Taylor based Neuro-Genetic Algorithm for Secure and Energy aware multi hop routing protocol in WSN

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Abstract:
Wireless Sensor Network (WSN) is used to monitor, collect and organise the data at central location. One of the major challenges is the security and energy in WSN where energy is consumed more when the battery activates the sensors. Proposed work deals with the energy and offers an effective multihop routing in WSN called Taylor-based Neuro Genetic Algorithm (Taylor NGA) by adjusting NGA with Taylor series. This research work represents in this article, goes through two phases for multihop routing, which incorporates choosing the Cluster Head (CH) and communicating information. At first, cluster heads are taken for better data transmission; sensor nodes send information to the Cluster Head, which communicates the information to the gateway through best optimal hop . The best hop is made with the Taylor NGA to show the best performance in energy, alive nodes, delay, and throughput with estimations of 0.150, 52, 0.398, and 0.1 respectively for 100 nodes.

Keywords: Wireless Sensor Network (WSN), Taylor based NGA algorithm, Energy, Delay Throughput and Alive nodes

1. Introduction

WSNs have been used in many applications, for example, environment observing, military surveillance and healthcare (N. K. Suryadevara, et.al. (2015) M. P. Durisic, et. Al.(2012), H. Furtado and R. Trobec,(2011)). WSNs are comprised of more sensor nodes that are thickly conveyed and imparted remotely to transfer and receive environment data. Every sensor node is furnished with a radio transceiver, a processor and battery. What's more, a few significant necessities should be fulfilled during the WSN plan, for example, the energy utilization prerequisite, which speaks to the primary key. Hence, a considerable lot of the research studies are going on WSN reviews. (I. F. Akyildiz et. al.(2002), L. Mottola and G. P. Picco(2006)., The author clearly explaining the idea of WSN where they depicted the generations, routing, architecture, and storage management. Further examinations (Q. Jiang and D. Manivannan(2004), S. R. Madden et.al (2005)) describing about the existing protocols for WSN. The authors indicated a few existing protocols for the sensors (M. M. Molla et. al.(2006). In (R. C. Shit et. al.(2018)), the author explained about sensor restriction strategies and various levelled scientific categorization.in (R. C. Shit, S. Sharma, D. Puthal et al 2019), the author addresses sensor location schemes and their implementation for the IoT infra-structure and also presented a survey on the localization of sensors for the intelligent world. The authors demonstrated how each system defines oral behaviour and network behaviour and also the modelling tool for every approach. Authors also discussed about the main software design approaches and modelling ideas which are used to develop WSN. From this, we bring together and discuss about the low level and high level based technologies of Wireless Sensor Networks. Our research is to find the high level based approach which will reduce the WSN system development and increase the performance of the maintenance (R. Newton, G. Morrisett, and M. Welsh(2007)). Based on the MDE method (D. C. Schmidt(2006)) and standard methods such as MARTE (OMG Object Management Group 2011) and processing system (J. Vlissides(1995)). Taylor's proposed NeuroGenetic Algorithm

(NGA) is a combination of the Neural Network and Genetic algorithm that has proven more effective than the Evolutionary algorithm in finding the best solution. One of the machine learning approaches is neural networks (NN), which contain artificial neurons and have analytical models based on the biological human brain. The neural network acts like a human thought and handles noisy or missing data. The collected data is used for learning, training and evaluation of network performance and linked with neurons to solve the particular problem. Evolutionary Algorithm (EA) is the population-based algorithm that is used for optimization problems based on the idea of biological evolution. In EA, parallel implementation is easier and optimization problems like multi-model and goal setting are used to solve the different solutions. The main characteristics or operators of EA are representation, selection, recombination, mutation, fitness function. The genetic algorithm (GA) is based on the EA, which can be classified as a global search heuristic. GA is a biologically inspired optimization algorithm and the operators used by EA are used here. The optimal solution is achieved from the best solution through the technology "Survival of the fittest". GA is a technique for finding the optimal solutions to search problems. GA starts with the randomly generated population of individuals and assesses the fitness of all individuals. From the current numbers, it selects a few modified people in order to create the next most used number and it ceases after the best solution has been found. The NeuroGenetic Algorithm (NGA) is a combination of a neural network and a genetic algorithm - an organism bears its expressed characteristics, i.e. it can either be inherited or determined by environmental factors, also sometimes it arises as a mixing of both (en.wikipedia.org/wiki/Neurogenetics-2016). GA selects the population at random and evaluates eligibility. Select a few populations for editing to get a better solution, but when the output of GA is sent to the input of NN, the learning process provides the best solution for WSN to extend the lifespan.

2. Related Work

In (Cengiz, K., Dag, T., (2018)), Multi-Hop Routing Protocol is created by the authors for energy effective. Here, an inexperienced protocol was designed to lessen immoderate overhead. The approach could considerably growth network lifestyles which could probable reduce overhead and the relay nodes on this approach, allow the transmission of cluster. Also, the scalability becomes maximum and furnished a positive result at the same time as dissipating power in the WSN.

In (Purkait, R., Tripathi, S., (2017)), the authors explain a protocol called fuzzy logic-based totally electricity-green cluster-primarily based routing protocol that makes use of a multi-hop routing method, wherein the cluster length changed into dynamic. The configuration of the cluster is designed, with a complex device for enforcing the machine. The performance become evaluated based totally on a protocol designed primarily based at the rely of live nodes and other protocols. The method progressed the lifespan of the community and carried out minimum lifeless node speed. The computation time for this method becomes excessive.

In (Selvi, M., Velvizhy, P., Ganapathy,et. al. (2017)), the authors evolved an energy green routing method with delay constraint for multi-hop routing in Wireless Sensor Networks and the technique presents dependable routing to lessen electricity via assembling green clusters without delay. This method is totally based on the life of the network. However, this system does not keep in mind a mobility machine to enhance QoS performance based totally on lock control, mobility and rotation.

In (Sert, S.A., Alchihabi, A., Yazici, A., (2018)), to maximize the WSNs lifetime, the author invented Two-Tier Distributed Fuzzy Logic Based Protocol (TTDFP). Distribution adaptive protocol is a technique for sensor network applications. Wool Cluster gadget for WSN efficiency performance. This method is incompatible with other optimization equipment, inclusive of the performance device (PSO) and requires the addition of WSN in conjunction with components.

In (Chen, Z., Shen, H., (2018)), the authors evolved a protocol called Grid-based Reliable Multi-Hop Routing Protocol to perform routing in WSN. This method used to balance energy consumption based on residual electricity and node location. The system advanced stability time and showed better overall performance on the premise of energy. But, the technique will not produce a strong and scalable protocol. In addition, all the strength consumption for the transmitter and receiver has been merged to model the weight of the links between the nodes. Dijkstra's algorithms are used to find path

with least cost. Here the author proposed MH protocols which have been started primarily based on the BEEMH algorithms.
In (Fawzy, A.E., Shokair, M., Saad, W., (2018)), the author designed an algorithm referred to as Balanced and energy efficient Multi-Hop (BEEMH) to carry out multi-hop routing in Wireless Sensor Networks. This method is followed by the Dijkstra algorithm and it is delivered with great interest inside the residual electricity of the node. Therefore, the nodes with the very best energy have been taken into consideration for the transmitting and receiving nodes to offer the cluster head between cluster routing protocols and it provides an efficient platform to find the best cluster head using several parameters, inclusive of energy and location. This method does not have an effect on the grid location and impacts the reliable conversation between the given overall performance providers.
In (Akila, I.S., Venkatesan, R., (2018)), the authors created geo clustering manner based on the location of the node to get energy savings in WSN. This technique increases the network lifetime and turned into complex due to the fact the performance parameters appropriate for routing offered a complex trade-off between parameters.
In (Laouid, A., Dahmani, (2017)), the authors evolved a technique commonly referred to as a multi-threading process based on the energy of residues and number of hops of each gateway to determine the best way to place them inside the destination desk. This system is primarily based at the network automation and Ant Colony Optimization (ACO). The performance of the algorithm was totally based on the best path and provided the less power paths. Here scalability and fault tolerance has been given as negative for this approach.
In (Huynh, T., Tran, C., (2016)), the introduced a model for the distributed clustering technique which provided the right energy consumption between trade-off values and ensured end-to-end delay, but the major issue was choosing the effective hops.
In (Sajwan, M., Gosain, D., Sharma, A.K., (2018)), the authors had succeeded in developing a multi-path routing algorithm which is an hybrid energy efficient model that minimized power consumption at the nodes, however distance became a major component affecting overall performance.

3. Proposed multihop routing using Taylor based NGA algorithm

Here we illustrate the safety aware multi-hop routing protocol based totally on multiple locations in WSN by using the newly advanced best algorithm. Here, a confidence model is hired that considers numerous confidence elements, together with direct confidence, oblique confidence, integration factor and transmission rate factors in conjunction with parameters, involving energy, delay, throughput and alive nodes.
To offer high security to the network trust model is involved. Taylor's Neuro Genetic Algorithm (Taylor NGA) has been introduced for the conversion process. Taylor NGA was developed by linking the Taylor series (Mangai, S.A.et. al.(2014)) to the NGA. The proposed Taylor NGA are used to perform protection-conscious multi-hop routing in WSN. First, CH is selected the usage of the LEACH protocol (Masdari, M., Bazarchi,(2013)) to gain the optimal CH with more energy. Then the second step is to select the optimal jumps using the proposed Taylor NGA primarily based at the designed multi-lenses. FIG. 1 shows a graphical diagram of a system to observe some of procedures based at the Taylor NGA algorithm.

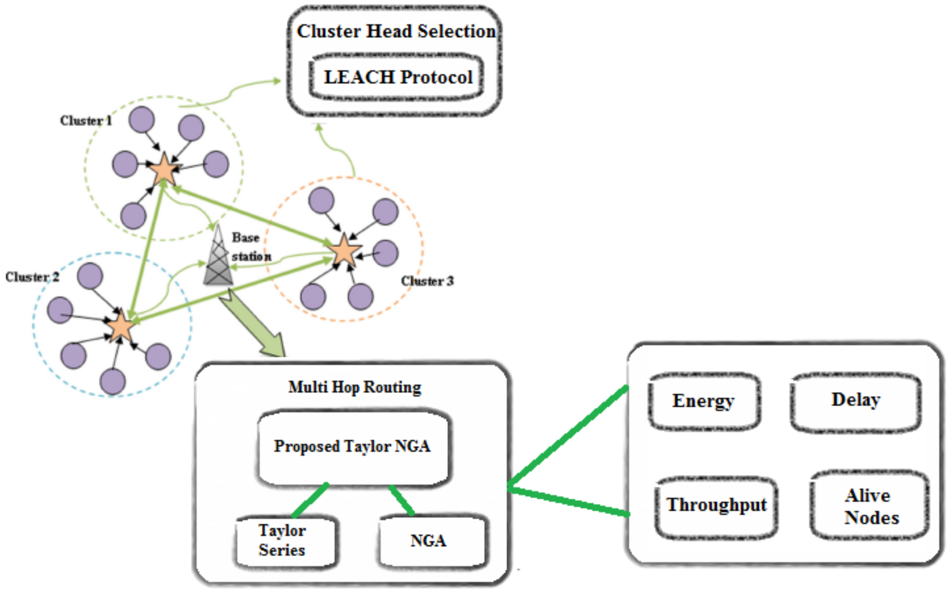


Fig 1. Proposed multihop routing using Taylor based NGA algorithm

4. Proposed Taylor NGA

Taylor NGA was created for the installation of hops effectively to move forward and rotate multiple paths. The required method is established via the introduction of the Taylor method and the NGA algorithm that is an aggregate of Neural Network and Genetic algorithms for figuring out the exceptional hops to operate multi-hop in the WSN. Safety-conscious multi-hop routing is conceived by way of inclusive of the trust model inside the fitness function. Therefore, the multihop routing keeps the use of the proposed model named Taylor NGA-based fitness function.

The proposed Taylor NGA, that is the combination of the Taylor NGA series inheriting the advantage of the Taylor and NGA series algorithms. The Taylor series can be used to expect the linear part and describes the past historic values. The benefits of the Taylor method are easy to calculate answers, even in the presence of complicated operations. Its foremost benefits include Taylor series which will ensure the estimation accuracy of common functions and achieves convergence.

NGA is the combination of neural network and genetic algorithm which acquires the attributes of both algorithms acquires the best solution and affords the benefits of the two algorithms which provide an awesome stability among the stages of exploitation and exploration, and to attain the overall most efficient solution. The NGA is simple to put in force and has a single replace update manager.

The proposed algorithm is able to acquire for composite data, unimodal and multimodal. Taylor NGA algorithm is used to solve the constraints where NGA is combined with the Taylor series so that Taylor-NGA will become able to obtain best solution. The combination of the two strategies enables to determine a best answer and improves convergence and gives an finest strategy to gain best multihop routing.

4.1 The steps to be followed for the proposed Taylor NGA algorithm:

i. Initial population

The initial population is generated by a genetic algorithm. First, the crossover operator is used to find the order represented in the population.

$$C= \{C1, C2\ldots.C_0,\ldots C_u\}$$

Where, Co constitutes to the position of o^{th} population, and u constitute to the position of u^{th} population.

ii. Evaluation of fitness function

Fitness function is used to find the solution by using parameters. Taylor NGA makes use of parameters such as confidence model, distance, energy, inter-cluster distances, link lifetime, delay and intra-cluster distances, routing uses solution that gives provides maximum trust, maximum link life, intra-cluster, power, and distance, less delay, and inter-cluster distance. Therefore, multihop routing is considered by the maximum fitness value. Taylor NGA is computed as follows:

$$O = W_1 \times P + W_2 \times (1 - T) + W_3 \times (1 - X^*) + W_4 \times X + W_5 \times (1 - D) + W_6 \times M + W_7 \times K$$

Where, W1, W2, W3,W4, W5, W6 and W7 are weights calculated by fuzzy function (Dennis & Muthukrishnan, 2014). P - node's energy, T - transmission delay, X - inter-cluster distance, D - distance between two hops and M is the link-time, and the trust model is denoted as K. following formula shows how to calculate the weights,

$$W = \begin{cases} 0; & \text{if} \quad r < f \\ \frac{r-f}{p-f}; & \text{if} \quad f \leqslant r \leqslant p \\ \frac{q-r}{q-p}; & \text{if} \quad p \leqslant r \leqslant q \\ 0; & \text{if} \quad r \geqslant q \end{cases}$$

where, p; q; and r – vertices with lower boundary, medium margin with value 1 and upper margin with value 0, T(f) - triangular membership function.

iii. Computation of the solutions

Here, optimal solutions are obtained with our Taylor NGA with trade-off between the exploitation and exploration phases.

5. Results and discussion

Here the analysis of the parameters such as delay, power, alive nodes and throughput is compared with proposed and existing algorithms.

i. **Experimental setup :** Simulation parameters are shown below in the Table 1 which can be implemented our algorithm in MATLAB.

Table1: Simulation Parameters

Parameters	Values
simulator	matlab
area	100 × 100 m
no.of nodes	50 and 100
transmission range	40 m
simulation time	2000 rounds
receiver energy consumption	5 × 10^−8 J
transmitter energy consumption	5 × 10^−8 J
initial energy	0.5 J
traffic type	CBR

ii. **Performance metrics :** Performance metrics are used for analysing the delay, power, alive nodes and throughput.

iii. **Energy:** To save the energy in the WSN, the data between the nodes are used. The node which has high energy will be taken for the evaluation. The summation of the energy must constitute a high value and it is formulated as,

$$P = \frac{1}{b} \sum_{k=1}^{b} E(J_k)$$

Where, b - hops in multihop routing, and $E(j_k)$ - energy of k^{th} hop.

iv. **Delay:** Delay is calculated with more nodes. If nodes increase, then the delay also increases. For the best solution the delay must be less. With more hops, delay is computed for the routing in Wireless Sensor Network and is formulated as,

$$T = \frac{b}{l}$$

where, l - nodes in WSN, and b -hops for the routing.

v. **Alive nodes:** Foe communication in WSN, the alive nodes is used for initiating.

vi. **Throughput:** The packets are forwarded at specific time and acknowledged is referred as throughput.

$$\text{Throughput} = N_r/T$$

Where, N_r is total no. of nodes obtained and T is the time taken for simulation.

5.2 Comparative Results

Taylor NGA algorithm has the better performance while it is compared with the existing methods. The following graphs shown below with the existing algorithms are Geo clustering, Grid clustering, C-SSA, FABC-EACO and Taylor C-SSA clustering compared with proposed Taylor NGA.

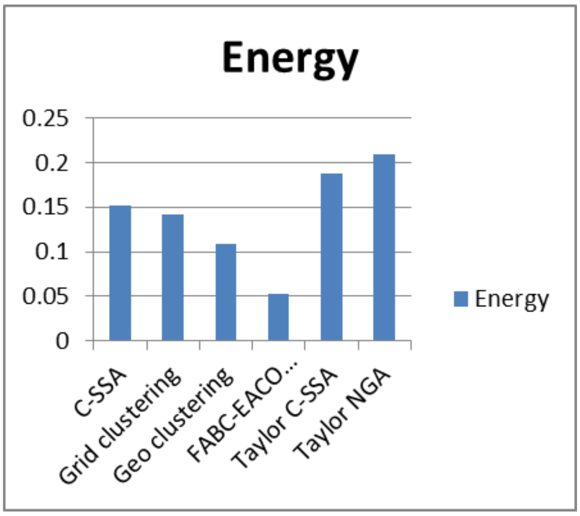


Figure 2: Energy Analysis

In fig 2, For 50 nodes, energy is slightly increased when compared to existing algorithms.

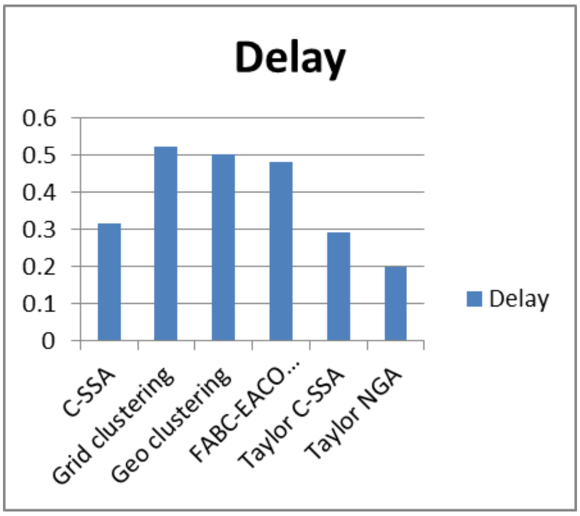
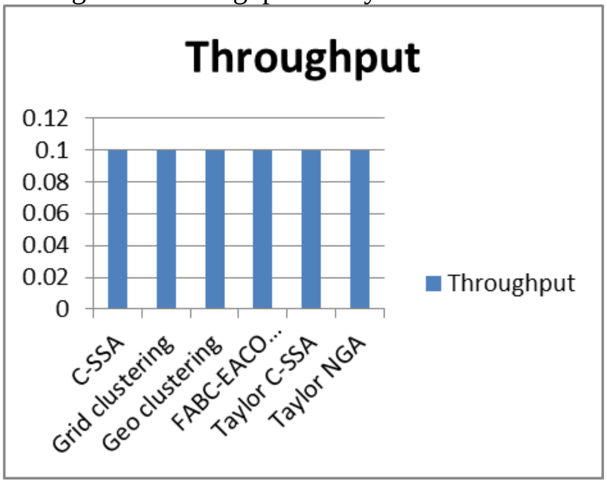


Figure 3: Delay Analysis

In fig 3, For 50 nodes, delay is decreased slightly when compared to existing algorithms.

Figure 4: Throughput Analysis for 50 nodes



In fig. 4, For 50 nodes, throughput is equal when compared to existing algorithms.

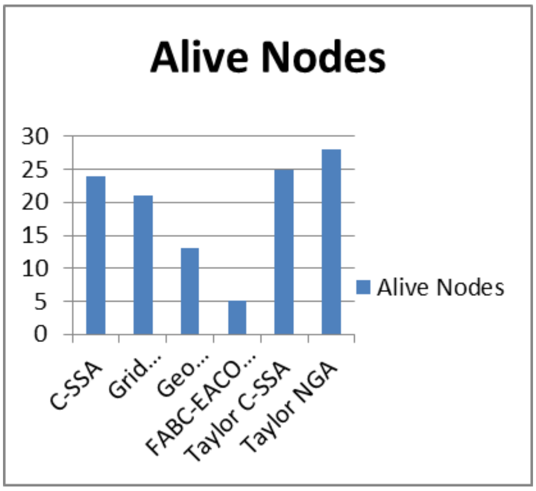


Figure 5: Throughput Analysis

In fig. 5, For 50 nodes, alive nodes are increased when compared to existing algorithms.

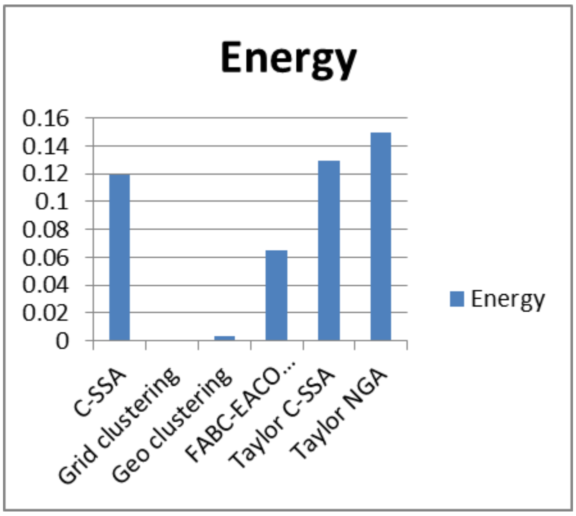


Figure 6: Energy Analysis

In fig 6, For 100 nodes, energy is slightly increased when compared to existing algorithms.

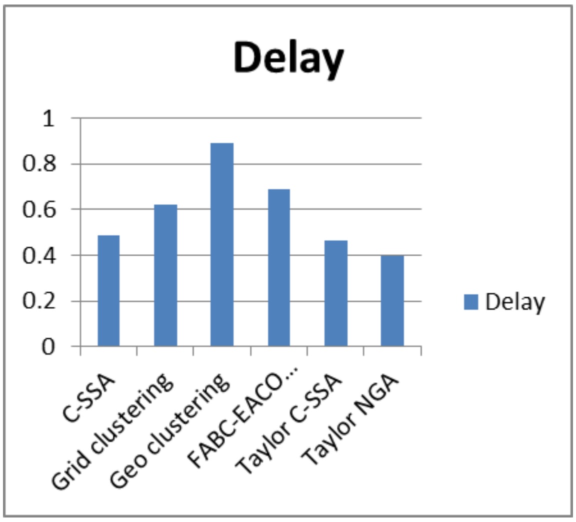


Figure 7: Delay Analysis

In fig 7, For 50 nodes, delay is decreased slightly when compared to existing algorithms.

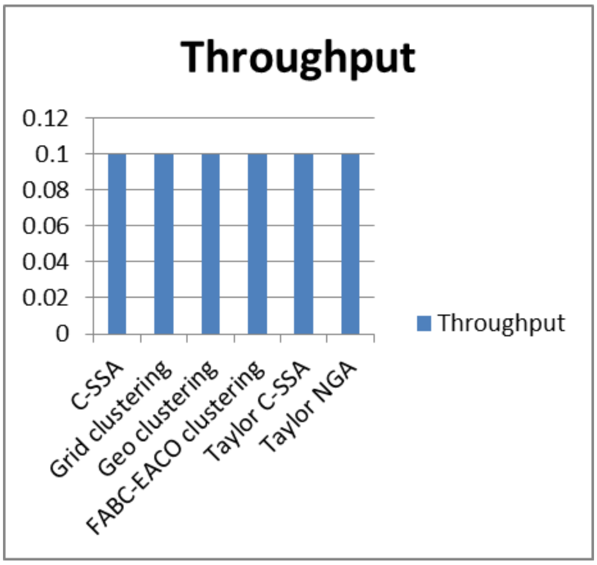


Figure 8: Throughput Analysis for 100 nodes

In fig 8, For 100 nodes, throughput is equal when compared to existing algorithms.

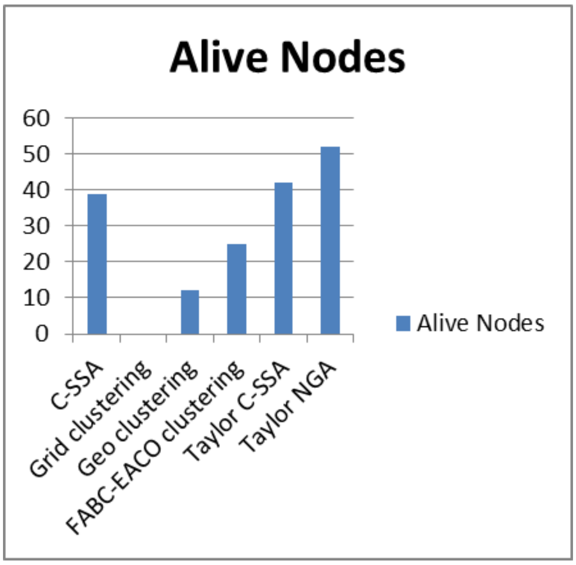


Figure 9: Alive nodes Analysis

In fig 9, For 50 nodes, alive nodes are increased when compared to existing algorithms.

In (A. Vinitha, M. S. S. Rukmini and Dhirajsunehra(2019)), Comparative result is taken for the factors like delay, power, alive nodes and throughput. Table 2 shows the results of 50 and 100 nodes with 2 and 3 hops dependent on the analysis method. For 100 nodes, compare to the existing algorithms like as Geo clustering, Grid clustering, C-SSA, FABC-EACO and Taylor C-SSA clustering, the energy values are 0.119,0, 0.003, 0.065 and 0.129, our proposed Taylor NGA has the highest value as 0.150. For 50 nodes, the delay values for existing algorithms such as Geo clustering, Grid clustering, C-SSA, FABC-EACO and Taylor C-SSA clustering are 0.481, 0.524, 0.316, 0.481 and 0.291. When proposed algorithm is compared with existing algorithms the delay value is 0.199 which is minimum value that can used for improving the performance and also the throughput which has the value as 0.1. For 100 nodes, the maximum alive nodes as 52 which can be achieved by our proposed algorithm. So we can conclude that our Taylor NGA algorithm has the best performance in all the four parameters when compared to the existing algorithms.

Table2: Analysis of Energy, Delay Throughput and Alive nodes

Metrics	Nodes	C-SSA	Grid clustering	Geo clustering	FABC-EACO clustering	Taylor C-SSA	Taylor NGA
Energy	50	0.152	0.142	0.108	0.052	0.188	0.210
	100	0.119	0	0.003	0.065	0.129	0.150
Delay	50	0.316	0.524	0.501	0.481	0.291	0.199
	100	0.485	0.621	0.889	0.687	0.465	0.398
Throughput	50	0.1	0.1	0.1	0.1	0.1	0.1
	100	0.1	0.1	0.1	0.1	0.1	0.1
Alive nodes	50	24	21	13	5	25	28
	100	39	0	12	25	42	52

Conclusion

Major focus of this paper is Secure and Energy aware protocol of multi hop routing in WSN and as important prototype which considers security for performing multi-hop routing and the parameters are delay, power, alive nodes and throughput. The process goes through two stages to achieve best multi-hop routing. The first level is the CH option; the second level is transmission of data. From cluster heads, the optimal number is selected as the cluster head by the LEACH method and transmission of data is adjusted on the selected hops using the required Taylor NGA function to support quality health care. Taylor NGA algorithm is combination of the Neural Network and Genetic Algorithm and it is tested with 50 and 100 nodes. Comparative analysis is done with existing algorithms on the following constraints, namely energy, delay, throughput and alive nodes for 100 nodes with values 0.150, 0.398, 0.1, and 52 respectively.

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