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A Novel Approach for Detecting Network Intrusion Using Genetic Network Programming and Fuzzy Class Association Rule Mining

Ms. Smita D. Shinde*
Department of Computer Engineering& Pune University
Pune, India

Prof. G. M. Bhandari
Department of Computer Engineering& Pune University
Pune, India

Abstract*— As the internet services spread all over the world, many kinds of security threats are increasing. Therefore, intrusion detection systems are effectively used for detecting intrusion accesses. A new approach is proposed called a fuzzy class-association rule mining (FCRM) method based on genetic network programming (GNP) for detecting network intrusions and help IDS to achieve higher accuracy in detection and less positive false ratio. The general procedure of proposed method is as follows: Firstly the fuzzy rule extraction is done using fuzzy membership values, and use of sub attributes method is used to avoid the information loss. By combining fuzzy set theory with GNP, the system deals with the mixed database that contains both isolated and constant attributes and also extract many important class association rules that improve the detection ability. After the withdrawal of class-association rules, categorization is done using these rules. Finally two kinds of classifiers are built up for misuse detection and anomaly detection in order to categorize new data correctly. Therefore, the proposed system is flexibly applied to both misuse and anomaly detection in intrusion detection issues.

Keywords*— Class-association rule mining, Fuzzy membership function, Genetic Network Programming, Intrusion detection.

I. INTRODUCTION

Intrusion detection is defined as identifying a set of malicious action that affects integrity, availability and confidentiality of network resources. Intrusion Detection System (IDS) is one of the important ways to solve such kind of security issues. Rate of detection and strength in detection are two major parameters to evaluate IDS. Techniques like categorization, clustering, artificial neural network, rule based systems and expert system are used in intrusion detection system. These methods can be used in combination to provide better performance

Large number of data mining techniques has been introduced to improve accuracy in detection and constancy in detection but they suffer from large computational difficulty for rule extraction from dense database. In order to detect remarkable rules from a dense database, genetic algorithm (GA) [18] and genetic programming (GP) are together used to form association rule and mining of rules properly. Using this idea a FCRM method based on Genetic Network Programming (GNP) is proposed. By combining fuzzy set theory with GNP, the proposed method deals with the mixed database that contains both isolated and constant attributes. GNP can withdraw rules that include both isolated and constant attributes continuously. Fuzzy sets can help us to defeat sharp boundary problem by allowing different degrees of memberships.

The concept of GNP-based FCRM is introduced in detail. The fuzzy membership values are used for fuzzy rule extraction, and use of sub attributes method is proposed to avoid the information loss. In the meantime, a novel GNP structure for association-rule mining is built up so as to carry out the rule extraction step. In addition, a new fitness function that provides the flexibility of mining more new rules and mining rules with higher accuracy is given in order to detect different kinds of detection.

After the extraction of class -association rules, these rules are used for categorization. Two kinds of classifiers are built up for misuse detection and anomaly detection, respectively, in order to categorize fresh data correctly. For misuse detection, the normal-pattern rules and intrusion-pattern rules are retrieve from the training dataset. Classifiers are built up according to these retrieved rules and for anomaly detection; focus is on retrieving as many normal-pattern rules as possible. Retrieved normal-pattern rules are used to detect novel or unidentified intrusions by evaluating the divergence from the normal behaviour [22].

II. LITERATURE SURVEY

Intrusion detection is categorized into misuse detection and anomaly detection. Misuse detection mainly searches for particular patterns or sequence of programs and user behaviours that match well-known intrusion scenarios and anomaly detection develops models of normal network behaviour, and new intrusions are detected by evaluating considerable divergence from the normal activities.

In order to detect the intrusion, various approaches have been developed and proposed over number of years. One of this approaches, Genetic Network Programming (GNP) procedure and data mining are extensively used. W. Lu and I. Traore has proposed a rule evolution approach based on Genetic Programming (GP) called "Detecting New Forms of Network Intrusion Using Genetic Programming" for detecting novel attacks on network is presented and four genetic operators that is reproduction, mutation, crossover and dropping condition operators are used to develop new rules. New rules are used to detect novel or well-known network attack. But the detection result is not good for s ome runs because the selection of crossover and mutation points in equivalent operations is arbitrary [1]. Therefore rules extracted using this approach is less which directly affects on accuracy in detection.

K. Shimada, K. Hirasawa, and J. Hu have proposed method "Genetic Network Programming with acquisition method of association rules ". This method improves the performance of association rule withdrawal from dense database. Rule withdrawal is done without identifying repeated item sets used in a priori-like methods [2]. This method cannot retrieve all the rules satisfying given definitions of importance.

Z. Bankovi´c, D. Stepanovi´c, S. Bojani´c, and O. Nieto - Taladriz have proposed a system for Improving network security using genetic algorithm. This approach is used for evolving and testing new rules for intrusion detection . In this method, the KDD99Cup training and testing dataset are used [4]. But this approach is not works good with mixed database which contains binary and constant attributes.

Chuanhuan Yin, Shengfeng Tian, Houkuan Huang, and Jun He have proposed "Applying Genetic Programming to Evolve Learned Rules for Network Anomaly Detection". In this approach GP is used to evolve new rules from the initial learned rules through genetic operations. GP-based rule learning approach outperforms the original rule learning algorithm. The limitation of this method is that the algorithm needs two passes during training, resulting in the inefficiency of detector [23].

Daniel Barbarra, Julia Couto, Sushil Jajodia, Leonar Popyack, and Ningning Wu have proposed "ADAM: Detecting Intrusions by Data Mining". This method mainly detects probe attacks and DoS attacks but the accuracy in detection is low as compared to other techniques [12]

After analyzing existing approaches, a system is proposed called GNP and Fuzzy Rule Based Intrusion Detection System to solve some drawbacks of the existing system i.e. low detection precision, use of only one kind of database and extraction of minimum number of rules.

III. PROPOSED SYSTEM

In this section, proposed approach is elaborated. First architecture of proposed system is presented. Then modules of this system are described**.**

A. System Architecture

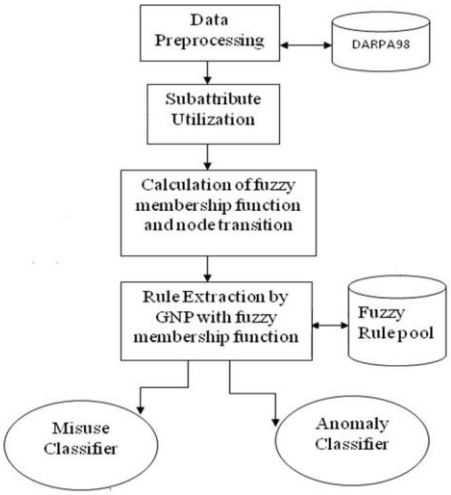

Fig. 1.System Architecture

In this approach preprocessing is done on testing database. After preprocessing of data, sub attributes are utilized to avoid information loss. Based on these attributes fuzzy membership function is calculated and rules are extracted for classification of new data correctly.

a. Data Preprocessing

First data preprocessing is done. In this the DARPA98 training data includes "list file", which identifies each network connection's time stamps, service type, source IP address, source port, destination IP address, destination port and the type of each attack [3]. Tcptrace utility software [5] is used to extract information on packets to construct new intrinsic features such as data bytes, SYN and FIN packets flowing from the source to the destination as well as from the destination to the source.

After the data preprocessing for each network connection, 30 attributes including the list file features, intrinsic features and time based features are obtained. Another database KDD99CUP originally includes 41 attributes that do not need data preprocessing.

b. Subattribute Utilization

Network connection data have their own characteristics, such as discrete and continuous attributes, and these attribute values are important information that cannot be lost. Therefore for avoiding information los s Subattribute utilization method is used. It concern about binary, symbolic, and continuous attributes to keep the completeness of data information. Binary attributes are divided into two subattributes corresponding to judgment functions. For example, binary attribute *A*1 (=land) was divided into *A*_11 (representing land= 1) and *A*_12 (representing land= 0). The symbolic attribute was divided into several subattributes, while the continuous attribute was also divided into three subattributes concerning the values represented by linguistic terms (low, middle, and high) of fuzzy membership functions predefined for each continuous attribute

c. Fuzzy Membership Function for Continuous Attributes and Node Transition

Each continuous attribute is divided into three subattributes with linguistic terms. A predefined membership function is assigned to each continuous attribute and the linguistic terms can be expressed by the membership function

The parameters α, β, and γ in a fuzzy membership function for attribute *Ai* is set as follows:

β = average value of attribute *Ai* in the database

γ = the largest value of attribute *Ai* in the database

$\alpha + \gamma = 2\beta$.

d. Rule Extraction by GNP with Fuzzy Membership Functions

GNP examines the attributes of tuples at judgment nodes and calculates the measurements of association rules at processing nodes [2]. Judgment nodes judge the values of the assigned subattributes, e.g., Land= 1, Protocol=tcp, etc. The GNP-based fuzzy class -association rule mining with subattribute utilization successfully combines discrete and continuous values in a single rule.

The extracted fuzzy class -association rules are stored in a rule pool through generations. When an important rule is extracted by GNP, it is stored in the pool with its support, confidence, $\chi 2$ value, and the parameters of the fuzzy membership function.

Calculation of $\chi 2$ value of rule $X \rightarrow Y$ is shown as follows. Assume support(X) = x, support(Y) = y, support($X \rightarrow Y$) = z, and the total number of tuples is N.

$\chi 2$ is calculated using following formula

$$\chi 2 = \frac{N(z-xy)^2}{xy(1-x)(1-y)} \quad (1)$$

If required, a fuzzy rule already stored in the pool would be extracted again. In that case, the membership function and $\chi 2$ value might be changed. If the fuzzy rule has higher $\chi 2$ value, it will replace the same old fuzzy rule in the pool along with its fuzzy parameters. Therefore, the pool is updated every generation and only important fuzzy rules with higher $\chi 2$ values and better-adapted fuzzy parameters are stored.

e. Classifiers for misuse and anomaly detection

After rule Extraction by GNP, classifiers for anomaly detection and misuse detection are built up for classifying new data correctly.

IV. RESULTS

a. Data Sets

The Defence Advanced Research Projects Agency (DARPA) DARPA98 and DARPA99 datasets provided by MIT Lincoln Laboratory are used as training datasets and real-time testing dataset is used for evaluation of system

b. Results

First classification of input training dataset is done as shown in Table 1. The training dataset are DARPA98 and DARPA99. From these datasets connections are classified as normal or intrusion.

Table 1: Classification of input training dataset as DARPA98 and DARPA99

Dataset	**Total number of Normal Connections**	**Total number of Intrusion Connections**
1998	114	432
1999	153	544

After classification of input training dataset, real time testing dataset is classified as normal connection or intrusion connection as shown in Table 2.

Table 2: Classification of input real time testing dataset

Dataset	**Total number of Normal Connections**	**Total number of Intrusion Connections**
1998	8	6
1999	10	1

V. CONCLUSION

A GNP-based fuzzy class-association-rule mining with sub attribute utilization and the classifiers based on the extracted rules have been proposed, which consistently uses and combine discrete and continuous attributes in a rule and efficiently extract many good rules for categorization. The important function of the proposed method is to efficiently extract many rules that are statistically significant and they can be used for several purposes. For example, GNP can extract many rules of normal connections and known intrusion connections from the training database. When we use them for misuse detection, the matching of a new connection with the normal rules and the intrusion rules are calculated, respectively, and the connection is classified into the normal class or intrusion class. When we use the rules
for anomaly detection, only the rules of the normal connections are used to calculate the deviation of a new connection from the normal area. Therefore, many rules extracted by GNP cover the spaces of the classes widely. The proposed method is used to improve detection rate (DR) and to reduce positive false ratio (PFR).

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