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SECURITY ENHANCEMENT IN MANET BY PROPOSED FUZZY TRUST ROUTING SCHEME

Dr. G. Srinaganya M.C.A., M.Phil., Ph.D
Assistant Professor,Department of Computer Science,
Shrimati Indira Gandhi College, Trichy, Tamilnadu, India.

S. Sowmiya
Research Scholar, Department of Computer Science
Shrimati Indira Gandhi College, Trichy, Tamilnadu, India

Abstract

MANETs are much more susceptible to various attacks because of openness in network topology and being away of a centralized administration in management. As an outcome of that, more malicious nodes are often comes in and goes out without being detected from the network topology. Hence, MANET needs very specialized security methods to isolate the false entrance. As well as there is no single solution that fitting in different types of the network where the nodes can be behave like any apparatuses. The networks works well if the nodes are trusty and act rightly cooperatively. In order to improve the security of the network, this paper gets started the new interesting approach to evaluate the trustworthiness of the nodes. Fuzzy Trust-based Secured Routing (FTSR) approach provides a flexible and feasible approach to choose trusted route to meet the requirement of the security of the data transmission. In this, fuzzy logic rule prediction mechanism is adopted to notice the future behavior of node by updating the node's trust. We have also analyzed the performance metrics such as packet delivery ratio, end-to-end delay and average throughput which can also increase accordingly through newest approach.

Keywords: Mobile Ad Hoc Network, Fuzzy Logic, Fuzzy Trust based Secured Routing, Ad Hoc On Demand

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1. Introduction

A self-configuring and self-organizing network architecture in which different mobile devices are connected by wireless link is called MANET [1]. MANET is a less-infrastructure [2] in which mobile nodes are moving arbitrary without any managerial dependent. As an outcome, topology may change frequently at unpredictable times. Mobile devices in ad-hoc network are connected via wireless links. Therefore, quantifying a trust value is major issue because ad-hoc networks depend on cooperative and trust nature of nodes. Due to the energetic nature of the nodes, the degree of trust additionally changes.

On another side, Security [3] is additionally main concern to function the network congruously where message can altered through the third party. In other words, we can verbally express that the security issue have been met by achieving the availability of the network services, confidentiality and integrity of the data. MANETs suffers from several security attacks due to have several feature such as dynamic topology, lack of central coordinator, cooperative algorithms. Wireless links are much more susceptible to sundry attacks which makes easier for attacker to go inside and come outside without being detected. Hence, we can verbalize that security of MANETs is cry of the day. In order to provide secure and reliable communication and transmission, the researcher has to get clearly the variants of threat and there effect on MANETs. Moreover, MANETs are open for different threat because communication is based on different nodes which have a mutual trust in one another.

For prosperous communication or transmission, it is compulsory to observe the node's behavior whether node will take part or not. For this, paper establishes incipient approach FTSR which utilizes a fuzzy logic rules. Fuzzy logic is a computational paradigm that builds a set-of user-defined human language rules which are converted into mathematically equivalents to handle the quandary of imprecise and incomplete data. In

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other words, Fuzzy logic deals with approximate reasoning rather than fixed and exact reasoning. The fuzzy logic may have truth value which has a range in between 0 and 1. The benefit of this system is flexibility and simple.

The newest approach avoids the inclusion of misbehaving node during route establishments by using the trust metrics. The FTSR categorized the misbehaving nodes and trustworthy nodes according to fuzzy levels such as very trustworthy, trustworthy, untrustworthy, and Very untrustworthy which is represented by the trust values. After getting the nodes trustworthiness, FTSR utilizes the fuzzy inference rules based on fuzzy levels for secure routing.

2. Related Works

We have survey many research paper [4] on the basis of trust management and fuzzy logic. Some of important paper is define as below

SrinivasSethi et al. [5] proposed FTAR that utilized ACO (Ant-Colony Optimization). The food-searching algorithm of real ant-agent is called ACO. FTAR is using two parameters such as Time-ratio and Dropped packet to categorized the healthy and malicious nodes. Fuzzification utilized the time-ratio which is ratio between the route-reply time and time-to-live. It withal access dropped packet parameter utilized to measure the number of packet dropped at node. FTAR utilizes the ACO by using two types of control packet: BANT and FANT.

N.Marchang et al. [6] Light-weight means estimating the trust that one node has for another. In this, every node maintains the trust value for its neighbor node. The trust value can be habituated to quantify the trust of neighbor node. For this eachneighbor node contains the three data structures: To Forward, Forwarded, Source list.

Hui Xia et al. [7] TSR is the on-demand trust-based unicast routing protocol which is flexible to find the optimal route for secure routing. TSR that contains four major blocks: Route discovery, Trust computation, Trust application and Route maintenance. Trust

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computation contains two processes: Computation of node's historical trust and node's current trust. In node's current trust, the trust value of node current position is computed by fuzzy logic rules prediction method. Trust application contains three processes: Route discovery, Route update and Route handoff process. The secure routing path is chosen based on minimum trust value of the route.

Radha Krishna Bar et al. [8] the computation of trust value is depending upon two properties such as packet forwarding ability and weight factor. The weight factor measures through the number of RREQ received and through the number of RREP sent. After calculation, this trust value is inserted into the routing table and route discovery is done based on this trust values rather than the traditional shortest path. During the route establishment less trusted node can be avoided in AODV routing protocol.

SuparnaBiswas et al. [9] Trust evaluation of every node is defined by three parameters: Rank, Remaining battery power, and Stability factor. Rank measures the reliability of the node. Rank of node drops to 0 defined the node is untrusted or malicious node. Remaining battery power of node is considered at a certain time, Stability factor includes two parameters: (i) Pause time (Tpause) and (ii) Velocity for node is defined by Vmax.

Hui Xia et al. [10] proposed FAPtrust define the multiple trust decision factor based on fuzzy theory. AHP theory based on entropy weight factor used to calculate the multiple decision factors and utilize the fuzzy logic prediction rules for compute the node's trust value. In this, author establishes two types of trust, namely, direct and indirect trust. The new approach establishes the trust relationship based on entropy weight method and fuzzy logic rules prediction mechanism. Fuzzy logic theory is suitable for define the uncertainty and imprecision of the network. In node's current trust, the trust value of current position of node is computed by the fuzzy logic rules prediction method.

3. Proposed Fuzzy Trust based Routing Scheme

In this section we introduced the improvement of the selection of most secure and reliable route by establishing the trust management [4] between the nodes. As well as, we

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also define the fuzzy logic rule prediction method to detect the secure route by isolating the malicious nodes. The steps of most incipient scheme is defines as below.

3.1 Before Transmission Process

Step 1: In the proposed trust model, each node maintains trust value for its neighbor node.

Calculate the level of trust value:

$$T_i(j) = \alpha T_{i(self)}(j) + \beta T_{i(neighbor)}(j)$$

Where, $T_i(j)$is the trust of node i on neighbor node j.

$T_{i(self)}(j)$represent the trust of node i on node j.

$T_{i(neighbor)}(j)$represent the trust that neighbor of node i has on node j,

and, α, β are weighting factor (α + β =1 and α>=0, β<=1)

Let a_1,a_2,a_3...an be the neighbor of node i such that they are also node of j and n is the number of neighbor node, than trust value can be calculated as,

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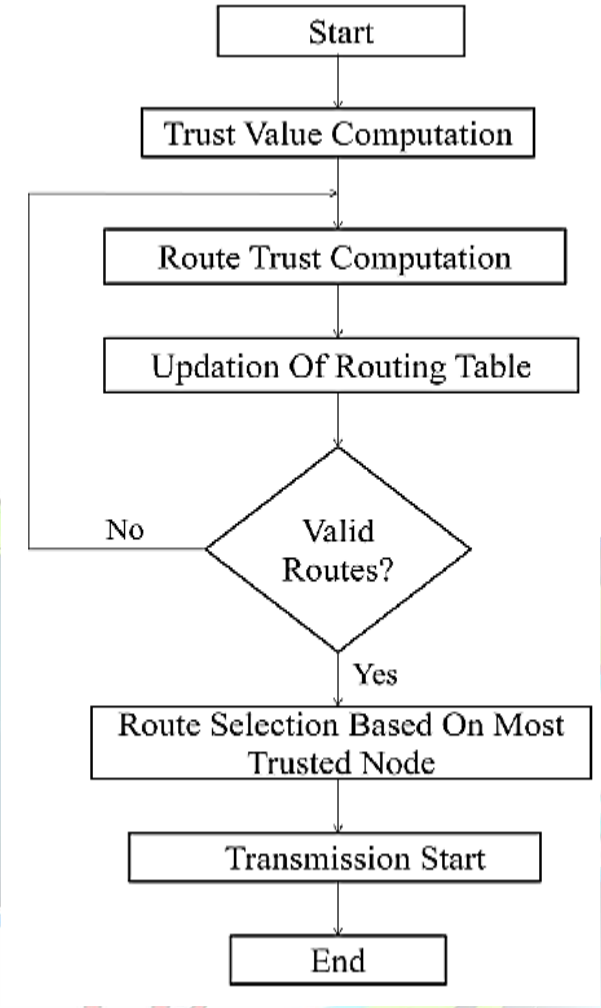

Figure 1: Before Packet Transmission Process

$$T_{i(neighbor)}(j) = \frac{1}{n}\sum Ta_k(j)$$

Step 2: In trust model, routes that are established which are withal associated with the trust value. It designates routes are nothing that the sequence of the nodes. Let r is consider as a route and l nodes are represented as a sequence $a_1,a_2,a_3,..a_l$ than the trust value of routes are represented by the R_r

$$Rr = Ta1(a2)\ Ta2(a3)\ldots\ Tal\text{-}2(al\text{-}1) = \Pi\ Tai\text{-}2(ai\text{-}1)$$

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Step 3: For a neighbour node, we have establishes a three data structures: ToForward, Forwarded, and Source List.

ToForward: it is utilized to store the number of packet to be forwarded.

Forwarded: it is utilized to store the number of packet that are already forwarded.

Source List: it is utilized to define the progenitor of the packet to be forwarded.

Each above data structures is divided into N slots or windows. Each window or slot the positive integer value called a number of packets. The maximum number of packets that each window can store have a fixed size number, M. M and N are define as a configurable parameters. The windows or slots are defined in circular fashion. We have additionally defined the CurrentWindow for two data structure which is utilized to point the current window or slot in both data structure. Initially, The CurrentWindow can set any number between 0 to N-1.

Surmise those promiscuous nodes are take place into the communication. If we consider node i as a promiscuous node in the communication, it watched for two kinds of action of node j. Firstly, node i watches for the packet that is sent to the node j which is to be forwarded further. And secondly, node i watch for the packet that is forwarded by neighbor of node i to the node j. In this both cases, whenever node i find that node j has received the packets which is to be forwarded further than ToForward count of node j is incremented by one. In another case, whenever node finds that node j has forwarded that packet which is received than Forwarded count is incremented by one. If both count is exceeded the limit M than incipient window will be initialized.

3.2 During Packet Transmission Process

Step 1: Promiscuous node maintains the Source List (sc_list) and observes the source of the packet.

Step 2: If [(Forwarded) $_{\text{node j}}$ and (sc_list contains p rogenitor node)]

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Step 3: (Forwarded) $_{node\ j}$++;

Step 4: (ToForward) $_{node\ j}$++;

Step 5: If [((Forwarded) $_{node\ j}$>=M or (ToForward) $_{node\ j}$>=M] (CurrentWindow + 1) mod N = 0;

Step 6: Else

Step 7: Trust Value Calculation

$$T_{i(self)}(j)=\sum_{k=0}^{N-1} Forwarded(k) / \sum_{k=0}^{N-1} ToForward(k)$$

Step 8: Else

Step 9: Promiscuous node fail to update Forwarded and ToForward count of node j or progenitor node is not in sc_list.

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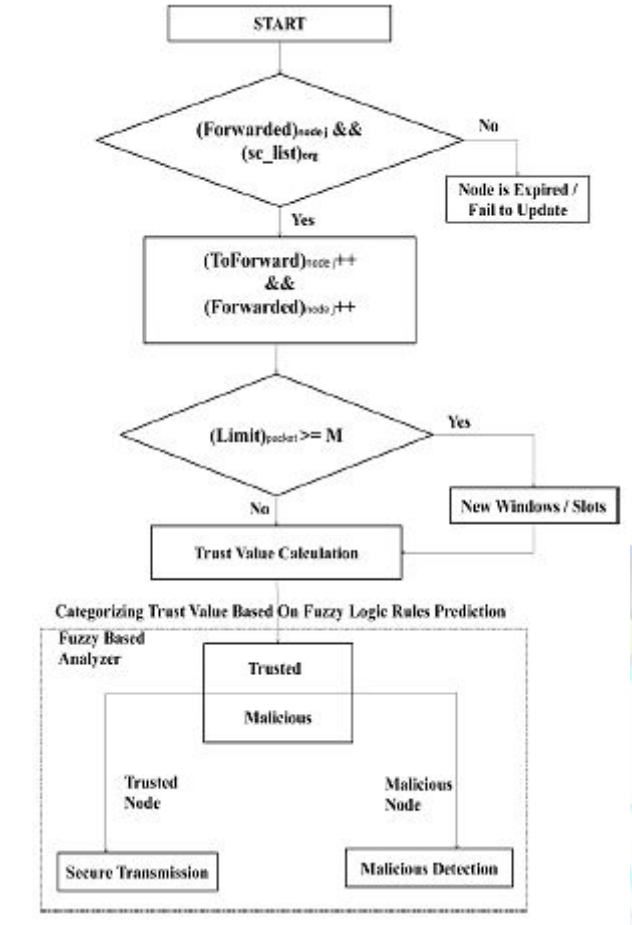

Figure 2: During Packet Transmission Process

3.3 Current Behavior Observation using Fuzzy Logic RulesPrediction Method

Fuzzy logic provides ability to handle uncertainty and imprecision effectively. Fuzzy logic based algorithm for trust has been devised and it is applied to the calculated trust value of the nodes. Trust values are computed based on $T_{i\ (self)(j)}$. These values are treated as fuzzy input variables and the Fuzzy logic based algorithm marks the nodes as either trusted or malevolent.

Step 1: Trust value calculation

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$$T_{i\,(self)}(j) = \sum_{k=0}^{N-1} Forwarded(k) \,/\, \sum_{k=0}^{N-1} ToForward$$

Step 2: Fuzzy Based Analyzer verifies the trust value of the requesting node and performs a look up in the fuzzy table for the fuzzy trust value. Fuzzy Based Analyzer determines the node as TRUSTED or MALICIOUS.

Table 1: Fuzzy Discrimination

Fuzzy level	Trust Value	Semantics
1.High	0.8 to 1	Trustworthy
2.Medium	0.6 to 0.8	0.6 to 0.8
3.Low	0.4 to 0.6	Trustworthy
4.Very Low	0 to 0.4	Untrustworthy

Step 3: Fuzzy Inference rules can be applied based on trust-levels to detect untrustworthy node.

IF Trust value is High THEN node is trustworthy

IF Trust value is Very Low THEN node is malicious

3.4 Future Behavior Observation Using Fuzzy Logic Rules Prediction Method

When node A sends a request packet to another node B, it's hard for node A to evaluate whether the node B is willing or not to provide service. For this,

Step 1: Consider TV(t) and C(t+1), Where, TV(t): Historical trust value at t time interval C(t+1): Node's capability level at t+1 time interval. Node's capability level can be achieved through providing the services such as remaining utilization of ratio of battery [11].

Step 2: Apply fuzzy operator

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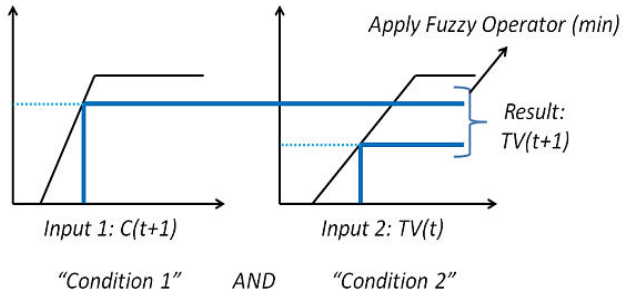

IF Capability level is X AND Trust value is Y THEN TV(t+1) = min(X,Y)

Step 3: Compare trust value TV(t+1) with static threshold value.

If (TV(t+1) >= TValue)

Node is Trustworthy

Else

Node is Malicious

Node's trust value will not be updated into the routing table or trusted node will be considered during the transmission process.

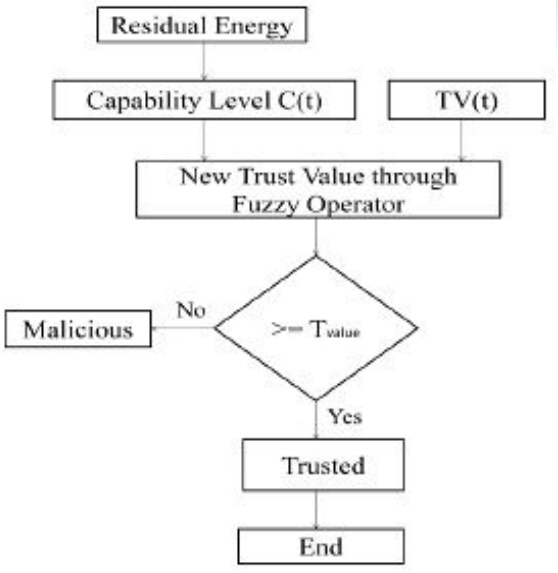

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Figure 3: Future Behavior Observation using Fuzzy Logic Rules Prediction Method

4. Experimental Setup and Result &Discussion

4.1 Simulation Parameters and performance metrics

(i) *Packet Loss*. The total number of data packets lostlegitimately or through malicious action without anynotification.

(ii) *PacketDelivery Ratio (PDR)*.The ratioof total numberof data packets delivered to the total number of datapackets sent.

(iii) *ControlOverhead*.The ratioof total number of controlpackets generated in the network to the total numberof data packets received.

(iv) *Energy Consumption*. The average energy consumedby each node during the given simulation time andexpressed in Joules (J).

(v) *Network Lifetime*. Time taken for the energy of thefirst node to fall from 0.5 J to zero and expressed inseconds.

(vi) *End-to-End Delay*. The delay experienced by thedata packet during transmission from source tosink, including processing, queuing, and propagationdelay.

(vii) *Communication Overhead*.The total number of packetsgenerated for trust establishment in the network.It included TREQ, TREP, acknowledgments, andwarning and response packets.

(viii) *Memory Consumption*.The totalmemory space exclusivelyused for trust derivation and representation,expressed in bits.

Table 2: Simulation Parameters

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Simulation time	800 secs
Simulation area	300m × 300m
Number of nodes	600
Frequency of operation	2.4GHz
Node placement	Random
Transmission range	45m
Propagation model	Two-ray
Movement model	Static
Traffic type	CBR (UDP)
Packet size	50 bytes
Packet interval	10 secs
Maximum number of malicious nodes	180
Type of attack	Black hole, on-offattack, conflictingbehavior attack, andbad-mouthing attack
Initial energy	2 Joules

4.2 Result and Discussion

Figure 4 depicts the performance comparison of the proposed method with other existing method under the packet loss against malicious nodes. Figure 5 gives the performance comparison of packet delivery ratio of the proposed FTRS with other existing methods like 2-ACKT, GTMS and AODV. Figure 6 represents the performance comparison of control overhead of the proposed FTRS with other existing methods like 2-ACKT, GTMS and AODV. Figure 7 gives the performance comparison of energy consumption using proposed FTRS, 2-ACKT, GTMS and AODV against percentage of malicious nodes. Figure 8 gives the performance comparison of network lifetime (secs) using proposed FTRS, 2-ACKT, GTMS and AODV against percentage of malicious

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nodes. Figure 9 gives the performance comparison of normalized end to end delay using proposed FTRS, 2-ACKT, GTMS and AODV against percentage of malicious nodes.

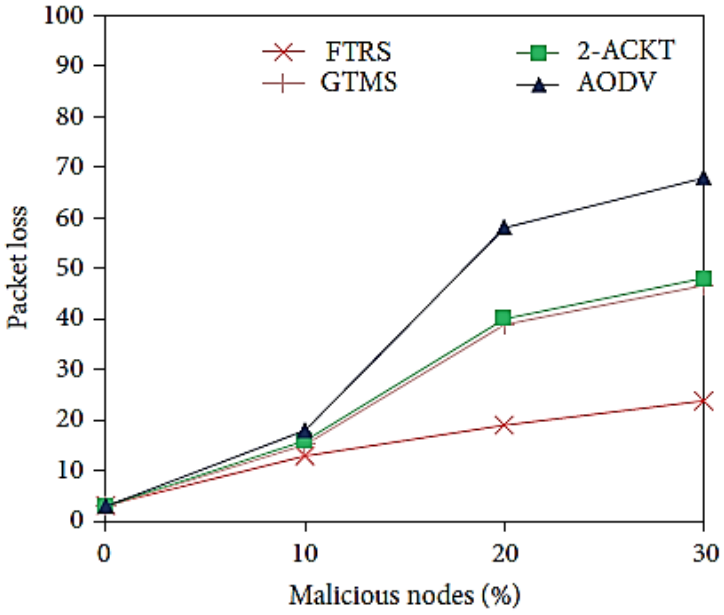

Figure 4: Performance analysis of packet loss using proposed FTRS, 2-ACKT, GTMS and AODV against percentage of malicious nodes

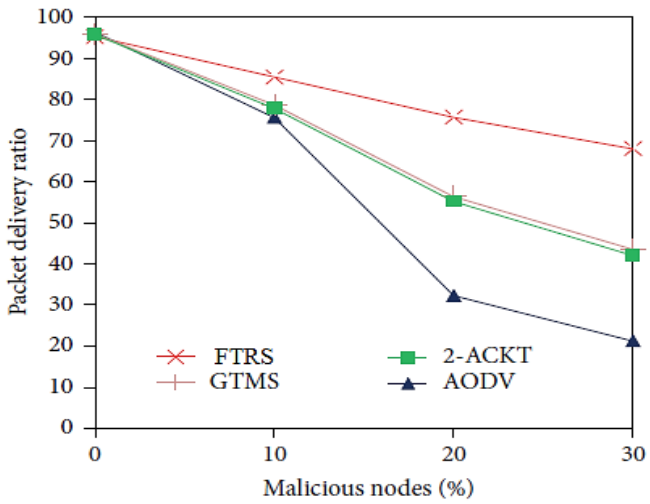

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Figure 5: Performance analysis of packet delivery ratio using proposed FTRS, 2-ACKT, GTMS and AODV against percentage of malicious nodes

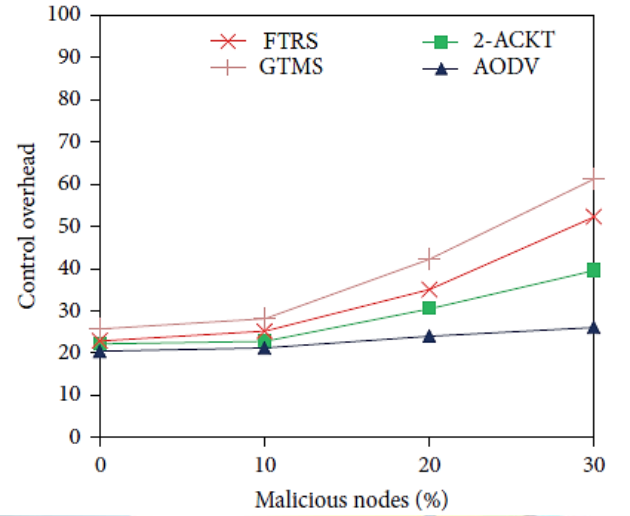

Figure 6: Performance analysis of control overhead using proposed FTRS, 2-ACKT, GTMS and AODV against percentage of malicious nodes

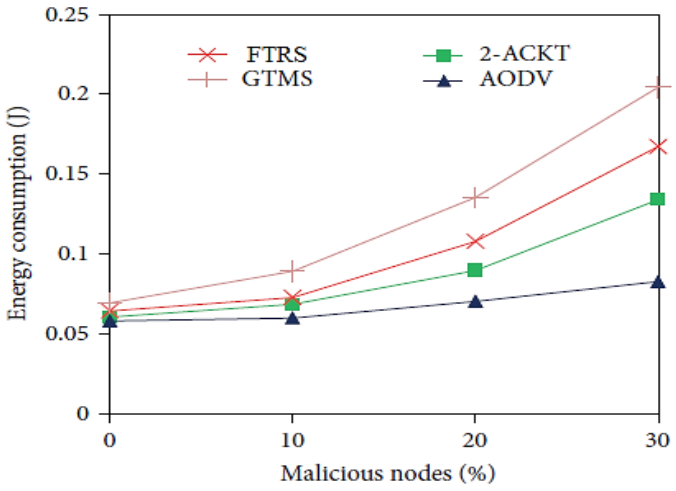

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Figure 7: Performance analysis of energy consumption using proposed FTRS, 2-ACKT, GTMS and AODV against percentage of malicious nodes

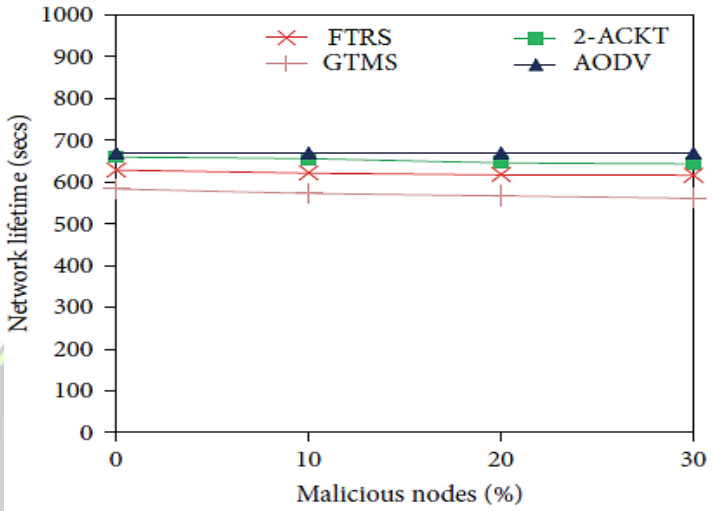

Figure 8: Performance analysis of network lifetime (secs) using proposed FTRS, 2-ACKT, GTMS and AODV against percentage of malicious nodes

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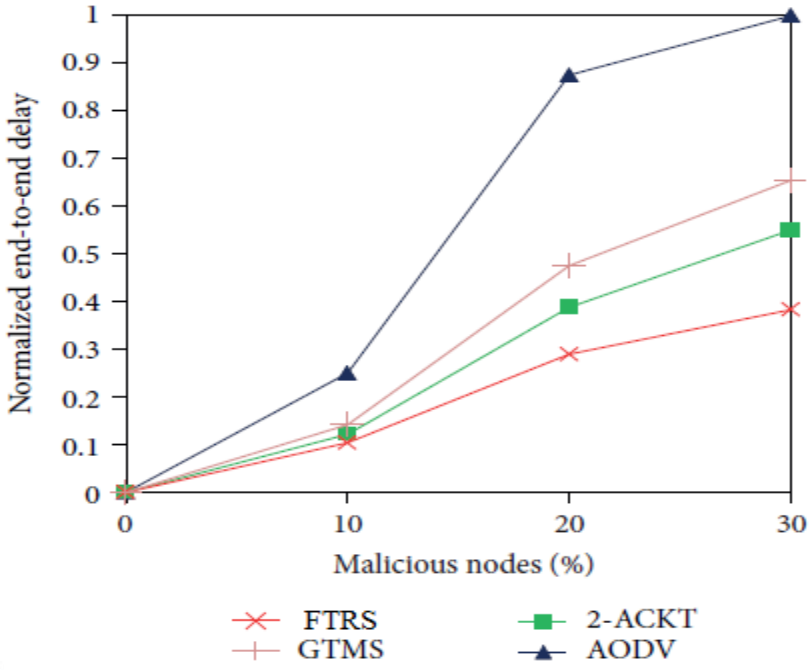

Figure 9: Performance analysis of normalized end to end delay using proposed FTRS, 2-ACKT, GTMS and AODV against percentage of malicious nodes

From the above figures, it is clear that the proposed method performs well concerning all the performance metrics than the existing methods like 2-ACKT, GTMS and AODV.

5. Conclusion

In this paper, we proposed FTPR protocol to effectivelythwart black hole attack, on-off attack, conflicting behaviorattack, and bad-mouthing attack. It employed a fuzzy-basedtrust prediction model to predict the future behavior ofa neighboring node based on its historical behavior, trustfluctuations, and recommendation inconsistency. It derivedthe trust based on the direct and indirect observations. Itreduces the energy consumption significantly by avoiding thepromiscuous mode of operation for direct trust derivationand by gathering recommendations only from a subset ofneighbors for indirect trust derivation.

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