Improving QoS by using Mobility Management Algorithm in Wireless Sensor Network

Karmvir Singh , Jasvir Singh

Abstract—**Wireless sensor networks are expected to be one of the key enabling technologies in the next ten years Protocols for such networks should be highly flexible because dynamic change in the network may leads to performance degradation of the network. However many recent applications make use of mobile sensor nodes , which pose some unique challenges to WSN researchers. Nodes may move individually or in group with respect to some reference mobility model, thus changing network topology. A mobility management Scheme has been proposed in this paper to manage the mobility in WSN and analysis has been done against basic QoS parameters**.

Index Terms-**WSN , Moblity , RSSI , Trilateration**,

I. INTRODUCTION

Wireless Sensor Network is distributed system of nodes with sensing capabilities, data processing and storage capabilities, wireless communication interfaces and limited power. They are used for surveillance and control applications in a diverse range of micro and macro environments, such as wildlife habitats, technical and biological systems and structures. One of the main concern in WSN is the design of the protocols to optimize and maximize the performance of the network. Mobility is characterized by physical movement of the sensor nodes in the network. It has been shown experimentally that mobility in WSN often cause degradation in performance of WSN. Nodes in WSNs are generally assumed to be static . However ,many recent applications make use of mobile sensor nodes , which pose some unique challenges to WSN researchers. Depending on their roles in WSNs (sinks, routers, sensors) , nodes may move individually of in groups with respect to some reference system. The previous studies has shown that when we consider mobility , out of on demand routing protocols AODV performance is better than any other protocol so we have chosen AODV to carry out our experiment[12].

We define the problem of localization as estimating the position or spatial coordinates of wireless sensor nodes. Localization is an inevitable challenge when dealing with wireless sensor nodes, and a problem which has been studied for many years. Nodes can be equipped with a Global Positioning System (GPS), but this is a costly solution in terms of volume, money and power consumption.

While much research has focused on developing different algorithms for localization, less attention has been paid to the problem of mobility. In this paper, we discuss a robust and distributed RSSI-based position estimation algorithm with respect to mobility for wireless sensor network in the presence of range measurement inaccuracy.

II. RELETED WORK

In the past several years, a number of location discovery protocols have been proposed to reduce or completely remove the dependence on GPS in wireless sensor networks. Most solutions for location discovery in sensor networks require a few nodes called beacons (they are also called anchors or reference points), which already know their absolute locations via GPS or manual configuration. The density of the anchors depends on the characteristics and probably the budget of the network since GPS is a costly solution. Anchors are typically equipped with high-power transmitters to broadcast their location beacons. The remainder of the nodes then compute their own locations from the knowledge of the known locations and the communication links. Based on the type of knowledge used in location discovery, localization schemes are divided into two classes: range-based schemes and range-free schemes.

Range-based protocols use absolute point-to-point distance or angle information to calculate location between neighbouring sensors. Common techniques for distance/angle estimation include Time of Arrival (TOA) [8], Time Difference of Arrival (TDOA) [1], [2], [5], Angle of Arrival (AOA) [7], and Received Signal Strength (RSS) [1]. While producing fine-grained locations, range-based protocols remain cost ineffective due to the cost of hardware for radio, sound, or video signals, as well as the strict requirements on time synchronization and energy consumption.

Recently, a number of approaches have been proposed that required few anchors [9, 10]. These

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are quite similar and operate as follows; a node measures the distances to its neighbours and then broadcasts this information. This results in each node knowing the distance of its neighbour and some distances between those neighbours. This allows for the construction of (partial) local maps with relative positions. Adjacent local maps are combined by aligning (mirroring, rotating) the co-ordinate systems. The known positions of the anchor nodes are used to obtain maps with absolute positions. When three or more anchors are present in the network, a single absolute map results. However this style of locationing is not very efficient because range errors usually accumulate when combining the maps.

RSSI has been widely used as a distance measurein the context of static WSNs because of its simplicity. The impact of a number of parameters, such as the operating frequency, the transmitter–receiver distance, the variation of transceivers, the antenna orientation, and the environment, on (received signal strength) RSS measurements were investigated using Tmote Sky nodes in real outdoor environments [3]. The results in [6] describe a thorough empirical study of the RSS in Mica2 sensor node for indoor environments with considering parameters such as operating frequency, antenna orientation, battery voltage, temporal and spatial properties of environment, and the environmental dynamics. Lymberopoulos et al. [4]investigated the RSS variability in 3-D indoor environment. In their experiments, all the sensor nodes are equipped with Chipcon CC2420 radio with monopole antennas. Their study is mainly focusing on the impact of the antenna orientation over the RSS.

L. Eirod and D. Estrin in [11] claimed that much better results were obtained based on node localization, when time of flight measurements were used as the range method, particularly when acoustic and Rf signals were combined, though they have a good point, but their report can only be justified when the nodes to be localized are unobstructed in terms of the lines of sight, whereas, if there is no line of sight between nodes then this algorithm will be ineffective, in addition, acoustic signals are temperature dependant, hence, the accuracy of this algorithm will be dependant also on temperate conditions.

Trilateration based localization algorithm is a distributed beacon-based localization algorithm; which is range based, i.e. it uses distance estimation to compute the 2D position of nodes in a network with the help of a feature of the communicating signal from the sender node to the receiving node called Received Signal Strength Indicator(RSSI). It differs from Time of Flight (TOF), Angle of Arrival (AOA) and Time Difference of Arrival (TDOA) range based distance estimation scheme in [11] in that TOF needs line of sight to effectively locate nodes, AOA needs extra hardware to be added to nodes before effective localization can take place, TDOA measurements accuracy is usually affected by multipath. Where as RSSI measurements don't need any extra hardware or line of sight to localize nodes, though multipath and shadowing are two major phenomena that affect the reliability of RSSI measurements because different magnitude signals arriving out of phase at the receiver causes both constructive and destructive interferences. However, spread spectrum radios have effectively mitigated those problems by averaging the received power over multiple frequencies. Hence this paper proposes a RSSI based trilateration localization algorithm that uses range based distance estimation scheme to accurately localize these nodes.

III. TRILATERATION TECHNIQUE

Trilateration is the process of determining absolute or relative locations of points by measurement of distances, using the geometry of circles, spheres or triangles. In addition to its interest as a geometric problem, trilateration does have practical applications in surveying and navigation, including global positioning systems (GPS). In contrast to triangulation, it does not involve the measurement of angles. Trilateration basically make use of three nodes to estimate the location of a node which we address as blind node. Blind node is a node which has not accurately deployed in network. Here in the figure given below all three spheres representing the anchor nodes to estimate the position of blind node

In two-dimensional geometry, it is known that if a point lies on two circles, then the circle centers and the two radii provide sufficient information to narrow the possible locations down to two. Additional information may narrow the possibilities down to one unique location. This section describes a method for determining the intersections of three sphere surfaces given the center and radii of the three spheres. The intersections of the surfaces of three spheres is found by formulating the equations for the three sphere surfaces and then solving the three equations for the three unknowns, x, y, and z. To simplify the calculations, the equations are formulated so that the centers of the spheres are on the $z = 0$ plane.

Figure 1. The plane $z = 0$, showing the three sphere centers, $P1$, $P2$, and $P3$; their x,y-coordinates; and the three sphere radii, $r1$, $r2$, and $r3$. The two intersections of the three sphere surfaces are directly in front and directly behind the point designated intersections in the $z = 0$ plane. As we are considering 2d flatgrid approach we assuming the plane z = 0.

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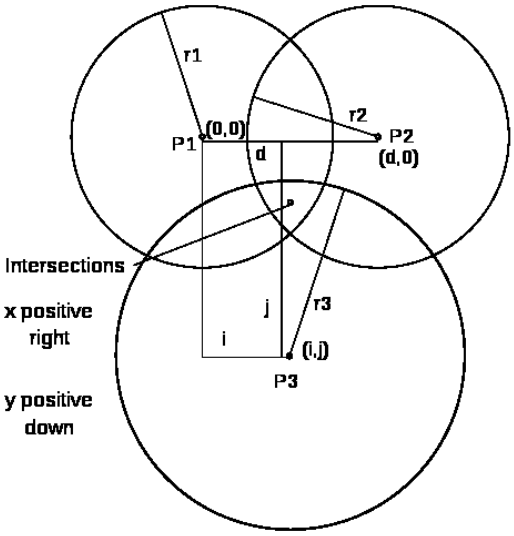

Figure 1 Showing the centers of three sphere

We start with the equations for the three spheres:

$$r_1^2 = x^2 + y^2 + z^2 \quad (1)$$
$$r_2^2 = (x-d)^2 + y^2 + z^2 \quad (2)$$
$$r_3^2 = (x-i)^2 + (y-j)^2 + z^2 \quad (3)$$

d Is the x coordinate of point P2. You have to subtract it from x to get the length of the base of the triangle between the intersection and r2 (*x*, *y*, *z* are coordinates, not lengths).We need to find a point located at (*x*, *y*, *z*) that satisfies all three equations. We need to use r1 and r2 to eliminate y and z from the equation and solve for *x*:

$$r_1^2 = x^2 + y^2 + z^2 \quad (4)$$
$$r_2^2 = (x-d)^2 + y^2 + z^2. \quad (5)$$
$$r_1^2 - r_2^2 = x^2 - (x-d)^2 \quad (6)$$
$$r_1^2 - r_2^2 = x^2 - (x^2 - 2xd + d^2) \quad (7)$$
$$r_1^2 - r_2^2 = 2xd - d^2$$
$$r_1^2 - r_2^2 + d^2 = 2xd \quad (8)$$
$$x = \frac{r_1^2 - r_2^2 + d^2}{2d}. \quad (9)$$

We assume that the first two spheres intersect in more than one point, that is that

$$d - r_1 < r_2 < d + r_1.$$

In this case, substituting the equation for *x* back into the equation for the first sphere produces the equation for a circle, the solution to the intersection of the first two spheres:

$$y^2 + z^2 = r_1^2 - \frac{(r_1^2 - r_2^2 + d^2)^2}{4d^2}. \quad (10)$$

Substituting $z^2 = r_1^2 - x^2 - y^2$ into the formula for the third sphere and solving for *y* there results:

$$y = \frac{r_1^2 - r_3^2 - x^2 + (x-i)^2 + j^2}{2j}$$
$$y = \frac{r_1^2 - r_3^2 + i^2 + j^2}{2j} - \frac{i}{j}x. \quad (11)$$

Now that we have the *x*- and *y*-coordinates of the solution point, we can simply rearrange the formula for the first sphere to find the *z*-coordinate:

$$z = \pm\sqrt{r_1^2 - x^2 - y^2}. \quad (12)$$

A . RSSI based Ranging Model

Currently, RSSI propagation models in wireless sensor networks include free-space model[13], ground bidirectional reflectance model and log-normal shadow model. Free-space model is applicable to the following occasions:

1) The transmission distance is much larger than the antenna size and the carrier wavelength λ

2) There are no obstacles between the transmitters and the receivers. Suppose the transmission power of wireless signal is, the power of received signals of nodes located in the distance of d can be determined by the following formula :

$$P_r(d) = \frac{P_t G_t G_r \lambda^2}{(4\pi)^2 d^2 L}$$

Where $P_{r(d)}$ = Received power at the receiver
P_t = Transmission Power of sender
G_t = Gain of Transmitter
G_r = Gain of Receiver
λ = Wavelength
d = Distance between the sender and the receiver normally
$G_t = G_r = 1$, in embedded devices.

B. Path Loss in Free Space Model

It is customary to express the power attenuation in terms of the 'path loss' (*PL*), which is defined as

$$PL = 10\log_{10}\frac{P_t}{P_r}.$$

where *Pr*,*Pt* is the power at the receiver and the transmitter respectively
Therefore, the path loss in free space can be expressed in dB as:

$$PL_{Free-space} = -27.56 + 20\log_{10}(f) + 20\log_{10}(d)$$

d is the distance between the transmitter and the receiver

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IV. PROPOSED ALGORITHM

The aim of this algorithm is to determine a location by running trilateration ,once the location found a blind node is to be moved to localize the blind node and converted it into anchor node. In order to initiate the algorithm a node must be provided with mobility and as per the mobility following can be the various conditions:

1. A sensor node can move anywhere in the network area.
2. The node starts moving towards the destination with a velocity
3. After reaching the destination, the node stops at the destination for a duration specified by pause time.

This procedure is summarized in the following piece of pseudo code:

1. **When** a positioning packet has been broadcast by anchors
1. **IF** a blind node is within the range of broadcast
2. **Then** store the positioning packet and compute the estimated range to the anchor using, broadcast the anchor node position to other blind nodes.
3. **Else** do nothing
4. **IF** a blind node receives packets from at least three different anchors
5. 6 **Then** perform trilateration
6. **Else** do nothing
7. **If** the trilateration is successful, blind node becomes converted anchor node
8. **Then** Go to 1
9. **Else** repeat 6
10. **Call Setdestination()** to localize the node
11. **End**

A . Algorithm Implementation

We implemented our algorithm in NS-2 simulator. We used AODV protocol with 24 nodes. We compared the performance with mobility control scheme and without this too.

For the algorithm to actually compute the location of the blind node it needs some input parameters. The table 2.0 shows all necessary inputs to the algorithm.

Table 1.0 Inputs to the Algorithm

Name	Value	Description
N = n	2.2	Path loss exponent
X,Y	(0,0) to (100,100)	X,Y coordinates to fix the position of anchor node
RSSI	-44 to -100	To to know the dimension of a node

B. Performance Evolution

In order to evaluate the performance of the proposed algorithm based on the above stated metric, a scenario of 24 is considered and nodes are deployed in 2d flatgrid topology ; source and destination is defined . Initially all nodes are static in the scenario and path created by running AODV protocol. Now a node is provided with mobility with a velocity taken from speed vector as shown in figure given below:

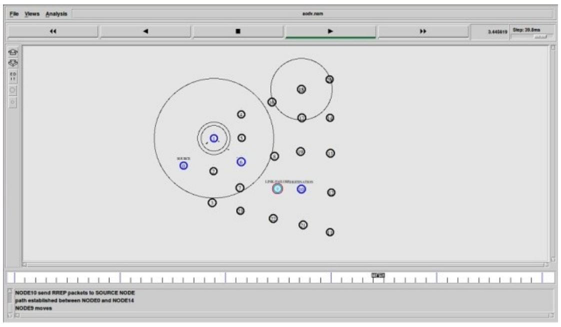

Fig 2: Link failure due to mobility

The goal is to determine how to fix the link failure along the path with minimum mobility to the nodes by accurate localization algorithm . The actual distance between the blind nodes and the anchors are measured and recorded, the estimated distances between the blind nodes and anchor nodes were also calculated through the algorithm and recorded.

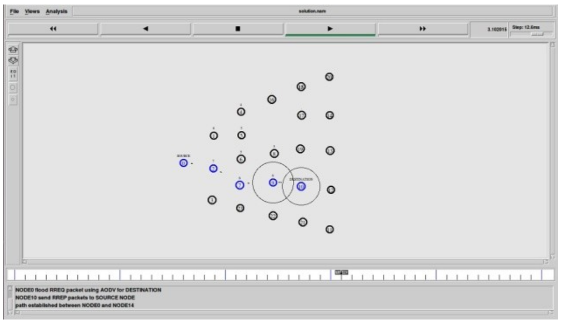

Fig 3: Path established using Mobility Management

In the provided solution , blind node in the path has been positioned to a new location by running Trilateration based mobility management scheme and converted into anchor node. Path again established with minimum number hops along the path , hence improved the performance of AODV protocol . Path loss by using is this algorithm found to be negligible. And localization error computed is reduced to 0.75 which can be tolerable .

To evaluate the performance of the proposed Trilateration based mobility management algorithm graphs are given below :

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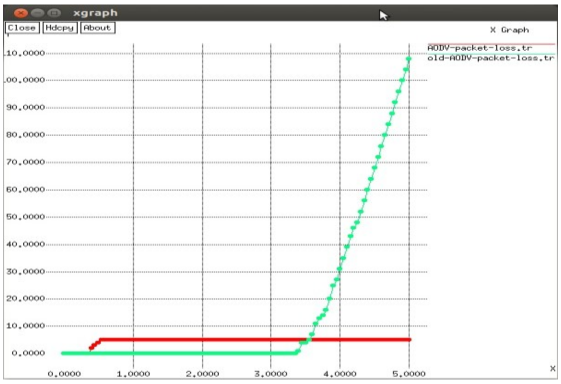

Figure 4 Graph packet loss

Table 2.0 AODV performance

	Without Algorithm	With Algorithm
Packet Loss	110	08

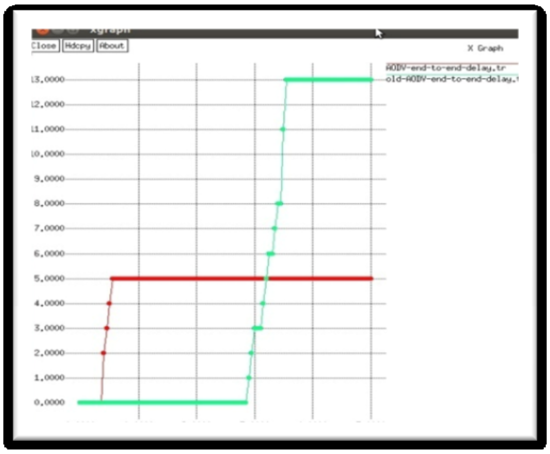

Figure 5 Graph End-to-End delay

Table 3.0 AODV Performance for delay

	Without Algorithm	With Algorithm
End-to-End Delay	13	05

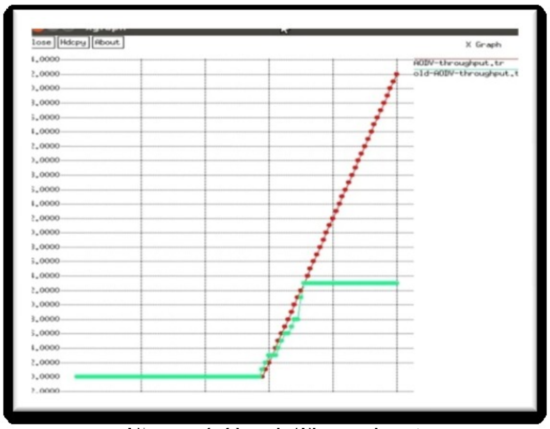

Figure 6 Graph Throughput

Table 4.0 AODV Performance for Throughput

	Without Algorithm	With Algorithm
Throughput	14	42

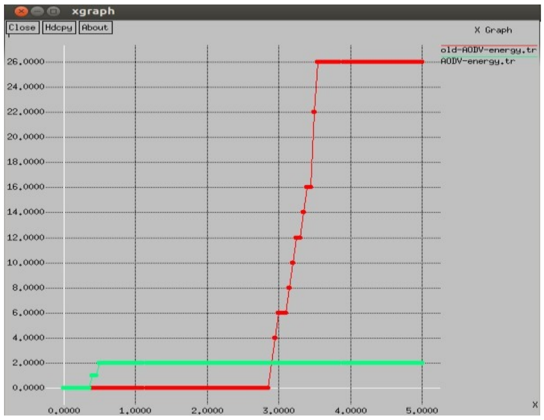

Figure 7 Graph Energy consumption

Table 4.0 Energy Consumption

	Without Algorithm	With Algorithm
Energy Consumption	26	2

V. CONCLUSION

In this research work, a Trilateration based localization algorithm for wireless sensor networks (WSNs) was developed. We studied the Mobility issues over wireless sensor network and analyzed the network performance by controlling the impact of mobility This was achieved through experimental analysis. We analyzed the performance of the protocols on the basis of QoS parameters like Throughput, Packet Delivery Ratio, Delay and energy consumption. On the basis of performance results, we can conclude that impact of mobility control scheme also depends upon the selection of routing protocol From this analysis, we conclude that whenever anchor nodes broadcast packets containing their locations and other sensed parameters, the location of blind node within the broadcast range can always estimate by applying Trilateration if the blind nodes receive packets from at least three anchors, the blind node can localize its position and establish path between source and destination.

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