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Research paper

Improved Energy Efficient Wireless Sensor Networks Using Balanced Multi-Hop Routing Protocol

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Abstract

In this paper, consumption of energy by the sensor nodes in Wireless Sensor Nodes (WSNs) is been handled effectively using a combined technique. The objective of the paper is to increase the network lifetime with dynamic routing protocol. Here, the proposed routing algorithm, named Balanced Multi-Hop (BMH) protocol combines the multi-hop and direct transmission communication. This method further uses Dijkstra algorithm to route the packets between the sensor nodes and base station in mobile network. This method avoids the use of central router to control the other nodes. The results of the proposed method is tested against various result metrics. The evaluation over other existing methods prove that the BMH method achieves higher lifetime and high network throughput.

Keywords: *Dijkstra protocol, wireless sensor network, energy-efficient routing, least-hop routing.*

1. Introduction

In recent years, the effective utilization of sensor nodes in wireless sensor networks (WSN) to improve the power consumption is one the recent trends in current research [3]. Routing of the nodes in the WSN plays a major role in consuming the energy. Thus energy efficient routing protocol is considered as a major goal for most researches to attain reduced power consumption in networks. Conventional techniques can be classified into two types: direct transmission [1-3] and multi hop transmission [4-18].

In direct transmission, the data is sent directly from nodes to base station. The cost of transmission increases exponentially as the distance increases and hence far nodes exhausts larger power. Thus larger power is consumed by the nodes in the network and leads to excessive battery drain. This problem is avoided by the use of multihop transmission, where the nodes cooperatively work by transmitting the packets through intermediate nodes. The distance in entire network is thus divided into smaller portions. Even if the multihop technique distributesuniformlythe transmission cost between the sensor nodes, however, minimum consumption of energy is not definite. Thus, total energy cost of multihop transmission is higher than direct transmission [5].

Further, there are many protocol investigates to reduce the consumption of power in network. Such protocols further extended to improve the residual energy of nodes. Hence, the lifetime of network is increased by minimizing the node energy variance.

These techniques in [1-18] 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 a combined mechanism to improve the network lifetime with higher energy efficiency.

Hence, to attain improved lifetime in WSN, the proposed method uses Balanced MultiHop algorithm (BMH) with Dijkstra algorithm for route establishment. This algorithm serves to combine the direct transmission and multihop transmission for the near and far nodes in the network, respectively. This helps to reduce the consumption of energy in the network by balancing the nodes in network. It increases the lifetime of the network with reduced energy cost in network through direct transmission and multihop transmission.

2. Proposed Method

The proposed method uses modified Dijkstra protocol to improve the energy efficiency in multi-hop environment and to serve the purpose of load balancing in network. This section discusses the utilization of proposed algorithm in routing of sensor nodes in WSN.

The main aim is to increase the lifetime of the network i.e. life of the sensor nodes before its death.

The proposed method uses centralized approach to route the packets from sensor nodes to base station.

The timeslots for the proposed algorithm consist of three phases: initiation,setup and steadystate phase, which is shown in Figure 1.

The entire operation has two phases, where initiation phase is the initial phase and the second phase has two rounds, which include setup and steady state phase.

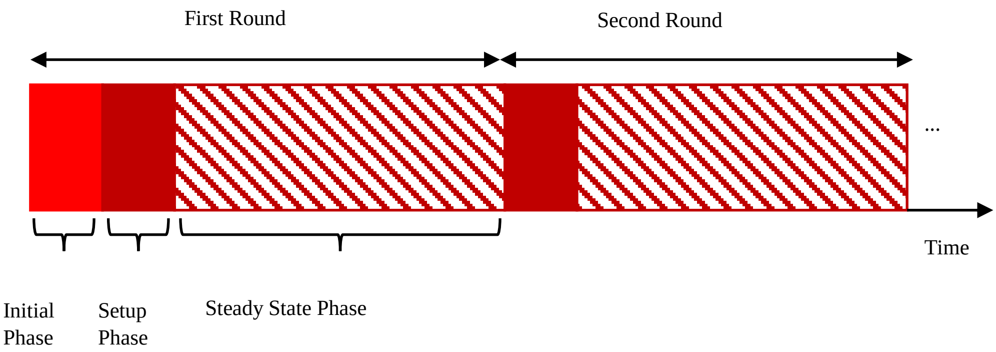

Figure 1: Proposed timeslots

Initiation phase

The initiation phase starts after the deployment of the sensor nodes. The base station broadcast a route request message to the entire nodes for the purpose of self-identification. The sensor nodes repliesfor the message request for the purpose of authenticating within the network using a control packet. The data packet consists of location dimension, identification value and initial energy. The base station uses the location of nodes to classify it to near and far nodes, which is classified as per distance (d_i) of nodes from base station. The structure of network using the proposed protocol is shown in Figure 2.

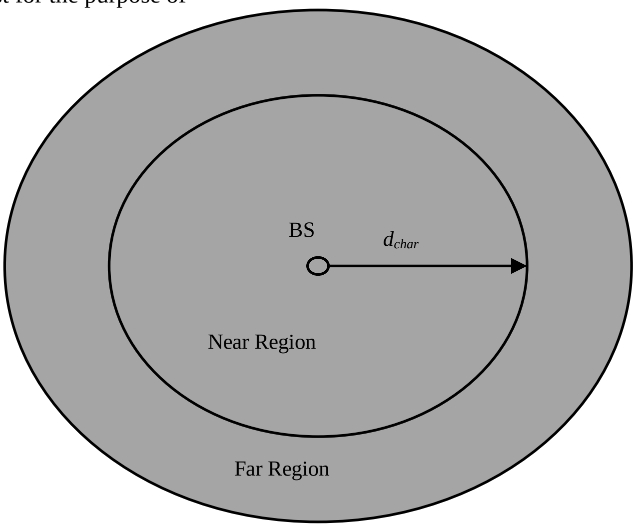

Figure 2: Network structure using proposed protocol

The nodes lying inside the near node when d_i is lesser than d_{char}(characteristic distance, which decides to use direct transmission or multi hop) and vice versa. When the characteristic distance is lesser than d_i, multi hop transmission is used and on the other hand if the characteristic distance is greater than d_i, direct transmission is used. It depends entirely on design parameter, which is given by,

$$d_{char} = \sqrt{\frac{-b+\sqrt{b^2-4ac}}{2a}} \quad (1)$$

Where,
$a = \varepsilon_{mp}$, $b = -0.5\varepsilon_{fs}$,$c = -2E_{elec}$.
ε_{mp} is themultipath loss coefficient
$\varepsilon_{fs}$is the free space loss coefficient
$E_{elec}$is the consumed energy per bit in during transmission or reception.

Setup phase

The optimal paths are assigned during this phase for transmission of sensor data to base station. Here, the weight matrix is formed using energy level and location information about the nodes in network. This is exploited using base station and it uses Dijkstra algorithm to find the optimal route for each sensor node to its base station.Once the paths for nodes are known, base station announces the paths to all nodes. The sensor nodes builds and updates the routing table with nearby hop node. Also, the routing table is updated with far nodes for the upcoming rounds. However, the direct transmission is used by near nodes and hence there the requirement of routing table is not defined here. This reduces well the cost of energy consumption to setup and update the routing table for nearby nodes.

Algorithm 1: Dijkstra Algorithm

Step: 1.	Assign the nodes with tentative cost i.e. zero for source node S and infinity for other nodes.
Step: 2.	Have a visited nodes group Q′ and it initiates with Source node S.
Step: 3.	For present node (u), contemplate its neighbour unvisited nodes v ϵ Q.
Step: 4.	Estimate the total cost of energy of u + energy to reach v from u.
Step: 5.	If total cost <present cost of node v, update the node with new value.
Step: 6.	Repeat the process for all nodes, which are neighbours to v
Step: 7.	Find the node near v with minimum cost in terms of current node u
Step: 8.	Remove node u from unvisited set of nodes Qand hence mark the node as u ϵ Q′
Step: 9.	End the process
Step: 10.	Return to step 3.

Steady-state phase

In this phase, the nodes are attached with energy levels and it is allowed to transmit to next hop nodes. The packets are passed through intermediate nodes until it reaches the base station finally. After the reception of packets by the base station, the energy information is extracted. Thus weight matrix is updated with the energy information.

The entire process is repeated for all the nodes in the network and this is seen as flowchart in figure 3 and in Figure 4.

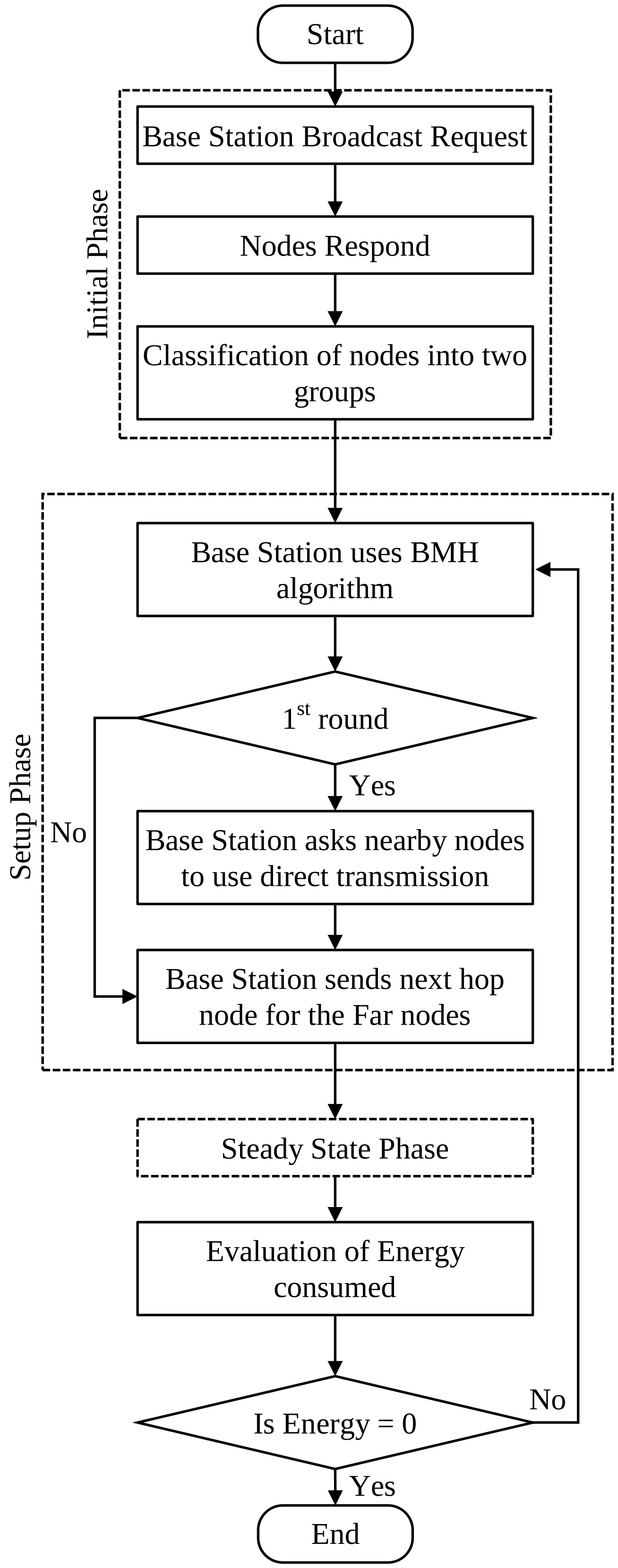

Figure 3: BEERAD protocol flowchart

//Energy Estimation
$E_t = 0$
For all nodes $v \in V$
  $E_t = E_t + E_{RS}$
End
$E_{avq} = E_t / N$
//Initialization
For all nodes $v \in V$
  If $v = S$
    $v_{cost} = 0$
  End
  If $E_{RS} \geq Eavg$
    v_{cost} = infinity
    $v_{previous}$ = []
    $v \in Q$
  End
End
Main iteration
While$Q$!=[]
  U=min(Q,$cost$)
  Remove u from q
  If$u = D$
    Break
  End
  For$v \in Q$ and u
    If$u_{cost} + cost(u,v) < v_{cost}$
      $V_{cost} = u_{cost} + cost(u,v)$
      $V_{previous} = u$
    End
  End
End
Return$previous$[]

Figure 4: Proposed algorithm

3. Evaluation and discussions

The proposed routing algorithm is simulated using OMNET++ simulator and sensor nodes are created with a battery module. The nodes are dynamic and are awakened in periodical manner with a broadcast message by the individual cluster head.The evaluation uses 24 nodes in a 1000×1000 m^2 area. The sink node is positioned at a nearest location from the source nodes, which is shown in Figure 5.The simulation parameters is given in Table.1.

Figure 5: Network Setup

The nodes with high energy broadcast a message and the other nodes will reply back to this broadcast message. The high energy nodes after receiving reply from the nearby nodes sets the high energy nodes as cluster head. Hence node is assigned with an id and hence destination node is set for transmission of packets. The route is established using proposed routing algorithm and path loss model is utilized for simulation.

Table 1: Simulation Parameters

Parameter	**Value**
Size of the cluster	1000 × 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

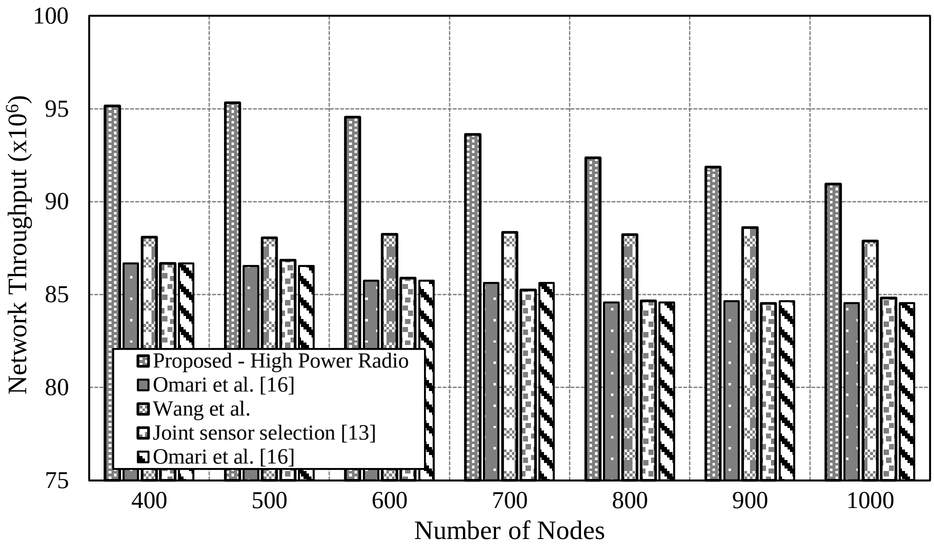

Figure 6: Energy consumption in WSN using direct and multihop transmission

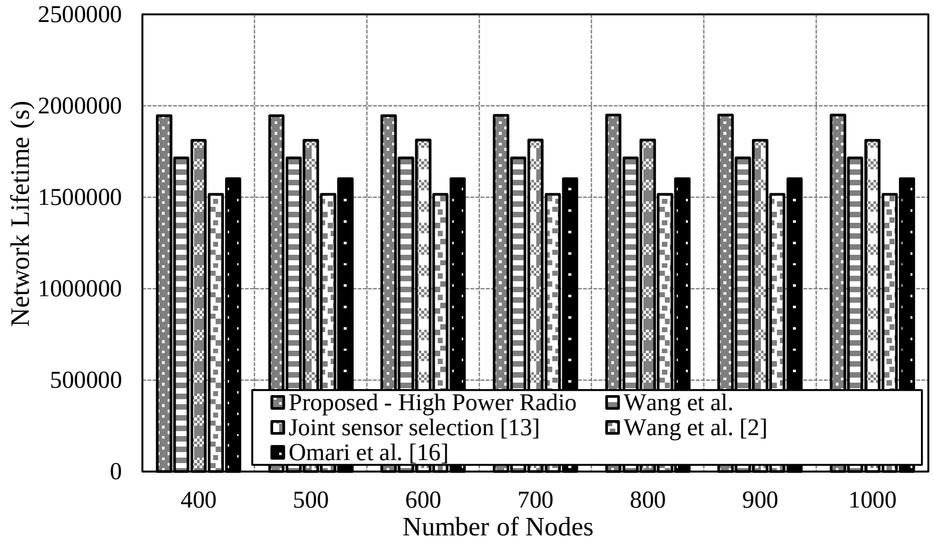

Figure 7: Network Lifetime in WSN using direct and multihop transmission

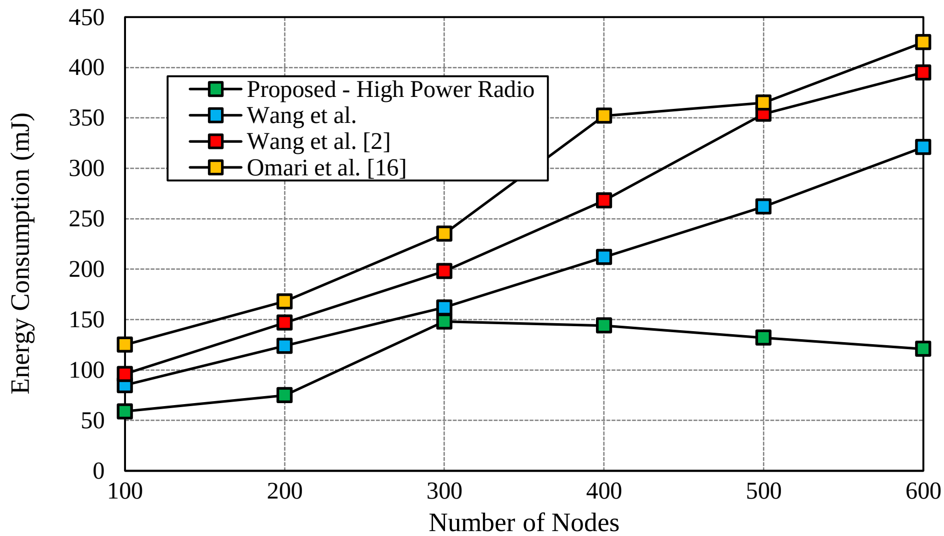

Figure 8: Network throughput in WSN using direct and multihop transmission

The proposed method reduces the transmission power with the help of direct communication to nearby nodes and multihop communication to far nodes.

The testing of proposed routing mechanism over a single scenarios with conventional methods is shown in Figure 6,7 and 8. The figure 6 shows the consumption of energy between the proposed and conventional method. Figure 7 shows cluster head lifetime between the proposed and conventional method. Figure 6 shows that consumption of energy by the proposed method has reduced well than conventional technique. This is due to the use of direct and multi-hop transmission. This has directly increased the lifetime of network and hence the period between initial and dead time of each nodes has increased considerably using this combined mode. Further, routing established using Dijkstra algorithm proves to be effective in terms of network through, where the throughput rate of proposed algorithm is higher than other conventional algorithm, which is seen in Figure 8.

4. Conclusion

In this paper, a combined dynamic direct and multihop mechanism is combined with Dijkstra algorithm to route the packets effectively. This method uses three phases to reduce the power consumption by the near and far nodes in network. Here, stability is the major concern to attain increased network lifetime. The proposed algorithm selects route in an optimal manner between source and destination nodes usingDijkstra algorithm. From the simulation results, it is seen that the throughput of the network is improved with BMH protocol to a greater degree. Further, the work can be extended by testing the proposed system in inter-cluster communication in WSNs.

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