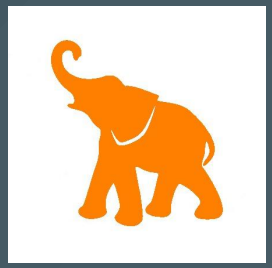


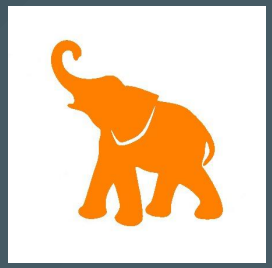
- **SPOF??**
  - Sim.

GTM



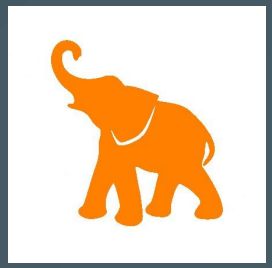
- **SPOF??**
  - Sim.
  - Solução: **GTM Standby**

GTM



- **Performance bottleneck??**

GTM



- **Performance bottleneck??**
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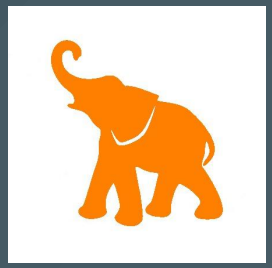
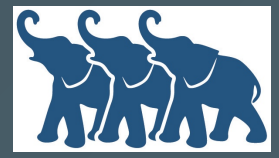
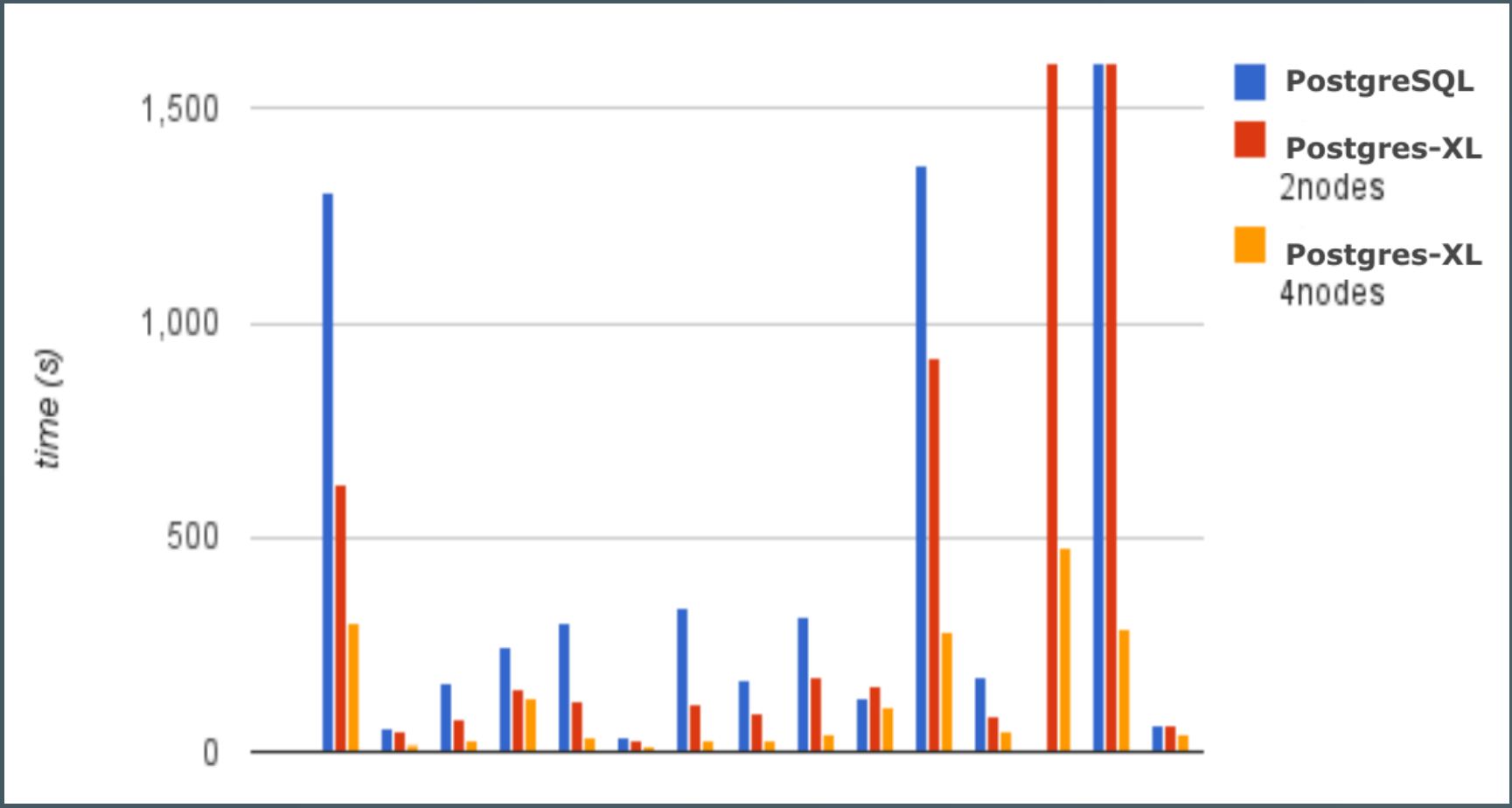


- **Performance bottleneck??**
  - Sim.
  - Solução: **GTM Proxy**
    - Roda no mesmo servidor físico que o Datanode ou Coordinator
    - Agrupa requisições e manda uma só vez
    - Recebe uma range de GXID e snapshots do GTM

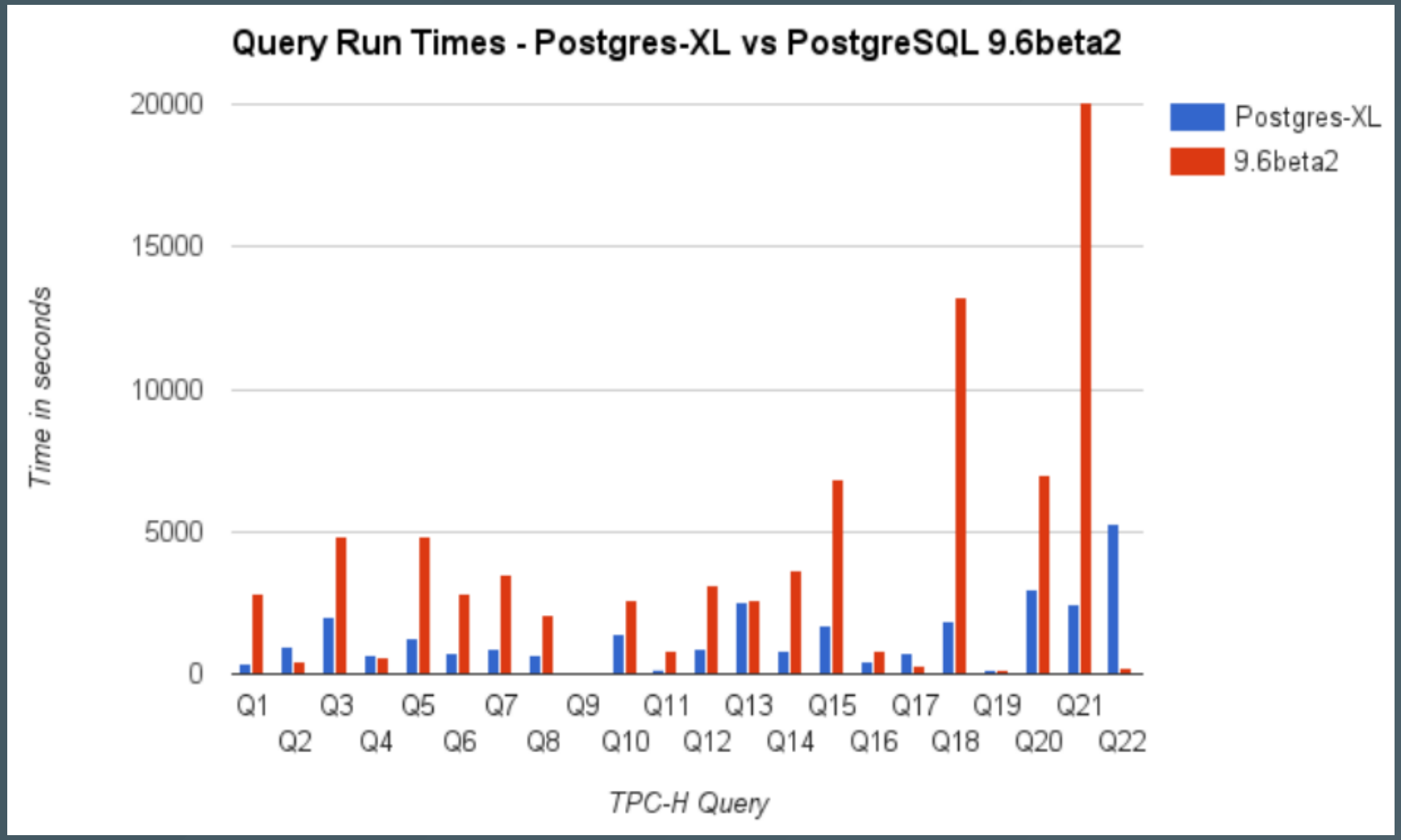
Parte 2: Desempenho



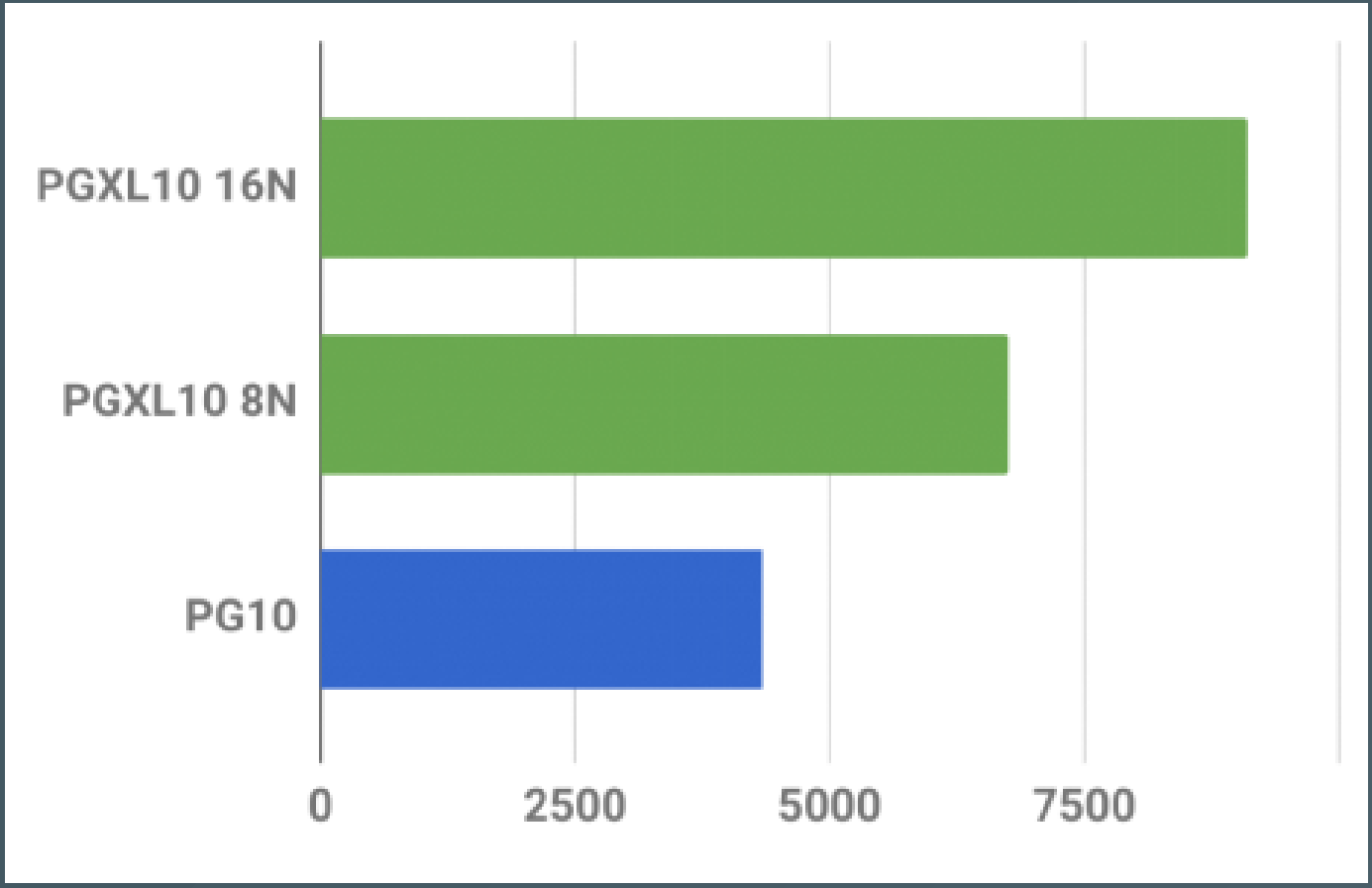
Desempenho PGXL 9.5



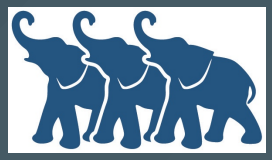
Desempenho PGXL 9.6



Desempenho PGXL 10

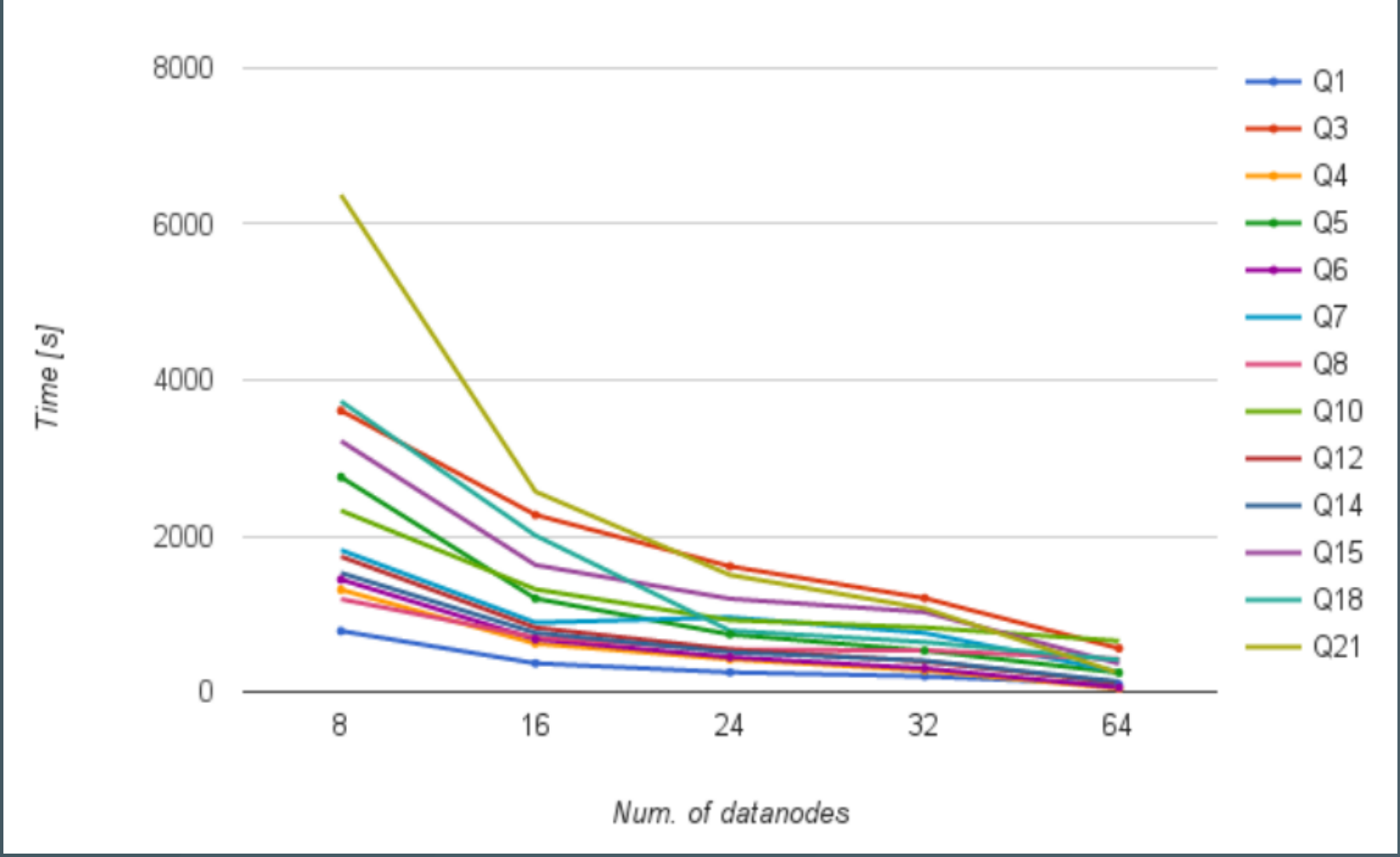


Desempenho Escalável

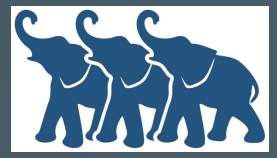


- Custo do Paralelismo: **~30% overhead** (TPC-W workload)
- Cluster com 1 GTM, 1 Coordinator, 1 Datanode:
  - **70%** do desempenho do "vanilla" PostgreSQL
- **10 nodos** deveria ter **desempenho 7x maior** que o do PostgreSQL
- Resultado atual: **6x - 6.4x**
- Mais nodos, mais transações abertas, maiores snapshots e maior verificação de visibilidade

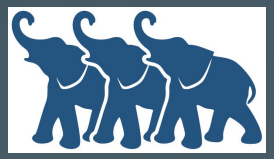
Desempenho Escalável



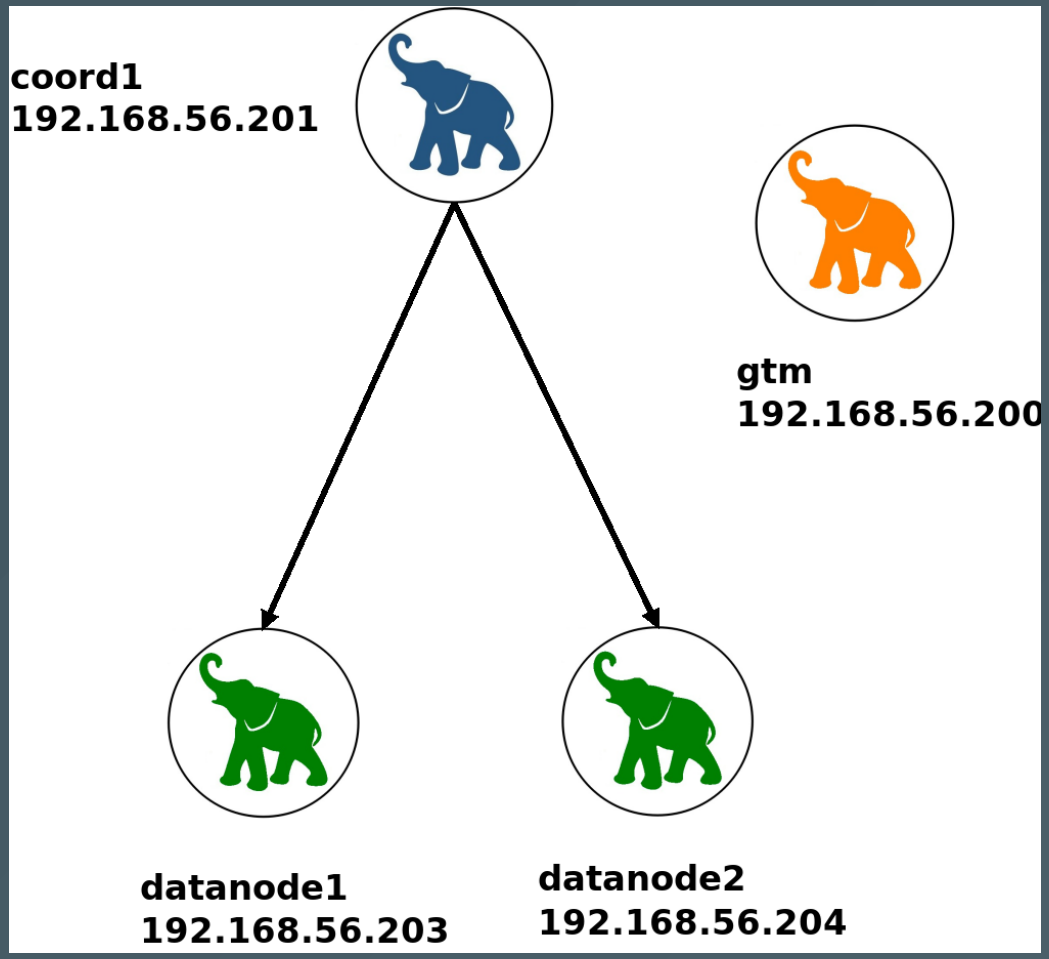
Parte 3: Instalação



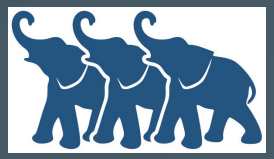
Instalação



- Cluster:
  - 1 GTM
  - 1 coordinator
  - 2 datanodes



Em todos os nodos



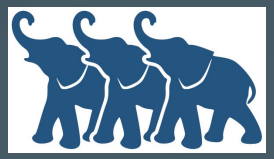
- Instalar dependências:

```
apt-get update
apt-get -y upgrade
apt-get -y install build-essential git bison flex \
        libreadline-dev zlib1g-dev
```

- Clonar repositório:

```
git clone git://git.postgresql.org/git/postgres-xl.git
cd postgres-xl
git checkout XL9_5_STABLE
```

Em todos os nodos



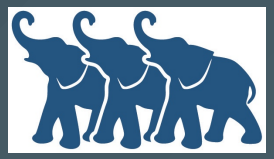
- Compilar:

```
./configure
make -j4
make install
cd contrib
make -j4
make install
```

- Adicionar `/usr/local/pgsql/bin` ao `$PATH`:

```
echo "PATH=/usr/local/pgsql/bin:$PATH" > /etc/environment
```

Em todos os nodos



- Criar usuário `postgres`:

```
useradd -m -s /bin/bash -U postgres
```

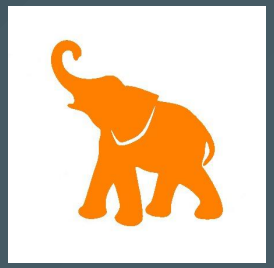
- Criar data folder:

```
mkdir /usr/local/pgsql/data
chown postgres /usr/local/pgsql/data
```

- Logar como `postgres`:

```
su postgres
```

GTM



- Inicializar diretório de dados:

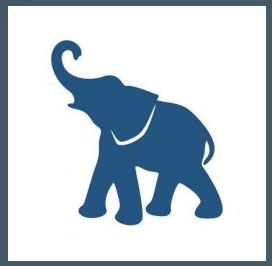
```
initgtm -D /usr/local/pgsql/data -Z gtm
```

Porta padrão é `6666`. É possível mudar a porta e outras opções no arquivo `gtm.conf`.

- Iniciar GTM:

```
gtm_ctl -Z gtm -D /usr/local/pgsql/data -l logfile start
```

Coordinator 1



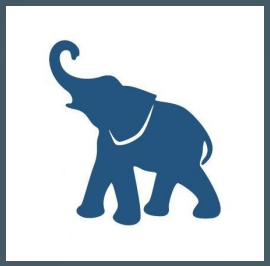
- Inicializar diretório de dados:

```
initdb -D /usr/local/pgsql/data --nodename coord1
```

- Alterar `postgresql.conf`:

```
listen_addresses = '*'
pooler_port = 40100                 # único para cada node
gtm_host = '192.168.56.200'
gtm_port = 6666
```

Coordinator 1



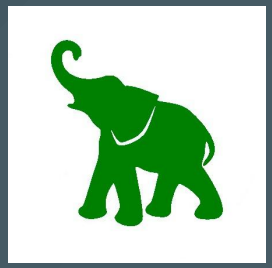
- Alterar `pg_hba.conf`:

```
local all postgres                      trust
host  all postgres 127.0.0.1/32         trust
host  all postgres ::1/128              trust
host  all postgres 192.168.56.203/32 trust # Datanode 1
host  all postgres 192.168.56.204/32 trust # Datanode 2
host  all all      192.168.56.1/32   md5
```

- Iniciar coordinator 1:

```
pg_ctl -D /usr/local/pgsql/data -Z coordinator \
       -l logfile start
```

Datanode 1



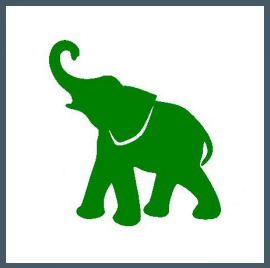
- Inicializar diretório de dados

```
initdb -D /usr/local/pgsql/data --nodename datanode1
```

- Alterar `postgresql.conf`:

```
listen_addresses = '*'
pooler_port = 40102                 # único para cada node
gtm_host = '192.168.56.200'
gtm_port = 6666
```

Datanode 1



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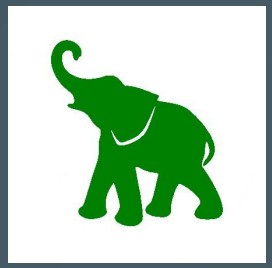
```
local all postgres                      trust
host  all postgres 127.0.0.1/32         trust
host  all postgres ::1/128              trust
host  all postgres 192.168.56.201/32 trust # Coord 1
host  all postgres 192.168.56.204/32 trust # Datanode 2
host  all all      192.168.56.1/32   md5
```

- Iniciar datanode 1:

```
pg_ctl -D /usr/local/pgsql/data -Z datanode \
       -l logfile start
```

Datanode 2



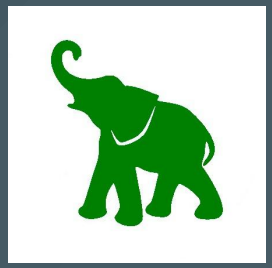
- Inicializar diretório de dados

```
initdb -D /usr/local/pgsql/data --nodename datanode2
```

- Alterar `postgresql.conf`:

```
listen_addresses = '*'
pooler_port = 40103                 # único para cada node
gtm_host = '192.168.56.200'
gtm_port = 6666
```

Datanode 2



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```
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host  all postgres ::1/128              trust
host  all postgres 192.168.56.201/32 trust # Coord 1
host  all postgres 192.168.56.203/32 trust # Datanode 1
host  all all      192.168.56.1/32   md5
```
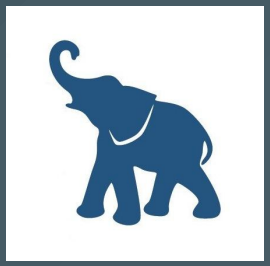

- Iniciar datanode 2:

```
pg_ctl -D /usr/local/pgsql/data -Z datanode \
       -l logfile start
```

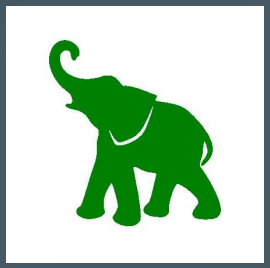
Coordinator 1



- Criar todos os nodes:

```
ALTER NODE coord1 WITH (TYPE = 'coordinator',
        HOST = 'localhost', PORT = 5432);

CREATE NODE datanode1 WITH (TYPE = 'datanode',
        HOST = '192.168.56.203', PORT = 5432);

CREATE NODE datanode2 WITH (TYPE = 'datanode',
        HOST = '192.168.56.204', PORT = 5432);

SELECT pgxc_pool_reload();
```

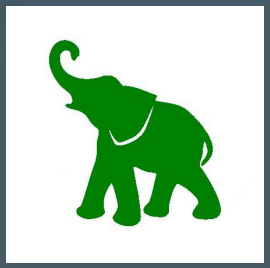
Datanode 1



- Criar todos os nodes:

```
ALTER NODE datanode1 WITH (TYPE = 'datanode',
        HOST = 'localhost', PORT = 5432);

CREATE NODE coord1 WITH (TYPE = 'coordinator',
        HOST = '192.168.56.201', PORT = 5432);

CREATE NODE datanode2 WITH (TYPE = 'datanode',
        HOST = '192.168.56.204', PORT = 5432);

SELECT pgxc_pool_reload();
```

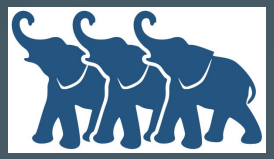
Datanode 2



- Criar todos os nodes:

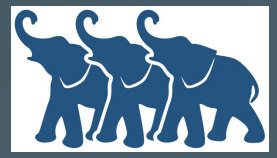
```
ALTER NODE datanode2 WITH (TYPE = 'datanode',
        HOST = 'localhost', PORT = 5432);

CREATE NODE coord1 WITH (TYPE = 'coordinator',
        HOST = '192.168.56.201', PORT = 5432);

CREATE NODE datanode1 WITH (TYPE = 'datanode',
        HOST = '192.168.56.203', PORT = 5432);

SELECT pgxc_pool_reload();
```

Pronto!

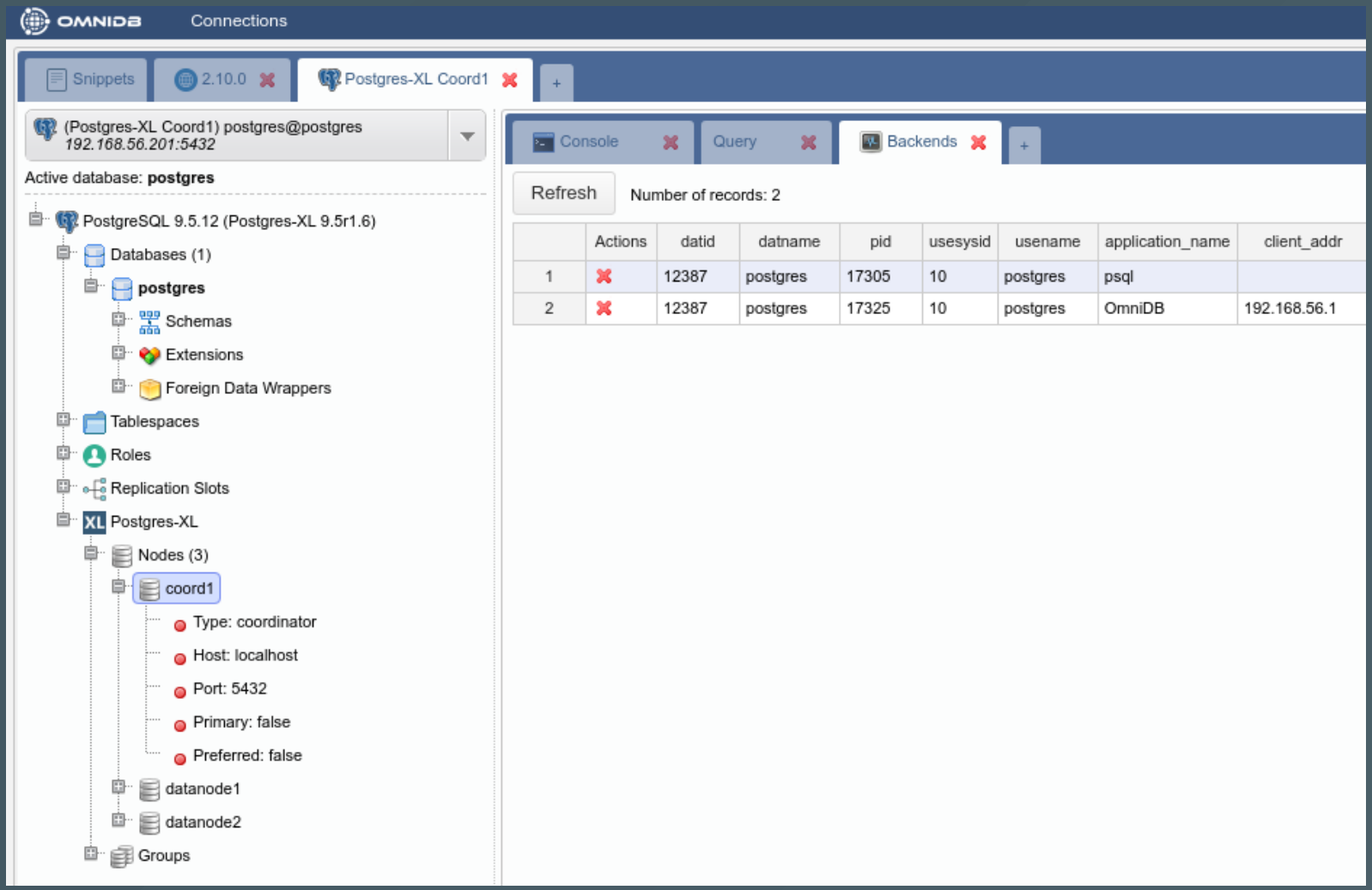


- Agora seu cluster XL está pronto para uso
- Teria sido mais fácil usar `pgxc_ctl` (recomendado também para clusters muito grandes)
- Agora você pode:
  - Mudar a senha do usuário `postgres`
  - Criar tabelas e começar a alimentar o cluster
  - Usar `pg_dump`/`pg_restore` para migrar de uma instância PostgreSQL existente

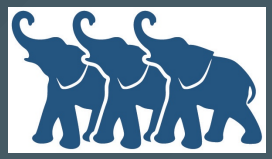
Parte 4: Utilização



Conectando ao cluster



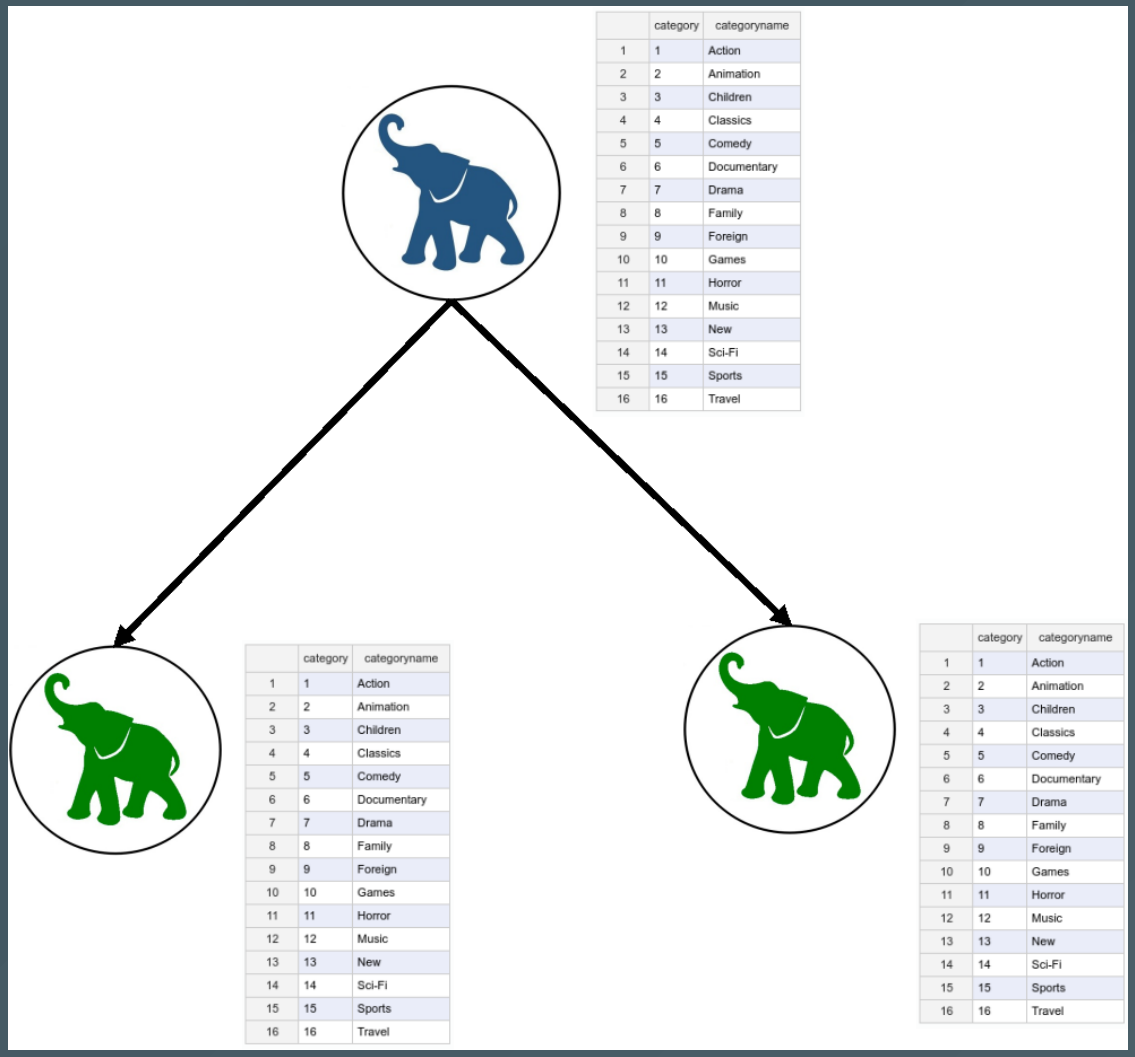
Tabelas Replicadas



- Cada registro existe em **todos os datanodes**
- Bom para tabelas **read-only** e **read-mainly**

```
CREATE TABLE categories
(
    category integer NOT NULL,
    categoryname character varying(50) NOT NULL,
    CONSTRAINT categories_pkey PRIMARY KEY (category)
)
DISTRIBUTE BY REPLICATION;
```

Tabelas Replicadas



	category	categoryname
1	1	Action
2	2	Animation
3	3	Children
4	4	Classics
5	5	Comedy
6	6	Documentary
7	7	Drama
8	8	Family
9	9	Foreign
10	10	Games
11	11	Horror
12	12	Music
13	13	New
14	14	Sci-Fi
15	15	Sports
16	16	Travel

	category	categoryname
1	1	Action
2	2	Animation
3	3	Children
4	4	Classics
5	5	Comedy
6	6	Documentary
7	7	Drama
8	8	Family
9	9	Foreign
10	10	Games
11	11	Horror
12	12	Music
13	13	New
14	14	Sci-Fi
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	category	categoryname
1	1	Action
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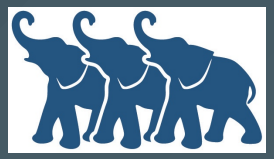
8	8	Family
9	9	Foreign
10	10	Games
11	11	Horror
12	12	Music
13	13	New
14	14	Sci-Fi
15	15	Sports
16	16	Travel

Tabelas Replicadas



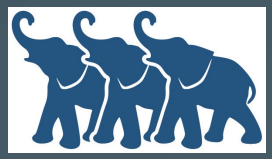
- Datanodes podem ser especificados como `PRIMARY` ou `PREFERRED`
- `PRIMARY` significa que será escrito primeiro

```
ALTER NODE datanode1 WITH (PRIMARY = true);
```

- `PREFERRED` significa que o datanode é preferido em operações de leitura

```
ALTER NODE datanode1 WITH (PREFERRED = true);
```

Tabelas Distribuídas

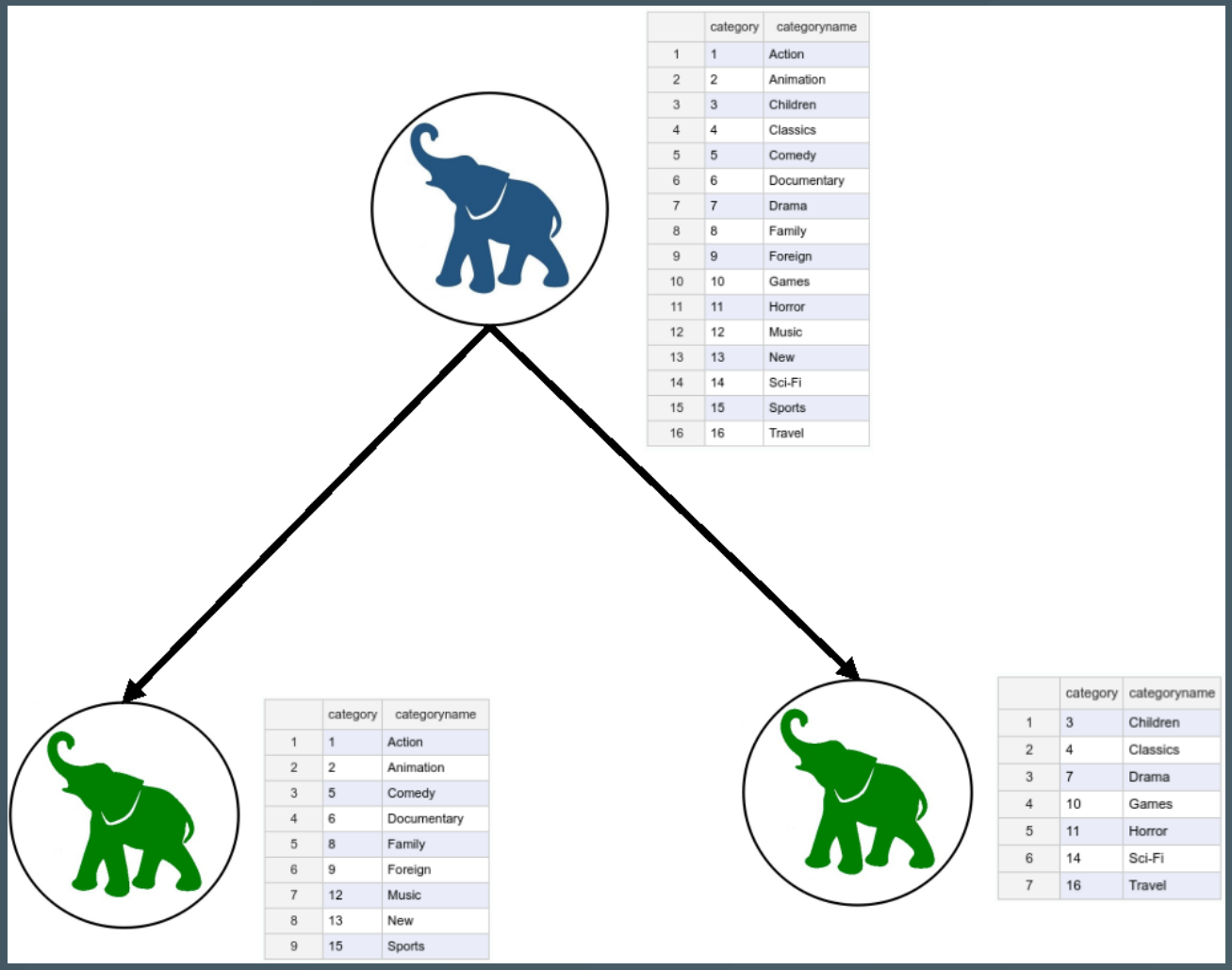


- **Fragmentação**: um registro qualquer existe em **apenas 1 datanode**
- Bom para tabelas **write-only** e **write-mainly**

```
CREATE TABLE categories
(
    category integer NOT NULL,
    categoryname character varying(50) NOT NULL,
    CONSTRAINT categories_pkey PRIMARY KEY (category)
)
DISTRIBUTE BY HASH(category);
```

- `HASH(col)`, `MODULO(col)`, `ROUNDROBIN`

Tabelas Distribuídas

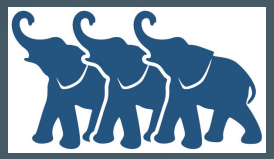


	category	categoryname
1	1	Action
2	2	Animation
3	3	Children
4	4	Classics
5	5	Comedy
6	6	Documentary
7	7	Drama
8	8	Family
9	9	Foreign
10	10	Games
11	11	Horror
12	12	Music
13	13	New
14	14	Sci-Fi
15	15	Sports
16	16	Travel

	category	categoryname
1	1	Action
2	2	Animation
3	5	Comedy
4	6	Documentary
5	8	Family
6	9	Foreign
7	12	Music
8	13	New
9	15	Sports

	category	categoryname
1	3	Children
2	4	Classics
3	7	Drama
4	10	Games
5	11	Horror
6	14	Sci-Fi
7	16	Travel

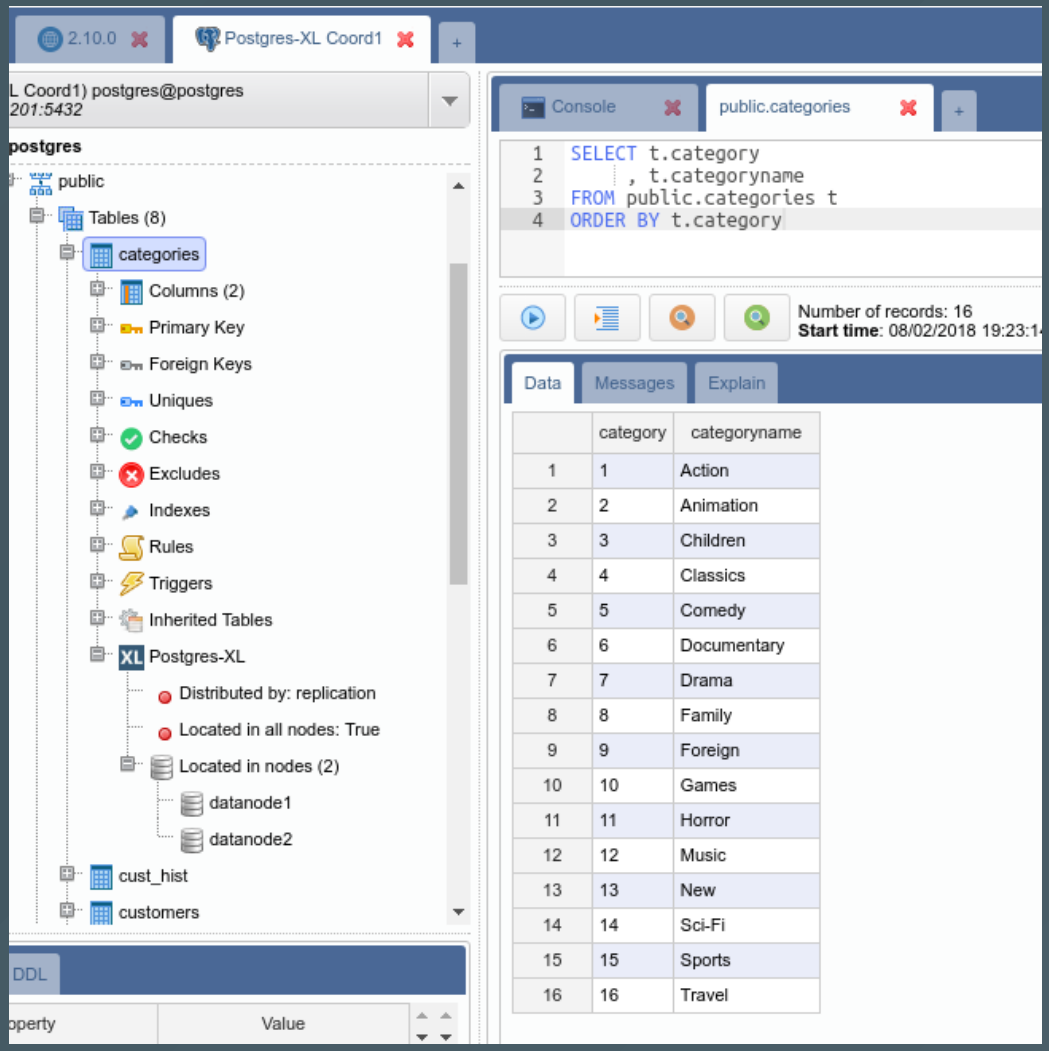
EXECUTE DIRECT



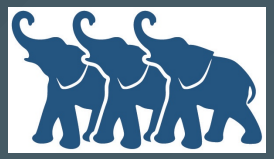
- Permite executar consultas diretamente em um datanode específico
- Deve ser rodado em um coordinator
- Somente superusuários podem rodar
- Transações, DDL e DML são proibidos!

```
EXECUTE DIRECT ON (datanode2) $$
SELECT *
FROM categories
ORDER BY category
$$
```

Dados da Distribuição

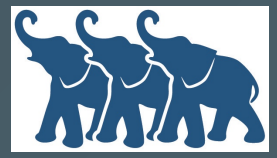


Limitações

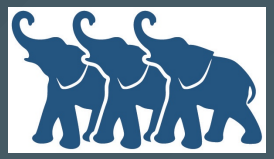


- Só é possível distribuir por apenas 1 coluna
  - PK e/ou FK precisam incluir essa coluna
- Não suportados no Postgres-XL atualmente:
  - Triggers
  - `CREATE INDEX CONCURRENTLY`
  - Foreign Data Wrappers
  - Mais detalhes: https://www.postgres-xl.org/documentation/release-xl-9-5r1.html

Parte 5: Escalabilidade

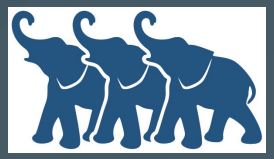


Escalabilidade



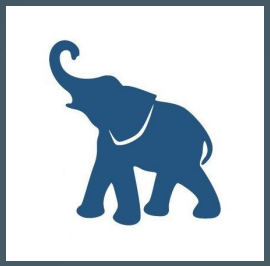
- **Escalabilidade horizontal** significa poder adicionar novos servidores ao cluster
- Por que adicionar mais nodos?
  - Dados aumentaram, limitação de hardware
  - Aumentar o desempenho do cluster atual
  - Se os dados aumentaram, manter o desempenho atual

Escalabilidade



- Vamos expandir o cluster para ter:
  - Novo coordinator `coord2`
  - Dois novos datanodes `datanode3` e `datanode4`
- Obrigatório que o cluster seja colocado em **modo de backup**
- Adicionar um novo nodo de cada vez

Coordinator 1

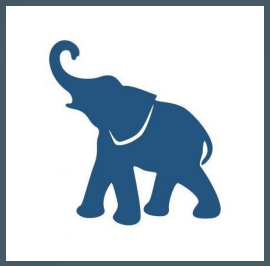


- Alterar `pg_hba.conf`:

```
local all postgres                    trust
host  all postgres 127.0.0.1/32       trust
host  all postgres ::1/128            trust
host  all postgres 192.168.56.202/32 trust # Coord2
host  all postgres 192.168.56.203/32 trust # Datanode 1
host  all postgres 192.168.56.204/32 trust # Datanode 2
host  all postgres 192.168.56.205/32 trust # Datanode 3
host  all postgres 192.168.56.206/32 trust # Datanode 4
host  all all      192.168.56.1/32   md5
```

- Recarregar: `select pg_reload_conf();`

Coordinator 2



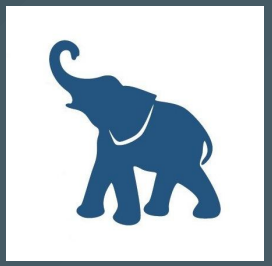
- Inicializar diretório de dados:

```
initdb -D /usr/local/pgsql/data --nodename coord2
```

- Alterar `postgresql.conf`:

```
listen_addresses = '*'
pooler_port = 40101                 # único para cada node
gtm_host = '192.168.56.200'
gtm_port = 6666
```

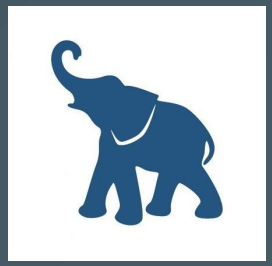
Coordinator 2



- Alterar `pg_hba.conf`:

```
local all postgres                      trust
host  all postgres 127.0.0.1/32         trust
host  all postgres ::1/128              trust
host  all postgres 192.168.56.201/32 trust # Coord1
host  all postgres 192.168.56.203/32 trust # Datanode 1
host  all postgres 192.168.56.204/32 trust # Datanode 2
host  all postgres 192.168.56.205/32 trust # Datanode 3
host  all postgres 192.168.56.206/32 trust # Datanode 4
host  all all      192.168.56.1/32   md5
```

Coordinator 2



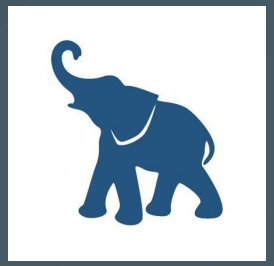
- No coordinator 1, bloquear o cluster inteiro (manter sessão aberta):

```
select pgxc_lock_for_backup();
```

- Criar dump do coordinator1:

```
pg_dumpall -h 192.168.56.201 -s --include-nodes \
        --dump-nodes --file=coord1.sql
```

Coordinator 2



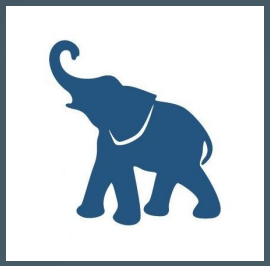
- Iniciar coordinator2 em modo de recuperação

```
pg_ctl -D /usr/local/pgsql/data -Z restoremode \
        -l logfile start
```

- Restaurar dump do coordinator1 no coordinator2:

```
psql -f coord1.sql
```

Coordinator 2



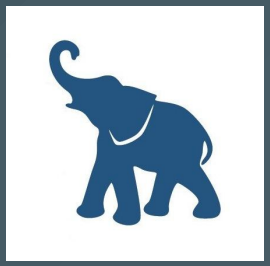
- Reiniciar coordinator2

```
pg_ctl -D /usr/local/pgsql/data -Z restoremode \
        -l logfile stop
pg_ctl -D /usr/local/pgsql/data -Z coordinator \
        -l logfile start
```

- Ajustar endereços:

```
ALTER NODE coord2 WITH (TYPE = 'coordinator',
        HOST = 'localhost', PORT = 5432);
ALTER NODE coord1 WITH (TYPE = 'coordinator',
        HOST = '192.168.56.201', PORT = 5432);
SELECT pgxc_pool_reload();
```

Coordinator 2

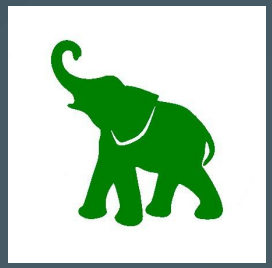


- Em todos os demais nodos:

```
CREATE NODE coord2 WITH (TYPE = 'coordinator',
        HOST = '192.168.56.202', PORT = 5432);
SELECT pgxc_pool_reload();
```

- Matar sessão do coordinator1 que estava bloqueando o cluster para backup

Datanode 1

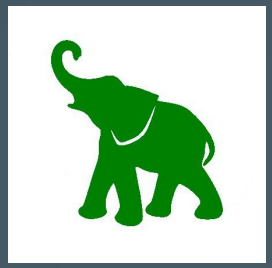


- Alterar `pg_hba.conf`:

```
local all postgres                      trust
host  all postgres 127.0.0.1/32         trust
host  all postgres ::1/128              trust
host  all postgres 192.168.56.201/32 trust # Coord 1
host  all postgres 192.168.56.202/32 trust # Coord 2
host  all postgres 192.168.56.204/32 trust # Datanode 2
host  all postgres 192.168.56.205/32 trust # Datanode 3
host  all postgres 192.168.56.206/32 trust # Datanode 4
host  all all      192.168.56.1/32   md5
```

- Recarregar: `select pg_reload_conf();`

Datanode 2

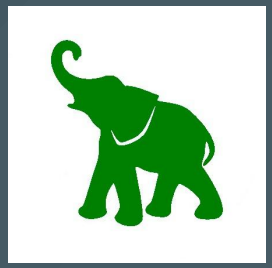


- Alterar `pg_hba.conf`:

```
local all postgres                      trust
host  all postgres 127.0.0.1/32         trust
host  all postgres ::1/128              trust
host  all postgres 192.168.56.201/32 trust # Coord 1
host  all postgres 192.168.56.202/32 trust # Coord 2
host  all postgres 192.168.56.203/32 trust # Datanode 1
host  all postgres 192.168.56.205/32 trust # Datanode 3
host  all postgres 192.168.56.206/32 trust # Datanode 4
host  all all      192.168.56.1/32   md5
```

- Recarregar: `select pg_reload_conf();`

Datanode 3



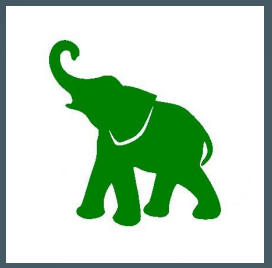
- Inicializar diretório de dados

```
initdb -D /usr/local/pgsql/data --nodename datanode3
```

- Alterar `postgresql.conf`:

```
listen_addresses = '*'
pooler_port = 40104                    # único para cada node
gtm_host = '192.168.56.200'
gtm_port = 6666
```

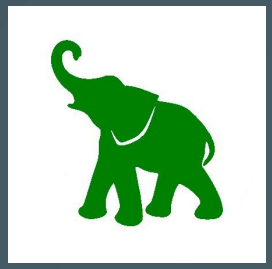
Datanode 3



- Alterar `pg_hba.conf`:

```
local all postgres                      trust
host  all postgres 127.0.0.1/32         trust
host  all postgres ::1/128              trust
host  all postgres 192.168.56.201/32 trust # Coord 1
host  all postgres 192.168.56.202/32 trust # Coord 2
host  all postgres 192.168.56.203/32 trust # Datanode 1
host  all postgres 192.168.56.204/32 trust # Datanode 2
host  all postgres 192.168.56.206/32 trust # Datanode 4
host  all all      192.168.56.1/32   md5
```

Datanode 3



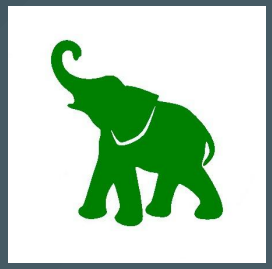
- In coordinator 1, bloquear o cluster inteiro (manter sessão aberta):

```
select pgxc_lock_for_backup();
```

- Criar dump do datanode1:

```
pg_dumpall -h 192.168.56.203 -s --include-nodes \
        --dump-nodes --file=datanode1.sql
```

Datanode 3



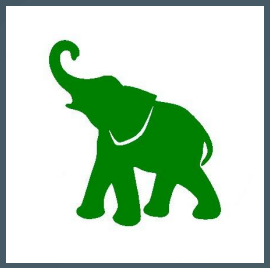
- Iniciar datanode3 em modo de recuperação

```
pg_ctl -D /usr/local/pgsql/data -Z restoremode \
        -l logfile start
```

- Restaurar dump do datanode1 no datanode3:

```
psql -f datanode1.sql
```

Datanode 3



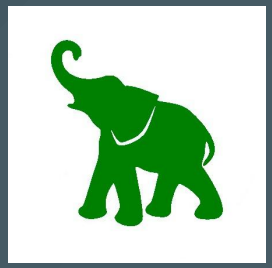
- Reiniciar datanode3

```
pg_ctl -D /usr/local/pgsql/data -Z restoremode \
        -l logfile stop
pg_ctl -D /usr/local/pgsql/data -Z datanode \
        -l logfile start
```

- Ajustar endereços:

```
ALTER NODE datanode3 WITH (TYPE = 'datanode',
        HOST = 'localhost', PORT = 5432);
ALTER NODE datanode1 WITH (TYPE = 'datanode',
        HOST = '192.168.56.203', PORT = 5432);
SELECT pgxc_pool_reload();
```

Datanode 3

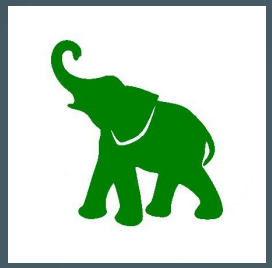


- Em todos os demais nodos:

```
CREATE NODE datanode3 WITH (TYPE = 'datanode',
        HOST = '192.168.56.205', PORT = 5432);
SELECT pgxc_pool_reload();
```

- Matar sessão do coordinator1 que estava bloqueando o cluster para backup

Datanode 4



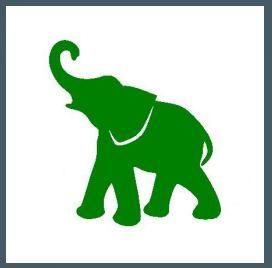
- Inicializar diretório de dados

```
initdb -D /usr/local/pgsql/data --nodename datanode4
```

- Alterar `postgresql.conf`:

```
listen_addresses = '*'
pooler_port = 40105                 # único para cada node
gtm_host = '192.168.56.200'
gtm_port = 6666
```

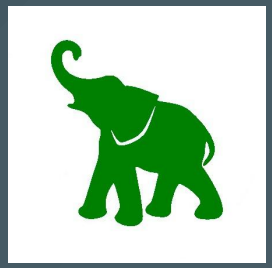
Datanode 4



- Alterar `pg_hba.conf`:

```
local all postgres                      trust
host  all postgres 127.0.0.1/32         trust
host  all postgres ::1/128              trust
host  all postgres 192.168.56.201/32 trust # Coord 1
host  all postgres 192.168.56.202/32 trust # Coord 2
host  all postgres 192.168.56.203/32 trust # Datanode 1
host  all postgres 192.168.56.204/32 trust # Datanode 2
host  all postgres 192.168.56.205/32 trust # Datanode 3
host  all all      192.168.56.1/32   md5
```

Datanode 4



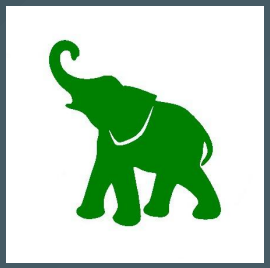
- In coordinator 1, bloquear o cluster inteiro (manter sessão aberta):

```
select pgxc_lock_for_backup();
```

- Criar dump do datanode1:

```
pg_dumpall -h 192.168.56.203 -s --include-nodes \
        --dump-nodes --file=datanode1.sql
```

Datanode 4



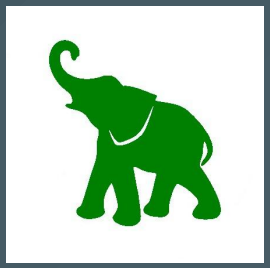
- Iniciar datanode4 em modo de recuperação

```
pg_ctl -D /usr/local/pgsql/data -Z restoremode \
        -l logfile start
```

- Restaurar dump do datanode1 no datanode4:

```
psql -f datanode1.sql
```

Datanode 4



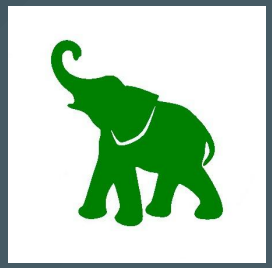
- Reiniciar datanode4

```
pg_ctl -D /usr/local/pgsql/data -Z restoremode \
        -l logfile stop
pg_ctl -D /usr/local/pgsql/data -Z datanode \
        -l logfile start
```

- Ajustar endereços:

```
ALTER NODE datanode4 WITH (TYPE = 'datanode',
        HOST = 'localhost', PORT = 5432);
ALTER NODE datanode1 WITH (TYPE = 'datanode',
        HOST = '192.168.56.203', PORT = 5432);
SELECT pgxc_pool_reload();
```

Datanode 4

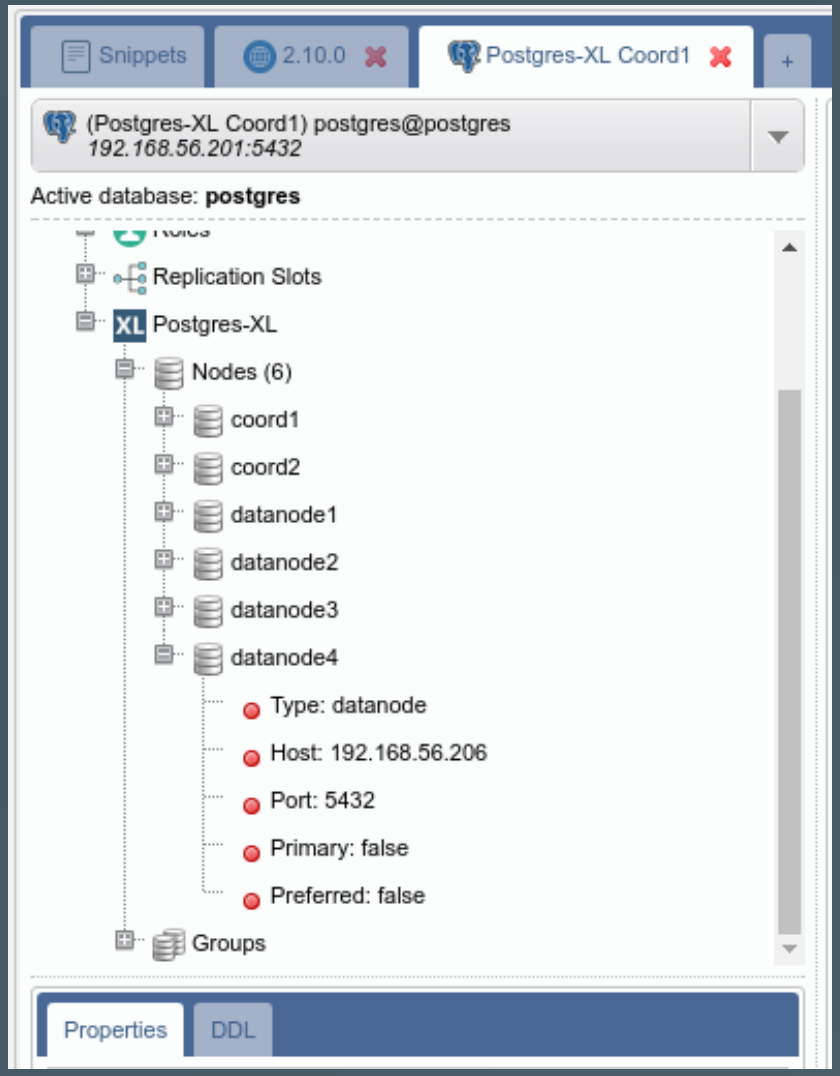


- Em todos os demais nodos:

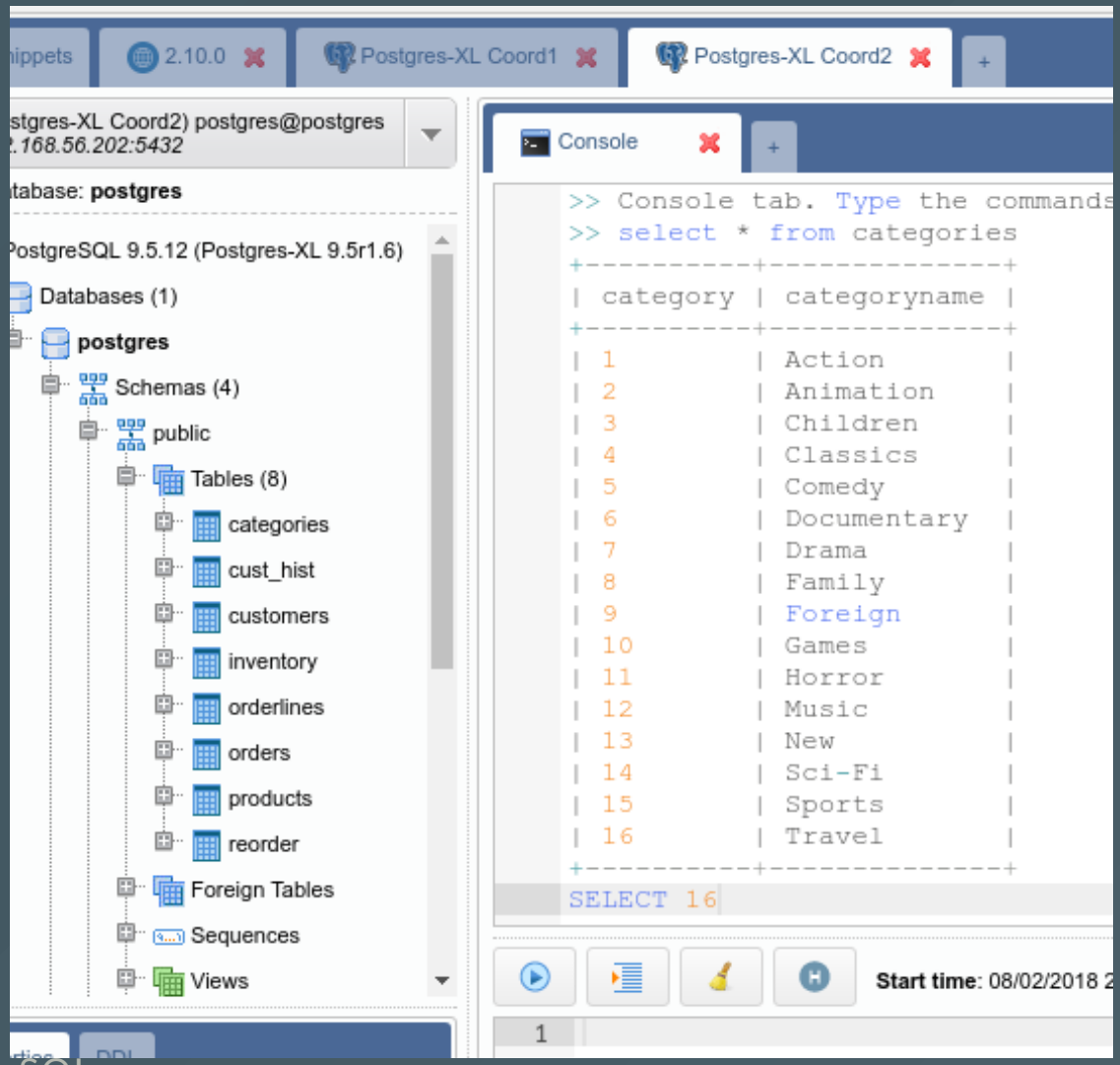
```
CREATE NODE datanode4 WITH (TYPE = 'datanode',
        HOST = '192.168.56.206', PORT = 5432);
SELECT pgxc_pool_reload();
```

- Matar sessão do coordinator1 que estava bloqueando o cluster para backup

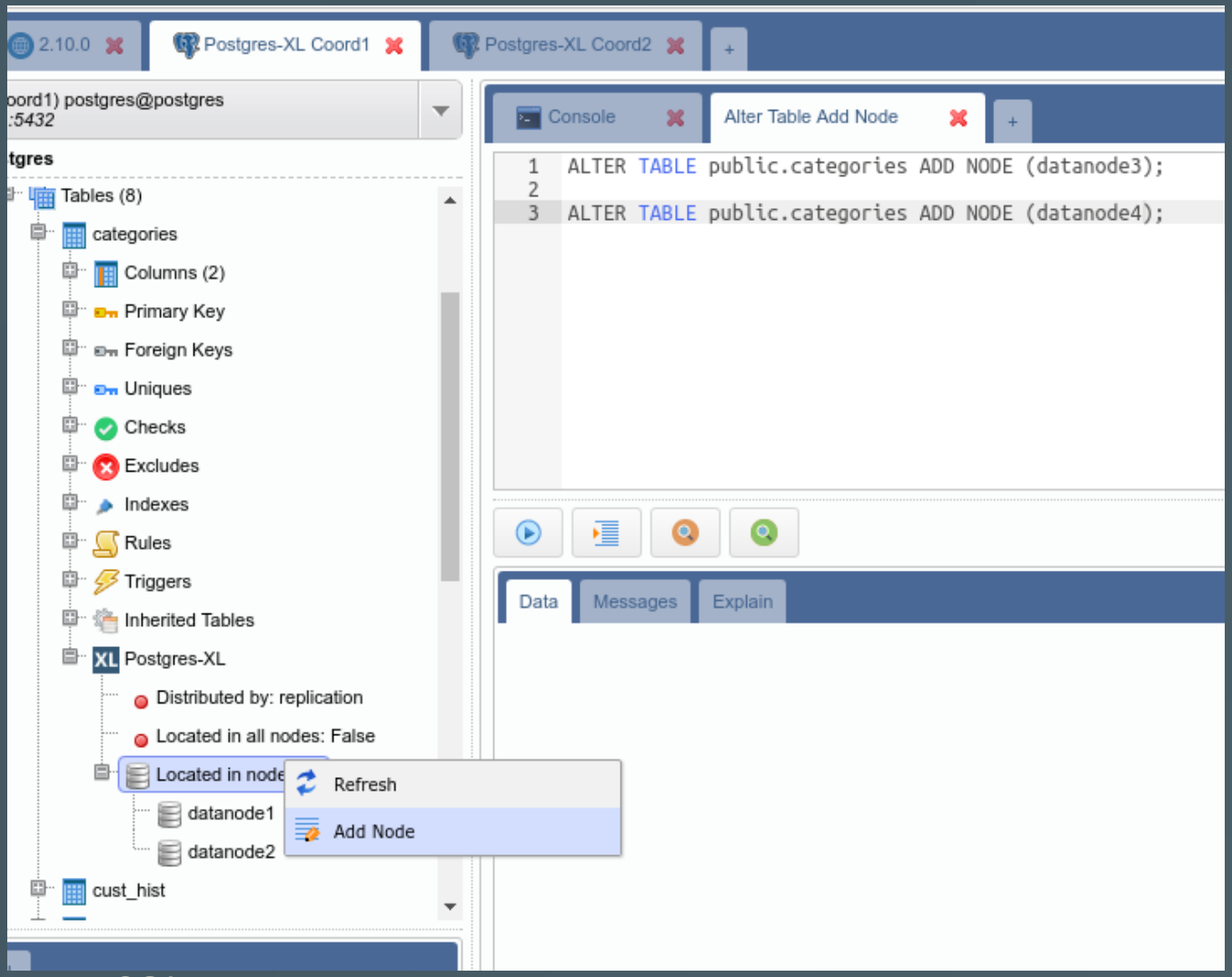
Novo Cluster



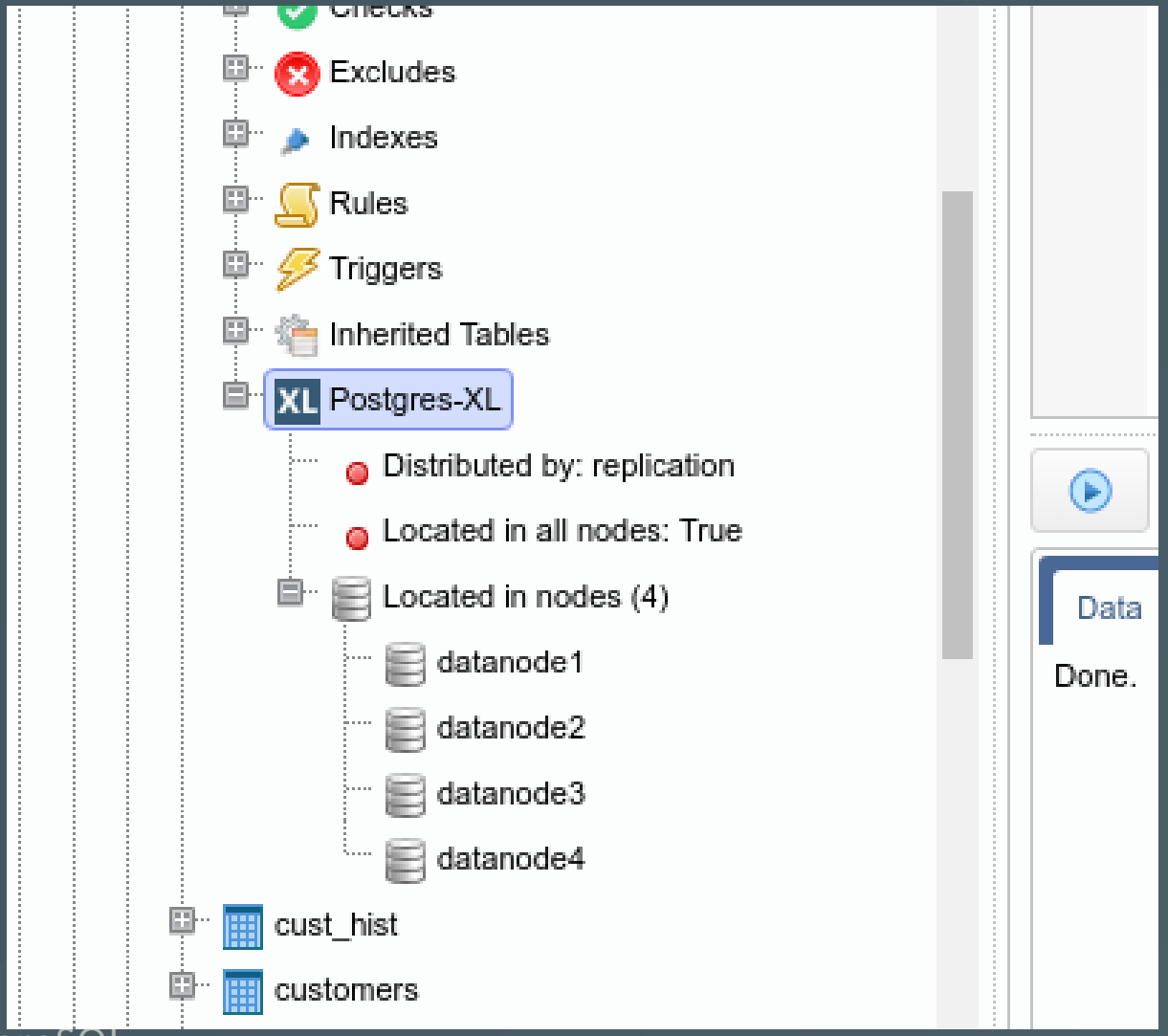
Novo Cluster



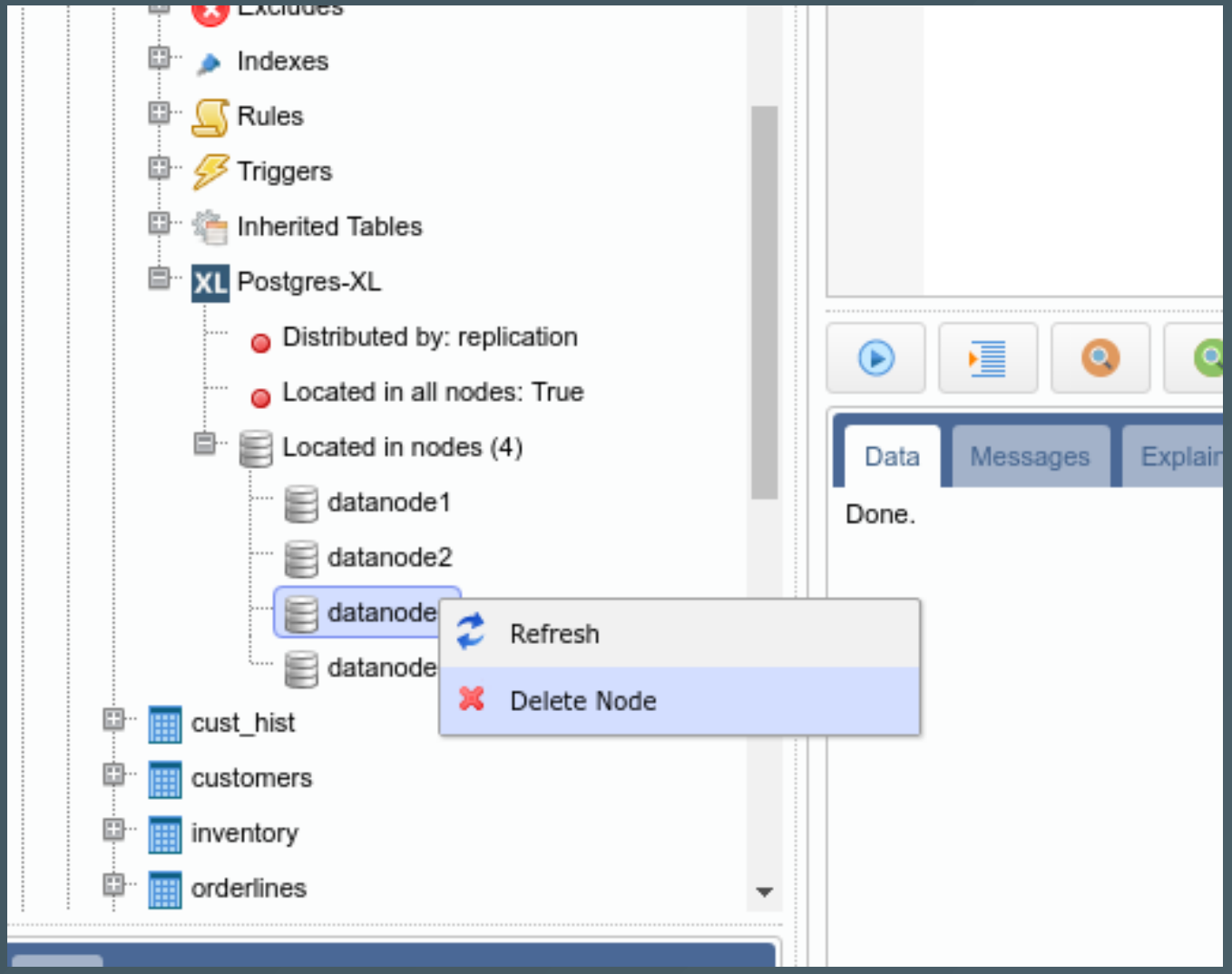
Tabelas no Novo Cluster



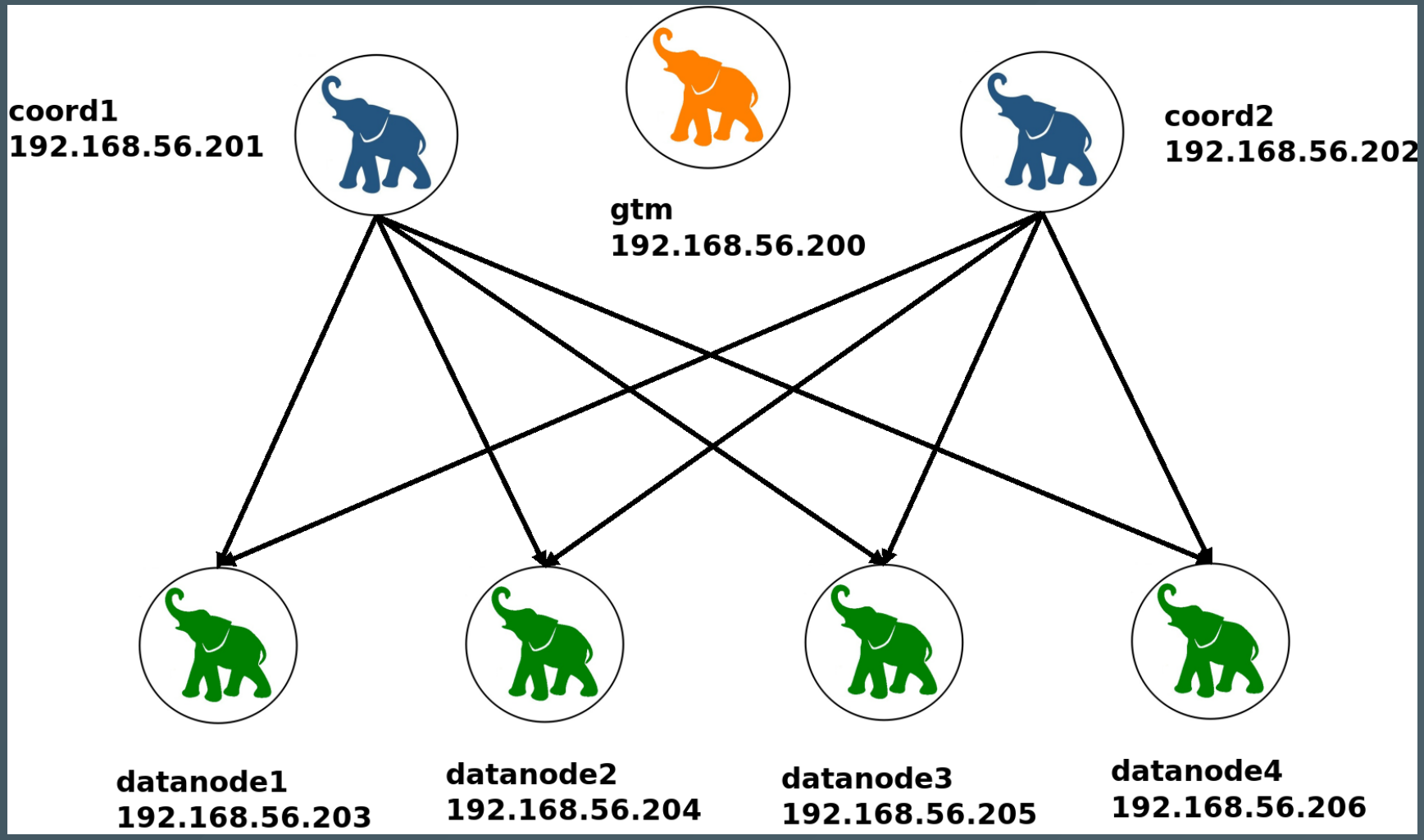
Tabelas no Novo Cluster



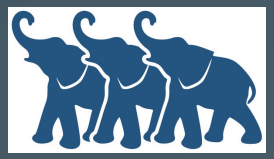
Tabelas no Novo Cluster



Novo Cluster

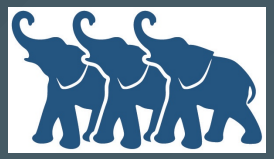


Manutenção



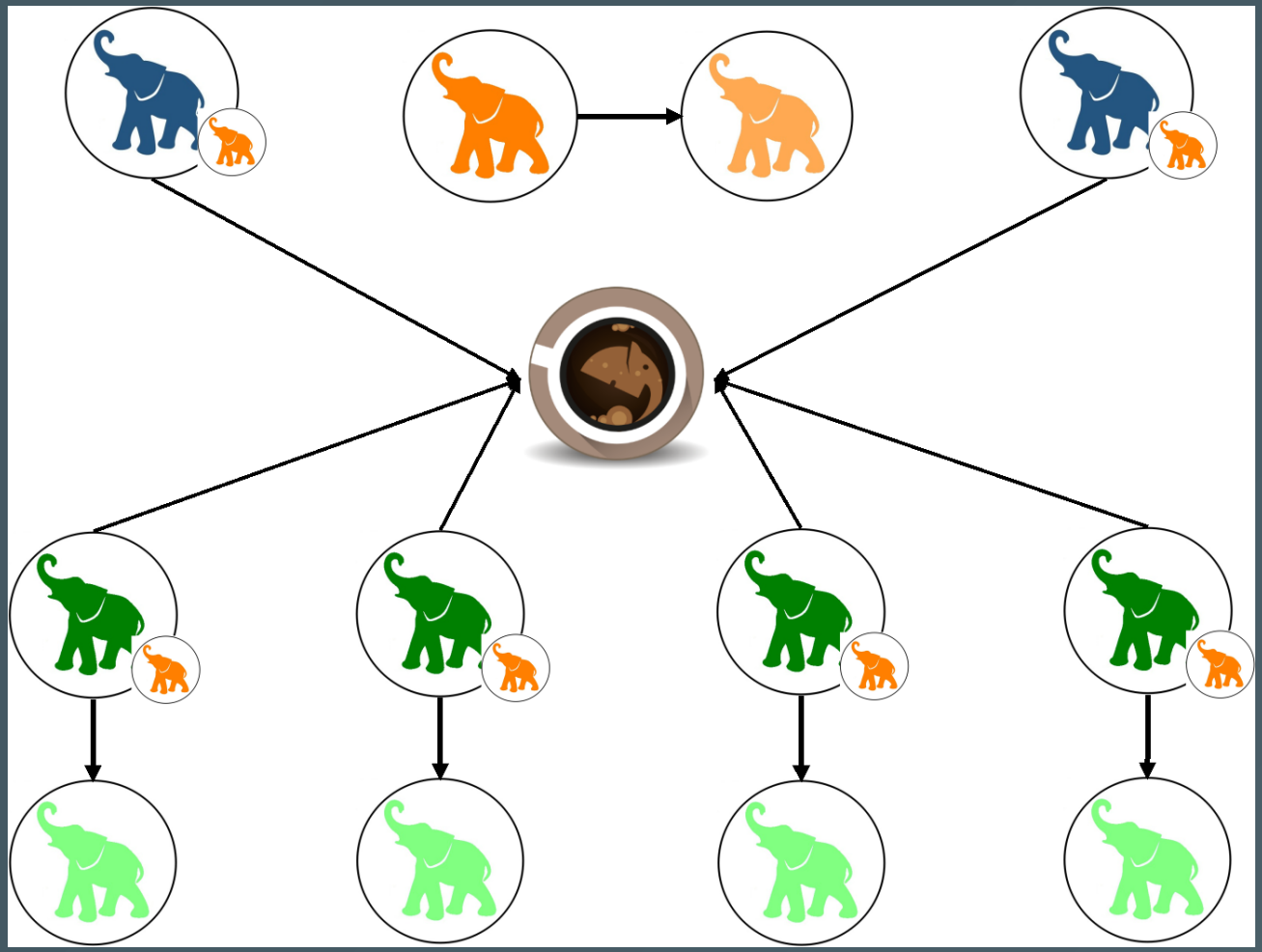
- **High Availability**:
  - Datanodes podem ser replicados via **SR**
  - Replicação Sync / Async
  - **Hot Standby** atualmente não suportado
  - **Failover** precisa ser feito manualmente
  - `pgxc_ctl` facilita bastante

Manutenção



- **Disaster Recovery**:
  - `pg_dump` / `pg_restore`
  - `pg_basebackup` combinado com WAL archiving/restore
    - PITR, `barman`
  - `CREATE BARRIER sunday_night`
    - `recovery_target_barrier` in **recovery.conf**

Novo Cluster + DR + HA



Perguntas?

Muito obrigado!!

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