British Journal of Mathematics & Computer Science
7(4): 266-279, 2015, Article no.BJMCS.2015.122
ISSN: 2231-0851

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WSN: Lifetime Maximization of Rumor Routing Protocol with Optimization Scheme and Bandwidth Evaluation

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Article Information

DOI: 10.9734/BJMCS/2015/15452
Editor(s):
(1) Doina Bein, Applied Research Laboratory, The Pennsylvania State University, USA.
Reviewers:
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(2) Anonymous, India.
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(6) Anonymous, Taiwan.
Complete Peer review History: http://www.sciencedomain.org/review-history.php?iid=935&id=6&aid=8168

Original Research Article

Received: 26 November 2014
Accepted: 06 February 2015
Published: 18 February 2015

Abstract

Rumor routing protocol in wireless sensor networks (WSNs), is based on query system. It selects the next hop randomly, but the resultant path from source to destination is not optimal. Most of the work reported on energy efficient and bandwidth estimation in the literature are based on hierarchical protocol. However in this work we have considered data centric protocol and used optimization scheme. We have used ant colony optimization (ACO) in rumor routing protocol. This approach optimizes the route search and helps in establishing a complete route by minimizing the probability of the loop route generated by routing scheme. Energy of the nodes has been calculated and compared for normal routing process with optimizing route searching using ACO. Results are compared with non-optimized route of rumor routing protocol. Further the bandwidth of non-optimal route has been calculated and compared with optimize route.

Keywords: Rumor routing; optimization; energy; bandwidth; WSN.

1 Introduction

Wireless sensor networks have supported by group of sensor technology e.g, micro electro mechanical system and wireless communication [1]. WSNs have been used in the different areas like disease surveillance, security, military, environmental monitoring etc [2]. Wireless sensor node

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has limited energy, sensing capability, processing, memory capacity and bandwidth. Therefore, the most important issue is to use the energy economically to maximize the lifetime of WSNs. The research challenges are to maximizing the sensor network lifetime, sensing range of node and coverage area using different techniques in wireless sensor network [3]. The various routing protocols used in wireless sensor network are classified as data- centric, hierarchical and location based. Rumor routing, part of data- centric routing protocol proposed in WSN. Route in the network based on event driven, query driven, time driven or hybrid [3]. In rumor routing, when events occur in the sensor network, node propagates few agents named event agent. All nodes receiving that agent transmit it to its random neighbor and this process continues while agent lifetime ended. Every agent consists of data on the route that arrives at the event's position. The information data is store in the node's event chart and is maintained for incomplete time. Besides, as the sink sensor node requests to be conscious of the position of a special event in the sensor network, it propagates few query agents in the sensor network. Movement of agents in the sensor network is random and encounters a sensor node. Which transmit via an event agent, then follows the event agent route. Network lifetime and bandwidth has become the key feature for evaluating application specific of sensor networks. Network life time are affected by different factors, such as power-aware routing, topology management, error control & flow control technique and MAC design [4].

In this paper we analyze the performance of energy and bandwidth in wireless sensor network. Thus section 2 present the review on related research. Section 3 describes the brief concept of rumor routing protocol. In Section 4 the simulation environment is given. Section 5 presents the calculation of distance between of two node and signal strength. Section 6 describes implementation of rumor routing with optimization. In Section 7 gives an evaluation of bandwidth in source to sink node and Section 8 analyzes the simulated result. And Section 9 concludes the paper.

2 Related Work

A wireless sensor network is thousands of random outspread sensor nodes with a bounded data transmission capacity. Since high-range transmissions dissipate a lot of energy, so routing should be based on small hops between transmission nodes. A review on routing protocols of wireless sensor network depends of the routing system on the sensor network area and characterized it into three types: hierarchical, data centric (flat) and location-based routing protocols. These routing protocols can also be categorized into query, multipath; QoS and negotiation based routing procedure [5-11].

In Flat protocol, each node in the network area behaves in the similar manner. Flat network structures offer some advantages e.g. it maintains the network area between communicating nodes maintaining minimum overhead. Hierarchical Protocols on this system impose an area on the network to get power efficiency and stability. In this class of protocols, network nodes are prepared in clusters in which a sensor node with large remaining energy assumes the role of a cluster head. In this article we focus mainly on data centric protocol mainly the energy-efficient routing protocols, discussing the energy of shortest path and bandwidth. Review on the present routing scheme in wireless sensor network area which emphasizes the challenges for routing technique in WSNs has been discussed. This survey explains the design tradeoffs among energy and transmission for each of the routing system considered [5]. C. Intannagonwiwat, et al. have data-centric (flat routing) and application-aware concept named directed diffusion in which sensors determine events and generate gradients of information in their relevant neighborhoods have discussed. It begins with a communication of interest having the tasks necessary of neighbors which is flooded with the whole sensor network. A node that obtains the information sets up a gradient toward the sensor nodes that transmit the interest. This scheme continues until the better route towards the sink node along the interest gradient is established. In [7,8], the author have explained and estimated assent for queries to be send to events in the sensor network by simulation. It assents for tradeoffs among delivery reliability and setup overhead. A customized Rumor Routing protocol is discussed [9] in which it is established that a very efficient data centric scenario of routing is most likely to enhance the sustainability of the network area. A algorithm handles node breakdowns and assent for tradeoffs between delivery reliability and setup overhead. The scheme of intersecting event path and query path is explained in [10] as a routing system exclusive of any geographic message. A performance investigation of source, shortest route, geographical routing and hierarchical approach is offered in [11]. Li, Moaveninejad [12], have reported zonal rumor routing which raises the query delivery rate by introducing zone in wireless sensor network. Ehsan Ahvar et al. [13], have been reported an energy-aware routing protocol (ERP) for query-based applications in WSNs.The approaches like neural network [14], artificial intelligence [15], swarm optimization [16], deferential evaluation [17], genetic algorithm [18], fuzzy logic [19], and [20-28] ant colony optimization have been used in WSNs by various authors. The fundamental scheme is to model the problem to resolve as the search for a minimum path in a graph. Xue Wang, et al. [21] reported the accuracy and effectiveness of data fusion in wireless sensor networks. Ling yun [22], the optimized path is obtained by accepting enhanced ant colony algorithm sensor network. Alaya I. et al. [22] has used different multi objective problem in WSNs. Wen-Hwa Liao et al. [24] have used sensor deployment to realize whole coverage and increases the lifetime of the wireless sensor network. Long Chengzhi et al. [25] have suggested a load balance scheme based on ant colony optimization technique for wireless sensor network. Ouyang xi et al. [26] used optimization scheme for carry forward a reputation-based ant secure routing protocol to discover the optimum route path of WSN; Huang R. et al. [27] based on ant colony optimization principle, forward an energy aware routing scheme and ant searching optimal path of wireless sensor network. Liao Ming-hua et al. [28] WSNs routing protocol support on ant colony optimization and LEACH protocol with energy calculation. Ziming Zeng et al. [29] have reported that bandwidths are used for shortest path routing algorithm in wireless sensor network to get better performance. Bandwidth allocation has used for frequency slot assignment to optimize energy in WSNs [30]. Bandwidth management depends on traffic generated in the wireless sensor network and it has mostly used bandwidth constraints quantization algorithm [31-33]. In this paper we have calculated link bandwidth and energy during data transmission from source to sink node in wireless sensor network.

3 Rumor Routing Protocol

OSI layer with corresponding application and various protocols on network layer are shown in Fig. 1 the routing protocol at the network layer are categorized into flat, hierarchical, and location-based routing protocols.

In the present analysis we have consider data centric category in which various routing protocol like GBR, Directed Diffusion, Rumor routing etc are reported in literature. Rumor routing protocol has been used for analysis. Rumor routing protocol [34,35] provides path to data towards a target mainly when the geographical location is unavailable. It discovers the shortest route among the source node and query creating nodes and query data are flooded through the sensor network. Firstly, the queries are outspread at random throughout in the whole network. Then queries are moved along the paths created by the agents. Here, every node in the sensor network is needed to retain the list of its neighbours and a table of events such that the data can be transmitted throughout the sensor network area. In respect to find the data the agents generate the required route by ensuring that the overhead involved in the procedure is reduced. With reduction in the amount of queries flooded, the power consumed reduces too. This routing protocol ensures robustness of the sensor network like it helps to maintain node breakdown, thus assure increase of wireless sensor network lifetime.

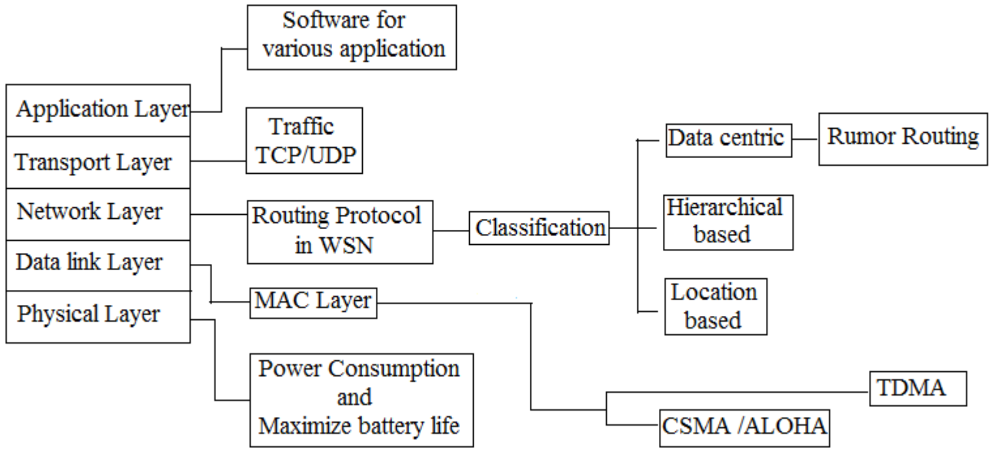


Fig. 1. OSI layers with corresponding protocols in WSN

The sensor nodes that represent WSN have some limitations like restricted battery power, memory limitation, restricted bandwidth etc. then scheming an efficient MAC layer protocol are a difficult task. TDMA-based MAC protocols know how to avoid collisions, overhearing and inactive listening and hence energy efficient.

4 Simulation Model

Wireless sensor networks (WSN) are used for collection of spatially dispersed In the present analysis, we have consider grid of (100×100 square meter area), number of nodes (40), each node energy (0.25 joule), all node transmission range (50m)and source node has placed at coordinates $(90,10)$ and sink node coordinate $(20,76)$ as shown in Fig. 2.

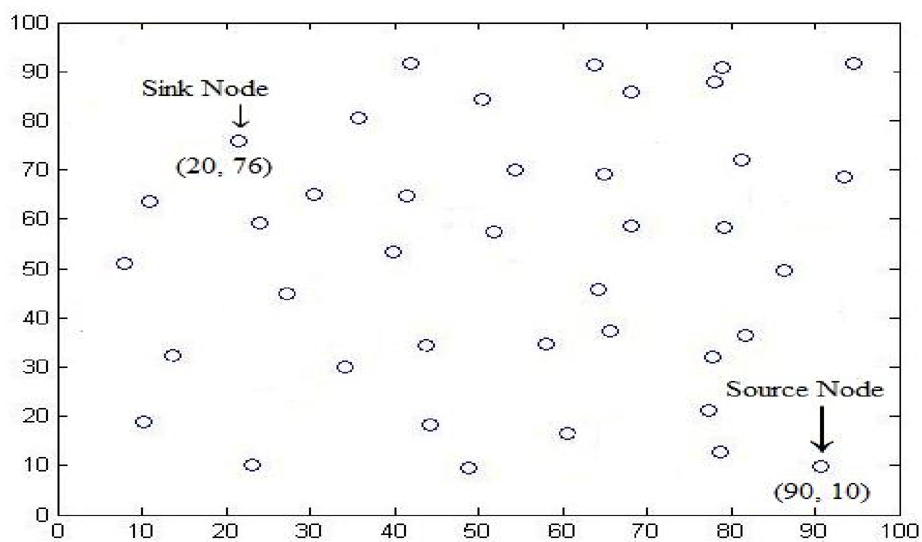


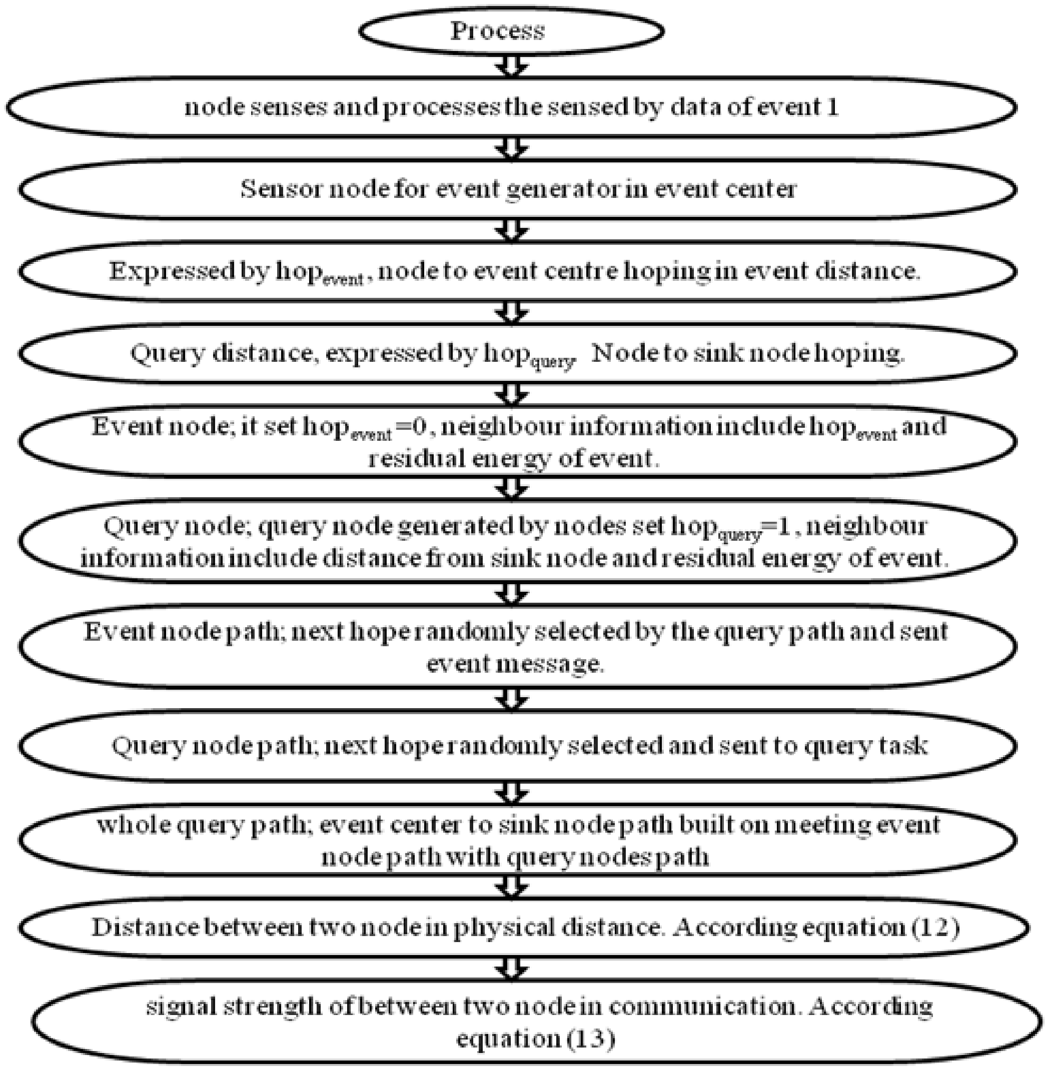
Fig. 2. Simulation environment of wireless sensor network with 40 Nodes

5 Calculation of Distance between of Two Node and Signal Strength

Distance between two nodes in physical distance and signal strength between to node n and m in communication range are calculated with help of following equations: the procedure of calculation is given in flow sheet 1.

$$d_p = \sqrt{(a_n - a_m)^2 + (b_n - b_m)^2} \tag{1}$$

$$d_{n,m} = \frac{1}{E_{\text{remaining}}} d_p{}^2 \tag{2}$$



Flow chart 1. Calculation of physical distance and signal strength between two nodes

6 Rumor Routing with ACO

Rumor routing doesn't consider node energy to select next hop. Path may have loop and may not be optimal. In this rumor routing, ant colony optimization based selection of next hop by node is ended and nodal residual energy is calculated and energy efficient path is observed. In order to obtain complete query path, energy consumption at threshold level, volatilization of signaling was increased so that node can select complete query in order to balance WSN energy consumption.

It has analyzed event node to select the next hop. Event node $k\,(k=1,2....l, l<n$, l = number of event node) adjust its transfer way according to the signaling on the route through its movement. Now, we have analyzed remaining energy of neighbor node and evaluate the communication range according to signaling of the edge. It has used $tabu_k\,(k=1,2...l)$ to record the node presently traversed node, after that the probability in support of node (k) from node n to choose node m and next hop time t is probability $P_{n,m}^{k}(t)$

$$p_{n,m}^{k}(t)=\begin{cases}\dfrac{\{\tau_{n,m}(t)\}^{\alpha}\,\{\eta_{n,m}(t)\}^{\beta}}{\sum\limits_{m\notin tabu_k}\{\tau_{n,m}(t)\}^{\alpha}\,\{\eta_{n,m}(t)\}^{\beta}}\ ,\ if\ m\notin tabu_k\\ 0,\quad if\quad m\notin tabu_k\end{cases} \qquad 3$$

$\tau_{n,m}(t)$ = the signaling of the path (n,m) at time (t) and every path has similar signaling in the primary network area.

$\tau_{n,m}(0)=const$,

$\eta_{n,m}(t)=$ Heuristic function

$E_{n\_\text{remaining}}=$ Neighbor node remaining energy

$d_{n,m}$ = distance of the two nodes, heuristic function for node the select the next hop

$$\eta_{n,m}(t)=\frac{E_{m\_\text{remaining}}}{d_{n,m}} \qquad 4$$

These are α and β signaling heuristic factors, heuristic factor replicated the effect of the signaling collected by their node through their movement after the nodes select next hop, the superior its value the node tends to select the support with nodes. Every node regulated the signaling of the path depend on equation (5), after event node encounter query node or sink node. The signaling of path (n,m) at time of $(t+g)$ on this equation

$$\tau_{n,m}(t+g)=(1-\rho).\tau_{n,m}(t)+\Delta\tau_{n,m}(t) \qquad 5$$

$$\Delta\tau_{n,m}(t)=\sum_{k=1}^{h}\Delta\tau_{n,m}^{k}(t) \qquad 6$$

$$\Delta\tau_{n,m}^{k}(t)=\begin{cases}\dfrac{Q}{L_k} & if\ signaling\ k\ traversesa\ path\,(n,m)\\ 0\end{cases} \quad 7$$

$(1-\rho)$ = evaporation coefficient of the signaling

Q = total signaling node

L_k = total distance to node k traverses in cycle (from node n to node m).

$0 \le \rho \le 1,\ \Delta\tau_{n,m}(t)$ = the increase of signaling in path (n,m) through this cycle.

$\Delta\tau_{n,m}(0)=0,\ \Delta\tau^{k}_{n,m}(t)$ = the amount of information of signaling (k) of the path (n,m) produce by node (k) in cycle.

Query node selects their next hop according to the similar probability; the dissimilarity has that query nodes regulate their signaling according to equation. (5) after they gather source nodes or event nodes.

6.1 Movement Step of Event Node

Stage 1: The hop_{query} and hop_{event} of every node has NULL through the network initialization.

Stage 2: it has evaluate the communication range to neighbor node by event node and chooses its next hop by (6) equation.

a. If the neighbour nodes hop_{event} =$NULL$, then it has choose as the next hop, and locates $hop_{event} = hop_{event} + 1$.
b. If neighbour nodes $hop_{event} \ne NULL$, then node is already in $tabu_k$, and its situation transition probability is 0.
c. If event node has not met query node, and every neighbour node has in the $tabu_k$, it has to withdraw and choose any more node like its next hop.

Stage 3: if query node met event node, the total query path will be produced, or else go stage 2.

Stage 4: Event node revises signaling of the path, it's according to equation (5)

6.2 Query Node Movement Steps

Stage 1: Node receiving query task from sink node produces query node K_q , sets hop_{query} , and add itself to $tabu_{k_q}$.

Stage 2: a node calculates the communication distance to neighbor nodes and hence selects the next hop by neighbor nodes residual energy, equation (3).

- If (Neighbour Node's $hop_{query} = NULL$), node s select this node as its next hop and $hop_{query} = hop_{query} + 1$

- If (Neighbour Node's $hop_{query} \neq NULL$), means this node is already in $tabu_{k_q}$, and probability of transition is 0
- if node' s neither meets event nor event centre, and all of its neighbour nodes are in $tabu_{k_q}$, it will withdraw a step and select another node as its next hop

Stage 3: If query event nodes met the event nodes and event centre, the complete query path will be formed, or go to step 2.

Stage 4: query node updates the signaling according to equation (5).

7 Bandwidth Evaluation

Now, we consider a wireless sensor network where every node with wireless link has a capacity B (bit/sec) and every node (n) has an initial battery $E_n(m)$.

We have assumed link bandwidth allocation of random nodes to non real time traffic demand, to satisfy the delay and traffic rate obligations. The transmitted packet, and routed packet are consuming allocated bandwidth.

Node (n) generates sensory data at rate of R_n bit per second $R_n > 0$

If the node (n) is a source

$R_n = 0$ If it is a pure relay node

$R_n = 1$ If it is sink

The source node is predefined and node "n" rate R_n is known. The transmission rate is unknown from "n" node to "m" node. Evaluate data rate R_{nm} on the link (n, m).

The all node has same transmission power and all symmetric links. We assume N_i nearest node of

(n). We commence variable (f_n).

$$f_n = 1, \quad if \ \sum_{m \in N} R_{mn} > 0;$$
$$f_n = 0, \quad otherwise$$

If the node (n) has then value of (f_n) will be 1.

Then, we can formulate the rate allotment difficulty as follows.

$$\sum_{m\in N_n}(R_{nm}-R_{mn})=R_n \quad 8$$

$$\sum_{m\in N_n}R_{nm}+f_n\sum_{m\in N_n}\sum_{k\in N_m}R_{mk}\le B \quad 9$$

$$0\le R_{nm}\le B \quad 10$$

$$f_n=\{0,1\} \quad 11$$

Supervision as every node satisfies according to equation (8) for all constraint and bandwidth constraint an equation (9) and (10) respectively has defined. Link $f(n,m)\le C(m,n)$ where $f(m,n)$ flow network for that link has a $C(m,n)$ fixed link capacity for used link transmitter over single link depend on raw capacity for B and packet (data) transmitted over other link in the collision field. According to equation (11), total the transmission in the similar collision should less then B , where B is the bandwidth capacity. Algorithm to find the bandwidth of shortest path.

Set $f_n=1$ for sink node, $f_n=0$, for every other node

Modify $f_n=1, \quad if \sum_{m\in N_n}R_{mn}>0;$ for all (n), otherwise go next step

1. Find out optimized route from source node to sink node.
2. For receiving node $f_n=1$. If $\sum_{m\in N_n}R_{mn}>0;$ an $f_n=0$, modify $f_n=1$
3. Repeat step 3 until there has no change for (f_n) or the linear program has infeasible.
4. If f_n converges output link (R_{nm}) for every link (n,m).
5. If it has infeasible means if $f_n=1$ but $\sum_{m\in N_n}R_{mn}=0$, and $R_{mn}=0,\forall\in N_n$ as input, if solution has infeasible then solve the process repeat. In most of the cases it requires 5 to 6 times of rotation to get a sub optimal solution.

8 Results and Analysis

To analyze the sensor network performance in term of energy and bandwidth has been calculated considering different parameter. The remaining energy of nodes has been computed in wireless sensor network area using the parameter mentions in Table 1. The number nodes versus energy with supporting rumor routing protocol as shown in Fig. 4. Similar analysis has been carried out by using ACO with rumor routing. It is observed that the life time of sensor node increase WSNs using ACO as it optimized path (Source to Destination) and calculated bandwidth. P. Eftekhari et al. [36] work on Cluster based methods and reduces energy consumption considerably by predicting next event randomly and estimated the location of future events. N.W Kouassi et al. [37] work on relative coordinates rumor routing to improve the energy cost for specific and random scenario. The similar analysis has been carried out by used the energy of sensor node has been improve lower path by using LEACH protocol with ACO optimization scheme, orojloo, et al. [38] by optimizing routing path energy of wireless sensor network improve using ACO in Fig. 4 which helps to estimate bandwidth as shown in Fig. 3.

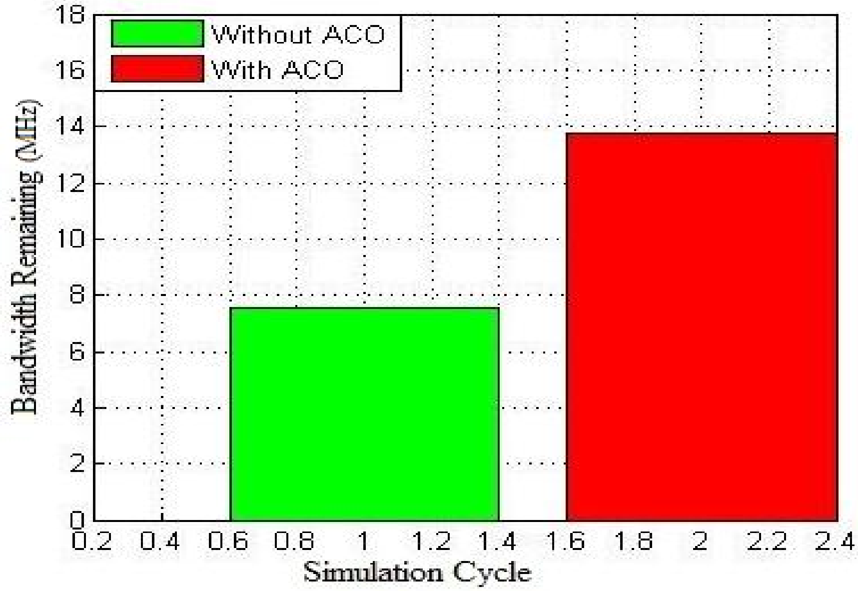


Fig. 3. Remaining Bandwidth analysis without ACO and With ACO

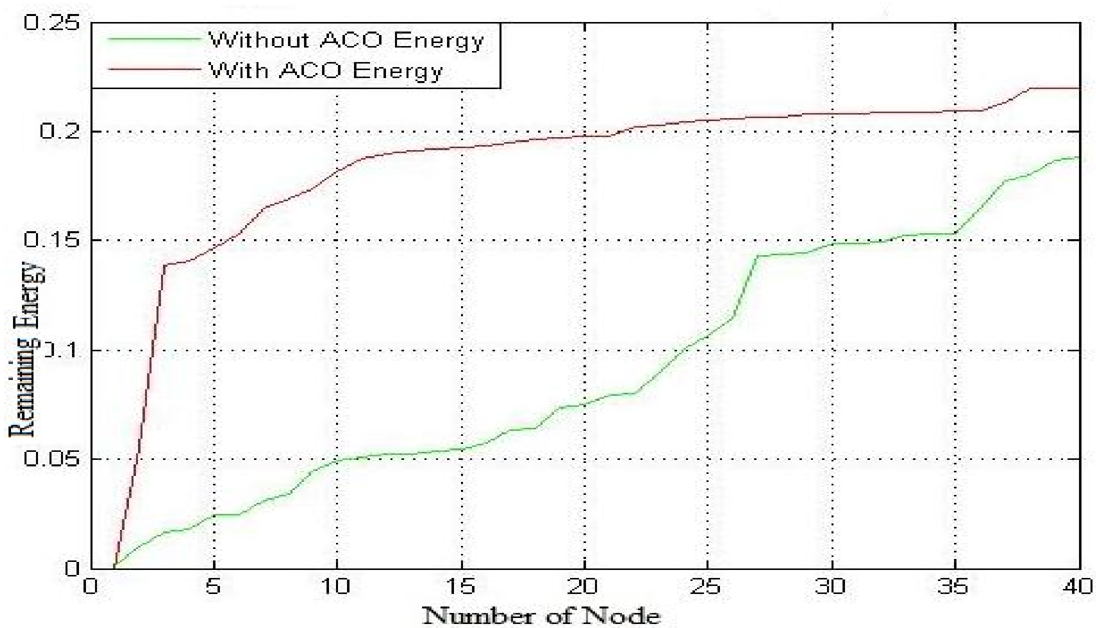


Fig. 4. Comparison of without ACO and With ACO energy

The performance of network with ant colony optimization rumor routing protocol and without optimization rumor routing protocol in wireless sensor network has been compared Fig. 4 with respect to same scenario. The bandwidth has been analyzed between the nodes with and without optimized path. The remaining energy of nodes has been computed in wireless sensor network area.

Table 1. Simulation parameter for bandwidth and energy

Components	Values
Simulation area	$100 \times 100\,(meter\ square)$
MAC Layer	TDMA
Channel Bandwidth	18 MHz
Transmission range	50m
Routing protocol	Rumor Routing
Data rate	450 kbps
CBR Packet Size	20 bytes
Number of Node	40

9 Conclusion

Rumor routing has a classic protocol depend on data query and the path created by rumor routing is non optimal. It requires maintain event table. It sends and receive agent which get additional energy depletion. In this paper, the network performance has been analyzed with help of MATLAB. We have used optimization scheme with rumor routing protocol to optimize routing process in wireless sensor network. The protocol is realized by using ant colony optimization algorithm to optimize routing path. We expected to preserve network life time in enhance and evaluate link bandwidth of optimized route with the help expression, while data communication is gated well.

Acknowledgements

The authors would like to acknowledge ministry of human resource and development, India (MHRD-INDIA) for providing financial support for this work under research scholar’s grant.

Competing Interests

Authors have declared that no competing interests exist.

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