



**EDB**

Postgres for the AI Generation

# Postgres Workshop - Hands-on



# Prep hands-on



# Hand-on documentation



<https://tinyurl.com/fr7hbjms>



Download the Hand-on Document  
**Workshop\_Hands\_On.pdf**



# Hands-on



# Features shown during the hands-on session

- Process and Memory Architecture
- Database Cluster Data Directory Layout
- Creation the PostgreSQL Cluster
- Working with the utility psql
- Postgres Configuration
- Routine Maintenance Tasks
- Develop and tune the database application



# Setup the demo env



# Connect to your demo environment

- Connect to the terminal:
  - Run in the browser `https://<your vm ip address>`
  - Connect to the terminal as user **postgres** with the password **edb**
- Download the hands-on from the GitHub:
  - Run:  
`git clone https://github.com/borysneselovskyi/postgres\_workshop.git`



# Getting started with Postgres



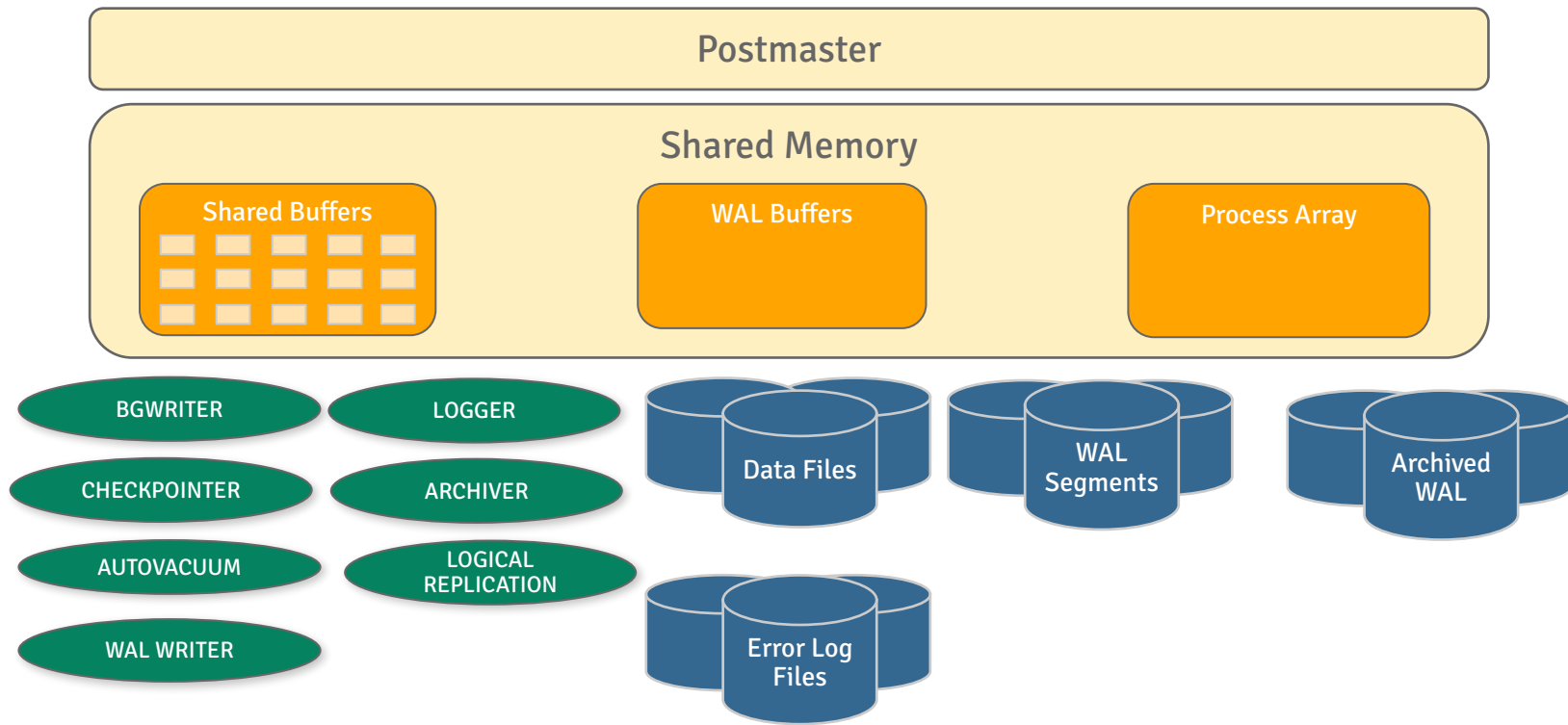


# Objectives

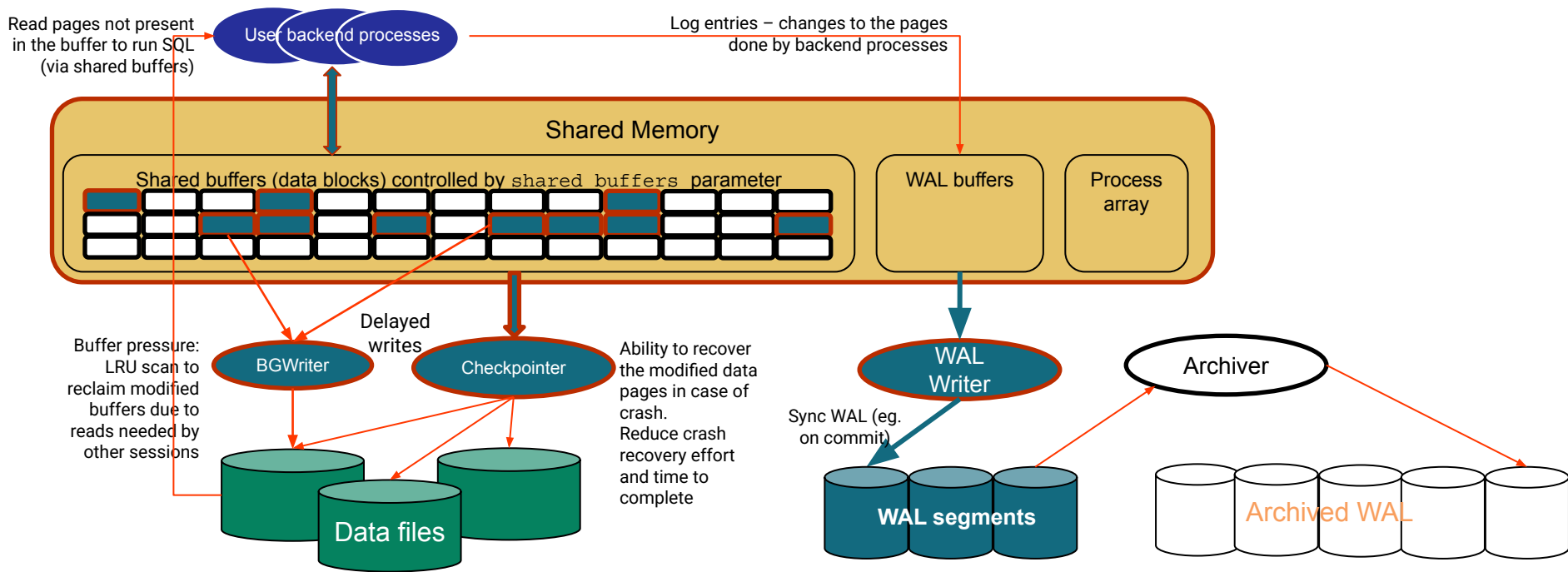
- In this session we will:
  - learn about the Postgres architecture, processes and physical layout
  - create the postgres cluster using the utility `initdb`
  - start the postgres cluster using the utility `pg_ctl`
  - connect to (and disconnect from) the postgres cluster using the utility `psql`



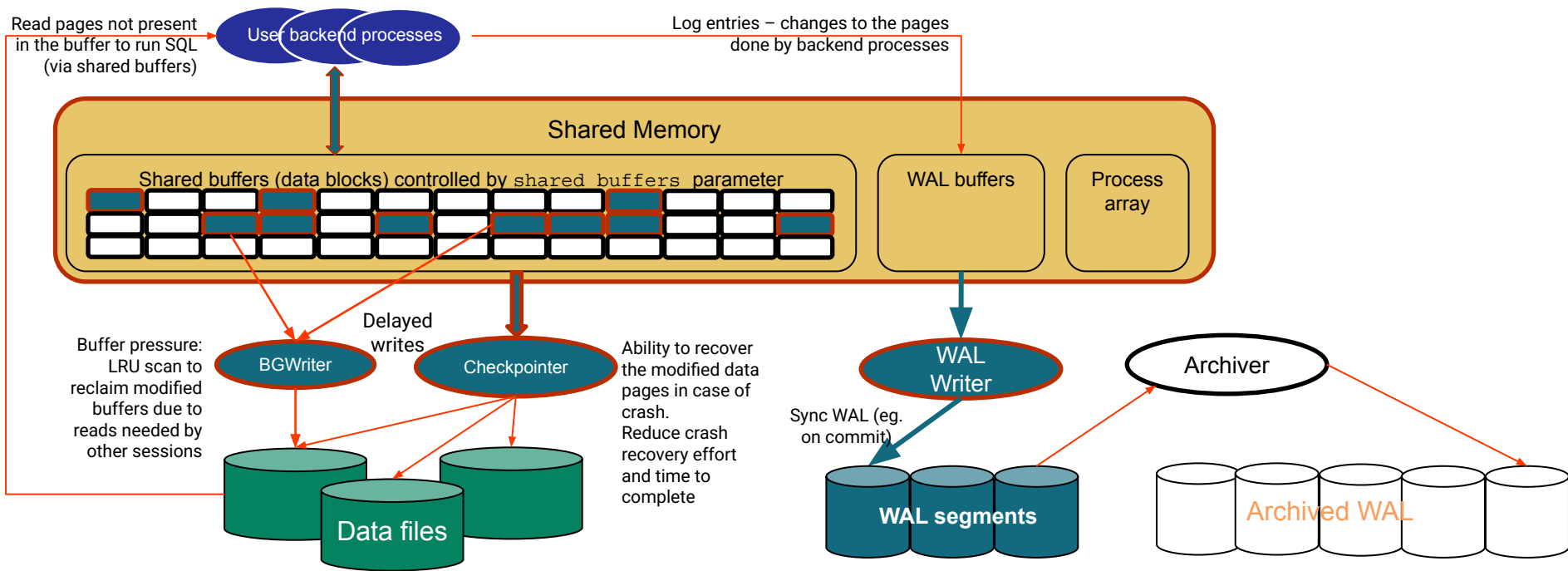
# Process and Memory Architecture



# Key processes affecting disk and memory



# Key processes affecting disk and memory



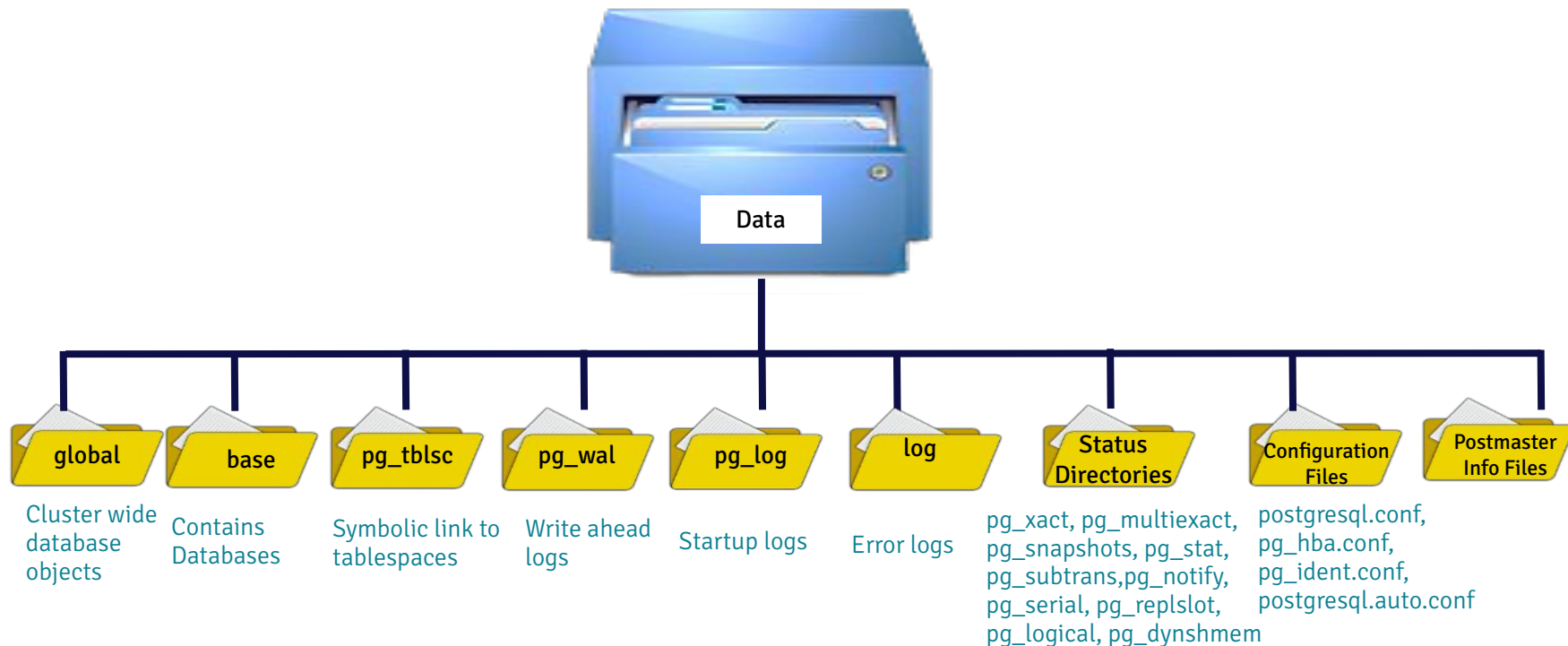
To be adjusted for current template (Piotr)

# Physical Database Architecture

- Database cluster is a collection of databases managed by single server instance
- Each cluster has a separate
  - Data directory
  - TCP port
  - Set of processes
- A cluster can contain multiple databases
- Default Installation Directory Location:
  - Linux - `/usr/lib/postgresql/17`
    - `bin` - Programs
    - `lib` - Libraries
    - `share` - Shared data
- Default Data directory: `/var/lib/pgsql/17/data`
- Data directory used in this workshop: `/opt/postgres/data`



# Database Cluster Data Directory Layout



# Lab Exercise - 1: Create the PostgreSQL Cluster

- In the terminal 1:
  - Go to the directory `/var/lib/postgresql/postgres_workshop`:  
`cd /var/lib/postgresql/postgres_workshop`
  - Create the postgres cluster - run the command:  
`initdb -D /opt/postgres/data -U postgres -W`  
Enter new superuser password (twice): **edb**
  - Start the postgres cluster:  
`pg_ctl -D /opt/postgres/data -l logfile start`
  - Verify the postgres cluster status:  
`pg_ctl -D /opt/postgres/data status`



# Lab Exercise - 2: Verify the environment

- In the terminal 1:

- Check the OS Processes:

- ```
ps -ef | grep postgres | egrep 'postgres:|data'
```

- Check the structure the Data directory (PGDATA):

- ```
ls -al /opt/postgres/data
```

- Check the environment variables inclusive PATH:

- ```
cat $HOME/.bashrc | egrep 'PATH|PG'
```





# Lab Exercise - 3: Connect to the postgres

- In the terminal 1:

- Connect the postgres cluster via the tool psql:

```
psql -h localhost -p 5432 -d postgres -U postgres
```

- Check the databases in the cluster:

```
\l
```

- Disconnect from the cluster:

```
\q
```

- Run the sql script and create workshop database with some objects:

```
cd $HOME/postgres_workshop
```

```
psql -h localhost -p 5432 -d postgres -U postgres -f ./edbstore.sql
```



# Summary

- In this session we:
  - learned about the Postgres architecture, processes and physical layout
  - created the postgres cluster using the utility `initdb`
  - learned about how to start the postgres cluster using the utility `pg_ctl`
  - connected to the postgres cluster using the utility `psql`



# Working with the utility `psql`



# Objectives

- In this session we will learn about `psql` utility:
  - Connect options
  - Listing of database objects
  - Working with SQL commands
  - Copy Command



# Introduction to psql

- **psql** is a command line interface (CLI) to Postgres
- Can be used to execute SQL queries and psql meta commands
- **psql** has its own set of commands, all of which start with a backslash (\).
- Some commands accept a pattern. This pattern is a modified regex. Key points:
  - \* and ? are wildcards
  - Double-quotes are used to specify an exact name, ignoring all special characters and preserving case

```
[postgres@pgsrv1 ~]$ psql -p 5432 -U postgres -d postgres
Password for user postgres:
psql (16.0)
Type "help" for help.

postgres=# \q
```



# Connecting to a Database

## psql Connection Options:

- -d <Database Name>
- -h <Hostname>
- -p <Database Port>
- -U <Database Username>

## Environmental Variables

- PGDATABASE, PGHOST, PGPORT and PGUSER



# psql: The primary CLI client

## Usage:

```
psql [OPTIONS]... [DBNAME [USERNAME]]
```

## General options:

- d DBNAME specify database name to connect to (default: "oddbjorn")
- c COMMAND run only single command (SQL or internal) and exit
- f FILENAME execute commands from file, then exit
- l list available databases, then exit
- v NAME=VALUE set psql variable NAME to VALUE
- X do not read startup file (~/.psqlrc)
- help show this help, then exit
- version output version information, then exit

## Input and output options:

- a echo all input from script
- e echo commands sent to server
- E display queries that internal commands generate
- q run quietly (no messages, only query output)
- o FILENAME send query results to file (or |pipe)
- n disable enhanced command line editing (readline)
- s single-step mode (confirm each query)
- S single-line mode (end of line terminates SQL command)

## Output format options:

- A unaligned table output mode (-P format=unaligned)
- H HTML table output mode (-P format=html)
- t print rows only (-P tuples\_only)
- T TEXT set HTML table tag attributes (width, border) (-P tableattr=)
- x turn on expanded table output (-P expanded)
- P VAR[=ARG] set printing option VAR to ARG (see \pset command)
- F STRING set field separator (default: "|") (-P fieldsep=)
- R STRING set record separator (default: newline) (-P recordsep=)

## Connection options:

- h HOSTNAME database server host or socket directory (default: "local socket")
- p PORT database server port (default: "5432")
- U NAME database user name (default: "oddbjorn")
- W prompt for password (should happen automatically)



# psql: \?: Listing the internal commands

## General

\c[connect] [DBNAME]- [USER]]  
    connect to new database  
\cd [DIR]  
    change the current working directory  
\copyright  
    show PostgreSQL usage and distribution terms  
\encoding [ENCODING]  
    show or set client encoding  
\h [NAME]  
    help on syntax of SQL commands, \* for all commands  
\q  
    quit psql  
\set [NAME [VALUE]]  
    set internal variable, or list all if no parameters  
\timing  
    toggle timing of commands (currently off)  
\unset NAME  
    unset (delete) internal variable  
\! [COMMAND]  
    execute command in shell or start interactive shell

## Query Buffer

\e [FILE]  
    edit the query buffer (or file) with external editor  
\g [FILE]  
    send query buffer to server (and results to file or  
    |pipe)  
\p  
    show the contents of the query buffer  
\r  
    reset (clear) the query buffer  
\s [FILE]  
    display history or save it to file  
\w [FILE]  
    write query buffer to file

## Input/Output

\echo [STRING]  
    write string to standard output  
\i FILE  
    execute commands from file  
\o [FILE]  
    send all query results to file or |pipe  
\qecho [STRING]  
    write string to query output stream (see \o)

## Informational

\d [NAME]  
    describe table, index, sequence, or view  
\d{t|i|s|v|S} [PATTERN] (add "+" for more detail)  
    list tables/indexes/sequences/views/system tables  
\da [PATTERN]  
    list aggregate functions  
\dc [PATTERN]  
    list conversions  
\dc  
    list casts  
\dd [PATTERN]  
    show comment for object  
\dD [PATTERN]  
    list domains  
\df [PATTERN]  
    list functions (add "+" for more detail)  
\dn [PATTERN]  
    list schemas  
\do [NAME]  
    list operators  
\dl  
    list large objects, same as \lo\_list  
\dp [PATTERN]  
    list table access privileges  
\dT [PATTERN]  
    list data types (add "+" for more detail)  
\du [PATTERN]  
    list users  
\l  
    list all databases (add "+" for more detail)  
\z [PATTERN]  
    list table access privileges (same as \dp)

## Formatting

\a  
    toggle between unaligned and aligned output mode  
\C [STRING]  
    set table title, or unset if none  
\f [STRING]  
    show or set field separator for unaligned query output  
\H  
    toggle HTML output mode (currently off)  
\pset NAME [VALUE]  
    set table output option  
    (NAME := {format|border|expanded|fieldsep|footer|null|  
    recordsep|tuples\_only|title|tableattr|pager})  
\t  
    show only rows (currently off)  
\T [STRING]  
    set HTML <table> tag attributes, or unset if none  
\x  
    toggle expanded output (currently off)

## Copy, Large Object

\copy ...  
    perform SQL COPY with data stream to the client host  
\lo export  
\lo import  
\lo\_list  
\lo\_unlink  
    large object operations





# psql: \d: Describe

`\d [NAME]`      **describe** table, index, sequence, or view

`\d{t|i|s|v|S} [PATTERN]` (add "+" for more detail)  
    **list tables/indexes/sequences/views/system tables**

`\da [PATTERN]`    list aggregate functions  
`\dc [PATTERN]`    list conversions  
`\dC`              list casts  
`\dd [PATTERN]`    show comment for object  
`\dD [PATTERN]`    list domains  
`\df [PATTERN]`    list functions (add "+" for more detail)  
`\dn [PATTERN]`    list schemas  
`\do [NAME]`        list operators  
`\dl`              list large objects, same as `\lo_list`  
`\dp [PATTERN]`    list table access privileges  
`\dT [PATTERN]`    list data types (add "+" for more detail)  
`\du [PATTERN]`    list users  
`\l`                list all databases (add "+" for more detail)  
`\z [PATTERN]`    list table access privileges (same as `\dp`)



# psql: \h: SQL-help

|                           |                       |                           |
|---------------------------|-----------------------|---------------------------|
| ABORT                     | CREATE LANGUAGE       | DROP TYPE                 |
| ALTER AGGREGATE           | CREATE OPERATOR CLASS | DROP USER                 |
| ALTER CONVERSION          | CREATE OPERATOR       | DROP VIEW                 |
| ALTER DATABASE            | CREATE RULE           | END                       |
| ALTER DOMAIN              | CREATE SCHEMA         | EXECUTE                   |
| ALTER FUNCTION            | CREATE SEQUENCE       | EXPLAIN                   |
| ALTER GROUP               | CREATE TABLE          | FETCH                     |
| ALTER LANGUAGE            | CREATE TABLE AS       | GRANT                     |
| ALTER OPERATOR CLASS      | CREATE TRIGGER        | INSERT                    |
| ALTER SCHEMA              | CREATE TYPE           | LISTEN                    |
| ALTER SEQUENCE            | CREATE USER           | LOAD                      |
| ALTER TABLE               | CREATE VIEW           | LOCK                      |
| ALTER TRIGGER             | DEALLOCATE            | MOVE                      |
| ALTER USER                | DECLARE               | NOTIFY                    |
| ANALYZE                   | DELETE                | PREPARE                   |
| BEGIN                     | DROP AGGREGATE        | REINDEX                   |
| CHECKPOINT                | DROP CAST             | RESET                     |
| CLOSE                     | DROP CONVERSION       | REVOKE                    |
| CLUSTER                   | DROP DATABASE         | ROLLBACK                  |
| COMMENT                   | DROP DOMAIN           | SELECT                    |
| COMMIT                    | DROP FUNCTION         | SELECT INTO               |
| COPY                      | DROP GROUP            | SET                       |
| CREATE AGGREGATE          | DROP INDEX            | SET CONSTRAINTS           |
| CREATE CAST               | DROP LANGUAGE         | SET SESSION AUTHORIZATION |
| CREATE CONSTRAINT TRIGGER | DROP OPERATOR CLASS   | SET TRANSACTION           |
| CREATE CONVERSION         | DROP OPERATOR         | SHOW                      |
| CREATE DATABASE           | DROP RULE             | START TRANSACTION         |
| CREATE DOMAIN             | DROP SCHEMA           | TRUNCATE                  |
| CREATE FUNCTION           | DROP SEQUENCE         | UNLISTEN                  |
| CREATE GROUP              | DROP TABLE            | UPDATE                    |
| CREATE INDEX              | DROP TRIGGER          | VACUUM                    |



# Lab Exercise - 4: Working with psql

- In the terminal 1:
  - Connect the postgres database postgres  
`psql -h localhost -p 5432 -d postgres -U postgres`
  - Check the connection information:  
`\conninfo`
  - Get help for the psql information commands:  
`\?`
  - List installed extensions:  
`\dx`



# Lab Exercise - 4: Working with psql

- In the terminal 1:
  - Install extension `pg_stat_statements`:  
`create extension pg_stat_statements;`
  - Check installed extensions again:  
`\dx`
  - List the Catalog tables and views:  
`\dS`



# Lab Exercise - 4: Working with psql

- In the terminal 1:
  - Connect to the database edbstore with the user edbuser:  
`\c edbstore edbuser`
  - Check the connection information:  
`\conninfo`
  - List the tables:  
`\dt`
  - Get table definition of the table categories:  
`\d categories`



# Lab Exercise - 4: Working with psql

- In the terminal 1:
  - Get the help for the SQL commands:  
`\h`
  - Get help for the Syntax of "CREATE TABLE":  
`\h CREATE TABLE`
  - Get content of the table categories:  
`select * from categories;`  
`or`  
`table categories;`



# Lab Exercise - 4: Working with psql

- In the terminal 1:
  - Use internal functions:
    - Check the postgres version:  
`select version();`
    - Check the current connected user and database:  
`select current_user;`  
`select current_database();`
  - Disconnect:  
`\q`



# Lab Exercise - 5: Use copy command

- In the terminal 1:
  - In this exercise we will put the data from the csv file into the postgres table:
    - Show the content of the csv file score.csv:  
`cat $HOME/postgres_workshop/score.csv`
    - Connect the postgres database postgres  
`psql -h localhost -p 5432 -d postgres -U postgres`
    - Create table footballranking:  
`create table footballranking (team text, ranking text, played_games integer);`
    - Insert data from the score.csv into the table footballranking:  
`\copy footballranking from '/var/lib/postgresql/postgres_workshop/score.csv' delimiter ',';`
    - Query the table:  
`select * from footballranking;`





# Summary

- In this session we learned:
  - How to connect to postgres using `psql`
  - How to get information about database objects using `psql`
  - How to run SQL commands using `psql`
  - How to use the copy command using `psql`



# Postgres Configuration



# Objectives

- In this session we will learn about how to change the settings for the postgres on several levels:
  - Session
  - Database
  - Cluster



# Setting Server Parameters

- There are many configuration parameters that affect the behaviour of the database system
- All parameter names are case-insensitive
- Every parameter takes a value of one of five types:
  - boolean
  - integer
  - floating point
  - string
  - enum
- One way to set these parameters is to edit the file **postgresql.conf**, which is normally kept in the data directory



# The Server Parameter File - postgresql.conf

- Holds parameters used by a cluster
- Parameters are case-insensitive
- Normally stored in data directory
- **initdb** installs default copy
- Some parameters only take effect on server restart (**pg\_ctl restart**)
- **#** used for comments
- One parameter per line
- Use include directive to read and process another file
- Can also be set using the command-line option



# Viewing and Changing Server Parameters

Configuration parameters can be viewed using:

- SHOW command
- pg\_settings
- pg\_file\_settings

Configuration parameters can be modified for:

- Single session using the SET command
- Database user using ALTER USER
- Single database using ALTER DATABASE



# Changing Configuration Parameter at Cluster Level

```
[postgres@pgsrv1 ~] psql edb postgres

edb=# ALTER SYSTEM SET work_mem=20480;
ALTER SYSTEM

edb=# SELECT pg_reload_conf();

edb=# ALTER SYSTEM RESET work_mem;
ALTER SYSTEM

edb=# SELECT pg_reload_conf();
```

Use ALTER SYSTEM command to edit cluster level settings without editing **postgresql.conf**

ALTER SYSTEM writes new setting to **postgresql.auto.conf** file which is read at last during server reload/restarts

Parameters can be modified using ALTER SYSTEM when required



# Lab Exercise - 6: Change parameter work\_mem - Session

- In the terminal 1:
  - Connect the postgres database postgres  
`psql -h localhost -p 5432 -d postgres -U postgres`
  - Show settings for the parameter work\_mem:  
`show work_mem;`
  - Change work\_mem, set the value to "8MB";  
`set work_mem="8MB";`
  - Show settings for the parameter work\_mem:  
`show work_mem;`
  - Exit the psql:  
`\q`





# Lab Exercise - 6: Change parameter work\_mem - Cluster

- Open the new browser window:
  - Connect the postgres database postgres again  
`psql -h localhost -p 5432 -d postgres -U postgres`
  - Show settings for the parameter work\_mem:  
`show work_mem;`  
We can see, the value is "4MB"
  - Change work\_mem on the cluster level and reload the configuration:  
`alter system set work_mem="8MB";`
  - Show settings for the parameter work\_mem (Change is not visible):  
`show work_mem;`
  - Reload configuration and show settings again:  
`select pg_reload_conf();`  
`show work_mem;`



# Lab Exercise - 6: Change parameter work\_mem - Cluster

- Open the new browser window:

- Exit the psql:

`\q`

- Connect the postgres database postgres again

`psql -h localhost -p 5432 -d postgres -U postgres`

- Show settings for the parameter work\_mem:

`show work_mem;`

We can see, the value is "8MB"



# Lab Exercise - 6: Change parameter `shared_preload_libraries` in the file `postgresql.conf` and restart the postgres

- Open the new browser window:

- Show installed extensions:

`\dx`

`create extension pg_stat_statements;`

- Run statement:

`select * from pg_stat_statements;`

-> You see the error message: `ERROR: pg_stat_statements must be loaded via "shared_preload_libraries"`

- Exit the psql:

`\q`



# Lab Exercise - 6: Change parameter `shared_preload_libraries` in the file `postgresql.conf` and restart the postgres

- Change directory to:

```
cd $HOME/postgres_workshop/
```

- Run the shell script `change_postgres_parameter.sh`

```
./change_postgres_parameter.sh
```

-> The script will set the parameter `shared_preload_libraries` to activate extension `pg_stat_statements` and restart the postgres

- Connect the postgres database postgres again

```
psql -h localhost -p 5432 -d postgres -U postgres
```

- Execute:

```
show shared_preload_libraries;
```

```
select * from pg_stat_statements;
```

- Exit the psql:

```
\q
```



# Summary

- In this session we learned about how to change the settings for the postgres on several levels:
  - Session
  - Database
  - Cluster



# Routine Maintenance Tasks



# Objectives

- In this session we will learn about how to
  - Updating Optimizer Statistics
  - Handling Data Fragmentation using Routine Vacuuming
  - Preventing Transaction ID Wraparound Failures
  - Automatic Maintenance using Autovacuum



# Database Maintenance

- Data files become fragmented as data is modified and deleted
- Database maintenance helps reconstruct the data files
- If done on time nobody notices but when not done everyone knows
- Must be done before you need it
- Improves performance of the database
- Saves database from transaction ID wraparound failures





# Maintenance Tools

- Maintenance thresholds can be configured using the pgAdmin Client
- Postgres maintenance thresholds can be configured in postgresql.conf
- Manual scripts can be written watch stat tables like **pg\_stat\_user\_tables**
- Maintenance commands:
  - **ANALYZE**
  - **VACUUM**
  - **CLUSTER**
- Maintenance command vacuumdb can be run from OS prompt
- Autovacuum can help in automatic database maintenance



# Optimizer Statistics

- Optimizer statistics play a vital role in query planning
- Not updated in real time
- Collects information for relations including size, row counts, average row size and row sampling
- Stored permanently in catalog tables
- The maintenance command **ANALYZE** updates the statistics



# Lab Exercise - 7: Updating statistics

- In the terminal 1:
  - Connect the postgres database postgres again  
`psql -h localhost -p 5432 -d postgres -U postgres`
  - Create table testanalyze and insert 10.000 rows:  
`create table testanalyze(id integer, name varchar);`  
`insert into testanalyze values(generate_series(1,10000), 'Sample');`
  - Check the postgres data dictionary to view the current statistics for the table:  
`select relname, reltuples from pg_class where relname = 'testanalyze';`
  - Update statistics using the command ANALYSE:  
`analyze testanalyze ;`
  - Check the postgres data dictionary to view the current statistics for the table:  
`select relname, reltuples from pg_class where relname = 'testanalyze';`



# Data Fragmentation and Bloat

- Data is stored in data file pages
- An update or delete of a row does not immediately remove the row from the disk page
- Eventually this row space becomes obsolete and causes fragmentation and bloating



# Routine Vacuuming

- Obsoleted rows can be removed or reused using vacuuming
- Helps in shrinking data file size when required
- Vacuuming can be automated using autovacuum
- The **VACUUM** command locks tables in access exclusive mode
- Long running transactions may block vacuuming, thus it should be done during low usage times



# Vacuuming Commands

- When executed, the **VACUUM** command:
  - Can recover or reuse disk space occupied by obsolete rows
  - Updates data statistics
  - Updates the visibility map, which speeds up index-only scans
  - Protects against loss of very old data due to transaction ID wraparound
- The **VACUUM** command can be run in two modes:
  - **VACUUM**
  - **VACUUM FULL**



# Vacuum and Vacuum Full

- **VACUUM**

- Removes dead rows and marks the space available for future reuse
- Does not return the space to the operating system
- Space is reclaimed if obsolete rows are at the end of a table

- **VACUUM FULL**

- More aggressive algorithm compared to **VACUUM**
- Compacts tables by writing a complete new version of the table file with no dead space
- Takes more time
- Requires extra disk space for the new copy of the table, until the operation completes



# Lab Exercise - 7: Vacuuming

- In the terminal 1:
  - Connect the postgres database postgres:  
`psql -h localhost -p 5432 -d postgres -U postgres`
  - Create table `key_value` and insert 10.000 rows:  
`create table key_value (key bigint primary key, value bigint);`  
`insert into key_value select i, i FROM generate_series(10, 10000) AS t(i);`
  - Check the table size:  
`select pg_size_pretty(pg_total_relation_size('key_value')) as table_size;`
  - Update 7500 rows in the table:  
`update key_value set value = value * 2 where key > 2500;`
  - Check the table size:  
`select pg_size_pretty(pg_total_relation_size('key_value')) as table_size;`





## Lab Exercise - 7: Vacuuming (continued)

- Run vacuum for the table:

```
vacuum key_value;
```

- Check the table size again:

```
select pg_size_pretty(pg_total_relation_size('key_value')) as table_size;
```

We can see, the table size is not changed

- Run vacuum **full** for the table::

```
vacuum full key_value;
```

- Check the table size:

```
select pg_size_pretty(pg_total_relation_size('key_value')) as table_size;
```

The space in the table is reclaimed



# Lab Exercise - 8: Show settings for the autovacuuming

- In the terminal 1:
  - Connect the postgres database postgres:  
`psql -h localhost -p 5432 -d postgres -U postgres`
  - Show settings for the parameter autovacuum:  
`show autovacuum;`
  - Show settings for the parameter autovacuum\_max\_workers:  
`show autovacuum_max_workers;`
  - Show settings for the parameter autovacuum\_vacuum\_threshold:  
`show autovacuum_vacuum_threshold;`
  - Show settings for the parameter autovacuum\_analyze\_threshold:  
`show autovacuum_analyze_threshold;`



# Working with Postgres database



For this part  
we may use the  
following link on  
the GitHub



[https://github.com/borysneselovskyi/postgres\\_workshop/tree/main/exercises](https://github.com/borysneselovskyi/postgres_workshop/tree/main/exercises)



# Before we begin

- **Note: All the exercises scripts are intended run from \$HOME/postgres\_workshop/exercises directory**
- Go to the lab terminal session connected as OS user postgres and perform:  

```
cd $HOME/postgres_workshop/exercises
```



# Setting up dev01 database and the role (user) u1

- In the lab terminal session connected as OS user postgres:

```
cd $HOME/postgres_workshop/exercises
```

- Invoke psql (connecting to postgres database user) to run creation script

```
psql -f 00-setup.sql
```

- Verify you can connect to the dev01 Postgres database as u1 by running

```
./u1-psql.sh
```

```
\conninfo
```

- Exit the psql session (type \q at the prompt)



# Preload pg\_stat\_statements extension shared library

- In the lab terminal session connected as OS user postgres:

```
cd /opt/postgres/data
```

```
cp postgresql.conf postgresql.conf.backup
```

```
vi postgresql.conf # alternatively use nano editor
```

- Find and edit **shared\_preload\_libraries** parameter, uncomment it and edit as below:

```
shared_preload_libraries = 'pg_stat_statements'
```

- Save **postgresql.conf**, exit the editor and restart the database

```
cd /var/lib/postgresql
```

```
pg_ctl -D /opt/postgres/data stop
```

```
pg_ctl -D /opt/postgres/data -l logfile start
```

```
cd $HOME/postgres_workshop/exercises
```

Not needed



# Make sure that pg\_stat\_statements library is preloaded

- Invoke psql (connecting to postgres database user)

```
psql
```

- Run the following command

```
SHOW shared_preload_libraries;
```

- It needs to show the string containing pg\_stat\_statements

Not needed





# Exercise #1: Introduction

- There is a performance degradation on the production database
- Over a time since go-live, a simple query executes longer and longer
- Caught by application timeouts or in Postgres log showing long-running queries
- The query text (Java)

```
SELECT * FROM s1.tst_bind_bigint WHERE ext_id = ?
```

- The table definition is

```
\d+ s1.tst_bind_bigint
```

| Table "s1.tst_bind_bigint" |        |          |          |
|----------------------------|--------|----------|----------|
| Column                     | Type   | Nullable | Storage  |
| id                         | bigint | not null | plain    |
| ext_id                     | bigint | not null | plain    |
| info                       | text   | not null | extended |

Indexes:

```
"tst_bind_bigint_pk" PRIMARY KEY btree (id)
"tst_bind_bigint_il"          btree (ext_id)
```



# Exercise #1: Step 1

- Create a testcase schema (s1) and load some data (smaller set than in production)

`./01-create-schema.sh`

- The script calls the SQL code, see on the lab machine or use browser to see at GitHub

- [https://github.com/borysneselovskyi/postgres\\_workshop/blob/main/exercises/01-create-schema.sql](https://github.com/borysneselovskyi/postgres_workshop/blob/main/exercises/01-create-schema.sql)



# Exercise #1: Step 2

- Review the test-case application code: TableAccess.java
  - See at the lab machine in exercises directory, OR use GitHub link
  - [https://github.com/borysneselovskyi/postgres\\_workshop/blob/main/exercises/TableAccess.java](https://github.com/borysneselovskyi/postgres_workshop/blob/main/exercises/TableAccess.java)
- Run test application invocation for ext\_id=12345

```
./02-app-behavior.sh # this invokes: java TableAccess 12345
```
- What is the execution time?
- Is this normal according to the experience? If not, why?



# Exercise #1: Step 3

- Compare it with the execution in psql (03-query-psql.sql)
  - See at the lab machine in exercises directory, OR use GitHub link:
  - [https://github.com/borysneselovskyi/postgres\\_workshop/blob/main/exercises/03-query-psql.sql](https://github.com/borysneselovskyi/postgres_workshop/blob/main/exercises/03-query-psql.sql)
- Run test application invocation for ext\_id=12345

```
./03-query-psql.sh
```

```
## runs: SELECT * FROM s1.tst_bind_bigint WHERE ext_id = 12345;
```
- What is the difference with running it from Java program?
- What could be the reasons?



# Exercise #1: Step 4 and 5

- Try with a different parameter (44213) in an opposite direction - psql first, Java next

```
./04-query-psql.sh      # uses ext_id = 44213  
./05-app-behavior.sh    # invokes: java TableAccess 44213
```

- Any difference?
- Any other hypothesis?



# Exercise #1: Step 6

- See the query execution planner and runtime data (06-explain-analyze.sql)
  - See at the lab machine in exercises directory, OR use GitHub link:
  - [https://github.com/borysneselovskyi/postgres\\_workshop/blob/main/exercises/06-explain-analyze.sql](https://github.com/borysneselovskyi/postgres_workshop/blob/main/exercises/06-explain-analyze.sql)

```
./06-explain-analyze.sh
```

- What plan is used?
- Does it use the index?
- Any progress with explanations and remediations?



# Exercise #1: Step 7

- Inspect `pg_stat_statements` for query stats (`07-pg-stat-statements.sql`)
  - See at the lab machine in exercises directory, OR use GitHub link:
  - [https://github.com/borysneselovskyi/postgres\\_workshop/blob/main/exercises/07-pg-stat-statements.sql](https://github.com/borysneselovskyi/postgres_workshop/blob/main/exercises/07-pg-stat-statements.sql)

```
./07-pg-stat-statements.sh
```

- What stands out?
- Is the application's query using the index?
- How does the Java bind variable map to Postgres type? See `TableAccess.java` again?



# Exercise #1: Step 8

- Reproduce in psql with the application's bind-variable type (08-gotit-explain-analyze.sql)
  - See at the lab machine in exercises directory, OR use GitHub link:
  - [https://github.com/borysneselovskyi/postgres\\_workshop/blob/main/exercises/08-gotit-explain-analyze.sql](https://github.com/borysneselovskyi/postgres_workshop/blob/main/exercises/08-gotit-explain-analyze.sql)

```
./08-gotit-explain-analyze.sh
```

- How does the SQL planner behave now?





# Exercise #1: Step 9

- Demonstrate the recommended fix in the application code (ExplainTableBigInt.java)
  - See at the lab machine in exercises directory, OR use GitHub link:
  - [https://github.com/borysneselovskyi/postgres\\_workshop/blob/main/exercises/ExplainTableBigInt.java](https://github.com/borysneselovskyi/postgres_workshop/blob/main/exercises/ExplainTableBigInt.java)

```
./09-difference.sh
```

## Old code

```
// 2) parse the bind value
BigDecimal bindBig;
try {
    bindBig = new BigDecimal(args[0]);
```

## Changed code:

```
// 2) parse the bind value
BigDecimal bindBig;
int bindInt;
try {
    bindBig = new BigDecimal(args[0]);
    bindInt = Integer.parseInt(args[0]);
```



# Exercise #1: Step 10

- What if the application code fix will not come soon and the performance problem is more and more painful?
- Workaround at the database side - an extra function based index (10-hotfix-function-index.sql)
  - See at the lab machine in exercises directory, OR use GitHub link:
  - [https://github.com/borysneselovskyi/postgres\\_workshop/blob/main/exercises/10-hotfix-function-index.sql](https://github.com/borysneselovskyi/postgres_workshop/blob/main/exercises/10-hotfix-function-index.sql)

```
./10-hotfix-function-index.sh
```

- Code:

```
create index tst_bind_bigint_hotfix_i2 on s1.tst_bind_bigint (cast (ext_id as numeric));
```
- Why we may consider it rather as a temporary workaround than the permanent fix?



# Exercise #1: Step 11

- Look at the query behavior after applying the quick fix (workaround)

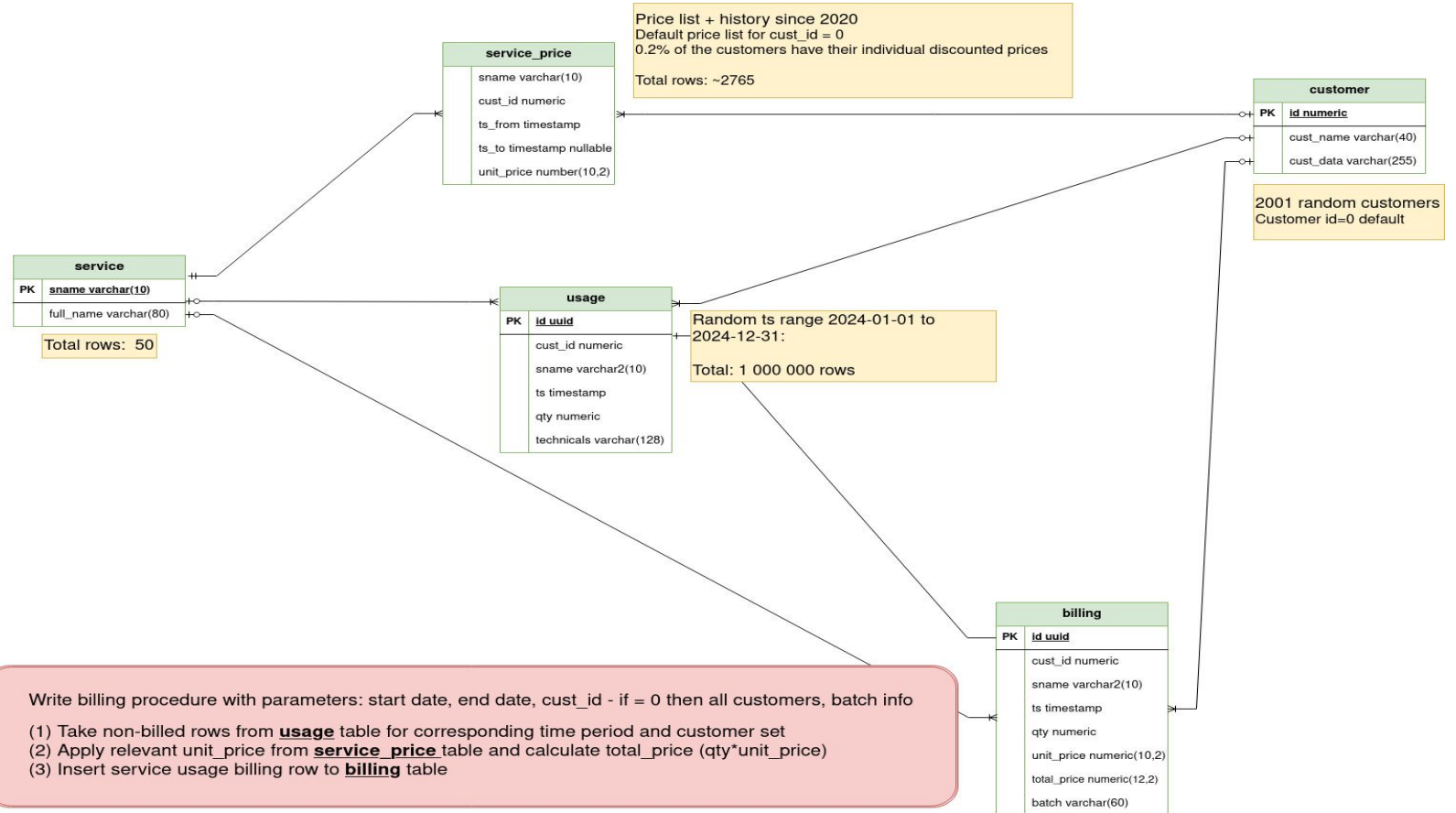
```
./02-app-behavior.sh
```

```
./07-pg-stat-statements.sh
```

```
./09-difference.sh
```



# Exercise #2: Introduction



## Exercise #2: Step 1

- Create tst schema, objects and load the data (30-create-schema.sql)
  - See at the lab machine in exercises directory, OR use GitHub link:
  - [https://github.com/borysneselovskyi/postgres\\_workshop/blob/main/exercises/30-create-schema.sql](https://github.com/borysneselovskyi/postgres_workshop/blob/main/exercises/30-create-schema.sql)
  - How the precision of partition keys based on timestamp data type is handled?

```
./30-create-schema.sh
```



## Exercise #2: Step 1

- Verify objects and row count following Step 1
  - Please verify the objects by using psql command connecting to dev01 database as u1 user:

`./u1-psql.sh`

- Tables:

`\dt tst.*`

- Indexes:

`\di tst.*`

- Record count:

`select count(*) from tst.service;`

`select count(*) from tst.service_price;`

`select count(*) from tst.customer;`

`select count(*) from tst.usage;`

- Exit psql:

`\q`



## Exercise #2: Step 2

- Let's go through classical procedure implementation (31-create-proc-billing.sql)
  - See at the lab machine in exercises directory, OR use GitHub link:
  - [https://github.com/borysneselovskyi/postgres\\_workshop/blob/main/exercises/31-create-proc-billing.sql](https://github.com/borysneselovskyi/postgres_workshop/blob/main/exercises/31-create-proc-billing.sql)

```
./31-create-proc-billing.sh
```



## Exercise #2: Step 3

- Let's run the first procedure (32-exec-proc-billing.sql)
  - See at the lab machine in exercises directory, OR use GitHub link:
  - [https://github.com/borysneselovskyi/postgres\\_workshop/blob/main/exercises/32-exec-proc-billing.sql](https://github.com/borysneselovskyi/postgres_workshop/blob/main/exercises/32-exec-proc-billing.sql)

```
./32-exec-proc-billing.sh  
# psql runs 32-exec-proc-billing.sql which:  
# truncates tst.billing table, sets the \timing on and run  
# call tst.proc_billing (date '2024-01-01', date '2024-12-31', 0);
```

- What is its execution time? Please write it down
- How can it be improved?





## Exercise #2: Step 4

- Let's check one of the concepts: no lookup to `tst.service_price` table, use a fixed cost
- Indicate the performance limits of reading `tst.usage` and write to `tst.billing`
- Comment out the `tst.service_price` lookup and create a new procedure `tst.proc_billing0` (33-create-proc-null-billing.sql)
  - See at the lab machine in exercises directory, OR use GitHub link:
  - [https://github.com/borysneselovskyi/postgres\\_workshop/blob/main/exercises/33-create-proc-null-billing.sql](https://github.com/borysneselovskyi/postgres_workshop/blob/main/exercises/33-create-proc-null-billing.sql)

```
./33-create-proc-null-billing.sh
```



## Exercise #2: Step 5

- Let's run “null-billing” procedure `tst.proc_billing0` (34-exec-proc-null-billing.sql)
  - See at the lab machine in exercises directory, OR use GitHub link:
  - [https://github.com/borysneselovskyi/postgres\\_workshop/blob/main/exercises/34-exec-proc-null-billing.sql](https://github.com/borysneselovskyi/postgres_workshop/blob/main/exercises/34-exec-proc-null-billing.sql)

```
./34-exec-proc-null-billing.sh
# psql runs 34-exec-proc-null-billing.sql which:
# truncates tst.billing table, sets the \timing on and run
# call tst.proc_billing0 (date '2024-01-01', date '2024-12-31', 0);
```

- What is its execution time? Please write it down and compare with the time from Step 3
- Any thoughts?



## Exercise #2: Step 6

- How to improve the code to be more performant BUT with the real processing?
- Cache lookup data in the procedure variable
- Option #1: Use the variable of HSTORE data type: procedure tst.proc\_billing4\_1 (35-create-proc-opt1.sql)
  - See at the lab machine in exercises directory, OR use GitHub link:
  - [https://github.com/borysneselovskyi/postgres\\_workshop/blob/main/exercises/35-create-proc-opt1.sql](https://github.com/borysneselovskyi/postgres_workshop/blob/main/exercises/35-create-proc-opt1.sql)

```
./35-create-proc-opt1.sh
```



## Exercise #2: Step 7

- Let's run the procedure `tst.proc_billing4_1` using HSTORE variable to cache the relevant `tst.service_price` subset (`36-exec-proc-billing-opt1.sql`)
  - See at the lab machine in exercises directory, OR use GitHub link:
  - [https://github.com/borysneselovskyi/postgres\\_workshop/blob/main/exercises/36-exec-proc-billing-opt1.sql](https://github.com/borysneselovskyi/postgres_workshop/blob/main/exercises/36-exec-proc-billing-opt1.sql)

```
./36-exec-proc-billing-opt1.sh  
# psql runs 36-exec-proc-billing-opt1.sql which:  
# truncates tst.billing table, sets the \timing on and run  
# call tst.proc_billing4_1 (date '2024-01-01', date '2024-12-31', 0);
```

- What is its execution time? Please write it down and compare with the time from Step 3 and 5



## Exercise #2: Step 8

- How to improve the code to be more performant BUT with the real processing - revisited ?
- Cache lookup data in the procedure variable in another way
- Option #2: Use the variable of JSONB data type: procedure tst.proc\_billing5\_4 (37-create-proc-opt2.sql)
- Remark: Possible since Postgres 17
  - See at the lab machine in exercises directory, OR use GitHub link:
  - [https://github.com/borysneselovskyi/postgres\\_workshop/blob/main/exercises/37-create-proc-opt2.sql](https://github.com/borysneselovskyi/postgres_workshop/blob/main/exercises/37-create-proc-opt2.sql)

```
./37-create-proc-opt2.sh
```



## Exercise #2: Step 9

- Let's run the procedure `tst.proc_billing5_4` using JSONB variable to cache the relevant `tst.service_price` subset (`38-exec-proc-billing-opt2.sql`)
  - See at the lab machine in exercises directory, OR use GitHub link:
  - [https://github.com/borysneselovskyi/postgres\\_workshop/blob/main/exercises/38-exec-proc-billing-opt2.sql](https://github.com/borysneselovskyi/postgres_workshop/blob/main/exercises/38-exec-proc-billing-opt2.sql)

```
./38-exec-proc-billing-opt2.sh  
# psql runs 38-exec-proc-billing-opt2.sql which:  
# truncates tst.billing table, sets the \timing on and run  
# call tst.proc_billing5_4 (date '2024-01-01', date '2024-12-31', 0);
```

- What is its execution time? Please write it down and compare with the time from Step 3, 5 and 7



## Exercise #2: Step 10

- Run procedure set for Q1 2024, not for full 2024
  - See at the lab machine in exercises directory, OR use GitHub workshop repo to see sh and sql scripts

```
./42-exec-proc-billing.sh          # As ./32-exec-proc-billing.sh, but for Q1 2024 only
./44-exec-proc-null-billing.sh     # As ./34-exec-proc-null-billing.sh, but for Q1 2024 only
./46-exec-proc-billing-opt1.sh     # As ./36-exec-proc-billing-opt1.sh, but for Q1 2024 only
./48-exec-proc-billing-opt2.sh     # As ./48-exec-proc-billing-opt2.sh, but for Q1 2024 only
```

- What are the execution times?

