LOCALIZATION ALGORITHM USING VARYING SPEED MOBILE SINK FOR WIRELESS SENSOR NETWORKS

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ABSTRACT

Localization of sensor nodes is important in many aspects in wireless sensor networks. The known location of sensor node helps in determining the event of interest. A mobile sink is introduced to track the event driven sensor nodes in the path of the event, thus conserving energy and time. We present a novel range based localization algorithm which helps the mobile sink to compute the location of the sensor nodes efficiently. The data transfer from the mobile sink and the sensor nodes is used to estimate the sensor location. The sensor nodes do not need to spend energy on neighbouring interaction for localization. The localization mechanism has been implemented in TOSSIM. The simulation results show that our scheme performed better than other range-based schemes.

KEYWORDS

Mobile Sink, Location sensing, Range based location scheme, Beacon Communication range, IDSQ

1. INTRODUCTION

Due to advances in wireless technologies, Wireless Sensor Networks have been used for many applications such as military, home, health, industries etc. Wireless Sensor Network is a dynamically changing localized network formed on-the-fly as mobile nodes move in and out of each others' transmission ranges [1]. Actually, the mobile ad hoc networking model followed by wireless sensor networks make no assumption that nodes know their own locations. However, recent research on localization shows that location-awareness can be beneficial to fundamental tasks such as routing and energy-conservation [2]-[16].Because of the deployment of a large number of sensor nodes specific to a particular application, it is often not possible to hand place these sensor nodes. Fundamental design objectives of sensor networks include reliability, accuracy, flexibility, cost effectiveness and ease of deployment [3]. It is not possible to keep Global Positioning System (GPS)for all the nodes. The capabilities of individual Sensor nodes are extremely limited due to many factors and their collaboration is required with minimum energy expenses. This paper proposes a mechanism that allows non-GPS equipped nodes in the network to derive their exact locations from a limited number of GPS-equipped nodes. In this method, a mobile sink is introduced, which has the prior knowledge about the sensor field. The mobile sink is used for data collection whenever any event of interest occurs. It travels in the sensor field in a randomized way with dynamic speed. During its travel, it broadcasts its location information to all sensor nodes within the sensor field. A mobile sink can compute the location of sensor nodes when it finds the entry and exit point over the communication circle of the sensor node, if the sensors are homogeneous. This scheme only requires broadcasting of beacon messages by the mobile sink and performs accurately in spite of irregular radio transmission due to obstacles.

1.1 Related Work

Several schemes have been proposed to locate the events which are broadly classified into two categories such as range-based and range-free. Range Based Localization introduced ways to localize nodes based on range (i.e. distance or angle) information. Several mechanisms require more hardware on sensor nodes in order to obtain higher location accuracy. Localization protocols either make simplifying assumptions (e.g., line of sight with sensor nodes, high density of anchor nodes, deployment knowledge) or require sophisticated hardware [2]-[4].

On the other hand, Range free localization approaches expect no knowledge about communication range to be available; instead they include other metrics to calculate a node's position. The approaches typically need a large amount of stationary reference points for achieving higher accuracy and extensive communication among neighbouring sensor nodes [5]-[9].

Over the years, many systems have addressed the problem of automatic location sensing. Triangulation, scene analysis, and proximity are the three principal techniques for automatic location sensing. One of the most well known location-based systems is the Global Positioning System (GPS), a satellite-based navigation system made up of a network of 24 satellites placed into orbit. GPS is widely used to track moving objects located outdoors. However, GPS, as it is satellite dependent, has an inherent problem of accurately determining the location of objects located inside buildings. Different approaches have been proposed and tested for their effectiveness and utilities in order to achieve the ability to locate objects within buildings. At present, there are several types of location-sensing systems, each having their own strengths as well as limitations. Infrared, 802.11, ultrasonic, and RFID are some examples of these systems.

1.1.1 Using Mobile Beacons

Many schemes have been introduced, using mobile sink as a beacon node, in estimating the location of sensor nodes in a wireless sensor network. One of the scheme proposed by Sichitiu and Ramadurai, uses a single mobile beacon transmitting its current location, to find the location of unknown sensor node [12]. Any sensor node receiving the beacon packet will be able to infer that it must be somewhere around the mobile beacon with a certain probability. This information constrains the possible locations of a node. Combined with the RSSI technique, possible locations of the sensor node can be estimated. The accuracy can be improved when the sensor node receives more beacons. The precision of the localization is good and uniform as long as the trajectory of the beacon covers the entire deployment area in such a way that each sensor node receives at least three non-collinear beacon messages.

The Scheme proposed by Dutta and Bergbreiter, estimates the distance from a sensor node to a mobile object based on ultrasound technology [13]. Neighbouring sensor nodes cooperated to evaluate the distance between them by exploiting common tangent concept. As long as the node-to-node distances are available, the position of a sensor node can be measured by the communication range of sensor nodes in range-based schemes.

Sun and Guo proposed probabilistic localization scheme with a mobile beacon [14]. The approaches use time of arrival[TOA] technique for ranging and utilize Centroid formula with distance information to calculate a sensor node's position. The above approaches need to integrate with communication range information for localization. Galstyan *et al.* proposed a coarse-grained range-free localization algorithm to lower the uncertainty of node positions using radio connectivity constraints [15]. With each received beacon, the receiver's location lies within the transmission area of the sender. Another localization scheme proposed in [16] in which mobile anchor points are used as reference points for localization in wireless sensor network. The scheme presented in this paper makes use of the communication range of the sensor nodes as a reference for locating the points of mobile anchor point. The mobile beacon is assumed to know its location (through GPS). However, in their scheme three distinct beacon points are needed and a well-defined mobility of the mobile beacon is required. Further, our scheme makes use of only two beacon points in estimating the location of the sensor nodes.

Another scheme proposed by Saad Ahmed Munir, Yu Wen Bin and Ma Jian, the approach was based on the communication range of the sensor nodes [17]; and with the help of the motion of a mobile sink in a straight line, the localization of the sensor nodes is estimated. A geometrical topology representation of the sensor nodes was implemented by the mobile sink based on the communication range of each sensor node. The inter-node distance was calculated by the mobile sink with reference to its line of motion.

Bin Xiao, Hekang Chen and Shuigeng Zhou presented two distributed range-free localization methods (ADO and RSS) that use only one moving beacon within a sensor network [18]. The basic idea of the ADO method is to narrow down the possible location of a node by using arrival and departure constraint areas derived from the moving beacon. To estimate the position, a node should obtain four critical positions of the moving beacon: pre arrival position, arrival position, departure position and post-departure position to compute its *ADO*. The RSS method seeks the location of a sensor from a sequence of RSS broadcasted from the moving beacon. Both methods employ the range-free techniques in the sense that they do not rely on the direct distance measurement from RSS but on a sequence of constraints. Ecolocation for the ideal scenario considered zero multi-path fading and shadowing effects [19], Relative location estimation algorithms are implemented in a wireless sensor network deployed in indoor and outdoor environments [20-21].

The Remainder of this paper is organized as follows. Section 2 identifies the objectives and the requirements of localization algorithm. Section 3 presents Factors affecting location estimation. Section 4 presents the Location Estimation Algorithm using varying speed mobile sink. Section 5 presents the performance analysis. Section 6 presents the conclusion.

2. Objectives and Requirements

An efficient and accurate range-based scheme is proposed here, with the help of a mobile sink. This comes up with the near-accurate co-ordinates of sensor nodes within a wireless sensor network. Simulations are conducted for varying sink velocity and for different packet generation interval for obtaining minimum localization errors. Similarly, the performance is demonstrated by varying radio communication range error.

In this section, localization mechanism for estimating the location of sensor nodes within a wireless sensor network is described. This approach is based on the communication range of the sensor nodes; and with the help of the motion of a mobile sink, the localization of the sensor nodes is achieved. Some of the assumptions that have been made are;

1. The mobile sink moves at a randomized speed initially.

2. It changes its speed when any event occurs, according to the position of the information driven sensor node.

3. The velocity of the mobile sink does not remain constant while moving through the sensor network.

This scheme is independent of the use of RSSI or GPS in finding the location of sensor nodes and relies only on the communication range of the sensor node. This implementation is not only cost effective but is also simple in implementation and can locate the sensor. A mobile beacon has been used in many proposed localization schemes wherein reference points are used for estimation of sensor.

2.1 Proposed Scheme

In this paper, a novel range based scheme for efficient localization of sensor nodes within a network with a varying speed mobile sink is explained in detail. The scheme is based on the mobility of a mobile sink introduced within the network. It is assumed that the mobile sink moves in a randomized fashion initially and then the speed and the direction of the mobile sink changes according to the event of interest. With the known communication range of the sensor nodes, the mobile sink is able to estimate the location of each and every node in the geographical field.

2.1.1 Event Detection Mechanism

A randomly moving target is introduced as an event, which has to be detected by the set of sensor nodes in the path of the target. The occurrences of this event must be made known to the mobile sink by the sensor nodes. And this will be achieved by the collaboration among the sensor nodes. It is not necessary that the mobile sink should be near to the event driven node. Information driven sensor querying mechanism is followed by the sensor nodes in sensor selection criteria. Information-driven sensor querying (IDSQ) is a sequential tracking scheme where, at a given point of time t, there is only one sensor active. All the other nodes remain in power-conserving sleep states. The active sensor takes a measurement and updates the belief $p(x^t|z^t)$. It then decides which sensor in its neighbourhood is the most informative, hands the belief off to that sensor and returns to the sleep state. The sensor receiving the handoff becomes active and this operation repeats. Intuitively, by selecting the most informative neighbour, the active sensor is seeking good quality data.Our aim is to locate the sensor nodes which are tracking the event of interest. The mobile sink has to travel nearer to the location of the event driven sensor, so that the sensor can estimate its location and combine it with the target tracking information. Therefore an autonomous speed mobile sink is introduced to estimate the location of the sensor node.

2.1.2 Varying Speed Mobile Sink Mechanism

The mobile sink speed is not necessarily the same as that of the target speed. It must be lesser than or equal to the speed of the target. Once the event is known to the mobile sink, the varying speed mechanism is adopted. It varies its speed according to the location of the event driven sensor. Mobile sink is assumed to have prior knowledge about the sensor field. The mobile sink is able to move by them selves or other carriers such as RC plane. The following figure shows the mobile sink broadcasting its Information Driven Sensor Querying message [IDSQ]to know the event driven node's location according to its communication range. Sensor nodes were expected to give acknowledgement containing the information about the event that occurred within the sensor field.

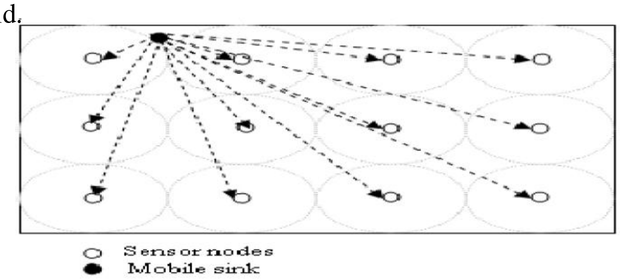

Figure 1: Mobile sink broadcasting its IDSQ message to all sensors, to identify the information driven sensors in the sensor field.

If any node detects the target, it starts sending continuous periodical target information messages to mobile sink. The neighbour nodes within the area of that event driven node will also receive the target information. The neighbour nodes will also start sending the same message. Inter node collaboration is executed. Two possibilities are taken into consideration for analyzing our algorithm. In the first case, if mobile sink is nearer to the event driven node, then it can come close and collect sensor data. In the second case, if the mobile sink is far away from the event driven sensor node, called as source node, then mobile sink gets the notification about the target through the other nodes. To illustrate this concept, in figure 2, the target was detected by the node S_4, and takes a measurement. Now S_4 wants to give notification to mobile sink by acknowledging to its beacon message. The acknowledgement message contains target notification data and its information. It then decides which sensor in its neighbourhood is the most informative to handoff the acknowledgement, say S_3. Now S_3 appends its information to the received packet from S_4 and hand off to the next informative neighbourhood. This process repeats until it reaches the mobile sink. Once the sink detects the notification, it instantly changes its speed level and move towards the even driven node S_4, since the mobile sink knows the path towards the source node by means of received acknowledgement packet. Thus the speed of the mobile sink will change from one level to another level according to the event of occurrence in the sensor field. If there is no event detection, then the mobile sink is in one speed level. If any detection of event takes place, its speed will be in another level.

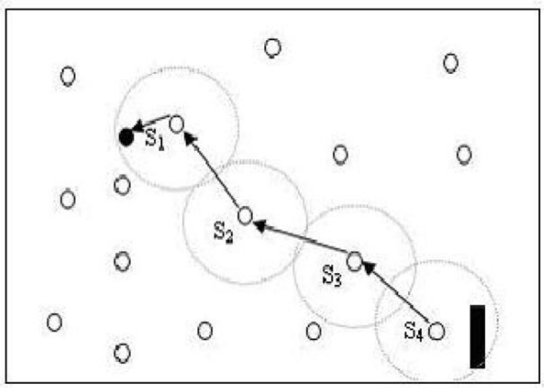

Figure 2: The event driven node S4, gives notification about the target to mobile sink, by deciding which sensor in its neighbourhood is the most informative in order to handoff the data in the sensor field..

Our algorithm, comes up with area localization within a wireless sensor network and has an advantage of localizing the desired area. The desired region to be localized is traversed by the mobile sink. This scheme also facilitates the location estimation of the places of interest and thereby minimizes the energy and time it takes to localize the whole network.

Assumptions:

• The mobility is controllable and thus predictable,
• The pause time of the mobile sink along its moving trace is negligible.

Localization compensates all the existing problems through the following characteristics**:**

1. A varying speed varying mechanism is introduced in the mobile sink.
2. A variable RF communication range is taken into consideration.
3. The number of beacon points is reduced to two for the mobile sink.
4. The path of the mobile sink is also varied so as to overcome the limitation of the existing localization scheme.

5. Sensor nodes placed farthest from the mobile sink should not face greater error if they lie within the communication range.
6. Line error should be reduced for the sensor nodes placed on the path of the mobile sink.
7. Only one reference point (Mobile Sink) is introduced which knows the entire heterogeneous network topology.
8. Node mobility is kept uniform.
9. Target speed is not a criterion to collect the optimized information about the target
10. Sensors must record the communication details of the mobile sink.

3. Factors Affecting Location Estimation

The following parameters were varied to check the performance of MOBISPEED.

3.1 Communication Range

The communication range has considerable effect in the estimation of localization. For varying communication ranges the difference between actual and estimated locations of sensor nodes were calculated and tabulated.

3.2 Packet Interval

The periodical intervals between packet transfer from mobile sink and sensor node are also varied. As a performance measure, the intervals between the packets also have considerable effect.

3.3 Varying Mobile Sink Velocity

The accuracy of location estimation increases as the number of times the mobile sink visits the unknown sensor nodes. For varying mobile sink velocity, the algorithm gives better results.

3.4 Radio Frequency

One of the problems of using RF to locate objects is the inconsistency of the signal strength reception. This can primarily be due to the environment and the device itself. In most cases, the environmental factors always have the most impact on the accuracy and maximum detectable range. For convenience the environmental factors are not considered in Mobispeed, as it uses only the distance to estimate location of sensor nodes.

3.5 Varying the Path of Mobile Sink

The path of the mobile sink within the sensor field is varied. The impact of path variation on localization error is made negligible by making the mobile sink to move nearer to the event of interest in a randomized fashion.

4. Location Estimation

4.1 Assumptions And System Environments

Fig. 1 and 2 illustrates the system environment where a sensor network consists of sensor nodes and mobile sink. The sensor nodes are distributed randomly in the sensing field. Once the nodes are deployed, they will stay at their locations for sensing tasks. The sensor nodes can receive messages from both other nodes and from mobile sink. The mobile sink is able to traverse through the sensor field with sufficient energy and broadcast beacon messages during the localization process. The mobile sink is able to move by themselves or other carriers such as RC plane or vehicles.

For simplicity the network environments are given below.

a. Sensor nodes are S1 to Sn..
b. One Mobile Sink M.
c. One Moving Target for Event of Interest.
d. Communication range of sensor nodes is r.
e. All sensor nodes form a sensor field E.
f. Sensors can communicate with each other within the communication range of r.
g. Mobile sink communicate with all sensor nodes, in turn sensor node communicate to mobile sink, only when the sensor start sending the acknowledgement packet to the mobile sink.

4.2 Localization Mechanism

The center of the circle is the location of the sensor node; the radius of the circle is the largest distance where the sensor node can communicate with the mobile sink. The endpoints of the chord are the position where the mobile sink passes through the circle (Entry and Exit point). In the mechanism, two endpoints (Entry & Exit) on the circle must be collected for establishing a chord. Mobile sink periodically broadcast beacon message when it moves in the sensor network. The beacon message contains the mobile sink id, location and timestamp.

4.3 Location Calculation

As, Mobile Sink knows the entire topology information, based on the entry & exit of the mobile sink over the communication range of the sensor node, it calculates the location of the sensor node based on the simple geometrical equations. Suppose, let (a, b) be the location coordinates of the sensor node to be estimated. Let (x_1, y_1) be the entry location point of the mobile sink and (x_2, y_2) be the exit location point of the mobile sink based on the communication range of the sensor node, whose location (a, b) to be estimated. Then the following equations will help to estimate the (a, b) as follows,

$$(a - x_1)^2 + (b - y_1)^2 = r^2$$
$$(a - x_2)^2 + (b - y_2)^2 = r^2$$

Where r represents the radius, which is communication range of sensor node. Solving the above two equations will give the two possible locations. Sensor node may be resided at either one of the estimated location. The most informative sensor must provide the target information to the mobile sink since the sensor nodes which sense the target information have to inform to the Mobile Sink. The exception of locating the most Informative sensor lies on both parts of the chord, as per the mathematical calculation. The exception to be overcome is identified by the location of the most informative sensor. As the information received by the mobile sink through the event driven sensor detects the location of the sensor and also the location of the target. Orientation of the target will be analyzed for every event occurrence (target movement). The stored information in the mobile sink and the sensor node give the sensor location.

Algorithm:

Mobile Sink: 1. Generate Location Information Packet Li.

2. Send it to the sensor nodes S1 to Sn. (To all nodes)
3. Receive Ack from (Si-Sj)
   (From a set of nodes which can hear)

Sensor Node: 3. Save Location Information Li as Ei
   (Entry Point).

(Si - Sj) 4. Send Ack to Mobile sink
(Sensing region).

5. Update Li to Li+1.

6. Go to step 4

7. If Update = Lost
Stop Ack..

8. Store Last Li as Ej (Exit Point).
9. Use distance formula to estimate
location coordinates.

Corollary:

The most informative sensor node may lie either above or below the chord. To identify the Location of the most informative sensor, the following steps have been executed.

1. There may be two sensors in two possible locations.
2. Say S1 is in the upper part and S2 is in the lower part of the chord.
3. If the target is in the upper part of the sensor, S1 will transmit the signal along with its id and target information to the mobile sink.
4. Mobile sink receives this information in due course of time as the mobile sink moves in the sensor field with varying speed capability.
5. As mobile sink captures the information from the sensor nodes directly and it is able to capture the target information from the most informative sensor S1.
6. Else it has to capture from S2.

Thus the localization algorithm comes up with efficient localization of sensor nodes and our mechanism reduces needed power consumption compared to other schemes

This mechanism only requires mobile sink to broadcast beacon messages. The ordinary sensor nodes do not spend energy on neighbouring interaction for localization.

4.4 Beacon Points and Information Base in Mobile Sink

This mechanism utilizes mobile sink that move around in the sensing area and periodically broadcast beacon messages, including the current location information. After sensor nodes receive the beacon message, it should give acknowledgement packet containing, its id, location of the mobile sink found in beacon message. The acknowledgement packet is received by the mobile sink when it enters into the communication range of that sensor node.

The point it enters into the communication range and the point it exit the communication range of the sensor node is taken into account. In between entry and exit, there may be periodical communication between mobile sink and sensor node take place. But, only the entry and exit point were considered and thus the valid beacon points and chords will be determined. Here only these two beacon points act as input. And these two endpoints on the circle were stored in the information base by the mobile sink for efficient localization of the sensor node in the future while it visits the same sensor node once again.

Entry and exit points:

The sensor node once it heard the signal from the mobile sink, it starts acknowledging the mobile sink. The entry point is ascertained by sending the first acknowledgement to the mobile sink. After the first acknowledgement is over, the sensor keeps on sending acknowledgements, as long as it is receiving the location information packets from the mobile sink. The location information from the mobile sink is stored in an information base of the sensor node. The instant the sensor is not able to receive the packets from the mobile sink, it selects the last received packet from the information base, as the departure packet of the mobile sink and thus the sensor ascertains the exit point.

The mobile sink is designed to traverse the sensing area in such a way that it should visit all sensor node in one complete round it takes. During its one complete round, there may be possibility that the mobile sink can visit some of the sensor nodes one or more times. Each time it visits a particular sensor node, it will estimate the location of the sensor node and will store that estimated information into the information base.

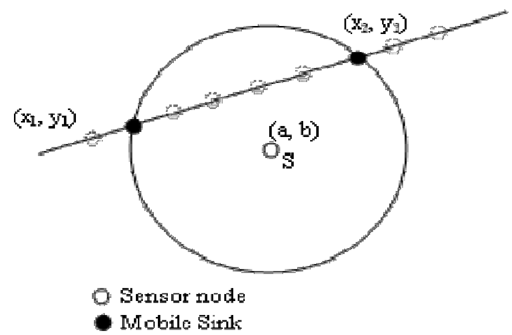

Figure 3: Selection of Beacon Point (Entry & Exit of mobile sink) - first possibility.

If suppose mobile sink found that it visited a sensor node two times, then by our algorithm, four possible locations will be estimated. Out of four, two location coordinates may be same or differ in near ranges and these only two points were considered by the mobile sink. Other two location coordinates mostly differ in far ranges and it will be skipped. Thus the mobile sink is able to come up with a conclusion in estimating the exact location of the sensor node.

Let us see the illustration. Consider the figure 3, where the mobile sink is traveling through the communication range of the sensor node S. The mobile sink is designed to maintain a set of beacon points. The beacon point is considered as an approximate endpoint on the sensor node's communication circle. In the figure 3, the mobile sink has chosen (x1, y1) as entry point and (x2, y2) as exit point. The entry point is the point from which the mobile sink and the sensor node can communicate with each other and the exit point is the point at which the last communication between them takes place.With the chosen two points on the communication circle, the mobile sink can able to estimate the possible location of sensor nodes. According to the mobile sink, it can get two possible locations and the sensor node is expected to reside in only one of the two possible locations. These estimated locations were then stored in the information base by the mobile sink with sensor node's id.

Let the two possible estimated location by the mobile sink be (a, b) and (c, d). The exact location is identified in one of two ways. Either when the mobile sink visits the same sensor node once again or by the capability of most informative sensor node as mentioned in previous section. (refer corollary in previous section). The next possible assumption is that the mobile sink visited the same sensor node S, as shown in the following figure 4.

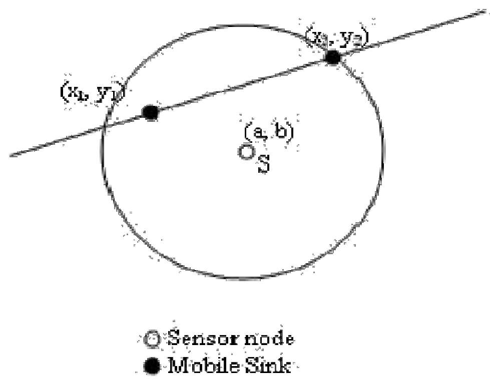

Figure 4: Selection of Beacon Point when the mobile sink visits the same sensor node S once again – second possibility.

This time the entry and exit point will differ and the mobile sink can estimate the location of the sensor node S using our mechanism. Again it can get two possible location of the sensor node. In order to come into conclusion, it will check the information base whether it had visited the same sensor node before during the same current round. If it found that it had visited, it will take both the previously estimated two possible locations and the present estimation. Out of four possible estimated locations, two location coordinates must be same or differ in few meters and these two will be taken into account by the mobile sink and the remaining two coordinates must be differ with wide ranges and thus it will be skipped. Finally, the mobile sink can able to come up with exact location of the sensor node, possible with few estimation errors. And the above mentioned mechanism will be suitable only for the situation where the sensor nodes were assumed to be static. For the situation where the sensor nodes are mobile, the mobile sink will estimate the location of the sensor node by the capability of most informative sensor node when there is a possibility to reside on both side of the chord.

Selection of the beacon points is the most important criteria in this localization algorithm. The localization of the sensor nodes will be accurate when the selected beacon points are exact on the communication circle. However there are situations, particularly, in case of practical environments, incorrect beacon points could be chosen due to collision or inappropriate intervals. The chords generated using the beacon points thus fails to estimate the position of the sensor. Figure 5 displays selection of incorrect beacon points that leads to large localization errors. Almost this can be avoided by decreasing the beacon broadcasting interval and increasing the number of beacon messages.

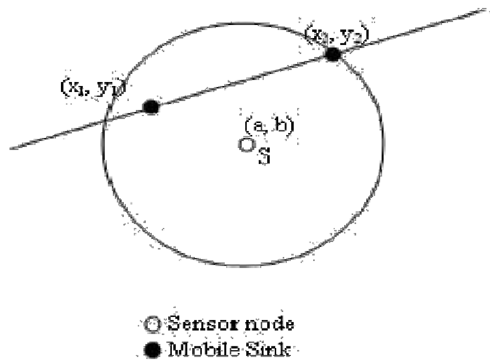

Figure 5: Incorrect selection of beacon points leads to large localization errors – third possibility

The more the beacon messages and less the beacon broadcasting interval will lead to efficient selection of entry and exit point, that is, beacon points on the communication circle. With the enhanced beacon selection mechanism, Localization is performed accurately in spite of irregular radio transmission due to obstacles.

5 Performance Evaluation

The sensor field for simulation was a square of 100 * 100 m2. For simplicity, in the sensing field 12 sensor nodes were placed. In the practical environment, the sensor nodes were deployed randomly in the field. The mobile sink was randomly introduced at any corner of the sensing field at the beginning, as illustrated in figure 6. The mobile sink cannot be placed within the sensing area. It will move through the sensor field with a different speed. The level of speed will change according to the situation in the sensor field. Thus the mobile sink is designed with an autonomous speed varying mechanism. The localization scheme was analyzed with different communication range of the sensor node.

A sensor network as shown in figure 7 is implemented wherein a mobile sink was introduced to traverse through the sensor field in a random direction at various levels of speed. For simplicity, the direction of the mobile sink initial movement is shown in the figure.

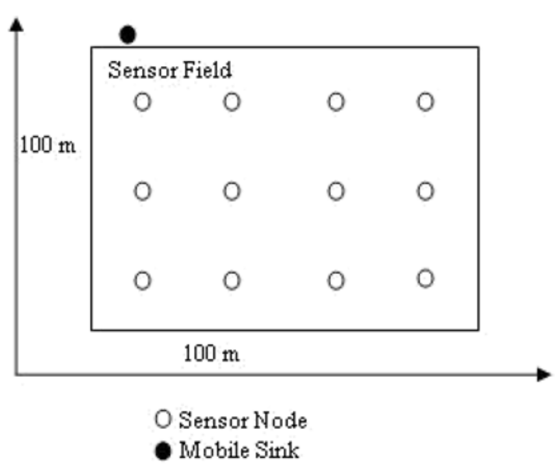

Figure 6: Simulation Environments

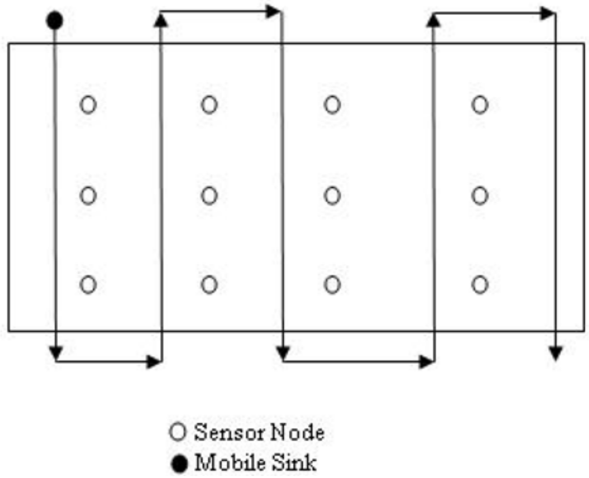

Figure 7: Area localization for sensor nodes with a mobile sink

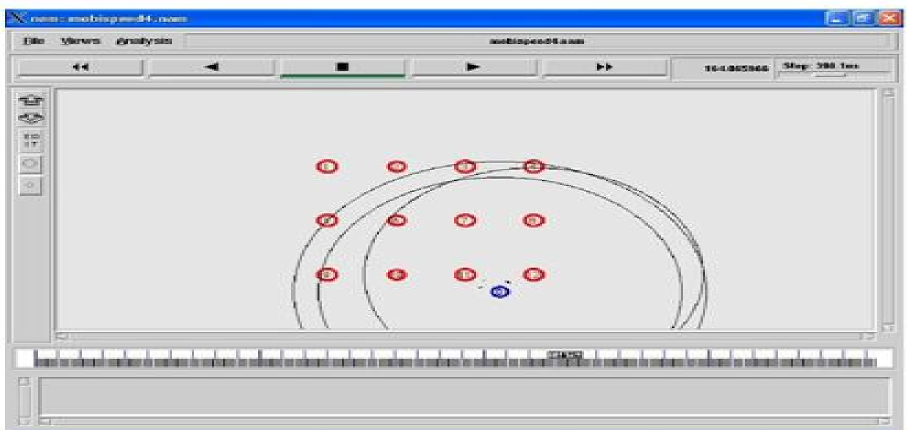

Figure 8:Node11-Sink-Node12

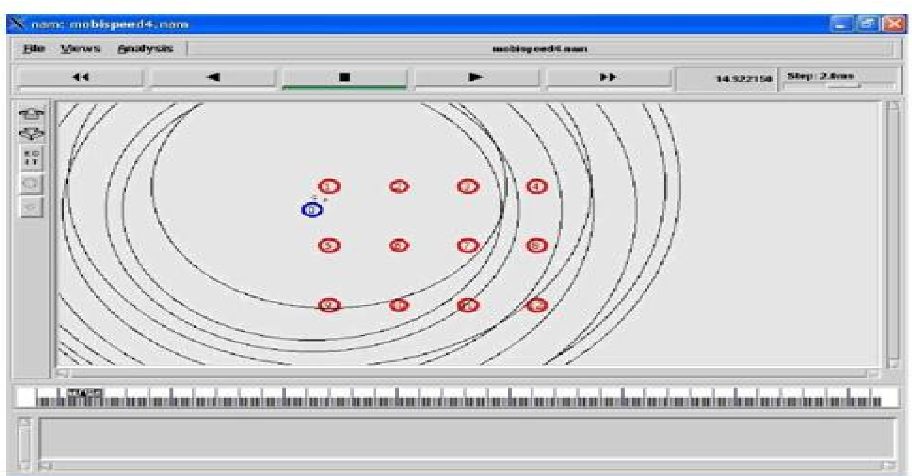

Figure 9: Ns2 NAM of MobiSpeed 4

Node 1 Sink

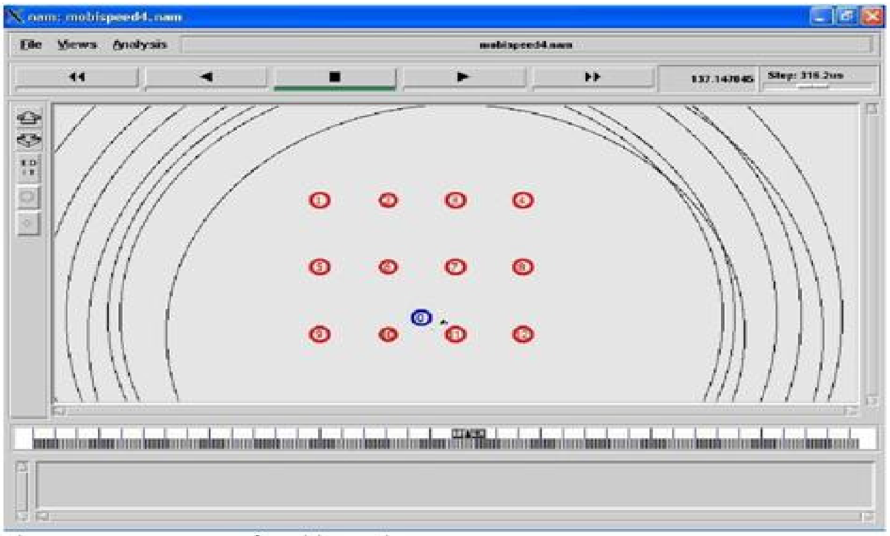

Figure 10:Ns2 NAM of MobiSpeed 4

Node11 Sink

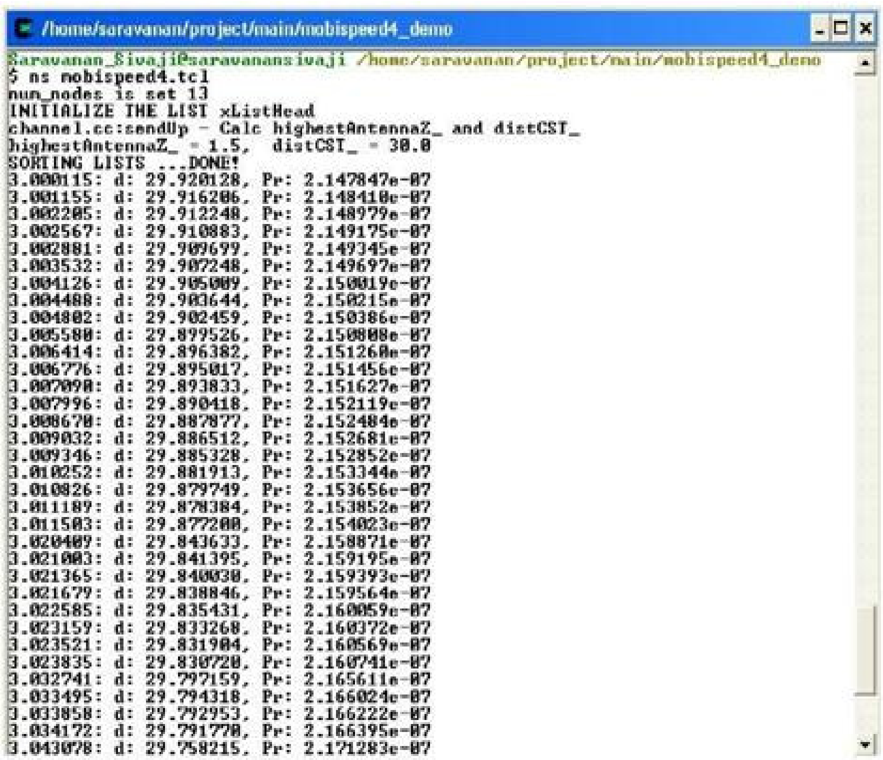

Figure 11:Ns2 Simulation of MobiSpeed4

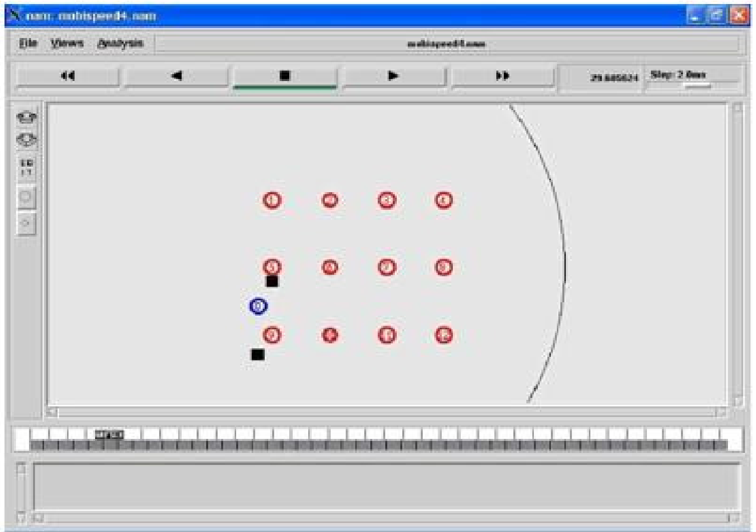

Figure 12: Packet Drop

Figure 13: Packet Drop-Minimum

Performance results are presented for the difference in location estimation based on our implementation and the actual location of the sensor nodes. Simulations were conducted to study the effect of two values, that is, the sink speed and induced radio communication range error. Simulations were conducted for different radio communication range errors are presented. Before that, the information base maintained by the mobile sink about the location estimation of the twelve sensor nodes of our simulated environment of figure 7 is shown in Table 1 and also Table 2 for different radio range.he location estimation error (e) is calculated as follows: Distance between the sensor node's
real coordinates (x_0, y_0) and the computed Coordinates (x, y), given by

$$e = \sqrt{(x - x_0)^2 + (y - y_0)^2}.$$

The average location estimation error is calculated as,

Average location error = Sum (e) / number of nodes.

TABLE 1

SAMPLE SIMULATION RESULT – LOCATION ESTIMATION OF THE SENSOR NODES FOR RADIO COMMUNICATION RANGE ERROR 0.15

Sensor Nodes	Actual location	Estimated location	Estimation Error
S1	(20.0, 80.0)	(20.03, 80.0)	0.03
S2	(40.0, 80.0)	(40.28, 80.0)	0.28
S3	(60.0, 80.0)	(59.71, 80.0)	0.28
S4	(80.0, 80.0)	(80.03, 80.0)	0.03
S5	(20.0, 60.0)	(20.03, 60.0)	0.03
S6	(40.0, 60.0)	(40.28, 60.0)	0.28
S7	(60.0, 60.0)	(59.71, 60.0)	0.28
S8	(80.0, 60.0)	(80.03, 60.0)	0.03
S9	(20.0, 40.0)	(20.03, 40.0)	0.03
S10	(40.0, 40.0)	(40.28, 40.0)	0.28
S11	(60.0, 40.0)	(59.72, 40.0)	0.28
S12	(80.0, 40.0)	(80.03, 40.0)	0.03

TABLE 2

ANOTHER SAMPLE SIMULATION RESULT – LOCATION ESTIMATION OF THE SENSOR NODES FOR RADIO COMMUNICATION RANGE ERROR 0.64

Sensor Nodes	Actual location	Estimated location	Estimation Error
S1	(20.0, 25.0)	(19.28, 25.00)	0.72
S2	(40.0, 25.0)	(39.11, 25.88)	1.25
S3	(60.0, 25.0)	(60.88, 25.88)	1.24
S4	(80.0, 25.0)	(79.83, 25.03)	0.17
S5	(20.0, 50.0)	(18.70, 50.49)	1.39
S6	(40.0, 50.0)	(39.92, 49.73)	0.28
S7	(60.0, 50.0)	(59.71, 50.28)	0.40
S8	(80.0, 50.0)	(80.63, 49.96)	0.63
S9	(20.0, 75.0)	(20.15, 74.79)	0.25
S10	(40.0, 75.0)	(39.41, 75.20)	0.62
S11	(60.0, 75.0)	(60.73, 75.01)	0.73
S12	(80.0, 75.0)	(80.00, 75.00)	0.00

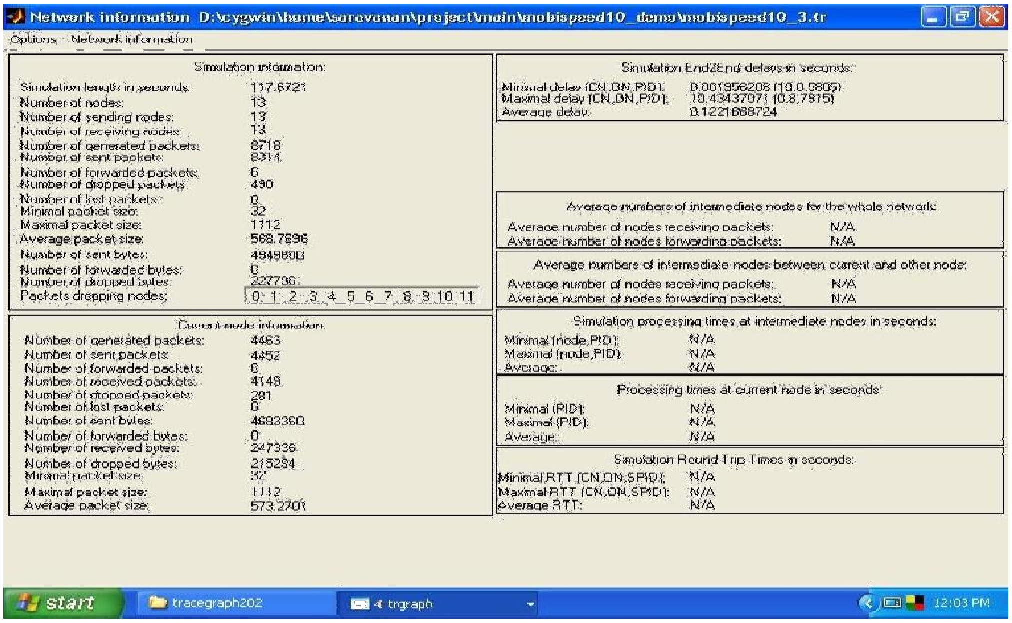

Figure 14: Simulation Parameters

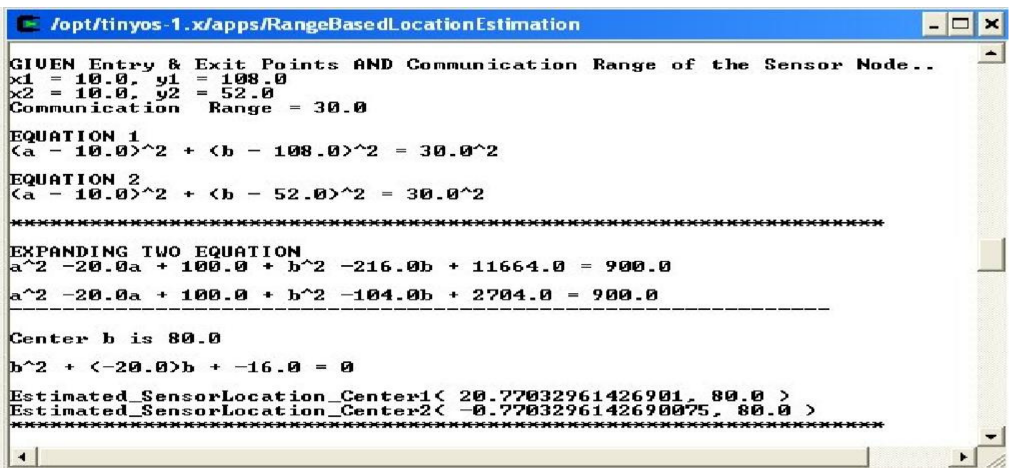

Figure 15: Simulation Results

Location Estimation of Sensor Node S_1, based on Entry & Exit point of Mobile Sink in the sensor field as per the simulation, (10, 108) & (10, 52)

Similarly, simulation results for different radio communication range error are presented in figures 8, 9, 10 and 11. These induced errors correspond to varying degree in communication range error as part of the theoretical known communication range. In our simulation, radio range was set at 10, 20, 25 and 30m. The induced error, of course has some effect on the performance of the localization of sensor nodes. With an increased induced communication range error, the performance degrades and is worse for the high value of range error as 1.22. For a low value of range error, that is 0.15, the performance of our proposed scheme is greatly better than existing schemes. Simulation of the proposed localization scheme shows that the sensor nodes placed farthest from the mobile sink path and the sensor nodes placed on the path of the mobile sink have a fewer error as shown in all graphs.

Thus the distance of the mobile sink from the sensor nodes is also a factor to have little influence upon the accuracy of the location estimation of sensor nodes. Finally, communication overhead in localization algorithm is only included the broadcasting information driven sensor querying (beacon) message.Figure 12-19 exhibits the localization error graphs.

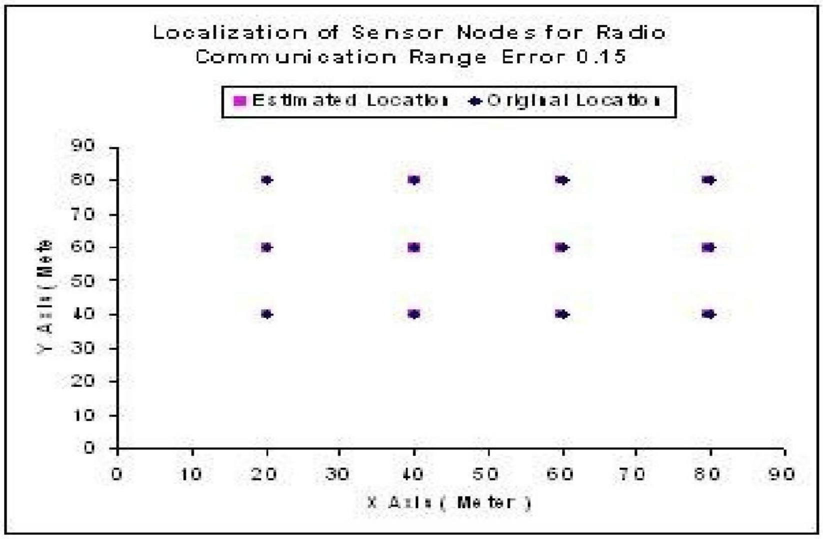

Figure 16: Localization of sensor nodes for radio communication range error 0.15

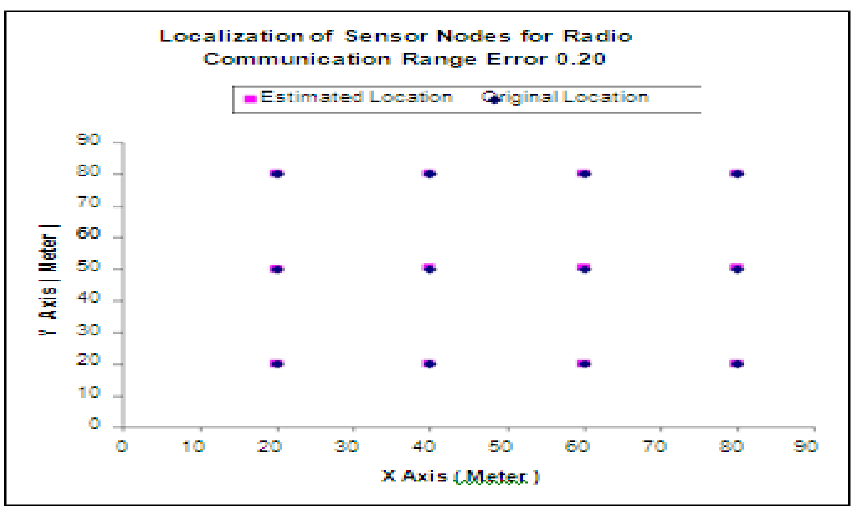

Figure 17: Localization of sensor nodes for radio communication range error 0.20

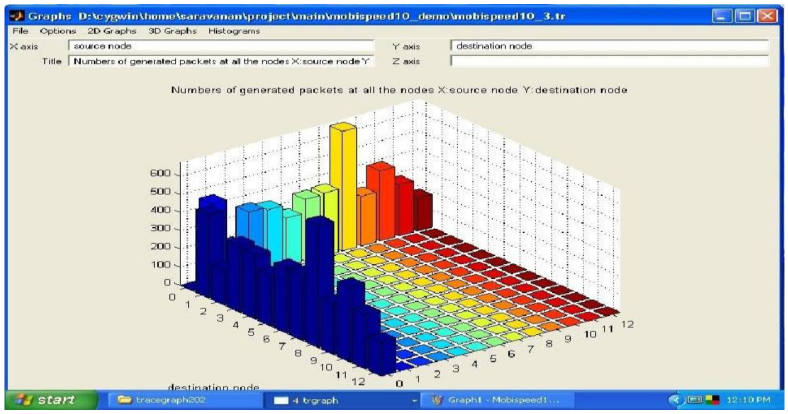

Figure 18: Number of generated packets at all the nodes. x-source node, y-destination node

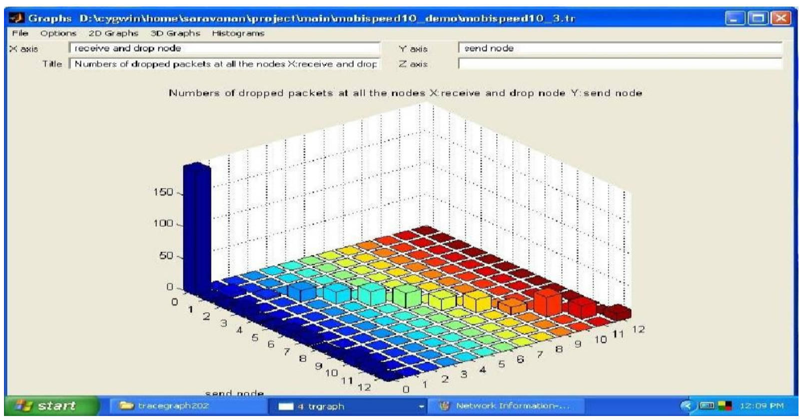

Figure 19: Number of dropped packets at all the nodes. x-source node, y-destination node

Analysis

The speed of the mobile sink is varied for different packet intervals and the performance analysis is made. The increase in mobile sink speed and the increase in packet interval size made the localization error also to increase.

6. Conclusion

In this paper we have presented a range based localization scheme, MOBISPEED, without using constraints or angle information. The scheme was designed to come with efficient localization of sensor nodes within a sensor network. With the help of mobility of mobile sink presented within the network, location estimation is performed. Based on the location information from mobile sink and the principles of elementary geometry, the mobile sink can compute the sensor nodes position without additional interactions. It is assumed that the mobile sink moves in a network in random fashion. It can vary its speed level according to the situation of event occurrence in the sensor field. Based on the selection of beacon points, the mobile sink can comes up with an efficient localization of the sensor nodes.

The localization mechanism that proposed here reduces needed power consumption compared to other schemes. Our mechanism only requires that mobile sink broadcast beacon messages. The ordinary sensor nodes do not spend energy on neighbouring interaction for localization. Simulations conducted in TOSSIM [22-23] and NS2 verify that MOBISPEED performs efficiently and is accurate in its functionality. As in" An Efficient Directed Localization Recursion Protocol for Wireless Sensor Networks" a different scheme in which only two reference points are required in order to estimate a position was discussed.[24]This can also be useful in predicting location coordinates of an unknown sensor node.

Bahi, J.M et al proposed that a solution has been given to the question "What is the optimum mobile beacon trajectory and when should the beacon packets be sent?", and then proposed a simple localization algorithm which was based on one mobile beacon.[25] Critical to the location accuracy of sensor nodes are two parameters, the radio transmission range of the beacon, and how often the beacon broadcasts its position. Theoretical analysis shows that these two parameters determine the upper bound of the estimation error when the traverse route of the beacon is a straight line had been explained by B.Xiao et al in [26]. Simulations were conducted with varying mobile sink velocity and for various communication ranges of sensor nodes. The execution time for the localization mechanism can be shortened if the moving speed is increased and by reducing the beacon interval and increasing the number of beacon messages. Our localization scheme comes with an efficient localization with minimum error as compared to other range-based localization schemes.

Mobile Sink (m/s) / Packet Interval (ms)	10 meter/second	4 meter/second
0.3 millisecond	1.004167	0.3725
0.6 millisecond	1.065833	0.40833

Table3: Average Estimation Error at Different Mobile Sink Speed and Packet Interval

Our future work involves the signal strength effects and the impact of localization accuracy due to the number of dropped packets by the sensor node.

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