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Unequal Cost Multi-Path Forwarding for the WSN Load Balancing

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Abstract: **The energy based routing protocols are the most appropriate routing techniques for the maximum lifetime of the sensor networks during their applications. In this research, we have proposed the new energy based routing protocol with energy aware routing and load balancing. The proposed model is intended to improve the efficiency of the proposed model. The proposed model has been designed with the multiple metric based tree-routing. The proposed tree-based routing protocol utilizes the residual energy, distance, hop-count, bandwidth and neighbor node id for the purpose of the metric calculation for every available route. The load balancing is enabled between the two or more than two available paths between the target node and base station. The proposed model offers the load balancing between two unequal cost paths with unequal load division for the purpose of efficient data delivery. The proposed model results have been obtained upon the various performance parameters of network load, transmission delay, throughput, energy consumption and route persistence. The experimental results have proved to be efficient and better in comparison with the existing models. The proposed model has been proved to be efficient on the basis of almost all of the given performance parameters.**

Keywords: **Tree-based routing, WSN routing, Energy efficient routing, Multi-path routing.**

1. INTRODUCTION

Over the last half a century, computers have exponentially increased in processing power and at the same time decreased in both size and price. These rapid advancements led to a very fast market in which computers would participate in more and more of our society's daily activities. In recent years, one such revolution has been taking place, where computers are becoming so small and so cheap, that single-purpose computers with embedded sensors are almost practical from both economical and theoretical points of view. Wireless sensor networks are beginning to become a reality, and therefore some of the long overlooked limitations have become an important area of research [1, 3, 4, 5].

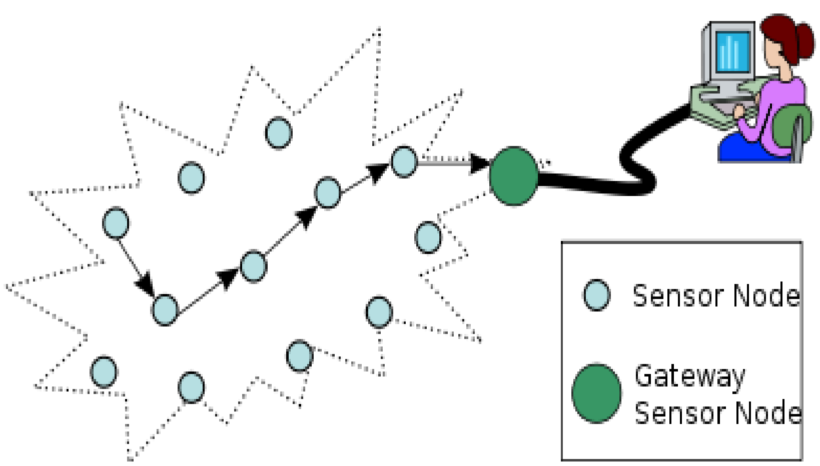

Figure 1: Wireless Sensor Network Architecture

Today in the market of rapid growth of computers the processing power are increased unexpectedly but the price and size of computers have greatly reduced which encourages the use of computers very much. The latest technologies have made vast advancements in computers era and also enhance the use of computers in our daily activities. In recent years, from the economic point of view, the single-purpose desktop computers having sensors embedded in them are highly used due to cheapness in prices and reduction in size of computers.

Wireless Sensor Networks have been receiving a great amount of attention recently due to their substantial applicability to improve our lives. They aid us by extending our ability to accurately monitor, study, and control objects and environments of various scales and conditions such as human bodies, geological surveys, habitats, and security surveillance. Large no. of sensor nodes in a field connected with a sink node to transmit information about events to satellite associated is shown in Figure 1.

In this paper, we have worked upon the new routing protocol based upon the tree-based topology for the load balancing in the complex WSN structure. The proposed model has been aimed at solving the problem of the high latency and low network load in order to facilitate the hassle-free data delivery of higher volumes of data in the WSNs.

2. LITERATURE REVIEW

In [1], (Delaney, D., Russell Higgs, and G. O'Hare 2014), the authors have worked on a stable routing framework for tree-based routing structures in WSNs. The central concept introduces neighborhood heuristics (NHs), a method of combining a sensor's routing metric with those of its neighbors to highlight both the quality of the current route and the quality of the routing options available to the sensor should its current route become unavailable. The new optimistic routing [2] (Ghadimi, Euhanna et. al. 2014) have been proposed in Low Duty-Cycled Wireless Sensor Networks. In this paper the authors have introduced ORW, a practical opportunistic routing scheme for wireless sensor networks. In [3], (Sahin, Dilan et. al. 2014) the authors have worked upon QoS differentiation in single-path and multi-path routing for wireless sensor network-based smart grid applications. Wireless sensor network (WSN) concept places an important role in this modernization process of the power grid with its efficient and low-cost deployment characteristics. In [4] (Singh, Dharmendra et. al., 2014) the authors have developed an energy efficient source based tree routing with time stamp in WSN. Wireless sensor network most recently used technology. Different routing protocols and topologies are used to transmit data from source to sink. The authors [5] (Kwon, Kiwoong et. al., 2012) have implemented SPR in our IP-WSN platform named SNAIL and conduct a simulation and a measurement to verify the performance of SPR. The simulation results show SPR provides improved hop count compared to HiLow and RPL. It also provides reduced memory usage and the number of control packets compared to RPL.

3. DESIGN AND IMPLEMENTATION

A wireless sensor network consists of tiny sensing devices, which normally run on battery power. Sensor nodes are densely deployed in the region of interest. Each device has sensing and wireless communication capabilities, which enable it to sense and gather information from the environment and then send the data and messages to other nodes in the sensor network or to the remote base station. Considering the limited energy capabilities of an individual sensor, a sensor node can sense only up to very limited area, so a wireless sensor network has a large number of sensor nodes deployed in very high density (up to 20nodes/m), Which causes severe problems such as scalability, redundancy, and radio channel contention. Reducing the amount of communication by eliminating or aggregating redundant sensed data and using the energy-saving link would save large amount of energy, thus prolonging the lifetime of the WSNs. Data gathering (collecting the sensed information from the sensor nodes and routing the sensed information) has to be done in an energy efficient way to ensure good life time for the network. Hence, data gathering protocols play an important role in wireless sensor networks keeping in view of severe power constraints of the sensor node. Therefore, a major part of the research work concentrates on extending life time of networks by designing energy efficient protocols, which is the core of this thesis work. In this paper, we propose a distributed and energy efficient protocol, called TBRP for data gathering in wireless sensor networks. TBRP, select cluster head with considering the distance to the neighborhoods and the residual energy of node, and so define new algorithm for cluster head election. This can better handle heterogeneous energy circumstances than existing clustering algorithms which elect the cluster head only based on a node's own residual energy. After the cluster formation phase, TBRP constructs a fuzzy spanning tree over all of the cluster heads. Only the root node of this tree can communicate with the sink node by single-hop communication. Because the energy consumed

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for all communications in in-network can be computed by the free space model, the energy will be extremely saved and thus leading to sensor network longevity.

The existing system will be improved and enhanced for its metric calculation to elect the best route and route for load balancing while sending the data towards the BTS. The BTS will be receiving the data from the cluster heads in the wireless networks. The metric calculation would be improved by combining the values of the next hop energy, hop count, all hop energy (all hops in the link), node id and bandwidth between the source and destination node. The adaptive load balance balancing rainbow protocol will use this new metric route to find the shortest route with balanced energy and higher bandwidth. The route cost calculation for load balancing will be based on the individual load on the relay node/s, the alternative routes with the minimum load will be also considered to find the alternative route. Among the shortlisted routes using the load as metric, the route with minimum total route cost will be used to forward the data. The existing algorithm will be compared with our proposed algorithm using end to end delay/latency, packet delivery ratio, network/route load and packet Efficiency of the alternative route. The project will be developed using NS2 simulator. The algorithm to detect the connectivity hole or link failure will be used to update the routing table while the primary route becomes unavailable. We will be using reply back method to detect the link failure, and to execute the backup and load balance route finder event based improved adaptive load balancing rainbow protocol for WSNs.

For the purpose of path selection, the energy is the main parameter. The path energy of all of the nodes in the path has been evaluated to find the lowest energy node in the whole path. The energy of all of the nodes will be stored in the form of energy array on the source node in order to evaluate the energy based path cost of the path:

E = $(E_1, E_2, E_3, E_4, E_5, E_6, \_\_\_\_\_\_\_\_\_, E_N)$

Energy Consumption model has been designed in the proposed simulation using the following formula, where the energy consumption has been evaluated for the packet transmission, packet receiving and packet

$$P_{ETX} = \int_1^N ((P_T(i)\{(NP_T) * (NP_T - 1) * E_{TX}) - 1) + ((P_T(i)\{(NP_T) * (NP_T - 1) * E_{RC}) - 1)$$

Algorithm 1: Proposed Model Algorithm

1. Node i will send query 'a' to the neighbor node to find the path towards sink node.
2. If the neighbor node NN_i knows the path to the sink,
   a. It will reply with route information to the querying node i.
   b. node i will update the routing information
3. Else/Otherwise,
   a. Neighbor node NN_i will pass the query to its querying node & it will continue till it reaches the sink node.
   b. Once the path to sink is found, nodes will send the route reply towards the querying node.
4. Node i after receiving the path info, trims the path with duplicate entries of nodes among multipath on the basis of low path cost.
5. Verify the finalized path cost.
6. When Node i has some data to forward, it reevaluate the possible paths towards sink node.
7. Node i compares the Path P = $\{P_1, P_2, P_3, \_\_\_\_\_\_\_, P_N\}$ on the basis of their cost information.
8. Node i compare the path information on the basis of Residual Energy (RE_p), Next Hop, Neighbor ID (Nid_p) & Available Bandwidth (bw_p).
9. The path with higher RE_p is selected.
10. If all path have similar RE_p then,
    a. Path with maximum bw_p is selected.
    b. Path with highest id is selected if bw_p is found similar among available paths.
11. Data is channelized through the selected path P.
12. The threshold value T is computed as the weight to select the best alternative path P_A.
13. The alternative path P_A and best path P_B are evaluated for division of data volume across the multiple best paths.
14. The data volume D_A and D_B becomes the permitted data volumes for data transmission across the select paths P_A and best path P_B respectively.

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4. RESULT ANALYSIS

The results have been obtained from the proposed model in the form of various performance parameters. The performance parameters of localization coverage rate and the location error rate are the most deciding parameters in order to evaluate the quality of the proposed model. Positioning rate and positioning coverage are the parameters used for the evaluation of positioning accuracy of the nodes in the wireless sensor network.

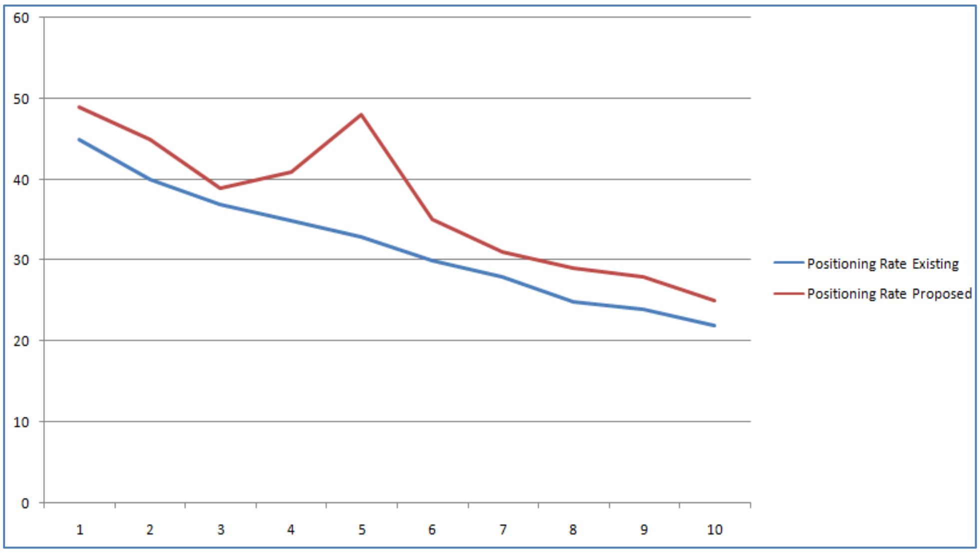

Figure 2: Positioning Rate

In the applications of localization algorithm, where the local coordinate system is used to define the local coordinates & system where all other nodes are referred to. Because of constraints on the cost and size of sensors, energy consumption, implementation environment (e.g., GPS is not accessible in some environments) and the deployment of sensors (e.g., sensor nodes may be randomly scattered in the region), most sensors do not know their locations. These sensors with unknown location information are called non-anchor nodes and their coordinates will be estimated by the sensor network localization algorithm.

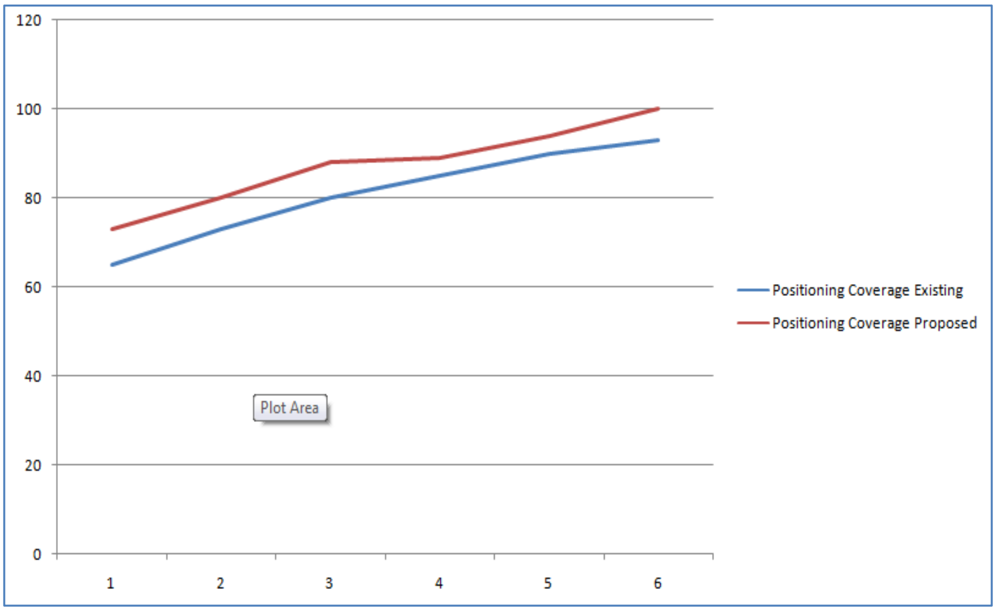

Figure 3: Positioning Coverage

Positioning deviation is the deviation between actual location and estimated position for the unknown nodes. Positioning deviation rate is the average positioning deviation. It refers to the ratio of the positioning deviation of all nodes to the communication radius As shown in Fig. 2, the data were compared for localization accuracy in the case of different

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numbers of anchor nodes. With the increase of the anchor nodes, localization accuracy is more accurate. Improved algorithms have been improved on the basis of the original algorithm no matter which anchor node works.

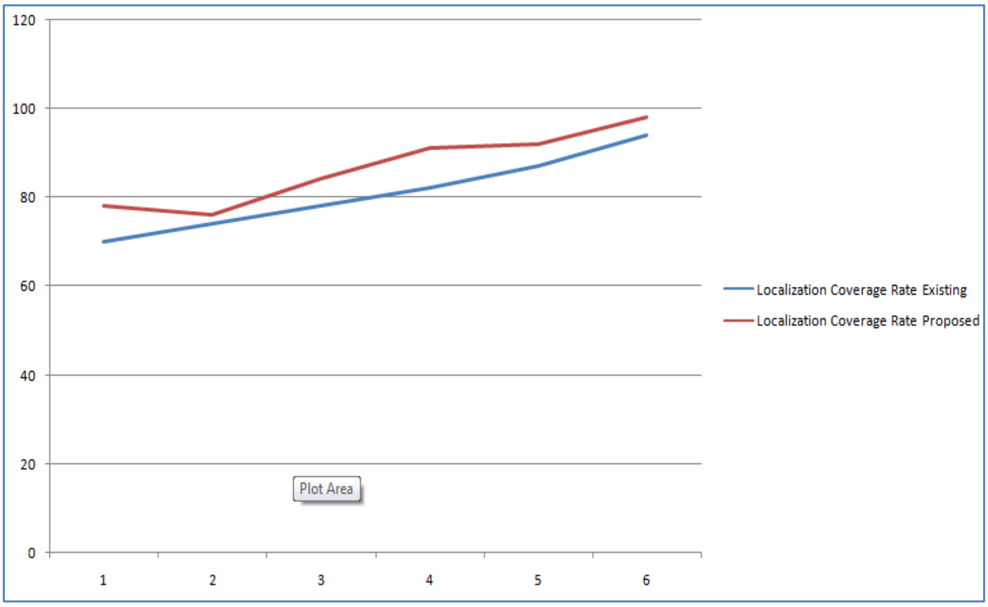

Figure 4: Localization Coverage

Compared with other three dimensional localization algorithm, this algorithm reduce the positioning error, greatly improving the positioning coverage, as shown in Fig. 3, the APIT-3D localization algorithm, APIS localization algorithm and this algorithm. With the increase of the anchor nodes, the average positioning error decreases continuously, localization accuracy is more accurate. Fig. 4 shows the result of the localization coverage for three-dimensional DV-Hop localization algorithm and a novel three-dimensional localization DV-Hop algorithm. With the increase of communication radius, network node localization coverage more widely.

Compared with other three dimensional localization algorithm, this algorithm reduce the positioning error, greatly improving the positioning coverage, as shown in Fig. 5, the APIT-3D localization algorithm, APIS localization algorithm and this algorithm. With the increase of the anchor nodes, the average positioning error decreases continuously, localization accuracy is more accurate.

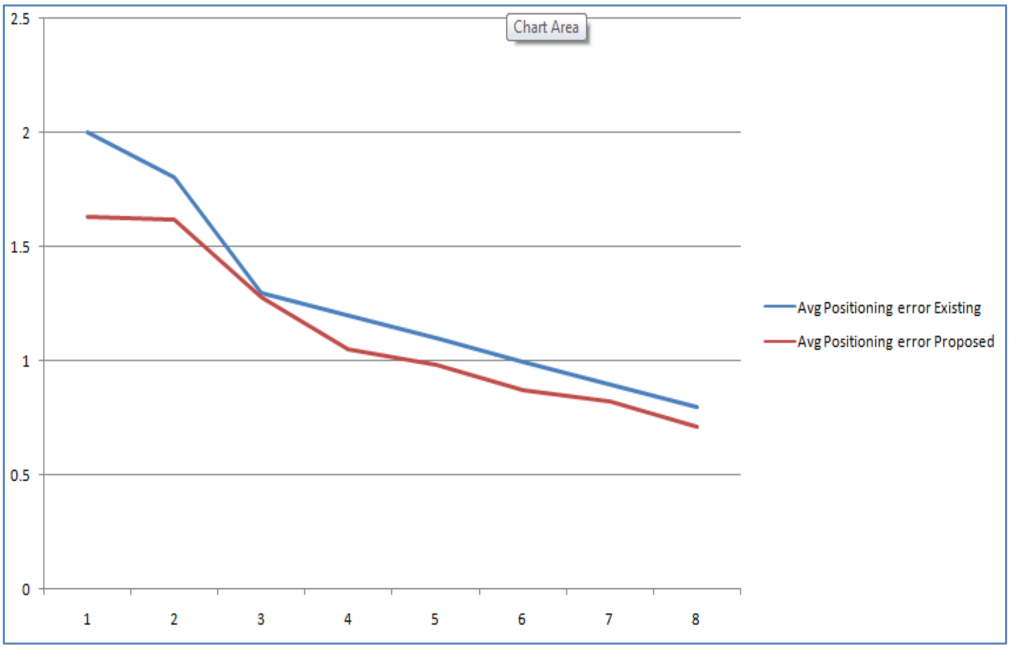

Figure 5: Average Positioning

5. CONCLUSION

The proposed model is based upon the tree-based smart routing for the balanced path routing. The proposed model has been designed for the load balanced routing for the elongated lifetime of the WSNs. The proposed model has been designed to work in the traditional three phase routing architecture with path marking, path selection and load balancing. The proposed model is capable of performing the unequal cost path load balancing between two or more paths. The proposed model has been evaluated against the existing model on the basis of the various performance parameters and found performing better than the existing model. The proposed model has been evaluated better than the existing models on the basis of the network connectivity parameters of localization coverage, localization errors, etc.

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