TEST Engineering & Management

January - February 2020
ISSN: 0193 - 4120 Page No. 5959 - 5969

An End-To-End Model for Sensor Node Localization, Routing and Security in Wireless Sensor Networks

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Article Info
Volume 82
Page Number: 5959 - 5969
Publication Issue:
January-February 2020

Article History
Article Received*: 18 May 2019*
Revised*: 14 July 2019*
Accepted*: 22 December 2019*
Publication*: 29 January 2020*

Abstract:
The wireless sensor networks play important role in various real-time application such as surveillance and environment monitoring. These networks have limited storage and power capacity to collect, process and transmit the data from source to destination node. During this process, the energy consumption increases which reduces the network lifetime. Moreover, accurate data collection by knowing the position of sensor node and securing the data during transmission are also considered as a crucial challenge.In this work, we focus on these issues of sensor node localization, energy aware routing and data security. We present a combined model which uses RSSI based model for localization, genetic algorithm for energy aware cluster head selection and routing to improve the network lifetime. Moreover, we incorporate SHA-256 model for hashing, AES algorithm for data encryption and Diffie-Hellman key exchange model. The performance of proposed approach is carried out in terms of localization error, alive nodes and residual energy.

Keywords – *Localization, Routing, Network Security, WSN*

1. Introduction

The demand of wireless sensor has increased drastically during last decade. This increased development of sensor network has gained huge attraction by research community. The wireless sensor network consists multiple homogenous or heterogenous sensor devices, called as sensor nodes. These sensor nodes are deployed randomly in the certain geographical area to monitor several activities such as temperature monitoring, humidity, health monitoring and surveillance etc. [1].The sensor node collects the desired information and transmit it to the desired location. These nodes are equipped with a limited capacity, computation and power supply source. Generally, these networks are deployed in the hostile and unattended environment where replacing the battery is not possible. Hence, reducing the power consumption can help to improve the network-lifetime [2].

On the other hand, these sensor nodes are distributed randomly in the given geographical area where identifying the location of sensor becomes a tedious task. Without having the accurate information about node location, the quality of data aggregation suffers and it affects the overall Quality-of-service (QoS) for the deployed network. Initially, during deployment of sensor nodes, each sensor node is provided a location reference which is done manually or with the help of GPS devices equipped by the sensor nodes. However, computing the manual location reference and allocating GPS for each sensor nodes require more human effort and cost. Hence, several techniques have been developed for accurate localization of sensor nodes. In most of the existing techniques, initial few nodes are provided their

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location reference and later localization techniques can be implemented to obtain the node locations. Several techniques have been reported during last decade for localization which are characterized as known location-based techniques such as GPS [4], proximity-based techniques such as Bluetooth and infrared [5], angle-based techniques such as Angle of Arrival [6], range-based technique such as RSSI (Received signal strength) [7] and distance-based techniques such as DV-Hop technique [3].Numerous localization techniques are present in this field of WSN localization such as improved DV-Hop for dynamic anchor nodes [8], RSSI-TOA based technique [9], hybrid DV-hop RSSI based localization and many more [10]. However, these techniques suffer from localization error issues for high density network models.

As mentioned before, these sensor nodes have limited power supply which affects the network lifetime because data sensing, data collection, and transmission consume certain amount of energy. The studies have reported that data transmission consume the most of the energy hence efficient data transmission is the important task which can reduce the energy consumption and improve the network lifetime. Routing techniques plays important role in energy efficient data transmission. Several routing schemes have been reported during last decade. Generally, these routing schemes are characterized based on the network organization which includes flat, hierarchal routing and location-basedrouting, route discovery techniques such as reactive, proactive and hybrid techniques and protocol operations such as multipath based, query based and QoS based routing protocols [11]. Various routing techniques are presented such as clustering based routing [12], CL-LEACH [13], EESRA [14], TL-LEACH [15] and many more [16].

These networks are deployed in hostile environment where the data collection process can be tampered by outside attackers and sensitive information can be leaked which can be harmful for the network.Similarly, during data transmission, the communication channels can be attacked by hackers. Hence, protecting the sensitive information from various types of attacks. In order to deal with these issue, the secure routingtechniques are developed which are based on the encryption, hashing and trust-based packet forwarding. Elhoseny et al. [17] introduced elliptic curve cryptography and homomorphic encryption based secure routing protocol, ActiveTrust [18], and key exchange-based authentication CAKE [19] etc.

Currently, optimization techniques, evolutionary and machine learning based intelligent techniques have gained huge attraction in this field. Several techniques have been reported for localization such as ANN based localization [20], fuzzy logic for localization [21] and bio-inspired algorithms [22]. Based on these techniques, various routing models are also presented such as evolutionary algorithms [23], ant-colony optimization [24] and genetic algorithm [25].

From above discussions, we identify that localization of sensor nodes, energy aware routing technique and secure communication are the important parameter which have significant impact on network lifetime. Hence, in this work, we focus on these objectives and introduce a novel approach to improve the overall performance of the network. The main contributions of this work are summarized as follows:

(a) Development of Assisted Adaptive Sensor Localization (AASL) scheme to localize the sensor nodes
(b) In our previous work, we have introduced genetic algorithm-based energy aware routing [26] and cluster head selection [33]. In this work we extend the work presented in [26] with improved genetic algorithm
(c) We introduce a novel hashing and trust-based [32] mechanism for maintaining the location anonymity and to packet transmission to next-hop.
(d) Finally, we present a comparative analysis to show the improvement in the network performance using proposed approach.

Rest of the article is organized in V sections. The section II presents a brief literature review about existing localization, routing and security-based scheme in WSN, section III presents proposed solution for aforementioned objectives, section IV discusses about perforamcne measurement and comparative analysis using proposed model, and finally, section V provides concluding remarks about this research work.

2. Literature survey

This section presents a brief literature review about WSN localization, energy aware routing and secure data transmission-based routing protocols for wireless sensor networks.

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2.1. WSN localization techniques

RSSI based WSN localization techniques have been considered as the promising techniques for WSN localization. Several variants of these localization techniques exist in the current literature. Moreover, bio-inspired, artificial intelligence and other optimization schemes have been incorporated to improve the localization performance.

Zhang et al. [6] focused on mobile sensor node localization in industrial WSN and presented a three-dimensional localization model. this model uses Angle-of-Arrival (AOA) based Three-dimensional Multi-target Localization (ATML) technique. According to this approach, two anchor nodes are deployed to receive the broadcast spectrum signal by sensor nodes. Along with this, a multi-target single-input-multiple-output (MT-SIMO) signal transmission scheme and maximum likelihood estimator is also designed which helps to estimate the 2D AOAs. The errors of AOA are mitigated using skew line theorem of 3D geometry. Similarly, Zhang et al. [8] focused on the 3D mobile sensor localization and presented a combined model using received signal strength indicator (RSSI) and time of arrival (TOA) model. According to this process, a mobile anchor node is deployed which moves according to Gauss–Markov three-dimensional mobility model. Finally, maximum-likelihood estimation is applied to estimate the position of unknown nodes.

Cao et al. [7] reported that the conventional DV-Hop based localization schemes use all anchor nodes for localization and result in the localization error. To overcome the issue of DV-Hop, authors presented improved DV-Hop approach for dynamic anchor nodes. Here, first of all, anchor nodes are selected with the help of combinatorial optimization problem. This optimization problem is solved by designing particle coding and fitness functions. Similar to this approach, Cheikhrouhou et al. [9]introduced hybrid DV-Hop localization using RSSI algorithm. The existing ranging based methods use triangulation model to estimate the node location for the node which are located at one-hop node distance. In this work, authors reported the popularity of DV-Hop algorithm but it suffers from reduced localization accuracy. To overcome this issue, enhanced DV-Hop algorithm is presented which uses RSSI values of links between one-hop neighboring nodes.

In this field, the evolutionary computation and optimization schemes are also incorporated which shows a significant performance to reduce the localization error. Singh et al. [27] introduced particle swarm optimization strategy (PSO) to overcome the issues of DV-Hop algorithm. Tuba et al. [28] developed firefly optimization algorithm for sensor node localization. Sharma et al. [29] introduced range-free localization using genetic algorithm for three-dimensional WSNs.

2.2. Secure and Energy aware routing techniques for WSN

Sensor node clustering is considered one of the promising techniques to minimize the energy consumption. In clustering process, the nodes with similar configuration are grouped together and a cluster head is selected to process the collected data. Further, the cluster head transmits the data using multihop communication. Wang et al. [12] presented LECH-Impt protocol for clustering. Marappan et al. [13] presented another variant of LEACH protocol. This scheme is based on the cross-layer optimization hence represented as Cross Layer-Low Energy Adaptive Clustering Hierarchy model (CL-LEACH). During the cluster head selection process, it considers residual energy for CH selection. In [14] Elsmany et al. introduced EESRA: an energy aware routing protocol. According to this approach, it adapts three-layer model for cluster head selection and randomize the load of cluster heads to minimize the power consumption. Manzoor et al. [15] focused on LEACH protocol and presented two-level LEACH protocol to improve the energy efficiency by reducing the communication overhead. According to [23], the evolutionary techniques can improve the performance significantly. Several optimization schemes are studied such as Particle Swarm Optimization (PSO), Gravitational Search Algorithm (GSA) and Least Distance Clustering (LDC).

Jiang et al. [24] studied ant colony optimization (ACO) technique to improve the performance of WSN but conventional ACO suffer from various challenges such as energy consumption, load balancing and dynamic network topology. In order to overcome these issues, authors introduced a hybrid ACO with minimum hop count. This scheme helps to find the optimal path with minimal energy consumption to transmit the data packets.

Hawbani et al. [30] presented a combined scheme to handle the load balancing and routing related issues in WSNs. The opportunistic routing techniques have reported a significant improvement in the low-duty cycled network performance. This scheme performs two main tasks where first of all,

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each node defines the candidate zone and prioritizing the candidate zone based on the dour types of distribution such as direction distribution, transmission-distance distribution, perpendicular-distance distribution, and residual energy distribution. In [31] Manjunath et al. presented a combined secured and energy aware routing for WSN. According to this process, the network is divided into multiple geographical locations. Each grid has assigned a grid head node which identifies next hop based on the distance to sink, and energy level. Hence, the data is transmitted in a multihop manner. Further, a SHA-256 hashing algorithm is also applied to protect the location of sensor nodes in the gird. Mehra et al. [19] presented a secure routing protocol based on authentication mechanism to ensure the data privacy in WSN communication. Authors reported that key management is the promising technique to prevent the different types of attack on the network. Hence, this work presents a highly secure Codeword Authenticated Key Exchange (CAKE) protocol. This protocol is based on the one-way hashing, one-time password and codeword authentication.

3. Proposed Model

In this section, we discuss about the two issues have significant impact on the WSN communication. these two issues are known as: (a) Sensor Node Localization and (b) energy aware routing.

The Localization approach helps to improve the data sensing and collection capacity, moreover, if the sensor network has better localization accuracy then it can improve the data aggregation which leads towards reliable data collection. On the other hand, the collected data needs to be transmitted to the base station without affecting the network lifetime and energy consumption for transmitting the data also must be reduced to prolong the network lifetime. Based on these two assumptions, we present a combined solution to improve the network performance in terms of data aggregation, energy consumption, and network lifetime. The complete section is divided into two main sub-sections as: (a) Sensor Node Localization, (b) energy aware routing, (c) hashing with data encryption the node locations and (d) computing the trust factor for next hop selection.

3.1 Sensor Node Localization

In this sub-section, first of all, we present the problem formulation for sensor node localization in the given sensor network deployment and later, anRSS (Received Signal Strength) based solution is developed to improve the localization and mitigate the localization error issues.

(a) Problem formulation

Let us consider a WSN network scenario for sensor node localization in the given deployed network. here, we assume that total $\mathcal{N}$ number of sensor nodes are deployed in a 2-dimensional area $\mathcal{R}^2$ with the bidirectional communication constraints. In this scenario we consider that $\mathcal{A}$ number of anchor nodes are present and the location of all anchor nodes is known. The distance between two node m and n as Euclidean distance denoted as d_{mn} for the neighbouring set of nodes. this condition can be expressed as:

$$(m,n) \in \mathcal{N}_m \ where\ \mathcal{N}_m = \{(m,n): \|x_m - x_n\| = d_{mn} \le r\} \tag{1}$$

The above given eq. (1) shows the condition that a sensor node is considered to be the neighbouring node if it is in the range of the current m^{th} node. The true location of node m and n can be denoted as $x_m \in \mathcal{R}$ and $x_n \in \mathcal{R}$ and r denotes the transmission rage of the node. In this work it is assumed that we have measured the distance between neighbouring sensor nodes. based on these distance values between neighbouring node pairs, we formulate a problem to minimize the sum of square of errors between the sensor node pairs which is used for fitting the distance measurements for the deployed network. This problem can be given as:

$$\min_{\hat{x}} \left\{ D(\hat{x}) = \sum_{i=\mathcal{A}+1}^{\mathcal{N}} \sum_{n \in \mathcal{N}_m} \left(\hat{d}_{mn} - \hat{d}_{mn}\right)^2 \right\} \tag{2}$$

Where $\hat{d}_{mn}$ is the distance between two nodes which is computed as $\hat{d}_{mn} = \|\hat{x}_m - \hat{x}_n\|$, $\hat{x}_m$ denotes the positions of node m and $\hat{x}_n$ denotes the position of node n. Here, our main aim is to develop a robust approach for sensor node localization which can reduce the positioning error.

(b) Proposed Attenuation Assisted Adaptive Sensor Localization (AASL)

In this section, we present a proposed solution for the localization in sensor network based on the RSSI computation scheme. As discussed in section II, the RSSI based approaches have gained huge attraction from research community for sensor node localization due to less complexity, low cost and better performance for unreliable environments. According to RSSI based technique, we compute the distance between transmitter and receiver node by using signal –strength and relation between loss of signal and propagation distance. Hence, we use a propagation model given as:

$$\mathcal{S}(d) = \mathcal{S}(0)\frac{c}{d^{\alpha}} \quad (3)$$

Where $\mathcal{S}$ denotes the signal-strength measured at distance d, c is a constant ,$\mathcal{S}(0)$ denotes the signal strength at unit distance and α denotes the attenuation parameter. According to the existing approaches [1], the RSSI scheme computes the distance between two nodes d based on $\mathcal{S}(d)$ and the other parameters, which can be expressed as:

$$d = e^{\frac{\ln^{c} - \ln^{\mathcal{S}(d)/\mathcal{S}(0)}}{\alpha}} \quad (4)$$

However, in practical real-time scenarios, these parameters get affected due to several environmental and sensor hardware factors such as radiation power variation, interference and radio characteristics etc. In this work, $c = 1$ and the parameters variations are of Eq. (3) are assumed such as $\alpha^{'} = \alpha + \delta\alpha$ and $\mathcal{S}'(0) = \mathcal{S}(0) + \delta\mathcal{S}$, with the help of this Eq. (3) can be represented as:

$$\mathcal{S}'(d) = (\mathcal{S}(0) + \delta\mathcal{S})\frac{c}{d^{\alpha+\delta\alpha}} \quad (5)$$

This shows that any variation in input would affect the received signal strength.

In order to address the localization problem, we consider the mobile reference nodes which are equipped with the additional device which is used for computations during the movement of the sensor nodes and the mobile node is used for computing the attenuation parameter. Based on this model, the signal propagation is presented as:

$$s_{im} = \frac{s_i}{(d_{im})^{\alpha_i}} \quad (6)$$

Where s_{im} denotes the received signal strength value of i^{th} reference node, and d_{im} denotes the distance between mobile and reference node, s_i denotes the initial RSS value. Based on these parameters, here out aim is to find the attenuation parameter to compute the distance and node positions. In this approach, we consider a single reference node for computing the initial RSS value which can be initially computed such as $\overline{s_0} = \sum_{i=1}^{\mathcal{N}} \frac{s_i}{\mathcal{N}}$. With the help of this, we compute the relation between signal attenuation and RSS, given as:

$$\alpha_i ln^{d_{im}} = ln^{\overline{s_0}} - \ln^{s_{im}} \quad (7)$$

Based on this, the following relations of attenuation can be obtained as:

$$\begin{gathered}\alpha_1 ln^{d_{1m}} - \alpha_2 ln^{d_{2m}} = \ln^{c_{2m}} - \ln^{c_{1m}} \\ \alpha_1 ln^{d_{1m}} - \alpha_3 ln^{d_{3m}} = \ln^{c_{3m}} - \ln^{c_{1m}} \\ \vdots \\ \alpha_{\mathcal{N}-1} ln^{d_{(\mathcal{N}-1)m}} - \alpha_{\mathcal{N}} ln^{d_{\mathcal{N}m}} = \ln^{c_{\mathcal{N}m}} - \ln^{c_{(\mathcal{N}-1)m}}\end{gathered}$$

This can be rewritten a given below in the form of matrix,

$$\mathcal{H}\begin{bmatrix}\alpha_1 \\ \alpha_2 \\ \vdots \\ \alpha_{\mathcal{N}}\end{bmatrix} = \begin{bmatrix}\ln^{c_{2m}} - \ln^{c_{1m}} \\ \ln^{c_{3m}} - \ln^{c_{1m}} \\ \vdots \\ \ln^{c_{\mathcal{N}m}} - \ln^{c_{(\mathcal{N}-1)m}}\end{bmatrix} \quad (9)$$

Where $\mathcal{H}$ can be determined using (8) and attenuation parameters can be computed as:

$$[\widehat{m}, \widehat{n}]^T = (\mathcal{H}^T\mathcal{H})^{-1}\mathcal{H}^T X \quad (10)$$

Where $X = \begin{bmatrix}\ln^{c_{2m}} - \ln^{c_{1m}} \\ \ln^{c_{3m}} - \ln^{c_{1m}} \\ \vdots \\ \ln^{c_{\mathcal{N}m}} - \ln^{c_{(\mathcal{N}-1)m}}\end{bmatrix}$, Similarly, the expected attenuation can be computed based on $\bar{\alpha} = \sum_{i=1}^{\mathcal{N}} \frac{(\alpha_i)}{\mathcal{N}}$, such as

$$\bar{\alpha}\left(ln^{d_{im}} - ln^{d_{jm}}\right) = \ln^{c_{jm}} - \ln^{c_{im}}, \forall_{i,j}, i \neq j \quad (11)$$

Hence, the final estimated attenuation values can be given as:

$$\bar{\alpha} = \frac{1}{\mathcal{N}(\mathcal{N}-1)}\sum_{i=1}^{\mathcal{N}}\sum_{j=1, j\neq i}^{\mathcal{N}}\frac{\ln^{c_{jm}} - \ln^{c_{im}}}{\ln^{d_{jm}} - \ln^{d_{im}}}$$

In this phase, we have discussed about the WSN localization scheme and developed a novel approach to improve the localization performance. In the next phase, we focus on the energy consumption and network lifetime related issues. To overcome these issues, we develop an energy aware routing approach which can be useful for improving the performance.

3.2 Energy Aware Routing

In this section we present the proposed solution for energy aware routing to improve the network lifetime performance. In order to obtain the desired routing, the optimization-based schemes play significant role as discussed in the previous section II. Hence, in this work also we have considered evolutionary computation-based mechanism for cluster formulation and shortest path computation. The complete proposed approach is mainly categorized into two sections where first of all we apply Genetic Algorithm (GA) technique for cluster formation.

(a) Genetic Algorithm for Cluster formation

In this section we discuss about the proposed solution for cluster head formation with the help of genetic algorithm. In general, the main aim of clustering is to improve the network lifetime. In order to achieve this, we apply genetic algorithm approach which helps to identify the optimal number of CHs in the network based on the residual energy, distance between nodes, energy consumption, and delay. Once the cluster head is selected, then the neighbouring sensor node will join the CH based on the minimum Euclidean distance between cluster head and cluster member. This distance can be computed as:

$$distance = \sum_{i=0}^{m} dist(i, CH) \quad (13$$

Where $dist(i, CH)$ denotes the Euclidean distance between CH and cluster member node. According to the process of GA, the optimization problem needs to be encoded as an optimization problem which can be represented in a vector form. The solution of this optimization problem can be achieved in terms of fitness function. In this work, we consider variable-length chromosomes coding with the help of sensor nodes and the corresponding node's ID represents the genes in the context of GA. In order to achieve the best solution, we perform the fitness function computation process where residual energy of individual chromosome in the network is given as $f\big(p(id_i, s)\big) = \frac{\sum_{l\in p_j(id_i,s)} E_{res}(id_l)}{\gamma_1 f_1+\gamma_2 f_2+\gamma_3 f_3+\gamma_4 f_4}$ where f_1, f_2, f_3 andf_4 denotes energy, distance , delay and relay node for packet routing which can be computed as $f_1 = \frac{\sum_{e\in P_j(id_i,s)} dist\ (e)}{\sum_{e\in E} dist\,(e)}$, $f_2 = \frac{\sum_{e\in P_j(id_i,s)} ene\ (e)}{\sum_{e\in E} ene\,(e)}$, $f_3 = \frac{\sum_{id\in P_j(id_i,s)} delay\ (id_i)}{\sum_{e\in E} delay\,(id_i)}$ and $f_4 = \frac{hop\,(p_j(id_i,s)}{\sum hop\,(p_j(id_i,s)}$ respectively. These functions denote the distance, energy consumption, delay and hop count which are used for selecting the cluster head. Their respective weight functions are denoted by γ_1, γ_2, γ_3 and γ_4 which need to satisfy a condition as $\gamma_1 + \gamma_2 + \gamma_3 + \gamma_4 = 1$.

In the next phase, according to the GA, selection, crossover and mutation phases are applied to obtain the final solution. According to the selection approach, the healthier individuals from the generated population are considered which can be used for further process of crossover. In crossover phase, we generate new offsprings by swapping over the genetic materials among parents. The proposed approach of crossover is described in Algorithm 1.

Algorithm 1: Crossover algorithm
Step 1: Select the two chromosome individuals from the generated population Step 2: Compute the optimal number of cluster head and their positions i.e. let CH_1 and CH_2 are the two-cluster head Step 3: Compute the threshold distance as $\frac{\sqrt{(x_{max} - x_{min}\ )^2 + (y_{max} - y_{min}\ )^2}}{n}$ where x_{max} and y_{max} denotes the maximum co-ordinatesand x_{min} and y_{min} coordinates of the considered node Step 4: *while* Compute the distance (d)between cluster head$CH_1$and CH_2 Step 5:if computed distance $d < T$ do Step 6: if $Energy$ of current CH is less than the new CH Step 7: replace the node i.e. add the new node as cluster head *else* Step 8: Do not add the new node and discard End while

Finally, the crossover and mutation processes are finished and a best fit chromosome is selected as new CH which results in smallest difference in the energy consumption when compared with the previous round. Thus, this process can achieve the prolonged network lifetime.

3.3 Including security and trust aspects in WSN routing

In this section, we present a hash function model to secure the locations of different sensor nodes. Hashing is process to generate the Hash function for the considered sensor network. In this process, the arbitrary data is mapped into a fixed size. Moreover, this is one-way function to secure the information hence it can not be reverted. In this work, we have

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adopted SHA-256 algorithm [31] for Hash generation for each node. Further, we use AESalgorithm for data encryption and decryption. Moreover, we incorporate Diffie-Hellman key exchange model/ Below given figure 2 shows the process of AES encryption. The AES approach is based on the 'substitution–permutation network'which contains several operations including substitutions and permutations. AES performs these operations on byte hence it considers 128-bit plane text as 16-byte block.

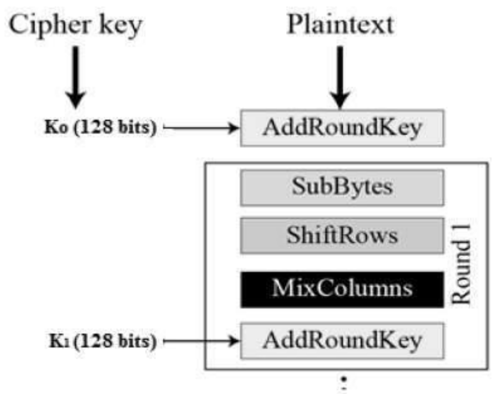

Fig.2. AES encryption

The AES encryption contains following phases such as: Byte Substitution (SubBytes),Shiftrows,MixColumns and Addroundkey. Similarly, the decryption process, performs these operations in reverse order as add round key, mix columns, shift rows and byte substitution. Before transmitting the data to the next hop, we evaluate the trust factor of the next hop. We model the behavior of node (k) as $M(k)$ as given in Eq. (1). We assume that the faulty node can result in misbehavior during packet forwarding. The trust model can be presented as:

$$M(k) = \begin{cases} 1 \textit{then node k forwards the packet} \\ 0 \textit{ then node k drops the packet} \end{cases}$$

In order to measure the trust, we measure the packet forwarding ratio for each node in the routing path where node i transmits the packet to the j^{th} node. Hence, the packet forwarding ratio can be computed as:

$$m_{i,j} = \frac{S_{i,j}}{S_{i,j} + F_{i,j}}$$

Where $S_{i,j}$ denotes the successful packet transmission and $F_{i,j}$ denotes the packet failure from node i to j. In order to consider the for transmission, we define a threshold $m_{i,j} > 75\%$, if the packet forwarding ratio is higher than the threshold then it is considered as genuine node otherwise considered as malicious node and discarded from the routing path.

4. Results and discussion

In this section we present the performance analysis of proposed approach for WSN and compared the performance of proposed approach with the existing techniques. The simulation analysis is divided into two categories where first of all we evaluate the localization error performance and later we compare the network lifetime and QoS related performance.

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4.1 Localization performance evaluation

In this sub-section we compute the sensor node localization performance and compare it with existing approaches such as Basic DV Hop [2], RSSI DV Hop [2], and Hybrid DV Hop [2]. The performance is evaluated in terms of localization error which is computed by varying the anchor node rates, transmission range for 100 node scenario. The complete simulation parameters for this analysis, are presented in table 1.

Simulation Parameter	Considered Value
Number of Nodes	100
Network Area	100mx100m
Anchor Nodes	10%-50%
Transmission Range	20m

Based on these simulation parameters, we evaluate the performance of proposed approach in terms of localization error for 100 nodes. figure 1 shows a comparative performance in terms of localization

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error for 100 nodes where communication range is varied and anchor nodes are considered as 10%. And transmission range is considered as 20 m

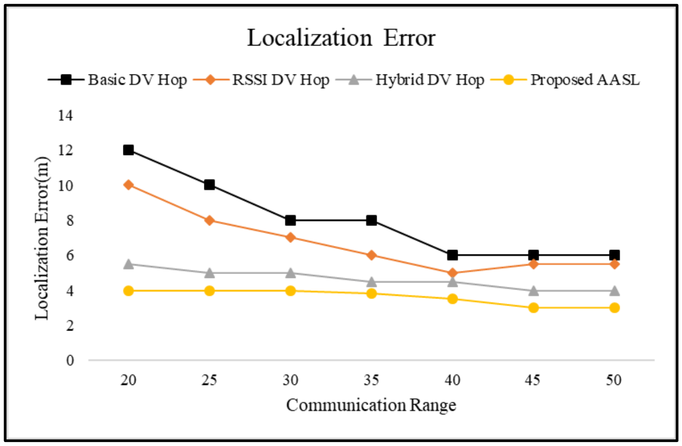

Fig.3. Localization error performance for varied Communication range

According to this analysis, the average localization error is obtained as 8m, 6.7m, 4.6m, and 3.6m using Basic DV Hop, RSSI DV Hop, Hybrid DV Hop, and Proposed AASL. This analysis shows that proposed approach achieves better performance when the communication range is also increased whereas as existing approaches provides less accuracy in localization when the communication range is varied. Similarly, we evaluate the performance in terms of localization error where number of anchor nodes are varied from 10% to 50% for 100 node scenarios where transmission range is considered as 20m.

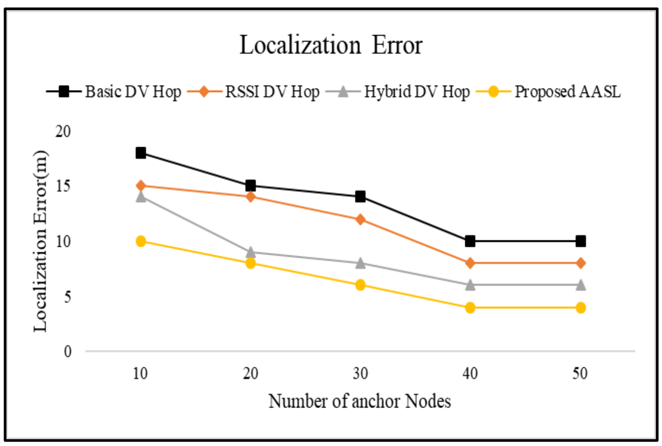

Fig. 4. Localization Error for varied anchor nodes.

The above given figure shows the localization error performance for varied number of anchor nodes with the 20m range of transmission. According to this simulation scenario, the average localization error is obtained as 13.4m, 11.4m, 8.6m and 6.4m using Basic DV Hop, RSSI DV Hop, Hybrid DV Hop and Proposed AASL techniques.

4.2 Network QoS related performance

In this section we present a comparative analysis in terms of total alive nodes and residual energy. The obtained performance is compared with the exiting techniques as mentioned in [14]. Below given figure shows a comparative performance in terms of alive nodes.

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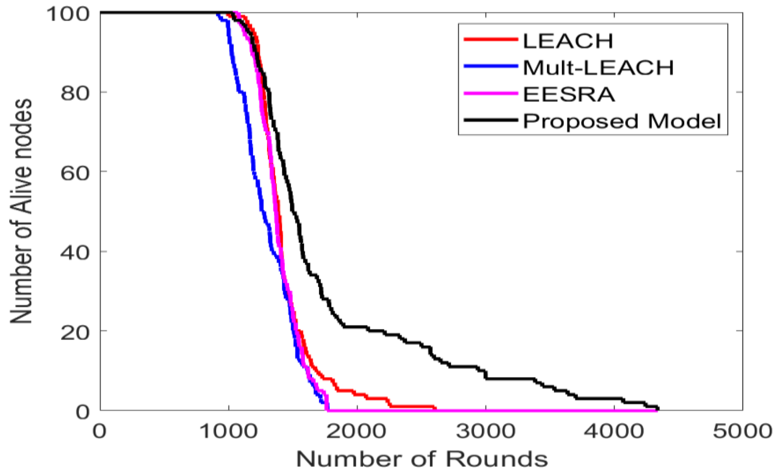

Fig.5. Alive Node performance

According to this experiment, the average number of alive nodes are 30, 33, 36, 42 using LEACH, multi-LEACH, EESRA and proposed model. Similarly, we measure the performance in terms residual energy.

Figure 6 shows a comparative analysis.

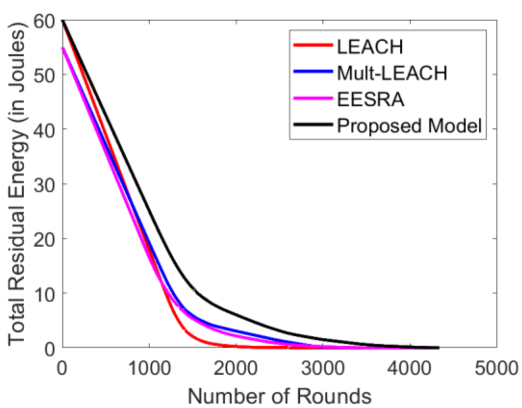

Fig.6. Residual energy comparison

These experimental studies show that the proposed approach obtains better localization rate, minimizing the power consumption and maintains the better residual energy to improve the network lifetime.

5. Conclusion

In this work, we focus on several challenging issues of WSN such as sensor node localization, energy aware routing and improving the security of the network. First of all, we present RSSI based model for sensor node localization which helps to reduce the localization error. In the next phase, we present genetic algorithm-basedenergy aware routing protocol to minimize the energy consumption. The GA approach helps to select the optimal cluster head. In next phase, we use SHA-256 for hashing to maintain the node location privacy, followed by AES based encryption model to ensure the security to the data. The experimental study shows that proposed approach reduces localization error, minimizes the energy consumption and improves the network lifetime.

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