

Postgresql

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History

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Developed by PostgreSQL Global Development Group

- 1985 : post-ingres project
- 1989 : postgres v1
- 1994 : postgres95 with SQL instead of POSTQUEL, client psql
- 1996 : project renamed PostgreSQL + website postgresql.org
- 2016 : PostgreSQL 9.6
- 2017 : PostgreSQL 10
- 2018 : PostgreSQL 11
- 2019 : PostgreSQL 12
- 2020 : PostgreSQL 13
- 2021 : PostgreSQL 14
- 2022 : PostgreSQL 15
- 2023: PostgreSQL 16

Assets

- RDBMS (SGBDR)
- Compliance standard SQL (last version 2023): 99.99%
- Open-source (C/C++)
- Multi-platform
- Object, XML, JSon, Array
- Programming Languages
- Extensions : PostGIS, ...
- Clients : PgAdmin4, psql (CLI)

Architecture PostgreSQL

- Logic:
 - Database(s) : postgres by default
 - schema(s) : public (default, transparent, non secure)
 - Variable search_path = "\$user", public (by default)
 - Objects: table, view, sequence, index, ...
 - stored code : function, trigger (2 parts): language plpgsql, python, C, perl, ...
 - types
 - materialized view, foreign table
 - FDW (Foreign Data Wrapper)
 - NB: no synonym (schema+view)
 - User/role : postgres (user admin)
 - Physique : processus, système de fichiers

Types, functions, operators

<https://www.postgresql.org/docs/current/datatype.html>

- Numeric types :
 - smallint/smallserial, integer/serial, bigint/bigserial : intervals
 - numeric/decimal : integer or decimal with number of digits fixed
 - real/double precision : float numbers IEEE754
- temporal : timestamp, date, time, interval, with/without timezone
- boolean
- char(n), varchar(n), text
- xml, json/jsonb
- bytea : binary data
- geometric types (and more with PostGis)
- array version of each type : integer[]

Max size of data : 1GB (clob/blob : provided by an extension)

Primary Key

- smallserial, serial, bigserial (resp smallint, int, bigint)
 - sequence created and ids taken from the sequence by default
- Identity constraint (standard SQL)
 - sequence created

Functions and operators

Complete list here:

<https://www.postgresql.org/docs/current/functions.html>

- User : CURRENT_USER
- Conditional : case, coalesce, nullif
- Temporal : CURRENT_DATE, CURRENT_TIME, CURRENT_TIMESTAMP
 - DATE_STYLE parameter
 - Formats de types temporels et numériques :

<https://www.postgresql.org/docs/current/functions-formatting.html>

Server PostgreSQL

- 1st process :
 - postgres.exe -D directory_data (windows)
 - postgres -D directory_data (unix/linux)
- Multi-process server with shared memory
- Life cycle controlled by a service or tool pg_ctl : start/stop/restart/reload
- Create new server: initdb
 - encoding
 - locale
 - wal size
- Documentation:
 - <https://www.postgresql.org/docs/current/app-pg-ctl.html>
 - <https://www.postgresql.org/docs/current/app-initdb.html>

Data directory

Files :

- postgresql.conf : main configuration
- pg_hba.conf : access filters (user, host, database, authentication)

Directories :

- base : data of each database (oid as its name)
- global : global catalog (databases, users, tablespaces)
- log
- pg_tblspc : links to external tablespaces
- pg_wal : journaling files

Backup/Restore

<https://www.postgresql.org/docs/current/backup.html>

- Dump: backup, extraction
 - pg_dump (1 database), pg_dumpall (server, multi-databases, users)
 - psql or pg_restore to restore dump
- External File System Tool (zip, rar, tar, ..., cp, ...) : système arrêté
- PITR : Point In Time Recovery (uses files WAL)
 - Setup archiving WAL files
 - Backup database : pg_backup (copy data directory + tablespaces + tag WAL)
 - Recover database : 9 points process to follow

Tools : pg_dump/pg_dumpall

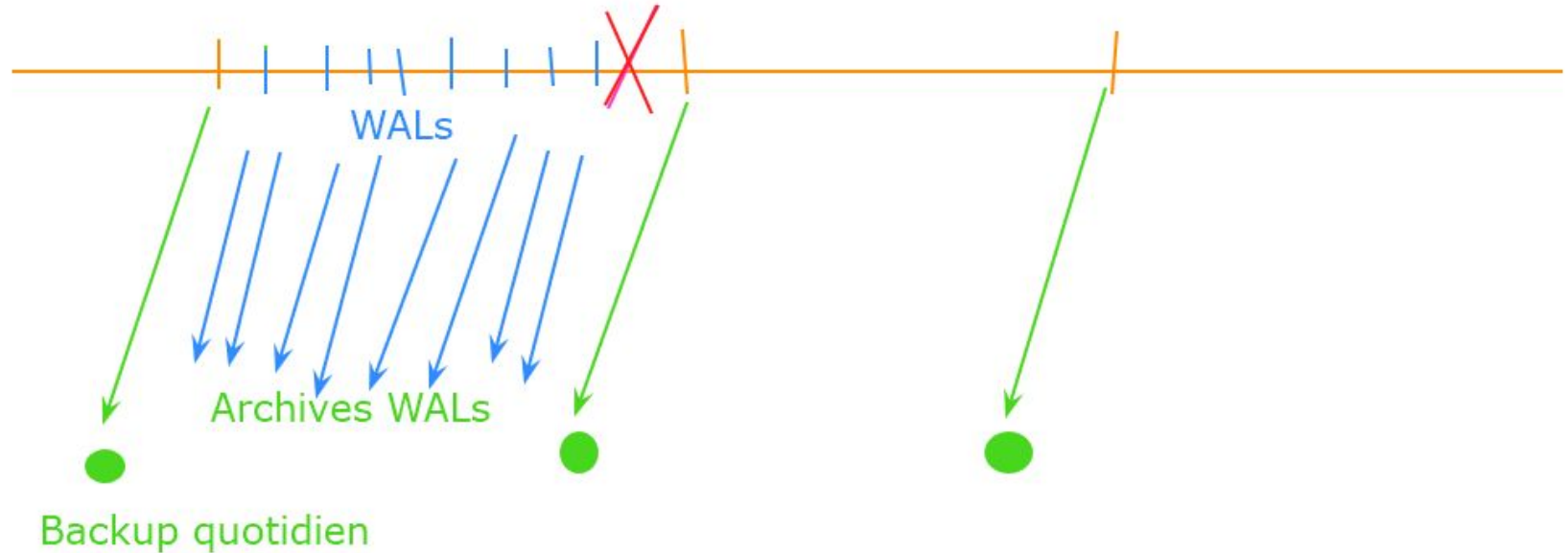
- Format : plain (SQL)
 - Backup with pg_dump => restore with psql
- Format : custom, directory, tar
 - Backup with pg_dump => restore with pg_restore
- Main switches :
 - -F format : plain, tar, directory, custom
 - -E encoding
 - -c --clean + --if-exists : drop objects before recreating
 - Data only : -a --data-only + --disable-triggers (--inserts/--column-inserts for insert vs copy)
 - DDL only : -s --schema-only
 - Selection : -n -N (schema) -t -T (table), include or Exclude

Continuous Archiving Logs

<https://www.postgresql.org/docs/current/wal-configuration.html>

- WAL : Write Ahead Log, journalization files
 - Switch on archiving in postgresql.conf
 - Choose command or script to archive : copy, cp, scp, ftp, ...
 - Choose command or script to restore archives
 - pg_switch_wal function
- Current WAL is tagged backup while backuping database
- File recovery.conf => recovery.done (recovery.signal PG 12+)
 - control recover process
 - parameterized in postgresql since PG 12

Backup + Continuous archive WALs



Vacuum

- <https://www.postgresql.org/docs/current/routine-vacuuming.html>
- Each table, index, sequence has at least:
 - 1 file of data (relfilenode)
 - 1 file FSM : free space map (fragmentation)
 - 1 file VM : visibility map (current tuples used in transactions)
- Big table, index can use:
 - Several files
 - Toast technique
- Vacuum : simple or combined with analyze and full mode
- Autovacuum: parameters in postgresql.conf

Indexation

<https://www.postgresql.org/docs/current/indexes.html>

<https://www.postgresql.org/docs/current/sql-createindex.html>

<https://www.postgresql.org/docs/current/sql-reindex.html>

- B-tree: =, <, between, like, ~ (begin pattern fix: 'Star%', '^Star')
- hash: =
- GiST: GiS index with GiS operators
- SP-GiST: more complex GiS index
- GIN: inverted index (for array, full text search)
- BRIN: Block Range Indexes

Query Planner

<https://www.postgresql.org/docs/current/runtime-config-query.html>

<https://www.postgresql.org/docs/current/planner-stats.html>

<https://www.postgresql.org/docs/current/runtime-config-query.html>

- Explain, Explain Analyze
- Statistics:
 - reltuples, relpages: in pg_class
 - others in pg_statistics (pg_stats for human read)
- Just In Time compilation

Optimize Plan

- Optimize plan:
 - Adjust costs
 - Increase default_statistics_target
 - ALTER TABLE SET STATISTICS
 - Create statistics (dependencies, ndistinct)
 - Supervision Queries:
 - extension/view: pg_stat_statements
- <https://www.postgresql.org/docs/current/pgstatstatements.html>

Supervision

- Database:
 - service or pg_ctl tool or signal: start|stop|restart|reload
 - pg_reload_conf function
 - pg_rotate_logfile function
- Transactions : pg_lock
- Sessions : pg_stat_activity
 - Kill session : pg_terminate_backend
 - Kill request : pg_cancel_backend
 - Tutorial: https://wiki.postgresql.org/wiki/Lock_Monitoring
- Disk : <https://www.postgresql.org/docs/current/functions-admin.html>
 - functions computing size of database, schema, tablespace, table, index
 - functions to obtain filepath or oid from object name (table, index, sequence, ...)

Configuration

- PostgreSQL.conf
 - listener/port
 - memory
 - wal, disk writing
 - directories, logs
 - statistics, costs
 - autovacuum
 - restore/recover
- Pg_hba.conf : protocol, database, user, computer, authentic

<https://www.postgresql.org/docs/current/config-setting.html>

https://wiki.postgresql.org/wiki/Performance_Optimization