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Original Research Article
**WSN: Lifetime Maximization of Rumor Routing
Protocol with Optimization scheme and
Bandwidth Evaluation**

10 **ABSTRACT**
11

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. In this paper, Most of the work reported on energy efficient and bandwidth estimation the literature based on hierarchical based protocol. However in this work we have considered data centric protocol and used optimization scheme. the authors have used ant colony optimization (ACO) in rumor routing protocol. This approach optimizes the route search and helps in establishing a complete route by minimizes the probability of the loop route generated by routing scheme. Energy of the nodes has been calculated and compare for normal routing process with optimize route search path using ACO. Results are compared with non-optimize route of rumor routing protocol. In the present and QPSK signal are generated with help of matlab. Further the bandwidth of non-optimal route has been calculated and compared with optimize route.

12
13 *Keywords: OFDM, QPSK, Rumor Routing, Optimization, Energy, Bandwidth*
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15 **1. INTRODUCTION**
16

17 Wireless sensor networks have supported by group of sensor technology e.g, micro electro mechanical system and
18 wireless communication [1]. WSNs have been used in the different areas like disease surveillance, security, military,
19 environmental monitoring etc [2]. Wireless sensor node has limited energy, sensing capability, processing, memory
20 capacity and bandwidth. Therefore, the most important issue is to use the energy economically to maximize the lifetime of
21 WSNs. The research challenges are to maximizing the sensor network lifetime, sensing range of node and coverage area
22 using different techniques in wireless sensor network [3]. The various routing protocols used in wireless sensor network
23 are classified as data- centric, hierarchical and location based. Rumor routing, part of data- centric routing protocol
24 proposed in WSN. Route in the network based on event driven, query driven, time driven or hybrid [3]. In rumor routing,
25 when events occur in the sensor network, node propagates few agents named event agent. All nodes receiving that agent
26 transmit it to its random neighbor and this process continues while agent lifetime ended. Every agent consists of data on
27 the route that arrives at the event's position. The information data is store in the node's event chart and is maintained for
28 incomplete time. Besides, as the sink sensor node requests to be conscious of the position of a special event in the
29 sensor network, it propagates few query agents in the sensor network. These agents movement in the sensor network
30 randomly and as encountering a sensor node. Which have been traverse via an event agent, will follow the event agent
31 route.
32 Network lifetime and bandwidth has become the key feature for evaluating application specific of sensor networks.
33 Network life time are affected by different factors, such as power-aware routing, topology management, error control &
34 flow control technique and MAC design [4]. In this paper performance analysis of energy and bandwidth in wireless
35 sensor network section 2 present the review on related research. section 3 describe the brief concept of rumor routing
36 protocol. section 4 simulation environment is given. Section 5 calculation of BER and mathematical analysis. Section 6
37 calculation of distance between of two node and signal strength. Section 7 implementation of rumor routing with

optimization. In Section 8 evaluation of bandwidth in source to sink node and section 9 analyzed the simulated result. At last section 10 present the conclusion.

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. This 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, X., Moaveninejad, K [12], have reported zonal rumor routing which raises the query delivery rate by introducing zone in wireless sensor network.

The approaches like neural network [13], artificial intelligence [14], swarm optimization [15], deferential evaluation [16], genetic algorithm [17], fuzzy logic [18], and [19-27] 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. [20] reported the accuracy and effectiveness of data fusion in wireless sensor networks. Ling yun [21], 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. [23] have used sensor deployment to realize whole coverage and increases the lifetime of the wireless sensor network. Long Chengzhi et al. [24] have suggested a load balance scheme based on ant colony optimization technique for wireless sensor network. Ouyang xi et al. [25] 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. [26] 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. [27] WSNs routing protocol support on ant colony optimization and LEACH protocol with energy calculation. Ziming Zeng et al. [28] 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 [29]. Bandwidth management depends on traffic generated in the wireless sensor network and it has mostly used bandwidth constraints quantization algorithm [30-32]. 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 figure.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 [33, 34] provide 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.

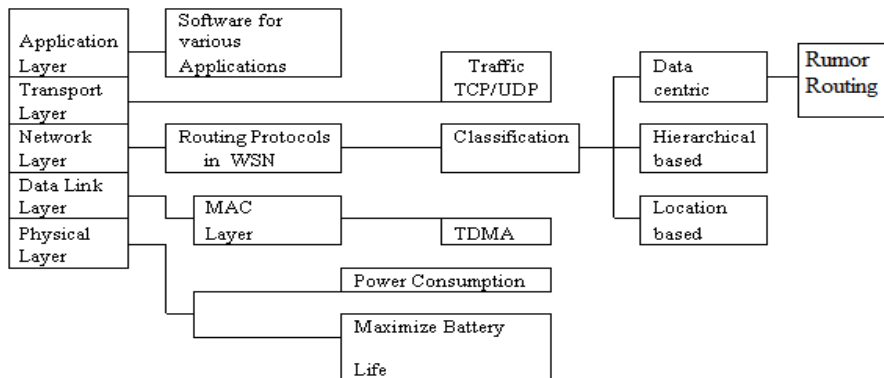


Figure1. OSI layer with a corresponding application in WSN

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 (0,0) and sink node coordinate (100,100) as shown in figure .2

In order to maintain a minimum loss of signal, various digital modulation methods (ASK, PSK, FSK QAM, and QPSK) are used in wireless sensor network or wired network [35, 36]. Generally two methods QAM and QPSK are applied in wireless sensor network [37] as these methods minimize the consumed bandwidth [38]. Different spread spectrum techniques like DSSS, FHSS and OFDM are used in WSN. In the present analysis QPSK modulation scheme has been used because of we have considered phase shift in the analysis. OFDM spread spectrum technique has been used best for multipath fading environment and robust against narrow band and highly sensitive to inter channel interference compared to DSSS and FHSS.

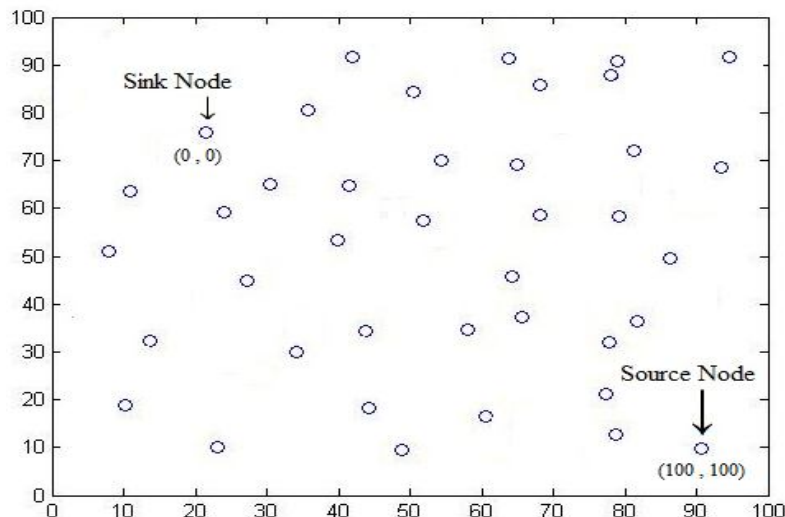


Figure2. Simulation environment of wireless sensor network with 40 Nodes

5. CALCULATION OF BER

An OFDM method is applied for getting energy effectiveness in wireless sensor networks. The nodes help by shifting the carrier frequency of the signal since the source node and retransmit it to the target nodes, where multicarrier getting with OFDM method is used to realize low difficulty and better performance. Bit error rate (BER) has been calculated to analyze

the network performance. The QPSK signal has extension of BPSK and M-ary signal. QPSK modulate over AWGN (Additive white Gaussian noise) channel method and mapping gray code by set $\pi / 4$ radian. OFDM and QPSK signal are generated with help of matlab using parameter given a table.1 OFDM Process shown in figure.3

Table.1 Parameter for generation of OFDM and QPSK

Parameter	value
Number of carriers	64
Single frame size	96 bit
Sampling rate	25 MHz
Number of frame	100
Modulation scheme	QPSK
Delay times	250 ns
Doppler frequency	30 Hz
Guard interval	2.56×10^{-6}

$u(t)$ is QPSK with as binary PSK, information carried the transmitted signal

$$u(t) = \begin{cases} \sqrt{\frac{2E}{T}} \cos\{2\pi f_c t + (2i-1)\frac{\pi}{4}\} & 0 \leq t \leq T_s \\ 0 & \text{elsewhere} \end{cases} \dots\dots\dots(1)$$

$\phi_1(t)$ and $\phi_2(t)$ are defined quadrature carries

$$\phi_1(t) = \sqrt{\frac{2}{T}} \cos(2\pi f_i t) \quad 0 \leq t \leq T_s \dots\dots\dots(2)$$

$$\phi_2(t) = \sqrt{\frac{2}{T}} \sin(2\pi f_i t) \quad 0 \leq t \leq T_s \dots\dots\dots(3)$$

Quadrature message point the signal vector are defined

$$u = \begin{bmatrix} +\sqrt{E} \cos(2i-1)\frac{\pi}{4} \\ -\sqrt{E} \sin(2i-1)\frac{\pi}{4} \end{bmatrix}$$

Parallel data are modulated then path in to IFT circuit is given by

$$u(t) = \sum_{p=-\infty}^{\infty} \sum_{i=0}^{N-1} w_i(p) \exp(j2\pi f_i(t-pT_{total})) f(t-pT_z) \dots\dots\dots(4)$$

$f_i(i=0,1,2,\dots\dots\dots)$

The frequency of i^{th} sub carrier given by

$$f_i = f_0 + \frac{i}{T_z} \dots\dots\dots(5)$$

$f(t)$ is the wave form of the symbol and define as

$$f(t) = \begin{cases} 1 & (0 \leq t \leq T_z) \\ 0 & \text{otherwise} \end{cases} \dots\dots\dots(6)$$

Later then the insertion of guard interval the OFDM signal is given by

$$u'(t) = \sum_{p=-\infty}^{\infty} \sum_{i=0}^{N-1} w_i(p) \exp(j2\pi f_i(t-pT_{total})) f'(t-pT_{total}) \dots\dots\dots(7)$$

Here $f'(t)$ is update pulse waveform of each symbol define as

$$f'(t) = \begin{cases} 1 & (-T_g \leq t \leq T_z) \\ 0 & (t < -T_g, t > T_z) \end{cases} \dots\dots\dots(8)$$

Received signal is given as

155
$$r(t) \int_0^{\infty} h(\tau, t) u(t-\tau) d\tau + n(t) \dots \dots \dots (9)$$

156 Output $\hat{u}_i(p)$ is given by

157
$$\hat{u}_i(p) = \frac{1}{T_z} \int_{pT_{total}}^{T_p + pT_{total}} r(t) \exp(-j2\pi f_i(t - pT_{total})) dt \dots \dots \dots (10)$$

158 Multipath fading environment the received data given as

159
$$\hat{\hat{u}}_i(p) = \frac{\hat{h}_i^*(p)}{\hat{h}(p)\hat{h}^*(p)} \hat{u}_i(p) \dots \dots \dots (11)$$

160 We compute the bit error rate (BER) by comparing $\hat{\hat{u}}_i(p)$ and $\hat{u}_i(p)$ in figure.4 and figure. 5

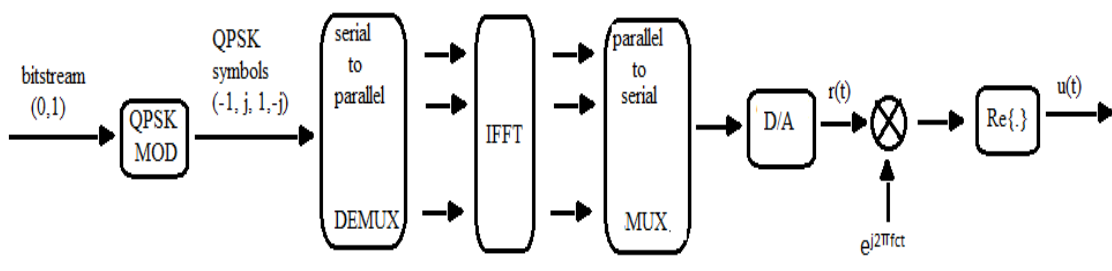


Fig. 3 OFDM Transmitter

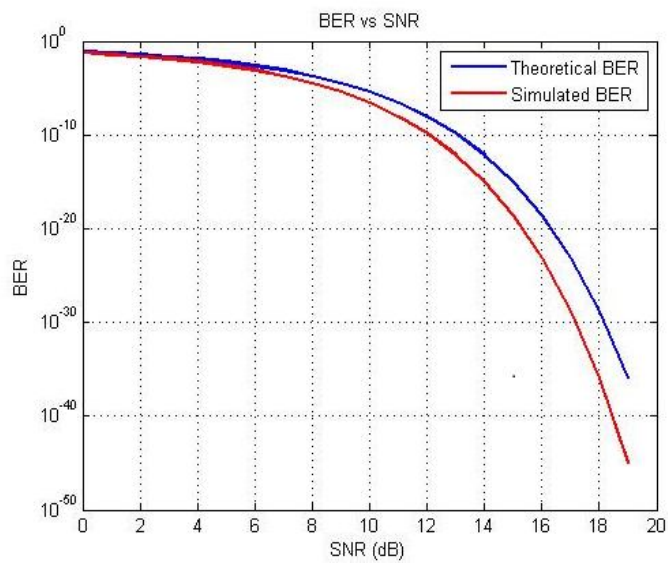


Figure4. BER of QPSK-OFDM with AWGN

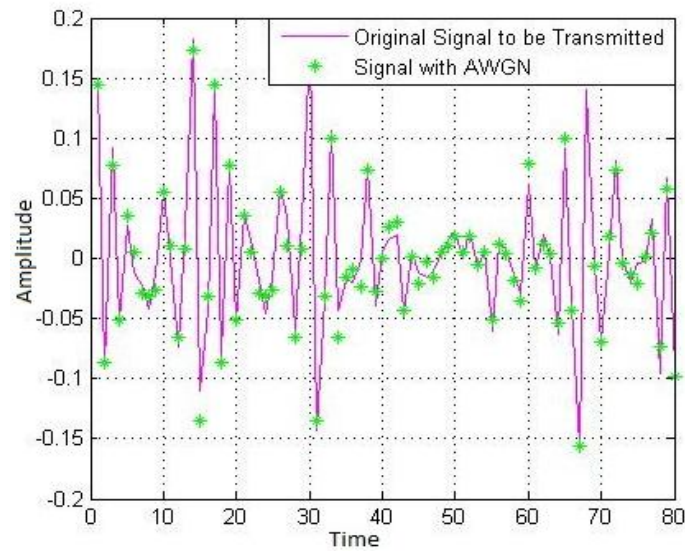


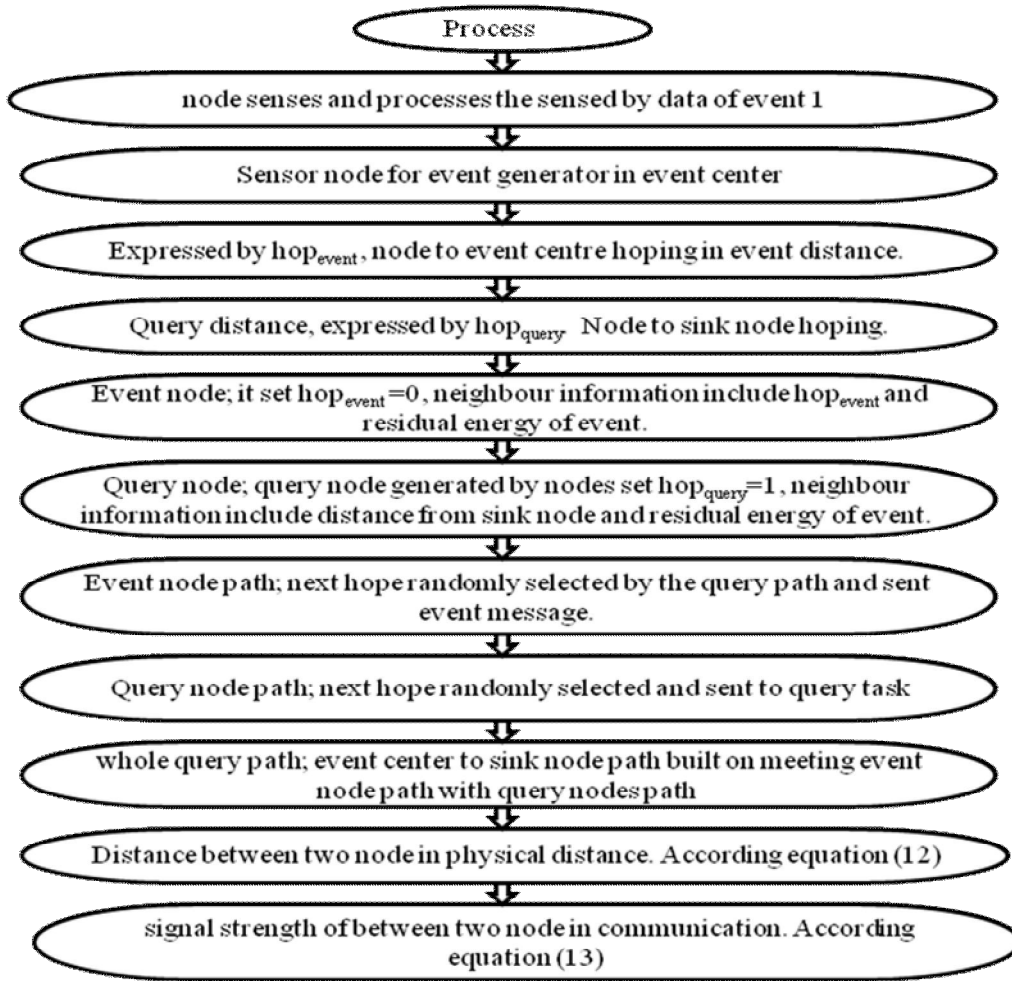
Figure 5. Generated OFDM Signal using MATLAB

6. 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 sheet1

$$d_p = \sqrt{(a_n - a_m)^2 + (b_n - b_m)^2} \dots\dots\dots(12)$$

$$d_{n,m} = \frac{1}{E_{\text{remaining}}} d_p^2 \dots\dots\dots(13)$$



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

7. RUMOR ROUTING WITH ACO

Rumor routing in next hop selected by event node and query node in order to transmit message after their generation for their random selection and it doesn't consider node energy. 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 signalling 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 ($k = 1, 2, \dots, l, l < n$, l = number of event node) adjust its transfer way according to the signalling on the route through its movement. Now, we have analyzed remaining energy of neighbour node and evaluate the communication range according to signalling of the edge. It has used $tabu_k$ ($k = 1, 2, \dots, l$) 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 $P_{n,m}^k(t)$

$$P_{n,m}^k(t) = \begin{cases} \frac{\{\tau_{n,m}(t)\}^\alpha \{\eta_{n,m}(t)\}^\beta}{\sum_{m \in tabu_k} \{\tau_{n,m}(t)\}^\alpha \{\eta_{n,m}(t)\}^\beta}, & \text{if } m \notin tabu_k \\ 0, & \text{if } m \in tabu_k \end{cases} \quad \dots\dots\dots(14)$$

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

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

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

199 $E_{n_remaining}$ = Neighbor node remaining energy
200 $d_{n,m}$ = distance of the two nodes, heuristic function for node the select the next hop
201 $\eta_{n,m}(t) = \frac{E_{n_remaining}}{d_{n,m}} \dots \dots \dots (15)$
202 These are α and β signaling heuristic factors, heuristic factor replicated the effect of the signaling collected by their
203 node through their movement after the nodes's select next hop, the superior its value the node tends to select the support
204 with nodes. Every node regulated the signaling of the path depend on equation (16), after event node encounter query
205 node or sink node. The signaling of path (n, m) at time of $(t + g)$ on this equation
206 $\tau_{n,m}(t+g) = (1-\rho) \cdot \tau_{n,m}(t) + \Delta\tau_{n,m}(t) \dots \dots \dots (16)$
207 $\Delta\tau_{n,m}(t) = \sum_{k=1}^h \Delta\tau_{n,m}^k(t) \dots \dots \dots (17)$ $\Delta\tau_{n,m}^k(t) = \begin{cases} \frac{Q}{L_k} & \text{if signaling } k \text{ traverses a path } (n, m) \\ 0 & \end{cases} \dots \dots \dots (18)$
208 $(1 - \rho)$ = evaporation coefficient of the signaling
209 Q = total signaling
210 L_k = total distance to node k traverses in cycle (from node n to node m).
211 $0 \leq \rho \leq 1$, $\Delta\tau_{n,m}(t)$ = the increase of signaling in path (n, m) through this cycle.
212 $\Delta\tau_{n,m}(0) = 0$, $\Delta\tau_{n,m}^k(t)$ = the amount of information of signaling (k) of the path (n, m) produce by node (k) in cycle.
213 Query node selects their next hop according to the similar probability; the dissimilarity has that query nodes regulate their
214 signaling according to equation. (16) after they gather source nodes or event nodes.
215
216 **7.1 Movement step of event node:**
217 Stage 1: The hop_{query} and hop_{event} of every node has NULL through the network initialization.
218 Stage 2: it has evaluate the communication range to neighbour node by event node and chooses its next hop by (17)
219 equation.
220 a. If the neighbour nodes $hop_{event} = NULL$, then it has choose as the next hop, and locate $hop_{event} = hop_{event} + 1$.
221 b. If neighbour nodes $hop_{event} \neq NULL$, then node has already in $tabu_k$, and its situation transition probability has
222 0.
223 c. If event node has not met query node, and every neighbour node has in the $tabu_k$, it has to withdraw and choose
224 any more node like its next hop.
225 Stage 3: if query node met event node, the total query path will be produced, or else go stage 2.
226 Stage 4: Event node revises signalling of the path, it's according to equation (16)
227 **7.2 Query node movement steps:**
228 Stage 1: Node receiving query task from sink node produces query node K_q , sets hop_{query} , and add itself to $tabu_{k_q}$.
229 stage2: a node calculates the communication distance to neighbour nodes and hence selects the next hop by neighbour
230 nodes residual energy, equation (14).
231 • If (Neighbour Node's $hop_{query} = NULL$), node s select this node as its next hop and
232 $hop_{query} = hop_{query} + 1$
233 • If (Neighbour Node's $hop_{query} \neq NULL$), means this node is already in $tabu_{k_q}$, and probability of transition is 0
234 • if node' s neither meets event nor event centre, and all of its neighbour nodes are in $tabu_{k_q}$, it will withdraw a
235 step and select another node as its next hop
236 Stage 3: If query event nodes met the event nodes and event centre, the complete query path will be formed, or go to step
237 2.
238 Stage 4: query node updates the signalling according to equation (16).
239
240 **8. EVALUATION BANDWIDTH**
241

242 In the present testing, we consider a wireless sensor network we consider every node with wireless link has a capacity B
243 (bit/sec) and every node (n) has an initial battery $E_n(m)$.
244 We have assumed link bandwidth allocation of random nodes to non real time traffic demand, to satisfy the delay and
245 traffic rate obligations. The transmitted packet, and routed packet are consuming allocated bandwidth.
246 Node (n) generates sensory data at rate of R_n bit per second $R_n > 0$
247 If the node (n) is a source
248 $R_n = 0$ If it is a pure relay node
249 $R_n = 1$ If it is sink
250 The source node is predefined and node " n " rate R_n is known. The transmission rate is unknown from " n " node to " m "
251 node. Evaluate data rate R_{nm} on the link (n, m) .
252 The all node has same transmission power and all symmetric links. We assume N_i nearest node of
253 (n) . We commence variable (f_n) .
254
$$f_n = 1, \quad \text{if } \sum_{m \in N} R_{nm} > 0;$$

255
$$f_n = 0, \quad \text{otherwise}$$

256 If the node (n) has then value of (f_n) will be 1.
257 Then, we can formulate the rate allotment difficulty as follows.

$$\sum_{m \in N_n} (R_{nm} - R_{nm}) = R_n \quad (19)$$

$$\sum_{m \in N_n} R_{nm} + f_n \sum_{m \in N_n} \sum_{k \in N_m} R_{mk} \leq B \quad (20)$$

$$0 \leq R_{nm} \leq B \quad (21)$$

$$f_n \in \{0, 1\} \quad (22)$$

258 Supervision as every node satisfies according to equation (19) for all constraint and bandwidth constraint an equation (20)
259 and (21) respectively has defined. Link $f(n, m) \leq C(m, n)$ where $f(m, n)$ flow network for that link has a $C(m, n)$ fixed
260 link capacity for used link transmitter over single link depend on raw capacity for B and packet (data) transmitted over
261 other link in the collision field. According to equation (22), total transmission in the similar collision should less then B ,
262 where B is bandwidth capacity. Algorithm to find the bandwidth of shortest path.
263
264 Set $f_n = 1$ for sink node, $f_n = 0$, for every other node
265 Modify $f_n = 1$, if $\sum_{m \in N_n} R_{nm} > 0$; for all (n), otherwise go next step
266 1. Find out optimized route from source node to sink node.
267 2. For receiving node $f_n = 1$. If $\sum_{m \in N_n} R_{nm} > 0$; an $f_n = 0$, modify $f_n = 1$
268 3. Repeat step 3 until there has no change for (f_n) or the linear program has infeasible.
269 4. If f_n converges output link (R_{nm}) for every link (n, m) .
270 5. If it has infeasible means if $f_n = 1$ but $\sum_{m \in N_n} R_{nm} = 0$, and $R_{mn} = 0, \forall \in N_n$ as input, if solution has infeasible then
271 solve the process repeat. In most of the cases it requires 5 to 6 times of rotation to get a sub optimal solution.
272
273

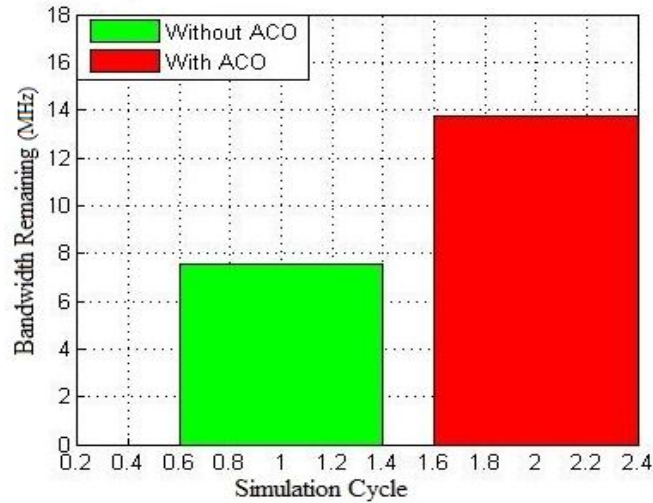


Fig.6. Remaining Bandwidth analysis without ACO and With ACO

9. RESULT AND ANALYSIS

To analyze the network performance bit error rate (BER) has been calculated considering number of carriers (64), sampling rate (25 MHz) and frame size (96 bit). OFDM and QPSK signal have been generated with help of matlab. The remaining energy of nodes has been computed in wireless sensor network area using the parameter mentions in table2. The number nodes versus energy with supporting rumor routing protocol as shown in figure 7. 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. [39] 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, [40] 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, Hamed orojloo, Reza Askari. et al. [41] By optimizing routing path energy of wireless sensor network improve using ACO in figure.7 which helps to estimate bandwidth as shown in figure 6.

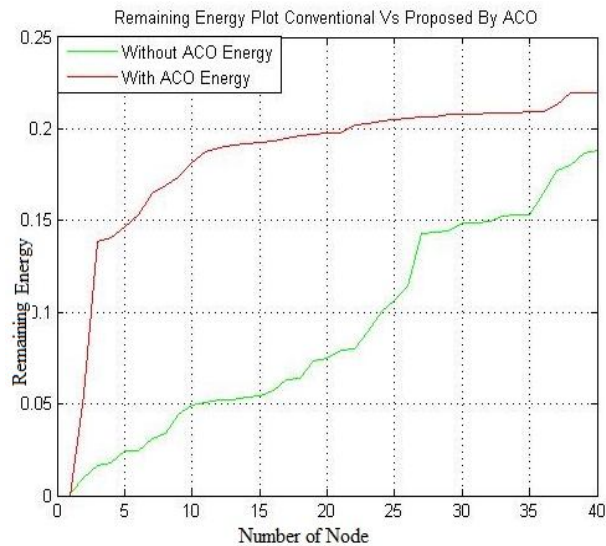


Fig.7. Comparison of without ACO and With ACO energy

The performance of network with ant colony optimization rumor routing protocol and without optimization rumor routing protocol in wireless sensor network has been compared figure1 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.

Table2. Simulation parameter for bandwidth and energy

Components	Values
Simulation area	100×100 (<i>meter square</i>)
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

10. 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.

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