Preventing DDoS attack using Data mining Algorithms

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***Abstract*-** Distributed denials of service (DDOS) attack have strong impact on the cyber world. As far as cyber-attack is concerned that it halts the normal functioning of the organization by Internet protocol (IP) spoofing, bandwidth overflow, consuming memory resources and causes a huge loss. There has been a lot of related work which focused on analyzing the pattern of the DDOS attacks to protect users from them. A User datagram protocol (UDP) flood is a network flood and still one of the most crucial network floods today. This paper presents a comprehensive survey of preventing DDOS attack recognize by data mining techniques with the use of identifying DDOS attack patterns and analyze patterns by machine learning algorithms. There are some leading machine learning algorithms used to recognize the DDOS attack such as k-Nearest Neighbors algorithm (KNN), support vector machines (SVM), Random Forest as well as Naïve Base. The paper also highlights open issues, research challenges and possible solutions in this area. The result shows the highest accuracy rate of preventing DDOS attack recognizing by data mining algorithms.

***Index Terms*-** DDOS, Machine Learning, KNN, SVM, Naïve Base, Random Forest, UDP.

I. INTRODUCTION

Now a days the Internet becomes a daily need of the society. Everybody using the Internet for everything. While improvement of communication and distribution of information, some disadvantage happened. Information security becomes a crucial need. Since billions of transaction occur through the Internet. Network failure in one-second impacts on millions of losses for that organization. There are lots of hacking methods are used to hack the client servers. The DDOS attack becomes the most famous attack than the other cyber-attacks nowadays. Hacking associative have lots of machines attach to their botnets. These botnets are capable to shut down any network, and it is a dangerous issue on the Internet. Recognition of a DDOS attack is not easy, but it can happen in small range of time. Attackers visible from thousands of IP addresses and Security of the Internet also increases because of there are many threats to servers and networks. One of them is Distributed Denial of Service (DDoS) attack and it is trying to make online servers/services unavailable with massive traffic using multiple sources. Which means attackers make Servers busy or down. Attackers send malicious to personal computers and attackers remotely controlling the infected personal computers as botnets against any targets. And there are preventing methods for DDoS attacks and using Data mining algorithms are the most efficient option to detect DDoS attack. Following data mining algorithms are utilized in this research, random forest algorithm, support vector algorithm, Naive base algorithm and K-nearest Neighbors Algorithms.

II. BACKGROUND AND RELATED WORKS

The research paper “The Design of the Network Service Access Control System through” [1] is shown that unauthorized network users increase network traffic (increase the signaling and packet delivery) and decrease the availability of network resources. And they use address setup, duplicate address exploring, layer address change, and path redirection methods to access the network. This thesis purposes a new network security system by using ICMP and ARP of IPv4 system to reduce the network traffic by blocking MAC/IP addresses of the unauthorized network users. As shown in figure 1 the proposed system is not use additional protocols or network devices and use the only agent in the link-local scope unit. The agent will mainly identify continuous resource allocations and store their MAC/IP addresses and block them. Unauthorized users need to re-examine their initial IP address through the ICMPv6 message to access the network. And then network security system checks the user and send ICMPv6 response message.

According to this research paper “Detecting and Blocking Unauthorized Access in Wi-Fi Networks” [2], nowadays Wi-Fi hotspots should have a good secure system to prevent unauthorized users. Although captive portal or mac address checking is used to authenticate users, session hijacking or freeloaders can be gone through. So this research purpose to prevent session hijacking by using session id verification method and avoid the freeloading by using the mac sequence number checking. Detecting the more than one of successive packets from a one mac address (as shown in figure 2) can be used to identify the freeloaders. Session management page which associated with secure and a non-persistent cookie which contains the cryptographically random session id can be used to prevent session hijacking. Further, the page will be reloaded in a certain period and verify the session id in the cookie.

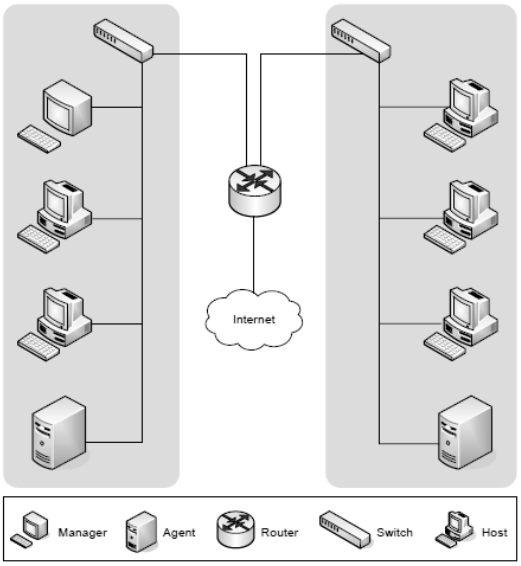

Figure 01: Increase ofnetwork traffic

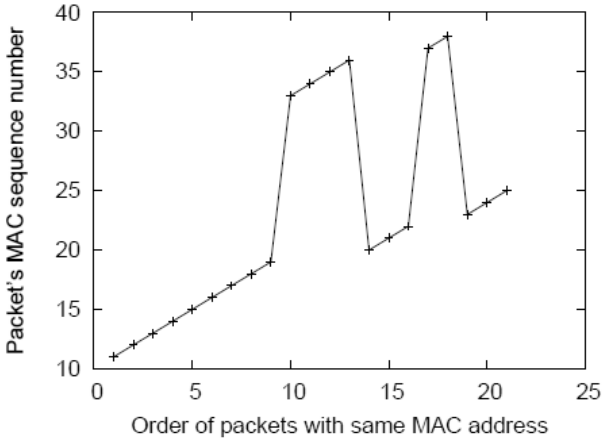

Figure 02:Detecting packets from mac-address

According to this paper, author has focused on increasing the detection rates and reduce the false positive rates in the network intrusion detection system (NIDS). The author proposed machine learning algorithms such as Random Forest, AdaBoost and Naïve Bayes to build an efficient intrusion detection model. Results on the network audit data show that AdaBoost is not a proper one for building the network intrusion detection model but the Naïve Bayes, and Random Forest is suitable to create an efficient NIDS. When applied to KDDCup'99 data set, developed algorithms for learning classifiers are successful in detecting network attacks than standard data mining techniques based on neural networks. Comparisons for Different machine learning algorithms has shown in Figure 03. The proposed paper would enlarge this above-mentioned idea to develop more learning methods for more real world applications in the future. [3]

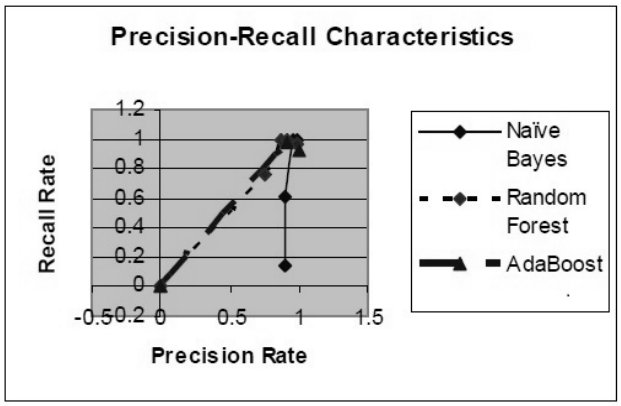

Figure 03:Comparisons for Different machine learning algorithms

Feature selection used for increased the classification accuracy and reduce false positive. The proposed research paper has concentrated on exploring feature selection and classification methods for detect DOS attacks. Here, authors initially focused on study the best feature selection algorithms. Random Forest is computationally efficient for intrusion detection system (IDS), but the best classification algorithm is KNN because it has been widely used for IDS and most important features for data set also using by KNN. The system architecture of the proposed model shown in Figure 04. Random Forest algorithm will use in the filtering stage at the same time the k-NN algorithm will use as a classifier in the future by the proposed model of the research paper. [4]

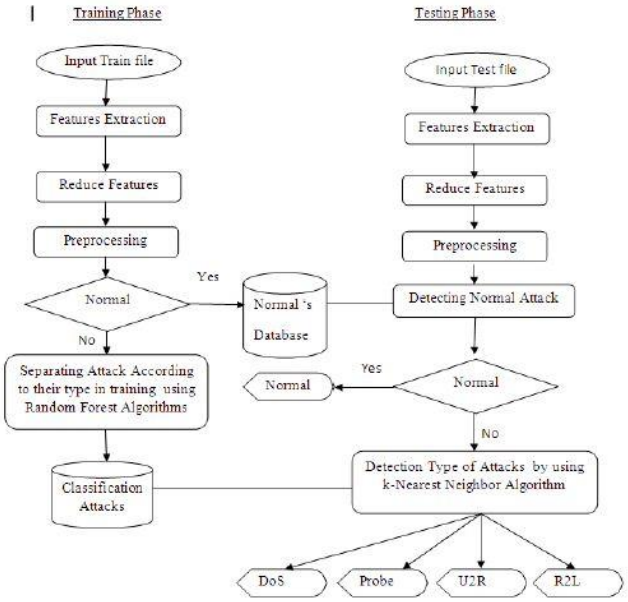

Figure 04:The system architecture

This paper showed an architecture (III Proposed Work) how to detect the DDOS attack with the help of KNN and Random Forest algorithm for classification of packets whether normal or attacked. The research focused on finding the higher accuracy and less error by using KNN and Random Forest to detect DDOS attack. Here, using the classification scheme based on extraction features using the UCLA data set. The performance evaluation of proposed system using UCLA dataset, it is evaluated using the following formulas that recall (how many selected items are relevant), precision (how many relevant items are selected) and F-measure (combination of recall and precision). Classification to detect and prevent DDOS attack by using Random Forest is the highest accuracy with less error rate to compare with other classifiers. [5]

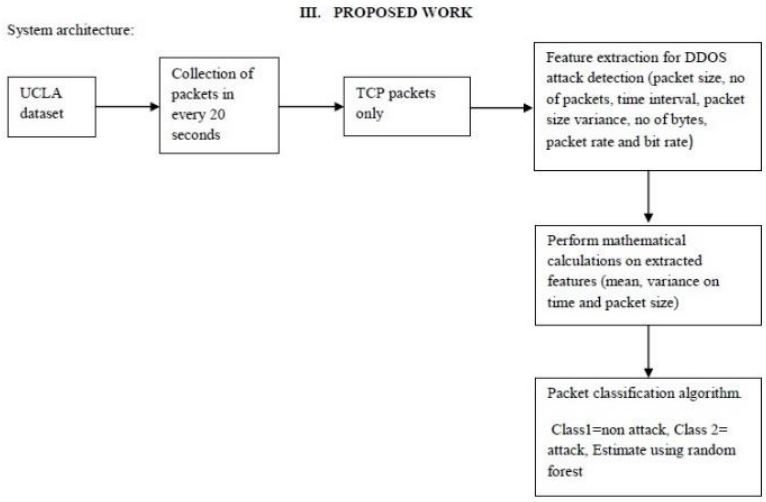

Figure 05:III Proposed Work

This research paper analyzed to predicting possible intrusions by using some neural network based techniques to NSL-KDD intrusion dataset. Following classification methods have used, Radial Basis Function Network, Self-organizing Map, Sequential Minimal Optimization, and Projective Adaptive Resonance. Three entropy-based feature selection methods have been applied to enhance the performance of the classifiers. The system architecture of the ANN-based Classification Model is mentioned in Figure 06. Above mentioned methodologies are described and explained with the exact diagrams as well as proper formulas clearly in the Methodology part of the paper. At last, research paper came up with the conclusion of Projective Adaptive Resonance Theory (PART) classification with symmetrical uncertainty feature selection gives the highest accuracy, highest detection rate as well as lowest false alarm rate. These results suggest that PART classification technique outperforms other techniques, and thus more suitable for building intrusion detection systems. [6]

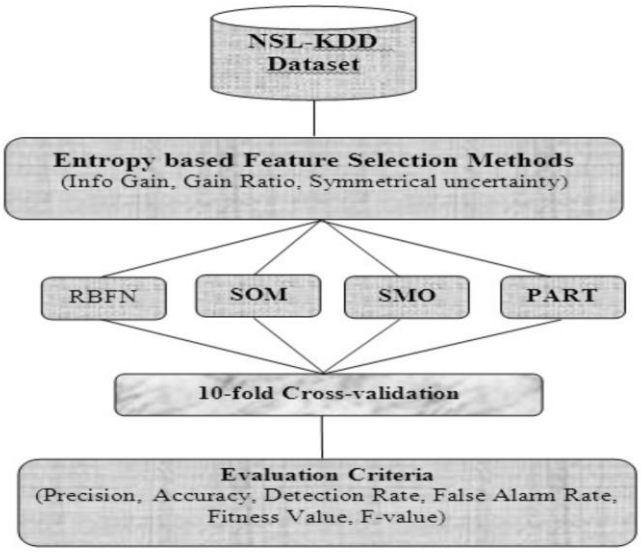

Figure 06:ANN-based Classification Model

Research paper mainly focused on the detecting of low and high rate of DDoS attack using metrics with SVM algorithm in FireCol. The structure (Figure 07) explains the working of FireCol system. In the existing system, the decision table had been used to detect the attack happened in distributed network. In spite of that, SVM has been focused here on classifying Low, High & Normal flows. As a future scope to increase the accuracy in detection other classifiers or different IPS rule structures will be focused. [7]

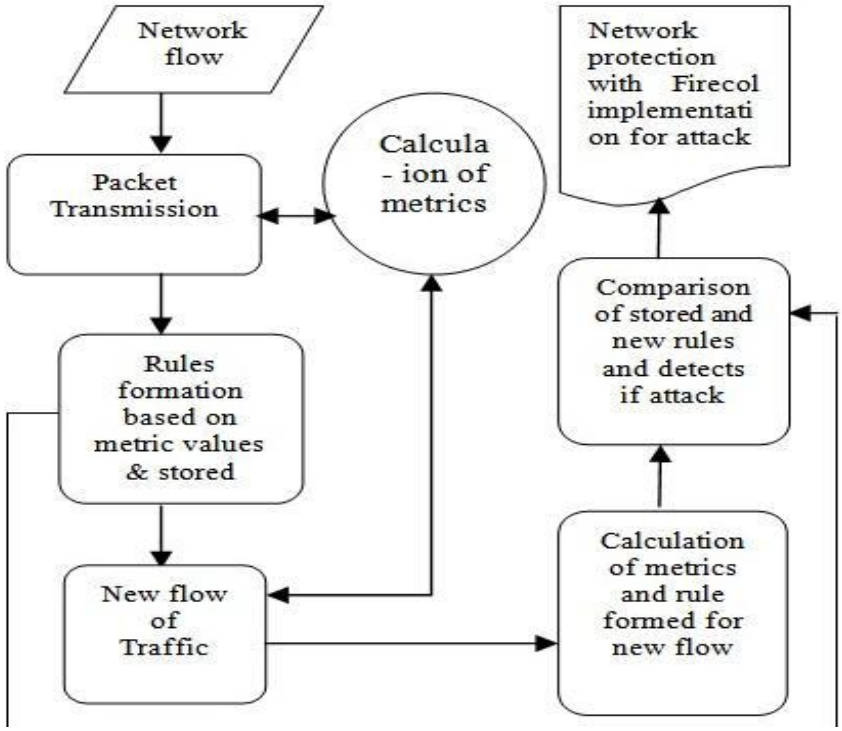

Figure 07:Explains the working of FireCol system

The aim of this research is finding the accuracy of detecting cyber-attacks with the improved SVM algorithm. Features were extracted among the 41 features, 34 features are numeric and 7 features are symbolic. The data contains 22 attack types that could be classified into four main categories Denial of Service attacks, R2L: Remote to Local attacks, U2R: User to Root attacks, Surveillance. The experimental results demonstrate that the proposed class specific cyber-attack detection system can reduced training time and, testing time where false alarm rate with high cyber-attack detection accuracy is improved. Therefore, combining the two approaches, feature reduction, and classification approach give better performance. Future work will be able to give 100% detection rate for all the classes, and investigate the possibility and feasibility of implementing this approach in real time cyber-attack detection system.[8]

This paper uses the naive Bayes to identify intrudes packets in the network.The researchers proposed the INDB (Intrusion Detection using Naive Bayes) mechanism detect intrusion packet. The reason of using naive Bayes is its predictability feature.
Researchers Packet analysis has been shown as a reach of generating packet filters that combine most of the targeted properties as processing speed, memory consumption, flexibility and simplicity in specifying protocol formats and filtering rules, active filter composition and low run-time overhead for safety enforcement [9]

The researchers used the naive bayes as the data mining algorithm .The task of DoS (Denial of Service) detection considered as a two-category classification problem, one category is to a normal network condition and another category to an existence of DoS attack. Used the multiple Bayesian classifiers to take individual decisions for the monitored features of the traffic and combined them in an information combination phase to detect DoS attacks in incoming traffic [10]

The researchers give a comparable study of several unusual detection schemes for identifying novel network intrusion detections. Researchers get experimental results on KDDCup'99 data set and apply the naive Bayes for anomaly based network intrusion detection.

In Bayesian classification, the researchers have a hypothesis that the given data belongs to a particular class. Then calculate the probability for the hypothesis to make it true. This is among the most practical approaches for certain kinds of problems. To address the problem a total data scan is required. Also, if at some stage there are additional training data, then each and every training example can incrementally increase/decrease the probability that a hypothesis is correct [11]

People and organizations use several mechanisms to defend their servers against powerful DDoS attacks. The most common way of analyzing and detecting DDoS attack is to implement an IDS (Intrusion Detection System) which analyzes and detects existing identified malicious attacks. Firewalls are also placed after the IDS to filter the malicious packets and harden the firewall policies when the attack is unidentified. Hardening policies imposed on firewall blocks many legitimate users of a particular server from using it as well. Currently, several IDS's does the job to analyze identified malicious attacks even though having struggled to identify the attacker when the attack signature is entirely new. This becomes particularly complex and tedious in larger networks that carry a substantial amount of traffic. For this reason, embedding machine learning techniques or pattern recognition techniques into systems like IDS can be very effective. Machine learning is a mechanism which enhances the decision making of computer systems by using several data which is accumulated by the system in the past. Using several techniques and algorithms machine learning enables, machines to make their own decisions independently without being intervened by a user. The algorithms proposed in this paper are KNN (K-Nearest Neighbor), SVM (Support Vector Machine), Naïve Bayes and Random Forest to classify and cluster the packets which are inbound to the network. A research paper done in Dublin City University proposes the usage of an Artificial Neural Network (ANN), where the data collected in deferent levels of the network stack is fed into a training algorithm. To test the accuracy of the classification of the machine learning the group uses ICMP flooding and UDP flooding and excessive web page requests generated through Apache Bench as the test samples. The test uses networks with 10 hidden neurons with a maximum of 100 training rounds to limit the time needed for training. The learning algorithm was presented with 100 benign and 100 malicious samples in each round. The results proved a staggering performance with a high degree of accuracy while classifying the samples. The table below show the error rate of the proposed method with 3 different types of malicious attacks.

The above-mentioned result was obtained with a clean dataset but later the research group tested the system with some dirty data which has a mix of benign samples with malicious traffic. This mix depicts the real world scenario. Even though the clean data had almost 100% accuracy in classification, with the presence of dirty data there was an error rate below 10%. When noise was deliberately added to traffic a small percentage was classified wrongly (e.g. about 6% of the malicious packets are wrongly accepted if the baseline contains 10% attack traffic and the attack traffic includes 10% legitimate requests) [12].

Malicious Sample	Traffic Probe	Error
Flood Ping	IP Header	0.00018324
UDP Flood	IP Header	0.00000502
Apache Bench	Spec HTTP hdrs	0.00000001

Figure 08:error rate of the proposed method with 3 different types of malicious attacks

The above-mentioned paper even mentions the major limitations or difficulties faced against identifying DDOS attacks. They are having multiple attack vectors, multiple sources, a mix of benign and malicious traffic, and packet differentiation at various levels of the network stack, flash crowds, filter placement and throughput. Pattern recognition can be the other form of a technique used to identify DDoS attack. With the help of the research study done at Curtin University of Technology [13] we can conclude that It's possible for a firewall to statistically analyze its own traffic patterns using firewall logs to identify an "attempted" attack. The previously mentioned research group accomplished this by using linear regression and holt-winter methods to make a comparison with the baseline. The approach proposed by them was to develop a statistical forecast of expected network traffic levels upon baseline derived from normal traffic on that network. A possible DOS attack is then indicated by comparing the real-time activities with the forecast.

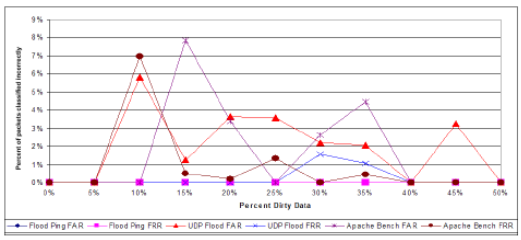

Figure 09: False acceptance (FAR) and false rejection rates (FRR) for input data of different quality

III. IMPLEMENTATION

DDOS (Distributed denial of service) attacks are usually happening via a botnet. Since malicious person uses a botnet. There are different IP addresses and MAC addresses in receiving data packets but contents of a data packets are similar. By the contents of data packet, it can be recognized whether it is regular request to the server or its malicious request to the server. To compare these data packets the data mining technology can be applied by using several data mining algorithms. It can measure probability as well as do classifications of data packets. Once the packet identifies that MAC address is temporarily blocked for 10 minutes. In this process that can be used classification data mining algorithms to group the data packets through data packets contents. Then it can be verified by finding the probability of occurrences. It can be used network packet sniffer to read data packets.

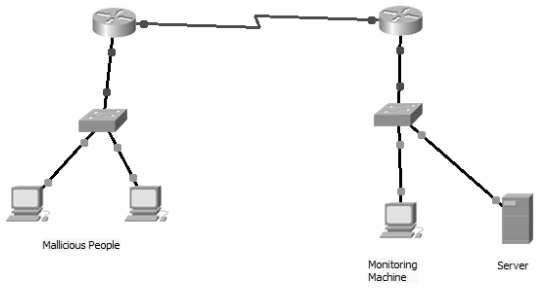

Figure 10: System architecture

A. Scalar Vector Machine

SVM is a classification data mining algorithm. That can use to group entities. By using SVM it can easily group packet received. Network packets contain source mac address in the header part of the data packet. When sniffing network from monitoring machine as shown in figure 11 all packets can be recorded in a database. It can do in real-time. By analyzing that data with SVM algorithm it generates a graph like in figure 11. Analyzing is doing considering frequently of mac addresses recorded and content inside data packet. If similar packet receive it can detect by visualization that data. Like in figure 11. If similar packets received from different networks it can be a DDOS attack. Then DDOS attack can detect through analyzing this pattern.

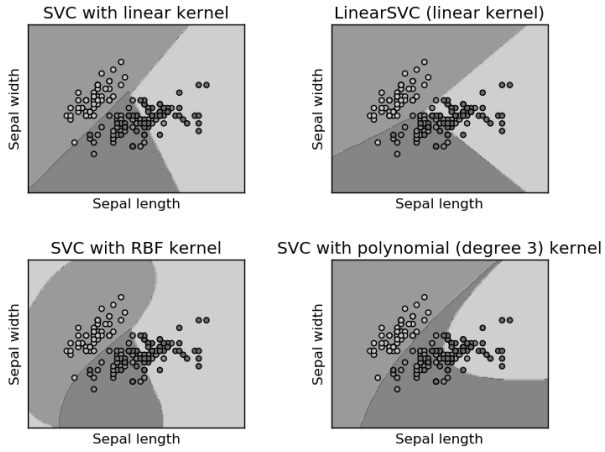

Figure 11: Sniffing packets using SVM

B. K-nearest Neighbor Algorithm.

K – Nearest neighbor is a data mining algorithm that make predictions. It takes a decision by comparing most nearby element in a graph. Using nearby element input can be classified into one of a group. By using this factor geographically nearby positions can be detected in real-time. First, it has to record IP addresses received to a server. Then it has to record them in a file and plot a graph with longitude against latitude. If visualization shows there is extremely high density in some geographical location. It can be a DDOS attack.

After recognizing attackers IP addresses, it is possible to find the geographical position of it and plot it according to longitude and latitude. This research suggesting to use Google API for to find location geographical location of IP addresses. After drawing the graph it can identify whether a new IP address in new geographical location is related to DDOS attack. KNN algorithm finds the nearest location to particular IP geographical location by longitude and latitude. If it has related neighbors that in the nearby system block that IP addresses for short time.

C. Random forest Algorithm.

Random Forest is one of the data mining algorithm using for classification or regression. It was developed by LEO Breiman and Adele Cutler. This algorithm using random datasets on a dataset and making decision trees. It is mostly suitable to use in a server that has higher traffic generated because it searches data tuples randomly. That reduce the effect to network bandwidth by this system.
By considering packet size, a time interval between packets receiving, count of packets receiving as well as bit rate which are used to detect the attack whether it is DDOS attack or other network attacks. In DDOS attack, receiving packet size is same. So, it can be used to identify the attack. In addition, if the count of packet receiving is increased in particular time then very highly it can be used to identify the DDOS attack with more accurate. DDOS attack sends the large number of packets to the victim network. Therefore, the number of packets are increases as compared to normal case.

D. Naïve Bayes Algorithm.

Naïve Bayes algorithm is prediction algorithm based on Past data. Algorithm working on three methods Prior, Likelihood and posterior. The prior method is using past data, Likelihood Is chances of possibilities might happen. Posterior is prediction Based on the given information. Below refer the equation of the posterior method.

$$\text{Posterior} = \frac{\text{likelihood X prior}}{\text{Evidence}}$$

By declaring conditions and measure value their probability with Naive Bayes it can identify a DDoS attack. The probability of packet receive in a time period can predict using Naive Bayes. If that exceed the average probability of data packets receive it should be a DDOS attack. Using Naive Bayes condition that use to take a measurement in the network can be change. By customizing conditions in Naive Bayes it can accurately detect a DDOS attack.

IV. CONCLUSION AND FUTURE WORK

As number of devices used to access internet increases day by day the danger of DDoS attack also increases at an alarming rate. Most of the current systems such as IPS and IDS which are used to detect and prevent DDoS attacks are not able to detect and prevent attacks which have new signatures or attacks which haven't been identified. Thus, therefore, the use of machine learning and pattern recognition comes into place to give the systems like IDS or IPS to analyze new forms of DDoS attacks and prevent it without being intervened by a user. Algorithms such as Random Forest, SVM, KNN and Naïve' Bayes helps to classify and cluster the packets inbound to the network. This paper in depth focuses on identifying DDoS attacks based on UDP Flooding, but classifying other types of DDOS attacks such as TCP Flood, ICMP Flood, Smurf attack and HTTP Flood can be researched later as future works.

APPENDIX

Functions / Research	Detect DDoS Attack Patterns	Analyze Patterns By Machine Learning	KNN	SVM	Random Forest	Naïve Base	Block MAC Address of Victims
Detecting Distributed Denial of Service (DDoS) Attacks through Inductive Learning	✓	✓	x	x	x	x	x
The Design of the Network Service Access Control System through Address Control in IPv6 Environments	x	x	x	x	x	x	✓
Proactively Detecting Distributed Denial of Service Attacks Using Source IP Address Monitoring	✓	x	x	x	x	x	x
A Survey of Distance and Similarity Measures Used Within Network Intrusion Anomaly Detection	x	✓	✓	✓	x	x	x
Network Intrusion detection using Naïve Bayes	x	x	x	x	x	✓	x
Evaluating Machine learning Algorithms for detecting Network Intrusion	x	✓	x	x	✓	✓	x
An Ann Approach for network Intrusion Detection using Entropy Based Feature Selection	x	x	x	✓	x	x	x
Automatic Analysis of Malware Behavior using machine learning	x	✓	x	✓	x	x	x
Detecting And Blocking unauthorized Access in Wi-Fi networks	x	x	x	x	x	x	✓
Detecting distributed Denial of service attacks	✓	x	x	✓	x	x	x
Detecting DDOS Attacks Against webserver via Lightweight TCM-KNN Algorithm	x	x	✓	x	x	x	x
DOS attack detection Based on naïve Bayes classifier	x	x	x	x	x	✓	x
Detection model for denial of service attack using Random Forest and K-Nearest Neighbors	x	x	✓	✓	✓	x	x
Detection of low and High rate DDOS attack using matrix with SVM in fireCol Distributed Network	x	x	x	✓	x	x	x
Machine learning Techniques used in detection of DOS attacks	x	✓	x	✓	x	✓	x
Investigation of DHCP packets using Wireshark	x	x	x	x	x	x	✓
A covariance Analysis model for DDOS attack detection	✓	x	x	x	x	x	x
Detecting Denial of service attacks with incomplete audit data	x	x	✓	x	x	x	x
Detecting denial of service attacks with Bayesian classifiers and the random Neural networks	x	x	x	x	x	✓	x
DDOS attacks detection and prevention using ensemble classifier(Random forest)	✓	x	✓	x	✓	x	x
Improved Support Vector Machine for cyber-attack detection	x	x	x	✓	x	x	x
Preventing DDoS attack using Data mining	✓	✓	✓	x	x	✓	✓

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