An Improved Location based Routing Protocol for WSN Using Novel Location Proximity Algorithm

C. Sivakumar, P. Latha Parthiban

Abstract--- The main characteristics of Wireless Sensor Network (WSN) include its: dynamic changing topology, multihop connections between the nodes and an effective dynamic routing protocol. These concerns are addressed in current research and it aims to improve the effective utilization of nodes in WSN. To improve the location search information of next hop, a novel Location Proximity (LP) search algorithm is used. Hence, proposed system addresses the concerns related to high energy consumption in WSN network characteristics under balanced and unbalanced network condition. The simulation results proved that proposed method fits well to changes in network than conventional algorithms. Also, the proposed method adopts well to dynamic change in network that results in increased throughput (23%) with improved lifetime (10%)and reduced energy consumption (reduced to 78%).

Keywords--- Location based routing, wireless sensor network, increased throughput, energy efficiency.

I. INTRODUCTION

Innovation in the field of wireless sensor technology has made the possibility of building the sensor nodes. This advancement has made the researches to test large scale networks over various applications in the field of WSNs. It is particularly applied for homeland and military security purposes. The WSN network has sensor nodes with one or more potential sinks. The main work of sensor node is to collect data and transmit it to sink node.

The consumption of energy in battery powered sensor hubs is a major challenge in WSN design. The consumption of energy at various protocol stack can be considered as an improvement in WSN. Since, most of the collected data by sensor nodes is of battery powered, hence, the limitations are extended to its resource allocation and data acquisition ability. The reduction of energy by such sensor nodes are not possible to a further extent. The energy wasted by sensor nodes are often related to its channel detection. Further, the wastage of energy deals with collision of packets, when same nodes sends packets over a same channel. The other reasons involved with extra consumption of energy is its channel or control overhead and routing overhead. However, it undergoes major problems like limited bandwidth and battery capacity [25].

Hence to improve the network lifetime, numerous routing protocols are proposed [26, 27]. However, the nodes mostly undergo several problems like high dissipation of energy in sink, placed at source node i.e. far away from sink nodes. To avoid the dissipation of energy and to improve network lifetime, a balanced consumption of energy protocol is required.

The energy consumption in both direct and hop by hop transmission increases as the transmission distance increases and this leads to imbalanced node condition. Hence, to solve the traffic load in network, two conditions are utilized. The traffic load is maintained in such a way that the nodes consumes lesser energy with nearby nodes than far nodes. However, this leads to increased unbalancing of network, which is resolved by balancing the network nodes.

In this paper, the problem with incompetent and imbalanced energy utilization is solved using proposed method over WSNs. We divide the entire node into segments to solve the unbalanced consumption of energy in two step:

a) Balanced Conditions and
b) Unbalanced Conditions.

The balanced condition of nodes in the network is divided into three segments, namely, High Group with Positive Rank, Middle Group with Zero Rank and Low Group with Negative Rank. The unbalanced condition of nodes in the network is divided into two segments, namely, Middle Group with Zero Rank and Low Group with Negative Group. The energy efficiency in WSN is improved using different groups or segments of balanced and unbalanced condition.

The main contributions in the proposed method is summarized as follows.

- A novel Location Proximity (LP) search algorithm is proposed to search the location of nodes and groups it into different segments based on network conditions.
- The proposed network is utilized to improve the lifetime of network under two conditions, which minimizes and balances the consumption of energy based on optimal node selection into zones.
- Extension evaluation is conducted to test the effectiveness of proposed method and results are compared with existing algorithms.

The outline of the paper is mentioned as follows: Section 2 discusses the techniques related to location based algorithms to provide better consumption of energy in WSN. Section 3 provides the proposed LP based protocol under two network conditions. Section 4 tests the proposed method with existing method under different conditions. Section 5 concludes the paper with future work.

Manuscript received February 01, 2019

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II. RELATED WORKS

Various techniques are used to obtain location and coverage distance in WSN environment, which includes, Genetic Algorithm [1], trace cost based source location privacy protection scheme [2], balanced energy adaptive routing with three phases [3], mixed integer programming framework [4,9,16] with effective Benders decomposition [19], mode-switched grid-based routing protocol [5], fair cooperative routing [6], data gathering scheme [7], game theoretical algorithm [8], k-dimensional tree algorithm with three-phase energy-balanced heuristic [10], weakest node protection mechanism [11], dynamic routing approach with reliability model [12], mobile node rotation method [13], novel coverage hole detection method [14], collaborative location-based sleep scheduling [15], tree-based diversionary routing [17], fault-tolerance structural health monitoring method [18], delaunay-based coordinate-free mechanism [20], power-aware data dissemination [21], delay-tolerant mobile sink model [22], approximation algorithm [23] and resource provisioning method [24].

These techniques discusses the strategies to improve the lifetime of nodes in WSN. They achieve better efficiency of energy in WSN with increased lifetime of network. However, the technique used in above approaches uses more-or-less the same techniques used in conventional literatures. The lifetime of the network is considerably less to process and transmit the messages over longer instance of time. To solve such limitation, the proposed method is intended to use tree based dynamic mechanism to improve the network lifetime with higher energy efficiency.

III. PROPOSED WORKLOCATION PROXIMITY SEARCH

The main contribution of proposed system involves the design of LP search algorithm, which segregates the nodes into three groups with different energy level. The network load in WSN is evaluated under two criterion, which are discussed as follows:

Network under balanced Conditions

Consider the nodes in WSN are in normal state (i.e. their energy lies in nominal value – not too high or not too low). Hence, there is no fluctuation in the network due to unbalanced nodes. The users of WSN should get the required information without losses. Hence, the participation of the nodes with nominal energy is considered higher. The node is further ranked into three groups depending on its parameters like: previous participation level in the network, its energy and compatibility with the network for the selected packets. Wilcoxon signed rank sum test [28] is carried out to perform the ranking of the network into three different clusters. The Case 1 in [28] is selected to rank all the nodes in the network.

Step 1: Calculate the Null Hypothesis

Null Hypothesis (H_0) of location based WSN with n nodes considers it the previous participation level in the network (pl_n), energy level (e_n) and compatibility (c_n) of the sensor node in the network. The mean difference, M is considered zero. ***Assume***: $M = 0 \; \forall \; pl_n = 1$, $e_n = 1$ and $c_n = 1$ (The value one represents nominal value i.e. high) otherwise $M = 1$.

Step 2: Paired Difference

The paired differences between the nodes in WSN is calculated.

$$d_n = x_n - y_n$$

The x_n and y_n represents the observation node pairs.

Step 3: Rank the Paired Difference

The results of the paired differences are ranked d_ns, without considering the signs. Hence, assign rank 1 to the smallest d_n and rank 2 to the next smallest d_n and so on. Under H_0, distribution of the differences are symmetric around '0' and the distribution of positive and negative differences are randomly distributed among the ranks.

Step 4: Labelling

The ranks are labelled along with its sign i.e. ranked based on the d_n sign.

Step 5: Wilcoxon signed rank

Calculate the Wilcoxon signed rank W^+ and W^-, which is the ranks' sum of the positive and negative d_i, respectively. Depending on the results of the test, the nodes are clustered into three different groups. The ranks of the nodes are shown in Table.1.

Table.1. Wilcoxon signed rank Values

Ranks	Cluster Group
Zero Rank	Middle Group
Positive Rank	High Group
Negative Group	Low Group

The ranks of the nodes are purely based on the three parameters considered. The cluster groups of WSN is called as middle, high and low groups. Depending on the ranks, the nodes are clustered in the overall population of WSN.

High Group – Positive Rank

The High group contains the highest ranked nodes that provide high access for the transmissions inside WSN. The network poses lowest risk for transferring the data during the balanced condition of these nodes. These nodes forms 10 – 35% of the overall nodes in the network with 75-100% of energy ratio. This provides high compatibility to WSN without much variations in its energy.

Middle Group – Zero Rank

This group account for the middle ranked nodes and this nodes uses the differences of high group nodes energy during transmission. The nodes of this group searches for the nearby optimal node in case of an optimization problem. These nodes forms 45 – 75% of the overall energy in the network. To find the optimal node from the first group, the comparisons is made between the nodes in terms of its parameters mentioned (refer Definition 1). The selection of high ranked node is done randomly to provide inter-connection between a node in the middle group to the highest ranked node in the high group.

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The difference between the pl_n, e_n and c_n of all the nodes in the high and middle group to route the information efficiently is done using (1):

$$p_j^M = r \cdot p_{i,1}^H + (1-r)\, p_{i,2}^H \quad (1)$$

$i = 1,2,\ldots,n_i$ and $j = 1,2,\ldots,n_j$.

where,

n_i is the i^{th} node of the High group

n_j is the j^{th} node of the middle group

r is the random number $\in [0,1]$

p_j^M is the j^{th} node of the Middle group

$p_{i,1}^H, p_{i,2}^H$ is the i^{th} node of the High group.

Low Group – Negative Rank

The nodes in the network takes low fitness value than the middle group. Hence, to provide stability in the network, the packet transmission is done with the nodes in High group than the nodes in Middle group. Here, the Low group nodes uses the value of energy difference of the High group and the energy values' difference than the High group nodes. Then, the nodes exchanges the packet between them. The transmissions between the high group is found by comparing the energy of the nodes. The individual risk of the nodes in the Low group is increased with two random numbers, whose value is 1. The nodes in the Low group exchanges its packet with the using (2) to attain higher benefits:

$$p_k^{Lnew} = p_k^L + 0.8e_l = 2r_{l1}\left(p_{i,1}^H - p_k^L\right) + 2r_{l2}\left(p_{i,2}^H - p_k^L\right) \quad (2)$$

where,

r_{l1} and r_{l2} are the random numbers $\in [0,1]$

e_l is the energy variation of l^{th} node in Low group

p_k^L is the l^{th} node in Low group.

The nodes in the Low group searches well the optimal points in the desired optimal point in a broader perspective than the middle group members. These nodes forms 15 – 35% of the overall energy in the network.

Network under Unbalanced Conditions

During certain times, the dynamicity of the network changes rapidly due to sudden drops of nodes, random mobility of nodes, bandwidth fluctuation and high use of energy in the nodes or energy consumption [29]. Under such conditions, the reevaluation of nodes and its ranking is needed to improve the choice of selecting the nodes for transmission. This makes the network a broad choice for transmission in WSN environment in the fitness point of view. Since, the nodes of each clusters holds different energy levels, the choice of choosing the nodes for better data transmission with reduced latency is highly risky. However, the High group remains the same in its risk level and other two groups or clusters changes w.r.t the above change and that are discussed below:

Middle Group – Zero Rank

The nodes are trying to find the best location of a node to further transmit the packet. The level of risk in choosing the node increases with decrement in rank. Here, overall energy of the nodes are constant and the location of the nodes changes often in random manner. This accounts for constant energy level in the middle group, however, the initial energy of each node increases. This is shown as:

$$\Delta n_t = 2r\mu\eta_1 + n_t - \delta \quad (3)$$

$$\mu = t_p / n_p$$

$$\eta_1 = n_{t1} g_1$$

$$n_{t1} = \sum_{y=1}^{n} t_y s$$

and

$$g_1^k = \max(g_1) - k\left(\frac{\max(g_1) - \min(g_1)}{\max(i)}\right)$$

where,

Δn_{t1} represents the energy required in excess to transmit the packet,

n_{t1} represents the overall energy of t^{th} node in deficit,

$t_y s$ represents the energy of t^{th} node,

δ represents the packet transmission information,

g_1 common risk rate for transmitting the packets between the nodes, which decreases with increase in iteration,

$\max(g_1)$ and $\min(g_1)$ represents the maximum and minimum risk level for transmitting the packet efficiently,

μ represents the constant co-efficient of each node or its location information, n_p and t_p represents the initial and final location of nodes in a group, η_1 represents the risk level in correlation with Medium group and max (i) represents the maximum iteration.

Low Group – Negative Group

The nodes in the group finds the better location of nodes using the energy information. Hence, the risk rate for packet transmissions increases with the decrements in ranking. The overall energy of the group is meagre and it is considered a single value. Here, the nodes finds the nodes with best energy, which is defined as follows:

$$\Delta n_{tl} = 4r_l\mu\eta_2 \quad (4)$$

$$r_l = 0.5 - rand \in [-0.5, 0.5]$$

$$\eta_2 = n_{t1} g_2$$

where,

Δn_{tl} represents the energy required in excess to transmit the packet,

$g_2 \in [0,1]$ represents the variable risk rate for transmitting the packets between the nodes,

μ represents the constant co-efficient of each node or its location information,

η_2 represents the risk level in correlation with Low group and uses the fitness function for undergoing more risk to improve the performance of this group.

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LP Search Algorithm

The steps of the proposed algorithm is shown here:

Location Proximity Search Algorithm

1: Initialize the parametric values pl_n, e_n, c_n, n and location of nodes (t_p,n_p)
2: Calculate the ranking based on the initial values Calculate the Fitness function [29]
3: If the network is balanced
4: Evaluate the energy of nodes and changes in location over Middle group or zone using Eq.(1)
5: Evaluate the energy of nodes and changes in location over Low group or zone using Eq.(2)
6: Calculate the Fitness function w.r.t changes in location and energy in WSN
7: End
8: If the network is unbalanced
9: Evaluate the energy of nodes and changes in location over Middle group or zone using Eq.(8)
10: Evaluate the energy of nodes and changes in location over Low group or zone using Eq.(4)
11: Calculate the Fitness function w.r.t changes in location and energy in WSN
12: Else if the network conditions is balanced Goto step 2.
13: End

IV. RESULTS AND DISCUSSIONS

The proposed method is simulated with OMNET++ simulator and the network is created with multiple sensor nodes with battery module. Here, the nodes are considered mobile and it is awakened at periodically using a broadcast by cluster heads. The proposed method uses 500 nodes in an area of 10000 × 10000 m^2. The sink nodes are made mobile which moves randomly in the network i.e. towards or away from source nodes. The parameters required for simulation is shown in Table.2.

The sensor node with higher energy tend to broadcast a wake up message to all nodes in the network and nodes which gives acknowledgement are included in the network. The high energy nodes will be considered as cluster head with each zone and the node is assigned with an id and the sink nodes are set for packet transmission.

The total energy consumed in the network is estimated as the difference between initial energy and residual energy, where the residual energy considers the transmission energy of sensor node and reception energy of sensor nodes, transmission bit energy and distance between the nodes during transmission and reception.

The proposed method helps in setting up the network load to balance the network, where the nodes are divided into clusters or zones based on its rank and location.

Table 2: Simulation Parameters

Parameter	Value
Size of the cluster	10000× 10000 m^2
Protocol Type	802.11
Propagation Space	Free Space
Propagation limit	-100 dB
Traffic Type	CBR
Data rate	2.4 Mbps
Message size	1000 bits
Packet size	5000 bits

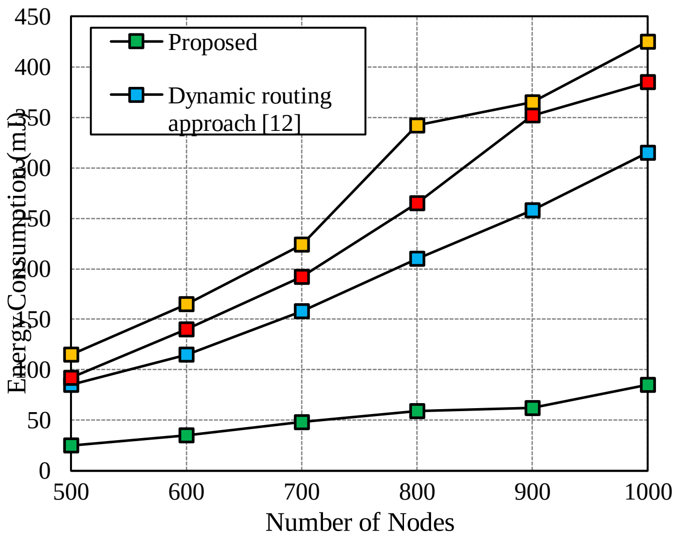

Figure 1: Energy Consumption in balanced WSN using proposed and other systems

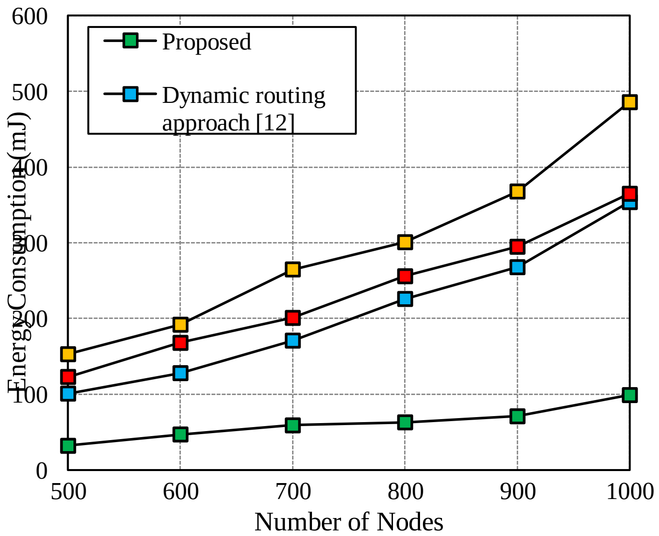

Figure 2: Energy Consumption in unbalanced WSN using proposed and other systems

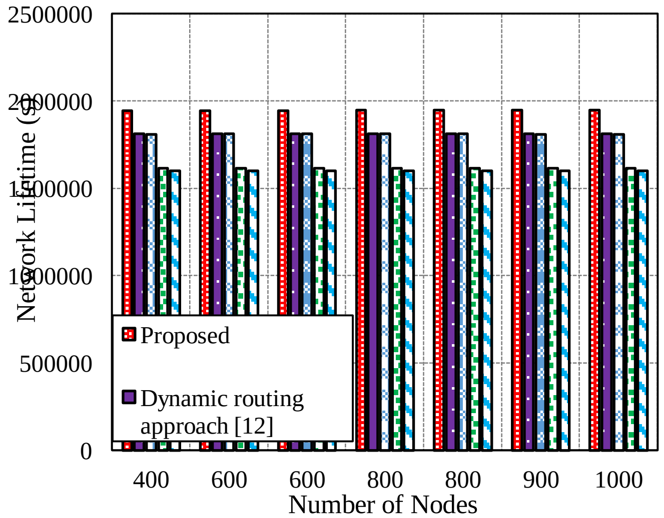

Figure 3: Network Lifetime in balanced WSN using proposed and other systems

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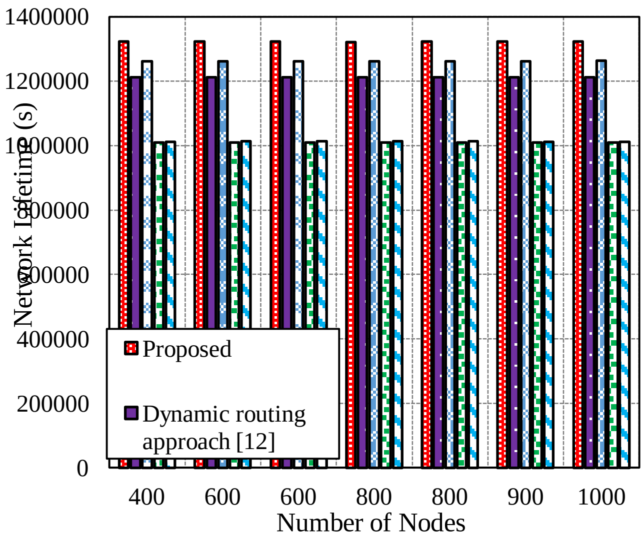

Figure 4: Network Lifetime in unbalanced WSN using proposed and other systems

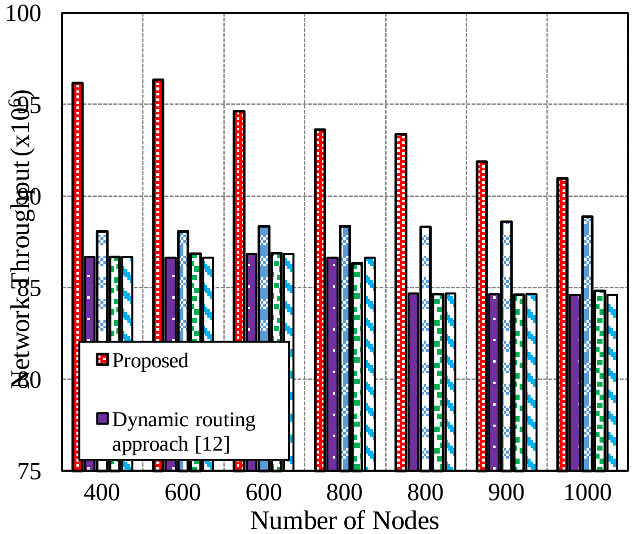

Figure 5: Network throughput in balanced WSN using proposed and other systems

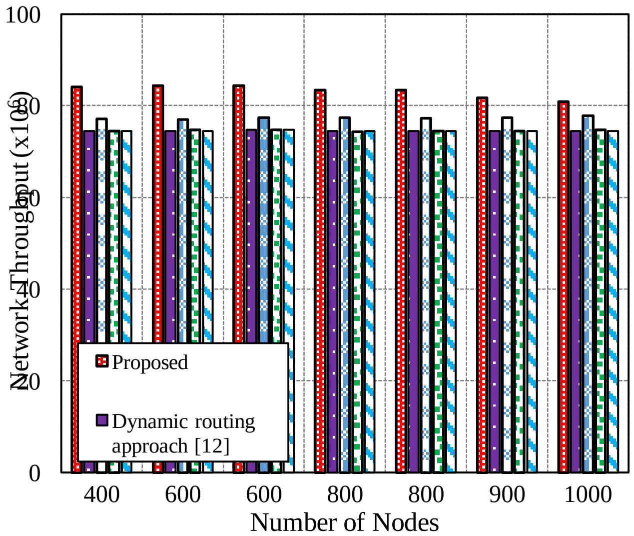

Figure 6: Network throughput in unbalanced WSN using proposed and other systems

The consumption of energy between the proposed and existing system is shown in Figure 1 for balanced network condition and Figure 2 for unbalanced network condition. The result from Figure 1 shows the reduced consumption of energy by the proposed system than other existing. This is similar in case of unbalanced condition in Figure 2. However, the different between balanced and unbalanced condition is very high, where the balanced condition offers higher consumption of energy than the unbalanced network. This is due to easier allocation of mobile nodes in balanced network as compared with unbalanced condition in network. However, proposed algorithm in both conditions provides better consumption of energy than other existing techniques.

The reduced consumption of energy leads to increased network lifetime, which is seen in Figure 3 for balanced node and Figure 4 for unbalanced nodes. The results shows that proposed method attain higher network lifetime than other existing algorithm. However, the results shows that the proposed algorithm is effective if the network is balanced and the network consumption slightly falls when the network is unbalanced, however, it is higher than existing methods. This is purely due to proper allocation of nodes within its zone in the network using the proposed algorithm. Such ranking of algorithm provides improved condition. This has enhanced the network throughput in both balanced and unbalanced conditions, which is seen in Figure 5 and Figure 6. The results shows that the network throughput for proposed method is higher than existing method in both the conditions. However, the proposed method in balanced condition attains higher throughput due to increased life than the proposed method applied in unbalanced condition.

This proves that proposed method provides a better placement of nodes in the network to attain higher lifetime. Further, it provides better allocation of nodes in the zones contributing to increased throughput with reduced consumption of energy in nodes.

V. CONCLUSIONS

In this paper, a novel LP algorithm is used to improve the energy efficiency of WSN by reducing the delay arising the network. The results over outdoor and indoor environments benefits the postulate of the proposed algorithm. The comparisons of the proposed LP with conventional protocols proves that LB algorithm provides an outstanding performance in terms of its robustness and reduced overhead. The technique is not prominently concentrated on packet drops in WSNs. However, the future work can be improved by reducing the errors arising due to increased packet drops in WSNs through a linear error control technique.The research failed to focus on the security concerns associated with the network and hence, further researches can concentrate on security mechanism.

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