AN EFFECTIVE FIREFLY ALGORITHM FOR NODE LOCALIZATION IN DISTRIBUTED MOBILE WIRELESS SENSOR NETWORK

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ABSTRACT

Wireless sensor networks (MWSNs) have as of late been broadly explored because of its various applications in procedures that must be shared over an extensive region. One of the vital issues of MMWSN is localization of node, node localization ability is exceedingly alluring for the execution assessment in checking applications. Localization is characterized as evaluating the areas of sensors with at first obscure area data as the majority of sensors do not contain about its regions because of the expense and size of sensors. In a multidimensional space, the fundamental target of localization is to discover the nodes locations in a short period with a low energy cost. Therefore, ongoing methodologies depending on swarm intelligence procedures are used, and localization of node is viewed as an optimization issue. As of late, the meta-heuristic Bat calculation was projected as an answer for the localization of node issue. This paper projects an efficient firefly method for the node localization issue, the efficiency of that depends on the adjustment of attractiveness of fireflies by hybridization, with Doppler effect for enhancing the execution. Sending this calculation on an extensive MWSN with many sensors shows nice execution as far as node localization. The simulation results indicate that the proposed scheme demonstrates more consistent and accurate location of nodes and to compare the existing BOA and FA-based node localization schemes.

1. INTRODUCTION

A mobile wireless sensor network (MWSN) is an ad-hoc network with countless that are micro sensors equipped for gathering and broadcasting ecological information in a self-ruling method. The nodes locations are not really foreordained they can be arbitrarily scattered in a land zone, known as "detecting region," comparing to the region of interest for the wonder being caught. In MWSN, an expansive sum of nodes are conveyed in the network, the data recognized through the sensor node will be accumulated and broadcasted through multi-hop methods to sink i.e. every node sends the data to its neighbor (so one jump among two neighbor) in anticipation of it achieves the end and transmits it to BS. Lately, MWSN has turned into a functioning examination domain, and the productive business of MWSN has opened different new study regions for application, for example, atmosphere forecast, investigation of normal, environmental weight [1], thus on where a few issues are tended to in the MWSN, for example, minimization of energy, pressure plans, self-arranging network calculations, directing, conventions, security, and nature of administration management. Node localization [2-3] is one among the critical difficulties of MWSN; it assumes a crucial job in a few fields, for example, inclusion, organization purposes, steering data, area administration, target following, and mortar propelling. The fundamental goal of node localization is to assess the sensors area with at first obscure area data, so as to accomplish this, the procedure utilizes learning of the supreme spaces of sensors couple and among estimations of sensor, for instance, bearing and separation estimations. The sensors with obscure area data are known as non-anchor nodes, when sensors with area data are known stay or guides nodes. Self-localization capacity is exceedingly attractive in natural observing applications, for example, interruption identification, street traffic checking, wellbeing observing, etc. One conceivable arrangement of localization of node is to furnish every node with global positioning system (GPS) gadgets, however, this arrangement isn't appropriate for 2 reasons:

- The staggering expense of the gadget as far as esteem, space, energy and calculation power.
- The poor exactness of the administration in uncommon situations (inside, underground, and so forth).

The principal provisional versus localization of node is projected in [4], where curved optimization is projected to limit the network nodes. At present, localization needs every obscure node to comprise GPS introduced yet utilizes just a couple of grapple nodes, and it utilizes correspondence systems proposed in [5, 6] to restrict the obscure nodes, where their directions will be evaluated through the localization of sensor network calculation. Truth be told, the node localization issue has been viewed as a multidimensional optimization issue, wherever optimization calculations are utilized to determine this issue, and the as of late created Bat calculation is projected as a meta-heuristic calculation. The recurrence attribute is unaltered in the Bat calculation amid the moving of the Bats, this issue creates the calculation substantial, however the computation time is extremely impressive. A proficient Bat calculation is projected by refreshing the recurrence attribute; besides, the speed and the area attributes are likewise changed, and the idea of the Doppler effect is coordinated into the first calculation [7].

2. RELATED WORK

Localization of node has gained much consideration over the most recent couple of decades, and a few overviews are point by point [8– 10]. The node localization classification is separated after much thought and as indicated by a few criteria:

- The portability of the nodes (static versus versatile, blended).
- The execution condition (incorporated versus circulated, blended).
- The separation estimation (extend free and range-based).

Then again, the localization plan can be separated into 3 phases joined. The essential assignment of the primary stage is assessing the separation among reference point nodes and goal nodes, and a few systems, for example, [11], time difference of arrival (TDOA), time of arrival (TOA) and Received Signal Strength Indication (RSSI), [12] and Angle of Arrival (AOA) [13] are utilized to figure the distance or angle. Moreover, the device to device (D2D) procedure [14] has been projected to interface specially appointed networks and incorporated networks [15], etc. Every one of the estimation separate strategies has favorable circumstances and disadvantages, and the determination of the separation estimation strategy is viewed as an essential factor, which extraordinarily impacts the execution of the framework. Also, every strategy is determined by the application domain. The next phase of the localization plot is the calculation of position by misusing the information got in the past stage (computing distance). It is conceivable to ascertain the directions of the objective nodes, and an astounding sum of methodologies are projected in this stage; such techniques incorporate multilateration, trilateration, triangulation, probabilistic methodologies, bounding box, the focal position, and fingerprinting [16]. Besides, it presents other work focuses all data about separations registering that uses numerical optimization strategies to compute the places of the nodes. In the third phase of the procedure (localization conspire), so as to ascertain the places of the obscure nodes through reference point nodes, a mix task is started among the past 2 stages. There are extensive examinations centered around the localization calculation, and meta-heuristic strategies have as of late been viewed as critical to take care of the optimization issue, while node localization is treated as a multidimensional optimization issue, and a generous number of strategies that utilization populace based stochastic systems are projected. In 2008, particle swarm optimization (PSO) was projected as the main endeavor to understand the node localization problem [17] and a couple of stay nodes were utilized to find the staying obscure nodes within the square network. The projected technique depended on amassed data through grapple nodes to find whatever is left of the sensors. The essential thought of this methodology was that every single obscure node send their determined organizes and evaluated separation to the base station, and the base station runs a PSO to limit the localization mistake characterized. This methodology has 5 noteworthy imperfections: The framework functions admirably just when the node is encompassed by at least 3 grapple nodes. A range estimation of all objective nodes situated around the reference point nodes must be made by the base station. This requires much correspondence that can traffic, delays, and the exhaustion of energy.

The projected plan has constrained versatility in light of the fact that the dimensionality PSO is double the quantity of goal nodes. The issue of flip vagueness isn't treated in this methodology, and this impacts the localization blunder and the quantity of confined nodes. The projected methodology works just in the incorporated MWSN model, and this model needs a huge correspondence run. In 2011, the Honey bee mating optimization (HBOA) was projected for localization of node [18] where RSSI is used in the computation stage. Then again, 2 sending models are run over in the recreation network; the first is the better organization, in that the objective nodes are encompassed by 4 (set in the corner) reference point nodes in various ways, and the next is in a more awful condition where the guide nodes are sent in the medium situated a solitary way in respect to 1 obscure node. The acquired outcome demonstrated that BOA was productive and has exceptional execution. Besides, a near report was directed among the projected methodology and the Cramer-Rao Bound (CRB), and the last outcome showed that the exactness of projected rate methodology dependent on TOA is superior to the RSSI estimation. In any case, there are a few reactions that ought to be accounted for: BOA is adjusted for localization of node difficulty, yet there is no relative examination with the other meta-heuristics approaches. The versatility difficulty isn't tended to in this paper. The BOA attributes are not assessed. The present examination has just explored localization mistake, though the energy utilization and localization time are unequivocal elements for the proposed methodology effectiveness. For the node localization challenge [19] differential evolution (DE) was projected in 2014, so as to limit the localization blunder, every node in the network executes DE to decide its directions. The methodology has demonstrated that joins after a couple of emphases permit the protection of energy and the expense of the nodes; notwithstanding, there are a few reactions that ought to be called attention to: DE has couple of attributes and three simple stages, however in this paper just DE is reenacted, so the relative examination is required with late calculations. The versatility problem isn't settled for testing the scale improvement of the projected calculation.

The present examination has just researched localization blunder, while localization time and energy utilization are significant variables for the proposed methodology effectiveness. Another meta-heuristic procedure is Flower pollination (FP) was that was projected in 2015 [20] for the localization of node issue. The key thought is to assess the directions of the best nodes through bringing these neighbors nearer by 1 bounce. A near work is checked on in this paper, and the recreation results acquired (the directions of determined nodes) by FP were contrasted and the different enhancements of the PSO calculation. Also, a few topologies of network are worked out, and the reenactment results demonstrate that the localization rate acquired by the FP calculation is higher than the different enhancements of the PSO calculation.

3. PROPOSED FIREFLY ALGORITHM WITH DOPPLER EFFECT

By scholar Yang in literature, Firefly Algorithm is projected. In nature, FA models the fact that the fireflies flash and attract every other. It is one type of colony searching technology.

The brightness can easily be relative to the rate of the goal function for a maximization problem. Three definitions are expressed as following in the Firefly algorithm depending on these three rules.

1. The light intensity $I(r)$ can be demonstrated as

$$I(r) = I_0 e^{-\gamma r^2} \tag{1}$$

Where I_0 refers to the actual light intensity, γ is the light absorption coefficient that is fixed, r refers to the distance.

2. As the attractiveness is relative to the light intensity, so the attractiveness β can derived as

$$\beta(r) = \beta_0 e^{-\gamma r^2} \tag{2}$$

Where β_0 is the attractiveness at r = 0 .

3. While a firefly i is attracted through a firefly j ,the firefly i moves to the firefly j and the firefly i state can be described as

$$x_i = x_i + \beta_0 e^{-\gamma r^2}\left(x_j - x_i\right) + \alpha\varepsilon_i \tag{3}$$

Where x_i, x_j is the state of firefly j and firefly i correspondingly, the third term is randomization with α being the randomization attribute, and ε_i is a random numbers vector derived from a uniform distribution or Gaussian distribution.

3.1 The Improved Firefly Algorithm with node localization of MWSN

With the change in frequency, an improved firefly algorithm (IFA) was formulated in periodic event while an observer moves relating to the source. It is called as Doppler effect fig. 1.Because of the relative movement among the source and receiver, the droplet effect, source wavelength modification. In the line of sight (LOS) among the receptor and transmitter, the related movement is that affects the gained frequency. Fig. 2 shows the overall process of the proposed method and the operation of proposed method is given in Algorithm 1. The firefly will attract the brighter ones and update the location. In the environment fly over arbitrarily and revise its frequency Doppler to store brighter fireflies with their within the constrained frequency measurement area. It comprises high sensible ability of hearing, and this feature is due to the Doppler shift compensation. Doppler shift benefit is the capability to hear the wings beating as little difference in frequency in the range of fireflies intensity. To estimate the brightness of the fireflies, two Doppler shifts takes place.

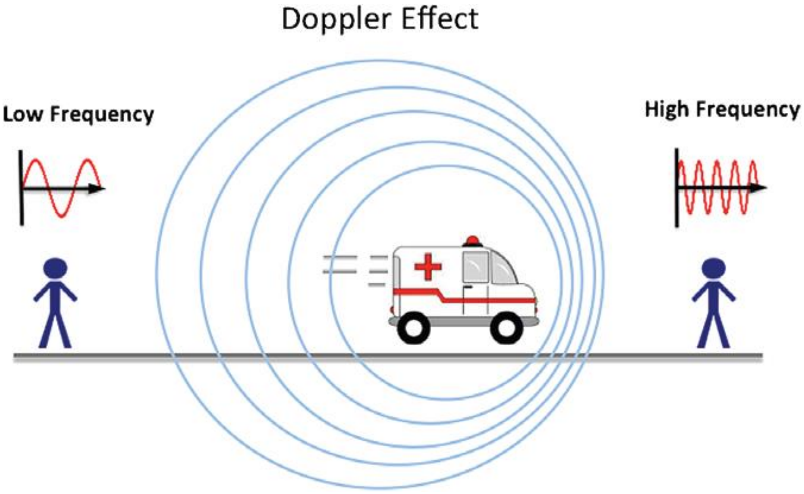

Fig. 1. An illustration of Doppler effect

Let $\boldsymbol{f_t/v_t}$ and $\boldsymbol{f_r/v_r}$ are the speeds/frequencies of the receiver and transmitter, correspondingly. With the wavelength, the actual frequency has a relation, where $\boldsymbol{f_0 = C/\lambda_0}, \boldsymbol{\lambda_0}$ the wavelength of the source, and C is is the wave speed in the medium. The velocity of flying is negative, if the source is displacing forward from the observer; so:

$$f' = f_0 \left[\frac{C+v_r}{C}\right] \tag{4}$$

The flying velocity is positive if the source is moving far from the observer; so:

$$f' = f_0 \left[\frac{C-v_r}{C}\right] \tag{5}$$

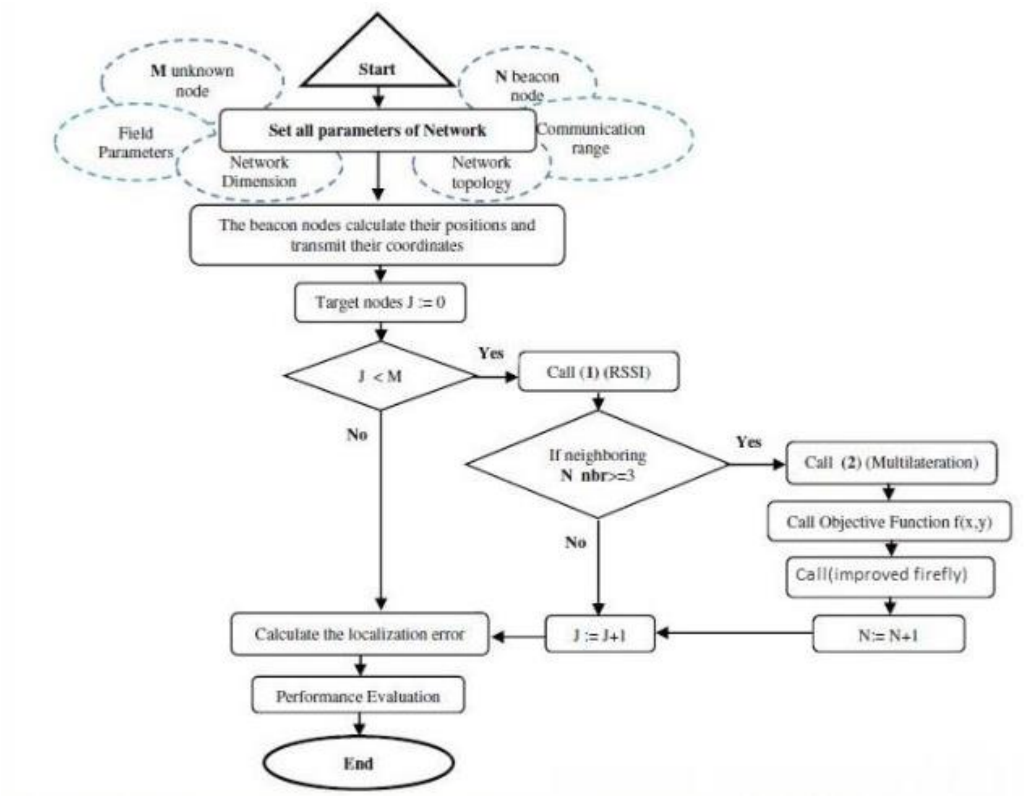

Fig. 2. Flowchart of proposed model

The deducted Doppler effect equation can be expressed as

Algorithm 1 Improved Firefly Algorithm for Node Localization

Objective function f(x), x= (x1, x2, x3…xi)
Initialize population of fireflies x_i (i=1, 2…n)
Light intensity L_i at x_i is determined by f(x_i)
Light absorption coeff. ϕ, and the parameter c;
While (t<Max_Generation)
For∀ i=1 to n
For∀ j=1to n
If(Li <Lj)
Move firefly i towards j;
End If
If k reaches a setted value (K can be changed by using **Doppler Effect(v_r,v_i,f_t,f_r,c)**
Move the badfireflies to the better place;
End If
Diverge the attractiveness with distance r via exp[-r γ];
Evaluate new solutions and update light intensity;
End For j
End For i
Postprocess results and visualization;

$$f_r = f_t \left[\frac{C \pm v_r}{C \mp v_r}\right] \tag{6}$$

4. RESULTS AND DISCUSSION

In MWSN, the sensor nodes handling is a difficult thing. The projected method is compared over two other methods named as FA and BOA. The comparison is made by means of MLE, Packets received and computation and NL while transmitting data to the destination node. A set of two measures has been used to evaluate the performance of the proposed method.

1. Average localization errors (ALE): ALE represents the average distance among the determined location (*xi*, *yi*) and the definite node coordinates (*Xi*, *Y*i) .

$$E_L = \frac{1}{M_L}\sqrt{(x_i - X_i)^2 + (y_i - Y_i)^2} \tag{6}$$

2. Average execution time (AET): This is the average time required for the localization of all sensor nodes.

$$AET = \frac{\sum_{i=1}^{n} execution\ time}{n\ (no.of\ sensor\ node)} \tag{7}$$

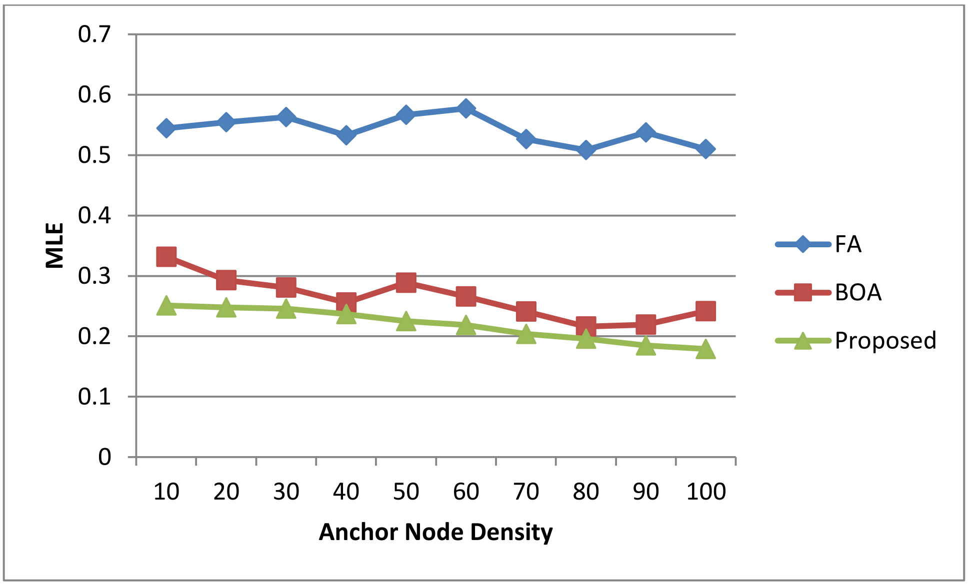

Fig. 3. Impact of varying anchor node density in-terms of MLE

From the fig. 3, it is obvious that the FA is the poor performer due to MLE which has higher number of varying anchor node density from initial, hence the FA exhibits poor performance by means of MLE. When to compare the impact of varying nodes in BOA, it exhibits improved performance when comparing with FA however it fails to exhibit reduced sum of varying anchor nodes in consequent rounds when compared to projected Improved firefly algorithm. The projected method has reduced sum of varying anchor nodes in each round;

hence, the projected technique exhibits improved performance over the comparative method by means of MLE.

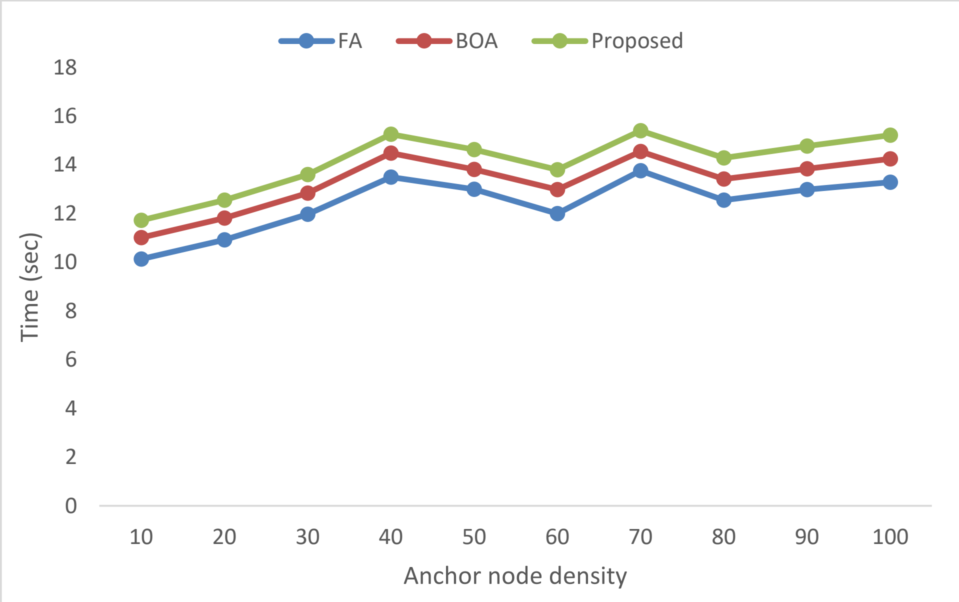

Fig. 4 Impact of varying anchor node density interms of computation time

Fig. 4 exhibits the impact of varying anchor node density with methods such as FA, BOA and Improved firefly algorithm by means of computation time at each round. The computation time is reasonably poor at every round and in the end round for FA when comparing to the other techniques. BOA performs better by when comparing to FA but it fail in accordance with the proposed method.

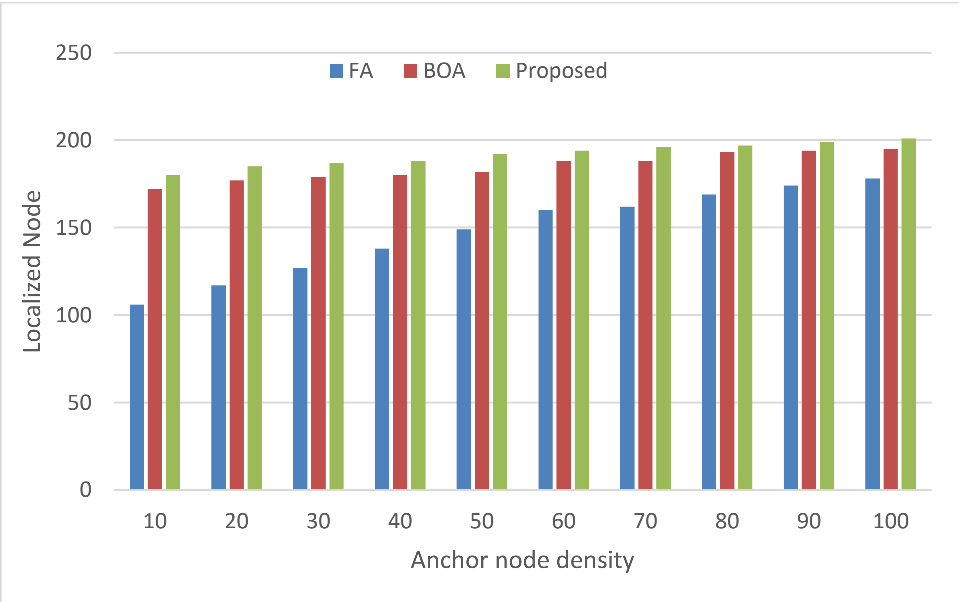

Fig. 5 Impact of varying anchor node density in terms of NL

From Fig. 5 shows the Impact of varying anchor node density with methods such as FA, BOA and Improved firefly algorithm by means of NL. The number of localized in each round is low for FA; BOA attains poor performance when comparing with all. BOA handles the energy up to 170 NL but it fail to better the proposed method. Impact of varying anchor node density by means of NL is high in entire rounds and it maintains the energy upto 200 at end rounds, therefore it exhibits enhanced performance.

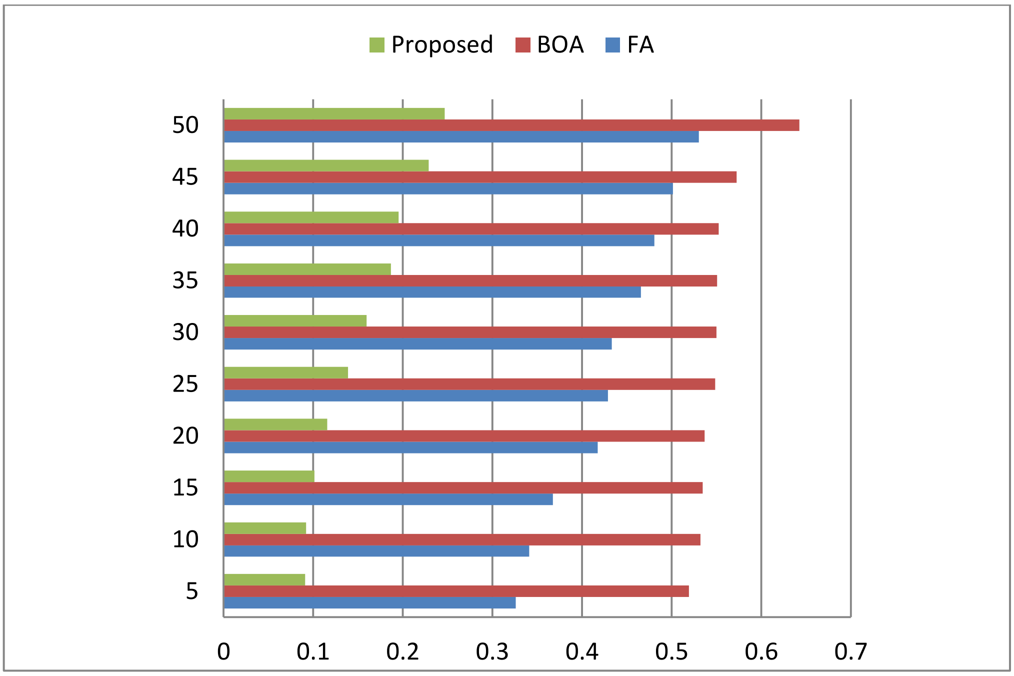

Fig. 6. Impact of ranging error interms of MLE

From the fig. 6, it is obvious that the BOA is the poor performer due to MLE which has higher number of varying anchor node density from initial, hence the BOA exhibits poor performance by means of MLE. While comparing the impact of varying nodes in FA, it exhibits improved performance when comparing with BOA but it fails to show reduced number of varying anchor nodes in consequent rounds while comparing to proposed Improved firefly algorithm. The projected method has reduced number of varying anchor nodes in each round; hence, the proposed method exhibits improved performance when compared to the other method by means of MLE.

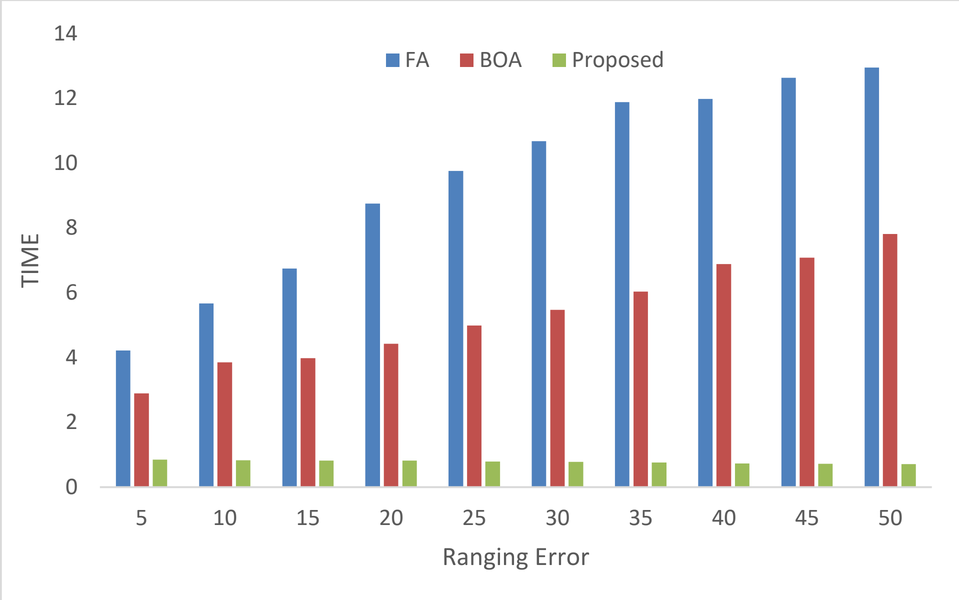

Fig. 7. Impact of ranging error interms of computation time

Fig. 7 shows the Impact of varying anchor node density with methods such as FA, BOA and Improved firefly algorithm by means of computation time at each round. The computation time is comparatively poor at each round and also in the end round for FA when compared to the other methods. BOA performs better by when compared to FA but it fails on behalf of the proposed method.

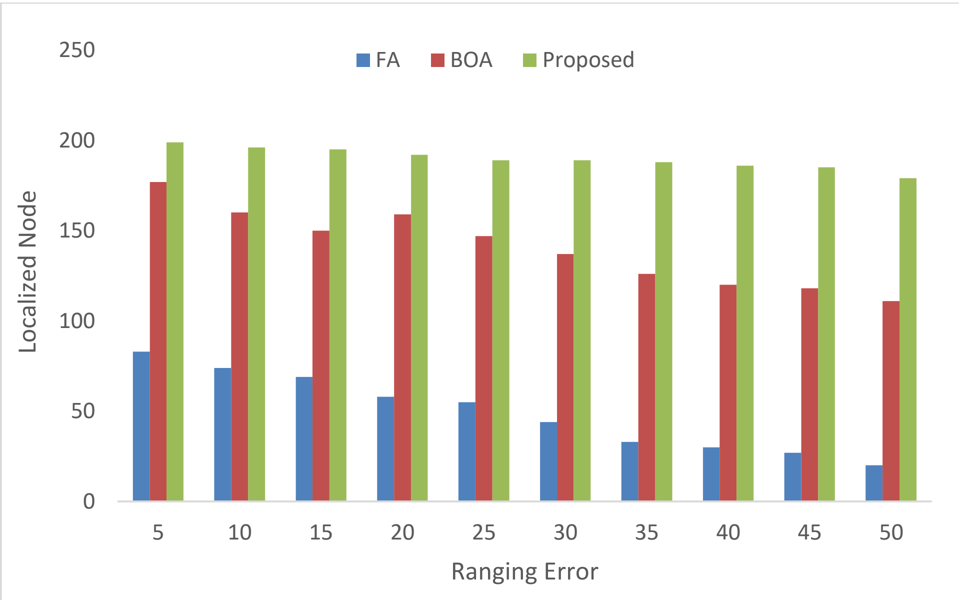

Fig. 8. Impact of ranging error interms of NL

Fig. 8 demonstrates the Impact of varying anchor node density with methods such as BAT, M-BAT and Improved firefly algorithm by means of NL. The number of localized in each round is low for BAT; and, comparing with the other methods, M-BAT achieves poor performance while comparing with others. M-BAT handles the energy up to 170 NL but it fails to exhibit better than projected method Firefly. Impact of varying anchor node density by means of NL is high in all rounds and it handles the energy upto 200 at end rounds; hence it shows superior performance over the other methods. Hence, with the methods compared by means of MLE, Packets established and computation and NL, the proposed method exhibit greater performance in entire conditions.

5. Conclusion

In MWSN, an expansive sum of nodes are conveyed in the network, the data recognized by the sensor node would be accumulated and broadcasted by multihop methods to BS. The fundamental goal of localization of node is to assess the sensors area with at first obscure area data; so as to accomplish this, the procedure utilizes learning of the supreme places of a sensors couple and among estimations of sensor. This paper projects an efficient firefly method for the localization of node issue, the efficiency of that depends over the adjustment of attractiveness of fireflies through hybridization, with Doppler Effect for enhancing the execution. The projected Improved firefly algorithm method has reduced sum of varying anchor nodes in every round. Therefore, the proposed method exhibits improved performance by means of MLE.

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