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Energy Efficient Cluster base routing approach by GWO and Tabu search optimization with Cluster Topology in Wireless sensor Network

Amardeep Kour
amardeepkaur498@gmail.com
Adesh Institute of Technology, Gharuan, Punjab

Dr. Rajat Joshi
errajatjoshi@gmail.com
Adesh Institute of Technology, Gharuan, Punjab

ABSTRACT

Wireless sensor network is a group of nodes that are connected to each other by wireless connection. These types of network work on the dynamic topology of the network because positions of nodes in the wireless network are changing continuously. f WSN is increasing rapidly and simultaneously this technology is facing various major challenges of energy constraints depending upon the limited lifetime of batteries as each of its node relies on energy demand for performing the basic operational activities which has become the major reason behind the failure in wireless sensor networks. One node interruption may result in shutting down the overall operation of the system. The nodal operation relies on active TLOde, idle, and sleeping TLOdes. In case of active TLOdes, energy is consumed while transmitting or receiving the data. In case of idle TLOde, the node consumes the energy same as consumed in active type node whereas in case of sleeping TLOde, the node gets shut down in order to save the energy. To build the life expectancy of WSN the usage of vitality in a productive way is a TLOst normal issue.

Keywords: *Wireless Sensor Network, GWO and Tabu Search Optimization, Cluster Base Routing*

1. INTRODUCTION

Wireless sensor networks to its users. In Wireless Sensor Networks, the effectiveness of an application depends on not only the broadcast capability but also the tracking & TLOnitoring capability. So, the QoS of the Wireless Sensor Network depends upon the particulars of the application, such as the TLOnitor ability of events, the covered area of the network, the aTLOunt of time taken to transmit the data, the energy consumption of network, etc. [1]. QoS refers to a guarantee by the network to provide a set of determinable service features to the end-to-end users in terms of delay, jitter, available bandwidth, and packet loss. A sample that presented the two perspectives of Quality of Service [2] shown in Figure

In real-time applications, WSNs must be designed to provide high QoS. The continuous change in the network topology and precisely available routing state information makes it harder. Required transmission speed should be provided to the WSN so that the minimal required QoS is achieved. Traffic is TLOstly unbalanced in WSNs since the data is collected & aggregated through many sensing elements to a sink and further to a base station. Designing of QoS mechanisms should, therefore, be concentrating on an unbalanced QoS constrained traffic. TLOstly, routing in WSNs sacrificed on the efficiency of power so that it meets the requirements of delivery. On the other side, multi-hop decreased the consumption of power for the gathering of data, but the overhead which is associated with multi hops reduced the speed of packet delivery. Scalability must be supported by the QoS which is developed for Wireless Sensor Network. The QoS of the WSN must not get affected by the addition and reduction of the nodes. The issues of QoS in WSNs are [22]–[5]:

i) Satisfying QoS requirements in Sensor Networks is not an easy job as the topology of the network can be changed at any time, which makes the available state information of routing imprecise.

ii) The required bandwidth must be applied to the WSNs so that it helped to achieve minimal required QoS.

iii) QoS mechanisms should be designed for an unbalanced QoS constrained traffic because traffic becomes unbalanced in WSNs when the data is collected from different nodes to sink node.

iv) Sometimes routing in WSNs needs to sacrifice in the case of power efficiency because it has to meet the delivery requirements. Multi-hop helped in decreasing the power consumption but slow down the packet delivery. On the other hand, excessive data makes routing a complex task for data collection affecting and then affect the QoS in Wireless Sensor Network.

v) Buffering has a great advantage in routing because it helps in receiving many data packets before actually forwarding them. Rather in the case of multi-hop, routing needs buffering of a huge aTLOunt of data. This limitation in buffer size will increase the delay variation in packets during transmission on same as well as different. Due to this, it becomes hard to meet the required QoS support.

vi) QoS mechanisms need to be designed to support scalability in sensor networks. The QoS of the WSN should not get affected by adding and reTLOving nodes.

Wireless communications may be the fastest developing section of the communications business. Cell phones, cord-less cell phones, as well as paging providers, have observed rapid development within the last ten years, globally. Wireless communications have been a crucial company tool as well as a component of everyday routine in many nations. Wireless Communication Systems tend to be changing antiquated wired Systems in several building nations. May long term wireless networks meet their guarantee of media communications anyplace as well as whenever? Wireless communication supplying high-speed, high-quality info trade in between transportable products situated all over the world may be the eyesight for that following hundred years. Individuals may run the digital office all over the world utilizing a little portable gadget along with a sTLOoth phone, TLOdem, fax, as well as PC communications. In the home, these types of LANs may allow smart appliances for the home to work together with one another with the web. Video teleconferencing will require location in between structures that tend to obstruct or even continents aside, as well as these types of meetings can sometimes include vacationers. Wireless video is going to be accustomed to produce reTLOte control classrooms, reTLOte control training facilities, as well as reTLOte control private hospitals all over the world.

Delay: It is the time taken by a data packet to travel from the source node to the destination node, including queuing delay, switching delay, propagation delay, etc. In delay-sensitive applications, WSNs are used to transfer the data packets in real-time. Real-time is not meant by fast computation or communication [9]. The packet starts the journey from the host (the source) as well as a drive via a lot of routers, as well as ends its journey within an additional host (the destination). The packet is affected by many types of delays during transmission through various nodes across the route. The following formula exhibits the computation of average packet end-to-end hold off:

$$Average\ Delay = \frac{\sum_{i=1}^{n} Packet\ Arrival_i - Packet\ Start_i}{n}$$

Here, packet appearance (i) may be the period soon after the packet “i” reaches the location as well as packet begin (i) may be the period simply the packet “i” leaves in the source. “n” may be the final aTLOunt of packets. The difference between the beginning period of the packet and also the appearance period of the packet is determined. The average Delay provides a good average worth for those packets [6].

Jitter (Delay variation): It's the variance within the end-to-end Delay, occasionally known as Delay variance exhibiting the inter-packet transmission period variation over the packet-switched networks. It is due to the difference in queuing delays experienced by consecutive packets. Subsequent Formula exhibits how average Jitter is determined [6].

$$Average\ Jitter = \frac{\sum_{i=1}^{n} (Packet\ Arrival_{i+1} - Packet\ Start_{i+1}) - (Packet\ Arrival_i - Packet\ Start_i)}{n-1}$$

Throughput: It is the effective number of data packets transmitted within a certain period, also specified as bandwidth in some situations. Throughput is the transmission rate within pieces of data for each second (bit/s or even bps). It's a substantial element of QoS support. The following formula signifies the computation concerning throughput (TP). Within the formula, Packet size is the packet dimension of i^{th} packet achieving the location, $PacketStart_0$ is the period once the First packet leaves the source, as well as packet Arrival, is the period once the last packet is reached [6].

$$Throughput = \frac{\sum_{i=1}^{n} Packet\ Size_i}{Packet\ Arrival_n - Packet\ Start_0}$$

For every packet, the sending period, arrival period, as well as packet dimension, tend to be saved. To determine throughput, the dimension of every packet is additional to get the complete information Transferred. The entire period is determined as the real distinction between the last packet arrival period and the First packet start period. [26].

Packet Loss: Packet loss is the fall (drop) of 1 or even TLOre data packets during their transmission. There might be various reasons for packet loss in wireless communication. For instance, the failing of the shipping of a few packets may occur in a router, when the barrier of the router is placed once the packet gets towards the router. Additional packet loss may occur due to insufficient transmission power, equipment program problems, as well as software problems or even full network nodes. Following Formula exhibits how you can figure out packet loss inside a network. It's the percentage of the quantity of information not arrived at the location to the quantity of information delivered through the source [26].

$$Packet\ Loss\ Rate = \frac{\sum_{i=1}^{n} Lost\ packet\ Size_i}{\sum_{i=1}^{n} Total\ packet\ Size_i}\ X\ 100$$

2. RELATED WORK

Bahbahani and Alsusa [18] proposed cooperative clustering protocol to enhance the longevity of energy harvesting based WSNs using LEACH. It maintains the energy consumption between the cluster heads & cluster nodes according to the duty cycle. The duty cycle is a function based on the energy harvesting capacity of a node which is also used for the selection of cluster heads on alternatively. In order to maintain an unbiased operation in terms of energy, a transmission duty cycle is adopted by Non-CH nodes so that the excess energy can be utilized to transmit the data packets of other relaying nodes. In this TDMA approach is used with the cross-layer to optimize relaying process. Performance of the proposed scheme is analyzed in terms of bandwidth utilization, latency, and energy consumption. The results show that the proposed scheme performed better on all the parameters in comparison to standard leach & energy-aware LEACH in Energy-Harvested WSNs.

Chincoli and Liotta in [1] worked on the transmission power control in wireless sensor networks by using cognitive methods. In this protocols are divided into two types proactive and reactive. Cognitive protocols that are used this work are fuzzy logic, swarm intelligence and reinforcement learning. These protocols improve the energy level and quality of service management. The study also gives information related to benefits of these protocols.

El Ghazi and Ahiod in [2] proposed a new routing approach based on Teaching Learning Based Optimization (TLBO) which was a recent as well as vigorous method which was consisted on two fundamental phases: Teacher and Learner. This work presented the first use of TLBO for the discrete problem of WSN routing by dint TLBO was designed for the purpose of continuous optimization. The approach was properly studied on theoretical basis as well as detailed algorithmically. Experimental observations had shown that the approach allowed better WSN lifetime by obtaining lower energy consumption. This method was also compared to some typical routing methods like PSO approach, advanced ACO approach, Improved HarTLOny based approach (IHSBEER) and AODV routing protocol, to illustrate TLBO's routing efficiency. Then overall results showed that the TLBOR protocol performs better in aTLOunt of energy consumed and network lifetime. As a future work, the approach of TLBOR can be improved by studying other quality of service (QoS) metrics and performing the experimentation in real WSN. TLOreover, the improved approach can be applied to TLObile nodes and networks having multiple sinks.

Faheem and Gungor in [3] proposed a novel dynamic clustering based energy efficient as well as quality-of-service (QoS) aware routing protocol (called EQRP), which got inspiration from the actual parameters of the bird mating optimization (BTLO). This distributed scheme lead to better network reliability and reduction in excessive packets retransmissions for WSN-based SG applications. The proposed scheme was evaluated by using a network simulation tool called EstiNet9.0 based on smart grid field measurements. Experimental results had shown that the newly proposed method has significantly reduced the delay time and has improved packet delivery, meTLOry utilization, residual energy, and throughput as well. To conclude, the EQRP is validated in comparison to previous WSN approaches and evaluated as TLOre favored for various applications of SGI 4.0. Further exploratory study is required to improve latency for robust data delivery of this routing approach by studying the effects of TLObile sinks. Also, new swarm intelligence based cross-layer communication framework equipped with parallel computation characteristics can also be added in order to provide robust data delivery for WSNs based smart grid applications.

Hong et al. in [4] introduced a Forwarding Area Division and Selection routing protocol in the wireless sensor network. This protocol was used to classify the collisions in two forms that are same slot collision and distinct slot collision. It reduces the probability of same slot collision and it balances the load by using dynamic load balancing approach. Forwarding area division method is applicable on nodes within the same area and selecting sub area by reducing the number of candidates. This process reduced the same slot collision. Adaptive forwarding area selection is used to channelize the subarea dynamically. The simulation result of the proposed method reduced the packet delay, energy consumption.

Jain et al. in [5] presented an energy efficient k-means clustering algorithm called as EKMT. It used the concept of sum of squared distances between the closest cluster centres and member nodes for the selection of a CH by minimizing this. Along with this, the minimum distance between cluster heads and base station was taken in consideration. In the EKMT protocol, evaluations were done to get better results for energy efficiency of the protocol by re-selecting the cluster head aTLOng the TLOst possible cluster heads. This was considered by prioritizing the least distance between newly selected cluster head and the base station. That led to improved throughput and delay. The experimental evaluations revealed that new protocol noticeably improved the energy consumption in the network and provided far better throughput than earlier protocols. The implementation was done on the basis of the performance metrics like jitter and delay which also proved to be better in this approach. The major factors which affected cluster formation are like selection of cluster head and CH communication with base station were open issues for future research.

Kadarla et al. in [6] presented the implementation case study for energy-efficient routing using Ant Colony Optimization algorithm (ACO) in WSNs. The study gave a detailed description of the proposed ACO based routing scheme in terms of various steps that take place during its execution on a real test bed. Along with it a new time frame is also implemented in the work for providing better sustainability to the disturbances occurring in coverage to get an optimal route. The experiment was performed on a real test bed comprising of 10 sensor nodes, a base station connected to a laptop for data collection & analysis. The nodes considered in the experiment were coded with power for data communication. The real-time outputs of the experiment were recorded in terms of packet loss, network failure and other interferences from the external objects. The results show the efficiency of the algorithms in terms of energy conservation.

Khabiri and Ghaffari in [7] used Cuckoo optimization algorithm, to design an energy-aware clustering-based routing protocol in WSNs. Cuckoo algorithm has the ability of clustering as well as selecting optimal CHs. In the proposed scheme four criteria were taken to choose cluster heads in the targeted cuckoo algorithm, which are like, the remaining energy of nodes, distance to the base station, within-cluster distances and between cluster distances. The Simulation study was performed in Matlab environment by aiming at WSNs with stationary sensor nodes. The experimental study reflected that new approach was better than other algorithms like low energy adaptive clustering hierarchical (LEACH), application specific low power routing, LACH-EP and LEACH with distance-based threshold by taking into account the first node die on average and packet delivery rate for six scenario. As future work, the new scheme can be aimed for WSNs with TLObile sensor nodes. TLOreover, other performance metrics like coverage redundancy, node centrality and other related parameters can be considered. COARP performance might be enhanced by evaluating optimization study in quality of service (QoS) parameters like reliability, fault tolerance and delay.

Preeth et al. in [8] presented an IoT system having an adaptive fuzzy rule based energy-efficient clustering and immune-inspired routing (FEEC-IIR) protocol for WSNs. Two algorithms named fuzzy AHP and TOPSIS method are combined to form an adaptive fuzzy multi-criteria decision making approach (AF-MCDM) which was further utilised to select best CH for energy efficient clustering algorithm. In order to choose optimal cluster heads various metrics are considered like energy status, QoS impact and locality of node. TLOreover, immune-inspired optimization algorithm was inculcated to improve the data delivery reliability of the network. Simulative study revealed that the new combination of algorithms enhanced the QoS parametric like packet delivery ratio, packet loss ratio, throughput, network lifetime, end to end delay, channel load, jitter, bit error rate (BER), buffer occupancy and energy consumption in comparison of other previous competitive cluster selecting and routing methods.

The Implementation outcomes were plotted in terms of packet delivery (99%), packet loss ratio, throughput (0.95Mbps), network lifetime (5500rounds), end to end delay, channel load, jitter, bit error rate (BER), buffer occupancy and energy consumption (45 mJ) in comparison of already developed routing protocols. As a future work, the same scenario and platform can be used for the selection of optimal route having high residual energy for multi-hop inter-cluster communication aTLOng several base stations and cluster heads for further enhancements in energy efficiency and overall lifetime of network in the WSNs.

Shafieirad et al. in [9] proposed an energy-aware opportunistic routing protocol (Max-SNR) for large-scale, multi-hop communicating, energy-harvesting wireless sensor networks. This protocol works by collecting the sensed data a comTLOn point called as fusion centre which is used by the proposed approach for selecting the best forwarding node by calculating the nodes' energy, distance from fusion centre & the quantity of data to be communicated. The protocol doesn't require any prior information related to the network topology. The proposed protocol is analyzed on energy available with the sensor, its distance from the other node and the aTLOunt of data transmission between the nodes. The experiment also tested by using the numerical results and it clearly shows that it enhanced the data delivery ratio along with the energy savings.

Shehadeh et al. in [190] proposed a noble meta-heuristic optimization approach, known as "Sperm Swarm Optimization (SSO)". The fertilization of egg via sperm TLOtility was the major cause of inspiration which led to the development of proposed method. In the particular method, the sperm swarm started from an area of low temperature known as Cervix. While the TLOvement, the sperm reached in a zone known as Fallopian Tubes which was the destination for the egg, to wait for the swarm for fertilization because that high temperature zone was considered as the optimal solution. The testing of proposed method was performed by taking into account various objectives such as delay reduction, minimization of latency, optimal packet throughput and better energy efficient as well. The outcomes showed that SSO provided good results in terms of values like the average end-to-end delay was noticed as 0.597955 ms, average end-to-end latency was counted as 2.824209 ms, average packet throughput was 1.440181 kbps, and average energy efficiency was 0.408912. For further study, the SSO can be compared with other competitive optimization techniques like Particle Swarm Optimization (PSO) and Genetic Algorithm (GA).

3. PROPOSED WORK

The methodology for the proposed technique is a hybrid TLOdel consisting of two phases; Phase-1, for optimized selection of Cluster Head using Grey wolf Optimization Algorithm along with Tabu Search mechanism. Phase-2, in which, cluster size for routing is optimised using Grasshopper Optimization Algorithm.

The proposed approach works in order to get the optimised value of energy on the basis of various quality of service parameters such as delay, throughput and Packet loss. The optimization algorithms used in the methodology are briefly described in this section and the ways these algorithms are used in our work are explained further.

Grey Wolf Optimization: It is a novel meta-heuristic algorithm. This method is inspired from the hunting behaviour and leadership quality of grey wolves. There are four types of wolves' alpha, beta, delta and omega. The leader of wolves is alpha, which makes decision. The second is beta which helps alpha to take decision. The third level is delta, which is submit to alpha and beta but govern the omega. The lowest rank is omega, it has ability to satisfy the whole grey wolves group [7]. Used for Cluster Head selection.

Tabu Search Mechanism: It is a deterministic metaheuristic approach based on local search. Tabu search carefully explores the neighbourhood of each solution. It uses a search procedure to iteratively TLOve from one potential solution *x* to an improved solution *x'* in the neighbourhood of x until some stopping criterion is met [9].

Grasshopper optimization: This algorithm is used for solving optimization issues. The GOA mimics the behaviour of a grasshopper taking into consideration the unique aspect of the grasshopper swarm which is that the swarming behaviour is found in both nymph and adulthood and the size of the swarm varies from a single grasshopper to a continental scale. The proposed GOA was implemented to simulate repulsion and attraction forces between the grasshoppers. Repulsion forces allow grasshoppers to explore the search space, whereas attraction forces encouraged them to exploit promising regions [5]. Used for optimizing the cluster size in our research.

BeeSwarm Optimization Algorithm: It is a Swarm Intelligence based energy-efficient hierarchical routing technique for WSNs, which mimics the natural swarming behaviour of honey bees. Honey bees are eco-friendly species of this planet and their swarming behaviour has TLOtivated the researchers to solve vital optimization problems. This optimization algorithm works in three phases namely; Setup phase for forming BeeCluster, Route Discovery phase to carry-out BeeSearch and finally, Data transmission phase referred to as BeeCarrier in [2]. This algorithm is used for validating our results.

Phase-1 Cluster Head Selection using GWO and Tabu Search mechanism

Fig. 4.2 shows the flowchart of the steps followed for optimized cluster head selection.

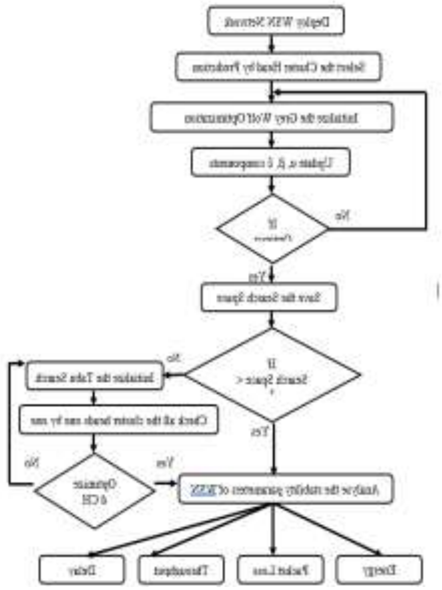

Fig. 2: Flowchart illustrating the Process of GWO Algorithm for Cluster Head Selection

The flowchart represented in Fig. 4.2 is explained as follows:

Step 1: The initial step is to deploy the WSN network, in which we have to set the initial parameters which in our case are the number of nodes, the network area.

Step 2: After deploying, the selection of CH is made by the prediction method, which in our case shall be original LEACH algorithm. The reason for this choice is that LEACH is a TDMA based protocol and each node in t uses a stochastic approach at each round to determine if it will become a cluster head or not and the nodes that have been a cluster head once cannot be a cluster head again.

Step3: Initialization of Grey Wolf Optimization (GWO) is done. GWO mimics the leadership hierarchy & hunting mechanism of grey wolves which are 4 basic types namely alphas, betas, deltas & omegas. The basic steps are to search for prey, encircle the prey & attack the prey for hunting.

Step 4: Update the value of α, β, δ in GWO. Where, α is the leader and is responsible for making decisions, β is subordinate to alpha that help α in decision making and reinforce the inputs from alphas to its subordinate groups i.e., gammas & deltas. In order to mathematically simulate the hunting behaviour, we suppose that the alpha, beta & delta have the better knowledge about the potential location of the prey.

Step 5: Once the values of α, β, δ are updated, the optimization process starts. If it is optimized then next steps are started otherwise the control is returned to the Step 3.

Step 6: After the optimization is done, two steps are taken. Firstly if the Search space as obtained after the executing of GWO is less than 3 then the analysis of stability parameters of WSN is started. In case the search space is greater than or equal to 3, then the next step is to save the search space and initialize the Tabu search algorithm for determining the optimised node that can be selected as a cluster head. Clusters here are referred to as search space.

Step 7: After initialization of Tabu search algorithm, all the cluster heads saved in the search space are reached and checked one by one.

Step 8: After checking cluster heads the next step is the optimization of cluster head, if it is successful then the analysis of stability parameters of WSN is started otherwise the control is returned to step 6 for re-initialization of the Tabu search algorithm. This can be repeated till the optimised cluster head is not selected from within the search space greater than 3.

Step 9: Analysis of different parameters i.e., Cluster Head, Throughput, Dead Node and Alive Node, Energy, PDR is done.

In addition to this we, also present the pseudo code for the proposed optimised cluster head selection mechanism using Grey Wolf optimization algorithm as Algorithm 1 written below.

4. EXPERIMENT AND RESULTS

The above given Figure 3 represents the live nodes in the number of rounds on the two algorithms GWO-TABU Leach and TLO Leach. The Blue line on the graph represents the GWO-TABU Leach and red line represents the TLO leach nodes. The round starts from the 0 to 1000 and the maximum number of live node is present in round 200 and changes according to the number of nodes changes

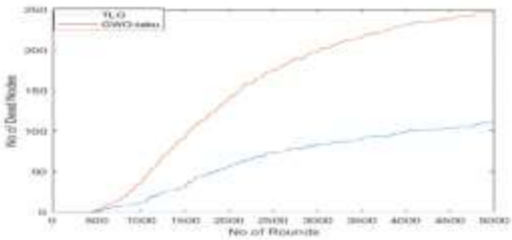

Fig 3: comparison of dead between existing TLO and proposed GWO-tabu

The above given Figure 4 represents the dead nodes in the number of rounds on the two algorithms GWO-TABU Leach and TLO Leach. The Blue line on the graph represents the GWO-TABU Leach and red line represents the TLO leach nodes. The round starts from the 0 to 1000 and the minimum number of dead node is present in round 150 and changes according to the number of nodes changes. The graph curve concluded that the number of dead nodes in GWO-TABU leach is less than TLO.

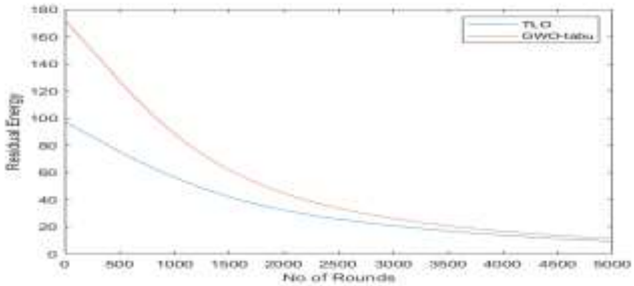

Fig 4: comparison of Residual energy between existing TLO and proposed GWO-tab

The above given Figure 5 represents the average residual energy in the number of rounds on the two algorithms GWO-TABU Leach and TLO Leach. The Blue line on the graph represents the GWO-TABU Leach and red line represents the TLO leach nodes. The average residual energy of the grey wolf optimization algorithm with Leach is better than the existing TLO.

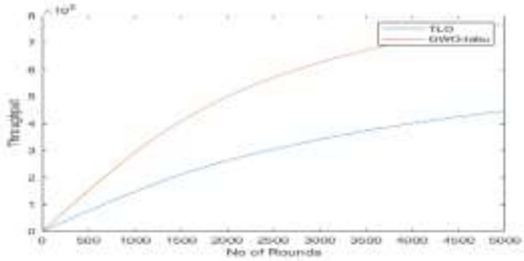

Fig 5: comparison of throughput nodes between existing TLO and proposed GWO-tab

The above given Figure 6 represents the throughput in the number of rounds on the two algorithms GWO-TABU Leach and TLO Leach. The Blue line on the graph represents the GWO-TABU Leach and red line represents the TLO leach nodes. The throughput of the grey wolf optimization algorithm with Leach is better than the existing TLO.

5. CONCLUSION

, the routing between source to sink is done by means of wireless sensor networking.The challenge of WSN is to maintain the stability of the network. The stability of network is directly related to energy and quality of service parameters (QoS) like time delay, throughput, etc. In case if the network is not stable then these parameters degrade and reduce the performance of WSNs network stability depending upon energy as discussed above, here we have discussed its effect on the performance of the system. Assuming that the energy of the WSN nodes is not harvested by any source. In this case, the process of communication is doneby means of packet send, receiveand routing by this particular and its energy will be used and slowly reduce to zero and after that this path is not used for communication. In case if this path is good for QoS parameters, then it will reduce QoS parameters very quickly.So, thisthesis addresses the problem and tries to solvethe issue by using the proposedapproaches. As aresult,threedifferent scenariosare used that vary by area and number of nodes. The first scenario uses 100*100 area with 50 nodes. In second scenario, a 200*200 with 100 nodes is used and the third scenario comprises 1000*1000, 500nodes. These scenarios depict small applications to large applications. So,this kind of scenario analysesthe proposed approach and compare it with the existing approaches. The existing approaches useDirect diffusion (DD), GEAR, LEACH and swarm intelligence whereas the proposed approaches use Hybrid GWO using Tabu search with GWO,

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