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# A Review on the Performance Analysis of EAACK, TSTMC, AB-UBTM and HSCT for Intrusion Detection in Mobile Ad-Hoc Network

**Dr.V. UMADEVI**

Principal, New Prince Shri Bhavani Arts and Science College, Chennai, 600100, India

vumadevi76@gmail.com.

## ABSTRACT

An efficient design of network architecture for intrusion detection using Tuning Spanning Tree Multiclass Classifier (TSTMC) mechanism in MANET is provided. The construction of spanning tree using Tuning Tutte polynomial operation in mobile ad-hoc network improves the classification rate of abnormal nodes in MANET. The spanning tree based classification using breadth first search reduces the time complexity in detecting abnormal activities and significantly reduces the packet delay rate. To enhance the security level for different mobile nodes in ad hoc network, the Uninterrupted Bayesian Time Mobile algorithm is designed. Adaptive Boosting algorithm improves the resource utilization factor using probability of success and failure factor. Next, an Uninterrupted Bayesian Time Mobile (UBTM) is designed depending on the node class state to increase the trust accuracy rate. Hybrid Symmetric Cryptography Technique is provided based on the novel mixture of two symmetric cryptographic techniques using SP-AES algorithm and MD5-MAR for MANET. This technique reduces packet delay time and improves the true positive rate on abnormal activities in Mobile Ad Hoc Network.The experiments of intrusion detection system are conducted for Tuning Spanning Tree Multiclass Classifier (TSTMC) mechanism, Adaptive Boosting with Uninterrupted Bayesian Time Mobile (AB-UBTM) Networks, Hybrid Symmetric Cryptography Technique (HSCT) with the existing method named as Enhanced Adaptive ACKnowledgement (EAACK) illustrated by Elhadi M. Shakshuki., et al., 2013. Some of the parameter used for analyzing the intrusion in mobile networks was security, packet delay time, true positive rate, trust accuracy, resource utilization factor, classification sensitivity rate and multiclass error rate.

**Keywords:** MANET, TSTMC, AB-UBM, HSCT, EAACK

## 1. INTRODUCTION

Enhanced Adaptive ACKnowledgement (EACK) was designed in [1][6][7] which was proven to be secured using digital signature with appendix and digital signature with message recovery. However, network overhead increased and security remained unaddressed with the increase in varying node density. Classification methods were used in [2] to detect the intrusion for varied traffic patterns and node density. The method proved to be efficient in terms of classification error generated that reduced with the increase in the node density.Location-Based Efficient Routing Protocol (ALERT) [3] provided anonymity protection to sources, destination and routes through counter intersection strategy.An efficient design of network architecture for intrusion detection using Tuning Spanning Tree Multiclass Classifier (TSTMC) mechanism in MANET is provided. This mechanism provides multi-classifier intrusion detection system in mobile ad-hoc network. The value of packet delay achieved using the proposed Tuning Spanning Tree Multiclass Classifier (TSTMC) mechanism is lower when compared to two other existing techniques namely, Genetic Programming (GP) [4] and Smart Server Update Mechanism (SSUM) [5]. Hybrid Intrusion Detection (HID) model [8] addressed the intrusion detection rate with respect to accuracy using Tree Augmented Naïve Bayes (TAN). Reduced Error Pruning (REP) algorithm was used for efficient classification of intrusion being detected. Selection of features and classification based on intrusion was designed in [9] using rule-based attribute selection algorithm. Though efficient, multilayer model remained unaddressed. Maximum Overlap Discrete Overlap Transform (MODOT) [10] introduced clustering algorithm based on geometric properties to minimize the false positive and false negative rates. A signature based Intrusion Detector was designed in [11] to not only minimize the consumption of resources but also to improve the detection rate. Based on the aforementioned techniques and methods, in this work, an effective network of design architecture called Tuning Spanning Tree Multiclass Classifier (TSTMC) is designed in mobile ad-hoc network. The mechanism is implemented to identify the multiclass error rate by minimizing the packed delay by improving the classification sensitivity. As the method uses multiple classification process in MANET, it increases coarser construction of true positive rate on detecting abnormal activities. As a result, the proposed Neural Shannon's Entropy algorithm minimizes the multiclass error rate during packet transfer on the basis of packet type, packet size, payload and source destination pair count. The construction of spanning tree using Tuning Tutte polynomial operation in mobile ad-hoc network improves the classification rate of abnormal nodes in MANET. The spanning tree based classification using breadth first search reduces the time complexity in detecting abnormal activities and significantly reduces the packet delay rate. A series of simulation results are performed with varied node density and node velocity to test the multiclass error rate, bandwidth, true positive rate on detecting abnormal activities, classification sensitivity rate and packet delay to measure the effectiveness of the mechanism TSTMC

An Adaptive Boosting with Uninterrupted Bayesian Time Mobile (AB-UBTM) Networks for improving the trust accuracy rate of intrusion detection model is presented. Adaptive boosting mechanism has been designed to enhance the security level for different mobile nodes in ad hoc network using the Uninterrupted Bayesian Time Mobile algorithm. Adaptive Boosting algorithm improves the resource utilization factor using probability of success and failure factor. Next, an Uninterrupted Bayesian Time Mobile (UBTM) is designed depending on the node class state to increase the trust accuracy rate. The proposed AB-UBTM networks uses the posterior and prior probability for each class label by measuring how often each mobile node flows through a specific network to determine the rate of intrusion. In addition, the class conditional probability for each mobile node is measured by counting the total number of occurrences of the mobile nodes in ad hoc network at less time and therefore improves the intrusion detected rate being detected at an early time. Experimental evaluation is conducted to improve the evaluation and measured the performance in terms of resource utilization factor, trust accuracy rate, rate of intrusion being detected and security with respect to node density and different packets of different sizes.

## 2. Performance Analysis

The performance analysis of intrusion detection system in mobile ad hoc network is provided for security while transmitting the data packets in the network. In specific, Hybrid Symmetric Cryptography Technique is provided based on the novel mixture of two symmetric cryptographic techniques using SP-AES algorithm and MD5-MAR for MANET. This technique reduces the packet delay time and improves the true positive rate on abnormal activities in Mobile Ad Hoc Network. It uses the SP-AES algorithm in a dynamic manner that improves the packet transmission rate in MANET through efficient selection of unique key for each round whenever a source mobile node has to transmit packets. As a result, the proposed SP-AES algorithm performs data packet transmission in an efficient manner reducing the packet delay time in an efficient manner and helps in improving the security. By applying the MD5 based malicious attack removal process in HSCT, true positive rate on abnormal activities is improved and overcomes the vulnerability of computation overhead in MANET. Finally, with the application of two algorithms namely SP-AES and MD5-MAR, ensure high security to information on MANET. Different mobile nodes with varied data packet sizes on MAENT using HSCT carefully analyze the data packet transmission and therefore significantly secure the mobile network system from malicious attacks in MANET.

Intrusion detection system in mobile ad hoc network uses the NS-2 simulator with the network range of 1400 * 1400 m size. For experimental purpose, the mobile nodes selected are 70 nodes and experiments are conducted with the aid of Destination Sequence Based Distance Vector DSDV. The moving speed of each mobile node in MANET is about 20 m/s with a simulation rate of 30 seconds to perform data packet transmission between mobile nodes.

The network range of size uses KDD Cup '99 dataset and DARPA Intrusion Detection System (IDS) Evaluation dataset for experimental work. DARPA dataset really appear like real network traffic information but contains synthetic data generates using a closed network. The data contains several proprietary network traffic generators, and hand inserted attacks. In the Random Way Point (RWM) model, each mobile node moves to an irregularly chosen location. The irregular movement leads to the intrusion detection on some part of the network architecture. The RWM uses normal number of mobile nodes for scheduling the nodes. The network range in the system chooose the location and speed which contains the quality and speed count.

## 3. ANALYSIS OF THE PARAMETERS BASED ON EAACK, TSTMC, AB-UBTM AND HSCT

The experiments of intrusion detection system are conducted for Tuning Spanning Tree Multiclass Classifier (TSTMC) mechanism, Adaptive Boosting with Uninterrupted Bayesian Time Mobile (AB-UBTM) Networks, Hybrid Symmetric Cryptography Technique (HSCT) with the existing method named as Enhanced Adaptive ACKnowledgement (EAACK) illustrated by Elhadi M. Shakshuki., et al., 2013. Some of the parameter used for analyzing the intrusion in mobile networks was security, packet delay time, true positive rate, trust accuracy, resource utilization factor, classification sensitivity rate and multiclass error rate.

### 3.1 Performance analysis of Security

Security is obtained based on the difference between the data packets being transmitted and the data packets dropped during transmission. Security is measured using packets per second (PPS). Higher the security, more efficient the method is said to be. The mathematical formulation for security is as given below.

Security(PPS) = Transmitted data packet – Dropped data packets.

…..Eqn (1)

**For example:**

i. **EAACK method**
Security (PPS) = 50-8 = 42 PPS

ii. **TSTMC mechanism**
Security (PPS) = 50-6 = 44 PPS

iii. **AB-UBTM Networks**
Security (PPS) = 50-5 = 45 PPS

iv. **HSCT method**
Security (PPS) = 50- 3 = 47 PPS

**1.Tabulation of Security**

| Data Packet | Security (PPS) | | | |
|---|---|---|---|---|
| | Existing EAACK method | Proposed TSTMC mechanism | Proposed AB-UBTM Networks | Proposed HSCT method |
| 50 | 42 | 44 | 45 | 47 |
| 100 | 72 | 77 | 82 | 85 |
| 150 | 109 | 118 | 127 | 135 |
| 200 | 158 | 167 | 175 | 189 |
| 250 | 210 | 219 | 228 | 235 |
| 300 | 248 | 259 | 265 | 279 |
| 350 | 306 | 319 | 324 | 339 |

The Table 1 represents the value of security obtained using NS-2 simulator in proposed HSCT method and comparison is made with other methods, namely existing Enhanced Adaptive ACKnowledgement (EAACK) illustrated by Elhadi M. Shakshuki., et al., 2013 and proposed TSTMC mechanism and proposed AB-UBTM Networks. To conduct experiments, the data packets being transmitted and protecting the data packets from malicious attacks with respect to number of data packets in the range of 50 to 350. The packet transmitted is measured in terms of kilobytes (KB).

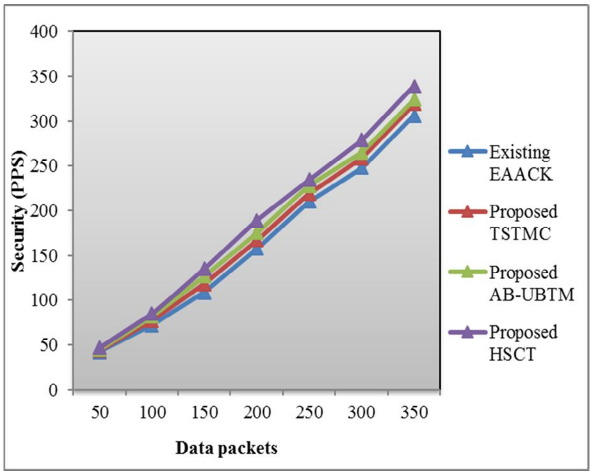

**Figure 1 Measure of Security**

From the Figure 1, it is evident that the security is improved using HSCT. This confirms the efficiency of the proposed technique HSCT. The security in HSCT is improved by applying MD5-based malicious attack removal (MD5-MAR) algorithm. Furthermore by applying SP-AES and MD5-based malicious attack removal process fused together on the mobile nodes to communicate data packets higher security rate is ensured. With the application of mixture of two symmetric cryptographic techniques, SP-AES and MD5-MAR, security with unique key and cryptographic function is provided in HSCT.

As illustrated in the Figure 6.1, the security is improved by applying SP-AES and MD5-MAR algorithm in HSCT method by 13% when compared with existing Enhanced Adaptive ACKnowledgement (EAACK) illustrated by Elhadi M. Shakshuki., et al., 2013. Similarly, the other proposed methods AB-UBTM Networks and TSTMC mechanism also improves the security by 9% and 5% respectively. Therefore, proposed HSCT method obtains better security.

### 3.2 Performance analysis of True Positive Rate

True positive rate on abnormal activities is defined as the ratio of abnormal activities correctly identified as abnormal to the summation of abnormal activities correctly identified as normal and wrongly identified as abnormal. The true positive rate is measured in terms of percentage (%). Higher the true positive rate more efficient the method is said to be. The mathematical formulation for true positive rate on abnormal activities is given as below.

$$TPR_{\text{detecting abnormal activities}} = \frac{\text{Abnormal}_{\text{correctly identified}}}{\text{Abnormal}_{\text{correctly identified}} + \text{Abnormal}_{\text{wrongly identified}}} * 100$$

…..Eqn (2)

**For example:**

i. **Existing EAACK method**
True Positive Rate (%) = (6/ (6+4))*100 = 60%

ii. **Proposed TSTMC mechanism**
True Positive Rate (%) = (8/ (8+2))*100 = 80%

iii. **Proposed AB-UBTM Networks**
True Positive Rate (%) = (7/ (7+3))*100 = 70%

iv. **Proposed HSCT method**
True Positive Rate (%) = (8/ (8+2))*100 = 80%

**1. Tabulation of True Positive Rate**

| Node Density | True positive rate on abnormal activities (%) | | | |
|---|---|---|---|---|
| | Existing EAACK method | Proposed TSTMC mechanism | Proposed AB-UBTM Networks | Proposed HSCT method |
| 10 | 61 | 76 | 67 | 84 |
| 20 | 55 | 81 | 63 | 89 |
| 30 | 60 | 78 | 68 | 85 |
| 40 | 63 | 80 | 71 | 88 |
| 50 | 57 | 73 | 65 | 82 |
| 60 | 59 | 71 | 67 | 84 |
| 70 | 62 | 75 | 70 | 87 |

The Table 2 represents the value of true positive rate on abnormal activities obtained using NS-2 simulator in proposed HSCT method and comparison is made with other methods, namely existing Enhanced Adaptive ACKnowledgement (EAACK) illustrated by Elhadi M. Shakshuki., et al., 2013 and proposed TSTMC mechanism and proposed AB-UBTM Networks. To conduct experiments, the node density is considered from 10 to 70 nodes.

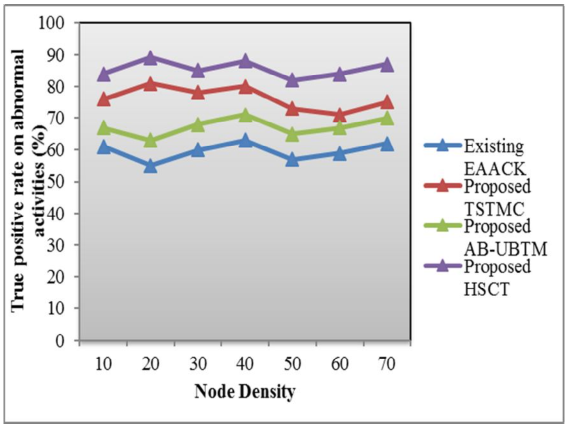

**Figure 2 Measure of True Positive Rate**

Figure 2 presents the variation of true positive rate on abnormal activities with respect to node density in MANET. All the results provided in Figure 6.2 confirm that the proposed HSCT method significantly outperforms when compared with other methods namely, existing Enhanced Adaptive ACKnowledgement (EAACK) illustrated by Elhadi M. Shakshuki., et al., 2013, proposed TSTMC mechanism and proposed AB-UBTM Networks. The true positive rate on abnormal activities is improved in the HSCT using the MD5-based malicious attack removal process. With the application of MD5-based malicious attack removal process, cryptographic technique to combat against stronger attacks in MANET is ensured. Followed by this, Cryptographic Function is applied to the source mobile nodes ready for data packet transmission. Moreover, 64 operations using MD5 are grouped in four rounds of 16 operations which improve the true positive rate.

As illustrated in the Figure 2, the true positive rate on abnormal activities is improved in proposed HSCT method by 30% when compared with existing Enhanced Adaptive ACKnowledgement (EAACK) illustrated by Elhadi M. Shakshuki., et al., 2013. Similarly, the other proposed methods AB-UBTM Networks and TSTMC mechanism also improves the true positive rate by 11% and 22% respectively. Therefore, proposed HSCT method obtains better true positive rate.

### 3.3 Performance analysis of Packet Delay Time

The packet delay time is the difference between the estimated time for the data packets to reach the destination node and the actual time to reach the destination node. Lower the packet delay time more efficient the method is said to be and it is measured in terms of milliseconds. The mathematical formulation of packet delay time is measured as given below.

$$\text{Packet Delay Time (ms)} = \text{Number of data packets} * (\text{Estimated time} - \text{Actual time})$$

…..Eqn (3)

**For example:**

i. **Existing EAACK method**
Packet Delay Time (ms) = 7*(0.85 ms- 0.40 ms)
= 3.15 ms

ii. **Proposed TSTMC mechanism**
Packet Delay Time (ms) = 7*(0.85 ms- 0.55 ms)
= 2.10 ms

iii. **Proposed AB-UBTM Networks**
Packet Delay Time (ms) = 7*(0.85 ms- 0.49 ms)
= 2.52 ms

iv. **Proposed HSCT method**
Packet Delay Time (ms) = 7*(0.85 ms- 0.58 ms)
= 1.89 ms

**2. Tabulation of Packet Delay Time**

| Data Packet | Packet delay time (ms) | | | |
|---|---|---|---|---|
| | Existing EAACK method | Proposed TSTMC mechanism | Proposed AB-UBTM Networks | Proposed HSCT method |
| 7 | 3.14 | 2.13 | 2.50 | 1.85 |
| 14 | 3.99 | 3.15 | 3.56 | 2.18 |
| 21 | 5.34 | 4.46 | 5.12 | 3.76 |
| 28 | 4.98 | 3.98 | 4.72 | 2.83 |
| 35 | 6.13 | 5.27 | 5.87 | 3.37 |
| 42 | 6.89 | 5.92 | 6.20 | 4.59 |
| 49 | 7.23 | 6.49 | 6.86 | 5.12 |

The Table 3 represents the value of packet delay time obtained using NS-2 simulator in proposed HSCT method and comparison is made with other methods, namely existing Enhanced Adaptive ACKnowledgement (EAACK) illustrated by Elhadi M. Shakshuki., et al., 2013 and proposed TSTMC mechanism and proposed AB-UBTM Networks. To conduct experiments, the data packets are ranged from 7 to 49. The packet delay time is based on the number of data packets send.

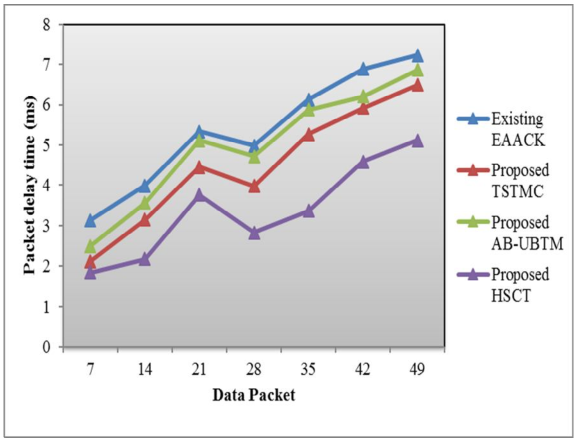

**Figure 3 Measure of Packet Delay Time**

From Figure 3, it is evident that the packet delay time is reduced using the proposed HSCT. The SP-AES algorithm with optimal strategy results in the reduced packet delay time in HSCT. With the application of SP-AES algorithm, rounding function is produced at different time intervals resulting in the improvement of packet delay time (i.e. reducing the packet delay time). At the same time, in HSCT, the efficient shifting of different row is made in an efficient manner using Shift Rows function. With the shifting, the source mobile node performs data packet transmission and sends the data packet along with the key generated to the destination node in MANET.

As illustrated in the Figure 3, the packet delay time is reduced by applying SP-AES and MD5-MAR algorithm in HSCT method by 63% when compared with existing Enhanced Adaptive ACKnowledgement (EAACK) illustrated by Elhadi M. Shakshuki., et al., 2013. Similarly, the other proposed methods AB-UBTM Networks and TSTMC mechanism also reduces the packet delay time by 23% and 10% respectively. Therefore, proposed HSCT method obtains better packet delay time.

### 3.4 Performance analysis of Trust accuracy

Trust accuracy is measured using the class label that efficiently classifies depending on the class node's stage with respect to node density. It is measured in terms of percentage (%).

$$\text{Trust Accuracy (\%)} = \frac{\text{Class label}}{\text{Node density}} * 100$$

…… Eqn (4)

**For example:**

**i. Existing EAACK method**
Trust accuracy (%) = (4/10)*100 = 40%

**ii. Proposed TSTMC mechanism**
Trust accuracy (%) = (5/10)*100 = 50%

**iii. Proposed AB-UBTM Networks**
Trust accuracy (%) = (7/10)*100 = 70%

**iv. Proposed HSCT method**
Trust accuracy (%) = (6/10)*100 = 60%

**3. Tabulation of Trust accuracy**

| Node density | Trust accuracy (%) | | | |
|---|---|---|---|---|
| | Existing EAACK method | Proposed TSTMC mechanism | Proposed AB-UBTM Networks | Proposed HSCT method |
| 10 | 43 | 52 | 71 | 61 |
| 20 | 54 | 66 | 75 | 70 |
| 30 | 68 | 73 | 82 | 77 |
| 40 | 62 | 71 | 80 | 75 |
| 50 | 66 | 74 | 84 | 79 |
| 60 | 69 | 71 | 82 | 75 |
| 70 | 73 | 78 | 87 | 82 |

The Table 4 represents the values of trust accuracy obtained using NS-2 simulator in proposed AB-UBTM method and comparison is made with other methods, namely existing Enhanced Adaptive ACKnowledgement (EAACK) illustrated by Elhadi M. Shakshuki., et al., 2013 and proposed TSTMC mechanism and proposed HSCT Networks. To conduct experiments, performance with node density in the range of 10 to 70 mobile nodes in ad hoc network is considered for experimental purpose.

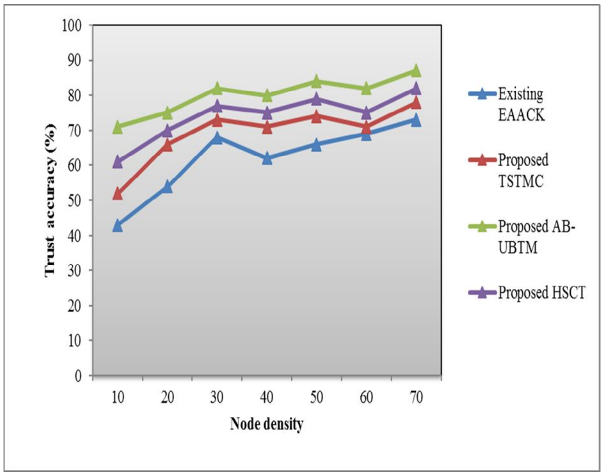

**Figure 4 Measure of Trust accuracy**

Figure 4 shows the trust accuracy level of AB-UBTM networks for 10 to 70 nodes in ad hoc network. The performance of all trust accuracy level is improved as the number of nodes increases though minimizes for 40 mobile nodes considered. But comparatively, the trust accuracy level is increased in the proposed AB-UBTM networks when compared to other methods. By applying Uninterrupted Bayesian Time Mobile (UBTM) algorithm that initializes the weight, depending on the nodes class state and therefore increases the trust accuracy level. In addition, by evaluating the posterior and prior probability for obtaining conditional probability, efficiently classifies depending on the class node's stage thus improving the trust accuracy.
As illustrated in the Figure 4, the trust accuracy is improved by applying UBTM algorithm in proposed AB-UBTM Networks by 23% when compared with existing Enhanced Adaptive ACKnowledgement (EAACK) illustrated by Elhadi M. Shakshuki., et al., 2013. Likewise, the other proposed methods TSTMC mechanism and HSCT method also improves the trust accuracy by 11% and 17% respectively. Therefore, proposed AB-UBTM Networks obtains better trust accuracy.

### 3.5 Performance analysis of Classification Sensitivity Rate

Classification sensitivity rate is defined as the ratio of correctly identified packets in the node to the sum of correctly identified packets and incorrectly rejected packets in nodes. It is measured in terms of percentage (%).

$$\text{Classification Sensitivity Rate (\%)} = \frac{\text{correctly identified packets (count)}}{\text{correctly identified + incorrectly rejected packets (count)}} * 100$$

……. Eqn (5)

**For example:**

**i. Existing EAACK method**
Classification sensitivity rate (%)
= (55(count)/ (55+97) (count))*100 = 36%

**ii. Proposed TSTMC mechanism**
Classification sensitivity rate (%)

= (73(count)/ (73+79) (count))*100 = 48%

iii. **Proposed AB-UBTM Networks**
Classification sensitivity rate (%)
= (59(count)/ (59+93) (count))*100 = 39%

iv. **Proposed HSCT method**
Classification sensitivity rate (%)
= (67(count)/ (67+85) (count))*100 = 44%

**4. Tabulation of Classification Sensitivity Rate**

| Maximum node velocity (m/sec) | Classification Sensitivity Rate (%) | | | |
|---|---|---|---|---|
| | Existing EAACK method | Proposed TSTMC mechanism | Proposed AB-UBTM Networks | Proposed HSCT method |
| 2 | 36 | 48 | 39 | 44 |
| 4 | 38 | 51 | 40 | 47 |
| 6 | 51 | 63 | 58 | 61 |
| 8 | 42 | 57 | 47 | 54 |
| 10 | 56 | 69 | 61 | 68 |
| 12 | 61 | 74 | 66 | 72 |
| 14 | 67 | 79 | 71 | 77 |

The higher influence of classification sensitivity rate with respect to the node velocity is listed in Table 6.5 for proposed TSTMC mechanism and comparison is made with other schemes. It is compared with existing Enhanced Adaptive ACKnowledgement (EAACK) illustrated by Elhadi M. Shakshuki., et al., 2013, proposed AB-UBTM Networks and proposed HSCT Networks. Here, the maximum node velocity is ranges from 2 to 14. It can also be seen that the classification sensitivity rate increases with the increase in the node velocity which is measured in terms of m/sec.

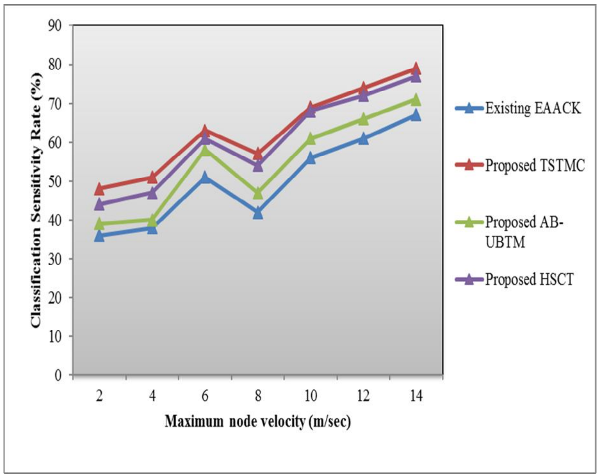

**Figure 5 Measure of Classification Sensitivity Rate**

In Figure 5, the node velocity is varied between 2 and 14. From the figure it is illustrative that the classification sensitivity rate is improved using the proposed Tuning Spanning Tree Multiclass Classifier (TSTMC) mechanism when compared with other schemes. This improvement rate is significant with the aid of Tuning Tutte polynomial operation. The polynomial time processing of network structure classifies accurately the internal and external traffic over mobile ad-hoc network. Finally, with the application of Spanning tree in the TSTMC mechanism that detects the intrusions through the sub graph edge points, further improves the classification sensitivity rate.

As illustrated in the Figure 5, the classification sensitivity rate is improved with the aid of Tuning Tutte polynomial operation in proposed TSTMC mechanism by 21% when compared with existing Enhanced Adaptive ACKnowledgement (EAACK) illustrated by Elhadi M. Shakshuki., et al., 2013. Likewise, the other proposed methods AB-UBTM Networks and HSCT method also improves the classification sensitivity rate by 8% and 17% respectively. Therefore, proposed TSTMC mechanism obtains better classification sensitivity rate.

### 3.6 Performance analysis of Multiclass Error Rate

Multiclass error rate in mobile ad-hoc network is defined as the ratio of total number of unequal packets to the total number of packet send. It is measured in terms of percentage (%).

$$\text{Multiclass Error Rate } (\%) = \frac{\text{Total number of unequal packets}}{\text{Total number of packet sends}} * 100$$

……. Eqn (6)

**For example:**

i. **Existing EAACK method**
Multiclass Error Rate (%)
= (94(count)/ 152(count))*100 = 62%

ii. **Proposed TSTMC mechanism**
Multiclass Error Rate (%)
= (68(count)/ 152(count))*100 = 45%

iii. **Proposed AB-UBTM Networks**
Multiclass Error Rate (%)
= (77(count)/ 152(count))*100 = 51%

iv. **Proposed HSCT method**
Multiclass Error Rate (%)
= (86(count)/ 152(count))*100 = 57%

**5. Tabulation of Multiclass Error Rate**

| Node Density | Multiclass Error Rate (%) | | | |
|---|---|---|---|---|
| | Existing EAACK method | Proposed TSTMC mechanism | Proposed AB-UBTM Networks | Proposed HSCT method |
| 50 | 62 | 45 | 51 | 57 |
| 100 | 65 | 48 | 54 | 59 |
| 150 | 67 | 51 | 56 | 63 |
| 200 | 70 | 53 | 59 | 67 |
| 250 | 67 | 50 | 56 | 62 |
| 300 | 71 | 54 | 60 | 69 |
| 350 | 75 | 58 | 64 | 73 |

Table 6 evaluates the multiclass error rate measured in terms of percentage achieved with the different number of nodes ranging from 50 to 350. It is compared with existing Enhanced Adaptive ACKnowledgement (EAACK) illustrated by Elhadi M. Shakshuki., et al., 2013, proposed AB-UBTM Networks and proposed HSCT Networks.

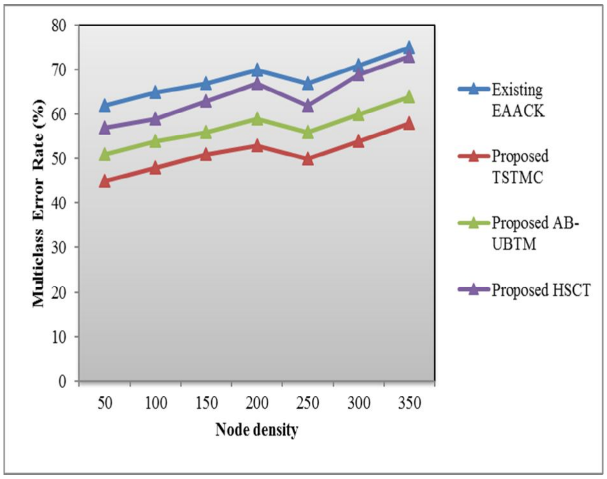

**Figure 6 Measure of Multiclass Error Rate**

Figure 6 describes the multiclass error rate based on the different node densities in mobile ad-hoc network. The entropy measure of network properties of each packet is measured based on packet size, packet type payload and source destination pair. With this network traffic feature, uncertainties are obtained and help to reduce the multiclass error rate. Using the entropy source destination pair, the entropy value is measured with the predefined path structures and path selected for packet transfer. The Neural Shannon's Entropy procedure considers the single output unit using the log function 'f' which reduces the multiclass error rate.

As illustrated in the Figure 6, the multiclass error rate is reduced with entropy measure of network properties in proposed TSTMC mechanism by 33% when compared with existing Enhanced Adaptive ACKnowledgement (EAACK) illustrated by Elhadi M. Shakshuki., et al., 2013. Likewise, the other proposed methods AB-UBTM Networks and HSCT method also reduces the multiclass error rate by 19% and 6% respectively. Therefore, proposed TSTMC mechanism obtains better multiclass error rate.

### 3.7 Performance analysis of Resource Utilization Factor

Resource utilization factor measures the ratio of available nodes to the nodes being utilized. Higher the resource utilization, more efficient the method is said to be. It is measured in terms of percentage (%). The mathematical formulation of resource utilization is as given below

$$\text{Resource Utilization Factor (\%)} = \frac{\text{Utilized nodes}}{\text{Available nodes}} * 100$$

…… Eqn (7)

**For example:**

**i. Existing EAACK method**

Resource utilization factor (%)
= (4/10)*100 = 40%

**ii. Proposed TSTMC mechanism**

Resource utilization factor (%)
= (5/10)*100 = 50%

**iii. Proposed AB-UBTM Networks**

Resource utilization factor (%)
= (7/10)*100 = 70%

**iv. Proposed HSCT method**

Resource utilization factor (%)
= (6/10)*100 = 60%

**6. Tabulation of Resource Utilization Factor**

| **Node density** | **Resource Utilization Factor (%)** | | | |
|---|---|---|---|---|
| | **Existing EAACK method** | **Proposed TSTMC mechanism** | **Proposed AB-UBTM Networks** | **Proposed HSCT method** |
| 10 | 41 | 54 | 73 | 61 |
| 20 | 48 | 58 | 76 | 63 |
| 30 | 57 | 63 | 80 | 68 |
| 40 | 52 | 57 | 74 | 62 |
| 50 | 59 | 62 | 79 | 67 |
| 60 | 63 | 67 | 78 | 71 |
| 70 | 69 | 73 | 84 | 78 |

The Table 7 represents the values of resource utilization factor obtained using NS-2 simulator in proposed AB-UBTM method and comparison is made with other methods, namely existing Enhanced Adaptive ACKnowledgement (EAACK) illustrated by Elhadi M. Shakshuki., et al., 2013 and proposed TSTMC mechanism and proposed HSCT Networks. To conduct experiments, performance with node density in the range of 10 to 70 mobile nodes in ad hoc network is considered for experimental purpose.

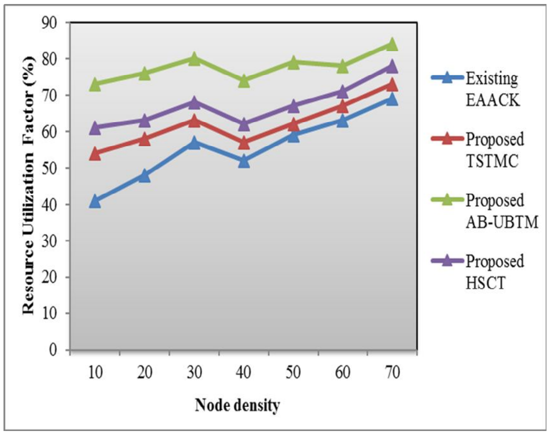

**Figure 7 Measure of Resource Utilization Factor**

Figure 7 shows the measure of resource utilization based on the number of nodes in the range of 10 and 70. The resource utilization for differing node density is measured based on the available and utilized nodes in ad hoc network. From the figure it is evident that the resource utilization using the proposed method is comparatively greater than the other methods. This is because by applying the Adaptive Boosting adaptively updates the weights during each round of boosting using Uninterrupted Bayesian Timed Mobile nodes. In addition, each mobile node payoff is evaluated which are the residue between the mean utility and the mean cost given the views of node further increases the resource utilization rate.

As illustrated in the Figure 7, the resource utilization factor is improved with adaptive boosting algorithm in proposed AB-UBTM Networks by 29% when compared with existing Enhanced Adaptive ACKnowledgement (EAACK) illustrated by Elhadi M. Shakshuki., et al., 2013. Likewise, the other proposed methods TSTMC mechanism and HSCT method also improves the resource utilization factor by 11% and 18% respectively. Therefore, proposed AB-UBTM Networks obtains better resource utilization factor.

## CONCLUSION

An efficient design of network architecture for intrusion detection using Tuning Spanning Tree Multiclass Classifier (TSTMC) mechanism in MANET is provided with multi-classifier intrusion detection system in mobile ad-hoc network. As the method uses multiple classification process in MANET, it increases coarser construction of true positive rate on detecting abnormal activities. The security levels for different mobile nodes are enhanced in ad hoc network using the Uninterrupted Bayesian Time Mobile algorithm. The proposed networks uses the posterior and prior probability for each class label by measuring how often each mobile node flows through a specific network to determine the rate of intrusion. In addition, the class conditional probability for each mobile node is measured by counting the total number of occurrences of the mobile nodes in ad hoc network at less time and therefore improves the intrusion detected rate being detected at an early time. Hybrid Symmetric Cryptography Technique is provided based on the novel mixture of two symmetric cryptographic techniques using SP-AES algorithm and MD5-MAR for MANET. This technique reduced packet delay time and improves the true positive rate on abnormal activities in Mobile Ad Hoc Network.

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