# Intrusion Detection In Mobile Ad Hoc Networks Using GA Based Feature Selection

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#### Abstract

Mobile ad hoc networking (MANET) has become an exciting and important technology in recent years because of the rapid proliferation of wireless devices. MANETs are highly vulnerable to attacks due to the open medium, dynamically changing network topology and lack of centralized monitoring point. The various attacks against mobile nodes are flooding, black hole, warm hole, packet dropping and Byzantine attack etc. It is important to search new architecture and mechanisms to protect the wireless networks and mobile computing application. Intrusion detection system (IDS) tools are suitable for identifying these attacks. IDS analyze the network activities by means of audit data and use patterns of well-known attacks or normal profile to detect potential attacks. There are two methods to analyze: misuse detection and anomaly detection. Misuse detection is not effective against unknown attacks and therefore, anomaly detection method is used. In this approach, the audit data is collected from each mobile node after simulating the attack and compared with the normal behavior of the system. If there is any deviation from normal behavior then the event is considered as an attack. Some of the features of collected audit data may be redundant or contribute little to the detection process. So it is essential to select the important features to increase the detection rate. This paper focuses on implementing two feature selection methods namely, markov blanket discovery and genetic algorithm. In genetic algorithm, bayesian network is constructed over the collected features and fitness function is calculated. Based on the fitness value the features are selected. Markov blanket discovery also uses bayesian network and the features are selected depending on the minimum description length. During the evaluation phase, the performances of both approaches are compared based on detection rate and false alarm rate.

*Keywords:* Anomaly detection, feature selection, markov blanket discovery, genetic algorithm.

## 1. Introduction

The rapid proliferation of wireless networks and mobile computing applications has changed the landscape of network security. The nature of mobility creates new vulnerabilities that do not exist in a fixed wired network, and yet many of the proven security measures turn to be ineffective. Therefore, the traditional way of protecting networks with firewalls and encryption software no longer sufficient. We need to develop new architecture and mechanisms to protect the wireless networks and mobile computing applications.

In traditional wireless networks, mobile devices associate themselves with an access point, which is in turn connected to other wireline machinery such as a gateway or name server that manages the network management functions. Ad hoc networks, on the other hand, do not have a centralized piece of machinery such as a name server, which if present, as a single node can be a single point of failure. The absence of infrastructure and the subsequent absence of authorization

facilities impede the usual practice of establishing a line of defense, distinguishing nodes as trusted and nontrusted. There may be no ground for an a priori classification, since all nodes are required to cooperate in supporting the network operation, while no prior security association (SA) can be assumed for all the network nodes. Freely roaming nodes form transient associations with their neighbors, joining and leaving sub domains independently with and without notice.

The wireless links between nodes are highly susceptible to link attacks, which include passive eavesdropping, active interfering, leakage of secret information, data tampering, impersonation, message replay, message distortion, and denial of service (DoS). Eavesdropping might give an adversary access to secret information, violating confidentiality. Active attacks might allow the adversary to delete messages, inject erroneous messages, modify messages, and impersonate a node, thus violating availability, integrity, authentication, and non repudiation.

The presence of even a small number of adversarial nodes could result in repeatedly compromised routes; as a result, the network nodes would have to rely on cycles of timeout and new route discoveries to communicate. This would incur arbitrary delays before the establishment of a non-corrupted path, while successive broadcasts of route requests would impose excessive transmission overhead. In particular, intentionally falsified routing messages would result in DoS experienced by the end nodes.

## 2. Related Work

Most of current works on IDS for ad hoc networks employ either distributed or cooperative architecture (i.e., node based IDS) or distributed and hierarchical architecture (i.e., cluster-based IDS). Zhang and Lee [11] proposed the first distributed and cooperative anomaly-based IDS framework. In this framework, local anomaly detection engine is built on a rule based classification algorithm. RIPPER and local response is activated when a node locally detects an anomaly or intrusion with high confidence. When a node detects an anomaly or intrusion with weak evidence, it then initiates a global intrusion detection procedure through a cooperative detection engine. Yu Liu and Yang Li [8] node-based anomaly IDS for ad hoc networks using cross-feature analysis technique. It uses the MAC layer feature set to characterize normal behavior of mobile nodes. They have illustrated how feature vectors are constructed from audit data, and how to perform cross-feature analysis on these feature vectors.

Chi Hoon Lee et al. [2] proposed another approach using Genetic algorithm (wrapper approach) combined with selective naïve bayesian classifiers (SNBN). They used GA for feature selection and SNBN for evaluation. This method extracts 21 relevant features out of 41 features of KDDCUP 99 data set by maximizing classification accuracy. Finally their experiments result shows that the performance of GA is impressive, compared to IDS with all features while detecting unknown attacks.

Srilatha Chebrolu et al. [3] used two data mining techniques namely Markov blanket feature selection and Classification and Regression Trees (CART) for feature selection and classification in intrusion detection system. The former method selects 12 features and the later method selects 17 features. The performance of each method was better for particular class of KDDCUP 99 data set. Therefore, the above two techniques were combined to create ensemble approach. Finally, they proposed a hybrid architecture involving ensemble and base classifiers for intrusion detection based on the performance of detection rate.

Gary stein et al. [4] used a genetic algorithm to find an optimal subset of features for decision tree classifiers based on the KDDCUP 99 data set. In this wrapper approach, the search component is a genetic algorithm and the evaluation component is a decision tree classifier. During feature selection the feature may be weeded out or selected as important features for next generation based

on gene frequency. Finally, the features having highest frequency of last generation is chosen for building final decision tree classifier.

Taeshik Shon et al. [5] also have proposed machine learning framework that uses Genetic Algorithm (GA) for feature selection and SVM for attack classification. The SVM combines the benefit of supervised and unsupervised learning. Finally the results are tested and compared with real world products such as Snort and Bro.Khaja Mohammad Shazzad and Jong Sou Park [6] have proposed a hybrid feature selection method, which combines Correlation-based Feature Selection (CFS), SVM and Genetic Algorithm (GA). GA is used to generate subsets of features from given feature set. Then, the generated subset is evaluated by CFS. Finally, the subset having highest merit was evaluated by SVM and that subset will be used for attack classification.

Yongxuan Zhu et al. [7] proposed a modified genetic algorithm to acquire the finally modified genetic algorithm, named RICGA (ReliefF Immune Clonal Genetic Algorithm), based on the ReliefF algorithm and Immune Clonal Selection algorithm, which is inspired by elitist reserved genetic algorithm. The RICGA method first employs ReliefF algorithm to remove the irrelevant features then uses genetic algorithm based on immune clonal selection algorithm to get optimal feature subset.

Sung et al. [10] use Support Vector Machines (SVMs) and Neural Networks to identify important features for 1998 DARPA Intrusion Detection data. They delete one feature at a time and build SVMs and Neural Networks using the remaining 40 features. The importance of this deleted feature depends on training time, testing time and the accuracy for SVMs or overall accuracy, false positive rate and false negative rate for Neural Networks. The same evaluation process is done for each feature. Features are ranked according to their importance. They conclude that SVMs and neural network classifiers using only important features can achieve better or comparable performance than classifiers that use all features

Most of the feature selection algorithms used Bayesian classifiers for attack classification. A. H. M. Rezaul Karim et al [1] proposed collaborative IDS for Mobile Ad Hoc Networks using Bayesian method. Bayesian method is used classify the event of audit data. In order to do that, Naive Bayes assumes the variables are independent of one another. This assumption is called class conditional independence. This approach achieved the overall detection accuracy of more than 90%.

Amor et al [9] build a predictive model to differentiate attacks and normal connections of KDDCUP 99 data set with naïve bayes and decision tree classifiers. They conclude that the naïve bayes classifier is competitive and required less training time than the decision tree classifier, although the latter had slightly better performance.

# 3. System Architecture

The main task of the intrusion detection system (IDS) is to discover the intrusion from the network packet data or system audit data. One of the major problems that the IDS might face is that the packet data or system audit data could be overwhelming. Some of the features of audit data may be redundant or contribute little to the detection process. So the reduction in the size of data set is needed. To perform the reduction, two methods of feature selection, namely, markov blanket discovery and genetic algorithm are proposed.

The Intrusion Detection System is distributed in nature so each node of a mobile ad hoc network equipped with an IDS. System

architecture of IDS comprises four components:

- Data collection module
- Profile module
- Feature selection module
- Intrusion Detection and Response module

#### **3.1.** Data collection module

The module collects audit data for each node. The proposed system considers unknown attacks. So the IDS need normal behavior of the system (normal profile) and violation of normal behavior (attack profile). Normal profile is created using the data collected during the normal scenario. Attack profile is created by simulating the attacks.



Figure 1. Proposed Intrusion Detection Model

## **3.2.** Profile module

In this module audit data is transformed into appropriate format for the detection process. From the attack data,

training data set is created to train the bayesian classifier. Training data consists of labeling of events whether it is a normal event or an attack. Test data is collected under simulated attack environment and it is given to the bayesian classifier to identify an event whether it is an attack or normal.

## **3.3.** Feature selection module

Feature selection is the process of selecting important features from the large data set. The selected features are relevant to the detection process. In order to perform this operation the following feature selection method is proposed. GA-based Feature selection algorithm is based on the wrapper model. In the adapted algorithm, the search component is a GA and the evaluation component is a bayesian network.

The initial population is randomly generated. Every individual of the population is represented by means of genes, each of which represents a feature. If the feature value is '1', it is used during constructing of bayesian network if it is '0' that feature is not used.

## **Random population:**

In Genetic feature selection the initial population is randomly generated. Each feature of a data set is represented in the form of gene and each record of a data set is represented in the form of chromosome. Each individual of a population consists of string of 1's and 0's.

## **Bayesian constructor:**

Bayesian network is constructed by using the selected features. It is trained by using training data. Training data consists of normal and intrusive events with labels. Each label is used to identify whether the particular event is normal or an attack.

#### **Bayesian Evaluator**

Constructed bayesian network is evaluated by using validation data. Validation data is like training data. Resulting bayesian network is tested with nine validation data sets based on the

labeling. Each validation data finds the classification error rates and it will be used during fitness computation.

#### **Fitness computation:**

The fitness of each individual is the aggregate total of all classification error rates. The lower the classification error rate, the better the fitness of individual. The fitness function is used a parameter to select the individual.

#### Generate next generation:

# Once the fitness of each individual in the population is computed, the GA operation is performed.

#### The algorithm for GA is

Procedure GA Begin Initialize population; Evaluate population members; While termination condition not satisfied do

#### Begin

Select parents from current population; Apply genetic operators to selected parents; Evaluate offspring; Set offspring equal to current population; End

End

This procedure is iterated until last generation. Finally, the features of best individual are considered as selected subset that will be given for classification purpose.

#### **3.4.** Intrusion Detection and Response module

This module detects deviation from the norm. In order to detect the anomalies Bayesian classifier is used. Classifier will be trained by the training data. The test data will be given as input to the trained Bayesian classifier. Any deviation from the threshold level is considered level as anomalies. Once all the attacks are identified then the notification will be given to all the nodes in the ad hoc environment.

#### 4. System Implementation

The IDS uses NS-2 simulator under LINUX environment for simulating the attacks in mobile ad hoc networks. The various parameters and its corresponding values of NS-2 simulation environment are given in table 4.1.AWK script is used for preprocessing the data sets.

#### NS-2 Simulator

NS-2 is a discrete event simulator and it is one of the most widely used network simulators for wired and wireless networks. It is based on two languages: an object oriented simulator, written in C++, and an OTcl (an object oriented extension of Tcl) interpreter, used to execute user's command

scripts. NS has a rich library of network and protocol objects. There are two class hierarchies: the compiled C++ hierarchy and the interpreted OTcl, with one to one correspondence between them. When a simulation completes at the end of simulation time, it will attempt to run a nam visualization of the simulation on the screen. The software developed is applicable to operate on AODV routing protocol for communication between the nodes. The nodes can able to pass the packet from source to the destination node in the MANET environment.

## Simulated attacks

In this project the black hole attack and flooding attack are simulated.

## **Flooding attack**

An attacker injects faked Route Request (RREQ) packets into the network. So all the nodes in MANET consumes its energy for transmitting unnecessary RREQ packets. Finally the nodes cannot transmit the data packets to the neighboring nodes.

#### **Black hole attack**

An attacker injects faked Route Reply (RREP) packets to the source node advertising that, it having shortest path to the destination. As a result the source node sends the data packets to the malicious node instead of destination node. The anomaly detection for MANET considers the characterization of normal behavior of mobile nodes. This technique detects the intrusion by comparing the normal behavior with the attack behaviors. So it is essential to collect normal and attack profile for each node.

Sno.	Parameters	Value
1	Simulation duration	100 seconds
2	Topology	1000m*1000 m
3	Number of mobile nodes	50
4	Transmission range	250 m
5	Node Movement model	Random waypoint model
6	Traffic type	CBR (UDP)
7	Data payload	512 bytes

## Table 1. NS-2 Simulation Environment

Normal profile is collected with the absence of attacks. The attack profile is created by simulating the black hole and flooding attacks. Various traffic related features are collected. They are listed in table 2.

#### **Table 2. Traffic related features**

Packet type	Data, ROUTE REQUEST, ROUTE REPLY, ROUTE ERROR and HELLO
Flow Direction	Sent, Received, Forwarded and Dropped

The data collected in a file is preprocessed to get appropriate form used for detection. The preprocessed data contains the details of transmitted data and routed packets to all the nodes. There are five packet types and four flow directions. HELLO packets will be sent and received by the neighboring nodes .So there is no forward and dropping of HELLO packets. Therefore, totally (5\*4-2) = 18 features are considered for intrusion detection [11].

#### Training data

The attack data is compared with normal profile and labeled. The classification label consists of two classes namely, normal and abnormal. This data set is used to train the Bayesian classifier.

Data packets	NBDataSend, NBDataRecv
	NBDataDrop, NBDataFwd
RREQ packets	NBRREQSend, NBRREQRecv
	NBRREQDrop, NBRREQFwd
<b>RREP</b> packets	NBRREPSend, NBRREPRecv
	NBRREPDrop, NBRREPFwd
RERR packets	NBRERRSend, NBRERRRecv
	NBRERRDrop, NBRERRFwd
Hello packets	NBHelloSend, NBHelloRecv

## Table 3. Collected features

NB represents Number of packets. Each feature is represented by a packet type and flow direction.

## Validation data

# The collected trained data will be divided into parts. That part will be a validation data. Test data

Test data is collected by simulating black hole and flooding attacks by varying the attackers. It will be given as input to the classifier to identify whether the particular event is an attack or normal.

Once the data is collected it will be given for feature selection module. The collected features converted in to chromosomes, then the bayesian classifier is constructed. Constructed classifier is trained with training data and validated by the validation data. The fitness function is computed based on classification error rates. The features having the lowest fitness value will be selected.

In order to perform the detection process supervised learning technique of Bayesian classifier is used. The selected features will be given as input to the classifiers. After classification the performance of detection is measured.

#### **5.** Performance evaluation

The effectiveness of the proposed anomaly detection will be evaluated using the performance measurement by the following parameters: Detection Rate, False Positive Rate and False Negative Rate. Detection Rate is defined as the ratio of the number of attacks being detected correctly to the total number of attacks occurred. False Positive Rate is defined as the ratio of the number of attack-free events falsely being identified as anomalies to the total number of events. False Negative Rate is defined as the ratio of the number of attack events falsely identified as normal events to the total number of events.

## 6. Conclusion and Future Work

In this the project, the anomaly detection method is applied for mobile ad hoc networks to detect the intrusions. This method uses the network layer data to characterize the behavior of mobile nodes. The audit data is collected from all the mobile nodes under various scenarios to classify the events. The normal profile is created under the absence of attacks and the attack profile is created

by simulating attacks such as black hole and flooding. After collecting the audit data, it was converted into an appropriate form for the detection process. The size of the audit data is reduced by means of feature selection technique. In order to perform the feature selection operation genetic algorithm is used. The selected features are used for detection. During the detection process, the attack profile is compared with the normal profile. If there is any deviation from the normal behavior then the event is labeled as an attack. Finally the performance of genetic feature selection method, therefore it will give reasonable improvement in performance. In future, the feature selection is evaluated with various different classifiers. Finally it will be combined to produce a desired result for different type of attacks.

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