# Node Consistency based Localization System for Wireless Sensor Network

**Ankur mishra, Ranjeet Jaiswal**
M Tech Scholar, Asst. Professor

**Abstract**
Stability is one of the major concerns in advancement of Wireless Sensor Networks (WSN). A sensor networks consist of numerous tether less devices that are released into the environment and organize themselves in an ad-hoc fashion. The goal of the network is to perform a monitoring task, and knowledge the physical location of the individual nodes is therefore essential. Death of the first node might cause instability in the network. Therefore, all of the sensor nodes in the network must be alive to achieve the goal during that period. we have address these challenges in the context of application where the accurate location estimation of the sensor node is essential nodes This paper considers localization in Wireless Sensor Net-works (WSNs) using trilaterlation algorithm which is the most widely used approach in experimental and industrial localization systems. And estimated distance between nodes is calculated by using Received Signal Strength (RSSI) method. The performance of the proposed scheme is evaluated by simulating it using NS2. Proposed method along with the previous method is simulated. Many experiments were performed with different topologies and random deployment of the nodes. Simulations with our approach have shown significant reductions to the required processing and communication overhead.

***Keywords***
*Localization, Positioning, Trilaterlation, ORV, NS2.*

## 1. Introduction

Advance in wireless communication and digital electronic have made networked micro sensor possible which led to produce large amount of small size, low cost sensors which integrate sensing, processing, and communication and storage capabilities together and form an autonomous entity where each sensor individually sense the environment and achieves task of information gathering and processing. Wireless sensor network composed of small and cheap devices as a sensing unit, processing unit, radio transceiver and power unit. Large amount of these sensors can be quickly deploy in field where each sensor independently sense the environment and also achieve complex information gathering and dissemination task like intrusion detection, target tracking, environmental monitoring, remote sensing, global surveillance, etc. Knowledge of location for a node is essential task in wireless sensor network to perform various tasks as routing, cooperative sensing, or service delivery in adhoc network. Global positioning system (GPS) can greatly facilitate this task but straight full adding GPS to all nodes in WSN is not feasible because GPS device consume more power energy thus reduce battery life of the sensor node and also reduce the effective life time of entire network in presence of dense forests, mountains or other obstruct that block line of sight from GPS satellites in such case GPS cannot be implemented also sensor node require to be small , but the size of GPS and its antenna increase the size of a node for these reasons alternate solution of GPS is require which is cost effective, rapidly deployable and can operate in diverse environments also GPS system are relatively expansive and consume a significant amount of energy. Therefore only a limited sub set of node is equipped with GPS and other nodes compute there locations by measuring distances between themselves. Thus one of the fundamental task in WSN is location discovery which refer to the task where all the unknown location nodes seek to determine the relative or absolute position using the measured distance between different nodes For this purpose a variety of distance measurement technologies have been employed including signal strength attenuation techniques, ultra wide band approaches etc.

it is observed that the network is Not always entirely localizable. Theoretical analyses also suggest that, in most cases, it is unlikely that all nodes in a network are localizable, although a (large) portion of the nodes can be uniquely located. All of the nodes currently available in the market are battery-operated, and hence they have a limited life-time. Moreover, the memory capacity of a node is also limited. There are a number of telecommunication problems which needs to be overcome when using wireless, such as understanding, modeling and anticipating the wireless channel. A balance needs to be realized between the quality of service provided and the cost of the devices, these are the determining factors when providing a product. The overall objective is to use a simple wireless sensor network to calculate the position of a mobile node by using minimum resources and communication overhead. Position estimation means to determine location of nodes in a network. With the support of some infrastructure, a node can determine its location in the network by extracting information received from the infrastructure; also, by making a node to send signals periodically, the infrastructure can calculate the location of the node.

Manuscript received May 5, 2015
Manuscript revised May 20, 2015

Localization in sensor network is to identify location or position of sensor nodes .location is required --
(a) To identify the location from where sensor reading originates.
(b) For communication with other sensing nodes to route data.
(c) When providing other location based services.
Node in a sensor network is often randomly distributed. To assign measurements to locations, each node has to determine its own position. Many localization techniques have been proposed to provide location information of the unknown sensor node in WSN. GPS Based Estimation: GPS is a typical localization system. There are 24 satellites [1] positioned at the altitude of 20200 km and distributed in 6 orbital planes [2]. These satellites share the high accurate atomic clocks and they know exactly their coordinates. A GPS receiver can receive signals from at least 4 satellites if the receiver is not hidden from the line of sight. By matching the code pattern in the signal, a receiver can calculate the time shift and know the distance away from that satellite by multiply the time shift to the speed of light. After that, the GPS receiver can figure out its coordinate based on some localization algorithm. GPS Free Estimation: Wireless sensor nodes are very small having very short energy, that's why they cannot carry GPS devices. In order to do position estimation in a network, generally some beacons, also known as anchor notes should be set up. These anchors know exactly their coordinates. If a node with unknown coordinate can measure by some approaches the distances away from these anchors, the node can calculate its coordinate using trilaterlation [3] algorithm.
Challenges in Implementing Localization in WSN
WSN is a resourced constraint network. Because of the limited battery power supply and have to avoid interference, the effective communication range is limited to some extent..

*A. Price*

The cost of each node can affect the feasibility of the installation .expensive add-on equipment such as GPS receivers, complex radio modules and complex actuators in each node can make a vast improvement in cost. GPS systems are relatively expensive

*B. Lifetime*

Sensor nodes usually compose of four basic units a sensing unit, a processing unit, a transceiver unit, and a power unit. The power unit supports all the activities on a sensor node, including communication, local data processing, sensing, etc. GPS device consume more power energy thus reduce battery life of the sensor node and also reduce the effective life time of entire network In order to save power, redundant activities should be reduced if not eliminated. Nodes in WSNs present stringent energy constraints. They consume much more energy when they are in communication.

*C. Scalability*

Scalability refers to the number of nodes in the network. Once the network grows, different problems related to communication overhead and large data volumes arise failures in communication nodes are more probable in WSNs than classical networks, as nodes are often located in unattended places and they use a limited power supply..

*D. Accuracy*

Ranging accuracy should reflect the application of the nodes. Some applications require that events are located with an error of only a few centimeters. Other applications require less accuracy, for example in some applications, such as motion capturing installations, supporting computer animation, localization centimeter level spatial positioning and precise temporal resolution [4] is required.

*E. Attack*

In fact, there are a numbers of attacks possible in WSN an attacker can launch attack in the network if a certain number of sensor nodes have been compromised. In literature, for instance, HELLO flooding attacks [9], sink hole attacks [9], Sybil attack [12], black hole attack [15], worm hole attacks [6], or DoS attacks [4] are options for an attacker. These attacks lead to anomalies in network behaviors.
The rest of the paper is organized as follows. In section 2, a brief introduction to the recent work on positioning algorithm is given. Section 3 gives the proposed algorithm and numerical computation of the coordinates. In Section 4 Simulation setup for the NS-2 and the simulation results are given. Section 5 concludes the paper and possible future enhancement is discussed.

## 2. Literature Survey

Generally speaking, localization schemes can be classier into two categories: range-based schemes and range-free schemes. The former covers the protocols that use absolute point-to-point distance (i.e., range) estimates or angle estimates to calculate locations Range based approaches rely on range measurements to compute the position of the unknown nodes. Most existing approaches assume exact (or almost exact) range measurements while the latter makes no assumptions about the availability or validity of such range information Although range-based protocols can provide more accurate position estimates, they need additional hardware for distance measures, which will increase the network cost. In [6], the time difference of arrival (TDOA) technique is used to estimate the difference time of two sensor nodes. The authors measure the time difference between two simultaneously transmitted radio signal and ultrasound signals. Based on the time difference, the distance of two sensor nodes can be calculated by multiplying the time difference and the speed of sound. The TDOA technique does not depend on the synchronization of the transmitting time of two sensor nodes. Like TOA technique, TDOA relies on additional hardware that is high cost and energy consuming. The RADAR system [13] uses RSSI technique to estimate the distance to some known landmarks (anchor nodes). It first records the received signal strengths with respect to the landmarks at various locations. It then computes the location of the sensor node by finding the best fit data of the received signal strengths. Since the radio signal strength is unstable and varied under different environments, it is difficult to measure the distance. The GPS [7] uses the time of arrival (TOA) to measure the difference in the time of arrival of signals from several satellites and use the triangulation to infer the position. However, using GPS to locate sensor nodes may not feasible due to cost, energy prohibition, and indoor constraints.

On the other hand, Range free (or proximity based) schemes approaches infer constraints on the proximity to anchor nodes. These approaches, although attractively simple (they do not require any additional hardware and most require only simple operations), have inherently limited precision. The APIT scheme [14] uses anchor nodes to divide a sensing area into triangular regions. A sensor node locates itself according to whether it is inside or outside these triangular regions. Both Centroid and APIT schemes need anchor nodes equipped with powerful radios and a high density of anchor nodes deployment in a WSN to achieve better accuracy of locations. In [8], author inquired about the RSSI solutions on indoor localization, and proposed a Closer Tracking Algorithm (CTA) to locate a mobile user in the house. The proposed CTA was implemented by using ZigBee CC2431 modules. The experimental results show that the proposed CTA can accurately determine the position with error distance less than 1 meter.

In contrast, selecting a subset of references in order to optimize localization accuracy has intensively been studied in the literature. In [19], [20], [21], range measurements are weighted according to their variance and distance or references are selected based on the difference between distances and estimated locations [18]. Others apply tests to detect outliers in order to exclude them from calculations or just choose the nearest references for estimation of location [22], [23].

## 3. Proposed Method

In our proposed method we assume a small subset of nodes as anchor nodes who know there location with help of GPS or other such devices ,rest of the node are known as unknown node who are not aware of their location .these unknown nodes estimate there location with our method describe below . all unknown nodes depend on anchor nodes for their position estimation .they send request to anchor nodes for location calculation once they estimate there coordinates ,they also became an anchor and broadcast its location information to rest of node in given network thus enabling other nodes to calculate there locations. The localization process will complete when all unknown node meet a certain criteria in the network. Many proposed system uses the information from all the reference nodes to update their location which involve high traffic overhead, heavy computation and energy consumption. in this proposed system we have used only subset of the reference nodes which can contribute on accurate positioning. The accuracy of our algorithm depends upon the selection of the reference nodes. Previous method discussed above gives inaccurate result if nearest reference nodes having big location error. to overcome these deficiencies we have used best three references to update the location of the node. We have assumed that the nodes are stationary. Each node has an attribute which shows whether it is anchor node or not. Each node also has another additional attributes which shows the accuracy and stability of the node our method works on four steps.

### *F. Location Request*

Initially anchor nodes provided accuracy level AL =1, and Stability level SL=1 and all other nodes are assigned value 0, 0 in first face a nodes broadcast the location request message. Which consist of its node_id and its probability of accuracy and stability level.

### *G. Location Response*

On receiving the location request from the known node each node will not respond until its accuracy level, and stability level is higher than the required accuracy level AL and stability level SL i.e.

$$AL_{[res]} > AL_{[req]}$$

$$\text{Stablevel}_{[rec]} > \text{Stab level}_{[req]}$$

Only nodes whose accuracy level should be higher than of unknown node or greater than of requesting node And stability level should also be greater than of requesting node and distance should be minimum. Should respond to a node for location request hence total communication overhead reduced in this method.

The location response message includes accuracy level, Stability level, location and node_id of the sender.

$$\text{Loc\_res} = (AL\ SL\ z,\ id,)$$

### *H. Reference selection*

In the third step, on receiving location response from all reference nodes, Node selects the subset of the reference which can give highest accuracy level. and stability level. This step is the most important face because we perform

⊂

calculation on the most accurate responses only, hence the computation time and cost reduces. If total incoming response is set R, and we select a subset S than S R

Only such nodes should be selected which can give better location estimation. Location accuracy, and stability level depends upon two parameters.

- Accuracy of the references
- Stability level of the reference
- Distance of the reference

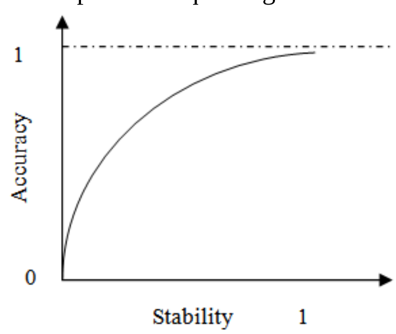
A node should be selected for calculation which has minimum distance and maximum accuracy, and high stability level.

## 4. Location calculation

A node calculate its coordinate using trilaterlation [3] algorithm with help of selected references, hence accuracy and stability level are determined respectively.

*Impact of Node Stability on Localization*

The accuracy of a node depends upon location accuracy of its neighbors. Once a neighbor finds its position it contains some error. This error can be minimized when neighbor calculate its position periodically. But, if neighbors changes location then it again got some error and error minimizing process start again. Hence, the unstable node contains more error and not fit to be selected as a reference for location estimation. We have defined a metric to measure stability of the node by stability level. The stability level is proportional to accuracy level .as stability of a node increases its accuracy level also increases. Value of Stability level and accuracy level lies between 0 to 1 the stability level of a node can be calculated by considering some last location in given period. Negative value of stability level should be ignored or such Node with negative value does not respond to requesting Node




There are some thresh hold value up to which movement of a node is set to be stable this threshold value we have given by permissible value, the permissible value depend on size of the network as size of network in small indoor environment 1 or 2 meter moment is permissible but in large territorial area variation of 2 to 3 km is permissible we use following formula to calculate

Stability level =
$$\frac{\text{permissible value} - \textit{Average standard deviation}}{\textit{permisible value}}$$

Let in given time five different location of the node are: (x1 , y1) (x2 , y2) (x3, y3) (x4 , y4) (x5 , y5), then

Arithmetic mean:

$$\bar{x} = \frac{(x_1 + x_2 + x_3 + x_4 + x_5)}{5}$$

$$\bar{y} = \frac{(y_1 + y_2 + y_3 + y_4 + y_5)}{5}$$

Variance: $Var(x) = \sigma^2$

$$\sigma^2 = \frac{(x_1 - \bar{x})^2 + (x_2 - \bar{x})^2 + (x_3 - \bar{x})^2 + (x_4 - \bar{x})^2 + (x_5 - \bar{x})^2}{5}$$

Variance: $Var(y) = \sigma^2$

$$\sigma^2 = \frac{(y_1 - \bar{y})^2 + (y_2 - \bar{y})^2 + (y_3 - \bar{y})^2 + (y_4 - \bar{y})^2 + (y_5 - \bar{y})^2}{5}$$

Hence, standard deviation $S_N$

For x coordinate:

$$S_{N[x]} = \sqrt{\frac{1}{N}\sum_{i=1}^{N}(x_i - \bar{x})^2}$$

For y coordinate:

$$S_{N[y]} = \sqrt{\frac{1}{N}\sum_{i=1}^{N}(y_i - \bar{y})^2}$$

Average deviation:

$$S_{avg} = \frac{(S_{N[X]} + S_{N[Y]})}{2}$$

Now we calculate stability level

$$\text{Stab level (SL)} = \frac{\text{permisible value} - \text{Savg}}{\text{permisible value}}$$

*Optimum reference value (ORV)*

We have assigned a value called “optimum Reference Value (ORV)” to all incoming reference .Which is the measure of the suitability of the node to be chosen as a reference. A node with low ORV is better than the node with high ORV the value of ORV can be calculated by using the Stability level, and accuracy level of the reference we also consider distance of the reference.

Calculating Distance:

On receiving the responses from the different reference node calculate the distances using RSSI method. For calculating the distance from the reference we use RSSI method.

Received Signal Strength Indicator (RSSI :

RSSI method is used to compute the estimated distance between requesting node and responding node with help of signal at the receiver and known transmit power . the effective propagation loss can be calculate then using theoretical and empirical models we translate those loss into distance estimation

*Why Radio Signal Strength? :*

In wireless Sensor network unknown node need to compute there location with respect to anchor nodes. to compute there estimated distance we use the RSSI method ,providing distance estimates between two arbitrarily placed nodes may be suitable for our ad-hoc location sensing research. Given our target scenario, we believe applying received radio signal strength information to the problem is reasonable.

The idea behind RSS is that the configured transmission power at the transmitting device (PT) directly affects the receiving power at the receiving device (PR). According to Friis' free space transmission equation, the detected signal strength decreases quadratic ally (n is usually two) with the distance to the sender.

$$P_R = P_T \cdot G_T \cdot G_R \cdot \left(\frac{\lambda}{4\pi}\right)^2 \cdot \left(\frac{1}{d}\right)^n$$

$P_T$ and $P_R$ are the power of the transmitter and receiver, $\mathbf{G_T}$ and $G_{\mathbf{R}}$ are the gains of the transmitter and receiver antennas respectively. $\boldsymbol{\lambda}$ is the wavelength and **d** the distance between transmitter and receiver. The received power increases with the square of the wavelength (or decrease with the square of the frequency). The free space equation is valid only for values of d that are relatively far from the transmitting antenna. For values of $d_0$ within the so called close-in distance, the path loss can be assumed to be constant. $d_{\mathbf{0}}$. In practical scenarios, the ideal distribution of $P_R$ is not applicable, because the propagation of the radio signal is interfered with a lot of influencing effects e.g. Reflections of metallic objects, Superposition of electro-magnetic fields, Diffraction at edges, Refraction by media with different propagation velocity.ORV Calculation: After calculating distance the ORV for the reference is calculated by using following formula.

ORV = D* (1- AL) (1- SL)

Calculated ORV values are stored in an array in ascending order of ORV. And then the three references with minimum ORV are selected for applying trilaterlation the three references which have minimum value of ORV

We also calculate the accuracy level of the node by following formula-

$$AL = 1 - \frac{1}{\sum_{i=0}^{i<j} Al(ref[i])}$$

Where j is cardinality of the subset, *i*.e. j=3;

Final face is to estimate the position of the node in global coordinate using trigonometric formulas. We use a maximum-likelihood (ML) estimation to estimate the position of a target by minimizing the differences between the measured and estimated distances. ML estimation of a target's position can be obtained using the mini-mum mean square error (MMSE) [16], which can resolve the position from data that includes errors. We explain the calculation for a two-dimensional case as follows. MMSE needs three or more sensor nodes to resolve a target's position. First, the sink node searches for the same data in terms of a target ID and a packet number by collecting data from sensor nodes. The difference between measured and estimated distances is defined by:

$$f_i(x_0, y_0) = d_i - \sqrt{(x_i - x_0)^2 + (y_i - y_0)^2},$$

Where x0, y0 is the unknown position of the target node, xi, yi for i= 1, 2, 3 is the sensor node position, and N=3 is the total number of data that the node has selected, and di is the distance between sensor node i and the target. The targets Where x0, y0 is the unknown position of the target node, xi, yi for i= 1, 2, 3 is the sensor node position, and N=3 is the total number of data that the node has selected, and di is the distance between sensor node i and the target. The target's position (x0, y0) can be obtained by MMSE. By setting f=0, Eq. (1) is transformed into

$$-x_i^2 - y_i^2 + d_i^2 = (x_0^2 + y_0^2) + x_0(-2x_i) + y_0(-2y_i). \quad (2)$$

After getting Eq. (2), we can eliminate the $x_0^2 + y_0^2$ terms by subtracting $k_{th}$ equation from the rest, as follows.

$$-x_i^2 - y_i^2 + d_i^2 - (-x_k^2 - y_k^2 + d_k^2) = 2x_0(x_k - x_i) + 2y_0(y_k - y_i)$$

(3)

Then Eq. (3) is transformed into Eq. (4), which can be solved using the matrix solution given by Eq. (5). Position $(x_0,y_0)$ can be obtained by calculating Eq.(5).

$$y = Xb \quad (4)$$

$$b = (X^T X)^{-1} X^T y, \quad (5)$$

Where
$$X = \begin{bmatrix} 2(x_k - x_1) & 2(y_k - y_1) \\ \vdots & \vdots \\ 2(x_k - x_{k-1}) & 2(y_k - x_{y-1}) \end{bmatrix} \quad (6)$$

$$y = \begin{bmatrix} -x_1^2 - y_1^2 + d_1^2 - (-x_k^2 - y_k^2 + d_k^2) \\ \vdots \\ -x_{k-1}^2 - y_{k-1}^2 + d_{k-1}^2 - (-x_k^2 - y_k^2 + d_k^2) \end{bmatrix} \quad (7)$$

$$b = \begin{bmatrix} x_0 \\ y_0 \end{bmatrix} \quad (8)$$

## 5. Simulation Setup and Result

We have used NS2 to simulate the proposed system. NS-2 is extended to support positioning in [17]. The NS-2 simulator is a discrete event simulator widely used in the networking research community. We have implemented our algorithm along with the recently proposed algorithms, nearest reference algorithm [16].

### 5.1 Simulation Setup

To satisfy the applicability of proposed algorithm in large scale WSNs we have performed experiment in different setups. The Unknown nodes and anchor nodes are distributed across the field. All nodes have limited transmission range of 50 m. We have performed simulation on different density of anchor nodes. Figure 2 shows the deployment of anchors and anchors in NS2. At each experiment the simulation were run 100 times; the duration of each run was600 second. We have performed experiment in 10 different densities of anchors.

### 5.2 Results

*Average error and anchor density*
Figure 2 shows the graph between average error and node density. From figure 2 it is clear that our algorithm perform with better accuracy than the other in low anchor density. Result shows that our algorithm performs localization with better accuracy level and power consumption reduced in our method. Table 6.2 shows the error and anchor relation..

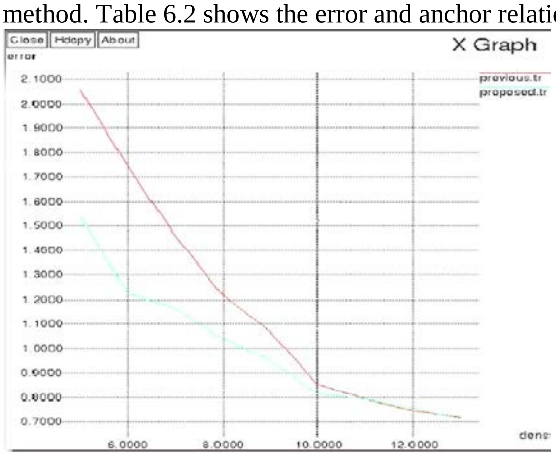


Figure 2: Average error vs Node density

*Remaining Energy vs Time*
Energy consummation is the most critical issue in wireless sensor networks. In figure 3 the graph between the Time and Energy is given.

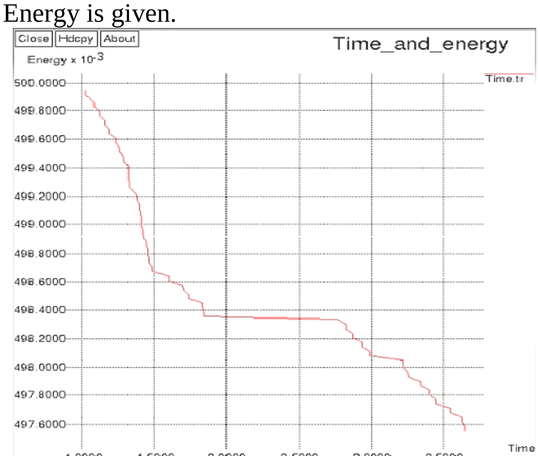


Figure 3: Time vs Energy

## 6. Conclusion and Future Work

In our proposed mechanism localization system uses RSSI to calculate estimate distance for the Wireless sensor network. The aim of this study was to create a practical, robust and accurate localization algorithm by appropriate references to Wireless Sensor Network. In the proposed system various efforts are made to minimize the computation and communication overhead. And also the accuracy and stability of the location was improved. The nodes with errors are excluded which restricts the location error to be propagated throughout the network. Hence overall communication overhead is reduced by filtering the ineffective responses. However, in the further development we may estimate the accuracy, and stability of the localization in three dimensional space with more accuracy and the quality of service provided by the system..

## References

[1] Bo Cheng “An Accurate GPS-Based Localization in Wireless Sensor Networks: A GM-WLS Method” Parallel Processing Workshops (ICPPW), 2011 40th International Conference on PARALLEL PROCESSING WORKSHOPS 2011.
[2] I.F. Akyildiz, Y. Sankarasubramaniam W. Su, and E. Cayirci, "A Survey on Sensor Networks," IEEE Communications Magazine, vol. 40, no. 8, pp. 104–112, August 2002.
[3] M. Tubaishat and S. Madria, "Sensor Networks: An Overview," IEEE Potentials, vol. 22, no. 2, pp. 20-23, April 2003.
[4] A. Nasipuri and K. Li, “A Directionality based Location Discovery Scheme for Wireless Sensor Networks.”, in First ACM International Workshop on Wireless Sensor Networks and Applications, (Atlanta, GA), Sep. 2002.
[5] A. Savides, C. Han and M. Srivatava, “Dynamic fine-grained localication in Ad-Hoc networks of sensors.” in Proc. ACM MobiComm, 2001.
[6] B. W. Parkinson, J. Spilker, “Global Positioning System: theory and applications,” in Progress in Aeronautics and Astronautics, vol. 163, 1996.
[7] Yu-Tso Chen, Chi-Lu Yang, Yeim-Kuan Chang and Chih-Ping Chu, "A RSSI-based Algorithm for Indoor Localization Using ZigBee in Wireless Sensor Network," in Proceedings of the 15th International Conference on Distributed Multimedia Systems, San Francisco, USA, Sep. 2009, pp. 70-75
[8] D. Niculescu and B. Nath, “Ad Hoc Positioning System (APS) Using AOA.” In Proceedings of INFOCOM, 2003.
[9] G. L. Joo and S. V. Rao, “Grid-Based Location Estimation Scheme using Hop Counts for Multi-hop Wireless Sensor Networks.” in Conf. Wireless Ad-Hoc Networks, May. 2004, pp. 330-334.
[10] N. Bulusu, J. Heidemann and D. Estrin, “GPS-less Low Cost Outdoor Localization for Very Small Devices.” in IEEE Personal Communications Magazine, Special Issue on Smart Spaces and Environments, Oct. 2000, pp. 28-34.
[11] N. Patwari and A.O. Hero III, “Using proximity and quantized RSS for sensor localization in wireless networks,’’ in Proc. IEEE/ACM 2nd Workshop Wireless Sensor Networks and Applications, Sept. 2003, pp. 20–29.

[12] N. Patwari, J. N. Ash, S. Kyperountas, A. O. Hero III, R. L. Moses and N. S. Correal, “Locating the Nodes: Cooperative localization in wireless sensor networks,” Signal Processing Magazine, IEEE, Volume 22, Issue 4, 2005, pp. 54 – 69.

[13] T. He, C. Huang, B. Blum and J. A. Stankovic, T. Abdelzaher, “Range-Free Localization Schemes for Large Scale Sensor Networks.” in The Ninth Annual International Conference on Mobile Computing and Networking, Sep. 2004.

[14] K. Y. Cheng, V. Tam and K. S. Lui, "Improving aps with anchor selection in anisotropic sensor networks," in Proceedings of the Joint International Conference on Autonomic and Autonomous Systems and International Conference on Networking and Services ICAS-ICNS '05, October 23-28, Papeete, Tahiti, 2005, pp. 49-54.

[15] A. Savvides, C. C. Han and M. B. Strivastava, "Dynamic fine-grained localization in ad-hoc networks of sensors," in Proceedings of the 7th Annual International Conference on Mobile Computing and Networking â€” MobiCom '01, July 16-21, Rome, Italy, 2001, pp. 166-179.

[16] Adnan M. Abu-Mahfouz ”ns-2 Extension to Simulate localization System in Wireless Sensor Networks” 2012

[17] J. Albowicz, A. Chen, and L. Zhang, “Recursive position estimationin sensor networks,” in Proceedings IEEE ICNP. Los Alamitos, CA,USA: IEEE Computer Society, 2001, pp. 35–41

[18] J. Liu, Y. Zhang, and F. Zhao, “Robust istributed node localization witherror management,” in proc. ACM MobiHoc ’06. ACM Press, 2006,pp. 250–261.

[19] J. A. Costa, N. Patwari, and I. Alfred O. Hero, “Distributed weighted-multidimensional scaling for node localization in sensor networks.” ACM Transactions on Sensor Networks, vol. 2, no. 1, pp. 39–64, February2006.

[20] J. Blumenthal, F. Reichenbach, and D. Timmermann, “Minimal trans-mission power vs. signal strength as distance estimation for localization in wireless sensor networks,” in Proceedings of IEEE IWWAN, June2006,w orkshop, pp. 761–766, new York, USA.

[21] E. Olson, J. J. Leonard, and S. Teller, “Robust range-only beacon localization,” in IEEE AUV, 2004

[22] .N. B. Priyantha, A. Chakraborty, and H. Balakrishnan, “The cricket location-support system,” in ACM/IEEE MobiCom, 2000.