

# IDS00-J. Prevent SQL injection

SQL injection vulnerabilities arise in applications where elements of a SQL query originate from an untrusted source. Without precautions, the [untrusted data](#) may maliciously alter the query, resulting in information leaks or data modification. The primary means of preventing SQL injection are [sanitization](#) and validation, which are typically implemented as parameterized queries and stored procedures.

Suppose a system authenticates users by issuing the following query to a SQL database. If the query returns any results, authentication succeeds; otherwise, authentication fails.

```
SELECT * FROM db_user WHERE username='<USERNAME>' AND
        password='<PASSWORD>'
```

Suppose an attacker can substitute arbitrary strings for `<USERNAME>` and `<PASSWORD>`. In that case, the authentication mechanism can be bypassed by supplying the following `<USERNAME>` with an arbitrary password:

```
validuser' OR '1'='1
```

The authentication routine dynamically constructs the following query:

```
SELECT * FROM db_user WHERE username='validuser' OR '1'='1' AND password='<PASSWORD>'
```

If `validuser` is a valid user name, this `SELECT` statement yields the `validuser` record in the table. The password is never checked because `username='validuser'` is true; consequently, the items after the `OR` are not tested. As long as the components after the `OR` generate a syntactically correct SQL expression, the attacker is granted the access of `validuser`.

Similarly, an attacker could supply the following string for `<PASSWORD>` with an arbitrary username:

```
' OR '1'='1
```

producing the following query:

```
SELECT * FROM db_user WHERE username='<USERNAME>' AND password='' OR '1'='1'
```

`'1'='1'` always evaluates to true, causing the query to yield every row in the database. In this scenario, the attacker would be authenticated without needing a valid username or password.

## Noncompliant Code Example

This noncompliant code example shows JDBC code to authenticate a user to a system. The password is passed as a `char` array, the database connection is created, and then the passwords are hashed.

Unfortunately, this code example permits a SQL injection attack by incorporating the unsanitized input argument `username` into the SQL command, allowing an attacker to inject `validuser' OR '1'='1`. The `password` argument cannot be used to attack this program because it is passed to the `hashPassword()` function, which also [sanitizes](#) the input.

```

import java.sql.Connection;
import java.sql.DriverManager;
import java.sql.ResultSet;
import java.sql.SQLException;
import java.sql.Statement;

class Login {
    public Connection getConnection() throws SQLException {
        DriverManager.registerDriver(new
            com.microsoft.sqlserver.jdbc.SQLServerDriver());
        String dbConnection =
            PropertyManager.getProperty("db.connection");
        // Can hold some value like
        // "jdbc:microsoft:sqlserver://<HOST>:1433,<UID>,<PWD>"
        return DriverManager.getConnection(dbConnection);
    }

    String hashPassword(char[] password) {
        // Create hash of password
    }

    public void doPrivilegedAction(String username, char[] password)
        throws SQLException {
        Connection connection = getConnection();
        if (connection == null) {
            // Handle error
        }
        try {
            String pwd = hashPassword(password);

            String sqlString = "SELECT * FROM db_user WHERE username = '"
                + username +
                "' AND password = '" + pwd + "'";
            Statement stmt = connection.createStatement();
            ResultSet rs = stmt.executeQuery(sqlString);

            if (!rs.next()) {
                throw new SecurityException(
                    "User name or password incorrect"
                );
            }

            // Authenticated; proceed
        } finally {
            try {
                connection.close();
            } catch (SQLException x) {
                // Forward to handler
            }
        }
    }
}

```

## Noncompliant Code Example (PreparedStatement)

The JDBC library provides an API for building SQL commands that sanitize [untrusted data](#). The `java.sql.PreparedStatement` class properly escapes input strings, preventing SQL injection when used correctly. This code example modifies the `doPrivilegedAction()` method to use a `PreparedStatement` instead of `java.sql.Statement`. However, the prepared statement still permits a SQL injection attack by incorporating the unsanitized input argument `username` into the prepared statement.

```

import java.sql.Connection;
import java.sql.DriverManager;
import java.sql.ResultSet;
import java.sql.SQLException;
import java.sql.Statement;

class Login {
    public Connection getConnection() throws SQLException {
        DriverManager.registerDriver(new
            com.microsoft.sqlserver.jdbc.SQLServerDriver());
        String dbConnection =
            PropertyManager.getProperty("db.connection");
        // Can hold some value like
        // "jdbc:microsoft:sqlserver://<HOST>:1433,<UID>,<PWD>"
        return DriverManager.getConnection(dbConnection);
    }

    String hashPassword(char[] password) {
        // Create hash of password
    }

    public void doPrivilegedAction(
        String username, char[] password
    ) throws SQLException {
        Connection connection = getConnection();
        if (connection == null) {
            // Handle error
        }
        try {
            String pwd = hashPassword(password);
            String sqlString = "select * from db_user where username=" +
                username + " and password =" + pwd;
            PreparedStatement stmt = connection.prepareStatement(sqlString);

            ResultSet rs = stmt.executeQuery();
            if (!rs.next()) {
                throw new SecurityException("User name or password incorrect");
            }

            // Authenticated; proceed
        } finally {
            try {
                connection.close();
            } catch (SQLException x) {
                // Forward to handler
            }
        }
    }
}

```

## Compliant Solution (PreparedStatement)

This compliant solution uses a parametric query with a ? character as a placeholder for the argument. This code also validates the length of the username argument, preventing an attacker from submitting an arbitrarily long user name.

```

public void doPrivilegedAction(
    String username, char[] password
) throws SQLException {
    Connection connection = getConnection();
    if (connection == null) {
        // Handle error
    }
    try {
        String pwd = hashPassword(password);

        // Validate username length
        if (username.length() > 8) {
            // Handle error
        }

        String sqlString =
            "select * from db_user where username=? and password=?";
        PreparedStatement stmt = connection.prepareStatement(sqlString);
        stmt.setString(1, username);
        stmt.setString(2, pwd);
        ResultSet rs = stmt.executeQuery();
        if (!rs.next()) {
            throw new SecurityException("User name or password incorrect");
        }

        // Authenticated; proceed
    } finally {
        try {
            connection.close();
        } catch (SQLException x) {
            // Forward to handler
        }
    }
}

```

Use the `set*()` methods of the `PreparedStatement` class to enforce strong type checking. This technique mitigates the SQL injection [vulnerability](#) because the input is properly escaped by automatic entrapment within double quotes. Note that prepared statements must be used even with queries that insert data into the database.

## Risk Assessment

Failure to sanitize user input before processing or storing it can result in injection attacks.

Rule	Severity	Likelihood	Remediation Cost	Priority	Level
IDS00-J	High	Probable	Medium	<b>P12</b>	<b>L1</b>

## Automated Detection

Tool	Version	Checker	Description
<a href="#">The Checker Framework</a>	2.1.3	<b>Tainting Checker</b>	Trust and security errors (see Chapter 8)
<a href="#">CodeSonar</a>	5.0p0	<b>FB.SECURITY. SQL_PREPARED_STATEMENT_GENERATED_FROM_NONCONSTANT_STRING FB.SECURITY.SQL_NONCONSTANT_STRING_PASSED_TO_EXECUTE</b>	A prepared statement is generated from a nonconstant String Nonconstant string passed to execute method on an SQL statement
<a href="#">Coverity</a>	7.5	<b>SQLI FB.SQL_PREPARED_STATEMENT_GENERATED_ FB.SQL_NONCONSTANT_STRING_PASSED_TO_EXECUTE</b>	Implemented
<a href="#">Findbugs</a>	1.0	<b>SQL_NONCONSTANT_STRING_PASSED_TO_EXECUTE</b>	Implemented
<a href="#">Fortify</a>	1.0	<b>HTTP_Response_Splitting SQL_Injection_Persistence SQL_Injection</b>	Implemented

Klocwork		SV.DATA.BOUND SV.DATA.DB SV.HTTP_SPLIT SV.PATH SV.PATH.INJ SV.SQL	Implemented
Parasoft Jtest	10.3	BD-SECURITY-TDSQL	Implemented
SonarQube	6.7	S2077  S3649	Executing SQL queries is security-sensitive  SQL queries should not be vulnerable to injection attacks

## Related Vulnerabilities

[CVE-2008-2370](#) describes a [vulnerability](#) in Apache Tomcat 4.1.0 through 4.1.37, 5.5.0 through 5.5.26, and 6.0.0 through 6.0.16. When a `RequestDispatcher` is used, Tomcat performs path [normalization](#) before removing the query string from the URI, which allows remote attackers to conduct directory traversal attacks and read arbitrary files via a `..` (dot dot) in a request parameter.

## Related Guidelines

SEI CERT C Coding Standard	STR02-C. Sanitize data passed to complex subsystems
SEI CERT C++ Coding Standard	VOID STR02-CPP. Sanitize data passed to complex subsystems
SEI CERT Perl Coding Standard	IDS33-PL. Sanitize untrusted data passed across a trust boundary
ISO/IEC TR 24772:2013	Injection [RST]
MITRE CWE	CWE-116, Improper Encoding or Escaping of Output

## Android Implementation Details

This rule uses Microsoft SQL Server as an example to show a database connection. However, on Android, `DatabaseHelper` from SQLite is used for a database connection. Because Android apps may receive [untrusted data](#) via network connections, the rule is applicable.

## Bibliography

[OWASP 2005]	A Guide to Building Secure Web Applications and Web Services
[OWASP 2007]	OWASP Top 10 for Java EE
[Seacord 2015]	IDS00-J. Prevent SQL Injection LiveLesson
[W3C 2008]	Section 4.4.3, "Included If Validating"

