

A Comparative Analysis of Machine Learning Algorithms for Website Traffic Classification from Network Packets

Matthew Berthoud, Lake Bradford, Justin Crescent, Will Katabian
William & Mary
Williamsburg, Virginia, USA

ABSTRACT

Accurately Identifying web traffic destination and origins is crucial for the efficiency of a network. This project explores the potential of machine learning in reference to web traffic classification based on the analysis of network packets. We monitored and analyzed web traffic data from ChatGPT, Blackboard, and LinkedIn, with the objective of building models which will be able to predict the web traffic origin of a specific packet. The collection of data was performed using Wireshark, then the data was reformatted to eliminate bias and get more accurate results. Using the collected data we then trained four models which had varying levels of accuracy, Logistic Regression (56%), K-Nearest Neighbors (77%), Random Forest (78%), and finally a neural network (80%). This project shows the importance of machine learning within the field of network traffic analysis as automation is much more efficient and precise compared to manually examining web traffic, especially in a scale as large as the internet. One example of our project's significance is that this can be crucial data analysis for network administrators and security professionals, whom would examine the network for malicious traffic.

KEYWORDS

Network Traffic, Machine Learning, Web Traffic Classification, Network Packets, Data Analysis, Neural Networks, Random Forest, K-Nearest Neighbors, Logistic Regression

1 INTRODUCTION

The ability to monitor and analyze network traffic is crucial for the efficiency and security of a network [3]. It helps to manage the overall network performance, detect and prevent malicious activities, and ensure the network is operating as intended. The present day internet is composed of a vast variety of diverse web traffic, of which requires a more sophisticated approach to analyze and classify network traffic[1]. This project investigates a variety of machine learning algorithms to see which most accurately and effectively classify web traffic based on data from a set of captured network packets.

Traffic classification is very significant in practice, if done accurately and effectively [4]. For reasons mentioned previously, the observed capabilities of this and other projects can be crucial for network administrators and security professionals, whom would examine the network for malicious traffic.

For this project, many sets of packet data were collected from three popular websites: ChatGPT, Blackboard, and LinkedIn. These sets were then merged into a single dataset, which was then split into training and testing sets. Three models were then trained and tested on this data: Logistic Regression, K-Nearest Neighbors, Random Forest, and Neural Network [2].

A thorough evaluation of the models was conducted through testing and validation sets, hyperparameter optimization along with cross-validation, and computing accuracy and Macro F1 scores. The results showed that the Neural Network model achieved the highest accuracy of 80% and Macro F1 score of BLANK. These scores show the model's ability to accurately classify the selected websites based on captured network packet data.

Overall, the significance of this project is seen in its use of Machine Learning and the extensions of these applications into the discipline of network traffic analysis. This practice has potential to be utilized in real-world applications, and many sources proving it already is [1].

2 PROPOSED METHOD

This section presents the methodology for how this project goes about capturing network packet data, analyzing the data, and classifying it based on its website of origin.

2.1 Capturing Data

2.2 Data Preparation and Processing

2.3 Employed models

3 EVALUATION

This section comprehensively evaluates our models and their performance on the dataset and validating sets. Later, goes on to determine the model which best classified our selected websites based on network packet data.

3.1 Dataset

3.2 Model Evaluation

3.3 Model Comparison and Evaluation Results

4 DISCUSSION & FUTURE WORK

4.1 Analysis of Results

4.2 Future Work

5 CONCLUSION

REFERENCES

- [1] Kay Boldt, Kenneth B. Kent, and Rainer Herpers. 2020. Investigation of encrypted and obfuscated network traffic utilizing machine learning.

In *Proceedings of the 30th Annual International Conference on Computer Science and Software Engineering* (Toronto, Ontario, Canada) (CASCON '20). IBM Corp., USA, 43–52.

- [2] F. Pedregosa, G. Varoquaux, A. Gramfort, V. Michel, B. Thirion, O. Grisel, M. Blondel, P. Prettenhofer, R. Weiss, V. Dubourg, J. Vanderplas, A. Passos, D. Cournapeau, M. Brucher, M. Perrot, and E. Duchesnay. 2011. Scikit-learn: Machine Learning in Python. *Journal of Machine Learning Research* 12 (2011), 2825–2830.
- [3] Hiroshi Tsunoda and Glenn Mansfield Keeni. 2012. Security by simple network traffic monitoring. In *Proceedings of the Fifth International Conference on Security of Information and Networks* (Jaipur, India) (SIN '12). Association for Computing Machinery, New York, NY, USA, 201–204. <https://doi.org/10.1145/2388576.2388608>
- [4] Jun Zhang, Xiao Chen, Yang Xiang, Wanlei Zhou, and Jie Wu. 2015. Robust network traffic classification. *IEEE/ACM Trans. Netw.* 23, 4 (aug 2015), 1257–1270. <https://doi.org/10.1109/TNET.2014.2320577>
- [3] [1] [4] [2]