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Optimal Energy and Network Lifetime Maximization using a Modified Bat Optimization Algorithm (MBAT) under Coverage Constrained Problems over Heterogeneous Wireless Sensor Networks

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ABSTRACT

Recent years have witnessed an increasing interest in Wireless Sensor Networks (WSNs) for various applications such as environmental monitoring and military field surveillance. WSN have a number of sensor nodes that communicate wirelessly and it deployed to gather data for various environments. But it has issue with the energy efficiency of sensor nodes and network lifetime along with packet scheduling. The target coverage problem is another problem hence the overall network performance is reduced significantly. In this research, new Markov Chain Monte Carlo (MCMC) is introduced which solves the energy efficiency of sensor nodes in HWSN. At initially graph model is modelled to represent distributed and heterogeneous (HWSNs) with each vertex representing the assignment of a sensor nodes in a subset. Modified Bat Optimization (MBAT) is proposed to maximize the number of Disjoint Connected Covers (DCC) and K Coverage (KC) known as MBAT-MDCCKC. Based on echolocation capability from the MBAT, the bat seeks an optimal path on the construction routing for packet transmission that maximizes the MDCCKC. MBAT bats thus focus on finding one more connected covers and avoids creating subsets particularly. It designed to increase the search efficiency and hence energy efficiency is improved prominently. The proposed MBAT-MDCCKC approach has been applied to a variety of HWSNs. The results show that the MBAT-MDCCKC approach is efficient and successful in finding optimal results for maximizing the lifetime of HWSNs. Experimental results show that, proposed MBAT-MDCCKC approach performs better than, TFMGA, Bacteria Foraging Optimization (BFO) based approach, Ant Colony Optimization (ACO) method, and the performance of the MBAT-MDCCKC approach is closer to the energy conserving strategy.

Keywords: *Wireless Sensor Networks (WSNs), Modified Bat Optimization (MBAT), maximize the number of Disjoint Connected Covers (DCC) and K Coverage (KC), Packet scheduling, energy efficiency, network lifetime*

1. INTRODUCTION

Wireless Sensor Network (WSN) includes several sensor nodes utilized collaboratively to achieve a common mission. Each senor nodes in the system are responsible to gather the information from background circumstance. Then the composed information is promoted to the sink or Base Station (BS). These sinks begin the boundary through which the WSN collaborates along with the exterior world. Though the sensor nodes are accountable to self-organize and co-operate together to generate and reserve the network [1]. These nodes are frequently small in size along with controlled dispensation power, limited memory and limited energy [2] [3].

Commonly, sensor nodes are organized so compactly that the sensing scales of neighbouring nodes regularly have serious overlaps, resulting in redundant sensing of data and superfluous expense in correlating the same data. Data-aggregation technology [4] [5] is used to access the raw data, remove repeated or superfluous data, and preserve power via achieving that the network works resourcefully. The security of WSNs taken into consideration when they are deployed in uncertain and hostile environments, thus secure data-aggregation progressively is becoming a key technology.

Energy efficiency, routing and attacks are major issue in WSN [6].The Quality of service (QOS) is significant factor in all routing protocols [7]. These QoS requirements contain end-to-end delay assurance, bandwidth storage, energy efficiency, packet loss and the network life time, etc. In WSN, there exist many approaches to find the routing problem. However maximum of all try their finest to assume the power consumption since the energy is a prominent to sensor node. The lower protocols include the QoS provision at the same time. Normally, it can be separated into five categories: they are data-centric method, hierarchical approach, location/position-based method, network-flow approach and QoS-constrained algorithm.

Coverage problem is considered as a minimization problem [8]. The objective function of minimization function is to minimize the total area of the coverage holes in the network. Coverage problem in WSN is based on three main reasons; first is sensors are not sufficient to cover the whole ROI, second is limited sensing range and third is random deployment. Because the sensors use limited power supply, sometimes few sensors are not working therefore resulting in inadequate sensors to fully cover the whole ROI that causes the holes to exist. The sensing range of sensors is restricted to certain radius which brings coverage problem. This problem can be solved by using expensive sensors with larger sensing range. For target coverage problem of WSN, lot of previous studies is concentrated on homogeneous wireless sensor networks with single sensing unit based on centralized policies. A target problem to maximal set cover problem and considered heuristic algorithms with centralized policies [9].

In [10] range set cover problem is adjusted to extend network lifetime in the adjustable sensing ranges WSN. However these works did not consider the multiple sensing units. The approximation algorithm of K-coverage problem was solved in recent work [11-12] for considering single sensing units only. In [13] used RACE algorithm, a real-time scheduling policy for large scale wireless sensor networks. The main goal of RACE algorithm is to support a soft real-time communication service through the path with minimum delay. Thus the end-to-end delay in the sensor network becomes proportional to congestion of nodes between source and destination.

Packet-scheduling methods of WSN use First Come First Served (FCFS), non-preemptive priority and preemptive priority scheduling algorithms. These approaches sustain a high processing overhead and long end-to-end data transmission delay due to the FCFS concept, starvation of high priority real-time data packets due to the transmission of a large data packet in nonpreemptive priority scheduling, starvation of non-real-time data packets due to the probable continuous arrival of real-time data in preemptive priority scheduling, and improper allocation of data packets to queues in multilevel queue scheduling algorithms. Moreover, these approaches are not dynamic to the changing requirements of WSN applications because their scheduling policies are found. A Dynamic Multilevel Priority (DMP) packet scheduling system for WSNs in which sensor nodes are virtually organized into a classified structure. Nodes that have the same hop distance from the BS are assumed to be located in the same hierarchical level [14].

In this research, the distributed packet scheduling algorithm schedules the packet transmission to further reduce the packet transmission time. The mobility-based packet resizing algorithm resizes the packets into smaller packets and transmits packets to nodes with faster mobility to guarantee the routing QoS in a highly mobile environment. Modified Bat (MBAT) algorithm is proposed to maximize the number of DCC and KC known as MBAT -MDCCKC.

The remaining work of the paper is described as follows. Section II presents the literature review on the techniques and approaches for network lifetime maximization. Section III starts with the network model and describes the target coverage problem exactly. Section IV develops MBAT algorithm for solving target coverage problem and improves network lifetime, and Section V evaluates the simulation results of the proposed MBAT -MDCCKC approach via the use of network simulation tool. At final section concludes the entire research paper with scope of the future work.

2. RELATED WORK

Zhang and Hou [15] addressed the issues of preserving sensing coverage and connectivity via keeping a slight number of sensor nodes on the active mode over WSN. It finds the association among coverage and connectivity via resolving the following two sub-problems. Initially, it proves that if the radio range is at least twice of the sensing range, a complete coverage of a convex area implies connectivity between the working set of nodes. With such a proof, it focused only on the coverage problem. Second, it derive, under the ideal case in which node density is appropriately high, a group of optimality constraints under which a subset of working sensor nodes can be preferred for full coverage

Tian and Georganas [16] used a node-scheduling scheme, which be able to decrease system overall energy consumption, consequently increasing system lifetime, via turning off some redundant nodes. This coverage-based off duty eligibility rule and backoff-based node-scheduling method guarantees that the original sensing coverage is maintained after turning off redundant nodes. It executed by using NS-2 as an extension of the Low-Energy Adaptive Clustering Hierarchy (LEACH) protocol. It evaluates the energy consumption of LEACH with and without the extension and analyze the effectiveness of our scheme in terms of energy saving. Simulation results show that our scheme can preserve the system coverage to the maximum extent. Additionally, after the node-scheduling method turns off some nodes, certain redundancy is still guaranteed, which provides enough sensing reliability in many applications

Jandaeng et al [17] used an algorithm that schedule packets on the network layer and application layer to decrease network congestion over data link layer. It reduces the packet collision and increase the throughput. The Packet Scheduling Approach (PSA) is to schedule packet in network layer and higher to decrease packet congestion in Media Access Control (MAC) layer and to reduce the packet collision and end-to-end delay; better packet delivery ratio is a byproduct. A greedy technique is used in this algorithm that is simple and easily implemented in a sensor node. The PSA limitation is that the average delay is more than other algorithms.

Bahmani-Firouzi and Azizipanah-Abarghooee [18] introduces a new cost-based formulation to compute the energy efficiency nodes. Moreover, a number of restrictions, i.e. power capability of Distributed Generators (DGs), power and energy capability of Battery Energy Storage (BES), charge/discharge effectiveness of BES, effective distance and load demand approval must be considered as well. The proposed problem is a modelled as optimization problem, the complexity of which is improved by considering the above mentioned issues. So, a robust and scalable optimization algorithm is needed to solve it. So in this work introduces a new improved bat algorithm with the purpose of is used for introducing corrective strategies and to perform least cost dispatches. The results of the corrective strategies are measured by one grid-connected low voltage MG where the optimal size of BES is determined efficiently.

Kavitha and Ramesh Chand Kashyap [19] used objective function for the implementation of bat Algorithm. The distance among nodes is calculated by using the Bat Algorithm. The distance is then used for clustering in the network. The results of the method are then compared along with the basic algorithm. The results also verify the algorithm and compared on the basis of performance parameters like residual energy, end to end delay and throughput of the network.

Yu et al [20] used Energy aware Temporarily Ordered Routing Algorithm (E-TORA). It is used for reducing the energy consumption of the nodes. It makes routing over head on main routing path because of the same node repeatedly involved in route phase and also the repeated nodes are run out of its energy that reduce the routing performance. This method used for shorter path but it is not considering their power that reduce whole network lifetime

Lei et al [21] presents a novel scheduling approach called as Energy, Time, Reward, and Interest (ETRI) packet scheduling algorithm. Within this approach every packet has four parameters. They are (1) energy utilization of this packet, (2) time limit of this packet, (3) significant stage of this packet, and (4) interest level of this packet. It can dynamically join ETRI packet-scheduling algorithms to acclimatize to diverse sensor nodes' real working purposes. By using the ETRI packet scheduling algorithms, it can easily utilize different ETRI versions to different sensor nodes to decrease energy expenditure, improve information quality as well as the WSN performance.

Dener [22] illustrates optimum packet length over data transmission for WSN. Optimal packet length is changeable in every of application. Therefore network topology is significant point. If distance among nodes in network too far, there will be packet lose. When optimum packet length is established then dropped packets and packet errors decreases. Though, energy efficiency provides which is decisive for sensor networks. The simulation is performed by using Objective Modular Network Testbed in C++ (OMNet) simulation platform with IEEE standard 802.15.4. Optimum packet length is established in terms of energy efficiency.

Goyal and Patterh [23] presents the localization problem over WSN which is formulated as an optimization problem and bat algorithm is used to resolve this issue. The result demonstrates that the localization accuracy is high and bat algorithm can attain higher accurate spot estimation. A hybrid stochastic algorithm may be used to accomplish better accuracy. The efficiency of the algorithm may confirm on experimental set up of sensor network.

Yan et al [24] presents a new surveillance service for sensor networks depends on a scattered energy-efficient sensing coverage protocol. In this approach, every node is capable to energetically choose a plan for itself to assurance a certain Degree of Coverage (DOC) along with average energy consumption inversely proportional to the node density. The technique is to improve the basic design with a better load-balance feature and a longer network lifetime. It assumes the impact of the target size and the unbalanced original power capability of individual nodes to the network life span. Many practical challenges such as the localization error, irregular sensing choice, and changeable communication links are solved in this work. Simulation results demonstrated that the energy-efficient sensing coverage protocol increase network lifetime considerably with lesser energy consumption. It performs better than other conventional methods by as much as 50% decrease in energy consumption and as much as 130% increase in the half-life of the network.

3. PROPOSED METHODOLOGY

In the proposed methodology, Modified Bat (MBAT) algorithm is used to maximize the number of DCC and KC nodes. In MBAT bats thus focuses on finding one more connected covers and avoids creating subsets particularly. The problem formulation of MDCCKC is described briefly in previous methodology. The k-coverage constraints are also discussed which satisfy the given wireless sensors of coverage conditions.

3.1.Distributed Packet Scheduling

Packet scheduling schemes depends on the deadline of arrival of data packets to the Base Station (BS). Packet scheduling in every node level is executed alongwith variable-length time periods. Data are transferred from the lowermost level nodes to BS via the nodes of intermediate levels. Hence, nodes at the intermediate and upper levels have more tasks and processing necessities evaluated to lower-level nodes. Assuming this reflection, the length of timeslots at the upper-level nodes is set to a higher value compared with the timeslot length of lower-level nodes. On the other hand, real-time and time critical emergency applications should stop intermediate nodes from aggregating data since they should be delivered to end-users with a minimum possible delay. The packet scheduling scheme considers that nodes are virtually systematized following a hierarchical arrangement [25]. Nodes that are at the same hop distance from the base station (BS) are measured to be positioned in the same level.

Packet queue sizes vary depends on the application necessities. Packets that attain from the sensor nodes in lower level are located over the preemptable priority queue. The processing of these data packets can be pre-empted through the highest priority real-time tasks and subsequently a definite time slot if tasks on the lower priority queue do not get processed since of the continuous arrival of higher priority data packets. Real-time packets are typically handled in FCFS manner.

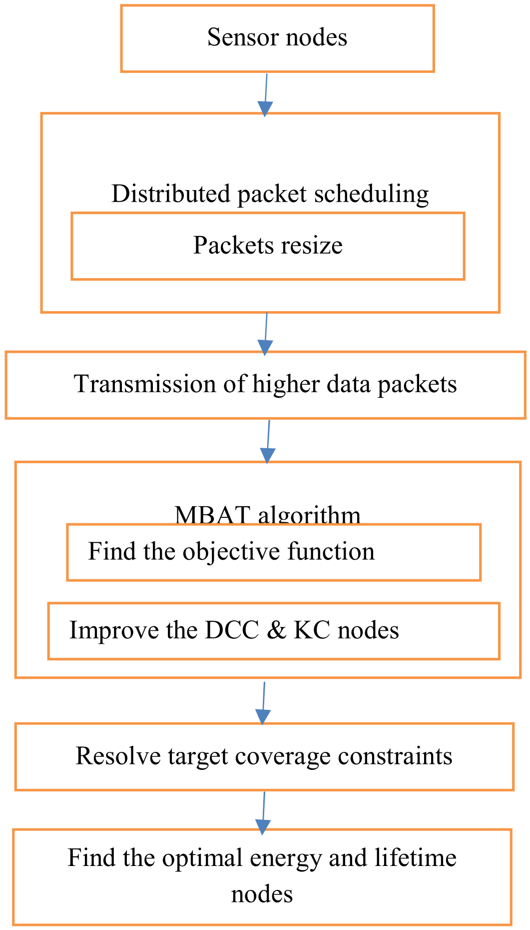

Figure 1: Overall block diagram of the proposed system

Every packet has an ID, which includes two parts such as level ID and node ID. When two equal priority packets arrive at the ready queue at the same time, the data packet which is produced at the lower level will have higher priority. This phenomenon reduces the end-to-end delay of the lower level tasks to reach the BS. For two tasks of the same level, the smaller task (i.e., in terms of data size) will have higher priority.

3.2 MBAT for energy efficiency and network lifetime

A new meta-heuristic search algorithm called Bat algorithm (BA) [27]. Bats are fascinating. The mammals have wings along with progressive echolocation capability. Micro bats employed sonar called echolocation to detect prey, avoid obstacles, and locate roosting crevices in the dark. Bats produce a loud sound pulse and attend to the resounding echo from the nearby objects. Their pulse differs in properties and is connected along with their species-dependent hunting approaches.

If the features of the echolocation of micro bats are ideal, a BAT algorithm is industrialised. For simplicity, the following approximate rules are utilized:

Bats custom echolocation to intellect the distance and there by deduce the difference between food/prey and background barriers [26]

Bats fly randomly with a velocity *vi* at position *xi* at a frequency *fmin*, varying wavelength *λ,* and loudness *A0* to search for their prey. They automatically adjust the wavelength (or frequency) of the emitted pulses as well as the pulse emission rate r Є [0, 1], based on the target proximity.

Though loudness differs in numerous ways, it can be considered that loudness varies from a great (positive) A_0 to a minimum constant value A_{min}. Based on approximation and idealization, the BAT algorithm's basic steps (BA)[28] have been summarized as a pseudo code in the next section.

In this research, MBAT-MDCCKC is proposed to maximize the number of Disjoint Connected Covers (DCC) and K Coverage. Consequently, energy efficiency have been becomes a most important issue in distributed WSNs. To solve this problem, Markov Chain Monte Carlo (MCMC) is introduced in this work. In MBAT -MDCCKC algorithm initially converts the coverage problem and energy efficiency problem into a Constructed Graph (CG) model. In the CG model, vertex is denoted as the assignment of a device in a subset. Heuristic information from MBAT is used for calculating its constraint violations such as DCC and KC for coverage problem, routing constraints and energy constraints [29]. In MBAT algorithm, efficient sensor nodes are used for finding target coverage nodes, energy efficiency and avoid constructing subsets extremely. It improves the optimal MDCCKC solutions by updating of Coverage Set (CS) nodes. For performing this task, MBAT-MDCCKC approach is initially introduced for network lifetime maximization and above mentioned constraints is checked simultaneously under the number of connected covers in a WSN. From the constraints objective function is defined and it is used as fitness function to MBAT-MDCCKC. Secondly the working procedure Markov Chain Monte Carlo (MCMC) is introduced which solves the energy efficiency constraints problem. Then the working procedure of MBAT-MDCCKC is described to solve MDCCKC problem. Finally, the overall working procedure of the MBAT-MDCCKC algorithm will be discussed at end of the section. Let us consider the coverage constraint solution as

$\mathrm{SOL} = \{\mathrm{Sol}_1, \ldots, \mathrm{Sol}_N\}$where $\mathrm{SOL}_i \subseteq \mathrm{SEN} \cup \mathrm{SIN}$ denotes a subset of sensors $U_i$and V_i sinks, $i = 1, \ldots, N$, and N be the total number of subsets. Each cover subset is Disjoint and K Coverage Constraint (DCKCC) by each other's and the combination of the N subsets equals to the set of $SEN \cup SIN$.

Objective function: Energy

$$E_{trns}=k*E_{select}+k*E_{dist} \quad d<d0 \qquad (1)$$

Where E_{trans} is Energy node packet transmission, K is bit size packet over distance d

$$E_{reception}(k, d)=k*E_{select} \qquad (2)$$

The fitness of bat is computed as follows:

$$f = \alpha * (d_{total} - d_i)(1 - \alpha) * \left(N_{total} - N_{energy}\right)$$
(3)

Where α is predefined weight, d_{total} is the distance of all nodes to the sink, d_i is the sum of distance of nodes to energy nodes, N_{total} is the number of nodes in the wireless sensor network, and N_{energy} is the number of energy nodes. The fitness of the node increases as the distance decreases and the number of energy node is less. During initialization, the algorithm randomly selects nodes to be energy in the network. Based on the fitness function, the algorithm searches for appropriate number of energy and its location

Objective function: f(x), $x=(x_1, \ldots, x_d)^t$

1. Initialize bat population SEN (sensor nodes) xi and velocity v_i i=1, 2, ….n
2. Initialize sink nodes SIN = $\{Sin_1, Sin_2, \ldots Sin_n\}$
3. Define pulse frequency at f_i and x_i
4. Initialize pulse rate r_i and loudness A_i
5. Compute the objective value of every sensor nodes in population
6. While (t < maximum number of iterations)
7. Generate new sensor node solutions by adjusting frequency and
8. Compute energy nodes using (1) and (2)
9. Update objective function values using (3)
10. Updating sensor node velocities and location / solutions.
11. F (rand >*ri)*
12. Select a solution among the best solutions
13. Generate a local solution around the selected best solution
14. End if
15. If (rand< A_i and f (x_i) < f(x*))
16. Accept new solutions
17. Increase r_i reduce A_i
18. End if
19. Ranks the bats (nodes) and find current best x*
20. End while
21. Display final results

The algorithm considers more than one factor of sensor node for instance residual energy, no. of sensors present in each sensor to ensure energy consumption and longer network lifetime. Along with that sensor node selection can further be optimized by using any one of the bat optimization algorithms. This research focuses on using bat algorithm for optimizing sensor node and then analysing it by varying the base-station location and initial energy of sensor nodes.

Frequency Tuning: BA utilizes echolocation and frequency tuning to resolve issues. Although echolocation does not directly mimic the real function, it uses frequency variations. This ability provides some functionality that are similar to the key feature in PSO and harmony search. Therefore, BA possesses advantages over other swarm-intelligence algorithms.

Automatic Zooming: BA provides a major benefit over meta-heuristic algorithms. BA can automatically zoom into region where promising solutions occur. Zooming is accompanied by automatic switching from explorative moves to local intensive exploitation, leading to quick convergence rate at iterations early stages as compared to other algorithms.

Parameter Control: Numerous meta-heuristic algorithms fix the parameters through pre-tuned algorithm-dependent parameters. In contrast, BA uses parameter control, which differs the parameters (A and r) values as iterations proceed, viewing a way to repeatedly switch from exploration to exploitation under optimal solution.

4. SIMULATION RESULTS

In this section simulation work is experimented and measured results between proposed algorithms and existing ACO-MNCC, Energy-efficient Distributed Target Coverage (EDTC) algorithm. The simulation work is simulated using network OMNET++ simulator tool with three different sets of HWSNs environment is used with varied scales and redundancy. In Set A, WSNs are formed by the use of randomly positioning sensors and sinks in a 50 x 50 area. From the simulation results, it concludes that MBAR-MDCCKC, TFMGA-MDCCKC, BFO-

MDCCKC, and ACO-MNCC are able to determine a solution via the use of Ĉ connected covers designed for each case. Accordingly, the value of a maximum number of connected covers is Ĉ in the Set A. In the simulation setup, initially the energy value of sensors nodes is predefined to 50 units. The sensing range of each sensor node is predefined to 50m. The initial phase ends with 8 seconds, and the period of a round is 10 minutes. To measure the simulation results the following parameters have been used in this work for measuring the results of several approaches in HWSNs. The parameters description is specified as follows:

I. Average Energy consumption of each and every one node in the known area for transmitting a data packet to the nearest sink.

II. Network lifetime of the node is measured as the network running out of its energy and how in the direction of increasing the lifetime.

III. Success ratio is computed the success ratio in the direction of sending packets from source to destination node.

Table 1: Network lifetime vs. No. of sensors

No of nodes	Network lifetime (ms)				
	EDTC	ACO-MNCC	BFO-MDCCKC	TFMGA-MDCCKC	MBAT-MDCCKC
10	8	9	12	15	25
20	9	11	13	18	29
30	13	14	16	21	33
40	16	17	18	23	35
50	21	23	25	28	38
60	25	26	29	32	40
70	28	29	31	33	42
80	31	33	35	38	48
90	33	35	38	42	50
100	36	38	41	45	54

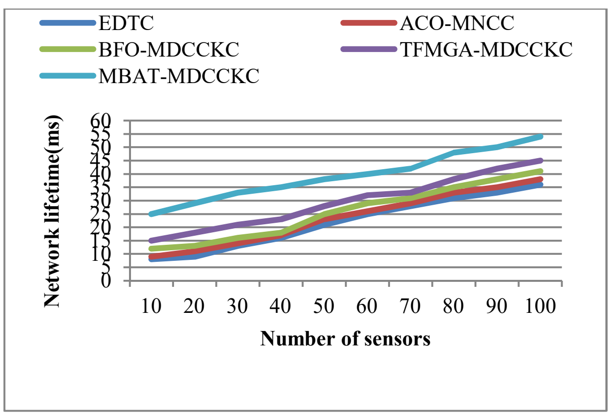

Figure 2: Network lifetime vs No. of sensors

Figures 2 shows the results of network lifetime are measured by varying the number of sensors node between 10 and 100. At the same time the number of targets and attributes are assumed to 25 and 4 equally. From the simulation results, it concludes that the proposed MBAT-MDCCKC produces maximum network lifetime results of 54 ms for 100 no. of nodes which are 9 ms, 13 ms,16 ms and 18 ms higher when compared to TFMGA, BFO, ACO and EDTC methods respectively and discussed in table 1.

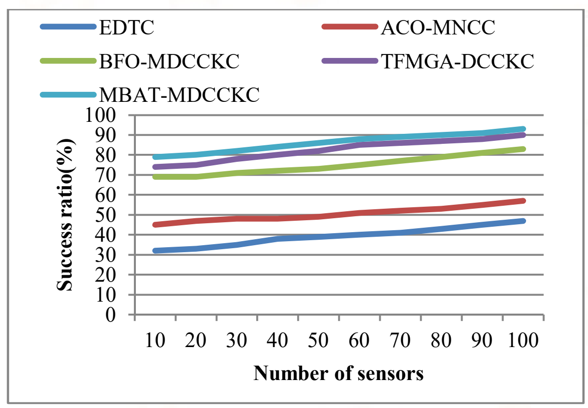

Figure 3: Success Ratio vs. No. of nodes

Figure 3 shows the performance comparison results of success ratio in terms of number of nodes. From the results it concludes that the proposed MBAT-MDCCKC produces higher success ratio results of 93% for 100 no. of nodes which is 3%, 10%, 26% and 36% higher when compared to TFMGA, BFO, ACO and EDTC methods correspondingly. As a result, MBAT-MDCCKC is more suitable and gives best results for improving the network lifetime and data transmission. It demonstrated that if the number of nodes increases the success ratio of the proposed MBAT-MDCCKC system is moreover increases (shown in Figure 3 and see table 2).

Table 2: Success Ratio vs. No. of nodes

No of nodes	Success Ratio (%)				
	EDTC	ACO-MNCC	BFO-MDCCKC	TFMGA-MDCCKC	MBAT-MDCCKC
10	32	45	69	74	79
20	33	47	69	75	80
30	35	48	71	78	82
40	38	48	72	80	84
50	39	49	73	82	86
60	40	51	75	85	88
70	41	52	77	86	89
80	43	53	79	87	90
90	45	55	81	88	91
100	47	57	83	90	93

Table 3: PLR vs. No. of nodes

No of nodes	PLR (%)				
	EDTC	ACO-MNCC	BFO-MDCCKC	TFMGA-MDCCKC	MBAT-MDCCKC
10	68	55	31	26	21
20	67	53	31	25	20
30	65	52	29	22	18
40	62	52	28	20	16
50	61	51	27	18	14
60	60	49	25	15	12
70	59	48	23	14	11
80	57	47	21	13	10
90	55	45	19	12	9
100	53	43	17	10	7

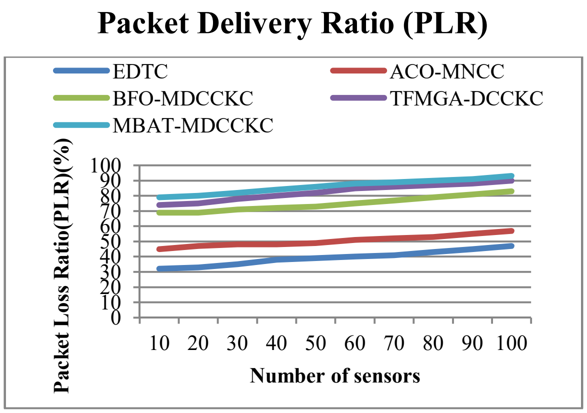

Figure 4: Packet Loss Ratio (PLR) vs. No. of nodes

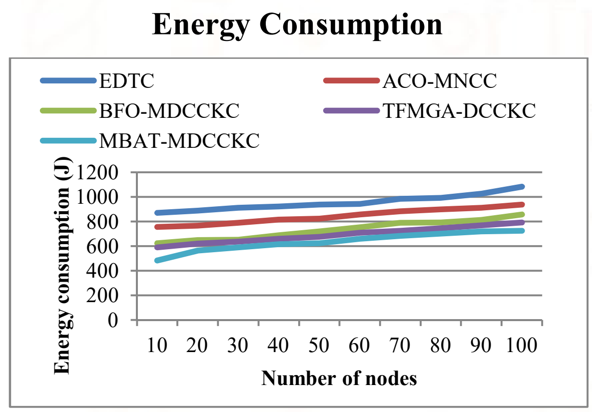

Figure 5: Energy Consumption vs. No. of nodes

Figure 4 shows the performance comparison results of Packet Loss Ratio (PLR) in terms of number of nodes. From the results it demonstrated that the proposed MBAT-MDCCKC algorithm produces lesser PLR results of 7 % which is 3%, 10%, 36%, 46% lesser when compared to other existing TFMGA, BFO, ACO, EDTC methods correspondingly. It demonstrated that the proposed MBAT-MDCCKC algorithm work better when compared to other methods. It demonstrated that if the no of nodes increases the PLR results of the proposed MBAT-MDCCKC algorithm system becomes increases however decreases when compared to other existing methods (shown in Figure 4 and table 3).

Figure 5 shows the performance comparison results of energy consumption in terms of no of nodes. From the results it demonstrated that the proposed MBAT-MDCCKC consumes lesser energy results of 723 J which is 69J, 133J, 215J and 361 J lesser when compared to other TFMGA, BFO, ACO and EDTC methods correspondingly. It demonstrated that the proposed TFMGA- DCCKC work better when compared to other methods (See table 4).

Table 4: Energy Consumption vs. No. of nodes

No of nodes	Energy consumption (J)				
	EDTC	ACO-MNCC	BFO-MDCCKC	TFMGA-MDCCKC	MBAT-MDCCKC
10	869	756	623	589	482
20	889	765	648	621	563
30	912	789	652	635	589
40	921	814	687	658	615
50	938	823	718	675	623
60	942	858	752	708	658
70	984	882	788	725	682
80	992	898	793	746	701
90	1025	912	813	768	718
100	1084	938	856	792	723

5. CONCLUSION AND FUTURE WORK

In this research, the methods proposed to resolve the target coverage problem under MDCCKC over WSNs with the purpose of network lifetime maximization and energy efficiency constraints. This research work focused on energy-efficient target coverage problem under maximize the number of Disjoint Connected Covers (DCC) and K Coverage (KC) namely MDCCKC in HWSN. Modified BAt Algorithm (MBAT) is introduced to MDCCKC problem known as MBAT-MDCCKC for solving target coverage problem. A distributed target coverage algorithm is presented in this work to HWSN with many sensing units which saves energy and extend network lifetime. The MBAT is to improve the sensor priority, which is obtained by integrating three parameters together, which are the coverage, routing constraint, lifetime nodes and the remaining energy. The experimental results demonstrate that the proposed MBAT-MDCCKC approach performs betters in terms of network lifetime maximization, energy efficiency and Packet Delivery Ratio (PDR). In the future work, it is extended with the purpose of the different optimization methods are integrated to progress the large-scale distributed WSNs. It would be improving the Quality of Service(QoS) parameters such as throughput, bandwidth, energy utilization, PDR, delay rather than the existing methods.

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