An Effective Localization Based Optimized Energy Routing for Wireless Sensor Networks

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Abstract: Localization is one of the more important tasks in Wireless Sensor Networks. The accurate location information could greatly improve the performance of tasks such as routing, energy conservation, data aggregation and maintaining network security. Here, we have proposed an Efficient Location Optimized Energy Routing (ELOER) approach which attains to make a balance between network life times, location updated rate and delay among the sensor nodes. In the first phase of the scheme, multipath routing is proposed. In second phase, sensor election scheme is deployed to save energy of sensor nodes. In third phase, localization algorithm is proposed based on energy and trilateration method. In four phase, packet format is proposed. It contains following factors location update rate, location estimated field to favour better route selection and reduce energy consumption of sensor nodes. By simulation results we have shown that the ELOER achieves high network lifetime, high location update rate, while attaining low end to end delay, low overhead than the existing scheme ELMARP and ALARM while varying the number of nodes, speed, mobility and pause time.

Key words: WSN • Multipath routing • Localization • Sensor chosen method • Network lifetime • End to end delay • Overhead • Throughput and location update rate

INTRODUCTION

Localization algorithms require techniques for location estimating depending on the beacon nodes’ location. These are called multi-lateration techniques.

Iterative multi-lateration: Some nodes may not be in the direct range of three beacons. Once a node estimates its location, it sends out a beacon, which enables some other nodes to now receive at least three beacons. Iteratively, all nodes in the network can estimate their location but location estimation may not be accurate as errors may propagate.

Collaborative multi-lateration: When two or more nodes cannot receive at least three beacons each, they collaborate with each other. In the figure shown below nodes A and B have three neighbors each. Of the six participating nodes, four are beacons, whose positions are known. Proximity technique is used when there is no range information available. It reveals whether or not a node is in range or near to a reference point. Localization algorithms using this technique determine if a node is in proximity to a reference point by enabling the reference to transmit periodic beacon signals and whether the node is
able to receive at least certain value of the beacon signals set as threshold. In a period \( t \) if it receives \( n \) beacons greater than the set threshold then it is in proximity to that reference point.

- Position algorithms - It determines how the information concerning distances and positions, is manipulated in order to allow most or all nodes of WSN to estimate their position. Optimally the localization algorithms may involve algorithms to reduce the errors.

**Design goals of Wireless Sensor Networks WSNs:**
Routing protocols for WISNs must be carefully designed to consider resource constraints such as low processing power, small memory and limited energy of sensor nodes. In addition, WISNs must be scalable and able to tolerate dynamic network changes. They range from tens to thousands of sensor nodes. Therefore, the complexity of the routing algorithm must be independent of the size of the networks or the number of sensor nodes. They would be impractical if memory utilization increases as the number of nodes increases. New nodes may be newly deployed, or some nodes may disappear, due to malfunctions. Therefore, routing algorithms must adapt to dynamic network changes.

WISNs may use routing protocol for wireless mobile adhoc Networks or wireless sensor networks (WSNs), because they have similar wireless networks characteristics. In several studies real-time, reliable communication has been studied for wireless mobile adhoc networks. However, there were problems in applying these studies to WSNs, because the scalability of WSNs or constraints of sensor nodes were not considered. There have been studies about real-time, reliable communication in WSNs. Most of these studies do not provide simultaneous real-time, reliable and energy aware communication. The design goals are given below.

- Localization
- Scalability
- Unattended operation
- Resource limitation
- Computational power
- Wireless medium
- Reliability

**Related Work:** Jiang et al. [1] proposed a novel localization approach where unknown nodes through their near anchor nodes to obtain their position. In order to reduce error during localization, a new means was used to approximate the distance between unknown nodes and anchor nodes when it is larger than node’s communication radius. Including this, self-adapting genetic algorithm is proposed to calculate the similar position of nodes, it makes the localization error much lower than the common method.

Yetkin and Gungor [2] proposed a new Received Signal Strength Indicator (RSSI) based fingerprint technique which uses logical inferences. Here closed area was divided into the cells of 1 x 1 mt. The RSSI characteristics of each cell were recorded into a database in order to prepare a radio map. At real time, the RSSIs of anchor nodes received from base station were compared with radio map according to logical algorithms. In this scheme, the target localization was carried out mathematically.

Wei Zhag et al. [3] proposed a two-phase robust localization algorithm based on Consistency of Beacons in Grid. In the first-phase, a voting method based on the consistency of beacons in the grid is used to filter out part of the suspicious nodes. In the second-phase, it was adopted the loss function in M-estimation of Robust Statistics to obtain a robust solution with the remained nodes.

Zhang and Hong Pei et al. [4] explored a two-hop Collaborative Multilateral Localization Algorithm (CMLA). This algorithm was implemented through event-driven schemes. It is also introduced a new method which is used to estimate the distances between two hop nodes, applies anchor nodes within two hops to localize unknown nodes and uses the minimum range error estimation to compute coordinates of unknown nodes. If any unknown node cannot be localized through two hop anchors nodes, it was localized by anchors and localized nodes within two hops.

Chengpei et al. [5] implemented a WSN localization method based on plant growth simulation algorithm (PGSA). This algorithm is a bionic random algorithm that characterizes the growth mechanism of plant phototropism. Based on simulation analysis, this algorithm (PGSA) is simple, fast convergence and robustness, which is more suitable for the large-scale environment.

Long Cheng et al. [6] presented a comprehensive analysis of these challenges: localization in non-line-of-sight, node selection criteria for localization in energy-constrained network, scheduling the sensor node to optimize the trade off between localization performance and energy consumption, cooperative node localization
and localization algorithm in heterogeneous network. Including this it was introduced that the evaluation criteria for localization in wireless sensor network.

Adewale Abe et al. [7] implemented a localization system that uses a RSSI trilateration approach in a wireless sensor network. The system position estimation accuracy was also evaluated. Finally it was concluded that for the proposed system to work there must be the availability of at least three anchor nodes within the network and whenever anchor nodes broadcast packets containing their locations and other sensed parameters, the blind node within the broadcast range can always estimate its distance to the anchor nodes and if peradventure the blind nodes receive packets from at least three anchors, the blind node can localize its position.

Xiajoun Zhu et al. [8] examined two candidate solutions developed from existing ideas, with one assuming that nodes can hear from each other if and only if they are within transmission range and the other assuming closer nodes observe larger RSSI. Both candidate solutions do not work well in practice. After changing “closer” to “the closest” and “larger” to “the largest” in the second approach, it was found that the new assumption is quite reliable in practice.

Rama Prabha and Parvadha Devi [9] proposed a fuzzy logic based restriction system suitable for remote sensor hubs that are portable in uproarious, savage situations. The constituent frameworks used fuzzy multi lateration and a grid prediction to process the area of a hub as a zone. The signal strength is thrown into bins which encode the imprecision.

Laslo Gogolak et al. [10] presented WSN based fingerprinting localization method. The RSSI values of the communication links between the previously situated sensors and the mobile sensor were recorded in an indoor environment through the experiment. Using the recorded RSSI values a feed-forward type of neural network was trained. The result of the training is a neural network capable of performing indoor localization. The accuracy of the localization between the real and the calculated values was measured with Euclidean distance and demonstrated with the cumulative distribution function.

Priti Narwal and Tyagi [11] proposed a technique called Multidimensional scaling which computes the position of nodes which are in the communication range of each other. This analysis technique find out the relative position of nodes with accuracy sufficient enough for most of the applications so as to solve the problem of recreation.

Martin Victor and Ramalakshmi [12] developed a localization system that carries high-location estimation accuracy at low cost. The system used spatiotemporal properties of well-controlled events in the network; light in this case, to obtain locations of sensor nodes. The system was to detect the multiple events in the network and to increase the area of the sensor field by increasing the number of nodes. By handling this kind of detection of multiple events in the network at once, mainly the time was saved.

Sachin Deshpande et al. [13] presented the methodology that gives a solution to compute the state parameters of the adversary target and tracks it and associate the same with the location in the periphery of wireless sensor networks.

Nirmala et al. [14] discussed a new technique that aims to localize all the sensor nodes in the network using trilateration and a security protocol was used for providing confidentiality and authentication between anchor nodes and sensor nodes.

Baihua shen and Guoli wang [15] proposed a new method, based on radial distance modulation, to detect and locate moving object from top view angle. This method has advantages of extracting information directly from the moving object characteristics of movement and spatial position, small computation, good robustness, convenient configuration, non-contact etc. It can locate the moving object with simple information after modulating and encoding the perception area of sensors.

Dan Pescaru and Daniel [16] proposed another anchor node localization technique that can be used when GPS devices cannot accomplish their mission or are considered to be too expensive. This novel technique was based on the fusion of video and compass data acquired by the anchor nodes and is especially suitable for video- or multimedia-based wireless sensor networks.

Divya Bharti et al. [17] proposed a mobility control scheme and we explored the impact of mobility over the performance of wireless sensor network. Two different protocols were used for the performance analysis of proposed mobility control scheme and the impact of this method over the selected protocols. It was analyzed the performance of the protocols on the basis of different parameters like Throughput, Packet Delivery Ratio, Routing Load and energy consumption.

Jang Ping Sheu et al. [18] proposed distributed localization scheme where each normal node gathers the necessary information via two-hop flooding and is thus scalable. Aside from this, each normal node uses a
simplified approach and the proposed improved grid-scan algorithm to find the initial estimated locations of the normal node, thus reducing the computation cost. It also introduced a vector-based refinement scheme to correct the initial estimated location of the normal node, thus improving the accuracy of the estimated location.

In this paper [20], some interesting issues are addressed arising in such MANETs by designing an anonymous routing framework (ALARM). It uses node’s current locations to construct a secure MANET map. Based on the current map, each node can decide which other nodes it wants to communicate with, ALARM takes advantage of some advanced cryptographic primitives to achieve node authentication, data integrity, anonymity and untraceability. It also offers resistance to certain insider attacks.

The paper is organized as follows. The Section 1 describes introduction about WSNs, localization algorithms and design goals of WSNs. Section 2 deals with the previous work which is related to the localization algorithms. Section 3 is devoted for the implementation of proposed scheme. Section 4 describes the performance analysis and the last section concludes the work.

Implementation of Proposed Scheme: In the proposed scheme, multipath route is deployed to improve the load balancing and network lifetime. The sensor choosing approach is proposed to provide less performance loss and high energy saving against the more battery consumption. Localization scheme is proposed to locate target node and unknown sensor nodes based discrete fourier transform and distributed algorithm.

Load balancing through Multipath: Due to the presence of path’s poor quality, packets will be retransmitted or lost. It will cause more local energy consumption and serious congestion. Path quality decides the reliability of packets forwarding. The remaining energy of all sensor nodes determines the survival time of the network. Therefore, the way only using hops as a criterion to evaluate the quality of routing has failed to meet the requirements of the network service quality. By selecting the hops to the destination node, residual energy and transmission delay to comprehensively evaluate the nodes’ quality, the preferred cluster heads are selected to establish the optimal transmission path. This has great significance to improve the transmission reliability. Angle value is used to restrict the direction of interest packets’ broadcasting and data transmission.

When packets are need to transmit, global optimal paths must be distributed and established from the source node to the destination node according to the cluster heads residual energy. It mainly includes the phases of topology establishment, nodes’ residual energy calculation, multipath route discovery, routing maintenance and so forth. Before transmission starts, the source node has data packets, it firstly reports to its cluster head. The cluster head chooses the sensor node with the minimum hop distance and the next hop within the transmission power coverage to discover the first optimal transmission path. Then the cluster head selects one node as the next hop which is with the minimum hop distance and within the transmission power coverage.

An exception arises when a message is created, where only one MAC needs to be checked by the immediate neighbour of the source node. It is obvious that two adjacent nodes can cooperatively compromise the communication path. It is able to manipulate and inject arbitrary messages that are routed through them. This seems to be only a slight improvement over simple hop-to-hop authentication at first. Instead of compromising one node, an attacker now has to gain control over two of them. And since they are co-located, an attack should be easy. Thus it seems nothing much is gained.

Sensor Election Phase: In this approach, the whole sensor field is divided into many smaller regions and a coarse target position is used to select regions in which sensors need to report their decisions to the Cluster Head (CH). Therefore, this method can greatly save sensor energy. The energy a sensor uses can be divided into three main categories. The first category $E_1$, is the energy a sensor uses to measure the signal from the target. The second category $E_2$, is the energy a sensor uses to maintain essential functions, such as receiving information from the fusion center and keeping itself awake. The third category $E_3$, is the energy a sensor uses to send the decisions to the CH.
A sensor election phase can reduce energy consumption by choosing sensors containing more useful information and allowing those sensors to send the decisions to the Cluster Head (CH) while sensors containing less useful information are not allowed to send decisions to the cluster head. Sensors are selected based on target information from all sensors. The computation cost of this selection method may be prohibitive if the total number of sensors is large. The computation cost can also be alleviated based on sensor election phase.

The steps of proposed approach are as follows:

- Partition the whole sensor network into different regions. Place M, number of anchor sensor nodes in grid points.
- Use anchor sensor nodes and the weighted average method to estimate a common target position.
- Use the coarse target position to choose all sensors in the region where the estimated target is located.
- If the target falls into region \( \mathcal{O}_m \), sensors in the remaining neighboring region will be chosen.
- Selected sensors will report decisions to the cluster head. Sensors not in selected regions will not report decisions.

**Optimized Energy Routing:** The set of sensor nodes has been deployed to implement the localization of sensor nodes in wireless sensor network. In this network, anchor sensor nodes need to propagate the whole network for localizing the sensor nodes. Hence more number of anchor nodes is required for localization of sensor nodes. To minimize number of anchor nodes involved in the localization of network new technique Trilateration has been implemented which aims to localize more number of sensor nodes using with greedy technique. An acoustic signal from a target decays as distance from the target to the measurement location increases.

Every unknown sensor node in the network will execute a distributed algorithm as follows:

**Step 1:** The unknown node initializes its position estimate to the entire space.

**Step 2:** The node then waits to receive beacon packet from its neighboring nodes and upon receiving a beacon packet, updates its position estimate by computing the constraint and intersects it with the current estimate to obtain the new estimate.

**Step 3:** If the position estimate improves, it will wait for a specific period of time and will broadcast its new estimate to all of its neighbors.

**Step 4:** Every node receives a beacon packet either directly from a beacon or from another unknown node. Each such packet contains a location estimate field of the node originating the packet.

**Step 5:** The finer the grid, the greater the memory required to store the estimates. There is a clear trade-off between the precision of the position estimate and the storage requirement. Wireless sensor nodes usually have limited memory resources and the grid representation would consume most of those resources.

**Step 6:** When a beacon sends a beacon packet, all of its neighbors may update their position estimates; and, in return, each sends a beacon packet, which will reach the neighbor’s neighbors and will keep multiplying. In reality, fewer numbers of beacon messages propagate in the network and, hence, maintain the locality of the algorithm.

**Energy Consumption Model:** The energy model of proposed algorithm is given below. In this model energy consumption for transmitting M bit is equal to:

\[
E_n(M, d) = E_{elec} \times M + \delta_{adp} \times M \times d^2 - E_{rest}(P_{adp})
\]

M = bit contain some information like current energy level of the node, data label, node’s location and hop count.

**Proposed Packet Format:** In Figure 2, the proposed packet format is shown. Here the source and destination node ID carries 4 bytes. Third one is authentication status of the node. The location update rate induces the whether the sensor nodes are located with anchor nodes. In fourth field, the location estimate is indicated to maintain memory requirement of unknown sensor nodes. The last filed CRC i.e. Cyclic Redundancy Check which is for error correction and detection in packet while route maintenance process.

**Performance Analysis:** We use Network Simulator (NS2.34) to simulate our proposed algorithm. Network Simulator-3 (NS2.34) is used in this work for simulation. NS2 is one of the best simulation tools available for Wireless sensor Networks. We can easily implement the designed protocols either by using the otel coding or by writing the C++ Program. In either way, the
tool helps to prove our theory analytically. In our simulation, 100 sensor nodes move in a 1200 meter x 1200 meter square region for 60 seconds simulation time. All nodes have the same transmission range of 250 meters. Our simulation settings and parameters are summarized in Table 1.

### Performance Metrics:
We evaluate mainly the performance according to the following metrics.

**End-to-end delay:** The end-to-end delay is averaged over all surviving data packets from the sources to the destinations.

**Location Update Rate:** It is the ratio of number of nodes location updated to location not reported successfully.

**Communication Overhead:** It is defined as the total number of routing control packets normalized by the total number of received data packets.

**Network Lifetime:** It is defined as the nodes lifetime based on energy consumption.

### Performance Metrics:
We evaluate mainly the performance according to the following metrics.

**Communication Overhead:** Communication overhead can be defined as the average number of control and data bits transmitted per data bits delivered. Control bits include the cost of location updates in the preparation step and destination searches and retransmission during the routing process.

**Packet Delivery Ratio:** The delivery rate is defined as the ratio of numbers of messages received by the destination and sent by senders. The best routing methods employing this metric are those that guarantee delivery in which message delivery is guaranteed assuming “reasonably” accurate destination and neighbor location and no message collisions.

**Node Degree:** It is the important metric to evaluate the performance of topology control algorithms. If the node degree is higher, it indicates that higher collision will be. So value of node degree should be kept small.

**Network Connectivity Ratio:** It determines the nodes are connected in the intermediate region. It should be kept small while varying the average speed.

**End-to-End Delay:** This is also referred to as latency and is the time needed to deliver the message. Data delay can be divided into queuing delay and propagation delay. If queuing delay is ignored, propagation delay can be replaced by hop count, because of proportionality.

The simulation results are presented in the next part. We compare our proposed scheme ELOER with EMLARP [19] and ALARM [20] in presence of topology control environment.

Figure 3 shows the results of connectivity ratio for varying the mobility from 5 to 25. From the results, we can see that ELOER scheme has slightly lower connectivity ratio than the EMLARP and ALARM method because of location update of node calculations.

Fig. 4, presents the comparison of node degree It is clearly shown that the node degree of ELOER has low overhead than EMLARP and ALARM.
Figure 5 shows the results of Time Vs End to end delay. From the results, we can see that ELOER has slightly lower delay than the EMLARP and ALARM scheme because of stable routes.

Fig. 6, presents the comparison of overhead while varying the nodes from 0 to 200. It is clearly shown that the of ELOER has low overhead than EMLARP and ALARM method.

Figure 7 show the results of average packet delivery ratio for the simulation time 10, 20…50 secs for the 200 nodes scenario. Clearly our ELOER scheme achieves more delivery ratio than EMLARP and ALARM scheme since it has both multipath routing and cluster enhancement features.

CONCLUSION

In this research work, proposed approach consists of three phases. In first phase, multipath route is integrated to ensure load balancing. In second phase, sensor nodes are chosen to alleviate computation cost and save sensor nodes energy. In third phase, localization method is proposed based on energy consumption in multipath routing. To locate the target and sensor node distributed algorithm was used. By simulation results, the proposed approach ELOER achieves high location updated rate, improved network lifetime, less end to end delay and overhead in terms of mobility, pausetime, throughput and number of nodes than existing scheme ELMARP and ALARM.
REFERENCES


