'-- sql injection

the old dog of data security

Photo credit: Fabian Gieske (Unsplash)

LIVE

BREAKING NEWS

CHANNEL 10

URGENT

BREAKING NEWS

BREAKING NEWS

Another embarrassing data breach. Personal data all over the Internet.

• No clue how this happened: CIO • It was a ticking time bomb all this time: DBA •

'-- the evergreen vulnerability

And although declining in recent years, it just won't go away.

- 6.7% of all vulnerabilities in open-source.
- 10% of all vulnerabilities in closed-source.

(2024)

'-- in the news

You may have heard about some of these fine companies?

- Sony Playstation Network
- Equifax
- Yahoo
- Epic Games / Fortnite
- SQL Server Reporting Services
- 7-Eleven
- Sony Pictures
- Marriott International
- TSA

The good news is, it's relatively easy to fix.

learning objectives

- What is a SQL injection
- What are the risks
- What to look for
- How to fix your code

so who am I?

'-- daniel hutmacher

sql server consultant
conference organizer
dog person

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daniel@strd.co
@dhma.ch
/in/danielhutmacher/

MVP
Microsoft
Most Valuable Professional

Conference Partners

Data Point Prague 2025

sazka

Data Brothers

Woodler

Microsoft

BYTECA

Gordon & Webster

Consulting and Investment Inc.

GOPAS

DATA TALK

Komunita datových profesionálů

meet Ali

Ali

Sales rep of the year, 2024
Good boy

meet Ali

Ali

Sales rep of the year, 2024
Good boy

meet Ali

Ali

Sales rep of the year, 2024
Good boy

http

```
POST /login

username=ali
password=password123
```

meet Ali

Ali

Sales rep of the year, 2024
Good boy

http

```
POST /login

username=ali
password=password123
```

sql

```sql
SELECT UserName
FROM dbo.SalesAgents
WHERE UserName='ali'
  AND PasswordText='password123';
```

what is sql injection?

powershell

```
$email = "daniel@strd.co"

$sqlQuery = @"
    SELECT id, firstName, lastName
    FROM dbo.Users
    WHERE email='$email';
"@
```

sql

```
    SELECT id, firstName, lastName
    FROM dbo.Users
    WHERE email='daniel@strd.co';
```

what is sql injection?

powershell

```
$email = "daniel@strd.co' OR 1=1 --"

$sqlQuery = @"
    SELECT id, firstName, lastName
    FROM dbo.Users
    WHERE email='$email';
"@
```

sql

```
    SELECT id, firstName, lastName
    FROM dbo.Users
    WHERE email='daniel@strd.co' OR 1=1 --';
```

types of sql injection

types of sql injection

out-of-band attack

powershell

```
$email = "daniel@strd.co'; CREATE LOGIN legit WITH
PASSWORD='1234’; GRANT CONTROL SERVER TO legit; --"

$sqlQuery = @"
    SELECT id, firstName, lastName
    FROM dbo.Users
    WHERE email='$email';
"@
```

sql

```
    SELECT id, firstName, lastName
    FROM dbo.Users
    WHERE email='daniel@strd.co'; CREATE LOGIN legit WITH
PASSWORD='1234'; GRANT CONTROL SERVER TO legit; --';
```

types of sql injection

out-of-band attack

powershell

```
$email = "daniel@strd.co'; xp_cmdshell 'del
C:\Windows\System32\*'; --"

$sqlQuery = @"
    SELECT id, firstName, lastName
    FROM dbo.Users
    WHERE email='$email';
"@
```

sql

```
    SELECT id, firstName, lastName
    FROM dbo.Users
    WHERE email='daniel@strd.co'; xp_cmdshell 'del
C:\Windows\System32\*'; --';
```

types of sql injection

error-based injection

powershell

```
$email = "daniel@strd.co' OR 1=CAST(@@SERVERNAME AS int) --"

$sqlQuery = @"
    SELECT id, firstName, lastName
    FROM dbo.Users
    WHERE email='$email';
"@
```

sql

```
SELECT id, firstName, lastName
FROM dbo.Users
WHERE email='daniel@strd.co' OR 1=CAST(@@SERVERNAME AS int) --';
```

types of sql injection

error-based injection

powershell

```
$email = "daniel@strd.co' OR 1=CAST(@@SERVERNAME AS int) --"

$sqlQuery = @"
    SELECT id, firstName, lastName
    FROM dbo.Users
    WHERE email='$email';
"@
```

sql

```
SELECT id, firstName, lastName
FROM dbo.Users
WHERE email='daniel@strd.co' OR 1=CAST(@@SERVERNAME AS int) --';
```

```
Msg 245, Level 16, State 1, Line 1
Conversion failed when converting the nvarchar value 'SQL01' to
data type int.
```

types of sql injection

error-based injection

-- demo

```
Test-Injection.ps1
```

types of sql injection

blind injection

powershell

```
$email = "daniel@strd.co'; IF (SUSER_NAME()='sa') WAITFOR DELAY
'00:00:01'; --"

$sqlQuery = @"
    SELECT id, firstName, lastName
    FROM dbo.Users
    WHERE email='$email';
"@
```

sql

```
SELECT id, firstName, lastName
FROM dbo.Users
WHERE email='daniel@strd.co'; IF (SUSER_NAME()='sa') WAITFOR
DELAY '00:00:01'; --';
```

types of sql injection

blind injection

`sqlmap demo`

Daniels zsh

```
~/Desktop/sqlmap 👉 python3 sqlmap.py -u http://localhost:3000/login --data="username=hello&password=helloagain" --tables
--columns -dbms=MSSQL -D InjectionDemo
```

let's inject some sales

because we're worth it.

-- demo

```
Injection demo code.txt
```

dynamic sql

ETL frameworks can be vulnerable, too.

ID	Source_object	Dest_object	Dependency	TimestampColumn
1	Staging.Currencies	dbo.Currencies	NULL	Updated
2	Staging.CurrencyRates	dbo.Fx_Rates	1	Updated
3	Staging.Contracts	dbo.Contracts	2	Updated

dynamic sql

ETL frameworks can be vulnerable, too.

ID	Source_object	Dest_object	Dependency	TimestampColumn
1	Staging.Currencies	dbo.Currencies	NULL	Updated
2	Staging.CurrencyRates	dbo.Fx_Rates	1	Updated
3	Staging.Contracts	dbo.Contracts	2	Updated

sql

```
SELECT TOP (1) @sql='
    INSERT INTO '+Dest_object+'
    SELECT * FROM '+Source_object+'
    WHERE '+TimestampColumn+'>'+
       '(SELECT MAX('+TimestampColumn+') FROM '+Dest_object+');'
FROM Metadata.ETL_flows;

EXEC(@sql);
```

dynamic sql

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ID	Source_object	Dest_object	Dependency	TimestampColumn
1	Staging.Currencies	dbo.Currencies	NULL	Updated
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sql

```sql
SELECT TOP (1) @sql='
    INSERT INTO '+Dest_object+'
    SELECT * FROM '+Source_object+'
    WHERE '+TimestampColumn+'>'+
       '(SELECT MAX('+TimestampColumn+') FROM '+Dest_object+');'
FROM Metadata.ETL_flows;

EXEC(@sql);
```

sql

```sql
INSERT INTO dbo.Currencies
SELECT * FROM Staging.Currencies
WHERE Updated>(SELECT MAX(Updated) FROM dbo.Currencies);
```

dynamic sql

ETL frameworks can be vulnerable, too.

ID	Source_object	Dest_object	Dependency	TimestampColumn
1	Staging.Currencies	dbo.Currencies	NULL	1=0; DROP TABLE dbo.AuditLog; UPDATE Metadata.ETL_flows SET TimestampColumn='Updated'--
2	Staging.CurrencyRates	dbo.Fx_Rates	1	Updated
3	Staging.Contracts	dbo.Contracts	2	Updated

sql

```sql
INSERT INTO dbo.Currencies
SELECT * FROM Staging.Currencies
WHERE 1=0; DROP TABLE dbo.AuditLog; UPDATE Metadata.ETL_flows SET
TimestampColumn='Updated'-->(SELECT MAX(1=0; DROP TABLE
dbo.AuditLog; UPDATE Metadata.ETL_flows SET
TimestampColumn=''Updated''--
) FROM dbo.Currencies);
```

dynamic sql

ETL frameworks can be vulnerable, too.

ID	Source_object	Dest_object	Dependency	TimestampColumn
1	Staging.Currencies	dbo.Currencies	NULL	1=0; DROP TABLE dbo.AuditLog; UPDATE Metadata.ETL_flows SET TimestampColumn='Updated'--
2	Staging.CurrencyRates	dbo.Fx_Rates	1	Updated
3	Staging.Contracts	dbo.Contracts	2	Updated

1. finish the INSERT:

sql

```sql
INSERT INTO dbo.Currencies
SELECT * FROM Staging.Currencies
WHERE 1=0;

DROP TABLE dbo.AuditLog;

UPDATE Metadata.ETL_flows SET TimestampColumn='Updated'-->(SELECT
MAX(1=0; DROP TABLE dbo.AuditLog; UPDATE Metadata.ETL_flows SET
TimestampColumn=''Updated''--
) FROM dbo.Currencies);
```

dynamic sql

ETL frameworks can be vulnerable, too.

ID	Source_object	Dest_object	Dependency	TimestampColumn
1	Staging.Currencies	dbo.Currencies	NULL	1=0; DROP TABLE dbo.AuditLog; UPDATE Metadata.ETL_flows SET TimestampColumn='Updated'--
2	Staging.CurrencyRates	dbo.Fx_Rates	1	Updated
3	Staging.Contracts	dbo.Contracts	2	Updated

1. finish the INSERT:

2. do bad things:

sql

```sql
INSERT INTO dbo.Currencies
SELECT * FROM Staging.Currencies
WHERE 1=0;

DROP TABLE dbo.AuditLog;

UPDATE Metadata.ETL_flows SET TimestampColumn='Updated'-->(SELECT
MAX(1=0; DROP TABLE dbo.AuditLog; UPDATE Metadata.ETL_flows SET
TimestampColumn=''Updated''--
) FROM dbo.Currencies);
```

dynamic sql

ETL frameworks can be vulnerable, too.

ID	Source_object	Dest_object	Dependency	TimestampColumn
1	Staging.Currencies	dbo.Currencies	NULL	1=0; DROP TABLE dbo.AuditLog; UPDATE Metadata.ETL_flows SET TimestampColumn='Updated'--
2	Staging.CurrencyRates	dbo.Fx_Rates	1	Updated
3	Staging.Contracts	dbo.Contracts	2	Updated

1. finish the INSERT:

2. do bad things:

3. remove evidence:

sql

```sql
INSERT INTO dbo.Currencies
SELECT * FROM Staging.Currencies
WHERE 1=0;

DROP TABLE dbo.AuditLog;

UPDATE Metadata.ETL_flows SET TimestampColumn='Updated'-->(SELECT
MAX(1=0; DROP TABLE dbo.AuditLog; UPDATE Metadata.ETL_flows SET
TimestampColumn=''Updated''--
) FROM dbo.Currencies);
```

but wait, there's more:

connection string injection

connection string injection

powershell

```
$username = "daniel"
$password = "Pa$$w0rd!"

$connectionString = "Server=sql01.strd.co;Database=Prod_DB;User
Id=$username;Password=$password;"
```

connection string

```
Server=sql01.strd.co;Database=Prod_DB;User
Id=daniel;Password=Pa$$w0rd!;
```

connection string injection

powershell

```
$username = "daniel"
$password = "Pa$$w0rd!;Integrated Security=True"

$connectionString = "Server=sql01.strd.co;Database=Prod_DB;User
Id=$username;Password=$password;"
```

connection string

```
Server=sql01.strd.co;Database=Prod_DB;User
Id=daniel;Password=Pa$$w0rd!;Integrated Security=True;
```

'-- mitigations

- Parameterizing inputs
- Manually sanitizing inputs
- Using an ORM
- Using stored procedures
- Restrictive permissions
- Disabling error messages on web sites
- Web application firewalls (WAF)
- Rate-limit your web app or API

mitigations

parameterizing inputs

```c#
string query = "SELECT id, firstName, lastName FROM dbo.Users
WHERE email = @Email";

Command command = new SqlCommand(query, connection)

command.Parameters.Add(
    new SqlParameter("@Email", SqlDbType.NVarChar) {
        Value = email
    }
);
```

mitigations

parameterizing dynamic t-sql

sql

```sql
SET @sql=N'
    UPDATE dbo.Users
    SET firstName=@first, lastName=@last
    WHERE email=@email;'

EXECUTE sys.sp_executesql
    @sql,
    @params = N'@first nvarchar(100), @last nvarchar(100), @email varchar(255)',
    @first = @new_firstname,
    @last = @new_lastname,
    @email = @email;
```

mitigations

use an ORM

using parameterized SQL
(EF Core 2.0+)

c#

```
var email = "daniel@strd.co";

var users = context.Users
    .FromSqlInterpolated($"SELECT id, firstName, lastName FROM
dbo.Users WHERE email = {email}")
    .ToList();
```

using DbSet.SqlQuery
(EF6+)

c#

```
var email = "daniel@strd.co";

var users = context.Users
    .SqlQuery("SELECT id, firstName, lastName FROM dbo.Users
WHERE email = @p0", email)
    .ToList();
```

mitigations

sanitizing dynamic sql

ID	Source_object	Dest_object	Dependency	TimestampColumn
1	Staging.Currencies	dbo.Currencies	NULL	Updated
2	Staging.CurrencyRates	dbo.Fx_Rates	1	Updated
3	Staging.Contracts	dbo.Contracts	2	Updated

sql

```sql
SELECT TOP (1) @sql='
    INSERT INTO '+Dest_object+'
    SELECT * FROM '+Source_object+'
    WHERE '+QUOTENAME(TimestampColumn)+'>'+
       '(SELECT MAX('+QUOTENAME(TimestampColumn)+') FROM
'+Dest_object+');'
FROM Metadata.ETL_flows;

EXEC(@sql);
```

sql

```sql
INSERT INTO dbo.Currencies
SELECT * FROM Staging.Currencies
WHERE [Updated]>(SELECT MAX([Updated]) FROM dbo.Currencies);
```

mitigations

sanitizing dynamic sql

I ❤️ QUOTENAME()

sql

```sql
SELECT QUOTENAME('hello');
SELECT QUOTENAME('object', '[');
SELECT QUOTENAME('quote', '"');
SELECT QUOTENAME('apostrophe', '''');
```

```
[hello]
[object]
"quote"
'apostrophe'
```

mitigations

sanitizing dynamic sql

- OBJECT_ID() returns the unique id of a table/view/etc.
- OBJECT_NAME() returns the name of an object.
- OBJECT_SCHEMA_NAME returns the name of the schema of an object.
- QUOTENAME quotes (and sanitizes) a string.

sql

```sql
-- DECLARE @Source_object nvarchar(100)='Staging.Currencies';

SELECT
    QUOTENAME(OBJECT_SCHEMA_NAME(OBJECT_ID(@Source_object)))+
    N'.'+
    QUOTENAME(OBJECT_NAME(OBJECT_ID(@Source_object)));
```

```
[Staging].[Currencies]
```

mitigations

sanitizing inputs

powershell

```
$email = "daniel@strd.co'; IF (SUSER_NAME()='sa') WAITFOR DELAY
'00:00:01'; --"

$email_escaped = $email -replace "'", "''"

$sqlQuery = @"
SELECT id, firstName, lastName
FROM dbo.Users
WHERE email='$email_escaped';
"@
```

sql

```
SELECT id, firstName, lastName
FROM dbo.Users
WHERE email='daniel@strd.co''; IF (SUSER_NAME()=''sa'') WAITFOR
DELAY ''00:00:01''; --';
```

mitigations

sanitizing inputs

powershell

```
$id = "123; DROP TABLE dbo.Students--"

$id_escaped = [int]$id

$sqlQuery = @"
SELECT id, firstName, lastName
FROM dbo.Users
WHERE id=$id_escaped;
"@
```

```
InvalidArgument: Cannot convert value "123; DROP TABLE
dbo.Students--" to type "System.Int32". Error: "The input string
'123; DROP TABLE dbo.Students--' was not in a correct format."
```

mitigations

sanitizing inputs

- There are theorized highly advanced exploits, where you could use specially crafted unicode strings with multi-byte characters.
- This is the only realistic option for languages where no parameterization can be done, like PowerShell.

mitigations

stored procedures with restrictive permissions

- Only grant the application account EXECUTE permissions on stored procedures
- Do not grant SELECT, UPDATE, INSERT or DELETE

🖐 This is not a sufficient mitigation on its own, but a good defense-in-depth strategy when combined with other mitigations.

mitigations

stored procedures with restrictive permissions

- If you're brave enough, actually denying access to the system DMVs would prevent enumeration of tables, views, etc, but this could affect your application.

🖐 This is not a sufficient mitigation on its own, but a good defense-in-depth strategy when combined with other mitigations.

sql

```sql
DENY SELECT ON SCHEMA::sys TO [databaseUser];

DENY SELECT ON SCHEMA::INFORMATION_SCHEMA TO [databaseUser];
```

mitigations

disabling web server error messages

- Not showing error messages on your web page makes it much harder for attackers to use error-based injections

🖐️ This is not a sufficient mitigation on its own, but a good defense-in-depth strategy when combined with other mitigations.

mitigations

web application firewalls

- A web application firewall (WAF) can detect sql injection patterns and block the client from running repetitive exploratory queries.

🖐 This is not a sufficient mitigation on its own, but a good defense-in-depth strategy when combined with other mitigations.

mitigations

rate limiting

- Timing-based attacks require *a lot* of http calls. Rate limiting your site may mitigate timing-based attacks, but is not a fully secure solution on its own.

🖐 This is not a sufficient mitigation on its own, but a good defense-in-depth strategy when combined with other mitigations.

mitigations

sanitize connection strings

- Quote strings with apostrophes or double quotes
- Escape apostrophes/quotes accordingly

Not a very common vector, but relatively easy to mitigate.

```
Server=sql01.strd.co;Database=Prod_DB;User
Id=daniel;Password=Pa$$w0rd!;Integrated Security=True;
```

connection string

```
Server="sql01.strd.co";Database="Prod_DB";User
Id="daniel";Password="Pa$$w0rd!;Integrated Security=True";
```

the "swiss cheese model"

the "swiss cheese model"

the "swiss cheese model"

the "swiss cheese model"

the "swiss cheese model"

the "swiss cheese model"

mitigations

✅ = Complete mitigation
✓ = Partial mitigation

	Parameterized inputs	ORM	QUOTENAME	Sanitizing inputs	Restricted permissions	Disabling error messages	Web Application Firewall	Rate limiting
Out-of-band injections	✅	✅		✅	✅			
Error-based injections	✅	✅		✅	✓	✅	✓	✓
Blind injections	✅	✅		✅	✓		✓	✓
Escaping dynamic SQL			✅	✅	✓			
Connection string injection	✅*			✅				

← defense in depth →

'-- questions?

'-- thank you

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slides and demos

github.com/sqlsunday/presentations
github.com/sqlsunday/injection-demo

Photo credit: Fabian Gieske (Unsplash)