Energy Efficient Trust Node Based Routing Protocol (EETRP) to Maximize the Lifetime of Wireless Sensor Networks in Plateaus

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Nandoori Srikanth (✉), Muktyala Sivaganga Prasad
Koneru Lakshmiah Educational Foundation, Green fields, Vaddeswaram, India
srilovesnature@gmail.com

Abstract—Wireless sensor networks (WSNs) can extant the individual profits and suppleness with regard to low-power and economical quick deployment for numerous applications. WSNs are widely utilized in medical health care, environmental monitoring, emergencies and remote control areas. Introducing of mobile nodes in clusters is a traditional approach, to assemble the data from sensor nodes and forward to the base station. Energy efficiency and lifetime improvements are key research areas from past few decades. In this research, to solve the energy limitation to upsurge the network lifetime, energy efficient trust node based routing protocol is proposed. An experimental validation of framework is focused on packet delivery ratio, network lifetime, throughput, energy consumption and network loss among all other challenges. This protocol assigns some high energy nodes as trusted nodes, and it decides the mobility of data collector. The energy of mobile nodes, and sensor nodes can save up to a great extent by collecting data from trusted nodes based on their trustworthiness and energy efficiency. The simulation outcome of our evaluation shows an improvement in all these parameters than existing clustering and routing algorithms.

Keywords—WSN, EETRP, Mobile Node, Trust Node, Sub-Cluster (SC)

1 Introduction

The main objective of wireless sensor network (WSN) is to observe physical or ecological conditions, such as sound, temperature, pressure, vibration, motion or contaminants and to co-operatively pass their data by the network to a central position (i.e., base station or sink) [1]. WSNs are developing as an important and popular ways of provided that prevalent computing environments for several applications and harshly challenged by limited energy. It's essential to use available energy in efficient manner to maintain sustainability in networks [2]. In WSNs, the deployment of sensor nodes (SN) is performed whichever in the arbitrary manner. Firstly, WSNs was similar in nature, i.e. all the SN and cluster-heads are undistinguishable with reference to power consumption, storage capacity and computing capability [3]. WSN is an arrangement of several nodes for efficient performance of WSN; we have required

competent routing protocol with well-planned data aggregation methods as well as very low energy consumption. These networks are drastically resource limited by their bound power supply. To figure out this issue hierarchical routing protocol based on clustering is taken into consideration [4].

Mahajan et al., (2014) [5] reported a rank based metric approach which is recommended to choose clusters from the set of sensors in view of network performance parameters that allocates load consistently in the cluster and consume least energy. Heterogeneous mobile sensor network environment wireless sensor network is a dispersed network, which includes a set of independent and self-organized sensor nodes and one or more base station (BS). This sort of network can be designed and arranged to observe and track applications for instance smart environments like smart cities, smart grid, smart home; habitat monitoring and surveillance etc. [6]. In wireless sensor networks, trust model stipulates a significant role in recognizing misbehavior nodes and provided that co-operation amid trustworthy nodes. Trust node plays a most important role to sense a node which is not performing as expected (whichever defective or maliciously). Trust judges the quality of node and their services. It improves the lifetime of networks that motivate anticipations amid future interactions in WSNs [7].

1.1 Motivation of the paper

Clustering is a technique which is utilized to progress the lifetime of nodes and several clustering algorithms have been established to enhance the energy balance of the WSN's due to energy is the principal feature of WSN's during data transmission. These algorithms are mainly used for increasing the lifetime of sensor networks. The whole sensing field is distributed into sub clusters. In every sub cluster, few mobile nodes are introduced for various parameters, which include energy or distance from the base station. Introduced a mobile node (MN) in a sub cluster is the initial motivation of this paper, because deployment of SN and collection of data in plateaus and military areas is a major challenging issue, thus mobile node has to ingest more energy to collect the data from those nodes. Energy efficient trust node based routing protocol was proposed to upsurge the lifetime of the network.

1.2 Contributions of the paper

In this research, an Energy efficient trust node based routing protocol (EETRP) was proposed in WSN. Nodes are structured into clusters, cluster is divided into the sub clusters, and we assign some sub-cluster nodes as trust nodes. However, EETRP algorithm is initially performed on all sub cluster nodes to form balanced sensor nodes, proper mobile node and trust node are designated. The main contributions of this research are as follows:

- Energy efficient trust node based routing protocol (EETRP) is proposed, which aims to minimize energy consumption for data transmission in WSN.

- EETRP protocol is utilized to optimize the sub clustering algorithm rules to upsurge the network lifetime, based on the applications like plateaus and military areas.
- This protocol differs from the traditional clustering approaches due to uneven deployment and placement of sensor nodes in plateaus.
- EETRP utility system to concurrently ponder two elements: trustworthiness of nodes and energy efficiency.

2 Related Work

WSNs can extant the individual profits and suppleness as regards low-power and economical fast deployment for a number of applications. Sensor arrangement is an acute problem for some important objectives in WSNs like coverage, lifetime and connectivity. Deployment of tactic was depends on potential field theory to deploy the mobile sensor nodes in an unfamiliar environment to enhance the network coverage [8]. Numerous energy efficient schemes are well-defined as a cluster based routing is found to be a more energy efficient and ascendable way to form sensor nodes [9]. As shortest path spanning trees instinctively have short delay, it is extremely significant to find an energy-efficient shortest path tree for time-critical applications [10]. Hybrid energy efficient distributed clustering (HEED) was reported which is a multi-hop clustering algorithm for WSN. HEED contain distributing energy consumption to prolong network lifetime, reducing energy consumption during CH selection phase and reduce the control overhead of network [11].

Efficient sleep awake aware (EESAA) is an intelligent routing protocol for WSNs which presented a method of pairing amid nodes. Amid these pairs just a single member node awakes in a every single round to forward sensed data even though the other member node stays in sleep mode to save the energy resources [12]. Deployment of relay nodes results fault-tolerance in heterogeneous WSN with higher network connectivity. Heterogeneous WSN contain sensor nodes with unlike transmission radius. Further relay node proved more advantages when deployed in clustered sensor networks [13]. Chuanhe et al., (2007) [14] was introduced a reputation-based trust management scheme using a stimulus mechanism. Trust management scheme encourages packet forwarding and discourages selfish behaviors based on quantified objective measures and reputation propagation by a one-way hash chain based authentication. The performance of this scheme in the malicious nodes, as may be expected in a hostile environment has not been investigated. Trust and energy aware routing protocol was proposed for WSNs and it aims to report the energy limitations. By keeping resource constrained distinctive of WSNs in mind, the design of Trust and energy aware routing protocol is centered on trustworthiness and energy efficiency. Routing Protocol is proficient of energetically sensing and segregate misbehave nodes during trust assessment phase whereas energy awareness feature was amalgamated in route setup phase which aids in improved load balancing among trust nodes [15].

The hierarchical trust management for WSNs performs multi path routing when intrusion detected in WSNs. It assesses the trustworthiness of node utilizing subjective

trust (performance at running time) and objective trust (node status) [16]. Higher energy consumption for the duration of data gathering and delivery process is decreased utilizing a clustering method; hierarchical routing exploits upon these advantages by the division of nodes into clusters. Clustering method generally selects the node with more energy as Cluster Head (CH), which collects the information and transmitted through lower-energy nodes by clustering method [17]. The Cluster based routing protocols (CBR-MOBILE) is proposed to face the challenges of packet loss and energy consumption in Hybrid networks like some sensor nodes are fixed, and other are mobile. It is traffic adaptive protocol that assigns timeslots of mobile nodes which are moves out of cluster can be reassign to the incoming mobile nodes into that cluster. Based on receiving signal strength, data is transmitted to the cluster head [26].

A secure mobile data collector is introduced in clusters to collect the data from cluster head, and forward to the base station. Authors proposed and analyzed three protocols for secure data collection, and it follows tree based connection management among sensor nodes [27]. Optimization of mobile data collector speed, and it's mobility is changed adaptively based on the requirements of network, are the objectives of paper, and this can be achieved by providing cooperation between sensing nodes, and mobile data collector nodes [28].

The comparison of clustering protocols regarding different attributes was represented in Table 1. In this paper, trust based routing protocol, sub-clustering algorithm was proposed to decrease energy consumption, and leads to a rise in network lifetime, network throughput were assessed. In WSNs, trust stipulates the dependability or trustworthiness of sensor node. The trust value was calculated based on the actual sensed data of the sensors in WSNs is termed as data trust.

Table 1. Comparison of clustering protocols with clustering attributes

Clustering Protocol	Clustering Approach	Clustering Method	Number of Cluster head	Network type	Energy Model	Connectivity to the BS
EEHC[18]	Prob./Energy	Distributed	Variable	Homogeneous/ Heterogeneous	First Order	One-hop
LEACH [19]	Prob./Randm	Distributed	Variable	Homogeneous	First Order	One-hop
S-EEP [20]	Prob./Energy	Distributed	Variable	Homogeneous	First Order	One-hop
TPSO-CR [21]	PSO	Centralized	Fixed	Homogeneous/ Heterogeneous	Discrete (CC2420)	Multi-hop
M-EEP[20]	Greedy	Centralized	Variable	Homogeneous/ Heterogeneous	First Order	One-hop/ Multi-hop
LEACH-C [19]	SA	Centralized	Fixed	Homogeneous	First Order	One-hop

3 Methodology

In wireless sensor networks, there are a number of trust based routing protocols was proposed. To enhance the network lifetime, efficiency, throughput, various techniques are implemented based on trust values of nodes. In existing works, mobile nodes (MN) are introduced in fixed wireless sensor networks to gather the infor-

mation from sensor nodes and send it to CH. This type of implementations gives great results in military applications, plateaus, hill and valley places, etc. In this research, trust based routing protocol and sub-clustering algorithm was proposed in WSN. Fig. 1 displays the scenario of trust node in WSN. Cluster node is divided into the sub clusters and we assign some sub-cluster nodes as trust nodes. In sub cluster the mobile nodes are moving around the sensor node and MN comes near to the SN then node awake and sends data to MN. If the mobile node is stationary, the trust node will send the data to MN.

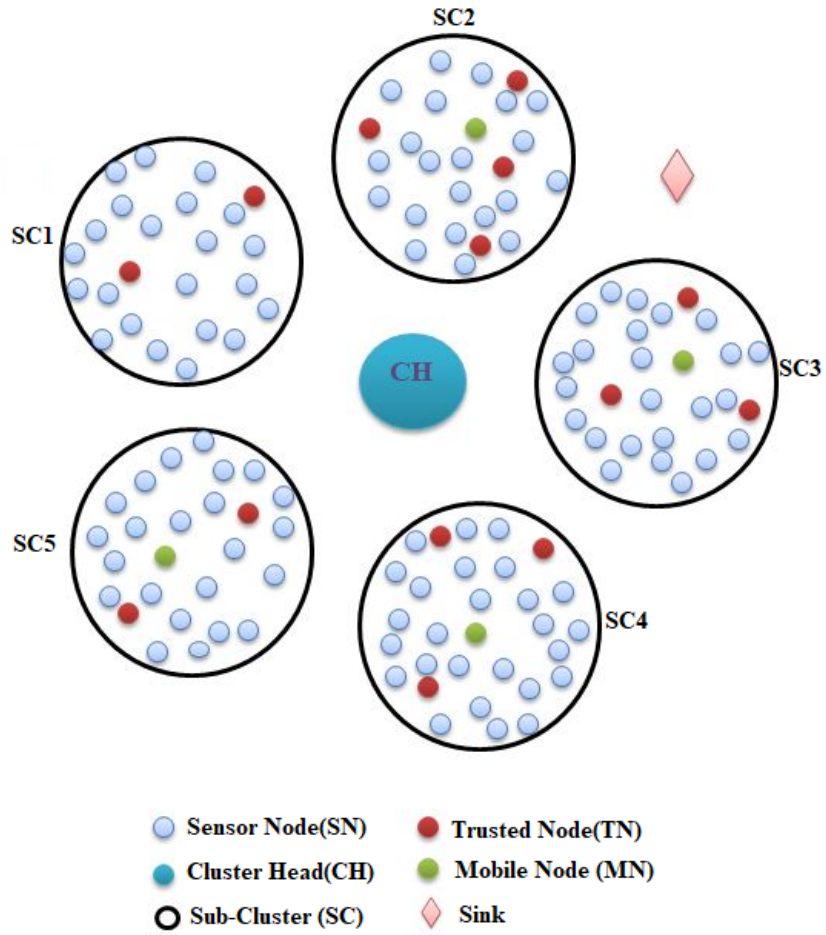


Fig. 1. Scenario of trusted node in WSN

3.1 Proposed energy efficient trust node based routing protocol

Design flow of trust node in WSN: The data flow diagram of proposed EETRP protocol and sub clustering algorithm was given in Fig. 2 which represents the for-

mation of the sub cluster region and energy harvesting was described by the below important steps.

Step1: The BS monitors WSNs sensor nodes with cluster head and it forms cluster into sub cluster region separately.

Step2: Deployment of sensor nodes (SN) selected randomly. In the sensor network, all sensor nodes are arbitrarily deployed in a circular area with a radius of R. The network model can be clarified as an undirected connectivity graph G(S, E), where S is the set of all SN and E (i, j) is the set of wireless link amongst node i and node j .All the SN are homogeneous and stationary [22]. We divide the entire sub cluster region into several sectors named as fixed sensor nodes, one mobile node and two or three trust nodes.

Step3: Deployment of one mobile node (MN) for each sun-cluster.

Step4: Move the mobile node (MN) for first round (odd number of round) around the Sub-cluster (SC).

Step5: When the mobile node (MN) comes near to the sensor node then sensor node (SN) awake from sleep mode and sends the data to the mobile node (MN) (same procedure for every node).

In WSNs, the life cycle can be influenced by the residual energy of each node. Thus, energy plays an important role in the construction and operation of the network. All the sub cluster nodes have restricted energy, which will be consumed when the nodes send or receive data [15]. The first-order radio model is used as the energy consumption model. The quantity of energy consumption in transmitting l-bit packet from node i to node j can be represented by:

$$E_{Tx}(l, d_{ij}) = E_{elec} \times l + E_{amp}(d_{ij}) = \begin{cases} E_{elec} \times l \times \varepsilon_{fs} \times l \times d_{ij}^2 \text{ if } d_{i,j} < d_0 \\ E_{elec} \times l \times \varepsilon_{fs} \times l \times d_{ij}^4 \text{ if } d_{i,j} \geq d_0 \end{cases} \tag{1}$$

Here E_{elec} is the energy necessary for driving and controlling electronic components. E_{amp} Depends on the Radio Frequency (RF) amplifier's consumed energy for free space ε_{fs} and multipath fading channel models ε_{mp} and d_{ij} represents the Euclidean distance between node i and node j. The threshold, d_0 is calculated as follows

$$d_0 = \sqrt{\frac{\varepsilon_{fs}}{\varepsilon_{mp}}} \tag{2}$$

The node consumes the following amount of energy in receiving E_{Rx} l-bit packet

$$E_{Rx}(l) = E_{elec} \times l \tag{3}$$

Step 6: The mobile node (MN) will be stationary for second round (even number of rounds) then trust node (TN) sends data to the mobile node (MN) from their location. After sending the data SN will be stationary.

A trust node of route will be calculated so as to ignore the encountering malicious nodes through the data-forwarding phase [23]. Trust nodes are initialized to 0 by default but since the model is totally local, nodes are free to initiate some trust node. The evolution of the trust node n_i on the node n_j is given by the following formula

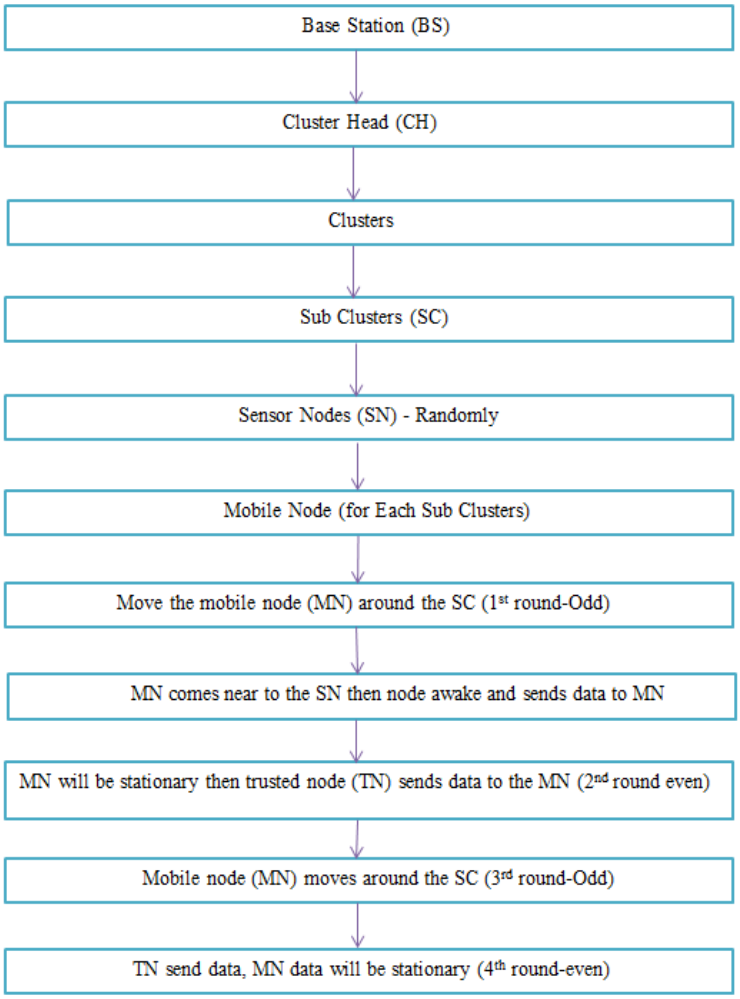


Fig. 2. Design flow of EETRP in WSN

$$C^{D}_{n_i n_j}(t) = \begin{cases} -1 & if\ P_{ni,nj}(t) < 0 \\ 1 - \propto^{P_{ni,nj}(t)} & Otherwise \end{cases} \quad (4)$$

Here $\propto \in (0,1)$, (higher is$\propto$, slower a direct trust goes from 0 to 1 with time, vice versa) and $P_{ni,nj}(t)$depends on the number of positive experiences $P^{+}_{ni,nj}(t)$ (the number of good behaviors) and the number of negative experiences $P^{-}_{ni,nj}(t)$ (the number of bad behaviors) of n_i observed by n_i until time *t*. The value *of* $P_{ni,nj}(t)$ is d number of bad behaviors) of n_j observed by n_i un is defined as

$$P_{ni,nj}(t) = P^{+}_{ni,nj}(t) - \beta * P^{-}_{ni,nj} \tag{5}$$

Where $\beta (\beta \geq 1)$ is a parameter which allows t the modulation of the importance of negative experiences (greater is β, larger is the influence of negative experiments), β is introduced so that a definite number of faults may be tolerated. Both $\propto$ and β should be relatively high to keep the efficacy of the model. According to the above formula,

- If a node always behaves well, its trust value will rapidly increase to 1
- If a node is moderately malicious or failing, its trust node will be stable
- If the node is malicious or quite failing, then it will immediately become untrust.

Step7: For third round (odd number of round) again mobile node (MN) moves around the sub cluster (SC)

Step8: In fourth round (even number of round) again trust node (TN) send data and the MN will be stationary.

Pseudo code for EETRP with sub-clustering algorithm: Event detection can be possible by checking the sensed data of trusted node with neighbor nodes data, to decide the event occurrence. Trusted nodes will send data to mobile node to avoid malfunctions or malicious attacks.

Sub clustering algorithm

```
No. of nodes (n) =51
    Divide the clusters (C) = node position
    Calculate residual energy for each node.
    For (i= 1 to n)
    Dn ← calculate degree difference (n)
    N(n)←identify neighbors (n)
    Tc← calculate cumulative time (n)
    Cn←calculate the character (n)
    Wn←calculate the weight (n)
    En←calculate the energy (n)
Call the combined weight based energy calculation
    For (every n€N)
        If n is high weight then
        CH←high weight (n)
        Update in neighbor table
        Else
```

CM←cluster member (N)
End if
End for
Cluster→ division to SCH
SCH ←Node position
Each SCH ←1MN
No of MN = validate the no. of clusters

Energy Efficient Trust node based Routing Protocol

No of rounds=N
N=[n+1/2],[2n+1/2]
N= $\sum_{n=0}^{N}[n + 1/2]$ for all odd rounds
N= $\sum_{n=0}^{N}[2n + 1/2]$ for all even rounds
When
N= odd round
MN←data broadcast from SCH
N= even round
MN←data broadcast from trust nodes

Continuous sensing, and data collection in plateaus, military areas results large energy consumption, and effected with a limited lifetime due to their uneven placement. Hence, this protocol proposes, an alternative round of data collection in WSN to improve lifetime of the network. During initial round, Mobile data collector will collect the data from sensed nodes individually and aggregated, forwarded the data to cluster head. Due to uneven placement of sensor nodes in plateaus, they are not efficiently clustered as traditional approaches like tree structured clustering. Hence we collect data individually from each sensor nodes; due to this secure data, collection is possible, without any additional overhead. After completion of first round, Mobile data collector collects data from only trusted nodes, trusted nodes will check their sensed data with neighbors and forward to the nearest Mobile data collector. After data collection from trusted nodes, again the mobile data collector node will collect data from sensor nodes individually in next round of data collection, to avoid failures in event detection, and malicious attacks. This alternative round of data collection gives lower values in energy consumption and higher values in Network lifetime. Based on application, we can increase the number of trusted node data collection rounds rather than mobile data collector rounds. By increasing the number of trusted nodes, throughput can be increased, and by increasing number of trusted nodes data collection rounds per cycle, throughput can be decreased.

4 Simulation Parameters

This paper assumes 51 (i.e. n = 51) mobile sensor nodes that are arbitrarily deployed inside the area of 1320*1032. The 3 kinds of nodes which include sink node, cluster node and trust nodes with the initial energy of 500 J respectively. The BS was located at any random place outdoor the sensing field. All the residual parameters are presented in Table 2. The SNs sense the data at a fixed rate and these SNs have always some data to send.

Table 2. Simulation Parameters

Parameters	Values
Simulation Period	100ms
Coverage Area	1320*1032
No of Nodes	51
No of sink node	1
No of mobile node	5
No of Sub cluster	5
No of Cluster Head	1
Traffic Type	CBR
Agent Type	UDP
Routing protocol	EETRP
Initial power	100 J
Transmission Power	0.2 J
Receiving Power	0.2 J
Queue Type	Drop-Tail

5 Results and Discussion

The results of proposed EETRP protocol with sub clustering algorithm has evaluated and compared the results with existed SPT, MLPA and GLBD by using ns2 simulator. The simulation results has given the parameters of Network throughput, Network lifetime, Network energy efficiency, Network energy consumption, Control overhead, Network packet delivery ratio and Network packet loss. The simulation has been performed by using EETRP protocol with sub clustering algorithm and free space propagation. In WSN scenario, a SNs network contains total number of nodes (51) is installed arbitrarily above an area of size 1320*1032 within the network field. Table 3 displays the evaluation of proposed EETRP protocol with sub clustering algorithm with existing trust algorithm in WSNs.

Table 3. Comparison of existing algorithm with proposed TBRP Algorithm

Algorithm	Aim	Technique used	Energy efficient	Goals achieved
Trust and Energy aware routing protocol Wireless Sensor Network	Best path to reach destination	Trust, energy Location calculation	Yes	Avoid suspicious node
Providing trust in wireless sensor network using a bio-inspired Technique.	Trust and reputation, Reputable path	Ant colony Optimization system	No	Avoid Misbe-having server
A Direct Trust Dependent Link State Routing Proto-col using Route Trust For WSNs(DTLSRP)	Trustworthy route	Direct trust calculation	No	Routing attacks
Neighbor based malicious node discovery in wireless sensor networks	Precise malicious node detection	Data smoothing variation test and confidence level evaluation	No	Low false alarm rates.
TARF: A trust aware routing framework for wireless sensor networks	Routing includes Trustworthiness of node	Trust manager, energy watcher	Yes	Authentication, replay of routing information
Proposed: EETRP protocol	Reducing Energy consumption and Prolong network life time	Trust based routing proto-col with sub clustering algorithm	Yes	Avoid malicious node and trust-worthy

5.1 Network throughput

The amount of packets received by the BS from non-base station nodes is called throughput. As number of nodes upsurges throughput will increase in all other data aggregation and EETRP protocol with sub clustering algorithm data aggregation provides throughput as 1153 Mbps. The proposed EETRP Protocol with sub clustering algorithm provides maximum throughput when compared to existing GLBD [24], MLPA and SPT [10] algorithm. Fig. 3 defines the throughput evaluation amongst EETRP Protocol with sub clustering algorithm and its contestant's. Throughput of EETRP protocol with sub clustering algorithm was found to be 1153 Mbps which is greater than SPT (886) , MLPA (542) and GLBD (244) algorithm respectively. Throughput depends on number of packets received for a specific node. By increasing number of trusted nodes, the throughput can increase, but by depending on more number of trusted data collection rounds, throughput will decreases. The throughput of proactive routing protocol is openly linked to cluster lifetime, higher cluster life time effects higher throughput. EETRP Protocol with sub clustering algorithm life time is superior to its opponents, then it has superior throughput that is evidently stated in Fig. 3. Due to mobile data collector node, data collected individually from all sensor nodes, therefore data faults, and malicious attacks are less compared with existed protocols.

5.2 Network lifetime

From the beginning of the operation of the sensor network to the battery depletion of the last node is the network lifetime. In the simulation, the lifetime is assessed in terms of a cycle in WSN. Fig. 4 shows that EETRP protocol with sub clustering algorithm has higher stable lifetime than the other three hierarchical routing techniques. Due to maintaining large number of sensor nodes in sleep state until mobile data collector collects data from nodes individually, and by maintaining mobile data collector in idle condition in trust node based data collected rounds, the energy consumption is reduced greatly, and lifetime of the network also increases potentially than existing algorithms. The network lifetime of EETRP Protocol with sub clustering algorithm was found to be 68% which is greater than GLBD (56%), MLPA (35%) and SPT (20%) algorithm respectively. Fig. 4 clearly represents the EETRP protocol with sub clustering algorithm was far superior and more efficient in expressions of the number of active nodes and the network lifetime.

5.3 Network energy efficiency

Network Energy and Network Lifetime are Key parameters of WSN. Those two parameters are linear in Relation. The Performance of WSN depends on Network Energy Efficiency. Energy efficiency upsurge the performance of WSNs, and it can be expressed as the ratio of networks lifetime and sensor node's energy. The Lifetime and Energy Efficiency of Network are enhanced when the sensor node's Energy is stable. Total energy consumed by all the nodes in the network is expressed by

$$Energy\ Efficiency = \sum_{i=1}^{N} E_i$$

E_i Signifies the energy consumed by the nodes in rounds. It decreases the energy wastage and performs the number of rounds with limited energy. The network Energy efficiency of EETRP Protocol with sub clustering algorithm is 68% which is greater than GLBD, MLPA and SPT 56%, 35% and 20% [10] algorithm respectively.

5.4 Network packet delivery ratio

The packet delivery ratio lies in the loss-rate explanation observed by transport protocols and disturbs the entire network throughput. This metric accentuates the correctness and completeness of the routing protocol. Fig. 5 show that the comparison of packet delivery ratio between proposed EETRP Protocol with existing algorithm.

$$Packet\ Delivery\ Ratio = \frac{Total\ number\ of\ packets\ that\ have\ been\ sent\ from\ the\ source\ node}{Total\ number\ of\ packet\ that\ had\ reached\ the\ destination}$$

The EETRP protocol with sub clustering algorithm shows a considerable improvement in packet delivery ratio over GLBD, MLPA and SPT. As the integer of nodes upsurges the packet delivery ratio will increase in all other data aggregation and EETRP Protocol with sub clustering algorithm data aggregation provides maximum

packet delivery ratio for 51 nodes was 97.77%, which is higher than 91.77%, 77% and 72% GLBD, MLPA [25] and SPT respectively.

5.5 Network energy consumption

Energy used by the network is proportional to the diameter of the network. Table 4 shows comparison of various simulated parameters. Fig. 6 depicts the energy consumption amongst proposed EETRP Protocol with sub clustering algorithm. Due to deployment of trusted nodes per each sub cluster, remaining sensor nodes can spend more time in sleep state, until mobile collector gives wake-up notification. On other hand mobile data collector can be placed idle in even number of rounds, and it can collect data directly from trusted nodes. Due to these reasons, network consumes very less power compared with conventional protocols. Energy consumption of EETRP Protocol with sub clustering algorithm was found to be 32% which is lesser than GLBD (44%), MLPA (65%) [25] and SPT (80%) respectively.

Table 4. Comparison of various simulated parameters

Parameters	SPT	MLPA	GLBD	EETRP
Control Overhead	1564	1265	969	2373
Packet Delivery Ratio (%)	72	77	91.77	97.77
Network Loss	564	432	207	154
Network Energy Efficiency (%)	20	35	56	68
Network Energy Consumption (%)	80	65	44	32
Network Throughput (Kbps)	244	542	886	1153
Network Lifetime (%)	21	36	54	66

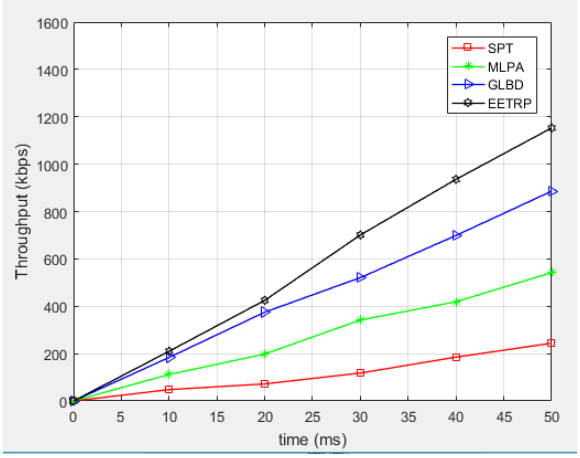


Fig. 3. Comparison of network throughput

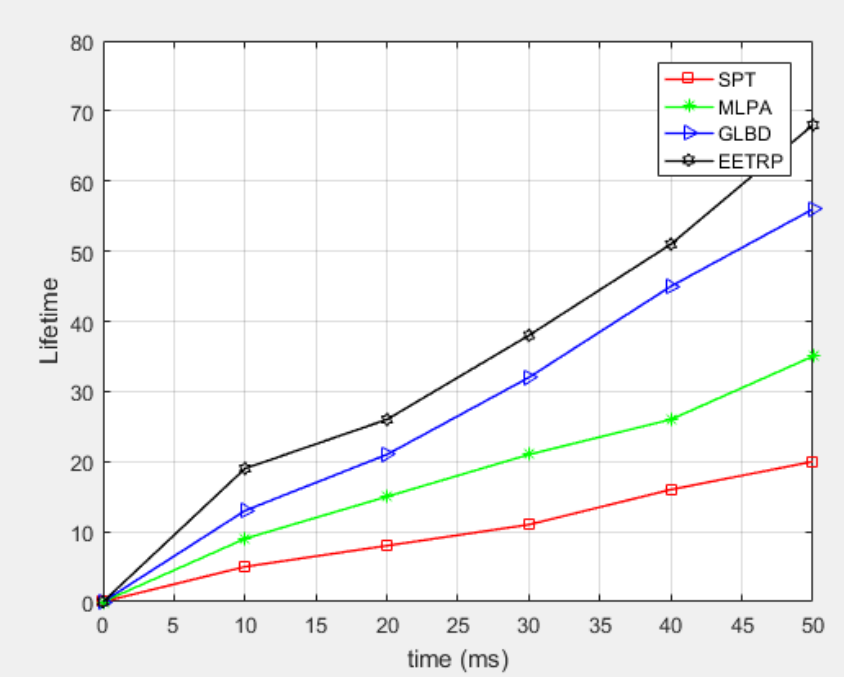


Fig. 4. Comparison of network lifetime

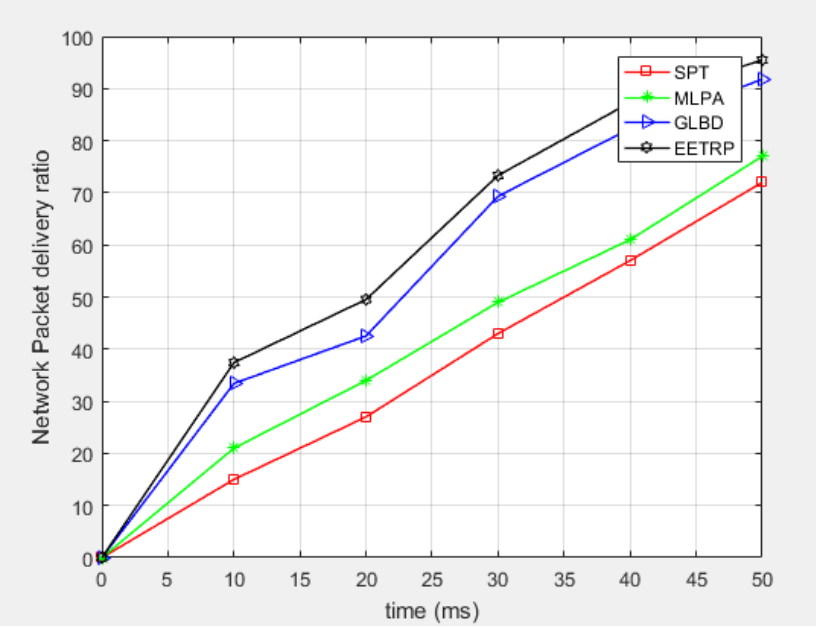


Fig. 5. Comparison of network packet delivery ratio

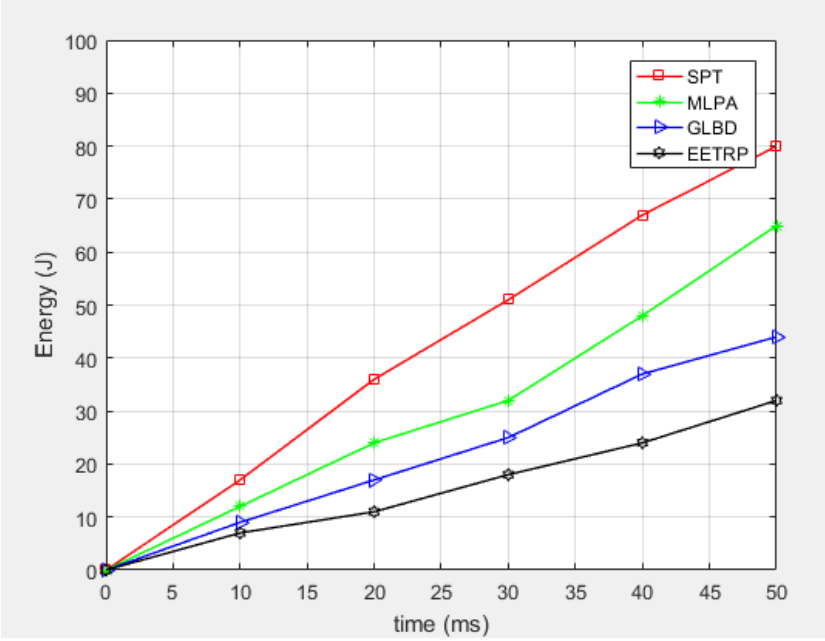
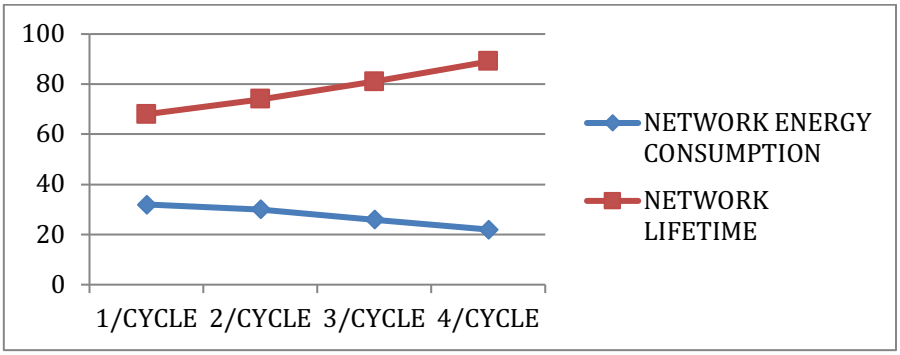


Fig. 6. Comparison of network energy consumption

5.6 Parametric Analysis of Lifetime, Energy Consumption based on No of Trusted Routing iterations per Cycle.

Parametric analysis can be obtained by varying the trusted routing iteration number with respect to mobile routing iteration number. By increasing trusted round Iteration number, the lifetime of the network increases linearly. On the other hand the network energy consumption is keeps on decreasing. The problem arises in this type of analysis is TRUST Dependency. When trust iterations are more in a cycle, then QOS may decrease.

Parameter	Alternative rounds (one trusted routing iteration per onemobile routing iteration)	Two trusted routing iterations per one mobile routing iteration	Three trusted routing iterations per one mobile routing iteration	Four trusted routing iterations per one mobile routing iterations
Network energy consumption	32	30	26	22
Network lifetime	68	74	81	89



The graph shows variations of energy consumption and lifetime of the network for various trusted iterations.

6 Conclusion

The sensor nodes in WSNs have limited computation, storage and interaction abilities. In this paper, EETRP protocol with sub clustering algorithm in WSNs is presented to balance energy and prolong network lifetime. This algorithm divides the clusters into several sub clusters and assigned each sub cluster with a mobile node. Sensor nodes perform the data interaction by the sub clustering structure and trust nodes are depends on data collection, thus increasing the energy efficiency of network. Therefore, the proposed approach improves the energy efficiency and network lifetime at the same time. The simulation outcomes indicate that energy consumption of network is greatly reduced by our proposed energy efficient trust based routing algorithm while compared with other clustering algorithm.

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8 Authors

Nandoori Srikanth is one of the part time Ph.D. scholars in Koneru Lakshmiah Educational Foundation, from the department of Electronics & Communication Engineering. He published many research papers in various reputed journals and he is working as an Assistant professor in NRI Institute of Technology. His Research area is Wireless Sensor Networks. His research interests are wireless communications, signal processing.

Muktyala Sivaganga Prasad is one of the Professors in Koneru Lakshmiah Educational Foundation, from the department of Electronics & Communication Engineering. He published many research papers in various reputed International journals and he guided many more researchers in the fields of wireless communication, Antennas and wireless sensor networks. His research interests are wireless communications, Antennas and signal processing.

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