IT350 Group #1 Project Report

Introduction

This project focuses on hardening a deliberately vulnerable Metasploitable Linux server by first demonstrating common attacks and then applying security measures to prevent the attacks from being used in the future. The system environment for this project consisted of a Proxmox VM pool with three machines: Metasploitable (the server under test), Kali Linux (the attacker), and Ubuntu (a benign client). We execute three representative attacks against the Metasploitable host: an ARP poisoning (man-in-the-middle) attack using Ettercap, exploiting a vulnerability in ProFTPd version 1.3.5, and an SSH brute-force login attack. After exploiting each vulnerability, we implemented patches or configuration changes to secure the system and prevent the vulnerability from being exploited in the future. Once the patches have been implemented, we attempted to use the exploit again to ensure that the security measures were successful. Lastly, we continued to strengthen the host by implementing additional hardening measures and procedures, including firewall configuration, a password policy, and two-factor authentication.

Background information

Host hardening is the process of securing a computer system by reducing its attack surface and locking down configuration settings. In practice, this means removing unnecessary services and user accounts, closing unused network ports, applying patches, and enforcing strict access controls for all users of a system. The goal is to eliminate as many vulnerabilities as possible so that attackers have fewer options to exploit. Since operating systems are not adequately hardened by default, system administrators must customize configurations manually to protect the host from any potential threat actor. These configurations often include disabling unused default services and requiring strong authentication for logging in.

Host hardening is crucial to system and network security because it lowers the risk of compromise. A hardened host has fewer exploitable flaws and vulnerabilities. For example, are correctly hardened host might have no open file shares or remote-login services left unintentionally enabled, and all software would be up-to-date. Hardening is just one layer in a multi-layered defense strategy for system security. It works with firewalls, intrusion detection, and other controls to minimize the chance of successful attacks. In an enterprise context, comprehensive host hardening is often required for compliance and is continuously updated as new threats arise.

Use Case Scenario

In our simulated environment, the Metasploitable server and Ubuntu client are configured to reflect a realistic small business network. Specifically, the Metasploitable VM serves as an internal company website, hosting resources that employees need to access as part of their daily operations. The Metasploitable server uses Linux as the operating system, Apache for the webserver, MySQL for the database, and PHP for the scripting language. The Ubuntu client represents a typical employee workstation that interacts with the internal web server, browsing company information or accessing internal tools hosted on the Metasploitable system.

This setup generates legitimate network traffic between the client and server, establishing the foundation for normal business operations. While this traffic is occurring, the Kali VM operates as an internal threat actor located within the same network, attempting to exploit vulnerabilities through man-in-the-middle attacks, reconnaissance, and other techniques. Without an active client–server relationship, attacks such as ARP poisoning would have no meaningful data to target or manipulate.

Scanning for Vulnerabilities

To begin our processes, we had to figure out how to exploit the Metasploitable VM. In order to scan for vulnerabilities, we had to use Kali VM terminal and run the command: sudo nmap –sS –sV –O metasploitable IP address which performs a stealth scan, service version detection, and lastly an OS detection. Through this scan the results we received were multiple ports that are vulnerable to being exploited. The scan was useful and helped us determine a legitimate approach to choosing our exploits. Overall, using the nmap command is a great way to detect whether or not a machine is secure or not. (Shown in Appendix A.1)

Along with using nmap for scanning, we also used the Msfconsole to search for potential exploits. For example, if you know the service and version number obtained from nmap, you are able to search for potential exploits and vulnerabilities in the service. This is a very useful tool for ensuring that a host is properly hardened from threats. (Shown in Appendix A.2)

Attacks

To better understand the security weaknesses commonly found in under-hardened systems, we conducted a series of targeted attacks against the Metasploitable server using our Kali Linux machine. These attacks were chosen to simulate realistic threat scenarios that a small business might face from an internal or nearby network adversary. Each attack focused on a specific vulnerability within core services, rather than third-party applications, and demonstrated how a determined attacker could exploit misconfigurations or outdated software. By successfully executing these attacks, we were able to show the importance of basic security and later validate the effectiveness of our remediations.

Attack 1: ARP Poisoning via Ettercap

The first attack was an ARP cache poisoning (spoofing) attack using Ettercap on the Kali machine. ARP (Address Resolution Protocol) inherently lacks authentication since any host can reply to an ARP query with its own MAC address, and other hosts will trust it. By sending forged ARP replies, the attacker deceived the Ubuntu client and server into associating the attacker's MAC address with the IP of the other host. To do this, Ettercap repeatedly broadcasted ARP responses claiming, "I am the gateway" and "I am the server," so both victim machines updated their ARP tables to point to Kali's MAC. As a result, network traffic between Ubuntu and Metasploitable was redirected through Kali, allowing packet capture and modification, demonstrating a classic man-in-the-middle attack. After starting the attack, the attacker could then sniff or alter what should have been a direct connection between client and server. The vulnerability exploited here is simply that ARP trusts any reply.

Furthermore, to mitigate the ARP poisoning attack, we decided to configure static ARP entries on the Ubuntu server. This was done by binding the LAN IP address of pfSense to the Ubuntu server which connects the VM back to its original MAC address as seen above. This prevents the vulnerable server from accepting malicious ARP packets for the gateway. Once the static ARP entry was added we attempted to poison Metasplpoitable's ARP entries and Kali VM and Ettercap was unsuccessful as it was no longer effective.

We proved that this attack cannot be reused again with the static entry. However, even though Kali sent spoofed ARP packets, the ARP table on Ubuntu stayed unchanged. Due to setting up the static ARP entry it created a permanent ARP cache that added a layer of protection to prevent such attacks. No network traffic was redirected through Kali, and packet captures on Wireshark confirmed that addresses on Ubuntu and pfSense proceeded with no interceptions. In conclusion the static ARP configuration worked perfectly, and ARP spoofing was no longer possible.

Attack 2: ProFTPD 1.3.5 Vulnerability Exploit

Our second attack targeted the ProFTPD service running on the Metasploitable server, specifically version 1.3.5. This version is known to contain a critical vulnerability in the mod_copy module, which permits unauthenticated attackers to write files to the server. In a small business environment where internal systems often go unpatched for extended periods, such vulnerabilities pose a significant risk, especially when exploited by insider threats or infected internal machines.

To exploit this weakness, we used Kali to inject a payload that exploited the mod_copy functionality to create a malicious Python shell on the target system's web root. Once in place, we accessed the shell through a web browser, allowing full remote code execution without valid credentials. Our simulated attack demonstrated that, if left unpatched, this service could serve as a gateway for privilege escalation or network pivoting.

To mitigate the threat, we implemented a two-part solution. First, we disabled the ProFTPD service entirely using sudo service proftpd stop and sudo update-rc.d proftpd disable, effectively removing the vulnerable surface from the network (Shown in Appendix B.1). Due to the scenario that we chose, a small shop, we decided that FTP functionality was not necessary since a small business would likely be able to use SSH for their remote file management needs. However, if FTP functionality is required, a more appropriate fix would involve upgrading to a more secure version such as ProFTPD 1.3.6, which addresses the mod_copy vulnerability, or SFTP could be installed and used.

Lastly, we verified that the vulnerability had been mitigated by reattempting the original mod_copy exploit and performing a fresh Nmap scan. The updated service no longer exhibited the vulnerable behavior, and our attack payloads failed to execute (Shown in Appendix B.2), confirming that the system was successfully hardened. This attack shows how outdated services, when left unchecked, can compromise the integrity of internal infrastructure, and it shows how proper patching and configuration management are essential to a secure network environment.

Attack 3: SSH Brute-Force Attack

Our third and final attack simulated a brute-force password guessing attack on the Metasploitable server's SSH service, conducted from the Kali Linux machine. A brute-force attack is a form of credential-based cyberattack where an adversary attempts to gain unauthorized access by systematically trying all possible username and password combinations until the correct credentials are discovered. While this method is not technically sophisticated, it remains highly effective, especially against systems that use weak or default login credentials and lack proper access control mechanisms.

In our scenario, we identified that the Metasploitable server had SSH running on port 22, using OpenSSH, and that the service was exposed to the internal network. This observation indicated that the server might be vulnerable to password-guessing attacks if default or weak credentials were in use.

To initiate the brute-force attack, we utilized tools available on Kali Linux to automate the login attempts against SSH. The process involved feeding a list of common usernames and passwords, sourced from publicly available dictionaries, into the msfconsole attack module (Shown in Appendix C.1). After repeated attempts and extended trial-and-error, we successfully authenticated using the credentials username: vagrant and password: vagrant, confirming that the Metasploitable server still used easily guessable default login credentials.

This successful login demonstrated a critical security flaw:

- The server permitted authentication with widely known default credentials.
- Anyone with access to the network and basic knowledge of Metasploitable could easily gain full remote shell access via SSH.

Had this been a real-world production server, the attacker would have had complete command-line access, enabling them to escalate privileges, exfiltrate data, install backdoors, or pivot to other systems on the network.

To mitigate this vulnerability, we implemented the following corrective actions:

1. **Replaced Default Credentials:** The vagrant account password was changed to a complex string that adheres to our strong password policies.
2. **Restricting SSH Access: W**e also discussed using the AllowUsers directive within the /etc/ssh/sshd_config file. This limits SSH access to specific users and IP addresses, thereby adding an additional layer of access control. Such a measure prevents brute-force attempts from unauthorized IP ranges, even if the attacker guesses the correct password. (Shown in Appendix C.2)

To validate the remediation, we re-ran the brute-force script against the SSH service after the password change. This time, all login attempts failed, and no unauthorized access was achieved, confirming that the attack vector had been successfully closed. This exercise highlighted the dangers of relying on default configurations and underscored the importance of immediate post-deployment hardening—especially for services like SSH that are frequently targeted by attackers.

Enhancements

In addition to identifying and fixing specific exploits on the Metasploitable server, we implemented several proactive security enhancements to further harden the system against threats. These improvements were designed to bring the server more in line with modern security best practices for a small business environment, where internal infrastructure often lacks dedicated security oversight. The enhancements we chose focused on access control, authentication hardening, traffic filtering, and password management.

Implementing Two-Factor Authentication (2FA) for SSH

To strengthen user authentication, we added two-factor authentication to the SSH service using the Google Authenticator PAM module. This addition provides an extra layer of security by requiring users to provide a time-based one-time password (TOTP) in addition to their regular SSH credentials. We began by installing the libpam-google-authenticator package on the Metasploitable server and configuring the one SSH user to have unique code that is used with the Google Authenticator app to create a time-based one-time password.

To enforce two-factor authentication, we modified the /etc/pam.d/sshd and /etc/ssh/sshd_config files to integrate Google Authenticator into the SSH login. After restarting the SSH service, we verified that all subsequent login attempts now required both the user's password and a valid time-based verification code. This setup significantly reduces the risk of credential-based attacks, including brute force and dictionary attacks, by rendering stolen passwords alone insufficient for access. (Shown in Appendix G.1-5)

Firewall Configuration Using iptables

To reduce the Metasploitable server's attack surface and enforce proper network security, we configured a system-level firewall using iptables, a powerful utility that enables administrators to define IP packet filter rules within the Linux kernel. By default, Metasploitable is exposed to a wide range of unnecessary services, which is both unrealistic for our scenario's environment and extremely dangerous from a security perspective. Our goal was to implement a minimal, well-defined firewall policy that permits only legitimate traffic and blocks all other inbound and outbound connections.

We began by deleting the default iptables rule set to ensure that no previous configurations interfered with our custom policy. From there, we applied a new set of rules to meet the needs of our internal business scenario. First, we allowed loopback traffic to ensure the system could handle local communication, which is essential for internal services and debugging operations. We then permitted incoming connections to essential service ports:

- Port 22 for SSH, allowing administrators to manage the server remotely.
- Port 80 for HTTP, enabling standard web traffic for the internal website.
- Port 443 for HTTPS, ensuring encrypted communication with the server.
- Port 3306 for MySQL, supporting internal database queries from authorized clients.

After explicitly allowing these services, we applied a default-deny policy, which drops all other incoming and forwarding traffic. This ensures that only known, approved communication channels remain open, effectively blocking common attack vectors such as Telnet, FTP, and unfiltered UDP services that are often enabled by default on vulnerable systems like Metasploitable. (Shown in Appendix F)

To verify the effectiveness of our rules, we performed a follow-up Nmap scan from Kali Linux. The results confirmed that only the explicitly allowed ports were accessible, and all other services appeared closed or filtered. This firewall configuration significantly improves the system's security posture by enforcing strict control over what types of connections are permitted. This is a critical practice for any environment, especially within small businesses where oversight and intrusion detection resources may be limited.

By taking a "least privilege" approach to network traffic, iptables allowed us to replicate a production-like firewall policy and demonstrate how simple filtering rules can drastically reduce a system's vulnerability to external reconnaissance and attacks.

Password Policy Enforcement

Recognizing the importance of strong credential requirements, we implemented a robust password policy on the Metasploitable server. This policy requires that all user passwords must be at least 12 characters in length and include a mix of uppercase letters, lowercase letters, and digits. Additionally, passwords are now set to expire every 30 days, forcing regular rotation and minimizing the window of exposure in the event of credential leakage.

To enforce this policy, we edited the /etc/login.defs and /etc/pam.d/common-password configuration files, applying parameters such as PASS_MAX_DAYS, minlen, ucredit, lcredit, and dcredit through PAM modules. After applying the changes, we tested the policy by attempting to create new user accounts and change passwords that did not meet the criteria, each attempt was correctly rejected with an error message stating the rule that was broken. (Shown in Appendix D.1-4)

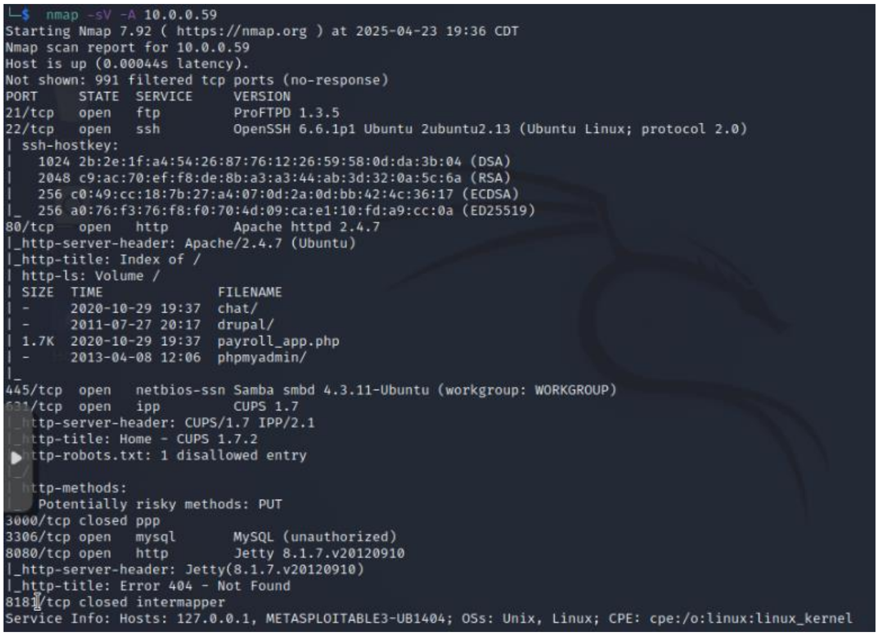
The implementation of this password policy ensures that all accounts on the system are protected by strong, regularly updated credentials, significantly reducing the likelihood of successful brute force or dictionary attacks. It also reinforces security awareness among users by encouraging better password practices, which is something especially important in smaller organizations with limited cybersecurity training.

Conclusion/what we Learned

This project provided valuable hands-on experience in identifying, exploiting, and mitigating real-world security vulnerabilities within a controlled, simulated network environment. By working with Metasploitable as a vulnerable internal server, Ubuntu as a legitimate user system, and Kali as the attacker, we gained a practical understanding of how common attack vectors, such as ARP poisoning, SSH brute-forcing, and remote file upload exploits, can compromise internal systems, particularly in small business networks that often lack robust defenses. More importantly, the process of implementing countermeasures, from setting up iptables firewalls and enforcing password policies to deploying two-factor authentication and system updates, shows the importance of defense-in-depth and proactive host hardening. This project also emphasized the critical role of continuous monitoring, secure configurations, and layered security practices in maintaining the confidentiality, integrity, and availability of networked systems. In conclusion, this exercise not only enhanced our technical skills but also deepened our understanding of the mindset and tools used by attackers, which is essential for any cybersecurity professional.

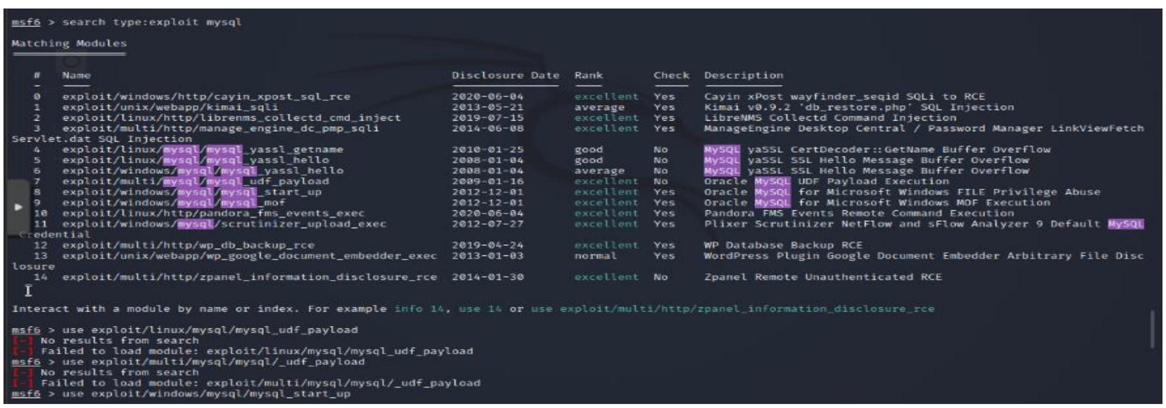
Appendix

Appendix A.1:



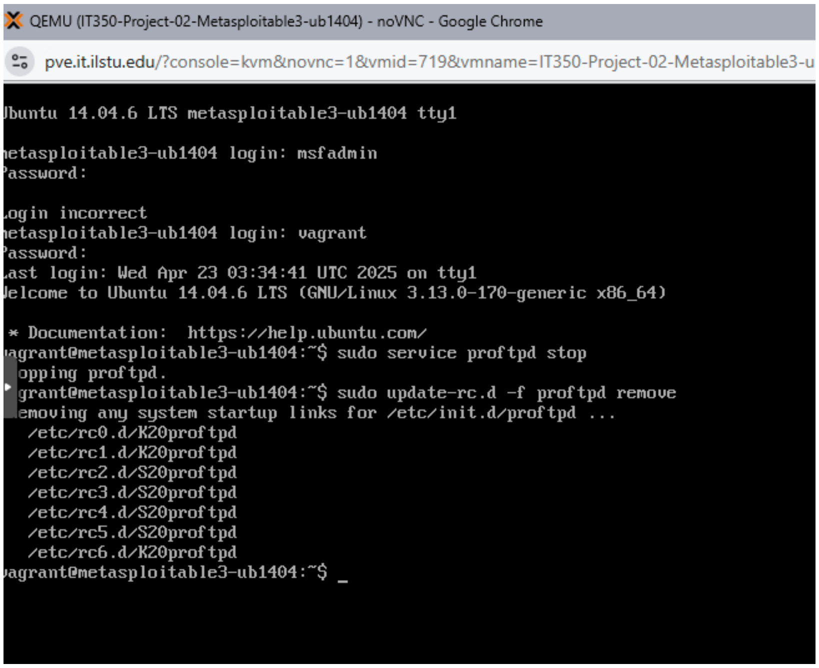
```
└─$ nmap -sV -A 10.0.0.59
Starting Nmap 7.92 ( https://nmap.org ) at 2025-04-23 19:36 CDT
Nmap scan report for 10.0.0.59
Host is up (0.00044s latency).
Not shown: 991 filtered tcp ports (no-response)
PORT     STATE  SERVICE     VERSION
21/tcp   open   ftp         ProFTPD 1.3.5
22/tcp   open   ssh         OpenSSH 6.6.1p1 Ubuntu 2ubuntu2.13 (Ubuntu Linux; protocol 2.0)
| ssh-hostkey:
|   1024 2b:2e:1f:a4:54:26:87:76:12:26:59:58:0d:da:3b:04 (DSA)
|   2048 c9:ac:70:ef:f8:de:8b:a3:a3:44:ab:3d:32:0a:5c:6a (RSA)
|   256 c0:49:cc:18:7b:27:a4:07:0d:2a:0d:bb:42:4c:36:17 (ECDSA)
|_  256 a0:76:f3:76:f8:f0:70:4d:09:ca:e1:10:fd:a9:cc:0a (ED25519)
80/tcp   open   http        Apache httpd 2.4.7
|_http-server-header: Apache/2.4.7 (Ubuntu)
|_http-title: Index of /
| http-ls: Volume /
| SIZE  TIME              FILENAME
| -     2020-10-29 19:37  chat/
| -     2011-07-27 20:17  drupal/
| 1.7K  2020-10-29 19:37  payroll_app.php
| -     2013-04-08 12:06  phpmyadmin/
|_
445/tcp  open   netbios-ssn Samba smbd 4.3.11-Ubuntu (workgroup: WORKGROUP)
631/tcp  open   ipp         CUPS 1.7
|_http-server-header: CUPS/1.7 IPP/2.1
|_http-title: Home - CUPS 1.7.2
| http-robots.txt: 1 disallowed entry

| http-methods:
|   Potentially risky methods: PUT
3000/tcp closed ppp
3306/tcp open   mysql       MySQL (unauthorized)
8080/tcp open   http        Jetty 8.1.7.v20120910
|_http-server-header: Jetty(8.1.7.v20120910)
|_http-title: Error 404 - Not Found
8181/tcp closed intermapper
Service Info: Hosts: 127.0.0.1, METASPLOITABLE3-UB1404; OSs: Unix, Linux; CPE: cpe:/o:linux:linux_kernel
```

Appendix A.2:

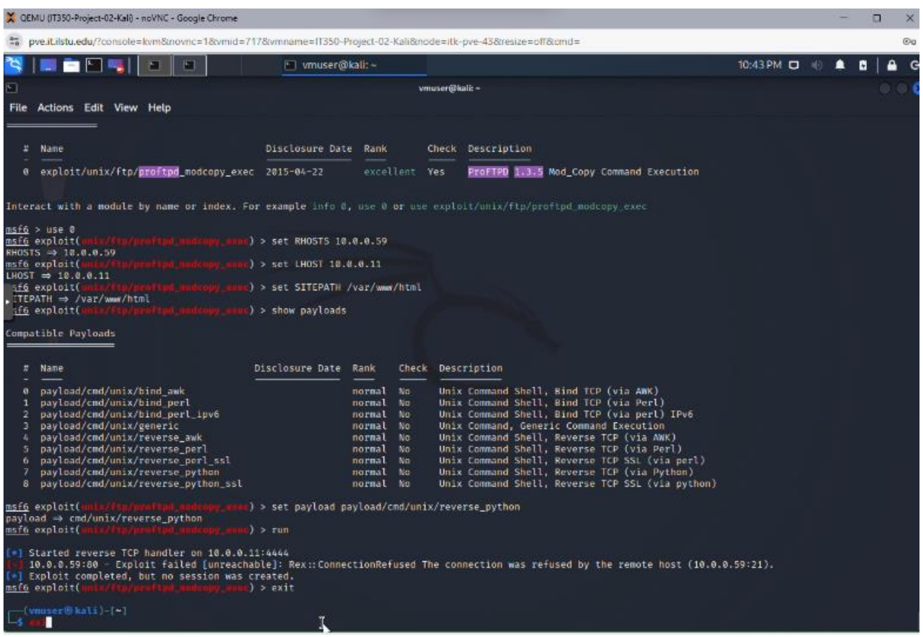


```
msf6 > search type:exploit mysql

Matching Modules
================

   #   Name                                              Disclosure Date  Rank       Check  Description
   -   ----                                              ---------------  ----       -----  -----------
   0   exploit/windows/http/cayin_xpost_sql_rce          2020-06-04       excellent  Yes    Cayin xPost wayfinder_seqid SQLi to RCE
   1   exploit/unix/webapp/kimai_sqli                    2013-05-21       average    Yes    Kimai v0.9.2 'db_restore.php' SQL Injection
   2   exploit/linux/http/librenms_collectd_cmd_inject   2019-07-15       excellent  Yes    LibreNMS Collectd Command Injection
   3   exploit/multi/http/manage_engine_dc_pmp_sqli      2014-06-08       excellent  Yes    ManageEngine Desktop Central / Password Manager LinkViewFetch
Servlet.dat SQL Injection
   4   exploit/linux/mysql/mysql_yassl_getname           2010-01-25       good       No     MySQL yaSSL CertDecoder::GetName Buffer Overflow
   5   exploit/linux/mysql/mysql_yassl_hello             2008-01-04       good       No     MySQL yaSSL SSL Hello Message Buffer Overflow
   6   exploit/windows/mysql/mysql_yassl_hello           2008-01-04       average    No     MySQL yaSSL SSL Hello Message Buffer Overflow
   7   exploit/multi/mysql/mysql_udf_payload             2009-01-16       excellent  No     Oracle MySQL UDF Payload Execution
   8   exploit/windows/mysql/mysql_start_up              2012-12-01       excellent  Yes    Oracle MySQL for Microsoft Windows FILE Privilege Abuse
   9   exploit/windows/mysql/mysql_mof                   2012-12-01       excellent  Yes    Oracle MySQL for Microsoft Windows MOF Execution
   10  exploit/linux/http/pandora_fms_events_exec        2020-06-04       excellent  Yes    Pandora FMS Events Remote Command Execution
   11  exploit/windows/mysql/scrutinizer_upload_exec     2012-07-27       excellent  Yes    Plixer Scrutinizer NetFlow and sFlow Analyzer 9 Default MySQL
Credential
   12  exploit/multi/http/wp_db_backup_rce               2019-04-24       excellent  Yes    WP Database Backup RCE
   13  exploit/unix/webapp/wp_google_document_embedder_exec  2013-01-03   normal     Yes    WordPress Plugin Google Document Embedder Arbitrary File Disc
losure
   14  exploit/multi/http/zpanel_information_disclosure_rce  2014-01-30   excellent  No     Zpanel Remote Unauthenticated RCE


Interact with a module by name or index. For example info 14, use 14 or use exploit/multi/http/zpanel_information_disclosure_rce

msf6 > use exploit/linux/mysql/mysql_udf_payload
[-] No results from search
[-] Failed to load module: exploit/linux/mysql/mysql_udf_payload
msf6 > use exploit/multi/mysql/mysql/_udf_payload
[-] No results from search
[-] Failed to load module: exploit/multi/mysql/mysql/_udf_payload
msf6 > use exploit/windows/mysql/mysql_start_up
```

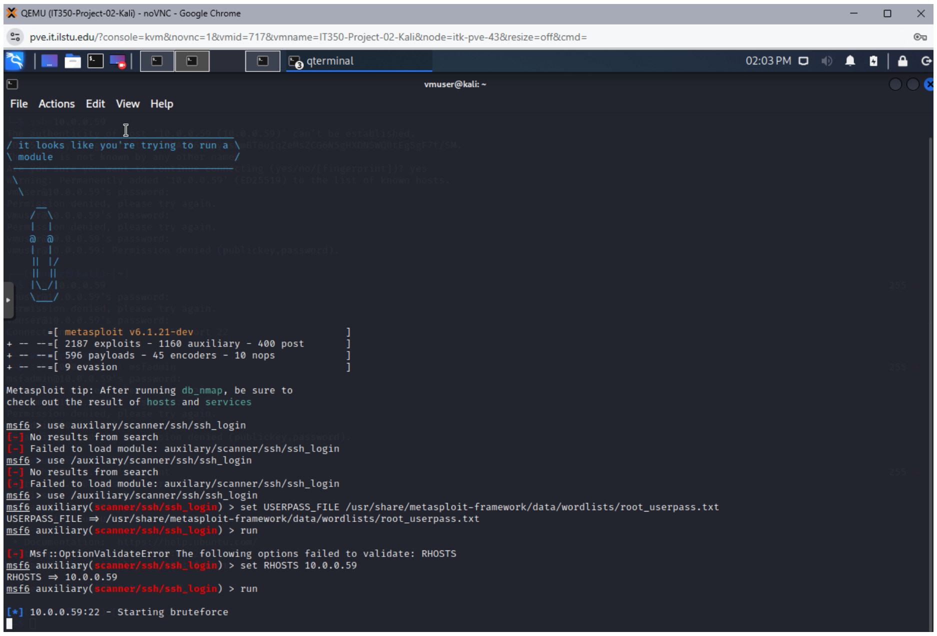
Appendix B.1:



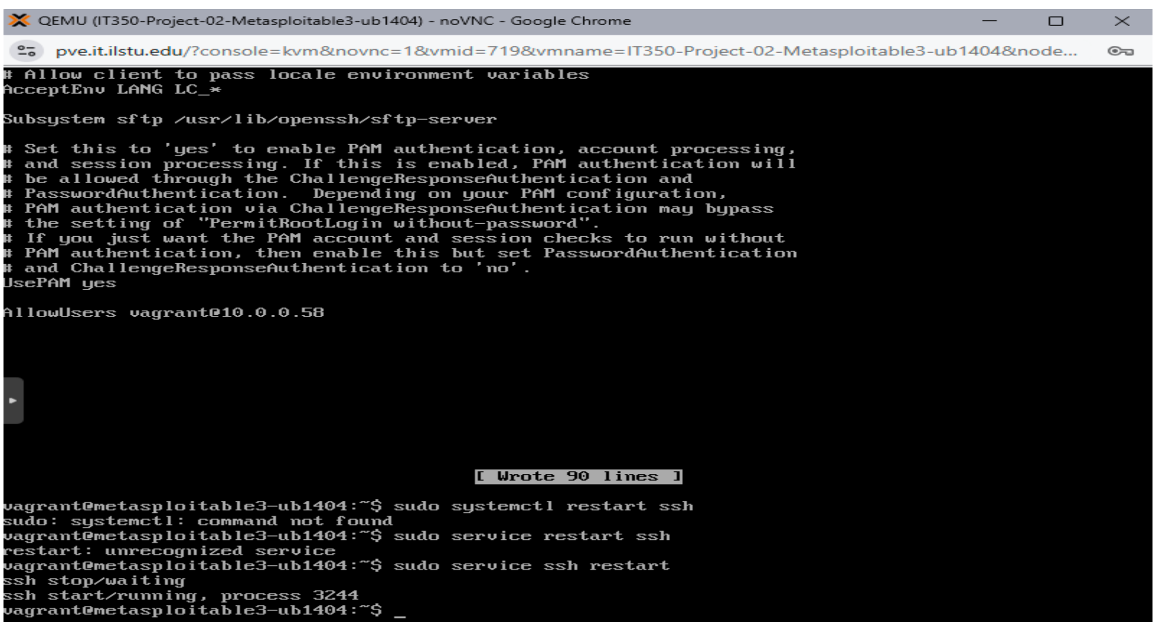
Appendix B.2:



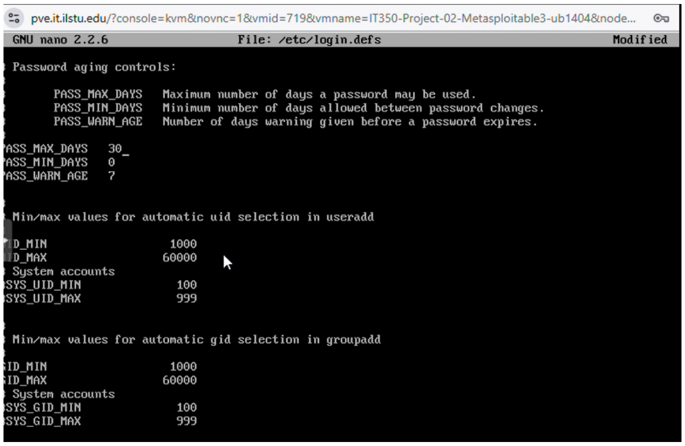
Appendix C.1:



Appendix C.2:



Appendix D.1:



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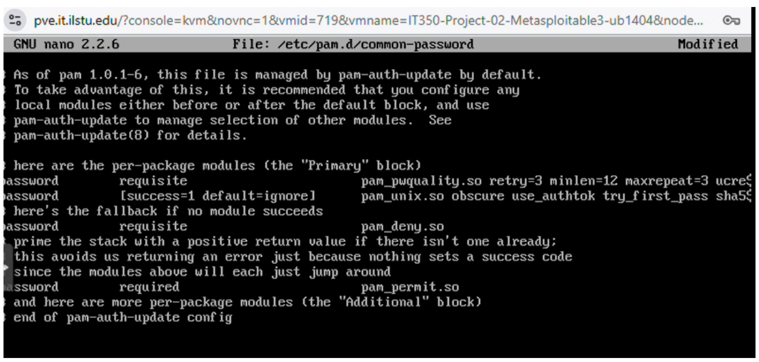
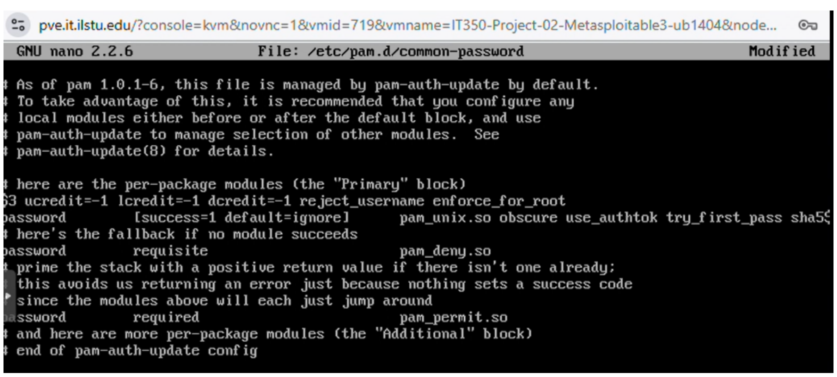
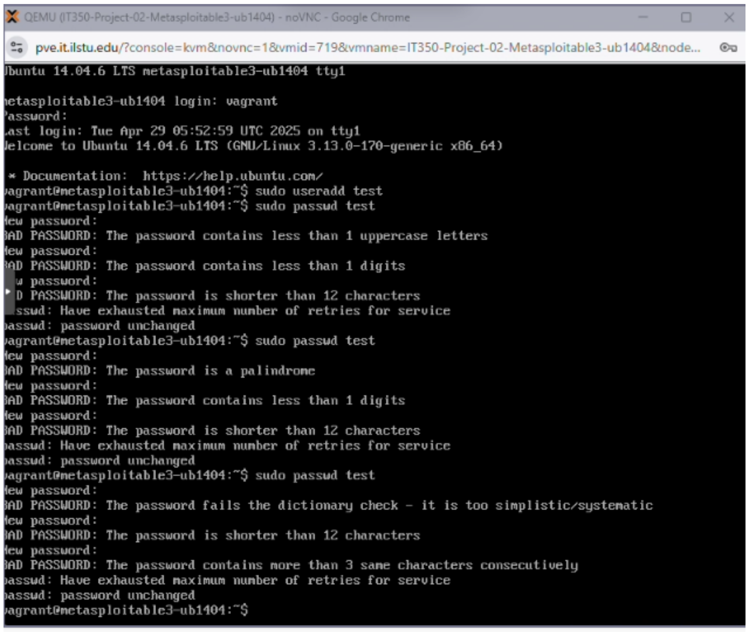


Appendix D.3:



Appendix D.4:

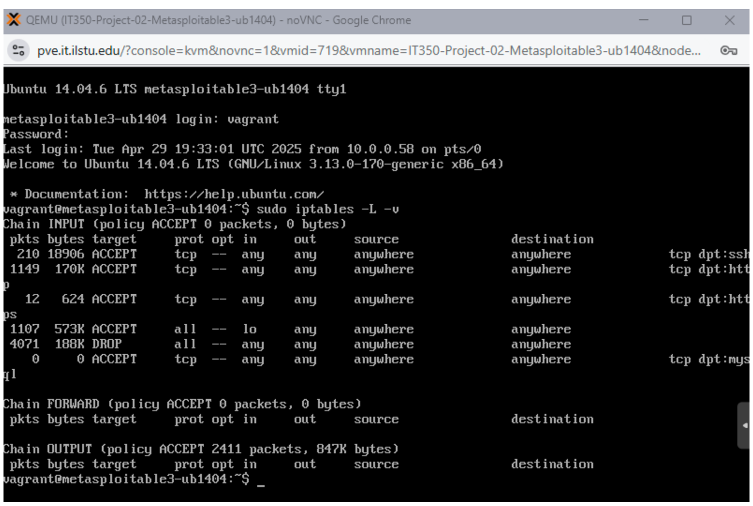


QEMU (IT350-Project-02-Metasploitable3-ub1404) - noVNC - Google Chrome

pve.it.ilstu.edu/?console=kvm&novnc=1&vmid=719&vmname=IT350-Project-02-Metasploitable3-ub1404&node...

```
buntu 14.04.6 LTS metasploitable3-ub1404 tty1

etasploitable3-ub1404 login: vagrant
assword:
ast login: Tue Apr 29 05:52:59 UTC 2025 on tty1
elcome to Ubuntu 14.04.6 LTS (GNU/Linux 3.13.0-170-generic x86_64)

 * Documentation:  https://help.ubuntu.com/
agrant@metasploitable3-ub1404:~$ sudo useradd test
agrant@metasploitable3-ub1404:~$ sudo passwd test
ew password:
AD PASSWORD: The password contains less than 1 uppercase letters
ew password:
AD PASSWORD: The password contains less than 1 digits
w password:
D PASSWORD: The password is shorter than 12 characters
sswd: Have exhausted maximum number of retries for service
asswd: password unchanged
agrant@metasploitable3-ub1404:~$ sudo passwd test
ew password:
AD PASSWORD: The password is a palindrome
ew password:
AD PASSWORD: The password contains less than 1 digits
ew password:
AD PASSWORD: The password is shorter than 12 characters
asswd: Have exhausted maximum number of retries for service
asswd: password unchanged
agrant@metasploitable3-ub1404:~$ sudo passwd test
ew password:
AD PASSWORD: The password fails the dictionary check - it is too simplistic/systematic
ew password:
AD PASSWORD: The password is shorter than 12 characters
ew password:
AD PASSWORD: The password contains more than 3 same characters consecutively
asswd: Have exhausted maximum number of retries for service
asswd: password unchanged
agrant@metasploitable3-ub1404:~$
```

Appendix F:

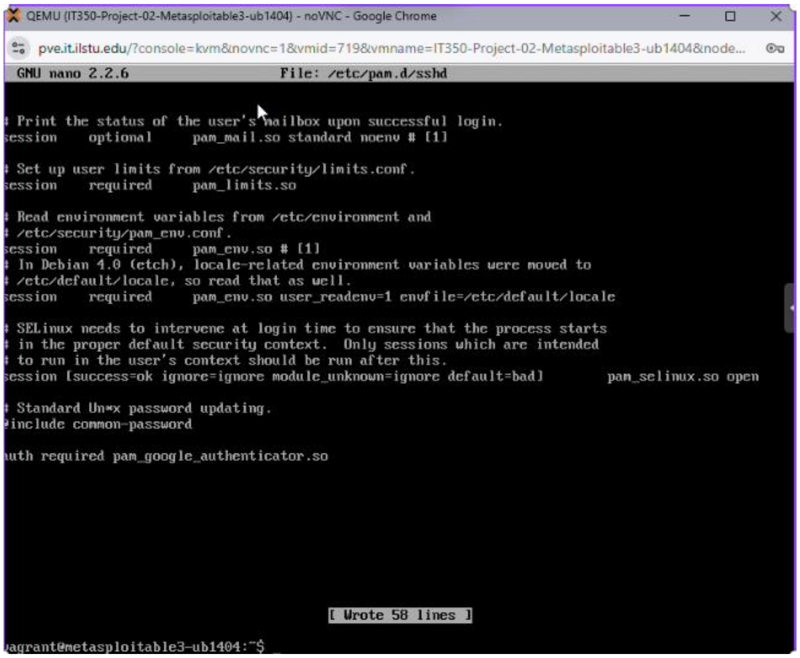


QEMU (IT350-Project-02-Metasploitable3-ub1404) - noVNC - Google Chrome

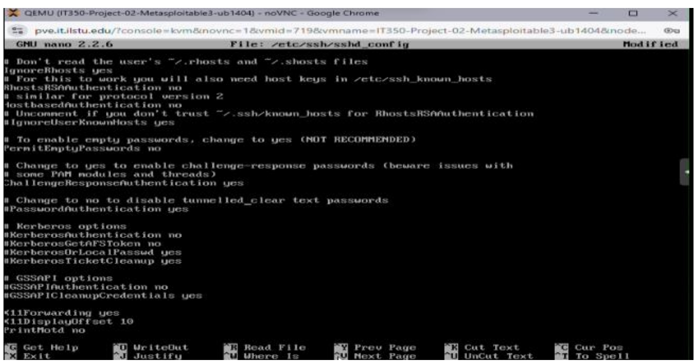
pve.it.ilstu.edu/?console=kvm&novnc=1&vmid=719&vmname=IT350-Project-02-Metasploitable3-ub1404&node...

```
Ubuntu 14.04.6 LTS metasploitable3-ub1404 tty1

metasploitable3-ub1404 login: vagrant
Password:
Last login: Tue Apr 29 19:33:01 UTC 2025 from 10.0.0.58 on pts/0
Welcome to Ubuntu 14.04.6 LTS (GNU/Linux 3.13.0-170-generic x86_64)

 * Documentation:  https://help.ubuntu.com/
vagrant@metasploitable3-ub1404:~$ sudo iptables -L -v
Chain INPUT (policy ACCEPT 0 packets, 0 bytes)
 pkts bytes target     prot opt in     out     source               destination
  210 18906 ACCEPT     tcp  --  any    any     anywhere             anywhere             tcp dpt:ssh
 1149  170K ACCEPT     tcp  --  any    any     anywhere             anywhere             tcp dpt:htt
p
   12   624 ACCEPT     tcp  --  any    any     anywhere             anywhere             tcp dpt:htt
ps
 1107  573K ACCEPT     all  --  lo     any     anywhere             anywhere
 4071  188K DROP       all  --  any    any     anywhere             anywhere
    0     0 ACCEPT     tcp  --  any    any     anywhere             anywhere             tcp dpt:mys
ql

Chain FORWARD (policy ACCEPT 0 packets, 0 bytes)
 pkts bytes target     prot opt in     out     source               destination

Chain OUTPUT (policy ACCEPT 2411 packets, 847K bytes)
 pkts bytes target     prot opt in     out     source               destination
vagrant@metasploitable3-ub1404:~$ _
```

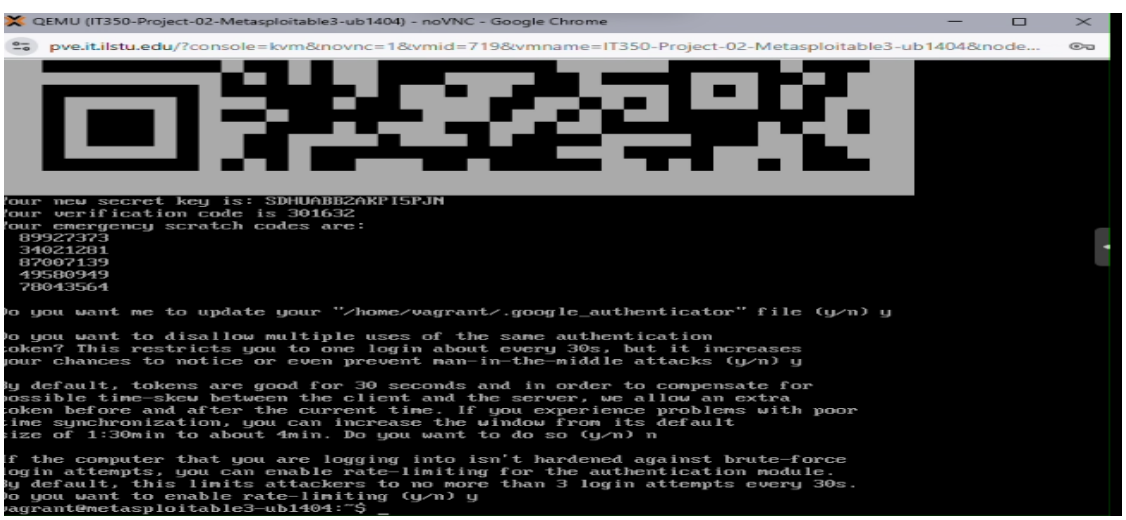
Appendix G.1:



Appendix G.2:



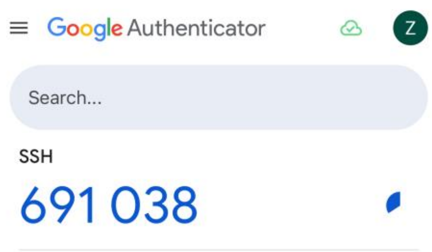
Appendix G.3:



Appendix G.4:

```
debug1: Next authentication method: keyboard-interactive
Verification code:
```

Appendix G.5:



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