Artifact Genome Project

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1. Assignment Type

Learn By Doing

2. Assignment Name

Web Forensics: Using Logs to investigate SQL Injection Attack

3. Assignment Overview

Despite the advantage that web applications have, they frequently become targets for attackers because of poor coding or inadequate security monitoring. Attackers attempt to take advantage of coding flaws and access database contents in order to obtain sensitive data. When such web application attacks take place, forensic investigation enters the picture. Web application forensics entails forensic investigation of web applications and their data, such as logs, to track down the attack, identify its source, ascertain how it spread, as well as the tools used and the individuals responsible for carrying it out. A server's log file is one of the most important pieces of data it offers. A log file keeps track of all the activities that happen while a service or application is running. Log files give us a clear picture of a server's activities as well as vital details like when, how, and by whom a server is being used. This information helps forensic investigators unfold the chain of events that led to a malicious activity. This module discusses the steps of analyzing log files to find digital evidence of SQL Injection on a compromised web application running on Apache web server and MySQL 8.0.28 database in an Ubuntu 20.04.03 operating system environment. This assignment will provide a deep understanding of how defenders can detect the use of SQLMAP tool to exploit SQL injection flaws.

4. Learning Objectives

- To find digital evidence of SQL Injection attack
- To detect that a MySQL database records has been extracted
- To understand the commands used in Linux filesystem

5. Tools Needed

- Epoch Converter
- Oracle VirtualBox 6.1
- Ubuntu 20.04.3

6. Artifact Tags

Demo Website running on Ubuntu Operating System - Open Virtual Application file (.ova)

7. Task 1: Artifact Investigation

Click on the Artifact Tag above or search the artifact names within AGP. Read through each artifact and gather an understanding of all the presented information. You may view the download files through the artifact view, or if a different view is desired, you may use the download files. Review the information. Once you have a basic understanding of the information these artifacts are presenting, continue with Task 2.

8. Task 2: Load the demo website in Oracle VirtualBox

- If you do not have VirtualBox already installed please use the link above to install it.
- Once VirtualBox is installed click on the artifact and download it.
- After installing VirtualBox, open it and import the artifact which contains the compromised demo website.
- Load the demo website by entering the URL - "http://localhost/beunique" in the browser.
- The Ubuntu operating system password is sqlinjection$12&

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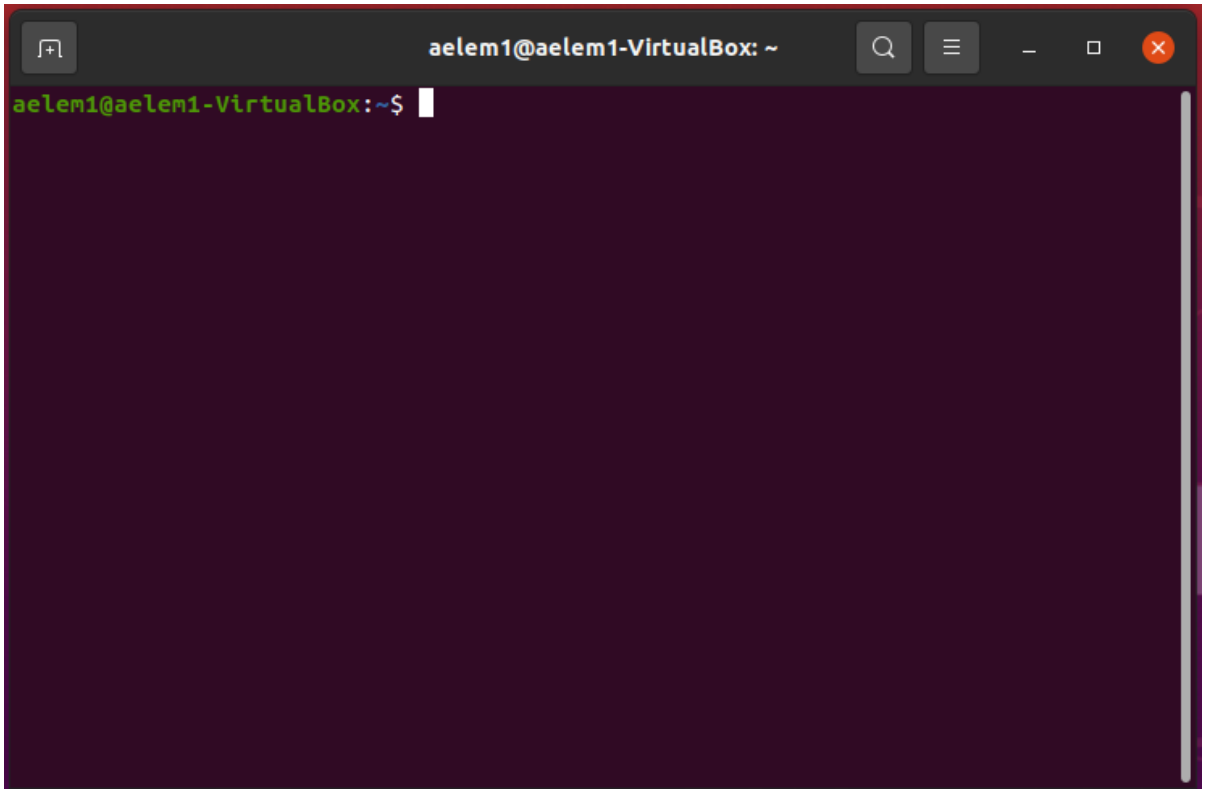
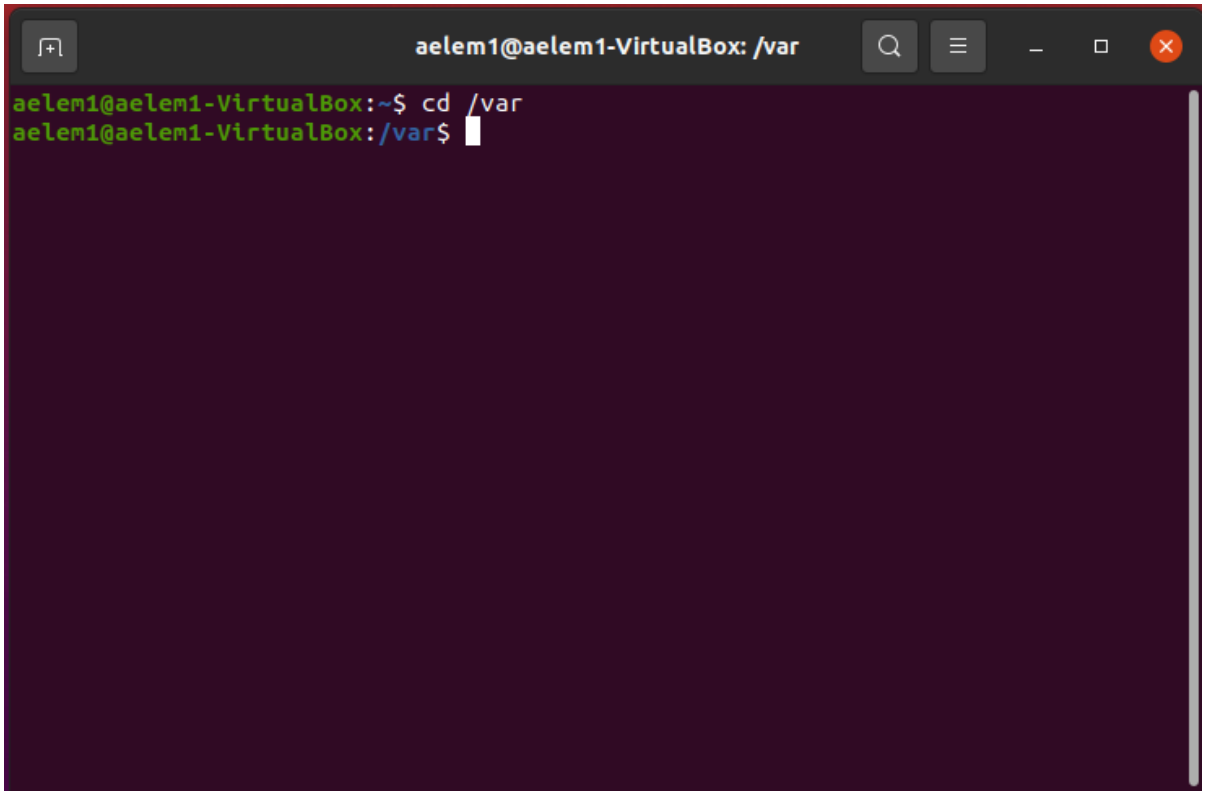
9. Task 3: Examine Apache access log files

- The Apache access logs are text files that include information about all the requests processed by the Apache server. You can expect to find information like the time of the request, the requested resource, the response code, time it took to respond, and the IP address used to request the data.
- The Apache access logs are located in the directory: var/log/apache2
- Open the terminal in the Ubuntu VM.
- Here is what the output might look like:



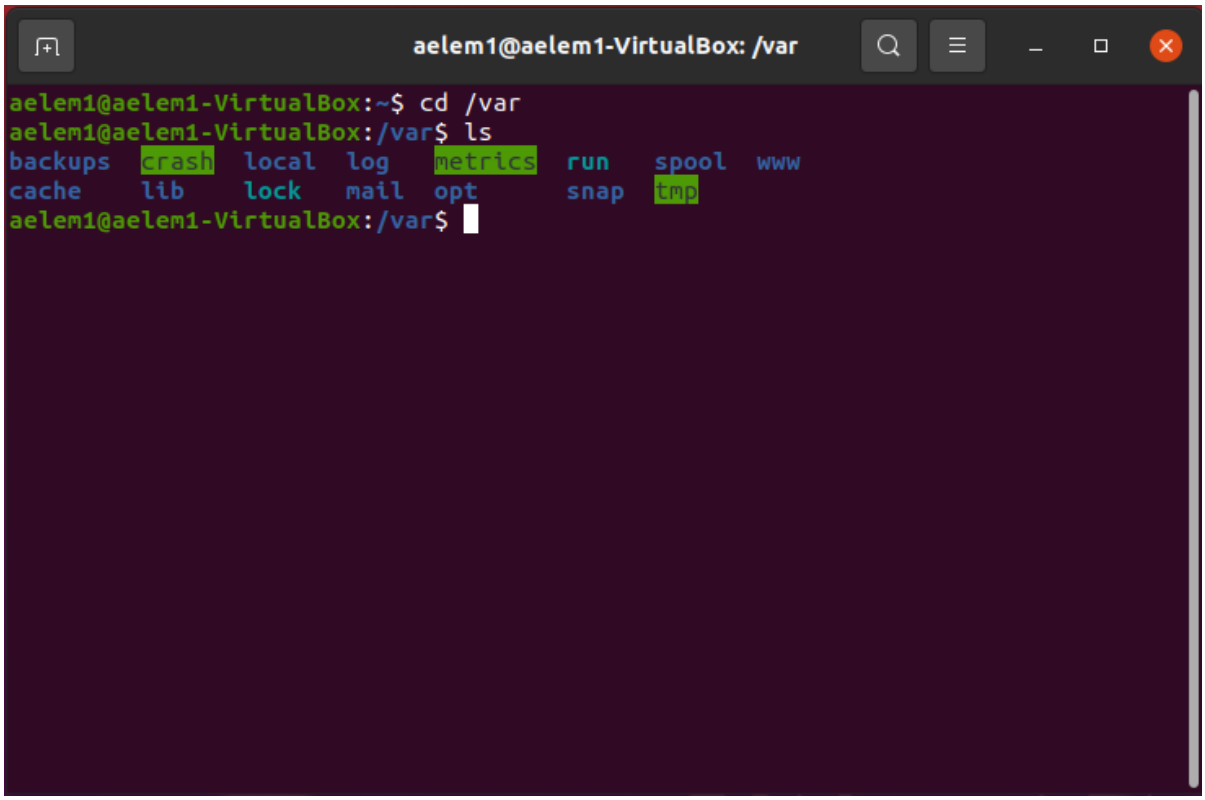
Ubuntu Terminal

- Run the command: cd /var
- Here is what the output might look like:



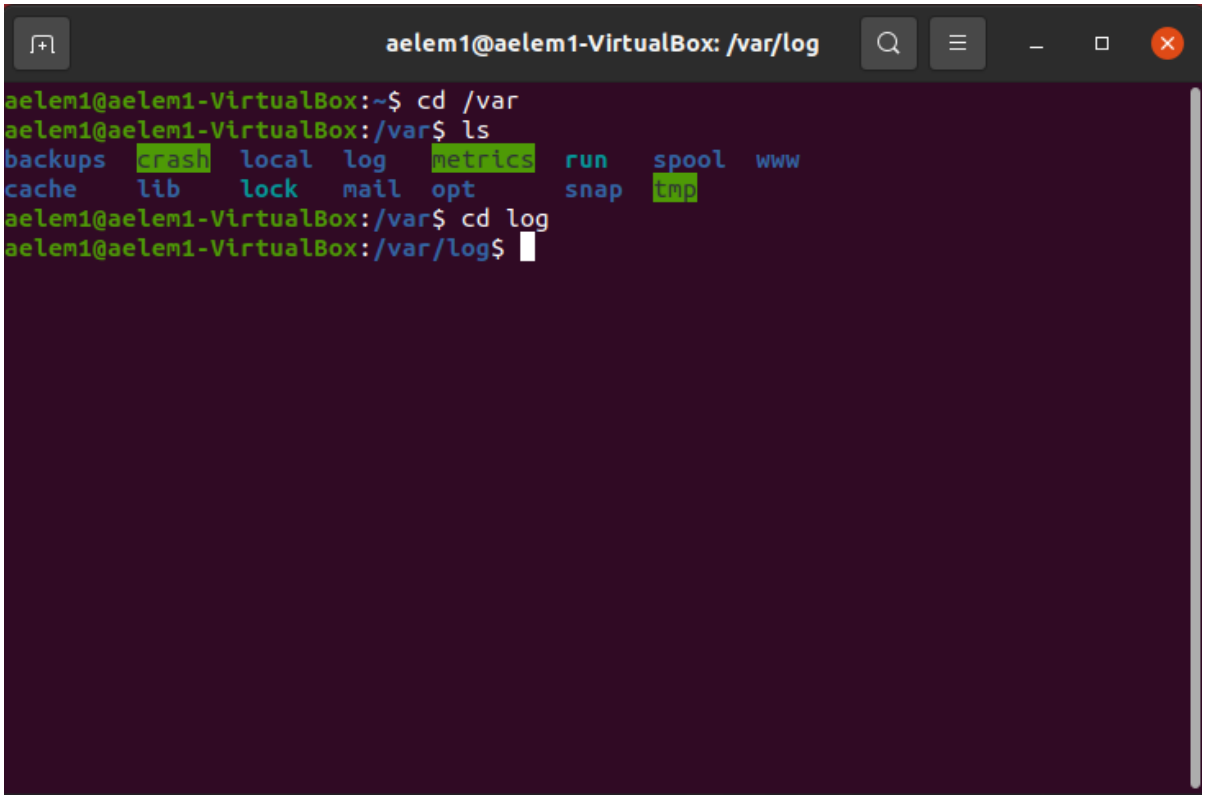
changing directory to var

- Run the command: ls to lists files and directories within the var directory
- Here is what the output might look like:



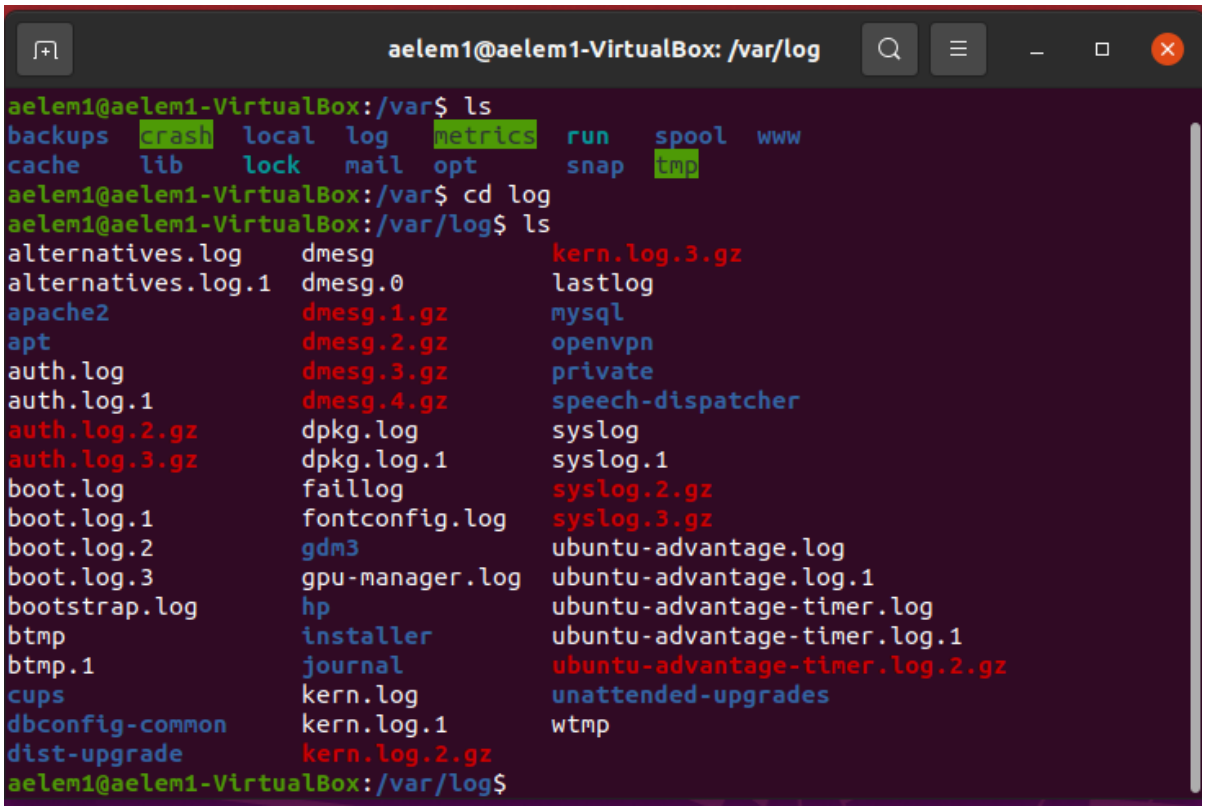
Listing files and directories within var

- Run the command: cd log
- Here is what the output might look like:



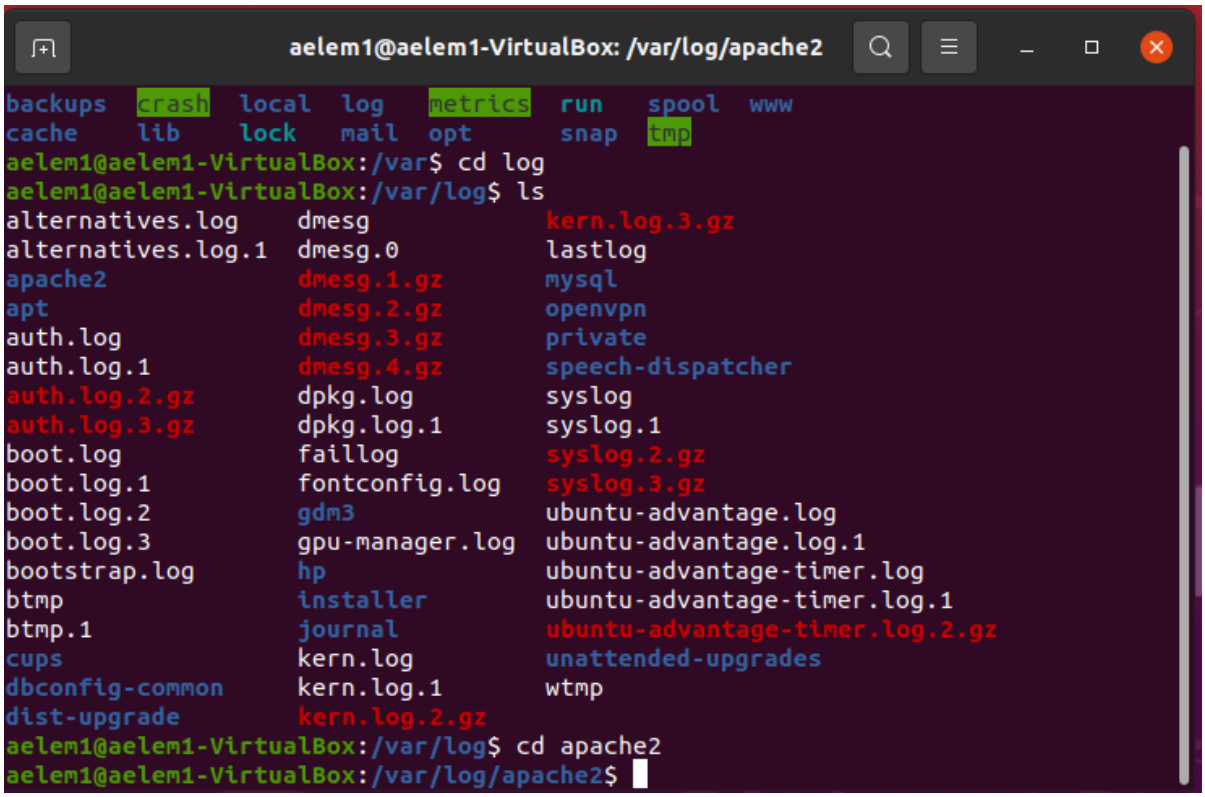
changing directory to log

- Run the command: ls to lists files and directories within the log directory
- Here is what the output might look like:



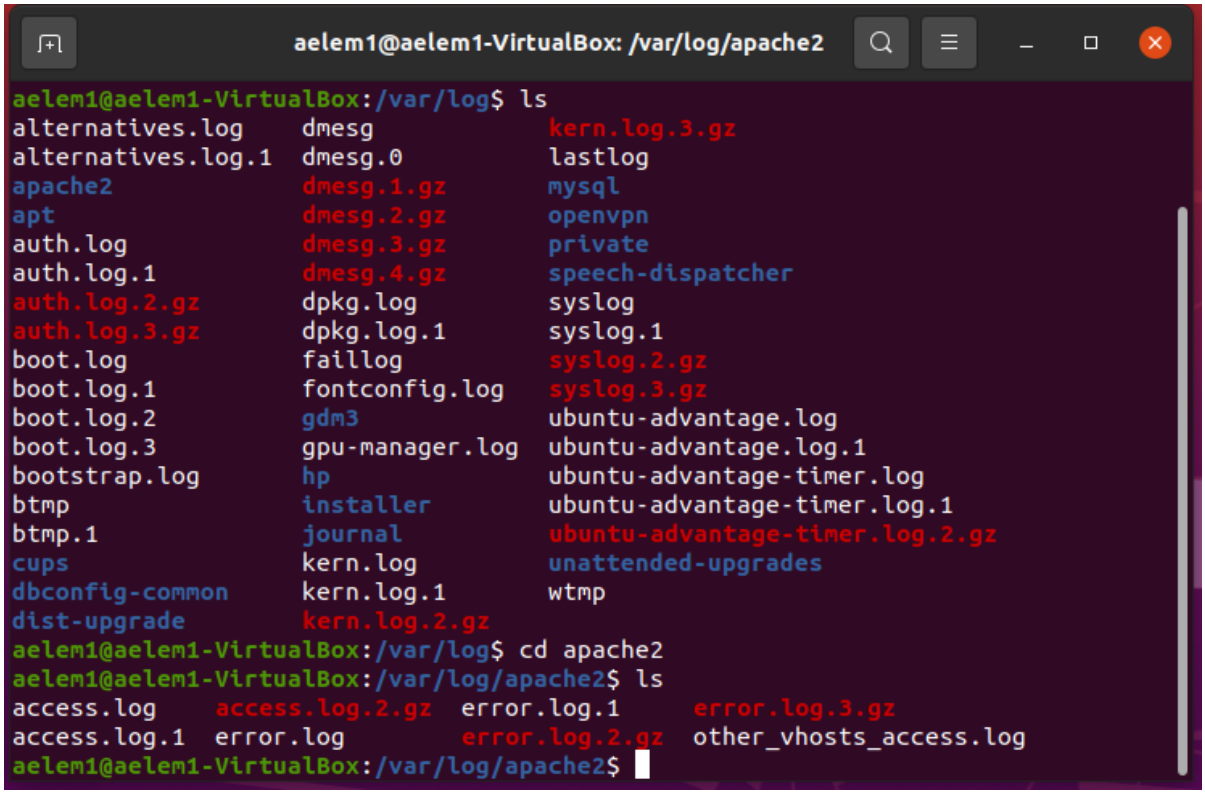
Listing files and directories within log

- Run the command: cd apache2
- Here is what the output might look like:



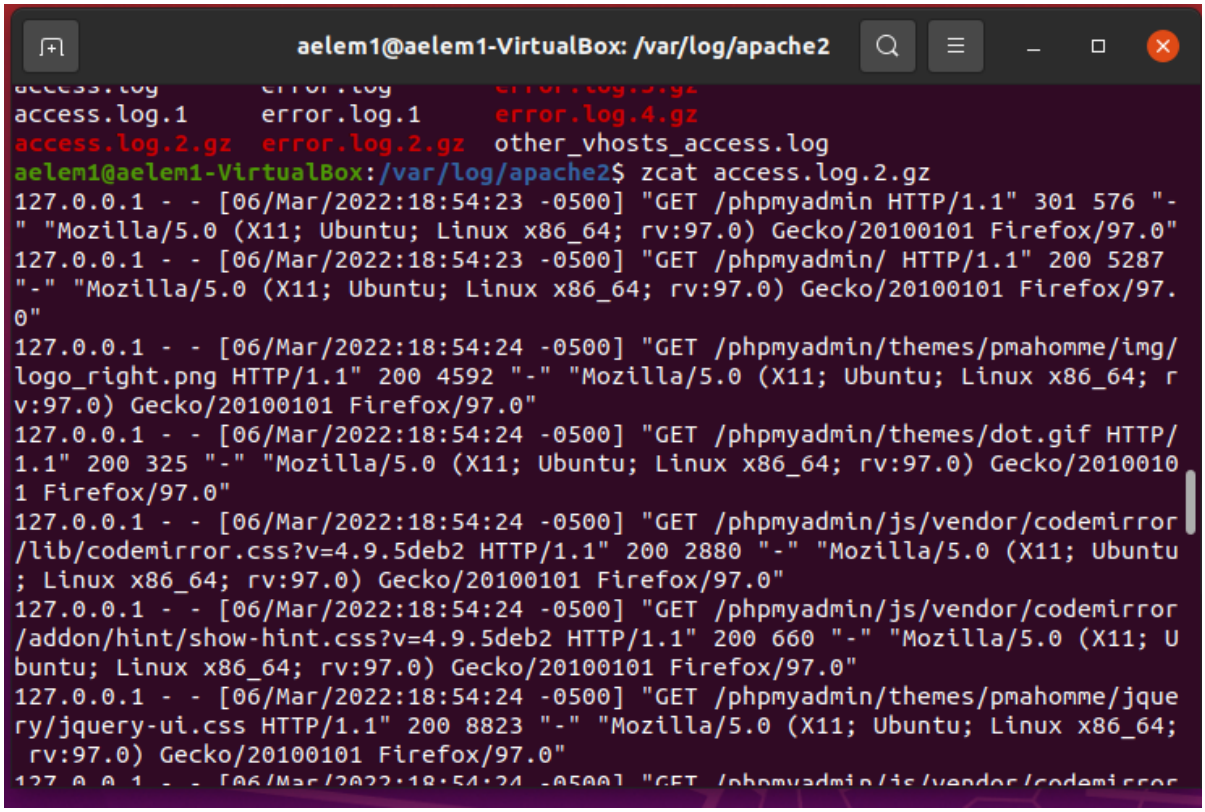
changing directory to apache2

- Run the command: ls to lists files and directories within the apache2 directory
- Here is what the output might look like:



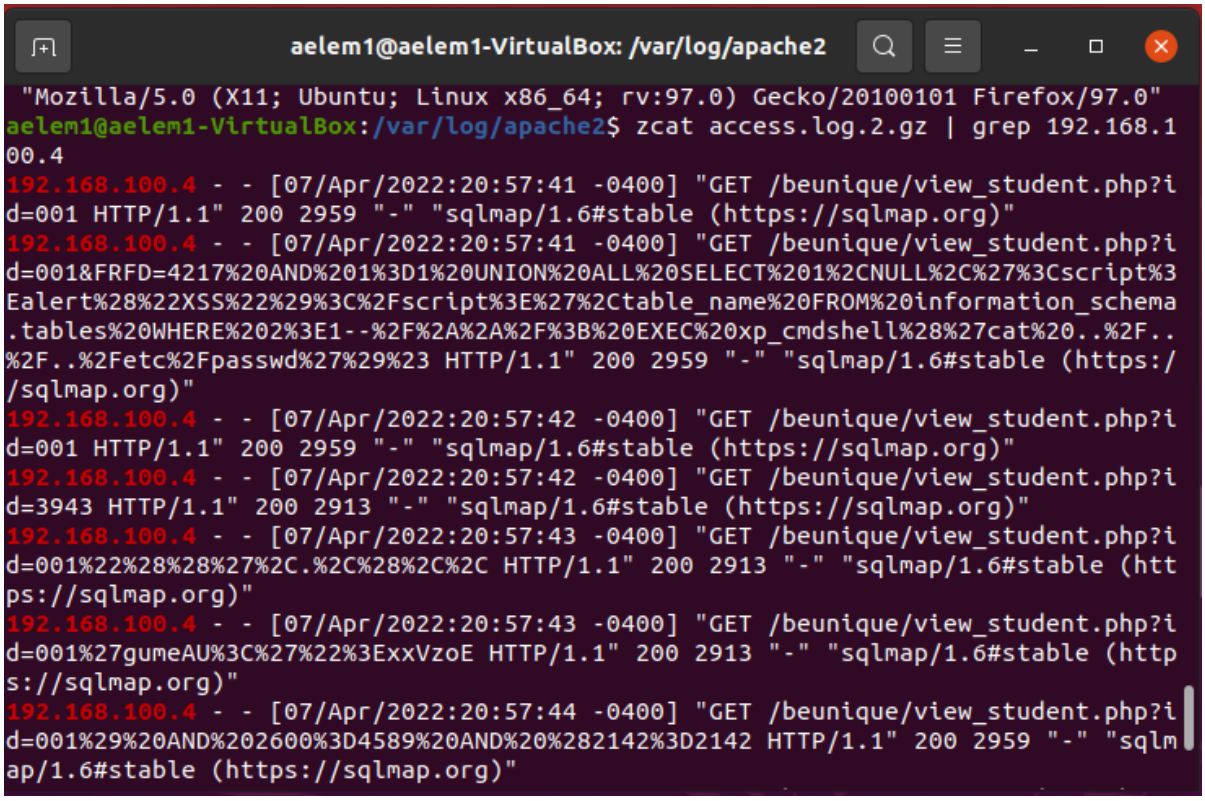
Listing files and directories within apache2

- The command "cat" is used to output the contents of the log file to the screen.
- The command "zcat" is used to output the contents of the compressed log files(.gz) to the screen.
- The log files are numbered in a reverse order i.e the highest number is the oldest log file.
- From the above, we can see that access.log.2.gz is the oldest and first access log file.
- View the contents of access.log.2.gz by running the command: zcat access.log.2.gz
- Here is what the output might look like:



Contents of access.log.2.gz

- Scrolling through the contents of the access.log.2.gz file shows that the attacker's system had an IP Address of 192.168.100.4
- We need to see all the requests that came from the IP Address 192.168.100.4 using the "grep" command thereby filtering out unneeded resources like images, css and javascript files.
- Run the command: zcat access.log.2.gz | grep 192.168.100.4
- Here is what the output might look like:



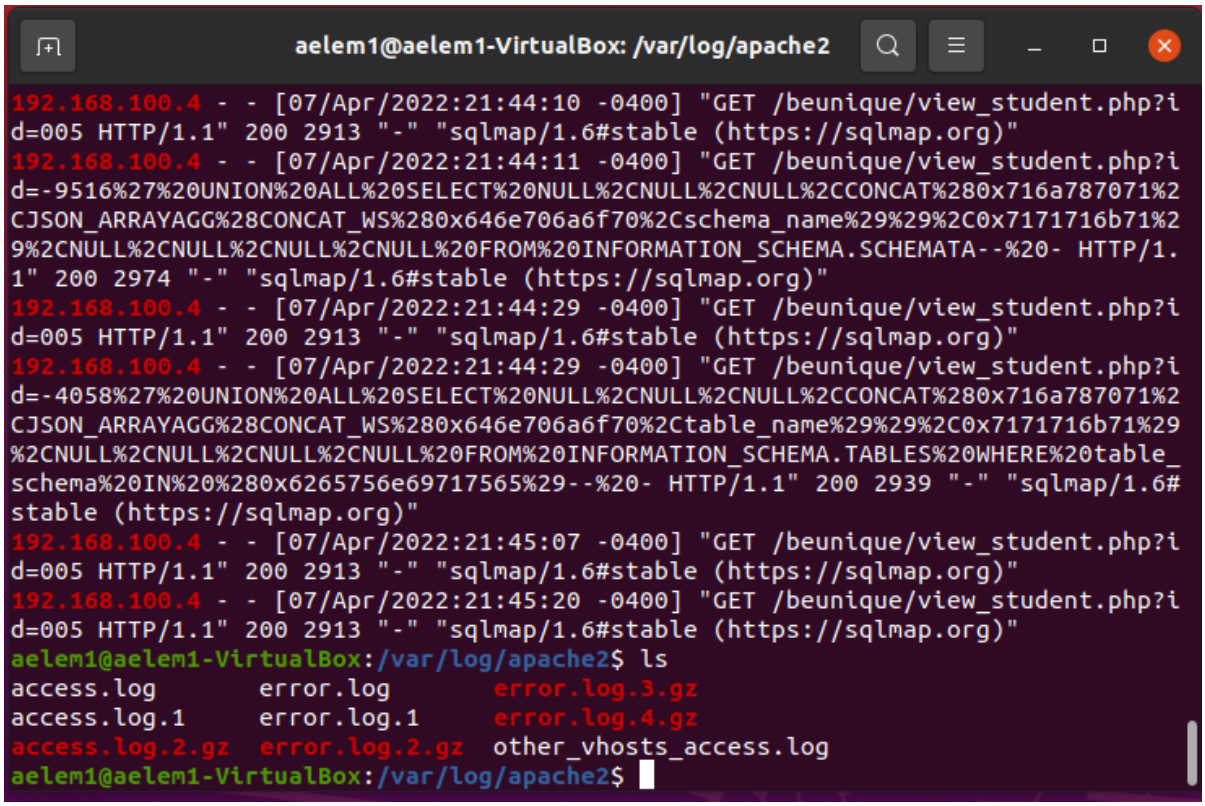
Requests of IP ADDRESS 192.168.100.4 in access.log.2.gz

- The first entry in the log shows that the attack took place on the 7th of April 2022 at 20:57:41 UTC.
- The SQL Injection attack utilized GET method requests which means parameter values was transmitted to the web server within the URL to query the backend database.
- The vulnerable webpage is /beunique/view_student.php?id=001
- The HTTP 200 status response code indicates that the request was successful.
- The quantity of entries in the access.log and the pattern indicate that a SQL injection vulnerability was exploited by the attacker using a SQL injection exploitation tool. The exploitation tool is SQLMAP as shown in the first entry that SQLMAP version 1.6 was used to scan the website. Some log entries of the attack may look like gibberish , but they are SQL queries that are frequently used to extract data via a SQL injection vulnerability. As part of the enumeration process, SQLMAP employs a variety of SQL injection techniques to discover the database name, table name, and columns.
- You can repeat the same process for the access.log.1 file and the access.log file.

10. Task 4: Examine Apache error log files

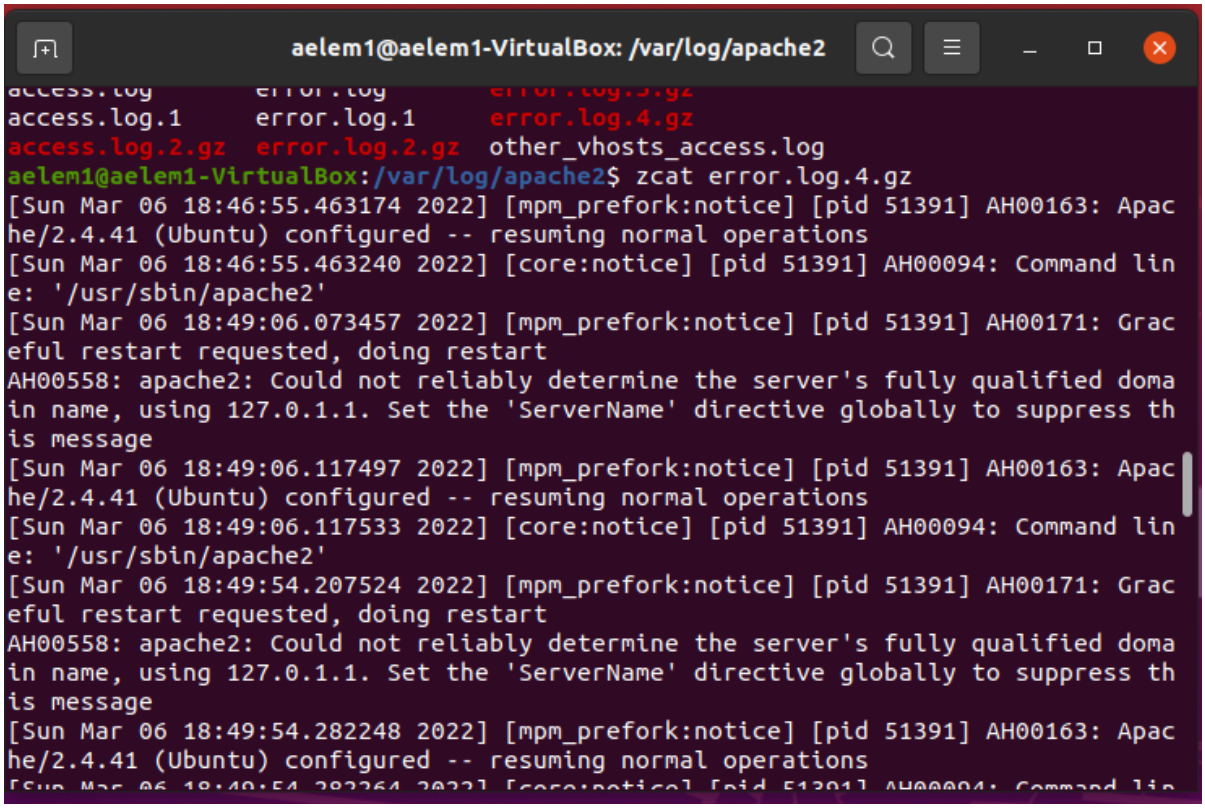
- The Apache error files are in the same apache2 directory.
- Run the ls command to list the files within the apache2 directory

- Here is what the output might look like:



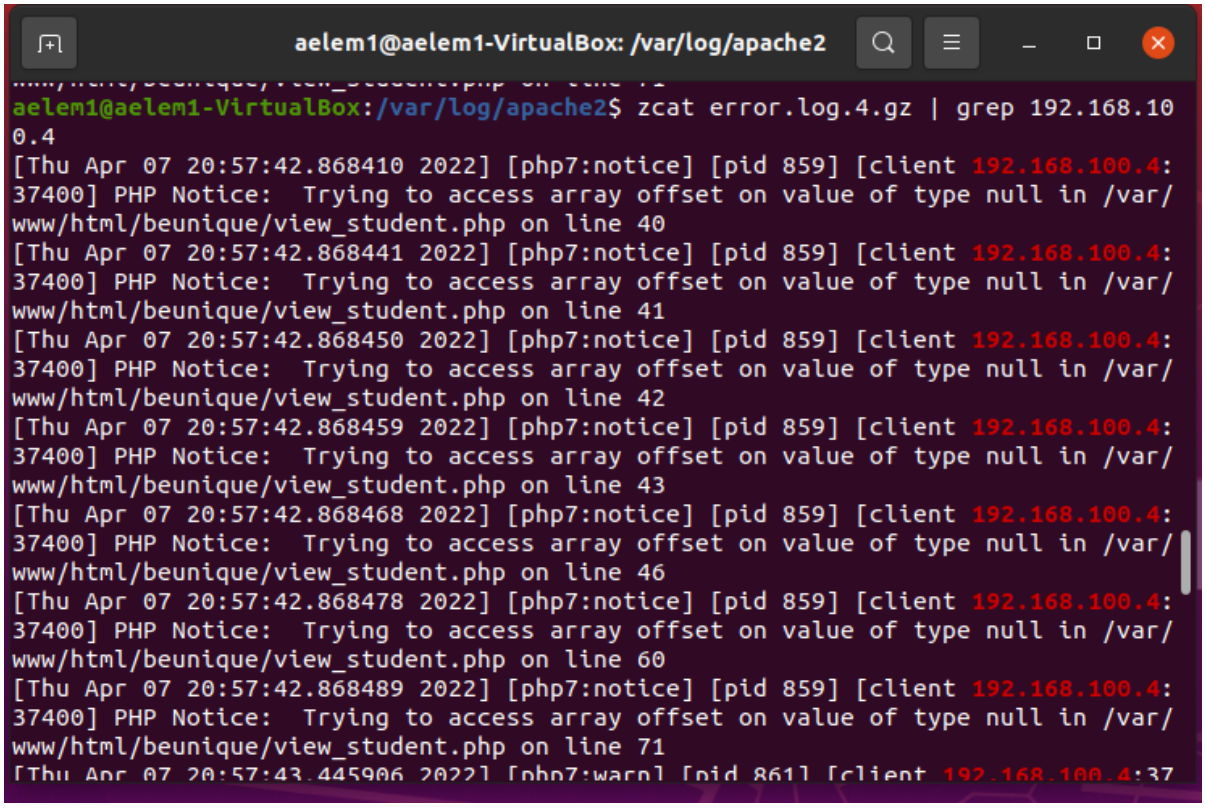
Files in the apache2 directory

- The error log files are also listed in a reverse order so error.log.4.gz is the first and oldest log file
- View the contents of error.log.4.gz by running the command: zcat error.log.4.gz
- Here is what the output might look like:



Contents of error.log.4.gz

- Scrolling through the contents shows the same IP Address of the attacker - 192.168.100.4
- View the error generated by the attacker's IP Address by running the command: zcat error.log.4.gz | grep 192.168.100.4
- Here is what the output might look like:

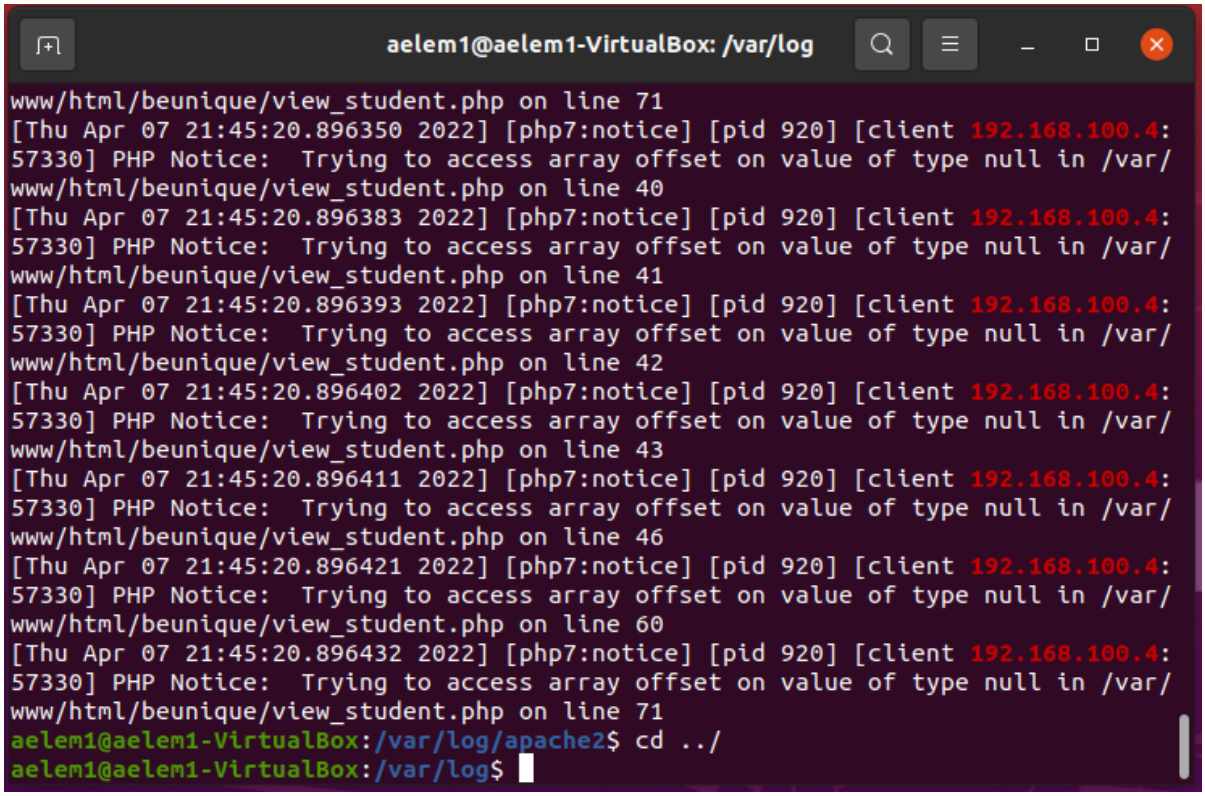


Errors generated by 192.168.100.4 in error.log.4.gz

- Examining the errors shows the PHP Notice on several lines of the code: Trying to access array offset on value of type null in /var/www/html/beunique/view_student.php
- This proves the vulnerability exists in the view_student.php file.
- The first entry shows that the error was generated the same day and time the attack took place in access.log.2.gz - 7th of April 2022 at 20:57 UTC.
- The attacker used an automated tool(SQLMAP) to query the database using an id that does not exist in the table.
- This led to the PHP Notice: Trying to access array offset on value of type null.

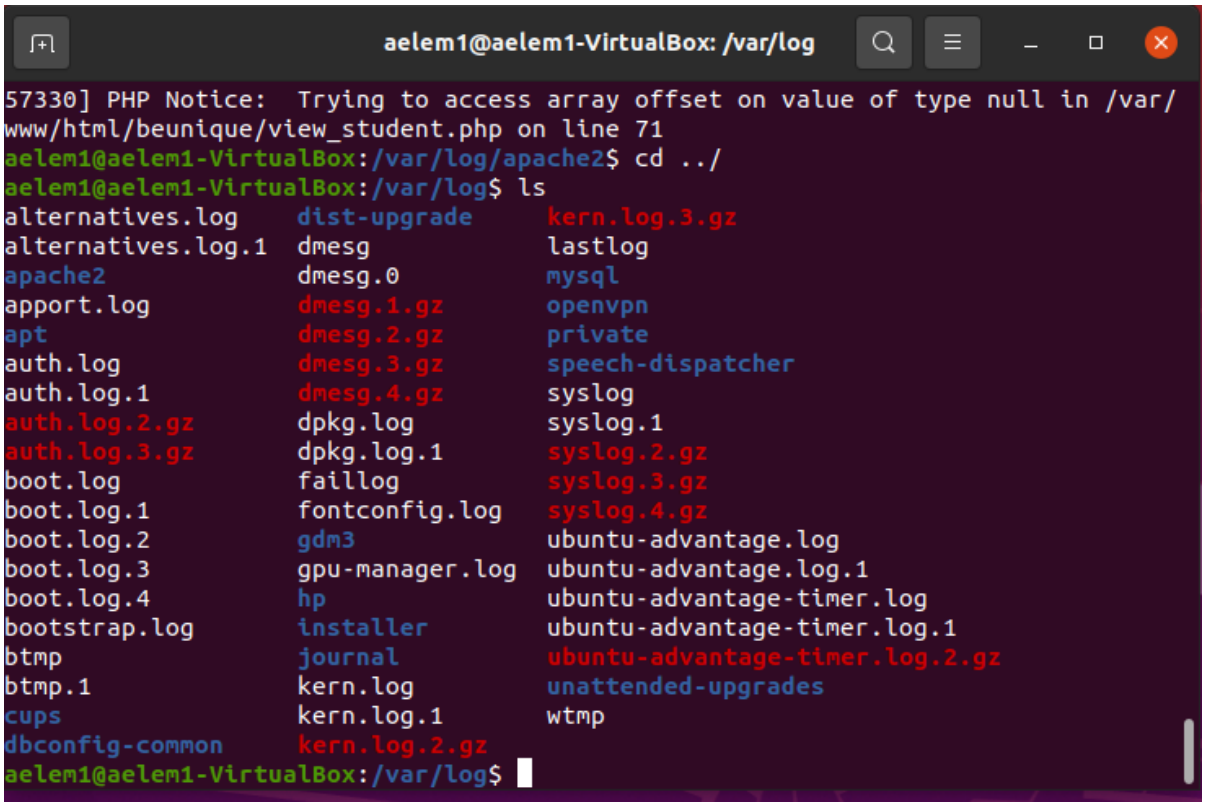
11. Task 5: Examine MySQL query log files

- The MySQL log files are located in the /var/log/mysql directory
- Run the command: cd ../ to go back to the log directory
- Here is what the output might look like:



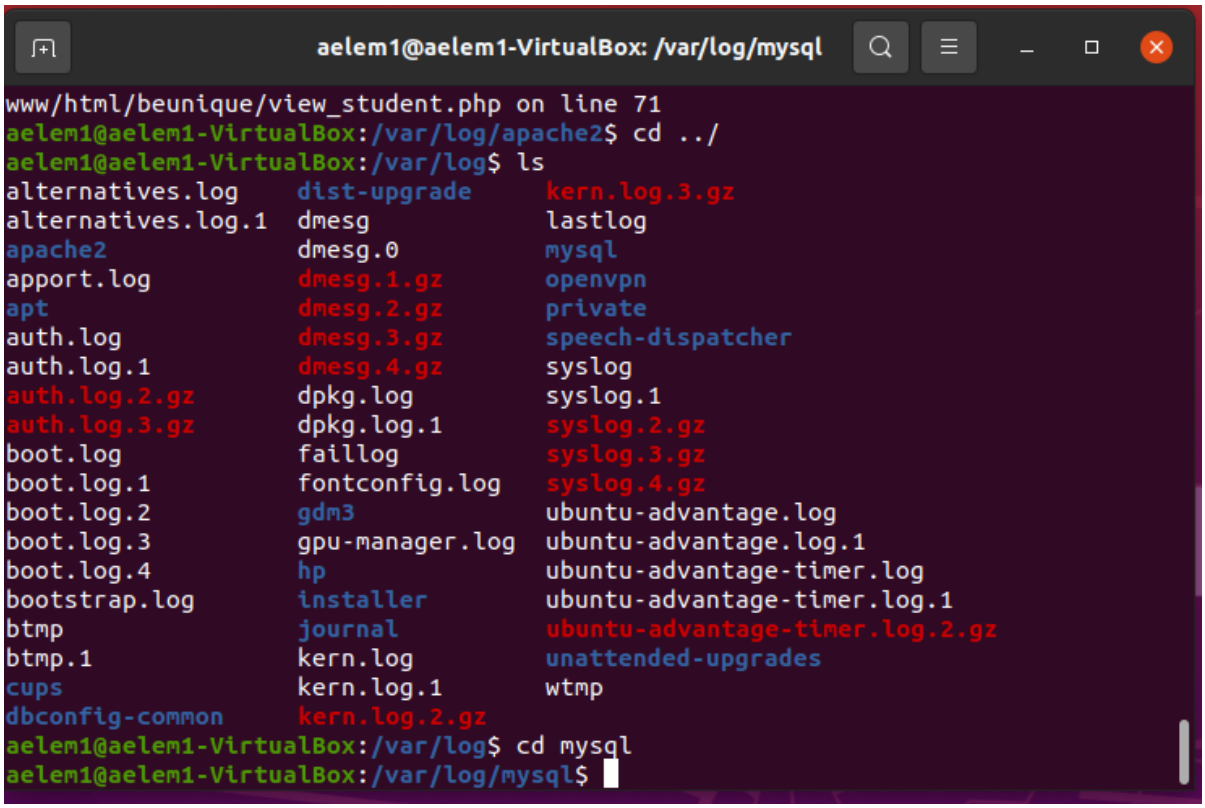
Back to the log Directory

- Run the ls command to list the folders in the log directory
- Here is what the output might look like:



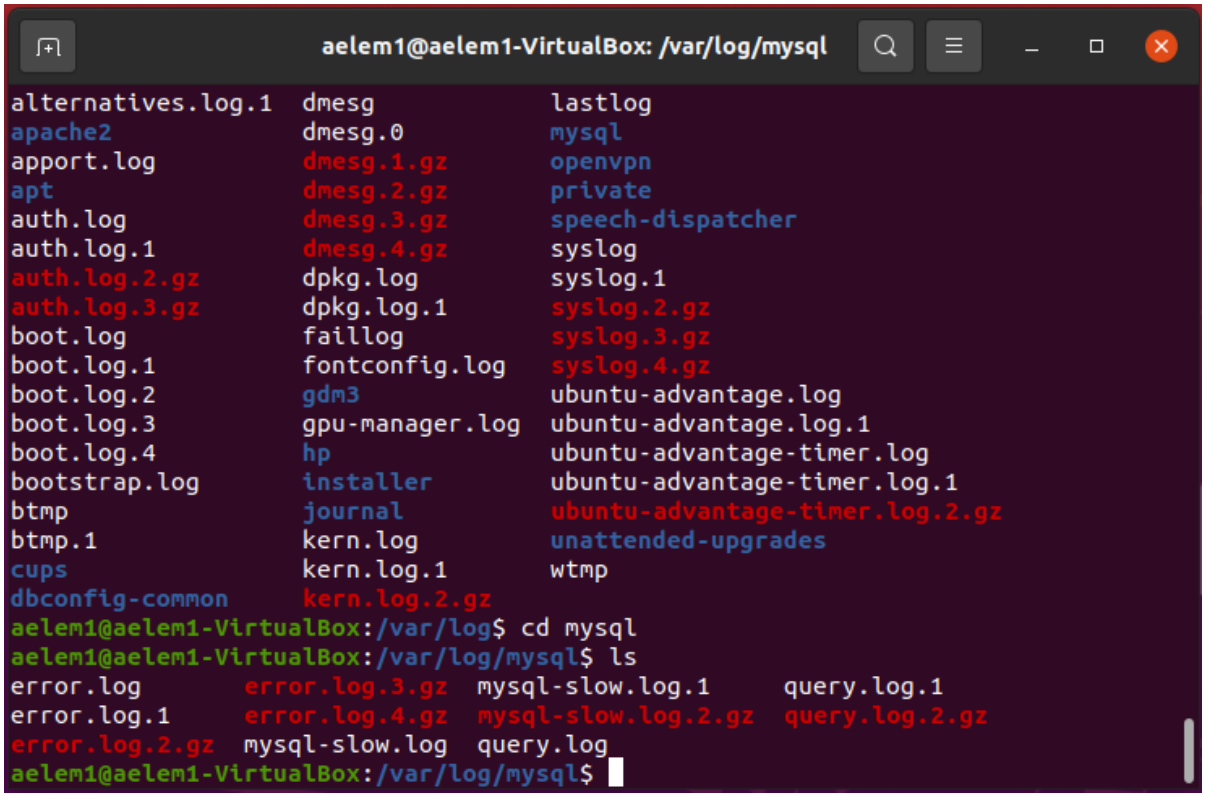
Folders in the log Directory

- Change the directory to Mysql by running the command: cd mysql
- Here is what the output might look like:



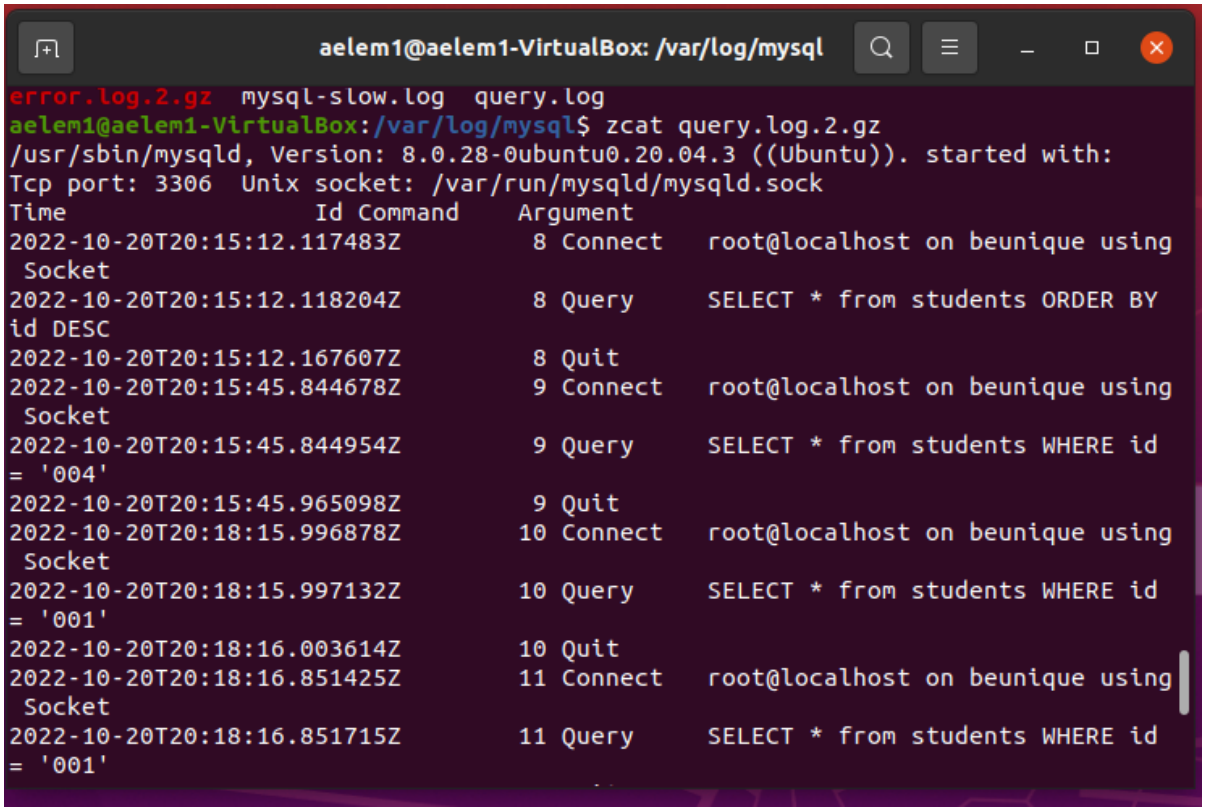
Changing directory to mysql

- Run the ls command
- Here is what the output might look like:



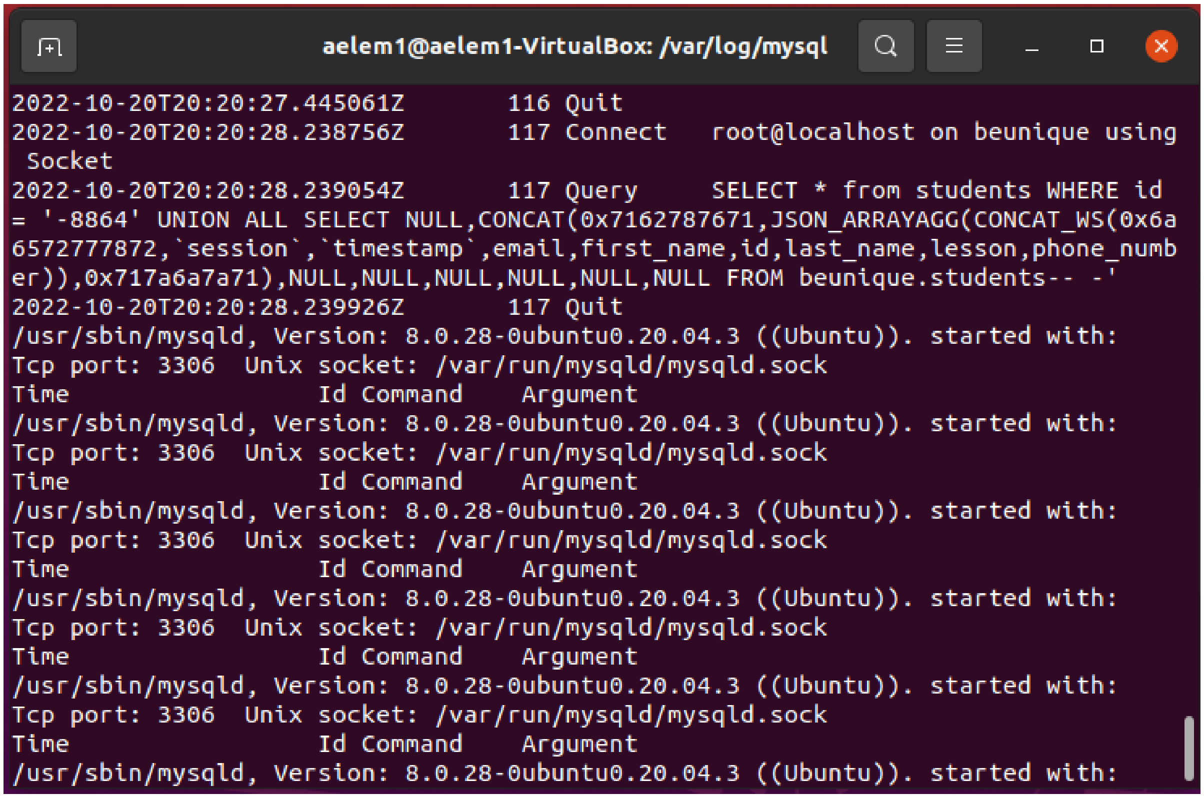
Listing contents of mysql directory

- The query log files follow the same reverse naming system therefore query.log.2.gz is the first and oldest log file.
- View the contents of query.log.2.gz by running the command: zcat query.log.2.gz
- Here is what the output might look like:



Viewing contents of query.log.2.gz

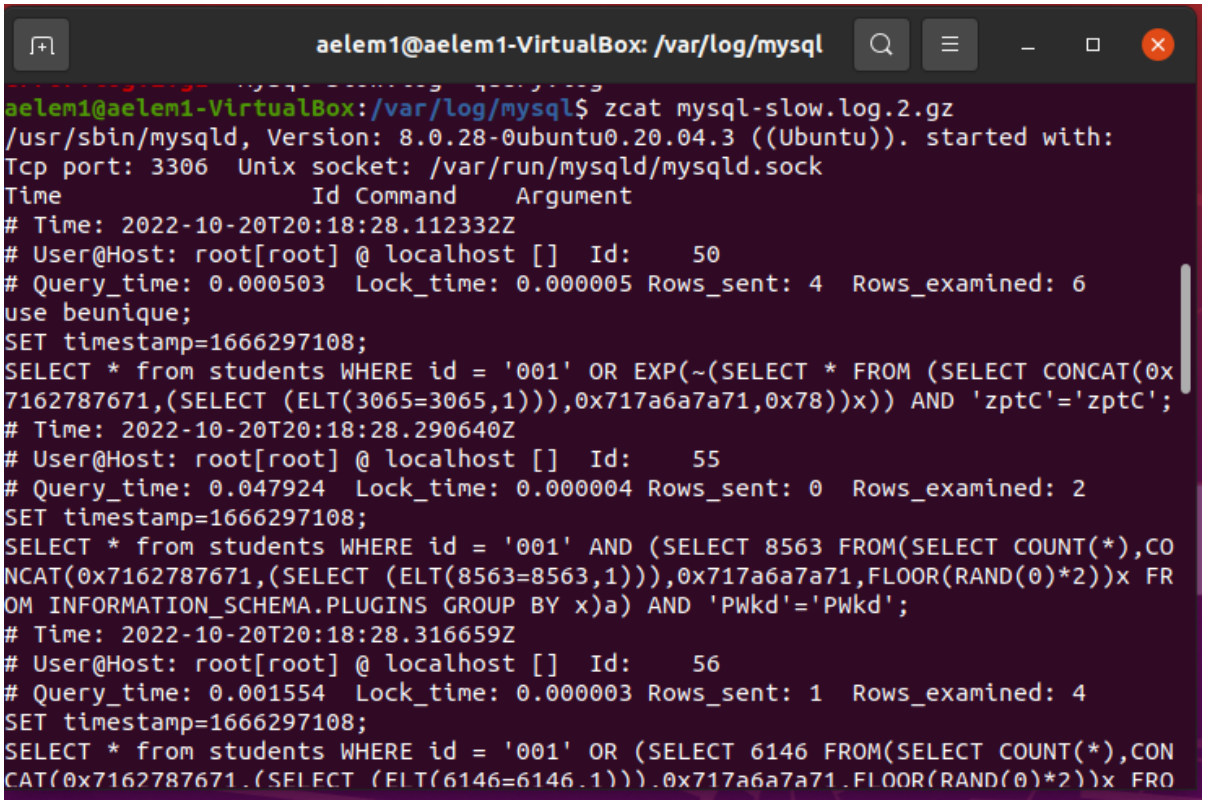
- Scrolling through the contents shows the various queries that were executed.
- Scroll down to the point where the entire database is extracted.
- Here is what the output might look like:



Query showing all the fields in the students table were extracted

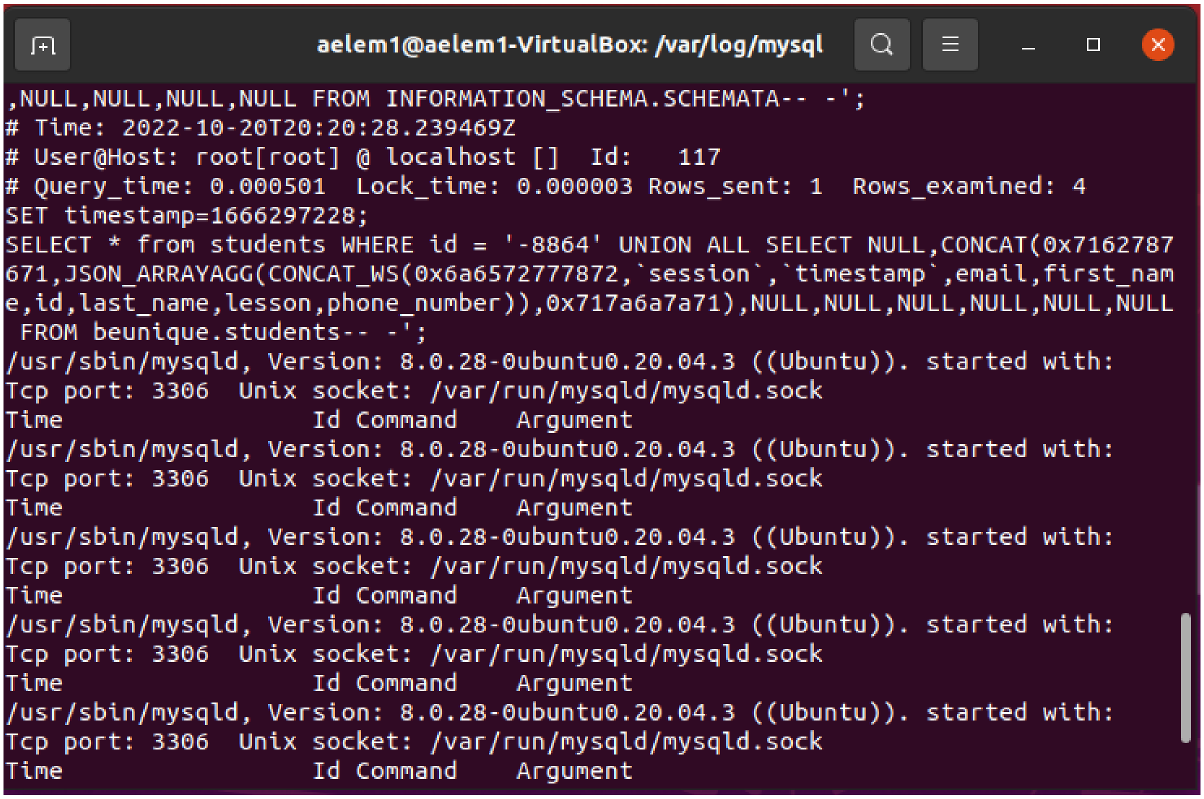
12. Task 6: Examine MySQL mysql-slow log files

- The mysql-slow.log files follow the same reverse naming system therefore mysql-slow.log.2.gz is the first and oldest log file.
- View the contents of mysql-slow.log.2.gz by running the command: zcat mysql-slow.log.2.gz
- Here is what the output might look like:



Viewing contents of mysql-slow.log.2.gz

- Scrolling through the contents shows the various queries that were executed.
- Scroll down to the point where the entire database is extracted.
- Here is what the output might look like:



Query showing all the fields in the students table were extracted

13. Analysis

- Who was responsible for the attack is one of the unanswered mysteries. The attacker's IP address is the only information that is currently accessible. If the attacker did not leave behind tangible proof that could be linked to a specific person's identity, it would be difficult to try and credit most attacks. Keep in mind that most assaults are conducted by attackers using proxies and anonymity networks like Tor to conceal their true location.
- The bottom line is that view_student.php included vulnerable code that enabled a SQL injection attack. The attacker would not have been able to exploit the security flaw that led to the extraction of the database if the website had undergone security vulnerability testing before going live in a production environment.
- In the fictitious example above, the attacker was very careless and left behind a lot of evidence, which made the investigation relatively simple. However, keep in mind that this is not always the case, particularly when dealing with more advanced attacks.

14. Task 7: Test Your Understanding

Complete the questions listed below. At the end of this exercise, attempt to analyze the whole case and answer the *Thought Question(s)* on your own before displaying the answer(s). Note, the latter are not graded.

15. Task 8: Additional Resources

Continuing SQL Injection with SQLMap - Detection via logs

15.1 Flag Questions:

1. What exact time did the attacker first access the website?

   (a) 05/Apr/2022:20:57:41
   (b) 13/Nov/2022:21:47:52
   (c) 07/Apr/2022:20:57:41
   (d) 15/Nov/2022:21:47:53

   - **Correct Answer:** 15/Nov/2022:21:47:53
   - **Answer Description:** To find this, Go to Task 1: Examine Apache access log files
   - **Difficulty:** Hard
   - **Total Points:** 8
   - **Retries:** 2

2. What is the linux command to view a compressed file without uncompressing that file

   (a) cat
   (b) zcat
   (c) head
   (d) tail

   - **Correct Answer:** zcat
   - **Answer Description:** To find this, check Task 1:Examine Apache access log files
   - **Difficulty:** easy
   - **Total Points:** 2
   - **Retries:** 2

3. What linux command would you use to filter log lines of a suspicious IP address?

   (a) ls
   (b) cd
   (c) grep
   (d) var

   - **Correct Answer:** grep
   - **Answer Description:** To find this, check Task 1:Examine Apache access log files
   - **Difficulty:** easy

- **Total Points:** 2
- **Retries:** 2

4. What exact time was data extracted from the students table in the query log?

   (a) 2022-21-16T02:45:15
   (b) 2022-10-20T20:20:24
   (c) 2022-11-16T02:50:15
   (d) 2022-10-20T20:20:28

   - **Correct Answer:** 2022-11-16T02:50:15
   - **Answer Description:** To find this, Go to Task 3:Examine MySQL query log files
   - **Difficulty:** Hard
   - **Total Points:** 8
   - **Retries:** 2

5. What is the first process ID of the second Apache error log generated by the attacker?

   (a) 878
   (b) 51391
   (c) 859
   (d) 3319

   - **Correct Answer:** 878
   - **Answer Description:** To find this, Go to Task 2:Examine Apache error log files
   - **Difficulty:** Hard
   - **Total Points:** 8
   - **Retries:** 2

6. What is the IP Address of the attacker?

   (a) 192.168.100.5
   (b) 192.168.100.3
   (c) 192.168.100.2
   (d) 192.168.100.4

   - **Correct Answer:** 192.168.100.5
   - **Answer Description:** To find this, Go to Task 1:Examine Apache access log files
   - **Difficulty:** Intermediate
   - **Total Points:** 4
   - **Retries:** 2

7. What is the time in UTC when the extraction of the data took place in mysql-slow.log(Hint: Use Epoch Converter)

   (a) Friday, October 21, 2022 4:20:28 PM
   (b) Tuesday, November 15, 2022 9:50:15 PM
   (c) Thursday, October 20, 2022 4:20:28 PM
   (d) Wednesday, November 16, 2022 9:50:15 PM

   - **Correct Answer:** Tuesday, November 15, 2022 9:50:15 PM
   - **Answer Description:** To find this, Go to Task 4:Examine MySQL mysql-slow log files
   - **Difficulty:** Hard
   - **Total Points:** 8
   - **Retries:** 2

8. What is the ID of the query that extracted all the records from the students table in the query log?

   (a) 117
   (b) 114
   (c) 116
   (d) 118

   - **Correct Answer:** 116
   - **Answer Description:** To find this, Go to Task 3:Examine MySQL query log files
   - **Difficulty:** Intermediate
   - **Total Points:** 4
   - **Retries:** 2

9. What is the linux command to determine the type of a file?

   (a) filename
   (b) file
   (c) filetype
   (d) filekind

   - **Correct Answer:** file
   - **Answer Description:** To find this, Go to Task 6: Additional Resources
   - **Difficulty:** Easy
   - **Total Points:** 2
   - **Retries:** 2

10. What linux command is used to view a text file without modifying it?

(a) cat
(b) type
(c) zcat
(d) head

- **Correct Answer:** type
- **Answer Description:** To find this, Go to Task 6: Additional Resources
- **Difficulty:** Easy
- **Total Points:** 2
- **Retries:** 2

15.2 Thought Questions:

1. Create the chain of events that led to this attack?

   - **Correct Answer:**

Chain of events that led to the attack

2. Why is log analysis important in cyber security?

   - **Correct Answer:** Organizations that want to improve their security posture must develop capabilities in log analysis that will enable them to actively recognize and counteract cyber attacks. Businesses that use log analysis to successfully monitor their systems can increase the defenses around their network assets. Splunk and Datadog, as well as other log monitoring technologies, can assist firms achieve compliance standards for cyber security, such as ISO/IEC 27002:2013, PCI DSS V3.1, and NIST 800-137.

They can also lessen the frequency and severity of cyberattacks. The following logs need to be monitored by organizations: System activity logs, Endpoint logs, Application logs, Authentication logs, Physical security logs, Email logs, Firewall logs, VPN logs, Netflow logs, HTTP proxy logs, DNS, DHCP and FTP logs, AppFlow logs, Web and SQL server logs, Malware protection software logs, Network intrusion detection system (NIDS) logs, Network intrusion prevention system (NIPS) logs and Data Loss Prevention (DLP) logs. To save time and resources, cyber security specialists should identify the most crucial logs for ongoing monitoring and use automated or software-based log analysis techniques.

16. References

https://www.acunetix.com/blog/articles/using-logs-to-investigate-a-web-application-attack/