Postgres Workshop - Hands-on

Prep hands-on

VMs IP Addresses - Group 1

vm	vm ip	public ip
vm01	54.93.172.252	
vm02	3.75.187.11	
vm03	3.79.179.153	
vm04	35.159.40.170	
vm05	3.64.192.147	

vm	vm ip	public ip
vm06	35.156.191.4	
vm07	3.76.45.149	
vm08	3.67.10.131	
vm09	3.77.57.246	
vm10	3.120.147.88	
vm11	18.195.222.235	

VMs IP Addresses - Group 2

vm	vm ip	public ip
vm12	54.74.132.109	
vm13	34.253.155.127	
vm14	52.208.10.208	
vm15	108.130.15.214	
vm16	34.246.198.152	

vm	vm ip	public ip
vm17	3.252.80.171	
vm18	54.171.180.222	
vm19	52.19.39.251	
vm20	108.130.16.137	
vm21	54.75.30.62	
vm22	54.170.29.229	

VMs IP Addresses - Group 3

vm	vm ip	public ip
vm23	13.40.101.168	
vm24	35.179.184.28	
vm25	35.177.53.245	
vm26	3.8.115.35	
vm27	3.8.209.184	

vm	vm ip	public ip
vm28	18.134.243.189	
vm29	18.171.59.227	
vm30	3.8.210.31	
vm31	18.130.27.108	
vm32	35.179.115.183	
vm33	18.171.246.242	

Hand-on documentation

https://tinyurl.com/fr7hbjms

Download the Hand-on Document
Workshop_Hands_On.pdf

Get your public ip address and provide us:

CLI:

curl -4 ifconfig.co

dig +short myip.opendns.com @resolver1.opendns.com

Browser:

https://www.whatsmyip.org/

Send us via email your vm number + your public ip

To Email : borys.neselovskyi@enterprisedb.com

Subject: Warsaw Workshop - VM Number

Information:

VM Number : Public IP Address

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 hans-on rom the GitHub:
  - Run:

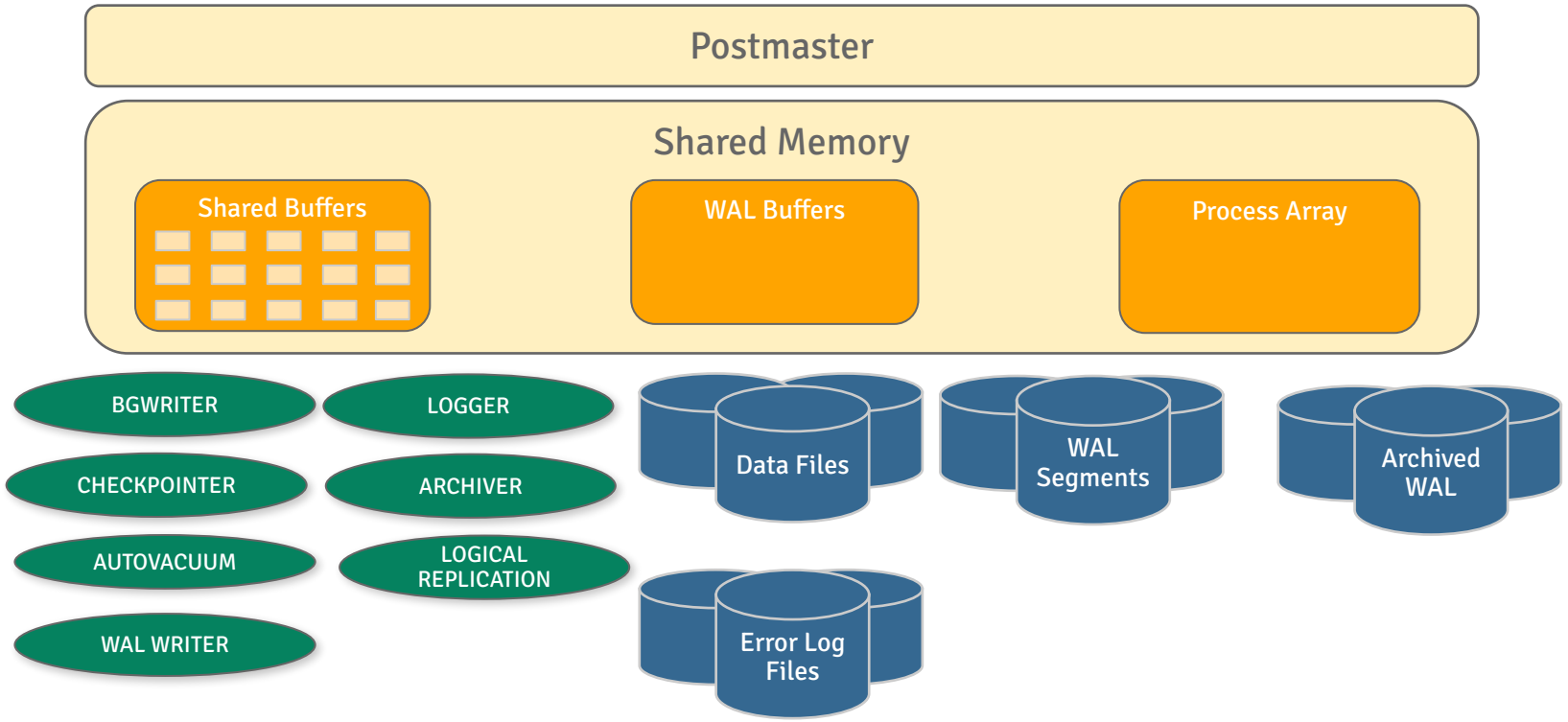
    git clone https://github.com/borysneselovskyi/postgres_workshop.git

Getting started with Postgres

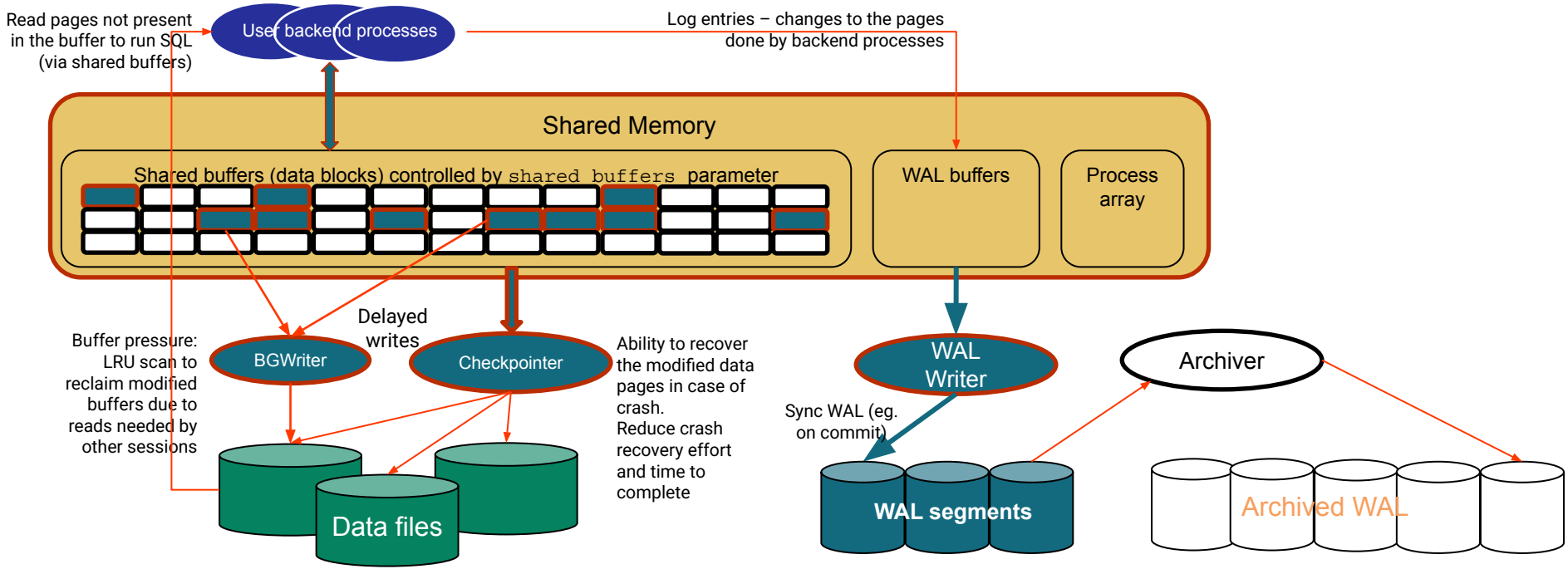
Objectives

- 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

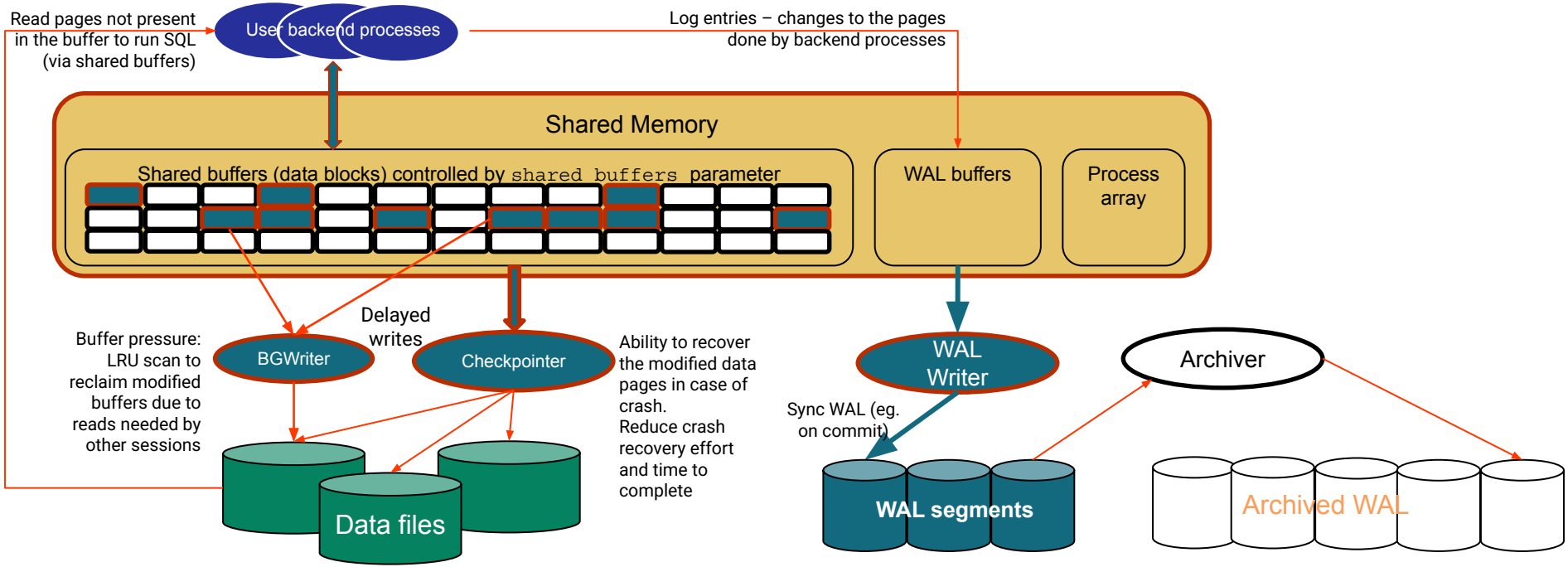
Process and Memory Architecture



Key processes affecting disk and memory



Key processes affecting disk and memory

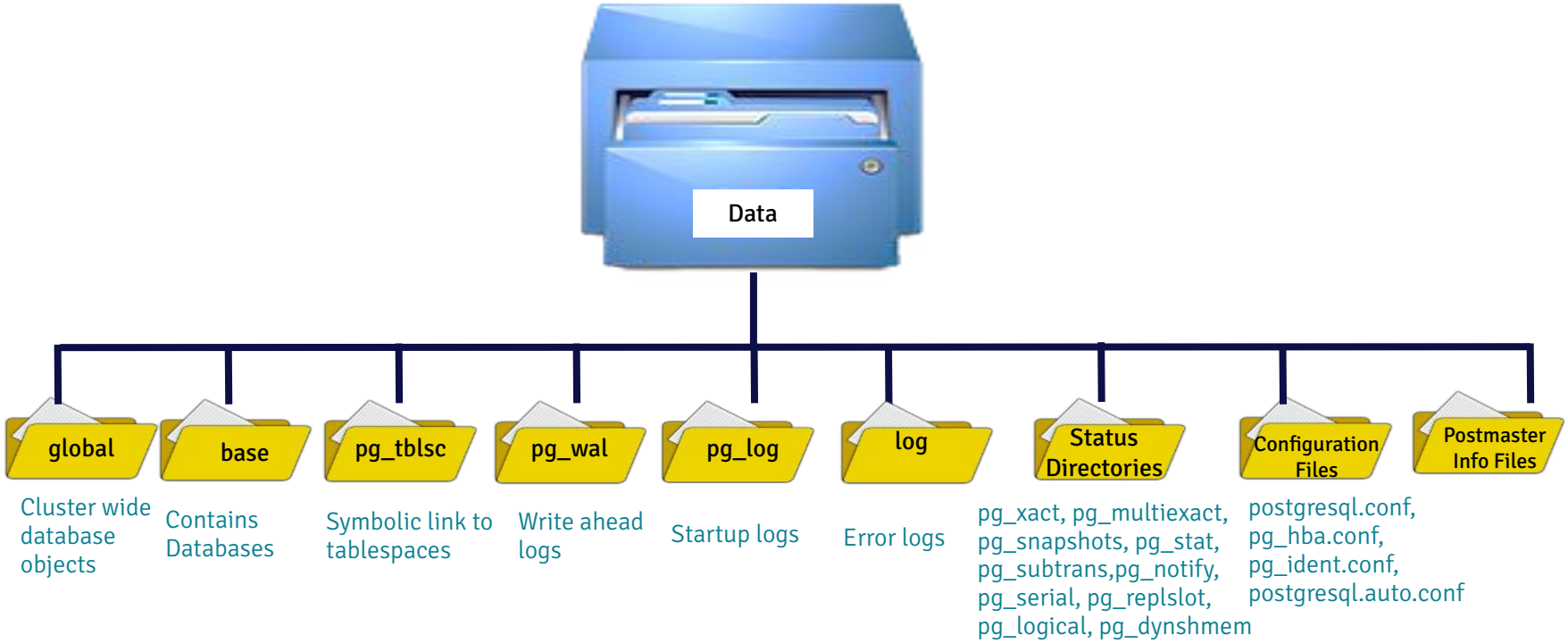


To be adjusted for current template (Piotr)

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[onnect] [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 plsq 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

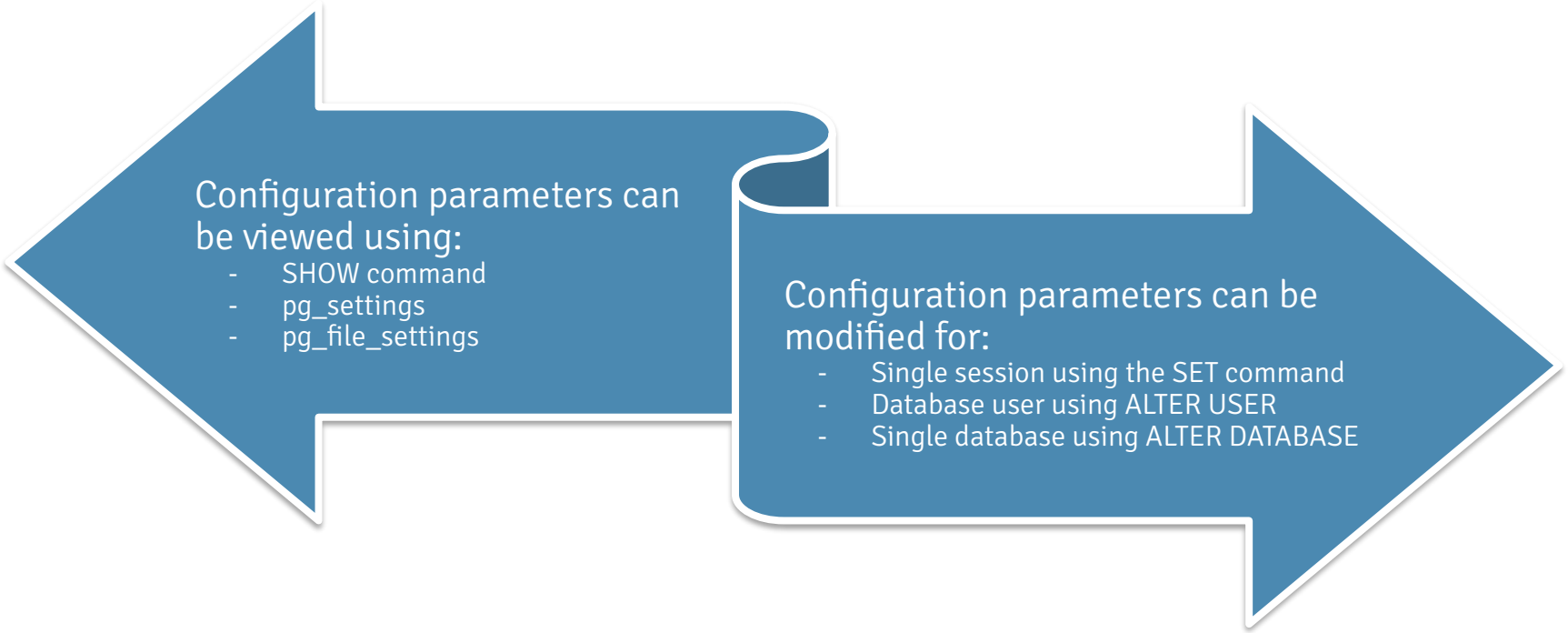
Setting Server Parameters

- 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



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

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 another 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/pgsql
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_i1"           btree (ext_id)
```

https://github.com/borysneselovskyi/postgres_workshop/tree/main/excersises#2-exercise-1---simple-performance-misbehavior

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

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
- 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
- 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

```
./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

```
./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

```
./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

```
./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

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

- Code:

```
create index tst_bind_bigint_hotfix_i2 on s1.tst_bind_bigint (cast (ext_id as numeric));
```

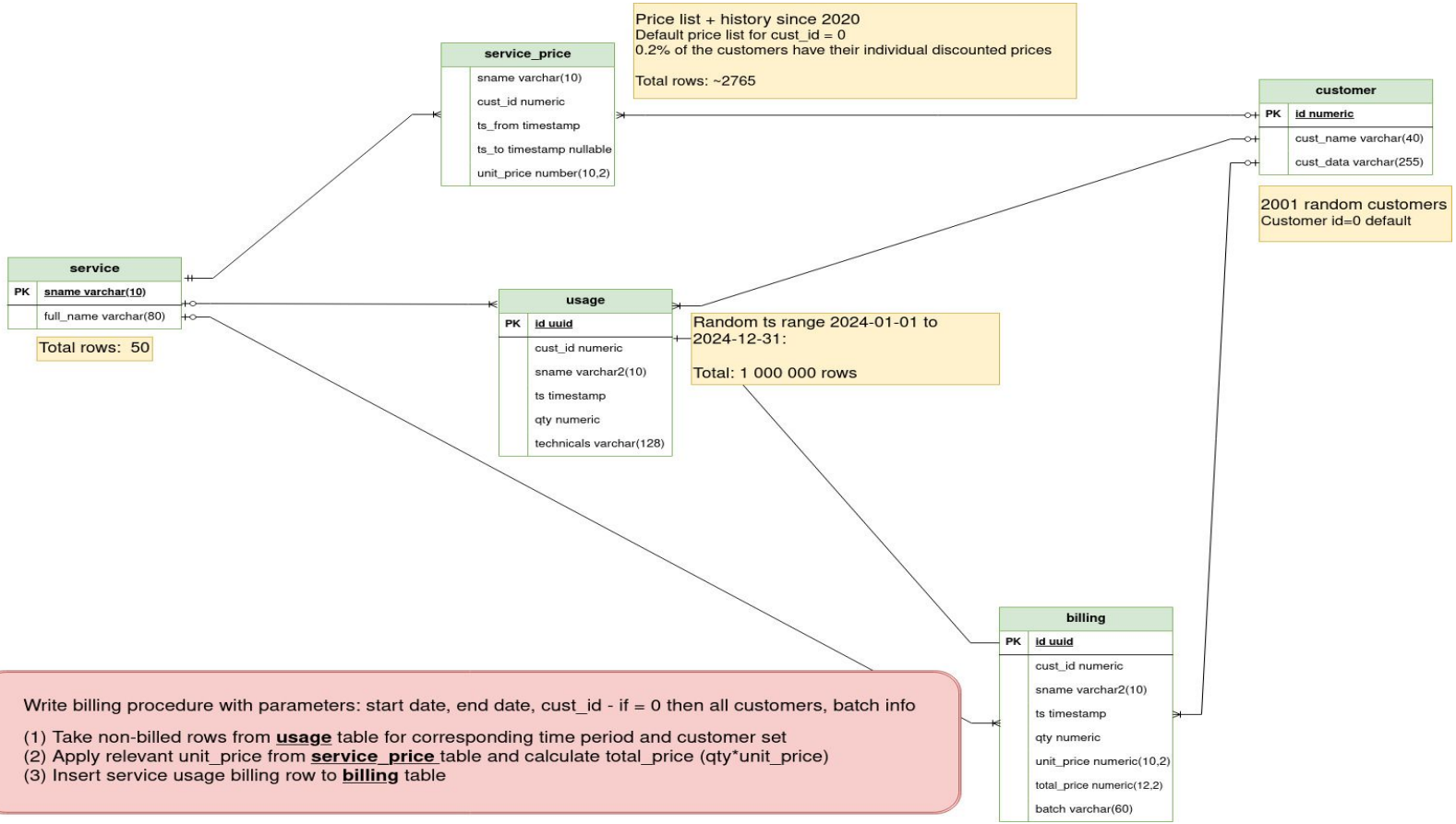
- Why we may consider it rather as a temporary workaround than the permanent fix?

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
  - 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

```
./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

```
./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

```
./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

```
./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

```
./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

```
./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

```
./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

```
./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?