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«Научно-образовательная корпорация ИТМО»

Факультет программной инженерии и компьютерной техники
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Отчёт по лабораторной работе №4

По дисциплине «Бизнес логика программных систем» (семестр 6)

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Цель работы

Цель работы - ознакомиться с методами и средствами построения отказоустойчивых решений на базе СУБД Postgres; получить практические навыки восстановления работы системы после отказа.

Задание

- В качестве хостов использовать одинаковые виртуальные машины.
- В первую очередь необходимо обеспечить сетевую связность между ВМ.
- Для подключения к СУБД (например, через psql), использовать отдельную виртуальную или физическую машину.
- Демонстрировать наполнение базы и доступ на запись на примере не менее, чем двух таблиц, столбцов, строк, транзакций и клиентских сессий.

Ход работы

Создан ведущий сервер, настроены параметры для репликации.

```
2025-04-29 16:53:53.657 GMT [1] LOG: starting PostgreSQL 15.12 (Debian 15.12-1.pgdg120+1) on aarch64-unknown-linux-gnu, compiled by gcc (Debian 12.2.0-14) 12.2.0, 64-bit
2025-04-29 16:53:53.657 GMT [1] LOG: listening on IPv4 address "0.0.0.0", port 5432
2025-04-29 16:53:53.657 GMT [1] LOG: listening on IPv6 address "::", port 5432
2025-04-29 16:53:53.658 GMT [1] LOG: listening on Unix socket "/var/run/postgresql/.s.PGSQL.5432"
2025-04-29 16:53:53.661 GMT [29] LOG: database system was shut down at 2025-04-29 16:53:51 GMT
2025-04-29 16:53:53.664 GMT [1] LOG: database system is ready to accept connections
2025-04-29 16:54:04.767 GMT [41] FATAL: database "user" does not exist
2025-04-29 16:54:04.809 GMT [27] LOG: checkpoint starting: immediate force wait
2025-04-29 16:54:04.815 GMT [27] LOG: checkpoint complete: wrote 3 buffers (0.0%); 0 WAL file(s) added, 0 removed, 1 recycled; write=0.002 s, sync=0.001 s, total=0.007 s; sync files=2, longest=0.001 s, average=0.001 s; distance=16383 kB, estimate=16383 kB
```

Создан ведомый сервер, настроены параметры для репликации.

```
2025-04-29 16:54:05.194 UTC [1] LOG: starting PostgreSQL 15.12 (Debian 15.12-1.pgdg120+1) on aarch64-unknown-linux-gnu, compiled by gcc (Debian 12.2.0-14) 12.2.0, 64-bit
2025-04-29 16:54:05.195 UTC [1] LOG: listening on IPv4 address "0.0.0.0", port 5432
2025-04-29 16:54:05.195 UTC [1] LOG: listening on IPv6 address "::", port 5432
2025-04-29 16:54:05.196 UTC [1] LOG: listening on Unix socket "/var/run/postgresql/.s.PGSQL.5432"
2025-04-29 16:54:05.198 UTC [28] LOG: database system was interrupted; last known up at 2025-04-29 16:54:04 UTC
2025-04-29 16:54:05.265 UTC [28] LOG: entering standby mode
2025-04-29 16:54:05.265 UTC [28] LOG: starting backup recovery with redo LSN 0/24000028, checkpoint LSN 0/24000060, on timeline ID 1
2025-04-29 16:54:05.267 UTC [28] LOG: redo starts at 0/24000028
2025-04-29 16:54:05.267 UTC [28] LOG: completed backup recovery with redo LSN 0/24000028 and end LSN 0/24000100
2025-04-29 16:54:05.267 UTC [28] LOG: consistent recovery state reached at 0/24000100
2025-04-29 16:54:05.267 UTC [1] LOG: database system is ready to accept read-only connections
2025-04-29 16:54:05.270 UTC [29] LOG: started streaming WAL from primary at 0/25000000 on timeline 1
```

Запросы с хост машины на ведущий сервер.

```
[L[$] psql -U user -d mydatabase -h localhost [20:54:02]
psql (14.17 (Homebrew), server 15.12 (Debian 15.12-1.pgdg120+1))
WARNING: psql major version 14, server major version 15.
        Some psql features might not work.
Type "help" for help.

mydatabase=# CREATE TABLE employees (
        employee_id SERIAL PRIMARY KEY,
        first_name VARCHAR(50) NOT NULL,
        last_name VARCHAR(50) NOT NULL,
        hire_date DATE,
        department_id INTEGER
);
CREATE TABLE
mydatabase=#
```

```

[[$] psql -U user -d mydatabase -h localhost [20:54:02]
psql (14.17 (Homebrew), server 15.12 (Debian 15.12-1.pgdg120+1))
WARNING: psql major version 14, server major version 15.
        Some psql features might not work.
Type "help" for help.

mydatabase=# CREATE TABLE employees (
            employee_id SERIAL PRIMARY KEY,
            first_name VARCHAR(50) NOT NULL,
            last_name VARCHAR(50) NOT NULL,
            hire_date DATE,
            department_id INTEGER
);
CREATE TABLE
mydatabase=#

```

```

mydatabase=# SELECT * FROM departments;
SELECT * FROM employees;
  department_id | department_name
-----+-----
              1 | Engineering
(1 row)

 employee_id | first_name | last_name | hire_date  | department_id
-----+-----+-----+-----+-----
              1 | Alice      | Smith     | 2023-01-15 |              1
(1 row)

mydatabase=#

```

```
mydatabase=# SELECT * FROM departments;
```

```
SELECT * FROM employees;
```

```
department_id | department_name
```

```
-----+-----
```

```
1 | Engineering
```

```
2 | Sales
```

```
(2 rows)
```

```
employee_id | first_name | last_name | hire_date | department_id
```

```
-----+-----+-----+-----+-----
```

```
1 | Alice | Smith | 2023-01-15 | 1
```

```
2 | Bob | Johnson | 2023-03-10 | 2
```

```
3 | Charlie | Brown | 2022-11-20 | 1
```

```
(3 rows)
```

Эмуляция отказа

Кладём сервер ведущий.

```
[root@7f87c8c9827b:/# pkill
pkill: no matching criteria specified
Try `pkill --help' for more information.
[root@7f87c8c9827b:/# pkill -9 postgres
root@7f87c8c9827b:/# %
[alexalex@Alexs-MacBook-Pro] - [~/Distrib
[$]
```

Логи реплики

```
total=0.019 s; sync files=0, longest=0.000 s, average=0.000 s; distance=285 kB, estimate=363 kB
2025-05-01 12:12:30.392 GMT [8] LOG: recovery restart point at 0/30A4750
2025-05-01 12:12:30.392 GMT [8] DETAIL: Last completed transaction was at log time 2025-05-01 12:01:01.164102+00.
2025-05-01 12:12:33.458 GMT [31] FATAL: could not connect to the primary server: could not translate host name "primary" to address: Name or service not known
2025-05-01 12:12:33.458 GMT [10] LOG: waiting for WAL to become available at 0/30A4850
2025-05-01 12:12:38.468 GMT [32] FATAL: could not connect to the primary server: could not translate host name "primary" to address: Name or service not known
2025-05-01 12:12:38.469 GMT [10] LOG: waiting for WAL to become available at 0/30A4850
2025-05-01 12:12:43.484 GMT [33] FATAL: could not connect to the primary server: could not translate host name "primary" to address: Name or service not known
2025-05-01 12:12:43.484 GMT [10] LOG: waiting for WAL to become available at 0/30A4850
2025-05-01 12:12:48.483 GMT [34] FATAL: could not connect to the primary server: could not translate host name "primary" to address: Name or service not known
2025-05-01 12:12:48.484 GMT [10] LOG: waiting for WAL to become available at 0/30A4850
2025-05-01 12:12:53.498 GMT [35] FATAL: could not connect to the primary server: could not translate host name "primary" to address: Name or service not known
2025-05-01 12:12:53.498 GMT [10] LOG: waiting for WAL to become available at 0/30A4850
```

Делаем реплику ведущей.

```
postgres@ca1eae84abde:/$ /usr/lib/postgresql/15/bin/pg_ctl promote -D $PGDATA
waiting for server to promote.... done
server promoted
```

Проверка данных на новом ведущем сервере.

```
SELECT * FROM departments ORDER BY department_id;
SELECT * FROM employees ORDER BY employee_id;
 department_id | department_name
-----+-----
              1 | Engineering
              2 | Sales
(2 rows)

 employee_id | first_name | last_name | hire_date | department_id
-----+-----+-----+-----+-----
              1 | Alice     | Smith-Jones | 2023-01-15 |              1
              2 | Bob       | Johnson     | 2023-03-10 |              2
              3 | Charlie   | Brown       | 2022-11-20 |              1
(3 rows)

postgres=#
```

Эмуляция работы и изменения данных на новом ведущем сервере.

```
SELECT * FROM departments ORDER BY department_id;
SELECT * FROM employees ORDER BY employee_id;
 department_id | department_name
-----+-----
              1 | Engineering
              2 | Sales
             34 | Marketing
(3 rows)

 employee_id | first_name | last_name | hire_date | department_id
-----+-----+-----+-----+-----
              1 | Alice     | Smith-Jones | 2023-01-15 |              1
              2 | Bob       | Johnson     | 2023-03-10 |              2
              3 | Charlie   | Brown       | 2022-11-20 |              1
             34 | Grace     | Hopper      | 2025-05-01 |             34
(4 rows)
```

Восстановление

Из-за специфика докера, пришлось залезть в volume старого ведущего контейнера через другой временный контейнер и сделать следующие действия.

(само создание контейнера)

```
docker run --rm -it --network lab-4_pg_network -v lab-4_pg_primary_data:/var/lib/postgresql/data ubuntu:22.04 bash
apt-get update && apt-get install -y postgresql-client-15 postgresql-15
export PGDATA=/var/lib/postgresql/data
chown -R postgres:postgres $PGDATA
```

Удаление старого постмастера

```
rm -f $PGDATA/postmaster.pid
```

Запуск утилиты pg_rewind, которая сделает старый ведущий сервер ведомым.

```
su postgres -c "/usr/lib/postgresql/15/bin/pg_rewind --target-pgdata=$PGDATA --source-server='host=replica port=5432 user=postgres dbname=postgres'"
```

Создание standby.signal и настройка подключения

```
touch $PGDATA/standby.signal
echo "primary_conninfo = 'host=replica port=5432 user=postgres application_name=old_primary'" > $PGDATA/postgresql.auto.conf
```

После этих действий можно запускать новый ведущий сервер.

```
База данных уже инициализирована, пропускаем initdb.
Запуск PostgreSQL...
2025-05-01 14:19:14.806 GMT [7] LOG: starting PostgreSQL 15.12 (Ubuntu 15.12-1.pgdg22.04+1) on aarch64-unknown-linux-gnu, compiled by gcc (Ubuntu 11.4.0-1ubuntu1~22.04) 11.4.0, 64-bit
2025-05-01 14:19:14.806 GMT [7] LOG: listening on IPv4 address "0.0.0.0", port 5432
2025-05-01 14:19:14.806 GMT [7] LOG: listening on IPv6 address ":::", port 5432
2025-05-01 14:19:14.807 GMT [7] LOG: listening on Unix socket "/var/run/postgresql/.s.PGSQL.5432"
2025-05-01 14:19:14.810 GMT [10] LOG: database system was interrupted while in recovery at log time 2025-05-01 14:16:40 GMT
2025-05-01 14:19:14.810 GMT [10] HINT: If this has occurred more than once some data might be corrupted and you might need to choose an earlier recovery target.
2025-05-01 14:19:14.883 GMT [10] LOG: entering standby mode
2025-05-01 14:19:14.883 GMT [10] LOG: starting backup recovery with redo LSN 0/30A4750, checkpoint LSN 0/30A4788, on timeline ID 1
2025-05-01 14:19:14.886 GMT [10] LOG: redo starts at 0/30A4750
2025-05-01 14:19:14.887 GMT [10] LOG: completed backup recovery with redo LSN 0/30A4750 and end LSN 0/30A5888
2025-05-01 14:19:14.887 GMT [10] LOG: consistent recovery state reached at 0/30A5888
2025-05-01 14:19:14.887 GMT [10] LOG: invalid record length at 0/30A5888: wanted 24, got 0
2025-05-01 14:19:14.887 GMT [7] LOG: database system is ready to accept read-only connections
2025-05-01 14:19:14.891 GMT [11] LOG: started streaming WAL from primary at 0/3000000 on timeline 2
2025-05-01 14:24:14.823 GMT [8] LOG: restartpoint starting: time
2025-05-01 14:24:15.572 GMT [8] LOG: restartpoint complete: wrote 9 buffers (0.1%); 0 WAL file(s) added, 0 removed, 0 recycled; write=0.736 s, sync=0.007 s, total=0.749 s; sync files=8, longest=0.004 s, average=0.001 s; distance=4 kB, estimate=4 kB
2025-05-01 14:24:15.572 GMT [8] LOG: recovery restart point at 0/30A58C0
2025-05-01 14:24:15.572 GMT [8] DETAIL: Last completed transaction was at log time 2025-05-01 12:20:02.820717+00.
```

lab-4-primary-1



44347db3b871



52e206819a13 (was primary:latest)

5432:5432



Logs

Inspect

Bind mounts

Exec

Files

Stats



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```
postgres=# \dt
```

```
      List of relations
```

Schema	Name	Type	Owner
public	departments	table	postgres
public	employees	table	postgres

(2 rows)

```
postgres=# SELECT * FROM departments ORDER BY department_id;
```

```
SELECT * FROM employees ORDER BY employee_id;
```

department_id	department_name
1	Engineering
2	Sales
34	Marketing

(3 rows)

employee_id	first_name	last_name	hire_date	department_id
1	Alice	Smith-Jones	2023-01-15	1
2	Bob	Johnson	2023-03-10	2
3	Charlie	Brown	2022-11-20	1
34	Grace	Hopper	2025-05-01	34

(4 rows)

Вывод

Лабораторная работа была выполнена два раза до момента восстановления, так как в первый раз образ postgres докера не проходил проверку healthcheck. Переписано на чистую ubuntu с полной конфигурацией.