COMPUTER INTRUSION DETECTION SYSTEM VIA PATTERN RECOGNITION TECHNIQUE

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DEDICATION

To my parents the symbols of giving, kindness, and sympathy, for there infinite support, for there ever lasting love and care, for their patients, faith, and for every thing I have today.

♣Thank you♣

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LIST OF ABBRIVIATIONS AND SYMBOLS

ABBRIVIATION	MEANING
ACK	Acknowledge
ANN	Artificial Neural Networks
ARPA	Advanced Research Projects Agency
ART	Adaptive Resonance Theory
ASNN	Associative Neural Network
BNN	Biological Neural Network
BSM	Basic Security Module
DARPA	Defense Advanced Research Projects Agency
DoS	Denial of Service
DR	Detection Rate
FAR	False Alarm Rate
FBNN	feed-forward backpropagation networks
FN	False Negative
FP	False Positive
FPR	False Positive Rate
GAU	Gaussian classifier
GEP	Gene Expression Programming
hardlim	Hard limit
hardlims	Symmetric hard limit
HYP	Hypersphere algorithm
ID	Identifier / or Intrusion Detection
IDP	IDProgram
IDS	Intrusion Detection System
ip	Input
IRBF	Incremental Radial Basis Function
IT	Information Technology
IW	Input Weight
KDD	Knowledge Discovery Database
K-M	K-Means
KNN	K Nearest Neighbor
LAN	Local Area Network
LEA	LEader Algorithm
LGP	Linear Genetic Programming
logsig	Log sigmoid
LVQ	learning Vector Quantization
MEP	Multi-Expression Programming
MLP	MultiLayer Perceptron
MSE	Mean-Squared Error

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N/A	**Not/Available**
NEA	**NEarest cluster Algorithm**
NIDS	**Network Intrusion Detection System**
NN	**Neural Network**
NNB	**Neural network Block**
PC	**Personal Computer**
PCC	**Principal Component Classifier**
PEs	**Processing Elements**
PN	**Positive Negative**
poslin	**Positive linear**
PSP	**Percentage Successful Prediction**
purelin	**Linear**
R2L	**Remote to Local**
radbas	**Radial basis**
RAM	**Random Access Memory**
RBF	**Radial Basis Function**
ROC	**Receiver Operating Characteristic**
satlin	**Saturating linear**
satlins	**Symmetric saturating linear**
SNN	**Shared Nearest Neighbor**
SOMs	**Self-Organizing feature Maps**
STD	**STandard Deviation**
SVM	**Support Vector Machine**
tansig	**Hyperbolic tangent**
TCP	**Transmission Control Protocol**
TP	**True Positive**
TPR	**True Positive Rate**
tribas	**Triangular basis**
U2R	**User to Root**

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Computer Intrusion detection System via Pattern Recognition Technique

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ABSTRACT

In this thesis, an intrusion detection system based on pattern recognition with neural network is proposed. A standard benchmark known as KDDCUP99, that contains a training dataset that has a size of 708 MB of 4898430 records and a testing dataset that has a size of 45.0 MB of 311032is used in training and testing. These datasets are found to be redundant, thus SQL commands are used to generate unique datasets. The redundancy factor of the training dataset is four and a half times of the distinct dataset and it is approximately four times of the testing.

After taking the average performance of the proposed classifier on both redundant and distinct datasets, it is found that performing the IDS on the redundant dataset gives higher performance results than applying the distinct/disjoint dataset. Therefore, testing on redundant dataset may give inaccurate high performance results. Because of the different redundancy factors in those datasets, it is advisable to use distinct datasets for any IDS performing on the KDDCup99. We propose to use of the TruePerformance measure that depends on Percentage Successful Prediction (PSP), False Positive Rate (FPR) and False Negative Rate (FNR) performance measurements instead of just using the True Positive Rate (TPR) and False Positive Rate (FPR) measurements.

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INTROUDUCTION

INFORMATION SECURITY

Introduction

In this section we will give some definitions of terminologies used in information security.

Information security

Information security is a commitment that combines the efforts of people, policy, education training, awareness, procedures and technology to improve the confidentiality, integrity and availability of an organization's information (Whitman and Mattord, 2008).

1.1 Confidentiality

"It is the protection of data from passive attacks" (Stalling, 2003).

1.2 Data Integrity

"The assurance that the received data does not contain any modification, insertion, deletion and is exactly as it was sent by an authorized user" (Stalling, 2003).

1.3 Availability

"It is the property of a system or a system resource being accessible and usable upon demand by an authorized system entity according to performance specifications for the system" (Stalling, 2003).

1.4 Threat

A potential for violation of security, this exists when there is a capability or a circumstance, or an action, or an event that destroys the security and causes harm. So it is a possible danger that might use a weakness (Stalling, 2003).

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1.5 Intruders

The most popular threats to security are the intruders and the viruses, the intruders are usually named hackers or crackers, try to gain additional privileges. There are three classes of intruders:

- Masquerader: Are person/persons who don't have authorization to use the computer, they penetrate a system's access controls to use a user's account; they are likely to be an outsider.
- Misfeasor: a legitimate user who misuses his/her privileges, or accesses not authorized data, programs or resources, it is usually insider.
- Clandestine user: an individual that takes supervisory control of the system and uses this control to escape or/and access controls or to block audit collection. Can be either insider or outsider (Stalling, 2003).

1.6 Virus

A virus is a program that attaches itself to other programs which may damage them; it is loaded onto a computer (Whitman and Mattord, 2008).

1.7 Attack

An act on system security that comes from an intelligent threat, there are two types of attacks one is the passive attack, while the other one is the active attack (Stalling, 2003).

1.8 Passive attacks

Passive attacks are like the type of eavesdropping and monitoring the transmissions. The objective of the attacker is to get information that is being transmitted. Passive attacks are very difficult to be detected because they do not cause any change in data, but can be easily prevented (Stalling, 2003). There are two types of passive attacks, they are:

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- Release of message contents: gathers the content of the message.
- Traffic analysis: the attacker can determine the location and identity of communicating hosts and determine the frequency and length of the messages being exchanged.

1.9 Active attacks

Active attacks involve some modification and creation of the data stream. This kind is hard to prevent, easy to detect (Stalling, 2003); it is classified into four categories:

- Masquerade: occurs when one entity pretends to be a different entity.
- Replay: includes the passive capture of data and its subsequent retransmission to produce an unauthenticated effect.
- Modification of messages: a part of the message is altered, or messages are delayed or reordered, to produce an unauthorized effect.
- Denial-of-Service: prevents the normal use of communication facilities, it may have a specific target, or disruption of an entire network, by disabling the network by overloading it with messages to spoil the performance (Stalling, 2003).

1.10 Denial of Service (DoS)

DoS attacks are active attacks. It makes a computer resource unavailable to its users, for example unavailable web pages. DoS have two forms:

- Force the victim to reset or consume the resources that it can't provide its service.
- Block the communication between the users and the victim.

For example the land attack**;** which sends a spoofed TCP SYN packet with the target host's IP

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address as both source and destination. This causes the target to reply to itself continuously and crash (en.wikipedia.org/wiki/Denial-of-service, 2008).

1.11 Remote to Local attacks (R2L)

R2L attacks are active attacks. The attacker sends packets to a machine over a network then exposes the machine's weakness to gain local access as a user (Mukkamala et al., 2004). For example loadmodule, which is appended to a secret file, then, removes important files (www.ll.mit.edu/IST/ideval/docs/1999/stealthy_u2r_table, 2008).

1.12 User to Root attack (U2R)

U2R attacks are active attacks. They are used to get unauthorized access to local root (administrator) and its privileges for example, rootkit attack, it is designed to take primary control of the operating system running on the hardware of a computer system, without authorization from the administrators, it exist for many operating systems, such as Microsoft Windows, Mac OS X , Linux and Solaris (en.wikipedia.org/wiki/Rootkit, 2008).

1.13 Probe attack

In probing a passive attack, the attacker scans a network to get information to look for weaknesses, for example, ipsweep attack (Mukkamala et al., 2004).

The category of the attacks spoken about in this section are those that are detected by intrusion detection systems tested on the KDD dataset in many years. The intrusion detection systems and their properties are described in the next section.

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PROTECTION MECHANISMS

Protection mechanisms

Protection mechanisms are included in the computer architecture; to support the some security policies. Security policy is a plan to influence and determine some decisions, such as classifying resources to employees for example the answer to the question, Who may use what information in a computer system. The protection mechanisms for the information are:

- Access control.
- Firewalls.
- Intrusion detection systems.
- Remote access protection.
- Wireless Networking protection.
- Scanning and Analysis Tools.
- Cryptography.

Figure (1) shows the spheres of security (Whitman and Mattord, 2008).

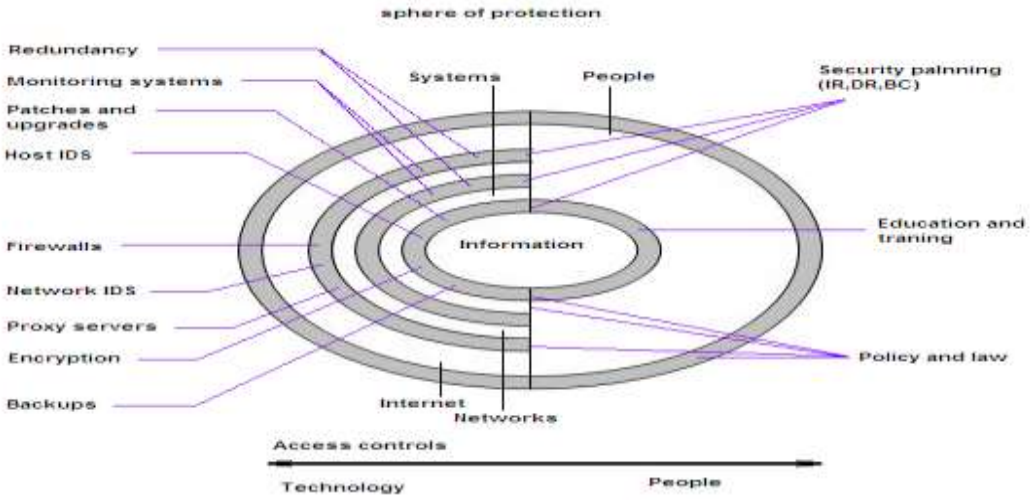

Figure (1) Spheres of security (Whitman and Mattord, 2008).

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1.14 Access control:

The prevention of unauthorized use of a resource (Stalling, 2003). The controls that protects against threats from out side the organization are shown in the left side of Figure (1), and the protection against threats from inside are shown on the right side of Figure (1). Because individuals inside the organization have direct access to the information, they can roll around many of the most technical controls (Whitman and Mattord, 2008), such as Finger prints, Identifying Cards…etc.

1.15 Firewalls

A firewall is any device that prevents some information from moving between the outside world and the inside world (Whitman and Mattord, 2008).

1.16 Remote access protection:

This type of protection is used for private networks, for example to protect the dial-up access from users (Whitman and Mattord, 2008).

1.17 Wireless Networking protection

The wireless network has a footprint (a geographical area to provides network connection), to protect this service from becoming abused some encryption techniques are used such Wired – Equivalent – Privacy (WEP) (Whitman and Mattord, 2008).

1.18 Scanning and Analysis Tools

This allows the administrator to see what an attacker sees, these tools can find weaknesses in a system and some unsecured points in the network, but cant know the unpredicted behavior of people these scanning tools collect information that is needed by the attacker to succeed

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(Whitman and Mattord, 2008).

1.19 Cryptography

Are embedded encryption technologies to keep private information concealed from unauthorized people, and can provide information integrity by for example hashing, and assures the authentic entities, encryption is a process to change the original message into other that cant be used by unauthorized entities(Stalling, 2003).

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INTRUSION DETECTION SYSTEM

Intrusion detection system (IDS)

In this section, intrusion detection will be defined. Some of intrusion detection benefits and characteristics. Intrusion detection is based on assumption that the behavior of the intruder is different from the behavior of a legitimate normal user, but however there is an overlap between the two as shown in Figure (2) (Stalling, 2003) .

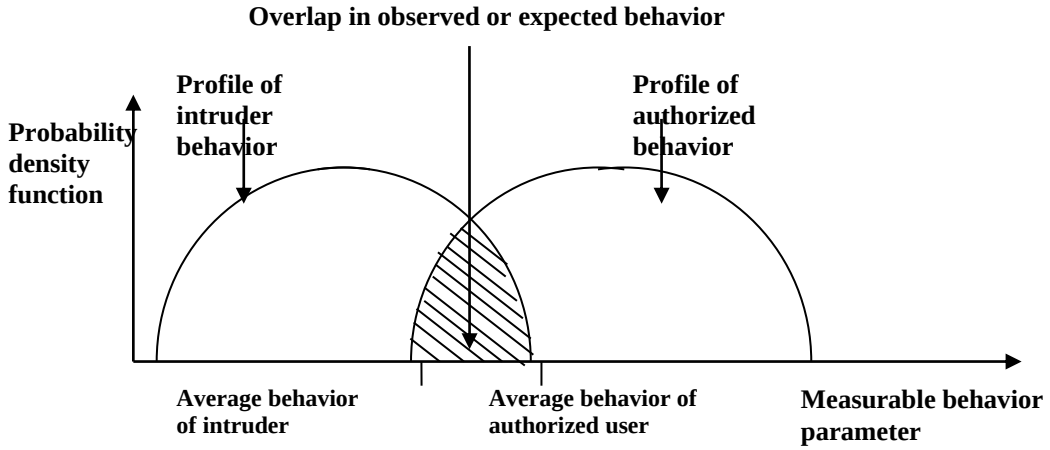

Figure (2) The profiles of behavior of intruders and authorized users (Stalling, 2003) page 570.

Intrusion detection is the process of monitoring and analyzing the events happening in a computer system or network to find any intrusions. Information security Intrusion Detection Systems (IDS) work like burglar alarms. When the system detects a violation (such as an opened or broken window) it executes an alarm. The alarm can be visible (such as noise and lights) or it can be invisible (silent) only sends a message to a monitoring part. The IDSs are either network-based to protect network information, or host-based to protect the server or host information, some of them are used to monitor both network connection activity and current information on host servers.

Because of the increasing in attacks on computers and networks in recent years, improved and automated surveillance has become a necessary addition to information technology (IT) security.

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1.20 Why using IDS?

The most important reasons of using IDS are that, if the intrusion is detected quickly, the intruder can be identified and blocked out from the system before any damage is done or any data are compromised, therefore quicker recovery can be done. Also detecting attacks and other violations, which have not been prevented by other protection mechanisms (such as firewalls, authentication…etc) (Stalling, 2003). There are two types of IDS used to analyze events and to detect attacks, these are:

1.21 Signature-base detection (Rule-based)

- Depends on previous representation of patterns known as intrusions, and then reports any matching to the patterns. These patterns are called signatures. This system examines data traffic for anything matches the signatures. It works like antivirus software.
- The disadvantage of it is that the signatures must be updated, for new attacks. And if the time spent for attacks, is long, the IDS may not detect it, in this case the IDS is based upon duration of the events. The only way to solve this problem is to collect and analyze data for longer time, this needs large data storage space and processing capacity (Whitman and Mattord, 2008).

1.22 Anomaly Detection

- Identifies anomaly (abnormal behavior). It requires the previous building of profiles for the normal traffic of users, hosts or network connections. Then it monitors current events

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- and uses different statistical measures and compares between user behavior and the profile built. These systems have high false alarms, because the user's behavior is unstable. The maintenance of these profiles has large overhead but they are able to detect unseen (new) attacks without previous details. The advantage of this IDS is the ability of the system to detect new types of attacks because it looks for abnormal activity of any type (Stalling, 2003) (Whitman and Mattord, 2008).
- The disadvantage is the need to match the whole activity with the normal profile; this may produce false alarms or called false positive rate (FPR) (Whitman and Mattord, 2008). This type of IDS is not commonly used (Stalling, 2003).

Important performance measures of the efficiency of an analysis technique are the FPRs, where normal connections are detected as abnormal, and the percentage of a more dangerous false negative (FN) attacks that are classified as normal. Other classifications of IDS are:

1.23 Host-based

- It works by classifying different categories of systems and data files. It provides few levels of alert notification. It looks for changes in file attributes (create, modify, delete), for example, an administrator could set the IDS to report an alarm when changes happen to some system folders such as (C:\Windows or C:\Winnt), or set it to instantly page or email them when some events occur, or just record them for other events. The most concern is when the unauthorized changes happen in sensitive areas; this kind can monitor many computers simultaneously. It is positioned on the machines as shown in the right side of Figure (3).

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1.24 Network-based (NIDS)

- It monitors the network traffic. When a previous known condition happens, the NIDS produces an alert. It looks for patterns of network traffic. This IDS is placed inside any network, shown in Figure (3). Its disadvantage that it needs a more complex configuration and maintenance than the host-based IDSs. It produces more FPR than the host-based IDSs, because it reads the network activity pattern to distinguish between normal and abnormal connections (Whitman and Mattord, 2008).

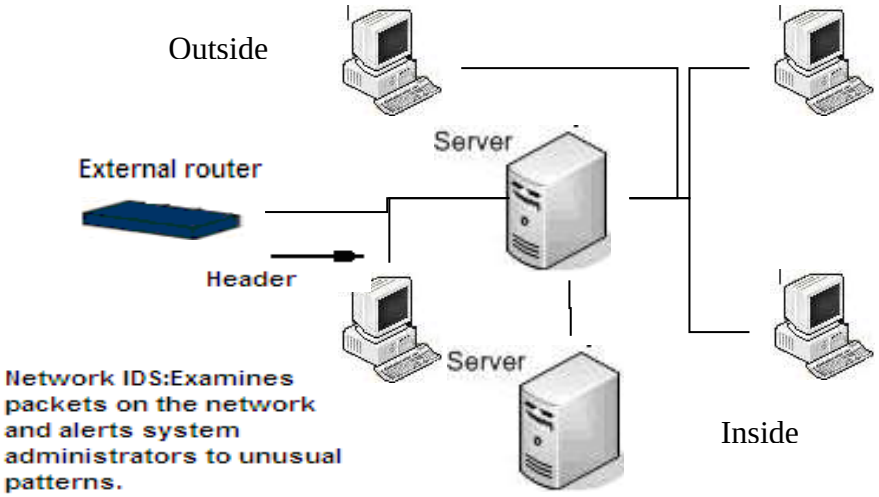

Figure (3) Position of network IDS (Whitman and Mattord, 2008).

Nowadays, many researchers, such as in (Agarwal and Joshi, 2000), (Levin, 2000), (Levin, 2002), (Yeung and Chow, 2002), (Sabhnani and Serpen, 2003), (Yao and Yao, 2007)…etc, turned into data mining and pattern recognition techniques to solve the security weakness. Data mining is the process of choosing useful and previously unnoticed patterns from large data stores. A wide range of IDS techniques has been applied to intrusion detections where we will discuss in the

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literature review section. Pattern recognition is a part of machine learning. It does the action depending on the category of the data given. Most research in pattern recognition is about methods for supervised learning and unsupervised learning (en.wikipedia.org/wiki/Pattern_recognition, 2008).

A receiver operating characteristic (ROC) curve, is a graphical plot, it is represented by plotting TPR versus FPR. ROC is also called Relative Operating Characteristic curve. ROC analysis is related in a direct way for cost/benefit analysis of diagnostic decision making. It is widely used in machine learning and data mining (en.wikipedia.org/wiki/ROC_curve, 2008).

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PATTERN RECOGNITION USING NEURAL NETWORKS

Pattern Recognition

The objective of pattern recognition is to classify data (called patterns) depending on previous information taken from them. Theses data can be a collection of measurements or observations, in a multidimensional space. Any algorithm can be applied such as simple Bayesian classifiers and powerful neural networks. In this section we will consider the K-means, clustering and neural network methods.

1.25 Neural networks

Neural Networks (NN) is an active area of research based on human brain. This field has many names such as (connectionism, parallel distributed processing, neuro-computing, natural intelligent systems, machine learning algorithms, and artificial neural). There are two kinds of NNs, Artificial neural network and Biological neural network (BNN).

1.26 Artificial neural networks (ANNs)

ANNs are used perfectly for pattern recognition, and have good training capabilities (leenissen.dk/fann/report/node4, 2008). They are used to understand the BNN by simulating some properties of the human brain, for solving problems, providing a powerful and speedy tool for building classifiers (Duda et al, 2007). ANNs change their structure based on external or internal information that flows through the neural network, and have good generalization (if they were not over-fitted discussed later); the ANN is a network of a large number of highly connected (dense) processing elements (PEs) (neurons) working to solve a specific problem, each PE has probably a

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small amount of memory, these connection are unidirectional, we will use NN as a brief of ANN for simplicity.

Neural Networks (NN) are similar to a basic knowledge of how the brain works. The brain is an important part of the central nervous system, we can think that it consists of a very large NN; Figure (4) shows the nervous network in the brain. The biological neurons are much more complicated than the mathematical neurons. Neurons are electrically executable cells in the neurons system that process and transmit information. The center of the neuron is called the nucleus. When a neuron receives electrical pulses higher than a threshold amount, it activates and sends a pulse to other neurons through synaptic connection to reach the dendrites of other neurons. The synaptic connections are changeable and the threshold changes too. Neurons could activate in parallel, because the computation of each neuron is independent, this will cause that the information propagates through the NN (called training), then the NN learns, so the NN learns from examples. A simplified neuron is shown in Figure (5), the general mathematic definition of a neuron is shown in equation (1), and a mathematical model of a neuron is shown in Figure (6), if the node had just one output it would be called a perceptron (leenissen.dk/fann/report/node4, 2008).

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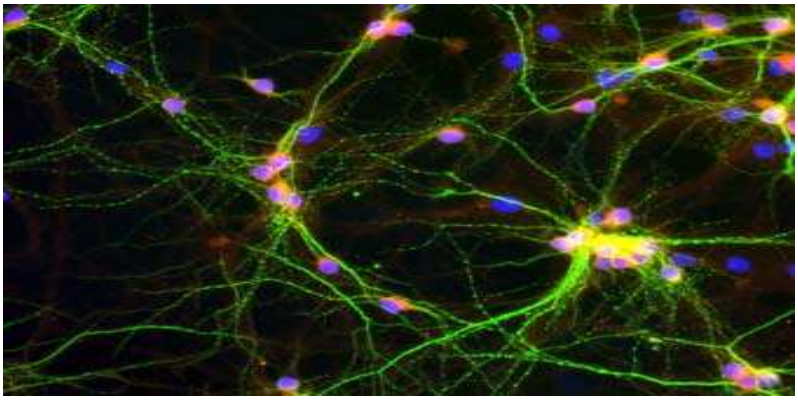

Figure (4) The nervous system in the human brain (Hagen , 2006).

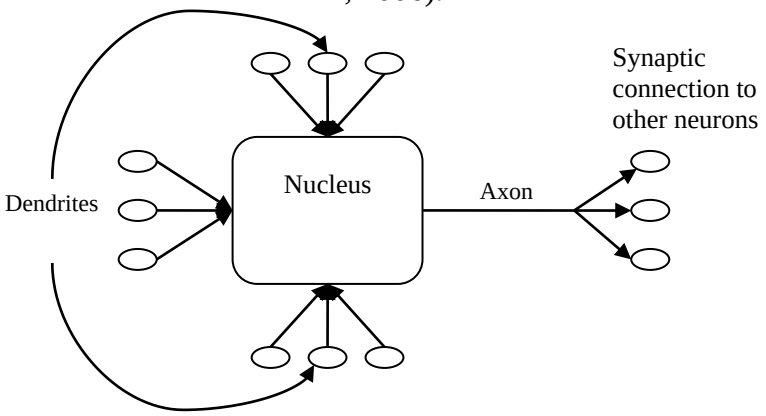

Figure (5) A simplified biological neuron (leenissen.dk/fann/report/node4, 2008).

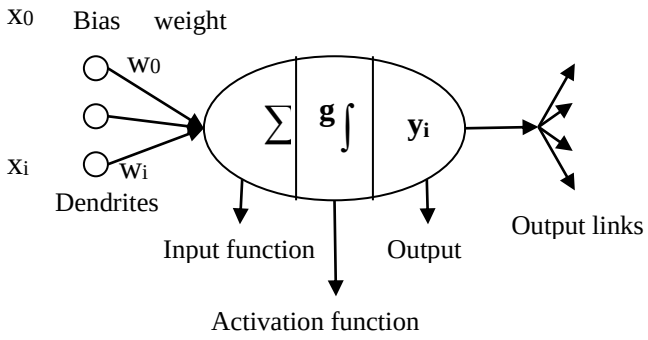

Figure (6) Mathematical model for an artificial neuron (leenissen.dk/fann/report/node4, 2008).

$$y(x) = g(\sum_{i=0}^{n} wi * xi) \qquad \text{.....(1)}$$

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Where *x* is the input and y is the output, w is the weight of the link between the layers, and g is the activation function (transfer function). In the simplest case, *g* is the identity function, and the output is just its net input ($w_i x_i$). This is called a linear unit. The most common activation functions used for example threshold as shown in equation (2), and sigmoid, and *w* is the weight of an input (strength of the connection) (leenissen.dk/fann/report/node4, 2008).

$$g(x) = \{0 \quad if \quad x+t \leq 0, \quad 1 \quad otherwi \quad \text{.....(2)}$$

Where t is the threshold.

1.27 Training (learning) a NN model

This procedure selects a training function for a minimum cost. There are many algorithms for training NN models; the cost shows us how much we are far from the optimal solution to our problem (en.wikipedia.org/wiki/Artificial_neural_network, 2008).

1.28 Benefits of NNs

- Problems can be symbolized into network architectures by selecting units, feedback connections, number of hidden layers, for example (number of inputs is the feature space dimension and the number of outputs of the network is the number of categories).
- Enables classifier designers to try (many, fast, parallel) models, because selecting topologies and parameters of the network are simple (Duda et al, 2007) (en.wikipedia.org/wiki/Artificial_neural_network, 2008).
- The designer gains experience through analysis and repeated experiments.
- To gather between the computational capability of computers and some desirable functions

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of the human brain (such as recognizing patterns including noise, recall memories, make decisions for problems based on experience …etc) (Duda et al, 2007).

- Their ability to be used as an arbitrary function approximation mechanism which 'learns' from observed data.
- Almost any algorithm will work well with the correct parameters for training on a particular fixed dataset.
- Needs a large amount of experimentations until the best is chosen.
- It is powerful (robust) when the (structure, and cost function, and learning algorithm) are carefully selected.
- Can be used for large dataset applications.
- Are able to deal with incomplete or noisy data.
- Effective when there is no rules or steps to guide to the solution of the problem.
- Partial recovery from damage is possible
    - When healthy neurons learn to operate the functions previously done by the damaged ones (en.wikipedia.org/wiki/Artificial_neural_network, 2008).

1.29 Architecture of NNs

The architecture of a network shows the number of layers in a network, the number of neurons in every layer, the transfer function of each layer, and the connection between layers (Ljung, L., 2007). The architecture or topology of the network is important for NN classification; the best architecture depends on the nature of the problem it deals with (en.wikipedia.org/wiki/Artificial_neural_network, 2008). The networks have three kinds of layers, an example of NN architecture is shown in Figure (7):

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Input layer: where its number is the dimension of the feature space, which is just a passing layer with no processing.

- Output layer: its number is the number of categories is an active layer processes an activation function.
- Hidden layer: placed in between the input and output layer and there activation are not directly seen by the input and output layers.

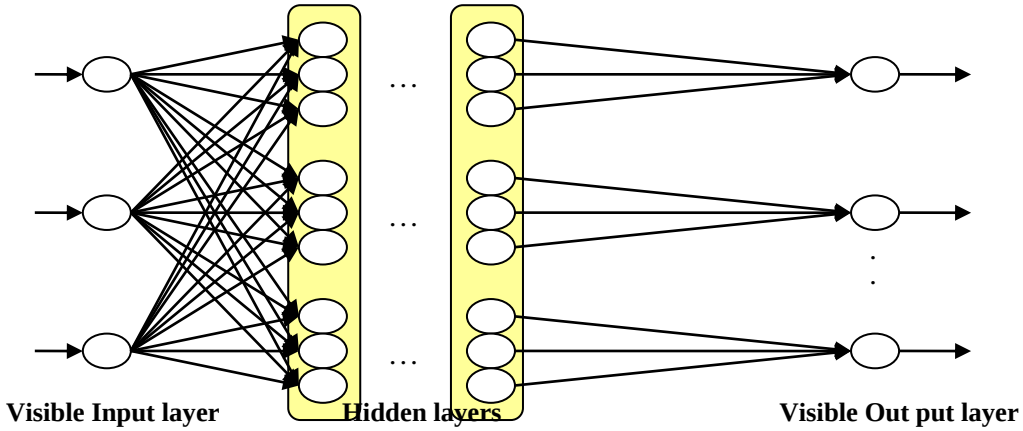

Figure (7) Example of NN architecture.

The input layer is connected to the hidden layers by modifiable weights. The weights are modified by learning. There is a single bias unit in each layer (a bias is a neuron parameter that is used to generate the output as shown in equation (1)) connected to all units other than the input units. There are a number of neurons in each hidden layer. Every hidden unit sums the product of the weights of its inputs (input function) with the inputs to create the net activation (or called net) (Duda et al.,). NN topology can be classified as single layer, multilayer, recurrent, and self organized.

1.30 Some types of NNs

- Feed forward backpropagation NN.
- Radial basis function (RBF) network.

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- Kohonen self-organizing network.
- Recurrent network: such as (Simple recurrent network …)
- Stochastic NNs, such as (Boltzmann machine)
- Modular NNs, such as (Associative Neural Network (ASNN)…).
- Holographic associative memory, such as (cascading NNs…) (leenissen.dk/fann/report/node4, 2008).

In this thesis the discussion will be about the multi-layer feedforward network, because of these properties:

- Easy to use small number of parameters.
- Most commonly used.
- Give a network greater freedom:
    - In constructing and design of networks.
- It is a directed acyclic graph (easy to understand).
- Not time dependent (Ljung, L., 2007).

In this kind of NN , each layer only receives the inputs from previous layers; starts from the input layer until the output layer (where the output is returned) through any number (or none) of hidden layers. The connections of the forward NN only move in one direction, the feed forward NN works in two phases:

- Training phase:
    - Here the NN is trained on some set of data, to produce a specific output for a specific input.
- Execution phase or called Testing phase:

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- Here the NN produces outputs depending on only the inputs (leenissen.dk/fann/report/node4, 2008).

1.31 Learning Strategies

There are three types of NN learning rules; NNs must be first trained before being used to analyze new data, these algorithms modify the weights, and biases of a NN, they are:

- Supervised learning.
- Unsupervised learning.
- Reinforcement learning.

But through training it is preferred to avoid over-fitting, when a NN is over-fitted, this means the ANN is too specific, and it gives correct outputs for the training data, but wrong results for new cases (en.wikipedia.org/wiki/Artificial_neural_network, 2008).

1.31.1 Supervised learning

Supervised learning is a method of machine learning , here a set of samples (or called training set) are given to the NN in pairs (input, target). When applying the inputs to the NN, the outputs are then compared to the targets given for each input, so the learning rule will adjust the biases and weights of the NN to get close to the targets, as shown in Figure (8) (Ljung, L., 2007). The supervised learning paradigm can also be applied on sequential data such as speech and gesture recognition (en.wikipedia.org/wiki/Artificial_neural_network, 2008). An example of a NN that uses supervised learning is the Feed-forward backpropagation NNs.

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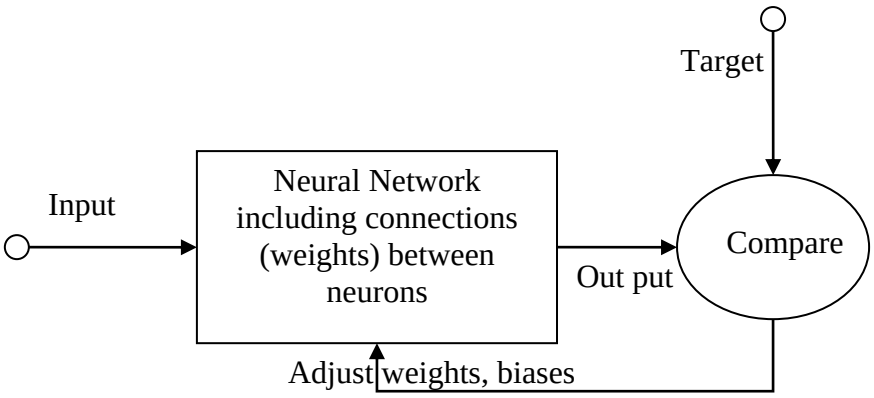

Figure (8) The process of supervised training in NNs (Ljung, L., 2007).

1.31.2 Unsupervised learning

Unsupervised learning is a method of machine learning; here the (weights, biases) are changed depending only on the network inputs. There are no target outputs (no teacher). It can be used, to identify groups of data; an example of a NN that uses unsupervised learning is the Hopfield NNs. Some examples of unsupervised learning are:

- Clustering operations.
- Data compression (Ljung, L., 2007).

1.31.3 Reinforcement learning

It is a sub-area of machine learning interested in how an agent must take actions in an environment to maximize some reward (For example, when training an animal a new trick , if it did the trick right it will be rewarded , but if it didn't it will be punished. It has to know what it did to be rewarded or punished; this is called the credit assignment problem. A similar method is used to

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train NNs to do many tasks, such as playing chess, scheduling jobs, and controlling robot limbs). The objective is to discover a way for selecting actions that minimizes some measure of a cost. The difference between Reinforcement learning and supervised learning is:

- The input/output pairs are not presented in it.
- The sub-optimal actions are not corrected.
- It focuses on on-line performance (Ljung, L., 2007).

1.32 Some training functions

The basic feedforward-backpropagation algorithm is a method to find weights for a multi-layer feed forward network ,it carries an input through the NN, then the error is calculated and the error is transmitted back through the NN and the weights are modified, to make the error smaller (leenissen.dk/fann/report/node4, 2008), these weights are modified in the steepest descent direction (Steepest descent is an optimization algorithm, to find a local minimum of a function, the procedure is to Take steps proportional to the negative of the gradient of the function from the current point. This is called also Gradient descent). This is the direction where the performance quickly decreases (reaches to the goal), but this does not produce the fastest convergence. In the conjugate gradient algorithms (which is an iterative method, to solve optimization problems (en.wikipedia.org/wiki/Gradient_descent, 2008)), a search is performed along conjugate directions this produces faster convergence than the prior (en.wikipedia.org/wiki/Neural_network, 2008), Figure (9) shows the difference of both.

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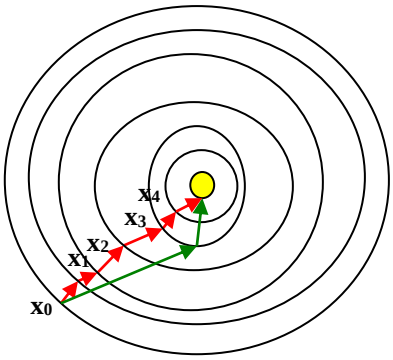

Figure (9) A comparison of the convergence process of steepest descent in thin and conjugate directions in thick (en.wikipedia.org/wiki/Gradient_descent, 2008).

The training stops when some conditions happen, such as:

- The maximum number of epochs is reached.
- The maximum amount of time has been exceeded.
- Performance reached to the goal (Ljung, L., 2007).

1.33 Some of the common error performance functions:

1.33.1 Mean-squared error (MSE) function:

- MSE tries to minimize the average error between the network's outputs, with the targets value y for all the example pairs (input, target) (en.wikipedia.org/wiki/Artificial_neural_network, 2008).
- The better way for minimizing the MSE for all the training data, is to train on data sequentially, one input after another at a time, not training on the combined data. This provides an efficient way of avoiding getting stuck in a local minima (leenissen.dk/fann/report/node4, 2008).

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- Gradient descent function:
- It is used in most of the algorithms used in training ANN (en.wikipedia.org/wiki/Artificial_neural_network, 2008).
- It is used for MLP (en.wikipedia.org/wiki/Artificial_neural_network, 2008), it makes changes to (weights, biases), these changes are to find the global minimum of error for a network (Ljung, L., 2007).

The following are four different examples for the conjugate gradient algorithms (Ljung, L., 2007).

1.33.1.1 Fletcher-Reeves Update (traincgf):

- It modifies the (weight and bias) depending on the conjugate gradient backpropagation with Fletcher-Reeves updates.

1.33.1.2 Polak-Ribiére Update (traincgp):

- It modifies (weight and bias) depending on the conjugate gradient backpropagation with Polak-Ribiere updates.

1.33.1.3 Powell-Beale Restarts (traincgb):

- It modifies (weight and bias) depending on the conjugate gradient backpropagation with Powell-Beale restarts.

1.33.1.4 Scaled Conjugate Gradient (trainscg):

- It modifies (weight and bias) depending on the scaled conjugate gradient method.
- This function does not use a line search in each iteration, so it is faster than the previous ones (Ljung, L., 2007).

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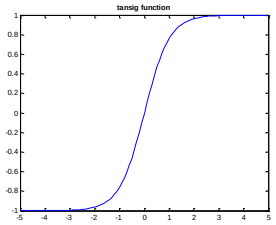
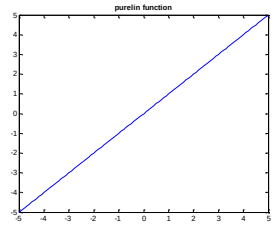
1.34 Some of the common transfer functions

Transfer function is the function that maps a neuron's (or layer's) output to its actual output. In this section some of these functions are executed in MATLAB, the result is shown in Table (1) (Ljung, L., 2007), some of these functions are as follows:

- Hyperbolic tangent sigmoid transfer function (tansig) ,this function we used in our work:
    - It is mathematically equivalent to the function tanh (n), but it runs faster, with a small difference in the results.
    - It is a good for neural networks, because speed is important and the exact shape of the transfer function is not.
- Linear transfer function (purelin):
    - The output of this function is the input to this function

Table 1 Details of transfer functions (Ljung, L., 2007).

Function name	create a NN by calling	algorithm	Shape
Hyperbolic tangent sigmoid transfer function			
tansig	newff, newcf.	$N=(2/(1+\exp(-2*n)))-1$	
Linear transfer function			
purelin	newlin , newlind	purelin(n) = n	

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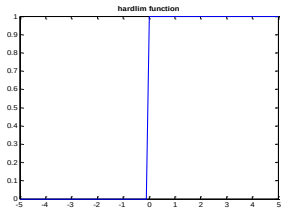
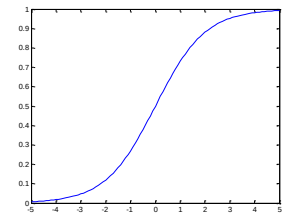
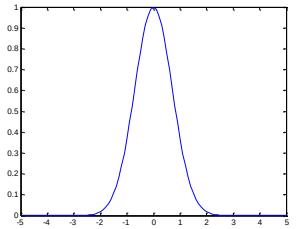
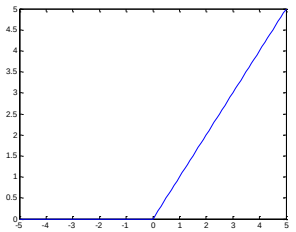
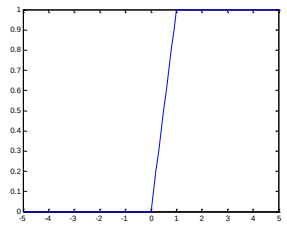
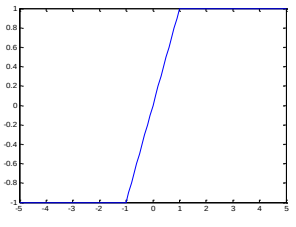
Hard limit transfer function			
hardlim	newp	$hardlim(N)=\{1 \ if \ n\geq 0, \ 0 \ otherwi$	
Log sigmoid transfer function			
logsig	newff , newcf	$logsig(N)=1/(1+\exp(-n))$	
Radial basis transfer function			
radbas	newpnn, newgrnn	$a=\exp(-n^2)$	
Positive linear transfer function			
poslin	$poslin(n)=\{n \ if \ n\geq 0, 0 \ otherwi$		
Saturating linear transfer function			
satlin	$satlin(n)=\begin{cases}0 & if \ n\leq 0 \\ n & if \ 0\leq n\leq 1 \\ 1 & if \ 1\leq n\end{cases}$		
Symmetric saturating linear transfer function			
satlins	newhop	$satlins(n)=\begin{cases}-1 & if \ n\leq -1 \\ n & if \ -1\leq n\leq 1 \\ 1 & if \ 1\leq n\end{cases}$	

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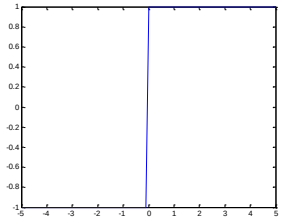
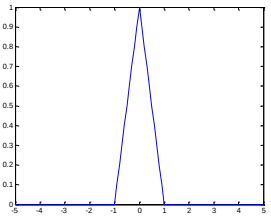
Symmetric hard limit transfer function			
hardlims	newp	$hardlims(n) = \begin{cases} 1 & if \quad n \geq 0 \\ -1 & otherwise \end{cases}$	
Triangular basis transfer function			
tribas		$tribas(n) = \begin{cases} 1-\lvert n \rvert & if \quad -1 \leq n \leq 1 \\ 0 & otherwise \end{cases}$	

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PROBLEM STATEMENT

Due to the exponential increase and use of networked computers, computer security has become a very important topic for academics and Information Technology (IT) cooperation as well. All networked computers, by different degrees, are vulnerable to malicious attacks that result security violations, such as unauthorized user access to a system (Frank, 1994). Previous security approaches have focused on preventing threats from occurring through the use of firewalls and security policies…etc. The complete attack prevention is not realistically possible because of the complexity of most systems. The configuration and administration errors and abuse by authorized users may all weaken the attack prevention. Therefore, talking about attack detection using pattern classification is more realistic and has been an important aspect of recent computer security researches and efforts (Ghosh et al., 1999) (Paxon, 1997). This thesis uses NN combination system for classification of normal and attack connections.

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1.35 Input datasets to our IDS

The purpose of this thesis is to focus on the IDS and the input data nature to it as a component of the IDS. Doing this research online using real-world networks and Internet traffic is very difficult because of the short-lived nature of packets limits the detection of attacks, and needs a real environment and the existence of real attacks accruing with the knowledge of the time and source of attack and many other requirements. The 'Knowledge Discovery Database (KDD) Cup 1999 Data' is presented as the data source; the purpose of this data is to provide designers of IDS with a benchmark to evaluate different methodologies, so it is used for our work. These data were derived from one of the original DARPA data sets produced in 1998. DARPA is the Defense Advanced Research Projects Agency that was working on interconnecting networks; DARPA is developed from the initial ARPAnet, which is a single, closed network (Kurose and Ross, 2005). There was two parts in the 1999 DARPA Intrusion Detection Evaluation:

- Off-line evaluation.
- Real-time evaluation (www.ll.mit.edu/IST/ideval/pubs/pubs_index, 2008).

For the off-line evaluation (this is used in this thesis) the IDS were tested using network traffic collected on a simulation network by a sniffer that records them using the tcpdump format. The source of these Data sets used is the tcpdump audit data sets. The network topology involves several LAN networks to simulate the victim machines (as an inside network) and a simulated real-world Internet traffic (an outside network), see Figure (10). IDSs were tested as part of the off-line evaluation, the real-time evaluation or both (www.ll.mit.edu/IST/ideval/pubs/pubs_index, 2008),

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the attacks fall in one of five categories (probe, DoS, U2R, and R2L) described in previous section.

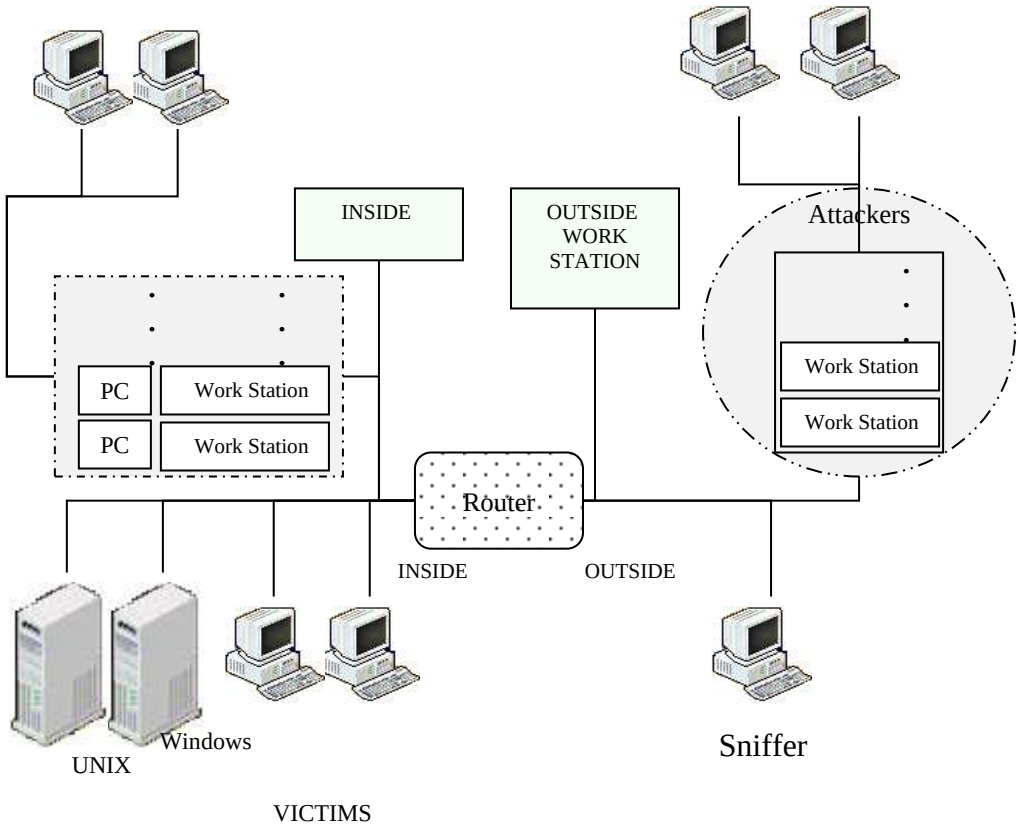

Figure (10) The network simulation model used for traffic collection (Lippmann et al,2000).

The training data was provided in a period of three weeks for the DARPA1999 ID off-line evaluation. The 1'st and 3'rd weeks don't have any attack data. The 2'nd week has some attacks from the 1998 evaluation and some new attacks (www.ll.mit.edu/IST/ideval/pubs/pubs_index, 2008) these data were labeled with the attack types or normal as the 42'Th feature of the dataset. Tcpdump is a UNIX tool used to collect TCP packets from the network. It was executed (three times for intrusions and once for normal network traffic) to collect only the headers of the network packets that were passing through the network interface from outside and also the headers of the broadcasted packets inside the network (Lee and Stolfo, 1998). The KDDCUP99 data files that we used are the following:

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- Kddcupnames: this file contains the list of fields (features) of the packet.
- Kddcupdata.zip: contains the full training dataset that has a size of 708M uncompressed file. This file is used in the analysis that would be denoted as KDDdata for short.
- Kddcupdata10percent.zip: contains a 10% subset of the KDDdata file has a size of 75M uncompressed file. This is not used in the analysis since it is a subset of KDDdata.
- TrainingAttackTypes: contains a list of only 23 attack types including normal.
- Corrected.zip: contains the full testing data with labels. Called corrected that has a size of 45.0MBuncompressed (www.acm.org/sigs/sigkdd/kddcup/index.php?section=1999&method=info, 2008).

The features of KDDCup99 of the network packet extracted by the tcpdump tool, with their description are shown in Table (2).

Table 2 The fields of KDDCUP99 datasets with there (Meaning and type).

Fields of the KDDCUP99 and there Meaning and type		
F1	Duration	length (number of seconds) of the connection continuous
F2	protocol_type	type of the protocol, there are 3 types.
F3	Service	network service on the destination, they are 70 types
F4	flag	Normal or error status of the connection discrete, there are 11 types.
F5	src_bytes	# of data bytes from source to destination. Continuous.
F6	dst_bytes	# of data bytes from destination to source .Continuous
F7	land	# of data bytes from destination to source .Continuous
F8	wrong_fragment	# of data bytes from destination to source .Continuous
F9	urgent:	1 if connection is from/to the same host/port; 0 otherwise .Discrete
F10	hot	# of ``wrong'' fragments .Continuous
F11	num_failed_logins	# of urgent packets .Continuous
F12	logged_in	# of ``hot'' indicators .Continuous
F13	num_compromised	# of failed login attempts. Continuous
F14	root_shell	1 if successfully logged in; 0 otherwise. Discrete
F15	su_attempted	# of ``compromised'' conditions. Continuous
F16	num_root	1 if root shell is obtained; 0 otherwise .Discrete
F17	num_file_creations	1 if ``su root'' command attempted; 0 otherwise .Discrete
F18	num_shells	# of ``root'' accesses. Continuous
F19	num_access_files	# of file creation operations .Continuous
F20	num_outbound_cmds	# of shell prompts .Continuous
F21	is_host_login	# of operations on access control files .Continuous
F22	is_guest_login	# of outbound commands in an ftp session .Continuous
F23	count	1 if the login belongs to the ``hot'' list; 0 otherwise .Discrete
F24	srv_count	1 if the login is a ``guest'' login; 0 otherwise .Discrete
F25	serror_rate	# of connections to the same host as the current connection in the past two seconds .Continuous

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F26	srv_serror_rate	# of connections to the same service as the current connection in the past two seconds. Continuous
F27	rerror_rate	# of connections that have ``SYN" errors .Continuous
F28	srv_rerror_rate	# of connections that have ``SYN" errors .Continuous
F29	same_srv_rate	# of connections that have ``REJ" errors .Continuous
F30	diff_srv_rate	# of connections that have ``REJ" errors .Continuous
F31	srv_diff_host_rate	# of connections to the same service .Continuous
F32	dst_host_count	# of connections to different services .Continuous
F33	dst_host_srv_count	# of connections to different hosts .Continuous
F34	dst_host_same_srv_rate	Percentage of connections having the same destination host and using the same service. Continuous
F35	dst_host_diff_srv_rate	Percentage of different services on the current host. Continuous.
F36	dst_host_same_src_port_ rate	Percentage of connections to the current host having the same src port. continuous
F37	dst_host_srv_diff_host_r ate	Percentage of connections to the same service coming from different hosts. continuous
F38	dst_host_serror_rate	Percentage of connections to the current host that have an S0 error. continuous
F39	dst_host_srv_serror_rate	Percentage of connections to the current host and specified service that have an S0 error. continuous
F40	dst_host_rerror_rate	Percentage of connections to the current host that have an RST error. continuous
F41	dst_host_srv_rerror_rate	Percentage of connections to the current host and specified service that have an RST error. continuous
F42	Attack name	There are 39 attacks

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1.36 The Encodings for the datasets

For using neural networks an encoding is preformed on the string values to numbers of the features of the datasets. Table (3) shows our encoding for these features .

Table 3 The encoding of the string features of KDDCup99.

a)

Flag	Encoding
RSTR	0
S0	1
SF	2
REJ	3
S1	4
RSTO	5
OTH	6
RSTOS0	7
S2	8
S3	9
SH	10

b)

Protocol type	Encoding
Udp	0
TCP	1
ICMP	2

c)

Attack category	Encoding
PROB	1
DoS	2
U2R	3
R2L	4
Normal	5

d)

Service	Encoding	Service	Encoding	Service	Encoding
Auth	0	iso_tsap	24	Smtp	48
Bgp	1	klogin	25	sql_net	49
Courier	2	kshell	26	ssh	50
csnet_ns	3	ldap	27	sunrpc	51
Ctf	4	link	28	supdup	52
Daytime	5	login	29	systat	53
Discard	6	mtp	30	telnet	54
Domain	7	name	31	tftp_u	55
domain_u	8	netbios_dgm	32	tim_i	56
Echo	9	netbios_ns	33	time	57
eco_i	10	netbios_ssn	34	urp_i	58
ecr_i	11	netstat	35	uucp	59
Efs	12	nnsp	36	uucp_path	60
Exec	13	nntp	37	vmnet	61
Finger	14	ntp_u	38	whois	62
ftp	15	other	39	X11	63
ftp_data	16	pm_dump	40	Z39_50	64
Gopher	17	pop_2	41	Aol	65
Hostnames	18	pop_3	42	Harvest	66
http	19	printer	43	http_2784	67
http_443	20	private	44	http_8001	68
icmp	21	remote_job	45	red_i	69
imap4	22	rje	46	urh_i	70
IRC	23	shell	47		

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There are 23 attack type including the normal records in the training dataset and 40 in the testing dataset also including the normal. Table (4) shows the encoding for these attack type and their categories that are used for preprocessing the data before entering the IDS system for both training and testing phases.

Table 4 All attacks and their categories for both the training and testing datasets of the KDDCUP99 used.

Attack Name (type)	Encoding Attack ID	Attack Category	Encode Attack Category	Attack Name	Encoding Attack ID	Attack Category	Encode Attack Category
back.	1	DOS	2	portsweep.	20	prob	1
buffer_overflow.	2	U2R	3	rootkit.	21	U2R	3
ftp_write.	3	R2L	4	warezclient.	22	R2L	4
guess_passwd.	4	R2L	4	spy.	23	R2L	4
satan.	5	prob	1	apache2.	24	DoS	2
imap.	6	R2L	4	mailbomb.	25	DoS	2
ipsweep.	7	prob	1	mscan.	26	prob	1
land.	8	DoS	2	named.	27	R2L	4
loadmodule.	9	U2R	3	processtable.	28	DoS	2
smurf.	10	DoS	2	ps.	29	U2R	3
teardrop.	11	DoS	2	saint.	30	prob	1
multihop.	12	R2L	4	sendmail.	31	R2L	4
warezmaster.	13	DoS	2	snmpgetattack.	32	R2L	4
neptune.	14	DoS	2	snmpguess.	33	R2L	4
nmap.	15	prob	1	sqlattack.	34	U2R	3
normal.	16			udpstorm.	35	DoS	2
perl.	17	U2R	3	worm.	36	R2L	4
phf.	18	R2L	4	xlock.	37	R2L	4
pod.	19	DoS	2	xsnoop.	38	R2L	4
xterm.	39	U2R	3	httptunnel.	40	R2L	4

After many analyses using the SQL commands it is realized that there is a great deal of redundancy in these datasets so a two different datasets are generated, both encoded but one with non-redundant samples that have no common (disjoint) records with the training dataset, the resulted number of samples after uniqueness is shown in Table (6), then they are divided into a total of 73 text files each one for a different attack type for the training and testing dataset, to be read from our program for the training we used the KDDdataset distinct and for the testing we used the

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Corrected distinct and disjoint dataset, Table (7) shows the percentage of redundancy for each attack category included the normal. In Table (5) a sample of KDDCup99 before and after encoding is shown.

Table 5 The sample of KDDCup99 before and after encoding.

Sample of KDDCup99 data before encoding
0, icmp, eco_i, SF, 8, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 1, 3, 0, 0, 0, 0, 1, 0, 1, 1, 83, 1, 0, 1, 0.51, 0, 0, 0, 0, ipsweep.
Sample of KDDCup99 data after encoding
0, 43, 10, 2, 8, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 1, 3, 0, 0, 0, 0, 1, 0, 1, 1, 83, 1, 0, 1, 0.51, 0, 0, 0, 0, 7.

Table 6 The number of records for every Attack ID in the training and testing datasets.

Attack ID	**Corrected**	CorrectedDistinct	**CorrectedKdddataDifference**	**KdddataDistinct**	KdddataCorrectedDifference	KdddataCorrectedNoIntersection	CorrectedkdddataIntersection
1	1098	386	365	968	947	1312	21
2	22	22	22	30	30	52	0
3	3	3	3	8	8	11	0
4	4367	1302	1302	53	53	1355	0
5	1633	860	844	5019	5006	5853	13
6	1	1	1	12	12	13	0
7	306	155	44	3723	3613	3658	110
8	9	9	5	19	15	20	4
9	2	2	2	9	9	11	0
10	164091	936	573	3007	2644	3217	363
11	12	12	9	918	915	924	3
12	18	18	18	7	7	25	0
13	1602	1002	1002	20	20	1022	0
14	58001	20332	9220	242149	231037	240257	11112
15	84	80	80	1554	1554	1634	0
16	60593	47913	46320	812813	811271	857642	1542
17	2	2	2	3	3	5	0
18	2	2	2	4	4	6	0
19	87	45	22	206	182	203	24
20	354	174	153	3564	3543	3696	21
21	13	13	13	10	10	23	0
22	0	0	0	893	893	893	0
23	0	0	0	2	2	2	0
24	794	794	794	0	0	794	0
25	5000	308	308	0	0	308	0

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26	1053	1049	1049	0	0	1049	0
27	17	17	17	0	0	17	0
28	759	744	744	0	0	744	0
29	16	16	16	0	0	16	0
30	736	364	360	0	0	364	0
31	17	15	15	0	0	15	0
32	7741	179	109	0	0	179	0
33	2406	359	359	0	0	359	0
34	2	2	2	0	0	2	0
35	2	2	2	0	0	2	0
36	2	2	2	0	0	2	0
37	9	9	9	0	0	9	0
38	4	4	4	0	0	4	0
39	13	13	13	0	0	13	0
40	158	145	145	0	0	145	0
#	311029	77291	63950	1074991	1061778	1125856	13213
New attacks							
#	18729	4022	3948				
%	6.021625	5.203711	6.173573				

Table 7 The percentage of redundancy for each attack type and the new attacks in the testing dataset.

Testing type	New attacks	Probe	DoS	U2R	R2L	Normal	Testing dataset	Training dataset
Distinct	4022	2682	24570	70	2056	47913	77291	1074991
Redundant	18729	4166	231455	70	14745	60593	311029	4898432
Redundancy Factor	4.65663	1.55331	9.420227	1	7.171692	1.264646	4.024129	4.5567191

Then the records are removed from the testing dataset that are included in the training dataset and in the testing dataset for another attack to have accurate performance results of this work and there won't be any common records in both datasets, the statistics are shown in Table (8).

Table 8 As previous Table, the percentage of redundancy for each attack type and the new attacks in the testing dataset, but after removing common records.

Testing type	New attacks	Probe	DoS	U2R	R2L	Normal	Testing dataset	Training dataset
Distinct	3948	2530	13044	70	1986	46320	63950	1074991
Redundant	18729	4166	231455	70	14745	60593	311029	4898432
Redundancy Factor	4.74392	1.646640	17.74417	1	7.424471	1.308139	4.024143	4.556719

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LITERATURE REVIEW

Network Intrusion detection (NID) is the process of monitoring the events occurring in a network and analyzing these events for any sign of intrusions. A wide variety of algorithms and techniques has been applied to intrusion detections. NIDSs monitor the network traffic. When an abnormal event occurs, the NIDS notify the administrator. A system second line of defense is the ID and this was the focus of much research in recent years. This section will demonstrate some of them, including there performance (DR or called TPR, FPR, number of samples taken from the KDD dataset) and structures, dated from 1999 to 2007 in this section.

1.37 PNrule: A New Framework for Learning Classifier Models in Data Mining:

This study, presented by (Agarwal and Joshi, 2000)

- It is a two-stage general-to-specific framework.
- It was evaluated on the KDD testing data set (corrected set), it has detected many new R2L attacks not in the KDD training dataset (KDDdata set).
- Its objective was for developing rule-based (PN-rule) classifier models to learn on a data set that has different class distributions for both training and testing data.
- P-rules predict presence of a class, and are created using the training set, to increase the TPR.
- N-rules predict absence of a class, to reduce the FPR.
- Then apply both rules to the testing set.
- There results of performance are shown in table (9).

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- Table 9 The performance of each attack type for PNrule (Agarwal and Joshi, 2000).

Attack type	TPR%	FPR%	Total FN	FNR%	PSP%
Probe	73.2	0.45	22339	8.920043	92.58847
DoS	96.9				
U2R	6.6				
R2L	10.7				

1.38 KDD-99 Classifier Learning Contest LLSoft's Results Overview:

This study, presented by (Levin, 2000):

- Is a machine learning algorithm, used (Kernel Miner tool with a Multi-class detection approach on the KDD data set)
- The Kernel Miner is a data mining tool
    - For classifying and predicting new cases.
    - And used to cerate a set of locally optimal decision trees.
- The decision trees were used to select the optimal subset of trees.
- This is used to predict new cases of attacks (in testing set not seen in training set).
- The Multi-class detection approach is used to detect different attack categories.
- This study selected a random sample from the 10% of the KDD training data for training and the full testing dataset.
- The TPR results are shown in Table (10) (Levin, 2000);

Table 10 The performance of KDD-99 Overview (Levin, 2000).

Attack type	TPR%	FPR %	Total FN	FNR%	PSP%
Probe	84.5	0.58	21224	8.47482	92.91931
DoS	97.5				
U2R	11.8				
R2L	7.32				

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1.39 Finding Clusters of Different Sizes, Shapes, and Densities in Noisy, High Dimensional Data:

This study was presented by (Ertoz et al (2003)):

- It is called "shared nearest neighbor (SNN) technique".
- They used two clustering algorithms: K-means and SNN technique.
- The number of clusters used is 300 clusters.
- The selected 97,000 records from the entire KDD dataset (training set).
- And 10,000 records were randomly picked from both the training and the testing datasets, so the testing of this techniques was on a small partition of the corrected set not the complete set, the total number of samples used for the testing is 44424 samples.
- The DR results are shown in Table (11) (Ertoz et al (2003)).
- In this work they didn't include the FN or FNR which is more important than the FPR error and more dangerous.

Table 11 The performance of each attack type of K-means and SNN (Ertoz et al (2003)).

Attack type	K-means%	SNN%
Probe	91.88	73.43
DoS	97.85	77.76
U2R	5.6	37.82
R2L	77.04	68.15
FPR	4	30
PSP	94	73

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1.40 Parzen-window Network Intrusion Detectors:

This study was presented by (Yeung and Chow, 2002):

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It uses non-parametric density evaluation based on Parzen-window estimators with Gaussian kernels with 119 dimensions,

- They used two sets of only normal data to build the model.
- The number of normal records is randomly chosen from the KDD training dataset is 30,000 records.
- And 30,000 records (also from the KDD training dataset) is used to create the threshold, these sets have no overlapping, so they didn't use the testing dataset which contains many new attack not included in the training dataset.
- The symbolic values where represented as binary values.
- The TPR is shown in Table (12) (Yeung and Chow, 2002).
- In their work they didn't include the FN or FNR measurements.
- They didn't use the testing file which contains many new attacks.

Table 12 The TPR of each attack type of the Parzen-Window method (Yeung and Chow, 2002).

Attack type	TPR%
Probe	99.17
DoS	96.71
U2R	26.32
R2L	10.27
FPR	0.55

1.41 Application of machine learning algorithms to KDD Iddataset within misuse detection context:

This study was presented by (Sabhnani and Serpen, 2003):

- They used K-Means & MLP (multilayer perceptron) & Gaussian for each attack category.
- The MLP is used for detecting probe attacks.
- K-Means for detecting DoS and U2R.

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- Gaussian for detecting R2L attacks.
- The duplicates were removed for the training dataset, a total of 812,813 records for Normal, 13,860 for Probe, 247,267 for DoS, 52 for U2R, and 999 for R2L gives a total of 1074991 training samples.
- Used the full testing dataset for evaluation.
- Figure (11) shows the structure of there work.
- They added some experiment results of some algorithms in there work to show that there work had better results as shown in Table (13), and Table(14) (Sabhnani and Serpen, 2003).
- In their work the PSP, FN and FNR are not included.

Table 13 The TPR of each attack category of (Sabhnani and Serpen, 2003).

Attack type	TPR%
Probe	88.7
DoS	97.3
R2L	9.6
U2R	29.8
FPR	1.3

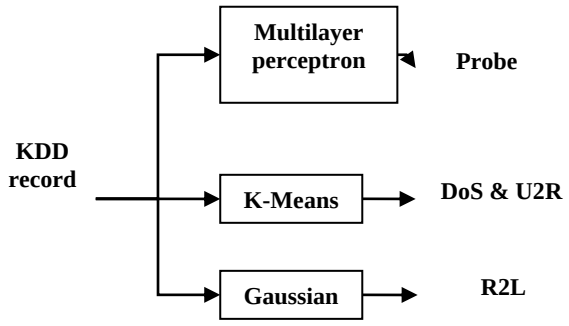

Figure (11) Multi-classifier model (Sabhnani and Serpen, 2003)

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Table 14 TPR and FPR for various algorithms (Sabhnani and Serpen, 2003).

Method		Probe%	DoS %	U2R%	R2L%
MLP	TPR	88.7	97.2	13.2	5.6
	FPR	0.76			
GAU	TPR	90.2	82.4	22.8	9.6
	FPR	12.8			
K-M	TPR	87.6	97.3	29.8	6.4
	FPR	3.1			
NEA	TPR	88.8	97.1	2.2	3.4
	FPR	0.8106			
RBF	TPR	93.2	73.0	6.1	59
	FPR	19.34			
LEA	TPR	83.8	97.2	6.6	0.1
	FPR	0.633			
HYP	TPR	0.848	0.972	8.3	1
	FPR	0.714			
ART	TPR	77.2	97.0	6.1	3.7
	FPR	0.505			
C 4.5	TPR	80.8	97.0	1.8	4.6
	FPR	1.007			

1.42 Winner of KDD'99 classifier learning contest, Australian Research Institute for Artificial Intelligence:

This study was presented by (www-cse.ucsd.edu/~elkan/clresults , 2008):

- They used 10 C5.0 decision trees.
- The data amount taken is 4,000 samples from probe attack records.
- And 80000 from normal records.
- And 400000 from DoS records, all records of R2L and U2R records.
- The TPR results are shown in Table (15) (Sabhnani and Serpen(2004)) (www-cse.ucsd.edu/~elkan/clresults , 2008).
- Testing with full testing dataset.

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Table 15 the TPR of the decision trees (www-cse.ucsd.edu/~elkan/clresults, 2008).

Attack type	TPR%	FPR%	FN	FNR %	PSP%
Probe	83.3	0.5	20505	8.187721	92.7
DoS	97.1				
U2R	13.2				
R2L	8.4				

1.43 Detecting Known and Novel Network Intrusions:

This study was presented by (Bouzida and Cuppens, 2006):

- It is a machine learning algorithm based on decision trees.
- The objective is to discover known and unknown attacks in real time.
- They used an enhanced C4.5 algorithm , they defined the enhancement as follows:
    - A *Newclass* was assigned to any new class that does not have an identical class in the training dataset.
    - If a new instance does not fit in any of the rules that are generated by the decision tree then this instance is classified as a new class instead of assigning it to a default class.
- The performance result of there work and the TPR is shown in Table (16) (Bouzida and Cuppens, 2006).
- They used 60593 samples for normal, 4166 samples for probe, 229853 for DoS, 228 for U2R and 16189 samples for R2L attack, gives a total of 311092 samples (the total testing dataset).
- No information about the training dataset.

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Table 16 The performance of each attack type (Bouzida and Cuppens, 2006).

Attack category	TPR %	FPR%	FN	FNR%	PSP%
DoS	97.14	0.57	18442	7.364	92.87
Probe	72.73				
R2L	2.85				
U2R	7.02				

1.44 A Distributed Hebb Neural Network for Network Anomaly Detection:

This study was presented by (Daxin Tian, Yanheng Liu, and Bin Li, August 2007):

- They used two phase process the first is the learning process, second is the Hebb Rule Risk bounds.
- The KDD dataset is randomly divided into 50 slices that each has 10,000 records, used the full training dataset and full testing dataset.
- These slices are send to separate different NNs with different number of neurons for each (distributed learning), used 368 neurons for the output ,each slice has different number of neurons in the range of [1-240].
- The results of the distributed NNs are entered into one NN and trained again (concentrated learning), the structure is shown in Figure (12).
- There best results are shown in the table (17) (Tian et al., 2007):

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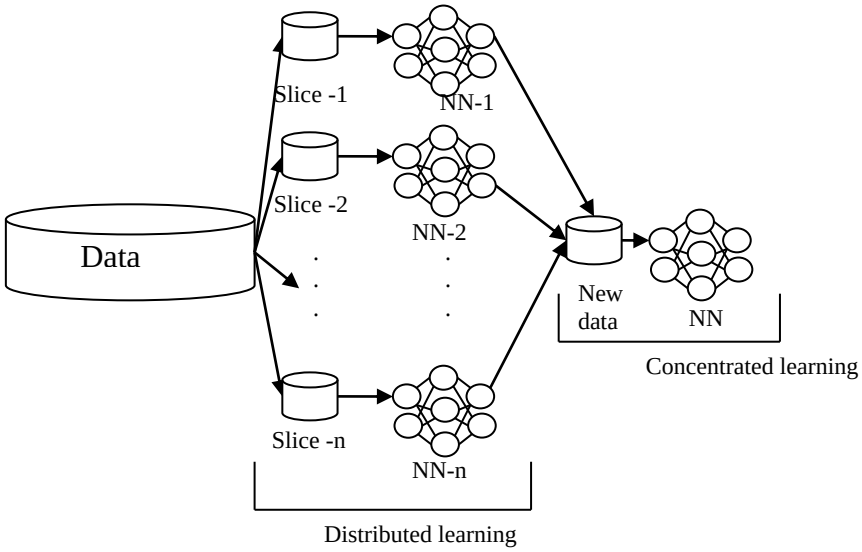

Figure (12) The learning process of distributed NN (Tian et al., 2007).

Table 17 The performance of (Tian et al., 2007).

Attack category	TPR Each%	TPR%	FPR%	FN	FNR%
Prob	84.108	93.9	4.1%	15199	6.07994
DoS	97.455				
U2R	11.2				
R2L	9.01				

1.45 A Low Complexity Intrusion Detection Algorithm:

This study was presented by (Lin Yao, Kai Yao, 2007):

- It is based on wave clusters.
- The values of each feature are first normalized in the range of [0, 1].
- Normal records are used, in addition to the attack types of only (ipsweep, smurf, neptune.).
- They executed two experiments the first experiment results with a TPR of 98.7% and a FPR of 1.7%. , the second experiment gave a TPR of 98.3% and a FPR of 1.8%.

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- The experimental results are on a subset of KDD-99 dataset.
- They didn't include the measurements FN PSP FNR or even the cost matrix so we can calculate these measurements as in the previous works.
- They didn't make clear what did they use for the testing phase.
- The algorithm is given in table (18) (Yao and Yao, 2007).

Table 18 The algorithm used in (Yao and Yao, 2007).

Algorithm. Input: Multidimensional data objects feature vectors. Output: clustered objects.
1. Divide the feature space into cells, and then assign objects to the cells. 2. Apply wavelet transform on the divided feature space, results a new feature space (cells). 3. Find the neighbors of transformed feature space using Euclidean and indexing scheme such as an R-tree. 4. Make a lookup table to map the cells in the original feature space, because that the clusters are based on wavelet coefficients, cannot directly point to the clusters in the original feature space. 5. Assign labels to the cells. 6. Map the objects to the clusters.

1.46 A Modified RBF Neural Network for Network Anomaly Detection:

This study was presented by (Wei et al, 2006):

- It is a modified RBF NN, for network anomaly detection, and similar to a 3-layer Back Propagation network.
- It has two phases, first the training phase, second the detecting phase.

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- The structure of this system is shown in Fig (13) and Fig (14).
- Best results TPR (or called DR), are shown in Table (19) and Table (20).
- For the training they used the 10% of the training dataset.
- Evaluated their system using the full testing dataset.
- They didn't include the important measurement of FN, PSP in their work, but after calculating FNR from the total TPR of the system we get 1.7%.
- Disadvantages:
    - Radial basis networks usually require more neurons than standard feed-forward backpropagation networks (FBNN) (Ljung, 2007).
    - And because RBF NN work best when many training vectors are available (Ljung, 2007), but many types of attacks that don't match this property are available, such as (teardrop, bufferoverflow, ftp-write, impap, land, loadmodule, perl, phf, rootkit, sqlattack, udpstream, worm, xlock, xsnoop, spy, and others).

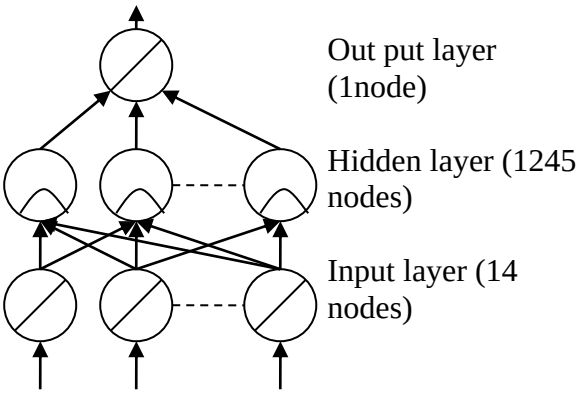

Figure (13) The structure of RBFNN at the training stage with an activation function of purelin in the first layer and a radial basis function for the second layer and purelin function for the out put layer (Wei et al., 2006).

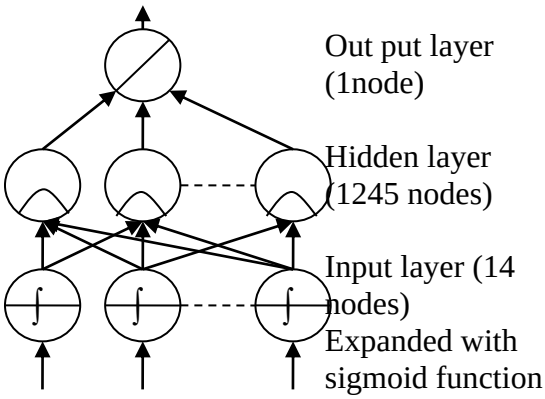

Figure (14) The structure of RBFNN at the detecting stage with an activation function of tansig in the first layer and a radial basis function for the second layer and purelin function for the out put layer (Wei et al., 2006).

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Table 19 The TPR and the FPR of the whole system (Wei et al., 2006).

Λ	0.1	0.4	0.6	1.5
TPR	95.685	95.651	94.419	93.824
FPR	6.129	5.066	4.065	2.68

Table 20 The TPR of the attack types focused in (Wei et al., 2006).

Attack name	TPR %
apache2	99.7448
httptunnel	100
mailbomb	100
mscan	100
named	94.118
processable	100
ps	93.75
saint	18.886
sendmail	64.706
snmpgetattack	0
snmpgguess	0.083
sqlattack	100
udpstorm	50
worm	100
xlock	100
xsnoop	100
xterm	100
Average = 77.723%	

1.47 Anomaly based unsupervised intrusion detection:

This study was presented by (Zareno, 2007):

- It unsupervised payload clustering and classification techniques.
- The results of (Zareno, 2007) are shown in table (21).
- No information about the FN, FNR, PSP measurements or even the cost matrix are included, nor the testing or training datasets used.

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Table 21 The TPR and FPR of (Zareno, 2007).

Threshold	TPR%	FPR
0.03%	66.7	3.1
0.05%	72.2	5.5
0.08%	77.8	8.6
0.09%	88.9	9.5

1.48 Neural Networks Learning Improvement using the K-Means Clustering Algorithm to Detect Network Intrusions:

This study was presented by (Faraoun and Boukelif, 2006):

- It is a competitive learning multi-layered feed-forward back propagation NN that uses :
    - K-means clustering algorithm.
    - Back propagation learning mechanism.
- There work has a TPR of 91.9% and FPR of 3.36% with an execution run time 29 hours 51 minutes, the TPR and FPR with the number of samples used of each attack category are shown in Table (22) (Faraoun and Boukelif, 2006).
- They used 3 hidden layers with 30, 15, 30 neurons.
- It has 41 input and 5 outputs. With training function traingdx and transfer function tangsig. And training epochs of 1000.
- Used the TRAINGDX train function with the learning function LEARNGDM.
- They used 11673 normal , 7829 DoS , 4107probe, 1119 R2L , 52 U2R from training set (a total of 24780 samples) and the full testing dataset (corrected file).
- And there were no information about the FN, FNR and PSP measurements, or the Cost matrix.

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Table 22 The TPR and FPR of each attack category in (Faraoun and Boukelif, 2006).

Attack category	Samples used	TPR %
Normal	60,593	FPR = 6.21
DoS	229,853	97.23
Probe	4,166	96.63
R2L	16,347	30.97
U2R	70	87.71

1.49 On Dataset Biases in a Learning System with Minimum A Priori Information for Intrusion Detection:

This study was presented by (Kayacik et al., 2004):

- It is an unsupervised learning architecture, based on a hierarchy of self-organizing feature maps (SOMs).
- Dataset biases are studied through portions of KDD not the complete dataset:
  - Training 10% of KDD dataset (system 1).
  - Training with normal connection only of 10% of KDD (system2).
  - Training with 10% KDD Modified – (50% attack/50%) normal connections (system3).
  - The performance results are shown in Table (23) (Kayacik et al., 2004).
- No information about FN, FNR and PSP measurements or the Cost matrix.

Table 23 The TPR and FPR of (Kayacik et al., 2004).

(a)Test Set Results for training under a balanced data set (Kayacik et al., 2004).

FPR%	TPR%
14.3	91.3

(b)Recent Results on THE KDD Benchmark (Kayacik et al., 2004).

Technique	TPR %	FPR%
Data Mining	70-90	2
Clustering	93	10
KNN	91	8
SVM	98	10

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(c) Performance of the three systems on different categories (Kayacik et al., 2004).

Attack category TPR%	System1	System2	System 3
Normal	92.4	85.5	85.7
DoS	96.5	96.5	96.7
Probe	72.8	91.0	79.7
U2R	22.9	22.9	30.0
R2L	11.3	20.5	18.4

1.50 Learning Vector Quantization Neural Network Method for Network Intrusion Detection:

This study was presented by (Degang et al., 2007):

- A method based on learning vector quantization (LVQ).
- The LVQ NNs were used as a classifier to detect an intrusion.
- There are three phases for detection:
    - Feature selection and data normalization.
    - learning the training data selected from the feature data set;
    - Identifying the intrusion and generating the result report of machine condition classification.
- The LVQ NN Architecture is shown in Figure (13).
- The performance is shown in Table (24) (Degang et al., 2007).
- Used 500 random different samples from the KDD for testing.
- They didn't define the systems shown in Table (24).

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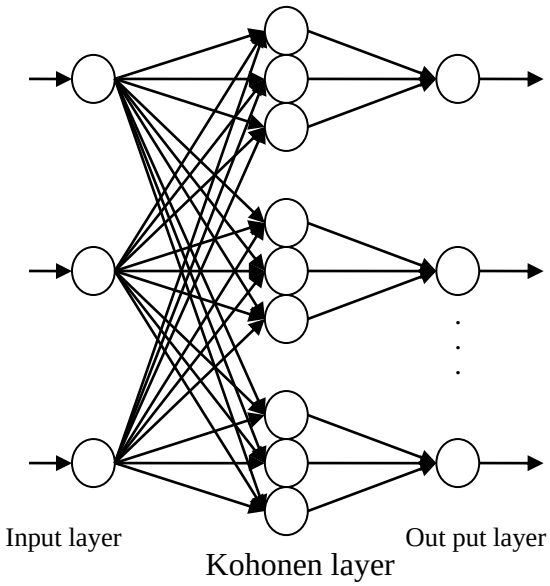

Figure (13) The architecture of LVQ NN.

Table 24 DR for different attack categories of (Degang et al., 2007).

Data set name	DOS	R2L	U2R	Probe
Training data set	84	100	58.3	91.7
Testing data set 1	100	59.3	100	47.1
Testing Data set 2	80.4	73.1	75	83.3
Testing Data set 3	84.5	55.6	53.8	57.7
Testing Data set 4	76.3	62.2	37.5	66.7

1.51 Network Anomalous Attack Detection Based on Clustering and Classifier:

This study was presented by (Yang et al., 2007):

- An approach to detect abnormal behaviors in network traffic:
  - Map the data into different feature spaces matching their services and protocols.
  - Group the training data into clusters, from which some clusters were selected as normal and known-attack profile.
  - Use the data not in the profile, to build a classifier.
  - The classifier has two distinct characteristics:
- This work was trained on the 10 % KDDdata set, and tested on the full testing dataset.
- They used normalization and feature extraction techniques.

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- A comparison of their work is made with other approaches, is shown in Table (25) (Yang et al., 2007).
- No information about the FN, FNR, PSP measurements or the Cost matrix.
- In the testing phase the detected only 37 attack type not the full 39 attack type.

Table 25 The Comparison of their system with other approaches (Yang et al., 2007).

METHOD	FAR	PROBE	DOS	U2R	R2L
(Yang et al., 2007)	0.7%	99.5%	97.92%	81.14%	10.44%
C5 Bagged Boosting	0.55%	87.73%	97.7%	26.32%	10.27%
Kernel Miner	0.55%	89%	97.57%	22.37	7.38%
NN	0.45%	83.3%	97.3%	8.33%	2.5%
Decision Tree	0.5%	77.92%	97.24%	13.6%	0.52%
Naive Bayes	2.32%	88.33%	96.65%	11.84%	8.66%
Pnrule	0.5%	78.67%	97%	14.47%	10.8%

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System Structure & Experimental results Discussion and Analysis

This section demonstrates the performance results achieved during this work, including the system resources and algorithm, and many comparisons with the different structures of the IDS and different performance measurements.

1.52 System Resources

Some experiments performed are tested on a Pentium IV IBM compatible PC, with a 512 MB RAM and 3.0 GHz processor speed Centrino Mobile technology Intel inside, others are tested on an HP Intel® Pentium® M with a 512 MB of RAM and 1.6 GHz processor speed. Windows® XP professional edition is the operating system. MATLAB 7.0 is used as the hosting environment.

1.53 Experimental Results

Several experiments are performed with different system structure of the neural networks such as number of layers, number of hidden neurons for each layer; and parameters such as maximum number of samples feed into the systems, different performance functions (Rate or called percentage of successful prediction (PSP), Cost, TPR, FPR, FN, FNR), for both redundant (original encoded datasets) and non-redundant (unique) and disjoint datasets. This enables comparing the performance of each one of them, and selects the most suitable and appropriate system structure for the detection. These experiments were performed after making some experiments using K-means and Clustering, and are focused because the performance results of them were low and unsatisfactory, this will be shown in this section.

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1.54 Training and Testing datasets:

Forty testing datasets (corrected file splitted into datasets for each attack type and normal connections, their string fields are encoded to numbers) for the redundant and the distinct data, 23 training dataset (KDD dataset file splitted into a dataset for each attack type, and encoded to numbers) are used as a framework. The results are shown in tables in the appendix A, and then the maximum results of these tables are taken; which are introduced in this section. The detailed results will be in Appendix B; the results with the figures corresponding to them will be viewed in this section.

1.55 Pattern matching using K-Means:

K-means is an unsupervised learning algorithm, it solves clustering problems. For k clusters define a centroid for each cluster. These centroids must be far from each other. then take each point of data and put it to the nearest centroid. This is repeated until no changes occure in the centroid location. In this experiment we used kmeans function in MATLAB. Kmeans (X, k) partitions the points into k clusters. Here we used k = 2, it is an iterative partitioning method to minimize the sum, over all clusters. kmeans uses the squared Euclidean distances as a default (Ljung, 2007). Table (26) shows the misclassified samples using the kmeans function.

Table 26 The misclassified number of samples using k-means.

AttackID	#of total records	# of misclassified records
1	730	1
2	44	22
3	6	2
4	2604	1246
5	1688	317
6	2	0
7	88	18
8	10	5
9	4	0
10	1146	12

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11	18	7
12	36	17
13	2004	752
14	18440	8549
15	160	42
17	4	0
18	4	1
19	44	4
20	306	84
21	26	11
24	1588	323
25	616	0
26	2098	461
27	34	16
28	1488	237
29	32	8
30	720	155
31	30	12
32	218	104
33	718	141
34	4	0
35	4	1
36	4	0
37	18	7
38	8	2
39	26	8
40	290	144
PSP=63.956%	FP=1333	FN=11376
FPR =7.560976%	TPR =35.47%	FNR = 64.52638%

1.56 Pattern matching Clustering:

Clustering is a method where large sets of data are grouped into clusters. These clusters of smaller sets have similar data. It finds groups of data having similarities. In this experiment we used clusterdata function in MATLAB. This function uses the pdist, linkage, and cluster functions to construct clusters from data X. The maximum number of clusters used is 2. The pdist is pairwise distance between observations which computes the Euclidean distance between pairs. Linkage is a function that creates a hierarchical cluster tree (Ljung, 2007). Table (27) shows the number of misclassified samples using clusterdata function.

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Table 27 The misclassified number of samples using clusterdata.

AttackID	#of total records	# of misclassified records
1	730	0
2	44	21
3	6	2
4	2604	1291
5	1688	842
6	2	Must have more than 3 records not classified
7	88	43
8	10	5
9	4	0
10	1146	108
11	18	8
12	36	17
13	2004	1001
14	6920 (a portion)	3457
15	160	79
17	4	0
18	4	1
19	44	4
20	306	152
21	26	11
24	1588	791
25	616	0
26	2098	1045
27	34	16
28	1488	237
29	32	15
30	720	359
31	30	12
32	218	108
33	718	358
34	4	0
35	4	1
36	4	0
37	18	8
38	8	2
39	26	8
40	290	144
PSP=57.25%	TPR =53.138	FN=5562 ,FP = 4545 , FPR= 38.29 ,FNR = 46.86

1.57 System structure for Pattern matching using neural networks:

After having some experiments using kmeans and clustering methods we decided to move deeply in the neural networks approach of pattern matching, because of the low performance we got

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from the previous methods. The NN system structure of this work is a combination of 22 neural network block (NNBs), which are equal to the number of attacks available in the training KDD data set –so we have a multi-classifier neural network - the NNB type used is the feed-forward backpropagation NN, each one of them generates an output of the rage of [-1, 1] for each input vector (40 field, because of deletion of the 20’th and the 42’th column from the original dataset), $X=(x_1 \dots x_{40})$, each input vector is passed through a normalization phase as shown in equation (3) . All the 22 NNBs, The outputs then are passed through a sign function to produce outputs of {1’s,-1’s} then passes through the voter phase.

$$x = x - mean(x) \qquad \text{……………………..………………………(3)}$$

Where x is the values of a row in the array dataset both training and testing according to the function it is being used. Then transform the results to the number 1 if the input is determent as an attack (abnormal) connection and to the number -1 if the input is determent as a normal connection. Then these (1’s and -1’s) generated for each type are entered to the voter decision phase. It generates a final output which is the result of the detection. This voter counts the number of 1’s and -1’s of each classifier for the specific sample then decides that if the result is an attack it will output a 1 and if it is not it will output a -1. This result depends on the number of 1’s and -1’s. The system structure is shown in Figure (14). The detailed structure of the NNB depends on the number of its layers and the number of neurons in each layer. Each internal structure of the NNB is shown in its section. It will start with a 2-layered (Multi-Layered) NN, then a three and a four Multi-Layered NN. Because of the small number of layers the sequential links do not represent any substantial loss of time (Zupan, J. and Gasteiger, J., 1993). The number of neurons in each layer will be changed. Because that the number of layers and the number of neurons in each layer depend on the

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application that any NN solve a problem so it is determined by trial and error (Zupan, J. and Gasteiger, J.,1993), to find the best structure.

In the training process a number of non-repeated random records have been taken from the normal connection exactly equal to the number of records in the attack type entered to the NN, and then apply the system for testing on both distinct and redundant datasets, then calculating the performance of the system structure.

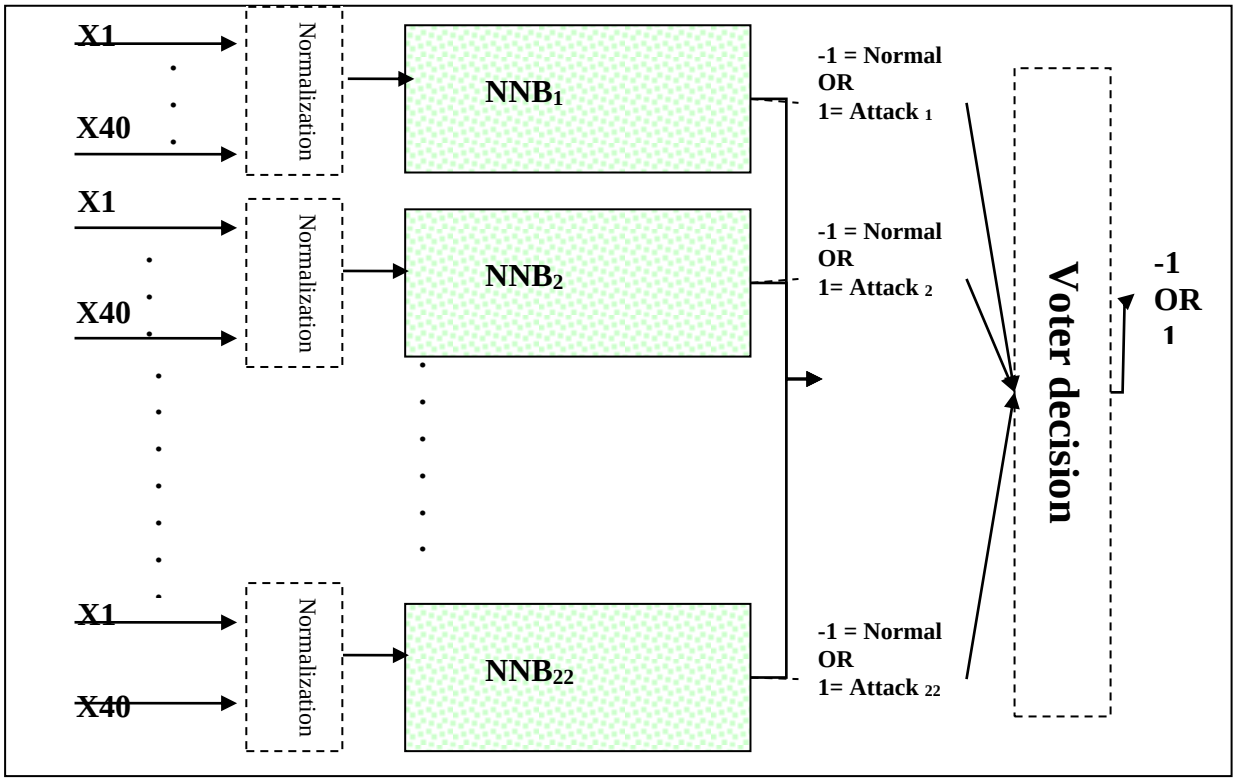

Figure (14) A general architecture of the proposed NN system.

1.58 The algorithm:

1. Data processing using SQL commands:
    a. Remove the redundant data.
    b. Encoding the strings in data to numbers.
    c. Dividing the data into attacks for both training and testing data (we will have 23 datasets for the training and 40 datasets for the testing data).

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d. Remove fields 20 and field 42 from the data sets. the feature 20 has all of its values are equal to zero. Feature 42 is the labeling of the attack type.

e. Removing the data from the testing set that are included in the training set for each attack ID for each attack.

2. Training the NN system then testing the distinct dataset:

Algorithm1 IDS_EngineUpdatedForNormal
Input: No.Max Inputs, No.Hidden neurons, No.Classifiers=23, NoOfAttacks =40. **Output**: Trained NNT and performance measurements of the distinct dataset.
1. For attackID (1: No.Classifiers) 2. If attackID =16 continue. End if 3. Call ReadInput 4. Create NNT 5. Train the NNT 6. End for. 7. For attackID (1:NoOfAttacks) 8. If attackID = 22 or 23 continue. End if 9. Call ReadAllRecords 10. For I (1: No.Classifiers) 11. If 1 = 16 continue. End if 12. Outputs=Test the distinct data using the previous NNT 13. Call FindClassValue 14. End for. 15. End for. 16. Call FindAccuracyVector

Algorithm2 ReadInput
Input : No.Max Inputs , AttackID **Output**: Combined Attack and Normal train and target Matrix
1. Read a number of No.Max Inputs from the file (AttackID) 2. Call GetRandomRecords

Algorithm3 ReadAllRecords
Input : AttackID **Output**: Normalized Testing data
1. Read all records from file (AttackID) 2. Call NormalizationFunction

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Algorithm4 FindClassValue **Input** : x **Output**: sign of x (-1 or 1)
1. Take the sign of x

Algorithm5 FindAccuracyVector (Voting phase) **Input** : No.Max Inputs **Output**: excel file containing the performance measures
1. Call FindAccuracy 2. Calculate the performance measurements 3. Write them into an excel file

Algorithm6 GetRandomRecords **Input** : fileID **Output**: normalized random non-repeated records of the file
1. Read random non-repeated records of fileID 2. Call NormalizationFunction

Algorithm7 NormalizationFunction **Input** : Values of records **Output**: normalized records
1. value -mean(value)

a.Calculate the new attack detection rate and add it to the excel file:

Algorithm8 NewAttackRecognitionRat **Input** : No.Max Inputs **Output**: added the file of excel the performance of the new attacks
1. Calculate the performance of the rows>23 %which are the unseen attacks in the training file.

3. Testing:

   a. Apply the neural network on the testing redundant data.

Algorithm9 ApplyNNTOnOriginalCorrectedData
Input : No.Max Inputs, NoOfAttacks=40 No.Classifiers=23 **Output**: performance measurements of the redundant dataset
1. For AttackID (1: NoOfAttacks) 2. If AttackID = 22 or 23 continue. End if 3. Call ReadAllRecords 4. For I (1: No.Classifiers) 5. If i=16 continue; End if 6. Test the data 7. Call FindClassValue 8. Call FindAccuracyVector

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b.Calculate the new attack detection rate and add it to the excel file:

Algorithm10 NewAttackRecognitionRat **Input** : No.Max Inputs **Output**: added the file of excel the performance of the new attacks
1. Calculate the performance of the rows>23 %which are the unseen 2. attacks in the training file.

Where the number of maximum input is defined as shown in equation (5).

$$\text{MaxInput} = \begin{cases} \text{\# of Max Inputs} & \text{if \# of records in attack} \geq \text{\# of Max Inputs} \\ \text{\# of records in attack} & \text{otherwise} \end{cases} \quad (5)$$

The previous algorithms are used for all the testing data with the difference of changing the number of max input entered the system, number of hidden neurons in the layers ,and number of layers for each system.

1.59 IDS Calculation Performance:

The equations for calculating the performance results are illustrated in this section, the cost of the non-correct detection is illustrated in Table (28) that shows the cost matrix of this thesis, TPR, FPR, TP, FP, FN, FNR and PSP formulas are defined in equations (5 – 14).

These equations are used in all the experiments in the thesis, and has been calculated for the previous work for the comparisons if they were not included in their work but can be calculated from other variables.

Table 28 The multiplier of each attack type that is used for the Cost Matrix.

Attack type	**Multiplier of attack**	**Multiplier of normal in the cost calculation**
prob	0	1
DoS	0	2
U2R	0	3
R2L	0	4
normal	1	0

$$TP = \sum \text{\# of recognized attacks.} \quad (5)$$

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TPR = TP / ∑ no of attacks. = TP / (TP+FN) = 1-β = 1- (FN/(TP+FN)) =DR (6)

FP= ∑ no of normal – ∑ no of recognized normal % FP think the normal is an attack. (7)

FN = ∑ no of attacks – TP; % False Negative think attack is a normal. (8)

FPR = FP/ ∑ no of normal connections. (9)

TPREach = TPR % of each attack category = average accuracy of each. (10)

Opposite Percentage = 100 – Average Accuracy. (11)

Cost = ∑ (multiplier * Opposite Percentage) / 11. (12)

Rate = # of recognized records / # of total records = PSP (13)

FNR = FN / ∑ no of attacks (14)

1.59.1 Two active layers of NN:

The Architecture:

The amount of Max Input to the NN is entered as a parameter variously, and only one neuron in its output layer to identify the attacks. The network is a 2-layer tan-sigmoid/ tan-sigmoid network. The tan-sigmoid transfer function was picked because its output range (-1 to 1). This gives perfect detection.

The first hidden layer has a number of (NoOfHidden) neurons; the second layer has only one neuron (the out put layer). The number of neurons is varied in the range of [40,300] for the experiments. The network is trained to fire an output of 1 in the case of an attack, and with -1 in the normal connection case. After the network is trained the output is passed through the normalization function used, and then added to the voter decision which counts the 1's and –1's and outputs the one having the greater count. This makes sure that the output corresponding to the connection most like the normal connection input vector takes on a value of -1, and all others have a value of 1's (attack connection). The result of this post-processing is the output that is actually used, the network is trained with number of input vectors of the KDD dataset

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labeled, for a maximum of 8000 epochs or until the network sum-squared error falls beneath 0.001, and sometimes using user stop. these are some parameters of the function used in all of the work which is the training function trainscg, because it doesn't need a line search at each iteration (of training) as in (traincgb, and traincgp, and traincgf), this line search is computationally expensive, because in this case the network must give a response to all training inputs which are being computed many times for every search. The trainscg was designed to avoid the time-consuming line search, and it is good for large NNs because it doesn't suffer from the Out Of Memory problem as in trainlm which needs high storage memory, trainscg performs well over a wide range of problems, especially for networks that have large number of weights (Ljung, L., 2007).

The transfer function used is for all layers the tansig function, faster than the tanh function with similar results in MATLAB implementation (Ljung, L., 2007), Figure (15) shows the structure of the two layered neural network.

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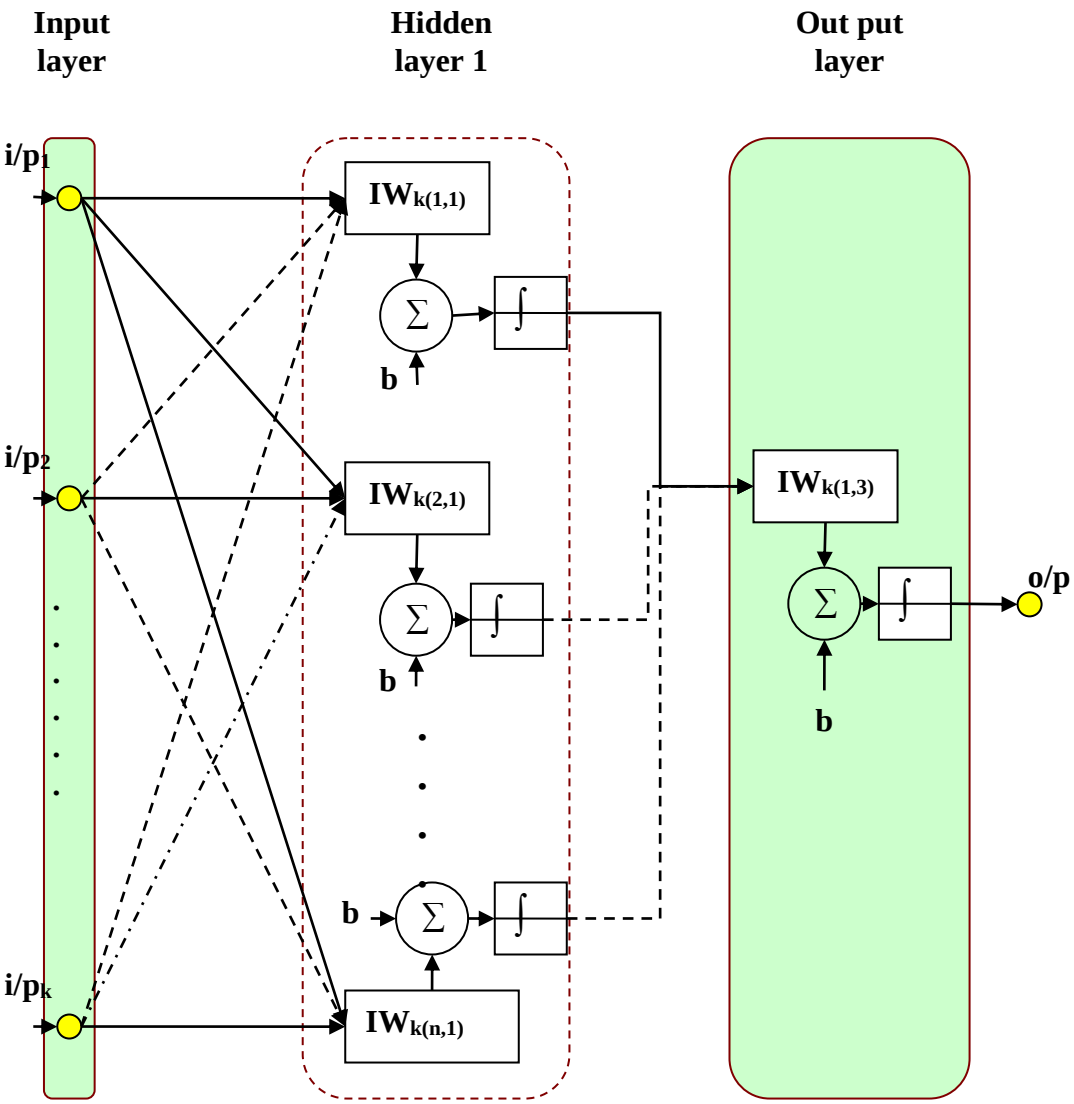
The Neural Network of 2 layers



Input$_1$ = [i/p$_{1,1}$,….,i/p$_{1,k}$]
Connection to 1'st layer =k= [1...40]
Connection to 2'nd layer =k= [1...n]
n= # of hidden neurons
b is the bias ,randomly choosed for each neuron.
IW (inputID)(neuronID,layerID)

Figure (15) The architecture of the 2 layered neural network.

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In this section the 2-layered NN system will be covered. Different Maximum inputs are entered to all the systems, Table (29) shows the performance measurements, of 100 Max Input to different systems, the testing data is distinct and disjoint as described previously. Table (32) shows the performance for redundant testing data. Each record of Table (29) and tables illustrated in APPENDIX A are calculated from a 40 record table for each attack type shown in Table (30) and tables of APPENDIX B. For example the first records of Table (29) came from calculating the results of Table (30). This shows the detailed detections of each attack type, the table of other experiments of the detailed detection are in APPENDIX B, which are 830 tables for all experiments, to be brief the same is repeated for all the coming experiments and the related tables are placed in APPENDIX A. The max TPR of each Table has been taken, and draws a comparison between the performance of the distinct and the redundant data for each Max Input as shown in Table (33), applying the system on the distinct dataset the total number of attacks is equal to 17630 and for the redundant dataset is 250436. Table (29) shows a 2-layer network with 100 as Max Input with different hidden neurons for both distinct and redundant processed data records (100/2/x):

Table 29 Using a 2-layer neural network system with, max input 100 of each attack type on distinct records, using different hidden neurons (100/2/x).

# Hidden neurons	Rate%	Cost%	Attack category	TPR Each%	TPR%	FPR%	FP	TP	FN
40	88.38	51.71	Prob	71.07	78.98	8.05	3727.00	13924.00	732.00
			DoS	90.50					1239.00
			U2R	42.86					40.00
			R2L	14.65					1695.00
			Normal	91.95					
	86.58	52.89	Prob	64.31	77.43	9.94	4605.00	13651.00	903.00
			DoS	89.83					1326.00
			U2R	42.86					40.00
			R2L	13.90					1710.00
			Normal	90.06					
	88.55	52.81	Prob	72.29	80.49	8.39	3885.00	14190.00	701.00
			DoS	92.82					937.00
			U2R	41.43					41.00
			R2L	11.33					1761.00
			Normal	91.61					
50	80.79	47.43	Prob	83.91	83.01	20.06	9291.00	14635.00	83.91
			DoS	92.47					92.47
			U2R	48.57					48.57
			R2L	20.95					20.95
			Normal	79.94					79.94
	84.88	62.41	Prob	48.77	71.51	10.03	4646.00	12607.00	1296.00
			DoS	85.92					1837.00
			U2R	24.29					53.00

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			R2L	7.50					1837.00
			Normal	89.97					
	86.14	53.02	Prob	72.77	77.74	10.66	4938.00	13705.00	689.00
			DoS	88.55					1494.00
			U2R	40.00					42.00
			R2L	14.40					1700.00
			Normal	89.34					
60	87.42	56.74	Prob	67.59	76.69	8.50	3936.00	13521.00	820.00
			DoS	88.49					1501.00
			U2R	30.00					49.00
			R2L	12.44					1739.00
			Normal	91.50					
	86.74	55.79	Prob	44.90	73.48	8.21	3804.00	12955.00	1394.00
			DoS	89.39					1384.00
			U2R	48.57					36.00
			R2L	6.29					1861.00
			Normal	91.79					
	81.86	50.41	Prob	78.18	81.91	18.15	8409.00	14441.00	552.00
			DoS	92.92					923.00
			U2R	45.71					38.00
			R2L	15.61					1676.00
			Normal	81.85					
70	86.77	48.97	Prob	73.48	79.32	10.40	4816.00	13984.00	671.00
			DoS	90.77					1204.00
			U2R	55.71					31.00
			R2L	12.39					1740.00
			Normal	89.60					
	79.40	68.75	Prob	10.47	49.10	9.07	4200.00	8656.00	2265.00
			DoS	63.68					4737.00
			U2R	34.29					46.00
			R2L	3.02					1926.00
			Normal	90.93					
	84.50	43.91	Prob	83.56	83.93	15.28	7078.00	14797.00	416.00
			DoS	92.82					937.00
			U2R	51.43					34.00
			R2L	27.19					1446.00
			Normal	84.72					
80	86.71	49.56	Prob	63.04	79.69	10.61	4916.00	14050.00	935.00
			DoS	93.00					913.00
			U2R	52.86					33.00
			R2L	14.45					1699.00
			Normal	89.39					
	82.20	42.14	Prob	86.96	88.23	20.09	9305.00	15555.00	330.00
			DoS	97.19					366.00
			U2R	48.57					36.00
			R2L	32.38					1343.00
			Normal	79.91					
	85.46	53.73	Prob	64.19	70.23	8.74	4049.00	12381.00	906.00
			DoS	80.42					2554.00
			U2R	48.57					36.00
			R2L	11.73					1753.00
			Normal	91.26					
90	87.63	51.31	Prob	74.11	79.42	9.25	4283.00	14001.00	655.00
			DoS	90.56					1231.00
			U2R	44.29					39.00
			R2L	14.20					1704.00
			Normal	90.75					
	81.50	40.14	Prob	89.80	85.16	19.89	9212.00	15014.00	258.00
			DoS	93.35					868.00
			U2R	65.71					24.00
			R2L	26.18					1466.00

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			Normal	80.11					
	86.54	40.26	Prob	94.78	86.57	13.47	6237.00	15262.00	132.00
			DoS	93.71					821.00
			U2R	55.71					31.00
			R2L	30.31					1384.00
			Normal	86.53					
100	86.50	51.12	Prob	57.08	76.27	9.60	4447.00	13446.00	1086.00
			DoS	89.74					1338.00
			U2R	52.86					33.00
			R2L	13.04					1727.00
			Normal	90.40					
	87.50	53.08	Prob	72.09	77.92	8.86	4103.00	13738.00	706.00
			DoS	89.04					1430.00
			U2R	40.00					42.00
			R2L	13.70					1714.00
			Normal	91.14					

Table 30 All the attacks recognized and not recognized when performing the testing on the data, on 2-layered neural network system on distinct datasets, for a maximum input of 100, and 40 hidden neurons in first and second layer (100/2/40/40/).

Attack Category	attack ID	Total No Of Records	Attack Recognized	Percentage recognition%
DoS	1	365	365	100.00
U2R	2	22	9	40.91
R2L	3	3	2	66.67
R2L	4	1302	91	6.99
probe	5	844	843	99.88
R2L	6	1	1	100.00
probe	7	44	0	0.00
DoS	8	5	4	80.00
U2R	9	2	2	100.00
DoS	10	573	87	15.18
DoS	11	9	0	0.00
R2L	12	18	5	27.78
DoS	13	1002	721	71.96
DoS	14	9220	9186	99.63
probe	15	80	80	100.00
normal	16	46320	42593	8.05
U2R	17	2	1	50.00
R2L	18	2	0	0.00
DoS	19	22	20	90.91
probe	20	153	152	99.35
U2R	21	13	8	61.54
DoS	24	794	505	63.60
DoS	25	308	308	100.00
probe	26	1049	469	44.71
R2L	27	17	11	64.71
DoS	28	744	607	81.59
U2R	29	16	4	25.00
probe	30	360	254	70.56
R2L	31	15	8	53.33

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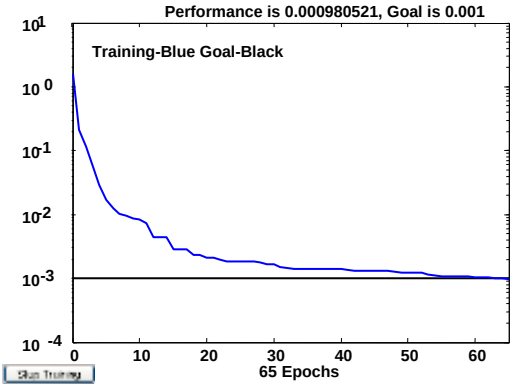
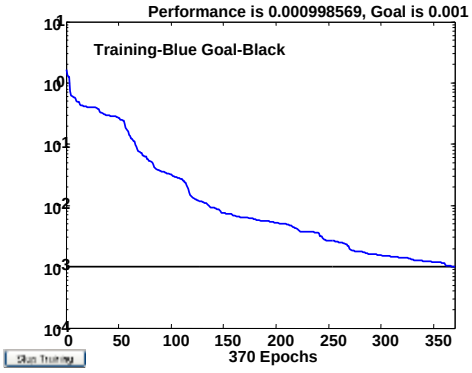
R2L	32	109	15	13.76
R2L	33	359	1	0.28
U2R	34	2	0	0.00
DoS	35	2	2	100.00
R2L	36	2	2	100.00
R2L	37	9	7	77.78
R2L	38	4	3	75.00
U2R	39	13	6	46.15
R2L	40	145	145	100.00

The convergence curve, of the training process, of the 100 Max Input with a number of 40 neurons for the hidden first and second layer, as an example. The convergence of the first record of Table (29) for each attack included in the KDD training dataset which are 22 (which is the number of out classifiers used in the system), is shown in Figure (16).



(a) attack 1(back)



(b) Attack 2 (buffer_overflow)

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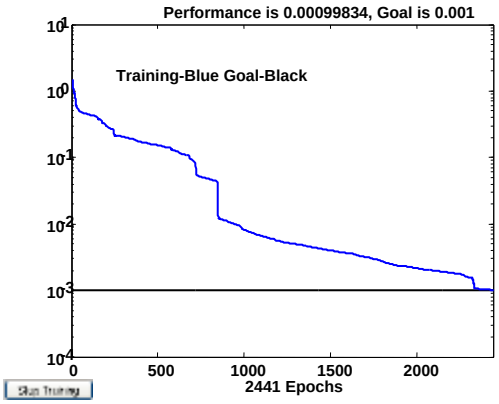
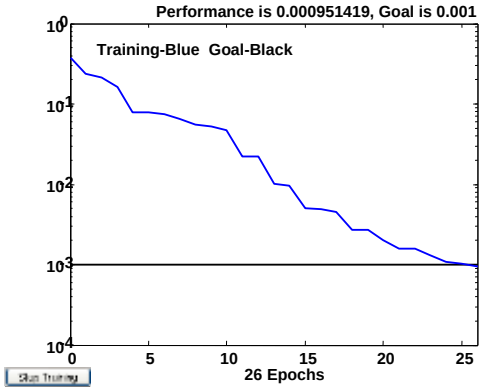
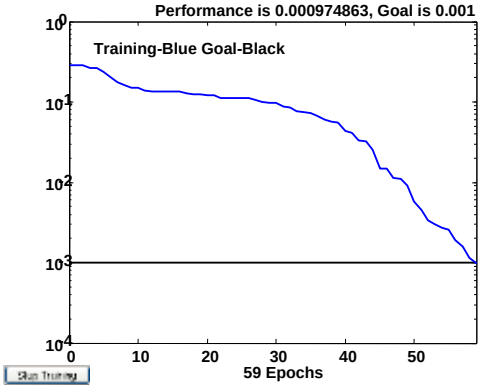


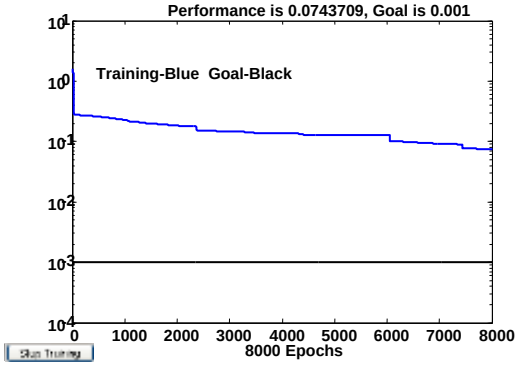
(c) Attack 3(ftp_write)



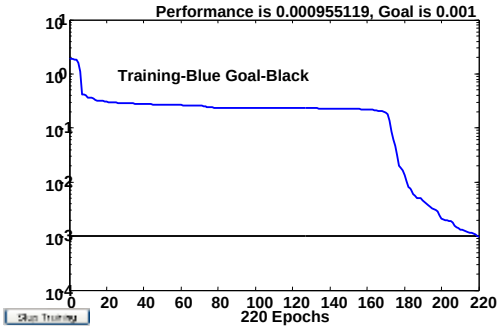
(d) Attack 4 (guess_passwd)



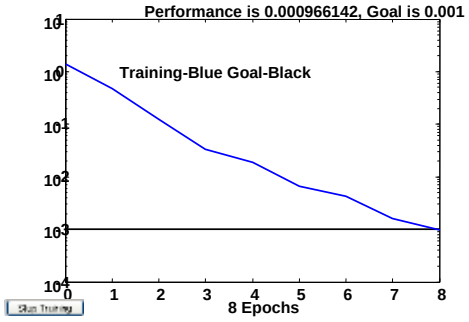
(e) Attack 5 (satan)



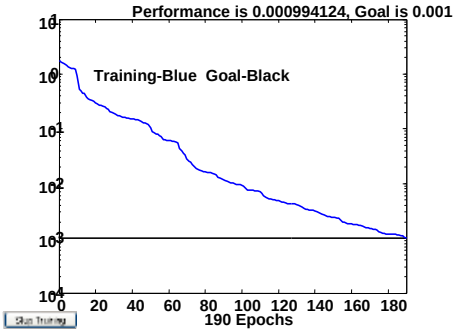
(f) Attack 6 (imap).



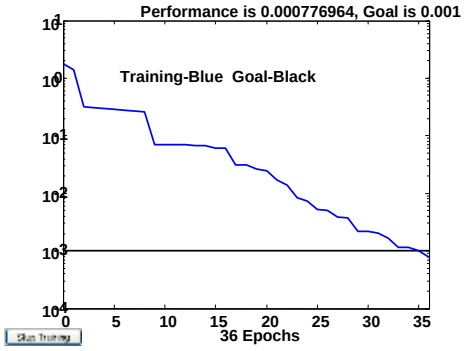
(g) Attack7 (ipsweep)



(h) Attack 8(land)



(i) Attack 9 (loadmodule)



(j) Attack 10(smurf)

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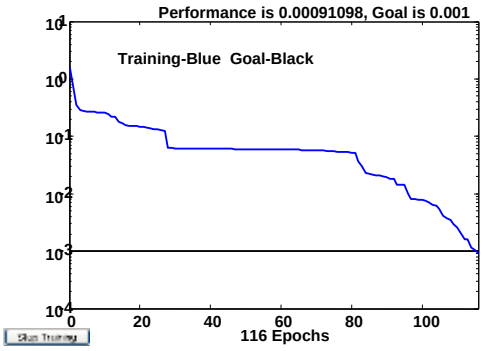
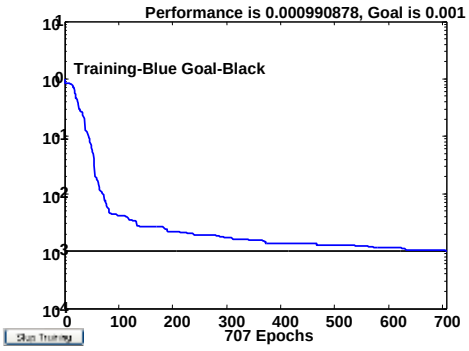
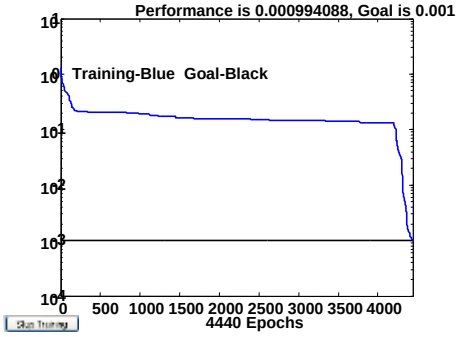


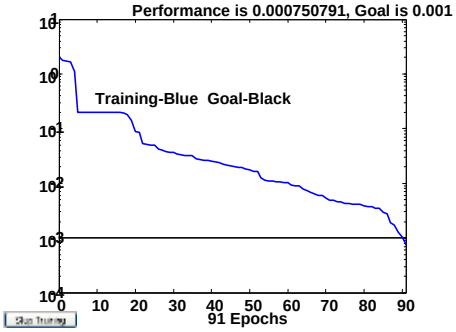
(k) Attack 11(teardrop)



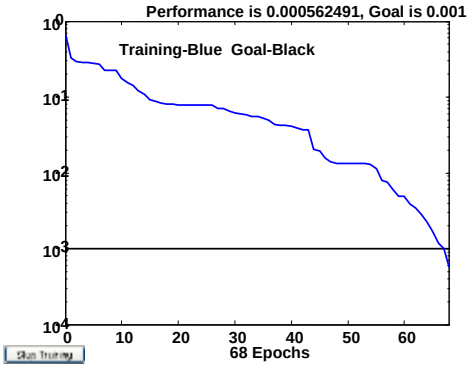
(l) Attack 12(multihop)



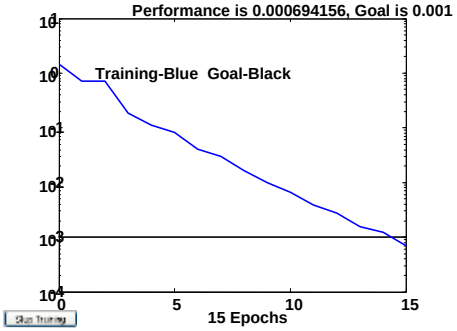
(m) Attack 13(warezmaster.)



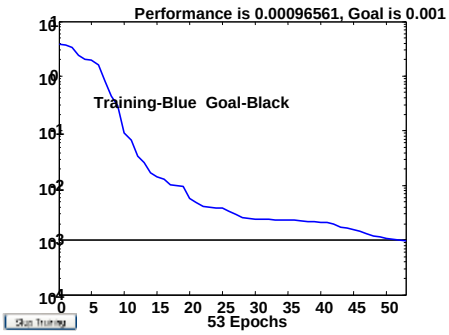
(n) Attack 14(neptune.)



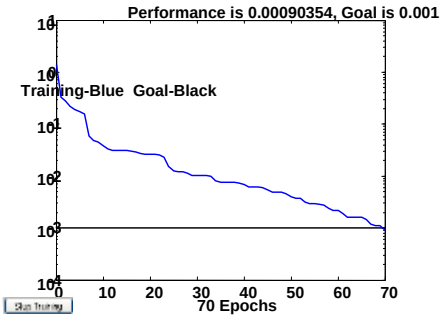
(o) Attack 15(nmap.)



(p) Attack 17(perl.)



(q) Attack 18(phf.)



R2L Attack 19(pod.)

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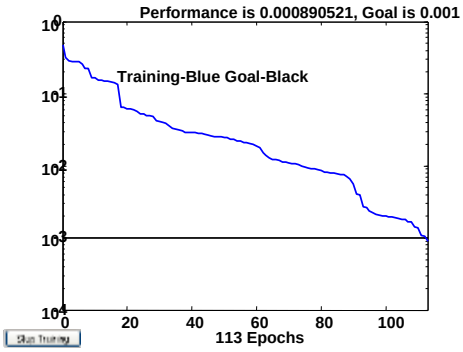
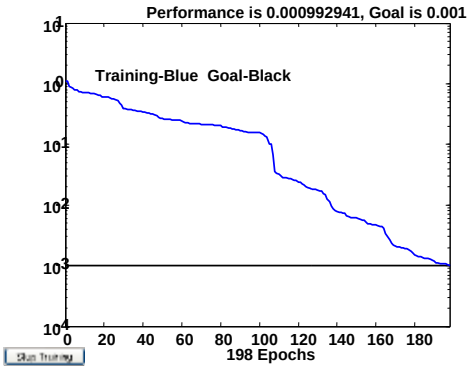
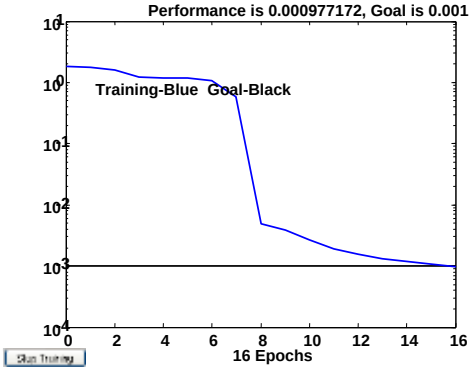


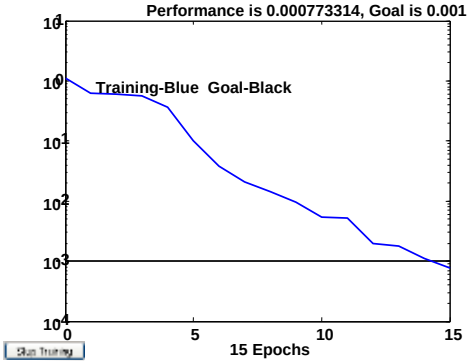
(s) Attack 20(portsweep.)



(t) Attack 21(rootkit.)



(u) Attack 22(warezclient.)



(v) Attack 23(spy.)

Figure (16) The convergence of the attacks available in the KDD training dataset, using encoding, for the 2-layered neural network, with the Max Input of 100 and a number of 40 hidden neurons in the first and second layers.

The convergence for the previous system with various learning parameters (sigma, lambda), for the attacks 6, 12 and 13, is shown in Table (31) for the same number of hidden neurons and maximum input samples of a 2 layer neural network. The rest attacks all converge.

Table 31 The convergence of attacks 6 and 12 and 13 for the experiment of a 2layered neural network with max 100 input, 40 hidden neurons.

σ	λ	# Hidden neurons	Max input	6	12	13
5e-005	5e-007	40	100	0/10	8/10	10/10
5e-004	5e-007	40	100	0/10	10/10	6/10
5e-006	5e-007	40	100	4/10	8/10	8/10
5e-004	5e-006	40	100	2/10	10/10	10/10
5e-004	5e-008	40	100	2/10	10/10	6/10
5e-006	5e-006	40	100	4/10	10/10	6/10
5e-006	5e-008	40	100	2/10	10/10	8/10

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Table 32 Using a 2-layered neural network system with, max input 100 of each attack type on redundant records, using different hidden neurons (100/2/x).

#Hidden neurons	Rate%	Cost%	Attack category	TPR Each%	TPR%	FPR%	FP	TP	FN
40	56.31	65.44	Prob	76.12	47.26	6.29	3812.00	118347.00	995.00
			DoS	49.62					116608.00
			U2R	34.29					46.00
			R2L	2.07					14440.00
			Normal	93.71					
	40.34	68.24	Prob	72.01	27.78	7.74	4691.00	69576.00	1166.00
			DoS	28.63					165196.00
			U2R	40.00					42.00
			R2L	1.96					14456.00
			Normal	92.26					
	93.30	56.89	Prob	76.88	93.26	6.53	3958.00	233557.00	963.00
			DoS	99.41					1362.00
			U2R	32.86					47.00
			R2L	1.61					14507.00
			Normal	93.47					
50	65.56	61.83	Prob	83.92	61.08	15.92	9648.00	152968.00	670.00
			DoS	64.38					82439.00
			U2R	37.14					44.00
			R2L	2.92					14315.00
			Normal	84.08					
	92.50	60.61	Prob	62.03	92.63	8.04	4870.00	231975.00	1582.00
			DoS	99.04					2231.00
			U2R	25.71					52.00
			R2L	1.01					14596.00
			Normal	91.96					
	40.24	67.43	Prob	77.12	27.79	8.31	5038.00	69608.00	953.00
			DoS	28.54					165389.00
			U2R	41.43					41.00
			R2L	2.03					14445.00
			Normal	91.69					
60	82.67	60.47	Prob	74.03	80.07	6.62	4009.00	200529.00	1082.00
			DoS	85.18					34291.00
			U2R	30.00					49.00
			R2L	1.76					14485.00
			Normal	93.38					
	92.74	57.22	Prob	55.38	92.50	6.30	3815.00	231664.00	1859.00
			DoS	99.03					2251.00
			U2R	40.00					42.00
			R2L	0.85					14620.00
			Normal	93.70					
	91.94	54.69	Prob	80.48	93.39	14.06	8520.00	233879.00	813.00
			DoS	99.45					1282.00
			U2R	41.43					41.00
			R2L	2.20					14421.00
			Normal	85.94					
70	40.35	64.35	Prob	77.56	27.96	8.44	5117.00	70028.00	935.00
			DoS	28.73					164954.00
			U2R	52.86					33.00
			R2L	1.76					14486.00
			Normal	91.56					
	34.99	78.91	Prob	6.55	20.93	6.93	4200.00	52425.00	3893.00
			DoS	22.50					179383.00
			U2R	28.57					50.00
			R2L	0.41					14685.00
			Normal	93.07					
	39.86	67.04	Prob	83.70	28.30	12.35	7486.00	70878.00	679.00
			DoS	28.82					164748.00

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			U2R	38.57					43.00
			R2L	4.46					14088.00
			Normal	87.65					
80	92.93	53.11	Prob	71.27	93.23	8.30	5029.00	233476.00	1197.00
			DoS	99.45					1283.00
			U2R	48.57					36.00
			R2L	2.04					14444.00
			Normal	91.70					
	74.48	56.73	Prob	86.80	72.17	16.00	9694.00	180740.00	550.00
			DoS	76.20					55095.00
			U2R	44.29					39.00
			R2L	4.97					14012.00
			Normal	84.00					
	38.58	67.22	Prob	71.48	25.36	6.76	4094.00	63505.00	1188.00
			DoS	26.03					171206.00
			U2R	45.71					38.00
			R2L	1.67					14499.00
			Normal	93.24					
90	42.57	65.58	Prob	77.94	30.41	7.15	4334.00	76146.00	919.00
			DoS	31.35					158884.00
			U2R	45.71					38.00
			R2L	2.01					14449.00
			Normal	92.85					
	39.22	62.64	Prob	87.49	28.36	15.89	9628.00	71021.00	521.00
			DoS	28.86					164653.00
			U2R	55.71					31.00
			R2L	3.63					14210.00
			Normal	84.11					
	50.73	60.04	Prob	90.71	41.41	10.75	6512.00	103707.00	387.00
			DoS	42.85					132287.00
			U2R	51.43					34.00
			R2L	4.91					14021.00
			Normal	89.25					
100	75.30	58.56	Prob	67.62	71.12	7.42	4495.00	178104.00	1349.00
			DoS	75.60					56469.00
			U2R	45.71					38.00
			R2L	1.82					14476.00
			Normal	92.58					
	40.50	67.76	Prob	76.74	27.79	6.94	4206.00	69591.00	969.00
			DoS	28.55					165375.00
			U2R	40.00					42.00
			R2L	1.94					14459.00
			Normal	93.06					

After 40 experiments for using 100 Max Input to the 2-layered NN system with different number of hidden neurons to each layer, by using first the preprocessed distinct records, then using encoded redundant records. The maximum TPR record taken from the previous tables for both distinct and redundant datasets results are been compared in the Table (33), Figure (17) shows the comparison.

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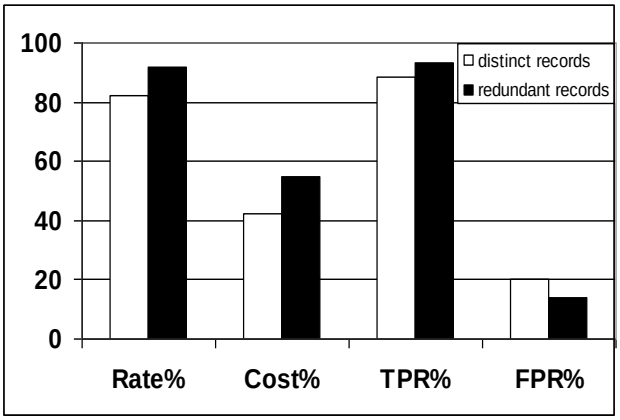
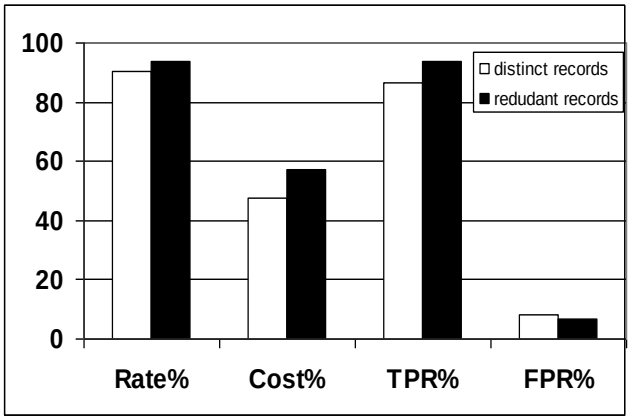
Table 33 The performance comparison between different distinct and redundant records of testing datasets, for a maximum input of 100, and different hidden neurons in their layers, for the 2-layered neural network (x/2/x).

Records Type/Max Input /# hidden neurons for both first layer One for second layer	Performance	Rate%	Cost%	TPR%	FPR%
Distinct /100 /80		82.20	42.14	88.23	20.09
Redundant /100 /60		91.94	54.69	93.39	14.06
Distinct /256 /90		90.18	47.61	86.38	8.37
Redundant /256 /90		93.68	57.38	93.74	6.59
Distinct /512 /90		44.92	22.20	93.48	73.57
Redundant /512 /90		84.01	19.53	99.31	79.23
Distinct /1200 /90		87.80	47.36	89.09	12.70
Redundant /1200 /70		82.74	64.11	80.73	8.93
Distinct /2000 /100		87.34	40.98	89.65	13.53
Redundant /2000 /100		93.22	55.50	94.21	10.89



(a)



(b)

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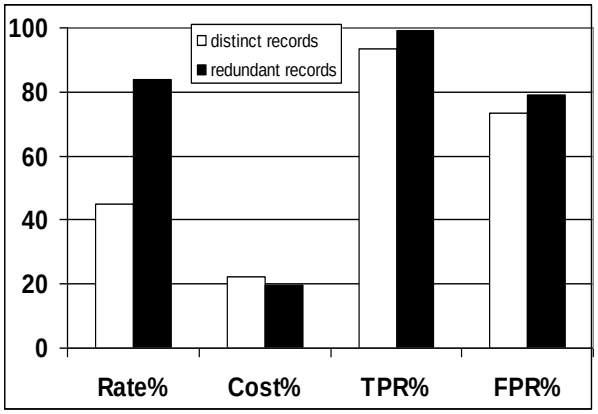
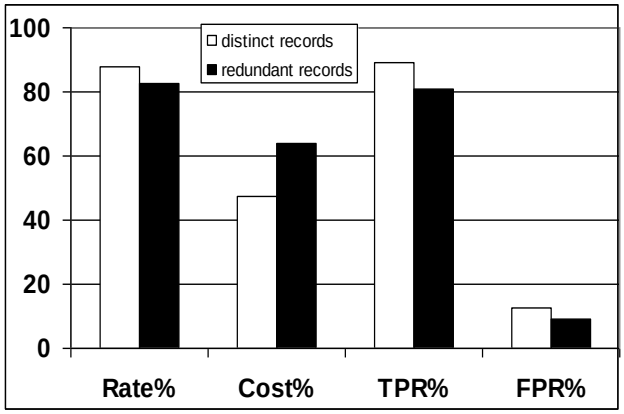
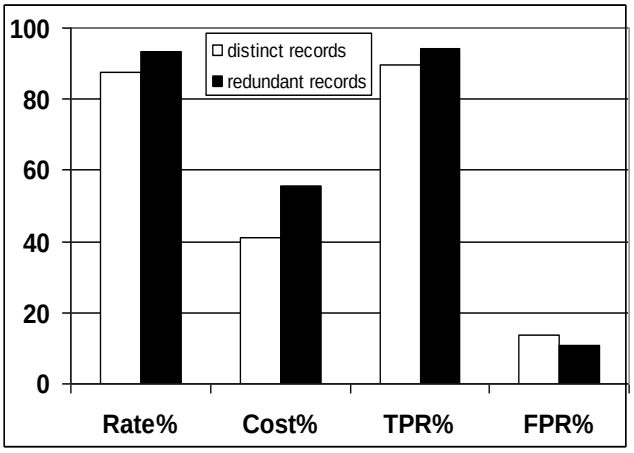


(c)



(d)



(e)

Figure (17) The comparison between the performance of Distinct & redundant datasets for the record of maximum TPR (a) for the 100 Max Input to the 2 layer neural network system. After performing 40 experiment and generating 20 neural network system). (b) For the 256 Max Input to the 2 layer neural network system. After performing 42 experiment and generating 11 neural network system). (c) For the 512 Max Input to the 2 layer neural network system, After performing 51 experiments. (d) for the 1200 Max Input to the 2 layer neural network system , After performing 42 experiment.(e) for the 2000 Max Input to the 2 layer neural network system, After performing 42.

After 217 experiments shown in APPENDIX A, for the 2-layered NN system with both distinct and redundant datasets, it is noticed that the Rate for most of the redundant testing dataset is more than the Rate of the distinct testing dataset. The Cost for most of the redundant testing dataset is more than the Cost of the distinct testing dataset, and that the TPR for most of the redundant testing dataset is more than the TPR of the distinct testing dataset, and that the FPR for most of the

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redundant testing dataset is less than the FPR of the distinct testing dataset.

1.59.2 Three active layers of NN:

Architecture of this 3-layered NN. The network is a 3-layer tan-sigmoid/tan-sigmoid / tan-sigmoid, network as shown in Figure (18). The first and second hidden layers have a number of (NoOfHidden) neurons, and the third layer has only one neuron (the out put layer). The number of neurons is varied in the range of [40,200] for the experiments and comparisons.

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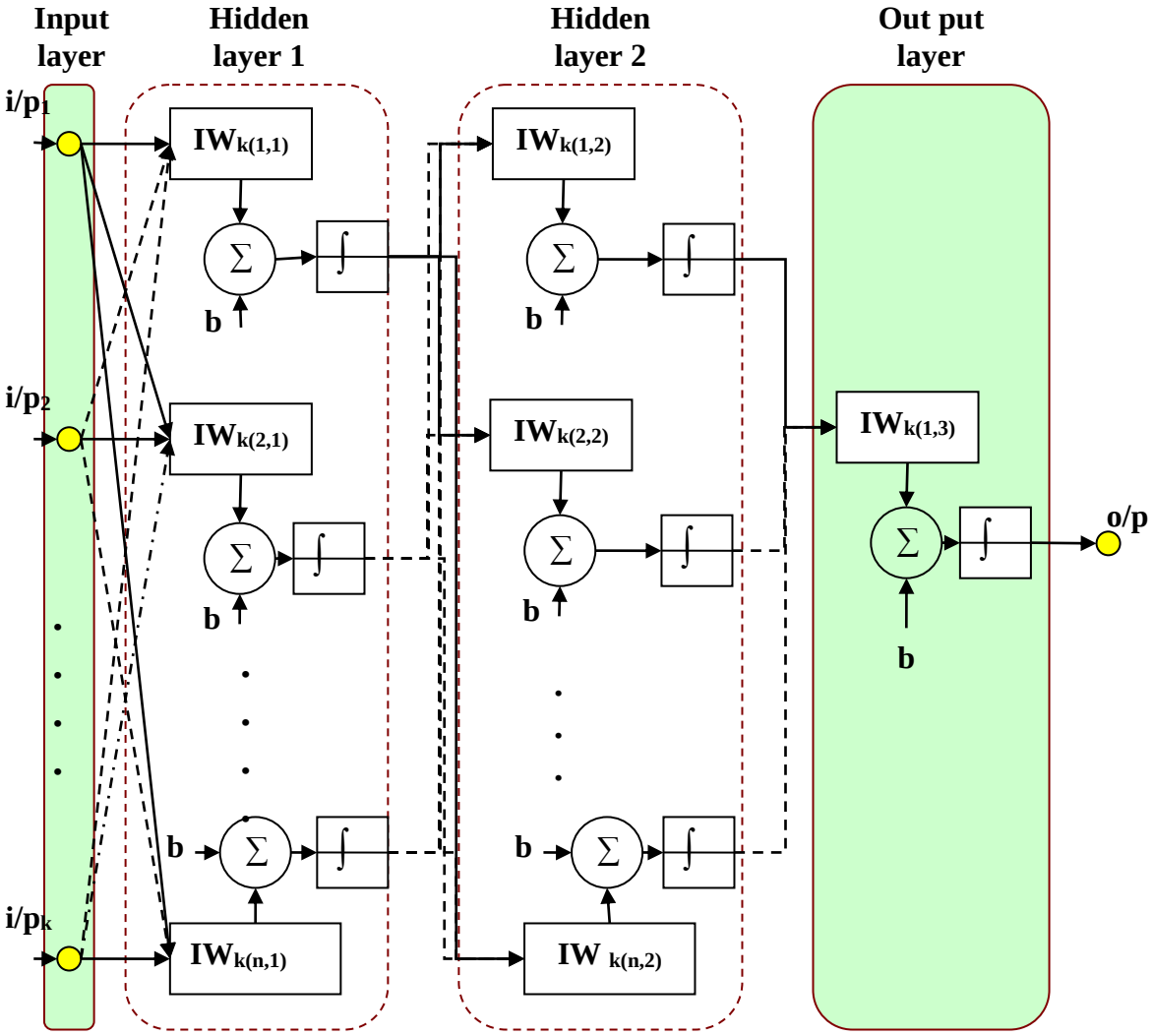
The Neural Network of 3-layers



Input1 = [i/p1,1,….,i/p1,k]
Connection to 1'st layer =k= [1...40]
Connection to 2'nd layer =k= [1...n]
Connection to 3'rd layer =k= [1...n]
n= # of hidden neurons
IW (inputID)(neuronID,layerID)

Figure (18) The architecture of a 3-layer neural network.

After 43 experiments shown in APPENDIX A, for applying the 100 Max Input to the 3-layered NN system with different number of hidden neurons to each layer. Using first the preprocessed distinct records, then using encoded redundant real records. Both distinct and

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redundant datasets results are compared in the Table (34), Figure (19) also shows the comparison.

Table 34 The performance comparison between the distinct and redundant testing dataset of a 3-layered neural network with different Max Input (x/3/x).

Records Type/Max Input /# hidden neurons of both first and second layer One for the third layer	**Performance**	**Rate%**	**Cost%**	**TPR%**	**FPR%**
Distinct /100/70		67.45	36.01	92.60	42.12
Redundant/100/80		88.38	33.40	97.10	47.69
Distinct /256/40		80.37	39.69	92.38	24.20
Redundant/256/100		89.32	38.03	96.53	40.48
Distinct /512/80		87.64	34.92	92.97	14.39
Redundant/512/200		90.72	38.06	97.41	36.91
Distinct /1024/40		82.46	21.30	98.64	23.70
Redundant/1024/40		92.44	24.77	99.87	38.26
Distinct /1200/100		66.55	39.29	92.08	43.17
Redundant/1200/100		87.70	51.68	95.11	42.95
Distinct /2000/80		70.06	33.37	93.72	38.95
Redundant/2000/70		92.96	59.43	94.17	12.04

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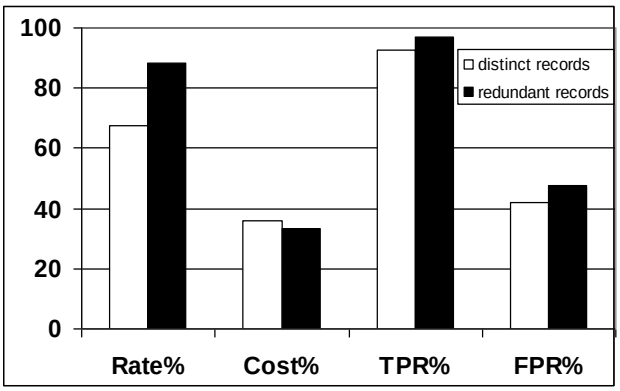
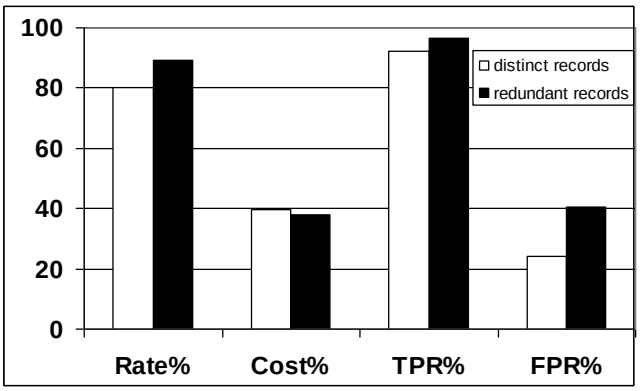
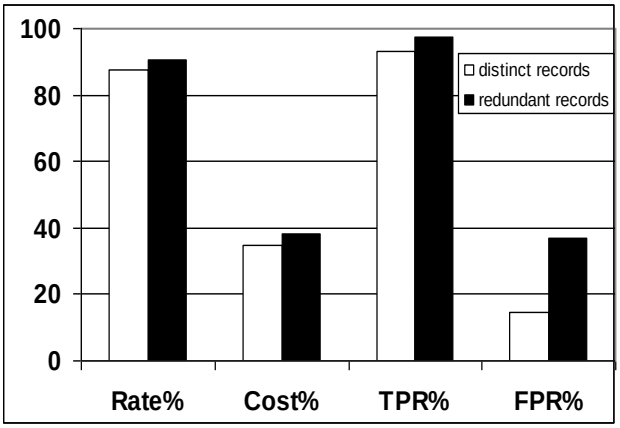


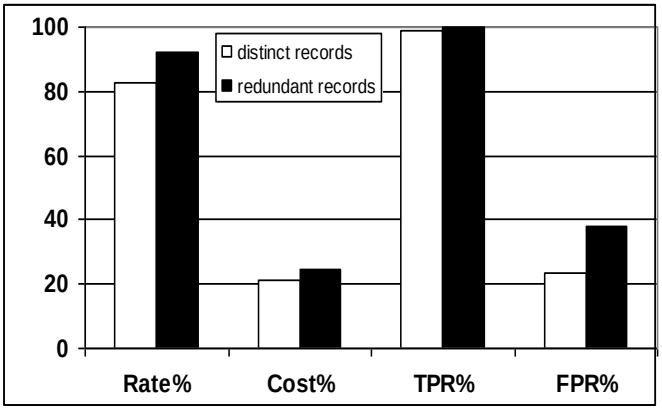
(a)



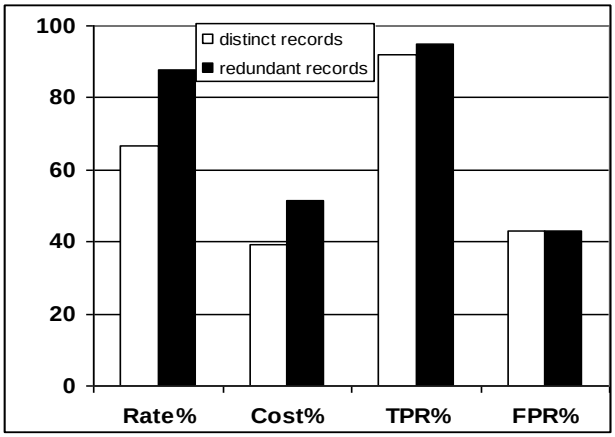
(b)



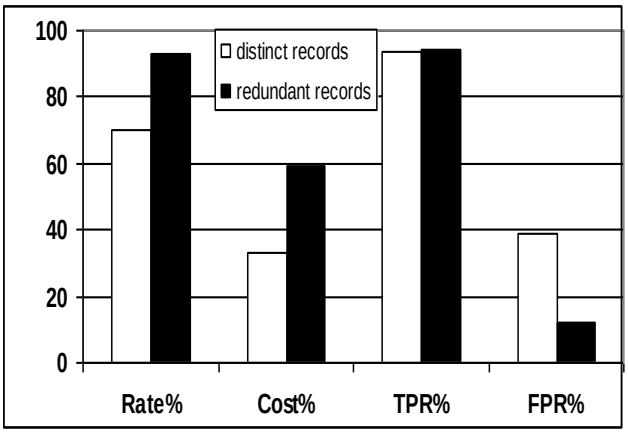
(c)



(d)



(e)



(f)

Figure (19) The comparison between the performance of Distinct & redundant datasets for the record of maximum TPR (a) for the 100 Max Input to the 3 layer neural network system, After performing 51 experiments 43. (b) For the 256 Max Input to the 3 layer neural network system, after performing 48 experiments(c) for the 512 Max Input to the 3 layer neural network system, after performing 54 experiments (d) for the 1024 Max Input to the 3 layer neural network system, after performing 53 experiments (e) for the 1200 Max Input to the 3 layer neural network system, after performing 42 experiments (f) for the2000 Max Input to the 3 layer neural network system, after performing 42 experiments.

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After 282 experiments shown in APPENDIX A, for the 3-layered NN system with both distinct and redundant datasets, it is obvious that the Rate for most of the redundant testing dataset is more than the Rate of the distinct testing dataset, and that the Cost for most of the redundant testing dataset is more than the Cost of the distinct testing dataset, and that the TPR for most of the redundant testing dataset is more than the TPR of the distinct testing dataset, buts that the FPR for the redundant and distinct testing dataset are similar, for the 3-layered system.

1.59.3 Four active layers of NN:

Architecture: The Max Input number of the NN is entered as a parameter variously and only one neuron in its output layer to identify the attacks. The network is a 4-layered tan-sigmoid/tan-sigmoid network. Figure (20) shows the architecture of this NNB. The first hidden layer has a number of (NoOfHidden/2) neurons, the second layer has (NoOfHidden), and the third layer has (NoOfHidden/2), and the forth layer is the output and has only one neuron.

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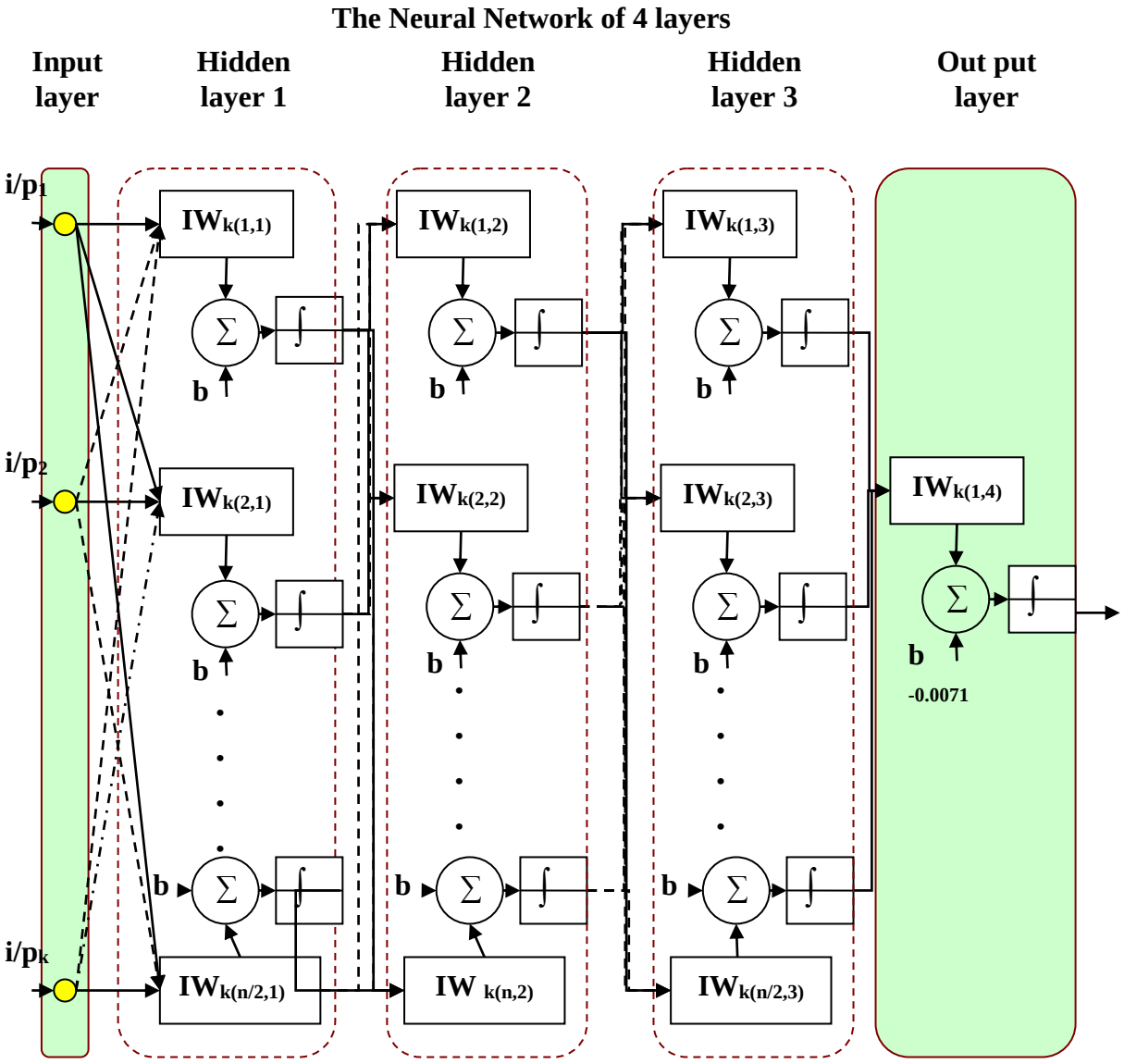

$Input_1 = [i/p_{1,1},\ldots,i/p_{1,k}]$
Connection to 1'st layer =k= [1...40]
Connection to 2'nd layer =k= [1...n/2]
Connection to 3'rd layer =k= [1...n]
Connection to 4'th layer =k= [1...n/2]
n= # of hidden neurons
b is randomly choosed for each neuron
IW (inputID)(neuronID,layerID)

Figure (20) A detailed architecture of our 4-layered neural network.

After 50 experiment using the 100 as Max Input to the 4-layered NN system with different number of hidden neurons to each layer. Using first the preprocessed distinct records, then using

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encoded redundant real records. The maximum TPR record taken from the corresponding tables in appendix A, for both distinct and redundant datasets results are been compared in the Table (35), Figure (21) shows the comparison.

Table 35 The performance comparison between the distinct and redundant records of a 4-layered neural network with different Max Input (x/4/x).

Records Type/Max Input /# ½ hidden neurons for 1'st layer / hidden neurons for 2'nd/ ½ hidden neurons for 3'rd layer/ one for 4'th layer	**Performance**	**Rate%**	**Cost%**	**TPR%**	**FPR%**
Distinct /100/64		75.31	41.36	90.20	30.36
Redundant/60		87.48	50.41	94.65	42.13
Distinct /256/100		75.07	39.54	88.38	30.00
Redundant/256/100		89.77	36.09	97.81	43.46
Distinct /512/100		74.65	18.46	98.66	34.49
Redundant/512/100		90.35	19.29	99.84	48.90
Distinct /1024/200		69.82	21.20	99.50	41.47
Redundant/1024/200		89.38	24.12	99.89	54.08
Distinct /1200/70		69.39	21.53	99.56	42.09
Redundant/1200/70		89.31	23.37	99.97	54.76
Distinct /2000/100		87.38	44.61	89.47	13.41
Redundant/2000/40		93.18	56.20	94.07	10.52

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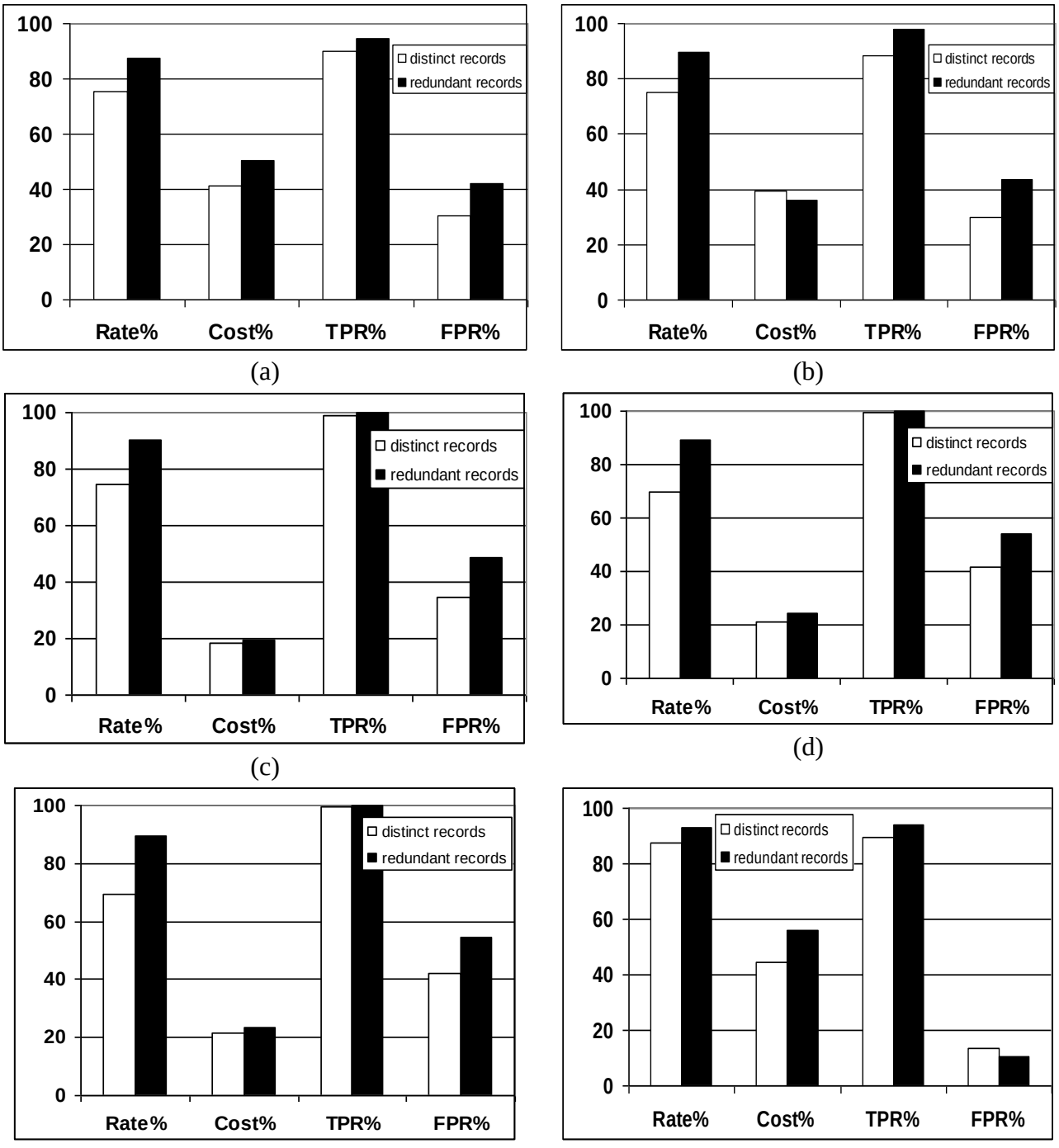

Figure (21) The comparison between the performance of Distinct & redundant datasets for the record of maximum TPR (a) for the 100 Max Input to the 4 layer neural network, after performing 50 experiments (b) for the 256 Max Input to the 4 layer neural network system, after performing 48 experiments (c) for the 512 Max Input to the 4 layer neural network system, after performing 80 experiments (d) for the 1024 Max Input to the 4 layer neural network system, after performing 55 experiments (e) for the 1200 Max Input to the 4 layer neural network system, after performing 50 experiments (f) for the 2000 Max Input to the 4 layer neural network system, after performing 48 experiments.

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After 331 experiments, we determine that the Rate for most of the redundant testing dataset is more than the Rate of the distinct testing dataset, and that the Cost for most of the redundant testing dataset is less than the Cost of the distinct testing dataset. The TPR for most of the redundant testing dataset is more than the TPR of the distinct testing dataset, but for the FPR the redundant is more than the distinct testing dataset, for the case of 4 layered systems.

The total number of experiments for the 4-layered neural networks was 331 experiments and generated 165 neural network systems having 22 neural networks for each system. The total number of experiments for the 3 layered neural networks was 282 and for the 2layered neural network was 217 ,so we had generated a total number of 415 neural network system in our work and compared there performance.

1.60 Further Analysis

After performing 830 experiments we generated more than 410 different NN systems and applied them to the distinct and redundant data. The best of each type will be chosen, as follows and illustrate the performance in Table (36) that shows the structure of the system and the type of dataset used for testing, the time of training and testing is included with the time of reading the files of datasets, so it is in real less than what is written in the Table, as we see as the number of neurons increase the testing time also increases that is the reason that we didn't make any further experiments for a larger number of neurons.

Table 36 The description of our systems with their training time and testing time, and the type of dataset applied on.

Our method	**# of layers**	**# of Max Inputs**	**# of hidden neurons**	**Time of training in sec**	**Time of testing in sec**	**Time / #record sec**	**Time of calculations in sec**	**Description in testing dataset type: best result of**
Sys 1	2	256	90	102.703	345.891	0.018468	27.218	**PSP** in **redundant**
Sys 2	4	1200	70	745.984	493.031	0.026324	28.094	**TPR** and **R2L** in **redundant**

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Sys 3	2	2000	50	422.141	246.985	0.013187	18.203	**FPR** in **redundant**
Sys 4	4	1200	70	1012.265	105.922	0.026829	17.859	**FN** and **TPR** in **distinct**
Sys 5	2	512	90	123.468	343.328	0.018331	22	**Cost** in **redundant**
Sys6	2	2000	50	422.141	53.61	0.013579	30.438	**FPR** in **distinct**
Sys 7	2	512	90	176.906	72.844	0.018451	33.078	**U2R** and **probe** in **distinct**
Sys 8	4	512	100	702.312	651.453	0.034783	39.547	**DoS** in **redundant**
Sys 9	4	1200	100	787.782	140.172	0.035505	19	**PSP** in **distinct**
Sys 10	3	1024	200	982.1870	3079.156	0.779928	24.828	**DoS** in **distinct**
Sys 11	3	1024	90	484.312	219.296	0.055546	28.859	**R2L** and **Cost** in **distinct**
sys12	4	1200	50	972.719	98.172	0.000316	21.718	**redundant**
sys13	4	2000	40	1395.484	67.406	0.000217	26.141	**redundant**
sys14	2	100	40	47.641	100.266	0.000322	20.625	**redundant**
sys15	2	512	50	125.375	52.984	0.00017	42.578	**redundant**
sys16	4	512	90	638.86	209.391	0.000673	36.437	**redundant**
sys17	4	2000	60	1958.25	90.688	0.000292	33.75	**redundant**
sys18	**2**	2000	100	537.171	77.812	0.00025	25.328	**redundant**
sys19	4	512	40	421.266	80.797	0.00026	15.765	**redundant**
sys20	4	2000	64	1712.938	102.39	0.000329	**11.36**	**redundant**
sys21	2	512	60	163.468	57.047	0.000892	25.407	**distinct**
sys22	2	1200	90	297.312	70.282	0.001099	24.735	**distinct**
sys23	**2**	2000	50	337.266	49.063	0.000767	14.563	**distinct**
sys24	2	1200	60	262.625	57.359	0.000897	25.312	**distinct**
sys25	**2**	2000	100	619.844	76.485	0.001196	14.719	**distinct**
sys26	**2**	512	80	133.594	68.016	0.001064	31.688	**distinct**
sys28	4	2000	70	1193.235	103.265	0.001615	30.984	**distinct**
sys29	2	1200	70	261.703	62.125	0.000971	25.328	**distinct**
sys30	**2**	512	80	170.953	68	0.001063	35.219	**distinct**

Table (38) shows the previous works performance and their datasets used for training and testing (type and amount), at the end of this table, 11 systems are chosen from the best records performance for each dataset type (distinct and redundant), and to compare them, Figure (22) shows the performance of the systems. The (N/A) symbol means that it wasn't introduced in their work. For the small space in figures we will indexed the previous works as in Table (37).

Table 37 The indexed previous systems.

index	The system of previous work as in references.
[1]	Agarwal and Joshi.(2000)
[2]	Levin (2000)
[3]	Ertoz et al (2003).
[4]	Yeung and Chow(2002)
[5]	Sabhnani and Serpen (2003)
[6]	www-cse.ucsd.edu/~elkan/clresults (2008)
[7]	Bouzida and Cuppens (2006)
[8]	Tian et al (2007)
[10]	Yao and Yao (2007)

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[11]	Wei et al(2006)
[14]	Faraoun and Boukelif (2006)
[15]	Kayacik et al (2004)
[17]	Yang et al (2007)
[42]	Delamer (2002)

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Table 38 The important performance of previous systems and the systems in this thesis.

Method	Probe%	DoS%	U2R%	R2L%	FPR%	TPR%	PSP %	our Cost%	Total FN	FNR %	New Attack Recognition %	Training dataset and other parameters	Testing data
[1]	73.2	96.9	6.6	10.7	0.45	N/A	92.588	59.68	22339	8.920043	Many	Training dataset	redundant
[2]	99.71	99.99	46.15	19.72	0.59	N/A	92.919	43.96	21224	8.47482	N/A	random sample from the 10% of the KDD training data	redundant
[3]	91.88	97.85	5.6	77.04	4	N/A	94	N/A	N/A	N/A	N/A	A cap of 10; 000 records for each sub-attack type. Picked 10; 000 normal sessions from both the test and training sets, which resulted in a data set of approximately 97; 000 records. We then removed duplicate sessions, reducing the data set size to 45; 000 records.	44424 total samples of both testing and training datsets
[3]	73.43	77.76	37.82	68.15	30	N/A	73	N/A	N/A	N/A	N/A		
[4]	87.73	97.69	26.32	10.27	0.55	N/A	93.73	54.309	N/A	N/A	N/A	Used 30000 random samples normal. Another 30000 random samples normal connections form the threshold determination set, which has no overlap with the training set.	Didn't use the testing dataset.
[5]	88.7	97.3	29.8	9.6	<=4	N/A	92.7	53.573	N/A	N/A	N/A	Distinct training dataset	Redundant
[6]	83.3	97.1	13.2	8.4	0.5	91.812279	92.7	59.07	20505	8.187721	N/A	4,000 samples from probe, 80000 from normal, And 400000 from DoS. They used the same data for both training and testing.	Redundant
[7]	72.73	97.14	7.02	2.85	0.57	92.636	92.87	63.736	18442	7.364	10.06% probe 0.36% DoS 60.96% U2R 2.20% R2L	N/A	Redundant
[8]	84.11	97.45	11.2	9.01	4.081	93.92006	92.77	N/A	15199	6.07994	N/A	Redundant each slice has a different # of neurons in the range of [1-240] The output slice has 368 neurons	Redundant
[10]	N/A	N/A	N/A	N/A	1.8	98.3	N/A	N/A	N/A	1.7	N/A	The normal instances and instances of three popular attacks: ipsweep smurf, neptune. only	N/A
[11]	N/A	N/A	N/A	N/A	6.129	95.685	N/A	N/A	N/A	4.315	42.586	10% KDD training dataset	Redundant
[14]	96.63	97.23	87.71	30.97	6.21	N/A	N/A	36.531	N/A	N/A	N/A	a total of 24780 samples	Redundant
[15] Sys1	72.8	96.5	22.9	11.3	7.6	N/A	N/A	57.08	N/A	N/A	33.12	10% (system1). Normal only of 10% (system2). 10% KDD Modified (50% attack/50%) normal (system3).	N/A
[15] Sys2	91.0	96.5	22.9	20.5	14.5	N/A	N/A	52.7	N/A	N/A	42		
[15]Sys3	79.7	96.7	30.0	18.4	14.3	N/A	N/A	52.509	N/A	N/A	39.4		
[17]	99.5	97.92	81.14	10.44	0.7	N/A	N/A	N/A	N/A	N/A	N/A	10% KDD training	redundant
[42]	56.3130	96.2213	0	0.92643	0.55121	89.9813	91.7748	68.0081	22542	9.001102	0	Redundant training set	redundant
Sys1	85.09	99.66	25.71	3.445	6.588	93.74	93.676	57.384	15677	6.2598827	42.970	256 as max input /2 layer NNB	redundant

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Sys2	99.95	99.999	32.857	99.796	54.75	99.968	89.306	23.368	80	0.0319442	43.456	1200 as max input / 4 layer NNB	Redundant
Sys3	83.485	25.39	5.714	1.186	2.057	24.926	39.151	76.90	188010	75.073072	12.082	2000 as max input / 2 layer NNB	Redundant
Sys4	99.921	99.99	37.142	98.489	42.087	99.563	69.394	21.526	77	0.436755	99.164	1200 as max input /4 layer NNB	distinct
Sys5	81.493	99.51	77.14	97.88	82.04	99.109	83.299	16.232	2231	0.8908463	94.505	512 as max input /2 layer NNB	Redundant
Sys6	83.202	76.586	5.714	8.1571	2.114	69.546	90.073	65.087	979	5.5530346	47.188	2000 as max input /2 layer NNB	distinct
Sys7	79.921	93.683	85.714	84.541	77.269	90.647	41.454	19.515	1649	9.3533749	74.113	512 as max input /2 layer NNB	distinct
Sys8	93.567	99.999	48.571	99.3625	48.896	99.841	90.345	19.288	399	0.1593221	99.247	512 as max input /4 layer NNB	Redundant
Sys9	78.379	84.936	7.143	8.559	3.739	75.082	90.422	63.620	4393	24.917753	55.243	1200 as max input /4 layer NNB	distinct
Sys 10	96.047	99.785	37.142	43.756	39.732	92.689	69.205	41.605	1289	7.3114010	86.676	1024 as max input /3 layer NNB	distinct
Sys 11	99.683	98.374	52.857	98.388	45.915	98.383	66.297	17.941	285	1.6165626	94.680	1024 as max input /3 layer NNB	distinct
sys12	83.41335	99.57357	15.71429	1.804001	6.83907	93.52489	93.45399	60.90179	16216	6.4751074	42.0364141	1200 as max input /4 layer NNB	Redundant
sys13	89.84638	99.66862	40	4.923703	9.0109418	93.91022	93.34114	52.73932	15251	6.0897794	43.5634577	2000 as max input /4 layer NNB	Redundant
sys14	76.8843	99.41155	32.85714	1.614106	6.532108	93.26015	93.30062	56.89062	16879	6.7398457	39.564312	100/2 as max input layer NNB	Redundant
sys15	84.66155	99.47549	17.14286	2.07528	7.431551	93.47139	93.29548	60.37176	16350	6.5286140	42.426184	512 as max input /2 layer NNB	Redundant
sys16	83.84542	99.37569	11.42857	2.617837	7.159242	93.39592	93.28776	61.80049	16539	6.604082	42.2072721	512 as max input /4 layer NNB	Redundant
sys17	85.18963	99.68547	24.28571	1.675144	8.5768983	93.65267	93.21832	60.45181	15896	6.3473302	43.0295264	2000 as max input /4 layer NNB	Redundant
sys18	89.77436	99.77058	25.71429	8.491014	10.8907	94.2093	93.21575	55.49711	14502	5.7907010	42.5863634	2000 as max input /2 layer NNB	Redundant
sys19	87.229956	99.61374	17.14285	2.8280773	8.8558084	93.686211	93.190989	59.96886	15812	6.3137887	43.040205	512 as max input /4 layer NNB	Redundant
sys20	89.150264	99.890259	28.57142	4.421837	10.516066	94.070740	93.177164	56.19851	14849	5.9292593	43.9692456	2000 as max input /4 layer NNB	Redundant
sys21	83.280632	89.25942	11.42857	16.062437	4.0975820	79.846851	91.476153	58.52388	3553	20.153148	62.4873354	512 as max input /2 layer NNB	distinct
sys22	87.707509	91.00735	8.571428	16.918429	5	81.860465	91.377639	58.35362	3198	18.13953	68.1610942	1200 as max input /2 layer NNB	distinct
sys23	84.940711	87.35817	4.285714	12.437059	3.6312607	78.241633	91.371384	61.94262	3836	21.758366	66.8439716	2000 as max input /2 layer NNB	distinct
sys24	87.193675	82.82735	14.28571	21.953675	3.5319516	76.324446	90.914777	56.3647	4174	23.675553	55.3951368	1200 as max input /2 layer NNB	distinct
sys25	94.031620	87.68015	27.14285	79.405840	7.8756476	87.419171	90.827209	30.85743	2218	12.580828	79.0526849	2000 as max input /2 layer NNB	distinct
sys26	82.687747	88.66911	14.28571	9.0130916	4.7301381	78.542257	90.658327	60.52679	3783	21.457742	68.8703141	512 as max input /2 layer NNB	distinct
sys28	86.126482	91.36767	17.14285	10.120845	6.3514680	81.168462	90.207975	58.68888	3320	18.831537	99.164134	2000 as max input /4 layer NNB	distinct
sys29	88.458498	83.01901	25.71428	26.938569	5.0086355	77.254679	90.101642	51.41954	4010	22.745320	54.8378926	1200 as max input /2 layer NNB	distinct
sys30	76.640316	92.348973	32.857143	15.911379	6.5889464	81.247872	90.057858	53.00307	3306	18.752127	62.816616	512 as max input /2 layer NNB	distinct

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The new attack types (unseen attacks in KDDCup99 training set) that are determined and their rate of recognition for each proposed system are shown in Table (39).

Table 39 The rate of recognizing of new attacks that are in testing set (not seen in training set).

Our Method	Total Of New Attacks	Total Of New Recognized Attacks	# of New Attacks Types recognized	Attack ID
Sys1	18729	8048	14	24; 25; 26; 27; 28; 29; 30; 31; 32; 33; 35; 37; 39; 40
Sys2	18729	8139	14	24; 25; 26; 27; 28; 29; 30; 31; 32; 33; 35; 37; 39; 40
Sys3	18729	2263	10	24; 26; 27; 28; 30; 32; 33; 35; 37; 40
Sys4	3948	3915	14	24; 25; 26; 27; 28; 29; 30; 31; 32; 33; 35; 37; 39; 40
Sys5	18729	17700	**17**	24; 25; 26; 27; 28; 29; 30; 31; 32; 33; 34; 35; 36; 37; 38; 39; 40
Sys6	3948	1863	10	24; 26; 27; 28; 30; 32; 33; 35; 37; 40
Sys7	3948	2926	**17**	26; 27; 28; 29; 30; 31; 32; 33; 34; 35; 36; 37; 38; 39; 40
Sys8	18729	18588	15	26; 27; 28; 29; 30; 31; 32; 33; 35; 36; 37; 39; 40
Sys9	3948	2181	11	24; 26; 27; 28; 30; 32; 33; 35; 37; 39; 40
Sys10	3948	3422	14	24; 25; 26; 27; 28; 29; 30; 31; 32; 33; 35; 37; 39; 40
Sys 11	3948	3738	14	24; 25; 26; 27; 28; 29; 30; 31; 32; 33; 35; 37; 39; 40
sys12	18729	7873	14	24, 25, 26, 27, 28, 29, 30, 31, 32, 33, 35, 37, 39, 40
sys13	18729	8159	14	24, 25, 26, 27, 28, 29, 30, 31, 32, 33, 35, 37, 39, 40
sys14	18729	7410	16	24, 25, 26, 27, 28, 29, 30, 31, 32, 33, 35, 36, 37, 38, 39, 40
sys15	18729	7946	14	24, 25, 26, 27, 28, 29, 30, 31, , 32, 33, 35, 37, 39, 40
sys16	18729	7905	14	24, 25, 26, 27, 28, 29, 30, 31, 32, 33, 35, 37, 39, 40
sys17	18729	8059	15	24, 25, 26, 27, 28, 29, 30, 31, 32, 33, 35, 36, 37, 39, 40
sys18	18729	7976	14	24, 25, 26, 27, 28, 29, 30, 31, 32, 33, 35, 37, 39, 40
sys19	18729	8061	14	24, 25, 26, 27, 28, 29, 30, 31, 32, 33, 35, 37, 39, 40
sys20	18729	8235	14	24, 25, 26, 27, 28, 29, 30, 31, 32, 33, 35, 37, 39, 40
sys21	3948	2467	12	24, 26, 27, 28, 30, 31, 32, 33, 35, 37, 39, 40
sys22	3948	2691	12	24, 26, 27, 28, 30, 31, 32, 33, 35, 37, 39, 40
sys23	3948	2639	11	24, 26, 27, 28, 30, 31, 32, 33, 35, 37, 40
sys24	3948	2187	12	24, 26, 27, 28, 29, 30, 31, 32, 33, 35, 37, 40
sys25	3948	3121	14	24, 25, 26, 27, 28, 29, 30, 31, 32, 33, 35, 37, 39, 40
sys26	3948	2719	14	24, 25, 26, 27, 28, 29, 30, 31, 32, 33, 35, 37, 39, 40

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sys28	3948	2925	14	24, 25, 26, 27, 28, 29, 30, 31, 32, 33, 35, 37, 39, 40
sys29	3948	2165	13	24, 26, 27, 28, 29, 30, 31, 32, 33, 35, 37, 39, 40
sys30	3948	2480	14	24, 25, 26, 27, 28, 29, 30, 31, 32, 35, 36, 37, 39, 40

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Conclusions and Future Work

Conclusions

- Some experiments on the systems were made, to determine what classifiers could be neglected to give proper accurate performance results and to gain faster execution for the system, however it was found after many experiments, that when neglecting any classifier it will generate less accurate results from when containing all the classifiers (23). For example see Table (40) which is the equivalent of the first record in Table (29) with all the classifiers used.

Table 40 An example of neglecting a classifier from the neural network system.

# Hidden neurons	Rate%	Cost%	Attack category	TPR Each%	TPR%	FPR%	FP	TP	FN
40 (no neglecting)	88.37686	51.7086	Prob	71.06719	78.97901	8.0462	3727	13924	732
			DoS	90.50138					1239
			U2R	42.85714					40
			R2L	14.65257					1695
			Normal	91.9538					
40 (neglect 1)	86.1188	53.67625	Prob	69.13043	77.58934	10.63472	4926	13679	781
			DoS	89.07544					1425
			U2R	38.57143					43
			R2L	14.3001					1702
			Normal	89.36528					

- feature selection wasn't used, the feature selection method was included in many of the previous works, the feature selection not only gives less performance accuracy, because from each field in the samples gains information (except for the 20'th field) it also increases the complexity of the system and time needed to be build (Maaten et al, 2007), and for every feature there is some gained information (other than the 20'th feature) (Kayacik et al,2005).

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- Table 41 The complexity of some feature selection methods.

Techniques of feature selection	Computational	Memory
PCA/LDA	$O(nD) + O(D^3)$	$O(D^2)$
Isomap	$O(Dn \log n) + O(nk + n \log n) + O(n^3)$	$O(n^2)$
Kernel PCA	$O(Dn^2) + O(Dn^3)$	$O(n^2)$
Diffusion maps	$O(Dn^2) + O(n^3)$	$O(n^2)$
Autoencoders	O(inw)	O(w)
LLE	$O(Dn \log n) + O(nk^3) + O(pn^2)$	$O(pn^2)$
Laplacian Eigenmaps	$O(Dn \log n) + O(pnD) + O(pn^2)$	$O(pn^2)$
Hessian LLE	$O(Dn \log n) + O(nk^3) + O(nkD^2) + O(pn^2)$	$O(pn^2)$
LTSA	$O(Dn \log n) + O(nk^3) + O(pn^2)$	$O(pn^2)$
LLC	$O(imD^3) + O(Dn \log n) + O(pk^2)$	O(mnd)

Where **D** is the original dimensionality, **n** is the number of samples, **d** is the target dimension, **k** is the parameter of nearest neighbors, "**i**" is the number of iterations, the ratio of nonzero elements in a sparse matrix, **m** is the number of models, and **w** is the number of weights in a neural network.

- In Sys5 and Sys7 all of the *new* attacks are recognized (a total of 17 attack type available in testing dataset not in training dataset), but in Sys8, Sys4, Sys11, and Sys5 the best recognition of the new attacks are produced, as shown in Table (36), the comparison of these systems with there Recognition Rate of the new attacks for both previous and proposed systems, are shown in Figure (26).
- From Table (35) the probe attack type in the previous systems for more than 80% are the IDS in (Levin, 2000),(Levin, 2002) K-means ,(Yeung and Chow, 2002),(Sabhnani and Serpen, 2003),(www-cse.ucsd.edu/~elkan/clresults, 2008),(Tian et al., 2007),(Faraoun and Boukelif, 2006),(Kayacik et al., 2004)system2,(Yang et al., 2007), and in Sys1, Sys2, Sys3, Sys4, Sys5, Sys6, Sys7, Sys8, Sys10, Sys11, of the thesis work.

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- For the DoS attack type in the previous systems, the detection rate for more than 90%, are (Agarwal and Joshi, 2000),(Levin, 2000),(Levin, 2002),(Yeung and Chow, 2002),(Sabhnani and Serpen, 2003),(www-cse.ucsd.edu/~elkan/clresults, 2008),(Bouzida and Cuppens, 2006),(Tian et al., 2007),(Faraoun and Boukelif, 2006),(Kayacik et al., 2004),(Yang et al., 2007), and in Sys1, Sys2, Sys4, Sys5, Sys7, Sys8, Sys10, Sys11, of the thesis work.
- For the U2R attack type in the previous systems for the detection rate of more than 60% are the IDS in (Faraoun and Boukelif, 2006)(Yang et al., 2007) , and in Sys5, and Sys7, of the thesis work.
- For the R2L attack type in the previous systems for the detection rate of more than 83% do not exist, and in Sys2, Sys4, Sys7, Sys11 of the thesis work, this is shown in Figure (22).
- For the TPR in the previous work are only determined in (Yao and Yao, 2007) and (Wei et al., 2006) for more than 90%, and in Sys1, Sys2, Sys4, Sys5, Sys7, Sys8, Sys10, Sys11 of the thesis work, shown in Figure (23).
- For the FPR in the previous work they are less than 16% for (Agarwal and Joshi, 2000),(Levin, 2000),(Yeung and Chow, 2002),(Sabhnani and Serpen, 2003),(Bouzida and Cuppens, 2006),(Tian et al., 2007),(Yao and Yao, 2007),(Wei et al., 2006),(Faraoun and Boukelif, 2006),(Kayacik et al., 2004),(Yang et al., 2007), and in Sys1, Sys3, Sys6, Sys9 of the thesis work, this is shown in Figure (23) .
- For the Cost there is no Cost less than 30% in the previous work, but there are in Sys2, Sys4, Sys5, Sys7, Sys8, and Sys11 of the thesis work.

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- For the PSP in the previous work that are more than 90% is in (Bouzida and Cuppens, 2006), but there are in Sys1, Sys2, Sys6, Sys6, Sys9 of the thesis work, this is shown in Figure (24).
- The ROC Curve of proposed systems is shown in Figure (25). For diction of new attacks in the previous work for more than 45% is only in (Bouzida and Cuppens, 2006), but there are in Sys4, Sys5, Sys6, Sys7, Sys8, Sys9, Sys10 and Sys11 of the thesis work.
- For the FN in the previous work they are all more than 4500 records, but it is so in only Sys1, this is a great threat, this is shown in Figure (27).
- Table (36) shows the average training time of the systems in the thesis which is 542.0183 sec, and the average testing time of 0.09463 sec per record, which is a very efficient fast method for building such systems, compared to previous work.
- The DoS and probe attack types have been better recognized than the R2L and U2R attack types, because R2L and U2R are content-base attack not as DoS and probe that have sequential nature, and it is not dependable on the number of samples given to the IDS, because the probe and R2L attacks have approximately similar number of samples.
- To compare the systems by a single complete measurement we will use the equation (15), the best system is that having the highest value, which is sys6, see Table (42).

$$TruePerformance = PSP / (FPR+FNR) \quad \ldots\ldots\ldots\ldots\ldots\ldots \quad (15)$$

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Table 42 The systems sorted from the best to the worst of both proposed and previous works.

idx	Method	TruePerformance	idx	Method	TruePerformance
1	Sys6	11.74809	19	sys22	3.948984
2	[7]	11.70532	20	sys21	3.772099
3	[6]	10.67023	21	sys28	3.598768
4	[2]	10.25051	22	sys30	3.582097
5	[1]	9.881278	23	sys23	3.55383
6	[42]	9.607601	24	sys26	3.461843
7	[8]	9.130061	25	sys24	3.341533
8	Sys1	7.291162	26	sys29	3.246443
9	sys14	7.029908	27	Sys9	3.155347
10	sys12	7.019134	28	Sys4	1.841696
11	sys16	6.777996	29	Sys 10	1.631888
12	sys15	6.682978	30	Sys 11	1.630209
13	sys17	6.246106	31	Sys8	1.471088
14	sys13	6.181237	32	Sys2	1.3948
15	sys19	6.143274	33	Sys3	1.004439
16	sys20	5.665875	34	Sys5	0.507597
17	sys18	5.588005	35	Sys7	0.47856
18	sys25	4.440022	36		

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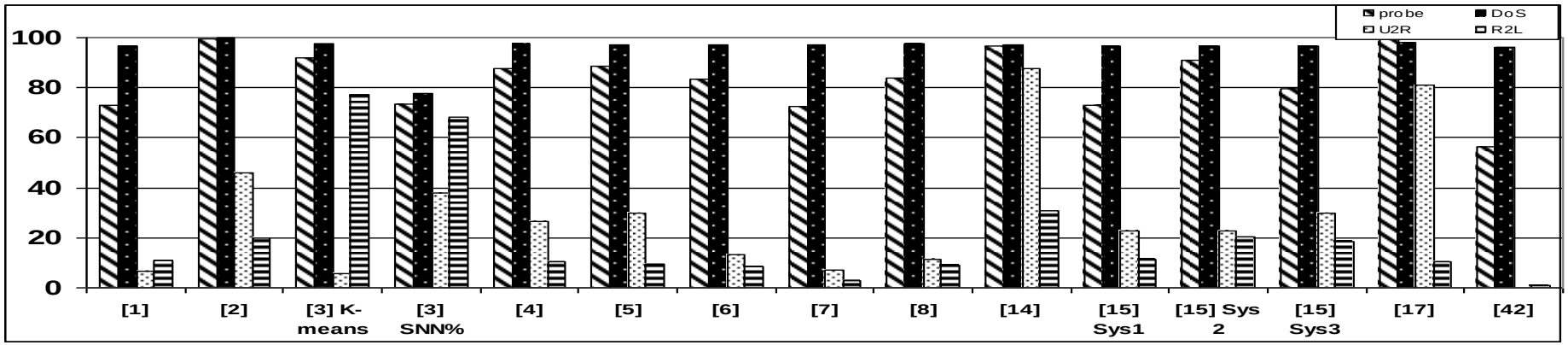
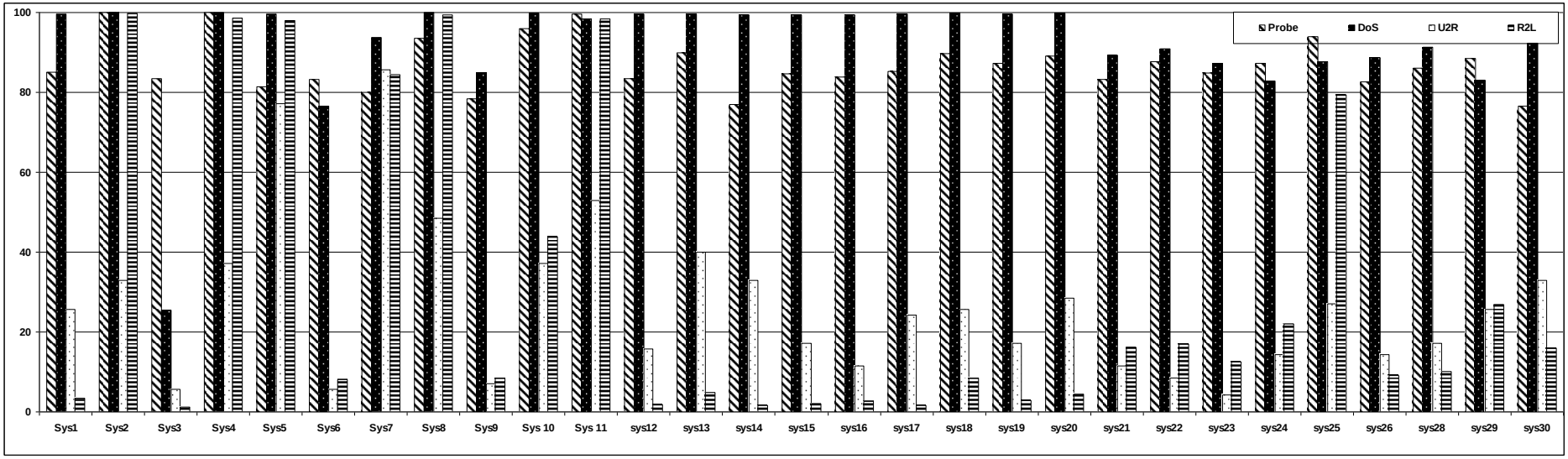


(a)



(b)

Figure (22) (a) The comparison of each attack type detection of previous systems. (b) the comparison of each attack type detection of proposed systems

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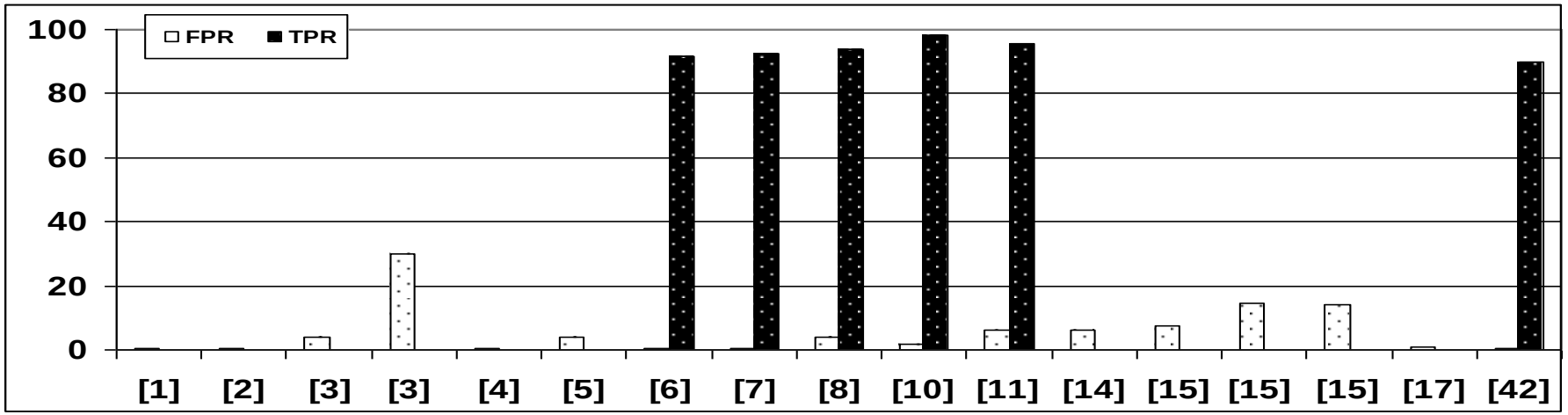

(a)

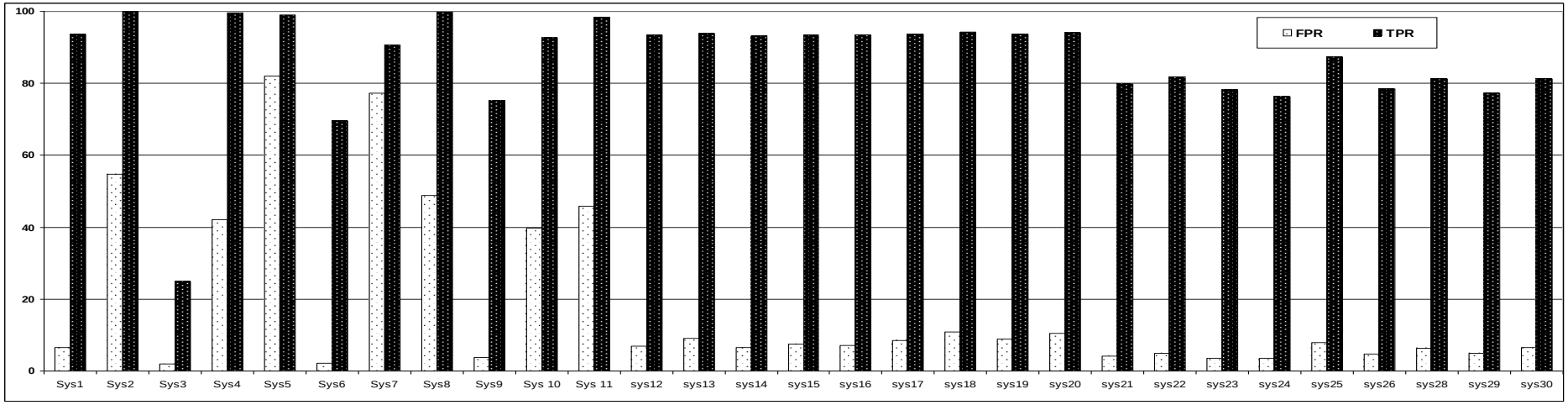

Figure (23) (a) The comparison of FPR and TPR of previous systems. (b) the comparison of FPR and TPR of proposed systems

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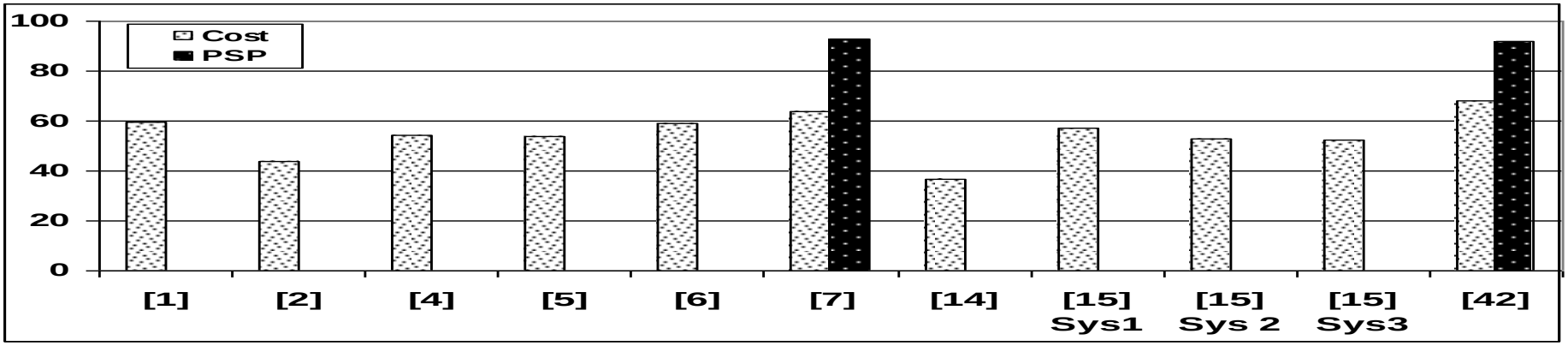
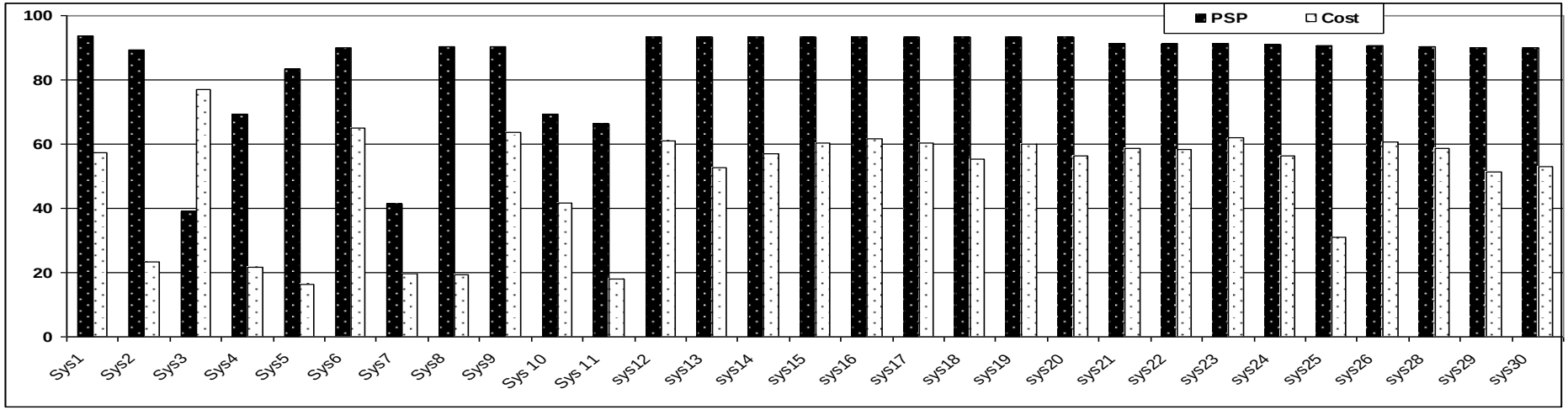


(a)



(a)

Figure (24) (a) The comparison of Cost of previous systems. (b) the comparison of PSP and Cost of proposed systems

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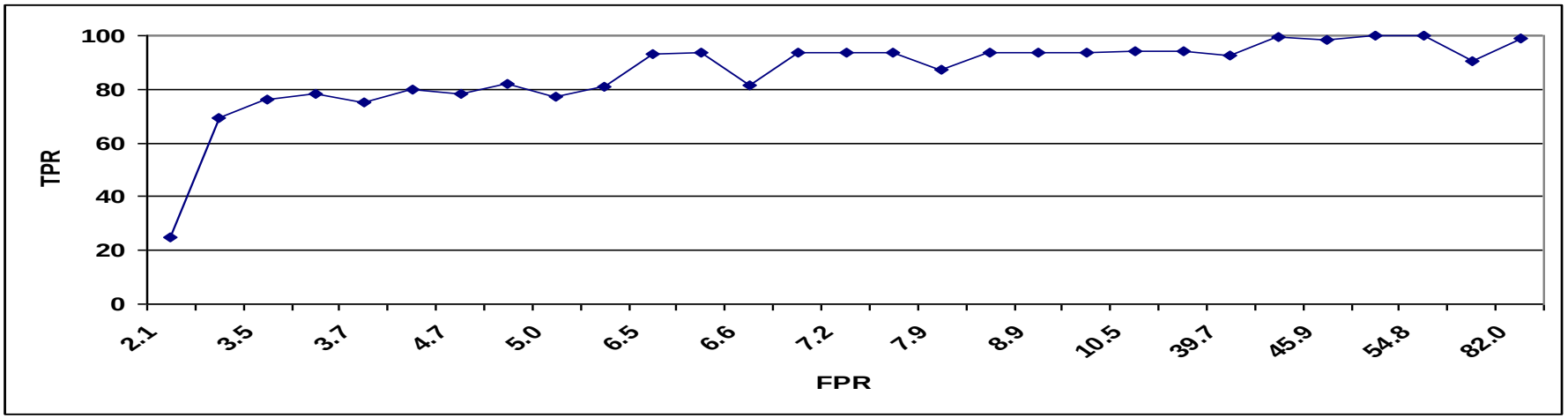

Figure (25) The ROC Curve of proposed systems

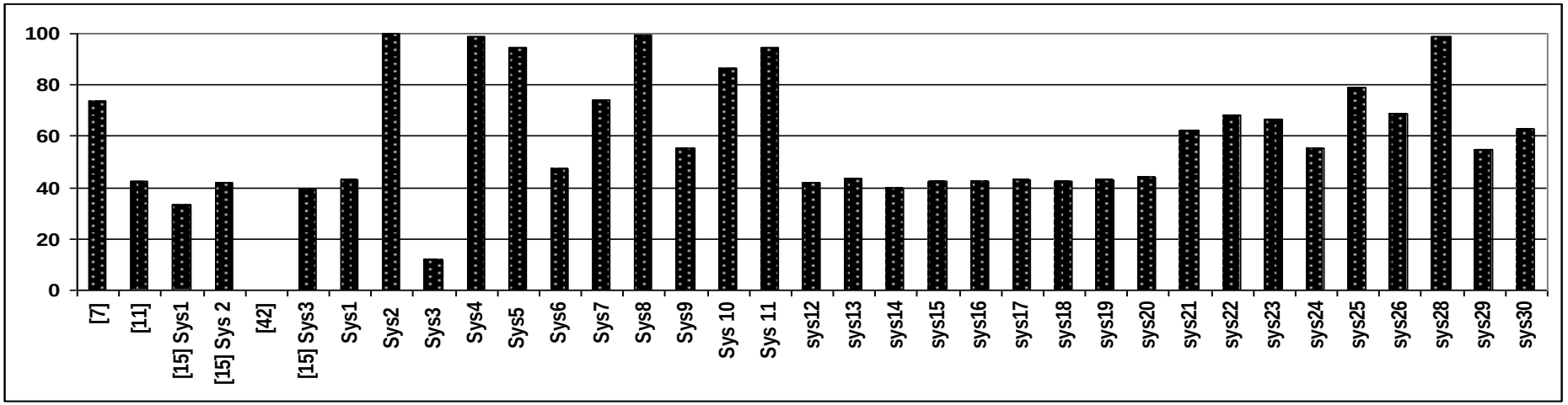

Figure (26) The New Attack detection between the previous and proposed systems.

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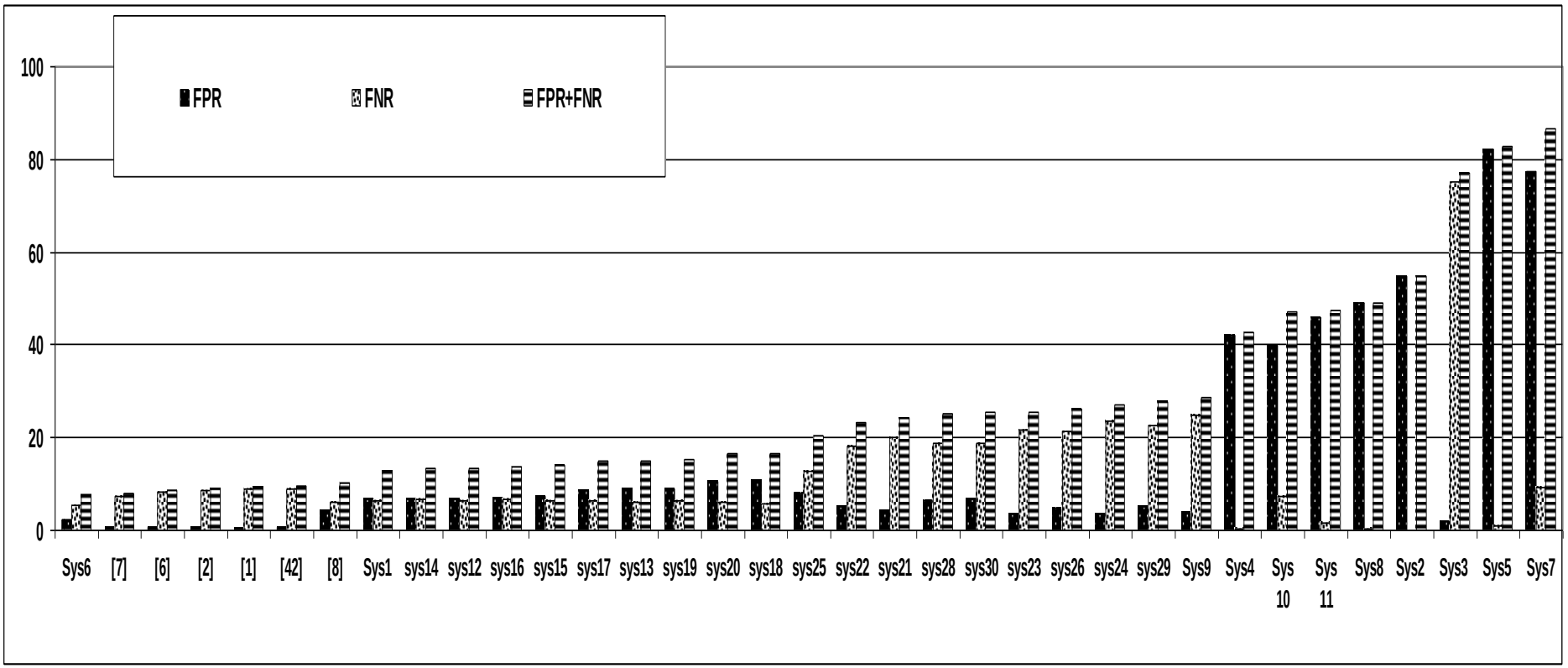

Figure (27) The FPR, FN and the summation of them of previous systems and proposed systems.

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Even though the experimental results show that this work has remarkable classification performance compared to existing previous works when performing testing on the redundant and distinct datasets, However it is understood from the performance results that it is inconsistent to perform the testing on the redundant datasets, because this situation gives us un- accurate results (un-real high performance), because there is a variant redundancy factor in these datasets for each type of attacks, as shown in Table (43).

Table 43 The redundancy factor in the KDDdataset.

Testing type	New attacks	Probe	DoS	U2R	R2L	Normal	Testing dataset	Training dataset
Redundant	18729	4166	231455	70	14745	60593	311029	4898432
Distinct	4022	2682	24570	70	2056	47913	77291	1074991
Redundancy Factor	4.65663	1.55331	9.420227	1	7.171692	1.264646	4.024129	4.5567191

After tacking the average of the neural network systems on both redundant and distinct/disjoint datasets is shown in Table (44), it is found that performing the IDS on the redundant dataset gives us higher performance results than on distinct dataset, as shown in Table (43), Figure (23) shows this comparison. This makes us conclude that when testing on redundant dataset gives us high inaccurate performance results, because of the different redundancy factor in those datasets, so we advise the use of distinct and disjoint datasets for any IDS performing on the KDDCup99 dataset.

Table 44 The comparison between the performance when applying IDS on redundant and distinct datasets.

	Probe	DoS	U2R	R2L	FPR	TPR	PSP	Cost	FNR	Testing data
AVG	90.025	99.792	46.0695	75.1208	48.0685	98.1645	89.1565	29.068	11.07491	Redundant
AVG	89.525	92.2256	37.6186	56.9816	35.1426	87.6516	71.1408	38.2156	2.688038	distinct
STD	8.33097	30.3913	23.9339	49.8762	30.40498	30.10715	20.66889	25.1751	24.26377	Redundant
STD	9.75408	9.7820	33.5120	41.9313	31.54034	12.31812	20.23671	22.8254	2.465532	distinct

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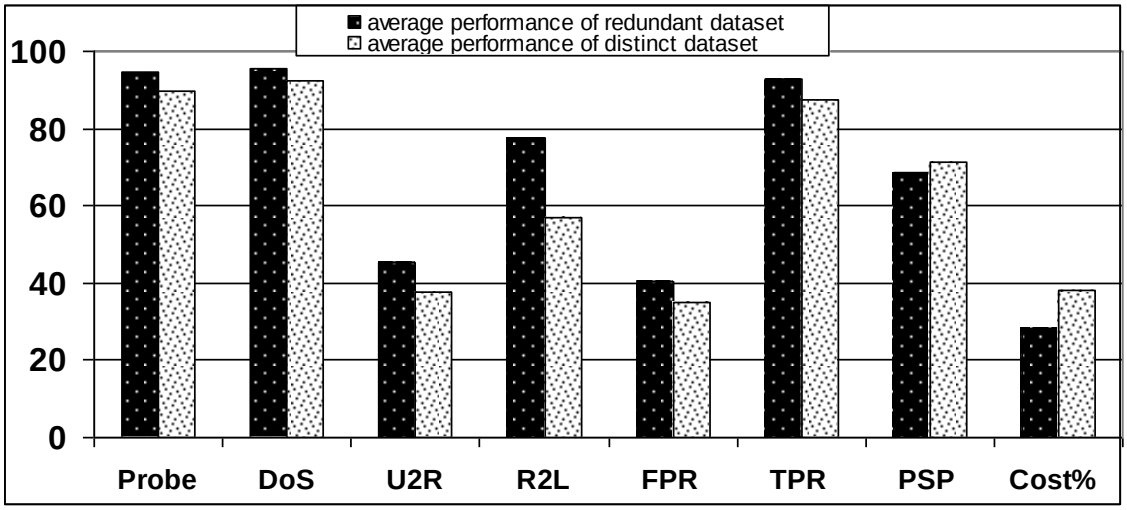

Figure (28) The comparison between the performance when applying IDS on redundant and distinct datasets.

- From this thesis we found that the important detection measurement is not just the TPR and FPR results, in addition if not more important the FN or the FNR which is not calculated in any previous work, and can cause attacks to inter the system as normal connections and the PSP measurement that we see it is more general than the TPR and the FPR together, and gives us more certain measurement for the performance of the detection systems.
- The number of previous works that used the full testing dataset is equal to 10 and it is 4 for the previous works that used a subset of this dataset, neither used a distinct dataset.

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1.61 Future Work

- It is noticed in Sys2, Sys4, Sys5, Sys7, Sys8, Sys10, Sys11 a FPR higher than 20% which is a disadvantage in those systems, so as a future work, build a hierarchical (M-N)Stage NN system, that will filter the normal connection first by using NN systems with best FN results (minimum) for M times, then applying N times a NN system with best TPR results, this approach could enhance to give less FPR, and gives a capability of dynamic change of security levels for the administrator to choose for the administrated recourses, this is called adaptivity for the IDS , this structure is shown in Figure (29).
- We can use other types of neural networks to perform the same experiments.
- The output of the NN system is one of two results (attack or normal), this may look as a disadvantage but in the real-world the basic intention really is to know if there is a threat to some resources, or not, to inform the proper administrator and produce an alarm, with no concern of the attack type.

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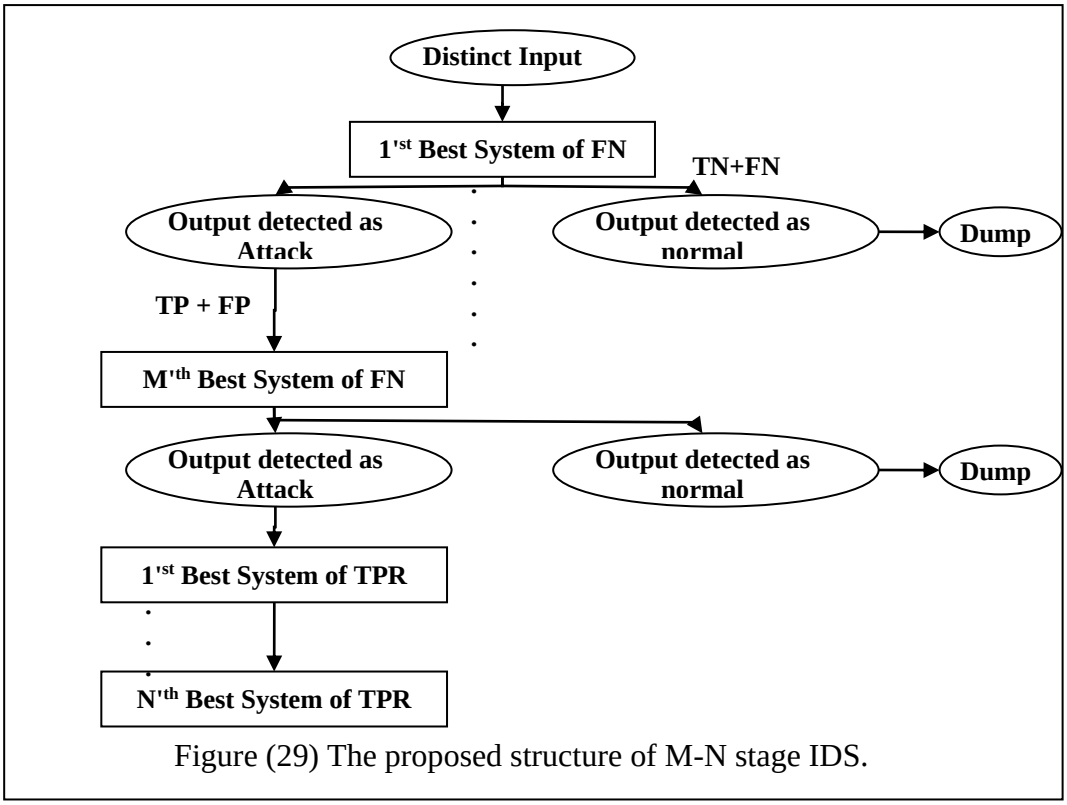

Figure (29) The proposed structure of M-N stage IDS.

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Appendices

APPENDIX A

The tables of performance measures results are shown in this APPENDIX.

Two layer network with 100 as Max Input with different hidden neurons for both distinct and redundant processed data records:

Table (A.1) 2-layer, Max Input 100 with distinct records, different hidden neurons.

Hidden	Rate%	Cost%	Attack category	TPR Each%	TPR%	FPR%	FP	TP	FN
40	88.37686	51.7086	Prob	71.06719	78.97901	8.0462	3727	13924	732
			DoS	90.50138					1239
			U2R	42.85714					40
			R2L	14.65257					1695
			Normal	91.9538					
	86.57701	52.89128	Prob	64.3083	77.43052	9.94171	4605	13651	903
			DoS	89.83441					1326
			U2R	42.85714					40
			R2L	13.89728					1710
			Normal	90.05829					
	88.54574	52.80533	Prob	72.29249	80.4878	8.387306	3885	14190	701
			DoS	92.81662					937
			U2R	41.42857					41
			R2L	11.32931					1761
			Normal	91.61269					
50	80.78812	47.42738	Prob	83.91304	83.01191	20.05829	9291	14635	83.91304
			DoS	92.47163					92.47163
			U2R	48.57143					48.57143
			R2L	20.94663					20.94663
			Normal	79.94171					79.94171
	84.88038	62.41405	Prob	48.7747	71.50879	10.03022	4646	12607	1296
			DoS	85.9169					1837
			U2R	24.28571					53
			R2L	7.502518					1837
			Normal	89.96978					
	86.14073	53.01797	Prob	72.7668	77.73681	10.66062	4938	13705	689
			DoS	88.54646					1494
			U2R	40					42
			R2L	14.40081					1700
			Normal	89.33938					
60	87.41986	56.74315	Prob	67.58893	76.69314	8.497409	3936	13521	820
			DoS	88.49279					1501
			U2R	30					49
			R2L	12.43706					1739
			Normal	91.50259					
	86.7412	55.78556	Prob	44.90119	73.4827	8.212435	3804	12955	1394
			DoS	89.38976					1384
			U2R	48.57143					36
			R2L	6.294058					1861
			Normal	91.78756					
	81.86396	50.41314	Prob	78.18182	81.91151	18.15415	8409	14441	552
			DoS	92.92395					923
			U2R	45.71429					38
			R2L	15.60926					1676
			Normal	81.84585					

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70	86.76779	48.97181	Prob	73.47826	79.31934	10.39724	4816	13984	671
			DoS	90.7697					1204
			U2R	55.71429					31
			R2L	12.38671					1740
			Normal	89.60276					
	79.39953	68.75295	Prob	10.47431	49.09813	9.067358	4200	8656	2265
			DoS	63.68445					4737
			U2R	34.28571					46
			R2L	3.021148					1926
			Normal	90.93264					
	84.50195	43.91301	Prob	83.55731	83.9308	15.28066	7078	14797	416
			DoS	92.81662					937
			U2R	51.42857					34
			R2L	27.19033					1446
			Normal	84.71934					
80	86.71462	49.56294	Prob	63.04348	79.6937	10.61313	4916	14050	935
			DoS	93.00061					913
			U2R	52.85714					33
			R2L	14.45116					1699
			Normal	89.38687					
	82.20485	42.13845	Prob	86.95652	88.23029	20.08851	9305	15555	330
			DoS	97.19411					366
			U2R	48.57143					36
			R2L	32.37664					1343
			Normal	79.91149					
	85.46052	53.73351	Prob	64.18972	70.22689	8.741364	4049	12381	906
			DoS	80.42012					2554
			U2R	48.57143					36
			R2L	11.73212					1753
			Normal	91.25864					
90	87.62783	51.30507	Prob	74.11067	79.41577	9.246546	4283	14001	655
			DoS	90.56271					1231
			U2R	44.28571					39
			R2L	14.1994					1704
			Normal	90.75345					
	81.5043	40.1380	Prob	89.80237	85.16166	19.88774	9212	15014	258
			DoS	93.3456					868
			U2R	65.71429					24
			R2L	26.18328					1466
			Normal	80.11226					
	86.54418	40.26173	Prob	94.78261	86.56835	13.46503	6237	15262	132
			DoS	93.70592					821
			U2R	55.71429					31
			R2L	30.31219					1384
			Normal	86.53497					
100	86.50352	51.11855	Prob	57.0751	76.26773	9.600604	4447	13446	1086
			DoS	89.74241					1338
			U2R	52.85714					33
			R2L	13.04129					1727
			Normal	90.3994					
	87.49805	53.08231	Prob	72.09486	77.92399	8.857945	4103	13738	706
			DoS	89.03711					1430
			U2R	40					42
			R2L	13.69587					1714
			Normal	91.14206					

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Table (A.2) 2-layer, Max Input 100 with redundant records, different hidden neurons.

Hidden	Rate%	Cost%	Attack category	TPR Each%	TPR%	FPR%	FP	TP	FN
40	56.306	65.43679	Prob	76.11618	47.25638	6.291156	3812	118347	995
			DoS	49.61958					116608
			U2R	34.28571					46
			R2L	2.068498					14440
			Normal	93.70884					
	40.34286	68.23964	Prob	72.01152	27.78195	7.741818	4691	69576	1166
			DoS	28.62716					165196
			U2R	40					42
			R2L	1.959986					14456
			Normal	92.25818					
	93.30062	56.89062	Prob	76.8843	93.26015	6.532108	3958	233557	963
			DoS	99.41155					1362
			U2R	32.85714					47
			R2L	1.614106					14507
			Normal	93.46789					
50	65.56077	61.83156	Prob	83.91743	61.08068	15.92263	9648	152968	670
			DoS	64.38228					82439
			U2R	37.14286					44
			R2L	2.916243					14315
			Normal	84.07737					
	92.49877	60.61402	Prob	62.02592	92.62846	8.037232	4870	231975	1582
			DoS	99.0361					2231
			U2R	25.71429					52
			R2L	1.010512					14596
			Normal	91.96277					
	40.24159	67.42532	Prob	77.12434	27.79473	8.314492	5038	69608	953
			DoS	28.54378					165389
			U2R	41.42857					41
			R2L	2.034588					14445
			Normal	91.68551					
60	82.66528	60.46964	Prob	74.02784	80.07195	6.616276	4009	200529	1082
			DoS	85.18459					34291
			U2R	30					49
			R2L	1.76331					14485
			Normal	93.38372					
	92.73798	57.22485	Prob	55.37686	92.50427	6.296107	3815	231664	1859
			DoS	99.02746					2251
			U2R	40					42
			R2L	0.847745					14620
			Normal	93.70389					
	91.93741	54.69171	Prob	80.48488	93.38873	14.06103	8520	233879	813
			DoS	99.44611					1282
			U2R	41.42857					41
			R2L	2.197355					14421
			Normal	85.93897					
70	40.35122	64.34795	Prob	77.55641	27.96243	8.44487	5117	70028	935
			DoS	28.73172					164954
			U2R	52.85714					33
			R2L	1.756528					14486
			Normal	91.55513					
	34.98645	78.9128	Prob	6.553048	20.93349	6.931494	4200	52425	3893
			DoS	22.49768					179383
			U2R	28.57143					50
			R2L	0.406918					14685
			Normal	93.06851					
	39.86284	67.04313	Prob	83.70139	28.30184	12.35456	7486	70878	679
			DoS	28.82072					164748

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			U2R	38.57143					43
			R2L	4.455748					14088
			Normal	87.64544					
80	92.93024	53.11465	Prob	71.2674	93.22781	8.299639	5029	233476	1197
			DoS	99.44568					1283
			U2R	48.57143					36
			R2L	2.04137					14444
			Normal	91.70036					
	74.47505	56.7333	Prob	86.79789	72.17014	15.99855	9694	180740	550
			DoS	76.19624					55095
			U2R	44.28571					39
			R2L	4.971177					14012
			Normal	84.00145					
	38.5829	67.21779	Prob	71.48344	25.35778	6.756556	4094	63505	1188
			DoS	26.03055					171206
			U2R	45.71429					38
			R2L	1.668362					14499
			Normal	93.24344					
90	42.56999	65.57554	Prob	77.94047	30.40537	7.152641	4334	76146	919
			DoS	31.35426					158884
			U2R	45.71429					38
			R2L	2.00746					14449
			Normal	92.84736					
	39.22014	62.6378	Prob	87.494	28.35894	15.88962	9628	71021	521
			DoS	28.86177					164653
			U2R	55.71429					31
			R2L	3.628349					14210
			Normal	84.11038					
	50.73096	60.03813	Prob	90.71051	41.41058	10.74712	6512	103707	387
			DoS	42.84548					132287
			U2R	51.42857					34
			R2L	4.910139					14021
			Normal	89.25288					
100	75.29909	58.55946	Prob	67.61882	71.11757	7.418349	4495	178104	1349
			DoS	75.6026					56469
			U2R	45.71429					38
			R2L	1.824347					14476
			Normal	92.58165					
	40.50362	67.75845	Prob	76.74028	27.78794	6.941396	4206	69591	969
			DoS	28.54983					165375
			U2R	40					42
			R2L	1.939641					14459
			Normal	93.0586					

Two layer network with 256 as Max Input with different hidden neurons for both distinct and redundant processed data records:

Table (A.3) 2-layer, Max Input 256 with distinct records, different hidden neurons.

Hidden	Rate%	Cost%	Attack category	TPR Each%	TPR%	FPR%	FP	TP	FN
40	84.0344	51.2864	Prob	85.8893	85.6097	16.5652	7673	1509	357
			DoS	94.9708					656
			U2R	24.2857					53
			R2L	25.9315					1471
			Normal	83.4348					
	81.8795	63.5562	Prob	42.5691	70.4878	13.7845	6385	12427	1453
			DoS	86.16989					1804

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			U2R	27.14286					51
			R2L	4.582075					1895
			Normal	86.21546					
	86.58014	59.35323	Prob	71.89723	75.76858	9.304836	4310	13358	711
			DoS	86.5532					1754
			U2R	21.42857					55
			R2L	11.78248					1752
			Normal	90.69516					
50	87.47459	55.62982	Prob	64.58498	80.31764	9.801382	4540	14160	896
			DoS	93.57559					838
			U2R	28.57143					50
			R2L	15.10574					1686
			Normal	90.19862					
	81.92025	47.46298	Prob	74.94071	83.61316	18.72409	8673	14741	634
			DoS	93.2536					880
			U2R	34.28571					46
			R2L	33.08157					1329
			Normal	81.27591					
	82.68335	46.18767	Prob	93.91304	84.09529	17.85406	8270	14826	154
			DoS	89.20577					1408
			U2R	25.71429					52
			R2L	40.08056					1190
			Normal	82.14594					
60	90.67709	53.07936	Prob	88.4585	81.29325	5.751295	2664	14332	292
			DoS	88.97577					1438
			U2R	20					56
			R2L	23.86707					1512
			Normal	94.2487					
	76.47694	50.53907	Prob	81.93676	83.90811	26.35147	12206	14793	457
			DoS	94.08924					771
			U2R	38.57143					43
			R2L	21.14804					1566
			Normal	73.64853					
	86.13761	61.98132	Prob	65.37549	72.12138	22.40499	3950	12715	876
			DoS	83.87764					2103
			U2R	24.28571					53
			R2L	5.186304					1883
			Normal	65.37549	72.12138	22.40499	3950	12715	876
70	88.03753	54.05363	Prob	79.92095	78.92796	22.31991	3935	13915	508
			DoS	88.63079					1483
			U2R	31.42857					48
			R2L	15.60926					1676
			Normal	91.50475					
	88.46286	54.67716	Prob	86.95652	78.50255	20.35167	3588	13840	330
			DoS	86.62987					1744
			U2R	27.14286					51
			R2L	16.16314					1665
			Normal	92.25389					
	87.05864	64.95115	Prob	68.6166	74.23142	21.17413	3733	13087	794
			DoS	85.76357					1857
			U2R	7.142857					65
			R2L	8.006042					1827
			Normal	91.94085					
80	91.48241	57.59427	Prob	85.5336	77.41917	8.315372	1466	13649	366
			DoS	85.61791					1876
			U2R	17.14286					58
			R2L	15.3575					1681
			Normal	96.83506					
	89.23534	51.70314	Prob	88.10277	76.90868	15.95576	2813	13559	301
			DoS	82.15271					2328
			U2R	21.42857					55

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			R2L	30.16113					1387
			Normal	93.92703					
	87.09773	61.31107	Prob	71.46245	78.53659	25.33749	4467	13846	722
			DoS	90.53971					1234
			U2R	12.85714					61
			R2L	11.02719					1767
			Normal	90.35622					
90	86.2674	57.06066	Prob	49.52569	73.92513	9.034974	4185	13033	1277
			DoS	88.45446					1506
			U2R	37.14286					44
			R2L	10.87613					1770
			Normal	90.96503					
	86.78342	59.02393	Prob	69.40711	76.2734	9.216321	4269	13447	774
			DoS	88.07114					1556
			U2R	25.71429					52
			R2L	9.315206					1801
			Normal	90.78368					
	90.17983	47.61176	Prob	85.73123	86.3755	8.372193	3878	15228	361
			DoS	96.13615					504
			U2R	35.71429					45
			R2L	24.87412					1492
			Normal	91.62781					
100	90.95231	62.19272	Prob	75.41502	76.47192	3.536269	1638	13482	622
			DoS	87.33517					1652
			U2R	11.42857					62
			R2L	8.761329					1812
			Normal	96.46373					
	87.77482	46.78592	Prob	88.49802	86.18832	11.62133	5383	15195	291
			DoS	95.22386					623
			U2R	38.57143					43
			R2L	25.57905					1478
			Normal	88.37867					
	87.21345	61.11648	Prob	70.47431	75.74022	8.419689	3900	13353	747
			DoS	87.25084					1663
			U2R	18.57143					57
			R2L	8.862034					1810
			Normal	91.58031					

Table (A.4) 2-layer, Max Input 256 with redundant records, different hidden neurons.

Hidden	Rate%	Cost%	Attack category	TPR Each%	TPR%	FPR%	FP	TP	FN
40	91.58085	60.84861	Prob	85.23764	92.74585	13.2342	8019	232269	615
			DoS	98.58417					3277
			U2R	15.71429					59
			R2L	3.587657					14216
			Normal	86.7658					
	91.81427	62.92719	Prob	53.88862	92.48071	10.94021	6629	231605	1921
			DoS	99.04906					2201
			U2R	21.42857					55
			R2L	0.617158					14654
			Normal	89.05979					
	40.37405	74.5275	Prob	76.59626	27.6941	7.218656	4374	69356	975
			DoS	28.47465					165549
			U2R	15.71429					59
			R2L	1.681926					14497
			Normal	92.78134					
50	93.10289	61.88578	Prob	72.22756	93.27054	7.589986	4599	233583	1157
			DoS	99.47895					1206
			U2R	15.71429					59
			R2L	2.129535					14431

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			Normal	92.41001					
	91.98338	58.98565	Prob	78.51656	93.60356	14.71292	8915	234417	895
			DoS	99.47592					1213
			U2R	21.42857					55
			R2L	6.029162					13856
			Normal	85.28708					
	55.58678	67.57375	Prob	90.08641	48.41157	14.75748	8942	121240	413
			DoS	50.35752					114900
			U2R	18.57143					57
			R2L	6.232621					13826
			Normal	85.24252					
60	39.64936	75.07149	Prob	86.77388	26.17395	4.655653	2821	65549	551
			DoS	26.54425					170017
			U2R	8.571429					64
			R2L	3.32316					14255
			Normal	95.34435					
	90.68318	58.73238	Prob	82.78925	93.52649	21.06844	12766	234224	717
			DoS	99.51049					1133
			U2R	27.14286					51
			R2L	2.943371					14311
			Normal	78.93156					
	75.21742	64.76004	Prob	72.25156	70.80691	6.553562	3971	177326	1156
			DoS	75.26085					57260
			U2R	22.85714					54
			R2L	0.712106					14640
			Normal	93.44644					
70	65.2354	65.86422	Prob	81.54105	58.42251	6.606374	4003	146311	769
			DoS	61.59901					88881
			U2R	22.85714					54
			R2L	2.197355					14421
			Normal	93.39363					
	56.80917	69.83463	Prob	85.76572	47.83538	6.101365	3697	119797	593
			DoS	50.06416					115579
			U2R	14.28571					60
			R2L	2.292302					14407
			Normal	93.89864					
	49.32305	75.00098	Prob	74.53193	38.5871	6.304359	3820	96636	1061
			DoS	40.33354					138101
			U2R	7.142857					65
			R2L	1.166497					14573
			Normal	93.69564					
80	39.78343	75.14118	Prob	84.90158	25.87807	2.744541	1663	64808	629
			DoS	26.33168					170509
			U2R	10					63
			R2L	2.156663					14427
			Normal	97.25546					
	49.45745	71.64254	Prob	86.58185	38.49886	5.249781	3181	96415	559
			DoS	39.82891					139269
			U2R	11.42857					62
			R2L	4.164123					14131
			Normal	94.75022					
	93.03538	63.67568	Prob	76.40422	93.16432	7.497566	4543	233317	983
			DoS	99.32643					1559
			U2R	8.571429					64
			R2L	1.573415					14513
			Normal	92.50243					
90	75.22835	63.34654	Prob	62.96207	70.92551	6.987606	4234	177623	1543
			DoS	75.50064					56705
			U2R	30					49
			R2L	1.553069					14516

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			Normal	93.01239					
	50.83095	71.05394	Prob	75.06001	40.65829	7.124585	4317	101823	1039
			DoS	42.54996					132971
			U2R	20					56
			R2L	1.342828					14547
			Normal	92.87541					
	93.67615	57.38487	Prob	85.09361	93.74012	6.58822	3992	234759	621
			DoS	99.66862					767
			U2R	25.71429					52
			R2L	3.445236					14237
			Normal	93.41178					
100	89.58039	65.77104	Prob	78.80461	87.73379	2.787451	1689	219717	883
			DoS	93.42853					15210
			U2R	2.857143					68
			R2L	1.268227					14558
			Normal	97.21255					
	73.36551	61.89406	Prob	86.8699	69.21569	9.482944	5746	173341	547
			DoS	73.09455					62274
			U2R	27.14286					51
			R2L	3.540183					14223
			Normal	90.51706					
	65.05117	68.67827	Prob	75.80413	58.17295	6.520555	3951	145686	1008
			DoS	61.49273					89127
			U2R	15.71429					59
			R2L	1.28179					14556
			Normal	93.47944					

Two layer network with 512 as Max Input with different hidden neurons for both distinct and redundant processed data records, in a 2-layer NN system:

Table (A.5) 2-layer, Max Input 512 with distinct records, different hidden neurons.

Hidden	Rate%	Cost%	Attack category	TPR Each%	TPR%	FPR%	FP	TP	FN
40	59.59812	32.61017	Prob	77.74704	88.20193	51.28886	23757	15550	563
			DoS	94.2809					746
			U2R	58.57143					29
			R2L	62.63847					742
			Normal	48.71114					
	48.11884	43.45125	Prob	72.72727	83.89677	65.4987	30339	14791	690
			DoS	94.67188					695
			U2R	71.42857					20
			R2L	27.79456					1434
			Normal	34.5013					
	89.44019	55.80203	Prob	82.01581	80.28928	7.076857	3278	14155	455
			DoS	89.94174					1312
			U2R	21.42857					55
			R2L	16.76737					1653
			Normal	92.92314					
50	86.71931	52.36293	Prob	85.65217	80.54453	10.93048	5063	14200	363
			DoS	90.17173					1282
			U2R	40					42
			R2L	12.23565					1743
			Normal	89.06952					
	87.56841	46.06434	Prob	75.8498	85.25808	11.55225	5351	15031	611
			DoS	94.32689					740
			U2R	27.14286					51
			R2L	39.7281					1197

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			Normal	88.44775					
	88.43159	54.67361	Prob	85.01976	83.21044	9.581174	4438	14670	379
			DoS	93.59859					835
			U2R	25.71429					52
			R2L	14.70292					1694
			Normal	90.41883					
60	91.47615	58.52388	Prob	83.28063	79.84685	4.097582	1898	14077	423
			DoS	89.25943					1401
			U2R	11.42857					62
			R2L	16.06244					1667
			Normal	95.90242					
	59.44644	39.18929	Prob	74.3083	84.10096	49.93739	23131	14827	650
			DoS	92.90862					925
			U2R	67.14286					23
			R2L	39.32528					1205
			Normal	50.06261					
	90.35184	53.85908	Prob	87.31225	83.15939	6.910622	3201	14661	321
			DoS	92.87795					929
			U2R	25.71429					52
			R2L	16.06244					1667
			Normal	93.08938					
70	88.38311	54.82984	Prob	85.61265	80.17584	8.493092	3934	14135	364
			DoS	89.00644					1434
			U2R	24.28571					53
			R2L	17.22054					1644
			Normal	91.50691					
	78.1767	34.74251	Prob	69.56522	88.50255	25.75345	11929	15603	770
			DoS	93.91291					794
			U2R	22.85714					54
			R2L	79.40584					409
			Normal	74.24655					
	88.29085	54.16223	Prob	82.37154	82.31991	9.436528	4371	14513	446
			DoS	92.18031					1020
			U2R	22.85714					54
			R2L	19.58711					1597
			Normal	90.56347					
80	64.20485	29.70057	Prob	74.03162	86.49461	44.27893	20510	15249	657
			DoS	90.20239					1278
			U2R	48.57143					36
			R2L	79.35549					410
			Normal	55.72107					
	90.05786	53.00307	Prob	76.64032	81.24787	6.588946	3052	14324	591
			DoS	92.34897					998
			U2R	32.85714					47
			R2L	15.91138					1670
			Normal	93.41105					
	90.65833	60.52679	Prob	82.68775	78.54226	4.730138	2191	13847	438
			DoS	88.66912					1478
			U2R	14.28571					60
			R2L	9.013092					1807
			Normal	95.26986					
90	80.58327	48.84145	Prob	83.39921	84.35054	20.8506	9658	14871	420
			DoS	92.09598					1031
			U2R	22.85714					54
			R2L	36.85801					1254
			Normal	79.1494					
	44.91634	22.20449	Prob	78.57708	93.47703	73.56649	34076	16480	542
			DoS	97.90708					273
			U2R	72.85714					19
			R2L	84.08862					316

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			Normal	26.43351					
	41.45426	19.51565	Prob	79.92095	90.64663	77.269	35791	15981	508
			DoS	93.68292					824
			U2R	85.71429					10
			R2L	84.54179					307
			Normal	22.731					
100	88.83503	57.94145	Prob	81.50198	82.26886	8.665803	4014	14504	468
			DoS	93.82858					805
			U2R	21.42857					55
			R2L	9.466264					1798
			Normal	91.3342					
	88.02346	57.36883	Prob	87.31225	83.67555	10.32168	4781	14752	321
			DoS	93.90524					795
			U2R	15.71429					59
			R2L	14.24975					1703
			Normal	89.67832					
	83.70602	46.54883	Prob	92.49012	86.33012	17.29275	8010	15220	190
			DoS	93.40693					860
			U2R	30					49
			R2L	33.98792					1311
			Normal	82.70725					
200	74.79593	27.6822	Prob	71.93676	87.10153	29.88774	13844	15356	710
			DoS	90.9537					1180
			U2R	47.14286					37
			R2L	82.52769					347
			Normal	70.11226					
	87.24003	54.86533	Prob	89.96047	84.01588	11.53282	5342	14812	254
			DoS	93.2766					877
			U2R	20					56
			R2L	17.87513					1631
			Normal	88.46718					
	87.74355	50.30856	Prob	92.49012	84.29382	10.94344	5069	14861	190
			DoS	91.72033					1080
			U2R	24.28571					53
			R2L	27.19033					1446
			Normal	89.05656					
300	62.15012	28.98123	Prob	68.69565	87.0051	47.31002	21914	15339	792
			DoS	91.567					1100
			U2R	50					35
			R2L	81.6717					364
			Normal	52.68998					
	37.21814	24.89666	Prob	73.47826	89.27396	82.59499	38258	15739	671
			DoS	92.79362					940
			U2R	67.14286					23
			R2L	87.05942					257
			Normal	17.40501					
	45.36513	24.0654	Prob	68.22134	88.95632	71.22625	32992	15683	804
			DoS	93.47593					851
			U2R	68.57143					22
			R2L	86.40483					270
			Normal	28.77375					

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Table (A.6) 2-layer, Max Input 512 with redundant records, different hidden neurons.

Hidden	Rate%	Cost%	Attack category	TPR Each%	TPR%	FPR%	FP	TP	FN
40	87.24685	41.49561	Prob	80.22084	95.79493	48.08311	29135	239905	824
			DoS	99.53857					1068
			U2R	48.57143					36
			R2L	41.6548					8603
			Normal	51.91689					
	84.13621	46.79727	Prob	77.10034	94.33787	58.02816	35161	236256	954
			DoS	99.55326					1034
			U2R	65.71429					24
			R2L	17.47711					12168
			Normal	41.97184					
	74.39049	67.30959	Prob	82.83725	69.54352	5.576552	3379	174162	715
			DoS	73.60308					61097
			U2R	8.571429					64
			R2L	2.35334					14398
			Normal	94.42345					
50	91.64033	58.06554	Prob	85.04561	93.30967	15.25919	9246	233681	623
			DoS	99.30829					1601
			U2R	28.57143					50
			R2L	1.790437					14481
			Normal	84.74081					
	92.43768	52.11033	Prob	79.02064	94.74876	17.11419	10370	237285	874
			DoS	99.54116					1062
			U2R	22.85714					54
			R2L	24.30654					11161
			Normal	82.88581					
	93.29548	60.37176	Prob	84.66155	93.47139	7.431551	4503	234086	639
			DoS	99.47549					1214
			U2R	17.14286					58
			R2L	2.07528					14439
			Normal	92.56845					
60	39.84773	77.18305	Prob	83.50936	26.0905	3.29246	1995	65340	687
			DoS	26.58227					169929
			U2R	2.857143					68
			R2L	2.258393					14412
			Normal	96.70754					
	86.41413	44.62198	Prob	78.08449	94.57746	47.3256	28676	236856	913
			DoS	99.46123					1247
			U2R	62.85714					26
			R2L	22.72635					11394
			Normal	52.6744					
	65.67973	66.84686	Prob	86.05377	58.69524	5.452775	3304	146994	581
			DoS	61.81072					88391
			U2R	17.14286					58
			R2L	2.258393					14412
			Normal	94.54722					
70	40.54477	74.25252	Prob	84.94959	27.76757	6.645982	4027	69540	627
			DoS	28.35843					165818
			U2R	12.85714					61
			R2L	2.407596					14390
			Normal	93.35402					
	91.0899	29.73615	Prob	75.18003	98.95143	41.40247	25087	247810	1034
			DoS	99.51783					1116
			U2R	17.14286					58
			R2L	97.16514					418
			Normal	58.59753					
	51.19458	72.12903	Prob	82.95727	41.15622	7.316027	4433	103070	710
			DoS	42.8606					132252

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			U2R	11.42857					62
			R2L	2.73313					14342
			Normal	92.68397					
80	88.18438	23.81025	Prob	77.86846	98.81167	55.73911	33774	247460	922
			DoS	99.30872					1600
			U2R	42.85714					40
			R2L	97.19227					414
			Normal	44.26089					
	83.15655	60.8182	Prob	79.57273	80.40657	5.47753	3319	201367	851
			DoS	85.41833					33750
			U2R	25.71429					52
			R2L	2.231265					14416
			Normal	94.52247					
	41.18233	75.29321	Prob	83.17331	27.84743	3.703398	2244	69740	701
			DoS	28.5481					165379
			U2R	10					63
			R2L	1.302136					14553
			Normal	96.2966					
90	91.60882	44.7486	Prob	83.67739	96.5021	28.61552	17339	241676	680
			DoS	99.40896					1368
			U2R	11.42857					62
			R2L	54.89997					6650
			Normal	71.38448					
	84.00889	19.53011	Prob	80.72492	99.3096	79.23027	48008	248707	803
			DoS	99.74898					581
			U2R	64.28571					25
			R2L	97.82977					320
			Normal	20.76973					
	83.29963	16.23299	Prob	81.49304	99.10915	82.04248	49712	248205	771
			DoS	99.51092					1132
			U2R	77.14286					16
			R2L	97.88403					312
			Normal	17.95752					
100	75.70002	67.02544	Prob	82.5252	71.4458	6.716948	4070	178926	728
			DoS	75.72962					56175
			U2R	10					63
			R2L	1.363174					14544
			Normal	93.28305					
	75.63571	67.36192	Prob	86.05377	71.80038	8.512534	5158	179814	581
			DoS	76.00959					55527
			U2R	7.142857					65
			R2L	2.00746					14449
			Normal	91.48747					
	38.47005	72.61517	Prob	89.12626	28.53623	20.47266	12405	71465	453
			DoS	28.96503					164414
			U2R	18.57143					57
			R2L	4.733808					14047
			Normal	79.52734					
200	90.30476	23.95578	Prob	76.59626	98.8548	45.03325	27287	247568	975
			DoS	99.35193					1500
			U2R	38.57143					43
			R2L	97.62631					350
			Normal	54.96675					
	91.74579	62.23615	Prob	87.66203	93.55843	15.74604	9541	234304	514
			DoS	99.48673					1188
			U2R	11.42857					62
			R2L	2.556799					14368
			Normal	84.25396					
	60.94834	67.35736	Prob	89.12626	53.65163	8.893767	5389	134363	453
			DoS	56.20315					101370
			U2R	17.14286					58

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			R2L	3.750424					14192
			Normal	91.10623					

Two layer network with 1200 as Max Input with different hidden neurons for both distinct and redundant processed data records:

Table (A.7) 2-layer, Max Input 1200 with distinct records, different hidden neurons.

Hidden	Rate%	Cost%	Attack category	TPR Each%	TPR%	FPR%	FP	TP	FN
40	88.42064	57.86874	Prob	93.87352	76.0295	6.863126	3179	13404	155
			DoS	80.80343					2504
			U2R	5.714286					66
			R2L	24.42095					1501
			Normal	93.13687					
	87.04457	56.18299	Prob	84.74308	80.31197	10.39292	4814	14159	386
			DoS	89.55075					1363
			U2R	21.42857					55
			R2L	16.06244					1667
			Normal	89.60708					
	87.36669	55.55645	Prob	87.90514	81.83778	10.52893	4877	14428	306
			DoS	90.28672					1267
			U2R	15.71429					59
			R2L	20.94663					1570
			Normal	89.47107					
50	87.79515	47.36127	Prob	97.62846	89.09246	12.69862	5882	15707	60
			DoS	96.29715					483
			U2R	22.85714					54
			R2L	33.23263					1326
			Normal	87.30138					
	89.07428	62.94604	Prob	65.09881	69.63698	3.527634	1634	12277	883
			DoS	80.59644					2531
			U2R	21.42857					55
			R2L	5.135952					1884
			Normal	96.47237					
	90.85848	58.07489	Prob	88.18182	74.95179	3.087219	1430	13214	299
			DoS	80.77277					2508
			U2R	8.571429					64
			R2L	22.20544					1545
			Normal	96.91278					
60	90.70211	61.53393	Prob	82.01581	75.03687	3.335492	1545	13229	455
			DoS	83.83165					2109
			U2R	11.42857					62
			R2L	10.62437					1775
			Normal	96.66451					
	90.91478	56.3647	Prob	87.19368	76.32445	3.531952	1636	13456	324
			DoS	82.82735					2240
			U2R	14.28571					60
			R2L	21.95368					1550
			Normal	96.46805					
	87.9656	61.16139	Prob	91.50198	80.81112	9.311313	4313	14247	215
			DoS	90.09506					1292
			U2R	10					63
			R2L	8.710977					1813
			Normal	90.68869					
70	87.60125	54.01523	Prob	87.15415	81.27623	9.991364	4628	14329	325
			DoS	89.42042					1380
			U2R	20					56
			R2L	22.4572					1540

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			Normal	90.00864					
	90.10164	51.41954	Prob	88.4585	77.25468	5.008636	2320	13620	292
			DoS	83.01901					2215
			U2R	25.71429					52
			R2L	26.93857					1451
			Normal	94.99136					
	87.46677	55.47263	Prob	88.93281	83.34657	10.96503	5079	14694	280
			DoS	92.26464					1009
			U2R	15.71429					59
			R2L	20.04028					1588
			Normal	89.03497					
80	88.68335	41.36075	Prob	92.17391	88.68973	11.31908	5243	15636	198
			DoS	93.62925					831
			U2R	20					56
			R2L	54.22961					909
			Normal	88.68092					
	89.58092	50.11157	Prob	88.10277	82.41066	7.689983	3562	14529	301
			DoS	89.91874					1315
			U2R	25.71429					52
			R2L	27.84491					1433
			Normal	92.31002					
	87.88428	57.2308	Prob	77.3913	75.29779	7.32513	3393	13275	572
			DoS	85.40325					1904
			U2R	32.85714					47
			R2L	7.75428					1832
			Normal	92.67487					
90	85.84363	56.58944	Prob	86.04743	81.97391	12.68351	5875	14452	353
			DoS	92.35664					997
			U2R	25.71429					52
			R2L	10.57402					1776
			Normal	87.31649					
	88.5129	53.43325	Prob	89.40711	82.34827	9.14076	4234	14518	268
			DoS	90.8847					1189
			U2R	24.28571					53
			R2L	19.33535					1602
			Normal	90.85924					
	91.37764	58.35362	Prob	87.70751	81.86047	5	2316	14432	311
			DoS	91.00736					1173
			U2R	8.571429					64
			R2L	16.91843					1650
			Normal	95					
100	89.48866	56.5011	Prob	89.48617	76.79524	5.680052	2631	13539	266
			DoS	82.76602					2248
			U2R	11.42857					62
			R2L	23.71601					1515
			Normal	94.31995					
	87.35106	49.47742	Prob	93.35968	83.84005	11.31261	5240	14781	168
			DoS	91.02269					1171
			U2R	28.57143					50
			R2L	26.4854					1460
			Normal	88.68739					
	87.83737	53.38642	Prob	88.53755	82.63188	10.18135	4716	14568	290
			DoS	91.04569					1168
			U2R	21.42857					55
			R2L	22.00403					1549
			Normal	89.81865					

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Table (A.8) 2-layer, Max Input 1200 with redundant records, different hidden neurons.

Hidden	Rate%	Cost%	Attack category	TPR Each%	TPR%	FPR%	FP	TP	FN
40	39.0896	76.51168	Prob	89.96639	25.75229	5.786147	3506	64493	418
			DoS	26.02795					171212
			U2R	2.857143					68
			R2L	3.39098					14245
			Normal	94.21385					
	40.55795	74.41065	Prob	84.44551	28.13174	8.083442	4898	70452	648
			DoS	28.77147					164862
			U2R	12.85714					61
			R2L	2.251611					14413
			Normal	91.91656					
	40.56599	74.80666	Prob	86.34181	28.24833	8.524087	5165	70744	569
			DoS	28.82202					164745
			U2R	10					63
			R2L	2.916243					14315
			Normal	91.47591					
50	41.87712	73.31902	Prob	93.90302	30.33869	10.43355	6322	75979	254
			DoS	30.84142					160071
			U2R	10					63
			R2L	4.584605					14069
			Normal	89.56645					
	40.80359	74.1864	Prob	67.64282	27.14586	2.747842	1665	67983	1348
			DoS	28.10309					166409
			U2R	20					56
			R2L	0.712106					14640
			Normal	97.25216					
	39.40436	75.54654	Prob	86.55785	25.44043	2.881521	1746	63712	560
			DoS	25.77002					171809
			U2R	7.142857					65
			R2L	3.085792					14290
			Normal	97.11848					
60	47.20846	74.13902	Prob	82.76524	35.15988	2.993745	1814	88053	718
			DoS	36.45417					147080
			U2R	8.571429					64
			R2L	1.519159					14521
			Normal	97.00625					
	39.42751	75.23274	Prob	85.90975	25.53986	3.173634	1923	63961	587
			DoS	25.89099					171529
			U2R	8.571429					64
			R2L	3.051882					14295
			Normal	96.82637					
	40.58464	75.13525	Prob	88.71819	28.0415	7.573482	4589	70226	470
			DoS	28.66086					165118
			U2R	10					63
			R2L	1.261445					14559
			Normal	92.42652					
70	40.62194	74.73789	Prob	85.88574	28.18684	7.98277	4837	70590	588
			DoS	28.75073					164910
			U2R	10					63
			R2L	3.119702					14285
			Normal	92.01723					
	42.18803	71.18437	Prob	86.67787	29.25218	4.347037	2634	73258	555
			DoS	29.84684					162373
			U2R	20					56
			R2L	3.73686					14194
			Normal	95.65296					
	82.74116	64.1078	Prob	87.08593	80.72522	8.926774	5409	202165	538
			DoS	85.59634					33338
			U2R	11.42857					62

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			R2L	2.794168					14333
			Normal	91.07323					
80	51.47334	49.75174	Prob	88.95823	45.04624	21.96293	13308	112812	460
			DoS	42.97509					131987
			U2R	12.85714					61
			R2L	65.30349					5116
			Normal	78.03707					
	40.89812	72.73293	Prob	86.46183	28.14651	6.398429	3877	70489	564
			DoS	28.6479					165148
			U2R	15.71429					59
			R2L	3.858935					14176
			Normal	93.60157					
	73.28031	62.83481	Prob	79.9808	68.27732	6.041952	3661	170991	834
			DoS	72.35748					63980
			U2R	28.57143					50
			R2L	1.112241					14581
			Normal	93.95805					
90	50.6808	69.88113	Prob	85.23764	41.20733	10.16454	6159	103198	615
			DoS	42.9496					132046
			U2R	21.42857					55
			R2L	1.512377					14522
			Normal	89.83546					
	39.25454	72.34788	Prob	87.30197	26.36961	7.490964	4539	66039	529
			DoS	26.78274					169465
			U2R	20					56
			R2L	2.69922					14347
			Normal	92.50904					
	39.87249	75.77285	Prob	86.2218	26.36003	4.279372	2593	66015	574
			DoS	26.81644					169387
			U2R	7.142857					65
			R2L	2.373686					14395
			Normal	95.72063					
100	39.13815	73.99543	Prob	87.37398	25.58538	4.847095	2937	64075	526
			DoS	25.89747					171514
			U2R	12.85714					61
			R2L	3.289251					14260
			Normal	95.15291					
	40.44542	72.35542	Prob	89.70235	28.25991	9.190831	5569	70773	429
			DoS	28.72351					164973
			U2R	17.14286					58
			R2L	3.675822					14203
			Normal	90.80917					
	75.34731	65.42815	Prob	86.79789	71.39509	8.317792	5040	178799	550
			DoS	75.48854					56733
			U2R	12.85714					61
			R2L	3.065446					14293
			Normal	91.68221					

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Two layer network with 2000 as Max Input with different hidden neurons for both distinct and redundant processed data records:

Table (A.9) 2-layer, Max Input 2000 with distinct records, different hidden neurons.

Hidden	Rate%	Cost%	Attack category	TPR Each%	TPR%	FPR%	FP	TP	FN
40	90.5645	52.3778	Prob	82.52964	80.19285	5.48791	2542	14138	442
			DoS	89.57375					1360
			U2R	32.85714					47
			R2L	17.2709					1643
			Normal	94.51209					
	90.32838	51.52701	Prob	91.2253	84.52638	7.463299	3457	14902	222
			DoS	92.80129					939
			U2R	22.85714					54
			R2L	23.81672					1513
			Normal	92.5367					
	89.14621	50.41433	Prob	92.09486	82.65457	8.382988	3883	14572	200
			DoS	89.20577					1408
			U2R	21.42857					55
			R2L	29.75831					1395
			Normal	91.61701					
50	90.07349	65.0879	Prob	83.20158	69.54623	2.113558	979	12261	425
			DoS	76.58694					3054
			U2R	5.714286					66
			R2L	8.1571					1824
			Normal	97.88644					
	87.07584	44.33798	Prob	89.05138	87.80488	13.20164	6115	15480	277
			DoS	96.65747					436
			U2R	41.42857					41
			R2L	29.70796					1396
			Normal	86.79836					
	91.37138	61.94262	Prob	84.94071	78.24163	3.631261	1682	13794	381
			DoS	87.35817					1649
			U2R	4.285714					67
			R2L	12.43706					1739
			Normal	96.36874					
60	90.22361	47.85416	Prob	95.37549	82.94385	7.005613	3245	14623	117
			DoS	88.14014					1547
			U2R	22.85714					54
			R2L	35.09567					1289
			Normal	92.99439					
	83.10555	44.88424	Prob	94.26877	81.09472	16.1291	7471	14297	145
			DoS	83.56332					2144
			U2R	20					56
			R2L	50.25176					988
			Normal	83.8709					
	88.5473	50.86071	Prob	87.50988	85.57005	10.31952	4780	15086	316
			DoS	95.20852					625
			U2R	28.57143					50
			R2L	21.80262					1553
			Normal	89.68048					
70	88.58483	48.50704	Prob	84.38735	82.34827	9.041451	4188	14518	395
			DoS	92.19565					1018
			U2R	47.14286					37
			R2L	16.3142					1662
			Normal	90.95855					
	89.28538	49.98101	Prob	80.67194	83.68123	8.581606	3975	14753	489

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			DoS	94.61822					702
			U2R	40					42
			R2L	17.22054					1644
			Normal	91.41839					
	89.95309	55.85267	Prob	86.917	73.87408	3.927029	1819	13024	331
			DoS	79.37749					2690
			U2R	17.14286					58
			R2L	23.11178					1527
			Normal	96.07297					
80	87.44175	50.58493	Prob	92.01581	77.15258	8.642055	4003	13602	202
			DoS	82.91935					2228
			U2R	35.71429					45
			R2L	21.80262					1553
			Normal	91.35794					
	89.38702	55.58264	Prob	83.00395	81.72433	7.696459	3565	14408	430
			DoS	91.07636					1164
			U2R	15.71429					59
			R2L	20.99698					1569
			Normal	92.30354					
	86.48944	45.51315	Prob	87.78656	87.85593	14.03066	6499	15489	309
			DoS	96.09782					509
			U2R	30					49
			R2L	35.85096					1274
			Normal	85.96934					
90	89.69038	43.57014	Prob	94.34783	84.94611	8.503886	3939	14976	143
			DoS	90.58571					1228
			U2R	34.28571					46
			R2L	37.714					1237
			Normal	91.49611					
	89.56059	56.58403	Prob	84.11067	76.99943	5.658463	2621	13575	402
			DoS	85.01993					1954
			U2R	20					56
			R2L	17.2709					1643
			Normal	94.34154					
	89.16966	48.60361	Prob	88.02372	83.04027	8.497409	3936	14640	303
			DoS	91.48267					1111
			U2R	37.14286					44
			R2L	22.86002					1532
			Normal	91.50259					
100	90.82721	30.85743	Prob	94.03162	87.41917	7.875648	3648	15412	151
			DoS	87.68016					1607
			U2R	27.14286					51
			R2L	79.40584					409
			Normal	92.12435					
	87.44644	50.25391	Prob	84.42688	80.39705	9.870466	4572	14174	394
			DoS	88.74578					1468
			U2R	35.71429					45
			R2L	22.00403					1549
			Normal	90.12953					
	87.3448	40.98063	Prob	93.32016	89.654	13.53411	6269	15806	169
			DoS	95.92916					531
			U2R	31.42857					48
			R2L	45.82075					1076
			Normal	86.46589					

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Table (A.10) 2-layer, Max Input 2000 with redundant records, different hidden neurons

Hidden	Rate%	Cost%	Attack category	TPR Each%	TPR%	FPR%	FP	TP	FN
40	41.08299	71.08169	Prob	83.05329	27.96403	4.695262	2845	70032	706
			DoS	28.60081					165257
			U2R	24.28571					53
			R2L	2.42116					14388
			Normal	95.30474					
	41.14343	72.69698	Prob	88.35814	28.43321	6.324163	3832	71207	485
			DoS	28.95898					164428
			U2R	15.71429					59
			R2L	3.309596					14257
			Normal	93.67584					
	40.88558	72.82656	Prob	89.05425	28.26351	6.946347	4209	70782	456
			DoS	28.71098					165002
			U2R	14.28571					60
			R2L	4.130214					14136
			Normal	93.05365					
50	39.15133	76.90002	Prob	83.48536	24.92693	2.057993	1247	62426	688
			DoS	25.39111					172686
			U2R	5.714286					66
			R2L	1.186843					14570
			Normal	97.94201					
	50.81391	65.58535	Prob	87.06193	41.48685	10.63654	6445	103898	539
			DoS	43.03342					131852
			U2R	32.85714					47
			R2L	4.374364					14100
			Normal	89.36346					
	64.29497	71.2861	Prob	84.61354	56.44516	3.261103	1976	141359	641
			DoS	59.4379					93883
			U2R	2.857143					68
			R2L	1.76331					14485
			Normal	96.7389					
60	39.37864	72.24307	Prob	91.38262	26.13881	5.900021	3575	65461	359
			DoS	26.31311					170552
			U2R	15.71429					59
			R2L	5.01865					14005
			Normal	94.09998					
	62.39708	64.87613	Prob	91.02256	56.49986	13.22925	8016	141496	374
			DoS	58.86198					95216
			U2R	17.14286					58
			R2L	9.854188					13292
			Normal	86.77075					
	57.43644	67.53665	Prob	86.10178	49.13191	8.240226	4993	123044	579
			DoS	51.41172					112460
			U2R	21.42857					55
			R2L	3.031536					14298
			Normal	91.75977					
70	40.7753	67.32352	Prob	84.20547	28.23875	7.410097	4490	70720	658
			DoS	28.88121					164608
			U2R	38.57143					43
			R2L	2.292302					14407
			Normal	92.5899					
	75.88328	59.64264	Prob	82.02112	71.65703	6.649283	4029	179455	749
			DoS	75.89294					55797
			U2R	35.71429					45
			R2L	2.407596					14390
			Normal	93.35072					
	39.23107	72.91946	Prob	85.74172	25.37255	3.490502	2115	63542	594

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			DoS	25.70089					171969
			U2R	17.14286					58
			R2L	3.201085					14273
			Normal	96.5095					
80	40.46632	68.64724	Prob	89.00624	27.79193	7.149341	4332	69601	458
			DoS	28.26511					166034
			U2R	31.42857					48
			R2L	3.051882					14295
			Normal	92.85066					
	49.74906	72.72881	Prob	83.36534	39.13575	6.385226	3869	98010	693
			DoS	40.65542					137356
			U2R	10					63
			R2L	2.923025					14314
			Normal	93.61477					
	50.87178	67.66206	Prob	86.2698	41.72683	11.33134	6866	104499	572
			DoS	43.17729					131519
			U2R	22.85714					54
			R2L	6.463208					13792
			Normal	88.66866					
90	39.30952	69.35695	Prob	90.44647	26.33048	7.047019	4270	65941	398
			DoS	26.47858					170169
			U2R	25.71429					52
			R2L	5.893523					13876
			Normal	92.95298					
	39.39215	73.75068	Prob	84.03745	25.89164	4.809136	2914	64842	665
			DoS	26.34335					170482
			U2R	15.71429					59
			R2L	2.42116					14388
			Normal	95.19086					
	39.39215	73.75068	Prob	84.03745	25.89164	4.809136	2914	64842	665
			DoS	26.34335					170482
			U2R	15.71429					59
			R2L	2.42116					14388
			Normal	95.19086					
100	40.42935	44.74476	Prob	90.06241	30.70006	19.35867	11730	76884	414
			DoS	26.28632					170614
			U2R	17.14286					58
			R2L	83.27569					2466
			Normal	80.64133					
	40.62065	69.82913	Prob	84.20547	28.12096	7.717063	4676	70425	658
			DoS	28.70752					165010
			U2R	28.57143					50
			R2L	3.065446					14293
			Normal	92.28294					
	93.21575	55.49711	Prob	89.77436	94.2093	10.8907	6599	235934	426
			DoS	99.77058					531
			U2R	25.71429					52
			R2L	8.491014					13493
			Normal	89.1093					

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Three layer network with 100 as Max Input with different hidden neurons for both distinct and redundant processed data records on 3-layer NN system:

Table (A.11) 3-layer, Max Input 100 with distinct records, different hidden neurons

Hidden	Rate%%	Cost%	Attack category	TPR Each%	TPR%	FPR%	FP	TP	FN
40	67.87177	70.41489	Prob	32.09486	38.616	20.99309	9724	6808	1718
			DoS	44.9632					7179
			U2R	34.28571					46
			R2L	5.387714					1879
			Normal	79.00691					
	75.27443315	46.46795	Prob	68.89328	82.49007	27.47193	12725	14543	787
			DoS	95.01687					650
			U2R	61.42857					27
			R2L	18.27795					1623
			Normal	72.52807					
	76.55356	51.0752	Prob	73.99209	84.07828	26.31045	12187	14823	658
			DoS	96.7648					422
			U2R	45.71429					38
			R2L	14.95468					1689
			Normal	73.68955					
50	73.06959	50.13329	Prob	81.6996	85.69484	31.73575	14700	15108	463
			DoS	97.17878					368
			U2R	45.71429					38
			R2L	16.76737					1653
			Normal	68.26425					
	72.01251	45.31731	Prob	80.23715	83.66421	32.42228	15018	14750	500
			DoS	93.2536					880
			U2R	54.28571					32
			R2L	26.08258					1468
			Normal	67.57772					
	82.96169	52.16098	Prob	70.67194	75.04821	14.02634	6497	13231	742
			DoS	85.44925					1898
			U2R	48.57143					36
			R2L	13.2427					1723
			Normal	85.97366					
60	75.38858	54.76305	Prob	49.05138	71.96256	23.30743	10796	12687	1289
			DoS	85.38025					1907
			U2R	48.57143					36
			R2L	13.84693					1711
			Normal	76.69257					
	78.67396	45.66051	Prob	74.62451	81.23653	22.30138	10330	14322	642
			DoS	91.05336					1167
			U2R	52.85714					33
			R2L	26.18328					1466
			Normal	77.69862					
	75.19937	46.00051	Prob	91.97628	86.80091	29.21632	13533	15303	203
			DoS	95.63017					570
			U2R	48.57143					36
			R2L	23.56495					1518
			Normal	70.78368					
70	85.20563	41.51596	Prob	76.24506	83.84572	14.27677	6613	14782	601
			DoS	94.22723					753
			U2R	62.85714					26
			R2L	26.08258					1468
			Normal	85.72323					
	74.62236	41.71675	Prob	83.24111	87.26602	30.18998	13984	15385	424
			DoS	97.65409					306

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			U2R	64.28571					25
			R2L	24.97482					1490
			Normal	69.81002					
	67.45426	36.01024	Prob	95.65217	92.59784	42.11572	19508	16325	110
			DoS	99.77768					29
			U2R	60					28
			R2L	42.69889					1138
			Normal	57.88428					
80	70.64738	48.08497	Prob	81.5415	83.99887	34.43437	15950	14809	467
			DoS	94.52622					714
			U2R	52.85714					33
			R2L	19.08359					1607
			Normal	65.56563					
	71.29789	38.93245	Prob	85.25692	89.38741	35.58722	16484	15759	373
			DoS	98.4284					205
			U2R	60					28
			R2L	36.30413					1265
			Normal	64.41278					
	64.72869	44.14133	Prob	78.3004	84.46398	42.78282	19817	14891	549
			DoS	93.95891					788
			U2R	55.71429					31
			R2L	30.96677					1371
			Normal	57.21718					
90	64.80688	47.96565	Prob	79.48617	85.68917	43.14119	19983	15107	519
			DoS	96.7648					422
			U2R	51.42857					34
			R2L	22.05438					1548
			Normal	56.85881					
	73.2541	47.35694	Prob	77.35178	83.6245	30.69301	14217	14743	573
			DoS	94.00491					782
			U2R	48.57143					36
			R2L	24.67271					1496
			Normal	69.30699					
	71.75293	48.04705	Prob	69.80237	81.90017	32.10924	14873	14439	764
			DoS	94.02024					780
			U2R	57.14286					30
			R2L	18.58006					1617
			Normal	67.89076					
100	79.91243	47.61958	Prob	84.03162	82.84742	21.20466	9822	14606	404
			DoS	92.92395					923
			U2R	54.28571					32
			R2L	16.16314					1665
			Normal	78.79534					
	67.55903	74.40918	Prob	0.711462	16.16563	12.87997	5966	2850	2512
			DoS	20.7375					10339
			U2R	44.28571					39
			R2L	4.833837					1890
			Normal	87.12003					
	64.52541	46.15345	Prob	79.01186	82.50709	42.31865	19602	14546	531
			DoS	93.08494					902
			U2R	65.71429					24
			R2L	18.07654					1627
			Normal	57.68135					

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Table (A.12) 3-layer, Max Input 100 with redundant records, different hidden neurons

Hidden	Rate%	Cost%	Attack category	TPR Each%	TPR%	FPR%	FP	TP	FN
40	78.8203	65.33356	Prob	47.31157	77.74801	16.74781	10148	194709	2195
			DoS	83.2179					38843
			U2R	27.14286					51
			R2L	0.72567					14638
			Normal	83.25219					
	43.20433	65.36518	Prob	74.77196	34.77855	21.97118	13313	87098	1051
			DoS	36.1068					147884
			U2R	48.57143					36
			R2L	2.563581					14367
			Normal	78.02882					
	66.2263	62.69204	Prob	77.89246	63.0724	20.73837	12566	157956	921
			DoS	66.69763					77080
			U2R	37.14286					44
			R2L	2.102408					14435
			Normal	79.26163					
50	90.07842	56.46016	Prob	83.7734	93.81039	25.34616	15358	234935	676
			DoS	99.83453					383
			U2R	37.14286					44
			R2L	2.35334					14398
			Normal	74.65384					
	72.08042	57.50285	Prob	81.73308	71.66102	26.18619	15867	179465	761
			DoS	75.81992					55966
			U2R	48.57143					36
			R2L	3.641913					14208
			Normal	73.81381					
	57.40204	63.91394	Prob	75.85214	49.80793	11.21087	6793	124737	1006
			DoS	52.3955					110183
			U2R	40					42
			R2L	1.878603					14468
			Normal	88.78913					
60	90.35974	58.1518	Prob	57.89726	92.54141	18.65727	11305	231757	1754
			DoS	98.9579					2412
			U2R	38.57143					43
			R2L	1.865039					14470
			Normal	81.34273					
	89.15953	55.2142	Prob	78.30053	90.86433	17.88655	10838	227557	904
			DoS	96.66112					7728
			U2R	41.42857					41
			R2L	3.655476					14206
			Normal	82.11345					
	48.23795	64.85856	Prob	88.91023	41.42975	23.62319	14314	103755	462
			DoS	42.97077					131997
			U2R	40					42
			R2L	3.831807					14180
			Normal	76.37681					
70	92.54378	51.31478	Prob	79.28469	93.53727	11.56239	7006	234251	863
			DoS	99.53511					1076
			U2R	51.42857					34
			R2L	3.614785					14212
			Normal	88.43761					
	90.32341	50.12579	Prob	83.55737	93.78564	23.98627	14534	234873	685
			DoS	99.73429					615
			U2R	58.57143					29
			R2L	3.465582					14234
			Normal	76.01373					
	88.77339	49.93632	Prob	91.31061	94.29235	34.03693	20624	236142	362
			DoS	99.94427					129
			U2R	55.71429					31

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			R2L	6.598847					13772
			Normal	65.96307					
80	89.3817	54.40336	Prob	82.5252	93.54965	27.8448	16872	234282	728
			DoS	99.55283					1035
			U2R	45.71429					38
			R2L	2.658528					14353
			Normal	72.1552					
	88.37697	33.39579	Prob	84.85358	97.10305	47.68868	28896	243181	631
			DoS	99.81163					436
			U2R	54.28571					32
			R2L	58.25025					6156
			Normal	52.31132					
	88.16606	54.71685	Prob	80.58089	93.63231	34.42642	20860	234489	809
			DoS	99.52777					1093
			U2R	44.28571					39
			R2L	5.011868					14006
			Normal	65.57358					
90	88.17184	54.95847	Prob	81.253	93.67423	34.57	20947	234594	781
			DoS	99.6846					730
			U2R	45.71429					38
			R2L	3.065446					14293
			Normal	65.43					
	90.01379	54.44136	Prob	80.0048	93.50692	24.42361	14799	234175	833
			DoS	99.50358					1149
			U2R	44.28571					39
			R2L	3.42489					14240
			Normal	75.57639					
	65.17206	60.09744	Prob	75.27604	62.93105	25.56566	15491	157602	1030
			DoS	66.55678					77406
			U2R	48.57143					36
			R2L	2.597491					14362
			Normal	74.43434					
100	73.84488	57.72313	Prob	84.06145	71.58476	16.81382	10188	179274	664
			DoS	75.78363					56050
			U2R	45.71429					38
			R2L	2.271957					14410
			Normal	83.18618					
	30.73025	78.97216	Prob	0.432069	16.35747	9.865826	5978	40965	4148
			DoS	17.63928					190628
			U2R	34.28571					46
			R2L	0.651068					14649
			Normal	90.13417					
	88.12458	51.25608	Prob	80.98896	93.44583	33.8686	20522	234022	792
			DoS	99.47204					1222
			U2R	60					28
			R2L	2.529671					14372
			Normal	66.1314					

Three layer network with 256 as Max Input with different hidden neurons for both distinct and redundant processed data records:

Table (A.13) 3-layer, Max Input 256 with distinct records, different hidden neurons

Hidden	Rate%	Cost%	Attack category	TPR Each%	TPR%	FPR%	FP	TP	FN
40	80.3706	39.69132	Prob	98.53755	92.3823	24.20121	11210	16287	37
			DoS	98.85771					149
			U2R	38.57143					43
			R2L	43.90735					1114
			Normal	75.79879					

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	86.13761	56.1076	Prob	69.05138	78.00908	10.76857	4988	13753	783
			DoS	90.29439					1266
			U2R	34.28571					46
			R2L	10.2719					1782
			Normal	89.23143					
	86.20797	56.99902	Prob	72.9249	81.16846	11.87392	5500	14310	685
			DoS	92.60196					965
			U2R	17.14286					58
			R2L	18.83182					1612
			Normal	88.12608					
50	81.74668	41.41077	Prob	89.76285	87.81622	20.56347	9525	15482	259
			DoS	94.58755					706
			U2R	38.57143					43
			R2L	42.59819					1140
			Normal	79.43653					
	76.43159	49.69975	Prob	86.52174	86.61373	27.44387	12712	15270	341
			DoS	96.51181					455
			U2R	35.71429					45
			R2L	23.5146					1519
			Normal	72.55613					
	83.26505	49.78016	Prob	77.70751	81.12876	15.92185	7375	14303	564
			DoS	90.48605					1241
			U2R	35.71429					45
			R2L	25.62941					1477
			Normal	84.07815					
60	81.13057	47.05392	Prob	87.62846	86.30176	20.83765	9652	15215	313
			DoS	95.61484					572
			U2R	41.42857					41
			R2L	25.02518					1489
			Normal	79.16235					
	67.40735	41.81246	Prob	95.96838	91.04368	41.58895	19264	16051	102
			DoS	97.74609					294
			U2R	40					42
			R2L	42.54783					1141
			Normal	58.41105					
	72.83972	39.75839	Prob	94.86166	91.94555	34.43221	15949	16210	130
			DoS	96.93346					400
			U2R	25.71429					52
			R2L	57.80463					838
			Normal	65.56779					
64	80.51134	48.31126	Prob	93.83399	84.10664	20.85708	9661	14828	156
			DoS	91.08402					1163
			U2R	34.28571					46
			R2L	27.6435					1437
			Normal	79.14292					
	88.51916	59.148	Prob	61.50198	75.77992	6.632124	3072	13360	974
			DoS	89.01411					1433
			U2R	27.14286					51
			R2L	8.761329					1812
			Normal	93.36788					
	85.60594	48.90879	Prob	72.37154	83.52808	13.6032	6301	14726	699
			DoS	95.43852					595
			U2R	42.85714					40
			R2L	20.94663					1570
			Normal	86.3968					
70	84.39093	52.46856	Prob	77.94466	81.84912	14.64162	6782	14430	558
			DoS	92.93928					921
			U2R	37.14286					44
			R2L	15.55891					1677
			Normal	85.35838					
	75.7326	45.92119	Prob	80.19763	85.68917	28.05699	12996	15107	501

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			DoS	94.82521					675
			U2R	38.57143					43
			R2L	34.34038					1304
			Normal	71.94301					
	86.405	55.02249	Prob	67.50988	80.59558	11.38385	5273	14209	822
			DoS	93.98957					784
			U2R	35.71429					45
			R2L	10.87613					1770
			Normal	88.61615					
80	81.10086	53.53504	Prob	81.81818	83.64152	19.86615	9202	14746	460
			DoS	94.33456					739
			U2R	30					49
			R2L	17.62336					1636
			Normal	80.13385					
	72.37217	53.23348	Prob	69.8419	81.40102	31.06434	14389	14351	763
			DoS	92.64796					959
			U2R	31.42857					48
			R2L	24.01813					1509
			Normal	68.93566					
	84.02346	54.54556	Prob	74.62451	81.02099	14.83377	6871	14284	642
			DoS	92.5483					972
			U2R	31.42857					48
			R2L	15.20645					1684
			Normal	85.16623					
90	82.28772	69.94134	Prob	13.16206	58.14521	8.523316	3948	10251	2197
			DoS	75.17633					3238
			U2R	18.57143					57
			R2L	4.984894					1887
			Normal	91.47668					
	74.33776	53.54427	Prob	82.33202	83.88542	29.2962	13570	14789	447
			DoS	94.55688					710
			U2R	32.85714					47
			R2L	17.57301					1637
			Normal	70.7038					
	83.08835	53.20981	Prob	88.6166	82.10437	16.53713	7660	14475	288
			DoS	89.91874					1315
			U2R	21.42857					55
			R2L	24.62236					1497
			Normal	83.46287					
100	83.53714	56.17633	Prob	78.37945	77.54396	14.18178	6569	13671	547
			DoS	86.75253					1728
			U2R	24.28571					53
			R2L	17.87513					1631
			Normal	85.81822					
	77.28382	60.82987	Prob	66.20553	79.0017	23.37003	10825	13928	855
			DoS	92.16498					1022
			U2R	20					56
			R2L	10.92649					1769
			Normal	76.62997					
	69.84363	42.91065	Prob	75.25692	84.75326	35.83117	16597	14942	626
			DoS	93.95124					789
			U2R	50					35
			R2L	37.66365					1238
			Normal	64.16883					

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Table (A.14) 3-layer, Max Input 256 with redundant records, different hidden neurons

Hidden	Rate%%	Cost%	Attack category	TPR Each%	TPR%	FPR%	FP	TP	FN
40	90.38643	56.01343	Prob	97.09554	94.38659	26.14658	15843	236378	121
			DoS	99.93562					149
			U2R	28.57143					50
			R2L	6.829434					13738
			Normal	73.85342					
	92.76305	60.44879	Prob	74.93999	93.10882	8.666018	5251	233178	1044
			DoS	99.2949					1632
			U2R	21.42857					55
			R2L	1.478467					14527
			Normal	91.33398					
	92.81321	62.58605	Prob	77.29237	93.35239	9.415279	5705	233788	946
			DoS	99.44611					1282
			U2R	11.42857					62
			R2L	2.624619					14358
			Normal	90.58472					
50	91.8432	55.76186	Prob	87.68603	93.85472	16.47055	9980	235046	513
			DoS	99.54505					1053
			U2R	30					49
			R2L	6.578501					13775
			Normal	83.52945					
	90.66196	59.198	Prob	85.5977	93.73533	22.0405	13355	234747	600
			DoS	99.66603					773
			U2R	24.28571					53
			R2L	3.268905					14263
			Normal	77.9595					
	74.58051	62.70165	Prob	80.22084	71.5033	12.70114	7696	179070	824
			DoS	75.68858					56270
			U2R	25.71429					52
			R2L	3.560529					14220
			Normal	87.29886					
60	74.11785	61.31679	Prob	86.2458	71.87864	16.62733	10075	180010	573
			DoS	75.99015					55572
			U2R	30					49
			R2L	3.479145					14232
			Normal	83.37267					
	88.82066	55.79065	Prob	95.41527	94.27239	33.71181	20427	236092	191
			DoS	99.85699					331
			U2R	32.85714					47
			R2L	6.578501					13775
			Normal	66.28819					
	90.08324	58.00914	Prob	93.80701	94.48961	28.12866	17044	236636	258
			DoS	99.82588					403
			U2R	17.14286					58
			R2L	11.28518					13081
			Normal	71.87134					
64	67.10725	63.41133	Prob	93.95103	63.25488	16.97061	10283	158413	252
			DoS	66.49889					77540
			U2R	25.71429					52
			R2L	3.838589					14179
			Normal	83.02939					
	40.74636	74.65823	Prob	70.23524	27.65657	5.15241	3122	69262	1240
			DoS	28.57402					165319
			U2R	17.14286					58
			R2L	1.275008					14557
			Normal	94.84759					
	92.67946	57.15078	Prob	76.93231	93.50253	10.72236	6497	234164	961
			DoS	99.59042					948

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			U2R	31.42857					48
			R2L	2.916243					14315
			Normal	89.27764					
70	91.22976	59.3044	Prob	80.34085	93.39831	17.73307	10745	233903	819
			DoS	99.4608					1248
			U2R	25.71429					52
			R2L	2.244829					14414
			Normal	82.26693					
	47.21875	65.91693	Prob	81.66107	41.78952	30.34179	18385	104656	764
			DoS	42.97898					131978
			U2R	30					49
			R2L	11.90912					12989
			Normal	69.65821					
	91.63101	61.04918	Prob	73.97984	93.30847	15.3021	9272	233678	1084
			DoS	99.51956					1112
			U2R	21.42857					55
			R2L	1.614106					14507
			Normal	84.6979					
80	91.66637	60.77632	Prob	82.71723	93.49574	15.89458	9631	234147	720
			DoS	99.51092					1132
			U2R	18.57143					57
			R2L	2.475415					14380
			Normal	84.10542					
	89.78841	61.97154	Prob	75.39606	93.3468	24.91872	15099	233774	1025
			DoS	99.42797					1324
			U2R	18.57143					57
			R2L	3.316378					14256
			Normal	75.08128					
	92.30811	59.39373	Prob	78.30053	93.32005	11.87431	7195	233707	904
			DoS	99.42019					1342
			U2R	24.28571					53
			R2L	2.136317					14430
			Normal	88.12569					
90	66.2472	75.30288	Prob	8.233317	59.66514	6.548611	3968	149423	3823
			DoS	64.36327					82483
			U2R	12.85714					61
			R2L	0.671414					14646
			Normal	93.45139					
	90.24239	60.64051	Prob	83.02928	93.51651	23.28982	14112	234199	707
			DoS	99.52734					1094
			U2R	21.42857					55
			R2L	2.468633					14381
			Normal	76.71018					
	90.3726	62.11542	Prob	86.8459	92.89479	20.05182	12150	232642	548
			DoS	98.72416					2953
			U2R	12.85714					61
			R2L	3.479145					14232
			Normal	79.94818					
100	39.39504	75.87246	Prob	80.55689	27.50403	11.45842	6943	68880	810
			DoS	28.14716					166307
			U2R	10					63
			R2L	2.502543					14376
			Normal	88.54158					
	89.58296	64.78116	Prob	73.18771	93.19746	25.35606	15364	233400	1117
			DoS	99.41673					1350
			U2R	11.42857					62
			R2L	1.614106					14507
			Normal	74.64394					
	89.31836	38.03431	Prob	78.68459	96.52925	40.48487	24531	241744	888
			DoS	99.51092					1132

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			U2R	41.42857					41
			R2L	55.02882					6631
			Normal	59.51513					

Three layer network with 512 as Max Input with different hidden neurons for both distinct and redundant processed data records:

Table (A.15) 3-layer, Max Input 512 with distinct records, different hidden neurons

Hidden	Rate%%	Cost%	Attack category	TPR Each%	TPR%	FPR%	FP	TP	FN
40	87.67318	45.21844	Prob	85.45455	84.46398	11.10535	5144	14891	368
			DoS	92.69396			0.888946		953
			U2R	40					42
			R2L	30.71501					1376
			Normal	88.89465					
	83.86083	52.15442	Prob	68.7747	81.25355	15.1468	7016	14325	790
			DoS	93.11561			0.848532		898
			U2R	34.28571					46
			R2L	20.89627					1571
			Normal	84.8532					
	86.87568	50.24904	Prob	79.80237	80.85649	10.83333	5018	14255	511
			DoS	90.15639			0.891667		1284
			U2R	35.71429					45
			R2L	22.70896					1535
			Normal	89.16667					
50	87.10242	56.59662	Prob	82.09486	83.57913	11.55656	5353	14735	453
			DoS	94.74854			0.884434		685
			U2R	20					56
			R2L	14.35045					1701
			Normal	88.44344					
	86.38937	59.60337	Prob	78.57708	75.08792	9.309154	4312	13238	542
			DoS	84.03864			0.906908		2082
			U2R	17.14286					58
			R2L	13.89728					1710
			Normal	90.69085					
	75.86396	56.88197	Prob	82.29249	80.8962	26.05138	12067	14262	448
			DoS	89.14443			0.739486		1416
			U2R	10					63
			R2L	27.44209					1441
			Normal	73.94862					
60	84.03284	50.86324	Prob	67.03557	80.3063	14.54879	6739	14158	834
			DoS	92.80895			0.854512		938
			U2R	45.71429					38
			R2L	16.3142					1662
			Normal	85.45121					
	87.02267	65.92936	Prob	65.01976	72.24617	7.353195	3406	12737	885
			DoS	83.77032			0.926468		2117
			U2R	5.714286					66
			R2L	8.106747					1825
			Normal	92.6468					
	80.03909	56.87497	Prob	84.42688	86.00113	22.23014	10297	15162	394
			DoS	97.41644			0.777699		337
			U2R	18.57143					57
			R2L	15.40785					1680
			Normal	77.76986					
64	86.63956	52.44797	Prob	73.32016	80.44243	11.00173	5096	14182	675
			DoS	90.7927			0.889983		1201

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			U2R	28.57143					50
			R2L	23.36354					1522
			Normal	88.99827					
	71.76544	39.62252	Prob	89.16996	90.52184	35.37349	16385	15959	274
			DoS	97.39344					340
			U2R	40					42
			R2L	48.89225					1015
			Normal	64.62651					
	87.0649	59.37213	Prob	71.89723	77.23766	9.194732	4259	13617	711
			DoS	88.88378					1450
			U2R	22.85714					54
			R2L	9.466264					1798
			Normal	90.80527					
70	87.2338	60.29112	Prob	76.71937	78.07147	9.278929	4298	13764	589
			DoS	89.1981					1409
			U2R	18.57143					57
			R2L	8.811682					1811
			Normal	90.72107					
	83.5872	54.41919	Prob	77.19368	83.1764	16.25648	7530	14664	577
			DoS	93.97424					786
			U2R	21.42857					55
			R2L	22.05438					1548
			Normal	83.74352					
	85.54965	58.41319	Prob	65.61265	77.06183	11.21978	5197	13586	870
			DoS	89.84207					1325
			U2R	28.57143					50
			R2L	9.415911					1799
			Normal	88.78022					
80	80.55981	53.27647	Prob	67.2332	79.39308	18.99611	8799	13997	829
			DoS	89.48942					1371
			U2R	21.42857					55
			R2L	30.6143					1378
			Normal	81.00389					
	81.99375	52.68699	Prob	84.26877	85.67215	19.4063	8989	15104	398
			DoS	96.18982					497
			U2R	27.14286					51
			R2L	20.4431					1580
			Normal	80.5937					
	87.63722	34.91701	Prob	91.85771	92.96653	14.39119	6666	16390	206
			DoS	99.08004					120
			U2R	38.57143					43
			R2L	56.143					871
			Normal	85.60881					
90	83.76701	58.66508	Prob	59.92095	71.85479	11.69905	5419	12668	1014
			DoS	83.11101					2203
			U2R	27.14286					51
			R2L	14.70292					1694
			Normal	88.30095					
	84.87568	64.7568	Prob	64.78261	73.22178	10.68869	4951	12909	891
			DoS	85.0736					1947
			U2R	10					63
			R2L	8.35851					1820
			Normal	89.31131					
	72.03284	54.09971	Prob	87.19368	85.26943	33.00518	15288	15033	324
			DoS	95.86017					540
			U2R	32.85714					47
			R2L	15.10574					1686
			Normal	66.99482					
100	85.86083	64.31953	Prob	62.72727	74.36756	9.76468	4523	13111	943
			DoS	86.93652					1704

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			U2R	10					63
			R2L	8.912387					1809
			Normal	90.23532					
	82.16732	41.90241	Prob	86.04743	88.87691	20.38644	9443	15669	353
			DoS	97.66943					304
			U2R	44.28571					39
			R2L	36.30413					1265
			Normal	79.61356					
	73.52306	46.77579	Prob	93.79447	88.66137	32.23877	14933	15631	157
			DoS	96.92579					401
			U2R	37.14286					44
			R2L	29.6576					1397
			Normal	67.76123					
200	64.97889	51.21113	Prob	72.80632	82.60352	41.72927	19329	14563	688
			DoS	93.72892					818
			U2R	41.42857					41
			R2L	23.46425					1520
			Normal	58.27073					
	82.34089	41.09054	Prob	94.26877	91.79807	21.25864	9847	16184	145
			DoS	99.47869					68
			U2R	38.57143					43
			R2L	40.08056					1190
			Normal	78.74136					
	87.03049	59.85726	Prob	74.22925	77.03347	9.164508	4245	13581	652
			DoS	86.89819					1709
			U2R	10					63
			R2L	18.17724					1625
			Normal	90.83549					

Table (A.16) 3-layer, Max Input 512 with redundant records, different hidden neurons

Hidden	Rate%%	Cost%	Attack category	TPR Each%	TPR%	FPR%	FP	TP	FN
40	93.06688	56.59989	Prob	84.90158	93.57201	9.020844	5466	234338	629
			DoS	99.4392					1298
			U2R	28.57143					50
			R2L	4.231943					14121
			Normal	90.97916					
	92.30329	60.22111	Prob	74.72396	93.33363	11.95518	7244	233741	1053
			DoS	99.4513					1270
			U2R	21.42857					55
			R2L	2.902679					14317
			Normal	88.04482					
	52.57002	67.56062	Prob	81.42103	43.2326	8.837655	5355	108270	774
			DoS	45.10337					127061
			U2R	27.14286					51
			R2L	3.153611					14280
			Normal	91.16235					
50	75.02034	67.43103	Prob	82.88526	71.23377	9.32946	5653	178395	713
			DoS	75.45225					56817
			U2R	8.571429					64
			R2L	2.021024					14447
			Normal	90.67054					
	50.73418	73.48558	Prob	80.67691	40.55847	7.208753	4368	101573	805
			DoS	42.30455					133539
			U2R	8.571429					64
			R2L	1.966768					14455
			Normal	92.79125					
	90.42629	45.07707	Prob	83.00528	96.2725	33.73657	20442	241101	708
			DoS	99.12899					2016

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			U2R	11.42857					62
			R2L	55.58494					6549
			Normal	66.26343					
60	92.36438	56.58816	Prob	73.71579	93.26455	11.3561	6881	233568	1095
			DoS	99.42926					1321
			U2R	35.71429					45
			R2L	2.292302					14407
			Normal	88.6439					
	82.56433	68.19991	Prob	72.44359	79.72496	5.700328	3454	199660	1148
			DoS	84.88302					34989
			U2R	2.857143					68
			R2L	1.180061					14571
			Normal	94.29967					
	91.45031	63.21978	Prob	84.30149	93.68821	17.79909	10785	234629	654
			DoS	99.71312					664
			U2R	10					63
			R2L	2.163445					14426
			Normal	82.20091					
64	50.88497	69.30044	Prob	77.46039	41.09034	8.63301	5231	102905	939
			DoS	42.75561					132495
			U2R	21.42857					55
			R2L	4.767718					14042
			Normal	91.36699					
	89.6791	37.61617	Prob	89.07825	97.32546	41.92398	25403	243738	455
			DoS	99.71874					651
			U2R	30					49
			R2L	62.4076					5543
			Normal	58.07602					
	75.42158	65.2865	Prob	76.66827	71.19464	7.108082	4307	178297	972
			DoS	75.56069					56566
			U2R	18.57143					57
			R2L	1.363174					14544
			Normal	92.89192					
70	40.43224	74.80077	Prob	79.54873	27.84144	7.528922	4562	69725	852
			DoS	28.60729					165242
			U2R	14.28571					60
			R2L	1.275008					14557
			Normal	92.47108					
	92.18369	61.35442	Prob	79.90879	93.49375	13.2309	8017	234142	837
			DoS	99.52302					1104
			U2R	15.71429					59
			R2L	3.058664					14294
			Normal	86.7691					
	77.10985	63.72086	Prob	72.85166	73.67192	8.680871	5260	184501	1131
			DoS	78.30853					50206
			U2R	24.28571					53
			R2L	1.356392					14545
			Normal	91.31913					
80	91.58085	43.9298	Prob	73.78781	96.13314	27.23417	16502	240752	1092
			DoS	99.24262					1753
			U2R	18.57143					57
			R2L	54.00475					6782
			Normal	72.76583					
	91.25194	61.78386	Prob	84.20547	92.97785	15.88137	9623	232850	658
			DoS	98.9013					2543
			U2R	14.28571					60
			R2L	2.848423					14325
			Normal	84.11863					
	92.06537	54.42012	Prob	90.30245	94.59103	18.37341	11133	236890	404
			DoS	99.94815					120

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			U2R	27.14286					51
			R2L	12.0312					12971
			Normal	81.62659					
90	62.81922	69.64723	Prob	69.25108	56.06662	9.271698	5618	140411	1281
			DoS	59.2828					94242
			U2R	15.71429					59
			R2L	2.048152					14443
			Normal	90.7283					
	73.2787	69.43225	Prob	72.29957	68.92739	8.736983	5294	172619	1154
			DoS	73.19911					62032
			U2R	7.142857					65
			R2L	1.213971					14566
			Normal	91.26302					
	72.30901	63.82932	Prob	86.02976	71.91099	26.04591	15782	180091	582
			DoS	76.11631					55280
			U2R	25.71429					52
			R2L	2.129535					14431
			Normal	73.95409					
100	92.71065	65.11699	Prob	71.09938	92.86005	7.906854	4791	232555	1204
			DoS	99.11171					2056
			U2R	5.714286					66
			R2L	1.288572					14555
			Normal	92.09315					
	90.37292	38.64204	Prob	85.28565	97.03477	37.16106	22517	243010	613
			DoS	99.73602					611
			U2R	31.42857					48
			R2L	58.26382					6154
			Normal	62.83894					
	90.04369	57.27846	Prob	90.08641	93.99607	26.29182	15931	235400	413
			DoS	99.81076					438
			U2R	30					49
			R2L	4.130214					14136
			Normal	73.70818					
200	86.9816	59.63595	Prob	77.19635	93.43505	39.69105	24050	233995	950
			DoS	99.48759					1186
			U2R	31.42857					48
			R2L	3.309596					14257
			Normal	60.30895					
	90.72177	38.06487	Prob	90.99856	97.40812	36.9135	22367	243945	375
			DoS	99.97062					68
			U2R	30					49
			R2L	59.31502					5999
			Normal	63.0865					
	66.99086	70.32113	Prob	78.01248	60.7233	7.104781	4305	152073	916
			DoS	64.13558					83010
			U2R	5.714286					66
			R2L	2.536453					14371
			Normal	92.89522					

Three layer network with 1024 as Max Input with different hidden neurons for both distinct and redundant processed data records:

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Table (A.17) 3-layer, Max Input 1024 with distinct records, different hidden neurons

Hidden	Rate%%	Cost%	Attack category	TPR Each%	TPR%	FPR%	FP	TP	FN
40	82.45973	21.29992	Prob	99.88142	98.63868	23.69819	10977	17390	3
			DoS	98.79638					157
			U2R	32.85714					47
			R2L	98.33837					33
			Normal	76.30181					
	69.4871	27.53815	Prob	99.48617	94.78729	40.14249	18594	16711	13
			DoS	95.88316					537
			U2R	37.14286					44
			R2L	83.63545					325
			Normal	59.85751					
	87.21032	54.19768	Prob	86.917	83.57913	11.4076	5284	14735	331
			DoS	92.34897					998
			U2R	15.71429					59
			R2L	24.11883					1507
			Normal	88.5924					
50	76.62705	48.29823	Prob	87.3913	87.57799	27.54102	12757	15440	319
			DoS	95.45385					593
			U2R	21.42857					55
			R2L	38.41893					1223
			Normal	72.45898					
	78.46755	46.05132	Prob	92.21344	87.32275	24.90285	11535	15395	197
			DoS	95.03987					647
			U2R	35.71429					45
			R2L	32.22558					1346
			Normal	75.09715					
	84.2674	55.20417	Prob	83.35968	81.50312	14.68048	6800	14369	421
			DoS	90.40172					1252
			U2R	17.14286					58
			R2L	22.96073					1530
			Normal	85.31952					
60	88.32525	50.0224	Prob	86.64032	86.46058	10.96503	5079	15243	338
			DoS	96.41981					467
			U2R	30					49
			R2L	22.80967					1533
			Normal	89.03497					
	88.32525	50.0224	Prob	86.64032	86.46058	10.96503	5079	15243	338
			DoS	96.41981					467
			U2R	30					49
			R2L	22.80967					1533
			Normal	89.03497					
	87.44957	58.67965	Prob	87.78656	82.7907	10.7772	4992	14596	309
			DoS	92.26464					1009
			U2R	8.571429					64
			R2L	16.81772					1652
			Normal	89.2228					
64	88.84128	50.94259	Prob	84.07115	85.3772	9.840242	4558	15052	403
			DoS	96.57314					447
			U2R	37.14286					44
			R2L	15.20645					1684
			Normal	90.15976					
	74.60985	37.78587	Prob	97.74704	92.63755	32.25173	14939	16332	57
			DoS	98.84238					151
			U2R	44.28571					39
			R2L	47.07956					1051
			Normal	67.74827					
	83.26505	48.7249	Prob	90.43478	88.83721	18.85579	8734	15662	242
			DoS	98.00675					260
			U2R	27.14286					51

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			R2L	28.75126					1415
			Normal	81.14421					
70	83.74199	45.11188	Prob	85.5336	85.43392	16.90199	7829	15062	366
			DoS	93.47593					851
			U2R	37.14286					44
			R2L	34.18933					1307
			Normal	83.09801					
	73.17905	43.38987	Prob	99.72332	91.6903	33.86658	15687	16165	7
			DoS	97.40877					338
			U2R	25.71429					52
			R2L	46.22356					1068
			Normal	66.13342					
	87.68256	58.1506	Prob	81.42292	80.52184	9.591969	4443	14196	470
			DoS	90.50138					1239
			U2R	14.28571					60
			R2L	16.16314					1665
			Normal	90.40803					
80	77.92338	44.06696	Prob	99.24901	89.79013	26.59326	12318	15830	19
			DoS	95.14719					633
			U2R	24.28571					53
			R2L	44.86405					1095
			Normal	73.40674					
	86.22361	50.5803	Prob	90.23715	86.68746	13.95294	6463	15283	247
			DoS	96.44281					464
			U2R	31.42857					48
			R2L	20.04028					1588
			Normal	86.04706					
	79.84519	48.47088	Prob	84.78261	86.46058	22.67271	10502	15243	385
			DoS	96.38914					471
			U2R	37.14286					44
			R2L	25.12588					1487
			Normal	77.32729					
90	73.5387	40.94174	Prob	97.98419	88.91662	32.31434	14968	15676	51
			DoS	94.61822					702
			U2R	42.85714					40
			R2L	41.54079					1161
			Normal	67.68566					
	66.29711	17.94144	Prob	99.68379	98.38344	45.91537	21268	17345	8
			DoS	98.37473					212
			U2R	52.85714					33
			R2L	98.38872					32
			Normal	54.08463					
	84.21423	52.41772	Prob	88.06324	82.62053	15.17919	7031	14566	302
			DoS	90.96903					1178
			U2R	25.71429					52
			R2L	22.86002					1532
			Normal	84.82081					
100	88.05317	49.08068	Prob	86.87747	87.09019	11.58031	5364	15354	332
			DoS	96.68047					433
			U2R	28.57143					50
			R2L	26.43505					1461
			Normal	88.41969					
	72.4785	44.93294	Prob	87.86561	88.76914	33.72193	15620	15650	307
			DoS	97.69243					301
			U2R	41.42857					41
			R2L	32.98087					1331
			Normal	66.27807					
	81.28694	48.17751	Prob	91.18577	88.21327	21.34931	9889	15552	223
			DoS	95.43852					595
			U2R	17.14286					58

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			R2L	39.47633					1202
			Normal	78.65069					
200	69.20563	41.60549	Prob	96.04743	92.6886	39.7323	18404	16341	100
			DoS	99.78534					28
			U2R	37.14286					44
			R2L	43.75629					1117
			Normal	60.2677					
	83.28069	65.47628	Prob	77.62846	69.85252	11.60838	5377	12315	566
			DoS	77.92855					2879
			U2R	7.142857					65
			R2L	9.113797					1805
			Normal	88.39162					
	78.46912	42.95889	Prob	94.82213	88.92229	25.5095	11816	15677	131
			DoS	94.67188					695
			U2R	28.57143					50
			R2L	45.77039					1077
			Normal	74.4905					

Table (A.18) 3-layer, Max Input 1024 with redundant records, different hidden neurons

Hidden	Rate%%	Cost%	Attack category	TPR Each%	TPR%	FPR%	FP	TP	FN
40	92.43929	24.77354	Prob	98.22372	99.86703	38.2602	23183	250103	74
			DoS	99.92569					172
			U2R	22.85714					54
			R2L	99.7762					33
			Normal	61.7398					
	89.30775	24.88921	Prob	95.75132	99.20379	51.59342	31262	248442	177
			DoS	99.76194					551
			U2R	38.57143					43
			R2L	91.70566					1223
			Normal	48.40658					
	49.66321	72.11814	Prob	85.81373	39.71554	9.222187	5588	99462	591
			DoS	41.21103					136070
			U2R	11.42857					62
			R2L	3.350288					14251
			Normal	90.77781					
50	73.06328	65.07495	Prob	86.07777	71.86706	21.99264	13326	179981	580
			DoS	75.79875					56015
			U2R	14.28571					60
			R2L	6.408952					13800
			Normal	78.00736					
	91.18957	57.86875	Prob	89.12626	93.90942	20.05182	12150	235183	453
			DoS	99.71528					659
			U2R	25.71429					52
			R2L	4.448966					14089
			Normal	79.94818					
	73.29767	66.32321	Prob	83.62938	69.75435	12.0575	7306	174690	682
			DoS	73.76207					60729
			U2R	12.85714					61
			R2L	3.194303					14274
			Normal	87.9425					
60	75.72702	62.69379	Prob	85.66971	71.99005	8.827752	5349	180289	597
			DoS	76.14309					55218
			U2R	22.85714					54
			R2L	3.167175					14278
			Normal	91.17225					
	75.72702	62.69379	Prob	85.66971	71.99005	8.827752	5349	180289	597
			DoS	76.14309					55218

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			U2R	22.85714					54
			R2L	3.167175					14278
			Normal	91.17225					
	50.97081	73.2544	Prob	86.2698	41.23289	8.781542	5321	103262	572
			DoS	42.90856					132141
			U2R	7.142857					65
			R2L	2.366904					14396
			Normal	91.21846					
64	51.36531	67.9329	Prob	84.03745	41.46528	7.717063	4676	103844	665
			DoS	43.2084					131447
			U2R	27.14286					51
			R2L	2.143099					14429
			Normal	92.28294					
	89.16628	36.62787	Prob	96.35142	97.49078	45.23955	27412	244152	152
			DoS	99.93476					151
			U2R	35.71429					45
			R2L	59.74229					5936
			Normal	54.76045					
	92.21262	60.00261	Prob	88.1181	94.01324	15.22948	9228	235443	495
			DoS	99.87859					281
			U2R	17.14286					58
			R2L	3.974229					14159
			Normal	84.77052					
70	92.35955	57.06366	Prob	84.94959	93.85831	13.83493	8383	235055	627
			DoS	99.62368					871
			U2R	25.71429					52
			R2L	6.198711					13831
			Normal	86.16507					
	90.17616	57.74388	Prob	97.11954	94.42213	27.3728	16586	236467	120
			DoS	99.84792					352
			U2R	20					56
			R2L	8.843676					13441
			Normal	72.6272					
	75.50036	67.19804	Prob	82.45319	71.45219	7.768224	4707	178942	731
			DoS	75.6808					56288
			U2R	8.571429					64
			R2L	2.265175					14411
			Normal	92.23178					
80	91.07543	40.56572	Prob	95.6313	97.25359	34.45943	20880	243558	182
			DoS	99.72046					647
			U2R	18.57143					57
			R2L	59.3625					5992
			Normal	65.54057					
	92.83025	58.5555	Prob	87.99808	93.8639	11.44192	6933	235069	500
			DoS	99.79262					480
			U2R	22.85714					54
			R2L	2.794168					14333
			Normal	88.55808					
	73.95227	62.33914	Prob	84.56553	71.99684	17.96577	10886	180306	643
			DoS	76.14871					55205
			U2R	27.14286					51
			R2L	3.485927					14231
			Normal	82.03423					
90	72.64371	57.4578	Prob	92.75084	72.27116	25.81651	15643	180993	302
			DoS	76.05582					55420
			U2R	40					42
			R2L	7.229569					13679
			Normal	74.18349					
	88.66344	19.50654	Prob	93.78301	99.78517	57.30365	34722	249898	259
			DoS	99.90841					212

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			U2R	50					35
			R2L	99.78298					32
			Normal	42.69635					
	74.65895	63.03327	Prob	86.50984	71.52686	12.39582	7511	179129	562
			DoS	75.62636					56414
			U2R	22.85714					54
			R2L	3.173957					14277
			Normal	87.60418					
100	53.15003	69.61136	Prob	85.71771	44.08551	9.385573	5687	110406	595
			DoS	45.91908					125173
			U2R	17.14286					58
			R2L	3.66904					14204
			Normal	90.61443					
	89.97425	56.18574	Prob	86.46183	94.10308	27.09059	16415	235668	564
			DoS	99.86736					307
			U2R	32.85714					47
			R2L	6.069854					13850
			Normal	72.90941					
	90.60891	60.44268	Prob	88.45415	94.06555	23.67765	14347	235574	481
			DoS	99.73688					609
			U2R	14.28571					60
			R2L	7.005765					13712
			Normal	76.32235					
200	88.01752	57.33782	Prob	91.57465	94.38739	38.30971	23213	236380	351
			DoS	99.9879					28
			U2R	28.57143					50
			R2L	7.582231					13627
			Normal	61.69029					
	55.33471	73.91433	Prob	80.07681	46.83073	9.517601	5767	117281	830
			DoS	49.14519					117706
			U2R	4.285714					67
			R2L	1.308918					14552
			Normal	90.4824					
	89.972	41.18734	Prob	90.73452	97.19968	39.90065	24177	243423	386
			DoS	99.69368					709
			U2R	18.57143					57
			R2L	60.25093					5861
			Normal	60.09935					

Three layer network with 1200 as Max Input with different hidden neurons for both distinct and redundant processed data records:

Table (A.19) 3-layer, Max Input 1200 with distinct records, different hidden neurons

Hidden	Rate%%	Cost%	Attack category	TPR Each%	TPR%	FPR%	FP	TP	FN
40	83.0258	49.61403	Prob	93.67589	87.41917	18.64637	8637	15412	160
			DoS	94.95554					658
			U2R	20					56
			R2L	32.32628					1344
			Normal	81.35363					
	87.0227	57.96162	Prob	86.95652	80.29495	10.41667	4825	14156	330
			DoS	90.12573					1288
			U2R	22.85714					54
			R2L	9.264854					1802
			Normal	89.58333					
	88.0829	51.72701	Prob	89.68379	85.76858	11.03627	5112	15121	261
			DoS	93.47593					851
			U2R	11.42857					62

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			R2L	32.77946					1335
			Normal	88.96373					
50	78.9664	60.71102	Prob	73.32016	76.35281	20.03886	9282	13461	675
			DoS	86.49954					1761
			U2R	14.28571					60
			R2L	15.76032					1673
			Normal	79.96114					
	82.1267	48.83027	Prob	86.71937	87.23766	19.81865	9180	15380	336
			DoS	94.95554					658
			U2R	15.71429					59
			R2L	39.7281					1197
			Normal	80.18135					
	87.0195	59.29497	Prob	85.88933	75.59274	8.631261	3998	13327	357
			DoS	82.75836					2249
			U2R	11.42857					62
			R2L	17.67372					1635
			Normal	91.36874					
60	81.9922	46.6078	Prob	88.97233	89.05842	20.69732	9587	15701	279
			DoS	98.71972					167
			U2R	37.14286					44
			R2L	27.5428					1439
			Normal	79.30268					
	78.8569	42.48819	Prob	93.35968	90.86217	25.71244	11910	16019	168
			DoS	99.04937					124
			U2R	41.42857					41
			R2L	35.64955					1278
			Normal	74.28756					
	79.8202	47.51157	Prob	86.36364	87.6177	23.14767	10722	15447	345
			DoS	96.51947					454
			U2R	30					49
			R2L	32.77946					1335
			Normal	76.85233					
70	87.7858	55.11947	Prob	85.37549	81.44073	9.799223	4539	14358	370
			DoS	89.96473					1309
			U2R	15.71429					59
			R2L	22.75932					1534
			Normal	90.20078					
	75.3432	50.75562	Prob	88.57708	88.34373	29.60492	13713	15575	289
			DoS	98.07574					251
			U2R	27.14286					51
			R2L	26.28399					1464
			Normal	70.39508					
	87.2823	60.16147	Prob	80.23715	80.9983	10.32599	4783	14280	500
			DoS	92.11132					1029
			U2R	12.85714					61
			R2L	11.37966					1760
			Normal	89.67401					
80	82.025	55.22777	Prob	79.92095	79.50085	17.01425	7881	14016	508
			DoS	89.48175					1372
			U2R	30					49
			R2L	15.15609					1685
			Normal	82.98575					
	82.5098	39.10612	Prob	88.14229	88.44583	19.74957	9148	15593	300
			DoS	94.60288					704
			U2R	37.14286					44
			R2L	50.20141					989
			Normal	80.25043					
	87.5668	55.99034	Prob	85.65217	80.18151	9.622193	4457	14136	363
			DoS	88.64612					1481
			U2R	17.14286					58
			R2L	19.83887					1592

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			Normal	90.37781					
90	86.9789	58.51425	Prob	85.65217	81.384	10.89162	5045	14348	363
			DoS	90.99203					1175
			U2R	12.85714					61
			R2L	15.2568					1683
			Normal	89.10838					
	81.2869	51.20088	Prob	84.66403	85.54736	20.33463	9419	15082	388
			DoS	94.0509					776
			U2R	17.14286					58
			R2L	33.23263					1326
			Normal	79.66537					
	86.3487	64.05123	Prob	68.22134	75.42258	9.49266	4397	13297	804
			DoS	87.4425					1638
			U2R	10					63
			R2L	7.95569					1828
			Normal	90.50734					
100	66.5489	39.28799	Prob	93.75494	92.07601	43.1671	19995	16233	158
			DoS	98.42073					206
			U2R	40					42
			R2L	50.1007					991
			Normal	56.8329					
	71.8327	56.45257	Prob	89.28854	78.92796	30.86788	14298	13915	271
			DoS	85.19626					1931
			U2R	14.28571					60
			R2L	26.83787					1453
			Normal	69.13212					
	87.5966	47.26936	Prob	86.95652	86.57402	12.01425	5565	15263	330
			DoS	96.25115					489
			U2R	38.57143					43
			R2L	24.21954					1505
			Normal	87.98575					

Table (A.20) 3-layer, Max Input 1200 with redundant records, different hidden neurons

Hidden	Rate%%	Cost%	Attack category	TPR Each%	TPR%	FPR%	FP	TP	FN
40	92.084	60.46491	Prob	90.13442	93.85592	15.23938	9234	235049	411
			DoS	99.64183					829
			U2R	14.28571					60
			R2L	4.46253					14087
			Normal	84.76062					
	58.0962	69.48693	Prob	86.67787	49.99002	8.40031	5090	125193	555
			DoS	52.43957					110081
			U2R	15.71429					59
			R2L	1.336046					14548
			Normal	91.59969					
	75.7061	48.16717	Prob	87.61402	75.07786	21.69723	13147	188022	516
			DoS	75.97892					55598
			U2R	7.142857					65
			R2L	57.71448					6235
			Normal	78.30277					
50	91.1487	64.20634	Prob	77.5084	92.97825	16.41279	9945	232851	937
			DoS	99.06548					2163
			U2R	8.571429					64
			R2L	2.197355					14421
			Normal	83.58721					
	91.9474	59.66611	Prob	85.74172	94.19213	17.33038	10501	235891	594
			DoS	99.70793					676
			U2R	11.42857					62

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			R2L	10.38996					13213
			Normal	82.66962					
	82.3393	65.16882	Prob	85.21363	79.69581	6.735101	4081	199587	616
			DoS	84.53782					35788
			U2R	8.571429					64
			R2L	2.468633					14381
			Normal	93.2649					
60	91.9577	57.14988	Prob	87.13394	94.01883	16.56132	10035	235457	536
			DoS	99.90927					210
			U2R	28.57143					50
			R2L	3.811462					14183
			Normal	83.43868					
	72.4775	59.7396	Prob	89.72636	72.32107	26.87604	16285	181118	428
			DoS	76.30339					54847
			U2R	35.71429					45
			R2L	5.066124					13998
			Normal	73.12396					
	91.4355	58.40123	Prob	85.47768	93.88107	18.67212	11314	235112	605
			DoS	99.67035					763
			U2R	22.85714					54
			R2L	5.717192					13902
			Normal	81.32788					
70	50.9666	71.50589	Prob	84.85358	41.02565	7.946462	4815	102743	631
			DoS	42.65754					132722
			U2R	12.85714					61
			R2L	3.160393					14279
			Normal	92.05354					
	90.5642	61.77205	Prob	86.8699	93.98409	23.57038	14282	235370	547
			DoS	99.89156					251
			U2R	14.28571					60
			R2L	3.641913					14208
			Normal	76.42962					
	75.4904	67.12104	Prob	81.75708	71.57757	8.337597	5052	179256	760
			DoS	75.86918					55852
			U2R	10					63
			R2L	1.62767					14505
			Normal	91.6624					
80	90.4662	61.19582	Prob	81.54105	91.46768	13.6732	8285	229068	769
			DoS	97.35931					6112
			U2R	18.57143					57
			R2L	2.136317					14430
			Normal	86.3268					
	67.5474	43.6387	Prob	86.48584	66.65575	28.76735	17431	166930	563
			DoS	66.6838					77112
			U2R	28.57143					50
			R2L	60.79349					5781
			Normal	71.23265					
	41.2318	74.00386	Prob	84.9736	28.9016	7.806182	4730	72380	626
			DoS	29.56169					163033
			U2R	12.85714					61
			R2L	2.773822					14336
			Normal	92.19382					
90	75.3795	66.3079	Prob	85.04561	71.54562	8.774941	5317	179176	623
			DoS	75.74215					56146
			U2R	11.42857					62
			R2L	2.143099					14429
			Normal	91.22506					
	91.8879	60.87175	Prob	84.42151	93.87229	16.31377	9885	235090	649
			DoS	99.65825					791
			U2R	12.85714					61

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			R2L	6.103764					13845
			Normal	83.68623					
	82.3827	67.83615	Prob	69.58713	79.97293	7.65765	4640	200281	1267
			DoS	85.20836					34236
			U2R	5.714286					66
			R2L	1.078332					14586
			Normal	92.34235					
100	87.6986	51.68316	Prob	91.43063	95.11412	42.95051	26025	238200	357
			DoS	99.911					206
			U2R	32.85714					47
			R2L	21.15293					11626
			Normal	57.04949					
	87.8754	63.52893	Prob	87.34998	90.96296	24.88571	15079	227804	527
			DoS	96.6002					7869
			U2R	10					63
			R2L	3.879281					14173
			Normal	75.11429					
	75.5695	60.73458	Prob	85.83773	71.99724	9.666133	5857	180307	590
			DoS	76.13273					55242
			U2R	30					49
			R2L	3.370634					14248
			Normal	90.33387					

Three layer network with 2000 as Max Input with different hidden neurons for both distinct and redundant processed data records:

Table (A.21) 3-layer, Max Input 2000 with distinct records, different hidden neurons

Hidden	Rate%%	Cost%	Attack category	TPR Each%	TPR%	FPR%	FP	TP	FN
40	83.63096	43.18636	Prob	88.4585	86.0295	17.28195	8005	15167	292
			DoS	94.31156					742
			U2R	48.57143					36
			R2L	29.85901					1393
			Normal	82.71805					
	86.11572	55.30509	Prob	74.18972	75.74589	9.937392	4603	13354	653
			DoS	85.95523					1832
			U2R	35.71429					45
			R2L	12.08459					1746
			Normal	90.06261					
	85.36826	46.41552	Prob	94.90119	89.5122	16.20898	7508	15781	129
			DoS	97.97608					264
			U2R	32.85714					47
			R2L	29.05337					1409
			Normal	83.79102					
50	87.13683	47.42961	Prob	89.09091	84.56041	11.88256	5504	14908	276
			DoS	92.85495					932
			U2R	37.14286					44
			R2L	25.98187					1470
			Normal	88.11744					
	83.26349	55.36829	Prob	86.24506	85.47362	17.57772	8142	15069	348
			DoS	96.68813					432
			U2R	25.71429					52
			R2L	12.94058					1729
			Normal	82.42228					
	74.57858	45.14349	Prob	92.80632	88.91095	30.87651	14302	15675	182
			DoS	97.4471					333
			U2R	42.85714					40
			R2L	29.50655					1400

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			Normal	69.12349					
60	81.13526	40.87045	Prob	99.72332	91.40669	22.77418	10549	16115	7
			DoS	98.16007					240
			U2R	41.42857					41
			R2L	38.21752					1227
			Normal	77.22582					
	85.45895	58.7639	Prob	78.65613	79.27964	12.18912	5646	13977	540
			DoS	89.82674					1327
			U2R	18.57143					57
			R2L	12.94058					1729
			Normal	87.81088					
	88.08288	48.28331	Prob	92.64822	87.34543	11.63644	5390	15399	186
			DoS	96.5578					449
			U2R	35.71429					45
			R2L	21.90332					1551
			Normal	88.36356					
70	68.48475	49.80884	Prob	82.7668	85.71753	38.07427	17636	15112	436
			DoS	95.27752					616
			U2R	34.28571					46
			R2L	28.4995					1420
			Normal	61.92573					
	86.45348	49.321	Prob	96.20553	90.19285	14.96978	6934	15901	96
			DoS	98.77338					160
			U2R	21.42857					55
			R2L	28.6002					1418
			Normal	85.03022					
	87.7717	52.23775	Prob	88.33992	84.56608	11.0082	5099	14909	295
			DoS	93.69059					823
			U2R	24.28571					53
			R2L	21.95368					1550
			Normal	88.9918					
80	78.10633	41.62375	Prob	90.51383	90.31197	26.53929	12293	15922	240
			DoS	98.63539					178
			U2R	44.28571					39
			R2L	37.00906					1251
			Normal	73.46071					
	70.05629	33.37339	Prob	94.4664	93.72093	38.95078	18042	16523	140
			DoS	99.0417					125
			U2R	47.14286					37
			R2L	59.46626					805
			Normal	61.04922					
	80.77248	48.94315	Prob	87.11462	85.54169	21.04275	9747	15081	326
			DoS	94.93254					661
			U2R	37.14286					44
			R2L	23.56495					1518
			Normal	78.95725					
90	87.7717	36.80899	Prob	88.81423	90.2439	13.16926	6100	15910	283
			DoS	96.01349					520
			U2R	34.28571					46
			R2L	56.143					871
			Normal	86.83074					
	84.04222	47.79331	Prob	85.25692	86.52864	16.90415	7830	15255	373
			DoS	94.65655					697
			U2R	22.85714					54
			R2L	37.00906					1251
			Normal	83.09585					
	78.64738	50.12991	Prob	88.41897	87.30573	24.6481	11417	15392	293
			DoS	96.6728					434
			U2R	28.57143					50
			R2L	26.43505					1461
			Normal	75.3519					

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100	70.63643	57.12681	Prob	63.67589	76.05786	31.42703	14557	13409	919
			DoS	88.63079					1483
			U2R	40					42
			R2L	10.52367					1777
			Normal	68.57297					
	86.37217	49.37458	Prob	85.29644	82.39932	12.11572	5612	14527	372
			DoS	90.70071					1213
			U2R	32.85714					47
			R2L	25.93152					1471
			Normal	87.88428					
	79.44957	50.6747	Prob	83.20158	85.0709	22.68998	10510	14998	425
			DoS	94.94787					659
			U2R	31.42857					48
			R2L	24.4713					1500
			Normal	77.31002					

Table (A.22) 3-layer, Max Input 2000 with redundant records, different hidden neurons

Hidden	Rate%%	Cost%	Attack category	TPR Each%	TPR%	FPR%	FP	TP	FN
40	55.8427	61.25284	Prob	86.67787	48.54733	14.00492	8486	121580	555
			DoS	50.64613					114232
			U2R	44.28571					39
			R2L	4.849101					14030
			Normal	85.99508					
	57.784	67.06808	Prob	77.96447	49.51325	8.032281	4867	123999	918
			DoS	52.05418					110973
			U2R	27.14286					51
			R2L	1.69549					14495
			Normal	91.96772					
	92.6762	57.59494	Prob	90.73452	94.06635	13.06917	7919	235576	386
			DoS	99.88248					272
			U2R	24.28571					53
			R2L	4.042048					14149
			Normal	86.93083					
50	41.0515	68.97613	Prob	87.08593	29.11882	9.629825	5835	72924	538
			DoS	29.70081					162711
			U2R	30					49
			R2L	3.601221					14214
			Normal	90.37017					
	92.2535	60.93422	Prob	85.40566	93.78125	14.06103	8520	234862	608
			DoS	99.81292					433
			U2R	17.14286					58
			R2L	1.831129					14475
			Normal	85.93897					
	90.397	56.4126	Prob	89.3903	94.02482	24.5969	14904	235472	442
			DoS	99.8557					334
			U2R	32.85714					47
			R2L	4.096304					14141
			Normal	75.4031					
60	72.7575	59.64527	Prob	95.31925	70.56134	18.16546	11007	176711	195
			DoS	74.24078					59621
			U2R	31.42857					48
			R2L	5.995253					13861
			Normal	81.83454					
	92.6058	61.46267	Prob	80.77292	93.20785	9.88233	5988	233426	801
			DoS	99.27632					1675
			U2R	15.71429					59
			R2L	1.831129					14475
			Normal	90.11767					

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	51.1193	66.51298	Prob	89.27028	41.57988	9.453237	5728	104131	447
			DoS	43.17988					131513
			U2R	30					49
			R2L	3.0451					14296
			Normal	90.54676					
70	89.0242	60.32731	Prob	83.26932	93.79243	30.68341	18592	234890	697
			DoS	99.72694					632
			U2R	22.85714					54
			R2L	3.947101					14163
			Normal	69.31659					
	92.9643	59.4297	Prob	93.30293	94.17496	12.03934	7295	235848	279
			DoS	99.92698					169
			U2R	15.71429					59
			R2L	4.503221					14081
			Normal	87.96066					
	75.5949	65.00924	Prob	86.77388	71.83791	8.877263	5379	179908	551
			DoS	75.96855					55622
			U2R	14.28571					60
			R2L	3.051882					14295
			Normal	91.12274					
80	91.1378	53.5053	Prob	88.04609	94.12704	21.21697	12856	235728	498
			DoS	99.92266					179
			U2R	41.42857					41
			R2L	5.12038					13990
			Normal	78.78303					
	71.9817	58.02517	Prob	90.49448	72.80064	31.40297	19028	182319	396
			DoS	76.31289					54825
			U2R	32.85714					47
			R2L	12.8586					12849
			Normal	68.59703					
	49.5291	67.06768	Prob	85.86174	41.49403	17.26107	10459	103916	589
			DoS	43.13322					131621
			U2R	31.42857					48
			R2L	3.275687					14262
			Normal	82.73893					
90	76.18	55.87979	Prob	86.96591	72.98392	10.61014	6429	182778	543
			DoS	76.12884					55251
			U2R	25.71429					52
			R2L	19.89149					11812
			Normal	89.38986					
	92.3242	60.05605	Prob	84.80557	93.77725	13.68145	8290	234852	633
			DoS	99.51697					1118
			U2R	14.28571					60
			R2L	6.592065					13773
			Normal	86.31855					
	73.6504	64.57179	Prob	86.79789	72.06552	19.79932	11997	180478	550
			DoS	76.1742					55146
			U2R	18.57143					57
			R2L	3.662258					14205
			Normal	80.20068					
100	71.6342	63.95322	Prob	66.80269	70.91073	25.37587	15376	177586	1383
			DoS	75.4233					56884
			U2R	32.85714					47
			R2L	1.41743					14536
			Normal	74.62413					
	60.0819	66.09795	Prob	84.75756	52.77875	9.733798	5898	132177	635
			DoS	55.34553					103355
			U2R	24.28571					53
			R2L	3.587657					14216
			Normal	90.2662					

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	73.6806	64.49186	Prob	83.53337	71.74208	18.3074	11093	179668	686
			DoS	75.89985					55781
			U2R	20					56
			R2L	3.39098					14245
			Normal	81.6926					

Four layer network with 100 as Max Input with different hidden neurons for both distinct and redundant processed data records:

Table (A.23) 4-layer, Max Input 100 with distinct records, different hidden neurons

Hidden	Rate%	Cost%	Attack category	TPR Each%	TPR%	FPR%	FP	TP	FN
40	85.14621	61.64363	Prob	55.17787	69.16619	8.771589	4063	12194	1134
			DoS	81.95339					2354
			U2R	31.42857					48
			R2L	4.330312					1900
			Normal	91.22841					
	84.7975	46.47904	Prob	82.01581	84.827	15.21373	7047	14955	455
			DoS	95.55351					580
			U2R	51.42857					34
			R2L	19.13394					1606
			Normal	84.78627					
	82.59265	64.30323	Prob	21.77866	66.08054	11.12263	5152	11650	1979
			DoS	83.84698					2107
			U2R	28.57143					50
			R2L	7.15005					1844
			Normal	88.87737					
50	71.13683	74.59629	Prob	7.509881	18.08281	8.670121	4016	3188	2340
			DoS	22.31677					10133
			U2R	41.42857					41
			R2L	2.920443					1928
			Normal	91.32988					
	86.73808	51.40921	Prob	64.03162	80.26092	10.79663	5001	14150	910
			DoS	93.31493					872
			U2R	42.85714					40
			R2L	16.51561					1658
			Normal	89.20337					
	83.87177	61.75255	Prob	59.56522	71.04368	11.24568	5209	12525	1023
			DoS	83.40233					2165
			U2R	27.14286					51
			R2L	6.042296					1866
			Normal	88.75432					
60	66.28929	39.26652	Prob	88.69565	90.09643	42.77202	19812	15884	286
			DoS	97.89942					274
			U2R	52.85714					33
			R2L	41.94361					1153
			Normal	57.22798					
	73.07897	51.15706	Prob	66.99605	78.63868	29.03713	13450	13864	835
			DoS	90.41705					1250
			U2R	50					35
			R2L	17.11984					1646
			Normal	70.96287					
	68.46912	49.97197	Prob	70.59289	82.68293	36.94085	17111	14577	744
			DoS	95.0322					648
			U2R	51.42857					34
			R2L	18.07654					1627
			Normal	63.05915					

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64	84.43315	53.85373	Prob	73.83399	84.4186	15.56131	7208	14883	662
			DoS	97.14045					373
			U2R	30					49
			R2L	16.26385					1663
			Normal	84.43869					
	85.46521	51.99311	Prob	66.28458	80.3063	12.57124	5823	14158	853
			DoS	93.36093					866
			U2R	44.28571					39
			R2L	13.69587					1714
			Normal	87.42876					
	75.31196	41.36222	Prob	91.02767	90.2042	30.35622	14061	15903	227
			DoS	98.62006					180
			U2R	48.57143					36
			R2L	35.34743					1284
			Normal	69.64378					
70	75.16966	52.55807	Prob	66.99605	78.6557	26.15717	12116	13867	835
			DoS	89.68108					1346
			U2R	37.14286					44
			R2L	22.55791					1538
			Normal	73.84283					
	86.64425	53.81763	Prob	78.10277	79.37039	10.58722	4904	13993	554
			DoS	90.23306					1274
			U2R	38.57143					43
			R2L	11.07754					1766
			Normal	89.41278					
	87.81548	53.00562	Prob	72.80632	80.40272	9.363126	4337	14175	688
			DoS	92.82429					936
			U2R	42.85714					40
			R2L	9.818731					1791
			Normal	90.63687					
80	79.70289	57.32972	Prob	47.47036	70.46512	16.78109	7773	12423	1329
			DoS	84.38362					2037
			U2R	44.28571					39
			R2L	9.264854					1802
			Normal	83.21891					
	68.96794	77.12561	Prob	22.49012	20.76574	12.68566	5876	3661	1961
			DoS	22.00245					10174
			U2R	18.57143					57
			R2L	10.52367					1777
			Normal	87.31434					
	80.55512	54.50929	Prob	62.7668	78.71242	18.74352	8682	13877	942
			DoS	92.00399					1043
			U2R	40					42
			R2L	13.09164					1726
			Normal	81.25648					
90	84.19077	53.40793	Prob	64.90119	81.26489	14.6956	6807	14327	888
			DoS	94.20423					756
			U2R	32.85714					47
			R2L	18.83182					1612
			Normal	85.3044					
	79.46364	52.25848	Prob	58.14229	73.25014	18.17142	8417	12914	1059
			DoS	85.31125					1916
			U2R	52.85714					33
			R2L	13.99799					1708
			Normal	81.82858					
	71.10086	43.53854	Prob	87.11462	88.16222	35.39292	16394	15543	326
			DoS	97.24011					360
			U2R	50					35
			R2L	31.21853					1366
			Normal	64.60708					

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100	73.66224	69.37412	Prob	32.7668	36.01248	12.00777	5562	6349	1701
			DoS	41.44434					7638
			U2R	38.57143					43
			R2L	4.380665					1899
			Normal	87.99223					
	76.57232	72.66204	Prob	29.96047	34.16336	7.286269	3375	6023	1772
			DoS	39.71941					7863
			U2R	28.57143					50
			R2L	3.222558					1922
			Normal	92.71373					
	75.94683	47.29567	Prob	84.18972	85.41123	27.65544	12810	15058	400
			DoS	96.06716					513
			U2R	52.85714					33
			R2L	18.12689					1626
			Normal	72.34456					

Table (A.24) 4-layer, Max Input 100 with redundant records, different hidden neurons

Hidden	Rate%	Cost%	Attack category	TPR Each%	TPR%	FPR%	FP	TP	FN
40	40.0715	74.34258	Prob	65.93855	27.19817	6.721899	4073	68114	1419
			DoS	28.19814					166189
			U2R	21.42857					55
			R2L	0.583249					14659
			Normal	93.2781					
	92.44797	52.94614	Prob	82.83725	93.59517	12.2935	7449	234396	715
			DoS	99.59517					937
			U2R	45.71429					38
			R2L	2.678874					14350
			Normal	87.7065					
	91.48536	67.09514	Prob	17.97888	91.49204	8.542241	5176	229129	3417
			DoS	98.60448					3230
			U2R	17.14286					58
			R2L	0.96982					14602
			Normal	91.45776					
50	56.84036	71.38343	Prob	4.776764	48.00149	6.627828	4016	120213	3967
			DoS	51.81569					111525
			U2R	37.14286					44
			R2L	0.393354					14687
			Normal	93.37217					
	92.93281	55.36398	Prob	71.41143	93.26774	8.451471	5121	233576	1191
			DoS	99.4742					1217
			U2R	40					42
			R2L	2.271957					14410
			Normal	91.54853					
	76.7295	65.15043	Prob	68.69899	73.21431	8.741934	5297	183355	1304
			DoS	77.92357					51097
			U2R	21.42857					55
			R2L	0.813835					14625
			Normal	91.25807					
60	87.48348	50.4068	Prob	88.1421	94.64933	42.13358	25530	237036	494
			DoS	99.88162					274
			U2R	47.14286					37
			R2L	14.58121					12595
			Normal	57.86642					
	90.01572	56.85203	Prob	73.66779	93.14476	22.91684	13886	233268	1097
			DoS	99.29317					1636
			U2R	38.57143					43
			R2L	2.394032					14392
			Normal	77.08316					

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	88.94701	57.16559	Prob	75.85214	93.44663	29.65029	17966	234024	1006
			DoS	99.57184					991
			U2R	38.57143					43
			R2L	2.529671					14372
			Normal	70.34971					
64	92.36759	59.40087	Prob	77.84446	93.58519	12.66483	7674	234371	923
			DoS	99.70577					681
			U2R	24.28571					53
			R2L	2.285521					14408
			Normal	87.33517					
	92.68621	56.60427	Prob	73.23572	93.26495	9.705742	5881	233569	1115
			DoS	99.4608					1248
			U2R	35.71429					45
			R2L	1.939641					14459
			Normal	90.29426					
	90.50796	53.57775	Prob	88.91023	94.16657	24.6134	14914	235827	462
			DoS	99.92223					180
			U2R	41.42857					41
			R2L	5.554425					13926
			Normal	75.3866					
70	90.4009	58.75245	Prob	73.64378	93.16432	21.02058	12737	233317	1098
			DoS	99.26984					1690
			U2R	30					49
			R2L	3.140047					14282
			Normal	78.97942					
	58.07626	66.44438	Prob	80.36486	49.91535	8.194016	4965	125006	818
			DoS	52.45296					110050
			U2R	28.57143					50
			R2L	1.580197					14512
			Normal	91.80598					
	93.11511	57.02409	Prob	77.22036	93.28651	7.593286	4601	233623	949
			DoS	99.44698					1280
			U2R	32.85714					47
			R2L	1.410648					14537
			Normal	92.40671					
80	91.36061	59.13649	Prob	56.8891	92.4292	13.05596	7911	231476	1796
			DoS	98.89482					2558
			U2R	34.28571					46
			R2L	1.254663					14560
			Normal	86.94404					
	74.16929	70.92602	Prob	39.34229	70.38724	10.1992	6180	176275	2527
			DoS	75.35763					57036
			U2R	11.42857					62
			R2L	1.41743					14536
			Normal	89.8008					
	91.61975	58.48168	Prob	70.97936	93.15314	14.71787	8918	233289	1209
			DoS	99.38779					1417
			U2R	31.42857					48
			R2L	1.844693					14473
			Normal	85.28213					
90	92.42836	58.52103	Prob	72.39558	93.35599	11.40561	6911	233797	1150
			DoS	99.53295					1081
			U2R	28.57143					50
			R2L	2.624619					14358
			Normal	88.59439					
	91.44935	56.35315	Prob	68.21892	92.7766	14.03627	8505	232346	1324
			DoS	99.01925					2270
			U2R	40					42
			R2L	1.97355					14454
			Normal	85.96373					

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	89.5058	54.63134	Prob	85.95775	93.86031	28.49174	17264	235060	585
			DoS	99.71312					664
			U2R	41.42857					41
			R2L	4.469312					14086
			Normal	71.50826					
100	79.27139	64.12264	Prob	47.81565	76.4914	9.238691	5598	191562	2174
			DoS	81.85695					41993
			U2R	30					49
			R2L	0.590031					14658
			Normal	90.76131					
	69.35591	68.95168	Prob	46.01536	63.37547	5.926427	3591	158715	2249
			DoS	67.71035					74736
			U2R	21.42857					55
			R2L	0.434045					14681
			Normal	94.07357					
	90.54911	55.33431	Prob	84.15747	93.64828	22.26	13488	234529	660
			DoS	99.63967					834
			U2R	40					42
			R2L	2.536453					14371
			Normal	77.74					

Four layer network with 256 as Max Input with different hidden neurons for both distinct and redundant processed data records:

Table (A.25) 4-layer, Max Input 256 with distinct records, different hidden neurons

Hidden	Rate%	Cost%	Attack category	TPR Each%	TPR%	FPR%	FP	TP	FN
40	87.06333	56.04911	Prob	75.96838	79.17754	9.935233	4602	13959	608
			DoS	90.00307					1304
			U2R	27.14286					51
			R2L	13.99799					1708
			Normal	90.06477					
	86.77404	53.41628	Prob	74.07115	80.24957	10.74266	4976	14148	656
			DoS	91.84299					1064
			U2R	37.14286					44
			R2L	13.49446					1718
			Normal	89.25734					
	82.90852	58.56363	Prob	73.71542	78.88826	15.56131	7208	13908	665
			DoS	90.19473					1279
			U2R	21.42857					55
			R2L	13.2427					1723
			Normal	84.43869					
50	85.92807	57.12215	Prob	83.083	81.19115	12.269	5683	14314	428
			DoS	90.62404					1223
			U2R	14.28571					60
			R2L	19.18429					1605
			Normal	87.731					
	82.87256	54.66379	Prob	77.66798	81.87748	16.7487	7758	14435	565
			DoS	93.76725					813
			U2R	35.71429					45
			R2L	10.77543					1772
			Normal	83.2513					
	85.97498	60.40403	Prob	37.62846	72.90414	9.050086	4192	12853	1578
			DoS	89.13677					1417
			U2R	25.71429					52
			R2L	12.89023					1730

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			Normal	90.94991					
60	85.6982	67.44626	Prob	40.71146	69.31934	8.067789	3737	12221	1500
			DoS	85.42625					1901
			U2R	15.71429					59
			R2L	1.863041					1949
			Normal	91.93221					
	68.48475	79.71355	Prob	4.347826	18.40045	12.4525	5768	3244	2420
			DoS	23.45906					9984
			U2R	24.28571					53
			R2L	2.870091					1929
			Normal	87.5475					
	87.32604	59.91815	Prob	61.06719	73.74929	7.506477	3477	13002	985
			DoS	86.09322					1814
			U2R	24.28571					53
			R2L	10.57402					1776
			Normal	92.49352					
64	86.36747	57.55219	Prob	71.46245	78.46285	10.62392	4921	13833	722
			DoS	90.20239					1278
			U2R	25.71429					52
			R2L	12.13494					1745
			Normal	89.37608					
	86.1767	56.70822	Prob	66.83794	77.94668	24.99784	11579	13742	839
			DoS	89.75774					1336
			U2R	30					49
			R2L	16.21349					1664
			Normal	75.00216					
	75.81392	57.19466	Prob	77.54941	78.66137	10.96287	5078	13868	568
			DoS	89.12144					1419
			U2R	24.28571					53
			R2L	13.29305					1722
			Normal	89.03713					
70	76.67084	55.21237	Prob	87.82609	83.06863	25.76425	11934	14645	308
			DoS	92.66329					957
			U2R	27.14286					51
			R2L	15.96173					1669
			Normal	74.23575					
	78.32525	51.2715	Prob	79.56522	82.74532	23.35708	10819	14588	517
			DoS	92.23398					1013
			U2R	30					49
			R2L	26.33434					1463
			Normal	76.64292					
	73.31196	56.32948	Prob	77.50988	79.84118	29.17314	13513	14076	569
			DoS	89.71174					1342
			U2R	24.28571					53
			R2L	19.93958					1590
			Normal	70.82686					
80	77.74042	61.73655	Prob	50.35573	73.83437	20.77288	9622	13017	1256
			DoS	88.97577					1438
			U2R	30					49
			R2L	5.840886					1870
			Normal	79.22712					
	82.96951	60.66965	Prob	61.42292	76.98809	14.75389	6834	13573	976
			DoS	89.80374					1330
			U2R	15.71429					59
			R2L	14.80363					1692
			Normal	85.24611					
	88.69586	61.50002	Prob	54.90119	71.85479	4.894214	2267	12668	1141
			DoS	84.34529					2042
			U2R	17.14286					58
			R2L	13.3434					1721

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			Normal	95.10579					
90	85.79359	58.50161	Prob	60.07905	75.38854	10.24611	4746	13291	1010
			DoS	88.2398					1534
			U2R	27.14286					51
			R2L	12.1853					1744
			Normal	89.75389					
	74.97107	55.90555	Prob	70.79051	82.06466	27.72884	12844	14468	739
			DoS	93.62925					831
			U2R	21.42857					55
			R2L	22.60826					1537
			Normal	72.27116					
	73.86865	55.09209	Prob	74.07115	83.40896	29.76252	13786	14705	656
			DoS	95.59951					574
			U2R	30					49
			R2L	17.11984					1646
			Normal	70.23748					
100	79.78108	63.02025	Prob	73.51779	78.01475	19.54663	9054	13754	670
			DoS	89.79607					1331
			U2R	12.85714					61
			R2L	8.660624					1814
			Normal	80.45337					
	85.83894	58.9849	Prob	64.18972	78.93931	11.53497	5343	13917	906
			DoS	92.06532					1035
			U2R	20					56
			R2L	13.59517					1716
			Normal	88.46503					
	75.06646	39.54067	Prob	78.81423	88.38344	30.00216	13897	15582	536
			DoS	95.86017					540
			U2R	37.14286					44
			R2L	53.27291					928
			Normal	69.99784					

Table (A.26) 4-layer, Max Input 256 with redundant records, different hidden neurons

Hidden	Rate%%	Cost%	Attack category	TPR Each%	TPR%	FPR%	FP	TP	FN
40	93.01512	59.8005	Prob	79.16467	93.18628	7.692308	4661	233372	868
			DoS	99.27113					1687
			U2R	21.42857					55
			R2L	1.97355					14454
			Normal	92.30769					
	75.27401	62.74646	Prob	77.98848	71.40347	8.728731	5289	178820	917
			DoS	75.7253					56185
			U2R	27.14286					51
			R2L	1.912513					14463
			Normal	91.27127					
	92.09334	61.55577	Prob	77.77244	93.1791	12.39417	7510	233354	926
			DoS	99.29619					1629
			U2R	17.14286					58
			R2L	1.871821					14469
			Normal	87.60583					
50	92.72415	63.61882	Prob	83.48536	93.32404	9.755252	5911	233717	688
			DoS	99.30224					1615
			U2R	5.714286					66
			R2L	2.678874					14350
			Normal	90.24475					
	92.06987	58.78084	Prob	80.17283	93.38354	13.35963	8095	233866	826
			DoS	99.49191					1176
			U2R	27.14286					51
			R2L	1.546287					14517

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			Normal	86.64037					
	74.84865	69.42288	Prob	29.16467	70.45912	7.00906	4247	176455	2951
			DoS	75.5905					56497
			U2R	18.57143					57
			R2L	1.824347					14476
			Normal	92.99094					
60	74.97372	69.79228	Prob	52.73644	70.414	6.180582	3745	176342	1969
			DoS	75.21981					57355
			U2R	11.42857					62
			R2L	0.250933					14708
			Normal	93.81942					
	73.27034	72.3632	Prob	2.712434	69.16857	9.776707	5924	173223	4053
			DoS	74.7614					58416
			U2R	20					56
			R2L	0.386572					14688
			Normal	90.22329					
	58.09587	70.40206	Prob	69.85118	49.37309	5.852161	3546	123648	1256
			DoS	52.06368					110951
			U2R	17.14286					58
			R2L	1.505595					14523
			Normal	94.14784					
64	92.8714	61.74462	Prob	76.40422	93.13637	8.223722	4983	233247	983
			DoS	99.28409					1657
			U2R	15.71429					59
			R2L	1.7294					14490
			Normal	91.77628					
	90.60345	61.29811	Prob	73.54777	93.11601	19.78116	11986	233196	1102
			DoS	99.27675					1674
			U2R	21.42857					55
			R2L	2.278739					14409
			Normal	80.21884					
	75.21614	64.91999	Prob	80.07681	71.29406	8.573598	5195	178546	830
			DoS	75.57409					56535
			U2R	18.57143					57
			R2L	1.878603					14468
			Normal	91.4264					
70	90.75745	60.45374	Prob	87.71003	93.50453	20.59644	12480	234169	512
			DoS	99.44438					1286
			U2R	20					56
			R2L	2.251611					14413
			Normal	79.40356					
	91.05485	59.92395	Prob	81.34902	93.44982	18.84376	11418	234032	777
			DoS	99.39988					1389
			U2R	21.42857					55
			R2L	3.811462					14183
			Normal	81.15624					
	90.04916	61.21546	Prob	80.10082	93.24179	23.14624	14025	233511	829
			DoS	99.26292					1706
			U2R	20					56
			R2L	2.787386					14334
			Normal	76.85376					
80	90.96997	61.3497	Prob	63.01008	92.79457	16.57122	10041	232391	1541
			DoS	99.21237					1823
			U2R	25.71429					52
			R2L	0.786707					14629
			Normal	83.42878					
	49.57769	74.14374	Prob	66.15458	38.3028	3.822224	2316	95924	1410
			DoS	40.12961					138573
			U2R	11.42857					62
			R2L	1.885385					14467

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			Normal	96.17778					
	92.11938	63.65537	Prob	70.28325	93.03215	11.65316	7061	232986	1238
			DoS	99.2599					1713
			U2R	11.42857					62
			R2L	2.088844					14437
			Normal	88.34684					
90	71.29882	66.44594	Prob	69.41911	66.27162	7.923357	4801	165968	1274
			DoS	70.34067					68648
			U2R	20					56
			R2L	1.7294					14490
			Normal	92.07664					
	90.4099	62.48412	Prob	75.97216	93.41349	22.00419	13333	233941	1001
			DoS	99.50185					1153
			U2R	15.71429					59
			R2L	3.140047					14282
			Normal	77.99581					
	88.94765	61.69001	Prob	77.98848	93.50972	29.90775	18122	234182	917
			DoS	99.61159					899
			U2R	21.42857					55
			R2L	2.45507					14383
			Normal	70.09225					
100	91.37605	64.44729	Prob	77.62842	93.1216	15.83846	9597	233210	932
			DoS	99.27848					1670
			U2R	8.571429					64
			R2L	1.254663					14560
			Normal	84.16154					
	75.19106	66.80346	Prob	71.98752	71.34198	8.900368	5393	178666	1167
			DoS	75.77024					56081
			U2R	14.28571					60
			R2L	1.919295					14462
			Normal	91.09963					
	89.77394	36.08602	Prob	80.86894	97.81381	43.45551	26331	244961	797
			DoS	99.62973					857
			U2R	22.85714					54
			R2L	74.45236					3767
			Normal	56.54449					

Four layer network with 512 as Max Input with different hidden neurons for both distinct and redundant processed data records:

Table (A.27) 4-layer, Max Input 512 with distinct records, different hidden neurons

Hidden	Rate%	Cost%	Attack category	TPR Each%	TPR%	FPR%	FP	TP	FN
40	79.65285	52.52948	Prob	74.66403	83.17073	21.6861	10045	14663	641
			DoS	95.66851					565
			U2R	41.42857					41
			R2L	13.39376					1720
			Normal	78.3139					
	87.84363	58.33946	Prob	68.81423	78.23596	8.499568	3937	13793	789
			DoS	90.59338					1227
			U2R	24.28571					53
			R2L	10.97684					1768
			Normal	91.50043					
	87.71384	53.18279	Prob	89.24901	84.36756	11.01252	5101	14874	272
			DoS	93.50659					847
			U2R	22.85714					54
			R2L	20.29204					1583

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			Normal	88.98748					
50	87.43706	60.96185	Prob	76.20553	77.8616	8.918394	4131	13727	602
			DoS	88.79178					1462
			U2R	14.28571					60
			R2L	10.42296					1779
			Normal	91.08161					
	82.36904	50.34273	Prob	86.95652	86.71015	19.28325	8932	15287	330
			DoS	96.19749					496
			U2R	27.14286					51
			R2L	26.18328					1466
			Normal	80.71675					
	86.70055	46.35711	Prob	88.33992	86.90868	13.37867	6197	15322	295
			DoS	96.54247					451
			U2R	42.85714					40
			R2L	23.36354					1522
			Normal	86.62133					
60	86.89601	56.23919	Prob	84.78261	82.43902	11.4076	5284	14534	385
			DoS	92.30297					1004
			U2R	18.57143					57
			R2L	16.91843					1650
			Normal	88.5924					
	85.87803	58.14695	Prob	65.41502	74.08962	9.635147	4463	13062	875
			DoS	85.30359					1917
			U2R	27.14286					51
			R2L	13.14199					1725
			Normal	90.36485					
	73.11024	29.54282	Prob	94.3083	95.19569	35.29577	16349	16783	144
			DoS	99.977					3
			U2R	50					35
			R2L	66.51561					665
			Normal	64.70423					
	84.26583	50.00425	Prob	81.46245	80.89053	14.44948	6693	14261	469
			DoS	89.83441					1326
			U2R	37.14286					44
			R2L	22.96073					1530
			Normal	85.55052					
	83.6466	61.76724	Prob	72.17391	72.56381	12.13515	5621	12793	704
			DoS	82.29071					2310
			U2R	17.14286					58
			R2L	11.1279					1765
			Normal	87.86485					
64	77.46833	45.75525	Prob	83.55731	85.13897	25.45121	11789	15010	416
			DoS	94.32689					740
			U2R	45.71429					38
			R2L	28.19738					1426
			Normal	74.54879					
	84.55199	64.93288	Prob	68.65613	66.19966	8.462867	3920	11671	793
			DoS	74.65501					3306
			U2R	12.85714					61
			R2L	9.415911					1799
			Normal	91.53713					
	87.40266	57.25829	Prob	80.47431	81.57119	10.37781	4807	14381	494
			DoS	92.26464					1009
			U2R	18.57143					57
			R2L	14.95468					1689
			Normal	89.62219					
70	84.32369	51.36499	Prob	74.26877	83.73795	15.45337	7158	14763	651
			DoS	94.94787					659
			U2R	30					49

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			R2L	24.06848					1508
			Normal	84.54663					
	81.79515	44.07339	Prob	85.96838	86.13159	19.85535	9197	15185	355
			DoS	94.84054					673
			U2R	45.71429					38
			R2L	30.56395					1379
			Normal	80.14465					
	87.52306	56.4537	Prob	78.69565	81.30459	10.1101	4683	14334	539
			DoS	92.32597					1001
			U2R	22.85714					54
			R2L	14.3001					1702
			Normal	89.8899					
80	86.2674	60.45413	Prob	72.17391	73.06296	8.706822	4033	12881	704
			DoS	82.73536					2252
			U2R	18.57143					57
			R2L	12.58812					1736
			Normal	91.29318					
	76.97263	54.19128	Prob	79.09091	84.1747	25.76857	11936	14840	529
			DoS	95.1242					636
			U2R	25.71429					52
			R2L	20.79557					1573
			Normal	74.23143					
	87.22752	55.34528	Prob	88.93281	83.37493	11.30613	5237	14699	280
			DoS	92.40264					991
			U2R	17.14286					58
			R2L	19.33535					1602
			Normal	88.69387					
90	67.28225	38.83544	Prob	86.12648	89.54056	41.18955	19079	15786	351
			DoS	95.70684					560
			U2R	38.57143					43
			R2L	55.1863					890
			Normal	58.81045					
	78.0907	45.33425	Prob	95.5336	86.79524	25.22237	11683	15302	113
			DoS	93.87458					799
			U2R	40					42
			R2L	30.81571					1374
			Normal	74.77763					
	88.48006	55.15146	Prob	83.67589	82.21781	9.136442	4232	14495	413
			DoS	91.93499					1052
			U2R	20					56
			R2L	18.73112					1614
			Normal	90.86356					
	79.12901	49.81839	Prob	94.70356	89.71072	24.89853	11533	15816	134
			DoS	98.47439					199
			U2R	24.28571					53
			R2L	28.09668					1428
			Normal	75.10147					
	79.78421	47.48104	Prob	90.43478	86.56268	22.79577	10559	15261	242
			DoS	94.79454					679
			U2R	34.28571					46
			R2L	29.40584					1402
			Normal	77.20423					
	88.14699	44.55246	Prob	82.88538	82.69427	9.777634	4529	14579	433
			DoS	92.31064					1003
			U2R	57.14286					30
			R2L	20.19134					1585
			Normal	90.22237					
	84.10633	53.03893	Prob	70.67194	81.45774	14.88558	6895	14361	742
			DoS	93.16927					891
			U2R	31.42857					48

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			R2L	20.04028					1588
			Normal	85.11442					
95	82.85536	52.90493	Prob	71.93676	80.35167	16.19171	7500	14166	710
			DoS	91.728					1079
			U2R	35.71429					45
			R2L	17.92548					1630
			Normal	83.80829					
	87.54808	55.25985	Prob	84.42688	84.56041	11.31477	5241	14908	394
			DoS	95.86783					539
			U2R	25.71429					52
			R2L	12.53776					1737
			Normal	88.68523					
	86.81001	57.22922	Prob	72.64822	79.66534	10.47064	4850	14045	692
			DoS	91.95799					1049
			U2R	28.57143					50
			R2L	9.667674					1794
			Normal	89.52936					
	81.28225	50.31774	Prob	78.02372	82.62621	19.22927	8907	14567	556
			DoS	92.05765					1036
			U2R	30					49
			R2L	28.39879					1422
			Normal	80.77073					
100	84.4222	47.68299	Prob	90.27668	88.96767	17.30786	8017	15685	246
			DoS	98.15241					241
			U2R	30					49
			R2L	29.05337					1409
			Normal	82.69214					
	74.64894	18.46323	Prob	95.65217	98.6557	34.48834	15975	17393	110
			DoS	99.99233					1
			U2R	51.42857					34
			R2L	95.36757					92
			Normal	65.51166					
	79.48084	37.75828	Prob	87.19368	85.84799	22.94257	10627	15135	324
			DoS	91.22968					1144
			U2R	45.71429					38
			R2L	50.20141					989
			Normal	77.05743					
	86.89445	55.7112	Prob	71.62055	76.97674	9.330743	4322	13571	718
			DoS	87.38884					1645
			U2R	27.14286					51
			R2L	17.17019					1645
			Normal	90.66926					
	77.3761	40.70639	Prob	89.72332	90.72036	27.70294	12832	15994	260
			DoS	98.39773					209
			U2R	40					42
			R2L	43.35347					1125
			Normal	72.29706					
	75.7748	37.39143	Prob	97.2332	92.01361	30.40587	14084	16222	70
			DoS	97.40877					338
			U2R	40					42
			R2L	51.76234					958
			Normal	69.59413					
110	77.87177	59.21137	Prob	69.96047	74.22008	20.73834	9606	13085	760
			DoS	85.08893					1945
			U2R	30					49
			R2L	9.818731					1791
			Normal	79.26166					
	84.88194	58.78912	Prob	76.95652	80.99263	13.63774	6317	14279	583
			DoS	92.5713					969
			U2R	18.57143					57

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			R2L	12.286					1742
			Normal	86.36226					
	86.3018	54.88561	Prob	71.62055	82.0363	12.0747	5593	14463	718
			DoS	94.13523					765
			U2R	25.71429					52
			R2L	17.82477					1632
			Normal	87.9253					

Table (A.28) 4-layer, Max Input 512 with redundant records, different hidden neurons

Hidden	Rate%	Cost%	Attack category	TPR Each%	TPR%	FPR%	FP	TP	FN
40	91.3484	58.3934	Prob	78.34854	93.49095	17.50697	10608	234135	902
			DoS	99.61764					885
			U2R	30					49
			R2L	1.898949					14465
			Normal	82.49303					
	67.46381	68.08351	Prob	74.72396	61.18449	6.583269	3989	153228	1053
			DoS	64.75211					81583
			U2R	15.71429					59
			R2L	1.573415					14513
			Normal	93.41673					
	93.19099	59.96886	Prob	87.22996	93.68621	8.855808	5366	234624	532
			DoS	99.61375					894
			U2R	17.14286					58
			R2L	2.828077					14328
			Normal	91.14419					
50	58.12931	71.9818	Prob	79.21267	49.67856	6.943046	4207	124413	866
			DoS	52.23262					110560
			U2R	8.571429					64
			R2L	1.437776					14533
			Normal	93.05695					
	91.99528	61.16877	Prob	85.93375	93.85951	15.70974	9519	235058	586
			DoS	99.77447					522
			U2R	14.28571					60
			R2L	3.628349					14210
			Normal	84.29026					
	92.81225	56.94538	Prob	86.67787	93.76048	11.10689	6730	234810	555
			DoS	99.67423					754
			U2R	28.57143					50
			R2L	3.241777					14267
			Normal	88.89311					
60	92.91352	63.18038	Prob	84.51752	93.43625	9.246943	5603	233998	645
			DoS	99.42451					1332
			U2R	7.142857					65
			R2L	2.366904					14396
			Normal	90.75306					
	82.33895	63.79199	Prob	72.65963	79.88947	7.537174	4567	200072	1139
			DoS	85.00918					34697
			U2R	18.57143					57
			R2L	1.858257					14471
			Normal	92.46283					
	88.94798	35.46939	Prob	93.1349	97.62894	46.93116	28437	244498	286
			DoS	99.9987					3
			U2R	38.57143					43
			R2L	61.98033					5606
			Normal	53.06884					
	92.30843	57.85483	Prob	82.5012	93.21344	11.43201	6927	233440	729
			DoS	99.16096					1942
			U2R	27.14286					51
			R2L	3.194303					14274

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			Normal	88.56799					
	91.67666	64.0519	Prob	76.83629	91.97559	9.55886	5792	230340	965
			DoS	98.03115					4557
			U2R	8.571429					64
			R2L	1.593761					14510
			Normal	90.44114					
64	90.88895	56.28587	Prob	83.7494	93.61354	20.37199	12344	234442	677
			DoS	99.52475					1100
			U2R	34.28571					46
			R2L	3.892845					14171
			Normal	79.62801					
	56.22723	73.64223	Prob	74.62794	47.23921	6.624528	4014	118304	1057
			DoS	49.6818					116464
			U2R	5.714286					66
			R2L	1.356392					14545
			Normal	93.37547					
	93.03216	63.43664	Prob	81.9011	93.37595	8.388758	5083	233847	754
			DoS	99.42321					1335
			U2R	7.142857					65
			R2L	2.102408					14435
			Normal	91.61124					
70	75.45149	65.90083	Prob	80.79693	71.49132	8.180813	4957	179040	800
			DoS	75.76678					56089
			U2R	14.28571					60
			R2L	2.021024					14447
			Normal	91.81919					
	92.39621	59.36776	Prob	78.1325	93.5205	12.25059	7423	234209	911
			DoS	99.56363					1010
			U2R	22.85714					54
			R2L	3.343506					14252
			Normal	87.74941					
	91.83902	56.30787	Prob	85.95775	93.71576	15.91768	9645	234698	585
			DoS	99.57141					992
			U2R	31.42857					48
			R2L	4.286199					14113
			Normal	84.08232					
80	92.85597	62.79423	Prob	76.8603	92.76142	6.753255	4092	232308	964
			DoS	98.86803					2620
			U2R	11.42857					62
			R2L	1.783655					14482
			Normal	93.24674					
	89.51898	63.32668	Prob	81.06097	93.56363	27.19786	16480	234317	789
			DoS	99.58566					959
			U2R	12.85714					61
			R2L	2.950153					14310
			Normal	72.80214					
	92.97525	61.25611	Prob	87.15795	93.51132	9.240341	5599	234186	535
			DoS	99.43488					1308
			U2R	12.85714					61
			R2L	2.706002					14346
			Normal	90.75966					
90	87.82589	55.95069	Prob	85.30965	94.48322	39.6894	24049	236620	612
			DoS	99.62455					869
			U2R	24.28571					53
			R2L	16.70397					12282
			Normal	60.3106					
	91.12494	54.9728	Prob	92.15074	93.88946	20.30102	12301	235133	327
			DoS	99.64874					813
			U2R	35.71429					45
			R2L	4.252289					14118
			Normal	79.69898					

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	93.28776	61.80049	Prob	83.84542	93.39592	7.159243	4338	233897	673
			DoS	99.37569					1445
			U2R	11.42857					62
			R2L	2.617837					14359
			Normal	92.84076					
	91.3201	60.07898	Prob	92.55881	94.11387	20.22676	12256	235695	310
			DoS	99.91316					201
			U2R	17.14286					58
			R2L	3.886063					14172
			Normal	79.77324					
	91.33682	58.00382	Prob	88.04609	93.77206	18.72824	11348	234839	498
			DoS	99.61029					902
			U2R	25.71429					52
			R2L	4.069176					14145
			Normal	81.27176					
	82.75691	56.18176	Prob	83.41335	80.44131	7.672503	4649	201454	691
			DoS	85.34445					33921
			U2R	41.42857					41
			R2L	2.821295					14329
			Normal	92.3275					
	92.34541	60.53218	Prob	75.92415	93.36597	11.87266	7194	233822	1003
			DoS	99.47247					1221
			U2R	20					56
			R2L	2.787386					14334
			Normal	88.12734					
95	92.02968	59.91955	Prob	76.69227	93.2885	13.17314	7982	233628	971
			DoS	99.39211					1407
			U2R	22.85714					54
			R2L	2.502543					14376
			Normal	86.82686					
	93.07396	60.91719	Prob	85.52568	93.61434	9.159474	5550	234444	603
			DoS	99.63362					848
			U2R	15.71429					59
			R2L	1.783655					14482
			Normal	90.84053					
	92.9759	60.98884	Prob	77.14834	93.2362	8.099946	4908	233497	952
			DoS	99.39945					1390
			U2R	18.57143					57
			R2L	1.390302					14540
			Normal	91.90005					
	46.83936	70.47255	Prob	80.31685	37.63476	15.11726	9160	94251	820
			DoS	38.9229					141366
			U2R	20					56
			R2L	5.439132					13943
			Normal	84.88274					
100	91.22333	58.33498	Prob	89.91839	94.06675	20.52877	12439	235577	420
			DoS	99.89588					241
			U2R	24.28571					53
			R2L	4.069176					14145
			Normal	79.47123					
	90.34592	19.28785	Prob	93.56697	99.84068	48.89674	29628	250037	268
			DoS	99.99957					1
			U2R	48.57143					36
			R2L	99.3625					94
			Normal	51.10326					
	90.81854	48.76367	Prob	85.98176	94.83621	25.78681	15625	237504	584
			DoS	99.43618					1305
			U2R	34.28571					46
			R2L	25.41879					10997
			Normal	74.21319					

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	75.37657	64.95506	Prob	76.47624	71.18585	7.302824	4425	178275	980
			DoS	75.48811					56734
			U2R	18.57143					57
			R2L	2.407596					14390
			Normal	92.69718					
	89.68617	39.23525	Prob	87.518	97.16654	41.23084	24983	243340	520
			DoS	99.77879					512
			U2R	28.57143					50
			R2L	59.21329					6014
			Normal	58.76916					
	89.41224	36.04927	Prob	96.2554	97.49357	43.98858	26654	244159	156
			DoS	99.85397					338
			U2R	35.71429					45
			R2L	61.08511					5738
			Normal	56.01142					
110	90.50378	61.71001	Prob	75.46807	92.21398	16.56462	10037	230937	1022
			DoS	98.32192					3884
			U2R	20					56
			R2L	1.410648					14537
			Normal	83.43538					
	92.46533	62.44517	Prob	79.76476	93.32444	11.08544	6717	233718	843
			DoS	99.42667					1327
			U2R	12.85714					61
			R2L	1.749746					14487
			Normal	88.91456					
	92.86079	61.91442	Prob	76.47624	93.41029	9.410328	5702	233933	980
			DoS	99.53123					1085
			U2R	14.28571					60
			R2L	2.488979					14378
			Normal	90.58967					

Four layer network with 1024 as Max Input with different hidden neurons for both distinct and redundant processed data records:

Table (A.29) 4-layer, Max Input 1024 with distinct records, different hidden neurons

Hidden	Rate%	Cost%	Attack category	TPR Each%	TPR%	FPR%	FP	TP	FN
40	81.35731	51.27976	Prob	88.81423	85.66081	20.280656	9394	15102	283
			DoS	94.39589					731
			U2R	24.28571					53
			R2L	26.43505					1461
			Normal	79.71934					
	86.12666	47.91485	Prob	91.66008	86.1713	13.890328	6434	15192	211
			DoS	94.0739					773
			U2R	30					49
			R2L	29.25478					1405
			Normal	86.10967					
	87.84676	68.34433	Prob	63.63636	63.87975	3.0310881	1404	11262	920
			DoS	72.70009					3561
			U2R	2.857143					68
			R2L	8.408862					1819
			Normal	96.96891					
50	87.08522	61.22327	Prob	86.44269	80.21554	10.300086	4771	14142	343
			DoS	90.23306					1274
			U2R	11.42857					62
			R2L	8.912387					1809
			Normal	89.69991					

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	84.87412	56.11964	Prob	83.20158	79.07544	12.918826	5984	13941	425
			DoS	86.6912					1736
			U2R	11.42857					62
			R2L	26.18328					1466
			Normal	87.08117					
	87.69351	62.5175	Prob	69.20949	75.06523	7.5	3474	13234	779
			DoS	86.47654					1764
			U2R	12.85714					61
			R2L	9.768379					1792
			Normal	92.5					
60	87.40422	54.3444	Prob	83.59684	82.3823	10.68437	4949	14524	415
			DoS	92.09598					1031
			U2R	22.85714					54
			R2L	19.13394					1606
			Normal	89.31563					
	86.22518	64.15441	Prob	72.72727	70.06239	7.623057	3531	12352	690
			DoS	79.30083					2700
			U2R	12.85714					61
			R2L	8.006042					1827
			Normal	92.37694					
	87.59969	59.26429	Prob	83.04348	82.00794	10.272021	4758	14458	429
			DoS	93.21527					885
			U2R	17.14286					58
			R2L	9.365559					1800
			Normal	89.72798					
64	87.31196	56.33546	Prob	87.35178	83.9308	11.401123	5281	14797	320
			DoS	93.59092					836
			U2R	14.28571					60
			R2L	18.58006					1617
			Normal	88.59888					
	89.2025	59.01393	Prob	86.40316	80.61826	7.5302245	3488	14213	344
			DoS	89.94174					1312
			U2R	11.42857					62
			R2L	14.45116					1699
			Normal	92.46978					
	88.62862	56.44607	Prob	84.42688	81.41237	8.6247841	3995	14353	394
			DoS	91.40601					1121
			U2R	21.42857					55
			R2L	14.04834					1707
			Normal	91.37522					
	84.91634	45.01599	Prob	80.31621	83.28417	14.462435	6699	14683	498
			DoS	91.43668					1117
			U2R	38.57143					43
			R2L	35.09567					1289
			Normal	85.53756					
70	86.4441	57.4816	Prob	77.0751	79.7958	11.025475	5107	14068	580
			DoS	89.47409					1373
			U2R	11.42857					62
			R2L	22.10473					1547
			Normal	88.97453					
	71.7326	49.63063	Prob	86.67984	85.73454	33.596718	15562	15115	337
			DoS	93.56792					839
			U2R	24.28571					53
			R2L	35.24673					1286
			Normal	66.40328					
	79.94214	48.52358	Prob	87.86561	87.33976	22.873489	10595	15398	307
			DoS	97.00245					391
			U2R	35.71429					45
			R2L	25.02518					1489
			Normal	77.12651					

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80	75.03987	48.69298	Prob	87.70751	86.73284	29.410622	13623	15291	311
			DoS	94.43422					726
			U2R	22.85714					54
			R2L	37.16012					1248
			Normal	70.58938					
	88.6208	49.20733	Prob	89.64427	86.95406	10.744819	4977	15330	262
			DoS	96.44281					464
			U2R	31.42857					48
			R2L	23.16213					1526
			Normal	89.25518					
	87.60751	58.12985	Prob	80.59289	80.43108	9.6610535	4475	14180	491
			DoS	91.67433					1086
			U2R	24.28571					53
			R2L	8.35851					1820
			Normal	90.33895					
90	88.27052	47.38645	Prob	87.43083	87.35678	11.381693	5272	15401	318
			DoS	98.23674					230
			U2R	45.71429					38
			R2L	17.2709					1643
			Normal	88.61831					
	84.39875	52.65739	Prob	79.24901	81.46341	14.484024	6709	14362	525
			DoS	91.23735					1143
			U2R	28.57143					50
			R2L	21.95368					1550
			Normal	85.51598					
	87.18374	57.40583	Prob	81.42292	79.94328	10.060449	4660	14094	470
			DoS	89.46642					1374
			U2R	15.71429					59
			R2L	17.77442					1633
			Normal	89.93955					
100	75.49648	43.61842	Prob	89.96047	88.20193	29.339378	13590	15550	254
			DoS	94.41122					729
			U2R	27.14286					51
			R2L	47.33132					1046
			Normal	70.66062					
	79.02737	57.85518	Prob	81.02767	83.1764	22.551813	10446	14664	480
			DoS	94.28856					745
			U2R	18.57143					57
			R2L	15.20645					1684
			Normal	77.44819					
	83.03049	53.47807	Prob	83.32016	82.92116	16.927893	7841	14619	422
			DoS	92.78596					941
			U2R	27.14286					51
			R2L	19.58711					1597
			Normal	83.07211					
200	69.82486	21.19565	Prob	99.68379	99.50085	41.470207	19209	17542	8
			DoS	99.98467					2
			U2R	38.57143					43
			R2L	98.23766					35
			Normal	58.52979					
	69.84206	21.55819	Prob	99.80237	99.50085	41.446459	19198	17542	5
			DoS	99.96167					5
			U2R	37.14286					44
			R2L	98.28802					34
			Normal	58.55354					

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Table (A.30) 4-layer, Max Input 1024 with redundant records, different hidden neurons

Hidden	Rate%	Cost%	Attack category	TPR Each%	TPR%	FPR%	FP	TP	FN
40	91.82584	59.56262	Prob	87.08593	93.79362	16.307164	9881	234893	538
			DoS	99.67812					745
			U2R	20					56
			R2L	3.66904					14204
			Normal	83.69284					
	75.31002	62.31076	Prob	88.7662	71.98646	10.95341	6637	180280	468
			DoS	76.02817					55484
			U2R	22.85714					54
			R2L	4.035266					14150
			Normal	89.04659					
	38.77452	78.82206	Prob	71.50744	24.53242	2.3616589	1431	61438	1187
			DoS	25.17854					173178
			U2R	2.857143					68
			R2L	1.220753					14565
			Normal	97.63834					
50	74.85026	68.22645	Prob	85.6217	70.78096	8.3309953	5048	177261	599
			DoS	74.96058					57955
			U2R	5.714286					66
			R2L	1.288572					14555
			Normal	91.669					
	64.33419	69.8527	Prob	83.55737	58.20569	10.336177	6263	145768	685
			DoS	61.24214					89707
			U2R	7.142857					65
			R2L	3.621567					14211
			Normal	89.66382					
	65.13798	71.05133	Prob	70.21123	58.10427	5.791098	3509	145514	1241
			DoS	61.51909					89066
			U2R	8.571429					64
			R2L	1.3157					14551
			Normal	94.2089					
60	75.46338	64.6431	Prob	83.79741	71.61111	8.6148565	5220	179340	675
			DoS	75.79962					56013
			U2R	17.14286					58
			R2L	2.678874					14350
			Normal	91.38514					
	38.46458	77.04209	Prob	77.05233	25.09304	6.2697011	3799	62842	956
			DoS	25.68707					172001
			U2R	8.571429					64
			R2L	1.166497					14573
			Normal	93.7303					
	93.07235	62.38244	Prob	83.46135	93.4031	8.2946875	5026	233915	689
			DoS	99.47117					1224
			U2R	11.42857					62
			R2L	1.34961					14546
			Normal	91.70531					
64	93.1	62.13799	Prob	86.07777	93.66864	9.2502434	5605	234580	580
			DoS	99.63233					851
			U2R	10					63
			R2L	2.597491					14362
			Normal	90.74976					
	58.58232	71.06782	Prob	85.42967	49.98443	5.8818675	3564	125179	607
			DoS	52.41321					110142
			U2R	8.571429					64
			R2L	2.04137					14444
			Normal	94.11813					

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	51.18237	71.1053	Prob	84.22948	41.07596	7.0470186	4270	102869	657
			DoS	42.79752					132398
			U2R	15.71429					59
			R2L	1.980332					14453
			Normal	92.95298					
	57.62582	64.50467	Prob	81.70907	50.12937	11.390755	6902	125542	762
			DoS	52.35575					110275
			U2R	30					49
			R2L	6.354697					13808
			Normal	88.60925					
70	91.77762	63.99693	Prob	79.81277	91.94445	8.9119205	5400	230262	841
			DoS	97.85055					4975
			U2R	5.714286					66
			R2L	3.072228					14292
			Normal	91.08808					
	72.41061	48.33471	Prob	85.66971	74.79636	37.44987	22692	187317	597
			DoS	76.00009					55549
			U2R	18.57143					57
			R2L	53.09596					6916
			Normal	62.55013					
	90.00833	58.27377	Prob	86.43783	92.0319	18.355256	11122	230481	565
			DoS	97.79396					5106
			U2R	27.14286					51
			R2L	3.472364					14233
			Normal	81.64474					
80	90.80825	50.08328	Prob	86.31781	95.89875	30.231215	18318	240165	570
			DoS	99.66775					769
			U2R	11.42857					62
			R2L	39.84401					8870
			Normal	69.76879					
	74.76377	62.36127	Prob	87.47	70.77217	8.7386332	5295	177239	522
			DoS	74.78948					58351
			U2R	24.28571					53
			R2L	3.214649					14271
			Normal	91.26137					
	75.48106	64.11162	Prob	81.97312	71.4422	7.8259865	4742	178917	751
			DoS	75.74172					56147
			U2R	21.42857					55
			R2L	1.213971					14566
			Normal	92.17401					
90	77.70594	58.54563	Prob	86.17379	74.52922	9.1644249	5553	186648	576
			DoS	78.9242					48781
			U2R	37.14286					44
			R2L	2.427942					14387
			Normal	90.83558					
	74.77663	64.65158	Prob	81.15699	71.49851	11.674616	7074	179058	785
			DoS	75.70068					56242
			U2R	18.57143					57
			R2L	3.058664					14294
			Normal	88.32538					
	50.9004	72.37337	Prob	82.38118	40.99211	8.1478059	4937	102659	734
			DoS	42.70895					132603
			U2R	11.42857					62
			R2L	2.488979					14378
			Normal	91.85219					
100	89.92763	36.5961	Prob	87.78205	97.81541	42.673246	25857	244965	509
			DoS	99.58178					968
			U2R	20					56
			R2L	73.29264					3938
			Normal	57.32675					

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	91.16803	62.72738	Prob	82.23716	93.48975	18.427871	11166	234132	740
			DoS	99.53641					1073
			U2R	12.85714					61
			R2L	2.136317					14430
			Normal	81.57213					
	92.11456	58.83964	Prob	83.62938	93.51611	13.678148	8288	234198	682
			DoS	99.49796					1162
			U2R	24.28571					53
			R2L	2.739912					14341
			Normal	86.32185					
200	89.37655	24.11906	Prob	95.48728	99.89019	54.077204	32767	250161	188
			DoS	99.99914					2
			U2R	31.42857					48
			R2L	99.74907					37
			Normal	45.9228					
	89.36016	24.17702	Prob	94.86318	99.87901	54.115162	32790	250133	214
			DoS	99.99784					5
			U2R	31.42857					48
			R2L	99.75585					36
			Normal	45.88484					

Four layer network with 1200 as Max Input with different hidden neurons for both distinct and redundant processed data records:

Table (A.31) 4-layer, Max Input 1200 with distinct records, different hidden neurons

Hidden	Rate%%	Cost%	Attack category	TPR Each%	TPR%	FPR%	FP	TP	FN
40	80.49883	41.68052	Prob	98.06324	89.65967	22.98791	10648	15807	49
			DoS	95.90616					534
			U2R	38.57143					43
			R2L	39.7281					1197
			Normal	77.01209					
	86.82565	60.96385	Prob	58.3004	76.08054	9.0846287	4208	13413	1055
			DoS	90.71604					1211
			U2R	27.14286					51
			R2L	4.330312					1900
			Normal	90.91537					
	88.92416	45.84621	Prob	93.24111	84.135	9.2530225	4286	14833	171
			DoS	90.92303					1184
			U2R	37.14286					44
			R2L	29.60725					1398
			Normal	90.74698					
50	87.76857	60.30568	Prob	76.87747	74.59444	7.2171848	3343	13151	585
			DoS	84.00797					2086
			U2R	17.14286					58
			R2L	11.88318					1750
			Normal	92.78282					
	87.69038	48.28352	Prob	83.12253	79.84118	9.3221071	4318	14076	427
			DoS	87.61883					1615
			U2R	38.57143					43
			R2L	26.03223					1469
			Normal	90.67789					
	89.13995	56.00488	Prob	83.00395	83.81736	8.8341969	4092	14777	430
			DoS	95.1242					636
			U2R	22.85714					54
			R2L	12.73917					1733

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			Normal	91.1658					
60	87.01486	60.09127	Prob	85.29644	78.88259	9.8898964	4581	13907	372
			DoS	88.48513					1502
			U2R	15.71429					59
			R2L	9.869084					1790
			Normal	90.1101					
	87.77482	47.0995	Prob	89.36759	87.83891	12.249568	5674	15486	269
			DoS	97.6081					312
			U2R	38.57143					43
			R2L	23.46425					1520
			Normal	87.75043					
	87.36513	56.31826	Prob	85.92885	83.31821	11.09456	5139	14689	356
			DoS	93.10794					899
			U2R	15.71429					59
			R2L	18.07654					1627
			Normal	88.90544					
64	84.28616	56.36597	Prob	81.34387	79.18888	13.773748	6380	13961	472
			DoS	88.92978					1444
			U2R	25.71429					52
			R2L	14.35045					1701
			Normal	86.22625					
	87.69664	54.5373	Prob	83.67589	81.4464	9.9244387	4597	14359	413
			DoS	91.33701					1130
			U2R	27.14286					51
			R2L	15.55891					1677
			Normal	90.07556					
	81.29476	48.2842	Prob	86.12648	85.90471	20.459845	9477	15145	351
			DoS	96.02883					518
			U2R	42.85714					40
			R2L	20.64451					1576
			Normal	79.54016					
70	69.73886	57.37102	Prob	84.4664	84.08395	35.721071	16546	14824	393
			DoS	94.61055					703
			U2R	21.42857					55
			R2L	16.66667					1655
			Normal	64.27893					
	88.04378	51.7238	Prob	90.23715	85.92172	11.148532	5164	15148	247
			DoS	94.44189					725
			U2R	18.57143					57
			R2L	26.83787					1453
			Normal	88.85147					
	84.04066	55.19809	Prob	82.13439	81.60522	15.032383	6963	14387	452
			DoS	91.41368					1120
			U2R	22.85714					54
			R2L	18.58006					1617
			Normal	84.96762					
	69.39484	21.52689	Prob	99.92095	99.56324	42.087651	19495	17553	2
			DoS	99.99233					1
			U2R	37.14286					44
			R2L	98.48943					30
			Normal	57.91235					
80	84.40031	52.37129	Prob	79.09091	83.18775	15.138169	7012	14666	529
			DoS	93.96657					787
			U2R	31.42857					48
			R2L	19.43605					1600
			Normal	84.86183					
	80.96794	57.40723	Prob	86.32411	85.29212	20.677893	9578	15037	346
			DoS	95.52285					584
			U2R	11.42857					62
			R2L	19.3857					1601
			Normal	79.32211					

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	77.94214	46.48624	Prob	91.06719	89.77879	26.56304	12304	15828	226
			DoS	97.94542					268
			U2R	27.14286					51
			R2L	36.70695					1257
			Normal	73.43696					
90	85.00704	60.62413	Prob	59.28854	72.43335	10.207254	4728	12770	1030
			DoS	85.51825					1889
			U2R	31.42857					48
			R2L	4.682779					1893
			Normal	89.79275					
	87.46364	58.92471	Prob	84.62451	81.66194	10.328152	4784	14397	389
			DoS	91.613					1094
			U2R	11.42857					62
			R2L	15.00504					1688
			Normal	89.67185					
	86.90539	46.80607	Prob	89.96047	85.81963	12.681347	5874	15130	254
			DoS	94.2349					752
			U2R	37.14286					44
			R2L	26.98892					1450
			Normal	87.31865					
100	90.4222	63.62003	Prob	78.37945	75.08225	3.7392055	1732	13237	547
			DoS	84.9356					1965
			U2R	7.142857					65
			R2L	8.559919					1816
			Normal	96.26079					
	86.86005	58.85267	Prob	82.56917	77.40783	9.5423143	4420	13647	441
			DoS	87.08218					1685
			U2R	22.85714					54
			R2L	9.214502					1803
			Normal	90.45769					
	85.64973	52.89803	Prob	85.49407	80.89053	12.53886	5808	14261	367
			DoS	89.1981					1409
			U2R	25.71429					52
			R2L	22.40685					1541
			Normal	87.46114					

Table (A.32) 4-layer, Max Input 1200 with redundant records, different hidden neurons

Hidden	Rate%	Cost%	Attack category	TPR Each%	TPR%	FPR%	FP	TP	FN
40	91.65898	56.76306	Prob	92.79885	94.11546	18.493885	11206	235699	300
			DoS	99.76324					548
			U2R	25.71429					52
			R2L	6.15802					13837
			Normal	81.50611					
	75.26887	65.9744	Prob	63.56217	71.0413	7.2582642	4398	177913	1518
			DoS	75.67951					56291
			U2R	21.42857					55
			R2L	0.583249					14659
			Normal	92.74174					
	39.44327	69.79608	Prob	89.63034	26.5453	7.248362	4392	66479	432
			DoS	26.79657					169433
			U2R	25.71429					52
			R2L	4.781282					14040
			Normal	92.75164					
50	68.8402	68.00625	Prob	79.69275	62.66152	5.6227617	3407	156927	846
			DoS	66.25392					78107
			U2R	12.85714					61
			R2L	1.69549					14495
			Normal	94.37724					

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	40.62869	69.68422	Prob	83.43735	28.0367	7.3275791	4440	70214	690
			DoS	28.59519					165270
			U2R	28.57143					50
			R2L	3.614785					14212
			Normal	92.67242					
	93.45399	60.90179	Prob	83.41335	93.52489	6.8390738	4144	234220	691
			DoS	99.57357					987
			U2R	15.71429					59
			R2L	1.804001					14479
			Normal	93.16093					
60	40.46279	75.08633	Prob	84.75756	27.99438	8.0042249	4850	70108	635
			DoS	28.6708					165095
			U2R	11.42857					62
			R2L	1.41743					14536
			Normal	91.99578					
	93.14662	57.15164	Prob	87.30197	93.94057	10.134834	6141	235261	529
			DoS	99.85742					330
			U2R	27.14286					51
			R2L	3.255341					14265
			Normal	89.86517					
	93.10579	62.21319	Prob	85.35766	93.61793	9.0109419	5460	234453	610
			DoS	99.59474					938
			U2R	10					63
			R2L	2.529671					14372
			Normal	90.98906					
64	39.80754	74.21615	Prob	82.33317	27.96683	11.253775	6819	70039	736
			DoS	28.64444					165156
			U2R	15.71429					59
			R2L	2.027806					14446
			Normal	88.74622					
	93.16334	59.66895	Prob	83.82141	93.36837	7.6840559	4656	233828	674
			DoS	99.37094					1456
			U2R	20					56
			R2L	2.190573					14422
			Normal	92.31594					
	49.60277	67.2172	Prob	85.23764	41.44212	16.668592	10100	103786	615
			DoS	43.11335					131667
			U2R	31.42857					48
			R2L	2.882333					14320
			Normal	83.33141					
70	89.30421	63.76053	Prob	84.32549	93.64908	28.653475	17362	234531	653
			DoS	99.65868					790
			U2R	11.42857					62
			R2L	2.339776					14400
			Normal	71.34653					
	93.11801	60.01291	Prob	87.90206	93.64229	9.0489	5483	234514	504
			DoS	99.49796					1162
			U2R	15.71429					59
			R2L	3.716514					14197
			Normal	90.9511					
	92.39781	60.75772	Prob	82.90927	93.45661	11.978281	7258	234049	712
			DoS	99.45778					1255
			U2R	17.14286					58
			R2L	2.597491					14362
			Normal	88.02172					
	89.30646	23.36819	Prob	99.95199	99.96806	54.758801	33180	250356	2
			DoS	99.99957					1
			U2R	32.85714					47
			R2L	99.79654					30
			Normal	45.2412					

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80	74.8763	63.98574	Prob	81.03697	71.65184	11.796742	7148	179442	790
			DoS	75.88991					55804
			U2R	21.42857					55
			R2L	2.712784					14345
			Normal	88.20326					
	91.71685	62.81297	Prob	85.45367	93.75489	16.70655	10123	234796	606
			DoS	99.72954					626
			U2R	10					63
			R2L	2.712784					14345
			Normal	83.29345					
	91.16513	59.73549	Prob	88.33413	94.21569	21.443071	12993	235950	486
			DoS	99.88378					269
			U2R	15.71429					59
			R2L	7.277043					13672
			Normal	78.55693					
90	72.52989	66.2253	Prob	64.16227	67.86604	8.1940158	4965	169961	1493
			DoS	72.22959					64276
			U2R	22.85714					54
			R2L	0.630722					14652
			Normal	91.80598					
	93.05081	63.5957	Prob	84.3975	93.38593	8.334296	5050	233872	650
			DoS	99.38865					1415
			U2R	5.714286					66
			R2L	2.115972					14433
			Normal	91.6657					
	75.39008	62.07516	Prob	87.73404	71.9629	10.445101	6329	180221	511
			DoS	76.03983					55457
			U2R	24.28571					53
			R2L	3.73686					14194
			Normal	89.5549					
100	63.9413	71.90148	Prob	80.6289	55.98317	3.1670325	1919	140202	807
			DoS	59.04301					94797
			U2R	2.857143					68
			R2L	1.241099					14562
			Normal	96.83297					
	92.92349	59.70237	Prob	83.1493	93.08286	7.7352169	4687	233113	702
			DoS	99.12856					2017
			U2R	21.42857					55
			R2L	1.329264					14549
			Normal	92.26478					
	75.238	64.10008	Prob	84.94959	71.59713	9.7139934	5886	179305	627
			DoS	75.73524					56162
			U2R	18.57143					57
			R2L	3.119702					14285
			Normal	90.28601					

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Four layer network with 2000 as Max Input with different hidden neurons for both distinct and redundant processed data records:

Table (A.33) 4-layer, Max Input 2000 with distinct records, different hidden neurons

Hidden	Rate%	Cost%	Attack category	TPR Each%	TPR%	FPR%	FP	TP	FN
40	86.14855	50.31428	Prob	87.62846	84.50936	13.227547	6127	14899	313
			DoS	93.4376					856
			U2R	30					49
			R2L	23.81672					1513
			Normal	86.77245					
	87.64973	51.24458	Prob	95.25692	79.82416	9.3717617	4341	14073	120
			DoS	85.03527					1952
			U2R	22.85714					54
			R2L	27.94562					1431
			Normal	90.62824					
	88.6724	43.09766	Prob	93.47826	88.12252	11.118307	5150	15536	165
			DoS	96.06716					513
			U2R	42.85714					40
			R2L	30.71501					1376
			Normal	88.88169					
50	87.54808	61.83976	Prob	78.93281	78.76347	9.1083765	4219	13886	533
			DoS	89.87274					1321
			U2R	12.85714					61
			R2L	7.905337					1829
			Normal	90.89162					
	88.10633	60.0147	Prob	84.34783	78.44583	8.216753	3806	13830	396
			DoS	88.04048					1560
			U2R	15.71429					59
			R2L	10.12085					1785
			Normal	91.78325					
	83.94527	54.97269	Prob	83.75494	81.26489	15.034542	6964	14327	411
			DoS	90.70837					1212
			U2R	24.28571					53
			R2L	18.07654					1627
			Normal	84.96546					
60	88.26583	52.47027	Prob	85.88933	85.37153	10.632556	4925	15051	357
			DoS	96.74946					424
			U2R	35.71429					45
			R2L	11.73212					1753
			Normal	89.36744					
	87.05708	50.21998	Prob	91.34387	87.43052	13.08506	6061	15414	219
			DoS	96.54247					451
			U2R	25.71429					52
			R2L	24.77341					1494
			Normal	86.91494					
	84.9742	46.86523	Prob	92.88538	88.87691	16.511226	7648	15669	180
			DoS	97.91475					272
			U2R	35.71429					45
			R2L	26.28399					1464
			Normal	83.48877					
64	87.36669	56.37043	Prob	75.01976	79.5519	9.6588946	4474	14025	632
			DoS	90.19473					1279
			U2R	21.42857					55
			R2L	17.47231					1639
			Normal	90.34111					

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	77.81548	46.7035	Prob	85.77075	82.9949	24.155872	11189	14632	360
			DoS	91.80466					1069
			U2R	50					35
			R2L	22.75932					1534
			Normal	75.84413					
	87.67005	45.42637	Prob	91.73913	89.41577	12.994387	6019	15764	209
			DoS	98.05274					254
			U2R	32.85714					47
			R2L	31.72205					1356
			Normal	87.00561					
70	90.20797	58.68888	Prob	86.12648	81.16846	6.351468	2942	14310	351
			DoS	91.36768					1126
			U2R	17.14286					58
			R2L	10.12085					1785
			Normal	93.64853					
	86.78186	51.37083	Prob	83.87352	82.76234	11.688256	5414	14591	408
			DoS	92.05765					1036
			U2R	30					49
			R2L	22.15509					1546
			Normal	88.31174					
	86.86787	51.55243	Prob	88.6166	81.14577	10.954231	5074	14306	288
			DoS	88.3318					1522
			U2R	24.28571					53
			R2L	26.43505					1461
			Normal	89.04577					
80	87.38233	44.61217	Prob	92.56917	89.46682	13.411054	6212	15773	188
			DoS	97.93775					269
			U2R	35.71429					45
			R2L	31.77241					1355
			Normal	86.58895					
	76.34715	48.53351	Prob	84.74308	85.06523	26.971071	12493	14997	386
			DoS	94.87887					668
			U2R	42.85714					40
			R2L	22.50755					1539
			Normal	73.02893					
	86.6036	44.06206	Prob	91.6996	89.25128	14.404145	6672	15735	210
			DoS	97.98375					263
			U2R	40					42
			R2L	30.5136					1380
			Normal	85.59585					
90	77.99062	54.98061	Prob	78.26087	82.32558	23.659326	10959	14514	550
			DoS	94.34989					737
			U2R	37.14286					44
			R2L	10.12085					1785
			Normal	76.34067					
	87.48241	52.68922	Prob	85.61265	82.93817	10.787997	4997	14622	364
			DoS	92.82429					936
			U2R	31.42857					48
			R2L	16.4149					1660
			Normal	89.212					
	79.62627	45.59227	Prob	87.15415	87.91832	23.529793	10899	15500	325
			DoS	97.45477					332
			U2R	42.85714					40
			R2L	27.84491					1433
			Normal	76.47021					
100	72.07975	50.20294	Prob	85.49407	86.211	33.298791	15424	15199	367
			DoS	96.25115					489
			U2R	37.14286					44
			R2L	22.91037					1531
			Normal	66.70121					

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	76.89601	37.46414	Prob	87.66798	89.42144	27.87133	12910	15765	312
			DoS	94.69488					692
			U2R	34.28571					46
			R2L	58.96274					815
			Normal	72.12867					
	85.23534	46.29463	Prob	84.38735	85.0312	14.68696	6803	14991	395
			DoS	94.38056					733
			U2R	42.85714					40
			R2L	25.93152					1471
			Normal	85.31304					

Table (A.34) 4-layer, Max Input 2000 with redundant records, different hidden neurons

Hidden	Rate%	Cost%	Attack category	TPR Each%	TPR%	FPR%	FP	TP	FN
40	75.28076	63.16625	Prob	86.2458	71.86547	10.603535	6425	179977	573
			DoS	75.98885					55575
			U2R	21.42857					55
			R2L	3.316378					14256
			Normal	89.39646					
	40.66245	73.60836	Prob	90.90254	28.08183	7.3407819	4448	70327	379
			DoS	28.49884					165493
			U2R	11.42857					62
			R2L	3.865717					14175
			Normal	92.65922					
	93.34114	52.73932	Prob	89.84638	93.91022	9.0109419	5460	235185	423
			DoS	99.66862					767
			U2R	40					42
			R2L	4.923703					14019
			Normal	90.98906					
50	75.55598	66.91486	Prob	80.91695	71.42783	7.3820408	4473	178881	795
			DoS	75.75209					56123
			U2R	11.42857					62
			R2L	1.152933					14575
			Normal	92.61796					
	40.59814	75.03777	Prob	84.18147	27.86061	6.756556	4094	69773	659
			DoS	28.53427					165411
			U2R	11.42857					62
			R2L	1.451339					14531
			Normal	93.24344					
	74.74737	64.22219	Prob	83.89342	71.49891	11.826449	7166	179059	671
			DoS	75.68512					56278
			U2R	20					56
			R2L	2.529671					14372
			Normal	88.17355					
60	93.21832	58.58715	Prob	85.18963	93.65267	8.5768983	5197	234540	617
			DoS	99.68547					728
			U2R	24.28571					53
			R2L	1.675144					14498
			Normal	91.4231					
	93.07974	60.46225	Prob	88.50216	93.91701	10.380737	6290	235202	479
			DoS	99.79305					479
			U2R	14.28571					60
			R2L	3.587657					14216
			Normal	89.61926					
	92.63188	57.30312	Prob	91.43063	94.05038	13.230901	8017	235536	357
			DoS	99.87773					283
			U2R	25.71429					52
			R2L	3.641913					14208
			Normal	86.7691					

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64	77.414	64.67443	Prob	78.56457	73.84242	7.8243361	4741	184928	893
			DoS	78.32322					50172
			U2R	17.14286					58
			R2L	2.441506					14385
			Normal	92.17566					
	77.414	64.67443	Prob	78.56457	73.84242	7.8243361	4741	184928	893
			DoS	78.32322					50172
			U2R	17.14286					58
			R2L	2.441506					14385
			Normal	92.17566					
	93.17716	56.19851	Prob	89.15026	94.07074	10.516066	6372	235587	452
			DoS	99.89026					254
			U2R	28.57143					50
			R2L	4.421838					14093
			Normal	89.48393					
70	41.13893	74.74794	Prob	85.26164	28.18005	5.3009424	3212	70573	614
			DoS	28.86047					164656
			U2R	11.42857					62
			R2L	1.451339					14531
			Normal	94.69906					
	40.32582	71.16586	Prob	83.89342	28.17886	9.4697407	5738	70570	671
			DoS	28.77579					164852
			U2R	24.28571					53
			R2L	3.085792					14290
			Normal	90.53026					
	50.85924	70.4436	Prob	86.8459	41.12588	8.9119205	5400	102994	548
			DoS	42.69728					132630
			U2R	15.71429					59
			R2L	3.662258					14205
			Normal	91.08808					
80	93.11479	56.6017	Prob	89.41431	94.06036	10.793326	6540	235561	441
			DoS	99.87643					286
			U2R	27.14286					51
			R2L	4.39471					14097
			Normal	89.20667					
	48.4315	67.3341	Prob	84.42151	41.2852	22.032248	13350	103393	649
			DoS	42.94269					132062
			U2R	32.85714					47
			R2L	3.119702					14285
			Normal	77.96775					
	75.35567	59.92098	Prob	88.81421	72.19529	11.582196	7018	180803	466
			DoS	76.23901					54996
			U2R	31.42857					48
			R2L	4.218379					14123
			Normal	88.4178					
90	91.06546	57.70201	Prob	80.53289	93.43225	18.716683	11341	233988	811
			DoS	99.54246					1059
			U2R	32.85714					47
			R2L	1.451339					14531
			Normal	81.28332					
	75.50036	62.32942	Prob	85.0216	71.70455	8.8112488	5339	179574	624
			DoS	75.89985					55781
			U2R	25.71429					52
			R2L	2.305866					14405
			Normal	91.18875					
	91.42684	56.6307	Prob	85.95775	93.96453	19.061608	11550	235321	585
			DoS	99.85613					333
			U2R	31.42857					48
			R2L	4.042048					14149
			Normal	80.93839					

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100	89.8151	58.52283	Prob	84.9736	93.8052	26.676349	16164	234922	626
			DoS	99.75719					562
			U2R	28.57143					50
			R2L	3.180739					14276
			Normal	73.32365					
	72.55658	40.44136	Prob	86.31781	76.00744	41.706138	25271	190350	570
			DoS	76.06403					55401
			U2R	22.85714					54
			R2L	72.45846					4061
			Normal	58.29386					
	75.05988	61.00805	Prob	84.30149	71.85788	11.705973	7093	179958	654
			DoS	75.9962					55558
			U2R	30					49
			R2L	3.580875					14217
			Normal	88.29403					

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APPENDIX B

In this section the detailed tables are shown for the detection rate of each attack type, we only placed the tables of the 2-layer NN system for all the Max Inputs and all number of hidden neurons respectively as shown in tables APPENDIX A, we didn't place all the detailed tables because of the lack of the space of this thesis, and at the end placed the detailed tables of the 11 system of our choice used in the comparisons

Table (B.1) MAX INPUT 100 2 LAYER DISTINCT FOR DIFFERENT HIDDEN NEURONS.

Attack Category	attack ID	Total No Of Records	Attack Recognized
2	1	365	365
3	2	22	9
4	3	3	2
4	4	1302	91
1	5	844	843
4	6	1	1
1	7	44	0
2	8	5	4
3	9	2	2
2	10	573	87
2	11	9	0
4	12	18	5
2	13	1002	721
2	14	9220	9186
1	15	80	80
5	16	46320	42593
3	17	2	1
4	18	2	0
2	19	22	20
1	20	153	152
3	21	13	8
6	22	0	0
6	23	0	0
2	24	794	505
2	25	308	308
1	26	1049	469
4	27	17	11
2	28	744	607
3	29	16	4
1	30	360	254
4	31	15	8
4	32	109	15
4	33	359	1

Attack Category	attack ID	Total No Of Records	Attack Recognized
2	1	365	365
3	2	22	11
4	3	3	1
4	4	1302	77
1	5	844	843
4	6	1	1
1	7	44	0
2	8	5	3
3	9	2	2
2	10	573	117
2	11	9	5
4	12	18	9
2	13	1002	704
2	14	9220	9167
1	15	80	78
5	16	46320	41715
3	17	2	0
4	18	2	1
2	19	22	22
1	20	153	151
3	21	13	9
6	22	0	0
6	23	0	0
2	24	794	516
2	25	308	308
1	26	1049	302
4	27	17	15
2	28	744	509
3	29	16	2
1	30	360	253
4	31	15	8
4	32	109	8
4	33	359	0

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3	34	2	0
2	35	2	2
4	36	2	2
4	37	9	7
4	38	4	3
3	39	13	6
4	40	145	145

3	34	2	0
2	35	2	2
4	36	2	2
4	37	9	8
4	38	4	1
3	39	13	6
4	40	145	145

Attack Category	attack ID	Total No Of Records	Attack Recognized
2	1	365	365
3	2	22	10
4	3	3	1
4	4	1302	28
1	5	844	843
4	6	1	1
1	7	44	0
2	8	5	2
3	9	2	2
2	10	573	515
2	11	9	7
4	12	18	8
2	13	1002	681
2	14	9220	9146
1	15	80	75
5	16	46320	42435
3	17	2	1
4	18	2	1
2	19	22	22
1	20	153	148
3	21	13	6
6	22	0	0
6	23	0	0
2	24	794	553
2	25	308	308
1	26	1049	511
4	27	17	13
2	28	744	507
3	29	16	4
1	30	360	252
4	31	15	8
4	32	109	7
4	33	359	3
3	34	2	0
2	35	2	1
4	36	2	2
4	37	9	7
4	38	4	2
3	39	13	6
4	40	145	144

Attack Category	attack ID	Total No Of Records	Attack Recognized
2	1	365	365
3	2	22	7
4	3	3	2
4	4	1302	191
1	5	844	844
4	6	1	1
1	7	44	0
2	8	5	5
3	9	2	2
2	10	573	387
2	11	9	9
4	12	18	10
2	13	1002	785
2	14	9220	9175
1	15	80	79
5	16	46320	37029
3	17	2	0
4	18	2	1
2	19	22	22
1	20	153	152
3	21	13	10
6	22	0	0
6	23	0	0
2	24	794	517
2	25	308	141
1	26	1049	793
4	27	17	16
2	28	744	654
3	29	16	8
1	30	360	255
4	31	15	7
4	32	109	34
4	33	359	3
3	34	2	0
2	35	2	2
4	36	2	0
4	37	9	7
4	38	4	1
3	39	13	7
4	40	145	143

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Attack Category	attack ID	Total No Of Records	Attack Recognized
2	1	365	365
3	2	22	6
4	3	3	0
4	4	1302	84
1	5	844	770
4	6	1	1
1	7	44	0
2	8	5	0
3	9	2	2
2	10	573	551
2	11	9	1
4	12	18	7
2	13	1002	257
2	14	9220	8662
1	15	80	0
5	16	46320	41674
3	17	2	0
4	18	2	0
2	19	22	22
1	20	153	117
3	21	13	3
6	22	0	0
6	23	0	0
2	24	794	534
2	25	308	308
1	26	1049	125
4	27	17	11
2	28	744	507
3	29	16	1
1	30	360	222
4	31	15	8
4	32	109	7
4	33	359	1
3	34	2	0
2	35	2	0
4	36	2	0
4	37	9	7
4	38	4	0
3	39	13	5
4	40	145	23

Attack Category	attack ID	Total No Of Records	Attack Recognized
2	1	365	365
3	2	22	10
4	3	3	1
4	4	1302	91
1	5	844	843
4	6	1	1
1	7	44	0
2	8	5	4
3	9	2	2
2	10	573	63
2	11	9	6
4	12	18	10
2	13	1002	508
2	14	9220	9160
1	15	80	80
5	16	46320	41382
3	17	2	0
4	18	2	1
2	19	22	22
1	20	153	153
3	21	13	6
6	22	0	0
6	23	0	0
2	24	794	516
2	25	308	308
1	26	1049	512
4	27	17	10
2	28	744	596
3	29	16	3
1	30	360	253
4	31	15	8
4	32	109	9
4	33	359	0
3	34	2	0
2	35	2	2
4	36	2	2
4	37	9	9
4	38	4	0
3	39	13	7
4	40	145	144

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Attack Category	attack ID	Total No Of Records	Attack Recognized
2	1	365	365
3	2	22	6
4	3	3	2
4	4	1302	68
1	5	844	843
4	6	1	1
1	7	44	0
2	8	5	5
3	9	2	1
2	10	573	313
2	11	9	1
4	12	18	6
2	13	1002	294
2	14	9220	9123
1	15	80	79
5	16	46320	42384
3	17	2	0
4	18	2	0
2	19	22	22
1	20	153	152
3	21	13	6
6	22	0	0
6	23	0	0
2	24	794	516
2	25	308	308
1	26	1049	384
4	27	17	14
2	28	744	594
3	29	16	2
1	30	360	252
4	31	15	8
4	32	109	2
4	33	359	1
3	34	2	0
2	35	2	2
4	36	2	2
4	37	9	6
4	38	4	0
3	39	13	6
4	40	145	137

Attack Category	attack ID	Total No Of Records	Attack Recognized
2	1	365	365
3	2	22	14
4	3	3	1
4	4	1302	32
1	5	844	769
4	6	1	1
1	7	44	0
2	8	5	1
3	9	2	2
2	10	573	455
2	11	9	0
4	12	18	10
2	13	1002	765
2	14	9220	8718
1	15	80	63
5	16	46320	42516
3	17	2	0
4	18	2	0
2	19	22	22
1	20	153	26
3	21	13	8
6	22	0	0
6	23	0	0
2	24	794	517
2	25	308	308
1	26	1049	50
4	27	17	13
2	28	744	507
3	29	16	2
1	30	360	228
4	31	15	8
4	32	109	8
4	33	359	0
3	34	2	0
2	35	2	2
4	36	2	2
4	37	9	7
4	38	4	1
3	39	13	8
4	40	145	42

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Attack Category	attack ID	Total No Of Records	Attack Recognized
2	1	365	365
3	2	22	11
4	3	3	1
4	4	1302	101
1	5	844	844
4	6	1	1
1	7	44	0
2	8	5	2
3	9	2	2
2	10	573	559
2	11	9	4
4	12	18	8
2	13	1002	681
2	14	9220	9155
1	15	80	79
5	16	46320	37911
3	17	2	0
4	18	2	1
2	19	22	22
1	20	153	147
3	21	13	9
6	22	0	0
6	23	0	0
2	24	794	516
2	25	308	308
1	26	1049	653
4	27	17	14
2	28	744	507
3	29	16	3
1	30	360	255
4	31	15	8
4	32	109	20
4	33	359	3
3	34	2	0
2	35	2	2
4	36	2	2
4	37	9	7
4	38	4	0
3	39	13	7
4	40	145	144

Attack Category	attack ID	Total No Of Records	Attack Recognized
2	1	365	365
3	2	22	13
4	3	3	2
4	4	1302	45
1	5	844	843
4	6	1	1
1	7	44	0
2	8	5	4
3	9	2	2
2	10	573	148
2	11	9	1
4	12	18	8
2	13	1002	776
2	14	9220	9194
1	15	80	80
5	16	46320	41504
3	17	2	0
4	18	2	1
2	19	22	22
1	20	153	152
3	21	13	10
6	22	0	0
6	23	0	0
2	24	794	513
2	25	308	308
1	26	1049	531
4	27	17	15
2	28	744	507
3	29	16	6
1	30	360	253
4	31	15	8
4	32	109	8
4	33	359	1
3	34	2	0
2	35	2	2
4	36	2	2
4	37	9	9
4	38	4	1
3	39	13	8
4	40	145	145

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Attack Category	attack ID	Total No Of Records	Attack Recognized
2	1	365	365
3	2	22	9
4	3	3	0
4	4	1302	1
1	5	844	236
4	6	1	1
1	7	44	0
2	8	5	0
3	9	2	2
2	10	573	94
2	11	9	0
4	12	18	7
2	13	1002	650
2	14	9220	5852
1	15	80	0
5	16	46320	42120
3	17	2	0
4	18	2	0
2	19	22	22
1	20	153	11
3	21	13	6
6	22	0	0
6	23	0	0
2	24	794	509
2	25	308	308
1	26	1049	0
4	27	17	11
2	28	744	507
3	29	16	1
1	30	360	18
4	31	15	8
4	32	109	6
4	33	359	0
3	34	2	0
2	35	2	0
4	36	2	2
4	37	9	6
4	38	4	0
3	39	13	6
4	40	145	18

Attack Category	attack ID	Total No Of Records	Attack Recognized
2	1	365	365
3	2	22	7
4	3	3	2
4	4	1302	324
1	5	844	844
4	6	1	1
1	7	44	0
2	8	5	5
3	9	2	2
2	10	573	139
2	11	9	7
4	12	18	12
2	13	1002	778
2	14	9220	9220
1	15	80	80
5	16	46320	39242
3	17	2	0
4	18	2	1
2	19	22	22
1	20	153	153
3	21	13	10
6	22	0	0
6	23	0	0
2	24	794	519
2	25	308	308
1	26	1049	781
4	27	17	17
2	28	744	742
3	29	16	9
1	30	360	256
4	31	15	8
4	32	109	19
4	33	359	2
3	34	2	0
2	35	2	2
4	36	2	2
4	37	9	7
4	38	4	1
3	39	13	8
4	40	145	144

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Attack Category	attack ID	Total No Of Records	Attack Recognized
2	1	365	365
3	2	22	12
4	3	3	2
4	4	1302	80
1	5	844	844
4	6	1	1
1	7	44	0
2	8	5	2
3	9	2	2
2	10	573	573
2	11	9	3
4	12	18	8
2	13	1002	722
2	14	9220	9101
1	15	80	78
5	16	46320	41404
3	17	2	0
4	18	2	0
2	19	22	22
1	20	153	148
3	21	13	9
6	22	0	0
6	23	0	0
2	24	794	516
2	25	308	308
1	26	1049	273
4	27	17	15
2	28	744	517
3	29	16	4
1	30	360	252
4	31	15	8
4	32	109	17
4	33	359	1
3	34	2	0
2	35	2	2
4	36	2	2
4	37	9	7
4	38	4	1
3	39	13	10
4	40	145	145

Attack Category	attack ID	Total No Of Records	Attack Recognized
2	1	365	365
3	2	22	8
4	3	3	2
4	4	1302	410
1	5	844	844
4	6	1	1
1	7	44	11
2	8	5	5
3	9	2	2
2	10	573	479
2	11	9	9
4	12	18	13
2	13	1002	974
2	14	9220	9220
1	15	80	80
5	16	46320	37015
3	17	2	1
4	18	2	1
2	19	22	22
1	20	153	153
3	21	13	11
6	22	0	0
6	23	0	0
2	24	794	553
2	25	308	308
1	26	1049	853
4	27	17	15
2	28	744	741
3	29	16	6
1	30	360	259
4	31	15	9
4	32	109	32
4	33	359	4
3	34	2	0
2	35	2	2
4	36	2	2
4	37	9	7
4	38	4	2
3	39	13	6
4	40	145	145

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Attack Category	attack ID	Total No Of Records	Attack Recognized
2	1	365	363
3	2	22	12
4	3	3	1
4	4	1302	45
1	5	844	841
4	6	1	1
1	7	44	0
2	8	5	2
3	9	2	2
2	10	573	12
2	11	9	0
4	12	18	6
2	13	1002	599
2	14	9220	8926
1	15	80	79
5	16	46320	42271
3	17	2	0
4	18	2	0
2	19	22	9
1	20	153	135
3	21	13	6
6	22	0	0
6	23	0	0
2	24	794	13
2	25	308	57
1	26	1049	317
4	27	17	9
2	28	744	507
3	29	16	4
1	30	360	252
4	31	15	8
4	32	109	15
4	33	359	0
3	34	2	0
2	35	2	2
4	36	2	2
4	37	9	9
4	38	4	1
3	39	13	10
4	40	145	136

Attack Category	attack ID	Total No Of Records	Attack Recognized
2	1	365	365
3	2	22	9
4	3	3	2
4	4	1302	74
1	5	844	840
4	6	1	1
1	7	44	0
2	8	5	3
3	9	2	2
2	10	573	130
2	11	9	0
4	12	18	8
2	13	1002	773
2	14	9220	9190
1	15	80	78
5	16	46320	42037
3	17	2	0
4	18	2	1
2	19	22	22
1	20	153	148
3	21	13	8
6	22	0	0
6	23	0	0
2	24	794	513
2	25	308	308
1	26	1049	555
4	27	17	15
2	28	744	507
3	29	16	5
1	30	360	254
4	31	15	8
4	32	109	19
4	33	359	1
3	34	2	0
2	35	2	2
4	36	2	0
4	37	9	8
4	38	4	0
3	39	13	7
4	40	145	145

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Attack Category	attack ID	Total No Of Records	Attack Recognized
2	1	365	365
3	2	22	14
4	3	3	2
4	4	1302	275
1	5	844	844
4	6	1	1
1	7	44	3
2	8	5	5
3	9	2	2
2	10	573	122
2	11	9	9
4	12	18	15
2	13	1002	784
2	14	9220	9220
1	15	80	80
5	16	46320	37108
3	17	2	0
4	18	2	1
2	19	22	19
1	20	153	152
3	21	13	11
6	22	0	0
6	23	0	0
2	24	794	598
2	25	308	308
1	26	1049	937
4	27	17	15
2	28	744	744
3	29	16	11
1	30	360	256
4	31	15	9
4	32	109	43
4	33	359	3
3	34	2	0
2	35	2	2
4	36	2	2
4	37	9	7
4	38	4	2
3	39	13	8
4	40	145	145

Attack Category	attack ID	Total No Of Records	Attack Recognized
2	1	365	365
3	2	22	10
4	3	3	2
4	4	1302	359
1	5	844	844
4	6	1	1
1	7	44	38
2	8	5	5
3	9	2	2
2	10	573	223
2	11	9	9
4	12	18	12
2	13	1002	779
2	14	9220	9220
1	15	80	80
5	16	46320	40083
3	17	2	0
4	18	2	1
2	19	22	22
1	20	153	153
3	21	13	11
6	22	0	0
6	23	0	0
2	24	794	549
2	25	308	308
1	26	1049	1025
4	27	17	16
2	28	744	741
3	29	16	8
1	30	360	258
4	31	15	9
4	32	109	44
4	33	359	3
3	34	2	0
2	35	2	2
4	36	2	2
4	37	9	7
4	38	4	1
3	39	13	8
4	40	145	145

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Attack Category	attack ID	Total No Of Records	Attack Recognized
2	1	365	365
3	2	22	15
4	3	3	1
4	4	1302	88
1	5	844	842
4	6	1	1
1	7	44	0
2	8	5	2
3	9	2	2
2	10	573	493
2	11	9	0
4	12	18	9
2	13	1002	645
2	14	9220	8846
1	15	80	78
5	16	46320	41873
3	17	2	0
4	18	2	0
2	19	22	22
1	20	153	148
3	21	13	8
6	22	0	0
6	23	0	0
2	24	794	516
2	25	308	308
1	26	1049	127
4	27	17	14
2	28	744	507
3	29	16	3
1	30	360	249
4	31	15	8
4	32	109	7
4	33	359	0
3	34	2	0
2	35	2	2
4	36	2	2
4	37	9	7
4	38	4	2
3	39	13	9
4	40	145	120

Attack Category	attack ID	Total No Of Records	Attack Recognized
2	1	365	365
3	2	22	11
4	3	3	2
4	4	1302	84
1	5	844	843
4	6	1	0
1	7	44	0
2	8	5	5
3	9	2	2
2	10	573	49
2	11	9	4
4	12	18	7
2	13	1002	773
2	14	9220	9170
1	15	80	80
5	16	46320	42217
3	17	2	0
4	18	2	1
2	19	22	3
1	20	153	153
3	21	13	8
6	22	0	0
6	23	0	0
2	24	794	486
2	25	308	250
1	26	1049	491
4	27	17	8
2	28	744	507
3	29	16	1
1	30	360	257
4	31	15	2
4	32	109	13
4	33	359	0
3	34	2	0
2	35	2	2
4	36	2	2
4	37	9	9
4	38	4	0
3	39	13	6
4	40	145	144

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Table (B.2) MAX INPUT 256 2 LAYER DISTINCT FOR DIFFERENT HIDDEN NEURONS

Attack Category	attack ID	Total No Of Records	Attack Recognized
2	1	365	359
3	2	22	0
4	3	3	2
4	4	1302	295
1	5	844	844
4	6	1	1
1	7	44	8
2	8	5	5
3	9	2	0
2	10	573	493
2	11	9	9
4	12	18	10
2	13	1002	709
2	14	9220	9220
1	15	80	80
5	16	46320	38647
3	17	2	0
4	18	2	1
2	19	22	22
1	20	153	153
3	21	13	9
6	22	0	0
6	23	0	0
2	24	794	541
2	25	308	308
1	26	1049	831
4	27	17	14
2	28	744	720
3	29	16	5
1	30	360	257
4	31	15	9
4	32	109	30
4	33	359	4
3	34	2	0
2	35	2	2
4	36	2	0
4	37	9	5
4	38	4	0
3	39	13	3
4	40	145	144

Attack Category	attack ID	Total No Of Records	Attack Recognized
2	1	365	365
3	2	22	6
4	3	3	0
4	4	1302	21
1	5	844	795
4	6	1	1
1	7	44	0
2	8	5	1
3	9	2	0
2	10	573	573
2	11	9	0
4	12	18	7
2	13	1002	668
2	14	9220	8278
1	15	80	18
5	16	46320	39935
3	17	2	0
4	18	2	0
2	19	22	22
1	20	153	9
3	21	13	6
6	22	0	0
6	23	0	0
2	24	794	517
2	25	308	308
1	26	1049	28
4	27	17	13
2	28	744	507
3	29	16	1
1	30	360	227
4	31	15	8
4	32	109	8
4	33	359	1
3	34	2	0
2	35	2	1
4	36	2	2
4	37	9	6
4	38	4	0
3	39	13	6
4	40	145	24

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Attack Category	attack ID	Total No Of Records	Attack Recognized
2	1	365	365
3	2	22	2
4	3	3	1
4	4	1302	29
1	5	844	843
4	6	1	1
1	7	44	0
2	8	5	5
3	9	2	2
2	10	573	154
2	11	9	3
4	12	18	7
2	13	1002	267
2	14	9220	9151
1	15	80	80
5	16	46320	42010
3	17	2	0
4	18	2	1
2	19	22	22
1	20	153	151
3	21	13	6
6	22	0	0
6	23	0	0
2	24	794	506
2	25	308	308
1	26	1049	492
4	27	17	14
2	28	744	507
3	29	16	1
1	30	360	253
4	31	15	8
4	32	109	24
4	33	359	0
3	34	2	0
2	35	2	2
4	36	2	0
4	37	9	6
4	38	4	0
3	39	13	4
4	40	145	143

Attack Category	attack ID	Total No Of Records	Attack Recognized
2	1	365	365
3	2	22	3
4	3	3	1
4	4	1302	90
1	5	844	844
4	6	1	1
1	7	44	0
2	8	5	3
3	9	2	2
2	10	573	573
2	11	9	6
4	12	18	7
2	13	1002	767
2	14	9220	9149
1	15	80	80
5	16	46320	41780
3	17	2	0
4	18	2	1
2	19	22	19
1	20	153	149
3	21	13	9
6	22	0	0
6	23	0	0
2	24	794	507
2	25	308	308
1	26	1049	308
4	27	17	13
2	28	744	507
3	29	16	3
1	30	360	253
4	31	15	5
4	32	109	30
4	33	359	0
3	34	2	0
2	35	2	2
4	36	2	0
4	37	9	7
4	38	4	1
3	39	13	3
4	40	145	144

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Attack Category	attack ID	Total No Of Records	Attack Recognized
2	1	365	365
3	2	22	3
4	3	3	2
4	4	1302	438
1	5	844	844
4	6	1	1
1	7	44	0
2	8	5	2
3	9	2	1
2	10	573	565
2	11	9	8
4	12	18	9
2	13	1002	677
2	14	9220	9191
1	15	80	79
5	16	46320	37647
3	17	2	0
4	18	2	1
2	19	22	22
1	20	153	148
3	21	13	9
6	22	0	0
6	23	0	0
2	24	794	517
2	25	308	308
1	26	1049	570
4	27	17	12
2	28	744	507
3	29	16	5
1	30	360	255
4	31	15	8
4	32	109	30
4	33	359	4
3	34	2	0
2	35	2	2
4	36	2	2
4	37	9	6
4	38	4	0
3	39	13	6
4	40	145	144

Attack Category	attack ID	Total No Of Records	Attack Recognized
2	1	365	365
3	2	22	0
4	3	3	2
4	4	1302	563
1	5	844	844
4	6	1	0
1	7	44	3
2	8	5	5
3	9	2	1
2	10	573	140
2	11	9	9
4	12	18	11
2	13	1002	539
2	14	9220	9219
1	15	80	80
5	16	46320	38050
3	17	2	0
4	18	2	1
2	19	22	19
1	20	153	153
3	21	13	9
6	22	0	0
6	23	0	0
2	24	794	499
2	25	308	95
1	26	1049	1038
4	27	17	11
2	28	744	744
3	29	16	5
1	30	360	258
4	31	15	5
4	32	109	50
4	33	359	4
3	34	2	0
2	35	2	2
4	36	2	0
4	37	9	6
4	38	4	0
3	39	13	3
4	40	145	143

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Attack Category	attack ID	Total No Of Records	Attack Recognized
2	1	365	364
3	2	22	0
4	3	3	2
4	4	1302	249
1	5	844	844
4	6	1	0
1	7	44	12
2	8	5	5
3	9	2	1
2	10	573	54
2	11	9	9
4	12	18	9
2	13	1002	708
2	14	9220	9214
1	15	80	80
5	16	46320	43656
3	17	2	0
4	18	2	1
2	19	22	9
1	20	153	153
3	21	13	9
6	22	0	0
6	23	0	0
2	24	794	497
2	25	308	0
1	26	1049	892
4	27	17	10
2	28	744	744
3	29	16	3
1	30	360	257
4	31	15	2
4	32	109	51
4	33	359	4
3	34	2	0
2	35	2	2
4	36	2	0
4	37	9	6
4	38	4	0
3	39	13	1
4	40	145	140

Attack Category	attack ID	Total No Of Records	Attack Recognized
2	1	365	364
3	2	22	6
4	3	3	2
4	4	1302	203
1	5	844	844
4	6	1	1
1	7	44	1
2	8	5	5
3	9	2	2
2	10	573	573
2	11	9	9
4	12	18	11
2	13	1002	685
2	14	9220	9188
1	15	80	80
5	16	46320	34114
3	17	2	0
4	18	2	1
2	19	22	22
1	20	153	153
3	21	13	10
6	22	0	0
6	23	0	0
2	24	794	516
2	25	308	308
1	26	1049	742
4	27	17	13
2	28	744	601
3	29	16	3
1	30	360	253
4	31	15	8
4	32	109	26
4	33	359	3
3	34	2	0
2	35	2	2
4	36	2	0
4	37	9	7
4	38	4	0
3	39	13	6
4	40	145	145

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Attack Category	attack ID	Total No Of Records	Attack Recognized
2	1	365	365
3	2	22	7
4	3	3	0
4	4	1302	6
1	5	844	831
4	6	1	1
1	7	44	0
2	8	5	2
3	9	2	0
2	10	573	491
2	11	9	3
4	12	18	7
2	13	1002	462
2	14	9220	8264
1	15	80	78
5	16	46320	42370
3	17	2	0
4	18	2	0
2	19	22	22
1	20	153	135
3	21	13	3
6	22	0	0
6	23	0	0
2	24	794	515
2	25	308	308
1	26	1049	363
4	27	17	14
2	28	744	507
3	29	16	1
1	30	360	247
4	31	15	8
4	32	109	8
4	33	359	0
3	34	2	0
2	35	2	2
4	36	2	2
4	37	9	5
4	38	4	0
3	39	13	6
4	40	145	52

Attack Category	attack ID	Total No Of Records	Attack Recognized
2	1	365	365
3	2	22	6
4	3	3	1
4	4	1302	97
1	5	844	844
4	6	1	1
1	7	44	2
2	8	5	5
3	9	2	0
2	10	573	168
2	11	9	5
4	12	18	7
2	13	1002	520
2	14	9220	9135
1	15	80	80
5	16	46320	42385
3	17	2	0
4	18	2	1
2	19	22	19
1	20	153	153
3	21	13	8
6	22	0	0
6	23	0	0
2	24	794	510
2	25	308	308
1	26	1049	691
4	27	17	14
2	28	744	524
3	29	16	2
1	30	360	252
4	31	15	8
4	32	109	25
4	33	359	3
3	34	2	0
2	35	2	2
4	36	2	2
4	37	9	7
4	38	4	0
3	39	13	6
4	40	145	144

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Attack Category	attack ID	Total No Of Records	Attack Recognized
2	1	365	365
3	2	22	2
4	3	3	2
4	4	1302	132
1	5	844	844
4	6	1	1
1	7	44	0
2	8	5	5
3	9	2	2
2	10	573	117
2	11	9	8
4	12	18	10
2	13	1002	712
2	14	9220	9179
1	15	80	80
5	16	46320	42732
3	17	2	0
4	18	2	1
2	19	22	22
1	20	153	153
3	21	13	9
6	22	0	0
6	23	0	0
2	24	794	506
2	25	308	216
1	26	1049	869
4	27	17	14
2	28	744	168
3	29	16	3
1	30	360	254
4	31	15	5
4	32	109	3
4	33	359	3
3	34	2	0
2	35	2	2
4	36	2	0
4	37	9	6
4	38	4	0
3	39	13	3
4	40	145	144

Attack Category	attack ID	Total No Of Records	Attack Recognized
2	1	365	365
3	2	22	2
4	3	3	0
4	4	1302	26
1	5	844	843
4	6	1	1
1	7	44	0
2	8	5	3
3	9	2	0
2	10	573	310
2	11	9	1
4	12	18	7
2	13	1002	252
2	14	9220	9175
1	15	80	33
5	16	46320	42587
3	17	2	0
4	18	2	0
2	19	22	6
1	20	153	144
3	21	13	2
6	22	0	0
6	23	0	0
2	24	794	513
2	25	308	0
1	26	1049	467
4	27	17	7
2	28	744	561
3	29	16	0
1	30	360	249
4	31	15	3
4	32	109	4
4	33	359	1
3	34	2	0
2	35	2	1
4	36	2	0
4	37	9	6
4	38	4	0
3	39	13	1
4	40	145	104

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Attack Category	attack ID	Total No Of Records	Attack Recognized
2	1	365	357
3	2	22	0
4	3	3	2
4	4	1302	129
1	5	844	843
4	6	1	1
1	7	44	1
2	8	5	5
3	9	2	1
2	10	573	67
2	11	9	8
4	12	18	9
2	13	1002	403
2	14	9220	9184
1	15	80	80
5	16	46320	44854
3	17	2	0
4	18	2	1
2	19	22	4
1	20	153	152
3	21	13	8
6	22	0	0
6	23	0	0
2	24	794	484
2	25	308	0
1	26	1049	835
4	27	17	8
2	28	744	654
3	29	16	3
1	30	360	253
4	31	15	3
4	32	109	6
4	33	359	0
3	34	2	0
2	35	2	2
4	36	2	0
4	37	9	5
4	38	4	0
3	39	13	0
4	40	145	141

Attack Category	attack ID	Total No Of Records	Attack Recognized
2	1	365	0
3	2	22	1
4	3	3	2
4	4	1302	384
1	5	844	844
4	6	1	1
1	7	44	4
2	8	5	5
3	9	2	1
2	10	573	191
2	11	9	9
4	12	18	9
2	13	1002	573
2	14	9220	9189
1	15	80	80
5	16	46320	43507
3	17	2	0
4	18	2	1
2	19	22	19
1	20	153	153
3	21	13	8
6	22	0	0
6	23	0	0
2	24	794	15
2	25	308	0
1	26	1049	892
4	27	17	9
2	28	744	713
3	29	16	4
1	30	360	256
4	31	15	3
4	32	109	42
4	33	359	4
3	34	2	0
2	35	2	2
4	36	2	0
4	37	9	1
4	38	4	0
3	39	13	1
4	40	145	143

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Attack Category	attack ID	Total No Of Records	Attack Recognized
2	1	365	365
3	2	22	0
4	3	3	1
4	4	1302	35
1	5	844	843
4	6	1	1
1	7	44	0
2	8	5	3
3	9	2	0
2	10	573	573
2	11	9	0
4	12	18	6
2	13	1002	353
2	14	9220	9160
1	15	80	80
5	16	46320	41853
3	17	2	0
4	18	2	0
2	19	22	22
1	20	153	149
3	21	13	4
6	22	0	0
6	23	0	0
2	24	794	517
2	25	308	308
1	26	1049	485
4	27	17	14
2	28	744	507
3	29	16	2
1	30	360	251
4	31	15	8
4	32	109	6
4	33	359	0
3	34	2	0
2	35	2	2
4	36	2	0
4	37	9	6
4	38	4	0
3	39	13	3
4	40	145	142

Attack Category	attack ID	Total No Of Records	Attack Recognized
2	1	365	365
3	2	22	9
4	3	3	0
4	4	1302	54
1	5	844	783
4	6	1	1
1	7	44	0
2	8	5	1
3	9	2	2
2	10	573	518
2	11	9	0
4	12	18	6
2	13	1002	692
2	14	9220	8609
1	15	80	31
5	16	46320	42135
3	17	2	0
4	18	2	0
2	19	22	22
1	20	153	132
3	21	13	7
6	22	0	0
6	23	0	0
2	24	794	516
2	25	308	308
1	26	1049	78
4	27	17	10
2	28	744	507
3	29	16	2
1	30	360	229
4	31	15	8
4	32	109	6
4	33	359	0
3	34	2	0
2	35	2	0
4	36	2	2
4	37	9	7
4	38	4	0
3	39	13	6
4	40	145	122

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Attack Category	attack ID	Total No Of Records	Attack Recognized
2	1	365	365
3	2	22	5
4	3	3	0
4	4	1302	3
1	5	844	844
4	6	1	1
1	7	44	0
2	8	5	1
3	9	2	0
2	10	573	406
2	11	9	4
4	12	18	6
2	13	1002	253
2	14	9220	9104
1	15	80	78
5	16	46320	42051
3	17	2	0
4	18	2	0
2	19	22	22
1	20	153	146
3	21	13	4
6	22	0	0
6	23	0	0
2	24	794	516
2	25	308	308
1	26	1049	435
4	27	17	13
2	28	744	507
3	29	16	1
1	30	360	253
4	31	15	8
4	32	109	8
4	33	359	0
3	34	2	0
2	35	2	2
4	36	2	0
4	37	9	6
4	38	4	0
3	39	13	8
4	40	145	140

Attack Category	attack ID	Total No Of Records	Attack Recognized
2	1	365	365
3	2	22	5
4	3	3	2
4	4	1302	277
1	5	844	844
4	6	1	1
1	7	44	1
2	8	5	5
3	9	2	1
2	10	573	541
2	11	9	9
4	12	18	10
2	13	1002	733
2	14	9220	9220
1	15	80	80
5	16	46320	42442
3	17	2	0
4	18	2	1
2	19	22	22
1	20	153	153
3	21	13	10
6	22	0	0
6	23	0	0
2	24	794	593
2	25	308	308
1	26	1049	835
4	27	17	14
2	28	744	742
3	29	16	4
1	30	360	256
4	31	15	8
4	32	109	27
4	33	359	4
3	34	2	0
2	35	2	2
4	36	2	0
4	37	9	7
4	38	4	0
3	39	13	5
4	40	145	143

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Attack Category	attack ID	Total No Of Records	Attack Recognized
2	1	365	353
3	2	22	0
4	3	3	1
4	4	1302	0
1	5	844	844
4	6	1	0
1	7	44	0
2	8	5	1
3	9	2	0
2	10	573	442
2	11	9	7
4	12	18	6
2	13	1002	382
2	14	9220	9196
1	15	80	78
5	16	46320	44682
3	17	2	0
4	18	2	0
2	19	22	4
1	20	153	147
3	21	13	6
6	22	0	0
6	23	0	0
2	24	794	498
2	25	308	0
1	26	1049	587
4	27	17	7
2	28	744	507
3	29	16	1
1	30	360	252
4	31	15	8
4	32	109	3
4	33	359	3
3	34	2	0
2	35	2	2
4	36	2	0
4	37	9	4
4	38	4	0
3	39	13	1
4	40	145	142

Attack Category	attack ID	Total No Of Records	Attack Recognized
2	1	365	365
3	2	22	4
4	3	3	2
4	4	1302	298
1	5	844	844
4	6	1	1
1	7	44	11
2	8	5	5
3	9	2	2
2	10	573	382
2	11	9	9
4	12	18	11
2	13	1002	885
2	14	9220	9220
1	15	80	80
5	16	46320	40937
3	17	2	0
4	18	2	1
2	19	22	5
1	20	153	153
3	21	13	10
6	22	0	0
6	23	0	0
2	24	794	509
2	25	308	308
1	26	1049	894
4	27	17	10
2	28	744	731
3	29	16	6
1	30	360	257
4	31	15	9
4	32	109	23
4	33	359	4
3	34	2	0
2	35	2	2
4	36	2	0
4	37	9	6
4	38	4	0
3	39	13	5
4	40	145	143

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Table (B.3) MAX INPUT 512 2 LAYER DISTINCT FOR DIFFERENT HIDDEN NEURONS

Attack Category	attack ID	Total No Of Records	Attack Recognized
2	1	365	365
3	2	22	15
4	3	3	1
4	4	1302	704
1	5	844	841
4	6	1	1
1	7	44	3
2	8	5	3
3	9	2	2
2	10	573	573
2	11	9	8
4	12	18	11
2	13	1002	277
2	14	9220	9207
1	15	80	70
5	16	46320	22563
3	17	2	1
4	18	2	0
2	19	22	22
1	20	153	144
3	21	13	8
6	22	0	0
6	23	0	0
2	24	794	790
2	25	308	308
1	26	1049	658
4	27	17	10
2	28	744	744
3	29	16	3
1	30	360	251
4	31	15	9
4	32	109	1
4	33	359	356
3	34	2	2
2	35	2	1
4	36	2	2
4	37	9	6
4	38	4	4
3	39	13	10
4	40	145	139

Attack Category	attack ID	Total No Of Records	Attack Recognized
2	1	365	365
3	2	22	17
4	3	3	1
4	4	1302	60
1	5	844	837
4	6	1	1
1	7	44	3
2	8	5	2
3	9	2	2
2	10	573	573
2	11	9	4
4	12	18	15
2	13	1002	489
2	14	9220	9173
1	15	80	37
5	16	46320	15981
3	17	2	2
4	18	2	1
2	19	22	22
1	20	153	134
3	21	13	9
6	22	0	0
6	23	0	0
2	24	794	793
2	25	308	308
1	26	1049	582
4	27	17	11
2	28	744	619
3	29	16	7
1	30	360	247
4	31	15	10
4	32	109	6
4	33	359	308
3	34	2	2
2	35	2	1
4	36	2	2
4	37	9	8
4	38	4	4
3	39	13	11
4	40	145	125

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Attack Category	attack ID	Total No Of Records	Attack Recognized
2	1	365	365
3	2	22	0
4	3	3	1
4	4	1302	127
1	5	844	844
4	6	1	1
1	7	44	1
2	8	5	5
3	9	2	2
2	10	573	488
2	11	9	8
4	12	18	10
2	13	1002	276
2	14	9220	9174
1	15	80	80
5	16	46320	43042
3	17	2	0
4	18	2	1
2	19	22	21
1	20	153	153
3	21	13	9
6	22	0	0
6	23	0	0
2	24	794	510
2	25	308	167
1	26	1049	742
4	27	17	14
2	28	744	716
3	29	16	1
1	30	360	255
4	31	15	8
4	32	109	20
4	33	359	3
3	34	2	0
2	35	2	2
4	36	2	2
4	37	9	6
4	38	4	0
3	39	13	3
4	40	145	140

Attack Category	attack ID	Total No Of Records	Attack Recognized
2	1	365	365
3	2	22	8
4	3	3	2
4	4	1302	54
1	5	844	844
4	6	1	1
1	7	44	0
2	8	5	5
3	9	2	2
2	10	573	555
2	11	9	9
4	12	18	10
2	13	1002	349
2	14	9220	9219
1	15	80	80
5	16	46320	41257
3	17	2	1
4	18	2	1
2	19	22	22
1	20	153	151
3	21	13	8
6	22	0	0
6	23	0	0
2	24	794	516
2	25	308	308
1	26	1049	839
4	27	17	12
2	28	744	412
3	29	16	3
1	30	360	253
4	31	15	8
4	32	109	2
4	33	359	4
3	34	2	0
2	35	2	2
4	36	2	2
4	37	9	6
4	38	4	0
3	39	13	6
4	40	145	141

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Table (B.4) MAX INPUT 1200 2 LAYER DISTINCT FOR DIFFERENT HIDDEN NEURONS

Attack Category	attack ID	Total No Of Records	Attack Recognized
2	1	365	0
3	2	22	0
4	3	3	2
4	4	1302	286
1	5	844	844
4	6	1	0
1	7	44	1
2	8	5	5
3	9	2	1
2	10	573	137
2	11	9	9
4	12	18	8
2	13	1002	358
2	14	9220	9220
1	15	80	80
5	16	46320	43141
3	17	2	0
4	18	2	1
2	19	22	6
1	20	153	153
3	21	13	2
6	22	0	0
6	23	0	0
2	24	794	59
2	25	308	0
1	26	1049	1041
4	27	17	7
2	28	744	744
3	29	16	1
1	30	360	256
4	31	15	2
4	32	109	35
4	33	359	4
3	34	2	0
2	35	2	2
4	36	2	0
4	37	9	2
4	38	4	0
3	39	13	0
4	40	145	138

Attack Category	attack ID	Total No Of Records	Attack Recognized
2	1	365	365
3	2	22	1
4	3	3	2
4	4	1302	122
1	5	844	844
4	6	1	1
1	7	44	3
2	8	5	5
3	9	2	2
2	10	573	102
2	11	9	7
4	12	18	7
2	13	1002	563
2	14	9220	9057
1	15	80	80
5	16	46320	41506
3	17	2	0
4	18	2	1
2	19	22	22
1	20	153	153
3	21	13	6
6	22	0	0
6	23	0	0
2	24	794	506
2	25	308	308
1	26	1049	809
4	27	17	13
2	28	744	744
3	29	16	3
1	30	360	255
4	31	15	5
4	32	109	13
4	33	359	3
3	34	2	0
2	35	2	2
4	36	2	0
4	37	9	7
4	38	4	0
3	39	13	3
4	40	145	145

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Attack Category	attack ID	Total No Of Records	Attack Recognized
2	1	365	364
3	2	22	0
4	3	3	2
4	4	1302	194
1	5	844	844
4	6	1	1
1	7	44	2
2	8	5	5
3	9	2	0
2	10	573	54
2	11	9	9
4	12	18	10
2	13	1002	460
2	14	9220	9218
1	15	80	80
5	16	46320	41443
3	17	2	0
4	18	2	1
2	19	22	21
1	20	153	153
3	21	13	4
6	22	0	0
6	23	0	0
2	24	794	592
2	25	308	308
1	26	1049	889
4	27	17	14
2	28	744	744
3	29	16	2
1	30	360	256
4	31	15	8
4	32	109	35
4	33	359	4
3	34	2	0
2	35	2	2
4	36	2	0
4	37	9	6
4	38	4	0
3	39	13	5
4	40	145	141

Attack Category	attack ID	Total No Of Records	Attack Recognized
2	1	365	362
3	2	22	0
4	3	3	2
4	4	1302	414
1	5	844	844
4	6	1	1
1	7	44	39
2	8	5	5
3	9	2	2
2	10	573	117
2	11	9	9
4	12	18	12
2	13	1002	989
2	14	9220	9220
1	15	80	80
5	16	46320	40438
3	17	2	0
4	18	2	1
2	19	22	22
1	20	153	153
3	21	13	9
6	22	0	0
6	23	0	0
2	24	794	783
2	25	308	308
1	26	1049	1045
4	27	17	14
2	28	744	744
3	29	16	2
1	30	360	309
4	31	15	6
4	32	109	56
4	33	359	4
3	34	2	0
2	35	2	2
4	36	2	0
4	37	9	6
4	38	4	0
3	39	13	3
4	40	145	144

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Attack Category	attack ID	Total No Of Records	Attack Recognized
2	1	365	365
3	2	22	6
4	3	3	0
4	4	1302	11
1	5	844	818
4	6	1	1
1	7	44	0
2	8	5	2
3	9	2	0
2	10	573	7
2	11	9	4
4	12	18	2
2	13	1002	252
2	14	9220	8443
1	15	80	62
5	16	46320	44686
3	17	2	0
4	18	2	0
2	19	22	19
1	20	153	28
3	21	13	3
6	22	0	0
6	23	0	0
2	24	794	509
2	25	308	308
1	26	1049	514
4	27	17	13
2	28	744	602
3	29	16	1
1	30	360	225
4	31	15	8
4	32	109	2
4	33	359	0
3	34	2	0
2	35	2	2
4	36	2	2
4	37	9	5
4	38	4	0
3	39	13	5
4	40	145	58

Attack Category	attack ID	Total No Of Records	Attack Recognized
2	1	365	0
3	2	22	1
4	3	3	1
4	4	1302	254
1	5	844	844
4	6	1	1
1	7	44	4
2	8	5	5
3	9	2	0
2	10	573	1
2	11	9	9
4	12	18	8
2	13	1002	434
2	14	9220	9220
1	15	80	80
5	16	46320	44890
3	17	2	0
4	18	2	1
2	19	22	4
1	20	153	153
3	21	13	3
6	22	0	0
6	23	0	0
2	24	794	98
2	25	308	19
1	26	1049	895
4	27	17	8
2	28	744	744
3	29	16	2
1	30	360	255
4	31	15	2
4	32	109	18
4	33	359	4
3	34	2	0
2	35	2	2
4	36	2	0
4	37	9	1
4	38	4	0
3	39	13	0
4	40	145	143

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Attack Category	attack ID	Total No Of Records	Attack Recognized
2	1	365	1
3	2	22	1
4	3	3	1
4	4	1302	40
1	5	844	844
4	6	1	1
1	7	44	0
2	8	5	4
3	9	2	2
2	10	573	194
2	11	9	8
4	12	18	8
2	13	1002	316
2	14	9220	9215
1	15	80	80
5	16	46320	44775
3	17	2	0
4	18	2	0
2	19	22	22
1	20	153	152
3	21	13	2
6	22	0	0
6	23	0	0
2	24	794	498
2	25	308	0
1	26	1049	745
4	27	17	10
2	28	744	675
3	29	16	0
1	30	360	254
4	31	15	2
4	32	109	9
4	33	359	4
3	34	2	0
2	35	2	2
4	36	2	0
4	37	9	3
4	38	4	0
3	39	13	3
4	40	145	133

Attack Category	attack ID	Total No Of Records	Attack Recognized
2	1	365	0
3	2	22	1
4	3	3	2
4	4	1302	243
1	5	844	844
4	6	1	1
1	7	44	1
2	8	5	5
3	9	2	2
2	10	573	40
2	11	9	9
4	12	18	9
2	13	1002	654
2	14	9220	9217
1	15	80	79
5	16	46320	44684
3	17	2	0
4	18	2	1
2	19	22	4
1	20	153	153
3	21	13	4
6	22	0	0
6	23	0	0
2	24	794	148
2	25	308	0
1	26	1049	874
4	27	17	6
2	28	744	725
3	29	16	3
1	30	360	255
4	31	15	2
4	32	109	23
4	33	359	5
3	34	2	0
2	35	2	2
4	36	2	0
4	37	9	2
4	38	4	0
3	39	13	0
4	40	145	142

Table (B.5) MAX INPUT 2000 2 LAYER DISTINCT FOR DIFFERENT HIDDEN NEURONS

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Attack Category	attack ID	Total No Of Records	Attack Recognized
2	1	365	365
3	2	22	6
4	3	3	2
4	4	1302	157
1	5	844	843
4	6	1	0
1	7	44	0
2	8	5	3
3	9	2	1
2	10	573	19
2	11	9	6
4	12	18	11
2	13	1002	468
2	14	9220	9201
1	15	80	79
5	16	46320	43778
3	17	2	1
4	18	2	1
2	19	22	6
1	20	153	152
3	21	13	6
6	22	0	0
6	23	0	0
2	24	794	562
2	25	308	308
1	26	1049	759
4	27	17	11
2	28	744	744
3	29	16	7
1	30	360	255
4	31	15	3
4	32	109	3
4	33	359	1
3	34	2	0
2	35	2	2
4	36	2	2
4	37	9	7
4	38	4	2
3	39	13	2
4	40	145	143

Attack Category	attack ID	Total No Of Records	Attack Recognized
2	1	365	365
3	2	22	0
4	3	3	2
4	4	1302	242
1	5	844	844
4	6	1	1
1	7	44	1
2	8	5	5
3	9	2	1
2	10	573	121
2	11	9	9
4	12	18	8
2	13	1002	824
2	14	9220	9219
1	15	80	80
5	16	46320	42863
3	17	2	0
4	18	2	1
2	19	22	2
1	20	153	152
3	21	13	8
6	22	0	0
6	23	0	0
2	24	794	506
2	25	308	308
1	26	1049	973
4	27	17	12
2	28	744	744
3	29	16	4
1	30	360	258
4	31	15	9
4	32	109	44
4	33	359	4
3	34	2	0
2	35	2	2
4	36	2	0
4	37	9	6
4	38	4	0
3	39	13	3
4	40	145	144

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Attack Category	attack ID	Total No Of Records	Attack Recognized
2	1	365	365
3	2	22	1
4	3	3	2
4	4	1302	348
1	5	844	844
4	6	1	0
1	7	44	11
2	8	5	5
3	9	2	1
2	10	573	25
2	11	9	9
4	12	18	10
2	13	1002	465
2	14	9220	9220
1	15	80	80
5	16	46320	42437
3	17	2	0
4	18	2	1
2	19	22	5
1	20	153	153
3	21	13	7
6	22	0	0
6	23	0	0
2	24	794	488
2	25	308	308
1	26	1049	980
4	27	17	13
2	28	744	744
3	29	16	3
1	30	360	262
4	31	15	11
4	32	109	53
4	33	359	4
3	34	2	0
2	35	2	2
4	36	2	0
4	37	9	6
4	38	4	0
3	39	13	3
4	40	145	143

Attack Category	attack ID	Total No Of Records	Attack Recognized
2	1	365	0
3	2	22	1
4	3	3	1
4	4	1302	11
1	5	844	844
4	6	1	0
1	7	44	0
2	8	5	5
3	9	2	1
2	10	573	1
2	11	9	8
4	12	18	0
2	13	1002	84
2	14	9220	9206
1	15	80	79
5	16	46320	45341
3	17	2	0
4	18	2	1
2	19	22	1
1	20	153	153
3	21	13	2
6	22	0	0
6	23	0	0
2	24	794	2
2	25	308	0
1	26	1049	777
4	27	17	7
2	28	744	681
3	29	16	0
1	30	360	252
4	31	15	0
4	32	109	3
4	33	359	4
3	34	2	0
2	35	2	2
4	36	2	0
4	37	9	6
4	38	4	0
3	39	13	0
4	40	145	129

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Attack Category	attack ID	Total No Of Records	Attack Recognized
2	1	365	365
3	2	22	5
4	3	3	2
4	4	1302	342
1	5	844	844
4	6	1	1
1	7	44	4
2	8	5	5
3	9	2	2
2	10	573	351
2	11	9	9
4	12	18	11
2	13	1002	792
2	14	9220	9220
1	15	80	80
5	16	46320	40205
3	17	2	1
4	18	2	1
2	19	22	22
1	20	153	153
3	21	13	10
6	22	0	0
6	23	0	0
2	24	794	790
2	25	308	308
1	26	1049	916
4	27	17	15
2	28	744	744
3	29	16	5
1	30	360	256
4	31	15	8
4	32	109	49
4	33	359	5
3	34	2	0
2	35	2	2
4	36	2	2
4	37	9	7
4	38	4	2
3	39	13	6
4	40	145	145

Attack Category	attack ID	Total No Of Records	Attack Recognized
2	1	365	348
3	2	22	0
4	3	3	1
4	4	1302	74
1	5	844	843
4	6	1	1
1	7	44	0
2	8	5	5
3	9	2	1
2	10	573	157
2	11	9	7
4	12	18	8
2	13	1002	251
2	14	9220	9220
1	15	80	80
5	16	46320	44638
3	17	2	0
4	18	2	1
2	19	22	4
1	20	153	152
3	21	13	2
6	22	0	0
6	23	0	0
2	24	794	657
2	25	308	0
1	26	1049	820
4	27	17	9
2	28	744	744
3	29	16	0
1	30	360	254
4	31	15	2
4	32	109	6
4	33	359	1
3	34	2	0
2	35	2	2
4	36	2	0
4	37	9	5
4	38	4	0
3	39	13	0
4	40	145	139

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Attack Category	attack ID	Total No Of Records	Attack Recognized
2	1	365	16
3	2	22	1
4	3	3	2
4	4	1302	461
1	5	844	844
4	6	1	0
1	7	44	24
2	8	5	5
3	9	2	2
2	10	573	1
2	11	9	9
4	12	18	12
2	13	1002	884
2	14	9220	9220
1	15	80	80
5	16	46320	43075
3	17	2	0
4	18	2	1
2	19	22	4
1	20	153	153
3	21	13	8
6	22	0	0
6	23	0	0
2	24	794	612
2	25	308	0
1	26	1049	1030
4	27	17	11
2	28	744	744
3	29	16	4
1	30	360	282
4	31	15	6
4	32	109	S51
4	33	359	4
3	34	2	0
2	35	2	2
4	36	2	0
4	37	9	5
4	38	4	1
3	39	13	1
4	40	145	143

Attack Category	attack ID	Total No Of Records	Attack Recognized
2	1	365	0
3	2	22	1
4	3	3	2
4	4	1302	767
1	5	844	844
4	6	1	1
1	7	44	42
2	8	5	5
3	9	2	2
2	10	573	177
2	11	9	9
4	12	18	10
2	13	1002	610
2	14	9220	9220
1	15	80	80
5	16	46320	38849
3	17	2	0
4	18	2	1
2	19	22	5
1	20	153	153
3	21	13	6
6	22	0	0
6	23	0	0
2	24	794	128
2	25	308	0
1	26	1049	951
4	27	17	7
2	28	744	744
3	29	16	5
1	30	360	315
4	31	15	6
4	32	109	55
4	33	359	4
3	34	2	0
2	35	2	2
4	36	2	0
4	37	9	2
4	38	4	0
3	39	13	0
4	40	145	143

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Attack Category	attack ID	Total No Of Records	Attack Recognized
2	1	365	365
3	2	22	3
4	3	3	2
4	4	1302	212
1	5	844	844
4	6	1	1
1	7	44	0
2	8	5	5
3	9	2	2
2	10	573	460
2	11	9	9
4	12	18	11
2	13	1002	804
2	14	9220	9183
1	15	80	79
5	16	46320	41540
3	17	2	0
4	18	2	1
2	19	22	22
1	20	153	152
3	21	13	7
6	22	0	0
6	23	0	0
2	24	794	517
2	25	308	308
1	26	1049	885
4	27	17	14
2	28	744	744
3	29	16	4
1	30	360	254
4	31	15	8
4	32	109	29
4	33	359	3
3	34	2	0
2	35	2	2
4	36	2	0
4	37	9	7
4	38	4	1
3	39	13	4
4	40	145	144

Attack Category	attack ID	Total No Of Records	Attack Recognized
2	1	365	365
3	2	22	11
4	3	3	2
4	4	1302	103
1	5	844	844
4	6	1	1
1	7	44	1
2	8	5	5
3	9	2	2
2	10	573	31
2	11	9	9
4	12	18	11
2	13	1002	805
2	14	9220	9219
1	15	80	80
5	16	46320	42132
3	17	2	0
4	18	2	1
2	19	22	22
1	20	153	153
3	21	13	7
6	22	0	0
6	23	0	0
2	24	794	516
2	25	308	308
1	26	1049	801
4	27	17	15
2	28	744	744
3	29	16	5
1	30	360	256
4	31	15	8
4	32	109	25
4	33	359	4
3	34	2	0
2	35	2	2
4	36	2	2
4	37	9	7
4	38	4	1
3	39	13	8
4	40	145	144

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Attack Category	attack ID	Total No Of Records	Attack Recognized
2	1	365	365
3	2	22	8
4	3	3	1
4	4	1302	152
1	5	844	843
4	6	1	1
1	7	44	0
2	8	5	5
3	9	2	2
2	10	573	468
2	11	9	4
4	12	18	10
2	13	1002	757
2	14	9220	9183
1	15	80	80
5	16	46320	42345
3	17	2	0
4	18	2	1
2	19	22	22
1	20	153	153
3	21	13	6
6	22	0	0
6	23	0	0
2	24	794	516
2	25	308	308
1	26	1049	711
4	27	17	16
2	28	744	712
3	29	16	3
1	30	360	254
4	31	15	8
4	32	109	7
4	33	359	0
3	34	2	0
2	35	2	2
4	36	2	0
4	37	9	7
4	38	4	2
3	39	13	9
4	40	145	137

Attack Category	attack ID	Total No Of Records	Attack Recognized
2	1	365	0
3	2	22	2
4	3	3	1
4	4	1302	282
1	5	844	844
4	6	1	1
1	7	44	2
2	8	5	5
3	9	2	2
2	10	573	15
2	11	9	9
4	12	18	10
2	13	1002	375
2	14	9220	9188
1	15	80	80
5	16	46320	44501
3	17	2	0
4	18	2	1
2	19	22	18
1	20	153	153
3	21	13	4
6	22	0	0
6	23	0	0
2	24	794	0
2	25	308	0
1	26	1049	867
4	27	17	9
2	28	744	742
3	29	16	3
1	30	360	253
4	31	15	2
4	32	109	5
4	33	359	4
3	34	2	0
2	35	2	2
4	36	2	0
4	37	9	2
4	38	4	1
3	39	13	1
4	40	145	141

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Attack Category	attack ID	Total No Of Records	Attack Recognized
2	1	365	365
3	2	22	6
4	3	3	2
4	4	1302	205
1	5	844	844
4	6	1	1
1	7	44	21
2	8	5	5
3	9	2	2
2	10	573	27
2	11	9	8
4	12	18	14
2	13	1002	423
2	14	9220	9220
1	15	80	80
5	16	46320	42317
3	17	2	1
4	18	2	1
2	19	22	19
1	20	153	153
3	21	13	5
6	22	0	0
6	23	0	0
2	24	794	30
2	25	308	308
1	26	1049	955
4	27	17	13
2	28	744	409
3	29	16	8
1	30	360	275
4	31	15	12
4	32	109	39
4	33	359	4
3	34	2	0
2	35	2	2
4	36	2	0
4	37	9	4
4	38	4	2
3	39	13	3
4	40	145	136

Attack Category	attack ID	Total No Of Records	Attack Recognized
2	1	365	365
3	2	22	1
4	3	3	2
4	4	1302	219
1	5	844	843
4	6	1	0
1	7	44	0
2	8	5	4
3	9	2	1
2	10	573	384
2	11	9	3
4	12	18	10
2	13	1002	535
2	14	9220	9175
1	15	80	78
5	16	46320	42755
3	17	2	0
4	18	2	1
2	19	22	4
1	20	153	152
3	21	13	4
6	22	0	0
6	23	0	0
2	24	794	493
2	25	308	173
1	26	1049	773
4	27	17	11
2	28	744	742
3	29	16	4
1	30	360	254
4	31	15	5
4	32	109	19
4	33	359	1
3	34	2	0
2	35	2	2
4	36	2	0
4	37	9	6
4	38	4	1
3	39	13	1
4	40	145	142

THE DETAILED TABLES OF THE 11 SYSTEMS OF COMPARISON

Table (B.6) The detailed recognition of sys1.

Table (B.7) The detailed recognition of sys2.

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Attack ID	Total No Of Records	Attack Recognized	%
1	1098	1098	100
2	22	5	22.7272
3	3	2	66.6666
4	4367	277	6.34302
5	1633	1633	100
6	1	1	100
7	306	4	1.30719
8	9	9	100
9	2	1	50
10	164091	164021	99.9573
11	12	12	100
12	18	10	55.5555
13	1602	1108	69.1635
14	58001	58001	100
15	84	84	100
16	60593	56601	6.58822
17	2	0	0
18	2	1	50
19	87	87	100
20	354	354	100
21	13	3	23.0769
22	0	0	0
23	0	0	0
24	794	593	74.6851
25	5000	5000	100
26	1053	839	79.6771
27	17	14	82.3529
28	759	757	99.7365
29	16	4	25
30	736	631	85.7337
31	17	8	47.0588
32	7741	28	0.36171
33	2406	4	0.16625
34	2	0	0
35	2	2	100
36	2	0	0
37	9	7	77.7777
38	4	0	0
39	13	5	38.4615
40	158	156	98.7341

Table (B.8) The detailed recognition of sys3.

attack ID	Total No Of Records	Attack Recognized	%
1	1098	1098	100
2	22	1	4.545
3	3	2	66.66
4	4367	4356	99.74
5	1633	1633	100
6	1	1	100
7	306	306	100
8	9	9	100
9	2	2	100
10	164091	164091	100
11	12	12	100
12	18	13	72.22
13	1602	1601	99.93
14	58001	58001	100
15	84	84	100
16	60593	27413	45.2
17	2	0	0
18	2	1	50
19	87	87	100
20	354	354	100
21	13	8	61.53
22	0	0	0
23	0	0	0
24	794	794	100
25	5000	5000	100
26	1053	1052	99.90
27	17	16	94.11
28	759	759	100
29	16	6	37.5
30	736	735	99.86
31	17	14	82.35
32	7741	7741	100
33	2406	2406	100
34	2	0	0
35	2	2	100
36	2	0	0
37	9	7	77.77
38	4	0	0
39	13	6	46.15
40	158	158	100

Table (B.9) The detailed recognition of sys5..

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Attack ID	Total No Of Records	Attack Recognized	%
1	1098	0	0
2	22	1	4.545455
3	3	1	33.33333
4	4367	11	0.251889
5	1633	1633	100
6	1	0	0
7	306	0	0
8	9	9	100
9	2	1	50
10	164091	1	0.000609
11	12	10	83.33333
12	18	0	0
13	1602	84	5.243446
14	58001	57970	99.94655
15	84	83	98.80952
16	60593	59346	2.057993
17	2	0	0
18	2	1	50
19	87	2	2.298851
20	354	354	100
21	13	2	15.38462
22	0	0	0
23	0	0	0
24	794	2	0.251889
25	5000	0	0
26	1053	781	74.16904
27	17	7	41.17647
28	759	689	90.77734
29	16	0	0
30	736	627	85.19022
31	17	0	0
32	7741	3	0.038755
33	2406	4	0.166251
34	2	0	0
35	2	2	100
36	2	0	0
37	9	6	66.66667
38	4	0	0
39	13	0	0
40	158	142	89.87342

Table (B.10) The detailed recognition of sys8.

attack ID	Total No Of Records	Attack Recognized	%
1	1098	1098	100
2	22	21	95.45455
3	3	3	100
4	4367	4136	94.71033
5	1633	1629	99.75505
6	1	1	100
7	306	6	1.960784
8	9	3	33.33333
9	2	2	100
10	164091	164091	100
11	12	12	100
12	18	15	83.33333
13	1602	1002	62.54682
14	58001	57984	99.97069
15	84	62	73.80952
16	60593	10881	82.04248
17	2	2	100
18	2	1	50
19	87	87	100
20	354	345	97.45763
21	13	5	38.46154
22	0	0	0
23	0	0	0
24	794	793	99.87406
25	5000	5000	100
26	1053	730	69.32574
27	17	11	64.70588
28	759	252	33.20158
29	16	11	68.75
30	736	623	84.64674
31	17	12	70.58824
32	7741	7684	99.26366
33	2406	2406	100
34	2	2	100
35	2	1	50
36	2	2	100
37	9	8	88.88889
38	4	4	100
39	13	11	84.61538
40	158	150	94.93671

Table (B.11) The detailed recognition of sys4.

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Attack ID	Total No Of Records	Attack Recognized	%
1	1098	1098	100
2	22	7	31.818
3	3	2	66.666
4	4367	4295	98.351
5	1633	1633	100
6	1	1	100
7	306	149	48.692
8	9	9	100
9	2	2	100
10	164091	164091	100
11	12	12	100
12	18	13	72.222
13	1602	1601	99.937
14	58001	58001	100
15	84	84	100
16	60593	30965	51.103
17	2	0	0
18	2	1	50
19	87	87	100
20	354	354	100
21	13	9	69.230
22	0	0	0
23	0	0	0
24	794	794	100
25	5000	5000	100
26	1053	1043	99.050
27	17	16	94.117
28	759	759	100
29	16	8	50
30	736	635	86.277
31	17	9	52.941
32	7741	7741	100
33	2406	2406	100
34	2	0	0
35	2	2	100
36	2	2	100
37	9	7	77.77
38	4	0	0
39	13	8	61.538
40	158	158	100

Table (B.12) The detailed recognition of sys7.

attack ID	Total No Of Records	Attack Recognized	%
1	1098	1098	100
2	22	1	4.545
3	3	2	66.66
4	4367	4356	99.74
5	1633	1633	100
6	1	1	100
7	306	306	100
8	9	9	100
9	2	2	100
10	164091	164091	100
11	12	12	100
12	18	13	72.22
13	1602	1601	99.93
14	58001	58001	100
15	84	84	100
16	60593	27413	45.24
17	2	0	0
18	2	1	50
19	87	87	100
20	354	354	100
21	13	8	61.53
22	0	0	0
23	0	0	0
24	794	794	100
25	5000	5000	100
26	1053	1052	99.90
27	17	16	94.11
28	759	759	100
29	16	6	37.5
30	736	735	99.86
31	17	14	82.35
32	7741	7741	100
33	2406	2406	100
34	2	0	0
35	2	2	100
36	2	0	0
37	9	7	77.77
38	4	0	0
39	13	6	46.15
40	158	158	100

Table (B.13) The detailed recognition of sys9.

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Attack ID	Total No Of Records	Attack Recognized	%
1	365	365	100
2	22	21	95.45455
3	3	3	100
4	1302	1071	82.25806
5	844	840	99.52607
6	1	1	100
7	44	3	6.818182
8	5	3	60
9	2	2	100
10	573	573	100
11	9	9	100
12	18	15	83.33333
13	1002	706	70.45908
14	9220	9203	99.81562
15	80	60	75
16	46320	10529	77.269
17	2	2	100
18	2	1	50
19	22	22	100
20	153	144	94.11765
21	13	11	84.61538
22	0	0	0
23	0	0	0
24	794	793	99.87406
25	308	308	100
26	1049	727	69.3041
27	17	11	64.70588
28	744	237	31.85484
29	16	11	68.75
30	360	248	68.88889
31	15	12	80
32	109	55	50.45872
33	359	359	100
34	2	2	100
35	2	1	50
36	2	2	100
37	9	8	88.88889
38	4	4	100
39	13	11	84.61538
40	145	137	94.48276

Table (B.14) The detailed recognition of sys10.

attack ID	Total No Of Records	Attack Recognized	%
1	365	12	3.287671
2	22	0	0
3	3	1	33.33333
4	1302	2	0.15361
5	844	844	100
6	1	0	0
7	44	0	0
8	5	5	100
9	2	1	50
10	573	245	42.75742
11	9	0	0
12	18	6	33.33333
13	1002	477	47.60479
14	9220	9210	99.89154
15	80	80	100
16	46320	44588	3.739206
17	2	0	0
18	2	1	50
19	22	18	81.81818
20	153	151	98.69281
21	13	3	23.07692
22	0	0	0
23	0	0	0
24	794	517	65.11335
25	308	0	0
26	1049	659	62.82173
27	17	13	76.47059
28	744	593	79.7043
29	16	0	0
30	360	249	69.16667
31	15	0	0
32	109	6	5.504587
33	359	3	0.835655
34	2	0	0
35	2	2	100
36	2	0	0
37	9	4	44.44444
38	4	0	0
39	13	1	7.692308
40	145	134	92.41379

Table (B.15) The detailed recognition of sys11

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Attack ID	Total No Of Records	Attack Recognized	%
1	365	365	100
2	22	1	4.545455
3	3	2	66.66667
4	1302	611	46.9278
5	844	844	100
6	1	1	100
7	44	34	77.27273
8	5	5	100
9	2	2	100
10	573	573	100
11	9	9	100
12	18	12	66.66667
13	1002	974	97.20559
14	9220	9220	100
15	80	80	100
16	46320	27916	39.7323
17	2	0	0
18	2	1	50
19	22	22	100
20	153	153	100
21	13	10	76.92308
22	0	0	0
23	0	0	0
24	794	794	100
25	308	308	100
26	1049	1016	96.85415
27	17	16	94.11765
28	744	744	100
29	16	7	43.75
30	360	303	84.16667
31	15	8	53.33333
32	109	61	55.9633
33	359	5	1.392758
34	2	0	0
35	2	2	100
36	2	0	0
37	9	7	77.77778
38	4	0	0
39	13	6	46.15385
40	145	145	100

attack ID	Total No Of Records	Attack Recognized	%
1	365	365	100
2	22	9	40.90909
3	3	2	66.66667
4	1302	1291	99.15515
5	844	844	100
6	1	1	100
7	44	41	93.18182
8	5	5	100
9	2	2	100
10	573	573	100
11	9	9	100
12	18	13	72.22222
13	1002	966	96.40719
14	9220	9220	100
15	80	80	100
16	46320	25052	45.91537
17	2	0	0
18	2	1	50
19	22	22	100
20	153	153	100
21	13	10	76.92308
22	0	0	0
23	0	0	0
24	794	793	99.87406
25	308	308	100
26	1049	1048	99.90467
27	17	16	94.11765
28	744	569	76.47849
29	16	8	50
30	360	356	98.88889
31	15	11	73.33333
32	109	108	99.08257
33	359	359	100
34	2	0	0
35	2	2	100
36	2	0	0
37	9	7	77.77778
38	4	0	0
39	13	8	61.53846
40	145	145	100

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Table (B.16) The detailed recognition of sys6.

attack ID	Total No Of Records	Attack Recognized	%
1	365	0	0
2	22	1	4.545455
3	3	1	33.33333
4	1302	11	0.844854
5	844	844	100
6	1	0	0
7	44	0	0
8	5	5	100
9	2	1	50
10	573	1	0.17452
11	9	8	88.88889
12	18	0	0
13	1002	84	8.383234
14	9220	9206	99.84816
15	80	79	98.75
16	46320	45341	2.113558
17	2	0	0
18	2	1	50
19	22	1	4.545455
20	153	153	100
21	13	2	15.38462
22	0	0	0
23	0	0	0
24	794	2	0.251889
25	308	0	0
26	1049	777	74.07054
27	17	7	41.17647
28	744	681	91.53226
29	16	0	0
30	360	252	70
31	15	0	0
32	109	3	2.752294
33	359	4	1.114206
34	2	0	0
35	2	2	100
36	2	0	0
37	9	6	66.66667
38	4	0	0
39	13	0	0
40	145	129	88.96552

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نظام كشف الاختراق الحاسوب بواسطة تقنية تمييز الانماط

إعداد
ياسمين إقبال الزوقري

المشرف
الدكتور محمد الراوي

المشرف المشارك
الدكتور عبد اللطيف ابودلهوم

ملخص

في هذة الاطروحة يتم اقتراح نظام لكشف الاختراق مبني على تمييز الانماط باستخدام الشبكات العصبونيةز باستخدام قاعدة معلومات عالمية يعرف ب KDDCup99 , حيث يتضمن مجموعة بيانات تدريبية متكاملة بحجم 708 ميجابايت به 4898430 من السجلات و مجموعة بيانات اختبارية بحجم 45 ميجابايت به 311032 من السجلات استخدمت للتدريب و التجربة.

تم اكتشاف وجود تكرار بهذة البيانات لهذا استخدمنا اوامر ال SQL للتخلص من هذا التكرار في مجموعة من .عامل التكرارللبيانات التدريب كانت اكثر من اربعة و نصف بالنسبة للبيانات بدون التكرار و اكثر بحوالي اربع مرات لبيانات الاختبار.

بعد تطبيق النظام المقترح على البيانات السابقة تم ايجاد أنه يعطي نتائج اعلى في حالة تطبيقه على البيانات المتكررة من حالة تطبيقه على البيانات الغير متكررة , و الذي من خلاله تم استنتاج أنهيجب استخدام البيانات الغير متكررة عند اختيار البيانات المتكررة فانه سيعطي نسبة عالية من التحسين و لكن هذا التحسين غير حقيقي بسبب وجود عامل التكرار بهذه البيانات , لذلك ينصح باستخدام البيانات الغير متكررة بالنسبة لاي نظام كشف اختراق يعتمد على بيانات ال KDDCup 99 . لقد اقترحنا استخدام مقياس جديد سمي بالتأدية الحقيقية و هي تعتمد على المقاييس FPR , PSP &FNR لامكانية المقارنة الدقيقة للانظمة باستخدام مقياس وحيد بدلا عن استخدام ال TPR & FPR

المنارة للاستشارات
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