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Lifetime Improvement and Bandwidth Evaluation of Directed Diffusion Routing using Optimization technique in WSN

Rajeev Arya
Research Scholars, Electronics and Communication Discipline, DPT, Indian Institute of Technology, Roorkee, INDIA

S.C. Shrama
Professor, Electronics and Communication Discipline, DPT, Indian Institute of Technology, Roorkee, INDIA

Abstract **- Wireless sensor network has many challenges like hospital, university campus, big museum and health care residence etc. in this article we have focused on energy and bandwidth in the network layer routing protocol. The network layer routing protocol are divided in three part i.e. hierarchical, location-based routing protocols and data centric routing. We have used directed diffusion routing technique which is a part of data centric protocol i.e. energy-efficient routing protocols. The data communication paths with directed diffusion algorithm are formulated using ant colony optimization in wireless senor network. The performance analyses have been carried out in the terms of BER, energy, bandwidth. Bit error rate (BER) has been calculated to understand the network performance. Energy of the nodes has been calculated and compare for directed diffusion routing process with and without optimize route search path. The bandwidth of non-optimal route has been calculated and compared with optimize route. For above analysis QPSK modulation scheme has been used because we have considered phase shift in the analysis. OFDM spread spectrum technique has been used because it is best for multipath fading environment, robust against, narrow band and highly sensitive to inter channel interference as compared to DSSS and FHSS. Results are compared with optimized and non-optimized route of directed diffusion routing protocol in terms of energy and bandwidth for wireless sensor network.**

Keywords – Energy, Bandwidth, Ant colony optimization, Directed Diffusion routing protocol,

I. INTRODUCTION

Wireless sensor network has collection of number of sensor nodes that have densely expended in network area. Sensor node consists of data processing, sensing, communication components. In earlier days sensor networks were mainly associated with the application of inaccessible locations like military area & disaster scene etc. Now-a-days, as recent exploration of wireless sensor network, particular interests are in the industrial purpose, are hospital, university campus, big museum and health care residence etc comes out to be the hot area in research and its increasing exponentially [1]. In such areas, wireless sensor networks have considered contain energy efficiency, bandwidth and mobility. In a typical example of WSNs, predetermined sensor nodes have varied with movable sensor node inside area because of movable sensor node. Sensor node also has confined wireless evolutional energy to system and conveys the sensing information (data) to information collection hub [2, 3]. It classifies the routing procedure, based on the network arrangement, into three classes: flat, hierarchical, and location-based routing protocols. In the data centric (flat) protocol, all nodes in the network area behave in a similar manner and it maintains the network area between communicating nodes and minimum overhead [4, 5]. It is based on Directed diffusion concept. Ramesh Govindan et al. in [6.] proposed an accepted data aggregation concept for wireless sensor networks describe directed diffusion. Directed diffusion is data-centric and every node in a directed diffusion-based network is application-aware. This allows diffusion to get energy reserves by choose empirically excellent paths and by caching and processing information (data) in sensor network. Directed diffusion has composed of some elements: interests, gradients, data messages and reinforcements. Network lifetime and bandwidth becomes 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 [7].

II. RELATED WORK

Routing protocols of wireless sensor network are characterized into three types: hierarchical, location-based routing protocols and data centric (flat). In hierarchical protocols network nodes are prepared in clusters in which a sensor node with large remaining energy assumes the role of a cluster head to get the power efficiency and stability [5]. In location based protocol the basics of location-aided or position-based routing, through methods proposed for WSNs, is presented. This type of protocols acknowledges the influence of physical distances and distribution of nodes to areas as significant to network performance. In the data centric (flat) protocol, all nodes in the network area behave in a similar manner and it maintains the network area between communicating nodes and minimum overhead. It is based on Directed diffusion concept; where more than one routing and delivery that finds some partially disjoint routes is studied in [8, 9]. The application of more than one path routing offered viable choice for energy efficient recovery from unsuccessful communication in WSN. In [10-14] the energy have been calculated and analyzed for various energy aware routing protocol at the network layer in wireless sensor network. The energy expenditure has been linked with probable paths from the source sensor to sink node by apply localized flooding by Shah R.C. et al. [10]. Kim et al. in [11] created a more than one path in energy-aware routing to find node-disjoint routes and takes into report of the network area reliability at the localization. Jiun huei Ho, et al. reported have ladder diffusion with ACO [12] to solve the energy expenditure and transmission routing difficulty in wireless sensor networks.

Zytoune O. et al. [13] analysis the complete network life time by selected the nodes whose remaining energies were better than threshold energy for identical estimation energy routing protocol. Chen and Nasser in [14] have reported an energy assessment multipath routing protocol, which has based on client-server. The energy expenditure manages by directed diffusion to reduce the transmission by Ramesh Govindan et al. in [6]. Ant colony optimizations have been used in WSNs by various authors [15-23]. [15]The fundamental scheme is to model the problem to resolve the searching of a minimum path in a network area. Xue Wang, et al. [16] has reported data diffusion to improve the accuracy and effectiveness of data fusion in wireless sensor networks. Ling yun [17], has used enhance ant colony algorithm to optimized path in wireless sensor network. Alaya I. et al. [18] have used ACO in different multi objective problem in WSNs. Wen-Hwa Liao et al. [19] have used sensor deployment to realize whole coverage and increases the lifetime of the wireless sensor network. L. Chengzhi et al. [20] have suggested a load balance scheme based on ant colony optimization technique for wireless sensor network. Ouyang xi et al. [21] used optimization scheme for carry forward a reputation-based ant secure routing protocol to discover the optimum route of WSN. Huang R. et al. [22] used on ant colony optimization principle, for forward energy aware routing scheme and ant searching optimal path of wireless sensor network. Liao Ming-hua et al. [23] have used ant colony optimization for energy calculation using LEACH protocol in WSN. Ziming Zeng et al. [24] have reported that bandwidth is used to find shortest path routing algorithm in wireless sensor network to get better performance. Arslan munir et al. [26] have used Bandwidth allocation for frequency slot assignment to optimize energy in WSNs. [26, 28] has been used quantization algorithm for Bandwidth management depends on traffic generated. In this paper we have calculated link bandwidth and energy during data transmission from source to sink node in wireless sensor network with ACO.

III. DIRECTED DIFFUSION ROUTING PROTOCOL

Fig.1. indicate architecture with a corresponding application and protocols at network layer in WSN, the routing at the network layer mainly classify into data centric, hierarchical based, location base.

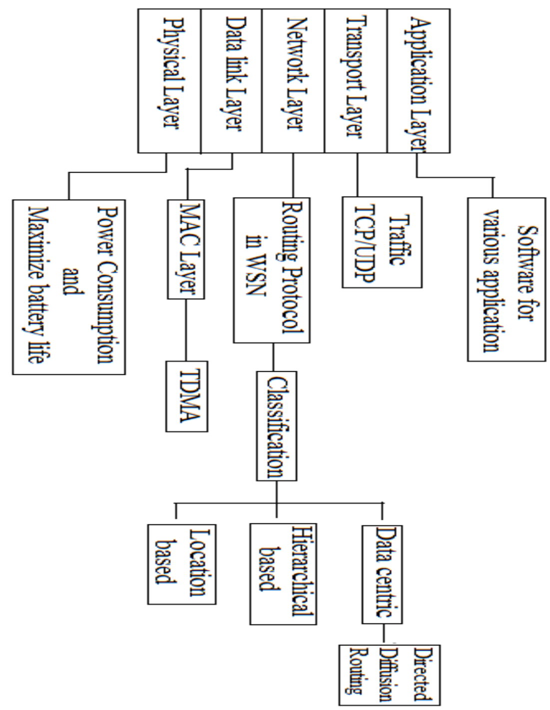

Figure.1.Layered architecture with a corresponding application in WSN

In the present work data-centric with Directed Diffusion is considered for analysis because of it get rid of unnecessary procedure of network layer routing in order to accumulate power, and it utilizing attribute-value pairs for queries and the data sensors. In order to create a query, awareness is defined using a record of attribute-value pairs like distance, interval objects and geographical region, etc. Every node receiving the significant data can do caching for further usage. The interests in the catching are then applied to judge the received information (data) through the values in interests. The interest accesses also restrain some gradient areas. A gradient is a respond link to a neighbour as of which the interest has received. It is considered with the duration, expiration time and data rate derived from the received interests areas. Therefore, with operate gradients and interest, paths are recognized between sources and sink. Some routes can be recognized so that one of them is chosen by reinforcement.

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The sink retransmit the novel interest message (information) through the chosen path with a minor interval, thus support the source node on that route to transmit data more commonly.
Fig. 2 demonstrates the path setup of directed diffusion protocol. When a route among a sink node and the source node fails, a substitute path must be known. For this, Directed Diffusion mainly reinitiates support by searching with other route, which is transmitting data in minor rates. Akkaya Kemal et al. [29] propose various routes in advance so that in case of an unsuccessful of a route, one of the substitute routes is selected. Of course, there is an additional overhead of keeping these substitute paths alive with low data rate, which will absolutely use extra power but more power can be saved when a route is unsuccessful and a novel route is selected.

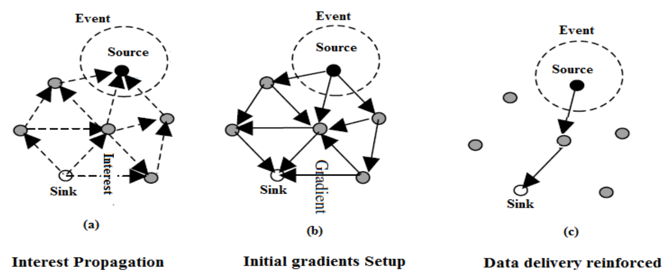

Figure.2 Path setup of direct diffusion using (a) Interest Propagation, (b) initial gradients setup, (c) data delivery reinforced

IV. DEVELOPED SCENARIO

Wireless sensor network (WSN) is a collection of spatially dispersed and devoted sensors for monitoring the physical conditions. WSNs are applied to measure pollution levels, temperature, sound, pressure, wind speed, direction, humidity etc. In the present scenario, we have considered grid of (100 x 100) square meter area, number of nodes 40, each node energy 0.25 Joule. All nodes have transmission range (50m x50m) and source node has placed at coordinates (0,0) and sink node coordinates (100, 100) as shown in fig.3. 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 [30, 31]. Generally QAM and QPSK are applied in wireless sensor network [32] as these methods minimize the consumed bandwidth [33]. Different spread spectrum techniques like DSSS, FHSS and OFDM are used in WSN to get better the data rate and resistance to interference. 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, robust against narrow band and highly sensitive to inter channel interference as compared to DSSS and FHSS.

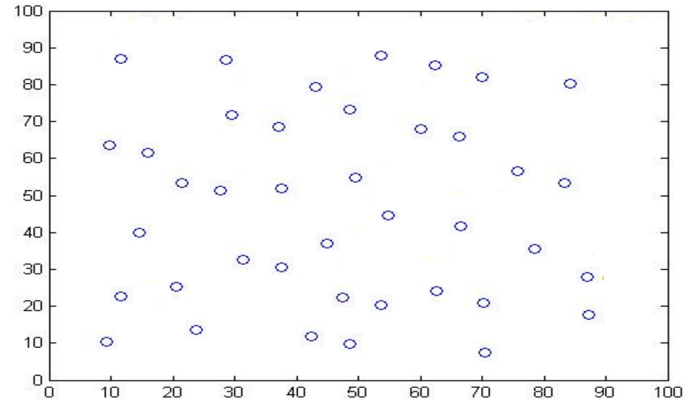

Figure 3. Wireless Sensor Network Area (100 x100msquere) with 40 Nodes

V. BIT ERROR RATE COMPUTATION

For the calculation of bit error rate different spreading scheme like OFDM, DSSS, FHSS, are used. In the present analysis OFDM spreading scheme has been used because it is best for multipath fading environment and robust against narrow band and highly sensitive to inter channel interference compared to DSSS and FHSS. The different modulation technique like ASK, FSK, QPSK, BPSK, PSK, M-ary has been used for the modulate signal with carrier. QPSK is most suitable technique because of multipath fading environment. The QPSK signal has expansion of BPSK and M-ary signal. QPSK modulate over AWGN (*Additive white Gaussian noise*) channel scheme and mapping gray code by set of $\pi/4$ radian as shown in fig.4. The transmitted packets (data) have been converted into parallel data (packet) of sub channel. The generated OFDM signal is shown in fig.5. Bit error rate (BER) has been calculated to analyze the network performance. The various parameters for generation of OFDM and QPSK are given in table 1.

Table.1 Parameter for generation of OFDM and BER

Parameter	Value
Number of carriers	64
Single frame size	96 bit
Sampling rate	25 MHz
Number of frame	100

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

$$y(t)=\begin{cases}\sqrt{\frac{2E}{T}}Cos\{2\pi f_c t+(2i-1)\frac{\pi}{4}\} & 0\le t\le T_z \\ 0 & elsewhere\end{cases} \quad (1)$$

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

$$\phi_1(t)=\sqrt{\frac{2}{T}}Cos(2\pi f_i t) \qquad 0\le t\le T_z \quad (2)$$

$$\phi_2(t) = \sqrt{\frac{2}{T}} Sin(2\pi f_i t) \qquad 0 \le t \le T_z \tag{3}$$

Quadrature message point the signal vector are defined

$$y = \begin{Bmatrix} +\sqrt{E} Cos(2i-1)\dfrac{\pi}{4} \\ -\sqrt{E} Sin(2i-1)\dfrac{\pi}{4} \end{Bmatrix}$$

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

$$y(t) = \sum_{p=-\infty}^{\infty} \sum_{i=0}^{N-1} x_i(p) \exp(j2\pi f_i (t - pT_z)) f(t - pT_z) \tag{4}$$

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

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

$$f_i = f_0 + \frac{i}{T_z} \tag{5}$$

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

$$f(t) = \begin{cases} 1 & (0 \le t \le T_z) \\ 0 & otherwise \end{cases} \tag{6}$$

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

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

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

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

Received signal is given as

$$r(t) = \int_0^{\infty} h(\tau, t)\, y(t - \tau) d\tau + n(t) \tag{9}$$

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

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

Multipath fading environment the received data given as

$$\hat{\hat{y}}_i(p) = \frac{\hat{h}_i^*(p)}{\hat{h}_i(p)\hat{h}_i^*(p)} \hat{y}_i(p) \tag{11}$$

We compute the bit error rate (BER) by comparing $\hat{y}_i(p)$ and $\hat{\hat{y}}_i(p)$ in fig.5.

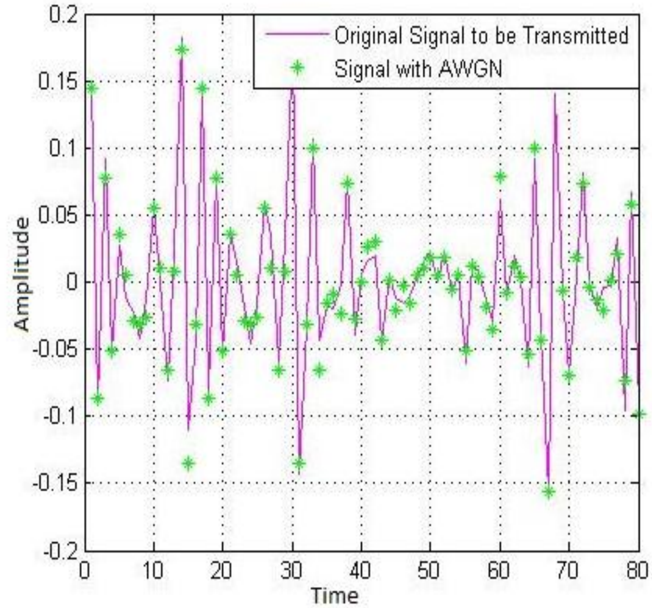

Figure. 4. Generated OFDM Signal

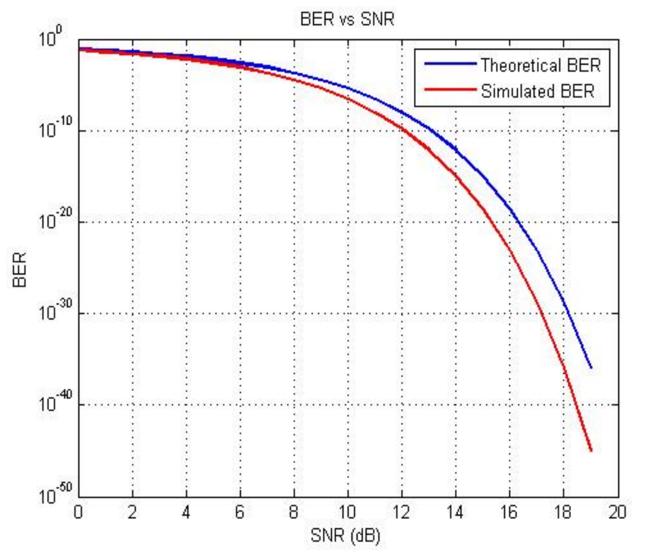

Figure.5. BER of QPSK-OFDM with AWGN

VI. IMPLEMENTATION OF OPTIMIZATION SCHEME

To implement the optimization scheme we need to configure the fitness function and searching phase in the network area.

Fitness function

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Suppose during the directed diffusion phase a path from source node (A) to sink node (D) is designed as show in figure 6. Initial parameters are configured as follows:

- Select the artificial ant's initial point. All ants start from source node (A) follows a routing path and ends at destination node (D).
- Set the choice rate of the routing path for artificial ants (a^0), pheromone evaporation rate (α) and surroundings area pheromone (τ_0): all parameters value ranges from zero to one.

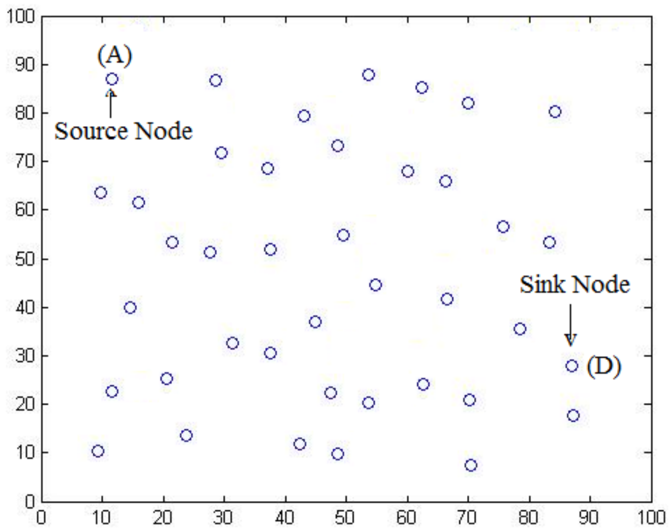

Figure. 6. Routing Source node (A) to sink node (D)

When the ants traverse between the nodes, the route of movement is decided by the pheromone. The sensor nodes transmit data, fitness function and calculate the energy exhausted as:

$$p(s_1,s_2)=r(\alpha_1+\alpha_2\, d^n_{s_1 s_2})+n_{s_2} \quad (12)$$

Energy consumption is directly proportional to the data transfer rate (r). Euclidean distance between nodes (s_1) and (s_2) is denoted by the parameters $d(s_1,s_2)$. Since the energy expenditure is proportional to the distance, therefore the parameter n is set at $2(n_{s_2})$. The consumptive energy $p(s_1,s_2)$ is maximize if (n_{s_2}) maximize. This technique avoids selecting a node that has additional energy expenditure than the others. The parameters (α_1) and (α_2) are the pheromone value from first node to nearest node. The performance of sensor nodes (battery performance), parameters (α_1) and (α_2) can be tuned. Parameters (r), (α_1) and (α_2) are constant values in the simulation because all the nodes are similar.

The energy expenditure $p(s_1,s_2)$ is calculated when node (s_1) sent data to node (s_2); (α_1) the distance-independent parameter; (α_2) the distance-dependent parameter.

Searching Phase

Using a random parameter (a) and another parameter (a^0), artificial ants select the routing path where (a) is a uniformly distributed random number in [0,1] and (a^0) is a parameter $(0 \le a^0 \le 1)$. If (a) is larger than (a^0) then ''exploring rule'' is applied, else ''using rule'' is used. Usable energy of all secondary nodes is evaluated by "exploring rule" and then evaluates the rate for all secondary nodes using equation 13:

$$G_k(s_1,s_2)=\frac{[\tau(s_1,s_2)].[p^{-1}_{s_1,s_2}]^{\beta}}{\sum_{s_{2(s_1)}}[\tau(s_1,s_2)].[p^{-1}_{s_1 s_2}]^{\beta}},\; s_2 \in s_{2(s_1)} \quad (13)$$

In equations (13), $G_k(s_1,s_2)$ is the probability that ant (k) on node (s_1) chooses to move to node (s_2); $s_{2(s_1)}$ the set of back-up nodes for node (s_1); $p(s_1,s_2)$ the signalling between node (s_1) and node (s_2); (β) the evaluation parameter of signalling versus energy expenditure.

With the residual signalling, the "using rule" directly chooses the path. As per the ACO transition rule, an ant selects the successive node (s_2) which initially positioned at node (s_1) to move in accordance with the equation (14), where random variable (D) chosen according to the probability distribution given in equation (12).

$$\begin{cases} \arg\max_{s_2 \in s_{2(s_1)}} \tau(s_1,s_2), & \text{if } a \le a^0 \\ D & \text{otherwise} \end{cases} \quad (14)$$

The signalling of the path that the artificial ants choose is reorganized by applying equation (12) and equation (15), (n) is the n^{th} wireless sensor node on the path

$$\tau(s_1,s_2)=(1-\rho).\tau(s_1,s_2)+\rho(n\times p_{(s_1,s_2)}(r,D))^{-1} \quad (15)$$

Based on signalling along the route for all nodes, ant colony optimization algorithm updates the new optimum path if the energy expenditure of new path is less than that of older one.

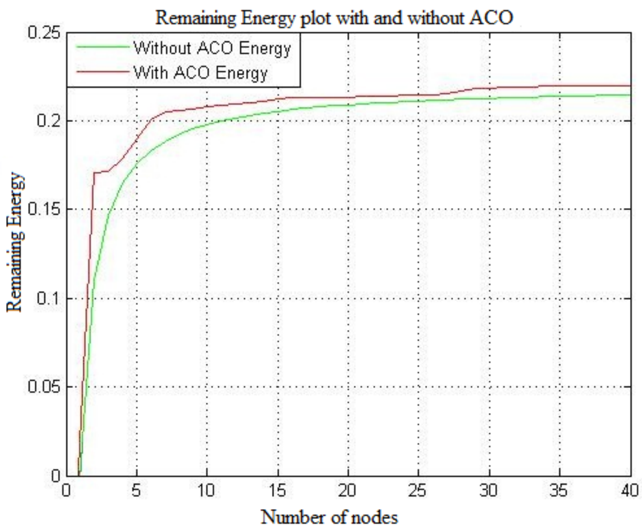

Figure.7. Comparison of remaining energy with and without ACO

VII. BANDWIDTH EVALUATION

For the calculation of bandwidth we have assume that that the link bandwidth allocation of random nodes in non-real time traffic demand, which satisfy to delay and traffic rate obligations. After that, the end to end latency refers that the delay are incurred on a multi-hop route from base station to a random node. Suppose that the time slot be long enough to transmit coordination message and data packets. The most of allocated bandwidth is consume in transmitting and routed packet. The packets are created by the referred nodes. The Packet consists of a collective message from the near non-backbone nodes.

In the present scenario all nodes have wireless link capacity of B bit per second and every node (s_1) has an initial battery every $E_{s_1}(s_2)$ and node (s_1) generates sensory data at rate of R_{s_1} bit per second $R_{s_1} > 0$

If the node (s_1) is a source node

$R_{s_1} = 0$ If it is a pure relay node

$R_{s_1} = 1$ If it is sink node

The source node is predefined and node "S_1" rate R_{s_1} is known. The data rate is unknown from "s_1"node to "s_2" node. To evaluate data rate $R_{s_1 s_2}$ on the link (s_1, s_2). We assume that, all node has same transmission power and all symmetric links. Let's assume s_i nearest node of (s_1). We define variable (f_{s_1}).

$$f_{s_1} = 1, \quad if \sum_{s_2 \in S} R_{s_2 s_1} > 0;$$

$$f_{s_2} = 0, \quad otherwise$$

If the node (s_1) has then value of (f_{s_1}) will be 1.

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

$$\sum_{s_2 \in S_{s_1}} (R_{s_1 s_2} - R_{s_2 s_1}) = R_{s_1} \tag{16}$$

$$\sum_{s_2 \in S_{s_1}} R_{s_1 s_2} + f_n \sum_{s_2 \in S_{s_1}} \sum_{k \in S_{s_2}} R_{s_2 k} \le B \tag{17}$$

$$0 \le R_{s_1 s_2} \le B \tag{18}$$

$$f_{s_1} = \{0,1\} \tag{19}$$

Supervision as every node satisfies according to equation (16) for all construct and bandwidth construct an equation (17) and (18) respectively has defined. According to equation (19), all probable transmission in the similar collision has a total depend less then B. Without any conflict transmission them enough situations has find out if TDMA technique uses MAC layer.

Find the bandwidth of shortest path by following algorithm.

1. Set $f_{s_1} = 1$ for sink node, $f_{s_1} = 0$, for every other node
   Modify $f_{s_1} = 1, \quad if \sum_{s_2 \in S_{s_1}} R_{s_2 s_1} > 0;$ for all (s_1), otherwise go next step
2. Find out optimized route from source node to sink node.
3. For receiving node s_1 . If $\sum_{s_2 \in S_{s_1}} R_{s_2 s_1} > 0;$ an $f_{s_1} = 0$, modify $f_{s_1} = 1$
4. Repeat step 3 until there has no change for (f_{s_1}) or the linear program has infeasible.
5. If f_n converges output link ($R_{s_1 s_2}$) for every link ($R_{s_1 s_2}$).
6. If it has infeasible means if $f_{s_1} = 1$ but $\sum_{s_2 \in S_{s_1}} R_{s_2 s_1} = 0$, and $R_{s_2 s_1} = 0, \forall \in S_{s_1}$ as input, if solution has infeasible then solve the linear program repeat. In most of the cases it requires 5 to 6 times of epoch to get a sub optimal solution.

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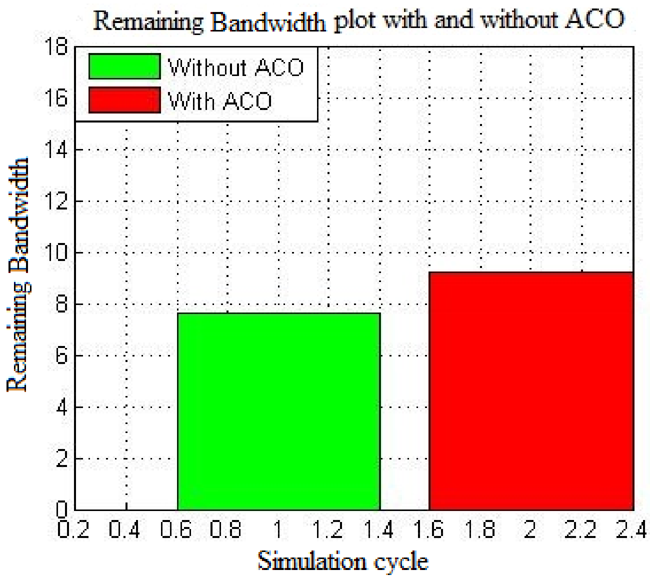

Figure.8. Remaining Bandwidth with and without ACO

VIII. ANALYSIS OF RESULT

The network performance has been analysis in terms of bit error rate, remaining energy and bandwidth. For calculation of bit error rate OFDM and QPSK signal have been generated with the help of matlab by considering number of carriers (64), sampling rate (25 MHz) and frame size (96 bit). The figure indicates the theoretical and simulated bit error rate with respect to signal to noise ratio. It is observer that stile variation in simulate bit error rate compare to theoretical because of network performance. The remaining energy of the node has been computed in wireless sensor network area using the parameters mentioned MAC Layer, CBR Packet Size, Data rate, Channel Bandwidth in table2. The number of nodes versus energy for directed diffusion routing protocol is shown in figure 7. The ant colony optimization has been applied to optimize the path source node to sink node. In figure 7, 8 the energy and bandwidth have been computed and compared with without optimized path. It is observed that directed diffusion routing protocol with optimization performs better than directed diffusion routing protocol without optimization in terms of energy and bandwidth in WSN. Similar analysis has been carried out by Farnaz Dargahi et al. [34] to reduces energy consumption with traffic load allocation using ACO for Cluster based directed diffusion methods. Malika Belkadi et al. [35] have change the properties directed diffusion routing to maximized the network life time and security. In the present work the performance of network with ant colony optimization for directed diffusion routing protocol has been analysis and compared with without optimization. The results shown in figure 7, 8 indicate in improvement in energy and bandwidth with ACO. It result are comparable with above mention work.

Table.2 Parameter for Energy and Bandwidth

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

IX. CONCLUSION

The performance analysis of Directed Diffusion routing protocol has been carried out in the terms of BER, energy and bandwidth. Bit error rate (BER) has been calculated to understand the network performance as shown in figure 4, 5. The average energy expenditure and bandwidth have been computed and analyzed with and without ant colony optimization for directed diffusion routing algorithm and the results are shown in figure 7, 8. It is observed in figure 7 that ant colony optimization minimizes the energy expenditure effectively, when the numbers of nodes increase in the wireless sensor network area. Bandwidth has been computed and analyzed for optimized and non optimized path as shown in figure 8. Figure 7 and 8 also implies that an ant colony optimization efficiently used in order to solve the network routing problem with decrease in energy expenditure and bandwidth to maximize the lifetime of wireless sensor network.

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