An Efficient Technique for Minimizing Localization Errors in Wireless Sensor Networks

Sudha H.Thimmaiah, Mahadevan.G

***Abstract:** Wireless Sensor Networks (WSNs) has become one of the huge research topics and numerous researchers are working on numerous areas encircling WSNs. Wireless sensor networks comprise of low-cost sensors that are deployed in the network for transmission of messages within the network. Though the use of wireless sensor networks has gained an intensive response in the digital environment, there still exists some sorts of issues that need to be improvised. One such problem that affects most of the transmissions in a WSN is localization error. Finding the exact location of a particular sensor in a wireless network is one of the major issues. In this paper, we propose a technique for minimizing the localization error by making use of the Time of Arrival (TOA) technique. The proposed technique is efficiently compared with the existing techniques and the performance analysis is done. The experimental setup was done by making use of Matlab 2018b and the same was used to obtain efficient results. Some of the parameters used for finding the efficiency of the system was the calculation of the distance error between the proposed and the existing technique. The analysis shows the accuracy rate of finding the location of the sensors and also portrays the minimization of localization error in a given WSN.*

***Keywords** : Network, Wireless, Sensor, Efficiency, Localization Error, ToA*

I. INTRODUCTION

A wireless sensor network could be stated as an ad-hoc network that generally consists of low-cost autonomous sensors deployed in a specific area for carrying out a required task depending upon the application. There is numerous application that makes use of these wireless sensor nodes to carry out a specific task such as target tracking or routing. In this kind of applications, without the localization information about the sensors, the data gathered by the deployed sensors becomes of no use and gathering the exact location of the sensors plays a vital role.

In this kind of applications, without the localization information about the sensors, the data gathered by the deployed sensors becomes of no use and gathering the exact location of the sensors plays a vital role. One of the prominent solutions is to fix GPS on each sensor to obtain the exact location, but this, in turn, makes the wireless sensor network to lose its most prominent cost-effective feature. GPS also faces some of the other issues such as being deployed in an open filed and its inability to work underwater and in an indoor environment. In order to come out of these situations, numerous researchers have designed various techniques to overcome the challenges of locating the sensors.

Localization has been one of the most common issues that exist while working with wireless sensor networks. The localization problems are effectively classified into two main categories one being the range-based and another one that is range free. Range-based localization techniques[1-6], calculates or measures the location of a particular node with respect to other neighbor nodes in its region. The location of an unknown node is specially calculated by measuring the angle and distance of the known nodes. This type of location method is not very cost-effective and hence we tend to move on to another technique which is range-free localization technique that makes use of information from the topology and the vital connectivity within the network. Minimizing the overall localization error in a WSN is a challenging task and very few innovations have been carried out to minimize this without bearing any unnecessary overhead costs. Finding the accurate distance between the sensor nodes is also one of the major aspects in a localizing technique that most of the existing techniques fail to look upon.Models consisting of higher accuracy rates of locating the exact location of the sensors are very much desirable in numerous applications.

In this paper, in order to overcome issues arising out of range-based techniques in wireless sensor networks, we have proposed a method of calculating the exact Time of Arrival (ToA) of the signals from one sensor node to another sensor node. This is done by gathering the other related information such as the Angle of Arrival(AoA) the signals and the Time Difference of Arrival(TDoA).

The proposed system is evaluated on various parameters and is observed to perform better than the existing systems. The rest of the section is as follows: Section II consists of Literature Survey, section III consists of the methodology used in the paper and section IV consists of various results obtained. The paper is concluded in the last by mentioning the relevant future works that could be applied or added to the proposed work.

II. LITERATURE SURVEY

WSNs is one among the most vibrantly used networks for communication techniques[6] widely used in numerous applications, designed in such a way that it increases the reliability of the air interface [7].

In order to calculate the localization error, it is very important to find out the exact location of each sensor nodes in a WSN. In[8], a localization

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technique was used to locate the exact location of the sensors. This was effectively done by making use of trust-based messages sent to the sensors adjacent to each other. In[9], the author has made use of the shortest path algorithm for finding the location of the sensors by knowing the location of the adjacent sensors. Many hybrid based localization techniques are also used as portrayed in[10]. Bio-inspired algorithms are also gaining high popularity as many researchers have used these techniques. In[11], a genetic algorithm is used whereas in[12], the PSO algorithm is used. Neural networks are gaining much attention in numerous fields and WSN is not an exception as depicted in[13].

As minimization of localization errors is one of the most important factors, numerous researchers are working on it. A localization technique used in[14], used a cooperative and distributed strategy very efficiently in order to maintain the total energy of the wireless network. Messages were sent to the neighbour nodes with the help of an anchor which could be also known as the localized node in[15]. This was done by making use of adopted distributed and asynchronous protocol which highly helped in reducing the energy. The network making use of this protocol did not require any information priority for processing. In [16], it could be noted that metaheuristic approaches have been used in order to minimize localization errors. The algorithms predominantly used were the Cuckoo Search and Firefly Optimization algorithm. RMSE is used as an evaluation parameter for comparing the proposed model with the existing techniques and to prove its efficiency. An error model designed by Anil Kumar et.al [17], proposed an error model for by making use of the PSO algorithm to estimate the location of a specific node in a network. The model claimed to perform better than the existing models which used other algorithms such as GA and SAA.

III. PROPOSED APPROACH

The proposed model makes use of an existing model [18], where Received Signal Strength (RSS) is used as one of the methods for receiving the signal is a WSN. The model claimed that while making use of the RSS method, it makes the model more flexible and reduces the amount of localization error encountered to a higher extent. As an advanced method, in this proposed model we have proposed a way of approximately estimating the TOA measurements while using various sensor nodes which is denoted by 'b'. In this, let us consider an example of a system that consists of numerous reference nodes and also comprises of q number of nodes that are blindfolded p times. The nodes factors $\alpha = K1,\dots, Kp+q$ is present where all the nodes, $Kx = [ix + jx]B$ is supposed to be the absolute

$$\varphi = [i_1,\dots,i_q], \qquad \varphi = [j_1,\dots,j_q] \tag{1}$$

error that is relative to the axis coordinate $\varphi = [\varphi 1, \varphi 1]$. While making use of TOA, $I_{xy} = B_{xy}$ is considered to be the computed TOA present among the entire nodes x and y in seconds, where x and y are the coordinates of the location of the sensor nodes.

$$T_{xy}(dBm) \sim H\left(T_{xy}(dBM), \sigma_{dB}^2\right)$$

$$T_{xy}(dBm) \sim T_0(dBM) - 10h_t \log_{10}\left(\frac{I_{xy}}{I_0}\right) \tag{2}$$

While making this study, only the subset of M(n) which is the pairwise assessments of the nodes are evaluated by making use of $((B_{xy}))_{xy}$ and $((T_{xy}))_{xy}$. Bxy is Gaussian distributed calculated as

$$B_{xy} \sim H\left(I_{xy}/_{s,\sigma_b^2}\right), I_{xy} = I(k_x, k_y) = \|k_x - k_y\|^{1/2} \tag{3}$$

and

$$F_\varphi = -E\nabla_\varphi(\nabla_\varphi v(I|\gamma))^B = \begin{bmatrix} w_{1,1} & \cdots & w_{1,q} \\ \vdots & \ddots & \vdots \\ w_{q,1} & \cdots & w_{q,q} \end{bmatrix} \tag{4}$$

where the variance is not the function of Ixy and the propagation speed of the transmission is given by the value of s. Ixy is the AIES range and is also determined by the power obtained in the entire model depicted by Txy as in

$$w_{n,y} = \{-X_{M(n)}R\left[\partial^2/_{\partial\varphi_n^2} v_{n,y}\right]$$

$$w_{n,v} = \{-\Sigma_{\gamma\in m(n)}R\left[\partial^2/_{\partial\varphi_n^2} I_{k,l}\right] \tag{5}$$

The AIES is the Adaptive Information Estimation Strategy that is used for calculating the maximum likelihood density function. All the parameters need to be calculated by making use of a specific device known as infrastructure estimator. The likelihood density function is depicted as shown in (4) from that, we are able to calculate the adaptive information matrix as the off-diagonal elements when n=v (v si the odd diagonal elements) and is measured by making use of and the same is measured when n≠1 as the total maximum likelihood that needs to be computed for φ while making use of a particular q and p is computed as follows

$$\varphi_B = \arg^1_{(k_x)} \sum_{x=1}^{p+q} \sum_{y\in B(x)} \left(sB_{xy} - I(k_x,k_y)\right)^2 \quad y < x \tag{6}$$

IV. PROPOSED APPROACH

The experimental results were performed on Windows 8.1 and involved a 4GB RAM. The processor used was Intel Pentium with a 64-bit processor. Simulations were also done on Matlab 2018b version.

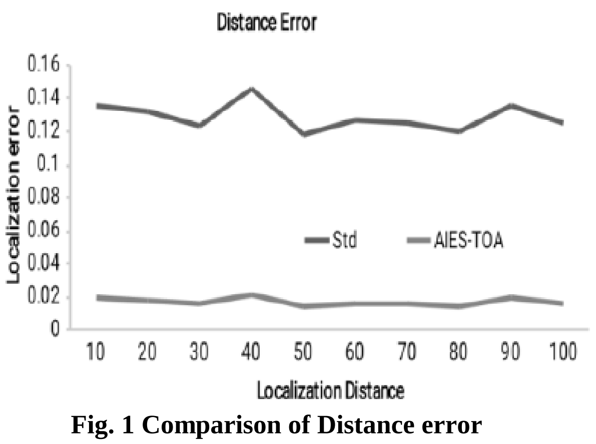

Fig. 1 Comparison of Distance error

In Fig. 2 it could be noticed that the overall RMSE value changes according to the techniques that have been used.
It is compared without the current technique and the existing technique. We can clearly notice that in all the categories, the currently proposed method seems to have a better performance when compared with the AIES_TOA_STD.

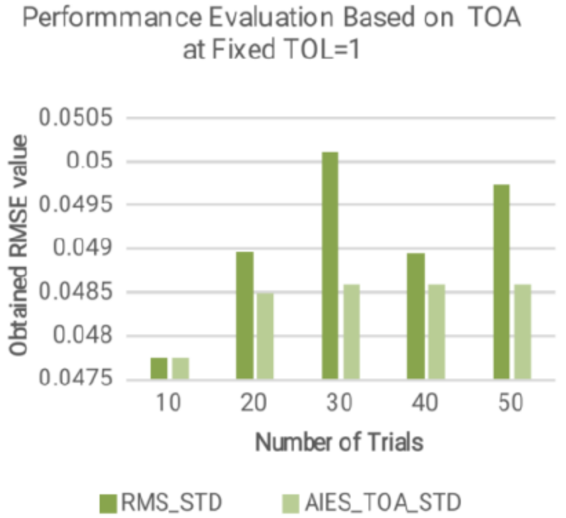

Fig. 2 Comparison of Error Tolerance

In Fig 3, the overall performance for tolerance are compared while calculating the overall values. It is clearly observable that the proposed technique seems to produce much less localization error when compared to the existing methods.

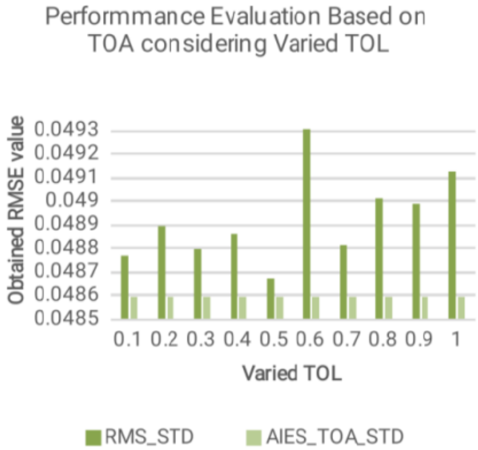

Fig. 3 Performance for Tolerance

V. CONCLUSION

IoT Wireless Sensor Networks has gained numerous trend of being used in most of the applications. Some specific applications require the need for locating the exact location of these sensors in the networks. Nowadays, numerous amount of information is being transferred through wireless channels and locating the exact location of the sensors in the network plays a vital role. In this paper, we have proposed a technique of using Time of Arrival (TOA) that produces an effective way of calculating the error when compared to the existing systems. The efficiency of the technique is observed by making use of MatLab 2018b. The system has produced an accuracy level of about 82% and is proved to be efficient when compared to other traditional systems. The future work could include the implementation of this technique in a real-world environment and observing the error rate in locating the sensors in real-time.

REFERENCES

1. P Bergamo and G Mazzini. “Localization in sensor networks with fading and mobility”. In Proc. IEEE Int. Symp. Personal, Indoor Mobile Radio Conf. 2002: 750–754
2. A Nasipuri and K Li. “A directionality based location discovery scheme for wireless sensor networks”. In Proc. ACM Int. Workshop Wireless Sensor Netw. Appl. 2002: 105–111
3. P Bahl and VN Padmanabhan. “RADAR: An in-building RF-based user location and tracking system”. In Proc. IEEE Joint Conf. IEEE Comput. Commun. Soc. 2000: 775–784
4. D Niculescu and B Nath. “Ad hoc positioning system (APS) using AoA”. In Proc. IEEE Joint Conf. IEEE Comput. Commun. Soc. 2003: 1734–1743
5. A Savvides, H Park and M Srivastava. “The bits and flops of the Nhop multilateration primitive for node localization problems”. In Proc. ACM Int. Workshop Wireless Sensor Netw. Appl. 2002: 112– 121.
6. Savvides, A., Han, C. C., & Strivastava, M. B. (2001, July). Dynamic fine-grained localization in ad-hoc networks of sensors. In Proceedings of the 7th annual international conference on Mobile computing and networking (pp. 166-179). ACM.
7. D Niculescu and B Nath. “DV based positioning in ad hoc networks”. Telecommun. Syst. 2003; 22(1): 267–280.
8. T Van Haute, E De Poorter, I Moerman, F Lemic, V Handziski, A Wolisz, N Wirstr¨om and T Voigt. “Comparability of RF-based Indoor Localization Solutions in Heterogeneous Environments: An Experimental Study”. Inderscience Publishers. 2015.
9. D Niculescu and B Nath. “Ad hoc positioning system (APS)”. In Proc. of IEEE Global Telecommunications Conf. (GLOBECOM01). 2001; 5: 2926-2931.
10. Kegen Yu, Hedley M, Sharp I and Guo YJ. “Node Positioning in AdHoc Wireless Sensor Networks”. In Proc. of IEEE International Conference on Industrial Informatics (INDIN’06). 2006: 641-646.
11. Wang JS and Shen ZX. “An improved MUSIC TOA estimator for RFID positioning”. RADAR 2002. 2002: 478-482.
12. Min Yin, Jian Shu, Linlan Liu and Hengfeng Zhang, “The influence of beacon on DV-Hop in wireless sensor networks”. In Proc. of Fifth International Conference on Grid and Cooperative Computing Workshops (GCCW '06). 2006: 459-462.
13. Mohammed Farrag, Mohammed Abo-Zahhad, MM Doss and Joseph V Fayez. “Different Aspects of Localization Problem for Wireless Sensor Networks: A Review”. International Journal of Computer Networks and Communications Security. 2016; 4(5): 130–140.
14. Benkic, K., Malajner, M., Planinsic, P. and Cucej, Z.. Using RSSI value for distance estimation in wireless sensor networks based on ZigBee, Proceedings of the 15th International Conference on Systems, Signals and Image Processing, IWSSIP 2008, Bratislava, Slovakia, 2008, pp. 303–306.
15. Akyildiz, I. and Vuran, M. Wireless Sensor Networks, John Wiley & Sons, West Sussex, 2010.
16. Sivakumar, S., & Venkatesan, R. (2015). Meta-heuristic approaches for minimizing error in localization of /wireless sensor networks. Applied Soft Computing, 36, 506-518.
17. Kumar, A., Khosla, A., Saini, J. S., & Singh, S. (2012, June). Meta-heuristic range based node localization algorithm for wireless sensor networks. In 2012 International Conference on Localization and GNSS (pp. 1-7). IEEE.
18. SH Thimmaiah and G Mahadevan. "An adaptive localization error minimization approach for wireless sensor network". 2016 3rd International Conference on Devices, Circuits and Systems (ICDCS), Coimbatore. 2016: 170-173.

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