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Aims and Scope

Journal of Wireless Communication and Simulation has become very important with the ever increasing demands of the software development to serve the millions of applications across various disciplines. For large software projects, innovative software development approaches are of vital importance. In order to gain higher software standards and efficiency, software process adaptation must be derived from social behavior, planning, strategy, intelligent computing, etc., based on various factors. This Journal addresses the state of the art of all aspects of software engineering, highlighting the all tools and techniques for the software development process.

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Contents

Adaptive Neuro-Fuzzy Inference System for Anomaly-Based Intrusion Detection

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A B S T R A C T

With the increase in the growth of computer networks throughout the past years, the network security has become an essential issue. Among the numerous network security measures, intrusion detection systems play a dynamic function with integrity, confidentiality and accessibility of resources. It appears that the existence of uncertainty and the imprecise nature of the intrusions make detection systems hard to solve the problem. In network based intrusion detection system, the large number of relatively, redundant characteristics of features increases the processing and saving time data. For improving the anomaly detection accuracy, implementation of significant rough set based feature selection techniques is discussed in previous publication, in which original data set is reduced to some essential feature subset based on certain defined criterion. The previous publication discusses the entropy-Based feature reduction technique, in which it determines only those attributes that provides more gain in information. Secondly, open-loop and closed loop based feature selection technique. Open-loop based feature selection is centered on selection of features based on between-class separability criterion and closed-loop based feature selection based on feature selection criterion based on predictor performance to select the feature subset. The important objective of this work is to utilize adaptive neuro-fuzzy inference system as a classifier to detect intrusions in computer networks. It considers the reduced data set as input and by generating rules they can observe the various anomalies. Experiment for evaluation of the classifier was performed with the KDD Cup 99 intrusion detection data set. The inclusive results demonstrate that ANFIS can be operative in detecting various intrusions.

Key Words Intrusion detection system; Anomaly detection; Rough set; ANFIS

1. INTRODUCTION

As network-based computer systems play larger roles in modern society, information becomes more important to drive economic and social developments. The problem of data security is gradually outstanding while people share resources highly. In the network environment, it has become the target of intrusion by intruders. As it is well known as second safety wall after firewall, Intrusion Detection Systems (IDSs) could collect information from network or system and analyze information, so that it can identify who are using a computer system without authorization and who have legitimate access to the system but are abusing their privileges. On Network Intrusion Detection (NID), the system needs to manage massive amounts of network data in real-time. Network data comprises a variety of features [1], where there exist many irrelevant and redundant features that will drop the intrusion detection accuracy. For developing IDS, the principal objective is to focus on the classification rate. To achieve high accuracy most of the detection system not efficient to address the existence of intrusion. All the features of a data set are used to compare with the known intrusive patterns which are a very overlong detection technique. In general, there are mainly two approaches for detecting intrusion into computer networks: misuse detection and anomaly detection. Misuse detection systems use forms of well-known attacks to match and identify known intrusions; it is useless to unknown attacks. The anomaly detection system controls the abnormality by measuring the distance between the anomalous activity and the normal activity based on a chosen threshold.

For developing more accurate IDS, two main approaches have been used in this work; one is Rough Set Theory (RST) and the second is Adaptive-Neuro-Fuzzy Inference System (ANFIS). RST defines an initial work in determining the optimal subset of features presented in previous publication [2]. It can be used as a tool to find the data dependencies and to reduce the number of features contained in the data set. The proposed ANFIS classification system explained in the next subsection of Section 3, extracts feature-wise information of input form to different classes. Since all features are not equally important in discriminating all classes, the feature-wise belonging is expected to help in the classification process. From the classification point of view, the primary work of building IDS is to build a classifier which can classify normal and intrusive event data from the novel dataset.

ANFIS can include human expertise as well as adopt itself through repeated training. This ability among others qualifies ANFIS as a fuzzy classifier for IDS.

1.1 Intrusion Detection System

Before looking forward to IDS, first discuss what an intrusion is, it is unauthorized access to the network through which an intruder can steal or modify user data from the system. An example is, a hacker can obtain access into the server of the bank and steal important information about credit cards of employees. Another small example is intruder, accesses the school or college server and obtains the student social network identity and password. As the web is growing rapidly, network security is an important issue; hence IDS comes into consideration. IDS design for detecting the unauthorized intrusions and attacks by knowing and doing studies about network behaviors, security logs, by auditing dataset and internet information to observe the network for presence of intrusion and attacks. It is recognized as second security level after firewall protection because it furnishes the real time protection for both internal and external attacks [3].

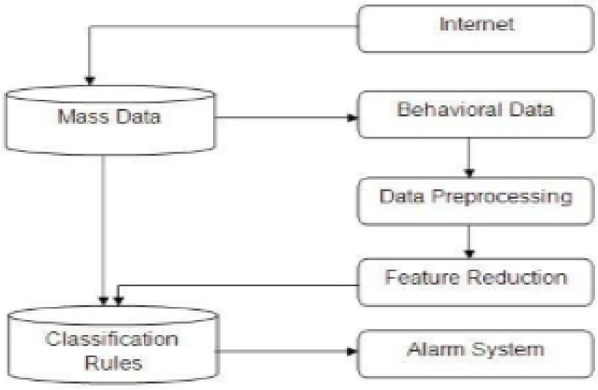

Fig 1 Process of intrusion detection system

The architecture of IDS as shown in "Fig. 1" depicts that how behavioral features are extracted from processing data comes from the internet [4]. It preprocesses extracted behavioral features and transforms it into low dimensional data as it is in high dimensional data. This process eliminates irrelevant or redundant feature to improving the detection accuracy. Now classification rules are obtained according to results obtained from feature reduction. Finally, mass data are screened from the classification rule. When any intrusion detected it will give an alarm.

1.2 Anomaly Based Intrusion Detection System

Anomaly based intrusion detection system uses the process of comparing normal definitions which is considered against observed events for observing behaviors. Consideration of normal activity is described by a profile, which normally describes the normal behavior of specific things such as users, hosts, network, connections and applications by events and statistical data developed by monitoring the certain characteristics of normal activity over period of duration. The IDS can for example use statistical methods for comparing the characteristics of current network activity to the threshold defined by profile. Anomaly based detection has two main advantages, First is the ability to detect unknown and "zero day" attack. This is done by comparing the normal activity with that of deviation from them. For example, a new type of malware typically results in deviated behavior such as there is a certain increase in sent emails, abnormally large number of network connection or any behavior that exceed threshold established by the profile for the given computer. The initial profile is generated at the time of training which may be typically days or sometimes weeks long. Second one is the normal activity profile are customized for system, network and therefore making it very difficult for an attacker to know with certainty what activities it can carry out without getting detected [5].

1.3 Paper Organization

This paper is organized as follows. Related literature survey is discussed in Section 2. The detailed background and basics of ANFIS is reviewed in Section 3. Fuzzy logic and neuro-fuzzy that is used to build the ANFIS explained briefly in subsection of Section 3. Section 4 presents a brief overview of the proposed work along with the elaborate description of each stage. Next, the simulation results of the proposed work are shown in Section 5. In this Section, implementation of rough set based feature selection algorithms and ANFIS classification result is shown. Next subsection of Section 5 clarified the comparison of ANFIS classification over the different number of samples and also the standard metrics such as detection rate, false positive etc. is computed. The next section of the paper contains the conclusion of proposed work along with future scope followed by summary references.

2. RELATED LITERATURE

Tianen Liu in [6] discussed the different types of approaches for identifying anomalies intrusion based on NIDS. Statistical anomaly detection, rule based anomaly detection, and data mining algorithms to detect anomalies. Anomaly detection is the behavior based detection, sets up the observed behavior model for learning phase. If a certain behavior does not match with existence behavior, then network considers it as intrusion [7]. Starting with statistical anomaly detection, it utilizes the analysis obtained from audit logs for detection of anomalies from normal user behavior. Learning from the Past behavior of user is useful for most statistical anomaly detection. If any change occurs in in behavior, it generates alerts. Mean and standard deviation method can be applied in determining normal behavior, e.g. Intrusion Detection Expert System (IDES). Next is rule based anomaly detection, in which analysis of audit data and it automatically developed set of patterns to describe normal behavior. As a new event occurs is tested with developed rule to check it is normal. Statisticgenerates rules; hence large database of rules needs to better work. The data mining approach involves various sets of technique that processes a set of data and detects the required pattern and deviations which is otherwise difficult to detect.

Zadeh in [8] presented the general idea of fuzzy set theory and it was principally proposed mathematically to show uncertainty and vagueness with formalized logical tools for dealing with the vagueness associated with many real world problems. The membership value of a fuzzy set of an element defines a basic function knows as membership function in which the universe of discourse is the domain and the interval lies in the range [0, 1]. The value 0 and 1 refers to the element which is not a member of the fuzzy set and fully a member of the fuzzy set respectively. The values that remain between 0 and 1 distinguish fuzzy members, which restricted to the fuzzy set merely partially. Only the source presented an explanation that the fuzzy membership value and fuzzy membership function for the counterpart of a fuzzy set are same concepts and the surface value is always calculated from the primer floor.

In the networked computers there are two cases of behavior one is normal and another is abnormal behaviors which are difficult for prediction, as the boundaries cannot be explained clearly. This detection method generally produces fake alarms in many various anomaly based intrusion detection systems. Authors in [9] presented the concept of fuzzy logic for bringing down the false alarm rate in determining intrusive behavior. The calculated set of fuzzy rules is applied to classify the normal and abnormal behavior in a computer network. The authors in this particular paper proposed a technique to generate fuzzy rules which are applied to detect malicious activities and certain specific intrusions. This system presented a novel approach for the presentation of generating fuzzy rules in classifying different types of intrusions. The significant benefit of their suggested mechanism is that the fuzzy rules are capable to find out the malicious actions. One problem observed here that, they ignored to go through the real time network traffic, additional attributes for the categorization patterns. In defining the fuzzy rules, the writer applied the concept of fuzzy membership function and reference function, but they stated that the MF and extension function are same. In reality, these two concepts are completely different.

Gong et al in [10] provided an implementation of genetic based approach to NID using genetic algorithm and presented software implementation for detecting the malicious activities. The approach obtained lots of classification rules from network audit data and operates a support-confidence framework to judge the quality of each rule. The produced rules are then used in IDS to detect and to classify network intrusions capably in a real-time environment. Principally, certain restrictions of their implemented method are observed. First, the generated rules were incomplete to the training data set. Second, though the support-confidence framework is simple to implement and provides improved accuracy to final rules, it demands the whole training datasets to be loaded into memory before any computation. For huge training data sets, it is neither effective nor feasible.

Hoque et al in [11] presented an implementation of IDS by applying the principle of genetic algorithm to capably detect various types of network intrusive activities. To utilize and evaluate the effectiveness of their system they employed the standard KDD CUP'99 intrusion detection standard data set and obtained the truthful detection rate.

3. FUZZY LOGIC AND NEURO-FUZZY

Fuzzy logic explained by Zadeh [8] which is extension of Boolean logic, which is normally used for computer based complex decision making. In classical boolean logic an element can either a complete member or non-member of a Boolean or crisp set. The membership value of an element of a fuzzy set lies in the interval [0, 1], which also allow partial membership of an element in the set and the function which determine this range value called as MF. A fuzzy expert system consists of three various types of entities: fuzzy set, fuzzy variables and fuzzy rules. Fuzzy variables are particularly divided into mainly two groups: one is antecedent variables, which are assigned to the input data of fuzzy expert system and another is consequent variables that are assigned with the result calculated by the system. Next, the fuzzy rules outline link among the antecedent and the consequent fuzzy variables, and are regularly using natural language philological terms. Fuzzy rules are of “if- then” types, e.g.” if the temperature is cold and the wind is strong then wear warm clothes”, here temperature and wind are antecedent fuzzy variables, wear is a consequent fuzzy variables and cold, strong and warm clothes are fuzzy set.

The process of typical fuzzy process has mainly three steps, which are fuzzification, rule evaluation and defuzzification. In first step, i.e. fuzzification, the input crisp values are transformed into degree of membership in the fuzzy sets. The degree of membership of each crisp value in the fuzzy set is calculated by persevering the values into the MF related with the fuzzy set. In rule evaluation step, a strength value is allocated to fuzzy rule. The degree of membership determines the strength of crisp input values in the fuzzy sets of antecedent part of the fuzzy rule. The final step, Defuzzification stage transposes the fuzzy outputs into the crisp values.

Baruah [12] discovered that a fuzzy number [a, b, c] which can be clarified with reference to a MF $\mu(x)$ remaining between 0 and 1, $a \le x \le c$. Further author has described this definition in the following manner. Let $\mu1(x)$ and $\mu2(x)$ be two functions, $0 \le \mu2(x) \le \mu1(x) \le 1$. The author has concluded $\mu1(x)$ the fuzzy membership function, and $\mu2(x)$ a reference function, such that $(\mu1(x) - \mu2(x))$ is the fuzzy membership value for any x. Finally he has categorized such a fuzzy number by $\{x, \mu1(x), \mu2(x); x \quad \Omega\}$.

3.1. Fuzzy Inference System

Fuzzy inference systems are also identifies by the name fuzzy rule based systems, fuzzy models etc. FIS is composed of five functional blocks.

- a rule base containing a number of fuzzy if-then rules;
- a database which defines the MF of the fuzzy sets used in the fuzzy rules;
- a decision-making unit which performs the inference operations on the rules;
- a fuzzification interface which transforms the crisp inputs into degrees of match with linguistic values;

- a defuzzification interface which transform the fuzzy results of the inference into a crisp output. Usually, the rule base and the database are mutually denoted to as knowledge. Fuzzy reasoning steps as explained below (inference operations upon fuzzy if-then rules) which performed by fuzzy inference system:
- Compare the input variables with the MF on the premise part to obtain the membership values (or compatibility measures) of each linguistic label. (This step is often called fuzzification).
- Membership values on the premise part to get firing strength (weight) of each rule.
- Generate the qualified consequent (either fuzzy or crisp) of each rule depending on the firing strength.
- Aggregate the qualified consequents to produce a crisp output. (This step is called defuzzification.)

3.2. Adaptive Neuro-Fuzzy Inference System

This section discusses the ANFIS structure as a class of adaptive network which is functionally correspondent to the sugeno fuzzy inference systems. There are some modeling situations in which one cannot just look at the data and differentiate what the MFs should appear. Rather than picking the parameters which are connected to a given MF arbitrarily, choosing these parameters such that they modify the MFs to the input/output data in order to account for these types of variations in the data values. ANFIS can help this type of neuro-adaptive learning technique. Consider a fuzzy inference system with inputs x, y and only one output z with the first order of sugeno fuzzy model. Fuzzy rule set with two fuzzy if-then rules are as follow:

If x is A1 and y is B1, then f1=p1x+q1y+r1

If x is A2 and y is B2, then f2=p2x+q2y+r2

Following “Fig. 2” demonstrates the reasoning mechanism for this sugeno model. “Fig. 3” show the implementation of reasoning mechanism into feed forward neural network with supervised learning capability, known as ANFIS architecture. The square and circle nodes are for adaptive nodes with parameters and fixed nodes without parameters, respectively. The working of first layer, it consists of square a node which performs fuzzification with chosen MF. The parameters in this layer are called as premise parameters. In second layer, the t-norm operation is performed for producing firing strength of each rule. In the third layer the ratio of ith rule firing strength to the sum of all rule's firing strength is calculated by generating the normalized firing strengths. The fourth layer consists of square a node that performs multiplication of normalized firing strength with the corresponding rule. The parameters in this layer are known as as consequent parameters. Next, the overall output is calculated by summing all incoming signals in the fifth layer [13].

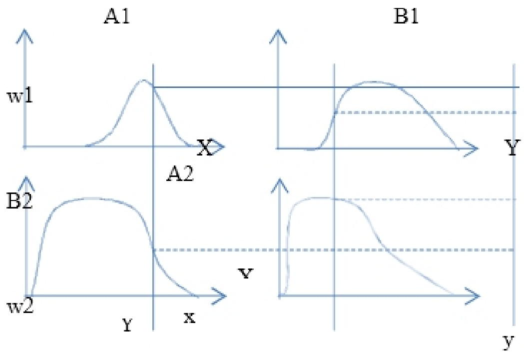

Fig. 2. The Sugeno fuzzy model reasoning

$$f_1 = p_1x + q_1x + r_1$$

$$\Rightarrow \quad f = \frac{w_1f_1 + w_2f_2}{w_1 + w_2}$$

$$f_1 = p_1x + q_1x + r_1$$

$$= \overline{w_1} f_1 + \overline{w_2} f_2$$

ANFIS provides a method for fuzzy modeling procedure to learn information about data set, for compute the MF parameters that agree to the associated fuzzy inference system to track the input/output data. This learning method works in the same way of neural networks. The parameters related with the MFs will change through the learning process. ANFIS uses either back propagation or a combination least square estimations back propagation for MF parameter estimations. FIS generation can implement either in grid partitioning or subtractive clustering. In grid partitioning, all the rules are generated based on the number of MFs for each input. For example in a two dimensional input space, with three MFs in the input sets, the number of rules in grid partitioning will result in 9 rules. Thispartitioning strategy needs only a small number of MFs for each input and it encounters problems when there is large number of inputs. So subtractive clustering has been used to determine the number of rules, the MFs and their initial points [14]. It is an annex of the mountain clustering method suggested by Yager [15]. The clusters' information obtained by this method is used for determining the initial number of rules and antecedent MFs. A substantial advantage of applying a clustering method to find patterns is that the resultant rules are more tailored to the input data than they are in a FIS generated without clustering. This study uses subtractive clustering to determine the number of rules and antecedent MFs. Then ANFIS is applied for further fine-tuning of the MFs.

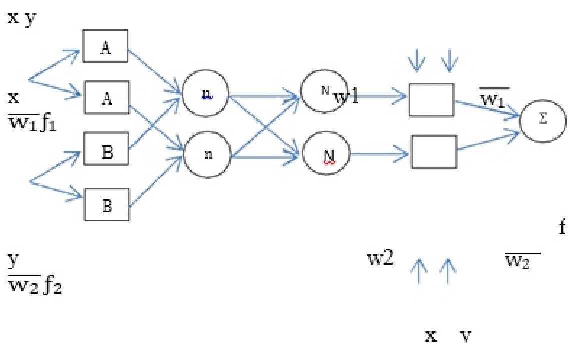

Fig. 3. Equivalent ANFIS structure

3.3. Subtractive Clustering

Here subtractive clustering method is used for determination of number of rules, membership functions and their initial points. The ANFIS is applied for further fine tuning of the membership functions. Subtractive clustering [14] is a fast, one-pass algorithm for calculate approximately the number of clusters and the cluster centers in a data set. Consider a collection of m data points {x1 … xm} in an N-dimensional space. Subtractive clustering accepts every data point as a potential cluster center and determines a measure of the potential for each data point centered on the density of surrounding data points. Density measure at data point xj is calculated as follows:

$$D_j = \sum_{i=1}^{N} \exp\left(-\frac{|x_j - x_i|^2}{\left(\frac{r}{2}\right)^2}\right)$$

where ra is a positive constant and it describes the neighborhood radius. The algorithm chooses the data point with the highest density measure as the first cluster center and then destroys the potential of data points near the first cluster center. The algorithm then selects the data point with the highest remaining potential (next highest density measure has been remained) as the next cluster center and destroys the potential of data points near this new cluster center. This process of obtaining a new cluster center and destroying the potential of surrounding points repeats until the potential of all data points fall below a threshold. The certain range of impact of a cluster center in each of the data dimensions is called cluster radius. A small cluster radius will lead to find many minor clusters in the data (resulting in numerous rules) and vice versa. The clusters' information obtained by this method is used for determining the initial number of rules and antecedent membership functions, which is used for identifying the FIS. So FIS structure is obtained that contains a set of fuzzy rules to cover the feature space.

3.4 Standard Metrics

Following section explains the metrics for dataset used for detecting the anomalies and normal behavior. These standard metrics helps in calculating the accuracy of the classifier.

$$TP = \sum_{i=1}^{p} \text{predicted (class\_data}_i)$$

$$TN = \sum_{i=1}^{q} 1 - \text{predicted (other\_class\_datai)}$$

$$FP = \sum_{i=1}^{q} \text{predicted (other\_class\_data}_i)$$

$$FN = \sum_{i=1}^{p} 1 - \text{predicted (class\_datai)}$$

Where,

Sensitivity = TP/ (TP+FN)

Specificity = FP/ (FP+ TN)

TP, TN, FP, FN are true positive, true negative, false positive, false negative value for the rule, p is the number of samples of the evolved class in the training data set, q is the number of samples of the remaining class in the training data set, predicted is the fuzzy value of the conditional part of the rule.

3. PROPOSED METHOD

In this Section detailed information about the proposed approach is illustrated. In this, KDD CUP'99 data set used as input for IDS. As the feature values in the data set are in symbolic format, to put them in one format preprocessing of data is done. Further rough set based feature selection algorithms are described with their characteristics. This Section will elaborate methodology employed to training neuro-fuzzy classifiers. Classification basically consists of two processes, which are training the parameters of the classifier from a training dataset and using this classifier to categorize a test dataset. Following section shows the flow diagram of proposed work along with detailed description of each phase in brief. Following "Fig. 4" gives the brief description about proposed work followed by detailed explanation of each phase in details.

4.1. Data Preprocessing

As the 41 features in the KDD cup'99 dataset had all forms of continuous, discrete, and symbolic, with significantly varying resolution and ranges. To simulate the presented ideas, the 1998 DARPA intrusion detection evaluation program data provided by MIT Lincoln Labs is used. Feature values in KDD CUP'99 have various types including such as continuous (numeric) and discrete (symbolic). It is hard to process data in such format for their varying ranges. Hence before further processing it is important to transform the symbolic data to numeric data.

4.2. Feature Selection

With the rapid development of the network, intrusion detection system has to exam features of increasing number of data every day in order to find out attacks and malicious network traffic. However, plenty of features are redundant or have little significance during the detection process. These features will affect computational efficiency and final classification effects. Therefore, selecting useful features by features relevance analysis is a critical step for the whole system. In this paper, three main RST based feature selection techniques, namely entropy-based, open loop and closed loop are implemented. Entropy based feature selection algorithm select only those features that provides most Information Gain (IG). Open loop feature selection works on interclass separability criterion. The algorithm selects those features which have small within- class scatter and a large between-class scatter. Next in the closed loop feature selection, the algorithm obtains feature subset by using a predictor classification result depends on certain criteria.

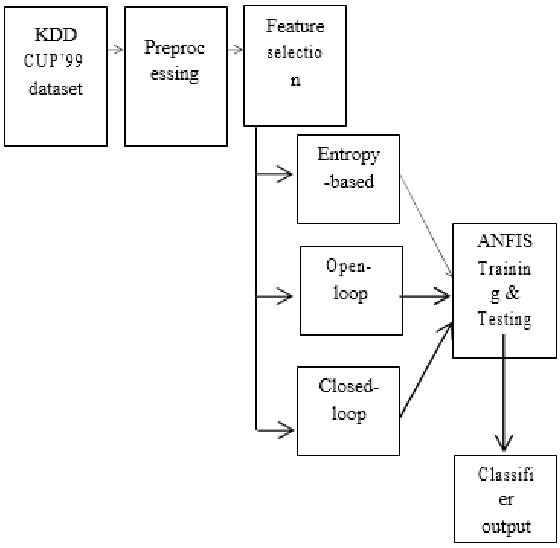

Fig. 4. Proposed method overview

4.3. Adaptive Neuro-Fuzzy Inference System

ANFIS used all the above reduced feature set as the inputs of the neuro-fuzzy classifiers. ANFIS provides a method for the fuzzy modeling procedure to learn information about a dataset, in order to compute the MF parameters that best allow the associated FIS to track the given input/output data. This learning method works similarly to that of neural networks. The parameters associated with the membership functions will change through the learning process. ANFIS uses either back propagation or a combination of least square estimations and back propagation for MF parameter estimations. There are two main procedures in Adaptive neuro fuzzy inference system, training and testing explained below.

4.4. ANFIS Training

In Neural network section of ANFIS, in training phase accepts all of data vectors in train data set and generates if- then rules of FIS. The training of ANFIS is very time consuming process. After training, it is used to classify vectors of test data set.

4.5 ANFIS Testing

Test data set is given to ANFIS in this unit. It is expected that all given data vectors from alerts with attack labels are resulted the corresponding output. Each data vector entering in this section is converted to fuzzy values, and then suitable rule is selected from learned rules. After selecting specific rule for an input data vector, ANFIS generates output value. Since there are some errors in ANFIS results, the output value is a floating point number which should be rounded and then mapped in to an attack label.

5. SIMULATION RESULTS

In this Section, detailed simulation result of the proposed work is shown. KDD CUP'99 dataset is used for simulation purpose. Mainly the implementation of three important rough set based feature selections is shown along with time required to estimate the feature subset. Further the classification results obtained by using the reduced feature subset are shown. It also gives the standard metrics along with the accuracy of each classifier on different feature subset is displayed. Classification results are compared which are obtained by using different number of samples.

5.1 Experimental Configuration

For simulation Intel core i3 processor with 1.68 GHz of speed with 8 GB of RAM and windows XP operating system. The feature selection algorithms have been implemented in MATLAB R2011b. Randomly selected 15000 rows from 10 % of original KDD CUP'99 dataset are used for simulation process of the proposed method. From this selected 15000 samples 14 classes are obtained.

Next section shows the rough set based feature selection simulation results. In first step, "Fig. 5" shows the basic data loading of KDD CUP'99 data set. There are 41 features and one decision feature positioned in last column.

5.2. Preprocessing

Next preprocessing the data set for mapping symbolic valued attributes to numeric shown in "Fig. 6". Here, preprocessing involved mapping symbolic valued attributes to numeric ones. Symbolic features like protocol_type, service and flag were mapped to integer values ranging from 0 to N-1 where N is the number of symbols. For example protocol_type feature with three different symbols namely TCP, UDP, ICMP were appropriately mapped to three discrete numeric values 0, 1 and 2. All the other features were either discrete or continuous used as the original forms.

5.3 Entropy-Based Feature Selection

First, entropy-based feature selection is based on the criteria of IG. It selects those features that provide most gain in information. For calculating information gain of features first calculation of probability and entropy of classes is required presented in data set shown in "Fig. 7".

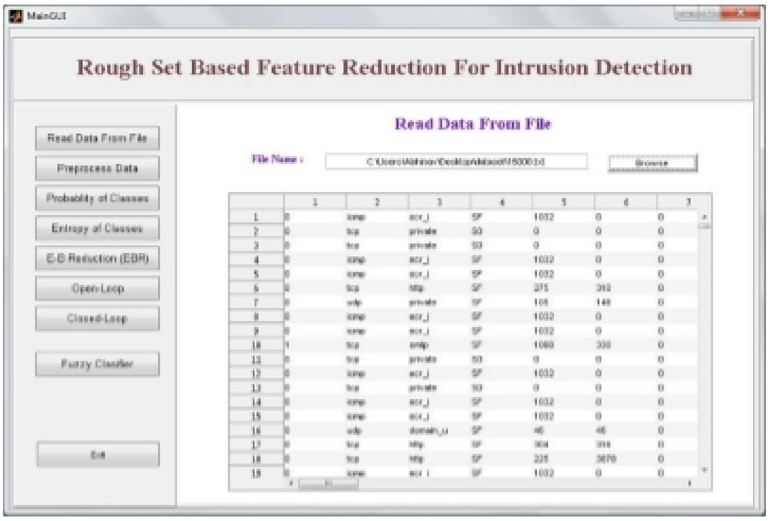

Fig. 5. KDD CUP 1999 data set

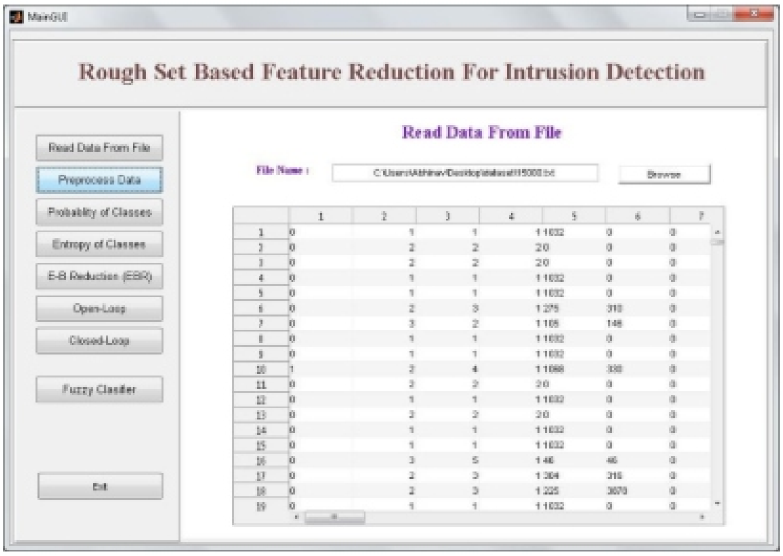

Fig. 6. Preprocessing of data

This section shows the simulation result of three rough set based feature selection techniques namely entropy-based, open-loop and closed-loop discussed previously.

As shown in "Fig. 8", now based on the entropy-based criteria of comparing the original data set with generating subset, it gives the feature subset when their stopping criteria meet.

5.4 Open-Loop Feature Selection

Next, Open-loop feature selection criteria are basically work on the idea of information (like interclass separability) contained only in the data set. The selection criterion for features is based on the class scatter value. This algorithm generates the feature subset by selecting those features which have within-class scatter is smaller or a between- class scatter is larger.

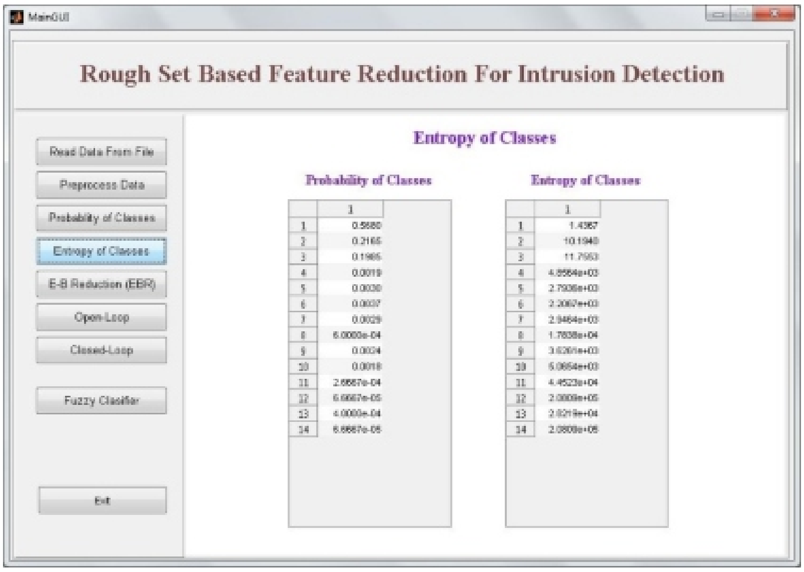

Fig. 7. Probability and Entropy of classes

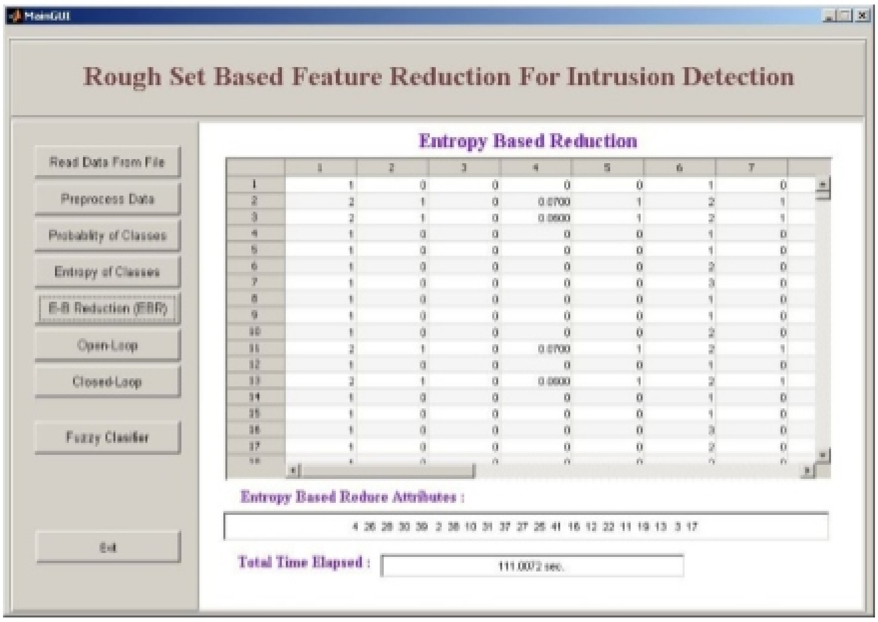

Fig. 8. Entropy-based feature selection

From the above simulation results feature subset containing 21 features is obtained and required time for processing subset is 111.0072 sec. It shows the better results as it selects the random features from 41 features present in the original dataset.

5.5 Closed-Loop Feature Selection

Simulation result obtained from closed loop feature selection technique shown in "Fig. 10". A subset containing 18 features have been evaluated from original data set and time required for processing subset is 70.2876 sec. A predictor (Knn Classifier) has been selected for calculating the quality of features. Estimation of feature goodness can be provided by defining certain criteria and an error counting method which will show how to estimate the performance through averaging of results.

5.6 Adaptive Neuro-Fuzzy Inference System

There are total 41 features in KDD CUP 99 data set. Proposed work reducing feature present in the dataset by three rough set based feature selection methods, namely Entropy-based, open loop and Closed loop. It used the reduced features obtained from above three methods as the input of the neuro-fuzzy classifier. Random 15000 samples of 10% of original data are used for training and testing.

Subtractive clustering method with ra = 0.5 (neighborhood radius) partition the training data and generates the FIS structure. So three fuzzy rules and two membership functions for each input was obtained. All the input MFs are the Gaussian function which are specified by four parameters. Then for further fine-tuning and adaptation of membership functions, training dataset was used for training ANFIS. The ANFIS architecture used in this paper is equivalent to Sugeno Fuzzy Model [18].

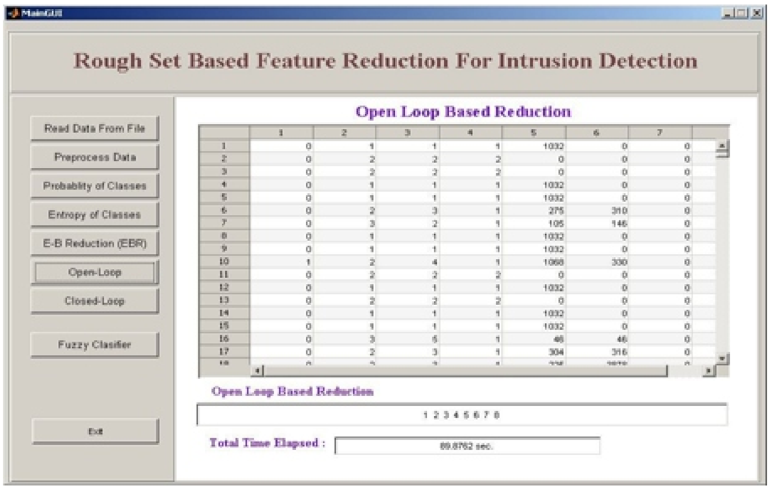

Fig. 9. Open-loop feature selection

From simulation result obtained in “Fig. 9” shows the subset which contains only first 8 features which are in sequence and required time for processing subset is 89.8762 sec obtained by open-loop feature selection.

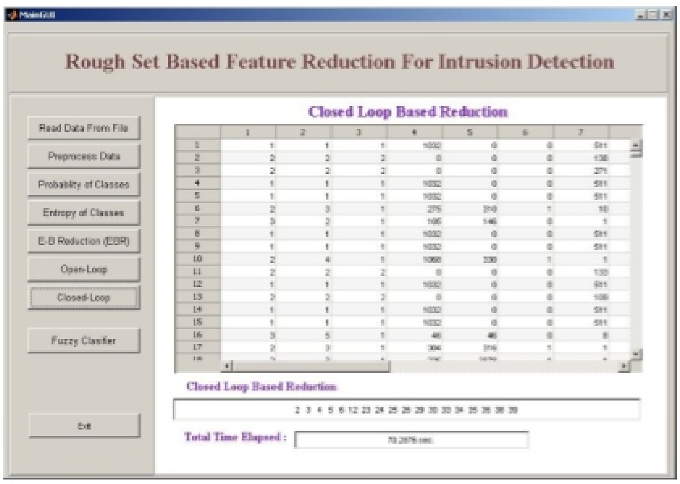

Fig. 10. Closed loop feature selection

The ANFIS used here contains 156 nodes and a total number of 192 fitting parameters, of which 66 are premise parameters and 126 are consequent parameters.

The average RMSE (Root Mean Squared Error) for the training after 10 epochs of learning is 0.030267. “Fig. 11” displays the error measure (RMSE) as function of epoch number for training dataset obtained by reducing by entropy-based feature selection method, it shows that as number of iteration increases the error value goes down and from particular iteration it becomes almost stable with minor change in values.

As it has been previously mentioned in section 3, ANFIS structure has one output. In this paper, the ANFIS output specifies the class number of the 41 input featured vector.

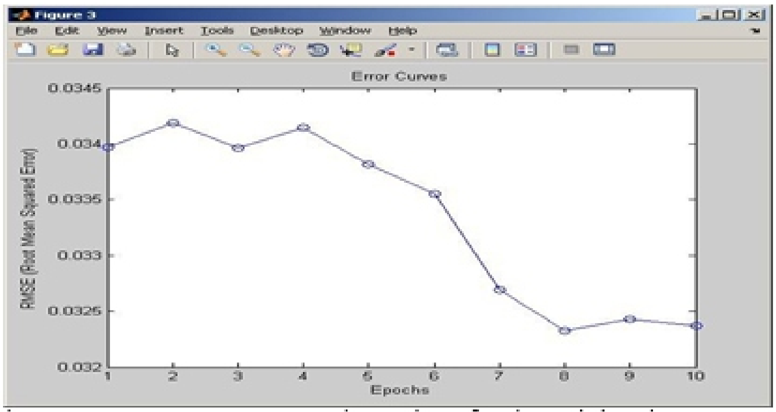

Fig. 11.Error measures vs. epoch numbers for the training dataset

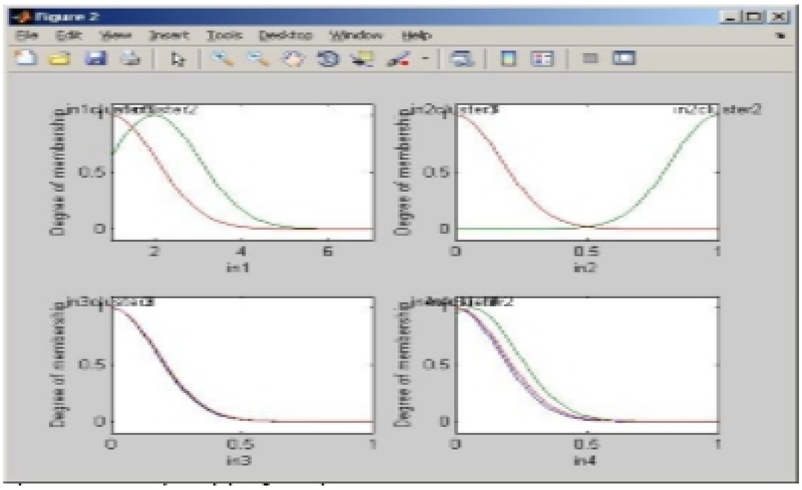

Fig. 12. Membership function

Standard metrics that were developed for evaluating network intrusion detections are detection rate and false alarm rate. Detection rate is computed as the ratio between the number of correctly detected attacks and the total number of attacks, while false alarm (false positive) rate is computed as the ratio between the number of normal connections that is incorrectly misclassified as attacks and the total number of normal connections.0As mentioned earlier, training ANFIS causes further fine-tuning and adaptation of initial membership functions.Initial and final membership functions of some inputfeatures are illustrated in “Fig. 12”.

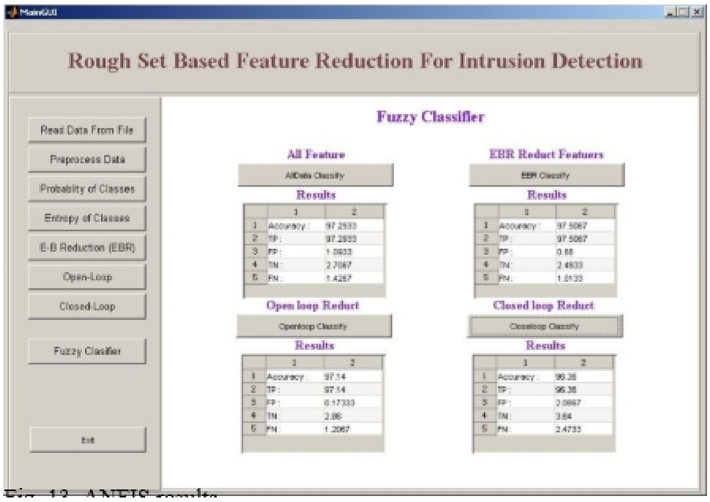

Fig. 13. ANFIS results

Above Fig. shows the classification results of ANFIS. We used the 15000 random rows from 10% KDD CUP'99 data set. It also shows the accuracy obtained from different feature subset along with the fitness parameters.

5.7 Performance Comparison Measures

Standard metrics that were developed for evaluating network intrusion detections are detection rate and false alarm rate. Detection rate is computed as the ratio of the number of correctly detected attacks to the total number of attacks, while false alarm (false positive) rate is computed as the ratio of the number of normal connections (that is incorrectly misclassified as attacks) to the total number of normal connections.

Table 1: Result comparison on different number of samples

Number of samples	Feature selection method	Reduced fratures	TP %	FP %	T N %	F N %	Accuracy in %
4000	All	41	96.4	2.55	3.6	2.67	96.4
	Entro py- Based	21	96.32	2.1	3.67	2.17	96.32
	Open- loop	37	96.4	2.55	3.6	2.67	96.4
	Close d-loop	18	96.8	1.87	3.2	2.2	96.8
5000	All	41	95.84	3.3	4.16	3.32	95.84
	Entro py- Based	21	96.32	2.36	3.68	2.44	96.32
	Open- loop	8	96.4	2.44	3.96	2.46	96.04
	Close d-loop	14	94.38	4.2	5.62	4.28	94.38
10000	All	41	97.29	1.72	2.71	1.85	97.29
	Entro py- Based	21	97.88	0.59	2.12	17	97.88
	Open- loop	37	97.29	1.72	2.71	1.85	97.29
	Close d-loop	18	97.15	1.28	2.85	1.51	97.15
15000	All	41	97.29	1.9	2.70	1.42	97.29
	Entro py- Based	21	97.5	0.68	2.49	1	97.5
	Open- loop	8	97.14	0.17	2.66	1.20	97.14
	Close d-loop	18.36	96.8	2.4	3.67	3.4	96.36

“Table 1” shows detection rate and the fitness parameters i.e. true positive, false positive, true negative and false negative.

6 CONCLUSION

In this paper basic of rough set theory is discussed and also present the use of rough set theory for feature selection for simulation purpose. A good number of feature subset are obtained from the three important rough set based feature selection techniques: Entropy-based, Open loop and Closed loop. ANFIS as a neuro-fuzzy classifier is applied to the intrusion detection methods. Subtractive clustering determines the number of rules and MFs with their initial locations. The method used here is capable of producing fuzzy rules without the aid of human experts. From simulation result it is very much clear that the proposed method have shown efficient results.

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A Survey on Wireless Networks: Architecture, Applications, uses and Challenges

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A B S T R A C T

Wireless networks have become increasingly popular in the computing industry since 1970. It is particularly true within the past decade, which has seen wireless networks being adapted to enable mobility. The area of wireless communication has been and is continuing to develop at a rapid pace over the years. Wireless networks allow a more flexible communication model than traditional networks since the user is not limited to a fixed physical location. Unlike cellular wireless networks, ad hoc wireless networks do not have any fixed communication infrastructure.

Keywords: Wireless Networks, MANET,

1.0 INTRODUCTION:

The first professional wireless network was developed under the brand ALOHA net in 1969 at the University of Hawaii and became operational in June 1971. The first commercial wireless network was the Wave LAN product family, developed by NCR in 1986.

- 1991 2G cell phone network
- June 1997 802.11 "WiFi" protocol first release
- 1999 803.11 VoIP integration

There is an important question arise with wireless networks. What is a wireless network, exactly? A wireless local-area network (LAN) uses radio waves to connect devices such as laptops to the Internet and to your business network and its applications. When you connect a laptop to a WiFi hotspot at a cafe, hotel, airport lounge, or other public place, you're connecting to that business's wireless network.

1.1 Wireless network is a network set up by using radio signal frequency to communicate among computers and other network devices. Sometimes it's also referred to as WIFI network or WLAN. This network is getting popular nowadays due to easy to setup feature and no cabling involved. You can connect computers anywhere in your home without the need for wires.

1.2 Here is simple explanation of how it works? Let say you have two computers each equipped with wireless adapter and you have set up wireless router. When the computer sends out the data, the binary data will be encoded to radio frequency and transmitted via wireless router. The receiving computer will then decode the signal back to binary data.

It doesn't matter you are using broadband cable/DSL modem to access internet; both ways will work with wireless network. If you heard about wireless hotspot that means that location is equipped with wireless devices for you and others to join the network.

2. 0 WIRELESS NETWORK VS. WIRED NETWORK

A wired network connects devices to the Internet or other network using cables. The most common wired networks use cables connected to Ethernet ports on the network router on one end and to a computer or other device on the cable's opposite end.

In the past, some believed wired networks were faster and more secure than wireless networks. But continual enhancements to wireless networking standards and technologies have eroded those speed and security differences.

3.0 ARCHITECTURE OF WIRELESS NETWORKS:

The two main components are wireless router or access point and wireless clients.

If you have not set up any wired network, then just get a wireless routerand attach it to cable or DSL modem. You then set up wireless client by adding wireless card to each computer and form a simple wireless network. You can also cable connect computer directly to router if there are switch ports available.

Wireless router or access points should be installed in a way that maximizes coverage as well as throughput. The coverage provided is generally referred to as the coverage cell. Large areas usually require more than one access point in order to have adequate coverage. You can also add access point to your existing wireless router to improve coverage.

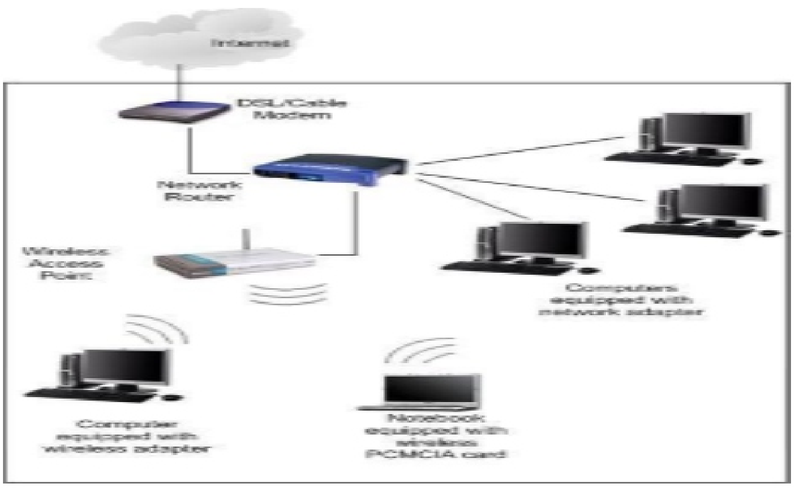

Fig 3.0 Architecture of a wireless networks

4.0 BENEFITS OF WIRELESS NETWORKS

Small businesses can experience many benefits from a wireless network, including:

- **Convenience.** Access your network resources from any location within your wireless network's coverage area or from any WiFi hotspot.

- **Mobility.** You're no longer tied to your desk, as you were with a wired connection. You and your employees can go online in conference room meetings, for example.

- **Productivity.** Wireless access to the Internet and to your company's key applications and resources helps your staff get the job done and encourages collaboration.

- **Easy setup.** You don't have to string cables, so installation can be quick and cost- effective.

- **Expandable.** You can easily expand wireless networks with existing equipment, while a wired network might require additional wiring.

- **Security.** Advances in wireless networks provide robust security protections.

- **Cost.** Because wireless networks eliminate or reduce wiring costs, they can cost less to operate than wired networks.

5.0 Applications of Wireless networks

A wireless network use in many fields as per the requirement of it's by the user. Following are the application areas of wireless networks.

1. Home and Entertainment:

- Home/office wireless networking
- PAN (Personal Area Network)
- Multiuser games
- Outdoor Internet Access

2. Educational:

- Virtual Class Rooms or Conference Rooms
- Set up ad-hoc communication during conferences, meeting or lectures

3. Emergency Services:

- Search and rescue Operations
- Disaster Recovery-Earthquakes, Hurricanes

4. Tactical Networks:

- Military Communication
- Automated Battlefields

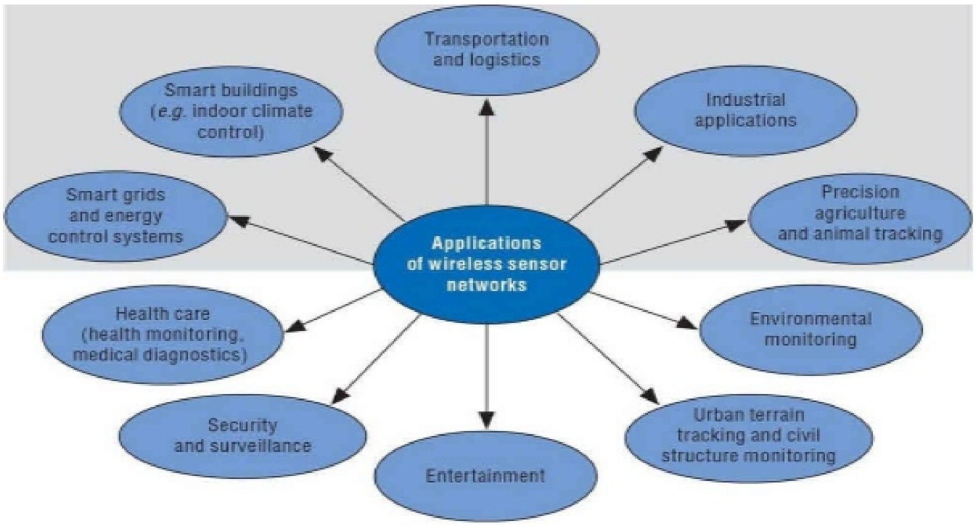

Fig 5.0 Applications of Wireless Networks

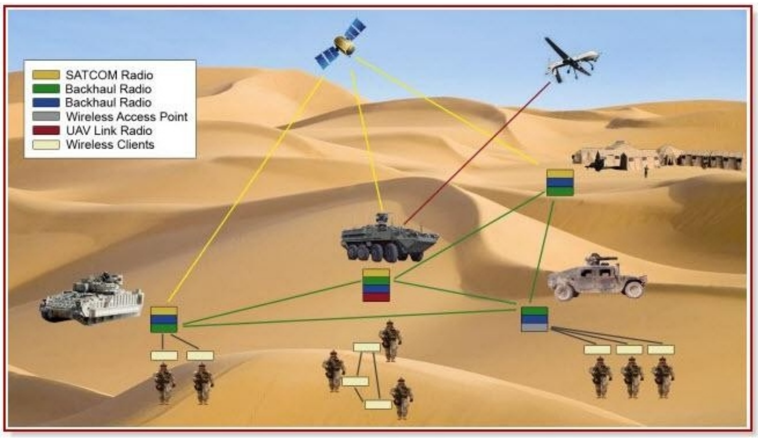

Fig 5.1 Wireless Networks in Military Applications

6.0 CHALLENGES OF WIRELESS NETWORKS

With a lot of benefits there are some challenges of wireless networks as following:

1. **Infrastructure less:** Bring new network designing challenges

2. **Dynamically changing topologies:** Cause route changes, frequent network partition and packets loss.

3. **Physical layer Limitations:** Limited wireless range, Packet loss during transmission, Broadcast nature of the communication

4. **Limitations of Mobile Nodes:** Short battery life, limited Capacity

5. **Network Security**

Conclusions:

After the completion of this paper we find overall conclusion of the wireless networks that this network play a very important role in human life in day to day routine. Also we find the better use of this network in education and very important in Military Applications.

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Relay Node Backbone Scheme in Vehicular ADHOC Network

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A B S T R A C T

Vehicular Ad hoc networking is a peculiar networking communication which transmits messages and warnings between vehicles and access points which incorporates rural, urban and highways. These communications bring all the road side systems to work together by establishing routes and communication links. It offers intelligent transportation, comfort, security and infotainment applications. In VANET the vehicles are the nodes and it forms high mobility topology. Timely delivery of messages is the most vital aspect in vehicular networks to reduce road side issues. So selecting the node for messaging transmission is a critical job for correct delivery. There are variant ways for selecting and this paper discuss about relay node selection in which the vehicles are elected automatically as Relay nodes. It has many benefits in relay node selection as the packet delivery is high, loss is low and end to end delay is reduced. This paper examines the highway regime and it chooses the freeway mobility model

Keywords : VANET, Topology, WAVE, RSU, Freeway Mobility model

I. INTRODUCTION

The network is setup with the principles of mobile ad hoc which dynamically create the nodes in the highway for exchanging data. It is firstly introduced for "car-to-car" communication where the message can be relayed between them.

Features

- "V2V & V2R" architecture will exists to provide safety, navigation and other roadside services.
- It is key for Intelligent Transportation System.
- It is considered as safer and more efficient by providing timely information and makes travelling more convenient.
- V2R provides better service in sparse networks and in long distance.

Requirements in VANET

- **Authentication and Integrity**

Transmitted data should be verified and checked for authorized identification and correct delivery.

- **Confidentiality**

Transmission should be secret by using encryption schemes.

- **Privacy and Anonymity**

Messages should be transferred to authorize vehicles and not to be used by misbehaved vehicles.

- **Access Control**

Should have the ability of receiving available services offered by remote vehicles.

- **Non-Repudiation**

Senders of message should not deny their identities which will lead to wrong location of events, weaken negotiation and cooperation.

- **ID Traceability**

The capability to retrieve real identities of vehicles and owners who sent messages.

- **Scalability**

Accepting number of communicating vehicles without any loss in transferring since traffic loading will increase the complexity and decrease the performance.

  - Efficiency and Robustness Capability to provide service under different attacks.
  - Availability Ensure communication even in bad conditions or false events.
  - Resistance against „In-Transit-Traffic & On-Board-Tampering"

In-transit traffic tampering- Malevolent vehicle can corrupt data of other vehicles.

On-board tampering- Vehicle can know special detail about some the position and velocity.

Characteristics of VANET

Dynamic topology - The speed and direction will change frequently.

Periodic connectivity - Connectivity between devices can connect or disconnect at any time. Mobility

Patterns - Vehicles follow a certain patterns to move.

High power and storage - Nodes have a unlimited amount of power and storage capacity.

- **Components of VANET**
  - Vehicles,
  - Electronic hardware components,
  - Intelligent actuators- engine,
  - Transmissions,
  - Suspension,
  - Integrated vehicle control,
  - Sensor devices-radar,
  - Video camera,
  - GPS,
  - On Board Units,
  - Roadside devices,
  - Control of vehicle groups and fleets.

II. LITERATURE REVIEW

G. Korkmaz et al [1] proposed a fully Ad-Hoc Multi-hop Broadcast protocol. This protocol highly eliminates the infrastructure dependence of the UMB protocol by intersecting the broadcast mechanism. In this, while there is an intersection in the path during dissemination, the directional broadcasts to all segments are initiated without the a priori topology information. The simulation results confirm that the proposed protocol has a very high success rate and efficient channel utilization. And it is also concluded it can be employed in non-infrastructure support.

G. Huang et al [2] designed a new called Efficient Directional Broadcast (EDB) for VANET with the help of directional antennas. EDB is comprised of two things namely directional broadcast on the road and at the intersection. In EDB, generally the furthest receiver is responsible to forward the packet in the opposite direction where the packet arrives. A real mobility model is generated by mapping the GPS data of 4200 taxis of Shanghai. EDB has many advantages such as long transmission range, space reuse, low redundancy and collisions. The result shows that EDB not only increases the delivery ratio but also decreases the network resource consumption.

Mohammad Jalil Piran et al [3] introduce a sensor network in the Vehicular ad hoc network. By exposing the new technologies such as wireless sensor networks is a solution to reduce the rate of data loss. This paper employs „Wireless Sensor networks‟ for Vehicular Ad Hoc or VASNET. It is a self-organizing Ad Hoc consists of numerous sensor nodes. The sensor nodes can be placed in two ways. By modelling in the vehicle-vehicle and by deployed in predetermined distances in the road. By installing base stations VASNET provides capability of wireless communication between vehicular and stationary nodes. This paper discusses the fundamentals and challenges faced in VASNET.

J. B. Kenney et al [4] analyse the „Dedicated short-range communication technology" for the use in vehicle-to-vehicle and vehicle-to-roadside communication. Vehicles use a numerous of wireless technologies to communicate with other devices. These technologies depend on the standards. The standards discussed in this paper are „DSRC standards, IEEE 802.11p amendment for wireless access in vehicular environments , the IEEE 1609.2, 1609.3, and 1609.4 standards for Security, Network Services and Multi-Channel Operation, the SAE J2735 Message Set Dictionary, and the emerging SAE J2945.1".It explains the content and status of the major standards which support interoperable DSRC in the United States.

Izhak Rubin et al [5] proposed a Directional Vehicular Backbone Network protocol to distribute the message between the vehicle to vehicle and vehicle to Road side unit in a highway. By using Global Positioning system with election algorithm vehicles which lies in the closest to the nominal positions are selected as a relay nodes. This paper concentrate on two things: using varying inter-RN nominal position ranges to show the effectiveness, demonstrate the superior performance of the DVBN protocol which is opposed to the VBN protocol that employs omni- directional antennas. Simulations are carried out to show under which broadcast the throughput increases.

III. METHODOLOGY

Working Principle of VANET

VANET turns every car into a wireless router or node, allowing distance from 100 to 400 metres of each to connect and create a network with a range. As one falls out of the signal and leave the network others can join in. The first systems that will begin this may be a police and fire services to communicate for security purposes.

A special electronic device called On Board Unit will be placed inside each vehicle which will act as a node in the Ad-Hoc network to pass messages between the vehicles and also can receive and relay messages through the wireless called Road side Unit. This operates without any fixed infrastructure. The RSU transmission range is 1000 m as per the USDOT. There are also multimedia and internet connection within the wireless coverage of every car.

- An OBU is a mobile node and RSU is a static node. An RSU can be connected to the Internet through the gateway. It can communicate with each other directly or by multi hop. The two types of infrastructure domain access are RSU and Hot Spot. OBUs‟ may communicate with net via this RSU or HS. Also it can communicate by cellular radio networks such as "GSM, GPRS, UMTS, Wi-MAX, and 4G".

The IEEE 802.11p (2010) standard with Wireless Access for Vehicular Environment (WAVE) – IEEE 1609.3 is used for communication. It has the bandwidth of 10 MHz and bit rate of 27 Mbps. It includes data exchange between high-speed vehicles and the roadside infrastructure in the licensed ITS band of 5.9 GHz. In this protocol, the vehicles send information about their traffic parameters such as speed, distance from other vehicles etc. to nearby vehicles. And it has CSMA/CD collision protocol to avoid collision during node transmission.

Relay Node selection

The source node in the highway generates the messages in case of collision, road disorder or dangerous accident. The message is sent to the nearby Roadside Unit. The RSU select any one of the vehicle within its coverage area (1000 m) as a relay node to pass the message. To disseminate the data to all other nodes within its coverage area (250m), the relay node broadcast the message through the „On Board Unit‟ equipped in it and thus form the relay node driven backbone network. Both these formation extend the RSU coverage area and limits the number of RSU to be installed. It is a one hop communication between the RSU and the relay node in this model and thus it offers a quick dissemination of data.

The selection of the relay node depends on the speed, distance from the danger zone and the lane number which the node is travelling. The node which is travelling in the other lane will not be disturbed. And all other nodes can be able to slow its speed or stop travelling depends on the situation on seeing the messages. If the relay node goes beyond the coverage area another relay is selected until the timer expires and the message is deleted from the buffer.

Relay Node Selection Module

The structure would be fulfilled if the participating vehicles are selected as the Relay Nodes. These relay nodes are used to forward the messages to the vehicles. So any fault by the RN‟s in the forwarding process might make the complete system to fail. Hence, the relay node selection algorithm must be most effective. In this paper the relay nodes are chosen based on speed, distance, position and Lane number.

For speed - The slow moving vehicle will elected since it reside in coverage area for a longer time.

For position - The distance between the relay nodes within the RSU is lesser than the nearer RSU so data transfer is effective.

For distance - The distance from the vehicle must be closer to the danger prone.

For Lane number - The lane number is included to disseminate the message in the particular lane.

Algorithm

Receive msg from Source (V-ID, Lno, msg).
Check V-ID of the source in RSU.
For V-ID in the RSU
If (Spd < 90 km/h & > 60 km/h, N_{pos} - RSU_{pos} *= low,* N_{dis} - S_{dis} *=low,*
$N_{lno} = S_{lno}$*) then*
Set V-ID = RN.
Store RN in RSU.
Return.

Where,

V-ID = Vehicle ID,

Lno = Lane Number,

Msg = Message.

RSU = Road Side Unit,

S_{pd} = Speed,

N_{pos} = Node Position.

RSU_{pos} = Road Side Unit position,

N_{dis} = Node distance.

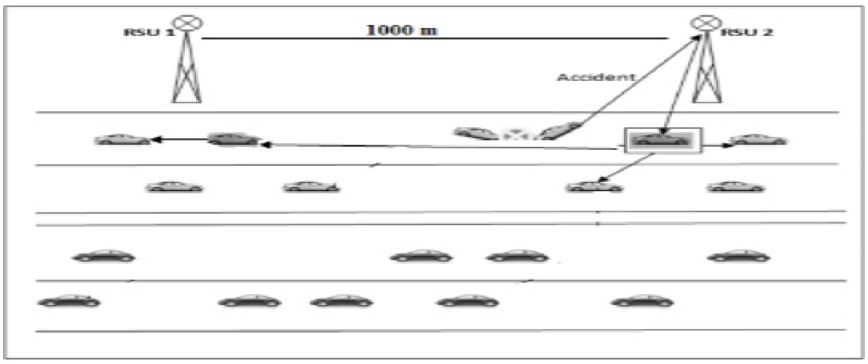
S_{dis} = Source distance,

N_{lno} = Node Lane Number.

S_{lno} = Source Lane number,

RN = Relay node, Low = 50-100m.

If more than two nodes match the constraints, then the vehicle which is registered first while entering into the coverage will be given first preference to act as a relay node.



Message transformation with relay node

The source node generates message in case of collision and sends it to nearby RSU. The RSU elect relay node on the basis of proposed constraints and relay node broadcast the message to all its neighbours in its coverage area.

IV. CONCLUSION

In the proposed relay node scheme the vehicle in the other lane is not disturbed. And the communication extend above 1000m via the relay node driven thus the installation of RSU is limited. The End To End delay will be increased due to network congestion in other schemes but in the relay node scheme the delay is getting reduced though the node increases. The message has to be disseminated before the node leaves from the coverage area as it is in high mobility in VANET. As per the relay node selection algorithm the slow moving vehicle is choose as a relay node so the packet delivery ratio will be high.

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Difference Between SQL and No SQL Databases

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A B S T R A C T

This article explores the various differences between SQL and NoSQL databases. It begins by giving brief descriptions of both SQL and NoSQL databases and then discussing the various pros and cos of each database type. This article also examines the applicability differences between the two database types. Structured Query Language (SQL) refers to a domain-specific or standardized programming language used by database designers in designing and managing relational SQL databases or controlling data stored in RDSMS (relational database management system). The scope of SQL database encompasses data query, data definition (creation and modification of schema), data manipulation (inserting, deleting, and updating), as well as control of data access. NoSQL databases are non-relational and can exist together with relational databases. NoSQL databases are most suitable for use in applications that involve large amounts of data, and the data can either be unstructured, structured, or semi- structured. SQL databases have been the most widely used databases in the world over the years. However, it is the requirements that drive data models, which in turns, influence the choice between SQL and NoSQL databases

1. INTRODUCTION TO SQL DATABASE

Structured Query Language (SQL) refers to a domain-specific or standardized programming language used by database designers in designing and managing relational SQL databases or controlling data stored in RDSMS (relational database management system) [10]. Some of the common SQL databases include MySQL, Oracle, Sybase, and IBM DM2 [7]. In such SQL databases, SQL helps in executing queries, retrieving data, and editing data by deleting, updating, and creating new data records [7]. SQL is a lightweight and declarative language that performs several heavy liftings for the relational database by acting as a version of the server-side script of the database [1].

The SQL concept got introduced in the 1970s, and it is often used by database developers and administrators in performing various activities, such as setting up and running analytical queries, as well as writing data integration scripts [10]. SQL databases are built around tuple relational calculus and relational algebra, and they provide mechanisms for data storage and retrieval through the use of tables [10]. The tables used for data storage in SQL databases exist in the form of Excel spreadsheets with columns and rows. The only difference is that a database table has a much stricter structure [7]. A row in such data tables represents a single record, whereas the columns form the attributes for that particular record. SQL databases are specifically used for handling structured data whose different variables or entities have relations, and they allow users to access several records using a single command [7].

SQL databases consist of a broad range of statements, often referred to as sublanguages and include DQL (data query language), DCL (data control language), DDL (data definition language), and DML (data manipulation language) [3]. The scope of SQL database encompasses data query, data definition (creation and modification of schema), data manipulation (inserting, deleting, and updating), as well as control of data access [10]. Despite being described largely as a 4GL (a declarative language), SQL also has various procedural elements. SQL became the ANSI (American National Standards Institute)'s standard in the year 1986 and a standard of the ISO (International Organization for Standardization) in the year 1987 [3], [10]. The SQL database has, since then, been revised to incorporate other features. However, even with such additional features, most SQL codes are not entirely compatible with other databases without further adjustments [7], [10].

2. INTRODUCTION TO NOSQL DATABASE

NoSQL implies or stands for “Not Only SQL. NoSQL databases are non-relational and can exist together with relational databases. NoSQL databases are most suitable for use in applications that involve large amounts of data, and the data can either be unstructured, structured, or semi-structured [2], [6]. NoSQL databases exist in different forms or types, which include Apache Cassandra, Coach DB, Mongo DB, HBase, Infinite Graph, and Redis among others. All the NoSQL databases differ in the context of their usage and structure [2], [6]. Additionally, NoSQL databases are different from the relational SQL databases in the sense that while relational databases require the creation of tables, the definition of a schema, and setting of data types before inserting the data, NoSQL databases allow for direct insertion and updating of data [4], [9].

In NoSQL document stores, the data is often stored or kept in collections, which consist of objects known as documents. The collections act as or are the equivalent of tables in relational databases, while the documents resemble the records [8], [9]. Therefore, in NoSQL databases, a collection consists of documents, and each document represents a different user. NoSQL is the next generation database, and most NoSQL databases are open source with the capability of horizontal scalability [8], [9]. Despite the advanced nature of NoSQL database, there exist certain situations where one would prefer SQL database over NoSQL database. However, when handling amounts of data, NoSQL database is often the best choice [5].

NoSQL database is increasingly gaining popularity with its most significant implementations being MongoDB and Apache Cassandra among others [6]. NoSQL database has primarily been developed to address the scalability issue or problem that characterizes SQL database. Besides, NoSQL database has emerged as a schema-free database build on distributed systems, which gives it the required scalability and makes it easy to shard [6], [9]. Despite presenting new challenges, NoSQL database provides great rewards to users who can effectively incorporate or integrate it into their solution portfolio [4]. The primary benefits of NoSQL database revolve around improved data comprehension, productivity, and flexible scaling solutions [4], [8].

3. PROS AND CONS OF SQL DATABASE

3.1. Pros

One of the advantages of SQL databases is that they are simple and powerful, which makes it possible for the retrieval of related data stored across different tables using a single command in such databases [9]. SQL databases also fit naturally into a broad range of old software stacks, including Ruby and LAMP-based stacks. Besides, SQL databases are well- understood and broadly supported, which makes it easy for solving common problems [4], [9].

SQL databases also have high speeds, and SQL queries can be used for quick and efficient retrieval of large amounts of records from SQL database [1]. SQL databases also have a well-defined standard, which makes it easy for the management of a substantial amount of data without having to write several codes [1], [7]. Also, SQL databases make use of object-oriented DBMS, which allows for the extension of their object storage capabilities [3], [9].

SQL databases have portability since SQL is compatible with a broad range of computer programs [10]. Besides, SQL databases have an interactive language, which can be used for quick communication with other databases [10]. SQL databases also provide platforms for multiple data views with the help of SQL language. Moreover, SQL databases comply with the ACID (atomicity, consistency, isolation, and durability) principles, which makes them stable, secure, and predictable [9], [10].

3.2. Cons

One of the disadvantages of SQL database relates to the difficulty in interfacing. The process of interfacing an SQL database is more sophisticated than adding a few code lines (Severance 9). Additionally, SQL database programmers do not have full control over such databases because of the concealed business rules [7], [10]. Some SQL databases also go for proprietary extensions as a means of ensuring the vendor lock-in [3], [9]. Also, some SQL databases have high operating costs, which makes their access difficult for some programmers.

Moreover, SQL databases are challenging to scale since their performances often deteriorate as they become larger [3], [10].

4. PROS AND CONS OF NOSQL DATABASE

4.1. Pros

One of the advantages of NoSQL database is that it has elastic scalability. NoSQL databases are designed for transparent scaling or expansion due to their new nodes features, and they are specifically designed for application in low-commodity hardware [2], [4]. NoSQL databases are, therefore, fit in the current world, where outward scalability is replacing upward scalability [2], [4]. Additionally, NoSQL databases are used for handling big data applications, which RDBMSs cannot manage [4].

Another advantage of NoSQL databases is that they require little hands-on management since they have auto repair and data distribution capabilities, as well as simplified data models, less turning, and fewer administration requirements [3], [6]. NoSQL databases are also economical in the context of their installation since they can easily be installed in less expensive commodity hardware clusters as data volumes and transactions increase. In other words, with NoSQL databases, one can store and process more data at significantly lower cost [5], [9].

4.2. Cons

One of the disadvantages of NoSQL databases is that they are less mature compared to RDBMSs, which have been existing for an extended period, thus becoming more stable and richly functional. In contrast, most NoSQL databases are in their pre-production stages, and most of their features have not been implemented, which makes them have less functionality and low stability [3], [5]. NoSQL databases also have little support. All businesses need the assurance that they will get timely, competent support if a major function of their data management system fails. However, NoSQL databases appear to be open-sourced, with just a few firms managing the databases from the support viewpoint [5], [9]. Besides, most of the NoSQL databases have been designed by startups that lack the required resources to fund global support [5], [8].

Another disadvantage of NoSQL databases is the lack of business intelligence and analytics features. NoSQL databases emerged due to the demands of modern-day web applications. Therefore, most NoSQL database features are aligned to meeting such demands, and NoSQL databases usually provide few analysis features when the demands of a given data application go beyond the typical web app cycle characteristic of 'insert-read-update-delete' [6], [9]. Additionally, NoSQL databases still require administration. NoSQL database introduction aimed at providing a solution that would not require administration. However, NoSQL databases still need more technical skills for both their installation and maintenance [6], [8]. Also, since NoSQL databases are still new, they lack advanced expertise, and it is easier to find an RDBMS specialist than a NoSQL expert. Therefore, any organization intending to implement NoSQL solutions has to proceed with caution [4].

Another downside of NoSQL databases relates to their use of the eventual consistency principle. Meaning, if a particular data item fails to get new updates for a given period, all its accesses will eventually return to the last updated value. That is why NoSQL databases are considered to offer BASE (Basically Available, Soft state, Eventual consistency) guarantees [3], [9]. Also, since there exist several types of NoSQL databases with little uniformity, they vary greatly in the context of their performances, flexibility, scalability, and complexity, which makes it challenging to choose one with the best performance [5].

5. EXAMPLES OF WHERE SQL DATABASE IS USED

One of the applications of SQL databases is writing of data integration scripts by database developers and administrators [7], [10]. SQL databases are also used for the retrieval of information for transaction processing and analytics applications [7], [10]. Also, SQL databases are useful for regular setting and running of analytical queries [1], [7]. SQL databases are used by a broad range of organizations, including healthcare organizations (in managing cancer registries), business organizations (in managing inventories and making trends analysis), as well as educational institutions in managing performance data [8], [10].

6. EXAMPLES OF WHERE NOSQL DATABASE IS USED

One of the areas where NoSQL databases are used relates to systems that are used for storing and retrieving vast amounts of data [5], [9]. NoSQL databases are also used when one is not interested in the relationship between the stored data, as well as when the stored data grows continuously [5]. Additionally, NoSQL databases are used when there is a need for personalization since a personalized experience requires large amounts of data. With a distributed NoSQL database, data can be extended elastically to meet the user's workloads, as well as build and update other information on the fly, thereby allowing for real-time engagement with clients [1].

NoSQL database is also used where there is a need for profile management. The management of user profile is key to both mobile and web applications as it allows for user preferences, online transactions, as well as authentication among other functions [4]. With a NoSQL database, it is easy to increase capacity by adding commodity servers, which makes the database less expensive and much easier to scale [4], [8]. NoSQL databases are also used where big real-time data is required. For an agile enterprise, the ability to obtain real-time information from operational data is critical. NoSQL databases help in increasing operational efficiency, reducing costs, and improving revenues for agile enterprises by allowing them to act immediately on real-time data [4].

Additionally, NoSQL databases are used for content management. NoSQL databases enable businesses to select different contents, aggregate them and present the aggregated content to the customer at the time of interaction. Therefore, NoSQL databases allow enterprises to develop and produce new content quickly, as well as incorporate the user-generated content with the same agility and ease [2], [6]. NoSQL databases are also useful in managing catalogues as their flexible data models allow enterprises to easily aggregate catalogue data in a single database [2], [6].

NoSQL databases are also used by organizations that require 360 degrees customer view. Customers always anticipate a consistent experience irrespective of the channel. At the same time, organizations need to capitalize on cross-sell opportunities, as well as offer the best customer service. With a NoSQL database, organizations that require 360 degrees customer view can access the same customer data using multiple applications and add new information without interfering with other applications [2]. NoSQL databases are also used in mobile applications. With a NoSQL database, mobile apps can begin with a small deployment and increase as the user base expands, as opposed to deploying a large, expensive relational server from the start [2], [9].

Another area where NoSQL databases can be used is a financial service organization, for fraud detection. With NoSQL databases, customers can get immediate confirmation when they make payments with their debit or credit cards [2], [5]. Also, in an enterprise environment, NoSQL databases can be used for digital communications in the form of online interaction through direct messaging. NoSQL databases provide the elastic scalability and sub-millisecond responsiveness required by digital communication applications [2], [5].

7. CONCLUSION

SQL databases have been the most widely used databases in the world over the years, and SQL language has become the International Organization for Standardization's standard, as well as the standard for the American National Stands Institute. However, a challenging question still exists for any organization or company that has to choose between the traditional SQL database and NoSQL database. Organizations making such choices would benefit from a database system that better matches the amount of data they store and retrieve in practice. Other organizations may also resort to a hybrid mix of database solutions, as opposed to an absolute commitment to one solution model. Additionally, there is a significant change in the way web applications handle data over the past decade due to the increased amount of data and users. Meaning, performance and scalability are becoming a challenge for relational databases than ever. While the SQL databases provide consistency, they are not improved or optimized for best performance in applications that frequently store and process massive data. Fortunately, most NoSQL databases address such challenges by providing new features that boost reliability and scalability. However, the implementation of NoSQL databases under various changes, and their performances may vary. NoSQL database is a better addition or complement to the traditional SQL database standards, although NoSQL databases offer a specialized solution since they work with limited applications. Nevertheless, SQL databases are not becoming obsolete any time soon despite the emergence of NoSQL databases, which provide a different and exciting perspective of data. It is, therefore, essential to remember that it is the requirements that drive data models, which in turns, influence the choice between SQL and NoSQL databases.

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Control Charts for Waiting Time using Method of Weighted Variance and Power Transformation for (M/M/s) : (∞ : FCFS) Model

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ABSTRACT

In this paper to monitor the waiting time of the (M/M/S) : (∞ : FCFS) queuing model , control chart for the random waiting time is constructed using method of weighted variance and Nelson's power transformation. The performance measure average run length for these charts is obtained and compared.

Keywords : False alarm rate, Type II error, Average queue length, Average run length, average queue length, average waiting time , Weibull distribution

1. INTRODUCTION

Various types of control charts for the random queue length N and waiting time i.e. W_s for the (M/M/1):(∞/FCFS) queuing model are constructed by Khaparde M.V. and Dhabe S.D. In this paper control charts for random waiting time for (M/M/s) : (∞ / FCFS) queuing model are constructed .

2 (M/M/S) : (∞/FCFS) QUEUING MODEL

Notations

Let Pn denote steady state probability of having exactly n customers in the system

λ = mean arrival rate , μ = mean service rate per busy server

s = number of parallel servers , ρ = Traffic intensity l/sm

W_s = waiting time per customer in the system

W_Q = waiting time per customer in the queue

$f(W_s)$ = density function of waiting time of the customer in the system.

$f(W_Q)$= density function of waiting time of the customer in the queue

Multichannel queuing theory deals with the condition in which there are several service stations in parallel and each element in the waiting line can be served by more than one station. Each service facility is prepared to deliver the same type of service. The new arrival selects one station without any external pressure. When a waiting line is formed, a single line usually breaks down into shorter lines in front of each service station. The arrival rate l and service rate m are mean values from Poisson distribution and exponential distribution respectively. Service discipline is first come first serve and customers are taken from a single queue i.e. any empty channel is filled by the next customer in line.

When n < s, there is no queue because all arrivals are being serviced, and the rate of servicing will be nm as only n channels are busy, each at the rate of m. When n = s, all channels will be working and when n > s, there will be (n – s) persons in the queue and rate of service will be sm as all the s channels are busy.

3. CONSTRUCTION OF CONTROL CHARTS

For any queuing system, average queue length and average waiting time are the main observable characteristics. Customers want to have waiting time in the system as minimum as possible i.e.queue length should be small. Haim Shore (1999) has made pioneering attempt of extending the application of statistical process control to queuing systems. He obtained control limits for the random queue length N for (M/M/s) queuing model. These control limits are explicitly expressed in terms of mean, standard deviation and skewness of the distribution of r.v.N. This control chart monitors the stability of the queuing system in terms of N. If an out of control signal is generated it will indicate a change in the parameter arrival rate or service rate which determine N.

To monitor the waiting time of the customers in the queuing system ,the following control charts for random waiting time are constructed .

3.1 The following two control charts for WQ are constructed .

I) Control chart sW_Q^1 - This is simple Shewhart control chart and

I) Control chart sW_Q^2 - This chart is constructed using method of weighted variance.

3.2 The following three control charts for r.v.Ws are constructed which are referred to as sW_s^1, sW_s^2 and sW_s^3

i) Control chart sW_s^1 - This is simple Shewhart control chart

ii) Control chart sW_s^2 - This chart is constructed using method of weighted variance.

iii) Control chart sW_s^3 -This chart is constructed using Nelson's transformation.

4. CONTROL CHARTS FOR R.V.WQ FOR (M/M/S : ∞/FCFS) MODEL

In this section ,Shewhart control chart for WQ for (M/M/s : ∞/FCFS) model is constructed Waiting time distribution of WQ Construction of control limits for WQ , needs the distribution of WQ , its expectation and variance. The r.v.WQ denote the waiting time of customer in the queue. Assuming that the queue discipline is FCFS, from queuing theory ,the distribution f(x) of WQ is given by

$$f(x)dx = 1 - \frac{(\lambda/\mu)^s}{(s-1)!\left(s - \frac{\lambda}{\mu}\right)} p_0 = 1 - \frac{(\lambda/\mu)^s}{s!(1-\rho)} p_0, \quad x = 0$$

$$= \frac{(\lambda/\mu)^s}{(s-1)!} \mu e^{-(s\mu-\lambda)x} p_0, \quad x > 0 \ldots\ldots\ldots\ldots\ldots\ldots 4.1$$

4.1 Moments of W_Q

First two raw moments of W_Q are obtained

$$\mu_1^Q = E[W^Q] = [W^Q = 0]P[W^Q = 0] + \int_{\epsilon}^{\infty} x f(x)dx, \quad \text{as } \epsilon \to 0$$

Now

$$\int_{\epsilon}^{\infty} x f(x)dx = \int_{\epsilon}^{\infty} \frac{(\lambda/\mu)^s p_0 \mu}{(s-1)!} \{x e^{-(s\mu-\lambda)x}\} dx \to \left\{\frac{(\lambda/\mu)^s \mu p_0}{(s-1)!}\right\} \frac{1}{(s\mu-\lambda)^2}$$

$$= \frac{(\lambda/\mu)^s}{(s\mu)(s!)(1-\rho)^2} p_0 = \frac{p_s}{s\mu(1-\rho)^2}$$

$$E[W_Q] = \frac{P[N \geq s]}{s\mu(1-\rho)_Q} = \frac{(\lambda/\mu)^s}{(s-1)!} p_0 \mu \frac{1}{(s\mu-\lambda)2} \ldots\ldots\ldots\ldots\ldots\ldots 4.1.1$$

$$\mu_1^{2} = E[W^{2}_Q] = \int_{\epsilon}^{\infty} x^2 f(x)dx$$

on simplification

$$E[W_Q^2] = \frac{(\lambda/\mu)^s}{(s-1)!} p_0 \mu \frac{2}{(s\mu-\lambda)^3}$$

Let σ^2 denote variance of WQ

$$o^2 = V[W_Q] = \mu_2^1 - (\mu_1^1)^2$$

$$o^2 = V[W_Q] = E[W_Q^2] - \{E[W_Q]\}^2$$

$$= \frac{p_0 \mu (\lambda/\mu)^s}{(s-1)!(s\mu-\lambda)^2}\left[\frac{2}{(s\mu-\lambda)} - \frac{(\lambda/\mu)^s p_0 \mu}{(s-1)!(s\mu-\lambda)^2}\right] \ldots\ldots\ldots\ldots\ldots\ldots 4.1.2$$

5 Control chart sW_Q^1

Knowing $E[W_Q]$ and $V[W_Q]$,the 3 sigma control limits for W_Q are given by

$$UCL = E[W_Q] + 3\sqrt{V(W_Q)}$$
$$CL = E[W_Q] \qquad \text{.......... ....} \; 5.1$$
$$LCL = E[W_Q] - 3\sqrt{V(W_Q)}$$

False alarm rate

Let αu denote type I error probability generated in the upper tail or false alarm rate which is given by αu = P [WQ > UCL]

where UCL is obtained from 5.1 and P[WQ > UCL] is obtained using expression 4.1

6. CONTROL CHART sW_Q^2

Control chart for the r.v. WQ using method of weighted variance

In order to obtain control limits for WQ using this method, the probability PWQ defined as follows ,is needed

$$P_{W_Q} = P\left[W_Q \leq E(W_Q)\right]$$
$$= \int_0^{E[W_Q]} f(x)dx \qquad = \int_0^{E[W_Q]} \frac{(\lambda/\mu)^s p_0 \mu}{(s-1)!} e^{-(s\mu-\lambda)x} dx$$

Solving the integral and substituting for E[WQ],

$$P_{W_Q} = \frac{\mu p_0 (\lambda/\mu)^s}{(s-1)!(s\mu-\lambda)} \left\{1 - e^{\frac{-\mu p_0(\lambda/\mu)}{(s\mu-\lambda)}}\right\} \qquad 6.1$$

If the underlying population is symmetric then PWQ = 0.5 and the chart for weighted variance reduce to Shewhart chart. However, if the underlying population is skewed to the right then PWQ > 0.5 and the distance of UCL from the Center Line (CL) is larger than that of LCL similarly if the underlying population is skewed to the left then PWQ < 0.5 and the distance of the LCL from the CL is larger than that of UCL.

6.1 Control limits using method of weighted variance

The 3 sigma control limits using method of weighted variance are given by:

$$UCL = E[W_Q] + 3\sqrt{V(W_Q)}.\sqrt{2P_{W_Q}}$$
$$CL = E[W_Q] \qquad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots 6.1.1$$
$$LCL = E[W_Q] - 3\sqrt{V(W_Q)}.\sqrt{2(1 - P_{W_Q})}$$

Where E[WQ], V[WQ] and PWQ are obtained using 4.1.1, 4.1.2 and 6.1

6.2 False alarm rate (FAR)

Let αu denote type I error probability generated in the upper tail or false alarm rate which is given by $\alpha u = P[WQ > UCL]$

where UCL is obtained from 6.1.1 and the corresponding probability can be obtained from expression 4.1

7 CONTROL CHARTS FOR THE R.V.WS FOR (M/M/S : ∞/FCFS) MODEL

The distribution of r.v.WQ and its moments are obtained in section 4. In this section ,control limits for the r.v.Ws using Shewhart method and method of weighted variance are to be constructed. In order to obtain control limits for the r.v.Ws, the expressions for E[Ws] and V[Ws] are required.

Let Ws denote the waiting time of the customer in the system.

$$\therefore W_s = W_Q + \frac{1}{\mu} \quad \ldots\ldots\ldots 7.1$$

where W_Q is the waiting time of the customer in the queue and $(1/\mu)$ is the service rate of individual channel.

$$E[W_s] = E\left[W_Q + \frac{1}{\mu}\right] = E[W_Q] + \frac{1}{\mu} \quad \ldots\ldots\ldots 7.2$$

and

$$V[W_s] = V\left[W_Q + \frac{1}{\mu}\right] == V[W_Q] \quad \ldots\ldots\ldots 7.3$$

where, $E(W_Q)$ and $V(W_Q)$ are obtained from 4.1.1 and 4.1.2.

7.1 Control chart sW_s^1

Control limits for W_s using Shewhart method

The 3 sigma control limits for r.v.W_s are

$$UCL = E[W_s] + 3\sqrt{V(W_s)}$$

$$CL = E[W_s]$$

$$LCL = E[W_s] - 3\sqrt{V(W_s)}$$

7.2 False alarm rate

It is of interest to know the probability that the time of waiting in the line plus the service time exceeds time t. This probability is denoted by $P[W_s > t]$. This probability is given by

$$P[W_s > t] = e^{-\mu t}\left[1 + \frac{W}{s} + \frac{1 - e^{-\mu s t\left[1 - \left(\frac{\lambda}{\mu s}\right) - \left(\frac{1}{s}\right)\right]}}{\left[1 - \left(\frac{\lambda}{\mu s}\right) - \left(\frac{1}{s}\right)\right]}\right] \quad \ldots\ldots\ldots 7.2.1$$

Where W is the probability that a customer has to wait in line, which is the sum of all probabilities that all service facilities are being used or that s or more customers are in line.

$$W = \frac{P_0}{s!}\left(\frac{\lambda}{\mu}\right)^s \sum_{n=0}^{\infty}\left(\frac{\lambda}{\mu s}\right)^n \quad W = \left(\frac{\lambda}{\mu}\right)^s \frac{P_0}{s!\left(1-\frac{\lambda}{\mu s}\right)}$$

Let αu denote false alarm rate given by αu = P[Ws > UCL] ,replacing t by UCL in expression 5.3.1 the expression for false alarm rate αu is obtained and is given by

$$\alpha_u = P\left[W_S > UCL\right] = e^{-\mu UCL}\left[1 + \frac{W}{S} + \frac{1 - e^{-\mu UCL\left[1-\frac{\lambda}{\mu s}-\frac{1}{s}\right]}}{\left[1-\left(\frac{\lambda}{\mu s}\right)-\left(\frac{1}{s}\right)\right]}\right] \qquad \text{.......... ....7.2.2}$$

7.3 Numerical analysis of Control char sW_s^1

In order to study effect of ρ on control limits, one set of values of λ, μ and s is selected. For this set of values of ρ, p0, LCL, UCL, αu and ARL are obtained and are displayed in table 1 From this table, it is observed that keeping λ and μ fixed, if s is increased, the value of αu increases which results in the corresponding decrease in the values of ARL. We also observe that for some combination of λ, μ and s, αu turns out to be 0. This will mean that in a queuing system with those particular combinations of λ, μ and s, there are no chances of system going out of control, which means that system is performing very well.

Table 1 : Lower and Upper Control limits and the associated values of αu for r.v. W_s for M/M/S queue using sW_s^1 chart with L = 3

Sr. No	λ	μ	s	p_0	variance	ρ	LCL	CL	UCL	α_u	ARL
1	20	15	2	0.2	0.0078	0.666667	0	0.12	0.3853	0	--
2	20	15	3	0.2542	0.0005	0.444444	0.005	0.0738	0.1427	0.0025	400
3	20	15	4	0.2621	0.000006	0.333333	0.0441	0.0679	0.0917	0.0339	30
4	20	15	5	0.2633	0.000008	0.266667	0.0582	0.0668	0.0755	0.0715	14
5	20	15	6	0.2635	0.000001	0.222222	0.0635	0.0667	0.0698	0.0936	11
6	10	15	2	0.5	0.0007	0.3333	0	0.075	0.1579	0.0026	385
7	10	15	3	0.5121	0.00005	0.222222	0	0.0675	0.0892	0.0508	20
8	10	15	4	0.5133	0.00004	0.166667	0.0607	0.0667	0.0728	0.0951	11
9	10	15	5	0.5134	0	0.133333	0.065	0.0666	0.0683	0.1131	9
10	100	35	3	0.0111	0.03968	0.952381	0	0.2108	0.8084	0	-
11	100	35	4	0.0464	0.00043	0.714286	0	0.0398	0.1025	0	-
12	100	35	5	0.0546	0.00006	0.571429	0.0071	0.0312	0.0553	0.0016	625
13	100	35	6	0.0567	0.000013	0.47619	0.0185	0.0293	0.0401	0.0175	57
14	100	35	7	0.0572	0.000003	0.408163	0.0237	0.0287	0.0337	0.0428	23
15	16	15	2	0.5333	0.0003084	0.533333	0	0.0931	0.2597	0.000003	3333333
16	16	15	3	0.339	0.00024	0.355556	0.0238	0.0703	0.1167	0.0121	82
17	16	10	2	0.1111	0.057284	0.8	0	0.2777	0.9958	0	-
18	16	10	3	0.1871	0.002411	0.533333	0	0.1195	0.2668	0.0002	5000
19	16	10	4	0.1992	0.000301	0.4	0.0517	0.1037	0.1557	0.0165	61
20	12	6	3	0.1111	0.019204	0.666667	0	0.2407	0.6564	0	-

8. Control chart sW_s^2

Control limits for W_s using method of weighted variance

To obtain control limits, the method of weighted variance needs the probability P_{WS}, where P_{WS} is given by

$$P_{W_s} = P[W_s \le E(W_s)] = 1 - P[W_s > E(W_s)] \quad \text{8.1}$$

This probability can be obtained using7.2.1. The control limits of PWs using method of weighted variance are given by :

$$UCL = E[W_s] + 3\sqrt{V(W_s)}\sqrt{2P_{W_s}}$$
$$CL = E[W_s] \quad \text{.......................................8.2}$$
$$LCL = E[W_s] - 3\sqrt{V(W_s)}\sqrt{2(1-P_{W_s})}$$

8.1 False alarm rate

Let αu denote the false alarm rate which is given by $\alpha u = P[Ws > UCL]$

Where UCL is obtained using 8.2 and P[Ws > UCL] is obtained using expression 7.2.1

8.2 Numerical analysis

In order to study effect of ρ on control limits. the same set of values of λ, μ and s as in chart sW_s^1 are selected. For this set UCL, CL and LCL, P_{Ws}, P_0, α_u and ARL are obtained and are displayed in table 2. From this table it is observed that if we keep λ and μ fixed and s is increased then αu increases and consequently the associated ARL decreases very rapidly.

If ARL of this chart is compared with the ARL of chart sW_s^1 then the increase in values of ARL can be noticed. This means that the performance of this chart is better than performance of control chart sW_s^1 . This improvement in ARL is due to the presence of factor PWs in control limits which takes into account skewness of the underlying distribution of Ws for that particular combination of λ, μ and s.

Table 2 : Lower and Upper Control limits and the associated values of αu for r.v. Ws for M/M/s queue using method of weighted variance sW_s^2 with L = 3

Sr. No	λ	μ	s	p_0	Pws	ρ	LCL	CL	UCL	α_u	ARL
1	20	15	2	0.2	0.9975	0.666667	0.1013	0.12	0.4957	0	-
2	20	15	3	0.2542	0.9411	0.444444	0.0502	0.0738	0.1683	0.0008	1250
3	20	15	4	0.2621	0.913	0.333333	0.058	0.0679	0.1001	0.0245	41
4	20	15	5	0.2633	0.902	0.266667	0.063	0.0668	0.0784	0.0642	16
5	20	15	6	0.2635	0.8956	0.222222	0.0652	0.0667	0.0708	0.0903	11

6	10	15	2	0.5	0.9186	0.333333	0.0415	0.075	0.1873	0.0008	1250
7	10	15	3	0.5121	0.888	0.222222	0.0573	0.0675	0.0964	0.0392	26
8	10	15	4	0.5133	0.883	0.166667	0.0638	0.0667	0.0747	0.0889	11
9	10	15	5	0.5134	0.8804	0.133333	0.065	0.0666	0.0688	0.1111	9
10	100	35	3	0.0111	1.0000.	0.952381	0.2108	0.2108	1.056	0	-
11	100	35	4	0.0464	0.9954	0.714286	0.0388	0.0398	0.1283	0	-
12	100	35	5	0.0546	0.9672	0.571429	0.0251	0.0312	0.0648	0.00052	1923
13	100	35	6	0.0567	0.9449	0.47619	0.0257	0.0293	0.0441	0.0115	18
14	100	35	7	0.0572	0.9306	0.408163	0.0269	0.0287	0.0356	0.036	28
15	16	15	2	0.5333	0.9777	0.533333	0.058	0.0931	0.326	0	-
16	16	15	3	0.339	0.9176	0.355556	0.0514	0.0703	0.1332	0.0062	161
17	16	10	2	0.1111	0.9999	0.8	0.2762	0.2777	1.2932	0	0
18	16	10	3	0.1871	0.9651	0.533333	0.0806	0.1195	0.3242	0.000032	31250
19	16	10	4	0.1992	0.9277	0.4	0.084	0.1037	0.1746	0.0098	102
20	12	6	3	0.1111	0.9927	0.666667	0.1906	0.2407	0.8265	0	-

9. CONTROL CHART SW_s^3

Nelson's control chart for Ws for M/M/s model

Khaparde M. V. and Dhabe S. D. have constructed control chart using power transformation for r.v.Ws for (M/M/1: ∞/FCFS) model.Like (M/M/1 : ∞/FCFS) model, in (M/M/s: ∞/FCFS) model also the distribution of W_s is exponential. But this exponential distribution is a special case of Weibull

$W\left(\frac{1}{s\mu-\lambda},1\right)$ distribution.

Using the transformation $Y=(W_s)^{\frac{1}{3.6}}=W_s^{0.277}$ Y transforms to Weibull

$$W\left[\left(\frac{1}{s\mu-\lambda}\right)^{0.2777},3.6\right]$$

and thus follows approximate normal distribution. The mean of Y is given by

$$E(Y)=\left(\frac{1}{s\mu-\lambda}\right)^{0.2777}\Gamma\left(1+\frac{1}{3.6}\right)=(0.901)\left(\frac{1}{s\mu-\lambda}\right)^{0.2777} \quad \text{.......... .... 9.1}$$

This expression is used to set the center line of the control chart for Y. The standard deviation of Y is given by.

$$\sqrt{V(Y)}=\left(\frac{1}{s\mu-\lambda}\right)^{0.2777}\sqrt{\Gamma\left(1+\frac{2}{3.6}\right)-\left\{\Gamma\left(1+\frac{1}{3.6}\right)\right\}^2}$$

$$=\left(\frac{1}{s\mu-\lambda}\right)^{0.2777}(0.278) \quad \text{.................. ....9.2}$$

9.1 Control limits for W_s using Nelson Chart

Using the above approximation the control limits for Ws are given by

$$UCL = E[W_s] + L\sqrt{V(W_s)}$$

$$= (0.901)\left(\frac{1}{s\mu-\lambda}\right)^{0.2777} + L\left(\frac{1}{s\mu-\lambda}\right)^{0.2777}(0.278) \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots9.1.1$$

$$CL = (0.901)\left(\frac{1}{s\mu-\lambda}\right)^{0.2777}.$$

$$LCL = (0.901)\left(\frac{1}{s\mu-\lambda}\right)^{0.2777} + L\left(\frac{1}{s\mu-\lambda}\right)^{0.2777}(0.278) \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots9.1.2$$

where L is the distance of control limits from the center line. Taking L = 3, we get 3 sigma control limits.

9.2 Derivation and definition of α

Let α be the probability of type I error then $\alpha = \alpha_u + \alpha_l$

where α_u and α_l are the risk probabilities generated in the upper and lower tail respectively and are defined as

$\alpha_u = P[W_s > UCL]$; $\alpha l = P[W_s < LCL]$

The distribution of W_s is exponential. But after using transformation the distribution of W_s is not complete symmetrical about its mean. Therefore the probability of W_s exceeding upper control limit is obtained from C.D.F. of Weibull distribution.

$\therefore \alpha_u = P[W_s > UCL] = 1 - P[W_s < UCL] = 1 - F[UCL]$

where F(.) is the distribution function of 2 parameter Weibull distribution W(η, ν).

$$F[UCL] = 1 - \exp\left\{-\left(\frac{UCL}{\eta}\right)^{\nu}\right\} \square 9.2.1$$

but $\nu = 3.6$

$$= 1 - \exp\left\{-\left(\frac{UCL}{\eta}\right)^{3.6}\right\}$$

$$\alpha_l = P[W_s \le LCL] = \exp\left\{\left(-\frac{LCL}{\eta}\right)^{3.6}\right\} \ldots\ldots\ldots\ \ldots\ldots\ldots\ \ldots\ldots\ldots\ \ldots\ldots\ldots\ \ldots\ldots.9.2.2.$$

where $\eta = \left(\frac{1}{s\mu-\lambda}\right)^{0.2777}$

9.3 Numerical analysis

We have selected same set of values of λ, μ and s as that of control chart sW_s^1 and sW_s^2, control limits α_u and α_l are obtained. These are given in table 3 .

For this chart $\alpha_u = 0.000732$ and $\alpha_l = 0.000059$ for all values of λ, μ and s. If we are interested in detecting the shift in upper as well as lower direction then ARL is given by

$$ARL = \frac{1}{\alpha_u + \alpha_l} = \frac{1}{(0.000732) + (0.000059)} = \frac{1}{0.000791} = 1264.2225$$

This ARL remains same for all values of λ, μ and s. The main difference that can be observed in the ARL of this chart and the ARL of earlier two charts is that, in the chart sW_s^1 and sW_s^2, if we keep λ, μ fixed then ARL decreases with increase in value of s (the number of servers) but in this chart it remains same.

Using Nelson's chart if we want to detect the shift in the upward direction only then we have to consider value of α_u only and in that case

$$ARL = \frac{1}{\alpha_u} = \frac{1}{0.000732}$$
$$= 1366.1202$$
$$\cong 1366$$

10. Conclusion-

The comparison of the above three control charts for waiting time on the basis of ARL reveals that since ARL is highest for the third control chart sW_s^3

where Nelson transformation is used ,Therefore it is the best chart.

Table 3 : Lower and Upper Control limits and the associated values of α_u and α_l for r.v. Ws for M/M/s queue using Nelson transformation sW_s^3, with L = 3

Sr. No.	ë	μ	s	ñ	UCL	CL	LCL	α_u	α_l
1	20	15	2	0.66667	0.91538	0.47536	0.03535	0.00073	0.000059
2	20	15	3	0.44444	0.70973	0.36857	0.02741	0.00073	0.000059
3	20	15	4	0.33333	0.62288	0.32347	0.02405	0.00073	0.000059
4	20	15	5	0.26667	0.57017	0.29609	0.02202	0.00073	0.000059
5	20	15	6	0.22222	0.53323	0.27691	0.02059	0.00073	0.000059
6	20	15	7	0.19048	0.50524	0.26238	0.01951	0.00073	0.000059
7	10	15	3	0.22222	0.64642	0.33569	0.02496	0.00073	0.000059
8	10	15	4	0.16667	0.58546	0.30403	0.02261	0.00073	0.000059
9	10	15	5	0.13333	0.54432	0.28267	0.02102	0.00073	0.000059
10	100	35	3	0.95238	1.10967	0.57626	0.04285	0.00073	0.000059
11	100	35	4	0.71429	0.62288	0.32347	0.02405	0.00073	0.000059
12	100	35	5	0.57143	0.52311	0.27166	0.0202	0.00073	0.000059

13	100	35	6	0.47619	0.47033	0.24425	0.01816	0.00073	0.000059
14	100	35	7	0.40816	0.4356	0.22621	0.01682	0.00073	0.000059
15	16	15	2	0.53333	0.83372	0.43296	0.0322	0.00073	0.000059
16	16	15	3	0.35556	0.68107	0.35369	0.0263	0.00073	0.000059
17	16	10	2	0.8	1.18061	0.6131	0.04559	0.00073	0.000059
18	16	10	3	0.53333	0.83372	0.43296	0.0322	0.00073	0.000059
19	16	10	4	0.4	0.71782	0.37277	0.02772	0.00073	0.000059
20	12	6	3	0.66667	1.05489	0.54781	0.04074	0.00073	0.000059

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