Cluster File Encryption in Postgres

BRUCE MOMJIAN

This presentation explains the design of cluster file encryption in Postgres.

https://momjian.us/presentations

Last updated: June 2022

What Is Cluster File Encryption?

Cluster File Encryption (CFE) is a Postgres feature currently under development that will encrypt all user data stored in the file system

- Uses two-levels of encryption
- Cluster-level key (key encryption key) is stored externally
- Data encryption keys are encrypted with the cluster key
- Encrypts only files containing user data, not all files
- Uses AES128, AES192, or AES256
- Heap/index file encryption overhead is 2-4%; WAL encryption will cause additional overhead

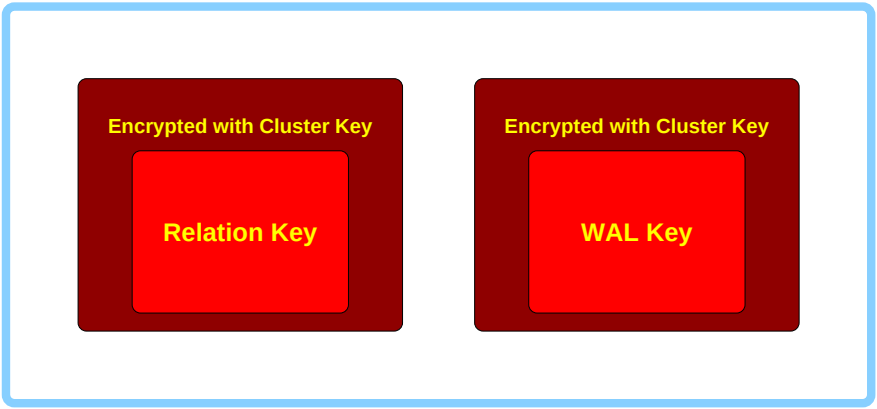
https://github.com/postgres/postgres/compare/master..bmomjian:_cfe-01-doc.patch

Protections

- Prevents users with read access on the directories from being able to access the user data stored in those files
- Provides data-at-rest security, including physical backups
- Does not protect against unauthorized file system writes
- Does not protect against users who have read access to database process memory

Key Storage

$PGDATA/pg_cryptokeys



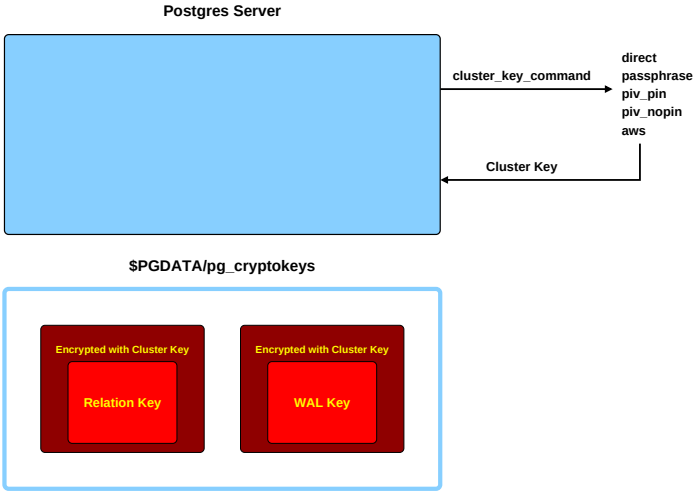
Cluster Key Retrieval

The cluster key, which unlocks the data keys stored in the file system, can be retrieved from:

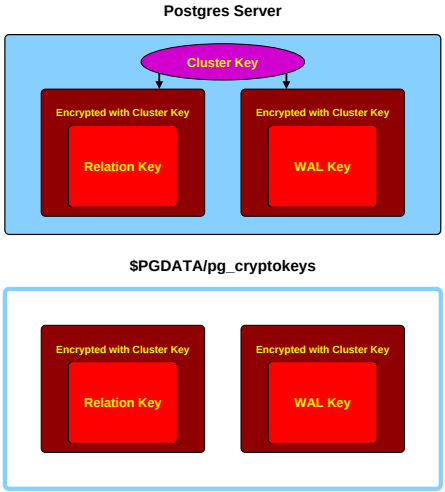
- User's terminal
- Cryptographic hardware
- External key store

https://github.com/postgres/postgres/compare/bmomjian:cfe-02-internaldoc..bmomjian:_cfe-03-scripts.patch

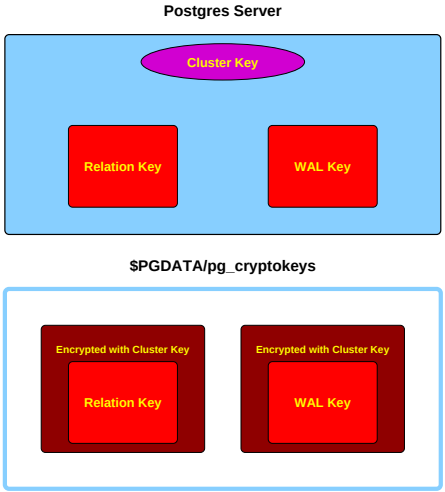
Key Retrieval



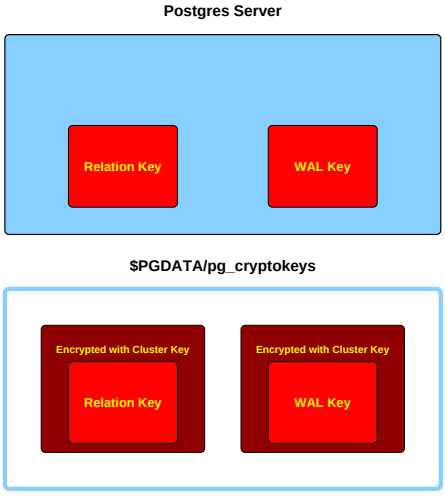
Using the Cluster Key



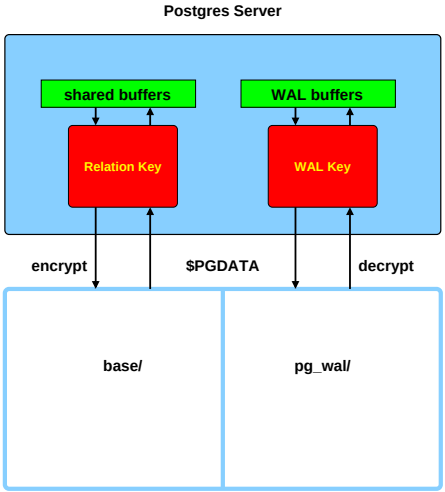
Unlocking Keys



Erasing the Cluster Key



Encryption/Decryption



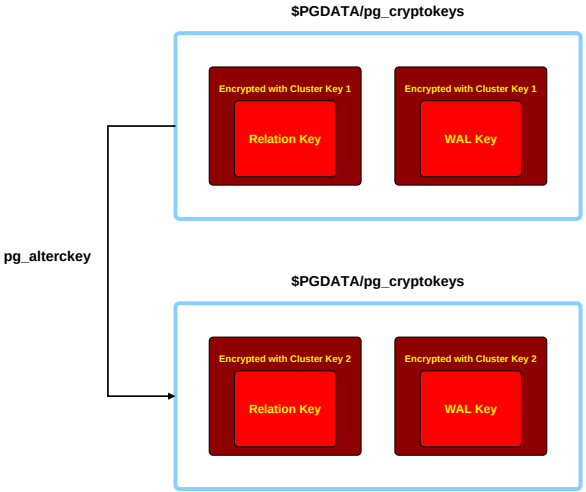
Key Rotation

Cluster file encryption allows cluster key and data key rotation

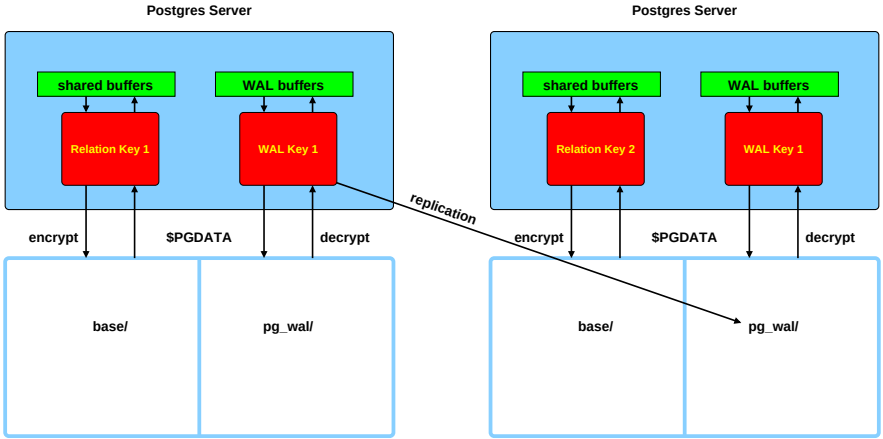
- Cluster key rotation is accomplished by running `pg_alterckey`, https://github.com/postgres/postgres/compare/bmomjian:cfe-07-bin..bmomjian:_cfe-08-pg_alterckey.patch
- Data key rotation is accomplished by creating a standby with a different data key and switching to it, then changing the WAL key

Encryption can be added to an existing cluster by creating and switching to a standby server that has encryption enabled.

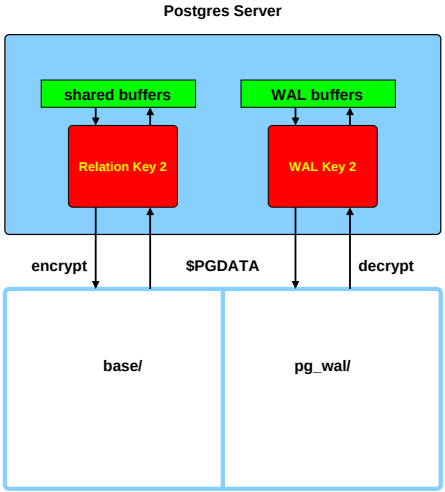
Cluster Key Rotation



Relation Key Rotation Using Replication



WAL Key Rotation



Current Status

- Dedicated feature page, https://wiki.postgresql.org/wiki/Transparent_Data_Encryption
- Several pending patches, https://wiki.postgresql.org/wiki/Transparent_Data_Encryption#Patches
- Testing possible
- Patch application is planned for Postgres 16
- Postgres 16 release planned for September/October 2023

Conclusion

https://momjian.us/presentations

https://www.flickr.com/photos/08dreizehn/