

UPGRADE

A practical guide

DALIBO

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Figure 1: PostgreSQL Anonymizer

Anonymization & Data Masking for Postgres

PostgreSQL Anonymizer is an extension to mask or replace personally identifiable information (PII) or commercially sensitive data from a Postgres database.

The project has a **declarative approach** of anonymization. This means you can declare the masking rules using the PostgreSQL Data Definition Language (DDL) and specify your anonymization policy inside the table definition itself.

The main goal of this extension is to offer **anonymization by design**. We firmly believe that data masking rules should be written by the people who develop the application because they have the best knowledge of how the data model works. Therefore masking rules must be implemented directly inside the database schema.

Once the masking rules are defined, you can apply them using 5 different **masking methods** :

- Anonymous Dumps : Simply export the masked data into an SQL file
- Static Masking : Remove the PII according to the rules
- Dynamic Masking : Hide PII only for the masked users
- Masking Views : Build dedicated views for the masked users
- Masking Data Wrappers : Apply masking rules on external data

Each method has its pros and cons. Different masking methods may be used in different contexts. In any case, masking the data directly inside the PostgreSQL instance without using an external tool is crucial to limit the exposure and the risks of data leak.

In addition, various Masking Functions are available : randomization, faking, partial scrambling, shuffling, noise or even your own custom function!

Finally, the extension offers a panel of detection functions that will try to guess which columns need to be anonymized.

Quick Start

Step 0. Launch docker image of the project

```
ANON_IMG=registry.gitlab.com/dalibo/postgresql_anonymizer
docker run --name anon_quickstart --detach -e POSTGRES_PASSWORD=x $ANON_IMG
docker exec -it anon_quickstart psql -U postgres
```

Step 1. Create a database and load the extension in it

```
CREATE DATABASE demo;
ALTER DATABASE demo SET session_preload_libraries = 'anon'
```

```
\connect demo
```

You are now connected to database "demo" as user "postgres".

Step 2. Create a table

```
CREATE TABLE people AS
    SELECT 153478      AS id,
           'Sarah'    AS firstname,
           'Conor'    AS lastname,
           '0609110911' AS phone
;

SELECT * FROM people;
   id | firstname | lastname |   phone
-----+-----+-----+-----
153478 | Sarah    | Conor   | 0609110911
```

Step 3. Create the extension and activate the masking engine

```
CREATE EXTENSION anon;
ALTER DATABASE demo SET anon.transparent_dynamic_masking TO true;
```

Step 4. Declare a masked user

```
CREATE ROLE skynet LOGIN;

SECURITY LABEL FOR anon ON ROLE skynet IS 'MASKED';
```

```
GRANT pg_read_all_data to skynet;
```

Step 5. Declare the masking rules

```
SECURITY LABEL FOR anon ON COLUMN people.lastname
    IS 'MASKED WITH FUNCTION anon.dummy_last_name()';

SECURITY LABEL FOR anon ON COLUMN people.phone
    IS 'MASKED WITH FUNCTION anon.partial(phone,2,$$*****$$,2)';
```

Step 6. Connect with the masked user

```

\connect - skynet
You are now connected to database "demo" as user "skynet"

SELECT * FROM people;
   id   | firstname | lastname |   phone
-----+-----+-----+-----
 153478 | Sarah     | Stranahan | 06*****11

```

Success Stories

With PostgreSQL Anonymizer we integrate, from the design of the database, the principle that outside production the data must be anonymized. Thus we can reinforce the GDPR rules, without affecting the quality of the tests during version upgrades for example.

— **Thierry Aimé, Office of Architecture and Standards in the French Public Finances Directorate General (DGFIP)**

Thanks to PostgreSQL Anonymizer we were able to define complex masking rules in order to implement full pseudonymization of our databases without losing functionality. Testing on realistic data while guaranteeing the confidentiality of patient data is a key point to improve the robustness of our functionalities and the quality of our customer service.

— **Julien Biaggi, Product Owner at bioMérieux**

I just discovered your postgresql_anonymizer extension and used it at my company for anonymizing our user for local development. Nice work!

— **Max Metcalfe**

If this extension is useful to you, please let us know !

Support

We need your feedback and ideas ! Let us know what you think of this tool, how it fits your needs and what features are missing.

You can either open an issue or send a message at contact@dalibo.com.

open an issue: https://gitlab.com/dalibo/postgresql_anonymizer/issues

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Backup Masking (aka Anonymous Dumps)

PostgreSQL Anonymous Dumps

Transparent Anonymous Dumps

To export the anonymized data from a database, follow these 3 steps:

1. Create a masked user

```
CREATE ROLE anon_dumper LOGIN PASSWORD 'x';
ALTER ROLE anon_dumper SET anon.transparent_dynamic_masking = True;
SECURITY LABEL FOR anon ON ROLE anon_dumper IS 'MASKED';
```

NOTE: You can replace the name `anon_dumper` by another name.

2. Grant read access to that masked user

```
GRANT pg_read_all_data to anon_dumper;
```

NOTE: If you are running PostgreSQL 13 or if you want a more fine-grained access policy you can grant access more precisely, for instance:

```
GRANT USAGE ON SCHEMA public TO anon_dumper;
GRANT SELECT ON ALL TABLES IN SCHEMA public TO anon_dumper;
GRANT SELECT ON ALL SEQUENCES IN SCHEMA public TO anon_dumper;

GRANT USAGE ON SCHEMA foo TO anon_dumper;
GRANT SELECT ON ALL TABLES IN SCHEMA foo TO anon_dumper;
GRANT SELECT ON ALL SEQUENCES IN SCHEMA foo TO anon_dumper;
```

3. Launch `pg_dump` with the masked user

Now to export the anonymous data from a database named `foo`, let's use `pg_dump`:

```
pg_dump foo \
    --user anon_dumper \
    --no-security-labels \
    --exclude-extension="anon" \
    --file=foo_anonymized.sql
```

NOTES:

- linebreaks are here for readability
- `--no-security-labels` will remove the masking rules from the anonymous dump. This is really important because masked users should not have access to the masking policy.

- `--exclude-extension` is only available with `pg_dump` 17 and later. As an alternative you can use `--extension plpgsql`.
- `--format=custom` is supported

Anonymizing an SQL file

In previous versions of the documentation, this method was also called « anonymizing black box ».

You can also apply masking rules directly on a database backup file !

The PostgreSQL Anonymizer docker image contains a specific entrypoint script called `/dump.sh`. You pass the original data and the masking rules to that `/dump.sh` script and it will return an anonymized dump.

Here's an example in 4 steps:

Step 1: Dump your original data (for instance `dump.sql`)

```
pg_dump --format=plain [...] my_db > dump.sql
```

Note this method only works with plain sql format (`-Fp`). You **cannot** use the custom format (`-Fc`) and the directory format (`-Fd`) here.

If you want to maintain the owners and grants, you need export them with `pg_dumpall --roles-only` like this:

```
(pg_dumpall -Fp [...] --roles-only && pg_dump -Fp [...] my_db ) > dump.sql
```

Step 2: Write your masking rules in a separate file (for instance `rules.sql`)

```
SECURITY LABEL FOR anon ON COLUMN people.lastname
IS 'MASKED WITH FUNCTION anon.dummy_last_name()';
```

```
-- etc.
```

Step 3: Pass the dump and the rules through the docker image and receive an anonymized dump !

```
IMG=registry.gitlab.com/dalibo/postgresql_anonymizer
ANON="docker run --rm -i $IMG /dump.sh"
cat dump.sql rules.sql | $ANON > anon_dump.sql
```

(this last step is written on 3 lines for clarity)

NB: You can also gather *step 1* and *step 3* in a single command:

```
(pg_dumpall --roles-only && pg_dump my_db && cat rules.sql) | $ANON > anon_dump.sql
```

NOTES:

You can use most the `pg_dump` output options with the `/dump.sh` script, for instance:


```
cat dump.sql rules.sql | $ANON --data-only --inserts > anon_dump.sql
```

Masking primary keys with Backup Masking

Primary keys (such as `SERIAL`) are often masked with the `anon.random_id()` function which will generate a unique random identifier every it is called.

However this function will not work with Backup Masking because `pg_dump` will * connect in read-only mode to the database (`default_transaction_read_only=on;`) and the `anon.random_id()` function needs to update a sequence to avoid generating the same value twice.

See issue #529 for more details:

https://gitlab.com/dalibo/postgresql_anonymizer/-/issues/529

Therefore if you use `'anon.random_id()' in some rules, the backup masking process will throw the following error :`

```
pg_dump: detail: Error message from server:
ERROR: permission denied for sequence random_id_seq
```

The solution is to rewrite the masking rules based on `anon.random_id()` and use `anon.pseudo_shift(BIGINT)` or `anon.pseudo_xor(BIGINT)` instead.

For instance the masking rule below:

```
SECURITY LABEL FOR anon ON COLUMN people.id
IS 'MASKED WITH FUNCTION anon.random_id()';
```

would become

```
SECURITY LABEL FOR anon ON COLUMN people.id
IS 'MASKED WITH FUNCTION anon.pseudo_xor(id)';
```

The `anon.pseudo_shift(BIGINT)` and `anon.pseudo_xor(BIGINT)` functions use a secret value (`anon.shift`) to pseudonymize the primary key. The secret value can be initialized randomly with `anon.set_shift()` or defined with `anon.set_shift(INT)`.

WARNING: Remember that Pseudonymization is not Anonymization !

DEPRECATED : `pg_dump_anon.sh` and `pg_dump_anon`

In version 0.x, the anonymous dumps were done with a shell script named `pg_dump_anon.sh`. In version 1.x it was done with a go lang script named `pg_dump_anon`. **Both commands are now deprecated.**

However `pg_dump_anon` is kept for backward compatibility. If you are still using `pg_dump_anon`, you should switch to the `pg_dump` method described above as soon as possible. — title: concepts draft: false toc: true —

Definitions of the terms used in this project

Two main strategies are used:

- **Dynamic Masking** offers an altered view of the real data without modifying it. Some users may only read the masked data, others may access the authentic version.
- **Permanent Destruction** is the definitive action of substituting the sensitive information with uncorrelated data. Once processed, the authentic data cannot be retrieved.

The data can be altered with several techniques:

- **Deletion** or **Nullification** simply removes data.
- **Static Substitution** consistently replaces the data with a generic value. For instance: replacing all values of a TEXT column with the value “CONFIDENTIAL”.
- **Variance** is the action of “shifting” dates and numeric values. For example, by applying a +/- 10% variance to a salary column, the dataset will remain meaningful.
- **Generalization** reduces the accuracy of the data by replacing it with a range of values. Instead of saying “Bob is 28 years old”, you can say “Bob is between 20 and 30 years old”. This is useful for analytics because the data remains true.
- **Shuffling** mixes values within the same columns. This method is open to being reversed if the shuffling algorithm can be deciphered.
- **Randomization** replaces sensitive data with **random-but-plausible** values. The goal is to avoid any identification from the data record while remaining suitable for testing, data analysis and data processing.
- **Partial scrambling** is similar to static substitution but leaves out some part of the data. For instance : a credit card number can be replaced by ‘40XX XXXX XXXX XX96’
- **Custom rules** are designed to alter data following specific needs. For instance, randomizing simultaneously a zipcode and a city name while keeping them coherent.
- **Pseudonymization** is a way to **protect** personal information by hiding it using additional information. **Encryption** and **Hashing** are two examples of pseudonymization techniques. However a pseudonymized data is still linked to the original data. — title: configure draft: false toc: true

—

Configuration

The extension has currently a few options that be defined for the entire instance (inside `postgresql.conf` or with `ALTER SYSTEM`).

It is also possible and often a good idea to define them at the database level like this:

```
ALTER DATABASE customers SET anon.restrict_to_trusted_schemas = on;
```

Only superuser can change the parameters below :

anon.algorithm

Type	Text
Default value	'sha256'
Visible	only to superusers

This is the hashing method used by pseudonymizing functions. Checkout the `pgcrypto` documentation for the list of available options.

See `anon.salt` to learn why this parameter is a very sensitive information.

anon.maskschema

Type	Text
Default value	'mask'
Visible	to all users

The schema (i.e. 'namespace') where the dynamic masking views will be stored.

anon.restrict__to__trusted__schemas

Type	Boolean
Default value	off
Visible	to all users

By enabling this parameter, masking rules must be defined using functions located in a limited list of namespaces. By default, only the `anon` schema is trusted.

This improves security by preventing users from declaring their custom masking filters. This also means that the schema must be explicit inside the masking rules.

For more details, check out the Write your own masks section of the Masking functions chapter.

anon.salt

Type	Text
Default value	(empty)
Visible	only to superusers

This is the salt used by pseudonymizing functions. It is very important to define a custom salt for each database like this:

```
ALTER DATABASE foo SET anon.salt = 'This_Is_A_Very_Secret_Salt';
```

If a masked user can read the salt, he/she can run a brute force attack to retrieve the original data based on the 3 elements:

- The pseudonymized data
- The hashing algorithm (see `anon.algorithm`)
- The salt

The GDPR considered that the salt and the name of the hashing algorithm should be protected with the same level of security that the data itself. This is why you should store the salt directly within the database with `ALTER DATABASE`.

anon.sourceschema

Type	Text
Default value	'public'
Visible	to all users

The schema (i.e. 'namespace') where the tables are masked by the dynamic masking engine.

Change this value before starting dynamic masking.

```
ALTER DATABASE foo SET anon.sourceschema TO 'my_app';
```

Then reconnect so that the change takes effect and start the engine.

```
SELECT start_dynamic_masking();
```

Custom Fake Data

This extension is delivered with a small set of fake data by default. For each fake function (`fake_email()`, `fake_first_name()`) we provide only 1000 unique

values, and they are only in English.

Here's how you can create your own set of fake data!

Alternative fake data packages

The project is offering alternative fake datasets (currently only French). You can download the zip file containing the dataset and load it into the extension like this:

1. Go to https://gitlab.com/dalibo/postgresql_anonymizer/-/packages
2. Click on “data”
3. Choose your preferred zip file and download it on your server
4. Unzip the file into a folder (for example `/path/to/custom_csv_files/`)
5. Run `SELECT anon.init('/path/to/custom_csv_files/')`

Generate your own fake dataset

As an example, here's a python script that will generate fake data for you:

https://gitlab.com/dalibo/postgresql_anonymizer/-/blob/master/python/populate.py

To produce 5000 emails in French & German, you'd call the scripts like this:

```
populate.py --table email --locales fr,de --lines 5000
```

This will output the fake data in CSV format.

Use `populate.py --help` for more details about the script parameters.

You can load the fake data directly into the extension like this:

```
TRUNCATE anon.email;

COPY anon.email
FROM
PROGRAM 'populate.py --table email --locales fr,de --lines 5000';

SELECT setval('anon.email_oid_seq', max(oid))
FROM anon.email;

CLUSTER anon.email;
```

IMPORTANT : This script is provided as an example, it is not officially supported.

Load your own fake data

If you want to use your own dataset, you can import custom CSV files with :

```
SELECT anon.init('/path/to/custom_csv_files/')
```

Look at the `data` folder to find the format of the CSV files.

Using the PostgreSQL Faker extension

If you need more specialized fake data sets, please read the Advanced Faking section.

Advanced Faking: [masking_functions.md#advanced-faking](#)

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classDiagram

```
class identifier_category{
    INTEGER id,
    TEXT name
    BOOL direct_identifier
    TEXT anon_function
}

class field_name{
    TEXT attname
    TEXT lang
    INTEGER fk_identifiers_category
}

field_name "1..N" --> "1" identifier_category
```

Put on your Masks !

The main idea of this extension is to implement the concept of **Privacy by Design**, which is principle imposed by the Article 25 of the GDPR.

With PostgreSQL Anonymizer, you can declare a **masking policy** which is a set of **masking rules** stored inside the database model and applied to various database objects.

The data masking rules should be written by the people who develop the application because they have the best knowledge of how the data model works. Therefore masking rules must be implemented directly inside the database schema.

This allows to mask the data directly inside the PostgreSQL instance without using an external tool and thus limiting the exposure and the risks of data leak.

The data masking rules are declared simply by using security labels:

```
CREATE TABLE player( id SERIAL, name TEXT, total_points INT, highest_score INT);

INSERT INTO player VALUES
( 1, 'Kareem Abdul-Jabbar', 38387, 55),
( 5, 'Michael Jordan', 32292, 69);

SECURITY LABEL FOR anon ON COLUMN player.name
IS 'MASKED WITH FUNCTION anon.fake_last_name()';

SECURITY LABEL FOR anon ON COLUMN player.id
IS 'MASKED WITH VALUE NULL';
```

Principles

- You can mask tables in multiple schemas
- Generated columns are respected.
- Row Security Policies aka RLS are respected.
- A masking rule may break data integrity. For instance, you can mask a NOT NULL column with the value NULL. This is up to you to decide whether or not the masked users need data integrity.
- You need to declare masking rules on views. By default, the masking rules declared on the underlying tables are **NOT APPLIED** on the view. For instance, if a view `v_foo` is based upon a table `foo`, then the masking rules of table `foo` will not be applied to `v_foo`. You will need to declare specific masking rules for `v_foo`. Remember that PostgreSQL uses the view owner (not the current user) to check permissions on the underlying tables.

Escaping String literals

As you may have noticed the masking rule definitions are placed between single quotes. Therefore if you need to use a string inside a masking rule, you need to use C-Style escapes like this:

```
SECURITY LABEL FOR anon ON COLUMN player.name
IS E'MASKED WITH VALUE \'CONFIDENTIAL\'';
```

Or use dollar quoting which is easier to read:

```
SECURITY LABEL FOR anon ON COLUMN player.name
IS 'MASKED WITH VALUE $$CONFIDENTIAL$$';
```

Listing masking rules

To display all the masking rules declared in the current database, check out the `anon.pg_masking_rules`:

```
SELECT * FROM anon.pg_masking_rules;
```

Debugging masking rules

When an error occurs due to a wrong masking rule, you can get more detailed information about the problem by setting `client_min_messages` to `DEBUG` and you will get useful details

```
postgres=# SET client_min_messages=DEBUG;
SET
postgres=# SELECT anon.anonymize_database();
DEBUG:  Anonymize table public.bar with firstname = anon.fake_first_name()
DEBUG:  Anonymize table public.foo with id = NULL
ERROR:  Cannot mask a "NOT NULL" column with a NULL value
HINT:   If privacy_by_design is enabled, add a default value to the column
CONTEXT: PL/pgSQL function anon.anonymize_table(regclass) line 47 at RAISE
SQL function "anonymize_database" statement 1
```

Removing a masking rule

You can simply erase a masking rule like this:

```
SECURITY LABEL FOR anon ON COLUMN player.name IS NULL;
```

To remove all rules at once, you can use:

```
SELECT anon.remove_masks_for_all_columns();
```

Multiple Masking Policies

By default, there is only one masking policy named ‘anon’. Most of the times, a single policy is enough. However in more complex situations, the database owner may want to define different sets of masking rules for different use cases.

This can be achieved by declaring multiple masking policies.

For instance, we can add 2 new policies with:

```
ALTER DATABASE foo SET anon.masking_policies TO 'devtests, analytics';
```

Important: You need to reconnect to the database so that the change takes effect !

We can now define a “devtests” policy for a developer name “devin”. Devin wants to run CI tests on his code using fake/random data.


```
SECURITY LABEL FOR devtests ON COLUMN player.name  
IS 'MASKED WITH FUNCTION anon.fake_last_name()';
```

```
SECURITY LABEL FOR devtests ON COLUMN player.highest_score  
IS 'MASKED WITH FUNCTION anon.random_int_between(0,50)';
```

```
SECURITY LABEL FOR devtests ON ROLE devin IS 'MASKED';
```

We can also define an “analytics” for a data scientist name “Anna”. Anna needs to run global stats over the dataset, she want to keep the real value on the `highest_score` column but she does not need to know the players names

```
SECURITY LABEL FOR analytics ON COLUMN player.name  
IS 'MASKED WITH VALUE NULL';
```

```
SECURITY LABEL FOR analytics ON ROLE anna IS 'MASKED';
```

Only one policy can be applied to a role. If you define that a role is masked in several masking policies, only the first one in the list will be applied.

The “anon” policy is always declared and cannot be removed.

If you declare a function as `TRUSTED`, it will be trusted for all masking policies.

Limitations

- The masking rules are **NOT INHERITED** ! If you have split a table into multiple partitions, you need to declare the masking rules for each partition.
- Masking identity columns is tricky. If an identity column is defined as `GENERATED ALWAYS`, then static masking will not work on that column. Note identity columns are used most of the time for surrogate keys (also known as “factless keys”) and in general those keys should not required to be masked. However if you really need to mask an identity column you can redefine it as `GENERATED DEFAULT`.

Searching for Identifiers

WARNING : This feature is at an early stage of development.

As we’ve seen previously, this extension makes it very easy to declare masking rules.

However, when you create an anonymization strategy, the hard part is scanning the database model to find which columns contains direct and indirect identifiers, and then decide how these identifiers should be masked.

The extension provides a `detect()` function that will search for common identifier names based on a dictionary. For now, 2 dictionaries are available: english

('en_US') and french ('fr_FR'). By default, the english dictionary is used:

```
# SELECT anon.detect('en_US');
table_name | column_name | identifiers_category | direct
-----+-----+-----+-----
customer   | CreditCard  | creditcard          | t
vendor      | Firstname   | firstname            | t
customer    | firstname    | firstname            | t
customer    | id           | account_id           | t
```

The identifier categories are based on the HIPAA classification.

Limitations

This is an heuristic method in the sense that it may report useful information, but it is based on a pragmatic approach that can lead to detection mistakes, especially:

- **false positive**: a column is reported as an identifier, but it is not.
- **false negative**: a column contains identifiers, but it is not reported

The second one is of course more problematic. In any case, you should only consider this function as a helping tool, and acknowledge that you still need to review the entire database model in search of hidden identifiers.

Contribute to the dictionaries

This detection tool is based on dictionaries of identifiers. Currently these dictionaries contain only a few entries.

For instance, you can see the english identifier dictionary [here](#).

You can help us improve this feature by sending us a list of direct and indirect identifiers you have found in your own data models ! Send us an email at contact@dalibo.com or open an issue in the project.

open an issue: https://gitlab.com/dalibo/postgresql_anonymizer/-/issues

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Development Notes

This folders contains weird ideas, failed tests and dodgy dead ends.

We use jupyter to write these notebooks. Most of them are probably outdated.

Here's how you can install jupyter:

```
$ pip3 install --upgrade pip
$ pip3 install --r docs/dev/requirements
$ export PATH=$PATH:~/local/bin
```

And then launch jupyter:

```
$ jupyter notebook
# or
$ jupyter notebook --no-browser --port 9999
```

Or convert the notebooks

```
jupyter nbconvert docs/dev/*.ipynb --to markdown
```

Hide sensitive data from a “masked” user

You can hide some data from a role by declaring this role as “MASKED”.

Other roles will still access the original data.

PostgreSQL Dynamic Masking

Example:

```
CREATE TABLE people ( id TEXT, firstname TEXT, lastname TEXT, phone TEXT);
INSERT INTO people VALUES ('T1','Sarah', 'Conor','0609110911');
SELECT * FROM people;
```

```
=# SELECT * FROM people;
 id | firstname | lastname |   phone
-----+-----+-----+-----
 T1 | Sarah    | Conor   | 0609110911
(1 row)
```

Step 1 : Activate the dynamic masking engine

```
=# CREATE EXTENSION IF NOT EXISTS anon CASCADE;
=# ALTER DATABASE foo SET anon.transparent_dynamic_masking TO true;
```

Step 2 : Declare the masking rules

```
SECURITY LABEL FOR anon ON COLUMN people.name
IS 'MASKED WITH FUNCTION anon.dummy_last_name()';

SECURITY LABEL FOR anon ON COLUMN people.phone
IS 'MASKED WITH FUNCTION anon.partial(phone,2,$$*****$$,2)';
```

Step 3 : Declare a masked user with read access

```
=# CREATE ROLE skynet LOGIN;
=# SECURITY LABEL FOR anon ON ROLE skynet IS 'MASKED';
```

```
GRANT pg_read_all_data TO skynet;
```

NOTE: If you are running PostgreSQL 13 or if you want a more fine-grained access policy you can grant access more precisely, for instance:

```
GRANT USAGE ON SCHEMA public TO skynet;
GRANT SELECT ON ALL TABLES IN SCHEMA public TO skynet;
-- etc.
```

Step 4 : Connect with the masked user

```
=# \c - skynet
=> SELECT * FROM people;
 id | firstname | lastname | phone
-----+-----+-----+-----
T1  | Sarah     | Stranahan | 06*****11
(1 row)
```

Principles

- Masked roles should not be allowed to insert, update or delete data.
- You can mask table in multiple schemas.
- Generated columns are respected.
- You can apply Row Security Policies aka RLS to a masked role.
- A masking rule may break data integrity. For instance, you can mask a column having a UNIQUE constraint with the value NULL. This is up to you to decide whether or not the mask users need data integrity.

Limitations

- Masked roles are not allowed to use EXPLAIN

How to unmask a role

Simply remove the security label like this:

```
SECURITY LABEL FOR anon ON ROLE bob IS NULL;
```

Legacy Dynamic Masking

In version 1.x, the dynamic masking method was done using a method named Legacy Dynamic Masking. Although this former method is still functional, it will be deprecated in version 3.

Transparent Dynamic Masking and Legacy Dynamic Masking cannot work at the same time. If you upgraded from version 1, be sure to disable Legacy Dynamic Masking with:

```
SELECT anon.stop_legacy_dynamic_masking();
```

Legacy Dynamic Masking: `legacy_dynamic_masking.md`

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Welcome to Paul's Boutique !

This is a 4 hours workshop that demonstrates various anonymization techniques using the PostgreSQL Anonymizer extension.

The Story

Paul's boutique

Paul's boutique has a lot of customers. Paul asks his friend Pierre, a Data Scientist, to make some statistics about his clients : average age, etc...

Pierre wants a direct access to the database in order to write SQL queries.

Jack is an employee of Paul. He's in charge of relationship with the various suppliers of the shop.

Paul respects his suppliers privacy. He needs to hide the personal information to Pierre, but Jack needs read and write access the real data.

Objectives

Using the simple example above, we will learn:

- How to write masking rules
- The difference between static and dynamic masking
- Implementing advanced masking techniques

About PostgreSQL Anonymizer

`postgresql_anonymizer` is an extension to mask or replace personally identifiable information (PII) or commercially sensitive data from a PostgreSQL database.

The project has a **declarative approach** of anonymization. This means you can declare the masking rules using the PostgreSQL Data Definition Language (DDL) and specify your anonymization strategy inside the table definition itself.

Once the maskings rules are defined, you can access the anonymized data in 4 different ways:

- Anonymous Dumps : Simply export the masked data into an SQL file
- Static Masking : Remove the PII according to the rules
- Dynamic Masking : Hide PII only for the masked users
- Generalization : Create “blurred views” of the original data

About GDPR

This presentation **does not** go into the details of the GDPR act and the general concepts of anonymization.

For more information about it, please refer to the talk below:

- Anonymisation, Au-delà du RGPD (Video / French)
- Anonymization, Beyond GDPR (PDF / english)

Requirements

In order to make this workshop, you will need:

- A Linux VM (preferably **Debian 11 bullseye** or **Ubuntu 22.04**)
- A PostgreSQL instance (preferably **PostgreSQL 14**)
- The PostgreSQL Anonymizer (anon) extension, installed and initialized by a superuser
- A database named “boutique” owned by a **superuser** called “paul”
- A role “pierre” and a role “jack”, both allowed to connect to the database “boutique”

A simple way to deploy a workshop environment is to install Docker Desktop and download the image below:

```
docker pull registry.gitlab.com/dalibo/postgresql_anonymizer:stable
```

Check out the **INSTALL** section in the documentation to learn how to install the extension in your PostgreSQL instance.

The Roles

We will with 3 different users:

```
CREATE ROLE paul LOGIN SUPERUSER PASSWORD 'CHANGEME';  
CREATE ROLE pierre LOGIN PASSWORD 'CHANGEME';
```

```
CREATE ROLE jack LOGIN PASSWORD 'CHANGEME';
```

Unless stated otherwise, all commands must be executed with the role **paul**.

Setup a `.pgpass` file to simplify the connections !

```
cat > ~/.pgpass << EOL
*:*:boutique:paul:CHANGEME
*:*:boutique:pierre:CHANGEME
*:*:boutique:jack:CHANGEME
EOL
chmod 0600 ~/.pgpass
```

The Sample database

We will work on a database called “boutique”:

```
CREATE DATABASE boutique OWNER paul;
```

We need to activate the **anon** library inside that database:

```
ALTER DATABASE boutique
SET session_preload_libraries = 'anon';
```

Authors

This workshop is a collective work from Damien Clochard, Be Hai Tran, Florent Jardin, Frédéric Yhuel.

License

This document is distributed under the PostgreSQL license.

The source is available at

https://gitlab.com/dalibo/postgresql_anonymizer/-/tree/master/docs/how-to

Credits

- Cover photo by Alex Conchillos from Pexels (CC Zero)
- “Paul’s Boutique” is the second studio album by American hip hop group Beastie Boys, released on July 25, 1989 by Capitol Records — title: how-to/1-static_masking draft: false toc: true —

1 - Static Masking

Static Masking is the simplest way to hide personal information! This idea is simply to destroy the original data or replace it with an artificial one.

The story

Over the years, Paul has collected data about his customers and their purchases in a simple database. He recently installed a brand new sales application and the old database is now obsolete. He wants to save it and he would like to remove all personal information before archiving it.

How it works

Learning Objective

In this section, we will learn:

- How to write simple masking rules
- The advantage and limitations of static masking
- The concept of “Singling Out” a person

The “customer” table

```
DROP TABLE IF EXISTS customer CASCADE;
```

```
DROP TABLE IF EXISTS payout CASCADE;
```

```
CREATE TABLE customer (  
    id SERIAL PRIMARY KEY,  
    firstname TEXT,  
    lastname TEXT,  
    phone TEXT,  
    birth DATE,  
    postcode TEXT  
);
```

Insert a few persons:

```
INSERT INTO customer  
VALUES  
(107,'Sarah','Conor','060-911-0911', '1965-10-10', '90016'),  
(258,'Luke', 'Skywalker', NULL, '1951-09-25', '90120'),  
(341,'Don', 'Draper','347-515-3423', '1926-06-01', '04520')  
;  
  
SELECT * FROM customer;
```


The “payout” table

Sales are tracked in a simple table:

```
CREATE TABLE payout (  
    id SERIAL PRIMARY KEY,  
    fk_customer_id INT REFERENCES customer(id),  
    order_date DATE,  
    payment_date DATE,  
    amount INT  
);
```

Let’s add some orders:

```
INSERT INTO payout  
VALUES  
(1,107,'2021-10-01','2021-10-01', '7'),  
(2,258,'2021-10-02','2021-10-03', '20'),  
(3,341,'2021-10-02','2021-10-02', '543'),  
(4,258,'2021-10-05','2021-10-05', '12'),  
(5,258,'2021-10-06','2021-10-06', '92')  
;
```

Activate the extension

```
CREATE EXTENSION IF NOT EXISTS anon CASCADE;
```

```
SELECT anon.init();
```

```
SELECT setseed(0);
```

Declare the masking rules

Paul wants to hide the last name and the phone numbers of his clients. He will use the `fake_last_name()` and `partial()` functions for that:

```
SECURITY LABEL FOR anon ON COLUMN customer.lastname  
IS 'MASKED WITH FUNCTION anon.fake_last_name()';
```

```
SECURITY LABEL FOR anon ON COLUMN customer.phone  
IS 'MASKED WITH FUNCTION anon.partial(phone,2,$$X-XXX-XX$$,2)';
```

Apply the rules permanently

```
SELECT anon.anonymize_table('customer');
```

```
SELECT id, firstname, lastname, phone  
FROM customer;
```

This is called **Static Masking** because the **real data has been permanently replaced**. We'll see later how we can use dynamic anonymization or anonymous exports.

Exercises

E101 - Mask the client's first names

Declare a new masking rule and run the static anonymization function again.

E102 - Hide the last 3 digits of the postcode

Paul realizes that the postcode gives a clear indication of where his customers live. However he would like to have statistics based on their "postcode area".

Add a new masking rule to replace the last 3 digits by 'x'.

E103 - Count how many clients live in each postcode area?

Aggregate the customers based on their anonymized postcode.

E104 - Keep only the year of each birth date

Paul wants age-based statistic. But he also wants to hide the real birth date of the customers.

Replace all the birth dates by January 1st, while keeping the real year.

HINT: You can use the `make_date` function !

E105 - Singling out a customer

Even if the "customer" is properly anonymized, we can still isolate a given individual based on data stored outside of the table. For instance, we can identify the best client of Paul's boutique with a query like this:

```
WITH best_client AS (  
    SELECT SUM(amount), fk_customer_id  
    FROM payout  
    GROUP BY fk_customer_id  
    ORDER BY 1 DESC  
    LIMIT 1  
)  
SELECT c.*  
FROM customer c  
JOIN best_client b ON (c.id = b.fk_customer_id)
```

This is called **Singling Out a person**.

We need to anonymize even further by removing the link between a person and its company. In the "order" table, this link is materialized by a foreign key on the field "fk_company_id". However we can't remove values from this column or insert fake identifiers because it would break the foreign key constraint.

How can we separate the customers from their payouts while respecting the integrity of the data?

Find a function that will shuffle the column "fk_company_id" of the "payout" table

HINT: Check out the static masking section of the documentation

Solutions

S101

```
SECURITY LABEL FOR anon ON COLUMN customer.firstname
IS 'MASKED WITH FUNCTION anon.fake_first_name()';
```

```
SELECT anon.anonymize_table('customer');
```

```
SELECT id, firstname, lastname
FROM customer;
```

S102

```
SECURITY LABEL FOR anon ON COLUMN customer.postcode
IS 'MASKED WITH FUNCTION anon.partial(postcode,2,$$xxx$$,0)';
```

```
SELECT anon.anonymize_table('customer');
```

```
SELECT id, firstname, lastname, postcode
FROM customer;
```

S103

```
SELECT postcode, COUNT(id)
FROM customer
GROUP BY postcode;
```

S104

```
SECURITY LABEL FOR anon ON COLUMN customer.birth
IS 'MASKED WITH FUNCTION make_date(EXTRACT(YEAR FROM birth)::INT,1,1)';
```

```
SELECT anon.anonymize_table('customer');
```

```
SELECT id, firstname, lastname, birth  
FROM customer;
```

S105

Let's mix up the values of the `fk_customer_id`:

```
SELECT anon.shuffle_column('payout','fk_customer_id','id');
```

Now let's try to single out the best client again :

```
WITH best_client AS (  
    SELECT SUM(amount), fk_customer_id  
    FROM payout  
    GROUP BY fk_customer_id  
    ORDER BY 1 DESC  
    LIMIT 1  
)  
SELECT c.*  
FROM customer c  
JOIN best_client b ON (c.id = b.fk_customer_id);
```

WARNING

Note that the link between a `customer` and its `payout` is now completely false. For instance, if a customer A had 2 payouts. One of these payout may be linked to a customer B, while the second one is linked to a customer C.

In other words, this shuffling method with respect the foreign key constraint (aka the referential integrity) but it will break the data integrity. For some use case, this may be a problem.

In this case, Pierre will not be able to produce a BI report with the shuffle data, because the links between the customers and their payments are fake. — title: how-to/2-dynamic_masking draft: false toc: true —

2- How to use Dynamic Masking

With Dynamic Masking, the database owner can hide personal data for some users, while other users are still allowed to read and write the authentic data.

The Story

Paul has 2 employees:

- Jack is operating the new sales application, he needs access to the real data. He is what the GDPR would call a **”data processor”**.
- Pierre is a data analyst who runs statistic queries on the database. He should not have access to any personal data.

How it works

Objectives

In this section, we will learn:

- How to write simple masking rules
- The advantage and limitations of dynamic masking
- The concept of ”Linkability” of a person

The “company” table

```
DROP TABLE IF EXISTS supplier CASCADE;
```

```
DROP TABLE IF EXISTS company CASCADE;
```

```
CREATE TABLE company (
    id SERIAL PRIMARY KEY,
    name TEXT,
    vat_id TEXT UNIQUE
);

INSERT INTO company
VALUES
(952,'Shadrach', 'FR62684255667'),
(194,E'Johnny\'s Shoe Store','CHE670945644'),
(346,'Capitol Records','GB663829617823')
;

SELECT * FROM company;
```

The ”supplier” table

```
CREATE TABLE supplier (
    id SERIAL PRIMARY KEY,
    fk_company_id INT REFERENCES company(id),
    contact TEXT,
    phone TEXT,
    job_title TEXT
);

INSERT INTO supplier
VALUES
```

```
(299,194,'Johnny Ryall','597-500-569','CEO'),  
(157,346,'George Clinton', '131-002-530','Sales manager')  
;  
  
SELECT * FROM supplier;
```

Activate the extension

```
CREATE EXTENSION IF NOT EXISTS anon CASCADE;  
  
SELECT anon.init();  
  
SELECT setseed(0);
```

Dynamic Masking

Activate the masking engine

```
SELECT anon.start_dynamic_masking();
```

Masking a role

```
SECURITY LABEL FOR anon ON ROLE pierre IS 'MASKED';  
  
GRANT SELECT ON supplier TO pierre;  
GRANT ALL ON SCHEMA public TO jack;  
GRANT ALL ON ALL TABLES IN SCHEMA public TO jack;
```

Now connect as Pierre and try to read the supplier table:

```
SELECT * FROM supplier;
```

For the moment, there is no masking rule so Pierre can see the original data in each table.

Masking the supplier names

Connect as Paul and define a masking rule on the supplier table:

```
SECURITY LABEL FOR anon ON COLUMN supplier.contact  
IS 'MASKED WITH VALUE $$CONFIDENTIAL$$';
```

Now connect as Pierre and try to read the supplier table again:

```
SELECT * FROM supplier;
```

Now connect as Jack and try to read the real data:

```
SELECT * FROM supplier;
```

Exercises

E201 - Guess who is the CEO of "Johnny's Shoe Store"

Masking the supplier name is clearly not enough to provide anonymity.

Connect as Pierre and write a simple SQL query that would reidentify some suppliers based on their job and their company.

Company names and job positions are available in many public datasets. A simple search on LinkedIn or Google, would give you the names of the top executives of most companies..

This is called **Linkability**: the ability to connect multiple records concerning the same data subject.

E202 - Anonymize the companies

We need to anonymize the "company" table, too. Even if they don't contain personal information, some fields can be used to **infer** the identity of their employees...

Write 2 masking rules for the company table. The first one will replace the "name" field with a fake name. The second will replace the "vat_id" with a random sequence of 10 characters

HINT: Go to the documentation and look at the faking functions and random functions!

Connect as Pierre and check that he cannot view the real company info:

E203 - Pseudonymize the company name

Because of dynamic masking, the fake values will be different every time Pierre tries to read the table.

Pierre would like to have always the same fake values for a given company. **This is called pseudonymization.**

Write a new masking rule over the "vat_id" field by generating 10 random characters using the md5() function.

Write a new masking rule over the "name" field by using a pseudonymizing function.

Solutions

S201

```
SELECT s.id, s.contact, s.job_title, c.name
FROM supplier s
JOIN company c ON s.fk_company_id = c.id;
```

S202

```
SECURITY LABEL FOR anon ON COLUMN company.name
IS 'MASKED WITH FUNCTION anon.fake_company()';
```

```
SECURITY LABEL FOR anon ON COLUMN company.vat_id
IS 'MASKED WITH FUNCTION anon.random_string(10)';
```

Now connect as Pierre and read the table again:

```
SELECT * FROM company;
```

Pierre will see different "fake data" every time he reads the table:

```
SELECT * FROM company;
```

S203

```
ALTER FUNCTION anon.pseudo_company SECURITY DEFINER;
```

```
SECURITY LABEL FOR anon ON COLUMN company.name
IS 'MASKED WITH FUNCTION anon.pseudo_company(id)';
```

Connect as Pierre and read the table multiple times:

```
SELECT * FROM company;
```

```
SELECT * FROM company;
```

Now the fake company name is always the same.

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3- Anonymous Dumps

In many situation, what we want is simply to export the anonymized data into another database (for testing or to produce statistics). This is what **pg_dump_anon** does!

The Story

Paul has a website and a comment section where customers can express their views.

He hired a web agency to develop a new design for his website. The agency asked for a SQL export (dump) of the current website database. Paul wants to "clean" the database export and remove any personal information contained in the comment section.

How it works

Learning Objective

- Extract the anonymized data from the database
- Write a custom masking function to handle a JSON field.

Load the data

```
DROP TABLE IF EXISTS website_comment CASCADE;
```

```
CREATE TABLE website_comment (  
    id SERIAL PRIMARY KEY,  
    message JSONB  
);
```

```
curl -Ls https://dali.bo/website_comment -o /tmp/website_comment.tsv  
head /tmp/website_comment.tsv
```

```
COPY website_comment  
FROM '/tmp/website_comment.tsv'
```

```
SELECT  
    message->'meta'->'name' AS name,  
    message->'content' AS content  
FROM website_comment  
ORDER BY id ASC
```

Activate the extension

```
CREATE EXTENSION IF NOT EXISTS anon CASCADE;  
SELECT anon.init();  
SELECT setseed(0);
```

Masking a JSON column

The "comment" field is filled with personal information and the fact the field does not have a standard schema makes our tasks harder.

In general, unstructured data are difficult to mask.

As we can see, web visitors can write any kind of information in the comment section. Our best option is to remove this key entirely because there's no way to extract personal data properly.

We can *clean* the comment column simply by removing the "content" key!

```
SELECT message - ARRAY['content']
FROM website_comment
WHERE id=1;
```

First let's create a dedicated schema and declare it as trusted. This means the "anon" extension will accept the functions located in this schema as valid masking functions. Only a superuser should be able to add functions in this schema.

```
CREATE SCHEMA IF NOT EXISTS my_masks;

SECURITY LABEL FOR anon ON SCHEMA my_masks IS 'TRUSTED';
```

Now we can write a function that remove the message content:

```
CREATE OR REPLACE FUNCTION my_masks.remove_content(j JSONB)
RETURNS JSONB
AS $func$
    SELECT j - ARRAY['content']
$func$
LANGUAGE SQL
;
```

Let's try it!

```
SELECT my_masks.remove_content(message)
FROM website_comment
```

And now we can use it in a masking rule:

```
SECURITY LABEL FOR anon ON COLUMN website_comment.message
```

```
IS 'MASKED WITH FUNCTION my_masks.remove_content(message)';
```

Finally we can export an **anonymous dump** of the table with `pg_dump_anon`:

```
export PATH=$PATH:$(pg_config --bindir)
pg_dump_anon --help

export PATH=$PATH:$(pg_config --bindir)
export PGHOST=localhost
export PGUSER=paul
pg_dump_anon boutique --table=website_comment > /tmp/dump.sql
```

Exercises

E301 - Dump the anonymized data into a new database

Create a database named "boutique_anon" and transfer the entire database into it.

E302 - Pseudonymize the meta fields of the comments

Pierre plans to extract general information from the metadata. For instance, he wants to calculate the number of unique visitors based on the different IP addresses. But an IP address is an **indirect identifier**, so Paul needs to anonymize this field while maintaining the fact that some values appear multiple times.

Replace the `remove_content` function with a better one called `clean_comment` that will:

- Remove the content key
- Replace the "name" value with a fake last name
- Replace the "ip_address" value with its MD5 signature
- Nullify the "email" key

HINT: Look at the `jsonb_set()` and `jsonb_build_object()` functions

Solutions

S301

```
export PATH=$PATH:$(pg_config --bindir)
export PGHOST=localhost
export PGUSER=paul
dropdb --if-exists boutique_anon
createdb boutique_anon --owner paul
pg_dump_anon boutique | psql --quiet boutique_anon
```

```
export PGHOST=localhost
export PGUSER=paul
psql boutique_anon -c 'SELECT COUNT(*) FROM company'
```

S302

```
CREATE OR REPLACE FUNCTION my_masks.clean_comment(message JSONB)
RETURNS JSONB
VOLATILE
LANGUAGE SQL
AS $func$
SELECT
  jsonb_set(
    message,
    ARRAY['meta'],
    jsonb_build_object(
      'name',anon.fake_last_name(),
      'ip_address', md5((message->'meta'->'ip_addr')::TEXT),
      'email', NULL
    )
  ) - ARRAY['content'];
$func$;

SELECT my_masks.clean_comment(message)
FROM website_comment;

SECURITY LABEL FOR anon ON COLUMN website_comment.message
IS 'MASKED WITH FUNCTION my_masks.clean_comment(message)';
```

4 - Generalization

The main idea of generalization is to "blur" the original data. For example, instead of saying "Mister X was born on July 25, 1989", we can say "Mister X was born is the 80's". The information is still true, but it is less precise and it can't be used to reidentify the subject.

The Story

Paul hired dozens of employees over the years. He kept a record of their hair color, size and medical condition.

Paul wants to extract weird stats from these details. He provides generalized views to Pierre.

How it works

Learning Objective

In this section, we will learn:

- The difference between masking and generalization
- The concept of "K-anonymity"

The "employee" table

```
DROP TABLE IF EXISTS employee CASCADE;
```

```
CREATE TABLE employee (  
  id INT PRIMARY KEY,  
  full_name TEXT,  
  first_day DATE, last_day DATE,  
  height INT,  
  hair TEXT, eyes TEXT, size TEXT,  
  asthma BOOLEAN,  
  CHECK(hair = ANY(ARRAY['bald','blond','dark','red'])),  
  CHECK(eyes = ANY(ARRAY['blue','green','brown'])) ,  
  CHECK(size = ANY(ARRAY['S','M','L','XL','XXL']))  
);
```

This is awkward and illegal.

Loading the data:

```
curl -Ls https://dali.bo/employee -o /tmp/employee.tsv  
head -n3 /tmp/employee.tsv  
  
COPY employee FROM '/tmp/employee.tsv'  
  
SELECT count(*) FROM employee;  
  
SELECT full_name,first_day, hair, size, asthma  
FROM employee  
LIMIT 3;
```

Data suppression

Paul wants to find if there's a correlation between asthma and the eyes color.

He provides the following view to Pierre.

```
DROP MATERIALIZED VIEW IF EXISTS v_asthma_eyes;  
  
CREATE MATERIALIZED VIEW v_asthma_eyes AS  
SELECT eyes, asthma
```

```
FROM employee;

SELECT *
FROM v_asthma_eyes
LIMIT 3;
```

Pierre can now write queries over this view.

```
SELECT
    eyes,
    100*COUNT(1) FILTER (WHERE asthma) / COUNT(1) AS asthma_rate
FROM v_asthma_eyes
GROUP BY eyes;
```

Pierre just proved that asthma is caused by green eyes.

K-Anonymity

The 'asthma' and 'eyes' are considered as indirect identifiers.

```
SECURITY LABEL FOR k_anonymity ON COLUMN v_asthma_eyes.eyes
IS 'INDIRECT IDENTIFIER';
```

```
SECURITY LABEL FOR k_anonymity ON COLUMN v_asthma_eyes.asthma
IS 'INDIRECT IDENTIFIER';
```

```
SELECT anon.k_anonymity('v_asthma_eyes');
```

The v_asthma_eyes has '2-anonymity'. This means that each quasi-identifier combination (the 'eyes-asthma' tuples) occurs in at least 2 records for a dataset.

In other words, it means that each individual in the view cannot be distinguished from at least 1 (k-1) other individual.

Range and Generalization functions

```
DROP MATERIALIZED VIEW IF EXISTS v_staff_per_month;
CREATE MATERIALIZED VIEW v_staff_per_month AS
SELECT
    anon.generalize_daterange(first_day,'month') AS first_day,
    anon.generalize_daterange(last_day,'month') AS last_day
FROM employee;

SELECT *
FROM v_staff_per_month
LIMIT 3;
```

Pierre can write a query to find how many employees were hired in november 2021.

```
SELECT COUNT(1)
```

```

        FILTER (
            WHERE make_date(2019,11,1)
            BETWEEN lower(first_day)
            AND COALESCE(upper(last_day),now())
        )
FROM v_staff_per_month;

```

Declaring the indirect identifiers

Now let's check the k-anonymity of this view by declaring which columns are indirect identifiers.

```

SECURITY LABEL FOR anon ON COLUMN v_staff_per_month.first_day
IS 'INDIRECT IDENTIFIER';

```

```

SECURITY LABEL FOR anon ON COLUMN v_staff_per_month.last_day
IS 'INDIRECT IDENTIFIER';

```

```

SELECT anon.k_anonymity('v_staff_per_month');

```

In this case, the k factor is 1 which means that at least one unique individual can be identified directly by his/her first and last dates.

Note that the security label provider is `k_anonymity` and not `anon`.

Exercises

E401 - Simplify `v_staff_per_month` and decrease granularity

Generalizing dates per month is not enough. Write another view called `'v_staff_per_year'` that will generalize dates per year.

Also simplify the view by using a range of int to store the years instead of a date range.

E402 - Staff progression over the years

How many people worked for Paul for each year between 2018 and 2021?

E403 - Reaching 2-anonymity for the `v_staff_per_year` view

What is the k-anonymity of `'v_staff_per_month_years'`?

Solutions

S401

```

DROP MATERIALIZED VIEW IF EXISTS v_staff_per_year;

```

```

CREATE MATERIALIZED VIEW v_staff_per_year AS

```

```

SELECT
    int4range(
        extract(year from first_day)::INT,
        extract(year from last_day)::INT,
        '[]'
    ) AS period
FROM employee;

```

'[]' will include the upper bound

```

SELECT *
FROM v_staff_per_year
LIMIT 3;

```

S402

```

SELECT
    year,
    COUNT(1) FILTER (
        WHERE year <@ period
    )
FROM
    generate_series(2018,2021) year,
    v_staff_per_year
GROUP BY year
ORDER BY year ASC;

```

S403

```

SECURITY LABEL FOR anon ON COLUMN v_staff_per_year.period
IS 'INDIRECT IDENTIFIER';

```

```

SELECT anon.k_anonymity('v_staff_per_year');

```

Conclusion

Clean up !

```

DROP EXTENSION anon CASCADE;

```

```

REASSIGN OWNED BY jack TO postgres;
REVOKE ALL ON SCHEMA public FROM jack;

```



```
REASSIGN OWNED BY paul TO postgres;
```

```
REASSIGN OWNED BY pierre TO postgres;
```

```
DROP DATABASE IF EXISTS boutique;
```

```
DROP ROLE IF EXISTS jack;
```

```
DROP ROLE IF EXISTS paul;
```

```
DROP ROLE IF EXISTS pierre;
```

Many Masking Strategies

- Static Masking : perfect for "once-and-for-all" anonymization
 - Dynamic Masking : useful when one user is untrusted
 - Anonymous Dumps : can be used in CI/CD workflows
 - **Generalization** good for statistics and data science
-

Many Masking Functions

- Destruction and partial destruction
- Adding Noise
- Randomization
- Faking and Advanced Faking
- Pseudonymization
- Generic Hashing
- Custom masking

RTFM -> Masking Functions

Advantages

- Masking rules written in SQL
- Masking rules stored in the database schema
- No need for an external ETL
- Works with all current versions of PostgreSQL
- Multiple strategies, multiple functions

Drawbacks

- Does not work with other databases (hence the name)
- Lack of feedback for huge tables (> 10 TB)

Also...

Other projects you may like

- pg_sample : extract a small dataset from a larger PostgreSQL database
- PostgreSQL Faker : An advanced faking extension based on the python Faker lib

Help Wanted!

This is a free and open project!

labs.dalibo.com/postgresql_anonymizer

Please send us feedback on how you use it, how it fits your needs (or not), etc.

This is a 4 hour workshop!

Sources are here: gitlab.com/dalibo/postgresql_anonymizer

Download the PDF Handout

Questions?

...

PostgreSQL Anonymizer How To

This is a 4 hours workshop that demonstrates various anonymization techniques.

Write

This workshop is written with jupyter-notebook. The *.ipynb files are mixing markdown content with live SQL statements that are executed on a PostgreSQL instance.

```
pip install -r requirements.txt
jupyter notebook
```

Build

The source files are converted to markdown and then exported to pdf, slides, epub, etc.

`make`

The export files will be available in the `_build` folder.

Type `make help` for more details

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Figure 2: PostgreSQL Anonymizer

Anonymization & Data Masking for Postgres

PostgreSQL Anonymizer is an extension to mask or replace personally identifiable information (PII) or commercially sensitive data from a Postgres database.

The project has a **declarative approach** of anonymization. This means you can declare the masking rules using the PostgreSQL Data Definition Language (DDL) and specify your anonymization policy inside the table definition itself.

The main goal of this extension is to offer **anonymization by design**. We firmly believe that data masking rules should be written by the people who develop the application because they have the best knowledge of how the data model works. Therefore masking rules must be implemented directly inside the database schema.

Once the masking rules are defined, you can apply them using 5 different **masking methods** :

- Anonymous Dumps : Simply export the masked data into an SQL file
- Static Masking : Remove the PII according to the rules
- Dynamic Masking : Hide PII only for the masked users
- Masking Views : Build dedicated views for the masked users
- Masking Data Wrappers : Apply masking rules on external data

Each method has its pros and cons. Different masking methods may be used in different contexts. In any case, masking the data directly inside the PostgreSQL

instance without using an external tool is crucial to limit the exposure and the risks of data leak.

In addition, various Masking Functions are available : randomization, faking, partial scrambling, shuffling, noise or even your own custom function!

Finally, the extension offers a panel of detection functions that will try to guess which columns need to be anonymized.

Quick Start

Step 0. Launch docker image of the project

```
ANON_IMG=registry.gitlab.com/dalibo/postgresql_anonymizer
docker run --name anon_quickstart --detach -e POSTGRES_PASSWORD=x $ANON_IMG
docker exec -it anon_quickstart psql -U postgres
```

Step 1. Create a database and load the extension in it

```
CREATE DATABASE demo;
ALTER DATABASE demo SET session_preload_libraries = 'anon';
```

```
\connect demo
```

You are now connected to database "demo" as user "postgres".

Step 2. Create a table

```
CREATE TABLE people AS
    SELECT 153478 AS id,
           'Sarah' AS firstname,
           'Conor' AS lastname,
           '0609110911' AS phone
;

SELECT * FROM people;
   id  | firstname | lastname |  phone
-----+-----+-----+-----
153478 | Sarah     | Conor    | 0609110911
```

Step 3. Create the extension and activate the masking engine

```
CREATE EXTENSION anon;
ALTER DATABASE demo SET anon.transparent_dynamic_masking TO true;
```

Step 4. Declare a masked user

```
CREATE ROLE skynet LOGIN;

SECURITY LABEL FOR anon ON ROLE skynet IS 'MASKED';

GRANT pg_read_all_data to skynet;
```

Step 5. Declare the masking rules

```
SECURITY LABEL FOR anon ON COLUMN people.lastname
IS 'MASKED WITH FUNCTION anon.dummy_last_name()';

SECURITY LABEL FOR anon ON COLUMN people.phone
IS 'MASKED WITH FUNCTION anon.partial(phone,2,$$*****$$,2)';
```

Step 6. Connect with the masked user

```
\connect - skynet
You are now connected to database "demo" as user "skynet"
```

```
SELECT * FROM people;
   id  | firstname | lastname | phone
-----+-----+-----+-----
153478 | Sarah     | Stranahan | 06*****11
```

Success Stories

With PostgreSQL Anonymizer we integrate, from the design of the database, the principle that outside production the data must be anonymized. Thus we can reinforce the GDPR rules, without affecting the quality of the tests during version upgrades for example.

— **Thierry Aimé, Office of Architecture and Standards in the French Public Finances Directorate General (DGFIP)**

Thanks to PostgreSQL Anonymizer we were able to define complex masking rules in order to implement full pseudonymization of our databases without losing functionality. Testing on realistic data while guaranteeing the confidentiality of patient data is a key point to improve the robustness of our functionalities and the quality of our customer service.

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I just discovered your postgresql_anonymizer extension and used it at my company for anonymizing our user for local development. Nice work!

— **Max Metcalfe**

If this extension is useful to you, please let us know !

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Figure 3: PostgreSQL Anonymizer

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```

```
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```

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;

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   id | firstname | lastname | phone
-----+-----+-----+-----
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```

```
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```

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-----+-----+-----+-----
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open an issue: https://gitlab.com/dalibo/postgresql_anonymizer/issues

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INSTALL

The installation process is composed of 4 basic steps:

- Step 1: **Deploy** the extension into the host server
- Step 2: **Load** the extension in the PostgreSQL instance
- Step 3: **Create** and **Initialize** the extension inside the database

There are multiple ways to install the extension :

- Install on RedHat / Rocky Linux / Alma Linux
- Install on Debian / Ubuntu
- Install with Ansible
- Install with PGXN
- Install from source
- Install with docker
- Install as a black box
- Install on MacOS
- Install on Windows
- Install in the cloud
- Uninstall

In the examples below, we load the extension (step2) using a parameter called **session_preload_libraries** but there are other ways to load it. See Load the extension for more details.

If you're having any problem, check the Troubleshooting section.

Choose your version : Stable or Latest ?

This extension is available in two versions :

- **stable** is recommended for production
- **latest** is useful if you want to test new features

Install on RedHat / Rocky Linux / Alma Linux

!!! warning "New RPM repository !"

DO NOT use the package provided by the PGDG RPM repository.
It is obsolete.

Step 0: Add the DaLibo Labs RPM repository to your system.

```
sudo dnf install https://yum.dalibo.org/labs/dalibo-labs-4-1.noarch.rpm
```

Alternatively you can download the `latest` version from the Gitlab Package Registry.

Step 1: Deploy

```
sudo yum install postgresql_anonymizer_16
```

(Replace 16 with the major version of your PostgreSQL instance.)

Step 2: Load the extension.

```
ALTER DATABASE foo SET session_preload_libraries = 'anon';
```

(If you're already loading extensions that way, just add `anon` to the current list)

The setting will be applied for the next sessions, i.e. **You need to reconnect to the database for the change to visible**

Step 3: Close your session and open a new one. Create the extension.

```
CREATE EXTENSION anon;  
SELECT anon.init();
```

All new connections to the database can now use the extension.

Install on Debian / Ubuntu

This is the recommended way to install the `stable` version

Step 0: Add the DaLibo Labs DEB Repo to your system.

```
apt install curl lsb-release  
echo deb http://apt.dalibo.org/labs $(lsb_release -cs)-dalibo main > /etc/apt/sources.list.d/dalibo-labs.list  
curl -fsSL -o /etc/apt/trusted.gpg.d/dalibo-labs.gpg https://apt.dalibo.org/labs/debian-dalibo-labs.gpg  
apt update
```

Alternatively you can download the `latest` version from the Gitlab Package Registry.

Step 1: Deploy

```
sudo apt install postgresql_anonymizer_16
```

(Replace 16 with the major version of your PostgreSQL instance.)

Step 2: Load the extension.

```
ALTER DATABASE foo SET session_preload_libraries = 'anon';
```

(If you're already loading extensions that way, just add `anon` the current list)

The setting will be applied for the next sessions, i.e. **You need to reconnect to the database for the change to visible**

Step 3: Close your session and open a new one. Create the extension.

```
CREATE EXTENSION anon;
SELECT anon.init();
```

All new connections to the database can now use the extension.

Install with Ansible

This method will install the `stable` extension

Step 1a: Install the Dalibo PostgreSQL Essential Ansible Collection

```
ansible-galaxy collection install dalibo.advanced
```

Step 1b: Write a playbook (e.g. `anon.yml`) to the `postgresql_anonymizer` role to the database servers. For instance:

```
---
- name: Install the PostgreSQL Anonymizer extension on all hosts of the pgsq group
  hosts: pgsq
  roles:
    - dalibo.advanced.anon
```

Step 1c: Launch the playbook

```
ansible-playbook anon.yml
```

Step 2: Load the extension.

```
ALTER DATABASE foo SET session_preload_libraries = 'anon';
```

(If you're already loading extensions that way, just add `anon` to the current list)

The setting will be applied for the next sessions, i.e. **You need to reconnect to the database for the change to be visible**

Step 3: Close your session and open a new one. Create the extension.

```
CREATE EXTENSION anon;
SELECT anon.init();
```

All new connections to the database can now use the extension.

Install With PGXN

!!! warning

This method is not available currently but you can use the "Install From Source" method below which is very similar.

Install From Source

This is the recommended way to install the `latest` extension

Important: Building the extension requires a full Rust development environment. It is not recommended to build it on a production server.

Before anything else, you need to install the PGRX System Requirements and install and initialise PGRX itself using

```
cargo install cargo-pgrx --version 0.14.3 --locked
cargo pgrx init
```

NOTE: You may need to specify your `pg_config` location in the second command by using the `--pg{version}` flag (e.g. `--pg16 /usr/lib/postgresql/16/bin/pg_config`).

Step 0: Download the source from the official repository on Gitlab, either the archive of the latest release, or clone the `latest` branch:

```
git clone https://gitlab.com/dalibo/postgresql_anonymizer.git
```

Step 1: Build the project like any other PostgreSQL extension:

```
make extension
sudo make install
```

NOTE: If you have multiple versions of PostgreSQL on the server or if the package does not build/install correctly, you may need to specify which version is your target by defining the `PG_CONFIG` and `PGVER` env variable like this:

```
make extension PG_CONFIG=/usr/lib/postgresql/14/bin/pg_config PGVER=pg14
sudo make install PG_CONFIG=/usr/lib/postgresql/14/bin/pg_config PGVER=pg14
```

Step 2: Load the extension:

Please note that in order to load the extension you must connect to PostgreSQL with a user having superuser privileges. Also, the extension (as all PostgreSQL extensions) will be created only in the given database and not globally.

```
ALTER DATABASE foo SET session_preload_libraries = 'anon';
```

(If you're already loading extensions that way, just add `anon` to the current list)

Step 3: Close your session and open a new one on the same PostgreSQL database. Create the extension.

```
CREATE EXTENSION anon;
SELECT anon.init();
```

All new connections to the given database can now use the extension.

Install with Docker

If you can't (or don't want to) install the PostgreSQL Anonymizer extension directly inside your instance, then you can use the docker image :

```
docker pull registry.gitlab.com/dalibo/postgresql_anonymizer:stable
```

The image is available with 2 two tags:

- **latest** (default) contains the current developments
- **stable** is the based on the previous release

You can run the docker image like the regular postgres docker image.

For example:

Launch a postgres docker container

```
docker run -d -e POSTGRES_PASSWORD=x -p 6543:5432 registry.gitlab.com/dalibo/postgresql_anon
```

then connect:

```
export PGPASSWORD=x
psql --host=localhost --port=6543 --user=postgres
```

The extension is already created and initialized, you can use it directly:

```
# SELECT anon.partial_email('daamien@gmail.com');
      partial_email
-----
da*****@gm*****.com
(1 row)
```

Note: The docker image is based on the latest PostgreSQL version and we do not plan to provide a docker image for each version of PostgreSQL. However you can build your own image based on the version you need like this:

```
DOCKER_PG_MAJOR_VERSION=16 make docker_image
```

Install as a “Black Box”

see Anonymous Dumps

Install on MacOS

WE DO NOT PROVIDE COMMUNITY SUPPORT FOR THIS EXTENSION ON MACOS SYSTEMS.

However it should be possible to build the extension if you install the PGRX Mac OS system requirements and then follow the regular install from source procedure.

Install on Windows

PostgreSQL Anonymizer is built upon the [PGRX] framework and currently [PGRX] does not support compiling PostgreSQL extensions for Windows.

This means that there’s no native build of PostgreSQL Anonymizer for Windows.

However it is possible to run PostgreSQL inside a WSL2 container, which is basically an Ubuntu subsystem running on Windows.

You can then install PostgreSQL Anonymizer inside the WSL2 container like you would on a regular Ubuntu server.

Please read the Windows documentation for more details:

- Install WSL2
- Install PostgreSQL in WSL2

Install in the cloud

This extension must be installed with superuser privileges, which is something that most Database As A Service platforms (DBaaS), such as Amazon RDS or Microsoft Azure SQL, do not allow. They must add the extension to their catalog in order for you to use it.

At the time we are writing this (Feb. 2025), the following platforms provide PostgreSQL Anonymizer:

- Alibaba Cloud
- Crunchy Bridge
- Google Cloud SQL
- Microsoft Azure Database
- Neon
- Postgres.ai
- Tembo

Please refer to their own documentation on how to activate the extension as they might have a platform-specific install procedure.

If your favorite DBaaS provider is not present in the list above, there is not much we can do about it... Although we have open discussions with some major actors in this domain, we DO NOT have internal knowledge on whether or not they will support it in the near future. If privacy and anonymity are a concern to you, we encourage you to contact the customer service of these platforms and ask them directly if they plan to add this extension to their catalog.

Addendum: Alternative way to load the extension

It is recommended to load the extension like this:

```
ALTER DATABASE foo SET session_preload_libraries='anon'
```

It has several benefits:

- First, it will be dumped by `pg_dump` with the `-C` option, so the database dump will be self efficient.
- Second, it is propagated to a standby instance by streaming replication. Which means you can use the anonymization functions on a read-only clone of the database (provided the extension is installed on the standby instance)

However, you can load the extension globally in the instance using the `shared_preload_libraries` parameter :

```
ALTER SYSTEM SET shared_preload_libraries = 'anon'
```

Then restart the PostgreSQL instance.

Addendum: Troubleshooting

If you are having difficulties, you may have missed a step during the installation processes. Here's a quick checklist to help you:

Check that the extension is present

First, let's see if the extension was correctly deployed:

```
ls $(pg_config --sharedir)/extension/anon
ls $(pg_config --pkglibdir)/anon.so
```

If you get an error, the extension is probably not present on host server. Go back to step 1.

Check that the extension is loaded

Now connect to your database and look at the configuration with:

```
SHOW local_preload_libraries;
SHOW session_preload_libraries;
SHOW shared_preload_libraries;
```

If you don't see `anon` in any of these parameters, go back to step 2.

Check that the extension is created

Again connect to your database and type:

```
SELECT * FROM pg_extension WHERE extname= 'anon';
```

If the result is empty, the extension is not declared in your database. Go back to step 3.

Check that the extension is initialized

Finally, look at the state of the extension:

```
SELECT anon.is_initialized();
```

If the result is not `t`, the extension data is not present. Go back to step 3.

Uninstall

Step 1: Remove all rules

```
SELECT anon.remove_masks_for_all_columns();
SELECT anon.remove_masks_for_all_roles();
```

Although this step is not mandatory, it is highly recommended.

In some situations ever, it may be useful to keep the masking rules inside the database schema even if the anon extension is removed ! Keep in mind that `pg_dump` and `pg_restore` both have an option `--no-security-labels` to exclude the masking rules when you want to import/export the database.

Step 2: Drop the extension

```
DROP EXTENSION anon;
```

Step 3: Unload the extension

```
ALTER DATABASE foo RESET session_preload_libraries;
```

Or modify `shared_preload_libraries` depending on how you loaded the extension...

Step 4: Uninstall the extension

For Redhat / Rocky:

```
sudo yum remove postgresql_anonymizer_17
```

Replace 17 by the version of your postgresql instance.

Compatibility Guide

PostgreSQL Anonymizer is designed to work on the most current setups. As we are trying to find the right balance between innovation and backward compatibility, we define a comprehensive list of platforms and software that we officially support for each version.

Version	Released	EOL	Postgres	OS
2.0	dec. 2024	dec. 2025	13 to 17	RHEL 8 & 9, Debian 11 & 12, Ubuntu 24.04
1.3	mar. 2024	dec. 2024	12 to 16	RHEL 8 & 9
1.2	jan. 2024	mar. 2024	12 to 16	RHEL 8 & 9
1.1	sept. 2022	jan. 2024	11 to 15	RHEL 7 & 8

The extension may work on other distributions than the ones above, however provide packages only for these versions and we do not guarantee free community support for other OS.

If you need support on other platforms, we may offer commercial support for it.

Please contact our commercial team at contact@dalibo.com for more details. —
title: legacy_dynamic_masking draft: false toc: true —

Hide sensitive data from a “masked” user using legacy dynamic masking

This page present the **Legacy Dynamic Masking** method that was developed in version 1. This method is now replaced by the Transparent Dynamic Masking method which is better in many ways. The **Legacy Dynamic Masking** is still supported in version3 but it will be deprecated in version 3.

You can hide some data from a role by declaring this role as a “MASKED” one. Other roles will still access the original data.

Example:

```
CREATE TABLE people ( id TEXT, firstname TEXT, lastname TEXT, phone TEXT);
INSERT INTO people VALUES ('T1','Sarah', 'Conor','0609110911');
SELECT * FROM people;
```

```
=# SELECT * FROM people;
 id | firstname | lastname |   phone
-----+-----+-----+-----
 T1 | Sarah    |  Conor   | 0609110911
(1 row)
```

Step 1 : Activate the dynamic masking engine

```
=# CREATE EXTENSION IF NOT EXISTS anon CASCADE;
=# SELECT anon.start_dynamic_masking();
```

Step 2 : Declare a masked user

```
=# CREATE ROLE skynet LOGIN;
=# SECURITY LABEL FOR anon ON ROLE skynet
-# IS 'MASKED';
```

Step 3 : Declare the masking rules

```
SECURITY LABEL FOR anon ON COLUMN people.name
IS 'MASKED WITH FUNCTION anon.random_last_name()';

SECURITY LABEL FOR anon ON COLUMN people.phone
IS 'MASKED WITH FUNCTION anon.partial(phone,2,$$*****$$,2)';
```

Step 4 : Connect with the masked user

```
=# \c - skynet
=> SELECT * FROM people;
```

```

id | firstname | lastname | phone
-----+-----+-----+-----
T1 | Sarah    | Stranahan | 06*****11
(1 row)

```

How to change the type of a masked column

When dynamic masking is activated, you are not allowed to change the datatype of a column if there's a mask upon it.

To modify a masked column, you need to switch of temporarily the masking engine like this:

```

BEGIN;
SELECT anon.stop_dynamic_masking();
ALTER TABLE people ALTER COLUMN phone TYPE VARCHAR(255);
SELECT anon.start_dynamic_masking();
COMMIT;

```

How to drop a masked table

The dynamic masking engine will build *masking views* upon the masked tables. This means that it is not possible to drop a masked table directly. You will get an error like this :

```

# DROP TABLE people;
psql: ERROR:  cannot drop table people because other objects depend on it
DETAIL:  (view mask.company depends on table people

```

To effectively remove the table, it is necessary to add the **CASCADE** option, so that the masking view will be dropped too:

```

DROP TABLE people CASCADE;

```

How to unmask a role

Simply remove the security label like this:

```

SECURITY LABEL FOR anon ON ROLE bob IS NULL;

```

To unmask all masked roles at once you can type:

```

SELECT anon.remove_masks_for_all_roles();

```

Limitations

Listing the tables

Due to how the dynamic masking engine works, when a masked role will try to display the tables in psql with the `\dt` command, then psql will not show any tables.

This is because the `search_path` of the masked role is rigged.

You can try adding explicit schema you want to search, for instance:

```
\dt *.*  
\dt public.*
```

Only one schema

The dynamic masking system only works with one schema (by default `public`). When you start the masking engine with `start_dynamic_masking()`, you can specify the schema that will be masked with:

```
ALTER DATABASE foo SET anon.sourceschema TO 'sales';
```

Then open a new session to the database and type:

```
SELECT start_dynamic_masking();
```

However static masking with `anon.anonymize()` and anonymous export with `anon.dump()` will work fine with multiple schemas.

Performances

Dynamic Masking is known to be very slow with some queries, especially if you try to join 2 tables on a masked key using hashing or pseudonymization.

Graphic Tools

When you are using a masked role with a graphic interface such as DBeaver or pgAdmin, the “data” panel may produce the following error when trying to display the content of a masked table called `foo`:

```
SQL Error [42501]: ERROR: permission denied for table foo
```

This is because most of these tools will directly query the `public.foo` table instead of being “redirected” by the masking engine toward the `mask.foo` view.

In order to view the masked data with a graphic tool, you can either:

1- Open the SQL query panel and type `SELECT * FROM foo`

2- Navigate to Database > Schemas > mask > Views > foo

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Ideas and Resources

Videos / Presentations

- French: <https://www.youtube.com/watch?v=KGS1p4UygdU>

- English: <https://www.youtube.com/watch?v=niIIFL4s-L8>
- Chinese: <https://www.youtube.com/watch?v=n9atI31FcSM>

Similar technologies

- database anonymizer An anonymizing ETL for MySQL and PostgreSQL
- greenmask Anonymous dump utility written in Golang
- pganonymize A commandline tool for anonymizing PostgreSQL databases
- pgantomizer Anonymous dumps based on masking rules written in a YAML file
- pgsodium and postgresql-anonymizer Pseudonymous Access To Encrypted Table
- pg_diffix PostgreSQL extension implementing differential privacy (inactive)
- pg_anonymize PostgreSQL extension implementing dynamic data anonymization
- pg-anonymizer Dump anonymized PostgreSQL database with a NodeJS CLI

Similar Implementations

- Dynamic Data Masking With MS SQL Server
- Citus : Using search_path and views to hide columns for reporting with Postgres
- MariaDB : Masking with maxscale

GDPR

- Ultimate Guide to Data Anonymization
- UK ICO Anonymisation Code of Practice
- L. Sweeney, Simple Demographics Often Identify People Uniquely, 2000
- How Google anonymizes data
- IAPP's Guide To Anonymisation

Concepts

- Differential_Privacy
- K-Anonymity

Academic Research

- L. Sweeney. k-anonymity: a model for protecting privacy. International Journal on Uncertainty, Fuzziness and Knowledge-based Systems, 10 (5), 2002, pp. 557-570. https://epic.org/wp-content/uploads/privacy/reidentification/Sweeney_Article.pdf
- A. Narayanan and V. Shmatikov, “Robust de-anonymization of large sparse datasets,” in 29th IEEE Symposium on Security and Privacy, 2008, pp. 111–125. https://www.cs.cornell.edu/~shmat/shmat_oak08netflix.pdf — title: masking_data_wrappers draft: false toc: true —

Masking Data Wrappers

The principle of a masking data wrappers is to use Postgres as a “masking proxy” in front of any type of external data source. Using Foreign Data Wrappers, we can apply masking rules to data stored in CSV files, in another RDBM, in a NoSQL store, in a LDAP directory, etc.

PostgreSQL Masking Data Wrappers

Of course the remote data source can be another PostgreSQL instance !

Example

Here’s a basic CSV file containing application logs

```
$ cat /tmp/app.log
Mon Nov 04 08:25:32 2024      sarah   10.0.0.45      view_dashboard
Mon Nov 04 09:15:00 2024      mike    172.16.0.89    update_profile
Mon Nov 04 09:30:45 2024      emma    192.168.2.200  download_report
[...]
```

Let’s create a foreign table based on this file

```
CREATE EXTENSION IF NOT EXISTS file_fdw;

CREATE SERVER external_files FOREIGN DATA WRAPPER file_fdw;

CREATE SCHEMA files;

CREATE FOREIGN TABLE files.app_log
(
    tms    TIMESTAMP,
    login  VARCHAR(255),
    ip     INET,
    action TEXT
)
SERVER external_files
```

```
OPTIONS ( filename '/tmp/app.log' )
;
```

We can now declare masking rules on the columns of the foreign table, just like we would do for a regular table.

```
SECURITY LABEL FOR anon ON COLUMN files.app_log.login
IS 'MASKED WITH VALUE $$CONFIDENTIAL$$';
```

```
SECURITY LABEL FOR anon ON COLUMN files.app_log.ip
IS 'MASKED WITH FUNCTION anon.dummy_ipv4()';
```

... and that's it ! The masked users will now see the filtered data :

```
SET ROLE some_masked_user;
```

```
SELECT * FROM files.app_log LIMIT 1;
```

tms	login	ip	action
Mon Nov 04 08:23:15 2024	CONFIDENTIAL	85.249.91.21	login_success

Or export the data to a new CSV file

```
SET ROLE some_masked_user;
```

```
COPY files.app_log TO '/tmp/anonymized_app.log'
```

Various Masking Strategies

The extension provides functions to implement 8 main anonymization strategies:

- Destruction
- Adding Noise
- Randomization
- Faking
- Advanced Faking
- Pseudonymization
- Generic Hashing
- Partial scrambling
- Conditional masking
- Generalization
- Using pg_catalog functions
- Image blurring
- Write your own Masks !

Depending on your data, you may need to use different strategies on different columns :

- For names and other 'direct identifiers' , Faking is often useful

- Shuffling is convenient for foreign keys
- Adding Noise is interesting for numeric values and dates
- Partial Scrambling is perfect for email address and phone numbers
- etc.

Destruction

First of all, the fastest and safest way to anonymize a data is to destroy it :-)

In many cases, the best approach to hide the content of a column is to replace all the values with a single static value.

For instance, you can replace a entire column by the word ‘CONFIDENTIAL’ like this:

```
SECURITY LABEL FOR anon
ON COLUMN users.address
IS 'MASKED WITH VALUE 'CONFIDENTIAL' ';
```

Adding Noise

This is also called **Variance**. The idea is to “shift” dates and numeric values. For example, by applying a +/- 10% variance to a salary column, the dataset will remain meaningful.

- `anon.noise(original_value, ratio)` where `original_value` can be an integer, a bigint or a double precision. If the ratio is 0.33, the return value will be the original value randomly shifted with a ratio of +/- 33%
- `anon.dnoise(original_value, interval)` where `original_value` can be a date, a timestamp, or a time. If `interval = ‘2 days’`, the return value will be the original value randomly shifted by +/- 2 days

WARNING : The `noise()` masking functions are vulnerable to a form of repeat attack, especially with Dynamic Masking. A masked user can guess an original value by requesting its masked value multiple times and then simply use the `AVG()` function to get a close approximation. (See `demo/noise_reduction_attack.sql` for more details). In a nutshell, these functions are best fitted for Anonymous Dumps and Static Masking. They should be avoided when using Dynamic Masking.

Randomization

The extension provides a large choice of functions to generate purely random data :

Basic Random values

- `anon.random_date()` returns a date
- `anon.random_string(n)` returns a TEXT value containing `n` letters
- `anon.random_zip()` returns a 5-digit code
- `anon.random_phone(p)` returns a 8-digit phone with `p` as a prefix
- `anon.random_hash(seed)` returns a hash of a random string for a given seed

Random between

To pick any value inside between two bounds:

- `anon.random_date_between(d1,d2)` returns a date between `d1` and `d2`
- `anon.random_int_between(i1,i2)` returns an integer between `i1` and `i2`
- `anon.random_bigint_between(b1,b2)` returns a bigint between `b1` and `b2`

NOTE: With these functions, the lower and upper bounds are included. For instance `anon.random_int_between(1,3)` returns either 1, 2 or 3.

For more advanced interval descriptions, check out the Random in Range section.

Random in Array

The `random_in` function returns an element a given array

For example:

- `anon.random_in(ARRAY[1,2,3])` returns an int between 1 and 3
- `anon.random_in(ARRAY['red','green','blue'])` returns a text

Random in Enum

This is one especially useful when working with ENUM types!

- `anon.random_in_enum(variable_of_an_enum_type)` returns any val

```
CREATE TYPE card AS ENUM ('visa', 'mastercard', 'amex');
```

```
SELECT anon.random_in_enum(NULL::CARD);
random_in_enum
-----
mastercard
```

```
CREATE TABLE customer (
  id INT,
  ...
  credit_card CARD
```



```
);
```

```
SECURITY LABEL FOR anon ON COLUMN customer.creditcard  
IS 'MASKED WITH FUNCTION anon.random_in_enum(creditcard)'
```

Random in Range

RANGE types are a powerful way to describe an interval of values, where can define inclusive or exclusive bounds:

<https://www.postgresql.org/docs/current/rangetypes.html#RANGETYPES-EXAMPLES>

There a function for each subtype of range:

- `anon.random_in_int4range(' [5,6] ')` returns an INT of value 5
- `anon.random_in_int8range(' (6,7] ')` returns a BIGINT of value 7
- `anon.random_in_numrange(' [0.1,0.9] ')` returns a NUMERIC between 0.1 and 0.9
- `anon.random_in_daterange(' [2001-01-01, 2001-12-31] ')` returns a date in 2001
- `anon.random_in_tsrage(' [2022-10-01,2022-10-31] ')` returns a TIMESTAMP in october 2022
- `anon.random_in_tstzrange(' [2022-10-01,2022-10-31] ')` returns a TIMESTAMP WITH TIMEZONE in october 2022

NOTE: It is not possible to get a random value from a RANGE with an infinite bound. For example `anon.random_in_int4range(' [2022,)'` returns NULL.

Random Sequence ID

When masking a SERIAL columns it can be useful to general a UNIQUE value based on a sequence.

- `anon.random_id()` returns a BIGINT
- `anon.random_id_int()` returns a INT
- `anon.random_id_small_int()` returns a SMALLINT

Each call to these functions will return a incremented value much like the `[nextval()]` function.

At any time, you can reset the current sequence value with a new value. For instance:

```
SELECT pg_catalog.setval('anon.random_id_seq', 42);
```

Faking

The idea of **Faking** is to replace sensitive data with **random-but-plausible** values. The goal is to avoid any identification from the data record while re-

maintaining suitable for testing, data analysis and data processing.

In order to use the faking functions, you have to `init()` the extension in your database first:

```
SELECT anon.init();
```

The `init()` function will import a default dataset of random data (iban, names, cities, etc.).

This dataset is in English and very small (1000 values for each category). If you want to use localized data or load a specific dataset, please read the Custom Fake Data section.

Once the fake data is loaded, you have access to these faking functions:

- `anon.fake_address()` returns a complete post address
- `anon.fake_city()` returns an existing city
- `anon.fake_country()` returns a country
- `anon.fake_company()` returns a generic company name
- `anon.fake_email()` returns a valid email address
- `anon.fake_first_name()` returns a generic first name
- `anon.fake_iban()` returns a valid IBAN
- `anon.fake_last_name()` returns a generic last name
- `anon.fake_postcode()` returns a valid zipcode
- `anon.fake_siret()` returns a valid SIRET

For TEXT and VARCHAR columns, you can use the classic Lorem Ipsum generator:

- `anon.lorem_ipsum()` returns 5 paragraphs
- `anon.lorem_ipsum(2)` returns 2 paragraphs
- `anon.lorem_ipsum( paragraphs := 4 )` returns 4 paragraphs
- `anon.lorem_ipsum( words := 20 )` returns 20 words
- `anon.lorem_ipsum( characters := 7 )` returns 7 characters
- `anon.lorem_ipsum( characters := anon.length(table.column) )` returns the same amount of characters as the original string

Advanced Faking

Generating fake data is a complex topic. The `fake_` functions provided above are limited to basic use case. For more advanced faking methods, in particular if you are looking for **localized fake data**, PostgreSQL Anonymizer provides an advanced faking engine with localisation support.

This engine (fake-rs) is available via more than 70 functions with the `dummy_` prefix:

tips:

The `fake_*` and `dummy_*` functions achieve the same goal.

The fake_ functions are the first implementation in pl/pgsql. They were introduced in Version 1. It's a rather naïve and limited approach.*

The dummy_ functions are a new implementation based on a Rust library. It provides a more advanced fake generator and adds localization. It was introduced in Version 2.*

New users should always prefer the dummy_ functions. The fake_* functions are kept for backward compatibility.*

- anon.dummy_bic()
- anon.dummy_bs()
- anon.dummy_bs_adj()
- anon.dummy_bs_noun()
- anon.dummy_bs_verb()
- anon.dummy_building_number()
- anon.dummy_buzzword()
- anon.dummy_buzzword_middle()
- anon.dummy_buzzword_tail()
- anon.dummy_catchphrase()
- anon.dummy_cell_number()
- anon.dummy_city_name()
- anon.dummy_city_prefix()
- anon.dummy_city_suffix()
- anon.dummy_color()
- anon.dummy_company_name()
- anon.dummy_company_suffix()
- anon.dummy_country_code()
- anon.dummy_country_name()
- anon.dummy_credit_card_number()
- anon.dummy_currency_code()
- anon.dummy_currency_name()
- anon.dummy_currency_symbol()
- anon.dummy_dir_path()
- anon.dummy_domain_suffix()
- anon.dummy_file_extension()
- anon.dummy_file_name()
- anon.dummy_file_path()
- anon.dummy_first_name()
- anon.dummy_free_email()
- anon.dummy_free_email_provider()
- anon.dummy_health_insurance_code()
- anon.dummy_hex_color()
- anon.dummy_hsl_color()
- anon.dummy_hsla_color()
- anon.dummy_industry()
- anon.dummy_ip()

- anon.dummy_ipv4()
- anon.dummy_ipv6()
- anon.dummy_isbn()
- anon.dummy_isbn13()
- anon.dummy_isin()
- anon.dummy_last_name()
- anon.dummy_latitude()
- anon.dummy_licence_plate()
- anon.dummy_longitude()
- anon.dummy_mac_address()
- anon.dummy_name()
- anon.dummy_name_with_title()
- anon.dummy_phone_number()
- anon.dummy_post_code()
- anon.dummy_profession()
- anon.dummy_rfc_status_code()
- anon.dummy_rgb_color()
- anon.dummy_rgba_color()
- anon.dummy_safe_email()
- anon.dummy_secondary_address()
- anon.dummy_secondary_address_type()
- anon.dummy_state_abbr()
- anon.dummy_state_name()
- anon.dummy_street_name()
- anon.dummy_street_suffix()
- anon.dummy_suffix()
- anon.dummy_timezone()
- anon.dummy_title()
- anon.dummy_user_agent()
- anon.dummy_username()
- anon.dummy_uuidv1()
- anon.dummy_uuidv3()
- anon.dummy_uuidv4()
- anon.dummy_uuidv5()
- anon.dummy_valid_status_code()
- anon.dummy_word()
- anon.dummy_words(int4range)
- anon.dummy_zip_code()

For each of this function, you can add the `_locale(...)` suffix and specify in which local context you want.

For example:

```
SELECT anon.dummy_last_name();
dummy_last_name
```

Tillman

```
SELECT anon.dummy_last_name_locale('fr_FR');  
dummy_last_name_locale
```

Granier

```
SELECT anon.dummy_last_name_locale('pt_BR');  
dummy_last_name_locale
```

Barreto

Currently 7 locales are available: ar_SA, en_US(default), fr_FR, ja_JP, pt_BR, zh_CN, zh_TW.

Not that some `dummy_` functions are not implemented for certain locales. If you wish to contribute or ask for missing fake data, please contact directly the fake-rs project, which is the library that this extension is using under the hood !

Pseudonymization

Pseudonymization is similar to Faking in the sense that it generates realistic values. The main difference is that the pseudonymization is deterministic : the functions always will return the same fake value based on a seed and an optional salt.

In order to use the faking functions, you have to `init()` the extension in your database first:

```
SELECT anon.init();
```

Once the fake data is loaded you have access to 10 pseudo functions:

- `anon.pseudo_first_name(seed,salt)` returns a generic first name
- `anon.pseudo_last_name(seed,salt)` returns a generic last name
- `anon.pseudo_email(seed,salt)` returns a valid email address
- `anon.pseudo_city(seed,salt)` returns an existing city
- `anon.pseudo_country(seed,salt)` returns a country
- `anon.pseudo_company(seed,salt)` returns a generic company name
- `anon.pseudo_iban(seed,salt)` returns a valid IBAN
- `anon.pseudo_siret(seed,salt)` returns a valid SIRET

The second argument (`salt`) is optional. You can call each function with only the seed like this `anon.pseudo_city('bob')`. The salt is here to increase complexity and avoid dictionary and brute force attacks (see warning below). If a specific salt is not given, the value of the `anon.salt` GUC parameter is used instead (see the Generic Hashing section for more details).

The seed can be any information related to the subject. For instance, we can consistently generate the same fake email address for a given person by using her login as the seed :

```
SECURITY LABEL FOR anon
ON COLUMN users.emailaddress
IS 'MASKED WITH FUNCTION anon.pseudo_email(users.login) ';
```

NOTE: You may want to produce unique values using a pseudonymization function. For instance, if you want to mask an `email` column that is declared as `UNIQUE`. In this case, you will need to initialize the extension with a fake dataset that is **way bigger** than the numbers of rows of the table. Otherwise you may see some “collisions” happening, i.e. two different original values producing the same pseudo value.

It is also possible to pseudonymize a primary key using:

- `anon.pseudo_shift(id)` returns a shifted version of the id
- `anon.pseudo_xor(id)` returns an exclusive OR value of the id

Both `anon.pseudo_shift(BIGINT)` and `anon.pseudo_xor(BIGINT)` functions use a secret value (`anon.shift`) to pseudonymize the primary key. That secret value can be initialized randomly with `anon.set_shift()` or defined with `anon.set_shift(INT)`.

This is very useful to replace `anon.random_id()` when using Backup Masking.

WARNING: Pseudonymization is often confused with anonymization but in fact they serve 2 different purposes : **pseudonymization** is a way to **protect** the personal information but the pseudonymized data is still “linked” to the real data. The GDPR makes it very clear that personal data which has undergone pseudonymization is still related to a person. (see GDPR Recital 26)

Generic hashing

Hashing is another pseudonymization technique (see **WARNING** above). In practice it is sometimes useful to generate a determinist hash of the original data.

For instance, when a pair of primary key / foreign key is a “natural key”, it may contain actual information (like a customer number containing a birth date or something similar).

Hashing such columns allows to keep referential integrity intact even for relatively unusual source data. Therefore, the

- `anon.digest(value,salt,algorithm)` lets you choose a salt, and a hash algorithm from a pre-defined list
- `anon.hash(value)` will return a text hash of the value using a secret salt (defined by the `anon.salt` parameter) and hash algorithm (defined by the

`anon.algorithm` parameter). The default value of `anon.algorithm` is `sha256` and possible values are: `md5`, `sha224`, `sha256`, `sha384` or `sha512`. The default value of `anon.salt` is an empty string. You can modify these values with:

```
ALTER DATABASE foo SET anon.salt TO 'xsfnjefnjsnfjsnf';
ALTER DATABASE foo SET anon.algorithm TO 'sha384';
```

Keep in mind that hashing is a form a Pseudonymization. This means that the data can be “de-anonymized” using the hashed value and the masking function. If an attacker gets access to these 2 elements, he or she could re-identify some persons using brute force or dictionary attacks. Therefore, **the salt and the algorithm used to hash the data must be protected with the same level of security that the original dataset.**

In a nutshell, we recommend that you use the `anon.hash()` function rather than `anon.digest()` because the salt will not appear clearly in the masking rule.

Furthermore: in practice the hash function will return a long string of character like this:

```
SELECT anon.hash('bob');
```

hash

```
95b6accef02c5a725a8c9abf19ab5575f99ca3d9997984181e4b3f81d96cbca4d0977d694ac490350e01d0d21363
```

For some columns, this may be too long and you may have to cut some parts the hash in order to fit into the column. For instance, if you have a foreign key based on a phone number and the column is a `VARCHAR(12)` you can transform the data like this:

```
SECURITY LABEL FOR anon ON COLUMN people.phone_number
IS 'MASKED WITH FUNCTION anon.left(anon.hash(phone_number),12)';
```

```
SECURITY LABEL FOR anon ON COLUMN call_history.fk_phone_number
IS 'MASKED WITH FUNCTION anon.left(anon.hash(fk_phone_number),12)';
```

Of course, cutting the hash value to 12 characters will increase the risk of “collision” (2 different values having the same fake hash). In such case, it’s up to you to evaluate this risk.

WARNING: The hashing functions will fail when the input contains an unescaped character (especially a single backslash). In most situation, this is the sign of a bug in the application, generally when data input is not sanitized properly. Users who really want to mask unescaped characters with this function should disable the `standard_conforming_strings` parameter. See Issue 539 for more details.

Partial Scrambling

Partial scrambling leaves out some part of the data. For instance : a credit card number can be replaced by '40XX XXXX XXXX XX96'.

2 functions are available:

- `anon.partial('abcdefgh',1,'xxxx',3)` will return 'axxxxfggh';
- `anon.partial_email('daamien@gmail.com')` will become 'da*****@gm*****.com'

Conditional Masking

In some situations, you may want to apply a masking filter only for some value or for a limited number of lines in the table.

For instance, if you want to “preserve NULL values”, i.e. masking only the lines that contains a value, you can use the `anon.ternary` function, which works like a CASE WHEN x THEN y ELSE z statement :

```
SECURITY LABEL FOR anon ON COLUMN player.score
IS 'MASKED WITH FUNCTION anon.ternary(score IS NULL,
                                     NULL,
                                     anon.random_int_between(0,100));
```

You may also want to exclude some lines within the table. Like keeping the password of some users so that they still may be able to connect to a testing deployment of your application:

```
SECURITY LABEL FOR anon ON COLUMN account.password
IS 'MASKED WITH FUNCTION anon.ternary( id > 1000, NULL::TEXT, password)';
```

WARNING : Conditional masking may create a partially deterministic “connection” between the original data and the masked data. And that connection can be used to retrieve personal information from the masked data. For instance, if NULL values are preserved for a “deceased_date” column, it will reveal which persons are still actually alive... In a nutshell: conditional masking may often produce a dataset that is not fully anonymized and therefore would still technically contain personal information.

Generalization

Generalization is the principle of replacing the original value by a range containing this value. For instance, instead of saying ‘Paul is 42 years old’, you would say ‘Paul is between 40 and 50 years old’.

The generalization functions are a data type transformation. Therefore it is not possible to use them with the dynamic masking engine. However they are useful to create anonymized views. See example below.

Let’s imagine a table containing health information:


```
SELECT * FROM patient;
```

id	name	zipcode	birth	disease
1	Alice	47678	1979-12-29	Heart Disease
2	Bob	47678	1959-03-22	Heart Disease
3	Caroline	47678	1988-07-22	Heart Disease
4	David	47905	1997-03-04	Flu
5	Eleanor	47909	1999-12-15	Heart Disease
6	Frank	47906	1968-07-04	Cancer
7	Geri	47605	1977-10-30	Heart Disease
8	Harry	47673	1978-06-13	Cancer
9	Ingrid	47607	1991-12-12	Cancer

We can build a view upon this table to suppress some columns (SSN and name) and generalize the zipcode and the birth date like this:

```
CREATE VIEW anonymized_patient AS
SELECT
    'REDACTED' AS lastname,
    anon.generalize_int4range(zipcode,100) AS zipcode,
    anon.generalize_tsrange(birth,'decade') AS birth
    disease
FROM patients;
```

The anonymized table now looks like that:

```
SELECT * FROM anonymized_patient;
```

lastname	zipcode	birth	disease
REDACTED	[47600,47700)	["1970-01-01","1980-01-01")	Heart Disease
REDACTED	[47600,47700)	["1950-01-01","1960-01-01")	Heart Disease
REDACTED	[47600,47700)	["1980-01-01","1990-01-01")	Heart Disease
REDACTED	[47900,48000)	["1990-01-01","2000-01-01")	Flu
REDACTED	[47900,48000)	["1990-01-01","2000-01-01")	Heart Disease
REDACTED	[47900,48000)	["1960-01-01","1970-01-01")	Cancer
REDACTED	[47600,47700)	["1970-01-01","1980-01-01")	Heart Disease
REDACTED	[47600,47700)	["1970-01-01","1980-01-01")	Cancer
REDACTED	[47600,47700)	["1990-01-01","2000-01-01")	Cancer

The generalized values are still useful for statistics because they remain true, but they are less accurate, and therefore reduce the risk of re-identification.

PostgreSQL offers several RANGE data types which are perfect for dates and numeric values.

For numeric values, 3 functions are available:

- generalize_int4range(value, step)
- generalize_int8range(value, step)
- generalize_numrange(value, step)

...where **value** is the data that will be generalized, and **step** is the size of each range.

Using `pg_catalog` functions

Since version 1.3, the `pg_catalog` schema is not trusted by default. This is a security measure designed to prevent users from using sophisticated functions inside masking rules (such as `pg_catalog.query_to_xml`, `pg_catalog.ts_stat` or the system administration functions) that should not be used as masking functions.

However, the extension allows using some useful and safe functions from the `pg_catalog` schema for your convenience. These are small subset of functions that are declared as `TRUSTED` for anonymization.

The list of `TRUSTED` `pg_catalog` functions is available via the `anon.pg_trusted_functions` views :

```
SELECT * FROM anon.pg_trusted_functions;
```

If you need to use a `pg_catalog` function which is not in this list, you can ask a superuser to trust it with:

```
SECURITY LABEL FOR anon ON FUNCTION pg_catalog.foo IS 'TRUSTED';
```

Note: Even when multiple masking policies are defined, the functions must be declared as `TRUSTED` in the “anon” policy and they will be trusted for all policies.

Image blurring

Images can show some sensitive data, for example

- A photo concerning personal data.
- A barcode representing personal data.

it is possible to blur this image using

- `anon.image_blur(data,sigma)` returns a `bytea`
- data type `bytea`: the image data
- sigma type `numeric`: This parameter controls the amount of blurring. A higher sigma value results in a more blurred image, while a lower sigma value results in a less blurred image.

usage :

```
CREATE TABLE images (  
    id SERIAL PRIMARY KEY,  
    name TEXT NOT NULL,  
    image_data BYTEA NOT NULL  
);
```

```

create extension anon;
SELECT anon.init();

SECURITY LABEL FOR anon ON COLUMN images.image_data
IS 'MASKED WITH FUNCTION anon.image_blur(image_data,1.0)';

SELECT anon.anonymize_database();

```

Write your own Masks !

You can also use your own function as a mask. The function must either be destructive (like Partial Scrambling) or insert some randomness in the dataset (like Faking).

Especially for complex data types, you may have to write your own function. This will be a common use case if you have to hide certain parts of a JSON field.

For example:

```

CREATE TABLE company (
  business_name TEXT,
  info JSONB
)

```

The info field contains unstructured data like this:

```

SELECT jsonb_pretty(info) FROM company WHERE business_name = 'Soylent Green';
      jsonb_pretty
-----
{
  "employees": [
    {
      "lastName": "Doe",
      "firstName": "John"
    },
    {
      "lastName": "Smith",
      "firstName": "Anna"
    },
    {
      "lastName": "Jones",
      "firstName": "Peter"
    }
  ]
}
(1 row)

```

Using the PostgreSQL JSON functions and operators, you can walk through the keys and replace the sensitive values as needed.

```
CREATE SCHEMA custom_masks;
```

```
CREATE FUNCTION custom_masks.remove_last_name(j JSONB)
RETURNS JSONB
VOLATILE
LANGUAGE SQL
AS $func$
SELECT
    json_build_object(
        'employees' ,
        array_agg(
            jsonb_set(e ,'{lastName}', to_jsonb(anon.fake_last_name()))
        )
    )::JSONB
FROM jsonb_array_elements( j->'employees') e
$func$;
```

-- This step requires superuser privilege

```
SECURITY LABEL FOR anon ON FUNCTION custom_masks.remove_last_name IS 'TRUSTED';
```

Then check that the function is working correctly:

```
SELECT custom_masks.remove_last_name(info) FROM company;
```

When that's ok you can declare this function as the mask of the info field:

```
SECURITY LABEL FOR anon ON COLUMN company.info
IS 'MASKED WITH FUNCTION custom_masks.remove_last_name(info)';
```

And try it out !

```
# SELECT anonymize_table('company');
# SELECT jsonb_pretty(info) FROM company WHERE business_name = 'Soylent Green';
      jsonb_pretty
```

```
-----
{
  "employees": [
    {
      "lastName": "Prawdzik",
      "firstName": "John"
    },
    {
      "lastName": "Baltazor",
      "firstName": "Anna"
    },
    {

```

```

        "lastName": "Taylan", +
        "firstName": "Peter"   +
    }                           +
]                               +
}                               +
(1 row)

```

This is just a quick and dirty example. As you can see, manipulating a sophisticated JSON structure with SQL is possible, but it can be tricky at first! There are multiple ways of walking through the keys and updating values. You will probably have to try different approaches, depending on your real JSON data and the performance you want to reach. — title: masking_views draft: false toc: true —

Masking Views

The principle of a masking view is simply to build dedicated interface upon a table. This is useful when the masking policy needs to modify the database model.

PostgreSQL Masking Views

Generalization

The idea of generalization is to replace data with a broader, less accurate value. For instance, instead of saying “Bob is 28 years old”, you can say “Bob is between 20 and 30 years old”. This is interesting for analytics because the data remains true while avoiding the risk of re-identification.

Generalization is a way to achieve k-anonymity.

PostgreSQL can handle generalization very easily with the RANGE data types, a very powerful way to store and manipulate a set of values contained between a lower and an upper bound.

Example

Here’s a basic table containing medical data:

```
# SELECT * FROM confidential.patient;
```

ssn	firstname	zipcode	birth	disease
253-51-6170	Alice	47012	1989-12-29	Heart Disease
091-20-0543	Bob	42678	1979-03-22	Allergy
565-94-1926	Caroline	42678	1971-07-22	Heart Disease
510-56-7882	Eleanor	47909	1989-12-15	Acne
098-24-5548	David	47905	1997-03-04	Flu
118-49-5228	Jean	47511	1993-09-14	Flu

```

263-50-7396 | Tim      | 47900 | 1981-02-25 | Heart Disease
109-99-6362 | Bernard | 47168 | 1992-01-03 | Asthma
287-17-2794 | Sophie  | 42020 | 1972-07-14 | Asthma
409-28-2014 | Arnold  | 47000 | 1999-11-20 | Diabetes
(10 rows)

```

We want the anonymized data to remain **true** because it will be used for statistics. We can build a view upon this table to remove useless columns and generalize the indirect identifiers :

```
CREATE SCHEMA stats;
```

```

CREATE MATERIALIZED VIEW stats.generalized_patient AS
SELECT
  'REDACTED'::TEXT AS firstname,
  anon.generalize_int4range(zipcode,1000) AS zipcode,
  anon.generalize_daterange(birth,'decade') AS birth,
  disease
FROM confidential.patient;

```

This will give us a less accurate view of the data:

```

# SELECT * FROM generalized_patient;

```

firstname	zipcode	birth	disease
REDACTED	[47000,48000)	[1980-01-01,1990-01-01)	Heart Disease
REDACTED	[42000,43000)	[1970-01-01,1980-01-01)	Allergy
REDACTED	[42000,43000)	[1970-01-01,1980-01-01)	Heart Disease
REDACTED	[47000,48000)	[1980-01-01,1990-01-01)	Acne
REDACTED	[47000,48000)	[1990-01-01,2000-01-01)	Flu
REDACTED	[47000,48000)	[1990-01-01,2000-01-01)	Flu
REDACTED	[47000,48000)	[1980-01-01,1990-01-01)	Heart Disease
REDACTED	[47000,48000)	[1990-01-01,2000-01-01)	Asthma
REDACTED	[42000,43000)	[1970-01-01,1980-01-01)	Asthma
REDACTED	[47000,48000)	[1990-01-01,2000-01-01)	Diabetes

```

(10 rows)

```

Now we can give read access only to the masking views for a given user:

```
CREATE USER bob;
```

```

REVOKE USAGE          ON SCHEMA confidential FROM bob;
REVOKE ALL PRIVILEGES ON ALL TABLES IN SCHEMA confidential FROM bob;
GRANT  USAGE          ON SCHEMA stats        TO bob;
GRANT  SELECT         ON ALL TABLES IN SCHEMA stats        TO bob;

```

Generalization Functions

PostgreSQL Anonymizer provides 6 generalization functions. One for each RANGE type. Generally these functions take the original value as the first parameter, and a second parameter for the length of each step.

For numeric values :

- `anon.generalize_int4range(42,5)` returns the range [40,45)
- `anon.generalize_int8range(12345,1000)` returns the range [12000,13000)
- `anon.generalize_numrange(42.32378,10)` returns the range [40,50)

For time values :

- `anon.generalize_tsrage('1904-11-07','year')` returns ['1904-01-01','1905-01-01')
- `anon.generalize_tstzrange('1904-11-07','week')` returns ['1904-11-07','1904-11-14')
- `anon.generalize_daterange('1904-11-07','decade')` returns [1900-01-01,1910-01-01)

The possible steps are : microseconds, milliseconds, second, minute, hour, day, week, month, year, decade, century and millennium.

Limitations

Singling out and extreme values

“Singling Out” is the possibility to isolate an individual in a dataset by using extreme value or exceptional values.

For example:

```
# SELECT * FROM employees;
```

id	name	job	salary
1578	xkjefus3sfzd	NULL	1498
2552	cksnd2se5dfa	NULL	2257
5301	fnefckndc2xn	NULL	45489
7114	npodn5ltyp3d	NULL	1821

In this table, we can see that a particular employee has a very high salary, very far from the average salary. Therefore this person is probably the CEO of the company.

With generalization, this is important because the size of the range (the “step”) must be wide enough to prevent the identification of one single individual.

k-anonymity is a way to assess this risk.

Generalization is not compatible with dynamic masking

By definition, with generalization the data remains true, but the column type is changed.

This means that the transformation is not transparent, and therefore it cannot be used with dynamic masking.

k-anonymity

k-anonymity is an industry-standard term used to describe a property of an anonymized dataset. The k-anonymity principle states that within a given dataset, any anonymized individual cannot be distinguished from at least $k-1$ other individuals. In other words, k-anonymity might be described as a “hiding in the crowd” guarantee. A low value of k indicates there’s a risk of re-identification using linkage with other data sources.

You can evaluate the k-anonymity factor of a table in 2 steps :

Step 1: First define the columns that are indirect identifiers (also known as quasi identifiers) like this:

```
SECURITY LABEL FOR k_anonymity ON COLUMN patient.firstname  
IS 'INDIRECT IDENTIFIER';
```

```
SECURITY LABEL FOR k_anonymity ON COLUMN patient.zipcode  
IS 'INDIRECT IDENTIFIER';
```

```
SECURITY LABEL FOR k_anonymity ON COLUMN patient.birth  
IS 'INDIRECT IDENTIFIER';
```

Step 2: Once the indirect identifiers are declared :

```
SELECT anon.k_anonymity('generalized_patient')
```

The higher the value, the better...

References

-

How Google Anonymizes Data

title: performances draft: false toc: true —

Performances

Any anonymization process has a price as it will consume CPU time, RAM space and probably a bunch of disk I/O... Here’s a quick overview of the question depending on what strategy you are using....

In a nutshell, the anonymization performances will mainly depend on 2 important factors:

- The size of the database
- The number of masking rules

Static Masking

Basically what static masking does it rewrite entirely the masked tables on disk. This may be slow depending on your environment. And during this process, the tables will be locked.

As an example: Anonymizing a 44GB database with 29 masking rules on an AWS EC2 instance takes approximately 25 minutes (see MR 107 for more details).

In this case, the cost of anonymization is “paid” by all the users but it is paid **once and for all**.

Dynamic Masking

With dynamic masking, the real data is replaced on-the-fly **every time** a masked user sends a query to the database. This means that the masking users will have slower response time than regular (unmasked) users. This is generally ok because usually masked users are not considered as important as the regular ones.

If you apply 3 or 4 rules to a table, the response time for the masked users should approx. 20% to 30% slower than for the normal users.

As the masking rules are applied for each queries of the masked users, the dynamic masking is appropriate when you have a limited number of masked users that connect only from time to time to the database. For instance, a data analyst connecting once a week to generate a business report.

If there are multiple masked users or if a masked user is very active, you should probably export the masked data once-a-week on a secondary instance and let these users connect to this secondary instance.

In this case, the cost of anonymization is “paid” only by the masked users.

Anonymous Dumps

Some benchmarks made in march 2022 suggest that the `pg_dump_anon` wrapper is twice as slow as the regular `pg_dump` tool.

If the backup process of your database takes 1 hour with `pg_dump`, then anonymizing and exporting the entire database with `pg_dump_anon` will probably take 2 hours.

In this case, the cost of anonymization is “paid” by the user asking for the anonymous export. Other users of the database will not be affected.

How to speed things up ?

Prefer MASKED WITH VALUE whenever possible

It is always faster to replace the original data with a static value instead of calling a masking function.

Sampling

If you need to anonymize data for testing purpose, chances are that a smaller subset of your database will be enough. In that case, you can easily speed up the anonymization by downsizing the volume of data.

Checkout the Sampling section for more details.

Materialized Views

Dynamic masking is not always required! In some cases, it is more efficient to build Materialized Views instead.

For instance:

```
CREATE MATERIALIZED VIEW masked_customer AS
SELECT
    id,
    anon.random_last_name() AS name,
    anon.random_date_between('1920-01-01'::DATE,now()) AS birth,
    fk_last_order,
    store_id
FROM customer;
```

Materialized Views: <https://www.postgresql.org/docs/current/static/sql-creatematerializedview.html>

title: privacy_by_default draft: false toc: true —

Privacy By Default

Principle

The GDPR regulation (and other privacy laws) introduces the concept of data protection by default. In a nutshell, it means that **by default**, organisations should ensure that data is processed with the highest privacy protection so

that by default personal data isn't made accessible to an indefinite number of persons.

By applying this principle to anonymization, we end up with the idea of **privacy by default** which basically means that all columns of all tables should be masked by default, without having to declare a masking rule for each of them.

To enable this feature, simply set the option `anon.privacy_by_default` to `on`.

Example

Imagine a database named `foo` with a basic table containing HTTP logs:

```
# SELECT * FROM access_logs LIMIT 1;
      date_open      |      ip_addr      |      url      |      browser_agent
-----+-----+-----+-----
2009-01-08 00:00:00 | 192.168.100.128 | /home.html | Mozilla/5.0 (Windows; en_US)
(1 row)
```

Now let's activate privacy by default:

```
ALTER DATABASE foo SET anon.privacy_by_default = True;
```

The setting will be applied for the next sessions, i.e. **You need to reconnect to the database for the change to visible**

We can now anonymize the table without writing any masking rule.

```
# SELECT anon.anonymize_database();
anonymize_database
-----
t

# SELECT * FROM access_logs LIMIT 1;
      date_open | ip_addr | url | browser_agent
-----+-----+-----+-----
              |        |    | unknown
```

Unmasking columns

As we can see, when the `anon.privacy_by_default` is defined all the values will be replaced by the column's default value or NULL. The entire dataset is destroyed.

Now instead of writing rules to mask the sensible columns, we will write rules to **unmask** the ones we want to allow.

For instance, let's say that we want to keep the authentic value of the `url` field, we can simply "unmask" the column like this:

```
SECURITY LABEL FOR anon ON COLUMN access_logs.url
IS 'NOT MASKED';
```

This can also be achieved by a masking rule that will replace the value with itself:

```
SECURITY LABEL FOR anon ON COLUMN access_logs.url
IS 'MASKED WITH VALUE url';
```

Now we'd like to unmask the `date_open` field in the anonymized dataset but we need to generalize the dates to keep only the year:

```
SECURITY LABEL FOR anon ON COLUMN access_logs.date_open
IS 'MASKED WITH FUNCTION make_date(EXTRACT(year FROM date_open)::INT,1,1)';
```

Caveat: Add a DEFAULT to the NOT NULL columns

It is a bit ironic that the `anon.privacy_by_default` parameter is **not** enabled by default. This reason is simple: activating this option **may or may not** lead to constraint violations depending on the columns constraints placed in the database model.

Let's say we want to add a NOT NULL constraint on the `date_open` column:

```
ALTER TABLE public.access_logs
  ALTER COLUMN date_open
  SET NOT NULL;
```

Now if we try to anonymize the table, we get the following violation:

```
SELECT anon.anonymize_table('public.access_logs') as test4;
ERROR:  Cannot mask a "NOT NULL" column with a NULL value
HINT:  If privacy_by_design is enabled, add a default value to the column
```

The solution here is simply to define a default value and this value will be used for the `privacy_by_default` mechanism.

```
ALTER TABLE public.access_logs
  ALTER COLUMN date_open
  SET DEFAULT now();
```

Other constraints (foreign keys, UNIQUE, CHECK, etc.) should work fine without a DEFAULT value. — title: replica_masking draft: false toc: true —

Anonymous Replica

WARNING! DO NOT USE IN PRODUCTION

This feature is currently under heavy development. This implementation of Replica Masking is provided for testing purpose only. Major breaking changes

may be introduced at any time and we may even remove this feature entirely if we feel it does not reach our standard of quality and stability.

We welcome any feedback, testing reports, comments and contributions. But at the moment, we do not guarantee any form of support for this feature.

Our current plan is to stabilize this feature in version 3.0, which is scheduled for early 2026.

Thanks for your understanding.

Principle

In some situations, you may want to have an anonymized copy of your production database on another instance like with Backup Masking (aka “Anonymized Dumps”) but you also would like this copy to be up-to-date with the original data like with Dynamic Masking...

With the Replica Masking feature, you can use PostgreSQL logical replication to create an anonymized clone of your production database.

PostgreSQL Replica Masking

Preamble: Learn about logical replication !

PostgreSQL logical replication is a powerful mechanism. Before setting up a anonymous replica, be sure that you are able to configure standard logical replication correctly.

There are many tutorials available for that and we also recommend reading the PostgreSQL manual:

<https://www.postgresql.org/docs/current/logical-replication.html>

Quick Setup

Example

Let's say we want to anonymize a table `person` in a database `foo` like this:

```
CREATE TABLE person (  
    id SERIAL PRIMARY KEY,  
    name TEXT,  
    company TEXT  
);  
  
INSERT INTO person VALUES (1, 'Alice', 'CompanyA');  
INSERT INTO person VALUES (2, 'Bob', 'CompanyB');  
INSERT INTO person VALUES (3, 'Charlie', 'CompanyC');
```

```
INSERT INTO person VALUES (4, 'David', 'CompanyD');
INSERT INTO person VALUES (5, 'Eve', 'CompanyE');
```

A- On the publisher database

A1- Create a replication role:

```
CREATE ROLE anon_replicator LOGIN REPLICATION PASSWORD 'CHANGE-ME-3747';
GRANT USAGE ON SCHEMA public TO anon_replicator;
GRANT SELECT ON ALL TABLES IN SCHEMA public TO anon_replicator;
```

Be sure to configure your `pg_hba.conf` file to allow `anon_replicator` to connect from the subscriber database.

A2- Create a publication:

```
CREATE PUBLICATION pub FOR TABLE person;
```

All of this is pretty standard. There's nothing special regarding anonymization on the publisher database. In fact, the publisher database “does not know” that the data will be masked on the subscriber.

B- On the subscriber database

B1- Create the table (DDL commands are NOT replicated):

```
CREATE TABLE person (
    id SERIAL PRIMARY KEY,
    name TEXT,
    company TEXT
);
```

B2- Enable replica masking:

```
ALTER DATABASE foo SET anon.replica_masking TO on;
```

B3- Reconnect to the database so that the configuration is applied.

B4- Define the masking rules:

```
SECURITY LABEL FOR anon ON COLUMN person.company
IS 'MASKED WITH FUNCTION pg_catalog.md5(company)';

SECURITY LABEL FOR anon ON COLUMN person.name
IS 'MASKED WITH FUNCTION anon.dummy_first_name()';
```

B5- start the replica masking engine:

```
SELECT anon.start_replica_masking();
```

B6- Create the subscription:

```
CREATE SUBSCRIPTION anon_sub
CONNECTION 'host=prod_srv user=anon_replicator password=CHANGE-ME-3747 dbname=foo'
PUBLICATION pub;
```

Wait for a few milliseconds while the data is being synchronized and masked...

Et voilà !

```
SELECT * FROM person;
```

id	name	company
1	Christine	a1e551387ba94e882ccc5356948d6462
2	Percival	75b4e152a05dae2f1d7991182e707fad
3	Ignatius	e2a211f97064ee5a86853ae61e1bb2b9
4	Karley	8d543957c23828bb0d888cf7da59a817
5	Alfredo	566ca1969819cbf2098202255914bf23

Changing the masking rules

Anytime you add or remove a masking rule, you need to update the replica masking engine.

```
SELECT anon.refresh_replica_masking();
```

Anonymized Standby

In complement to Replica Masking, it is possible to use Hot Standby replication to build a distant clone of the Anonymized Replica. This is useful to export the database to a remote datacenter because the Anonymized Replica will operate as a masking proxy, “cleaning” the personal information before it gets transferred to the Standby instance.

PostgreSQL Standby Masking

Security

Keep in mind that the masking rules are applied on-the-fly in the subscriber database, which means:

- The original data is transferred through the connection between the publisher and the subscriber. Therefore this connection should be protected like in a regular logical replication setup.
- The superuser of the subscriber instance and the owner of the subscriber database can disable Replica Masking at anytime. They can both access the original, just like the superuser and the owner of the publisher database. Therefore, a third role should be created on the subscriber database to provide unprivileged and read-only access to the data.

- The replication role is also able to access the original data at any time.
- The logs of the subscriber database may contain unmasked data.

Limitations

- Anonymous replication is based on logical replication, therefore it has the same restrictions, in particular: DDL commands, sequences, Large Objects are NOT replicated.
- The `REPLICA IDENTITY FULL` method is NOT supported. This means that all replicated tables MUST have a primary key.
- The primary key of a table should not be masked.

But I want to anonymize a primary key!

If you need to anonymize a primary key in a table, this means that it is a natural key (as opposed to a surrogate key).

Natural keys are problematic for many reasons:

- they can change over time (like email addresses or product codes), forcing cascading updates throughout related tables
- they're often not truly unique in practice, even seemingly unique values like SSNs can have duplicates or exceptions
- they tend to be longer and more complex than simple integers
- they make joins slower and indexes larger
- they can contain sensitive information that you might not want exposed in URLs or logs.
- they may change whenever business rules evolve, requiring database restructuring.

Surrogate keys (i.e. auto-incrementing integers) avoid these issues by providing stable, meaningless identifiers that never need to change.

In particular for anonymization: surrogate keys make your life easier since you don't have to mask them. In the other hand, natural keys are often a nightmare: in most situations they will force you to use complex pseudonymization techniques, and keep in mind that that Pseudonymization Is Not Anonymization !

Pseudonymization Is Not Anonymization: `masking_functions.md#pseudonymizat`

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Welcome to Paul's Boutique !

This is a 4 hours workshop that demonstrates various anonymization techniques using the PostgreSQL Anonymizer extension.

The Story

Paul's boutique

Paul's boutique has a lot of customers. Paul asks his friend Pierre, a Data Scientist, to make some statistics about his clients : average age, etc...

Pierre wants a direct access to the database in order to write SQL queries.

Jack is an employee of Paul. He's in charge of relationship with the various suppliers of the shop.

Paul respects his suppliers privacy. He needs to hide the personal information to Pierre, but Jack needs read and write access the real data.

Objectives

Using the simple example above, we will learn:

- How to write masking rules
- The difference between static and dynamic masking
- Implementing advanced masking techniques

About GDPR

This tutorial **does not** go into the details of the GPDR act and the general concepts of anonymization.

For more information about it, please refer to the talk below:

- Anonymisation, Au-delà du RGPD (Video / French)
- Anonymization, Beyond GDPR (PDF / english)

Requirements

In order to make this workshop, you will need:

- A Linux VM (preferably **Debian 12 bookworm** or **Ubuntu 24.04**)
- A PostgreSQL instance (preferably **PostgreSQL 17**)
- The PostgreSQL Anonymizer (anon) extension, installed and initialized by a superuser
- A database named "boutique" owned by a **superuser** called "paul"
- A role "pierre" and a role "jack", both allowed to connect to the database "boutique"

Check out the `INSTALL` section to learn how to install the PostgreSQL Anonymizer extension:

!!! tip

A simple way to deploy a workshop environment is to install [Docker Desktop] and download the image below:

```
ANON_IMG=registry.gitlab.com/dalibo/postgresql_anonymizer:stable
docker pull $ANON_IMG
```

And you can then launch it with:

```
docker run --name anon_tuto --detach -e POSTGRES_PASSWORD=x $ANON_IMG
docker exec -it anon_tuto psql -U postgres
```

!!! tip Check out the `INSTALL` section in the documentation to learn how to install the extension in your PostgreSQL instance.

The Roles

We will with 3 different users:

```
CREATE ROLE paul LOGIN SUPERUSER PASSWORD 'CHANGE ME';
```

```
CREATE ROLE pierre LOGIN PASSWORD 'CHANGE ME';
```

```
CREATE ROLE jack LOGIN PASSWORD 'CHANGE ME';
GRANT pg_read_all_data TO jack;
GRANT pg_write_all_data TO jack;
```

Unless stated otherwise, all commands must be executed with the role `paul`.

!!! Tip Setup a `.pgpass` file to simplify the connections !

```
cat > ~/.pgpass << EOL
*:*:boutique:paul:CHANGE ME
*:*:boutique:pierre:CHANGE ME
*:*:boutique:jack:CHANGE ME
EOL
chmod 0600 ~/.pgpass
```

The Sample database

We will work on a database called “boutique”:

```
CREATE DATABASE boutique OWNER paul;
```

We need to activate the `anon` library inside that database:

```
ALTER DATABASE boutique
SET session_preload_libraries = 'anon';
```

1- Static Masking

Static Masking is the simplest way to hide personal information! This idea is simply to destroy the original data or replace it with an artificial one.

Requirements

Please check out the intro of this tutorial if you haven't read it yet

The story

Over the years, Paul has collected data about his customers and their purchases in a simple database. He recently installed a brand new sales application and the old database is now obsolete. He wants to save it and he would like to remove all personal information before archiving it.

How it works

Learning Objective

In this section, we will learn:

- How to write simple masking rules
- The advantage and limitations of static masking
- The concept of “Singling Out” a person

The “customer” table

```
DROP TABLE IF EXISTS customer CASCADE;
```

```
DROP TABLE IF EXISTS payout CASCADE;
```

```
CREATE TABLE customer (  
    id SERIAL PRIMARY KEY,  
    firstname TEXT,  
    lastname TEXT,  
    phone TEXT,  
    birth DATE,  
    postcode TEXT  
);
```

Insert a few persons:

```
INSERT INTO customer  
VALUES  
(107, 'Sarah', 'Conor', '060-911-0911', '1965-10-10', '90016'),  
(258, 'Luke', 'Skywalker', NULL, '1951-09-25', '90120'),  
(341, 'Don', 'Draper', '347-515-3423', '1926-06-01', '04520')
```

```
;
SELECT * FROM customer;
```

The “payout” table

Sales are tracked in a simple table:

```
CREATE TABLE payout (
    id SERIAL PRIMARY KEY,
    fk_customer_id INT REFERENCES customer(id),
    order_date DATE,
    payment_date DATE,
    amount INT
);
```

Let’s add some orders:

```
INSERT INTO payout
VALUES
(1,107,'2021-10-01','2021-10-01', '7'),
(2,258,'2021-10-02','2021-10-03', '20'),
(3,341,'2021-10-02','2021-10-02', '543'),
(4,258,'2021-10-05','2021-10-05', '12'),
(5,258,'2021-10-06','2021-10-06', '92')
;
```

Activate the extension

```
CREATE EXTENSION IF NOT EXISTS anon;
```

Declare the masking rules

Paul wants to hide the last name and the phone numbers of his clients. He will use the `dummy_last_name()` and `partial()` functions for that:

```
SECURITY LABEL FOR anon ON COLUMN customer.lastname
IS 'MASKED WITH FUNCTION anon.dummy_last_name()';

SECURITY LABEL FOR anon ON COLUMN customer.phone
IS 'MASKED WITH FUNCTION anon.partial(phone,2,$$X-XXX-XX$$,2)';
```

Apply the rules permanently

```
SELECT anon.anonymize_table('customer');

SELECT id, firstname, lastname, phone
FROM customer;
```

This is called **Static Masking** because the **real data has been permanently replaced**. We'll see later how we can use dynamic anonymization or anonymous exports.

Exercises

E101 - Mask the client's first names

Declare a new masking rule and run the static anonymization function again.

E102 - Hide the last 3 digits of the postcode

Paul realizes that the postcode gives a clear indication of where his customers live. However he would like to have statistics based on their postcode area.

Add a new masking rule to replace the last 3 digits by 'x'.

E103 - Count how many clients live in each postcode area?

Aggregate the customers based on their anonymized postcode.

E104 - Keep only the year of each birth date

Paul wants age-based statistic. But he also wants to hide the real birth date of the customers.

Replace all the birth dates by January 1st, while keeping the real year.

You can use the `make_date` or `date_trunc` functions !

See <https://www.postgresql.org/docs/current/functions-datetime.html#FUNCTIONS-DATETIME-TABLE>

E105 - Singling out a customer

Even if the “customer” is properly anonymized, we can still isolate a given individual based on data stored outside of the table. For instance, we can identify the best client of Paul's boutique with a query like this:

```
WITH best_client AS (  
    SELECT SUM(amount), fk_customer_id  
    FROM payout  
    GROUP BY fk_customer_id  
    ORDER BY 1 DESC  
    LIMIT 1  
)  
SELECT c.*  
FROM customer c  
JOIN best_client b ON (c.id = b.fk_customer_id)
```

This is called **Singling Out a person**.

We need to anonymize even further by removing the link between a person and its company. In the `payout` table, this link is materialized by a foreign key on the field `fk_company_id`. However we can't remove values from this column or insert fake identifiers because it would break the foreign key constraint.

How can we separate the customers from their payouts while respecting the integrity of the data?

Find a function that will shuffle the column `fk_company_id` of the `payout` table

Check out the shuffling section of the documentation.

Solutions

S101

```
SECURITY LABEL FOR anon ON COLUMN customer.firstname
IS 'MASKED WITH FUNCTION anon.dummy_first_name()';
```

```
SELECT anon.anonymize_table('customer');
```

```
SELECT id, firstname, lastname
FROM customer;
```

S102

```
SECURITY LABEL FOR anon ON COLUMN customer.postcode
IS 'MASKED WITH FUNCTION anon.partial(postcode,2,$$xxx$$,0)';
```

```
SELECT anon.anonymize_table('customer');
```

```
SELECT id, firstname, lastname, postcode
FROM customer;
```

S103

```
SELECT postcode, COUNT(id)
FROM customer
GROUP BY postcode;
```

S104

```
SECURITY LABEL FOR anon ON FUNCTION pg_catalog.date_trunc(text,interval)
IS 'TRUSTED';
```

```
SECURITY LABEL FOR anon ON COLUMN customer.birth
```

```

IS $$ MASKED WITH FUNCTION pg_catalog.date_trunc('year',birth) $$;

SELECT anon.anonymize_table('customer');

SELECT id, firstname, lastname, birth
FROM customer;

```

S105

Let's mix up the values of the `fk_customer_id`:

```
SELECT anon.shuffle_column('payout','fk_customer_id','id');
```

Now let's try to single out the best client again :

```

WITH best_client AS (
    SELECT SUM(amount), fk_customer_id
    FROM payout
    GROUP BY fk_customer_id
    ORDER BY 1 DESC
    LIMIT 1
)
SELECT c.*
FROM customer c
JOIN best_client b ON (c.id = b.fk_customer_id);

```

WARNING

Note that the link between a `customer` and its `payout` is now completely false. For instance, if a customer A had 2 payouts. One of these payout may be linked to a customer B, while the second one is linked to a customer C.

In other words, this shuffling method with respect the foreign key constraint (aka the referential integrity) but it will break the data integrity. For some use case, this may be a problem.

In this case, Pierre will not be able to produce a BI report with the shuffle data, because the links between the customers and their payments are fake. — title: runbooks/2-dynamic_masking draft: false toc: true —

2- Dynamic Masking

With Dynamic Masking, the database owner can hide personal data for some users, while other users are still allowed to read and write the authentic data.

Requirements

Please check out the intro of this tutorial if you haven't read it yet

The Story

Paul has 2 employees:

- Jack is operating the new sales application, he needs access to the real data. He is what the GDPR would call a **"data processor"**.
- Pierre is a data analyst who runs statistic queries on the database. He should not have access to any personal data.

How it works

Objectives

In this section, we will learn:

- How to write simple masking rules
- The advantage and limitations of dynamic masking
- The concept of "Linkability" of a person

The company table

```
DROP TABLE IF EXISTS supplier CASCADE;
```

```
DROP TABLE IF EXISTS company CASCADE;
```

```
CREATE TABLE company (  
    id SERIAL PRIMARY KEY,  
    name TEXT,  
    vat_id TEXT UNIQUE  
);  
  
INSERT INTO company  
VALUES  
(952,'Shadrach', 'FR62684255667'),  
(194,E'Johnny\'s Shoe Store','CHE670945644'),  
(346,'Capitol Records','GB663829617823')  
;  
  
SELECT * FROM company;
```

The supplier table

```
CREATE TABLE supplier (  
    id SERIAL PRIMARY KEY,  
    fk_company_id INT REFERENCES company(id),  
    contact TEXT,  
    phone TEXT,  
    job_title TEXT  
);
```



```

INSERT INTO supplier
VALUES
(299,194,'Johnny Ryall','597-500-569','CEO'),
(157,346,'George Clinton', '131-002-530','Sales manager')
;

SELECT * FROM supplier;

```

Activate the extension

```

ALTER DATABASE boutique
    SET session_preload_libraries TO 'anon';

CREATE EXTENSION IF NOT EXISTS anon;

SELECT anon.init();

```

Dynamic Masking

Activate the masking engine

```

ALTER DATABASE boutique
    SET anon.transparent_dynamic_masking TO true;

```

Masking a role

```

SECURITY LABEL FOR anon ON ROLE pierre IS 'MASKED';

GRANT pg_read_all_data to pierre;

```

Now connect as Pierre and try to read the supplier table:

```
SELECT * FROM supplier;
```

For the moment, there is no masking rule so Pierre can see the original data in each table.

Masking the supplier names

Connect as Paul and define a masking rule on the supplier table:

```

SECURITY LABEL FOR anon ON COLUMN supplier.contact
    IS 'MASKED WITH VALUE $$CONFIDENTIAL$$';

```

Now connect as Pierre and try to read the supplier table again:

```
SELECT * FROM supplier;
```

Now connect as Jack and try to read the real data:

```
SELECT * FROM supplier;
```

Exercises

E201 - Guess who is the CEO of “Johnny’s Shoe Store”

Masking the supplier contact is clearly not enough to provide anonymity.

Connect as Pierre and write a simple SQL query that joins the supplier and the company tables. See how that could reidentify some suppliers based on their job and their company.

With this request we managed to link a person to a company and we know it’s job title. Since company names and job positions are available in many public datasets: a simple search on Linkedin or Google would give us the real names of many of the employees of these companies...

This is called **Linkability**: the ability to connect multiple records concerning the same data subject.

E202 - Anonymize the companies

We need to anonymize the `company` table, too. Even if they don’t contain personal information, some fields can be used to **infer** the identity of their employees...

Connect as Paul and write 2 masking rules (security labels) for the company table.

- The first one will replace the `name` field with a fake name.
- The second rule will replace the `vat_id` with a random sequence of 10 characters

Go to the documentation and look at the faking functions and the random functions !

Connect as Pierre and check that he cannot view the real company info.

Connect as Jack and check that he can view the real values.

E203 - Pseudonymize the company name

Because of dynamic masking, the fake values will be different every time Pierre tries to read the table.

Pierre would like to have always the same fake values for a given company.

This is called pseudonymization.

Connect as Paul and write a new masking rule over the `vat_id` field by generating a hash of 10 characters using the `anon.digest()` function.

Write a new masking rule over the name field by using a pseudonymizing function.

Solutions

S201

```
SELECT s.id, s.contact, s.job_title, c.name
FROM supplier s
JOIN company c ON s.fk_company_id = c.id;
```

S202

```
SECURITY LABEL FOR anon ON COLUMN company.name
IS 'MASKED WITH FUNCTION anon.dummy_company_name()';
```

```
SECURITY LABEL FOR anon ON COLUMN company.vat_id
IS 'MASKED WITH FUNCTION anon.random_string(10)';
```

Now connect as Pierre and read the table again:

```
SELECT * FROM company;
```

Pierre will see different “fake data” every time he reads the table:

```
SELECT * FROM company;
```

Jack still sees the real data

```
SELECT * FROM company;
```

S203

```
SECURITY LABEL FOR anon ON COLUMN company.vat_id
IS $$ MASKED WITH FUNCTION anon.left(anon.digest(vat_id, 'xxx', 'md5'),10) $$;
```

```
SECURITY LABEL FOR anon ON COLUMN company.name
IS 'MASKED WITH FUNCTION anon.pseudo_company(id)';
```

Connect as Pierre and read the table multiple times:

```
SELECT * FROM company;
```

```
SELECT * FROM company;
```

Now the fake company name is always the same.

title: runbooks/3-anonymous__dumps draft: false toc: true —

3- Anonymous Dumps

In many situation, what we want is basically to export the anonymized data into another database (for testing or to produce statistics). We will simply use `pg_dump` for that !

The Story

Paul has a website and a comment section where customers can express their views.

He hired a web agency to develop a new design for his website. The agency asked for a SQL export (dump) of the current website database. Paul wants to **clean** the database export and remove any personal information contained in the comment section.

How it works

Learning Objective

- Extract the anonymized data from the database
- Write a custom masking function to handle a JSON field.

Load the data

```
DROP TABLE IF EXISTS website_comment CASCADE;

CREATE TABLE website_comment (
    id SERIAL PRIMARY KEY,
    message JSONB
);

INSERT INTO website_comment
VALUES
(1, json_build_object(
    'meta', json_build_object(
        'name', 'Lee Perry',
        'ip_addr', '40.87.29.113'),
    'content', 'Hello Nasty!')),
(2, json_build_object(
    'meta', json_build_object(
        'name', '',
        'email', 'biz@bizmarkie.com'),
    'content', 'Great Shop')),
(3, json_build_object(
    'meta', json_build_object(
        'name', 'Jimmy'),
    'content', 'Hi ! This is me, Jimmy James'));
```

Check the content of the website comments:

```
SELECT
  message->'meta'->'name' AS name,
  message->'content' AS content
FROM website_comment
ORDER BY id ASC;
```

Activate the extension

```
CREATE EXTENSION IF NOT EXISTS anon;
```

Masking a JSON column

The `comment` field is filled with personal information and the fact the field does not have a standard schema makes our tasks harder.

In general, unstructured data are difficult to mask.

As we can see, web visitors can write any kind of information in the comment section. Our best option is to remove this key entirely because there's no way to extract personal data properly.

We can *clean* the comment column simply by removing the `content` key in the `message` column !

```
SELECT message - ARRAY['content'] AS message_without_content
FROM website_comment
WHERE id=1;
```

First let's create a dedicated schema and declare it as trusted. This means the `anon` extension will accept the functions located in this schema as valid masking functions. Only a superuser should be able to add functions in this schema.

```
CREATE SCHEMA IF NOT EXISTS my_masks;
```

```
SECURITY LABEL FOR anon ON SCHEMA my_masks IS 'TRUSTED';
```

Now we can write a function that remove the message content:

```
CREATE OR REPLACE FUNCTION my_masks.remove_content(j JSONB)
RETURNS JSONB
AS $func$
  SELECT j - ARRAY['content']
$func$
LANGUAGE SQL
```

;

Let's try it!

```
SELECT my_masks.remove_content(message)
FROM website_comment;
```

And now we can use it in a masking rule:

```
SECURITY LABEL FOR anon ON COLUMN website_comment.message
IS 'MASKED WITH FUNCTION my_masks.remove_content(message)';
```

Then we need to create a dedicated role to export the masked data. We will call this role `anon_dumper` (the name does not matter) and declare that this role is masked.

```
CREATE ROLE anon_dumper LOGIN PASSWORD 'CHANGEME';
```

```
ALTER ROLE anon_dumper SET anon.transparent_dynamic_masking TO TRUE;
```

```
SECURITY LABEL FOR anon ON ROLE anon_dumper IS 'MASKED';
```

```
GRANT pg_read_all_data TO anon_dumper;
```

For convenience, add a new entry in the `.pgpass` file.

```
cat > ~/.pgpass << EOL
*:*:boutique:anon_dumper:CHANGEME
EOL
```

Finally we can export an **anonymous dump** of the table with `pg_dump`:

```
export PATH=$PATH:$(pg_config --bindir)
export PGHOST=localhost
pg_dump -U anon_dumper boutique --table=website_comment > /tmp/dump.sql
```

Exercises

E301 - Dump the anonymized data into a new database

Create a database named `boutique_anon` and transfer the entire database into it.

E302 - Remove the email address

Replace the `remove_content` function with a better one called `remove_content_and_ip` that will nullify the `email` key.

HINT: you can use `jsonb_set(message, '{meta, email}', '{}')` to remove the email value.

E303 - Pseudonymize the IP address

Pierre plans to extract general information from the metadata. For instance, he wants to calculate the number of unique visitors based on the different IP addresses.

But an IP address is an **indirect identifier**, so Paul needs to anonymize this field while maintaining the fact that some values appear multiple times.

HINT: First you can create a new `meta` object using `jsonb_build_object()` and then use function `jsonb_set` replace the `meta` key

Solutions

S301

```
export PATH=$PATH:$(pg_config --bindir)
export PGHOST=localhost
dropdb -U paul --if-exists boutique_anon
createdb -U paul boutique_anon --owner paul
pg_dump -U anon_dumper boutique | psql -U paul --quiet boutique_anon
export PGHOST=localhost
psql -U paul boutique_anon -c 'SELECT COUNT(*) FROM company'
```

S302

```
CREATE OR REPLACE FUNCTION my_masks.remove_content_and_ip(message JSONB)
RETURNS JSONB
VOLATILE
LANGUAGE SQL
AS $func$
SELECT
    jsonb_set(message, '{meta, email}', '{}')
    - ARRAY['content'];
$func$;

SELECT my_masks.remove_content_and_ip(message)
FROM website_comment;

SECURITY LABEL FOR anon ON COLUMN website_comment.message
IS 'MASKED WITH FUNCTION my_masks.remove_content_and_ip(message)';
```

S303

```
CREATE OR REPLACE FUNCTION my_masks.clean_comment(message JSONB)
RETURNS JSONB
VOLATILE
LANGUAGE SQL
AS $func$
```

```

SELECT
  jsonb_set(
    message,
    ARRAY['meta'],
    jsonb_build_object(
      'name',anon.fake_last_name(),
      'ip_address', md5((message->'meta'->'ip_addr')::TEXT),
      'email', NULL
    )
  ) - ARRAY['content'];
$func$;

SELECT my_masks.clean_comment(message)
FROM website_comment;

SECURITY LABEL FOR anon ON COLUMN website_comment.message
IS 'MASKED WITH FUNCTION my_masks.clean_comment(message)';

```

4- Generalization

The main idea of generalization is to **blur** the original data. For example, instead of saying **Mister X was born on July 25, 1989**, we can say **Mister X was born in the 80's**. The information is still true, but it is less precise and it can't be used to reidentify the subject.

The Story

Paul hired dozens of employees over the years. He kept a record of their hair color, size and medical condition.

Paul wants to extract weird stats from these details. He provides generalized views to Pierre.

How it works

Learning Objective

In this section, we will learn:

- The difference between masking and generalization
- The concept of K-anonymity

The employee table

```
DROP TABLE IF EXISTS employee CASCADE;
```

```
CREATE TABLE employee (
  id INT PRIMARY KEY,
```



```

full_name TEXT,
first_day DATE, last_day DATE,
height INT,
hair TEXT, eyes TEXT, size TEXT,
asthma BOOLEAN,
CHECK(hair = ANY(ARRAY['bald','blond','dark','red'])),
CHECK(eyes = ANY(ARRAY['blue','green','brown'])) ,
CHECK(size = ANY(ARRAY['S','M','L','XL','XXL']))
);

```

This is awkward and illegal.

Loading the data:

```

INSERT INTO employee
VALUES
(1,'Luna Dickens','2018-07-22','2018-12-15',180,'blond','blue','L',True),
(2,'Paul Wolf','2020-01-15',NULL,177,'bald','brown','M',False),
(3,'Rowan Hoeger','2018-12-01','2018-12-15',202,'dark','blue','XXL',True)
;

SELECT count(*) FROM employee;

SELECT full_name,first_day, hair, size, asthma
FROM employee
LIMIT 3;

```

Data suppression

Paul wants to find if there's a correlation between asthma and the eyes color.

He provides the following view to Pierre.

```

DROP MATERIALIZED VIEW IF EXISTS v_asthma_eyes;

CREATE MATERIALIZED VIEW v_asthma_eyes AS
SELECT eyes, asthma
FROM employee;

SELECT *
FROM v_asthma_eyes
LIMIT 3;

```

Pierre can now write queries over this view.

```

SELECT
  eyes,
  100*COUNT(1) FILTER (WHERE asthma) / COUNT(1) AS asthma_rate
FROM v_asthma_eyes
GROUP BY eyes;

```

Pierre just proved that asthma is caused by blue eyes ;-)

K-Anonymity

The `asthma` and `eyes` columns are considered as indirect identifiers.

Indirect personal identifiers (or “quasi-identifiers”) are pieces of information that, when combined with other data can identify an individual. Examples of indirect identifiers include: Date of birth, Gender, Zip code, etc.

With PostgreSQL Anonymizer, we can declare that a column is an indirect identifiers, like this:

```
SECURITY LABEL FOR k_anonymity
ON COLUMN v_asthma_eyes.eyes
IS 'INDIRECT IDENTIFIER';
```

```
SECURITY LABEL FOR k_anonymity
ON COLUMN v_asthma_eyes.asthma
IS 'INDIRECT IDENTIFIER';
```

```
SELECT anon.k_anonymity('v_asthma_eyes');
```

The `v_asthma_eyes` has ‘2-anonymity’. This means that each quasi-identifier combination (the ‘eyes-asthma’ tuples) occurs in at least 2 records for a dataset.

In other words, it means that each individual in the view cannot be distinguished from at least 1 (k-1) other individual.

Range and Generalization functions

Now let’s add another view over the `employee` table.

We will generalize the dates of to keep only the month and year.

```
DROP MATERIALIZED VIEW IF EXISTS v_staff_per_month;
CREATE MATERIALIZED VIEW v_staff_per_month AS
SELECT
    anon.generalize_daterange(first_day,'month') AS first_day,
    anon.generalize_daterange(last_day,'month') AS last_day
FROM employee;

SELECT *
FROM v_staff_per_month
LIMIT 3;
```

Pierre can write a query to find how many employees were hired in november 2021.

```
SELECT COUNT(1)
    FILTER (
```

```

        WHERE make_date(2019,11,1)
        BETWEEN lower(first_day)
        AND COALESCE(upper(last_day),now())
    )
FROM v_staff_per_month;

```

Declaring the indirect identifiers

Now let's check the k-anonymity of this view by declaring which columns are indirect identifiers :

```

SECURITY LABEL FOR k_anonymity
ON COLUMN v_staff_per_month.first_day
IS 'INDIRECT IDENTIFIER';

```

```

SECURITY LABEL FOR k_anonymity
ON COLUMN v_staff_per_month.last_day
IS 'INDIRECT IDENTIFIER';

```

```

SELECT anon.k_anonymity('v_staff_per_month');

```

In this case, the k factor is 1 which means that there is at least one unique individual who be identified directly by his/her first and last dates.

Exercises

E401 - Simplify v_staff_per_month and decrease granularity

Generalizing dates per month is not enough. Write another view called v_staff_per_year that will generalize dates per year.

Also simplify the view by using a range of int to store the years instead of a date range.

E402 - Staff progression over the years

How many people worked for Paul for each year between 2018 and 2021?

E403 - Reaching 2-anonymity for the v_staff_per_year view

What is the k-anonymity of v_staff_per_month_years?

Solutions

S401

```

DROP MATERIALIZED VIEW IF EXISTS v_staff_per_year;

```

```

CREATE MATERIALIZED VIEW v_staff_per_year AS

```

```

SELECT
    int4range(
        extract(year from first_day)::INT,
        extract(year from last_day)::INT,
        '[]'
    ) AS period
FROM employee;
' [] ' will include the upper bound

```

```

SELECT *
FROM v_staff_per_year
LIMIT 3;

```

S402

```

SELECT
    year,
    COUNT(1) FILTER (
        WHERE year <@ period
    )
FROM
    generate_series(2018,2021) year,
    v_staff_per_year
GROUP BY year
ORDER BY year ASC;

```

S403

```

SECURITY LABEL FOR k_anonymity
ON COLUMN v_staff_per_year.period
IS 'INDIRECT IDENTIFIER';

SELECT anon.k_anonymity('v_staff_per_year');

```

Conclusion

Clean up !

```

DROP DATABASE IF EXISTS boutique;
REASSIGN OWNED BY jack TO postgres;

REASSIGN OWNED BY paul TO postgres;

```

```
REASSIGN OWNED BY pierre TO postgres;  
  
DROP ROLE IF EXISTS jack;  
DROP ROLE IF EXISTS paul;  
DROP ROLE IF EXISTS pierre;  
DROP ROLE IF EXISTS dump_anon;
```

Also...

Other projects you may like

- `pg_sample` : extract a small dataset from a larger PostgreSQL database

Help Wanted!

This is a free and open project!

labs.dalibo.com/postgresql_anonymizer

Please send us feedback on how you use it, how it fits your needs (or not), etc.

— title: sampling draft: false toc: true —

Sampling

Principle

The GDPR introduces the concept of “[data minimisation]” which means that the collection of personal information must be limited to what is directly relevant and necessary to accomplish a specified purpose.

If you’re writing an anonymization policy for a dataset, chances are that you don’t need to anonymize **the entire database**. In most cases, extract a subset of the table is sufficient. For example, if you want to export an anonymous dumps of the data for testing purpose in a CI workflow, extracting and masking only 10% of the database may be enough.

Furthermore, anonymizing a smaller portion (i.e a “sample”) of the dataset will be way faster.

With PostgreSQL Anonymizer, you can use 2 different sampling methods :

- Sampling with TABLESAMPLE
- Sampling with RLS Policies

You can also Truncate Tables for the masked users !

Sampling with TABLESAMPLE

Let's say you have a huge amounts of http logs stored in a table. You want to remove the ip addresses and extract only 10% of the table:

```
CREATE TABLE http_logs (  
    id integer NOT NULL,  
    date_opened DATE,  
    ip_address INET,  
    url TEXT  
);  
  
SECURITY LABEL FOR anon ON COLUMN http_logs.ip_address  
IS 'MASKED WITH VALUE NULL';  
  
SECURITY LABEL FOR anon ON TABLE http_logs  
IS 'TABLESAMPLE BERNOULLI(10)';
```

Now you can either do static masking, dynamic masking or an anonymous dumps. The mask data will represent a 10% portion of the real data.

The syntax is exactly the same as the TABLESAMPLE clause which can be placed at the end of a SELECT statement.

You can also defined a sampling ratio at the database-level and it will be applied to all the tables that don't have their own TABLESAMPLE rule.

```
SECURITY LABEL FOR anon ON DATABASE app  
IS 'TABLESAMPLE SYSTEM(33)';
```

Sampling with RLS policies

Another approach for sampling is to use Row Level Security Policies, also known as RLS or Row Security Policies.

Let's use the same example as a above, this time we want to define a limit so the mask users can only see the logs of the last 6 months.

```
CREATE TABLE http_logs (  
    id integer NOT NULL,  
    date_opened DATE,  
    ip_address INET,  
    url TEXT  
);  
  
SECURITY LABEL FOR anon ON COLUMN http_logs.ip_address  
IS 'MASKED WITH VALUE NULL';  
  
ALTER TABLE http_logs ENABLE ROW LEVEL SECURITY;
```

```
CREATE POLICY http_logs_sampling_for_masked_users
ON http_logs
USING (
    NOT anon.hasmask(CURRENT_USER::REGROLE)
    OR date_opened >= now() - '6 months'::INTERVAL
);
```

This RLS policy is based on 2 conditions:

- if the current user is not masked, the first condition is true and he/she can read all the lines
- if the current user is masked, the first condition is false and he/she can only read the lines that satisfy the second condition

Sampling with RLS policies is more powerful than the TABLESAMPLE method, however maintaining a set of RLS policies is known to be difficult in the long run. The benefits from Postgres RLS can dissipate when the size of the organization, the amount of data collected, and the number of restrictions grow in size and complexity.

Maintaining Referential Integrity

!!! note

The sampling methods described above ****MAY FAIL**** if you have foreign keys pointing at the table you want to sample.

Extracting a subset of a database while maintaining referential integrity is tricky and it is not supported by this extension.

If you really need to keep referential integrity in an anonymized dataset, you need to do it in 2 steps:

- First, extract a sample with `pg_sample`
- Second, anonymize that sample

There may be other sampling tools for PostgreSQL but `pg_sample` is probably the best one.

Truncate Tables for the masked users

In certain situations, you can also erase completely a table instead of just masking some of the columns.

For instance, let's say that masked users should not see anything in the `http_logs` table below

```
CREATE TABLE http_logs (
    id integer NOT NULL,
    date_opened DATE,
```

```

    ip_address INET,
    url TEXT
);

```

Using the TABLESAMPLE clause, you can simply set the sampling ratio to 0

```
SECURITY LABEL FOR anon ON TABLE http_logs IS ' TABLESAMPLE SYSTEM (0)';
```

Now the table will be erased for the masked users !

```
SET ROLE the_database_owner;
```

```
SELECT count(*) FROM http_logs;
count
```

```
-----
156706
```

```
SET ROLE a_masked_user;
```

```
SELECT count(*) FROM http_logs;
count
```

```
-----
0
```

Security

Permissions

Here's an overview of what users can do depending on the privileges they have:

Action	Superuser	Owner	Masked Role
Create the extension	Yes		
Drop the extension	Yes		
Init the extension	Yes		
Reset the extension	Yes		
Configure the extension	Yes		
Put a mask upon a role	Yes		
Start dynamic masking	Yes		
Stop dynamic masking	Yes		
Create a table	Yes	Yes	
Declare a masking rule	Yes	Yes	
Insert, delete, update a row	Yes	Yes	
Static Masking	Yes	Yes	
Select the real data	Yes	Yes	
Regular Dump	Yes	Yes	
Anonymous Dump	Yes	Yes	
Use the masking functions	Yes	Yes	Yes

Action	Superuser	Owner	Masked Role
Select the masked data	Yes	Yes	Yes
View the masking rules	Yes	Yes	Yes

Limit masking filters only to trusted schemas

By default, the database owner can only write masking rules with functions that are located in the trusted schemas which are controlled by the superusers.

Out of the box, only the `anon` schema is declared as trusted. This means that by default the functions from the `pg_catalog` cannot be used in masking rules.

For more details, read the Using `pg_catalog` functions section.

Security context of the functions

Most of the functions of this extension are declared with the `SECURITY INVOKER` tag. This means that these functions are executed with the privileges of the user that calls them. This is an important restriction.

This extension contains another few functions declared with the tag `SECURITY DEFINER`. — title: selective_masking draft: false toc: true —

Selective Masking (BETA)

Principle

In some context, it is relevant to mask only certain row of a table.

The selective masking syntax allows to filter based on a condition.

This feature is currently under heavy development. This implementation of Selective Masking is provided for testing purpose only. Major breaking changes may be introduced at any time and we may even remove this feature entirely if we feel it does not reach our standard of quality and stability

Example

Imagine a `users` table containing all the users of an application.

```
SELECT * FROM users;
 id | login | password | admin
----+-----+-----+-----
  1 | alice | adfsqfcksqhdqijsdizjdfiqqlq<iqq | f
  2 | bob   | a_very_bad_password | t
  3 | carol | 1234 | f
```

We want to anonymize the login and password columns with the 2 masking rules below:

```
SECURITY LABEL FOR anon ON COLUMN users.login IS 'MASKED WITH VALUE NULL';
SECURITY LABEL FOR anon ON COLUMN users.password IS 'MASKED WITH VALUE NULL';
```

We may want to anonymize most of the users in the table while keeping the real data of the administrators so that they can still use the application in anonymized environments.

We can add a rule on table to filter out all the admin users:

```
SECURITY LABEL FOR anon ON TABLE users IS 'MASKED WHEN admin IS FALSE';
```

Now let's anonymize the table:

```
SELECT anon.anonymize_table('users');
```

```
SELECT * FROM users;
```

id	login	password	admin
1			f
2	bob	a_very_bad_password	t
3			f

NOTE: The Selective Masking is incompatible with Sampling.

Sampling: Sampling.md

title: static_masking draft: false toc: true —

Permanently remove sensitive data

Sometimes, it is useful to transform directly the original dataset. You can do that with different methods:

- Applying masking rules
- Shuffling a column
- Adding noise to a column

These methods will destroy the original data. Use with care.

PostgreSQL Static Masking

Applying masking rules

You can permanently apply the masking rules of a database with `anon.anonymize_database()`.

Let's use a basic example :

```

CREATE TABLE customer(
    id SERIAL,
    full_name TEXT,
    birth DATE,
    employer TEXT,
    zipcode TEXT,
    fk_shop INTEGER
);

INSERT INTO customer
VALUES
(911,'Chuck Norris','1940-03-10','Texas Rangers', '75001',12),
(312,'David Hasselhoff','1952-07-17','Baywatch', '90001',423)
;

```

```
SELECT * FROM customer;
```

id	full_name	birth	employer	zipcode	fk_shop
911	Chuck Norris	1940-03-10	Texas Rangers	75001	12
112	David Hasselhoff	1952-07-17	Baywatch	90001	423

Step 1: Load the extension :

```

CREATE EXTENSION IF NOT EXISTS anon CASCADE;
SELECT anon.init();

```

Step 2: Declare the masking rules

```

SECURITY LABEL FOR anon ON COLUMN customer.full_name
IS 'MASKED WITH FUNCTION anon.dummy_name()';

```

```

SECURITY LABEL FOR anon ON COLUMN customer.employer
IS 'MASKED WITH FUNCTION anon.dummy_company_name()';

```

```

SECURITY LABEL FOR anon ON COLUMN customer.zipcode
IS 'MASKED WITH FUNCTION anon.random_zip()';

```

Step 3: Replace authentic data in the masked columns :

```
SELECT anon.anonymize_database();
```

```
SELECT * FROM customer;
```

id	full_name	birth	employer	zipcode	fk_shop
911	jesse Kosel	1940-03-10	Marigold Properties LLC	62172	12
312	leolin Bose	1952-07-17	Inventure Inc	20026	423

You can also use `anonymize_table()` and `anonymize_column()` to remove data from a subset of the database :

```
SELECT anon.anonymize_table('customer');
SELECT anon.anonymize_column('customer','zipcode');
```

WARNING : Static masking is a slow process. The principle of static masking is to update all lines of all tables containing at least one masked column. This basically means that PostgreSQL will rewrite all the data on disk. Depending on the database size, the hardware and the instance config, it may be faster to export the anonymized data (See Anonymous Dumps) and reload it into the database.

Disabling Static Masking

You may be scared that someone could accidentally run `anon.anonymize_database()` and wipe out all the data.

If so, you can disable this feature globally with:

```
ALTER SYSTEM SET anon.static_masking TO off
```

Or disable it for a single user :

```
ALTER ROLE bob SET anon.static_masking TO off;
```

Or disable it everyone except one user

```
ALTER DATABASE mydb SET anon.static_masking = FALSE;
ALTER ROLE daniel SET anon.static_masking = TRUE;
```

Static Masking and Multiple Masking Policies

When using multiple masking policies, you can simply add the policy name at the end of the static masking functions.

For instance, if you defined a masking policy named “rgpd”, you can apply it with

```
SELECT anon.anonymize_table('customer','rgpd');
SELECT anon.anonymize_column('customer','zipcode','rgpd');
```

By default, there’s a single masking policy named “anon”.

Shuffling

Shuffling mixes values within the same columns.

- `anon.shuffle_column(shuffle_table, shuffle_column, primary_key)` will rearrange all values in a given column. You need to provide a primary key of the table.

This is useful for foreign keys because referential integrity will be kept.

IMPORTANT: `shuffle_column()` is not a masking function because it works “vertically” : it will modify all the values of a column at once.

Adding noise to a column

There are also some functions that can add noise on an entire column:

- `anon.add_noise_on_numeric_column(table, column, ratio)` if `ratio = 0.33`, all values of the column will be randomly shifted with a ratio of $\pm 33\%$
- `anon.add_noise_on_datetime_column(table, column, interval)` if `interval = '2 days'`, all values of the column will be randomly shifted by ± 2 days

IMPORTANT : These noise functions are vulnerable to a form of repeat attack. See `demo/noise_reduction_attack.sql` for more details. — title: tutorials/0-intro draft: false toc: true —

Welcome to Paul’s Boutique !

This is a 4 hours workshop that demonstrates various anonymization techniques using the PostgreSQL Anonymizer extension.

The Story

Paul’s boutique

Paul’s boutique has a lot of customers. Paul asks his friend Pierre, a Data Scientist, to make some statistics about his clients : average age, etc...

Pierre wants a direct access to the database in order to write SQL queries.

Jack is an employee of Paul. He’s in charge of relationship with the various suppliers of the shop.

Paul respects his suppliers privacy. He needs to hide the personal information to Pierre, but Jack needs read and write access the real data.

Objectives

Using the simple example above, we will learn:

- How to write masking rules
- The difference between static and dynamic masking
- Implementing advanced masking techniques

About GDPR

This tutorial **does not** go into the details of the GDPR act and the general concepts of anonymization.

For more information about it, please refer to the talk below:

- Anonymisation, Au-delà du RGPD (Video / French)
- Anonymization, Beyond GDPR (PDF / english)

Requirements

In order to make this workshop, you will need:

- A Linux VM (preferably **Debian 12 bookworm** or **Ubuntu 24.04**)
- A PostgreSQL instance (preferably **PostgreSQL 17**)
- The PostgreSQL Anonymizer (anon) extension, installed and initialized by a superuser
- A database named “boutique” owned by a **superuser** called “paul”
- A role “pierre” and a role “jack”, both allowed to connect to the database “boutique”

Check out the **INSTALL** section to learn how to install the PostgreSQL Anonymizer extension:

!!! tip

A simple way to deploy a workshop environment is to install [Docker Desktop] and download the image below:

```
ANON_IMG=registry.gitlab.com/dalibo/postgresql_anonymizer:stable
docker pull $ANON_IMG
```

And you can then launch it with:

```
docker run --name anon_tuto --detach -e POSTGRES_PASSWORD=x $ANON_IMG
docker exec -it anon_tuto psql -U postgres
```

!!! tip Check out the **INSTALL** section in the documentation to learn how to install the extension in your PostgreSQL instance.

The Roles

We will with 3 different users:

```
CREATE ROLE paul LOGIN SUPERUSER PASSWORD 'CHANGEME';
```

```
CREATE ROLE pierre LOGIN PASSWORD 'CHANGEME';
```

```
CREATE ROLE jack LOGIN PASSWORD 'CHANGEME';
```

```
GRANT pg_read_all_data TO jack;
```

```
GRANT pg_write_all_data TO jack;
```

Unless stated otherwise, all commands must be executed with the role **paul**.

!!! Tip Setup a **.pgpass** file to simplify the connections !

```
cat > ~/.pgpass << EOL
*:*:boutique:paul:CHANGE ME
*:*:boutique:pierre:CHANGE ME
*:*:boutique:jack:CHANGE ME
EOL
chmod 0600 ~/.pgpass
```

The Sample database

We will work on a database called “boutique”:

```
CREATE DATABASE boutique OWNER paul;
```

We need to activate the **anon** library inside that database:

```
ALTER DATABASE boutique
SET session_preload_libraries = 'anon';
```

1- Static Masking

Static Masking is the simplest way to hide personal information! This idea is simply to destroy the original data or replace it with an artificial one.

Requirements

Please check out the intro of this tutorial if you haven’t read it yet

The story

Over the years, Paul has collected data about his customers and their purchases in a simple database. He recently installed a brand new sales application and the old database is now obsolete. He wants to save it and he would like to remove all personal information before archiving it.

How it works

Learning Objective

In this section, we will learn:

- How to write simple masking rules
- The advantage and limitations of static masking
- The concept of “Singling Out” a person

The “customer” table

```
DROP TABLE IF EXISTS customer CASCADE;
```

```
DROP TABLE IF EXISTS payout CASCADE;
```

```
CREATE TABLE customer (  
    id SERIAL PRIMARY KEY,  
    firstname TEXT,  
    lastname TEXT,  
    phone TEXT,  
    birth DATE,  
    postcode TEXT  
);
```

Insert a few persons:

```
INSERT INTO customer  
VALUES  
(107, 'Sarah', 'Conor', '060-911-0911', '1965-10-10', '90016'),  
(258, 'Luke', 'Skywalker', NULL, '1951-09-25', '90120'),  
(341, 'Don', 'Draper', '347-515-3423', '1926-06-01', '04520')  
;  
  
SELECT * FROM customer;
```

id	firstname	lastname	phone	birth	postcode
107	Sarah	Conor	060-911-0911	1965-10-10	90016
258	Luke	Skywalker	None	1951-09-25	90120
341	Don	Draper	347-515-3423	1926-06-01	04520

The “payout” table

Sales are tracked in a simple table:

```
CREATE TABLE payout (  
    id SERIAL PRIMARY KEY,  
    fk_customer_id INT REFERENCES customer(id),  
    order_date DATE,  
    payment_date DATE,  
    amount INT  
);
```

Let's add some orders:

```
INSERT INTO payout  
VALUES  
(1, 107, '2021-10-01', '2021-10-01', '7'),
```



```
(2,258,'2021-10-02','2021-10-03','20'),
(3,341,'2021-10-02','2021-10-02','543'),
(4,258,'2021-10-05','2021-10-05','12'),
(5,258,'2021-10-06','2021-10-06','92')
;
```

Activate the extension

```
CREATE EXTENSION IF NOT EXISTS anon;
```

Declare the masking rules

Paul wants to hide the last name and the phone numbers of his clients. He will use the `dummy_last_name()` and `partial()` functions for that:

```
SECURITY LABEL FOR anon ON COLUMN customer.lastname
IS 'MASKED WITH FUNCTION anon.dummy_last_name()';

SECURITY LABEL FOR anon ON COLUMN customer.phone
IS 'MASKED WITH FUNCTION anon.partial(phone,2,$$X-XXX-XX$$,2)';
```

Apply the rules permanently

```
SELECT anon.anonymize_table('customer');
```

anonymize_table
True

```
SELECT id, firstname, lastname, phone
FROM customer;
```

id	firstname	lastname	phone
107	Sarah	Abshire	06X-XXX-XX11
258	Luke	Goldner	None
341	Don	Sauer	34X-XXX-XX23

This is called **Static Masking** because the **real data has been permanently replaced**. We'll see later how we can use dynamic anonymization or anonymous exports.

Exercises

E101 - Mask the client's first names

Declare a new masking rule and run the static anonymization function again.

E102 - Hide the last 3 digits of the postcode

Paul realizes that the postcode gives a clear indication of where his customers live. However he would like to have statistics based on their postcode area.

Add a new masking rule to replace the last 3 digits by 'x'.

E103 - Count how many clients live in each postcode area?

Aggregate the customers based on their anonymized postcode.

E104 - Keep only the year of each birth date

Paul wants age-based statistic. But he also wants to hide the real birth date of the customers.

Replace all the birth dates by January 1st, while keeping the real year.

You can use the `make_date` or `date_trunc` functions !

See <https://www.postgresql.org/docs/current/functions-datetime.html#FUNCTIONS-DATETIME-TABLE>

E105 - Singling out a customer

Even if the “customer” is properly anonymized, we can still isolate a given individual based on data stored outside of the table. For instance, we can identify the best client of Paul's boutique with a query like this:

```
WITH best_client AS (  
    SELECT SUM(amount), fk_customer_id  
    FROM payout  
    GROUP BY fk_customer_id  
    ORDER BY 1 DESC  
    LIMIT 1  
)  
SELECT c.*  
FROM customer c  
JOIN best_client b ON (c.id = b.fk_customer_id)
```

id	firstname	lastname	phone	birth	postcode
341	Don	Sauer	34X-XXX-XX23	1926-06-01	04520

This is called **Singling Out a person**.

We need to anonymize even further by removing the link between a person and its company. In the `payout` table, this link is materialized by a foreign key on the field `fk_company_id`. However we can't remove values from this column or insert fake identifiers because it would break the foreign key constraint.

How can we separate the customers from their payouts while respecting the integrity of the data?

Find a function that will shuffle the column `fk_company_id` of the `payout` table

Check out the shuffling section of the documentation.

Solutions

S101

```
SECURITY LABEL FOR anon ON COLUMN customer.firstname  
IS 'MASKED WITH FUNCTION anon.dummy_first_name()';
```

```
SELECT anon.anonymize_table('customer');
```

```
SELECT id, firstname, lastname  
FROM customer;
```

S102

```
SECURITY LABEL FOR anon ON COLUMN customer.postcode  
IS 'MASKED WITH FUNCTION anon.partial(postcode,2,$$xxx$$,0)';
```

```
SELECT anon.anonymize_table('customer');
```

```
SELECT id, firstname, lastname, postcode  
FROM customer;
```

S103

```
SELECT postcode, COUNT(id)  
FROM customer  
GROUP BY postcode;
```

postcode	count
90xxx	2
04xxx	1

S104

```
SECURITY LABEL FOR anon ON FUNCTION pg_catalog.date_trunc(text,interval)
IS 'TRUSTED';

SECURITY LABEL FOR anon ON COLUMN customer.birth
IS $$ MASKED WITH FUNCTION pg_catalog.date_trunc('year',birth) $$;

SELECT anon.anonymize_table('customer');

SELECT id, firstname, lastname, birth
FROM customer;
```

S105

Let's mix up the values of the `fk_customer_id`:

```
SELECT anon.shuffle_column('payout','fk_customer_id','id');
```

shuffle_column
True

Now let's try to single out the best client again :

```
WITH best_client AS (
  SELECT SUM(amount), fk_customer_id
  FROM payout
  GROUP BY fk_customer_id
  ORDER BY 1 DESC
  LIMIT 1
)
SELECT c.*
FROM customer c
JOIN best_client b ON (c.id = b.fk_customer_id);
```

id	firstname	lastname	phone	birth	postcode
258	Lydia	Toy	None	1951-01-01	90xxx

WARNING

Note that the link between a `customer` and its `payout` is now completely false. For instance, if a customer A had 2 payouts. One of these payout may be linked to a customer B, while the second one is linked to a customer C.

In other words, this shuffling method with respect the foreign key constraint (aka the referential integrity) but it will break the data integrity. For some use case, this may be a problem.

In this case, Pierre will not be able to produce a BI report with the shuffle data, because the links between the customers and their payments are fake. — title: tutorials/2-dynamic_masking draft: false toc: true —

2- Dynamic Masking

With Dynamic Masking, the database owner can hide personal data for some users, while other users are still allowed to read and write the authentic data.

Requirements

Please check out the intro of this tutorial if you haven't read it yet

The Story

Paul has 2 employees:

- Jack is operating the new sales application, he needs access to the real data. He is what the GPDR would call a **"data processor"**.
- Pierre is a data analyst who runs statistic queries on the database. He should not have access to any personal data.

How it works

Objectives

In this section, we will learn:

- How to write simple masking rules
- The advantage and limitations of dynamic masking
- The concept of "Linkability" of a person

The company table

```
DROP TABLE IF EXISTS supplier CASCADE;
```

```
DROP TABLE IF EXISTS company CASCADE;
```

```
CREATE TABLE company (  
    id SERIAL PRIMARY KEY,  
    name TEXT,  
    vat_id TEXT UNIQUE  
);
```

```

INSERT INTO company
VALUES
(952,'Shadrach', 'FR62684255667'),
(194,E'Johnny\'s Shoe Store','CHE670945644'),
(346,'Capitol Records','GB663829617823')
;

SELECT * FROM company;

```

id	name	vat_id
952	Shadrach	FR62684255667
194	Johnny's Shoe Store	CHE670945644
346	Capitol Records	GB663829617823

The supplier table

```

CREATE TABLE supplier (
    id SERIAL PRIMARY KEY,
    fk_company_id INT REFERENCES company(id),
    contact TEXT,
    phone TEXT,
    job_title TEXT
);

INSERT INTO supplier
VALUES
(299,194,'Johnny Ryall','597-500-569','CEO'),
(157,346,'George Clinton', '131-002-530','Sales manager')
;

SELECT * FROM supplier;

```

id	fk_company_id	contact	phone	job_title
299	194	Johnny Ryall	597-500-569	CEO
157	346	George Clinton	131-002-530	Sales manager

Activate the extension

```

ALTER DATABASE boutique
SET session_preload_libraries TO 'anon';

CREATE EXTENSION IF NOT EXISTS anon;

SELECT anon.init();

```

Dynamic Masking

Activate the masking engine

```
ALTER DATABASE boutique
SET anon.transparent_dynamic_masking TO true;
```

Masking a role

```
SECURITY LABEL FOR anon ON ROLE pierre IS 'MASKED';
```

```
GRANT pg_read_all_data to pierre;
```

Now connect as Pierre and try to read the supplier table:

```
SELECT * FROM supplier;
```

id	fk_company_id	contact	phone	job_title
299	194	Johnny Ryall	597-500-569	CEO
157	346	George Clinton	131-002-530	Sales manager

For the moment, there is no masking rule so Pierre can see the original data in each table.

Masking the supplier names

Connect as Paul and define a masking rule on the supplier table:

```
SECURITY LABEL FOR anon ON COLUMN supplier.contact
IS 'MASKED WITH VALUE $$CONFIDENTIAL$$';
```

Now connect as Pierre and try to read the supplier table again:

```
SELECT * FROM supplier;
```

id	fk_company_id	contact	phone	job_title
299	194	CONFIDENTIAL	597-500-569	CEO
157	346	CONFIDENTIAL	131-002-530	Sales manager

Now connect as Jack and try to read the real data:

```
SELECT * FROM supplier;
```

id	fk_company_id	contact	phone	job_title
299	194	Johnny Ryall	597-500-569	CEO
157	346	George Clinton	131-002-530	Sales manager

Exercises

E201 - Guess who is the CEO of “Johnny’s Shoe Store”

Masking the supplier contact is clearly not enough to provide anonymity.

Connect as Pierre and write a simple SQL query that joins the supplier and the company tables. See how that could reidentify some suppliers based on their job and their company.

With this request we managed to link a person to a company and we know it’s job title. Since company names and job positions are available in many public datasets: a simple search on LinkedIn or Google would give us the real names of many of the employees of these companies...

This is called **Linkability**: the ability to connect multiple records concerning the same data subject.

E202 - Anonymize the companies

We need to anonymize the `company` table, too. Even if they don’t contain personal information, some fields can be used to **infer** the identity of their employees...

Connect as Paul and write 2 masking rules (security labels) for the company table.

- The first one will replace the `name` field with a fake name.
- The second rule will replace the `vat_id` with a random sequence of 10 characters

Go to the documentation and look at the faking functions and the random functions !

Connect as Pierre and check that he cannot view the real company info.

Connect as Jack and check that he can view the real values.

E203 - Pseudonymize the company name

Because of dynamic masking, the fake values will be different every time Pierre tries to read the table.

Pierre would like to have always the same fake values for a given company.

This is called pseudonymization.

Connect as Paul and write a new masking rule over the `vat_id` field by generating a hash of 10 characters using the `anon.digest()` function.

Write a new masking rule over the `name` field by using a pseudonymizing function.

Solutions

S201

```
SELECT s.id, s.contact, s.job_title, c.name
FROM supplier s
JOIN company c ON s.fk_company_id = c.id;
```

id	contact	job_title	name
299	CONFIDENTIAL	CEO	Johnny's Shoe Store
157	CONFIDENTIAL	Sales manager	Capitol Records

S202

```
SECURITY LABEL FOR anon ON COLUMN company.name
IS 'MASKED WITH FUNCTION anon.dummy_company_name()';
```

```
SECURITY LABEL FOR anon ON COLUMN company.vat_id
IS 'MASKED WITH FUNCTION anon.random_string(10)';
```

Now connect as Pierre and read the table again:

```
SELECT * FROM company;
```

id	name	vat_id
952	Bashirian LLC	Yg1GmRm0WW
194	Towne and Sons	IzzSE2QmEC
346	Cartwright and Sons	LjTIY7QrBm

Pierre will see different “fake data” every time he reads the table:

```
SELECT * FROM company;
```

id	name	vat_id
952	Wolf and Haley Group	T0UjIXqLu5
194	Rippin Inc	EpB97liUYC
346	Weber and Bayer LLC	flyM5UaRPV

Jack still sees the real data

```
SELECT * FROM company;
```

id	name	vat_id
952	Shadrach	FR62684255667
194	Johnny's Shoe Store	CHE670945644
346	Capitol Records	GB663829617823

S203

```
SECURITY LABEL FOR anon ON COLUMN company.vat_id
IS $$ MASKED WITH FUNCTION anon.left(anon.digest(vat_id, 'xxx', 'md5'),10) $$;
```

```
SECURITY LABEL FOR anon ON COLUMN company.name
IS 'MASKED WITH FUNCTION anon.pseudo_company(id)';
```

Connect as Pierre and read the table multiple times:

```
SELECT * FROM company;
```

id	name	vat_id
952	Wilkinson LLC	2db762afa4
194	Johnson PLC	61fddf8d83
346	Young-Carpenter	86fe3f164c

```
SELECT * FROM company;
```

id	name	vat_id
952	Wilkinson LLC	2db762afa4
194	Johnson PLC	61fddf8d83
346	Young-Carpenter	86fe3f164c

Now the fake company name is always the same.

title: tutorials/3-anonymous_dumps draft: false toc: true —

3- Anonymous Dumps

In many situation, what we want is basically to export the anonymized data into another database (for testing or to produce statistics). We will simply use `pg_dump` for that !

The Story

Paul has a website and a comment section where customers can express their views.

He hired a web agency to develop a new design for his website. The agency asked for a SQL export (dump) of the current website database. Paul wants to clean the database export and remove any personal information contained in the comment section.

How it works

Learning Objective

- Extract the anonymized data from the database
- Write a custom masking function to handle a JSON field.

Load the data

```
DROP TABLE IF EXISTS website_comment CASCADE;

CREATE TABLE website_comment (
  id SERIAL PRIMARY KEY,
  message JSONB
);

INSERT INTO website_comment
VALUES
(1, json_build_object(
  'meta', json_build_object(
    'name', 'Lee Perry',
    'ip_addr', '40.87.29.113'),
  'content', 'Hello Nasty!')),
(2, json_build_object(
  'meta', json_build_object(
    'name', '',
    'email', 'biz@bizmarkie.com'),
  'content', 'Great Shop')),
(3, json_build_object(
  'meta', json_build_object(
    'name', 'Jimmy'),
  'content', 'Hi ! This is me, Jimmy James'));
```

Check the content of the website comments:

```
SELECT
message->'meta'->'name' AS name,
message->'content' AS content
```

```
FROM website_comment
ORDER BY id ASC;
```

name	content
Lee Perry	Hello Nasty!
	Great Shop
Jimmy	Hi ! This is me, Jimmy James

Activate the extension

```
CREATE EXTENSION IF NOT EXISTS anon;
```

Masking a JSON column

The `comment` field is filled with personal information and the fact the field does not have a standard schema makes our tasks harder.

In general, unstructured data are difficult to mask.

As we can see, web visitors can write any kind of information in the comment section. Our best option is to remove this key entirely because there's no way to extract personal data properly.

We can *clean* the comment column simply by removing the `content` key in the `message` column !

```
SELECT message - ARRAY['content'] AS message_without_content
FROM website_comment
WHERE id=1;
```

message_without_content
{'meta': {'name': 'Lee Perry', 'ip_addr': '40.87.29.113'}}

First let's create a dedicated schema and declare it as trusted. This means the `anon` extension will accept the functions located in this schema as valid masking functions. Only a superuser should be able to add functions in this schema.

```
CREATE SCHEMA IF NOT EXISTS my_masks;
```

```
SECURITY LABEL FOR anon ON SCHEMA my_masks IS 'TRUSTED';
```

Now we can write a function that remove the message content:

```
CREATE OR REPLACE FUNCTION my_masks.remove_content(j JSONB)
RETURNS JSONB
AS $func$
    SELECT j - ARRAY['content']
$func$
LANGUAGE SQL
;
```

Let's try it!

```
SELECT my_masks.remove_content(message)
FROM website_comment;
```

remove_content
{'meta': {'name': 'Lee Perry', 'ip_addr': '40.87.29.113'}}
{'meta': {'name': '', 'email': 'biz@bizmarkie.com'}}
{'meta': {'name': 'Jimmy'}}

And now we can use it in a masking rule:

```
SECURITY LABEL FOR anon ON COLUMN website_comment.message
IS 'MASKED WITH FUNCTION my_masks.remove_content(message)';
```

Then we need to create a dedicated role to export the masked data. We will call this role `anon_dumper` (the name does not matter) and declare that this role is masked.

```
CREATE ROLE anon_dumper LOGIN PASSWORD 'CHANGEME';
```

```
ALTER ROLE anon_dumper SET anon.transparent_dynamic_masking TO TRUE;
```

```
SECURITY LABEL FOR anon ON ROLE anon_dumper IS 'MASKED';
```

```
GRANT pg_read_all_data TO anon_dumper;
```

For convenience, add a new entry in the `.pgpass` file.

```
cat > ~/.pgpass << EOL
*:*:boutique:anon_dumper:CHANGEME
EOL
```

Finally we can export an **anonymous dump** of the table with `pg_dump`:

```
export PATH=$PATH:$(pg_config --bindir)
export PGPHOST=localhost
pg_dump -U anon_dumper boutique --table=website_comment > /tmp/dump.sql
```

Exercises

E301 - Dump the anonymized data into a new database

Create a database named `boutique_anon` and transfer the entire database into it.

E302 - Remove the email address

Replace the `remove_content` function with a better one called `remove_content_and_ip` that will nullify the `email` key.

HINT: you can use `jsonb_set(message, '{meta, email}', '{}')` to remove the email value.

E303 - Pseudonymize the IP address

Pierre plans to extract general information from the metadata. For instance, he wants to calculate the number of unique visitors based on the different IP addresses.

But an IP address is an **indirect identifier**, so Paul needs to anonymize this field while maintaining the fact that some values appear multiple times.

HINT: First you can create a new `meta` object using `jsonb_build_object()` and then use function `jsonb_set` replace the `meta` key

Solutions

S301

```
export PATH=$PATH:$(pg_config --bindir)
export PGHOST=localhost
dropdb -U paul --if-exists boutique_anon
createdb -U paul boutique_anon --owner paul
pg_dump -U anon_dumper boutique | psql -U paul --quiet boutique_anon

export PGHOST=localhost
psql -U paul boutique_anon -c 'SELECT COUNT(*) FROM company'
```

S302

```
CREATE OR REPLACE FUNCTION my_masks.remove_content_and_ip(message JSONB)
RETURNS JSONB
VOLATILE
LANGUAGE SQL
AS $func$
SELECT
    jsonb_set(message, '{meta, email}', '{}')
```

```

- ARRAY['content'];
$func$;

SELECT my_masks.remove_content_and_ip(message)
FROM website_comment;

```

```

remove_content_and_ip
{'meta': {'name': 'Lee Perry', 'email': {}, 'ip_addr': '40.87.29.113'}}
{'meta': {'name': '', 'email': {}}}
{'meta': {'name': 'Jimmy', 'email': {}}}

```

```

SECURITY LABEL FOR anon ON COLUMN website_comment.message
IS 'MASKED WITH FUNCTION my_masks.remove_content_and_ip(message)';

```

S303

```

CREATE OR REPLACE FUNCTION my_masks.clean_comment(message JSONB)
RETURNS JSONB
VOLATILE
LANGUAGE SQL
AS $func$
SELECT
  jsonb_set(
    message,
    ARRAY['meta'],
    jsonb_build_object(
      'name',anon.fake_last_name(),
      'ip_address', md5((message->'meta'->'ip_addr')::TEXT),
      'email', NULL
    )
  ) - ARRAY['content'];
$func$;

SELECT my_masks.clean_comment(message)
FROM website_comment;

```

```

clean_comment
{'meta': {'name': 'Gill', 'email': None, 'ip_address':
'1d8cbcd5f988d55982af1536922ddcd1'}}
{'meta': {'name': 'Henson', 'email': None, 'ip_address': None}}
{'meta': {'name': 'McMahon', 'email': None, 'ip_address': None}}

```

```

SECURITY LABEL FOR anon ON COLUMN website_comment.message
IS 'MASKED WITH FUNCTION my_masks.clean_comment(message)';

```

4- Generalization

The main idea of generalization is to blur the original data. For example, instead of saying Mister X was born on July 25, 1989, we can say Mister X was born in the 80's. The information is still true, but it is less precise and it can't be used to reidentify the subject.

The Story

Paul hired dozens of employees over the years. He kept a record of their hair color, size and medical condition.

Paul wants to extract weird stats from these details. He provides generalized views to Pierre.

How it works

Learning Objective

In this section, we will learn:

- The difference between masking and generalization
- The concept of K-anonymity

The employee table

```
DROP TABLE IF EXISTS employee CASCADE;
```

```
CREATE TABLE employee (  
  id INT PRIMARY KEY,  
  full_name TEXT,  
  first_day DATE, last_day DATE,  
  height INT,  
  hair TEXT, eyes TEXT, size TEXT,  
  asthma BOOLEAN,  
  CHECK(hair = ANY(ARRAY['bald','blond','dark','red'])),  
  CHECK(eyes = ANY(ARRAY['blue','green','brown'])),  
  CHECK(size = ANY(ARRAY['S','M','L','XL','XXL']))  
);
```

This is awkward and illegal.

Loading the data:

```
INSERT INTO employee  
VALUES  
(1, 'Luna Dickens', '2018-07-22', '2018-12-15', 180, 'blond', 'blue', 'L', True),  
(2, 'Paul Wolf', '2020-01-15', NULL, 177, 'bald', 'brown', 'M', False),
```



```
(3,'Rowan Hoeger','2018-12-01','2018-12-15',202,'dark','blue','XXL',True)
;
```

```
SELECT count(*) FROM employee;
```

count
3

```
SELECT full_name,first_day, hair, size, asthma
FROM employee
LIMIT 3;
```

full_name	first_day	hair	size	asthma
Luna Dickens	2018-07-22	blond	L	True
Paul Wolf	2020-01-15	bald	M	False
Rowan Hoeger	2018-12-01	dark	XXL	True

Data suppression

Paul wants to find if there's a correlation between asthma and the eyes color.

He provides the following view to Pierre.

```
DROP MATERIALIZED VIEW IF EXISTS v_asthma_eyes;
```

```
CREATE MATERIALIZED VIEW v_asthma_eyes AS
```

```
SELECT eyes, asthma
FROM employee;
```

```
SELECT *
FROM v_asthma_eyes
LIMIT 3;
```

eyes	asthma
blue	True
brown	False
blue	True

Pierre can now write queries over this view.

```
SELECT
  eyes,
  100*COUNT(1) FILTER (WHERE asthma) / COUNT(1) AS asthma_rate
FROM v_asthma_eyes
```

```
GROUP BY eyes;
```

eyes	asthma_rate
brown	0
blue	100

Pierre just proved that asthma is caused by blue eyes ;-)

K-Anonymity

The `asthma` and `eyes` columns are considered as indirect identifiers.

Indirect personal identifiers (or “quasi-identifiers”) are pieces of information that, when combined with other data can identify an individual. Examples of indirect identifiers include: Date of birth, Gender, Zip code, etc.

With PostgreSQL Anonymizer, we can declare that a column is an indirect identifiers, like this:

```
SECURITY LABEL FOR k_anonymity
ON COLUMN v_asthma_eyes.eyes
IS 'INDIRECT IDENTIFIER';

SECURITY LABEL FOR k_anonymity
ON COLUMN v_asthma_eyes.asthma
IS 'INDIRECT IDENTIFIER';

SELECT anon.k_anonymity('v_asthma_eyes');
```

k_anonymity
1

The `v_asthma_eyes` has ‘2-anonymity’. This means that each quasi-identifier combination (the ‘eyes-asthma’ tuples) occurs in at least 2 records for a dataset.

In other words, it means that each individual in the view cannot be distinguished from at least 1 (k-1) other individual.

Range and Generalization functions

Now let’s add another view over the `employee` table.

We will generalize the dates of to keep only the month and year.

```
DROP MATERIALIZED VIEW IF EXISTS v_staff_per_month;
CREATE MATERIALIZED VIEW v_staff_per_month AS
```

```

SELECT
    anon.generalize_daterange(first_day,'month') AS first_day,
    anon.generalize_daterange(last_day,'month') AS last_day
FROM employee;

SELECT *
FROM v_staff_per_month
LIMIT 3;

```

first_day	last_day
[2018-07-01, 2018-08-01)	[2018-12-01, 2019-01-01)
[2020-01-01, 2020-02-01)	(None, None)
[2018-12-01, 2019-01-01)	[2018-12-01, 2019-01-01)

Pierre can write a query to find how many employees were hired in november 2021.

```

SELECT COUNT(1)
    FILTER (
        WHERE make_date(2019,11,1)
        BETWEEN lower(first_day)
        AND COALESCE(upper(last_day),now())
    )
FROM v_staff_per_month;

```

count
0

Declaring the indirect identifiers

Now let's check the k-anonymity of this view by declaring which columns are indirect identifiers :

```

SECURITY LABEL FOR k_anonymity
ON COLUMN v_staff_per_month.first_day
IS 'INDIRECT IDENTIFIER';

```

```

SECURITY LABEL FOR k_anonymity
ON COLUMN v_staff_per_month.last_day
IS 'INDIRECT IDENTIFIER';

```

```

SELECT anon.k_anonymity('v_staff_per_month');

```

In this case, the k factor is 1 which means that there is at least one unique individual who be identified directly by his/her first and last dates.

Exercises

E401 - Simplify v_staff_per_month and decrease granularity

Generalizing dates per month is not enough. Write another view called v_staff_per_year that will generalize dates per year.

Also simplify the view by using a range of int to store the years instead of a date range.

E402 - Staff progression over the years

How many people worked for Paul for each year between 2018 and 2021?

E403 - Reaching 2-anonymity for the v_staff_per_year view

What is the k-anonymity of v_staff_per_month_years?

Solutions

S401

```
DROP MATERIALIZED VIEW IF EXISTS v_staff_per_year;
```

```
CREATE MATERIALIZED VIEW v_staff_per_year AS  
SELECT
```

```
    int4range(  
        extract(year from first_day)::INT,  
        extract(year from last_day)::INT,  
        '[]'
```

```
    ) AS period  
FROM employee;
```

'[]' will include the upper bound

```
SELECT *  
FROM v_staff_per_year  
LIMIT 3;
```

period
[2018, 2019)
[2020, None)
[2018, 2019)

S402

```
SELECT
    year,
    COUNT(1) FILTER (
        WHERE year <@ period
    )
FROM
    generate_series(2018,2021) year,
    v_staff_per_year
GROUP BY year
ORDER BY year ASC;
```

year	count
2018	2
2019	0
2020	1
2021	1

S403

```
SECURITY LABEL FOR k_anonymity
    ON COLUMN v_staff_per_year.period
    IS 'INDIRECT IDENTIFIER';

SELECT anon.k_anonymity('v_staff_per_year');
```

Conclusion

Clean up !

```
DROP DATABASE IF EXISTS boutique;

REASSIGN OWNED BY jack TO postgres;

REASSIGN OWNED BY paul TO postgres;

REASSIGN OWNED BY pierre TO postgres;

DROP ROLE IF EXISTS jack;
DROP ROLE IF EXISTS paul;
DROP ROLE IF EXISTS pierre;
DROP ROLE IF EXISTS dump_anon;
```

Also...

Other projects you may like

- `pg_sample` : extract a small dataset from a larger PostgreSQL database

Help Wanted!

This is a free and open project!

labs.dalibo.com/postgresql_anonymizer

Please send us feedback on how you use it, how it fits your needs (or not), etc.

— title: tutorials/**DO_NOT_MODIFY_THESE_FILES** draft: false toc: true —

DO NOT MODIFY THESE FILES

The files in the `docs/tutorial` folder are artifacts generated based on the source files in `docs/runbooks`.

If you want to improve the tutorial, edit the `docs/runbooks/*.md` files.

And then run `make tutorial` to update the artifacts.

Upgrade

Currently there's no way to upgrade easily from a version to another. The operation `ALTER EXTENSION ... UPDATE ...` is not supported.

You need to drop and recreate the extension after every upgrade.

Upgrade to version 2.0 and further versions

With version 2, the entire core library was rewritten in Rust. This is a major change that brings new features, better performances and improved stability.

However the changes are mostly internal and for the most part the public interface of the extension does not change. A masking policy written with version 1.3 should work with version 2.0 !

!!! warning New RPM repository !

Version 2.0 is not available on the PGDG RPM repository.

If you installed PostgreSQL Anonymizer 1.x using the RPM package, you need to install the Dalibo Labs repository with the following command:

```
`dnf install https://yum.dalibo.org/labs/dalibo-labs-4-1.noarch.rpm`
```

Upgrade to version 1.3 and further versions

Starting with version 1.3, the extension enforces a series of security checks and it will refuse some masking rules that were previously accepted.

Here's a few example of the changes you may need to make to your masking policy

Using custom masking functions

If you have developed custom masking functions, you now need to place them inside a dedicated schema and declare that this schema is **trusted**

For example, let's say you have a function `remove_phone` that delete phone numbers from a `JSONB` field

First create a schema:

```
CREATE SCHEMA IF NOT EXISTS my_masks;
```

Then a superuser must declare it as trusted:

```
SECURITY LABEL FOR anon ON SCHEMA my_masks IS 'TRUSTED';
```

Now you can write the function:

```
CREATE OR REPLACE FUNCTION my_masks.remove_phone(j JSONB)
RETURNS JSONB
AS $$
    SELECT j - ARRAY['phone']
$$
LANGUAGE SQL ;
```

And finally use it in a masking rule:

```
SECURITY LABEL FOR anon ON COLUMN player.personal_details
IS 'MASKED WITH FUNCTION my_masks.remove_phone(personal_details)';
```

See the Write your own Masks ! section of the doc for more details...

Using `pg_catalog` functions

With version 1.3 and later, the `pg_catalog` schema is not longer trusted because it contains system administration functions that should not be used as masking functions.

However the extension provides bindings to some useful and safe commodity functions from the `pg_catalog` schema.

For instance, the following rule

```
SECURITY LABEL FOR anon ON COLUMN employee.phone
IS 'MASKED WITH FUNCTION md5(phone)'
```

```
SECURITY LABEL FOR anon ON COLUMN employee.phone
IS 'MASKED WITH FUNCTION anon.md5(phone)'
```

See the Using `pg_catalog` functions section of the doc for more details...

Operators

The MASKED WITH FUNCTION syntax is now more strict and in particular operators are not allowed as a masking value.

For instance, until version 1.3

```
SECURITY LABEL FOR anon ON COLUMN player.name
IS 'MASKED WITH FUNCTION anon.fake_first_name() || anon.fake_last_name()';
```

Now operators must be replaced by an actual function. For instance, the `||` operator would be replaced by `anon.concat`

```
SECURITY LABEL FOR anon ON COLUMN player.name
IS 'MASKED WITH FUNCTION anon.concat(anon.fake_first_name(),anon.fake_last_name())';
```

Conditional masking rules

The MASKED WITH VALUE CASE WHEN ... was never an intended feature but it work by accident.

Until version 1.3, the syntax below was accepted:

```
SECURITY LABEL FOR anon ON COLUMN player.score
IS 'MASKED WITH VALUE CASE WHEN score IS NULL
    THEN NULL
    ELSE anon.random_int_between(0,100)
    END';
```

The CASE syntax is now rejected and can be replaced by the `anon.ternary()` function:

```
SECURITY LABEL FOR anon ON COLUMN player.score
IS 'MASKED WITH FUNCTION anon.ternary(score IS NULL,
    NULL,
    anon.random_int_between(0,100)
)';
```

See the Conditional Masking section of the doc for more details...