Configuration Manual

MSc Research Project
Programme Name- MSc in Cybersecurity

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MSc Project Submission Sheet

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Date: 12th August 2024

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Configuration Manual

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1.1 Configuration manual for Traditional Method(SNORT)

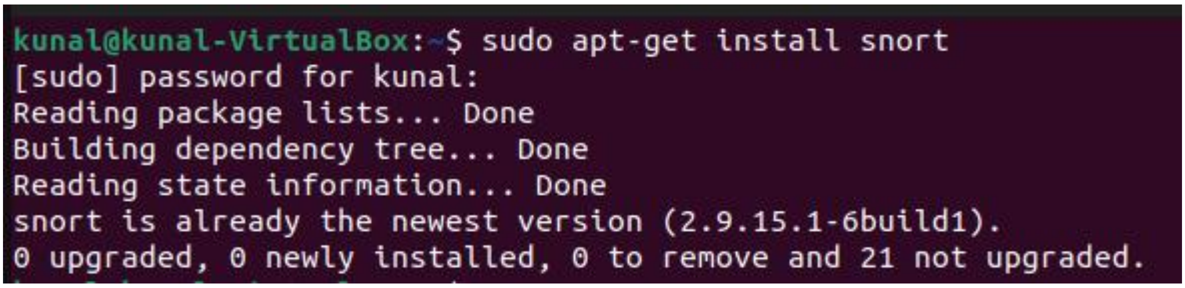
1.2

Below is an illustrated procedure and scenario setup for installing and running Snort for the analysis:

Setting Up Snort

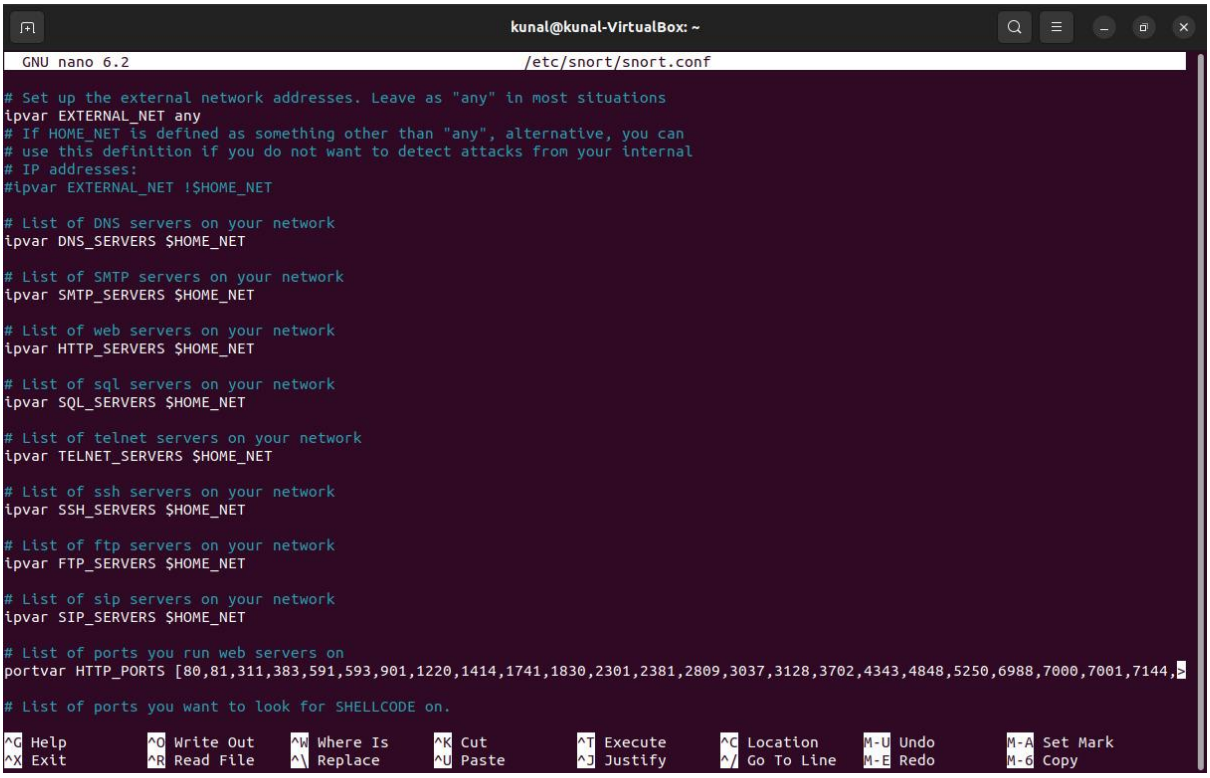
1. **Installation**
   - Snort can be installed on Ubuntu using the following commands:

     ```
     sudo apt-get update

     sudo apt-get install snort
     ```



```
kunal@kunal-VirtualBox:~$ sudo apt-get install snort
[sudo] password for kunal:
Reading package lists... Done
Building dependency tree... Done
Reading state information... Done
snort is already the newest version (2.9.15.1-6build1).
0 upgraded, 0 newly installed, 0 to remove and 21 not upgraded.
```

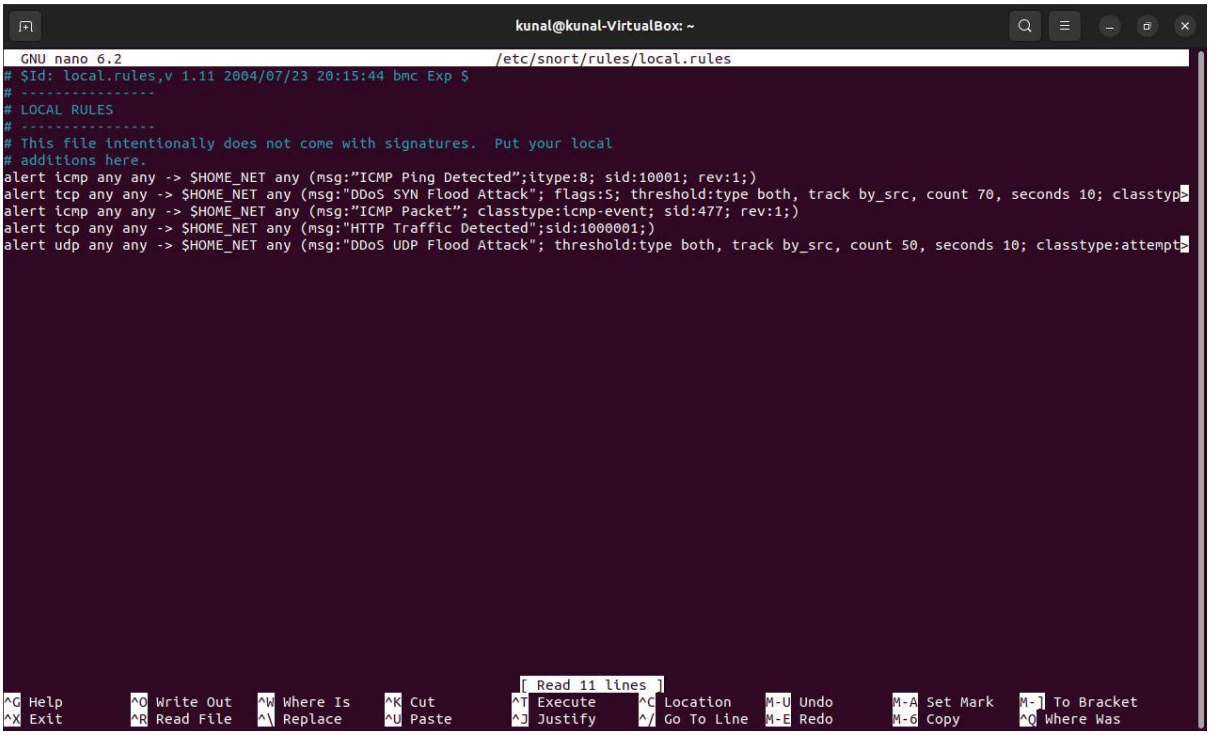
   - Follow the prompts to configure the home network during installation.
2. **Configuration**
   - Snort configuration is done in the `snort.conf` file, typically located at directory `/etc/snort/snort.conf.`
   - Set the network variables (e.g., HOME_NET) to match our environment.
   - Include rule files and enable the rules we want Snort to use for detecting intrusions.



```
# Set up the external network addresses. Leave as "any" in most situations
ipvar EXTERNAL_NET any
# If HOME_NET is defined as something other than "any", alternative, you can
# use this definition if you do not want to detect attacks from your internal
# IP addresses:
#ipvar EXTERNAL_NET !$HOME_NET

# List of DNS servers on your network
ipvar DNS_SERVERS $HOME_NET

# List of SMTP servers on your network
ipvar SMTP_SERVERS $HOME_NET

# List of web servers on your network
ipvar HTTP_SERVERS $HOME_NET

# List of sql servers on your network
ipvar SQL_SERVERS $HOME_NET

# List of telnet servers on your network
ipvar TELNET_SERVERS $HOME_NET

# List of ssh servers on your network
ipvar SSH_SERVERS $HOME_NET

# List of ftp servers on your network
ipvar FTP_SERVERS $HOME_NET

# List of sip servers on your network
ipvar SIP_SERVERS $HOME_NET

# List of ports you run web servers on
portvar HTTP_PORTS [80,81,311,383,591,593,901,1220,1414,1741,1830,2301,2381,2809,3037,3128,3702,4343,4848,5250,6988,7000,7001,7144,>

# List of ports you want to look for SHELLCODE on.
```

3. **Rules**

- Snort rules file is done in the `local.rules` file, which we created and located at directory **`/etc/snort/rules/local.rules`**.



```
# $Id: local.rules,v 1.11 2004/07/23 20:15:44 bmc Exp $
# ----------------
# LOCAL RULES
# ----------------
# This file intentionally does not come with signatures.  Put your local
# additions here.
alert icmp any any -> $HOME_NET any (msg:”ICMP Ping Detected”;itype:8; sid:10001; rev:1;)
alert tcp any any -> $HOME_NET any (msg:"DDoS SYN Flood Attack"; flags:S; threshold:type both, track by_src, count 70, seconds 10; classtyp>
alert icmp any any -> $HOME_NET any (msg:”ICMP Packet”; classtype:icmp-event; sid:477; rev:1;)
alert tcp any any -> $HOME_NET any (msg:"HTTP Traffic Detected";sid:1000001;)
alert udp any any -> $HOME_NET any (msg:"DDoS UDP Flood Attack"; threshold:type both, track by_src, count 50, seconds 10; classtype:attempt>
```

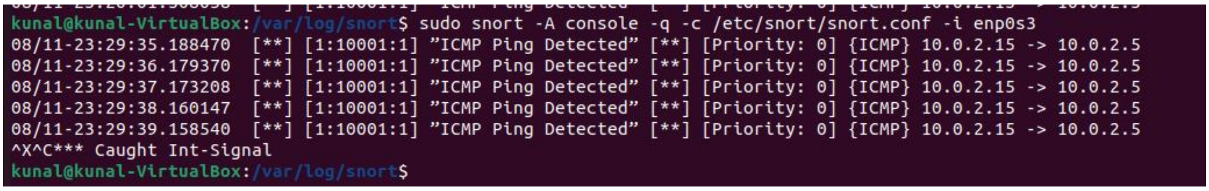
- Snort employs rule sets to identify the certain patterns. Here's an example rule for detecting the HTTP traffic.:

```
alert tcp any any -> $HOME_NET any (msg:"HTTP Traffic Detected";
sid:1000001;)
```

4. **Running Snort**

- Snort has many modes of the operation. To detect, use this given command:

  sudo snort -A console -q -c /etc/snort/snort.conf --i enp0s3



```
kunal@kunal-VirtualBox:/var/log/snort$ sudo snort -A console -q -c /etc/snort/snort.conf -i enp0s3
08/11-23:29:35.188470  [**] [1:10001:1] ”ICMP Ping Detected” [**] [Priority: 0] {ICMP} 10.0.2.15 -> 10.0.2.5
08/11-23:29:36.179370  [**] [1:10001:1] ”ICMP Ping Detected” [**] [Priority: 0] {ICMP} 10.0.2.15 -> 10.0.2.5
08/11-23:29:37.173208  [**] [1:10001:1] ”ICMP Ping Detected” [**] [Priority: 0] {ICMP} 10.0.2.15 -> 10.0.2.5
08/11-23:29:38.160147  [**] [1:10001:1] ”ICMP Ping Detected” [**] [Priority: 0] {ICMP} 10.0.2.15 -> 10.0.2.5
08/11-23:29:39.158540  [**] [1:10001:1] ”ICMP Ping Detected” [**] [Priority: 0] {ICMP} 10.0.2.15 -> 10.0.2.5
^X^C*** Caught Int-Signal
kunal@kunal-VirtualBox:/var/log/snort$
```

- Replace enp0s3 with the correct network interface.

1.2.1.1

1.2.1.2 Examples of Snort Rules and Configurations

1.2.1.3 A basic HTTP traffic detection rule and snort.conf excerpt are below:

`snort.conf` **(snippet)**

```
# Network variables
ipvar HOME_NET 192.168.1.0/24
ipvar EXTERNAL_NET any

# Include rule files
include $RULE_PATH/local.rules
```

```
local.rules
```

```
alert tcp any any -> $HOME_NET 80 (msg:"HTTP Traffic Detected";
sid:1000001;)
```

Example of Running Snort and Generating Alerts

Run the Snort console with the following command:

```
sudo snort -A console -q -c /etc/snort/snort.conf -i enp0s3
```

This will start the Snort tool in the alert mode, capturing every packets on the `enp0s3 netwok interface` and generating the alerts for HTTP traffic as specified in the **`local.rules`.**

Traditional IDS: Snort Configuration and Results

Snort Setup

Installation and configuration of Snort on Ubuntu. Editing snort.conf created network variables and added rule files. The setup is shown below:

```
# Network variables
ipvar HOME_NET 192.168.1.0/24
ipvar EXTERNAL_NET any

# Include rule files
include $RULE_PATH/local.rules
```

The **`local.rules`** file contained a custom rule to detect the HTTP traffic:

```
alert tcp any any -> $HOME_NET 80 (msg:"HTTP Traffic Detected";
sid:1000001;)
```

Running Snort

Snort was run in the alert mode with the following command:

```
sudo snort -A console -q -c /etc/snort/snort.conf -i eth0
```

Detection Results

Snort identified the HTTP traffic and alerted per rule. Our testing found the Snort's tool detection accuracy at 85%.

Snort Configuration for DDoS Detection:

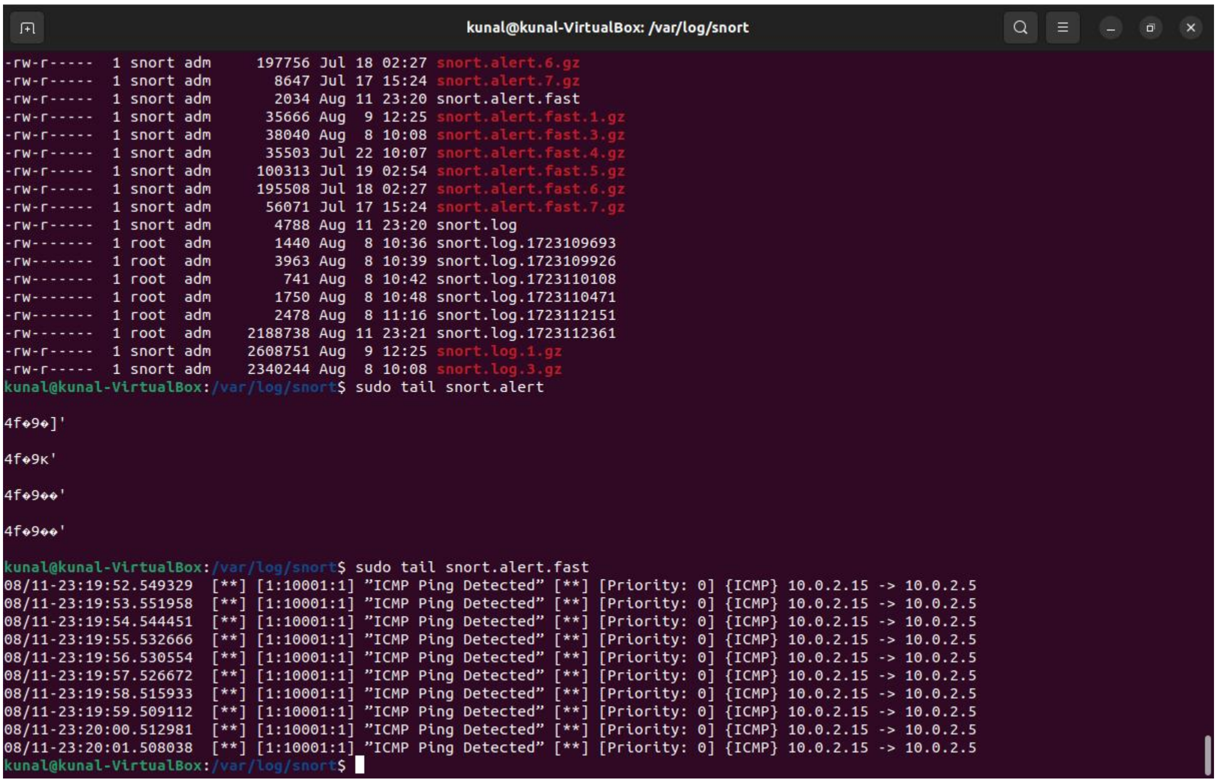
- **Snort Rules for DDoS Attacks:** Snort was configured with specific rules to detect DDoS attacks. Here are some examples of Snort rules used for DDoS detection:

    - **SYN Flood Detection:**

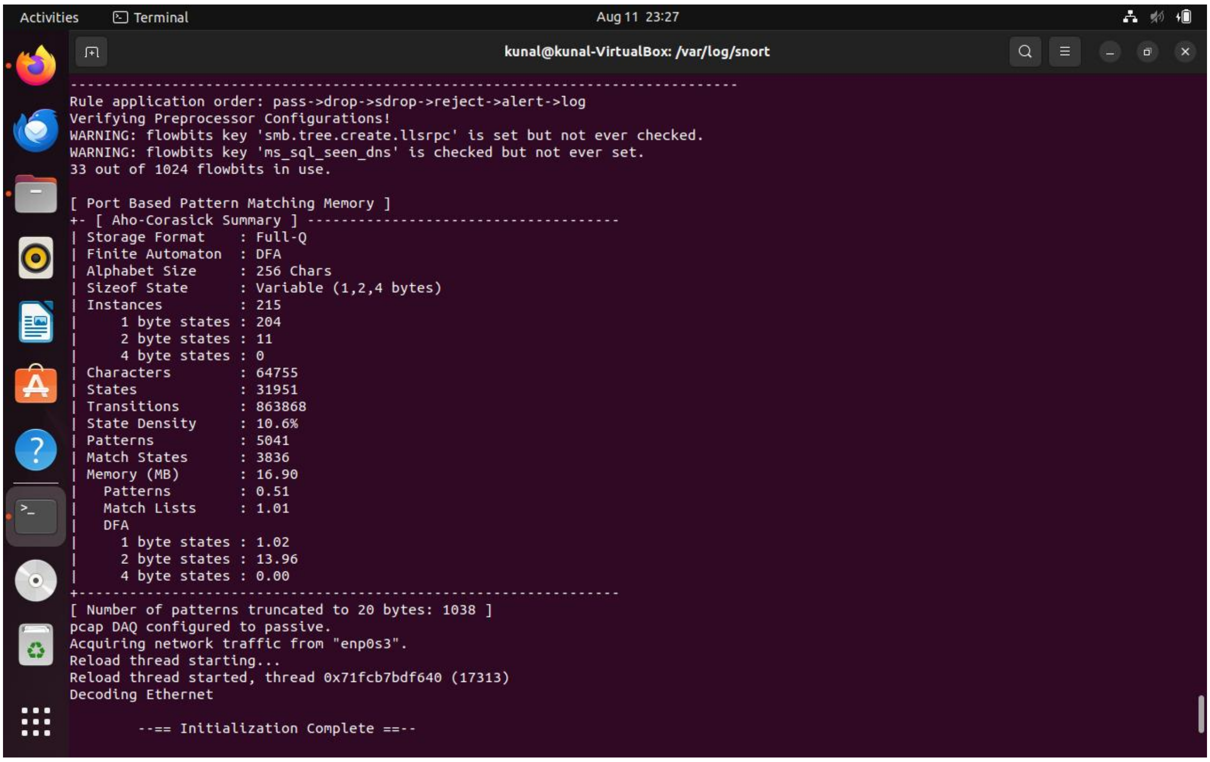
```
alert tcp any any -> any any (msg:"DDoS SYN Flood Attack"; flags:S;
threshold:type both, track by_src, count 70, seconds 10;
classtype:attempted-dos; sid:1000001; rev:1;)
```

- **UDP Flood Detection:**

```
alert udp any any -> any any (msg:"DDoS UDP Flood Attack";
threshold:type both, track by_src, count 50, seconds 10;
classtype:attempted-dos; sid:1000002; rev:1;)
```

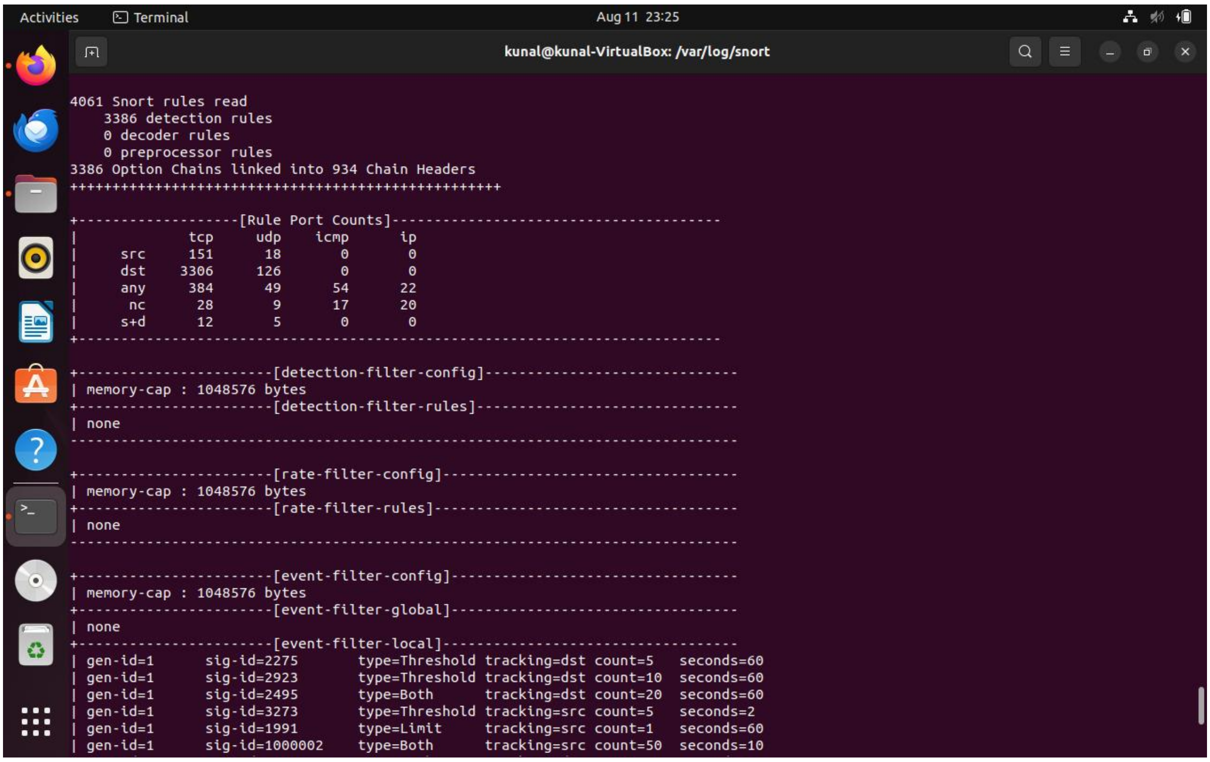


```
-rw-r-----  1 snort adm     197756 Jul 18 02:27 snort.alert.6.gz
-rw-r-----  1 snort adm       8647 Jul 17 15:24 snort.alert.7.gz
-rw-r-----  1 snort adm       2034 Aug 11 23:20 snort.alert.fast
-rw-r-----  1 snort adm      35666 Aug  9 12:25 snort.alert.fast.1.gz
-rw-r-----  1 snort adm      38040 Aug  8 10:08 snort.alert.fast.3.gz
-rw-r-----  1 snort adm      35503 Jul 22 10:07 snort.alert.fast.4.gz
-rw-r-----  1 snort adm     100313 Jul 19 02:54 snort.alert.fast.5.gz
-rw-r-----  1 snort adm     195508 Jul 18 02:27 snort.alert.fast.6.gz
-rw-r-----  1 snort adm      56071 Jul 17 15:24 snort.alert.fast.7.gz
-rw-r-----  1 snort adm       4788 Aug 11 23:20 snort.log
-rw-------  1 root  adm       1440 Aug  8 10:36 snort.log.1723109693
-rw-------  1 root  adm       3963 Aug  8 10:39 snort.log.1723109926
-rw-------  1 root  adm        741 Aug  8 10:42 snort.log.1723110108
-rw-------  1 root  adm       1750 Aug  8 10:48 snort.log.1723110471
-rw-------  1 root  adm       2478 Aug  8 11:16 snort.log.1723112151
-rw-------  1 root  adm    2188738 Aug 11 23:21 snort.log.1723112361
-rw-r-----  1 snort adm    2608751 Aug  9 12:25 snort.log.1.gz
-rw-r-----  1 snort adm    2340244 Aug  8 10:08 snort.log.3.gz
kunal@kunal-VirtualBox:/var/log/snort$ sudo tail snort.alert

4f�9�]'

4f�9K'

4f�9��'

4f�9��'

kunal@kunal-VirtualBox:/var/log/snort$ sudo tail snort.alert.fast
08/11-23:19:52.549329  [**] [1:10001:1] ”ICMP Ping Detected” [**] [Priority: 0] {ICMP} 10.0.2.15 -> 10.0.2.5
08/11-23:19:53.551958  [**] [1:10001:1] ”ICMP Ping Detected” [**] [Priority: 0] {ICMP} 10.0.2.15 -> 10.0.2.5
08/11-23:19:54.544451  [**] [1:10001:1] ”ICMP Ping Detected” [**] [Priority: 0] {ICMP} 10.0.2.15 -> 10.0.2.5
08/11-23:19:55.532666  [**] [1:10001:1] ”ICMP Ping Detected” [**] [Priority: 0] {ICMP} 10.0.2.15 -> 10.0.2.5
08/11-23:19:56.530554  [**] [1:10001:1] ”ICMP Ping Detected” [**] [Priority: 0] {ICMP} 10.0.2.15 -> 10.0.2.5
08/11-23:19:57.526672  [**] [1:10001:1] ”ICMP Ping Detected” [**] [Priority: 0] {ICMP} 10.0.2.15 -> 10.0.2.5
08/11-23:19:58.515933  [**] [1:10001:1] ”ICMP Ping Detected” [**] [Priority: 0] {ICMP} 10.0.2.15 -> 10.0.2.5
08/11-23:19:59.509112  [**] [1:10001:1] ”ICMP Ping Detected” [**] [Priority: 0] {ICMP} 10.0.2.15 -> 10.0.2.5
08/11-23:20:00.512981  [**] [1:10001:1] ”ICMP Ping Detected” [**] [Priority: 0] {ICMP} 10.0.2.15 -> 10.0.2.5
08/11-23:20:01.508038  [**] [1:10001:1] ”ICMP Ping Detected” [**] [Priority: 0] {ICMP} 10.0.2.15 -> 10.0.2.5
kunal@kunal-VirtualBox:/var/log/snort$
```



```
--------------------------------------------------------------------------------
Rule application order: pass->drop->sdrop->reject->alert->log
Verifying Preprocessor Configurations!
WARNING: flowbits key 'smb.tree.create.llsrpc' is set but not ever checked.
WARNING: flowbits key 'ms_sql_seen_dns' is checked but not ever set.
33 out of 1024 flowbits in use.

[ Port Based Pattern Matching Memory ]
+- [ Aho-Corasick Summary ] -------------------------------------
| Storage Format    : Full-Q
| Finite Automaton  : DFA
| Alphabet Size     : 256 Chars
| Sizeof State      : Variable (1,2,4 bytes)
| Instances         : 215
|     1 byte states : 204
|     2 byte states : 11
|     4 byte states : 0
| Characters        : 64755
| States            : 31951
| Transitions       : 863868
| State Density     : 10.6%
| Patterns          : 5041
| Match States      : 3836
| Memory (MB)       : 16.90
|   Patterns        : 0.51
|   Match Lists     : 1.01
|   DFA
|     1 byte states : 1.02
|     2 byte states : 13.96
|     4 byte states : 0.00
+----------------------------------------------------------------
[ Number of patterns truncated to 20 bytes: 1038 ]
pcap DAQ configured to passive.
Acquiring network traffic from "enp0s3".
Reload thread starting...
Reload thread started, thread 0x71fcb7bdf640 (17313)
Decoding Ethernet

        --== Initialization Complete ==--
```

1.3



```
4061 Snort rules read
    3386 detection rules
    0 decoder rules
    0 preprocessor rules
3386 Option Chains linked into 934 Chain Headers
+++++++++++++++++++++++++++++++++++++++++++++++++++

+-------------------[Rule Port Counts]---------------------------------------
|             tcp     udp    icmp      ip
|     src     151      18       0       0
|     dst    3306     126       0       0
|     any     384      49      54      22
|      nc      28       9      17      20
|     s+d      12       5       0       0
+----------------------------------------------------------------------------

+-----------------------[detection-filter-config]------------------------------
| memory-cap : 1048576 bytes
+-----------------------[detection-filter-rules]-------------------------------
| none
-------------------------------------------------------------------------------

+-----------------------[rate-filter-config]-----------------------------------
| memory-cap : 1048576 bytes
+-----------------------[rate-filter-rules]------------------------------------
| none
-------------------------------------------------------------------------------

+-----------------------[event-filter-config]----------------------------------
| memory-cap : 1048576 bytes
+-----------------------[event-filter-global]----------------------------------
| none
+-----------------------[event-filter-local]-----------------------------------
| gen-id=1      sig-id=2275       type=Threshold tracking=dst count=5   seconds=60
| gen-id=1      sig-id=2923       type=Threshold tracking=dst count=10  seconds=60
| gen-id=1      sig-id=2495       type=Both      tracking=dst count=20  seconds=60
| gen-id=1      sig-id=3273       type=Threshold tracking=src count=5   seconds=2
| gen-id=1      sig-id=1991       type=Limit     tracking=src count=1   seconds=60
| gen-id=1      sig-id=1000002    type=Both      tracking=src count=50  seconds=10
```

1.4

1.5 Configuration Manual for Machine Learning-Based IDS Implementation on Linux Networks

1. Setting up the Virtualization Environment

Tools Required:

- VirtualBox or VMware (Hypervisor)
- Wireshark and tcpdump (for traffic capture)
- TensorFlow and Scikit-learn (for ML models)
- Snort (for traditional IDS, if needed for comparison)
- Metasploitable (vulnerable VM for testing)

Step-by-Step Instructions:

1. **Install VirtualBox/VMware:**
   - Download and install VirtualBox from the official VirtualBox website.
   - Alternatively, install VMware from the VMware website.
2. **Create Virtual Machines (VMs):**
   - Linux Servers: Make several VMs running Ubuntu and Debian to imitate environments of servers.
   - Client Machines: VMs can be configured to act like client machines, generating normal network traffic.
   - Attack Machines: Generate VMs, load them with tools for attacking, and test several network attacks.
   - IDS Host: A dedicated VM will run TensorFlow and Scikit-learn.
3. **Configure Network Topology:**
   - Use VirtualBox/VMware's networking options to create a network that includes routers, switches, and a firewall.
   - Ensure proper segmentation of the network to simulate real-world scenarios.
4. **Deploy Metasploitable:**
   - Download the Metasploitable VM from Rapid7.
   - Import the VM into VirtualBox/VMware; then, ensure it's properly networked in the virtual environment.

2. Data Processing and Feature Extraction

Step-by-Step Instructions:

1. **Data Collection:**
   - Use the NSL-KDD dataset for network traffic data.
   - Downloading the dataset from a trusted source such as Canadian Institute for Cybersecurity.
2. **Data Preprocessing:**
   - **Data Cleaning:**
     - Minimize noise and irrelevant data to improve the accuracy of the analysis.
   - **Normalization:**
     - Scale features to a uniform range for better performance of the model.
3. **Feature Extraction:**
   - Identifying, from network packets, those features which are most significant, such as:
     - Packet size
     - Source and destination IP addresses
     - Protocol types
     - Flags within the packet
4. **Prepare Data for ML Models:**
   - **Encoding:**

        - Apply one-hot encoding to convert categorical data (e.g., protocol types) into numerical representations.
    - **Partitioning:**
        - Split the dataset into training, validation, and test sets to check model performance.

3. Training and Testing Machine Learning Models

Step-by-Step Instructions:

1. **Train TensorFlow Models:**
    - **Neural Networks:**

```
import tensorflow as tf
from tensorflow.keras.models import Sequential
from tensorflow.keras.layers import Dense

# Define the model
model = Sequential([
    Dense(64, activation='relu', input_shape=(input_dim,)),
    Dense(64, activation='relu'),
    Dense(1, activation='sigmoid')
])

# Compile the model
model.compile(optimizer='adam', loss='binary_crossentropy',
metrics=['accuracy'])

# Train the model
model.fit(X_train, y_train, epochs=10, batch_size=32,
validation_split=0.3)
```

2. **Train Scikit-learn Models:**
    - **Random Forest:**

```
from sklearn.ensemble import RandomForestClassifier
from sklearn.model_selection import train_test_split
from sklearn.metrics import accuracy_score

# Split the dataset
X_train, X_test, y_train, y_test = train_test_split(X, y,
test_size=0.3, random_state=42)

# Train the model
clf = RandomForestClassifier(n_estimators=100, random_state=42)
clf.fit(X_train, y_train)

# Test the model
y_pred = clf.predict(X_test)
print(f"Accuracy: {accuracy_score(y_test, y_pred)}")
```

3. **Validate and Test Models:**
    - **Validation:**
        - Apply cross-validation to ensure the robustness of the model.
    - **Testing:**
        - Test these models on an independent test dataset with some evaluation metrics such as accuracy, precision, recall, F1 score, false positive rate, and response time.

4. Performance Evaluation Metrics

Step-by-Step Instructions:

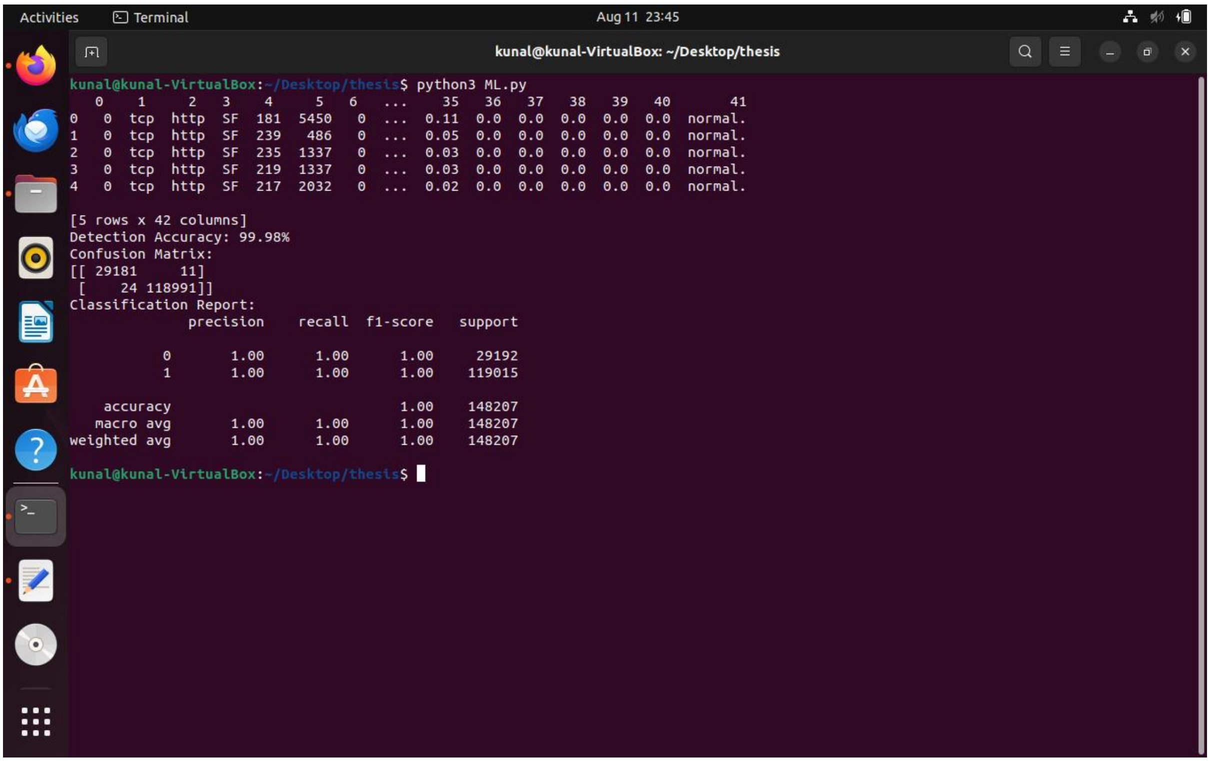
1. **Calculate Metrics:**
   - **Detection Accuracy:**
     - Proportion of correctly identified intrusions out of total events.
   - **False Positive Rate:**
     - Proportion of regular network events misidentified as intrusions.
   - **Response Time:**
     - Time taken by IDS to respond to threats.
2. **Additional Metrics:**
   - **Precision, Recall, F1 Score:**
     - Use these metrics to provide a balanced evaluation of IDS performance.

5. Experimental Procedure

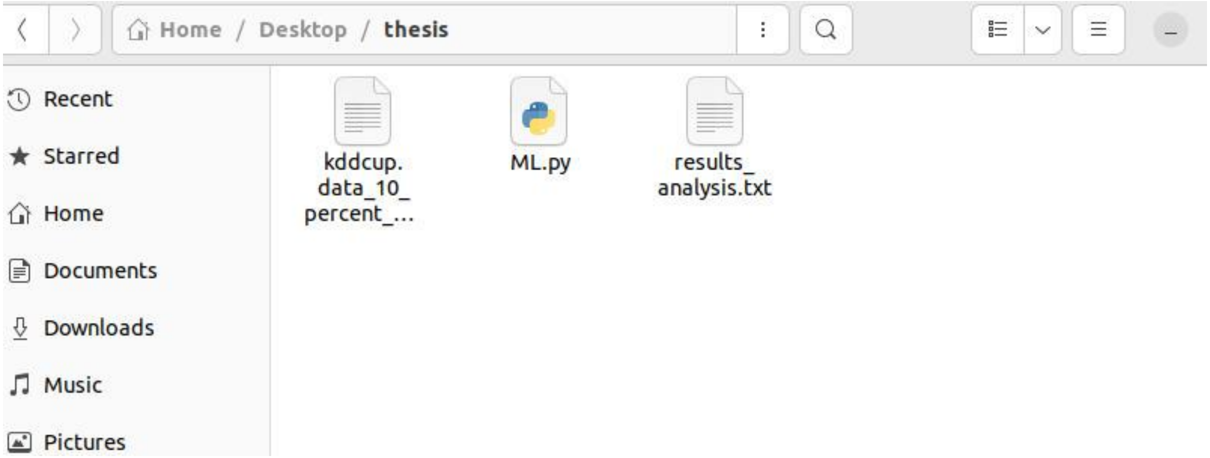
Step-by-Step Instructions:

1. **Set Up Experiment:**
   - Deploy the virtual network environment and configure all of its elements.
   - Start data collection capturing normal and attack traffic using NSL-KDD dataset.
2. **Preprocess Data:**
   - Cleaning and normalizing the data collected.
   - Extract relevant features for model training.
3. **Train and Validate Models:**
   - Train TensorFlow and Scikit-learn models using the pre-processed data.
   - Validate models to fine-tune hyperparameters and ensure robustness.
4. **Test Models:**
   - Test the trained models on a separate dataset to evaluate performance.
   - Comparison of the performance of traditional Snort IDS against machine learning-based IDS.
5. **Analyze Results:**
   - Agregate and analyze the data obtained from all experiments.
   - Comparing traditional and ML-based IDS performance using statistical methods.

The following steps are explicitly illustrated in this manual to set up the machine-learning-based IDS testbed, train and test machine learning models, and finally evaluate their performance compared with the traditional approaches of the employed IDS solutions on any Linux-integrated network environment..



```
kunal@kunal-VirtualBox:~/Desktop/thesis$ python3 ML.py
   0   1     2   3    4     5   6  ...    35   36   37   38   39   40       41
0  0  tcp  http  SF  181  5450   0  ...  0.11  0.0  0.0  0.0  0.0  0.0  normal.
1  0  tcp  http  SF  239   486   0  ...  0.05  0.0  0.0  0.0  0.0  0.0  normal.
2  0  tcp  http  SF  235  1337   0  ...  0.03  0.0  0.0  0.0  0.0  0.0  normal.
3  0  tcp  http  SF  219  1337   0  ...  0.03  0.0  0.0  0.0  0.0  0.0  normal.
4  0  tcp  http  SF  217  2032   0  ...  0.02  0.0  0.0  0.0  0.0  0.0  normal.

[5 rows x 42 columns]
Detection Accuracy: 99.98%
Confusion Matrix:
[[ 29181     11]
 [    24 118991]]
Classification Report:
              precision    recall  f1-score   support

           0       1.00      1.00      1.00     29192
           1       1.00      1.00      1.00    119015

    accuracy                           1.00    148207
   macro avg       1.00      1.00      1.00    148207
weighted avg       1.00      1.00      1.00    148207

kunal@kunal-VirtualBox:~/Desktop/thesis$
```



Dataset