Malware Detection and Classification using Machine Learning and Cuckoo Sandbox

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Introduction

- Battle between code makers and code breakers.
- Security tools- IDS, Honeypots, Sandbox.
- Need for dynamic malware analysis.
- Cuckoo Sandbox- Automated Malware Detection tool.
- Machine Learning for automating the process.

Motivation

- Importance of secure and robust codes in this information revolutionized world.
- Growing cyber attacks and threats.
- Need for stricter surveillance regimes to protect all individuals and data.

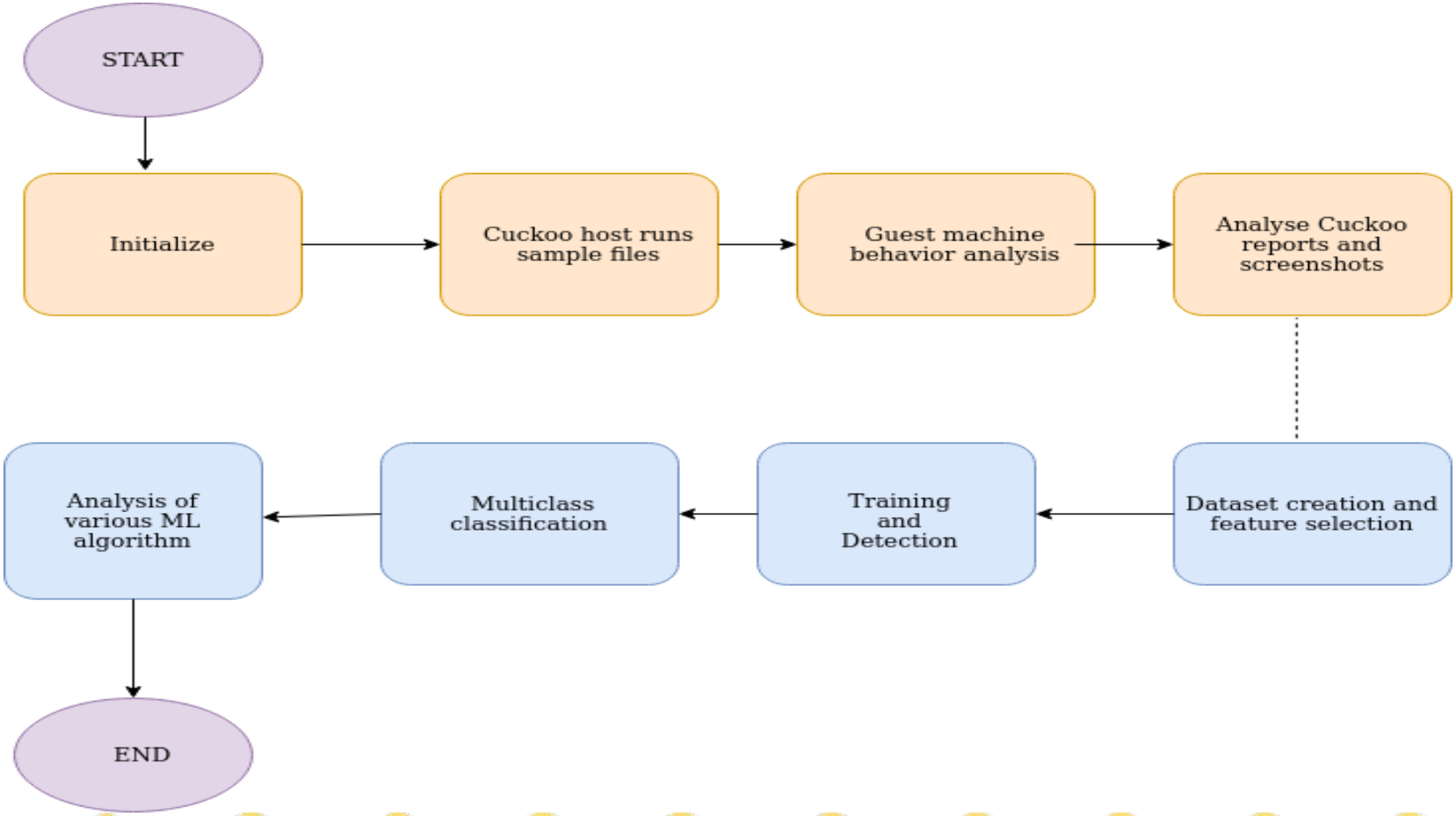
Literature Survey

Index	Paper	Authors	Methodology	Results/ Conclusion
1.	Deep Learning Approach for Intelligent Intrusion Detection System. [1]	R. Vinayakumar, Mamoun Alazab, K. P. Soman, Prabaharan Poornachan-dran, Ameer Al-Nemrat, Sitalakshmi Venkatraman	Analyses and studies various machine learning algorithms for the publicly available datasets and compares the intrusion detection results with Deep Learning approach	Found that minimal feature selection of the multi-class DNN worked more efficiently than traditional machine learning algorithms
2.	A Novel Machine Learning Based Malware Detection and Classification Framework. [2]	Kamalakanta Sethi, Rahul Kumar, Lingaraj Sethi, Padmalochan Bera, Prashanta Kumar Patra	New testing dataset is used by testing malicious files from VirusTotal and VirusShare sites using Cuckoo SandBox	A reduce in false positive rates is achieved and it is found that Decision Trees provide better results on analysis of the data

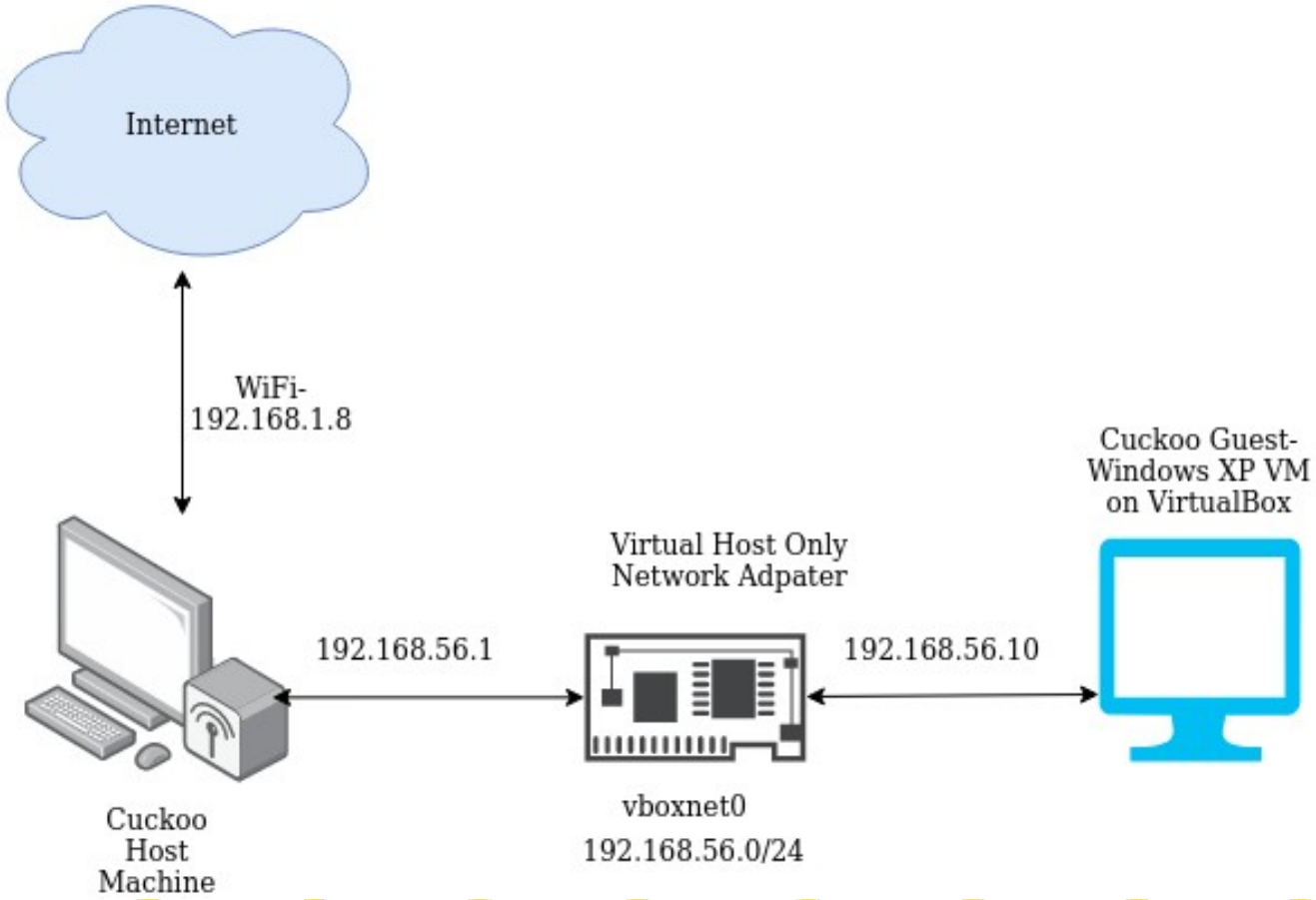
Problem Statement

- To set up a Cuckoo Sandbox environment and analyse behavior of malicious programs.
- To find the accuracy of various machine learning algorithms on the NSL-KDD dataset.

Implementation Workflow



Cuckoo Sandbox Architecture

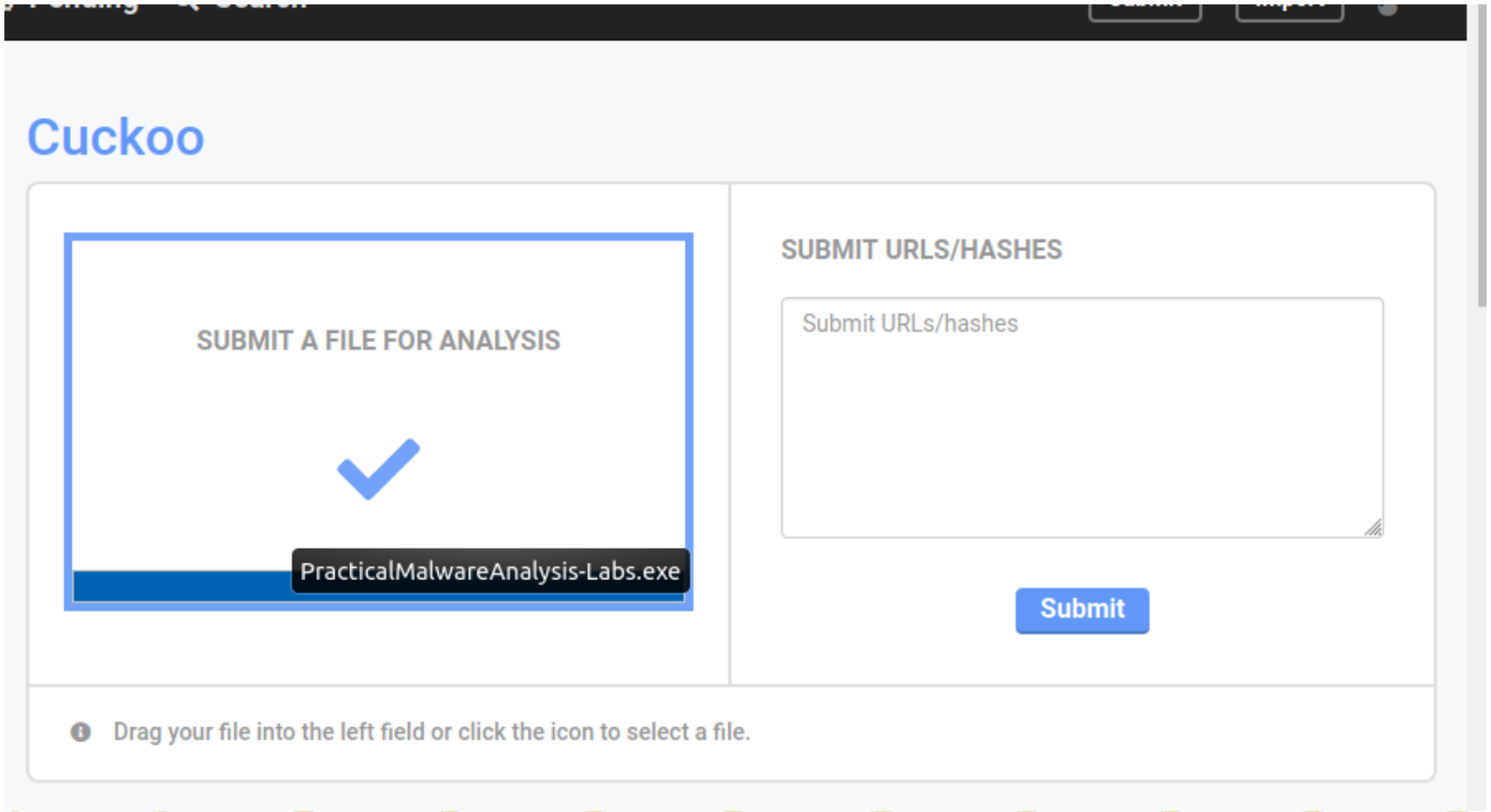


Network configurations and working

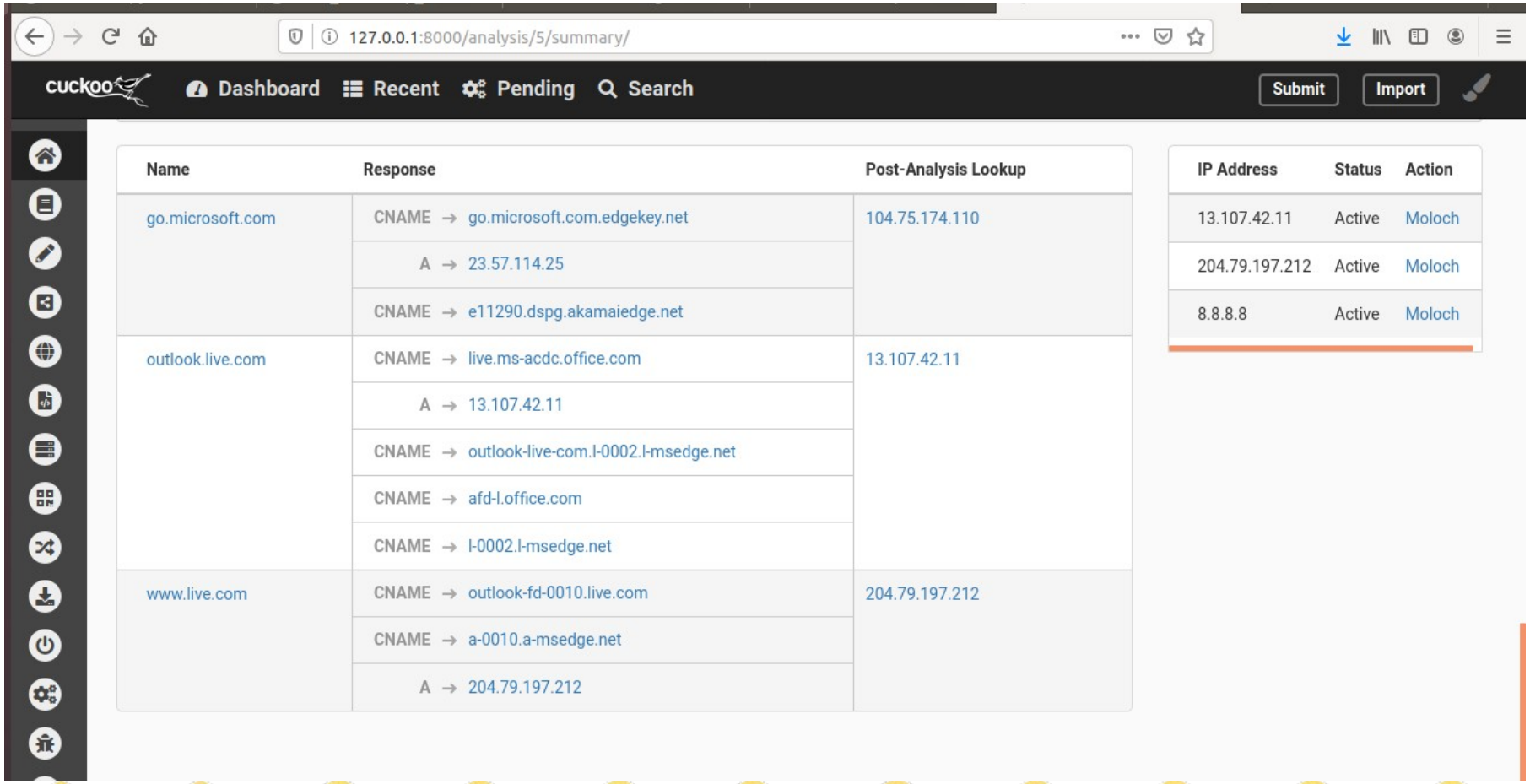
- Set up the Cuckoo installation on a different user other than main user on the Ubuntu machine.
- Create a virtual machine with Windows XP installation.
- Configure the network to create a virtual box network 192.168.56.0/24
- Setup the host ip as 192.168.56.1
- Setup the network configurations on guest virtual machine with ip 192.168.56.10
- Check if machines can ping.

- Now install suitable softwares on VM and install the python agent file from host to guest.
- Take the snapshot of stable VM
- Try installing malicious files from host to guest through command line or Cuckoo web server.
- Wait for analysis report.
- Check the report and screenshots to analyze the malicious activity.

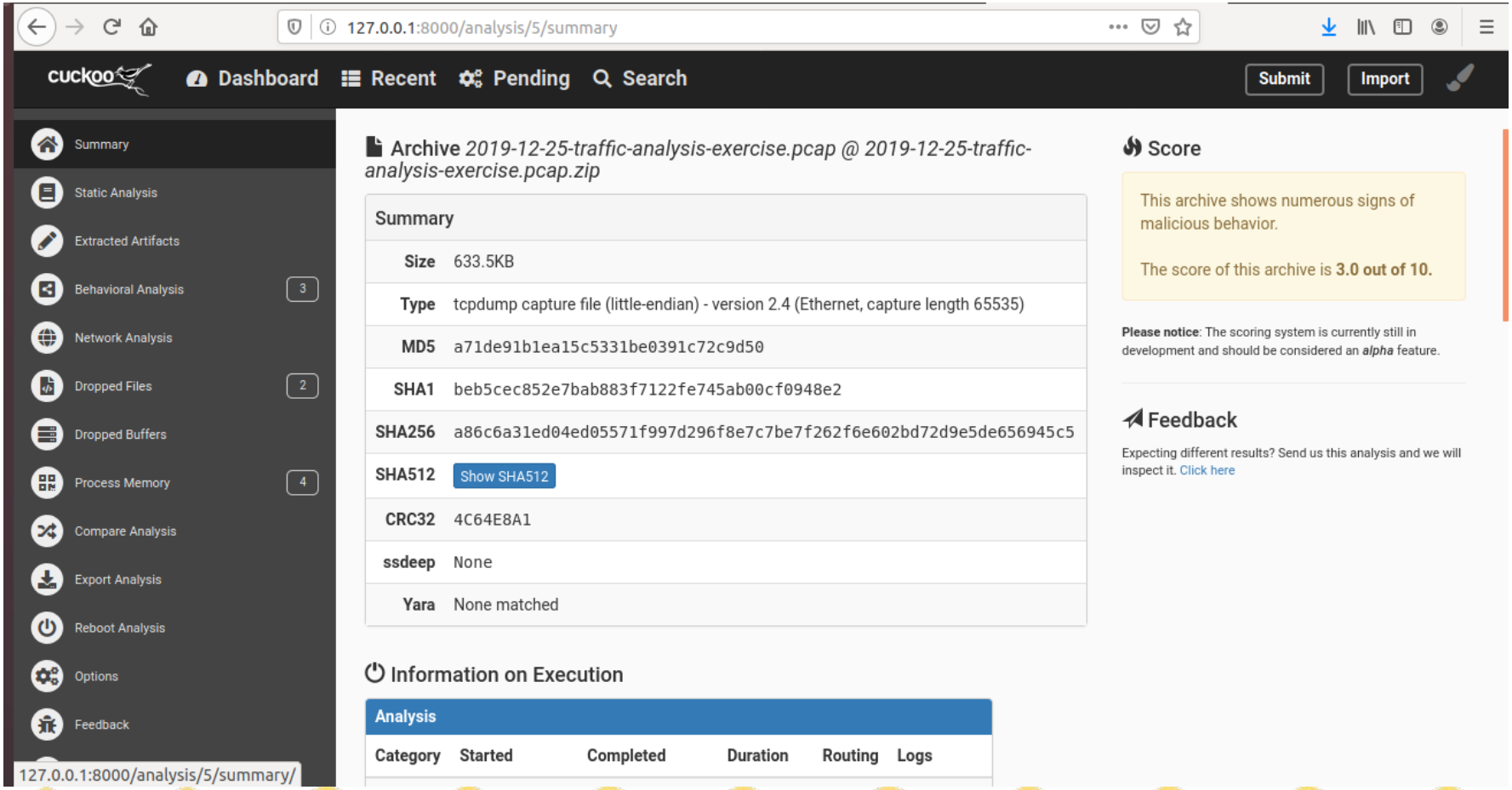
Working of Cuckoo Sandbox



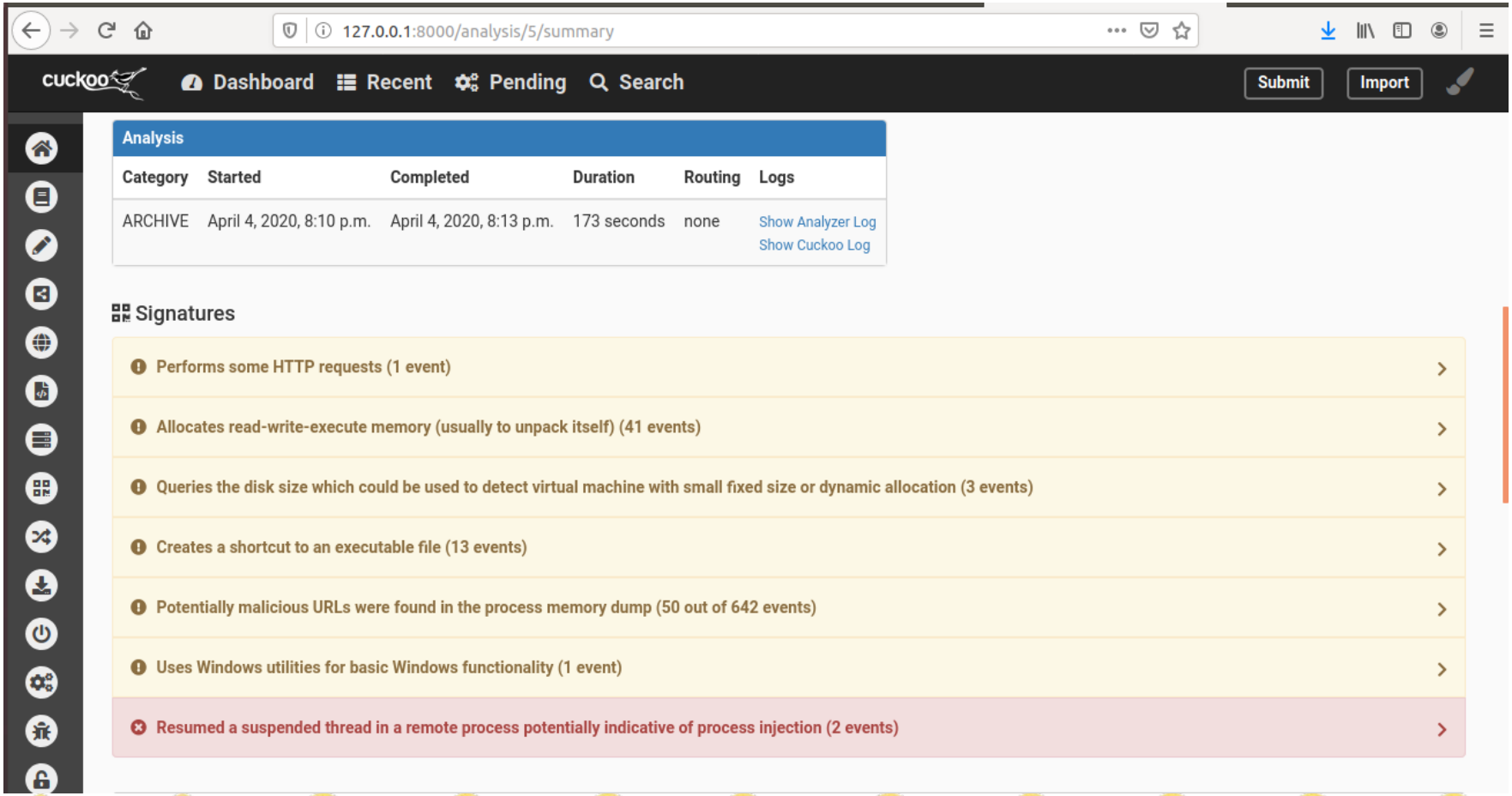
Analysis Reports



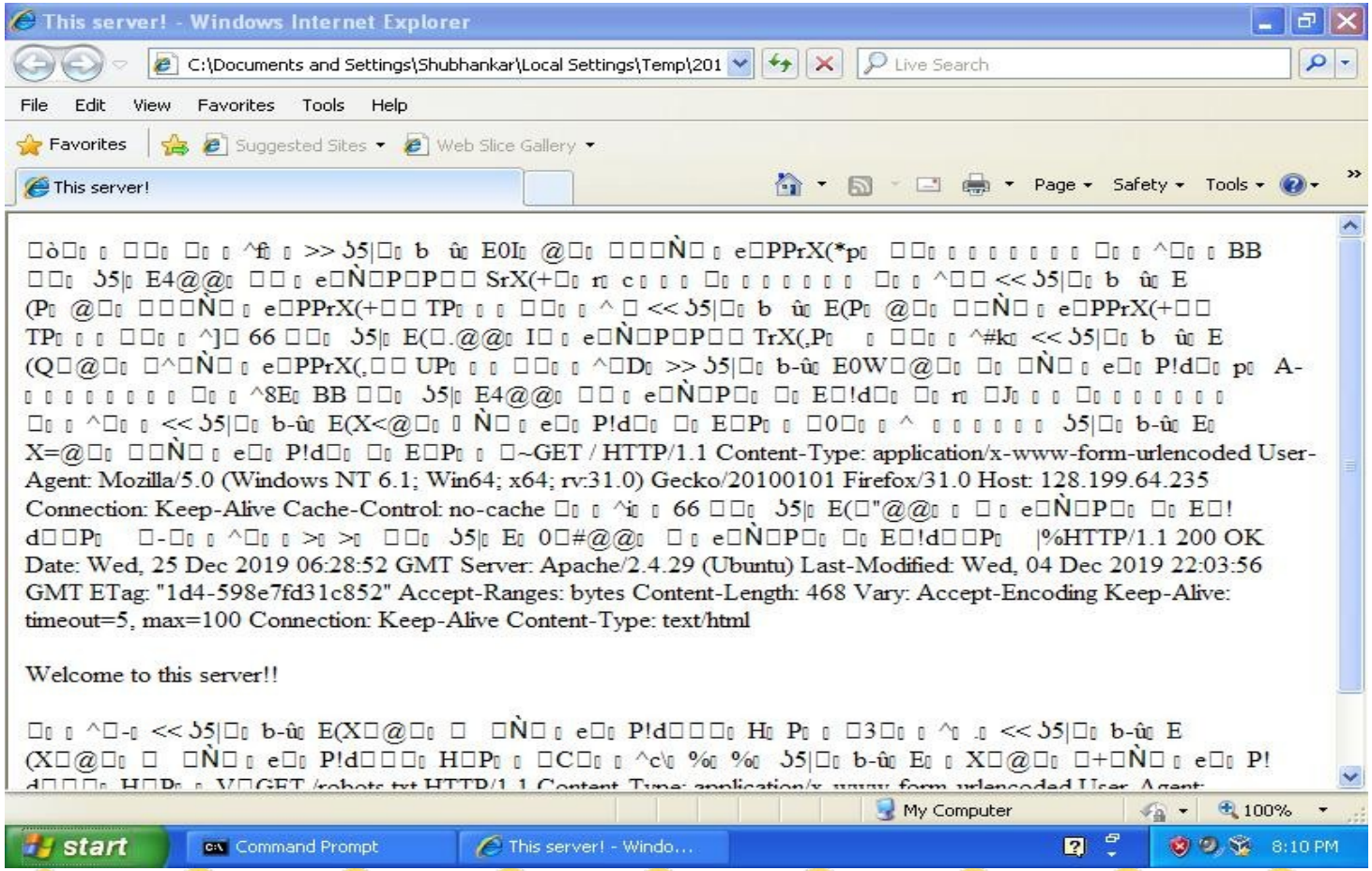
PCAP Generation and Scoring



Signatures Captured



Screenshot from the Cuckoo Guest



Machine Learning for Malware Detection

K-Nearest Neighbors-

- Discrete classification of a point by comparing to the majority of nearest k training points.
- Can be used to detect abnormal behaviors over wireless sensor networks.

Decision Trees-

- Leaf nodes contain labels and intermediate nodes are conditions.
- Repetitive checking is done against conditions to reach down to a label.
- Useful for signature based malware detection.

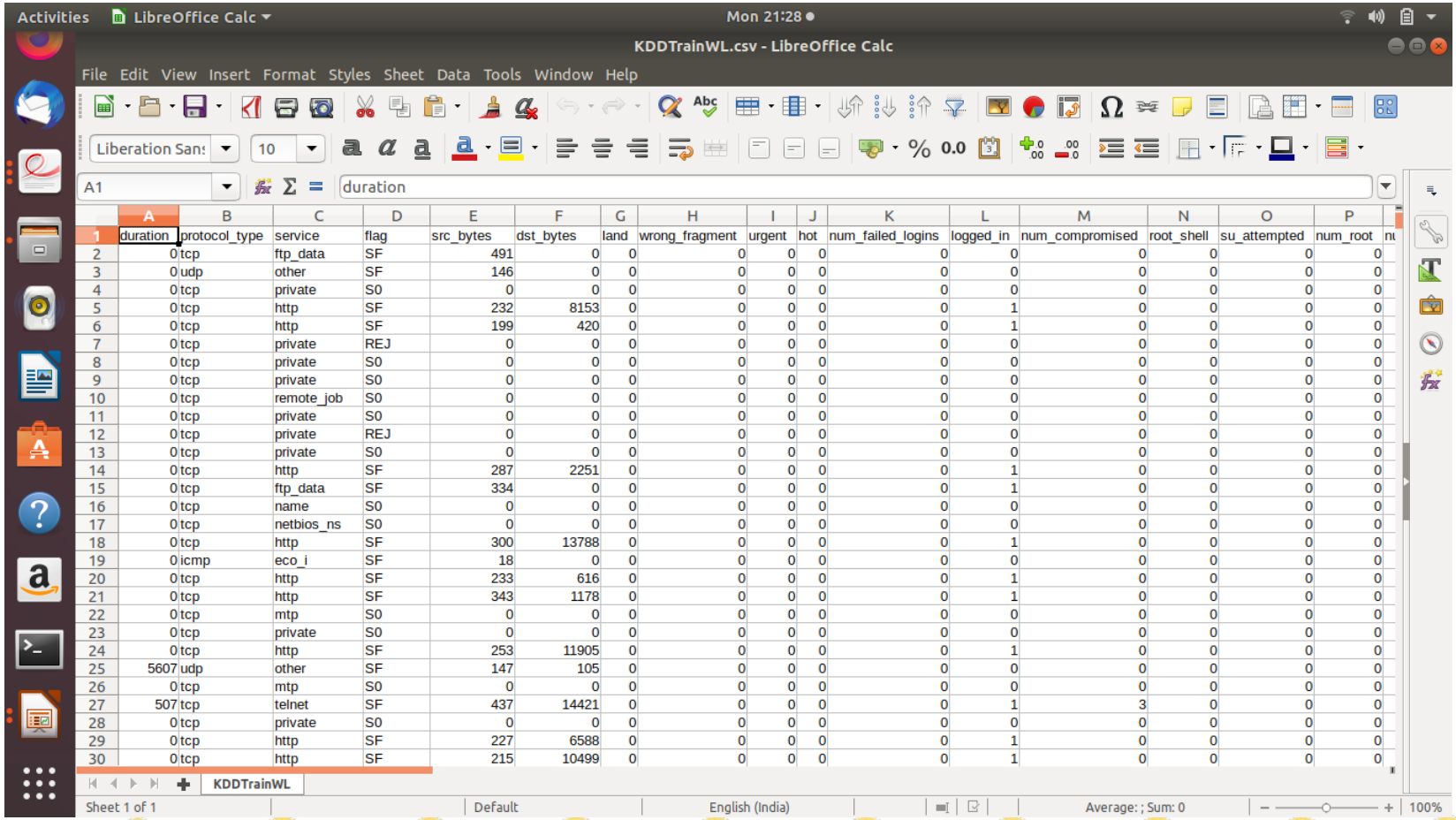
Random Forests

- It is similar to bagging.
- It creates large collection of de-correlated trees and then averages them out.

Neural Networks

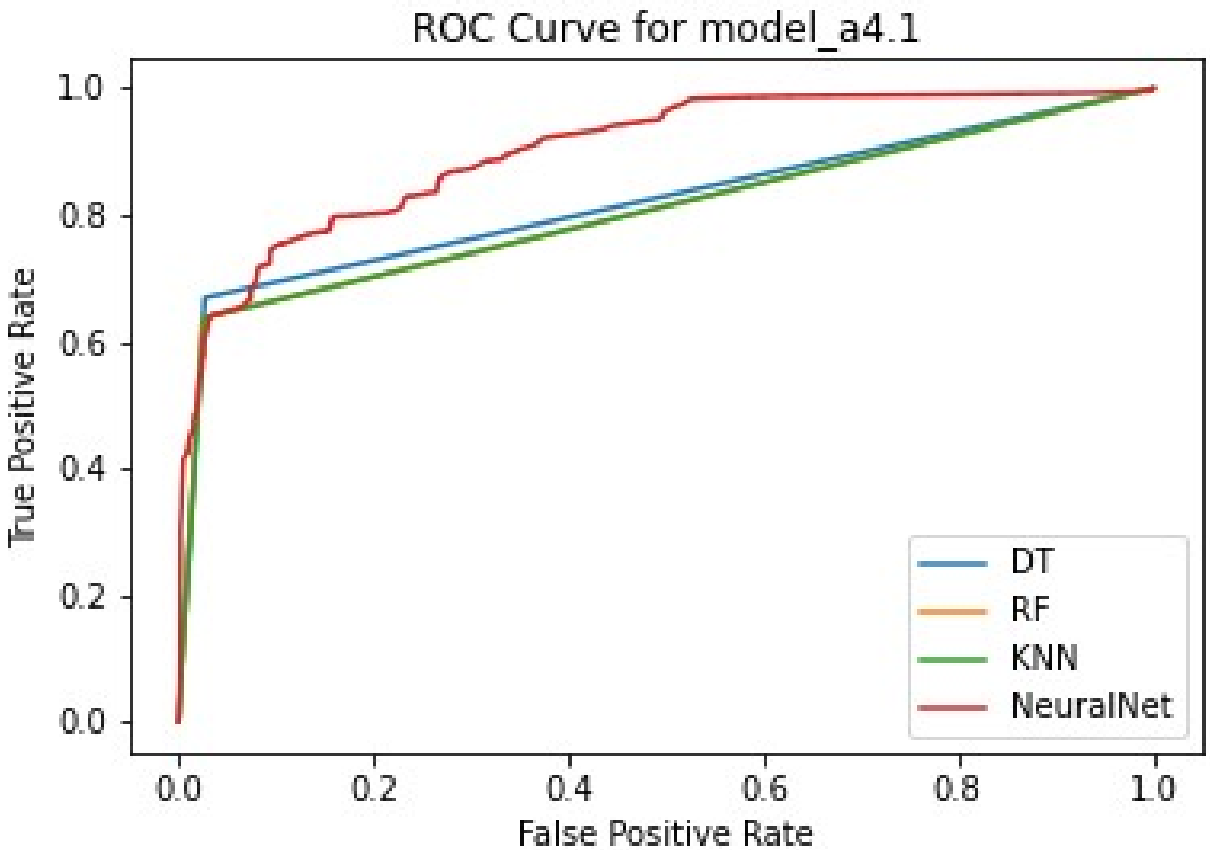
- Inspired by the biological neural networks.
- The input layer is activated and data is passed to hidden layers with hyper parameters.
- Multiclass output layer can be achieved.

NSL-KDD Dataset



	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P
1	duration	protocol_type	service	flag	src_bytes	dst_bytes	land	wrong_fragment	urgent	hot	num_failed_logins	logged_in	num_compromised	root_shell	su_attempted	num_root
2	0	tcp	ftp_data	SF	491	0	0	0	0	0	0	0	0	0	0	0
3	0	udp	other	SF	146	0	0	0	0	0	0	0	0	0	0	0
4	0	tcp	private	S0	0	0	0	0	0	0	0	0	0	0	0	0
5	0	tcp	http	SF	232	8153	0	0	0	0	0	1	0	0	0	0
6	0	tcp	http	SF	199	420	0	0	0	0	0	1	0	0	0	0
7	0	tcp	private	REJ	0	0	0	0	0	0	0	0	0	0	0	0
8	0	tcp	private	S0	0	0	0	0	0	0	0	0	0	0	0	0
9	0	tcp	private	S0	0	0	0	0	0	0	0	0	0	0	0	0
10	0	tcp	remote_job	S0	0	0	0	0	0	0	0	0	0	0	0	0
11	0	tcp	private	S0	0	0	0	0	0	0	0	0	0	0	0	0
12	0	tcp	private	REJ	0	0	0	0	0	0	0	0	0	0	0	0
13	0	tcp	private	S0	0	0	0	0	0	0	0	0	0	0	0	0
14	0	tcp	http	SF	287	2251	0	0	0	0	0	1	0	0	0	0
15	0	tcp	ftp_data	SF	334	0	0	0	0	0	0	1	0	0	0	0
16	0	tcp	name	S0	0	0	0	0	0	0	0	0	0	0	0	0
17	0	tcp	netbios_ns	S0	0	0	0	0	0	0	0	0	0	0	0	0
18	0	tcp	http	SF	300	13788	0	0	0	0	0	1	0	0	0	0
19	0	icmp	eco_i	SF	18	0	0	0	0	0	0	0	0	0	0	0
20	0	tcp	http	SF	233	616	0	0	0	0	0	1	0	0	0	0
21	0	tcp	http	SF	343	1178	0	0	0	0	0	1	0	0	0	0
22	0	tcp	mtp	S0	0	0	0	0	0	0	0	0	0	0	0	0
23	0	tcp	private	S0	0	0	0	0	0	0	0	0	0	0	0	0
24	0	tcp	http	SF	253	11905	0	0	0	0	0	1	0	0	0	0
25	5607	udp	other	SF	147	105	0	0	0	0	0	0	0	0	0	0
26	0	tcp	mtp	S0	0	0	0	0	0	0	0	0	0	0	0	0
27	507	tcp	telnet	SF	437	14421	0	0	0	0	0	1	3	0	0	0
28	0	tcp	private	S0	0	0	0	0	0	0	0	0	0	0	0	0
29	0	tcp	http	SF	227	6588	0	0	0	0	0	1	0	0	0	0
30	0	tcp	http	SF	215	10499	0	0	0	0	0	1	0	0	0	0

Result


ROC Curve for model_a4.1
True Positive Rate
False Positive Rate
0.0
0.2
0.4
0.6
0.8
1.0
DT
RF
KNN
NeuralNet

performance matrix

```
[ ] classifier_results_df
```

	model	fpr	acc	tpr	auc	TP	FP	TN	FN
0	RF	0.024697	0.784284	0.636857	0.806080	8453	253	9991	4820
1	KNN	0.026064	0.784029	0.637460	0.805698	8461	267	9977	4812
2	DT	0.026650	0.801548	0.668952	0.821151	8879	273	9971	4394
3	NN	1.000000	0.923077	1.000000	0.901289	24	2	0	0

Future Scope

- Creation of a more valid dataset.
- Testing the pcaps generated from Cuckoo Sandbox tool with ML algorithms.
- Development of an Intelligent Intrusion Detection System.

Conclusion

- Malware analysis and classification is of importance for securing information systems and networks.
- Cuckoo Sandbox tool helps in analysing the malwares effectively and quickly and provides vectors with new labels and features.
- These vector datasets are useful in classifying malwares with different machine learning algorithms to give better efficiencies.

References

[1] R. Vinayakumar, Mamoun Alazab, K. P. Soman, Prabaharan Poornachandran, Ameer Al-Nemrat, Sitalakshmi Venkatraman, “Deep Learning Approach for Intelligent Intrusion Detection System,” IEEE Access, vol. 7, pp.41525-41550, 2019.

[2] Kamalakanta Sethi, Rahul Kumar, Lingaraj Sethi, Padmalochan Bera,Prashanta Kumar Patra,“A Novel Machine Learning Based Malware Detection and Classification Framework,” International Conference on Cyber Security and Protection of Digital Services, Oxford, United Kingdom, pp. 1-4,2019.

[3] Cuckoo Sandbox-Automated Malware Analysis, ”Cuckoo Sandbox book” Available at: https://cuckoo.readthedocs.io/en/latest/ [Online]

[4] Trevor Hastie, Robert Tibshirani, Jerome H. Friedman, ”Elements of Statistical Learning- Data Mining, Inference, and Prediction” Springer Series in Statistics Available at: https://link.springer.com/book/10.1007/978-0-387-84858-7 [Online]