Machine Learning Algorithms' Significance in Identifying Botnet DDoS Attacks

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Nookala Venu
Madhav Institute of Technology & Science Gwalior

Machine Learning Algorithms' Significance in Identifying Botnet DDoS Attacks

Dr.A.Arun Kumar [#1] Dr.Nookala Venu [*1]

[1#] Professor & HoD, Department of Computer Science and Information Technology,
Marri Laxman Reddy Institute of Technology and Management (UGC Autonomous Institute),
Dundigal, Hyderabad -500043, Telangana,

[1*]Assistant Professor, Centre for IoT,
Madhav Institute of Technology & Science, Gwalior - 474 005, Madhya Pradesh, India,
(A Govt. Aided UGC Autonomous Institute).

Abstract

Botnets provide a significant threat within network environments. Botnets can be remotely managed by an individual known as the BotMaster. The utilization of bots plays a crucial role in highlighting the significance of machine learning algorithms in the detection of botnet DDoS attacks, malwares, and phishing attacks. DDoS attacks represent a highly perilous form of malware occurrences that have the capacity to interrupt an entire network. In order to mitigate Distributed Denial of Service (DDoS) attacks, numerous methodologies and techniques have been suggested. The K-means algorithm, which is an example of Unsupervised Learning (USML), is proposed in the work. This study presents a practical analysis utilizing machine learning technologies, specifically the K-means algorithm, for the detection of Botnet Distributed Denial of Service (DDoS) assaults. To conduct experimental analysis, it is recommended to utilize the UNBS-NB real-time datasets. In this experimental investigation, we conduct a performance-based comparison between K-means algorithms and many other machine learning techniques, namely Support Vector Machine (SVM), Artificial Neural Network (ANN), Naive Bayes (NB), and Decision Tree (DT). The results indicate that the K-means algorithm, specifically the unsupervised machine learning variant (USML), has superior performance compared to other machine learning algorithms.

Keywords *- Botnet, Distributed Denial of Service, Attacks, Machine learning.*

1. Introduction

Botnets pose significant security concerns, as they can facilitate various malicious activities, such as the notorious Distributed Denial of Service (DDoS) attacks, which are widely recognized as highly perilous dangers to the Internet. The primary function of server and client technologies is to deliver services to clients via the Internet. DDoS assaults have the capacity to impair the functioning of the Internet, thereby impeding the server's ability to deliver important services in response to client requests. Botnets are specifically designed to target internet services and enable remote control by individuals known as Bot-masters [1-3]. The diagram illustrates a scenario in which an assailant is engaged in communication with a server. The server is a high-configuration server that is responsible for managing client requests. Typically, the installation of malware software is responsible for the presence of malicious programmes on clients' systems. The agents are engaged in the process of following these Botnets in order to obtain information and monitor their activities. The clients lack awareness regarding the installation of malware on their systems. Clients consistently establish connections and engage in communication with servers. The servers are subject to malicious software threats. The aforementioned action causes disruption to the server network [4-7]. Detecting Botnet DDoS assaults is crucial in order to safeguard server and client systems. Machine learning algorithms play a crucial role in the identification and detection of malware, hence safeguarding systems from Distributed Denial of Service (DDoS) assaults. Machine learning algorithms serve as a means of acquiring knowledge from past experiments in order to engage with data and discern concealed patterns. The utilisation of machine learning algorithms aims to assess the optimal performance of Botnet DDoS attack detection methods [8-10]. The UNBS-NB-15 datasets are utilized for the purpose of conducting performance analysis evaluations. The evaluation of machine learning algorithms takes into account the False Alarm Rate (FAR) and the accuracy of the results obtained from this datasets.For intrusion detection system (IDS) incorporates edge computing and data augmentation approaches to accurately detect anomalies in Internet of Things (IoT) networks [11-13].

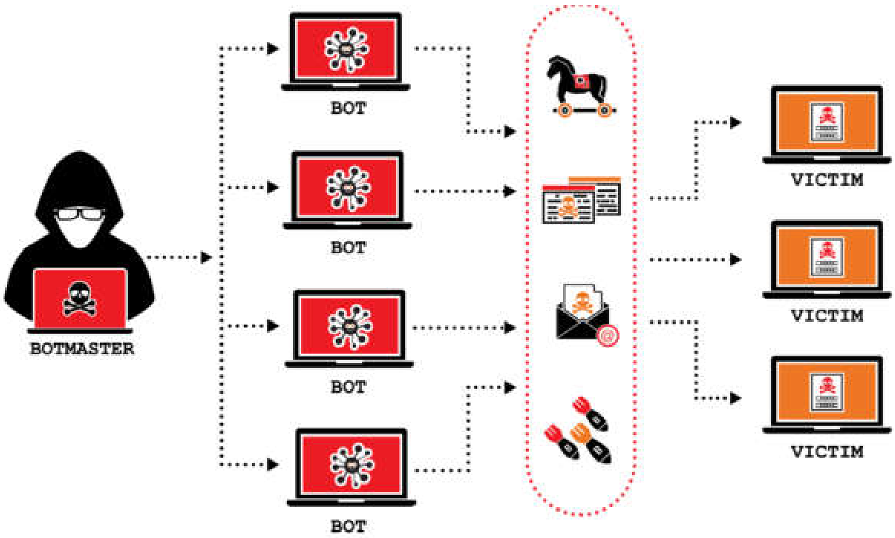

Figure 1. DDoS Attack

2. Related Works

Distributed Denial of Service (DDoS) operations are widely recognized as a significant threat, causing detrimental impacts on server performance and resulting in considerable harm. In a Distributed Denial of Service (DDoS) attack, the malevolent actor utilized compromised workstations, sometimes referred to as "corpses," to disseminate a significant volume of requests from these recently compromised machines to a specific target. This was achieved by exploiting known or undisclosed vulnerabilities that exist inside the system [14-19]. The victimized virtualized environment would require a substantial amount of data transmission or computation time. This paper presents a novel approach for detecting Distributed Denial of Service (DDoS) attacks by utilizing the C.4.5 technique. The proposed method effectively mitigates the risks posed by DDoS threats. When combined with trademark identification approaches, our approach yields a classification tree that promptly and effectively diagnoses distinctive forgeries related to Dos and DDoS attacks [20-26].

The study by [27-29] presents a warning system for DDoS attempts known as Deep Defense, which utilizes deep neural networks. The advent of technological advancements has facilitated the ability to engage in comprehensive modeling and inference. This is achieved by the extraction of pertinent high-level characteristics from average ones. The objective of this study is to develop a persistent recurrent neural network that can effectively analyze network activity cycles and detect instances of network attacks in order to identify common patterns [30-35].

In their study, the authors introduced two innovative botnet architectural models. These models involve the utilization of mobile devices for executing DNS amplification and TCP flooding assaults, as well as the consideration of costs associated with the command and control (C&C) channels. In this study, the authors want to conduct a structural analysis using the fearing framework to effectively classify botnets. To achieve this, they employ machine learning methods [36-41]. The experimental evolution was conducted by the authors using benchmark datasets to achieve selected patterns with low false positive rates. In their study, the authors introduced a method called Fuzzy Self Organizing Maps-based Distributed Denial of Service (DDoS) Mitigation (FSOMDM). This method was specifically developed to enhance the Software-Defined Networking (SDN) capabilities of cloud computing. In their study, the authors introduced a deep learning-based approach for evaluating botnet data, which they named Botnet data Shark (BotShark) [42-49].

3. Proposed Method

A Distributed Denial of Service (DDoS) attack is a form of cyber assault that leverages the computational capabilities of numerous systems infected with malware to impede network connectivity or service, hence causing a denial of service for users attempting to access the specific targeted resource. This study introduces two models that aim to detect and classify Distributed Denial of Service (DDoS) assaults. (i) A mathematical model refers to a representation of a real-world system or phenomenon using mathematical equations and relationships. It is a tool that allows researchers and scientists to analyze and understand complex systems by quantifying and formalizing their behavior. (ii) A machine learning model is a computational algorithm that is designed to learn patterns and make predictions or decisions based on input data. It is a subset of artificial intelligence that enables computers The mathematical model presented in this study establishes a correlation between the inter-arrival time of requests and throughput. Additional study of throughput was conducted in order to detect Distributed Denial of Service (DDoS) assaults.

Logistic Regression and Naive Bayes models are commonly employed in the construction of machine learning models for the purpose of detecting Distributed Denial of Service (DDoS) attacks.

Datasets - The UNBS-NB-15 dataset is commonly employed for the assessment of machine learning algorithm performance [52-55].

Research Methodology - Based on an extensive review of existing literature, we have been inspired to develop and present a novel research-oriented approach aimed at detecting Distributed Denial of Service (DDoS) attacks and safeguarding networks from these malicious activities. This methodology incorporates considerations for scalability, handling big data collections, ensuring correctness, and managing complicated data. We are now examining the application of machine learning techniques, such as Naive Bayes (NB), Artificial Neural Networks (ANN), and K-means, for the purpose of detecting Botnet Distributed Denial of Service (DDoS) assaults [56-61]. The objective of considering these machine learning algorithms is to conduct performance study on different algorithm types using real-time datasets. To facilitate the performance analysis, a framework has been built, as depicted in Figure 2.

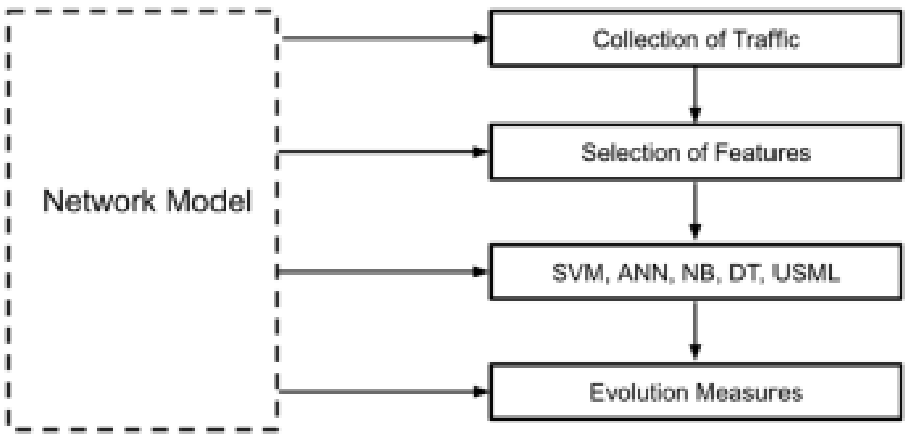

Figure 2. Framework to analyze attacks of Botnet DDoS

Traffic Collection - The tcpdump software utility is utilized for the analysis of packets in order to identify information that is being accessible through the Network Interface Card (NIC). The TCP tool is capable of gathering relevant data pertaining to attacks that specifically target the server's resources [62-66]. Tcpdump is a network packet capture mechanism utilized to facilitate framework support by capturing packets relevant to network activity. The Bro and Argus tools are frequently utilized for the extraction of features from packetized information in UNBS-NB-

15 datasets. Network sniffing strategies are employed in order to ascertain the flow being transferred through a router.

Support Vector Machine (SVM) - The Support Vector Machine (SVM) approach is utilized to construct a model that classifies data into one of two classes. The algorithm will determine if a more recent sample belongs to either of these two categories. The Support Vector Machine (SVM) approach is utilized to accurately detect and classify non-spoofed IP addresses. Additionally, it incorporates a Hop mechanism for effectively filtering and counting spoofed IP addresses [67-77].

Artificial Neural Network (ANN) - Artificial Neural Networks (ANNs) are a type of hybrid neural network that mimic the functioning of human neurons. In the context of identifying and classifying Distributed Denial of Service (DDoS) attacks, ANNs use a self-organizing map (SOM) algorithm. Artificial Neural Networks (ANN) have been shown to enhance the scalability of network systems. Artificial Neural Networks (ANNs) have the capability to implement a self-repair mechanism, which can enhance the fault-tolerance of a system and safeguard it from network-related problems [78-86].

4. Results and Discussions

This study focuses on five machine learning methods, namely Support Vector Machines, Artificial Neural Networks, Naïve Bayes, Decision Trees, and Unsupervised Learning Algorithms. The objective is to conduct a performance analysis by comparing these approaches using the UNBS-NB 15 data sets. The utilization of a confusion matrix is employed in order to obtain precise outcomes and evaluate performance. In this table we use performance algorithms the outcomes are presented as follows: a value of 1 indicates the detection of an attack, whereas a value of 0 signifies regular network activity. The confusion matrix represents the classification performance for four distinct conditions.

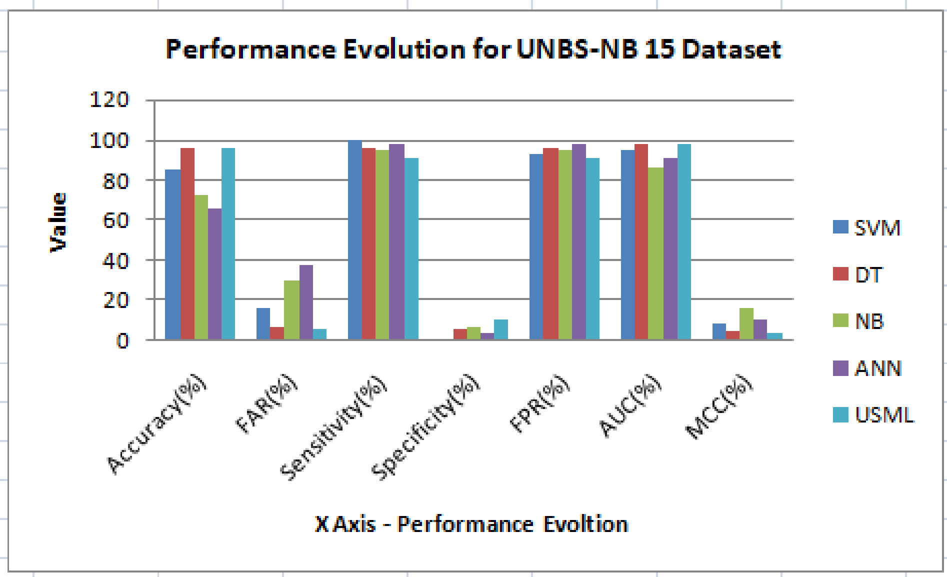

Figure 3. Performance evaluation

According to the findings obtained from the United States Medical Licensing examination (USMLE), the efficacy of decision trees and support vector machines (SVM) in decision-making processes is recognized. Both Naïve Bayes and Artificial Neural Networks (ANN) are not expected to yield perfect results. The United States Municipal League (USML) exhibits the lowest values for the Federal Acquisition Regulation (FAR), while Artificial Neural Networks (ANN) demonstrate the highest value. The methods used in this study involve the retrieval of information by employing a classification feature. The performance metrics obtained from these algorithms are as follows: the accuracy of the USML algorithm is 95.80%, the false acceptance rate (FAR) is 6.20%, the sensitivity is 90.79%, the specificity is 10.55%, the false positive rate (FPR) is 90.90%, the area under the curve (AUC) is 97.75%, and the Matthews correlation coefficient (MCC) is 3.75%. According to the findings of the experimental research, it has been determined that USML algorithms exhibit the highest level of value in comparison to other algorithms for the purpose of distinguishing Botnet identification challenges, achieving an accuracy rate of 95.80%. The research demonstrates that the K-means algorithm, which is a non-supervised algorithm, exhibits superior performance compared to other algorithms.

Table 1. Machine Learning Algorithm used Logistic Regression

	Total Instances	Correctly Classified Instances	Accuracy	Precision	Recall	Mean Absolute Error
Training data	14,063	13,929	99.04	1	0.981	0.007
Test data	5425	5417	99.85	1	0.997	0.0015
Validation data	602	594	98.67	1	0.974	0.0163

5. Conclusion

This research aims to conduct an analysis of the performance of machine learning (ML) methods in the detection of Botnet Distributed Denial of Service (DDoS) attacks. In this study, we utilized a range of techniques including Artificial Neural Networks (ANN), Decision Trees (DT), Support Vector Machines (SVM), Naive Bayes (NB), and Unsupervised Machine Learning (USML) specifically the K-means algorithm. We are utilizing the real-time datasets UNBS-NB 15 to detect Botnet DDoS attacks. Through the utilization of several performance indicators, it is evident that unsupervised learning algorithms (USML) outperform other algorithms in terms of accuracy, false alarm rate, sensitivity, false positive rate, and specificity when assessing the level of security in computer systems. In the future, the application of machine learning methods can be utilized to address Distributed Denial of Service (DDoS) assaults by including additional datasets. Various more types of attacks will be considered and addressed by utilizing a machine learning technique.

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