Securing Your PostgreSQL Data: A Comprehensive Guide to Protecting Your Database Assets

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Who am I

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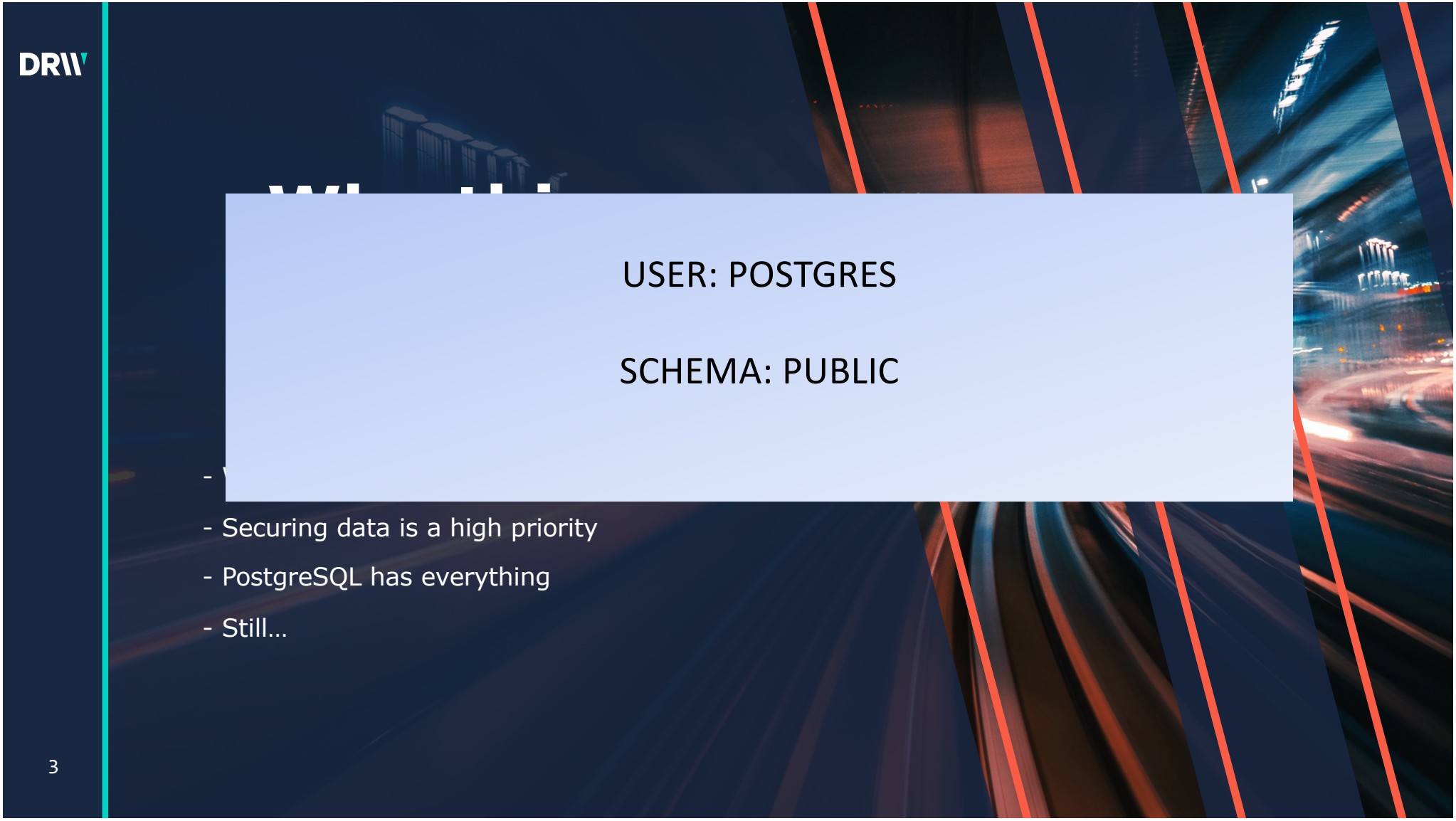
PG Day Chicago is on April 26, 2024!



- Securing data is a high priority
- PostgreSQL has everything
- Still…

What will be covered

- Common security challenges
- The necessity of standardization and its role in solving these challenges
- Adopted security models and their practical implementations
- Addressing a wide spectrum of access control needs
- Using automation to streamline security
- Ongoing issues and future prospects

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Challenge #1: PostgreSQL does not force you to create roles and schemas in order to start.

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And all examples in documentation create objects in PUBLIC schema!

As a result…

- Applications are developed using postgres user

- When they move to production, developer either forget to change the user or run into permissions problems they ~~do not have time~~ do not know how to fix

- When an application uses connection pools different application users can connect as the same database user

Challenge #2: The wonders of inheritance

- **Starting from PG 7.3, there is no distinction between users and roles (user=role+login)**

```
create role role1;
create role role2 login password ‘pwd’;
create user user1 password ‘pwd’;
```

- All of the grants below will work:

```
grant role1 to role2;
grant role2 TO user1;
grant user1 to role2;
```

… and if later you will execute

```
create role role3;
grant role3 to role1 ---will be inherited
```

Challenge #3: You think you created a role for a database? Think again!

- Roles are created on the instance level, not the database level

- If there are several databases on one instance, all users will have access to **all** databases, because…

By default, all user have `CONNECT` privilege to all databases on the instance

- Until PG 15, all users could create objects in `PUBLIC` schema. That includes public schema in all databases on the same instance.

- If a customer requested a superuser privilege, this superuser will be able to do **everything** on **all databases** on that instance.

Trying to do things the right way!

Grouping (objects and users):

- Using schemas for access control: all objects in each schema have the same set of privileges

- Granting privileges to groups (nologin roles) only. And granting roles to users

```
create schema orders owner orders_owner;
grant orders_owner to orders_admin;
create role orders_read_write;
create role orders_read_only;
grant select on all tables in schema orders to orders_read_only;
grant select, insert, update, delete on all tables in schema orders to
orders_read_write;
```

What is not going to work?

Challenge #4: Default privileges

- Yes, you also need to `grant usage`!

```
grant usage on schema orders to orders read_write, orders_read_only
```

- What else?

```
alter default privileges in schema orders grant select on tables to
orders_read_only;
alter default privileges in schema orders grant select, insert,
update, delete on tables to orders_read_write;
```

Now:

```
create table orders.customer (
customer_id int primary key,
customer_name text);
```

- Why were default permissions not applied?!

```
alter default privileges in schema orders for role orders_owner grant
select, insert, update, delete on tables to orders_read_write;
```

Challenge #5: The wonders of ownership!

- **When you run:**

```
create schema orders owner orders_owner;
```

It created a lot of privileges for orders_owner user:

```
grant all on schema orders to orders_owner
```

- **But what happens when you execute**

```
alter schema orders owner new_orders_owner;
```

Does anything change with permissions?

Challenges #6, #7, #8… Lots of weird things!

```
grant select orders.sales_points to role1;
grant insert, update, delete on orders.sales_points to role2;
grant role1 to user1;
grant role2 to user1;
revoke delete on orders.sales_points from user1;
```

Will this work?

- It won't, and moreover, errors won't be reported:
  REVOKE of permissions which are not granted
  GRANT permissions which are already granted except for roles
- You can't drop user that has any privileges
- You can't `drop role cascade`
- **And there is no easy way to see what permissions a given user has!**

Now imagine you have not five, not ten, but 280 databases, and new requests are coming each day!

We want to be isolated!

A separate instance for each new project – possible, but expensive.

What are the alternatives?


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Security Models Overview
Principles and implementation

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Basic principles

The only security model to support multi-tenancy within one PostgreSQL database

Principle of least privilege

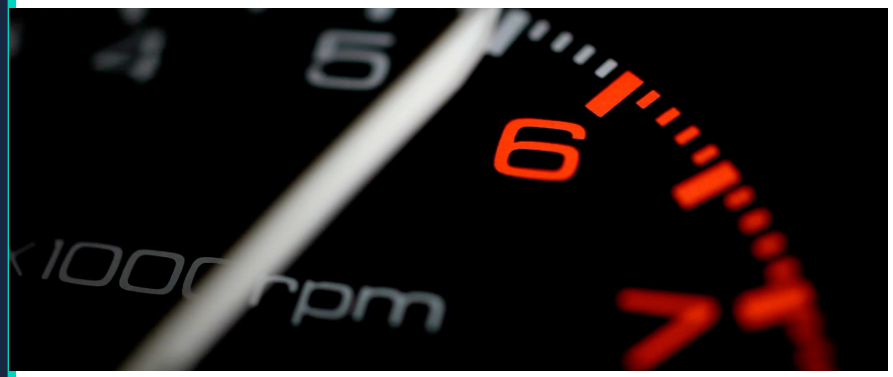
- A user is given the minimum levels of access needed to perform their job functions.

Durability

- Non-superuser users do not have a way to bypass security settings

Flexibility

- One package supports four security models with different permissions hierarchy.



Key features

Event trigger

- Forces all objects in each schema to be owned by the schema owner role and assigns default privileges

Security levels matrix

- Schema owner TRUE/FALSE
- Account owner TRUE/FALSE

Database level security

- Security modal is set up on the database level

Security-definer functions

- Schemas and roles creation/deletion are performed using security definer functions

Enabling security model

- Deploy the package
- If the package was previously deployed, the previous security settings will be used:

  you can't change the existing settings for a database
- If that's the first deployment run

```
select * from grant_create_schema_users(Boolean, Boolean)
```

This will

  - record security setting in the database
  - enable event trigger
  - grant execute on all security-definer functions to the database owner role

Security matrix

account_owner \ schema_owner	FALSE	TRUE
FALSE	- All schemas are created and owned by db_owner. - Users are created/ assigned roles by db_owner	All schemas are created by db_owner - Each schema has it's own owner. - Users are created/ assigned roles by db_owner
TRUE	- db_owner creates accounts - account can create schemas - schemas are owned by account_owner - Users are created/ assigned roles by account_owner - Accounts are isolated	- db_owner creates accounts - account can create schemas - Each schema has it's own owner - Users are created/ assigned roles by account_owner - Accounts are isolated

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```
CREATE SCHEMA orders
AUTHORIZATION my_db_owner;
ALTER DEFAULT PRIVILEGES IN
SCHEMA orders FOR USER
my_db_owner GRANT SELECT ON
TABLES TO orders_read_only;
ALTER DEFAULT PRIVILEGES IN
SCHEMA orders FOR USER
my_db_owner GRANT INSERT,
UPDATE, DELETE, SELECT ON TABLES
TO orders_read_write;
```

```
CREATE SCHEMA orders
AUTHORIZATION orders_owner;
ALTER DEFAULT PRIVILEGES IN
SCHEMA orders FOR USER
orders_owner GRANT SELECT ON
TABLES TO orders_read_only;
ALTER DEFAULT PRIVILEGES IN
SCHEMA orders FOR USER
orders_owner GRANT INSERT,
UPDATE, DELETE, SELECT ON
TABLES TO orders_read_write
```

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```
CREATE SCHEMA orders
AUTHORIZATION my_account_owner;
ALTER DEFAULT PRIVILEGES IN
SCHEMA orders FOR USER
my_account_owner GRANT SELECT ON
TABLES TO orders_read_only;
ALTER DEFAULT PRIVILEGES IN
SCHEMA orders FOR USER
my_account_owner GRANT INSERT,
UPDATE, DELETE, SELECT ON TABLES
TO orders_read_write;
```

```
CREATE SCHEMA orders
AUTHORIZATION orders_owner;
ALTER DEFAULT PRIVILEGES IN
SCHEMA orders FOR USER
orders_owner GRANT SELECT ON
TABLES TO orders_read_only;
ALTER DEFAULT PRIVILEGES IN
SCHEMA orders FOR USER
orders_owner GRANT INSERT,
UPDATE, DELETE, SELECT ON
TABLES TO orders_read_write
```

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Functions

create_schema_roles

Input parameters:

- schema_name
- app_user_name (opt)
- app_user_password (opt)
- ddl_user_name (opt)
- ddl_user_password (opt)
- account_owner (optional. Default current user)

Actions:

- creates schema (ownership is driven by security settings)
- creates read_write role
- creates read_only role
- creates owner role (if applicable)
- creates/assigns app and owner users

drop_schema_roles

Input parameters:

- schema_name

Actions:

- revokes read_only role from all users
- revokes read_write from all users
- revokes owner role (if applicable)
- drops all associated roles
- drops schema

assign_schema_owner_user

Input parameters:

- schema_name
- ddl_user_name
- ddl_user_password (opt)

Actions:

- creates user ddl_user_name if it does not exist
- changes password if user exists & password provided
- grants schema owner role to ddl_user_name

assign_schema_app_user

Input parameters:

- schema_name
- app_user_name
- app_user_password (opt)

Actions:

- creates user app_user_name if it does not exist
- changes password if user exists & password provided
- grants schema read_write role to app_user_name

assign_schema_ro_user

Input parameters:

- schema_name
- ro_user_name
- ro_user_password (opt)

Actions:

- creates user ro_user_name if it does not exist
- changes password if user exists & password provided
- grants schema read_only role to ro_user_name

Revoke functions

- revoke_schema_owner_role
- revoke_schema_app_role
- revoke_schema_ro_role

Additional security definer functions

- `select_all_privileges()`: all privileges on the current db
- `blocking_processes()`: blocking query with superuser privileges
- `pg_stat_activity()`: pg_stat_activity with superuser privileges

Code details

Event trigger forces new object ownership and permissions to the schema owner

```
FOR v_obj IN
  SELECT * FROM
pg_event_trigger_ddl_commands ()
 order by object_type desc
LOOP
 <fix perm>
END LOOP
```

Code details

Check whether the `current_user` has an ownership role for this schema (`grant execute` is not enough)

```
select
 exists (
   with recursive x as
   (
     select member::regrole,
            roleid::regrole as role
      from pg_auth_members as m
      union all
     select x.member::regrole,
            m.roleid::regrole
      from pg_auth_members as m
      join x on m.member = x.role
     )
     select 1
     from x
     where
        (member::text = current_user
        and role = (select nspowner::regrole from
pg_namespace
              where nspname=p_schema_name)
           or current_user=(select
(nspowner::regrole)::text from pg_namespace
              where nspname=p_schema_name)
```

Code details

Checking the execution stack inside security definer function

```
if not
   perm_check_stack(
'dba_tools.perm_drop_schema_roles')
  then
  raise exceaption 'You are not allowed
to drop schema %', p_schema_name;
end if;
```

Future work

- Reporting
- Unit tests
- Conversion automation

Q&A

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