A Perlustration On Localization Techniques In Mobile Ad-Hoc Network In Mixed Environment

Viral Patel[1] Ashish Christian[2]

[1,2]G. H. Patel College of Engineering & Technology Vallabh Vidhyanagar, India

Abstract— In Wireless Sensor Networks (WSNs), localization techniques plays a major role in identifying the location of any object. The exact co-ordinates should be traced, which will be helpful in identifying the location of an object. In this we have few nodes with the known co-ordinate values and with the help of them we are able to find the location of unknown sources. Also considering Mobile Ad-Hoc Network (MANET) for the same. Localization algorithms are mainly subdivided into two major categories, namely Range Free and Range Based. The paper gives the classification of algorithm techniques and explore two main algorithms that is Time of Arrival (TOA) for Line of sight(LOS) and Non Line of Sight(NLOS) environments and also Time Difference of Arrival (TDOA) for the same.

Keywords*:* WSNs, TOA, TDOA, LOS, NLOS,MANET.

I. INTRODUCTION

As the name suggests, a Wireless Sensor Network is a network which consists of large number of sensors which shares information wirelessly with each other in order to perform a specific task. Sensors are autonomous devices which are distributed randomly to monitor situations like environmental or physical conditions at different locations [1]. Sensors can be positioned in various ways as it may be randomly deployed or can be fixed at some regular intervals depending on the applications. Sensor nodes are highly deployed with respect to area as are having a high tendency of getting failed. They are having a limited memory for storage, less energy and low computational capability. Various applications of sensor networks consists of different types of sensors like temperature sensor, pressure sensor, vehicular movement sensor, humidity sensor, noise level indicator, etc.

A Mobile Ad-hoc Network (MANET) [13] is a network of mobile router which is self-configured and connected by wireless links – whose combination results into a form of random topology. As routers move randomly, it results into change of networks wireless topology rapidly and unpredictably. Internet may be operated by such a network. The plus factor of ad hoc network is that it is being configured easily and also fast deployment is used for various emergency situations such as natural calamities and other disasters created by human beings, medical emergencies, etc.

Localization term refers to the exact location of a sensor node as with the change in application, the deployment of sensor nodes vary from application to application leading to fixed and random location. So in order to find its exact location we have some algorithms which finds exact location of sensor node. Localization algorithms for wireless sensor network can be broadly classified in to two as: Range Based and Range free [1]. Range based algorithm needs hardware in order to find the exact position of an object. Whereas the range free algorithm needs no hardware in order to estimate the exact co-ordinates of an object [3]. The algorithms that come under the range free algorithms are as DV-hop, MDS-MAP, Amorphous, APIT, Centroid, Convex, etc. Though the results obtained by the later algorithm is not much accurate as compared to the former one, its advantage is of cost-effectiveness as it needs no hardware to compute location. And cost plays a major role when system is to be deployed on a large scale. Whereas Range based localization includes algorithms such as Time Of Arrival (TOA), Angle Of Arrival (AOA), Time Difference of Arrival (TDOA), Received Signal Strength and few more. In Fig.1 working of TOA is shown, as how position of a sensor if being estimated with the help of 3 Anchor nodes AP1, AP2 and AP3, whereas MT position is the point where all the three points intersects.

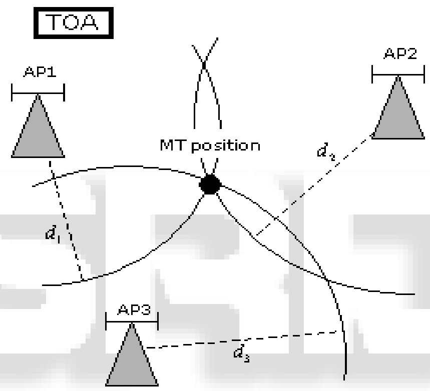

Fig. 1: Time of Arrival (TOA) [14]

Usually GPS can be used in order to determine the location of the event occurrence, but the reason that location is being traced with the help of mobile station (MS) using the aforesaid technique for Emergency services such as 911 is that GPS does not always gives accurate results and also it stops working in covered and fringed areas. So TOA and TDOA methods are finding their space for localization in mobile wireless sensor network. But here also comes another problem such as Non line of sight [4]. The results obtained through LOS are quite accurate. As we deal with mobile network, LOS is obligatory requirement in order to have a proper communication between sensor nodes.

Fig. 2 shows how a position of a sensor is being located in LOS and NLOS environment. Also the losses that occur in both are seen as the delay in NLOS is more than that in LOS environment. As seen above the effect of NLOS condition for sensor network, the same thing is also applicable for Mobile ad hoc network (MANET). Here also NLOS will result into degradation of the performance of MANET.

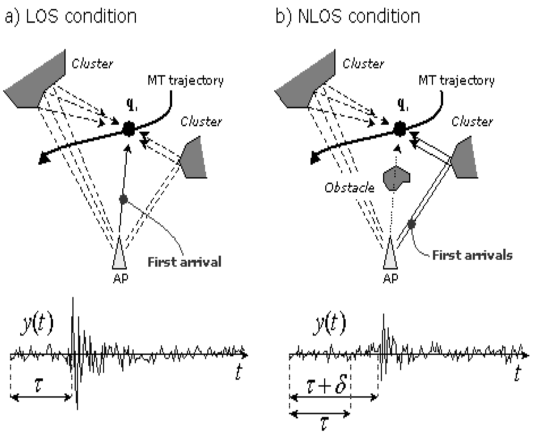

Fig. 2: LOS and NLOS environment for sensor network [14]

In this paper the location identification methodologies using TOA and TDOA in mixed environment i.e. LOS and NLOS environment are depicted which extends further with the factors influencing the accuracy while localizing the event occurrence.

The rest of this paper is organized as following sections: II. It introduces about various Localization Techniques in wireless sensor network, III. How MANET works in LOS and NLOS environment, IV. Description of TOA and TDOA in LOS and NLOS environment, V. Details of Comparison between TOA and TDOA in LOS and NLOS environment and finally, section V conclusion.

II. LOCALIZATION TECHNIQUES

Hitherto, numerous localization algorithms have been put forwarded for WSN; few of them are Received Signal Strength (RSS), Angle of Arrival (AOA), Time of Arrival (TOA), Time Difference Of Arrival (TDOA). Out of all the above, two localization methods that are considered to be accurate are TOA and TDOA. In order to estimate the location of mobile station MS in a mobile communication system of the present invention, a mobile station and several base stations espouse for the position estimation. First the base stations BS in which the mobile station is situated and other base stations vicinal thereto each quantify the receipt levels of the radio wave transmitted by the mobile station to enlighten the position supervising node of the receipt levels. Second the position supervising node instructs the mobile station to control the radio wave according to the receipt levels in such a manner the receipt levels become stable at last. In the third approach each base station measure the distance between the BS and the MS on the basis of the propagation time of the radio wave to enlighten the position supervising node of the distance. Finally, the position supervising node estimates the location of the mobile station based upon a point or several points given by the circles defined using the distances. The distance between base station and mobile station is measured by considering their propagation delay time; hence TOA method requires synchronization of time between MSs and BSs whereas TDOA method does not require synchronization of time between them because in this we are concerned about the time difference.

The range based localization algorithms TOA and TDOA are illustrated in Fig. 3. The TOA technique is one of the most popular techniques used for localization. Here, the propagation time Fig.3. TOA, TDOA and RSS based localization of a transmitting node at r0 using N sensors at locations r_1; r_2... r_N of the line-of-sight (LOS). In order to estimate the range between the source and all the sensors, the is measured from the node that is transmitted to the each node received. This requires time synchronization between the transmitter and receiver denoting ti0 as the propagation time from the source to the ith node and c as the propagation speed of signal. Here ρ is the range of the source and node [6]. Source here is ultrasound signal.

In contrast to TOA, TDOA measures the difference in propagation time at which the LOS signal arrives at the N receiving nodes.

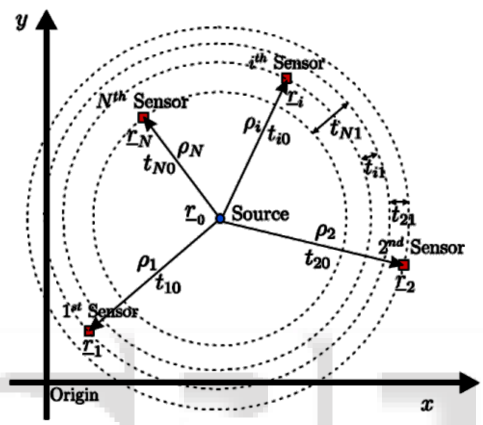

Fig. 3: TOA & TDOA Localization for transmitting node r_0 [6]

This removes the need for synchronization between the transmitter and receiver. Denoting ti1 as the difference in propagation time from the i^{th} node to the first node and t10 as the propagation time from the source to the first node, Note that both TOA and TDOA algorithms are known to suffer if there is insufficient bandwidth [6].

Now there are two different cases where "TOA" can be used: 1) Clock bias between transmitters and receivers does not exist if there is synchronization between them and 2) Clock bias between transmitters and receivers not exist if there is no synchronization between them; Here the first situation is considered and the synchronization is done by connecting cables between them or can also be achieved by wireless synchronization algorithms [5]. Here TDOA is being used when synchronization between transmitter and receiver fails. Here in this case only receivers are synchronized, as receiver is unaware of the time taken by a signal to travel, the difference of the time taken by a signal to travel between the receivers is employed.

Positioning problems in TDOA and TOA are classified into two object cases "active" and "passive". Here active means that the object will be considered as transmitter whereas passive means that it requires a separate transmitter to interact with a signal and it acts as a separate object, neither a receiver nor transmitter. There are various papers for active objects of TOA and TDOA, from them it can be said that, for TDOA the Cramer-Rao lower bound (CRLB) is achieved by two stage method and the Approximate Maximum Likelihood Estimation[9]. The lower bound of estimation error variance of an un-biased method is set by CRLB. Similarly for TOA, two methods are the Least-Square-Method [7] and the Approximate Maximum Likelihood Estimation Method [8], both of which achieve the CRLB of "active" TOA. The above mentioned methods for active are used for satellite positioning, cellular handsets, WLAN and active RFID. Whereas passive object is used in the situations like surveillance, medical patent monitoring, crime prevention, here target to be localized is a separate object which is neither a receiver nor a transmitter. TDOA for passive objects and active objects are essentially the same. Whereas for TOA, this is not the case. Up to our knowledge the methods for TOA for passive objects are not developed, but in[5] a method called as two step estimation (TSE) method is derived inspired from TDOA algorithm of [10].

III. LOS AND NLOS ENVIRONMENT FOR MANET

The network with no fixed infrastructure and in which nodes are free to communicate with each other directly with a condition of both being in the range, such network is termed as Mobile ad hoc network (MANET). For MANET, in order to deliver packet from source to destination multi-hops are required [13]. Hence because of this, it is found that many routing protocols and realistic propagation models are cruicial and challenging in MANET. Simulation tools such as Network Simulator (ns-2), OPNET Simulator, Qual-Net Network Simulator are used to analyze the routing performance of MANET assuming environment to be LOS. Assumption of LOS is not always preferred in urban environment, as the received signals are received after reflection along the streets referred to as NLOS propagation.

IV. TOA AND TDOA IN LOS AND NLOS ENVIRONMENT

TDOA and TOA methods for localization of WSN are discussed in section II, while in this section we will look over TDOA and TOA for NLOS and LOS environments:

A. TOA in LOS and NLOS environment

Y.T.Chan and et al have discussed in [2], for a mobile network, three or more base stations can locate an MS by measuring a signal from MS for LOS environment. TOA is nothing but the measurement of the distance between MS and one of the BS. Now the locus of point from obtained distance from BS is a circle and the intersection of all the three BS distances gives us an MS location. A unique point must be determined in TOA measurements, but the circles are not intersecting with each other at same point. By that we will be getting accurate location of a sensor node in the network. Circle intersecting at unit point will lead to accurate identification of nodes.

In TOA, the reasons for not getting accurate results are due to the reflection of the signals that arrives at BS, i.e. NLOS path. This usually occurs in urban environment which leads to large errors in position are caused mainly due to reflection and NLOS. Now in order to deal with this NLOS condition there are three ways which are as mentioned below [2]:

1. Matched field processing method measures the channel propagation characteristics and then scattering model is used to determine the MS location for localization. This method is same as TOA. But here the problem is that the model changes with the seasons and also there is change in the structures as an addition and removal of buildings, so we are not able to get an accurate result.

2. In this method we localize all LOS and NLOS measurements but provide weighing or scaling in order to reduce the effects of NLOS measurements. Here weighing is considered from the residuals of individual BS or either from the localization geometry and BS Layout. Here we have an advantage that though all BS are NLOS, we have an estimation. But the disadvantage is that there is always an NLOS error present, though it is reduced.

3. This last approach for NLOS is the identification and then localizing the same by various methods which are available such as time-history based hypothesis test, or a probabilistic model, or residual information. Here accuracy depends on the algorithm selected, but wrong identification is always possible in this case.

In this paper we are dealing with the last approach where we are considering residual test (RT) in which we are determining LOS BS dimensions and localizing with them only. Accuracy in this method is of 90% correct identification.

B. TDOA for LOS and NLOS environment

S. Hara and et.al in [4], TDOA is implemented using two different algorithms that is Taylor series based and another is new distance based algorithm. Now these both algorithms are being implemented under both the environments and a comparison is made for the result obtained through them.

It is found that on implementing for LOS and NLOS, errors that are occurring in both the cases are compared and it is said from the obtained results that when error is small and number of BS is more than five, the accuracy of new distance based algorithm is lesser than the Taylor series algorithm. But in [11], S. Hara and et.al, if the number of BS is less than six and error is more than the result obtained is opposite to the above obtained result. That is here accuracy of a new distance based algorithm is more than the Taylor series algorithm. In above case error is considered for 300 meters[11], and practically when dealing with mobile computing it is seen that error usually reaches more than 300 meters so we can say from this that the new distance based algorithm is quite better than Taylor series algorithm for the cases when we have error more than 300 meters. In [11], it is shown that increase in number of BS will not be affecting the accuracy while dealing with the new distance based algorithm. It is also shown that in [11] that in presence NLOS errors the new distance algorithm gives better performance as compared to Taylor series algorithm.

V. COMPARING TOA AND TDOA IN LOS AND NLOS ENVIRONMENT

In the paper [4], S.Hara et al. has shown comparison and performance of TOA and TDOA under LOS and NLOS environments. In [4] it is proved that TDOA localization methods gives a better performance under NLOS condition as compared to TOA whereas TOA methods works well for

LOS condition as compared to TDOA. In this paper the above result is being implemented theoretically as well as by simulation on a computer. Here we will be going for the various errors that were considered and how the result is being proved.

In [4], root mean square localization error is being decomposed into two factors, first is sampling error which is evaluated by cramer–rao lower bound and second factor is NLOS error which is evaluated by perturbation method.

A. Sources of Error

For TOA or TDOA, there are basically three sources of error which includes: 1. Time resolution and auto correlation of a PN signal, the remedy for this is a maximum likelihood method. 2. Multipath signal which is due to the reflection and diffraction of the transmitted signal and the remedy for the same is path detection. 3. NLOS propagation which causes power delays and occurs usually when MS and BS are not having a direct path for communication, the remedy for the same are proposed in various ways as NLOS identification and rejection or mitigation and NLOS non-identification and mitigation and many more are there.

In urban areas it is seen that NLOS channels are more than LOS and hence error due to NLOS are also more. So in order to reduce them Cramer-Rao lower bound is implemented in order to discuss the effect of NLOS range error. In [4] it is shown that if no prior information of NLOS ranges error is known before than NLOS channels will not be helpful in increasing the accuracy of localization. Whereas if some information about the source is available than it will be quite helpful. Also with the help of the above information effect of multipath delay spread can be examined.

In [4] it is discussed that any reference range can be selected out of all the possible ranges which are usually because of the time unsynchronicity between BSs and MS. Few select the range in the channel as “one”, and few select the shortest available range estimates. In [12], if total LOS channels are higher than NLOS channels, it is advantageous to select LOS range as a reference. Also, it is seen that the results are obtained for LOS channels, but still for mobile communication NLOS channels are dominant, for which the reference selection method is still not known.

Few results that are verified and proved in [4] are as shown below which gives us an idea about the performance of TOA and TDOA in LOS and NLOS environment:

For LOS channels in TOA and TDOA, The below result is found and for any value of N, the result obtained is $\in$ TOA $< \in TDOA$. Here $\in$ is the error in TOA and TDOA. From above it can be said that TOA outperforms TDOA method for LOS environment.

For NLOS channels in TOA and TDOA, the result are just inverse as here the error in TOA is larger as compared to TDOA , so it can be said that TDOA outperforms TOA method in NLOS environment. $\in$ TOA $> \in TDOA$. Here $\in$ is the error in TOA and TDOA.

The above obtained results are obtained theoretically, but the same are also proved using a software, the conclusion obtained after comparing both the results are as discussed below:

For uniformly distributed NLOS range error, the author in [4] has compared the results of TOA and TDOA under LOS and NLOS channels. Theoretical RMS localization performance of TOA and TDOA method for uniformly distributed NLOS range error and RMS localization performance of TOA and TDOA by Computer Simulation for uniformly distributed NLOS range error comparison is shown in [4]

Thus from the above two results of [4] we can say that the result obtained theoretically as well those obtained from computer are almost same, which concludes that TOA performs better in LOS and TDOA performs better in NLOS channel.

VI. CONCLUSION

Ubiquitous and Pervasive Computing is finding more and more space in the reality of Computing. Merely sensing the occurrence of event through wireless sensor nodes excluding the localization information is having hardly any use. This paper has provided a review on distinguished localization algorithms in LOS and NLOS environments.

(1) Paper has discussed some fundamental research problems in various localization algorithms along with
(2) the various errors in TOA and TDOA algorithms in different environments.
(3) The conclusive study states that the TOA algorithm works well in LOS environment and TDOA algorithm works well in NLOS environment.

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