Industrial Engineering
& Management Systems
Vol 15, No 3, September 2016, pp.268-277
ISSN 1598-7248 │ EISSN 2234-6473 │
http://dx.doi.org/10.7232/iems.2016.15.3.268

Enhanced Hybrid Routing Protocol for Load Balancing in WSN Using Mobile Sink Node

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(Received: July 30, 2016 / Accepted: August 19, 2016)

ABSTRACT

Load balancing is a significant technique to prolong a network's lifetime in sensor network. This paper introduces a hybrid approach named as Load Distributing Hybrid Routing Protocol (LDHRP) composed with a border node routing protocol (BDRP) and greedy forwarding (GF) strategy which will make the routing effective, especially in mobility scenarios. In an existing solution, because of the high network complexity, the data delivery latency increases. To overcome this limitation, a new approach is proposed in which the source node transmits the data to its respective destination via border nodes or greedily until the complete data is transmitted. In this way, the whole load of a network is evenly distributed among the participating nodes. However, border node is mainly responsible in aggregating data from the source and further forwards it to mobile sink; so there will be fewer chances of energy expenditure in the network. In addition to this, number of hop counts while transmitting the data will be reduced as compared to the existing solutions HRLBP and ZRP. From the simulation results, we conclude that proposed approach outperforms well than existing solutions in terms including end-to-end delay, packet loss rate and so on and thus guarantees enhancement in lifetime.

Keywords: Wireless Sensor Network (WSN), Border Nodes, Greedy Forwarding, Mobile Sinks, Load Balancing

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1. INTRODUCTION

In the current era, a scientific community treats the wireless networks as economical for the development of applications. With the rapid development of Micro-Electro-Mechanical Systems (Yadav and Yadav, 2016), tiny autonomous intelligent devices often called as sensor nodes which became the part of wireless communication technology lead to an establishment of the Wireless Sensor Network (WSN). These sensor nodes are furnished with a transducer, microprocessor, transceiver, memory and power. They are scattered densely and randomly over a monitoring region and make the network topology in order to attain a desired task. Basically, WSN is the form of ad-hoc network in which communication can take place between the wireless nodes without any requirement of fixed infrastructure. These wireless sensor nodes have the ability to self- configure, sense the environmental conditions that occur in their ambient environment and the produced results are disseminated to a corresponding data sink through single-hop or multi-hop communication for further decision-making. WSNs are low power and lossy networks (LLNs) as these intelligent sensor nodes are battery operated and have restricted power for performing the operation of sensing, computing, storing and communicating. Because of their resource constrained nature, they drain out their battery power very quickly while propagating the data towards the sink as well as towards the other nodes. Moreover, it is infeasible to periodically replace or recharge their batteries in large scale deployments. The energy diminution of a sensor node while path determination, transmission and reception of data packets etc. leads to degradation of network lifetime as well as their performance. Thus, energy conservation becomes the paramount factor while designing the WSNs. To eradicate this problem, researchers have proposed the concept of sink mobility for aggregating the information in an energy proficient manner for WSNs. With the introduction of mobile sinks, energy utilization of each node will be balanced in the more effective way in contrast to fixed sinks in which there is a possibility of occurrence of "routing hotspots" (Cheng *et al*., 2009; Di Francesco *et al*., 2011). It is assumed that mobile sink has adequate battery power to holdup long range communication than ordinary nodes available in the network.

Besides, WSN has achieved an important improvement to fulfill the requirement of ad hoc networks which are explained below:

- Controller: In WSNs, there is centralized administrator or controller for data communication between the sensor nodes within a network as compared to ad-hoc networks where each node works like a router and has no fixed infrastructure as well as controller for managing the network.
- Channel resources: The fundamental distinction of WSN is that it requires limited bandwidth for exchanging the data within a network when contrasted with ad hoc networks which require more bandwidth.
- Fault tolerance: In the case of WSNs, maintenance of sensor nodes on occurrence of failure due to power shortage, environmental interference or physical damage is hard to correct. Because of their minute size, it's difficult to locate them and hence, can restrain the network purpose. However, in ad-hoc networks fault can be easily localized and maintained in heterogeneous devices.
- Scalability: Another primary advantage that has been recognized is the magnitude of the sensor nodes which is quite large in WSNs than ad-hoc networks; hence the former is more scalable.
- Data fusion: WSNs have the key principle- data fusion to eliminate the redundancy of data from numerous nodes while routing and thus avoids the congestion problem at the sink by reducing the number of transmissions and consequently helps to achieve an energy efficient network. Still, this concept is rarely included in ad-hoc networks.
- Quality of service: Since WSNs are resource restrained because they have irreplaceable or non-rechargeable batteries with limited power and memory; hence they are unreliable in nature. On the other hand, ad-hoc networks are more reliable as they don't have any power and memory constraint.
- Security: In WSNs, sensor nodes don't have global IDs due to huge number of sensors in a network while ad-hoc networks have Global Addressing Scheme to provide unique identification to devices universally. But WSNs are characterized by several new attractive properties like ability of self-managing, self organizing or self configuring according to the demand and hence are helpful in improving the network's performance and provide security concept.

WSNs with mobile elements are application oriented and have a great potential in different areas such as fire detection systems, environment monitoring like temperature, weather, pressure, humidity, light etc, location tracking and mapping of traffic and vehicles, animals in habitation, surveillance of enemy and interruptions in the military field and so on (Tunca *et al*., 2014).

Besides their standout features over ad hoc networks, there emerges a substantial number of difficulties in WSNs due to dynamic variations such as node density. Consequently, high mobility may also fail and can disrupt the data communication due to link breakage. Moreover, failure of nodes may lead to change in network size due to which data loss may occur and hence requires rerouting of data packets. In such case, there is a need to design a network protocol that is intelligent enough to handle the failure of nodes due to battery depletion or any other environmental interference. The mechanism used in the protocol helps to find the most robust route to transport data packets to the targeted destination with the least delay.

Generally, routing in WSNs can be divided into three parts as per their network structure viz. flat, hierarchical or location-based protocols (Sara and Sridharan, 2014).

- Flat routing: In this, all sensor nodes within a network play a symmetric role i.e. of sensing data.
- Hierarchical routing: Under it, all nodes play different roles based on their capabilities i.e. some nodes perform the sensing task which has the lowest energy and the transmission task is performed by the nodes with the highest energy.
- Location-based routing: Underneath this, the geographical location information of the nodes i.e. of neighbors or sink within a network is taken into consideration. With the help of HELLO messages or any other location service scheme such as Global Positioning System (GPS), positions of the nodes especially mobile nodes can be located.

To make the routing successful via effective paths, the WSN faces some challenging task that is the establishment of route between them. Routing may be affected because of various obstacles like mobility patterns, variation in the number of nodes, dynamical changes etc. in the environment of WSN. These problems make the operation of routing protocol inappropriate. In order to design the energy efficient routing protocol for expanding the network lifetime, it's vital process to maintain the up-to-date information regarding the surrounding nodes either via flooding control packets like in topology-based routing protocol or by means of Hello beaconing messages as in position based routing protocols (Madani *et al*., 2010). However, the amount of

Hello messages exchanged should be kept the lowest to abstain the network from overburden with these exchanged messages, as it incurs numerous issues in network performance in terms of overheads, collisions and contentions. The taxonomy of the topology-based and position-based routing protocols is described in Table 1 at the end of the introduction.

The existing technique is entirely based on topology information in which sink periodically advertises its presence information messages to its neighboring nodes. By utilizing this information, nodes construct the Directed Acyclic Graph (DAG) to the sink and data transmission takes place either proactively or reactively based on node's DAG condition and the load is balanced among the nodes using data mule technique. This process helps to balance the load but on the other hand, the data delivery latency among the network increases which can have an effect on the energy efficiency, hence the network lifetime minimizes.

In this paper, a Load Distributing Hybrid Routing Protocol (LDHRP) which is a fusion of border-node based routing protocol and greedy forwarding routing has been presented to balance the network's load in more efficient way and to address the issue of data delivery latency in topology based WSNs. Aiming at solving this problem, hybrid routing technique is adopted which exploits the concept of geographical location-based routing for optimal node selection for relaying the data. In the proposed technique, border node acts as a relay node that is selected by considering the source's transmission range. The elected border node forwards the aggregated data to the respective destination (mobile sink) with a minimal number of hops that result in lower energy consumption as well as data delivery delay. Moreover, complete load of the network will be balanced between the ordinary nodes and border nodes. In case border node approach fails to transmit, the data will be routed via greedy forwarding routing.

Related Work

Bhende (2012) discussed about various limitations of topology viz. topology awareness and topology control in WSNs to address issues like power saving, restricted bandwidth, scalability, dynamical topological changes in network etc. The author surveyed that topology awareness mechanism lacks self-optimizing and configuring features in case variations occur in network topology but topology control mechanism aimed to provide energy efficient routing and communication reliability and hence improved network lifetime.

Jin *et al.* (2009) studied about various position-based routing protocols for WSNs to transmit the data in an effective and efficient manner by searching optimal routes in a network. The author discussed about four major classes that utilize position information named as 'flooding-based routing', 'curve-based routing', 'grid-based routing' and 'ant-based intelligent routing' and also outlined the relationship as well as their contribution depending

Table1. Difference between routing protocols for WSNs

Routing Protocols	Topology-based protocols	Position-based protocols
Feature	• Maintain the route information in a network	• Use location service scheme for communication
Categories	• Proactive, Reactive or Hybrid	• Delay tolerant or Non-delay tolerant
Examples	• Optimized Link State Routing (OLSR) • Destination sequenced Distance Vector (DSDV) • Ad-hoc On-Demand Vector Routing (AODV) • Dynamic Source Routing (DSR) • Zone Routing Protocol (ZRP)	• Greedy Perimeter Stateless Routing (GPSR) • Distance Routing Effect Algorithm for Mobility (DREAM) • Most Forward within Radius (MFR) • Border-node based Most Forward within Radius (B-MFR)
Pros	• Less resource consumption like bandwidth • Can send any type of messages i.e. unicast, multicast and broadcast • Provide route between source and destination node	• Lower processing overhead thus has good performance • No need of route creation and maintenance among nodes, thus avoids delays and don't occupy much of the network bandwidth. • With increase in mobility, stability also increases • Scale well and ensure data delivery even in mobile environments
Cons	• Undesired flooding results in limited performance • More overhead due to routing information or because of route discovery mechanism and has more delay • Due to dynamical changes or mobility, the desired path may get broken or lost	• Require Global Positioning System (GPS) • Sometimes location server goes into deadlock state • Satellite signal doesn't reach in tunnel, so GPS device stops working there

upon the popular parameters.

Raw and Lobiyal (2010) proposed a protocol addressed as Border-node based Most Forward within Radius (B-MFR) routing protocol for vehicular networks for searching the optimal routes with minimum delay while transferring the data. The addressed protocol takes into account only border nodes by exploiting position information of neighboring nodes and destination. The results of proposed protocol were compared with traditional MFR and found that proposed protocol achieved reduction in data delivery latency with minimum number of hop counts from the source node to destination even when the node density was high.

Zhang and Wolff (2007) proposed a Border node Based Routing (BBR) protocol for mobile ad hoc networks with less dense nodes. The proposed protocol composed of two major parts, first is neighbor discovery which periodically floods Hello messages to find out one-hop neighbor information and second one is border node selection algorithm which was used to determine the best border node for relaying the data packet in a network. From the comparison, it was evaluated that BBR outperforms DSR and produces better results with respect to Packet Delivery Ratio (PDR) and less delay under frequently changing conditions.

Batish *et al.* (2015) evaluated the performance of different position based protocols like DSR, GPSR, DSDV, BMFR and Trusted Border node based Most Forward within Radius routing protocol (TB-MFR) by taking into account border nodes for vehicular networks and compared these existing protocols on the basis of some criteria viz. size of the network, different number of nodes and network simulation duration. From the results, it was found that TB-MFR provided good results in PDR and throughput than all the other protocols, DSR gave better throughput, GPSR minimized end-to-end delay and BMFR gave ample results and was surely better than DSR, DSDV, and GPSR.

Palani *et al.* (2015) proposed a protocol named as Hybrid Routing Load Balancing Protocol (HRLBP) for mobile data collectors (MDCs) where route from source to respective destination is determined using Hybrid Routing Protocol (HRP) and the load was balanced in a network by employing data mules. They concluded from the results that proposed protocol can enlarge PDR and residual energy with decreased delivery delay and packets loss as compared to existing techniques HRP and Rendezvous Point selection with a Mobile Sink (RP-MS).

Singh *et al.* (2012) proposed a hybrid technique addressed as Zone Routing Protocol (ZRP) for WSNs. The analyzed performance of ZRP demonstrates that there was reduction in control overhead that was caused by proactive routing and also in latency that occurred during the discovery of route while reactive routing. In addition, proposed hybrid model achieved better throughput by minimizing the flooding process to a limited scope instead of entire network and hence guaranteed effective network performance.

Safdar *et al.* (2012) proposed a HRP for proficiently handling the changing position of multiple mobile sink in WSNs. In this paper, the nodes that are close to the data sink maintain DAGs i.e. up to fewer hops instead for an entire network. Sink discovery process is initiated only when nodes don’t have a path to sink. From the simulation results, it was found that proposed protocol reduces the number of packet retransmissions as well as required low standing cost for maintaining the DAGs thereby, enhanced the life of the network even under high mobility scenarios.

Liu *et al.* (2016) proposed a Grid-based Load-balanced Routing Method (GLRM) by taking into consideration single mobile sink with controlled mobility for data collection in WSN. The proposed protocol elected cell-header on certain metrics like number of packets to be relayed by the node, Euclidian distance as well as based on their residual energy. Furthermore, it also maintained best paths towards the recent location of mobile sink. The performance of proposed protocol was analyzed and evaluated and it was found that proposed protocol balanced the load and provided better network performance by consuming less amount of energy and hence ensured larger network lifetime.

Jung and Cho (2010) proposed a load balancing system that takes into account multiple sinks that act as a mobile robots for managing the sub-network with the aim to increase the lifetime of a network. The results concluded that the proposed system improves the network lifetime as well as its performance to a greater extent by evenly distributing the load of the nodes among mobile elements and managing the energy in more efficient manner.

Guan *et al.* (2010) proposed a novel data gathering algorithm for WSNs for balancing the load and to save power of sensor nodes concurrently fulfilling the demands of applications or end-users. The proposed algorithm initially divided the network nodes into different levels by considering their distance towards the sink and after that, sensing zones were partitioned into clusters and at last, routing trees were created between nodes and sink by taking certain selected parameters like energy as well as node’s communication cost. The results drawn from the simulation concludes that proposed protocol gained more improvement in network lifetime with uniform power utilization among the nodes.

Jea *et al.* (2005) proposed multiple mobility elements in order to obtain the coverage of an entire network region in both deterministic and randomized ways since employing a single mobile sink, network does not scale well and there is more traffic overhead. Then load balancing was presented to balance load for data collection process by assigning nodes equally among each sink. Also, an adaptive movement algorithm was proposed for handling the increased load in areas. Simulation result shows benefits in balancing the load.

The remainder of the research article is arranged as follows: Section 2 discusses the proposed LDHRP protocol and its flowchart. Section 3 gives the explanation about the network model of proposed technique with assumptions. Output of results is presented in Section 4. At last, Section 5 represents the conclusion of the article.

2. PROPOSED LOAD DISTRIBUTING HYBRID ROUTING PROTOCOL

This section presents our novelty that is proposed hybrid approach- LDHRP in WSN domain for better adaptability in event-driven networks since WSN has great potential in time critical applications like Intrusion Detection System in military applications for sensing intruders on bases, monitoring enemy troop or vehicle movements, Fire Detection in buildings, forests etc. (Sun *et al.*, 2011). However, energy consumption while data transmission and reception among the nodes can restrict the network lifetime.

In order to gain data reliability with least energy utilization and balanced load in networks with mobility, LDHRP is developed which employs the concept of BDRP and GF approach for the discovery of the best possible node for transmitting the data. This approach proves to be appropriate for successful data communication within a timestamp as it uses geographical position of the nodes. It differs from topology based protocols as it receives the neighbor node information with the help of GPS or any location service scheme instead of maintaining a large amount of information and then storing it in routing table. Thus proposed approach is considered as the best solution for efficient communication.

The operation of LDHRP comprises of three major phases. In the initialization phase, each node forms its own routing zone within a network and each node has its own fixed transmission range for maintaining the connectivity in a network. Source node has neighbor table present with it and checks its table to select the border node (BN) or any other intermediate node (IN). The BN or IN may further contain route information to the destination within its table and transmit a data packet to the mobile sink (MS). This effective way of communication helps to make the network more energy efficient. However, this form of communication has certain limitations and one of them is the probability of appearance of two or more border nodes on source's transmission range i.e. BNs are at equidistant from the destination. This confliction between nodes makes the selection of an appropriate border node for data transmission difficult, which in turn, makes the routing decision complex (Monika and Singh, 2012).

As we compare the proposed approach with traditional routing techniques, it requires only physical location information about the nodes for routing in an efficient manner. So there will be fewer chances of complexity in this protocol. Initially, there is no energy consumption by the sensor nodes since they are in sleep mode and wakeup only when nodes know it's time to transmit the data packets. During the initialization phase, computation of position and distance information of all network nodes is performed. After the reception of this information, respective information is accumulated in the neighbor table of each network node. The position of MS is obtained with the help of GPS device or using any other localization algorithm. All nodes acquire this information of its neighboring nodes as well as shares with other nodes and even to MSs in a network. At the same time, nodes and sink send back an acknowledgment (ACK) to the respective nodes and sinks. In this way, all the nodes get aware about the location of other nodes and distances among them within their routing zone by exchanging their neighbor's node information route tables with each other. Hence, source and sink nodes need not to broadcast HELLO messages periodically to each other to tell their existence and location information in the network which in turn, saves node's battery power. With this, the initial phase is completed. In the setup phase, optimal node selection is done based on the hybrid approach.

Next, in data transfer phase, when a source node has a data to forward to the destination, can directly transmit to MS if it is reachable, otherwise firstly BN (relay node) aggregates the data from the source node and forwards it to their respective MS if it's in range and the algorithm ends. Otherwise, BN transmits the data to next BN that lies on its radio transmission range. Now it's the responsibility of current BN to further transmit the received data of the previous node as well as of its own to the destination. The process will continue till the data gets transmitted to the respective MS. But in case BN is not found, it will follow greedy routing strategy. In this, each node makes a forwarding decision for packet transmission by choosing the intermediate node that has relatively larger available residual energy and is more progressed towards the destination. The current source node will select the newest next hop node every time based on these criterions. This property of selection of candidate node makes this approach a loop-free. The process repeats until forwarding node finds out the destination node and terminates when a packet reaches its final destination.

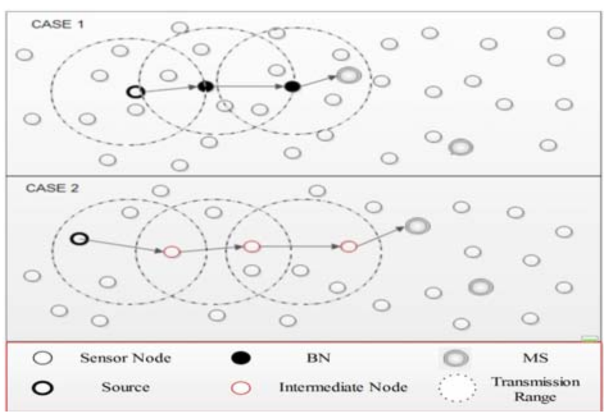

Figure 1. Proposed LDHRP scenario.

FLOWCHART OF PROPOSED HYBRID APPROACH

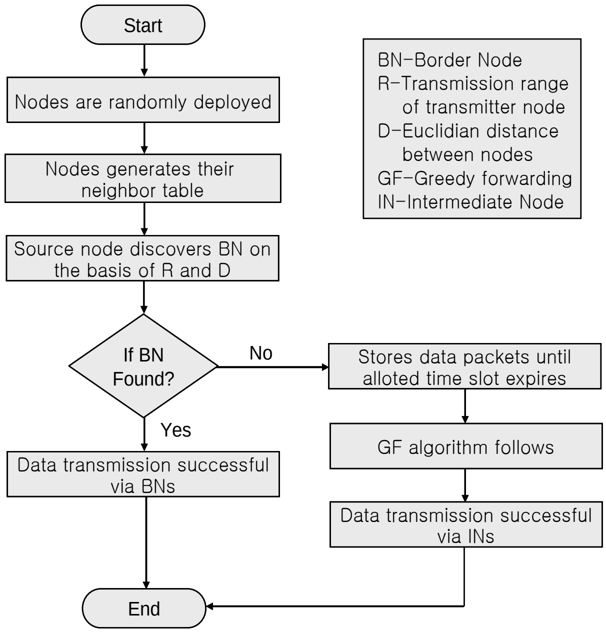

Figure 2. Data transmission in LDHRP.

Figure 1 depicts the working scenario of proposed approach in WSN by considering two cases. In this, number of homogeneous sensor nodes are arbitrarily scattered across the monitoring area. The mobile sinks are used for data collection from the sensor nodes. According to case 1, the source considers the BN as the optimal relay node for data transmission since it decreases the number of hops required for data delivery from a source to MS. Source transmits the data to BN that lies on its transmission range and has the maximum projection distance towards the MS. In case 2, if source fails to find BN on its transmission range then it routes the data by greedily selecting the intermediate node that has more remaining energy and closest distance towards the MS.

3. SYSTEM DESIGN

3.1 Assumptions

The proposed approach takes into account various assumptions for network model that are as follows:

- The links among all sensor nodes are symmetric
- All nodes are location aware by taking the concept of localization mechanisms

3.2 Network Model

Our proposed network model is composed of uniformly and randomly deployed sensor nodes and mobile sinks in an area of 1,000×1,000. The MS employed with unpredictable capabilities in terms of battery power, data gathering, processing as well as storage volume etc. as compared to other available sensor nodes in a network. Each node in a network has its own routing zone and fixed transmission range from which border node or intermediate node is elected to aggregate the data from current sending node.

In our network setup, each node initially creates its own neighbor table that consists of the information regarding the neighboring nodes that is node id, location information as well as distances among the nodes by negotiation procedure i.e. through Hello beaconing messages within a network. After that, relaying scheme is invoked in which source node selects the BN (relay node) which is responsible for data transmission to the destination. The transmission range of a source node helps to find out an appropriate BN for the data transmission. The BNs that are in the line of sight towards the destination are considered as the best next-hop for effective communication. Here BNs can be named as $B_1, B_2, \cdots, B_n$. Let us suppose the source node transmits data to the selected BN i.e. B_1 and if B_1 receives the data packets effectively, then it sends the ACK to the respective source node. In case the destination is too far from BNs, then selected BNs further have to find out the next BNs by using its transmission range, distance and projection information on the line joining source and destination. In this way, the complete data is transmitted to the destination via BNs and the first approach of a hybrid routing is terminated. But if the BNs are at equal distance from the transmitter (either source node or BNs), then the sender firstly computes the trust value of the nodes. Example:-let us suppose the trust value of the nodes are considered as T_i and T_j and if T_i has the highest trust value as compared to T_j then sender gives the highest priority to T_i for forwarding the data.

In the first phase, if BN fails to find next-hop node i.e. another BN for data transmission to the destination then the second approach named as greedy routing algorithm will be initiated. GF follows the process in which intermediate node with the highest priority on the basis of energy as well as closest in the distance is selected as a relay for data transmission process. In this way, data transmission takes place via intermediate nodes. This process continues until the data is successfully received by the destination and the algorithm ends.

3.3 Energy Consumption in LDHRP

When two nodes interact with each other, certain amount of energy is consumed while sensing the communication range of a node, transmitting the data to relay node as well as receiving the packets by that node over the distance covered by them. In setup phase, energy consumed while sensing the communication range of the sensor node is assumed to be negligible.

In data transfer phase, energy consumption while transmitting the packets of M bits from the source node towards the relay node over the distance D is given by Eq. (1):

$$EC_{tx} = M \times E_e + M \times E_a \times D^2 \quad (1)$$

Where EC_{tx} is the energy consumption while data packets' transmission, M is the number of bits to be transmitted, E_e is the energy consumption in transmission or reception electronics, E_a is the energy consumption in transmitting amplifier and D is the distance between the nodes.

Energy consumption while receiving the packets of M bits by the relay node from the source node is expressed by Eq. (2):

$$EC_{rx} = M \times E_e \quad (2)$$

EC_{rx} is the energy consumption while data packets' reception.

4. SIMULATION RESULTS

4.1 Simulation Setup

This section discusses the simulation results of a proposed protocol LDHRP. The performance evaluation of the proposed approach in WSN is carried out using network simulator version 2 (NS2) with respect to various selected parameters such as transmission range and rate. Table 2 summarizes the simulation environment settings. The size of the network is 1,000×1,000 meter that considers 100 sensor nodes in the entire region. Simulation time taken is 100 seconds.

4.2 Performance Metrics

We evaluate the performance of LDHRP technique with the existing techniques i.e. HRLBP and ZRP by taking constant range with variable rate and constant rate with variable range. The various parameters are analyzed and are discussed as follows:

1) Average End-to-End Delay: Packet delay can be defined by the amount of time taken by data packets to arrive at the destination node from the source node via a multi-hop transmission. It is expressed in milliseconds. The delay may happen because of propagation, transmission, processing as well as queuing delay that occurs at each node. The decrease in the value of delay means the protocol has better performance.
2) Packet Delivery Ratio (PDR): It is the fraction of amount of data packets obtained successfully at the destination node upon the total amount of packets propagated by the source node. It is expressed in percentage. The increase in the value of PDR indicates the better performance of the routing protocol.

Table 2. Environmental settings

Parameter	Setting Value
Topology size	1,000×1,000
Number of nodes	100
Packet size	512bytes
Transmission rate	100, 150, 200, 250, 300Kb
Transmission range	250 to 450m
MAC layer protocol	802.11
Traffic type	Constant Bit Rate (CBR)
Speed of sink	20m/s
Node's initial energy	25.1J
Idle power	1.2w
Transmitting power	1.5w
Receiving power	1.0w
Simulation duration	100 seconds

3) Packet Loss Rate: It is the performance metric that is used to evaluate the number of data packages that are being dropped as a result of buffer overflow or due to any other reason like congestion. Lower the value of packet loss means the better performance of the protocol.
4) Residual Energy: It is the remainder energy that network nodes are left with after performing all the computations and data transmissions. It is expressed in Joules. Highest residual energy means more energy efficient protocol.

4.3 Performance Evaluation

By keeping constant rate i.e. 300Kb but varying range of the network i.e. 250, 300, 350, 400 and 450 m the above-mentioned performance metrics are analyzed. Figures 3(a), 4(c), 5(e) and 6(g) demonstrate the output graphically for different transmission range scenarios. Blue line represents the LDHRP performance; red represents the HRLBP performance and green shows the ZRP performance. Similarly, by keeping constant range i.e. 250m but varying traffic rate i.e. 100, 150, 200, 250 and 300 m/s the above defined metrics are again evaluated. Figures 3(b), 4(d), 5(f) and 6(h) present the graphical output for different transmission rate scenarios.

Figure 3 reveals the proposed approach has less end-to-end delay as compared to existing techniques when there are variations in range from 250 to 450 m as well as when rate is increased from 100 to 300Kb. It implies that LDHRP performs better relating to end-to-end delay while the data transmission than HRLBP and ZRP. HRLBP has more delay than the proposed one because of its complex routing. ZRP has more delay due to route discovery process while reactive routing. Figure 3(a) presents that when range is increased, the delay of LDHRP is 12.72% less than the existing HRLBP and ZRP protocol, since it transmits data via border nodes or INs with minimum number of hops from source to sink. Figure 3(b) shows that when the rate is increased, the delay of LDHRP is 9.88% less than HRLBP as well as ZRP.

Figure 4 presents that the proposed approach generates high PDR than existing methods at diverse range and rate. LDHRP has higher PDR than the HRLBP and ZRP. It suggests that LDHRP is sending a larger quantity of data packets per unit time than the other protocols. Figure 4(c) presents that when range is increased, the delivery ratio of LDHRP is 96.5% higher than the existing HRLBP and ZRP protocol. Figure 4(d) reveals that when the rate is increased the delivery ratio of LDHRP is 95.3% more than the other two protocols.

Figure 5 shows the proposed approach has lower packet loss rate when contrasted with existing techniques at various range and rate. In terms of packet loss, LDHRP outperforms HRLBP and ZRP. The existing techniques have increased packet drops due to buffer overflow at nodes than proposed strategy. Figure 5(e) presents that when range is increased, the packet drops of LDHRP is less than the existing HRLBP and ZRP protocol since it conveys data to the sink via relay nodes only. From the Figure 5(f) it can be observed that with increase in rate, the packet drops of LDHRP are less than HRLBP and ZRP.

Figure 6 presents that the proposed approach has higher residual energy in contrast to the existing strategies at different range as well as rate. LDHRP gives better results with balanced energy consumption of nodes as compared to the HRLBP. In this way, proposed is better routing protocol in terms of residual energy than the others. Figure 6(g) presents that when range is increased, the residual energy of LDHRP is 20.97% higher than the existing HRLBP and ZRP protocol. From the Figure 6(h) it is concluded that when the rate is increased the residual energy of LDHRP is 19.37% more than HRLBP as well as ZRP.

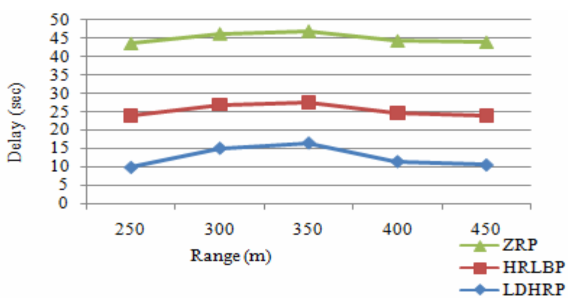

Fig. 3(a)

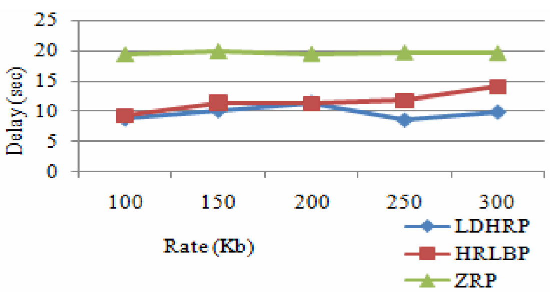

Fig. 3(b)

Figure 3. Average end-to-end delay 3(a) delay vs. range 3(b) delay vs. rate.

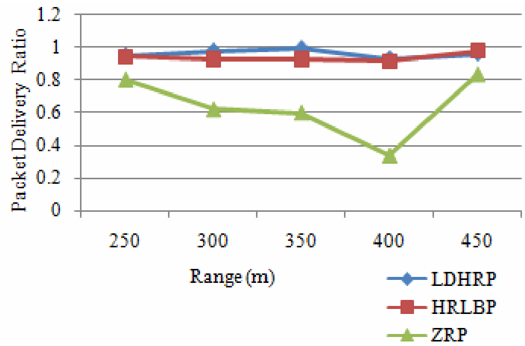

Fig. 4(c)

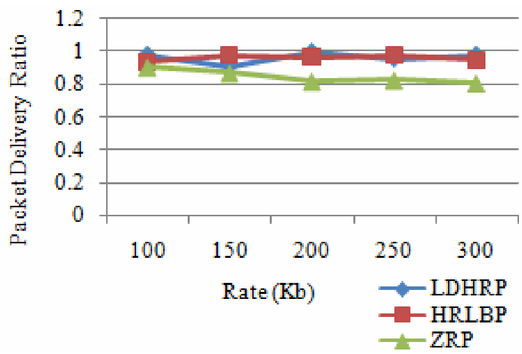

Fig. 4(d)

Figure 4. Packet delivery ratio 4(c) PDR vs. range, 4(d) PDR vs. rate.

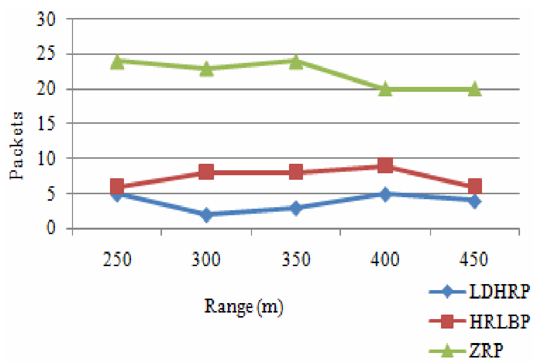

Fig. 5(e)

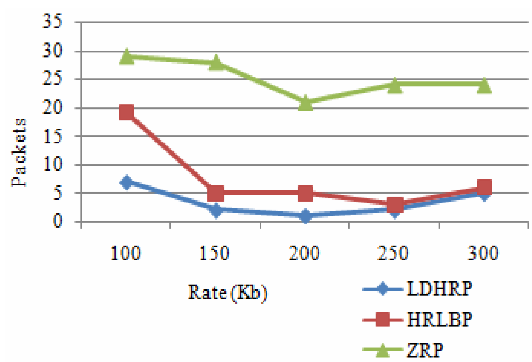

Fig. 5(f)

Figure 5. Packet loss rate 5(e) packets vs. range 5(f) packets vs. rate

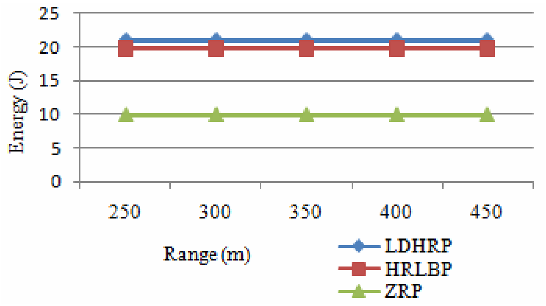

Fig. 6(g)

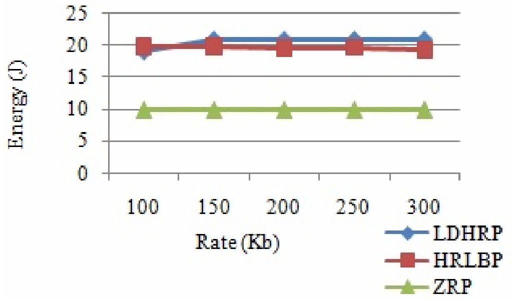

Fig. 6(h)

Figure 6. Residual energy 6(g) energy vs. range 6(h) energy vs. rate.

Table 3. Performance comparison among routing protocols

	HRLBP	ZRP	LDHRP
Protocol Type	Hybrid	Hybrid	Hybrid
Classification	Hierarchical	Flat	Location-based
Complexity	High	High	Low
Resource Awareness	Yes	Yes	Yes
Mobility	Limited	Limited	Supported
Energy Efficient	Limited	No	Yes
Scalability	Fair	Limited	Good
Load Balancing	Fair	Limited	Good

The HRLBP, ZRP and LDHRP have been compared according to their performances and are illustrated in the Table 3.

5. CONCLUSION

In this research article, we have proposed a hybrid approach i.e. LDHRP for WSN, to balance the load in a network which can directly affect network's lifetime. The existing hybrid technique for WSN doesn't bother the latency period of the network. But our proposed hybrid scheme, helps to reduce the latency via intermediate nodes which are responsible for data aggregation from source and further forwarding data to the destination. We analyzed the results of proposed approach and compared with the conventional routing schemes and found that this novel hybrid scheme provides us with guarantee to perform well either in low as well as highly dense environments. The conclusion drawn from the simulation results illustrate that protocol is highly energy efficient and balances the load as compared to the existing techniques using simulator NS2 with respect to end-to-end delay, packet delivery ratio, data packet loss rate and residual energy. In future work, we will make further extension by integrating this proposed approach with MAC protocol and making it adapt to the surrounding environment.

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