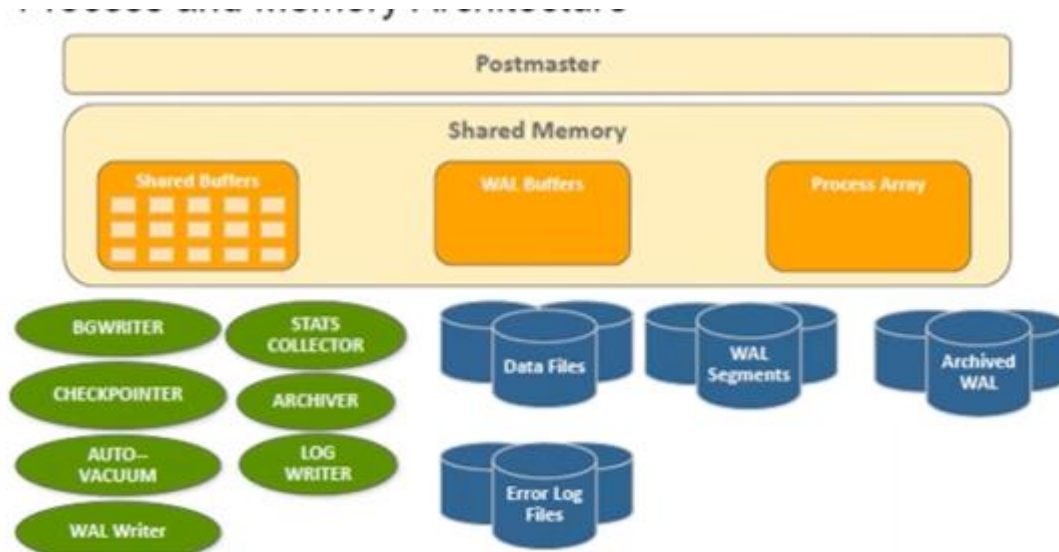


PostgreSQL Architecture

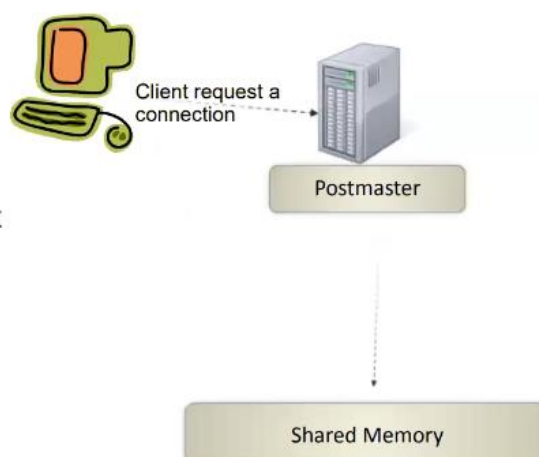


Postmaster

- The **Postmaster** is the main controller process that manages connections, initiates child processes, and oversees the overall database system.
- Postmaster process acts as the main server process and functions as the **listener** for client connections.

Postmaster as Listener

- Postmaster is the master process called postgres
- Listens on 1-and-only-1 tcp port
- Receives client connection request



2. Shared Memory

PostgreSQL uses shared memory for caching and storing critical information. It includes:

- **Shared Buffers:** Cache frequently accessed data pages from disk.
- **WAL Buffers:** Cache for the Write-Ahead Log (WAL) entries, which ensures data integrity.
- **Process Array:** An array to track the various running processes.

Background Processes

1. **WAL Writer:** Writes changes from the Write-Ahead Logging (WAL) buffer to disk.
2. **Checkpointer:** Periodically saves dirty buffers to disk to ensure data persistence.
3. **Background Writer:** Flushes dirty pages to disk, reducing the load on checkpoints.
4. **Archiver:** Handles WAL file archiving for backups.
5. **Logger process:** is responsible for handling all logging operations. It collects and writes error messages, activity logs, and other notices generated by the database server to log files.
6. **Autovacuum:** Cleans up dead tuples and updates table statistics.

Control logging behaviour through various settings in the `postgresql.conf` file, such as:

- `log_min_messages`: Defines the severity level of messages logged.
- `log_directory` and `log_filename`: Specify where the logs are stored.

wal_level parameter controls the amount of Write-Ahead Logging (WAL) data that is generated by the database server. Especially concerning replication and point-in-time recovery.

wal_level Settings

1. **minimal:**
 - Only enough WAL is generated to ensure the durability of transactions.
 - This level does not support replication or point-in-time recovery.
2. **replica** (default for most installations):
 - Generates additional WAL for replication.
 - This level allows for streaming replication and point-in-time recovery.
3. **logical:**
 - Includes all the information needed for logical replication.
 - This level allows changes to be captured in a format that can be sent to other systems (like logical decoding).

max_wal_size

- **Definition:** Maximum size that WAL files can grow before forcing a checkpoint.
- **Default:** Typically **1 GB**.
- **Purpose:** Controls disk space used by WAL; limits accumulation to improve performance and reduce I/O.

min_wal_size

- **Definition:** Minimum size for WAL files that PostgreSQL tries to maintain.
- **Default:** Typically **80 MB**.
- **Purpose:** Ensures sufficient WAL space is available to minimize overhead from creating/removing WAL files.

```
postgres=# show max_wal_size;
max_wal_size
-----
1GB
(1 row)
```

```
postgres=# show min_wal_size;
min_wal_size
-----
80MB
(1 row)
```

Checkpoint Trigger:

- When the size of the WAL files exceeds the `max_wal_size` limit, PostgreSQL will automatically trigger a checkpoint.
- The `checkpoint_timeout` being reached.

Logging configuration is managed through the `postgresql.conf` file,

Key Logging Parameters

1. **log_destination:** Defines where to send log messages.
 - **Options:** `stderr`, `csvlog`, `syslog`, or `eventlog` (on Windows).
`log_destination = 'stderr'` → Standard Errors
2. **logging_collector:** If enabled, it captures log messages and directs them to log files.
 - **Default:** `off`
`logging_collector = on`
3. **log_directory:** Directory where log files are stored.

- **Default:** Typically set to `pg_log` or similar.
`log_directory = 'pg_log'`

under PGDATA/pg_log

4. **log_filename:** The name format for log files.

`log_filename = 'postgresql-%Y-%m-%d_%H%M%S.log'`

```
postgres=# show log_filename;
log_filename
-----
postgresql-%a.log
(1 row)
```

%a → day of the week Mon,tue,wed ...

```
Primary postgres@Primary log$ ls -lrt
total 68
-rw-----. 1 postgres postgres 58864 Oct 21 06:24 postgresql-Sun.log
-rw-----. 1 postgres postgres   869 Oct 21 22:32 postgresql-Mon.log
-rw-----. 1 postgres postgres  2775 Oct 22 21:59 postgresql-Tue.log
```

5. **log_statement:** Controls which SQL statements are logged.

- **Options:** none, ddl, mod, all.
`log_statement = 'all'`

6. **log_min_error_statement:** Minimum error level for statements to be logged.

`log_min_error_statement = 'error' | 'Warning'` → it will write errors or warning to the logs

7. **log_line_prefix:** Prefix to add to each log line, useful for adding timestamps, user info, etc.

`log_line_prefix = '%m [%p]: [%l-1] user=%u,db=%d '`

8. **log_rotation_age:** Determines how often log files are rotated based on age.

`log_rotation_age = 1d`

9. **log_rotation_size:** Maximum size of log files before rotation occurs.

`log_rotation_size = 10MB`

10. **log_checkpoints** provides valuable insight into the database's checkpointing behavior,
Default Value: off

Connection options:

```
Connection options:
-h, --host=HOSTNAME      database server host or socket directory (default: "local socket")
-p, --port=PORT          database server port (default: "5432")
-U, --username=USERNAME  database user name (default: "postgres")
-w, --no-password        never prompt for password
-W, --password           force password prompt (should happen automatically)
```

Autovacuum is a background process that manages dead tuples and reclaims storage space automatically. This process ensures that table statistics are up-to-date and prevents table bloat. Key configuration options include:

- **autovacuum_vacuum_threshold:** The minimum number of dead tuples before a vacuum runs.
- **autovacuum_analyze_threshold:** Sets the threshold for triggering an analyze operation.
- **autovacuum_naptime:** Controls the interval between autovacuum runs.

Autovacuum works with the **Free Space Map (FSM)** to track and reuse free space efficiently, reducing storage bloat and maintaining performance.