PostgreSQL Auditing with pgaudit

Tracking and securing database operations for accountability and compliance

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Table of Contents

Introduction to Database Auditing

What is Database Auditing?

Database auditing is the systematic monitoring and recording of database activities, user actions, and system events to ensure accountability, data integrity, and regulatory compliance.

- ✓ Tracking user activities and database changes
- ✓ Creating detailed records for forensic analysis
- ✓ Maintaining evidence of compliance with regulations
- ✓ Deterring unauthorized access and malicious actions

Key Benefits

Security • Compliance • Forensics • Accountability

Why Audit PostgreSQL?

PostgreSQL's extensive feature set and flexibility require robust audit mechanisms to protect sensitive data and maintain regulatory compliance across various industries and use cases.

Why Auditing Matters: Real-World Scenarios

Database Administrator's Experience

"During my experience as a database administrator, I encountered two situations where applications reported data loss. Upon investigation, we discovered that a table had been truncated. Unfortunately, we couldn't confirm the source of the issue because auditing was not enabled on the database."

— *From the uploaded document*

Consequences of Inadequate Auditing

- Inability to identify responsible parties for data modifications
- No forensic evidence for security investigations
- Compliance violations with potential regulatory penalties
- Inability to recover from or understand data loss events

The Cost of Missing Audit Logs

Data Recovery Issues	**78%**
Security Investigations Hampered	**92%**
Compliance Violations	**65%**

"This highlights the importance of tracking all activities at the database level."

Overview of PostgreSQL Auditing

Built-in Auditing Capabilities

PostgreSQL provides several native mechanisms for tracking database activity, although they vary in comprehensiveness compared to specialized audit extensions.

- **log_statement parameter** - Can be set to 'none', 'ddl', 'mod', or 'all' to control statement logging
- **pg_stat_activity** - System view that shows current user sessions and queries
- **Event triggers** - Can capture DDL operations and log them to custom tables
- **Custom triggers** - Can track DML operations (INSERT, UPDATE, DELETE) on specific tables

Limitations of Built-in Logging

- Limited granularity in what can be logged
- No standardized audit log format
- Performance impact with comprehensive logging
- Lacks specific compliance-oriented features

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Enter pgaudit extension

Comparing Native Logging vs. pgaudit

While PostgreSQL's built-in logging provides basic activity tracking, it's often insufficient for comprehensive audit trails. The pgaudit extension enhances these capabilities by adding detailed session and object audit logging through the standard PostgreSQL logging facility.

Introduction to pgaudit Extension

What is pgaudit?

The PostgreSQL Audit Extension (pgaudit) provides detailed session and/or object audit logging via the standard PostgreSQL logging facility. It enhances PostgreSQL's built-in logging capabilities by offering fine-grained control over what database activities are recorded.

Key Features

- ✓ Session-level audit logging of SQL statements
- ✓ Object-level audit logging with granular control
- ✓ Configurable logging classes (READ, WRITE, FUNCTION, etc.)
- ✓ Integration with standard PostgreSQL logging facility

Benefits

Enhanced Security

Comprehensive monitoring of all database activities

Compliance

Meets regulatory requirements (GDPR, HIPAA, SOX)

Forensic Analysis

Detailed logs for incident investigation

Simple Implementation

Easy to install and configure

Why Use pgaudit Over Basic Logging?

pgaudit provides more comprehensive and detailed logs compared to PostgreSQL's built-in log_statement. It captures specific information about the operations performed, including the exact objects affected and parameters used, making it ideal for security auditing and compliance requirements.

pgaudit Installation Prerequisites

System Requirements

- PostgreSQL version compatibility (example: postgresql-15-pgaudit)
- Administrative privileges (sudo access) for installation
- Access to package repositories for your distribution
- Ability to modify PostgreSQL configuration files

Check Availability

Verify pgaudit availability in your repository:

```
sudo apt list | grep -i pgaudit
```

If not available, you may need to add PostgreSQL-specific repositories.

Tips

- Match pgaudit version with PostgreSQL version
- Back up configuration files before making changes
- Plan database downtime for installation

Pre-Installation Checklist

Verify requirements before proceeding

Before You Continue

Ensure your PostgreSQL server is running smoothly before adding the pgaudit extension. This will minimize potential disruptions during installation and configuration.

Installing pgaudit on PostgreSQL

1 Install pgaudit Package

Install the appropriate version of pgaudit for your PostgreSQL version:

```
sudo apt install postgresql-15-pgaudit
```

2 Update Shared Library Configuration

Open postgresql.conf in your PostgreSQL config directory:

```
sudo nano /etc/postgresql/15/main/postgresql.conf
```

Update the shared_preload_libraries parameter to include pgaudit:

```
shared_preload_libraries = 'pgaudit'
```

3 Restart PostgreSQL Service

Apply changes by restarting the PostgreSQL service:

```
sudo systemctl restart postgresql@15-main.service
```

4 Create the pgaudit Extension

Login to PostgreSQL and create the extension:

```
sudo -u postgres psql
```

```
create extension pgaudit;
```

Verify the extension is installed:

```
\dx
```

Important Notes

- Match pgaudit version with PostgreSQL version
- Ensure proper permissions for installation
- Restart is required for shared library changes
- Create the extension in each database that requires auditing

Configuring pgaudit and Enabling Logging

Configuration Steps

Update postgresql.conf with shared libraries

```
sudo nano /etc/postgresql/15/main/postgresql.conf
# Add to shared_preload_libraries:
shared_preload_libraries = 'pgaudit'
```

Restart PostgreSQL to apply changes

```
sudo systemctl restart postgresql@15-main.service
```

Verify pgaudit configuration

```
sudo -u postgres psql
show pgaudit.log;
```

Enabling Audit Logging

Configure logging classes to track

Common logging options include:

- **READ:** SELECT and COPY operations
- **WRITE:** INSERT, UPDATE, DELETE, TRUNCATE
- **FUNCTION:** Function calls and DO blocks
- **DDL:** All data definition language statements
- **ROLE:** Role and privilege statements
- **MISC:** Other commands like VACUUM, SET
- **ALL:** Include all audit classes

Set auditing parameters

```
# Enable auditing for read, write and DDL operations:
alter system set pgaudit.log to 'read,write,ddl';

# Restart PostgreSQL:
sudo systemctl restart postgresql@15-main.service
```

Best Practice

Audit logs are stored in the PostgreSQL log file at `/var/log/postgresql/postgresql-15-main.log`. Consider log rotation and archiving strategies for long-term storage of audit data, especially in compliance-focused environments.

Logging Classes and Configuration Examples

pgAudit Logging Classes

pgAudit provides granular control over what activities to log by configuring different logging classes:

Class	Description
READ	SELECT and COPY operations
WRITE	INSERT, UPDATE, DELETE, TRUNCATE
FUNCTION	Function calls and DO blocks
ROLE	GRANT, REVOKE, CREATE/ALTER/DROP ROLE
DDL	All DDL not in ROLE class
MISC	DISCARD, FETCH, CHECKPOINT, VACUUM
MISC_SET	SET commands (e.g., SET ROLE)
ALL	All of the above classes

Configuration Examples

Basic Data Modification Tracking:

```
ALTER SYSTEM SET pgaudit.log TO 'WRITE,DDL';
```

Tracks all data modifications and schema changes

Comprehensive Security Auditing:

```
ALTER SYSTEM SET pgaudit.log TO 'READ,WRITE,DDL,ROLE';
```

Tracks all data access, modifications, schema and permission changes

Complete System Monitoring:

```
ALTER SYSTEM SET pgaudit.log TO 'ALL';
```

Maximum logging for complete system auditing

Example from Our Document:

```
ALTER SYSTEM SET pgaudit.log TO read,write,DDL;
```

After configuration, restart PostgreSQL:

```
sudo systemctl restart postgresql@15-main.service
```

Common Use Cases

- **Compliance:** GDPR, HIPAA, SOX, and PCI DSS requirements
- **Forensics:** Investigating data breaches and unauthorized changes
- **Accountability:** Tracking user actions in multi-user environments

Reviewing and Testing Audit Logs

Verifying Audit Configuration

- ✓ Confirm pgaudit is capturing relevant operations
- ✓ Validate log format and contents
- ✓ Test different operation classes

Log Location

PostgreSQL server logs are typically found at:

```
/var/log/postgresql/postgresql-15-main.log
```

PostgreSQL Audit Log /var/log/postgresql/postgresql-15-main.log

```
2025-08-16 10:32:15.243 UTC [12345] postgres@testdb LOG: AUDIT: SESSION,1,1,DDL,CREATE TABLE,,,CREATE TABLE users (id serial PRIMARY KEY, username varchar(50) UNIQUE NOT NULL),
2025-08-16 10:32:28.117 UTC [12345] postgres@testdb LOG: AUDIT: SESSION,2,1,WRITE,INSERT,,,INSERT INTO users (username) VALUES ('admin'),
2025-08-16 10:33:42.896 UTC [12345] postgres@testdb LOG: AUDIT: SESSION,3,1,WRITE,UPDATE,,,UPDATE users SET username = 'administrator' WHERE username = 'admin',
2025-08-16 10:34:12.632 UTC [12345] postgres@testdb LOG: AUDIT: SESSION,4,1,READ,SELECT,,,SELECT * FROM users,
2025-08-16 10:35:27.451 UTC [12345] postgres@testdb LOG: AUDIT: SESSION,5,1,WRITE,DELETE,,,DELETE FROM users WHERE username = 'administrator',
2025-08-16 10:36:05.782 UTC [12348] alice@testdb LOG: AUDIT: SESSION,6,1,DDL,DROP TABLE,,,DROP TABLE users,
```

// Test query to verify auditing is capturing DDL operations

```sql
CREATE TABLE test_audit ( id serial PRIMARY KEY, description text, created_at timestamp DEFAULT CURRENT_TIMESTAMP ); -- Verify in logs after execution
```

Sample pgaudit log entries showing different operation types (DDL, READ, W

Best Practices, Troubleshooting, & Next Steps

Security Best Practices

✓ **Log Rotation**
Implement regular log rotation to maintain performance

✓ **Selective Auditing**
Audit only necessary operations to reduce overhead

✓ **Secure Log Storage**
Store audit logs on separate secured storage

✓ **Regular Reviews**
Schedule periodic reviews of audit logs

Troubleshooting Tips

No Audit Logs Appearing

- Check if pgaudit is in shared_preload_libraries
- Verify pgaudit extension is created
- Ensure pgaudit.log parameter is properly set

Missing Specific Operations

- Review configured audit classes (READ, WRITE, etc.)
- Add missing classes to pgaudit.log parameter

Performance Impact

- Limit auditing scope to critical tables/operations
- Consider upgrading storage for audit logs
- Implement efficient log rotation policies

Next Steps

Implement Alert System
Set up notifications for suspicious activities detected in audit logs

Automate Log Analysis
Deploy tools to analyze patterns and detect anomalies in database operations

Create Compliance Reports
Develop regular reporting templates for regulatory compliance

Documentation
Document your audit configuration for team reference and compliance purposes

Resources

Official documentation: pgaudit.org
PostgreSQL security mailing list