IBM Project Report

On

Detecting Malware Infection on Infrastructure Hosted in IaaS Cloud using Cloud Visibility and Forensics

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Institute of Computer Technology

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CERTIFICATE

This is to certify that the **IBM** Project work entitled **"Detecting Malware Infection on Infrastructure Hosted in IaaS Cloud using Cloud Visibility and Forensics"** by Jainam Shah(Enrolment No.18162121033), Het Patel(Enrolment No.18162171018) and Harshvardhansinh Rahevar (EnrolmentNo.18162101028) of Ganpat University, towards the partial fulfillment of requirements of the degree of Bachelor of Technology – Computer Science and Engineering, carried out by them in the CSE(CBA/BDA/CS) Department at Ganpat University Institute of Computer Technology. The results/findings contained in this Project have not been submitted in part or full to any other University / Institute for award of any other Degree/Diploma.

Name & Signature of Internal Guide

Name & Signature of Head

Place: ICT - GUNI

Date:

ACKNOWLEDGEMENT

IBM project is a golden opportunity for learning and self-development. I consider myself very lucky and honored to have so many wonderful people lead me through in completion of this project. First and foremost, I would like to thank Dr. Hemal Shah, Principal, ICT, and Prof. Dharmesh Darji , Head, ICT who gave us an opportunity to undertake this project. My grateful thanks to Prof. Ravindra Patel & Mr. Anoj Dixit (Internal & External Guides) for their guidance in project work Detecting Malware Infection on Infrastructure Hosted in IaaS Cloud using Cloud Visibility and Forensics, who despite being extraordinarily busy with academics, took time out to hear, guide and keep us on the correct path. We do not know where would have been without their help. CSE department monitored our progress and arranged all facilities to make life easier. We choose this moment to acknowledge their contribution gratefully.

JAINAM SHAH (Enrollment No:18162121033)

ABSTRACT

With the advent of Cloud computing being espoused very briskly by organizations with diverse businesses and sizes, the utilization of cloud services is soaring at an untrackable rate these days more importantly IaaS services as cloud providers allow more secured resources with supple offerings and models. This escalating adoption gives birth to new surface attacks to organizations that attackers tend to abuse with their malware to dominate these invaluable resources and the important data that is stored on them. Therefore, for organizations in order to well guard against these malware attacks they need to have full discernibility not only on their data centers but also on their resources which are stored on the cloud. This proposed project discusses and aims to yield the best approaches to attain continuous monitoring of malware attacks on the cloud along with their phases (before, during, and after). This project line ups to defines the best methods to bring loggings and forensics to the cloud platform and integrate them with on-premises visibility, thus attaining the full monitoring over the whole security standpoint of the organization assets whether they are on-premises or on the cloud.

INDEX

Title **Page No**

CHAPTER: 1 INTRODUCTION

CHAPTER 1 INTRODUCTION

The availability to store data on cloud is a modern technology. In recent years, utilization of services on cloud platform is skyrocketing at an alarming pace, now it has turned more famous after the emergence of the 4th Economic Industrial Revolution. In the year of 2020, nearly 83 percentage of workloads in business are functional on the cloud platform, and around 94 percentage of companies in today's market utilize a cloud service in one of their services. There are approximately 3 most used cloud services including Software as a Service (SaaS), Platform as a Service (PaaS), and Infrastructure as a Service (IaaS). Monitoring the current market, (IaaS) is the most rapidly growing service in Cloud Computing.

However due to ample number of exquisite features being available on the IaaS cloud, it is turning into a playground to many attacks of malware for the following reasons:

1) Companies which are providing cloud services unremittingly offer off the chart's performance with more computation power for their clients. These virtual machines on cloud are primary targets for crypto currency mining malware.

2) The rise of work from home era and internationally separated manpower and resources accessibility after the Sars-Cov2 (corona virus) has provided the attackers more ways to conceal their detrimental traffic to take over the cloud-hosted virtual machines, and utilize them for their malicious activities.

3) The definite rise in IoT applications that use cloud-hosted data and services to analyze the gigantic quantity of data created by these applications to construct business value and insights.

By considering this above scenario we decided to perform monitoring and analysis of data uploaded by user on cloud premises and how/she can mitigate the dangers if they are trapped in such circumstances. The main objectives of this project are as follows: -

- It directs its goal to utilize the best ways to attain non-stop monitoring of malware attacks on the cloud.
- The techniques of logging data and performing forensics have always been the foundations of accomplishing non-stop monitoring and detection of malware attacks.
- To arrogate the perfect methods to bring the concept of forensics and logging to the cloud and integrate them with on-premises visibility.
- Attaining the proper monitoring considering the whole security standpoint of the organization assets whether they are stored on an on-premises system or on the cloud platform.

Below is the list of the tools and technologies which we have used in this project: -

- AWS CloudTrail for creating data log files.
- AWS CloudWatch for monitoring.

CHAPTER: 2 PROJECT SCOPE

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The project is limited to only Desktop/Service system because data which is considered for malware analysis and monitoring must be uploaded by the user on cloud premises.

CHAPTER: 3 SOFTWARE AND HARDWARE REQUIREMENTS

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Minimum Hardware Requirements

Processor	2.0 GHz
RAM	8GB
HDD	Minimum 30GB

Table 3.1 Minimum Hardware Requirements

Minimum Software Requirements

OS	Any operating system which can support an internet browser.
Programming languages	-
Tools and Technologies	AWS, Splunk, kali Linux

Table 3.2 Minimum Software Requirements

CHAPTER: 4 PROCESS MODEL

CHAPTER 4 PROCESS MODEL

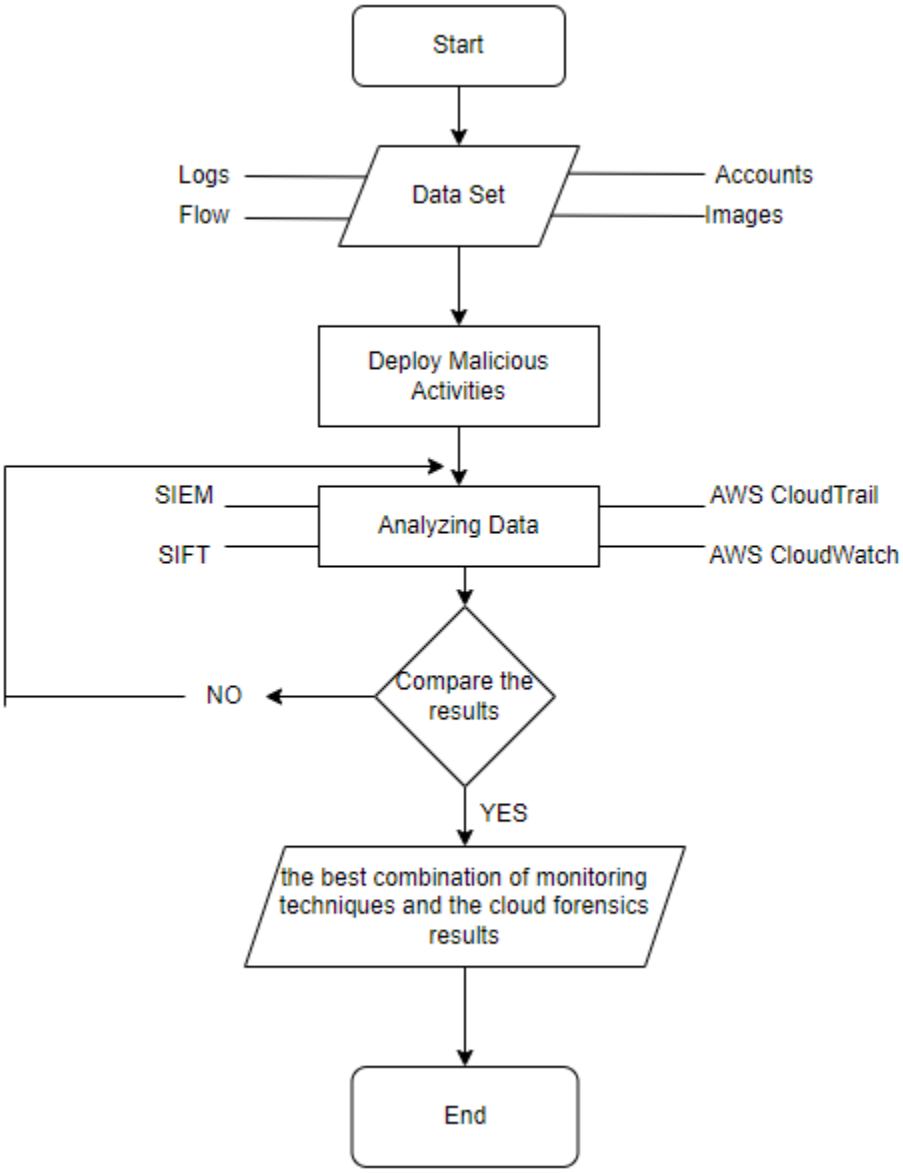


Figure 4.1 Process Model of Project

CHAPTER: 5 PROJECT PLAN

CHAPTER 5 PROJECT PLAN

5.1 List of Major Activities

5.1.1 Tasks for Implementing Data Monitoring in First Phase

Task: - 1 Exploring NIST and MITRE ATT&CK Frameworks
Task: - 2 Exploring AWS Tools (CloudTrail and CloudWatch) to generate data log files
Task: - 3 Creating and uploading data files on Amazon S3 for Analysis
Task: - 4 Malware Attack and Monitoring

5.1.2 Time Duration to Complete First Phase

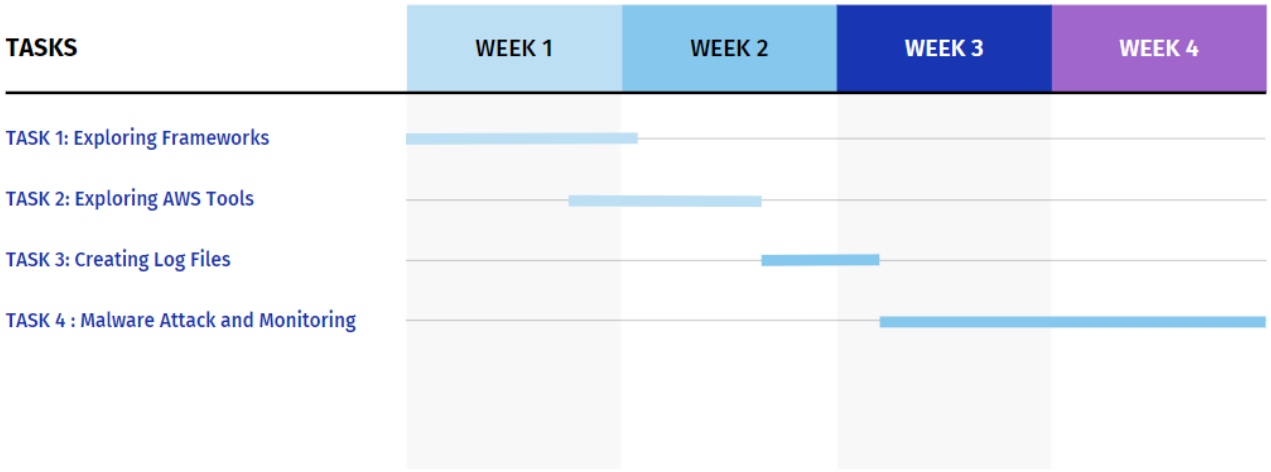


Figure 5.1 Task Completion Time Duration in First Phase

5.1.3 Tasks for Implementing Data Logging and Integration in Second Phase

Task: - 1 Exploring AWS CloudTrail and Gathering Data Log Files
Task: - 2 Implementing Data Monitoring and Logging on AWS Config
Task: - 3 Exploring to SIEM Tools to transfer logs
Task: - 4 Integrating Splunk with AWS CloudTrail Logs

5.1.4 Time Duration to Complete Second Phase

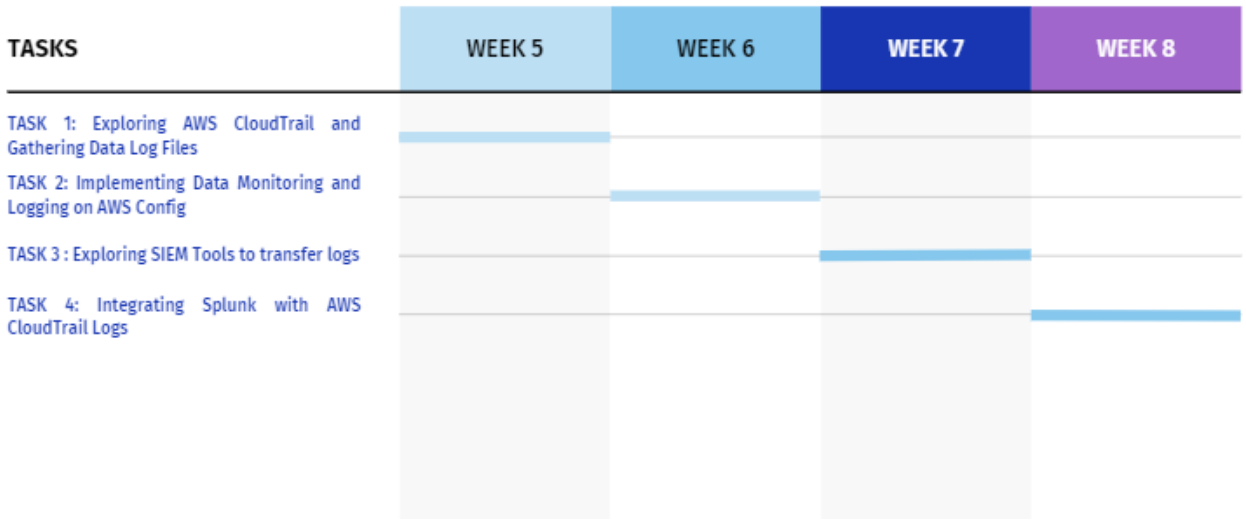


Figure 5.2 Task Completion Time Duration in Second Phase

5.1.5 Tasks for Evidence Capturing and Forensic Analysis in Third Phase

Task: - 1 SIFT Exploration
Task: - 2 AWS EC2 Exploration and setting up investigation tools on EC2
Task: - 3 Cloud Forensic Analysis and Evidence Capturing
Task: - 4 Additional Cloud Forensics

5.1.6 Time Duration to Complete Third Phase

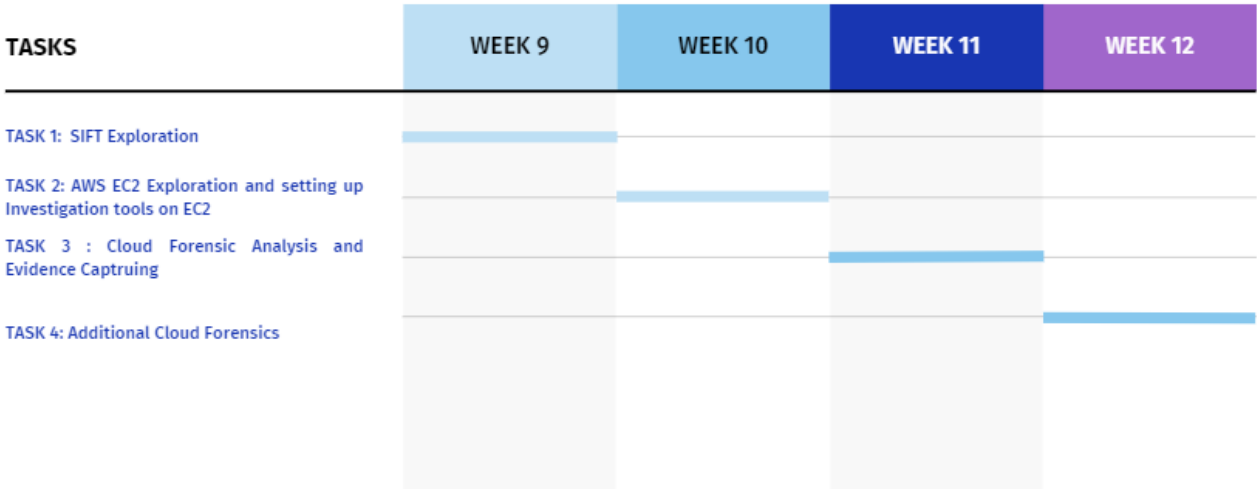


Figure 5.3 Task Completion Time Duration in Third Phase

CHAPTER: 6 IMPLEMENTATION DETAILS

CHAPTER 6 IMPLEMENTATION DETAILS

6.1 Background

The proposed project is based on 4 fundamental parts as follows: -

1. Infrastructure as a Service (IaaS) Cloud - It can be considered as the most important service, which provides basic computational services such as servers, networking, and storage. This service supplements the availability of the system on lower costs and providing a more pliable system.

2. Malware Attacks - In layman terms the term malware means dangerous and harmful, it has similar effect on software, networks, OS, or other components. The most major challenge while using IaaS cloud world is its vulnerability and the possibility of malware attacks; it is a vital concern to devices present at home as well as the devices used for business in a corporate and also on cloud VMs.

3. Malware Detection Methods – In order to prevent malware from hampering networks malware detections methods are necessary to implement in order for its proper functioning, a number of malware detection methods can be applied for e.g.: - Techniques based on Signature/Behavior for malware detection, Machine Learning Based malware detection methods etc.

4. Cloud Forensics – It can be defined as techniques that are utilized in order to perform collecting and storing incidents happening around and their visibility, remodeling events, recognizing when an incident is happening, how an incident is happening, and where an incident is happening, and implementing information/data regarding that.

6.2 Methodology

The methodology of the mentioned project has been segregated into two parts:

The First: Whenever or wherever a malware attack takes place, the investigator should make cloud analysis for that particular malware detection.
The Second: is to perform forensics analysis in the IaaS Cloud after the attack happens.

6.2.1 Gathering Data

In today's, there are two initiatives that define and segregate in an orderly manner how each cloud attack technique is witnessed; they are NIST Cybersecurity Framework and MITRE ATT&CK cloud framework.

For this project multiple csv files and data log files uploaded on NIST and MITRE ATT&CK website have been used for performing monitoring of data. Otherwise, any type of data can be used by a user as monitoring and analysis is done on cloud.

6.3 Cloud Analysis to Malware Detection

6.3.1. Test Environment - The tests for this mentioned project were performed on Amazon Web services (AWS), the main reason for choosing AWS for this project was because it is currently the market leader and provides so many public cloud services and possesses a varied range of service catalog and thus in turn making it a more suitable choice for the mentioned problem.

6.3.2. Data Set – Any data can be considered by a user for testing this module, for the sake of testing we have selected data which provided by NIST and MITRE ATT&CK frameworks from their websites.

Non-Stop monitoring on IaaS can be attained by collecting and processing the following

- Monitoring API Calls (CloudTrail's logs in AWS).
- Hosting logs and logs of deployed HIDs.
- VPC flows.
- Logs of numerous cloud resources (CloudWatch Logs in AWS)
- Validation and Integrity of images and instances.

6.3.3. Testing and Analysis – For performing testing and analysis multiple tools have been utilized to store date and perform malware attacks on it

AWS CloudWatch – to gather and monitor metrics, gather and monitor log files, setting alarms, and automatically react to changes.

AWS CloudTrail - A web service that logs your account's AWS API calls and provides you log files.

AWS S3 – For storing data and hosting a static website

Kali Linux – For performing malware attacks

6.3.4 Testing Phases

1. Creating AWS Billing Alarm

As per the MITRE ATT&CK framework, most majorly used attack vectors for attacks on cloud and malware attacks aiming cloud-hosted environments is the cloud account takeover. There are multiple ways to detect that, the most promising way is detecting changes in the billings on AWS. Most public cloud providers provide features to allow their customers to make billing tags and then send them emails whenever alarms are triggered.

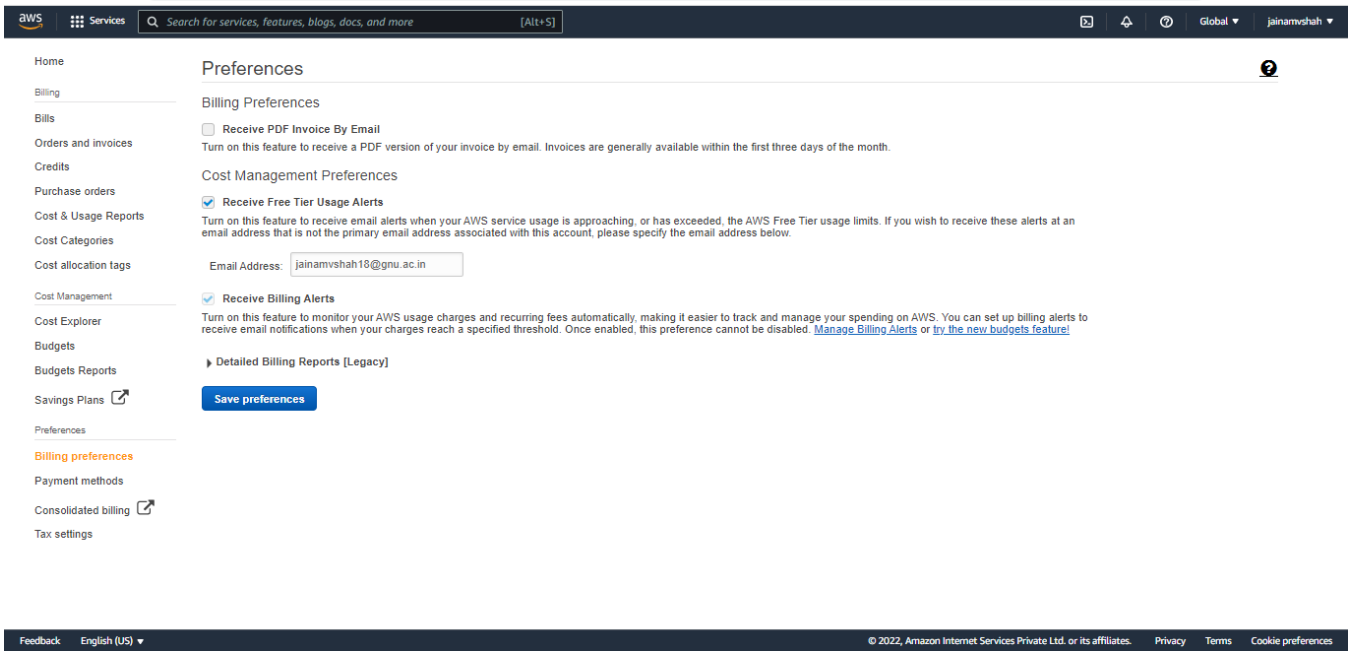


Figure 6.1 AWS Billing Preferences

If there is usage of any service on the respective cloud account AWS will sent notification to the respective email.

2. Performing Continuous Monitoring in AWS Environment

AWS Cloud platform provides a service called AWS Config, this service enables monitoring AWS resource configurations and keep tracks on resource inventory and varied changes that might take place within it, which can be utilized to detect any malicious configuration changes that an attacker might try to make in order to gain control over the compromised account's resources. The monitoring information gathered from this then can be obsorbed using AWS CloudWatch and SNS Notifications can be created based on them.

Malware attacks earmark and make changes to the data stored and any misconfigured cloud storage leading to data leak. By making use of AWS Config, the rules like proper storage versioning is kept on for AWS storage (S3). By enabling the s3-bucketversioning- enabled rule, another activity auditioned by attackers is to hide their vindictive API calls by disabling API calls monitoring, another rule that can be configured is to check if CloudTrail service is enabled or not and yet another rule to detect whether the volumes which are utilized are having encryption or not.

Initially starting by making S3 buckets in respective AWS account in order to perform monitoring and also to do malware attacks.

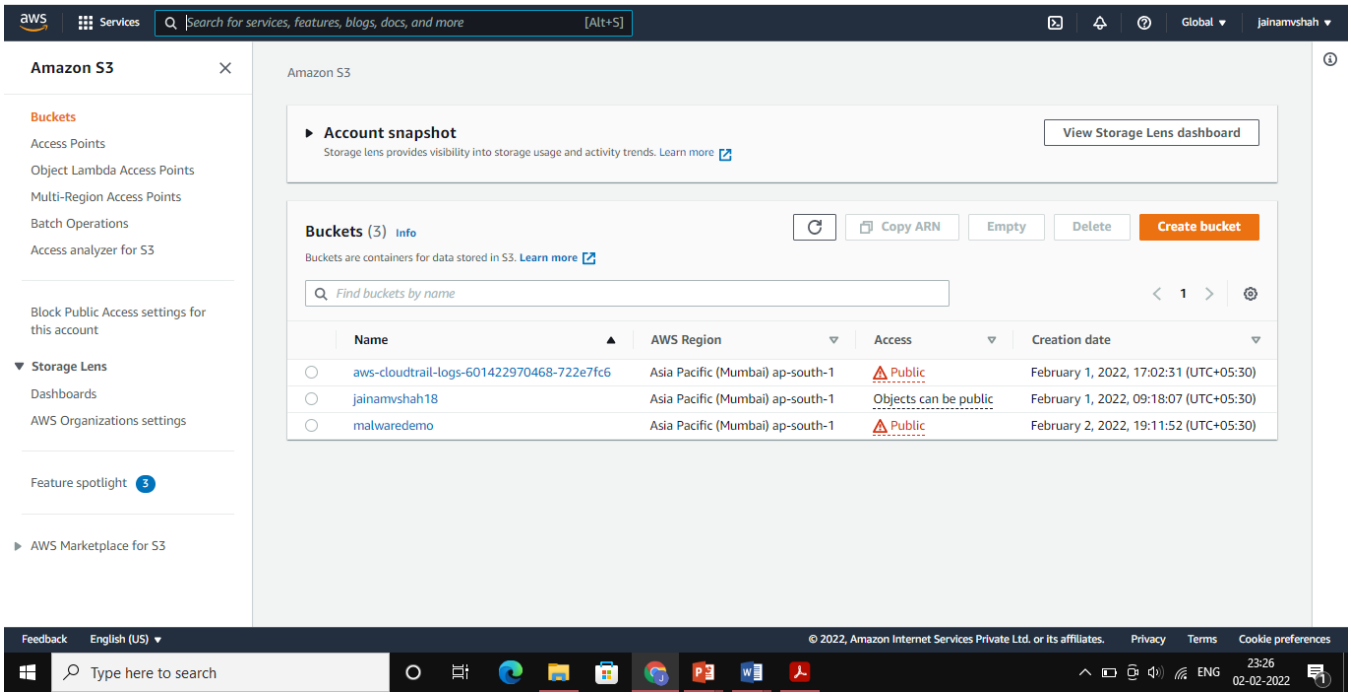


Figure 6.2 S3 Buckets

Furthermore, additional charts are being created for request and storage metrics in order to perform monitoring on our respective bucket

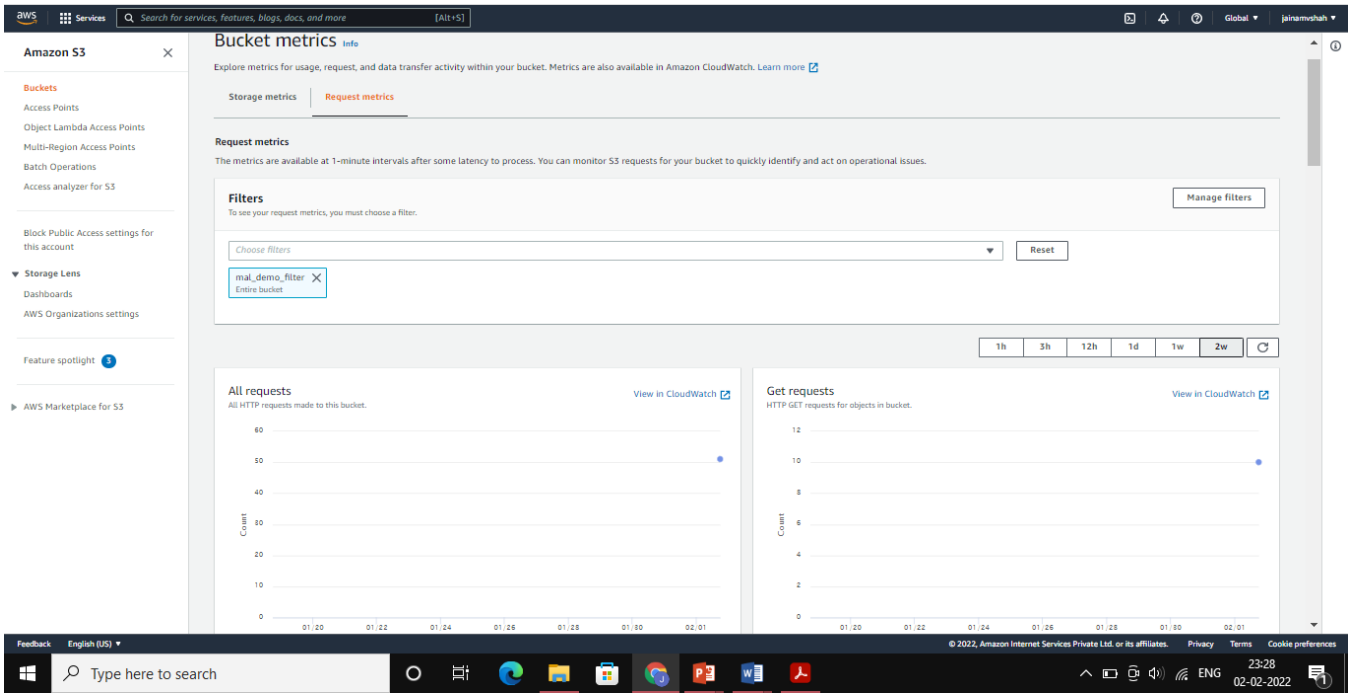


Figure 6.3 Creating Metrics for bucket

In order to monitor activities taking place within the S3 bucket like uploading or downloading files by a user or any malicious activities taking place without the awareness of the respective user AWS CloudWatch comes into place. An alarm configured on CloudWatch helps a user to track and monitor the S3 bucket in an efficient manner. An alarm for the respective bucket is created in the following manner.

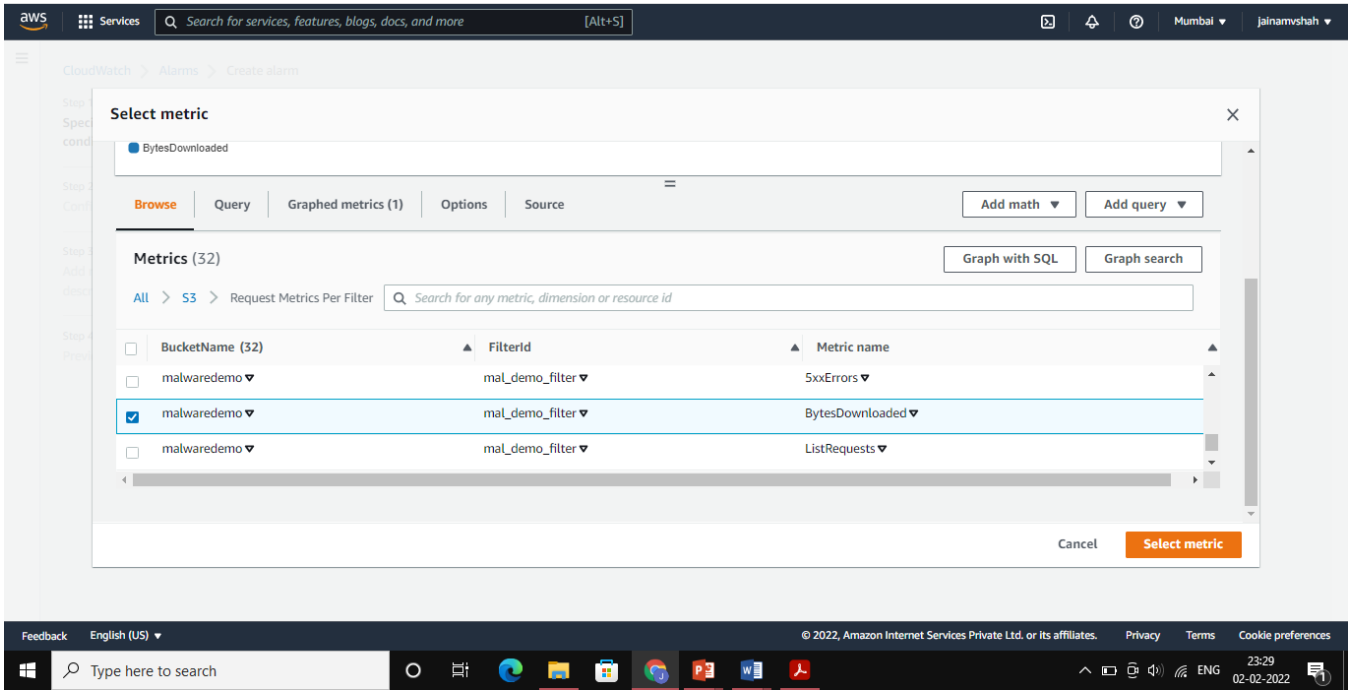


Figure 6.4 Setting up Alarm

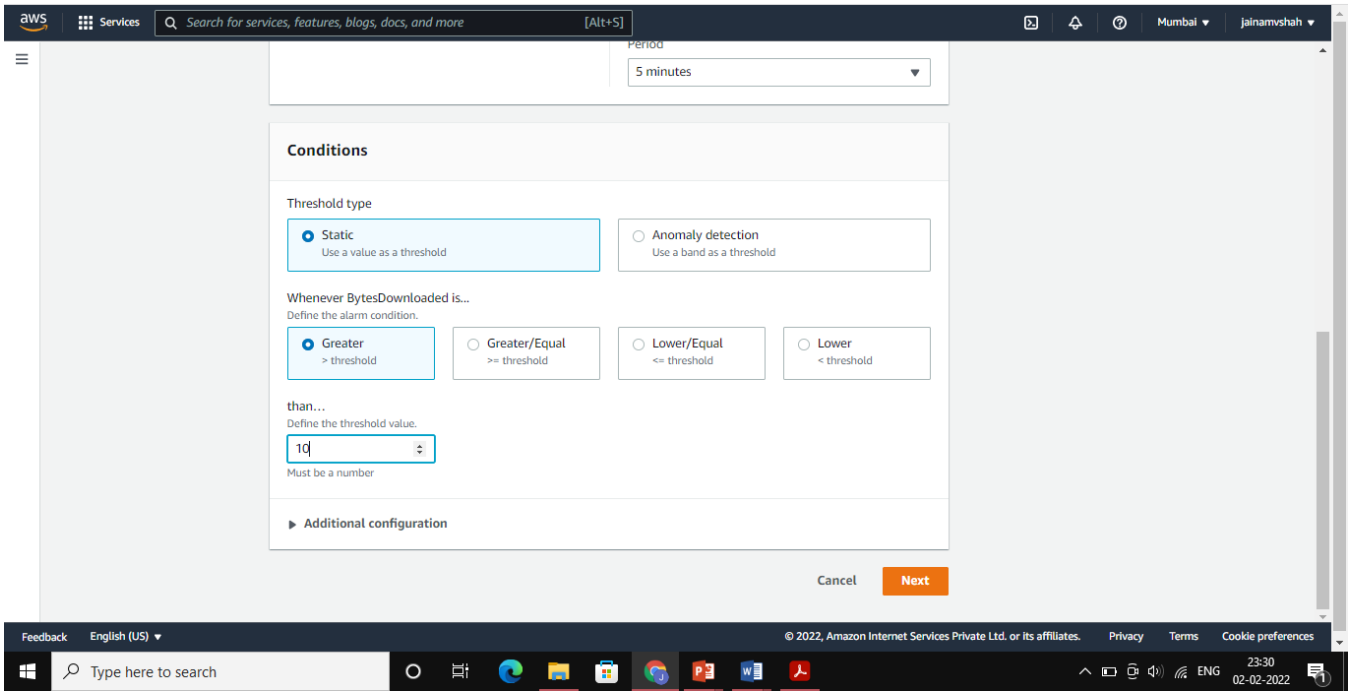


Figure 6.5 Defining threshold value for a definite amount of size

3. Performing a Malware Attack

After creating S3 bucket a malware attack has been initiated on the created S3 bucket using its respective URL. Following steps are performed in order to complete a malware attack on S3 Bucket

Step 1: First we identified the IP Address of this bucket URL using the following command

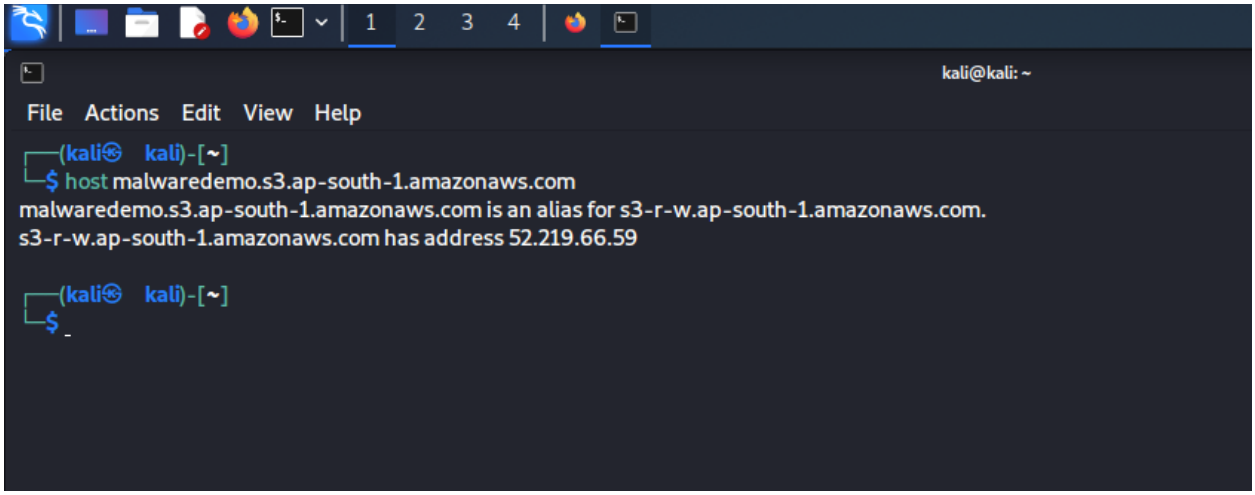


Figure 6.6 Identifying IP Address

Step 2: DNS attack on bucket URL to know number of servers through which that URL request passed

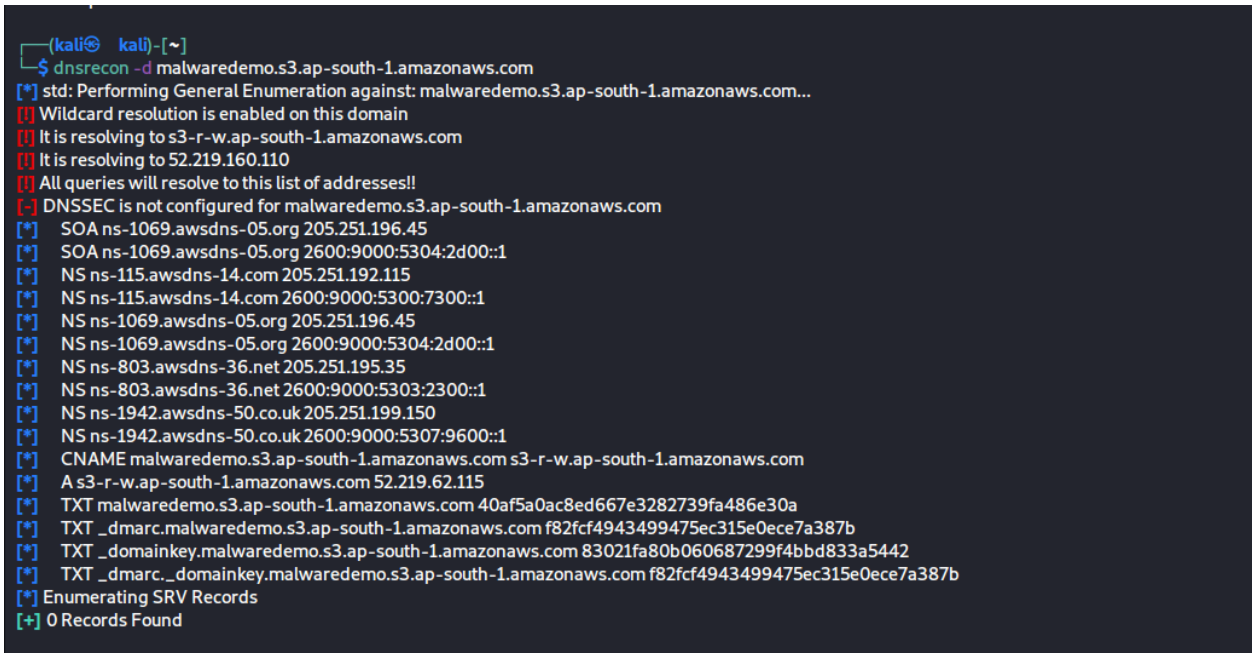


Figure 6.7 Initiating DNS Attack on the respective bucket

Step 3: Here we try to fetch the actual name of bucket URL.

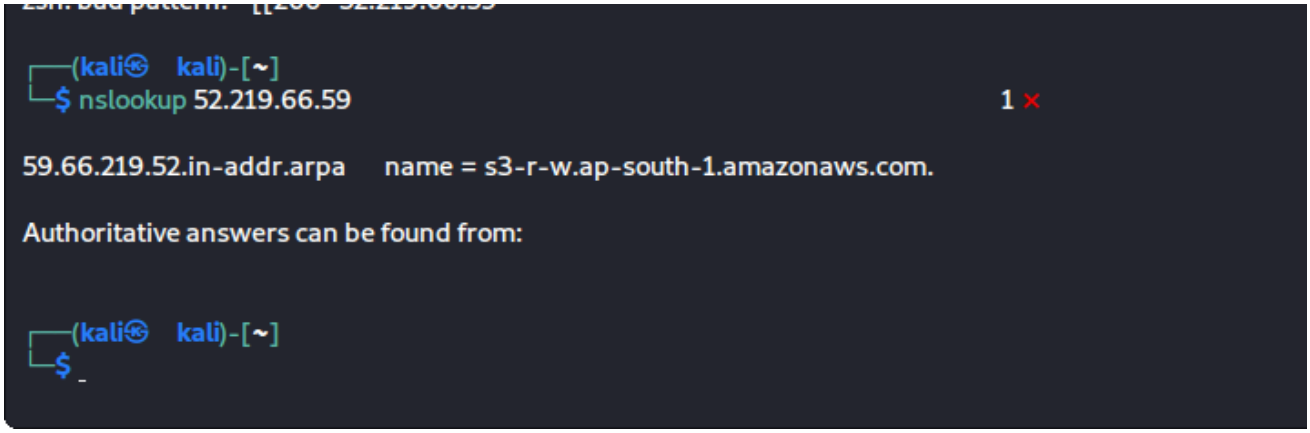


Figure 6.8 Name Revealing of S3 Bucket

We paste the acquired name in the browser to see the tree structure of files in the respective bucket. It is in XML format.

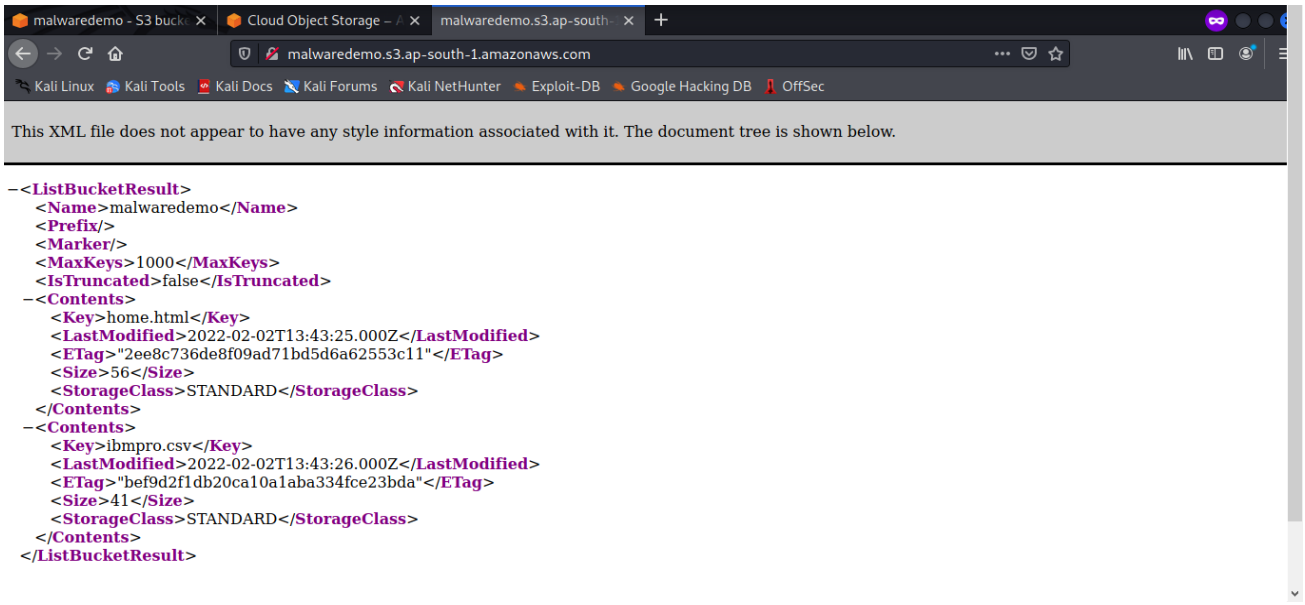


Figure 6.9 Tree structure of files present in the bucket

Step 4: Using the following command we get the list of files present in the bucket which do not require authentication to access it.

Figure 6.10 Revealing files not needing authentication to access

Here we tried to open the listed files in browser

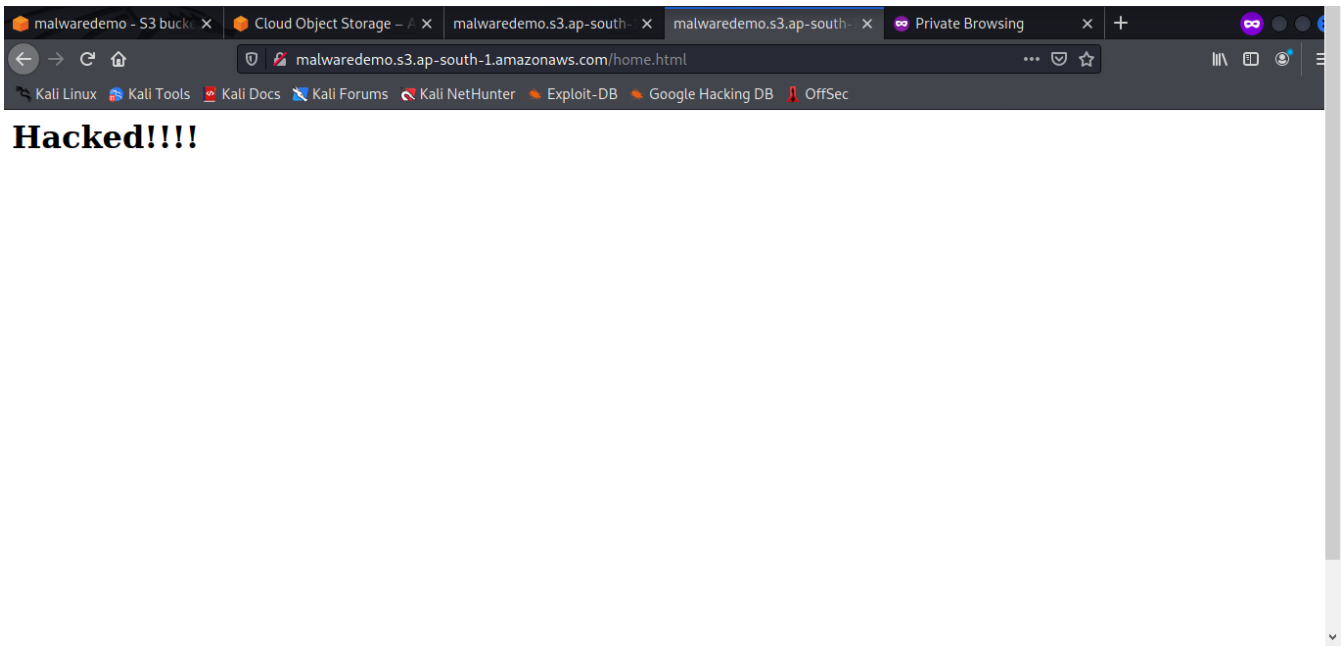


Figure 6.11 Home.html file

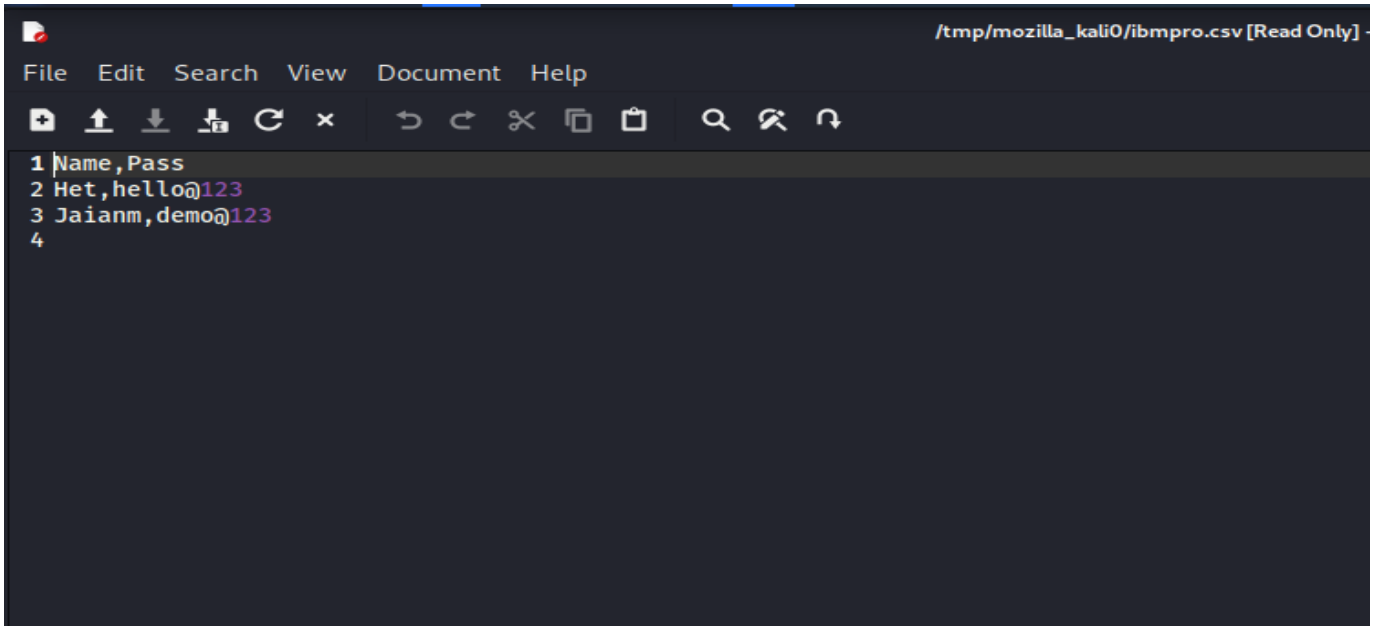


Figure 6.12 ibmpro.csv

Step 5: Then S3Scanner python file is used to find the S3 bucket data and dump its content to the local machine.Here this following command has been used to scan whether bucket is present or not and also lists out AuthUsers and AllUsers permissions

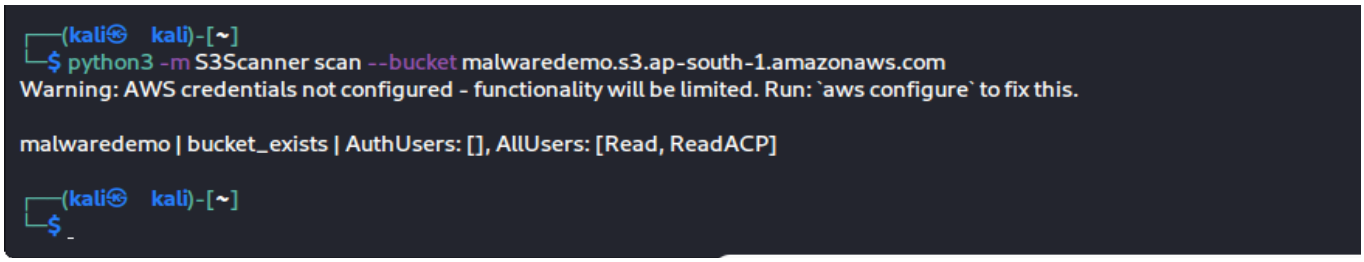


Figure 6.13 Listing Users

Step 6: The following command is used to dump all content from bucket to local machine at any location.

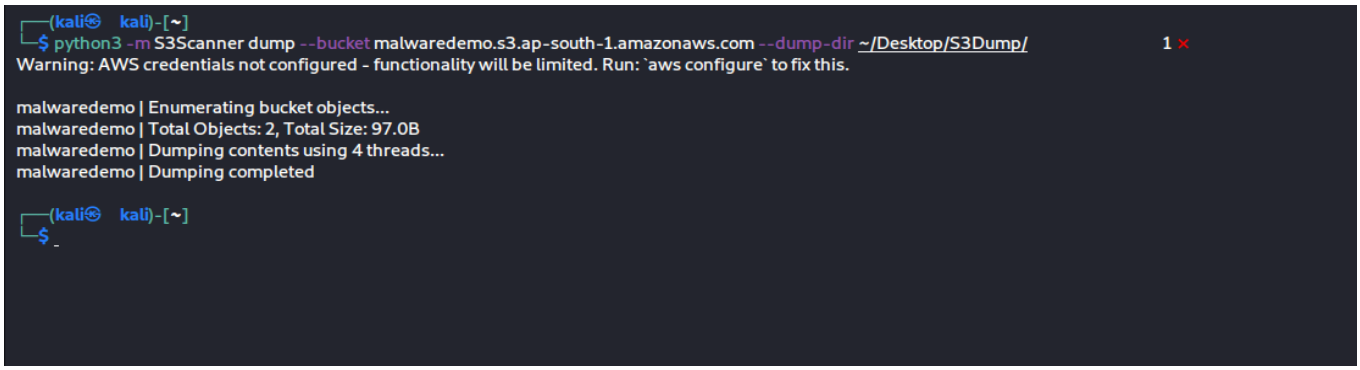


Figure 6.14 Dump status

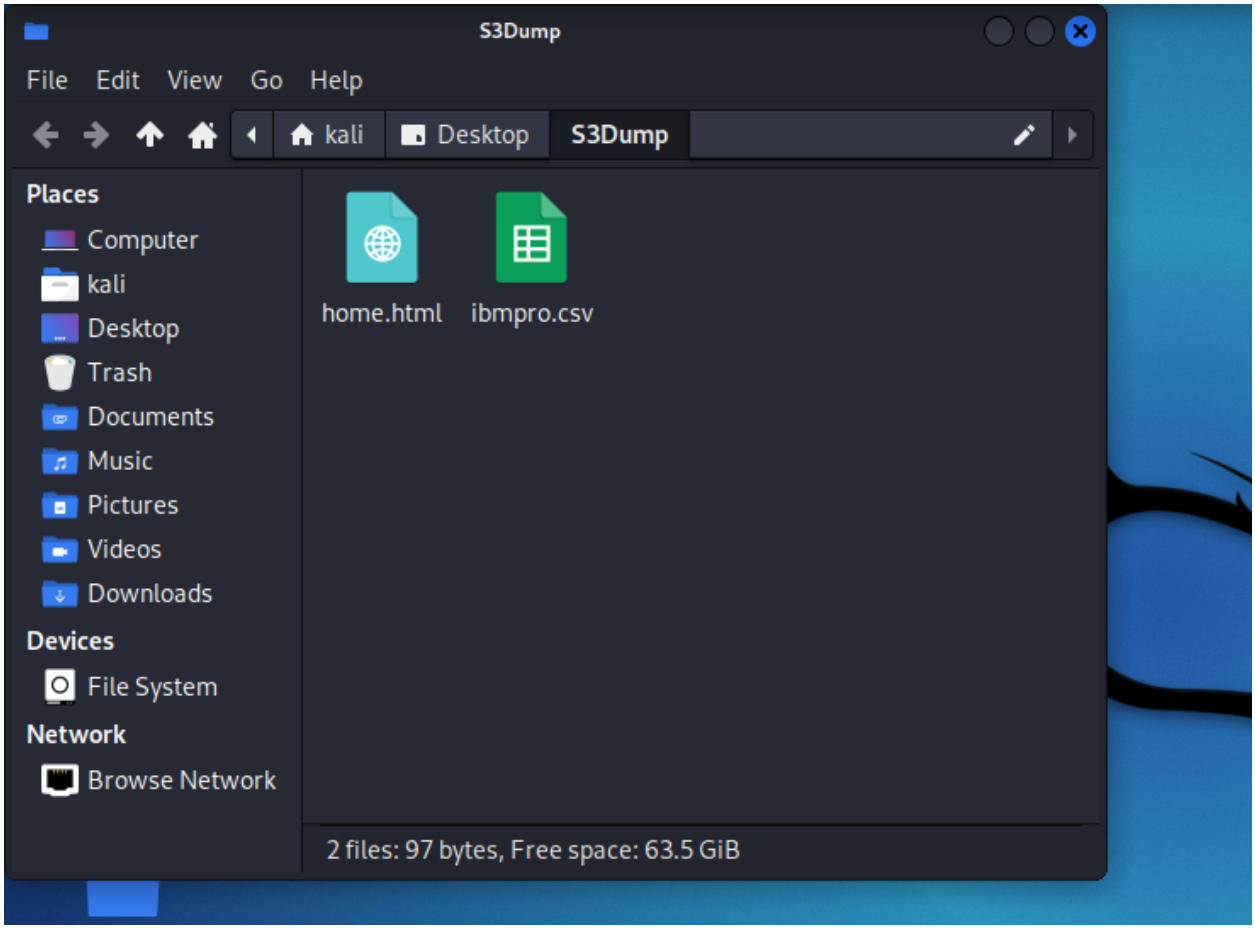


Figure 6.15 Files downloaded on local machine

As we can see malware alarm created earlier to monitor S3 bucket has been triggered based on intrusion being detected and we can see the size of files being downloaded from the bucket respectively.

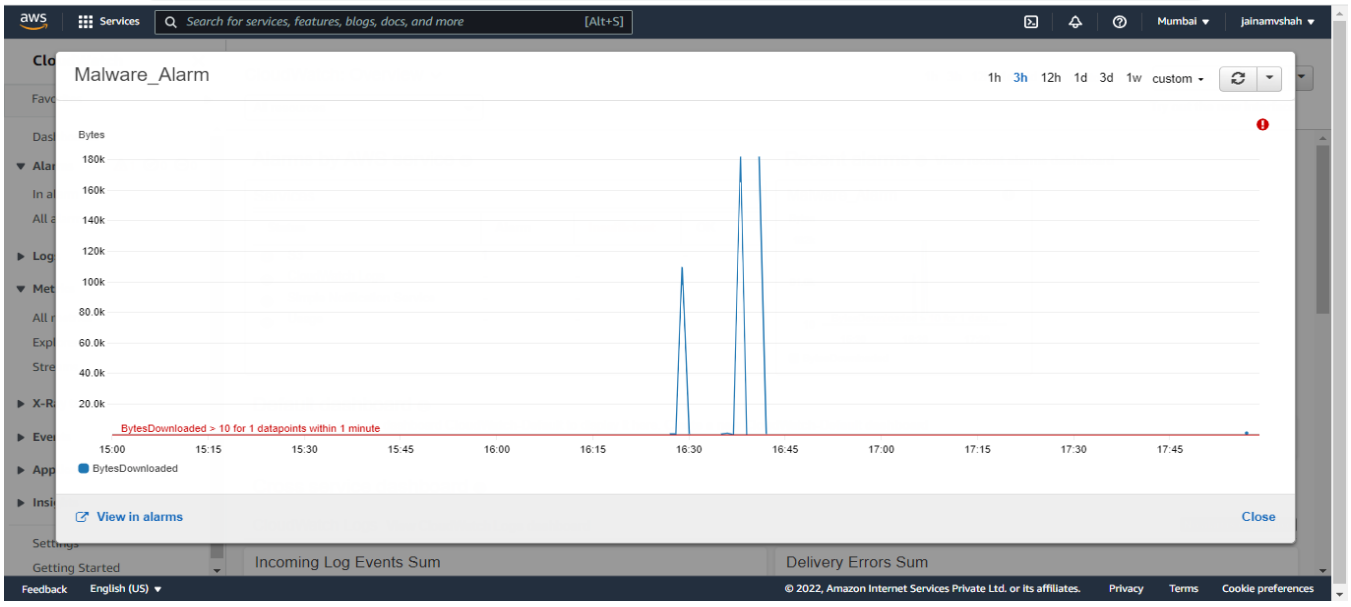


Figure 6.16 Malware Alarm

4. Implementing Data Monitoring using SNS

Amazon Simple Notification Service (Amazon SNS) is a fully managed messaging service for both application-to-application (A2A) and application-to-person (A2P) communication.

Through SNS we can monitor AWS services and it provides notification whenever there is a change happening in any respective service within respective AWS account.

For the purpose of this project an SNS Topic is created as follows on AWS CloudTrail to monitor data logging taking place within S3 Bucket.

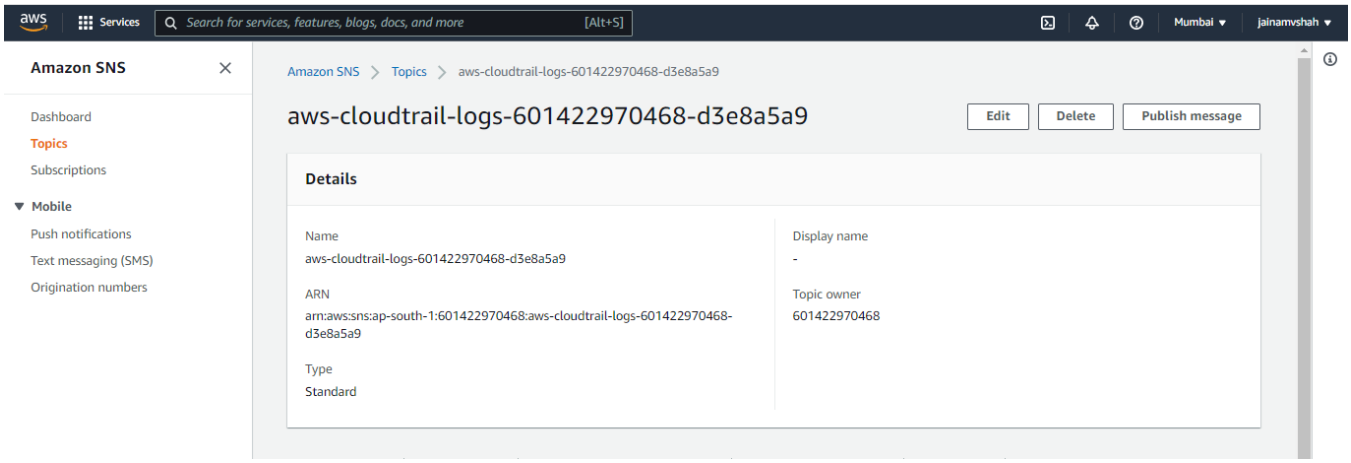


Figure 6.17 SNS Topic

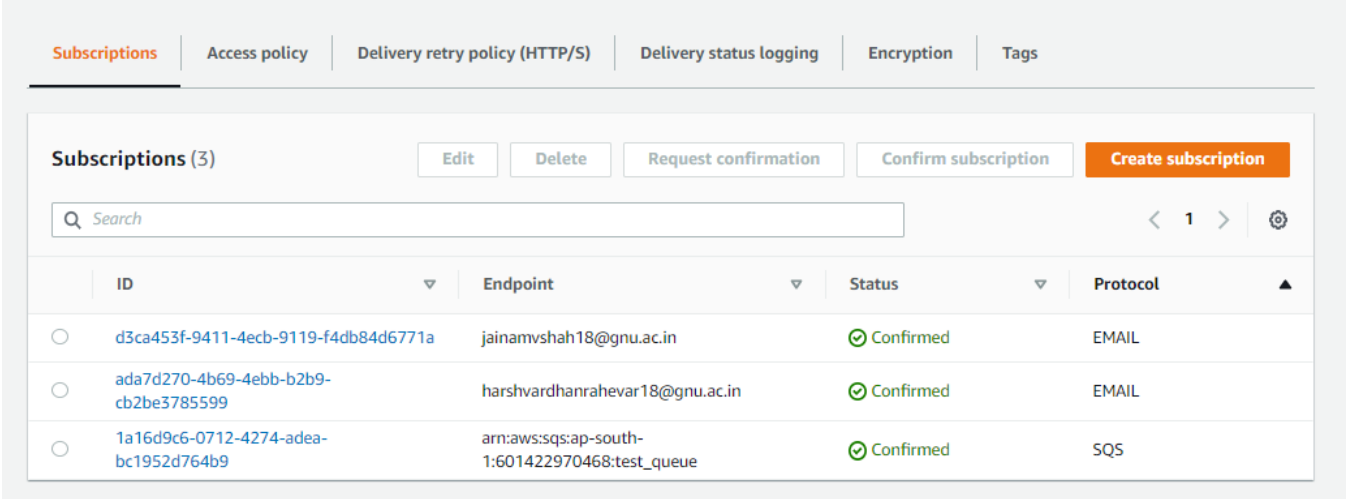


Figure 6.18 SNS Notification Subscriptions

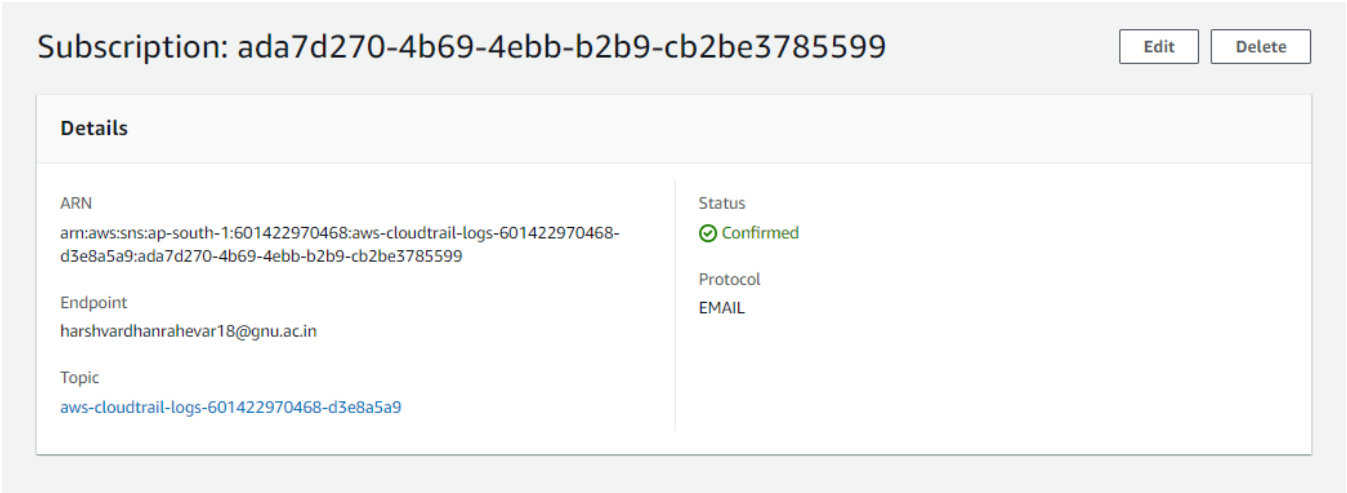


Figure 6.19.1 Subscription details of 1st Endpoint

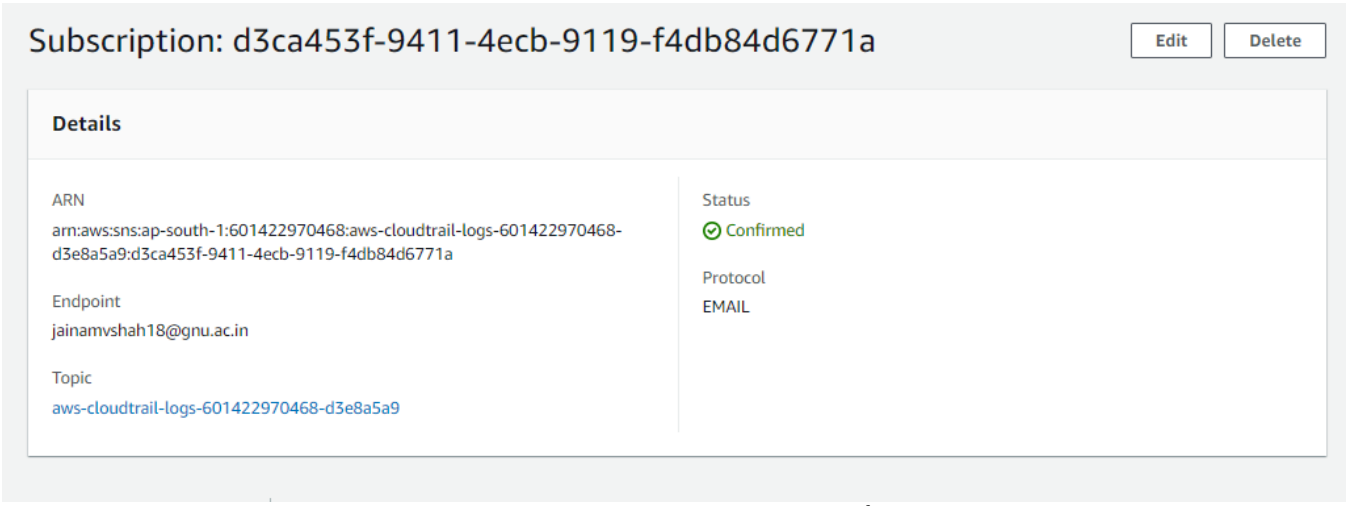


Figure 6.19.2 Subscription details of 2nd Endpoint

In order to subscribe properly with the created trail from AWS CloudTrail the following script is written for S3 bucket.

```
{
  "Version": "2012-10-17",
  "Statement": [
    {
      "Sid": "AWSCloudTrailAclCheck20150319",
      "Effect": "Allow",
      "Principal": {
        "Service": "cloudtrail.amazonaws.com"
      },
      "Action": "s3:GetBucketAcl",
      "Resource": "arn:aws:s3:::demo211"
    },
    {
      "Sid": "AWSCloudTrailWrite20150319",
      "Effect": "Allow",
      "Principal": {
```

```
            "Service": "cloudtrail.amazonaws.com"
        },
        "Action": "s3:PutObject",
        "Resource": "arn:aws:s3:::demo211/AWSLogs/601422970468/*",
        "Condition": {
            "StringEquals": {
                "AWS:SourceArn": "arn:aws:cloudtrail:ap-south-1:601422970468:trail/demo2.1",
                "s3:x-amz-acl": "bucket-owner-full-control"
            }
        }
    }
  ]
}
```

The above-mentioned script validates the destination configuration in accordance to API Response and provides SNS Notification to the respective subscription without any delay and in a timely manner.

6.3.5 Generating data logs from AWS CloudTrail

In AWS, the CloudTrail service is utilized to track account activity and API calls, as most cloud providers offer their services via APIs this is a very important service. These feeds from CloudTrail can also be integrated with AWS CloudWatch in order to create metrics for employing alarms for any suspicious account's behavior or any miscellaneous misuse.

For fulfilling the purpose of generating data logs, in CloudTrail ongoing delivery of events is enabled as log files to an Amazon S3 bucket. Then the logs are and API Calls are received from CloudTrail Event history. For the sake of monitoring the activity on S3 service a trail is created on an existing S3 bucket and SNS subscription can also be enabled to keep track of how many logs and events are generated every hour in a S3 bucket.

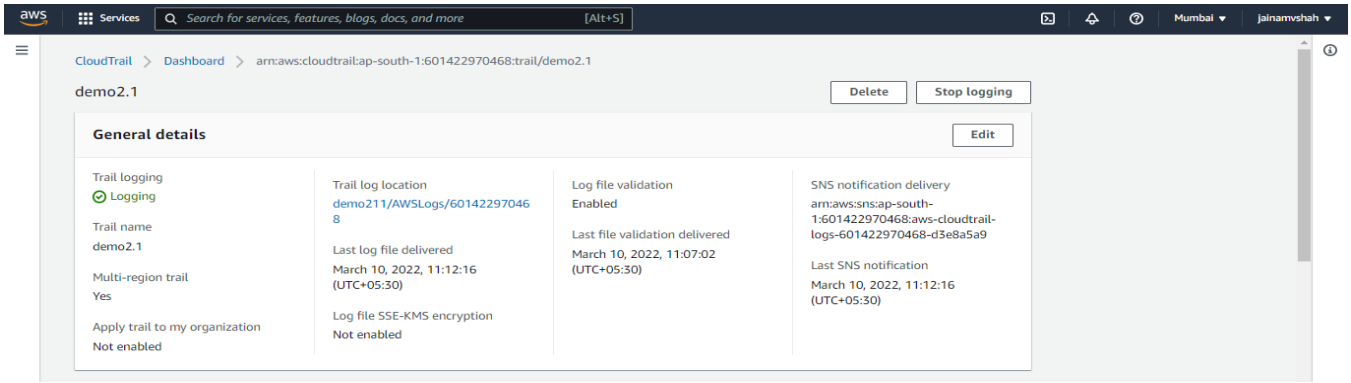


Figure 6.20 CloudTrail Details

After generating the trail, a folder is created within the S3 bucket called AWSLogs/ which stores all the log files containing activities within S3 in json.gz format.

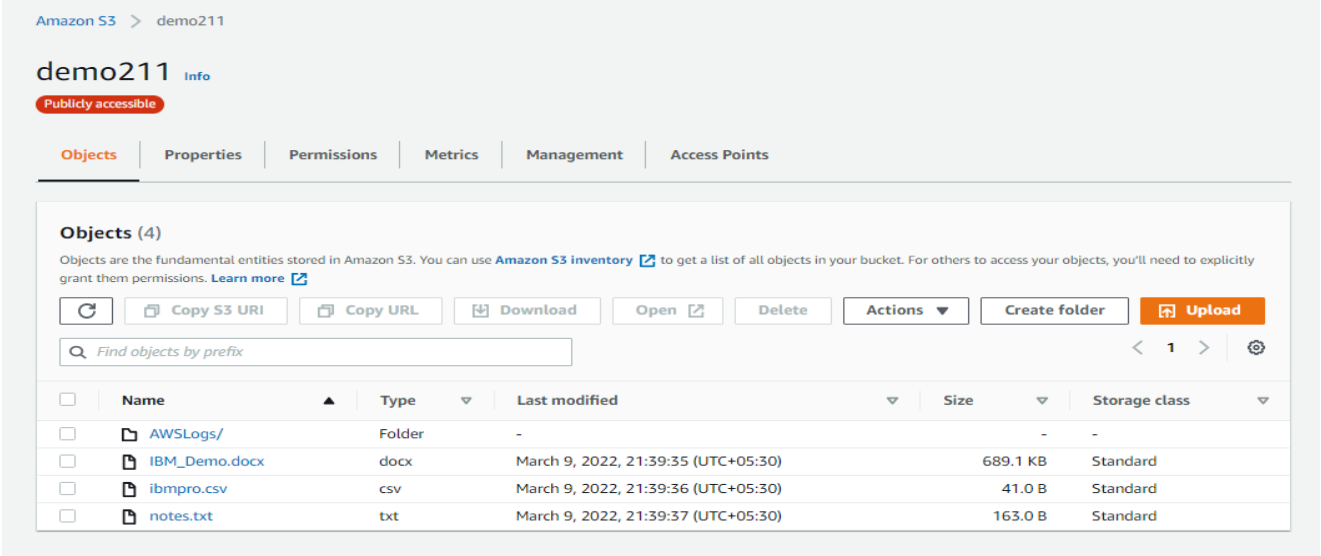


Figure 6.21 S3 Bucket with CloudTrail Logs

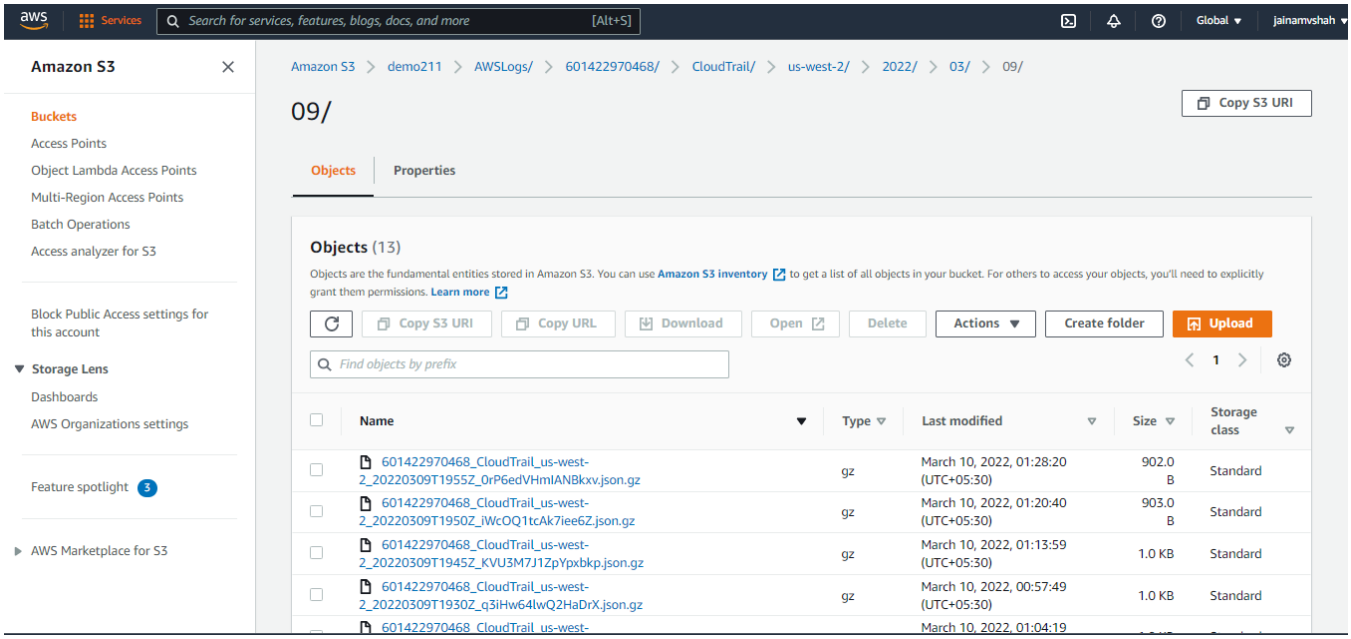


Figure 6.22 Data Log Files

CloudTrail provides detailed log data. It provides the following results: -

- Detect any third-party AWS console logins from unknown places or countries.
- In most cases, companies/organizations do transfer logs to their own data center for long term storage, it's crucial to generate the logs in a text-like format such as JSON, for better understanding of complex data, from a test, notice AWS uses this concept in their generated logs and flows.

- Anchorage the storage API i.e. s3 API to import cloud trails to a search and arranging platform or security management systems like (SIEM solution) for creating more secured and robust use cases monitoring.

6.3.6 Integrating AWS CloudTrail with Splunk

In order to have clear understanding of the logs and perform proper forensic analysis there is a must need of escorting cloud logs into a single point where they can be combined with on premises security events, thus enabling the investigator to have a single view of screen from which he/she can monitor the whole security strata.

To achieve this purpose Splunk has been utilized and configured to receive the AWS CloudTrail data logs which configured earlier to monitor different services of AWS account and its resources.

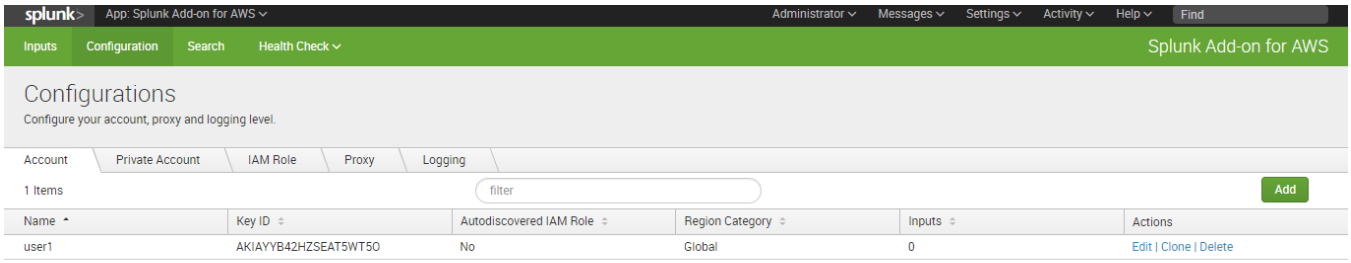


Figure 6.23 AWS Account Connection

First AWS Root account is connected and then input of CloudTrail is integrated with Splunk so the logs generated by AWS CloudTrail can be tracked from Splunk as follows: -

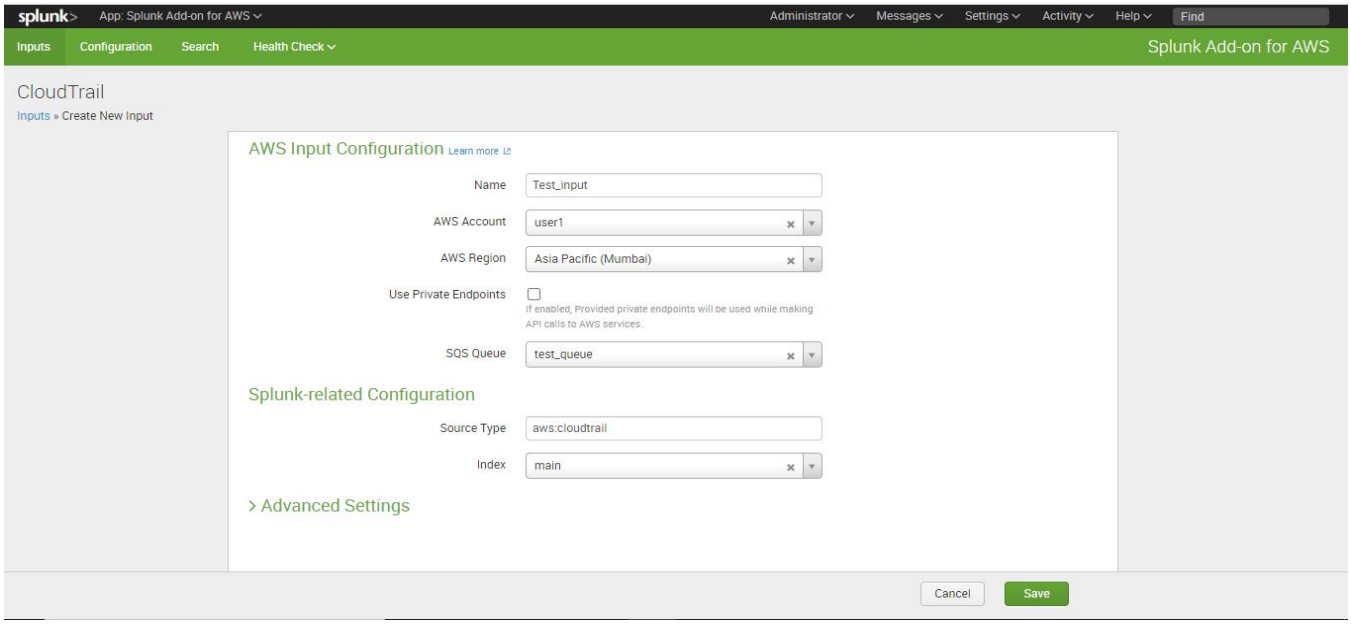


Figure 6.24 Source Input for Splunk

Figure 6.21 shows an input will be created for AWS CloudTrail to manage the logs generated by it and provide detailed information and analysis based on the fields selected in the IAM policy for Splunk Add-on.

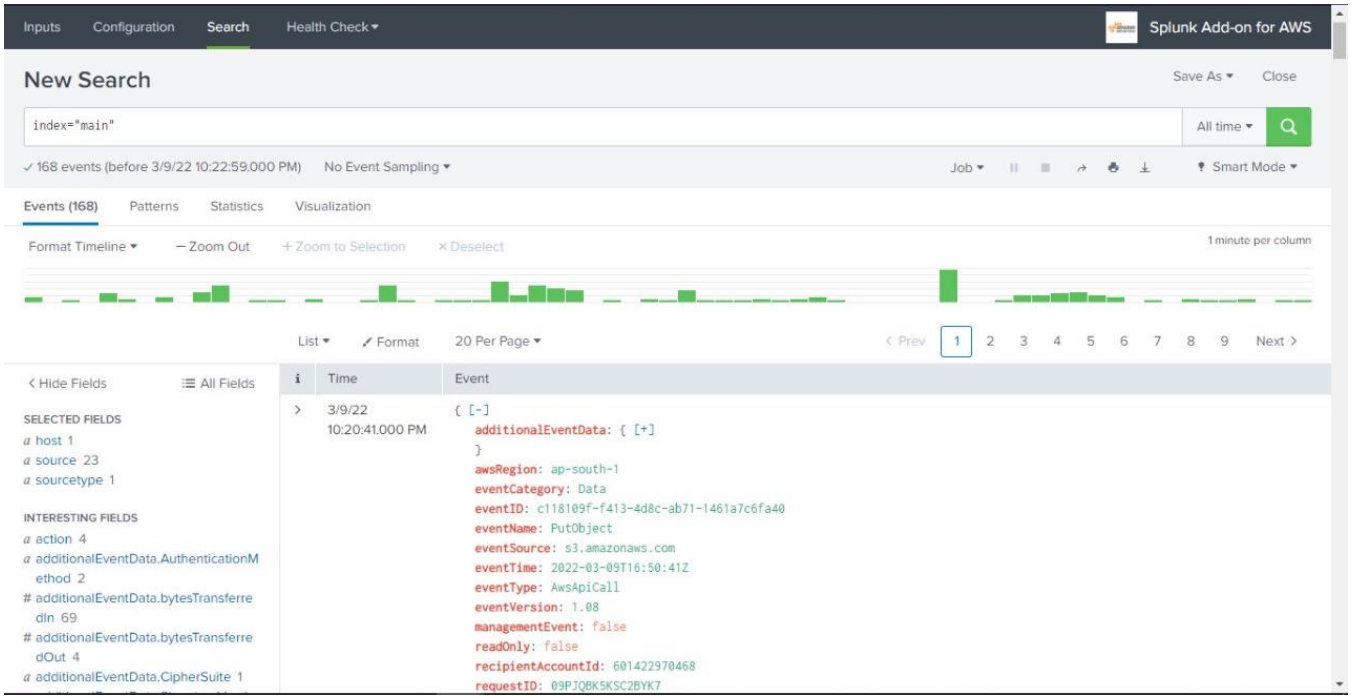


Figure 6.25 CloudTrail Logs Analysis

In order to provide the analysis based on the logs generated in the respective fields an IAM Policy called “Splunk Add-On” was created earlier by building a JSON script and integrated with respective AWS CloudTrail Trail and AWS account, a glimpse of the created JSON Script is as follows: -

```
{
    "Version": "2012-10-17",
    "Statement": [
        {
            "Sid": "VisualEditor0",
            "Effect": "Allow",
            "Action": [
                "config:GetComplianceSummaryByConfigRule",
                "sqs:DeleteMessage",
                "iam:GetAccountPasswordPolicy",
                "s3:GetLifecycleConfiguration",
                "s3:GetBucketTagging",
                "ec2:DescribeInstances",
                "ec2:DescribeAddresses",
                "s3:GetBucketLogging",
                "s3:PutBucketOwnershipControls",
                "ec2:DescribeRegions",
                "sqs:ReceiveMessage",
                "s3:GetAccelerateConfiguration",
                "ec2:DescribeSnapshots",
                "elasticloadbalancing:DescribeLoadBalancers",
```

Figure 6.26 JSON Script

The above-mentioned script provides details of all CloudTrail, EC2 and S3 services and integrates with Splunk as soon as one connects his/her account and provides analysis based on that.

Furthermore, an SQS (Simple Queue Service) service is also used to align the above given services in a queue so they can be tracked easily and if there is any change or discrepancy during adding, updating or deleting a file within a S3 bucket, an SNS (Simple Notification Service) will be sent to the respective cloud account to check any changes have occurred or not.

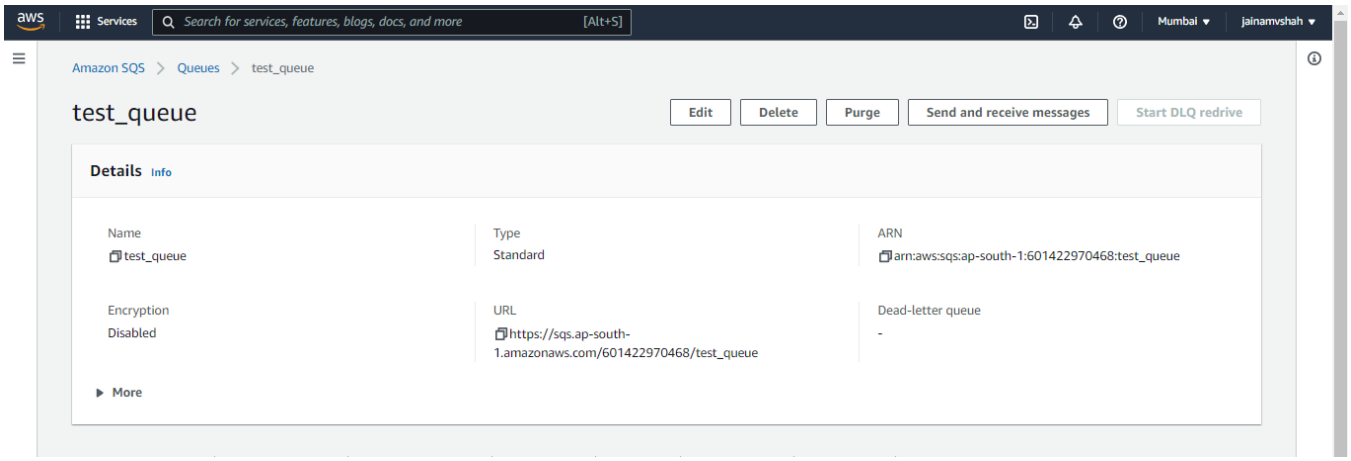


Figure 6.27 SQS Service

6.3.7 Forensic Analysis After Malware Attack

After performing a malware attack as shown above in 6.3.4 section a number of parameters can be considered to take account of from Splunk as they provide certain insights of the activities taking place within the S3 bucket.

Splunk provides a feature to export the results from CloudTrail logs in the form of a csv file as shown below.

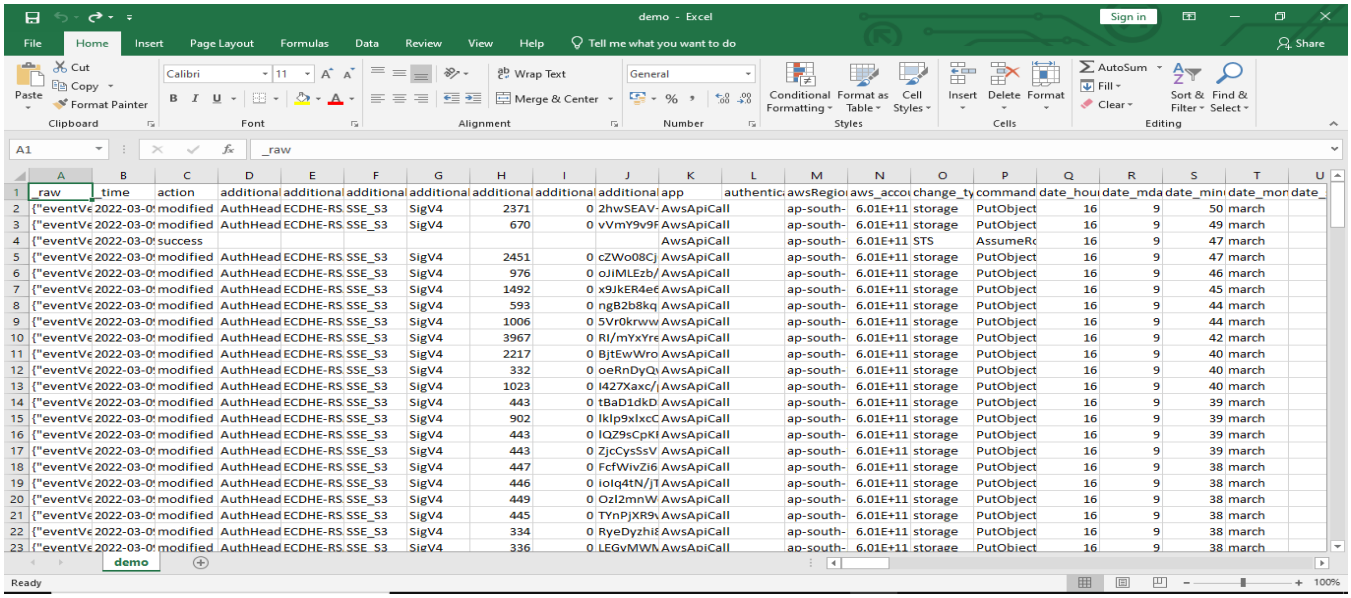


Figure 6.28 Results File

As shown above there is a csv file generated which contains certain important fields showing the activities performed within the S3. For example: -

Column B-time – shows the time at which a certain activity was performed within S3

Column C-action – shows which activity was performed like what was modified, deleted or was it done successfully or not.

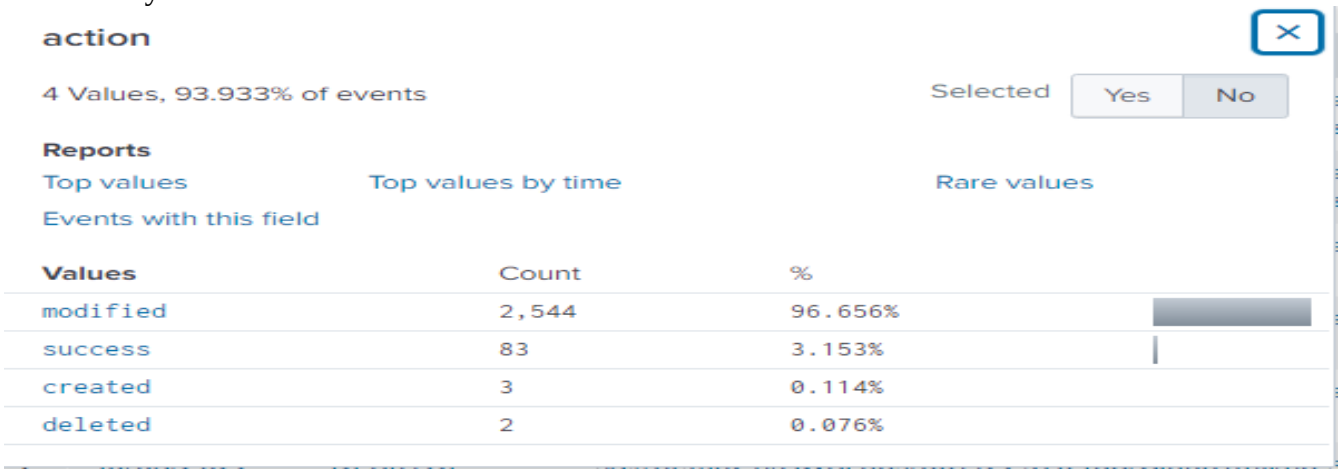


Figure 6.29 Action Field

Column P-command – this column shows what kind of command was executed within the bucket like PutObject, HeadObject, SetTopic, LookUpEvent etc.

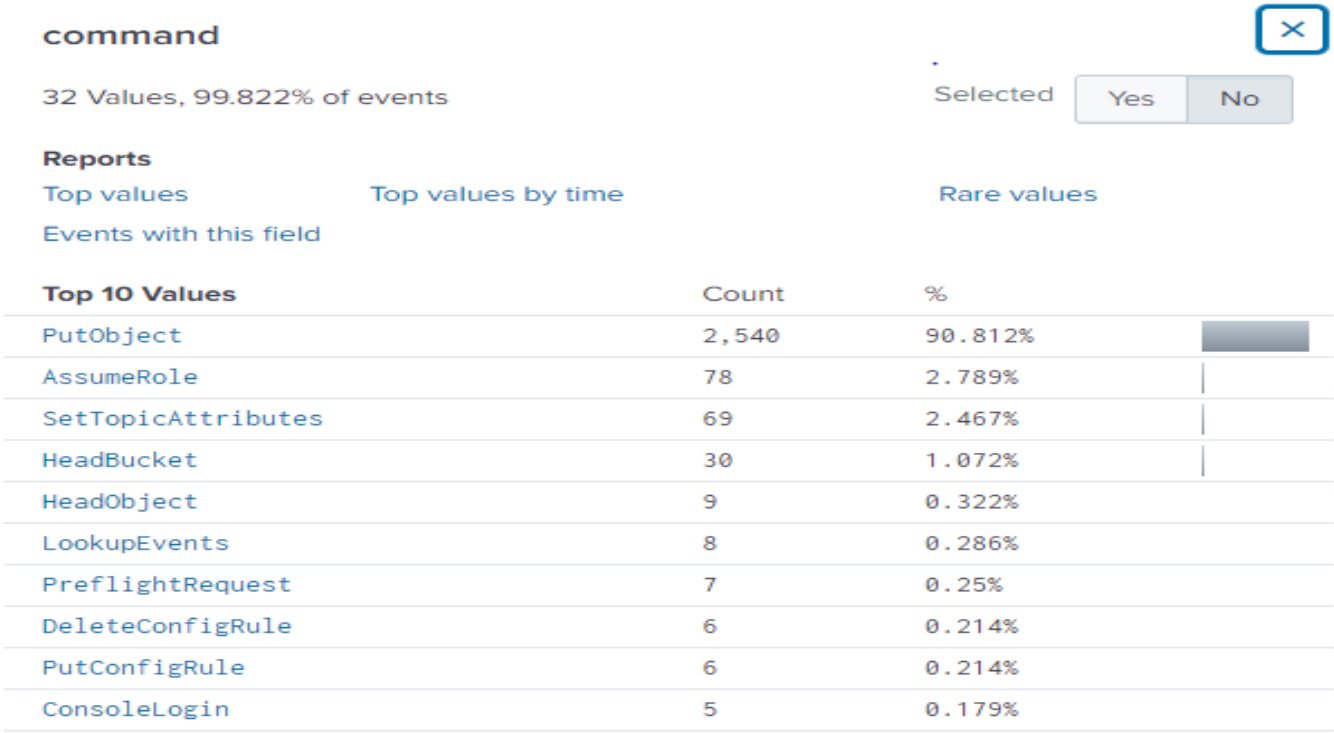


Figure 6.30 Command Field

Column AE-errorcode – shows whether the command was successful or access was denied.

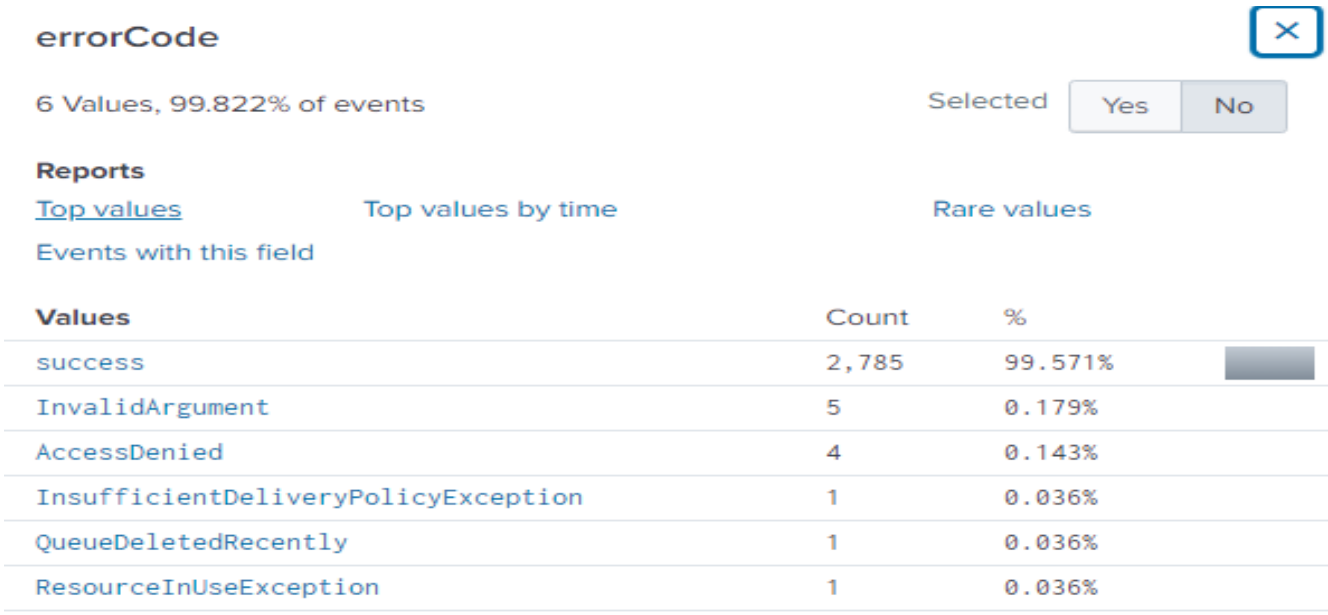
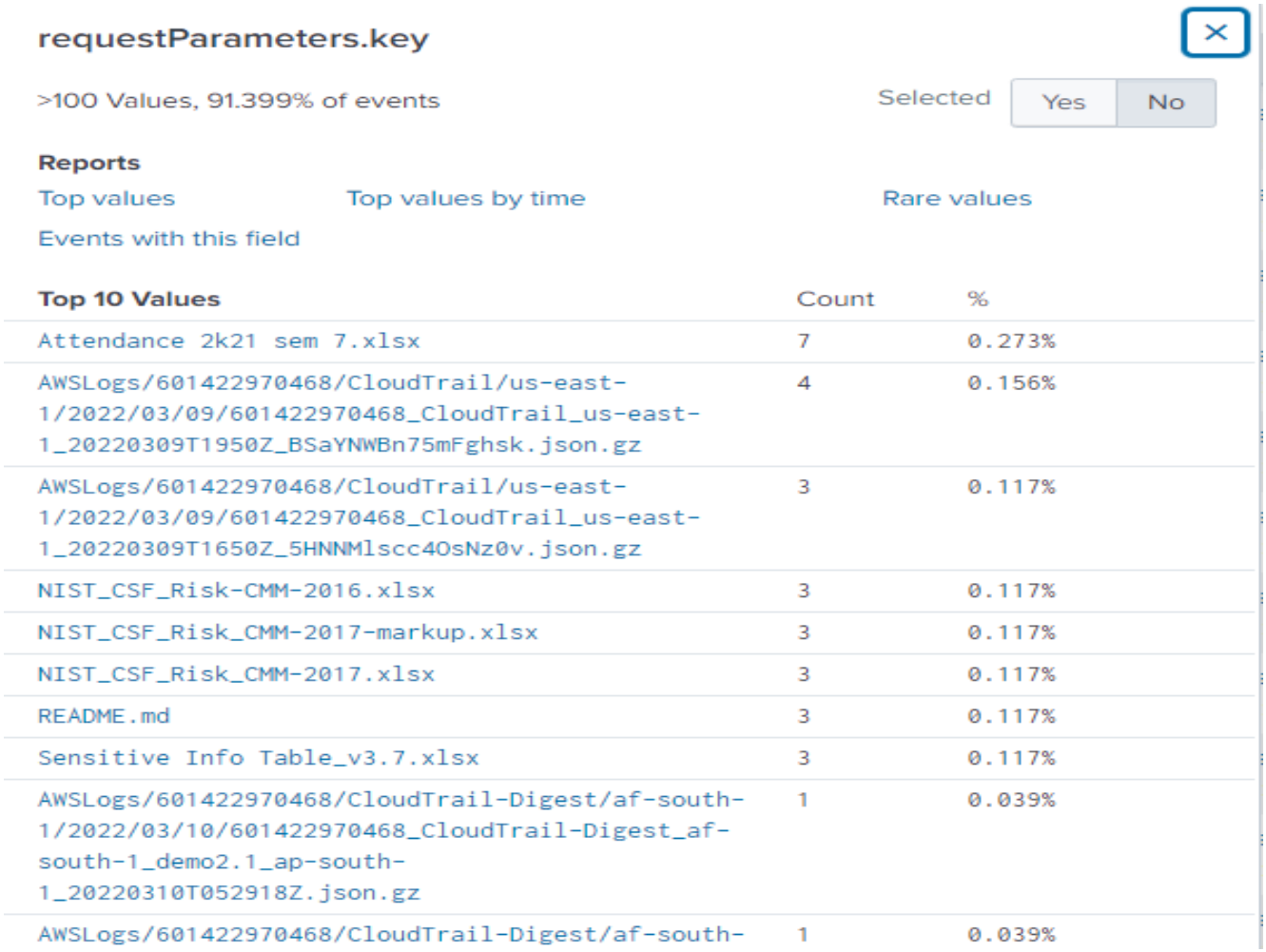


Figure 6.31 ErrorCode Field

Column AO -Host – this column shows from where was the above-mentioned commands were carried out on a respective bucket.

Figure 6.32 Host Field

Column CT – requestparameterkey – shows the name of files which are being uploaded within the respective S3 Bucket.



requestParameters.key

>100 Values, 91.399% of events

Selected Yes No

Reports

Top values Top values by time Rare values

Events with this field

Top 10 Values	Count	%
Attendance 2k21 sem 7.xlsx	7	0.273%
AWSLogs/601422970468/CloudTrail/us-east-1/2022/03/09/601422970468_CloudTrail_us-east-1_20220309T1950Z_BSaYNWBn75mFghsk.json.gz	4	0.156%
AWSLogs/601422970468/CloudTrail/us-east-1/2022/03/09/601422970468_CloudTrail_us-east-1_20220309T1650Z_5HNNMlscc4OsNz0v.json.gz	3	0.117%
NIST_CSF_Risk-CMM-2016.xlsx	3	0.117%
NIST_CSF_Risk_CMM-2017-markup.xlsx	3	0.117%
NIST_CSF_Risk_CMM-2017.xlsx	3	0.117%
README.md	3	0.117%
Sensitive Info Table_v3.7.xlsx	3	0.117%
AWSLogs/601422970468/CloudTrail-Digest/af-south-1/2022/03/10/601422970468_CloudTrail-Digest_af-south-1_demo2.1_ap-south-1_20220310T052918Z.json.gz	1	0.039%
AWSLogs/601422970468/CloudTrail-Digest/af-south-	1	0.039%

Figure 6.33 RequestParameterKey Field

6.4 Forensic Analysis in IaaS Cloud

Making use of cloud forensics to help organization in strengthening their incident response and threat detection capabilities, organizations must have proper forensics investigation tools to keep their cloud infrastructure secured in case of an attack, recognizing the signs of vulnerability as well as quickly locate an infection and its objectives before they have an impact on the organizations' important data.

If there is a case of a hacked virtual machine, most users terminate the virtual machine (VM), erasing all proof in the process. It would become very challenging to perform forensic analysis in such cases. Until now, there have been few tools and applications which monitor the system properly and gather data. When it comes to gathering and analyzing evidence, must look for the following:

- Network packet captures for forensics.
- Memory usage for a particular instance.
- Events and data logs

In order to provision a machine for forensic analysis, installing necessary forensic investigation tools is necessary in order to get insights. In order to implement this a package called SIFT has been utilized which provides access to most of the forensics tools from one executable package. The forensic machine for this mentioned scenario has been prepared in the following manner.

An EC2 instance called “cloudreasearch-instance” is created and then after logging into it by doing SSH SIFT investigation tools are downloaded with the following commands.

```
ubuntu@ip-172-31-5-38:~$ sudo curl -Lo /usr/local/bin/sift https://github.com/sans-dfir/sift-cli/releases/download/v1.14.0-rc1/sift-cli-linux
  % Total    % Received % Xferd  Average Speed   Time    Time     Time  Current
                                 Dload  Upload   Total   Spent    Left  Speed
100   147  100   147    0     0    630      0 --:--:-- --:--:-- --:--:--   630
100   651  100   651    0     0   1299      0 --:--:-- --:--:-- --:--:--  1299
100 55.0M  100 55.0M    0     0  9211k      0  0:00:06  0:00:06 --:--:-- 9942k
ubuntu@ip-172-31-5-38:~$ sudo chmod 755 /usr/local/bin/sift
ubuntu@ip-172-31-5-38:~$ sudo sift install
> sift-cli@1.14.0-rc1+0-g0582d2b
> sift-version: notinstalled
```

Figure 6.34 SIFT Installation

After installing SIFT tools a snapshot is created for the instance to perform forensic analysis on it. After creating snapshot, a volume is created from that snapshot and then attached to the earlier created EC2 instance.

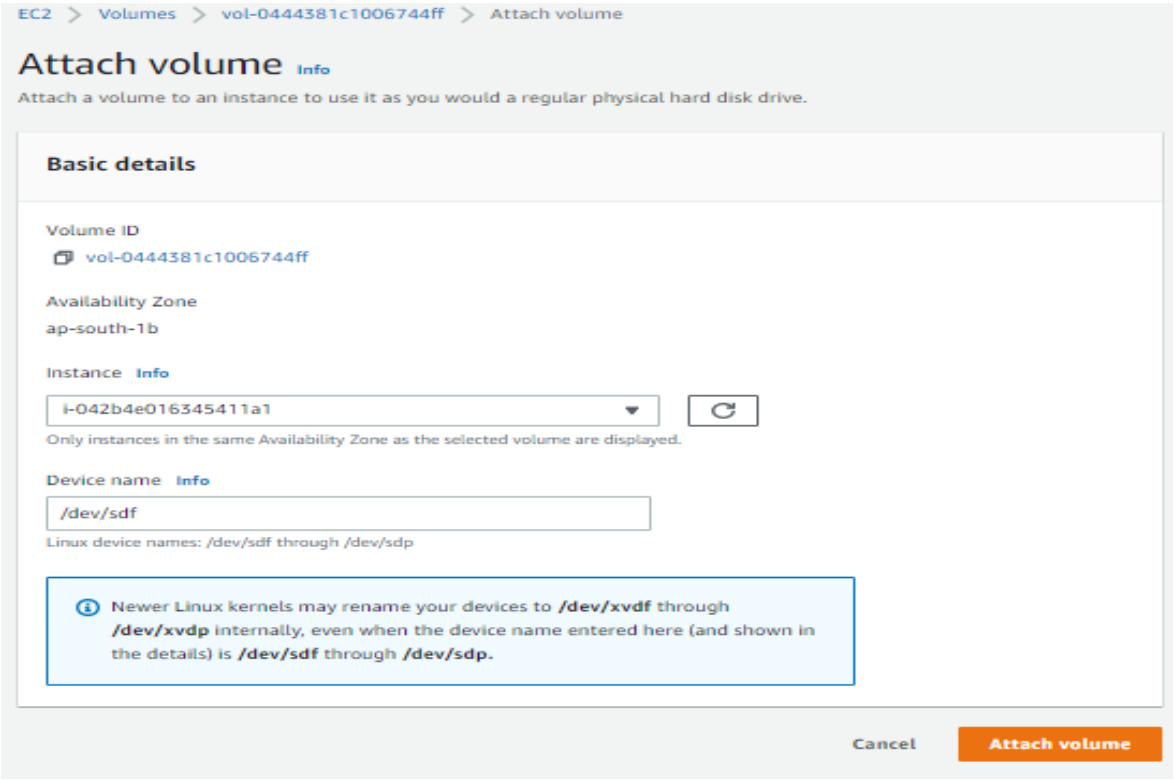


Figure 6.35 Attaching evidence volume to SIFT Workstation

Verifying evidence attached to a device using lsblk command.

```
ubuntu@ip-172-31-5-38:~$ sudo lsblk
NAME    MAJ:MIN RM   SIZE RO TYPE MOUNTPOINT
loop0     7:0    0 42.2M  1 loop /snap/snapd/14066
loop1     7:1    0 55.5M  1 loop /snap/core18/2253
loop2     7:2    0   25M  1 loop /snap/amazon-ssm-agent/4046
xvda    202:0    0   30G  0 disk
└─xvda1 202:1    0   30G  0 part /
xvdf    202:80   0   30G  0 disk
└─xvdf1 202:81   0   30G  0 part
```

Figure 6.36 Evidence Attached Verification

Using the file command to determine the format of the partition as shown below and also a directory has been made to mount the evidentiary Linux file system as read-only:

```
ubuntu@ip-172-31-5-38:~$ sudo file -s /dev/xvdf1
/dev/xvdf1: Linux rev 1.0 ext4 filesystem data, UUID=c1ce24a2-4987-4450-ae15-62eb028ff1cd, volume name "cloudimg-rootfs" (needs journal recovery)
extents) (64bit) (large files) (huge files)
ubuntu@ip-172-31-5-38:~$ sudo mkdir /mnt/linux_mount
ubuntu@ip-172-31-5-38:~$ mount -o ro /dev/xvdf1 /mnt/linux_mount/
mount: only root can use "--options" option
ubuntu@ip-172-31-5-38:~$ sudo mount -o ro /dev/xvdf1 /mnt/linux_mount/
ubuntu@ip-172-31-5-38:~$ sudo mount | grep "/mnt"
/dev/xvdf1 on /mnt/linux_mount type ext4 (ro,relatime)
```

Figure 6.37 Mounting evidentiary file on the system

Verifying the mounted data.

```
ubuntu@ip-172-31-5-38:~$ sudo ls -als /mnt/linux_mount/
total 124
 4 drwxr-xr-x  24 root   root  4096 Apr  4 06:52 .
 4 drwxr-xr-x  18 root   root  4096 Apr  4 07:11 ..
 4 drwxr-xr-x   2 root   root  4096 Apr  4 06:41 bin
 4 drwxr-xr-x   3 root   root  4096 Apr  4 06:49 boot
 4 drwxrwxr-x   2 ubuntu root  4096 Apr  4 06:52 cases
 4 drwxr-xr-x   4 root   root  4096 Nov 29 17:32 dev
12 drwxr-xr-x 155 root   root 12288 Apr  4 06:54 etc
 4 drwxr-xr-x   3 root   root  4096 Apr  4 06:10 home
 0 lrwxrwxrwx   1 root   root    30 Nov 29 17:39 initrd.img -> boot/initrd.img-5.4.0-1060-aws
 0 lrwxrwxrwx   1 root   root    30 Nov 29 17:39 initrd.img.old -> boot/initrd.img-5.4.0-1060-aws
 4 drwxr-xr-x  22 root   root  4096 Apr  4 06:16 lib
 4 drwxr-xr-x   2 root   root  4096 Apr  4 06:16 lib64
16 drwx------   2 root   root 16384 Nov 29 17:34 lost+found
 4 drwxr-xr-x   2 root   root  4096 Nov 29 17:27 media
 4 drwxr-xr-x  17 root   root  4096 Apr  4 06:52 mnt
 4 drwxr-xr-x   4 root   root  4096 Apr  4 06:36 opt
 4 drwxr-xr-x   2 root   root  4096 Apr 24  2018 proc
 4 drwx------   5 root   root  4096 Apr  4 06:52 root
 4 drwxr-xr-x   5 root   root  4096 Nov 29 17:39 run
12 drwxr-xr-x   2 root   root 12288 Apr  4 06:48 sbin
 4 drwxr-xr-x   6 root   root  4096 Apr  4 06:10 snap
 4 drwxr-xr-x   2 root   root  4096 Nov 29 17:27 srv
 4 drwxr-xr-x   2 root   root  4096 Apr 24  2018 sys
 4 drwxrwxrwt  18 root   root  4096 Apr  4 06:56 tmp
 4 drwxr-xr-x  12 root   root  4096 Apr  4 06:18 usr
 4 drwxr-xr-x  14 root   root  4096 Apr  4 06:14 var
 0 lrwxrwxrwx   1 root   root    27 Nov 29 17:39 vmlinuz -> boot/vmlinuz-5.4.0-1060-aws
 0 lrwxrwxrwx   1 root   root    27 Nov 29 17:39 vmlinuz.old -> boot/vmlinuz-5.4.0-1060-aws
```

Figure 6.38 Listing data of mounted directory

After the evidence is attached to the SIFT Workstation, the initial step is to chisel data from the unallocated space and segregate out the files that are known to be good.

Another EC2 Instance is launched and based on the AMI and another snapshot is created and a volume is attached from the snapshot in the same availability zone as the SIFT Workstation. A different name called “HASH-BASELINE” for both the snapshot and the volume is assigned so that it is easy to differentiate these objects and the SIFT Workstation itself. Using the same steps as above the volume is attached and mounted as the 3rd volume on the SIFT Workstation which is named as /mnt/linux_base.

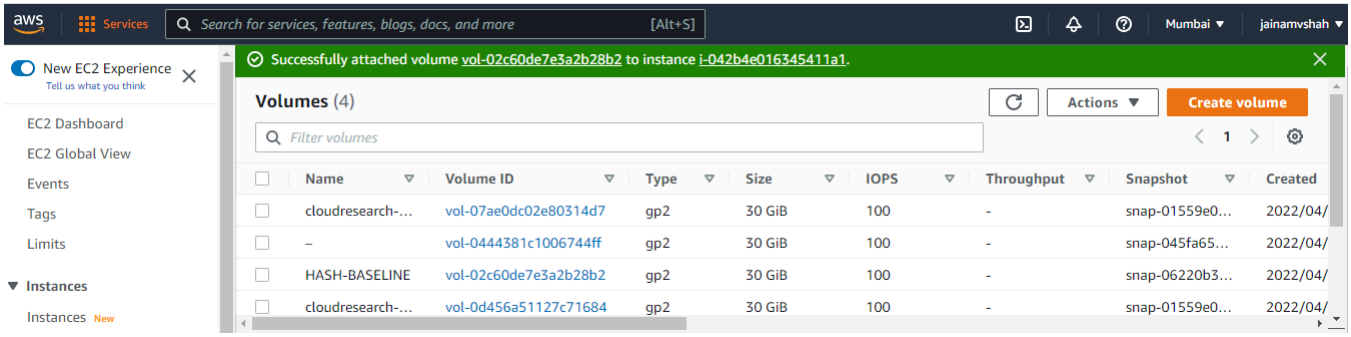


Figure 6.39 Newly Attached Volume to the instance

```
ubuntu@ip-172-31-5-38:~$ sudo mkdir /mnt/linux_base
ubuntu@ip-172-31-5-38:~$ sudo mount -o ro /dev/xvdg1 /mnt/linux_base/
ubuntu@ip-172-31-5-38:~$ sudo lsblk
NAME    MAJ:MIN RM  SIZE RO TYPE MOUNTPOINT
loop0       7:0    0 42.2M  1 loop /snap/snapd/14066
loop1       7:1    0 55.5M  1 loop /snap/core18/2253
loop2       7:2    0   25M  1 loop /snap/amazon-ssm-agent/4046
xvda      202:0    0   30G  0 disk
└─xvda1   202:1    0   30G  0 part /
xvdf      202:80   0   30G  0 disk
└─xvdf1   202:81   0   30G  0 part /mnt/linux_mount
xvdg      202:96   0   30G  0 disk
└─xvdg1   202:97   0   30G  0 part /mnt/linux_base
ubuntu@ip-172-31-5-38:~$
```

Figure 6.40 Attaching and verifying additional mounted volume on SIFT Workstation

A hash database of all files on the reference volume is created using hfind which is called "known_files.md5" and in order to identify which files are new or modified an another hast list of files is created for the volume under investigation, this is called "investigate_files.md5" and with that list an names additional list of files that are new or changed are stored in "changed_files.txt".

Then in order to search for known indicators of compromise for the server instance an IOC scanner called “Loki” is installed which detects indicators of compromise Detection is based on four detection methods:

- File Names of IOC- which matches regular expressions of file names
- Yara Rule Check-matches signature of data and processes memory
- Hash Check – it compares harmful hashes like MD5, SHA1, SHA256 with scanned files

The following results were obtained when Loki detected indicators of compromise.

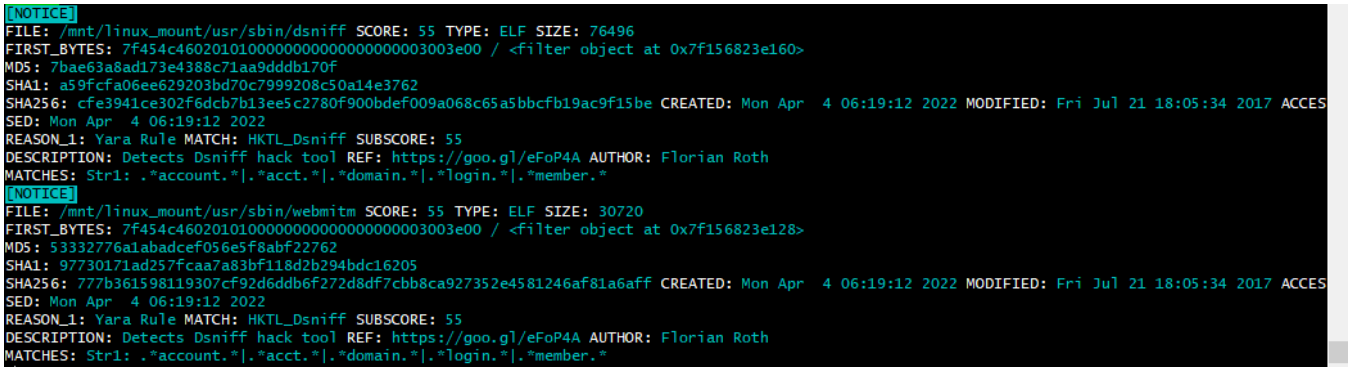


Figure 6.41 Notice for indicators of compromise

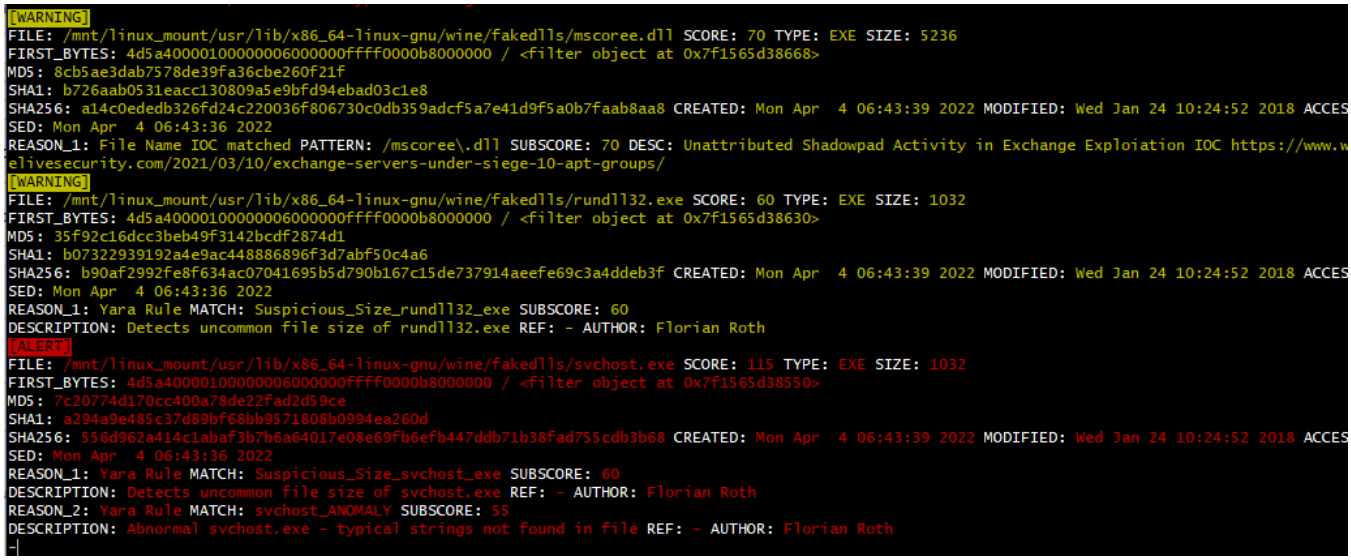


Figure 6.42 Warnings and Alerts for Compromise of Indicators 1

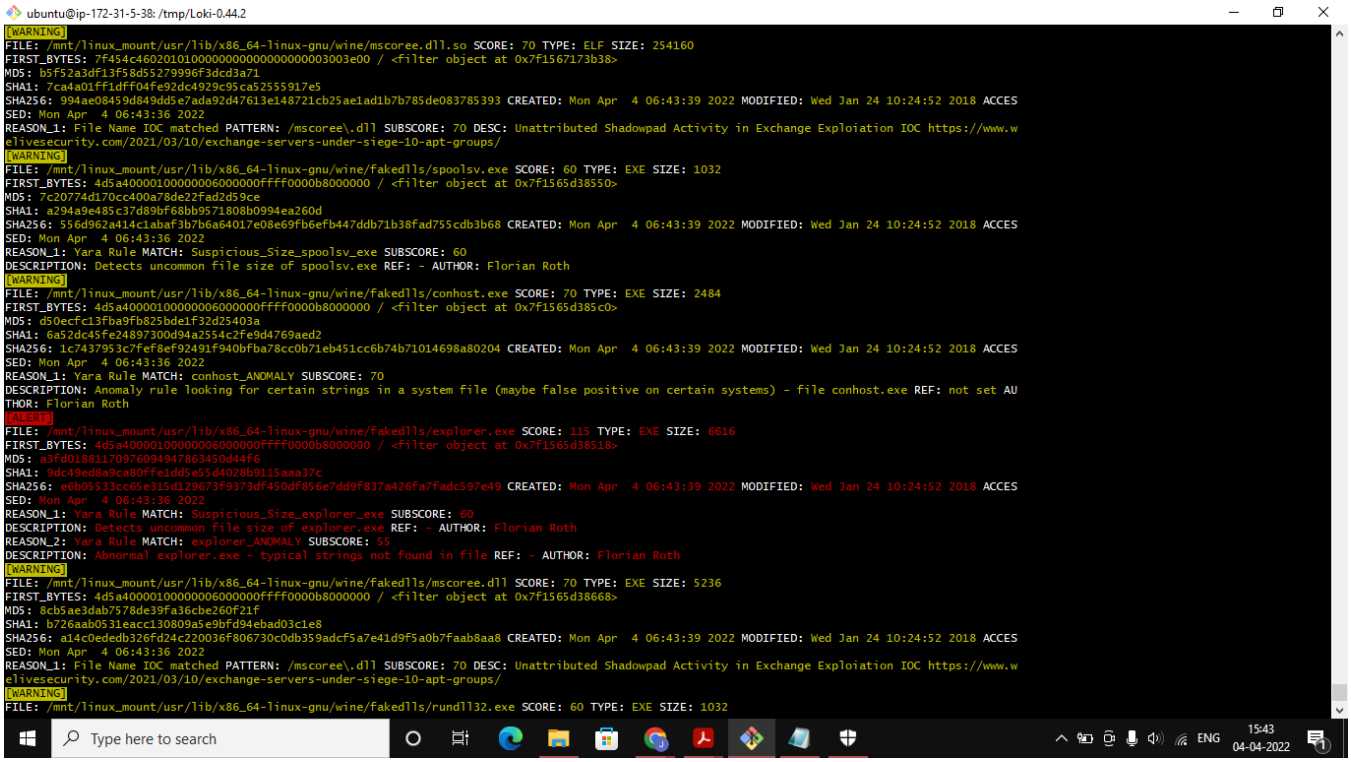


Figure 6.43 Warnings and Alerts for Compromise of Indicators 2

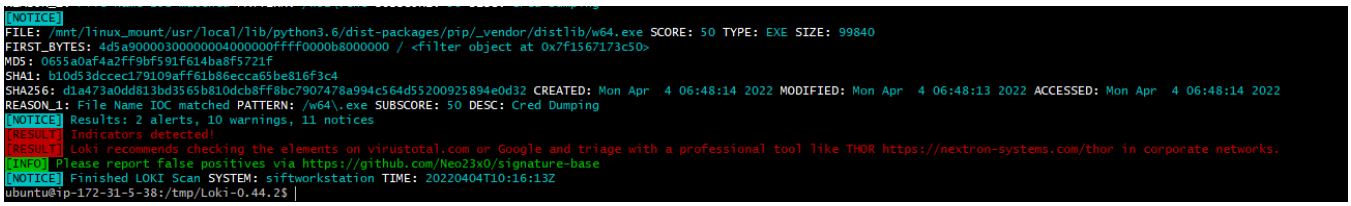


Figure 6.44 Final Results of Loki

6.4.1 Additional Forensic Analysis

Some malware or anomaly makes use of the start-up scripts that are initiated when the system is started and runs at boot time. On some distributions, these are found in /etc/init.d, but on Amazon Linux and Red Hat variants, the scripts will be in /etc/rc*.d.

```
ubuntu@ip-172-31-5-38:~$ ls -als -t /mnt/linux_mount/etc/rc*.d/
/mnt/linux_mount/etc/rc0.d/:
total 16
12 drwxr-xr-x 155 root root 12288 Apr  4 06:54 ..
 4 drwxr-xr-x   2 root root  4096 Apr  4 06:43 .
 0 lrwxrwxrwx   1 root root    17 Apr  4 06:43 K01winbind -> ../init.d/winbind
 0 lrwxrwxrwx   1 root root    15 Apr  4 06:42 K01saned -> ../init.d/saned
 0 lrwxrwxrwx   1 root root    22 Apr  4 06:42 K01avahi-daemon -> ../init.d/avahi-daemon
 0 lrwxrwxrwx   1 root root    19 Apr  4 06:42 K01bluetooth -> ../init.d/bluetooth
 0 lrwxrwxrwx   1 root root    18 Apr  4 06:40 K01stunnel4 -> ../init.d/stunnel4
 0 lrwxrwxrwx   1 root root    21 Apr  4 06:39 K01samba-ad-dc -> ../init.d/samba-ad-dc
 0 lrwxrwxrwx   1 root root    14 Apr  4 06:39 K01nmbd -> ../init.d/nmbd
 0 lrwxrwxrwx   1 root root    14 Apr  4 06:39 K01smbd -> ../init.d/smbd
 0 lrwxrwxrwx   1 root root    27 Apr  4 06:35 K01speech-dispatcher -> ../init.d/speech-dispatcher
 0 lrwxrwxrwx   1 root root    16 Apr  4 06:32 K01nfdump -> ../init.d/nfdump
 0 lrwxrwxrwx   1 root root    20 Apr  4 06:32 K01nbd-client -> ../init.d/nbd-client
 0 lrwxrwxrwx   1 root root    16 Apr  4 06:18 K01docker -> ../init.d/docker
 0 lrwxrwxrwx   1 root root    26 Apr  4 06:17 K01clamav-freshclam -> ../init.d/clamav-freshclam
 0 lrwxrwxrwx   1 root root    29 Apr  4 06:14 K01apache-htcacheclean -> ../init.d/apache-htcacheclean
 0 lrwxrwxrwx   1 root root    17 Apr  4 06:14 K01apache2 -> ../init.d/apache2
 0 lrwxrwxrwx   1 root root    23 Nov 29 17:31 K01lvm2-lvmpolld -> ../init.d/lvm2-lvmpolld
 0 lrwxrwxrwx   1 root root    22 Nov 29 17:31 K01lvm2-lvmetad -> ../init.d/lvm2-lvmetad
 0 lrwxrwxrwx   1 root root    13 Nov 29 17:31 K01lxd -> ../init.d/lxd
 0 lrwxrwxrwx   1 root root    23 Nov 29 17:31 K01open-vm-tools -> ../init.d/open-vm-tools
 0 lrwxrwxrwx   1 root root    18 Nov 29 17:31 K01plymouth -> ../init.d/plymouth
 0 lrwxrwxrwx   1 root root    20 Nov 29 17:31 K01cryptdisks -> ../init.d/cryptdisks
 0 lrwxrwxrwx   1 root root    26 Nov 29 17:31 K01cryptdisks-early -> ../init.d/cryptdisks-early
 0 lrwxrwxrwx   1 root root    20 Nov 29 17:31 K01irqbalance -> ../init.d/irqbalance
 0 lrwxrwxrwx   1 root root    15 Nov 29 17:31 K01lxcfs -> ../init.d/lxcfs
 0 lrwxrwxrwx   1 root root    29 Nov 29 17:31 K01unattended-upgrades -> ../init.d/unattended-upgrades
 0 lrwxrwxrwx   1 root root    18 Nov 29 17:31 K01ebtables -> ../init.d/ebtables
 0 lrwxrwxrwx   1 root root    15 Nov 29 17:31 K01uuidd -> ../init.d/uuidd
 0 lrwxrwxrwx   1 root root    15 Nov 29 17:31 K01mdadm -> ../init.d/mdadm
 0 lrwxrwxrwx   1 root root    24 Nov 29 17:31 K01mdadm-waitidle -> ../init.d/mdadm-waitidle
 0 lrwxrwxrwx   1 root root    20 Nov 29 17:31 K01open-iscsi -> ../init.d/open-iscsi
 0 lrwxrwxrwx   1 root root    16 Nov 29 17:31 K01iscsid -> ../init.d/iscsid
 0 lrwxrwxrwx   1 root root    13 Nov 29 17:31 K01atd -> ../init.d/atd
 0 lrwxrwxrwx   1 root root    17 Nov 29 17:27 K01rsyslog -> ../init.d/rsyslog
```

Figure 6.45 Startup Scripts

Looking for unusual files can be a hectic task, so in order to make it easy a security expert looks for SUID and SGID files (SUID Files - SUID is a special file permission for executable files which enables other users to run the file with effective permissions of the file owner while SGID Files - SGID is a special file permission that also applies to executable files and enables other users to inherit the effective GID of file group owner).The following commands perform the comparison on mounted volume for evidence capturing.

```
ubuntu@ip-172-31-5-38:~$ sudo find /mnt/linux_mount/ -uid 0 -perm -4000 -print > suid_evidence
ubuntu@ip-172-31-5-38:~$ sudo
usage: sudo -h | -K | -k | -V
usage: sudo -v [-AknS] [-g group] [-h host] [-p prompt] [-u user]
usage: sudo -l [-AknS] [-g group] [-h host] [-p prompt] [-U user] [-u user] [command]
usage: sudo [-AbEHknPS] [-r role] [-t type] [-C num] [-g group] [-h host] [-p prompt] [-T timeout] [-u user] [VAR=value] [-i|-s] [<command>]
usage: sudo -e [-AknS] [-r role] [-t type] [-C num] [-g group] [-h host] [-p prompt] [-T timeout] [-u user] file ...
ubuntu@ip-172-31-5-38:~$ sudo
usage: sudo -h | -K | -k | -V
usage: sudo -v [-AknS] [-g group] [-h host] [-p prompt] [-u user]
usage: sudo -l [-AknS] [-g group] [-h host] [-p prompt] [-U user] [-u user] [command]
usage: sudo [-AbEHknPS] [-r role] [-t type] [-C num] [-g group] [-h host] [-p prompt] [-T timeout] [-u user] [VAR=value] [-i|-s] [<command>]
usage: sudo -e [-AknS] [-r role] [-t type] [-C num] [-g group] [-h host] [-p prompt] [-T timeout] [-u user] file ...
ubuntu@ip-172-31-5-38:~$ sudo find /mnt/linux_base/ -uid 0 -perm -4000 -print > suid_base
ubuntu@ip-172-31-5-38:~$ sudo cut suid_base -d"/" -f4- > suid_base_relative
ubuntu@ip-172-31-5-38:~$ sudo cut suid_base -d"/" -f4- > suid_evidence_relative
ubuntu@ip-172-31-5-38:~$ sudo diff suid_base_relative suid_evidence_relative
ubuntu@ip-172-31-5-38:~$ ls
Desktop      changed_files.txt      investigate_files.md5-md5.idx   known_files.md5          known_files.md5-md5.idx2  output     suid_base_relative  suid_evidence_relative
changed.md5  investigate_files.md5  investigate_files.md5-md5.idx2  known_files.md5-md5.idx  loki_0.44.2.zip           suid_base  suid_evidence
ubuntu@ip-172-31-5-38:~$ echo suid_base_relative
suid_base_relative
ubuntu@ip-172-31-5-38:~$ vim suid_base_relative
ubuntu@ip-172-31-5-38:~$ vim suid_base_relative
ubuntu@ip-172-31-5-38:~$
```

Figure 6.46 Commands to look for unusual files

ubuntu@ip-172-31-5-38: ~

```
bin/mount
bin/fusermount
bin/umount
bin/ping
bin/su
usr/lib/x86_64-linux-gnu/lxc/lxc-user-nic
usr/lib/eject/dmcrypt-get-device
usr/lib/snapd/snap-confine
usr/lib/policykit-1/polkit-agent-helper-1
usr/lib/dbus-1.0/dbus-daemon-launch-helper
usr/lib/openssh/ssh-keysign
usr/bin/chsh
usr/bin/chfn
usr/bin/sudo
usr/bin/newgrp
usr/bin/traceroute6.iputils
usr/bin/newuidmap
usr/bin/passwd
usr/bin/gpasswd
usr/bin/pkexec
usr/bin/newgidmap
~
~
~
~
~
~
~
~
~
~
~
~
~
~
```

Figure 6.47 List of Unusual files

In order to look for files with high entropy there is a tool in SIFT called DensityScout which detects packing, compression, and encrypted files that exceed a "density" threshold. The following commands are implemented in order to find such files which exceed the threshold.

```
ubuntu@ip-172-31-5-38:~$ sudo densityscout -r -p 0.1 -l 0.1 -o high_density_evidence.txt /mnt/linux_mount/

DensityScout (Build 45)

by Christian Wojner

Calculating density for file ...
(0.08665) | /mnt/linux_mount/usr/share/man/man1/gawk.1.gz
(0.04133) | /mnt/linux_mount/usr/share/man/man1/x86_64-linux-gnu-gcc-7.1.gz
(0.07464) | /mnt/linux_mount/usr/share/man/man1/wget.1.gz
(0.08366) | /mnt/linux_mount/usr/share/man/man1/socat.1.gz
(0.05668) | /mnt/linux_mount/usr/share/man/man1/xterm.1.gz
(0.09947) | /mnt/linux_mount/usr/share/man/man1/less.1.gz
(0.09091) | /mnt/linux_mount/usr/share/man/man1/sh.distrib.1.gz
(0.09165) | /mnt/linux_mount/usr/share/man/man1/keytool.1.gz
(0.04133) | /mnt/linux_mount/usr/share/man/man1/g++-7.1.gz
(0.09927) | /mnt/linux_mount/usr/share/man/man1/git-fast-import.1.gz
(0.04133) | /mnt/linux_mount/usr/share/man/man1/g++.1.gz
(0.07959) | /mnt/linux_mount/usr/share/man/man1/x86_64-linux-gnu-ld.bfd.1.gz
(0.07728) | /mnt/linux_mount/usr/share/man/man1/gpg.1.gz
(0.09091) | /mnt/linux_mount/usr/share/man/man1/sh.1.gz
(0.07959) | /mnt/linux_mount/usr/share/man/man1/ld.1.gz
(0.08236) | /mnt/linux_mount/usr/share/man/man1/git-log.1.gz
(0.05229) | /mnt/linux_mount/usr/share/man/man1/bash.1.gz
(0.08055) | /mnt/linux_mount/usr/share/man/man1/cli.1.gz
```

Figure 6.48 High Entropy files in /mnt/linux_mount (Volume where SIFT is installed)

```
ubuntu@ip-172-31-5-38:~$ sudo densityscout -r -p 0.1 -l 0.1 -o high_density_base.txt /mnt/linux_base/

DensityScout (Build 45)

by Christian Wojner

Calculating density for file ...
(0.08665) | /mnt/linux_base/usr/share/man/man1/gawk.1.gz
(0.07464) | /mnt/linux_base/usr/share/man/man1/wget.1.gz
(0.09947) | /mnt/linux_base/usr/share/man/man1/less.1.gz
(0.09091) | /mnt/linux_base/usr/share/man/man1/sh.distrib.1.gz
(0.09927) | /mnt/linux_base/usr/share/man/man1/git-fast-import.1.gz
(0.07728) | /mnt/linux_base/usr/share/man/man1/gpg.1.gz
(0.09091) | /mnt/linux_base/usr/share/man/man1/sh.1.gz
(0.08236) | /mnt/linux_base/usr/share/man/man1/git-log.1.gz
(0.05229) | /mnt/linux_base/usr/share/man/man1/bash.1.gz
(0.09974) | /mnt/linux_base/usr/share/man/man1/find.1.gz
(0.09947) | /mnt/linux_base/usr/share/man/man1/pager.1.gz
(0.09091) | /mnt/linux_base/usr/share/man/man1/dash.1.gz
(0.08665) | /mnt/linux_base/usr/share/man/man1/nawk.1.gz
(0.07303) | /mnt/linux_base/usr/share/man/man1/rsync.1.gz
(0.07669) | /mnt/linux_base/usr/share/man/man1/top.1.gz
(0.08718) | /mnt/linux_base/usr/share/man/man1/tmux.1.gz
(0.08665) | /mnt/linux_base/usr/share/man/man1/awk.1.gz
(0.06611) | /mnt/linux_base/usr/share/man/man1/screen.1.gz
(0.07075) | /mnt/linux_base/usr/share/man/man1/git-config.1.gz
(0.08041) | /mnt/linux_base/usr/share/man/man1/curl.1.gz
(0.07633) | /mnt/linux_base/usr/share/man/man1/busybox.1.gz
(0.07022) | /mnt/linux_base/usr/share/man/man3/pcrepattern.3.gz
(0.08504) | /mnt/linux_base/usr/share/man/es/man8/dnsmasq.8.gz
(0.09558) | /mnt/linux_base/usr/share/man/man7/systemd.directives.7.gz
(0.09402) | /mnt/linux_base/usr/share/man/man7/mdoc.samples.7.gz
```

Figure 6.49 High Entropy files in /mnt/linux_base (Additional mounted volume containing forensic evidence)

Clamscan is a malware scanner that comes loaded when we install SIFT Workstation on our instances, it is used to scan all data and infected files present on the system.

```
ubuntu@siftworkstation: ~
$ clamscan -i -r --log=/cases/clam.log /mnt/linux_mount/
/mnt/linux_mount/usr/bin/upx-ucl: Unix.Trojan.Mirai-9936831-0 FOUND

----------- SCAN SUMMARY -----------
Known viruses: 8612220
Engine version: 0.103.5
Scanned directories: 18949
Scanned files: 152078
Infected files: 1
Total errors: 124
Data scanned: 7669.29 MB
Data read: 7304.66 MB (ratio 1.05:1)
Time: 2091.245 sec (34 m 51 s)
Start Date: 2022:04:20 12:29:25
End Date:   2022:04:20 13:04:16
ubuntu@siftworkstation: ~
$
```

Figure 6.50 Clamscan Results

At this stage, the forensic investigator must have realized that there must be multiple files which are infected, in order to check which files are infected third party hash hook-ups from online websites like virustotal.com can provide more clearer results to the investigator. After executing the below mentioned commands on SIFT workstation multiple csv files will be generated containing links of virustotal which can be pasted on the website to get better view of infected files present.

- virustotal-search.py investigate_files.md5 > virustotal-results.txt
- virustotal-submit.py virustotal-search.pkl

```
ubuntu@siftworkstation: ~
$ ls
Desktop                investigate_files.md5-md5.idx   known_files.md5-md5.idx2              virustotal-search-20220420-165827.csv
changed.md5            investigate_files.md5-md5.idx2  signature-base                        virustotal-search.pkl
changed_files.txt      known_files.md5                 virustotal-results.txt                virustotal-submit-20220420-122040.csv
investigate_files.md5  known_files.md5-md5.idx         virustotal-search-20220420-121606.csv virustotal-submit-20220420-133819.csv
ubuntu@siftworkstation: ~
$ cat virustotal-submit-20220420-133819.csv
Filename;Response;Message;md5;sha256;Scan ID;Permalink
virustotal-search.pkl;1;Scan request successfully queued, come back later for the report;1eff85ccd2bb7758438e2477ff7c6a67;05cdbd7c9bad8c73a64f273ea241
daf0beaf380dac9ad8beb1a6b1226bb6d12d;05cdbd7c9bad8c73a64f273ea241daf0beaf380dac9ad8beb1a6b1226bb6d12d-1650461901;https://www.virustotal.com/gui/file/0
5cdbd7c9bad8c73a64f273ea241daf0beaf380dac9ad8beb1a6b1226bb6d12d/detection/f-05cdbd7c9bad8c73a64f273ea241daf0beaf380dac9ad8beb1a6b1226bb6d12d-165046190
1
ubuntu@siftworkstation: ~
$
```

Figure 6.51 Linking Virustotal.com

The link generated from multiple .csv files as shown above will give details about the infected files present on the EC2 instance.

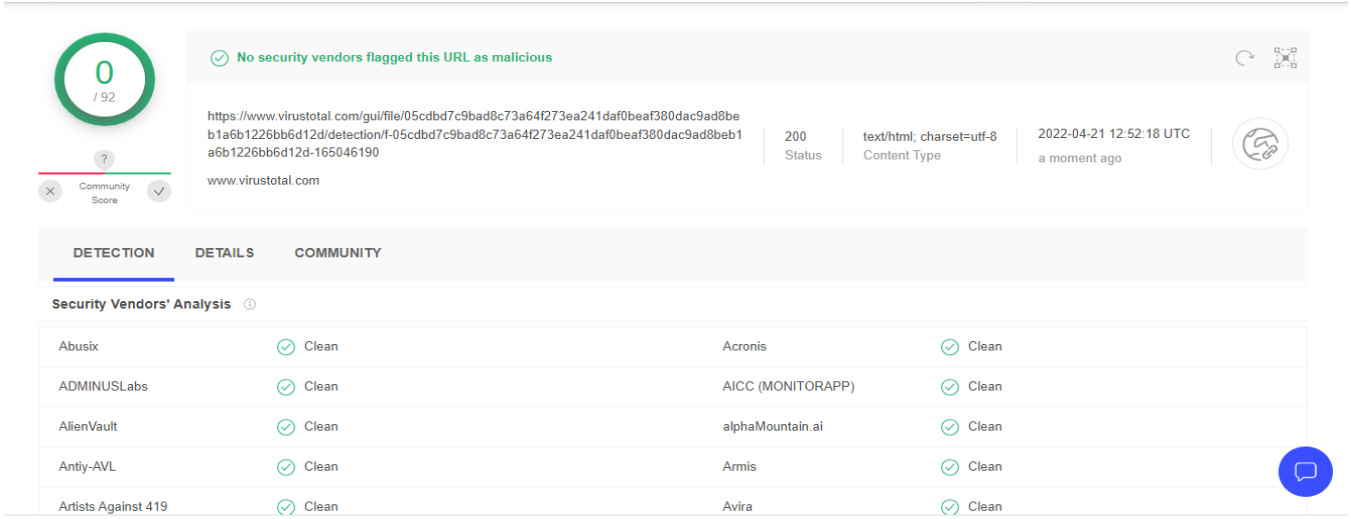


Figure 6.52 Third Party Hash Hook-ups 1

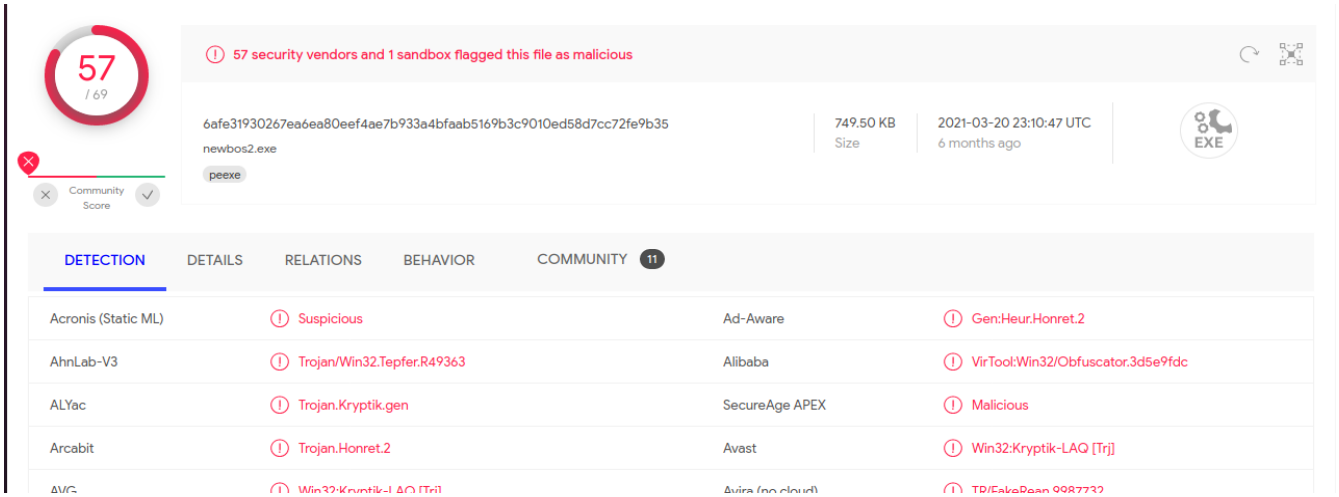


Figure 6.53 Third Party Hash Hook-ups 2

CHAPTER: 7 CONCLUSION AND FUTURE WORK

CHAPTER 7 CONCLUSION AND FUTURE WORK

Conclusion

In conclusion, the number of cases and the severity, refinement of malware attacks and expense of malware infect is increasing at an alarming rate. Malware should be detected as early as possible and mitigated. In this project, cybersecurity and security in-depth principles are applied to the cloud environment. These propositions indicate that defense controls of the cloud environment will not succeed at numerous cases and an attack might prevail so the companies must have response mechanisms to put off these attacks. Log monitoring and digital forensics gathering are the main trait for investigators for tracking and detecting active malware attacks. In this project we have successfully established a solution on how a user can monitor his/her data if it uploaded on cloud premises using Billing preferences alarm and CloudWatch Alarm. After that, we validated the applicability and limitation of deploying this baseline by doing a malware attack Any type of malicious activity which might takes place on the cloud account can be mitigated if the data is monitored properly. A baseline is built on AWS using a service called AWS CloudTrail which generated logs of activities taking place within S3. and then they were integrated with Splunk which is a SIEM Tool to perform investigation and analysis and take some steps regarding attack decision. Splunk provided data correlation, enrichment, integration with other security events, and long-term storage. Lastly in order to investigate the vulnerability of VMs Investigations were performed on the compromised IaaS VMs which displayed how a user should be careful and alert of the vulnerability of the system and take necessary steps to prevent it in future.

Future Work

As there are ample number of malware attacks happening day by day which are very difficult to track whether it is on-premises or on cloud environment, security management and investigation techniques should be given more value as the data uploaded on these environments is very important leading to changes to world economy at some stages. For future work, we believe that cloud services sources should provide the necessary tools for executing volatile memory analysis for their VMs. Also, develop a new automated tool for incident response and forensics investigation on the IaaS.

CHAPTER: 8 REFERENCES

CHAPTER 8 REFERENCES

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G20 IBM PROJECT REPORT

by Jainam Shah

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CHAPTER 1 INTRODUCTION

The availability to store data on cloud is a modern technology. In recent years, utilization of services on cloud platform is skyrocketing at an alarming pace; now it has turned more famous after the emergence of the 4th Economic Industrial Revolution. In the year of 2020, nearly 83 percentage of workloads in business are functional on the cloud platform, and around 94 percentage of companies in today's market utilize a cloud service in one of their services. There are approximately 3 most used cloud services including Software as a Service (SaaS), Platform as a Service (PaaS), and Infrastructure as a Service (IaaS). Monitoring the current market, (IaaS) is the most rapidly growing service in Cloud Computing.

However due to ample number of exquisite features being available on the IaaS cloud, it is turning into a playground to many attacks of malware for the following reasons:

1) Companies which are providing cloud services unremittingly offer off the chart's performance with more computation power for their clients. These virtual machines on cloud are primary targets for crypto currency mining malware.

2) The rise of work from home era and internationally separated manpower and resources accessibility after the Sars-Cov2 (corona virus) has provided the attackers more ways to conceal their detrimental traffic to take over the cloud-hosted virtual machines, and utilize them for their malicious activities.

3) The definite rise in IoT applications that use cloud-hosted data and services to analyze the gigantic quantity of data created by these applications to construct business value and insights.

By considering this above scenario we decided to perform monitoring and analysis of data uploaded by user on cloud premises and how/she can mitigate the dangers if they are trapped in such circumstances. The main objectives of this project are as follows: -

- It directs its goal to utilize the best ways to attain non-stop monitoring of malware attacks on the cloud.
- The techniques of logging data and performing forensics have always been the foundations of accomplishing non-stop monitoring and detection of malware attacks.
- To arrogate the perfect methods to bring the concept of forensics and logging to the cloud and integrate them with on-premises visibility.
- Attaining the proper monitoring considering the whole security standpoint of the organization assets whether they are stored on an on-premises system or on the cloud platform.

Below is the list of the tools and technologies which we have used in this project: -

- AWS CloudTrail for creating data log files.
- AWS CloudWatch for monitoring.

CHAPTER 2 PROJECT SCOPE

The project is limited to only Desktop/Service system because data which is considered for malware analysis and monitoring must be uploaded by the user on cloud premises.

CHAPTER 3 SOFTWARE AND HARDWARE REQUIREMENTS

Minimum Hardware Requirements

Processor	2.0 GHz
RAM	8GB
HDD	Minimum 30GB

Table 3.1 Minimum Hardware Requirements

Minimum Software Requirements

OS	Any operating system which can support an internet browser.
Programming languages	-
Tools and Technologies	AWS, Splunk, kali Linux

Table 3.2 Minimum Software Requirements

CHAPTER 4 PROCESS MODEL

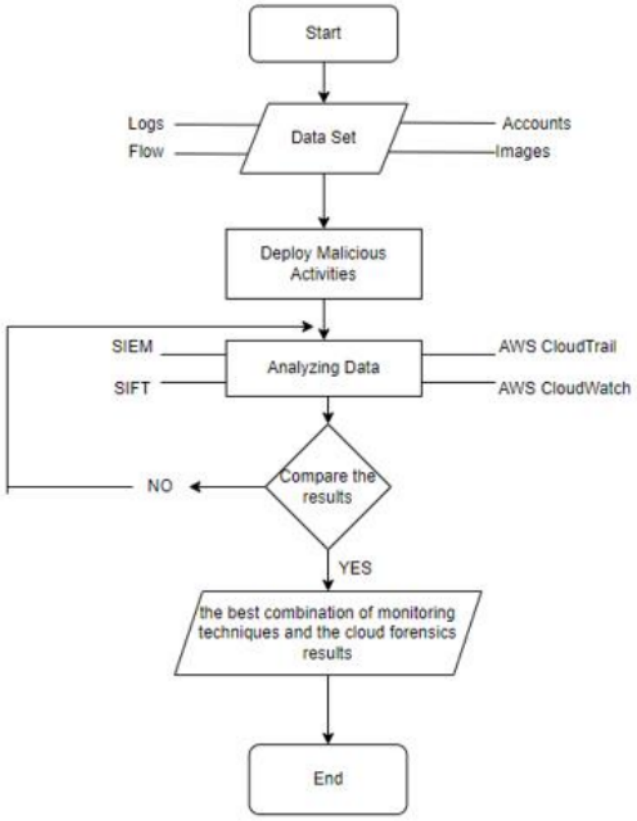

Figure 4.1 Process Model of Project

CHAPTER 5 PROJECT PLAN

5.1 List of Major Activities

5.1.1 Tasks for Implementing Data Monitoring in First Phase

Task: - 1 Exploring NIST and MITRE ATT&CK Frameworks
Task: - 2 Exploring AWS Tools (CloudTrail and CloudWatch) to generate data log files
Task: - 3 Creating and uploading data files on Amazon S3 for Analysis
Task: - 4 Malware Attack and Monitoring

5.1.2 Time Duration to Complete First Phase

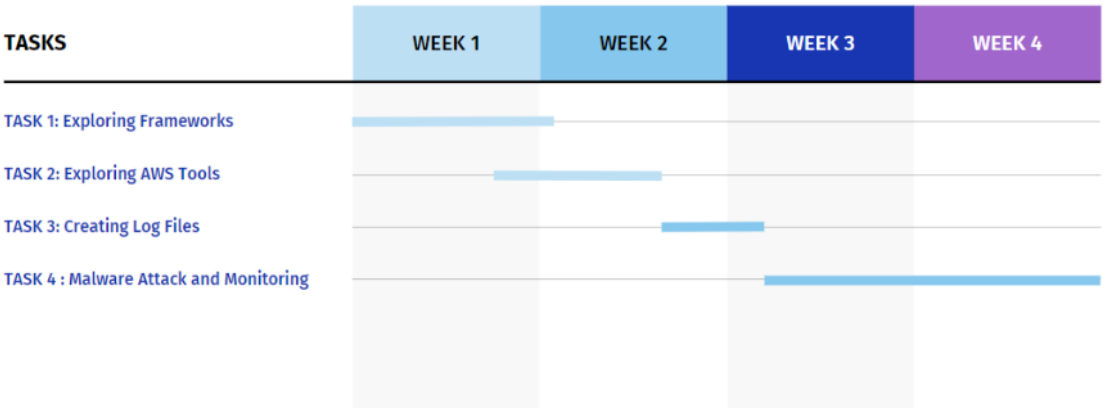

Figure 5.1 Task Completion Time Duration in First Phase

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5.1.3 Tasks for Implementing Data Logging and Integration in Second Phase

Task: - 1 Exploring AWS CloudTrail and Gathering Data Log Files
Task: - 2 Implementing Data Monitoring and Logging on AWS Config
Task: - 3 Exploring to SIEM Tools to transfer logs
Task: - 4 Integrating Splunk with AWS CloudTrail Logs

5.1.4 Time Duration to Complete Second Phase

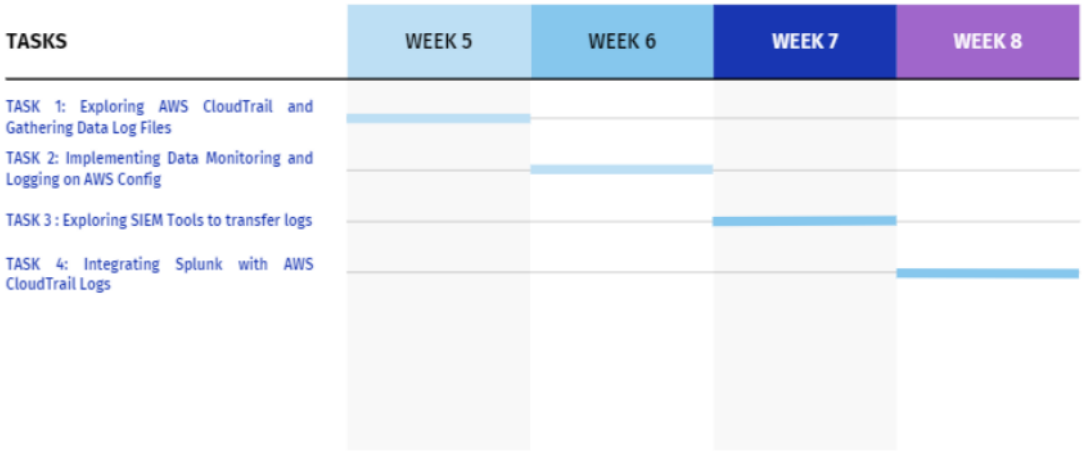


Figure 5.2 Task Completion Time Duration in Second Phase

5.1.5 Tasks for Evidence Capturing and Forensic Analysis in Third Phase

Task: - 1 SIFT Exploration
Task: - 2 AWS EC2 Exploration and setting up investigation tools on EC2
Task: - 3 Cloud Forensic Analysis and Evidence Capturing
Task: - 4 Additional Cloud Forensics

5.1.6 Time Duration to Complete Third Phase

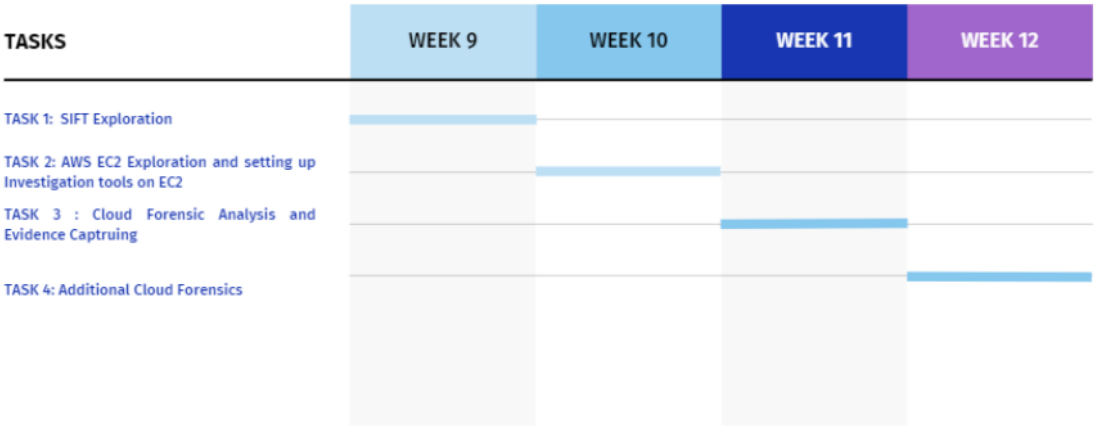


Figure 5.3 Task Completion Time Duration in Third Phase

CHAPTER 6 IMPLEMENTATION DETAILS

6.1 Background

The proposed project is based on 4 fundamental parts as follows: -

1. Infrastructure as a Service (IaaS) Cloud - It can be considered as the most important service, which provides basic computational services such as servers, networking, and storage. This service supplements the availability of the system on lower costs and providing a more pliable system.

2. Malware Attacks - In layman terms the term malware means dangerous and harmful, it has similar effect on software, networks, OS, or other components. The most major challenge while using IaaS cloud world is its vulnerability and the possibility of malware attacks; it is a vital concern to devices present at home as well as the devices used for business in a corporate and also on cloud VMs.

3. Malware Detection Methods – In order to prevent malware from hampering networks malware detections methods are necessary to implement in order for its proper functioning, a number of malware detection methods can be applied for e.g.: - Techniques based on Signature/Behavior for malware detection, Machine Learning Based malware detection methods etc.

4. Cloud Forensics – It can be defined as techniques that are utilized in order to perform collecting and storing incidents happening around and their visibility, remodeling events, recognizing when an incident is happening, how an incident is happening, and where an incident is happening, and implementing information/data regarding that.

6.2 Methodology

The methodology of the mentioned project has been segregated into two parts:

The First: Whenever or wherever a malware attack takes place, the investigator should make cloud analysis for that particular malware detection.
The Second: is to perform forensics analysis in the IaaS Cloud after the attack happens.

6.2.1 Gathering Data

In today's, there are two initiatives that define and segregate in an orderly manner how each cloud attack technique is witnessed; they are NIST Cybersecurity Framework and MITRE ATT&CK cloud framework.

For this project multiple csv files and data log files uploaded on NIST and MITRE ATT&CK website have been used for performing monitoring of data. Otherwise, any type of data can be used by a user as monitoring and analysis is done on cloud.

6.3 Cloud Analysis to Malware Detection

6.3.1. Test Environment - The tests for this mentioned project were performed on Amazon Web services (AWS), the main reason for choosing AWS for this project was because it is currently the market leader and provides so many public cloud services and possesses a varied range of service catalog and thus in turn making it a more suitable choice for the mentioned problem.

6.3.2. Data Set – Any data can be considered by a user for testing this module, for the sake of testing we have selected data which provided by NIST and MITRE ATT&CK frameworks from their websites.

Non-Stop monitoring on IaaS can be attained by collecting and processing the following

- Monitoring API Calls (CloudTrail's logs in AWS).
- Hosting logs and logs of deployed HIDs.
- VPC flows.
- Logs of numerous cloud resources (CloudWatch Logs in AWS)
- Validation and Integrity of images and instances.

6.3.3. Testing and Analysis – For performing testing and analysis multiple tools have been utilized to store date and perform malware attacks on it

AWS CloudWatch – to gather and monitor metrics, gather and monitor log files, setting alarms, and automatically react to changes.

AWS CloudTrail - A web service that logs your account's AWS API calls and provides you log files.

AWS S3 – For storing data and hosting a static website

Kali Linux – For performing malware attacks

6.3.4 Testing Phases

1. Creating AWS Billing Alarm

As per the MITRE ATT&CK framework, most majorly used attack vectors for attacks on cloud and malware attacks aiming cloud-hosted environments is the cloud account takeover. There are multiple ways to detect that, the most promising way is detecting changes in the billings on AWS. Most public cloud providers provide features to allow their customers to make billing tags and then send them emails whenever alarms are triggered.

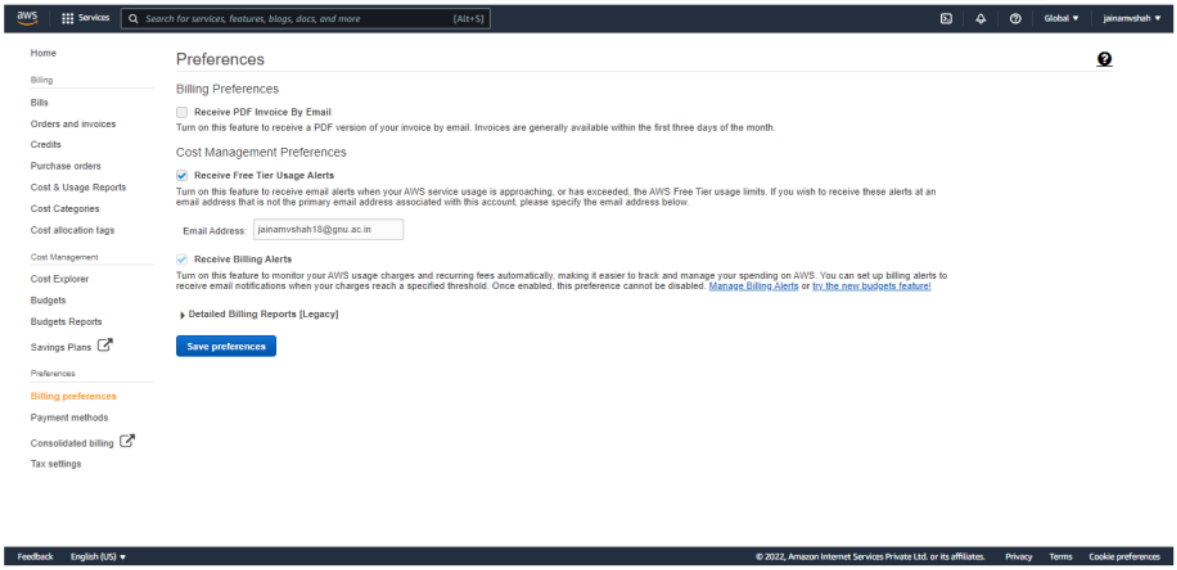


Figure 6.1 AWS Billing Preferences

If there is usage of any service on the respective cloud account AWS will sent notification to the respective email.

Verb ETS

2. Performing Continuous Monitoring in AWS Environment

AWS Cloud platform provides a service called AWS Config, this service enables monitoring AWS resource configurations and keep tracks on resource inventory and varied changes that might take place within it, which can be utilized to detect any malicious configuration changes that an attacker might try to make in order to gain control over the compromised account's resources. The monitoring information gathered from this then can be obsorbed using AWS CloudWatch and SNS Notifications can be created based on them.

Malware attacks earmark and make changes to the data stored and any misconfigured cloud storage leading to data leak. By making use of AWS Config, the rules like proper storage versioning is kept on for AWS storage (S3). By enabling the s3-bucketversioning- enabled rule, another activity auditioned by attackers is to hide their vindictive API calls by disabling API calls monitoring, another rule that can be configured is to check if CloudTrail service is enabled or not and yet another rule to detect whether the volumes which are utilized are having encryption or not.

Initially starting by making S3 buckets in respective AWS account in order to perform monitoring and also to do malware attacks.

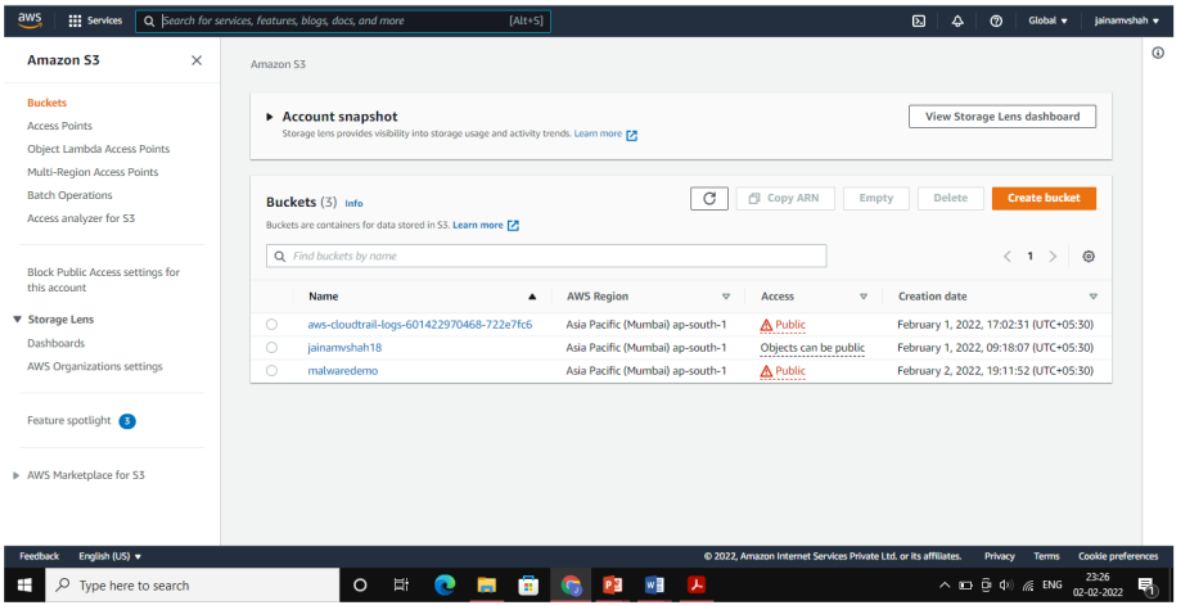


Figure 6.2 S3 Buckets

Furthermore, additional charts are being created for request and storage metrics in order to perform monitoring on our respective bucket

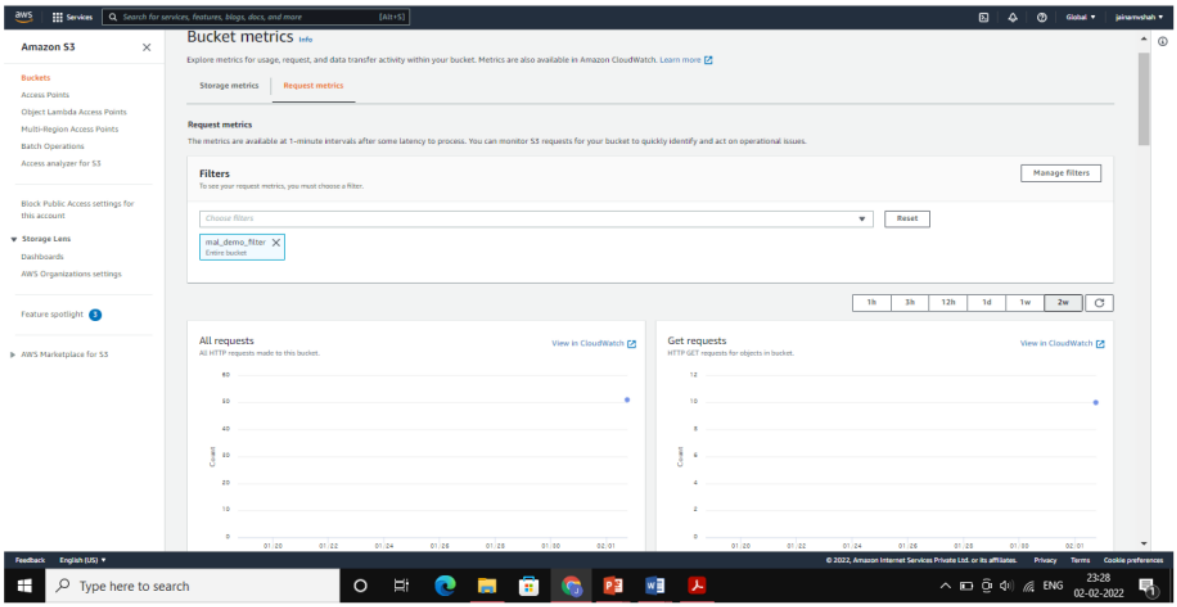


Figure 6.3 Creating Metrics for bucket

In order to monitor activities taking place within the S3 bucket like uploading or downloading files by a user or any malicious activities taking place without the awareness of the respective user AWS CloudWatch comes into place. An alarm configured on CloudWatch helps a user to track and monitor the S3 bucket in an efficient manner. An alarm for the respective bucket is created in the following manner.

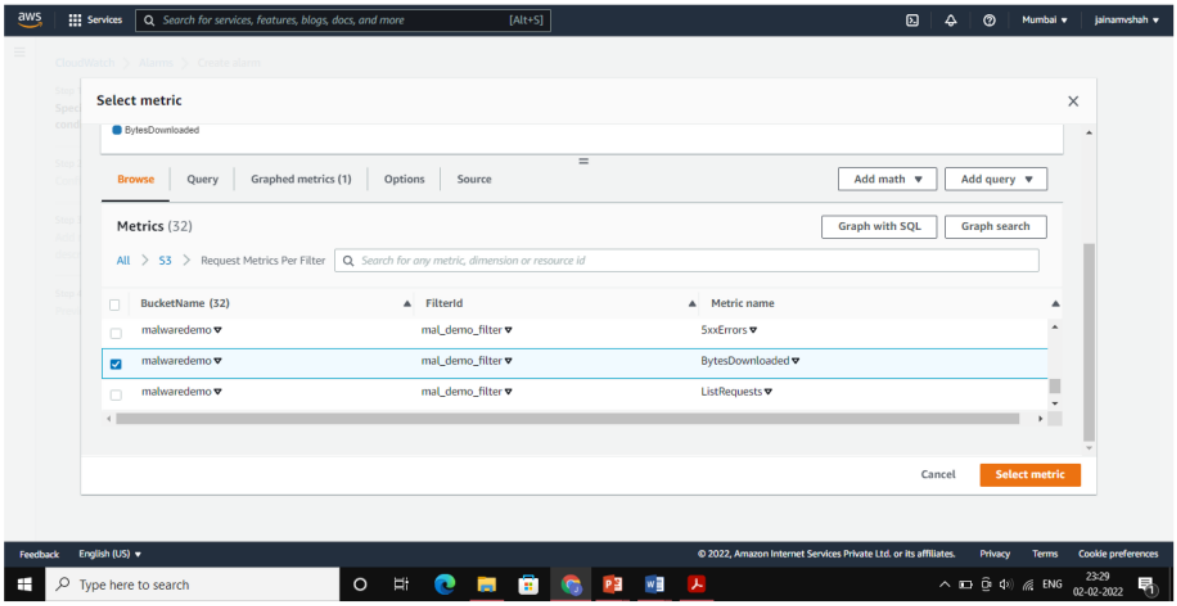


Figure 6.4 Setting up Alarm

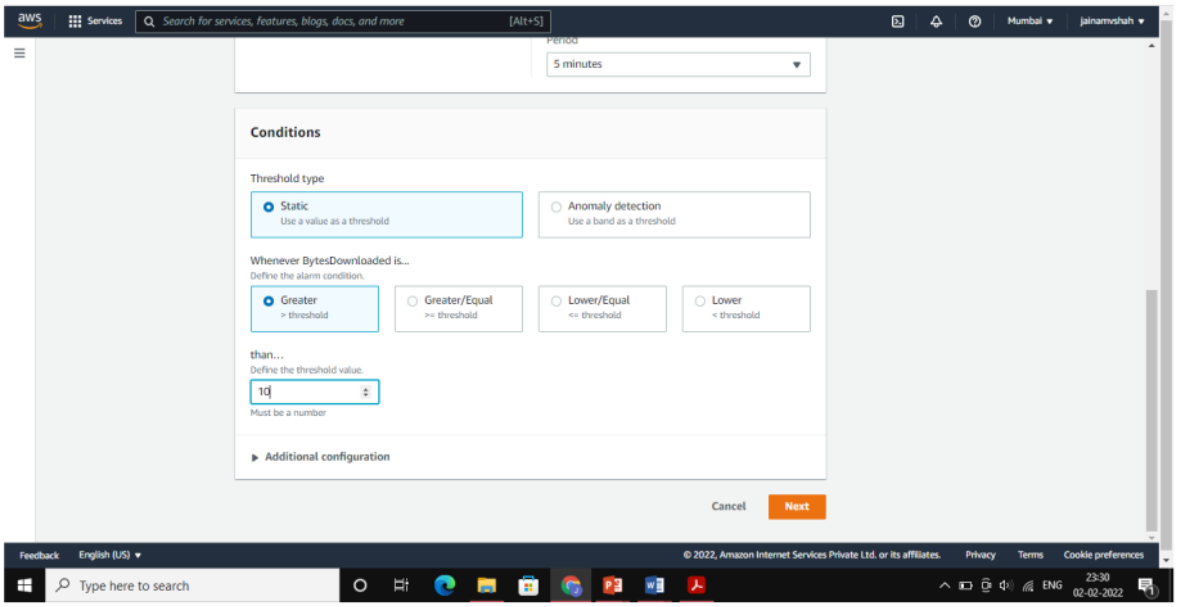


Figure 6.5 Defining threshold value for a definite amount of size

3. Performing a Malware Attack

After creating S3 bucket a malware attack has been initiated on the created S3 bucket using its respective URL. Following steps are performed in order to complete a malware attack on S3 Bucket

Step 1: First we identified the IP Address of this bucket URL using the following command

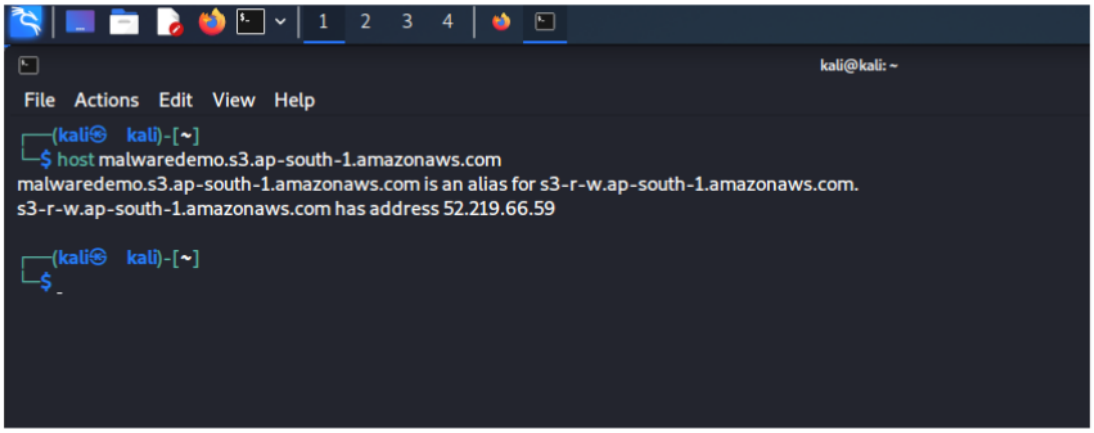


Figure 6.6 Identifying IP Address

Step 2: DNS attack on bucket URL to know number of servers through which that URL request passed

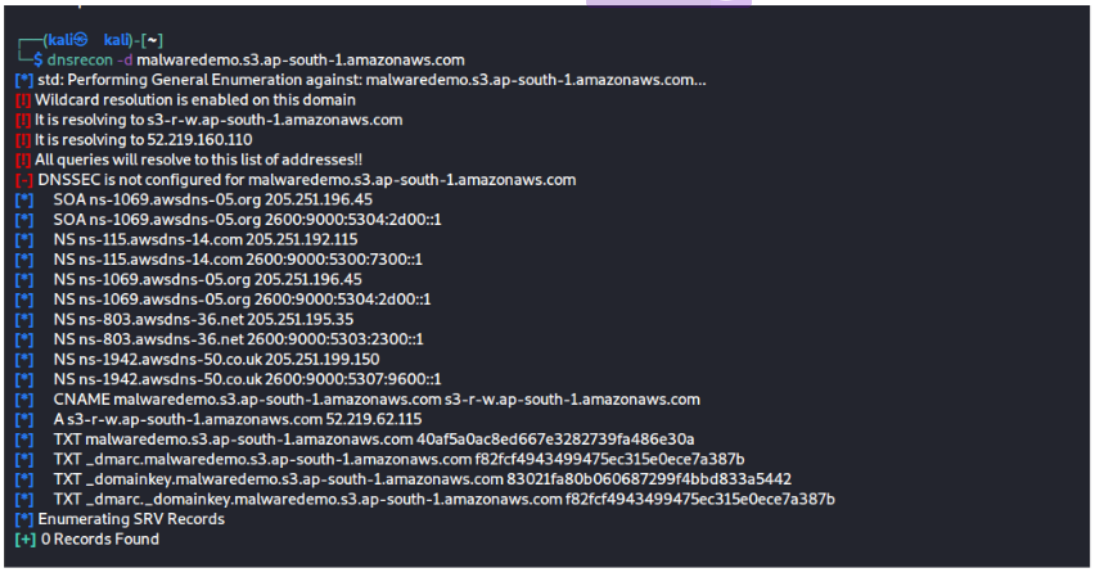


Figure 6.7 Initiating DNS Attack on the respective bucket

Step 3: Here we try to fetch the actual name of bucket URL.

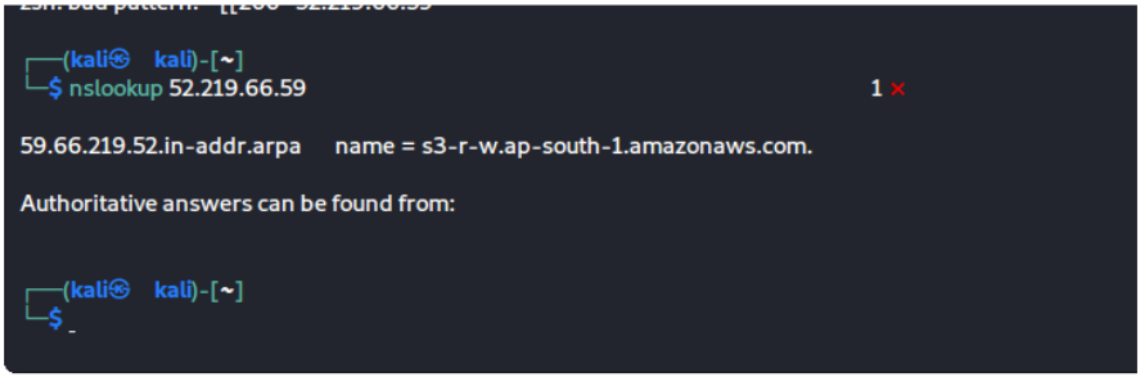


Figure 6.8 Name Revealing of S3 Bucket

We paste the acquired name in the browser to see the tree structure of files in the respective bucket. It is in XML format.

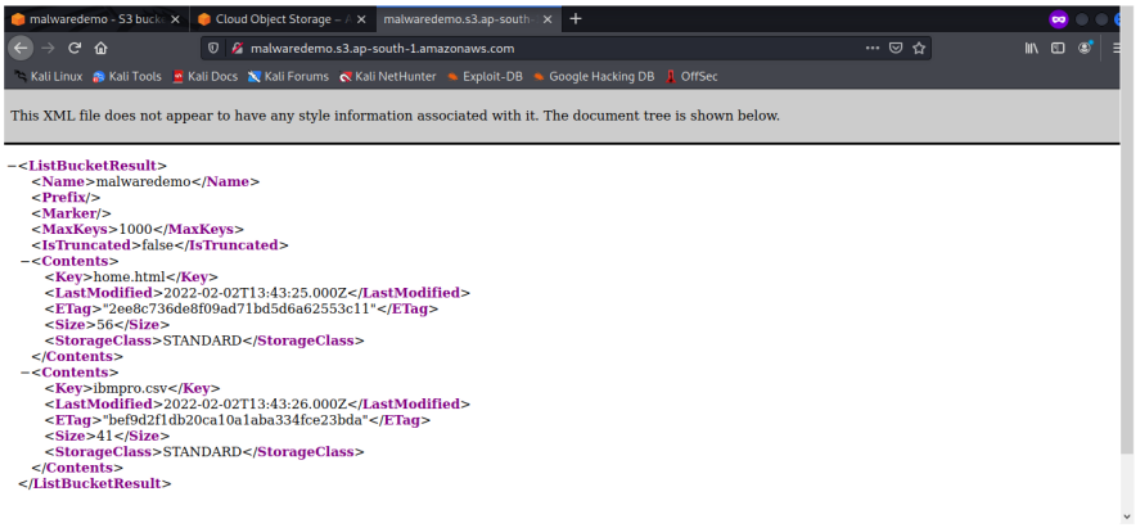


Figure 6.9 Tree structure of files present in the bucket

Step 4: Using the following command we get the list of files present in the bucket which do not require authentication to access it.

Figure 6.10 Revealing files not needing authentication to access

Here we tried to open the listed files in browser

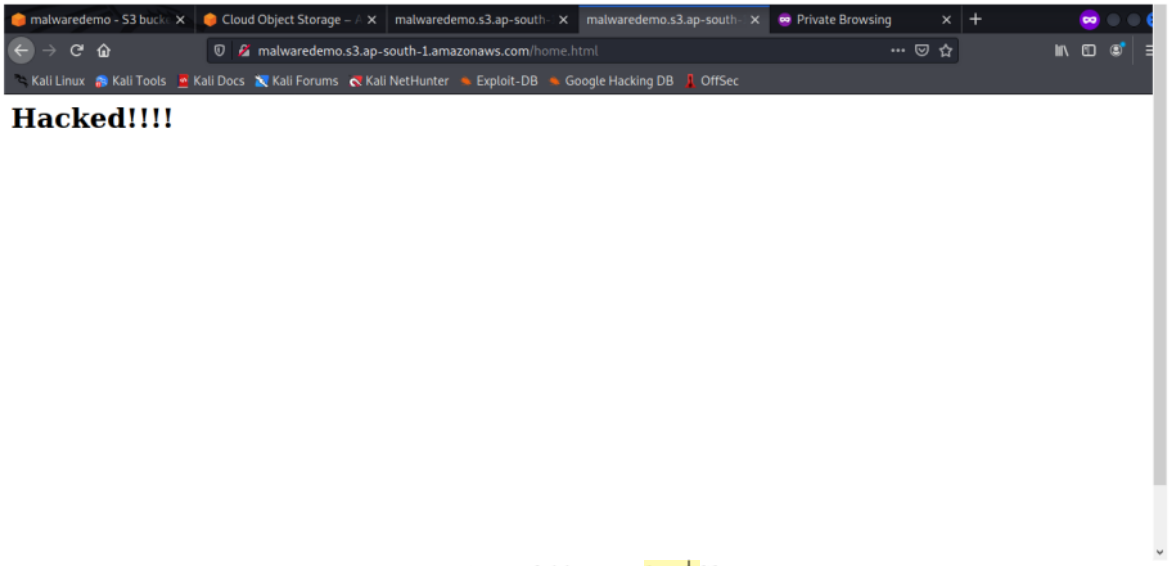


Figure 6.11 Home.html file

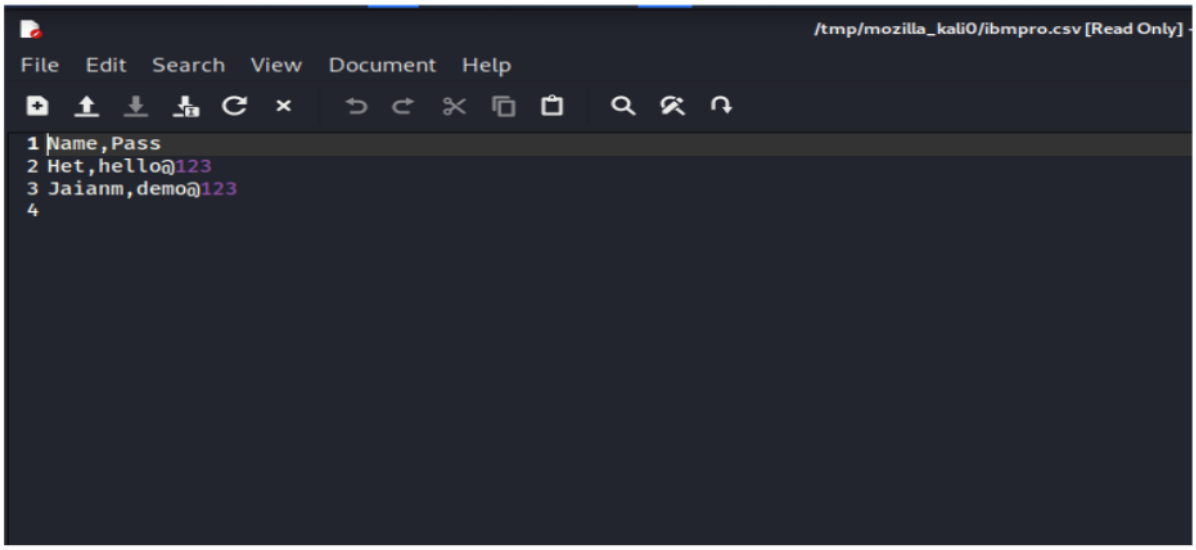


Figure 6.12 ibmpro.csv

Step 5: Then S3Scanner python file is used to find the S3 bucket data and dump its content to the local machine.Here this following command has been used to scan whether bucket is present or not and also lists out AuthUsers and AllUsers permissions

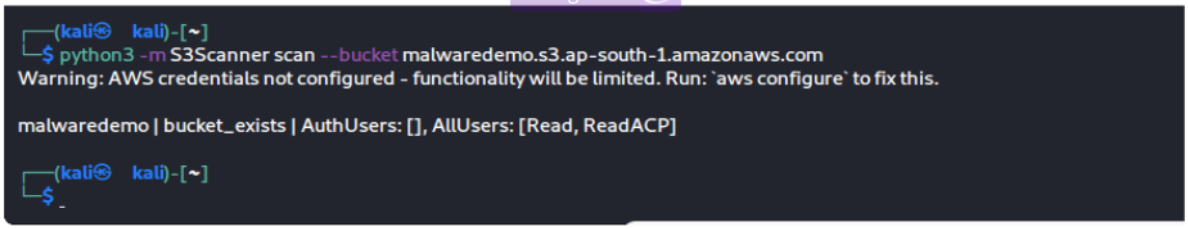


Figure 6.13 Listing Users

Step 6: The following command is used to dump all content from bucket to local machine at any location.

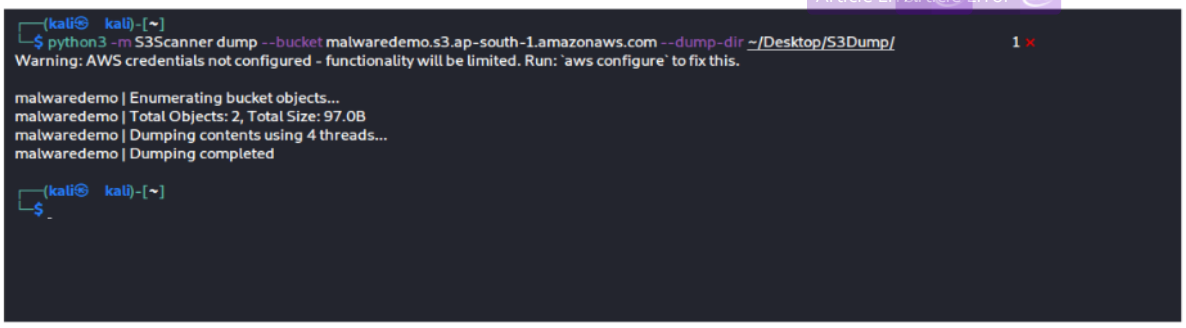


Figure 6.14 Dump status

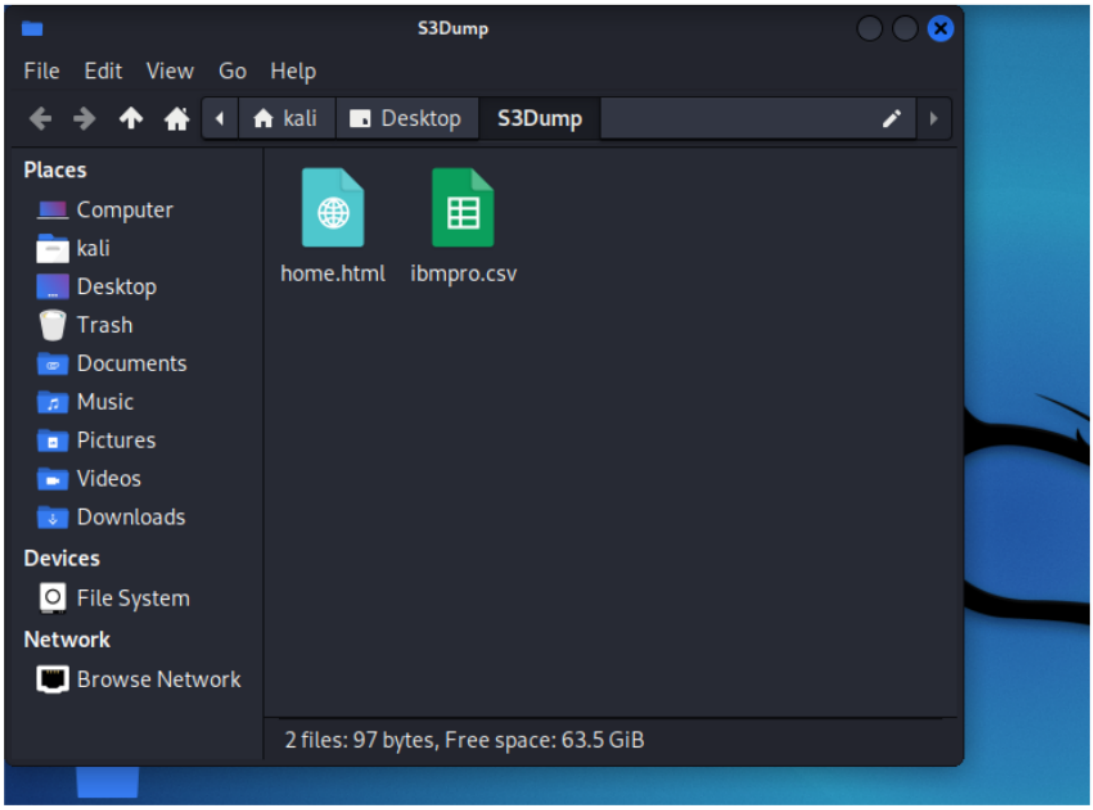


Figure 6.15 Files downloaded on local machine

As we can see malware alarm created earlier to monitor S3 bucket has been triggered based on intrusion being detected and we can see the size of files being downloaded from the bucket respectively.

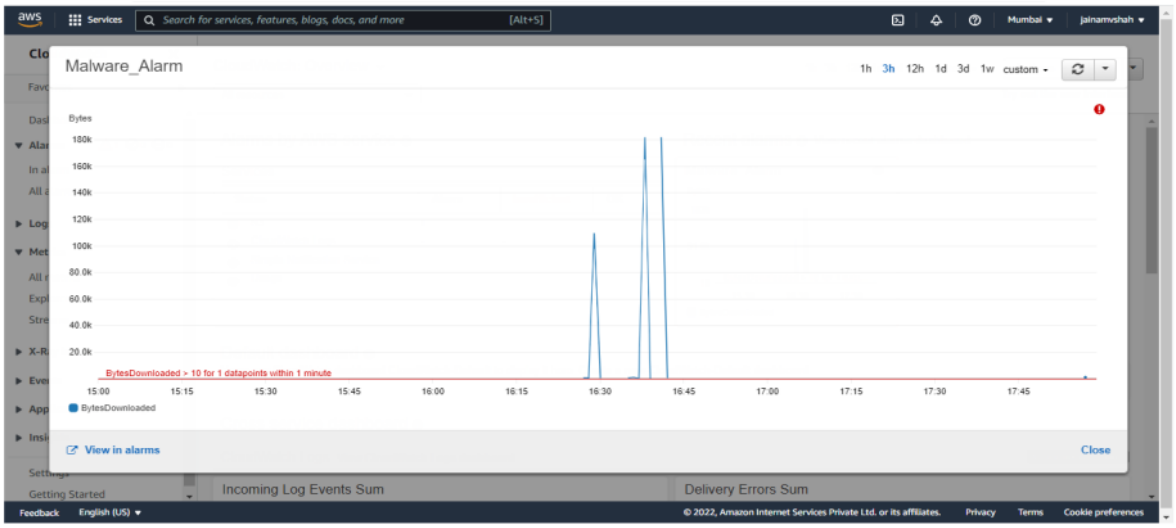


Figure 6.16 Malware Alarm

4. Implementing Data Monitoring using SNS

Amazon Simple Notification Service (Amazon SNS) is a fully managed messaging service for both application-to-application (A2A) and application-to-person (A2P) communication.

Through SNS we can monitor AWS services and it provides notification whenever there is a change happening in any respective service within respective AWS account.

For the purpose of this project an SNS Topic is created as follows on AWS CloudTrail to monitor data logging taking place within S3 Bucket.

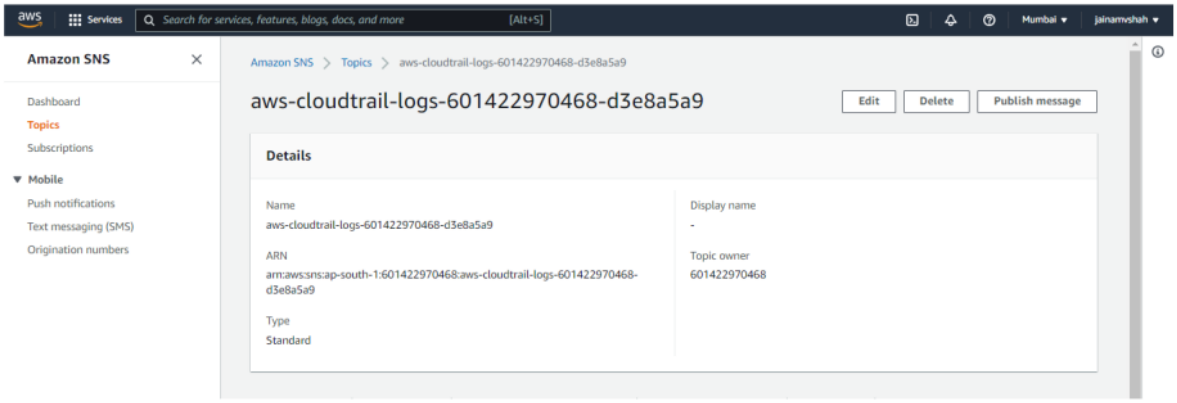


Figure 6.17 SNS Topic

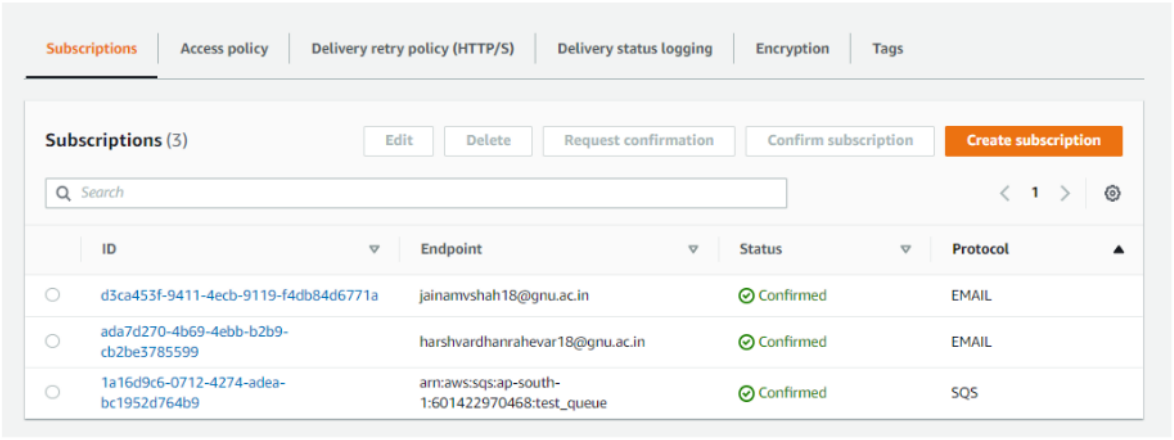


Figure 6.18 SNS Notification Subscriptions

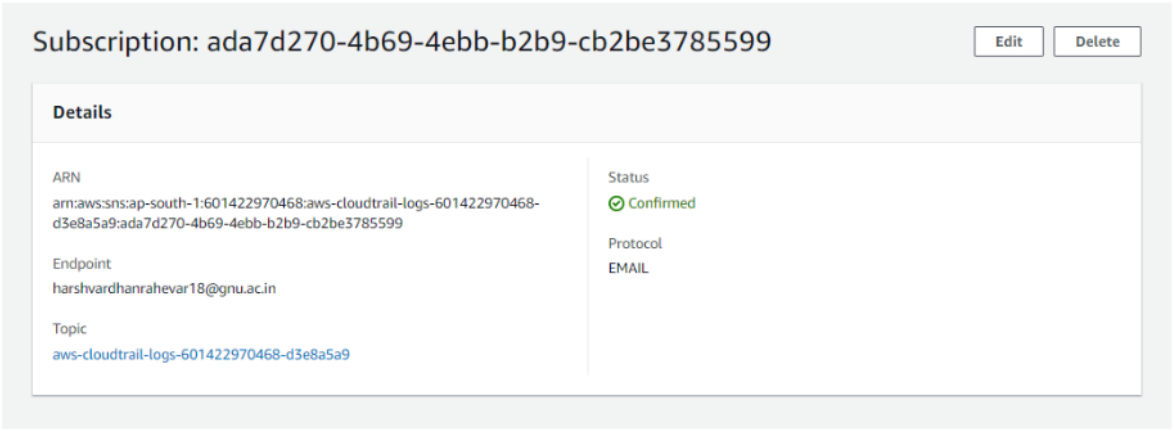


Figure 6.19.1 Subscription details of 1st Endpoint

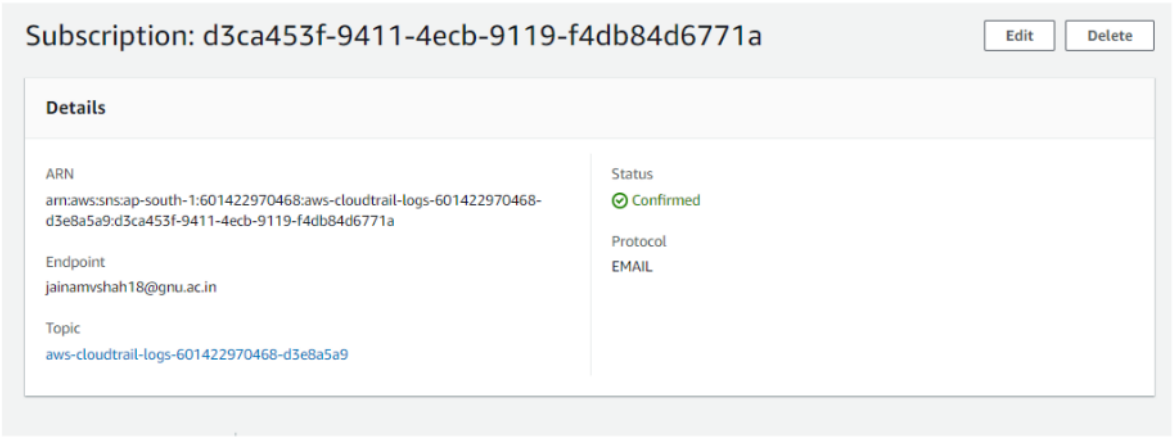


Figure 6.19.2 Subscription details of 2nd Endpoint

In order to subscribe properly with the created trail from AWS CloudTrail the following script is written for S3 bucket.

Missing "," ETS

```
{
  "Version": "2012-10-17",
  "Statement": [
    {
      "Sid": "AWSCloudTrailAclCheck20150319",
      "Effect": "Allow",
      "Principal": {
        "Service": "cloudtrail.amazonaws.com"
      },
      "Action": "s3:GetBucketAcl",
      "Resource": "arn:aws:s3:::demo211"
    },
    {
      "Sid": "AWSCloudTrailWrite20150319",
      "Effect": "Allow",
      "Principal": {
```

```
            "Service": "cloudtrail.amazonaws.com"
        },
        "Action": "s3:PutObject",
        "Resource": "arn:aws:s3:::demo211/AWSLogs/601422970468/*",
        "Condition": {
            "StringEquals": {
                "AWS:SourceArn": "arn:aws:cloudtrail:ap-south-1:601422970468:trail/demo2.1",
                "s3:x-amz-acl": "bucket-owner-full-control"
            }
        }
    }
  ]
}
```

The above-mentioned script validates the destination configuration in accordance to API Response and provides SNS Notification to the respective subscription without any delay and in a timely manner.

6.3.5 Generating data logs from AWS CloudTrail

In AWS, the CloudTrail service is utilized to track account activity and API calls, as most cloud providers offer their services via APIs this is a very important service. These feeds from CloudTrail can also be integrated with AWS CloudWatch in order to create metrics for employing alarms for any suspicious account's behavior or any miscellaneous misuse.

For fulfilling the purpose of generating data logs, in CloudTrail ongoing delivery of events is enabled as log files to an Amazon S3 bucket. Then the logs are and API Calls are received from CloudTrail Event history. For the sake of monitoring the activity on S3 service a trail is created on an existing S3 bucket and SNS subscription can also be enabled to keep track of how many logs and events are generated every hour in a S3 bucket.

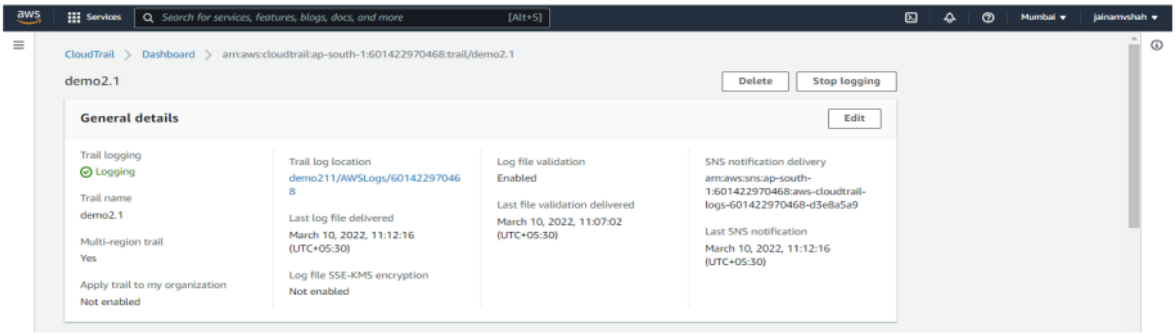


Figure 6.20 CloudTrail Details

After generating the trail, a folder is created within the S3 bucket called AWSLogs/ which stores all the log files containing activities within S3 in json.gz format.

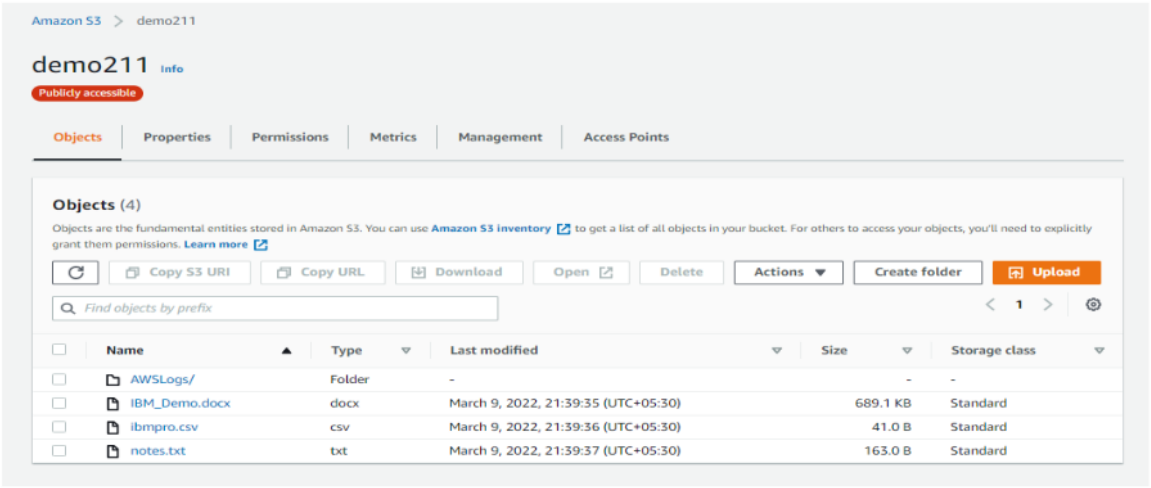


Figure 6.21 S3 Bucket with CloudTrail Logs

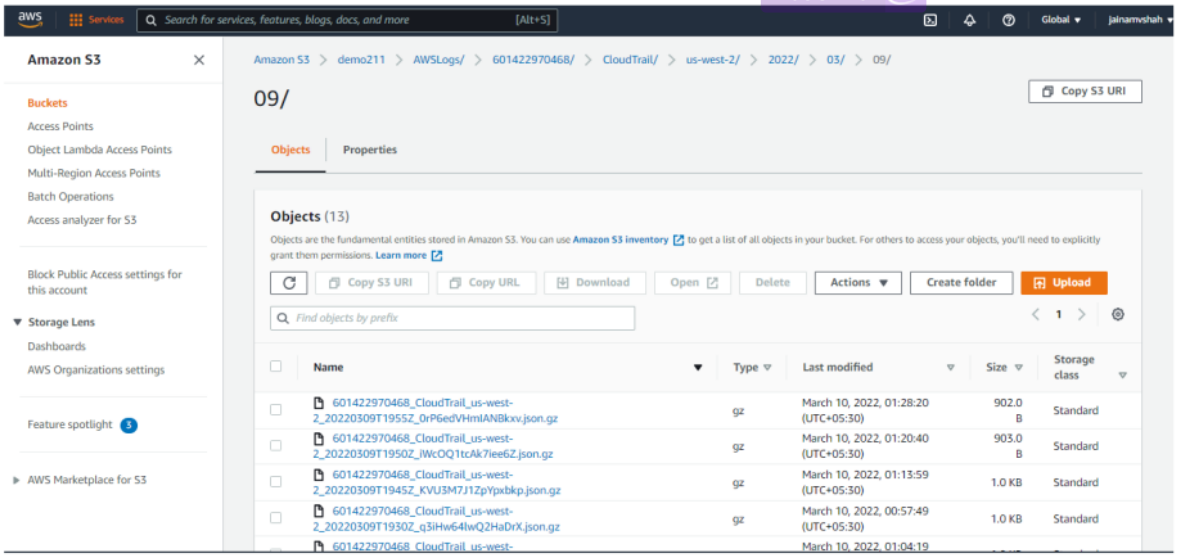


Figure 6.22 Data Log Files

CloudTrail provides detailed log data. It provides the following results: -

- Detect any third-party AWS console logins from unknown places or countries.
- In most cases, companies/organizations do transfer logs to their own data center for long term storage, it's crucial to generate the logs in a text-like format such as JSON, for better understanding of complex data, from a test, notice AWS uses this concept in their generated logs and flows.
- Anchorage the storage API i.e. s3 API to import cloud trails to a search and arranging platform or security management systems like (SIEM solution) for creating more secured and robust use cases monitoring.

6.3.6 Integrating AWS CloudTrail with Splunk

In order to have clear understanding of the logs and perform proper forensic analysis there is a must need of escorting cloud logs into a single point where they can be combined with on premises security events, thus enabling the investigator to have a single view of screen from which he/she can monitor the whole security strata.

To achieve this purpose Splunk has been utilized and configured to receive the AWS CloudTrail data logs which configured earlier to monitor different services of AWS account and its resources.

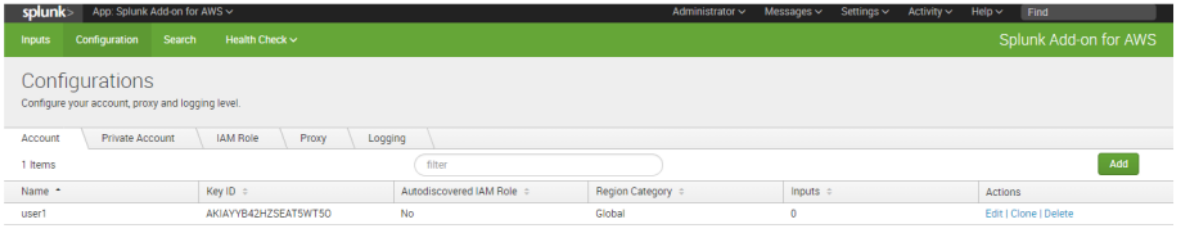


Figure 6.23 AWS Account Connection

First AWS Root account is connected and then input of CloudTrail is integrated with Splunk so the logs generated by AWS CloudTrail can be tracked from Splunk as follows:-

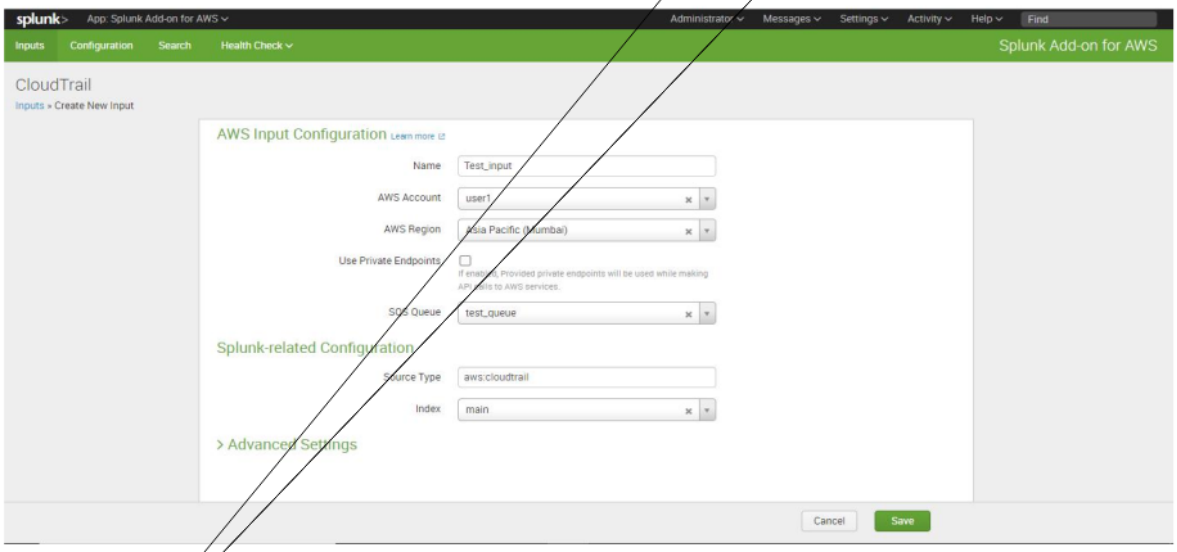


Figure 6.24 Source Input for Splunk

Figure 6.21 shows an input will be created for AWS CloudTrail to manage the logs generated by it and provide detailed information and analysis based on the fields selected in the IAM policy for Splunk Add-on.

P/V ETS

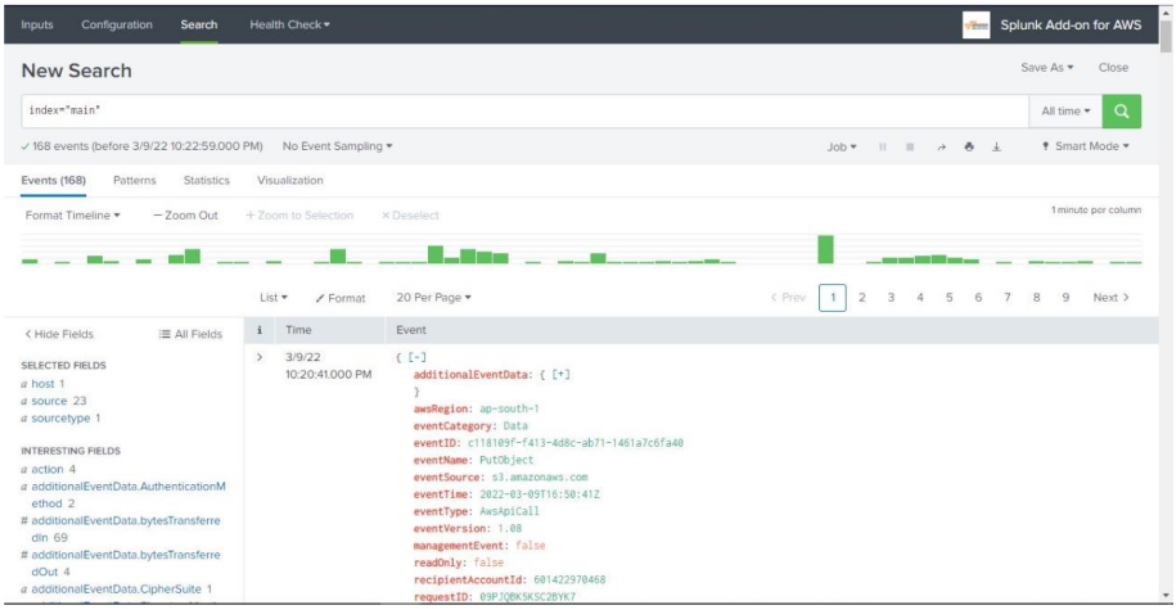


Figure 6.25 CloudTrail Logs Analysis

In order to provide the analysis based on the logs generated in the respective fields an IAM Policy called "Splunk Add-On" was created earlier by building a JSON script and integrated with respective AWS CloudTrail Trail and AWS account, a glimpse of the created JSON Script is as follows: -


```
{
    "Version": "2012-10-17",
    "Statement": [
        {
            "Sid": "VisualEditor0",
            "Effect": "Allow",
            "Action": [
                "config:GetComplianceSummaryByConfigRule",
                "sqs:DeleteMessage",
                "iam:GetAccountPasswordPolicy",
                "s3:GetLifecycleConfiguration",
                "s3:GetBucketTagging",
                "ec2:DescribeInstances",
                "ec2:DescribeAddresses",
                "s3:GetBucketLogging",
                "s3:PutBucketOwnershipControls",
                "ec2:DescribeRegions",
                "sqs:ReceiveMessage",
                "s3:GetAccelerateConfiguration",
                "ec2:DescribeSnapshots",
                "elasticloadbalancing:DescribeLoadBalancers",
```

Figure 6.26 JSON Script

The above-mentioned script provides details of all CloudTrail, EC2 and S3 services and integrates with Splunk as soon as one connects his/her account and provides analysis based on that.

Furthermore, an SQS (Simple Queue Service) service is also used to align the above given services in a queue so they can be tracked easily and if there is any change or discrepancy during adding, updating or deleting a file within a S3 bucket, an SNS (Simple Notification Service) will be sent to the respective cloud account to check any changes have occurred or not.

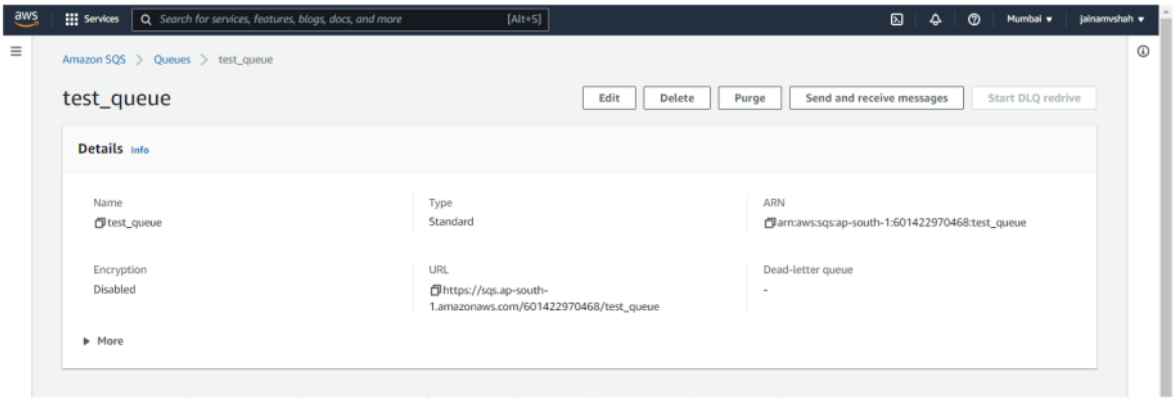


Figure 6.27 SQS Service

6.3.7 Forensic Analysis After Malware Attack

After performing a malware attack as shown above in 6.3.4 section a number of parameters can be considered to take account of from Splunk as they provide certain insights of the activities taking place within the S3 bucket.

Splunk provides a feature to export the results from CloudTrail logs in the form of a csv file as shown below.

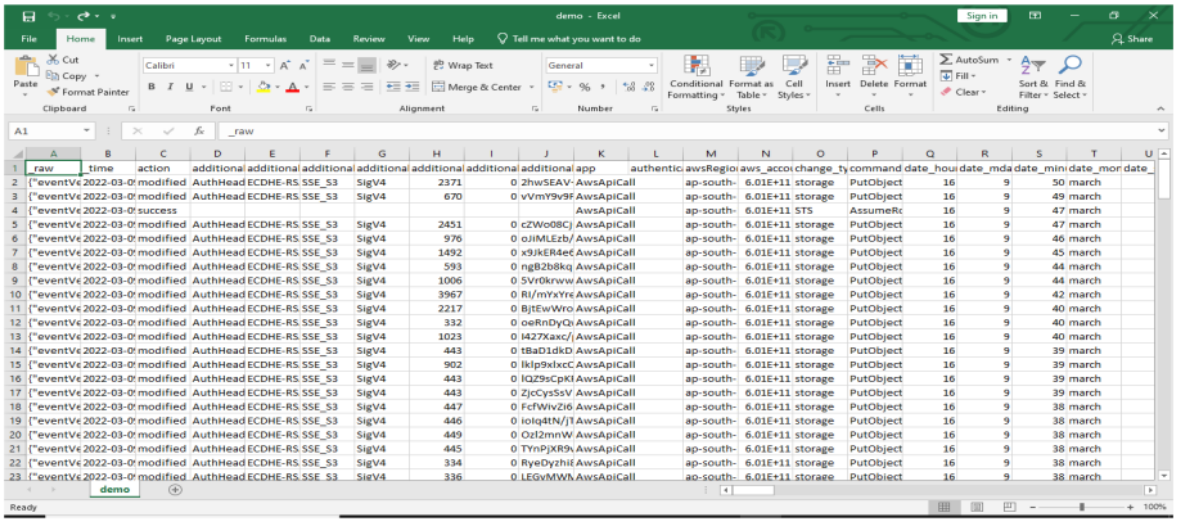


Figure 6.28 Results File

As shown above there is a csv file generated which contains certain important fields showing the activities performed within the S3. For example: -

Column B-time – shows the time at which a certain activity was performed within S3

Column C-action – shows which activity was performed like what was modified, deleted or was it done successfully or not.

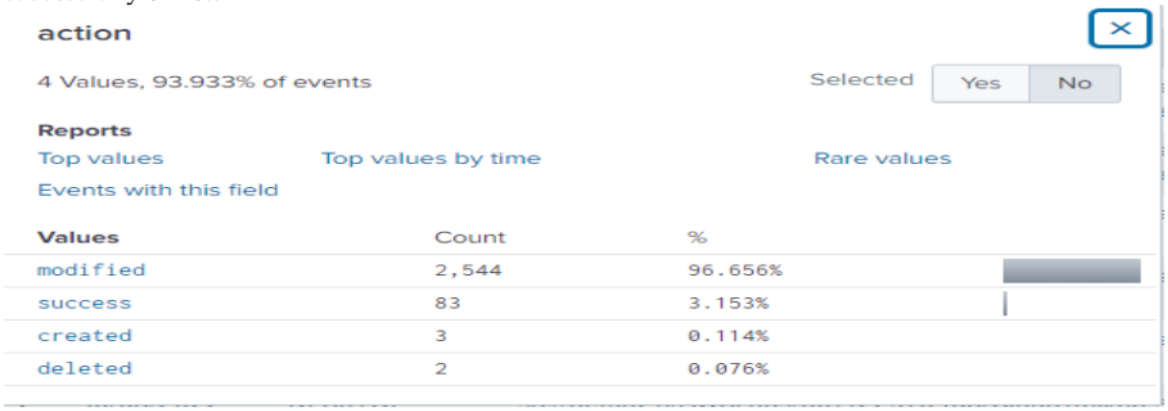


Figure 6.29 Action Field

Column P-command – this column shows what kind of command was executed within the bucket like PutObject, HeadObject, SetTopic, LookUpEvent etc.

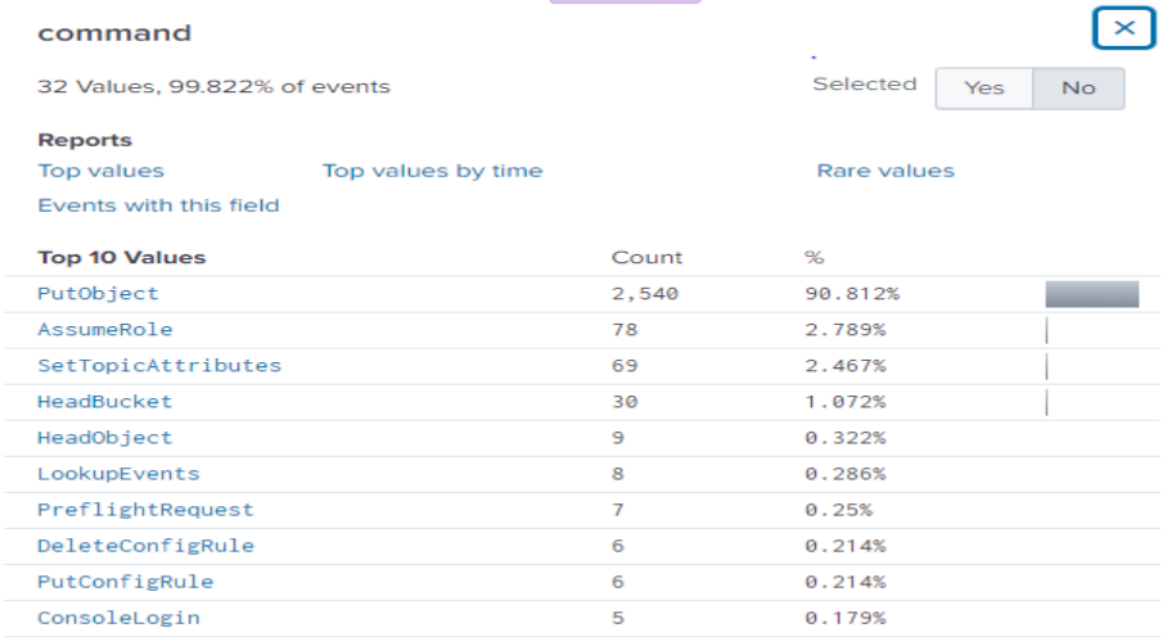


Figure 6.30 Command Field

Column AE-errorcode – shows whether the command was successful or access was denied.

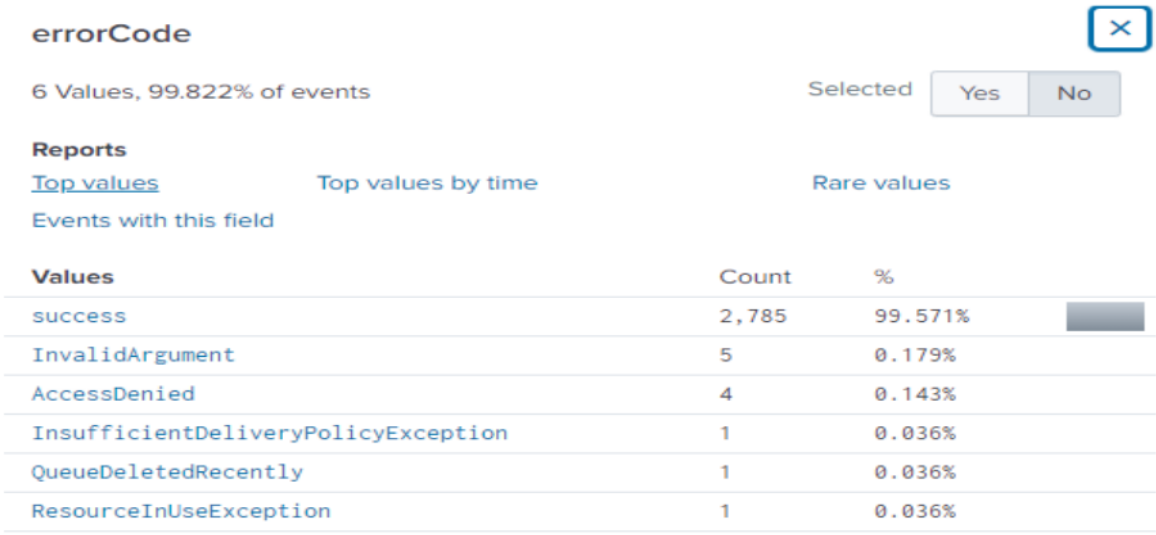
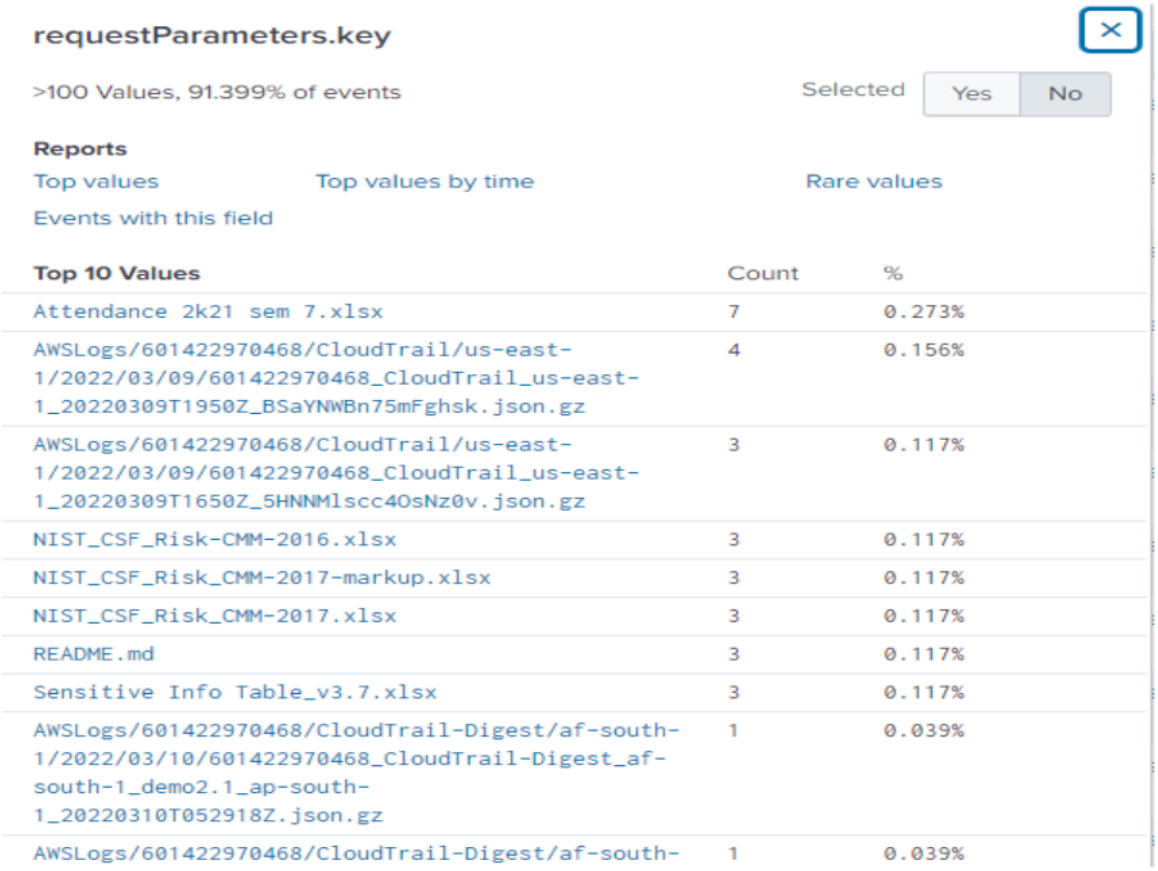


Figure 6.31 ErrorCode Field

Column AO -Host – this column shows from where was the above-mentioned commands were carried out on a respective bucket.

Figure 6.32 Host Field

Column CT – requestparameterkey – shows the name of files which are being uploaded within the respective S3 Bucket.



requestParameters.key

>100 Values, 91.399% of events

Selected Yes No

Reports

Top values Top values by time Rare values

Events with this field

Top 10 Values	Count	%
Attendance 2k21 sem 7.xlsx	7	0.273%
AWSLogs/601422970468/CloudTrail/us-east-1/2022/03/09/601422970468_CloudTrail_us-east-1_20220309T1950Z_BSaYNWBn75mFghsk.json.gz	4	0.156%
AWSLogs/601422970468/CloudTrail/us-east-1/2022/03/09/601422970468_CloudTrail_us-east-1_20220309T1650Z_5HNNMlscc4OsNz0v.json.gz	3	0.117%
NIST_CSF_Risk-CMM-2016.xlsx	3	0.117%
NIST_CSF_Risk_CMM-2017-markup.xlsx	3	0.117%
NIST_CSF_Risk_CMM-2017.xlsx	3	0.117%
README.md	3	0.117%
Sensitive Info Table_v3.7.xlsx	3	0.117%
AWSLogs/601422970468/CloudTrail-Digest/af-south-1/2022/03/10/601422970468_CloudTrail-Digest_af-south-1_demo2.1_ap-south-1_20220310T052918Z.json.gz	1	0.039%
AWSLogs/601422970468/CloudTrail-Digest/af-south-	1	0.039%

Figure 6.33 RequestParameterKey Field

6.4 Forensic Analysis in IaaS Cloud

Making use of cloud forensics to help organization in strengthening their incident response and threat detection capabilities, organizations must have proper forensics investigation tools to keep their cloud infrastructure secured in case of an attack, recognizing the signs of vulnerability as well as quickly locate an infection and its objectives before they have an impact on the organizations' important data.

If there is a case of a hacked virtual machine, most users terminate the virtual machine (VM), erasing all proof in the process. It would become very challenging to perform forensic analysis in such cases. Until now, there have been few tools and applications which monitor the system properly and gather data. When it comes to gathering and analyzing evidence, must look for the following:

- Network packet captures for forensics.
- Memory usage for a particular instance.
- Events and data logs

In order to provision a machine for forensic analysis, installing necessary forensic investigation tools is necessary in order to get insights. In order to implement this a package called SIFT has been utilized which provides access to most of the forensics tools from one executable package. The forensic machine for this mentioned scenario has been prepared in the following manner.

An EC2 instance called “cloudreasearch-instance” is created and then after logging into it by doing SSH SIFT investigation tools are downloaded with the following commands.

```
ubuntu@ip-172-31-5-38:~$ sudo curl -Lo /usr/local/bin/sift https://github.com/sans-dfir/sift-cli/releases/download/v1.14.0-rc1/sift-cli-linux
  % Total    % Received % Xferd  Average Speed   Time    Time     Time  Current
                                 Dload  Upload   Total   Spent    Left  Speed
100   147  100   147    0     0    630      0 --:--:-- --:--:-- --:--:--   630
100   651  100   651    0     0   1299      0 --:--:-- --:--:-- --:--:--  1299
100 55.0M  100 55.0M    0     0  9211k      0  0:00:06  0:00:06 --:--:-- 9942k
ubuntu@ip-172-31-5-38:~$ sudo chmod 755 /usr/local/bin/sift
ubuntu@ip-172-31-5-38:~$ sudo sift install
> sift-cli@1.14.0-rc1+0-g0582d2b
> sift-version: notinstalled
```

Figure 6.34 SIFT Installation

After installing SIFT tools a snapshot is created for the instance to perform forensic analysis on it. After creating snapshot, a volume is created from that snapshot and then attached to the earlier created EC2 instance.

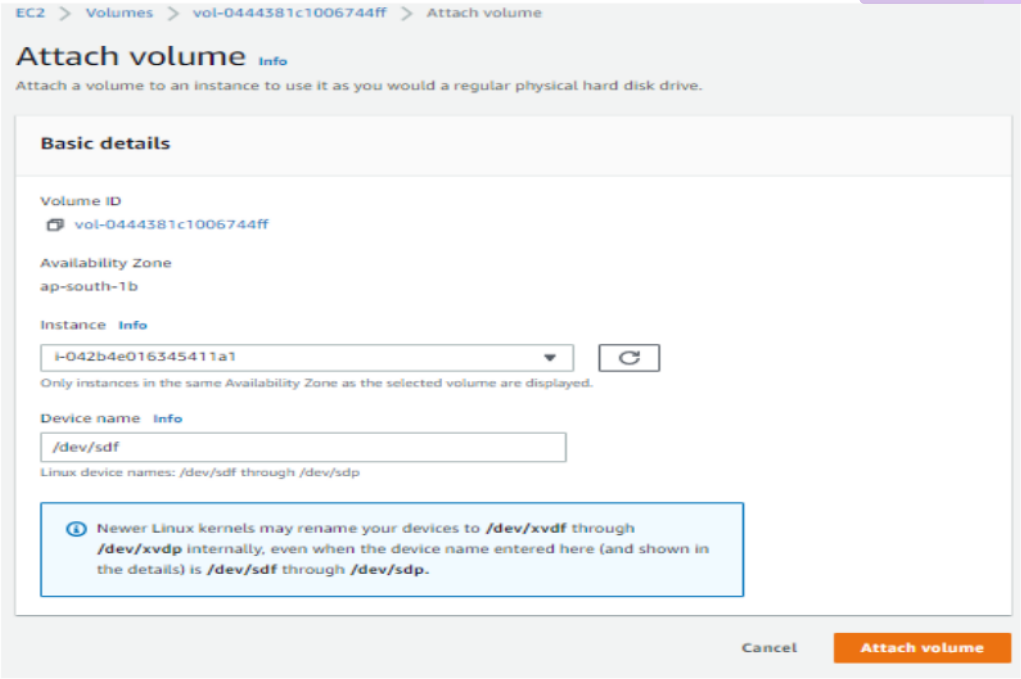


Figure 6.35 Attaching evidence volume to SIFT Workstation

Verifying evidence attached to a device using lsblk command.

```
ubuntu@ip-172-31-5-38:~$ sudo lsblk
NAME    MAJ:MIN RM  SIZE RO TYPE MOUNTPOINT
loop0     7:0    0 42.2M  1 loop /snap/snapd/14066
loop1     7:1    0 55.5M  1 loop /snap/core18/2253
loop2     7:2    0   25M  1 loop /snap/amazon-ssm-agent/4046
xvda    202:0    0   30G  0 disk
└─xvda1 202:1    0   30G  0 part /
xvdf    202:80   0   30G  0 disk
└─xvdf1 202:81   0   30G  0 part
```

Figure 6.36 Evidence Attached Verification

Using the file command to determine the format of the partition as shown below and also a directory has been made to mount the evidentiary Linux file system as read-only:

```
ubuntu@ip-172-31-5-38:~$ sudo file -s /dev/xvdf1
/dev/xvdf1: Linux rev 1.0 ext4 filesystem data, UUID=c1ce24a2-4987-4450-ae15-62eb028ff1cd, volume name "cloudimg-rootfs" (needs journal recovery)
extents) (64bit) (large files) (huge files)
ubuntu@ip-172-31-5-38:~$ sudo mkdir /mnt/linux_mount
ubuntu@ip-172-31-5-38:~$ mount -o ro /dev/xvdf1 /mnt/linux_mount/
mount: only root can use "--options" option
ubuntu@ip-172-31-5-38:~$ sudo mount -o ro /dev/xvdf1 /mnt/linux_mount/
ubuntu@ip-172-31-5-38:~$ sudo mount | grep "/mnt"
/dev/xvdf1 on /mnt/linux_mount type ext4 (ro,relatime)
```

Figure 6.37 Mounting evidentiary file on the system

Verifying the mounted data.

```
ubuntu@ip-172-31-5-38:~$ sudo ls -als /mnt/linux_mount/
total 124
 4 drwxr-xr-x  24 root   root  4096 Apr  4 06:52 .
 4 drwxr-xr-x  18 root   root  4096 Apr  4 07:11 ..
 4 drwxr-xr-x   2 root   root  4096 Apr  4 06:41 bin
 4 drwxr-xr-x   3 root   root  4096 Apr  4 06:49 boot
 4 drwxrwxr-x   2 ubuntu root  4096 Apr  4 06:52 cases
 4 drwxr-xr-x   4 root   root  4096 Nov 29 17:32 dev
12 drwxr-xr-x 155 root   root 12288 Apr  4 06:54 etc
 4 drwxr-xr-x   3 root   root  4096 Apr  4 06:10 home
 0 lrwxrwxrwx   1 root   root    30 Nov 29 17:39 initrd.img -> boot/initrd.img-5.4.0-1060-aws
 0 lrwxrwxrwx   1 root   root    30 Nov 29 17:39 initrd.img.old -> boot/initrd.img-5.4.0-1060-aws
 4 drwxr-xr-x  22 root   root  4096 Apr  4 06:16 lib
 4 drwxr-xr-x   2 root   root  4096 Apr  4 06:16 lib64
16 drwx------   2 root   root 16384 Nov 29 17:34 lost+found
 4 drwxr-xr-x   2 root   root  4096 Nov 29 17:27 media
 4 drwxr-xr-x  17 root   root  4096 Apr  4 06:52 mnt
 4 drwxr-xr-x   4 root   root  4096 Apr  4 06:36 opt
 4 drwxr-xr-x   2 root   root  4096 Apr 24  2018 proc
 4 drwx------   5 root   root  4096 Apr  4 06:52 root
 4 drwxr-xr-x   5 root   root  4096 Nov 29 17:39 run
12 drwxr-xr-x   2 root   root 12288 Apr  4 06:48 sbin
 4 drwxr-xr-x   6 root   root  4096 Apr  4 06:10 snap
 4 drwxr-xr-x   2 root   root  4096 Nov 29 17:27 srv
 4 drwxr-xr-x   2 root   root  4096 Apr 24  2018 sys
 4 drwxrwxrwt  18 root   root  4096 Apr  4 06:56 tmp
 4 drwxr-xr-x  12 root   root  4096 Apr  4 06:18 usr
 4 drwxr-xr-x  14 root   root  4096 Apr  4 06:14 var
 0 lrwxrwxrwx   1 root   root    27 Nov 29 17:39 vmlinuz -> boot/vmlinuz-5.4.0-1060-aws
 0 lrwxrwxrwx   1 root   root    27 Nov 29 17:39 vmlinuz.old -> boot/vmlinuz-5.4.0-1060-aws
```

Figure 6.38 Listing data of mounted directory

After the evidence is attached to the SIFT Workstation, the initial step is to chisel data from the unallocated space and segregate out the files that are known to be good.

Another EC2 Instance is launched and based on the AMI and another snapshot is created and a volume is attached from the snapshot in the same availability zone as the SIFT Workstation. A different name called "HASH-BASELINE" for both the snapshot and the volume is assigned so that it is easy to differentiate these objects and the SIFT Workstation itself. Using the same steps as above the volume is attached and mounted as the 3rd volume on the SIFT Workstation which is named as /mnt/linux_base.

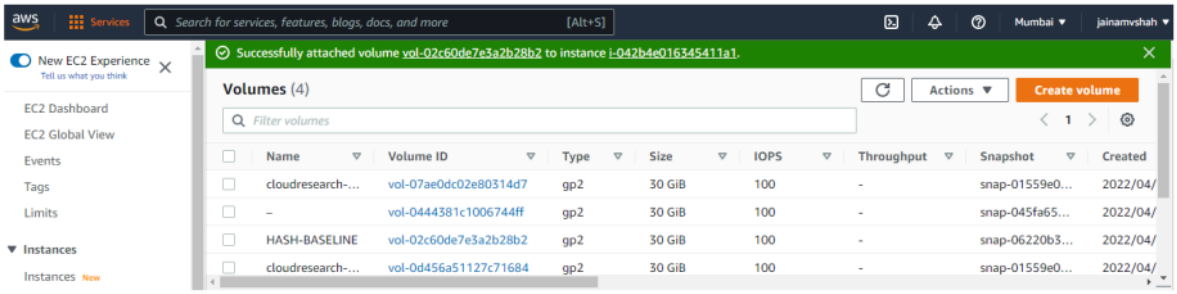


Figure 6.39 Newly Attached Volume to the instance

```
ubuntu@ip-172-31-5-38:~$ sudo mkdir /mnt/linux_base
ubuntu@ip-172-31-5-38:~$ sudo mount -o ro /dev/xvdg1 /mnt/linux_base/
ubuntu@ip-172-31-5-38:~$ sudo lsblk
NAME    MAJ:MIN RM   SIZE RO TYPE MOUNTPOINT
loop0     7:0    0 42.2M  1 loop /snap/snapd/14066
loop1     7:1    0 55.5M  1 loop /snap/core18/2253
loop2     7:2    0   25M  1 loop /snap/amazon-ssm-agent/4046
xvda    202:0    0   30G  0 disk
└─xvda1 202:1    0   30G  0 part /
xvdf    202:80   0   30G  0 disk
└─xvdf1 202:81   0   30G  0 part /mnt/linux_mount
xvdg    202:96   0   30G  0 disk
└─xvdg1 202:97   0   30G  0 part /mnt/linux_base
ubuntu@ip-172-31-5-38:~$
```

Figure 6.40 Attaching and verifying additional mounted volume on SIFT Workstation

A hash database of all files on the reference volume is created using hfind which is called "known_files.md5" and in order to identify which files are new or modified an another hast list of files is created for the volume under investigation, this is called "investigate_files.md5" and with that list an names additional list of files that are new or changed are stored in "changed_files.txt".

Then in order to search for known indicators of compromise for the server instance an IOC scanner called "Loki" is installed which detects indicators of compromise Detection is based on four detection methods:

- File Names of IOC- which matches regular expressions of file names
- Yara Rule Check-matches signature of data and processes memory
- Hash Check – it compares harmful hashes like MD5, SHA1, SHA256 with scanned files

The following results were obtained when Loki detected indicators of compromise.

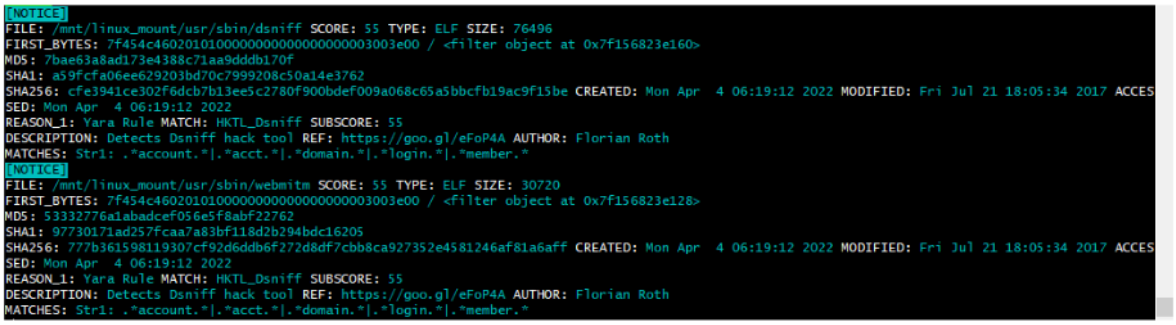


Figure 6.41 Notice for indicators of compromise

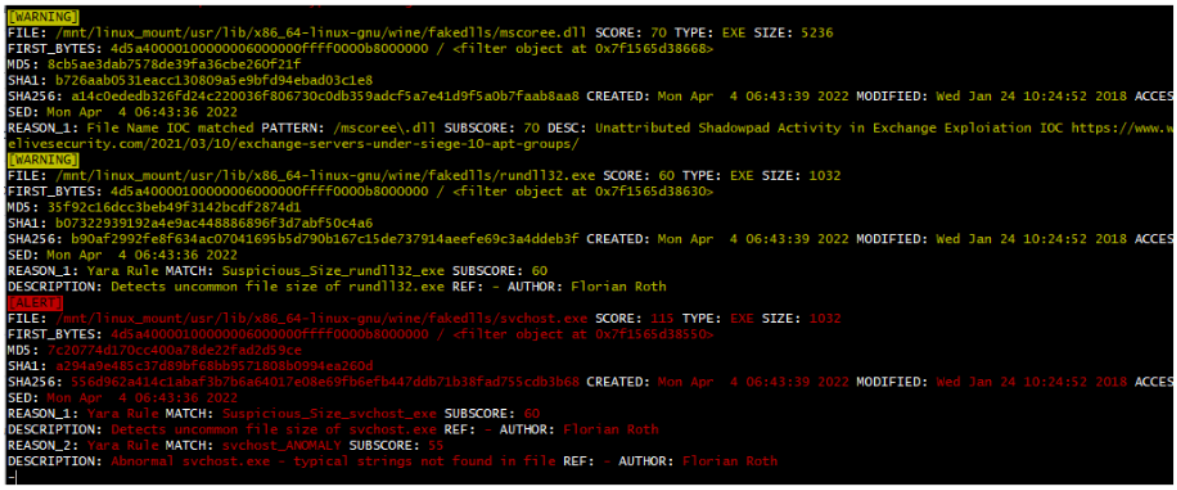


Figure 6.42 Warnings and Alerts for Compromise of Indicators 1

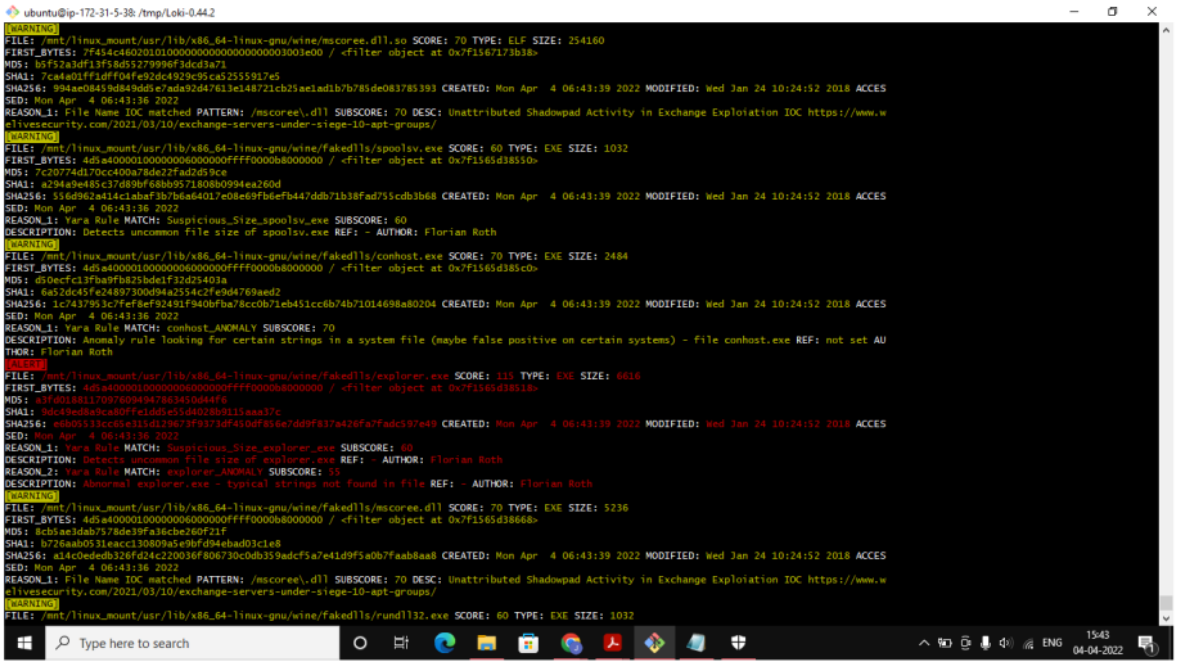


Figure 6.43 Warnings and Alerts for Compromise of Indicators 2

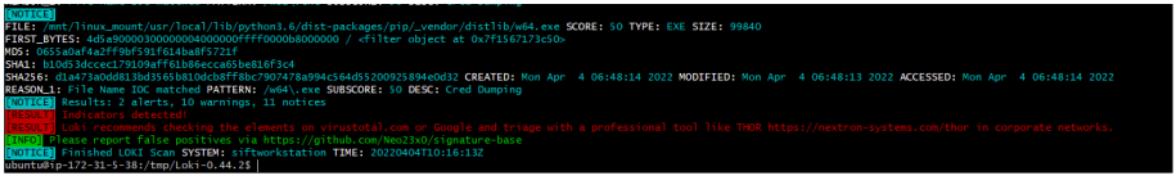


Figure 6.44 Final Results of Loki

6.4.1 Additional Forensic Analysis

Some malware or anomaly makes use of the start-up scripts that are initiated when the system is started and runs at boot time. On some distributions, these are found in /etc/init.d, but on Amazon Linux and Red Hat variants, the scripts will be in /etc/rc*.d.

```
ubuntu@ip-172-31-5-38:~$ ls -als -t /mnt/linux_mount/etc/rc*.d/
/mnt/linux_mount/etc/rc0.d/:
total 16
12 drwxr-xr-x 155 root root 12288 Apr  4 06:54 ..
 4 drwxr-xr-x   2 root root  4096 Apr  4 06:43 .
 0 lrwxrwxrwx   1 root root    17 Apr  4 06:43 K01winbind -> ../init.d/winbind
 0 lrwxrwxrwx   1 root root    15 Apr  4 06:42 K01saned -> ../init.d/saned
 0 lrwxrwxrwx   1 root root    22 Apr  4 06:42 K01avahi-daemon -> ../init.d/avahi-daemon
 0 lrwxrwxrwx   1 root root    19 Apr  4 06:42 K01bluetooth -> ../init.d/bluetooth
 0 lrwxrwxrwx   1 root root    18 Apr  4 06:40 K01stunnel4 -> ../init.d/stunnel4
 0 lrwxrwxrwx   1 root root    21 Apr  4 06:39 K01samba-ad-dc -> ../init.d/samba-ad-dc
 0 lrwxrwxrwx   1 root root    14 Apr  4 06:39 K01nmbd -> ../init.d/nmbd
 0 lrwxrwxrwx   1 root root    14 Apr  4 06:39 K01smbd -> ../init.d/smbd
 0 lrwxrwxrwx   1 root root    27 Apr  4 06:35 K01speech-dispatcher -> ../init.d/speech-dispatcher
 0 lrwxrwxrwx   1 root root    16 Apr  4 06:32 K01nfdump -> ../init.d/nfdump
 0 lrwxrwxrwx   1 root root    20 Apr  4 06:32 K01nbd-client -> ../init.d/nbd-client
 0 lrwxrwxrwx   1 root root    16 Apr  4 06:18 K01docker -> ../init.d/docker
 0 lrwxrwxrwx   1 root root    26 Apr  4 06:17 K01clamav-freshclam -> ../init.d/clamav-freshclam
 0 lrwxrwxrwx   1 root root    29 Apr  4 06:14 K01apache-htcacheclean -> ../init.d/apache-htcacheclean
 0 lrwxrwxrwx   1 root root    17 Apr  4 06:14 K01apache2 -> ../init.d/apache2
 0 lrwxrwxrwx   1 root root    23 Nov 29 17:31 K01lvm2-lvmpolld -> ../init.d/lvm2-lvmpolld
 0 lrwxrwxrwx   1 root root    22 Nov 29 17:31 K01lvm2-lvmetad -> ../init.d/lvm2-lvmetad
 0 lrwxrwxrwx   1 root root    13 Nov 29 17:31 K01lxd -> ../init.d/lxd
 0 lrwxrwxrwx   1 root root    23 Nov 29 17:31 K01open-vm-tools -> ../init.d/open-vm-tools
 0 lrwxrwxrwx   1 root root    18 Nov 29 17:31 K01plymouth -> ../init.d/plymouth
 0 lrwxrwxrwx   1 root root    20 Nov 29 17:31 K01cryptdisks -> ../init.d/cryptdisks
 0 lrwxrwxrwx   1 root root    26 Nov 29 17:31 K01cryptdisks-early -> ../init.d/cryptdisks-early
 0 lrwxrwxrwx   1 root root    20 Nov 29 17:31 K01irqbalance -> ../init.d/irqbalance
 0 lrwxrwxrwx   1 root root    15 Nov 29 17:31 K01lxcfs -> ../init.d/lxcfs
 0 lrwxrwxrwx   1 root root    29 Nov 29 17:31 K01unattended-upgrades -> ../init.d/unattended-upgrades
 0 lrwxrwxrwx   1 root root    18 Nov 29 17:31 K01ebtables -> ../init.d/ebtables
 0 lrwxrwxrwx   1 root root    15 Nov 29 17:31 K01uuidd -> ../init.d/uuidd
 0 lrwxrwxrwx   1 root root    15 Nov 29 17:31 K01mdadm -> ../init.d/mdadm
 0 lrwxrwxrwx   1 root root    24 Nov 29 17:31 K01mdadm-waitidle -> ../init.d/mdadm-waitidle
 0 lrwxrwxrwx   1 root root    20 Nov 29 17:31 K01open-iscsi -> ../init.d/open-iscsi
 0 lrwxrwxrwx   1 root root    16 Nov 29 17:31 K01iscsid -> ../init.d/iscsid
 0 lrwxrwxrwx   1 root root    13 Nov 29 17:31 K01atd -> ../init.d/atd
 0 lrwxrwxrwx   1 root root    17 Nov 29 17:27 K01rsyslog -> ../init.d/rsyslog
```

Figure 6.45 Startup Scripts

Looking for unusual files can be a hectic task, so in order to make it easy a security expert looks for SUID and SGID files (SUID Files - SUID is a special file permission for executable files which enables other users to run the file with effective permissions of the file owner while SGID Files - SGID is a special file permission that also applies to executable files and enables other users to inherit the effective GID of file group owner).The following commands perform the comparison on mounted volume for evidence capturing.

Figure 6.46 Commands to look for unusual files

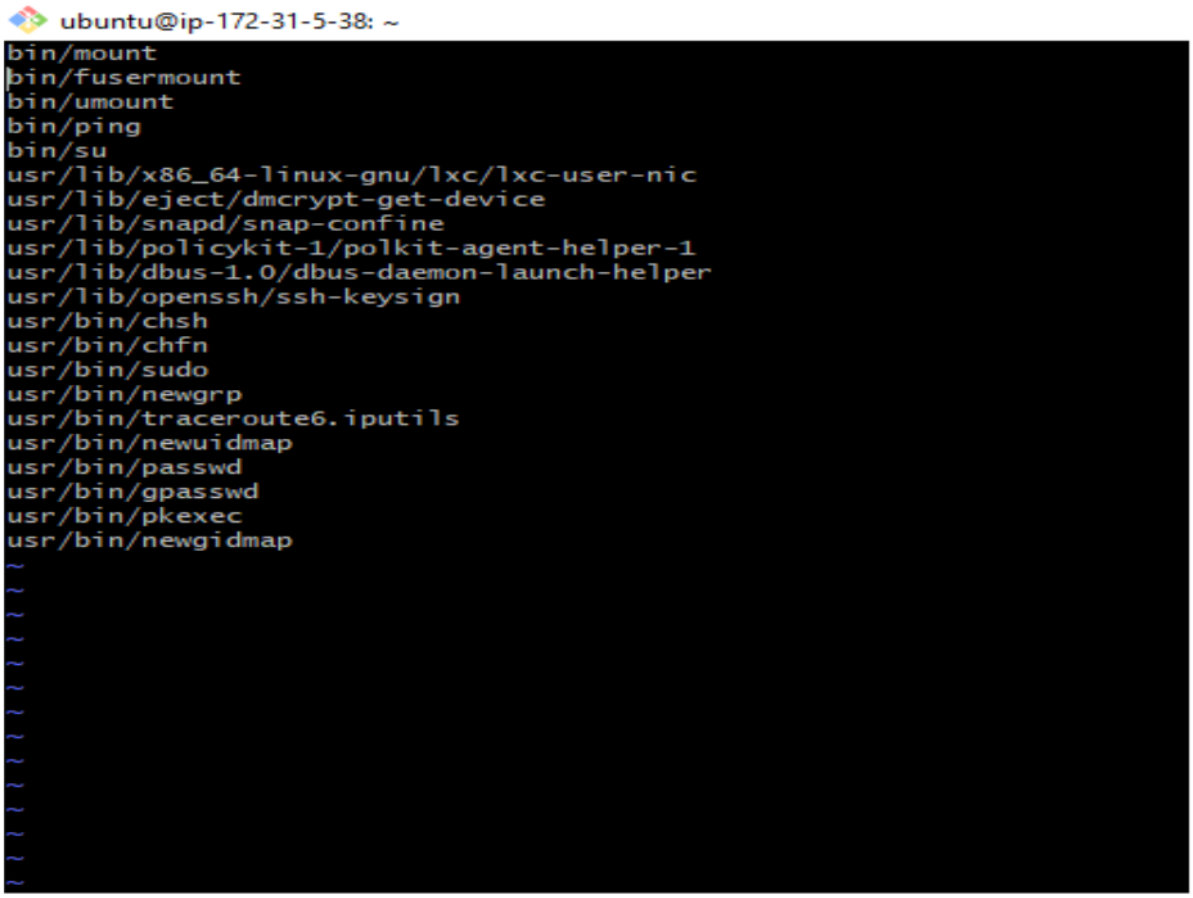


Figure 6.47 List of Unusual files

In order to look for files with high entropy there is a tool in SIFT called DensityScout which detects packing, compression, and encrypted files that exceed a "density" threshold. The following commands are implemented in order to find such files which exceed the threshold.

```
ubuntu@ip-172-31-5-38:~$ sudo densityscout -r -p 0.1 -l 0.1 -o high_density_evidence.txt /mnt/linux_mount/

DensityScout (Build 45)

by Christian Wojner

Calculating density for file ...
(0.08665) | /mnt/linux_mount/usr/share/man/man1/gawk.1.gz
(0.04133) | /mnt/linux_mount/usr/share/man/man1/x86_64-linux-gnu-gcc-7.1.gz
(0.07464) | /mnt/linux_mount/usr/share/man/man1/wget.1.gz
(0.08366) | /mnt/linux_mount/usr/share/man/man1/socat.1.gz
(0.05668) | /mnt/linux_mount/usr/share/man/man1/xterm.1.gz
(0.09947) | /mnt/linux_mount/usr/share/man/man1/less.1.gz
(0.09091) | /mnt/linux_mount/usr/share/man/man1/sh.distrib.1.gz
(0.09165) | /mnt/linux_mount/usr/share/man/man1/keytool.1.gz
(0.04133) | /mnt/linux_mount/usr/share/man/man1/g++-7.1.gz
(0.09927) | /mnt/linux_mount/usr/share/man/man1/git-fast-import.1.gz
(0.04133) | /mnt/linux_mount/usr/share/man/man1/g++.1.gz
(0.07959) | /mnt/linux_mount/usr/share/man/man1/x86_64-linux-gnu-ld.bfd.1.gz
(0.07728) | /mnt/linux_mount/usr/share/man/man1/gpg.1.gz
(0.09091) | /mnt/linux_mount/usr/share/man/man1/sh.1.gz
(0.07959) | /mnt/linux_mount/usr/share/man/man1/ld.1.gz
(0.08236) | /mnt/linux_mount/usr/share/man/man1/git-log.1.gz
(0.05229) | /mnt/linux_mount/usr/share/man/man1/bash.1.gz
(0.08055) | /mnt/linux_mount/usr/share/man/man1/cli.1.gz
```

Figure 6.48 High Entropy files in /mnt/linux_mount (Volume where SIFT is installed)

```
ubuntu@ip-172-31-5-38:~$ sudo densityscout -r -p 0.1 -l 0.1 -o high_density_base.txt /mnt/linux_base/

DensityScout (Build 45)

by Christian Wojner

Calculating density for file ...
(0.08665) | /mnt/linux_base/usr/share/man/man1/gawk.1.gz
(0.07464) | /mnt/linux_base/usr/share/man/man1/wget.1.gz
(0.09947) | /mnt/linux_base/usr/share/man/man1/less.1.gz
(0.09091) | /mnt/linux_base/usr/share/man/man1/sh.distrib.1.gz
(0.09927) | /mnt/linux_base/usr/share/man/man1/git-fast-import.1.gz
(0.07728) | /mnt/linux_base/usr/share/man/man1/gpg.1.gz
(0.09091) | /mnt/linux_base/usr/share/man/man1/sh.1.gz
(0.08236) | /mnt/linux_base/usr/share/man/man1/git-log.1.gz
(0.05229) | /mnt/linux_base/usr/share/man/man1/bash.1.gz
(0.09974) | /mnt/linux_base/usr/share/man/man1/find.1.gz
(0.09947) | /mnt/linux_base/usr/share/man/man1/pager.1.gz
(0.09091) | /mnt/linux_base/usr/share/man/man1/dash.1.gz
(0.08665) | /mnt/linux_base/usr/share/man/man1/nawk.1.gz
(0.07303) | /mnt/linux_base/usr/share/man/man1/rsync.1.gz
(0.07669) | /mnt/linux_base/usr/share/man/man1/top.1.gz
(0.08718) | /mnt/linux_base/usr/share/man/man1/tmux.1.gz
(0.08665) | /mnt/linux_base/usr/share/man/man1/awk.1.gz
(0.06611) | /mnt/linux_base/usr/share/man/man1/screen.1.gz
(0.07075) | /mnt/linux_base/usr/share/man/man1/git-config.1.gz
(0.08041) | /mnt/linux_base/usr/share/man/man1/curl.1.gz
(0.07633) | /mnt/linux_base/usr/share/man/man1/busybox.1.gz
(0.07022) | /mnt/linux_base/usr/share/man/man3/pcrepattern.3.gz
(0.08504) | /mnt/linux_base/usr/share/man/es/man8/dnsmasq.8.gz
(0.09558) | /mnt/linux_base/usr/share/man/man7/systemd.directives.7.gz
(0.09402) | /mnt/linux_base/usr/share/man/man7/mdoc.samples.7.gz
```

Figure 6.49 High Entropy files in /mnt/linux_base (Additional mounted volume containing forensic evidence)

Clamscan is a malware scanner that comes loaded when we install SIFT Workstation on our instances, it is used to scan all data and infected files present on the system.

```
ubuntu@siftworkstation: ~
$ clamscan -i -r --log=/cases/clam.log /mnt/linux_mount/
/mnt/linux_mount/usr/bin/upx-ucl: Unix.Trojan.Mirai-9936831-0 FOUND

----------- SCAN SUMMARY -----------
Known viruses: 8612220
Engine version: 0.103.5
Scanned directories: 18949
Scanned files: 152078
Infected files: 1
Total errors: 124
Data scanned: 7669.29 MB
Data read: 7304.66 MB (ratio 1.05:1)
Time: 2091.245 sec (34 m 51 s)
Start Date: 2022:04:20 12:29:25
End Date:   2022:04:20 13:04:16
ubuntu@siftworkstation: ~
$
```

Figure 6.50 Clamscan Results

At this stage, the forensic investigator must have realized that there must be multiple files which are infected, in order to check which files are infected third party hash hook-ups from online websites like virustotal.com can provide more clearer results to the investigator. After executing the below mentioned commands on SIFT workstation multiple csv files will be generated containing links of virustotal which can be pasted on the website to get better view of infected files present.

- virustotal-search.py investigate_files.md5 > virustotal-results.txt
- virustotal-submit.py virustotal-search.pkl

```
ubuntu@siftworkstation: ~
$ ls
Desktop               investigate_files.md5-md5.idx   known_files.md5-md5.idx2              virustotal-search-20220420-165827.csv
changed.md5           investigate_files.md5-md5.idx2  signature-base                        virustotal-search.pkl
changed_files.txt     known_files.md5                 virustotal-results.txt                virustotal-submit-20220420-122040.csv
investigate_files.md5 known_files.md5-md5.idx         virustotal-search-20220420-121606.csv virustotal-submit-20220420-133819.csv
ubuntu@siftworkstation: ~
$ cat virustotal-submit-20220420-133819.csv
Filename;Response;Message;md5;sha256;Scan ID;Permalink
virustotal-search.pkl;1;Scan request successfully queued, come back later for the report;1eff85ccd2bb7758438e2477ff7c6a67;05cdbd7c9bad8c73a64f273ea241
daf0beaf380dac9ad8beb1a6b1226bb6d12d;05cdbd7c9bad8c73a64f273ea241daf0beaf380dac9ad8beb1a6b1226bb6d12d-1650461901;https://www.virustotal.com/gui/file/0
5cdbd7c9bad8c73a64f273ea241daf0beaf380dac9ad8beb1a6b1226bb6d12d/detection/f-05cdbd7c9bad8c73a64f273ea241daf0beaf380dac9ad8beb1a6b1226bb6d12d-165046190
1
ubuntu@siftworkstation: ~
$
```

Figure 6.51 Linking Virustotal.com

The link generated from multiple .csv files as shown above will give details about the infected files present on the EC2 instance.

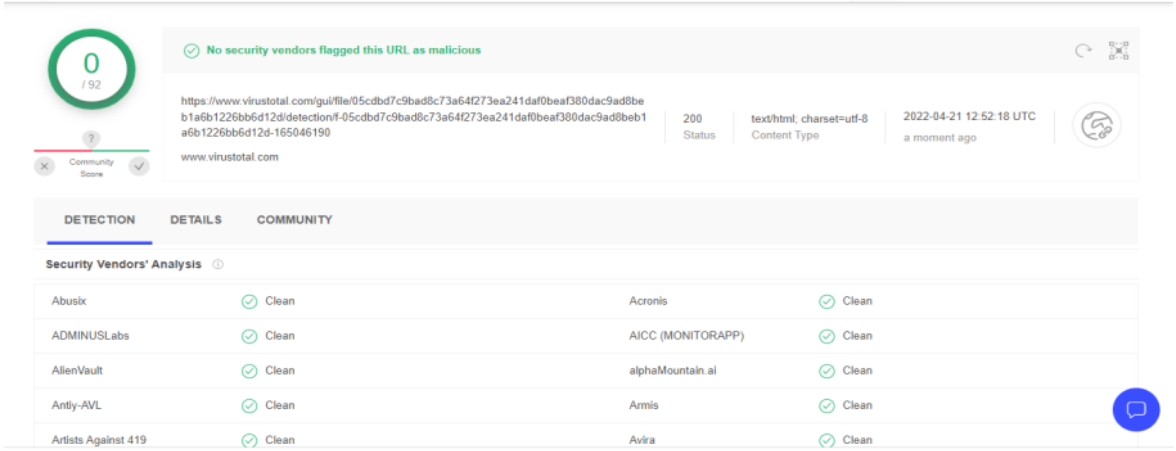


Figure 6.52 Third Party Hash Hook-ups 1

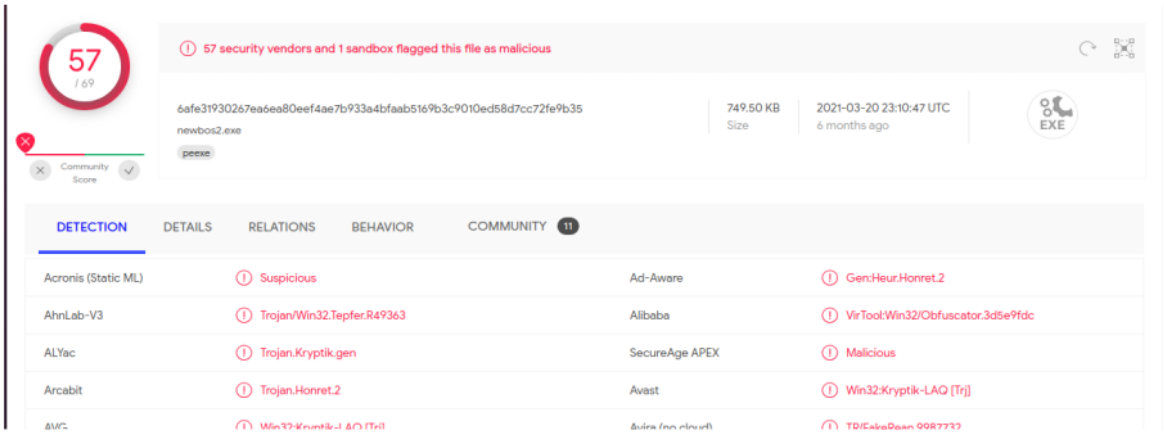


Figure 6.53 Third Party Hash Hook-ups 2

CHAPTER 7 CONCLUSION AND FUTURE WORK

Conclusion

In conclusion, the number of cases and the severity, refinement of malware attacks and expense of malware infect is increasing at an alarming rate. Malware should be detected as early as possible and mitigated. In this project, cybersecurity and security in-depth principles are applied to the cloud environment. These propositions indicate that defense controls of the cloud environment will not succeed at numerous cases and an attack might prevail so the companies must have response mechanisms to put off these attacks. Log monitoring and digital forensics gathering are the main trait for investigators for tracking and detecting active malware attacks. In this project we have successfully established a solution on how a user can monitor his/her data if it uploaded on cloud premises using Billing preferences alarm and CloudWatch Alarm. After that, we validated the applicability and limitation of deploying this baseline by doing a malware attack Any type of malicious activity which might takes place on the cloud account can be mitigated if the data is monitored properly. A baseline is built on AWS using a service called AWS CloudTrail which generated logs of activities taking place within S3. and then they were integrated with Splunk which is a SIEM Tool to perform investigation and analysis and take some steps regarding attack decision. Splunk provided data correlation, enrichment, integration with other security events, and long-term storage. Lastly in order to investigate the vulnerability of VMs Investigations were performed on the compromised IaaS VMs which displayed how a user should be careful and alert of the vulnerability of the system and take necessary steps to prevent it in future.

Future Work

As there are ample number of malware attacks happening day by day which are very difficult to track whether it is on-premises or on cloud environment, security management and investigation techniques should be given more value as the data uploaded on these environments is very important leading to changes to world economy at some stages. For future work, we believe that cloud services sources should provide the necessary tools for executing volatile memory analysis for their VMs. Also, develop a new automated tool for incident response and forensics investigation on the IaaS.

CHAPTER 8 REFERENCES

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Article Error You may need to use an article before this word.

Article Error You may need to remove this article.

Article Error You may need to use an article before this word.

Missing "," You may need to place a comma after this word.

Article Error You may need to use an article before this word.

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Missing "," You may need to place a comma after this word.

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Article Error You may need to remove this article.

Article Error You may need to use an article before this word. Consider using the article **a**.

Wrong Form You may have used the wrong form of this word.

Missing "," You may need to place a comma after this word.

Run-on This sentence may be a run-on sentence. Proofread it to see if it contains too many independent clauses or contains independent clauses that have been combined without conjunctions or punctuation. Look at the "Writer's Handbook" for advice about correcting run-on sentences.

Article Error You may need to remove this article.

PAGE 8

Article Error You may need to remove this article.

Missing "," You may need to place a comma after this word.

PAGE 9

Verb This verb may be incorrect. Proofread the sentence to make sure you have used the correct form of the verb.

PAGE 10

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PAGE 12

Article Error You may need to use an article before this word. Consider using the article **the**.

Article Error You may need to use an article before this word.

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Article Error You may need to use an article before this word.

PAGE 14

S/V This subject and verb may not agree. Proofread the sentence to make sure the subject agrees with the verb.

Article Error You may need to use an article before this word.

PAGE 15

Sp. This word is misspelled. Use a dictionary or spellchecker when you proofread your work.

Article Error You may need to use an article before this word. Consider using the article **the**.

Missing "," You may need to place a comma after this word.

Wrong Form You may have used the wrong form of this word.

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Article Error You may need to use an article before this word.

Confused You have a spelling mistake near the word **an** that makes **an** appear to be a confused-word error.

PAGE 18

Missing "," You have a spelling or typing mistake that makes the sentence appear to have a comma error.

PAGE 19

Sentence Cap. Remember to capitalize the first word of each sentence.

PAGE 20

Article Error You may need to use an article before this word.

PAGE 21

P/V You have used the passive voice in this sentence. Depending upon what you wish to emphasize in the sentence, you may want to revise it using the active voice.

PAGE 22

Article Error You may need to use an article before this word. Consider using the article **the**.

PAGE 23

P/V You have used the passive voice in this sentence. Depending upon what you wish to emphasize in the sentence, you may want to revise it using the active voice.

Confused You have a spelling mistake near the word **an** that makes **an** appear to be a confused-word error.

Hyph. You may need to add a hyphen between these two words.

Confused You have used **a** in this sentence. You may need to use **an** instead.

Confused You have a spelling mistake near the word **an** that makes **an** appear to be a confused-word error.

Confused You have used **of** in this sentence. You may need to use **off** instead.

PAGE 24

Wrong Article You may have used the wrong article or pronoun. Proofread the sentence to make sure that the article or pronoun agrees with the word it describes.

S/V This subject and verb may not agree. Proofread the sentence to make sure the subject agrees with the verb.

Missing "," You have a spelling or typing mistake that makes the sentence appear to have a comma error.

PAGE 25

PAGE 26

Sp. This word is misspelled. Use a dictionary or spellchecker when you proofread your work.

PAGE 27

P/V You have used the passive voice in this sentence. Depending upon what you wish to emphasize in the sentence, you may want to revise it using the active voice.

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Article Error You may need to remove this article.

PAGE 28

Sp. This word is misspelled. Use a dictionary or spellchecker when you proofread your work.

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Article Error You may need to remove this article.

PAGE 30

Article Error You may need to remove this article.

Article Error You may need to use an article before this word.

PAGE 31

Article Error You may need to use an article before this word.

PAGE 32

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PAGE 35

Verb This verb may be incorrect. Proofread the sentence to make sure you have used the correct form of the verb.

Faulty Comparison You cannot use these two words together to form a comparison. You can delete "more" or "most" to correct this mistake.

Sp. This word is misspelled. Use a dictionary or spellchecker when you proofread your work.

Frag. This sentence may be a fragment or may have incorrect punctuation. Proofread the sentence to be sure that it has correct punctuation and that it has an independent clause with a complete subject and predicate.

Sentence Cap. Remember to capitalize the first word of each sentence.

Sp. This word is misspelled. Use a dictionary or spellchecker when you proofread your work.

PAGE 36

Prep. You may be using the wrong preposition.

Sentence Cap. Remember to capitalize the first word of each sentence.