PostgreSQL pgroll: Zero downtime, reversible schema changes

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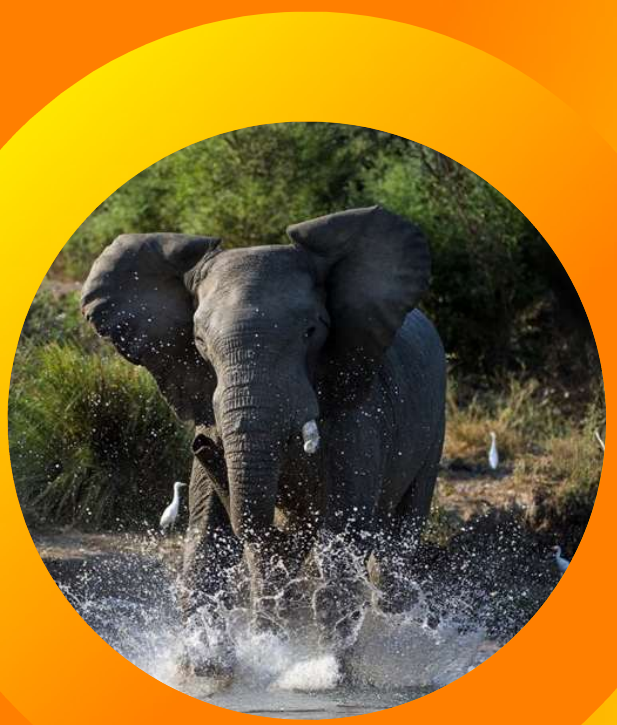
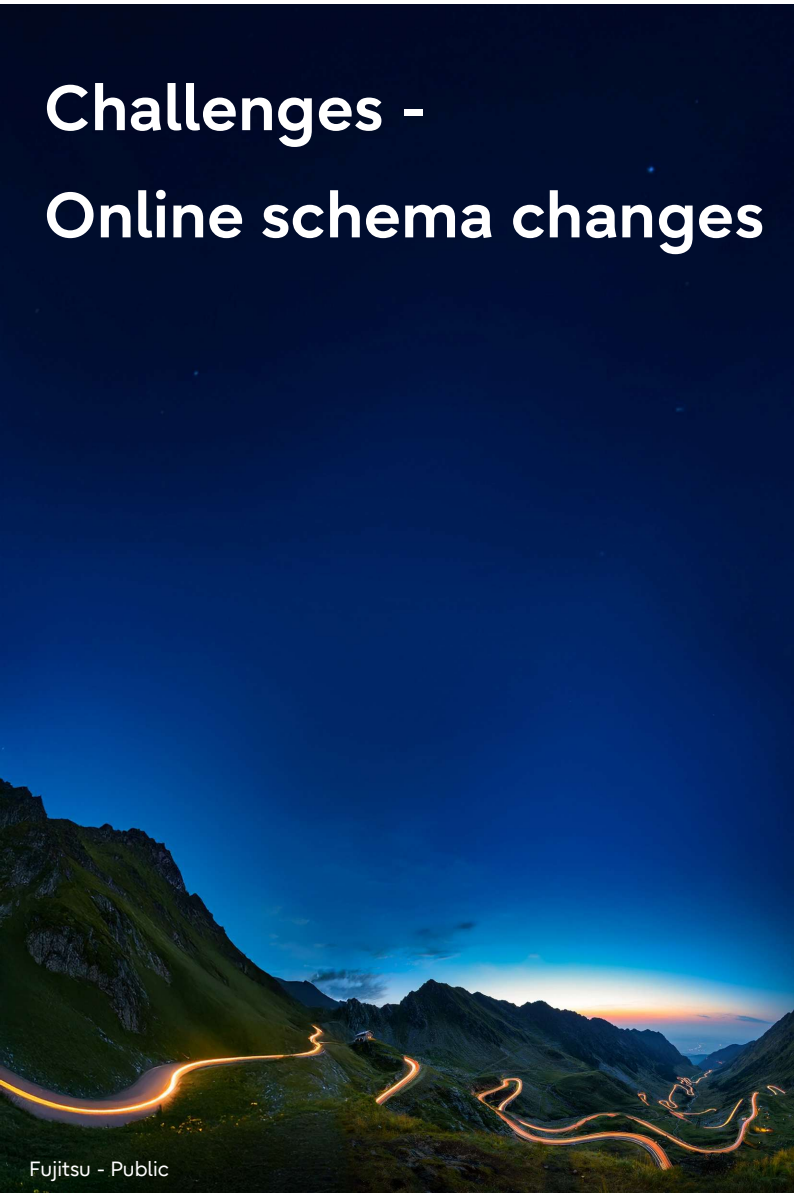
Agenda

- Challenges – Online schema changes
- Introduction - pgroll
- How it works
- Installation
- Usage
  - Add tables
  - Add columns
  - Add & rollback index
- Q&A



Challenges -
Online schema changes



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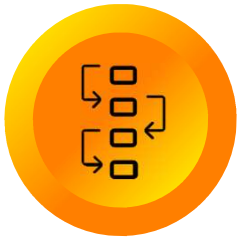
Online schema changes are painful

Breaking Applications



Multiple steps

Unexpected database locks

No easy rollbacks

Introduction - pgroll

Open-source command-line tool

Safe and reversible schema changes for PostgreSQL

Works with Postgres 14.0 or later

pg roll

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Features

Zero downtime changes (no DB locking, no breaking changes)

Keep old and new schema versions **working simultaneously**

Automatic **columns backfilling** when needed

Instant rollback in case of issues during change

Works against existing schemas, **no need to start from scratch**

Works with **any Postgres service**

Written in Go, **cross-platform single binary** with no external dependencies

Understanding how pgroll works

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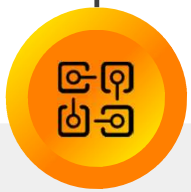
Virtual schemas using views

- pgroll creates virtual schemas using views instead of modifying physical tables directly
- This ensures existing users experience no disruption while database changes are being introduced



Controlled, non-disruptive changes

- Database structure modifications happen without breaking the existing schema
- Applications continue to function normally while schema changes are rolled out in the background

No immediate impact on users

- Unlike traditional schema changes, pgroll ensures smooth transitions by mapping new changes through views
- Client applications are not forced to upgrade immediately, allowing flexibility in rollout

pgroll - Expand/contract workflow

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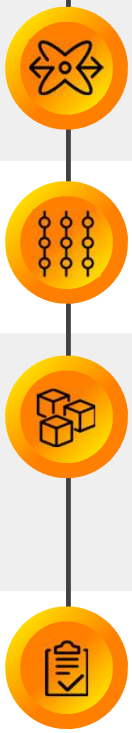

Expand phase (safe additions)

- New tables and columns are added first, ensuring no existing functionality breaks
- Applications can start using the new schema without affecting legacy users

Handling breaking changes

- Instead of modifying existing columns directly, pgroll creates new columns
- Triggers synchronize data between old and new columns to maintain consistency

Exposing the new schema

- The updated schema is made available as a new version
- Applications can gradually transition to the new schema version
- Applications start using the new schema while the old version remains active
- This staged rollout ensures smooth adoption without downtime

Completing the change

- When all applications have transitioned, the old schema is removed
- Unused tables and columns are cleaned up, and final names are assigned
- The system remains stable, ensuring continuous operation

How it works

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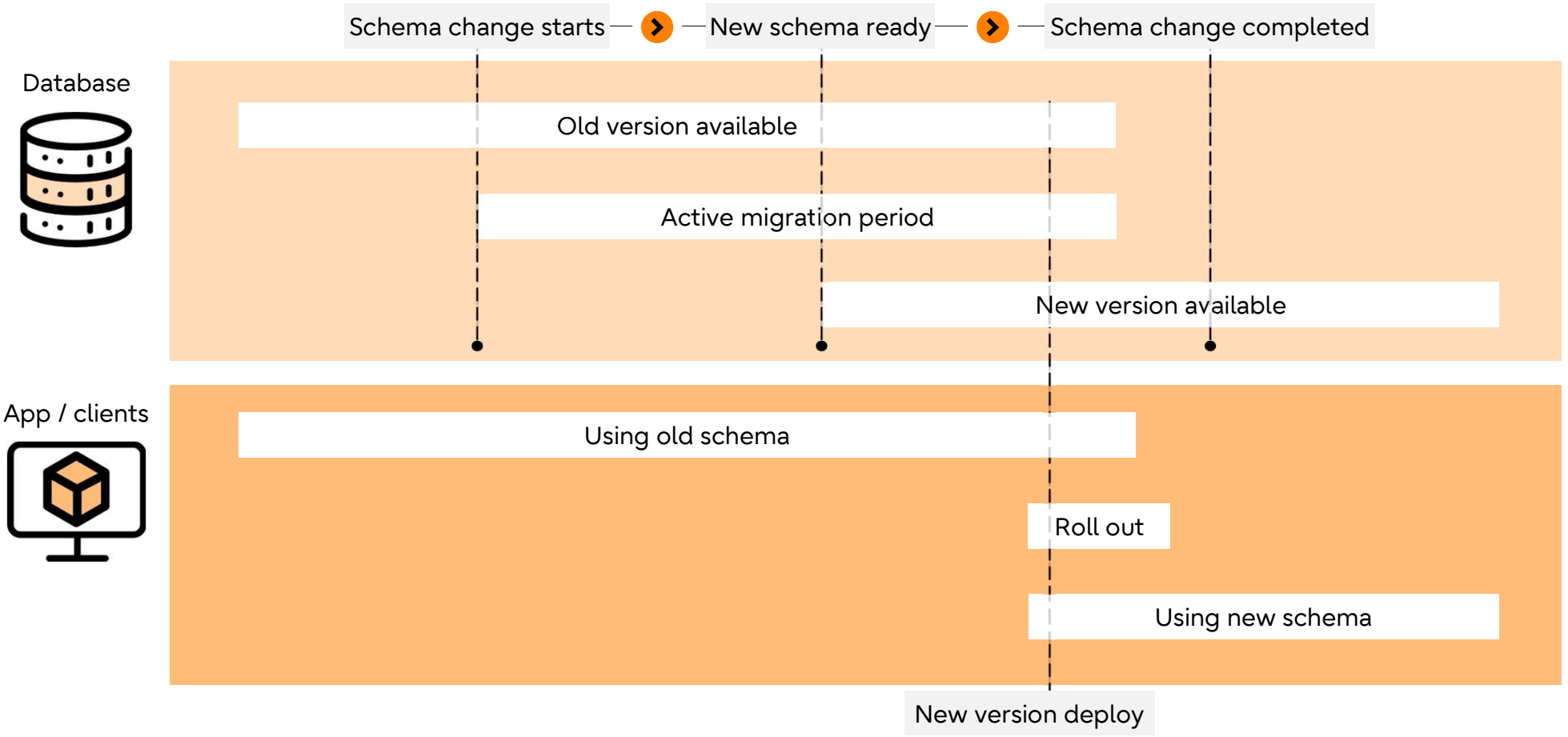
Schema changes flow



How it works

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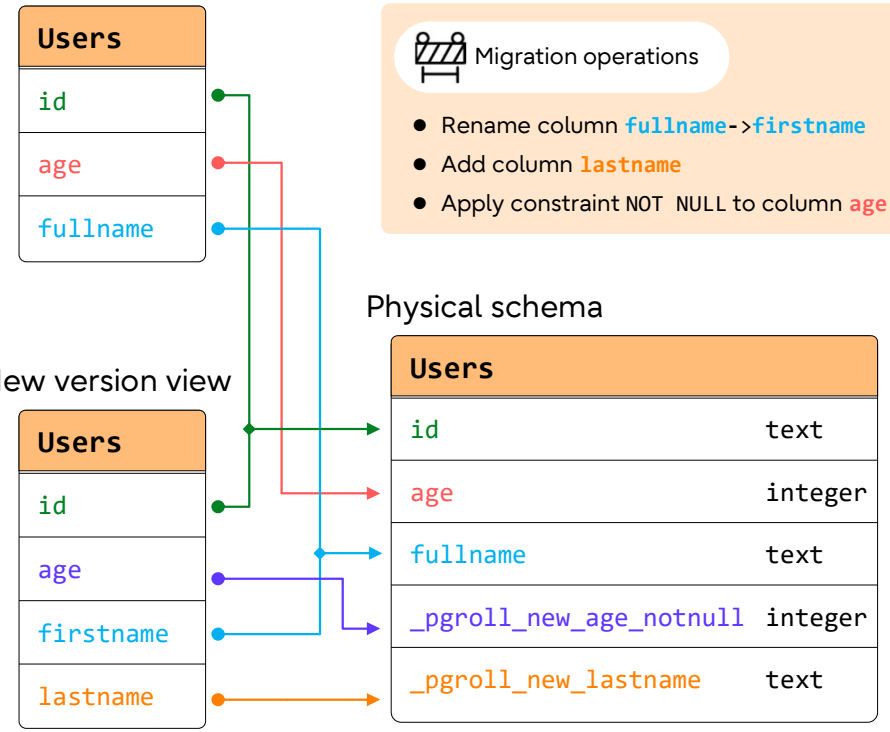
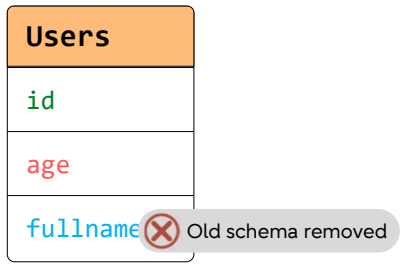
Active migration period

Old version view



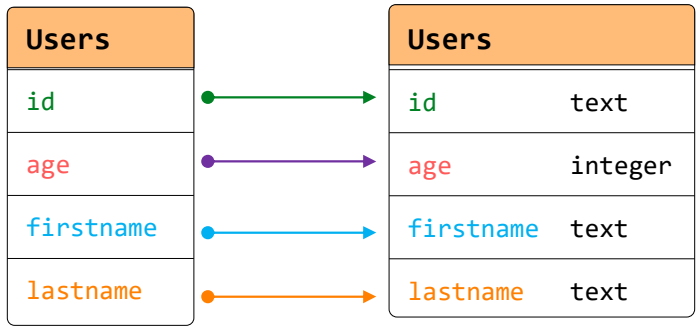
Migration complete

Old version view



New version view

Physical schema



How to install

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- Prerequisite: Go 1.24 or later

- To install pgroll from the source:

```
go install github.com/xataio/pgroll@latest
```

- The pgroll binary will be in `/root/go/bin`

- Copy the pgroll binary to `/usr/bin`

How to use

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- Prepare the database
  - Store some internal state in the database (Table & Functions)

SSL setup

```
pgroll init --postgres-url postgres://user:password@host:port/dbname
```

No SSL setup

```
pgroll init --postgres-url postgres://user:password@host:port/dbname?sslmode=disable
```

```
[fepuser@fep17-rhel9 ~]$ pgroll --postgres-url
postgres://fepuser:train@1987@localhost:27500/test_pgroll?sslmode=disable init
 SUCCESS  Initialization complete
[fepuser@fep17-rhel9 ~]$ psql -d test_pgroll
psql (17.0)
Type "help" for help.

test_pgroll=# \dn
      List of schemas
 Name   | Owner
--------+--------------------
 pgroll | fepuser
 public | pg_database_owner
(2 rows)

test_pgroll=# \dt pgroll.*
              List of relations
 Schema |      Name      | Type  |  Owner
--------+----------------+-------+---------
 pgroll | migrations     | table | fepuser
 pgroll | pgroll_version | table | fepuser
(2 rows)
```

How to add tables

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- Create a change file
  - You can check various examples at https://github.com/xataio/pgroll/tree/main/examples

```
vi create_users_table.json
{
 "operations": [
   {
     "create_table": {
       "name": "users",
       "columns": [
         {
           "name": "id",
           "type": "serial",
           "pk": true
         },
         {
           "name": "username",
           "type": "varchar(50)",
           "nullable": false
         },
         {
           "name": "email",
           "type": "varchar(100)",
           "nullable": true
         }
       ]
     }
   }
 ]
}
```

Users	
id	serial
username	varchar(50)
email	varchar(100)

How to add tables

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- Start the changes

```
[fepuser@fep17-rhel9 ~]$ pgroll --postgres-url postgres://fepuser:train@1987@localhost:27500/test_pgroll?sslmode=disable start create_users_table.json
 SUCCESS  New version of the schema available under the postgres "public_create_users_table" schema

[fepuser@fep17-rhel9 ~]$ psql -d test_pgroll
psql (17.0)
Type "help" for help.

test_pgroll=# \dt pgroll.*
           List of relations
 Schema |     Name   | Type  | Owner
--------+------------+-------+----------
 pgroll | migrations | table | fepuser
 (1 row)

test_pgroll=# SELECT * FROM pgroll.migrations;
 schema |       name         |                migration            | created at    | updated at    | parent | done | resulting schema | migration_type
--------+--------------------+-------------------------------------+---------------+---------------+--------+------+------------------+----------------
 public | create_users_table | {" operations": [{"create_table":... | 2025-09-15... | 2025-09-15... |        |   f  | {}               | pgroll
(1 row)

test_pgroll=# \dt public.*
              List of relations
 Schema | Name  | Type  |  Owner
--------+-------+-------+---------
 public | users | table | fepuser
(1 row)
```

How to add tables

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- Check the status and complete the changes

```
[fepuser@fep17-rhel9 ~]$ pgroll --postgres-url postgres://fepuser:train@1987@localhost:27500/test_pgroll?sslmode=disable status
{
  "schema": "public",
  "version": "create_users_table",
❯ "status": "In progress"
}

[fepuser@fep17-rhel9 ~]$ pgroll --postgres-url postgres://fepuser:train@1987@localhost:27500/test_pgroll?sslmode=disable complete
 SUCCESS  Migration successful!

[fepuser@fep17-rhel9 ~]$ psql -d test_pgroll
psql (17.0)
Type "help" for help.

test_pgroll=# \dt public.users
        List of relations
 Schema | Name  | Type  |  Owner
--------+-------+-------+---------
 public | users | table | fepuser
(1 row)

[fepuser@fep17-rhel9 ~]$ pgroll --postgres-url postgres://fepuser:train@1987@localhost:27500/test_pgroll?sslmode=disable status
{
  "schema": "public",
  "version": "create_users_table",
❯ "status": "Complete"
}
```

How to add columns

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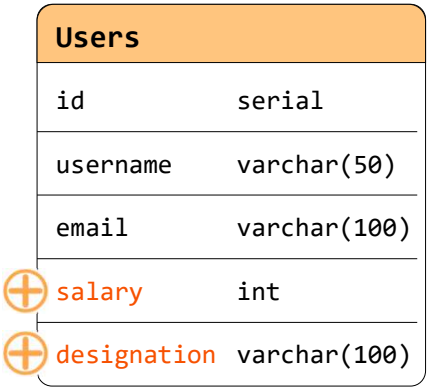
- Create a change file

```
vi add_salary_and_designation_to_users.json
{
"operations": [
    {
      "add_column": {
        "table": "users",
        "column": {
          "name": "salary",
          "type": "int",
          "nullable": false,
          "default": "5000"
        }
      }
    },
    {
      "add_column": {
        "table": "users",
        "column": {
          "name": "designation",
          "type": "varchar(100)",
          "nullable": true
        }
      }
    }
  ]
}
```



How to add columns

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- Start the changes and check the status

```
[fepuser@fep17-rhel9 ~]$ pgroll --postgres-url postgres://fepuser:train@1987@localhost:27500/test_pgroll?sslmode=disable start add_salary_and_designation_to_users.json
 SUCCESS  New version of the schema available under the postgres "public_add_salary_and_designation_to_users" schema

[fepuser@fep17-rhel9 ~]$ pgroll --postgres-url postgres://fepuser:train@1987@localhost:27500/test_pgroll?sslmode=disable status
{
  "schema": "public",
  "version": "add_salary_and_designation_to_users",
> "status": "In progress"
}

[fepuser@fep17-rhel9 ~]$ psql -d test_pgroll
psql (17.0)
Type "help" for help.

test_pgroll=# \d public.users
                                        Table "public.users"
         Column          |         Type           | Collation | Nullable |                    Default
-------------------------+------------------------+-----------+----------+-----------------------------------------------
 id                      | integer                |           | not null | nextval('_pgroll_new_users_id_seq'::regclass)
 username                | character varying(50)  |           | not null |
 email                   | character varying(100) |           |          |
> _pgroll_new_salary      | integer                |           | not null | 5000
> _pgroll_new_designation | character varying(100) |           |          |
Indexes:
    "users_pkey" PRIMARY KEY, btree (id)
```

How to add columns

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- Complete the changes

```
[fepuser@fep17-rhel9 ~]$ pgroll --postgres-url postgres://fepuser:train@1987@localhost:27500/test_pgroll?sslmode=disable complete
 SUCCESS  Migration successful!
[fepuser@fep17-rhel9 ~]$ psql -d test_pgroll
psql (17.0)
Type "help" for help.

test_pgroll=# \d public.users
 Table "public.users"
   Column    |         Type           | Collation | Nullable |                    Default
-------------+------------------------+-----------+----------+-----------------------------------------------
 id          | integer                |           | not null | nextval('_pgroll_new_users_id_seq'::regclass)
 username    | character varying(50)  |           | not null |
 email       | character varying(100) |           |          |
>salary      | integer                |           | not null | 5000
>designation | character varying(100) |           |          |
Indexes:
    "users_pkey" PRIMARY KEY, btree (id)
```

How to add indexes

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- Create a change file

```
vi add_create_index_to_users.json
{
  "operations": [
    {
      "create_index":
              {
        "name": "idx_salary_column",
        "table": "users",
        "columns":{
          "salary": {}
      }
              }
    }
  ]
}
```

Users		
id	serial	
username	varchar(50)	
email	varchar(100)	
salary	int	idx_salary_column
designation	varchar(100)	

How to add indexes

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- Start the changes and check the status

```
[fepuser@fep17-rhel9 ~]$ pgroll --postgres-url postgres://fepuser:train@1987@localhost:27500/test_pgroll?sslmode=disable start add_index_salary_column.json
SUCCESS New version of the schema available under the postgres "public_add_create_index_to_users" schema

[fepuser@fep17-rhel9 ~]$ pgroll --postgres-url postgres://fepuser:train@1987@localhost:27500/test_pgroll?sslmode=disable status
{
  "schema": "public",
  "version": "add_create_index_to_users",
❯ "status": "In progress"
}

[fepuser@fep17-rhel9 ~]$ psql -d test_pgroll
psql (17.0)
Type "help" for help.

test_pgroll=# \d public.users
                                        Table "public.users"
   Column    |         Type           | Collation | Nullable |                    Default
-------------+------------------------+-----------+----------+-----------------------------------------------
 id          | integer                |           | not null | nextval('_pgroll_new_users_id_seq'::regclass)
 username    | character varying(50)  |           | not null |
 email       | character varying(100) |           |          |
 salary      | integer                |           | not null | 5000
 designation | character varying(100) |           |          |
Indexes:
    "users_pkey" PRIMARY KEY, btree (id)
  ❯ "idx_salary_column" btree (salary)
```

How to add indexes

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- Roll back

```
[fepuser@fep17-rhel9 ~]$ pgroll --postgres-url postgres://fepuser:train@1987@localhost:27500/test_pgroll?sslmode=disable rollback
 SUCCESS  Migration rolled back. Changes made since the last version have been reverted

[fepuser@fep17-rhel9 ~]$ psql -d test_pgroll
psql (17.0)
Type "help" for help.

test_pgroll=# \d public.users
                                      Table "public.users"
   Column    |         Type           | Collation | Nullable |                    Default
-------------+------------------------+-----------+----------+-----------------------------------------------
 id          | integer                |           | not null | nextval('_pgroll_new_users_id_seq'::regclass)
 username    | character varying(50)  |           | not null |
 email       | character varying(100) |           |          |
 salary      | integer                |           | not null | 5000
 designation | character varying(100) |           |          |
Indexes:
  > "users_pkey" PRIMARY KEY, btree (id)

test_pgroll=# \q

[fepuser@fep17-rhel9 ~]$ pgroll --postgres-url postgres://fepuser:train@1987@localhost:27500/test_pgroll?sslmode=disable status
{
  "schema": "public",
  "version": "add_create_index_to_users",
> "status": "Complete"
}
```

Comparison with other tools

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	 pgroll	Liquibase Flyway	schemachange	DBeaver pgAdmin
	pgroll	**Liquibase & Flyway**	**Schemachange**	**Dbeaver & pgAdmin**
Purpose	Zero downtime, reversible schema changes	Schema versioning and migrations as part of CI/CD pipelines	Snowflake-specific migrations	Database management
Zero downtime	Ensures uninterrupted database operations	Not inherently designed for zero downtime, requires additional manual steps for the same	Not a primary focus	Not applicable

Q&A

Thank you

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